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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.

Anonymous Referee #1

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GENERAL COMMENTS

This is an excellent paper, comparing measurements of spectral actinic flux (and irradiance) at the surface and in the lower troposphere with detailed calculations using the uvspec model, in the context of a segment of the INSPECTRO project. The work generally confirms or corroborates findings in previous studies of actinic flux (both measured and modeled) below, above, and in clouds. This campaign, however, used multiple ground sites within a defined, 12×12-km^2 area, in part for better characterization of

the three-dimensional cloud field. The paper looks in detail at the model input data, getting a better handle on what characteristics of an inhomogeneous cloud field have to be specified in order to achieve a certain level of measurement–model agreement. The work shows under what circumstances 1-D radiative transfer models are no longer sufficient to model the radiation field (e.g., in broken cloud fields). Another benefit in connection with the work is that the uvspec model used here is publicly available.

I have no major concerns with the content of the paper, but I will enumerate several specific comments here, with suggestions for largely technical corrections in a separate Referee Comment.

SPECIFIC COMMENTS (in order of appearance in the paper)

[px.ly indicates page x, line y.]

p1423, Abstract: It would be worthwhile to mention “INSPECTRO” and “uvspec” by name, giving the reader a better point of reference.

p1428.l16: A reference to the recent *ACPD* technical note by Mayer and Kylling on the libRadtran software package would be appropriate here.

p1428.l24–26: *To get good agreement between measured and modelled UV spectra, see Sect. 5.1.1, an additional 10 DU was added to the ozone column[,] as the values from the instrument appeared to be low.*

This statement must be clarified. First of all, “appeared to be low” needs to be explained. Appeared to be low in comparison to what? Secondly, if I understand

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correctly, it appears that the model has in essence been “tuned.” If so, what impact does this have on the veracity of the measurement–model comparison conclusions of this paper? If I misunderstand, then something has to be clarified so that it is more clear to the reader what has been done. Sect. 5.1.1 did not help.

p1431.l18–19 & Fig. 3: *. . . are shown in the right panel of Fig. 3.*

Figure 3 is first referenced in this section (Sect. 4), but only the right half of the figure. The left half, containing the actinic flux for these days, is not referenced until p. 1436 in Sect. 5.2.1. It is useful to have the four panels together in the figure, analogous to Fig. 12, but it left me wondering the first time through if I had missed the discussion of Figs. 3a and 3c. It would be nice if the figure did not appear (or be numbered) until the reference on p. 1436 (but I do not know if the editor would permit this).

p1434.l3–4: *It is noted that no simple relationship exists between the irradiance and the actinic flux.*

There have been a number of papers in recent years on methods for the conversion of irradiance to actinic flux, including one by the author published in 2003. A reference to one of these papers may be appropriate here.

p1434.l20 & Fig. 8: *For the 58[-]m altitude spectrum[,] the overall agreement is reasonable.*

Only the upwelling radiation at 58 m is discussed here and shown in Fig. 8. What do the downwelling measurements look like? Are they comparable to the surface

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measurements? If the 58-m downwelling flux is not added to the figure, I would at least like to see a comment in the text about them.

p1435.l4–5: *. . . following the procedure of Jäkel et al. (2005).*

It would helpful to the reader if this procedure were briefly described, so that looking up the reference is not entirely necessary.

p1435.l13–14: *. . . the acceleration of the aircraft was in periods outside the operational range of the stabilization system of the input optics.*

There needs to be more of a discussion here. This statement completes a list of caveats that makes me wonder how meaningful the comparisons in Fig. 8 are. Does this statement mean that the measurements may not meaningful at all?! (I am assuming no.) Can you give the reader some idea of how large an impact being "outside of the operational range of the stabilization system" could have on the measurements?

p1435.l26–27: *. . . because as the altitude increase[s,] the amount of upscattered radiation increase[s] due to Rayleigh scattering.*

For the radiative transfer novice, it might be worthwhile to expand this statement, to state explicitly that the increase in Rayleigh scattering is because there is more atmosphere below the aircraft available for scattering when it is at higher altitudes.

p1435.l29–p1436.l1: *Similarly, the decrease in the downwelling actinic flux is largest*

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for the shortest wavelengths.

First of all, the downwelling flux *increases* with altitude, not decreases. And seeing as the scattering contribution to the actinic flux likely decreases with increasing altitude under these conditions, perhaps the authors mean that shorter wavelengths (of the downwelling flux) increase faster with altitude than at longer wavelengths, because Rayleigh scattering is diminishing more rapidly at shorter wavelengths. In any event, this statement should be clarified.

p1437.l13 & Fig 10: *. . . theory predicts a pronounced maximum in the actinic flux.*

The local maxima in the line plots do not really look “pronounced” to me—more like “blips.” They are there, but they are not huge. Is there any way to make the model profiles in these plots more clear?

p1437.l14–15 & Fig. 10: *The maximum is seen in both the measurements and the model simulations of the downwelling actinic flux on both days. Though, for the ascent on day 257[,] it is not seen.*

I see the maximum in the d263-downwelling-ascent-measurements in Fig. 10c, but not in the model. I do not see anything convincing in the d257-downwelling-descent-measurements. There are two larger points at the top of the cloud layer, but there are also several elevated points throughout the profile above the cloud. The d257-downwelling-descent-measurement points completely obscure the model, so I do not see the maximum there either. As I read Fig. 10, the maxima near cloud top height are not nearly as noticeable as the text leads me to think. This needs to be clarified.

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p1437.l17: *. . . these enhanced points are missed in the simulation. . .*

Could they be added, even with approximate input parameters?

p1438.l4 & Fig. 10: *. . . the model is consistently larger than the measurements.*

This is true only for day 257. On day 263, the model is smaller than the measurements.

p1438.l21: *. . . covered 4/8 over land.*

What does the “4/8” nomenclature mean? Is that the same as 4 oktas? This should be explained.

p1442.l26–p1443.l1, Conclusions: *. . . the total and downwelling actinic flux were reproduced. . .*

Is there anything that can be concluded from the discussion and Fig. 8 of the upwelling measurement–model comparison?

p1450, Table 1: *For an explanation of the acronyms[,] see Table 2.*

Actually, Table 2 does not define the acronyms themselves. However, I am not sure they need to be defined (they function essentially as serial numbers), but this

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sentence should be changed, perhaps to something like “For a description of the instrumentation, see Table 2.”

p1451, Table 2: Because it is not immediately obvious which instruments are ground-based and which are airborne, it would be helpful to add lines to the table segregating the instruments, e.g. “Ground-based:” and “Airborne:”.

p1452, Table 3: *8/8 St 1800–1950 m, 3/8 Ci west, 1/8 Cu at 1000 m*

This nomenclature needs to be explained in footnotes to the table. What does “8/8” mean? What does “Ci west” mean? And what does cumulus at a single altitude (1000 m) mean?

p1453, Fig. 1: Adding a legend like that in Fig. 10 would be helpful.

p1454, Fig. 2: Adding more to the legend, like that in Fig. 10, would be helpful.

p1460, Fig. 8: Adding a legend like that in Fig. 10 would be helpful. Also, in panel (a), the solid lines indicate the 1961-m measurements, but in panel (b) they indicate the 58-m spectra. These should be made consistent, to reduce confusion.

p1462, Fig. 10: Adding horizontal lines indicating the vertical extent of the cloud layers would help illustrate the effect of clouds on the actinic flux.

p1467, Fig. 15: Adding horizontal lines indicating the vertical extent of the cloud layers would help illustrate the effect of clouds on the actinic flux.

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