Karakteristike

turbulencije bure

HRZZ – CATURBO

Branko Grisogono i suradnici

PREGLED

- **Uvod :** suradnici, tema, motivacija
- **Plan rada:** podaci i obrada, turbulentni tokovi bure, TKE,
  modeliranje, prijenos i raspršenje…
- **Očekivani Rez:** znanost, studij, primjena, preporuke

Suradnici projekta

Maja Telišman-Prtenjak, *PMF: mezoskalna dinamika*

Amela Jeričević, *DHMZ: modeliranje i prijenos polutanata*

Danijel Belušić, *Monash Univ., Melbourne, Austral.: turbulencija, mezo-dinamika*

Željko Večenaj, *PMF: obrada podataka, turbulencija bure*

Antun Marki, *PMF: fizika atmosfere, admin.*

Stipo Sentić, *PhD student, NM, SAD (← IN, SAD): modeliranje*

Ključne riječi: *atmosfera, lom valova, atmosferski granični sloj, mezoskala, turbulentna kinetička energija (TKE, ili E), disipacija, energija vjetra, onečišćenje zraka, pitanja okoliša*

Tema natječaja: Temeljna istraživanja

Neslužbeni suradnici

Kristian Horvath, *DHMZ: WINDEX (SODAR, ultrasonični i klasični anemometri, modeliranje)*

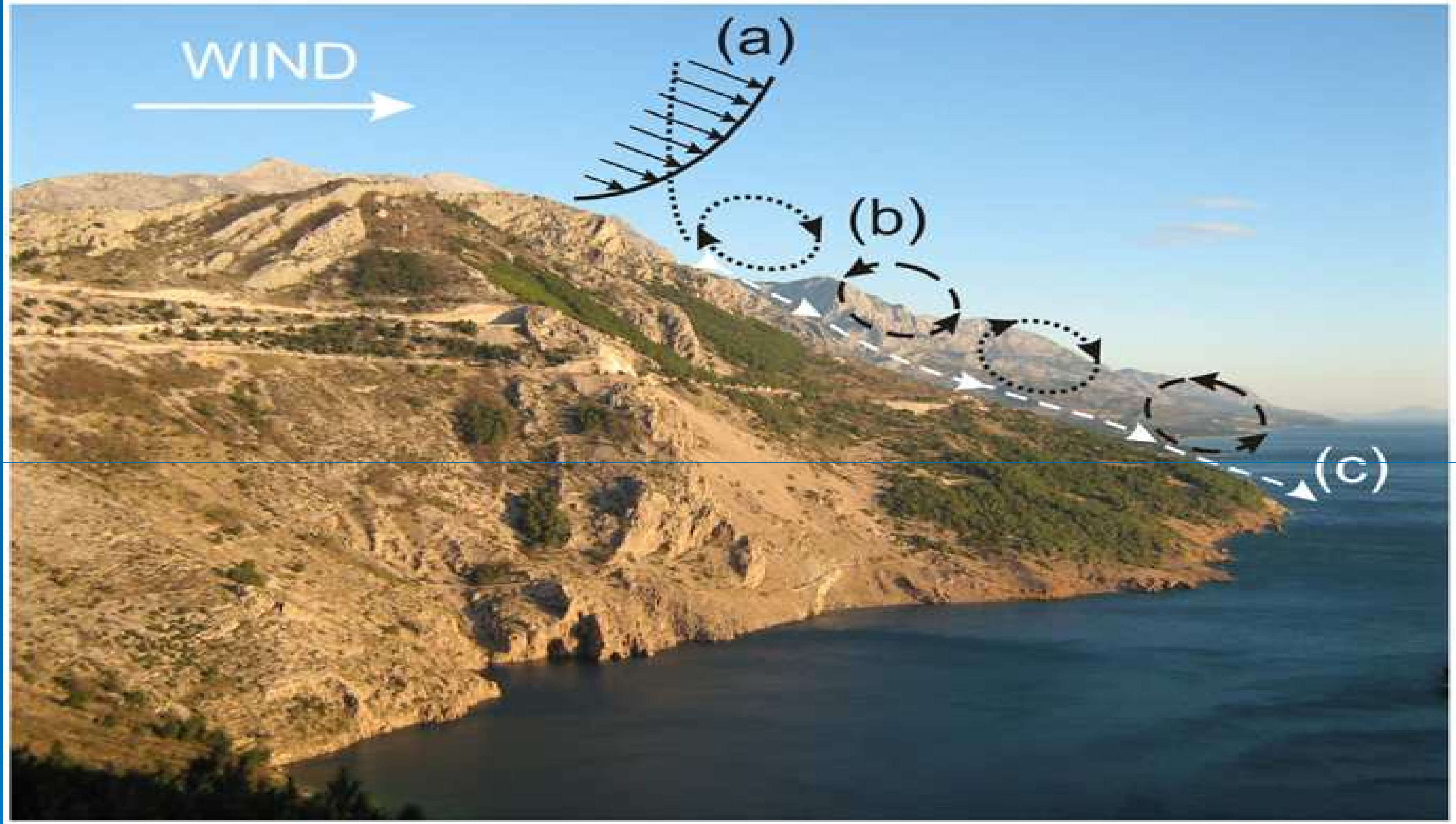
Hrvoje Kozmar, *FSB (turbulencija, zračni tuneli)*

Petra Lepri i Goran Gašparac, *PhD studenti (obrada podataka i modeliranje)*

Goran Lončar, *Građ.F (anemometar vruće žice)*

M. Viher, M. Orlić, V. Grubišić, B.I.-Picek, A. Bajić, Z.B. Klaić, M. Kuzmić, L. Enger, J. Jurković, A. Sajko, I. Kos, … N. Babić, I. Horvat ,T. Jurlina i I. Lisac *(diplomandi)*

Skica bure



H. Kozmar i sur. (JWEIA'12): stvaranje jednog tipa udara bure ***a****) atmos. turbulencija (srednji vjetar = puna, TKE = točkasta,* ***b****) vrtlozi se valjaju niz planinu,* ***c****) dalje otpuhani zrak. Foto:T. Kozmar, 43 km južno od Splita*

