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Potential Evaporation Computation through an Unstressed Surface Energy Balance and its Sensitivity to Climate Change Effect

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Potential evaporation (ETP) is a basic input for hydrological and agronomic models, as well as a key variable in most actual evaporation estimations. It has been approached through several diffusive and energy balance methods, out of which the Penman-Monteith equation is recommended as the standard one. In order to deal with the diffusive approach, ETP must be estimated at a sub-diurnal frequency, as currently done in land surface models (LSM). This study presents an improved method, developed in the ORCHIDEE LSM, which consists in estimating ETP through an unstressed surface energy balance (USEB method). The values provided confirm the quality of the estimation which is currently implemented (Milly, 1992). ETP has also been estimated using a reference equation (computed at a daily time step) provided by the Food and Agriculture Organization (FAO). In the first place, a comparison for a reference period of 11 years shows that both formulations differ, specially in arid areas. However, they supply similar values when FAO's assumption of neutral stability conditions is relaxed, by replacing FAO's aerodynamic resistance by the model's one. Additionally, if the vapour pressure deficit (VPD) is also substituted by either ORCHIDEE's VPD or its humidity gradient, the daily mean estimate is further improved.
ETP's sensitivity to climate change is assessed comparing trends in both formulations for the 21st Century. It is found that the USEB method shows a higher sensitivity mainly due to FAO's assumption of neutral stability conditions and to a lesser extent, to the approximation proposed for the VPD. Both FAO's VPD and the model's humidity gradient, as well as ORCHIDEE's aerodynamic resistance have been identified as key parameters in governing ETP trends. Finally, the sensitivity study is extended to 3 empirical approximations based on temperature, net radiation and mass transfer (Hargreaves, Priestley - Taylor and Rohwer, respectively). When compared to the USEB method, the first 2 approximations generally underestimate the trends yielded by USEB, resulting in a lower sensitivity. However, Rowher's equation provides higher ones, confirming the role of the VPD in ETP's sensitivity to climate change.