CMAQ (Community Multi-Scale Air Quality) atmospheric dispersion model adaptation for Hungary

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Introduction

The forecasts of ozone concentration are important by reason of the harmful effects of ozone (O_3) on both human health and the environment (McDonnell et al., 2002; Colette et al., 2012).
By adapting the CMAQ (Community Multi-scale Air Quality) model we have designed a combined ambient air-meteorological model (WRF–CMAQ) for forecast of ozone concentration.

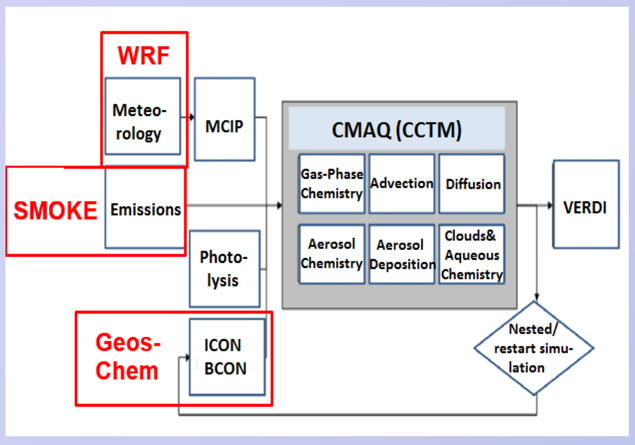

Fig. 1. Schematic picture of the WRF – CMAQ – SMOKE model system. Black arrow shows the direction of the construction of the model system. Red boxes are optional models within the system, blue boxes are the sub processors in the CMAQ model

The CMAQ – WRF – SMOKE model system has a complex model structure (Fig. 1).

<u>Input files:</u>
Meteorological data → WRF model (GFS)
Emission data → SMOKE model (EMEP)
Initial & Boundary → GEOS-Chem

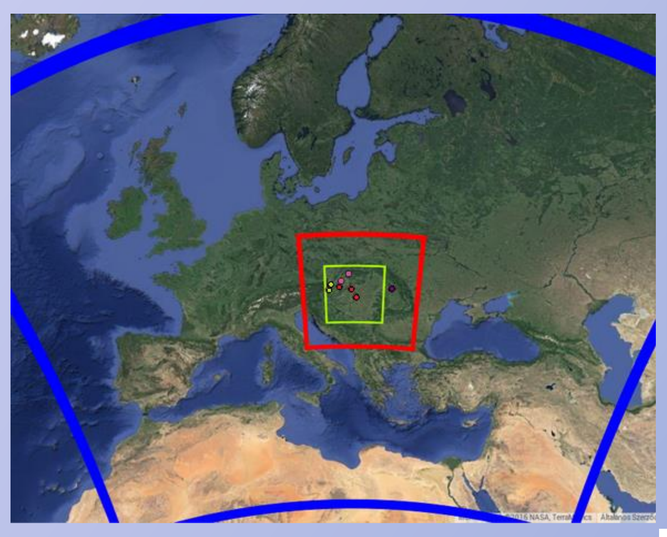

Fig. 2. Nested domains employed by WRF – CMAQ – SMOKE model system, a) blue domain: 108 km grid (Europe), b) 36 km grid (Carpathian Basin), c) 12 km (Hungary), d) point: air quality monitoring stations for verification study

Configuration

Our model settings were CMAQ CB05 (Carbon Bond 2005) chemical mechanism with 108 x 108 km, 36 x 36 km and 12 x 12 km grids for regions of Europe, the Carpathian Basin and Hungary respectively (Fig. 2).

