

IdRA Documents 3

10th HyMeX Workshop

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Barcelona, Spain*

**Maria Carmen Llasat
Javier Martín-Vide
(Coord.)**

**Water Research Institute (IdRA)
University of Barcelona**



IdRA Documents 3

10th HyMeX Workshop

Coordinators:

Maria Carmen Llasat, Faculty of Physics, University of Barcelona

Javier Martin-Vide, Director, Water Research Institute (IdRA), University of Barcelona

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INDEX

PRESENTATIONS	11
FOREWORD	13
ORAL COMMUNICATIONS	15
Towards a satellite driven land surface model using SURFEX modelling platform Offline Data Assimilation: an assessment of the method over Europe and the Mediterranean basin	17
Precipitation and Extreme Precipitation Trends over Israeli Regions and sub-regions- an overview & comparison to earlier studies.....	18
Flash-flood ensemble forecasting in two Spanish Mediterranean catchments: comparison of distinct hydrometeorological ensemble prediction strategies	18
Multiple equilibria and overturning variability of the Aegean-Adriatic Seas	19
The evolution of incidents due to intense rains in Barcelona in the last 20 years versus the alert levels set in the Civil Protection Plan.....	19
Representation of Integrated Water Vapor at different time scales and its impact on precipitation in MED-CORDEX simulations	20
Overview of Gravity Waves, Orographic Precipitation and related processes in The Cerdanya-2017 field experiment	21
Operational hydrometeor classification using polarimetric radar: focus on hail detection	22
LIAISE: land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment.....	22
A reflectivity forward operator designed for vertically-pointing W-band radars.....	23
Fine-scale atmospheric processes and sensitivity to sea-state representation during HyMeX IOP8 heavy precipitation event	24
The Floodscale Experiment at the Hillslope Scale: Physico-Chemical Characterization of Runoff Contributing to Flash Flood Generation in the Small Catchment of Valescure, France.....	25
Comparing various approaches for flash flood forecasting in the Yzeron periurban catchment (150 km ²) south-east Lyon, France	25

The marine atmospheric boundary layer during the HyMeX/ASICS-MED campaign: 1-D and large eddy simulations under strong wind conditions	26
Creation of a Med Forecast Center	27
Characterization of different GNSS-IWV data assimilation effects on the simulation of heavy precipitation during the HyMeX-SOP1	28
Coupling of watersheds, estuaries and regional seas through numerical modelling for Western Iberia: river discharge influence in the near open ocean	29
Statistical Downscaling of EURO-CORDEX climate change scenarios: Projections of droughts and heavy precipitations along the 21st century	29
Spatial daily rainfall descriptors to reproduce sub-daily dynamics in the analog method for temporal disaggregation	30
Storm-scale data assimilation using EnKF: Impact of conventional and radar data on the prediction of heavy precipitations during HyMeX IOP13.....	31
Forecasting acqua alta in Venice Lagoon with coupled BOLAM-SHYFEM: a model performance sensitivity test on three high tide case studies	32
Simulation of HyLMA lightning observations with Arome	33
Mediterranean extreme precipitation: A multi-model assesment	33
Anticipating Mediterranean High Precipitation Events : which decision strategy when using probabilistic forecasts from a convection-permitted Ensemble Prediction System?	34
The Western Mediterranean marine heat wave of summer 2015	35
Severe convection over the Mediterranean basin derived from microwave satellite observations	35
Flooding from Intense Rainfall.....	39
Properties of the lightning flashes recorded during the entire SOP1 period	40
Dynamics and predictability of Medicanes in the ECMWF ensemble forecast system	41
How much does Clausius-Clapeyron law predict humidity change under global warming in the Mediterranean region?	41
Which people and which companies are exposed to flood prone in the French department of the Gard (southern east of France)?	42
Multi-model analysis of the Adriatic-Ionian thermohaline circulation using an ensemble of multi-decadal regional ocean simulations.....	43

Comparison of flood modeling approaches in the High-Atlas Mountains (Morocco).....	43
Operational high temporal and spatial resolution soil moisture by multi-sensor remote sensing approach for water resources management.....	44
Ocean circulation, formation and dispersion of dense water in the western Mediterranean Sea	45
Spatio-temporal variability of extremes precipitation indices in Tunisia	46
Heavy rainfall in Mediterranean cyclones: Contribution of deep convection and warm conveyor belts.....	47
Extreme rainfall in South East of France during the autumn: added value of a convection permitting regional climate model	47
Impact of ocean-atmosphere coupling and increased resolution on the simulation and future projections of medicanes	48
Water level estimation over Ebre river basin.....	48
Regionalized rainfall-runoff model to estimate low-flow indices in gauged and ungauged basins	49
Numerical modelling of Ocean Convection Plumes in the Gulf of Lion using hydrostatic approximation.....	50
Implementation of water table dynamics in SURFEX based on explicit diffusion equations.....	51
On the impacts of dust on Mediterranean cyclones: The Mediane case of December 2005	52
An Eddy-Diffusivity Mass-Flux Parameterization for Oceanic Convection.....	52
Assessment of the impact of climate change on the water resources of the Tensift watershed	53
Model simulation of the Mediterranean Sea level variability and trends: the dynamic and steric effects	54
Synoptic classification approach in 21st Century CMIP5 Predictions over the E. Mediterranean with focus on cyclones.....	54
VIGICRUES-Flash: a French national flash flood warning system for ungauged catchments based on the AIGA method	55
Assessment of precipitation products over the Mediterranean Sea	56
Reconstruction of transports through the Strait of Gibraltar from limited observations	57

The interaction between aerosol particles, cloud and precipitation during the HyMeX IOP7a event.....	57
IOP7a event.....	58
Validation of an integrated flash flood impacts forecasting chain based on insurance claims.....	59
Insights into the moisture environment of mesoscale convective systems observed in Southern Italy during HyMeX IOP 13 based on the isotopic composition of water vapor.....	60
Potential contribution of global spatial data to operational drought management decisions in the Ebro basin	61
Coping with floods in the Northern part of the Mediterranean: the application of an international database on flood events for a 35 years period	62
New insights in the structure of anticyclonic eddies in the vicinity of the Balearic front: output of winter in situ experiments Protevs 2016 and 2017	63
The role of deep convection in the regulation of the Northwestern mediterranean basin.....	64
Surface hydrological budget from the ISAC micrometeorological station in Salento península.....	64
Assessments of the risk of longest dry spells phenomenon in Ghézala dam reservoir (Tunisia).....	65
Accounting for the uncertainties in radar-raingauge rainfall estimation and the parametric uncertainties of the hydrological model in the prediction of flash floods in the Cévennes-Vivarais region, France.....	65
SMOS SSS maps in the Northern Western Mediterranean: a comparison with in situ measurements	66
Role and capabilities of the GPM mission in the characterization and monitoring of extreme precipitation events in the Mediterranean region	67
Drivers of individual flood risk perception and preparedness: a behavioural survey targeting the citizens of Greece	68
Observing extreme long duration lightning flashes in South-East France	69
A global integration technique to describe the Mediterranean water cycle using satellite data.....	70
Small-scale processes in the Mediterranean Sea deep convection areas : a numerical study through nesting approach	71

RegCM4.6 high resolution numerical experiments on Mediterranean area: the challenge to explore climate by the new non-hydrostatic version of the ICTP regional climate model	72
Simulating the electrification of thunderstorms in Corsica and comparison with SAETTA records of 3D flashes	72
Exploring drought propagation in Land-Surface Models: evaluation of uncertainties related to meteorological forcing datasets and model structure	73
Radar retrieval of the raindrop size distribution: a double-moment normalisation approach	74
Winter time Very Long Dry Spells over the Mediterranean Basin: detection and associated atmospheric dynamics	74
ULMOi: A new teleconnection index for rainfall predictability in the Mediterranean basin	75
Observed increase in extreme daily rainfall in the French Mediterranean	76
Representation of turbulence in convective systems at kilometer-scale resolution: application to two IOPs during the HyMeX campaign	77
Water Use Restrictions under Climate Change: a Bottom up Perspective applied to the Rhône-Mediterranean basin	77
CMIP5-Based projection of future changes in the frequency and intensity of medicanes at subregional scale	78
Analysis of a damaging hydrometeorological event in the Balearic Islands. The December 2016 case	79
A climatological study of tropospheric cyclonic vortices in the Mediterranean region (25-50°N, 10°W-35°E) from ERA-Interim reanalyses	80
Potentiality of hydro-meteorological ensemble forecasting of flash floods for risk assessment: Application to the Agly catchment (Eastern Pyrenees)	80
Winter 2017 in the NW mediterranean. Was it just mild or clearly anomalous?	81
Rapid response to climate change in a marginal sea	82
Evaluation of the Levantine Intermediate Water formation in a multi-decadal simulation with the regional climate system model CNRM-RCSM6.....	83
Network integration of renewable power generation: How much weather variability influence the electrical consumption-production imbalance in Italy?	83

Intense air-sea exchanges and heavy orographic precipitation over Italy: the role of Adriatic Sea during Bora and Sirocco events.....	84
Representation of subgrid turbulent fluxes in convective clouds with LES and kilometer-scale resolution simulations.....	85
Multi-model analysis of the Eastern Mediterranean thermohaline circulation and representation of the EMT event in hindcast simulations.....	85
Validation of the 2 moment microphysical scheme LIMA based on HyMeX microphysical observations	86
Building a prototype model for probabilistic prediction of flash flood human impacts	86
Extreme dry spells modelling in the Mediterranean region in relation with atmospheric circulation patterns.....	87
Dense water formation in the coastal northeastern Adriatic Sea: the NAdEx 2015 experiment.....	88
Taking into account hydrodynamic parameters and initial soil moisture uncertainties in an ensemble-based flash-flood forecasting system.....	89
Does ocean intrinsic variability impact ocean deep convection? Answers from ensemble simulations of deep convection in the Northwestern Mediterranean Sea	89
Improving estimates of riverine fresh water into the Mediterranean sea	90
Synoptic Conditions for Dry Spells in Israel	91
POSTERS	93
European marginal seas coupled centennial scale regional climate simulations.....	94
Towards a high resolution drought monitoring system in Catalonia.....	94
Can precipitation over Israel be predicted from Eastern Mediterranean heat content?	95
Box modeling of the Eastern Mediterranean sea	95
Assimilation of dual-polarization radar observations into convective scale models	96
Understanding the flow intermittence dynamic of headwater streams using periodic observations of river flow state in South-East France	97
FerryBox: a new approach to study water masses properties and dynamics in the Western Mediterranean Basin	98

New version of MEDRYS, a mediterranean sea reanalysis during 1992-2013.....	99
Ensemble hydrological simulations over the Iberian Peninsula using a combined product of global reanalysis and satellite precipitation data	99
Variability of the Drop Size Distribution at small spatial and temporal scale in the Cevennes-Vivaraïs region, France	100
The October 2015 flash-floods in south eastern France: hydrological analyses, inundation mapping and impact estimations.....	101
J2000-Rhône: a distributed hydrological model including water use modelling to assess sustainability of the water management	101
The HyMeX data base.....	102
Integration of satellite data into SURFEX for better monitoring agricultural droughts.....	103
Ability of the Symphonie model to observe fine-scale dynamics in the North-Western Mediterranean Sea.....	103
Geostatistical conditional simulation for ensemble rainfall nowcasting: a case study in the Var region	104
The 3rd version of raingauge data in the north-western Mediterranean region for the HyMeX SOPs	105
Improved simulation of damaging Mediterranean precipitation events by the Met Office Europe-wide 2.2-km climate model.....	105
SAETTA: status on the high resolution lightning detection network in Corsica.....	106
Synoptic patterns of torrential rainfall in the Muga River Basin (NE Spain) in the Western Mediterranean area.....	107
Assessing the link between extreme precipitation and urban and peri-urban flood impacts: the case of Barcelona	107
A stochastic approach for the estimation of the occurrence probabilities of severe dry and wet events: an application in Southern Italy	108
Analysis of the 12 October 2016 flash-floods in Maresme, Catalonia	109
Explicit numerical forecasting of lightning activity in Greece.....	109
Future evolution of marine heat waves in the mediterranean: Coupled regional climate projections	110

Introducing the EXAEDRE (EXploiting new Atmospheric Electricity Data for Research and the Environment) project.....	111
A first glance on the field campaign of the EXAEDRE (EXploiting new Atmospheric Electricity Data for Research and the Environment) project	112
The 12th October 2016 Maresme flash-floods: a radar-based analysis	112
Rain/snow radar remote sensing with two X-band radars operating over an altitude gradient in the French Alps	113
Space-borne profiling of atmospheric thermodynamic variables with Raman lidar: an opportunity in the frame of the Revised Earth Explorer-9 Call	115
Water vapour mixing ratio and temperature intercomparison effort in framework of HyMeX SOP1	114
Offshore dynamics of the mistral during the HyMeX SOP2	115
Integration of nitrate aerosols into the CNRM regional climate system model and estimation of their radiative forcing over the Mediterranean region	116
Observation of a turbulent mesoscale organization during the mature (“stratiform”) stage of some intense precipitation systems. Case of the MCS observed during the 2012 HyMEX experiment.....	116
On the impact of lightning data assimilation on the (short-term) precipitation forecast.....	117
Nowcasting of Mediterranean flash-floods	131
Aerosol and Regional climate in the Mediterranean: A Model Intercomparison Exercice in the Context of Med-Cordex and ChArMEx	132
Cold outbreaks at the mesoscale in the Western Mediterranean basin: from raincells to rainbands.....	132
Heavy precipitating events in the south-east of France as simulated by the CNRM-RCSM: A case study	133
Evaluation of CNRM-RCSM simulations with interactive aerosols in the framework of the Med-CORDEX FPS Aerosol activities.....	134
The river routing scheme in Organising Carbon and Hydrology in Dynamic Ecosystems (ORCHIDEE) using high resolution data	135
Quasi-LES simulation of heavy precipitating Mesoscale Convective Systems Observed during the HyMeX SOP1.....	135
Reprocessed ground-based and ship-borne GPS data for assimilation and validation of the 2nd HyMeX reanalysis	136

Initialization Tests with CCLM/NEMOMED	136
Comparison of Flood Frequency Analysis methods for ungauged catchments in the French Mediterranean area.....	137
Evaluation of high-resolution PLEIADES digital elevation models for flood risk mapping. Case of the Ourika watershed (High Atlas, Morocco)	138
Sea surface temperature in the Mediterranean: climatology, trends and spatial patterns	138
HyMeX-IOP7a heavy precipitation event: A model intercomparison study.....	139
The SASER (SAfran-Surfex-Eaudysee-Rapid) hydrometeorological modeling system for Spain	140
Upper air conditions for tornadic storms in the Iberian Mediterranean area and Balearic Islands	140
LIFE EBRO-ADMICLIM: Adaptation and mitigation measures to climate change in the Ebro Delta	141
Implementation and calibration of a distributed hydrological model based on the finite volume method	142
Ocean-atmosphere coupling for Mediterranean heavy precipitation forecast: Better river runoff and sea state modelling.....	143
A Climatology of Heavy Precipitation on Corsica	143
A network of water vapor lidar systems to improve heavy precipitation forecasting in southern France – The WaLiNeAs initiative	144
How does mesoscale impact deep convection? Answers from ensemble Northwestern Mediterranean Sea simulations	145
Deriving key water resources indicators in the Mediterranean basin from a water resource re-analysis dataset based on 10 hydrological and land surface models	146

PRESENTATIONS

The Water Research Institute (IdRA) is composed of more than one hundred professors and researchers from nine faculties of the University of Barcelona. Most of them are part of consolidated and emergent research teams, which are recognised by the Regional Government of Catalonia and the University of Barcelona. The IdRA is an interdisciplinary research institution that studies water from a range of disciplines, which include: Geology, Meteorology and Climatology, Chemistry, Biology and Ecology, Geography, History, Pharmacy, Economy and the Arts.

IdRA research is funded by Spanish and European projects, as well as projects by other international institutions, and agreements with national and international companies and other administrations. IdRA research can be summarised with the following indicators: ISI publications: 790; percentage of ISI publications in the first quarter: 60.25%; and funding through projects and agreements: 14,060,000 Euros.

Even if most IdRA members are senior researchers, there is a large number of young pre- and postdoc researchers with strong potential in their field due to their advanced educational level and forward-thinking, competitive profile. These young researchers guarantee the continuity of high-level research activities from today.

The IdRA is proud to call itself the organiser of the 10th HyMeX Workshop, which will take place from 4 to 7 July 2017 in Barcelona (Spain), due to the excellent standard of the projects and the scientific expertise of the participants. The IdRA identifies with the goals of HyMeX, given that its biggest challenge lies in studying the comprehensive aspects of the water cycle of the Western Mediterranean Sea and the Iberian Peninsula.

The collection of abstracts that will be presented at the 10th workshop contains number 3 of IdRA documents with the intellectual property of Handle System and the support and universal accessibility of the Digital Repository of the University of Barcelona.

Barcelona, July 2017

Javier Martín-Vide
IdRA Director

Dear Participants of the 10th HYMEX Workshop,

It is a pleasure for me to welcome you to the University of Barcelona's Faculty of Physics and to the 10th edition of the HyMeX International Workshop. In the first HyMeX Workshop, in January 2007, we started the revision process to create the HyMeX white book, issued in September 2007. The white book was used to establish the main strategic lines of the five working groups: Water Budget; Hydrological Continental Cycle; Heavy Precipitation Flash Flooding; Intense Air-Sea Exchanges; and Vulnerability and Adaptation. Since then, different observation periods and campaigns have been developed in some target areas; new science and task teams have been created and; in the last successful workshop held in Mykonos in September 2015, the previous year's programme was reviewed.

The objective of the 2017 Workshop, the 10th of the series, is to provide an interdisciplinary forum for presentations and discussions about our current state of knowledge, as well as motivate new research and applications within the variety of disciplines related to the Mediterranean water cycle. The current HyMeX workshop is the first of the new stage, with a new distribution, which is composed of: seven task teams for observations, like sounding the atmosphere (TTO1); five task teams for modelling platforms, like regional climate models (TTM5); and eight transversal tasks to support TTO and TTM, like satellite products (TS2). In turn, the distribution is integrated in eight science teams:

- ST-HP: Heavy Precipitation
- ST-droughtswresources: Droughts & Water Resources
- ST-ffv: Flash-floods and Social Vulnerabilities
- ST-TIP: Towards Integrated Prediction of Heavy Precipitation, Flash-floods and Impacts
- ST-DWF: Ocean Circulation and Dense Water Formation
- ST-medcyclones: Mediterranean Cyclones
- ST-energy: Water Cycle and Renewable Energy

Specific and relevant topics are defined by the task force teams, which will merit their own meetings in the current workshop. These include: TF-MEDCORDEX (Regional climate modelling in the Mediterranean from CORDEX); and TF-FLOODHYMEX, led by our university and devoted to building a platform with a database on floods and their impact in the Mediterranean. This complicated structure reveals the complexity of studying the water cycle in the Mediterranean, and more than 160 valuable communications will be presented at the 10th workshop, which are included in the book of abstracts published by the IdRA.

I would like to thank the HyMeX coordinators and the International Scientific Steering Committee (ISSC) of HyMeX for the honour of selecting our city to hold the 10th workshop. This meeting would not have been possible without the support of the IdRA and the local organising committee, and I would like to express my sincere gratitude and appreciation.

Barcelona, July 2017

Maria Carmen Llasat
Local Committee Chair and member of the ISSC

FOREWORD

HyMeX (Hydrological cycle in the Mediterranean Experiment, www.hymex.org) is a concerted effort at the international level aiming at advancing the scientific knowledge of the water cycle, with emphases on the predictability and evolution of high-impact weather events with climate change.

After five years of setting up the project, HyMeX was launched in 2010 for a decade. The HyMeX observation strategy consists in three-level nested observation periods, from a long-term observation period (LOP, 2010-2020), to enhanced observation periods (EOP) and special observation periods (SOPs). During the first phase of HyMeX, two major international field campaigns took place in north-western Mediterranean. SOP1 was dedicated to heavy precipitation and flash-floods and took place in autumn 2012, followed by SOP2 in winter 2013 devoted to dense water formation in the Gulf of Lion. SOP2 was inserted in an annual monitoring of the ocean water column, taking part to the EOP in north-western Mediterranean, that also included repetition during four successive autumns of the hydrological measurements deployed during SOP1. The strong modelling component (ocean-atmosphere-hydrology, process-weather, prediction-climate models) of HyMeX, strongly associated with the observation strategy, includes among others: 1/ the development and improvement of regional climate system models within the Med-CORDEX initiative, 2/ the improvement of high-resolution prediction systems, 3 / the development of novel data assimilation systems for the different Earth compartments, 4/ the development of new process modelling, including models for assessing exposure, vulnerability and impacts.

The HyMeX workshops are an essential instrument for the success of the program. The first workshops aimed at promoting cooperation among the HyMeX community, at elaborating the science and implementation plans and then at conceiving the SOPs and EOPs in northwestern Mediterranean. Since 2013, the HyMeX workshops give more importance to the presentation and discussion of the scientific results.

After Toulouse (2007), Paris (2008), Heraklion (2009), Bologna (2010), Menorca (2011), Primosten (2012), Cassis (2013), Valetta (2014), Mykonos (2015), the HyMeX workshop is back to Spain for its tenth edition, in Barcelona. The 10th HyMeX workshop will be the first one after the programme's mid-term, and is a good opportunity to show the advances of the new HyMeX science teams and to discuss plans about future field campaigns and coordinated modelling experiments, such as Med-CORDEX. The response to the call for contributions was overwhelming, with 170 abstracts received. The workshop scientific committee has structured the submitted contributions in short oral presentations in plenary or parallel sessions and poster presentations for in-depth discussions with interested workshop participants during the 4-day workshop.

Barcelona, July 2017

For the International Scientific Workshop Committee and the Organizing Committee:
Véronique Ducrocq and Maria Carmen Llasat

ORAL COMMUNICATIONS

Towards a satellite driven land surface model using SURFEX modelling platform Offline Data Assimilation: an assessment of the method over Europe and the Mediterranean basin

Albergel, C.1, Munier, S.1, Leroux, D.1, Fairbairn, D.2, Dorigo, W.3, Decharme, B.1, Calvet, J.-C.1

¹CNRM, UMR 3589 (Météo-France, CNRS) Toulouse, France. ²Imperial College, London, UK. ³Department of Geodesy and Geo-Information, Vienna University of Technology, Vienna, Austria.

Modelling platforms including Land Surface Models (LSMs), forced by gridded atmospheric variables and coupled to river routing models are necessary to increase our understanding of the terrestrial water cycle. These LSMs need to simulate biogeophysical variables like Surface and Root Zone Soil Moisture (SSM, RZSM), Leaf Area Index (LAI) in a way that is fully consistent with the representation of surface/energy fluxes and river discharge simulations. Global SSM and LAI products are now operationally available from spaceborne instruments and they can be used to constrain LSMs through Data Assimilation (DA) techniques. In this study, an offline data assimilation system implemented in Météo-France's modelling platform (SURFEX) is tested over Europe and the Mediterranean basin to increase prediction accuracy for land surface variables. The resulting Land Data Assimilation System (LDAS) makes use of a simplified Extended Kalman Filter (SEKF). It is able to ingest information from satellite derived (i) SSM from the latest version of the ESA Climate Change Initiative as well as (ii) LAI from the Copernicus GLS project to constrain the multilayer, CO₂-responsive version of the Interactions Between Soil, Biosphere, and Atmosphere model (ISBA) coupled with Météo-France's version of the Total Runoff Integrating Pathways continental hydrological system (ISBA-CTRIP). ERA-Interim observations based atmospheric forcing with precipitations corrected from Global Precipitation Climatology Centre observations (GPCC) is used to force ISBA-CTRIP at a resolution of 0.5 degree over 2000-2012. The model sensitivity to the assimilated observations is presented and a set of statistical diagnostics used to evaluate the impact of assimilating SSM and LAI on different model biogeophysical variables are provided. It is demonstrated that the assimilation scheme works effectively. Its impact is assessed using (i) agricultural statistics over France, (ii) river discharge over Europe and (iii) land evapotranspiration satellite derived estimates from the GLEAM project (<http://www.gleam.eu/>). The SEKF is able to extract useful information from the data signal at the grid scale and distribute the RZSM and LAI increments throughout the model impacting soil moisture, terrestrial vegetation and water cycle, surface carbon and energy fluxes.

Precipitation and Extreme Precipitation Trends over Israeli Regions and sub-regions- an overview & comparison to earlier studies

Alpert, P., Breitgand, J.

Dept. Geophysics, Tel Aviv University, Israel.

Spatial and temporal distribution of trends in precipitation and in extreme precipitation (upper 5-percentiles; R95pTOT) in Israel are analyzed employing daily data based on extensive Israel Meteorological Service (IMS) data. Annual seasonal & monthly trends for Israel and for 8 sub-regions using data from 48 meteorological stations during the period of 1952 – 2015, are calculated for different periods of time from 20 to 60 year trend periods for each 3 years. Results are compared to many earlier studies on the same chart. Results show significant differences in regional and monthly trends through time and through sub-regions that are explored. Examination of R95pTOT trends over Israel with respect to the large-scale oscillations and the global temperature trends show dependencies in some months on the Global temperature, NINO3.4, EA-WR, Scandinavian, NAO and EA indices. These are discussed in view of earlier studies.

Flash-flood ensemble forecasting in two Spanish Mediterranean catchments: comparison of distinct hydrometeorological ensemble prediction strategies

Amengual, A.¹, Vincendon, B.²

¹Grup de Meteorologia, Dep. De Física, Universitat de les Illes Balears. Palma, Mallorca, Spain. ²CNRM (Météo-France, CNRS), 42 av. Coriolis/ 31057 Toulouse Cedex, Toulouse, France.

Hydrological Ensemble Prediction Systems (HEPS) are becoming more and more popular methods to deal with the meteorological and hydrological uncertainties that affect discharge forecasts. These uncertainties are particularly difficult to handle with Mediterranean flash-flood forecasting. In this work, the performances of distinct HEPS are compared on two heavy precipitation events that affected two semi-arid Spanish Mediterranean catchments: the case of 03 November 2011 on the Llobregat River in Catalonia, and the HYMEX IOP8 on the Guadalentín River near Murcia city.

The uncertainty on quantitative precipitation forecasting (QPF) is sampled by using two different meteorological ensemble generation strategies. First, a convection-permitting EPS which consists in dynamically downscaling directly the ECMWF-EPS by means of the WRF model. The second EPS strategy is based on the AROME-WMED convective-scale model. Its deterministic QPFs are perturbed based on a previous rainfall forecast error climatology and by using the probability density functions of the errors, in term of rain totals and location of the heaviest rains.

The population of both ensembles is of 50 members, which are used to drive the HEC-HMS and ISBA-TOP hydrological models. For each HEPS, the performance is assessed in term of

the quantitative discharge forecasts. Issues about the optimal number of members and impact of the forecasting lead time are addressed for optimal flash-flood forecasting purposes. Results point out the benefits of using (i) a hydrological model when evaluating highly-variable and convective-driven precipitation fields and (ii) an EPS to better encompass these uncertainties arising from different level of the HEPS.

Multiple equilibria and overturning variability of the Aegean-Adriatic Seas

Amitai, Y.¹, Ashkenazy, Y.², Gildor, H.¹

¹The Institute of Earth Sciences, The Hebrew University of Jerusalem, Israel. ²Solar Energy and Environmental Physics, BIDR, Ben-Gurion University of the Negev, Sede Boqer, Israel.

The Eastern Mediterranean Transient (EMT) – a transition and amplification of the Eastern Mediterranean Sea deepwater source from the Adriatic Sea to the Aegean Sea – was observed in the mid-90' and stimulated intense research. Here we demonstrate, using an oceanic general circulation model, that the meridional overturning circulation of the Eastern Mediterranean has multiple equilibria states under present-day-like conditions, and that the water exchange between the Aegean and the Adriatic Seas can drastically affect these states. More specifically, we found two stable states and a hysteresis behaviour of deep water formation in the Adriatic Sea when changing the atmospheric (restoring) temperature over the Aegean Sea. In addition, the overturning circulation in both seas exhibits large decadal variability of the deep water formation. The Aegean-Adriatic relationship can be summarized as follows: warm and saline water of the Aegean can either flow in the sub-surface to the Adriatic, switching “on” deep water formation in the Adriatic by increasing its salinity, or the Aegean water can feed the deeper layer of the Ionian and Levantine basins, turning “off” the deep water formation in the Adriatic. The “off” steady state resembles some aspects of the EMT in which the Adriatic source of deep water was weakened when the Aegean source became active.

The evolution of incidents due to intense rains in Barcelona in the last 20 years versus the alert levels set in the Civil Protection Plan

Aznar, B., Grima, J.O., Burdons, S.

Barcelona Cicle de l'Aigua (BCASA), Barcelona, Spain.

Barcelona as a Mediterranean city is prone to flash floods, caused by heavy rainfall events. The average precipitation in Barcelona is about 600 mm/year, but a 33% of the total accumulated precipitation is collected in only 7 days a year, in addition the intensities can exceed 60mm/h in 20 minutes. Over the last 20 years have been made large investments in

infrastructures and technology concerning to solve drainage problems. The main infrastructure investment has been the construction of 13 storm water storage tanks.

Concerning to technology, the telemetry system monitors the drainage network; the rainfall through 24 raingauges, the level in the drainage network (more than 200 points) and the state of the storm tanks and other devices. This extended network of sensors provides valuable information in real time to manage the drainage network.

Furthermore since the nineties, Barcelona has established alert protocols considering the rain intensity in order to anticipate and to reduce the damage caused by flooding. The Civil Protection Plan for floods in Barcelona is based on different levels of rainfall intensity. In recent years these alert levels have changed, since for the same rain intensity, less incidents and damages have been recorded. The proposed communication will present the evolution of the damages detected by urban services in the city compared to the rainfall events recorded, and the evolution of alert levels.

Representation of Integrated Water Vapor at different time scales and its impact on precipitation in MED-CORDEX simulations

**Bastin, S.¹, Bock, O.², Chiriaco, M.¹, Bosser, P.³, Ahrens, B.⁴,
Gallardo, C.⁵, Dominguez-Alonso, M.⁵, Roehrig, R.⁶, Li, L.⁷,
Drobinski, P.⁷, Parracho, A.^{1,2}**

¹LATMOS/IPSL. ²IGN/LAREG. ³ENSTA BRETAGNE. ⁴GUF. ⁵UCLM. ⁶CNRM/GAME.
⁷LMD/IPSL.

Thanks to efforts made to reanalyse observed data to produce long-term homogenized datasets of new parameters or multi-parameters in recent years, we can better characterize, evaluate and analyse the water cycle in models at different scales. In this paper, a few MED-CORDEX simulations covering the ERA-interim period are evaluated against reprocessed IWV from GPS datasets over the European domain, from 1995 to 2008.

The humidity is an important component of the water cycle, and models often have difficulties representing it. The high quality, consistent, long-term IWV dataset recently produced from GPS at more than 100 stations over Europe, with about half of the stations having nearly 15 years of data over the period from 1995 to 2010 is therefore used to evaluate the simulated IWV at seasonal, interannual and possibly diurnal time scales. The different sources of differences are analysed (e.g methodology, dynamics, thermodynamics, surface processes...). In particular, the relationship between IWV and surface temperature is assessed and shows that this relationship departs from Clausius-Clapeyron at high temperature. Both the temperature threshold and the maximum value of IWV reached present spatial variabilities that are in general well captured by the models.

Some analysis of the relationship between tropospheric temperature, IWV, and precipitation is also assessed by using French supersites over which multi-parameters are observed over more than 10 years. It gives some insight into the reasons why some models present too many light precipitation.

Overview of Gravity Waves, Orographic Precipitation and related processes in The Cerdanya-2017 field experiment

Bech, J.¹, Trapero, L.², Soler, M.R.¹, Udina, M.¹, Paci, A.³, Albalat, A.², Garcia- Benadí, A.^{1,4}, Gonzalez, S.^{1,5}, Mercader, J.⁶, Miró, J.R.⁶, Molinié, G.⁷, Codina, B.¹, Rossell, A.¹

¹University of Barcelona, Barcelona, Spain. ²Andorran Research Institute (IEA-CENMA), Andorra. ³CNRM, Météo-France & CNRS, France. ⁴Polytechnic University of Catalonia (UPC), Spain. ⁵AEMET, Spain. ⁶Servei Meteorològic de Catalunya (SMC), Spain. ⁷LTHE University of Grenoble Alps, France.

The Gravity Waves, Orographic Precipitation and related processes project (GWOP'17) is part of The Cerdanya-2017 field experiment, carried out in the Cerdanya county (Eastern Pyrenees), covering a small area over the Spanish, French and Andorra border, from December 2016 to April 2017. The overall objective of the field experiment is to study different meteorological processes highly influenced by complex terrain, including cold-pool formation and development, with a specific observation period from 10 January to 3 February 2017, and also gravity waves, rotors and orographic effects upon precipitation processes. The ground-based and remote sensing observing strategy was devised to characterize the gravity waves and associated phenomena as well as the description of the processes leading to orographically induced precipitation, including both enhancement and rain-shadow effects. The main goals of GWOP'17 are to improve the knowledge of:

- 1) lee mountain waves and associated processes as rotors and subrotors and boundary layer separation,
- 2) the dynamics and microphysics of the precipitation processes influenced by orographic effects, with emphasis on heavy precipitation events,
- 3) the interaction of gravity waves with cloud structures and its influence on precipitation processes in the Pyrenees.

The presentation provides an overview of the field campaign, database of events, and preliminary results of selected case studies for process understanding and fine scale numerical modeling. Examples of observations recorded during selected events will be included, covering wind-profiler, microwave-radiometer, Doppler lidar, micro-rain radar and disdrometer datasets and preliminary results comparing field-campaign behavior with previous climatological observations.

This study is performed with partial support from the Water Research Institute of the University of Barcelona and grant CGL2015-65627-C3-2-R (MINECO/FEDER).

Operational hydrometeor classification using polarimetric radar: focus on hail detection

Besic, N.^{1,2}, Trefalt, S.^{2,3}, Hamann, U.², Grazioli, J.^{1,2}, Figueras i Ventura, J.², Hering, A.², Boscacci, M.², Gabella, M.², Germann, U.², Bern, A.³

¹Environmental Remote Sensing Laboratory (LTE), EPFL, Lausanne, Switzerland. ²Radar, Satellite and Nowcasting Department, MeteoSwiss, Locarno, Switzerland. ³Institute of Geography, University of Berne, Berne, Switzerland.

Hydrometeor classification is an important added-value of dual-polarization Doppler radars. It is of a primary importance for severe weather monitoring, allowing us also to better understand the microphysics of clouds and precipitation. A new classification method was recently proposed. The method, categorized as a semi-supervised approach, is designed to be a combination of assets of the dominant family of supervised approaches (e.g. fuzzy logic) and a recently proposed unsupervised classification. Namely, the classification itself assumes labeling of radar sampling volumes by using as a criterion the Euclidean distance with respect to five-dimensional centroids, representing diverse hydrometeor classes. The positions of the centroids in the space, formed by four polarimetric radar variables and one external parameter (phase indicator: liquid, solid and mixed), are derived using k-medoids clustering, applied on a selected representative set of radar observations. Clustering is coupled with statistical testing which subtly introduces assumed microphysical properties of the considered hydrometeor types.

The method is applied on the data acquired by the EPFL research MXPOL radar, located in the region of Ardèche (FR) during the HyMeX campaign. The performances are notably illustrated by revisiting the event of 24 September 2012, also designated as IOP6.

In addition to applications based on research radar data, this method is being operationally implemented in the radar processing chain of MeteoSwiss, and we illustrate the potential of such operational classification for the study of hail storms, with a focus on hail detection. Comparison with the existing Probability of Hail product shows good performance. The hail detection is also challenged by involving more independent measurements as satellite observations, hail sensors and crowd-sourcing.

LIAISE: land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment

Best, M.J.¹, Brooke, J.¹, Polcher, J.², Boone, A.³

¹Met Office, Fitzroy Road, Exeter, UK. ²LMD, 4 pl. Jussieu, Paris, France. ³CNRM, 42 av. G. Coriolis, Toulouse, France.

Semi-arid regions, of which the Mediterranean is one, pose a significant challenge due to the highly heterogeneous nature of the land cover. This is largely driven by the limited availability of soil moisture and the nature of the precipitation. Modelling studies, such as PILPS San-Pedro (Hoge 2005, Bastidas 2006), have shown that the models lack the ability to capture such heterogeneity within semi-arid environments. Optimal performance for one site does not

give good performance at another with similar characteristics. However, Koster et al. (2006) showed that it is in these semi-arid regions where the coupling between soil moisture and precipitation is at its greatest. Hence this is perhaps the most important, yet challenging, environment for land surface models to accurately capture the flux exchange with the atmosphere, and in particular evaporation.

Evaporation is just one aspect of the terrestrial water cycle. The sparse nature of the rainfall also impacts on river flows and water resources. Human management of the natural river systems are often required in order to provide water for an ever increasing population. Dams impact on the timescale for water within rivers to reach the sea, whilst extractions for irrigation reduce the outflow into the oceans. These human influences change the fresh water fluxes that help to drive the coastal circulations through salinity density gradients. In order to reduce the uncertainty in weather and climate predictions, and to give better guidance on the impacts of weather and climate on society, land surface models need to be able to accurately capture all aspects of the terrestrial water cycle within these critical semi-arid environments. This includes the representation of the human influence on the natural system. However, progress is inhibited due to a lack of consistent and extensive observations. Here we present the initial plans for an observational campaign for a semi-arid environment within Iberia. The LIAISE (Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment) campaign will bring together ground-based and airborne measurements with modelling studies to lead to an improved understanding of processes such as soil moisture, evapotranspiration, precipitation through atmospheric coupling and the subsequent feedbacks to the Mediterranean boundary layer and basin hydrology, including aspects such as streamflow, irrigation and extraction methods.

We recognise that such a campaign undertaken in isolation would not deliver the observational requirements for such an ambitious proposal. Hence we intend to gauge the interest for a multi-institute campaign with European partners to maximise the benefits for both the observational and modelling scientific communities.

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A reflectivity forward operator designed for vertically-pointing W-band radars

Borderies, M.¹, Caumont, O.¹, Augros, C.², Delanoë, J.³, Ducrocq, V.¹

¹CNRM/GMME, Météo-France, UMR3589, 31057 Toulouse cedex 1, France. ²DSO/CMR, Météo-France, UMR3589, 31057 Toulouse cedex 1, France. ³LATMOS/IPSL, UPMC Univ. Paris 06, Sorbonne Universités, UVSQ, CNRS, Paris, France.

The high sensitivity of W-band radar data to cloud microphysical properties makes them appealing for atmospheric model validation and data assimilation. Here, we describe a

reflectivity forward operator developed for the validation and the assimilation of W-band radar data into regional NWP models of the class of Arôme-WMed. The forward operator is consistent with the one-moment microphysical scheme ICE3 of Arôme-WMed and is devised for vertically-pointing radars such as the airborne cloud radar RASTA.

A new neighbourhood validation method, called the Most Resembling Column (MRC) method, is conceived in order to disentangle model spatial mismatches from errors in the forward operator.

This novel method is used to validate and calibrate the forward operator using the data collected by RASTA during the HyMeX SOP1. The MRC method is then applied in order to retrieve by the least-square method the optimal effective shapes (ie, mean axis ratio) of predicted graupel, snow, and pristine ice.

Results indicate pristine ice can be approximated by a sphere and the optimum mean axis ratio is 0.8 for graupel and 0.8 for snow. It is shown that considering ice particles as oblate spheroids with axis ratios close to their optimal values leads to a good agreement between observations and simulations in ice levels. Conversely, there is a large bias if ice particles are considered either spherical or too flattened (ie, plate-like shape).

Fine-scale atmospheric processes and sensitivity to sea-state representation during HyMeX IOP8 heavy precipitation event

Bouin, M.N., Redelsperger, J.L., Lebeaupin-Brossier, C.

CNRM, Météo-France and LOPS CNRS-Ifremer-IRD-UBO-IUEM.

During the first observation period of the HyMeX programme, the Mediterranean coasts of Spain were impacted by several heavy precipitating events (HPEs). The most damaging one occurred during IOP 8 resulting in cumulative rainfall amount over 200 mm in the area of Murcia-Valencia. Numerical simulations using a high-resolution atmospheric model provide a very realistic representation of the mesoscale convective systems (MCSs) at the origin of this HPE and of the associated low-level conditions, consisting in two cold sectors surrounding a warm sector. This study provides a detailed analysis of the mechanisms of deep convection initiation and maintenance between 1200 UTC on 28 September and 0000 UTC on 29 September 2012. On the coastal mountainous area, the conditionally unstable inflow feeding the MCS is uplifted by the relief whereas at sea, a strong low-level convergence play the same role. At the coast, cold pools are generated and strengthened by a strong low-level jet (LLJ) carrying cold dense air parcels from the Gulf of Lion and by evaporation and cooling under the precipitating systems. These cold pools play a key role in triggering the deep convection, either by directly uplifting the air masses or by deflecting horizontally the inflow and enhancing the low-level convergence. They largely control the localisation and distribution of the heavy precipitation at sea near Valencia. A weak barrier wind over the cold pools and a secondary cyclonic circulation result in a bending of the convergence line at sea, in agreement with radar observations.

A sensitivity study to a more realistic representation of the sea state in the air-sea exchanges shows that the LLJ is decelerated by the increased sea-surface roughness, resulting in cold pools extending further at sea and shifting the precipitation patterns 50 km offshore.

The Floodscale Experiment at the Hillslope Scale: Physico-Chemical Characterization of Runoff Contributing to Flash Flood Generation in the Small Catchment of Valescure, France

Bouvier, C.¹, Patris, N.¹, Freyrier, R.², Guilhe-Batiot, C.³, Seidel, J.-L.², Taupin, J.-D.¹, Brunet, P.², Remes, A.²

¹IRD, UMR 5569, HydroSciences, Montpellier France. ²CNRS, UMR 5569, HydroSciences, Montpellier France ³UM, UMR 5569, HydroSciences, Montpellier France.

