Geophysical Research Abstracts
Vol. 18, EGU2016-8564, 2016
EGU General Assembly 2016

Impact of interactive vegetation phenology on the simulated pan-Arctic land surface state

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The pan-Arctic land surface is undergoing rapid changes in a warming climate, with near-surface permafrost projected to degrade significantly during the 21st century. This can have important impacts on the regional climate and hydrology through various feedbacks, including vegetation-related feedbacks. In this study, the impact of interactive phenology on the land surface state, including near-surface permafrost, is assessed by comparing two simulations of the Canadian Land Surface Scheme (CLASS) - one with interactive phenology, modelled using the Canadian Terrestrial Ecosystem Model (CTEM), and the other with prescribed phenology. These simulations are performed for the 1979–2012 period, using atmospheric forcing from ECMWF's ERA-Interim reanalysis. The impact of interactive phenology on projected changes to the land surface state are also assessed by comparing two simulations of CLASS (with and without interactive phenology), spanning the 1961–2100 period, driven by atmospheric forcing from a transient climate change simulation of the 5th generation Canadian Regional Climate Model (CRCM5) for the Representative Concentration Pathway 8.5 (RCP8.5).

Comparison of the CLASS coupled to CTEM simulation with available observational estimates of plant area index, primary productivity, spatial distribution of permafrost and active layer thickness suggests that the model captures reasonably well the general distribution of vegetation and permafrost. Significant differences in evapotranspiration, leading to differences in runoff, soil temperature and active layer thickness are noted when comparing CLASS simulations with and without interactive phenology. Furthermore, the CLASS simulations with and without interactive phenology for RCP8.5 show extensive near-surface permafrost degradation by the end of the 21st century, with slightly accelerated degradation of permafrost in the simulation with interactive phenology, pointing towards a positive feedback of changes in vegetation structure and phenology on soil temperatures.