Geophysical Research Abstracts,
Vol. 10, EGU2008-A-00979, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-00979
EGU General Assembly 2008

Simulation of Physiology Induced Hyperspectral Changes in a Virtual Citrus Orchard as Detected by Medium and High Resolution Remote Sensing Platforms

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Recent advances in remote sensing platforms and the increasing accessibility to time series have proven their potential use for monitoring agronomic production processes. Interpreting measured trends caused by physiological processes however poses problems. In complex production systems, such effects may be due to multiple causes and subject to natural variability and errors induced by the platform or viewing conditions.

This research attempts to gain basic insights in the potential of medium and high resolution multi- and hyperspectral remote sensing to monitor citrus production processes by simulating a realistic Valencia citrus orchard in a ray-tracing environment. All geometric primitives such as leaves, stems, fruits and weeds are represented by explicit 3D geometries. Structural calibration at tree and orchard level is based on allometry, hemispherical photography and measured orchard structure, obtained in a commercial South-African Valencia orchard. For each geometric primitive, a plausible hyperspectral bidirectional scattering distribution function (BSDF) is developed and calibrated by fitting measured reflection and transmission spectra.

The quantitative modeling of spectral and structural changes relevant to the citrus production process is outlined, and their known or putative causes in stress, reproductive physiology or management are described. Simulated changes will include variations in leaf angle, leaf curl, LAI (tree vigor), branch bending, chlorosis, vegetative flushes and presence of mature oranges, some of which are not easily simulated by use of

currently available radiative transfer models.

Simulated data of reference and modified situations will be compared side-by side. The detectability of these changes will be analyzed using statistical tests on established multi- and hyperspectral vegetation indices. The analysis will test the index robustness. Robustness is interpreted as the ability to cope with the variability caused by heterogeneities within an orchard such as weed patches, variable age and health of trees and differences in soil spectra. In a second set of simulations, the effects of variable illuminations, orchard orientation and viewing directions will be treated with respect to standardization of time series and establishment of optimal measurement conditions.