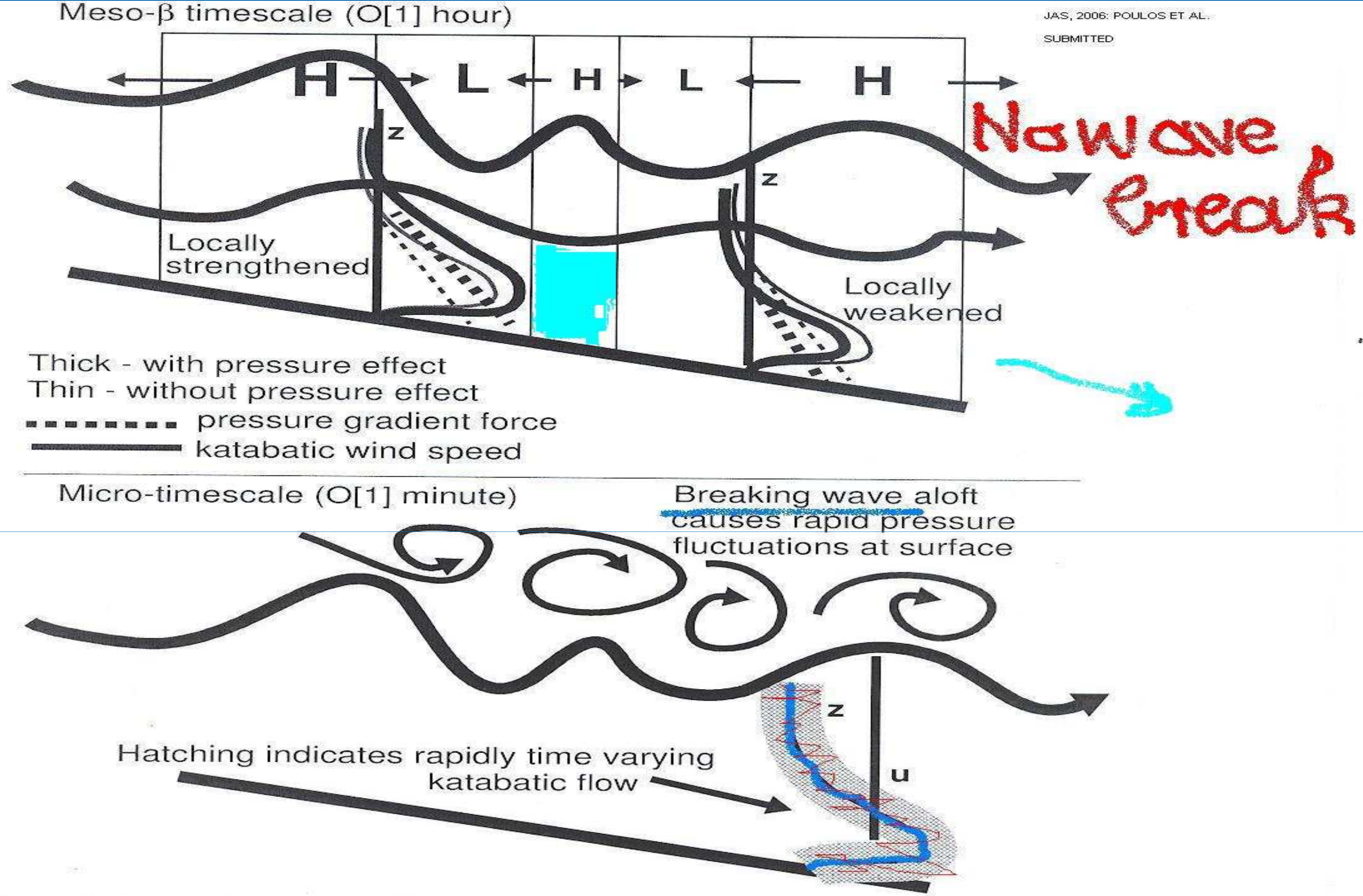
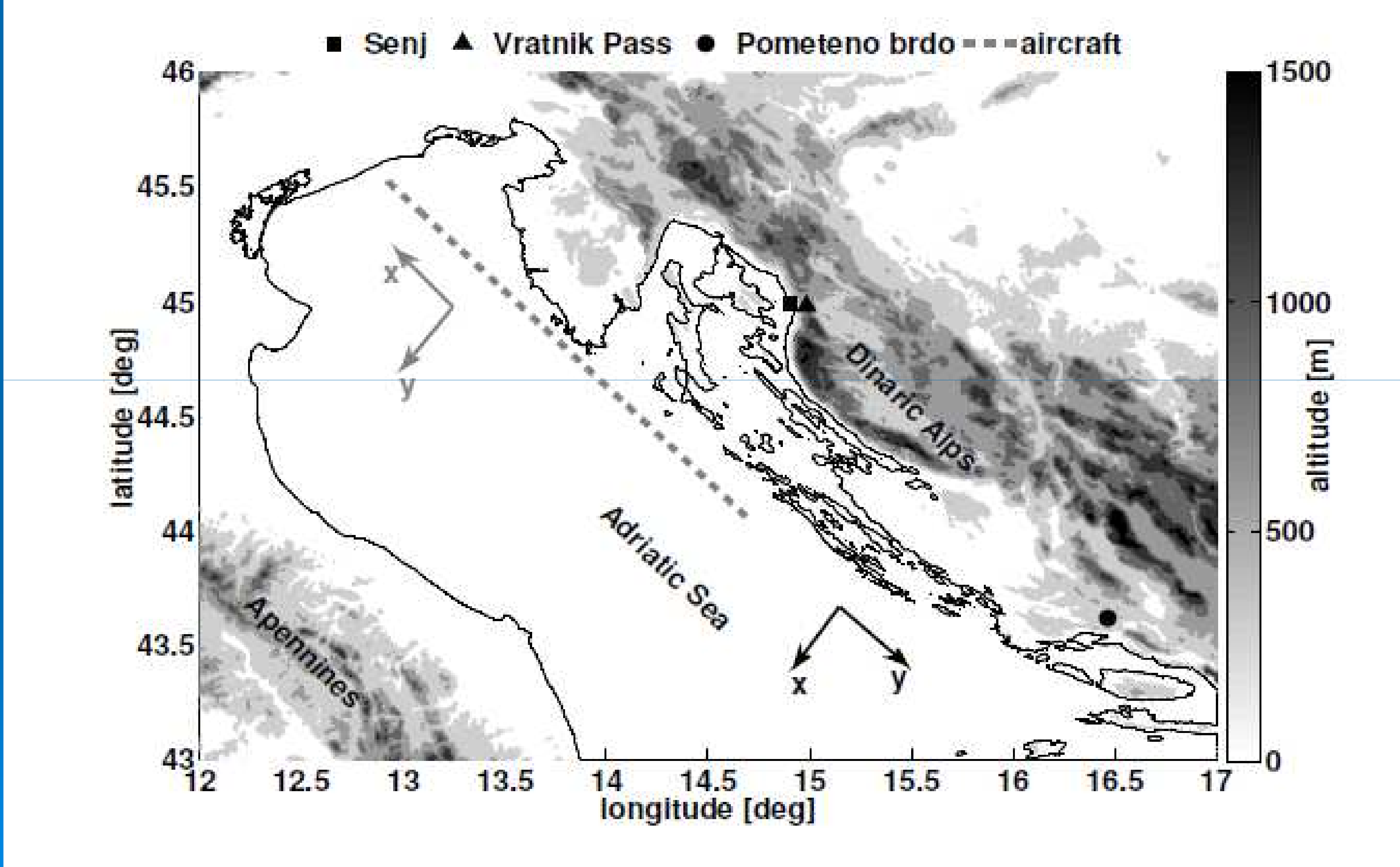
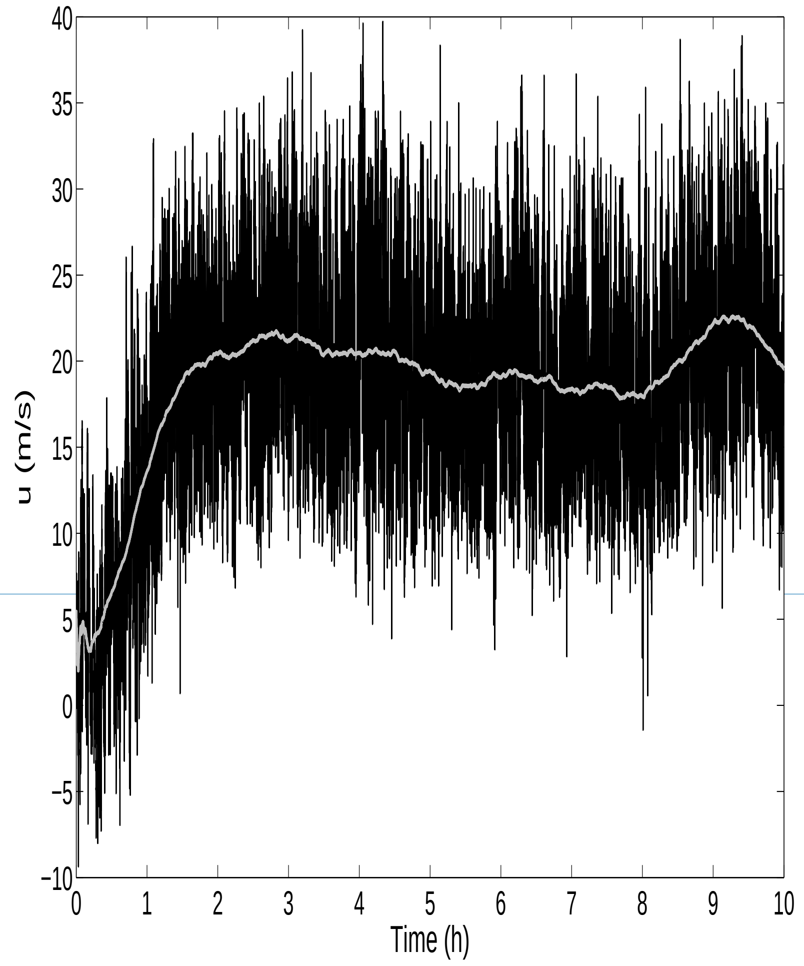


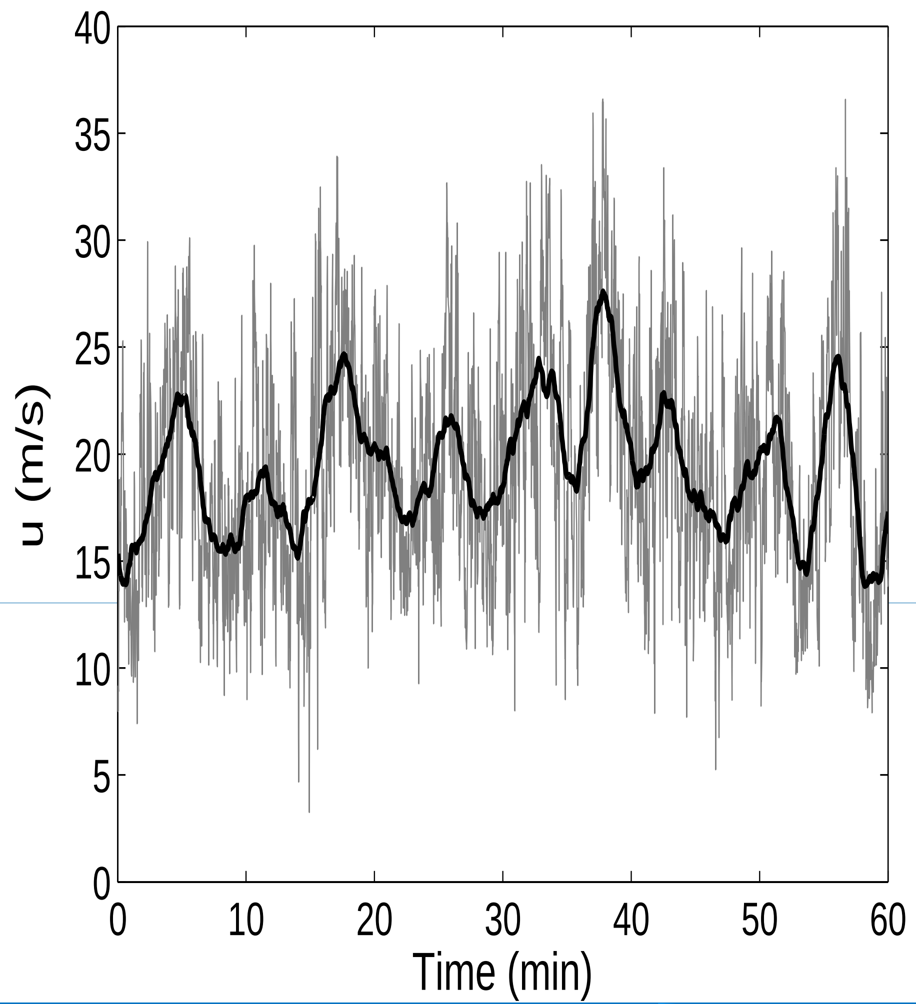
Figure 12. Schematic diagrams of the two dynamic pressure effects of mountain waves on katabatic flow. The upper diagram shows that, depending on location, katabatic flow can be either strengthened (upper slope case) or weakened (lower slope case), due to the integrated column pressure structure of the mountain wave and the locally induced pressure gradient (arrows). The lower diagram shows that a breaking mountain wave aloft causes rapid pressure fluctuations which, in turn, causes rapid katabatic flow fluctuations.

