Editor Decision: Publish subject to technical corrections (01 Sep. 2015) by Dr. Michel Van Roozendael

Comments to the Author:

I find the new ozone comparison rather interesting. Looking more closely at the plot, it strikes me that the disagreement between SBUV-MOD and GOZCARDS is mostly significant in a 3-year period after 1991, i.e. during the post-Pinatubo period! One possible explanation could be that SBUV (and by the way also TOMS) total ozone could have been slightly underestimated during this period due to the impact of Pinatubo aerosols on the radiation transfer at SBUV/TOMS wavelengths. You might eventually consider this in the discussion in addition to the terminator issue (and in fact both effects could add up, since I expect that light path alteration by aerosol would be enhanced at low sun).

Author Response (02 Sep. 2015):

Please see the revised (and iterated) discussion portion in cyan below. We agree that this can/should be modified to include this sort of comment, for more completeness at least.

We do appreciate the comments! We have also added "discussions (notably regarding ozone columns) with Michel Van Roozendael" in the acknowledgements.

5.3 GOZCARDS ozone sample results and discussion

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Here, we investigate ozone column results for the stratosphere, based on the global GOZCARDS data, in light of other column ozone datasets, including the work by Ziemke and Chandra (2012), hereafter referenced as ZC12. These authors analyzed total column and stratospheric column data from satellites, and their analyses yielded a rather strong near-global (60°S-60°N) average ozone increase since 1998. Their stratospheric columns depend on the convective-cloud differential (CCD) method and use Total Ozone Mapping Spectrometer (TOMS) and Ozone Monitoring Instrument (OMI) column data over convective clouds near the tropopause (see also Ziemke et al., 2005). In Fig. 22, we compare changes in 60°S-60°N ZC12 column ozone data (J. Ziemke, personal communication, 2013) to changes in GOZCARDS O_3 columns above 68 hPa for that region; note that GOZCARDS values do not provide for a continuous long-term time series down to pressures of 100 hPa or more in the SAGE I years (1979-1981). To eliminate biases between stratospheric columns as calculated using the CCD methodology and the GOZCARDS fixed bottom pressure approach, we reference all stratospheric columns to the 1980 total column value. These column series include SAGE I data and are linearly interpolated between 1981 and 1984, when no GOZCARDS source datasets exist. We observe that relative changes in GOZCARDS columns follow the ZC12 curves within a few DU in the downward

phase until about 1992, but the 1992-1997 decrease in total columns does not compare very well. Some of this discrepancy may occur because total columns capture a stronger decrease from levels below 68 hPa, not fully represented in GOZCARDS. Focusing on the late period (from Aura MLS and ACE-FTS), we also show the GOZCARDS columns above 68 hPa, referenced to 2007 instead of 1980. There is a good match in the variations between GOZCARDS and ZC12 columns during 2005-2010, in agreement with the fact that very good correlations were obtained by ZC12 between Aura MLS columns and stratospheric column data from the CCD technique. ZC12 values for stratospheric and total columns are in good agreement, although the stratospheric values have gaps when not enough data were present for near-global estimates. The increase in ZC12 data from 1997 to 1998 is not matched very well by GOZCARDS; this is also true if we remove the 11-yr solar cycle from both datasets (not shown here), as done by ZC12. However, the interannual changes in GOZCARDS columns are in better agreement with near-global total column variations in the Merged Ozone (Version 8.6) Dataset obtained from the suite of SBUV instruments (McPeters et al., 2013, Frith et al., 2014), as shown in Fig. 22. Discrepancies between the GOZCARDS and total column data (SBUV or TOMS) are largest between 1992 and 1997; this could be related to some issues in this portion of the GOZCARDS ozone data record or to the somewhat less robust SBUV data in this period, resulting from SBUV satellite orbits closer to the terminator (e.g., see Frith et al., 2014) and/or from errors introduced by Mount Pinatubo aerosols (e.g., Bhartia et al., 1993, Torres and Bhartia, 1995). Discrepancies between the various column results in Fig. 22 could also arise from differences in ozone column calculations or coverage because of different methodologies, grids, vertical coverage, or sampling to properly determine near-global results. We also note that recent analyses by Shepherd et al. (2014), who used a chemistry-climate model constrained by meteorology to investigate causes of long-term total column O_3 variations, show a partial return, in 2010, towards 1980 ozone column values, but not nearly as much as implied by ZC12. Long-term halogen source gas reductions that have occurred since the mid-1990s should only lead to column ozone increases of a few DU since 1997 (Steinbrecht et al., 2011).