Geophysical Challenges of the 21st Century

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Recent Achievements and Next Challenges in Volcanology

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Volcanology has rapidly developed during last decades to a multidisciplinary, quantitative branch of Geophysics. To-date, volcanology is still evolving through i) the set up of increasingly complex lab experiments to measure quantities characterizing magmatic and volcanic processes; ii) the development of advanced physical, mathematical and numerical approaches to simulate an increasing number of those processes; iii) the deployment of more and more sophisticated networks of instruments, and the development of numerical techniques to invert the recorded signals; iv) the full inclusion of the concepts of uncertainty and probabilities in volcanic scenario predictions and hazard forecast. The latter reflects the large inaccessibility of the volcanic systems, the extreme non-linear behaviour of volcanic processes put in light by the numerical studies, and the need of communicating in a formal and structured way the uncertain nature of volcanic predictions to emergency management authorities.

Future projections suggest a progressive relevance of structured volcano databases, that will provide large-scale sharing of basic knowledge and data for statistical analyses; full coverage of the frequency range of geophysical and geochemical signals at active volcanoes; the development of a global approach whereby knowledge from many different fields of investigation converges towards the definition of a coherent, internally consistent global volcano model; the creation of large-scale volcano infrastructures for sharing of data as well as of laboratory and computational resources; and the definition of international best practices for volcanic hazard and risk evaluation. Recent international initiatives are developing largely along these lines, providing a vision of the expected progress in volcanology in the next decade.

Measuring and Predicting Long Term Sea Level Changes

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This talk introduces some of the main topics in Sea Level Science at the moment with an emphasis on our work at the National Oceanography Centre in Liverpool. It starts with a description of how we measured sea level change in the past with float and stilling well tide gauges and how it is measured now with different tide gauge technologies including pressure, acoustic and radar devices. An appreciation of how it used to be measured is important as the data acquired in former years around the world has provided the historical record spanning two centuries maintained by the Permanent Service for Mean Sea Level (PSMSL) and used extensively in research. Since the early 1990s, satellite radar altimetry has provided regular quasi-global measurements of sea level from space which complement those by tide gauges at the coast, and the two methods together now provide an effective global observing system.

The talk then contains a discussion of how much global sea level has changed over the past century (an average rate of rise of approximately 1.7 mm/year increasing to over 3 mm/year since the 1990s) and whether we understand why it has changed. There has been great progress in understanding the reasons for change in the last few years. In addition to increases in sea level due to thermal expansion and melting of ice sheets and glaciers, the exchanges of water between the ocean and the terrestrial environment (e.g. storage of water in dams) appears to be a major factor. The talk then includes a discussion of whether extreme sea levels have risen at a similar rate as mean sea levels. This is especially important with regard to flooding of the coastal environment and infrastructure. The available evidence suggests that extreme and mean sea levels have risen at similar rates in most parts of the world.

The talk concludes with an overview of the status of sea level monitoring worldwide and with a forward look to research in the next few years, some of which will be summarised in the upcoming Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Grand Challenges in Seismology

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Seismology has gone through periods of rapid developments during the last century. Where is seismology standing today? Are we facing another period of rapid growth of knowledge or are we in a period of stagnation? We recall some of the recent findings in seismology and point to several questions that still need to be answered.

Understanding the nature of earthquake faulting and the variety of slip behavior (silent and slow events, super-shear ruptures, seismic tremors etc) still remains a major issue. To properly deal with it we have to understand what is the relationship between stress and strain in the lithosphere and how earthquake stresses are transmitted and redistributed? How is the continental crust built and what are the causes, nature and recurrence rate of intraplate earthquakes? The mechanism responsible for generating earthquakes at great depth is also still unknown. Can material around the slab shear during a large earthquake due to transient high strain rates?

The discovery that sources of the Earth's "hum" (a continuous excitation of the planet's free oscillations) are related to mid-latitude winter storms, poses the question how processes in the ocean and atmosphere couple into seismic waves in the solid Earth and how these can be used to monitor the global environment. The location and severity of most natural hazards is strongly influenced by near-surface materials and structure with acute heterogeneities. A detailed knowledge of Earth's near surface is therefore a crucial part of managing a sustainable environment for human civilization.

There are several unanswered questions regarding the deep structure of our planet. Tomographic velocity models of the Earth reveal that slabs can be disrupted by upwelling plume. The melt pathways generated by the oceanic crustal formation can produce asymmetrical melting regions and therefore remain enigmatic. How do plate boundary systems evolve and what are the relative contributions of thermal, chemical, and mineralogical variations to seismically detected heterogeneities? What is the cause of anisotropy in the deep mantle and the core? How are the Earth's internal discontinuities affected by geodynamics?

The variety of questions that seismology is faced today is a testimony of the fact that it is a vibrant science. In order to make it sustainable and able to make contributions to science and society, it requires continued strategic investments in future human and technical resources. Most notably, we need a dense system of long-term sustainable broadband seismological and geophysical instrumentation and observations, and a steady inflow to universities and research institutions of young talented seismologists.

Towards the Probabilistic Earth System Simulator for Climate Prediction

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There is no more challenging problem in computational science than that of estimating, as accurately as science and technology allows, the future evolution of Earth's climate; nor indeed is there a problem whose solution has such importance and urgency. Historically, the simulation tools needed to predict climate have been developed, somewhat independently, at a number of weather and climate institutes around the world. Whilst these simulators are individually deterministic, it is often said that the resulting diversity provides a useful quantification of uncertainty in global or regional predictions. However, this notion is not well founded theoretically and corresponding "multi-simulator" estimates of uncertainty can be prone to systemic failure. Separate to this, individual institutes are now facing considerable challenges finding the increased human and computational resources needed to develop more accurate weather and climate simulators with higher resolution and full Earth system complexity. A new approach, originally designed to improve reliability in ensemble-based numerical weather prediction, may help solve these two rather different problems. Using stochastic mathematics, this approach recognises uncertainty explicitly in the parametrised representation of unresolved climatic processes. Stochastic parametrisation can be shown to be more consistent with the underlying equations of motion, and provide more skilful estimates of uncertainty when compared with estimates from traditional multi-simulator ensembles, on timescales where verification data exists. Stochastic parametrisation can also help reduce long-term biases which have bedevilled numerical simulations of climate from the earliest days to the present. As a result, it is suggested that the need to maintain a large "gene pool" of quasi-independent deterministic simulators may be obviated by the development of probabilistic Earth-system simulators. This in turn implies that individual institutes will be able to pool human and computational resources in developing future-generation simulators, thus benefitting from economies of scale; the establishment of the Airbus consortium provides a useful analogy here.

Determination of turbulence averaging interval by Fourier analysis

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Lengths of averaging intervals applicable for investigation of intermitted turbulence during the nighttime stable, wintertime conditions are determined by two methods, both based on Fourier analysis. Wind data were measured by five ultrasonic anemometers with a sampling frequency of 5 Hz. Anemometers were placed at a mast located in a suburban, industrial area of Kutina, Croatia. Corresponding measurement heights were 20, 32, 40, 55 and 62 m above the ground, respectively. The mast is located above the grassy surface, surrounded by approximately 20 m high trees. The closest trees are about 20 – 30 meters far from the mast. The first method for determination of the length of the averaging interval is based on a cummulative integral of cospectrum of perturbances ogive) of the wind speed component and sonic temperature. The averaging interval is taken as a value at which ogive converges to a constant value. Second method assumes the length of averaging interval as an inverse of frequency at which a minimum in the velocity spectrum occurs. Variations of the lengths of averaging intervals with the height obtained by both methods are inspected and the differences between results obtained by the two methods are discussed.

