Evaluation of WRF-Chem performance in the Air Quality modeling over Metropolitan Area of Buenos Aires: inter-comparison of global vs. local emission inventories.

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Objective: Evaluate the WRF-Chem model sensitivity to different anthropogenic emission inventories, implementing the GEAA high-resolution inventory for Argentina compared to the EDGAR-HTAP global inventory.

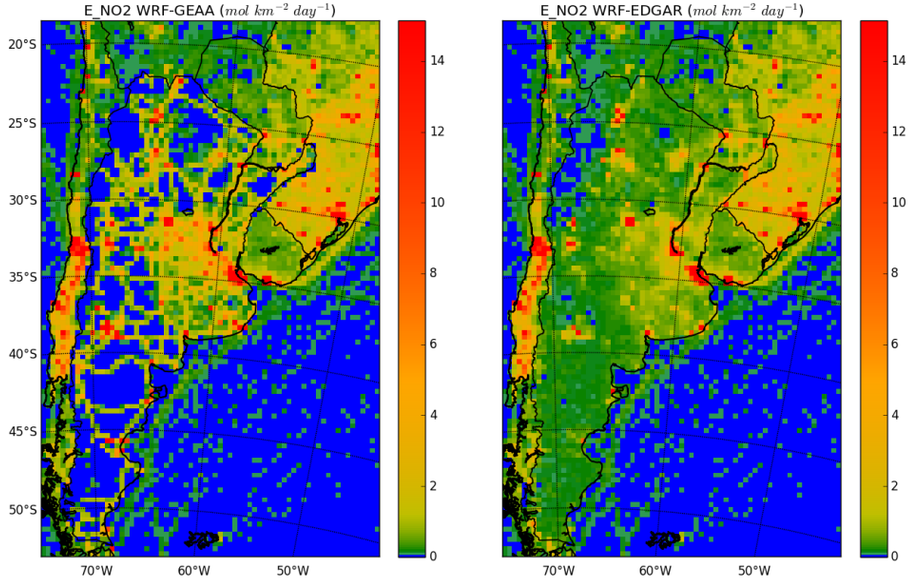
Methods and Data

1. Two simulations performed:
WRF-EDGAR: EDGAR-HTAP database for anthropogenic emissions
WRF-GEAA: GEAA database for anthropogenic emissions inside Argentina and EDGAR-HTAP outside.
2. Comparison against surface observation for 3 stations inside urban area and 1 station in sub-urban area.
3. Comparison of NO2 tropospheric column against satellite-product (Sentinel-5P - TROPOMI)

WRF-Chem Setup	
4 nested domains	Resolution: 36, 12, 4 and 1.3 km
Study area	Buenos Aires/ Argentina
Chemical Scheme	MOZART
Aerosol Scheme	GOCART
Dry Deposition	Coupled to Soil & Vegetation
Biomass Burning Database	Fire Inventory from NCAR (FINN)
Chemistry initial & boundary conditions	MOZART-4 global model
Simulation Dates	1-10 September 2017

We use the athro_emiss tool version modified by Fernandez et al. (2017) and Schiavone et al. (2017) (available upon request) to generate regional emissions both from global inventories, as well as from local emission inventories. Also an updated WPS to include the implementation of Political and Time-zone maps, as well as high-resolution land use and terrain height static fields.

