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Estimating the Carbon Cycle of South Africa with BETHY/DLR

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Quantifying sources and sinks of climatological relevant trace gases as well as understanding their exchange between atmosphere and land surface have become essential research topics in atmospheric sciences during the last years. Modelling of the net CO2 uptake by vegetation via photosynthesis (Net Primary Productivity, NPP) has become an important tool to study the mechanisms of CO2 exchange and to quantify the magnitude of terrestrial sinks and sources.
The vegetation model BETHY/DLR (Biosphere Energy Transfer Hydrology Model), used in our studies at the German Aerospace Center (DLR), is modified 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, and after subtracting the autotrophic respiration, NPP is estimated. 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 a temporal resolution of up to four times a day.
For information about the growth state of vegetation the model uses LAI time series derived from SPOT-VEGETATION data available in 1 km $\times$ 1 km spatial resolution as so called 10-day-composites, which give a representative value for a ten day period. 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 (27 km) and on high resolution (1 km) 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. In collaboration with other PhD students connected via the Earth Observation System network (EOS network) of the Helmholtz Association, the presented work contributes to the understanding and solution process of these problems in semiarid areas resulting from global change. Our studies are included in the EOS topic “Global Change and Processes on the Land Surface” where specifically semiarid ecosystems are investigated facing the problem of desertification and land degradation. For this we started to adjust our model to the specific needs of the semiarid landscapes of South Africa, where first NPP maps with 1km spatial resolution for several years will be presented and discussed. Further steps will be the implementation of a phenology model to simulate plant growth and the development of an assimilation procedure to forecast the trend of the changes in the analysed ecosystems.