

Stomatal control of transpiration by absorbed radiation

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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. The rate of transpiration at the leaf scale is proportional to the rate of radiation-supported evaporation inside the leaf. The well known Priestley-Taylor equation posits a similar dependence of transpiration on radiation at the canopy and regional scale. We suggest that the success of this approach may rest on this newly discovered regulation of transpiration at the leaf scale, and, further, that this may indicate a fairly direct scaling of control from leaf to canopy.