Session: C12 Poster: M39B

Simulation of climate and carbon cycle variability over the last millennium

Johann Jungclaus[†]; Victor Brovkin
[†] Max Planck Institute for Meteorology, Germany
Leading author: johann.jungclaus@zmaw.de

Ensemble simulations over the last 1200 years with a comprehensive Earth system model including a fully interactive carbon cycle are presented. Applying up-to-date reconstructions of external forcing including the recent low-amplitude estimates of solar variations, the ensemble simulations reproduce temperature evolutions in a reasonable agreement with the range of reconstructions. Volcanic eruptions are necessary to explain variations in pre-industrial climate such as the Little Ice Age; yet only the strongest, repeated eruptions lead to cooling trends that stand out against the internal variability across all ensemble members. The response of the coupled climate-carbon cycle system is analyzed in details for the largest eruption of the last millennium. After such eruptions, simulated global annual mean temperature drops substantially and recovers slowly during the next decade. Atmospheric CO2 concentration declines after the eruption to its minimum value and then starts to increase towards the pre-eruption level. This CO2 decrease is explained mainly by reduced heterotrophic respiration on land in response to the surface cooling, which leads to increased carbon storage in soils, mostly in tropical and subtropical regions. The ocean acts as a weak carbon sink, which is primarily due to temperature-induced solubility. In total, the simulated atmospheric CO2 concentrations exhibit a stable carbon cycle over the pre-industrial era with multi-centennial variations somewhat smaller than in the observational records. Early anthropogenic land cover changes have modulated atmospheric CO2 concentrations only slightly. We provide a model-based quantification of the sensitivity of the global carbon cycle to temperature for a variety of climate and forcing conditions. The magnitude of the sensitivity agrees with a recent statistical assessment based on reconstruction data. We diagnose a distinct dependence of on the forcing strength and time-scales involved, thus providing an explanation for the systematic difference in the observational estimates for different segments of the last millennium.