Integrating ecological dependencies in biodiversity modelling

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Supervisors

Wilfried Thuiller, Laboratoire d'Ecologie Alpine
Julyan Arbel, Inria

Context

Understanding the ecological processes driving the distribution of life on Earth has always been a central goal of Ecology. Nowadays, this knowledge is also crucial to project how biodiversity from various ecosystems will respond to global changes in order to propose adaptation and mitigation measures to safeguard biodiversity and associated ecosystem functions. Statistical ecology has arisen as a discipline that moves away from describing biodiversity patterns towards attempting to model the output of the ecological processes that generate these patterns. However, many statistical models apply to ecology, assumed independence between the modelled entities. For example, Species Distribution Models (SDMs) predict the distribution of each species in an ecosystem as a function of some environmental covariates, but independently of other species. However, we know that species interact, and how these biotic interactions shape biodiversity patterns even at large scale. Trait distribution models (TDMs) suffer from the same lacks in the context of functional traits, that are strongly characterised by trade-offs and synergies. These are just two ecological dependencies that drive biodiversity distribution and ultimately ecosystem functioning. The aim of the thesis is therefore to integrate these ecological dependencies in biodiversity modelling.

Methods and objectives

The thesis is structured along three main axes:

- **State of the art of species community models.** Here, the student will first review the state of the art of Joint Species Distribution Models, and specifically, propose a methodological extension to improve computation time and ecological realism in a second time. Third, he will rigorously analyze the mathematical differences of JSDM with respect to SDMs to provide a guide to quantative ecologists.
- **Including Biotic interactions into species community models.** Here, in a first step, the aim is to propose a framework to account for biotic interactions in species distribution models, when the knowledge on the species interaction network is available. Such a method will be applied to predict the distribution of vertebrates in Europe given their known trophic interactions. As an extension of this work, it would also be possible to propose a method for inferring the fundamental niche of species when biotic interactions are not explicitly known.

- **Accounting for phenotypic integration into trait distribution modelling.** Shifting to another side of the multi-faceted concept of biodiversity, the student will propose suitable methodologies to account for dependencies in traits distribution. He will first apply both 'assemble first predict later' and 'assemble later predict first' strategies (Ferrier and Guisan, 2006) to community-weigthed mean regression, highlighting the ecological hypothesis underlying them. Second, we aim to model how traits dependencies evolve along environmental gradients, to better understand trait trade-offs. Finally, we want to go further CWM, proposing a method that allows to model intra-specific trait variation, while taking into account trait trade-offs.

Pratical informations

The PhD fellowship will start on November 1st 2019. It will be funded by the GAMBAS project involving six partners (CIRAD, IRSTEA, CNRS, MNHN, Univ de Montpellier and Paris-Sud Orsay). The PhD student will be based at the Laboratoire d'écologie Alpine de Grenoble.

References

Ferrier, S. and Guisan, A. (2006). Spatial modelling of biodiversity at the community level. *Journal of Applied Ecology*, 43(3):393–404.