The Another Assimilation System for WRF-Chem (AAS4WRF): a new mass-conserving emissions pre-processor for WRF-Chem regional modelling

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Abstract

The Another Assimilation System for WRF-Chem (AAS4WRF) is a ncl based mass-conserving emissions pre-processor designed to create WRF-Chem ready emissions files from local inventories on a lat/lon projection. AAS4WRF is appropriate to scale emission rates from both surface and elevated sources. Two case studies performed in the metropolitan areas of Sao Paulo and Manizales in Brazil and Colombia, respectively, are presented to analyse the influence of using local or global emission inventories in the representation of regulated air pollutants such as O_3 and $PM_{2.5}$.

Background

➤ The WRF-Chem (Grell et al., 2005) is a state-of-the-art air quality model widely used for the study of pollutants transport, formation of secondary pollutants, as well as for the assessment of air quality policies implementation.
➤ Several tools are available to assist users in creating their own WRF-Chem emission files based on global inventories (e.g. anthro_emiss, prep-chem-src); however, there is no one that does build those emission files for any particular domain with local information at this time.

Research objective

Introduce a new methodology for building WRF-Chem emission files from local inventories on a lat/lon projection.

Overview

➤ A ncl based mass-conserving WRF-Chem emissions pre-processor.
➤ Since it was successfully tested for the first time for the city of Lima, Peru in 2014 (managed by SENAMHI, the National Weather Service of the country), several studies on air quality modelling have applied this utility to convert their emissions to those required for WRF-Chem.
➤ Although it works with local emissions information at the moment, further work is being conducted to make it compatible with global/regional emissions data file format.
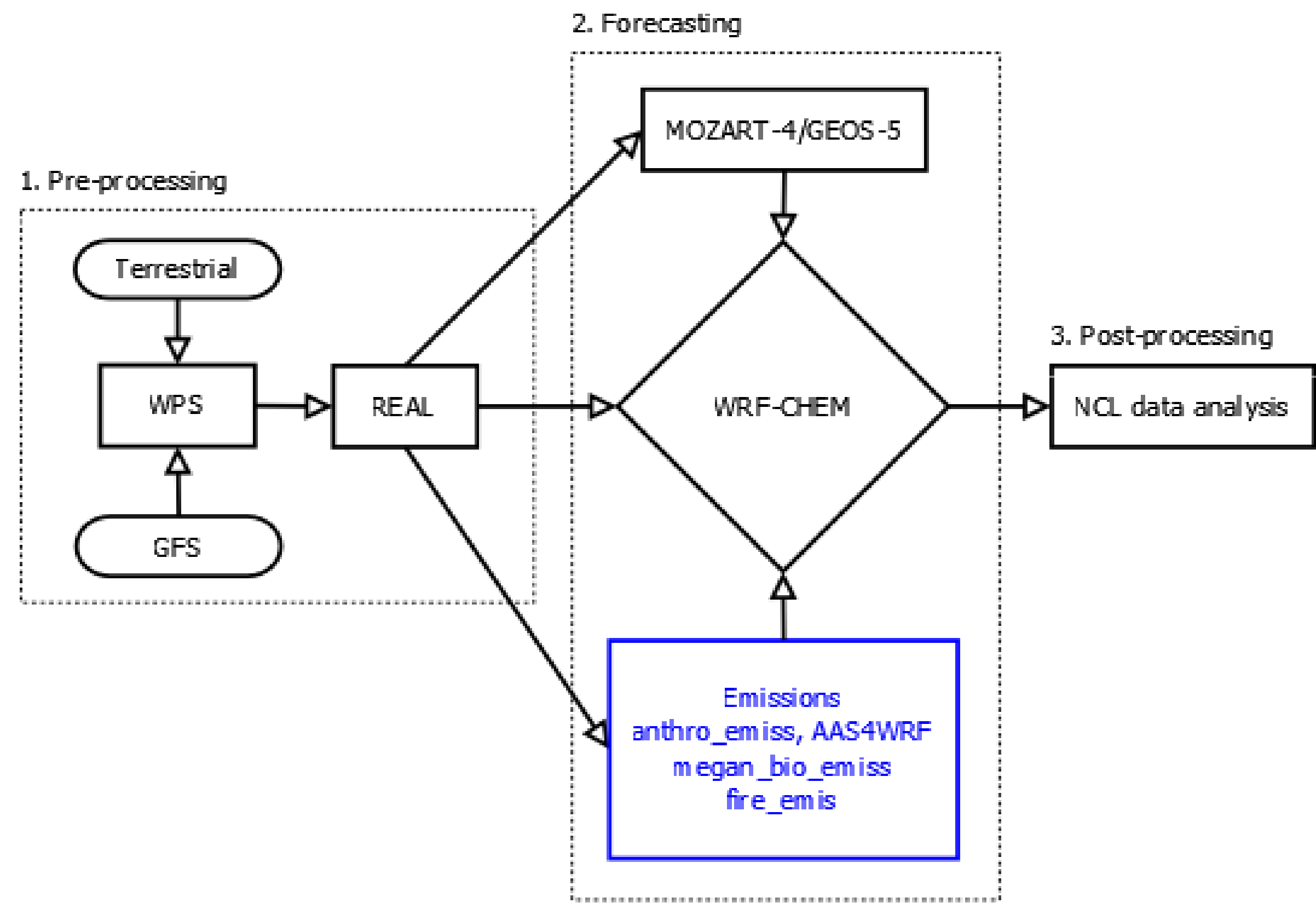

