Crescendo Project Summary 2018

Model Development

Several new land surface components (nitrogen, fire model SPITFIRE, improved landuse) were implemented into the land surface model of MPI-ESM-LR1.2 and prepared for using in CMIP6. The land model components are explained in the description paper by Mauritsen et al., JAMES, 2019.

Within WP1 of CRESCENDO, extra process improvements and analysis were done for the land surface scheme. The dynamical extent wetland scheme (WEED) was finalized. Is now considers not only land surface water fluxes but also affects albedo. Considering its resolution and simplicity, its simulated wetland fraction is a good represent ion of the observed wetland distribution (Fig 1).

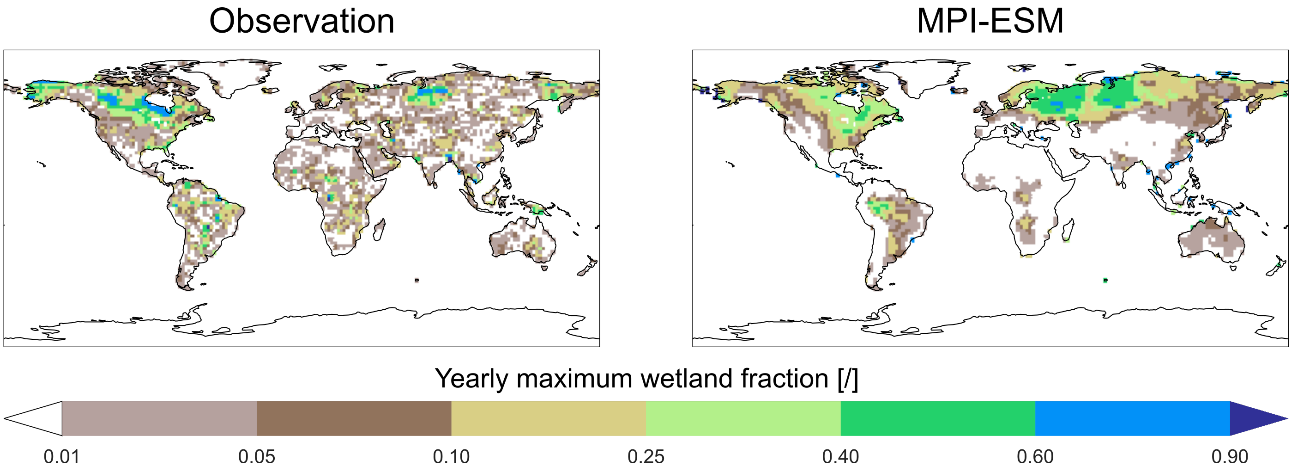

Figure 1: Yearly maximum wetland distribution as observed (left) and simulated by the MPI-ESM (right).

Furthermore, an analysis of evaporation computation in JSBACH was conducted revealing that up to 20% of evaporation does not result directly from the computed fluxes (Fig 2). Instead, this amount (evaporation deficit) is additionally extracted from the soil to close the gap between the evaporative demand of the atmosphere and the amount of water provided by the computed evaporation fluxes.

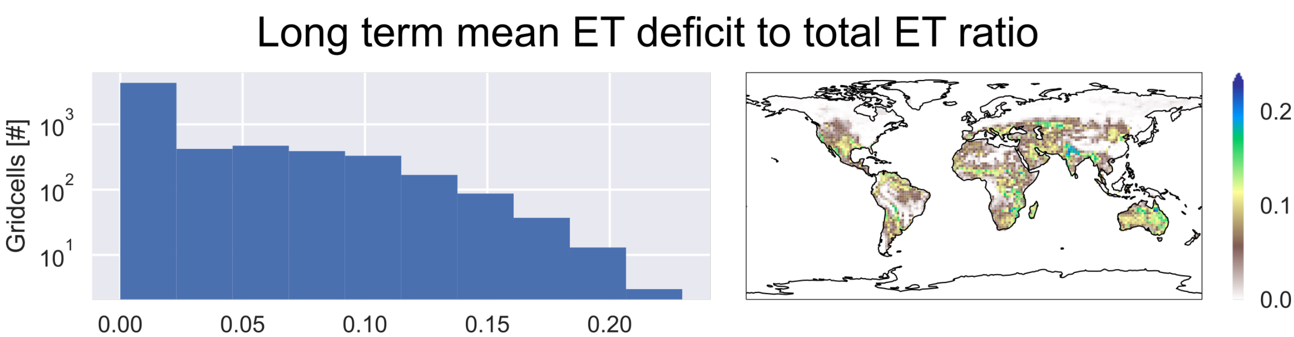

Figure 2: ET deficit to total ET ratio for a standard MPI-ESM simulation (left) and its regional distribution (right).

