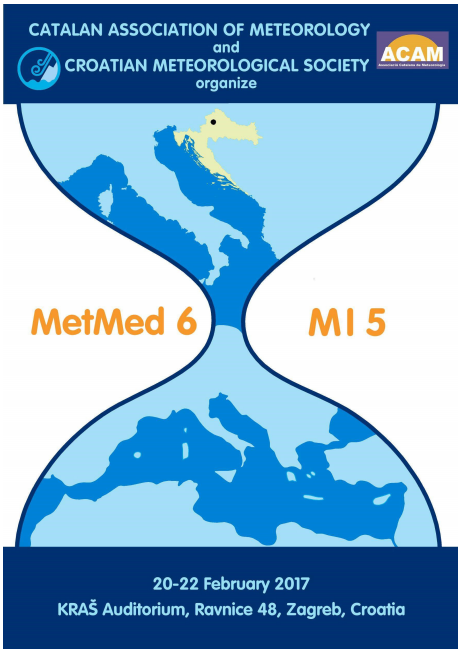


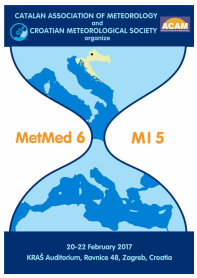
http://www.metmed.eu

Joint Congress of the 6th International Conference on Meteorology and Climatology of the Mediterranean & Challenges in Meteorology 5

Abstracts book

Organized by Catalan Meteorological Association (ACAM) and Croatian Meteorological Society (HMD) in collaboration with Center of Environmental Studies of the Mediterranean (CEAM), Meteorological and Hydrological Service, Croatia (DHMZ) and Department of Geophysics Faculty of Science, University of Zagreb (GFZ), and Tethys, Journal of Mediterranean Meteorology & Climatology

Zagreb, Croatia, February 20th-22nd 2017



General information

Location of the meeting

Kraš Auditorium
Ravnice 48, Zagreb (Croatia)

Organization

The Catalan Association of Meteorology (ACAM)
Croatian Meteorological Society (HMD)

in collaboration with
Center of Environmental Studies of the Mediterranean (CEAM), Meteorological and Hydrological Service, Croatia (DHMZ) and Department of Geophysics Fac. of Science, University of Zagreb (GFZ)

Support

Tethys, Jounal of the Mediterranan Meteoology and Climatology (`http://www.tethys.cat/en`)
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The Foundation of the Croatian Academy of Sciences and Arts (HAZU) Project "Messi", Institute of Oceanography and Fisheries (IZOR) Faculty of Science, University of Zagreb (PMF)

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Kristian Horvath (Meteorological and Hydrological Service, DHMZ, Croatia)

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Journals of the Joint Congress

Tethys
Croatian Meteorological Journal

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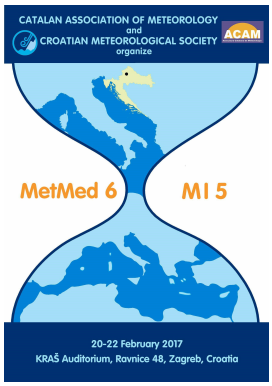

6th International Meeting on Meteorology and Climatology of the Mediterranean & Challenges in Meteorology 5

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Abstracts book

Croatia, Zagreb, February 20th-22nd 2017

Oral

Monday, 20th

8:00 : *Conference Registration, light Ice break*

Session 0: Welcome and Opening Session

9:15-9:20 Dr. **Jose Luis Palau**, Chair of Conference, on behalf of the Organizing Committee: *Welcome and opening the 6th MetMed Conference*

9:20-9:25 President of Croatian Meteorological Society: *Welcome words*

9:25-9:30 Director of Meteorological and Hydrological Service: *Greeting words*

9:30-9:35 Head of Geophysical Department, Faculty of Science, University of Zagreb: *Words to welcome*

9:35-9:45 Dr. **K. Horvath**, on behalf of the Local Committee: *General information*

Session 6: Interdisciplinarity in atmospheric, oceanic and hydrologic sciences

09:45-10:15: The interaction of atmospheric, oceanic & hydrological sciences at ECMWF

N. Wedi, **G. Balsamo**, **S. Keeley**, **K. Mogensen** and **F. Wetterhall**

ECMWF

The research at the European Centre for Medium Range Forecasts (ECMWF) has been re-organised one year ago in order to take a more holistic approach in modelling the global water cycle. As a result we will report on progress in describing both warm and cold processes interacting at the interface between the atmosphere and the land and ocean surfaces. We describe and assess the importance of soil, snow, sea-ice, lake, wave, and ocean processes with a view to enhance the medium-range predictive skill by considering increases in the complexity of the Earth System. In particular, we will report on the performance and future challenges of the new operational global high-resolution ensemble system which is coupled to the NEMO3.4 ocean model at 1/4 degree with 75 vertical levels, coupled to the LIM2 sea-ice model. Improved water cycle prediction performance is also expected to translate into improved capacity to support flood prediction applications, as explored in the framework of Global Flood Awareness System (GloFAS), and to lead to advanced water-cycle reanalyses under the framework of the Copernicus Climate Chance Services (C3s).

10:15-10:30: Influence of changes in climate on the operation of water resources systems

[1]**J. Berbić** and [2]**E. Ocvirk**

[1] *PhD candidate at The Faculty of Civil Engineering, University of Zagreb*

[2] *The Faculty of Civil Engineering, University of Zagreb*

Water resources systems are built for the design periods of longer duration, during which different hydrological conditions could appear. Climate changes in the last decades, due to their conspicuous intensity, make the possibility of occurence of water resources systems (more often) in extreme hydrological situations to be very likely. On the basis of assuming that water

quantity on disposition is going to be slightly changed, statistical distributions of hydrological quantities involving more extreme events can be generated. For such distributions, possibilities of satisfying the needs of different users dependent of multipurpose water resources system are evaluated, and are proposed in the paper, on the example of water reservoir.

10:30-10:45: Numerical modeling of meteorological conditions during the 2015 wildfires on Pelješac Peninsula

[1]**B. Omazić**, [2]**V. Vucetic**, [3]**M. Telišman Prtenjak**, [3]**A. Marki** and [2]**S. Ivatek-Šahdan**

[1]student of Faculty of Science, Deparment of Geophysics, University of Zagreb, Horvatovac 95, 10000 Zagreb, Croatia
[2]Meteorological and Hydrological Service (DHMZ), Grić 3, 10000 Zagreb, Croatia
[3]Deparment of Geophysics, Faculty of Science, University of Zagreb, Horvatovac 95, 10000 Zagreb, Croatia

Weather situation during the two forest fires, which were intentionally caused on the Pelješac Peninsula on the night 20/21 July, has been analyzed. The aim of this study is to research weather conditions that led, with the help of human factor to the begging of fire and to validate numerical simulations of models WRF and ALADIN/HR during the first few days of fire. The lack of precipitation and extremely hot weather in July caused the worst possible forest fires - fire crown. During the wildfires slightly lower air pressure prevailed on the southern Adriatic, and the warm air was up to 850 hPa. At the beginning of wildfires air temperature at 2 m achieved 39oC and relative humidity was around 40% during the day. Few hours before fires wind gusts reached 12 m/s. Canadian forest fire weather index (FWI) showed high risk of wildfire until 26 July 2015. Haines index showed high risk of forest fire during the day and moderate risk during nights. Simulated air temperature for both models gave good results, but model WRF produced slightly lower maximum temperature than observed temperature. However, some meteorological elements of the WRF and ALADIN models predicted differently. ALADIN/HR model produced lower relative air humidity, and WRF higher than observations, due to different model setup and selected parameterization. While model ALADIN/HR significantly underestimates 10-minutes mean wind speed, WRF overestimates them. We also compared simulated fields developed by the ALADIN/HR and WRF models with upper air observations. WRF model usually predicts higher wind speed up to 1 km altitude. But it should be noted that weak wind up to 5 m/s prevailed in the troposphere lower layer during the fire except at night on the beginning of fire the WRF model simulated a maximum of 12 m/s. Both models predicted decreasing air temperatures with height and almost neutral stratification of atmosphere. Although the man intentionally set fire, meteorological observations indicate very favorable weather conditions (dry and hot weather) in Pelješac Peninsula in the days before and during fires, for the outbreak and rapid spread of wildfire. Such weather conditions and very steep and inaccessible terrain have hampered fire-fighting which endangered human lives and residential buildings.

10:45-11:00: Steadiness of meteorological forcing and extreme wave heights at Adriatic sea

D. Klarić, **V. Tutis**, **L. Fuštar** and **T. Ljubas**

Meteorological and Hydrological Service (DHMZ), Croatia

Extreme sea state conditions with extreme wave heights at Adriatic Sea are analyzed with respect of weather patterns. The cases were selected related to the "in situ" and satellite observations, and sea state warnings reports. Steadiness of weather patterns were analyzed for North and central Adriatic areas. Steadiness of surface winds for extreme wave heights are considered. Comparison of ECMWF reanalyses products : ERA-interim, ERA-20C for atmosphere and wind wave products are performed.

11:00-11:15: A climatological study of the meteorological situations associated with the flooding of the Têt Mediterranean coastal river

[1]**M. Tous**, [1]**E. Richard**, [2]**H. Roux** and [2]**A. Lenica**

[1]*Laboratoire d'Aerologie*
[2]*Institut de Mecanique des Fluides de Toulouse*

Having its source on the North face of the Pyrenees and flowing into the Mediterranean Sea, the Têt river is situated in a place prone to ice melt and, especially, heavy precipitation. At the end of November 2014, the Têt daily averaged discharge exceeded 500m3/s in Perpignan which resulted in severe local flooding. For the last 30 years (1985- 2015), more than 70 events with daily averaged discharge over 100m3/s were recorded. These few figures illustrate the high risk of flood in the area.
Our study has two main objectives. On one hand, we evaluate the main common pattern of the meteorological fields related with events of heavy precipitation over the Têt watershed. Using Principal Component Analysis (PCA) applied to the 500 and 950hPa geopotential and the 950hPa equivalent potential temperature, we confirm the link between those heavy rain events and episodes of strong marine winds advecting towards the coast high values of humidity in the low levels of the atmosphere. Furthermore, depending on their eigenvectors, the collection of all the associated meteorological environments has been clustered using a K-means algorithm. Three well distinguishable clusters were identified. Cluster 1 and 3 are associated with a localized surface low located in the vicinity of the Balearic Islands whereas cluster 2 corresponds to a larger-scale cyclone. While cluster 3 exhibits a strong seasonal peak in autumn, the events of cluster 1 and 2 are relatively evenly distributed from October to April. The events in cluster 2 show the highest average precipitation but the lowest maximum precipitation. In contrast, the highest maximum precipitation is found

in cluster 3, which is also the cluster with the highest equivalent temperatures values and whose events take place over the highest sea surface temperatures.
On the other hand, we analyze some of the particularities of these heavy precipitation events, paying special attention to three situations of March 2011, March 2013, and November 2014 which correspond to the highest observed discharges in the last 5 years. All three cases have very similar meteorological pattern and fall into cluster 2. This suggests that while the most frequent situations (found in cluster 3) correspond to intense but short-duration convective events, the most severe ones in terms of flooding are associated with large scale disturbances and longer precipitating events (cluster 2).

11:45-12:00: Coupling of geophysical models

[1]**M. Dutour Sikirić**, [2]**A. Roland**, [3]**L. Cavaleri**, [3]**L. Bertotti** and [4]**L. Torrisi**
[1]Institut Rudjer Boskovic
[2]BGS IT&E GMBH
[3]ISMAR-CNR
[4]CNMCA, National Meteorological Service, Italian Air Force

Surface wave models are typically forced with wind obtained from an atmospheric model. The source term functions used in wave models yield as a byproduct the Charnock coefficient. This coefficient is key to the parameterization of the roughness of the sea. Thus in order to get better wind and wave forecasts one needs to couple wind and wave models.
Similarly, the currents acts on waves by changing how they see the wind. The Stokes drift computed from the wave spectra enters into the primitive equations of circulation in the ocean. Also wave statistics are used in several parameterizations of ocean models. Thus it is quite natural to have the wave model coupled with the circulation model.
We have developped an integrated system containing the Wave model WWM or WAM, circulation model ROMS and Atmospheric model COSMO. We designed the Parallel General Model Coupling Library (PGMCL) for efficient interfacing of the models. When applied to the Mediterranean Sea the coupling yield improved results.

12:00-12:15: Intense high-frequency sea level oscillations at tsunami timescales and their connection to synoptic atmospheric patterns

I. Vilibić and **J. Sepic**
Institute of Oceanography and Fisheries

The presentation aims to demonstrate contribution of intense atmospherically-generated sea level oscillations occurring at tsunami timescales to the sea level budget. These oscillations may be an important contributor to the coastal flooding, with wave height ranges of an order of tides, particularly in the low-tidal basins such as the Mediterranean Sea. They can even grow to destructive levels of several metres, causing a large damage and panic over limited coastal basins. In that case, they are considered to be meteotsunamis or meteorological tsunamis. Meteotsunamis and nonseismic sea level oscillations at tsunami timescales are normally driven by travelling atmospheric disturbances of variable intensity – the stronger is the disturbance the larger is the ocean wave – but some other prerequisites are needed for an efficient transfer of energy from the atmosphere to the sea. The most important prerequisite is matching between the speed of atmospheric disturbance and the speed of long ocean waves, so-called Proudman resonance, which is responsible for generation and amplification of long ocean waves. These waves can then be further amplified in certain harbours and bays through harbour resonance.
Although tsunamigenic atmospheric disturbances may have a different origin, being squall lines, ducted gravity waves, wave-CISK (Convective Instability of the Second Kind) cells or other, a common synoptic pattern is observed over the Mediterranean during the meteotsunamis. This pattern includes: (i) the existence of an unstable mid-troposphere jet, overtopping (ii) an inflow of warm and dry air in the lower troposphere, where (iii) a linear decrease in winds towards the surface, (iv) existence of a weak surface cyclone and (v) a temperature inversion favour a non-dissipative ducting of low-troposphere disturbances in the direction and with the speed of the jet. Tsunamigenic atmospheric disturbances are normally detectable as rapid changes of the air pressure (order of 1-5 hPa), occurring over a few minutes. It seems that similar connection between atmospheric conditions and tsunami timescale sea level oscillations is persistent over a large part of the World Ocean, particularly in subtropical and mid latitudes, allowing for creation of an efficient weekly forecast of high-frequency sea level oscillations from synoptic atmospheric forecast only.

12:15-12:30: Synoptic features of high-frequency sea level oscillations in the northern Baltic Sea and the Mediterranean

[1]**H. Pellikka**, [2]**J. Šepić**, [1]**I. Lehtonen** and [2]**I. Vilibić**
[1]*Finnish Meteorological Institute*
[2]*Institute of Oceanography and Fisheries, Croatia*

Meteotsunamis and other high-frequency sea level oscillations pose a threat to coastal safety in shallow sea areas, e.g. the Mediterranean and the Baltic Sea. Meteotsunamis are known to occur in the Baltic Sea, but their frequency, formation mechanisms and meteorological background are poorly known. Strongest reliably documented Baltic events have a wave height of ca. 1-1.5 m and have caused mild damage, while in the Mediterranean, locally destructive events with wave heights of up to 6 m have been observed. There are, however, historical records of mysterious, destructive high waves in the southern Baltic Sea, called Seebär, which is a local name connected to meteotsunamis.
This study aims to increase the understanding of meteorological conditions giving birth to meteotsunamis and other high-frequency sea level oscillations in the Baltic Sea. Data used comprise 10 years of sea level observa-

tions with 1-min resolution from 13 tide gauges on the Finnish coast, in the northern Baltic Sea. After despiking and quality control of the data, high-frequency sea level oscillations are extracted from the data using a high-pass filter and sorted by the height of the largest individual wave. A number of the strongest events are selected for further analysis, for summer months (May-Oct) and winter months (Nov-Apr), separately, and for two geographical regions, the Gulf of Finland and the Gulf of Bothnia. Criteria for selecting the events include wave height and the number of stations where the event is observed.
Synoptic analyses are made to study the meteorological conditions during the selected events. Results indicate clear seasonal differences between summer and winter events. The findings are compared with a similar study conducted in the Mediterranean to find out whether similar synoptic conditions create rapid sea level oscillations in the two seas.

12:30-12:45: Numerical Study of Balearic Meteotsunami Generation and Propagation under Synthetic Gravity Wave Forcing

[1]**M. Licer**, [2]**B. Mourre**, [2]**C. Troupin**, [2]**A. Krietemeyer** and [2]**J. Tintore**
[1]*NIB-MBS*
[2]*SOCIB-ICTS*

We present results from a high resolution nested ocean modelling system forced by synthetic atmospheric gravity waves, to determine how meteotsunami amplitude in the Balearic port of Ciutadella depends on gravity wave direction, speed and trajectory. We present meteotsunami propagation paths in the Menorca Channel for several forcing velocities and show that the Channel bathymetry serves as a converging lens for meteotsunami waves whose paths are constrained by the forcing direction and the Proudman resonance. The Channel is further demonstrated to be the key build-up region determining meteotsunami amplitude in Ciutadella. Northern and southern Mallorca shelves serve only as barotropic wave guides but do not contribute to seiche amplitude in Ciutadella. This fact seriously reduces early-warning alert times in cases of locally generated pressure perturbations. We estimate meteotsunami speed under sub- and supercritical forcing and derive a first order estimate of its magnitude.

12:45-13:00: Meteotsunamis of June 2014 in the Adriatic and northwestern Black Sea: Two amplification mechanisms

[1]**A. Rabinovich**, [2]**J. Šepić** and [2]**I. Vilibić**
[1]*Institute of Ocean Sciences*
[2]*Institute of Oceanography and Fisheries*

A chain of destructive events occurred on 23-27 June 2014 in the Mediterranean and Black Sea regions. On 25 June strong tsunami-like waves with heights up to 3 m struck a number of bays and harbors in the central and southern parts of the Adriatic Sea. The largest oscillations, with a period of about 20 min, were observed at the head of Vela Luka Bay, the location of a catastrophic 6-m flood on 21 June 1978. Similar oscillations were observed at a number of other sites, including Rijeka Dubrovacka, Stari Grad, Vrboska, Viganj and Ston. Two days later, on 27 June, tsunami-like waves hit the beaches of Odessa and the neighboring port town of Illichevsk, breaking beach structures and causing a number of injuries.
It appears that the events of June 2014 were a result of anomalous atmospheric conditions over the Mediterranean region characterized by: (1) the inflow of warm and dry air from Africa, (2) a strong south-westerly jet stream, and (3) the presence of unstable atmospheric layers characterized by a small Richardson stability number ($Ri < 0.25$). The atmospheric pattern first developed in the western Mediterranean on 23 June, where it affected the Balearic Islands (Spain). It then propagated eastward to the Adriatic on 25 June, and finally on 27 June arrived in the region of the northwestern Black Sea, being coincident with the time of the "Odessa tsunami". However, the character of the event at Odessa was quite different from those observed in the Adriatic and in some other Mediterranean regions. On the coast of the Adriatic Sea there were intense sea level oscillations that lasted for several hours and were accompanied by strong currents (of more than 10 knots), while the beaches of Odessa and Illichevsk were attacked by a solitary wave. The abrupt occurrence of the wave that arrived from a calm sea, its considerable height, and significant inundation beyond the beach are features typical for a tsunami, but the region was seismically quiet and no signatures of landslides were found.
A number of numerical experiments done for this study clearly demonstrated that despite their different character, anomalous waves in both the Adriatic and northwestern Black seas had been generated by similar small-scale short-life atmospheric pressure perturbations travelling with the jet-stream and inducing tsunami-like waves in specific areas. The governing parameter determining the sea level response to atmospheric disturbances is the Froude number, Fr, which is the ratio of the atmospheric gravity wave speed to the phase speed of long ocean waves. The extreme events of June 2014 occurred in regions with favourable conditions for meteotsunami generation ($0.9 < Fr < 1.1$). One of these regions is the Adriatic Sea and another is the northwestern part of the Black Sea ("Odessa Gulf"). Additional amplification of the waves in the Adriatic region was due to the harbour resonance of some bays along the Dalmatian coast, while in the area of Odessa the main amplification factor was a broad shallow-water coastal shelf strongly intensifying the arriving wave.

14:30-14:45: Quantifying the probability of meteotsunami occurrence from synoptic atmospheric patterns

[1]**J. Šepić**, [1]**I. Vilibić** and [2]**S. Monserrat**
[1]*Institute of Oceanography and Fisheries*
[2]*University of the Balearic Islands*

Meteorological tsunamis (also known as meteotsunamis)

- atmospherically generated sea level oscillations in the tsunami frequency band - threaten coastal communities throughout the World. In the Mediterranean, meteotsunamis are known to reach destructive wave heights of several meters at a few hot spot locations like the Balearic Islands, the Adriatic Sea and Sicily. As meteotsunamis are generated by short-lasting (a few hours) mesoscale (several tens of kilometers wide) atmospheric disturbances, they are extremely unpredictable and difficult to forecast by atmospheric numerical models. However, a characteristic synoptic pattern is commonly observed during the Mediterranean meteotsunamis. This pattern includes: (1) inflow of warm and dry air in the lower troposphere commonly associated to a (2) near surface temperature inversion and (3) weak surface cyclone and winds, and (4) strong mid-tropospheric winds embedded in (5) unstable atmospheric layers. Two questions naturally arise: (1) can a proper forecasting of this synoptic pattern be used to forecast meteotsunamis?, and, if so, (2) is it possible to quantify the probability of tsunami occurrence?

To answer these questions, a synoptic atmospheric index is constructed for the region of the Balearic Islands, Spain. The index links the occurrence of meteotsunamis to contemporaneous meteorological synoptic conditions above the region. The correlation between the synoptic index and wave heights is found to be significant and high (up to 0.75). The vertical wind profile is recognized as the most important variable governing the sea level response to atmospheric conditions. The probability of meteotsunami occurrence can be then evaluated from the synoptic atmospheric variables. The results show that there exists a threshold for the index below which the probability for an intense meteotsunami occurrence is extremely low. However, the meteotsunami-favorable synoptic conditions (the index exceeding the threshold value) are crucial but insufficient, some mesoscale features, not reflected in the synoptic pattern are found to play an important role in the meteotsunami generation. The constructed index is potentially applicable to other world locations where a set of tsunamigenic synoptic conditions may be defined in a similar way as at the Balearic Islands. The index can be used to estimate the rate of meteotsunami occurrence in the past, present and future climates. It can also be effectively used in meteotsunami warning systems, in particular to switch between a 'silent mode' (index below the threshold value) to an 'event mode'.

