amt-2014-337
"A method to derive the Site Atmospheric State Best Estimate (SASBE) of ozone profiles from radiosonde and passive microwave data."

Comments from Referee #1

I fail to see where the publication is describing a new measurement technique. It is about creating a new data product using existing data sets. Therefore I would suggest to transfer this publication to the copernicus journal "Earth system science data" and to make the data available to the community via a portal like www.pangaea.de, unless of course, the authors want to exploit the product for a scientific study in a later publication.

Author's answer to Referee #1

The publication is not describing a new measurement technique but describes and characterizes a new method to merge profiles measured by two different measurements techniques each of them presenting different performances and different vertical resolutions and ranges. In terms of the characterization of the SASBE new results are presented, for example an averaging kernel of a combined profile has to our best knowledge not been shown in literature so far. The purpose of the publication is first to describe the method (as mentioned on line 1 p 3400, line 6 p 3403, paragraph 3 p 3407) and then to produce a well characterized dataset. Therefore, the authors think that AMT is appropriate for this publication as it has been for other publications dealing with the merging of profiles without presentation of a new measurement technique (see for instance Deland, Hassler and von Clarmann in the present list of references). The dataset is available on request from the authors and is currently used in a study which will certainly be submitted for publication in the near future, therefore the authors are not ready to make it available without restriction to the community.

Author's changes in manuscript

Line 9 p 3412 :
"The SASBE dataset over Payerne is available for validation of satellite and other remote sensing instrument ranging from ground to 65 km height with a temporal resolution of 3 times a week for SASBE (using RS) and of 6 hours for SASBE using ECMWF. "The SASBE-RS and SASBE-ECMWF datasets presented in this study can be made available to other users upon request"

Comments from Referee #1

Also, I would suggest to exchange the publication Rodgers, D. C.: Characterisation and error analysis of profiles retrieved from remote sensing measurements, J. Geophys. Res., 95, 5587-5595, 1990.
by the publications
Rodgers, D.C.: Inverse Methods for Atmospheric Sounding, World Scientific Publishing Co. Pte. Ltd., 2000
and
Clive D. Rodgers and Brian J. Connor, Intercomparison of remote sounding instruments,
J. Geophys. Res., 2003
to reflect the development in the technique of anlysing, characterizing and comparing remote sensing measurements.
Especially Rodgers (2000) declared the definition of the smoothing error given in Rodgers (1990) as wrong.
Rodgers and Connor (2003) spell out how to compare different remote sensing measurements and summarize most developments in this field in earlier publications of the same authors.

Author's answer to Referee #1

Thank you for the suggestion. The references have been changed and added.
Rodgers (2000) do not declare the definition of the smoothing error given in Rodgers (1990) as wrong : in both publication, the definition of the smoothing error is given as the difference between the retrieved profile and the true state but in Rodgers (1990) this difference is called "null-space error" which is the portion of the profile not seen by the system.
Rodgers (2000) describes two ways of considering the retrieval : as an estimate of the smoothed state or as an estimate of the true state. In the second case, the error budget contains a smoothing error term. Discussion on the pertinence of considering the second case can be found in von Clarmann, Smoothing error pitfalls, Atmos. Meas. Tech., 7, 3023–3034, doi:10.5194/amt-7-3023-2014, 2014.

Author's changes in manuscript

Line 2 p 3402:

"If an averaging kernel is provided along with the low resolution data, the high resolution data can be convoluted with this averaging kernel (Tsou, 1995; Rodgers, 2003; Calisesi, 2005)."

Line 7 p 3405:
"For a real instrument, the width of the AVKs is a measure of the resolution of the system [Rodgers, 2000]."

Line 25 p 3415:
Rodgers, C. D.: Inverse Methods for Atmospheric Sounding: Theory and Practice, Vol. 2 of Series on Atmospheric, Oceanic and Planetary Physics, edited by: Taylor, F. W., World Scientific, 48-49, 2000.

Line 25 p 3415:

Rodgers, C. D. and Connor, B. J.: Intercomparison of remote sounding instruments, J. Geophys. Res., 108, 4116, doi:10.1029/2002JD002299, 2003.

