

# KRATKI SAŽETCI



Meteorološki  
izazovi

4

Klimatske promjene -  
odgovornosti današnje  
generacije

24.-25. studenog 2015.

KRAŠ Auditorium, Ravnice 48, Zagreb



DHMZ



Suorganizatori

HRVATSKA KONTROLA  
ZRAČNE PLOVIDBE



GFZ

**Cilj** skupa je, osim razmjene znanja među meteorolozima, ukazati na važnost meteorologije u mnogim djelatnostima te ojačati komunikaciju između meteorologa i drugih stručnjaka koji se koriste meteorološkim podacima. **Očekivani rezultati** su uža interdisciplinarna suradnja meteorologa s korisnicima iz svih područja društvenih i gospodarskih djelatnosti koje ovise o vremenu i klimi te razvijanje svjesnosti o potrebi pravovremene prilagodbe na klimatske promjene. Nakon završetka ovogodišnjeg skupa očekujemo da će i javnost bolje razumjeti važnost i značenje atmosferskih procesa i pojava te njihovu isprepletenost sa svim ljudskim aktivnostima.

**Pozvani predavači** su Vanda Grubišić (NCAR), Erika Coppola (ICTP), Ivana Stiperski (Sveučilište u Innsbrucku), Elisabeth Koch (ZAMG), Milan Kilibarda (Sveučilište u Beogradu).

**Pokrovitelji** su Predsjednica Republike Hrvatske Kolinda Grabar Kitarović, gradonačelnik grada Zagreba Milan Bandić, Ministarstvo zaštite okoliša i prirode, Ministarstvo znanosti, obrazovanja i sporta i Ministarstvo gospodarstva.



**PREDAVANJA  
PRESENTATIONS**



**SIMULATION OF PRECIPITATION FROM THE EURO-CORDEX  
ENSEMBLE OF REGIONAL CLIMATE MODELS**

LIDIJA SRNEC, IVAN GÜTTLER and ČEDO BRANKOVIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*lidija.srnec@cirus.dhz.hr*

**ABSTRACT**

EURO-CORDEX is an international project that provides downscaled simulations of historical climate and future climate scenarios over identical European domain and at the same regional climate models' (RCMs) resolutions.

In this study, an analysis of the present climate precipitation from a six-member ensemble is presented. All RCMs considered (CLMcom-CCLM, DMIHIRHAM5, ICTP-RegCM4, IPSL-INNERIS-WRF, KNMI-RACMO2 and SMHI-RCA4) were forced with ERA-Interim data over the period 1989–2008. All the models were integrated at the two horizontal resolutions: 50 km and 12.5 km. We examine the skill of RCMs in simulating precipitation and its sensitivity to horizontal resolution in terms of mean seasonal precipitation and interannual variability. In addition, a decomposition of seasonal precipitation into the wet-day frequency and wet-day precipitation is performed for each member of the ensemble. The RCMs are validated against the E-OBS gridded observational data available at the 0.25 deg regular grid.

# KLIMATSKE PROMJENE U JADRANU: STATUS I PERSPEKTIVE

IVICA VILIBIĆ, JADRANKA ŠEPIĆ i NATALIJA DUNIĆ

Institut za oceanografiju i ribarstvo  
Šetalište I. Meštrovića 63, 21000 Split, Hrvatska  
*vilibic@izor.hr*

## SAŽETAK

Iako dugoročni nizovi oceanografskih podataka nemaju pokrivenost, duljinu i kvalitetu kao meteorološki nizovi podataka, mjerenja i opažanja oceanografskih svojstava nepobitno ukazuju na promjene fizikalnih odrednica i ekosustava koje se događaju u posljednjih stotinjak godina. Promjene i vrlo vjerojatni utjecaj čovjeka manifestiraju se kroz porast razine mora, temperature, kiselosti, itd., što ugrožava opstojnost dijela živog svijeta u moru neotpornog na takve promjene.

Na temelju 60-godišnjih mjerenja u Jadranu zabilježen je trend porasta površinske temperature mora od 1–2 °C u 100 godina i saliniteta od 0.2–0.4 ppt na 100 godina, dok je razina mora porasla za oko 20 cm. Uz to, primijećeno je slabljenje termohaline cirkulacije, što zbog smanjenja udjela otopljenog kisika može imati izuzetne posljedice na živi svijet dubljih slojeva Jadrana. Ovaj fenomen je opažen kako u Jadranu tako i u svjetskim morima, gdje je posljedica smanjenja primarne produkcije odnosno fotosintetičkih procesa u moru. Predavanje će također uključiti i analizu produkata postojećih regionalnih oceanskih klimatskih modela, odnosno njihov kapacitet reproduciranja pojedinih opaženih procesa i svojstava Jadrana, uz diskusiju mogućih poboljšanja istih modela. Naposljetku, analizirat će se moguće posljedice klimatskih promjena na Jadran i područje uz Jadran, kao i predložiti mjere ublažavanja posljedica klimatskih promjena, ukoliko uopće postoje mogućnosti za iste.

# KLIMATSKE PROMJENE I EKOSUSTAV JADRANSKOG MORA

BRANKA GRBEC i GORDANA BEG PAKLAR

Institut za oceanografiju i ribarstvo  
Šetalište I. Meštrovića 63, 21000 Split, Hrvatska  
*grbec@izor.hr*

## SAŽETAK

U posljednjih nekoliko desetljeća brojna znanstvena istraživanja pokazala su povezanost klimatskih promjena i ekosustava Jadranskog mora. Klimatska varijabilnost događa se na nekoliko vremenskih razina, od desetljetne, preko stoljetne do tisućljetne (paleoklimatske) skale. Važnost višedesetljetne skale u ekologiji mora prepoznata je u posljednjih tridesetak godina, kada su kroz analizu dostupnih višedesetljetnih vremenskih serija in situ sakupljenih oceanografskih i bioloških podataka postali prepoznatljivi statistički pokazatelji ovih promjena. Jadran je prepoznat kao more vrlo osjetljivo na klimatske promjene (Zore-Armanda, 1991). Njegova dva moguća stanja, period jačeg ulaska sredozemne vode u intermedijalnom sloju (ingresijska razdoblja) i periodi slabog ulaska (ne-ingresijska razdoblja) tzv. bimodalna cirkulacija (Civitarese et al., 2010) povezana su s atmosferskim procesima na prostornoj skali većoj od Jadrana. Utjecaj promjenjive klime uočljiv je u cijelom vodenom stupcu Jadranskog mora, posebno na promjenama temperature, saliniteta i kisika. Osim toga, dosadašnja istraživanja Jadranskog mora pokazala su da dotok sredozemne vode u Jadran direktno i indirektno povećava produktivnost u njegovim vodama (Pucher-Petković et al. 1971; Marasović et al., 1999), ali utječe i na druge karike ekosustava (Grbec, et al., 2015). U ekosustavu pelagijala Jadranskog mora primijećene su velike fluktuacije u biomasi morskih organizama (od fitoplanktona do plave ribe). Izdvojena su signifikantno različita stanja ekosustava Jadrana prije i poslije kasnih osamdesetih godina prošlog stoljeća. Uzrok ovim različitim stanjima ekosustava dijelom se može povezati s modificiranom termohalinom cirkulacijom Jadrana koja je sprječavala ulazak toplije i slanije vode u Jadransko more, uzrokujući na taj način uočene promjene u ekosustavu.

# KLIMATSKE PROMJENE I PROMJENE REŽIMA OBORINA U BOSNI I HERCEGOVINI

ŽELJKO MAJSTOROVIĆ

Udruženje meteorologa u Bosni i Hercegovini  
Višnjik 8, 71000 Sarajevo, Bosna i Hercegovina  
*z.majstor.majstor@gmail.com*

## SAŽETAK

Istraživanja o utjecaju klimatskih promjena provedena od strane FHMIBIH u posljednjih petnaestak godina pokazuju da je prosječno povećanje srednje godišnje temperature za 100 godina oko 0,8 °C, dok sume oborine za isto razdoblje pokazuju stagnaciju ili minimalne promjene ( $\pm 5\%$ ). Međutim, režim oborine se mijenja čime njezini učinci pokazuju loše bilance. S jedne strane imamo povećan intenzitet oborine, odnosno veće količine oborine u kratkom vremenskom razdoblju, a s druge strane sve duža sušna razdoblja između njih. Ova slika je još nepovoljnija kada uzmemo u obzir da su navedene krajnosti veće u ljetnom razdoblju odnosno tijekom vegetacije. Povećanje srednje temperature uzrokuje povećano isparavanje što umanjuje efekte oborine, a povećava efekte suše. To je pokazano putem indeksa suše P/PET (količina oborine/potencijalna evapotranspiracija). Ovo ima mnogobrojne utjecaje na različite oblasti života i ekonomiju u BiH, prije svega na poljoprivredu, vodoprivredu, elektroprivredu, te povećava rizik od poplava s jedne strane i šumskih požara ili požara uopće s druge strane.

U svrhu pripreme ove studije analizirali smo trendove temperature zraka, količine oborine i manjak oborine tijekom vegetacije. Te promjene su prikazane u usporedivoj analizi dugoročnih nizova dva razdoblja: 1961.–1990. i 2000.–2012. Usporedba tih razdoblja daje nam jasnu sliku o povećanju deficita oborine i vegetacije u cjelini.



# UTJECAJ VLAŽNOSTI TLA I VEGETACIJSKOG POKROVA NA NUMERIČKE SIMULACIJE POVRŠINSKE TEMPERATURE, OBORINE I EVAPORACIJE NA PODRUČJU EUROPE

IRENA RUŽIĆ i IVANA HERCEG BULIĆ

*ire.ruzic@gmail.com*

## SAŽETAK

U ovom radu ispitan je utjecaj vegetacijskog pokrova i vlažnosti tla na klimatske simulacije na području Europe. U tu je svrhu korišten model opće cirkulacije atmosfere – ICTP AGCM. Napravljene su tri ciljane simulacije za vremensko razdoblje 1981.–2010. godina: kontrolni eksperiment u kojem je simulirano međudjelovanje tla i atmosfere jednostavnim modelom interakcije tla i atmosfere (eng. land-surface model), zatim eksperiment u kojem je atmosferski model združen s modelom vlažnosti tla (eng. land-surface temperature and soil moisture coupling) te eksperiment modelom vlažnosti tla i s interaktivnom vegetacijom (eng. interactive vegetation coupling). Ispitan je utjecaj modela vlage u tlu i dinamičke vegetacije na amplitudu i međugodišnju promjenjivost površinske temperature zraka, oborine i evaporacije za zimsku i ljetnu sezonu. U usporedbi s kontrolnim eksperimentom, model združen s modelom vlage u tlu simulira povećanje temperature iznad kontinentalnog dijela Europe tijekom obje promatrane sezone. Međutim, modelom s interaktivnom vegetacijom se povećanje temperature simulira samo tijekom ljeta, dok je zimi dobiveno njeno smanjenje. Općenito, model dinamičke vegetacije smanjuje ukupnu oborinu, a područja s najizraženijim smanjenjem se podudaraju s područjima reducirane evaporacije.

Rezultati prikazani u ovom radu ukazuju da model vlage u tlu i model interaktivne vegetacije značajno utječu na amplitude simulirane temperature zraka, oborine i evaporacije. Suprotno tome, nije dobiven značajan utjecaj na međugodišnju varijabilnost promatranih parametara.

# KLIMA KAO ČIMBENIK RAZGRANIČENJA I DINAMIKE ŠUMSKIH EKOSUSTAVA U HRVATSKOJ

IVAN PILAŠ, JASNA MEDAK, IVAN MEDVED i DAMIR MEDAK

Hrvatski šumarski institut  
Cvjetno naselje 41, 10450 Jastrebarsko, Hrvatska  
*ivanp@sumins.hr*

## SAŽETAK

Jedna od najvrijednijih značajki šumskog pokrova u Hrvatskoj je izrazita heterogenost vegetacije odnosno bogatstvo biljnih vrsta na relativno malom području rasprostiranja. Hrvatska, s 11 šumskih tipova (od ukupno 13 na prostoru EU), prema europskoj klasifikaciji šuma, zauzima visoko drugo mjesto, neposredno iza Francuske (12). Dosadašnja istraživanja šumskih ekosustava u Hrvatskoj pokazala su kako se šumski tipovi u prostoru pojavljuju prema utvrđenim zakonitostima u obliku pedo-vegetacijskog slijeda odnosno specifične kombinacije tla i flornog sastava koji čine šumski ekosustav. Utjecaj klime na ekosustave je višeznačan; klima uz geološku podlogu, reljef, organizme i vrijeme spada u glavne činitelje tvorbe tla odnosno pedogeneze. S druge strane, klimatske prilike na nekom području određuju pojavu vegetacije odnosno klimatogenih šumskih zajednica posebno adaptiranih na prevladavajuće klimatske uvjete. Izrazita vertikalna i horizontalna zonalnost klimatskih prilika na prostoru Hrvatske uvjetovala je diferencijaciju 11 klimatsko-vegetacijskih tipova odnosno bioklimata u rasponu od kserotermnih šuma sladuna i cera, klekovine bora u hladnom visinskom pojasu na granici šumske vegetacije do hrasta crnike i alepskog bora u vrućem eumediteranu. Zbog djelovanja ostalih činitelja (matični supstrat, reljef itd.) daljnjom razdiobom bioklimata, određeno je ukupno 66 šumskih tipova na cijelom prostoru Hrvatske koji su istraživani u višegodišnjim tipološkim istraživanjima šuma na Šumarskom institutu u Jastrebarskom te Šumarskom fakultetu u Zagrebu. Tipološka klasifikacija šumskih ekosustava u Hrvatskoj, danas ima svoju primjenu kako u šumskom gospodarstvu, zaštiti prirode i okoliša, tako i u daljnjim znanstveno – istraživačkim aktivnostima te izazovima koje pred nas postavljaju očekivan trend klimatskih promjena gdje poznavanje prilika u šumskim ekosustavima predstavlja dobru osnovu za praćenje i prognozu stanja promjena u tlu i vegetaciji.

