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Estimation of Carbon Balance in Drylands of Kazakhstan by Integrating Remote Sensing and Field Data with an Ecosystem Model

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Abstract

A monitoring system based on the use of remotely sensed derived data and quantitative information from field investigations was developed for estimation of carbon balance in drylands of Kazakhstan. In this system, carbon fluxes were derived from the combination of incoming solar radiation, Leaf Area Index (LAI) computed from the Normalized Difference Vegetation Index (NDVI) resulting from the data of SPOT-Vegetation satellite, and a biological conversion factor known as Light Use Efficiency (LUE) which describes the ability of vegetation to convert light energy into biomass. The amount of incoming solar radiation and its photosynthetically active part (PAR) was computed from the variables of Earth-Sun distance, solar inclination, solar elevation angle, geographical position and cloudness information of localities at a daily time-step and than summed to 10-day values. The product of this calculation was corrected for slope and aspect using a Digital Elevation Map. The fraction of PAR absorbed by plant canopies (fPAR) was estimated from 10-day maximum values of NDVI. A LUE value for every vegetation type was obtained through calibration of peak biomass data collected from a number of test sites against the amount of PAR computed for each of these locations. The LUE was reduced from the computed optimum value by modifiers dependent on atmospheric vapour pressure deficits and temperature. Separation of above-ground and under-ground biomass production was made using a root-shoot ratio computed from field measurements for each vegetation type. Autotrophic respiration was estimated by a quantitative approach described in recent literature. All modelling results were converted to carbon amounts using factor 0.47 and then to fluxes. The end outputs of the monitoring system were maps of assimilation, respiration and stocks with a spatial resolution of 1-km and 10-day time-step. The regional monitoring system allows detailed information on an area-wide carbon balance to be extracted using remote sensing and ground truth data. Our model can be used to quantify carbon stocks and flows over the whole territory of Kazakhstan and can serve as a basic assessment system for annual reports for the Kyoto Protocol signed by the Government of the Republic of Kazakhstan in 2003.

Keywords: Carbon estimation, drylands, Kazakhstan, LUE, remote sensing

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