Avio-podaci: MAP → Grubišić QJ 2004 →Večenaj i sur. BLM 2012

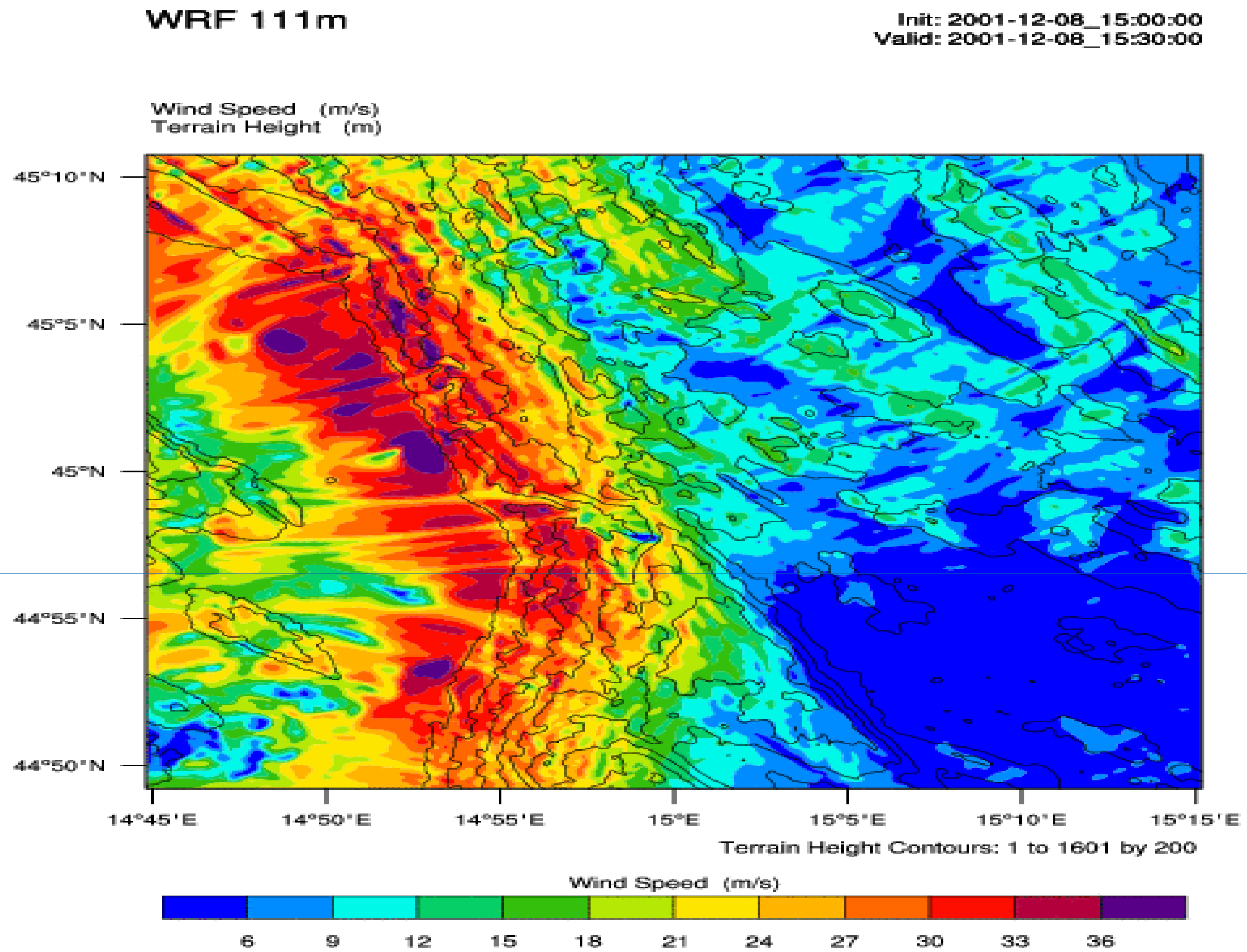
Ostali podaci: uglavnom Geofizički odsjek PMF-a, dio DHMZ





