ESTIMATION OF VEGETATION WATER CONTENT THROUGH GA-PLS MODELING OF MODIS REFLECTANCE DATA

L. Li [a], S. L. Ustin[b], D. Riaño[b], Y.-B. Cheng[c]

[a]Department of Earth Science, Indiana University-Purdue University, IN46202, USA;
Email address: ll3@iupui.edu
[b]Calspace, University of California, Davis, CA 95616, USA.
[b]NASA Goddard Space Flight Center, USA.

1. INTRODUCTION

Remote estimation of vegetation water content has applications in agriculture and forestry. Our previous studies have shown that the genetic algorithms (GA) and partial least square regression (PLS) method achieved high performance in estimating equivalent water thickness (EWT) from simulated, lab measured and the Airborne Visible and Near Infrared Imaging Spectrometer (AVIRIS) [1, 2] data. Studies also showed high correlation between measured canopy water content and those derived from the AVIRIS calibration [3], which supports that canopy water content can be reproduced by the AVIRIS derived equivalent water thickness (EWT). The good performance of GA-PLS for the hyperspectral datasets inspires us to assess the effectiveness of GA-PLS in estimating canopy vegetation water content from Moderate Resolution Imaging Spectroradiometer (MODIS) data. It is expected that the success of GA-PLS in mapping canopy vegetation water content from MODIS imagery could have important implications for monitoring the agricultural and forestry ecological systems considering MODIS high temporal resolution and large areal coverage.

2. METHODOLOGY

The study area is centered at the Walnut Gulch Experimental Watershed (31°25′N - 32°7′N, and 109°43′W - 110°14′W) near Tombstone, AZ and was the USDA 2004 Soil Moisture Experiment (SMEX04) site [4]. Both AVIRIS and MODIS images of this area were acquired during the period of the 2004 field campaign and processed with ACORN converting the AVIRIS image from radiance to reflectance and generating an EWT map from the image, and with ENVI degrading the AVIRIS 16 m to the MODIS 500 m spatial resolution and georeferencing the MODIS and AVIRIS images. To derive a GA-PLS model, we first randomly selected 1000 pair pixels from both the MODIS image and the AVIRIS EWT map, and then conducted the GA-PLS regression of the MODIS image spectra again the AVIRIS EWT values of the selected pixels. Because the MODIS image has a limited number of spectral bands, MODIS band ratios and curvatures were jointly used with seven original MODIS bands to increase the GA-PLS regression variables. The pixels (3200) not selected for the calibration were used to validate the GA-PLS model.

3. RESULTS

The results from GA-PLS modeling of MODIS imagery are shown in Figure 1a for calibration and Figure 1b for validation. The coefficient of determination (R^2) resulting from GA-PLS modeling is 0.77 for calibration and 0.76 for validation with a root mean square error (RMSE) of 0.018 (μm). While the equations shown in Figure 1 indicate that GA-PLS modeling of MODIS spectra resulted in underestimated EWT because the correlations have slopes less than 1, the resultant R^2 values are very encouraging considering a large number of pixels (3200) involved in the validation and uncertainties during image data acquisition and processing.

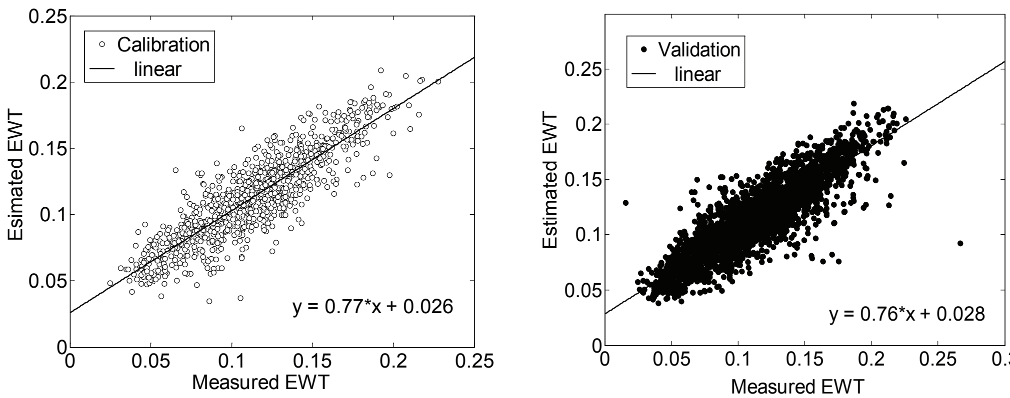

Figure 1. Comparison between measured and estimated EWT in the GA-PLS calibration (1a, left) and validation (1b, right)

4. CONCLUSIONS

The GA-PLS results for estimating vegetation canopy water content with MODIS image spectra are very encouraging though the effectiveness of this approach depends on the accuracy of the AVIRIS derived water content. If the AVIRIS derived EWT could reproduce *in situ* canopy water content, GA-PLS modeling of MODIS images may provide an approach to scale water content mapping to the MODIS platform level. Future work will be focused on addressing the effects of dry matter, soil background and data spectral characteristics.

5. REFERENCES

[1] Li, L., S. L. Ustin & D. Riaño, Retrieval of fresh leaf fuel moisture content using genetic algorithm–partial least squares modeling (GA-PLS), *IEEE Trans. Geosci. Remote Sens. Lett.*, 4:216-220, 2007.

[2] Li, L., Y.-B. Cheng, S. L. Ustin, X.-T. Hu & D. Riaño, Retrieval of vegetation equivalent water thickness from reflectance using genetic algorithm (GA)-partial least squares (PLS) regression, *Adv. Spac. Res.*, 41:1755-1763, 2008.

[3] Cheng, Y.-B., S. L.Ustin, D. Riaño & V.C. Vanderbilt, Water content estimation from hyperspactral images and MODIS indexes in Southern Arizona, *Remote Sens. Environ*. 112:363-374, 2008.

[4] Trombetti, M., D. Riaño, M. A. Rubio, Y.-B. Cheng & S. L. Ustin, Multi-temporal vegetation canopy water content retrieval and interpretation using artificial neural networks for the continental USA, *Remote Sens. Environ*. 112: 203-215, 2008.

[5] Yilmaz, M. T., E.R. Hunt Jr., L. D. Goins, S. L. Ustin, V. C. Vanderbilt & T. J. Jackson, Vegetation water content during SMEX04 from ground data and Landsat 5 Thematic Mapper imagery, *Remote Sens.Environ*. 112:350-362, 2008.