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Interactive comment on "Spectral actinic flux in the lower troposphere: measurement and 1-D simulations for cloudless, broken cloud and overcast situations" *by* A. Kylling et al.

A. Kylling et al.

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Referee 1:

Specific comments:

1. p1423, Abstract: The abstract has been modified to mention both INSPECTRO and uvspec.
2. p1428.l6: A reference to the Mayer and Kylling paper has been included.
3. p1428.l24-26: As the reviewer points out it is not clear from the text how the total

ozone column was handled and the potential impact. The text has been clarified and now reads “The ozone column was taken either from the GRT Brewer instrument or the Earth Probe Total Ozone Monitoring Spectrometer (TOMS) (table 3). The ozone column was assumed to be homogeneous over the measurement area. For days 257 and 261 the TOMS total ozone column was used as clouds prevented measurements with the GRT Brewer. For the other days the GRT measurements were utilized. The uncertainty in the total ozone column measurements are about 2% for the Brewer under cloudless conditions and about 4% for the TOMS. The ozone measurement did not always coincide in time with the radiation measurement, thus increasing the uncertainty in the total ozone column value used for the radiative transfer calculations. With these uncertainties in mind, 10 DU was added to the GRT total ozone column to achieve the agreement between model and measurement shown in section 5.1.1, an additional 10 DU was added to the GRT total ozone column. This decrease the model values by about 6% at 305 nm, but has negligible effect on the integrated UVB (205-320 nm) and cloud effects presented below.” In addition, the measured total ozone columns by the TOMS and GRT measurements have been included in table 3.

4. p1431.l18-19 & Fig. 3: As the referee comments, the different panels in Fig. 3 belong together. That is why they are presented this way. And to keep the figure in a similar format to Fig. 12 we prefer to keep it as is.

5. p1434.l3-4: A reference to Ruggaber et al, (1993), Weele et al. (1995) and Kylling et al. (2003) has been added to point the reader to papers discussing the relationship between the irradiance and the actinic flux.

6. p1434.l20 & Fig. 8: The reason for showing only one downwelling spectrum in Fig. 8 is that the agreement is similar for all altitudes. To clarify this the sentence starting at line 14 has been changed from “The downwelling measured and simu-

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lated actinic fluxes agree ..." to "The downwelling measured and simulated actinic fluxes for all altitudes agree ...".

7. p1435.l4-5: The angular correction procedure described by Jäkel et al. (2005) is rather complex. However, to shed somewhat more light on the procedure the text has been changed from "The measurements have been corrected for the non-perfect angular response following the procedure of Jäkel et al. (2005)" to "Angular correction factors as a function of wavelength, altitude, and cloud and surface albedo have been calculated using the discrete ordinate algorithm developed by Stamnes et al. (1988). A thorough discussion of the correction factors has been presented by Jäkel et al. (2005). The measurements have been corrected for the non-perfect angular response using these factors, however, an ...".

8. p1435.l13-14: The sentence stating that "Finally, during the ascent the acceleration of the aircraft was in periods outside the operational range of the stabilization system of the input optics." is inaccurate and has been replaced by "The operational pitch and roll angles range of the stabilization system is $\pm 6^{\circ}$. During the ascent the acceleration of the aircraft meant that this range in periods was exceeded. Data outside the operational range was excluded from the analysis. Nevertheless, part of the ascent and descent data may be influenced by aircraft movements although the magnitude is assumed to be small.".

9. p1435.l26-27: The following statement " The increase is largest for the upwelling actinic fluxes because as the altitude increase, the amount of upscattered radiation increases due to Rayleigh scattering" has been expanded to "The increase is largest for the upwelling actinic fluxes because as the altitude increase, the amount of atmosphere below the aircraft increase, thereby causing an increase of upscattered radiation due to Rayleigh scattering", as suggested.

10. p1435.l29-p1436.l1; p1437.l13 & Fig 10; and p1437.l17: The entire paragraph that these three comments apply to has been rewritten to address the questions

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raised. Furthermore, a new figure has been included to support the discussion. Generally, the solar zenith angles during the flights were such that the maxmimum might just be visible in the data. The revised discussion in the manuscript reflects this.

11. p1438.l4 & Fig. 10: The text has been corrected to state that "the model is consistently larger than the measurements for day 257 and smaller for then the measurements for day 263" as suggested by the referee.

