Investigation of temporal and spatial distribution of slant delay for low elevation angles on the basis of mezoscale weather model data

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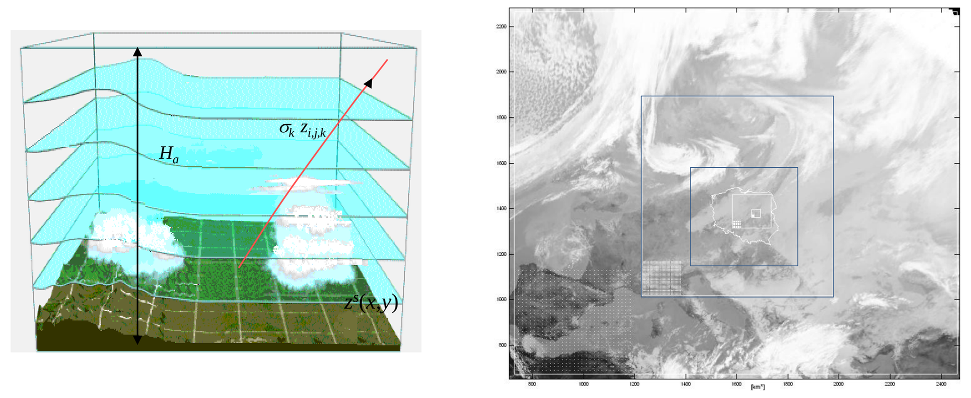
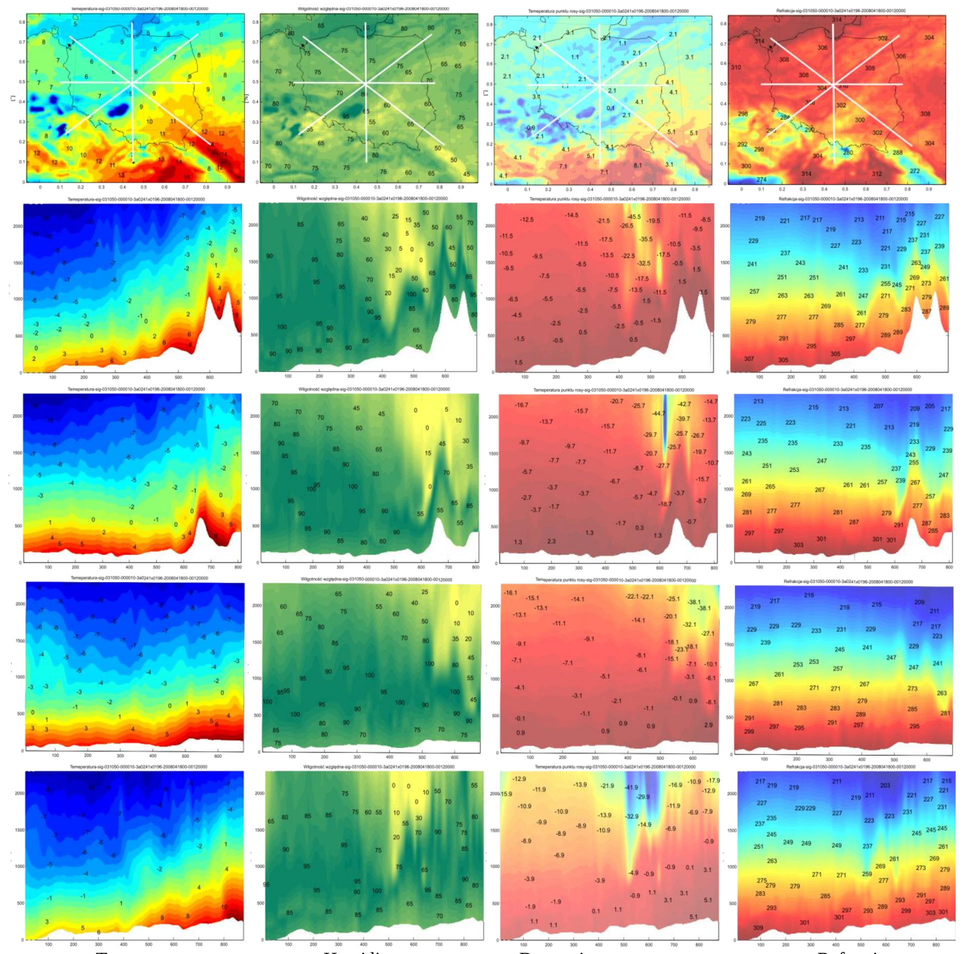
The poster presents investigations of neutral atmosphere slant delay based on analysis and forecast fields from mezoscale weather model. The Coupled Ocean / Atmosphere Mesocale Prediction System, Naval Research Laboratory, Monterey Marine Meteorology Division (COAMPS - NRL) was used. Model runs in operational mode in the Centre of Applied Geomatics (Faculty of Civil Engineering and Geodesy, Military University of Technology, Warsaw). Refraction fields required for caculation were interpolated from the model grid with the spatial resolutions of 13, 4.3 and 1.44 km for every hour in the 24-hour range. Slant delays were determined using ray tracing procedure - numerical realization of the eikonal equation solution. Spatial distribution of delays was obtained in the process of atmosphere scanning for the ASG-EUPOS sites positions. The scanning was performed in topocentric frames for the elevations [3° - 15°] and azimuths [0° – 360°]. The results enabled preliminary estimation of temporal and spatial slant delay fields changes and their dependencies on mezoscale model grids resolution. The results also helped to make the anisotropy characteristics of their local spatial distributions.