Associated CMIP6-MIPs

C4MIP

The idealized 1%BGC (Tier 1), 1%RAD, and 1%COU-Ndep (Tier 2) simulations have been performed. The first results out of the MPI-ESM C4MIP runs have been used for preparing an intercomparison paper among CMIP6 models focused on carbon-CO2 concentration and carbon-climate feedbacks (Arora et al., Biogeosciences, tbs). A number of other C4MIP papers including analysis of carbon response to N deposition is in preparation as well.

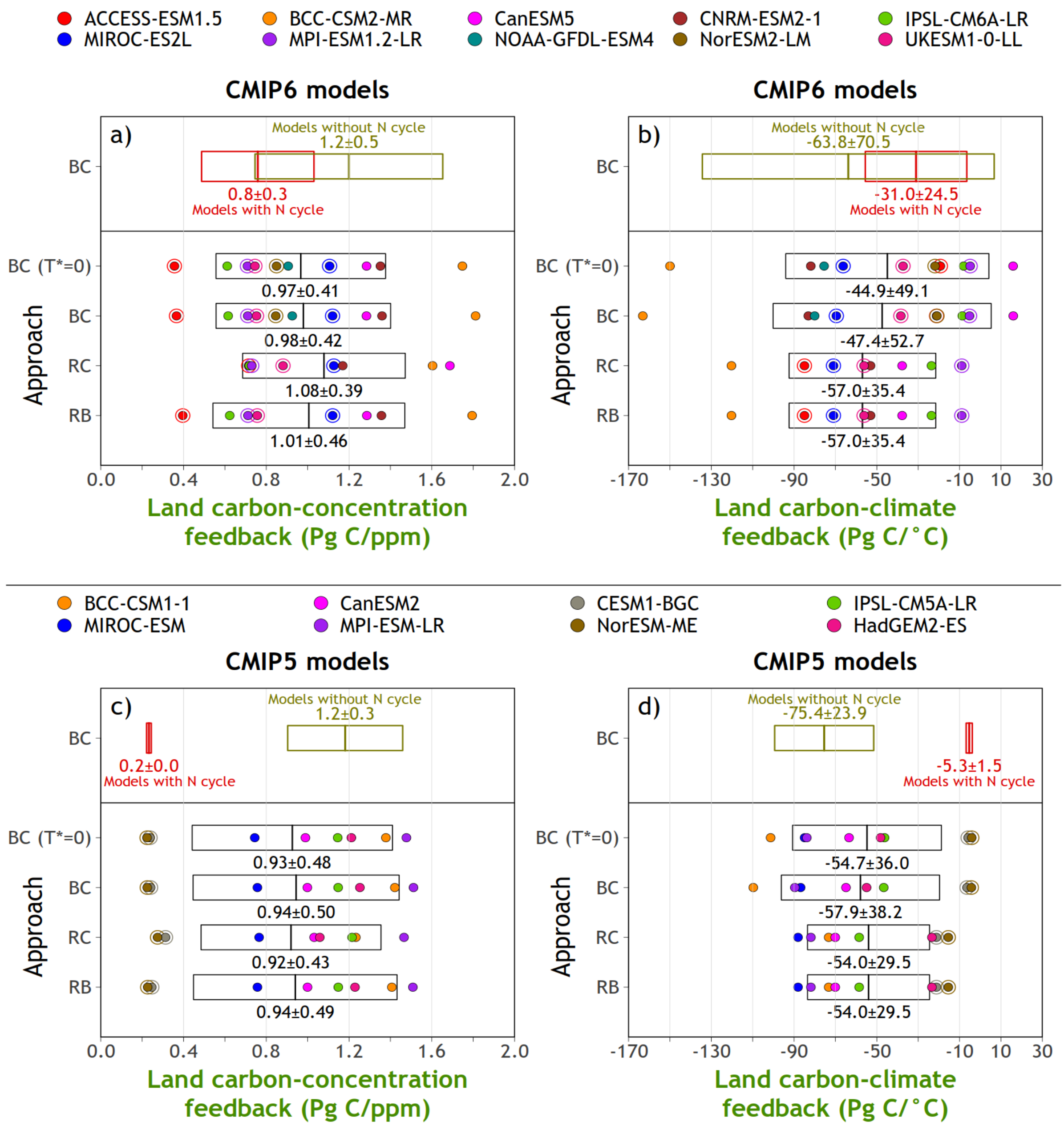

Figure 3. An uncertainty range between the models in land feedbacks (MPI-ESM-1.2 includes N cycle); climate-carbon land feedback in MPI-ESM is strongly reduced comparing to CMIP5. From Arora et al., to be submitted to Biogeosciences.

