Impact of mesoscale meteorological processes on the anomalous propagation conditions

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Aim & Motivation

❖ The anomalous propagation (so called **anaprop**) of radio waves: *radioducts*, *superrefractions* and *subrefractions* (Fig. 1) is created by the different properties of the atmosphere through the altitude difference in temperature, humidity and pressure.

❖ Atmospheric variability is a result of large scale conditions and mesoscale structures that influence PBL height and local fronts.

Aim:

❖ Study of the impact of 3 mesoscale phenomena (over the wider area of the northern Adriatic, Fig. 2) on the occurrence of anaprop conditions: sea/land breeze, the bora wind and cumulonimbus clouds .

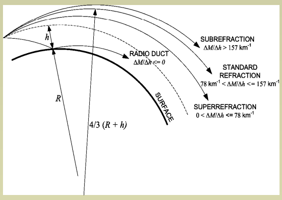


Figure 1: Geometrical relations between refraction types; the curvature of the standard refraction is approximately 4/3 of the Earth's radius plus the antenna height, while the curvature of the subrefraction has a much lower value; curvature of superrefraction lie between the curvatures of the standard refraction and the local curvature at height h, and radio ducts have a curvature higher than 1/(h + R) so that rays are inclined towards the surface (from Viher et al., 2013).

Figure 2: A location of the Adriatic Sea and the area of interest presented by the blue rectangle.

Data & Methodology

Radiosounding data: in Udine and San Pietro Capofiume, Fig. 2) (http: //weather.uwyo.edu)

Model WRF-ARW (Version 3):

➢ **Chosen case: 13-20 August 2000**

➢ initial and boundary conditions (updated every 6 h): 0.25°x0.25° ECMWF analysis;

➢ vegetation and land-use data: USGS 24 category dataset at a resolution of 30";

➢ 3 domains (Δx=13.5 km, 4.5 km, 1.5 km) & 2-way nesting on a Lambert conformal projection;

➢top of the atmosphere = 50 hPa & 70 sigma levels;

➢physical options for all domains:

▪MYJ scheme for the PBL;

▪RRTM for the longwave radiation;

▪Dudhia scheme for the shortwave radiation;

▪Lin microphysics scheme with ice and snow processes;

▪the Eta surface layer scheme based on MO theory;

▪a five-layer thermal diffusion scheme for the soil temp.;

▪the Betts-Miller-Janjić cumulus parameterization in 2 outer domain

The calculation of the modified refractive index, M (Skolnik, 1980):

(1) $N=(n-1)\cdot 10^6=\frac{77.6\cdot p}{T}+\frac{y\cdot 3.73\cdot 10^5}{T^2}$

(2) $y=\frac{rh\cdot 6.105}{100}\cdot exp\left(25.22\frac{T-273.15}{T}-5.31\cdot ln\left(\frac{T}{273.15}\right)\right)$

⇒ $\boxed{M=\left[\frac{h}{R_Z}+(n-1)\right]\cdot 10^6=157\left[km^{-1}\right]\cdot h+N}$

$\boxed{\frac{dM}{dh}=\frac{10^6}{R_Z}+\frac{dN}{dh}=157\left[km^{-1}\right]+\frac{dN}{dh}}$

Results

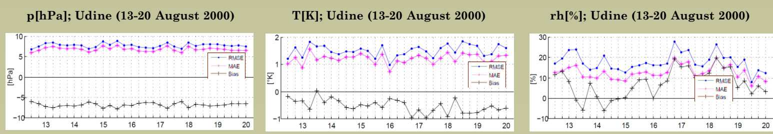


Figure 3: Temperature (*T*) and pressure (*p*) deviations do not exceed 2 K and 10 hPa, but in both cases the model underestimated their values (Bias). In general the model overestimates the humidity (*rh*) from about 5 to 30%. The PBL in the model is lower, colder and more humid than in reality, presumably due to used MYJ scheme for PBL (Weisman et al., 2008).

The bora wind (14-15 August 2000)

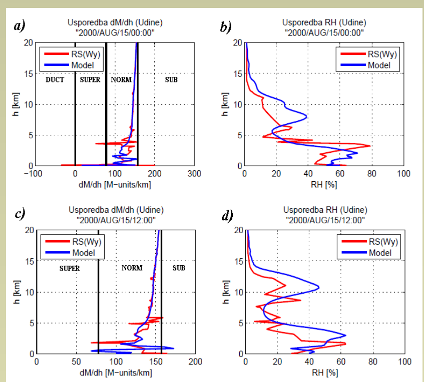


Figure 4: During 14-15 August, the bora wind blew in the domain of research. The value of the rh inside the first kilometer height is around 40% (measuring about 30%). The occurrence of anaprops in Udine were acceptably simulated, although their intensity were sometimes underestimated. The model has certain difficulties in reproducing the correct height and intensity of anaprops since the faithful vertical profile of the modified refractive index is the most dependent on the accuracy of the modeled vertical changes of rh.

