Statistical evaluation of reference evapotranspiration estimation methods for the assessment of hydrological impacts of photovoltaic power plants

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Large Scale Photovoltaic power plants (PV) may affect the hydrological cycle in all its components. Among the various components, evapotranspiration is one of the most important. As a preliminary step for assessing the impacts of PV plants on evapotranspiration, in this study we perform an evaluation study of methods for estimating reference evapotranspiration (ETo). FAO and ASCE recommend the Penman-Monteith (PM) method for the estimation of ETo when there is enough data. However, this is often not the case, and different empirical methods to estimate ETo, requiring mainly temperature data, can be used. This study aimed to assess the performance of different temperature and radiation based empirical ETo estimation methods against the standardized PM ETo method in Ambiens srl Environmental Lab in Piazza Armerina, Sicily, Italy. In order to study hydrological changes in PV sites, a meteorological station and a set of sensors for soil moisture were installed in the Ambiens Srl Environmental Lab. The meteorological data was obtained from the Lab from July 2017 to end of January 2022. By taking the ETo estimations by the PM method as a benchmark, the study assessed the performance of various empirical methods. In particular, the following methods were considered: Hargreaves and Samani (HS), Baier-Robertson (BR), Pristely and Taylor (PT), Makknik (MK), Turc (TC), Thornthwaite (TW), Blaney and Criddle (BC), Hamon (HM), Ritiche (RT) and Jensen and Haise (JH) methods, using several performance statistics. The result showed that the PT is the best method with a Nash-Sutcliffe efficiency (NSE) of 0.91. The second method in order of performance is HS, for which however performs significantly worse than PT (NSE=0.51); nonetheless this is the best among methods using only temperature data. BR, TC, TW, and HM, underestimate ETo; while MK, BC, RT, and JH showed overestimation of ETo against the PM ETo estimation method. The PT and HS methods are thus the most reliable in the studied site. Future research will consider the analysis of all available weather stations in Sicily.

Keywords

Statistical performance metrics, Penman-Monteith method, Empirical methods, PV panels