Fig. 1. WRF-Chem flowchart.

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Usage

The AAS4WRF is a code written entirely in the NCAR Command Language (NCL, 2017), then the users only need to correctly build both NCL and NCAR Graphics, or install the available binaries for their platform. Prior to run AAS4WRF, the user must set up a namelist file called "namelist.emiss". The workflow for using AAS4WRF is listed below.

1. Run GEOGRID, UNGRIB, METGRID and REAL normally as a standard WRF-Chem simulation.
2. Enter the following information into the namelist.emiss:

Variable Names	Description
&input_files	
wrf_dir	string; full path and name of wrfinput_d01
emiss_dir	string; full path and name of emissions.txt
&grid_points	
nx	integer; number of longitude points in emissions.txt
ny	integer; number of latitude points in emissions.txt
nt	integer; number of time points in emissions.txt
hemi	integer; hemisphere: NH→1; SH→-1
&time_control	
sy	integer; start year
sm	integer; start month
sd	integer; start day
ey	integer; end year
em	integer; end month
ed	integer; end day
&species_control	!column number from 3 to 38 according to emissions.txt
so2	integer; column number for so2
...	...
i	integer; column number for i
...	...
ecc	integer; column number for ecc

3. Run AAS4WRF by typing:

$ ncl AAS4WRF.ncl

• Input files: **emissions.txt**, **wrfinput_d01** and **namelist.emiss**
• Output files: two different output files can be produced, depending on the choice for **io_style_emissions**:
   1. **wrfchemi_00z_d01** and **wrfchemi_00z_d01** for **io_style_emissions = 1**
   or
   2. **wrfchemi_d01_<date/time>** for **io_style_emissions = 2**

Structure of input emissions

➤ The AAS4WRF requires that the user provides a file containing the gridded hourly emissions (emissions.txt in this example). Each line of the file is required to have the following format:

| id lon lat specie_1 specie_2...specie_n specie_(n+1)...specie_36 |

where
  - **id**: grid point ID

- **lon**: grid point longitude
- **lat**: grid point latitude
- **specie_n**: nth-specie in the **CBMZ-MOSAIC** mechanism.
   Complete with columns of "0" if data is not available.