Comments from Referee #1

Chapter 1
Ozone is also regularly retrieved fro solar absorption measurements and used in trend studies (e.g. Vigouroux, 2014). Even though those measurements are not used here, they should be mentioned in the introduction along with all other possibilities to measure Ozone, even though the authors mention it later.

Author's answer to Referee #1

Thank you for the suggestion. FTIR measurement are now mentioned in the introduction and the reference has been added.

Author's changes in manuscript

Line 13 p 3401:
"Radiosondes are measuring ozone profiles from ground up to 30-35 km (e.g. Hassler, 2013 and references therein), LIDAR measurements are performed during the night up to 50 km (e.g. Pelon, 1986), Ground-based Fourier transform infrared (FTIR) provide independent partial column amounts up to 45km (e.g. Vigouroux, 2015 and references therein) and microwave radiometers (MWR) measure ozone profiles from the lower stratosphere up to the lower mesosphere with a high temporal resolution (e.g. Boyd, 2007, Calisesi 2005)."

Line 23, p 3412:
Boyd, I. S., Parrish, A. D., Froidevaux, L. , von Clarmann, T. , Kyrola, E. , Russell, J. M., and Zawodny, J. M.: Ground-based microwave ozone radiometer measurements compared with Aura-MLS v2.2 and other instruments at two Network for Detection of Atmospheric Composition Change sites, J. Geophys. Res., 112, D24S33, doi:10.1029/2007JD008720.

Line 10, p 3416:
Vigouroux, C., Blumenstock, T., Coffey, M., Errera, Q., García, O., Jones, N. B., Hannigan, J. W., Hase, F., Liley, B., Mahieu, E., Mellqvist, J., Notholt, J., Palm, M., Persson, G., Schneider, M., Servais, C., Smale, D., Thölix, L., and De Mazière, M.: Trends of ozone total columns and vertical distribution from FTIR observations at eight NDACC stations around the globe, Atmos. Chem. Phys., 15, 2915-2933, doi:10.5194/acp-15-2915-2015, 2015.

Comments from Referee #1

Chapter 2
page 3405, line 16
Please define the smooting error according to Rodgers (2000), page 49. Especially explain which covariance you used for the true ozone climatology, which is needed to calculate the smoothing error.

Author's answer to Referee #1

As the statistics of the true state is not exactly known, the smoothing error is estimated using the a priori covariance matrix.. This matrix is described on lines 20-27 p 3404.
(Values: depending on the altitude, between 0.1 and 0.3 meaning 10 and 30% of the ozone a priori concentration)

Author's changes in manuscript

Line 10 p 3405;
"The smoothing error is the error contribution due to the smoothing of the true state by the AVK. As the true state is not exactly known, the smoothing error is estimated using the covariance matrix of the a priori."
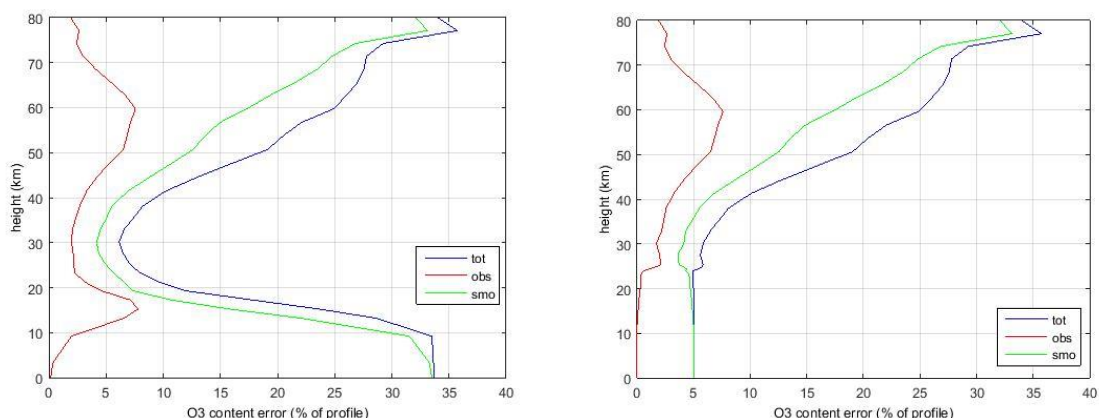
Comments from Referee #1

Chapter 4
I would suggest to make the characterisation of the SASBE profile more detailed. For example: how propagates an error in the O3 sonde profile to the combined profile and vice versa. Does the use of sonde profiles lower the error for O3 profile derived from the millimeterwave spectra? If so where?