Bura i opterećenje građevinskih konstrukcija vjetrom

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Djelovanje vjetra, uz djelovanje potresa, čini dominantno horizontalno djelovanje kojem su izloženi građevinski objekti u svom vijeku trajanja. Posebni značaj ovog djelovanja je što je ono promjenjivo u vremenu, a po intenzitetu varira i ovisi o meteorološkim karakteristikama pojedinog područja, te se ne može unificirati.

U postojećim opće prihvaćenim europskim standardima za proračun opterećenja građevisnkih konstrukcija vjetrom koristi se maksimalna očekivana 10-minutna brzina vjetra. Tlak kojim vjetar te brzine djeluje na građevinu ukazuje na tzv. statičko opterećenje. Međutim, brzina vjetra u 10-minutnom intervalu može značajno varirati. To je posebno izraženo u slučaju mahovitog, turbulentnog vjetra kao što je bura. Analiza utjecaja turbulencije na opterećenje građevinskih konstrukcija olujnim vjetrom pokazala je da se pri projektiranju građevina na priobalju i otocima gdje brzina vjetra postiže ekstremne vrijednosti u situacijama s olujnom burom mora uzeti u obzir utjecaj turbulentne komponente vjetra na opterećenje građevinske konstrukcije ili tzv. dinamičko opterećenje. Primjer jedne od najjačih ikad izmjerenih bura na Jadranu pokazao je da je tlak vjetra proračunat uzimajući u obzir dinamičko opterećenje konstrukcije gotovo 4 puta veći od onog koji se dobije uzimajući u obzir samo statičko opterećenje vjetrom.

Dakle, pri procjeni djelovanja vjetra na konstrukcije nužno je uzeti u obzir obje komponente opterećenja (statičko i dinamičko) kako bi parametri korišteni pri projektiranju osigurali izgradnju stabilne konstrukcije otporne na djelovanje vjetra. Neuvažavanje ove činjenice u praksi dovodi svake godine do rušenja ili oštećenja konstrukcija, posebno brojnijih i složenijih visokih objekata koji se grade (tornjeva, vjetroagregata, dalekovodnih stupova).

ANEMO-ALARM - upravljanje prometom s obzirom na opasnost za vozila zbog jakog vjetra

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Sve veće brzine kretanja vozila u cestovnom prometu i sve veći broj vozila na cestama čini pitanje sigurnosti sudionika u prometu sve značajnijim. Jedna od najznačajnijih vanjskih sila koje djeluju na kretanje vozila je posljedica puhanja olujnog vjetra. Utjecaj vjetra na kretanje vozila posebno je značajan na području hrvatskog priobalja i otoka gdje često puše jak i olujan vjetar koji je u slučaju bure i izuzetno mahovit, a njegov je smjer na mnogim dionicama bočan na smjer kretanja vozila. Jedan od značajnih koraka ka smanjenju mogućih negativnih posljedica jakog vjetra na cestovni promet je programska podrška ANEMO-ALARM razvijena u suradnji Državnog hidrometeorološkog zavoda, µM meteoroloških sustava i Hrvatskih cesta.

Na osnovi izmjerenih podataka u realnom vremenu, 72-satne prognoze smjera i brzine vjetra numeričkog meteorološkog modela ALADIN, te postavljenih graničnih nivoa brzina vjetra program predviđa početak i kraj pripremnog, predalarmnog i alarmnog stanja za ograničavanje prometa pojedinoj kategoriji vozila, kao i za ponovno poništenje ograničenja prometa, tj. uspostavljanje normalnog prometa. Ovdje je dan prikaz dosadašnjih iskustava s radom programa na Podvelebitskom području od Prizne do Lokvina, s posebnim osvrtom na usporedbu mjerenih i prognoziranih vrijednosti brzine vjetra. Pokazano je da program veoma dobro prognozira situacije s vjetrom jačine opasne po sigurnost prometa.

Princip rada ovog programskog paketa, uz male prilagodbe, moguće je iskoristiti i na drugim područjima kao što je prognoza smjera i brzine vjetra na lokacijama vjetroelektrana u svrhu ocjene rada vjetroagregata i očekivane proizvodnje energije.

Fine particles (PM1.0) concentrations in residential quarter of Zagreb, Croatia

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Mass concentrations of the airborne particulate matter with the aerodynamic diameter less than 1μm (PM1.0) were measured at the residential part of Zagreb during the period from 14 September to 6 October 2011. Measurements were performed by the DUSTTRAK^{TM} Aerosol Monitor at the temporal resolution of one minute. The monitor was mounted at the 3 m high mast located at the roof terrace of Geophysical Institute building at Horvatovac, with the inlet height at 15.8 m above the ground. At the same site 1-min means of the air pressure, temperature, wind speed and direction and relative humidity were also recorded. Diurnal variation of PM1.0 concentrations went along with the diurnal variation in human activities, and particularly in the traffic. Investigation of the relationships between the PM1.0 concentrations and ambient meteorological conditions suggests the importance of advection of pollution towards residential environment. Finally, results show the dependence of PM1.0 levels on relative humidity.

Modeliranje disperzije dušikovih oksida iz stacionarnih i pokretnih izvora na području Sisačko - moslavačke županije i grada Siska upotrebom WRF, CAMx i AERMOD modela

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Cilj ovoga rada bio je ispitati mogućnosti predviđanja disperzije dušikovih oksida združenim modelima WRF (**W**eather **R**esearch and **F**orecasting) i CAMx (**C**omprehensive **A**ir quality **M**odel with e**x**tensions) na regionalnoj skali (Sisačko-moslavačka županija) te WRF i AERMOD na lokalnoj skali (grad Sisak).

U radu su uzeti u obzir stacionarni (industrija, energetski objekti) i pokretni (promet) izvori emisija gdje su na lokalnoj skali emisije iz prometa računate na razini ulica, dok su u regionalnom modelu korištena površinska polja emisija, manje prostorne razlučivosti s dnevnom i tjednom varijabilnošću. Konverzija linijskih u površinske izvore napravljena je pomoću vlastitog GIS alata koristeći podatke o brojanju prometa na području grada Siska (gradske prometnice) i Sisačko-moslavačke županije (županijske ceste), vrsti vozila te CORINAIR emisijskih faktora. Stacionarni izvori podijeljeni su u dvije skupine: izvori s dinamičkom emisijom iz industrijske zone grada Siska i izvori s osrednjenom godišnjom emisijom svedenom na satni prosjek (ostali stacionarni izvori na području županije iz baze Registra onečišćivača okoliša).

Vremenski nizovi koncentracije dušikovog dioksida dobiveni CAMx i AERMOD modelom za simulirano razdoblje uspoređeni su s izmjerenim koncentracijama dušikovog dioksida na postajama za praćenje kvalitete zraka (u okviru državne i lokalne mreže za praćenje kvalitete zraka na području Sisačko-moslavačke županije) te pokazuju da se združivanjem meteorološkog modela i modela kvalitete zraka u prvom i drugom slučaju može opisati i prognozirati kvaliteta zraka.

