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Modelling and Validating Agricultural Biomass Potentials in Germany and Austria using BETHY/DLR

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Using process models to describe the carbon uptake by vegetation (Net Primary Production, NPP), has become an important tool to study the mechanisms of carbon exchange and to quantify the magnitude of terrestrial carbon sinks and sources. The German Remote Sensing Data Center (DFD) is operating the modified model BETHY/DLR (Biosphere Energy Transfer Hydrology Model) to simulate the carbon cycle in vegetated areas to estimate the NPP for different regions on regional to national scales. BETHY/DLR belongs to the family of dynamic vegetation models, which primarily compute the photosynthetic rate of vegetation types, taking into account the water balance and the radiative energy transfer between atmosphere, soil and vegetation. To determine NPP the amount of the cumulative plant maintenance respiration has to be subtracted from the Gross Primary Productivity (GPP), which is the output value of BETHY/DLR and is calculated daily. The model is driven by remote sensing data and meteorological data. As remotely sensed datasets time series about the Leaf Area Index (LAI), which describes the condition of the vegetation, and a land cover classification (GLC2000), which provides information about the type of land use, are needed. In addition meteorological datasets are used, i.e. precipitation, cloud cover, temperature and dew point temperature in 2m height, soil water content and wind speed, which are derived from the European Centre for Medium range Weather Forecast (ECMWF). They have a spatial resolution of about 0.5° x 0.5° and a temporal resolution of up to four times a day. The information about the soil water content of the four upper layers is used to initialize the soil water balance. It could be proven that in general a spin up phase of about one year is needed to reach equilibrium. Thenceforward the soil water content is computed dynamically. Photosynthetic active radiation is estimated considering the low, medium and high cloud coverage in conjunction with the solar zenith angle.

Information about the vegetation condition are delivered by time series of LAI, which are currently derived from SPOT-VEGETATION data available in a spatial resolution of 1km x 1km as so called 10-day composites. Land cover information is also derived from VEGETATION data (Global Land Cover 2000, GLC2000). The GLC2000 is representative for the year 2000 and provides 24 vegetation classes, which have to be translated into the currently 33 inherent vegetation types of BETHY/DLR, differing 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.

In order to validate the modelled NPP, data of crop yield estimates derived from national statistics of Germany and Austria are used to calculate above and below ground biomass by using conversion factors of corn to straw and leaf to beet relations. Furthermore conversion factors of above to below ground biomass are used. Finally the carbon content of dry matter is estimated. To correlate the modelled data with statistical results, they are aggregated to NPP per administrative district (NUTS-3 level). With this method a coefficient of determination (r^2) of about 0.67 combined with a slope of 0.83 is found for Germany. For Austrian NUTS-3 units an even slightly higher coefficient of determination is found (0.74) combined with a slope of 1.08. The results show that modelling NPP using the process model BETHY/DLR and remote sensing data and meteorological data as input delivers reliable estimates of above ground biomass when common agricultural conversion factors are taking into account.