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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

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

Anonymous Referee #2

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General comments:

This study applies Artificial Neural Networks (ANN) to reconstruct daily erythemally effective (ERY) doses of UV radiation (predictands) in the past for 8 European sites and additionally daily doses of UV-A and UV-B radiation for the nearby German sites Potsdam and Lindenberg. They use as ancillary input (predictors) long-term available meteorological data on parameters affecting UV radiation. There are up to 6 individual ANN for Potsdam and Lindenberg dependent on available observations in the past. In its training process ANN simulate the ability of the human brain to learn, and to derive complex rules that are hidden in the training material. ANN neither must know the physical laws of radiation transfer through the cloudless atmosphere nor the more complex modifications by clouds. Neither the relationship between predictors and predictands

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must be pre-described, nor must the statistical distributions of the input data be known. This is new in UV reconstruction and an advantage compared to previous statistical models. Meteorological observations can be applied without complex pre-processing. Substantial conclusions concerning UV in the past are reached. I recommend publication in ACP.

Nevertheless, it should be attended to the issues raised in the following:

The introduction states, that the study focuses inter alia on small-scale spatial characteristics that have been derived from data at two sites with small spatial distance (Potsdam and Lindenberg). From my point of view interesting is the finding of increased differences in daily sunshine duration on short distances compared e.g. to global irradiation. It will restrict significance in spatial differences applying ANN#1. The findings on small scale differences are of value to be mentioned in abstract and conclusions.

I miss some basic information on ANN concerning bias and root mean square error (RMS) given by Tab. 2. The bias shows the more pronounced differences (ANN#6 – ANN#1 = -16 % for UV-B) compared to RMS (-6.8 %), however, it is not discussed. P465, L15-L21 annotates only, that the bias has been removed after reconstruction. ANN#6, bias -4.5 % for ERY, differs from ANN#5, bias -1.2 %, by the inclusion of surface albedo. What is the advantage to use ANN#6 for 1984-2003 and not ANN#5? Is there a meaning of RMS to select an ANN version for application?

I am in doubt about absolute values of UV-B and ERY for Potsdam in the period before 1964 having no ozone available. Figure 11 shows a clear decrease in total ozone column between about 1970 and 2003. Thus, calculating clear-sky doses of UV-B and ERY using set values of aerosol optical depth and single scattering albedo would show a significant increase of the clear-sky values as it has been found e.g. by A. Lindfors, and L. Vuilleumier: Erythemal UV at Davos 1926-2003, J. Geophys. Res. 110, D02104, 2005. As far as I understand does the ancillary input before 1964 neither contain assumptions on clear-sky UV-B and ERY, nor on ozone. The ANN are trained with

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measured UV 1995 – 2003. How is it possible, to derive from this training set absolute values of UV-B and ERY 1893 - 1963 without any information / assumptions on ozone in this period (P464, L20-L22)?

There are publications on UV trends for some of the sites UV is reconstructed. The paper would be made more perfect by comparison to e.g.:

Lindfors, A. V., Arola, A., Kaurola, J., and Taalas, P.: Long-term erythemal UV doses at Sodankylä estimated using sunshine duration, and snow depth, J. Geophys. Res. 108, D16, 4518, doi: 10.1029/2002JD00335, 2003.

Den Outer, P. N., Slaper, H., and Tax, R. B.: UV radiation in the Netherlands. Assessing long-term variability and trends in relation to ozone and clouds, J. Geophys. Res., 110, D02203, 1-11, doi: 10.1029/2004JD004824, 2005.

Published after submission of the paper:

Lindfors, A., Kaurola, J., Arola, A., Koskela, T., Lakkala, K., Josefsson, W., Olseth. J. A., and Johnsen, B.: A method for reconstruction of past UV radiation based on radiative transfer modeling: Applied to four stations in northern Europe. J. Geophys. Res., 112, D23201, doi:10.1029/2007JD008454, 2007.

Specific comments:

P454, L3: Aerosol optical depths are not used in the ANN versions applied to reconstruct long-term trends. Sunshine duration is an essential input at least to ANN#1 and should be mentioned instead.

P456, L16-L18: For the purpose of comparison a Bentham DM150 instrument is used for Potsdam 2000 – 2003 (P457, L15-L16). The instrument should be listed in Tab. 1 as it has been done with SPECTRO 320D for Lindenberg.

