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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The impact of observation nudging on simulated meteorology and ozone concentrations during DISCOVER-AQ 2013 Texas campaign" *by* X. Li et al.

X. Li et al.

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Review of the manuscript titled "The impact of observation nudging on simulated meteorology and ozone concentrations during DISCOVER-AQ 2013 Texas campaign" By Xiangshang Li et al. Submitted to the ACP

Recommendation: minor revision

General response:

An updated manuscript is included as supplement.

Thanks for the very helpful comments. We think the reviewer's comments are based on

an earlier version (v1) of the manuscript. The version in discussion (ACPD) has added several missing references pointed out by the reviewer. It also has several new plots which we think are better than old version (please refer to uploaded updated manuscript according to the first reviewer's comments too). Also there are enough differences from v1 such that the line number changed substantially. In this response, we will refer to the version in ACPD regarding to line number through keeping the original line number in item title.

1. Comments Line 11-12, it is confusing to say observational nudging is objective analysis and to use "OA" representing observational nudging for the rest of the paper. In the WRF modeling community, objective analysis usually refers to "OBSGRID" which is an extra package in the WRF model system to take observations to improve the first guess fields (WPS output files) through an objective analysis method. Observational nudging is the Newtonian relaxation method implemented in WRF code to use observations to minimize model error during the simulation. It is known as "four-dimensional data assimilation (FDDA)" introduced by Stauffer and Seaman (1990). The observational nudging is not necessary to be run with objective analysis package even though the OBSGRID provides the observational data written in required by WRF for nudging. Stauffer, D., Seaman, N.L., 1990. Use of four-dimensional data assimilation in a limitedarea mesoscale model. Part I: Experiments with synoptic-scale data. Month. Weather Rev. 110, 1250e1277.

Reply: Thanks for pointing out the issue. We understand the differences between "objective analysis" and "observation nudging". In WRF, to perform obs-nudging, one has to use OBSGRID (Objective Analysis) to generate necessary input. As seen in the flow chart of OBSGRID (usually on page 7-2 of WRF-ARW User's Guide), after OBSGRID is run, three types of output files (metoa_em for OA, wrfsfdda for surface analysis nudging and OBS_DOMAIN for obs-nudging) are generated and all of them are to be used. This is because performing three tasks (OA+sfdda+obs-nudging) can maximize the benefit of assimilating observations. Therefore, running OBSGRID tends to imply

performing all three tasks. Although one can do obs-nudging without performing OA (i.e., discard "metoa_em"), this should not be considered normal since it is likely degrade WRF performance. To address the issue, we made two changes. We 1) included an explanation on objective analysis and obs-nudging in introduction (line 70-73) and clarified the case names in section 2.2 2) changed all the OA in paper to “obs-nudging” except for case names. Using “OA” and “No-OA” as case name seems easier.

2. Line 70-71, what does this mean??? There are detailed statistics about the nudging impacts shown in those studies (Deng 2009, Gilliam and Pleim 2010, Otte 2008 and Ngan et al 2012). Reply: The sentence is about the studies by Ngan et al. (2012), Deng (2009), Gilliam and Pleim (2010), which only have statistics for meteorological variables, not for chemical variables. Only Otte (2008) includes the chemical statistics in her paper.

It should be rewritten as:

“However, the statistics from their study cannot be used for interpreting the sensitivity of obs-nudging since its base WRF case is a forecast run which used a different analysis input “.

3. Line 91, Daum et al., 2004 Reply: Thanks. typo, corrected

4. Line 96, missing reference for Lefer and Rappengluck 2010. Olaguer et al., 2009 Reply: Thanks. missing in v1, already corrected in online ACPD version

5. Line 103, it is good to have a citation for DISCOVER-AQ. Reply: we added a link to the DISCOVER-AQ website (from which all the data were collected)

6. Line 141-143, suggesting not to use “OA” to refer observational nudging. Instead, just use “no-FDDA” .vs. “FDDA” Reply: Because the base case performed the “standard” grid nudging, so it did use “FDDA”. Hence it seems “no-FDDA” is not proper for base case. Please see our revisions outlined in item 1 reply.

7. Line 171, give citation for those prior modeling studies. Reply: added citations

8. Line 202-224, these three paragraphs should be shortened since this is not project report and technical note. Please summarize what are the data frequency for analysis nudging, surface nudging and observational nudging, what variables to be nudged, and for what vertical layers. Reply: Thanks for the suggestions. Modified (shortened) as suggested.

9. Line 242, missing reference for Willmott 1981 Reply: Thanks. added

10. Line 306, it is more desirable to see time-series of hourly temperature and ozone instead of daily average since both variables have strong diurnal variation. What did the authors choose to show the daily average plots? Reply: In the past we usually use daily average plots to check some important meteorological and chemical features during the simulated period, but we agree with reviewer’s point and replaced the daily time series with hourly time series. As a result, all the texts related to the two plots are modified. Updated figure 3 and 4 are attached.

11. Line 378, Figure 7 is hardly to read due to poor figure quality and small text. Reply: Thanks. Changed in ACPD online version, should be OK now.

12. Line 394, it should be showing hourly ozone plot instead of daily average. There are a lot variations for ozone through a day. Reply: Thanks. We replaced the plot as the reviewer suggested.

