ZNANSTVENI IZAZOVI: KAKO DOLAZI DO PROMJENE VERZIJE MODELA U OPERATIVI

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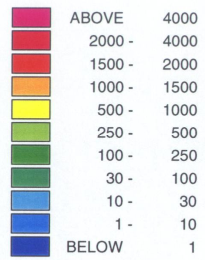
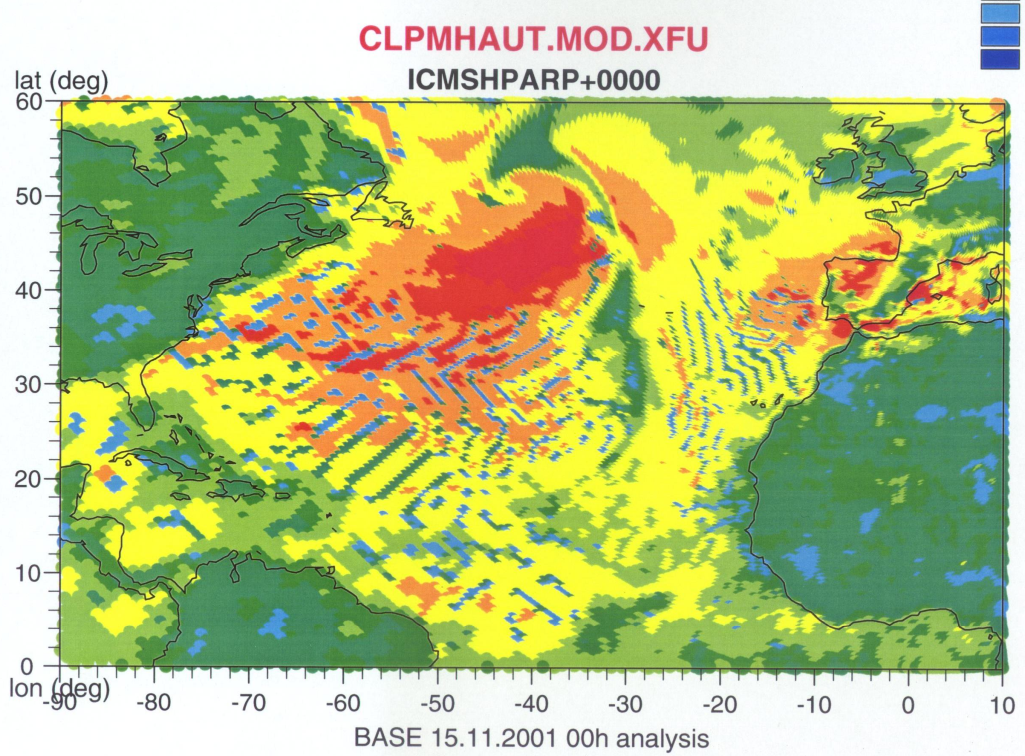
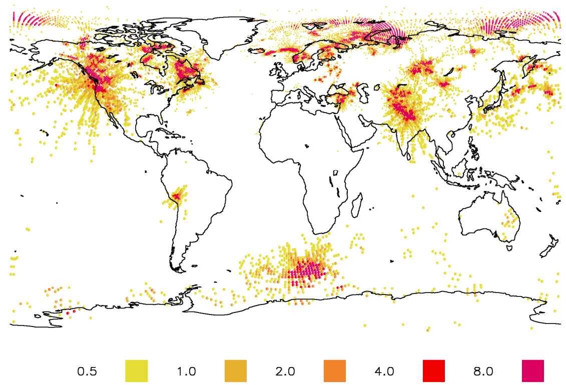
Visina PBL-a (2000-2001) i nestabilnost (2002-2003)

Na temelju Ri broja:
- prevelika promjenjivost
- pokazuje nestabilnost







$$A = \frac{1}{2} \left| T(t + \Delta t) + T(t - \Delta t) - 2T(t) \right|$$

Tudor (2013) GMD
Nestabilnost povezana sa različitom brzinom padanja i isparavanja kapi vode i čestica leda.

Prema Ayotte (1996) $h_{CLA} = \min(z)$ gdje je $\theta_V(z) \geq \frac{1}{z} \int_0^z \theta_V(z)\, dz + \chi_0$

Dinamička adaptacija polja vjetra

Tudor i Ivatek-Šahdan(2002) HMČ, Ivatek-Šahdan i Tudor (2004) MetZeit
Za uspješnu prognozu epizoda bure nastalih zbog međudjelovanja sinoptičkog polja tlaka sa lokalnom konfiguracijom terena dovoljna je 30 minutna dinamička adaptacija na 2km rezoluciju s parametrizacijom turbulencije.

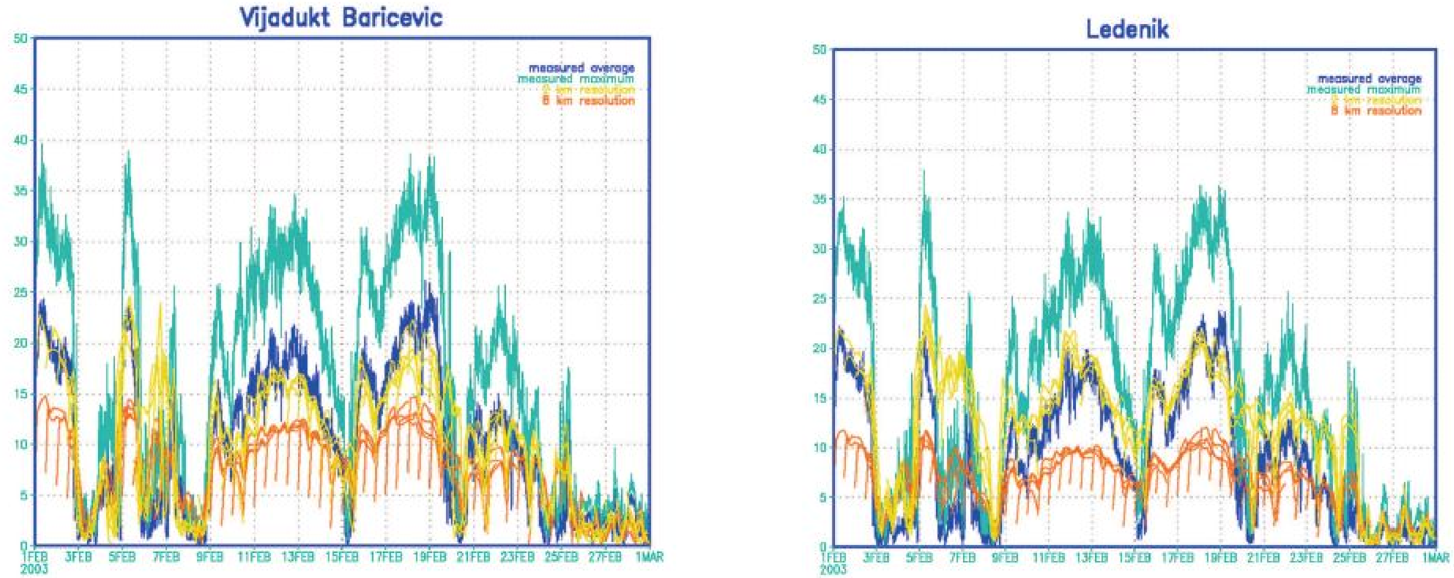
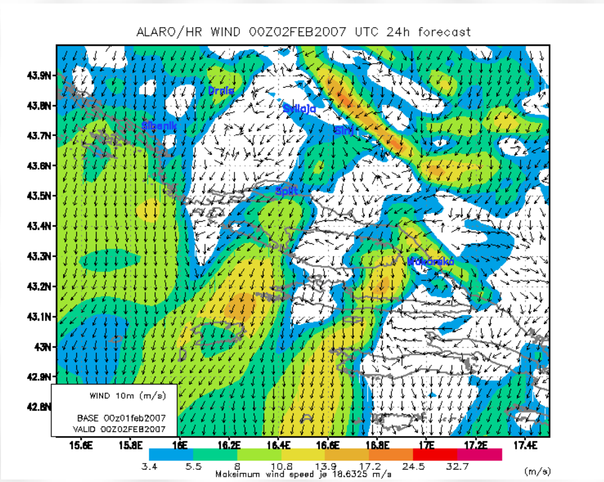
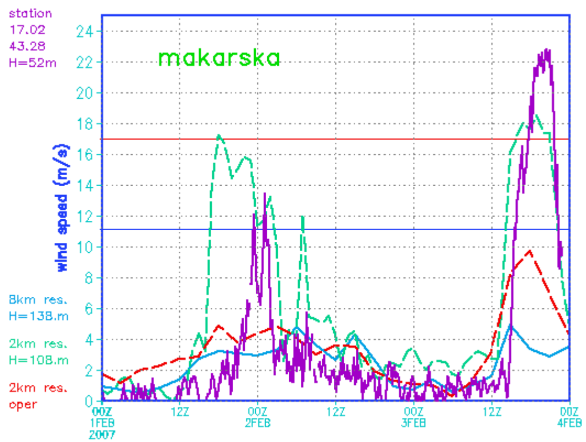
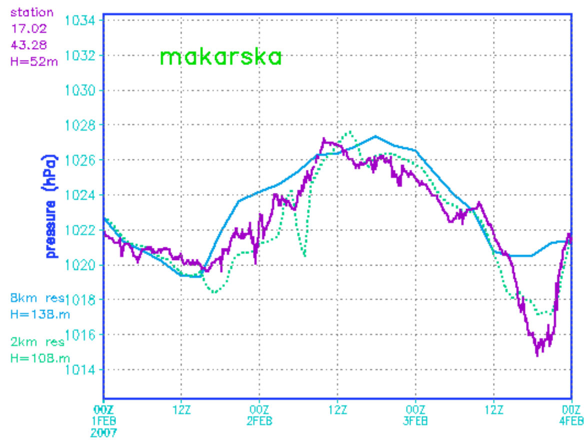


