Atmos. Chem. Phys. Discuss., 12, C13225–C13231, 2013
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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Stratospheric ozone interannual variability (1995–2011) as observed by Lidar and Satellite at Mauna Loa Observatory, HI and Table Mountain Facility, CA" *by* G. Kirgis et al.

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Received and published: 7 March 2013

We thank referee #2 for his positive and constructive comments and in particular on his suggestions to address vertical resolution and the magnitude of the drifts between MLS and the lidars. Our point-by-point responses are detailed below.

General points: 1. I miss more discussion of vertical resolution of the measurements, both concerning Lidar and satellite measurements. What means "high vertical resolution" in case of Lidar measurements, how are the averaging kernels of satellite measurements addressed ?

The TMF and MLO stratospheric ozone lidars instrumental vertical sampling is 300 m.

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The ozone profiles are vertically filtered during the ozone profile retrieval. As a result, the vertical resolution decreases with altitude, ranging from typically 1 km in the lower stratosphere to 4 km in the upper stratosphere. No satellite averaging kernels were used because not all of them were available. Considering the vertical extent of most of the responses, we do not think the difference in effective resolution between the satellite and lidar measurements is indeed an issue. However we recognize that this should be addressed in any future extension of the present study. In particular, another manuscript is indeed in preparation in which this topic will be addressed specifically.

2. Drift between ground based and satellite series: I think relative drifts in the order of 5% per year are dramatic preventing any useful comparison of trend analysis.

In average, drifts between lidar and satellite measurements are really close to zero. The highest median values were calculated with Aura/MLS: -1.1 at MLO and -0.8 at TMF while values calculated for SAGE II and HALOE are between -0.3 and 0.1. TMF is the only case with a drift that high at 38km and in this case we therefore treated our trends results with increased caution.

Specific points: 3. p. 30828, line 10: How is "high resolution vertical profile" defined ?

We added the following sentence: "The lidars vertical sampling resolution is 300 m, and the effective resolution of the ozone profiles range from less than 1 km in the lower stratosphere to 4 km in the upper stratosphere".

4. p. 30830, line 11-14: . . . .. Using air density and temperature obtained from Lidar or from daily NCEP data: How good is the quality of the retrieved ozone profiles when NCEP daily analysis are used instead of air density and temperature of Lidar measurements ?

To retrieve ozone mixing ratio, an air number density profile (N) is needed. The relative error associated with the use of a priori air number density can be expressed as: $(\partial O\_3vmr)/O\_3vmr = (\partial NO\_3)/(NO\_3\ ) + \partial N/N$. It will have an effect of the first order

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on the mixing ratio values, but only of second order on the trends since the observed drift between the two air number density datasets is very small. As shown in figure 1, calculating air density using actual measurements (lidar or radiosondes) instead of the once-daily NCEP analysis extracted from the NDACC website impacts the mixing ratio values by less than 3%, and the trends by less than 0.5% per decade.

5. p. 30830, line 14: How is “high vertical resolution” defined ?

See response above.

6. p. 30830, line 16: Can you give a reference (possibly report) concerning the technical details of instrumental changes ?

Metafiles describing the historical changes of the two lidars are available, on the NDACC data handling facility, and can be downloaded from: http://ftp.cpc.ncep.noaa.gov/ndacc/meta/lidar/jpl_tmf_aot_ldr.txt for TMF .http://ftp.cpc.ncep.noaa.gov/ndacc/meta/lidar/jpl_maunaloa_aot_ldr.txt for MLO There has been no major change to the instruments whatsoever since the last reported events (last major changes occurred in 2000 and 2001).

7. p. 30830, line 27: Please give a reference for definition of relative error.

We actually prefer to use the word “uncertainty” rather than “error”. We added in t he text the following sentence: "The relative uncertainty comprises measurement and retrieval. It includes the statistical uncertainty associated with the measurement (precision), and the combined uncertainty associated with the lidar signal saturation correction and atmospheric extinction correction".

8. p. 30832: Fig. 1: I suggest to mention in the text, that no measurements of the TMF Lidar are available around the year 2000.

Thank you for this suggestion. We added it in the lidar dataset description: " Nonetheless, no measurements of the TMF lidar are available around the year 2000".

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9. p. 30832,line 25: (lack of) correlation between at TMF and satellite series in higher stratosphere: Is it not possible, that the large drift between Aura MLS and other data also affects the correlation at these altitudes ?

We agree that large drifts and RMS can definitely explain this lack of correlation. We indeed emphasized it by adding the words "partly unexplained" after the discussion of figure 2.

