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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The spring 2011 final stratospheric warming above Eureka: anomalous dynamics and chemistry" *by* C. Adams et al.

C. Adams et al.

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RESPONSE TO REFEREE 1: Lynn Harvey

Thank you for the detailed review that was given during the technical review phase of this manuscript. Below we list the major changes and questions that were addressed during the technical review process, as we feel that these changes greatly improved the manuscript.

SPECIFIC COMMENTS:

Many suggestions were made regarding the overall structure of the paper. For the most part, we condensed and reorganized the material as recommended. To summarize:

- 2004-2011 profile figures were combined into one figure, with some of the panels removed.

- All time-altitude plots were combined into one figure, with some of the panels removed.

- We removed one of the figures associated with the NO_2-maximum section. Note that the figure at 850 K is also used to examine the early evolution of the FrIAC. Hopefully this is more clear in the present version of the text.

- We used 2004-2011 data only for GBS and OSIRIS (for consistency with GMI and DMPs).

- We made many minor changes to the figures, including changes to line colours, and flipping of polar plots.

We have decided to move the column timeseries figure to the start of the paper, to motivate the work. e.g., How can we explain these unusual column measurements? This also allows us to demonstrate that the GBS, OMI, and GMI datasets are showing essentially the same events from the start of the paper.

SPECIFIC COMMENTS: Below is a summary of the most significant specific comments made during the technical review phase. The reviewer's comments are given in italics, with the responses below.

Page 7, line 14: What is the longitudinal sampling resolution of OSIRIS? Can you defend interpolation to such a fine horizontal grid?

This was a typo – a 5x5° grid was used. The distribution of ozone measurements, with the ozone VMR given in the colour scale, for the OSIRIS map at 500 K on May 3 (Fig. 13a of the original submitted manuscript) is shown in Fig. 1.

We have added the text below to the paper to clarify the technique used to interpolate these data.

“To produce polar maps at fixed potential temperature levels, data were passed through a Gaussian filter with a 5° standard deviation onto a 5x5° grid. For each grid-point, the angular distance between the grid-point and the OSIRIS measurements was calculated. Weights based on the angular distance between the measurements and the grid-point were calculated using a Gaussian function, with a standard deviation of 5°. The weighted mean of OSIRIS measurements at the given grid-point was then calculated. If the sum of weights at a given grid-point was < 1, the grid-point was left empty. The filter and interpolation grid were tested for various cases to ensure that smoothing and interpolation were not introducing any spurious features to the maps. The 5° filter provided the best balance between showing the detail in the OSIRIS measurements, without introducing large gaps in the figure. The choice of interpolation grid did not have a significant impact on the maps for the measurement dates considered.”

Some examples of the smoothing tests are shown in Fig. 2, with the grid and standard deviation given in the figure titles. It was found that the 5° filter did the best job of showing the details in the OSIRIS measurements without leading to large gaps in the figure.

Page 8, line 6: It’s hard to believe that OMI has high enough spatial coverage to produce a realistic 1x1 grid. Defend this.

OMI covers the globe daily with a horizontal resolution of 13x24 km^2 to 24x48 km^2. It does this by scanning across the nadir track (see Levelt et al., 2006). The OMI gridded data product outputs the data on a 0.25x0.25° grid (http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omdoao3e_v003.shtml). Therefore, the horizontal resolution of OMI is more than good enough for a 1x1° grid. Fig. 3 shows the OMI measurement locations for 8 April 2011 for 70-71° N latitude. There are 3475 measurements during this period and a there is good longitudinal coverage.

Page 9, line 42: Why not MERRA for consistency with the CTM?

ATLAS model runs are not currently available for MERRA.

Page 10, line 3: It is also interesting how high EqL values "descend" during May. Does this correspond to the onset of the summer anticyclone?

This occurs after the onset of the summer anticyclone according to MLS meteorological plots (http://mls.jpl.nasa.gov/).

Page 10, line 18: The OMI and GMI data are in excellent agreement, while the GBS NO_2 data does not even agree qualitatively (i.e., the slope of the NO_2 column time-series is negative for GMI, near zero for OMI, and positive for GBS. All show a positive slope for previous years. Elaborate.