14:45-15:00: Intensive Adriatic storm-surge episodes and related across-basin sea-level slope

[1]**I. Međugorac**, [1]**M. Orlić**, [2]**I. Janeković**, [1]**Z. Pasarić** and [1]**M. Pasarić**

[1]*Andrija Mohorovičić Geophysical Institute, Faculty of Science, University of Zagreb, Croatia*
[2]*University of Western Australia, Perth, Australia*

In the Adriatic, storm surges pose a great threat to the northernmost coastal cities, with Venice being most prone to flooding. It has been noted that some flooding episodes have significantly different effects along the eastern and western Adriatic coasts and this may be connected with across-basin sea-level slope. The present study aims to determine specific atmospheric conditions under which the across-basin sea-level slope develops and to explore its connection with sea-level heights along the two coastlines. The study was carried out using sea-level time series recorded at Venice and Bakar tide-gauge stations over the 1984-2014 interval. The most intensive episodes were extracted using the 99.95th percentile as a threshold applied to the residual sea levels. The underlying meteorological conditions were documented by the ERA-Interim database. The extremes obtained were divided in three categories according to the across-basin sea-level slope: storm surges that slope strongly westward (I-type), storm surges that slope eastward (C-type) and ordinary storm surges (O-type). Average air-pressure and wind fields were calculated for the three types. They revealed features of meteorological fields controlling generation of across-basin sea-level slope: (i) across-basin wind stress above the northernmost part of the basin (TyA), (ii) Sirocco-wind shear along Rimini-Bakar transect (dTxB/dy) and (iii) across-basin wind stress along Rimini-Bakar transect (TyB). Furthermore, meteorological fields corresponding to the three types of storm surges were applied to oceanographic numerical model SCHISM, which resulted in sea levels comparing favourably with observations. Simulations have shown that the three meteorological parameters, TyA, dTxB/dy and TyB, contribute equally to the across-basin sea-level slope. Finally, it has been found that the intensity of storm surges along a particular Adriatic coast depends on the strength of sea-level slope towards that coast, but there are exceptions to this rule.

P6.1: Assessing the Role of changes in Land Uses in the accumulation and feedback of water vapor and pollutants. Research Project: VERSUS

[1]**J. Palau**, [1]**J. Valiente**, [1]**F. Pastor**, [2]**E. Chirino**, [1]**P. Beneto-valles** and [3]**E. K. Larsen**

[1]*Fundacion CEAM*
[2]*Universidad de Chimborazo*
[3]-

As it has been repeated in the various IPCC assessment reports, "It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent". However, as also noted in the same report, "although the ability of Atmosphere-Ocean General Circulation Models (AOGCMs) to simulate extreme events, especially hot and cold spells, has improved, the frequency and amount of precipitation falling in intense events are underestimated" (IPCC 697 2007).

From the definition of critical threshold for convective and orographically aided storms, VERSUS project aims to go a step further in its characterization in order to provide answers to some of the social challenges identified in the Spanish National Plan for Scientific Research, Technology and Innovation 2013-2016.

VERSUS project was launched in January 2016 and, during four years it aims to answer to what extent changes in land cover at local and regional scales in the Western Mediterranean coasts can cause changes in rainfall patterns in the basin.
Based on current knowledge, tasks are based on the combined use of different techniques and approaches including numerical modeling, satellite data, terrestrial meteorological and air quality data, field measurements (made specifically for this project), and with a multidisciplinary team of researchers from Valencia, Alicante and Ecuador.
In this communication we present the experimental deployment along the Turia River basin (including measurements of Total Evapotranspiration and water balance on six 20x20 m^2 pine plots along the Turia valley and the numerical experiments designed to: (a) Identify and characterize the accumulation of water vapor and secondary air pollutants in the western Mediterranean, and their interrelationships with episodes of atmospheric secondary pollutants and the occurrence of convective and orographically aided summer storms, and (b) analize the sensitivity of recharge processes (or feedback processes) of water vapor in the western Mediterranean basin to disturbances caused by changes in land uses.
Acknowledgements:
Research project VERSUS (Improvement of surveillance and forecasting regional systems of atmospheric risks. Assessing the Role of changes in Land Uses in the accumulation and feedback of water vapor and pollutants), CGL2015-67466-R (MINECO/FEDER) is funded by the Spanish National Programme for Scientific Research, Technology and Innovation 2013-2016.

P6.2: Possibilites of using machine learning in water resources management

[1]**J. Berbić** and [2]**E. Ocvirk**

[1]*PhD candidate at The Faculty of Civil Engineering, University of Zagreb*
[2]*The Faculty of Civil Engineering, University of Zagreb*

Usage of machine learning, that is, data-driven models, for forecasting water level, flow and sediment transport in rivers, groundwater levels, sea waves characteristics, etc. is increased in the last two decades. There are able to give very accurate results for forecasting in one space point, and are computationally not expensive. Due to the broad possibilities of appliacation of these models, when the databases from longer periods of observation are on disposition, it is worth of considering their usage. Review of usage and possibilities of machine learning application in water resources management is given in the paper.

P6.3: A panel data analysis for estimating the influence of human activities on CO2 emissions

[1]**G. Sedefoğlu** and [2]**J. Berbić**

[1]*Graduated student, Marmara University, Department of Econometrics, Istanbul, Turkey*
[2]*PhD candidate at The Faculty of Civil Engineering, University of Zagreb, Croatia*

Burning of the fossil fuels is widely considered as the first factor affecting the changes in climate by emitting the greenhouse gases into the air. Other human activities, such us urban population, population density, energy usage, GDP per capita also affect the air pollution, whether directly or indirectly. In this study, the panel data analysis is considered as an econometric approach for analyzing the influence of those activities on the air pollution. Provided data used in the study includes 29 European countries between the year of 2003 and 2011, and CO2 is used as the measure of the air pollution. After the test results were done, Panel Corrected Standard Errors (PCSE) is chosen as the robust estimator and applied to see the effects of variables affecting the CO2 emissions.

P6.4: Role of atmospheric and hydrological forcing in shaping dense water formation in the northern Adriatic Sea

[1]**I. Vilibić**, [1]**H. Mihanović**, [2]**I. Janeković**, [1]**J. Sepic** and [3]**M. Tudor**

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It has been known for a long time that dense water formation occurs in the Adriatic Sea. This dense water is of substantial importance for the whole Eastern Mediterranean as it ventilates its deep and abyssal waters. The formation occurs during wintertime, when prolonged and severe outbreaks of cold and dry bora wind may result in considerable heat loss from the sea, cooling the waters and increasing their density. The created dense waters then flow along the western shelf towards the Adriatic depressions. Bora wind is spatially and temporally very inhomogeneous, especially along the eastern Adriatic coast where it reaches its maximum intensity, resulting in high inhomogeneity of the energy uptake from the sea. The dense water formation is thus restricted to a few sites where bora is especially severe and persistent, the major one located within the bora-driven cyclonic gyre in the northernmost part of the Adriatic. The secondary site is located within the numerous channels and bays placed in the coastal northeastern Adriatic. This secondary site is normally affected by the freshwater load which may substantially decrease salinity and prevent the generation of dense waters.
The presentation is focused on recent findings on the dense water formation, mostly coming out of investigations of the severe winter of 2012. High-resolution atmospheric modelling of the event has been conducted by using ALADIN model. The results reveal the severity of the wintertime conditions, particularly in the eastern coastal area. A number of modelling exercises using the ROMS ocean model have been done to test the sensitivity of the dense water formation to different river discharges. It has been shown that the use of improper river climatology in models may prevent or reduce reproduction of dense water formation at both

formation sites. Finally, multi-year model run has been carried out for 2008 to 2015. The results stress the importance of both wind severity and persistency, and freshwater preconditioning for dense water formation at the secondary formation site. No substantial amount of dense waters has been formed there during winters other than 2012 which was preceded by an extremely dry year of 2011. By contrast, no dense water generation at the primary formation site occurred only during winters which were abnormally mild in terms of heat losses.

P6.5: Numerical analysis of atmospheric conditions during an exceptional meteotsunami event in the Mediterranean

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Meteotsunamis are long sea surface waves caused by propagating weakly dissipative atmospheric pressure perturbations formed by ducted internal atmospheric gravity waves and/or convection. Several high-amplitude meteotsunamis occurred in the northern Mediterranean countries during a major meteotsunami period from 23-27 June 2014. The largest sea level oscillations were recorded in Vela Luka Bay, Croatia, in the morning of 25 June 2014, where the amplitude of sea level oscillations reached 3 m. Sea level oscillations reaching 2 m were recorded also near Balearic Islands (Spain), Sicily (Italy), and Odessa (Ukraine). The extraordinary spatial dimension of this event shows that meteotsunamis can have a widespread influence that is comparable to other major tsunami-genic mechanisms.
The numerical analysis of the event was carried out using the Weather and Research Forecasting (WRF) mesoscale non-hydrostatic model. The model was configured over the entire Mediterranean with the coarse horizontal grid spacing resolution of 9 km and for the four affected regions of Balearic Islands, Sicily, Adriatic and Odessa/Black Sea with three nested domains.
The large-scale setting during the meteotsunami period was characterized by an incoming upper-level trough as well as the upper-level jet aloft and warm low-level advection from the African continent. As inferred by comparison with the ECMWF reanalysis, the model represents well these environmental conditions during the meteotsunami period. The dynamically unstable mid-troposphere with Richardson number smaller than 0.25 capped the warm statically stable air in the lower troposphere. These environmental conditions are generally favorable for sustaining the internal gravity waves provided the lower layer is statically stable and of sufficient depth. The oscillating surface pressure perturbations at the sea level were also represented in the simulation, especially well in the Adriatic area. Simulated pressure perturbations were sustained and reached amplitudes of several hPa at the mean sea level, which is of sufficient amplitude to cause a meteotsunami.
Finally, we discuss the strengths and weaknesses of mesoscale model simulations with respect to simulating atmospheric conditions favorable for meteotsunamis and discuss potentials of coupled atmospheric-ocean models for analysis of meteotsunami events. We also provide guidance on the model setup requirements necessary for inclusion of numerical weather prediction models in the operational applications of the meteotsunami warning system.

P6.6: The pillars of Adriatic marine meteorological Center - AMMC

D. Klarić
Meteorological and Hydrological Service (DHMZ), Croatia

Meteorological and Hydrological Service of Croatia (DHMZ Croatia) took a lead in organizing a regional cooperation of national meteorological services of Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro and Slovenia toward the better marine meteorological services at the Adriatic sea area (abb AMMC). The aim of the AMMC is to apply and enhance the World meteorological Organization (WMO) and Joined Commission for marine Meteorology (JCOMM) standards at regional and national levels, in particular at: the integration of meteorological, hydrological and oceanographic "in situ" observation systems at Adriatic sea area

P6.7: High-resolution operational NWP for forecasting meteotsunamis

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Meteorological tsunamis are long-ocean waves generated by intense small-scale air pressure disturbances. They can be several metres high and cause substantial damage to coastal towns. The main objective of the 'Meteotsunamis, destructive long ocean waves in the tsunami frequency band: from observations and simulations towards a warning system' (MESSI) project is to build a reliable prototype of a meteotsunami warning system.
Atmospheric numerical weather prediction models represent one of the main components of any meteotsunami warning system. The non-hydrostatic 2km resolution ALADIN-ALARO forecast running operationally in Meteorological and Hydrological Service of Croatia is an obvious candidate. Preliminary analyses of its operational outputs, which have been available since July 2011, reveal the presence of travelling small-scale pressure disturbances capable to excite meteotsunamis. However, the comparison of forecast pressure evolution to the measured data shows that the intensity of the observed pressure disturbances is simulated fairly by the model, but at a slightly different position and time, and propagate with slightly different speed and direction. Meteotsunamis are known to be highly sensitive to these parameters.
One-minute model time-step is used for reproducing

the disturbances. This allows for an accurate estimate of the error in the position, shape, variability in space and time, as well as speed and direction of the model disturbances with respect to those know to have generated meteotsunamis. Supplementary, an attempt to improve the operational forecast is documented, based on an use of more realistic SST, e.g.coming from the ROMS ocean model, and more realistic physiography of the terrain surrounding the Adriatic sea.
The recent meteotsunamis are investigated using available atmospheric data and meso-scale atmospheric model ALADIN with ALARO physics package. ALADIN-ALARO model is used for reproduction of travelling air pressure disturbances during the Adriatic meteotsunami events. Spatial, temporal and spectral properties of the meteotsunamigenic disturbances (travelling air pressure disturbances) are documented and assessed.
Recently, it has been shown that the physiography fields used by the model are of too low resolution and contain errors in the Adriatic area. These data have been replaced with more accurate data. More importantly, the sea surface temperature (SST) used in the model forecast arrives from the global model that is used for lateral boundary conditions. It has been shown that model SST can be quite far from real values over the Adriatic, especially over the coastal areas, such as in the WAC and Kvarner bay. Here we analyse if using more realistic SST, such as from the ROMS ocean model, and more realistic physiography of the terrain surrounding the Adriatic sea, can improve the forecast of intense small-scale pressure disturbances that can generate meteotsunamis.

P6.8: Application of Three-Dimensional Hydrodynamic Model for reservoir Butoniga

S. Grgurić, **M. Burić**, **A. Jurjević**, **G. Gašparac** and **J. Križan**

Gekom-Geophysical and ecological modeling Ltd.

The Butoniga Reservoir built on the Butoniga River is used for water supply of Istria and flood control in the downstream region. The water quality in the reservoir varies depending on season and water levels, whereas most problems occur in the summer when water consumption is highest, water level lowest and water temperature exceeds critical value for water supply, accompanied by a deterioration of physical-chemical characteristics of raw water which also adversely affects water conditioning process.
An impact of water level on thermal characteristics and consequently water quality was assessed in two cases: 1) reservoir recharge with water from major spring Bulaž by means of the existing pipeline, and 2) improvements that might be achieved by increase in capacity of the existing Jukani Retention Basin on the Butoniga river or by construction of two new upstream retentions on the Butoniga tributaries, i.e. the Draguc Retention Basin on the Dragućki and Podmeriški brooks and the Racice Retention Basin on the Racicki brook.
For assessment of different scenarios, a 3D prognostic model SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model) has been applied. The model was calibrated for year 2012, which was extremely dry. Input meteorological parameters (air temperature, atmospheric pressure, wind speed and direction, precipitation, evaporation, specific humidity, short–wave and long-wave radiation) were obtained with WRF (Weather Research and Forecast model) and measured data from climatological station Butoniga located next to the reservoir. Input hydrological parameters (water temperature, water level, inflows and outflows–water pumping, discharge, percolation) were obtained from local hydrological stations or were derived from water balance calculations. The model simulated daily and seasonal changes in the water level/volume, followed by changes in temperature and development of thermal stratification in the warm part of the year, the circulation of the lake and the impact of water recharge from Bulaž spring. The calibrated model has shown excellent agreement with measured water level and temperature.
Model simulations have shown that it is particularly important that the reservoir water levels are high in order to maintain acceptable reservoir water temperature. Better results in terms of reservoir thermal characteristic are achieved for the second scenario, i.e. development of additional retentions basins.
Usage of such model enables better understanding of processes in reservoirs as well as simulation of different management scenarios for purpose of effective water quantity and quality management.

P6.9: Wave modelling in the Adriatic

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The accurate modelling of sea surface gravity waves is essential for accurate oceanic forecasting with the wave height being a major concern for navigation andThe coastal activities. It is also very important for oceanic modelling, with the wave input being key to the accurate modelling of oceanic surface stress, sediment resuspension, and also to oceanic current modelling.
In DHMZ, we have implemented the Wind Wave Model III as an operational model. The wind forcing used is based on the numerical weather prediction model ALADIN/HR. The model is configured to dynamically adopt near-surface wind to 2km grid spacing over the 3-day forecast range. The boundary condition at the Ottranto strait is obtained from the WAM model forecasts computed at ECMWF. The model setup uses an implicit scheme on an unstructured grid to make the forecasts.
The forecasts are validated with Altimeter satellite estimates and wave radar measurements.

P6.10: Storm surge modelling

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The shallow water equations are a fundamental partial differential equation system that allow to model the free surface and barotropic momentum. It is a fundamental component of 2D models which are used in storm surge modelling but also of 3D baroclinic models, where it serves as an essential component when using the operator splitting method.
Here we implemented an advanced explicit scheme on unstructured mesh that is second order, conservative and preserves positivity of the free surface. The model is implemented in a parallel way which makes it suitable for application in Oceanography but also in rainfall modelling.
We applied the model on a variety of test cases that reflect how the model can be used.

P6.11: Towards the Adriatic meteotsunami early warning system: modelling strategy and validation

C. L Denamiel, **J. Šepić** and **I. Vilibić**
Institut za oceanografiju i ribarstvo

Destructive meteotsunamis are known to occur along the eastern Adriatic coastal areas and islands (Vilibić and Šepic, 2009). The temporal lag between the offshore generation of meteotsunamis due to specific atmospheric conditions and the arrival of a dangerous nearshore propagating wave at known locations is of the order of tens of minutes to a couple of hours. In order to reduce the risk for the coastal communities, an early warning system must rely on the ability to detect these extreme storms offshore with in-situ measurements and to predict the hydrodynamic response nearshore via numerical models within this short time lag.
However, the numerical modelling of meteotsunamis requires both temporal and spatial high-resolution atmospheric and ocean models which are highly demanding concerning time and computer resources. Furthermore, both a multi-model approach and an ensemble modelling strategy should be used to better forecast the distribution of the nearshore impact of meteotsunamis.
The modelling strategy used in this study thus rely on the development of an operational atmosphere-ocean model of the Adriatic Sea at 1km spatial resolution based on the state-of-the-art fully coupled COAWST model (Warner et al., 2010). The model allows for generation of meteotsunamis offshore, while various high-resolution (up to 5m) nearshore hydrodynamic models (such as ADCIRC - Luettich and Westerink, 1991, SELFE - Zhang et al., 2008 and GeoClaw–LeVeque, 2012) are setup to properly reproduce meteotsunami dynamics of the entire Croatian coastal areas, which are characterized by a great number of islands, channels and bays.
The implementation and validation of each component of this modelling system is first undertaken for the well documented meteotsunami event (Šepić et al., 2016), which was recorded along the Croatian Adriatic coast on the 25th and the 26th of June 2014. The validation of the modelling strategy as well as the model results is presented and discussed in this study.

Session 3: Remote and In-Situ Measurements

15:00-15:30: Challenges and Applications of Ground-Based Remote-Sensing Measurements

B. Adler
Karlsruhe Institute of Technology

There is a high demand for observations of atmospheric conditions and processes with high accuracy and high temporal-spatial resolution. Multiple in situ and remote sensing instruments exist to capture temperature, humidity, wind, aerosols and chemical components in the atmosphere and significant technological developments with respect to accuracy and reliability have been made in the last decades. Some of the great challenges when probing the atmosphere lie in the combination of the different measurement techniques as well as to account for the different temporal-spatial resolution of the instruments. In order to gain a most complete overview of the atmospheric conditions, different instruments have to be combined, scanning strategies have to be adopted and an optimal synergy has to be sought. Several research institutions set up integrated observation platforms consisting of multiple in situ and remote sensing instruments in order to improve our knowledge of atmospheric processes and their interactions –especially on the micro- to mesoscale. These platforms are permanently installed as well as mobile. In this talk, I will first give an overview of different ground-based instruments which are available for observing atmospheric properties. Furthermore, I will demonstrate the capabilities and benefits we gain from the simultaneous operation of multiple instruments using examples from recent field campaigns.

15:30-15:45: Comparison and optimization of different radar-based hail detection algorithms in Slovenia

G. Stržinar and **G. Skok**
University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana, Slovenia

Hail related to summertime thunderstorms is a small-scale phenomenon, and it often has a short time duration but can nevertheless cause severe damage to agriculture, buildings and cars. Because of the high spatial and temporal variability of hail, the proper detection of hail occurrences is almost impossible using ground station reports alone. An alternate approach uses information from weather radars. During the last few decades several different algorithms that use single-polarization radar data have been developed

for hail detection. The different criteria consider different levels or thresholds of radar reflectivity, some of them complemented by estimates of the height of the freezing level or cloud top temperature. In the study a verification and optimization of some commonly used algorithms was performed for the region of Slovenia for the summers in period 2002-2010. The results of the verification along with the derived hail climatology in Slovenia will be presented.

P3.5: The Cerdanya-2017 observation field campaign: Cold Pool (CCP'17) and Gravity Waves and Orographic Precipitation (GWOP'17)

[1]**J. Cuxart**, [2]**M. Soler**, [2]**J. Bech**, [3]**A. Paci** and [4]**J. Miró**

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La Cerdanya is one of the largest valleys in the Pyrenees, singularly oriented ENE to WSW, 35 km long and 9 km wide. The bottom of the valley is about 1000 m above sea level and it is surrounded by mountain ranges rising to above 2900 m. This configuration makes the Cerdanya basin prone to the formation of Cold Air Pools (CAP). Also the alignment of the mountains from west to east induces the formation of mountain gravity waves under northerly flow especially in winter. On the other hand, the geographic configuration supports the formation of orographically induced precipitation effects, including both enhancement on windward slopes and rain-shadow effects.
The Cerdanya-2017 field campaign takes place in this valley from October 2016 to April 2017. It is made up of two components: CCP'17 and GWOP'17, devoted to Cold Pools, and to Gravity Waves and Orographic Precipitation, respectively. CCP'17 will take place in January-February 2017, and aims to understand the mechanisms of CAP formation, thermal surface inversions, the surface energy budget and the corresponding evolution in winter conditions, expanding the research currently in progress coming from the analysis of the previous CCP'15 campaign, made in October 2015. GWOP'17 focuses on terrain induced flows and associated phenomena (mountain waves, rotors, subrotors and induced boundary layer separation) and also on the influence of orography on precipitation processes (triggering, intensification, maintenance and enhancement in both stratiform and convective regimes).
Preliminary findings will be substantiated with this new experimental effort which will use a considerable amount of instrumentation including extensive deployment of remote sensing (doppler LIDAR, UHF wind profiler, microwave radiometer, windrass sodar system, mini meteorological radar,...) and in-situ devices (eddy covariance stations, several scientific weather stations, radiosondes, tethered balloon, remotely-piloted drones ...). This research effort is organized by the Universities of the Balearic Islands and of Barcelona, METEO-FRANCE & CNRS and the Meteorological Service of Catalonia. It is funded by the Spanish projects CGL2015-65627-C3-1-R and CGL2015-65627-C3-2-R (MINECO/FEDER), by the Meteorological Service of Catalonia and by METEO-FRANCE & CNRS.

16:00-16:15: Land Surface Temperature Assesment with Remote Sensing Method – example of the Split Metropolitan Area

[1]**T. Duplančić Leder** and [2]**N. Leder**

[1]*Faculty of Civil eng., Architecture and Geodesy*
[2]*Hydrographic institute of Rep. of Croatia*

Land surface temperature (LST) is very important parameter for large amount of Earth processes. We can obtain land surface temperature from satellite thermal data. The most important and longest satellite mission with thermal band capability and sufficient spatial resolution is Landsat mission. In this research, Landsat thermal channels 5, 7 and 8 have been used to determine LST along the metropolitan area of Split (from Trogir to Omiš). Obtained results will show the phenomenon of urban heat island (UHI), as the simultaneous effect of the intensive urbanization in city of Split metropolitan area and observed climate changes. The occurrence of UHI significantly affects the quality of life in the urban area, especially in the summer period.