Modeliranje sadašnje klime i budućih klimatskih promjena na području istočnog Jadrana

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Temperatura zraka i oborina iz simulacija pet regionalnih klimatskih modela EU projekta ENSEMBLES uspoređena je s mjerenjima na trinaest postaja iz redovne mreže Državnog hidrometeorološkog zavoda duž istočnog Jadrana. Modeliranje klime ove regije predstavlja zahtjevan test za regionalne klimatske modele zbog kompleksne topografije i izraženog utjecaja mora. Regionalni modeli na rezoluciji 25 km su forsirani s globalnim klimatskim modelom ECHAM5/MPI-OM za period od 1951. do 2100. te reanalizom ERA40 za period 1961.-2000. Ovakva postavka eksperimenta omogućava procjenu utjecaja različitih fizikalnih parametrizacija na dinamičku prilagodbu te odvajanje doprinosa rubnih uvjeta i interne fizike ukupnoj pogrešci modela.

U prosjeku, mjesečni srednjaci temperature su precijenjeni u simulacijama tijekom hladnog dijela godine i podcijenjeni tijekom toplog dijela godine. Oborina je općenito precijenjena tijekom cijele godine. Pogreške modela se izrazito ne mijenjaju prostorno od postaje do postaje. U analizi dužih vremenskih nizova, međugodišnja varijabilnost je izraženo slična u modelima unatoč bitno različitim sistematskim pogreškama. Ovo upućuje na rubne uvjete kao veći utjecaj na međugodišnju varijabilnost od interne fizike u modelima.

Klimatske promjene s obzirom na period 1961.-1990. analizirane su za tri tridesetogodišnja razdoblja u 21. stoljeću (P1 2011.-2040., P2 2041.-2070., P3 2071.-2100.) za IPCC scenarij A1B. Za temperaturu, zagrijavanje je statistički značajno u svim sezonama i svim lokacijama u sva tri perioda. Za razdoblje P3 eksperiment upućuje na pojavu izraženog deficita u oborini tijekom proljeća i ljeta što područje istočnog Jadrana čini posebno ranjivim na klimatske promjene.

Winter ENSO teleconnections in a warmer climate

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Changes in the winter atmospheric response to sea surface temperature (SST) anomalies associated with the El Niño–Southern Oscillation (ENSO) in a warmer climate conditions are estimated from the two 20–member ensembles made by an atmospheric general circulation model of intermediate complexity. Warmer climate is simulated by a modification in the radiation parameterisation that corresponds to the doubled CO_2 concentration, and SST forcing is represented by the same SST anomalies as in current climate (1855–2002) experiment superimposed on the climatological SST that was obtained from a complex atmosphere–ocean general circulation model forced with the doubled CO_2. SST anomalies in the Niño3.4 region, categorised into five classes, enabled a composite analysis of changes in the Northern Hemisphere tropical/extratropical teleconnections.

The main features of the tropical–extratropical teleconnections are maintained in both experiments; for example, irrespective of the sign of SST anomalies, the amplitude of the atmospheric response is positively correlated with the intensity of ENSO event and the El Niño impact is stronger than that of La Niña of the same intensity. The strongest extratropical signal in the warmer climate, particularly significant for strong warm events, is found over the Pacific/North American region; however, this extratropical teleconnections is reduced in a warmer climate relative to the current climate. Over the North Atlantic/European region, a detectable signal linked to ENSO is found; this model response is significantly strengthened in the experiment with the doubled CO_2 concentration. Such an atmospheric response in a warmer climate is found to be associated with changes in the mean state followed as well as in the jet waveguiding effect and stationary wave activity.

Dynamical downscaling of wind speed in complex terrain prone to bora-type flows

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The global model reanalysis, forecast or climate data needs to be downscaled to provide information for regional interpretation. This is especially true in complex terrain of Croatia, where a significant portion of wind energy potential is related to wind systems resulting from interaction of the mountains and the atmosphere, such as bora winds.

Dynamical downscaling was performed with the use of ALADIN model, driven by the ERA-40 reanalysis, at 8 km horizontal grid spacing during a 10-yearly period (1992-2001). Thereupon, a simplified and cost-effective model version, so-called dynamical adaptation, was carried out with a 1-hourly frequency at 2 km horizontal grid spacing. Complimentary statistical and spectral verification, performed on a number of surface stations in different climate regions of Croatia, suggested that downscaling was successful. The greatest average wind speeds are associated with areas where gap flows and gravity-wave breaking take place during bora flows. Systematic errors of 10-m wind speed are close to 1% in flat terrain and reach up to 10 % for coastal stations.

in the vicinity of Dinaric Alps, the latter due to underestimation of the strongest wind speeds. The shape of the kinetic energy spectrum follows the expected seasonal dependence and generally relaxes towards the orography spectrum as approaching the ground. Near the surface, divergent flows contain more energy than rotational at wavelengths smaller than 200 km. The main improvement of the both mesoscale model versions is found for diurnal circulations, while for smaller frequencies dynamical adaptation shows beneficial primarily for winds in cross-mountain direction determined by the strong pressure gradient over the mountain range. Due to underestimation of energy of sub-diurnal motions, further improvement of wind resource assessment in complex terrain may be achieved through the use of higher resolution numerical modeling.

Operational NWP using ALADIN model in CMHS

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The primary goal of the numerical weather prediction (NWP) section in Croatian Meteorological and Hydrological Service (CMHS) is running and delivering the operational ALADIN (Aire Limitee Adaptation Dynamique developement InterNational) forecast products to a number of users on time

twice a day, every day. The operational forecast is a time critical application limited by the time span between the availability of the input data (measurements and the large scale model data) and the time when the users want the forecast to be available. This is a serious limiting factor for the model configuration used for the operational forecast, model resolution and domain size determined by the computer hardware equipment and the data transfer network. The operational forecast products are grib files of the model data, pseudo-TEMPs, figures and tables. They are distributed automatically to

the users that range from the forecast department, air traffic control, Ministry of Internal Affairs, Ministry of Defence, private companies, foreign institutions, TV and other media.

Changes of apple phenology in Croatia

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To investigate the impact of climate change on growth and development of apples, phenological data from 17 stations across the Croatian in the period 1979-2009 were analyzed. Six different varieties of apples, three varieties of old-fashioned autumn (Bobovec, Canada and Kolacarka), two autumn newer varieties (Jonathan and Golden Delicious) and the earliest variety of Petrovaca were analyzed. In the Croatian interior the growing season begins in the first half of April and ends in the first half of November. In the mountainous region of Croatia beginning of the growing season is shifted toward the end of April and ends in early November. Analysis of linear trends of phenological phases of different varieties of apples indicate that climate change effect all apple varieties, and especially on earlier beginning of leaf unfolding and flowering in in spring. Earlier beginning of leaf unfolding and beginning of flowering is the most expressed in mountainous region (3-6 days/10 years). Although the start of the vegetation of all varieties of apples moved earlier in the spring, old fashion autumn varieties of apple ends their vegetation period earlier in autumn. It follows that its length of vegetation did not change significantly the last three decades. Autumn newer apple varieties show greater sensitivity to change in length of growing period. It is noted shortening of vegetation period in the continental part and prolongation in the mountainous part of Croatia. The tendency of prolongation in the mountainous region points to the possibility of all favourable growing apples in this region. To test the impact of weather conditions at the beginning of flowering apple, into consideration were taken winter weather conditions during the winter dormancy of apples. Using Utah model we investigated the average chill units for different varieties of apple in different climatic zones in Croatia during the period 2001–2008. Using Utah model it was for the first time evaluated what area is favorable or unfavorable area for growing apples.