NO_2 has a strong diurnal variation. Therefore, the seasonal increase in NO_2 will depend on how the measurement SZA of the instrument varies over the course of the spring. Fig. 3a of Adams et al. (AMT, 2012) shows how the NO_2 column varies above Eureka over a year for twilight measurements (such as the GBS) versus noon measurements (closer to OMI/GMI). In April (around day 100), the seasonal slope of the twilight (GBS) NO_2 measurements is expected to be steeper than the slope of noon-time measurements (OMI/GMI). Therefore, it makes most sense to look at this NO_2 maximum relative to the previous years. We’ve tried to clarify this in the text.

Page 10, line 21: There is a lot of variability in the GBS data (too much to trust the data?). Defend this statement.

The OMI data is made up of the daily average of all data within 500 km of Eureka. This amounts to an average of 4000 data points. Therefore OMI is expected to be smoother than the GBS, for which two measurements per day are shown. GBS ozone and $_2$ measurements have been validated extensively against other satellite and ground-based instruments (e.g., Fraser et al., ACP, 2008; Fraser et al., JQSRT, 2009; Roscoe et al., AMT 2010; Adams et al, AMT, 2012). Laboratory testing in March 2011 and fitting errors/diagnostics in April/May 2011 indicate that the GBSs were performing well during this period.

Page 10, line 21: Also defend why you need to show column NO_2 and O_3 from three different sources. I suggest that only the OMI data be shown.

From an experimental point of view, this is interesting. It is useful to test agreement between datasets under unusual circumstances. We have attempted to make this more apparent in the text.

Page 13, line 24: The anticyclone is not well represented by PV. If you are going to talk about a FrIAC I suggest you show geopotential height or stream function contours.

While using PV fields may not be the most definitive way to identify anticyclones in general, Allen et al. (2011) and Thieblemont et al. (2011) have shown that FrIACs can be accurately identified in PV fields in the "spin-up" and "anticyclonic" phases.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 20033, 2012.

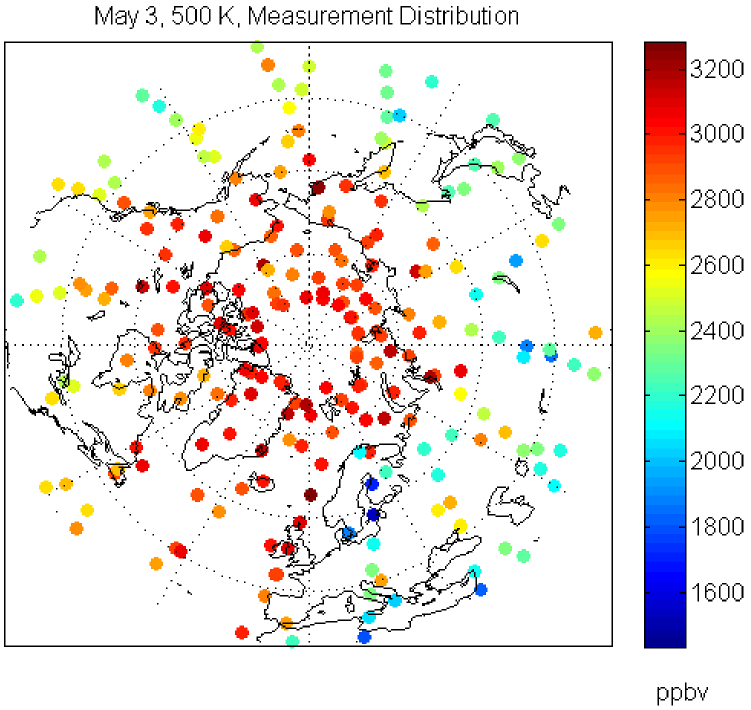

Fig. 1. Distribution of OSIRIS ozone measurements at 500 K on 3 May 2011, with ozone VMRs indicated by colour scale.