16:15-16:30: Hectometer-scale variability of atmospheric and surface variables

G. Simó and **J. Cuxart**

University of the Balearic Islands, Physics, Palma de Mallorca, Spain

Many applications, like numerical models and satellite products, have a certain spatial resolution, and the values of relevant variables such as temperature, represent the average value for each element of the grid. The scale of these mesh elements or pixels can vary from tens of meters to kilometres, depending on the application. These gridded fields are calibrated or validated with observational data from stations, therefore mean values are compared to point values without considering the subgrid variability of the terrain that can affect these results and lead us to erroneous estimations.
In order to evaluate the temporal and spatial variability at the hectometer scale, a heterogeneous area has been chosen, the Campus of the University of the Balearic Islands (Mallorca, 200 km to the east of the Iberian Peninsula) with an approximate area of 1 km^2 which is composed of different soil types and uses. LST values from Landsat 7 (30 m resolution) for the area are averaged and compared with the MODIS values for the Campus (at 1 km resolution) and an estimation of the subgrid variability is provided.
In June and July 2016, an ensemble of measuring stations were located at some positions in the Campus corresponding to different soil uses at an average

distance of 150 m between them. This way not only LST variability is inspected, but also the one of wind, energy fluxes or soil properties. Furthermore in 5 days of this period, there were almost simultaneous passes of MODIS, ASTER and Landsat-7 over the Campus, and during these periods a drone with a thermal camera was flown over the Campus to provide LST information at even higher spatial resolution (few meters).
Preliminary results show that LST in the Campus varies between 5 and 20 K at the sub-kilometer scale. The maximum temporal variation on one spot occurs in the artificial grass, showing the great role of the soil-vegetation system in regulating the temperature of the interface. It has been proven that variability is distinguished best on small scales, where a drone can provide higher time/space resolution information than other sources, as Landsat 7 and ASTER show finer variability in results than MODIS. When the 1 km average value of MODIS of LST is compared to a point value provided by a 4-component radiometer, a BIAS of 3.2 K and a RMSE of 4.2 K are found.
In the case of the atmosphere variables, it is seen that in the daytime, even if LST presents very large spatial differences, convective turbulent mixing manages to eliminate the horizontal variation at the 2 m screen level, while during nighttime thermal gradients up to 5 K may exist that are not relaxed by any systematic mixing process, and therefore may be advected by the local wind. Contrarily, the soil variables show well-defined spatial gradients that are sustained for the whole diurnal cycle.

P3.1: Cloud fraction retrieved from ceilometer and camera observations: a comparison

N. Garcia-prat, **J. González** and **J. Calbó**
Universitat de Girona

Clouds intervene in the energy and water balances in the atmosphere through multiple, intricate processes, affecting in turn the climate balance and its change. Therefore, reliable descriptions of cloud climatology and trends are crucial to understand climate change, and to test climate models. In the past, observations of cloud amount and typology have been performed by human observers at selected stations, giving place to many long-term cloud climatologies. Besides, other modern methodologies to monitoring cloudiness from earth surface, as those based on ceilometer measurements and on digital cameras, are receiving increasing interest. In this work we present a comparison among these methodologies, taken out from a year of observations at Girona (NE of Iberian Peninsula). There, a ceilometer takes measurements every 12 sec and a hemispherical camera stores digital images every minute. Diurnal periods from 10:00 to 16:00 UTC have been included in the analyses: these periods are centered at 13:00 UTC, a mandatory time for human observations of cloudiness at official meteorological stations. For each period within each day, the mean cloud occurrence derived from the ceilometer measurements is used as an estimator of the mean cloud fraction along the period. The single image taken at 13:00 UTC, as a mimic of the human observation, has been taken as another suitable estimator for the comparison. The cloud cover estimated from a set of seven images selected in the period from 10 to 16 h UTC (one image per hour) has been used as a reference against to which compare ceilometer and single image retrievals. Results show that, despite the known limitations of ceilometers, mainly due to the limited altitude range of detection and the limited field of view of these sensors, their retrieval allow describing some sky conditions more satisfactorily than by performing only single visual observations.

P3.2: Sensitivity of several ground based cloud and aerosol observation techniques

J. Calbó and **J. González**
Universitat de Girona

Differences between clouds and atmospheric aerosols are related to the different composition (e.g., much higher amount of condensed water in particles constituting a cloud) and/or particle size, and also to the different amount of such particles (10-10,000 particles per cubic centimeter depending on size and conditions). There are situations, however, when distinguishing between cloud and aerosol is far from being obvious, and even when broken or scattered clouds are present in the sky, their limits are not always well defined. The current paper presents a sensitivity analysis applied to three different passive, ground based observation methods that are commonly used to identify clouds and aerosols in the atmosphere. Specifically, we study sky camera images and broadband and spectral radiometric measurements taken at Girona (Spain). Results indicate that for about 5% of the daytime, the sky may be considered cloudless (yet containing aerosols) or cloudy (with some kind of optically thin clouds) depending on the thresholds applied in the involved methodologies and algorithms. Similarly, the extension of broken clouds may increase up to 25% depending on where the limit is put between cloud and aerosol (and also on the observing system) and taking as reference the extension of the unquestionable cloud patches. These findings are relevant given the different effect of clouds and aerosols on the Earth's radiation balance, and the different ways they are parameterized in models.

P3.3: Benefits of super rapid scan satellite data usage for utilization of satellite-based indicators of storm severity

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[2]*Meteorological and Hydrological Service (DHMZ), Croatia*
[3]*EUMETSAT*

Monitoring of convective storms, which often produce hazardous weather on the ground, in many cases heavily relies on satellite remote sensing observations from geostationary satellites. Not only due to a good spatial coverage, but especially in case of short term features on the top of the convective clouds, due to

ever enhancing temporal resolution of such data. Many of storm top features that may indicate severity of the storms have a relatively short lifetime. For instance, some overshooting tops last less than 5 minutes, what is observed using the 5-minute rapid scan data.
Some preliminary results over the Europe region have shown many benefits of rapid scanning (time step of 5 minutes) and super rapid scanning (time step of 2.5 minutes) with SEVIRI instrument onboard MSG satellites for the nowcasting purposes.
In this work special attention is given to a quantitative assessment of connection between higher temporal resolution and better depiction and description of satellite-based indicators of severe weather events (for instance overshooting tops, cold ring and cold U/V features). It will be observed what additional information can be obtained by moving gradually form 15 to 5, and to 2.5 minute time step. Benefits of using rapid scan satellite data in understanding of microphysical properties, genesis, duration and evaluation of storm top features and convective storm itself will be analysed.

P3.4: Fair weather atmospheric electric field in a coastal, urban site

J. Lorente, **Y. Sola** and **J. Montolio**
University of Barcelona

The vertical atmospheric electric field varies at different spatial ant temporal scales due to the influence of thunderstorm activity and clouds. Moreover, in undisturbed meteorological or fair-weather (FW) conditions, the atmosphere remains charged due to global and local influences. In polluted environments, the FW electric field is sensitive to local changes in the air pollution since the electrical conductivity is inversely proportional to the aerosol concentration.
Since the early 20th century, it is well known that the daily cycle of the potential gradient (PG), that is the negative of the vertical electric field, over the oceans (Carnegie curve) shows a peak around 18 UTC, as a consequence of the planetary active thunderstorms. On the other hand, over land the local effect of aerosols modifies the curve, blurring the global pattern and, in some cases, arising a second peak related to local time effects.
In this study, we have analyzed three years of PG data measured in Barcelona (NE of Spain) using an electric field meter (CS110 Campbell Scientific). Data is recorded at 60 Hz frequency but it has been averaged to 10 min values to compare them with other meteorological variables measured at the same place, such as wind and solar radiation. The selection of FW days was based on different criteria for meteorological data and the analysis of global and diffuse irradiance.
The PG under FW conditions shows a two-peak daily cycle, one at local morning hours related to the increase in aerosol concentrations and the sunrise effect. The increase of the convective mixing, when solar rays start heating, raises the positive charges that remained close to the ground at stable nights. In fact, the lowest daily values are detected from 23 to 05 UTC. The second maximum at around 20 UTC reflects the global impact of the planetary thunderstorm distribution. The increase of the solar heating around midday leads to convection and the development of the boundary layer that decreases the observed PG. The two-peak pattern is not observed in particular days due to the effect of the meteorological situation and the variation in the aerosol concentration.
The FW atmospheric electricity shows seasonal variations due to changes in the local meteorological conditions. Lower values detected in summer months are a consequence of higher convection associated with higher irradiation.
The PG annual mean in Barcelona is lower than those observed over the oceans and at continental stations, especially the night values. Similar differences were also reported in other coastal sites, such as Lisbon (Portugal). The observed PG in Barcelona is highly affected by the proximity of the Mediterranean Sea, as well as, by the local aerosol concentration and size distribution.

Session 5: Mountain Meteorology

17:00-17:30: Bora Downslope Windstorm

B. Grisogono
Faculty of Science

The eastern Adriatic coast, roughly N Mediterranean, is well known for Bora wind - a gusty downslope windstorm which typically blows from the NE quadrant with sustained wind speeds between 5-20 ms-1, its gusts surpassing 50-70 ms-1 in the lee of the coastal mountains. Similar bora-like flows occur elsewhere, at least at a couple of tens of other places, provided the presence of flow transcriticality. The bora has been studied at the NE coast more than at the central and SE Adriatic coast: the latter bora cases appear as more complex but less frequent than their NE counterparts. Efforts to study bora have gradually moved toward progressively smaller spatio-temporal scales and turbulence nowadays. A tentative result, obtained by using hotwire anemometer with sampling frequency of 104 Hz, suggests that the inertial dissipation method provides an accurate estimate of the bora turbulent kinetic energy dissipation rate in the surface layer, about 1 m2s-3, at least for moderate wind speeds, O(10 ms-1). Such and other bora turbulence details are needed for improving NWP and climate model turbulence parameterizations and to account for bora effects in traffic, engineering, air-pollution and coastal oceanography, to mention a few.
Moreover, known occasional occurrence of pulsations and rotors is further enriched by secondary low-level jets (LLJs) that are up to a few tens of kilometers long and several kilometers apart (primary LLJs and wakes relate to the mountain main passes and peaks). Preliminary results on contrasting deep and shallow bora events reveal sub-mesoscale structures that have not previously been reported in bora research. For example, spatial structures of O(1 km) may appear further offshore in the convective marine atmospheric boundary layer more than 50 km in the lee of the

coastal mountains.

17:30-17:45: Turbulence characteristics of mountain flows

[1]**I. Stiperski**, [1]**M. W Rotach** and [2]**C. D Whiteman**
[1] *University of Innsbruck*
[2] *University of Utah*

Orography presents a significant forcing to the atmosphere above and around it spanning a wide range of scales, from large scale to turbulence. In mountainous terrain turbulence is by definition considered to be heterogeneous inhibiting efforts of developing a unified similarity theory for complex terrain. This heterogeneity of turbulence stems from local surface characteristics such as changes in slope angle and vegetation cover and inhomogeneity in the thermal forcing as well as different type of dynamic forcing: under low synoptic forcing thermally driven flows develop in mountain valleys and on the slopes whereas under strong synoptic forcing downslope windstorm-type flows can develop. The question remains if these effects cause the flows in mountainous terrain to have different turbulence characteristics to those over flat terrain.
In this contribution we present results from long-term turbulence measurements from the Inn Valley, Austria, as part of i-Box project, together with short-term turbulence measurements during the Metcrax II field campaign in Winslow Meteor Crater in Arizona. We focus on the difference between the turbulence generated by thermally and dynamically driven winds and compare them to that over flat terrain.

17:45-18:00: The formation of the Aure valley exit jet during the BLLAST experimental field campaign

M. A Jiménez, **J. Cuxart** and **D. Martínez-villagrasa**
Universitat de les Illes Balears

Under clear-skies and weak-synoptic pressure gradients, the organization of the flow at lower levels is mainly controlled by the local effects, such as terrain or surface heterogeneities. This is the case of the thermal differences between the air adjacent to the slopes, within a valley and over the nearby plains that generate slope, valley and mountain winds with an opposite direction between day and night. During nighttime, downslope and down-valley wind tend to converge to the center of the valley axes and a valley exit jet can be formed. The aim of this work is to understand the physical mechanisms involved in the valley exit jet: from the conditions that favour its formation within the valley to its propagation beyond the valley limits towards the plain.
The Aure valley is chosen in this study. It is located at the north of the Pyrenees with the main axis pointing from South to North. The period of June-July 2011 is taken, when the BLLAST experimental field campaign took place in Lannemezan (located over a plateau at about 5 km from the exit of the Aure valley). High-resolution mesoscale simulations are analysed for several Intensive Operation Periods (IOPs), corresponding to cases that the wind had southern direction during nighttime.
It is found that downslope and down-valley winds are generated in the Aure Valley close to sunset favouring the formation a valley exit jet about 2h later. All the studied IOPs follow this pattern although the main features of the valley exit jet (intensity, height of the maximum) depend on the mesoscale or synoptical conditions reported at the exit of the valley. As a result, if larger-scale winds are from the northern quadrant, the formation of the valley exit jet is delayed until this wind weakens. On the other hand, when large-scale winds are weak the valley exit jet reaches Lannemezan close to midnight (it is lower and less intense than at the exit of the Aure valley) and interacts with the locally-generated downslope winds already present. There is a good agreement between the model results and the observations in Lannemezan, confirming that the model is able to reproduce the valley exit jet features.

18:00-18:15: Surface energy balance closure in the Owens Valley, CA

[1]**I. Marinović**, [2]**N. Babic**, [3]**I. Stiperski**, [4]**Ž. Večenaj** and [2]**S. F De Wekker**
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All weather and climate models apply conservation of energy at the earth's surface. In that ideal case the sum of the net radiation and ground heat flux (the available energy) balances the surface turbulent fluxes of sensible and latent heat which drive atmospheric boundary layer processes. However, such a closure in the surface energy balance is rarely achieved, resulting in a residual. This residual is typically on the order of 10-30 % of the total available energy with the sum of the turbulent fluxes smaller than the available energy. It is now well established that this residual cannot be solely attributed to measurement uncertainties. Other reasons for a non-closure in the energy balance include the presence of surface heterogeneities and large scale eddies, the presence of thermally and terrain forced flows, and varying flux footprints.
The objective of this study is to identify and quantify the sources of non-closure in the energy balance using data collected during the Terrain-Induced Rotor Experiment in Owens Valley, California, from 1 March to 30 April 2006. In particular, we use the 5 min data for sensible and latent heat fluxes collected at 5 m and 30 m heights, and for net radiation and ground heat flux collected at the 2 m height. Data were collected at three 34 m tall towers distributed along the valley's central axis and its western sidewall. We are also investigating a possibility that contribution of

low frequency structures could be one of the processes that cause non-closure in the energy balance at slope and valley locations during daytime. To select only the daytime conditions, two criterions were applied: short incoming radiation > 30 W/m2 and stability parameter < 0.
We determine the ratio between turbulent fluxes and available energy as a function of the measurement level of the turbulent fluxes, averaging time, the location in the valley, friction velocity, stability and the presence of valley and slope flows (wind speed and wind direction). We demonstrate that knowledge of the dependency of the surface energy balance ratio on these factors is crucial for a proper evaluation of surface layer parameterizations in complex mountainous terrain.

18:15-18:30: Physiography fields and operational NWP using ALADIN model

M. Tudor, **A. Stanešić** and **S. Ivatek-Šahdan**
Meteorological and Hydrological Service (DHMZ), Croatia

Fields that contain so called climatological or constant fields are prescribed to the model forecast. Some of these fields vary during the year and other are constant. These fields contain data that describe orography and land-sea mask, and other fields that describe terrain, such as roughness length (for bare ground, vegetation, different for momentum and heat). Then there are other fields describing surface, soil and vegetation characteristics, as well as monthly climatological values of soil temperature and moisture, modification of albedo and emissivity according to the climatology sea-ice limit, definition of the vegetation characteristics and modification of several surface characteristics.
However, the fields described above were extracted from a rather old database in quite low resolution so interpolation procedure created rather non-physical fields. These fields were used in the operational forecast in the absence of better ones. Many recent developments in the model were implemented and tuned using the physiography fields from this old database. These fields were replaced using data from a new high-resolution database.
Here we show how the new roughness length impacts the model forecast, particularly the 10m wind and 2m temperature and moisture as well as which tuning of the model physics, particularly turbulence, corresponds better with the new surface roughness length field. The old roughness length was too smooth for the Dinaric Alps area and had unnatural pattern over the Alps. The initially computed roughness length had much higher values there. Therefore, alternative ways of computing the roughness length due to unresolved topography were tested and applied to 2 km resolution non-hydrostatic forecast using ALADIN model and two different turbulence schemes. Results show that introducing new roughness length field has larger impact on the model forecast than more sophisticated turbulence scheme.
The impact of modified roughness length was tested by running 31 forecasts in 2 km resolution starting from 00 UTC for March 2016. The operational forecast used to produce excessive wind speed for several mountainous locations few times per year. The old database assumed rather smooth terrain there. That was unrealistic. The forecast of wind at 10m above ground depends on the roughness length. The introduction of new, rougher surface reduced the wind speed in cases with strong to severe bura wind (that blows from north-east therefore from land to sea). The reduction in wind speed varies from place to place and the excess wind speed was removed.

18:30-18:45: Microscale properties of a bora downslope windstorm event: observational and numerical analysis using the WRF model

[1]**K. Horvath**, [2]**Ž. Večenaj**, [2]**B. Grisogono** and [3]**B. Kosović**
[1]*Meteorological and Hydrological Service (DHMZ), Croatia*
[2]*Department of Geophysics, University of Zagreb, Zagreb, Croatia*
[3]*National Center for Atmospheric Research*

Turbulent downslope windstorm events are frequent phenomena over complex terrain of the eastern Adriatic coast. While severe northern-Adriatic downslope windstorms are since long in the focus of interest, strong bora winds in the hinterland of mid-Adriatic coast are much less studied, yet frequent and equally severe phenomena. The predictability of these events is considerably lower than for its northern counterpart due to the inflow complexity induced by the upwind chain of secondary orographic steep mountain sub-ranges and deep valleys.
A strong late-winter anticyclonic bora (28 Apr 2010) event was analyzed with the use of ultrasonic measurements on Pometeno brdo hill at the eastern Adriatic coast, a SODAR nearby and a range of mesoscale and multiscale numerical sensitivity experiments carried out with the Weather Research and Forecasting model. The tower was equipped by three levels of Gill WindMaster Pro ultra-sonic anemometers (at 10, 22 and 40 m AGL) that recorded all three wind speed components with a 5 Hz sampling frequency. The three-dimensional bora flow was characterized by a shallow bora layer, a pronounced directional vertical wind shear, and interaction with valley circulations in deep valleys. During the event, two regimes of sub-mesoscale pulsations were found: i) Regime A – pulsations observed predominantly during the night and morning hours with periods of 5 – 8 minutes and ii) Regime B – pulsations observed predominantly during the afternoon with periods of 8-11 minutes.
Furthermore, numerical analysis of the event used the WRF model with realistic initial and boundary conditions and multiple nested computational domains in two configurations. The first used a mesoscale model setup at a grid spacing reaching 333 m in the highest resolution domain and a Mellor-Yamada type of the planetary boundary layer scheme and the second used a multiscale setup at a grid spacing as fine as 37 m using explicit simulation of large turbulent eddies. The strongest simulated wind speed pulsations were of com-

parable periods as in the observations and originated beneath the primary mountain gravity wave. These pulsations propagated farther away from the point of origin during the daytime convective boundary layer than during the stable nighttime conditions, suggesting larger effect of advected turbulence during daytime. The roles of gravity-wave breaking, Kelvin-Helmholtz instability and surface fluxes were analyzed to study the formation and development of pulsations. We also point out some differences in simulation of pulsations in mesoscale and multiscale simulations. Furthermore, we also assess contributions of other sources and sinks to turbulence kinetic energy. Finally, main differences in the bora subtle structure over the middle and northern Adriatic areas, the latter pertaining to more known bora cases, are pointed out.

18:45-19:00: PILEUS, Environmental Solutions : Presentation on Environmental Instruments

PILEUS

P5.1: An initial approach to the night-time cold in the Sierra del Segura (Spain): study of the processes of intense thermal inversion in the Hernán Perea Plateau using direct observation and teledetection (thermography)

D. E Sánchez and **C. C García**

Dpto. Geography (University of Murcia)

The high plateau of Campos de Hernan Perea is an extensive calcareous platform (144 km2) located at more than 1650 m altitude in the Sierra del Segura, east of the province of Jaen (Betic Cordilleras, Spain). Its flat surface, widely occupied by sinkholes and poljes (karstic depressions), and its topographical isolation, with karst terrains at 2100 m altitude, favour the development in this area of intense thermal inversions (TI), usually accompanied by severe frosts during the winter months.

Through the installation of temperature sensors in the Polje of Cañada de la Cruz and in one of the sinkholes in the field of Pinar Negro, absolute minimum temperatures of -24 and -26^{o}C, respectively, have been recorded during the last two winter periods (2014/2015 and 2015/2016). These represent the lowest values of absolute minimum temperature recorded in Spain, in any of the official and amateur networks of meteorological stations, during that period. The chosen sites are 15 km from each other and exhibit very-different topographical features. The Poje of Cañada de la Cruz, whose flat floor has an altitude variation of barely 25 m, is relatively large (0.63 km2) and drains to the northwest: however, the sinkhole of Pinar Negro is small (0.004 km2), shows an altitude variation of 15 m and has hardly any drainage.

This paper aims to demonstrate the existence of one of the coldest areas of Spain, within a relatively-narrow latitudinal strip (X: 4204334

P5.2: Relationships in observed meteorological data series at Dubrovnik airport and upstream stations during Bora events

L. Gabela Šeperić and **J. Jurković**

Croatia Control ltd.

Considering the nature of the development of bora and its dependence on orography, it is very challenging to forecast the beginning of bora and maximum wind speeds in the southern Adriatic. For Dubrovnik Airport the model wind speed values usually deviate from the measured values by several dozens of KT which hinders nowcasting and issuing warnings to users in aviation. The experiences of local forecasters show that the relationship between the pressure differences at neighbouring upstream stations can be used when forecasting maximum wind gusts.

This poster explores the existence of this relationship and its possible application. METAR data from Dubrovnik, Mostar, Sarajevo and Split Airports were used for the analysis.

As was to be expected, the relationship between the observed parameters is non-linear. During bora events the pressure at Dubrovnik Airport is the lowest of all the observed stations. The obtained histograms show that during bora events the maximum wind speed can be assessed in only some cases. Unlike the better correlation in the northern Adriatic, such clear relations cannot be set probably due to the considerably wider mountain barrier.

The beginning of a bora event in Dubrovnik also shows considerable differences compared to the other observed stations. However, in frontal cases the bora in Mostar appears 2 hours earlier than in Dubrovnik.

P5.3: Idealized Mistral Simulations

[1]**A. Obermann** and [2]**B. Ahrens**

[1]*IAU, Goethe University*

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The correct simulation of wind speed in the Mistral area is important for, e.g., the modeling of deep-water formation in the Mediterranean Sea. The Mistral is funneled through the Rhône valley and shows extensive air-flow patterns in complex terrain and therefore is challenging for regional climate models. Besides these orographic effects, a good representation of Mistral has to include the effects of interactions with the sea surface (e.g., the charnock friction parameterization) and the coanda effect (wall attachment effect), which lets the Mistral flow stay attached to the Alps. We use idealized simulations with the regional climate model COSMO-CLM in the Mistral area to determine the impact of orography and surface roughness as well as coriolis force and coanda effect on spatial patterns in wind speed and wind direction.

