Future ranges of tropical tree species under climate change : improving the predicting capacity of a dynamic vegetation model

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Description:

Climate change is expected to severely impact the distribution of plant species in the future on all continents. This may have huge consequences for the ecosystems and the services they provide to human populations.

Species range projections for the future are often made with niche-based models (NBM). These are statistical models that establish empirical relationships between the distribution of a species and the climate variables. Another type of model is also commonly used to project the impact of climate change on vegetation: the dynamic vegetation models (DVM). These models are process-based. They are most often used for large groups of plant species (the so-called plant functional types, PFT, such as, the needle leaf trees or the broadleaf deciduous trees in temperate regions), for instance to project the carbon budget of ecosystems into the future. However, a few DVM can be run at the species level. They can then become very powerful tools to project the current ranges of plant species into the future and to assess the risk of reduction of their distribution, or even the risk of species extinction, in the face of climate change. Indeed, these models integrate ecological and physiological processes governing the growth of the species. However, they need a careful calibration and validation at the species level, to increase their predictive capacity, since up to now these models have mostly been used at the PFT level.

Our laboratory has developed such a species-based DVM: the CARAIB model. A recent comparison of CARAIB with a NBM (MaxENT) for more than 50 tropical tree species of South America showed two phenomena.

First, the DVM projected clearly larger present-day distributions than the NBM. Now, NBMs are recognized for their good ability to project the realized niche (ecosystem position taking into account the biotic interactions) and the current distributions. This raised the hypothesis that the DVM is able to predict the fundamental niche of the species, i.e. the distributions when the species are not limited by their parasites or predators. The natural enemies constrain species distributions to their most favourable climatic regions, where also the species are the most efficient. Indeed, in these conditions, the plants are able to grow rapidly and to replace their injured parts and they produce more secondary metabolites allowing them to poison their predators. The first objective of the master thesis would be to test the efficiency of one or several climate constraints in the model on its predictive power.

Secondly, the predictive power of the DVM shrank when the number of presence coordinates was low (< 20). The coordinates allow the determination of bioclimatic thresholds. It is probable that the information with small numbers of presence data did not encompass enough the thresholds. This raised the hypothesis that the use of the density distributions of the climatic factors would allow to determine with more precision the bioclimatic thresholds. The second objective of the master thesis would be to test this hypothesis.

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