P460, L3-L6: Do I understand correctly: UV(i) = UV(s)/G(s) * G(i), s = conditions at time of scan, i = one minute time steps between two scans? If so, the hourly and daily UV

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doses will additionally depend on measured global irradiation, see comment to P463, L22-L26.

P460, L3-L14: I derive from the comparison of Brewer to Bentham or SPECTRO measurements, respectively, that Brewer results in higher measured erythemal UV than Bentham and with the exception of the 5 highest daily doses SPECTRO too. Based on Fig. 2, I estimate a factor 1.06 to 1.09 for the ratio Brewer / Bentham. This seems to be a significant deviation for instruments traceable to the same calibration standard. Modelling would be confronted with two truths. Please, give reasons for that.

P460, L14: Figure 2 would be better readable, if a bisection line (diagonal between origin and point x = 0.55 and y = 0.55) would be provided. (This could be an improvement for Fig. 4 and 5 too).

P460, L18: Fig. 3 does not illustrate the reduction in uncertainty applying the method UV/G to Brewer measurements. Why is Fig. 3 required?

P461, L6-L9: Listed are the parameters that finally have been used as predictors. The list excludes cloud observations. However, Tab. 2 lists cloud cover (predictor 5) as included since 1951. Concerning measured surface albedo (predictor 9), please, state more precisely: Surface albedo in the UV, or in the visible spectral range?

P462, L10-L12: Concerning changes / trends, Fig. 8 would be better readable if the long-term average, DU, would be provided as a parallel to the x-axis.

P463, L3-L4: In contrast to production set (70 %) and training set (15 %) given in this paper, Junk et al. (2007) state: production set (15 %) and training set (70 %). Related to Tab. 2, I would prefer, if the years included in the sets for Potsdam are added to the percentage ratios. For a reader not familiar with ANN, it would improve comprehensibility to state according to Junk et al. (2007): The test set is used in training to determine the accuracy, and training is stopped when the bias remains unchanged. Both could be of avail to understand and interpret Tab. 2.

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P463, L9-L16: Concerning RMS, I understand the significant increase between ANN#2 and ANN#1 if global and diffuse irradiation are not more available as predictors. The increase between ANN#4 and ANN#3 may be regarded in essential parts as result of the decrease in RMS between ANN#3 and ANN#2. Why can RMS increase, if additional input parameters are included (ANN#2 to ANN#3), and does it make sense to include such parameters?

P463, L22-L26: Fig. 9 compares measured and modelled UV for Potsdam. For Potsdam global irradiation has been used to reduce scattering in UV measurements due to the non-equidistant longer time steps of Brewer data. Global irradiation is the most important predictor for ANN (section 3.1, Junk et al., 2007), i.e. ANN#2 through ANN#6 depends significantly on global irradiation. Thus, from a statistical point of view measured and modelled data are not completely independent. I suggest, compare with independent measured data, e.g. Bentham / SPECTRO or measurements of one of the other sites.

P465, L14-L15: Concerning ERY, Fig. 12 (also Fig. 13) is in contrast to Fig. 11. Fig. 11 states higher mean value of ERY in the period 1983 through 1950, and lower in 1960 through 2003. Fig. 12 states lower value in 1893 through 1950 and higher in 1960 through 2003. The explanation, the removed bias in Fig. 12, is somewhat hidden and the contrast to Fig. 11 is not explicitly mentioned. I would prefer ERY minus bias for Fig. 11.

P465, L22-L23: Concerning long-term trends, Fig. 13 would be better readable, if parallels to the x-axis for the anomalies 0 % would be provided. If the capture to Fig. 13 or the figure legend would note the long-term averages of UV-A, UV-B, and ERY, then Fig. 12 would be dispensable.

P467, L1-L16: As stated, the long-term patterns and inter-annual variations can more clearly be seen in Fig. 15 than in Fig. 14. Fig. 14 is dispensable.

P467, L14: Figure 15 would be better readable, if parallels to the x-axis would be

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provided for anomalies 0 %.

Technical corrections:

P455, L6: delete: "between input and"

P472, Tab. 2: Change in table caption: "Predictors, time period" to "Selected predictors for time periods". State the data set (production, test?), bias and RMS are related to.

P481, Fig. 8: Figure capture: "replace running ozone averages" by "running averages (R.A.)".

P484, Fig. 11: y-axis: check dimension of global irradiation.

P485, Fig. 12: y-axis: check dimension of UV-A.

P484, Fig. 14: y-axis: check dimension of ERY.

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