COAMPS data

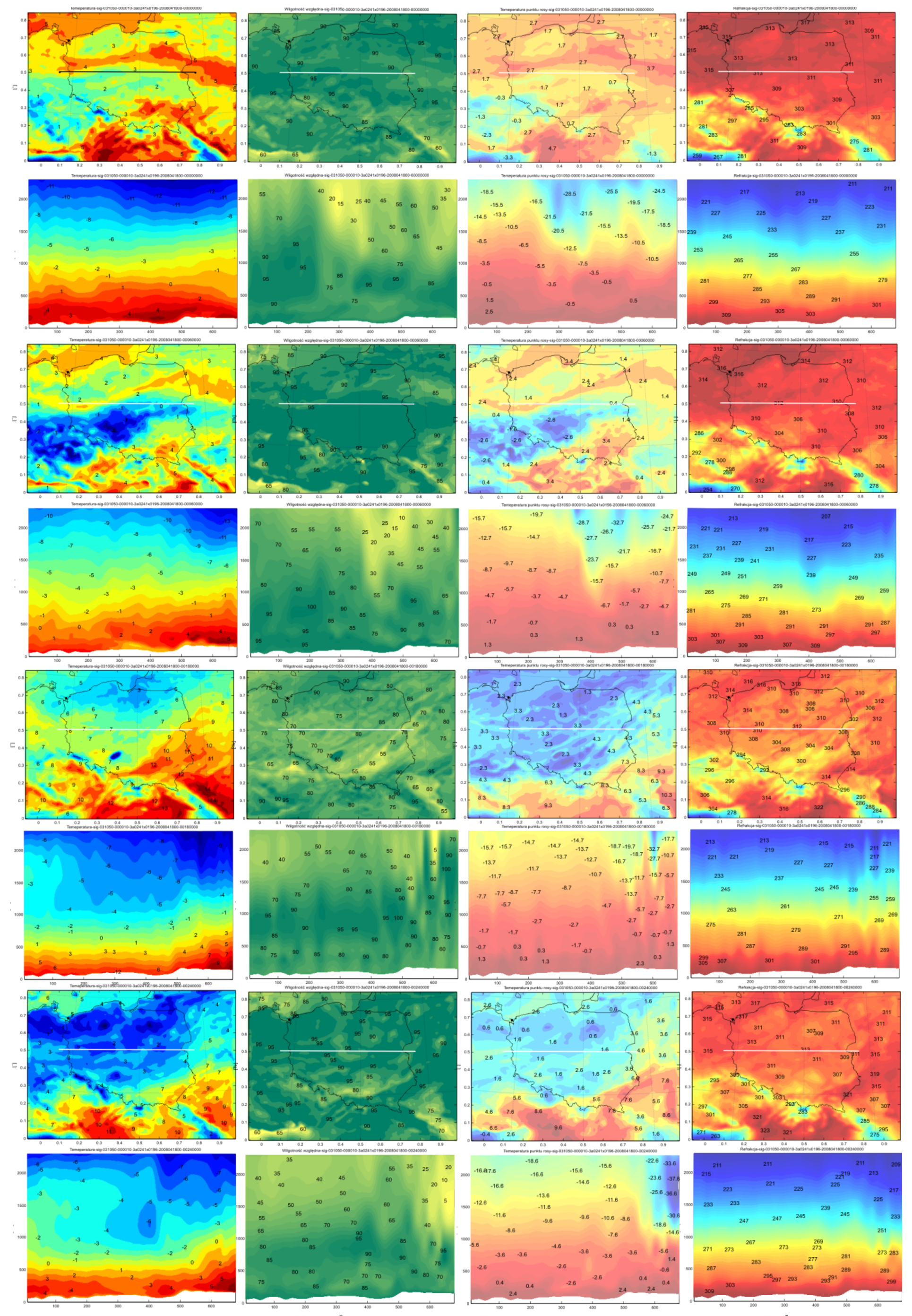


Sigma - z model levels. Areas of the mesocale model used in the calculations (39 km, 13 km, 4.3 km , 1.44 km grid)



Temperature | Humidity | Dew point temperature | Refraction

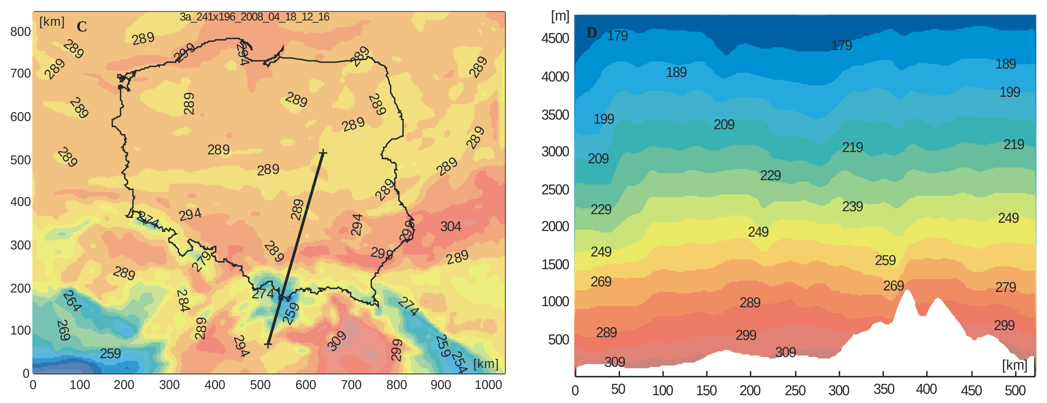
