SCALING UP EQUIVALENT WATER THICKNESS IN SAVANNA ENVIRONMENTS: FROM LOCAL TO BIOME SCALE, VIA GROUND, HYPERION, AND MODIS DATA

Laerte Guimaraes Ferreira Jr.[1]
Gregory P. Asner[2]
David Knapp[2]
Eric A. Davidson[3]
Mercedes Bustamante[4]

[1]Image Processing and GIS Lab, Federal University of Goias, Brazil
www.ufg.br/lapig - laerte@iesa.ufg.br
[2]Department of Global Ecology, Carnegie Institution, Stanford, CA
http://asnerlab.stanford.edu/ - {gpa, deknapp}@stanford.edu
[3]The Woods Hole Research Center, Falmouth, MA
www.whrc.org - edavidson@whrc.org
[4]Ecology Department, University of Brasilia
Mercedes@unb.br

1. INTRODUCTION

The Cerrado, the central Brazilian neotropical, moist savanna biome, encompassing an area of nearly 208 million hectares, is considered one of the world's biodiversity hotspots [1], for its natural value and endangerment level. Its different inner ecosystems – ranging from grasslands to tropical dry forests – and transitional areas toward all other major Brazilian biomes contain high levels of biodiversity, as well as endemism. Nevertheless, satellite based assessments indicate that about 50% of the original Cerrado vegetative cover has been converted and fragmented by deforestation and expansion of the agriculture frontier [2, 3]. Such large-scale conversion of the Cerrado, the headwater region of major rivers of eastern South America, has already significantly affected regional runoff and river discharge [4]. Within the scope of the NASA LCLUC sponsored project "*Interactions of Edaphic and Land-Use Factors on Water Resources of the Cerrado Region of Brazil* ", focused on understanding and quantifying the impacts and feedbacks of current and future land cover changes on the Cerrado hydrology, canopy water content based on the Earth Observing-1 (EO-1) Hyperion satellite imagery [5] has been successfully derived for different Cerrado physiognomies. In this paper, we describe an empirical approach for the regional extrapolation of these ground-truthed observations (r^2 against field-derived water content of about 0.75-0.85) based on the Terra MODIS sensor.

2. METHODOLY

The Hyperion "water" images were derived by iteratively fitting a curve to the water absorption features at 940 and 1140 nm in the spectrum (the 1140nm feature, in particular, served to separate atmospheric water vapor from liquid water). The image radiometric values were then compared to field-based measurements of canopy equivalent water thickness (EWT), i.e. the product of leaf area index (LAI), leaf water concentrations, and specific leaf area (SLA), resulting in canopy equivalent water thickness (EWT_c) images in units of mm H_2O $pixel^{-1}$.

From the set of five Hyperion scenes collected over the study area (Aguas Emendadas Ecological Reserve, near Brasilia) and processed to "liquid water" images, we selected those obtained for the beginning and end of the dry season (i.e. 06/17/2003 and 09/13/2006, respectively) for the regional scale extrapolation, which consisted of the following steps: a) georectification (in relation to Geocover) of the two hyperion EWT_c and two Landsat – TM images converted to apparent surface reflectances (06/16/2003 and 09/12/2006 overpasses); b) NDVI transformation of the Landsat images; c) data extraction of selected targets (both images, i.e. TM derived NDVI and Hyperion EWT_c at 30m spatial resolution) and preliminary regression analysis (i.e. NDVI against EWT_c values); d) use of a triangular low pass convolution filter for the spatial degradation of the images; e) development of a linear translation equation – based on the 250m NDVI and EWT_c images – applied to the MOD13Q1 Cerrado mosaick (i.e. five tiles).

3. RESULTS AND CONSIDERATIONS

Satellite-based canopy water content maps are instrumental for the evaluation of hydrological model estimates as well as a key spatial-temporal indicator of ecosystem water stress and sub-surface water availability. In particular, hyperspectral data, as that provided by the Hyperion sensor, has proven a valuable and reliable tool for deriving canopy water content. Aiming at the regional extrapolation of local scale Hyperion-based EWT_c estimates, in this paper we presented an empirical approach, in which a linear regression, relating spatially degraded Hyperion measures and TM derived NDVI values, was applied to the MOD13Q1 product.

Our results show a high precision (r^2 of 0.86 and 0.84 for the beginning and end of the dry season, respectively), with MODIS-EWT_c values consistently increasing from the Cerrado grassland to the Cerrado woodland physiognomies. Currently, we are in the process of deriving confidence intervals for our regional estimates, as well as producing EWT_c images from 2000 to 2008, so that long-term spatial and temporal patterns and trends in the functioning of the Cerrado ecosystems can be assessed.

4. REFERENCES

[1] N. Myers, R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca, J. Kent. Biodiversity hotspots for conservation priorities. *Nature*, London, v.403, pp. 853-858, 2000.

[2] E.E. Sano, R. Rosa, J.L.S. Brito, L.G. Ferreira. Mapeamento semi-detalhado do uso da terra do Bioma Cerrado. Pesquisa Agropecuária Brasileira, Embrapa, Brasília, v.43 (1), pp. 153-156, 2008.

[3] C.A. Klink, R.B. Machado. Conservation of the Brazilian Cerrado. *Conservation Biology*, Wiley, Hoboken, NJ, v. 19 (3), pp. 707-713, 2005.

[4] M.H. Costa, A. Botta, J.A. Cardille. Effects of large-scale changes in land cover on the discharge of the Tocantins River, Southeastern Amazonia. *Journal of Hydrology*, v. 283, pp. 206-217, 2003.

[5] G.P. Asner, D. C. Nepstad, G. Cardinot, D. Ray. Drought stress and carbon uptake in an Amazon forest measured with spaceborne imaging spectroscopy. *Proceedings of the National Academy of Sciences* 101, no. 16, pp. 6039-44, 2004.