<u>Air quality monitoring stations:</u>
- Győr (47°40'40.8"N 17°39'26.6"E)
- Budapest (47°28'33.0"N 19°02'24.8"E)
- K-puszta (46°58'00.0"N 19°35'00.0"E)
- Ilmitz (47°46'00.0"N 16°46'00.0"E)
- Masenberg (47°20'53.0"N 15°52'56.0"E)
- Poiana Stampei (47°19'29"N 25°08'04"E)
- Chopok (48°56'00.0"N 19°35'00.0"E)
- Topoľníky (47°57'36.0"N 17°51'38.0"E)

Case study

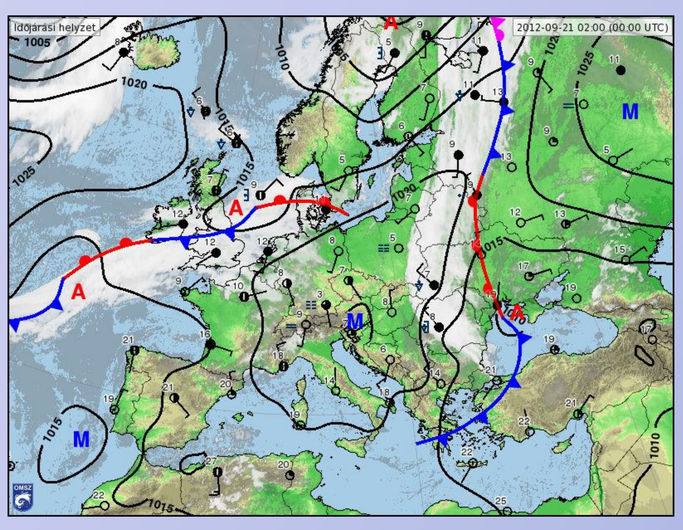

Fig. 3. Weather front analysis at 21st September 2012

In this section we represent the first results of our complex model for Hungary between 19th September 2012 and 27th September 2012.

Weather situation

An anticyclonic situation was selected which was placed in the central part of the Carpathian Basin (21st September 2012) and translocated to the east at 22nd September 2012, and due to more humid air had been flown over Hungary (Fig. 3.).

The model system was run with different time periods and starting dates for optimization the time gap of the air pollution forecast (Fig 4.). Nonetheless the model system did not forecast the measured small concentration values at 21st, 22nd and 23rd September at 108 km grid. Ozone concentration values were examined at 108 km, 36 km, 12 km grids in one point (K-puszta) separately in 21st and 25th September 2012 (Fig. 4) .

In the case of 25th September 2012 each the 108 km, 36 km and 12 km grid values were higher than the measurement data but morning and evening differences were smaller than forecast-measurement differences of 21st September 2012 (Fig. 4, 5).

