Abstract. Large uncertainties in climate projections exist due to uncertainties in physical climate feedbacks simulated by coupled Atmosphere-Ocean General Circulation Models (AOGCMs) and additional feedbacks that arise from complex interactions between climate and other components of the Earth system as simulated by Earth System Models (ESMs). Here we review important climate feedbacks and argue for a process-oriented evaluation in addition to the evaluation of Essential Climate Variables (ECVs). A set of core processes that are related to important feedbacks in the climate system is structured around three major topics (physical climate, global carbon cycle, and atmospheric composition). Each process is associated with one or more model diagnostics and with relevant observational datasets that can be used for the evaluation. Following this approach, outputs from individual component models and from coupled ESMs can be confronted with observations in a consistent and quantitative way. The review suggests that continued investment in systematic and consistent model evaluation will allow a rigorous assessment of the strengths and weaknesses of ESMs and should lead, on the long term, to a more quantitative estimate of uncertainties in climate projections and to improved ESMs with demonstrably enhanced projection skill.

Examples of Physical and Biogeochemical Climate Feedbacks

- Physical climate feedbacks, in particular fast cloud feedbacks, have been confirmed as a primary source for the spread of climate model estimates of the equilibrium warming for a doubling of CO2 concentration.
- Biogeochemical processes and feedbacks also represent a major impediment to our ability to make reliable climate projections for the 21st century. The impact of climate change on carbon and nitrogen cycles processes on atmospheric CO2 concentration is still a major source of uncertainty in the emission-concentration-climate pathways.
- Atmospheric composition feedbacks may emerge from climate impacts on methane emissions from wetlands or permafrost soils, on natural emissions of nitrous oxide from soils, on ozone concentrations mediated by multiple chemical pathways, and on emissions of natural aerosols.

Example: International Land Model Benchmarking (ILAMB)

1) Carbon Cycle Metrics (Cadule et al., 2010)

- CO2 analysis quantifies land (and ocean in coupled mode) carbon cycle characteristics on multiple timescales.
- Other ILAMB diagnostics include vegetation phenology and surface water budget evaluation.

References and Acknowledgement


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