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Water Stress Detection using Temperature, Emissivity, and Reflectance

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Water stress is one of the most critical abiotic stressors limiting crop development. The main imaging and non-imaging remote sensing based techniques for the detection of plant stress (water stress and other types of stress) are thermography, visible (VIS), near- and shortwave infrared (NIR/SWIR) reflectance, and fluorescence. Just very recently, in addition to broadband thermography, narrowband (hyperspectral) thermal imaging has become available, which even facilitates the retrieval of spectral emissivity as an additional measure of plant stress. It is, however, still unclear at what stage plant stress is detectable with the various techniques.
During summer 2014 a water treatment experiment was run on 60 potato plants (Solanum tuberosum L. Cilena) with one half of the plants watered and the other half stressed. Crop response was measured using broadband and hyperspectral thermal cameras and a VNIR/SWIR spectrometer. Stomatal conductance was measured using a leaf porometer. Various measures and indices were computed and analysed for their sensitivity towards water stress (Crop Water Stress Index (CWSI), Moisture Stress Index (MSI), Photochemical Reflectance Index (PRI), and spectral emissivity, amongst others).
The results show that water stress as measured through stomatal conductance started on day 2 after watering was stopped. The fastest reacting, i.e. starting on day 7, indices were temperature based measures (e.g., CWSI) and NIR/SWIR reflectance based indices related to plant water content (e.g., MSI). Spectral emissivity reacted equally fast. Contrarily, visual indices (e.g., PRI) either did not respond at all or responded in an inconsistent manner. This experiment shows that pre-visual water stress detection is feasible using indices depicting leaf temperature, leaf water content and spectral emissivity.