a) Spatial resizing over WRF domains for both inventories

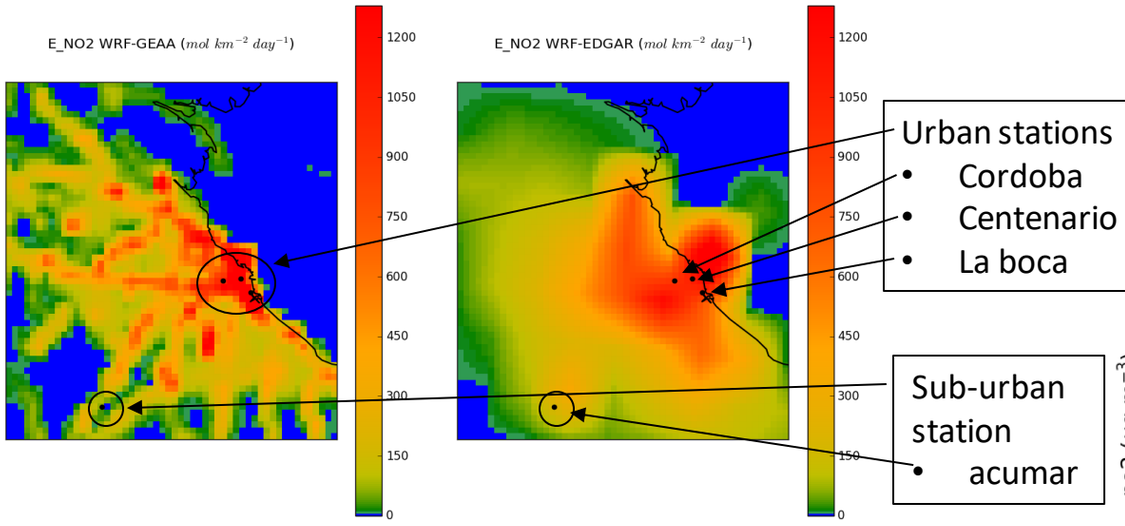


b) Different types of temporal profiles depending on the land-use. As well as the time-zone shift for zonal bands at different longitudes (only for WRF-GEAA)

Inner domain (d04, 1.3km resolution) spatial surface concentration distribution.

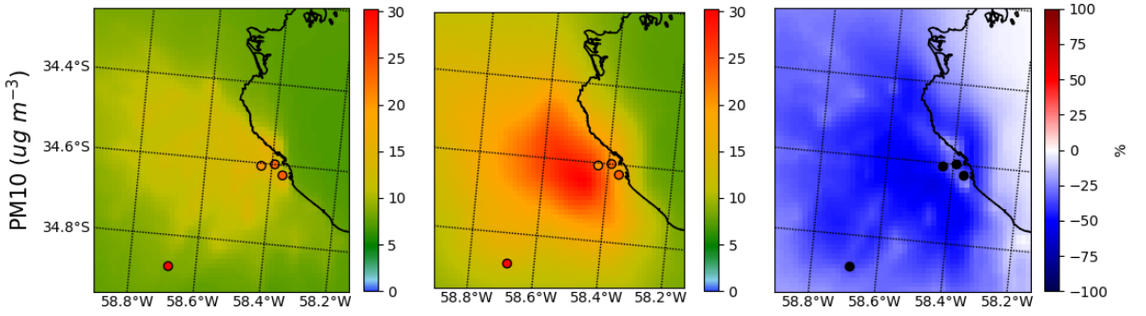
- Large differences between simulated surface PM10 concentrations at more polluted areas.
- Particulate Matter concentrations in the surface layer are clearly lower for WRF-GEAA.
- A better resolved distribution of vehicular emissions in the high-resolution inventory (GEAA) is reflected in the differences on the surface concentrations of NO2 between WRF-EDGAR and WRF-GEAA, with higher values being observed for WRF-GEAA near the main vehicular routes.

Anthropogenic NO2 emissions (d04)

