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Towards the prediction of actual evaporation from terrestrial surfaces using analytical complementary relationship

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Notwithstanding the centrality of potential evaporation (PE) in hydrologic and climate models, its definition and proper use remain widely debated. We propose a mechanistic, pore-based model for evaporation and energy partitioning over drying porous surfaces to define PE for a hypothetical steady-state reference surface temperature. Feedback between drying land surface and overlaying air properties is considered in the hypothetical steady-state with a vanishing sensible heat flux and diversion of available energy to evaporation. Surprisingly, the resulting steady-state PE tracks class A pan evaporation data very closely suggesting that pan evaporation occurs with negligible sensible heat flux (in agreement with summer observations). The new PE enables analytical derivation of asymmetric complementary relationship (CR) between potential and actual evaporation for a wide range of conditions in good agreement with measured actual evaporation. The derivations provide new insights into the origins of asymmetry in the CR linked to input weather data and evolution of the temperature of drying surfaces across scales. The analytical CR could offer physically-based estimates of regional scale actual evaporation during surface drying for a wide range of present and future external inputs that may resolve future energy partitioning patterns and issues related to droughts.