As a part of the multi-scale device deployed within the Floodscale project, geochemical data and methods brought valuable information about the hydrological processes at the hillslope or larger scales. A 3-year survey has been performed in the Cévennes mountain area, located in the South of France, in order to separate surface, shallow sub-surface and groundwater contributions to the flash flood processes. Electrical conductivity, major and trace elements, Total Organic Carbon and stable isotopes of water have been monitored during low flows and floods, in the small (3.9 km²) granitic catchment of Valescure (Gard, France). A coupled hydro-chemical model was designed in order to validate the main hydrological processes. Main results can be summarized as follows : i) pre-event water and event water proportions at the peak flow are close (~50-50%) in most cases, but the proportion of event water can increase (up to 70-80%) for the heaviest rainfalls, ii) pre-event water at peak flow is mostly made of shallow soil water, which flows laterally at small depths (1m, maybe deeper), iii) shallow soil drainage does not last more than 2 to 3 days, then stream water is mainly constituted of deep water. These results extend a few previous studies, and show that processes of fast shallow sub-surface lateral flow or exfiltration to the surface are important in such catchment. In addition, shallow soil water appears to be an important end-member to account in the decomposition of the flood hydrograph, and must be carefully monitored to avoid misinterpretations in the origin of stream water. Finally, the hydrological process-based model derived from these experiments should help to improve the contribution of the land surface in climate modelling.

Comparing various approaches for flash flood forecasting in the Yzeron periurban catchment (150 km²) south-east Lyon, France

Braud,, I.¹, Breil, P.¹, Javelle, P.², Ahrouch, S.¹, Furusho-Percot, C.³, Pejakovic, N.¹, Guérin, S.⁴

¹Irstea, UR HHLY (Hydrology Hydraulics), centre de Lyon-Villeurbanne, 5 rue de la Doua, BP 32108, 69616 Villeurbanne Cedex, France. ²Irstea, UR RECOVER, centre d'Aix-en-Provence, 3275 Route de Cézanne, CS 40061, 13182 Aix-en-Provence cédex 5, France. ³Irstea, UR HBAN, centre d'Antony, 1 Rue Pierre-Gilles de Gennes, CS 10030, 92761 Antony, cédex 5, France. ⁴Syndicat Intercommunal du Bassin de l'Yzeron (SAGYRC), 16, avenue Emile Evellier, 69290 Grézieu-la-Varenne, France.

The Yzeron periurban catchment (150 km²) is prone to flash floods leading to overflow in the downstream part of the catchment. A prevention and management plan has been approved and the set-up of a flood forecasting system is planned. The present study presents a comparison of several solutions for flood warning in the catchment. It is based on an extensive data collection (rain gauges, radar/rain gauge reanalyses, discharge and water level data) from this experimental catchment. A set of rainfall-runoff events leading to floods (problematic and non-problematic floods) was extracted and formed the basis for the definition of a first forecasting method. It is based on data analysis and the identification of explaining factors amongst the following: rainfall amount, intensity, antecedent rainfall, initial discharge. Several statistical methods including Factorial Analysis of Mixed Data and Classification and Regression Tree were used for this purpose. They showed that several classes of problematic floods can be identified. The first one is related to wet conditions characterized with high initial discharge and antecedent rainfall. The second class is driven by rainfall amount, initial discharge and rainfall intensity. Thresholds of these variables can be identified to provide a first forecasting. The second forecasting method assessed in the study is the system that will be operational in France in 2017, based on the AIGA method (Javelle et al., 2016). For this purpose, 18-year discharge simulation using the hydrological model of the AIGA method, forced using radar/rain gauges reanalysis were available at 44 locations within the catchment. The dates for which quantiles of a given return period were overtopped were identified and compared with the list of problematic events. The AIGA method was found relevant in identifying the most problematic events, but the model lead time needs further investigation in order to assess the usefulness for population forecasting. The third forecasting method is based on the GRP flood forecasting model running at the hourly time step. The model was calibrated on the Yzeron catchment and its performance in terms of flood forecasting was assessed based on the discharge data available at the catchment outlet for several forecasting time horizons. The various forecasting solutions were compared in order to define the best strategy for the Yzeron catchment.

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The marine atmospheric boundary layer during the HyMeX/ASICS-MED campaign: 1-D and large eddy simulations under strong wind conditions

Brilouet, P.-E.^{1,2}, Canut, G.¹, Durand, P.²

¹CNRM, UMR 3589, Toulouse, France. ²Laboratoire d'aérodynamique, UMR 5560, Toulouse, France.

During winter, cold air outbreaks take place in the northwestern Mediterranean sea. They are characterized by local strong winds (Mistral and Tramontane) which transport cold and dry continental air across a warmer sea. In such conditions, high values of surface sensible and latent heat flux are observed, which favor deep oceanic convection. The HyMeX/ASICS-MED

field campaign was devoted to the study of these processes. Airborne measurements, gathered in the Gulf of Lion during the winter of 2013, allowed for the exploration of the mean and turbulent structure of the marine atmospheric boundary layer (MABL).

This study is based on both airborne observations and a numerical approach in order to understand the structure of the MABL during strong wind events, well documented with 11 flights, during which latent heat fluxes as high as 600 W m^{-2} were observed. Airborne observations showed larger eddies along the mean wind direction associated with an organization of the turbulence field into longitudinal rolls.

The numerical study is based on the non-hydrostatic Meso-NH model. At first, 1-D simulations are designed based on observations of 13 March 2013, a case of strong Tramontane (25-30 m/s). The forcing terms required to constrain the 1-D model are estimated from the observations and from the AROME-WMED limited-area model. Sensitivity tests, covering a wide range of conditions, are conducted in order to evaluate the impact of advection terms and surface fluxes on the MABL structure. Eventually the simulation is able to reproduce the MABL development observed on this day.

The first results of an additional numerical study based on an LES are also presented. The setup is based on the optimized 1-D simulation. The goal of this study is to evaluate the capacity of the LES to realistically reproduce the large eddies of the turbulence and the coherent structures observed by aircraft, and to investigate their impact on surface fluxes and MABL structure.

Creation of a Med Forecast Center

Calas, C.

Ecole Nationale de la Météorologie, Météo-France, 42 avenue Coriolis 31057 Toulouse Cedex, France.

Heavy Precipitation Events (HPEs) over the Mediterranean basin are amongst the most serious high-impact weather events around the world, in terms of devastating floods and related damage and fatalities.

Recent research and measurement campaigns such as Hymex (including the SOP1 from September to November 2012) have helped improve our understanding of these deep and severe convection-related events. NWP models are now capable of forecasting these HPE with relatively good accuracy several hours ahead. However, predicting the intensity, the exact location, or the duration of these events remains a challenge for forecasters, because they involve many mesoscale processes that can lead to quasi-stationary convective systems which are still very difficult to simulate for the models.

HPEs can happen around the whole western Mediterranean basin, from north Africa, to eastern Spain, southern France, Italy, and Croatia, some events moving from one country to another. However, operational forecasting lacks international coordination, with each country being left to produce its own forecasts, without any exchange or feedback on forthcoming, ongoing, or past events.

The aim of this talk is to propose the creation of a Med Forecast Center that could monitor and provide forecasting guidance for the weather services of the western Mediterranean countries.

Characterization of different GNSS-IWV data assimilation effects on the simulation of heavy precipitation during the HyMeX-SOP1

Caldas-Álvarez, A., Khodayar, S.

Institute of Meteorology and Climate Research (IMK-TRO), Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany.

An accurate representation of the devastating Heavy Precipitation Events (HPEs), that typically strike the western Mediterranean regions by autumn, is still a challenge for current Numerical Weather Prediction (NWP) and climate models. The misrepresentation of the atmospheric moisture distribution and the interaction between atmospheric humidity and convection have been pointed out as sources of error in the prediction of such extreme events. Regional features, such as orography or distinctive wind flows, stringently determine the atmospheric moisture distribution which in turn influences the intensity and location of convection. That is why an improvement in the representation of heavy precipitation is expected from a finer and more realistic description of humidity within the models. In this regard, the Data Assimilation (DA) of very frequent Global Navigation Satellite System – Integrated Water Vapour (GNSS-IWV) data from dense networks and its application on very fine model grids are promising approaches to reduce the aforementioned model inaccuracies. The objective of the presented research work is to characterize the different impacts of a GNSS-IWV data assimilation on the representation of Heavy Precipitation Events during the HyMeX-SOP1.

To this end, a state-of-art GNSS-IWV data set, specially homogenized for the western Mediterranean with a high frequency (10 minutes) has been selectively assimilated in the Consortium for Small-scale Modeling (COSMO) model. The Nudging DA scheme is employed to produce the analyses of the HyMeX Special Observation Period 1 (SOP1) on two different grid spacings (~2.8km and ~7km) with COSMO in CLimate Mode (CCLM). In addition, selected intensive observation periods were reproduced with the NWP version to allow for reproduction of the HPEs in model grids reaching the lower mesoscale limit (~500m). The diverse corrections of humidity due to these methodologies and the corresponding impact on convection-related quantities and heavy precipitation are analyzed making use of our model output. Observational data sets of precipitation (Climate Prediction Center MORPHing technique – CMORPH and rain gauges) as well as of atmospheric humidity (GNSS-IWV and radiosondes) are employed to validate our model results and support the process studies. Results show remarkable discrepancies in the representation of the temporal evolution of IWV by COSMO, well corrected by the assimilation. The different responses to the assimilation observed for the various HPEs prevailed as they affected the different Mediterranean regions. The rectification of the moisture fields entailed generally an improvement in the representation of the timing of the events. However, the improvement in the representation of the amount was shown to be case-dependent.

Coupling of watersheds, estuaries and regional seas through numerical modelling for Western Iberia: river discharge influence in the near open ocean

Campuzano, F.J.¹, Brito, D.², Juliano, M.³, De Pablo, H.¹, Sobrinho, J.¹, Fernandes, R.², Neves, R.¹

¹MARETEC, Instituto Superior Técnico, Universidade de Lisboa, Portugal. ²Action Modulers, Consulting and Technology, Portugal. ³LAMTec-ID – Universidade dos Açores, Portugal.

In order to determine the inland waters contribution to the open ocean in terms of volume and composition, a novel methodology for integrating a system of numerical models was set up. The different interfaces that the water running-off from the watersheds found in their way to the open ocean where reproduced through numerical models for the first time for the Portuguese estuaries using the different components of the Mohid Water Modelling System (<http://www.mohid.com>).

At the watershed level, the Mohid Land provides operationally water flow and nutrients for the main river catchments for the Iberian Western area with a 2 km horizontal resolution. Downstream, several operational hydrodynamic and biological estuarine applications uses the previous results to provide fresh water input flows for those rivers where data is non-existent. The estuarine models would reproduce the inner dynamics of the estuary and its connection to the outer waters. Fluxes from the latter model, which are intermittent due to the tidal signal, are then imposed in the Portuguese Coast Operational Modelling System (PCOMS). The PCOMS model is a 3D fully baroclinic hydrodynamic and ecological regional model that covers the Iberian Atlantic front and that also provides boundary conditions to the estuarine applications. The estuarine and the PCOMS models are operated by the Mohid Water model.

This set of operational models when combined is able to fill information gaps and to obtain better estuarine results when compared with the use of river climatology. The PCOMS model has also been used to evaluate changes in land use. The employed methodology is generic and has been applied to several estuaries in the Portuguese coast achieving more precise coastal circulation forecasts and allowing the evaluation of their influence in the creation fronts and coastal phytoplankton growth.

Statistical Downscaling of EURO-CORDEX climate change scenarios: Projections of droughts and heavy precipitations along the 21st century

Cardell, M.F., Amengual, A., Romero, R., Homar, V., Ramis, C.

University of the Balearic Islands, Carr. de Valldemossa km 7,5 07122, Palma (Balearic Islands), Spain.

Extreme weather events (e.g. persistent droughts, heavy precipitation, heat waves, severe convective storms and violent cyclonic windstorms) are responsible for most of the nature-related economic costs and human losses in many regions of Europe, including the Mediterranean zone. In the context of climate change it is likely that extreme precipitation

events -and concomitant floods or flash floods- might become more intense over the mid-latitude continents while droughts might last longer by the end of the century. In many dry regions as southern Europe, soils are predicted to dry out as temperatures rise and rain-bearing atmospheric circulations become less frequent.

Prospects on the future of these extreme hydrological events are here derived by using observed and model projected daily meteorological data. Specifically, E-OBS high resolution gridded data sets of daily observed precipitation and surface minimum and maximum temperatures have been used as the regional observed baseline. For projections, the same meteorological variables have been obtained from a set of regional climate models (RCMs) integrated in the EURO-CORDEX European project, considering the rcp4.5 and rcp8.5 future emissions scenarios. To project the RCM data at local scale properly, a quantile–quantile adjustment has been applied to the simulated regional scenarios. The method is based on detecting changes in the cumulative distribution functions (CDFs) between the recent past and successive time slices of the simulated climate and applying these changes, once calibrated, to the observed series of max, min temperature and precipitation. But for our specific purposes dealing with the extreme phenomenology, the general method has been first adapted to explicitly focus on the tails of the distributions, instead of deriving the calibration parameters from the general spectrum of the CDFs.

Results about expected future temperature and precipitation changes at annual and seasonal scale (both means and extremes) will be presented for each emission scenario, scaling down the results from the whole European continent throughout Southern Europe and the Mediterranean lands. The most vulnerable geographical areas in terms of heavy precipitation and drought incidence as the century progresses will be identified.

Spatial daily rainfall descriptors to reproduce sub-daily dynamics in the analog method for temporal disaggregation

Carreau, J., Neppel, L., Ben Mhenni, N., Huard, F.

HSM Montpellier France - LMHE/ENIT Tunis Tunisie - AgroCLIM Avignon, France.

Precipitation is an important variable in many impact studies. Daily data are generally more widely available and cover often a longer time period than sub-daily data. However, to study impacts on certain processes that occur at sub-daily scale, it is necessary to employ sub-daily precipitation data. Temporal disaggregation methods have been developed to provide plausible sub-daily scenarios from daily data. Analog methods for temporal disaggregation have proved to perform well and are intuitively simple. The sub-daily pattern of an analog day is employed to decompose daily precipitation of a target day into sub-daily time intervals. Analog days are days that are similar in some ways to the target day. The core of the analog method is the adequate definition of the notion of similarity between two days. In this work, we exploit spatial information on daily rainfall to define similar days and show that it conveys information on the sub-daily dynamics. More precisely, the spatial information is based on the following three descriptors: the spatial average, coefficient of variation and fraction of rainfall at a given day. We consider several variants of the sets of descriptors to include the location of the rain shower. The ability of the variants at reproducing sub-daily dynamics is assessed by applying the analog method for temporal disaggregation. The temporally disaggregated days are evaluated against the observations in terms of rain shower characteristics and with

IDF curves computed at the watershed scale. We illustrate our approach at disaggregating daily precipitation into hourly precipitation with a 10 year (1997-2006) radar reanalyses on a 1 km grid provided by Météo-France, the French weather service. The grid is tailored to cover the Gardon at Anduze watershed in the French Mediterranean area, a region where the spatial variability of rainfall is important.

Storm-scale data assimilation using EnKF: Impact of conventional and radar data on the prediction of heavy precipitations during HyMeX IOP13

Carrió, D. S., Homar, V.

University of Balearic Islands, Cra. Valldemossa km 7.5, Palma, Spain.

The Special Observation Period 1 (SOP1) was a great milestone reached by the HyMeX scientific community. Observations sampling on 20 cases of severe weather were taken under an unprecedented international collaboration. The underlying objective of this campaign was to improve the knowledge of the mechanisms leading to heavy precipitation and flash flooding in the Mediterranean.

IOP 13 occurred between 15-16 October 2012 and was characterized by heavy precipitation over northern and central Italy. Storms formed over the French coastlands and over the sea, progressing eastwards across the Gulf of Genoa. The most affected areas were north-eastern Italy (160mm/24h), Liguria- Tuscany (120mm/24h) and central Italy (600mm/24h). The prediction of these maritime convection driven cases is highly demanding for both operational offices and high resolution numerical models. Ensemble data assimilation methods provide the tools to combine observational and modeling information to formalize the problem of optimal use and transference of information in the initialization and integration of a forecasting system.

We assess the benefits offered by a high-resolution (2.5 km) Ensemble Kalman Filter (EnKF) system for the prediction of the IOP13 event. We evaluate the impact of various in-situ observations such as buoys, aircrafts, metar or rawins, together with the inclusion of reflectivity data from Doppler radars. We discuss the performance of the EnKF system producing new analyses through statistical scores (RMSI, spread, BIAS sawtooth plots and consistency ratio plots). Then, we quantitatively verify the quality of the forecast using statistical verification methods, such as ROC curves (or AUC; area under ROC curves) or Brier Skill scores. Covariance among different model states are also diagnosed to provide more insight on how the data assimilation impacts on the analysis state. We discuss not only on the forecasts products but also in terms of the relevant physical mechanisms involved in this event.

Forecasting acqua alta in Venice Lagoon with coupled BOLAM-SHYFEM: a model performance sensitivity test on three high tide case studies

Casaioli, M.¹, Coraci, E.², Mariani, S.¹

¹ISPRA – Institute for Environmental Protection and Research, Via Vitaliano Brancati 48, Rome, Italy. ²ISPRA – Institute for Environmental Protection and Research, Castello 4665, Venice, Italy.

Since 2000, the ISPRA forecasting system named "SIMM – Sistema Idro-Meteo-Mare" has daily provided meteorological and marine forecast over the entire Mediterranean basin for monitoring and research purposes and ad hoc storm surge forecasts in the Northern Adriatic Sea. This latter feature is particularly relevant due to the national role of ISPRA in monitoring and forecasting hydrological and hydrographic parameters over the Venice Lagoon, since this area is strongly affected by the so-called acqua alta events.

SIMM is initialized using analyses and forecasts from the ECMWF IFS global model. A high resolution version of the hydrostatic BOLAM model, with a 0.07° horizontal grid space, coupled with a very high resolution version of the non-hydrostatic MOLOCH model, with a 0.0225° horizontal grid space, represent the meteorological core of the system. The Mediterranean-embedded Coastal WAVE Forecasting system (MC_WAF) is the SIMM component devoted to provide sea-state forecasts. For storm surge forecast, SIMM uses the Shallow water HYdrodynamic Finite Element Model (SHYFEM). Both the marine forecasting components are directly coupled with BOLAM.

In recent years, SIMM has undergone a series of upgrades and improvements, mainly consequence of the outcomes of verification activities, also performed in the framework of the HyMeX SOP campaigns, to keep state-of-the-art the forecasting system performance. In view of further possible development of the forecasting system, the effect on the SHYFEM forecast quality of changes in the meteorological model version, horizontal grid step, and initial and boundary conditions are tested in a case study framework. The added value of the SHYFEM data assimilation scheme is tested as well. The decay of the SHYFEM forecast quality for increasing BOLAM forecast lead time is also considered as a measure of the system performance; this is done by comparing for the same verification day different consecutive daily forecasts, in a time-lagged ensemble perspective.

Three intense storm surge events that occurred in 2016 over the Northern Adriatic Sea are considered. During the first event, south-southwesterly winds arose into a 112-cm sea level peak in Venice, at Punta della Salute tide gauge, on 11 January. A higher sea level peak was observed in Venice on 5 March, under Sirocco winds; the event includes as well two minor peaks of 103 cm and around 100 cm occurred on 29 February and 3 March, respectively, in presence of Bora winds. Finally, it is considered the event of mid-June when a sea peak level of 118 cm was observed in Venice, associated to Sirocco winds. Measurements from the tide gauges of the ISPRA observation network, which are located alongside the Italian northern Adriatic coastline, are considered for model comparison.

SHYFEM results are analysed and discussed during the workshop in light of the differences between the driving BOLAM forecasts and the observed meteorological situation.

Simulation of HyLMA lightning observations with Arome

**Caumont, O.¹, Defer, É.², Pinty, J.-P.², Bovalo, C.², Barthe, C.³,
Coquillat, S.², Lambert, D.²**

¹CNRM UMR 3589, Toulouse, France. ²LA UMR 5560, Toulouse, France. ³LACy UMR 8105, Saint-Denis, France.

A Lightning Mapping Array (LMA) has been deployed in south-eastern France during the first HyMeX SOP. This LMA, referred to as HyLMA, has collected lightning data for more than two months, allowing the documentation of many flashes as described by Defer et al. ('Properties of the lightning flashes recorded during the entire SOP1 period', this conference).

Lightning data are potentially useful to improve the prediction of severe weather by introducing information related to deep convection in the initial conditions of numerical weather prediction forecasts. For this, a relationship has to be devised between flash data and model variables through the so-called 'observation operator' used in data assimilation to project the model state onto the observation space. The advent of kilometre-scale models resolving deep convection makes it theoretically possible to find more accurate relationships than those used for coarser-resolution models. However, in practise, devising such a relationship remains a tedious task. The use of explicit lightning schemes like Meso-NH CELLS (see Pinty et al., this conference) is numerically expensive for real-time operational applications and the most relevant model variables (vertical velocity, hydrometeor contents) cannot be handled in a standard way in most up-to-date data assimilation systems. The purpose of this work is to propose a relationship between Arome and flash rate data based on Arome-WMed short-term forecasts and HyLMA observations during HyMeX SOP1. Different semi-empirical relationships are tested and different accumulation times are considered for flash rate data. The relative performance of these relationships is assessed by minimizing the departures between observations and simulations.

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Mediterranean extreme precipitation: A multi-model assesment

Cavicchia, L., Soccimarro, E., Gualdi, S.

CMCC.

Exploiting the added value of the ensemble of high-resolution model simulations provided by the Med-CORDEX coordinated initiative, an assessment of Mediterranean extreme precipitation as represented in different observational, reanalysis and modelling datasets is presented. A spatio-temporal characterisation of the long-term statistics of extreme precipitation is performed, using a number of different diagnostic indices. Employing a novel approach based on the timing of extreme precipitation, a number of physically consistent subregions are defined. Extreme precipitation diagnostics over the Mediterranean domain and physically homogeneous sub-domains are discussed, focussing on the impact of different

model configurations (resolution, coupling and physical parameterisations) on the performance in reproducing observed precipitation. It is found that the agreement between the observed and modelled long-term statistics of extreme precipitation is more sensitive to the model convective parameterisation than to resolution or coupling.

Anticipating Mediterranean High Precipitation Events : which decision strategy when using probabilistic forecasts from a convection-permitted Ensemble Prediction System?

Chabot, E.

Météo-France / French Met. School, 42 av G. Coriolis, 31400 Toulouse, France.

Nowadays, the use of Ensemble Prediction Systems in addition to deterministic models implies that weather forecasters have to deal with many complex statistical products (probabilities, quantiles, “stamps”, ...). However, final users mainly have to take binary decisions based on a “yes/no point of view” (e.g., protect or not protect before a possible significant hydro-meteorological episode).

When computing probabilistic scores from rain amount forecasts provided by an EPS, it is much more informative to look at objective scores based on the cost-loss ratio theory that specifically take into account the user's sensitivity to non-detections and false-alarms - such as the economic value score (Richardson, 2000) or the “missed forecasts score” (Bouttier, 2016).

These two scores potentially depend on the cost-loss ratio of the user, but also on the considered precipitation threshold, the geographical size of the verification area, the forecast range, the period of the verification sample and the number of members inside the ensemble. Thanks to such user-dependant scores, some optimal decision strategies based on the probabilities forecast by the pre-operational AROME Ensemble Prediction System developed by Météo-France (limited area, 2.5km horizontal resolution, 12 members, 2 runs/day, +45h max. range) can be determined. In particular, it can be proved that even quite low values of probabilities provided by such a convection-scale EPS should not be neglected in terms of risk by deciders, regarding the sensitivity of the society to HPE.

In order to optimize the calculation time of a convection-permitted EPS, some computing arbitrations are necessary between : either a larger domain, a finer horizontal resolution, more members (including a control or not), more daily runs or a longer range. Many post-productions can also be used to improve the calculation of the forecast probabilities finally used to take a decision : neighbouring method (spatial tolerance), temporal tolerance, calibration, time-lagging, weighed members. All these choices can strongly impact the way the forecasters will assess this kind of model.

Furthermore, the spread among the 12 forcing members selected by the clustering method (Nuissier et al., 2012) applied to the convection-parametrized ARPEGE Ensemble Prediction System of Météo-France (global, 10km horizontal resolution, 35 members, 2 runs/day, +102h max. range) has to be “reasonable” (typically, close to the multi-deterministic models corresponding spread), so that AROME-EPS can be usable by forecasters.

The estimation of the uncertainty related to a forecast also depends on the proximity of the 12 AROME-EPS members with the corresponding deterministic AROME forecast (limited area, 1.3km horizontal resolution, 5 runs/day, +42h max. range).

Besides, the confidence of a forecaster into a given scenario closely depends on the tendencies of probability and spread regarding several consecutive runs of AROME-EPS (the higher the probability and the lower the spread simultaneously evolve, the higher the confidence of the forecaster).

The Western Mediterranean marine heat wave of summer 2015

Chiggiato, J.¹, Schroeder, K.¹, Di Giuseppe, F.², Cerrano, C.³

¹CNR-ISMAR, Venice, Italy. ²ECMWF, Reading, UK. ³DISVA, UNIVPM, Ancona, Italy.

Summer 2015 for the Mediterranean region was one of the hottest in the last decades. Heatwaves affected Europe from May throughout September, with unusual in their duration. This caused also unprecedented sea surface temperatures over many sectors of the Western Mediterranean that experienced the sustained marine heat wave (MHW) during July/August 2015. The analysis of this extreme meteo-oceanographic event is investigated by means of remote sensing, ARGO floats, an oceanographic field campaign and models carrying out an objective analysis and comparison with the MHW occurred in 2003. The MHW in summer 2015 showed upper ocean temperature anomalies even larger than in 2003, however, the total (i.e., integrated over time) intensity of the MHW in 2003 was considerably larger. Observed mass-mortality events in the western Mediterranean resulted sporadic and not diffused as in 2003, suggesting an overall lower impact of the 2015 MHW on the ecosystem.

Severe convection over the Mediterranean basin derived from microwave satellite observations

Claud, C.¹, Rysman, J.-F.¹, Funatsu, B.M.², Dafis, S.¹, Chaboureau, J.-P.³

¹LMD, CNRS, Ecole Polytechnique, IPSL, UMR 8539, Palaiseau, France. ²Université Rennes 2, LETG/COSTEL, Place du Recteur Henri Le Moal, 35043 RENNES cedex, France. ³Laboratoire d'Aérodynamique, Université de Toulouse, CNRS, Toulouse, France.

The Mediterranean region is a densely populated area under climatic and environmental stresses, particularly concerning the availability of water resources, and is one of the most responsive regions to climate change. While the water availability is of great importance, severe weather events causing heavy rainfall and floods also add to the socioeconomic distress. Deep convective systems can accumulate considerable rain volumes in only a few hours, as for e.g., Vaison-la-Romaine in September 1992, and Draguignan in June 2010. A special class of intense convective events called convective overshootings (COV) has been shown to be associated with particularly severe weather such as heavy rainfall, damaging winds, hails, and tornadoes in the Mediterranean.

We use the data provided by the Advanced Microwave Sounding Unit (AMSU-B) and its successors (MHS, ATMS) onboard NOAA and METOP satellites to detect and analyze convective events over more than 15 years. In addition, microphysical properties are deduced

from colocated CloudSat observations. Based on these two sources of observation, the spatio-temporal distribution of very intense convection (COV) will be presented and discussed.

Evaluation of uncertainties in mean and extreme precipitation under climate changes for northwestern Mediterranean watersheds from high-resolution Med and Euro-CORDEX ensembles

Colmet-Daage, A.^{1,2,3}, Sanchez-Gomez, E.¹, Ricci, S.¹, Llovel, C.², Borrell-Estupina, V.³, Quintana-Seguí, P.⁴, Llasat, M.C.⁵, Servat, E.⁶

¹ECI, CERFACS – CNRS TOULOUSE, Toulouse, France. ²WSP France, Toulouse, France. ³Hydrosciences Montpellier, Univ. Montpellier, Montpellier, France. ⁴Observatori de l'Ebre Fundació, Tarragona, Spain. ⁵Universitat de Barcelona, Barcelona, Spain. ⁶Institut Montpelliérain de l'Eau et de l'Environnement – IRD, Montpellier, France.

The climate change impact on mean and extreme precipitation events in the northern Mediterranean region is assessed over high resolution EuroCORDEX and MedCORDEX simulations. The focus is made on three regions, the Lez and the Aude located in France, and the Muga, located in northeastern Spain and eight pairs of global and regional climate models are analyzed with respect to the SAFRAN product. First the model skills are evaluated in terms of bias for the precipitation annual cycle over past period. Then future changes in extreme precipitation, under two emission scenarios, are estimated through the computation of past/future change coefficients of quantile-ranked model precipitation outputs. Over past period, the cumulative precipitation is overestimated for most models over the mountainous regions and underestimated over the coastal regions in autumn and higher order quantile. The ensemble mean and the spread for future period remain unchanged under RCP4.5 scenario and decrease under RCP8.5 scenario. Extreme precipitation events are intensified over the three catchments with a smaller ensemble spread under RCP8.5 revealing more evident changes, especially in the last part of the 21th century.

Hydrological station-based observations and flood risk modelling over Italy

Coppola, E.¹, Fantini, A.^{1,2}, Giorgi, F.¹, Nogherotto, R.¹, Raffaele, F.¹

¹International Centre for Theoretical Physics, Trieste, Italy. ²University of Trieste, Trieste, Italy.

The number of people exposed to flood risk is projected to strongly increase by the end of the century due to climate change. However, in many regions, limited evidence is available pointing to an increase in extreme hydrological events. The evaluation of hydrological model simulations is particularly difficult as it requires a network of reliable observational stations with long historical time series, which is often not available.

In this work we present the analysis of rain, river discharge and river water level station-based datasets covering the Italian territory, with particular emphasis on their suitability for driving and/or validating hydrological models. We then proceed presenting preliminary results of hydrological simulations with the Cetemps Hydrological Model (CHyM) over selected Italian regions.

We also describe an integrated hydrological and hydraulic modeling approach for the risk assessment of flood-prone areas and we present the first results obtained over the Po river (Northern Italy) at 90m resolution. River discharges from the CHyM model are used to obtain Synthetic Design Hydrographs (SDHs) for different return periods along the river network. These are subsequently processed by the LISFLOOD-FP hydraulic model, which is specifically designed to simulate floodplain inundations over complex topography. Produced flood hazard maps for return periods of 50, 100, 500 and 1000 years are in good agreement with reference maps, suggesting strong potential of this approach for future applications.

Convective phenomena at high resolution over Europe and the Mediterranean. The join EURO-CORDEX and Med-CORDEX flagship pilot study

Coppola, E., Sobolowski, S., the FPS team

ICTP, Trieste, Italy; Bjerknes Centre for Climate Research, Bergen, Norway.

The join EURO-CORDEX and Med-CORDEX Flagship Pilot Study dedicated to the frontier research of using convective permitting models to address the impact of human induced climate change on convection, has been recently approved and the scientific community behind the project is made of 30 different scientific institutes distributed all around Europe. The motivations for such a challenge is the availability of large field campaigns dedicated to the study of heavy precipitation events such as HyMeX and high resolution dense observation networks like WegnerNet, RdisaggH (CH), COMEPHORE (Fr), SAFRAN (Fr), EURO4M-APGD (CH); the increased computing capacity and model developments; the emerging trend signals in extreme precipitation at daily and mainly sub-daily time scale in the Mediterranean and Alpine regions and the priority of convective extreme events under the WCRP Grand Challenge on climate extremes, because they carry both society-relevant and scientific challenges.

The main objective of this effort are to investigate convective-scale events, their processes and their changes in a few key regions of Europe and the Mediterranean using convection-permitting RCMs, statistical models and available observations. To provide a collective assessment of the modeling capacity at convection-permitting scale and to shape a coherent and collective assessment of the consequences of climate change on convective event impacts at local to regional scales.

The scientific aims of this research are to investigate how the convective events and the damaging phenomena associated with them will respond to changing climate conditions in several European regions with different climates. To understand if an improved representation of convective phenomena at convective permitting scales will lead to upscaled added value and finally to assess the possibility to replace these costly convection-permitting experiments with statistical approaches like "convection emulators". The common initial domain will be an extended Alpine domain and all the groups will simulate a minimum of 10 years period with ERA-interim boundary conditions, with the possibility of

other two sub-domains one in the Northwest continental Europe and another in the Southeast Mediterranean.

The scenario simulations will be completed for three different 10 years time slices one in the historical period, one in the near future and the last one in the far future for the RCP8.5 scenario.

The first target of this scientific community is to have few case studies and an ensemble of 1-2 years ERA-interim simulations ready by the first year of the project.

SAETTA: climatology of 3 years of lightning observation at high resolution in Corsica

Coquillat, S.¹, Defer, E.¹, Lambert, D.¹, Pinty, J.-P.¹, Pont, V.¹, Prieur, S.¹, Thomas, R.², Pédeboy, S.³

¹LA, UMR CNRS/UPS n°5560, Observatoire Midi-Pyrénées, Toulouse, France. ²New Mexico Tech, Socorro, USA. ³Météorologie, Pau, France.

The total lightning activity has been observed in the VHF range for about 3 years at high spatial and temporal resolutions by the SAETTA network (Suivi de l'Activité Electrique Tridimensionnelle Totale de l'Atmosphère), consisting of 12 LMA stations (Lightning Mapping Array, developed by New Mexico Tech, USA) and deployed in Corsica since July 2014. Coverage of the observation extends to about 350 km from the center of Corsica but the localization error of the VHF sources increases with distance from the network, and the low levels are no more documented far away from the network due to the roundness of Earth. Therefore, we limit the field of study to about 120 km from the center of Corsica, where VHF sources are localized with theoretical errors less than about 100 meters in the radial direction, 15 meters in the azimuthal direction, and 150 meters in altitude.

In this framework, we first evaluated the density of VHF sources for the total period and for each year, and then the number of days with lightning activity during the same periods. For this, we assumed that a pixel containing at least 5 VHF sources in a day can be considered as a pixel affected by lightning process. This threshold of 5 VHF sources per day makes it possible to disregard the noisy isolated VHF sources without neglecting the days of weak storm activity. In addition, night and day activities were separated to explore the behavior of convection in this mountainous/maritime region.

The results of the VHF sources density show a high variability during these 3 years with strong activity in the northeast part of the domain in 2014, especially above the sea in the Gulf of Genoa, while 2015 was mainly affected by diurnal convection above the relief. The 2016 year will be also analyzed.

With respect to the number of days of lightning activity (i.e. the frequency of thunderstorm), the specific year of 2015 identifies the most probable area of diurnal thunderstorm production, which appears to be located in the center of the island between Ponte Leccia and Corte. The comparison with the relief shows that this area clearly corresponds to a convergence of several valleys so that the valley breezes could be put forward as candidates for the triggering of convection in 2015 by low level convergence.

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individuals and regional institutions in Corsica that host the 12 stations of the network or helped us to find sites.

Aerosol indirect effects on summer precipitation in the Euro-Mediterranean region

Da Silva, N.¹, Mailler, S.^{1,2}, Drobinski, P.¹

¹CNRM / Meteo France, Toulouse, France. ²LEGOS / Observatoire Midi-Pyrénées, Toulouse, France. ENSTA Paristech and Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France. University of Bergen, Bergen, Norway. MERCATOR-Océan, Toulouse, France. LOCEAN, UPMC, Paris, France.

Aerosols affect atmospheric dynamics and precipitation through their direct and semi-direct radiative effects as well as through their indirect effects causing changes of cloud microphysics. The present study investigates the indirect effects of aerosols on summer precipitation in the Euro-Mediterranean region which is located at the crossroads of air masses carrying both natural and anthropogenic aerosols. While it is difficult to disentangle the indirect effects of aerosols from the direct and semi-direct effects in reality, a numerical sensitivity experiment is carried on using the Weather Research and Forecasting Model (WRF) model, which allows to isolate indirect effects, all others effects being equal. For this purpose, the Thompson aerosol-aware microphysics scheme is used in a pair of simulations run at 50 km resolution with extremely high and low aerosol concentrations, respectively. The results show two opposite responses to an increase of aerosol concentration. Convective (parameterized) precipitation decrease with increasing aerosol concentration, and therefore cloud condensation nuclei. Conversely, large-scale (explicit) precipitation increase with increasing aerosol concentration. A complex feedback chain is diagnosed beginning from the reduction of mean droplet radii, yielding an increase of atmospheric stability and a decrease of water availability in the planetary boundary layer for the formation of clouds and convective precipitation.

Flooding from Intense Rainfall

Dance, S.L.¹, Cloke, H.L.¹, Ballard, S.P.²

¹University of Reading. ²Met Office.

Brief periods of intense rainfall can lead to flash flooding with the potential to cause millions of pounds of damage to property, and to threaten lives. Accurate flood warnings even just a few hours ahead can allow preparations to be made to minimise damage. In order to improve the prediction of these events, more accurate forecasts of heavy rainfall are needed, and these can then be used to inform flood prediction and warning systems. The impact of a flood can be affected by a wide range factors (or processes) such as the location and intensity of the rainfall, the shape and steepness of the catchment it falls on, how much sediment is moved by the water and the vulnerability of the communities in the flood's path.

A broad agenda of research, funded under the UK Natural Environment Research Council (NERC) Flooding from Intense Rainfall (FFIR) programme in partnership with the UK Met Office and Environment Agency is addressing many of these issues. Improvements in numerical weather prediction of intense precipitation will be achieved by reducing initial condition errors. For example, in heavy rainfall, weather radar reflectivity measurements are strongly attenuated, leading to underestimation of the rainfall rate. Research funded under the FFIR programme has shown that radar reflectivities can be corrected using an emission technique that detects the “glow” of the storm. Further work has focussed on understanding the factors that cause FFIR, including assembling an archive of past FFIR events in Britain and their impacts, as a prerequisite for improving our ability to predict future occurrences of FFIR; making real time observations of flooding during flood events as well as post-event surveys and historical event reconstruction. This data is being used to improve flood models from urban scale (high spatial and temporal resolution); scaling up to larger catchments by improving the representation of fast riverine and surface water flooding and hydromorphic change (including debris flow) in regional scale models of FFIR; improving the representation of FFIR in the JULES land surface model by integrating river routing and fast runoff processes, and performing assimilation of soil moisture and river discharge into the model run. The last stage of the project will bring together successful components of research to test the benefits and feasibility of end-to-end flood forecasting.

Properties of the lightning flashes recorded during the entire SOP1 period

Defer, E.¹, Coquillat, S.¹, Ghilain, S.¹, Lambert, D.¹, Pinty, J.-P.¹, Prieur, S.¹, Pedeboy, S.², Schulz, W.³, Caumont, O.⁴, Labatut, L.⁴, Rison, W.⁵, Krehbiel, P.⁵, Thomas, R.⁵

¹Laboratoire d'Aérodologie, Toulouse, France. ²Météorage, Pau, France. ³OVE, Vienna, Austria. ⁴CNRM, Toulouse, France. ⁵NMT, Socorro, New Mexico, USA.

During the HyMeX SOP1 campaign, high spatial and temporal 3D lightning observations were recorded with the HyMeX Lightning Mapping Array (HyLMA; Defer et al., AMT, 2015) Combined to the EUCLID records, those observations provided an unprecedented description of the total lightning activity over the Cévennes-Vivarais (CV) domain (South-East of France). Total lightning activity includes intra-cloud (IC) flashes and cloud-to-ground (CG) flashes. We will present an overview of the properties of the lightning flashes recorded during the period June 2012-November 2012 in the CV domain. First a reminder of the lightning detection techniques will be provided. Then we will detail the methodology applied to combine the HyLMA and EUCLID observations in flashes. Statistics on several lightning parameters, e.g. flash duration, flash vertical and horizontal extension, flash triggering altitude, IC/CG density... will be discussed and related to their cloud environment as derived from ground-based radar and satellite-based products.

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Dynamics and predictability of Medicanes in the ECMWF ensemble forecast system

Di Muzio, E.¹, Fink, A.¹, Riemer, M.²

¹Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research - Department Troposphere Research (IMK-TRO), Wolfgang-Gaede-Strasse 1, Karlsruhe, Germany. ²Johannes Gutenberg University, Institute for Atmospheric Physics, Johann-Joachim-Becher-Weg 21, Mainz, Germany.

Medicanes are intense tropical-like cyclones which occasionally strike the Mediterranean region, constituting a major threat due to strong winds and intense precipitation which can lead to flooding. While originating as extratropical storms driven by baroclinic instability, Medicanes later undergo a transformation referred to as tropical transition (TT), developing tropical-like features such as a warm core, deep convection near their center with sometimes a cloud-free eye in the center, a largely axisymmetric appearance and surface fluxes from the underlying sea as the main energy source.

The dynamics and predictability of several Medicanes in the ECMWF ensemble prediction system (EPS) are analyzed in this presentation, from the planetary scale down to the mesoscale. At the planetary scale, the influence of Rossby wave breaking (RWB) on the formation and early phase of Medicanes is assessed by linking the accuracy of RWB forecasts with the uncertainty in storm intensity and position. A similar approach is employed at the synoptic scale, by examining forecasts of precursor upper-level geopotential height and PV troughs and relating their associated uncertainty with different storm development pathways. At the mesoscale, a suite of methods and diagnostics was utilized, including storm track comparison, cyclone phase space (CPS) "Hart" diagrams and track clustering, to assess the extent to which TT occurs and ultimately the ability of the ECMWF EPS to accurately predict Medicanes.

Preliminary results indicate a jump in forecast accuracy around 3 days lead time and a clear influence of large-scale processes on storm pathways. The occurrence of RWB and the presence of a deep upper-level cut-off trough, usually associated with PV streamers, are indeed instrumental in decreasing vertical wind shear and facilitate the development of intense convection. For this reason, the EPS members having large errors in large-scale processes also tend to have poorer accuracy in storm intensity, position and structure. Spatial uncertainty in storm tracks is high even for short lead times, whereas structural changes linked to TT are usually better forecast.

How much does Clausius-Clapeyron law predict humidity change under global warming in the Mediterranean region?

Drobinski, P.¹, Da Silva, N.¹, Bastin, S.², Muller, C.¹

¹LMD/IPSL, Ecole polytechnique, Université Paris-Saclay, Sorbonne Universités, UPMC Univ. Paris 06, CNRS, Palaiseau, France. ²LATMOS/IPSL, UVSQ, Université Paris-Saclay, Sorbonne Universités, UPMC Univ. Paris 06, CNRS/INSU, Guyancourt, France.

Extreme precipitation has been proposed to scale with the precipitable water content in the atmosphere. Assuming constant relative humidity, this implies an increase of precipitation extremes at a rate of $\sim 7\%/^{\circ}\text{C}$ globally as indicated by the Clausius-Clapeyron relationship. Using the HyMeX/MED-CORDEX regional climate simulations, this work shows the existence of regions in the Mediterranean displaying a strong sub-Clausius Clapeyron evolution of precipitable water content in a warming climate during summer. The regions displaying a significant sub-Clausius Clapeyron scaling are the Iberian Peninsula, the Sahara and the Arabic Peninsula. These regions correspond to heat-low regions. Heat lows are warm, shallow, non-frontal depression which form above continental regions, mostly in the subtropics, but also in the lower midlatitudes. They form mostly during the warm seasons because of the intense surface heating over land. Near surface vorticity isolates the heat low regions from moisture transport. The consequence is a decrease of relative humidity in a warmer climate and therefore a sub-Clausius Clapeyron evolution of precipitable water content.