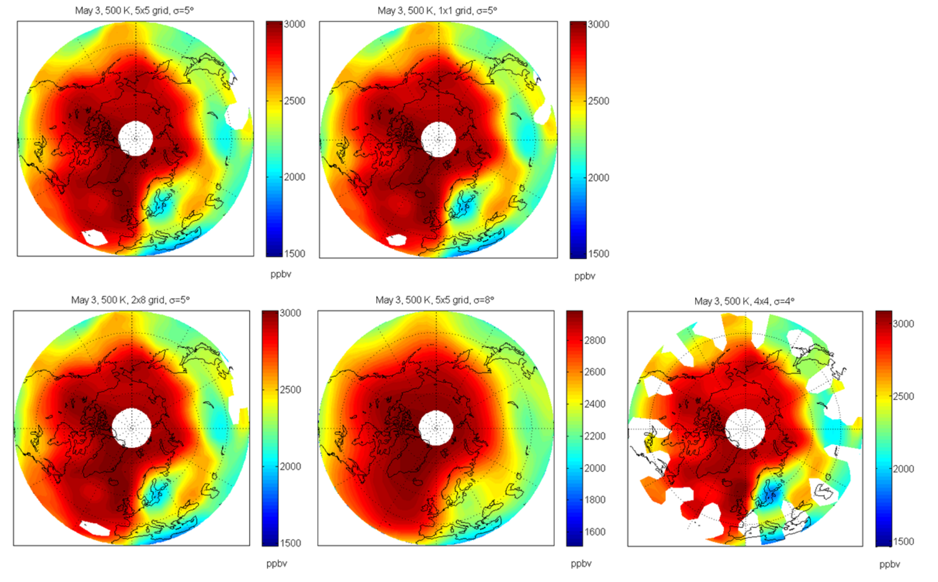

Fig. 2. Polar map of smoothed OSIRIS data on 3 May 2011, for various filter widths and standard deviations given in the figure titles.

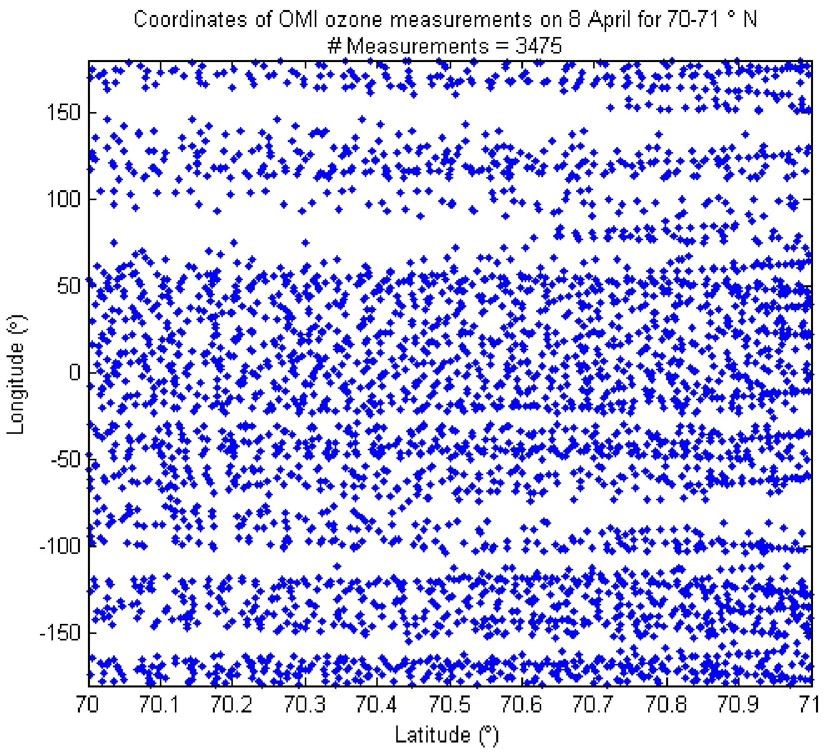

Fig. 3. OMI measurement longitudes for 8 April 2011 for 70-71° N latitude.