Cilj ovog rada je prikazati razvoj tipološke klasifikacije šumske vegetacije u Hrvatskoj te mogućnosti njene daljnje primjene u istraživanjima utjecaja klimatskih promjena na funkcije šumskih ekosustava (produktivnost, bioraznolikost, zaštita voda...). U radu će biti prikazani dosadašnji rezultati istraživanja na multidisciplinarnom projektu AFORENSA (Advanced FORest ENvironmental Services Assessment), prihvaćenog od Hrvatske zaklade za znanost, na kojem sudjeluju Hrvatski šumarski institut i Geodetski fakultet u Zagrebu sa širom grupom suradnika.

## **BURA, ČIMBENIK NA KOJI TREBA RAČUNATI (I) U ZAŠTITI PRIRODE**

KORALJKA VAHTAR-JURKOVIĆ, MARKO RANDIĆ i SONJA ŠIŠIĆ

Primorsko-goranska županija  
Adamićeva 10, 51000 Rijeka, Hrvatska  
*koraljka.vahtar-jurkovic@pgz.hr*

### **SAŽETAK**

Tijekom pleistocena snažni vjetrovi, osobito bura, koji su puhali s rubova ledenih polja i ledenjaka na Dinarskim planinama, vjerojatno su bili snažan čimbenik u oblikovanju ondašnje vegetacije u predjelima oko današnjeg Riječkog i Kvarnerskog zaljeva. To možemo naslutiti prema rasporedu recentne reliktna vegetacije koja je sastavljena od krških, planinskih i endemičnih vrsta odlično prilagođenih puhanju snažne bure. Takva vegetacija raširena je od vrhova Dinarskih planina u zaleđu Kvarnerskog zaljeva (Učka, Obruč, Snježnik, Risnjak, Burni Bitoraj, Viševica, Velebit), ali se spušta i niže, sve do mora, osobito na padinama kanjona i bujičnih jaruga, gdje je izražen osobit vegetacijski fenomen zbog tzv. „kanjonskog“ efekta. Lijepi primjeri su kanjon Rječine, dolina potoka Martinščice, Mala draga i Žrnovnica nedaleko Novog Vinodolskog, Senjska draga, Paklenica i brojne druge bujične drage i kanjoni na primorskim padinama Velebita – gdje bura ubrzava svoj tok postižući najveću snagu puhanja. U biogeografskom pogledu nije zanemariva ni činjenica da preostataka takve vegetacije na buri izloženim staništima – „burnjacima“ ima i na našim kvarnerskim otocima, osobito otocima Krku, Prviću, Cresu, Rabu i Pagu. Reliktna vegetacija na spomenutim otocima mogući je dokaz pretpostavci da je tijekom pleistocenskih klimatskih oscilacija vegetacija „burnjaka“ mijenjala svoje prostorno-visinsko raširenje (areale) i do danas se, vjerojatno, kao posljednji „ostatak ostataka“, zadržala (i) na kvarnerskim otocima u obliku izoliranih „otočića“ okružena uglavnom drukčijom, submediteranskom vegetacijom. Navedene činjenice i pretpostavke vrijedi uzeti u obzir prilikom napora u zaštiti prirode, ne samo zbog evidentnih klimatskih promjena te izraženih procesa zarastanja (sukcesije) vegetacije na „burnjacima“, već i zbog novih trendova u iskorištavanju energije vjetra i sunca.

# UTJECAJ ONEČIŠĆENJA ZRAKA I SINOPTIČKOG STRUJANJA NA ČESTINU MAGLE U ZAGREBU

NIKOLINA LEKO i IVANA HERCEG BULIĆ

*lekonikolina@gmail.com*

## SAŽETAK

Magla je važan faktor u čovjekovoj svakodnevici, a zbog kompleksnosti elemenata koji djeluju na njezino stvaranje teško ju je prognozirati. U ovom radu naglasak je na analizi djelovanja izravnih (meteoroloških) i neizravnih (onečišćenost zraka) utjecaja na broj dana s maglom u Zagrebu i njegovoj široj okolici. Analiza koncentracije sumpor dioksida, dima i ukupnih lebdećih čestica te broja dana s maglom provedena je za razdoblje 1971.–2003. godine za postaje Grič, Maksimir i Pleso. Podaci o promatranim meteorološkim varijablama preuzeti su iz ERA-40 reanaliza. Analiza meteoroloških podataka povezana je s razdiobom osnovnih polutanata i utvrđene su osnovne veze koje između njih postoje.

U prvom dijelu prezentacije je ispitana vremenska promjena broja dana s maglom na temelju podataka s 3 meteorološke postaje i analizirana je povezanost koncentracija sumpor dioksida, dima i ukupnih lebdećih čestica s tom promjenom. U drugom dijelu ispitan je utjecaj cirkulacije sinoptičke skale na broj dana s maglom na postaji Maksimir koja predstavlja grad Zagreb. Za odabrane godine koje su pretpostavljene kao reprezentativne (odabrano je prosječno 5 godina s maksimalnim i 5 godina s minimalnim brojem dana s maglom) ispitani su utjecaji: tlaka zraka, horizontalnog vjetra i visine graničnog sloja. Dobiveni rezultati pokazuju negativni trend broja dana s maglom i koncentracija promatranih polutanata tijekom promatranog razdoblja s najznačajnijim utjecajem u zimskoj sezoni. Također, cirkulacija sinoptičke skale ima značajan utjecaj na broj dana s maglom na način da niži granični sloj i slab vjetar, odnosno tišina uz viši tlak zraka pogoduju formiranju magle, što je najčešće karakteristika zimskog razdoblja.

**WorldDailyMeteo: GLOBAL SPATIO-TEMPORAL INTERPOLATION OF  
DAILY METEOROLOGICAL VARIABLES AT 1 KM RESOLUTION**

MILAN KILIBARDA

University of Belgrade, Faculty of Civil Engineering  
Department of Geodesy and Geoinformatics  
Bulevar kralja Aleksandra 73, 11000 Belgrade, Serbia  
*kili@grf.bg.ac.rs*

**ABSTRACT**

Global spatio-temporal variograms and regression models described by Kilibarda et al. (2014, 2015) are stored in the *meteo R* package for the purpose of automated mapping of daily temperatures at 1 km/ 1 day resolution.

This article describes the R package *meteo*. The package provides functionalities for the automated mapping of meteorological observations using spatio-temporal regression kriging. Automated spatio-temporal kriging interpolation procedure represents data driven approach designed for mapping with little or no human interaction. Currently, automated mapping with the *meteo* package can be decomposed in chunks:

1. defining input observations and covariates;
2. use of pre-calculated global models;
3. detecting and/or removing outliers;
4. creation of final prediction (and its export to GIS formats);
5. cartographic visualisation of results and/or creation of web maps (e.g. by using R package *plotGoogleMaps* (Kilibarda and Bajat, 2012) for automatic creation of interactive web maps).

In addition, *meteo* offers the possibility of using user defined covariates, regressions and variograms; thereby giving more flexibility of using the package in a semi-automated approach.

Presented mapping framework enables the use of spatio-temporal regression kriging for meteorological mapping. The implementation of the fast searching algorithm provides the advantage in computing large spatio-temporal grids. The advantage is especially noticeable in case of the grids containing longer time series (e.g. predictions made for the area of interpolation over a year period where each location contains around 365 observations).

The objective of WorldDailyMeteo project is to produce a time-series of predictions of climatic elements using package *meteo* for global spatio-temporal statistics (spatio-temporal regression-kriging). For each *meteo* variable global space-time model (regression + variogram parameters) should be fitted and then used for predicting values at daily interval and at resolution of 1/120 arcdegrees (or about 1 km).

# NEAR-SURFACE WIND CLIMATOLOGY OVER ADRIATIC AND PANNONIAN REGIONS IN AN ENSEMBLE OF RCM SIMULATIONS

ANDREINA BELUŠIĆ, IVAN GÜTTLER and MAJA TELIŠMAN PRTENJAK

Department of Geophysics, Faculty of Science, University of Zagreb  
Horvatovac 95, 10000 Zagreb, Croatia  
*andreina.belusic@gfz.hr*

## ABSTRACT

This study explores observed and simulated near-surface (i.e. 10 m) wind over the eastern Adriatic and Pannonian regions. The eastern Adriatic coast is represented by the complex coastline, steep topographic gradients and particular wind regime. The Dinaric Alps separate narrow coastal region from the inland, extending from northeast to southwest. The most famous typical winds along the Adriatic coast are *bura* (usually blowing in the direction perpendicular to the mountain and experiencing a strong influence of the terrain) and sirocco (usually parallel to the coastline and mostly during the wintertime) and sea/land breezes (dominantly in the warm part of the year) as a part of the regional Mediterranean wind system. In contrast, the Danube river splits Pannonian Basin into two parts bordered by the Alps in the northwest, the Dinaric Alps in the southwest and by the Carpathians in northeastern direction. South of the Danube, which includes the Croatian part of the Pannonian Plain, sporadic mountains have "insular" character with altitudes up to 1000 m above sea level contributing to the area complexity.

These particular areas represent a significant challenge for the evaluation of the modelled wind flow and pattern simulated by the latest generation of the regional climate models (RCMs). Surface station observation data from 1996–2008 period have been used due to the length of available observed time series and compared against the daily output obtained from a suite of six RCM simulations from the EURO-CORDEX initiative (CLMcom-CCLM4-8-17, DMI-HIRHAM5, IPSL-INERIS-WRF331F, KNMI-RACMO22E, SMHI-RCA4, DHMZ-RegCM4). All simulations are forced by the ECMWF ERA-Interim reanalysis.

Several methodological aspects related to the interpolation techniques when comparing RCMs and observations (or RCMs at two different resolutions) are examined. The evaluation reveals strong sensitivity of the simulated wind flow and wind pattern to the RCM horizontal resolution (12.5 km vs. 50 km). Additionally, different (non)dimensional skill measures discussed (e.g. bias, Brier skill score, Perkins skill score) depend on both seasons and locations analysed in this study. Moreover, RCMs are explored in terms of skill in reproducing specific wind regimes (e.g. *bura*) where large spread in the RCM ensemble is found.

# KLIMATOLOGIJA MAGLE NA MEĐUNARODNOJ ZRAČNOJ LUCI ZAGREB (MZZL)

MARKO ZOLDOŠ

Hrvatska kontrola zračne plovidbe d.o.o.  
Rudolfa Fizira 2, Velika Gorica, 10150 Zagreb-Zračna luka, Hrvatska  
*marko.zoldos@crocontrol.hr*

## SAŽETAK

Pojava magle predstavlja značajan problem u prometu, što je zbog sigurnosnih razloga posebno izraženo u zračnom prometu. Dugotrajne pojave magle na zračnim lukama mogu uzrokovati značajna kašnjenja letova te velike materijalne troškove, pa je kvalitetna prognoza magle uz dobru klimatološku podlogu od velikog značaja za zrakoplovnu industriju u cjelini.

U ovom radu je izvedena preliminarna studija pojave magle na Međunarodnoj zračnoj luci Zagreb (MZZL) korištenjem tzv. "event-based" i statističkog pristupa. Iz neprekinutog 21-godišnjeg niza podataka (1993.–2014.) izdvojeni su svi događaji magle i klasificirani u 5 tipova prema fizikalnim procesima formiranja. Za identifikaciju događaja magle korištena je modificirana "event-based" metoda koju su razvili Tardif i Rasmussen 2007.

Ukupno je izdvojeno preko 1000 događaja magle u vremenskom periodu 1993.–2014. Najveći udio događaja magle (69 %) otpada na radijacijsku maglu, dok ostala četiri tipa (advekcijaska, evaporacijska, magla spuštanja oblačne baze, oborinska) zauzimaju manji udio. 8 % događaja nije uspješno klasificirano niti u jedan navedeni tip. Događaji su razvrstani prema frekvenciji, trajanju i intenzitetu, a osim toga proučena je i veza između navedenih karakteristika magle i ostalih meteoroloških parametara kao što su vjetar, temperatura zraka itd.

