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Interactive Comment

Interactive comment on "Long-time global radiation for Central Europe derived from ISCCP Dx data" *by* N. Petrenz et al.

N. Petrenz et al.

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Referee #1

We would like to thank the reviewer for the positive overall view of our manuscript and the helpful specific comments. The suggested modifications have been included and listed below.

1. 'Page 8345, line 8: the difference should probably be +35 Wm^{-2}'

The differences between the considered ISCCP FD dataset and our dataset are positive and therefore modified as noted.

2. 'Page 8355, fig caption, line 3: the comparison should probably be GEBA - Dx, Page 8356, fig caption, line 4: the comparison should probably be DWD - Dx'

EGU

The captions of Figures 5 and 6 have been corrected to “GEBA-Dx” and “DWD-Dx”, respectively.

3. ‘The comparison between DWD and GEBA data is not justified. As far as this reviewer knows DWD and GEBA data from Germany are the same measurements stored in two different data banks. It is therefore not astonishing that the two datasets agree so well. The differences shown in fig. 7 are that small that it is most likely that these are originally the same measurements.’

Figure 7 has been removed an the appropriate text passage has been adapted in the final version.

Referee #2

We would like to thank the reviewer for the very careful reading of our manuscript and the constructive and detailed comments. Our manuscript has greatly improved by realising the suggested changes and additions. The reviewer general comments requiring a response are discussed below.

The reviewer suggested to point out more clearly what are the advantages of our method compared to existing approaches. At the beginning of our project satellite based datasets with shortwave and longwave radiant flux densities only exist for a short time (at most 10 years) and with standard spatial resolution of 2.5°, thus the intention of our studies was to compute a long time (20 years) radiation dataset with higher spatial resolution (30 km) to validate the results of regional climate models with spatial resolution of 1/6° (approx. 16 km). A further objective was to use a complex radiative transfer model (Streamer) instead of simplified parameterisations applied for different existing datasets. But the amount and duration of Streamer simulations for 50,000 time steps and 20,000 pixel oblige us to look for another solution. We decided to compute look-up-tables including shortwave and longwave radiant flux densities at both top of atmosphere and surface for relevant combinations of atmospheric and sur-

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face conditions as results of real radiative transfer simulations. Our actual results do not reduce the uncertainties associated with the derivation of radiant flux densities based on satellite data but it is the first version of a new method and options to improve our results in the next version are suggested more detailed in the revised manuscript. The higher spatial resolution is a great improvement - whether the uncertainties are not reduced - because this dataset is the only one with 30 km resolution over such a long period. Existing estimates possess at most 1° resolution.

The reviewer addresses the problem of our stronger biased estimates (in terms of overestimate). We could adapt the bias on the basis on regression functions or parameterisations, but we wanted to show how large the discrepancies between the considered data can be. The improvements should be realised on the physical point of view, means to improve and extent the input for the look-up-table.

The authors comments on the specific reviewer comments are answered and listed below point-by-point.

1. -p. 8335, line 15: "or derived" has been omitted

2. -p.8336, line 7: "...'the sum of' direct and diffuse incoming..." has been added

3. We thank the reviewer for the reference Evan et al. (2007) - we included the mentioned the study.

4. 'page 8837: is the time averaging (three hourly versus three-hourly monthly means the only important difference between D1 the and D2 datasets? In light of the considerable differences caused by the different ISCCP D datasets in Figure 3 I assume there must be further differences between the datasets.'

Yes, there are further differences in addition to the time averaging problem. Rossow et al. (1996, see page 49ff.) described the methods of spatial averaging, the merging of several satellites for the D1 data and other adjustments producing the D1 and D2 dataset - these facts influence the comparison between the datasets.

5. -p. 8337, line 15: "Figure 1d" has been corrected to "Figure 1a"

6. Figure 1 has been modified and the figure caption has been extended.

7. ‘Why is it necessary to work with lookup tables?’

We used look-up-tables because of the amount and duration of computations. The observed time series - 17 years - includes approx. 50,000 time steps for 20,000 pixel. That means 1 billion computations. That is not realisable because one radiative transfer computation takes 2-5 minutes depending on the used processor. That’s why we came to the decision to use look-up-tables to compute radiant flux densities for relevant atmospheric and surface conditions on the basis of multivariate interpolations. The computation time of the large set of look-up-tables was 6 month using 32 processors.

‘Can the additional uncertainties due to the introduction of lookup tables be estimated...?’

Yes, the uncertainties could be estimated:

a) Sensitivity studies, published and submitted in a dissertation prepared on our institute (Sommer, 2007), reveal that some single parameters, like the optical thickness, the surface temperature and the sun zenith angle, are implanted very detailed in the look-up-table. Their error rate is lower than 1 %. Others, like the humidity or the surface albedo, have coarser resolution and could cause increasing error rates. But within the computation process of global radiation an increasing error rate < 5 % due to the interactions between the single parameters could be observed.

b) Few parameters are implemented in the used look-up-table not enough detailed and have been determined very roughly.

c) A main important problem are clouds. We used only five cloud classes with specific effective radii and specific ice habitat for ice cloud classes. The appropriate properties are pre-determined, e.g. for the high cloud layer a special shape of ice crystals, the height, the cloud top temperature, and distributed homogenously over the entire layer.

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That yields uncertainties of 10-20 %.

We also had have the idea to realise real radiative transfer simulation to compare the results of the look-up-table. It is planned but not realised, because it needs a lot of time and technical effort and the utility could not pre-estimated.

8. We thank the reviewer for referring the highly relevant study of Wild et al. (2005, Science) to us. The general agreement of our results and the results in the study is absolute mentionable.