Figure 6: Measured wind speed for the Baricevic Viaduct (left) and the Ledenik Tunnel (right) automatic stations and modeled data from the closest model point for February 2003. Measured 10 min average wind speed (dark blue), 10 min maximum (light blue), all model forecasts for February 2003 (00 and 12 UTC runs) with 8 km resolution (orange) and 2 km resolution operational dynamical adaptations (yellow). The 2 km resolution predicts the occurrence and strength of the 10 min average wind speed well.

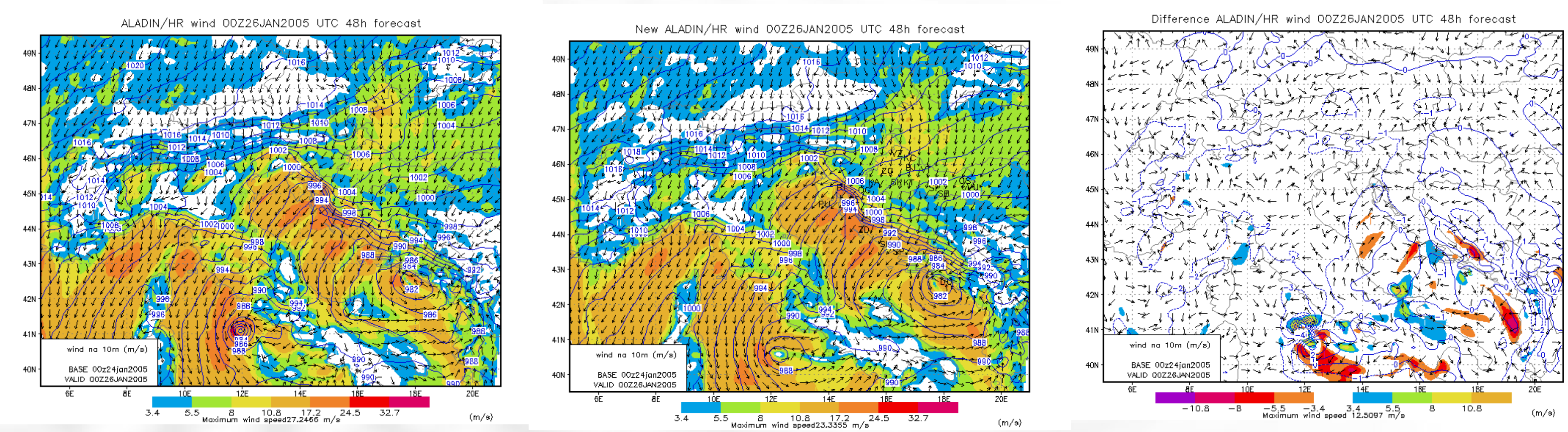
Tudor i Ivatek-Šahdan (2010) MetZeit
Za uspješnu prognozu kratkotrajnih epizoda bure nastalih zbog lokalnog dinamičkog razvoja (a ne samo prlagodbe polja vjetra terenu) potreban je "full-run" s nehidrostatskom dinamikom – operativan na 2km rezoluciji od 1. srpnja 2011.







Semi-Lagranžijanska horizontalna difuzija (SLHD) popravlja intenzitet i položaj jedne ciklone, dok dobro prognozirana ciklona ostaje neizmjenjena, uz to se poboljšava prognoza magle u dolinama za vrijeme anticiklone (Tudor,Tutiš,Drvar,Stiperski,Vana,2005,HMČ).

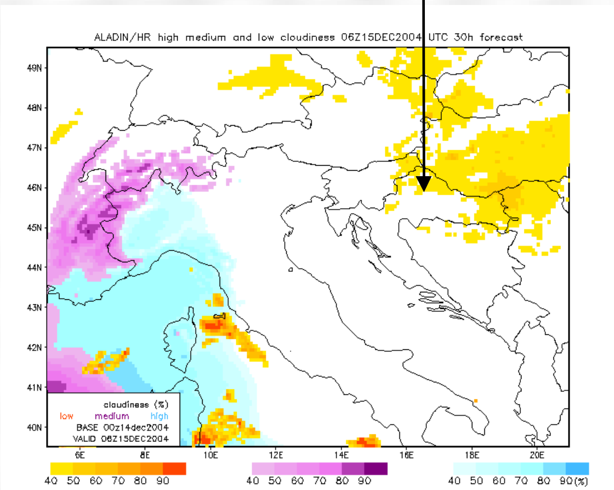


Vjetar na 10m i tlak sveden na srednju razinu mora dobiven numeričkom difuzijom (lijevo), SLHD (sredina) i razlika (desno), 48 satna prognoza s početkom u 00 UTC 24. siječnja 2005.