➤ There are **nx×ny×nt** lines in emissions.txt, arranged in blocks of time (each with length of **nx×ny**) as follows: lon and lat are periodic 1D strictly monotonically increasing and decreasing arrays, respectively, that have their components equally spaced at **dx** (same horizontal resolution as the WRF grid).
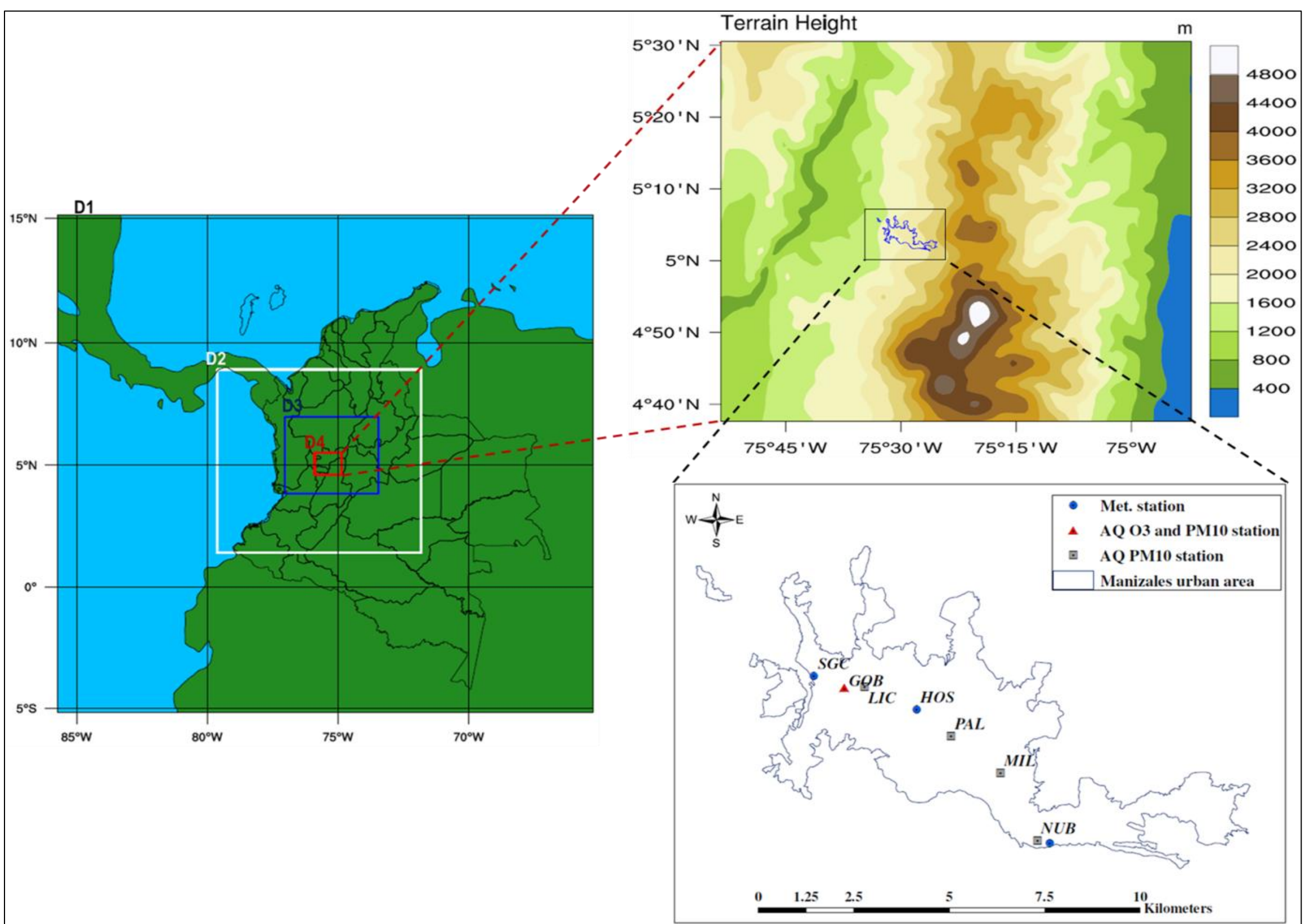
Model application for Manizales

