An air quality forecasting system based on WRF-Chem over Cuba: preliminary results

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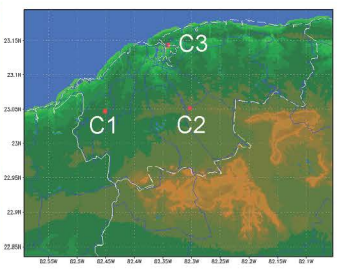
Introduction

The National Environmental Situation in Cuba recognizes that there are zones in the country in the local scale when the air quality is seriously compromise, without real possibilities for their evaluation and systematic control with measurements, and no capabilities for their integral diagnostic and forecast through models.
Detailed studies of the atmospheric environment in Cuba have been limited because of the lack of information. Nowadays, only two s tations are providing measurements on a daily basis in the country, so the knowledge of the air quality condition is limited to the information that Air Quality Models can provide.
Simulations with the on-line coupled model WRF-Chem were carried out to compare their results with measurements and to determine whether it's viable to implement an air quality forecast system based on this model over Cuba.

Data and Methods

Due to the lack of anthropogenic emissions inventories for the whole country it has been decided to use, as a first approach, the known global emission databases.
The prep_chem_sources preprocessor was used to include the global emissions in the model.

WRF-Chem model domains d01 and d02.
The red marker signals measured points locations.



Measured points for every case study

Model description and setup:

Model	WRF-Chem Version 3.6 (Peckham et al., 2014).
Domains	2 (27 Km and 9 Km of spatial resolution)
Lateral Boundary Conditions	GFS Forecast 0.5°X 0.5°
PBL	Mellor-Yamada-Janjic (Eta) TKE Scheme
Initial Conditions	Cold start
Microphysics	Morrison 2-Moment Scheme
Cumulus	Grell-Freitas Ensemble Scheme
Chemical Mechanism	RADM2 (Chang et al)
Photolysis	Madronich, 1987
Biogenic Emissions	Online using Simpson et al 1995 and Guenther et al 1994
Emissions input frequency	1 hour
Case studies	3 (C1: 15-09-2011, C2: 27-10-2011, C3: 09-12-2011)

Emissions Databases Used:
1) EDGARV4
2) RETRO
3) GOCART
4) Yevich-Logan

Results

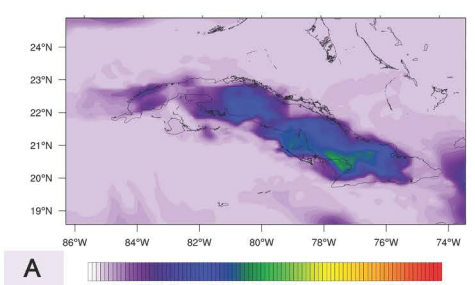
The chemical species analyzed were those also measured: NO2, CO and SO2.

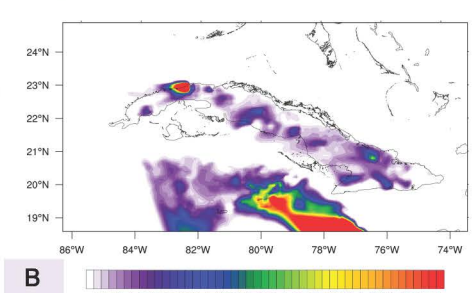
Other species did not behave as expected (not shown here):

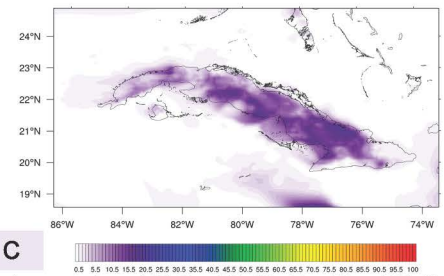
NO concentrations remained too low and constant over the entire domain (d02) due to the erroneous information over this region in the Global Emission Databases.

O3 concentrations values were lower than expected (similar to CO, NO2 and SO2).

