**Atmospheric
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Discussions**

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Comment

Interactive comment on "Long-term solar UV radiation reconstructed by Artificial Neural Networks (ANN)" *by* U. Feister et al.

U. Feister et al.

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General Comments:

The title of the paper will be changed to account also for spatial characteristics that are discussed in the paper to Long-term reconstruction of solar UV radiation by the Artificial Neural Networks (ANN) model with emphasis on spatial characteristics of input data

Specific Comments:

Reviewer:

In the Introduction I'ld suggest to motivate the choice of use the daily totals of erythema UV radiation as principal predictand.

Response:

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We will add the following wording to the section 2.1: Daily broadband UV irradiation such as erythemal, UV-B and UV-A radiation were selected as the target parameters in our study for UV reconstruction. The daily dose of UV radiation is a biologically effective radiation parameter that can be used to derive monthly and annual doses, and is thus appropriate to study longer-term effects of solar radiation to the environment. One of the parameters, erythemal irradiation, had been selected to be the target parameter within the action COST 726 Long term changes and climatology of UV radiation over Europe, and in the European project SCOUT O3, in which both processing and analysis of input data at the two sites Potsdam and Lindenberg as well as our ANN modeling approach have been embedded. Reconstruction models including the ANN model would allow for higher time resolution than daily values, for example hourly values to show diurnal patterns, but the non-availability of input data smaller than daily time steps in the decades before the 1970ies would have required assumptions on their diurnal changes.

Reviewer:

Harmonize the energy units in all the figures: avoid possible confusion in using alternatively Jcm-2 and Jm-2: I'ld recommend the use of kJm-2.

Response:

We will use one unit, J/cm^2, which is common for global irradiation as well, throughout the paper.

Reviewer:

Fig 2 shows differences in the values of daily erythemal doses derived from values computed on the base of Brewer data and Bentham&Spectro derived measurements. These latter appear to overestimate the daily ERY dose. In the text (pag 460 line 15) it is only mentioned the value of this uncertainty but no attempts to explain it is done. Is this due to differences in the instruments readings or to the procedure of temporal data

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integration between two Brewer readings, as more likely?

Response:

Daily UV irradiation derived from Brewer data was compared to corresponding daily values derived from Bentham and Spectro 320 D data for two different years and two different sites to show that the method to derive daily totals from Brewer measurements, which were taken at larger time steps, with the help of global irradiances available at one minute time steps works in general. The differences between those different estimates are due to remaining uncertainties of the method used to derive daily totals, the spectral extension of Brewer spectra to 400 nm, the uncertainties of the different types of instruments including cosine characteristics and remaining uncertainties of their corrections in the case of Brewer spectra, absolute calibration uncertainties, atmospheric variabilities and non-coincidence in scan time duration and time steps between spectral scans, and uncertainties due to missing data and filling data gaps. Taking into account all those uncertainties of the instruments and the resulting differences between the different instruments, an estimate of the uncertainty of daily UV irradiation derived from Brewer has been given in section 2.1.3, which is appreciably smaller than the uncertainties of UV totals derived without taking account of the variability of solar radiation in between the UV scans.

Reviewer:

Fig 3 does not appear essential

Response:

This Figure will be removed.

Reviewer:

Fig 4 shows daily erythemal doses measured at Potsdam as compared to Lindenberg but it is not clear whether data came from Bentham or Spectro measurements or from Brewer based data. Even more relevant (and worth to be cited in the text) appear the

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differences between the two close locations (70 km) that is still evident also after the normalization with the global irradiation (Fig 5). For Fig 4 I estimate that Lindenberg values are about 8.5% higher than Postadm at least at higher irradiances around 4 kJm-2. How is this explained? Potsdam has certainly an urban atmosphere while Lindenberg has a more rural one.

Response:

Figure 4 is based the UV data base as described in Table 1. The UV data base for the period 1995 to 2003 has been derived from spectral scans taken by different Brewer instruments. As explained in section 2.1, due to the different sources of calibration, different types of cosine correction, spectral extension and deriving daily totals from a very limited number of data, the resulting uncertainties of daily UV totals have to be taken into account as well as highly variable meteorological conditions at the two sites, when daily values at different sites are to be compared. The average difference between daily erythemal UV irradiation at Potsdam and Lindenberg derived by that method over the period 1995 to 2003 amounts to 6 to 7 % depending on whether the average or the median is considered. This value does not necessarily mean that there has been a constant systematic difference, because the individual differences are highly variable.

