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Upscaling instantaneous to daily evapotranspiration using modelled daily shortwave radiation for remote sensing applications: an artificial neural network approach

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Upscaling instantaneous evapotranspiration retrieved at any specific time-of-day (ET_i) to daily evapotranspiration (ET_d) is a key challenge in mapping regional ET using polar orbiting sensors. Various studies have unanimously cited the shortwave incoming radiation (RS) to be the most robust reference variable explaining the ratio between ET_d and ET_i . This study aims to contribute in ET_i upscaling for global studies using the ratio between daily and instantaneous incoming shortwave radiation (RS_d / RS_i) as a factor for converting ET_i to ET_d. This paper proposes an artificial neural network (ANN) machine-learning algorithm first to predict RS_d from RS_i followed by using the RS_d / RS_i ratio to convert ET_i to ET_d across different terrestrial ecosystems. Using RSi and RS_d observations from multiple sub-networks of the FLUXNET database spread across different climates and biomes (to represent inputs that would typically be obtainable from remote sensors during the overpass time) in conjunction with some astronomical variables (e.g. solar zenith angle, day length, exoatmospheric shortwave radiation), we developed the ANN model for reproducing RS_d and further used it to upscale ET_i to ET_d. The efficiency of the ANN is evaluated for different morning and afternoon times of day, under varying sky conditions, and also at different geographic locations. RS-based upscaled ETd produced a significant linear relation (R^2 = 0.65 to 0.69), low bias (-0.31 to -0.56 MJ m^{-2} d^{-1} ; approx. 4 %), and good agreement (RMSE 1.55 to 1.86 MJ m^{-2} d^{-1} ; approx. 10 %) with the observed ET_d, although a systematic overestimation of ET_d was also noted under persistent cloudy sky conditions. Inclusion of soil moisture and rainfall information in ANN training reduced the systematic overestimation tendency in predominantly overcast days. An intercomparison with existing upscaling method at daily, 8-day, monthly, and yearly temporal resolution revealed a robust performance of the ANNdriven RS-based ET_i upscaling method and was found to produce lowest RMSE under cloudy conditions. Sensitivity analysis revealed variable sensitivity of the method to biome selection and high ET_d prediction errors in forest ecosystems are primarily associated with greater rainfall and cloudiness. The overall methodology appears to be promising and has substantial potential for upscaling ET_i to ET_d for field and regional-scale evapotranspiration mapping studies using polar orbiting satellites.