10. p. 30833, line 7: . . . drifts are also low. . ..: I find the relative drift of Aura MLS vs. other satellite and Lidar data of 5% yr-1 at altitudes of 35 km and above dramatic making it useless to include the MLS data in the upper stratosphere for reliable trend analysis.

Yes there is clear high drift at 38 km. We agree that the interpretation of our results should be taken with caution at and above 35-40 km ($\sim$3%.year-1). At of today, we would rather question the quality of the TMF lidar measurements at these altitudes rather than that of MLS. As shown in attached figure 2, the standard deviation calculated for the lidar monthly means values are high between 2005 and 2008. Nevertheless, the Aura/MLS remains so far the best fit to the lidar measurements time series.

11. p. 30834, line 27: you might add the reference: S. Brönnimann, et al.: Extreme Climate of the Global Troposphere and Stratosphere 1940-1942 related to El Nino, Nature, 431, 971-974 (2004).

This reference was added.

12. p. 30836,line 15: Linear trends: I think you should be more precise: Single negative linear trend components were used in regression models when fitting ozone measurements until around 1995 and two slopes when fitting ozone data covering longer periods.

We added the following sentence: "Regression models usually use a single or piecewise (two slopes for long period) linear trend when fitting ozone measurements to sim-

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ulate ozone depletion at mid-latitudes due to halogens".

13. p. 30836, line 26 ff: ODGI (vs. EESC) definition: I am skeptical concerning the selection of zero in 1980: this would imply that anthropogenic stratospheric ODS concentrations were negligible before 1980 – though I admit that this is not relevant in the context of this paper.

Referee #2 is correct that selecting “zero” for 1995’s ODS level is somewhat arbitrary, but he is also correct that this is not the focus of the present study and therefore has no impact on our results. We added a short comment in the text to clarify it.

14. p. 30838, line 20: How is the “scale factor” defined ?

The scale factor from line 20 was defined to adapt the ozone anomaly scale to the altitude scale. It is equal to 10% so the time series is multiply by 0.10.

15. p. 30841, last paragraph and Fig. 9: I believe that the nonlinear time evolution of ODGI (or EESC) in the years after 1995 (see Fig. 4) explains, why a linear trend term is not appropriate to fit the time series.

Indeed, there are four breaks in the slope.

Spelling mistakes:

All typos corrected (some of them were not present in the PDF version)

20. p. 30845, line 27; I think, the sentence is not complete:Hence the study shows the need for high quality . . ...

Thank you for noticing this. We changed the sentence to: "Hence the study shows the need for high quality continued, long-term, routine measurements by the JPL lidars at TMF and MLO, as well as other ground-based instruments and satellite missions".

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 30825, 2012.

