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Decomposing the uncertainty in climate impact projections of Dynamic Vegetation Models: a test with the forest models LANDCLIM and FORCLIM

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Different levels of uncertainty should be considered in climate impact projections by Dynamic Vegetation Models (DVMs), particularly when it comes to managing climate risks. Such information is useful to detect the key processes and uncertainties in the climate model - impact model chain and may be used to support recommendations for future improvements in the simulation of both climate and biological systems. In addition, determining which uncertainty source is dominant is an important aspect to recognize the limitations of climate impact projections by a multi-model ensemble mean approach. However, to date, few studies have clarified how each uncertainty source (baseline climate data, greenhouse gas emission scenario, climate model, and DVM) affects the projection of ecosystem properties.
Focusing on one greenhouse gas emission scenario, we assessed the uncertainty in the projections of a forest landscape model (LANDCLIM) and a stand-scale forest gap model (FORCLIM) that is caused by linking climate data with an impact model.
LANDCLIM was used to assess the uncertainty in future landscape properties of the Visp valley in Switzerland that is due to (i) the use of different 'baseline' climate data (gridded data vs. data from weather stations), and (ii) differences in climate projections among 10 GCM-RCM chains. This latter point was also considered for the projections of future forest properties by FORCLIM at several sites along an environmental gradient in Switzerland (14 GCM-RCM chains), for which we also quantified the uncertainty caused by (iii) the model chain specific statistical properties of the climate time-series, and (iv) the stochasticity of the demographic processes included in the model, e.g., the annual number of saplings that establish, or tree mortality.

Using methods of variance decomposition analysis, we found that
(i) The use of different baseline climate data strongly impacts the prediction of forest properties at the lowest and highest, but not so much at medium elevations.
(ii) Considering climate change, the variability that is due to the GCM-RCM chains is much greater than the variability induced by the uncertainty in the initial climatic conditions.
(iii) The uncertainties caused by the intrinsic stochasticity in the DVMs and by the random generation of the climate time-series are negligible.

Overall, our results indicate that DVMs are quite sensitive to the climate data, highlighting particularly (1) the limitations of using one single multi-model average climate change scenario in climate impact studies and (2) the need to better consider the uncertainty in climate model outputs for projecting future vegetation changes.