A WRF-EMEP Forecast System for the Hubei Province, China

T. Svendby, S. Solberg, P. Schneider, L. Liu

NILU - Norwegian Institute for Air Research, NO-2027 Kjeller, Norway

Introduction

The air pollution in China, especially in the cities, often exceeds recommended air quality levels and can have adverse effects on human health. To reduce exposure to pollution the population will benefit from a warning system. Through the EU – China Environmental Governance Programme (EGP) NILU is developing an air quality forecast modelling system for the province of Hubei and Wuhan city in particular. The first stage of this work is presented.

Method

The aim is to provide daily forecasts of PM, NO_x and ozone for the capital Wuhan, a city of 10 million inhabitants. The system is based on a nested model set-up using the EMEP MSC-W Chemistry Transport Model (Simpson et al., 2012) driven by meteorological data from the WRF model (Skamarock et al., 2008).

In the final stage, the EMEP-WRF system will be run on a regional scale providing boundary values for NILU's urban model EPISODE (Slørdal et al., 2003) which will be run for the inner urban domain. Results from the EPISODE model is not presented here.

Figure 1: The WRF-EMEP model domains. The two nests (0.5° and 0.1° resolution) are marked as red rectangles.

WRF-EMEP is run on two nested domains in lat/long projection: An outer domain, covering the whole of China with 0.5° grid resolution and a 2nd domain centred around Hubei with a resolution of 0.1° (~11 km), as shown in Figure 1. The mother domain has 122×70 grid cells in longitudinal and latitudinal directions, respectively, whereas the inner domain contains 90 x 50 grid cells.

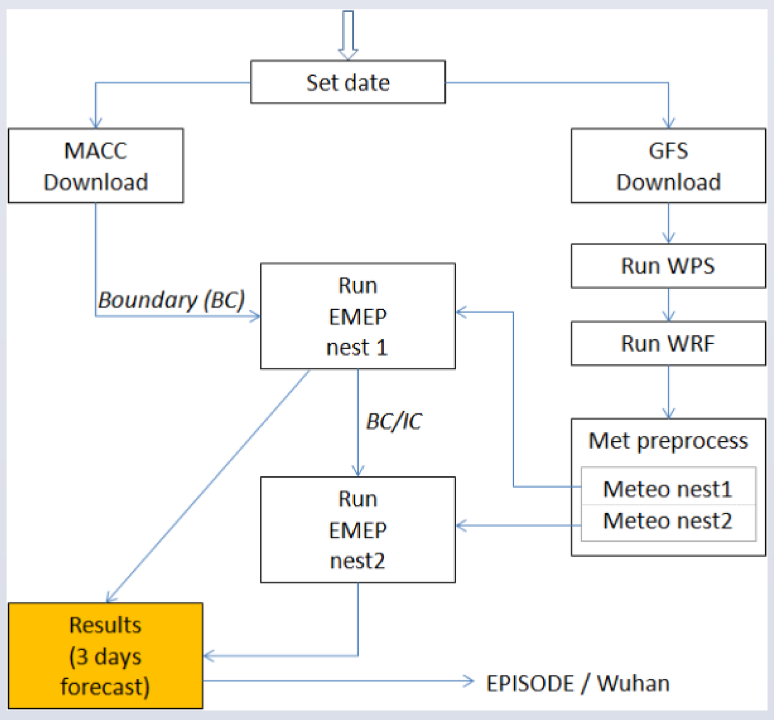

Figure 2: Structure of the WRF-EMEP-EPISODE modelling system

Figure 2 shows the structure and flow of information in the automated WRF-EMEP-EPISODE modelling system:

1. Download MACC-II/MOZART forecast data for boundary concentrations
2. Download GFS met data (forecast) for input to WPS preprocessor and WRF
3. Run WPS/WRF for the two nests on 0.5° and 0.1° resolution
4. Convert WRF output to EMEP input
5. Run the EMEP model for the outer nest, creating boundary for inner nest
6. Run the EMEP model for the 2nd nest, generating daily output for Hubei and boundary for the EPISODE model.

