Freshwater Species Distribution Models

Researchers
M. Kuemmerlen, S. Domisch, D. N. Shah, S. Jähnig, S. Pauls and S. Stoll

Principal Investigator
Prof. Dr. Peter Haase

Project Term
2010 - 2014

Project Areas
Atmospheric Science, Oceanography and Climate Research

Clusters
LOEWE CSC Cluster Frankfurt

Institute
Senckenberg Forschungsinstitut und Naturmuseum Frankfurt / GU

University
Goethe Universität Frankfurt am Main

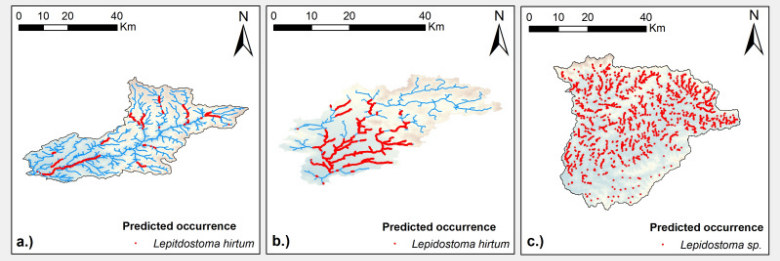


Fig. 1: Mapped predicted probability of occurrence for Lepidostoma hirtum or Lepidostoma sp. in 3 different catchments: a) Kinzig River catchment in Hesse, Germany; b) Treene River catchment in Schleswig-Holstein, Germany; c) Changjiang River catchment in Anhui and Jiangxi, China.

Introduction

Studies applying species distribution models (SDMs) have multiplied exponentially over the last years, however only few deal with freshwater ecosystems. As streams and rivers have environmental conditions that diverge strongly from terrestrial and marine habitats, adaptations have been explored on how SDMs can be applied in freshwater ecosystems in order to improve model performance and prediction accuracy[1-3].

Methods

SDMs are mostly applied to large areas, from the regional to the continental scale (> 10.000 km2) at rather coarse spatial resolutions (> 1 km2). These models support research for large taxonomic groups across wide areas[4]. The main outcomes of such models are continuous distribution predictions for single species and the relative importance of the environmental predictors that drive the distribution model. Frequently, predictions for the future are also made, based on future climate scenarios. These distribution predictions give hints on possible developments in the occurrence ranges of single species. In most cases, warm-adapted species expand their predicted distributions, while endemic and cold-adapted species see their suitable habitats reduced[5]. Freshwater SDMs have also been applied to much smaller scales (< 10.000 km2), at finer spatial

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN
TECHNISCHE UNIVERSITÄT DARMSTADT
UNIKASSEL VERSITÄT
Philipps Universität Marburg

resolutions (< 1 km2) (Fig. 1). This approach has focused on the catchment, using the stream network as a modeling extent, rather than continuous surfaces. In this way, environmental predictors unique to freshwater ecosystems can be included, such as discharge and flood events[6]. In addition, common predictors such as land use are adapted as to portray the hierarchical framework of stream networks[3].

Results

The combination of these properties has yielded improved predictions and model performance. Small scale freshwater SDMs have many potential applications as a regionally focused decision support tool in scientific monitoring, environmental conservation and landscape planning.

Discussion

Developed models have mainly focused on Europe and particularly Germany, but there are also experiences in China (Fig. 1). Large and small scale SDMs are built as ensemble models and consist of several replicates using different algorithms and allocation of pseudo-absences (random non-occurrences required to calibrate the model). Thus, for each species modeled, replicates can easily exceed 100 and many species are frequently modeled in parallel, which makes remote computing power absolutely necessary.

Outlook

Ongoing research further develops small scale (high resolution) freshwater SDMs applied to the Kinzig catchment (Hessen) using data from Senckenbergs long term ecological research (LTER) site Rhein-Main-Observatorium. Further applications are also ongoing or planned at regional and continental scales.

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN
TECHNISCHE UNIVERSITÄT DARMSTADT
UNIKASSEL VERSITÄT
Philipps Universität Marburg

Reference

[1] S.C. Jähnig, M. Kuemmerlen, J. Kiesel, S. Domisch, Q. Cai, B. Schmalz et al. (2012), Modelling of riverine ecosystems by integrating models: conceptual approach, a case study and research agenda. J Biogeogr. 39: 2253–2263. https://doi.org/10.1111/jbi.12009

[2] S. Domisch, M. Kuemmerlen, S.C. Jähnig, and P. Haase (2013), Choice of study area and predictors affect habitat suitability projections, but not the performance of species distribution models of stream biota. Ecol Model. 257: 1–10. https://doi.org/10.1016/j.ecolmodel.2013.02.019

[3] M. Kuemmerlen, B. Schmalz, B. Guse, Q. Cai , N. Fohrer, and S.C. Jähnig (2014), Integrating catchment properties in small scale species distribution models of stream macroinvertebrates. Ecol Model. 277: 77–86. https://doi.org/10.1016/j.ecolmodel.2014.01.020

[4] D.N. Shah, S. Domisch, S.U. Pauls, P. Haase, and S.C. Jähnig (2014), Current and Future Latitudinal Gradients in Stream Macroinvertebrate Richness Across North America. Freshw Sci. 33: 1136–1147. https://doi.org/10.1086/678492

[5] Domisch, M.B. Araújo, N. Bonada, S.U. Pauls, S.C. Jähnig, and P. Haase (2013), Modelling distribution in European stream macroinvertebrates under future climates. Glob Change Biol. 19: 752–762. https://doi.org/10.1111/gcb.12107

[6] M. Kuemmerlen, S. Domisch, B. Schmalz, Q. Cai, N. Fohrer, and S.C. Jähnig (2012), Integrierte Modellierung von aquatischen Ökosystemen in China: Arealbestimmung von Makrozoobenthos auf Einzugsgebietsebene. Hydrol Wasserbewirtsch. 56: 185–192. https://doi.org/10.5675/HyWa_2012,4_3

Last Update: 2020-08-27 16:19