Tuesday, 21th

Session 4: Numerical Modelling

8:30-9:00: Ensemble forecasting in Central Europe

Y. Wang
ZAMG

Society and economy have always demanded for more accurate prediction of high impact weather and better use of forecast information. Over recent years ensemble forecast has become more important as a scientific tool for improving prediction of high impact weather, and a lot of works on ensemble forecasting have been carried on. However, due to very limited knowledge on meso-scale predictability, ensemble foreacsting with high quality, with more details, in particular, the forecast to be covered with confidence, remains as one of the most difficult and challenging subject in Numerical Weather Prediction NWP in meteorology.
Since 2005 the NWP consortium RC-LACE (Regional Cooperation Regional Cooperation for Limited Area Modelling in Central Europe, participated by National (Hydro-) Meteorological Services Austria, Croatia, Czech, Hungary, Romania, Slovakia and Slovenia) has begun to conduct research studies in ensemble forecasting. Much progress has been made. In this talk, we will present the RC-LACE R&D results on meso-scale and convection permitting ensemble forecast, in particular, in perturbing initial atmospheric and land surface conditions, stochastic physics, ensemble land surface data assimilation etc.

9:00-9:15: Matching initial and lateral perturbations in a convection permitting ensemble

E. Keresturi, **Y. Wang**, **F. Meier**, **F. Weidle** and **C. Wittmann**
Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

A new idea for dealing with the consistent initial conditions (ICs) and lateral boundary conditions (LBCs) perturbation is proposed and implemented in a model framework with AROME. The idea is as follows. Ensemble 3DVAR is used for generating initial perturbations with randomly perturbed observations and first guess from the short range ensemble forecast. To have the large scale information correctly in the perturbed ICs and consistent with the perturbed LBCs, we introduce a new term in the 3DVAR data assimilation formulation ÂŨ Jk in addition to Jo (observation term) and Jb (background term). This is just the global gridded perturbed ICs as a new source of information in 3DVAR which we assimilate together with the mentioned EDA. The system used here is AROME in an ensemble framework (2,5L90) with 16 ensemble members (plus control) coupled to ECMWF-EPS (18L91). For complete implementation of Jk, we need ECMWF-EPS forecasts and their error covariances contained in V-matrix. V-matrix is calculated via ensemble method by interpolating ECMWF data directly to AROME domain. However, those newly added wavelengths due to interpolation, which contain no useful information, will be discarded during the 3DVAR itself. I.e. they are not allowed to impact Jk. Also, the scale selection (which scales are to be used from the driving model) is discussed. V-matrix is kept univariate for studies presented here. The system is tested in several case studies. Local strong convection in summer and a snowfall event in winter over South and Central Europe. Also, a long-term verification study is performed. The tests are still ongoing, results and data are still being analysed. Final conclusions and results, especially with respect to the Jk term, will be presented at the conference.

9:15-9:30: Predictability analysis of the 7 November 2017 Medicane

V. Homar Santaner and **D. S Carrió Carrió**
Universitat de les Illes Balears

During 7th November 2014 a Medicane formed in the central Mediterranean and affected the islands of Pantelleria, Lampedusa, Malta and Sicily. The physical analysis of the case clearly showed the tropical transition of the initial baroclinic development into a pure warm-core axissymetric system. Medicanes have got the attention of the community in the recent years and there is still open debate regarding their definition, genesis mechanisms, discriminant parameters for their formation and the requirements to predict them.
We investigate the predictability properties of the 7 November 2014 event by means of an ensemble data assimilation system based on Kalman filtering (EnKF). The predictability of these systems is tipically very limited owing to the highly diabatic (nonlinear) physical processes involved and their maritime (highly unobserved) origin. Consequently, we generate the ensemble assimilation and forecasting system sampling the uncertainty space of initial conditions and physical processes. Initial conditions sampling is adopted from the ECMWF ENS global forecasts. Aditionally, multiple PBL, Microphysics and radiative parameterized schemes are used to account for physical processes unvertainties.
The experimental high resolution ensemble allows to produce probabilistic forecasts of specific aspects of the genesis and evolution of the event. Besides providing a probability of accurrence of the event with lead times of 24-36h, forecasts provide valuable information about the intensity the wind and pressure fields. The trajectory forecast is a key aspect for accurate civil protection actions. The experimental system produces a fairly uncertainty and unaccurate trajectory, which largely depends on small scale features of the environment.
Additionally, we investigate the covariances that can be derived from the ensemble in order to shred some light on the discriminant aspects between medicane formation and non formation scenarios. Although constrained by linear assumptions, results show the connections of the central pressure and wind fields of the medicane with precursing fields.
Although based on a single case study, results are encouraging regarding the predictability of the formation, trajectory and intensity of medicanes based on ensemble data assimilation techniques. Additionally, covariance fields provide a valuable tool for physical processes diagnosis even in this highly nonlinear evolutions.

9:30-9:45: Diagnosis of background-error covariance matrix using different sampling

strategies

A. Stanešić and **K. Horvath**

Meteorological and Hydrological Service (DHMZ), Croatia

At Meteorological and hydrological service of Croatia regional numerical weather prediction model ALADIN is initialized using local data assimilation system. Currently, data assimilation system utilizes surface observations (including local non GTS stations), radio-soundings, airplane measurement (AMDAR and MODE-S), geowinds and satellite radiances. A majority of these observations are not used in data assimilation performed in global models and aid to better assess mesoscale conditions in the initial conditions of the numerical weather forecast. This is especially important in region, such as the Mediterranean and the Adriatic, where mesoscale processes such as related to terrain and surface inhomogenties result in important mesoscale phenomena (mountain flows, see breeze, mesoscale precipitation systems etc.).
The analysis is performed in two steps: surface analysis using optimal interpolation method and upper air analysis using 3D variational method. In variational data assimilation systems background-error covariance matrix (B) plays important role as it influences how information is spread from observational points, it weights the importance of a priori state and imposes balance constraints between control variables. Thus, correct estimation of B is very important. One of the techniques for estimation of B is so-called NMC method where differences of forecast initialized at different times but valid at same time are used as proxy of true forecast errors. Such sample of forecast differences is than used to estimate background-error covariances. In this research NMC method was used in order to estimate background-error covariances from samples of forecast differences obtained using different sampling strategies (seasonal/time dependency, lead forecast hour dependency, sample size). B matrix characteristics are then compared and influence of different B matrices on analysis and forecast is analyzed. Objective verification scores over period are calculated and also interesting meteorological events are analyzed in form of case study.

9:45-10:00: Evaluation of mesoscale near-surface wind and wind shear forecasts in complex terrain

S. Brzaj and **K. Horvath**

Meteorological and Hydrological Service (DHMZ), Croatia

The eastern Adriatic coast is an excellent area for the evaluation of mesoscale models due to the complex terrain and surface inhomogeneities such as arising from land-sea border. In this study, we first analyse 10-minute horizontal wind speed and direction from four 60-meters wind masts in Croatia collected during 2010. Analysed data were used for evaluation of forecasts of the nonhydrostatic test version of mesoscale numerical weather prediction model Aire Limitée Adaptation dynamique Développement Inter-National (ALADIN) at a horizontal grid spacing of 2 km. Evaluation was based on statistical scores and spectral measures in frequency domain.
The average values of wind speed grow with height, but negative shear occurs frequently during the night. Wind shear is stronger during northeasterly bora winds than during warm southeasterly 'jugo' (a type of sirocco winds). Spectral analysis indicates a pronounced share of energy for motions with diurnal and less-than-diurnal periods.
Model ALADIN represents the basic evolution and characteristics of wind speed and wind shear in the area. Daily course of wind speed and vertical profiles of observed statistical parameters are successfully reproduced. In some locations, the model systematically underestimates the value of mean wind speed. According to the RMSE, the model predicts winds equally well at all locations. However, the frequency of the weakest winds in the model is overestimated. The model is good at representing the variability of wind speed on the diurnal periods of motion, but somewhat underestimates the variability of the wind speed at less-than-diurnal periods (less predictable local winds). Furthermore, negative wind shear, especially frequent in weak wind situations, is too weak and infrequent. Observed characteristics of the predicted wind shear at various locations are similar to each other, which is not observed in the measured data.

10:00-10:15: Deterministic and Probabilistic Analog-based Wind Speed Predictions in Complex Terrain

[1]**I. Odak Plenković**, [2]**L. Delle Monache**, [1]**K. Horvath** and [1]**M. Hrastinski**

[1]*Meteorological and Hydrological Service (DHMZ), Zagreb, Croatia*
[2]*Research Applications Laboratory, NCAR, Boulder, CO, USA*

In this work the analog-based predictions are generated by Aire Limitée Adaptation dynamique Développement InterNational model (ALADIN) run. They are tested at several climatologically different regions across Croatia for point-based wind speed predictions at 10 m height. The focus is on the group of stations prone to high wind speeds (e.g., bora wind). The verification procedure is formulated and used to assess and improve the performance of analog-based wind speed predictions in coastal complex terrain.
This study shows that deterministic analog-based predictions, compared to model used to generate them, improve correlation between predictions and measurements while reducing bias and root-mean-square error, especially in coastal complex terrain. Distribution of analog-based deterministic predictions is more similar to the distribution of observations than the distribution of raw model predictions. The combination of analog and Kalman filter approach performs best for the high wind speed categories. Probabilistic analog-based predictions are statistically consistent and provide reliable information about their uncertainty. Discrimination between different outcomes that are tested in this study is higher for analog than for logistic regression

approach.

10:45-11:00: Mesoscale-Microscale coupling: a new time for the atmospheric modeling

[1,2]**A. Montornes**, [2]**P. Casso** and [2]**G. Lizcano**

[1] *University of Barcelona*
[2] *Vortex*

Large eddy simulations (LES) have traditionally been used to study the planetary boundary layer (PBL) fluxes under different ideal conditions and such as a laboratory for testing and improving turbulence parameterizations. With the exponential increment of the computational resources, real cases are about to be "feasible" for a LES approach. Recently, different studies have reported promising results that motivate the research in LES technology for wind resource industry applications.
In this work, the Weather Research and Forecasting LES (WRF-LES) model is assessed to obtain reliable turbulence information that wind and site engineers require. The WRF-LES formulation employed in these studies follows the potential temperature perturbation method proposed by Muñoz-Esparza et al. (2014) which has been adapted to real terrain cases driven by dynamic boundary conditions provided by reanalysis data-sets. The main questions this work wants to answer are: i) Is WRF-LES model a robust system for producing wind speed time-series? ii) Can real WRF-LES simulations generate turbulence? And more important, iii) is the turbulence pattern obtained from WRF-LES simulations realistic?
Answers to these questions are addressed within the frame of a comprehensive validation exercise where one year period WRF turbulence parameterized (WRF-PBL) and WRF-LES at 100 m runs were carried out at 50 sites around the world. Selected sites represent varying degrees of complexity in terrain characteristics as well as in synoptic and local weather regimes. A validation against wind mast observations (i.e. compliant with industry standards) was conducted.
The results show that WRF-LES outcomes provide realistic 10-min averaged wind condition patterns, remarkably improving WRF-PBL results for wind speed distribution shape and tail. Turbulence intensity was effectively triggered in WRF-LES, showing that this can be a promising tool in the PBL modeling. WRF-LES shows a good agreement with respect to the observations with a MAE of around 2% in the turbulence intensity. These results represent a significant step forward to consolidate WRF-LES technology as a reliable modeling solution for wind and site engineers and wind turbine manufacturers demand of realistic turbulence characterization. It also confirms the perturbed method as a robust turbulence's trigger.

11:00-11:15: Study of waterspout forecasting method over the eastern Adriatic using high resolution numerical weather model

[1]**S. Ivušić**, [1]**M. Telišman Prtenjak**, [2]**T. Renko**, [2]**I. Horvat** and [3]**V. Šoljan**

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[2] *Meteorological and Hydrological Service (DHMZ), Croatia*
[3] *Croatia Control Ltd.*

In this study a synoptic and mesoscale analysis was performed and Szilagyi's waterspout forecasting method was tested on ten waterspout events in the period 2013-2016. Data about waterspout occurrences were collected from the weather stations, an online survey at the official Web site of the Croatian Meteorological and Hydrological Service and eyewitness reports from newspapers and the internet. Synoptic weather conditions were analyzed using surface pressure fields and 500 hPa level synoptic charts, SYNOP reports and atmospheric soundings. For all observed waterspout events a synoptic type was determined using 500 hPa geopotential height chart. The occurrence of lightning activity was determined from the LINET lightning database and waterspouts were divided into thunderstorm related and "fair weather" ones. Mesoscale characteristics (with focus on thermodynamic instability indices) were determined by using the high resolution (500 m) mesoscale numerical weather model and model results where compared with the available observations. Because thermodynamic instability indices are usually insufficient for forecasting waterspout activity, the performance of the Szilagyi Waterspout Index (SWI) was tested using vertical atmospheric profiles provided by the mesoscale numerical model. The SWI successfully forecasted all waterspout events, even the winter waterspout event. This indicates that the Szilagyi's waterspout prognostic method could be used as valid waterspout prognostic method for the eastern Adriatic.

B4 11:15-11:30: Closing the global budget of CF_4

E. Michalopoulou

University of Bristol

CF4 and C2F6 emissions are attributed to the aluminium and the semi-conductor industry. Emissions inferred from measurements from the Advanced Global Atmospheric Gases Experiment (AGAGE) show that only around 50% of global tetrafluoromethane (CF4) emissions can be explained by current emissions inventories (Kim et al., 2014). This "missing source" is of concern because CF4 is a particularly strong infrared absorber (i.e. greenhouse gas) with a very long lifetime (around 50,000 years). The significant discrepancies emphasize the need for more accurate and complete emission reporting and for verification with atmospheric measurements in order to assess the emission sources.
The study case we will be presenting is Australia where the number of smelting factories is known, as is the primary aluminium production of every factory. Australia has no semi-conductor factories, so in the first stage we assume our emissions come only from the aluminium factories.
We run a hierarchical Bayesian inversion that, at this stage, is focused on the Australian region. In order to construct our prior we collected information regarding the locations of the aluminium factories, their production lines and the technology they are using. Using the

same emission factor for all five factories (as suggested by the IAI) we calculated the total annual emissions of CF4 for Australia. According to the existing literature we assumed a linear relation between the aluminium production and the CF4 emissions.
In general, the inversion infers a larger quantity of emissions from the location where the Tomago smelter is found than our prior was suggesting. It also underestimates the emissions that came from the Bell Bay smelter that is located very close to the Medusa and Cape Grim. One of the reasons the model seems to be overestimating the emissions that come from the Tomago smelter could be that the Medusa is picking up additional emissions that are coming from the rare earth smelting of the Dubbo deposit that is located 305 kilometres away from Tomago. Another reason these discrepancies are occurring is the fact that the topography around Tasmania is very complex and the way the model is simulating that topography is, at the moment too simplistic, and it cannot accurately resolve the local turbulence and shear. The model is averaging the meteorology over a 25 by 25 kilometre area assuming the area is flat, so it cannot simulate the turbulence created on a local level. Therefore, one possible explanation could be the complexity of the meteorology and the topography in the area that is preventing the model from simulating the emissions accurately.
Concluding, we find that the model is able to predict the timing of the pollution events but there are discrepancies in the magnitude of those events and this results in discrepancies when we are running the inversions.

11:30-11:45: Investigation of the AWR-WRF model configuration at high resolution over the domain of Greece

A. Sfetsos, **N. Politi**, **N. Gounaris**, **S. N Karozis** and **D. Vlachogiannis**
NCSR DEMOKRITOS

In the present study, the initial modelling steps are presented for high resolution climatology, over the area of Greece, using the Advanced Weather Research and Forecasting numerical model (WRF-ARW). This attempt is part of a PhD dissertation that is related to the investigation of climate change according to the Representative Concentration Pathways (RCPs) up to 2100, by applying the technique of dynamical downscaling in high resolution to Greece. Initially, a prerequisite for the model application was the proper selection and definition of a high resolution domain linked to the optimal computational power required for the runs.
The model was set up with two different one-way nests of horizontal resolutions for the European domain (D01), of 20 and 25 km, dynamically downscaled to the domain of Greece (D02) with grid spacing of 5 km. For each nesting, the model was forced by ERA-INTERIM reanalysis data, for a total period of one year. The first objective concerned the selection of the appropriate horizontal resolution of the first domain (at European scale) and the second was to investigate the effects of various physics parameterizations of the WRF-ARW at high resolution on temperature and precipitation predictions, in the domain of Greece. In total, seven different sets of physics parameterizations were applied to investigate the model predictions against observational data. Simulations were carried out with selected combinations of parameterization schemes among two Planetary Boundary Layers parameterizations along with the corresponding Surface Layer schemes, as well as, four Cumulus physics schemes and three Microphysics options.
The results of the model simulations were analysed and compared to all available station measurements of daily precipitation and 2-meter air temperature from the European Climate Assessment and Dataset (ECA&D) for the domain of Greece, by utilizing appropriate statistical metrics. The aim of the study was not only to validate the overall performance of the model using the different parameterisation schemes but also to investigate the main characteristics (land use, elevation) of the high resolution domains.

11:45-12:00: Modelling and assessment of particulate matter in stable boundary conditions

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Air pollution due to particulate matter (PM) was investigated at rural background mountain, elevated and surface stations in Europe during 2011. Seasonality of the PM observations at mountain sites was analysed and compared to elevated and surface stations for the whole year in order to identify the regional variability and differences across Europe. Two different regional models were applied to analyse the trans-boundary transport of aerosols and the effect at background stations. The EMEP chemical transport model was run during colder part of the year (October and November) as well as the "online" meteorological and chemical transport model WRF-Chem, with different boundary layer schemes on different horizontal resolutions. Various tests were made with the implementation of the new, improved mixing length applicable for stable atmospheric (SA) conditions and vertical diffusion schemes in MYJ PBL scheme. Special attention was given to the regional characteristics of PM in Central and South - Eastern Europe during episode of observed high daily PM concentrations at background mountain stations which occurred during SA conditions. The accumulation of pollutants was governed by the large scale anticyclone conditions that prevailed over the Eastern and Central Europe enabling SA conditions characterized with low dispersion and mixing. Statistic analysis overview showed very scattered discrepancies between modeled concentrations and measurements. Both models underestimated PM concentrations at mountain stations during the episode indicating problems with regional transport of air pollution in SA conditions. EMEP model showed better agreements with measurements from the mountain and the elevated stations, and it

tends to produce higher concentrations contrary to WRF-Chem which overall showed lower performance. Significant improvements in model performance due to increase of horizontal resolution of WRF-Chem model was found. The model inter-comparison showed large discrepancies in spatial distribution of daily averaged PM concentrations, however both models properly estimated gradual day to day increase of the surface PM concentration.

12:00-12:15: The genesis of the 7 November 2014 tropical-like cyclone: Numerical Sensitivity Study

[1]**D. S Carrió Carrió**, [1]**V. Homar Santaner**, [1]**A. Jansà Clar**, [1]**R. Romero March** and [2]**M. À. Picornell**

[1] *Universitat de les Illes Balears*
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The Mediterranean basin is known to be a region prone to cyclogenesis due mainly to its location, topographical configuration and relative warm Sea. These cyclones tend to be relatively small in size and are occasionally associated to strong winds and heavy precipitations, generating high social impact on exposed humans and property assets. Mediterranean cyclogenesis mechanims range from pure baroclinic to quasi-tropical processes. In the last decade, a rare type of Mediterranean cyclones has got the attention of the atmospheric scientific community. These Mediterranean systems share morphological characteristics with Hurricanes such as a warm core, convective cloud bands, axisymmetric structure and cloud-free eye, and have been consequently named "Mediterranean Hurricanes" or Medicanes. Leaving aside definition concerns, detection and forecast of Medicanes are difficult tasks and many efforts are devoted to their investigation.
During 7 November 2014, a mid-levels synoptic trough was extending across the western Mediterranean, reaching as far south as southern Algeria. Cyclonic conditions were present at low levels over the western Mediterranean since 4 November, but on 7 November a small intense cyclone formed in the South Central Mediterranean Sea and moved northeasterly towards southern Sicily, affecting Pantelleria, Lampedusa and Malta Islands. The small and rapidly-rotating system dissipated as it crossed the Catanian coast, during the first hours of 8 November.
Through the 7 November case, the main scope of this study is to further our understanding of the physical mechanisms involved in the cyclogenesis of Medicanes, with a special focus on a diagnostics of the extratropical and tropical characteristics based on satellite, gridded analysis and high-resolution numerical simulations.
A set of high-resolution (2.5 km horizontal grid length) sensitivity experiments, combined with the factor separation and PV-Inversion techniques indicate the key roles of the upper-level dynamics (i.e., Potential Vorticity) and synergisms for the genesis and posterior development of this intense small-scale cyclone. Diabatic heating associated with surface heat fluxes and latent heat release is the chief factor during the tropical-like phase of the system, which in any case requires the initial baroclinic cyclogenetic preconditioning environment to form. These diagnoses are confirmed through the analysis of thermal wind and thickness asymmetry parameters by means of Hart's diagrams, which clearly reinforce the delineation of an axisymmetric deep warm-core cyclone (i.e. Medicane).

12:15-12:30: The interaction of the downslope winds and fog formation over the Zagreb area

[1]**M. Telišman Prtenjak**, [1]**M. Klaic**, [2]**J. Cuxart** and [3]**A. Jeričević**

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This study investigates fog development over a wider Zagreb area. According to the climatological data, haze and fog occur frequently over the Zagreb-airport area and cause severely low visibility that can last for several days. Zagreb airport is located in a flat terrain south of Zagreb near the Sava river at a height of 108 m above sea level (asl). To the north, the city of Zagreb (∼120 m asl) is a main source of urban pollution including condensation nuclei. There are heavy traffic roads around the airport which also generate pollutants. North of Zagreb, the Medvednica mountain rises up to 1000 m asl in a relatively short distance of about 10 km, with a very well defined downslope forest area.
We focus on a case study of a long-lasting fog event that took place during 6-8 November 2013 to understand of the dynamic processes of fog development and fog persistence. The selected case was analyzed by means of available measurements and numerical simulations performed by the WRF-ARW high-resolution numerical model in several model setups. The model was able to reproduce this fog event with small differences among the various model setups. The results revealed the roles of: (i) the downslope wind which usually occurred over city when the net radiation over the Medvednica slopes becomes negative and (ii) the effect of urban Zagreb area which adds pollution to the downslope flow and consequently decreases fog duration over the city. The effect of the downslope flow was not apparent in the surface layer over the airport because it occurred above the thermal inversion contributing to the fog persistence. The influence of the Sava river has been also estimated and discussed. This comprised an additional calculation of backward/forward trajectories.