On Reynolds averaging scale for mid-Adriatic summer bora flows

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Bora is a downslope windstorm that blows at the eastern Adriatic coast from the northeast quadrant, most often during winter seasons. Due to its gustiness it reaches speeds even greater than 60 m s-1. During such events, the turbulence is strongly developed in the lee of the mountains; moreover, sub-mesocale and turbulent structures are additionally complicated at the middle of the NE Adriatic coast due to the surrounding mountains. The intensity of the bora investigation decreases from the northern toward the southern part of Adriatic, mainly because it occurs more often at the northern Adriatic and is stronger there. Nevertheless, severe bora at the middle-eastern and southern Adriatic coast is not a rarity at all. Partially inspired by this fact, we have installed three levels of horizontal and vertical wind and sonic temperature sensors at the middle-eastern Adriatic coast: on the hill of Pometeno Brdo (43.62°N, 16.47°E, 600 m above MSL), inland from the city of Split, at heights of 10, 20 and 40 m above the ground. Measurements are performed with WindMaster ultrasonic anemometers (Gill Instruments) with a sampling frequency of 5 Hz.

In order to investigate turbulence, a suitable time/space interval for Reynolds averaging has to be used in order to determine turbulent perturbations, which define turbulent kinetic energy, gustiness, etc. Without the proper Reynolds averaging, turbulent fluxes are either over- or under-estimated. This study addresses the turbulence averaging interval for bora events on the hill of Pometeno Brdo (”Swept-Away Hill”) during three months of the summer in 2010.

Comparison and validation of satellite-based overshooting top detection methods

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Overshooting convective cloud tops (OT), dome-like protrusions above a cumulonimbus anvil, indicate the location of vigorous updrafts where severe weather including heavy rainfall, hail, strong winds and tornadoes most often occurs. OTs are apparent in satellite data with a lumpy textured appearance in visible channel imagery. Since visible channel imagery is only available during daytime, meteorologists must also use the infrared (IR) channels for observing and objective detection of OTs.

The aim of this investigation is to compare the detection characteristics and relative accuracy of several different satellite–based OT detection methods. Research by the authors has shown that OTs can be detected from the satellite data using the brightness temperature difference (BTD) of the water vapor and the IR channel (6.2–10.8 μm), BTD of the ozone and IR channel (9.7–10.8 μm) or BTD of carbon dioxide and IR channel (13.4–10.8 μm). A combination of the 6.2-10.8 μm and 9.7-10.8 μm BTDs can also be used. All these methods include thresholds for both IR brightness temperature and the BTD.

A more complex method, called IRW-texture, includes a combination of infrared channel brightness temperature and spatial gradient criteria with a numerical weather prediction model tropopause temperature forecast to detect OT signatures at their characteristic spatial scale.

The theoretical background of all mentioned methods will be explained and the results of detection will be compared with the High Resolution Visible (HRV) satellite images during day-time in order to validate each method.

Correlating overshooting tops and severe weather

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Overshooting convective cloud top (OT) is a dome-like protrusion above a cumulonimbus anvil, often penetrating into the lower stratosphere. It represents a very strong updraft. A single OT exists for less than 30 minutes and has a maximum diameter of ~15 km. According to some investigations, deep convective storms with OTs often produce hazardous weather conditions such as heavy rainfall, damaging winds, large hail, cloud-to-ground lightning and tornadoes. The OTs also generate gravity waves which can produce significant turbulence. These events can cause considerable property damages, influence everyday activities and even endanger the human lives.

Relationship between the occurrence of the OTs and severe weather conditions over Central Europe is established. The OTs are detected from Meteosat 8 and 9 data, using a combination of brightness temperature difference of the water vapor and the infrared channel (6.2-10.8 μm), and of the ozone and the infrared channel (9.7-10.8 μm). This method includes the infrared brightness temperature and brightness temperature difference criteria. Locations and times of appearance of the OTs are compared with the occurrence of the strong wind and wind gusts measured by the automatic stations. Additionally, hailpad and raingauge measurements are used to determine the relationship between the occurrence of the OTs and severe weather conditions.

Flash-flood in Pula, in the North Adriatic in the night of 24 to 25 September 2010

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A case with the extreme precipitation is analyzed by means of measurements and NWP model data. The satellite, radar, lightning and rain-gauge data were included, whereas for the forecast part ECMWF and ALADIN models were used. Synoptic analysis showed a deep upper-level trough stretching from western Scandinavia to the Gulf of Genoa with the secondary trough located over Sicily. The low-level situation was characterized by the south-easterly flow at the front side of a cyclone moving eastwards through the Tyrrhenian Sea. In the afternoon of the 24th scattered showers in the area started, intensified and spread to the whole North Adriatic basin. According to the radar data the hourly precipitation amounts exceeded 50 millimeters. Around midnight second cyclone in the Gulf of Genoa caused the strong convergence along the west coast of Istrian Peninsula. Pronounced vertical wind-sheer induced severe convective development in the vicinity of the horn of Istria moving over the land and producing almost 200 mm of rain in less than 6 hours. In south-western Istria roads and settlements were flooded. The rain-gauge amount of 176 mm is the highest daily value ever measured in city of Pula. Operational 8km resolution hydrostatic ALADIN model forecast the existence of twin cyclones quite satisfyingly giving the correct precipitation maximum over the sea. Nevertheless, there was no indication for the secondary maximum over the Istrian land. The processes that lead to the development of the secondary maximum were further explored using the 2km resolution non-hydrostatic ALADIN model.

Testing waterspout forecasting indices over the Adriatic sea using ALADIN model

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Waterspouts are severe mesoscale phenomena that can cause great damage to lives and property. Many waterspout events have been recorded in Croatia over the past several years, especially during the summer months. This motivated us to test and develop some forecasting tools that will help forecast waterspout events. Two forecasting indices are most often cited in the literature: the Szilagyi Waterspout Index (SWI) and KHS – Index to calculate risk of (water)spout development. For the SWI a combination of three parameters correlates strongly with waterspout events: difference between water temperature – 850 mb air temperature, convective cloud depth and 850 mb wind speed. The KHS index is based on four parameters: vertical wind shear 0-3 km, 0-500 m lapse-rate, average humidity in the first kilometer and 10 m wind speed. In this study we test these two indices on several case studies. The SWI and KHS are calculated from the Aladin model used operationally in the MHS of Croatia. During the 2010 19 days with waterspouts observed along the Adriatic coast were identified. For all 19 events short description about time, location, synoptic situation (weather type and thermodynamic environment) is given as well as yes/no for the value of both indices. Results of a detail analysis of 4 waterspout events are presented. The research shows that most of the waterspout events were thunderstorm related; however, for those that are not (fair-weather) more than just common thermodynamic instability indices are needed. Our study shows that SWI and KHS indices improve the waterspout forecast.