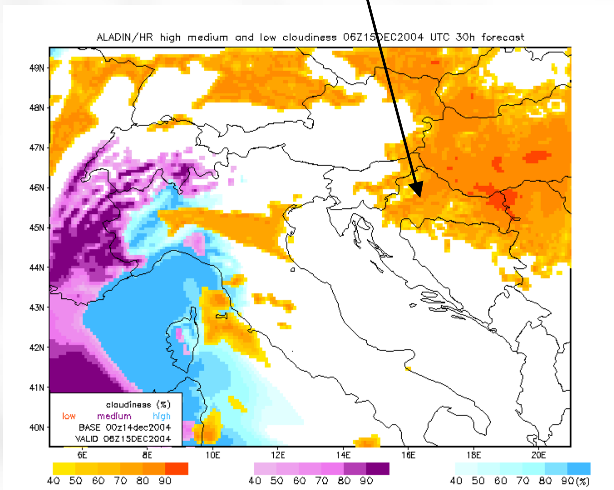
Naoblaka i zračenje (2005)

Alternativna kombinacija naoblake i zračenja poboljšava prognozu magle i niskih stratusa za Hrvatsku (Tudor, 2010, MAP).

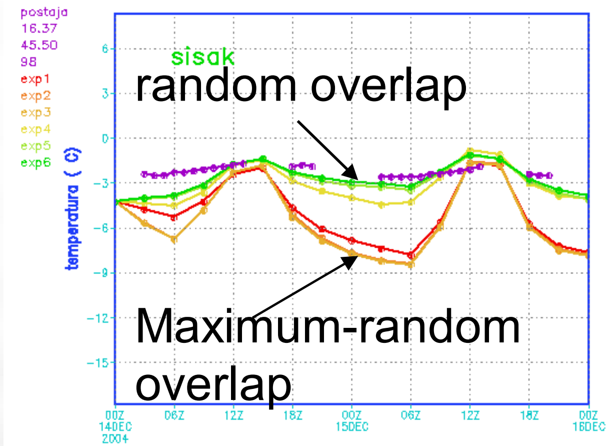
Nedostaje magle i niskih oblaka



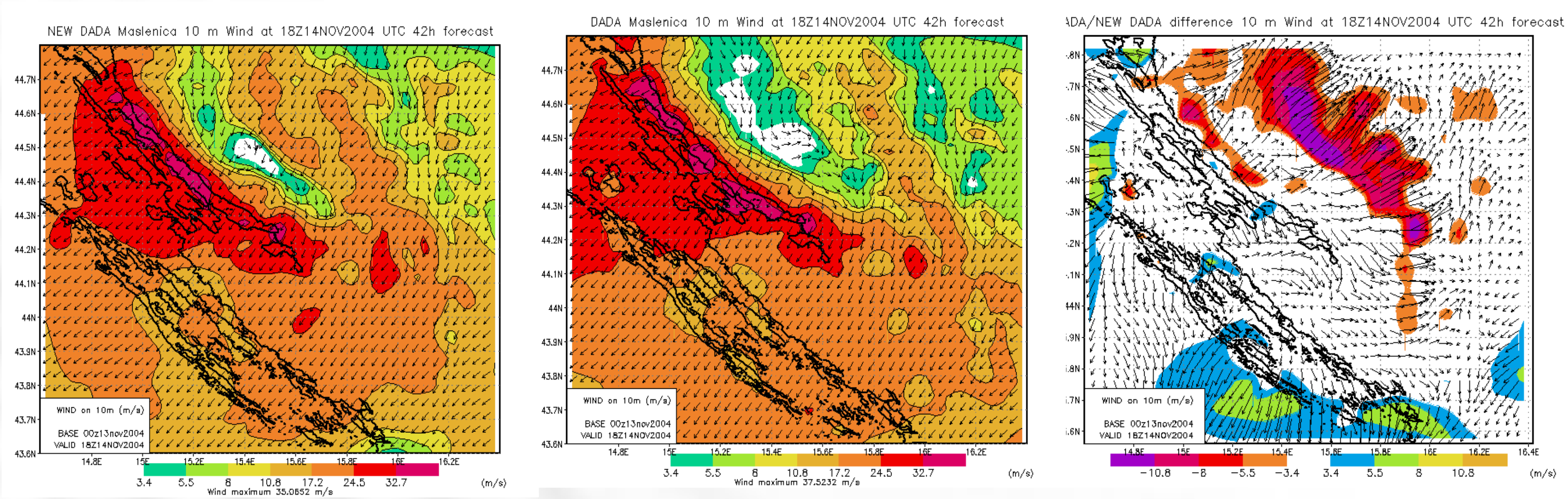
Random overlap



Temperatura na 2m
- mjerena
- prognoze sa različitim opcijama



Uklanjanje ovojnice i izmjene u parametrizaciji gravity wave drag značajno mijenja prognozirano polje vjetra.



Prognozirana brina vjetra 10m nad tlom sa envelope (lijevo) bez (sredina) i razlika (desno) u 2km rezoluciji, 42 satna prognoza s početkom u 00 UTC 13. studenog 2004 (Drvar, Stiperski, Tudor, Tutiš, 2005, HMČ).

Phasing - Advekcija/difuzija GFL prognostičkih polja (2003)