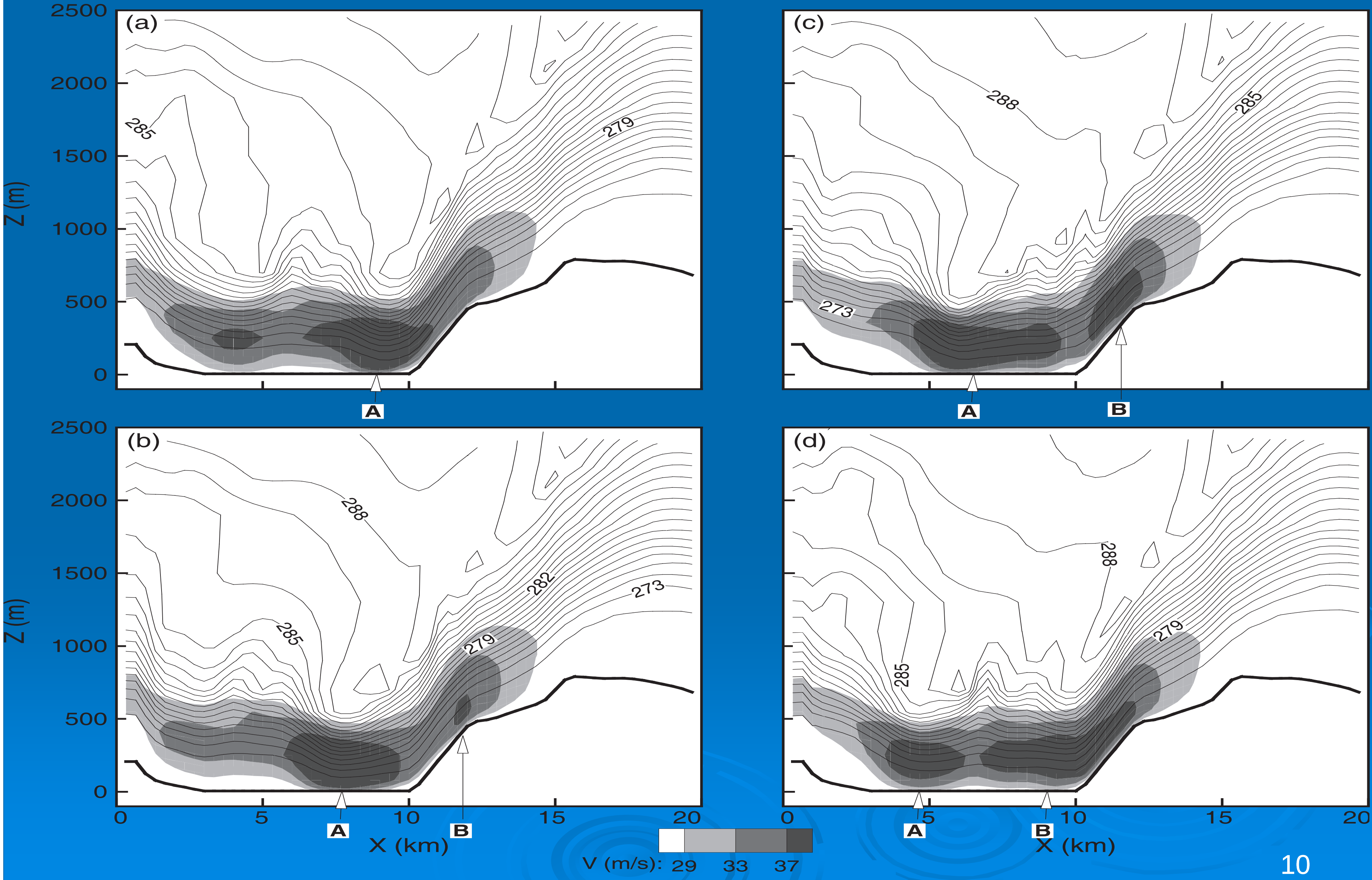


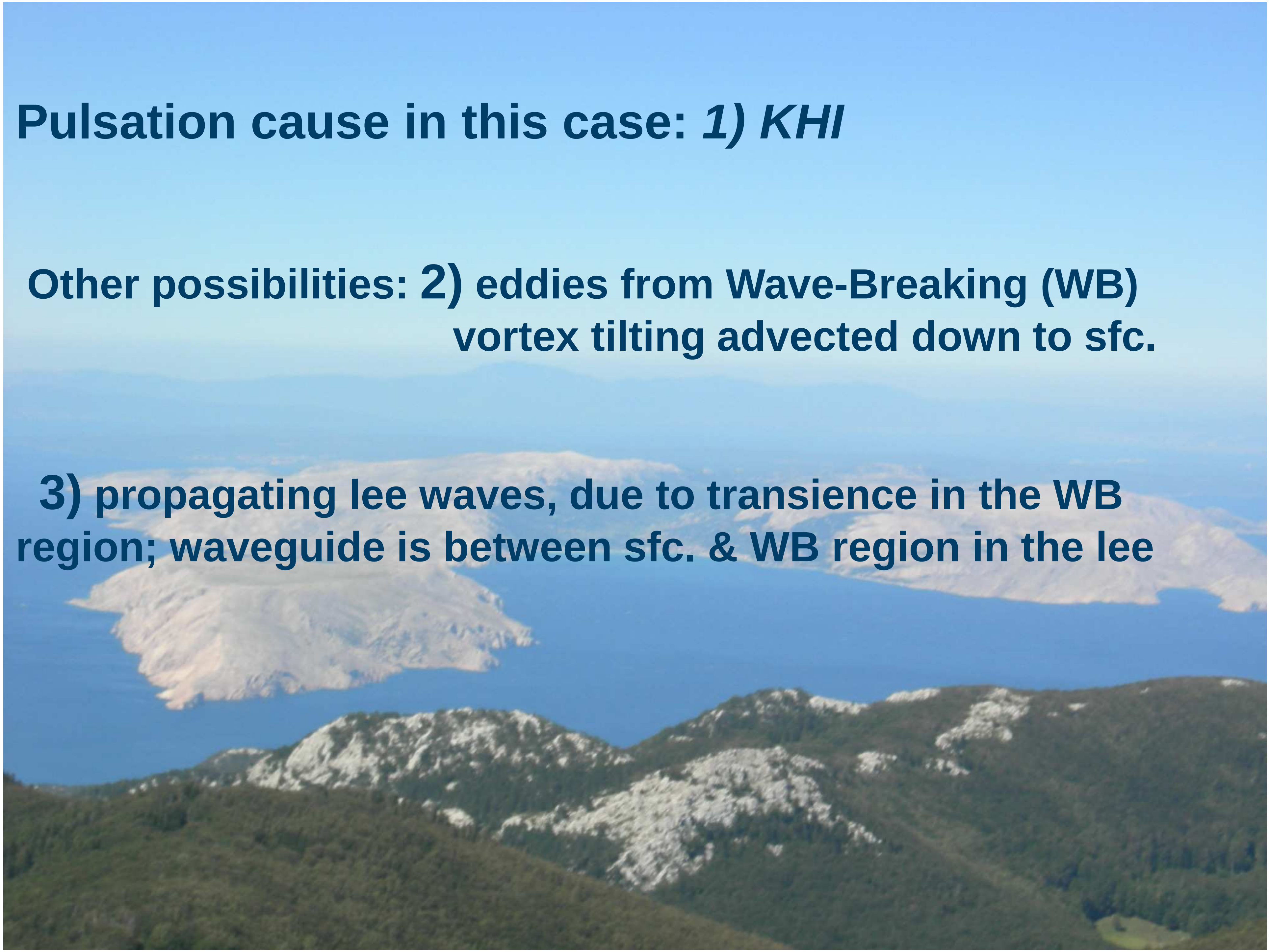
TYPICAL BORA EPISODE, SENJ, 08/12/2001; 6TH H EXPANDED – PULSATIONS! sampling 1 sec. (Grisogono & Belušić, Tellus'09)



Courtesy of Mark Zagar, VESTAS, DK, 2010 (soon in Tellus as Rakovec et al.)

Pulsations: WS > 28m/s shaded, θ by 1K, 09 UTC 08/12/2001, a→d) 650, 750, 850, 950 sec. **A**, **B** = individual pulsations *(Belušić et al. QJ07)*



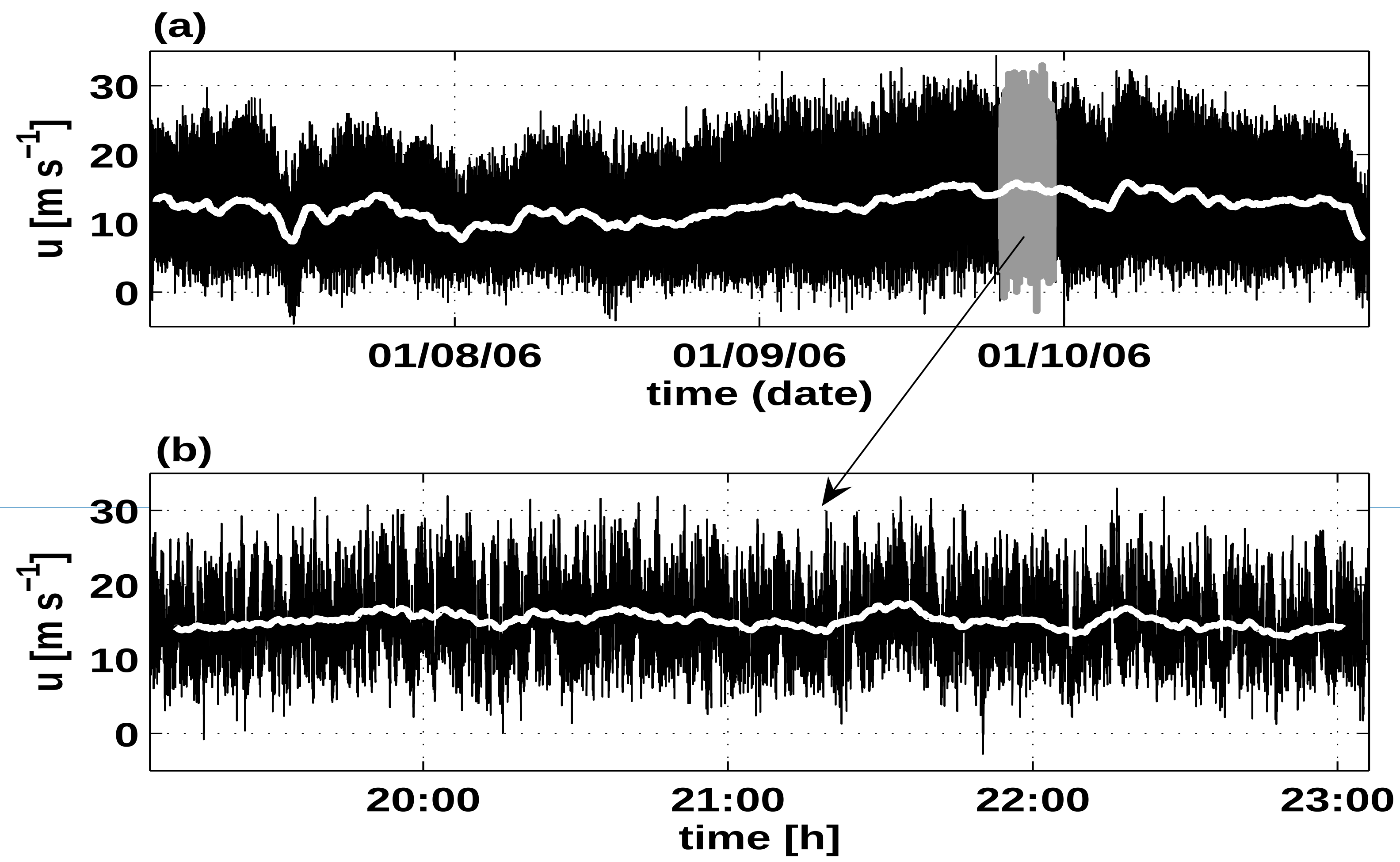


Pulsation cause in this case: *1) KHI*

Other possibilities: 2) eddies from Wave-Breaking (WB) vortex tilting advected down to sfc.

3) propagating lee waves, due to transience in the WB region; waveguide is between sfc. & WB region in the lee

Senj, 2006



*(**a**) 4 day raw 4 Hz data time series, 07-11/01/2006, streamwise-wind comp., u, 1h mean superimposed (**b**) 4 h with 10 min mean superimposed; Večenaj et al. 2010 ⬄TKE ~ 10 – 20 m^2s^{-2}, TKE-dissipation ~ 0.5 – 1 m^2s^{-3}*

