Geophysical Research Abstracts,
Vol. 11, EGU2009-13537, 2009
EGU General Assembly 2009

Evaporative demand, transpiration, and photosynthesis: How are they changing?

G.D. Farquhar and M.L. Roderick
Australian National University (ANU)

Carbon dioxide concentration is increasing. This affects photosynthesis via increases in substrate availability (Farquhar et al. 1980). It reduces the amount of water transpired by plants to fix a given amount of carbon into an organic form; i.e it increases transpiration efficiency (Wong et al. 1979). It also warms the earth's surface. It is commonly supposed that this warming causes an increase in evaporative demand – the rate of water loss from a wet surface. This supposition has then been extended to effects on plant water availability, with the idea that there would be offsets to the gains in productivity associated with increased transpiration efficiency. The assumption that increased temperature means increased evaporative demand has also been applied to global maps of changes in soil water content. However, observations of pan evaporation rate show that this measure of evaporative demand has been decreasing in most areas examined over the last few decades. We reconcile these observations with theory by noting that, on long time scales, warming also involves water bodies, so that the vapour pressure at the earth's surface also increases. Using the physics of pan evaporation (Rotstayn et al. 2006) we show that the reduction in evaporative demand has been associated with two main effects, (1) "dimming", a reduction in sunlight received at the earth's surface because of aerosols and clouds, being the first phenomenon identified (Roderick and Farquhar 2002), and (2) "stilling", a reduction in wind speed, being the second (Roderick et al. 2007). We show that better accounting for changes in evaporative demand is important for estimating soil water changes, particularly in regions where precipitation exceeds evaporative demand (i.e where there are rivers) (Hobbins et al. 2008). We synthesise some of these results with others on vegetation change.

References:

Farquhar, GD, von Caemmerer, S, and Berry, JA, 1980: A biochemical model of photosynthetic CO2 assimilation in leaves of C3 species. Planta 149: 78-90.

Hobbins, MT, Dai, A, Roderick, ML, and Farquhar, GD, 2008: Revisiting the parameterization of potential evaporation as a driver of long-term water balance trends. Geophysical Research Letters. 35, L12403, doi:10.1029/2008GL033840.

Roderick, ML, and Farquhar, GD, 2002: The cause of decreased pan evaporation over the last 50 years. Science 298: 1410-1411.

Roderick, ML, Rotstayn, LD, Farquhar, GD, and Hobbins, MT, 2007: On the attribution of changing pan evaporation. Geophysical Research Letters VOL. 34, L17403, doi:10.1029/2007GL031166.

Rotstayn, LD, Roderick, ML, and Farquhar, GD, 2006: A simple pan-evaporation model for analysis of climate simulations: Evaluation over Australia. Geophysical Research Letters 33: L17715, doi: 10.1029/2006GL027114

Wong, SC, Cowan, IR, and Farquhar, GD, 1979: Stomatal conductance correlates with photosynthetic capacity. Nature 282: 424-426.