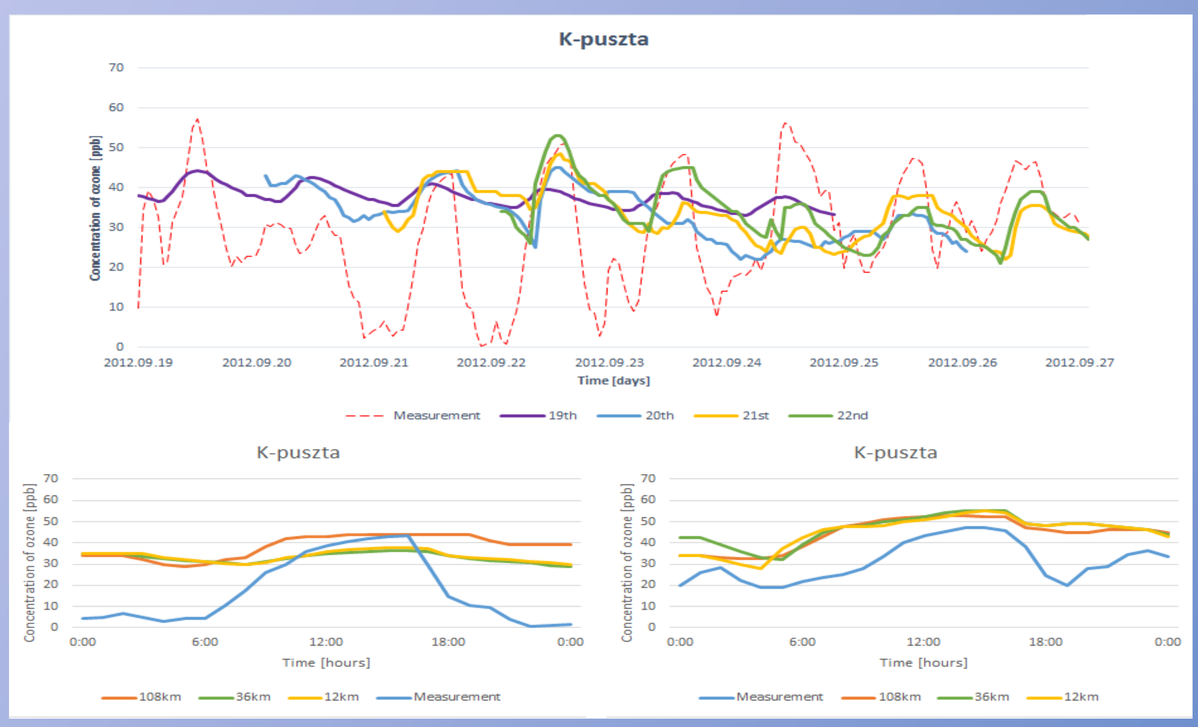

Fig. 4. Concentration of ozone (O_3) on K-puszta. a.) eight-days with different starting times at 108 km grid, b.) at 21st September 2012. c.) at 25th September 2012.

