Geophysical Research Abstracts
Vol. 14, EGU2012-10953, 2012
EGU General Assembly 2012

A sensitivity study on the impacts of climate change on European tree species distribution based on ENSEMBLES RCMs

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Climate change will affect the distribution of European forest tree species. The aim of our study is to analyse the shift of some of the most common species (Norway spruce, Picea abies; European beech, Fagus sylvatica; Scots pine, Pinus sylvestris; Sessile oak, Quercus petraea) under projected future climate change conditions. The use of a multi-model regional climate change ensemble dataset thereby allows for a better quantification of the uncertainties of such distribution shifts. Bioclimatic envelopes are a well-established and straightforward method to determine the climatic growth conditions of a specific forest tree species and hence also for approximating the impacts of climate change. For that reason they are commonly used as decision support tools to determine forest management strategies. Here we present a sensitivity study that is part of the Interreg IV B NWE ForeStClim project. It uses a basic bioclimatic envelope approach based on annual mean air temperatures and precipitation sums during the growing season. Data on the present-day natural tree species distribution is derived from the 'Map of the Natural Vegetation of Europe'. As climatic inputs, we use daily air temperature and total precipitation simulation results from regional climate models (RCMs) at 25km spatial resolution. These are derived from 13 different modelling chains, combining the SRES A1B emission scenario with overall four different global climate models and eight RCMs (dynamical downscaling) as run within the ENSEMBLES project. To ensure an overall consistent, extensible and easy-to-handle dataset, the RCM control (1951 to 2000) and projection (2001 to 2100) simulation results undergo an extensive automatic pre-processing, consisting of data retrieval, restructuring, grid transformation to a common equal area grid, different bias correction methodologies and finally extraction and various spatio-temporal aggregations. The bias correction effectively reduces systematic biases in the RCM outputs; it uses the ENSEMBLES Observations gridded dataset (E-OBS) as reference data. Changes in annual mean temperature, total precipitation and the growing season between the far future (2069 to 2089) with reference to present-day conditions (1961 to 1990) are shown including the bandwidths of the change signals. Detailed information from a previous study on tree species bioclimatic envelopes and distribution shifts for a region in Western Germany is used for validation. Per tree species we analyse (1) changes in the bioclimatic envelopes for the existing present habitats as well as (2) European-wide maps on tree species distribution shifts. Due to the multi-model ensemble approach, we are able to classify the results based on different levels of uncertainty (or rather likeliness) e.g. the lowest level of uncertainty is assigned if all ensemble members project the same tree species at the same grid element.