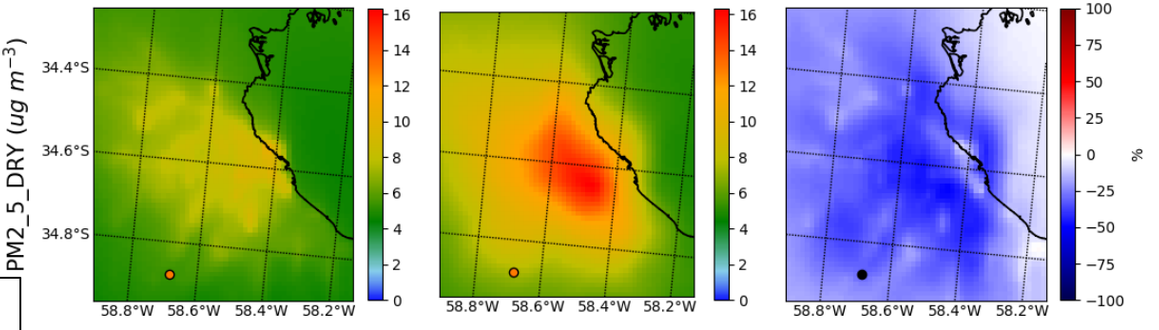


WRF_{GEAA} WRF_{EDGAR} $WRF_{GEAA} - WRF_{EDGAR} / WRF_{EDGAR}$

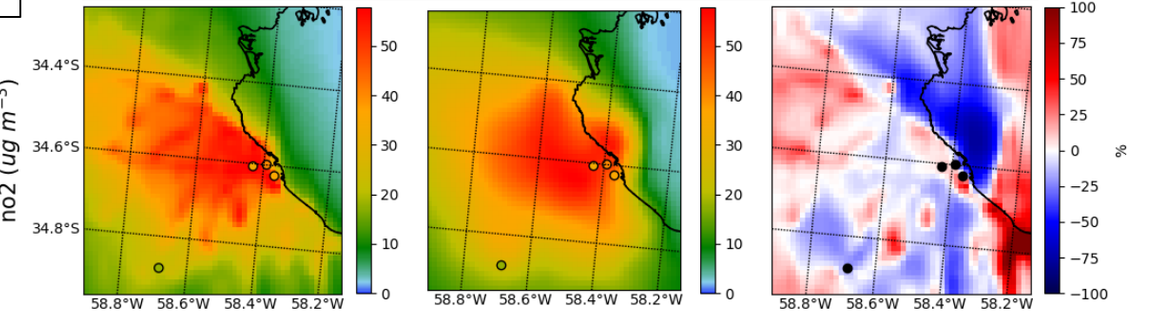
PM10 surface simulation average



PM2.5 surface simulation average



NO2 surface simulation average



PM10 daily average concentration

WRF-GEAA					
Station	Obs-avg (ug m⁻³)	Model-avg (ug m⁻³)	RMSE (ug m⁻³)	R	NMB (%)
1. cordoba	22.89	12.70	12.28	0.23	-44.52
2.centenario	20.13	14.38	7.92	0.52	-28.60
3. la boca	23.13	12.82	12.11	0.42	-44.55
4. acumar	28.19	8.46	25.55	0.83	-69.99

WRF-EDGAR					
Station	Obs-avg (ug m⁻³)	Model-avg (ug m⁻³)	RMSE (ug m⁻³)	R	NMB (%)
1. cordoba	22.89	19.49	7.88	0.34	-14.88
2.centenario	20.13	24.07	7.58	0.51	19.57
3. la boca	23.13	18.16	8.09	0.48	-21.49
4. acumar	28.19	14.42	18.28	0.91	-48.85

NO2 daily average concentration

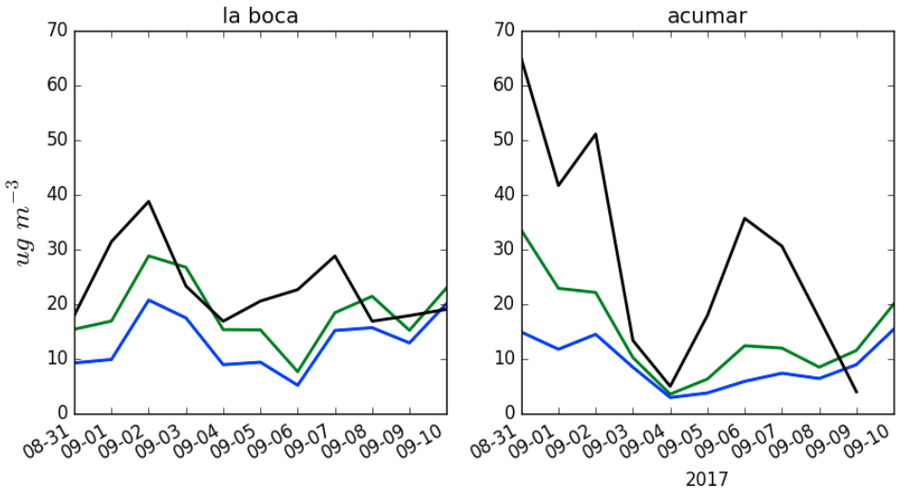
WRF-GEAA					
Station	Obs-avg (ug m⁻³)	Model-avg (ug m⁻³)	RMSE (ug m⁻³)	R	NMB (%)
1. cordoba	40.34	42.38	30.64	0.07	5.07
2.centenario	33.38	58.52	36.33	0.17	75.31
3. la boca	35.81	49.78	30.81	-0.02	39.00
4. acumar	17.73	21.11	16.59	0.58	19.02

