EGU2020-5670
https://doi.org/10.5194/egusphere-egu2020-5670
EGU General Assembly 2020
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Improving reference evapotranspiration (ETo) calculation under limited data conditions in the Tropical Andes

Cristina Vásquez[1,2], Mario Córdova[1], Galo Carrillo[1,3], and Rolando Célleri[1,2]
[1]Departamento de Recursos Hídricos y Ciencias Ambientales, Universidad de Cuenca, Cuenca , Ecuador (cristina.vasquezo@ucuenca.edu.ec) (marioandrescm89@gmail.com)
[2]Facultad de Ingeniería, Universidad de Cuenca, Cuenca, Ecuador (rolando.celleri@ucuenca.edu.ec)
[3]Facultad de Ciencias Químicas, Universidad de Cuenca, Cuenca, Ecuador (galo.carrillo@ucuenca.edu.ec)

The correct determination of reference evapotranspiration (ET_o) is fundamental for countless scientific and management applications such as closing the catchment water balance, the planning of irrigation schemes, and for simulation models. Nevertheless, the records of weather variables are often not available or incomplete. This usually happens when a sensor breaks or malfunctions due to severe weather conditions, lack of maintenance or electronic failure, which leads to data loss and consequently makes it hard to estimate ET_o. Frequently, that is the case in mountain regions where meteorological sensors are subject to harsh environmental conditions as in the Andes. In case of missing data, the only solution is to estimate the required variable using a given equation. Therefore, these equations need to be calibrated to specific local conditions. The aim of this study was to calibrate and validate equations to estimate Solar Radiation (R_s) on daily and monthly scales and to evaluate the impact of using these estimations for the calculation of ET_o through the Penman Monteith (PM) equation in an Andean altitudinal gradient in the páramo ecosystem. The páramo occupies the upper portion of the northern Andes, where the tussock grasslands are the dominant vegetation. In addition, this ecosystem provides essential environmental services for inter-Andean cities. We used six years of observations (2013–2019) from the Quinoas Ecohydrological Observatory. This Observatory has four meteorological stations: Toreadora (3955 m a.s.l), Virgen Cajas (3626 m a.s.l), Chirimachay (3298 m a.s.l) and Balzay (2610 m a.s.l). We evaluated five models to estimate R_s based on the maximum and minimum daily air temperature. A calibration was performed for each weather station and a simultaneous calibration for the entire gradient. We used four years of data for calibration and validation of the R_s model, and two years to evaluate the impact on ET_o calculations. We found that all models yielded estimations that are highly correlated with the observed data. However, no model was able to capture high R_s values, greater than 185.4 W m^{-2} (16 MJ m^{-2} d^{-1}), found in cloud-free days. The best model to estimate R_s was the locally calibrated Chen model, which showed a mean error of 2.9 W m^{-2} (0.25 MJ m^{-2} d^{-1}). Estimated R_s values reduced the estimation error of PM-ET_o and, thus, allows its application for further studies.