Fig. 2. Study area, WRF-Chem domains and the air quality monitoring sites considered for model evaluation.
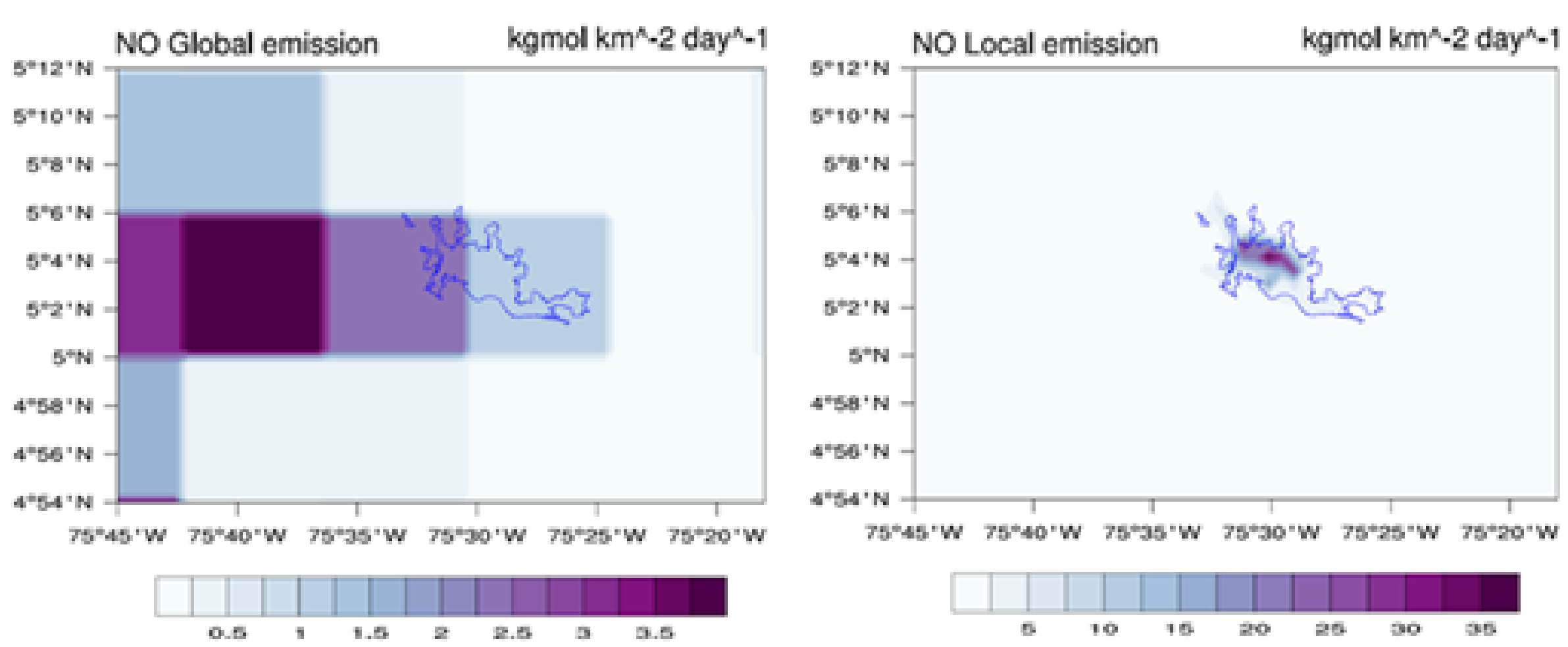

