C4MIP simulations, plans and evaluation requirements

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Climate-carbon cycle feedbacks are potentially large and play a leading order contribution in determining the atmospheric composition in response to human emissions of CO2 and in the setting of emissions targets to stabilise climate or avoid dangerous climate change. For over a decade The Coupled Climate-Carbon Cycle Model Intercomparison Project (C4MIP) has coordinated coupled climate-carbon cycle simulations and in the coming few years C4MIP will be an endorsed activity of CMIP6. It is hoped that this will encourage widespread adoption of the C4MIP set of simulations and enable increased understanding and predictability of future changes in both terrestrial and marine carbon cycle.
C4MIP has 3 key strands of scientific motivation and the requested simulations are designed to satisfy their needs: (1) pre-industrial and historical simulations (formally part of the common set of CMIP6 experiments) to enable model evaluation; (2) idealised coupled and partially-coupled simulations with 1% per year increases in CO2 to enable diagnosis of feedback strength and its components; (3) future scenario simulations to project how the Earth System will respond over the 21st century and beyond to anthropogenic activity.
In this talk I will outline some previous C4MIP results and present some key priorities for evaluation. It is clear that in biogeochemical modelling and the drive for increased complexity in ESMs, process-based model evaluation has not kept pace. As a result there is very large quantitative spread between CMIP5 carbon cycle results which hinder their usefulness. It is also the case that we have not been able to show demonstrable progress - as a coherent community - in the quality and process-realism of our modelling. There are no agreed quality criteria or metrics which measure whether our ESMs are fit for purpose or if they have improved since the last generation. It is essential that we focus our efforts in the coming years on addressing this deficiency. It is not enough that under CMIP6 there are more models within C4MIP analyses or more advanced processes. We must be able to demonstrate that we have made real progress since CMIP5 in our modelling skills, analysis techniques and our ability to constrain future projections.

There are multiple ways of evaluating carbon cycle models. Activities such as TRENDY and OCMIP (part of OMIP) will perform evaluation activities of offline land and ocean components respectively. It is the role of C4MIP to evaluate the coupled climate-carbon cycle system. Our primary simulations for this activity will be the coupled historical simulations from 1850 up to 2014. There will be two variants. Within the CMIP “DECK” (the central core of CMIP6) all models will perform a “concentration driven” historical run. This means the atmospheric concentration of CO2 is prescribed to follow the historical record. The second variant, which is required for all models contributing to C4MIP is a parallel “emissions driven” historical simulation in which CO2 emissions are prescribed to the model and the models simulate the time evolution of CO2 concentration.

In order to fully exploit these simulations we need to be prepared with some top-level evaluation criteria (e.g. as presented by Anav et al 2013); some rigorous process-based criteria and metrics (such as sensitivity of stores and fluxes to environmental drivers); carefully assembled and processed observational datasets; carefully defined model diagnostic outputs. Here I will briefly outline these requirements in the hope of stimulating discussion to move our plans forward ahead of

model simulations being started by the end of 2016.

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