Author's answer to Referee #1

Below 25 km, the error in the ozone sonde profile is the same as the error in the SASBE ozone profile as the part of the SASBE profile below 25 km is the measured ozone sonde profile. As mentioned on line 7 and 14 p 3407, the a priori below 25 km is the ozone profile measured by the radiosonde with its corresponding error.
Below, you can find a plot of the total, smoothing and measurement error for SOMORA (left hand side) and SASBE (right hand side) showing a negligible difference in the errors profiles for h>25 km.

Author's changes in manuscript

Line 12 p 3409:

"In the case of the SOMORA retrieval, the error below 20 km increases to 35% due to the large a priori uncertainty while the error of the SASBE retrieval remains small at 6% below 20 km corresponding to the uncertainty of the radiosonde measurement used as a priori in this case."
Line 15 p 3409:
"The error is in both cases around 10% at 40km. The total error difference between SOMORA and SASBE is negligible above 25 km."

Comments from Referee #1

Chapter 5
No information is given, how the 1SD difference of the respective comparisons is calculated. Please refer to Rodgers and Connor (2003) on how to do this.
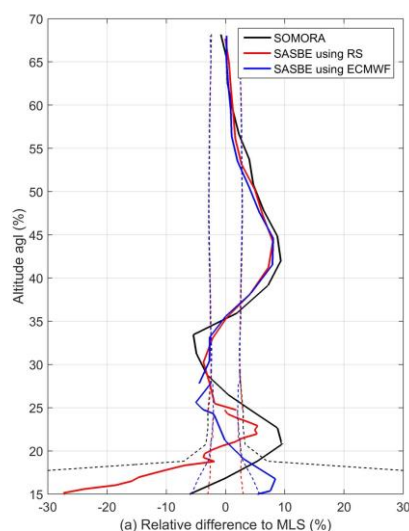
Author's answer to Referee #1

When comparing profiles presenting different vertical resolution, Rodgers and Connor (2003) recommend the AVK smoothing of the profile with higher vertical resolution in order to get reasonable difference and 1SD. The smoothing of the MLS profiles by the AVK of SOMORA is used in this publication and described on lines 10-18 p 3410. The plotted 1SD is the statistical standard deviation calculated on the 3 year timeseries of the differences between the AVK smoothed MLS ozone profiles and the SOMORA respectively SASBE ozone profiles. The authors propose to modify figure 6 by plotting the standard deviation of the mean difference, which is calculated by dividing the statistical standard deviation by the square root of the sample number. The value is then reduced to 5 % in the stratosphere (Figure 6(a)).

Author's changes in manuscript

Figure 6:
Change of the statistical standard deviation of the differences for the standard deviation of the mean difference.

Line 19 p 3410:
"The arithmetic means and standard deviation of the 3 years relative differences of SOMORA resp. SASBE to MLS and RS are shown in Fig. 6(a) and 6(b)), together with the standard deviation of the mean difference in dashed.

Technical remarks:
page 3402 line 6, please correct the citation
page 3405 line 21, please add a link to the webpage of NDACC

Author's answer to Referee #1

Thank you for the remarks. The citation has been corrected and the link added.

Author's changes in manuscript

Line 6 p 3402:
"A third method to downscale the high resolution data consists of applying a Gaussian filter centered around the levels of the coarse grid on the high resolution data as it has been done for the "Binary Database of Profiles" (BDBP) in Hassler et al. (Hassler, 2008) to combine ozone sonde and satellite vertical profiles."

Line 21 p 3405:
SOMORA belongs to the Network for the Detection of Atmospheric Composition Change (NDACC, http://www.ndsc.ncep.noaa.gov/).