12. p1438.l21: The text has been changed from "covered 4/8 over land" to "covered 4 oktas (4/8) oved land". This should clarify the meaning of 4/8 and similar subsequent use.

13. p1442.l26-p1443.l1, Conclusions: The following item concerning the upwelling actinic flux, has been added to the Conclusions: "Under cloudless conditions the upwelling actinic flux contributed between 5 to 30% to the total actinic flux depending on wavelength and altitude. Above 400 nm the measured and simulated downwelling actinic fluxes agreed within $\pm$10%. For shorter wavelengths the differences were larger."

14. p1450, Table 1: Wording has been changed as suggested by the referee.

15. p1451, Table 2: Textlines segregating the ground-based and airborne instruments have been added as suggested.

16. p1452, Table 3: A description of the nomenclature used in the table has been added to the table caption as suggested.

17. p1453, Fig. 1: A legend identifying the various lines have been added to the Figure.

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18. p1454, Fig. 2: There is already a legend identifying which colour is liquid water content and which is effective radius in Fig. 2b. Due to the nature of the lines in Fig. 1a it is difficult to add a legend identifying ascent and descent curves without overlying the data curves. The identification is, however, clearly stated in the figure caption.

19. p1460, Fig. 8: A legend have been added to the figure. The use of line types have been made consistent between figs. 8a and 8b.

20. p1462, Fig. 10: Horizontal lines indicating the vertical extent of the clouds have been added as suggested by the referee.

21. p1467, Fig. 15: Horizontal lines indicating the vertical extent of the clouds have been added as suggested by the referee.

All technical corrections have been applied.

Referee 2:

- Introduction page 1: The explanation of the effect in the upper troposphere on ozone formation rates by increased NO concentration, has been expanded as suggested by the referee.

- Introduction page 2: The reference to Matthijsen et al. (1998) should have been there in the first place. It has now been added. In addition also a reference to Lantz et al. (1996) has been added.

- Section 2.2: The EP-TOMS and the Brewer GRT total ozone columns have been included in table 3. In addition a discussion about the ozone values used have been included. Please also see answer to comment by referee # 1.

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- Figure 1: It is a daunting task to specify a wavelength dependent uncertainty estimate for radiation measurements and such an uncertainty estimate is rarely available (G. Bernhard and G. Seckmeyer, Uncertainty of measurements of spectral solar UV irradiance, J. Geophys. Res., 104, 14,321-14,345, 1999). The usual way of displaying these type of data is to include all data. Obviously the uncertainty increases as the wavelength decreases. This is reflected in the model/measurement ratio. Excluding the low wavelength data would make the figure look nicer. However, we prefer to present all data and leave the figure as is.

- Section 5.1: Decrease changed to increase and a reference made to the fact that the increase is with increasing altitude.

- Figure 10: Lines representing the cloud top and cloud bases have been included. Also, the discussion of the cloud maximum has been expanded. Please also see answer to comment by referee # 1.

- Figure 10: The descent was made outside the grid box under investigation and are thus not shown. This comment has been added to the figure caption.

- Section 5.3.2: Generally it is certainly possible that clouds at other altitudes missed by the PVM may affect the cloud optical depth. However, on day 256 distinct cloud bands dominated the sky. This is evident in Fig. 11 which shows cloud bands on a background of a clear blue sky. These cloud bands was also visible both from satellite images and from the aircrafts. No clouds were present above the cloud bands. Hence, the variations in cloud optical depth is due to what part of sky the detector is viewing and how much of the sky that is covered with clouds.

- Reference list: The Webb et al. reference has been updated.

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Technical corrections:

- Introduction page 2: Spelling error corrected.
- Table 1: Spelling error corrected.
- Table 2: Spelling error corrected.
- Table 3: Units included in header information.
- Section 2.2: grammar corrected
- Section 3: grammar corrected
- Section 4: grammar corrected
- Figures 1,7,8: That the model (blue line) is on top of the measurement (green line) such that the latter is not seen indicates the good agreement between the two. Which one is the most important is a question open for debate. Hence, we prefer to show both.
- Figure 3: ACP encourages the use of colours. Colours indeed make it easier to distinguish different pieces of information. We hence prefer to keep the figure as is.
- Figure 5: See response below.
- Figure 6-15: The sizes may be fully controlled by the publisher. It is assumed they will choose a size that confirms with their standards.

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