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Geoscientific Model Development Discussions

Interactive comment on "Simulations over South Asia using the Weather Research and Forecasting model with Chemistry (WRF-Chem): set-up and meteorological evaluation" *by* R. Kumar et al.

Anonymous Referee #1

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This paper presents a meteorological evaluation of WRF-Chem over South Asia. Even though WRF/WRF-Chem has been deployed by now at many locations on earth, I consider the careful evaluation of the simulated meteorology over South Asia as a valuable contribution to the scientific community. This region is strongly influenced by very local phenomena like the Indian monsoon and thus by distinctively different meteorological conditions than e.g. the United States, an area WRF-Chem has been applied to frequently. The quality of the model is demonstrated by a large number of comparisons of model results with observations allowing for a thorough model evaluation. The paper is well written and I recommend publication after minor revisions.

Model Setup:
I could not (yet) find the cited companion paper Kumar et al in ACPD and for clarification it might be worth extending the model setup description, particularly the treatment of aerosols which might directly affect meteorological parameters (Are aerosol radiative feedbacks treated explicitly? Are aerosol indirect effects treated explicitly? Is dust treated explicitly?).

India comprises various different climatological regions. For readers not so familiar with the geography of India it might be helpful to mention that (e.g location of deserts, regions of moist climate) in addition to showing the surface elevation in fig. 1. This would further help the reader to follow your explanation of the spatial and temporal variability in temperature and water vapour (p. 3080, l. 14-17).

Figure 2, Text on p.3080:
- The 2m Temperature shows a distinctive North-South gradient especially during Winter but not during autumn. Can you comment on that? Or is the colour code just misleading?
- You state that north of 20°, Temperature shows a stronger seasonal cycle than further south. Could you add 1 or 2 sentences why this is the case?

Figure 3, Text on p.3080 l.24 - p.3081 l.10
This section is rather descriptive. Could you add a few explanations for the predominance of certain wind directions. Mentioning the (predominant) synoptic situations during the different seasons would help the reader to see that the model is capable of simulating various different weather patterns correctly.

Figure 5, Text on p. 3082 l.1-6:
Looking at the scatter plot and especially at the frequency analysis for summer it appears as if the model and AIRS are a perfect match - in contrast to the index of

agreement and the coefficient of determination (however, the figure is very small and difficult to read). I am a bit surprised by that as the frequency analysis for water vapour also shows a difference between WRF and AIRS in summer and the scatter for water vapour is larger in summer than in winter. Is the reason that you see differences in the temperature only at 2 pressure levels? Following this, I did not really understand why the difference in temperature should be 'so large' only at those 2 levels (925hpa and 500hpa). Can you comment on that?

p.3084, l.22,23: Why should the agreement be automatically worse if less samples are available (if you only analyse 'pairs' es explained in section 3.4)?

Evaluation of u,v wind: Have you thought about evaluating the wind direction and wind speed additionally with observational data sets, such as are available from radio sondes?

Overestimation of summer-time rainfall: I am fully aware that one can endlessly test different convection parametrisation schemes and none will give perfect results at the end. However, as you mention sensitivity studies: Did you perform tests with other convection schemes for summer? If yes, was precipitation always overestimated? Did you have any other particular reason for choosing the Kain-Fritsch scheme?
You mention the coarse model resolution as a potential error source for the overestimation of precipitation: Would an increase of the horizontal model resolution not most likely lead to an even stronger overestimation?

Section 4.6 needs either further explanation or skip the part referring to chemistry.
I do not fully understand the differences in NO_x:
- At first I am not totally surprised to see the largest differences in NO_x (e.g. shorter lifetime compared to CO and O_3, direct local emissions with large spacial differences)

- Maybe it is misleading to present the differences in Percent. The regions with maximum differences seem to be as well the regions with highest NO_x emissions (e.g. the highly populated areas along the coast) so presumably absolute mixing ratios in those region are high?
- Do you use a lightning-NO_x parametrisation? That should actually rather lead to higher column NO_x when more precipitation is simulated (assuming that a large fraction of precipitation is convective precipitation and that several of these precipitation events should be accompanied by lightning)
- I also do not immediately understand why higher NO_x should be correlated to reduced precipitation - NO and NO_2 are (almost) not soluble so a reduced scavenging due to reduced precipitation cannot be an explanation. But maybe indirect effects of reduced scavenging? Changes in temperature and changes in the NO_x/NO_y ratio?
This certainly needs further explanation.

Figures
The quality of some figures is not so good; specifically:

Figure 1: Could you change the colour code? I can hardly see a difference between 400m and 1600m, it all just looks pinkish to me. I have the same opinion about figure 13.

Figure 2, 4, 10: The plots are too small.
It is very difficult to see e.g. differences between the AIRS data and the simulated values.
The labels referring to the colour bar are also too small, I can hardly read them.

I also find Figures 5, 6, 8, 9 very small

Caption of Figure 2: You write: 'For the case of precipitation, *data above* 1400

mm are *not shown* and *regions shown* by orange colour are implicitly *having values above 1400 mm*.'
Isn't there a contradiction in the sentence?

The number of figures in this article is very large and at least Figure 15 could be deleted, from my point of view.

Rephrase p.3093, l.11,12 (the grammar of this sentence is not correct)

Interactive comment on Geosci. Model Dev. Discuss., 4, 3067, 2011.