P4.1: Solar eclipses prediction coupled to the WRF-ARW model: forecasting and impacts

[1,2]**A. Montornes**, [1]**B. Codina**, [3]**J. W Zack** and [1]**Y. Sola**

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Solar eclipses are predictable astronomical events that reduce momentarily the incoming radiation into the Earth's atmosphere inducing significant changes on the meteorological fields, such as it has been analyzed in many studies since the late 60s. Moreover, the growth of the solar renewable energy industry is increasing the interest for adding new specifications in Numerical Weather Prediction (NWP) models oriented to solar resource assessment and forecasting applications. The recent partial and total solar eclipses that occurred in USA (October 23, 2014) and Europe (March 20, 2015), respectively, are showing the necessity to incorporate these astronomical events on the current solar parameterizations, beyond the purely meteorological interest.
Although in the 90s and 2000s, some studies added solar eclipse episodes within NWP codes, they worked with basic eclipse parameterizations adapted for dealing with particular cases of study. We present a new package for the Weather Research and Forecasting-Advanced Research WRF (WRF-ARW) model ready for considering any partial, annular, total or hybrid solar eclipse. The algorithm computes analytically the trajectory of the Moon's shadow and the degree of obscuration of the solar disk at each grid-point of the domain based on the Bessel's method and the Five Millennium Catalog of Solar Eclipses provided by NASA, with a negligible computational time. Then, the incoming radiation is modified accordingly.
We present a description of the implementation of the Bessel's method within the WRF-ARW model together with a validation for the period 1950-2050 of all solar eclipse trajectories with respect to NASA values. Second, we analyze the model response in the solar eclipse of 11 August 1999 that crossed Europe, producing significant effects over the Mediterranean region. This part includes a validation of the global horizontal irradiance compared with different Baseline Surface Radiation Network sites as well as a discussion about the impact on surface temperature, pressure and wind speed.

P4.2: Performance Evaluation of the WRF Model for the New European Wind Atlas Project of Turkey

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In this study, we assessed the results of the New European Wind Atlas project for Turkey. The main purpose of this study is to evaluate the performance of the WRF model in the wind speed and direction for 8 different measurement points located in different regions of Turkey. The WRF domains for these measurement points are constructed as 3 nested domains with the horizontal resolutions starting from 27 km by ratio 3. We evaluated the coupled model performance by using the hourly data for the year of 2015. The resulting models of 2015 are compared with observational wind data in terms of error analyses namely root mean square error (RMSE) and normalized root mean square errors (nRMSE). Wind speed model results for each measurement point were also evaluated seasonally. Consequently, results of the model shows variability at different seasons for depending on the measurement locations including the complexity of the terrain of the interest.

P4.3: Inclusion of the Sea Surface Temperature in operational NWP model ALADIN

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[2]*UWA, IRB*

Sea Surface Temperature (SST) has a significant influence on the atmospheric model forecast. For example: it is important for the correct representation of the land/sea breeze, as well as it influences the intensity and location of the precipitation downstream. Currently, within our operational forecast and ALADIN model, SST is originating from the initial file and is kept constant during the whole model forecast (up to 72 hours). There are two sets of SST fields available from the coupling files that originate from the operational forecasts of IFS and ARPEGE, provided by ECMWF and Meteo-France respectively. In this study we used measured SST on a number of coastal stations in Croatia and Italy to validate SST available from global models over Adriatic and part of the Mediterranean.
The ARPEGE operational SST analysis is a mixture of the AVHRR satellite data and in situ measurements used in the operational oceanographic model Mercator. The SST from IFS forecast is on the other hand derived from the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) analysis. In our case we used SST from the Regional Ocean Modelling System (ROMS) defined over the Adriatic Sea with OSTIA analysis over the rest of the Mediterranean.
The impact of the SST on the intensity and location of intensive rainfall is explored by using alternative SST fields within the initial conditions, first from ARPEGE and then from IFS. In the first set of experiments SST effects on forecast precipitation are performed by altering the SST field inside the initial file, by shifting the SST field uniformly. For each model forecast, the SST field obtained from ARPEGE is modified by increasing or decreasing SST values by 2K and 5K and finally decreasing by 10K for all sea points in the model domain. These values have been chosen on the basis of evaluation of model and analysed SST against in situ data.
In the further set of experiments, SST in the model was replaced using OSTIA and MUR (The Multiscale Ultrahigh Resolution) analyses as well as ROMS model outputs. In one experiment we also nudged the SST field towards the measurements in order to test if precipitation forecast can be improved when SST is based on measurements.
We compared the SST fields from the coupling files and found that errors in SST over Adriatic can exceed

10K (positive bias). In reality, Kvarner Bay and Velebit Channel are often much colder than the rest of the Adriatic. In the winter, Western Adriatic Current (WAC) is as well colder then the rest of the Adriatic having cold and fresh water of the Po River. The sea surface with warm bias within the model makes the evaporation stronger yielding excess in the precipitation at the coastal mountain regions. Consequently, turbulent heat fluxes are also too strong above the sea surface. Reducing SST in coastal areas has an effect of reducing the precipitation on the mountain slopes.

P4.4: Numerical modelling of turbulence in a bora downslope windstorm

[1]**K. Horvath**, [2]**B. Kosović** and [1]**M. Hrastinski**

[1]*Meteorological and Hydrological Service (DHMZ), Croatia*
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Downslope windstorm events are frequent phenomena in complex terrain worldwide. Over the region of the eastern Adriatic coast, exceptionally turbulent bora downslope windstorms may reach wind speeds over 40 m/s and hurricane five scale gusts, resulting in closures of road, sea and air transport and large infrastructural damage. In this work, we assess the ability of the mesoscale and multiscale formulations of the WRF model to simulate local and non-local turbulence as well as turbulence budget in downslope windstorms.
The event chosen for analysis is a moderate downslope anticyclonic windstorm that took place on 28 Apr 2010. The tower was equipped with ultra-sonic sensors at 10m, 22m and 40m AGL that recorded wind speed components with a 5 Hz sampling frequency. Numerical analysis of the event used the WRF model with realistic initial and boundary conditions and multiple nested computational domains in two configurations. The first used a mesoscale setup at a grid spacing as low as 333 m and a Mellor-Yamada type planetary boundary layer scheme and the second used a multiscale setup at a grip spacing as low as 37 m using explicit simulation of large turbulent eddies and 1.5 order 3D TKE closure eddy-coefficient formulation to parametrize the effects of the sub-grid scale turbulence.
The observational and numerical analysis suggests a large share of turbulent kinetic energy originates from advected non-local turbulence. We also assess contributions of other sources and sinks of turbulence kinetic energy, and point out differences between mesoscale and multiscale simulations in terms of contributions to the turbulence kinetic energy budget.

P4.5: Comparison of different turbulence schemes within the TOUCANS framework

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Third Order moments (TOMs) Unified Condensation Accounting and N-dependent Solver (for turbulence and diffusion) – TOUCANS is a compact 2.5 level turbulence parametrization which integrates several ideas into its framework: non existence of critical Richardson number (Ricr), anisotropy of turbulence, prognostic treatment of Turbulent Kinetic Energy (TKE) and Total Turbulent Energy (TTE), parametrization of moisture influence on turbulence, TOMs parametrization, as well as possibility of prognostic treatment of mixing length and 3D turbulence parametrization. TOUCANS is based on the framework of four free parameters which influence the basic properties of the scheme and three functional dependencies which define the shape of stability functions. There are two basic schemes within the TOUCANS parametrizations, i.e. model I and II. The main difference is that model II includes influence of heat flux on the vertical component of the TKE, as well as stability dependence of the ratio of TKE dissipation and pressure-temperature correlation time scales. By adjusting free parameters and including stability dependence in functional dependencies, TOUCANS is able to emulate Quas-Normal Scale Elimination (QNSE) and Energy- and Flux-Budget (EFB) schemes. On the other hand, TOUCANS is also able to go step backwards, i.e. it can simulate its long term predecessor – diagnostic Louis scheme.
In this work we use the emulation property of TOUCANS parametrization and compare the performance of above mentioned turbulence schemes, focusing on wind speed, temperature, humidity and precipitation. For that purpose we run the regional NWP ALADIN-CZ 4.7 km horizontal grid spacing model with 87 vertical levels during the period of intensive summer convection over central Europe in 2009. Model outputs are verified against the surface and radio soundings measurements by calculating typical moment-based statistical scores like bias, standard deviation and root-mean-square error. Additionally, TOUCANS based momentum and heat flux values are compared with measurements from 40 m tall Pometeno Brdo wind tower for a single bora wind case. This is further supported by WRF-LES simulation results.

Session 2: Processes and Applications

14:00-14:30: From the meteorological processes analysis to society and policy makers

M. C. Llasat

University of Barcelona

The aim of the presentation is showing the transference of knowledge on meteorology and climate from the scientists to the society and policymakers. The presentation is conducted following recent results of the impact of climate change on meteorological and climatic extremes in Mediterranean Region and it is based in three main pillars. The first one shows the Spanish project HOPE (CGL2014-52571-R). It treats flooding from a holistic perspective that integrates both bottom-up (from impact and vulnerability) and top-down (from hazard) approaches. Its objective is to improve the estimates of the present and future impacts of floods in the Eastern of the Iberian Peninsula. With an interdisciplinary team, more than five stakeholders

and including citizen science activities, it has been selected as an example of the complete process starting in the meteorological analysis and ending in the society. The second pillar shows the Catalan Advisory Council for Sustainable Development (CADS). It is a boundary organization between Science and Decision-Making. Attached to the Catalan Government, its mission is to contribute to the transition of Catalonia towards sustainable development. The members of CADS produce specific reports for the Catalan Government, or assess new procedures, strategies, plans or programs, and future legislation from the sustainability perspective, that also includes hydrometeorological risks and climate change. It is an example of a governmental entity that has been created to bridge the gap between Science / Research and Policy-making. This part also includes other initiatives like the UfM Climate Change Expert Group of the Mediterranean Experts on Climate and Environmental Change group (MedECC).
In the case of climate change, the CADS also have a very strong and fluent collaboration with the GECCC (Experts Group on Climate Change of Catalonia) that was created with the objective of prepare the First Report on Climate Change in Catalonia in 2005, and it has ended recently the Third Report on Climate Change in Catalonia (TICCC). Following the IPCCC schema, this report is mainly organized into four major areas: 1) the scientific basis of climate change, 2) natural systems: impacts, vulnerability and adaptation, 3) human systems: impacts, vulnerability, adaptation and mitigation, 4) assessment of different policy and social domains, and economic sectors, that includes an epilog with the main conclusions and the potential impacts in Catalonia of the COP-21 that was held in Paris. This third pillar shows an example of the transference of the knowledge from scientists to society. Main conclusions of the chapter of Risks of climatic origin will be also presented.

14:30-14:45: The role of the EU HEAT-SHIELD project in the Mediterranean

T. Pogačar, **M. Zalar**, **Z. Črepinšek** and **L. Kajfež Bogataj**

University of Ljubljana, Biotechnical faculty

During the 20th century, the temperature in Europe increased by 0.34°C per decade, more than the global average of 0.27°C per decade, last August was the warmest in the last 136 year. It was 0.98°C above the global average. The situation is similar in the Mediterranean region. This was accompanied by increased frequency and length of heat waves that can affect health even among acclimatized populations living in warm climates like the Mediterranean region. It is beyond any doubt that climate change is the biggest global-health threat of the 21st century with enormous consequences for humanity. Heat waves have significant impacts on weather patterns, especially on precipitation events, human beings, and ecosystems. Future climate scenarios indicate that the warming in the Mediterranean is likely to be largest in summer with more frequent and intense heat waves. We will present the HEAT-SHIELD project funded by the European Commission which started in January 2016. It is focusing on labor productivity loss due to climate change. In addition to other well-known effects of heat exposure, a number of studies have confirmed a 2% productivity loss for each degree centigrade above 25°C. The project is comprehensively addressing the thermal resilience of all European workers in the context of global warming and rising workplace temperatures as a consequence of rising air temperature using a multidisciplinary approach. Project objectives are to forecast weather patterns with special emphasis on extreme temperatures and heat waves in different European regions, one of them is the Mediterranean region, for various climate change scenarios. One of project objective is also to develop an online access service to help industry and society anticipate threats to workers' health and to disseminate adaptation guidelines to relevant stakeholders and to assess the efficacy of formulated strategies. The importance of the project is evidenced by the fact that the proposal was endorsed by supporting stakeholders, such as the World Health Organization, the Intergovernmental Panel on Climate Change, the United Kingdom Ministry of Health, the Cyprus Ministry of Environment, as well as relevant private sector and civil society entities from across the EU.
The work was supported, in part, by the European Union Horizon 2020 Research and Innovation action (Project number 668786: Heat Shield). We are indebted to Profs. Lars Nybo, Andreas Flouris and Tord Kjellstrom for their assistance.

14:45-15:00: Impact of heat waves on Slovenian workers

T. Pogačar, **M. Zalar**, **Z. Črepinšek** and **L. Kajfež Bogataj**

University of Ljubljana, Biotechnical faculty

Summer temperatures in Europe are rising significantly, which is even more pronounced in the Mediterranean. Increasing number and intensity of heat waves, which is for example already notable in Slovenia, will worsen heat related problems in occupational settings that are even in present time experienced by millions of Europeans. According to World Health Organisation, it is anticipated that the rising temperatures in Europe during the 21st century will have significant detrimental impacts on the health of local populations – especially in occupational settings – and, as climate change becomes more prevalent, excess heat-related morbidity and mortality will rise between 3% and 6%. In addition to the well-known health effects of heat exposure, hot weather is associated with reduced productivity. Moreover, recent studies by members of the EU Heat-Shield project consortium have shown that as the workforce ages, its resilience to heat stress becomes diminished with even further negative effects on productivity. Thus, it is crucial to develop strategies to mitigate the detrimental health, societal, and economic effects of rising workplace temperatures. 5-year Horizon 2020 Heat-Shield project is an inter-

and multidisciplinary project, the aim of which is to develop solutions and recommendations for workers in five industrial sectors (agriculture, manufacturing, construction, transportation, tourism). By putting the worker health as the centre of the approach, different aspects of the problem will be investigated, in relation with the specificities of each occupational setting, the stress put on the worker's body, and possibilities (i.e. solutions to be investigated and assessed) to help them cope with thermally demanding scenarios. As one of the first steps in the project, there is an on-going study in Slovenia with measurement of temperature and humidity in a manufacturing plant. Besides, current working conditions in manufacturing plant and in various occupational settings (like Biotechnical Faculty, Publishing House etc.) are under research using comprehensive questionnaires to determine common knowledge of heat waves, workers' daily habits and temperature sensation, awareness of existing regulations and any special actions taken during heat episodes of heat stress. This first overlook will in the last year of the project serve as a basis for assessment of formulated guidelines' effects for workers' health, economic and social benefits and their impact on reducing inequalities. The study is on-going, and the final results will be presented at the meeting, comparing relations to gender, age, and searching for other correlations.

The work was supported, in part, by the European Union Horizon 2020 Research and Innovation action (Project number 668786: Heat Shield). We are indebted to Profs. Lars Nybo, Andreas Flouris and Tord Kjellstrom for their assistance.

15:00-15:15: Turbulence spectral characteristics in the nocturnal boundary layer over heterogeneous terrain

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The turbulence characteristics of flows over heterogeneous and patchy vegetation still present an ongoing issue, mainly due to the lack of experimental results. In this study we focus on turbulence spectral characteristics in the wintertime, nocturnal boundary layer over inhomogeneous surface. Through the spectral representation the amount of kinetic energy, variance or eddy flux is associated with each scale of motion. Measurements from a tall mast which was situated in a small deciduous forest were analyzed. Measurements at five levels above the 18 m high canopy were influenced by the upwind conditions which represent different types of surfaces. In this study we focus on the combined influence of the roughness sublayer (RSL) found above tall vegetation and the internal boundary layer (IBL).

The objective is to investigate turbulence spectral characteristics and TKE dissipation rate within and above the RSL. The validity of the local isotropy hypothesis is tested for measurements above an inhomogeneous surface. Results show that the ratio of the horizontal spectral densities (Sv/Su) approaching the 4/3, while the ratio of the vertical to the longitudinal spectral density (Sw/Su) was less than 1 for all levels indicating an anisotropic turbulence above the canopy. We found that an appropriate stability function for the non-dimensional dissipation of TKE calculated from spectra in the inertial subrange differs from the classical linear function obtained for the Kansas data and a modified relationship is proposed. The appropriate scaling parameters needed to collapse spectra are obtained. Spectra obtained in this study are compared with the existing models which are valid for HHF terrain. We compared our results with the empirical models of Kaimal et al. (Q J R Meteorol Soc 98:563–589, 1972) and Olesen et al. (Boundary-Layer Meteorol 29: 285–312, 1984). Using Kaimal's model, normalized spectra show that -2/3 slope is followed quite closely for a wide range of frequencies in the inertial subrange. Extending the analysis to the Olesen approach, normalized spectra collapse to one single curve.

15:15-15:30: Testing the turbulence scaling theory on bora surface layer flows

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[2]*Swedish Meteorological and Hydrological Institute*

The town of Senj, settled at the north-eastern Adriatic coast (44.99°N, 14.90°E, 2 m above MSL), is famous for frequent occurrence of bora windstorm, which makes it to be a perfect natural laboratory for investigation of bora flows. While large- and mesoscale features of the northern bora are intensively investigated in the past few decades and nowadays well understood, there is still insignificant amount of knowledge about its turbulence characteristics. Thus, from March 2004 to June 2006, single point 3D high frequency wind measurements were conducted in Senj using WindMaster ultrasonic anemometers (Gill Instruments) mounted 13 m above the ground. This instrument recorded the data with a sampling frequency of 4 Hz. It was continuously operational for more than two years recording all kinds of airflows. Using very basic criteria to define a bora event (wind of azimuth between 30° and 90° blowing at least for 3 h), we sorted out 294 bora events from this dataset with cumulative duration of almost 7000 h. Possessing such a large dataset gives us an opportunity to test turbulence scaling theory (TST) on bora surface layer flows.

According to TST, one of the first steps in investigation of turbulence is to obtain spatial/temporal scale within which the turbulence will be defined in an observed flow. This scale is referred to as the turbulence scale (TS). Regarding the TS, one can find a variety of different formulations in the literature. Most frequently used are the spectral gap scale at mesoscale derived from Fourier spectrum, integral scales derived from the autocorrelation function (so called 1/e and zero crossing scales) and the scale at which a normalized Fourier spectrum achieves its maximum value. Therefore, it

appears that there is no consensus in the scientific community on the unique definition of the TS, and this can lead to inconsistencies in its parameterization in NWP and climate models (e.g., the TS is in NWP models often parameterized using turbulent kinetic energy and its dissipation rate, but in different models and different turbulence parameterization schemes, different coefficients are used).
In this work we estimate the TS and show that its different formulations significantly differ for bora flows in Senj. While the spectral gap scale seems to converge to 30 min, integral and maximum spectrum scales show pronounced dependence on the mean bora wind speed. In order to detect the formulation of TS that is most suitable for bora, we will compare the results obtained for Senj with the results obtained from CASES99 dataset (which is considered as the reference data for a flat, homogeneous terrain) and T-REX dataset (which is considered as the reference data for a complex, mountainous terrain).

16:00-16:15: HyMeX activities in Croatia during SOP1

B. Ivančan-Picek, **M. Tudor**, **K. Horvath**, **A. Stanešić** and **S. Ivatek-Šahdan**

Meteorological and Hydrological Service (DHMZ), Croatia

HyMeX (HYdrological cycle in the Mediterranean Experiment) experimental activity during the SOP1 (Special Observing Period – 5 September to 6 November 2012) focused mostly on the Western Mediterranean, but many events that affected the Western Mediterranean expanded to the Adriatic area. During SOP1, 16 IOPs were dedicated to heavy precipitation events (HPE) over the western Mediterranean and 8 of these events subsequently affected the eastern Adriatic Sea and Croatia. All of them produced localized heavy precipitation and often were properly forecast by the available operational model ALADIN but exact prediction of the amount, precise time and the location of maximum intensity were missed. The total precipitation for the SOP1 was above the corresponding climatology for the Adriatic. Maximum of precipitation (more than 1.000 mm in 61 days at some locations) was recorded on the northern Adriatic (city of Rijeka) and its mountainous hinterland of Gorski Kotar.
Most the HPEs contain similar ingredients and synoptic setting but of different intensity: a deep upper level through, a cyclone strengthening over the Mediterranean (or developing over Gulf of Genoa, Lyon or Tyrhennian sea), a strong southwesterly low-level jet stream that advects the moist and warm air towards the orographic obstacles along eastern Adriatic coastline and destabilizes the atmosphere and the strong low level winds which pick up the moisture from the sea.
Here we will provide: 1. a scientific overview of the HPEs that affected the Adriatic during SOP1, 2. and examine the operational numerical models skill of the precipitation forecasts in Croatia, 3. a detailed description of the extraordinarily rare heavy precipitation event IOP2 (12 September 2012). Obtained results highlights the need for enforcement an intensive observation period in the future over the Adriatic region, to better understand the relevant processes and validate the simulated mechanisms as well as to improve numerical forecasts models via data assimilation (sufrace and upper-air over land and sea) and improvements of model representation of moist processes and sea-land-atmosphere interaction.

16:15-16:30: Using satellite observations to evaluate the radiative impact due to a dust storm in the Western Mediterranean

[1]**C. Peris-Ferrús**, [1]**J. L Gómez-amo**, [1]**C. Marcos**, [1]**M. D Freile-Aranda**, [1]**M. P Utrillas** and [2]**J. A. Martínez-Lozano**

[1] *University of Valencia*
[2] -

We present a vertically-resolved analysis of the radiative impact due to a dust storm being transported throughout the western Mediterranean on 23 May, 2008. The measured aerosol optical depth was 0.5 and the dust layer flew at an average altitude of 3-5 km. The analysis is carried out combining different satellite observations (CALIPSO and MODIS) and detailed radiative transfer modeling. With this, we determine the aerosol radiative forcing (ARF), forcing efficiency (FE) and heating rate profiles (AHR). Our working spatial resolution is defined by the MODIS Level 3 AOD product and fixed to 1^ox1^o (Latitude x Longitude).
The total radiative effect (i.e. shortwave (SW) + longwave (LW)) produced by the event induces a net cooling in the studied region, with FE average values (sza=20^o) of -167.2 Wm-2 and -24.8 Wm-2, on surface and TOA, respectively. The corresponding LW/SW offset is 14% and 40% on surface and TOA. It is observed an increasing of the offset (up to 82%) with the land fraction, which causes a FE decrease (increase) in the SW (LW).On the other hand, the AHR profiles show a net warming within the dust layer, with a maximum value of 3.2 Kd-1. Furthermore, we analyze the sensitivity of our simulations to the dust optical properties by comparing the results obtained using experimental measurements and those obtained using Optical Properties of Aerosols and Clouds (OPAC) dust model. When measured optical properties are used, the ARF in the LW substantially reduces on surface and TOA (up to 55%), the SW ARF is reduced by 15% on surface and enhanced by 33% on TOA. Moreover, the AHR present less warming in the entire profile, with deviations up to 53% within the dust layer, with respect to the results obtained with OPAC. Our results prove that our methodology with low spatial resolution and radiative transfer modelling gets comparable results to those obtained in intensive campaigns.

16:30-16:45: Forecasting Methodology and Challenges of creating Convection Nowcast for Air Traffic Management

V. Soljan

Croatia Control ltd.

