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Estimating Regional Effects of Climate Change and altered Land Use on Biosphere Carbon Fluxes using Distributed Time Delay Neural Networks with Bayesian Regularized Learning

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Abstract

The ability to accurately predict changes of the carbon and energy balance on a regional scale is of great importance for assessing the effect of land use changes on carbon sequestration under future climate conditions. Here, a suite of land cover-specific Distributed Time Delay Neural Networks with a parameter adoption algorithm optimized through Bayesian regularization was used to model the statewide atmospheric exchange of CO_2, water vapor, and energy in Oregon with its strong spatial gradients of climate and land cover. The network models were trained with eddy covariance data from 9 atmospheric flux towers. Compared to results derived with more common regression networks utilizing non-delayed input vectors, the performance of the DTDNN models was significantly improved with an average increase of the coefficients of determination of 64%.

The optimized models were applied in combination with downscaled climate projections of the CMIP5 project to calculate future changes in the cycle of carbon, associated with a prescribed conversion of conventional grass-crops to hybrid poplar plantations for biofuel production in Oregon. The results show that under future RCP8.5 climate conditions the total statewide NEP increases by 0.87 TgC per decade until 2050 without any land use changes. With all non-forage grass completely converted to hybrid poplar the NEP averages 32.9 TgC in 2046-2050, an increase of 9%. Through comparisons with the results of a Bayesians inversion study, the results presented demonstrate that DTDNN models are a specifically well-suited approach to use the available data from flux networks to assess changes in biosphere-atmosphere exchange triggered by massive land use conversion superimposed on a changing climate.