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Comparison of terrestrial ecosystem productivity of five ecosystem models and its relationship with climatic variables in the Sunderban Biosphere Reserve area, India

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Net ecosystem productivity (NEP) is the amount of carbon (C) stored by the biosphere through the process of photosynthesis, and terrestrial NEP is a major component of the global C cycle. NEP is defined as the difference between net primary productivity (NPP) and heterotrophic respiration (neglecting other terms such as fire and river runoff). Accurate quantification of net primary production (NPP) of a mangrove based ecosystem is essential to correctly estimate the terrestrial carbon pools and fluxes at any ecosystem scale and to understand its sensitivity to changes in climatic constituents and causative anthropogenic drivers. The present study incorporates five light use efficiency (LUE) models: Carnegie- Ames- Stanford-Approach (CASA), Eddy Covariance-Light Use Efficiency (EC-LUE), Vegetation Photosynthesis Model (VPM), Global Production Efficiency Model (GLO-PEM) and Moderate Resolution Imaging Spectroradiometer (MODIS) 17 (MOD17) model to estimate the NPP from 2000 to 2013 in the Sunderban Biodiversity Region (SBR), India. A significant declining trend of NPP was observed by the LUE models for different Land Use Land Cover classes (LULC) (Mangrove: R^2 = 0.27, followed by mixed forest: R^2 = 0.16 and cropland R^2 = 0.05 respectively). Amongst all climatic determinants, precipitation has been found to have an insignificant control on NPP (R^2 = 0.0001), whereas a high positive correlation was observed between annual solar radiation and NPP (R^2 = 0.67), followed by average temperature (R^2 = 0.53) and optimum temperature (R^2 = 0.51) with NPP. All the selected LUE models perform better in the areas occupied by cropland ecosystem (CASA & GLO-PEM: R^2 = 0.80, CASA & VPM: R^2 = 0.79 and CASA & MOD17: R^2 = 0.66), whereas comparatively higher unexplained variances ($>$ 20%) and uncertainty was detected in areas occupied by mangrove and mixed forest ecosystem. The biophysical parameters studied in this research includes - Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI) and Fraction of Photosynthetically Active Radiation (fPAR). These biophysical parameters found maximum in the post monsoon season and minimum in the summer and rainy season. Unexplained variances in the model's predicted NPP can be attributed to the varied structural construction and climatic and environmental stress components used to drive the model. Amongst all models, EC-LUE, CASA, GLOPEM and VPM could explain largest variances ($>$ 60 %) in the datasets, compared to that of MOD 17 model ($>$ 35 %). Results reveals that GLOPEM and VPM are the best pair model having minimum unexplained variances (R^2 = 0.94, RMSE = 68 gC m^{-2} $year^{-1}$). Likewise, a significant declining trend of NPP (R^2 = 0.34) has been found during this survey period. As regards spatial distribution of NPP, it was found to be highest in the south-eastern part of mangrove forested region ($>$ 800 gC $m^{-2}year^{-1}$). An improved surface moisture dynamics (especially using VPM approach), and the model structural formulation is required to enhance the performances of the chosen models in the Sunderban Biosphere Reserve ecosystem where robust flux network based real time measurement is not available.