EMEP model details

Emissions:

- Based on the Emission Database for Global Atmospheric Research (EDGAR) version 4.2. (http://edgar.jrc.ec.europa.eu/overview.php?v=42)
- 0.1° x 0.1° spatial resolution
- Species: CO, NH_3, NMVOC, NO_x, PM10, and SO_2. PM2.5 obtained from PM10 scaling
- Data converted to SNAP classification used by the EMEP model

Boundary values:

- Obtained from the EU FP7 project MACC-II (Monitoring Atmospheric Composition and Climate)
- Daily 5 days forecasts from the MOZART model (experiment "fnyp", http://join.iek.fz-juelich.de/macc/workspace)
- Spatial resolution of 1.125° x 1.125° with 47 vertical layers

Meteorological data:

- Based on WRF version 3.4
- Input data from NCEP Global Forecast System (GFS) data, 1.0° x 1.0° grid resolution in GRIB2 format and 3-hour forecast data frequency
- For historical runs: Input data from FNL (Final) Operational Global Analysis data computed with the same model as GFS

Validation and sensitivity tests

Currently there is limited access to ground based AQ measurements in China for model evaluation. An evaluation based on NO_2 satellite data have been made. Figure 3 shows the modelled tropospheric NO_2 column from WRF-EMEP (left) and from the OMI satellite (right) one selected day. The agreement between modelled data and satellite observation is satisfactory.