Which people and which companies are exposed to flood prone in the French department of the Gard (southern east of France)?

Dubos-Paillard, E., Boulier, J., Pavard, A.

Université Paris 1, Panthéon -Sorbone, Laboratoire Géographies-cités UMR8504, France.

According to the French Ministry of Ecology, sustainable development and energy, in 2009, 44 % of housing and 41 % of the population were exposed to the risk of flooding in 2009 in the Gard. Despite the 1988 and 2002 major floods that have caused important damages and fatalities, many municipalities kept on urbanizing in exposed areas (including “red zones”) before the approbation of the Flood-risk prevention plans. This presentation considers the urban functions of constructed buildings since 1980 with a specific attention to the buildings dedicated to business activities: offices, hotels, commerce, industry, public facilities etc. The aim is to analyze the variation of exposed people in these buildings according to the time of the day and the week, taking into account the different type of people who go to these businesses buildings in three municipalities located in the Gard (Nîmes, Alès and Sommières).

Multi-model analysis of the Adriatic-Ionian thermohaline circulation using an ensemble of multi-decadal regional ocean simulations

Dunić, N.¹, Vilibić, I.¹, Šepić, J.¹, Sevault, F.², Somot, S.², Waldman, R.², Arsouze, T.^{3,4}, Pennel, R.⁴, Nabat, P.², Jordà, G.⁵

¹Institute of Oceanography and Fisheries, Šetalište Ivana Meštrovića 63, 21000 Split, Croatia. ²CNRM (CNRS/Météo-France), 42, avenue Coriolis, 31057 Toulouse, France. ³ENSTA-ParisTech, Université Paris-Saclay, 828 bd des Maréchaux, 91762 Palaiseau cedex France. ⁴IPSL/Laboratoire de Météorologie Dynamique, Ecole Polytechnique, ENS, UPMC, ENPC, CNRS, Palaiseau, France. ⁵IMEDEA (CSIC-UIB), Miquel Marquès 21, 07190 Esporles, Spain.

Dense water formation (DWF) is the major driver of the Adriatic thermohaline circulation (THC) and water mass exchanges with the Ionian Sea and Eastern Mediterranean. It is highly variable in both space (down to 1 km) and time (down to 1 hour), demanding mesoscale approach in both atmospheric and ocean modelling. Recent analysis based on long-term in-situ measurements revealed a possible change in the Adriatic THC, showing a significant reduction of the DWF processes. On top of that, the circulation and Adriatic thermohaline properties resemble substantial decadal variations, which are coherent with the sea level height fluctuations in the northern Ionian Sea. This phenomenon is called Adriatic-Ionian Bimodal Oscillating System (BIOS). An initial study has shown that a regional ocean hindcast model succeeded to reproduce only partially the patterns of the BIOS, so that an extension of the analysis to a variety of state-of-the-art hindcast models is required for proper assessment of the changes over a long term. To achieve that, we took seven different NEMOMED regional hindcast simulations covering ERA Interim period (1980-2012) and analyzed them focusing on their capacities to reproduce the Adriatic DWF and the BIOS. Verification of the models has been carried out on the in-situ long-term data collected over the Palagruža Sill transect, at Jabuka Pit and deep South Adriatic Pit, as well as on the AVISO+ satellite altimetry data. We performed multi-model analysis in order to investigate the effects of spatial (from 10 to nearly 2 km) and vertical (43 to 75 z-levels) resolution, atmosphere model resolution (50 and 12 km) and high-frequency coupling, as well as the effects of the aerosol representation. In addition, we investigated impact of freshwater forcing using different climatologies or river coupling on the interannual and decadal variations of the Adriatic-Ionian thermohaline properties.

Comparison of flood modeling approaches in the High-Atlas Mountains (Morocco)

El Khalki, E.¹, Trambly, Y.², Saidi, E.M.¹

¹Laboratoire de Géosciences et Environnement Département des Sciences de la Terre, Faculté des Sciences et Techniques, Université Cadi Ayyad, Av, A. Khattabi, BP 549, 40000 Marrakech, Morocco. ²IRD HydroSciences, Montpellier, France.

In semi-arid regions such as the Mediterranean basin, floods are frequently causing extended damages to the populations and infrastructures. In addition, climate scenarios indicate a possible increase in extreme hydro-meteorological events in the Mediterranean region.

Therefore, it is necessary to model floods to better understand the processes involved and increase forecasting delays to mitigate these risks. The Moroccan watersheds flowing downstream from the High Atlas Mountains are among the areas most vulnerable to flooding. The Rheraya research catchment is a mountainous basin with altitudes ranging from 1000m to 4165m and affected by violent floods that constitute a threat to the villages located in low elevation areas. This paper compares the effectiveness of two rainfall-runoff models: The distributed physically based TOPKAPI model and the global conceptual SCS-CN model in HEC-HMS. TOPKAPI is based on the physical characteristics of the catchment that can be estimated from soil databases. In HEC-HMS, the SCS-CN model requires calibration and is strongly related to antecedent wetness conditions. The initial conditions for both models are estimated from the ESA-CCI soil moisture data obtained from remote sensing. The calibration results show a good reproduction of the events, with an acceptable Nash criterion for both models. In validation, events are also well reproduced using the ESA-CCI soil moisture data to set initial conditions. Since both models are found adequate, a preliminary analysis of the meteorological forecasts provided by the AROME and ALADIN models is performed to evaluate the feasibility of flood forecasting in this catchment. Key words: flood modeling, HEC-HMS, TOPKAPI, Rheraya, floods, Morocco.

Operational high temporal and spatial resolution soil moisture by multi-sensor remote sensing approach for water resources management

Escorihuela, M.J.^{1*}, Merlin, O.², Er-Raki, S.³, Ferrer, F.⁴, Gao, Q.¹, Olivera, L.², Amazirh, A.³, AitHssaine, B.³, Fontanet, M.⁴, Quintana, P.⁵

¹isardSAT. ²CESBIO. ³UCAM. ⁴LabFerrer. ⁵Observatori de l'Ebre.

Modern irrigation agencies rely on in situ root-zone soil moisture measurements to detect the onset of crop water stress and to trigger irrigations. However, in situ point measurements are costly, are not available over extended areas and may not be representative at the field scale. Remote sensing is a cost-effective technique for mapping and monitoring broad areas. However, an operational remote sensing algorithm dedicated to root zone soil moisture monitoring at the parcel scale still needs to be developed.

By taking advantage of recent multi-sensor remote sensing developments, the REC project proposes a solution to the need of root-zone soil moisture at the field scale for irrigation management. It is based on an innovative and operational algorithm that will allow for the first time to: 1) to map root zone soil moisture on a daily basis at the field scale and 2) to quantitatively evaluate the different components of the water budget at the field scale from readily available multi-sensor remote sensing data.

The methodology relies on the coupling between a surface model representing the water fluxes at the land surface-atmosphere interface (infiltration, evaporation, transpiration) and in the soil (drainage), and remote sensing data including land surface temperature, multi-spectral surface reflectances, and the near-surface soil moisture retrieved from microwave radiometers and radars. These modelling and remote sensing tools will be integrated in an irrigation management system that will be used to trigger irrigation.

REC proposes an innovative approach to take advantage of the complementarity between thermal-disaggregated SMOS/SMAP Soil Moisture (SM) (no need for calibration) and radar

derived SM (with a need for calibrating the radiative transfer model) at 100 m resolution. On the cloud free days when thermal data are available at approximately the same time as the SAR data, we calibrate the inversion algorithm of radar data from the SM data estimated at similar spatial resolution by the thermal-based disaggregation method of SMOS/SMAP SM. As a result, we are able to provide high-resolution SM every 3 days in all weather conditions. REC purpose is to develop a Land Surface Model (LSM) driven by multi-sensor remote sensing and meteorological data to map root-zone SM (RZSM) at the daily and parcel scales. The LSM will be used to estimate RZSM at the daily time scale and to forecast irrigation schedules.

The project, awarded a H2020-MSCA-RISE-2014 grant, is being implemented and validated over two sites: the modern irrigated area of Segarra- Garrigues in Lleida, Catalonia, Spain and an irrigated perimeter of the Haouz Plain in the Tensift watershed, Morocco.

Ocean circulation, formation and dispersion of dense water in the western Mediterranean Sea

Estournel, C., Marsaleix, P.

CNRS, Laboratoire d'Aérodologie, Toulouse, France.

Convection and dense shelf water formation in the western Mediterranean basin feeds thermohaline circulation through the transformation of Atlantic water into deep water masses. During the winter 2011 2012, a large amount of deep water was formed. During the summer 2012 - summer 2013 period, a huge data set documenting the different phases of convection have been collected in the frame of the HyMeX and MerMex programs. Numerous processes have been documented from the scale of the mixed patch to the mesoscale and submesoscale. This data set is invaluable to test the ability of numerical models to reproduce these processes.

This study uses the SYMPHONIE model at very high resolution at the scale of the whole western basin. The initial state of the model has been carefully prepared thanks to assimilation of temperature and salinity profiles available in the basin.

In a first part, the simulation is validated. The simulated oceanic circulation is described at the scale of the basin. Then the dense water dispersion toward the southern part of the basin is discussed with an emphasis on the spatial scales of this dispersion. Submesoscale processes are highlighted through the documentation of submesoscale coherent vortices, the existence of which has been proven by observations.

Spatio-temporal variability of extremes precipitation indices in Tunisia

Feki, H.¹, Ouachani, R.^{2,3}, Dridi, S.¹

¹Ecole supérieure des ingénieurs de Mezez el Bab, Route du Kef km5, 9070, Medjez el beb, Tunisia. ²Ecole Nationale d'Architecture et d'Urbanisme, Université Carthage, Tunisia. ³Ecole Nationale d'Ingénieurs de Tunis, Université El Manar, Tunisia.

Analysis of changes in extreme climate events is important due to the potentially high social, economic and ecological impact of such events. In some regions, extreme precipitations have already shown amplified responses to changes in mean values. This study attempts to provide new information on trends, in a regional scale, using long-term records of daily precipitation over Medjerda basin in Tunisia, through the analysis of different extreme precipitation indices based on observational data from multiple stations in the region. The study site is Wadi Medjerda that controls a watershed of 23,700 square kilometers, of which 32% are in Algerian territory. It is the most important hydro system in Tunisia. The water problem appears every year in its two aspects: a large excess in winter and a deficit in the summer. Daily precipitation data were taken from 46 meteorological stations across Medjerda basin, with data series length varying between 42 and 115 years. Data were processed using freely available software packages: RClimDex, which performs data quality control and calculates indices, and RHtest, which performs homogeneity tests. We calculate nine indices characterizing the precipitation extremes such as: maximum 1-day precipitation amount, number of heavy precipitation days, extremely wet days, ...etc. and we analyze their spatio-temporal variability. In the other hand, using cross-wavelet analysis, the climatic modes most associated with the variability of precipitation extremes are identified. The variability of precipitation extremes in northern Tunisia seems to be related not only to global teleconnections but also to the regional effect of the Mediterranean through the MOAC. A very significant covariability can be distinguished in the same time bands as with the NAO and predominantly from the 80s. The amount of very wet days RX1day shows a diminution in the South West part of the basin. The 95th quantile showed nine stations with positive significant trends against only one station with negative significant trend, showing that the amount of very wet days are increasing. In general, the significant increasing values are in the North West/ South East direction which corresponds to the direction of winter frontal disturbances. Most precipitation indices show statistically significant trends in the region with an upward trend especially for extremely heavy rainfall, very rainy days and maximum rainfall of 1 or 5 consecutive days.

Heavy rainfall in Mediterranean cyclones: Contribution of deep convection and warm conveyor belts

Flaounas, E.¹, Kotroni, V.¹, Lagouvardos, K.¹, Gray, S.², Rysman, J.F.³, Claud, C.³

¹National Observatory of Athens, Greece. ²Department of Meteorology, University of Reading, UK. ³Laboratoire de Météorologie Dynamique, Institut Pierre Simon Laplace CNRS, École Polytechnique, Université Paris-Saclay, Palaiseau, France.

In this study, we provide an insight to the role of deep convection (DC) and the warm conveyor belt (WCB) as leading processes to Mediterranean cyclones heavy rainfall. To this end, we use reanalysis data, lightning and satellite observations in order to quantify the relative contribution of DC and the WCB to cyclones rainfall, as well as to analyse these processes spatial and temporal variability respect to the cyclones centre and life cycle.

Results show that the relationship between cyclone rainfall and intensity shows high variability and demonstrates that even intense cyclones may produce low rainfall amounts. However, when considering rainfall averages for cyclone intensity bins, a linear relationship was found. We focus on the 500 most intense tracked cyclones (responsible for about 40-50% of the total Mediterranean rainfall) and distinguish between the ones producing high and low rainfall amounts. DC and the WCB are found to be the main cause of rainfall for the former (producing up to 70% of cyclone rainfall), while, for the latter, DC and WCB play a secondary role (producing up to 40% of rainfall). Further analysis showed that DC and WCB are rather distinct processes, being rarely collocated. In fact, rainfall due to DC tends to occur close to the cyclones' centre and to their eastern sides, while WCB tends to produce rainfall towards the northeast. Finally, DC was found to be able to produce higher rain rates than WCBs.

Our results demonstrate in a climatological framework the relationship between cyclones intensity and processes that lead to heavy rainfall, one of the most prominent environmental risks in the Mediterranean. This study has been performed with support from the Marie Skłodowska-Curie actions (grant agreement-658997) in the framework of the project ExMeCy.

Extreme rainfall in South East of France during the autumn: added value of a convection permitting regional climate model

Fumière, Q.¹, Déqué, M.¹, Nuissier, O.², Somot, S.¹, Alias, A.¹

¹Météo-France CNRM/GMGEC. ²Météo-France CNRM/GMME.

The Southeastern (Mediterranean) regions of France are regularly affected by extreme precipitation that often lead to devastating flash-floods which are often associated with both human and material damages. The evolution of such events in terms of occurrence and severity with climate change remains an open question. AROME-climat model has the highest horizontal resolution (2.5km) among Météo-France climate models. It is controlled in its lateral boundary conditions by ALADIN-climat which has a 12.5km resolution. The ALADIN-climat model does not resolve explicitly the convection phenomena. AROME-climat, a non-

hydrostatic model, is able to explicitly solve vertical motions linked to convective events responsible for the heavy accumulated rainfall.

ALADIN-Climat simulations driven by ERA-interim data are performed to drive the AROME-Climat simulations. The domain of the study goes from North of France (50°N) to South of Italy (39°N) and from West of France (-1°E) to East of the Czech Republic (17°E). ALADIN-Climat simulations and AROME-Climat simulations will be compared to study the added value of the high resolution model. Then, the model data will be compared to COMEPHORE data, a high-resolution (1 km), 10-year reference database (1997–2006) of hourly quantitative precipitation estimations covering the entire French metropolitan territory. This study will take part of the CORDEX Flagship Pilot Study "Convective phenomena at high resolution over Europe and the Mediterranean".

Impact of ocean-atmosphere coupling and increased resolution on the simulation and future projections of medicanes

Gaertner, M.A., González-Alemán, J.J., Gutiérrez, J., De la Vara, A., Gallardo, C., Romera, R., Domínguez, M., Gil, V., Sánchez, E.

University of Castilla-La Mancha, Toledo, Spain.

Tropical-like cyclones over the Mediterranean Sea, also called medicanes, can produce significant damage due to the combination of intense winds and heavy precipitation. Due to their small size and the importance of air-sea interaction in their formation and intensification, the high resolution and regional ocean-atmosphere coupled simulations from MedCORDEX and EURO-CORDEX projects can provide an improved representation of such cyclones, as well as more complete information about their future evolution under climate change conditions. Using ensembles of regional climate model simulations, we assess the impact of increased resolution and ocean-atmosphere coupling on the frequency and intensity of medicanes, as well as on their seasonal and spatial distributions. The importance of ocean variables like the oceanic mixed layer depth is also evaluated.

Water level estimation over Ebre river basin

Gao, Q.^{1,2,3}, Escorihuela, M. J.¹, Quintana, P.², Garcia-Mondejar, A.¹, Zribi, M.³

¹isardSAT, Advanced Industry Park, Carrer de Marie Curie, 8, 08042 Barcelona, Spain.

²Observatori de l'Ebre (OE), Univ. Ramon Llull CSIC, Spain. ³CESBIO (CNRS/CNES/UPS/IRD), 18 av. Edouard Belin, bpi 2801, 31401 Toulouse cedex9, France.

Quantification of the inland water level is essential in order to correctly understand and quantify the continental water cycle and, also, for water balance management. However, sometimes, in-situ data is no existent or not publicly available. Satellite altimetry is a solution in these cases.

The altimeter is an essential tool designed to monitor the oceans, and it can be also used for inland water surfaces including lakes and rivers. The altimeters transmit a short microwave pulse in the nadir direction, and the signal reflected by the surface is received by the instruments. The elapsed time corresponds to the range between the satellite and the Earth's surface. The water level from an altimeter is derived from the satellite range, subtracted from the altitude of the satellite, and by applying the different needed corrections. As of today, the use of SAR mode, which gives a better resolution, allows satellite altimeter monitor smaller water bodies including small lakes and rivers. Before the launch of Sentinel-3 in 2016, there was only the CryoSat-2 mission provides SAR mode altimetry data since mid-2010, but the CryoSat-2 mission flies on a geodetic orbit, making it impossible to derive water level time series from a fixed location (virtual stations). With the newest Sentinel-3 satellite data, which has a revisit time of 27 days, we can combine both waveform and satellite range data to retrieve water level more precisely and automatically over small lakes.

The study is performed in the Ebre river basin in Spain, where in-situ data is available and, thus, the methods can be tested. The lake size and river width in Ebre river basin are rather small (about 1km or even less), as it is often the case in the Mediterranean region, which makes the study quite challenging, but also more relevant.

First, the waveform is analyzed for data filtering and the possibility of water level retrieval. Then an iteration method is proposed to retrieve the height from Level-2 altimeter data with a strict water mask. The water level from an altimeter is derived from the satellite range, subtracted from the altitude of the satellite, and by applying the different needed corrections. In our study, the corrections of the wet troposphere, dry troposphere, ionosphere, solid earth tide and pole tide are made, and the geoid correction is applied.

The aim of this study is to reduce the land contamination and get a clear signal for inland water level retrieval by combining waveforms and range data. For a rough surface, the leading edge of the return waveform is stretched because of scattering. For water surface, the power of the signal received by the instrument is much larger than for the rough land, and the energy which is the total amount of waveform is larger as well. By analyzing the waveform, the land contamination can be reduced. From Level-2 range data, an iteration method is developed to control the standard deviation. For each track, start from the middle point within the lake, calculate the height standard deviation of the middle three points, add more points to the border if the standard deviation is smaller than a threshold (0.3 meters). In this case, the standard deviation is controlled below 0.3 meters and land contamination is restricted.

Regionalized rainfall-runoff model to estimate low-flow indices in gauged and ungauged basins

Garcia, F.¹, Folton, N.¹, Oudin, L.²

¹Irstea - UR RECOVER, 3275 route Cézanne CS 40061, 13182 Aix-en-Provence, France.

²Université Pierre et Marie Curie (Paris VI) UMR 7619 METIS, (T.56-55, 4e étage) Case 105, 4 place Jussieu, 75252 Paris Cedex 05, France.

Estimating low-flow indices is of paramount importance to understand low flows and to manage water resources and risk assessments. These indices are derived from time-series of river discharges which are measured at gauged sites over long periods. However, the indices must be estimated at ungauged sites. Different estimation methods exist to estimate these low-flow indices from observed discharges in neighboring catchments and from catchment characteristics. Regression or geostatistical methods performed on the low-flow

indices are the most common types of methods. Another less common method consists in regionalizing rainfall-runoff model parameters, from catchment characteristics or by spatial proximity, to estimate low-flow indices from simulated hydrographs.

We developed a conceptual daily rainfall-runoff model, LoiEau, combined with a regionalized model of snow storage and melt, to simulate low-flow indices at daily or longer time intervals. This model relies on two free parameters, which is sufficient to provide accurate enough estimates of low-flow indices, yet making easier the regionalization of the model. The model is flexible in the sense that it is designed to fit to a wide variety of catchments and hydro-meteorological behaviors, including Mediterranean catchments.

The aim of this work is to regionalize the two parameters of the LoiEau model in order to estimate any low-flow indices at ungauged sites. Two regional methods are tested and are based on geostatistical and regression models. The first method is the inverse distance weighting to estimate the parameter sets from the neighboring catchments and the second one is the regional regression method. This last method is based on relationships between the parameter sets and optimal sets of catchment characteristics established using forward stepwise linear regression for homogenous regions. The chosen regions are hydro-eco-regions that are homogenous in terms of geology, relief and climate. The analysis is carried out on 700 French catchments that are representative of various hydro-meteorological behaviors, with a focus on the Mediterranean hydro-eco-region. The results are validated with a cross-validation procedure and are compared, on the one hand, with the ones obtained with a regional regression model performed on a specific low-flow index and, on the other hand, with the ones obtained with a regionalized monthly rainfall-runoff model to show the advantage of a daily time step to account for the temporal variability of precipitations.

Numerical modelling of Ocean Convection Plumes in the Gulf of Lion using hydrostatic approximation

Garreau, P., Garnier, V.

IFREMER/LOPS, Ifremer centre de Brest, 29270 Plouzané, FRANCE.

The HYMEX experiment had monitored an event of deep convection in the Gulf of Lions during the winter 2013. Nowadays, hydrostatic numerical experiments simulate a volume of newly formed deep water mass which is coherent with observations. And thanks to the high horizontal resolution (about 1 km) and improvements in numerical operators, the mesoscale processes are also much better resolved. In convection areas, both the restratification and redistribution of water masses properties by mesoscale processes are now simulated.

But increasing the effective resolution leads, during extreme convection events, to spurious vertical velocity behaviour. The convective adjustment under static instabilities propagates along a water column much faster than the action of the horizontal diffusion of momentum or buoyancy. It leads to a grid scale "instability" not removed or even intensified by finer grid cells: neighbouring columns have (strong) opposite vertical velocities. It results, inside the chimney area, in a strong vertical and horizontal mixing during a few hours, mimicking the convection process. To overcome this problem and (or) control the convection, some strategies have been developed (smoothing the buoyancy loss by distributing it throughout the mixed layer depth, triggering an enhanced vertical mixing... or even occulting the vertical velocity dynamics!)

Using the two-way downscaling technics Agrif, a high horizontal resolution modelling (400 m) of the convection area is performed. A simplified LES (Large Eddy Simulation) approach is also introduced to remove the lack of coupling in hydrostatic models between the horizontal

and vertical motion. Vertical velocities are then distributed according to convective plumes in the convection chimney. The dynamics of these plumes are analysed regarding to the observations. Results are encouraging and this approach might be a powerful alternative to non-hydrostatic modelling.

Obviously, the properties of the newly formed deep water is dependent on the relative weight of the processes acting on its formation (mainly vertical mixing vs vertical advection). A comparison of the effect of the different parametrisations of the convection will be proposed.

Implementation of water table dynamics in SURFEX based on explicit diffusion equations

Gestal Souto, L., Sánchez Perrino, J. C., Rodriguez Camino, E.

AEMET, Leonardo Prieto Castro 8, 28071 Madrid, Spain.

Land surface models (LSM) commonly ignore groundwater and water table effects. However, recent studies have shown that groundwater can have considerable influence on root zone soil moisture and land-surface fluxes and hence, on climate simulations. The groundwater acts like a buffer that dampens and retards soil moisture variations and also affects surface fluxes mainly in areas where the water table is shallow.

We study the effect of considering the water table (WT) and the humidity fluxes between it and the resolved layers in a diffusive scheme into SURFEX_v8 model (a state of the art LSM). SURFEX can be run either offline –forced with reanalysis or observations- or coupled to different models, for example HARMONIE. The new WT parametrization is taken from the LEAFHYDRO model which includes groundwater dynamics based on explicit diffusion equations.

Our preliminary results show a water table depth compatible with piezometer observations. The implementation of water table interacting with non-saturated soil changes the near-surface soil moisture, evapotranspiration and surface fluxes. The improvements with respect to the widely used free drain approach will be studied in the future and will still require to refine the new water table formulation in SURFEX.

On the impacts of dust on Mediterranean cyclones: The Mediane case of December 2005

Giannaros, T.M.¹, Chen, S.-H.², Dafis, S.¹, Flaounas, E.¹, Kotroni, V.¹, Lagouvardos, K.¹, Mallet, M.³, Miglietta, M.M.⁴, Nabat, P.³, Rizza, U.⁴, Solmon, F.^{5,6}

¹National Observatory of Athens, Institute for Environmental Research and Sustainable Development, Vas. Pavlou & Metaxa, 15236 Penteli, Greece. ²Land, Air and Water Resources, University of California Davis, One Shields Avenue, Davis CA 95616, USA. ³CNRM UMR 3589, Meteo-France/CNRS, Toulouse, France. ⁴CNR/ISAC, Unit of Lecce, Strada Provinciale Lecce-Monteroni km 1.2, 73100 Lecce, Italy. ⁵Laboratoire d'Aerologie, CNRS/OMP/UPS, 3400 Toulouse, France. ⁶ICTP, Strada Costiera 11, 34151 Trieste, Italy.

It is well known that aerosols modify the Earth's radiative budget by scattering and absorbing solar and terrestrial radiation. In addition, they affect cloud development and precipitation formation by acting as cloud condensation nuclei (CCN) and ice nuclei (IN), thus indirectly changing the energy budget. Dust aerosols, in particular, have been recently shown to play an important role in the development and evolution of Atlantic tropical cyclones. Considering this, the present study aims to examine the potential effects of dust on the genesis and evolution of tropical-like Mediterranean cyclones (Medicanes). To this end, a Mediane event that took place between 13 and 16 December 2005 is selected for a case study. Analysis of satellite imagery shows clearly that a significant amount of mineral dust was advected into the Mediane, thus making it an ideal case study. In the context of a multi-model inter-comparison, four (4) different regional climate models are employed for simulating the event. The effects of dust (both direct and indirect) on the Mediane genesis and development will be quantified and compared among the four models.

An Eddy-Diffusivity Mass-Flux Parameterization for Oceanic Convection

Giordani, H.¹, Bourdallé-Badie, R.², Piron, A.³, Mercier, H.³

¹CNRM-GAME. ²Mercator-Océan. ³LOPS-IFREMER.

A new unified way of parametrizing simultaneously local and non-local turbulent transport for the convective oceanic boundary layer is proposed to represent the shallow, intermediate and deep convection in ocean general circulation models (OGCMs). This research is motivated by the need for OGCMs to better simulate the production of intermediate and deep water masses and the thermohaline circulation.

The traditional way to parameterize turbulent transport in the oceanic boundary layer is through an eddy-diffusivity approach. One well-known drawback of this method is that it cannot adequately describe downward turbulent flux in the lower part of the convective boundary layer because of a slightly stable potential temperature profile, so-called coutergradient zone. In order to improve the turbulent transport and entrainment in this lower part, especially during deep convection events, OGCMs activate either a coutergradient term either a convective adjustment either an eddy diffusivity coefficient enhancement. These

techniques are not satisfactory because the parcels penetrate downward with an inappropriate degree of mixing until they reach their level of neutral stability. The proposed new approach assumes that in the convective boundary layer the subgrid-scale fluxes result from two different mixing scales: small eddies, that are parametrized by an eddy-diffusivity approach (TKE, GLS ...), and large eddies or thermals, which are represented by an advective mass-flux contribution. Since the interaction between the thermocline and the upper-layers predominantly takes place through strong downdraughts, this approach offers an interesting way of establishing a consistent description of the turbulent transport in the mixed-layer and mainly in the entrainment zone. The strong downdraughts (~10 cm/s), represented by the mass-flux term, are of primary importance because they are responsible of the deep ocean ventilation (overshoot) and subduction of mode waters.

The new parameterization was validated by comparison to observations collected in the Northwestern Mediterranean (HyMeX/ASICS-Med, February 2013), in the Irminger Sea (2012-2015. Piron et al., 2015; Piron et al., 2016), in the North Pacific (Papa station, 2011) and in the North Atlantic (FASTEX, 1997). In this presentation, the focus will be given to the Mediterranean.

Assessment of the impact of climate change on the water resources of the Tensift watershed

Hanich, L.¹, Marchane, A.¹, Trambly, Y.², Simonneaux, V.³

¹Laboratoire de Géoressources - Unité associée au CNRST (URAC42), Département des Sciences de la Terre, Faculté des Sciences et Techniques, Université Cadi Ayyad, Av. A. Khattabi, BP 549, 40000 Marrakech, Morocco. ²IRD, Hydrosciences, Montpellier, France. ³IRD, CESBIO, Toulouse, France.

The Tensift basin is formed by two parts; mountainous chain of the High Atlas to the south and the Haouz plain to the north. The High Atlas constitutes a “water tower” providing most of the water supply for the Haouz arid plain. In winter, precipitation falls at high altitude and snowfall represents, 80% of total precipitation measured on the northern slopes of the High Atlas range. At the level of the Haouz plain the annual rainfall is about 250 mm. Future climate projections indicate a temperature increase of 2–3°C for the Mediterranean basin by 2050, associated with a decrease in precipitation of about 20–30%.

This study aims to quantify the possible impacts of climate change on runoff for three sub-basin of the High Atlas (N'fis, Rheraya and Ourika), using a set of regional climate models from the Med-CORDEX program. The GR2M conceptual water balance models, which include a snow module, was used to reproduce the scenarios on the likely evolution of future water resources in these three watersheds. GR2M was forced by the outputs of four Med-CORDEX Regional Climate Models (RCMs) under both scenarios RCP4.5 and RCP8.5. The results show that flows should continue to decrease by the end of the 21st century in the three sub-basin of the High Atlas.

The assessment of precipitation simulated by the RCMs shows a strong underestimation, but a good reproduction of the cycle for the temperatures. For the N'fis watershed, the projections for the 4 RCMs under both scenarios RCP4.5 and RCP8.5 show a rise in temperatures (+ 1.8°, + 2.2°) in conjunction with a decrease in total precipitation (-16%, 26%). Forecasts of flows (2040-2056) show a large expected decrease in surface runoff (-48%, -63%), due to

decreased precipitation and increased temperature. As for the Ourika watershed, the two scenarios RCP4.5 and RCP8.5 show an increase in temperatures (+ 1.7°, + 2.3°) and a decrease in precipitation (-15%, 26%). The forecasts on flows of the Ourika also show a sharp decrease (-53%, -69%). Concerning the Rheraya watershed, the increase in temperatures is of the order of + 1.55 ° C according to the scenario RCP4.5 and of 2.17 ° C according to the scenario RCP8.5. The decrease in precipitation is around (-16%, 28%). The projections of the flows of the Rheraya also show a decrease of (-38%, -59%) respectively for RCP4.5 and RCP8.5.

Model simulation of the Mediterranean Sea level variability and trends: the dynamic and steric effects

Harzallah, A.

INSTM, 28 rue du 2 mars 1934, 2025 Salammbô, Tunisia.

The Mediterranean Sea level variability and trends are investigated using the INSTMED06 ocean model. The model uses the downscaled ERA40 atmospheric fields as forcing at the sea surface and ORAS4 hydrographic conditions in the Atlantic area. Tide gauges are also used for both model boundary conditions and model validation. A set of seven simulations are performed considering different configurations (varying or constant atmospheric pressure, climatic or interannually-varying hydrographic conditions in the Atlantic area, use or not of the Boussinesq approximation). The period considered is from 1958 to 2007. It is shown that sea level variations in the Mediterranean basin are dominated by the interannual to decadal variability and are related to the dynamic and steric effects of the Atlantic area. On the other hand the response to the dynamic and steric effects generated inside the basin is a continuous sea level decrease, balanced by an inflow from the Atlantic for the latter effect. The results permitted a model-based view of the dynamic and steric effects on the sea level variability and trends. However as the results of the present work are based on one single model additional validation studies are needed using other Mediterranean Sea models.

Synoptic classification approach in 21st Century CMIP5 Predictions over the E. Mediterranean with focus on cyclones

Hochman, A.^{1,2,3}, Harpaz, T.^{1,2}, Saaroni, H.^{1,2}, Alpert, P.¹

¹Department of Geophysics, School of Geosciences, Tel-Aviv University, Tel-Aviv, Israel, 69978. ²Department of Geography and the Human Environment, School of Geosciences, Tel-Aviv University, Tel-Aviv, Israel, 69978. ³Porter School of Environmental Studies, School of Geosciences, Tel-Aviv University, Tel-Aviv, Israel, 69978.

The Mediterranean has been recognized as a 'hot spot', currently influenced by climate change, and predicted to be strongly affected in the future by warming and drying. This trend is expected to be expressed in changes in the occurrence and intensity of

Mediterranean cyclones, in general, and of East Mediterranean (EM), i.e., Cyprus Lows (CL), in particular, as well as in the occurrence of all other synoptic systems typifying the region.

Here, we have modified the semi-objective synoptic classification (Alpert et al., 2004) to investigate future changes in the occurrence of EM synoptic types, with an emphasis on CLs. The modified classification was applied to eight CMIP5 models for the present (1986-2005), mid- 21st century (2046-2065) and end- 21st century (2081-2100) periods, for both RCP4.5 and RCP8.5 scenarios.

The modified classification captured the synoptic type frequencies for the present period relatively well, and excelled in capturing that of the CLs. For the future period, a ~34% reduction in CL occurrence is found towards the end of the 21st century. Analysing this reduction for each of the specific types of CLs showed that lows located to the west of Cyprus are the main contributors to this decrease. The reductions of CLs is accompanied by an increase in the frequencies of Red Sea Troughs in winter. The prediction of changes in occurrence of the various synoptic types in general and of CLs, in particular, can lead to a more accurate forecast of local potential climatic hazards.

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VIGICRUES-Flash: a French national flash flood warning system for ungauged catchments based on the AIGA method

Javelle, P.¹, Demargne, J.², Organde, D.², Saint-Martin, C.¹, de Saint-Aubin, C.³, Garandeau, L.³, Janet, B.³

¹IRSTEA, UR RECOVER, Hydrology, Aix-en-Provence, France. ²HYDRIS Hydrologie, Saint Mathieu de Trévières, France (julie@demargne.com). ³SCHAPI, French national service for hydrometeorology and support to flood forecasting, Toulouse, France.

To better anticipate flash floods (FF) events and mitigate their impacts, the French Ministry in charge of Ecology (SCHAPI) has launched in 2017 a national FF warning system. Based on a discharge-threshold flood warning method called AIGA and initially co-developped by Irstea and Météo-France (Javelle et al. 2014), the current version of the system uses a simplified hourly distributed hydrologic model, running with operational radar-gauge QPE grids from Météo-France at a 1-km². This system is dedicated to ungauged catchments and is therefore complementary to the SCHAPI's national "vigilance" system which concerns only gauged catchments. It consists in comparing real time generated discharges to reference flood quantiles obtained using the same model and a continuous radar rainfall re-analysis.

The present presentation focuses on first operational results obtained with the operational chain. It aims at evaluating the usefulness of the warnings on recent events. It also presents some on-going research aiming at improving the operational method. Among them, we can mention the use of ensemble precipitation forecasts (for instance based on AROME-NWC, Auger et al. 2015) in order to improve the warning lead time, or a current PhD research

aiming at integrating information on the vulnerability of the flooded areas, in order to estimate risk rather than simply hazard levels.

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Assessment of precipitation products over the Mediterranean Sea

Jordà, G.¹, Martínez-Asensio, A.²

¹IMEDEA (UIB-CSIC), c/Miquel Marqués 21, Esporles, Spain. ²LIENSs (CNRS-University of La Rochelle) Bâtiment ILE, 2, rue Olympe de Gouges. 17000 La Rochelle, France.

To characterize the precipitation over the Mediterranean Sea is not an easy task. Although several reanalyses, models and satellite products are available all of them suffer from large uncertainties. The lack of a dense network of in situ measurements prevents the calibration of all those products. Here we will present a comprehensive intercomparison of precipitation gridded products for the Mediterranean Sea and an assessment of their skills when compared to observations (coastal gauges, radars and buoys).

Our results show that there are large discrepancies among satellite products, reanalysis and models. Differences among products are not only due to the magnitude of the variations but there are also different spatial patterns of variability. Regarding to the observational products, ocean buoys suffer from different problems that hamper their usefulness. Radar observations also suffer from technical issues but is the most reliable reference available so far (although limited in space). The comparisons with different radars in the NW Mediterranean suggest that ERA-interim, TRMM and CMORPH are the best products, although the first underestimates and the others overestimate the rain rates. The buoy data, even with their limitations also confirm this. Concerning the numerical models, the process of regional downscaling introduces significant differences with respect to the "parent" reanalysis. The ocean-coupling seems to have little effect on the quality of the precipitation fields, while an increase in model resolution in general leads to higher precipitation rates. However, the most determining factor in the modelled precipitation seems to be the model physics.

Reconstruction of transports through the Strait of Gibraltar from limited observations

Jordà, G., Sánchez-Román, A., Gomis, D.

IMEDEA (UIB-CSIC), c./Miquel Marqués 21, Esporles, Spain.

Observing the water transports through the Strait of Gibraltar is a difficult task. Here we present a methodology aimed to obtain the inflow, outflow and net transport of water from the limited set of available observations, currently consisting of an upward looking ADCP deployed at Espartel sill, two tide gauges located at each side of the Strait and radars monitoring the surface velocities. More precisely, we reconstruct the velocity field over a vertical section across the Strait using a Reduced Order Optimal Interpolation technique fed with the spatial covariance patterns deduced from high resolution numerical simulations. As a first step we carry out some sensitivity experiments with synthetic data that demonstrate the high potential of the approach. The reconstruction methodology can reproduce very satisfactorily the variability of the transports with estimated correlations for the inflow, outflow and net over 0.9 ($p < 0.05$) in all the cases and estimated RMS errors of 0.03, 0.08 and 0.05 Sv, respectively. However, we have also found that the reconstruction is sensible to bias problems, mostly due to the sensitivity of the method to the differences between the statistics of the actual and modeled velocity profiles. The sensitivity experiments have been used to tune the parameters of the method and a reconstruction of actual monthly transports has been performed for the period 2004-2016 along with an estimate of the associated uncertainty. This reconstruction provides for the first time a multiannual time series of the inflow and the net transports solely based on in-situ observations. Therefore it can be used as an independent estimate for the validation of numerical models and surface freshwater fluxes in the Mediterranean.

The interaction between aerosol particles, cloud and precipitation during the HyMeX IOP7a event

Kagkara, C.¹, Planche, C.¹, Wobrock, W.¹, Flossmann, A.¹, Banson, S.¹, Van Baelen, J.¹, Boudevillain, B.²

¹Université Clermont Auvergne, Laboratoire de Météorologie Physique (LaMP), CNRS-INSU, UMR6016, Clermont-Ferrand, France. ²Université Grenoble-Alpes, Laboratoire d'étude des Transferts en Hydrologie et Environnement (LTHE), CNRS, UMR5564, Grenoble, France.

The ANR-MUSIC project (MULTiscale process Studies of Intense Convective precipitation events in Mediterranean) aims to identify critical parameters to improve the forecast of intense convective precipitation events in the Mediterranean. In the current study the aerosols-cloud-precipitation interactions are being investigated. For this purpose, the HyMeX (HYdrological cycle in Mediterranean EXperiment) IOP7a, heavy precipitation event (26th September 2012), that occurred during the Special Observation Period 1 (SOP1) in the Cévennes-Vivarais region in the South of France has been selected to assess in particular the role of the aerosol particles on cloud and precipitation development and quantity. Observations from the 95GHz cloud radar RASTA, as well as in-situ measurements obtained by the combination of two particle imagers (2-D stereo and precipitation) probes on-board of the French Falcon 20

aircraft are exploited in order to evaluate quantitatively the respective simulation results from the 3-D mesoscale model DESCAM (Flossmann and Wobrock, 2010). This research model uses bin resolved microphysics and a detailed representation of the aerosol particles as well as multiple staggered grids. Ground observations from X band radar and rain gauges were also incorporated into the comparison. Different scenarios concerning the initial number concentration of aerosol particles are being compared and discussed, in relation to the formation, structure and evolution of the convective system. According to the results, the rain accumulation at the ground is significantly depended on the total number of aerosol particles at the beginning of each simulation. The spatial and temporal distributions of the rainfall, as well as its amount vary between the different study cases.

IOP7a event

Kagkara, C.¹, Planche, C.¹, Wobrock, W.¹, Flossmann, A.¹, Banson, S.¹, Van Baelen, J.¹, Boudevillain, B.²

Université Clermont Auvergne, Laboratoire de Météorologie Physique (LaMP), CNRS-INSU, UMR6016, Clermont-Ferrand, France. ²Université Grenoble-Alpes, Laboratoire d'étude des Transferts en Hydrologie et Environnement (LTHE), CNRS, UMR5564, Grenoble, France.

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Model predictability of a heavy precipitation event over Cyprus

Kushta, J.¹, Lelieveld, J.^{1,2}

¹The Cyprus Institute, Energy, Environment and Water Research Centre, Nicosia, Cyprus.

²Max Planck Institute for Chemistry, P.O. Box 3060, 55020 Mainz, Germany.

A severe precipitation event in Cyprus on 4 March 2014 is analysed in this study. The event impacted mostly the west coast, causing extensive flooding and damages to building and vehicles. Satellite estimates from the TRMM_3B42 v7 product give 3-hour accumulated precipitation rate that exceed 30mm during the peak activity of the rainfall. The mesoscale atmospheric Weather Regional Forecasting coupled with Chemistry (WRF-Chem) was used to study the predictability potential of the spatiotemporal characteristics of the event. Three nested domains with a grid spacing of 40-8-2 km were utilized, covering the Eastern Mediterranean and Cyprus. The initial and boundary condition for the meteorological parameters are provided by GFS datasets of 1x1 and 0.5x0.5 degrees while the chemical pollutants are initialized with MOZART-4 datasets. The simulation period varied with the initial day being March 1, 2 and 3 in different sensitivity tests. Two cloud microphysical schemes were tested. The aerosol calculations from the chemical component of WRF-Chem have been utilized to predict cloud condensation nuclei (CCN). The different configurations resulted in widely different rain intensity and temporal evolution with daily accumulated precipitation ranging from 24mm to 42mm. The later the initialization of the model, the less realistic the evolution of the aerosols, especially regarding dust particles that were abundant on the day previous to the event, which affected regional scale rainfall. The intensity of the rainfall was not captured unless the spatial resolution of the model was increased to 2km. The results appear to be sensitive to the choice of cloud microphysical scheme, the use of prognostic aerosols as CCN and the initialization period prior to the event.

