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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieving Vertical Ozone Profiles from Measurements of Global Spectral Irradiance" *by* Germar Bernhard et al.

Anonymous Referee #2

Received and published: 19 September 2017

General Comments:

This paper presented a new algorithm titled global-Umkehr algorithm to retrieve the vertical distribution of ozone from global spectral irradiances. The algorithm was tested using the data measured at Summit, Greenland and the retrievals were validated with ozonesonde and MLS data. The validation demonstrates good retrieval performance comparable to those from the standard Umkehr technique. As similar global irradiance measurements have been routinely measured at a number of stations, applying this technique to those measurements has the potential to complement the Umkehr measurements and contribute to the long-term monitoring of ozone profiles.

This paper is very suitable for publication in AMT. It is generally well written and organized except that some subsections of section 2 can be rearranged to further improve

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Discussion paper

the organization. The validations with ozonesonde and MLS data are very well presented and discussed. Overall, I recommend it to be published after addressing the following minor comments.

Specific Comments:

1. It is good to provide more details about how to derive a priori profiles from MLS and ozonesonde data. Are MLS data collocated with ozonesonde data around the Summit station? How MLS and ozonesonde data are merged as they cover different altitude ranges? Have other ozone profile climatologies such as McPeters et al. (2007) and McPeters and Labow (2012) been considered?

2. Instead of using fixed a priori error of 0.1 and 0.4, you mentioned the use of altitude-dependent a priori errors in the discussion (P21 L18), which is likely more appropriate as the ozone variability is relatively small in most of the stratosphere, ∼10% based on your analysis, but increases significantly in the lower stratosphere and upper troposphere to ∼40%. You can modify Eq 4 to be more generic, allowing for altitude-dependent a priori errors: [Sa]mn = sigma_amˆ2 * [Xa]m * sigma_anˆ2 * [Xa]n * exp(-|m-n|/d)

3. P5, L8, one of the most important diagnostics is averaging kernels A, which is described in section 2.4. I suggested moving section 2.4 to in front of L8 as ds, is typically derived from A, as the trace of A. The diagonal elements of A are the ds at each layer.

4. P6, Equation 8 is confusing. Looks like Dc(theta(t)) is not based on actual measurement, but based on the parameterization of clearly sky measurement as a function of SZA. You may change “Dc(theta(t)) is the measurement . . .” to “Dc(theta(t)) is the modeled photodiode measurement at time t that would be observed during clear skies, parameterized a function of SZA after filtering cloudy measurements.” Also what criteria are used to filter cloudy measurements?

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5. It is better to switch sections “Retrieval method” and “Measurements” as the section of retrieval method depends on the description of measurements.

6. P6, L18-21, what is the main motivation of interpolating measurements to a common SZA grid that has 8 SZAs other than reducing the computation time. What is the typical number of spectra during the collection period (SZA change form 70 to 90)? Looks like it is much larger than 8, so interpolating it to 8 SZAs only while keeping the same measurement error can reduce the available information content and increase the measurement error. Have retrievals been conducted using the measurements at individual SZAs and compared with retrievals interpolated to 8 common SZAs?

7. P6, L30, why not using more recent ozone cross sections based on the activities of ACSO (Absorption Cross-Sections of Ozone) summarized in Orphal et al. (2016), which recommends that the BP data should not be used. Is this for consistency with the OMI TOC retrieval, which also used the BP data?

8. Are both SDISORT and MYSTIC RTMs based on scalar (rather than vector) radiative transfer models? If so, this is another source of forward model bias. What are the impacts of neglecting polarization (i.e., assuming scalar) on the calculated radiances? Just check if any such analysis has been done for either SIDOSRT and MYSTIC RTM.

9. P10, L12, how is this threshold of 20 DU be determined?

10. P11, MLS measurements from consecutive days are used to quantify the temporal variation of ozone. It should be noted that the MLS measurements from consecutive days will be measured at different locations, maybe $\sim$100 km apart. So some of the MLS1/2 difference is due to spatial variability. What is the average distance between MLS 1 and 2?

11. P12, L3-15, a lot of the description can be reduced as this has been described in the figure caption.

12. P21 L20, you may consider using some recent cross sections as suggested in Or-

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phal et al. (2016), and use meteorological data (e.g., temperature profiles) to account for the temperature dependence of the ozone absorption cross section. To reduce the impact of Ring effect, you may consider optimizing not only wavelengths, but also the magnitude of bandpass (currently 2 nm) used to degrade the spectral resolution. In addition, you can also mention the correction of forward model errors due to the neglect of polarization as commented earlier.

13. P22 L8, multiple scattering effect is also important for zenith sky measurements. You may say multiple scatterings effects become more important and the sphericity of the viewing geometry should be taken into account.

14. P24, L21, The poor sensitivity of the Umkehr method to ozone retrieval at layer 0 & 1 was mentioned here. Because only 2 wavelengths are used in the retrievals, measurements at other wavelengths especially the global irradiance spectrum can be used to improve the retrieval sensitivity in the first few layers as shown in Liu et al. (2005). You may add a few sentences about the possibility of exploring this for future studies.

Technical comments

1. P2, L20, change "a.s.l" to "a.s.l."

2. The section of "1 Method" should be "2 Method" and "1.1 Retrieval method" should be "2.1 Retrieval method"

3. P2, L25, change "depends" to "depend"

4. P5, L17, "and is part of. . ."

5. P5, L27, change "wavelengths shifts" to "wavelength shifts"

6. P6, L17, this sentence can be grouped to the above paragraph.

7. P6, L28, change "result are" to "results are"

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8. P7, L6, change “reference” to “references”

9. P7, L24, change “considered” to “considered as”

10. P15, L18, add “,” before “interquartile”

11. P19, L28, change “decreased” to “has decreased” or “decreases”

12. P19, L18, change “is varies” to “varies”

13. P19 L26ïijŇ change to “compared”

14. P20, L1, L2, L5, L6, change to “compared”, “found”, “concluded”, “compared”

15. P23 L10, change to “on a weekly basis”

16. P24, L17, add “,” after “Phys.”

17. P24, L18, add “,” after “Res.”

18. P26, last line, use normal font for the journal title.

McPeters, R. D., Labow, G. J., and Logan, J. A.: Ozone climatological profiles for satellite retrieval algorithms, J. Geophys. Res., 112, D05308, doi: 10.1029/2005jd006823, 2007. McPeters, R. D., and G. J. Labow (2012), Climatology 2011: An MLS and sonde derived ozone climatology for satellite retrieval algorithms, J. Geophys. Res., 117, D10303, doi:10.1029/2011JD017006.

Orphal, J., et al., Absorption cross-sections of Ozone in the ultraviolet and visible spectral regions – Status report 2015, J. Mol. Spectrosc., 327, 105-121, doi:10.1016/j.jms.2016.07.007, 2016.

Liu, X., K. Chance, C.E. Sioris, M.J. Newchurch, T.P. Kurosu, Tropospheric ozone profiles from a ground-based ultraviolet spectrometer: a new retrieval method, Appl. Opt., 45(10), 2352-2359, 2006.

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