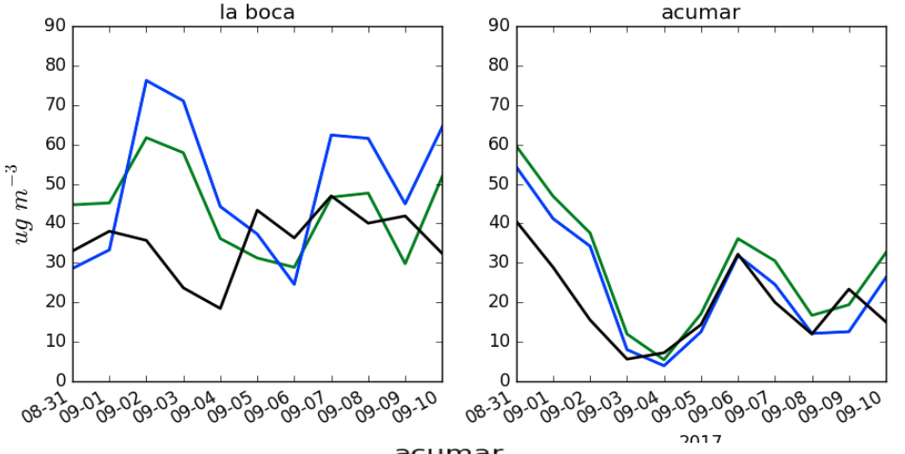
WRF-EDGAR					
Station	Obs-avg (ug m⁻³)	Model-avg (ug m⁻³)	RMSE (ug m⁻³)	R	NMB (%)
1. cordoba	40.34	51.05	28.67	-0.02	26.55
2.centenario	33.38	53.58	31.01	0.08	60.52
3. la boca	35.81	42.18	24.84	-0.04	17.78
4. acumar	17.73	25.80	18.09	0.63	45.52

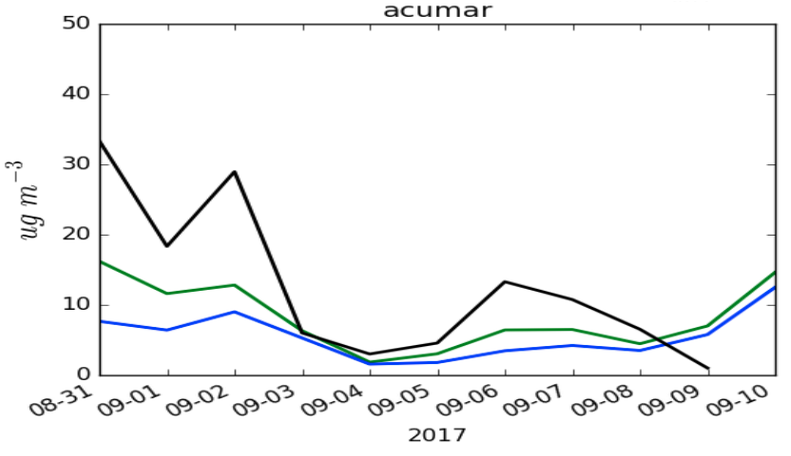
PM2.5 daily average concentration

WRF-GEAA					
Station	Obs-avg (ug m⁻³)	Model-avg (ug m⁻³)	RMSE (ug m⁻³)	R	NMB (%)
4. acumar	12.58	4.76	11.68	0.87	-62.14

WRF-EDGAR					
Station	Obs-avg (ug m⁻³)	Model-avg (ug m⁻³)	RMSE (ug m⁻³)	R	NMB (%)
4. acumar	12.58	7.58	8.33	0.95	-39.70



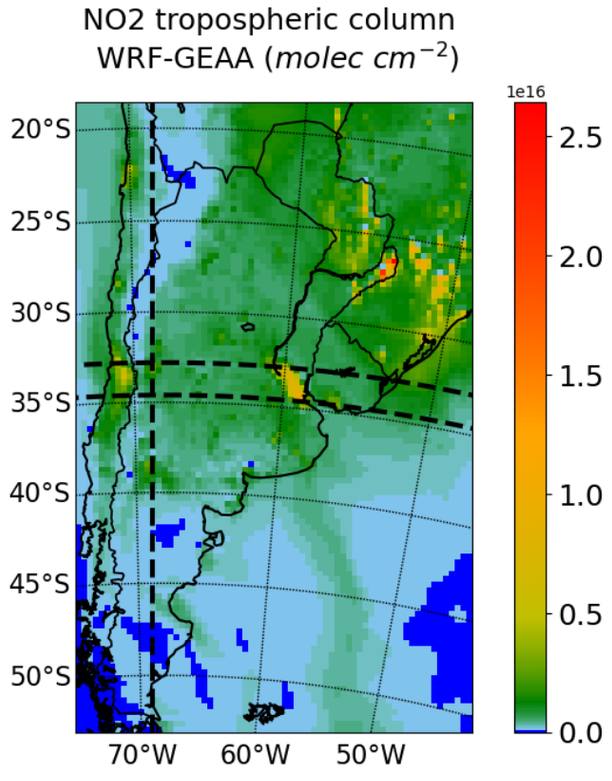




Inner domain (d04, 1.3 km resolution) temporal analysis for urban (*la boca*) and suburban station (*acumar*).

