Final scientific report

1. General information

Project title: Challenges and promises of using predictive, spatially continuous variables in species distribution models: methods and applications

Workshop number: 45-510: 002

Dates and location: 05-09.02.2018, University of Zurich, Switzerland

2. Description of the Workshop

2.1 Preamble

In the planning phase of the workshop, an opportunity arose to co-develop an event with the GlobDiversity project of Prof. Michael Schaepman, chair of bioDISCOVERY, and thereby bring together members of the ecological modelling, biodiversity assessment, and remote sensing communities for an entire week. The workshop was organized in two parts: the first one, under the responsibility of the Global Mountain Biodiversity Assessment, bioDISCOVERY, and the Global Land Programm focused on the use of Remote Sensing (RS) data for informing Species Distribution Models (SDMs). The second one, under the responsibility of the GlobDiversity project officers, focused on data requirements for the development of ecologically useful RS-enabled Essential Biodiversity Variables (EBVs). Deficit guaranties and co-funding were obtained from the Swiss National Science Foundations and the University of Zurich.

2.2 Activities

The first half of the workshop, with a focus on the use of Remote Sensing (RS) data for informing Species Distribution Models (SDMs), started with a series of open keynote lectures delivered by international experts on various aspects of species distribution modelling and biodiversity monitoring in the Anthropocene. Following these lectures, which attracted numerous scientists from Swiss research institutions, the approximately 40 workshop participants sat together for a first discussion about the three main objectives of the workshop: (1) review how the RS and SDM communities currently benefit from each other; (2) explore the methodological and conceptual challenges of using RS data in SDMs, in particular those associated with measurement errors and error propagation, using mountain-specific case studies; and (3) evaluate how high spatial resolution remotely sensed Essential Biodiversity Variables (EBVs) can contribute to large scale biodiversity monitoring and simultaneously inform local SDMs. The outcomes of this discussion included a clear repartition of the workshop participants into two working groups and a preliminary outline of ideas to develop during the subsequent days. The second day of the workshop was spent in two working groups who reconvened twice for plenum summaries and discussions. The first working group, led by Dr. Christophe Randin, focused on the first and third objective of the workshop and developed the outline of a perspective paper summarizing the needs, opportunities, and challenges of ecological distribution models and Earth Observations (EO) in the Anthropocene. The second working group, led by Prof. Nigel Yoccoz, focused on the second objective and on applied case studies illustrating opportunities and shortcomings of using current EO products for modelling species distribution in mountain regions. In the morning of the third day, the working groups focused on their paper outlines and on identifying the next steps. This first part of the workshop ended with a talk summarizing key messages and laying

the ground for the subsequent discussions focused on the development of EBVs observed with remote sensing (RS-enabled EBVs).
The first afternoon of the second part of the workshop was dedicated to public talks on EBVs and biodiversity assessment with RS techniques, delivered by selected high-level international workshop participants. Following the first series of public talks delivered on Monday, these interventions were equally well attended by the public and researchers from the University of Zurich (UZH) and other Swiss institutions. Due to the speakers' diverse background in RS predictions of terrestrial ecosystems (P. Moorcroft, Harvard University), global coordination for biodiversity monitoring (N. Fernandez, Group on Earth Observations Biodiversity Observation Network, GEO BON) or development of satellite missions (D. Schimel, JPL & NASA), the audience was given a broad background on current developments in these topics. The afternoon was then closed with an inspiring panel discussion on the general topic of how RS-enabled EBVs provide information about global biodiversity. The fourth and fifth day of the workshop were dedicated to discussions on four RS-enabled EBVs. Thanks to the high number of participants, all four RS-enabled EBVs that are part of the GlobDiversity project could be covered instead of the three mentioned in the proposal. The workshop participants were split into smaller groups for fruitful discussion depending on their field of expertise and interest. Next to break-out groups on land surface phenology (led by UZH), fragmentation (led by Wageningen University & Research) and canopy chlorophyll (led by University of Twente), the fourth break-out group on vegetation height, also lead by UZH, discussed user needs and applications. The discussions focused on how the biodiversity community should define and communicate their observation requirements for the RS-enabled EBVs to both GEO BON and various space agencies, following a bottom-up approach. The structure of a strategic document for bottom-up communication of requirements was tested with the four different RS-enabled EBVs and highly valuable input for defining crucial requirements for the use of RS-enabled EBVs in biodiversity conservation was already given. The participation of both ecologists and RS-specialists allowed for a comprehensive assessment of interests in these two communities of research and expertise.