COAMPS vertical cross sections of prognostic fields



Temperature | Humidity | Dew point temperature | Refraction

COAMPS horizontal cross sections of prognostic fields

Rrefractivity fields



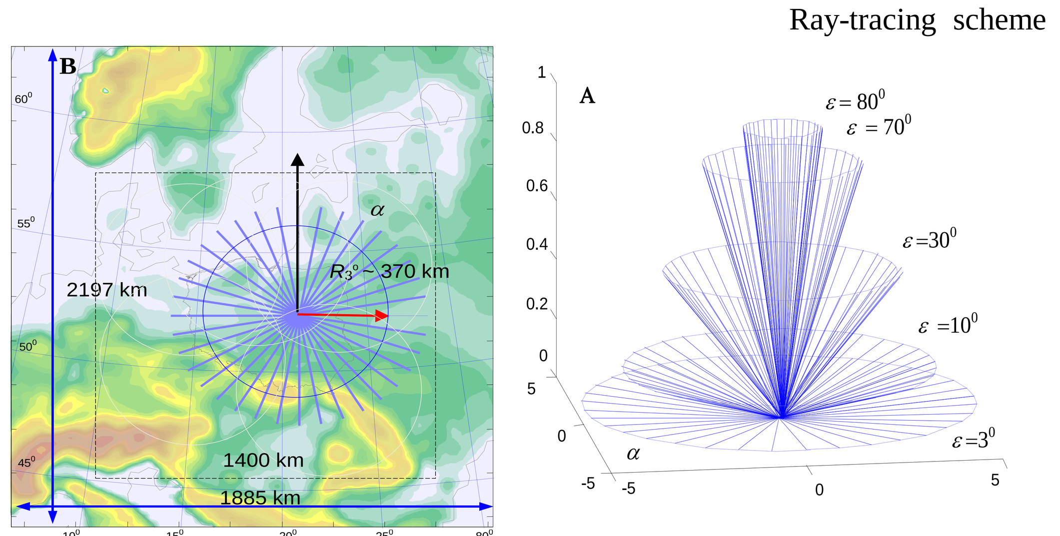
Horizontal and vertical cross section of refractivity fields. (GPS tropospheric weather).

