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LIFE+ PROJECT NAME or Acronym

Climate change indicators and vulnerability of boreal zone applying innovative observation and modelling techniques

Data Project

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1 Summary

This report describes availability and processing of the climatic data that is used for driving the two ecosystem models JSBACH and PRELES utilized in Actions B4, B5 and B6. Characteristics and usability of gridded regional climate hindcasts and predictions (that is, past and future climate) are tackled. The bias corrections needed to achieve reliable regional forcing data in the required spatial and temporal resolutions are explained. Furthermore, the requirements by both models for their driving data are described in the report. The report is structured as follows: First we give an introduction on the existing climate projection data sources and on bias correction approaches; Second, we explain the driving data needs of both MONIMET models; Third, we describe the current climate driving data that is produced in this project and currently used for model calibration, then we describe the data primarily intended to use for scenario runs in this project, and finally we introduce optional data sources for the project.

2 Introduction

In order to contain the covariation of the climatic variables, the data for driving impact models have to be derived from a complete and consistent dataset that provides simultaneous estimates (modelled or measured) of all the variables the impact model needs, with the time resolution the impact model operates on. In our project the impact models are land ecosystem models JSBACH and PRELES. The correct covariation of drivers is central for capturing the dynamics of concurrent, non-linear land ecosystem processes. For current climate (in this project, the hindcasts through past 30 years) good driving data options include gridded homogenized measured data, re-analysis data, such as ERA data products of ECMWF (European Centre for Middle range Weather Forecasts), or regional climate model data driven with boundary data from re-analysis products.

For global climate projections the most up to date sources are the last two Coupled Model Intercomparison Projects, CMIP3 (Meehl et. al., 2007) and CMIP5, targeted for the 4th and 5th IPCC Assessment Report, respectively (http://cmip-pcmdi.llnl.gov/). In the CMIP projections the driver of the climate change predicted by global climate models (GCM, also: general circulation model) are the changes of greenhouse gas (GHG) concentrations in the atmosphere due to burning of fossil fuels and land cover changes. In CMIP3 the prospected changes of these largely anthropogenic sources is given in the Special Report on Emissions Scenarios (SRESs). The total number of SRES is 3 and the amount of CMIP3 models is 25. In CMIP5 the development GHG concentrations and land use changes are prescribed according to optional representative concentration pathways (RCPs). There are altogether four RCPs; RCP2.6, RCP4.5, RCP6.0 and RCP8.5, ordered by increasing severity of the climate impact. Altogether 28 models participated CMIP5. In the following, both different SRESs and RCPs are called scenarious. The regional climate projection studies ENSEMBLES and is successor CORDEX (http://cordex.dmi.dk/joomla/) focus on selected regions with relatively high spatial resolution using climate projections from global models as lateral boundary. Thus the GHG concentration scenarios and global land cover changes of regional projects follow those of the driving model.

Modeled climate variable statistics are often biased from observations over a period of time representing mean climate. Biases are inherent in both global and limited area climate simulations, partly model specific, and their magnitudes vary regionally. Various calibration strategies have been develop to account for the impact of these biases in future climate predictions. The strategies typically take either a bias-correction or a delta-change approach (Ho et al., 2012; Räisänen & Räty, 2013; Räty et al., 2014). The former stategy assumes that current day deviations between the model and the observations will persist in the future simulations whereas the latter approach adopts the climate change signals from the model and apply those to the present observations to gain the unbiased future climate. Regardless of the selection of the principal calibration strategy, there is still the form of the transfer function to be selected. Overall the optimal strategy is region, variable and model specific. Existing calibration methods are typically developed and applied for each variable independently.

This project will produce hindcast land ecosystem model runs that will start from three decades back and scenario runs will be extended to future until year 2100. The land ecosystem models will be run in relatively high spatial resolution of 10 to 20 km and the models operate with daily or subdaily climatic drivers. Thus in addition to the bias correction, the climate data has to be downscaled in space and processed into the intended time resolution.

3 Models and their forcing data format

We model the effects of climate change on ecosystem carbon and water balances with two models, JSBACH that is a land surface model (LSM) of an earth system model of Max Planck institute for meteorology (MPI-MET) and a semi-empirical stand flux model PRELES. PRELES is developed and used in University of Helsinki and METLA. JSBACH can be operated either in daily or subdaily timestep over a global or regional domain. A regional domain can consist of a single point representing a single ecosystem site that can be alternatively forced with locally measured meteorological data. We run JSBACH for a domain covering Finland and surroundings in a rotated rectangular grid as well as for selected point locations for which there is forcing data available. The input variables for JSBACH are air temperature, specific humidity, precipitation, 10 meter wind speed, incoming short-wave radiation, potential incoming radiation and incoming long-wave radiation. PRELES domain covers Finland and is run in 10km spatial resolution. PRELES can be run also with single point meteorological data. PRELES operates in daily resolution and requires air temperature, precipitation, relative humidity and short-wave radiation as input.

