ESTIMATION OF VEGETATION PARAMETERS FROM MODIS FPAR TIME SERIES AND LANDSAT TM AND ETM+ PRODUCTS FOR SOIL EROSION MODELLING

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Under case of constant topography, the major factors controlling the dynamics of soil erosion are the vegetative cover, the soil, and rock material [1]. With soil erosion generally considered to increase with decreasing protective s cover [2], mapping and monitoring of the vegetative cover has major relevance for land and water natural resource management.

The vegetative cover is in soil erosion models commonly described by a vegetative cover-factor representing the protection from erosion by canopy and ground cover [2]. The vegetative cover is comprised of green as well as non-green vegetation components. The presence, rather than the condition, of the canopy and ground cover controls the soil protective function for raindrop interception and against splash erosion and reduces the velocity of overland flow [2].

As large-scale vegetative cover-factor parameterization and quantifications are cost and labor intensive to collect and produce [2], much effort has been put into research to integrate remotely sensed imagery into erosion models [3]. Three major groups of studies can be differentiated in how they derive cover-factor estimates: (a) through direct linear regression to indices or band ratios [4, 5] or (b) through applying vegetative cover-factor values from literature to land use classifications [6] or (c) through spectral mixture analysis (SMA) [2, 7]. The latter take green, non-green, and bare fractions into account.

In the state of Queensland, Australia, the use of remotely sensed imagery to derive temporally variable vegetative cover-factor at larger scale (> 10 000 km^2) has been for a long time restricted to land use class-specific estimates [8]. Recent studies have calculated monthly or seasonal remotely sensed vegetative cover-factor estimates at pixel scale for selected vegetation structural categories with low woody foliage cover [9] or at pixel-scale with no differentiation of vegetation structural categories [8]. A more complex approach has used a time series of AVHRR NDVI data [10] of decomposed woody and herbaceous vegetation components for the estimation of monthly vegetative cover-factors. However, no attention has been given to the fact that high proportions of non-green vegetation cover can be present in the majority of the semi-arid savannas covering a majority of the state.

These non-green vegetation components can exist at any time of year and are often non-linearly related to the green vegetation component.

Modeling and remote sensing studies of the Fraction of Photosynthetically Active Radiation absorbed by vegetation (FPAR) have demonstrated its advantage over classical vegetation indices in heterogeneous landscapes [11]. Understory components can here affect landscape and canopy FPAR substantially [12, 13]. Asner et al. (1998) [13] have also shown that the variability of FPAR at landscape level can be strongly affected by non-photosynthetically active vegetation components and structural vegetation components.

This study presents results from a comparison between three different remotely sensed vegetative cover-factor estimates on a long term grazing trial site in north Queensland, Australia [14]. The vegetative cover-factor estimates for soil erosion modeling were derived from:

(i) a time series of global, quality controlled MODIS FPAR 8-day composites (2000-2006, 1 km spatial resolution) [15, 16] which were exponentially related to the vegetative cover-factor [as applied in 8],

(ii) a regionally developed Landsat fractional ground cover (fGC) product [17] which provides estimates of green, non-green, and bare fractions based on a SMA (2000-2006; 25 m spatial resolution, ~ 10 images each year), and

(iii) a combination of the fGC (ii) and a regionally developed Landsat woody FPC (wFPC) product (2004, 25 m spatial resolution) [18] to enable a differentiation between ground and canopy cover parameters [see 19 for details].

Both Landsat products fGC and wFPC are based on a standardized Landsat TM and ETM+ time series developed at the Department of Environment and Resource Management (DERM) [20]. The estimates of wFPC could be predicted from Landsat TM imagery with less than 10% RMSE [21]. The time series of Landsat based fGC [22] has recently been developed with the integration of more than 600 field observations in Queensland and New South Wales using a modified SMA. The product has been validated and is correlated with field sites measured to predicted fractions with RMSE of 11.8% and a r^2 of 0.82 [22].