Impact of Radar Data Assimilation on Numerical Simulation of a Severe Storm in Croatia

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A severe thunderstorm hit the north-western part of Croatia in the late afternoon and evening of 24 June 2008. Strong wind gusts and hail were observed and there were even reports of a small tornado. The storm was initiated in Austria and traveled southeast through Slovenia and Croatia reaching as far as Bosnia and Herzegovina. This severe event was used as a test case for the Advanced Regional Prediction System (ARPS) high resolution numerical prediction model for exploring the impact of assimilating conventional and radar data. Nested model grids were used with horizontal grid spacing of 24 km (ARPS24), 8 km (ARPS8), and 2.5 km (ARPS2.5). Without data assimilation, the models were unable to represent the development of the storm nor the proper environment for it. Assimilation of SYNOP data in ARPS8 sets up proper environment for storm development but because of too coarse resolution ARPS8 did not properly resolve the storm development. ARPS8 with assimilation of SYNOP data was used as driving model for ARPS2.5 model that produced slightly more realistic storm development. To improve the forecast further high resolution data must be assimilated. This is done via assimilating radar data from the Bilogora radar, located in northern Croatia. Radar radial velocity was assimilated using three-dimensional variational analysis (3DVAR). Radar reflectivity data were used through a cloud analysis procedure where hydrometeors and cloud fields are defined, and adjustments to the in-cloud temperature and moisture fields are made. The best results were obtained by assimilating radar data in two sequential steps 15 minutes apart.

Assimilation system at DHMZ

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Numerical weather prediction (NWP) can be seen as an initial problem in mathematics where, if the initial state of the atmosphere at a given time is known, geophysical systems equations can be solved to obtain values for variables at future time points. Sensitivity to initial conditions can be even greater if the nonlinearity of a geophysical system is taken into account, which requires “best possible” initial conditions for the NWP model. Data assimilation is technique of approximating “true” state of atmosphere at given time taking into account dynamical properties of the physical system. A description of the setup for a local assimilation system for a limited area model, ALADIN (Aire Limiteé Adaptation Dynamique dévelopement InterNational) is given. The assimilation system at DHMZ (Meteorological and Hydrological Service of Croatia) consists of two parts: the surface assimilation, which is used to change the state of a model land surface variables, and the upper air assimilation, which changes the upper air model fields. The surface assimilation is performed by the optimal interpolation (OI) technique, while the upper air assimilation is conducted using the 3D variational technique (3DVAR). A basic verification was performed for a forecast starting from the initial state given by the assimilation system and the operational forecast. The verification results showed a positive impact of assimilation on forecast for the upper airfields and for screen-level variables.

Saharan dust in Croatia

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The Sahara is the world's largest source of the aeolian desert dust. The dust can be entrained over large areas in dust storms, transported over thousands of kilometers and then deposited downwind. Saharan dust has a major influence on soil characteristics, oceanic productivity, air chemistry and climate.

Most Saharan dust is deposited from the atmosphere over Mediterranean countries of southern Europe by dry or wet deposition. Here, the characteristics of Saharan dust episodes over part of the southern Europe (Croatia) will be shown. We tried to determine the frequency of mud rains over Croatia and investigated their influence on precipitation chemistry. Further on, we analyzed the influence of Saharan dust on the coarse fraction levels (PM_{10}) at several measurement sites in Croatia. Saharan dust episodes were identified using satellite data and backward trajectories.

In addition, synoptic situations prevailing during the investigated Saharan episodes were analyzed. Three main types of weather situations connected to the transport of the dust from Sahara desert to Croatia were revealed and their characteristics will be shown.

The convective activity above Croatia and its relationship with the sea breeze

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The aims of this study were twofold. Firstly, the analysis of the frequency of different synoptic conditions with convective activity was performed. Secondly, the sea breeze/synoptic wind interaction and its relationship with the simultaneously cumulonimbus (Cb) clouds development has been investigated in a more detail. In the first part, a study of convection was made using lightning flashes (LINET network) during the warm part of the year (2006–2009). Spatial and temporal analyzes, based on the overall lightning flashes (cloud-to-cloud and cloud-to-ground), have shown that the western parts of Croatia, i.e. Istria and Kvarner, represent the most lightning active areas. Furthermore, starting and decaying times differ somewhat between the continental and coastal Croatian parts. The convective activity starts around noon (and soon after), and stops late in the evening. Along the coast, night-time convection is more frequent than in the continental part. The lightning flashes are frequently connected with several weather types defined by the surface pressure distribution over Croatia: ~ 23% in the non-gradient field, ~ 18% in the cyclone center, ~ 15% in the forward and ~ 12% in the backward parts of the cyclone, and ~ 11% in the forward part of trough. These pressure formations are associated with SW (38%), NW (18%), and NE (23%) wind regimes. Above Istria, the most convective active area, dominant weather and wind regimes (SW, NE and NW wind) already mentioned, are observed on more than 80% of all days with lightning flashes. Therefore, we investigate, via three chosen cases (for every type of the synoptic wind regime), the influence of the interaction of the synoptic wind with local thermal onshore flow on the Cb development. Results show that the SW synoptic wind is superimposed on the western sea breeze increasing the humidity advection at the foot of the mountains in Istria. Although the opposing NE synoptic wind retards inland penetration of the western sea breeze, their interaction enhances the convergence in the wind field and consequently the intensity of the sea breeze front and its updrafts. The effects of NW and SW synoptic winds are somewhat similar. In all cases, the result is favorable conditions for the Cb development in the form of multi-cells.

Atmospheric dynamics during high pollen concentrations in Zagreb in 2002 and 2003

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Back-trajectories, in conjunction with measured meteorological data, were used to examine the ragweed pollen concentration maximums that occurred during the first week of September in years 2002 and 2003 in Zagreb. Based on the maximum ragweed pollen concentration occurrence, two periods of research were defined, period A (3rd and 4th September 2002) and period B (6th and 7th September 2003). According to the two-hour pollen measurements, besides very high daytime maximum concentrations that exceeded 600 grains/m3, the night-time concentrations were unusually high as well. Prognostic charts show that synoptic conditions in both periods were very similar, with a slow eastward moving high pressure system over the south-eastern Europe. The mesoscale WRF numerical model results demonstrated a successful multi-day simulation in Zagreb reproducing (i) the local topography influence on local wind flow as well as (ii) the formation of an urban heat island over the city and (iii) reasonable agreement with the available observations. The model indicated that in the first period, the moderate synoptic flow was predominantly from the east, while during period B, a weaker (than in period A) easterly synoptic wind allowed a more significant local thermal circulation development over Zagreb. Hourly back-trajectories, based on the wind field obtained by the WRF model, indicated the most probable reasons for high nightly two-hour concentration peaks recorded in Zagreb. The long-range transport of pollen grains from the Pannonian Plain was the presumable cause of the rather high pollen concentrations during period A, especially during its night-time part. During period B, the westward long-range transport, suggested by trajectories, was significantly supplemented by the horizontal recirculation of the pollen grains within diurnal local thermal circulation over the city, causing the higher late evening concentration increase.

The meteorological aspects of the DART field experiment

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DART (Dynamics of the Adriatic in Real-Time) is a project devoted to real time observational and modelling study of the Adriatic Sea involving a considerable number of organisations from Europe and US. Several ocean and wave models were run using different meteorological model outputs for input atmospheric conditions. The main purpose of DART was to test the real time measurement and modelling capabilities for the Adriatic Sea that were available at the time of the field experiments. Two field campaigns (research cruises) were organised, during March and August 2006.

The preliminary analysis of the measured and modelled data reveals several issues that should be adressed. These require more detailed insight into the involved processes, meteorological model evaluation as well as the complex air-sea interaction mechanisms. Improved knowledge of vertical gradients of meteorological quantities in the layer above the sea surface, particularly air temperature, wind speed and direction in different weather, wave and ocean conditions lead to better understanding and description of the air-sea interaction processes. Inclusion of the latter in the operational meteorological models used for numerical weather prediction improves the weather forecast not only above the sea surface, but also for the coastal areas and inland.

