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Atmospheric Chemistry and Physics Discussions

Interactive comment on "An investigation of methods for injecting emissions from boreal wildfires using WRF-Chem during ARCTAS" *by* W. R. Sessions et al.

Anonymous Referee #1

Received and published: 5 December 2010

Dear Authors,

Congratulations on a very good manuscript. This paper describes an important and well-designed experiment to uncover the sources of pollution in the Arctic and evaluate the capacity of current model simulations and observations to accurately describe Arctic pollution transport events. I have a few major points and then a lot of minor points, but this paper is ready for publication with a few hours of work.

I should explain what I think is important about this work, which I would hope might color the authors' revisions to the presentation.

1) The plume height results from the observations and model suggest that in both the

real and simulated atmospheres, there is a certain level of fire energy that will cause a plume to overcome the real or simulated stability of the PBL and ascend buoyantly into the free troposphere. From the observations, we infer that this level of fire energy is attained in only a fraction of cases, but a large fire outbreak in the boreal zone will generally have some fires that exceed this level and release emissions into the free troposphere. From the simulations, we infer that the default level of fire energy used in 'prep_chem_sources' is always higher than what is needed to overcome the stability of the simulated PBL, while the diurnal variation used by FLAMBE gives fire energies both above and below the critical level. I am not implying that the level is a single number, but I think your results are beginning to paint a quantitative picture of injection, and reveal where we should be looking for discrepancies between the simulated atmosphere and the real atmosphere.

1b) The implications of Figure 3 (WRF injection heights vs MISR max. stereo heights) are complicated. Despite the same satellite fire detections underlying both methods, the 'prep_chem_sources' method has no skill, while the FLAMBE method shows moderate skill compared to MISR observations. In the MS, the discussion focuses on the (extremely simple) diurnal cycle of burning that FLAMBE uses as the key difference: FLAMBE makes sure than overnight burning is damped relative to daytime burning. However, the MS does not specify the temporal pattern of emissions release of the 'prep_chem_sources' method. Does it simply release all the emissions during the hour of detection? The FLAMBE diurnal cycle representation does more than represent daytime vs. nighttime burning: it also spreads the emissions to cover periods between satellite observations. If 'prep_chem_sources' is not doing that for areas that are only observed by MODIS, that is likely the reason it shows no skill. However, if the 'prep_chem_sources' release is also spread, then other differences such as the different fuels information used must be considered. Some more detailed discussion of the inputs required by the Freitas 1-D plume rise model and how those inputs are calculated might be appropriate.

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2) The use of MODE for analysis of model/satellite comparisons is very interesting. While I think the presentation could be more complete, the idea that it is possible to take a satellite observation with incomplete coverage and calculate numerically (although "quantitatively" may still be overstating the case) the relative agreement between different model simulations and observations, this could become an important tools for modelers working with atmospheric composition and transport.

3) We would expect the WRF regional simulation at 45km resolution to have better resolution of the PBL than a GEOS-4 global simulation at 1 degree resolution. I am not aware of any publication that directly analyzes this, so it cannot be claimed as fact, but for any informed reader, it should prejudice their estimation toward your results, in cases where they differ from GEOS-CHEM results. This is a subject worthy of further investigation: researchers in atmospheric composition tend to think of it as "not my problem," but the tools and especially the observations used for studying atmospheric composition allow more direct analysis of model-simulated PBL heights than conventional meteorological observations can achieve.

Now, on to the suggestions for revision of this paper:

1) Why so few MODE results? I cannot find in the manuscript where it explains what the conditions are for a successful MODE analysis. The AIRS figure shows 6 days of data with very clear features in each day, so why is MODE analysis done on only 2 days of data, or two scenes, the MS is not completely clear about this. Some treatment of the challenges of MODE analysis would be helpful, beyond the limited discussion of missing data included at present, because this method is unfamiliar and interesting to many readers.

2) Two extremely important numerical details color any analysis involving MISR plume height data from MINX: the metric employed (average vs median vs maximum height), and the horizontal aggregation (MISR pixel vs whole plume vs WRF grid cell). The authors seem to be aware of this, but still leave the reader guessing at several critical

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points in the MS (noted below). "Maximum observed height within a WRF grid cell" is not the same as "Maximum observed height for a plume," and the differences will be systematic, and vary systematically with the resolution of the grid. Below I identify specific places to be careful in your explanation.