# **ECO OSCILACIJA POVRŠINSKE TEMPERATURE, UKUPNE VLAGE U TLU, VLAGE U PRVIH 10 CM TLA, UKUPNE OBORINE I EVAPOTRANSPIRACIJE TE NJIHOVA MEĐUSOBNA POVEZANOST**

PETRA SVILIČIĆ i IVANA HERCEG BULIĆ

Državni hidrometeorološki zavod  
Grič 3, 10000 Zagreb, Hrvatska  
*svilicic@cirus.dhz.hr*

## **SAŽETAK**

U ovome radu istraživani su obrasci promjene signala ECO oscilacije (European Climate-Change Oscillation) površinske temperature, ukupne vlage u tlu, vlage u prvih 10 cm tla, ukupne oborine i evapotranspiracije u odnosu na buduću klimu. Analize signala ECO oscilacije napravljene su na temelju podataka dobivenih numeričkim simuliranjem regionalnim klimatskim modelom RegCM3 prema A1B klimatskom scenariju u razdoblju od 1951. do 2100. godine. Promatrana su dva buduća razdoblja, 2011.–2040. i 2061.–2090., koja se uspoređuju s kontrolnom klimom 20. stoljeća. Mjesečne vrijednosti zonalno usrednjenih promjena definirane su kao razlika zonalno usrednjenih polja buduće i kontrolne klime svakog pojedinog parametra. Međugodišnja varijabilnost ispitana je pomoću razlika standardnih devijacija. Statistička signifikantnost promjena polja srednjaka utvrđena je provedbom *t*-testa, dok je moguća međusobna povezanost parametara ispitana prostornim korelacijama. U gotovo svim promatranim parametrima uočeni su signali ECO oscilacije s pripadnim dipolarnim karakterom, koji pokazuje većinom smanjenje nad južnim dijelovima domene te povećanje nad sjevernim dijelovima. Gotovo sve promjene su statistički signifikantne na nivou značajnosti 5 %. Prepoznati su pozitivni odzivi ECO oscilacija nad južnim dijelom domene, posebice Sredozemljem, u proljetnim i ljetnim mjesecima, koji prema literaturi podržavaju nastanak toplinskih valova. Premještanje ovog signala pogoduje prodiranju toplinskog vala prema sjevernim krajevima, što je posebno izraženo u drugom razdoblju. Također, stvaraju se uvjeti za ekstremne suše pa time i povećane učestalosti pojave požara. Kako se oblik oscilacije prema kraju stoljeća ne mijenja značajno, no njen intenzitet se vremenom pojačava u budućem razdoblju, valjalo bi istražiti njeno ponašanje obzirom na druge postojeće scenarije.



# USKLAĐENOST DINAMIKE POPULACIJE ŠUMSKOG ŠTETNIKA GUBARA (*LYMANTRIA DISPAR*) I KLIMATSKIH ANOMALIJA U HRVATSKOJ

IVAN PILAŠ i MILAN PERNEK

Hrvatski šumarski institut  
Cvjetno naselje 41, 10450 Jastrebarsko, Hrvatska  
*ivanp@sumins.hr*

## SAŽETAK

Gubar (*Lymantria dispar* L.) je polifagni leptir čije su gusjenice u vrijeme masovne pojave sposobne obrstiti krošnje stabala na vrlo velikim površinama te spada u jedan od najznačajnijih biotskih uzročnika propadanja šuma hrasta lužnjaka. Veće gradacije bilježe se u razdobljima 1948.–1950., 1962.–1966., 1970.–1975., 1982.–1984., 1992.–1994. te u proteklom desetljeću u 2004.–2006. i 2013.–2014. godine. Praćenje brojnosti populacije gubara u Hrvatskoj provodi se kao jedna od mjera unutar Izvještajno-prognoznih poslova, sukladno Zakonu o biljnom zdravlju, u Hrvatskom šumarskom institutu od 1970. godine. Prikupljeni vremenski nizovi omogućili su analizu i usporedbu dinamike populacije gubara i klimatskih anomalija kao što su sušne i vlažne epizode.

U radu su prikazani rezultati analize periodiciteta pojave gradacije gubara kao i osnovnih meteoroloških pokazatelja, srednjih godišnjih temperatura i godišnjih količina oborine te sušnih perioda utvrđenih jednostavnim obračunom bilance vode. Analiza je napravljena pomoću metode spektralne analize (FFT). Rezultati su pokazali značajan periodicitet pojave gubara od 10.6 godina te identičan ali nešto manje značajan periodicitet pojave sušnih perioda. Također je utvrđeno da je početak gradacije populacije vezan uz pojavu značajno većih temperatura tijekom zimskog razdoblja (prosinac) dok je pad populacije vezan uz pojavu prekomjerno velikih količina oborine u proljeće (ožujak).

Na osnovu iznesenog, nameće se pitanje o značaju ekoindikatorske uloge dinamike populacije gubara kod predviđanja ekstremno kišnih razdoblja (kao u 2014. godini) koje je nastupilo nakon maksimuma gradacije u prethodnoj godini.

# THE PERFORMANCE OF THE RegCM4 ENSEMBLE IN SIMULATING HISTORICAL CLIMATE

IVAN GÜTTLER, LIDIJA SRNEC and ČEDO BRANKOVIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*ivan.guettler@cirus.dhz.hr*

## ABSTRACT

An ensemble of regional climate model (RegCM4) simulations applied over the EURO-CORDEX domain is used to estimate model performance for historical climate. Earlier experiments at the 12.5 km and 50 km, when RegCM4 was forced by ERA-Interim, showed strong sensitivity of simulated near-surface temperature, total cloud cover and total precipitation to horizontal resolution.

In this study, we assess an enlarged set of experiments when RegCM4 was forced by global climate models (GCMs) HadGEM2-ES, EC-EARTH, MPI-ESM-LR and CNRM-CM5 for the period 1970–2005 at the 50-km resolution and for the period 1970–1974 at the 12.5-km resolution. Model performance is evaluated against the E-OBS gridded temperature, precipitation and the mean sea-level pressure data and also compared with the results from forcing GCMs. In order to estimate potential impact of reduced time step on the RegCM 12.5-km simulations, an additional set of 50-km simulations is performed with the same time step as in the 12.5-km simulations. We explore how the RegCM4 time stepping relates to overestimation of the total cloud cover when large time step is used in model integrations.

**VREMENSKA ANALIZA ZA VRIJEME VELIKOG ŠUMSKOG POŽARA  
NA STRAHINJČICI U OŽUJKU 2012.**

DIANA KURAŽI, VIŠNJICA VUČETIĆ i ANTUN MARKI

Državni hidrometeorološki zavod  
Grič 3, 10000 Zagreb, Hrvatska  
*kurazidiana@gmail.com*

**SAŽETAK**

Po prvi puta je analizirana vremenska situacija tijekom velikog šumskog požara u kontinentalnom dijelu Hrvatske. U požaru od 22. do 27. 3. 2012. na gori Strahinjčica, smještenoj sjeveroistočno od Krapine, spaljeno je oko 350 ha i smatra se najvećim požarom na području Krapinsko-zagorske županije. Analizirano je koji vremenski uvjeti u unutrašnjosti Hrvatske utječu na nastanak i razvoj šumskog požara, te jesu li slični uvjetima na jadranskom području. Specifičnost ovog požara je i u tome što je izbio puno prije početka požarne sezone. Pokazano je kako je najpovoljnija vremenska situacija za nastanak i širenje šumskog požara nastupila pretposljednog dana kada je požar već bio praktički ugašen. Time se zaključuje da je ljudski nemar započeo požar tj. zbog paljenja korova u proljeće, no mudrost i spretnost vatrogasaca spriječila je još veću katastrofu.

# OPAŽENE PROMJENE FENOLOŠKIH FAZA MASLINE DUŽ JADRANA

DANIJELA JELOVIĆ, VIŠNJICA VUČETIĆ i ĐANI BENČIĆ

Student Fakulteta agronomije Sveučilišta u Zagrebu, Hrvatska

*gdica.jelovic@gmail.com*

## SAŽETAK

Vremenske prilike posljednjih godina sve manje prate poznate godišnje i sezonske hodove i sve je više ekstremnih vremenskih događaja koji ugrožavaju poljoprivrednu proizvodnju. Istraživanja u Hrvatskoj pokazuju da je jadranska obala s otocima najosjetljivija s obzirom na globalno zatopljenje i klimatske promjene. Kako biljni svijet prvi reagira na vremenske i klimatske promjene u prirodi, praćenje i proučavanje razvojnih faza biljaka, čime se bavi fenologija, su dobar pokazatelj klimatskih promjena. Za jadransko područje posebno je gospodarski važna maslina i proizvodnja njezinog ulja. Koliko ona obilježava naše priobalje najbolje pokazuje činjenica da se mediteranska klima, koja prevladava na tom području, naziva i klima masline.

Zbog svega navedenog cilj ovoga rada je utvrditi postoje li promjene u nastupu fenoloških faza masline duž jadranske obale i otoka. Analizirano je sedam fenoloških postaja (Rab, Hvar, Vela Luka, Lastovo, Mljet i Trsteno) koje raspolazu s dugogodišnjim nizovima podataka u razdoblju 1961.–2014. Kod masline se opaža pet fenofaza: početak, puno i završetak cvjetanja, te početak zrenja plodova i berba. Početak cvjetanja najčešće je krajem svibnja, a samo cvjetanje traje u prosjeku oko 3 tjedna. Zrenje plodova najčešće počinje u drugoj polovici listopada. Međutim, od godine do godine ti pomaci mogu biti i do tjedan dana prije ili poslije. Analize linearnih trendova fenofaza masline duž jadranske obale i otoka posljednje 54 godine pokazale su statistički značajan raniji početak njihova cvjetanja kao posljedicu povećanja proljetnih vrijednosti temperature zraka posljednjih 100 godina. Raniji početak i puno cvjetanje masline jest 2–4 dana/10 godina ovisno o lokaciji. Na postaji Hvar je opaženo i ranije dozrijevanje njezinih plodova za 3 dana/10 godina što nije opaženo na ostalim postajama. Međutim, ranija berba maslina 2–4 dana/10 godina nije samo posljedica utjecaja vremenskih prilika već ovisi i o raspoloživim postrojenjima za preradu maslinova ulja, količini uroda koji se može u danom trenutku preraditi, te o potražnji tržišta za određenom kakvoćom ulja. Utvrđeni raniji početak razvojnih faza masline od nekoliko dana u deset godina na prvi pogled ne izgleda puno. No, ako se uzme da bi u budućnosti do kraja 21. st. masline cvale i dozrijevale prije i do mjesec dana, onda to pokazuje velik poremećaj u vegetacijskom ciklusu.

# UTJECAJ VREMENSKIH PRILIKA U EKSTREMNIM GODINAMA NA SASTAV FENOLA U SORTNIM EKSTRA DJEVIČANSKIM MASLINOVIM ULJIMA

DANI BENČIĆ i CVIJETA JAKOBUŠIĆ BRALA

Agronomski fakultet, Sveučilište u Zagrebu  
Svetošimunska cesta 25, 10000 Zagreb, Hrvatska  
*Bencic@agr.hr*

## SAŽETAK

Rezultati iz već objavljenih radova istraživanja sastava fenola u sortnim maslinovim uljima dobivenim iz dvije vremenski bitno različite godine uzgoja, pokazuju variranje sastava ukupnih fenola za do šest puta višim koncentracijama u uzorcima ulja dobivenih u godini ekstremne suše u odnosu na uzorke ulja dobivene iz plodova istih stabala u godini ekstremne vlažnosti. Nadalje rezultati fenolnog profila, koji uključuje sadržaj 12 fenolnih spojeva, u ove dvije vremenski različite godine, pokazuju da postoji značajna razlika u sadržaju jednostavnih fenolnih spojeva između te dvije godine, s time da su neki od ovih spojeva, kao što je hidroksitirozol bili prisutni u većim koncentracijama u godini koja je imala malu količinu oborine, a drugi, kao što je tirozol u godini s velikom količinom oborine.

## **EXAMINING MULTIPLICITY OF SCALES IN MOUNTAINOUS TERRAIN**

IVANA STIPERSKI

Institute of Atmospheric and Cryospheric Sciences, University of Innsbruck  
Innrain 52, A-6020 Innsbruck, Austria

*Ivana.Stiperski@uibk.ac.at*

### **ABSTRACT**

Orography acts a significant forcing to the flow over it. As the orographic features span different scales, thus also the response in the atmosphere is found for all scales of motions, ranging down to turbulence. Thus the complexity of the atmospheric response increases with increasing terrain complexity. This complexity is also visible near the surface where it impacts the exchange processes within the boundary layer.

Motions in the boundary layer are thus disturbed by mesoscale influences unknown in flat terrain. In situations with low synoptic forcing valley/slope wind systems are the dominant mesoscale driver, while under strong synoptic forcing downslope windstorms can develop and disturb the boundary layer.

Since some of these motions are still smaller than (or comparable to) the resolution of most operational numerical models, they need to be parameterized and therefore their interaction with turbulence needs to be well understood.