2.3 Results

The 2015 seminal review by He and co-authors clearly demonstrates that improvements can be achieved in SDMs by using RS to ameliorate occurrence data and spatially explicit predicting variables. However, the pace at which both SDMs evolve and EO technologies improve calls for a regular re-evaluation of the opportunities for achieving rapid and safe assessments of biodiversity and of its spatio-temporal response to drivers of global change in the Anthropocene, as well as of the pitfalls associated with rapid developments in different communities of expertise. With experts from both the SDMs and the EO field, the first working group was perfectly suited for such a necessary evaluation. The two days of discussions led to a robust manuscript outline, organized around the following sections: (1) a review of the remotely sensed datasets and products that are available to ecological modelers; (2) a review of five key ways in which remotely sensed data could improve ecological modelling and a discussion of whether current products indeed do so (and why they don't); (3) a discussion of how the needs and expertise of ecologists can help shape the future of remote sensing technologies as well as data collection, and facilitate collaborations; and (4) a review of some remaining challenges associated with the integration of RS data into distribution models. Beyond informing on the distribution of biodiversity regionally and globally, the combination of remotely sensed data products with species occurrences in advanced ecological models offers great promise for conservation planning, policy advice, and progress towards meeting the sustainable development goals. Challenging existing data, methods, and concepts as this working group did and is currently reporting on, is therefore crucial for

identifying existing and creating new opportunities to achieve robust and rapid progress in inter-disciplinary biodiversity science and policies.

The work performed in the second working group greatly complements the above summarized conceptual efforts by offering a data-based assessment of the benefits of existing EO products for the delivery of detailed knowledge on ecological variables and their spatio-temporal response to drivers of global change. By looking at the statistical structure of the error made by complementing local climate measurements with gridded EO data from various sources and quantifying different error components, the analyses initiated during the workshop contributes to addressing some fundamental challenges associated with the use of EO in ecological models and biodiversity conservation. The specific focus on mountains chosen for this work, and the use of data from four starkly different mountain regions (Switzerland, northernmost Fennoscandia, Ethiopia-Kenya, and Northwest Argentina) is particularly important as the conservation of mountain ecosystems is explicitly prioritized in the sustainable development agenda and the challenge of achieving high accuracy in climatic as well as ecological predictions is exacerbated by many mountain-specific characteristics (e.g., topography) that create complex climatic and biological patterns.

The second half of the workshop focused on the definition of the RS-enabled EBVs and of the satellite observations required for biodiversity assessment and monitoring. The fruitful discussion about the definition and the use of the different RS-enabled EBVs served as a broad community consultation. The input of the workshop and the resulting report will be used to update the project's assessment of data requirements for the design of RS-enabled EBVs, as a reference for future developments, and as a baseline for the GlobDiversity project partners in designing and developing the data underlying the four focus RS-enabled EBVs. Co-authorship by both ecologists and RS-specialists renders this report particularly relevant for co-designing Research and Development agendas in the future but also for improving the uptake of concepts and methods in the different communities. The document is planned to be published within the GEO BON community, which is the responsible institution for devolopping the EBV-framework (observed with RS or other data networks).

The planned deliverable as initially proposed consisted of (i) a journal publication describing and discussing benchmark cases developed during the workshop on how to safely integrate spatial predictive variables in SDMs; (ii) a roadmap expected to address methodological needs but also data requirements and conceptual requirements associated with different applications; and (iii) a statistics R-library for using spatially continuous data in species distribution models.

The actual deliverables consist of two publications (planned for the second half of 2018) and one report:

(1) Randin et al.: Observing the Anthropocene: Integrating remote sensing in ecological distribution models
(2) Yoccoz et al.: Towards more accurate climate data for ecological predictions and sustainable development planning in mountain regions using remote sensing
(3) GlobDiversity report

Together, these three outputs go beyond deliverables (i) and (ii) above. The planned deliverable (iii) was not pursued as three of the workshop participants (Profs. Antoine Guisan, Wilfried Thuiller, and Niklaus Zimmermann) published in 2017 a book entitled "Habitat Suitability and Distribution Models: With Applications in R" that includes relevant tools.