Geophysical Research Abstracts
Vol. 21, EGU2019-1225, 2019
EGU General Assembly 2019

A new approach for assessing climate change impacts in ecotron experiments

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Studying climate change effects on terrestrial ecosystems requires manipulating climate variables as well as monitoring ecosystem processes at multiple spatio-temporal scales. Ecotron facilities allow accurate control of many environmental variables coupled with extensive monitoring of ecosystem processes. They therefore require multivariate perturbation of climate variables, close to what is observed in the field and to projections for the future.

Here we present a new experimental design for studying climate change impacts on terrestrial ecosystems and apply it to the UHasselt Ecotron Experiment, an infrastructure consisting of 12 climate-controlled units, each equipped with a lysimeter containing a dry heathland soil monolith extracted from the National Park Hoge Kempen in Belgium. The new methodology consists of generating climate forcing along a gradient representative of increasingly high global mean temperature anomalies and uses data derived from the best available regional climate model projection under Representative Concentration Pathway (RCP) 8.5. The six units thus follow a global mean temperature gradient, representing conditions of a 0° (pre-industrial), +1° (present-day), + 1.5°, +2°, +3° and +4° warmer world.

We first identified the best performing regional climate model (RCM) simulation for the ecotron site from the Coordinated Regional Downscaling Experiment in the European Domain (EURO-CORDEX) ensemble with a 0.11° (12.5 km) resolution based on two criteria: (i) highest skill of the reanalysis downscaling and global climate model (GCM) downscaling compared to observations from a nearby weather station and (ii) the trend of the simulation for the future can be no outlier compared to the multi-model mean.

The results reveal that no single RCM simulation has the best score for all possible combinations of the four meteorological variables and ten evaluation metrics that were considered. Therefore, weights were subjectively assigned to those variable/metric combinations that were judged most important for this particular experiment. The model simulations deviated most for precipitation, with values ranging up to double the observed values. Because of these large absolute differences and the fact that precipitation is a very important variable for the ecosystem, the absolute bias of precipitation served as a decisive factor to choose the CCLM4-8-17/EC-EARTH simulation as climate forcing for the ecotron experiment. The time window is subsequently selected from the RCM projection for each ecotron unit based on the global mean temperature of the driving GCM. The ecotrons are forced with 3-hourly output from the RCM projections of the five-year period spanning the year in which the global mean temperature crosses the predefined values.