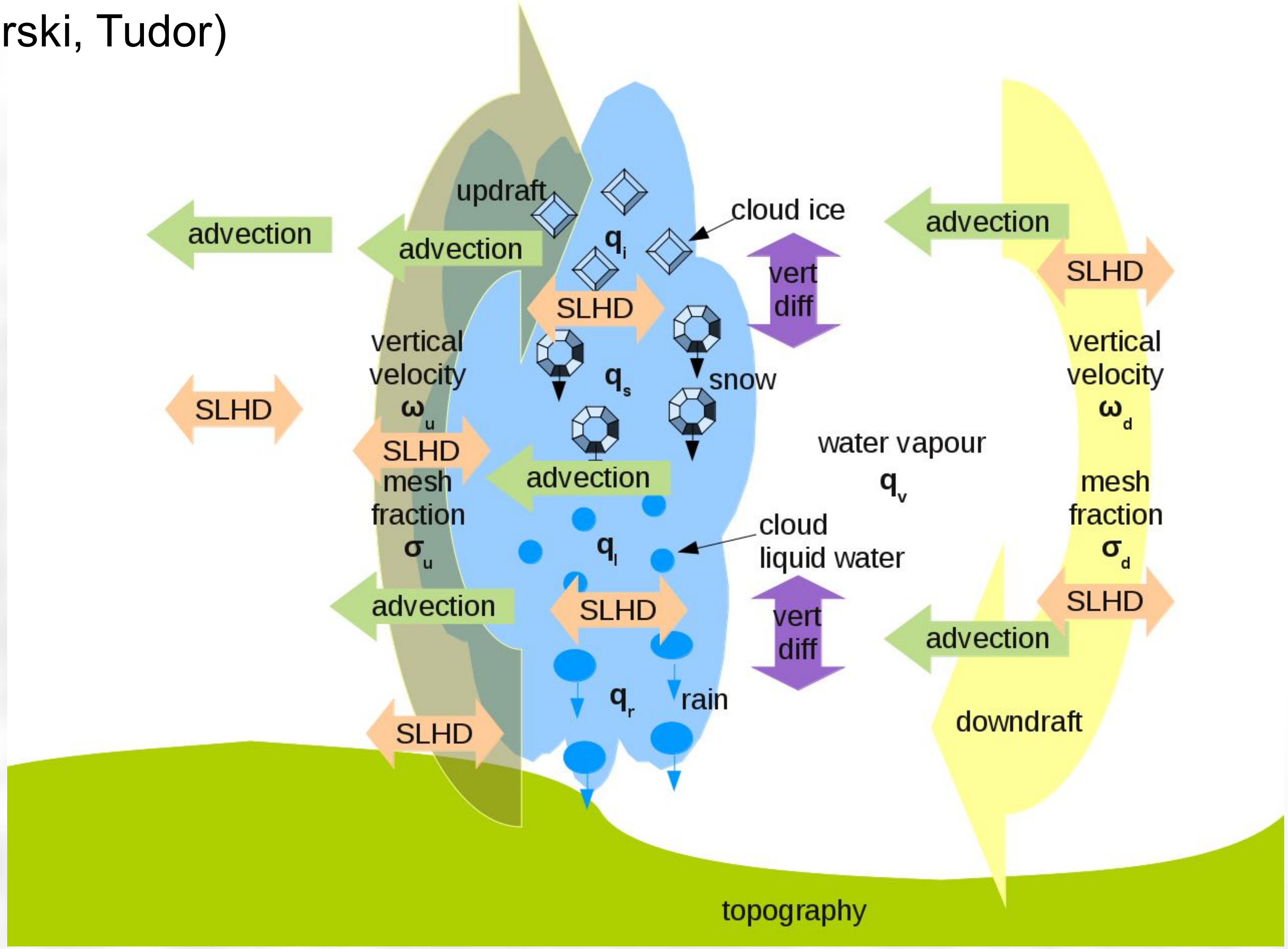
GFL: q_v, q_l, q_i, q_r, q_s, TKE, ω_u, ω_d, σ_u, σ_d, …

```
YTKE_NL%LADV=.TRUE., ! advektiramo
YTKE_NL%LCDERS=.FALSE., ! Ne računamo horiz. derivacije
YTKE_NL%LGP=.TRUE., ! Isključivo grid-point polje
YTKE_NL%LGPINGP=.FALSE., ! Ne čitamo kao gridpoint polje
YTKE_NL%LHV=.FALSE., ! Hermite interp. U vertikali
YTKE_NL%LQM=.FALSE., ! Monotone interpolacije
YTKE_NL%LQMH=.FALSE., ! Horiz. Monotona interp.
YTKE_NL%LREQOUT=.T., ! ispisujemo
YTKE_NL%LSLHD=.T., ! radimo horizontalnu difuziju
YTKE_NL%LSP=.FALSE., ! Ne koristi spektralni transform
YTKE_NL%LT5=.FALSE., ! Za 4Dvar
YTKE_NL%LVSPLIP=.F., ! spline interpolacija u vertikali (samo O3)
YTKE_NL%NCOUPLING=0, ! Bez lateralnih rubnih uvjeta
YTKE_NL%NREQIN=0, ! Ne čita iz ulazne datoteke
```

Definiramo tretman prognostičkih polja u ovisnosti o tome da li su dostupna u ulaznim datotekama, te za što ih koristimo u modelu.

Prognostička konvekcija (2005, 2006)

(Stiperski, Tudor)



AROME (2004)

Analiza numeričke stabilnosti modela te svojstava jednadžbi, metode izračunavanja doprinosa različitih procesa, zakoni sačuvanja etc.

- if DELT - mixing length is determined by vertical resolution

$$L_l = z_{\bar{l}+1} - z_{\bar{l}}$$

- if DEAR - mixing length is first computed from vertical resolution

$$L_l = z_{\bar{l}+1} - z_{\bar{l}}$$

and afterwards it is limited by stability according to Deardorff formulation

$$\theta_v = \theta \frac{1 + \frac{R_v}{R_d} r_v}{1 + r_v + r_c + r_r + r_i + r_s + r_g}$$

where $\frac{1}{2}\left(\frac{\theta_{vl+1}-\theta_{vl}}{\Delta z_{l+1}} + \frac{\theta_{vl}-\theta_{vl-1}}{\Delta z_l}\right)\frac{g}{\theta_{vref}} > 0$

$$L = min\left(L, 0.76\left(\frac{TKE}{\frac{1}{2}\left(\frac{\theta_{vl+1}-\theta_{vl}}{\Delta z_{l+1}} + \frac{\theta_{vl}-\theta_{vl-1}}{\Delta z_l}\right)\frac{g}{\theta_{vref}}}\right)^{\frac{1}{2}}\right)$$

- if BLKR - mixing lenth is first set to 100 and afterwards (the initialization with 100 is actually not neccesary)

$$L_l = \alpha \frac{l_0\left(\frac{1}{2}(z_{\bar{l}+1} + z_{\bar{l}}) - z_b\right)}{l_0 + \alpha\left(\frac{1}{2}(z_{\bar{l}+1} + z_{\bar{l}}) - z_b\right)}$$

where $\alpha = \frac{1}{2}^{-\frac{3}{2}}$ and $l_0 = 100$.

- if KEPS K-ϵ mixing length is calculated

$$L_l = C_d \frac{TKE^{\frac{3}{2}}}{\epsilon}$$

– dissipative lenths is first set equal to the mixing length an afterwards corrected in the surface layer (only?) by Monin-Obukhov if ORMC01 (this is hardcoded to false for Arome).

Jednadžbe modela (Catry et al. 2007, Tellus)

Za temperaturu

$$\begin{aligned}\frac{\partial T}{\partial t} + \vec{u}_a \cdot \nabla T &= \frac{1}{\rho C_p}\frac{dp}{dt} + \frac{1}{C_p}\dot{Q}_i + \frac{1}{C_p \rho}\sigma_{\alpha\beta}\frac{\partial u_\beta}{\partial x_\alpha} \\ &- \delta_m \frac{P}{C_p \rho^2}\frac{\partial p}{\partial z} - \frac{1}{C_p}((1-\delta_m)C_{pd}\frac{P}{\rho}\frac{\partial T}{\partial z} - C_{prec}\frac{P}{\rho}\frac{\partial T}{\partial z}) \\ &- \frac{1}{\rho C_p}(L_{21}(\dot{\rho}_2 + \dot{\rho}_3) + L_{41}(\dot{\rho}_4 + \dot{\rho}_5))\end{aligned}$$

ovog člana nema u AROME

$$\frac{\partial q_k}{\partial t} + \vec{u}_a \cdot \nabla q_k = \frac{\dot{\rho}_k}{\rho} - \delta_m \frac{q_k}{\rho}\frac{\partial P}{\partial z}$$

Za vodenu paru, vodene kapi i kristale leda u oblaku, kišu i snijeg.