Fig. 3. Spatial distribution of NO emission rates in the 1 km modelling domain. Emissions on the left panel are based on the HTAPv2.2 estimates, whereas those on the right panel are based on the local emission inventory.
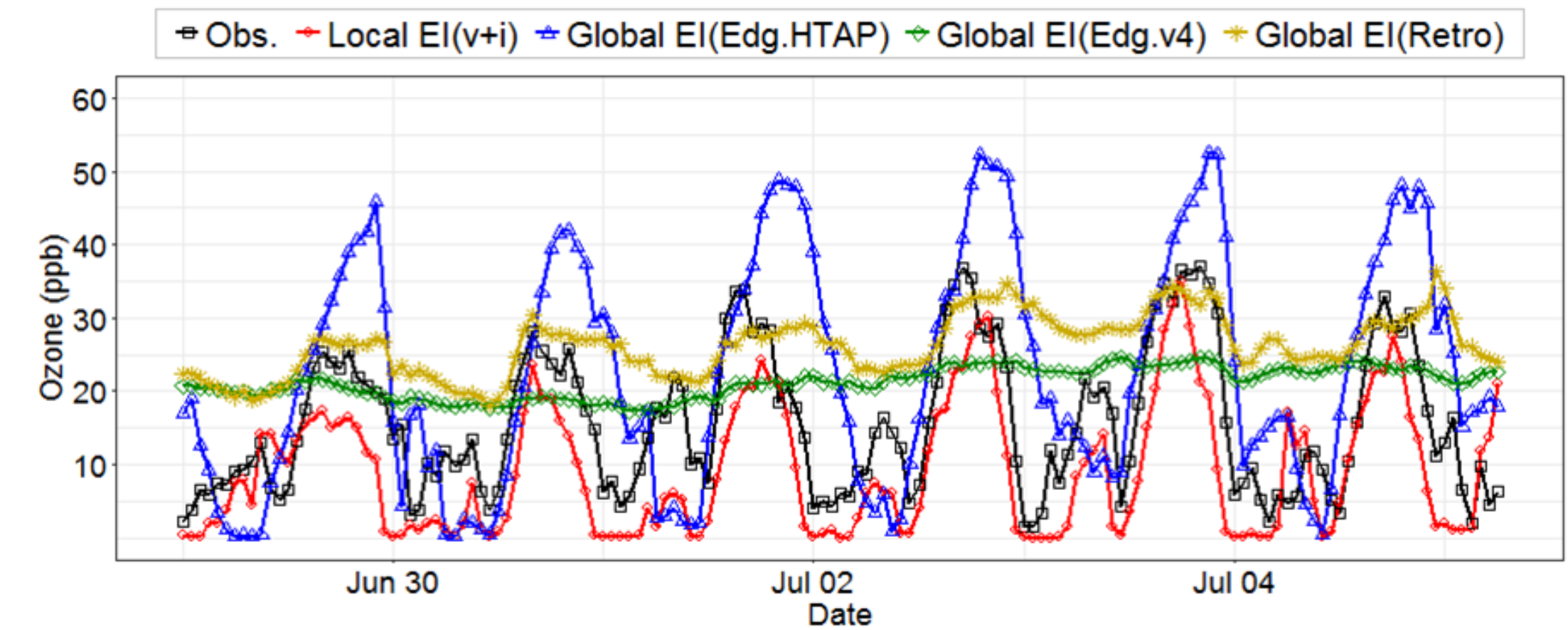

Fig. 4. Hourly variations in O_3 concentrations at all sites during the period from 28th June to 5th July 2015.

