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Modelling the Carbon Balance of South Africa with BETHY/DLR

M. Niklaus, M. Tum, and K. P. Günther

German Aerospace Center (DLR), German Remote Sensing Data Center (DFD), Land Surface Dynamics, Oberpfaffenhofen, Germany (Email: markus.niklaus@dlr.de / Fax: +49 (0) 8153 28 - 1363)

Interactions between terrestrial ecosystems and atmosphere are essential issues when dealing with regional carbon balance. Hence the modelling of net carbon uptake by vegetation (Net Primary Productivity, NPP) has gained in importance throughout the last decade for studies regarding the mechanisms of carbon exchange and to the quantification of magnitudes of terrestrial carbon sinks and sources.

At the German Aerospace Center (DLR) the vegetation model BETHY/DLR (Biosphere Energy Transfer Hydrology Model) is driven to simulate the carbon cycle in vegetated areas, computing the NPP for different regions on regional to national scales. The model is driven by remote sensing data of leaf area index (LAI) and land cover classification (GLC2000) and meteorological input data which is provided by the European Center for Medium Range Weather Forecast (ECMWF).

This dynamic vegetation model primarily computes the photosynthetic rate of vegetation types in time steps of one hour, also considering the water balance and the radiative energy transfer between atmosphere, vegetation and soil. From this the Gross Primary Productivity (GPP) is calculated, followed by the NPP by subtracting the autotrophic respiration. For this purpose meteorological datasets are needed, i.e. precipitation, cloud cover, temperature and dew point temperature in 2m height, soil water content and wind speed. These datasets have spatial resolutions of $0.5° \times 0.5°$ and are available in the needed temporal resolution of up to four times a day. The soil water content of the four upper layers is used initially to start the model, where generally a spin up phase of about one year is enough to reach equilibrium. Henceforward the soil water content is computed dynamically. The solar radiation reaching the ground is processed, considering the low, medium and high cloud coverage along with the solar angle.

For information about the growth state of vegetation the model uses LAI time series derived from SPOT-VEGETATION data available in 1km $\times$ 1km spatial resolution as so called 10-day-composites, which give a representative value for a ten day period. These composites have to be pre-processed, to handle lacks and outliers in the datasets. This is done by applying time series analysis. In this study the method of the harmonic analysis (HA) is used. The HA belongs to the method of "least squares", whose most famous member is the Fourier transformation. Extensive tests showed that it reaches very low root mean square errors (RMSE). To classify the regional vegetation types, the 24 vegetation classes of the Global Land Cover 2000 product, which is representative for the year 2000 (GLC2000; spatial resolution 1km $\times$ 1km), also derived from SPOT-VEGATATION data, have to be translated into the 33 inherent vegetation types. These types differ in plant-physiologic parameters, i.e. the maximum electron transport rate and the maximum carboxylation rate, as well as the plant height and rooting depth. Hence the model distinguishes the two different photosynthetic schemes of C3 and C4 plants and also can treat two vegetation types for each pixel, hence the variety of the vegetated areas can be considered.

The model was widely tested and validated for Europe on coarse resolution (27km) and on high resolution (1km) for forests and croplands in Germany and Austria using statistical data for validation. The actual area of investigations is South Africa with special interest to analyse desertification and land degradation in terms of NPP. First NPP maps of South Africa with 1km spatial resolution for several years will be presented and discussed.