Prediktor-korektor shema s parametrizacijama (2003)

Jednadžbe su razdvojene na linearne i nelinearne članove te fizikalne parametrizacije.
Linearni doprinos se izračunava implicitno
Nelinearni iterativno

Predictor

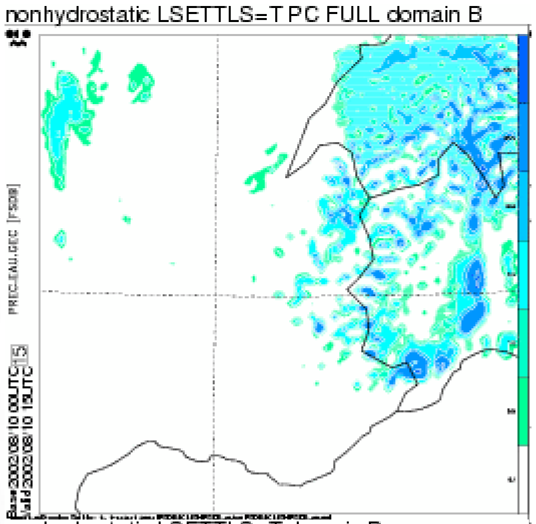
$$\frac{X_{Apred}^{t+\delta t}-X_O^t}{\delta t} = L(\frac{X_{Apred}^{t+\delta t}) + X_O^t}{2})+N(X_M^{t+\frac{\delta t}{2}})+\phi(X_O^t)$$

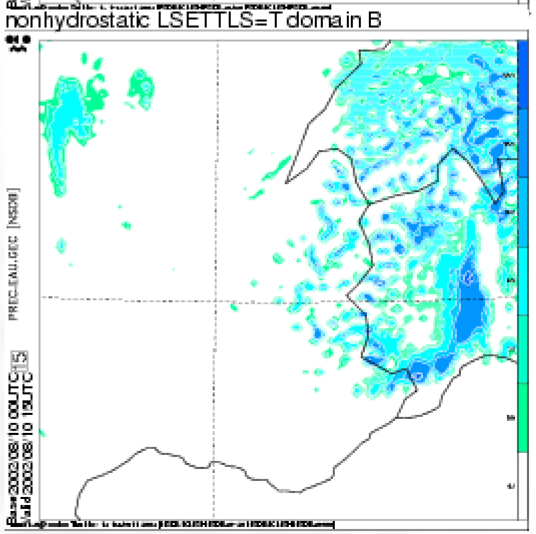
Corrector

$$\frac{X_{Acorr}^{t+\delta t}-X_O^t}{\delta t} = L(\frac{X_{Acorr}^{t+\delta t}+X_O^t}{2})+\frac{N(X_{Fpred}^{t+\delta t})+N(X_O^t)}{2}+\phi(X_O^t)$$

we can use $\phi(X_O^t)$, $\phi(X_A^t)$ or $\frac{\phi(X_O^t)+\phi(X_A^t)}{2}$

Položaj O točaka i fizikalne tendencije u njima se izračunavaju iterativno.





Stratiform precipitation, 5 km res, Alps, 10th Aug 2002.

Doprinosi modela u početnoj (O) I završnoj (F) točki semi-lagranžijanske putanje se kombiniraju radi povećanja preciznosti modela

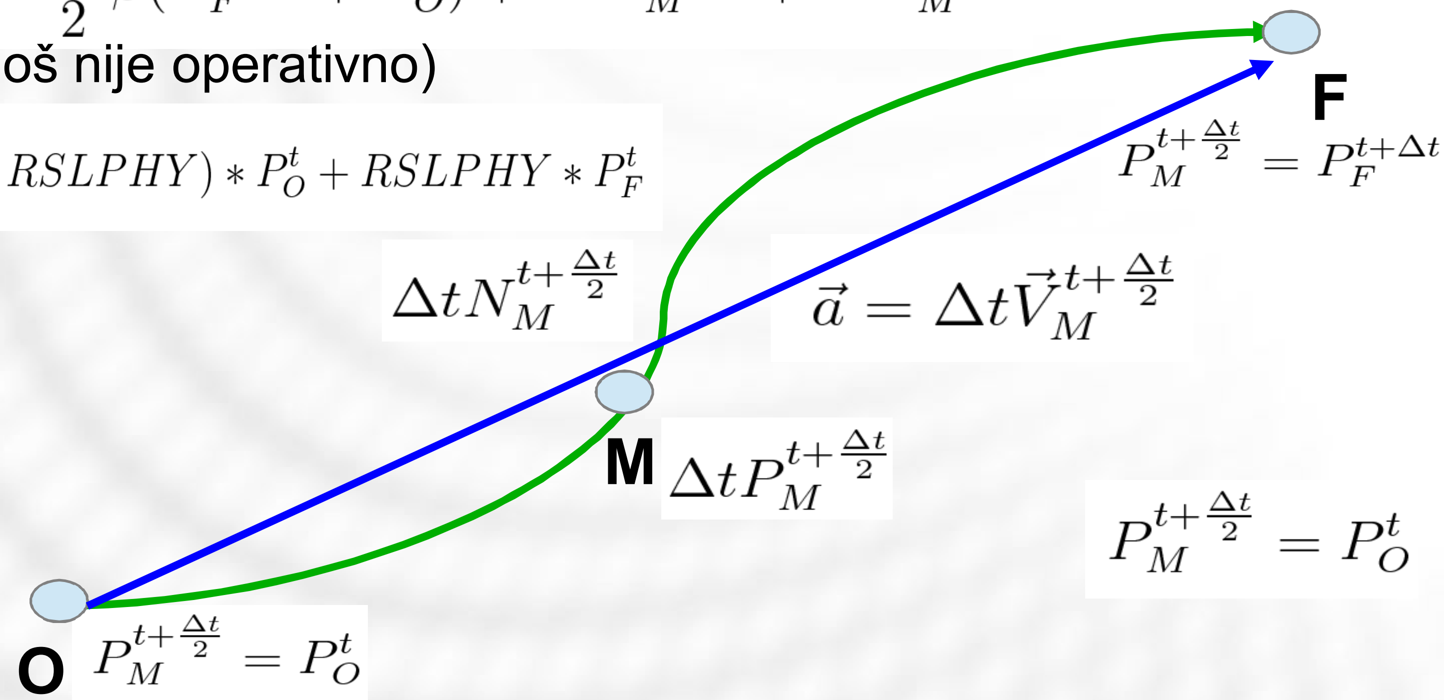
$$\psi_F^{t+\Delta t} - \psi_O^t = \frac{\Delta t}{2}(B_F^{t+\Delta t} + B_O^t) + \frac{\Delta t}{2}(N_F^{t+\Delta t} + N_O^t) + \frac{\Delta t}{2}(P_F^{t+\Delta t} + P_O^t)$$