Večenaj diss. 2012

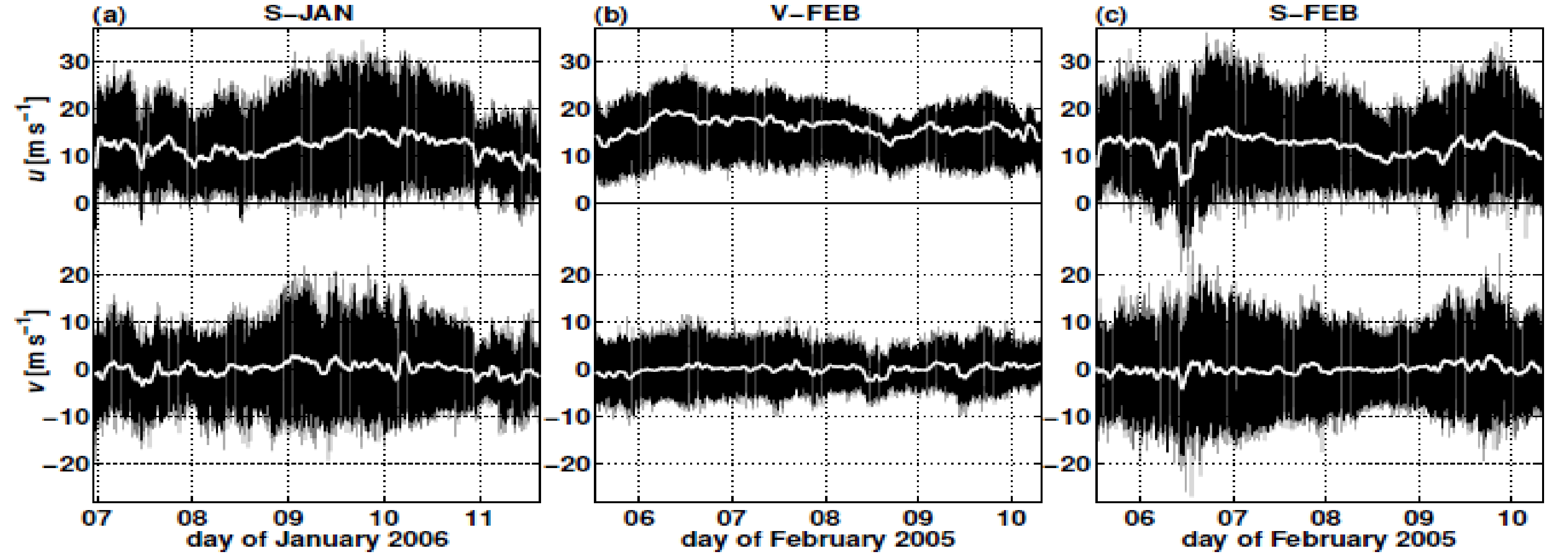
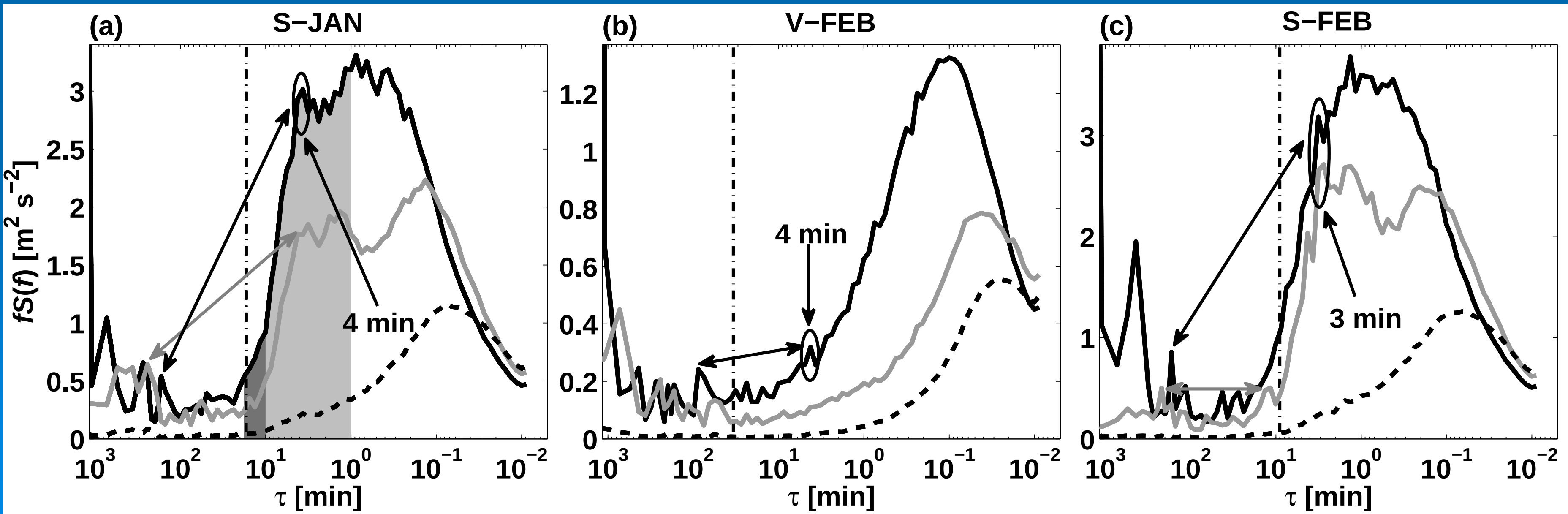
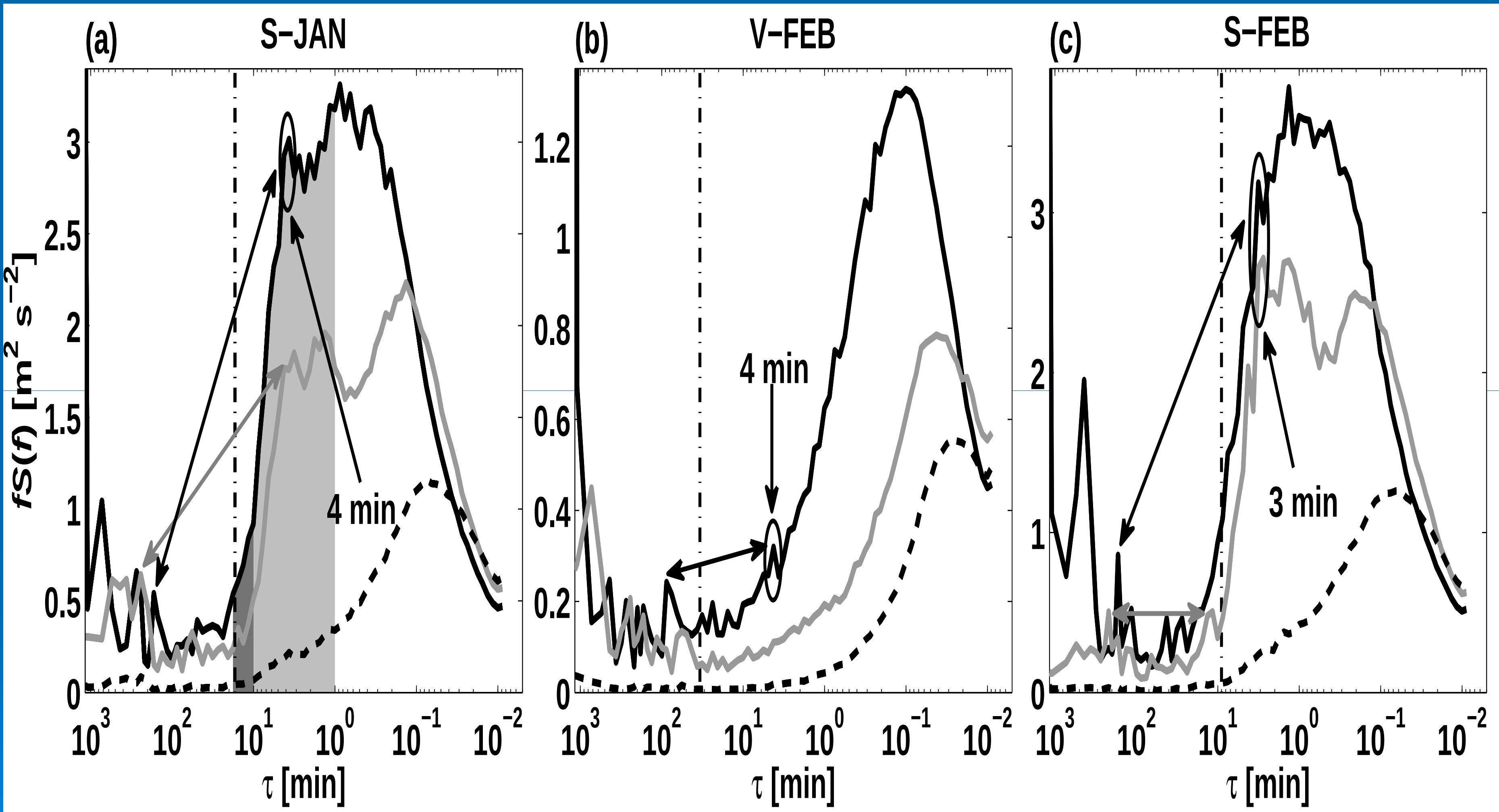


Figure 2. Raw horizontal wind speed components (black curves), with the 1-h mean superimposed (white curves), for (a) S-JAN, (b) V-FEB and (c) S-FEB. In each panel, higher curves denote the longitudinal (streamwise), u, and lower curves denote the lateral (transverse), v, wind speed components, respectively.