4 Available driving data

4.1 Current day drivers

We possess the ERA-Interim boundary data for a regional climate model for past 3 decades (1979-2011). REMO regional climate model (MPI-Meteorology and Climate Service Center, Hamburg) have been run with ERA-Interim as boundary data through 1979 to 2011 with a resolution of 18km. The REMO derived daily and hourly climate variables have been corrected for model biases with the FMI gridded harmonized temperature and precipitation data (Aalto et. al., 2012). In bias corrections a quantile-quantile type bias correction algorithm for daily mean temperature (Räisänen et. al. 2013) and parametric quantile mapping for daily precipitation (Räty et. al. 2014) were used. The daily mean air temperature correction was applied to the hourly modeled air temperature values too, while the range of variability was preserved from the original REMO run. The hourly precipitation values were multiplied by the ratio of daily precipitation to its corrected value. Thus for current climate we posses both daily and hourly forcing fields where temperature and precipitation are bias corrected, whereas the original REMO values of specific humidity, wind speed and shortwave and longwave radiation have been preserved. The data was first produced and bias corrected for JSBACH model and the regional JSBACH domain that have been previously worked on in Life+ project Snowcarbo. As PRELES model is operated in another grid with resolution of 10km, the bias corrected REMO data was further interpolated to the PRELES grid and the missing data fields were produced. PRELES also uses the FMI gridded harmonized data as such for current day runs.

Table 1. Current day data.

Data	Target model	Spatial cover	Time resolution	Time-span
ERA-Interim	REMO boundary data	Fennoscandia	Six hourly	1979-2011
FMI gridded harmonised data	PRELES and bias corrections	Finland	Daily	1979-2011 continued
REMO with ERA-Interim boundaries	JSBACH and PRELES	Fennoscandia	Hourly and daily	1979-2011

4.2 Climate scenario data

For the future scenarios FMI possess daily mean, minimum and maximum temperatures, precipitation, relative humidity, short-wave radiation and wind speed from 1980 to 2099 from seven CMIP5 runs (each with different model, see Table 2) that are all bias corrected with FMI gridded homogenized data. The emission scenarios follow trajectories RCP4.5 and RCP8.5. This data comprises a complete set of variables for driving PRELES. To meet also the needs of JSBACH, the incoming longwave radiation from the same seven models and two scenarios have to be uploaded from the CMIP5 data-base were it is available (http://cmip-pcmdi.llnl.gov/cmip5/docs/standard_output.pdf). Furthermore, the relative humidity has to be converted into specific humidity and the potential incoming shortwave radiation have to be calculated. Additionally coordinate conversions and respective interpolations of the driver fields are required as the data is currently in 0.1º times 0.2º longitude-latitude -grid.

Table 2. CMIP5 model runs that are donwscaled and biascorrected for Finland.

Model	Institute(s), Countr(y)ies	Scenarios	Time-span
BCC-CSM1	Beijing Climate Center, China Meteorological Administration, China	RCP 4.5 r1 RCP 8.5 r1	1980-2099
CanESM2	Canadian Centre for Climate Modelling and Analysis, Canada	RCP 4.5 r1 RCP 8.5 r1	1980-2099
CNRM-CM5	National Centre for Meteorological Research, Météo France and CERFACS, FRANCE	RCP 4.5 r1 RCP 8.5 r1	1980-2099
GFDL-CM3	Geophysical Fluid Dynamics Laboratory, NOAA, USA	RCP 4.5 r3 RCP 8.5 r1	1980-2099
HadGEM2-ES	Met Office, UK	RCP 4.5 r1 RCP 8.5 r1	1980-2099
MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology, Japan	RCP 4.5 r2 RCP 8.5 r2	1980-2099
MPI-ESM	Max Planck Institute for Meteorology, Germany	RCP 4.5 r1 RCP 8.5 r1	1980-2099

4.3 Substitute and complementing datasets

Also other bias corrected scenario (CMIP4 and CMIP5 as well as regional ENSEMBLES) datasets exist that are already suited for running the two MONIMET models. These will serve as testing and complementing datasets in the case of any technical delays in converting the above mentioned data in the form suitable for our models. Currently bias corrected data suited for PRELES exists from eigth SRES runs for two scenarios. Furthermore, Beer et. al. (2014) have composed a dataset targeted to specifically to study the importance and impact of extreme weather phenomena on carbon cycle. This data combines re-analysis products for current climate (1979-2001) and REMO data from ENSEMBLES project for the future (1970-2100) (see Beer et. al., 2014 for details). This daily data with 0.25º spatial resolution contains all the driving variables for JSBACH.

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