Combination of remote sensing and in situ measurements for a detailed assessment of biophysical properties of East African rainforests: a case study for Kakamega Forest, Kenya, and Budongo Forest, Uganda

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Tropical rain forests are the most important habitat type for biodiversity conservation worldwide (Myers et al. 2000). Although they only cover about 7% of the global land surface (Hansen & DeFries 2004), they shelter a large variety of life. At least 44% of the world's vascular plants and 35% of terrestrial vertebrate species are endemic to 25 global biodiversity hotspots, 15 of which are tropical rain forests (Brooks et al. 2002, Myers et al. 2000).

One of the biggest challenges to the estimation of changes in forest cover (and thus a possible change in biodiversity) is the monitoring of forest areas on a reliable, fast, cost effective and area-wide basis. Here, operational remote sensing techniques form a valuable data source for the scientific and political community since they permit repetitive and synoptic observations of vegetation cover. Changes in forest structure and dynamics can, for instance, be monitored through repeated measurement of remotely measured biophysical attributes. In contrast to discrete representations of land cover, biophysical variables alter continuously over space and time and may thereby reveal early ecosystem modifications (Lambin 1999). In this context, leaf area index (LAI) is one of the key biophysical variables. Operational standard products of LAI derived from satellite data, as e.g. the MODIS LAI product, can thus contribute to the constant and repetitive monitoring of forest areas. However, a prerequisite for the use of operational satellite products is the evaluation of their accuracy in a process called validation based on field measurements (Morisette et al. 2006).

Within the framework of the BIOTA East Africa project a detailed assessment of LAI was performed in Budongo Forest (Uganda) and Kakamega Forest (Kenya). Ground-based measurements of LAI were collected with LAI-2000 PCA and digital hemispherical photography. Based on Theil-Sen regression, transfer functions were established between in situ and high resolution satellite data (ASTER and SPOT-4) in order to produce high spatial resolution LAI maps of the test sites. Finally an upscaling of the high resolution LAI maps to the spatial resolution of the MODIS LAI product was performed, in order to validate the MODIS LAI product with respect to its spatial and temporal accuracy. The spatial validation for Budongo Forest revealed that the MODIS LAI product represented the up-scaled *in situ* LAI with an accuracy of 0.53. This corresponds to a relative accuracy of 9%, which is identical to the accuracy of the high resolution LAI maps. For Kakamega Forest validation led to a comparatively low accuracy of the MODIS LAI product of 1.5 (relative accuracy of 25%). This is most likely the result of inferior field data quality for this test site and the resulting degradation of accuracy in the upscaling process. The investigation of the temporal consistency of the MODIS LAI product was based on a time series analysis for the years 2000-2005. Results showed that the data was reliable and stable, but only if temporal interpolation was applied to bad data quality pixels. The observed variability in LAI (0.4 for intermediate and late forest stages) further corresponds to *in situ* measured seasonal LAI trajectories found by other studies for comparable semi-deciduous rain forests (e.g. De Wasseige et al. 2003). Maximum LAI values are associated with the end of the rainy season, minimum LAI values with the dry season. It can thus be assumed that the MODIS LAI product responds correctly to biome-level LAI changes associated with interannual climate variability.

This study shows that the MODIS LAI product represents the LAI of the two East African test sites with an accuracy that is comparable to the accuracy of field measurements. In addition, seasonal variations are captured correctly, but only if quality information for the MODIS LAI product is included in the analyses. Although structural changes in rain forests can only be monitored if absolute LAI values are affected (differences in *in situ* LAI of intermediate and late forest changes were not found to be significant for the test sites), the outcomes of this study can nevertheless help to improve knowledge of tropical rain forests and their response to climatic changes and human disturbances. The results may e.g. help to reduce predictive uncertainties in biophysical process models and serve as supplementary data for model calibration.

Bibliography:

Brooks, T.M., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Rylands, A.B., Konstant, W.R., Flick, P., Pilgrim, J., Oldfield, S., Magin, G. and C. Hilton-Taylor (2002). Habitat loss and extinction in the hotspots of biodiversity. – In: Conservation Biology, 16, pp. 909-923.

De Wasseige, C., Bastin, D. and P. Defourny (2003). Seasonal variation of tropical forest LAI based on field measurements in Central African Republic. – In: Agricultural and Forest Meteorology, 119, pp. 181-194.

Hansen, M.C. and R. DeFries (2004). Detecting long-term global forest change using continuous fields of treecover maps from 8-km advanced very high resolution radiometer (AVHRR) data for the years 1982-99. – In: Ecosystems, 7, pp. 695-716.

Lambin, E.F. (1999). Monitoring forest degradation in tropical regions by remote sensing: some methodological issues. – In: Global Ecology and Biogeography, 8, pp. 191-198.

Morisette, J.T., Baret, F., Privette, J.L., Myneni, R.B., Nickeson, J.E., Garrigues, S., Shabanov, N.V., Weiss, M., Fernandes, R.A., Leblanc, S.G., Kalacska, M., Sánchez-Azofeifa, G.A., Chubey, M., Rivard, B., Stenberg, P., Rautiainen, M., Voipio, P., Manninen, T., Pilant, A.N., Lewis, T.E., Iiames, J.S., Colombo, R., Meroni, M., Busetto, L., Cohen, W.B., Turner, D.P., Warner, E.D., Petersen, G.W., Seufert, G. and R. Cook (2006). Validation of global moderate-resolution LAI products: A framework proposed within the CEOS Land Product Validation Subgroup. – In: IEEE Transactions on Geoscience and Remote Sensing, 44, pp. 1804-1817.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. and J. Kent (2000). Biodiversity hotspots for conservation priorities. – In: Nature, 403, pp. 853-858.