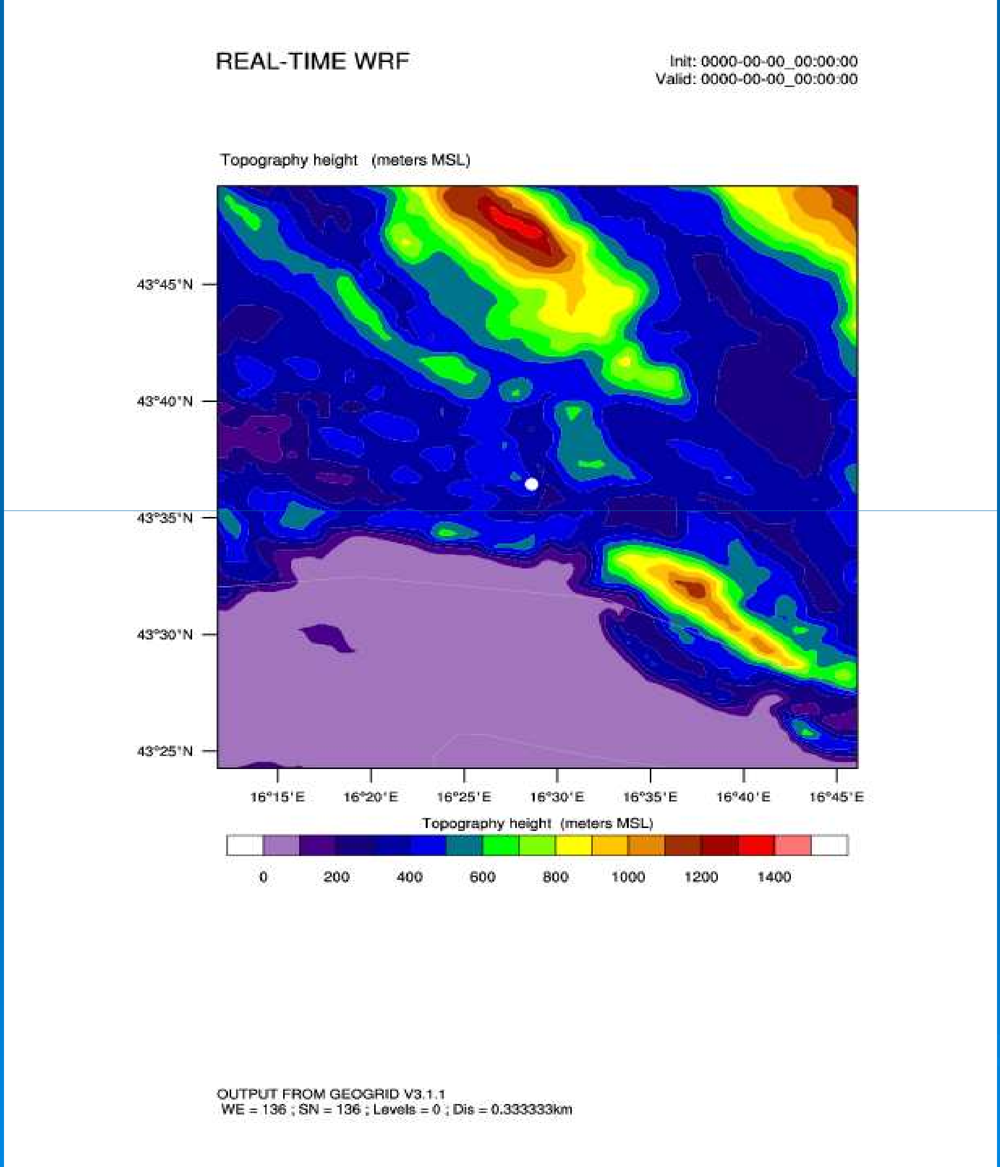
Spektri snage vjetra u Senju, siječanj; Vratniku,veljača; i Senju, veljača

Večenaj, dis. 2012.



Vertical dash-dotted lines ⇔ turbulence averaging scale = 17, 34 & 9 min.

WINDEX (K. Horvat, DHMZ,…) , BORA, … → CATURBO…

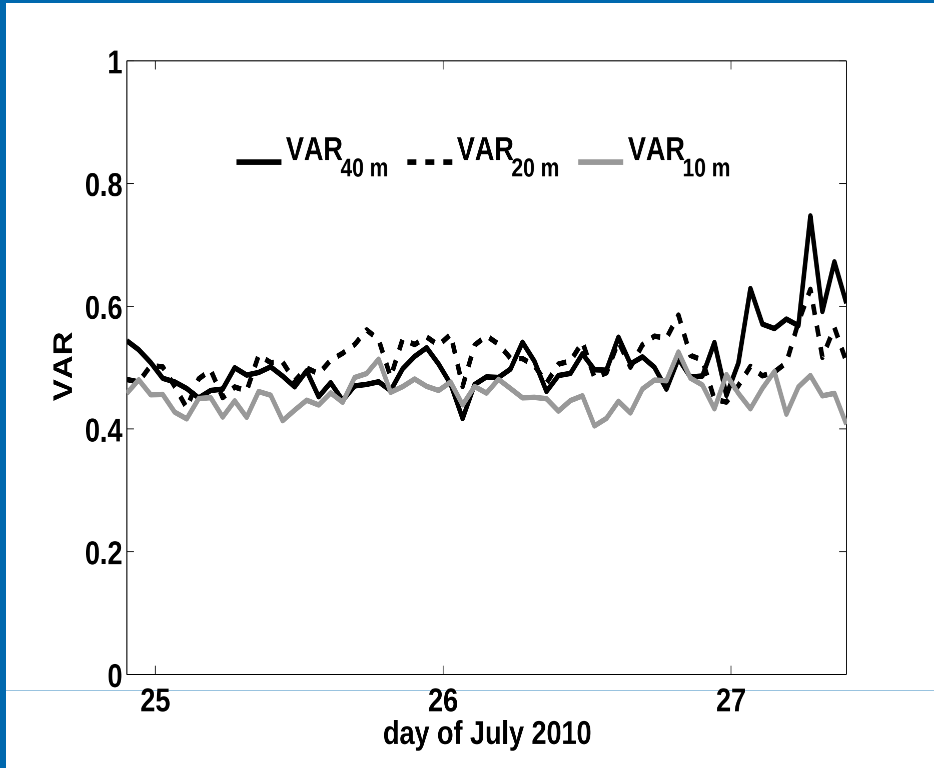


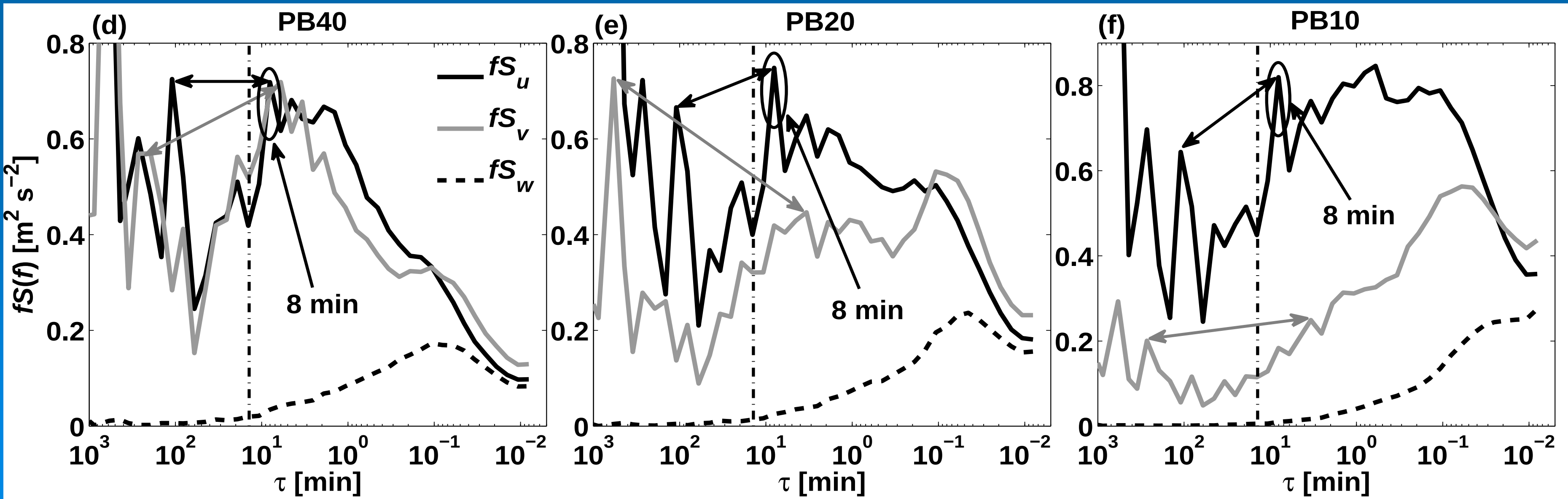
K. Horvat: WindEx, DHMZ, EIHP, IRK, …
Ž. Večenaj, Z. Matica

-Omjer varijanci fluktuacije (=vert/ horiz; desno) na Pometenom brdu, 2010.

$VAR \equiv 2^{1/2}\sigma_w/[\sigma^2_u + \sigma^2_v]^{1/2}$ →

-Spektri snage vjetra bure na Pometenom brdu na 3 nivoa (dolje)





Osn. jednadžbe gibanja → jedn. za prognozu TKE (=E) i vertikalnog turbulentnog prijenosa horizontalnog gibanja (u'w')

$$\frac{\partial E}{\partial t} = -\overline{u'w'}\frac{\partial \overline{U}}{\partial z} + \frac{g}{\theta}\overline{w'\theta'} - \frac{\partial}{\partial z}\left[\overline{w'\left(\frac{p'}{\rho_0} + E\right)}\right] - \varepsilon$$

$$\frac{\partial(\overline{u'w'})}{\partial t} = -(\overline{w'^2})\frac{\partial \overline{U}}{\partial z} + \left(\frac{g}{\overline{\Theta}_v}\right)\left[\overline{u'\Theta'_v}\right] + \overline{\frac{p'}{\rho_0}\left(\frac{\partial u'}{\partial z}\right)} - \frac{\partial(\overline{u'w'^2})}{\partial z} - 2\varepsilon_{uw}$$

Diplomski radovi u tijeku:

