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

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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 R_0, time and location specific

$R_0 = R_E (0.2 \sin \Psi + 0.6)$

R_0: ref. surface radiation under clear skies and optimal transmissivity
Ψ: local elevation angle

2 temporal turbidity variations, parameterized with rH

$Rg^* = R_0 (1 - rHf)^b$

rHf: fraction of relative air humidity

3 local climate/ geography "calibration" based on rH-climatology

$$Rg = \frac{R_0 (1\text{-}rHf)^{0.34}}{1.05\text{-}0.25\ rHf_{DT}}$$

rHf_{DT}: average daytime humidity

Model Development and Parameterization (step 2)

relation between transmissivity and rH(**Figure 1**)

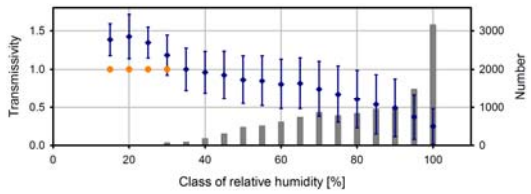
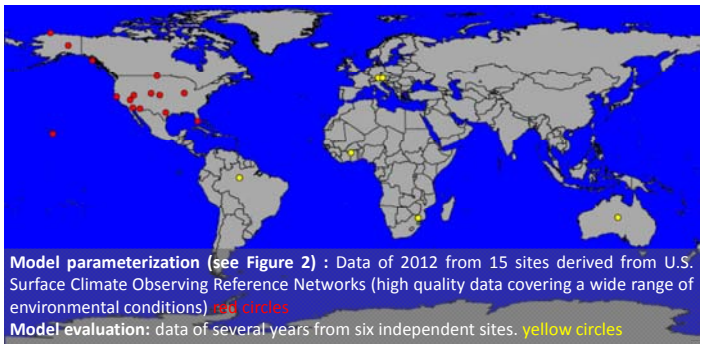


Figure 1: Effective local transmissivity ($Rg_{obs}\ R_0^{-1}$) against binned values of relative humidity (blue diamonds). Transmissivity was set to 1 (circles) where data availability was below 30%. Figure from Lindauer et al. (2014).



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) red circles
Model evaluation: data of several years from six independent sites. yellow circles

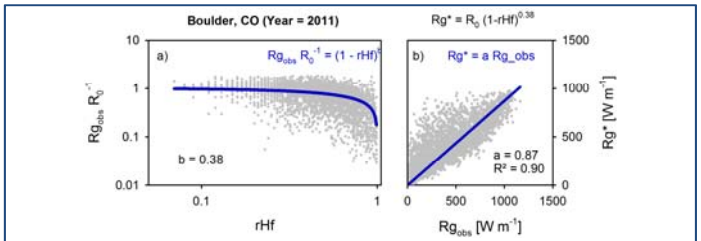


Figure 2: a) $Rg_{obs}\ R_0^{-1}$ against rHf at Boulder in 2011. The blue line shows the power-law regression with an estimated parameter of b = 0.38. **b)** modelled values of Rg* (step2) against observed Rg. The blue line is the linear regression. Figure from Lindauer et al. (2016)

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 annual average daytime relative humidity rHf_{DT} **(Figure 3)**.

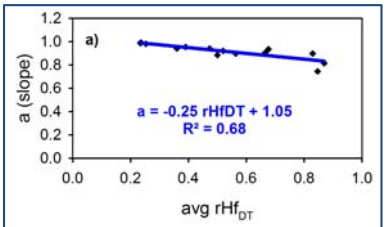


Figure 3: Slope of linear regressions against annual average daytime humidity (rHfDT). Figure from Lindauer et al. (2016)

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

$$Rg = \frac{R_0 (1\text{-}rHf)^{0.34}}{1.05\text{-}0.25\ rHf_{DT}}$$

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

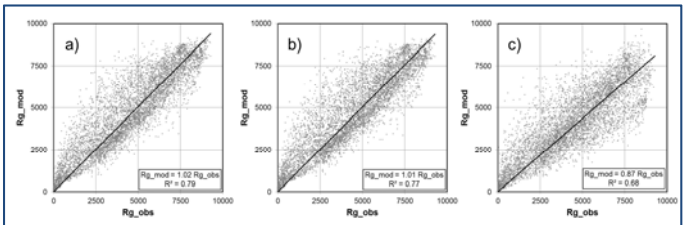


Figure 4: Estimated daily Rg values derived from hourly air humidity (a), daily air humidity (b), and minimum and maximum air temperature according to Hargreaves and Samani (1982) (c) - compared with daily aggregated observations (Units in W m^{-2}). Figure from Lindauer et al. (2016)

- 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:
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Hargreaves, G.H. and Samani, Z.A., 1982. Estimating potential evapotranspiration. Journal of the Irrigation and Drainage Division 108(3), 225-230

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