➤ Figures adapted from González et al. (2017), submitted to APR.
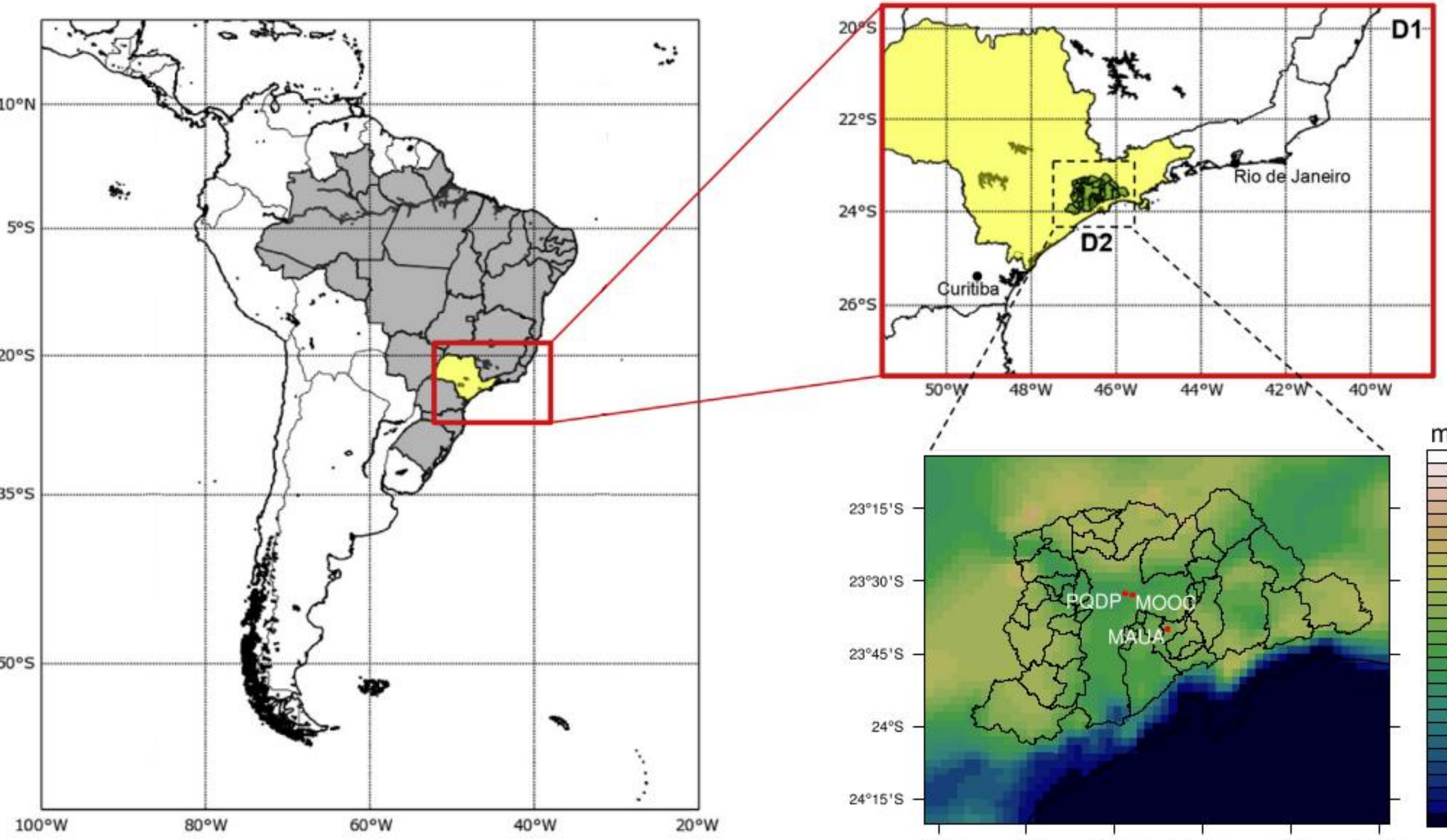
Model application for São Paulo

