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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The high Arctic in extreme winters: vortex, temperature, and MLS and ACE-FTS trace gas evolution" *by* G. L. Manney et al.

G. L. Manney et al.

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Final Response for "The high Arctic in extreme winters: vortex, temperature, and MLS and ACE-FTS trace gas evolution" (Reviewer/editor comments *italicized.*)

We are submitting a revised paper to be considered for publication in ACP, as encouraged by the editor.

In response to the "Editor's comment":

One of the reviewers was unfortunately not able to submit a detailed review after a positive first assessment, in spite of repeated reminders and extensions of the submission deadline. I therefore add my own thoughts to the report of the second reviewer.

The paper "The high Arctic in extreme winters: vortex, temperature, and MLS and ACE-FTS trace gas evolution" by G. L. Manney et al. presents a detailed overview of the meteorological conditions during the three ACE validation campaigns at Eureka. It includes data from several satellite instruments (SABER, MLS, ACE-FTS), ground-based instrumentation (LIDAR, radio sondes) and compares it to results from different models.

The paper is well written and provides an excellent background for interpretation of the results from the ACE validation campaigns which will be presented in other papers of this special issue. It also presents a discussion of three very different NH winters which in its own is interesting to read and highlights the large degree in variability both in time and space that is characteristic of the NH stratosphere and mesosphere. This is of particular relevance when using measurements from one specific site (Eureka) for validation of satellite data.

The problem I have with the paper is that in my opinion, it tries to include too many different things instead of focusing on its central part which from my point of view is the description of the dynamical evolution in the three years. In its current form, the manuscript deals with - among other things

- *the description of the evolution of stratosphere and mesosphere in the three winters based on measurements and model results*
- *a comparison of different satellite measurements and model results with some aspects of model verification*
- *a comparison of LIDAR temperature profiles with satellite and model profiles which in part could be seen as qualitative validation of satellite profiles but also includes some discussion of possible LIDAR problems when an inappropriate seeding value is used*

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- *a comparison of satellite and model temperatures with radio sonde data which again could be seen a s a qualitative validation*
- *a comparison of temperature data from three satellite instruments sampled at the time and place of ACE measurements, again a qualitative validation*
- *plots of CO, H2O, N2O, O3, HCl, and HNO3 from MLS and CO and H2O from ACE-FTS with a very brief discussion*

While the various comparisons of the different data sets are interesting and provide confidence in some features observed from several platforms while raising questions about others, they do not necessarily add a lot of information for the discussion of the meteorological evolution of the winters. At the same time they are not quantitative enough for a validation of the ACE-FTS temperature measurements as it is very difficult to draw firm conclusions from the colour coded plots shown on top of each other.

The same is true for the discussion of the model data - it is instructive to compare model and measurements as done in Fig. 4 and the model problems are quite obvious but it is not clear to me what we learn in addition by Figs. 7 - 13 apart from the fact that different model (versions) have different problems and that the measurements disagree in the upper parts of the profiles. Full model verification would have to go into much more detail on the model side and in its present form, the comparison remains somewhat superficial.

Finally, the discussion of the trace gas measurements is very brief and I do not see the additional value of showing data from MLS and ACE (and again SABER for T) unless it is intended as a first quick look validation. A detailed discussion of how the meteorology affects chemistry would be a separate study and clearly is out of the scope of the paper.

In summary, I think that the paper could actually be improved by removing some of the data shown in the plots and focusing the discussion more on the meteorology of

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the three winters and how it affects the measurements at Eureka. I also recommend removing some of the qualitative comparisons between different data sets which in my opinion do not add much to the main point of the paper and are not quantitative enough for a validation of ACE-FTS measurements. Once the paper is changed in this sense and also the comments of the reviewer are into account, I will be happy to accept it for publication in ACP.

We thank the editor for his helpful comments. We agree that the focus of the paper is, and should be, on the contrasting meteorological conditions in the three winters. However, upon considering the paper in light of the above comments, we realized that our intention of focusing on the importance of those conditions both at Eureka **AND** for interpretation and validation of the ACE measurements was not clearly apparent in the original version: The effect of the meteorological conditions on ACE measurements was not highlighted as explicitly as it should be, and our selection of materials for presentation and discussion in the ACE section was not the best for focusing on impacts of different meteorological conditions.

We agree with the editor that the comparisons of satellite and ground-based data with meteorological analyses are not and should not be a substantial focus of the paper. However, we believe some very brief discussion of deficiencies in the meteorological analyses will be helpful to other authors using one or another of these analyses. The satellite/ground-based data comparisons, likewise, are not the primary focus of the paper – except where showing such comparisons provides relevant information on how the local meteorological conditions for single-station measurements such as those at Eureka may affect the interpretation of such comparisons.