Validation of an integrated flash flood impacts forecasting chain based on insurance claims

Le Bihan, G.¹, Payrastre, O.¹, Gaume, E.¹, Moncoulon, D.²

¹LUNAM Université, Ifsttar/GERS/LEE, CS4, 44844 Bouguenais cedex, France. ²CCR, 157 boulevard Haussmann, 75008 Paris, France.

Le Bihan et al. (2016) recently developed an integrated flash floods impacts forecasting chain, combining a rainfall-runoff model and a simplified impacts model. The method provides a direct assessment of the number of buildings located in the estimated flood areas. The presentation will illustrate how an insurance claim database can be used for the validation of such a forecasting chain. If successful, the approach could be particularly interesting to evaluate flash floods forecasts in ungauged areas.

The CCR insurance claim database has been used in this study. CCR is the main reinsurance company in France. Its database is certainly the most comprehensive and detailed (georeferenced) source of information about damages related to natural hazards in France.

The challenge of validating the model results based on insurance claims will be presented, based on two case studies: the Gard (2002) and Var (2010) major flash flood events. The presentation will be focused on the main difficulties encountered, related to the specific

features of the insurance data, to the fact that there is not a simple one to one match between buildings and insurance policies, and finally to the surprising features of the claims vs policies relation. Despite these significant difficulties, the validation process could be conducted, with encouraging results.

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Le Bihan G., Payrastra O., Gaume E., Moncoulon D. and Pons F., 2016. Regional models for distributed flash-flood nowcasting: towards an estimation of potential impacts and damages. Floodrisk conference, Lyon, 17th – 21st October 2016.

Le Bihan Guillaume (2016). Modèles hydrologiques régionaux pour la prévision distribuée des crues rapides: vers une estimation des impacts et des dommages potentiels, PhD thesis of Université Bretagne Loire / Ecole Centrale de Nantes, 248 p.

Insights into the moisture environment of mesoscale convective systems observed in Southern Italy during HyMeX IOP 13 based on the isotopic composition of water vapor

Lee, K.-O.¹, Pfahl, S.², Flamant, C.¹, Lacour, J.-L.^{1,3}, Aemisegger, F.², Ducrocq, V.⁴

¹LATMOS/IPSL, UPMC Univ. Paris 06, Sorbonne Universités, UVSQ, CNRS, Paris, France.

²Institute for Atmospheric and Climate Science, ETH Zurich, 8092 Zurich, Switzerland.

³Institute of Earth Sciences, University of Iceland, Reykjavik, Iceland. ⁴CNRM, UMR 3589, Météo-France & CNRS, Toulouse, France.

During Intensive Observation Period 13 (15–16 October 2012) of the first Special Observing Period of the Hydrological cycle in the Mediterranean Experiment (HyMeX), Southern Italy (SI) was affected by two consecutive heavy precipitation events (HPEs). Both HPEs were associated with mesoscale convective systems (MCSs); the first one was triggered in the south Tyrrhenian Sea by a local-scale convergence between the south-westerlies ahead of the mistral and the very warm and moist marine low-level southerlies from Strait of Sicily; the second one developed over the strait of Sicily due to the combination of large moisture contents and a marked convergence ahead of the cold front. In addition, the enriched mid-level moisture plume from tropical Africa ahead of a south-north elongated upper-level trough favoured the efficiency of the convection to produce more precipitation on 15 October (for details, see Lee et al. 2016). In the present study, we investigate the origin of the moisture present in the environment of the MCSs over SI using the stable isotopic composition of water vapour (i.e. the main isotopes H₂¹⁶O and HDO) obtained from a combination of space-borne measurements (e.g. the Infrared Atmospheric Sounding Interferometer IASI and the Moderate Resolution Imaging Spectroradiometer, MODIS) as well as numerical simulations with the limited-area model COSMOiso. The COSMOiso simulation has been conducted with fine temporal (1-hr) and spatial (7-km) resolutions. The IASI-retrieved δD (relative HDO abundance, maximum sensitivity in the free troposphere) field shows a relatively enriched air mass ($-180\text{‰} \leq \delta D \leq -120\text{‰}$) over the southern Tyrrhenian Sea where local-scale convergence occurred ahead of the mistral from the evening of 14 until the next day, while a very-enriched air mass (δD values $\geq -100\text{‰}$) was captured over the strait of Sicily and northern Algeria continuously for 3 days from the morning of 14 October. MODIS moisture

retrievals suggest that this air mass originated from tropical West Africa. The COSMOiso simulation and the observations are used to identify the processes (e.g. transport from the tropics) leading to the moisture variability in the vicinity of the MCSs and their impact on the life cycle of deep convection over SI.

Potential contribution of global spatial data to operational drought management decisions in the Ebro basin

Linés, C.¹, Iglesias, A.², Garrote, L.³, Sotés, V.², Werner, M.¹

¹UNESCO-IHE, Department of Water Science and Engineering, Delft, the Netherlands. ²Technical University of Madrid (UPM), Department of Agricultural Economics and Social Sciences, Madrid, Spain. ³Technical University of Madrid (UPM), Department of Hydraulic and Energy Engineering, Madrid, Spain.

Decision processes were analysed at three spatial scales in the Ebro basin with the aim to assess whether improved global data can contribute to inform drought management decisions at basin and subbasin scale. Representative decision-makers at basin (Confederación Hidrográfica del Ebro, CHE), irrigation district (Comunidad de Regantes del Canal de Aragón y Cataluña, CAC) and farm scale (a large wine producer) participated in the analysis providing detailed descriptions of their decision processes in relation to drought. At basin level, CHE is responsible for monitoring drought conditions and classifying the situation into severity categories with associated mitigation measures. At irrigation district level, Irrigator Associations such as CAC are in charge of distributing water from the reservoir to the users. In drought situations they introduce restrictions to the irrigation water quotas according to water availability in the reservoir. At farm level, information on crop condition is used to take decisions and make the most of scarce water.

A preliminary analysis of the information gaps was performed. The data that was found to be of potential value at irrigation and basin levels are quantification of snow in the headwaters and melt rate, crop identification and water demands. At farm level information is mainly used to detect spatial differences in crop performance in order to take measures such that production is as uniform as possible. This requires data at high spatial resolution.

Subsequent work is being carried out to quantify the value of information to support drought management decisions at basin and irrigation district scale.

Coping with floods in the Northern part of the Mediterranean: the application of an international database on flood events for a 35 years period

**Llasat, M.C.¹, Llasat-Botija, M.¹, Cortès, M.¹, Kotroni, V.²,
Lagouvardos, K.², Papagiannaki, K.², Petrucci, O.³, Pasqua, A.A.³,
Rosselló, J.⁴, Vinet, F.⁵, Boissier, L.⁵**

¹Department of Applied Physics, University of Barcelona, Barcelona, Spain. ²Institute of Environmental Research and Sustainable Development, National Observatory of Athens, Greece. ³CNR IRPI, Cosenza, Italy. ⁴Grup de Climatologia, Hidrologia, Riscs i Territori, Universitat Illes Balears, Palma de Mallorca, Spain. ⁵Department of Geography, UMR GRED "Gouvernance, risques, environnement, développement", University of Montpellier, Montpellier, France.

The contribution departs from the updating of the FLOODHYMEX database (Llasat et al, 2013) that at present includes all the catastrophic flood events produced on the period 1981-2015 in Catalonia, Valencia and Balearic Islands (Spain), PACA, Languedoc-Roussillon and Midi Pyrenees (France), Calabria (Italy) and Greece. After the proposal of a common definition of catastrophic event (including the event duration, starting and ending) and the analysis of the main climatic features and statistics, this updated data base has been compared with Emergency Events Database (EM-DAT), the Natural Hazards Assessment Network (NATHAN) of the reinsurance firm Munich Re and Civil Protection flood databases. Trends have been compared with those obtained for other periods in order to understand the potential influence of non-climatic factors. The precipitation thresholds associated to floods (mainly flash floods) have been analysed from daily precipitation data that has been provided by AEMET (Agencia Estatal de Meteorología, Spain), NOA (National Observatory of Athens, Greece) and Météo France, and has been complemented by EOBS (25x25 km²). The study has been complemented with the data base on casualties, for the same period, which records detailed information about the time of occurrence and place where fatalities occurred, circumstances in which fatalities occurred, age, gender and specific vulnerability circumstances.

In order to analyse specific events with a detailed information (including economic one), a minimum of two cases of study have been selected for each country. Selected cases have been identified as "remarkable cases" using the definition proposed by Boudou (2015). As an example, the flood event of June 2013 that affected Catalonia and Midi-Pyrenees, and the flood event that affected Greece on October 2015. These cases have been useful to illustrate the early warning systems, recovery measures and post-event analysis in each region.

This contribution follows the European Directive on Floods (DIRECTIVE 2007/60/CE, European Parliament, 2007) which looks at flood risk management plans focusing on prevention, protection and preparation. The contribution has been developed by the FloodHymeX Task Force of HYMEX and has been supported by the Spanish project HOPE (CGL2014-52571-R).

New insights in the structure of anticyclonic eddies in the vicinity of the Balearic front: output of winter in situ experiments Protevs 2016 and 2017

Louazel, S.¹, Dumas, F.¹, Garreau, P.², Garnier, V.², Le Vu, B.³, Stegner, A.³

¹Shom. ²Laboratoire d'océanographie physique et spatiale. ³Laboratoire de Météorologie Dynamique, France.

The North Balearic Front (NBF) divides the Western Mediterranean Sea, separating the sub-surface water in two parts. The Algerian Basin, mainly constituted by Modified Atlantic Water (MAW) is fresher and warmer than the Northern Gyre, constituted by denser waters formed during winter. Satellite scenes analyzes pointed out the presence of numerous mesoscale structures in this area. The frontal dynamics generates itself instabilities. Algerian eddies detached from the unstable Algerian Current may reach the frontal zone and then interact with the latter. Modal structures of Western Intermediate Water are present as “wedgies” in the northern side. The resulting high eddy kinetic energy present in this area masks the hypothetical eastwards return of the Northern Gyre deduced from altimetry and sometime from drifters.

The NBF has been seldom studied by high resolution in situ experiments and marginally concerned by Hymex SOP1 and SOP2. ProtevsMed 2016 (late march) and ProtevsMed2017 (February) field campaigns focused this area and targeted the surface (first 400m below the surface) mesoscale structures. Intense and rapid capability sampling such as undulated towed vehicles (Seasoar and MVP) and drifting buoys dropped at their cores associated with classical CTD casts were performed.

An overview of the frontal situation and of the background dynamics in the convection area will be first proposed before to focus on a large surface anticyclonic eddy investigated in the Southern side during ProtevsMed2016 and on Submesoscale Coherent Vortices (SCVs) intensively sampled during ProtevsMed2017 in the Northern side.

The large anticyclonic structure (radius=70km) observed in 2016 is suspected to be originated from the Algerian current. Despite such Algerian eddies has already been described, new important and original insights were pointed out. It appears first that the eddy is formed by two water masses from very different origin (MAW and WIW) spinning together in an anticyclonic way through a gear which was caught during the experiment. Second, the eddy interacts with a subsurface anticyclonic eddy of modal water across the front. Third, the high resolution sampling reveals for the first time in Algerian eddies sub-mesoscales processes. The evolution of the eddy along his life is also discussed. During 2017 experiment, two anticyclonic structures of smaller size (radius=15km) were observed at very high resolution (700m horizontally) revealing complex, despite coherent, structures. A Winter Deep Water SCV extending between -250 and 700 m deep- and WIW SCVs -present in the surface layer- will be presented.

Part of the experiments where guided by an eddy detection tools (position, strength, properties...) based on altimetric products. Their altimetric signatures compared to the in situ experiment raised some questions in the context of drawing up climatological atlas intended for example to validate the eddy kinetic energy of numerical model.

The role of deep convection in the regulation of the Northwestern mediterranean basin

**Margirier, F.¹, Testor, P.¹, Heslop, E.³, Bosse, A.^{1,2}, Mortier, L.⁶,
Arsouze, T.⁴, Houpert, L.⁵, L'Heveder, B.¹, Mallil, K.^{1,7}**

¹LOCEAN-IPSL, Paris, France. ²University of Bergen, Geophysical Institute, Allegaten 70, 5007 Bergen, Norway. ³ICTS-SOCIB. 07121 Palma de Mallorca, Spain. ⁴ENSTA ParisTech, Université Paris-Saclay, Palaiseau France; Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France. ⁵SAMS, Dynamic Oceans, Oban, United Kingdom. ⁶ENSTA ParisTech, Université Paris-Saclay, Palaiseau France. ⁷ENSSMAL, Alger, Algeria.

The observational effort in the northwestern Mediterranean in recent years (gliders, ship cruises, profiling floats, moorings, XBTs) allows a new and quasi continuous monitoring of the water masses. Computing time series characterizing the different water masses in different regional boxes, we follow the water properties along the cyclonic boundary circulation. Evaluating the samplings' ability to account for the evolution of the water masses with the Nemo-Med12 model at the scale of the sub-basin allows a quantification of the impact of deep convection in regulating the heating and salinity increase, notably in LIW waters.

Surface hydrological budget from the ISAC micrometeorological station in Salento peninsula

Martano, P.¹, Delle Rose, M.¹, Elefante, C.², Grasso, F.¹

¹CNR-Istituto di Scienze dell'Atmosfera e del Clima - UOS Lecce, Via Monteroni, 73100 Lecce, Italy. ²Ripartizione Informatica, Università del Salento, Viale Gallipoli 49, 73100 Lecce, Italy.

Data from 14 years (2003-2016) of activity of the ISAC-Lecce eddy covariance micrometeorological station (www.basesperimentale.le.isac.cnr.it) have been analyzed with focus on the atmosphere-surface water budget in the Salento Peninsula, the far South-East region in the Italian peninsula (Apulia region). Seasonal and annual totals for precipitation and evapotranspiration have been calculated together with some suitable indices such as the aridity index, the precipitation intensity and the ground water infiltration fraction (difference between precipitation and real evapotranspiration, divided by precipitation). An analysis of the footprint associated to the measured scalar fluxes has been performed to assess their areal representativeness. An evaluation of the uncertainty of the results, related to the measurement errors, the data gaps in the time series and the surface energy budget closure has been attempted. A decadal analysis of the surface water budget is important for the evaluation of the surface water infiltration potentially affecting the recharge of the karstic aquifer that provides fresh water to the whole region.

Assessments of the risk of longest dry spells phenomenon in Ghézala dam reservoir (Tunisia)

Mathlouthi, M.¹, Lebdi, F.²

¹Research Laboratory in Sciences and Technology of Water in INAT, 43 avenue Charles Nicolle, 1082 Tunis, Tunisia, Majid_Mathlouthi@yahoo.fr. ²National Agronomic Institute of Tunisia (INAT), 43 av. Charles Nicolle, 1082 Tunis - University of Carthage – Tunisia, lebdi.fethi@iresa.agrinet.tn.

An analysis by event of dry event, according to a predetermined threshold, from series of observations of the daily rainfall was carried out. The approach has been illustrated on a case study of the Ghézala dam (Northern Tunisia) with Mediterranean climate where the average rainfall is 680 mm. The dry events are constituted of a series of dry days framed by the rainfall event. Rainfall events are defined themselves in the form a uninterrupted series of rainfall days understanding at least a day having received a precipitation superior or equal to a threshold of 3.6 mm. The rainfall events are defined by depth and duration, which are found to be correlated. An analysis of the depth per event conditioned on the event duration has been undertaken. The negative binomial distribution appears the best overall fit for the depth per event. The duration of the rainfall event follows a geometric distribution while that the dry event follows the negative binomial distribution. The length of the climatically cycle adjusts to the Incomplete Gamma. A procedure of stage simulation by stage by the method Monte Carlo has been executed to generate a synthetic sequence of rainfall events and dry with correspondent lengths of rainy season. While the expected number of events/season is still derived from few data, this estimate is more reliable than the approximative expected length of the longest seasonal dry spell, since the variability of the former is usually less than that of the latter, for the same data sets.

The methodological improvement used here is of potential importance for agrarian planning, since it yields more precise estimation of extreme droughts risks. The method should also be of benefit in crop management, as it facilitates the drawing of risk and the drafting of preventive and palliative plans for the mitigation of the effects of drought.

Key words: climate change, rainfall events, extreme dry event, risk analysis, threshold amount of rainfall.

Accounting for the uncertainties in radar-raingauge rainfall estimation and the parametric uncertainties of the hydrological model in the prediction of flash floods in the Cévennes-Vivarais region, France

Navas, R., Delrieu, G.

Institut des Géosciences de l'Environnement

The Cévennes-Vivarais is a Mediterranean medium-elevation mountainous region of about 32000 km² located in the south-east of France, prone to heavy precipitation events and subsequent flash floods and floods occurring mainly during the autumn season. Due to this

vulnerability, it is a well instrumented region in terms of rainfall (4 weather radars of the French ARAMIS radar network, 250 hourly raingauges) and river discharge (45 stations) observations. A high-resolution (1 km², 1 hour) radar-raingauge rainfall re-analysis has been established for the period 2007-2014 by using the kriging with external drift (KED) technique (Delrieu et al. 2014; Boudevillain et al. 2016). In the present communication, we present first a geostatistical method aimed at generating radar-raingauge rainfall ensembles based on the KED error standard deviations and the space-time structure of the residuals to the drift. The method is implemented over the four main watersheds of the Cévennes-Vivarais region by considering a spatial segmentation in hydrological meshes of variable sizes from 10 to 300 km². A distributed hydrological model based on the SCS curve number and unit hydrograph concepts is then implemented in continuous mode for these watersheds. A sensitivity analysis allows us to identify the most sensitive parameters and to generate ensembles of “acceptable” hydrological simulations by using 16 discharge time series. Several results of this simulation framework will be highlighted: (1) the overall quality of the hydrological simulations as a function of the gauged watershed characteristics, (2) the transferability of the acceptable parameter sets from one year to another, (3) the effect of the space and time resolution of rainfall estimations on the hydrological simulations for gauged watersheds, (4) the respective impact of rainfall and model parametric uncertainties over a range of spatial and temporal scales for ungauged watersheds.

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SMOS SSS maps in the Northern Western Mediterranean: a comparison with in situ measurements

Olmedo, E., Salat, J., Turiel, A., González-Gambau, V., Martínez, J., Isern-Fontanet, J.

Institut de Ciències del Mar (CSIC), Barcelona, Spain.

Soil Moisture and Ocean Salinity (SMOS) mission is an innovative European Space Agency Earth Observation satellite launched on November 2009 to remotely measure for the first time sea surface salinity (SSS) over the oceans and soil moisture (SM) over land, by a single space-borne instrument. The SMOS single payload is a Microwave Imaging Radiometer using Aperture Synthesis (MIRAS), a L-band 2D synthetic aperture radiometer with multi-angular and full polarization capabilities. This novel type of instrument involved a technological challenge for which development of dedicated calibration and image reconstruction algorithms have been required.

Although the accuracy of SMOS L2 Ocean Salinity (OS) products fits with the mission requirements, there are still many error patterns, either not well understood nor accounted for, such as the Land-Sea Contamination (LSC), seasonal biases, differences between ascending and descending orbits, the impact by systematic sources of Radio Frequency Interference

(RFI), etc. After more than six years of SMOS data acquisition, the systematic part of these errors is being characterized so as to mitigate their impact.

Recently, a novel technique (Debiased Non-Bayesian (DNB)) developed at the Barcelona Expert Center has been introduced for the retrieval of SSS from SMOS data, to strongly reduce systematic biases near the coastlines and increase the number of retrievals in regions where no or little valid measurements were provided up to now. As recent example of DNB was its successful use in the Algerian basin, to track the evolution of the eddies of recent Atlantic Waters (AW) into the Mediterranean through its signature in salinity.

Now, a new challenge for DNB was to monitor the evolution of the preconditioning phase of the typical Deep Water Formation (DWF) process in the NW Mediterranean. It is well known that this phase consists in an increase of surface salinity in the central part of the basin. However, contrasts in open sea surface salinity are not expected as large as in the Algerian basin, that are only comparable to those found in a narrow variable coastal band under the influence of runoff waters.

In this work, we describe the evolution of the preconditioning phase triggered by an episode of Polar and Siberian cold air irruption in January 2017. The DNB exercise continued until March but unfortunately no more irruptions of cold air have been detected this year so that, the DWF process is expected to be likely absent this year. Besides the exceptional situation, different source of in-situ data: ARGO floats, a fixed buoy of Puertos del Estado and thermosalinograph data of an oceanographic cruise (Winfish), have been used to provide a quality assessment of the DNB.

Role and capabilities of the GPM mission in the characterization and monitoring of extreme precipitation events in the Mediterranean region

Panegrossi, G.¹, Dietrich, S.¹, Marra, A.C.¹, Sanò, P.¹, Casella, D.², Baldini, L.¹, Mugnai, A.¹, Vulpiani, G.³, Petracca, M.^{3,4}, Porcù, F.⁵

¹Institute of Atmospheric Sciences and Climate (ISAC)—National Research Council (CNR), Rome, Italy. ²SERCO S.p.A. ³Department of Civil Protection (DPC), Presidency of the Council of Ministers, Italy. ⁴Department of Physics and Earth Science, Univ. of Ferrara, Italy. ⁵Department of Physics and Astronomy, Univ. of Bologna, Italy.

The Mediterranean area is a particular meteorological environment and a weather forecasting challenge, where severe weather events of different nature often originate over the relatively warm sea and develop to hit coastal regions, causing major damages and casualties. Over the last decade several studies and coordinated international efforts, including the HYdrological cycle in the Mediterranean EXperiment (HyMeX), have focused on the exploitation of in-situ and remote observations, combined with the use of advanced numerical weather prediction models, towards a better understanding and prediction of extreme events in the Mediterranean region.

The complex orography of the Mediterranean coastal regions, and the need to monitor severe events during their offshore development, make the use of conventional ground-based instruments (e.g., raingauges and weather radar networks) inadequate to provide the observational details on the whole region necessary to improve the monitoring and forecasting of severe weather in terms of time, location, and strength. On the other hand, the increasing global Earth Observation (EO) capacity provides today an unprecedented potential to monitor precipitation systems, estimate precipitation amounts, and analyze key processes governing

the water cycle from local to global scales. In particular, the NASA/JAXA Global Precipitation Measurement (GPM) Core Observatory [3], equipped with the most advanced microwave radiometer (GPM Microwave Imager, GMI) and with the first spaceborne dual-frequency precipitation radar (DPR), allows for the analysis of the 3-D structure of precipitation, while the constellation of microwave radiometers of the GPM mission [1] orbiting around the Earth provides 1-3 hourly global coverage of precipitation. The goal of this presentation is to show the potentials of the GPM constellation of microwave radiometers to monitor precipitation associated to extreme events, also in particularly challenging regions, with complex orography and extremely variable surface conditions, such as the Mediterranean area. Extreme precipitation events that hit the coast of Italy in the last years will be presented and analyzed to show that, by combining the overpasses from different radiometers, it is possible to obtain precipitation estimates at different temporal scales in agreement with reference ground-based radar and raingauge measurements [2]. Moreover, the results of the observational analysis of the impressive hailstorm that hit the Gulf and the city of Naples in Italy on September 05, 2015 (dropping 7-10 cm diameter hailstones along its path over the sea) will be presented [2]. The comparative use of measurements from GMI and DPR with those available from other satellite-based and ground-based sensors provides observational evidence of extremely rare features of such severe hailstorm (rarely found in the Mediterranean region), and demonstrates the potentials of the GPM Core Observatory in providing unique spaceborne measurements of 3-D structure of the precipitation.

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Drivers of individual flood risk perception and preparedness: a behavioural survey targeting the citizens of Greece

Papagiannaki, K.¹, Kotroni, V.¹, Lagouvardos, K.¹, Papagiannakis, G.²

¹Institute for Environmental Research and Sustainable Development, National Observatory of Athens, Lofos Koufou, P. Penteli, Athens, GR-15236, Greece. ²Athens University of Economics and Business, Department of Management Science and Technology Patission 76, Athens 10434, Greece.

The aim of this study is to examine the pathways between social factors, flood risk perception and preparedness, through a behavioral survey targeting the Greek society. Critical variables that might influence people's risk perception and preparedness behavior have been identified and statistically analyzed, based on an internet-based questionnaire that attracted over 1850 valid responses. A path analysis was performed, to test the hypotheses about the relationships between flood risk awareness, prior experience, demographic factors, cognitive

and emotional components of risk perception, coping appraisal and preparedness. Two distinct variables for preparedness behavior were examined, to account for the present state of preparedness and people's future intention to invest in precautionary measures. Results have theoretical implications, indicating the significant effects of individual coping appraisal and feelings of worry on both dimensions of preparedness. Risk perception was found to have only a small direct effect on the intention of people to take precautionary actions. Instead, it was found to mediate the effect of risk awareness on preparedness. Prior experience and risk communication were found to have an indirect effect on preparedness by influencing emotions and coping appraisal. Practical implications are discussed in relation to the weaknesses and to the potential for improvement of flood risk communication by the Greek local authorities and actors in the field of Civil Defense.

Observing extreme long duration lightning flashes in South-East France

Pedeboy, S.¹, Defer, E.², Coquillat, S.², Lambert, D.², Pinty, J.-P.², Prieur, S.², Caumont, O.³, Labatut, L.³, Lojou, J.-Y.⁴

¹Météorage, Pau, France. ²LA, Toulouse, France. ³CNRM, Toulouse, France. ⁴IS2, Marseille, France.

A complete lightning flash is made of a set of several transient current discharges occurring between areas containing electrical charges of opposite sign, all of them usually taking place in less than one second. Depending on the spatial distribution of these charge centres in the atmosphere and on the ground the lightning flash may propagate vertically and horizontally, sometimes on long distances. As most of the electrical charges are located inside the thundercloud, the biggest part of a lightning flash remains inside the cloud making a detailed observation quite difficult without lightning locating systems operating in the VHF range.

Such a system was deployed during the Special Observation Period of Hymex between August and November 2012 in the South-East of France. Thus, the HyLMA consisted in a network of 12 VHF stations installed in the Cevennes-Vivarais region capable of mapping the propagation of the different leaders produced in a lightning flash with a very high spatial-temporal resolution. A total of 14 significant thunderstorms were observed leading to a huge amount of data made available for analysis.

From this dataset, some interesting and surprising events could be identified like these flashes lasting several seconds where typical durations do not exceed one second. Out of them, this flash lasting 7.74 seconds detected on 30 August 2012 that was recently validated by the WMO as the "Longest Duration" record lightning extreme for the globe recently.

This study aimed at identifying and determining long duration flashes characteristics from the HyLMA dataset collected during the SOP1 of HyMEX. Considering the huge amount of data, it was necessary to develop an algorithm to group VHF sources in consistent lightning flashes capable to process the HyLMA dataset. A flash scale analysis will be performed on individuals whose duration exceeds 4 seconds in the goal to describe the electrical processes taking place in such events. In addition, a thunderstorm scale analysis will be run on every thunderstorm generating long duration flashes to highlight the conditions of occurrence of such extreme lightning discharges.

In this paper, we will present the flash grouping algorithm and the method used to validate the duration of the flashes. Then, the selected long duration flashes and their corresponding thunderstorms systems will be described and their physical characteristics presented.

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A global integration technique to describe the Mediterranean water cycle using satellite data

Pellet, V.¹, Aires, F.², Munier, S.³

¹Estellus, Paris, France. ²LERMA, Obs. de Paris, France. ³Meteo-France, Toulouse, France.

An increasing number of satellite missions can be used to monitor the Mediterranean region. However, using Earth Observations (EO) to study the water cycle is still a challenge, at the regional as at the global scale.

Indeed, EO data suffer from numerous systematic and/or random errors and they are often not coherent with each other. Therefore, several integration techniques are currently being investigated to optimise the use of EO data to study the water cycle (Pan et al. 2012; Aires et al. 2014) at the basin (Sheffield et al. 2009; Munier et al. 2016) or the global (Rodel et al. 2015; Munier et al. 2017) scales. In this study, we present an improved integration technique based on spatio-temporal multi-scale constraints related to the budget closure. We consider not only the terrestrial, but also the oceanic and the atmospheric water cycles. Our approach allows to calibrate the EO datasets towards a consensus dataset that is more hydrologically coherent. Furthermore, an estimate of the uncertainties is provided. This EO-analysis of the water cycle should improve the calibration and the validation of the numerical models and facilitate the estimation of missing data.

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Small-scale processes in the Mediterranean Sea deep convection areas: a numerical study through nesting approach

Pennel, R.¹, Arsouze, T.^{1,2}, Akuetevi, C.^{1,2}, Waldman, R.³

¹LMD/IPSL, Ecole Polytechnique, Univ Paris Saclay, Palaiseau, France. ²ENSTA ParisTech, Univ Paris Saclay, Palaiseau, France. ³CNRM, Météo France, Toulouse, France.

Oceanic circulation of the Mediterranean Sea is mainly driven by two important processes : the surface circulation of Atlantic buoyant water along the southern coasts and the winter deep convection in several locations of the northern part of the basin : North-Western sub-basin, Adriatic Sea and Aegean Sea. The latter is a key process impacting the long term general thermohaline circulation of the Mediterranean Sea by redistributing the water masses throughout the whole water column and playing a major role in the ventilation of surface waters. Recent progress in observation networks have highlighted the formation of submesoscale coherent vortices at the end of the convection episode implying the need to provide new insights regarding the mechanisms at small-scales involved in the turbulent mixing of surface waters and the subsequent export of newly formed water mass outside of the convection area.

This study aims to explore the impact of such structure on the deep-convection and in fine on the general thermohaline circulation. We follow a two-ways nesting approach, ie inside a low resolution (eddy-permitting) simulation, key areas are modelled using a higher (eddy-resolving) resolution and both part of the domain are interacting with each other. We use a mediterranean regional configuration of NEMO general circulation model at 1/12° resolution (NEMO-MED12) associated with the Adaptive Mesh Refinement module AGRIF included in NEMO to implement two-ways nested domain at 1/36° resolution. Nested domain are defined in the largest convection area of the Mediterranean Sea i.e. Gulf of Lion, Adriatic Sea and Aegean Sea. Several simulations covering the 1979-2013 time frame are carried-out: a control case without nesting as well as a set of 3 simulations with a single nested domain in one of the convection area.

Impacts of small-scales are adressed in terms of mixing, deep water characteristics and spreading at mesoscale in other parts of the basin. A decrease in deep convection as well as formation of lighter dense water are observed in association with an enhanced local eddy kinetic energy in the convection area. Remote effects of such modified intermediate and deep waters are important and impact the general thermohaline circulation.

RegCM4.6 high resolution numerical experiments on Mediterranean area: the challenge to explore climate by the new non-hydrostatic version of the ICTP regional climate model

Pichelli, E., Coppola, E., Giorgi, F.

Abdus Salam International Centre for Theoretical Physics, Trieste, Italy.

The shared effort of the research community to increase knowledge about past and future climate over the Mediterranean area, and the need of more in depth investigation of local-scale mechanisms, is one of the motivations that led to the new non-hydrostatic core implementation in the ICTP regional model RegCM4. This allows to run the model at high resolution (2-3km) and, hence, in convection-permitting mode.

As a preliminary step, case studies verification has been performed to assess the model performances. Selected cases within the SOP1 of HyMeX have been simulated and compared to observations to investigate model capability to reproduce severe events scenarios, with a particular focus on convective systems evolution. Among the others, results for the IOP16 case will be presented, with the aim of highlighting potentialities and eventual limits of the new core, and the possibility to use it for climate studies. The model is overall able to reproduce main pattern of precipitation structures, besides some bias is found for timing and amount of some of the convective systems.

Simulating the electrification of thunderstorms in Corsica and comparison with SAETTA records of 3D flashes

Pinty, J.-P.¹, Defer, É.¹, Coquillat, S.¹, Prieur, S.¹, Lambert, D.¹, Pédeboy, S.²

¹Lab. Aérologie, 14 av. E. Belin, 31400 Toulouse, France. ²Météorage, Hélioparc, 2 av. P. Angot, 64053 Pau, France.

Since 2014, the lightning observing network SAETTA made up of 12 LMA stations has been deployed in Corsica to monitor the 3D electrical activity within a range of about 350 km from the center of the island, with better performances over and nearby the network, that is 120 km. In complement, the operational lightning location system Météorage provides routinely informations about flash count and location, and discrimination between cloud-to-ground and intra-cloud flashes. Both SAETTA and Météorage data were used to evaluate the accuracy of the CELLS cloud electrification module implemented in the mesoscale cloud-resolving model Meso-NH.

The presentation will focus on a local convection case (25 July 2014 afternoon) that produced more than a thousand of flashes, on the case of an eastward propagating system (21 July 2014) which was more difficult to reproduce, and on a recent case taken from the 2015 dataset which showed an inverted polarity, a relatively rare situation which was indeed simulated by MesoNH. So this study aims at illustrating the realism and the potential of explicitly modeling electrified clouds like MesoNH in preparation to the use of the available in-orbit optical

detection of the lightning flashes from space (ISS-LIS (LEO) and MTG-LI (GEO)) over the Mediterranean area.

The study was also motivated by the preparation of the EXAEDRE field experiment in Sept-Oct 2018, which purpose is to observe and characterize the microphysics state, the electric field and the flash rate of electrified clouds in Corsica and surroundings. It is then intended to reuse some model outputs to refine the flight plans of the SAFIRE Falcon-20 with microphysics probes, RASTA radar and AMPERA electric field measurements on board.

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Exploring drought propagation in Land-Surface Models: evaluation of uncertainties related to meteorological forcing datasets and model structure

Quintana-Seguí, P.¹, Míguez-Macho, G.², Barella-Ortiz, A.^{3,1}

¹Observatori de l'Ebre, Universitat Ramon Llull - CSIC, Roquetes, Spain. ²Universidade de Santiago de Compostela, Santiago de Compostela, Spain. ³Universidad de Castilla-La Mancha, Toledo, Spain.

Drought affects different aspects of the continental water cycle, from precipitation (meteorological drought), to soil moisture (agricultural drought), streamflow, lake volume and piezometric levels (hydrological drought). The spatial and temporal scales of drought, together with its propagation through the system must be well understood. Particularly, drought may have important socioeconomic impacts in our area of study: Spain.

Indices are often used to characterize different aspects of drought. Similar indices can be built for precipitation (SPI), soil moisture (SSMI), streamflow (SSI) and water table depth. Other indices, such as SPEI, may combine several drought related variables. These indices allow us to analyse the temporal scales of drought and its spatial patterns. Precipitation and streamflow data are abundant in Spain; however soil moisture data is scarce. Land-Surface Models (LSM) physically simulate the continental water cycle and, thus, are appropriate tools to quantify soil moisture and other relevant, but difficult to observe, variables and processes. These models can be run offline, forced by a gridded dataset of meteorological variables, usually a re-analysis. The quality of the forcing dataset affects the quality of the subsequent modeling results and is, thus, crucial. Also, model structure influences the spatial and temporal patterns of drought propagation within the model.

The objective of this study is to investigate how sensitive LSM simulations are to the forcing dataset and model structure, with a focus on drought. Global and a local datasets at different resolutions are used to run LSM simulations. The global dataset is the earth2Observe dataset (0.25°), which is based on ERA-Interim. The local dataset is the SAFRAN meteorological analysis system (in two versions at 5 km and 30 km). The LSMs used are SURFEX (using the multi-layer diffusion and 3-layer force-restore versions) and LEAFHYDRO. Standardized indices of the relevant variables are produced for all the simulations performed. Then, we analyze how differently drought propagates through the system in the different forcing-model combinations and how similar are spatial and temporal scales of drought. The results of this

study will be useful to understand the applicability of global datasets for local studies on drought and to better understand the related uncertainties.

Radar retrieval of the raindrop size distribution: a double-moment normalisation approach

Raupach, T.H., Berne, A.

EPFL (École Polytechnique Fédérale de Lausanne) LTE, Switzerland.

The raindrop size distribution (DSD) describes the microstructure of rain. All bulk rainfall variables can be derived from the DSD, and it is required knowledge for radar applications. While usually measured at the point scale using disdrometers, areal estimates of the DSD are often required, and it would often be useful to be able to remotely infer the DSD. For these reasons, remote sensing of the DSD through its retrieval from polarimetric radar data has been a long-standing goal. We present a new approach for such DSD retrieval. The new method uses an existing double-moment normalised form of the DSD to reconstruct the full drop size distribution from two of its statistical moments, which we show may be estimated from polarimetric radar data. The method has been tested on disdrometer and X-band radar data from three instrument networks in three different climatic regions -- Ardeche in France, Payerne in Switzerland, and Iowa in the United States of America. Using these data, the new technique is shown to perform as well as and often better than a current DSD-retrieval technique. We also propose a method for noise-correction of polarimetric variables that improves DSD-retrieval performance when real radar data are used.

Winter time Very Long Dry Spells over the Mediterranean Basin: detection and associated atmospheric dynamics

Raymond, F.¹, Ullmann, A.¹, Camberlin, P.¹, Drobinski, P.²

¹Centre de Recherches de Climatologie, UMR6282 Biogéosciences, CNRS, Dijon, France.

²Laboratoire de Météorologie Dynamique, Institut Pierre Simon Laplace, CNRS, Ecole Polytechnique, Université Pierre et Marie Curie, Palaiseau and Paris, France.

Mediterranean winter precipitations (September to April) are important for annual water resources, summer ground moisture, vegetation and agriculture. Long period without precipitation during this season may cause many impacts.

The study focuses on the identification and variability analyse of very long dry spells (VLDS) in the Mediterranean region, relying on observations. E-obs Data grid from ECA&D are used to 0.25° spatial resolution to the 1957-2013 period. NCEP-NCAR reanalysis are then used to associate different atmospheric conditions to the very long dry spells events.

76 events are detected throughout the Mediterranean Basin for a total duration of 4423 days. Clustering analysis was applied to the 76 events and have detected 4 main cluster. The first spatial pattern, called North-East Mediterranean, grouped 11 VLDS events mainly located in the Balkans. The second pattern, called West Mediterranean, grouped 15 VLDS events

mainly located in the Iberian Peninsula. The third pattern, called Scattered Localized, grouped 25 VLDS events occurring in different areas around the Mediterranean basin. The last spatial pattern, called South-East Mediterranean, grouped 25 VLDS events mainly located in the Levant, but also in the Iberian Peninsula for 10 of them.

VLDS patterns are associated with anticyclonic conditions, which lead blocking high and large scale subsidence of the cold air flow, coming from northern latitude. It is noteworthy that for both the Balkans (North-East pattern) and the Iberian Peninsula (West pattern), the anticyclonic anomalies accompanying VLDS are located about 1000km north-west of the area experiencing drought conditions, instead of being centred on the latter. Significant negative anomalies of TCC and PW also are associated with VLDS patterns, indicating that anticyclonic conditions promote low amounts of water vapour and non-saturated atmosphere that lead to clear sky and the absence of precipitation, promoting the occurrence of VLDS.

A classification in the daily Sea Level Pressure is also performed to assess the influence of the main Euro-Atlantic large scale Weather Regimes on the VLDS events. There is some control of Euro-Atlantic WR on the VLDS: NAO+ WR promote the VLDS in the western Mediterranean, AR WR in the Eastern Mediterranean, and long WR sequences seem promote the occurrence of VLDS events.

This study also assesses the ability of regional climate simulations performed within the context of the HyMeX and MED-CORDEX programs to represent the spatio-temporal characteristics of very long dry spells, to the 1979-2009 period. Models accurately reproduce the occurrence of precipitation around the Mediterranean Basin, and therefore the occurrence of VLDS with 70% VLDS in common with E-OBS dataset. They also accurately simulate the spatio-temporal characteristics. A clustering analysis shows that all models accurately reproduce the main VLDS spatial patterns, associated with anticyclonic conditions above the affected regions.

All these analysis are different steps for analysis of future wet season Very Long Dry Spell variability in the Mediterranean Basin.

ULMOi: A new teleconnection index for rainfall predictability in the Mediterranean basin

Redolat, D.¹, Monjo, R.², Lopez-Bustins, J. A.³, Martin-Vide, J.³

¹Climate Research Foundation (FIC) Complutense University of Madrid (UCM), Madrid, Spain. ²Climate Research Foundation, Madrid, Spain. ³University of Barcelona, Barcelona, Spain.

Research in climatic teleconnections is driven by the need of seasonal forecasts. Because of the large variability of the Mediterranean climate and the orographic complexity of the Mediterranean basin, it presents a greater difficulty in predicting climate anomalies. This work reviews teleconnection indices commonly used for the Mediterranean Basin and explores possible extensions of one of them, the Mediterranean Oscillation index (MOi). Especially, the anomalies of the geopotential height field at 500 hPa are analyzed using segmentation of the basin in seven windows: three at eastern and four at western. Namely, different versions of a new Upper-Level Mediterranean Oscillation index (ULMOi) are calculated, and the predictability of monthly and annual precipitation is analyzed for 37 observatories throughout the Mediterranean basin from 1950 to 2015. Best versions are selected according to the Pearson correlation coefficient, its related p-value, and two measures of standardized error. The combination of Gibraltar Strait and Libya windows is found to be the best for precipitation.

In this sense, the no statistical dependence between the Western Mediterranean Oscillation index (WeMOi) and ULMOi results in a good predictability (mean error between 15% and 25%) of precipitation for most of studied area.

Observed increase in extreme daily rainfall in the French Mediterranean

Ribes, A.¹, Thao, S.², Vautard, R.³, Dubuisson, B.⁴, Somot, S.¹, Colin, J.¹, Planton, S.¹, Soubeyroux, J.-M.⁴

¹CNRM, Météo France - CNRS, 42 avenue Gaspard Coriolis, Toulouse, France. ²Universitat de Valencia, Avenida Blasco Ibáñez, Valencia, Spain. ³LSCE, IPSL, CEA - Orme les Merisiers, Gif-sur-Yvette, France. ⁴DCSC, Météo France, 42 avenue Gaspard Coriolis, Toulouse, France.

In spite of a relatively dry mean climate, the Mediterranean regions in South-Eastern France use to experience heavy rainfalls over short durations - typically a few minutes to one day. Here we examine long-term trends in the historical record of extreme precipitation events occurring over the French Mediterranean area, where more than 70 long homogeneous time-series are available. Extreme events are considered in terms of their intensity, frequency, extent and precipitated volume.