Here we use a multi-year dataset from mountainous terrain to investigate different scales on which orography impacts the boundary layer characteristics. The scales of inhomogeneity are significantly dominated by the type of forcing, which in turn is strongly impacted by the orography. In particular we look at the difference between radiatively driven low-synoptic and strong-synoptic forcings on near surface response.

## RECENT CHANGES IN THE ALADIN OPERATIONAL SUITE

MARTINA TUDOR, STJEPAN IVATEK-ŠAHDAN and ANTONIO STANEŠIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*tudor@cirus.dhz.hr*

### ABSTRACT

National weather services issue weather forecasts based on the output from the numerical weather prediction models. Particular weather phenomena that have significant effect on safety can be characteristic of a certain country or region and may require specific model set-up in terms of model resolution and complexity to be forecast. However, the computational expenses of model set-up for operational purposes are limited by the available computer resources. In Meteorological and Hydrological Service (MHS) the operational numerical weather prediction uses ALADIN model.

This paper describes the changes introduced to the operational suite during the last few years. The operational suite in 8 km resolution and the dynamical downscaling of the wind field to 2 km resolution is run more often, the large scale model that provides the prognostic lateral boundary conditions has changed, operational forecast uses new model version with changes in model physics, dynamics and vertical discretization. Nonhydrostatic setup of ALADIN has been running in 2 km resolution and 4 km resolution forecast using ALADIN model has been introduced. Here we show that improvements in the model physics that are beneficial for certain weather types can deteriorate forecast quality otherwise. Although the increase in horizontal and vertical resolution improves the forecast, it partially restores the moist bias in the upper troposphere.

# VALIDATION OF MESOSCALE NEAR-SURFACE WINDS OBTAINED WITH ALADIN MESOSCALE NWP MODEL IN COMPLEX TERRAIN OF CROATIA

MARIO HRASTINSKI, KRISTIAN HORVATH, IRIS ODAK PLENKOVIĆ,  
STJEPAN IVATEK-ŠAHDAN and ALICA BAJIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*mario.hrastinski@cirus.dhz.hr*

## ABSTRACT

Mesoscale numerical models of progressively finer horizontal resolution are used to refine wind predictions in the complex terrain, where wind climate is governed by regional and local winds. As traditionally used moment-based verification measures (like RMSE, MBIAS, MAE, etc.) are not always able to show the benefits of higher resolution models, we utilized spectral analysis as a supplementary verification method to provide a scale-dependent measure of model performance. An emphasis is on understanding the sources of prediction errors through relating various aspects of physical and spectral verification measures.

The verification was performed on wind forecasts obtained by ALADIN mesoscale NWP model with 8 km horizontal grid spacing in period 2010–2012. These forecasts were further refined to 2 km grid spacing using: i) full-physics based model and ii) so-called dynamical adaptation method (DADA).

Based on variety of statistical and spectral scores, it is suggested that wind speed forecast generally improves with increasing the model horizontal resolution. The largest portion of root mean square errors (RMSE) can be attributed to phase errors at majority of stations, while the most significant increase of accuracy was found for diurnal and sub-diurnal periods of motions. Furthermore, we found a significant correlation between different sources of RMSE and spectral scores related to synoptic, diurnal and sub-diurnal motions. Finally, it was shown that nonhydrostatic and full-physics based model at 2 km horizontal resolution was valuable in forecasting wind properties at stations with significant portion of weaker, thermally driven flows.



## POST-PROCESSING WIND SPEED PREDICTIONS WITH AN ANALOG-BASED METHOD IN COMPLEX TERRAIN

IRIS ODAK PLENKOVIĆ, LUCA DELLE MONACHE, KRISTIAN HORVATH,  
MARIO HRASTINSKI and ALICA BAJIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*odak@cirus.dhz.hr*

### ABSTRACT

Analog method is based on the search for similar (i.e. analogs) past predictions across several variables to the current prediction. The measurements corresponding to the analogs form the analog ensemble (AnEn). Ensemble can be used to generate deterministic and probabilistic short or medium-range forecasts.

The AnEn was generated by Aire Limitée Adaptation dynamique Développement InterNational model (ALADIN) run over two nested domain with 8 and 2 km horizontal resolution. It was tested at several climatologically different locations across Croatia for point-based wind speed predictions at 10 m height. Results were verified and compared to Kalman filter based predictions (KF) or forecast generated via logistic regression. Results were verified and compared to ALADIN model to address the following question: which point-based post-processing method is best suited for wind forecasting in complex terrain?

This study shows that deterministic AnEn predictions, compared to model used to generate it, improve linear correlation between predictions and measurements and reduce bias and root mean square error, especially in complex terrain. The best results are achieved when forecasting mean of analog ensemble or Kalman filter of analog ensemble. Refinement of ALADIN model horizontal resolution used to generate AnEn additionally improves AnEn predictions for high wind speeds. Besides, probabilistic AnEn predictions are properly dispersive, while having better resolution, discrimination and skill than forecast generated via logistic regression. These results encourage the potential use of AnEn in an operational environment at meteorological station locations, as well as at wind farms.

## **EVALUATING THE EFFECT OF ALBORZ MOUNTAINS ON SOUTHERN COAST OF CASPIAN SEA'S RAINFALL USING RegCM4**

ABDOLHALIM BAYAT INCHEHBOROUN

University of Tehran  
Keshavarz Blvd., 37, Ghods St., Tehran, Iran  
*saeedbayat7276@gmail.com*

### **ABSTRACT**

Given the importance of mountains and their role in the distribution and density of rainfall, a study was conducted using a regional climate model (RegCM4). For investigating the effect of Alborz mountains the model was performed in Caspian region by eliminating the Alborz mountain for the years 2003 to 2005. In order to demonstrate the effect of mountains on the Caspian region's rainfall, rainfall distribution maps and diagrams were prepared for the control and simulation runs. To study the dominant mechanisms at the time of precipitation occurrence, vorticity, streamlines, cloud moisture and vertical velocity were computed in the horizontal and vertical profiles.

The results indicate that there is the uplift in the northern slope of Alborz which will increase its severity with increasing wind intensity. Also, in the southern slopes a decline in airflow is seen which weakens by increasing the intensity of the northern wind. By eliminating the Alborz mountains, there is no specific pattern and calm condition prevails over the region. Precipitation maps from the model output also show that rainfall distribution is a function of altitude, surface features and coastline. It is also found that by eliminating the roughness, precipitation is displaced to the west, east and southern parts of central Iran. The research findings emphasized that the Alborz mountains, as a mechanical factor, has an important role in reinforcement and formation of Caspian region's rainfall.

## WIND FORECAST VERIFICATION DURING VARIOUS *BURA* EVENTS AT DUBROVNIK AIRPORT

JADRAN JURKOVIĆ and IGOR KOS

Croatia Control Ltd.  
Rudolfa Fizira 2, Velika Gorica, 10150 Zagreb-Airport, Croatia  
*jadran.jurkovic@crocontrol.hr*

### ABSTRACT

Several airports are situated in the lee side of the Dinaric Alps where the *bura* flow is well-known. It reduces air traffic operations especially if its direction is perpendicular to the runway direction as is the case at Dubrovnik airport.

Terminal Aerodrome Forecast (TAF) is important in decision making during the flight planning process. The forecasts are verified compared to observed METAR reports in the period 2009–2014. Climatology shows that the frequency of hours with NE wind greater than  $7.5 \text{ ms}^{-1}$  (15 KT) is 10–15 % in winter time. The *bura* is dominantly driven by large scale dynamics, hence it is forecasted well. The diagnostic verification results are shown according to lead time, issue time, months. Additionally, profiles from ALADIN model are used to determine the type of flow (shallow, deep or nocturnal downslope flow).

## **CASE STUDY OF A MESOSCALE CONVECTIVE COMPLEX OVER THE ADRIATIC ON 20<sup>th</sup> SEPTEMBER 2014**

VINKO ŠOLJAN, TANJA RENKO and PETRA MIKUŠ JURKOVIĆ

Croatia Control Ltd.  
Rudolfa Fizira 2, Velika Gorica, 10150 Zagreb-Airport, Croatia  
*vinko.soljan@crocontrol.hr*

### **ABSTRACT**

A mesoscale convective complex (MCC) developed over the Northern Italy during the night of 20<sup>th</sup> September 2014. Following the westerly flow in the center part of an upper level ridge, MCC moved to Croatia and Bosnia and Herzegovina before the noon. In the afternoon, after reaching Montenegro, it started to dissipate, so most of the severe weather occurred over Northern Italy and Adriatic Sea. Some flooding still occurred in coastal cities along MCC path. One curiosity about this MCC is that two airline flights, flying through its peripheral parts at ~11533 m and ~12192 m, reported unusually high horizontal temperature gradients (27 °C and 30 °C over distance of 74 km).

Synoptic and mesoscale analysis was performed in order to identify key ingredients which caused observed convective organization and upscale growth to such extent. Detailed analysis of MCC development and structure was made using the MSG SEVIRI infrared 10.8 m and high resolution visible (HRV) channel satellite data. At its maximum extent the MCC covered an area of approximately 240000 km<sup>2</sup> and had extraordinarily high cloud tops with minimum infrared 10.8 m brightness temperature of approximately -75 °C. Lightning properties, such as number, type, polarity and electric current of lightning strokes during the MCC lifetime were analyzed using LINET data.

The numerical weather prediction model ALADIN was used in order to analyze meteorological parameters before, during and after the MCC occurrence. Numerical forecast was compared to observations to assess the model performance.

## PERFORMANCE OF ALAR00 BASELINE IN PRE-OPERATIONAL TESTING

MARTINA TUDOR, STJEPAN IVATEK-ŠAHDAN and ANTONIO STANEŠIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*tudor@cirus.dhz.hr*

### ABSTRACT

The ALAR00 model is based on the ALADIN model and includes a physics package that is designed to work in the grey zone, multi-scale and suitable for operational numerical weather prediction. Parts of the ALAR00 physics package have been available before and have been used in the operational forecast. The ALAR00 baseline has been released in 2014.

Here we show how the ALAR00 baseline has been tested using cycle AL38T1 on the domain used for operational forecast with 8 km resolution on 37 levels in the vertical. Tests with higher vertical resolution on 73 levels in the vertical and non-hydrostatic dynamics were also performed running 72 hour forecasts for the two whole months, for January and May 2014. ALAR00 baseline was applied and tested in 4 km resolution on 37 and 73 levels in the vertical with hydrostatic and non-hydrostatic dynamics. The standard scores of forecasts in 4 km resolution are superior to the 8 km forecast.

## POSSIBILITIES OF LONG RANGE DROUGHT FORECASTING USING STANDARDIZED PRECIPITATION INDEX

LOVRO KALIN, DOMAGOJ MIHAJLOVIĆ, KSENIJA CINDRIĆ KALIN  
and BLAŽENKA MATJAČIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*kalin@cirus.dhz.hr*

### ABSTRACT

Drought is a complex natural phenomenon that causes the highest economic losses in Croatia. Since damages are increasing, development of a comprehensive drought monitoring system should include a forecasting component in order to provide in-time warning.

In this study the possibilities on drought forecasting are investigated using the Standardized Precipitation Index (SPI). It was calculated at 1- and 3-month time scales, employing the long-range ensemble precipitation forecasts by the European Centre for Medium-Range Weather Forecasts (ECMWF). They were validated by SPI values obtained from the observed monthly precipitation amounts at 23 stations, spanning the 2011–2014 period. The verification has been performed using standard scores: Brier skill score, ROC score as well as reliability diagrams. Results reveal a good skill for the one-month SPI forecast and considerably worse skill for three-month forecast.

**ANALIZA MAKSIMALNIH VIŠEDNEVNIH KOLIČINA OBORINE  
U HRVATSKOJ**

IRENA NIMAC, KSENIJA CINDRIĆ KALIN, MELITA PERČEC TADIĆ  
i MARJANA GAJIĆ-ČAPKA

Državni hidrometeorološki zavod  
Grič 3, 10000 Zagreb, Hrvatska  
*irena.nimac@gmail.com*

**SAŽETAK**

Maksimalne dnevne ili višednevne količine oborine imaju važnu ulogu kod projektiranja i održavanja hidrotehničkih sustava. Do sada su za područje Hrvatske najčešće analizirane jednodnevne i petodnevne maksimalne količine oborine jer ta trajanja pripadaju skupini indeksa oborinskih ekstrema koje je definirala Svjetska meteorološka organizacija. Međutim, višednevna kišna razdoblja s velikom količinom oborine najčešće su uzrokovana intenzivnim kišnim epizodama u trajanju oko tri dana.