LS3MIP

As the CMIP6 model was finalized during the last year, most of the planned LS3MIP simulations could be done. The historical land surface offline simulations including spin-up were conducted as well as the first ensemble members of the AMIP-type scenario simulations forced with prescribed soil moisture states. The fully coupled simulations were cancelled by the LS3MIP project on short notice as several participating institutes experienced problems with water conservation for this setup.

Fist analysis of the AMIP simulations showed, that the constraint of soil moisture on global mean fluxes is very weak (Fig 3). Differences in the global mean fluxes between the reference simulations and constraint simulations are most like related the reduced soil moisture variability rather than to is state change.

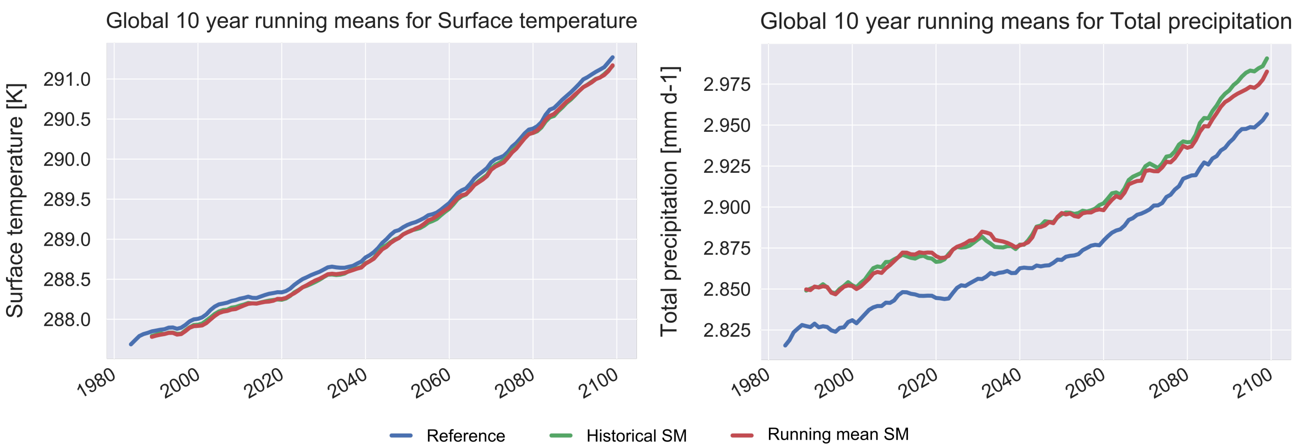

Figure 4: Global mean temperature (left) and precipitation (right) for AMIP type simulations with prescribed soil moisture for SSP585.

Unfortunately, progress was slowed as the cmorization scripts are not yet available for simulation post-processing and subsequent upload to the ESGF. For this reason and due to limited disk space, only the first ensemble member of the AMIP scenario could be simulated. The remaining simulations are prepared, but can only be conducted after the first ensemble members are cmorized and uploaded to ESGF.

LUMIP

Idealized deforestation simulations were performed in LUMIP. 10 ensemble members of 80-yr simulations with MPI-ESM-LR of linear deforestation of 20 mln km2 were used for preparation of the intercomparison paper on biogeochemical and biogeophysical effects of large-scale deforestation (Boysen et al., Biogesoceinces, to be submitted). MPI-ESM demonstrates average temperature sensitivity to deforestation, cooling in the high latitudes and warming in tropics (Fig. 5), as well as a reasonable response of the land carbon losses to deforestation. The ensemble mode was essential to investigate signal-to-noise ratio, and to quantify Time of Emergency of the temperature signal (Fig. 6).