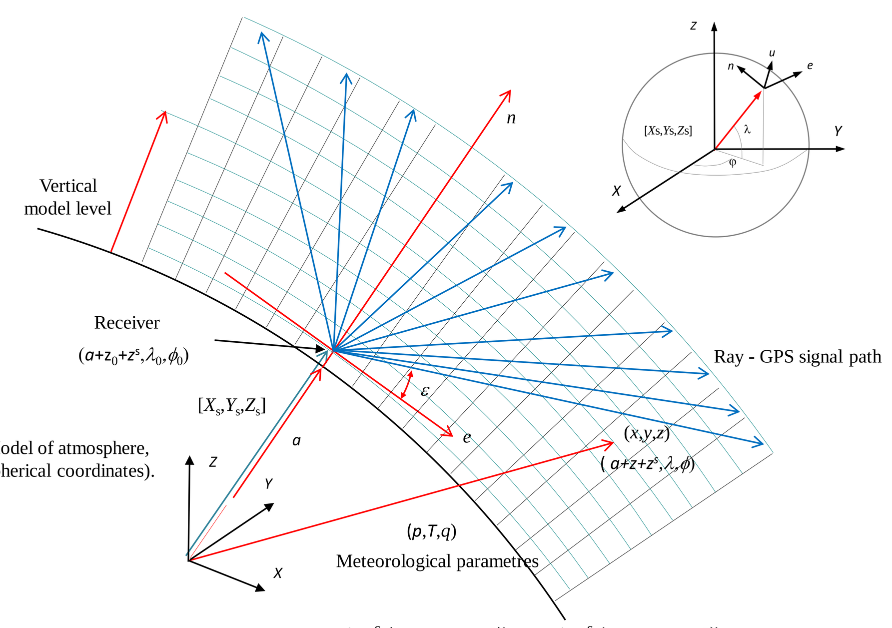
$$N_{i,j,k} = \underbrace{k_1 \frac{(p-e)_{i,j,k}}{T_{i,j,k}} Z_d^{-1}}_{N_{dry}} + \underbrace{k_2 \frac{e_{i,j,k}}{T_{i,j,k}} Z_w^{-1} + k_3 \frac{e_{i,j,k}}{T_{i,j,k}^2} Z_w^{-1}}_{N_{wet}}$$

$$e = qp/(0.622 + 0.378q), \quad p_d = p - e$$

p, T, e and q - model temperature, water vapour, pressure and specific humidity, (i, j, k) grid points of COAMPS model.

