Session: B10 Oral presentation

Role of land use in past and future carbon response

Ronald Stouffer [†]; Elena Shevliakova; Sergey Malyshev; Lori Sentman; John Dunne; Jasmin John; John Krasting
[†] GFDL/NOAA, USA
Leading author: ronald.stouffer@noaa.gov

NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) has developed two new Earth System Models (ESMs) which differ mainly in their ocean formulation. The land components of these ESMs contain a new bio-geochemical component that can simulate forest age, land use and the changes in biomes distributions due to the climate change. This land use heterogeneity is represented by up to 15 subgrid tiles which keep track of the primary (undisturbed forest), secondary forest (abandoned land which became reforested) and agricultural lands as land-use transitions are applied. In order to simulate age and carbon storage in the secondary forests and agricultural lands, a unique method for initializing the historical or C20C runs of CMIP5 with land use scenario has been developed. In this scheme, we first perform a long integration with only potential vegetation in a pre-industrial control run. We then use this control to initialize a second integration in which the land-use transitions from 1700 to 1860 are applied while all other forcing terms are held at their control run values. At 1861 the historical simulation is started, all the forcing terms, including the land use, change in a manner consistent with observationally based estimates. The globally averaged land carbon fluxes into the atmosphere simulated by the model are about 1 PgC per year from 1861 to about 1960. These fluxes are largely the result of land-use changes. Over the 1970s, the globally averaged land carbon fluxes abruptly decrease and become negative from about 1980 to present day in general agreement with the observational estimates due to a combination of land use changes and CO2 fertilization effects. In the future, the land sink increases in RCP45, 6.0 and 8.5. By 2100, in these 3 RCPs the global land carbon flux returns to near present day values. In RCP2.6, the land sink remains near present day values until 2050 when the land becomes a carbon source for the atmosphere. The changes in the future land fluxes result from the interplay of the land use projections, the climate changes and the CO2 fertilization effect. The size of the future climate change is crucially dependent on the magnitude of the CO2 fertilization of land plants. While the direct effect of CO2 on land plant photosynthesis is well known, the ecosystem level response could be mitigated or limited by the availability of other nutrients such as nitrogen, phosphorus, or water and sunlight. The magnitude of the uncertainty associated with CO2 fertilization on future climate change is quite large - of the same magnitude as the uncertainty associated with clouds - and a central uncertainty in the centennial scale global climate change response.