N. Babić i I. Lisac - računaju gornje jedn. za Pometeno brdo, Dugopolje

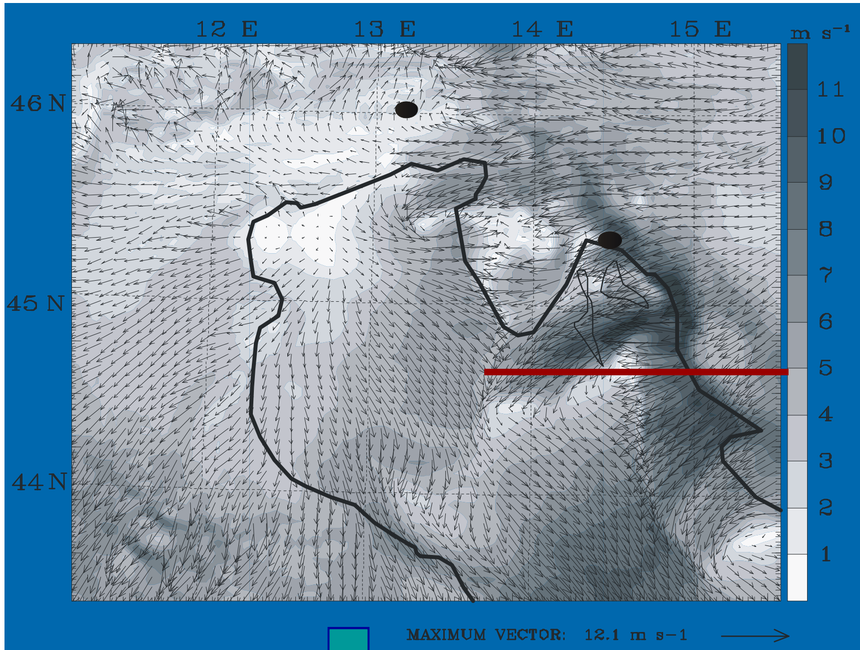
T. Jurlina - za slabu buru razvija blago-nelinearnu analitičku 1-D teoriju

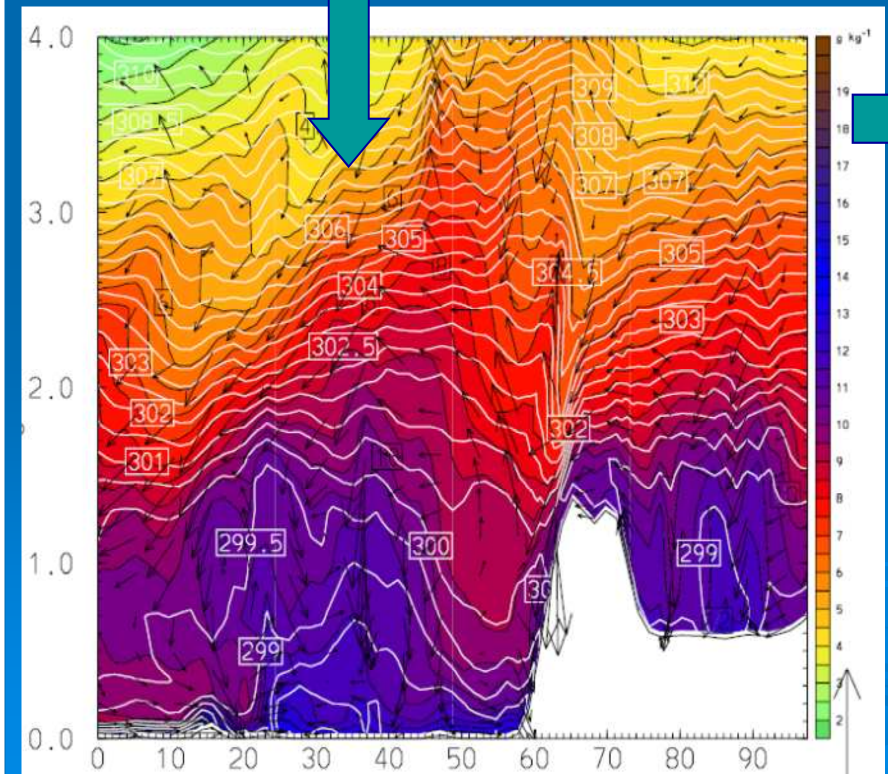
Efekti bure i pripadne turbulencije

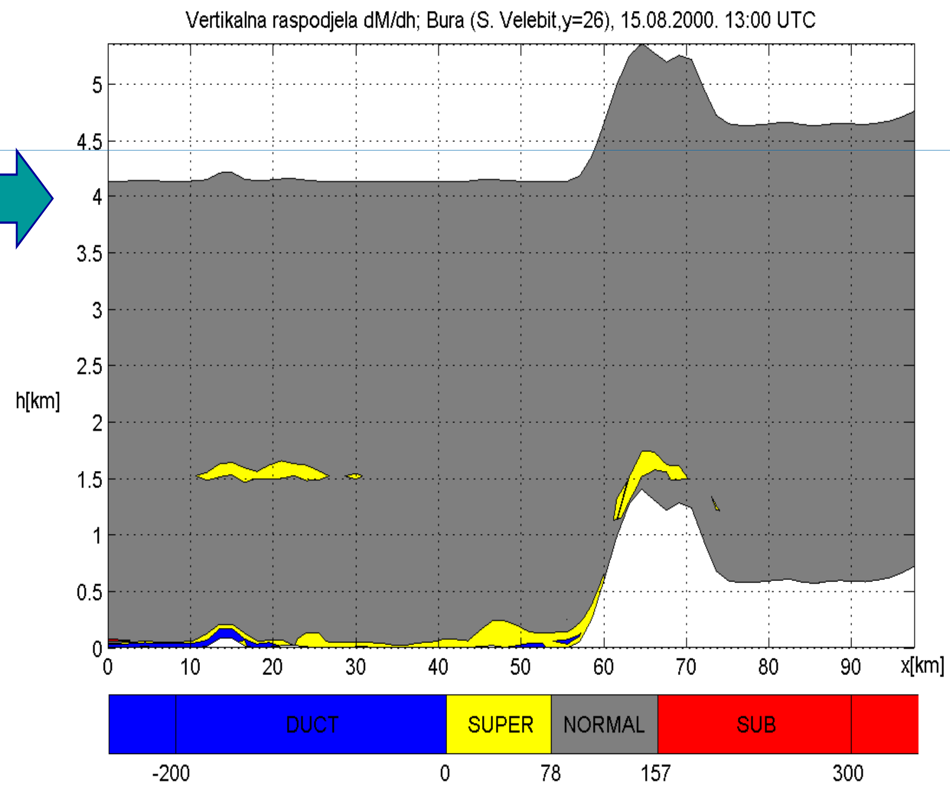
- *Nestandardna refrakcija radio valova u donjoj atmosferi*
- *Onečišćenje - količina prizemnog O_3*
- *Uključivanje nove generalizirane turbulentne duljine miješanja (GB, QJRMS'10) u numeričke modele*
- *Korištenje en. vjetra, poljoprivreda, promet, požari…*

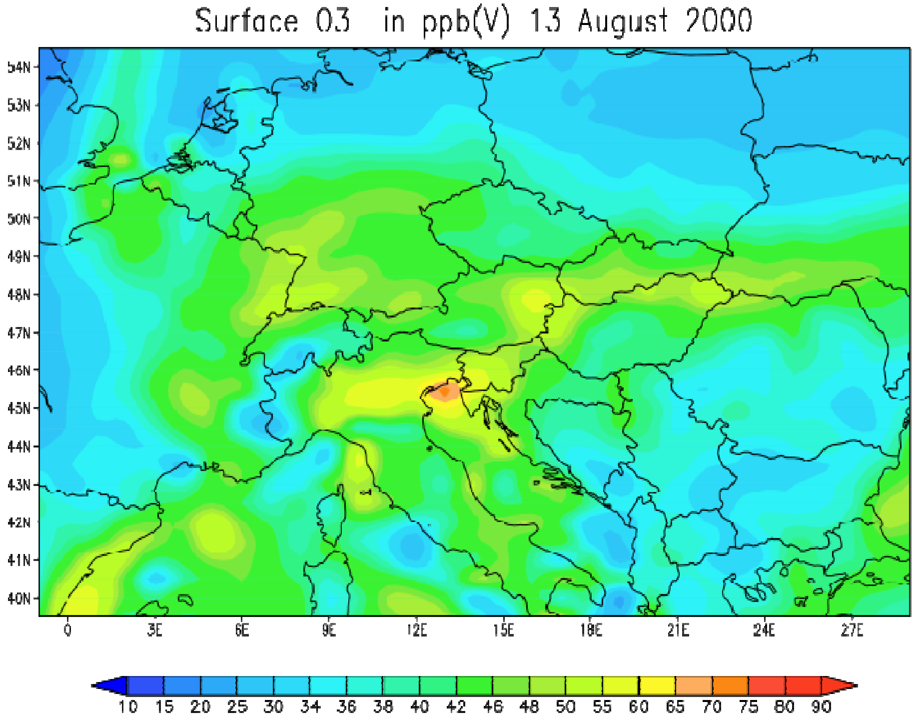
Nestandardna refrakcija radio-valova pri buri

