A simple new model for incoming solar radiation dependent only on relative humidity

M. Lindauer1,2, H.P. Schmid3, R. Grote3, R. Steinbrecher3, M. Maurer4, B. Wolpert1

1 Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT)/IFU, Garmisch-Partenkirchen, Germany
2 present affiliation: MeteoSwiss, ETH Zurich, Zürich, Switzerland
3 present affiliation: MeteoSwiss, Federal Institute of Meteorology and Climate Research (FMI), Zurich, Switzerland
4 present affiliation: University of Applied Sciences of Baden-Württemberg (HfG), Ludwigsburg, Germany

Background and Objective
Global incoming shortwave radiation (Rg) is the energy source for the majority of biogeochemical processes on Earth and therefore, one of the most important drivers for land surface models. Radiation measurements are not standard at most climate stations, and it is thus necessary to model or parameterize them based on whatever data available.

A simple but reliable model for global radiation was developed based on screen-level relative humidity

Schematic Overview
1. Rg, time and location specific
2. temporal turbulence, solar zenith angle, and solar altitude
3. local climate/ geography "calibration" based on R_g climatology

Model Development and Parameterization (step 2)
Model parameterization (see Figure 2): Data of 2012 from 15 sites derived from U.S. Surface Climate Observing Reference Networks [high quality data covering a wide range of environmental conditions].

Model evaluation: data of several years from six independent sites, yellow circles

Figure 1: Effective local transmissivity (R_gobs/R_0) against binned values of relative humidity (blue diamonds). Transmissivity was set to 1 (circles) where data availability was below 30%. Figure from Lindauer et al. (2014).

Effective local transmissivity (R_gobs/R_0) against relative humidity. Figure from Lindauer et al. (2014).

Results
• No trend in the variation of parameter b could be detected. Average of b for the 15 test sites was about 0.34.
• In contrast, the slope-parameter a shows a linear relation to the average annual daytime relative humidity RHfDT (Figure 3).

R_g can be modelled using the average value of b = 0.34, and the site-specific climatological influence (step 3):

\[ R_g = R_0 (1 - RHf)_{0.34}^{1.05 - 0.25 \text{ RHfDT}} \]

Model Evaluation and Sensitivity test
We used data of several years from six independent sites:
• Under certain conditions (e.g. surface advection, strong aerosol loading) the relation between transmissivity and relative humidity near the surface is likely uncoupled.
• The uncertainty of our radiation model is less at dry (continental) sites than in humid regions

Daily Values
Figure 4: Estimated daily R_g values derived from hourly air humidity (a), daily air humidity (b), and minimum and maximum air temperature according to Hargreaves and Samani (1982) (c) - compared with daily aggregated observations (Units in W m^-2).

Using daily temporal resolution of relative humidity values is superior to a conventional temperature based method.
Using sub-daily values performs better than using daily time resolution (Figure 4).

Conclusion
A comparatively simple and general model has been developed that:
• only depends on screen-level relative humidity
• is applicable to sub-daily as well as daily temporal resolution of relative humidity
• presents an efficient alternative to more labor- and data-intensive models

References:

Contact: m.lindauer@web.de