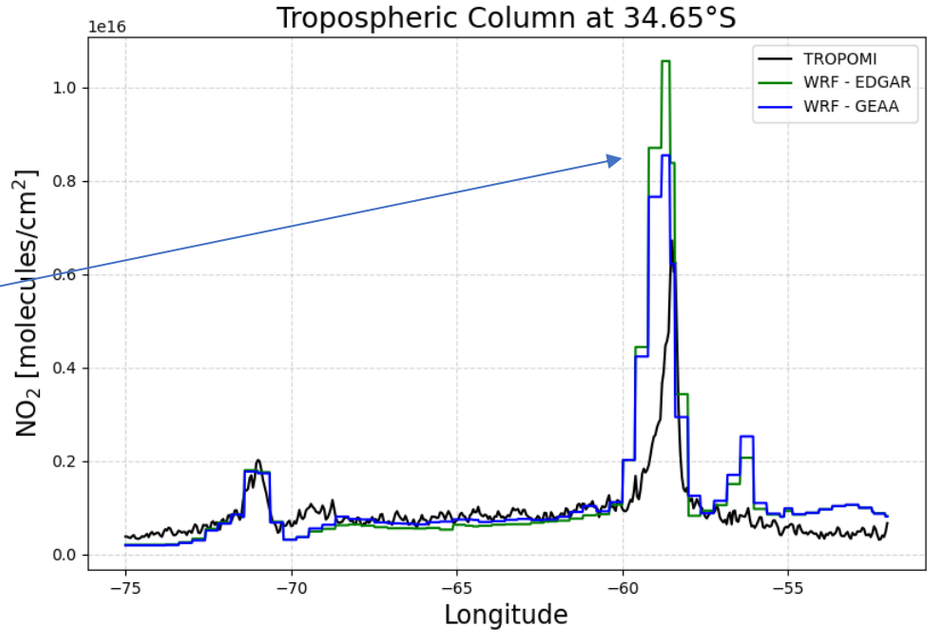
- General PM10 behavior is well represented for ***la boca***, with slight underestimation.
- High pearson correlation coefficients for PM10 and PM2.5.
- Overestimation in the daily concentration of NO2 for both simulation cases at ***la boca*** station .
- Good agreement for daily NO2 concentration in ***acumar*** (sub-urban area).
- Changes in spatial resolution do not have a remarkable impact on the temporal distribution compared to the simulation with the global inventory

WRF-Chem vs TROPOMI NO2 Tropospheric Column (d01)



NO2 levels higher than the satellite are observed over the Buenos Aires area (34.6 S, 58.3 W).

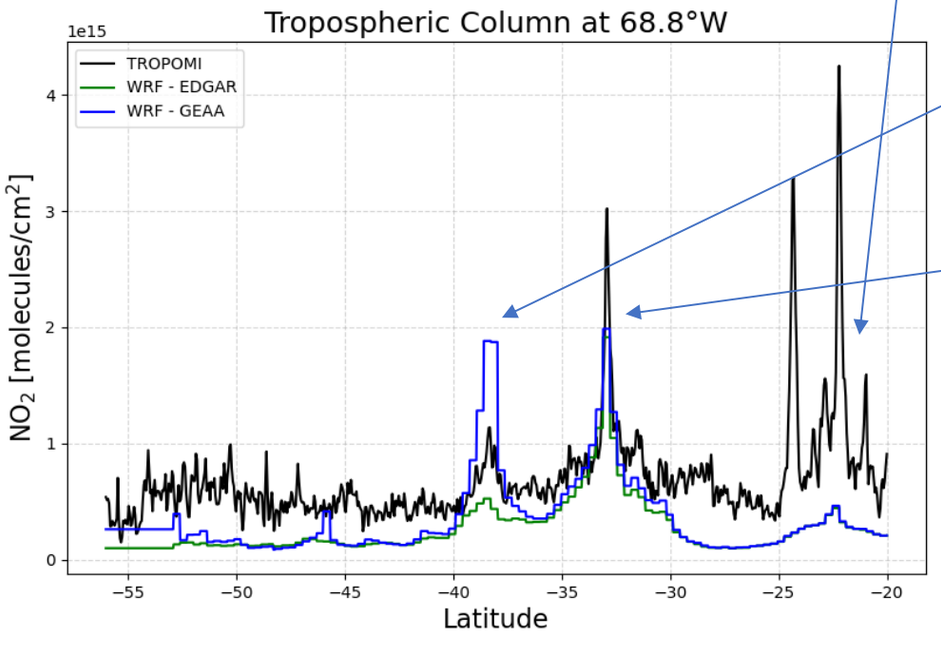
EDGAR-HTAP values used for both simulation near the mountain range, lower background no2 levels are observed for the simulation. Also, high simulated background values observed North-East Argentina.