Warm season convection represents great challenge for Air Traffic Management (ATM). Widespread storms of great vertical extent cause large air traffic detours and congestion of airspace around convectively active areas, increasing workload on air traffic controllers. To improve fuel and speed efficiency, jet airplanes have to fly at altitudes above 10km, which makes them vulnerable to deep convection penetrating these heights. Therefore, precise and accurate short range forecasts of convective coverage and cloud tops are essential for tactical planning and flow planning in ATM, and are of great importance for flight safety.
To address some of these issues, in 2016, Croatia Control meteorological division introduced new forecast product for ATM - Convection Nowcast. ATM Convection Nowcast is a graphical forecast of deep moist convection horizontal and vertical coverage of ATM sectors. It is generated by forecasters, using ingredients-based methodology. Ingredients-based methodology of forecasting deep moist convection is based on assumption that three main ingredients must exist in order for convection to occur - conditional instability, low level moisture and a mechanism to lift air to the level of free convection. Forecasters assess synoptic factors, which act to destabilize atmosphere: quasigeostrophic forcing, upper level divergence, airmass boundaries: and mesoscale factors: surface wind convergence, mesoscale fronts, low level moisture, conditional instability and vertical wind shear. Vertical wind shear is additional ingredient, important for organization of deep moist convection. Convective initiation is usually correlated with local surface wind convergence zones, which enhance local instability and low level moisture, but mainly act as a lifting mechanism. In this presentation, optimal forecasting methodology and problems faced in this forecasting process will be discussed.

16:45-17:00: Relationship between "atmospheric rivers" and extreme precipitation events

[1]**M. Martinković**, [2]**N. Strelec Mahović** and [2]**P. Mikuš Jurković**

[1] *Geophysical Institute, Faculty of Science*
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Extreme precipitation events cause notable socioeconomic impacts all over Europe. In the extreme cases 24 hours precipitation amounts can exceed even average monthly amounts of precipitation, consequently causing severe floods in certain areas. In this study the relationship between the extreme precipitation events and "atmospheric rivers" is investigated. Atmospheric rivers are narrow bands of high total column water vapor content being advected by strong low level winds, usually connected to a warm conveyor belt of an extratropical cyclone. Overlap of the atmospheric rivers with the favorable synoptic patterns usually leads to extreme amounts of precipitation, especially along the western European coastal regions. Because of the strong water vapor absorption line within the microwave range, microwave radiometers on-board polar-orbiting satellites are used to measure total column water vapor. Using all available satellites enables retrieving the information rather frequently, thus allowing us to see the advection of high water vapor content.
60 extreme precipitation events in the period from 2010 to 2016 were studied. For identifying the atmospheric rivers, blended Total Precipitable Water product derived from the microwave satellite measurements was used. The large-scale atmospheric patterns were analyzed using European Centre for Medium-Range Weather Forecast (ECMWF) analyses fields and DWD surface charts. The main goal of this study is to relate atmospheric rivers to local precipitation extremes and to examine their potential as feeders for heavy precipitation, thus providing additional information for forecasting.

P2.1: Observed and simulated features of the phases of the sea-breeze in the island of Mallorca

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[1] *Universitat de les Illes Balears*
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In order to better understand the diurnal cycle of the Sea-Breeze (SB) in the island of Mallorca, during September 2013 and June 2014 two experimental field campaigns have been conducted in the Campos basin (at the south side). A total of 6 Intensive Operation Periods (clear skies and weak pressure gradient conditions) are analysed using observations taken close to the coastline (about 900 m inland) that consist on a surface portable station (equipped with a temperature and humidity probe, and one 2-D and 3-D sonic anemometers), a captive balloon (temperature and humidity) and a multicopter (temperature and humidity). Besides, observations from automatic weather stations of the AEMET network are taken as well as satellite-derived surface temperatures that together with the model outputs from high-resolution mesoscale simulations are used to better understand the organization of the flow at lower levels.
With the combined inspection of observations and model results it is found that during the previous phase (after sunrise) land-breeze conditions were present and the sensible heat flux turned to positive meanwhile the turbulence started. In the preparatory phase (about 3 hours after sunrise) the wind close to the coast started to veer progressively towards the SB direction. As soon as the SB was initiated (about 5 hours after sunrise), the SB front progressed to the inland direction reaching a mature phase starting at noon. Afterwards, the SB decaying starts and close to sunset the wind speed was close to zero and veered towards the land to sea direction. During the campaigns all phases were measured with special emphasis to the morning transition (from LB to SB) and the evening transition (from SB to LB) because of the strong wind shear (turbulence) reported during the mature phase.
It is found that for all the different phases the model

is able to capture the organization of the flow at lower levels although it experiences some difficulties in reproducing the thermal profile during the preparatory phase, when the model energy budget usually differs a lot from the observed one. Nevertheless, at the end of this phase the model agrees with the observations, showing that the general energetics of the morning transition are well captured.

P2.2: Comparison of the cloud cover estimations from different ground-based measurement techniques

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Clouds have a great impact on the Earth's climate. Besides their critical implications in the Earth's water cycle, clouds are the main parameter affecting the energy balance in the Earth-atmosphere system at regional and planetary scales, which is decisive for climate studies. Clouds strongly modulate the radiative budget by absorbing and scattering solar and thermal radiation. This radiative impact is mostly dependent on the fraction of the sky covered by clouds, cloud cover. Until the end of the last century, cloud cover estimates from the ground were carried out mainly by human observers. Nowadays, automatic instruments and routinely applied algorithms for cloud detection and separation between clear sky and cloudy conditions have been further improved to reduce uncertainties in deriving cloud cover and distribution. Therefore, several methods using radiation instruments in the shortwave (pyranometers) or longwave (pyrgeometers) spectral ranges, all-sky cameras and vertical profiling (ceilometer) have been proposed and are routinely applied. This automatization allows replacing the human observers, increasing the temporal resolution of the cloud cover determination and reducing costs. The aim of this work is to analyze different automatic methods for the cloud detection by comparing their results with the classical method of detection by observers. The ultimate goal of this study is to save the possible discontinuities in long-time series of cloud observations, from a climatological point of view. To do this, we have use three years (2013-2015) of continuous measurements provided by a ceilometer and an all sky camera at Burjassot measurements station, sited in the Mediterranean coast of Spain. All the cloud cover estimates are presented in oktas to homogenize the results. When we analyze only low level clouds, our results show coincidences with the human observations (with maximum differences of 1-okta) larger than the 60 and 70 % for ceilometer and all-sky camera, respectively. When we consider all cloud types, these coincidences increase eceeding 70 and 75 % for ceilometer and all-sky camera, respectively.

P2.3: Apple Tree Bud burst time modelling in Iran

M. Rahimi

Semnan University

The bud burst phase of orchard trees is the most critical phase in relation to low temperature and frost since the most parts of bud especially ovary are very sensitive to the low temperature. Therefore, predicting the time of bud burst is very important. If a model can predict the time of budding, it would be possible to protect buds from late spring frosts. In this study, the budding time of apple trees at two agrometeorological stations in Northeast and Northwest of Iran was predicted by using a chilling and forcing model. Data for years 2002 to 2006 was used to calibrate the bud burst prediction model and respective information for the years 2007 and 2008 was used to validate it. For this purpose, five threshold temperatures (TC) and 11 chill requirements (Cr) were used. Among 55 combinations of Tc and Cr, the combination with minimum Root Mean Square Error (RMSE) was selected for predicting bud burst of apple for each region. Meanwhile, the probability of last date of frost in spring was estimated by statistical distribution. By comparing the probability of frost occurrence with the date of predicted bud burst, the risk of frost damage on apple budding was estimated.

Wednesday, 22th

Session 1: Climatology

9:15-9:45: The VALUE perfect predictor experiment

D. Maraun

Wegener Center for Climate and Global Change, University of Graz

VALUE is an open European network to validate and compare downscaling methods for climate change research. A key deliverable of VALUE is the development of a systematic validation framework to enable the assessment and comparison of both dynamical and statistical downscaling methods. VALUE's main approach to validation is user-focused: starting from a specific user problem, a validation tree guides the selection of relevant validation indices and performance measures. We consider different aspects: (1) marginal aspects such as mean, variance and extremes, (2) temporal aspects such as spell length characteristics, (3) spatial aspects such as the de-correlation length of precipitation extremes, and multi-variate aspects such as the interplay of temperature and precipitation or scale-interactions.
Several experiments have been designed to isolate specific points in the downscaling procedure where problems may occur. Experiment 1 (perfect predictors): what is the isolated downscaling skill? How do statistical and dynamical methods compare? How do methods perform at different spatial scales? Experiment 2 (Global climate model predictors): how is the

overall representation of regional climate, including errors inherited from global climate models? Experiment 3 (pseudo reality): do methods fail in representing regional climate change?
Here, we present a summary of the results of the first VALUE experiment. In this experiment, downscaling methods are driven with ERA-Interim reanalysis data to eliminate global climate model errors, over the period 1979-2008. As reference data we use observations from 86 meteorological stations distributed across Europe. With more than 40 contributing methods, this study is the most comprehensive downscaling intercomparison project so far.

9:45-10:00: Evaluation of EURO-CORDEX regional climate models over the Mediterranean region

T. Stilinović, **I. Güttler**, **L. Srnec** and **Č Branković**

Meteorological and Hydrological Service (DHMZ), Croatia

Regional climate models (RCMs) are designed to simulate climate at local and regional spatial scales. They can be forced by either atmospheric reanalyses (such as ECMWF ERA-Interim) or global climate models (GCMs). In this work we analyse over the Mediterranean region an ensemble of RCMs driven by ERA-Interim and an ensemble of RCMs driven by CMIP5 GCMs. All RCM simulations are part of the EURO-CORDEX project. We evaluate the impacts of the boundary conditions, different horizontal resolutions (0.44°/50 km vs. 0.11°/12.5 km), and the impact of convective parameterisation on RCMs' systematic errors. The latter refers specifically to the RegCM4 model used at DHMZ. The near-surface air temperature T2m and total precipitation amount R are evaluated by using the pan-European gridded dataset E-OBS (version 11) at the regular 0.25°ÃŮ0.25° grid for the two periods: 1989-2008 for the ERA-Interim-driven ensemble and 1971-2000 for the GCMs-driven ensemble. We apply the following metrics to evaluate RCM ensembles: spatially-averaged differences between RCMs and observations, the spatial 95th percentiles of simulated and observed temperature and precipitation, spatial correlation coefficients between models and observations, the ratio of spatial standard deviations between simulated and observed fields, and the Spearman rank correlations between simulated and observed time-series of spatially-averaged temperature and precipitation. Our evaluation show a significant sensitivity of RCMs' results to the selection of metric, season, model resolution and boundary conditions that force RCMs. As in some other studies, total RCM precipitation is often overestimated and spatial correlations are noticeably lower than for temperature. The overestimation is more pronounced in RegCM4 than in other RCMs. This deficiency can be considerably improved by using an alternative convective parameterization so that RegCM4 was able to simulate the observed spatial variability of the Mediterranean temperature climate quite successfully. This is indicated by high spatial correlations with values higher than 0.9 and values for normalized standard deviation below 1 for Mediterranean region. The results of this study will make the basis for an estimate of the climate change signal from the EURO-CORDEX simulations carried out at DHMZ.

10:00-10:15: Precipitation climatologies and high-resolution monthly secular precipitation records for Italy

[1]**A. Crespi**, [2]**M. Brunetti** and [1]**M. Maugeri**

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The availability of gridded high-resolution spatial climatologies and corresponding secular records has acquired an increasing importance in the recent years both to research purposes and as decision-support tools in the management of natural resources and economical activities.
High-resolution monthly precipitation climatologies for Italy were computed by gridding on a 30-arc-second-resolution Digital Elevation Model (DEM) the precipitation normals (1961-1990) obtained from a quality-controlled dataset of about 6200 stations covering the Italian surface and part of the Northern neighbouring regions. Starting from the assumption that the precipitation distribution is strongly influenced by orography, especially elevation, a local weighted linear regression (LWLR) of precipitation versus elevation was performed at each DEM cell. The regression coefficients for each cell were estimated by selecting the stations with the highest weights, expressed as the product of several Gaussian weighting functions in which the distances and the level of similarity between the station cells and the considered grid cell, in terms of orographic features, are taken into account. An optimisation procedure was then set up in order to define, for each month and for each grid cell, the most suitable decreasing coefficients for the weighting factors to be used in the LWLR scheme. At each point of a 1°x1° resolution grid covering the study area, the normals of the stations in the range of 200 km are recursively reconstructed to find the optimal values of the coefficients that minimise the error estimators. Optimised coefficients were then interpolated into the high-resolution grid by inverse distance weighting (IDW) and used to produce the climatologies.
The model performances were compared with the results provided by two other widely used interpolation methods, i.e. IDW and regression kriging (RK), highlighting the best agreement of LWLR leave-one-out reconstructions with the observed station normals, especially when considering specific station clusters (high elevation sites in particular). The analysis of the discrepancies between LWLR climatologies and the ones obtained by RK and IDW suggested that LWLR results are more affected by the poor station coverages especially in areas featuring complex pluviometric and orographic gradients, where improvements in the data availability are needed to overcome these model drawbacks. Nevertheless, LWLR provides monthly

precipitation maps with the finest spatial detail and allows to estimate the prediction intervals for each gridded value, which could be useful tools to detect the most critical reconstructed regions.
After producing the high-resolution precipitation climatological field, the temporal component was superimposed by following the anomaly method. The secular precipitation anomaly records were estimated for each cell of the grid by averaging the anomaly values of neighbouring stations, by means of Gaussian weighting functions, taking into account both the distance and the elevation differences between the stations and the considered grid cell. The local secular precipitation records were then obtained by multiplying the local estimated anomalies for the corresponding 1961-1990 normals.
This methodology will be presented and some representative results will be discussed.

10:15-10:30: Comparison of the Climate Extremes between the High Resolution COSMO-CLM Simulations and Observations in Istanbul City

C. Yuruk and **Y. S Ünal**

Istanbul Technical University, Department of Meteorological Engineering

Extreme weather conditions are one of the main concerns related to the climate change since their frequency, intensity and duration are expected to increase in the future. The objectives of this study are to explore the performance of the model to simulate the contemporary climate and to study the occurrences of heat waves and extreme precipitation events in the greater city of Istanbul by using fine resolution climate simulations. MPI-ESM-LR earth system model simulations are dynamically downscaled to first 0.44 coarse resolution, then to 0.11medium resolution and finally to 0.0275 finer resolution by using non-hydrostatic regional climate model, COSMO-CLM (CCLM). The capability of CCLM to capture minimum, average and maximum temperature and also precipitation over Istanbul city is analyzed by comparing model simulations with observations obtained from 12 Turkish State Meteorological Service (TSMS) stations. The period of reference simulation is selected as 1971-2005. When the seasonal precipitation averages are analyzed, it is seen that CCLM mimics the summer precipitation quite well and the biases over 11 out of 12 stations lie between 10 and -10 mm. On the other hand, the largest positive bias (>70 mm) is observed in winter season, particularly over the northern part of Istanbul. In winter, the model produces warmer temperatures than observations whereas in summer, the model simulates relatively colder temperatures. CCLM has a tendency to overestimate minimum temperatures up to 4 and underestimate the maximum temperatures in summer season almost 3.0. The agreement between the extreme values of high resolution simulations and observations are explored by using the climate indices.
This work is supported by TUBITAK project, number 114Y047.

10:30-10:45: Downscaling of future scenarios of temperature and precipitation across Europe based on quantile-quantile correction of EURO-CORDEX projections

M. F Cardell, **A. Amengual**, **R. Romero** and **V. Homar**

University of the Balearic Islands

Extreme weather events (e.g. heat waves, persistent droughts, heavy precipitation, severe convective storms and violent cyclonic windstorms) are responsible for most of the natural, human and economic costs in many regions of Europe, including the Mediterranean zone. In the context of climate change it is very likely that heat waves will occur more often and last longer while extreme precipitation events -and concomitant floods or flash floods- might become more intense. Prospects on the future of these events across Europe 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 properly project the RCM data at local scale, 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 distribution, instead of deriving the calibration parameters from the general spectrum of the CDFs. Preliminary results on future annual and seasonal temperature and precipitation changes (both means and extremes) will be presented for each emission scenario, scaling down the results from the whole European continent throughout Southern Europe, the Mediterranean and Spain. We believe that with these sources of information at hand, including the identification of the most vulnerable geographical areas, policy makers and stakeholders can respond more effectively to the future challenges imposed by climate change.

11:15-11:30: Filling incomplete values and testing for the inhomogeneities in deriving the new climatological normals for the 1981–2010 period for Croatia

I. Nimac, **M. Perčec Tadić** and **D. Rasol**

Meteorological and Hydrological Service (DHMZ), Croatia

Creating long-term climatological normals is one of the most important climatological tasks for the national meteorological service. It is also a demanding task due

to a significant effort for pre-processing the data that are often incomplete and sometimes inhomogeneous. Data "cleaning" is necessary since missing or inhomogeneous data can significantly alter the estimated statistical properties of the whole series.
The missing data problem can be diminished or even overcome if the missing data are replaced with some statistically justified estimates. Old climatological practice relies on the data from the nearest neighbouring station from the same climate region to fill the missing values

11:30-11:45: New national climate monitoring product: gridded monthly temperature fields for 1981–2010 period for Croatia

M. Perčec Tadić

Meteorological and Hydrological Service (DHMZ), Croatia

Climate monitoring provides users with the information they need for effective planning and operations according to climate variations. This is particularly important in the case of variations in frequency, intensity or location of extreme weather events like heat waves, droughts, heavy precipitation or flooding, because of their often disastrous impacts on the society. National meteorological services provide such climate information to the public and professionals in different sectors, from health sector where information about prolonged heat wave or cold is important to the energy sector where information about the prolonged drought is important for power consumption planning in near or more distant future. With global warming, extreme events, and the one that significantly deviate from the long-term normals, are expected to occur with greater frequency and severity so accessing their present frequency and spatial extent is becoming increasingly important.
While it is relatively easy to derive climate information from the national weather network on the observation locations, different methods or background information is used to provide the estimates for the locations where there are no measurements.
A range of spatial or spatio-temporal interpolation techniques (splines, regression, kriging, neural networks and machine learning techniques) have been used for the interpolation of meteorological data to produce maps, that is to provide the best estimates of the values away from the observing locations.
Also, it has been shown that most of those techniques perform better if auxiliary grids are used. The predictors can be morphological like elevation from the digital elevation model, exposition, distance from the coast-line, but also time series of remote sensed images like land surface temperature or satellite estimated precipitation rate.
Following those needs and building on the existing experience in deriving the long term normals for the 1961–1990 in the Croatian Climate Atlas 1961–1990, 1971–2000, the newly developed gridded monthly temperature fields for Croatia for the 1981–2010 period are presented.
Another important application of the gridded climatological data, besides estimating the meteorological variables at locations away from observing stations is validation of Regional Climate Models (RCMs). The RCM fields generally represent area averaged rather than point processes so it is most appropriate to validate the model results with interpolated observed data for present climate since such comparison assumes that the observations and model are indicative of processes at the same spatial scale.
Hence, there is a high motivation to derive sets of gridded climate data of different temporal and spatial scales for Croatia. Moreover, the intention is to outperform in accuracy, and provide the fields in higher spatial resolution, than available similar European projects.

11:45-12:00: An analysis of sounding-derived parameters associated to tornadic storms in Catalonia

O. Rodríguez and **J. Bech**

University of Barcelona, Department of Applied Physics - Meteorology

Catalonia is one of the most affected egions by tornadoes and waterspouts in the Iberian Peninsula (Gayà et al 2011, Gayà 2015). Every year, around 5 tornadoes (classified between EF0 to EF2 in the Enhanced Fujita Scale) and 10 waterspouts are registered in this area of 32 000 km2. It is important to study the environmental conditions that are favourable for the formation of this kind of phenomenon given their potential damaging effects.
The aim of this study is to search differences between the tornadic and waterspout conditions and other weather types, following other authors that studied different areas around the world (Monteverdi et al 2003, Groenemeijer and van Delden 2007, Renko et al 2016, Matsangouras et al 2016). Firstly, 5 sounding stations close to Catalonia (Barcelona, Palma, Zaragoza, Murcia and Nîmes) have been used to characterise every tornado (EF0 and EF1+) and waterspout event from 2000 to 2015. To do that the methodology exposed in Rasmussen and Blanchard (1998) has been used. Moreover, 50 soundings associated to days without precipitation in a radius of 50 km around Barcelona city, and other 50 soundings associated to days with non-tornadic thunderstorms in the same area along the period 2013-2015, distributed randomly throughout the months. With all these data, a database of 232 soundings of five different weather types has been built. Comparing the values of 69 different sounding-derived parameters depending on the weather-type sounding, we found values statistically different of wind shear (WS), Bulk Richardson Number shear (BRN shear), Storm-relative Helicity (SRH), Mixed-Layer Convective Available Potential Energy (MLCAPE), and others 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). All of them characterise the convective energy and the helicity of an air mass, the two principal conditions that are needed for

tornadogenesis.

12:00-12:15: Scaling and Intensification of Extreme Precipitation in Convection-Resolving Climate Change Simulations

N. Ban, **D. Leutwyler**, **D. Lüthi** and **C. Schär**

Institute for Atmospheric and Climate Science, ETH Zürich

Consistent with the Clausius-Clapeyron relation, it is generally accepted that the intensity of extreme precipitation will increase at a rate of about 6-7% per degree warming for daylong events. However, recent studies suggest that sub-daily (e.g., hourly) events may increase at about twice this rate (referred to as super-adiabatic scaling). Whether the adiabatic or super-adiabatic scaling applies is a question with important implications.

Conventional climate models are not suited to assess sub-daily events, due to the limited spatial resolution and the need to parameterize convective precipitation. Here we employ a regional climate model at a horizontal resolution of 2.2 km across an extended region covering the European Alps and its larger-scale surrounding from Northern Italy to Northern Germany. Validation using ERA-Interim driven simulations with rain-gauge observations reveals significant improvements with the 2.2 km resolution, in particular regarding the diurnal cycle of mean and extreme precipitation, the representation of hourly extremes, and the replication of the observed super-adiabatic and adiabatic scaling at precipitation stations (Ban et al., 2014). Analysis of climate change simulations, which use an RCP8.5 greenhouse gas scenario, reveals a significant decrease of mean summer precipitation, but increases in the intensity of extreme events consistent with Clausius-Clapeyron scaling (Ban et al., 2015), for both daily and hourly events. While the super-adiabatic scaling is simulated within the control period, we demonstrate that it cannot be extrapolated into the future.

In a second set of simulations, we have extended our analysis to decade-long convection-resolving climate simulations at horizontal resolution of 2.2 km over Europe using the COSMO model on a computational domain with 1536x1536x60 grid points (Leutwyler et al., 2016a,b). Such simulations have become feasible with a COSMO model version that runs entirely on Graphics Processing Units. We will demonstrate the applicability of this approach to continental-scale climate simulations and discuss the thermodynamic effects on the intensification of extreme precipitation.

12:15-12:30: Classification of air temperature and precipitation pattern over the Adriatic-Ionian basin associated with Northern hemispheric teleconnection indices

F. Matić and **B. Grbec**

Institute of oceanography and fisheries

Due to its geographical orientation deeply embedded into the European continent the area of Adriatic-Ionian basin can be regarded as a transitional zone between the influences of continental Europe and the oceanic effect of the Mediterranean.

