5th International Symposium on
Recent Advances in Quantitative Remote Sensing

"MOD-PROSAIL: a Coupled Atmosphere-canopy Radiative Transfer Model for the Retrieval of Vegetation Properties from Remote Sensing Observations with Application to Drought Effects Detection"

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Abstract

Monitoring ecosystem responses to water stress in various phases of a drought is a vital need especially for early detection purposes. Out of all elements of a terrestrial ecosystem, vegetation is of particular relevance due to its crucial role in controlling earth-atmosphere interactions and, therefore, is a valuable indicator of ecosystem responses. Thus, greater efforts are needed to understand the responses of vegetation biophysical and biochemical properties to soil moisture deficit over time in a drought episode. In this study, we coupled an atmospheric and a canopy radiative transfer model for the simultaneous atmospheric correction and retrieval of vegetation properties from 20 Landsat TM5 and ETM7 observations during a drought episode in California Mediterranean grasslands in 2004. This coupled model, called MOD-PROSAIL, combines the MODerate resolution atmospheric TRANsmission model (MODTRAN) and the PROspect-SAIL (PROSAIL) radiative transfer model. In MOD-PROSAIL, first the best-fitting atmospheric properties (visibility, aerosol type and vertical profile) are found for various days through a look-up table (LUT). Next, the PROSAIL model is inverted against the calculated TOC reflectance by means of an optimization algorithm and, therefore, vegetation properties (mainly, Leaf Area Index (LAI), leaf chlorophyll content (Cab), leaf water content (Cw), leaf dry matter content (Cdm), and senescent material (Cs)) are retrieved during the drought episode. The small error in the model inversion ($0.003 < RMSE < 0.03$) showed that the model was able to accurately reproduce the observed reflectance spectra under different soil moisture contents during the drought episode. Finally, the trend of all retrieved properties was investigated over time during the drought episode. The proposed approach might be feasible to generate long time series of reliable vegetation properties using multi-temporal satellite observations from multiple sensors to detect drought signals and effects in the ecosystem.

Keywords: MODTRAN, PROSAIL, MOD-PROSAIL; satellite observations; model inversion; LUT; optimization; vegetation properties; grasslands; drought; soil moisture deficit.