Review

“Development of WRF/CUACE v1.0 model and its preliminary application in simulating air quality in China” by Lei Zhang et al.

This publication presents a new model called “WRF/CUACE” being the implementation of the chemistry model CUACE into the NWP model WRF version 3. This new model is similar in his implementation to WRF-chem. The authors also presents new developments on aerosol dry deposition scheme and heterogeneous chemistry. The model is evaluated over China on several selected month and deals with PM2.5, ozone and NO_2. An other evaluation deals with the model ability to simulate secondary inorganic aerosols and shows the impact of heterogeneous chemistry freshly developed.

This publication is interesting as it presents a new model and proves the feasibility of an easy implementation of a chemistry module into WRF-Chem. But the description of the different compounds are not precise enough and some references are lacking. The available code is very hard to navigate and to understand what part is used, especially concerning the chemical scheme. I just navigate in the directories without trying to compile and run it.

General comments

This new model aims at replace the actual operational coupled model CUACE with MM5/GRAPES, because the development of the MM5 model has been stopped in favour of WRF. There are no comparison between the actual model and the new WRF/CUACE model. Yet it might have been interesting to compare these two model in order to assess the viability of the newly developed model.

It is not very clear how the different processes are treated by the different sub-model. For example at page 4 on line 108: “emissions, gaseous chemistry, and a size-segregated multicomponent aerosol algorithm (Zhou et al., 2012), and has been designed as a unified chemistry module”. But on line 130 the authors said CUACE also treat particle dry deposition. The authors need to clarify what processes is done by which model. This includes the Figure 1 where it would be interesting to have a CUACE box that shows what in included in CUACE. Also on Figure 1 processes done by WRF need to be in the WRF box (convection for example). Also consider to rewrite the section 4, as a reader does not necessarily know how the model WRF-Chem works.

In section 3.2, the authors describe the added heterogeneous chemistry added to the model. I wonder if “Aerosol” stands for all the aerosols in the model, treated the same way or if only a sample of all aerosols are considered in the reaction. Also, the way the reactions are written may let think that the aerosol used as a reactant disappear, or I guess it only acts as a support for the reaction.

The description of the model CUACE is not precise enough, essentially concerning the chemical scheme and the reference Zhou et al, (2012) does not either. You claim that RADM2 has 121 reactions, but there are more in Stockwell et al, (1990). Please add the reference for RADM2

and explain the differences between the original publication and you version of RADM2. In section 4, authors explain they added the possibility to use the chemical scheme CBM-Z using KPP. But they do not precise which chemical scheme is finally used. If it is RADM2, then this section should be in the conclusion as future work. If it is CBM-Z then it should be on section 2.2 about CUACE module and more developed: number of species, number of reactions, number of photochemical reactions, way the photochemical reactions are taken into account (especially above the 100hPa upper limit), etc.

The present paper deals with a new combination of a NWP and a chemistry model. But only a part of the chemistry is evaluated. It would have been interesting to evaluate the meteorological fields during the simulation made. Moreover the fact that the SCB region seems badly represented for PM2.5 is due to the complex terrain could be illustrated.

In section 5.2, the authors talk about the negative bias in winter in NCP region by saying that the model misses secondary aerosols. But in summer it seems to be a positive bias almost as dramatic as the negative bias in winter. Do the authors have an explanation for this bias?

The authors detailed the implementation of the new dry deposition scheme. Also in the conclusion, they wrote “it is difficult to evaluate he dry deposition process is improved”, but they did not present any comparison between the two parametrization. A comparison over the already used observed concentrations for the evaluation might be a start for evaluating the improvement.

Specific comments

- Page 3, line 70: A or several reference for WRF are missing here.

- Page 4, line 114: Please add ‘primary’ for organic carbon if it is the case. Otherwise add a sentence to explain how secondary organic aerosols are treated.

- Page 4, line 123: Please add the fact that X_i is the mixing ratio of the species i.

- Page 4, line 124: I do not understand what the authors mean by clear-air tendency, please explain.

- Page 5/6: Generally speaking this part on deposition is not always easy to read because the are parenthesis missing for function [e.g. $\tanh\eta \rightarrow \tan(h\eta)$] or multiply sign also missing (e.g. $LAIE_Th \rightarrow LAI*E_T*h$).

- Page 5, line 132: “that developed by Petroff and Zhang” → “~~that~~ developed by Petroff and Zhang” for example.

- page 5, line 138: Please add a sentence saying that V_d is the dry deposition velocity.

- Page 5, line 143: V_g and V_{phor} are not detailed. Please add a formula or a reference for both of them.

- Page 5, line 153: It is not clear that $E_g = E_{gb} + E_{gt.}$

- Page 5, line 159: t_{ph}^+ is not detailed. Please add a reference or a formula.

- Page 5, line 183: R_s is not defined.

- Page 7, line 216: What is “chem_opt(122)”?

- Page 8, line 223: A reference is missing for KPP.

- Page 8, line 247: The authors does not specify whether WRF is used in hydrostatic or NH mode.

- Page 9, line 268: Is it possible to add a figure showing the extent of the MEIC inventory? Maybe it could be added on Figure 2.

- Page 9, line 270: Why do the authors use anthropogenic emissions representative for 2012, 2014 and 2016 to represent the years 2013, 2015 and 2017? Moreover for which year(s) is the MIX inventory representative?

- Page 10, line 296: Please add the mention ‘not shown’ for the time series comparison.

- Page 10, line 303: Please add a reference for the aerosol composition.

- Page 11, line 351: Please explain what is the index of agreement exactly.

- Page 11, line 351: Why do the authors only evaluate the simulations against O_3 and NO_2 observations? Indeed SO_2 observations might be a good observation since it is the direct precursor for sulfate aerosols.

- Figure 3: (a), (b), (c) and (d) are missing on the figure. The 3 of mg m^{-3} is not in exponent size.

- Table 1: What are the value of γ_{low} and γ_{high}? What is the value of RH_{max}? There seems to be a problem at the end of the line with a lonely bracket for the uptake coefficient for N_xO_y and SO_2.

- Table 3: Please add “hourly” in the description of the table.