Ray-tracing scheme



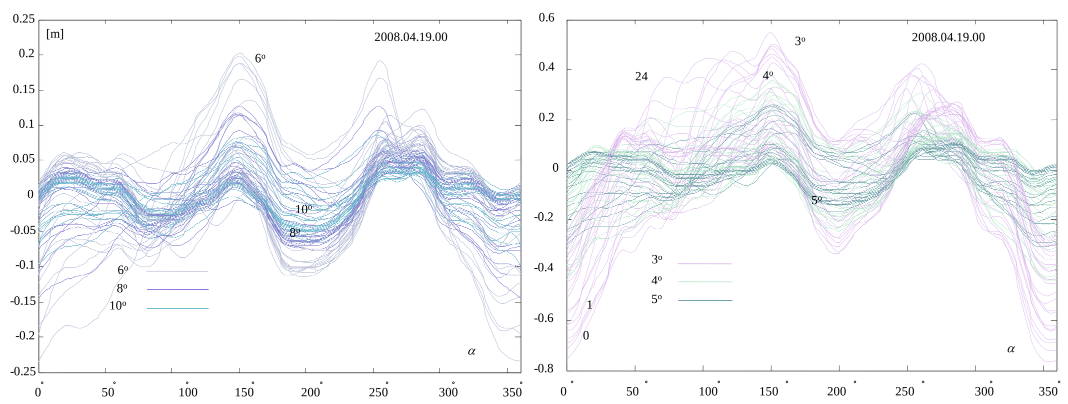


$$m_c(\varepsilon_i, \alpha_j, t_k, \vec{x}) = \frac{\Delta\tau^s(\varepsilon_i, \alpha_j, t_k, \vec{x})}{\Delta\tau^s(\varepsilon = 90^\circ, t_k, \vec{x})} = \frac{\Delta\tau^s(\varepsilon_i, \alpha_j, t_k, \vec{x})}{\Delta\tau^z(t_k, \vec{x})}$$

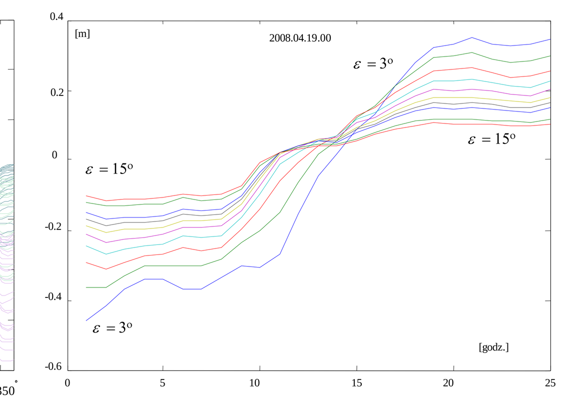
$$i = [3^\circ, 4^\circ, ..., 9^\circ, 10^\circ, ..., 15^\circ, ..., 90^\circ], \quad j = 0^\circ, 10^\circ, 20^\circ, ..., 350^\circ, \quad k = 1, 2, ..., 24 \text{ h},$$

Discrete mapping functions.

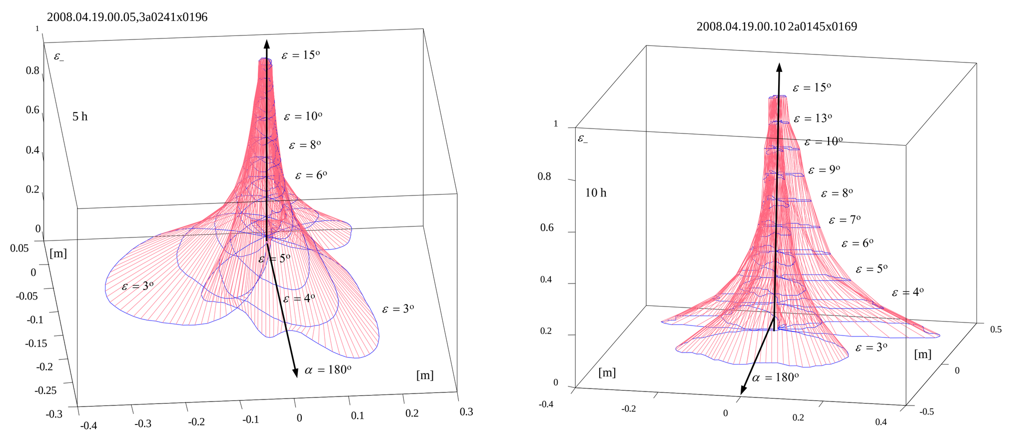
GPS slant delay anisotropy



Azimuthal (relative) distribution of slant delay. Differences of slant delays $\Delta\tau^s$ and their azimuth average values $\overline{\Delta\tau^s(\cdot,\alpha)}$ for each hour of COAMPS forecast.