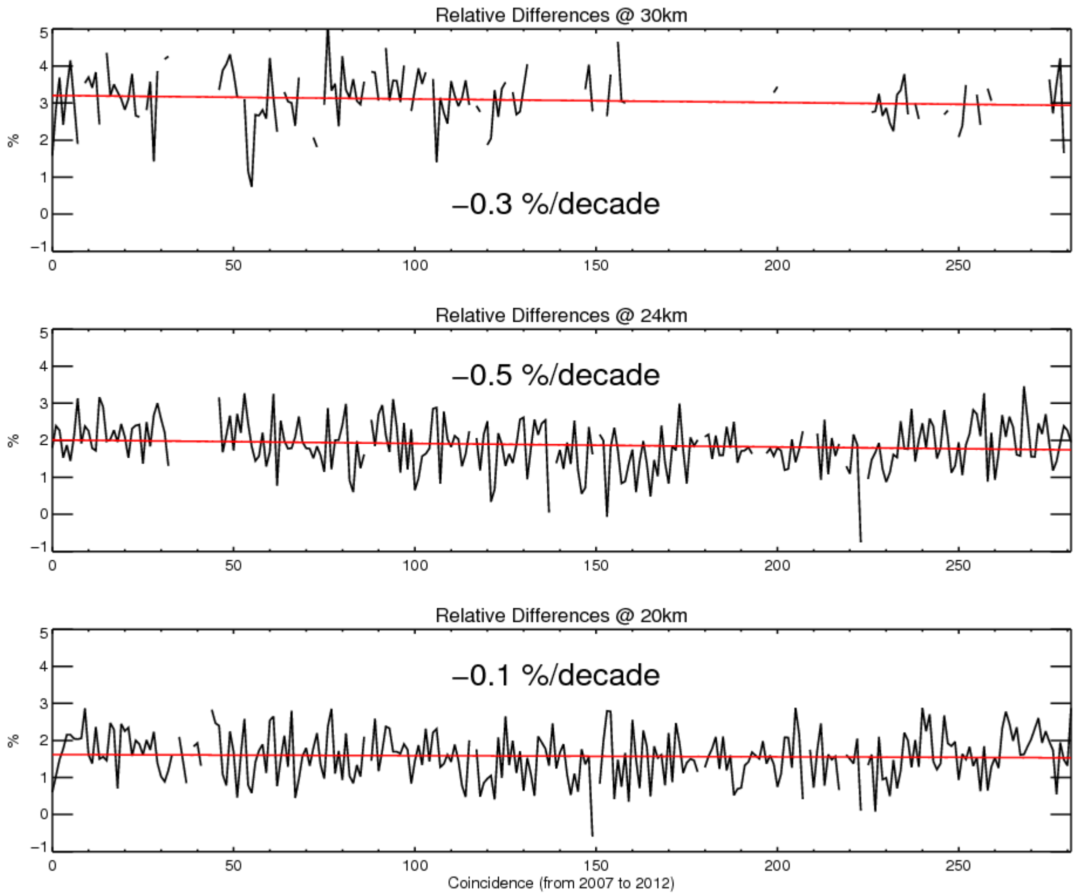

Fig. 1. Relative differences of air density calculation while using a NCEP a priori compare to the Radiosondes at TMF. Drifts values are shown for each altitude.

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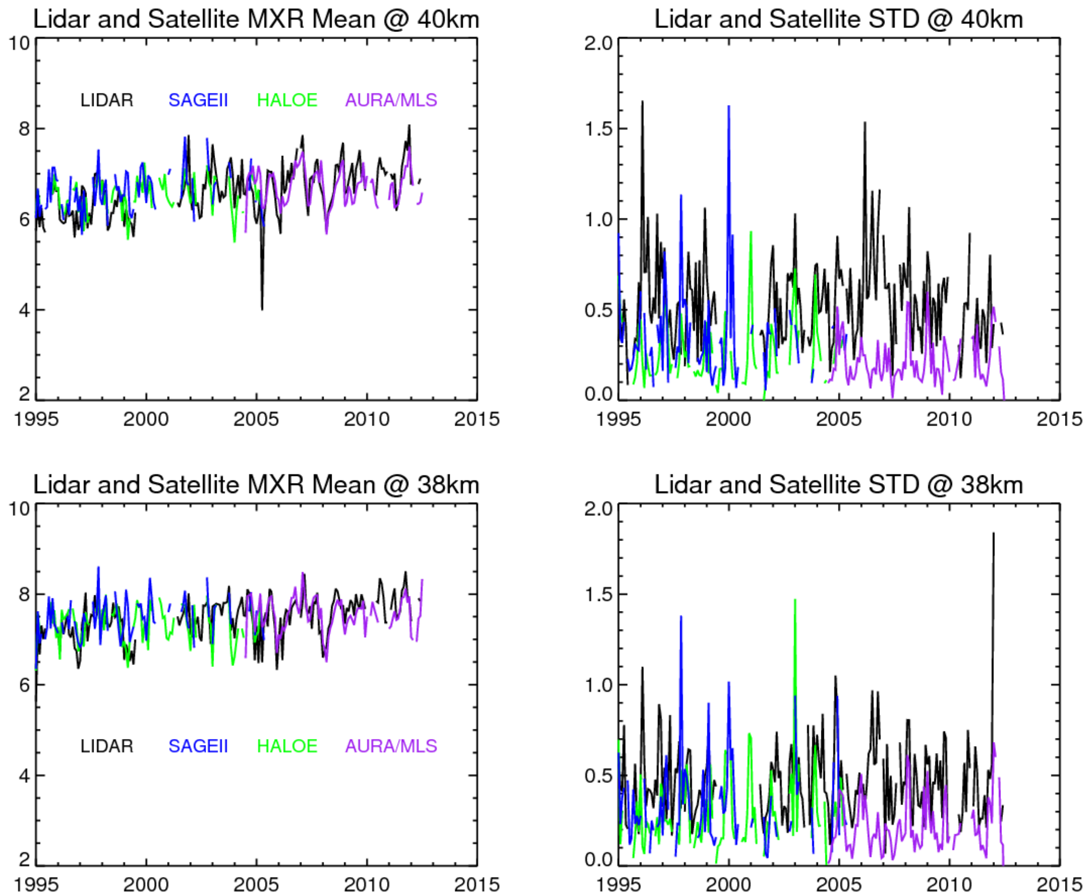

Fig. 2. TMF Lidar and satellite monthly means (right) and standard deviation (left) time series at 38 (low) and 40 km (up).

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