We agree, as well, that effects of the meteorological conditions on chemistry are beyond the scope of this paper. We do believe, though, that showing interannual comparisons of some long-lived trace gases is important to showing how differences in meteorological conditions affect transport, and aids in interpretation of measurements

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at Eureka under different meteorological conditions.

In summary, the paper is intended primarily to provide “meteorological context" for other papers in the ACE Validation special issue, and as such needs to clearly show how the meteorological conditions may affect both Eureka and ACE measurements of temperatures and trace gases.

With this focus in mind, we have made the following substantial changes:

- The radiosonde comparison section has been deleted (originally Section 3.4).
- The lidar comparison section has been condensed (now two figures rather than five), and rewritten to focus specifically on
  1. How the interannual differences in profile structure reflect the differing meteorology, and
  2. How many differences between lidar and satellite (ACE-FTS, MLS and SABER) data can be related to the local meteorological conditions.

  The comparisons with profiles from meteorological analyses have been removed from this section.
- The first reviewer had several questions related to whether GEOS-4 was the best choice of analyses to use. In descoping the comparisons with meteorological datasets, we have altered our response to this reviewers comments related to this:
  – Figure 5 (showing stratopause evolution at Eureka) has been altered to include GEOS-5 (2004-2005 and 2005-2006) and ECMWF L91 (2005-2006, current operational system) analyses when they are available, and brief discussion of the failings of each analysis given (Section 4.1).

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- Because the Manney et al. (2007, JGR, submitted) paper that discusses analysis/satellite data comparisons in much more detail is still not in press (the revision of that will be submitted to JGR within a few days of submission of this revised paper for ACP), we have included a little more description of the results of that paper where relevant to this point.

- The discussion of MLS tracers at Eureka has been condensed, and the original Figure 15 (showing MLS O3, HCl and HNO3) has been deleted. The discussion has been revised to focus specifically on interannual differences in transport and how those and interannual differences in vortex evolution affect interpretation of trace gas measurements at Eureka.

- The ACE section (formerly Section 4, now Section 5) has been substantially rewritten to focus on meteorological context for ACE sampling and measurement interpretation:

  - It now provides a more complete context for the ACE measurements used in other validation papers, including important information on interannual differences in vortex/extra-vortex sampling (shown in Figure 10, a new figure) that is cited as background in several other papers for this issue.
  - The original Figure 16 (now Figure 11) has been retained, as being, we believe, the best way to show how interannual differences are reflected in ACE-FTS temperature measurements.
  - Figure 17 has been replaced by Figure 12, showing vortex-averages of ACE-FTS long-lived tracers compared with those from MLS for the two years. This change focuses the discussion on interannual differences in vortex transport related to the meteorological conditions and how they are reflected in ACE data.
  - While the comparisons with MLS and SABER data in Figures 11 and 12 **ARE** qualitative, they complement the detailed quantitative, but generally

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globally and temporally averaged, comparisons given in several papers in this special issue with a focus on polar winter conditions, and are cited in several papers as such.

- The discussion in the Abstract, Introduction, and Summary and Conclusions has been modified to highlight the meteorological context for ACE measurements as well as for Eureka.
- The sections have been restructured, and discussion in the original Section 3.1 (now Section 3) altered to note conditions for both Eureka and ACE measurements.
- In the course of these revisions, the number of figures has been reduced from 17 to 12.

In response to the “Minor Comments" from the editor:

Abstract: Introduce acronym SABER

Done.

geo-location of Eureka varies through the text - is that intentionally?

No, we have changed this to consistently read “80°N, 86°W".

page 10249, line 17: "seen best" - I think it can only be seen in the model data

This refers to text that has been deleted in revisions.

page 10254, discussion of the LIDAR profiles at high altitude. If the problem is with the seeding value used for the LIDAR profiles, why don’t you use a more realistic value at least for a few examples to test if this improves the agreement with the satellite derived data?

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In the current version, values from SABER temperatures at the time and location of the lidar measurements are used for the seed. In Section 2.1, we discuss briefly the impact of this.

page 10263, "how these conditions affected transport and chemistry" - I think the discussion is really very much limited to transport. Chemical composition is touched, mainly with respect to the effect of descent but chemistry in the sense of chemical evolution is not really discussed.

The discussion is, indeed (especially in the revised version), limited to transport, and we have reworded to reflect this.

With regard to the first review, with the exception of the points related to analysis/satellite data comparisons mentioned above (which the editor's review modified our response to), we have implemented all of the planned changes in our original response to that reviewer.

Thanks again to both reviewers for their constructive comments. We believe the current paper, revised in light of those comments, more completely fulfills its intended purpose of elucidating the impacts of varying meteorological conditions on Eureka and ACE measurements and their validation.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 10235, 2007.