LIFE Project Number

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First Progress Report

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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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(%) of eligible costs	49.61

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1 Summary

This report from Action.B5 describes the implementation of the impact models for retrieving fate of selected climate change indicators thought the current century. The extraction of the selected climate change indicators from the current day land ecosystem model runs is explained and demonstrated.

2 Introduction

In our project the impact models are land ecosystem models JSBACH and PRELES. This project produces hindcast land ecosystem model runs that will start from three decades back and scenario runs are extended to future until year 2100. The land ecosystem models are run in relatively high spatial resolution of 10 to 20 km and the models operate with daily or subdaily climatic drivers. The target climate change indicators are duration of vegetation active season (VAP), vegetation carbon uptake rate, forest and soil respiration rates, methane emission rate, evapotranspiration (sum of surface evaporation and plant transpiration), soil moisture, length of soil frost period, snow cover (both ground snow cover and the forest intercepted snow when applicable) and surface albedo.

3 Models and their driving data

We model the effects of climate change on the climate change indicators with two land ecosystem models: JSBACH that is a land surface model (LSM) of an earth system model of Max Planck institute for meteorology (MPI-MET) implemented and operated in FMI, and a semi-empirical stand flux model PRELES, that is developed and used in University of Helsinki and LUKE. JSBACH can be operated either in daily or subdaily timestep and climatic driving data can be adopted for example from a climate model. In addition to our regional domain covering Finland and surroundings, a domain may consist of a single point representing an ecosystem site. A site run can be alternatively forced with locally measured meteorological data. PRELES domain covers Finland and is run in 10km spatial resolution and driven with daily data. PRELES can be run also with single point meteorological data. For current day simulations data is adopted from FMI gridded harmonized weather data and from pre-existing regional model runs. For future scenarios, data from seven CMIP5 models are adopted (http://cmip-pcmdi.llnl.gov/cmip5/docs/standard_output.pdf). See the “1st report on climate data processing” for more details on model requirements and driving data.

We have implemented and run JSBACH in FMI high performance computing facilities including state-of-art Cray XT5m computing system as well as in desk top computers. PRELES we have operated in desk top computers. Results of various hindcast runs performed so far in the context of model calibration are reported in the “1st progress report of Action B4: Methodologies developed, implemented and tested”.

4 Extracting climate change indicators

All the target climate change indicators are either among standard output data of both models or they can be derived from the standard output. As need of storage space increases directly proportionally to the increasing output frequency, relatively low frequencies will be favored in the long term runs or decades and centuries. However, as the models do not output other statistics but either sums or means over the output period, in order to achieve any other statistical values, such as variance, or depiction of daily cycle, the model have to be first run in high enough frequency and results post-processed into form suitable for further analysis. The excess data have to be consequenly deleted. In order to avoid relatively slow and space costly outputting of large amount of data and to recude consequent time consuming post-processing, for scenario runs we inspect higher order statictics (including daily cycles) for selected test periods of couple of years. Such test periods provide estimates of uncertainty due to the time variability of the drivers.

Climate change indicators that are outputted as such from the model runs are vegetation carbon uptake rate (in terms of gross primary production, GPP), forest and soil respiration rates, methane emission rate, surface evaporation, plant transpiration, snow cover and surface albedo. The postprocessing of those consists of time and spatial averaging to the target temporal and spatial resolutions and adjusting the units when needed. For instance, Fig. 1 shows the mean yearly GPP through past 30 years from JSBACH simulations for Scandinavia (see the “1st progress report of Action B4: Methodologies developed, implemented and tested” for more examples on GPP).

The remaining climate change indicators are derived by post processing from standard output variables. These derived varables are VAP, soil moisture, length of soil frost period and snow cover related variables. VAP have been defined and demonstrated in the report of monitoring action C1.

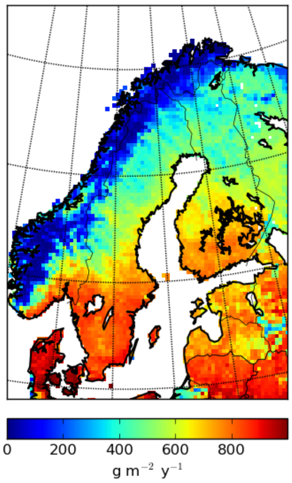

Figure 1. Average GPP through 1982-2011 in Scandinavia from JSBACH.

Soil moisture in JSBACH is calculated for 5 layers in terms of columetric soil moisture. This is translated into soil moisture index (SMI) as follows:

$$SMI = (\theta - \theta_{WILT}) / (\theta_{FC} - \theta_{WILT}),$$

where θ is the volumetric soil moisture [m^3_{H2O}/m^3_{soil}], θ_{FC} is the field capacity, θ_{WILT} is the permanent wilting point. The data from the second soil layer (0.065-0.319m) is used, because the soil moisture in the shallower layer is highly sensitive to small changes in climatic variables, and the soil moisture dynamics in the deeper layers are excessively suppressed. Furthermore, the second layer is representative of the root zone in forest soils. SMI distribution of the exceptionally dry period in summer 2006 is shown in Fig. 2.

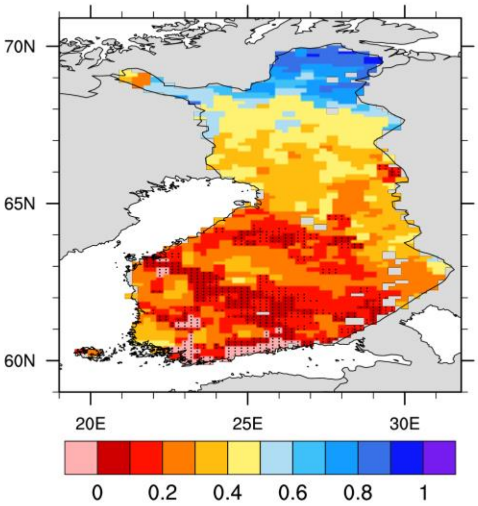

Figure 2. SMI in Finland during the dry summer 2006 from JSBACH simulations.

The length of soil frost period will be extracted based on soil temperature data from each model. This can be defined as the longest continuous period of soil temperature below freezing temperatures. Comparison to the measurements revealed that JSBACH model tends to predict lower than measured soil temperatures and thus either the temperature threshold of the soil layer used as a reference has still to be adjusted. Nevertheless, the tendency of the length of soil frost period can be achieved even if the absolute values do not match with the measured.