Estimation of the Permafrost Carbon Feedback Using The SiBCASA Terrestrial Carbon Cycle Model

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The Permafrost Carbon Feedback (PCF) is an amplification of surface warming due to the release of carbon and methane from thawing permafrost. Studies show that the extensive northern wetlands contribute up to 25% of global methane emission, whereas 2.3% of methane emissions occurs from thawing permafrost in these regions. To improve estimates of the PCF we added prognostic organic layer to the Simple Bioshpere/Carnegie-Ames-Stanford (SiBCASA) Terrestrial Carbon Cycle Model and quantified carbon and methane fluxes resulting from changes in terrestrial carbon storage in permafrost affected soils. Model simulations spanning from 1901 to 2010 were driven using Climatic Research Unit-National Centers for Environmental Prediction (CRUNCEP) reanalysis, atmospheric CO_2, and land use change information as modified by the Multi-Scale Terrestrial Model Intercomparison Project. From 2011 to 2300, multiple projections of CO_2 and methane emissions and changes in PCF were evaluated by scaling the CRUNCEP data using trends in weather data derived from the Fifth Coupled Model Intercomparison Project for 4.5 and 8.5 Representative Concentration Pathway (RCP) scenarios (Figure 1,2). Implementation of the dynamic organic layer into the model lowered the effective thermal conductivity between the soil and the atmosphere and increased the resilience of permafrost to climate warming and decreased permafrost seasonal thawing depth. The ensemble mean for each RCP is our best estimate of CO_2 and methane emissions from degrading permafrost and the standard deviation is a measure of uncertainty.

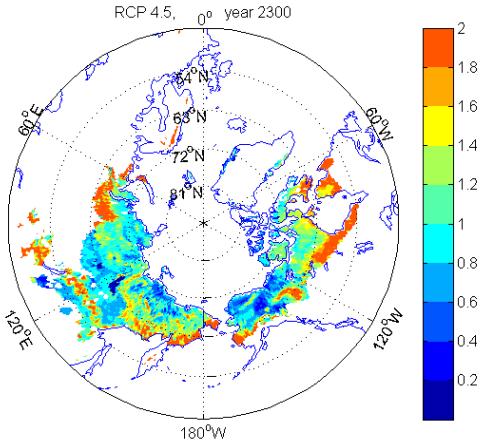

Figure 1. An average active-layer thickness for the periods 2290–99 for RCP 4.5. The colorbar is in meters.

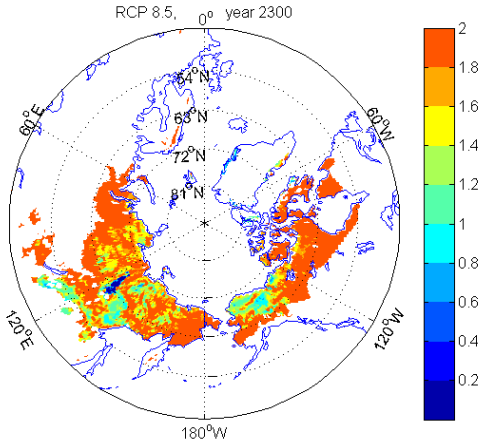

Figure 2. An average active-layer thickness for the periods 2290–99 for RCP 8.5. The colorbar is in meters.