During summer the weather is dry and warm with well-developed sea-land breeze system, as a consequence of subtropical pressure high influence. Specificity, Adriatic climate is under the influence of shorter-life cyclones which dynamic is partly controlled by extra-tropical cyclonic activity developed in the North Atlantic. These synoptic systems produce winter cyclones formed in the NW Mediterranean, which may propagate southeastward along the Italian coast or travel south-eastward along the middle and south Adriatic. Both extra-tropical cyclogenesis activity and regionally formed weather regimes are controlled by mid-latitude teleconnection patterns such as AO, NAO, EAWR and other, and in that way indirectly play a crucial role in Adriatic climate and oceanographic conditions.

In the analysis we used monthly means of air temperature and precipitation from the meteorological stations along the Adriatic-Ionian Basin, NCEP/NCAR reanalysis mean sea level pressure (MSLP) and teleconnection indices, all covering the period 1961-2015.

Self organized maps (SOM) were used to model air temperature, precipitation and joint temperature-precipitation anomaly patterns over Adriatic-Ionian basin as separate mods of variability. Also, we used SOM to find nonlinear connection between northern hemispheric teleconnection indices and meteorological variables.

Precipitation/temperature anomaly patterns can be classified info three patterns types: spatially homogenous anomaly patterns and patterns showing zonal/meridional gradient. Heavy precipitation zone over Ionian Sea, and high precipitation anomaly over the whole domain can be connected with existing centre of cyclonic activity over Ionian Sea and strong MSLP zonal gradient. Adriatic and Northern Adriatic, as a heavy precipitation zone are connected with negative MSLP anomaly over the whole examined area.

SOM model was performed for input data matrix containing precipitation/temperature and indices data. As result winning SOM model vectors (BMU) will be collection of spatial distribution of meteorological data and value of teleconnection index.

By the definition, all teleconnection indices are mutually orthogonal. Indices kept the orthogonality in BMU matrix in the way that NAO and EA are associated with different meteorological BMU part. The EAWR index is connected with same BMU as NAO index. Failed to distinguish NAO and EAWR can be found in the similarity of produced MSLP by those two indices. NAO acts from Atlantic Ocean and positive NAO index increase MSLP over central Europe just like positive EAWR index whose one center of action is located over central Europe.

The SOM model success to connect 39% precipitation variability over Adriatic Sea with NAO/EAWR indices. EA index acts opposite, dominantly controlling variability in the Ionian and South Adriatic Sea.

16:30-16:45: Spatial variability of climatic variables due to small scale heterogeneities of the surface: a case study

[1]**J. A Guijarro**, [2]**G. Simó**, [3]**D. Martínez-villagrasa**, [3]**A. López** and [3]**R. Picos**

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[3]*University of the Balearic Islands*

The project ATMOUNT aims at studying the influence of topography on atmospheric and surface variables, but these also present some variability on relatively flat terrain due to the heterogeneity of the surface. Therefore, differences in climatic observations in a complex terrain area need not be all attributed to topographic features only.
The department of physics of the University of the Balearic Islands maintain an observing site at the Campus consisting in a standard automatic weather station (AWS) plus other micro-meteorological instrumentation, and nine secondary observing sites at a mean distance of 150 m between them. On the other hand, the Spanish Meteorological Agency is operating another AWS at a similar distance.
Although the records of the experimental network are not very long, this high density of observations provide a unique set of data to study the spatial climatic heterogeneity in a Mediterranean site.
The differences in temperature and other climatic variables are evaluated to derive assessments on the influence that the small scale surface heterogeneity could have on the homogeneity of the series in case of eventual relocations of the stations.

14:15-14:30: Nonhydrostatic simulation over the Adriatic region using regional climate model RegCM4

[1]**I. Güttler**, [2]**G. Giuliani**, [2]**E. Coppola** and [2]**F. Giorgi**

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Recent model development of the ICTP regional climate model RegCM4 includes expansion of the model capabilities to the 1 km-10 km range of the spatial resolutions. Two main additions enable RegCM4 applications at these spatial scales: non-hydrostatic dynamical core and new microphysics parameterization. We will present results of the RegCM4 model applying new options over the Adriatic region, where three cases of the bora/bura events (November 1999, May 2005, February 2012) are simulated at horizontal resolutions of 3 km, nested into 12.5 km hydrostatic simulations forced by the ECMWF ERA-Interim reanalysis. Simulated wind speed and direction, temperature and humidity will be examined in relation to both SYNOP surface observation and radiosounding vertical profiles. Also, simulated total precipitation fields will be compared against EURO4M-APGD gridded observational product. In order to demonstrate added value of the new model capabilities, the impacts of hydrostatic and non-hydrostatic dynamical cores, but also of the default and new microphysics parameterizations will be discussed. Results of this study will provide supporting information concerning the planned longer (i.e., 10yr) non-hydrostatic simulations of both historical and future climate over the Adriatic region.

14:30-14:45: Can regional climate models realistically reproduce the near-surface wind variability over broader Adriatic region?

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Higher resolution of regional climate models (RCMs) is expected to contribute to a better representation of the small-scale variability than in global climate models (GCMs), especially in the coastal regions and over complex terrains, like the Adriatic region. Hence, the aim here is to identify if there is any added value in the near-surface wind when increasing horizontal resolution of RCMs using a multi-model ensemble composed of CORDEX RCM simulations at 50 km and 12.5 km resolution, COSMO-CLM convection-parametrizing model at 12.5 km and COSMO-CLM convection-resolving model at 2.2 km resolution. Surface station observation data and satellite QuikSCAT data have been compared against the (sub-)daily model output obtained from available simulations. The evaluation is carried out for both instantaneous wind speed and it's frequency distribution depending on the score elaborated. The standard scores for instantaneous wind speed are standard deviation, correlation coefficient and root-mean-square deviation summarized by the Taylor diagram. The frequency distribution is analyzed with Perkins skill score and wind rose. RCMs are also explored in terms of the skill in reproducing specific wind regimes over the Adriatic region (e.g. the bora wind) where large spread in the RCM ensemble is found. Yet, when considering the results of the EOF analysis, models frequently give the right angle of the bora flow, correctly reproducing the observed wind direction. The wind magnitude is overestimated, especially in strong wind cases. Moreover, the power spectrum is analysed when the sub-daily data is available. Power spectrum shows two large peaks at 12 h and 24 h period, also present in measurements, exposing the correct temporal variability of the simulated wind speed. Results of this work motivate the next steps where wind field from an ensemble of RCMs forced by the GCMs in historical and future climate runs will be examined.

14:45-15:00: Assesment of Wind Energy Potential over Turkey for 2021 - 2040 Period by using Regional Climate Model Coupled with Micro Scale Model

E. Yilmaz and **Y. S Ünal**

Istanbul Technical University, Department of Meteorological Engineering

In this study, the changes in wind speed and wind energy potential were examined by using high resolution simulation results of regional climate model RegCM4.3

driven by earth system model MPI-ESM-MR for the period between 2021-2040. Dynamically downscaled MPI-ESM-MR model outputs with 10 km resolution were analyzed for future period of 2021-2040 under RCP 4.5 and RCP 8.5 scenarios. The long term averages of the wind speed and wind energy density at height of 80 m are calculated for future period on annual time scale. The wind speed and wind power density changes in future period were determined with respect to the reference period averages, and the expected changes in the wind field are expressed as percentages to evaluate the potential wind energy changes. Bandirma and its surrounding area has been chosen as a pilot region to further downscale the high resolution climate model results to micro scale by using wind analysis and evaluation model (WAsP). Since WAsP is driven with the data provided only at a single point, closest grid of the regional climate model to Bandirma had been selected to drive the micro-scale model. Then wind energy change in the local scale is calculated for reference and future periods at the locations coinciding to the station with long term meteorological measurement, mast and grid point. The results reveals that the wind speed and wind energy potential will increase in the western and northern part of Turkey, and especially in southeastern Anatolia. However, Mediterranean region has a serious decline in wind speed. These decreases in the wind speed might be related to changes in the large-scale circulation as the Mediterranean coast line of Turkey is expected to have under the influence of less cyclonic but frequent anticyclonic weather regimes in the future.

15:00-15:15: Flow trends of Mediterranean temporary streams in Mallorca: effects of climate and land-cover changes

A. Amengual, **C. García**, **V. Homar** and **A. Zamora**

University of the Balearic Islands

Temporary streams are unique, sensitive and threatened fluvial systems. They periodically dry up and contribute to biodiversity by supporting different species. In Mediterranean regions, human pressures and climate change increase the duration of time each hydrological year that temporary streams are without water. We analysed the annual and seasonal trends on stream flow data from 14 gauging stations on temporary rivers on the island of Mallorca, the Balearics, eastern Spain. We used the Mann–Kendall trend test on annual and seasonal data from 1977 to 2009 (33 years) to identify trends in discharge, the number of days with water, precipitation, potential evapotranspiration (PET), and land cover change. Results show a general decreasing trend of stream flow during spring and summer. In some basins spring flows reduced between 4 and 17%. Although the inter-annual variability is high for both seasons, the decrease in precipitation, the increase in temperature, and the effects of colonization and growth of forests explain the reduction in the number of days with water. Correlation and elasticity analyses show that precipitation is the main driver for stream flow reduction, but the increase of temperature and land-cover changes also play a significant role in the decreasing of flows. These seasonal changes especially affect the headwaters of the basins, which are located in a mountainous area. These isolated temporary streams show a significant regional decreasing annual trend in the number of days with water after applying the Kendall regional test to the 12 studied basins in the Tramuntana range. The forest expansion and the increase of temperature cause a higher water demand, increasing the real evapotranspiration and, consequently, reducing the discharge in the temporary streams. The increase in the number of days during which channels and parafluvial habitats are disconnected negatively affects the aquatic habitat. The ecological implications of losing water in these temporary streams across imply urgent implementation of conservation plans to protect them from present and future changes and challenges.

15:15-15:30: Observed and simulated characteristics of climate trends in the air and sea temperatures in the eastern Adriatic

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Climatic evolution of the surface air and sea temperatures in the Adriatic is investigated using series of observations (including in-situ measurements and remote sensing products) and regional climate models (including coupled and uncoupled atmosphere-ocean architectures). One of the key datasets used in the study is a 50-year time series of the ship measurements on a transect from Split, Croatia to Gargano, Italy. The data indicate evolution of cross-coast changes of climate parameters and propagation of the coastal influence offshore. Two past periods were considered for the models' verification: a) a historical period 1950 - 2005, and b) an evaluation period 1989-2008. Three regional climate models from the EURO-CORDEX and MED-CORDEX projects archives were selected for the study. Seasonal results indicated stronger signals in the air and sea surface temperature trends during summer than during winter: however, most of the model results indicate a cold bias. To investigate causes for differences between the coastal and offshore temperature trends, the analysis includes computation of the surface heat fluxes using estimates of the ocean geostrophic flow and satellite data to reveal inflow/outflow characteristics in the Strait of Otranto. Future climate projections of the air and sea temperatures are also examined using two regional climate models for two scenarios of radiational forcing (4.5 and 8.5 Wm-2). The results show pronounced differences between the models and forcing and indicate significant uncertainties in the projections.

15:30-15:45: Scaling Laws for Extreme Rainfall Events over the Mediterranean during 1975-2015

[1]**S. Mathbout**, [2]**J. Bech**, [3]**J. López Bustins**, [4]**D. Royé**, [5]**F. Sanchez Rodrigo** and [6]**J. M. Vide**

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Extreme rainfall events on various time scales may cause floods, damaging ecological systems, generating landslides and threatening human lives and infrastructure. Under detected climate variability, many studies show that there is an increasing chance of intense rainfall and flooding in future warmer climates. The morphology of Mediterranean with numerous small and steep river catchments can turn the intense precipitation into severe flash floods. The objective of this work is to provide an overview of extreme rainfall recorded across the Mediterranean basin by studying rainfall maxima amounts temporal scaling and their spatial distribution covering time scales ranging from one day to four decades of duration. For this purpose, daily precipitation data of the European Climate Assessment & Dataset (ECA&D) has been used, and also the daily Global Historical Climatology Network (GHCN-Daily) dataset for 380 meteorological stations with a mean length of 40 years (1975-2015) in the Mediterranean basin. Preliminary results based on 150 stations located in Spain, France, Italy and Croatia are shown. They indicate that greatest rainfalls for durations from one day to one year show a robust power law relationship, R= 270.15 D^0.49 where R is rainfall in millimetres and D is duration in days. The shorter-term records (<7 days) are from Italian stations Ferrara and Genoa (1 day), Trapani-Birgi in Italy (2, 3 and 4 days), Mont Aigoual in France (5 days) and Palermo in Italy (6 days). Italian records are considerably higher than those in France, Spain and Croatia. The greatest observed rainfalls for all the durations from 12 days to one year were detected in Genoa (Italy) and the highest one year rainfall recorded in this station was between October 2009 and September 2010. The maximum precipitation depth-duration relationship is observed in the selected single-station and the all stations records with a stable scaling exponent close to 0.5. Thus, the so-called Jennings scaling law (P = D^b with b $\sim$ 0.5) appears to be generally applicable to both single-stations and to the global data set according to preliminary results. This study is performed under the framework of the HyMeX (Hydrological cycle in the Mediterranean Experiment) international programme, the Climatology Group (2014 SGR 300, Catalan Government) and the Spanish projects CSO2014-55799-C2-1-R and CGL2015-65627-C3-2-R (MINECO/FEDER). The first author is financially supported by a scholarship from the European Union (ERASMUS MUNDUS), AVEMPACE III Project.

P1.1: Objective climate classification of Slovenia

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In this study the climate regions of Slovenia were determined. The procedure was done predominately objectively, with methods of statistical clustering using climate data as input. The climate data in regular grid was used representing the period between 1981-2010. Preliminary analysis of climate data identified key climate variables that were later used to obtain climate regions. Classification was performed as a combination of two statistical methods. Firstly, factor analysis was applied which was followed by k-means clustering. With factor analysis the initial number of 31 variables was reduced to 4 variables or so called factors. These factors were then taken as input in cluster analysis process. The most logical and representative results were given by classification into 6 climate regions. With such classification we divided Slovenia into Littoral region, very wet region of northwestern Dinaric-Alpine barrier, higher region of Dinaric-Alpine world, the region of the highlands, dry lowland region of eastern and central Slovenia and higher, wetter region of central Slovenia. The entire analysis was repeated using data from the period 1961-1990 and the resulting classification was compared to classification from the original period. The comparison showed that these classifications are quite similar. The borders between regions were slightly changed, most notably in the regions that are most similar to each other. We also analyzed climate change in each region between the two periods. Significant climate changes have occurred within each of the six regions. In all of the regions temperature increased and rainfall decreased, some regions also experienced changes in precipitation regime. The climate within regions therefore changes over time, while the regions themselves are quite stable over time.

P1.2: Cloud cover in the Mediterranean region: differences between global and regional climate models

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In a recently published paper we have shown that global climate models included in the CMIP5 set of simulations tend to underestimate the total cloud cover in the Mediterranean region, when compared with suitable observational datasets such as satellite, ground based, and reanalysis products (Enríquez-Alonso et al., 2016, Climate Dynamics). The underestimation is especially remarkable during summertime, although the annual cycle is well simulated by most models. This result is quite general and apparently independent of the cloud parameterizations included in each particular model. A reason to explain this misbehavior might be the relatively coarse spatial resolution used by global

climate models, which is unable to reflect mesoscale induced clouds. Also recently, the Coordinated Regional Climate Downscaling Experiment (CORDEX) project has been releasing its results, which are climate simulations performed by a series of regional climate models forced by several global model results. The present study shows how cloudiness is simulated in the Mediterranean by the highest resolution regional climate models from CORDEX. Specifically, results of 14 combinations among five global models and five regional climate models, the latter working at 11 km of resolution, are presented for the variable "total cloud cover". These results clearly show the effect of the finer spatial resolution, as in many cases cloudiness underestimation by the global model turns into overestimation by the regional models. In addition, mesoscale effects as cloudiness generated (or enhanced) by orography are also found in the preliminary analyses of regional climate model results.

P1.3: Future heating and cooling needs at the seaside and in the mainland of Croatia

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The commonly used degree-days method is implemented to investigate climate change impact on future heating and cooling needs at the seaside (Hvar) and in the mainland (Zagreb) of Croatia. Two temperature parameters were analysed for the whole particular season, that is, heating degree-day (HDD) for the heating season (October-April) and cooling degree-day (CDD) for the cooling season (May-September). To assess heating and cooling parameters in future climate, a subset of nine regional climate models from the EU FP6 ENSEMBLES project was used. The assessment was done for two future periods: 2011-2040 (P1) and 2041-2070 (P2) when all models follow A1B greenhouse gases emission scenario. Horizontal resolution of each model was 25 km. Future projections of heating and cooling parameters for Hvar and Zagreb-Grič stations were determined by using simulated 2-m air temperatures from the grid points which are closest to the stations.
In order to evaluate the temperature simulations against observations, temperature biases (model minus observations) averaged over three periods over the year (January-April, May-September and October-December) and all months for the 1961-1990 control period were determined. For the same control period, nine present day simulations of heating and cooling degree-days were also calculated. Comparison of the degree-day simulations with temperature biases over the control period helped in detecting the simulations that are closest to the observations (i.e. the most realistic simulations). For P1 and P2 future climates, projected degree-day trends are shown as well as the range of degree-day changes that could be expected based on all considered simulations.
For both future periods the most realistic simulations show decreasing HDD trends and increasing CDD trends. Magnitudes of the P1 and P2 trends differ between themselves more for CDD than for HDD at both locations/areas under consideration.

P1.4: Extreme heat in the Guadalquivir and Segura River Valleys (Spain): contrasts and a case study of the summers in 2015-2016. Comparison using the high-resolution mesoscale model AROME 1.3 km

D. Espín Sánchez and **C. C García**
Dpto. Geography (University of Murcia)

In the south of the Iberian Peninsula are located two of the hottest valleys of southern Europe: those of the Guadalquivir and Segura Rivers (Spain). In these geographical enclaves, the absolute maximum temperatures have reached 47°C in recent times. The altitudes are between 30 and 350 m above sea level, with minimum distances from the sea of 30 and 90 km, respectively. The average monthly maximum temperatures have reached 37^{o}C in Cordoba, with average minimum values as high as 23^{o}C in the province of Jaen during the summer months.
This work presents a comparative analysis of the extreme heat of these two zones, accompanied by a map of the hazard associated with the heat wave magnitudes. The pattern of the daily maximum and minimum temperatures is shown in detail, in relation to the factors that explain it (e.g. the influence of the great mountain crag of the Sierras of Segura and Cazorla -2,100 m- in the genesis of katabatic winds that descend into two both valleys).The last two summers in the study area (2015-2016) are analysed from the synoptic and surface observations. Specifically, the summer of 2015 is catalogued as extremely hot by the State Meteorological Agency (AEMET), with record average summer temperatures in Cordoba (28.3^{o}C) and Murcia (28.6^{o}C), both observatories beating the previous record set in summer 2012. By contrast, the summer of 2016 shows anomalies of very-high temperatures in the Guadalquivir Valley (+1.5 to +2.5°C), while the Segura River Valley shows a behaviour that is normal or slightly cool (-0.5 to +0.5°C), with respect to the mean monthly values of the full historical data set. The results show that in municipalities such as Andujar (Jaen) more than 20 days were recorded with absolute maximum temperatures above 40°C, while villages of the Middle Segura Valley (La Vereda - Murcia) recorded up to 61 tropical dawns (> 20°C). The most paradigmatic case is that of Cordoba, which had 26 summer days with equatorial minimum temperatures (> 25°C).
As a methodological approach, useful for studies of prevention and mitigation of the effects of extreme heat in these areas, the high-resolution mesoscale meteorological model AROME 1.3 km has been adopted. This has provided estimates of quite-high reliability in many cases, according to the good fit between the values recorded in the meteorological stations used in the study and those estimated by modelling for the same places. The best fit, and therefore the most satisfactory results, were obtained in the case of maximum temperatures, with a margin of error between 0.2 and 0.3°C for

the July-August period. However, for minimum values related to thermal inversion the model has limitations, with thermal deviations between 1.6 and 2.5°C in the Segura River Valley.

P1.5: Basic climatology of fog at Eastern Adriatic airports based on METAR reports

M. Zoldoš and **J. Jurković**

Croatia Control Ltd.

The occurrence of fog represents a major problem in traffic, which is especially emphasized in air traffic due to safety concerns. Long-lasting fog events at airports can cause significant flight delays due to poor visibility and low cloud ceiling. These delays always bring considerable costs, as flights often have to be diverted to nearby airports. It is therefore that study of fog is important for aviation meteorology, as improved forecasts of visibility and ceiling can lead to considerable savings.

This poster is an example of an analysis of big datasets, which provides the operational forecaster with useful information on fog climatology at airports of interest. This can help improve the decision-making process in fog forecasting.

The data used consists of METAR reports collected in the 16-year period from Jan 1, 2002 to Dec 31, 2016. A METAR report (issued every 30 minutes) contains data on present weather and associated meteorological parameters at the airport. The poster presents information on basic fog climatology (types of fog, yearly number of fog events, persistence etc.) at major airports on the Eastern Adriatic coast.

P1.6: Absolute Extreme Point Rainfall Depth vs. Duration Scaling Analysis in Spain

[1]**S. Gonzalez** and [2]**J. Bech**

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In mid XX century, Jennings published the world greatest precipitation events ever recorded for different durations (Jennings AH, 1950: World's greatest observed point rainfalls. Mon. Wea. Rev. 78, 4-5). Posterior studies showed that these data points may be approximately described by a power law function. This function, often quoted as Jennings' power law, has been examined in different studies with more updated rain gauge data or with data coming from different sources as satellite precipitation estimates. In this communication we present a list of absolute greatest rainfall events for different durations between 10 minutes to 2 years recorded by the Spanish Meteorological Service (AEMET). To retrieve these data, all precipitation AEMET databases have been analyzed, ranging from 1805 to 2014 and with more than 11000 official rain gauges, being larger for time stamps equal or over a day. Rainfall extremes include historical events such as the daily amount of 817 mm recorded in Oliva, near Valencia, on the 3 November 1987.

From these extreme data, the power law scaling and the envelope line of the greatest rainfall points for different durations has been obtained. Results show that Spanish absolute extreme rainfall record temporal scaling is compatible with a power law function, and may be described as R = 21.8 D0.422, expressing R in mm and D in minutes (r2 = 0.978). The spatial distribution of the most extreme rainfalls in the Spanish territories show that greatest depths for all durations are located near the coast and near complex terrain, in Mediterranean areas for mid scales (12 h to 15 days) and Atlantic areas for longer scales (>15 days) meanwhile short scales (<12h) show extreme rainfalls in different areas, suggesting the important role of deep convection, moisture source and orographic effects as relevant contributing factors for these extreme values. We also studied the spatial and seasonal variability of the scaling law finding that the scaling factor does not change much between regions but it does between seasons. The scaling factor is for example much greater for winter than for summer and is more dependent on the precipitation amounts for larger scales than for shorter scales. This study is performed under the framework of the HyMeX (HYdrological cycle in the Mediterranean EXperiment) international programme and has been partly funded by the Spanish project CGL2015-65627-C3-2-R (MINECO/FEDER).