Changes in intensity are analysed via an original statistical approach where the annual maximum rainfall observed at each measurement station are aggregated into a univariate time-series, according to their statistical dependence. This procedure substantially enhances the signal-to-noise ratio. The mean intensity increase is significant and estimated at +22% (+7% to +39% at the 90% confidence level) over the 1961-2015 period. Given the observed warming over the considered area, this increase is consistent with a rate of about one to three times that implied by the Clausius-Clapeyron relationship.

Changes in frequency and other spatial features are investigated through a Generalised Linear Model. Changes in frequencies for events exceeding high thresholds (about 200mm in one day) are found to be significant, typically near a doubling of the frequency, but with large uncertainties in this risk ratio. The area affected by severe events and the water volume precipitated during those events also exhibit significant trends, with an increase by a factor of about 4 for a 200mm threshold, again with large uncertainties.

All diagnoses consistently point toward an intensification of the most extreme events during the last decades. We argue that it is difficult to explain the diagnosed trends without invoking the human influence on climate.

Representation of turbulence in convective systems at kilometer-scale resolution: application to two IOPs during the HyMeX campaign

Ricard, D., Rochetin, N., Lac, C., Verrelle, A.

CNRM UMR 3589 (Météo - France, CNRS), 42, avenue G. Coriolis, 31 057, Toulouse, France.

Although turbulence processes have been extensively studied for the boundary layer, there are fewer studies that evaluate the turbulence parameterization inside convective clouds in atmospheric models. Yet, turbulence can be strong inside cumulus and cumulonimbus. This study aims at evaluating the parameterization of subgrid turbulence in deep convective clouds simulated by numerical cloud resolving model at kilometer-scale resolution (500-m, 1-km and 2-km horizontal grid spacings). A new formulation of vertical turbulent fluxes of liquid-ice potential temperature and total non-precipitating water has been tested inside convective clouds with a reference LES (Verrelle et al, 2017). This formulation is based on products of horizontal gradients as in Moeng (2014), instead of the classical K-gradient formulation. This modified scheme is evaluated with the Méso-NH model (Lafore et al, 1998) on real convective systems observed during HyMeX IOP6 and IOP16a. Comparison with observed data enables the impact of this new scheme on convective systems to be objectively assessed. The modified scheme enhances the subgrid thermal production of turbulence with a better representation of counter-gradient areas and reduces the vertical velocities inside the clouds. The enhanced turbulent mixing produces more developed anvils with increased values of ice and snow, which are more realistic. It also affects the cold pool under the convective cells, in particular for IOP16a.

Water Use Restrictions under Climate Change: a Bottom up Perspective applied to the Rhône-Mediterranean basin

Richard, B.¹, Sauquet, E.¹, Prudhomme, C.²

¹IRSTEA, UR HHLY, Villeurbanne, France. ²Centre for Ecology and Hydrology, Wallingford, UK.

Drought management plans require an overview of possible future conditions for ensuring long term relevance of existing decision-support tools. To that end, “bottom up” approaches can be used to measure catchment intrinsic vulnerability to best match decision-making needs. For instance, a scenario-neutral approach has been developed by Prudhomme et al. (2010) with respect to flood risk, and low flow response surfaces have been explored for drought decision support (Prudhomme et al., 2015).

Due to severe low flow and drastic snowpack decrease, Mediterranean-climate catchments are subject to substantial alterations of water availability in France (Andrew et al., 2016; Chauveau et al., 2013; Hendrickx et al., 2013). In order to adapt to these concerns, drought action plans including water use restrictions have been set up by prefectures at catchment scale. In this study, we first inspect water use restriction decrees adopted by 28 prefectures located in the Rhone-Mediterranean basin over the period 2005-2016. The outputs of the GR5J rainfall-runoff model are post-processed to simulate decisions on the level of water

restrictions (between 1 and 4, the 4th level leads to the tightest restrictions) for 40 basins. Afterwards, we implement a bottom up framework for understanding potential flow responses to a large panel of 1352 climate scenarios. Scenarios are time series of temperature, PET and precipitation obtained by the delta change approach. They are defined to sweep up a large panel of possible future climate realizations. For each scenario, water restrictions are modeled from simulated flows and changes with respect to the current conditions are measured in terms of number of days. Finally, changes are shown as 2 dimensional response surfaces where the x- and y-axes are defined by climate indices and a set of GCM projections are positioned on the response surface to assess possible future changes in duration of water use restrictions.

GCM projections by 2050-2070 point out duration increase ranging from 2 to 10 decades. It reaches 5 to 15 decades with GCM projections by 2070-2100, either up to half of the year. Results highlight potential future needs to adapt water use restriction decrees. In addition, the bottom up approach demonstrates that sustainability in drought plans differs significantly from one basin to another.

Keywords: Drought management; water uses; climate change; bottom up; Rhône.

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CMIP5-Based projection of future changes in the frequency and intensity of medicanes at subregional scale

Romero, R.¹, Emanuel, K.²

¹Universitat de les Illes Balears, Departament de Física, Ctra. de Valldemossa km. 7.5, Palma de Mallorca 07122, SPAIN. ²Massachusetts Institute of Technology, Department of Atmospheric Science, 77 Mass. Ave., Cambridge, Massachusetts 02139, USA.

Medicanes are mesoscale maritime storms that from a physical point of view operate much as tropical cyclones. Although with typical wind intensities far below those registered in their tropical analogues, these Mediterranean cyclones pose serious threat to the affected islands and coastal regions and can adversely affect open sea activities. Concern about the way these extreme phenomena could respond to global warming (e.g. possible changes in frequency, intensity or regional variability) motivate the present work.

We apply a statistical-deterministic method, originally devised for the tropical cyclone problem but which has been adapted for the dynamics of mid latitudes, to generate thousands of synthetic tracks of medicanes along with their radial distributions of winds; these synthetic storms are compatible with the "climates" provided by 30 CMIP5 models in both historical and RCP85 simulations for a recent (1986-2005) and a future (2081-2100) period, respectively. We examine the present-to-future multimodel mean changes in medicane risk, with special attention to the most robust patterns in terms of consensus among individual models on the sign of change. Downscaled fields obtained using the ERA-interim and NCEP-ncar reanalyses will be used as reference.

Future change in the number of medicanes is unclear (on average the total frequency of storms does not vary) but it is found a profound redistribution of events depending on the lifetime maximum wind: results project a higher number of moderate and violent medicanes at the expense of "ordinary" storms. Spatially, the method projects an increased occurrence of medicanes in the western Mediterranean and Black Sea that is balanced by a reduction of storm tracks in contiguous areas, particularly in the central Mediterranean; however, future extreme events (winds >60 kt) become more probable in all subbasins.

Analysis of a damaging hydrometeorological event in the Balearic Islands. The December 2016 case

Rossello, J., Grimalt, M.

Grup de recerca de Climatologia, Hidrologia, Riscs Naturals i Territori. Universitat de les Illes Balears, Spain.

From December 16th to December 22nd 2016, a damaging hydrometeorological event (DHE) affected the Balearic Islands with heavy rainfall, strong winds and rough seas. The damages were high in terms of economical losses (agricultural lands flooded, roads closed, towns isolated) as well as in terms of natural impacts due to effects like rock fall, small landslides and the flooding of streams.

An analysis of meteorological causes is developed and a damages distribution is performed using data from fieldwork, official reports and the press. The results show that the geographical distribution of the impacts was related to the high amount of precipitation that fell over the islands, especially Mallorca and Ibiza, while the economical damages were related to the location of human settlements and activities in flood-prone areas. Meanwhile, the effects in the island of Menorca were linked to rough seas that closed the island harbors for 2 days and damaged coastal areas due to strong wind gusts.

A climatological study of tropospheric cyclonic vortices in the Mediterranean region (25-50°N, 10°W-35°E) from ERA-Interim reanalyses

Roux, F.

Laboratoire d'Aérodynamique (Université Toulouse 3 Paul Sabatier, CNRS), France.

An automatic procedure derived from Picornell et al. (2001) and Campins et al. (2011) to detect cyclonic perturbations from ERA-Interim reanalysis in the Mediterranean region (25-50°N, 10°W-35°E) provides a series of events with various lifetime, intensity, horizontal extent and vertical development. These storms are characterized with a series of diagnostics derived from Hart (2003) and McTaggart-Cowan et al. (2011) to quantify the relative signatures of baroclinic and convective, lower and upper tropospheric processes. The resulting data set reveals a large variety of phenomena which will be illustrated with a few significant examples. Geographical and temporal distributions of cyclonic perturbations with distinct characteristics will be discussed. Statistical analyses of storms and their environmental properties allow to propose a classification of various types of Mediterranean storms.

Potentiality of hydro-meteorological ensemble forecasting of flash floods for risk assessment: Application to the Agly catchment (Eastern Pyrenees)

Roux, H.¹, Amengual, A.², Romero, R.², Larnier, K.¹

¹Institut de Mécanique des Fluides de Toulouse (IMFT) - Université de Toulouse, CNRS-INPT-UPS, Toulouse, France. ²Grup de Meteorologia, Departament de Física, Universitat de les Illes Balears, Palma, Mallorca, Spain.

The Western Mediterranean region is prone to heavy precipitations resulting in devastating flash floods. In order to improve the predictability of this kind of events and to increase the forecasting lead time, accurate predictions of small-scale convective systems are needed. But quantitative precipitation forecasts (QPFs) are arduous due to the uncertainties arising from both the physical parameterizations of numerical weather prediction models and the representation of the atmospheric states. These uncertainties can result in deficient QPFs for hydrological forecasting purposes, especially over small-to-medium sized basins.

Nowadays, short-range ensemble prediction systems (EPSs) provide the state-of-art framework to generate quantitative discharge forecasts (QDFs) and to cope with the different sources of external-scale uncertainties. We examine the performance of two distinct hydrological EPSs (HEPSs), specially designed to explicitly cope with uncertainties in the initial and lateral boundary conditions of the meteorological state (IC/LBCs), and model physical parameterizations (MPS). Deterministic and probabilistic 48 h atmospheric forecasts have been generated using the Weather Research and Forecasting (WRF) model.

This study focuses on a catchment of the Eastern Pyrenees, the Agly catchment, as a test case for implementing the ensemble hydro-meteorological predictions. With a drainage area of 1050 km², the Agly is the second coastal river of the Eastern Pyrenees. It originates from

an elevation of approximately 700 m and drains the Pyrenees foothills. It flows into the Mediterranean Sea at Barcarès with a length of around 80 km. A dam dedicated to flood and water management controls approximately 400 km² of the catchment.

The MARINE distributed model, flash-flood dedicated and process-oriented, has been chosen for this study. This model has been extensively tested on a large panel of hydrologic behaviors around the French Mediterranean area. WRF-driven QPFs have been used to feed the MARINE hydrological model for the medium-size Agly river basin as a support tool for early warning and mitigation strategies. We also explore the uncertainty transference from the atmospheric context down to the hydrological system. Results highlight the benefits of accounting for uncertainties in QPFs and the value of the proposed set-up for the short-range forecasting of floods. Combination of both ensembles (hydrological and meteorological) helps limiting a possible inadequacy of calibrated set of parameters on one hand and takes into account meteorological and parametric uncertainties on the other hand.

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Winter 2017 in the NW mediterranean. Was it just mild or clearly anomalous?

Salat, J., Sabatés, A.

Institut de Ciències del Mar (CSIC), P. Marítim, 37-49, Barcelona, Spain.

The Mediterranean interannual variability is high and in winter this variability is reflected in the intensity and characteristics of the dense water formation processes. Variability ranges from years when huge amounts of new water was formed such as 2005 to those with almost no new contribution such as 1990. It is typically assumed that severe winters lead to the first situation while mild ones lie on the opposite side. Typically during those mild winters, new dense waters were produced in limited amounts or they not reached the deeper levels. Although there is still not enough data, the winter 2017 situation likely appears to lie on the above last cases since there is no evidence of new dense water formation.

Here is a non-exhaustive list of some elements found, most of them from a recent Winfish cruise in the NW Mediterranean, that may indicate or characterise this winter: (i) upper layer sea temperature (< 150 m) more than 1C above the average, up to 10 January, (ii) One week of strong and cold northerlies, after a severe cold air irruption in Europe, up to 18 Jan. were extracting heat of the upper ocean, (iii) successive depressions centered on the south western Mediterranean or active fronts, leading to severe easterlies and causing important precipitation rates on the central and northern side of the basin (19-24 and 27-29 Jan., 2-6, 8-10, 13-14 Feb., etc), (iv) there was almost no cyclogenesis in the Gulf of Genoa, (v) upper layer temperatures back again to values higher than the average just after the cold air irruption, (vi) high surface chlorophyll values both on the coastal side and in open sea since mid January, (vii) zooplankton populations typical of the post-spring bloom, etc.

The first impression from these few indicators was that the cold episode in January was the only dense water preconditioning process, and that it was aborted by the persistent easterlies and rain. However there are many questions open behind this exceptional situation so that

the present winter could be a good candidate for a case study to investigate atypical winter situations.

The objective of this presentation is to take advantage of the Hymex forum and the particular winter 2017 situation and invite everybody to discuss about its characteristics asking for observations, modelling efforts or suggestions to identify the relevant factors leading to such indicators. Here there are just some few open questions to start with: 1) Are the high upper layer temperatures in the mid season behind the easterlies in the northern basin and persistent rain episodes? 2) What can be the contribution of the rain episodes in the lack (if confirmed) of dense water formation? 3) Moreover, would this contribute to decline of northerlies via limiting the extraction of latent heat from the surface water? or 4) can it only due to the lack of cold air in Europe? 5) was the chlorophyll bloom based only on rain at the coastal regions? 6) Is the February-March post-bloom situation driven by the few cold days in mid January at open sea?

In summary, we aim to discuss if this winter was anomalous (or how anomalous was), identify what are the essential elements responsible for the anomaly and if this situation provides new information on the dense water formation processes.

Rapid response to climate change in a marginal sea

Schroeder, K.¹, Chiggiato, J.¹, Josey, S. A.², Borghini, M.¹, Aracri, S.¹, Sparnocchia, S.¹

¹CNR-ISMAR, Venice, Trieste, La Spezia, Italy. ²National Oceanography Centre, Southampton, UK.

The Mediterranean Sea is a mid-latitude marginal sea, particularly responsive to climate change as reported by recent studies. The Sicily Channel is a choke point separating the sea in two main basins, the Eastern Mediterranean Sea and the Western Mediterranean Sea. Here, we report and analyse a long-term record (1993-2016) of the thermohaline properties of the Intermediate Water that crosses the Sicily Channel, showing increasing temperature and salinity trends much stronger than those observed at intermediate depths in the global ocean. We investigate the causes of the observed trends and in particular determine the role of a changing climate over the Eastern Mediterranean, where the Intermediate Water is formed. The long-term Sicily record reveals how fast the response to climate change can be in a marginal sea like the Mediterranean Sea compared to the global ocean, and demonstrates the essential role of long time series in the ocean.

Evaluation of the Levantine Intermediate Water formation in a multi-decadal simulation with the regional climate system model CNRM-RCSM6

Sevault, F., Somot, S., Alias, A.

CNRM UMR 3589, Météo-France/CNRS, Toulouse, France.

Regional Climate System Models are used to represent medium scale atmospheric and oceanic phenomena on periods going from present time hindcast to scenarios for the 21st century.

The previous CNRM-RCSM4 model for the Mediterranean region (Sevault et al., 2014) and CNRM-RCSM5 (Nabat et al, 2015) were using a 50 km resolution in the atmosphere and an around 10 km resolution in the ocean ($1/8^{\circ} \times 1/8^{\circ} \cos(\text{lat})$ grid). In the new CNRM-RCSM6 version presented here, the most recent versions of atmosphere and ocean models available at the CNRM are used. The atmosphere model ALADIN-Climate v6 is the regional version of ARPEGE-Climate v6, and is linked with the SURFEX v8 surface modeling platform (Masson et al., 2013). The CTRIP river model is also included (Decharme et al., 2010). Finally, the ocean model is NEMOMED12, with a resolution about 6 km ($1/12^{\circ} \times 1/12^{\circ} \cos(\text{lat})$ grid) (Beuvier et al., 2012).

New physics in the model, new lateral boundary conditions, horizontal and vertical resolutions, coupling frequency, aerosol climatology among others, allow to give interest to this RCSM for a new 1980-2013 hindcast for the Mediterranean Sea in the frame of Med-CORDEX. A special attention will be given to the formation of the Levantine Intermediate Water (geography, spatial extension, formation rate, comparison to observations).

Network integration of renewable power generation: How much weather variability influence the electrical consumption-production imbalance in Italy?

Stefanon, M.¹, Tankov, P.², Concettini, S.³, Creti, A.³, Drobinski, P.¹, Badosa, J.¹

¹LMD/IPSL, Ecole polytechnique, Palaiseau, France. ²LPMA, Université Paris Diderot, Paris, France. ³Département d'économie de l'Ecole polytechnique, Palaiseau, France.

Increasing use of electric generation based on renewable energy sources (RES) raises structural and economic issues. Because of the intermittent nature of RES and the constant need to balance electricity supply and demand, some existing networks may not be adequately developed. On the other hand, the increase of RES would simultaneously reduce the wholesale prices and increase their variance, due to the large RES variability. In light of these facts, the case of Italy is interesting for two main reasons. The first one is related to the spatial configuration of Italian electricity market. The second one is about the current and expected market penetration of renewables.

Multiple questions therefore arise, predictability of renewable electric generation, electrical consumption-production imbalance, or optimization of renewable plant location. To resolve these complex issues, we build a simulation tool able to reproduce Italian electricity market

with different network configurations and several possible geographical distributions of renewable generation facilities. This tool consists of two modules: electrical consumption, and generation from RES.

We focus on the modelled electrical consumption and renewable production (wind turbine and photovoltaic) over the 1989-2012 period. We use the Weather Research and Forecasting (WRF) Model to provide meteorological inputs over the mediterranean region. Deficit or surplus of electricity on Italian network are analysed in terms of climatic criteria and atmospheric configurations. Based on these results, we propose several scenario for spatial optimization of renewable generation facilities.

Intense air-sea exchanges and heavy orographic precipitation over Italy: the role of Adriatic Sea during Bora and Sirocco events

Stocchi, P., Davolio, S.

National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR – ISAC).

The occurrence of strong winds over the Adriatic Sea is often associated with heavy precipitation over Italy. When cold, strong and gusty Bora winds blow from the northeast, especially during autumn and winter, heavy rainfall and snowfall can occur in particular over the eastern slopes of the Apennines and central Italy coastal areas. On the other hand, in case of intense moist southeasterly low-level winds (Sirocco), rainfall affects northeastern Italy and the Alpine chain. All these events are characterized by intense air-sea exchanges, due to strong low-level winds or relevant temperature differences between the atmosphere and the sea.

High-resolution simulations of different Bora and Sirocco events leading to severe precipitation are performed using a convection-permitting model (MOLOCH). Sensitivity tests and a diagnostic analysis of atmospheric water balance and water vapour fluxes are carried out in order to evaluate the impact of surface fluxes of sensible and latent heat and the role of Adriatic SST in relation with intense precipitation.

The sensitivity tests show that the picture that directly associates more intense precipitation upstream and over the orography with increasing surface heat fluxes or increasing SST, as a consequence of the degree of moistening of air during its passage over the sea, is too simplistic. The impact of SST and surface fluxes varies among the events and it mainly involves the modification of the PBL characteristics and thus the flow dynamics and its interaction with the orography, including complex non-linear effects.

Representation of subgrid turbulent fluxes in convective clouds with LES and kilometer-scale resolution simulations

Ricard, D., Strauss, C., Wirtz, J., Lac, C.

CNRM UMR 3589 (Météo - France, CNRS), 42, avenue G. Coriolis, 31 057, Toulouse, France.

An improved understanding of in-cloud turbulence can lead to a better representation of convective clouds in numerical weather prediction models at kilometer-scale resolution. This study aims at evaluating the parameterization of subgrid turbulence in convective clouds simulated with the Méso-NH model at cloud resolving model resolutions (500-m, 1-km and 2-km horizontal grid spacings) and LES resolution (50-m grid spacing).

Subgrid vertical turbulent fluxes are characterized from the LES at kilometer-scale resolutions by using a coarse-graining method as in Verrelle et al (2017). An ensemble of clouds is used to define the reference profiles and different stages of the cloud development are examined. Alternative formulations of subgrid vertical fluxes are assessed with online evaluation using simulations at kilometer-scale resolutions.

Multi-model analysis of the Eastern Mediterranean thermohaline circulation and representation of the EMT event in hindcast simulations

Struglia, M.V.¹, Carillo, A.¹, Adani, M.², Pisacane, G.¹, Sannino, G.¹, Beuvier, J.³, Lovato, T.⁴, Sevault, F.⁵, Somot, S.⁵, Vervatis, V.⁶

¹ENEA CLIM Lab, Via Anguillarese 301, I-00123, Roma, Italy. ²ENEA INAT Lab, Via Martiri di Monte Sole, 4 – I-40129 Bologna, Italy. ³Mercator Océan, Parc Technologique du Canal, 8-10 rue Hermès, 31520 Ramonville St-Agne France. ⁴Fondazione CMCC, ODA division, Via M. Franceschini, 31 I-40128 Bologna, Italy. ⁵CNRM, Météo-France, CNRS, Toulouse, France. ⁶Department of Environmental Physics, University of Athens, Greece.

Recent atmospheric reanalysis products, such as ERA40 and ERA-interim, and their regional dynamical downscaling, prompted the HyMeX/Med-CORDEX community to perform hind-cast simulations of the Mediterranean Sea, giving the opportunity to evaluate the response of different ocean models to a realistic inter-annual atmospheric forcing.

This work presents a review and an inter-comparison of six hind-cast simulations of the Mediterranean Sea Circulation, covering the period 1960-2013, at resolutions spanning from 1/8° to 1/16°, and reaching in some cases 1/30° over the Levantine sub-basin. The simulations available for this study differ as to resolution, specific prescription of air-sea fluxes and model settings, including different choices for Atlantic boundary conditions.

The analyzed simulations well represent the main characteristics of the mean circulation and the events that have been characterizing the thermohaline circulation (THC) in the Eastern Mediterranean, during the last decades. In particular, the Eastern Mediterranean Transient and the sequence of deep water formation events in the Aegean Sea are well captured with respect to timing and intensity, till the most recent events observed during the period 2006-

2012. The whole set of simulations show similar behaviours, once the proper density threshold to be used for the deep water formation analysis of each model is identified.

Validation of the 2 moment microphysical scheme LIMA based on HyMeX microphysical observations

Taufour, M., Vié, B.

CNRM Météo-France, 42 Avenue Gaspard Coriolis, Toulouse, France.

Aerosol particles affect the cloud microstructure through their ability to nucleate droplets or ice crystals. They are also involved in complex processes and in many feedbacks impacting both the cloud physics and the cloud dynamics. Thus the LIMA scheme aims at representing at best the diversity of aerosol particles and their different properties regarding the nucleation and cloud system interactions at convective scale.

The 2 moment mixed-phase microphysical scheme LIMA was developed in the MESO-NH (Lafore et al. 1998) non-hydrostatic mesoscale research model. This scheme is based on the 1 moment scheme ICE3 (daily used in the AROME operational model at Météo-France). Aerosols are represented by 3D, prognostic number concentrations for as many modes as deemed necessary. CCN activation (Cohard et al. 1998) and IFN nucleation (Phillips et al. 2008, 2013) explicitly depend on available aerosols properties and concentrations.

Results from simulations run for HyMeX IOP6 and IOP16 cases of heavy precipitation will be shown. A comparison between ICE3 and LIMA schemes highlights microphysical feedback on cloud dynamics, through changes in convection intensity and the formation of a cold pool, which affect both the MCS development and the rainfall intensity and location.

The cloud representation with both LIMA and the 1-moment scheme ICE3, is assessed in comparison to HyMeX microphysical observations, including ground based disdrometer, Micro Rain Radar, polarimetric radars and airborne measurements from the Falcon20 (such as RASTA reflectivities and derived microphysical fields). The results suggest that the representation of hydrometeors size distribution in LIMA could be improved by using new diagnostic parameters.

Building a prototype model for probabilistic prediction of flash flood human impacts

**Terti, G.¹, Ruin, I.¹, Gourley, J.², Kirstetter, P.³, Flamig, Z.³,
Blanchet, J.¹, Arthur, A.⁴, Anquetin, S.¹**

¹Institute Univ. Grenoble Alpes, IGE, F-38000 Grenoble, France. ²NOAA/National Severe Storms Laboratory (NSSL), Norman, OK 73072, United States. ³NOAA/National Severe Storms Laboratory, and Atmospheric Radar Research Center, University of Oklahoma, Norman, OK 73072, USA. ⁴Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, Norman, OK 73072, USA.

In the 21st century the prediction of and subsequent response to impacts due to sudden onset and localized flash flooding events remain a challenge for forecasters and emergency managers. Structural measures and/or advances in hydrological forecasting systems alone do not guarantee reduction of fatalities during short-fuse flood events. The literature highlights the need for the integration of additional factors related to social and behavioral vulnerability processes to better capture the risk for people during flash floods.

In this study, we propose a statistical classification approach that probabilistically assesses human risk to flash floods. The goal is to investigate and subsequently quantify the relationship between historic fatal and non-fatal flash flood events with relevant vulnerability indicators in certain circumstances (e.g., vehicle-related, inside buildings). A database of 38,106 flash floods from 2001-2011 in the United States is supplemented with extra datasets describing i) the critical hazard characteristics, and ii) the sensitive characteristics of the exposed population and built environment on the county level. Random Forest, a well-known ensemble machine-learning classifier, is then applied to assess the likelihood of fatality occurrence in a certain circumstance (here vehicle-related) as a function of selected risk predictors.

The developed model can be applied on a daily or hourly basis for every U.S. county. As a prototype case, the model is applied to the catastrophic flash floods of May 2015 in the U.S. with focus on Texas and Oklahoma. The estimated probabilistic risk is mapped dynamically for every county in the study area. The results indicate the importance of time and space-dependent risk assessment for short-fuse flood events, and suggest machine learning as a promising approach in disaster research. This method, based mainly on publicly available national datasets, can support a nationwide pre-operational prediction tool for forecasters and emergency managers to target their warnings on anticipated human impacts, using the model combined with hydrologic forecasts.

Extreme dry spells modelling in the Mediterranean region in relation with atmospheric circulation patterns

Tramblay, Y.¹, Hertig, E.²

¹IRD, HydroSciences Montpellier, France. ²Institute of Geography, University of Augsburg, Germany.

Droughts periods are affecting the Mediterranean region due the strong inter-annual variability of precipitation. The goal of this study is to analyze extreme dry spells occurring during the extended winter season (October-April), that could have severe impacts on water resources and agriculture. In particular, the spatial patterns of extreme dry spell and their relationships with large-scale atmospheric circulation are investigated. Then, different statistical models for extreme dry spells are tested with climatic covariates. The data from a network of 160 rain gauges having daily precipitations measurements between 1960 and 2000 are considered together with the ERA20C reanalysis of the 20th century to provide atmospheric variables (geopotential heights, humidity, winds).

A comparison of different sampling approaches for extreme dry spells was first performed: annual maximum (AM) sampling with Generalized Extreme Value (GEV) distributions or peaks-over-threshold (POT) sampling with Generalized Pareto (GP) distributions. Results indicate that both approaches provide very similar results in term of extreme dry spells quantiles. Therefore AM sampling has been retained to avoid issues related to the choice of the threshold in the POT method.

A regional classification on both the occurrence and the duration of annual maximum dry spells in the different stations has been performed using the Jaccard distance metric. Three spatially contiguous regions have been distinguished in which the regional distributions of annual maximum dry spell length (AMDL) were found homogeneous. From composite and principal component analysis, significant positive anomalies in geopotential height and negative anomalies in zonal wind and relative humidity were associated with AMDSL in the three regions. Finally, non-stationary GEV models have been compared, in which the location and scale parameters are related to different atmospheric indices with linear or quadratic relationships.

Dense water formation in the coastal northeastern Adriatic Sea: the NAdEx 2015 experiment

Vilibic, I.¹, Mihanovic, H.¹, Janekovic, I.^{2,3}, Denamiel, C.¹, Poulain, P.-M.⁴, Orlic, M.⁵, Dunic, N.¹, Dadic, V.¹, Pasaric, M.⁵, Muslim, S.¹, Gerin, R.⁴, Matic, F.¹, Sepic, J.¹, Mauri, E.⁴, Kokkini, Z.⁴, Tudor, M.⁶, Kovac, Z.¹, Dzoic, T.¹

¹Institute of Oceanography and Fisheries, Split, Croatia. ²Rudjer Boskovic Institute, Zagreb, Croatia. ³The University of Western Australia, School of Civil, Environmental and Mining Engineering & UWA Oceans Institute, Crawley WA, Australia. ⁴Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, Trieste, Italy. ⁵University of Zagreb, Faculty of Science, Andrija Mohorovicic Geophysical Institute, Zagreb, Croatia. ⁶Meteorological and Hydrological Service of Croatia, Zagreb, Croatia.

The paper investigates wintertime dynamics of the coastal northeastern Adriatic Sea, and is based on numerical modelling and in situ data collected through field campaigns executed during the winter and spring of 2015. The data have been collected by a variety of instruments and platforms (ADCPs, CTDs, glider, profiling float), and have been accompanied with a one-way coupled ALADIN/ROMS modelling effort. Research focus has been put on dense water formation (DWF), thermal changes and circulation, and water exchange between the coastal and open Adriatic. According to both observations and modelling results, dense waters are formed in the northeastern coastal Adriatic during cold bora outbreaks, even during milder-than-average winters (as was the winter of 2015). However, dense water formed in this coastal region has, due to lower salinities, lower densities than dense water formed at the open Adriatic. Since the sea is deeper in the coastal area than at the open Adriatic, dense waters from the open Adriatic occasionally enter the coastal area near the bottom of the connecting passages, while the surface flow is mostly outward from the coastal area. Median residence time of the coastal area is estimated to about 1-2 months, indicating that the coastal area may be relatively quickly renewed by the open Adriatic waters. The model significantly underestimates currents and transports in connecting channels, which may be a result of a too coarse resolution of atmospheric forcing, misrepresentation of bathymetry or absence of the air-sea feedback in the model. Obtained data represents a comprehensive marine dataset, pointing to a number of interesting phenomena to be investigated in the future.

Taking into account hydrodynamic parameters and initial soil moisture uncertainties in an ensemble-based flash-flood forecasting system

Vincendon, B.¹, Edouard, S.², Ducrocq, V.¹

¹CNRM (Météo-France, CNRS), 42 av. Coriolis/ 31057 Toulouse Cedex, Toulouse, France.

²SPC Alpes du Nord (Northern Alps Flood Forecasting Service), Grenoble, France.

Hydrometeorological prediction is affected by several sources of uncertainty, especially for Mediterranean flash floods. The major uncertainty comes from the rainfall data used to drive hydrological models. It can be considered using meteorological Ensemble Prediction Systems. But initial soil moisture knowledge is also uncertain and the hydrological model himself is affected by uncertainty.

In this study, the sensitivity of the ISBA-TOP coupled system, which has been developed to simulate the hydrological reaction of fast responding rivers, to its parameters and initial soil moisture is investigated to document those two sources of uncertainty. Discharge simulations with ISBA-TOP are sensitive to three hydro dynamical parameters and this sensitivity is found very dependant on initial soil moisture conditions.

Perturbation methods varying the 3 parameters that have the highest impact on discharge simulations as well as initial soil moisture allow to design an ensemble prediction system. This ensemble has been assessed for 6 real cases. Using this ensemble-based approach for discharge simulation lead to better results than using the deterministic version of ISBA-TOP. The conception of a complete hydrometeorological ensemble prediction system (HEPS) can then be achieved. The uncertainty that affects precipitation fields is sampled using the AROME ensemble prediction system (AROME-EPS). The rainfall scenarii are used to drive ISBA-TOP on which the perturbation of parameters and initial soil moisture fields is applied. The skill of this complete chain is better than an HEPS based on AROME-EPS and the deterministic version of ISBA-TOP.

Does ocean intrinsic variability impact ocean deep convection? Answers from ensemble simulations of deep convection in the Northwestern Mediterranean Sea

Waldman, R.¹, Somot, S.¹, Herrmann, M.², Sevault, F.¹

¹CNRM / Météo France, Toulouse, France. ²LEGOS / Observatoire Midi-Pyrénées, Toulouse, France.

Recent studies have shown the large modulation of ocean variability from daily to multidecadal scales by the intrinsic variability arising from eddying oceans. The deep convection phenomenon is known to be impacted by mesoscale dynamics which is a major source of intrinsic variability. However, to our knowledge the role of ocean intrinsic variability on deep convection hasn't been addressed so far.

In this study, we assess the impact of intrinsic variability on the deep convection phenomenon. For that, we use eddy-resolving (2km resolution) Northwestern Mediterranean Sea simulation ensembles with perturbed initial states from the regional configuration of NEMO called NEMOMED12 with the AGRIF refinement tool in the northwestern Mediterranean. The

ensemble spread allows to quantify intrinsic variability, whereas its mean is a measure of forced variability. We focus on the well-documented 2012-2013 period and on the multidecadal timescale (1979-2013).

The properties and timescales associated with deep convection are analyzed. We address the impact of intrinsic variability at the event, interannual and climatological mean timescales. We find a large modulation of the deep convection spatio-temporal variability by intrinsic variability but a marginal impact on its climatological mean state. Our results suggest intrinsic variability is a key element of deep convection variability.

Improving estimates of riverine fresh water into the Mediterranean sea

Wang, F., Polcher, J.

Laboratoire de Météorologie Dynamique/IPSL/CNRS, Ecole Polytechnique, F 91128 Palaiseau, France.

Estimating the freshwater input from the continents into the Mediterranean sea is a difficult endeavor due to the uncertainties from un-gauged rivers, human activities, and measurement of water flow at river outlet. One approach to estimate the freshwater inflow into the Mediterranean sea is based on the observed flux (about 63% available) and a simple annual water balance for rivers without observations (ignoring human usage and other processes). This method is the basis of most water balance studies of the Mediterranean sea and oceanic modelling activities, but it only provides annual mean values with a very strong assumption. Another approach is done by forcing a state of the art land surface model (LSM) with bias corrected atmospheric conditions. This method can estimate total fresh water flowing into the Mediterranean at daily scale but with all the caveats associated to models.

We use data assimilation techniques by merging data between the model output (ORCHIDEE LSM developed at Institut Pierre Simon Laplace) and the observed river discharge from Global Runoff Data Center (GRDC, about 600 stations) to obtain the optimized river discharge over the entire basin. Over each sub watershed, the monthly GRDC data (if available) are applied to correct modelled surface runoff and deep drainage at upstream, for the purpose of improving the estimation of downstream discharge to the Mediterranean sea. This will allow to compensate for systematic errors of model or missing processes and provide estimates of the riverine input into the sea at high temporal and spatial resolution. We will compare the freshwater inflow into the Mediterranean obtained here with different approaches reported in previous studies. We will also analyze the trend of freshwater discharge. The new estimates will serve for ocean modelling and water balance studies of the region.

Synoptic Conditions for Dry Spells in Israel

Ziv, B.¹, Saaroni, H.², Harpaz, T.^{1,2}, Lempert, J.²

¹Department of Natural Sciences, The Open University of Israel, Ra'anana, Israel.

²Department of Geography and the Human Environment, Tel Aviv University, Tel Aviv, Israel.

Prolonged dry spells (PDSs) which last a week or longer, during the rainy season, have been classified into three types; the 'subtropical' is associated with an expansion of the subtropical high over most of the Mediterranean basin (MB). The 'baroclinic' is induced by a pronounced stagnant ridge, a part of a Rossby wave, over the Eastern Mediterranean. The 'polar' is associated with a blocking high over Eastern Europe, which pushes lower-level dry polar air toward the Levant. The types' identification is based on quantitative indices developed by Saaroni et al. (2015).

Maps of cyclone tracks, derived for days belonging to each of the above types, show distinct distributions; for 'subtropical' days the entire MB is poor with tracks and the European cyclone track is densely populated with dominantly eastward direction. For 'baroclinic' days, the western and central MB are rich with tracks, and the eastern part is nearly empty. The tracks over Europe have dominant meridional northward direction. During 'polar' days, minimal tracks appear over the eastern Mediterranean and entire Europe, whereas the eastern Atlantic is densely populated with cyclone tracks, presumably because they are blocked from entering Europe.

The evolutions of PDSs are studied through composite maps of 500-hPa GPH anomalies, derived for the days preceding the onset of each type. Prior to the onset of 'subtropical' PDSs, zonal pattern covers Europe and the mid-latitudinal part of Asia, but, unexpected meridional pattern is discerned over the MB, expected to characterize the 'baroclinic' one. A zonal pattern expands gradually over the Mediterranean, extending to the northeast toward central and northern Asia, but from the third day of the PDS event, a meridional pattern starts to dominate the MB. Prior to the onset of 'baroclinic' PDS, being the dominant type, a meridional regime dominates the MB and south Europe, disconnected from the higher-latitudes. During its first days the meridional regime intensifies, extending toward higher latitudes. Prior to the onset of 'polar' PDSs, a blocking high covers Northwest Europe and expands eastward during the PDS. In all three types the evolution was accompanied by distinct anomalies over the Atlantic, Asia and the Pacific, indicating that they reflect anomalous synoptic configuration on the large-scale.

A parallel automatic classification of the PDSs, using the K-mean technique, indicated that when divided into 3 clusters they well resemble the ones defined subjectively. The analysis reveals the dominance of 'baroclinic' PDSs over the eastern MB and the tendency of 'subtropical' and 'polar' types to transform and become 'baroclinic'. No consistent relation was found between the PDS scenarios and the dominating northern hemispheric large-scale oscillations, such as the NAO and the AO.

POSTERS

European marginal seas coupled centennial scale regional climate simulations

Akhtar, N., Ahrens, B.

Institute for Atmospheric and Environmental Sciences, Goethe University Frankfurt, Germany.

The aim of this work is to study the impact of European marginal (Mediterranean, North and Baltic) seas on regional extremes in Europe. To achieve this a regional atmospheric model COSMO-CLM (~25 km resolution) is coupled to two regional ocean models NEMO-MED12 (for the Mediterranean Sea) and NEMO-NAB (for North and Baltic Seas) simultaneously. The simulations have been extended over the whole 20th century using MPI-ESM-LR global model output nudged against NOAA-CIRES 20C reanalysis. The results of the coupled simulations have been evaluated against their contemporary uncoupled COSMO-CLM simulations and reference data (e.g., ERA-20C and NOAA-CIRES 20C reanalysis).

Towards a high resolution drought monitoring system in Catalonia

Altava-Ortiz, V.^{1,2}, Barnolas, M.¹, Rius, A.¹, Prohom, M.¹, Sairouni, A.¹

¹Meteorological Service of Catalonia(SMC), Berlín 38, Barcelona E-08029, Catalonia, Spain

²Wildfire Forest Prevention Service(SPIF). Environmental and Biodiversity Section. Finca Torreferrussa 08130. Sta Perpètua Mogoda.

Drought is an inherent characteristic of any climatic regime. However, in the Mediterranean Basin, precipitation deficits are more frequent due to the high variability of precipitation. Moreover, related drought impacts on agriculture, water resources or natural environment can be aggravated thus below normal precipitations in the rainy season are rarely balanced during the dry season. In addition, the frequency and intensity of drought events in the Mediterranean Basin has increased appreciably during the last decades.

Droughts, as a natural hazard, also have a particularity: They are phenomena temporary persistent. That particular characteristic implies that drought has to be correctly monitored and sometimes it is not trivial. Depending on the impacted sector, the information required might differ, and useful information to agricultural impacts may be misleading for hydrological stresses evaluation. The Meteorological Service of Catalonia has created a first version of high resolution drought monitoring system daily updated. The first two indexes calculated are the Standardized Precipitation Index (SPI) at 3, 6, 9, 12 and 24 months aggregation and the Drought Code (DC) of the Canadian Forest Fire Index. These indexes are expected to provide useful information to the managing of future hydrological and agricultural impacts, forestry decays and wildfire forest prevention campaigns.

Can precipitation over Israel be predicted from Eastern Mediterranean heat content?

Amitai, Y., Gildor, H.

The Institute of Earth Sciences, The Hebrew University of Jerusalem, Israel.

Israel's location in a semi-arid region along the eastern coast of the Mediterranean Sea makes the prediction of winter precipitation socially and environmentally important. In 1982, Tzvetkov and Assaf proposed a connection between heat content (HC) in the Eastern Mediterranean (EM) in fall and precipitation over Israel in the following winter. We revisit their hypothesis using 21 years of remotely sensed sea surface temperature and sea surface height. The HC of the EM's upper layer is derived from these remotely sensed measurements under a reduced gravity approximation. Our results show a correlation of $R = 0.6$ between HC in the fall off the coastline of Lebanon and precipitation in Haifa, Tel-Aviv and Jerusalem. The depletion of HC during winter correlates moderately ($R = 0.4$) with precipitation in the three cities. Thus, according to our analysis, the upper layer HC in the EM in fall significantly impacts winter precipitation over Israel. Still, from a separate analysis, the atmospheric short-term condition seems to be important as well.

Box modeling of the Eastern Mediterranean sea

Ashkenazy, Y.

Ben-Gurion University of the Negev, Israel.

In ~1990 a new source of deep water formation in the Eastern Mediterranean was found in the southern part of the Aegean sea. Till then, the only source of deep water formation in the Eastern Mediterranean was in the Adriatic sea; the rate of the deep water formation of the new Aegean source is 1 Sv, three times larger than the Adriatic source. We develop a simple three-box model to study the stability of the thermohaline circulation of the Eastern Mediterranean sea. The three boxes represent the Adriatic sea, Aegean sea, and the Ionian seas. The boxes exchange heat and salinity and may be described by a set of nonlinear differential equations. We analyze these equations and find that the system may have one, two, or four stable flux states. We conjecture that the change in the deep water formation in the Eastern Mediterranean sea is attributed to a switch between the different states on the thermohaline circulation; this switch may result from decreased temperature and/or increased salinity over the Aegean sea.

Assimilation of dual-polarization radar observations into convective scale models

Augros, C.¹, Caumont, O.², Ducrocq, V.², Gaussiat, N.¹

¹Météo France Radar Center, Toulouse, France. ²Météo France CNRM, Toulouse France.

The main purpose of this study is to examine how dual-polarization weather radar observations could be used to improve the analyses and the short-term forecasts of convective scale atmospheric models.

First, a polarimetric radar forward operator has been added to the Meso-NH mesoscale model (Lafore et al., 1998) by taking advantage of the detailed mixed-phase microphysics of the model. Comparisons between simulated and observed polarimetric variables have been conducted at S, C and X-band on two mid-latitude deep-convection cases and have demonstrated a rather good agreement between observations and simulations (Augros et al., 2015). These comparisons have been used to validate the forward operator that was subsequently deployed into the Météo France convective scale operational model AROME (Seity et al. 2011) that has the same 1-moment microphysics scheme as Meso-NH.

