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Evaluation of advection-aridity complementary relations at the lab scale

Stanislaus J. Schymanski (1), Milad Aminzadeh (1), Michael L. Roderick (2), and Dani Or (1)

(1) ETH Zurich, Soil and Terrestrial Environmental Physics (STEP), Zurich, Switzerland (stan.schymanski@env.ethz.ch), (2) Australian National University, Canberra, Australia

A common view of evaporation from terrestrial surfaces considers limitations due to water supply in arid regions, and atmospheric demand (or energy) limitations to evaporation from wet surfaces in temperate regions. Evidence suggests that at large scales, energy and water limitations are not independent. While a surface dries and a larger fraction of the radiative energy is converted into sensible heat, that heat is injected into the air and altering its properties. This land-atmosphere feedback gives rise to the so-called complementary relationship (Bouchet 1963), referring to the simultaneous decrease in actual evaporation while potential evaporation increases as the surface dries. The effect of surface drying on atmospheric water demand is two-fold: an increase in air temperature and a decrease in water vapour content for fixed advective exchange rate across the system boundaries. To isolate the various mechanisms and improve understanding of the feedbacks, we designed an insulated wind tunnel, where wind speed, radiation, surface moisture and exchange rates of air and heat across the boundaries are controlled. Preliminary results show the magnitude of the feedbacks in terms of air and surface temperatures, and evaporation rates from drying and wet surfaces simultaneously. Experimental and associated simulation results provide a direct demonstration of the roles of advective exchange and the interplay between atmospheric boundary layer thickness and temporal variations in radiative energy input in determining the strength of surface-atmosphere feedbacks and the resulting phenomenon known as the complementary relationship.