Ili se izračunavaju u središnjoj točki putanje

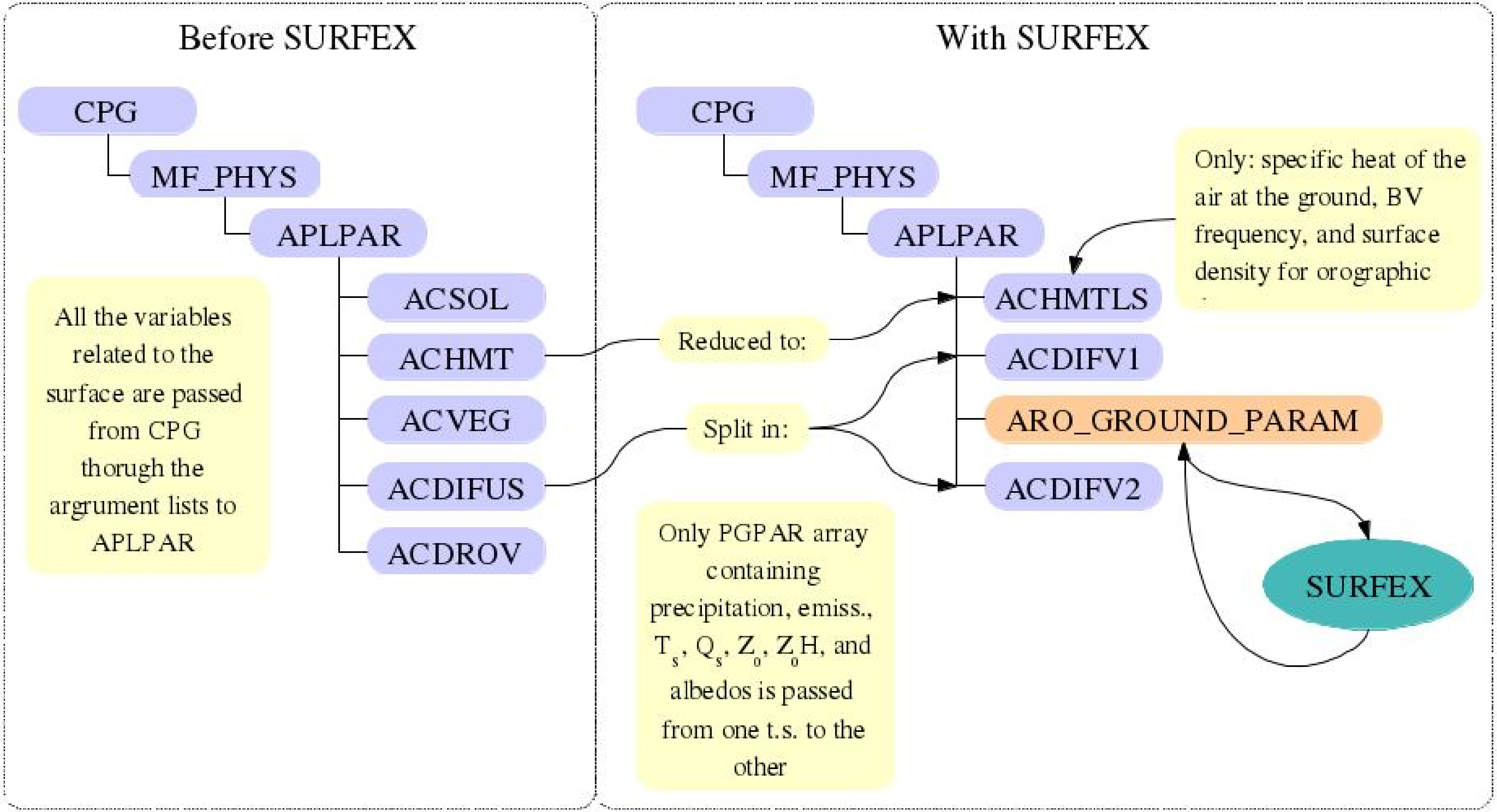
$$\psi_F^{t+\Delta t} - \psi_O^t = \frac{\Delta t}{2}\beta(B_F^{t+\Delta t} + B_O^t) + \Delta t N_M^{t+\frac{\Delta t}{2}} + \Delta t P_M^{t+\frac{\Delta t}{2}}$$

U ALADIN-u (još nije operativno)

$$\Delta t P_M^{t+\frac{\Delta t}{2}} = (1 - RSLPHY) * P_O^t + RSLPHY * P_F^t$$

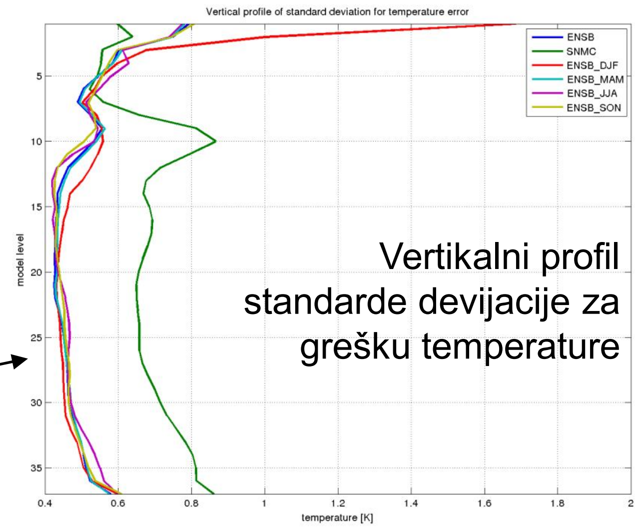


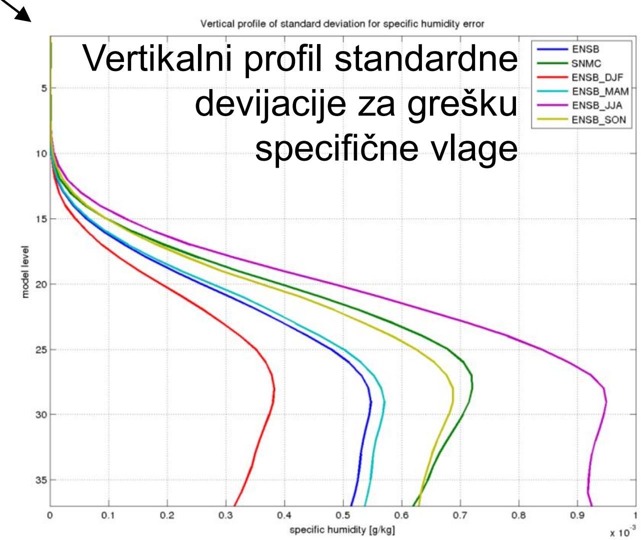
SURFEX (Lukša Kraljević 2005-2006)



ASIMILACIJA istraživanje

Stanešić, Horvath, Kovačić, Ivatek-Šahdan
Područja istraživanja:
- utjecaj mjerenja na analizu i prognozu – novi izvori (radar, GNSS-ZTD, sateliti…)
- **utjecaj načina proračuna B matrice na analizu i prognozu**
- Stanešić (2009) HMČ
- dizajn/podešavanje asimilacijskog sustava: ispravak pristranosti mjerenja, vrijeme između uzastopnih analiza, načini inicijalizacije, parametri površinske asimilacije (korelacije, oblik funkcije utjecaja)
- Asimilacija radarskih podataka u ALARO model