14 August 2000; 22 UTC

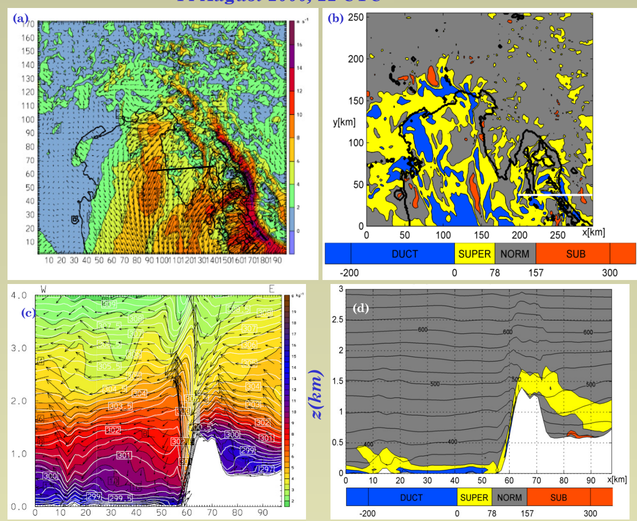
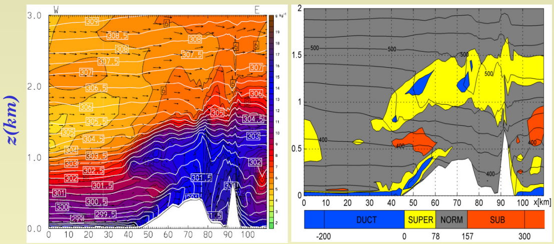


Figure 5: (a) 60-m modeled WRF wind field (m/s) with well formed bora jets; (b) corresponding horizontal modeled distribution dM/dh with a white line that indicates the position of the vertical profiles of: (c) the meteorological fields of wind (black vectors; m/s), potential temperature (white lines; K) and mixing ratio (colored areas with legend on the right; g/kg) and (d) corresponding types of (non)standard refractivity (M-index and dM/dh).

The sea/land breeze (17-18 August 2000)

17 August 2000; 16 UTC



18 August 2000; 00 UTC

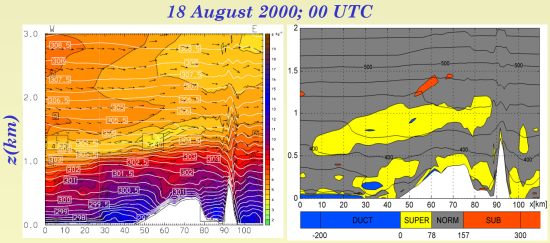
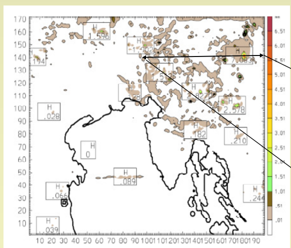


Figure 6: (a,c) the vertical profiles of the meteorological fields of wind (black vectors; m/s), potential temperature (white lines; K) and mixing ratio (colored areas with legend on the right; g/kg) for sea breeze (a) and land breeze (c) over Istria along black line in Fig. 5a. (b,d) corresponding vertical distribution of M-parameter (in *M*-units) and types of (non)standard refractivity.

The convection (13 August 2000)



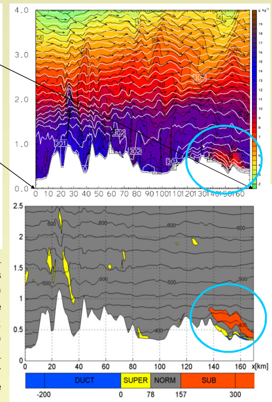


Figure 7: (a) Column integrated cloud hydrometeors at 14 UTC. Black line denotes base for the vertical cross-section in (b,c). (b) The vertical profiles at 16 UTC of the meteorological fields of wind (black vectors; m/s), potential temperature (white lines; K) and mixing ratio (colored areas with legend on the right; g/kg). Note the downdraft flow and corresponding ananprops (c) within blue circle.

Summary

❖ **The bora wind** through by the advection of colder and drier air, in the shallow surface layer usually creates:

(i) radioducts and superrefractions: over land and coast, inside the hydraulic jump, and over the sea and islands, in somewhat deeper layer.

(ii) subrefractions over the sea surface along the edges of bora jets where a lateral exchange of air with various moisture content occur due to the convergence of flow and increased vorticity, and on the windward side of Dinaric Alps where the formation of the local vortices below the mountain top affect the moisture profile.

❖ **Sea breezes** (SB) are notably associated with the anaprop formations, somewhat similar as in Atkinson & Zhu (2006):

(i) in the first 100 m above the ground within SB body where superrefractions and radioducts form due to advection of colder and moist air,

(ii) in upper region of the SB front which are usually connected with elevated radioducts and superrefractions,

(iii) inside transition layer between the SB body and anti-SB current with subrefractions.

❖ When a **deep convection** over land appears, we observe the elevated superrefractions and subrefractions between 0.5 and 1 km above ground. Subrefractions are caused by downdraft beneath the cumulonimbus cloud base in its mature phase that creates smaller pools of cold and dry air. Below subrefractions in the lowermost 200 m, the anaprop type changes from superrefraction to radioduct near the ground.

Acknowledgements

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