Zbog toga su u ovom radu pored maksimalnih godišnjih jednodnevnih i petodnevnih količina oborine, analizirane i maksimalne godišnje dvodnevne i trodnevne količine oborine prema dnevnim podacima sa 137 meteoroloških postaja u Hrvatskoj. Kao prvi uvid u regionalne razlike maksimalnih višednevnih oborina provedena je osnovna statistička analiza, dok su u svrhu ocjene opasnosti i rizika u budućnosti procijenjeni očekivani maksimumi za različita povratna razdoblja (2, 5, 10, 25, 50 i 100 godina) prilagođavanjem opće razdiobe ekstremnih vrijednosti. Prikazana je prostorna razdioba dekadnog trenda godišnjih maksimuma višednevne količine oborine iz razdoblja 1961.–2010. Provedena je i razdioba čestina pripadnih količina oborine za različite dekade kako bi se dobio uvid u tendenciju grupiranja pojedinih količina oborine. Rezultati ovoga rada su sastavni dio podloge za regionalizaciju ekstremne količine oborine i izradu karata opasnosti i rizika od poplava.

# **WATER BALANCE COMPONENTS DURING RECENT FLOODS IN CROATIA**

RENATA SOKOL JURKOVIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*renata.sokol@cirus.dhz.hr*

## **ABSTRACT**

Floods in continental part of Croatia during 2010, 2013 and 2014 caused high material damage, thus overview from different aspects was needed. In this study, water balance calculated according to the Palmer's model was analyzed. From water balance components (precipitation, loss, evapotranspiration, recharge and runoff) can be distinguished whether flood origins are in local extreme precipitation or precipitation and/or snow melting occurred elsewhere in the upper parts of the basin. The main difference between the floods in 2010, 2013 and 2014 is that water in 2010 came mainly from upper parts of the basins (Kupa and Sava), in 2013 combination of two factors resulted as flood and 2014 the long-lasting precipitation and soil saturation created conditions for flooding.



## FORECASTING OF SPACE WEATHER EFFECTS ON GNSS PNT SERVICES

DAVID BRČIĆ, RENATO FILJAR and SERĐO KOS

Faculty of Maritime Studies, University of Rijeka  
Studentska 2, 51000 Rijeka, Croatia  
*brcic@pfri.hr*

### ABSTRACT

The space weather effects are directly affecting the satellite signal propagation, degrading the time measurement accuracy and pseudorange determination, respectively. The factor which governs the features of signal propagation is the total electron content (TEC) the satellite signal encounters while propagating through ionized layers of the Earth's atmosphere. The TEC behaviour can be observed in relation to apparently distant events originating in the Sun-Earth environment. By monitoring the space weather phenomena and occurrences from the very beginning of their appearance, it is possible to detect and predict the TEC behaviour and its impact on satellite signal propagation. In the proposed research, TEC behaviour prediction is given regarding relevant space weather parameters which are describing solar, geomagnetic and ionospheric activity. Consequently, space weather parameters are defining satellite signal positioning environment conditions. In this way, risks and possible impact identification of space weather effects on Global Navigation Satellite System (GNSS) Position, Navigation and Timing (PNT) services performance can be identified and mitigated.

## CONTRASTING (SUB-)MESOSCALE *BURA* STRUCTURES

BRANKO GRISOGONO, MILIVOJ KUZMIĆ, SUSANNE LEHNER, XIAOMING LI  
and IVAN GÜTTLER

Department of Geophysics, Faculty of Science, University of Zagreb  
Horvatovac 95, 10000 Zagreb, Croatia  
*bgrisog@gfz.hr*

### ABSTRACT

Depending on future large-scale flow, affected by the current climate change, one shall witness possible structural changes in *bura* flows, or at least, variations in *bura* preferential statistics. Two different *bura* cases are addressed in this work: a moderate or strong, and a severe *bura*. Satellite TerraSAR-X (TS-X) images are supported by the Weather Research and Forecasting (WRF) numerical simulations and a few regular measurements. The moderate or strong case (Case 1) belongs to a deep anti-cyclonic *bura* setup, and the severe case (Case 2) is a shallow and predominantly cyclonic *bura* type, though the other two synoptic scenarios partially occur too due to the effects of a front and high-pressure system. In Case 1, the upstream (vertical) Froude number,  $Fr$  (or the inverse of dimensionless mountain height), obtained from Zagreb sounding was about  $0.7 < Fr < 1.1$ , while in Case 2 it was about  $0.6 < Fr < 0.7$ . High resolution TS-X image processing displays very fine *bura* spatial structures at  $L_x$  1 km, i.e., at the sub-mesoscale, that has not been shown in the previous *bura* research. For the severe Case 2, the Adriatic sea-surface convective heat fluxes induced by the vigorous surface temperature differences between the sea and the overflowing very cool fast air are responsible for those fine scale structures (plus the obvious complex coastal orography and geometry). The WRF simulations suggest that the extremely cold upstream airflow reinforced the mountain-wave breaking by enhancing the corresponding mesoscale pressure gradient over the mountains. The satellite images show for Case 2, characterized by the more vigorous cross-mountain flow, secondary and tertiary low-level jets of *bura* in the lee of Velebit mountain. Yet, we do not know which *bura* type of *bura* cases shall be dominant in the future.

## **ENERGETIKA BLAGO NELINEARNOG PRANDTLOVOG MODELA**

IVANA MARINOVIĆ, IVAN GÜTTLER, ŽELJKO VEČENAJ i BRANKO GRISOGONO

Geofizički odsjek, Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu  
Horvatovac 95, 10000 Zagreb, Hrvatska  
*ivana\_ma.5@hotmail.com*

### **SAŽETAK**

Prandtl model je jednostavan analitički model koji sadrži bit 1D dinamike i termodinamike stacionarnog graničnog sloja, te opisuje jednostavno katabatičko i anabatičko strujanje formirano nad ohlađenom, odnosno zagrijanom, uniformnom kosinom. Takvo strujanje odvija se uz pretpostavku ravnoteže između uzgonske sile i turbulentnog miješanja, koje nastaje kao reakcija na uzgon. U ovom radu istražena je energetika klasičnog i modificiranog Prandtl modela. Promatrani su članovi turbulentne difuzije i disipacije, te član interakcije temperature i vjetra, kao i njihovi doprinosi produkciji ukupne energije, tj. zbroja kinetičke i potencijalne energije. Napravljen je ansambl rješenja za različite početne uvjete. Ukupna energija blago nelinearnog Prandtl modela procijenjena je za podatke vjetra i temperature s mjerne postaje na Pasterze ledenjaku u austrijskim Alpama. Na ovaj način pokušava se unaprijediti korištenje Prandtl modela u mezoskalnim numeričkim modelima, te dodatno ispitati primjenu tog modela na nagnute površinske slojeve.

# RELATION OF RADAR AND HAIL PARAMETERS IN THE CONTINENTAL PART OF CROATIA

DAMIR POČAKAL

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*damir.pocakal@cirus.dhz.hr*

## ABSTRACT

Continental part of Croatia is exposed, mainly in the summer months, to the frequent occurrence of severe thunderstorms and hail. In the 1960s, aiming to protect and reduce the damage, an operational hail suppression system was introduced in that area. The current protected area is 26800 km<sup>2</sup> and has about 580 hail suppression stations (rockets and ground generators) which are managed with 8 radar centres (S-band radars).

In order to obtain objective and precise hailstone measurement for different research studies, hailpads were installed on all this stations in 2001. Additionally the dense hailpad network with the dimensions of 20 km x 30 km (1 hailpad per 4 km<sup>2</sup>), was established in the area with the highest average number of days with hail in Croatia in 2002.

This paper presents analysis of relation between radar measured parameters of Cb cells in the time of hail with physical parameters of hail (max. diameter, number of hailstones and kinetic energy) measured on hailpads in period 2002–2014. In addition, radar parameters of Cb cells are compared with and without hail on the ground located at the same time over the polygon area.

***BURA* TURBULENCE IN COMPARISON WITH INTERNATIONAL WIND  
ENGINEERING STANDARDS**

PETRA LEPRI, ŽELJKO VEČENAJ, HRVOJE KOZMAR and BRANKO GRISOGONO

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*petra.lepri@cirus.dhz.hr*

**ABSTRACT**

*Bura* is a strong, gusty, temporally and spatially variable downslope wind. *Bura* mean velocity is not that significant, but its strong gusts create significant problems to traffic and engineering structures. Therefore, further research is required to fully elucidate *bura* turbulence in a form usable for engineers.

In this study, unique high-frequency measurements, carried out on a meteorological tower in the hinterland of the city of Split, Croatia are analyzed. Time histories and vertical profiles are analyzed for turbulence intensity, Reynolds shear stress and turbulence length scales in comparison with recommendations provided in major international wind engineering standards. For mean wind velocities larger than  $5 \text{ ms}^{-1}$ , turbulence intensity and Reynolds shear stress are noticed to remain within the same range of values during the observed *bura* episode. Turbulence intensity and absolute Reynolds shear stress decrease with increasing height from the ground, while simultaneously turbulence length scales increase, all in accordance with the atmospheric physics. For the respective terrain type, the obtained vertical profiles of turbulence intensity, Reynolds shear stress and longitudinal turbulence length scales agree well with international standards. On the other hand, turbulence length scales related to lateral and vertical velocity fluctuations are considerably larger than the standard values that may have significant implications with respect to *bura* loads on engineering structures and vehicles.

# OSOBINE BURE NA ZRAČNOJ LUCI DUBROVNIK

ENDI KERESTURI

Zentralanstalt für Meteorologie und Geodynamik (ZAMG)  
Hohe Warte 38, 1190 Beč, Austrija  
*endi.keresturi@zamg.ac.at*

## SAŽETAK

Vjerojatno najpoznatija negativna posljedica bure jest ometanje normalnog odvijanja svih oblika prometa. Motivacija ovog rada prisutnost je velikih poteškoća u odvijanju zračnog prometa na zračnoj luci Dubrovnik (ZLD) za vrijeme puhanja bure. U tu su svrhu određene glavne osobine bure na tom području, napravljena je klimatologija bure te su uspoređena mjerenja bure pri tlu s podacima iz ALADIN-a.

Jedna od glavnih karakteristika bure na dubrovačkom području jasna je razlika između dva tipa bure. Jedan se javlja u situacijama kada postoji dobro definiran sloj bure u donjoj troposferi (SM-bura), dok je za drugi karakteristično da se sjeverni vjetar proteže kroz čitavu troposferu (N-bura). U ovom radu korišteni su podaci, iz anemometra, o srednjoj brzini, srednjem smjeru i udarima vjetra u razdoblju od 28. 11. 2007. u 00 UTC do 30. 4. 2014. u 23:30 UTC, a zapisani su u obliku METAR izvješća s razmakom od 30 min. Također, za isto razdoblje korišteni su i podaci o vertikalnoj raspodjeli brzine i smjera vjetra iz pesudotempa ALADIN-a. Ukupno je izdvojeno 235 epizoda bure na kojima je provedena daljnja analiza.

Analizom je ustanovljeno da SM-bura ima veću srednju vrijednost brzine, veći srednjak udara i ujednačeniji smjer puhanja. Kod N-bure prisutne su veće varijacije i smjera i brzine, a maksimalni udari usporedivi su s onima u SM-buri. Sva navedena svojstva čine N-buru opasnijom za zračni promet te teže predvidivom. U posljednjem su dijelu rada bile provjerene dvije empirijske metode koje prognostičari koriste pri prognozi bure na ZLD-u te je provedena verifikacija ALADIN-a.

# UTJECAJ GLOBALNOG ZAGRIJAVANJA NA TEMPERATURE MORA ISTOČNE OBALE JADRANA

RUŽICA POPOVIĆ i ŽELJKO ŠORE

Pomorski meteorološki centar Split, Državni hidrometeorološki zavod  
Glagoljaška 11, 21000 Split, Hrvatska  
*popovic@cirus.dhz.hr*

## SAŽETAK

Porast temperature zraka bio je prvi pokazatelj promjene klime na Zemlji. Povećanjem broja sušnih razdoblja, intenziviranjem opasnih meteoroloških pojava u obalnom i otočnom pomorskom području, uočavanjem i povećanjem ozonskih rupa i povećanjem UV zračenja, poremećajima u prehrambenim lancima u morima i na kraju i intenziviranjem poremećaja u cirkulaciji u atmosferi i moru, nastavio se niz pokazatelja globalnog zagrijavanja. Opća cirkulacija atmosfere je čvrsto vezana uz cirkulaciju mora. Naime, promjene u cirkulaciji i promjene temperature zraka vezane su za promjene temperature mora. Najznačajnija globalna cirkulacija u oceanima poznata je pod imenom Veliki oceanski transporter (Great Ocean Conveyor), koji se proteže preko Atlanskog, Indijskog i Tihog oceana. Takav veliki sustav je vrlo malih brzina. Zbog toga je vrlo teško govoriti o dugotrajnim promjenama klime bez dobrog poznavanja strujanja u morima od površine do dubinskih slojeva. Prateći promjene u interakciji atmosfera–more na globalnoj i regionalnoj razini, u ovom radu ćemo pokušati razmotriti, analizirati i utvrditi moguće promjene u temperaturi mora u zadnjim desetljećima 20. stoljeća duž istočne obale Jadrana, a prema podacima o temperaturi mora na mjernim postajama: Split, Hvar, Komiža, Senj, Rab i Sv. Ivan na pučini.