Next, the 1D+3D-Var assimilation scheme, used operationally to assimilate the reflectivity (Caumont et al, 2010; Wattrelot et al, 2014), has been extended to test the assimilation of the differential phase Zdr and the specific differential phase Kdp. In this indirect assimilation scheme, a 1D Bayesian method is used to infer vertical profiles of humidity at the observation location, from a linear combination of background humidity profiles, with weights determined by the difference between observed and simulated variables. The retrieved humidity profiles are then assimilated together with the other observations in AROME using 3D-Var.

The impact of the use of Zdr or Kdp on the retrieved humidity profiles is discussed and the profiles are validated by comparison with IWV (Integrated Water Vapor) from ground-based GPS observations.

Assimilation experiments have then been conducted, for two convective cases. The impact of the assimilation of Kdp was particularly evidenced in a case of strong convection and partial beam blockage. The impact of DPOL observations on precipitation forecast was found globally neutral, but slightly positive for the periods of intense convection. The examination of a larger number of cases with strong attenuations and/or in regions affected by partial beam blockage is necessary to comfort their benefit on precipitation forecasts.

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Understanding the flow intermittence dynamic of headwater streams using periodic observations of river flow state in South-East France

Beaufort, A.¹, Leblois, E.¹, Pella, H.², Datry, T.², Sauquet, E.¹

¹Irstea, UR HHLY, Villeurbanne, France. ²Irstea, UR MALY, Villeurbanne, France.

Due to their upstream position in river networks, many (HS) experience recurrent flow cessation and/or drying events. They have many ecological values since they are located at the interface between terrestrial and aquatic ecosystems and contribute to good status of rivers (sediment flux, input of organic matter...). However, the understanding of HS remains limited because gauging stations are preferentially located along perennial rivers and, consequently, the proportion of intermittent rivers (IR) is highly underestimated.

In France, the observation network ONDE (“Observatoire National Des Etiages”, in French) was designed by ONEMA to complement discharge data from the conventional French River Flow Monitoring network (HYDRO) to better understand HS dynamics. ONDE provides visual observations of flow state at 3300 sites along river channels located throughout France since 2012. In this work, we focus our analysis on the 750 sites located in south-east of France. One observation is made every month between April and October and the frequency of observations may increase during drought period to 4 visits / month. One of the following flow states is assigned at each observation: “flowing”, “no flow” or “dry”.

The objective of this work is to combine information from both networks for a better understanding of the spatio-temporal pattern of intermittent rivers in the south-east of France. A first analysis of the ONDE network shows that 50% of sites have shown that at least one zero-flow event between 2012 and 2016 (against only 8% of gauging stations available in the HYDRO database). The proportion of zero-flow events observed at 57 ONDE sites was higher than 50% and at least one zero flow is observed every year at 85 sites mostly located in the south of the region near the Mediterranean Sea. Dry events mainly occur during August and September and the most impacted years were 2012 and 2016 where more than 600 zero-flows were observed.

The second step consists in converting the sample of discontinuous observations into continuous time series of river flow states in order to study how flow intermittence develops in both time and space. For this purpose, 30 hydro-ecoregions (HER) homogeneous in terms of climate, topography and geological features were selected. The proportion of no-flow within each region with respect to hydrological regime was studied. Linear regressions have been fitted to link the observed discharges, the groundwater levels and the proportion of no-flow. A strong relation is noticed for 70% of HER with a determination coefficient higher than 60%. Regions with high probabilities of intermittent river segments are close to the Mediterranean Sea where the proportion of no-flow modelled may exceed 50% between July and October. Finally, geostatistical methods have been developed to assess the spatial distribution of IRs and to explore how flow intermittence patterns are related to environmental drivers.

FerryBox: a new approach to study water masses properties and dynamics in the Western Mediterranean Basin

Ben Ismail, S.¹, Ben Ismail, M.A.², Thyssen, M.², Sammari, C.¹

¹INSTM, National Institute of Marine Sciences and Technologies, Salammbô, Tunisia. ². CNRS/INSU, IRD, Mediterranean Institute of Oceanography, Aix Marseille Université, Marseille, France.

In the framework of DYMEDTUN (Tunisian national project), the National Institute of Marine Sciences and Technologies (INSTM) installed a FerryBox system in February 2016 on the Carthage ferry of the Compagnie Tunisienne de Navigation (CTN). The ferry crosses the western Mediterranean Sea between Tunis and Marseille and between Tunis and Genova on a weekly basis (Black trajectories). The FerryBox system will collect a large amount of data (physical and biological parameters) with a high spatial and / or temporal resolution. The FerryBox data proved to be a strong supplement to the traditional monitoring data. The high temporal resolution of the FerryBox data describes the high temporal “variability” of the hydrological dynamics in the Mediterranean, and thus improves the calibration data for the oceanographic models. It has been shown that SSS and SST data from FerryBoxes demonstrate the potential for operational use in data assimilation schemes (Grayek et al., 2011).

Continuous measurements of the Ferrybox in the Western Mediterranean will allow us to compare the observed surface front from surface edges detected by altimetry. The dataset will help in the characterization of the seasonal and annual variability of the frontal structures and improve our understanding of the relationship between the variability of the frontal structures and the phytoplankton distribution. Phytoplankton functional and structural characteristics will be available from high frequency and automated observations thanks to the AMIDEX CHROME (Continuous High Resolution Observation of the MEditerranean sea, <https://chrome.mio.univ-amu.fr/>) project, a collaborative project between the INSTM, the Mediterranean Institute of Oceanology (MIO, Marseille France), the INVG (Bologna Italy), the LOV (Villefranche, France), the LOG (Wimereux, France) and the SBR (Roscoff, France). The project consists in coupling standard parameters (temperature, salinity, dissolved oxygen and fluorescence) classically recorded by FerryBoxes, with a new version of automated flow cytometer (Cytosense, CytoBuoy) for single cell analysis of phytoplankton community, a pCO₂ sensor (OceanPack MK2, SubCtech) and a pH sensor (SeaFET, Satlantic). This innovative approach will allow us to study simultaneously the CO₂ system variability and the phytoplankton functional groups distribution of the Western Mediterranean at the sub-mesoscale. With this poster we wish to communicate the challenges which we still face on different levels and preliminary results of 6 month of data.

Keywords: Voluntary Observing Ship, FerryBox system, western Mediterranean Sea, Mesoscale variability, flow cytometry.

New version of MEDRYS, a mediterranean sea reanalysis during 1992-2013

Beuquier, J.^{1,2}, Hamon, M.¹, Desportes, C.¹, Drévilion, M.¹, Lellouche, J.-M.¹, Drillet Y.¹

¹Mercator Océan, 8-10 rue Hermès, Parc Technologique du Canal, 31520 Ramonville Saint-Agne, FRANCE. ²Météo-France, 42 avenue Coriolis, 31057 Toulouse Cedex, FRANCE.

The French research community on the Mediterranean Sea and the French operational ocean forecasting center Mercator Océan are gathering their skills and expertises in physical oceanography, ocean modelling, atmospheric forcings and data assimilation, to carry out a MEDiterranean Sea ReanalYsiS (MEDRYS) at high resolution for the period 1992-2013. The reanalysis is used to have a realistic description of the ocean state over the recent decades and helps to understand the long-term water cycle over the Mediterranean basin in terms of variability and trends, one of the goals of the HyMeX program.

This work describes the latest version of MEDRYS, its main results in terms of thermohaline contents, surface circulation, dense water formation, and compares them to other oceanic reanalyses and operational products.

Ensemble hydrological simulations over the Iberian Peninsula using a combined product of global reanalysis and satellite precipitation data

Bhuiyan, M.A.E.¹, Nikolopoulos, E.I.^{1,2}, Anagnostou, E.N.¹, Quintana-Segui, P.³, Barella-Ortiz, A.^{3,4}

¹Department of Civil and Environmental Engineering, University of Connecticut, Storrs, CT, USA. ²Innovative Technologies Center S.A., Athens, Greece. ³Ebro Observatory, Ramon Llull University – CSIC, Roquetes (Tarragona), Spain. ⁴Castilla-La Mancha University, Toledo, Spain.

Hydrological evaluation of a nonparametric tree-based error model, Quantile Regression Forests (QRF), used for ensemble generation of global precipitation datasets is investigated for the area of the Iberian Peninsula. The error model is developed based on information from three satellite precipitation products—CMORPH, PERSIANN and 3B42(V7)— precipitation and air temperature dataset from atmospheric reanalysis, satellite-based surface soil moisture and terrain elevation. A long-term (2000–2011) ground reference precipitation dataset (SAFRAN) available at high-resolution (5km/1h) is used to evaluate the error in precipitation. Both reference precipitation and error model-generated ensemble were used to force a distributed hydrological model (the SURFEX land-surface model coupled with the RAPID river routing scheme) to evaluate the impact of the proposed QRF-based blending technique in streamflow simulations. For the hydrologic analysis, streamflow simulations are evaluated for the Ebro river basin at Tortosa (84230 km²); and four upstream subbasins at Zaragoza (40434 km²); Cinca river at Fraga (9612 km²); Segre river at Lerida (11369 km²) and Jalon river at Grisen (9694 km²). Comparison against the reference (SAFRAN) based streamflow simulations shows that the magnitude of systematic error for combined product is significantly

lower than for individual precipitation products. The random error decreases with increasing scale and for all cases, results from combined product are associated with an error reduction (relative to other products) at the order of 40 to 88%. Overall, the findings of this work demonstrate that application of nonparametric statistical techniques have the potential to optimally combine multiple global precipitation datasets to generate realistic and improved precipitation ensembles for advancing hydrologic simulations.

Variability of the Drop Size Distribution at small spatial and temporal scale in the Cevennes-Vivarais region, France

Boudevillain, B.¹, Hachani, S.^{1,2}, Bargaoui, Z.², Delrieu, G.¹

¹Université Grenoble Alpes, CNRS, IGE, Grenoble, France. ²Université Tunis El Manar, ENIT, LMHE, Tunis, Tunisia.

As shown in a companion presentation (Hachani et al., this conference) dedicated to the drop size distribution (DSD) climatology in the Cevennes-Vivarais region, some of the variability of the DSD is explained by the seasons, the weather types, the rain types or by the localization (related to altitude and/or mountainous environment and/or proximity of the sea). Another part of this variability concerns the scale of the precipitating systems themselves.

This study aims at jointly exploiting radar-based QPE and ground-based DSD measurements in order to analyze the spatial and temporal variability of the DSD parameters (concentration, characteristic drop diameter, distribution shape) at small scale (1km², 5 minutes) in connection with the structure of the rainfall field and with the localization inside the rain system.

The analysis was performed on the basis of 4 years (2011-2015) of recordings on a network of 10 disdrometers located throughout the French Mediterranean region of Cévennes and Vivarais in the framework of the HyMeX (Hydrological Cycle in the Mediterranean Experiment, <http://www.hymex.org/>) project. The dataset was expanded during the HyMeX Special Observation Period (SOP, 2012 and 2013 fall season) with 8 other disdrometers deployed by EPFL on a small (5x7km²) sub-area of the region. The analysis was also performed with the corresponding operational radar-based QPEs over the period 2011-2015 as well as with research radar observations during SOP.

The study highlighted the situations for which DSD variability was significant. It attempted to highlight links between the spatial structure of the precipitating systems and the DSD parameters as well as Z-R relationships. Finally, it showed the importance of the relative localization in the precipitating systems (parts of the systems corresponding to development, maturation or senescence stages; parts of the systems localized in the upwind or the downwind sides).

The October 2015 flash-floods in south eastern France: hydrological analyses, inundation mapping and impact estimations

Bourgin, F., Payrastre, O., Lebouc, L., Le Bihan, G., Gaume, E.
CNIfstar, Geotechnical engineering, environment and risks, Bouguenais, France.

The October 2015 flash-floods in south eastern France caused more than twenty fatalities, high damages and large economic losses in high density urban areas of the Mediterranean coast, including the cities of Mandelieu-La Napoule, Cannes and Antibes.

Following a post event survey and preliminary analyses conducted within the framework of the HyMeX project, we set up an entire simulation chain at the regional scale to better understand this outstanding event. Rainfall-runoff simulations, inundation mapping and a first estimation of the impacts are conducted following the approach developed and successfully applied for two large flash-flood events in two different French regions (Gard in 2002 and Var in 2010) by Le Bihan (2016). A distributed rainfall-runoff model applied at high resolution for the whole area – including numerous small ungauged basins – is used to feed a semi-automatic hydraulic approach (Cartino method) applied along the river network – including small tributaries. Estimation of the impacts is then performed based on the delineation of the flooded areas and geographic databases identifying buildings and population at risk.

J2000-Rhône: a distributed hydrological model including water use modelling to assess sustainability of the water management

**Braud, I.¹, Branger, F.¹, Gouttevin, I.¹, Sauquet, E.¹, Tilmant, F.¹,
Montginoul, M.²**

¹Irstea Lyon, UR HHLY 5 rue de la Doua, CS70077, Villeurbanne, 69626 – France. ²Irstea Montpellier, UMR G-Eau, France.

We present a distributed hydrological model, J2000-Rhone, that was enhanced with water-use modules (hydro-power, irrigation and drinking water supply) and set-up over the whole Rhone river basin (Switzerland and France, 96 000 km²). The J2000-Rhone model is based on the concept of Hydrological Response Unit (HRU), which define the finest scale on which processes are simulated. The Rhone River basin is divided into 12345 HRUs (average size = 5 km²), allowing for robust results for catchments over 50 km². The project was co-funded by one of the French water agencies, with a view of assessing human influence on river flow regime and the sustainability of water resource management under changing climate. The model's skills were tested at more than 200 control gauging stations monitoring both near natural and influenced observed daily discharge. Coarse socio-economic scenarios were built for the evolution of the water demand, each corresponding to possible public incentives. The model highlights zones of possible upcoming tensions and the opportunity of mitigation by changes of practices. Data-collection and interpretation was both the cornerstone and the most limiting step of our construction: we encourage an effort in data collection and

management by the water management institutions if they want research to help them anticipate the future at their scales of interest.

The HyMeX data base

Brissebrat, G.¹, Belmahfoud, N.¹, Cloché, S.², Ferré, H.¹, Labatut, L.³, Ramage, K.²

¹SEDOO, OMP Data Service, Toulouse, France. ²ESPRI, IPSL Data Center, Palaiseau, France. ³CNRM, Toulouse, France.

The HyMeX data management system has been designed and developed in the context of the Mediterranean Integrated Studies at Regional And Local Scales program (MISTRALS) data portal. The MISTRALS data portal is a distributed system, that enables users to access datasets produced by every project (HyMeX, ChArMEx, MerMEx...) and managed by different data centers. The HyMeX database is managed in the scope of the AERIS thematic pole and relies on a strong collaboration between OMP and IPSL data centers. Local observation data (ground-based stations, mobile platforms, questionnaires...) are managed by OMP team while gridded data (satellite products, model outputs, radar data...) are managed by IPSL team.

The HyMeX database contains a wide variety of datasets:

- 273 hydrological, meteorological, ocean and soil in situ datasets,
- 47 radar datasets,
- 32 satellite products,
- 121 atmosphere, ocean and land surface model outputs from operational (re-)analysis or forecasts and from research simulations,
- 8 post event survey datasets.

All the datasets are documented in compliance with metadata international standards. Many in situ data have been inserted in a relational database, in order to enable more accurate data selection and download of different datasets in a shared format. Radar datasets and many model outputs have been homogenized and converted into the NetCDF format. All the data can be accessed at <http://mistrals.sedoo.fr/HyMeX>.

The website offers the usual, but user-friendly functionalities: registration procedure, data catalogue, web interface to select and access data... At present, the website counts about 210 registered users and processes more than 60 data requests every month. Every scientist is invited to visit the website, register and use the HyMeX datasets. Do not hesitate to contact databasecontact@hymex.org.

Another website has been designed in order to meet the operational needs for the HyMeX campaigns: <http://sop.hymex.org>. This day-to-day charts and report display website offers a convenient way to browse meteorological conditions and data during the campaign periods.

Integration of satellite data into SURFEX for better monitoring agricultural droughts

Calvet, J.C., Albergel, C., Barbu, A., Carrer, D., Dewaele, H., Fairbairn, D., Leroux, D.J., Mahfouf, J.-F., Munier, S.

CNRM (Meteo-France, CNRS), Toulouse, France.

The LDAS (Land Data Assimilation System) developed by CNRM permits the integration of satellite products into the ISBA Land Surface Model (LSM) using a data assimilation scheme. The obtained reanalysis accounts for the synergies of the various upstream products and provides statistics which can be used to monitor the quality of the assimilated observations. The ISBA generic LSM is able to represent the diurnal cycle of the surface fluxes together with the seasonal, interannual and decadal variability of the vegetation biomass. The LSM is embedded in the open-source SURFEX modeling platform together with a simplified extended Kalman filter. These tools, together with a python chain governing the data flow, form the LDAS.

The current operational version of the LDAS assimilates the European Copernicus Global Land Service (<http://land.copernicus.eu/global/>) LAI and ASCAT surface soil moisture (SSM) products over France (8km x 8km) and over the globe (0.5° x 0.5°).

It is shown that with respect to stand-alone ISBA simulations, drought events are better represented in LDAS analyses. The examples of the 2011 spring drought and of the 2015 summer drought in France are presented.

Drought indicators based on simulated LAI or above-ground biomass can be derived from the LDAS analyses for straw cereals and grasslands. The LDAS analyses are validated using grain yield observations over France. The consistency can be further improved tuning a key model parameter: the maximum available soil water content for plant transpiration (MaxAWC). It is shown that LDAS tuning (minimizing LAI increments in sequential assimilation) is more efficient than inverse modeling (minimizing LAI RMSE).

Ability of the Symphonie model to observe fine-scale dynamics in the North-Western Mediterranean Sea

Carret, A.¹, Birol, F.¹, Estournel, C.²

¹LEGOS/OMP, 14 avenue Edouard Belin, 31400 Toulouse, France. ²LA/OMP, 14 avenue Edouard Belin, 31400 Toulouse, France

The Symphonie model covers the North Western Mediterranean Sea where lots of fine scale structures are observed. It is implemented at 1km resolution and already demonstrated its usefulness when studying ocean dynamics at a wide range of scale. Regional simulations have been improved and new simulations are now available. Symphonie can be a powerful tool in studying oceanic processes, completing the spatio-temporal gaps in satellite altimetry and in situ measurements to obtain a synoptic view of the region, once it has been validated thanks to these data.

Intercomparisons between altimetry data and in situ observations have been made to study the capacity of the model to reproduce structures at different scales. We focused in

particular on the Northern current which follow the French and Spanish coasts and on the ratio between geostrophy and ageostrophy circulation.

The insitu data - symphonie comparisons led to good results in sampling the position and amplitude of the Northern current except in some particular cases. Comparison with Jason 2 altimetry shows greater differences maybe due to the spatio-temporal resolution and to the noise of the measures. However the use of recent technologies with the launch of new generation of satellites (Saral, Sentinel-3) might overcome these issues.

Geostatistical conditional simulation for ensemble rainfall nowcasting: a case study in the Var region

Caseri, A.¹, Ramos, M.H.², Javelle, P.¹, Leblois, E.³

¹IRSTEA, UR OHAX, Aix-en-Provence, France. ²IRSTEA, UR HBAN, Antony, France.

³IRSTEA, UR HHLY, Lyon, France.

Flash floods can be responsible for the loss of human lives and severe economic damages. These events are often difficult to monitor and forecast. This is mainly due to a strong space-time variability and quick evolution of the precipitation systems, as well as a rapid rise in the river water levels. Radar and rainfall data collected in real time can help to better detect the spatial and temporal evolution of rainfall fields and their intensities. However, in order to go beyond the observation in real time and be able to anticipate the risk of flooding, nowcasting techniques to predict scenarios for the near future are necessary. This study proposes a geostatistical conditional simulation framework to generate an ensemble of rainfall scenarios that can be used by a flash flood monitoring and warning system. We seek to generate a reliable ensemble of rain fields by making the best use of the strengths of the measurements often available for nowcasting: the spatial and temporal properties of rainfall fields provided by the radar data and the rainfall intensities measured by rain gauges. Based on 17 rainfall events observed in the Var department (south-east France), we illustrate our approach and evaluate a 30-member nowcasting system by considering the main attributes of forecast quality, such as accuracy, reliability, precision, discrimination and overall forecast performance. The results showed that a method based on the estimation of the parameters of the generator based on a moving window over the last four hours was more efficient than an estimation based on a growing window approach. It was also shown that the adjustment of the parameters of the non-zero rainfall distribution based on the last observed hourly rainfall, followed by the adjustment of the outputs based on the last forecast error, resulted in rainfall forecasts of better quality. Our methodology proved to be a good solution to combine information from radar fields and rain gauges to generate precipitation ensembles able to quantify uncertainties and anticipate risk alerts for flash floods.

The 3rd version of raingauge data in the north-western Mediterranean region for the HyMeX SOPs

Caumont, O., Nuret, M., Bresson, É., Jany, C., Fourrié, N., Ducrocq, V.

CNRM UMR 3589, Toulouse, France.

A joint effort from HyMeX partners has allowed to produce two initial sets of homogenized raingauge data in the north-western Mediterranean region for HyMeX SOPs, which have been available in the HyMeX database. The first data set was released in near-real time. The second one has been released as soon as possible after the field campaigns. The goal was to merge all the available data in a common format to ease their use by researchers. Since the release of these two data sets, additional data have been collected, especially over France, Italy, and Croatia. A 3rd version as thus been released, including these data and some bug fixes.

Like the previous versions, this new version provides 1-, 6-, and 24-h rainfall accumulations from September 1st, 2012, to March 31st, 2013. The main difference in terms of format is that the date of the files now refers to past accumulation instead of future accumulation in the previous data sets. Duplicates (based on latitude and longitude) were removed from the data set. When two stations had the same coordinates, but provided different values, the average was taken. Additional quality control was performed, such as consistency checks among the different accumulation times. When the same station recorded inconsistent accumulations, the data were removed from the data set.

The presentation will summarize the characteristics of this new data set and provide some examples of changes. Data users and providers are invited to provide feedback on this new data set.

Acknowledgements: This work is a contribution to and is supported by the MISTRALS/HyMeX programme. We thank AEMET, DHMZ, DPC, SMC, and Météo-France for providing the data, and SEDOO and ESPRI for making them available to the community.

Improved simulation of damaging Mediterranean precipitation events by the Met Office Europe-wide 2.2-km climate model

Chan, S.C.¹, Kendon, E.J.², Berthou, S.², Fosser, G.², Fowler, H.J.¹

¹Newcastle University, Newcastle-upon-Tyne, NE1 7RU, UK. ²Met Office, Fitzroy Road, Exeter, EX1 3PB, UK.

The Met Office is currently conducting Europe-wide 2.2-km convection-permitting (“explicit-convection”) regional climate simulations, driven by ERA-Interim and HadGEM3 general circulation model simulations. Case studies of damaging Mediterranean storms show that the 2.2-km simulation has much improved orographic precipitation over the Alps, Massif Central, and the Pyrenees relative to the 12-km parameterised-convection simulations. The 12-km simulations tend to have excessive orographic precipitation that “hugs” the windward side of

high orography (e.g. the Alps and the Pyreness), whilst the bias is significantly reduced in the 2.2-km simulation. However, both resolution models struggle to capture a realistic diurnal cycle over a high orography region (e.g. Switzerland).

SAETTA: status on the high resolution lightning detection network in Corsica

**Coquillat, S.¹, Defer, E.¹, Lambert, D.¹, Pinty, J.-P.¹, Pont, V.¹,
Priour, S.¹, Thomas, R.²**

¹LA, UMR CNRS/UPS n°5560, Observatoire Midi-Pyrénées, Toulouse, France. ²New Mexico Tech, Socorro, USA.

Implemented in the frame of the atmospheric observatory CORSiCA, SAETTA (Suivi de l'Activité Electrique Tridimensionnelle Totale de l'Atmosphère) is a network of 12 LMA stations (Lightning Mapping Array, developed by New Mexico Tech, USA) that observes lightning flashes in 3D and real time, at high temporal and spatial resolutions, within a range of about 350 km from the centre of the network. It detects the radiations emitted by cloud discharges in the 60-66 MHz VHF band in passive mode and standalone (solar panel and batteries). Each LMA station samples the signal at high rate within 80- μ s time windows, records data on internal hard disk, and transmits a decimated signal in real-time via the 3G phone network. The decimated data are received on a server that calculates the position of the detected VHF sources by the time-of-arrival method and manages a quasi real-time display on a website. The non decimated data intended for research applications are recovered later on the field. SAETTA initially operated from July 14 to October 15 in 2014 and from 11 April to 1 December in 2015. It is now in permanent operation since 17 April 2016 until at least the end of 2020. It is planned to be operated well beyond 2020 to obtain long-term observations for issues related to climatic trends.

The state of the network and its performance are presented, as well as its evolution over the past 3 years. So far SAETTA has allowed to document the lightning activity from the regional scale to the lightning scale with better performances over and nearby the network (within 120 km from the center of the network). Actually VHF sources are localized with theoretical errors of about 20 meters in the radial direction, 10 meters in the azimuthal direction, and 50 meters in altitude. The network has recently been modified by moving 2 stations to both South and North extremities of the island. The improved communication of the stations via the 3G phone network now allows access to observations in real time. SAETTA may be used in a broad range of scientific topics: physics of discharge; monitoring and simulation of storm systems; climatology of convection in the western Mediterranean; production of nitrogen oxides by lightning; influence of pollution and aerosols on the electrical activity. SAETTA is expected to become a validation tool for space observation of lightning (TARANIS and MTG-LI), but also a key instrument for field campaigns (EXAEDRE in Autumn 2018).

Acknowledgements are addressed to CORSiCA-SAETTA main sponsors (Collectivité Territoriale de Corse through the Fonds Européen de Développement Régional of the European Operational Program 2007-2013 and the Contrat de Plan Etat Région; HyMeX/MISTRALS; Observatoire Midi-Pyrénées; Laboratoire d'Aérodologie) and many individuals and regional institutions in Corsica that host the 12 stations of the network or helped us to find sites.

Synoptic patterns of torrential rainfall in the Muga River Basin (NE Spain) in the Western Mediterranean area

Cordobilla-Cascales, M.J., Martin-Vide, J.

Climatology Group, Water Research Institute (IdRA), University of Barcelona, Montalegre 6, 08001 Barcelona, Spain.

Torrential rainfall constitutes the climatic, and even natural, risk which causes the highest number of victims and damage in Catalonia. This study presents the synoptic patterns of torrential rainfall in the Muga River Basin in the Western Mediterranean area. These circulation patterns were obtained by the use of objective method applying the rules of Jenkinson and Collinson (J&C) to a daily hourly data grid (NCEP/NCAR reanalysis) at sea level pressure (SLP). For our study, the meteorological stations make use of the database Spain02 v4, and days which recorded equal or over 100mm in throughout the period 1971–2010. This work shows the catalogue of synoptic situations that give rise to the torrential rainfall and its statistical analysis. We also correlated the mean monthly value of the Western Mediterranean Oscillation Index (WeMOi) for the synoptic patterns obtained. The results showed a clear association between the negative values of this teleconnection index and the torrential rainfall in the Muga River Basin and in the Western Mediterranean area. Therefore, the WeMO is an essential tool for forecasting heavy rainfall in northeast of Spain. This work has been funded by the WEMOTOR project (CSO2014-55799-C2-1-R, 2015-2017) of the Ministry of Economy and Competitiveness, and by the Climatology Group of the Universitat de Barcelona (UB) (2014 SGR 300, Catalan Government).

Key words: Precipitation, torrential rainfall, climatic risk, synoptic patterns, Jenkinson&Collinson, WeMOi, Western Mediterranean.

Assessing the link between extreme precipitation and urban and peri-urban flood impacts: the case of Barcelona

Cortès, M., Turco, M., Llasat-Botija, M., Llasat, M.C.

GAMA, Dept. of Applied Physics, University of Barcelona, Spain.

Floods are the most critical natural hazard in the world. Consequently, improving mitigation and adaptation strategies to cope with floods has become a key topic in research programs and they are a priority in most government agendas. Yet many uncertainties exist to characterized present and future evolution of floods in Mediterranean urban areas. The study is focused on the Metropolitan Area of Barcelona (AMB), a high densely populated coastal area (5093 inhabitants/km²) with an average of three flood events every year. Floods in this region are usually due to drainage problems and flash floods in torrential catchments, while only few events are river floods. Between 1996 and 2015, AMB was affected for around 60 flood events, three of them causing catastrophic impacts. For this period, the Spanish public reinsurance (Insurance Compensation Consortium, CCS) has paid more than 86 million of euros in compensations for flooding.

The role played by the extremes precipitation is crucial to better understand the flood events in urban regions like AMB. The main objective of this contribution is to assess the relationship

between precipitation and the flood damage produced in this area. To this end, three different observable measures of precipitation are analyzed and correlated with the economics losses: 30-minute intensity, 24 h precipitation and total precipitation accumulated during the event. Precipitation data has been provided by the Meteorological Service of Catalonia (Servei Meteorològic de Catalunya, SMC) and the State Meteorological Agency of Spain (Agencia Estatal de Meteorología, AEMET). It has been found that the best observable measure of precipitation for assessing the damage produced by flood events in the AMB is the intensity, confirming the importance of the heavy and local precipitation in this area. This approach allows damages to be linked to the key precipitation drivers. The developed regression model appears to be promising for supporting flood risk management strategies.

This work has been developed in the framework of the Spanish project HOPE (CGL2014-52571-R).

A stochastic approach for the estimation of the occurrence probabilities of severe dry and wet events: an application in Southern Italy

Coscarelli, R.¹, Caloiero, T.², Ferrari, E.³, Sirangelo, B.⁴

¹National Research Council, Research Institute for Geo-Hydrological Protection (CNR-IRPI), Rende (Cs), Italy. ²National Research Council, Institute for Agricultural and Forest Systems in Mediterranean (CNR-ISAFOM), Rende (CS), Italy. ³Department of Computer Engineering, Modeling, Electronics, and Systems Science (DIMES), Rende (CS), Italy. ⁴University of Calabria, Department of Environmental and Chemical Engineering (DIATIC), Rende (CS), Italy.

The limited number of very wet or dry events in the historical rainfall series make it difficult to estimate their occurrence probabilities. For this reason, the scientists have to resort to stochastic models, by assuming a given structure of the underlying hydrological series. In this study, a stochastic procedure for modeling monthly data was applied to rainfall series registered in five regions of southern Italy (Campania, Apulia, Basilicata, Calabria and Sicily regions). The model adopts an autoregressive process for the residual correlative structure of monthly rainfall data, previously normalized and deseasonalised. Through a Monte Carlo technique, based on the proposed model, synthetic data were generated for each rain gauge. Then, extreme dry and wet periods and their occurrence frequencies were estimated at various time scales by applying the Standardized Precipitation Index (SPI) to the synthetic data. The results clearly show greater probabilities of dry conditions than wet conditions. These outcomes are more evident when long time scales are considered.

Analysis of the 12 October 2016 flash-floods in Maresme, Catalonia

Cuevas, G., Pascual, R.

AEMET. Delegación Territorial en Cataluña, C/Arquitecte sert, 1, 08005 Barcelona, Spain.

During 12-13 October 2016, an event of heavy and generalised rain took place all over the Iberian Peninsula. A cold front, associated with a cold low centred on the north-west of Portugal, crossed the Peninsula followed by two post-frontal instability lines. The passage of these frontal structures gave rise to persistent and occasionally strong downpours at many points of the territory. Previous to the cold front passage, the confluence of different fluxes with a trajectory over the Mediterranean formed a low level jet (LLJ) and an instability line that went across the Catalan coast during Wednesday 12th. This line originated a thunderstorm with very heavy showers, even torrential rain, which persisted at some points of the Maresme region (located in the northern coast of Barcelona province), accumulating more than 200 mm/m² at several points in less than 4 hours. This very intense rain caused traffic and railroad cuts, power outage and loss of cars parked at watercourses and, unfortunately, a man died trapped in his car at an underpass.

Highly convective episodes usually occur in summer and the beginning of autumn in the western Mediterranean. In Catalonia, autumn concentrates the highest flood-event occurrence. These events are generally short-lived and can lead to sudden swelling of rivers in the Pyrenees and in coastal streams. Catalan coastal regions are the most affected by flash-flood events and, in particular, the Maresme is the most impacted area as well as one of the most populated. As a consequence, the natural risk associated to this phenomenon is very high.

This study presents an in-depth analysis of the synoptic and mesoscale framework of this episode by the exploration of satellite and radar imagery, NWP outputs fields, conventional observations. The phenomenology and impacts of the event are also reviewed through media information analysis. A discussion on the accuracy of general forecasts and weather warnings issued by AEMET, the Spanish National Weather Service, is also held.

Explicit numerical forecasting of lightning activity in Greece

Dafis, S.¹, Giannaros, T.M.¹, Kotroni, V.¹, Lagouvardos, K.¹, Fierro, A.², Mansell, T.³

¹National Observatory of Athens, Institute for Environmental Research and Sustainable Development, Vas. Pavlou & Metaxa, 15236 Athens, Greece. ²Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, and NOAA/OAR/National Severe Storms Laboratory, Norman, Oklahoma. ³NOAA/OAR/National Severe Storms Laboratory, Norman, Oklahoma.

In the present study, the implementation of explicit electrification and lightning parameterizations within the Weather Research and Forecasting model (WRF) is evaluated. Convection-allowing model simulations for 10 single-day case studies over the Eastern Mediterranean are compared against lightning observations of ZEUS lightning detection

system. These case studies are chosen as they were characterized by widespread precipitation and lightning activity both over the sea and continental Greece, between 2010 and 2013. Overall, simulated flash origin density is in a good agreement with observations, however, most of the lightning activity over the sea is rather poorly simulated by the model. In general, results show that the WRF model could be used for real-time lightning prediction applications, at convection permitting kilometer scale resolution.

Future evolution of marine heat waves in the mediterranean: Coupled regional climate projections

Darmaraki, S.¹, Somot, S.¹, Sevault, F.¹, Nabat, P.¹, Sannino, G.², Djurdjevic, V.³, Li, L.⁴, Cavicchia, L.⁵, William, C.⁶, Sein, D.⁶, Bensoussan, N.⁷, Bensi, M.⁸, Cardi, V.⁸, Siena, G.⁸, Dunic, N.⁹, Garrabou, J.¹⁰, Vassilios, V.¹¹

¹Meteo France, Toulouse, France. ²ENEA, Rome, Italy. ³Univ. of Belgrad, Belgrad, Serbia. ⁴LMD, Paris, France. ⁵CMCC, Bologna, Italy. ⁶Univ. of Alcala, Madrid, Spain. ⁷IPSO FACTO, Marseille, France ⁸OGS, Trieste, Italy. ⁹Institute of Oceanography and Fisheries, Split, Croatia. ¹⁰ICM, Barcelona, Spain. ¹¹Ocean Physics and Modeling Group, National and Kapodistrian University of Athens, Athens, Greece.

The Mediterranean area is identified as a « Hot Spot » region, vulnerable to future climate change with potentially strong impacts over the sea. By 2100, climate models predict increased warming over the sea surface with possible implications on the Mediterranean thermohaline and surface circulation, associated also with severe impacts on the ecosystems (e.g. fish habitat loss, species extinction and migration, invasive species). However, a robust assessment of the future evolution of the extreme marine temperatures occurred under the anthropogenic pressure, remains still an open issue of primary importance. In this context, we study here the probability and characteristics of marine heat wave (MHW) occurrence in the Mediterranean Sea by means of future climate projections. To this end, we use an ensemble of fully coupled regional climate system models from the Med-CORDEX (COordinated Regional climate Downscaling Experiment) initiative. This multi-model approach includes a high-resolution representation of the atmospheric, land and ocean component, with a free air-sea interface. Specifically, dedicated simulations for the 20th and the 21st century are carried out with respect to the different IPCC-AR5 socioeconomic scenarios (1950-2100, RCP8.5, RCP4.5, RCP2.6). Model evaluation for the historical period is performed using satellite and in situ data. Finally, the spatial variability and temporal evolution of MHW are analyzed on an annual basis, along with additional integrated indicators (e.g. duration, intensity), that can be important for marine ecosystems functions.

Introducing the EXAEDRE (EXploiting new Atmospheric Electricity Data for Research and the Environment) project

Defer, E.¹, Coquillat, S.¹, Lambert, D.¹, Pinty, J.-P.¹, Prieur, S.¹, Caumont, O.², Labatut, L.², Blanchet, P.³, Buguet, M.³, Lalande, P.³, Labrousche, G.⁴, Pedeboy, S.⁵, Lojou, J.-Y.⁶, Schwarzenboeck, A.⁷, Delanoë, J.⁸, Bourdon, A.⁹

¹Laboratoire d'Aérodologie, Toulouse, France. ²CNRM, Toulouse, France. ³ONERA, Chatillon, France. ⁴CIELE Ingénierie, Créteil, France. ⁵Météorage, Pau, France. ⁶[IS]2, Marseille, France. ⁷LaMP, Aubière, France. ⁸LATMOS, Guyancourt. ⁹SAFIRE, Cugnaux, France.

The EXAEDRE (EXploiting new Atmospheric Electricity Data for Research and the Environment) project aims at consolidating the activities, which started during the HyMeX (HYdrological cycle in the Mediterranean EXperiment) field campaign by the French community on the research and operational exploitation of both observations and numerical simulations in relation with atmospheric electricity. The EXAEDRE activities rely on innovative multi-disciplinary and state of the art instrumentation and modelling tools to provide a comprehensive description of the electrical activity in thunderstorms.

The EXAEDRE observational part is based on i) existing lightning data collected during HyMeX Special Observation Period (SOP1), and permanent lightning observations provided by the research SAETTA (see Coquillat et al., this conference) and the operational Météorage lightning locating systems, ii) new lightning observations mapped with a brand new VHF interferometer especially developed within the EXAEDRE project, iii) a dedicated field campaign over Corsica (see Defer et al., this conference).

The modelling part of the EXAEDRE project relies on the electrification and lightning schemes developed in the French cloud resolving model MésoNH (see Pinty et al., this conference) and on the Météo-France operational model AROME for innovative investigation of lightning data assimilation (see Caumont et al. this conference).

Through its rather comprehensive observational and modelling approach, the EXAEDRE project will improve our knowledge on lightning physics and on the links between lightning occurrence, electrification, dynamics and microphysics. An overview of the EXAEDRE project will be given with an emphasis on the activities performed during the 1st year of the project.

Acknowledgements: The EXAEDRE project is sponsored by grant ANR-16-CE04-0005 with support from the MISTRALS/HyMeX program.

A first glance on the field campaign of the EXAEDRE (EXploiting new Atmospheric Electricity Data for Research and the Environment) project

Defer, E.¹, Coquillat, S.¹, Lambert, D.¹, Pinty, J.-P.¹, Prieur, S.¹, Caumont, O.², Labatut, L.², Blanchet, P.³, Buguet, M.³, Lalande, P.³, Labrousche, G.⁴, Pedeboy, S.⁵, Lojou, J.-Y.⁶, Schwarzenboeck, A.⁷, Delanoë, J.⁸, Bourdon, A.⁹

¹Laboratoire d'Aérodologie, Toulouse, France. ²CNRM, Toulouse, France. ³ONERA, Chatillon, France. ⁴CIELE Ingénierie, Créteil, France. ⁵Météorage, Pau, France. ⁶[IS]2, Marseille, France. ⁷LaMP, Aubière, France. ⁸LATMOS, Guyancourt. ⁹SAFIRE, Cugnaux, France.

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The EXAEDRE field campaign will rely on ground-based lightning location detection (SAETTA, Météorage, interferometer), a suite of ground-based instruments sensitive to lightning component properties and cloud electrification, the new airborne electric field mills AMPERA, a suite of airborne microphysics probes PMA and the airborne 95 GHz Doppler cloud radar RASTA onboard the French Falcon research aircraft, and operational weather radar and satellite imagers. Implementation of additional airborne instruments is being currently studied. The HyMeX community is welcome to contribute to the EXAEDRE field campaign.

The first version of the Instrumentation Implementation Plan will be presented. Preliminary flight plans will also be discussed. Potential contributions of the HyMeX community will also be suggested.

Acknowledgements: The EXAEDRE project is sponsored by grant ANR-16-CE04-0005 with support from the MISTRALS/HyMeX program.

The 12th October 2016 Maresme flash-floods: a radar-based analysis

del Moral, A.¹, Cortès, M.¹, Llasat, M.C.¹, Rigo, T.²

¹GAMA, Dept. of Applied Physics, University of Barcelona, Barcelona, Spain. ²Meteorological Service of Catalonia, Barcelona, Spain.

Floods are the main natural hazard in the world (UNISDR, 2009). According to INUNCAT, the Civil Protection Plan on Flood Risk in Catalonia (DGPC, 2012), more than 40 % of municipalities in Catalonia (NE of Spain) present a high flood risk (Llasat et al., 2014). The major part of them are located on the central coast of Catalonia, a region characterised by a great vulnerability and exposure due to the concentration of more than 50% of the population (that increases in summer) and the most important communication routes. These floods, usually flash-floods, are produced by heavy and local convective precipitation, mainly from stationary thunderstorms during summer season and early autumn, affecting short torrential and non-permanent streams that cross urban areas, and which are increasing in the recent times (Llasat et al., 2016). One of the most important tools for flash flood forecasting is the nowcasting of convective cells using weather radar. The knowledge of the precipitation intensity, the vertical structure, and the short-range forecasting of the future cells trajectories throughout their life cycle, are vital for understanding the effects that can occur in flood prone areas. In the last decades, there have been published several nowcasting techniques for studying the life cycle of thunderstorms (Dixon and Weiner, 1993; Johnson et al., 1998; Handwerker 2002; Han et al., 2009). However, the previous identification techniques of the cells of interest are restrictive and can led to an erroneous identification. This is the case of cells embedded in a unique precipitating structure, in which a correct evaluation of the evolution of cells throughout time is not possible.

The work presented here shows the study of the convective cells that caused the flash floods of the 12th October 2016 in the Maresme County (central coast). During this event, it was registered one death, important affectations and economic loses. These were produced because of the sudden and local precipitation of more than 200 mm during the episode and the associated floods due to drainage problems. The analysis has been made by means of a variant of the 3D identification of convective cells proposed by Rigo and Llasat (2005). The new methodology presents an adjustment of the reflectivity and extension thresholds in order to redefine the convective cells. The modification of the way in which the 3D cells are constructed helps to identify possible changing processes within the same thunderstorm. This work has been developed in the framework of the HYMEX project and sponsored by the Spanish project HOPE (CGL2014-52571- R).

