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Uncertainty in PET estimation associated with climate change

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Estimation of evapotranspiration (ET) is often a substantial source of uncertainty in modelling the hydrological system. Potential evapotranspiration (PET), constrained by soil moisture, is the most widely employed basis upon which ET is estimated. Estimates of PET generally derive from observations (pan evaporation data), empirical models based on commonly measured meteorological variables such as temperature, or physically based models (e.g. Penman-Monteith). For contemporary or historical applications, calibration coefficients ensure that empirical models closely approximate observations. However, application of calibrated empirical relationships to different climatological settings, including those that result from climate change, can introduce bias into the estimation of PET. Furthermore, different empirical relationships can introduce different magnitudes of bias in response to a given change in climatological setting. Here we investigate uncertainty in the estimation of monthly PET arising from five commonly used models (Penman-Monteith, Priestley-Taylor, Hargreaves, Hamon and Thornthwaite) over the global domain under global mean temperature rises of 2 and 4°C relative to a baseline period (1961-1990). Clear differences in the climate change signal for PET, precipitation minus PET (P-PET) and P/PET (aridity index) are produced among the five methods. For the 2 °C scenario, the climate change signal for annual global mean PET varies by over 100mm between methods, with the Hargreaves method providing the most similar values (<5mm difference) to those of the Penman-Monteith method. In contrast, the Priestley-Taylor PET annual global mean climate change signal is 30mm lower than Penman-Monteith, while the Hamon signal is higher by 80mm. With regional differences in the PET climate change signal approaching 50 mm·month-1, choice of the method of estimating PET is shown to substantially influence projections of future changes in terrestrial hydrology and freshwater availability.