Modeling the origin and fate of waste materials on the south-eastern Adriatic coast (Croatia)

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Waste accumulation was observed on the southeast coast of Adriatic, Croatia on 21st November 2010. The labels on the waste suggesteded that it arrived from Albania. The meteorological conditions are analyzed using available meteorological measurements from Croatia and Montenegro and the ALADIN model data on 8 and 2 km resolution. Heavy rainfall event of 8-10 November 2010 occured over Albania is estimated to be the most likely cause of a flash flood that washed the waste to the sea. The water level measurements on Bojana river in Montenegro show substantial increase

following that rainfall event. The sea currents responsible for pollution transport are computed using ROMS ocean model, forced with ALADIN 2km outputs, major Adriatic river inflows and tides at the open boundary. The results from ocean model are used as input to the forward trajectory computations initiated of the coast of Albania on 8th November 2010. Many of these trajectories end on the southeastern Adriatic coast in Croatia.

Heavy rainfall and flash flood in Dubrovnik on 22nd November 2010

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A case with the extreme precipitation in the morning on 22nd November 2010 in Dubrovnik, Croatia, is used as a testbed for the numerical weather prediction model ALADIN. The synoptic situation was characterized by a huge low moving over the Alps with the frontal system covering most of Central Europe and Mid-Mediterranean. During the passage of the cold front over the southern Italy and Adriatic Sea, a secondary cyclone developed and a meso-scale convective system grew within. The rain-gauge measurements exceeded 100 mm/24hr in the area and the one in Dubrovnik measured 161.4 mm/24hr, with a peak intensity of 71.5 mm/h. This was the measured maximum ever measured in Dubrovnik. Different options for initial and boundary conditions will be tested for the 8 km resolution run. In DHMZ, two options are operationally available, from ARPEGE run at Meteo France and IFS model run operationally in ECMWF. A possibility of improving the initial and lateral boundary conditions via the data assimilation is investigated. The ALADIN 8 km model results forecast 24 hour accumulated rainfall from 20 to 100 mm in the area around Dubrovnik, but the maxima over 100 mm are above the surrounding areas of Montenegro and Bosnia and Hercegovina.

Experiments using high-resolution (2 km) non-hydrostatic ALADIN model show strong dependency on the model, input data from initial and lateral boundaries. The position and time of the precipitation maxima is very similar to the lower resolution (8 km) run used for initial and lateral boundary conditions. One configuration forecasts precipitation exceeding 100 mm/ 24hr for Dubrovnik.

ALADIN model simulations of the severe convective precipitation event in Pula on 25th September 2010

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ALADIN model simulations of the severe precipitation event in Istria on 25th September 2010. The operational ALADIN forecast is run with 8 km horizontal resolution, it uses ARPEGE initial and boundary conditions and digital filter initialization. The parallel suite uses initial conditions obtained from data assimilation cycle. Alternatively, the initial and boundary contitions from IFS model were used with surface assimilation only and with 3Dvar. The results show that 3Dvar improves the

precipitation forecast in Istria for 8 km resolution run. Several experiments using high-resolution (2 km) non-hydrostatic ALADIN model runs have been performed. The experiment where the prognostic parametrization of convection has been used have indicated the existence of the secondary maximum over the Istrian land. Most of the precipitation was given by the convection scheme. This result suggests the importance of using the convective parametrization even in the resolutions in which it is assumed that the convection is resolved.

Climatology of the winds at the NE Adriatic coast based on the highfrequency measurements

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Strong winds are characteristic for the eastern Adriatic coast, mostly bora and sirocco, which, due to the frequent severity, represent a great threat to traffic, infrastructure, tourism and agriculture, as well as great potential in wind energy resources. Therefore, there is a significant and continuous interest in the meteorological and broader community for airflow studies in this region.

In this study the data collected in the town of Senj and Vratnik Pass at the northeastern Adriatic coast are used. Senj is a trully coastal town (44.99° N, 14.90° E) while Vratnik Pass (44.98° N, 14.98° E) is ~ 10 km east of Senj in the lee of Dinaric Alps, ~ 700 m ASL. Single point measurements of horizontal and vertical wind, sampled at 4 Hz with the WindMaster ultrasonic anemometers (Gill Instruments), were performed at 13 m and 10 m above the ground in Senj and Vratnik Pass, respectively. The anemometer in Senj was operative from March 2004 to June 2006, and the one at Vratnik Pass from October 2004 to September 2005. The data-sets in the period when both anemometers were operational are analyzed. Despite of various technical difficulties, this pertains to almost a nine-month period between October 2004 and September 2005. For this period, 1-h mean horizontal winds on both sites (classified with respect to the mean of horizontal wind speed and direction) are calculated and compared. Some interesting features and a sort of “polarized-statistics”, in relationships among certain winds on both sites, are revealed.

A severe Bora event at the Vratnik Pass and the town of Senj

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A downslope windstorm, blowing at the eastern Adriatic coast from the northeast quadrant and most often during winter seasons, is called bora. It possesses a wide spectrum of average wind speeds and, due to its gustiness, the speed maxima may surpass 60 m/s. During a bora event, the turbulence is strongly developed in the lee of the mountain.

All three wind speed components are measured at Vratnik Pass (44.98° N, 14.98° E, 700 m above MSL) at a height of 10 m above the ground, and several km downstream, in the coastal town of Senj (44.99° N, 14.90° E, 2 m above MSL) at a height of 13 m above the ground with the WindMaster ultrasonic anemometer (Gill Instruments). The anemometers simultaneously record the data in the period between October 2004 and September 2005 with a sampling frequency of 4 Hz. A case study is presented when bora occurred both at Vratnik Pass and Senj, former being the upwind elevated site for the later, historically well-known bora place. We address onset, evolution and cessation of bora at these two closely related places. Besides a dynamical background, certain turbulence features of this bora event are assessed as well.

Meteorološki čimbenici zrakoplovne nesreće na letu AF447

Mladen Viher

MORH

Pad Air Franceovog Airbusa 330 na letu Rio de Janeiro – Pariz, koji se dogodio u noći 1. lipnja 2009. godine bio je najveća nesreća u povijesti francuskog zrakoplovstva. Ostaci aviona i "crne kutije" pronađeni su tek nakon dvogodišnje potrage. Do nesreće je došlo tijekom prolaska kroz intertropsku zonu konvergencije, u uvjetima izuzetno jakog konvektivnog razvoja. Zbog naglog zaleđivanja sva tri senzora za mjerenje brzine aviona automatski sustav za upravljanje izgubio je podatke o visini te progresivnoj i vertikalnoj brzini i prešao je u tzv. alternativni mod upravljanja. Posada je pokušala upravljati letjelicom bez ovih podataka, ali je pritom prevukla avion što je dovelo do gubitka brzine i sloma uzgona. Avion je naglo izgubio visinu i nakon oko četiri minute pljoštimično je pao na površinu Atlantika. Ova nesreća pokazala je kako još uvijek ne znamo dovoljno o termodinamičkim pojavama u konvektivnim oblacima, posebno o pojavama vezanim za pothlađenu vodu na ekstremno niskim temperaturama. Od zrakoplovne industrije očekuju se poboljšanja na sustavima za drenažu i zagrijavanje senzora brzine kao i pronalaženje načina za njihovo ispitivanje na temperaturama nižim od -40°C. Pored toga, bit će potrebno pronaći način za prijem meteoroloških podataka u realnom vremenu na prekooceanskim letovima. Posebnu pozornost treba posvetiti školovanju i obuci posada aviona u korištenju meteoroloških radara, rezultata numeričkih modela i produkata daljinskih istraživanja.

