CDR-MIA

Carbon Dioxide Removal Model Intercomparison Assessment

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Summary

Continued anthropogenic greenhouse gas emissions are changing the climate threatening “severe, pervasive and irreversible” impacts. In response, there is increasing focus and study on the potential of Carbon Dioxide Removal (CDR) methods to enable “negative emissions” to complement CO_2 emission mitigation efforts. However, the potentially positive and negative impacts in response to large-scale CDR remain poorly quantified and elucidated. The main aim of this project is to analyze the output from the Carbon Dioxide Removal Model Intercomparison Project (CDR-MIP) experiments to better assess the potential, and risks of large-scale CDR. CDR-MIP is a new initiative that brings together a suite of Earth System Models in a common framework to investigate CDR. The 1st phase of CDR-MIP, which includes idealized experiments of direct CO_2 air-capture, as well as afforestation and ocean alkalinization, is designed to investigate key questions concerning (a) climate “reversibility”, in the context of using CDR to return high future atmospheric CO_2 concentrations to a lower (e.g. present day or pre-industrial) level and (b) the potential efficacy, feedbacks, time scales, and side effects of different CDR methods. As part of CDR-MIA, the information gained from analyzing the CDR-MIP experiments will be used to better constrain the assumed effectiveness of CDR technologies in the Integrated Assessment Model (IAM)-generated Shared Socioeconomic Pathway (SSP) scenarios that are used to facilitate climate change research and assessment. Currently, it is unknown how well carbon cycle feedbacks are accounted for when CDR is included in IAM simulations and there is an urgent need to fill this knowledge gap. The results from the CDR-MIP analyses will be used to calculate a carbon cycle feedback based discount factor for CDR, which will then be used to calibrate and re-run a SSP scenario with the IAM REMIND-MAgPIE. In addition to this, new experiments will also be designed and run with the UVic model to investigate the response of the carbon cycle and climate system to the simultaneous implementation of multiple CDR methods. These experiments will build upon the CDR-MIP ones by combining some of the methods, such as afforestation and artificial ocean alkalinization. Subsequent analyses will allow the efficacy and risks of combined CDR to be compared to that of the individual CDR implementations.

COREQUESTIONS

- **What components of the Earth's climate system exhibit "reversibility" when CO_2 increases and then decreases? On what timescales do these "reverses" occur? Which changes are irreversible? If reversible, is this complete reversibility or just on average**

(are there spatial and temporal aspects)?

- **What consequences might reversibility induced changes have on societal strategies for climate change adaptation?**
- **How much CO_2 would have to be removed to return to a specified level, e.g., present day or pre-industrial?**
- **How quickly could CDR**

remove atmospheric CO_2? Are there negative consequences from removing CO_2 too quickly or slowly?

- **What are the short term C-cycle feedbacks (e.g., rebound) associated with different CDR methods? What are the consequences for accounting for C removed?**

- **Are the ca**

librations of reduced-form climate models, i.e., IAMs, still correct when CO_2 is removed again from the atmosphere? Are CDR methods as effective as assumed? How does efficiency scale?

- What are the short- and longer-term physical/chemical/biological feedbacks and side

effects of different CDR methods? What are the related consequences for accounting? And, for societal adaptations to climate change?

- **Where is the C stored (land and ocean) and for how long? What are the consequences for accounting and the reward for the removed C?**
- **What**

happens when methods are combined? Does it affect efficiency or side effects?

- **If carbon cycle feedbacks are significant and the effectiveness of CDR assumed by IAMs is reduced, what is then the impact on the scale and timing of CDR deployment in various s**

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Collaboration with other SPP 1689 projects

CDR-MIA will collaborate with the ComparCE, CE-LAND+, and CEMICS SPP 1689 projects. The CDR-MIA afforestation analysis will compliment and provide opportunities for collaboration with similar research in the ComparCE and CE-LAND+ projects. The ocean alkalinization analysis in CDR-MIA will also likewise compliment and provide opportunities for collaboration with similar research in ComparCE. Moreover, since the Max Plank Institute Earth System Model (MPI-ESM) is used in both ComparCE and CE-LAND+ and the UVic model, in ComparCE, this will provide an opportunity to investigate uncertainties and differences due to experimental design, as both models will also be participating in the analyzed CDR-MIP experiments. Furthermore, CDR or CDR-SRM combinations will be developed in close collaboration with the ComparCE project, as they have also proposed to investigate such combinations. The opportunity for cooperation with the integrated assessment modelling component of the CEMICS project, which is explicitly concerned with the economic assessment and impact analysis of socioeconomic scenarios that include a mix of CDR options, will occur because CDR-MIA investigators Nico Bauer and Jessica Strefler are also participants in the CEMICS project.