P1.7: Analysis of precipitation trends in Murcia Region (Southeast Spain) over the period 1956-2015

V. Ruiz Álvarez, **R. García Marín** and **F. Belmonte Serrato**

UNIVERSIDAD DE MURCIA

In this paper, monthly, seasonal and annual precipitation in the territory of Murcia Region (Southeast of Spain) has been analyzed and calculated. We have used the records of 36 series of monthly precipitation, previously reconstructed from the database of Spanish Meteorological Agency (AEMET). These series of precipitation are distributed homogeneously along the territory of Murcia Region (11.313 km2). The magnitude, the sign of trends and statistical significances, have been evaluated by means of the application of Mann-Kendall non-parametric test. In this study, statistically significant trends are highlighted to a confidence level of 95%.

The main aim of this research is to perform time-space analysis of the magnitude and statistical significance of trends in rainfall calculated in Murcia Region, from the last 60 years (1956-2015). Precipitation trends have been calculated for each of the series that have been used in this paper. In addition, has been made, an average for Murcia Region, with the 36 series used. Overall, precipitation trends obtained for the analyzed period are mainly not significant to monthly, seasonal and annual scale.

On a monthly scale which has refeleted two trends with statistical significance in the average serie of Murcia Region, which are June which presents a negative trend (-2.25 mm/decade) and September with a positive trend (4.63 mm/decade). These trends with statistical

significance are also reflected in most of the analyzed series, evidenced more clearly the positive trend in September, in the series located in the northwestern interior of the Murcia Region. Moreover, a statistically significant negative trend in October is observed in most of the analyzed series located in coastal regions, and in the plains of the river Segura. With relation to the seasonal and annual trends, no significant trend has been observed, although it can highlighted a negative trend in summer.
Finally, we proceeded to compare the monthly average rainfall series of Murcia Region, for two reference periods of 30 years: 1956-1985 and 1986-2015. The observed data most notably, it is the increase of the rainfalls in September and the decrease of the same in October, a fact already observed in rainfall trends. In addition, other data observed, might suggest a change in the pattern of rainfall, so that the rainfall maximum typical of October could be weakening in favor, of September, November and spring months, together with drier summer records. It could be due to increased precipitation of Mediterranean advection. Definitively, the analysis time-space of the climate trends, is essential, even more, in areas of the Mediterranean coast, as the territory studied, which present a high interannual variability of rainfall, and where climatic variations can represent serious territorial and socioeconomic repercussions.

P1.8: Dry spells modeling using the extreme value distributions

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Two theoretically justified models of extremes are applied to dry spell (DS) series: The generalized Pareto distribution is applied to the peak-over-threshold data (POT-GP), and the Generalized Extreme Value distribution is applied to the annual maxima (AM-GEV). DS data are categorized according to three precipitation-per-day thresholds (1, 5 and 10 mm). The well-known classical methods for parameter estimation (L-moments and Maximum Likelihood) are applied both to measured (from the period 1961-2015) and to simulated DS time series. When applied within the GEV-model, both methods yield very similar results. However, in the case of the POT-GP model, these methods lead to substantially different estimates of parameters, as well as return values. The problem stems from applying the classical methods to estimate the parameters of continuous (GP) distribution from the dry spell data which are in fact discrete. The influence of two factors, the amount of rounding and the cutting above the threshold is discussed, eventually leading to some practical solutions when classical methods are applied to discrete data.
The inference is further conducted within the Bayesian paradigm, where the process of rounding can be incorporated in a straightforward manner. This approach reveals a high uncertainty that can occur in parameter estimations when very high thresholds (e.g. =90th percentile) are considered. It is found that there is no clear criteria in the assessment of some optimal threshold, nor is there a necessity for its detection. Instead, Bayesian inference provides a reasonable overall picture of the range of thresholds compatible with the GP-model. Furthermore, it is confirmed that the POT-GP approach yields more reliable estimates of the parameters than the AM-GEV approach. It seems that the problem of rounding is only occasionally addressed in the statistical literature on the extreme value theory, and especially so in applied climate studies. Our results revealed that a caution is needed when the classical methods are applied to discrete series and the Bayesian approach can be a viable alternative.

P1.9: New 1981–2010 climatological normal and comparison to previous 1961–1990 and 1971–2000 normals for temperature, precipitation and humidity in Croatia

I. Nimac and **M. Perčec Tadić**

Meteorological and Hydrological Service (DHMZ), Croatia

Average values of climate parameters over 30-year period (climatological normal) provide an insight into the climate characteristics of the region. Comparison of climate normals for different 30-year periods can gain an insight into the stability of climate conditions of some area or their variability may be an indication of climate change. In this paper, daily data from 20 meteorological stations in Croatia are used to calculate climatological normals for different meteorological parameters (temperature, precipitation and relative humidity) and three 30-year periods (1961–1990, 1971–2000 and 1981–2010). Although Croatia is relatively small country, large topographic variety, openness towards Pannonian Plain and position along the Adriatic Sea define different regions, so selection of the stations is in accordance with that. Spatial distribution of changes in climatological normals of chosen parameters comparing latest 1981–2010 and standard 1961–1990 period are shown. Changes in important temperature and precipitation indices, like number of cold or warm days and number of day above some precipitation threshold, as well as number of days with some of the weather phenomena (fog, hail and frost) are also shown. Changes in temperature and precipitation regimes can result in change of Köppen-Geiger climate classes. Therefore, Köppen-Geiger climate classes are determined for each 30-year period using ClimClass library in R statistical framework.

P1.10: Perspective of Croatian tourism in changing climate

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The aim of the paper is the comparison of suitability of climate conditions for future tourism in Croatia by means of the data provided by two different downscaling data sets. The suitability of climate for different types of tourist activities is estimated by means of

climate index for tourism (CIT) which integrates thermal, aesthetic and physical facets of atmospheric environment. Changes in climate potential of tourism in Croatia are estimated by changes of climate index for tourism in the two future 30-year periods 2011-2040 and 2041-2070. In the first experiment for future climate, two randomly chosen simulations from the global atmosphere-ocean circulation model ECHAM5-MPIOM under the IPCC emission scenario A2 were downscaled using regional climate model RegCM3 and compared with referent period 1961-1990. The integration domain covered almost the whole Europe with the 35-km horizontal resolution. For the second experiment the referent period was 1971-2000, and it is provided in the scope of the CORDEX initiative. The ensemble of five climate realisations with regional climate model (RCM) SMHI-RCA4 forced by five CMIP5 global atmosphere-ocean circulation models (GCM) HadGEM2-ES, CNRM-CM5, EC-EARTH, IPSL-CM5A-MR and MPI-ESM-LR is used. The change of touristic indices in the future is considered under two IPCC emission scenarios RCP4.5 and RCP8.5. The integration domain covered almost the whole Europe with approximately 12.5-km horizontal resolution and for the purpose of this study sub-daily fields were used.
The results indicate more pronounced bimodal distribution of CIT during year, resulting with the seasonality shift of ideal conditions for most activities to spring and autumn.

P1.11: Trend Analysis of Precipitation in the Muga River Basin (NE Spain) in Western Mediterranean area

M. Cordobilla-Cascales and **J. Martín-Vide**
University of Barcelona

Several hydrological and meteorological variables, such as rainfall and temperature, have been affected by global climate change. Any change in the pattern of precipitation can have a significant impact on water availability, agriculture, and the ecosystem. The Mediterranean region comprises the lands around the Mediterranean Sea presenting a Mediterranean climate as part of a Subtropical climate: this area appears to be more sensitive to changes in global warming, with a significant impact on the parameter of precipitation. The present study attempts to determine the long-term trends in annual, monthly and seasonal precipitation, and frequency of rainy days in the Muga River Basin (NE Spain) in the Western Mediterranean area. For our study, the meteorological stations make use of the database Spain02 v4, for the 1971-2010 period. To this end we employed the Mann-Kendall test and Sen's slope estimation. The most noteworthy result involves a downward precipitation trend in summer. The significance level of the decreasing precipitation trends is higher in the headwaters and the middle reaches than in the lower reaches. The frequency of the number of days of annual precipitation presents a significant upward trend for almost one third of the meteorological stations in the study area. The results of this study will provide for a better understanding of climate change in the Muga River Basin.

P1.12: The development of climate services from high resolution seasonal prediction model. Examples from case studies in Greece

A. Sfetsos, **N. Politi**, **N. Gounaris** and **S. N Karozis**
NCSR DEMOKRITOS

The provision of climate services is a scientific domain attracting great interest lately as shown in recent EU reports (`https://ec.europa.eu/research/environment/index.cfm?pg=climate_services`).
They constitute the boundary between the climatology community and the stakeholders of the different economic sectors that are critically impacted by climatic conditions. Amongst others, key issues remaining open are related to the translation of the climate data from models and observations into meaningful information to the end-users. The present study introduces a methodology to produce sector specific climate indicators (energy supply and demand, natural hazards) and investigate how these spatially vary across Greece.
For this study, the ARW-WRF (v3.6.1) model has been set up and validated to produce seasonal predictions at a very high horizontal spatial resolution of 5 km ÃŮ 5 km and a period of up to six months in the future. The CFSv2 model (`http://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2seasonal.shtml`) is used both for the initial conditions and six-hour interval boundary conditions of the simulations. This model configuration setup allows capturing small scale features of Greece very characteristic of the complex topography, coastline and vegetation cover of the country. The obtained fields are transformed into climate indicators for the following priority sectors.
For the energy sector, the related indicators include the supply and demand of buildings obtained through the calculation of the heating (HDD) and cooling degree days (CDD), and the generated power from renewable energy sources (wind farms and solar panel). For the case of natural hazards, extreme values of hydrometeorological indicators are estimated (rainfall intensity and precipitation values, wind and gusts, maximum temperatures and duration) while for fire risk, the Fire Weather Index (FWI) is calculated in monthly base, during fire season.

P1.13: The role of climate data in assessing critical infrastructure resilience to climate change

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Large scale infrastructures (energy, transport, water, ICT) and facilities are critical for the functioning of the modern European societies, but they are also exposed to hydrological and meteorological risks so

their operation may be severely devastated in case of the natural hazards. The objective of the European Horizon2020 project EU-CIRCLE is to move towards infrastructure network(s) that is resilient to today's natural hazards and prepared for the future changing climate. Furthermore, modern infrastructures are inherently interconnected and interdependent systems: thus extreme events can lead to cascading failures of several interconnected systems.
The presented study describes the methodological approach on how climate data may be introduced into a holistic risk and resiliency framework for assessing the impacts of climate change on critical infrastructures. Within the EU-CIRCLE approach, the risk on infrastructures from a specific climate hazard is quantified as the probability of occurrence of the climate hazard and the impact it causes to the infrastructure and the society.
The proposed approach starts from the generation or collection of climate information that is needed in order to address related scientific questions, such as: (1) how resilient are transport networks to the 500-year-return-period flooding event or, (2) what is the risk for electricity networks under changing climate conditions in a specific region. The orchestrated use of different data sets and their fusion is proposed that would allow responding to those scientific questions.
These data sets are used to generate specific indicators based on climate information, including the operational characteristics of the infrastructure systems when required depending on the type of infrastructure. The proposed approach relates the question under examination to a threshold value that is related to extreme events, change in trends, etc. The correlation of the threshold with the climate information is used to provide an estimation of the probability of occurrence of the risk, and it can be further classified into descriptive terms in accordance to the national risk assessment plans.
To estimate the impacts from the hazard, the damage function methodological approach is used with climate data as an input together with the secondary models, depending on the risk under examination (these include forest fire spreading models, flooding models, etc).
Some case studies across Europe will be presented, testing the validity of the proposed approach, by including forest fires in South France, flooding in the UK and Central Europe and storm surge in the Baltic Sea.

P1.14: The role of the WeMOi in the occurrence of torrential rainfall in Catalonia (NE Iberia)

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Previous studies have demonstrated the existence of a statistically significant correlation between the Western Mediterranean Oscillation index (WeMOi) and the pluviometric totals of the eastern façade of the Iberian Peninsula. Use of the WeMOi at daily resolution has proven to constitute an effective tool for analysing the occurrence of episodes of torrential rainfall over the east of the Peninsula. In the present study we selected the torrential episodes ($\geq$ 100 mm in 24 hours) that have taken place over the coastal provinces of Catalonia (Girona, Barcelona and Tarragona) (NE Spain) during the 1950-2016 study period (67 years). We evaluate the values for the WeMOi on the dates of these episodes and we construct WeMOi calendars based upon the mean values obtained for 10-day periods. Furthermore, we consider sea temperature records at one point on the Catalan coast since 1969 in order to relate this with possible changes in the frequency of the occurrence of episodes between the 1950-1983 and 1984-2016 sub-periods. Our principal results show that the episodes in the study area practically always occur on days presenting a negative WeMOi value. Specifically, the most negative WeMOi values are detected in autumn, during the second 10-day period of October (from the 11th to the 20th of October), coinciding with a torrential rainfall maximum. On comparing the sub-periods, we observed a decrease in the WeMOi values in the month of November, as well as an increase in these torrential episodes. Sea temperature has simultaneously shown a significant increase in this month over the last few decades. This might indicate a lengthening of the seasonality of the torrential rainfall period up to the end of autumn.

P1.15: Climate change and human health: correlation between bioclimatic conditions and hospital admissions

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It is now widely known that climate change is occurring and that has adverse implications on human health. Climate change may affect health through a range of pathways, for example as a result of increased frequency and intensity of heat waves, reduction in cold related deaths, increased floods and droughts, changes in the distribution of vector-borne diseases and effects on the risk of devastating weather events, wind storms, floods, etc. In particular, the effects of extreme heat events are increasing in recent years. Humans are forced to adjust themselves to adverse climatic conditions.
The impact of high temperatures on human health has become public health significance, and the effects of climatological variations on health are widely documented in the scientific community. Climate change has increased the likelihood of more frequent extreme weather events, therefore a better knowledge of the impact of high temperature on morbidity and mortality is needed.
In the recent years, many works showed that the temperature thresholds vary in different ways depending on different geographic area of the world and season. For this reason, it is important to study local thresholds to develop heat warning criteria, as well as the seasonal timing of a forecasted heat wave. Therefore, it is gaining momentum the study of "local warming".
In this context, is very important to improve heat

warning systems. This is possible trough a better knowledge of the full impact of extreme heat on public health.
The majority of studies who analyze the weather variables on health effects, investigate the effect of air temperature and bioclimatic indices. These indices combine air temperature, relative humidity, and wind speed and are very important to determine the human thermal comfort.
Italy adopt tools for adaptation to climate change through public health strategies and surveillance systems. In particular, was the first among countries in Europe which adopted tools to predict extreme events with 72 hours in advance (Heat Health Watch Warning System - HHWWS).
Analyses of the 2012 heat wave in Italy showed that it was a truly extreme event (high average temperatures showed +2.3°C in reference to the period 1971-2000) and the summer of 2012 was probably the hottest in Italy since 1800.
This study investigates the correlation between heat wave occurrence and the access to emergency room in the summer of 2012 (June-September), in two cities of Basilicata, Matera and Policoro, located in southern Italy.
Bioclimatic indicators (Scharlau Index, Relative Strain Index, Humidex Index, Difference Temperature Range) are estimated starting from climatic database that includes: temperature, humidity, precipitation, radiation, speed and wind direction. These were related to the health datasets obtained by Policoro and Matera hospitals, that includes: sex, age, residence zone, hospital admissions, ward type, diagnosis and triage.
The obtained results show a good correlation between the bioclimatic indicators adopted and hospital admissions, especially for the Matera case study.

P1.16: Homogenization of daily climatological series with Climatol 3.0

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The homogenization of observational series is a necessary stage before using them for a reliable assessment on climate variability. This need has been recognized for a long time, and a variety of software packages are available to the researchers and managers of climate data (see their characteristics at http://www.climatol.eu/tt-hom/index.html). These packages do a good job in general when homogenizing monthly data (comparative results obtained in the Spanish benchmarking project MULTITEST can be seen at http://www.climatol.eu/DARE/testhomog.html), but the daily series display a much higher variability that compromises the power of detection of shifts in their means due to the low noise/signal ratio.
Therefore, the homogenization of daily series is still a matter in active development, which is generally addressed by some of the available softwares by interpolating at the daily scale the correction terms found in a homogenization performed at monthly resolution. This strategy can work with variables with unbiased frequency distributions such as temperature, but fails for variables as wind and precipitation which bear a clear L-shape PDF.
The new version 3.0 of the R package Climatol (http://www.climatol.eu/tt-hom/index.html) can homogenize the daily series either directly or by splitting and reconstructing the series at the points found inhomogeneous at the monthly scale. In both cases, metadata from the histories of the observing stations can be incorporated to improve the results. Examples of the application of these two alternatives to real networks of daily data are shown, discussing their advantages and disadvantages.

P1.17: Sensitivity Analyses of CMIP5 simulations for heat waves occurred between 1965 and 2014 in Turkey

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Heatwave is an extreme weather event that affects human comfort and living organisms adversely due to excessive temperatures continuing for long periods of time accompanied by high humidity conditions. Depending on the severity of the event or the vulnerability, it can cause loss of lives if it is occurred suddenly. According to the 5th IPCC report, the frequency and magnitude of the heatwave events may be triggered depending on the region due to an increase in temperature. Studies show that summer temperatures of Turkey might reach to the limits of causing severe drought due to climate change. Therefore, in this study, the heat wave events occurred in Turkey between 1965-2014 are determined and they are analyzed in terms of both duration, magnitude, and frequency. Moreover, the performance of CMIP5 simulations in capturing these events for the same period are determined. CMIP5 simulations of CCGCM, HadGem, IPSL, and MPI Earth System models are evaluated for heat wave analyses to determine which model has the lowest bias comparing to the observations. Preliminary results show that the number of heat waves is increased between 1965 and 2014 in Turkey. Additionally, their rate of change is larger within the last decade and extremes are frequently observed after 1998.

P1.18: A Review on Climate Change in Weather Stations of Guilan Province Using Mann-Kendal Methodand GIS

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Climate has always been changing during the life time of the earth, and has appeared in the form of ice age, hurricanes, severe and sudden temperature changes, precipitation and other climatic elements, and has dramatically influenced the environment, and in some cases has caused severe changes and even destructions. Some of the most important aspects of climate changes

can be found in precipitation types of different regions in the world and especially Guilan, which is influenced by drastic land conversions and greenhouse gases. Also, agriculture division, industrial activities and unnecessary land conversions are thought to have a huge influence on climate change. Climate change is a result of abnormalcies of metorologyl parameters. Generally, the element of precipitation is somehow included in most theories about climate change. The present study aims to reveal precipitation abnormalcies in Guilan which lead to climate change, and possible deviations of precipitation parameter based on annual, seasonal and monthly series have been evaluated. The Mann-Kendal test has been used to reveal likely deviations leading to climate change. The trend of precipitation changes in long-term has been identifiedusing this method. Also, the beginning and end of these changes have been studied in five stations as representatives of all the thirteen weather stations. Then,the areas which have experienced climate change have been identified using the GIS software along with the severity of the changes with an emphasis on drought. These results can be used in planning and identifying the effects of these changes on the environment.

P1.19: Synoptic Anomalies Resulting in Pervasive Frosts in Iran

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This study has focused on synoptic anomalies resulting in pervasive frosts in Iran with the aim of improving the predictive capabilities of this phenomenon in Iran. So, to achieve this goal, Iran's frosts were classified based on a spatial principle into three categories, including pervasive frosts, semi-pervasive frosts and partial frosts. It should be noted that this analysis only studies the years having maximum and minimum frequencies the days with pervasive frosts that were a standard deviation above and below the average for a 43-year period from 1962 to 2004.
At low levels of atmosphere for the maximum frequency of days with pervasive frosts, a bipolar pressure anomaly with a positive value in the north east and a weak negative value in the north west of Iran above the Turkey are seen. In other words, with a strengthened Siberian high-pressure system and extending its western tongue on the Mediterranean sea, the conditions for establishment of a high pressure system on this sea is provided that the result of such an establishment would be pushing back the low pressure system tongue of Sudan monsoon to the lower latitudes as well as provided synoptic conditions for moving the cold air from the higher latitudes to the western part of Iran.
It is also seen for the minimum frequency of days with pervasive frosts that the entire studied area is dominated by a negative anomaly, which its central focus of severity is located over the Turkey. Thus, the spatial patterns configuration of this group indicates the weakening of the Siberian high pressure and its subsequent lack of extension of this pressure western tongue to the Mediterranean sea that as a result, the conditions for establishment of a low pressure system with a cyclonic circulation over the Mediterranean sea will be provided

P1.20: The role of wind structure in controlling vertical wind shears' variability over the Mediterranean region

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The vertical wind shears (VWS) are recognized as one of the key factors influencing the formation of the primary convective storm types. According to the most recent research, they have an important impact on intensity, longevity and organization of the convective system, such as bow echoes, squall lines and supercell thunderstorms. Therefore, the main goal of the study is to determine the role of the wind structure in controlling VWS' variability over the Mediterranean region. Taking into account the importance of the kinematic conditions for the convective systems development, the research are limited exclusively to 0-1 km, 0-3 km and 0-6 km wind shears. In order to calculate the values of each VWS, the information derived from ERA-Interim reanalysis for the period of 1981-2015 have been applied. The data consists of U and V components with 12-hourly sampling and horizontal resolution of 0.75ÃŮ0.75°. The preliminary results confirmed that the mean value of VWS and the frequency of VWS exceeding assumed thresholds were characterised by strong temporal variability – diurnal and seasonal, as well as significant spatial heterogeneity. It suggests that also the role of the wind structure – wind direction and speed on the different levels within the troposphere – in controlling vertical wind shears' values may be subjected to the spatial and temporal variability.

P1.21: Temperature and precipitation change over the Mediterranean region

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In the context of climate change, the Mediterranean region has been perceived as a very vulnerable area. Regarding the last IPCC reports, the climate of the Mediterranean is expected to become warmer and drier during the 21st century.
In this work we analyse an ensemble of regional climate models' (RCMs) simulations from the EURO-CORDEX initiative. RCMs were forced by CMIP5 global climate models (GCMs) at two horizontal resolutions (50 and 12.5 km). Uncertainty of the future climate is estimated by taking into account simulations which used three different representative concentration pathway (RCP) scenarios (RCP2.6, RCP4.5 and RCP8.5). Climate change is considered for three different periods: 2011-2040, 2041-2070 and 2071-2099 relative to the referent period 1971-2000.
Projections for the near-surface temperature in the early-future period (2011-2040) indicate a slight warming for RCP4.5 and RCP8.5. Towards the middle of the

century, the warming is more pronounced, particularly in summer and autumn - up to 2 $^{\circ}C$ for RCP2.6 and up to 4 $^{\circ}C$ for RCP4.5 and RCP8.5. By the end of century the projected warming becomes large with highest summer values for RCP8.5 scenario of about 4 - 6 $^{\circ}C$.

The future change of total precipitation is not as consistent as for temperature. For all scenarios in all future periods, the range of change includes both negative and positive values. However, towards the end of the century the climate change signal becomes unambiguous and for the RCP8.5 scenario most models show a decrease of precipitation, the largest being in spring and summer of up to -40%.

Contributions