Klimatske promjene i modeliranje poljodjelske proizvodnje u Hrvatskoj

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Modeliranje potencijalnih utjecaja klimatskih promjena na poljodjelsku proizvodnju vrlo je važno, pogotovo u današnjim prilikama, kada nestašica hrane zahvaća sve više zemalja. Kukuruz, kao najrasprostranjenija poljodjelska kultura u Hrvatskoj, odabran je za proučavanje učinka klimatskih promjena na njegov prinos kukuruza u središnjoj Hrvatskoj. Istraživanja su provedena u sadašnjim klimatskim uvjetima prema meteorološkim podacima postaje Zagreb-Maksimir (1949–2004) kao i projekcije u promijenjenoj klimi. Pomoću modela DSSAT, koji je jedan od najčešće primijenjenih agrometeoroloških modela u svijetu, simuliran je prinos kukuruza u sadašnjoj klimi. Od godine do godine u promatranom razdoblju mijenjani su samo meteorološki početni uvjeti. Fizikalni i kemijski podaci tla te fiziološki i morfološki podaci kukuruza, koji su dobiveni standardnim poljskim pokusom na poljoprivrednom dobru Agronomskog fakulteta Sveučilišta u Zagrebu 1999. godine, bili su konstantni. Rezultati linearnog trenda pokazuju signifikantno smanjenje prinosa kukuruza za 216 kg/ha u 10 godina, ali i raniji početak svilanja kukuruza (1.4 dana/10 god) i fiziološkog zrenja (4.5 dana/10 god) što ukazuje na skraćivanje vegetacijskog razdoblja posljednjih desetljeća. Za projekcije prinosa kukuruza tijekom 21. st. sintetički meteorološki niz modificiran je za različite klimatske scenarije (ECHAM, HadCM i CSIRO) pomoću stohastičkoga vremenskog generatora Met&Roll. Modificirani meteorološki podaci su bili ulazni podaci u model DSSAT kojim su procijenjene komponente kukuruza u budućoj klimi. Uz pretpostavku današnjih agrotehničkih mjera i hibrida kukuruza očekuje se ranija berba kukuruza i do mjesec i pol dana uz pad prinosa zrna od 14% do 25% u promijenjenim klimatskim uvjetima do kraja 21. st. u odnosu na sadašnje klimatske uvjete u središnjoj Hrvatskoj.

Using an artificial brain to interpret Adriatic surface currents

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A network of high-frequency (HF) radars was installed in the northern Adriatic in the second half of 2007, aimed to measure surface currents in the framework of the North Adriatic Surface Current Mapping (NASCUM) project. This study includes a detailed analysis of current measurements from February to August 2008, a period in which three radars were simultaneously operational. We applied self-organizing map (SOM) analysis - an emergent computational technique in oceanographic research - on data, obtaining 12 patterns that explain the majority of northern Adriatic surface currents. As a neural network technique, SOM analysis uses complex mathematical algorithms to train computers to pull patterns from jumbles of data, reducing complex multidimensional observations into simple visual maps. The approach is meant to emulate the learning abilities of biological brains. By comparing SOM analyses run using radar data against those performed using the radar data along with surface wind data derived from a high-resolution operational model, we deduced that surface currents in the northern Adriatic are controlled largely by surface winds. The number of patterns associated with each force indicates its relative importance in driving surface currents. We suggest that their SOM analysis–derived patterns potentially could be used within operational oceanography systems to provide real-time estimates and forecasts of surface currents for the northern Adriatic.

Possible improvement in the procedures for selection and granting access to the places of refuge based on the physical oceanography data

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ADRIAGIS is a computer application in a GIS environment. It uses Multi-Agency Model approach and enables rapid access and analysis of relevant safety, economic, legislative, ecological and technical parameters, for the persons responsible for final decision making about request for a place of refuge. The ADRIAGIS concept is based on the need to minimize subjective evaluation in the procedure of decision making and at the moment it is based on 13 relevant criteria.

Here we propose an improvement in the procedures for selection and granting access to the places of refuge based on the physical oceanography data, in particular circulation fields obtained from realistic numerical model simulations.

An example of the importance of the proper formulation of the sea circulation in the selection a place of refuge is given for the middle Adriatic coastal area. Significant differences could arise in the modelled current fields depending on the resolution of the selected atmospheric forcing. These differences are particularly considerable during the strong wind episodes of bora and sirocco, when the occurrence of accidents at the sea is highly possible. Small-scale atmospheric features, which arise due to the orographically complex mainland and the number of islands are reproduced by the fine atmospheric model and substantially affect surface currents in the coastal area during strong bora. During strong sirocco, currents on the lee sides of inner islands are sensitive to the atmospheric model resolution. The impact of the obtained differences in the circulation on the selection of a place of refuge is discussed.

Monitoring sea level in Croatia

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The eastern Adriatic coast is the part of the Mediterranean most densely covered with long, continuous, high-quality sea-level observations. Systematic sea-level measurements in Croatia were started in December 1929, when Geophysical Institute installed a tide gauge in Bakar. It has been operating ever since, except for a break around the Second World War, providing an uninterrupted record since 1949. The backbone of Croatian tide-gauge network was formed around 1950s, when four new float-operated tide gauges were installed along the coast: at Split (Harbour, in 1947 and Marjan, in 1952), Dubrovnik (1954) and Rovinj (1955), and they have been continuously operating in the entire period, except at Dubrovnik, where the measurements had to cease for 3 months in the winter of 1991/1992, during the period of the heaviest shelling. The tide-gauge network was modernised in 2003 when all the stations were upgraded with analog/digital converters and GSM (*Global System for Mobile Communications*) modems for near-real time acquisition of data. A new technology in sea-level measurements was introduced in the Adriatic in 2004, with the installation of a radar tide-gauge at Bakar. In the same year a CGPS (*Continuous Global Positioning System*) antenna was installed at the tide-gauge in Split, which enabled the measurement of absolute sea-level displacements.

Long, high-quality time series of tide-gauge measurements provide a valuable basis for the study of mean sea-level changes and climate fluctuations. On the other hand, the installation of digital instruments enabled a close study of high-frequency phenomena (*e.g.*, storm surges, abiki/meteotsunamis) which sometimes cause great damages to the coastal area.

Improving regional AVHRR SST measurements using AATSR SST data

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The sea surface temperature (SST) is an important parameter in many disciplines (e.g. oceanography, meteorology or climatology). Satellite SST measurements from different sensors are available but such data collected over the same area often exhibit considerable mutual differences. Advanced Along Track Scanning Radiometer (AATSR) onboard the European Space Agency (ESA) ENVISAT platform currently provides the most accurate and precise measurements for deriving SST, whereas Advanced Very High Resolution Radiometer (AVHRR), MODerate resolution Imaging Spectroradiometer (MODIS), and **Spinning Enhanced Visible Infra-Red Imager (SEVIRI)** sensors render spatially and temporally denser coverage of a given area.