Line-by-line suggestions follow:

Abstract Line 20: Injection heights are not derived from FLAMBE. FLAMBE is used to provide inputs to the Freitas 1-D plume rise model, which appears to work better than calculating those inputs using 'prep_chem_sources'. Please word carefully.

Introduction 1: "The Arctic acts as a barometer for the Earth's atmosphere" A barometer is an instrument for measuring atmospheric pressure. If this is intended as metaphor, use something else.

Introduction 18: "they pose an array of environmental threats to the Arctic's radiation budget." How about, "they represent important forcings to the radiative balance in the Arctic" or something. I do not think a radiation budget can be threatened, although perhaps a radiation balance can.

Introduction 26554-7: "improved representation of interactions between meteorology and the chemistry and physics of trace species and aerosol particles."

Introduction 26554-26: Specifically, you might mention that boreal forest fires have a higher contribution of smoldering combustion, and make a relatively stronger contribution to emissions of aerosol particles and products of incomplete combustion (see e.g. (Cofer III et al. 1996)).

Methods 26558-22: The primary reason MODIS is able to detect smaller fires is the higher spatial resolution of the MODIS sensor compared to GOES.

26561-4 : "CO measurement sensitivity is greatest near the surface." No. The CO retrieval uses a maximum-likelihood (or some variant) incorporating a prior estimate. The prior estimate dominates the retrieval values at the surface.

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26563-10: “plume radius” Although this is available in other papers, I think a somewhat more detailed discussion of the exact parameters required by the 1-D plume rise model and their derivation would be helpful to the readers.

26563-13 and 26564-20: Alan Robock, head of the AGU atmospheric science section, wrote an eloquent editorial in Eos recently imploring scientific writers to stop(start) using parentheses to indicate options (using actual English clauses, since digital journals are not concerned with a few extra words). The editorial is worth a read.

26564-5 “It is clear that accurately modeling the atmospheric state is important for reasons other than just simulating the evolution of the three dimensional wind field.” The point of this sentence is actually a very important one (accurate representation of pollutant transport requires more than just accurate uv winds); this sentence could certainly be changed to bring it out more clearly.

26565-1 “MISR-derived emission layers” Do you mean “MISR-derived maximum plume heights”? It is important to state carefully exactly what you mean when discussing these data.

26565-6 “5 to 18% of MISR plumes extended above the PBL” Does this mean those plumes had a median height which was above the PBL? I hope I’m not being more pedantic than necessary, but again, the details of these data make a big difference in interpretation of results.

26566-9 “meteorological settings” should be “conditions” or “contexts”.

26569-9 simulated “low-level winds vary little with height in the vicinity of the plumes”

26573-20 “a transport path that is oriented poorly with respect to CALIPSO’s track.” Does this mean that CALIPSO would not have observed the plume (assuming the simulation were correct), or that CALIPSO and the simulation disagree about the plume position/orientation?

26575-13 “On a more positive note” When describing your results, as they say, it is

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what it is.

26575-21 “Cloud cover....prevents reliable quantitative comparisons of the plumes with MISR products.” Do you mean AIRS? This section otherwise includes no MISR analysis.

Summary 26575-20 “Episodic events... represent a threat to the Arctic environment” Episodic events make an important contribution to the Arctic atmospheric composition, and evidence suggests these episodic events may occur more frequently in a warmer climate. Whether this is “a threat to the Arctic environment” is outside the scope of your study.

26577-27: “This is unfortunate since emissions are often transported within cloudy regions.” The environment does not exist to facilitate our experiments; I recommend just leaving this sentence out. The sentences before and after make the point quite clearly.

Table 1. Several of these settings have specific publications associated with them. Where possible, the table should include references that describe the schemes used.

Figure 1(c) has labels “A” and “B”. I thought maybe these were mentioned in the text, but couldn’t find them when I looked. If they are mentioned in the text, they should also be in the caption; if not, they should be removed.

Figure 4. When this paper is prepared for final publication, please take care to make sure the editors make this figure a reasonable size. In the discussions layout, it is too small.

Figure 6(a). “MISR stereo heights” Maximum, Average, Median, Single-pixel? Please describe these data carefully.

Reference

Cofer III, W.R., Winstead, E.L., Stocks, B.J., Overbay, L.W., Goldammer, J.G., Cahoon,

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D.R., & Levine, J.S. (1996). Emissions from Boreal Forest Fires: Are the Atmospheric Impacts Underestimated? In J.S. Levine (Ed.), Biomass Burning and Global Change (pp. 834-839). Cambridge, Massachusetts: The MIT Press

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 26551, 2010.