Rain/snow radar remote sensing with two X-band radars operating over an altitude gradient in the French Alps

Delrieu, G.¹, Kremer, S.¹, Cazenave, F.¹, Yu, N.², Boudevillain, B.¹, Faure, D.², Gaussiat, N.²

¹Institut des Géosciences de l'Environnement, Grenoble, France. ²Centre de Météorologie Radar, Toulouse, France.

Operating weather radars in high-mountain regions faces the following well-known dilemma: (1) installing radar on top of mountains allows for the detection of severe summer convective events over 360° but may give poor QPE performance during a very significant part of the year when the 0°C isotherm is located below or close to the radar altitude; (2) installing radar at lower altitudes may lead to better QPE over sensitive areas such as cities located in valleys, but at the cost of reduced visibility and detection capability in other geographical sectors. We have the opportunity to study this question in detail in the region of Grenoble (an Alpine city of 500 000 inhabitants with an average altitude of 210 m asl) with a pair of X-band polarimetric weather radars operated respectively by Meteo-France on top of Mount Moucherotte (1920

m asl) and by IGE on the Grenoble Campus (213 m asl). The XPORT radar (IGE) performs a combination of PPIs at elevations of 3.5, 7.5, 15 and 25° complemented by two RHIs in the vertical plane passing by the two radar sites, in order to document the 4D precipitation variability within the Grenoble intermountain valley. In the proposed communication, preliminary results of this experiment (started in September 2016) will be presented with highlights on (1) the calibration of the two radar systems, (2) the characterization of the melting layer during significant precipitation events (>5mm/day) occurring in autumn, winter and spring; (3) the simulation of the relative effects of attenuation and non-uniform beam filling at X-band and (4) the possibility to use the mountain returns for quantifying the attenuation by the rain and the melting layer.

Water vapour mixing ratio and temperature intercomparison effort in framework of HyMeX SOP1

Di Girolamo, P.¹, Flamant, C.², De Rosa, B.¹, Summa, D.¹, Bousquet, O.³, Chazette, P.⁴, Totems, J.⁴, Cacciani, M.⁵, Stelitano, D.¹

¹Scuola di Ingegneria, Università degli Studi della Basilicata, Potenza, Italy. ²LATMOS/IPSL, UPMC Univ. Paris 06 Sorbonne Universités, UVSQ, CNRS, Paris, France. ³Météo-France & Laboratoire de l'Atmosphère et des Cyclones, DIROI / CRC, Sainte Clotilde Cedex, France. ⁴Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS-UVSQ, Gif-sur-Yvette, France. ⁵Dipartimento di Fisica, Università di Roma "La Sapienza", Roma, Italy.

This paper reports the results of a water vapour and temperature inter-comparison effort which took place in the framework of the first Special Observing Period of the Hydrological cycle in the Mediterranean Experiment, involving the ground-based Raman lidar BASIL (deployed in Cévennes-Vivarais Atmospheric Supersite located in Candillargues), the airborne water vapour differential absorption lidar LEANDRE 2 flying on board the ATR42, as well as additional ground-based water vapour sensors on-site (radiosondes and a microwave radiometer) and aircraft in-situ sensors. The main objective of this inter-comparison is providing accurate error estimates for these sensors for both water vapour and temperature measurements. This effort benefits from the dedicated ATR42 flights in the frame of the EUFAR Project "WaLiTemp". Additional comparisons between LEANDRE 2, the in-situ humidity and temperature sensors, BASIL, radiosondes and the microwave radiometer were often possible also during the aircraft ascending and descending phases in the proximity of the Montpellier airport, shortly after take-off or before landing, respectively. Our attention was also focused on the water vapour inter-comparison between BASIL and the Raman lidar WALI, which took place in Candillargues on 30 October 2012, when WALI was temporarily deployed in Candillargues. Based on the available dataset and benefiting from the circumstance that BASIL could be compared with all other sensors, the absolute bias of all sensors with respect to the mean value could also be estimated. The intercomparison approach and the results will be illustrated and discussed in detail at the Workshop.

Space-borne profiling of atmospheric thermodynamic variables with Raman lidar: an opportunity in the frame of the Revised Earth Explorer-9 Call

Di Girolamo, P.¹, Wulfmeyer, V.², Behrendt, A.², Flamant, C.³, Comerón, A.⁴, Richard, E.⁵, Saunders, R.⁶, Schmid, H. P.⁷

¹Scuola di Ingegneria, Università degli Studi della Basilicata, Potenza, Italy. ²University of Hohenheim, Stuttgart, Germany. ³Sorbonne Univ., Paris, France. ⁴Universitat Politècnica de Catalunya, Barcelona, Spain. ⁵Laboratoire d'Aérodynamique, Université de Toulouse - CNRS, Toulouse, France. ⁶Met Office, Exeter, United Kingdom. ⁷Karlsruhe Institute of Technology, Garmisch-Partenkirchen, Germany.

Implemented the performance of a space-borne water vapour and temperature Raman lidar has been simulated, with a specific attention to the Earth Explorer Missions in the frame of ESA's Living Planet Program. We report simulations under a variety of atmospheric scenarios, demonstrating the capability of a space Raman lidar to provide global-scale water vapour and temperature measurements in the troposphere with an accuracy fulfilling most observational requirements for NWP and climate research.

Offshore dynamics of the mistral during the HyMeX SOP2

Drobinski, P.¹, Alonzo, B.¹, Basdevant, C.¹, Cocquerez, P.², Doerenbecher, A.³, Fourrié, N.³, Nuret, M.³

¹LMD/IPSL, Ecole polytechnique, Université Paris-Saclay, Sorbonne Universités, UPMC Univ. Paris 06, CNRS, Palaiseau, France. ²CNES, Toulouse, France. ³CNRM/GAME, CNRS and Météo-France, Toulouse, France.

The mistral refers to a severe wind blowing over the Gulf of Lions after being channeled in the Rhone valley. It influences the western Mediterranean climate as it brings cold and dry continental air over the warm western Mediterranean, generating intense air-sea heat exchanges and sea surface cooling, inducing the formation of the western Mediterranean deep water that moves into the Atlantic Ocean. The mistral is frequently observed to extend as far as a few hundred kilometers from the coast, and its fine-scale dynamics over the sea is still only partially understood as finely resolved observations in time and space are lacking. The boundary layer pressurized balloons (BLPB) developed by the Centre National d'Etudes Spatiales and deployed during HyMeX SOP2 allowed the Lagrangian documentation of the mistral events that occurred between beginning of February to mid-March 2013. Analyzed in synergy with the AROME-WMED weather forecast model, all the terms of the Lagrangian formulation of the momentum conservation equation could be quantified showing three different regions: (1) an injection zone where the mistral flow is directed toward the center of the Genoa cyclone due to a strong zonal pressure gradient, enhanced friction, and entrainment in the mountain wake; (2) an ejection zone where the flow is deflected outward of the cyclone due to either the non-negligible inertia pseudo-force or an inertial oscillation caused by a sudden friction decrease; and (3) a region of geostrophic deceleration due to the weakening of the pressure gradient.

Integration of nitrate aerosols into the CNRM regional climate system model and estimation of their radiative forcing over the Mediterranean region

Drugé, T., Nabat, P., Mallet, M., Somot, S.

CNRM, 42 Avenue Gaspard Coriolis, Toulouse, France.

The Mediterranean region is subject to high aerosol loads, from both anthropogenic and natural sources. Because of their optical and microphysical properties, aerosols play an important role in the Mediterranean climate system. Indeed, they interact with radiation and clouds and they provoke a negative radiative forcing at the surface with ensuing cooling and decrease in the activity of the hydrological cycle. However the role of aerosols in regional climate projections has been less explored than in past climate variability.

In order to estimate the role of aerosols on the future climate we use the CNRM-RCSM6 model, which is a coupled regional aerosol-atmosphere-ocean model. Its atmospheric model, namely ALADIN-Climate, incorporates a prognostic aerosol scheme (TACTIC), including already desert dust, sea salt, organic, black carbon and sulphate particles, but not the ammonium and nitrate aerosols, whose contribution to aerosol radiative forcing is expected to increase up to the end of the 21st century. That is the reason why we have recently added a new module in TACTIC, adapted from the LMDz-INCA module (Hauglustaine et al., 2014) to represent these types of aerosols.

The aim of this study is to evaluate (Aerosol optical Depth, surface concentration, vertical profile) this new ammonium-nitrate scheme, as well as their direct radiative forcing over the Mediterranean. The methodology is based on two parallel simulations of ten years (2005-2014), which have been realized using the atmospheric model of CNRM-RCSM, including or not the ammonium-nitrate aerosol module.

Observation of a turbulent mesoscale organization during the mature (“stratiform”) stage of some intense precipitation systems. Case of the MCS observed during the 2012 HyMEX experiment.

Duroure, C., Banson, S., Baray, J.L., Planche, C., Van Baelen, J.

CNRS, UMR6016, LaMP/OPGC, BP80026 Aubière, France.

In mid-latitude regions, as in the north Mediterranean region, intense rain events are frequent and explained as a product of a mesoscale convective system (MCS). These events are quite well predicted by meteorological models but some of the extreme rain events seem to be underestimated by the models. It is an open question, due to the difficulty to parametrize the convection process, especially if a 3D mesoscale organization is created using the deep convection kinetic energy of a field of isolated deep convection updrafts.

So, it is important to make statistical observations of the scaling properties for the normal, rare and extreme rain events using long time series of various rain measurements.

The data used for these statistical studies are extracted from the HyMEX database of the 2012 intensive experiment.

1. Three months of radar rain images (1 km horizontal scale and 5 minutes time scale) for two radars of the Météo France ARAMIS network.
2. Ten years of the pluviometers network (6 minutes time scale) for six sites in the same region.
3. Aircraft in-situ measurement of precipitating hydrometeors (20000 km of linear aircraft sampling with 2 km space scale, during the intensive observation period, september-november 2012).

Three different statistical methods are compared to detect a 3D turbulent signature in this rain data set. All of these are based on the detection of the extended inertial range, i.e. the observed scaling behavior for scales much larger than the vertical scale of deep convection: the Fourier spectrum, the morphological spectra (i.e. the probability distribution of the size of rain and drought event sizes) and the fractal dimension of rain regions (using box-counting and correlation algorithms)).

To estimate the Fourier density energy spectrum and detect the scaling inertial range, we compare the classical 2D Fourier spectra ring averaged (Ricard et al., QJMRS,2013) and a 1D “zigzag sampling” Fourier estimation, which is much less time consuming and presents very similar results for the rain radar images.

For three of the eight intense MCS observed, the three methods showed that after a local deep convection organization (without mesoscale scaling) appears a non classical “stratiform” mature stage with a mesoscale scaling range (few hundreds of km, more than six hours time scale). These observations cannot be explained with a succession of local deep convection updrafts events and imply 3D convective cascading organization (mesoscale turbulence).

Furthermore, the 1D Fourier and morphological spectra of long time series of pluviometer follow well a scaling transition (around 10km, 100 minutes scales). For smaller scale (“convective range”) the rain process is close to 1/F process possibly due to the microphysical growth processes in rain regions. For larger scales (“mesoscale range”), from 10km to several hundreds of km, the Fourier slope is larger than -1. For all the sites, the transition between these two ranges is quite clear, and some sites presents a “convective peak” for this transition scale.

The difference between the observed scaling behavior of nearly isolated deep convection MCS cases and mesoscale organized MCS cases are compared to the results of ECMWF ERA reanalysis and simulations results obtained with the WRF mesoscale models in the same situations.

On the impact of lightning data assimilation on the (short-term) precipitation forecast

**Federico, S.¹, Petracca, M.¹, Panegrossi, G.¹, Transerici, C.¹,
Torcasio, R.C.², Dietrich, S.¹**

¹ISAC-CNR UOS of Rome, via del Fosso del Cavaliere 100, Rome, Italy. ²ISAC-CNR UOS of Lamezia Terme, zona industriale comparto 15, Lamezia Terme (CZ), Italy.

Aerosols Continuous advances in computing power have made the regional atmospheric forecast available at convection-permitting scales (Δx 4km) worldwide. The adoption of these high horizontal resolutions paves the assimilation of convective scale observations, and alleviates the need of a cumulus parameterization scheme (CPS).

Lightning offers several advantages for the assimilation at the convective scale, because of their ability to locate precisely the convection, availability with few temporal gaps, long-range detection over the oceans and beyond the radars (Mansell et al., 2007). Several techniques have been developed in the last two decades to assimilate lightning both at non convection-permitting ($\Delta x > 4\text{km}$; Alexander et al. 1999; Chang et al., 2001; Papadopoulos et al., 2005; Mansell et al., 2007; Giannaros et al., 2016) and convection-permitting scales (Fierro et al., 2012; Qie et al. 2014; Federico et al., 2016; Dixon et al., 2016).

The studies at non convection-permitting scale demonstrate the positive impact of the lightning data assimilation not only on large-scale fields, as the sea-level pressure, but also on the precipitation. On the other hand, lightning data assimilation at convection-permitting scale has shown a positive impact on the precipitation forecast at different time ranges (from 1 h to 24 h).

This study investigates this point, i.e. the impact of the lightning data assimilation on the precipitation forecast at different forecast ranges. Lightning data are provided by LINET (Betz et al., 2009). This network has more than 550 sensors worldwide and is expanding. LINET has a very good performance for both precision and efficiency over Europe. The assimilation methodology of Federico et al. (2016) is used to evaluate the impact of total lightning data assimilation on the precipitation forecast at 3h, 6h, 12h and 24 h. The performance is evaluated considering twenty cases occurred over Italy in fall 2012, during the HyMeX-SOP1, using a dense raingauge network to verify the precipitation forecast. The impact of the model horizontal resolution is also considered. More in detail, two sets of simulations, referring to the twenty cases occurred in HyMeX-SOP1, at 4 km and 2.5 km horizontal resolutions are compared to show the impact of the horizontal resolution on the precipitation forecast.

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Impact of observation datasets in the AROME-WMED reanalysis

Fourrié, N.¹, Nuret, M.¹, Brousseau, P.¹, Doerenbecher, A.¹, Bénichou, H.², Moll, P.¹, Wattrelot, E.¹, Bock, O.³, Caumont, O.¹, Chazette, P.⁴, Di Girolamo, P.⁵, Flamant, C.⁶, Richard, E.⁷, Saïd, F.⁷

¹CNRM, Toulouse, France. ²Météo-France DirOP, Toulouse, France. ³LAREG IGN, Paris, France. ⁴LSCE 91191Gif sur Yvette Cedex, France. ⁵Scuola di Ingegneria, Università degli Studi della Basilicata, Potenza, Italy. ⁶LATMOS, Paris, France. ⁷LA, Toulouse, France.

A second reanalysis of the SOP1 has been run with several datasets corresponding either to reprocessed data (e. g. wind profiler, GPS, high resolution radiosoundings) or to new assimilated data types (Spanish radars, ground-based and airborne lidar data). In this poster the impact of these datasets on the quality of the forecast is obtained through denial experiments in which each dataset has been removed from the assimilation. Numerical experiments without i) reprocessed GPS data, ii) high resolution radiosoundings, iii) Spanish radar data and iv) lidar data have been carried out. Thereafter, the numerical experiments are compared with the second reanalysis of HyMeX SOP1 to quantify the impact of the various observation types.

The second AROME-WMED reanalysis of SOP1

Fourrié, N.¹, Nuret, M.¹, Brousseau, P.¹, Doerenbecher, A.¹, Bénichou, H.², Moll, P.¹, Wattrelot, E.¹, Bock, O.³, Caumont, O.¹, Chazette, P.⁴, Di Girolamo, P.⁵, Flamant, C.⁶, Richard, E.⁷, Saïd, F.⁷

¹CNRM, Toulouse, France. ²Météo-France DirOP, Toulouse, France. ³LAREG IGN, Paris, France. ⁴LSCE 91191Gif sur Yvette Cedex, France. ⁵Scuola di Ingegneria, Università degli Studi della Basilicata, Potenza, Italy. ⁶LATMOS, Paris, France. ⁷LA, Toulouse, France.

The two special observation periods of the Hydrological cycle in the Mediterranean experiment (HyMeX) took place during autumn 2012 (SOP1) and winter 2013 (SOP2) and aimed at studying the key processes of the water cycle. AROME-WMED (Fourrié et al, 2015) is a HyMeX-dedicated version of the mesoscale AROME-France model, developed at CNRM since 2008. AROME-WMED covers the western Mediterranean basin and provided the HyMeX operational centre with real time analyses and forecasts produced on a daily basis. These products allowed precise decision-making on the field campaign observation deployment.

A first reanalysis of the SOP1 has been carried out just after the experimental campaign with AROME-WMED using an upgraded version of the model with respect to the real-time one, thus accounting for a few more observations.

But a second reanalysis of the SOP1 has been built. A new orography is used. Dedicated background errors have been specifically computed over the SOP1 period and used in this new version. Thanks to the vast improvement in terms of several dataset reprocessing (wind profiler, GPS, high resolution radiosoundings, bias correction schemes) and assimilated data (Spanish radars, ground and airborne lidar data), a positive impact is expected. The presentation will detail the different components of the full reanalysis and the improvements in terms of analysis and forecast quality with respect to the real-time version and the first reanalysis will be illustrated with global scores and case study.

On the relationship between precipitation and lightning activity in South-East France during the HyMeX SOP1 campaign

Ghilain, S.¹, Coquillat, S.¹, Defer, E.¹, Lambert, D.¹, Pinty, J.-P.¹, Prieur, S.¹, Pedeboy, S.¹, Schulz, W.², Caumont, O.³, Labatut, L.³, Rison, W.⁴, Krehbiel, P.⁴, Thomas, R.⁴, Boudevillain, B.⁵, Molinié, G.⁵, Berne, A.⁶, Van Baelen, J.⁷

¹LA, Toulouse. ²OVE. ³CNRM, Toulouse. ⁴NMT. ⁵LTHE. ⁶EPFL. ⁷LaMP.

A thunderstorm is a complex phenomenon where dynamical, microphysical and electrical processes interact. Amongst these different processes, precipitation and lightning were documented during the HyMeX SOP1 campaign over South-East of France. Indeed precipitation field and properties were measured with rain gauges, disdrometers, and active remote sensing instruments like Météo-France operational weather radars, X-band EPFL and LaMP research radars and micro rain radars (MRR) (Bousquet et al., BAMS, 2015). The total lightning activity, i.e. intracloud and cloud-to-ground flashes, was documented thanks to HyLMA (HyMeX Lightning Mapping Array) and EUCLID (Defer et al., AMT, 2015; Schulz et al., NHESS, 2016; Poelman et al., NHESS, 2016).

Different methodologies have been developed to merge the lightning and precipitation datasets based on temporal and spatial criteria. A statistical approach has been first applied to characterize the relationship between lightning and precipitation using all available data collected over South-East of France during the entire SOP1 period. A second approach focusing on the study of spatial and temporal evolution of the precipitation and the lightning activity has been followed with for some cases the use of local disdrometer and MRR observations.

First the different datasets used in the present analysis will be presented. The different methodologies used to combine the observations will also be discussed. The main results of the study will then be presented with an emphasis on the properties of the lightning activity according to the type and intensity of the precipitation and the stage of convection. Finally we will conclude on the relevance of the total lightning activity as a rainfall proxy.

Flood risk assesment from local climate zones cartography. Application to Barcelona (Spain)

Gilabert, J.^{1,2}, Llasat, M.C.¹, Tardà, A.², Corbera, J.², Aznar, B.³

¹GAMA, Dept. of Applied Physics, University of Barcelona, Spain. ²Institute Cartographic and Geological of Catalonia, Spain. ³Barcelona Cicle de l'Aigua (BCASA), Spain.

Floods constitute the main natural hazard in the world (UNISDR, 2015). The socioeconomic damages are chiefly important in urban and peri-urban areas where the degree of exposure and vulnerability is significantly high. Cases such as the flash floods of November 4, 2011 in Genoa, which produced 19 people dead (Silvestro, 2012), or the floods between May and June of 2010 in Central Europe, which damaged many cities in eight different countries, constitutes as a good example. The dynamics of floods and their impacts are linked with land cover and land use, orography, etc., which in the case of cities is closely related to urban planning.

Urban areas constitute an ecosystem where climate trends are having, and will continue to have, big impact in the short, medium, and long term. Climate change in cities is more pronounced than global climate change specifically in the Mediterranean basin, mainly due to the addition of the heat island effect. The new classification proposed by Stewart and Oke (2012) named Local Climate Zones (LCZ) constitutes a standardization and generalization of urban and rural areas that have similar thermal characteristics.

Besides the LCZ includes thermal and radiative properties it is noteworthy physical properties about geometric and surface cover (pervious and impervious surface, terrain roughness, building heights or building density). These last parameters can be a great support for the studies of flood risk assessment.

In the present study it has been done a flood risk analysis through a superposition of floodplain maps for different return periods using LCZ as a reference layer. The study focuses on Barcelona and its surroundings and keep in mind the changes of the LCZ over time. The aim is to improve the estimation of urban and peri-urban vulnerability in front of flood events.

RegCM4 nonhydrostatic simulation over the CORDEX FPS Convection domain

Güttler, I.¹, Giuliani, G.², Coppola, E.², Giorgi, F.²

¹Meteorological and Hydrological Service (DHMZ), Zagreb, Croatia. ²Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy.

Applicability of the regional climate model RegCM4 was recently extended to the 1 km - 10 km range of the horizontal resolutions. We will present results of the RegCM4 model applying newly implemented (1) nonhydrostatic dynamical core and (2) cloud microphysics. In this setup, RegCM4 both hydrostatic and nonhydrostatic versions at the 3 km grid spacing over the CORDEX FPS Convection domain are nested into RegCM4 hydrostatic 12.5 km simulation over the EURO-CORDEX domain and forced by the ERA-Interim reanalysis. First, sensitivity study related to the dynamical core, cloud microphysics and vertical resolution will be summarized. Second, 1-year simulation over the CORDEX FPS Convection domain will be examined in comparison to EURO4M-APGD gridded observational product, SYNOP

surface observations and radiosounding vertical profiles. Results of this study are basis for 10-year simulations planned in the scope of the CORDEX FPS Convection.

Drop Size Distribution climatology in the Cevennes-Vivarais region, France

Hachani, S.^{1,2}, Boudevillain, B.¹, Bargaoui, Z.², Delrieu, G.¹

¹Université Grenoble Alpes, CNRS, IGE, Grenoble, France. ²Université Tunis El Manar, ENIT, LMHE, Tunis, Tunisia.

Climatology of DSD was studied during several years on a Mediterranean region in the framework of the HyMeX (Hydrological Cycle in the Mediterranean Experiment, <http://www.hymex.org/>) project. The objective is to analyze the influence of weather type, season, precipitation type, localization (related to altitude and/or mountainous environment and/or proximity of the sea) on the mean values and the variability of some DSD parameters (concentration, characteristic drop diameter, distribution shape) as well as on Z-R relationships. The analysis was performed on the basis of 4 years (2011-2015) of recordings on a network of 10 disdrometers located throughout the French Mediterranean region of Cévennes and Vivarais. The dataset was expanded during the Special Observation Period (2012 and 2013 fall season) with 8 other disdrometers deployed by EPFL on the same region as well as 2 others located in South French Alps and North-Eastern Tunisia since 2014 and 2015 respectively. All disdrometers used were OTT Parsivel of the first and the second generation. Data were carefully checked in order to keep only liquid precipitations and several methods were used to filter and/or to correct data (Jaffrain et al., 2011; Raupach and Berne, 2015). One of them, maximizing the consistency between daily rainfall totals derived from DSD and those measured by raingauges, was applied to the whole dataset. Daily weather types (WT) were computed with the method proposed by Garavaglia et al. (2010), which is based on the synoptic situations described by geopotential fields. In addition, precipitation types (organized convective systems, isolated thunderstorms, showers, orographic, stratiform widespread light rain and stratiform scattered light rain) were identified empirically from a visual inspection of the weather radar fields.

First results show large difference of the median values of drop concentrations and sizes according to weather types. Highest concentrations are recorded during “Atlantic wave” and “Steady Oceanic” WT corresponding to Northwest and West circulations as well as “South circulation” WT and “Central Depression” WT (that corresponds to South-Southwest circulation in this region). Smallest concentrations were observed for “Anticyclonic” WT, a particular type for which the presence of precipitation is rather due to isolated thunderstorms. For this particular WT, the characteristic diameters are the highest with the strongest variability. High diameters are also observed, but with less variability, for “Southwest circulation”. Concerning the precipitation types (independently of WT), both the median values and the interquartile range (IQR) of the characteristic diameters decrease from the organized convective systems to the stratiform systems. The contrary is observed on the R/Z (rainfall rate / radar reflectivity factor) ratio. The highest concentrations are found for organized convective systems, isolated thunderstorms and widespread light rain; the lowest for showers and stratiform scattered light rain. Not surprisingly, the shape of DSD was found to be more “gamma” (higher values of the μ parameter) for stratiform rain but also for showers. IQR in concentration and shape is important for all precipitation types. DSD climatology is strongly contrasted according to the seasons. DSD are quite similar during winter and spring seasons with small diameters and high concentrations, all with little variability. Fall season is

characterized by diameters a little more important in mean and more important in variability and by more small concentrations. During summer, the variability is more important, the concentrations are lesser and diameters significantly higher. The distribution of Z/R ratio is completely different in summer, and, to a lesser degree, in autumn. Finally, an upward trend is observed in the concentration from plain to mountain, and the contrary is observed for diameters. As a conclusion, synoptic weather type, season, precipitation type, and localization explain some trends in DSD characteristics. However, a large part of the variability remains at the scale of the precipitation systems, and sometimes on an even smaller.

Impact of simulations with realistic soil moisture initialization on soil-atmosphere interactions favouring extreme events

Helgert, S., Khodayar, S.

Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany.

In a warming Mediterranean climate an increase in the intensity and frequency of extreme events like floods, droughts and extreme heat are expected. The missing knowledge about soil moisture-atmosphere interactions and their representation in weather forecast and climate models leads to large prediction uncertainties of such events. The soil moisture (SM) plays a key role in the Mediterranean water cycle because it controls the partitioning of sensible and latent heat fluxes on the surface and consequently influences the boundary-layer stability and the precipitation formation. In this context, state-of-art satellite-derived soil moisture offers a great opportunity for a realistic model initialization because it has a more extensive spatial and temporal coverage than other observations.

The aim of this research work is to investigate the soil-moisture atmosphere interactions in the western Mediterranean (WMED) with a special attention on the coupling between soil-moisture and precipitation. In this respect the influence of realistic SM initialization on the model representation of extreme events is assessed.

High-resolution simulations of different regions in the WMED, representing the transition zone from moderate climate in parts of France and Italy to (semi-)arid climate in the southern part of the Iberian Peninsula and North Africa, are conducted with the atmospheric COSMO (Consortium for Small-scale Modeling) model in the numerical weather prediction and climate mode. A multiscale temporal and spatial approach is used (days to years, ~7km to 2.8km grid spacing). Moreover, the Effective Drought Index (EDI) and the convective adjustment time-scale are calculated to select extreme dry and wet periods and time-spans with weak synoptic conditions favouring a possible SM-precipitation coupling. In the selected periods, sensitivity studies with wet and dry extreme SM initialization scenarios are performed to analyse their impact to this coupling. For the realistic model initialization different high-resolution SM products (25km up to 1km grid spacing) of the satellite Soil Moisture Ocean Salinity mission (SMOS) are tested. The SMOS data are bias-corrected and root zone soil moisture is estimated with a well-established exponential filter. Observational data provided by the framework of the HyMeX as well as satellite data such as precipitation from CMORPH (CPC MORPHing technique), evapotranspiration from Land Surface Analysis Satellite Applications Facility (LSA-SAF) and atmospheric moisture from MODIS (Moderate Resolution Imaging Spectroradiometer) are used for further process understanding and for the model validation.

Evaluation of CNRM-ALADIN52 regional climate model simulations during SOP1 Intensive Observation Periods over Croatia

Ivušić, S., Güttler, I., Horvath, K.

Meteorological and Hydrological Service (DHMZ), Grič 3, 10 000 Zagreb, Croatia.

The Adriatic region is among the rainiest regions in Europe, usually affected by severe events such as heavy precipitation and flash floods. The first HyMeX Special Observation Period (SOP1) was conducted from 5 September to 6 November 2012. Our focus is on the six intensive observation periods (IOPs) during which heavy precipitation occurred in the eastern Adriatic and over the Dinaric Alps. Here, we analyzed MedCORDEX simulations of the CNRM-ALADIN52 regional climate model (RCM) forced by the ERA-Interim reanalysis. The performance of CNRM-ALADIN52 RCM in reproducing total precipitation amounts, near surface wind speed, temperature and mean sea level pressure was evaluated against E-OBS (daily gridded observational dataset in Europe), ERA-Interim reanalysis and the data from the observational network of the Meteorological and Hydrological Service, Croatia (DHMZ). CNRM-ALADIN52 successfully reproduced the spatial variability for all above-mentioned variables. The precipitation timing and the location of the maxima were reproduced in the model. In some cases, the performance of CNRM-ALADIN52 was rather successful in simulating the maximum precipitation amounts in comparison with the ERA-Interim reanalysis and E-OBS. However, the model was less successful to simulate heavy rainfall during the IOP2, when over 220 mm of precipitation were recorded in the city of Rijeka in the northern Adriatic. During IOP2 CNRM-ALADIN52 underestimated the total precipitation amount and was late in simulating the timing of the maximum rainfall over the target area.

The MedCORDEX Flagship Pilot Study on air-sea interactions

Jordà, G.¹, Sannino, G.², Somot, S.³, MedCORDEX Air-Sea coupling FPS team

¹IMEDEA (UIB-CSIC), c./Miquel Marqués 21, Esporles, Spain. ²ENEA, SSPT-MET-CLIM CR Casaccia, Bldg C59, Sp. 118, Via Anguillarese, 301 00123 Santa Maria di Galeria - Rome, Italy. ³CNRM Météo-France 42 avenue Coriolis / 31057 Toulouse Cedex France.

The mechanisms through which air-sea coupling can modify the Mediterranean climate will be investigated in the MedCORDEX Flagship Pilot Study (FPS) on air-sea interactions, with special emphasis on the role of small scale ocean processes and waves. In this presentation we will review the goals and preliminar results of this FPS which is a natural continuation of the activities of HyMeX, MedCORDEX and MedCLIVAR.

The selected region is the area surrounding the Mediterranean Sea, which is often referred to as an ocean in miniature due to the variety of processes occurring therein. These include strong air-sea interactions, active mesoscale and submesoscale dynamics and a permanent thermohaline overturning circulation. Moreover, this area is one of the best observed regions in the world. Besides the dense observational network of meteorological stations over Europe, the Mediterranean Sea is regularly sampled by different monitoring programs (e.g HyMeX, the regional component of Gewex) providing observations of the ocean-atmosphere coupled

system over the last decades. The Mediterranean region is therefore a particularly suitable candidate for this FPS.

Ocean mesoscale in the Mediterranean Sea is characterized by a Rossby deformation radius of 5-10 km. In consequence, the SST often shows narrow and sharp fronts (e.g. in upwelling regions) as well as filaments with associated strong temperature gradients that can significantly modify the air-sea interaction (Chelton et al., 2004) and affect the climate evolution (Artale et al., 2009). Ocean mesoscale also plays a crucial role in the main mechanism of heat uptake by the ocean, namely dense water formation, which modelling requires both atmospheric (~25 km) and oceanic (~5-10 km) high spatial resolution that present GCMs are not able to achieve. Last, the Mediterranean wind-wave climate is characterized by high temporal and spatial variability due to the channeling of winds acting over the sea by the orography (Lionello et al. 2005). Wave effects on the turbulent heat fluxes are known to be important and the inclusion of this interaction in regional models is also expected to have a significant impact on long term simulations.

A detailed analysis of how air-sea coupling at high resolution can modify the regional climate, and consequently the global climate, is still missing in the literature. There are some indications that it can provide an added value to RCMs in both present climate (Artale et al 2009, Nabat et al., 2015) and future scenarios (Somot et al., 2008), but the mechanisms underlying such impact are not completely understood. Global climate modelling should therefore benefit from this FPS as it will give clues for the future design of GCMs.

Heavy rainfall and floods in northwestern part of Croatia in November 2016

Jurlina, T., Oskoruš, D., Vujnović, T., Mutić, P., Berbić, J.

National Meteorological and Hydrological Service, Croatia.

Between 5th and 6th November over Croatia occurred rainfall and showers along with thunderstorms, locally even very heavy. Moderate and strong south-west and south wind was blowing. Genoa cyclone approached to Croatia on November 5th which shifted to the southeast on next day along with cold front. The heaviest rainfall occurred on 6th November in Gorski Kotar, the northern Adriatic and in the western parts of the inland. In only 24 hours locally fell average monthly rainfall amounts. The highest amount of precipitation was recorded on Platak meteorological station, which recorded 250 mm of precipitation in 24 hours. Several other meteorological stations recorded more than 100 mm of rainfall in 24 hour period. Therefore, there were torrents and water streams spills in Istia and in coastal region of Kvarner Bay. On 7th November, weather shortly calmed down. Then in the evening on the 10th over Croatia moved another cold front, and from 11th November new cyclone came from the western Mediterranean. During that events Croatian Meteorological and Hydrological Service (DHMZ) issued warnings for public that included both meteorological and hydrological warnings. Warnings for National Protection and Rescue Protectorate (NPRD) include flood possibilities and water levels prediction for several rivers in Primorsko-goranska region, Ličko-senjska region and Karlovačka region. Luckily, there were no human casualties. Hydro warnings were based on the results of Mike11 – hydrological and hydrodynamic model, European Flood Awareness System (EFAS) and Southeast Europe Flash Flood Guidance System (SEEFFGS). The paper will present two case studies for events over the same region that happened within an interval of a few days based on meteorological and hydrological analyses.

Smartphone technologies as a support to better inform and protect people in case of flash floods

Kouadio, J.S.

UMR Pacte Université Grenoble-Alpes, UMR Espace Université d'Avignon, France.

In France, government and specific services (SCHAPI) survey overflow stream floods (100.000km²) but flash floods characterized by fast, quick and dangerous responses (other 100.000km²) remain hard to predict and difficult to monitor. Consequently, we propose to use Smartphone technologies: to reduce the time required to alert and to protect population; to enhance information observed by any people at local scales; to built automatic vigilance based on these "citizens-sensors"; to use field experiment to improve knowledge on flash floods actually available after damaged events; to use geolocation of transmitter sources to alert people located at 5 km around.

Challenges are numerous: early warning for better watchfulness; optimal lecture for alert messages; incentive people to contribute and participate; territorial flexibility and identification of risk areas; improve people behavior in case of flash floods. Therefore some problems occur even if challenges are clearly founded: 1) How to manage the personal data without breach of privacy? Actually the government and specifically the stakeholders remains the decision level to inform on flooding risk. 2) What kind of hardware and software architecture deploy to alert population without depending on phone agencies and networks? 3) Whereas the actual system goes in a "top-down" approach (the State alert and the people react) how can we encourage the citizens to engage them in a proactive and collective action without putting in default the existing forecasting services and risk management? We mainly discuss in this paper of the condition of the establishment of a new system using the reactivity of Smartphones.

We hope 1) to reduce the time required for warnings and protect population; 2) to enhance data collection provided by citizens since local scales; 3) to built a collaborative vigilance and a standing guard network based on these "citizensensors" not depending on the official government systems; 4) to improve knowledge on flash floods damage observed in real-time. The solution is thought in the way to limit drawbacks between the classical approach (top-down) that imposed the government as a main warning source, and the citizens (bottom-up) we consider as "sensors" during crisis (both in going up or disseminating warning information). Addressing this is of paramount importance if we aim at minimizing material & human damages regarding the high acuity of flash floods.

Support of the CORSiCA atmospheric observatory to HyMeX LOP activities

Lambert, D., Coquillat, S., Defer, E., Pinty, J.-P., Pont, V., Prieur, S.

Laboratoire d'Aérologie, Université de Toulouse, CNRS, UPS, France.

CORSiCA (Corsican Observatory for Research and Studies on Climate and Atmosphere - ocean environment - Centre d'Observation Régional pour la Surveillance du Climat et de l'environnement Atmosphérique et océanographique en Méditerranée occidentale, <http://corsica.obs-mip.fr/>) is a scientific platform dedicated to the observation of the physics and chemistry of the atmosphere. It is located in the western Mediterranean basin, on the

island of Corsica. This location allows the site being exposed to air mass of various origins. It can also act as a sentinel for continental France and for Italy or, at a larger scale, for countries further east by measuring weather phenomena or air quality. Corsica is prone to convective heavy precipitation (see Scheffknecht et al., this conference) often associated to electrical activity.

The platform has been in operation since 2007. It combines several measuring sites on Corsica for atmospheric chemistry (gases and aerosols), dynamics, microphysics, and atmospheric electrical activity.

The observatory has a twofold mission: firstly, to serve as a permanent structure for observing the atmosphere particularly suited to the climate change studies, and secondly, to provide a platform for measurement campaigns.

From 2012 to 2014, Corsica has hosted more than one hundred researchers involved in measurement campaigns, mainly HyMeX (Hydrological Mediterranean Experiment; <http://www.hymex.org/>) and ChArMEx (the Chemistry-Aerosols Mediterranean Experiment; <http://charmex.lsce.ipsl.fr/>) Special Observation Periods.

CORSiCA has funded a dozen advanced instruments installed on multiple sites in Corsica, their operation and maintenance, and a technical local in the Cap Corse.

The present communication will present the support of the CORSiCA atmospheric observatory to HyMeX activities and more specifically to the ST-Lightning activities, mainly around the SAETTA network (see Coquillat et al. this conference) for hosting additional instrumentation (for example BLESKA from Institute of Atmospheric Physics, Prague) and in the preparation of the EXAEDRE campaign (see Defer et al. this conference).

Acknowledgements are addressed to CORSiCA main sponsors (Collectivité Territoriale de Corse through the Fonds Européen de Développement Régional of the European Operational Program 2007-2013 and the Contrat de Plan Etat Région; HyMeX/MISTRALS; Observatoire Midi-Pyrénées; Laboratoire d'Aérodologie), Qualitair Corse and many individuals and regional institutions in Corsica. This project is also supported by grants ANR-16-CE04-0005-01 EXAEDRE.

Overview of some heavy precipitation events in 2015 and 2016 on Corsica

Lambert, D., Richard, E., Coquillat, S., Defer, E., Pinty, J.-P., Prieur, S., Hilt, M., Wimmer, M.

Laboratoire d'Aérodologie, Université de Toulouse, CNRS, UPS, France.

Despite recent improvements in operational forecasting, numerical models still have difficulties in capturing with precision the intensity and average distribution of heavy rainfall at small scales. These difficulties are particularly present over the strongly orographic zones (where the flows are complex) as well as over maritime areas (where the upstream observations are scarce). In Corsica, both of these difficulties are present. It is situated close to the Gulf of Genoa, which is the zone the most prone to cyclogenesis in the western Mediterranean. It is regularly affected by violent winds, intense precipitation, strong waves which erode the coastlines, droughts and forest fires.

Corsica was one of the Atmospheric Sites of the HyMeX 2012 SOP1 campaign. Our objective was to study the precipitating events in an environment characterised by insularity and an important orographic zone at the centre of the north-western Mediterranean basin. The state of the local and large-scale environment and the impact of turbulence and microphysical

processes are elements whose effect upon heavy precipitation is still not well understood. In September and October 2012, three high precipitation events have affected Corsica and have been studied in details (see Scheffknecht et al., this conference).

The Corsica site is still active through the CORSiCA atmospheric observatory (<http://corsica.obs-mip.fr/>) (see Lambert et al., this conference) in the frame of the HyMeX Long Observation Period, mainly in support to HyMeX ST-Lightning activities through the SAETTA network (see Coquillat et al. this conference) and in preparation for the EXAEDRE campaign (see Defer et al. this conference).

This study presents an overview of some heavy precipitation events that have affected Corsica in 2015 and 2016. We will look at numerical simulations using the research model Meso-NH. They will be used to examine the different ingredients which lead to intense rainfall events and the capacity of the Meso-NH model to reproduce these events with respect to the collected observations, including atmospheric electrical observations given by the SAETTA network.

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Impact of upstream moisture structure on back-building heavy precipitation events in Southern France during HyMeX IOP 13

Lee, K.-O.¹, Flamant, C.¹, Duffourg, F.², Ducrocq, V.²

¹LATMOS/IPSL, UPMC Univ. Paris 06, Sorbonne Universités, UVSQ, CNRS, Paris, France.

²CNRM-GAME, UMR 3589, Météo-France & CNRS, Toulouse, France.

During Intensive Observation Period 13 (14 October 2012) of the first Special Observing Period of the Hydrological cycle in the Mediterranean Experiment (HyMeX), back-building heavy precipitating convective systems developed in Southern France shortly after 1300 UTC. The upstream environment was characterised by a moist conditionally unstable marine boundary layer topped by dry air masses just above. Duffourg et al. (submitted) have emphasized the importance of the low level moisture for feeding the convective systems observed during this case and the significance of the dry air above for strengthening the associated cold-pools. In the present study, the impact of the environmental moist structure on the development of a quasi-stationary convective line (which produced 67 mm of precipitation in 12 hours), observed a few kilometres offshore of the Var coast, is investigated through a series of sensitivity experiments using the French non-hydrostatic research numerical model, Meso-NH (horizontal grid of 2.5-km) initialized with the AROME-WMED analyses. The sensitivity experiments are conducted by modifying the 0900 UTC AROME water vapor field in the moist marine boundary layer and in the dryer layer above. In the experiments MST1P (MST1M), MST2P (MST2M) and MST5P (MST5M) the water vapor mixing ratio (WVMR) values in the key areas are increased (decreased) by 1 g kg⁻¹, 2 g kg⁻¹, and 5 g kg⁻¹, respectively, between 100 m and 1000 m above sea level (ASL); other conditions are the same as in the control experiment. The 12-hr accumulated rainfall amount is increased by 9.3% and 18% near the Var coast in simulation MST1P and MST5P, respectively, while a 11.5% reduction is obtained for MST1M. In addition, 6 sensitivity

experiments are conducted to test the impact of dry layer topping the moist boundary layer, named DRY1P (DRY1M), DRY2P (DRY2M) and DRY5P (DRY5M), in which the WVMR value is increased (decreased) by 1 g kg^{-1} , 2 g kg^{-1} , and 5 g kg^{-1} , respectively, between 1000 m and 2000 m ASL. Interestingly, both moisture-enhanced and reduced experiments lead to more 12-hr accumulated rainfall in the coastal region of southern France, for instance a 22% of 12-hr rainfall increase was produced in DRY2P while a 2.6% of the rainfall increase was obtained for DRY5M. Nevertheless, the processes involved in this increase in precipitation are quite different. The dynamical and thermodynamical impacts of upstream moisture structure on back-building heavy precipitation will be discussed.

