Comparison of algorithms and input data for modelling solar ultraviolet radiation in the past

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Introduction

The variation of UV-irradiance during the last decades is of interest for skin cancer development and other long-term studies of UV effects. Thus, to determine the geographical distribution of the UV-daily dose for whole Europe during the last 50 years, the COST action 726 "Long term changes and climatology of UV radiation over Europe" has been established. UV-radiation in the past can only be obtained by using adequate models running with the correct input data, i.e. values of the parameters that affect the solar UV radiation at the surface. Consequently, available numerical models and algorithms have been recorded, and the availability has been tested, both of the meteorological data, which are needed to run these models for different places in Europe, and of measured UV data that can be used to check the model results.

Method

To test the model quality, erythemal weighted daily dose have been calculated by each model and compared with measured values.

The reason for erythemal weighting was its relevancy for human health damage and it is the quantity that has been measured most frequently. The daily dose has been chosen as a compromise between the temporal resolution that is available for the input data and what is needed to investigate biological UV-processes. To check the widest range of meteorological conditions, two complete years have been chosen as time interval, 1999 and 2002, and four stations distributed over Europe: Bergen (Norway, 60.4°N, 5.3°E, 45 m asl), Davos (Switzerland, 46.8°N, 9.8°E, 1590 m asl), Potsdam (Germany, 52.4°N, 13.1°E, 107 m asl), Thessaloniki (Greece, 40.6°N, 23.0°E, 60 m asl). For the four stations and two years that should be modelled, observational data have been made available by working group 1 of the COST-action, which should be used by all modellers. An overview of the measured data is listed in the Table 1. The way how to use these data and to derive the needed input data, e.g. surface albedo from snow information or cloud impact on UV from solar radiation or cloud cover, was decided by the modellers as part of their algorithm (Table 2).

The modelled daily doses have been compared with the measured data with absolute differences for each day. Figure 1 shows the results for Bergen. To get a final estimation of the model quality, a combination of model-measurement correlation together with equality of root mean square values of the modelled and the measured data has been used, as proposed by Taylor (Figure 2).

Conclusion

The models with best performance to model erythemal weighted UV daily dose in the past are that which take a CMF_{UV} derived from a measured CMF_{sol} to describe the cloud effects. The reason is the fact that the global solar radiation is affected by the clouds similarly than the UV. Thus solar irradiance is the most important input parameter to model UV in the past Strong effects of course result from variable ozone, which however is less variable in space and therefore can be taken more easily from old measurements. To determine the quality of the effects of aerosols cloud free data have to be check independently which is in progress. As a first result it seems to be better, to use climatic aerosol properties with low variability than strong variations resulting from visibility. Also the snow effects should be analysed again, and perhaps can be improved even in the good models, since the correlation between snow height and age on the one hand, and regional albedo on the other hand, clearly depends on station altitude, longitude and skyline.

The modelling exercise was very successful. Models that are suitable to perform the COST action have been identified. And moreover, a large body of data is available which can be used for many scientific questions, like practical aspects of aerosol or albedo effects on UV and model improvement.

The complete report of the comparison is available at:

www.cost726.org

	Bergen	Potsdam	Davos	Thessaloniki
Cloud cover	X	X	X	X
(relative) sunshine duration	X	X	X	X
Diffuse solar radiation	X	X	X	
Global solar radiation	X	X	X	X
Visibility	X	X	X	X
Snow height	X	X	X	
Snow age			X	
Ozone	TOMS	Dobson or Brewer	Dobson (Arosa)	Brewer

Table 1: List of meteorological, radiation and ozone data made available for the modelling exercise. Meteorological and radiation data are from meteorological or synoptic observations.

Model	Cloud effects	Temp res.	Aerosol	Albedo
A	CMF_{UV} via CMF_{sol}	hourly	fix SSA, local fix AOD	snow effects
B	CMF_{UV} via CMF_{sol}	daily	climat SSA, climat AOD	snow effects
C	CMF_{UV} via CMF_{sol}	hourly	climat SSA, climat AOD	snow effects
D	broad avail. info	hourly	in cloud effects	in cloud effects
E	CMF_{UV} via CMF_{sol}			
F	CMF_{UV} via CMF_{sol}	hourly	AOD from visibility	snow effects
G	broad avail. info	hourly	fix SSA, fix AOD	snow effects
H	CMF_{UV} via CMF_{sol}	hourly	climat alpha,climat AOD	snow effects
I	CMF_{UV} via CMF_{sol}	hourly	in cloud effects	clim value visible
J	CMF_{UV} using GR_{sol}	hourly	AOD from visibility	snow effects
K	CMF_{UV} via CMF_{sol}	daily	fix SSA, fix AOD	snow effects
L	CMF_{UV} using GR_{sol}	hourly	AOD from direct meas	snow effects
M	sun shine duration	daily	local fix AOD	fix no snow, snow
N	cloud amount	hourly	AOD from visibility	snow effects
O	sun shine duration	hourly	AOD from visibility	snow effects
P	sun shine duration	daily	no aerosol	

Table 2: General properties of models

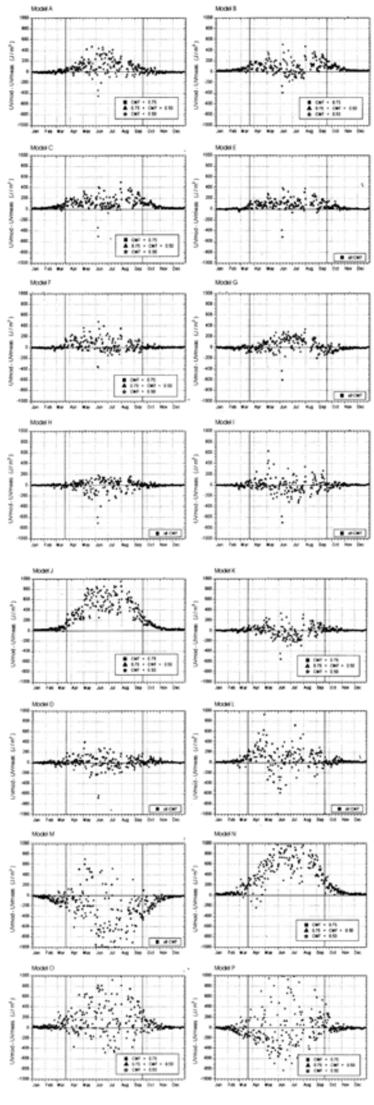

Figure 1: Differences between modelled and measured daily UV dose for Bergen 2002 Models as shown on the separated figures with the letter given in Table 2.

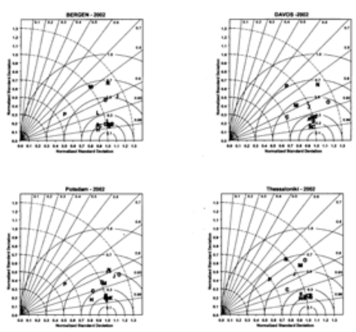

Figure 2: Taylor diagrams (See text) for absolute deviations between modelled and measured UV doses. The letters stand for the models, as described in Tab.2