13. Line 484, Did the nudged met data provide better ozone results than the base case in the comparison with aircraft measurements? Reply: Yes, the nudge case is better. In the two plots (Fig 11 and 12), we showed spatial ozone for base case as background. Fig.11 is intended to show the high ozone aloft in early morning, which contributed to later model underprediction. The comparison of model vs aircraft ozone is given in Figure 13 and 14.

14. Line 487, missing reference for Li and Rappengluck 2014 Reply: Thanks. added in ACPD online version

15. Line 500, the model under-predicted ozone both at the surface and aloft on Sep 25th. Even with nudged meteorology, there was not much improvement. Is that because the met data are still wrong or emission data may have problem?

Reply: We think that the missed high ozone on Sep 25th is a combination of transport (high observed ozone aloft in early morning), not-so-good meteorology even after nudging (even though we show some improvements in this study), and possibly unreported emission upsets. We already identified a problem in current WRF OA-ON process and developed new processes to correct the problem. In the paper, the ongoing study is briefly mentioned in the last section.

16. Line 543-548, the discussion about the impact of nudging on cloud/precipitation prediction is ambiguous. There is no comparison on these two variables shown. Did the nudging configuration help to prevent the inaccuracy of the prediction or make it worse?

Reply: We felt compelled to mention cloud/precipitation since they heavily impact ozone and performing obs-nudging certainly altered the two variables (despite that nudging coefficient is set to zero for moisture). Yet we do not have good observations to quantitatively analyze the changes brought by obs-nudging. It entails another study to analyze the impact of nudging on cloud/precipitation and how ozone might be ultimately affected.

17. Line 555, what does this "small-scale meteorological events" refer to? In what sense it is relevant to the high ozone events? Is this something for future works? The conclusion section is not clear. Suggest to revise and include future works.

Reply: Thanks for your suggestions. Small-scale events are discussed briefly in first paragraph of page 5(27361) of ACPD online version, with a few references. The conclusion section has been substantially modified in the online version. We value the comment and added future works.

The last section of Discussion now reads:

"Small-scale meteorological events are frequently cited for their contributions to high ozone events. Model's capability in reproducing these events is critical in simulating such high ozone episodes. The base case did not recreate the 25 September small-scale events likely due to the complex winds and a lack of local information which can be used to steer model state closer to reality. On the other hand, the inability of the sensitivity case to replicate the local winds is likely a result of the imperfection of the nudging process pending further investigation. An ongoing study by the current authors suggests that errors in the metrological fields from the default grid nudging files are important sources. Methods are being tested to improve the quality of grid nudging files. Early results showed that the bay breeze which caused the wind reversal around La Porte was well captured through improved grid nudging files. In addition, more observational data (e.g., more sites and higher data frequency) and more testing on the combination of nudging setting should help improve the obs-nudging performance. Also, the impact of obs-nudging on precipitation and clouds should be further investigated to understand their chain effect on chemistry."

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C9472/2015/acpd-15-C9472-2015-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 27357, 2015.

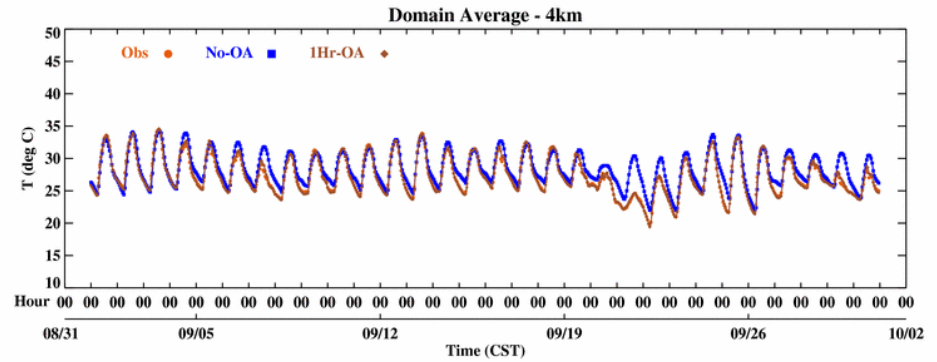

Fig. 1. figure 3 - hourly T time series

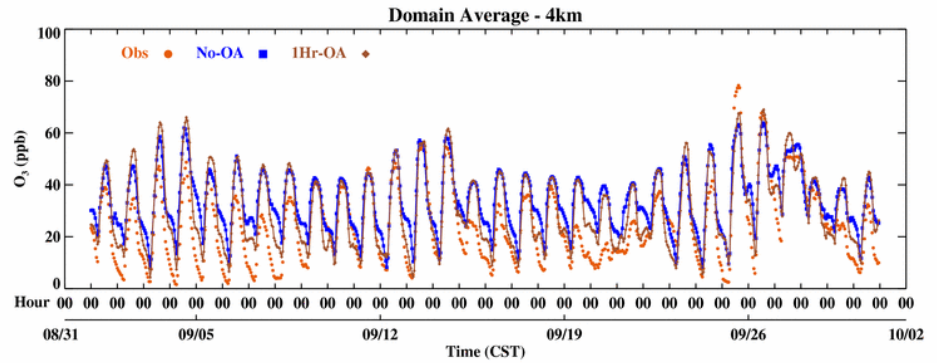

Fig. 2. figure 4 - hourly Ozone time series