Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA18201

Grantee name: Ward Fonteyn

Details of the STSM

Title: Accounting for extreme climatic events in tree species distribution modelling to inform climate-smart forestry practices

Start and end date: 01/06/2022 to 29/07/2022

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

(max. 500 words)

After a literature survey at the start of the STSM, two approaches to incorporating extremes into species distribution modelling (SDM). The first approach relies on detailed data and the choice of variables and thresholds dependent on the specific species or set of species being studied. The second approach is more general and uses only relatively coarse data, while being species-agnostic. As planned in the application of this STSM, we selected the second approach, building on publications by Zimmerman et al. (2009) and Stewart et al. (2021). It is therefore also against the methods put forward by these publications that we evaluate the improvements made by the methodology we developed.

Relying on the extreme value theory, which states that a sample of extremes follows the Generalised Extreme Value (GEV) distribution, characterised by three parameters: the location, scale and shape. We calculated the GEV parameters for Europe using the Terraclimate dataset for three bioclimatic variables: the minimum temperature of the coldest month, the maximum temperature of the hottest month and the precipitation of the driest quarter. Having three parameters, and explicitly quantifying the skew of thedistribution represents a key advancement over poses a benefit compare to using the normal distribution, as in Zimmerman et al. (2009), or using ad-hoc empirical quantiles, as in Stewart et al. (2021).

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

Instead of using occurrence records obtained from the GBIF and BIEN datasets, which were found to be lacking for tree species in Europe, we used the EU-Forest dataset, an aggregation of European national forest inventories. Using this dataset as presence-absence records, we constructed boosted regression trees models based on different approaches: a base model using only the mean, a model following Zimmerman et al. (2009) using the mean and standard deviation, a set of models following Stewart et al. (2021) using the mean and return levels for different return periods based on the empirical density function, and finally a model using the three GEV parameters.

In order to evaluate the improvement resulting from our novel approach, both random and spatially blocked cross validation was performed, using different metrics such as the AUC and TSS to quantify model performance.

As the aforementioned analysis showed much promise, the second part as described in the STSM application, concerning the use of a more detailed occurrence dataset developed at the host institution, was not carried out. Instead, the extra time was used to further develop and expand the analysis and evaluation of species distribution models using the GEV parameters.

Description of the STSM main achievements and planned follow-up activities

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

(max. 500 words)

The Goal of this STSM was foremost to improve the incorporation of extreme events in SDM. We succeeded in developing a novel method that achieved this goal during this STSM.

Calculating the GEV distribution parameters allows us to incorporate not only the centre and spread of a variable, but also the shape or skew into species distribution models. This approach showed improved model performance compared to the benchmark approaches based on the publications of Zimmerman et al. (2009) and Stewart et al. (2021), indicating that these three parameters can better capture the dynamics of extreme variables. Explicitly capturing the shape parameter allows us to differentiate between environments where values for extreme variables are bounded, never exceeding a certain threshold, and where they are heavy tailed. In the light of climate change, this explicit capturing can be important, as changes in shape do not necessarily correlate with changes in centre or spread characteristics.

The developed approach relies only on broadly available, monthly climate data, making it easily adoptable. Additionally, as no assumptions are made apart from dealing with extreme values, this approach can be applied to any species and any extreme variable. This means that animal and plant species other than trees, as well as rare or threatened species can benefit from this method. In this way, we intend to aid in filling knowledge gaps regarding extreme events for species distribution modelling (fitting in the objective of working 3).

We aim to publish the results of the analysis performed in this STSM as a high-impact, peer-reviewed journal article in an open-access journal later this year. Further, this analysis will be applied to develop more in-depth species distribution models for tree species in Europe in a continuation of my PhD research project. Results of which could better inform the management and by extension conservation of forest in Europe, contributing to the large proportion of threatened red list species residing in those habitats.

During this two-month STSM, I have gained a more detailed understanding in species distribution modelling. I focused mainly on boosted regression trees models, but also gained some experience with other modelling techniques such as MaxEnt. Additionally, in order to properly evaluate and contrast the different modelling approaches, I gained a better understanding of many performance metrics and cross-validation methods. Finally, I enjoyed a welcoming and creative working environment, providing me a new perspective and reference point on collaboration and the scientific process.