**FIRST OBSERVATIONS OF THE *BURA* WIND TURBULENCE  
USING THE HOT-WIRE ANEMOMETER**

ŽELJKO VEČENAJ, DAMIR PTIČAR, HRVOJE HEGEDUŠ, GORAN LONČAR  
and BRANKO GRISOGONO

Department of Geophysics, Faculty of Science, University of Zagreb  
Horvatovac 95, 10000 Zagreb, Croatia  
*zvecenaj@gfz.hr*

**ABSTRACT**

During *bura* event, i.e., a famous downslope windstorm at the eastern Adriatic coast, difficulties often emerge in traffic, industry and, generally, in everyday life. This is mainly due to *bura* persistency and severe gustiness (the wind speed maxima may surpass even  $70 \text{ ms}^{-1}$ ), which makes *bura* a subject of intensive scientific research. In the past few decades, statistical, synoptic and main mesoscale characteristics of the *bura* flow have been comprehensively studied, but some aspects of *bura* dynamics are still insufficiently investigated, especially its turbulence. The main reason for such situation has been the lack of suitable measurements which are needed to assess these aspects.

In this work we address the near-surface *bura* turbulence. We mounted a single point 1D hot-wire anemometer (HWA) (Dantec Dynamics Multichannel CTA Anemometer System) and 3D ultrasonic anemometer (USA) (Gill Instruments WindMaster) at the north-eastern Adriatic coast in Vratnik Pass ( $44.98^\circ \text{N}$ ,  $14.98^\circ \text{E}$ , 700 m above MSL) on the mast 2.8 m above the ground. We measured a moderate *bura* event that occurred on 25 September 2014. We gathered 267 min of data (1451 – 1918 LST). HWA sampled streamwise wind speed component with sampling rate of 50 kHz while USA sampled all three wind speed components using 10 Hz sampling rate. We performed an in situ calibration of the HWA voltage data using the wind speed data from the collocated USA. In this work we focus on calculation of turbulence kinetic energy dissipation rate, "epsilon". We calculate and compare using the direct dissipation technique and two indirect dissipation techniques: the inertial dissipation technique and the Kolmogorov's four-fifths law. The goal is to find out which of the two indirect techniques provides better results for *bura* wind turbulence because the use of indirect techniques significantly reduces expenses needed for the reliable estimation of "epsilon".



## **EKOLOŠKI TIP HIDROELEKTRANE**

LJUBOMIR SAMARDŽIJA

UG "Čovjek i prirodni resursi"

Ozimice I, H.K.Prušćaka P+12/1, 77000 Bihać, Bosna i Hercegovina

*ljubsa@bih.net.ba*

### **SAŽETAK**

Ekološki tip hidroelektrane je takvo hidroenergetsko postrojenje koje se može graditi i u zaštićenim područjima, bez gradnje brana i bez stvaranja umjetnih hidroakumulacija. Ovaj tip hidroelektrane obezbjeđuje visok stepen očuvanja prirodnog ekosistema koji je postojao i prije njene izgradnje.

Ekološki tip hidroelektrane proizvodi električnu energiju za vrijeme srednjeg i visokog nivoa voda. U vrijeme niskog vodostaja hidroelektrana prestaje s radom onog momenta kada proticaj opadne na proračunati ekološki protok vode. Dosadašnje privredne, sportske, kulturne i sve druge društvene aktivnosti na vodotoku, posebno one tradicionalne, koje imaju historijsko-kulturološke, pejzažne i druge vrijednosti za lokalnu zajednicu mogu ostati nepromijenjene kao i prije njene gradnje.

Ekološki tip hidroelektrana je originalan pristup gradnji hidroenergetskog objekta na području koje je bogato vodom i gdje je ovu vrstu obnovljivog izvora energije moguće koristiti na optimalan način.

Zajedno sa drugim tipovima gradnje hidroelektrana kao i drugim vrstama obnovljivih izvora energije (vjetar, solarna energija, energija biomase i sl.), ekološki tipovi hidroelektrana mogu Bosni i Hercegovini omogućiti ispunjavanje zacrtanih ciljeva da se do 2020. godine proizvodi 40 % energije iz obnovljivih izvora.

**IDENTIFIKACIJA IZVORA ONEČIŠĆENJA PRIMJENOM UVJETNE  
DVODIMENZIONALNE FUNKCIJE VJEROJATNOSTI**

VEDRANA DŽAJA GRGIČIN i AMELA JERIČEVIĆ

Državni hidrometeorološki zavod  
Grič 3, 10000 Zagreb, Hrvatska  
*vedrana.dzaja@cirus.dhz.hr*

**SAŽETAK**

U ovom radu primijenjena je metoda modeliranja receptora razvijena u svrhu identifikacije i opisa emisijskih izvora onečišćenja. Metoda je razvijena na uvjetnoj funkciji vjerojatnosti (CPF) tako da obuhvaća brzinu vjetra kao treću varijablu pri čemu omogućava dodatne informacije o tipu izvora. Metoda je primijenjena na mjerenja onečišćujućih tvari u zraku (PM<sub>10</sub>, PM<sub>2.5</sub>, ozon, dušikovih oksida i sumporovih oksida) u Hrvatskoj u urbanim i ruralnim sredinama u razdoblju 2006.–2013. godine i na rezultate kemijskog modela EMEP. Demonstrirana je primjena metode u uvjetima kompleksnih izvora čime je omogućena veća pouzdanost u identifikaciji izvora onečišćenja.

# MODELLING AND ASSESSMENT OF PARTICULATE MATTER USING EMEP AND WRF-CHEM MODELS AT RURAL BACKGROUND STATIONS IN EUROPE

GORAN GAŠPARAC and AMELA JERIČEVIĆ

Geofizikalno i ekološko modeliranje d.o.o.  
Trg senjskih uskoka 1-2, 10000 Zagreb, Croatia  
*ggasparac@gekom.hr*

## ABSTRACT

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 are analysed and compared to elevated and surface stations for the whole year allowing identifying regional variability and differences across Europe. Two different regional chemistry models were applied to analyse the transboundary transport of aerosols and the effect at background stations. The EMEP chemical transport model was run for the November 2011 as well as the “online” meteorological and chemical transport WRF-Chem model with novel mixing length scheme applicable for stable atmospheric conditions. Special attention was given to the regional characteristics and sources of PM in Central and South-Eastern Europe during episode of observed high daily PM concentrations at background mountain stations with daily PM concentrations  $\sim 70 \mu\text{g m}^{-3}$  and urban surface stations  $\sim 120 \mu\text{g m}^{-3}$ . Episode was analysed using monitored and modelled air quality and meteorological data and backward air mass trajectories which showed that all analysed stations were under the influence of the same air masses. According to WRF-Chem model elevated  $\text{PM}_{10}$  concentrations were the consequence of local anthropogenic sources and regional transport. The accumulation of pollutants was governed by the large scale anticyclone conditions that prevailed over the South-Eastern and Central Europe enabling stable atmospheric conditions characterized with low dispersion and mixing. Both models underestimated PM concentrations at mountain stations during the episode indicating problems with regional transport of air pollution in statically stable atmospheric conditions.

## KORIŠTENJE PMF METODE ZA ODREĐIVANJE IZVORA PM<sub>10</sub> NA PODRUČJU GRADA RIJEKE

BORIS MIFKA i ANA ALEBIĆ-JURETIĆ

Medicinski fakultet, Sveučilište u Rijeci  
Krešimirova 52, 51000 Rijeka, Hrvatska  
*borismfk1@gmail.com*

### SAŽETAK

U sklopu MED projekta Poseidon određeni su izvori PM<sub>10</sub> na širem području grada Rijeke. Korišteni su podaci prikupljeni pomoću uzorkivača velikog volumena zraka smještenog na terasi Nastavnog zavoda za javno zdravstvo. Postaja se nalazi na visini od 20 m.n.v. u sklopu koje se nalazi i digitalni anemometar. U periodu od 2008. do 2010. godine skupljeno je 198 uzoraka podjednako u zimskom i ljetnom periodu iz kojih je gravimetrijskom metodom određena koncentracija PM<sub>10</sub>, a uz pomoć HPLC (High Pressure Liquid Chromatography) i IC (Ion Chromatography) metoda određene su koncentracije 26 kemijskih tvari unutar 3 grupe: teški metali, ioni i PAU (Policiklički aromatski ugljikovodici). Ioni su zastupljeni sa 41 % ukupne mase, od kojih najviše sekundarni anorganski aerosoli (SIA), a metali i PAU su zastupljeni s manje od 3 %. 56 % mase PM<sub>10</sub> nije određeno. PMF (Positive Matrix Factorization) metodom identificirano je 5 glavnih izvora: metalna industrija, SIA, morski aerosoli, gorenje biomase i prašina od kojih najveći udio u poznatom dijelu PM<sub>10</sub> ima SIA s gotovo 50 %. Međutim, metodom je procijenjeno da najveći udio u česticama, oko 47 %, ima metalna industrija. Pomoću CPF (Conditional Probability Function) funkcije koja procjenjuje vjerojatnost pojave čestica iz određenog izvora ovisno o smjeru vjetra pokazalo se da su neki od mogućih izvora: brodogradilišta 3. maj i Viktor Lenac, rafinerije Urinj i Mlaka, termoelektrana Urinj, daljinski transport, domaćinstva te METIS i Luka; posebice prostor gdje se prekrcajavu umjetna gnojiva i metali. Izraženi godišnji hod sa maksimumima zimi imaju izvori metalna industrija i gorenje biomase, a prašina ljeti.

**POSTERI  
POSTERS**



**PROMJENE POTREBA GRIJANJA I HLAĐENJA NA HRVATSKOM  
JADRANU I U UNUTRAŠNJOSTI**

LIDIJA CVITAN

Državni hidrometeorološki zavod  
Grič 3, 10000 Zagreb, Hrvatska  
*cvitan@cirus.dhz.hr*

**SAŽETAK**

S obzirom na brzinu promjena u potrebama za grijanjem i hlađenjem, u Hrvatskoj su velike razlike utvrđene između jadranskog područja i hrvatske unutrašnjosti. Ove su promjene analizirane u razdobljima 1961.–2010. i 1986.–2010. za koja su raspoloživi temperaturni podaci na velikom broju meteoroloških postaja diljem Hrvatske. Promjene potreba grijanja i hlađenja su analizirane na temelju sedam izvedenih temperaturnih parametara: stupanj-dana i broja dana grijanja, početka, kraja i trajanja ogrjevnice sezone, te stupanj-dana i broja dana hlađenja. Određeni su linearni trendovi svih parametara, a njihova je statistička značajnost testirana pomoću neparametarskog Mann-Kendall-ovog testa. Uglavnom su i statistički značajne najveće utvrđene promjene potreba vezanih uz grijanje i hlađenje.

# KLIMATOLOGIJA VJETRA NA ZRAČNIM LUKAMA U HRVATSKOJ I OKOLICI TEMELJENA NA METAR IZVJEŠTAJIMA

JADRAN JURKOVIĆ i MARKO ZOLDOŠ

Hrvatska kontrola zračne plovidbe d.o.o.  
Rudolfa Fizira 2, Velika Gorica, 10150 Zagreb-Zračna luka, Hrvatska  
*jadran.jurkovic@crocontrol.hr*

## SAŽETAK

Ruža vjetra je prikaz učestalosti klasa brzina vjetra po smjerovima na danom mjestu kroz određeno razdoblje. Raširena je u klimatologiji i vrlo korisna u zrakoplovstvu. Pri odabiru smjera piste, ako topografija to dopušta, smjer se određuje tako da se minimizira jači bočni vjetar zbog sigurnog slijetanja. Obzirom da zračne luke obično nisu lokalno zaklonjene preprekama, mjerenja i posljedično ruže vjetra sa zračnih luka prezentiraju i lokalno strujanje u okolici.

Poster prikazuje ruže vjetra za zračne luke u Hrvatskoj i okolici. Korišteni su METAR podaci u razdoblju 1996.–2013. za zračne luke u Hrvatskoj i 2005.–2012. za inozemne. Dodatno su prikazane razdiobe mjesečnih učestalosti umjerenog i jačeg vjetra (>10 kt) koje ukazuju na različite godišnje hodove učestalosti nad širim područjem. Na kraju su dane karte maksimalnih udara vjetra i udio umjerenog (>10 kt) i jačeg vjetra u ukupnom.



# NUMERIČKE SIMULACIJE KLIMATSKIH PROMJENA UZROKOVANIH UDVOSTRUČAVANJEM KONCENTRACIJE UGLJIČNOG DIOKSIDA U ATMOSFERI

IRENA NIMAC i IVANA HERCEG-BULIĆ

Državni hidrometeorološki zavod  
Grič 3, 10000 Zagreb, Hrvatska  
*irena.nimac@gmail.com*

## SAŽETAK

U ovom radu je istražen utjecaj udvostručavanja koncentracije ugljičnog dioksida u atmosferi na klimu pomoću modela SPEEDY. Uspoređeni su rezultati četiriju SPEEDY eksperimenata: trenutna klima (CTRL), buduća klima (2xCO<sub>2</sub>), eksperiment izravnog (DIR) te eksperiment neizravnog utjecaja CO<sub>2</sub> (IND). Analizirane su promjene srednjih stanja buduće klime uzrokovane dvostrukim povećanjem koncentracije CO<sub>2</sub>, i to za zimsku (siječanj-veljača-ožujak) i ljetnu (srpanj-kolovoz-rujan) sezonu.