9. -p.8341, line 11: "...Central Europe 'compared to SRB and ISCCP FD'..." has been added.

10. -p. 8341, line 12: "compared to" has been added after "...considerable differences"

11. 'page 3841 line 13 "Incorrect atmospheric parameterisation" is a fairly general statement and rather meaningless. This paragraph needs to be formulated more carefully.'

The fact of inexact atmospheric parameterisation has been formulated more detailed:

"Considerable differences compared to the SRB dataset mainly exist for land surfaces suggesting some assumptions in our used method. In this context analyses regarding the surface albedo are carried out by varying the reference albedo of grassland (0.225 $\pm$ 0.1). This results in global radiation variations of $\pm$5 - 10 Wm^{-2} (5 - 8 %), especially with increasing optical thickness. Additional intensifications are observed over snow, where uncertainties of 10 - 20 % in global radiation could be determined. The impact of clouds on global radiation is without controversy. Therefore the detection of clouds in special developed algorithms is a decisive factor for the quality of the data basis. Over water surfaces clouds could be detected well, but over land surfaces it is difficult in many cases. Thus uncertainties and misconstructions due to land surface heterogeneities could occur. Furthermore cloud radiative forcing and absorption of solar radiation by clouds might be underestimated in the used radiative transfer model

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(Li, 1995, Cess et al.,1995) which leads to the higher values in global radiation just like a to transparent cloud-free atmosphere. Additional uncertainties are based on our computations processed using the standardised aerosol profile included in Streamer (aerosol profile of rural areas) with constant aerosol content over the investigated time period. An adaptation to altered conditions within the analysed time series is planned for future studies. The effects of changing aerosol content on global radiation in cloud-free atmospheres are discussed in Wild and Liepert (1998). There the included aerosol effect caused a mean decrease of 18 Wm^{-2} in global radiation at seven German sites. Another reason for discrepancies could be the altitude correction applied to the global radiation. Our correction method seems to overestimate the global radiation in mountainous regions noticeable in comparison to the SRB data. Raschke et al. (2006) compared the SRB and FD Data and emphasised uncertainties of –3 to 7 Wm^{-2} in global radiation between 30°N and 60°N between the datasets due to different initial input data (different total solar irradiance, sun angles above horizon, ancillary data from other sources) and different radiative transfer codes."

12. 'It would be worthwhile to perform a similar evaluation with GEBA and DWD data not just for the newly estimated Dx fluxes, but also for the SRB and FD fluxes, in order to get a handle on the uncertainty of the new product compared to the existing SRB and FD products.'

It could be worthwhile to prepare a similar evaluation, but it was not the aim of this study to compare the SRB or the FD fluxes with observation site measurements, like GEBA and DWD. It was the aim to rank our newly estimated Dx fluxes comparing the global radiation of our method with several other products.

13. 'Fig. 6 (right) does this figure not show DWD - Dx rather than Dx - DWD as given in the Figure caption?'

The captions of Figure 6 as well as of Figure 5 have been modified.

14. 'Fig. 7 can be omitted since DWD and German GEBA sites are virtually the same.'

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Figure 7 has been removed an the appropriate text passage has been changed to:

"Analyses regarding observation site measurements of GEBA and DWD show only minor deviations between the datasets. As expected the surface measurements agree and it is assumed that the surface sites of GEBA and DWD are the same."

15. ‘p. 8343 last paragraph of section 3.2, related to trends. Increasing surface solar radiation as seen in the surface measurements in Germany over this period is again in line with earlier studies pointing to a “brightening” in surface solar radiation measurements over this period (Wild et al. 2005, Science 308). My suspicion on why the satellite estimates do not show a similarly strong increase, is due to their difficulties in treating changes in absorbing aerosol, which seem to have played a significant role in the transition from “dimming to brightening” of surface solar radiation.’

We included the mentioned study of Wild et al. (2005, Science) as good comparison to our results. We agree that the absorption of solar radiation by aerosols (as well as by clouds) is an important fact and could be the reason why our results do not have such a strong increase over the investigation period like the observation site measurements. Because the aerosol content has been held constant over the 17 years (see 11)

16. ‘the smaller difference in winter can be expected since the absolute values are also smaller.’

We have modified the investigations regarding the differences between our Dx global radiation and the model results showing the relative differences instead of the absolute differences.

17. Figure 9 has been modified.

18. ’Overestimation of surface solar radiation over continents in summer is a common problem in many climate models, partly caused by an excessive summer dryness, as e.g. first noted in Wild et al. 1995, Climate Dynamics 11:469-486.’

We thank the reviewer for referring the highly relevant study of Wild et al. (1995, Cli-

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mate Dynamics) to us. This study is very helpful to get an impression about the problem of summer dryness in many climate models. The text passage has been modified:

"In summertime the REMO output and our results agree well with mean differences of approx. –2 to 4 Wm^{-2} (–1 to 2 %) but in wintertime there are stronger discrepancies between all datasets. Hence the mean annual cycles are examined (Fig. 8, right) and show clearly that our computed global radiation is nearly conform to the results of REMO within the summer months. In winter our results differ on the average 16 Wm^{-2} (27 %) from the model results. Largest deviations are registered compared to the non-hydrostatic model. The MM5 output is obviously lower, on average 30 Wm^{-2} (28 %). Wild et al. (1995) explain the problem of overestimation of global radiation over continents in many climate models amongst others due to an excessive summer dryness. Hence the good agreement to the REMO results in summertime might denote also an overestimation of the REMO global radiation."

19. To clarify our used method an appendix with an overview of the used technique and the look-up-table is provided in the final version.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 8333, 2007.

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