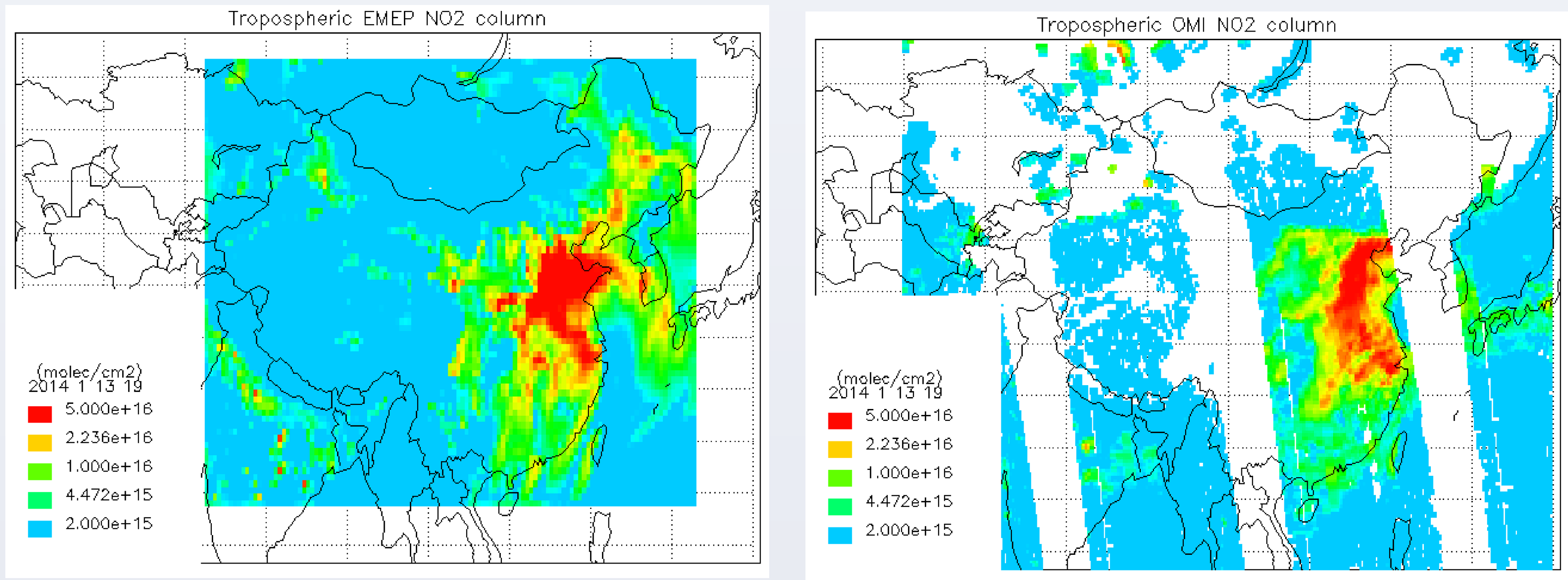

Figure 3: Tropospheric NO_2 column 13. January 2014 from WRF-EMEP (left panel) and OMI (right panel)

Two different emission data sets have been used to study the impact of emissions on modelled surface concentrations of ozone, NO_2 and PM:

- EDGAR emission data set, previously described
- EMEP_EMIS, 0.5° x 0.5° resolution, based on data from IIASA (www.iiasa.ac.at/web/home/research/researchPrograms/Overview2.en.html)

The yearly total NOx emission for China is comparable for the two data sets, however, the spatial and temporal distribution differ. Figure 4 shows modelled WRF-EMEP concentrations of NO_2 in Wuhan, based on EDGAR emission (blue curve) and EMEP_EMIS (red curve) for the period 1. July to 31. December 2012. Note that Figure 4 represents the model grid around Wuhan with the largest NO_2 difference.

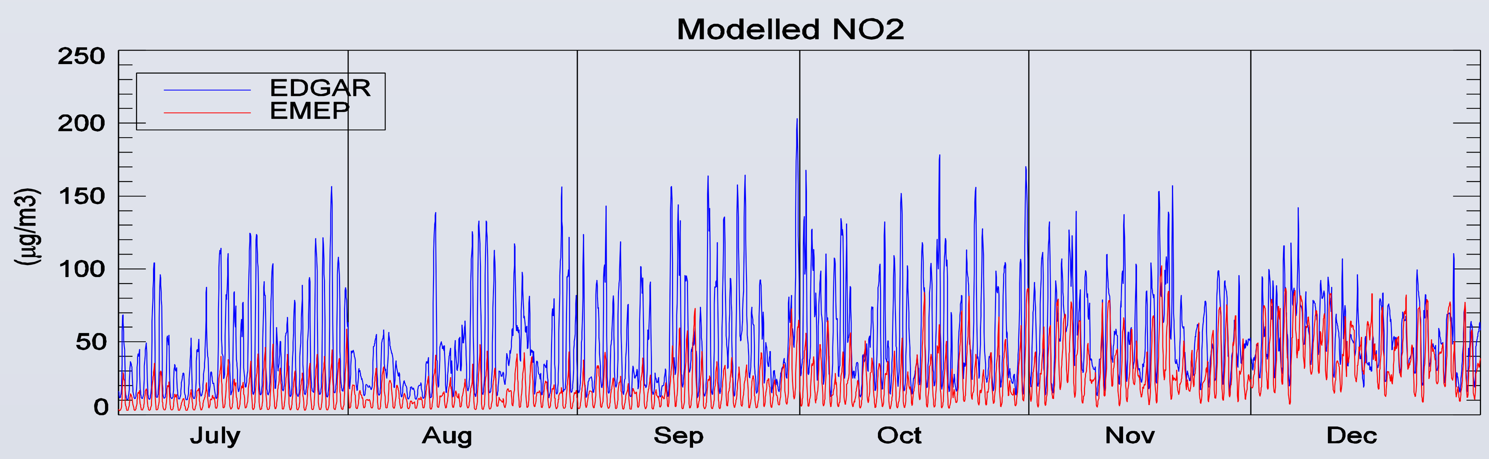

Figure 4: NO_2 time series from WRF-EMEP model simulation in Wuhan with EDGAR emission (blue curve) and EMEP global emission (red curve)

The two WRF-EMEP model simulations have also been compared to daily average O_3 and PM values from the background station Shen Nong Jia in the western part of Hubei. The results, presented in Figure 5, demonstrate good agreement for ozone. However, for PM_{10} the agreement is poorer and the modelled values are about twice as high as the measurements. This needs to be investigated further.