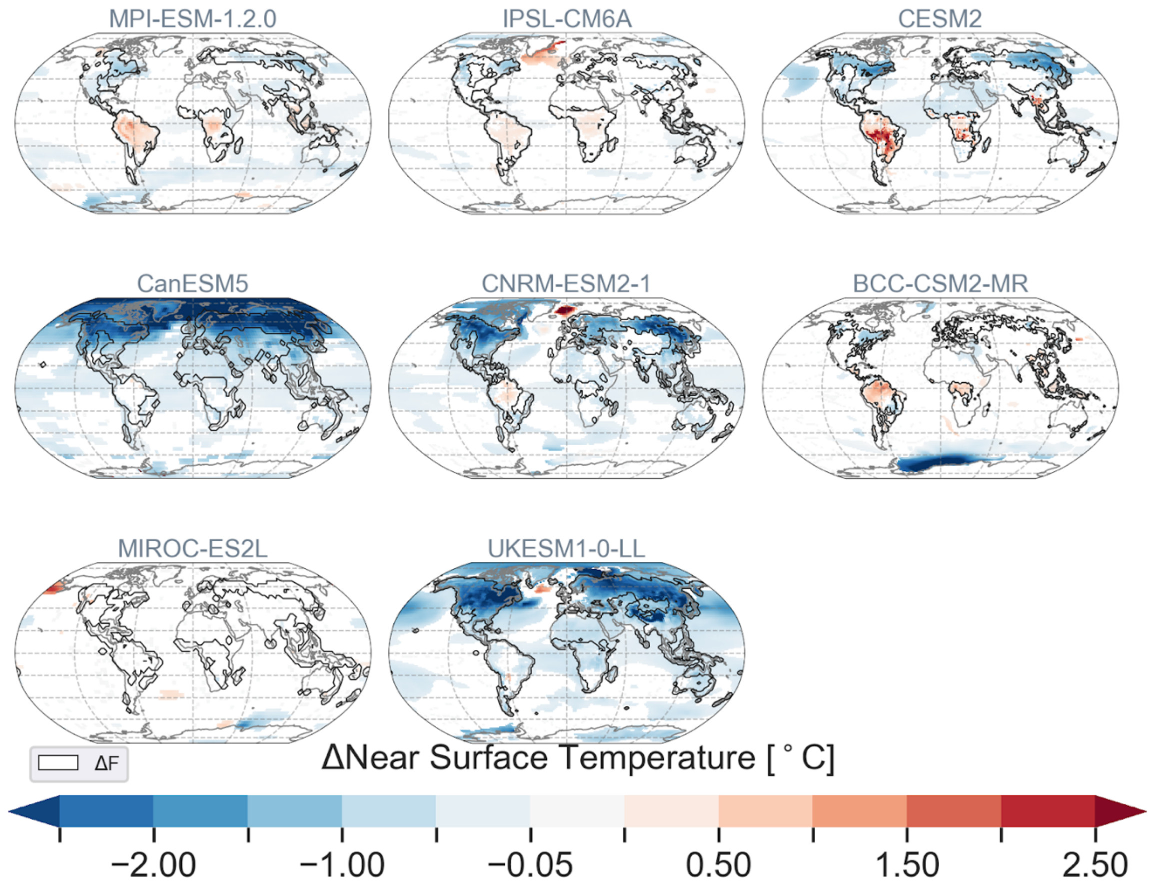

Figure 5. An annual temperature response to deforestation of 20 mln km² of forest cover in CMIP6 models. Boysen et al., Biogeosciences, to be submitted

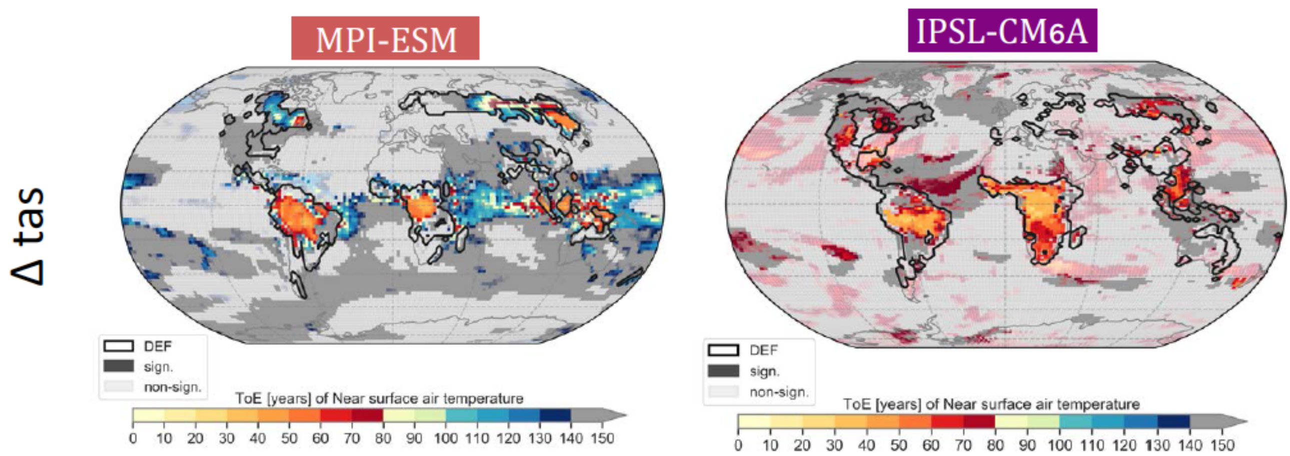

Figure 6. Time of Emergence (ToE, years) of near surface temperature in MPI-ESM-LR and IPSL-CM6A deforestation experiments. The signal-to-noise ratio is strongest in the centre of deforested tropical areas, with shortest ToE there. Boysen et al., Biogeosciences, to be submitted.