Geophysical Research Abstracts
Vol. 12, EGU2010-1760, 2010
EGU General Assembly 2010

The control of transpiration by absorbed radiation

Roland Pieruschka (1) and Joseph A. Berry (2)

(1) Forschungszenttum Jülich, Germany (r.pieruschka@fz-juelich.de), (2) Carnegie Institution for Science, Stanford, USA (joeberry@stanford.edu)

Transpiration plays a key role in the hydrological cycle and models of transpiration have been used in many applications. However, our understanding of mechanisms which control the rate of transpiration is still limited being a domain of two different disciplines. Meteorologists apply the top-down approach driven by physical descriptions and water vapour transport, stomatal conductance is regarded as a boundary condition. Plant physiologists focus on the bottom-up approach and emphasize the physiological control of transpiration by stomatal conductance.
It is generally accepted that transpiration is strongly influenced by the boundary layer outside the leaf and that feedback mechanisms within this layer decrease the sensitivity of transpiration to changes in stomatal conductance. This feedback mechanism is thought to increase with increasing scale from single stoma to canopy and ecosystem. In contrast, we propose a mechanism that would place much of the control inside the leaf. Most of the solar radiation reaching the leaf penetrates the epidermis with little interaction and the largest part of the energy is absorbed by chloroplasts in mesophyll cells. Thus, evaporation occurs into the intercellular air spaces of a leaf at cell walls adjacent to the chloroplasts of the leaf mesophyll and it is directly coupled to absorbed solar radiation. We present data showing that variation in the rate of transpiration and stomatal conductance at constant humidity and CO2 is closely proportional to changes in fluxes of energy (W m-2) absorbed by the leaf. Computer simulations of energy exchange between the leaf mesophyll and the atmosphere with different regimes of heat and water exchange operating on the inner and outer sides of the epidermis realistically simulate transpiration, stomatal response to a range of environmental conditions and provide a basis to calculate carbon fluxes. This approach has the potential for an up-scaling of water and carbon fluxes in canopies and ecosystems.