Fig. 5. Study area, WRF-Chem domains and the air quality monitoring sites considered for model evaluation (Figure adapted from Hoshyaripour et al. (2016)).
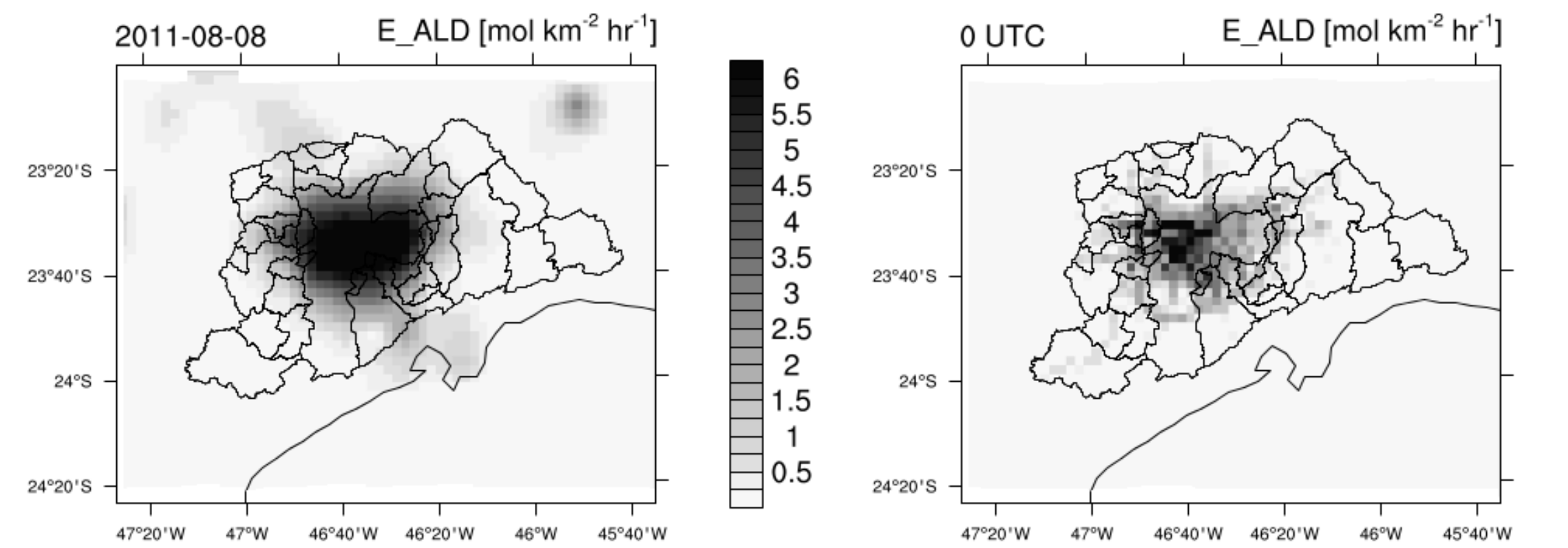

