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Theoretical and experimental insights into effects of wind on leaf heat and gas exchange

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Transpiration and heat exchange by plant leaves are coupled physiological processes of significant importance for surface-climate interactions and ecohydrology. The common practice of modelling transpiration as an isothermal process (assuming equal leaf and air temperatures) may introduce significant bias into estimates of transpiration rates and water use efficiency (WUE, the amount of carbon gained by photosynthesis per unit of water lost by transpiration). In contrast, explicit consideration of stomatal and leaf boundary layer resistances in series and the leaf energy balance in a physically-based model led to some surprising results, such as suppressed transpiration rates for increasing wind speed at constant stomatal conductance. The model predicts that for high wind velocities, the same leaf conductance (for water vapour and carbon dioxide) can be maintained with less evaporative losses. If this leaf-scale effect is consistent across most leaves, it may have profound implications for canopy-scale water use efficiency under globally decreasing wind speeds. This presentation reports the results of a systematic study of the effect of wind speed on leaf heat and gas exchange rates and introduces a novel experimental design to verify the modelling results using an insulated wind tunnel and artificial leaves with defined pore geometries, allowing to measure leaf-scale latent and sensible heat fluxes independently. First experimental results and new insights will be highlighted.