A study of the scaling properties of rainfall and their relationship to climate characteristics in Catalunya

Llabrés-Brustenga, A.¹, Casas-Castillo, M.C.², Rodríguez-Solà, R.³, Rius, A.¹, Redaño, Á.⁴

¹Servei Meteorològic de Catalunya, Berlin 38-46, 08029 Barcelona, Spain. ²Departament de Física, ESEIAAT, Universitat Politècnica de Catalunya, BarcelonaTech, Colom 1, 08222 Terrassa, Spain. ³Departament de Física, ETSEIB, Universitat Politècnica de Catalunya, BarcelonaTech, Diagonal 647, 08028 Barcelona, Spain. ⁴Departament de Física Aplicada, Facultat de Física, Universitat de Barcelona (UB), Martí i Franqués 1, 08028 Barcelona, Spain.

Many atmospheric processes, as rainfall generation, act in a wide temporal range giving rise to phenomena which accomplish self-similarity, i. e., that look the same regardless of the temporal scale where they are observed, a fractal property. While for mathematical fractals the parties are an exact copy of the whole, the fractal self-similarity of natural processes has a statistical nature, which means that the scaling properties of rainfall can be expressed by statistical relationships (Schertzer and Lovejoy, 2011). For instance, it has been widely observed (Koutsoyiannis and Foufoula-Georgiou, 1993; Burlando and Rosso, 1996; Menabde et al. 1999) that the probability distribution of the annual maximum rainfall intensity satisfies scale relationships. In the monofractal case or simple scaling, scale relationships can be expressed in function of a single parameter β which has to be determined. This parameter β can be useful, for instance, to perform a temporal downscaling to infer rainfall intensities for sub-daily durations from daily values (Menabde et al., 1999; Yu et al. 1994, Desramaut, 2008; Bara et al., 2010; Rodríguez-Solà et al., 2016). The scaling parameter β in a place seems to be related to some of its climate characteristics, in particular, its rainfall pattern (Menabde et al., 1999). Rodríguez-Solà et al. (2016) found a spatial distribution of β over the Iberian Peninsula related to the kind of precipitation contributing to high rainfall events and the proportion of convective rainfall in total. The higher absolute values match the eastern part of the Peninsula, where very intense torrential rainfall is registered, due to the advection of warm and humid air from the Mediterranean Sea.

In this work, we're presenting a scaling analysis performed in Catalunya, using more than a hundred daily series from rain gauges distributed all around the territory which passed a rigorous quality control and were determined to be homogeneous. The longitude of the selected series has a mean value of 32 years of data, covering a temporal period between 1890 and 2014. The range of values of the scaling parameter β calculated for these series is according to the high climatic variability of Catalunya and consistent with results of Rodríguez-Solà et al. (2016).

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A hydro-meteorological ensemble prediction system in the Milano area using a probabilistic approach

Lombardi, G.¹, Ceppi, A.¹, Ravazzani, G.¹, Homar, V.², Amengual, A.², Romero, R.²

¹Politecnico di Milano, Piazza Leonardo da Vinci 32, Milano, Italy. ²Universitat de les Illes Balears, Cra. de Valldemossa km 7.5, Palma (Illes Balears), Spain.

The number of important natural catastrophes is increasing worldwide; among these, the hydro-meteorological events represent the worst scenario due to thousand dead and huge damages to private and state ownership they can cause (Munich Re, 2015). To prevent this, beside various structural measures, many non-structural solutions have been proposed in the recent years.

In this study, we suggest a low computational cost method to produce a probabilistic prediction system starting from a single forecasted precipitation scenario through a spatial shift and an intensity variation.

In fact, it is well-known that accurate forecasts of deep moist convection and extreme precipitation are arduous due to uncertainties arising from the numeric weather prediction (NWP) physical parameterizations and high sensitivity to misrepresentation of the atmospheric state. These uncertainties in precipitation forecasts can be seen as a misplacing, in space and time, plus an under/over-estimation of the observed precipitation.

In order to run hydro-meteorological simulations and forecasts, we use a flood forecasting system which comprises the physically based rainfall-runoff hydrological model FEST-WB, developed by the Politecnico di Milano, and the Weather Research and Forecasting (WRF)

meteorological model provided by the Universitat de les Illes Balears. The area of study are the hydrological basins of the rivers Seveso, Olona and Lambro, located in the northern area of Milan city.

We selected thirty severe hydro-meteorological episodes that affected the Milano urban area between the years 2008 and 2016 for which the complex flood protection system of the city did not completely succeed. These thirty events are sixteen stratiform and fourteen convective, subdivided in calibration and validation set.

The calibration consists in the research of errors, in terms of longitude and latitude (spatial shift), time and intensity of the forecasted precipitation area hourly compared with the observed field for every investigated event. The results show how an error distribution is mainly present in the spatial shift of precipitation target (North-South and West-East) and in the intensity of rainfall, while no significance errors in time are highlighted.

Hence, in validation, we apply these error PDFs in order to generate probabilistic simulations, testing the performance of this statistical method.

These findings could help to predict flood episodes supporting the civil protection and local authorities for operational purposes.

Nowcasting of Mediterranean flash-floods

Lovat, A, Vincendon, B., Ducrocq, V.

CNRM (Météo-France, CNRS), Toulouse, France.

Devastating flash-floods, which are triggered by heavy rainfall events, often occur in Mediterranean watersheds during the fall. The mesoscale convective systems associated with these precipitating events and the geomorphologic characteristics of the region can lead to short hydrological response times. High spatial and temporal resolution short-term forecasts are needed to support timely decision making and planning of emergency management. Rainfall nowcasting products are being developed, covering very short forecasting ranges (0-6h typically). Among these products, radar quantitative precipitation estimates associated with their estimated errors are of interest for hydrological forecast at the range of the concentration time of the watersheds. Beyond this time, the very short range quantitative precipitation forecasts from numerical weather nowcasting (NWC) models are necessary. A new NWC system has been recently developed at Météo-France, based on the AROME numerical weather model. Those rainfall nowcasting products can be beneficial for probabilistic flood forecasting up to 6 hours ahead over Mediterranean watersheds. Forecasting flash-floods also requires hydrological models dedicated to fast responding rivers, such as the ISBA-TOP coupled system used at CNRM. The space and time resolution of the model as well as an improved representation of the surface and soil characteristics (land use, topography, soils texture,..) can help to better simulate both river discharges and intense runoff phenomena. This has been investigated with the ISBA-TOP system for watersheds of south-eastern France. Results for a study case that occurred in October 2015 will be presented.

Aerosol and Regional climate in the Mediterranean: A Model Intercomparison Exercise in the Context of Med-Cordex and ChArMEx

Mallet, M., Solmon, F.

CNRM/Meteo-France, Laboratoire Aerologie, France.

The Mediterranean basin is located at the crossroads of air masses carrying gas phase species such as ozone and precursors, as well as natural and anthropogenic aerosol particles. These species contribute to regional pollution and can have strong effects on the regional radiative budget with ensuing impact on regional climate fluctuations from daily to multidecadal time scales, as well as on ecosystems and air quality over the Mediterranean basin.

Aerosol linked processes still represent one of the main sources of uncertainty in past climate change attribution and future climate change projections notably due to high spatial and temporal variability. The use of high-resolution RCMs therefore offers an interesting potential for a better characterization of aerosol-radiations and climate interactions in the complex Mediterranean region. In the context of Med-CORDEX and MISTRALS-ChArMEx programs, a FPS (Flag Pilot Study) has been proposed with the aim of answering important scientific questions such as:

- Can we fully characterize the Mediterranean aerosol past variability and future evolution at climate scales in particular using RCMs.
- Can we understand the role of the Mediterranean aerosols on the past regional climate variability ? including issues related to regional climate change attribution and aerosols representation in climate models (GCM, RCM).
- Can we determine the role of regionally-born aerosols in the Mediterranean future climate sensitivity ? in particular using RCMs as complementary approach to GCMs.
- What is the aerosol role in shaping the Mediterranean extreme events ? (e.g. heat waves, heavy precipitation events).

The presentation will focus on the development of simulation strategies involving several research groups, and will give some preliminary results as well as relevant information to join the initiative.

Cold outbreaks at the mesoscale in the Western Mediterranean basin: from raincells to rainbands

Mazon, J.¹, Pino, D.^{1,2}

¹Department of Physics, Universitat Politècnica de Catalunya, BarcelonaTech, Esteve Terrades 5, building C3, office 105; 08860 Castelldefels - Barcelona, Spain. ²Institute for Space Studies of Catalonia (IEEC-UPC). Barcelona, Spain.

Three cold outbreaks forming offshore density currents over a region within the Western Mediterranean Basin (WMB) at meso-alpha, meso-beta and meso-gamma scales have been found and investigated.

Satellite images and reflectivity radar are used, respectively, to detect cloud and precipitation associated to these density currents. By using WRF-ARW model, the formation and evolution of these density currents over the western Mediterranean basin are described.

Cold outbreaks entering into the WMB at the meso-alpha (500-2000 km, 1-2 days) usually comes from the Gulf of Lion, associated to a synoptic northwesterly flow known as Mistral or tramontana wind. This was the case for the arc of clouds observed near the Gulf of Lion on 25 August 2012 moving offshore and reaching the North African coast on 26 August 2012. Regarding the meso-beta (50-500 km, 12-24 hours) and meso-gamma (5-50 km, 0.5-12 hours) scales, cold outbreaks in the WMB are usually associated to drainage flows, occurring during the night. If the maritime sea-airmass is warm enough, these nocturnal flows that drive the inland cold air offshore can form a meso-beta or meso-gamma density currents over the warmer and wetter Mediterranean sea-airmass, producing clouds and even precipitation. These type of flows were observed analyzed on 5 September 2011 and 11 October 2010, respectively, and will be analyzed.

Based on observations and simulations, this communication suggests a new point of view over the region of the WMB limited by the Balearic Island, the northeastern of the Iberian Peninsula and the gulf of Lion, where inland cold outbreaks develop to density current moving offshore which can be formed in the whole mesoscale, producing from rain cells to rainbands.

Heavy precipitating events in the south-east of France as simulated by the CNRM-RCSM: A case study

Mazoyer, M., Roehrig, R., Nuissier, O., Duffourg, F., Somot, S.

CNRM, Météo-France/CNRS, Toulouse, France.

The Mediterranean area is considered as one major “hot spot” with regards to on-going climate change: increase in rainfall interannual variability, strong warming and drying, possible but uncertain increase of Mediterranean vulnerability due to change in the probability density function (PDF) of precipitation (i.e. occurrence of droughts and heavy precipitating events). Climate projections are mainly based on regional climate system models (RCSMs), which unfortunately fail in representing realistically this PDF, especially over land. Small amounts of rain are too frequent, preventing any realistic representation of droughts or heat waves, while the intensity of heavy precipitating events is underestimated and not well located by most state-of-the-art RCSMs using parameterized convection (resolution from ~10 to ~50 km). Recently, the new physics implemented in the CNRM-RCSM has been shown to remarkably improve the representation of such events, even at a 50-km scale.

The present study seeks to further analyse the representation of heavy precipitating events by this new version of CNRM-RCSM. We focus on one particular event in the south-east of France, over the Cévennes. Two hindcasts experiments with the CNRM-RCSM (12 and 50 km) are performed and compared with a simulation based on the convection-permitting model Meso-NH, which makes use of a very similar setup as CNRM-RCSM hindcasts. The role of small-scale features of the regional topography and its interaction with the impinging large-scale flow in triggering the convective event are investigated. This study provide guidance in the ongoing implementation and use of a specific parameterization dedicated to account for subgrid-scale orography in the triggering and closure conditions of the CNRM-RCSM convection scheme.

Evaluation of CNRM-RCSM simulations with interactive aerosols in the framework of the Med-CORDEX FPS Aerosol activities

Nabat, P.¹, Mallet, M.¹, Brogniez, G.², Denjean, C.¹, Laurent, B.³, Michou, M.¹, Somot, S.¹

¹CNRM UMR 3589, Météo-France/CNRS, Toulouse, France (pierre.nabat@meteo.fr).

²Laboratoire d'Optique Atmosphérique (LOA), UMR CNRS 8518, Université de Lille 1, Villeneuve d'Ascq, France. ³Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA), Université Paris Diderot, Paris-Créteil, France.

The Mediterranean region is submitted to numerous and various aerosols, which play an essential role in the regional climate system due to their interactions with shortwave (SW) and longwave (LW) radiation and ensuing consequences on radiative budget and regional climate. The Med-CORDEX FPS Aerosol aims at analysing the different impacts of aerosols on Mediterranean regional climate, by gathering groups using various regional climate models. A first step in this direction is to evaluate regional simulations using interactive aerosols against measurements from field campaigns that have taken place between 2012 and 2014. In the present work, we will focus on the intensive airborne measurements of the ChArMEx/ADRIMED campaign in summer 2013, in order to focus on these aerosol-radiation interactions and their modeling in the regional climate model CNRM-RCSM. This model is now able to include a prognostic aerosol scheme in order to represent the main natural and anthropogenic aerosol species and their impact on SW/LW radiation and climate. However, up to now, the evaluation of such aerosol schemes is often limited to the integrated atmospheric aerosol content given by the aerosol optical depth. The objective of this study is to take advantage of the airborne and ground-based measurements available in the ChArMEx/ADRIMED field campaign in order to evaluate in detail the ability of the CNRM-RCSM regional climate model to simulate the aerosol microphysical and optical properties as well as the interactions with SW and LW radiation.

A simulation has been carried out with CNRM-RCSM over the period of the campaign (June-July 2013), driven by the ERA-Interim reanalysis as lateral boundary forcing. This simulation has been compared to different observations performed during the campaign, in terms of aerosol concentration, size and vertical distribution, as well as deposition. An original aspect concerns the comparison with SW and LW heating rate profiles obtained from aircraft measurements. The results show the relatively good performance of the model in the representation of aerosols, but also some discrepancies in terms of aerosol vertical and size distribution. Therefore this evaluation represents a step forward to improve the representation of aerosol radiative effect in regional climate models.

The river routing scheme in Organising Carbon and Hydrology in Dynamic Ecosystems (ORCHIDEE) using high resolution data

Nguyen-Quang, T., Jan Polcher, J., Ducharne, A., Arsouze, T.

Laboratoire de Météorologie Dynamique, École Polytechnique, 91128 Palaiseau, France.
L'Unité Mixte de Recherche METIS, Université Pierre et Marie Curie, 75005 Paris, France.

This study presents an improved version of river routing scheme in Organising Carbon and Hydrology in Dynamic Ecosystems (ORCHIDEE) land surface model. The routing scheme in ORCHIDEE is designed to be resolution independent. This is achieved by routing water through sub-grid hydrological transfer units. An approach which also allows to use refined residence times in each transfer unit which depends on the nature of the water to be routed. In the proposed evolution, the Hydrological data and maps based on Shuttle Elevation Derivatives at multiple Scales (HydroSHEDS) is used to enhance both these aspects. As a seamless near-global hydrological data set, HydroSHEDS is a suitable database for improving the water transfer scheme in ORCHIDEE. The approximately 1 km resolution HydroSHEDS data provides the ability of constructing more adequate transfer units in each LSM grid box. In addition, the slope factor of each transfer unit, which was calculated with new averaging algorithm, improves the time constant of the reservoirs. Moreover, the new routing scheme was designed to function on generalized grids to make it applicable in modern regional and global climate model.

We will present an analysis of the optimal transfer unit size which allows to ensure that the results of the routing scheme is independent of the grid at which ORCHIDEE operates. It is found that with transfer units of 10km² the model results are optimal and numerically stable. For the validation of this enhanced version of the routing scheme, 35-year simulations (1979-2013) were carried out forced by three atmospheric datasets on horizontal resolution of 0.5o and 0.25o. These datasets are: the Watch Forcing ERA-Interim dataset with bias-corrected precipitation using the (1) CRU station based product and; (2) GPCCv5 satellite based estimates and (3) the higher resolution version E2OFD. Investigating on monthly and daily timescale at 22 stations of 12 rivers which contribute freshwater to Mediterranean sea shows that the new scheme captures well the annual cycle of river discharge. A primary quantitative evaluation at daily timescales at 14 stations of 8 rivers also shows the good quality of the sub-monthly simulated discharge. The results also show the necessity, especially in the Mediterranean region, of considering not yet represented processes such as irrigation or dams. In fact, the development of this new routing scheme is a first step towards the development of parametrization for human water usage in ORCHIDEE.

Quasi-LES simulation of heavy precipitating Mesoscale Convective Systems Observed during the HyMeX SOP1

Nuissier, O., Duffourg, F., Martinet, M.

CNRM (Météo-France & CNRS), Toulouse, France.

The Mediterranean regions are regularly affected by heavy precipitation events (HPE) due to Mesoscale Convective Systems. During the first Special Observing Period (SOP1) a case of

offshore deep convection over the Mediterranean Sea was well documented while moving toward the coastal region of South-eastern France.

In the present study this HPE case is analysed to better understand the convective processes involved in the development and maintenance of the heavy precipitating systems. The analysis is based both on the campaign observations and numerical simulations of the event. The simulations are performed with the French research model Meso-NH. The horizontal resolution of the simulations is increased from 2.5 km to 150 m, thus avoiding the grey-zone of the turbulence. The simulations run over a large grid covering the north-western Mediterranean basin in order to encompass the precipitating systems during their whole life-cycle as well as the marine low-level moisture-supplying flow.

The HyMeX SOP1 observation dataset enables to evaluate the quality of the simulations and is useful to validate the meteorological environment over the sea as well as the convective processes simulated. A special attention is paid to assess the added-value of using a 150-m horizontal resolution, focussing especially on the physical processes contributing to the developing stage.

Reprocessed ground-based and ship-borne GPS data for assimilation and validation of the 2nd HyMeX reanalysis

Nuret, M.¹, Bock, O.², Fourrie, N.¹, Bosser, P.³

¹Institute Météo-France/CNRM CNRS. ²IGN. ³ENSTA.

An extended set of reprocessed GPS measurements (more than 1000 receivers) has been produced over the HyMeX domain to be assimilated in the 2nd AROME_WMED HyMeX reanalysis. Bock et al. (2016) showed an improvement of the reprocessed version against the operational data. The talk presents the last results, from the point of view of assimilation and validation, in the frame of the 2nd AROME_WMED reanalysis. An innovative validation against the EUMETSAT IWV product is also presented.

Initialization Tests with CCLM/NEMOMED

Obermann-Hellhund, A., Ahrens, B.

Goethe-Universität Frankfurt, Germany.

To make use of interactively coupled regional ocean-atmosphere models in decadal predictions, further investigations are needed concerning the initial- and lateral boundary conditions. Our work addresses the different restricting conditions of regional climate modeling in the regional climate model COSMO-CLM and the ocean component NEMO, coupled via the OASIS coupler. We present results on the impact of initial conditions on the ocean and atmospheric state over several years.

Comparison of Flood Frequency Analysis methods for ungauged catchments in the French Mediterranean area

Odry, J., Arnaud, P.

IRSTEA, 3275 route Cézanne, CS 40061, 13182 Aix en Provence Cedex 5, France.

Flood Frequency Analysis (FFA) intends to associate flood intensity to a probability of non-exceedance. Two FFA families can be employed. On the one hand, purely statistical approaches aim to fit a probability distribution to flood observations and to extrapolate this model towards rare events. This kind of solution is limited by the availability of flow data and made difficult by the non-linearity of the rainfall-runoff relationship. On the other hand simulation-based approaches deal with this non-linearity by extrapolating the rainfall information and using some kind of rainfall-runoff transformation.

Comparison of different FFA methods conducted over the French territory have demonstrated that relative performances of the FFA depends on the location [Kochanek et al., 2014]. Especially it appeared that techniques apparently similar for the whole French territory perform very differently over the Mediterranean area. Nevertheless, those conclusions were only drawn for gauged catchments where flow data is available.

Here we propose to move a step forward by associating FFA methods from both families with a range of regionalisation schemes (spatial proximity, regression,...). Those methods were applied and compared over a set of 192 Mediterranean catchments and a k-fold cross validation was implemented to evaluate the aptitude of each regionalised FFA to perform at ungauged sites.

Results confirmed that the Mediterranean area tends to discriminate more the different regionalised FFA than the other part of France. In addition, the implemented simulation-based FFA (SHYREG method [Arnaud et al., 2015]), demonstrated a higher stability regarding the regionalisation scheme as well as the sampling of donor catchments. The SHYREG regionalised quantiles were closer to those locally estimated than those from the implemented statistical method. In addition, SHYREG structurally ensures coherency between quantiles of different return period and time-step.

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Evaluation of high-resolution PLEIADES digital elevation models for flood risk mapping. Case of the Ourika watershed (High Atlas, Morocco)

Oumaima B.^{1,2,3}, Yves, T.^{2,4}, El Mehdi, S. M.^{1,2}, Gascoin, S.^{2,5},
Frédéric, L.^{6,3}

¹Laboratory of Geosciences and Environment, Cadi Ayyad University, Marrakesh, Morocco. ²LMI TREMA, Cadi Ayyad University, Marrakesh, Morocco. ³LMI MediTer, Cadi Ayyad University, Marrakesh, Morocco. ⁴IRD, HydroSciences Montpellier, France. ⁵CNRS, CESBIO, Toulouse, France. ⁶UMR GRED (UPVM & IRD), Montpellier, France.

The catchments in the High Atlas Mountains of Morocco, upstream of the city of Marrakech, are prone to extreme floods linked to intense rainfall events. Such episodes are frequent and often devastating, such as the event of August 1995 that caused over than 200 fatalities in the Ourika Catchment. The Ourika watershed (503 km²) has a complex and rugged topography, causing floods that can inundate communication routes, agricultural and touristic areas. The goal of this work consists in characterizing the flood hazard by simulating the water level and the lateral floodplain extensions during floods. The resolution and accuracy of digital elevation models (DEM) can strongly affect the hydraulic simulation results for predicting the effects of floods. A frequency analysis of peak flows has been performed using historical data to estimate the return levels of different flood magnitudes. Then, two digital elevation models (DEM) have been compared: "ASTER" with a 30 m spatial resolution and the more recent product "PLEIADES" with a 4 m resolution. Using a hydraulic model (HEC-RAS), we simulate the extent of floods corresponding to different return periods and compared the results between the two DEM resolutions. Two areas are selected for the evaluation, characterized by different types of exposure: a touristic area normally frequented by visitors, near to a regional road. The second zone selected is an agricultural sector on alluvial terraces where cultivated fields and infrastructures are vulnerable. Results showed that high-resolution PLEIADES DEM provides an added value for the mapping of floodplains to estimate the risk of damage.

Sea surface temperature in the Mediterranean: climatology, trends and spatial patterns

Pastor, F., Valiente, J.A., Palau, J.L.

Meteorology and Pollutant Dynamics Department - Fundación CEAM, Parque Tecnológico C/ Charles R. Darwin 14 ZIP code:46980, Paterna, Spain.

During the last years, a growing number of studies have dealt with the role of sea surface temperature (SST) in the genesis or development of heavy/extreme rain events in the Mediterranean region. Thus, a good knowledge of SST climatology is needed, in terms of both climatic and numerical modelling studies. For this purpose, a monthly climatology of SST has been built from daily data retrieved by satellites for the period 1982-2016. Once the climatology was built, SST trends from daily data have been investigated, showing that SST in the Mediterranean has undergone a remarkable increase, with a mean value of 0.036 degree per year, during the study period across the whole basin. It has to be noted that

regional differences can be found, despite the trend is positive for the whole Mediterranean, with total SST increase greater than 1°C in much of the Mediterranean basin.

In a large number of the numerical modeling experiments regarding SST role in precipitation, the SST field is uniformly modified over the whole simulation domain. Some previous studies have shown how different areas in the Western Mediterranean basin contribute differently to heavy rainfall events in the Eastern Iberian Peninsula. To deal with this issue, a cluster analysis has been performed to identify spatial patterns in the Mediterranean SST field across the study period. From this study, seasonal patterns in the SST spatial distribution have been found.

From the results obtained, further analysis will be done looking for correlation between the SST clustered areas in the Mediterranean to the moisture/heat source areas feeding some of the extreme rain events recorded in different Mediterranean coastal areas.

HyMeX-IOP7a heavy precipitation event: A model intercomparison study

Planche, C., Wobrock, W., Kagkara, C., Flossmann, A., Banson, S., Van Baelen, J.

Université Clermont Auvergne, Laboratoire de Météorologie Physique, OPGC/CNRS UMR 6016, Clermont-Ferrand, France.

Within the framework of the international HyMeX program (HYdrological cycle in Mediterranean EXperiment), the MUSIC project (MULTiscale process Studies of Intense Convective precipitation events in Mediterranean) aims to a better understanding and modelling of intense convective precipitation events in Mediterranean in order to improve their forecast by Numerical Weather Prediction (NWP) scale models.

A mesoscale model intercomparison study is conducted based on a mid-latitude convective event IOP7a observed during the HyMeX campaign which took place in autumn 2012 in the Mediterranean basin. The results of the 3-D mesoscale models: WRF (Weather Research and Forecasting; Skamarock et al., 2008) or Clark-Hall (Clark et al., 1996), using a bulk microphysics scheme or the bin resolved microphysics scheme DESCAM (DEtailed SCAvenging Model; Flossmann and Wobrock, 2010) are compared with the HyMeX observations. Driven by the ECMWF analyses or global model forecasts, the models are indeed compared with the available aircraft and ground based observations during the IOP7a. The robustness of mesoscale models in simulating convective systems at the cloud resolving scale has yet to be extensively evaluated. Hence, particular emphasis is put on the ability of simulations to capture the observed wide range of dynamical processes during a significant mid-latitude mesoscale convective event and to produce similar cloud fields and precipitation structures.

The SASER (SAfran-Surfex-Eaudysee-Rapid) hydrometeorological modeling system for Spain

Quintana-Seguí, P.¹, Barella-Ortiz, A.^{1,2}, Habets, F.³

¹Observatori de l'Ebre, Universitat Ramon Llull - CSIC, Roquetes, Spain. ²Universidad de Castilla-La Mancha, Toledo, Spain. ³UMR 7619 METIS, CNRS, UPMC, Paris, France.

Land surface models (LSM) physically simulate the water and the energy balance of the land-surface, taking into account numerous physical processes at the interface between soil, vegetation and atmosphere. When coupled to a river routing scheme, LSMs are also able to simulate riverflow. This converts them in physically based and distributed hydrological models, which may be used to quantify and understand hydrological processes at large scales. The SASER hydrometeorological system has been developed for Spain. It is based on the SURFEX land-surface model, more specifically, the ISBA soil-vegetation-atmosphere transfer (SVAT) scheme. SURFEX, which is run at a spatial resolution of 5 km, is forced by the Spanish SAFRAN meteorological analysis dataset. Its water outflows are routed by the RAPID river routing scheme, within the framework of EAU-DYSEE. The resulting system is a very complete and flexible simulation system which has been used to produce a 35-year long simulation of the Spanish continental hydrological cycle.

In this paper we present the general system, making emphasis on the river routing component, which is the most recent development of the model. We evaluate the quality of the simulated riverflow by comparing it, at the monthly scale, to the naturalized flows produced by the SIMPA model--which is the reference used by the Spanish water managers, and at daily scales, with the observations. We discuss how this evaluation can guide us for future improvements in the modeling system. Furthermore we also discuss current and potential applications and the main areas of future development.

Upper air conditions for tornadic storms in the Iberian Mediterranean area and Balearic Islands

Rodríguez, O., Bech, J., García, S.

University of Barcelona, Spain.

The Iberian Mediterranean area, composed by the regions of Catalonia, Valencia and Murcia, Andalusian provinces of Almeria, Granada and Malaga, and Balearic Islands are regularly affected by tornadic storms often associated to heavy rainfall events. From 2000 to 2012 around 12 tornadoes per year have been recorded in this area of study (Gayà 2015), representing 52% of tornadic events in Spain on an area which represents 20% of Spain surface. Although most of these tornadoes are weak -EF0 or EF1 in the Enhanced Fujita Scale (EF)- 6% of them reach EF2 category. As this area is densely populated important infrastructures can be affected by tornadoes, as happened with the Barcelona international airport during the 2005 tornado outbreak (Bech et al. 2007). Therefore it is important to know which upper air conditions are favorable for tornadic storms to improve operational forecasting and surveillance tasks, increasing the situational awareness in convective severe weather events.

For this study sounding data from Barcelona, Palma, Zaragoza, Murcia and Madrid (Spain), Gibraltar (United Kingdom) and Oran-Senia and Dar-El-Beida (Algeria) have been used to characterize every tornadic event. The association between a tornado event and a sounding launching has been done applying the proximity-inflow method exposed in Rasmussen and Blanchard (1998). Sounding-derived parameters as Surface-Based Convective Available Potential Energy (SBCAPE), Storm-relative Helicity (SRH) and wind-shear (WS) have been analyzed. As other authors (Groenemeijer and van Delden 2007, Grams et al. 2012) several combined parameters as Energy Helicity Index (EHI), Vorticity Generation Parameter (VGP), Significant Tornado Parameter (STP), Supercell Composite Parameter (SCP) and Universal Tornadic Index (UTI) (Taszarek and Kolendowicz 2013) have also been studied. All of them characterise the convective energy and the helicity of an air mass, the two principal conditions that are needed for tornadogenesis. Results for the period and region of analysis are presented and discussed, in comparison with previous studies.

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LIFE EBRO-ADMICLIM: Adaptation and mitigation measures to climate change in the Ebro Delta

Rovira, A.¹, Ibáñez, C.¹, Marturià, J.², Pérez, F.², Morà, O.², Corbera, J.²

¹Aquatic Ecosystems Unit, IRTA Apartat de correus 200 43540- Sant Carles de la Ràpita, Spain. ²Geological and Cartographic Institute of Catalonia Parc de Montjuïc. E-08038 Barcelona, Spain.

The project LIFE EBRO-ADMICLIM aims the implementation of an integrated approach for managing water, sediment and habitats (rice fields and wetlands) in the Ebro Delta (Catalonia); an area vulnerable to sea level rise and subsidence. The idea is to optimize ground elevation, increase carbon accumulation in the soil, reduce greenhouse gas emissions, and improve the water quality by managing the inputs of inorganic and organic matter (i.e. sediment and plant residues respectively) of the ground and the organic matter

decomposition (GHG emissions) in rice fields and constructed wetlands. This type of approach has not been applied so far in the EU, and it is clearly innovative internationally. The LIFE EBRO-ADMICLIM project puts forward pilot actions for adaptation and mitigation to climate change. Adaptation pilot actions focus on sediment inputs from the Ebro River into its Delta. The goal is: i) To demonstrate the feasibility of permanently restoring the sediment flow, both from a water purification plant on the Ebro (Consorci d'Aigües de Tarragona) and from the reservoirs along the lowest parts of the Ebro River and; ii) The accurate assessment of the Ebro Delta subsidence. Expected results are: 1) Demonstration of the feasibility of reincorporating ca 1,000 T/yr of Ebro River sediments currently retained in a water purification plant. 2) Determination of the real capacity of the Ebro River for sediment transport, and 3) Identification of the most vulnerable areas to rising relative sea level.

Pilot mitigation actions are focused on optimize GHG emissions, carbon sequestration and nutrients while increasing ground elevation of rice fields and wetlands. The outputs of these actions are: 1) Optimization of the performance of constructed wetlands and, 2) Accurate assessment of GHG emissions from Delta rice fields.

The obtained results will serve to establish guidelines for a Plan for Climate Action in the Ebro Delta following the directives of the Catalan Strategy for Adapting to Climate Change via a public participatory process with the main stakeholders. In the Plan specific and effective measures of adaptation and mitigation will be defined.

Keywords: Climate change, mitigation and adaptation measures, Ebro delta.

Implementation and calibration of a distributed hydrological model based on the finite volume method

Sanz-Ramos, M.¹, Bladé, E.¹, Amengual, A.², Roux, H.³, Romero, R.²

¹Flumen Institute (Universitat Politècnica de Catalunya – CIMNE), Spain. ²Grup de Meteorologia, Dept. De Física, Universitat de les Illes Balears, Spain. ³Institut de Mécanique des Fluides de Toulouse (IMFT) - Université de Toulouse, CNRS-INPT-UPS, Toulouse, France.

A distributed hydrological model has been developed on the basis of IBER, a previously existing two-dimensional hydrodynamic model (Bladé et al. 2014) (Cea and Bladé 2015). IBER solves the full shallow water equations using the finite volume method (Roe Scheme). The model has been enhanced to be used as a hydrological model adding the precipitation and losses processes as new source terms of the mass conservation equation. In this work the model has been implemented and calibrated with precipitation and discharge data to simulate flood events in the basin of La Muga river (North East of the Iberian Peninsula). The main goal of the project is to obtain management strategies in order to maximize the water resources while minimizing flood risk, based on meteorological forecasts. Within the PGRI-EPM project, the model was then operated using meteorological forecast for the same events in order to increase the forecasting lead time and to test the added value of accounting for meteorological uncertainties in rainfall-runoff modelling.

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Ocean-atmosphere coupling for Mediterranean heavy precipitation forecast: Better river runoff and sea state modelling

Sauvage, C.¹, Lebeaupin-Brossier, C.¹, Ducrocq, V.¹, Bouin, M-N.^{1,2}

¹CNRM, UMR3589, Toulouse, France. ²LOPS, UMR6523, Plouzané, France.

The Mediterranean region is often affected by heavy precipitation events (HPEs) with rainfall amounts higher than 150mm in 24h which can lead to devastating flash flood. Sometimes, such events are also associated with rough sea and submersion, which increase the coastal flooding risk. Our study aims to better and more finely describe the interactions between the three compartments (Atmosphere – Ocean – Continental Hydrology) during HPEs, and to evaluate the impact on the precipitation forecast of using this improved coupled system. This study is based on the Météo-France AROME numerical weather prediction model coupled to the NEMO ocean model over the Western Mediterranean basin.

As a first step, more accurate runoff data are used in the kilometer scale coupled system and an improved vertical distribution of the discharge in the ocean is assessed. Then, the ocean-atmosphere modelling system will be extended to the coupling with a wave model.

The AROME-NEMO coupled system and the first progresses concerning the river runoff implementation will be presented.

A Climatology of Heavy Precipitation on Corsica

Scheffknecht, P., Richard, E., Lambert, D.

Laboratoire d'Aérogéologie, Université de Toulouse, CNRS, UPS, France.

The island of Corsica in the western Mediterranean is frequently struck by devastating high precipitation events (HPEs), which endanger property and lives alike. In the framework of the HyMeX program, a sample of 173 HPEs (> 100 mm d⁻¹) is identified based on 31 years (1985-2015) of surface observations. Such events strike the island around 5-6 times a year and show a distinct seasonal cycle. They occur predominantly during autumn, with more than half of the HPEs occurring from September to December and almost 20% in October, the most active month. The eastern half of the island is most affected by HPEs. Composite fields for all events show a cyclone over the western Mediterranean west of Corsica and warm and moist low level air upstream of the orography, predominantly over the Tyrrhenian Sea southeast of the island.

The events are classified using their synoptic and mesoscale environment obtained from ERA-INTERIM data. Using equivalent orthogonal functions (EOFs) and a principal component (PC) analysis together with the k-means clustering algorithm, three clusters of events are identified. Over the island, each cluster has a different seasonal cycle, dominant wind direction, and precipitation distribution. Warm southeasterly events occur predominantly in autumn, produce the most extreme events and affect the coasts and slopes of eastern Corsica alike. Cool southeasterly events occur predominantly in winter and affect mostly the slopes along the east side of the orography whereas the west is hardly affected by them. Southwesterly events are more often associated with large scale Atlantic cyclones. This type of HPE is seen throughout almost the entire year and affects the orography over the entire island.

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A network of water vapor lidar systems to improve heavy precipitation forecasting in southern France – The WaLiNeAs initiative

Totems, J.¹, Wulfmeyer, V.², Chazette, P.¹, Caumont, O.³, Flamant, C.⁴, Potthast, R.⁵, Behrendt, A.², Brousseau, P.³, Di Girolamo, P.⁶, Fourrié, N.³, Ducrocq, V.³, Lee, K.-O.⁴, Nuret, M.³, Richard, E.⁷, Shang, X.^{1,4}

¹LSCE/IPSL, UMR 8212, CEA-CNRS-UVSQ, Gif-sur-Yvette, France. ²Institute of Physics and Meteorology, University of Hohenheim, Stuttgart, Germany. ³CNRM, UMR3589, Météo-France & CNRS, 42 avenue Gaspard Coriolis, Toulouse, France. ⁴LATMOS/IPSL, UPMC Université Paris 6, Sorbonne Universités, CNRS & UVSQ, Paris, France. ⁵Research and Development Division, Deutscher Wetterdienst (DWD), Offenbach, Germany. ⁶Scuola di Ingegneria, Università degli Studi della Basilicata, Potenza, Italy. ⁷Laboratoire d'Aérodynamique, Université de Toulouse and CNRS, Toulouse, France.

Climate change will likely increase the frequency of extreme precipitation events in Europe, which pose a threat to human life but remain difficult to predict. An integrated prediction tool, coupling network measurements of water vapor (WV) profiles and a weather forecast model to precisely estimate precipitable water upstream of an event 24 to 48 hours in advance, would be very beneficial.

In the framework of the WaLiNeAs (Water vapor Lidar Network Assimilation) initiative, a consortium of French, German and Italian research groups will deploy a network of 5 autonomous WV lidars. It will be installed across the Western Mediterranean in fall 2018 and will provide measurements with high vertical resolution and accuracy. The aim is to demonstrate the benefit of the assimilation of WV data in the operational AROME (French) and ICON (German) models for kilometer-scale prediction of heavy precipitation over Southeastern France. Near real-time processing and transmission to weather services will permit data assimilation with minute to hour updates, closing critical lower troposphere WV

observational gaps of the current operational observing networks and satellites. This project builds, among others, on the post-HyMeX SOP1 efforts conducted to assimilate water vapor mixing ratio observations from the airborne lidar LEANDRE 2 flown onboard the ATR and the two ground-based Raman lidar systems WALI and BASIL located in Menorca and Candillargues.

As part of the WaLiNeAs initiative, the lidar systems will be operated continuously during at least 2 months starting early September 2018, to cover the period most propitious to heavy precipitation events in southern France. The duration of the operation is imposed by the necessity to have a long enough record in order for the WV profiles assimilated to have an impact on the moisture fields in the model forecasts. This long dataset (longer than acquired during the HyMeX SOP1) is crucial to assess statistical errors and to genuinely evaluate the benefit of lidar water vapor data assimilation for operational numerical weather prediction.

How does mesoscale impact deep convection? Answers from ensemble Northwestern Mediterranean Sea simulations

Waldman, R.¹, Herrmann, M.², Somot, S.¹, Arsouze, T.³, Benshila, R.², Bosse, A.⁴, Chanut, J.⁵, Giordani, H.¹, Pennel, R.³, Sevault, F.¹, Testor, P.⁶

¹CNRM / Meteo France, Toulouse, France. ²LEGOS / Observatoire Midi-Pyrénées, Toulouse, France. ³ENSTA Paristech and Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France. ⁴University of Bergen, Bergen, Norway. ⁵MERCATOR-Océan, Toulouse, France. ⁶LOCEAN, UPMC, Paris, France.

Ocean deep convection is a major process of interaction between surface and deep ocean. The Gulf of Lions is a well-documented deep convection area in the Mediterranean Sea, and mesoscale dynamics is a known factor impacting this phenomenon. However, previous modelling studies don't allow to address the robustness of its impact with respect to the physical configuration and ocean intrinsic variability.

In this study, the impact of mesoscale on ocean deep convection in the Gulf of Lions is investigated using a multi-resolution ensemble simulation of the northwestern Mediterranean sea. The eddy-permitting Mediterranean model NEMOMED12 (6km resolution) is compared to its eddy-resolving counterpart with the 2-way grid refinement AGRIF in the northwestern Mediterranean (2km resolution). We focus on the well-documented 2012-2013 period and on the multidecadal timescale (1979-2013).

The impact of mesoscale on deep convection is addressed in terms of its mean and variability, its impact on deep water transformations and on associated dynamical structures. Results are interpreted by diagnosing regional mean and eddy circulation and using buoyancy budgets. We find a mean inhibition of deep convection by mesoscale with large interannual variability. It is associated with a large impact on mean and transient circulation and a large air-sea flux feedback.

Deriving key water resources indicators in the Mediterranean basin from a water resource re-analysis dataset based on 10 hydrological and land surface models

Werner, M.^{1,2}, Quintana-Seguí, P.³, Veldkamp, T.⁴

¹UNESCO-IHE, Delft, The Netherlands. ²Deltares, Delft, the Netherlands. ³Observatori de l'Ebre, Roquetes, Tarragona, Spain. ⁴Free University, Amsterdam, the Netherlands.

The transitional climate of the Mediterranean basin poses many challenges when estimating key water resources indicators that can be used for the assessment of key water resources indicators, including those necessary for policy as well as assessing hydrological drought. These challenges are exacerbated by the varying availability and quality of data in the countries surrounding the basin.

The emergence of global meteorological and water resources re-analysis (WRR) datasets, such as that developed in the European Union 7th Research Framework Earth2Observe project, offer the advantage that hydrological fluxes are consistently represented, allowing better comparison between climatic regions. The resolution of these datasets is also improving, with the global water resources re-analysis developed in the project recently having been refined to 0.25 degrees, from the original 0.5 degrees. The WRR dataset developed in the project comprises of 10 global hydrological and land-surface models, forced by a common meteorological re-analysis product.

In this paper we use both the first phase 0.5 degrees resolution, and the second phase 0.25 degrees resolution WRR to explore how these can be applied to determine indicators relevant to water resources managers and basin planners around the Mediterranean basin. We explore selected water resources and drought indicators; an aridity index; the water exploitation index; an indicator that calculates the frequency of occurrence of root zone stress; and selected hydrological drought indicators. Results show that the hydrological fluxes from each of the models participating in the WRR show significant differences, despite the use of a common meteorological forcing dataset. These differences are due to different representation and parameterisation of hydrological processes in each of the models. The Indicators calculated with the model outputs reflect these differences, showing considerable uncertainty, the magnitude of which depends also on the hydro-climatology. These uncertainties can be important when categorising areas based on the values of these indices. This is particularly apparent in transitional areas such as the Mediterranean basin. Our results show how the indicators, and the uncertainties in deriving these varies across the basin, as well as the influence of the improved resolution WRR in reducing uncertainties.

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