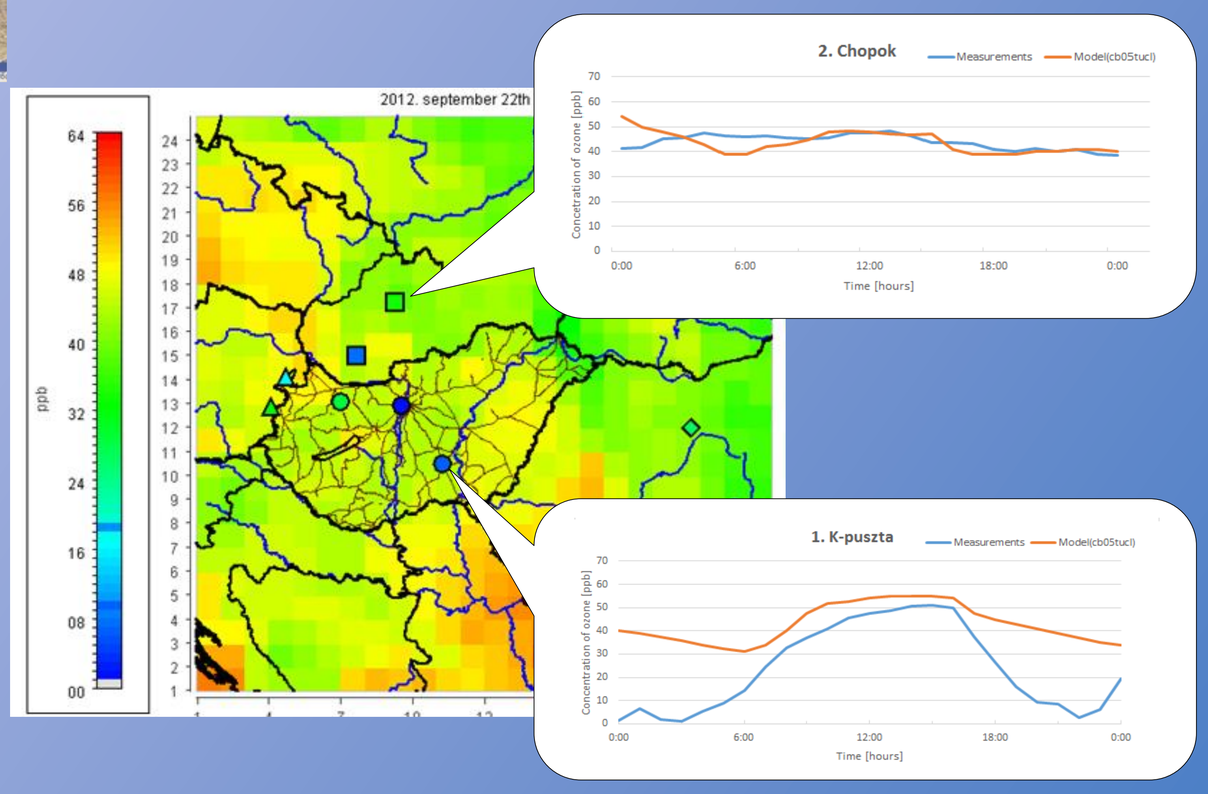

Fig. 5. Ozone concentration forecast in the Carpathian Basin [ppb] at 18 UTC 22nd September 2012. b.) Measurements (blue line) and forecast values (orange line) for K-puszta (Dot 1.) and Chopok (Dot 2.) at 22nd September 2012.

Sensitivity: Chemical mechanism

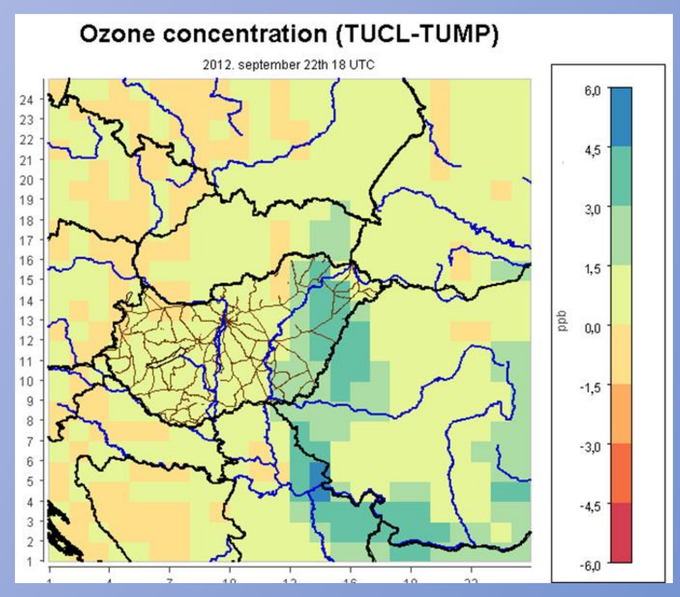

Fig 6. Differences of the two chemical mechanisms (TUCL: toluene and chlorine, TUMP: multi-pollutant) ozone forecasts in the Carpathian Basin at 22nd September 2012

On the map of the spatial differences (Fig 6.) there are chiefly small negative values, but in Romania and on the Great Plain (mostly in Eastern Hungary) higher positive difference values may appear **(**typical in the afternoon**).**

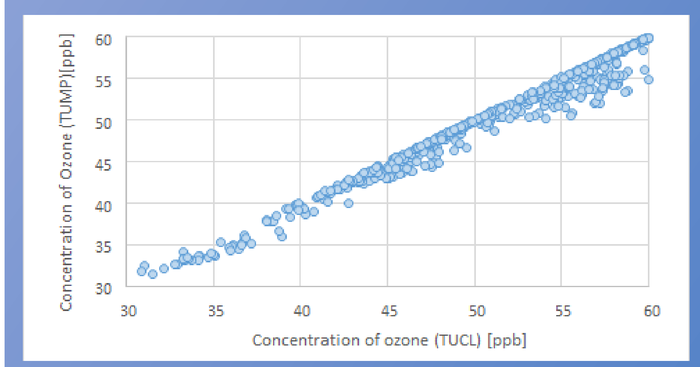

Fig. 7. Scatter plot of the ozone concentration [ppb] (x: TUCL, y: TUMP)