Rezultati pokazuju da udvostručenje koncentracije CO<sub>2</sub> uzrokuje zatopljenje od oko 2 °C na svim promatranim nivoima. U prizemnom sloju do najvećih promjena dolazi u polarnim područjima, dok u višim slojevima veće zatopljenje zahvaća uglavnom kontinentalne dijelove sjeverne hemisfere. Na nivou od 300 hPa uočava se zahlađenje u polarnim područjima. Promjene donjih graničnih uvjeta, a koje su posljedica porasta CO<sub>2</sub>, imaju veći doprinos globalnom zatopljenju od apsorpcijsko-radijacijskih procesa na samom CO<sub>2</sub>. Numeričkim simulacijama je pokazano da dolazi do značajnih promjena mlazne struje na sjevernoj hemisferi koje su izraženije zimi. Do značajnog porasta stratiformne oborine dolazi na zimskoj hemisferi u višim geografskim širinama, dok se smanjenje javlja uglavnom iznad oceana. Signifikantan porast konvektivne oborine javlja se ljeti iznad kontinenata sjeverne hemisfere. U južnom dijelu tropskog Pacifika u obje sezone dolazi do smanjenja stratiformne i konvektivne oborine.

# HIGH RESOLUTION CLIMATE CHANGE IMPACT STUDIES AND IMPROVEMENTS IN NUMERICAL MODELING OF THE EARTH SYSTEM COMPONENTS – SHORT REVIEW OF MODELING ACTIVITIES IN SEEVCCC

ANA VUKOVIĆ, MIRJAM VUJADINOVIĆ, BOJAN CVETKOVIĆ, VLADIMIR ĐURĐEVIĆ, MARIJA ĐORĐEVIĆ, ALEKSANDRA KRZIĆ, ĐURĐA STOJIČIĆ, SLOBODAN NIČKOVIĆ, GORAN PEJANOVIĆ and SLAVKO PETKOVIĆ

Faculty of Agriculture, University of Belgrade  
Nemanjina 6, 11080 Belgrade-Zemun, Serbia

*pazisadana@gmail.com*

## ABSTRACT

South East Europe has complex political map, terrain and climate features, and locally based economies. Climate change studies and adaptation strategies preferably require analysis with high-resolution approach. Latest research in SEEVCCC related to this subject involves 8 km resolution NMMB climate simulation using RCP8.5 (IPCCC, 2013) scenario for the SEE region, daily bias correction of the model data for the territory of Serbia, and use of such results for spatial climate change analysis with application mostly in agriculture and forestry, including heat and water availability change, as well as risk assessment of weather extremes. During the last year, flash floods in the region had priority in modeling and research activities. Dynamical hydrology model was developed as part of the NWPM add-on module. Its ability to predict extreme discharge events is tested with use of the radar data, as possible nowcasting tool with updates on every hour. Another hazards related to atmospheric particle transport are intense hail events, some of them closely related to the Saharan dust transport. In general dust transport is related to cloud formation. Prognostic component of nucleus transport and its interaction with the environment requires knowledge about its mineral composition. Latest modeling of atmospheric particle transport is focused on improvement of cloud formation in episodes with its intense transport from desert areas.

In this paper will be presented short review of studies related to the listed priority tasks and latest research and development achievements in SEEVCCC during the last year. The authors acknowledge to ORIENTGATE project (co-funded by the South East Europe Transnational Cooperation Programme) or providing and sharing data on climate change scenarios. This study was conducted under research project III 43007 supported by the Serbian Ministry of Science and Technological Development.

## **COLLAPSE-FREE FUTURE OR MATERIAL WEALTH: WHAT DO EUROPEANS WANT?**

MLADEN DOMAZET and BRANKO ANČIĆ

Institute for Political Ecology  
Preobraženska 2, 10000 Zagreb, Croatia

*mladen@ipe.hr*

### **ABSTRACT**

Avoiding a drastic and chaotic reduction of civilizational throughput due to collapse of the supporting ecosystems within this century will require a change in the social metabolism, as well as expectations and aspirations, behaviours and attitudes of the majority of the global population. Climate change aptly frames both the drivers and consequences of this interaction between humanity and the natural environment. For some it is a question of modifying aspirations and focusing on those whose realisation is most sustainable and most valued in the long-term period (developing world); whilst for others it is a matter of sacrifice of existing material manifold of wellbeing, a reduction in extraction of environmental resources and dumping of waste. In that context, European societies having the highest level of material and social development carry a significant strategic role in exemplifying a future aligned to a changing climate. Through comparing 'objective' development and environmental impact indices and population's attitudes across a range of European countries we aim to elucidate possible links between society's objective potential to transform its practices and material throughput to those more suitable to a globally just long-term sustainability, and its population's support for the required social transformations.

Our poster illustrates the respective populations' agreement or prevalence of support for, some of sustainability-compatible strategies against the dominant prosperity thesis, which claims that greater national wealth is the best predictor of population's environmental and development concerns. We present data from cross-country social surveys (EVS, ISSP) to map trends among European populations' attitudes.

# IMPLICATIONS OF CLIMATE CHANGE TO CROATIAN TOURISM

KSENIJA ZANINOVIĆ and LIDIJA SRNEC

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*zaninovic@cirus.dhz.hr*

## ABSTRACT

Weather and climate constitute one of the most important natural resource for recreation tourism because during their activities, tourists are affected by atmospheric conditions. Due to its geographical diversity Croatia has the potential for wide range of tourist activities and leisure. Different kinds of tourist activities need different weather requirements. For quantitative estimation of climate potential of different kinds of tourism, climate index for tourism (CIT) is used. CIT integrates thermal, aesthetic and physical facets of atmospheric environment and therefore is suitable for estimation of climate satisfaction that ranges from very poor to very good. The thermal component is estimated using the physiologically equivalent temperature (PET).

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. 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. The integration domain covered almost the whole of Europe with the 35-km horizontal resolution.

Generally for all types of tourism on the annual scale, there is an increase of ideal climate conditions for tourism in future climates, mostly on the account of reduction of unacceptable conditions. Analyzing by seasons, the results point at the shift of the most suitable seasons for most types of activities from summer to spring and autumn. The season of 3S tourism will be prolonged, but on the south a reduction of ideal condition for 3S condition appears during summer.

## **CLIMATE AND CLIMATE CHANGE ANALYSIS IN THE LOWER NERETVA RIVER BASIN, CROATIA**

MARJANA GAJIĆ-ČAPKA, KSENIJA CINDRIĆ KALIN, IVAN GÜTTLER and ČEDO BRANKOVIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*capka@cirus.dhz.hr*

### **ABSTRACT**

In the framework of EU project „DRINK ADRIA” (Programme IPA ADRIATIC CBC 2007-2013) climate and climate change have been analysed to provide an input for further assessment of present and future risks on water resources availability with emphasis on drinking water supply. The Prud spring catchment area in the lower Neretva River basin is selected as one pilot area out of two at the Croatian Adriatic coast. Air temperature and precipitation are analysed as basic input parameters used in hydrological calculations. Analyses of present climate (1961–1990) contain intra-annual variability and extremes and their temporal variations during 1961–2012 period on seasonal and annual scale for Opuzen climatological station within the catchment.

An assessment of present and future climate (2021–2050) is based on numerical simulations of three regional climate models (RCMs) which participated in the ENSEMBLES EU FP6 project. Analysis of the model data is carried out for those model grid cells which were the closest to the Opuzen location. The RCMs were forced by the observed concentrations of the greenhouse gases (GHGs) from 1951 to 2000; from 2001 onwards by IPCC A1B scenario of the GHGs emissions. The initial and boundary data for each RCM were provided from different global climate models (GCMs): the ECHAM5 GCM data were used to force RegCM3, the Arpege GCM for Aladin and the HadCM3Q GCM for Promes. For the present climate, models are compared with the DHMZ and EOBS observations. For the projected climate changes of the RCMcorr data an increase in the mean air temperature by mid 21st century is simulated by all three RCMs (0.5 °C to nearly 3.5 °C) and in most cases it is statistically significant. The amplitude of projected precipitation change varies greatly throughout the year from one model to the other (between -60 % and +60 %), but even so it is almost insignificant.

**THE EFFECTS OF ARCTIC, NORTH ATLANTIC AND EAST  
ATLANTIC/WEST RUSSIA OSCILLATION ON PRECIPITATION IN  
CROATIA CONSIDERING THE STANDARDIZED PRECIPITATION INDEX**

TOMISLAV STILINOVIĆ, IVANA HERCEG-BULIĆ and KSENIJA CINDRIĆ KALIN  
*tomislav.stilinovic@gmail.com*

**ABSTRACT**

The Arctic Oscillation (AO), North Atlantic Oscillation (NAO) and East Atlantic/West Russia Oscillation (EA/WR) are global modes of climate variability with a strong influence on European climate. Therefore, the climate variability of Croatia is affected by them as well.

This study investigates a possible influence of AO, NAO and EA/WR on precipitation over the Croatia considering correlation between respective indices and standardized precipitation index (SPI), a quantity that has been widely used in drought assessments. A possible time-delayed impact of these oscillations on SPI is also considered.

It is shown that there is a noticeable impact of wintertime (JFM) NAO, AO and EA/WR on precipitation in Croatia that may be reflected in SPI values. All three modes exert the strongest influence on SPI1 during the first overlapping month (January), with AO showing the strongest correlation. Results also indicate time delayed impact of wintertime NAO, AO and EA/WR on SPI3 calculated for subsequent seasons. The influence increases in magnitude towards the spring season, reaching its maximum in FMA season (for AO) and MAM season (for NAO and EA/WR).

The correlation between EA/WR and SPI indices shows a time lag compared with NAO and AO correlations having a longer influence. Besides, results indicate that strength and duration of investigated impacts are spatially dependent.

**SPATIAL AND SEASONAL VARIABILITY AND TRENDS OF EXTREME  
SOIL TEMPERATURE IN CROATIA**

PETRA SVILIČIĆ and VIŠNJICA VUČETIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*svilicic@cirus.dhz.hr*

**ABSTRACT**

Soil temperature analysis is becoming more important in the climate change issue.

In this paper, the focus is on the trend analysis of extreme soil temperatures, which are very important for the management of crops in agriculture. Maximal and minimal soil temperatures were analyzed on annual and seasonal scale for depths 2, 5, 10 and 20 cm for the period 1961–2010. Monthly, seasonal, and annual data were extracted from daily measurements at a standard climatological time (7 h, 14 h, 21 h CET) at 18 meteorological stations. The variability of detrended data is represented by interquartile range. Trends were determined by Theil Sen's estimator, and statistical significance on 5 % level was determined using the Mann-Kendall test. In general, variability decreases with depth in all seasons, and is larger for maximal soil temperature of surface layer. The results of trend analysis show a general increase of maximal soil temperature at almost all stations in spring and summer seasons, whilst the number of significant trends of minimal soil temperature is much smaller in all seasons. Trends of annual maximal soil temperature are almost equal to summer trends, and ranges from 1.0–2.3 °C/decade. Significant trends of minimal soil temperature are smaller for an order of magnitude (-0.4–0.7 °C/decade), with few exceptions in the surface layer of spring and summer season. The analysis shows a significant increase of the maximum soil temperature in spring and summer seasons in agricultural areas and the results may suggest the necessary adjustments to farmers when choosing seeding varieties.

## USE OF ECMWF PRODUCTS IN AGROMETEOROLOGICAL FORECAST IN CROATIA

IVANA TOMAŠEVIĆ

Meteorological and Hydrological Service  
Grič 3, 10000 Zagreb, Croatia  
*tomasevic@cirus.dhz.hr*

### ABSTRACT

The oldest agrometeorological weather forecast has been published on Croatian radio since 1990 and television since 1999. Over time there is a growing demand for agrometeorological information, particularly due to increased interest of farmers and general public. In preparing of agrometeorological forecast in the Department of Agrometeorology at Meteorological and Hydrological Service are regularly, among others, used products of the Centre for Medium Range Weather Forecasts, which is located in Reading in the United Kingdom (ECMWF).

This paper gives an overview of ECMWF products that meteorologists use in agrometeorological weekly bulletin and agrometeorological forecasts for various media. These products are related to ten day forecast of soil temperature and moisture, total daily value of solar radiation, insolation and evaporation, maximum and minimum air temperature and precipitation amount. In agrometeorology temperature sums are very important, estimated for four to seven days in advance, depending on the user's request. Specific requirements for products which could significantly improve the quality of agrometeorological information for users in the future are listed in this paper too.



