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MODELING AND ANALYSIS OF VEGETATION-CLIMATE INTERACTIONS USING NEURAL NETWORKS AND GENERALIZED LOGIT MODELS

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The importance of biosphere-climate interactions for energy and moisture balances and major biogeochemical cycles is well recognized. Climate change is expected to alter the functioning and distribution of major ecosystems. These changes have been investigated using global vegetation transfer models. Typically, these models are correlative in nature and use heuristics in the form of process based rules to classify vegetation types for a given set of climatic and soil variables. Based on these models and future climate scenarios from GCMs the global distributions of ecosystems in a $2XCO_2$ world are derived. In this paper, we describe probabilistic modeling approaches that use functional relationships between a set of explanatory variables and occurrence of vegetation types. Probabilistic models differ with the traditional transfer models in that they estimate the probability of occurrence for a particular vegetation type under different climatic and geomorphologic conditions. In transfer models, on the other hand the response is Boolean in nature. Therefore, probabilistic models provide a more robust way of characterizing a variety of climate vegetation interactions.

We use two different approaches for obtaining functional relationship between explanatory (e.g. climatic and geomorphologic variables) and ecosystem/vegetation occurrence. The first approach uses a multinomial generalized logit scheme to identify statistically significant explanatory variables and compare relative contribution of different explanatory variables in determining prevalent vegetation class. A major drawback of this approach is that it does not provide good approximation for the highly non-linear relationships between occurrence of vegetation/ecosystems and the set of explanatory variables. We address this concern using neural network models. Neural networks provide computationally efficient means for modeling highly nonlinear relationships between sets of input and output vectors, i.e., between prevalence of chosen ecological responses and a set of explanatory variables.

Two types of responses were used :1) aggregated Olson ecotypes and 2) Plant Functional Types. Considered explanatory variables were mean temperature of the coldest and warmest months, lowest and highest average monthly precipitation, potential evapotranspiration, soil properties, distance to the nearest human settlement/agricultural area and water bodies, spatial characteristics of neighborhood and elevation. These responses and dependent variables were derived from available global databases. The results of the modeling were compared to the present day distributions of ecosystems from the Olson database. Climate scenarios derived from the MECCA database were used to estimate possible changes in ecosystem areas. Using a range of estimated carbon densities for each ecosystem, we estimate the carbon exchange between the terrestrial ecosystem and atmosphere resulting from changes in ecosystem areas.

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