All three cover factors are compared and discussed for a grazing trial site in Wambiana, north Queensland of about 9 km^2. The three vegetative cover-factors were then derived for a river catchment of 9500 km^2 and integrated as one of five relevant factors into an empirical erosion model (Revised Universal Soil Loss Equation (RUSLE) [23] in the semi-arid savanna woodlands of Queensland. Areas of change or disturbance due to land clearing or fire were excluded using data from the Statewide Landcover and Trees Study [18]. For the third (iii) approach with the Landsat fGC and the wFPC, the catchment was classified into vegetation structural categories representing structural formations as well as floristic associations, including differing combinations of canopy and ground cover (over- and understory) [24]. The classification was based on an image of wFPC from 2004 depicting the estimated wFPC cover for that year [15]. Vegetation structural categories were not expected to have changed over the period from 2000-2006 (R. Fensham, pers. comm. 2009). For each of the vegetation structural categories, individual parameters of the canopy (cover (%) and height) and ground cover (%) were derived. The wFPC was used as surrogate for canopy cover, as it is a suitable indicator of Australian floristic and structural communities [21, 25]. Canopy height estimates were derived for each class of the vegetation structural categories [24]. Resulting soil loss predictions from the three RUSLE scenarios with the different vegetative cover-factor estimates will be compared with field measurements of soil loss and sediment concentration using a regression technique.

The advantage of the presented approach (i) lies in the high temporal resolution of the MODIS FPAR and in its sensitivity to VSC as shown in [15]. The assumption for the applicability of this approach is that the MODIS FPAR is, despite its known limitations and global algorithm design, sensitive to (a) vegetation structural categories, and hence to a degree to the canopy and the ground cover, and (b) to non-green vegetation components. Benefits of the Landsat based approaches (ii) and (iii) to derive vegetative cover-factor estimates lie firstly in their higher spatial resolution. Potential benefits to soil loss predictions due to the use of the refined vegetative cover-factors estimates that differentiate between green, non-green, and bare fractions (ii), and that additionally include canopy and ground cover parameters (iii) will be discussed. Comparison of the remotely sensed input data for the different vegetative cover-factor estimates, the MODIS FPAR for (i) and Landsat fGC (ii and iii) for the homogenous grazing trial site indicate the potential of the global MODIS FPAR as high temporal predictor for a vegetative cover-factor (Figure 1). It suggests sensitivity of the MODIS FPAR at that site to green and non-green vegetation components. A regression analysis of the MODIS FPAR and Landsat fGC will be presented to reveal more insight into the affect of green, non-geen and bare fractions on the variability of the MODIS FPAR.

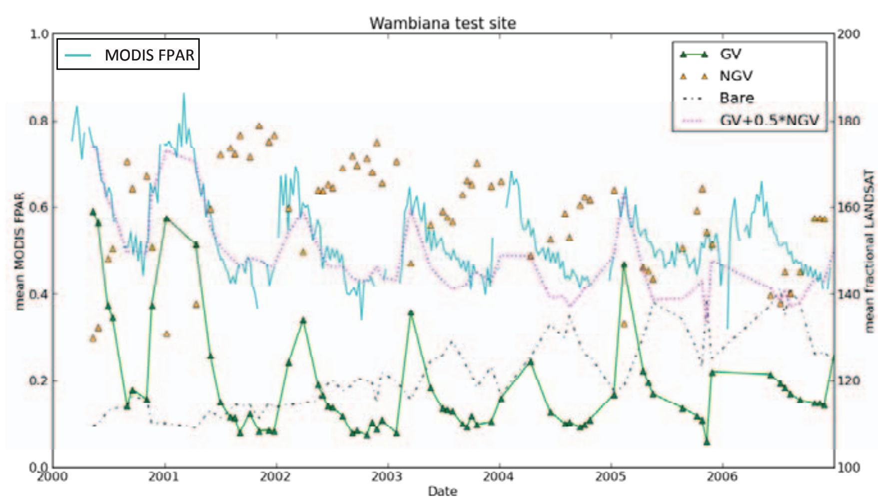

Figure 1: Time series of MODIS FPAR (scaled 0-1) and Landsat fractional ground cover (fGC) for the grazing site Wambiana, QLD (20° 34' S, 146° 07' E) from Feb. 2000 to Dec. 2006. Landsat fGC (GV – green vegetation; NGV – non green vegetation, Bare) (scaled 100-200). Mean data values were extracted for a window of 3x3 of 1km MODIS pixels and 100x100 25 m Landsat pixels in the centre of the site. Purple line shows an empirically weighted combination of GV and NGV Landsat fractions.

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