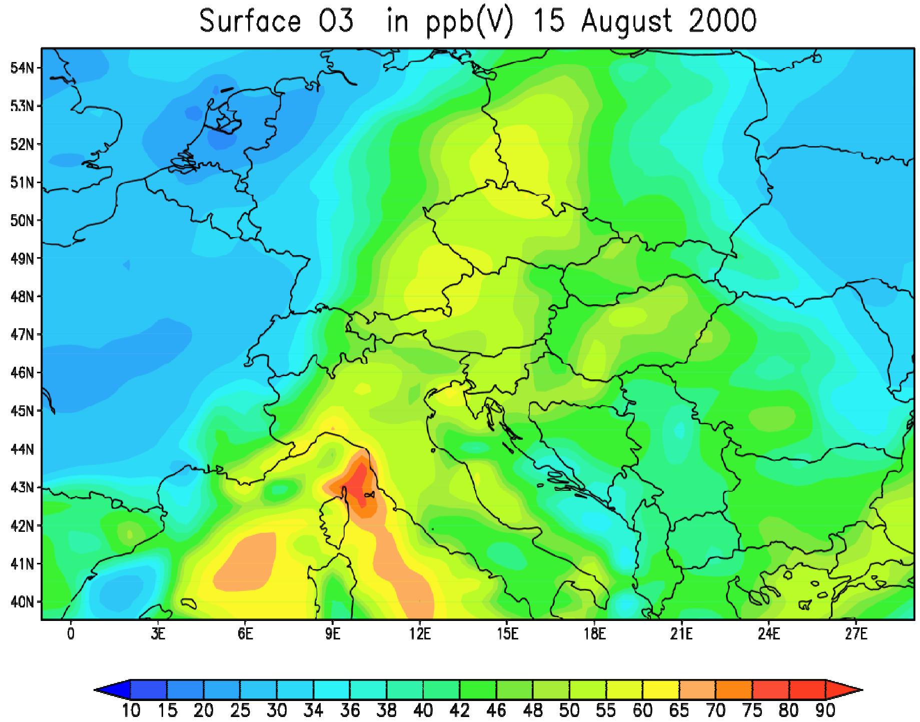
M. Viher i sur. J. Atmos. Sol. Ter. Phys. 2013. u pripremi za tisak + I. Horvat (diplomski u tijeku, MTP)

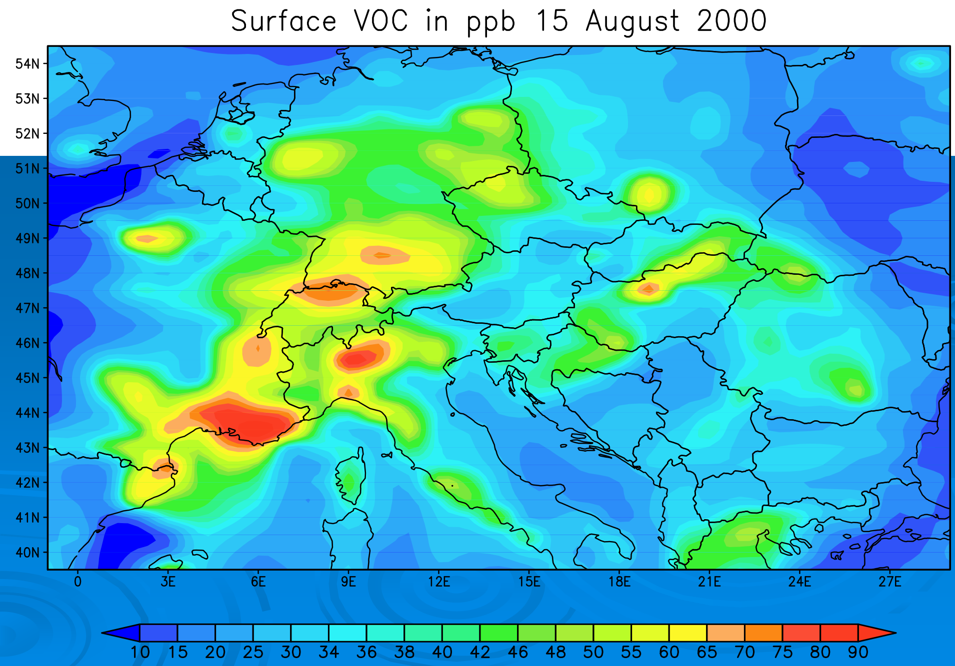












O prizemnom O3 i VOC-u ljeti
13.08. bez bure → 15.08. s burom

M.Telišman Prtenjak i sur.
Met. Appl. 2013. u tisku

Umjesto zaključka…

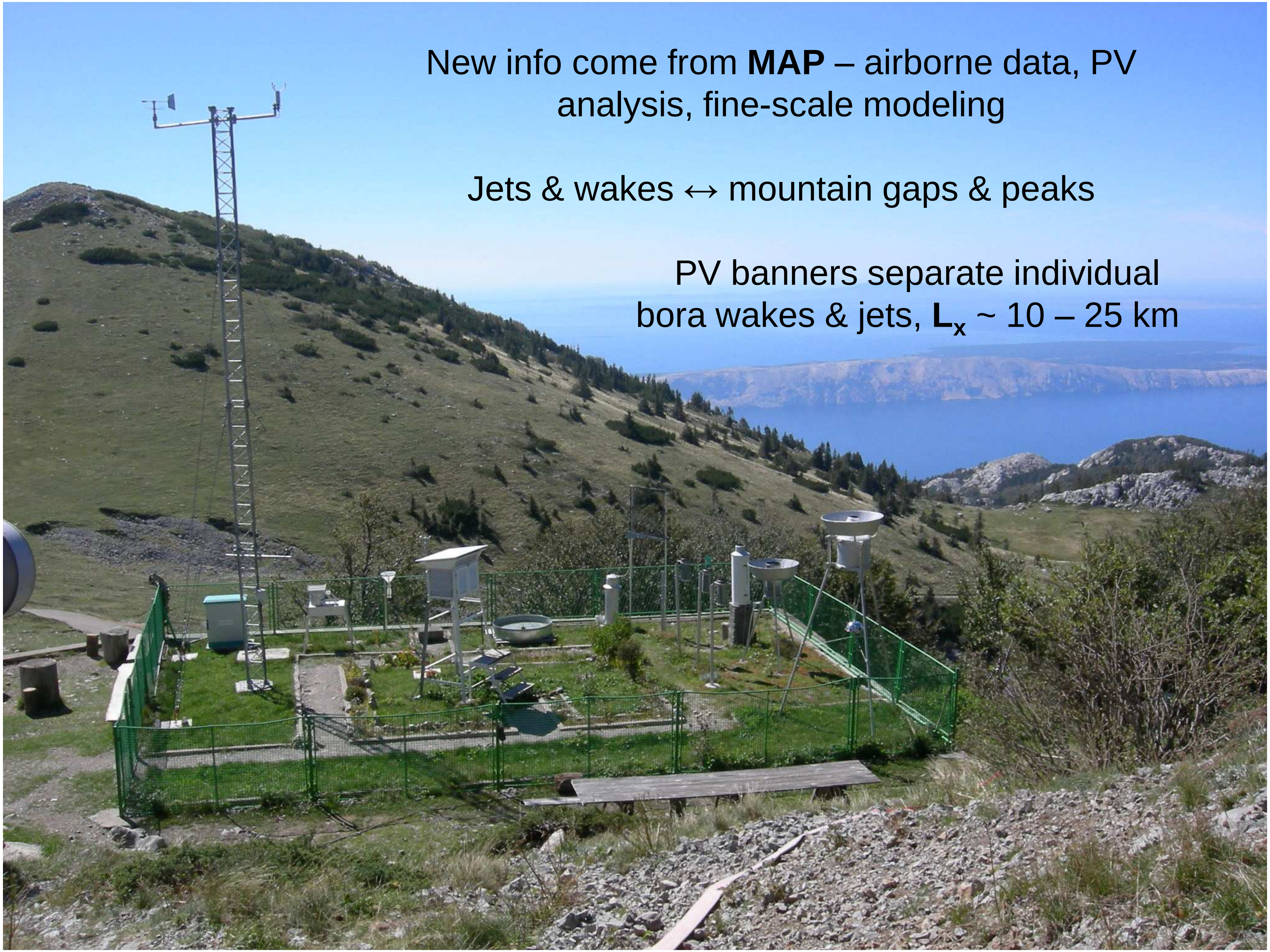
- *ICAM2013 Kranjska gora, DACA-13 Davos, …*
- ***Natprosječni CC/SCI članci, priprema novih mjerenja, modeliranja i razvoj teorije, Dr.-nastava,…***
- ***Nastavak prepoznatljivosti hrv. znanosti***

…unatoč teško podnošljivim uvjetima, nametnutom kontrolom i omalovažavanjem znanosti i znanstvenika…

http://www.pmf.unizg.hr/geof

bgrisog@gfz.hr

- **ALPEX 1982 ➔** R.B. Smith, JAS ‘85,’87 & J. Klemp & D. Durran, Cont. Atmos. Phys.’87. ➔ Strong(est) Bora is a type of severe downslope windstorm
- Mountain wave-breaking usually occurs… $\boldsymbol{Fr_v = U/(Nh) \leq 1}$
- **3D MODELING of Bora from late ’90s onward… DA (2km) in ALADIN (8km) helps operationally**
- **1→ 5 Hz wind sampling since ~2001…**
- **fine remote sensing data still missing**


New info come from **MAP** – airborne data, PV analysis, fine-scale modeling
Jets & wakes ↔ mountain gaps & peaks
PV banners separate individual bora wakes & jets, $\mathbf{L_x}$ ~ 10 – 25 km

Dugopolje: modeled pulsations at noon, > 12 h…

*Courtesy of Kristian Horvath, Cro. Hydro-Met . Inst. (*work in progress*)*