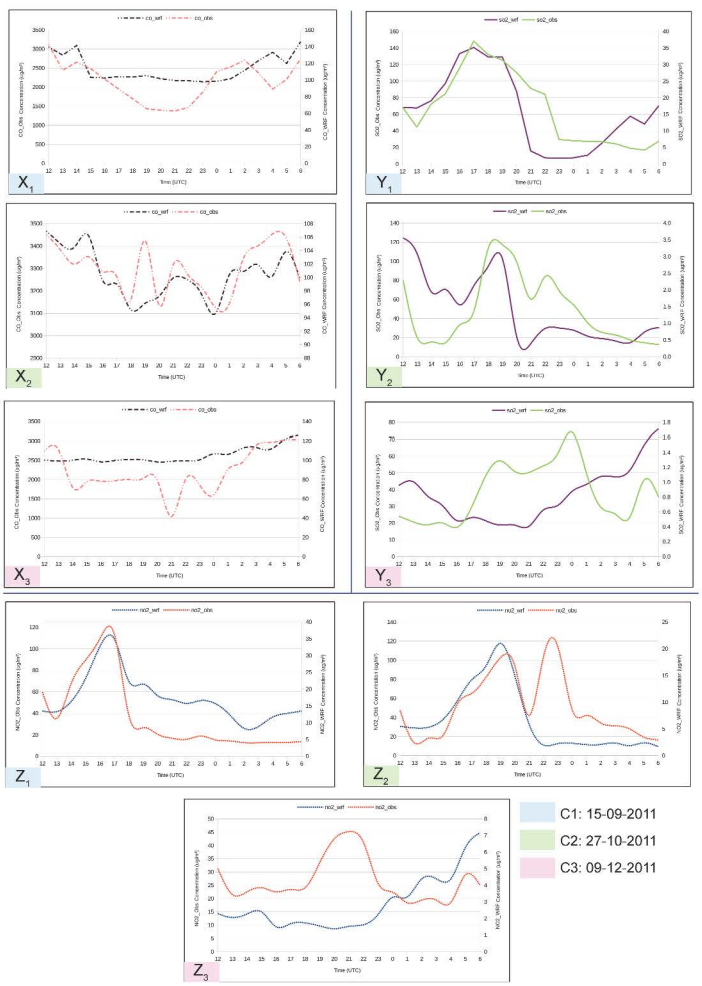
Also not shown here, it was observed a discontinuity on some chemical species fields in the coarser simulation domain (d01) over the area corresponding to the inner domain (d02). This suggest using one way nested runs (by means of the ndown.exe program) instead of two way nested runs, like in this case. This should fix the problem and in the same time, it will shorten the simulation run time.







Predicted concentrations of CO (Panel A), SO_2 (Panel B) and NO_2 (Panel C) at October 28 2011 at 06:00 UTC over domain d02 (9 Km). Units are in ug/m^3.



Diurnal variations (observed vs modeled) of the concentrations of CO (Panel X_1 to X_3), SO_2 (Panel Y_1 to Y_3) and NO_2 (Panel Z_1 to Z_3) for the three case studies over domain d02 (9 Km). Units are in ug/m^3.

Conclusions

The WRF-Chem model characterizes reasonably well the diurnal variations of the chemical species analyzed in two of the three cases. For the point located at Casablanca station (C3), the low resolution combined with the very special wind regimen of this location make the results less promising.

The chemical concentrations of all species computed by the model greatly underestimate those observed. These differences suggest that better results should be expected with the inclusion of the National Anthropogenic Emissions Inventory and also by increasing the spatial resolution of the model.

Despite the huge differences between the modeled and observed concentration values, the spatial distributions of the maxima horizontal fields agree with the areas where, it is known, the highest concentrations should be located.

These studies suggest that increasing domain resolution, including the National Anthropogenic Emissions Inventory, using one way nested runs and using initial and lateral boundary conditions from Global Chemistry Models data (i.e. MOZART), the WRF-Chem model could be a powerful tool for the implementation of an air quality forecast system over Cuba.