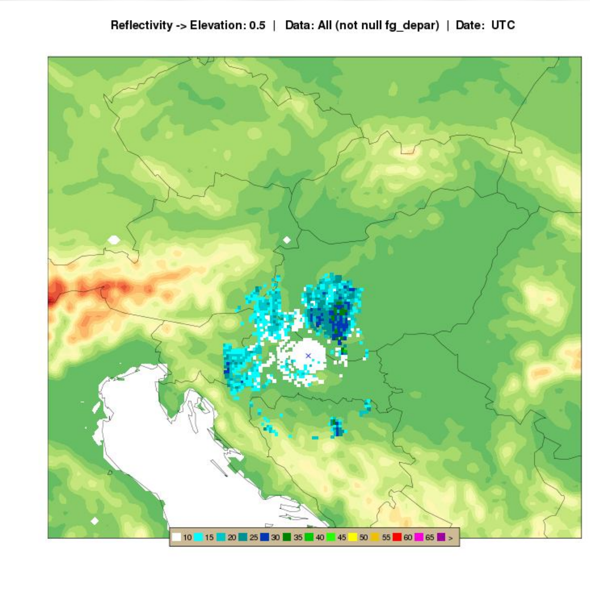


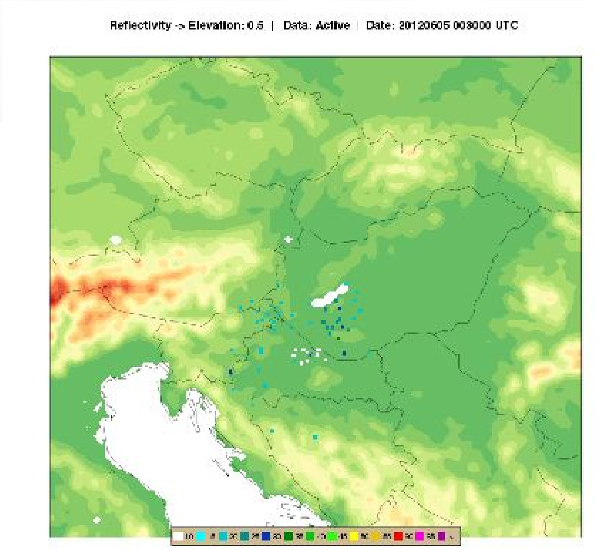


ASIMILACIJA radarskih podataka

Asimilacija radarskih podataka u ALARO

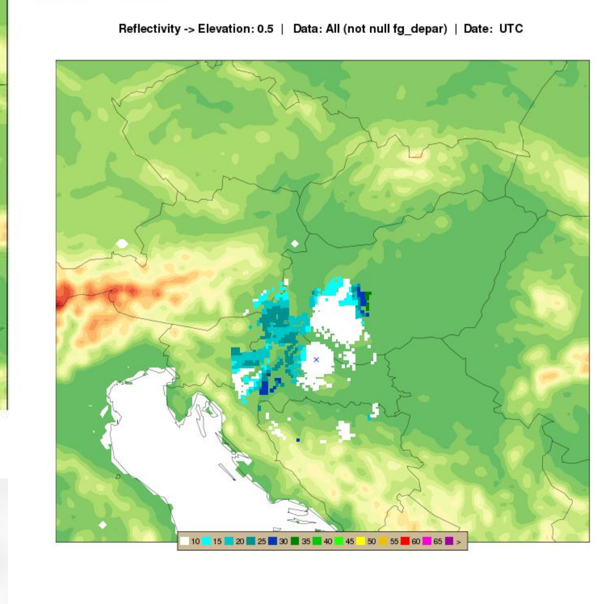
Mjerenja





Aktivni podaci

Model

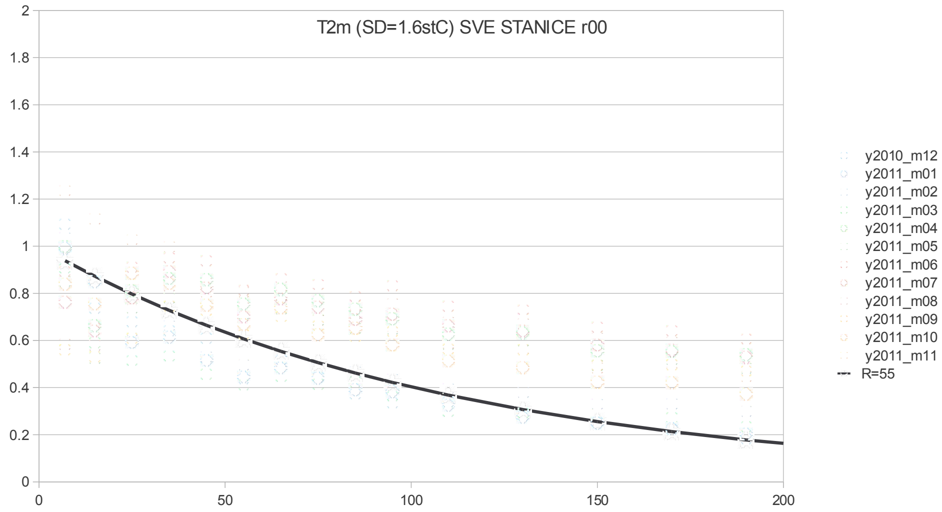


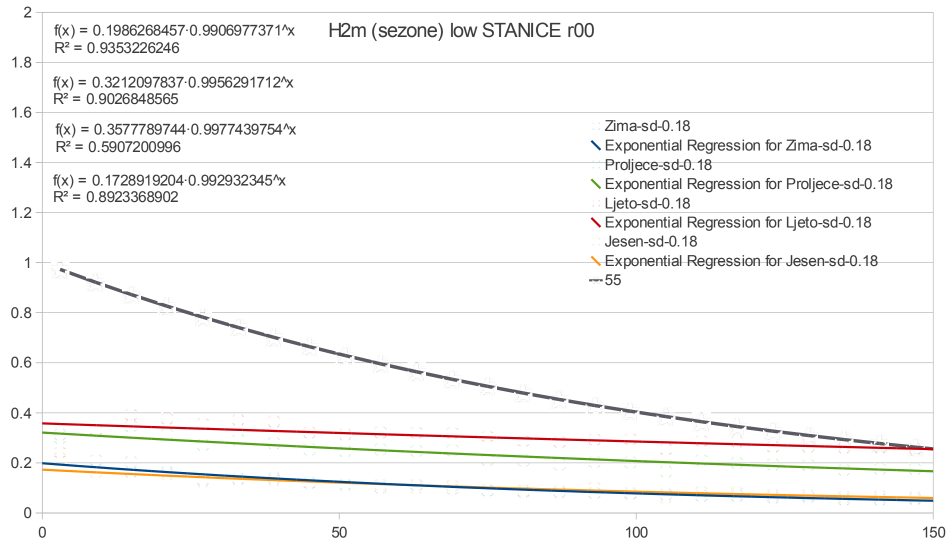
ASIMILACIJA prizemnih podataka

Određivanje koeficijenata korelacije odstupanja modela od mjerenja u ovisnosti o udaljenosti.