The question to what extent different aerosol characteristics may have contributed to the differences in daily UV radiation at the two sites is very interesting. Potsdam located SSW of the city of Berlin is closer to pollution sources of the city than Lindenberg, which is SE and more far from the large city. On the other hand, in addition to transport of polluted plumes from local sources, long-range transport of anthropogenic aerosols as well as biogenic sources may have also contributed to aerosol concentrations at the sites. Looking at data of measured aerosol optical depths AOD at 550 nm that are available over the period 1995 - 2003 with different time resolutions (measurements at Potsdam for SZA between about $75°$ and $85°$ only, whereas daily courses have been measured at Lindenberg), the overall averaged AOD between the two sites selected

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for SZA around 80° are only slightly different (0.164 and 0.166). These values do not contain diurnal AOD variations that would be relevant for aerosol effects on daily UV radiation. Further, they are available for about 50 per cent of all days, because AOD is derived from direct sun measurements. However, looking at the scatter plot between monthly mean AOD values at the two sites, for higher AOD values (> 0.2) there is a tendency of AOD being higher by about 0.05 to 0.1 at Potsdam compared to Lindenberg. We are aware that due to neglecting diurnal variations and due to the limited number of observations, these results need not necessarily reflect average conditions that are relevant for the record of daily UV radiation, but it may be an indication that small-scale variations of aerosol extinction can have contributed to the differences in daily UV irradiation at the two sites. We will add a short addition to the text in section 2.3.

Reviewer:

Fig 9. Is there any particular reason to use in this figure the letter H for daily erythemal irradiation while in other figure is used ERY? Moreover to me it is not clear wich data have been used for reconstructed daily ery doses: which ANN version (# 6?)?? Was the bias already removed?

Response:

ANN #6 was used. We changed labeling of the axis from H to ERY. Bias has been removed.

Reviewer:

Fig 11 and Fig 12 appear to conflict concerning the reconstructed values in the 1890-1950 and 1950-2003 period. In fig 11 the first period seems to be characterized by a higher average value than the second one which is just the opposite of what came out form fig 12. This differences cannot due to the different integration time used in the two figures. Please clarify this relevant point.

Response:

As mentioned in section 4.1 (page 465, lines 15 to 17), systematic differences of reconstruction according to Table 2 were removed in Fig. 12. To make Fig. 12 compatible with Fig. 11, we have also removed systematic differences in a corrected version of Fig. 11, and will mention the change in the part of section 4.1 describing Fig. 11.

Reviewer:

Fig 14 and Fig 15: according to which ANN version have been reconstructed the ERY doses in locations which have likely different type of meteorological data available? Is Fig 14 essential or its information can be integrated in Fig 15?

Response:

For the reconstruction of daily UV radiation at the European sites using the ANN model, only available input parameters could be used. The time periods of availability of input data at the individual sites will be discussed by the paper cited in section 4.2 (page 466).

Fig. 14 shows the main results of reconstruction by the ANN model at all sites. Both the large absolute level differences of annual erythemal UV irradiation as well as the short-term and long-term patterns can be seen very nicely. In Fig. 15 showing the anomalies, we tried to put together results of those sites in one of three panels that according to our impression, revealed similar patterns. Therefore, Fig. 14 is also useful for the reader to check, to what extent those similarities do occur according his/her own judgement. For example, Norrkoeping shows some similarities to the group of Central European sites as well similarities to the Northern European sites. Therefore, we do believe that both Figures 14 and 15 are thus useful.

Reviewer:

Tab. 3 Please clarify the meaning of “gain of information” referred in this table legend.

Response:

A gain of information by the ANN model application occurs, if the values shown in the last column are greater than 0. The closer this value is to 100 per cent, the better the model result.

Reviewer:

Harmonize in the text the way to refer to RMS or rms.

Response:

The notation of RMS is harmonized in the whole text.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 453, 2008.