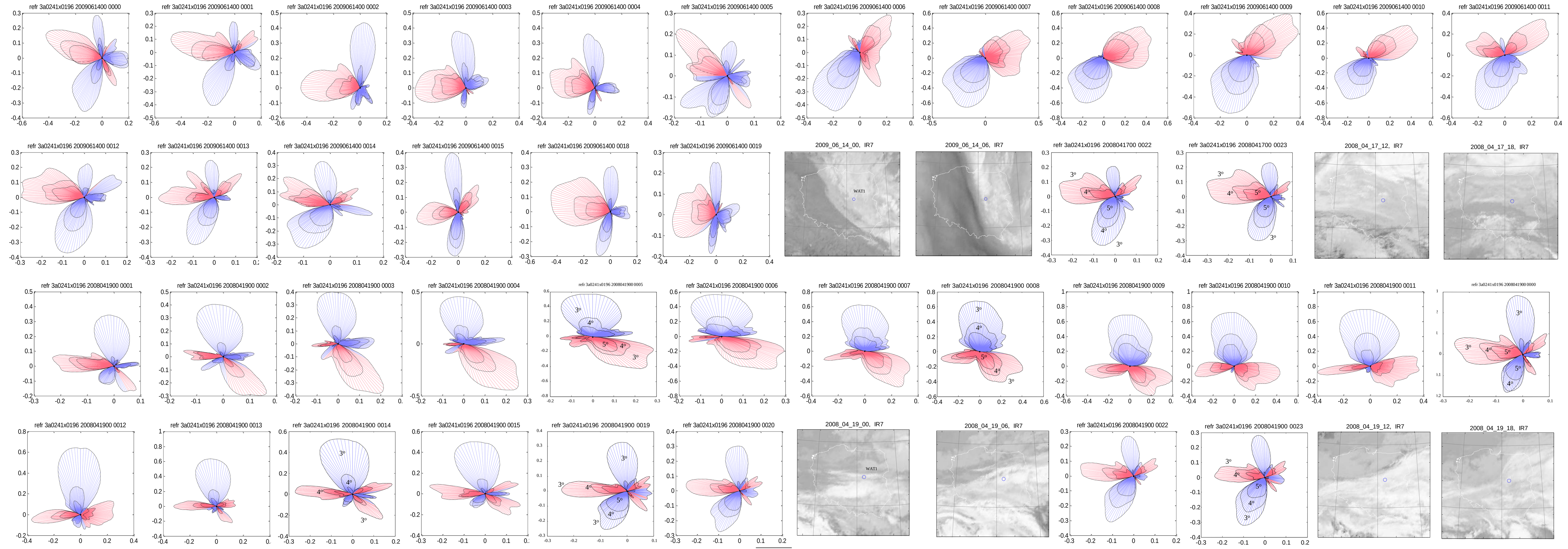
Azimuthally average differences of hourly and diurnal slant delays.



3D relative distributions of slant delay for 5th and 10th hour of COAMPS forecast.

$$x = |\Delta\tau_r^s(\cdot)|\cos\alpha, \quad y = |\Delta\tau_r^s(\cdot)|\sin\alpha,$$