Sensitivity: Source intensity

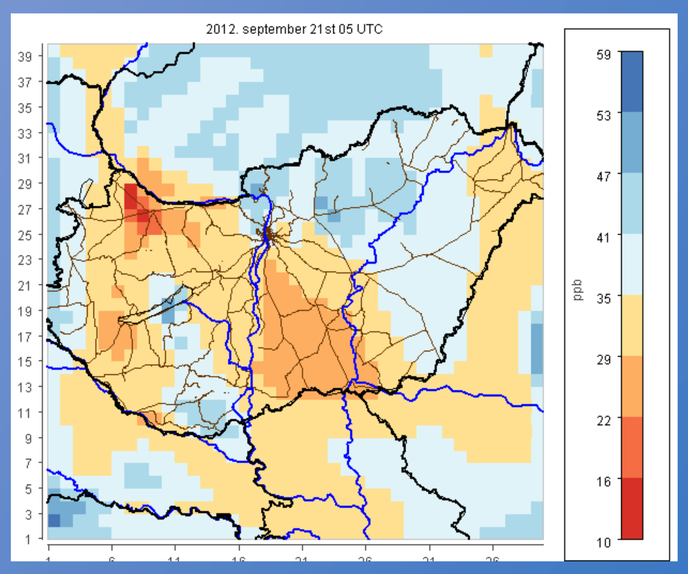

Fig. 8. Ozone concentration forecast in the Carpathian Basin [ppb] with a point source (Győr) at 18 UTC 21st September 2012.

On the map of the source intensity (Fig 8.) the Győr source point has a high NOx emission (~50 ppb), while the ozone concentration became lower in that point.

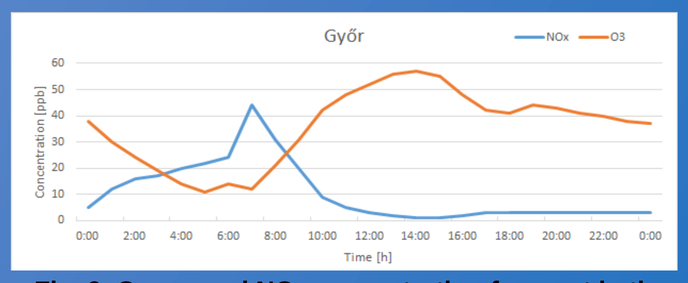

Fig. 9. Ozone and NO_x concentration forecast in the Carpathian Basin [ppb] with a hypothetic point source (Győr) at 21st September 2012.

Conclusions

– the model system shall be run for about 3 days
– the forecast values depend on the initial and boundary values of the O_3 concentration
– the cb05 TUMP mechanism produces typically lower forecast values than cb05 TUCL mechanism in the afternoon.

Our future plans

– to configure a more detailed emission dataset for Europe and Hungary,
– to examine the air pollution concentration forecasts for a full-year period,
– to test the model sensitivity with other air-quality models (e.g. WRF-Chem)
– to build up an ensemble ozone forecast.

References

Colette, A., C. Granier, Ø. Hodnebrog, H. Jakobs, A. Maurizi, A. Nyiri, S. Rao, A. Amann, B. Bessagnet, A. D;Angiola, M. Gauss, C. Heyes, Z. Klimont, F. Meleux, M. Memmesheimer, A. Mieville, L. Rouïl, F. Russo, S. Schucht, D. Simpson, F. Stordal, F. Tampieri, and M. Vrac, 2012: Future air quality in Europe: a multi-model assessment of projected exposure to ozone. Atmospheric Chemistry and Physics 12, 10613–10630.

McDonnell, W. F., J. A. Raub, D. C. Spencer, S. L. Stone, J. Brown, and E. Wildermann, 2002: Health Effects of Ozone in Patients with Asthma and Other Chronic Respiratory Disease. EPA webpage course (https://www3.epa.gov/apti/ozonehealth/effects.html)