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Biogeochemical feedbacks in HadGEM2-ES

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Many of the climate simulations for the CMIP5 project have been performed using Earth System models. These go beyond the physical climate models by including representations of biogeochemical components of the Earth System such as terrestrial and ocean ecosystems, and chemically reactive gases and aerosols. These components are coupled to each other through the impacts of composition changes on ecosystems and through the emission and removal of species from and to the biosphere. The components are also coupled to the physical climate system thus introducing feedback loops. Feedbacks involving interactions between the atmospheric composition and the biosphere can act to amplify or dampen climate change and hence affect the climate sensitivity. These feedbacks will be implicitly included in the CMIP5 predictions generated by Earth System models.
Here we present a framework for comparing biogeochemical feedbacks in Earth System models to quantify their relative importance and to compare them to physical feedbacks. We separate the steps in the feedback chain into: sensitivity of composition to climate change, cross impacts of one atmospheric constituent on another, and the radiative effects of composition change. The first two steps can involve interactions with the terrestrial and ocean biospheres.

We apply the above methodology to analysis of results from the HadGEM2 Earth System model which is used by the Met Office Hadley Centre in its submission to CMIP5. We quantify here the biogeochemical feedbacks in HadGEM2, for example the carbon cycle feedback, the wetland methane feedback, the CLAW hypothesis and many others. Apart from the carbon cycle feedback itself, the most important biogeochemical feedback in HadGEM2 is through wetland methane emissions. The least important is the CLAW feedback which is shown to be negligible. Biogeochemical feedback strengths (in W/m2/K) are summed to calculate the overall impact of the Earth System components on the HadGEM2 climate sensitivity.