**NUMERICAL WEATHER PREDICTION AT THE FACULTY OF SCIENCE,  
UNIVERSITY OF NOVI SAD**

VELIBOR ŽELI, ZORICA PODRAŠČANIN and BEATA BUKOSA

Faculty of Science, University of Novi Sad  
Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia  
*zeli.velibor@gmail.com*

**ABSTRACT**

At the Department of Physics, Faculty of Science, University of Novi Sad, students have learned the skill in running numerical weather forecast – WRF model. Both WRF cores (ARW and NMM) are being run daily over the region of Balkan peninsula with spatial resolution of about 10 km. The initial and boundary conditions for regional models are fed with NCEP GFS (global forecast system) output data. Both WRF model cores start their numerical procedure with the midnight GFS output data and run for the next 96 hours. The model outputs are saved every 3 hours. Fully operational weather forecast procedure is obtained in October 2014. Information after the postprocessing procedure are available at the official web page of Department of Physics, Faculty of Science, University of Novi Sad. Information is available in the form of 3-hourly meteograms for 63 cities and meteorological maps in our domain of Balkan peninsula.

We performed two test cases with WRF model. The model verification was attained for the surface temperature BIAS compared with observed values for time period of the April 2015. We used the same model set-up for the reconstruction of the weather situation for the extreme precipitation event for the May 2014. Our particular interest was in forecasting the amount of precipitation.

## **IZAZOVI GOVORNE KOMUNIKACIJE S KORISNICIMA U ZRAKOPLOVNOJ METEOROLOGIJI**

VINKO ŠOLJAN, JADRAN JURKOVIĆ i IGOR KOS

Hrvatska kontrola zračne plovidbe d.o.o.  
Rudolfa Fizira 2, 10150 Velika Gorica, Zagreb- Zračna luka , Hrvatska  
*vinko.soljan@crocontrol.hr*

### **SAŽETAK**

Meteorološka konzultacija definira se kao rasprava s meteorologom ili drugom kvalificiranom osobom o postojećim i/ili očekivanim meteorološkim uvjetima koji se odnose na letne operacije. Rasprava uključuje pitanja i odgovore.

Premda su korisnicima (najčešće piloti ili ostalo osoblje koje planira let) dostupni razni zrakoplovni meteorološki produkti, nerijetko se traži preciznija informacija o meteorološkim uvjetima na ruti. Korisnik predstavi planirani termin, rutu leta, način letenja, i eventualne specifične zahtjeve, a licencirani zrakoplovni prognostičar mu odgovara kakvi će biti očekivani meteorološki uvjeti. Pri tom je važno da prognostičar daje svoje stručno mišljenje samo o meteorološkoj situaciji a ne o tome hoće li se let moći provesti ili ne. Pilot je taj koji treba poznavati svoja ograničenja, kao i ograničenja svog zrakoplova, te na osnovu informacija dobivenih konzultacijama donijeti konačnu odluku o provođenju leta.

Nekada je na skoro svakom aerodromu bio dostupan prognostičar, te je u radno vrijeme aerodroma bilo moguće obaviti direktne konzultacije. Zbog tendencije centralizacije prognostičkih službi u svijetu a i kod nas, sve se više koriste telefonske konzultacije, što predstavlja poseban izazov za prognostičare.

Ključna stvar dobre govorne komunikacije je da korisnik dobro primi poruku, odnosno da ona odgovara poslanoj poruci. Također je važno da je usluga konzultacija ujednačena, tj. da što manje zavisi o u tom trenutku dežurnom prognostičaru.

Poster prezentira uobičajeni tijek konzultacija, neke od mogućih problema kao i preporuke za ostvarivanje optimalne komunikacije meteoroloških informacija korisniku.

## **NUMERICAL MODELING OF METEOROLOGICAL TSUNAMIS**

MAJA BUBALO, IVICA JANEKOVIĆ i MIRKO ORLIĆ

Andrija Mohorovičić Geophysical Institute, Department of Geophysics, Faculty of Science,  
University of Zagreb  
Horvatovac 95, 10000 Zagreb, Croatia  
*mbubalo@gfz.hr*

### **ABSTRACT**

Meteorological tsunamis are sea level oscillations with periods similar to those of tsunamis, but are of meteorological origin and are usually caused by a travelling air pressure disturbance. Stari Grad on the island of Hvar is one of the most affected locations in the Adriatic Sea and it was the focus of this study. Numerical modelling was done using SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model), which is based on unstructured grids. The model domain encompassed the entire Adriatic Sea, and meteorological forcing had the shape of a boxcar function travelling in an eastward direction. The results indicated that Proudman resonance takes place in the open Adriatic for velocities of the air pressure disturbance exceeding  $26 \text{ ms}^{-1}$  whereas the bay's funnel shape causes amplification for all velocities. The ratio of wave height inside and in front of the bay for different velocities and durations of the disturbance suggested the possibility of resonance and damping taking place in the bay.

**NUMERICAL SIMULATIONS OF FOG FORMATIONS  
OVER THE ZAGREB AREA**

MAJA TELIŠMAN PRTENJAK, MARTIN KLAIĆ, JOAN CUXART, MARKO KVAKIĆ,  
KARMEN BABIĆ, DARKO KORAČIN and AMELA JERIČEVIĆ

Andrija Mohorovičić Geophysical Institute, Department of Geophysics, Faculty of Science,  
University of Zagreb  
Horvatovac 95, 10000 Zagreb, Croatia  
*telisman@gfz.hr*

**ABSTRACT**

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 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 runs.

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 trajectories and simulations of the water vapor dispersion (a passive scalar in the atmosphere) by the FLEXPART Lagrangian particle dispersion model driven by the WRF output.

## THE SENSITIVITY TESTS OF A SEA BREEZE AND MOIST CONVECTION INTERPLAY OVER THE NORTHEASTERN ADRIATIC COAST

GABRIJELA POLJAK, MAJA TELIŠMAN PRTENJAK, MARKO KVAKIĆ, KRISTINA ŠARIRI and ŽELJKO VEČENAJ

Andrija Mohorovičić Geophysical Institute, Department of Geophysics, Faculty of Science,  
University of Zagreb  
Horvatovac 95, 10000 Zagreb, Croatia  
*poljakica555@yahoo.com*

### ABSTRACT

The study investigates the sensitivity of the high-resolution mesoscale atmospheric model by the model reproduction of the combined large-scale wind and thermally induced local wind (i.e. sea breeze) on the moist convection development. The area of the interest is Istria, the largest peninsula in the north-eastern Adriatic.

The three chosen cases were simulated by the Weather and Research Forecasting (WRF-ARW) model at three (nested) model domains with the 1.5 km horizontal grid spacing in the innermost domain. The sensitivity tests were made varying (i) the model setup, (ii) the sea surface temperature (SST) distribution and (iii) the model topography. The first set of the simulations, over the 3 summer 1.5 day periods were carried out through the modification of the model setup, varying microphysics and the boundary layer parameterizations.

The SST distribution has two representations in the model: a weakly time-varying SST field (every 6 hours) from the ECMWF skin temperature analysis and a varying SST field provided by hourly geostationary satellite data. The same events were simulated with the modified topography but without the largest mountains along Istria in the smallest domain when the mountain heights were reduced to 30 % of the initial height. A comprehensive set of the numerical experiments was statistically analyzed in a several ways: by the standard statistical measures, the image moment analysis approach and the spectral method.

The results of the each model setup were compared with available measurements, which were provided by the standard station measurements and each of these approaches showed optimal combination of the model schemes. The SST variations revealed the effect on the lowermost variations in the boundary layer and on the evolution of the turbulent fluxes, sea breeze cells and cumulonimbus clouds. The modified topography exposed variations in the origin, timing and the amount of the convective activity as well as on the sea breeze evolution and dimensions.

## **ANALIZA INDEKSA NESTABILNOSTI ATMOSFERE NA TEMELJU RADIOSONDAŽA I DETEKCIJE MUNJA**

MARTINA ČURIĆ, TOMISLAV STILINOVIĆ i MAJA TELIŠMAN PRTENJAK  
*tina242211@gmail.com*

### **SAŽETAK**

Indeksi nestabilnosti su pokazatelji stanja atmosfere pogodnih za nastanak i razvoj konvektivnih oblaka, sustava i popratnih pojava. Vrijednosti indeksa nestabilnosti povezane su s vjerojatnošću pojave konvektivnog razvoja i postoje granične vrijednosti koje određuju stabilno ili nestabilno stanje atmosfere.

Proučavani su indeksi nestabilnosti na području Zagreba, Zadra, Beča, Budimpešte, Szegeda, Udina i San Pietro Capofiume-a za sedmogodišnje razdoblje od 1. siječnja 2007. do 31. prosinca 2013. godine te su promatrani indeksi povezani s podacima detekcije električnih pražnjenja.

Granice nestabilnosti određene su metodom distribucije frekvencija, a za podnevne podatke dobivene su zadovoljavajuće vjerojatnosti za uspješnu prognozu konvekcije. Režimi vremena povezani s pojavom električnog pražnjenja su oborinski režim i bezgradijentsko strujanje, dok su režimi koji uključuju formacije visokog tlaka rijetko povezani s konvekcijom. Najčešći tip strujanja za dane s pražnjenjem je JZ tip. Najveće srednje vrijednosti CAPE i LI indeksa pojavljuju se kod bezgradijentskog strujanja i oborinskog režima. K i TPW indeksi povezani su s bezgradijentskim strujanjem, dok se najveće srednje vrijednosti SWEAT indeksa javljaju u oborinskom režimu. SWEAT indeks povezan je i sa SW tipom strujanja.

Provođenje ovakvih istraživanja je od izuzetne važnosti iz razloga što bi mogućim razvojem određenih metoda pravovremenog uočavanja nepovoljnih uvjeta mogli pravovremeno intervenirati i pokušati umanjiti moguće štete od olujnih nevremena.

**EVALUATION OF LOCAL SIMILARITY THEORY FOR STABLE  
CONDITIONS NEAR KUTINA, CROATIA**

KARMEN BABIĆ, MATHIAS W. ROTACH and ZVJEZDANA BENCETIĆ KLAJIĆ

Department of Geophysics, Faculty of Science, University of Zagreb  
Horvatovac 95, 10000 Zagreb, Croatia

*babick@gfz.hr*

**ABSTRACT**

In this study we investigate the applicability of Nieuwstadt's (1984) local scaling formulation for the stable boundary layer using the data from a 62 m tall tower (levels 20, 32, 40, 55 and 62 m above ground) within a small forest patch situated in the vicinity of town Kutina in heterogeneous terrain with agricultural land, forested hills, industrial and urban surfaces in different upwind sectors. We only analyze periods with stable stratification from winter 2008/2009 focusing on the influence of different wind directions, accounting for different surface characteristics, and different wind regimes. The large-scale forcing was classified into three wind regimes, namely, weak, intermediate and strong winds. We adopt local scaling approach for which similarity functions and the local stability parameter are based on local fluxes at measurement height. In the data analysis the role of self-correlation is examined. Values of scaled standard deviation for wind components in near-neutral conditions are found to be lower at the lowest measurement level and higher at upper levels in comparison to canonical Kansas values. The non-dimensional gradient of wind velocity is also investigated. It is found that the stability function for momentum supports the linear equation only up to values of the non-dimensional stability parameter  $\zeta = 0.5$ . Moreover, we find good agreement between our results and the Beljaars and Holtslag function, which increases more slowly with increasing stability. Our analysis supports the validity of  $z$ -less stratification for very stable conditions ( $\zeta > 1$ ) for scaled wind velocity variances and correlation coefficients for momentum and heat flux. As a preliminary conclusion it is found that local scaling is promising even over highly non-homogeneous terrain as in our case.

# THE AEROSOL OPTICAL PROPERTIES IN RELATION TO INFLOWING AIR MASSES OVER EUROPE

AGNIESZKA ZDUN

Polish Academy of Sciences, Institute of Oceanology  
Powstancow Warszawy 55, 81-712 Sopot, Poland

*zdun@iopan.gda.pl*

## ABSTRACT

The atmospheric aerosols are an important component of the atmosphere. Through their direct (extinction) and indirect (the modification of clouds microstructure) interaction with solar radiation and the Earth's thermal radiation they affect radiative balance of the atmosphere and stimulate the global climate variability. Aerosols are also a crucial problem from remotely sensed imagery. The optical characteristics of aerosols in the atmosphere are necessary to provide an estimate of the atmospheric correction. Aerosol optical properties depend on aerosol sources and phenomenon take place along the air path to the measurement station. They can also be modified by various processes such as wet and dry deposition, chemical processes, secondary aerosol nucleation and aerosol growing.

The aim of the poster is to present the influence of advection of different air masses on optical properties of aerosols (i. e. aerosol optical thickness at  $\lambda=500$  nm and Angström coefficient for  $\lambda=440-870$  nm, which can be considered as an indicator of spectral behaviour of the aerosol optical depth) as well as to illustrate influence of the meteorological factors along the air trajectory on changability of the optical characteristics of aerosols in the Baltic Sea region. The aerosol optical properties were obtained from ground network of sun-sky radiometers AERONET. The backward trajectories of air advected to the Gotland station at different heights were calculated by the HYSPLIT model. To group the transport paths of similar history and origin, cluster analysis was performed.