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Earth system component responses under LGM boundary conditions in HadGAM2

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In this work we use the atmospheric and terrestrial components of the Earth System model HadGEM2-ES to explore the sensitivity of vegetation, the mineral dust cycle and wetland methane emissions under boundary conditions relevant to the last glacial maximum (LGM) relative to the pre-industrial (PI). For the LGM we configured HadGAM2 with LGM greenhouse gas concentrations, 21kyr ice sheets, orography and sea level and 21kyr orbital parameters. For the PI and LGM simulations HadGAM2 was forced with sea surface temperatures and sea-ice cover from equivalent coupled atmosphere-ocean HadCM3 simulations. We have also optionally prescribed vegetation distributions simulated with HadCM3M2 which employs the TRIFFID vegetation model (this model is also used within HadGAM2).

In HadGAM2 the LGM-PI temperature change is generally similar to that found in HadCM3, though it is found to be more extreme over Asia, where feedbacks from snow cover and changes in vegetation enhance the local signal. The dust model is sensitive to changes in the bare soil fraction, with particularly large emissions changes over South America and Australia. The globally averaged radiative forcing from mineral dust changes is consistent with the higher end of the range found in previous studies, ranging from -0.4Wm^{-2} for no vegetation change to -1.7Wm^{-2} with prescribed HadCM3M2 vegetation distributions.

The HadGEM2 methane emission model is used both online and offline in a number of different configurations in order to address uncertainty in the model formulation. A subset of the model versions considered suggests a completely source driven change in atmospheric CH_4 at the LGM relative to the PI, consistent with recent modelling studies of the atmospheric composition at the LGM. Future work will consider the sensitivity of these HadGAM2 Earth System components to SST and sea-ice area perturbations.