In this study five different SST L2 products/datasets (NOAA17/AVHRR, METOPA/AVHRR, Terra/MODIS SST, Terra/MODIS SST4 and MSG/SEVIRI) and two auxiliary L2 products (MODIS Water vapour, MODIS Aerosol) were combined with a view to obtain better satellite estimates of the Adriatic Sea surface temperature. To that end, the AATSR-derived SST was used to improve estimates based on local collection of NOAA 17 AVHRR High Resolution Picture Transmission (HRPT) data stream. More specifically, six years (2003–2008) of AATSR and AVHRR SST L2 data were analyzed together with auxiliary aerosol and water vapour data from MODIS sensor aboard Terra platform for generation of new algorithms, while extension to 2010 was performed only for validation purposes of global SST products. The matchup data were stored in a relational SQL database to ensure smoother manipulation of couple of million data pairs. The analysis has shown that the application of all global SST night-time products to Adriatic Sea produces seasonality in the SST residuals (global SST - AATSR SST). A new set of AVHRR monthly-variable coefficients has produced an improvement in overall statistical parameters (night-time scatter is decreased from 0.46 to 0.34 K and bias from -0.07 K to –0.03 K) while eliminating noted seasonality in the residuals.

The state of the art in research of meteorological tsunamis

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Meteorological tsunamis or meteotsunamis, atmospherically induced destructive ocean waves in the tsunami frequency band, have been recognized as a threat to some coastal areas and researched in the last century in different parts of the World Ocean. Alike to research of other rare events like seismic tsunamis, the research effort had strong positive peaks after the most destructive events, like the English Channel wave of July 1929, the Great Lakes Surge of June 1954, abiki of March 1979, rissaga of June 1984 and June 2006, or Vela Luka ščiga of June 1978 and Stari Grad/Mali Ston ščiga of June 2003. A substantial increase in knowledge happened in the 1990s, originating from the research activities on rissaga events along the Balearic Islands' coastline, and in the 2000s, when a number of tsunami-like events of meteorological origin in the Adriatic and the Mediterranean Seas were investigated by means of high-resolution meteorological and oceanographic numerical models, in addition to the data analyses. The research activities encompassed all aspects of atmospheric generation, air-to-sea resonant energy transfer and growth and inundation of the meteotsunami waves. The research activities resulted in a large number of high-quality publications, including a special issue of the journal Physics and Chemistry of the Earth in 2009.

Recently, the U.S. NOAA/NWS operational service recognized that a meteotsunami threat along the U.S. coastline is under-researched. Therefore, they put a noteworthy amount of money in research and in definition of protocols for meteotsunami detection and early warning. Hopefully, the TMEWS (Towards a MEteotsunami Warning System along the U.S. coastline) project, which started in October 2011, lasts for 2 years and embraces the project team from Croatia, Spain, Canada and Russia will increase our knowledge which will be used for mitigation and risk assessment of this rare but vigorous phenomenon.

Mohorovičić's Wiechert runs again (The phoenix rises from its own ashes)

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The big horizontal Wiechert seismograph (1000 kg) in Zagreb recorded earthquakes in the period 1909–1983. In 1909 the seismogram of the Kupa valley earthquake was the one that ignited Mohorovičić's curiosity which eventually lead to discovery of the Moho. In the period 1985–1988 the instrument was moved to the new Institute building, where it was thoroughly restored. On the occasion of opening the Andrija Mohorovičić Memorial Rooms in 2005, the instrument was fine-tuned, and placed into the protective casing. During 2007, as part of marking the sesquicentennial of Mohorovičić's birth, this historical instrument was revitalized and brought into digital age by installing simple velocity transducers on the impact rod of each component. The signal is digitized by a Guralp digitizer and is being continuously recorded. We present the first calibration results, recorded seismograms, and comparisons with a co-located modern broad-band instrument.

Depth of Moho derived from receiver functions in relation to coda attenuation parameters in Croatia

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Seismic waves contain information about source and medium characteristics through which elastic waves propagate. Receiver function analysis provide a method in which teleseismic body waves are used to extract just the effect of the structure beneath the seismic station and discard influences from the source and path parts in which we are not interested in. We used it here to determine the crustal thickness, i.e. the depth of the Mohorovičić discontinuity (Moho). On the other hand, coda waves of local earthquakes are used to estimate the average attenuation in the form of the coda-Q factor (Qc) in the volume around seismic station. Qc was estimated using the single backscattering model. Qc is frequency (f) depended and is usually written as Qc=Q0fn. We want to determine if there is any correlation between Q0 or n and the Moho depth as some studies suggest. For this we use results from the two previously mentioned methods applied to seismograms recorded by seismic stations of the Croatian Seismological Network.

Seismic hazard maps of Croatia

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The long overdue, new seismic hazard map of Croatia has been prepared and accepted as a part of the National Annex of the Eurocode-8. Earthquake hazard is presented by the values of peak ground acceleration (PGA) expected to be exceeded on the average every 95 and 475 years. Underlying statistical analyses was based on the updated Croatian Earthquake Catalogue, which was expanded with the data for events well outside Croatian borders. The hazard computation was performed on a grid 5.5 x 5.5 km, by a zoneless, smoothed seismicity approach, with the stochastic Monte-Carlo simulation of 2.000.000 years of seismicity. The computations were performed for 6 different seismicity models, and for 6 selected attenuation relations. Epistemic uncertainties were accounted for by considering a simple logic tree with 36 branches, and by adopting the weighted median of values thus obtained. The results indicate the highest hazard to exist in Dalmatia – especially close to Ston and Dubrovnik where PGA for the return period of 475 years exceeds 0.35 g, in the greater Zagreb area, and in the Primorje coastal region. Comparison with the available hazard maps from the neighbouring countries reveals very good match in the border regions.

Comparing microseismic noise spectra by the image moments

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There are many sources of microseismic noise such as wind, traffic, variations in the atmospheric pressure, sea waves, tides, inverse seismoelectric effect of external electromagnetic waves, earthquake nucleation processes etc. Any change in these parameters causes differences in microseismic noise spectrum. The aim of this work is to check whether the image moments analysis is an applicable method for determining the differences between the microseismic noise spectra. In the end, we are interested whether the process of the earthquake nucleation changes the spectrum of microseismic noise recorded at a station near the epicenter in the detectable way. Preliminary results are promising.

Spectra of the microseismic noise were calculated for samples recorded at seismological station Banja Luka for a period of 10 days before and 10 days after an earthquake M=4.5.

Station Banja Luka was chosen because on April 28, 2011 (23:30:44.0 UTC, source: CSEM-EMSC) occurred earthquake with epicenter 10 km from the station. Data for the station Banja Luka were downloaded from ORFEUS web site (*www.**orfeus**-eu.org).*

Mean spectra were analyzed using image moment method. Image moments are numerical descriptors invariant to translation, rotation, change of scale and some types of image distortion and their analysis is one of the most often used methods in image processing and pattern recognition. There are many types of moments with different descriptive capability, noise sensitivity and numerical complexity. In this work Zernike moments were used because their great noise robustness. The results are in the form of Euclidean distances between each spectrum and the referent spectrum in the space of image moments.

Geomagnetism in Croatia

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Introduction to the Earth's magnetic field and its description is presented. The short historical overview of geomagnetism in Croatia is given. Furthermore, the recent measurements and modeled values of the Earth's magnetic field vector and its changes on the Croatian territory, together with anomalous field are shown. Good and quality geomagnetic data are essential in global or local modeling, navigation and other applied purposes. These data are provided by geomagnetic observatories, extensive surveys made on land, at sea, and from aircrafts and satellites. From all these observations only the geomagnetic observatories can ensure quality long-term measurements of the geomagnetic field and its variations. The first geomagnetic observatory in Croatia, located in the area of the National Park of Lonjsko Polje is going to start with preliminary measurements in the near future.