Fig. 6. Spatial distribution of ALD emission rates in the 1 km modelling domain. Emissions on the left panel are based on the HTAPv2.2 estimates, whereas those on the right panel are based on the local emission inventory.
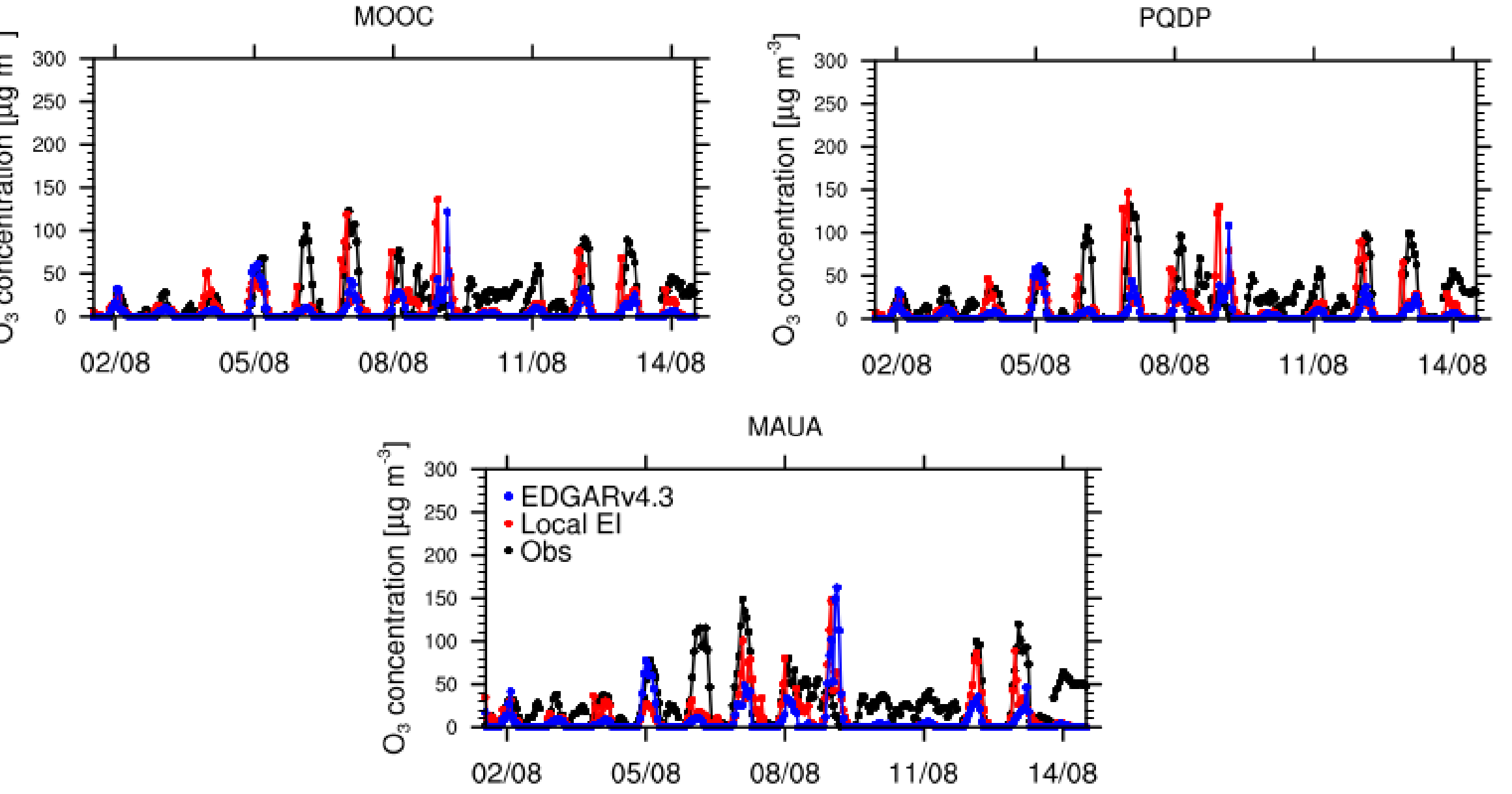

Fig. 7. Hourly variations in O_3 concentrations at three CETESB sites during the period from 2nd August to 14th August 2015.

Conclusions

➤ The use of local emissions in a high-resolution WRF-Chem simulation allowed significant improvements in the representation of O_3.
➤ The tool is freely available upon request to the corresponding author.

References

Grell, G. A., S. E. Peckham, R. Schmitz, S. A. McKeen, J. Wilczak, and B. Eder (2005), Fully coupled "online" chemistry within the WRF model, Atmos. Environ., 39, 6957-6975.
Hoshyaripour, G., G. Brasseur, M. F. Andrade, M. Gavidia-Calderon, I. Bouarar, and R. Y. Ynoue (2016), Prediction of ground-level ozone concentration in São Paulo, Brazil: Deterministic versus statistic models, Atmospheric Environment, 145, 365-375