COMPARISON OF VEGETATION WATER CONTENT ESTIMATES FROM WINDSAT AND MODIS

*E. Raymond Hunt, Jr. *[1], Li Li [2], M. Tugrul Yilmaz [3], and Thomas J. Jackson [1]*

[1] Hydrology and Remote Sensing Laboratory, USDA-ARS, Beltsville, MD, USA
[2] Naval Research Laboratory, Washington, DC, USA
[3] Geography and Geoinformation Science, George Mason University, Fairfax, VA, USA
* Corresponding author Tel: + 1 301 504 5278; Email: Raymond.Hunt@ars.usda.gov

1. INTRODUCTION

Determination of soil moisture content by microwave remote sensing is important for quantifying the global energy, water and biogeochemical cycles [1, 2]. Vegetation water content (VWC, kg m^{-2}) is one of the important parameters for retrieval of soil moisture using passive microwave radiometers [3]. Liquid water in leaves has strong absorption features at shortwave infrared wavelengths, which can be used to determine leaf water content, also called equivalent water thickness [4]. There exist “allometric” relationships between leaf and stem water contents, particularly for annual crops, because stems are required to support the leaves so satellite sensors with shortwave-infrared bands can be used to estimate VWC independently of microwave retrievals [5, 6]. We show that the VWC retrieved from WindSat [2] is linearly related to VWC estimated from MODIS imagery.

2. METHODS

WindSat data were collected for the months of May, June and July from 2003 to 2005. The brightness temperatures at five points were extracted over central Iowa and the method of Li et al. [2] was used to determine VWC. Terra MODIS surface reflectance data products (MOD09A1, 8-day composite, 500 m) for bands 1-7 were obtained from the Land Processes DAAC at the USGS EROS Data Center for the same time period. The Normalized Difference Infrared Index (NDII) was calculated:

$$NDII = (R_2 - R_6)/(R_2 + R_6) \quad (1)$$

where: R_2 is the reflectance from MODIS band 2 (0.86 μm wavelength), and R_6 is the reflectance from MODIS band 6 (1.64 μm wavelength). The USDA National Agricultural Statistics Service’s Cropland Data Layers were used to determine proportions of corn and soybean each year, and the allometric equations from Yilmaz et al. [6] were used to calculate total vegetation VWC, which was then aggregated to WindSat scale.

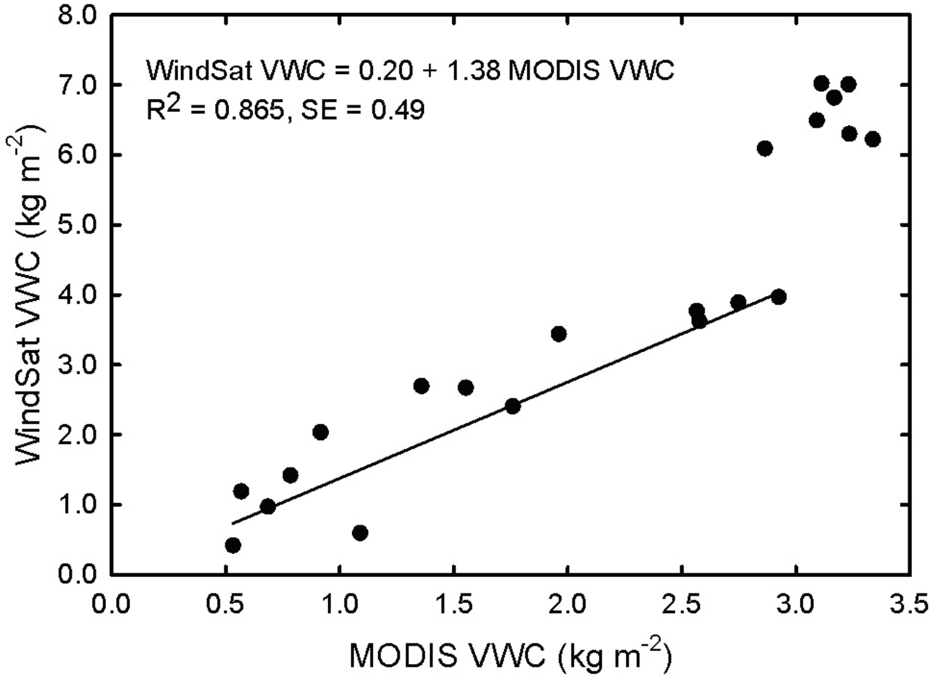

Fig. 1. Comparison of Vegetation Water Contents (VWC) over croplands in central Iowa calculated from WindSat and Terra MODIS for the months of May to July from 2003 to 2005. The solid line shows a linear relationship when MODIS NDII (Eq. 2) was not saturated with respect to canopy water content.

3. RESULTS AND DISCUSSION

The five points from WindSat had large areas of overlap, and were highly correlated with each other (all $r > 0.95$); therefore, VWC were averaged for each overpass. MODIS NDII saturates at high canopy water content [6], which affected the calculations of MODIS VWC during late July. Using the data from May through the first week of July, WindSat VWC was highly correlated with MODIS VWC (Fig. 1). The regression equation showed that on average, WindSat VWC was 38% greater than MODIS VWC ($P < 0.05$). However, the bias was not significantly different from zero (Fig. 1). Both the VWC retrieval from WindSat and the allometric equations relating stem to leaf VWC have uncertainties, but these uncertainties are reduced when averaged over a large area. Whereas the land cover of central Iowa is relatively simple (65% corn and soybean), the agreement between VWC from microwave and shortwave-infrared data indicates a combined sensor approach would be useful to increase the accuracy of soil moisture retrievals.

4. REFERENCES

[1] E.G. Njoku, T.J. Jackson, V. Lakshmi, T.K. Chan, and S.V. Nghiem, "Soil moisture retrieval from AMSR-E," IEEE Transactions on Geoscience and Remote Sensing, vol. 41, pp. 215-229, 2003.

[2] L. Li, P.W. Gaiser, B.C. Gao, R.M. Bevilacqua, T.J. Jackson, E.G. Njoku, C. Rëdiger, J.-C. Calvet, and R. Bindlish, "WindSat global soil moisture retrieval and validation," IEEE Transactions on Geoscience and Remote Sensing, in press.

[3] T.J. Jackson, "Vegetation effects on microwave emission of soils," Remote Sensing of Environment, vol. 36, pp. 203-212, 1991.

[4] E.R. Hunt and B.N. Rock, "Detection of changes in leaf water content using near- and middle-infrared reflectances," Remote Sensing of Environment, vol. 30, pp. 43-54, 1989.

[5] T.J. Jackson, D. Chen, M. Cosh, F. Li, M. Anderson, C. Walthall, P. Doraiswamy, and E.R. Hunt, "Vegetation water content mapping using Landsat data derived normalized difference water index for corn and soybeans," Remote Sensing of Environment, vol. 92, pp. 475-482, 2004.

[6] M.T. Yilmaz, E.R. Hunt, and T.J. Jackson, "Remote sensing of vegetation water content from equivalent water thickness using satellite imagery," Remote Sensing of Environment, vol. 112, pp. 2514-2522, 2008.