Postoji sezonska varijabilnost

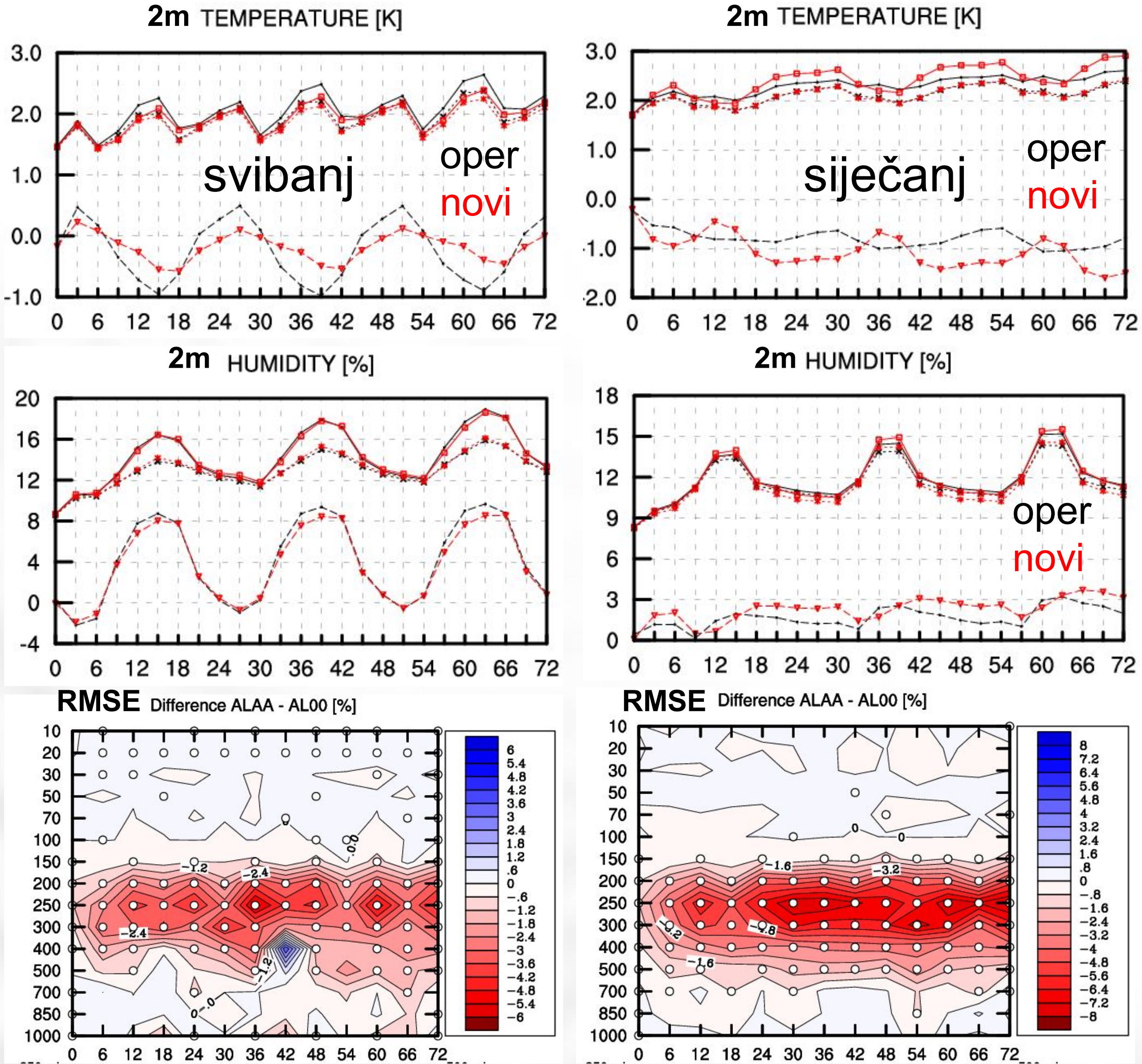
Promjenjena je funkcija kojom se izračunava koeficijent korelacije





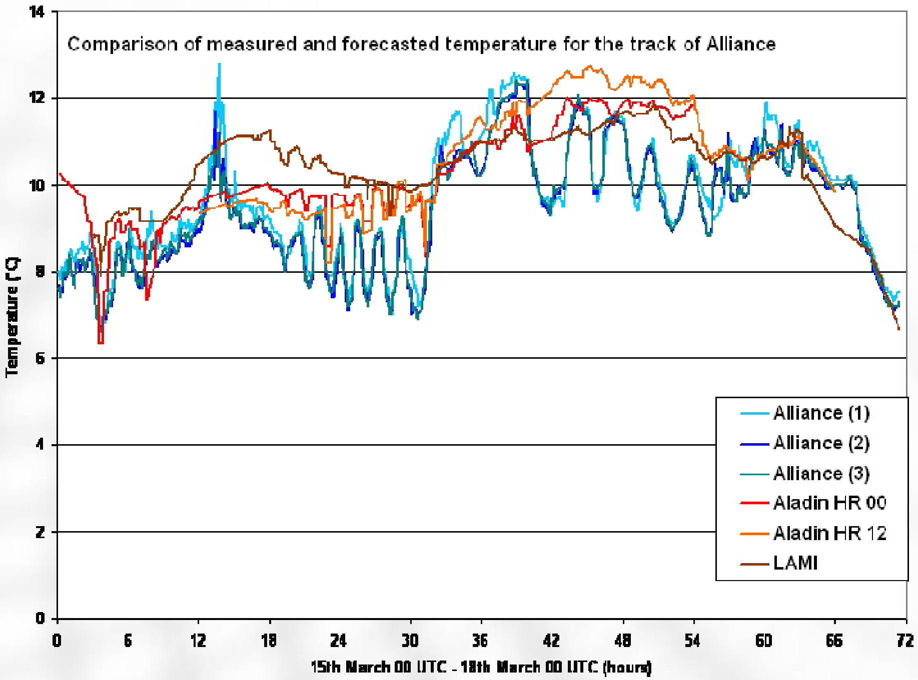
Pred-operativno testiranje (2014)

Testiranje modela
- specifične situacije (case study)
- dulja razdoblja
- kompletan novi cycle i doprinos novih komponenti zasebno
- tuniranje modela za lokalne potrebe



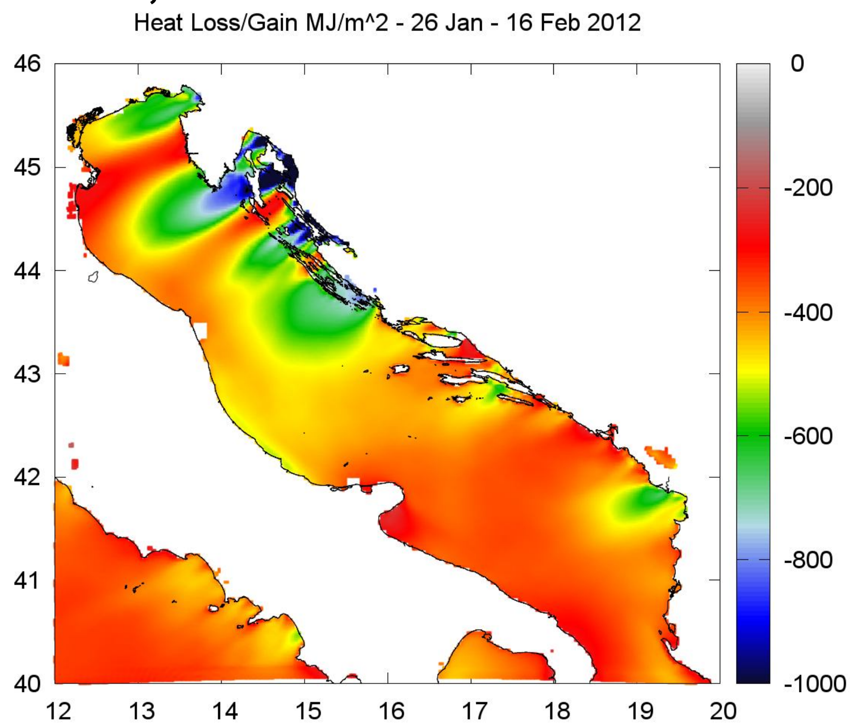
Međudjelovanje sa morem

DART



Martin et al. 2009 JGR
Bencetić et al. 2009 JMS
Rixen et al. 2009 JMS
Vilibić et al. 2009 JMS
Vanderbulcke et al. 2009 PiO
Tudor, M. 2009 HMČ

IOF, IRB



Mihanović et al. 2013 OS
Janeković et al. 2014 JGR

I još puno puno toga

Ali ne stane u 15 minuta ...