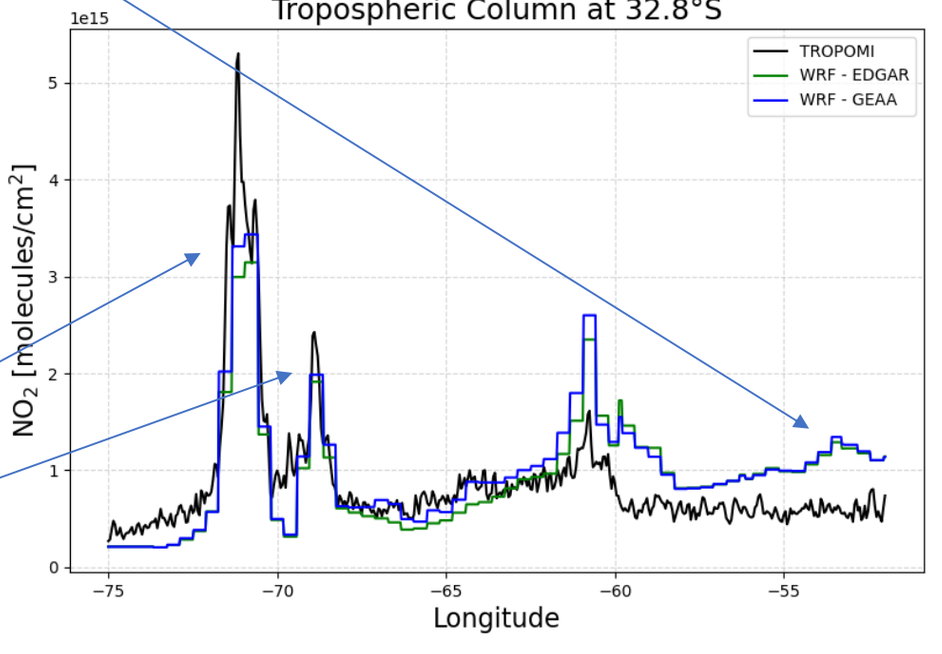


Neuquén (38.5S) is better represented by WRF-GEAA,

Mendoza (32.5S) is well represented by both inventories.

Santiago de Chile (70.6W) and Mendoza (68.4W) are well represented by both simulations





Conclusions

- The GEAA High-resolution inventory values together with global inventory values (for areas with unavailable high-resolution information) were successfully included as input data into WRF-Chem (Puliafito et al. 2017, Fernandez et al., 2017).
    - A relation is observed between how the emission inventory is distributed and the distribution of simulated surface concentrations: for WRF-GEAA the values are higher in areas with high emissions and low in areas of lower emissions.
    - Changes introduced in the spatial resolution had a greater impact than the time profiles introduced in WRF-GEAA.
- For all urban PM10 stations the mean fractional bias performance criteria MFB< + - 60% is achieved.
- The hourly temporal profile assigned to suburban areas was mainly characterized by the vehicular sector behavior, however, in the points of the domain with higher surface concentrations, high emissions from other sectors such as shipping and energy industry converge, a situation that does not happen in the suburban areas.
- The simulated no2 tropospheric column coincides with the satellite values; However, higher values were obtained for inner domains. Adjusting the simulation setup to better fit the magnitude and shape of observations is still a work in progress.

The modified anthro_emiss tool is available upon request, please refer to the author's e-mail for further information.

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