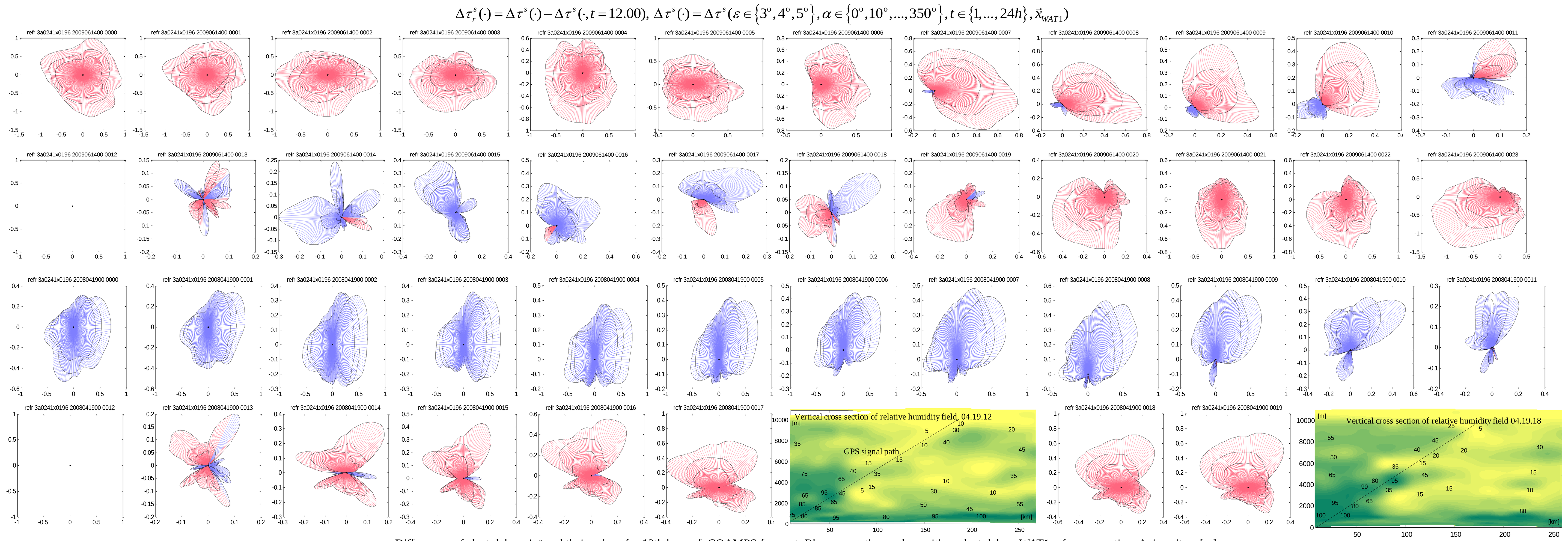
$$\Delta\tau_r^s(\cdot) = \Delta\tau^s(\cdot) - \overline{\Delta\tau^s(\cdot,\alpha)}, \ \Delta\tau^s(\cdot) = \Delta\tau^s(\varepsilon \in \{3^\circ, 4^\circ 5^\circ, ...\}, \alpha \in \{0^\circ, 10^\circ, ...355^\circ\}, t \in \{1, ..., 24\}, \vec{x}_{WAT1})$$



Polar differences (azimuthal distributions) of slant delays $\Delta\tau^s$ and their azimuth average values $\overline{\Delta\tau^s(\cdot,\alpha)}$ for each hour COAMPS forecast. Blue – negative, red – positive slant delay. WAT1 reference station. The weather situation is ilustrated on MSG IR pictures. Axis units – [m].

$$x = |\Delta\tau_r^s(\cdot)|\cos\alpha, \quad y = |\Delta\tau_r^s(\cdot)|\sin\alpha,$$

$$\Delta\tau_r^s(\cdot) = \Delta\tau^s(\cdot) - \Delta\tau^s(\cdot, t = 12.00), \ \Delta\tau^s(\cdot) = \Delta\tau^s(\varepsilon \in \{3^\circ, 4^\circ, 5^\circ\}, \alpha \in \{0^\circ, 10^\circ, ..., 350^\circ\}, t \in \{1, ..., 24h\}, \vec{x}_{WAT1})$$



Differences of slant delays $\Delta\tau^s$ and their values for 12th hour of COAMPS forecast. Blue – negative, red - positive slant delay. WAT1 reference station. Axis units – [m].

$$\Delta\tau_r^s(\cdot) = \Delta\tau^s(\cdot, t_{i+1}) - \Delta\tau^s(\cdot, t_i), \ i = 1, ..., 24, \ \ \Delta\tau^s(\cdot) = \Delta\tau^s(\varepsilon \in \{3^\circ, 4^\circ, 5^\circ, ...\}, \alpha \in \{0^\circ, 10^\circ, ...355^\circ\}, t \in \{1, ..., 24\}, \vec{x}_{WAT1})$$

Differences between slant delays for successive COAMPS forecast hours (ε = 3°, 4°, 5°, 6°, 7°). WAT1 reference station. Y axis units – [m].

Conclusions

Slant delay distributions for low elevation angles highly depend on the weather conditons changes. Obtained relative, azimuthal distributions are anisotropic.

The relative distributions of slant delays show, that the anisotropy is of the one meter (1m) order. Differences between slant delays for successive COAMPS forecast hours are of the one meter order .

The nonhydrostatic mesocale models (COAMPS, Hodur, RM. 1997. Mon. Wea. Rev) are able to model temporal and spatial variability of slant delay .

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