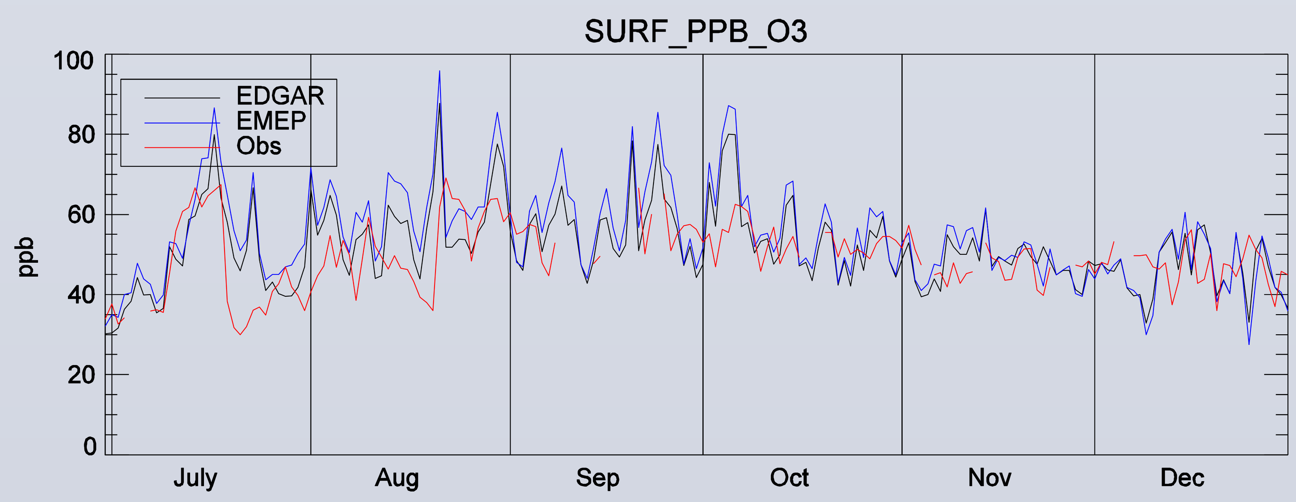

Figure 5: Time series of daily average O_3 from Shen Nong Jia in 2012: Observations (red curve) and WRF-EMEP model simulation with EDGAR emission (black curve) and EMEP global emission (blue curve)

Preliminary conclusions

An air quality forecasting system for Wuhan is under development. Preliminary validation of the WRF-EMEP model results is based on comparisons with satellite data and one surface station. The agreement is satisfactory. Sensitivity tests for Wuhan show that correct emission data is crucial for making reliable AQ forecasts.

Acknowledgement

The work is funded by EU – China Environmental Governance Programme (EGP), EuropeAid/132-005/L/ACT/CN. David Simpson, Peter Wind, Alvaro Valdebenito and Massimo Vieno are acknowledged for assistance with WRF-EMEP model development. We are also grateful for data provided by the MACC-II project (EU 7th Framework Programme).

References

- Simpson D., et al., 2012. The EMEP MSC-W chemical transport model - technical description, *Atmos. Chem. Phys.*, 12 (16), 7825-7865, Special Issue
- Skamarock, W. C., and Klemp, J. B.: A time-split nonhydrostatic atmospheric model for weather research and forecasting applications, *J. Comput. Phys.*, 10.1016/j.jcp.2007.01.037, 2008.
- Slørdal, L.H. et al., 2003. The urban air dispersion model EPISODE applied in AirQUIS2003. Technical description. Kjeller, Norwegian Institute for Air Research (NILU TR 12/2003).

Contact: *tove.svendby@nilu.no*