Fusion of Optical and Radar Imagery for Plant Water Stress Detection

Jiaguo Qi [1]

Cuizhen Wang [1] Susan M. Moran [2], and Yoshio Inoue [3]

1. Department of Geography, and Center for Global Change and Earth Observations, Michigan State University, East Lansing, Michigan.
2. USDA-ARS Southwest Watershed Research Center, Tucson, Arizona
3. National Institute for Agro-Environmental Sciences, Tsukuba, Ibaraki, Japan

ABSTRACT

Ability to detect plant stress and to map its spatial distribution is imperative for site-specific agricultural practices. Effort on plant stress detection in the 1980s primarily relied on the thermal characteristics of plant-soil systems because plant temperature is strongly correlated with plant water transpiration. Since plants and soils are coupled systems remote measurements of plant temperature are strongly affected by soil conditions such as water status. Therefore since 1990s approaches to plant stress detection have incorporated both thermal and optical characteristics of plants to develop crop water deficit index (WDI), which can be computed from spectral vegetation indices and surface and air temperatures. Due to their low spatial resolution, however, limited thermal channels are available from current satellite sensors. There is a need, therefore, to develop an alternative measure to indicate plant water status. Radar backscattering, which is free from clouds effect, is strongly sensitive to both soil and plant water content and can provide an alternative measure of plant stress. In this study, a synergistic radar/optical method was developed and used to examine its potential for plant stress detection. The method uses a microwave scattering model developed by Karam and his colleagues (1992) but modified to 1) take into account underneath soil backscattering properties and 2) use optical remote sensing as direct input variables to the model. The synergistic method was applied to two data sets from Maricopa Agricultural Center, Maricopa, Arizona, and the experimental fields of the National Institute for Agro-Environmental Sciences, Tsukuba, Japan. The data sets included images from Landsat and ERS satellites as well as some ground based soil and plant measurements. The preliminary results indicate that radar imagery can be effectively integrated with optical imagery for plant water stress detections and potentials exist to use such method for site-specific agricultural management practices.