Investigation of the Magnitudes and Probabilities of Abrupt Climate Transitions (IMPACTS)

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PARTNERS: Purdue University, Argonne National Laboratory, Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory (Lead), Pacific Northwest National Laboratory, Los Alamos National Laboratory

PROJECT WEBSITE: http://esd.lbl.gov/research/projects/abrupt_climate_change/impacts/

PROJECT DESCRIPTION

IMPACTS is a project that brings together six national laboratories to attack the problem of abrupt climate change (ACC). The focus will be on the risk of ACC on decadal rather than centennial time scales. Some of the most significant mechanisms proposed for ACC will be investigated through a series of linked projects that examine:

- Dynamics of ice shelf — ocean interaction and evaluation of marine ice sheet instability,
- Boreal/Arctic-climate positive feedbacks and ACC,
- Rapid destabilization of methane hydrates in Arctic Ocean sediments, and
- Mega droughts in North America, including the role of biosphere-atmosphere feedbacks

Since this project is focused on the future risk of abrupt phenomena, the onset of these phenomena will be predicted using a detailed representation of the Earth system called the Community Climate System Model (CCSM). In order to quantify the risk of ACC, the team will add new capabilities and functionality to CCSM and its accompanying diagnostic packages. The team will enhance CCSM with representations of ice shelves, terrestrial methanogenesis, gaseous oceanic plumes, and vegetative controls on soil moisture and evapotranspiration. The team will also create new versions of CCSM that can generate equilibrated solutions for the coupled ocean-atmosphere system much more rapidly than is feasible using standard forward solution methods. The team will test that the new physics, chemistry, and biogeochemistry is consistent with the comparative stability of the recent climate record. The enhancements to CCSM and its diagnostics together with the resulting model simulations will be shared with the wider CCSM community.

ORNL is focused on the Boreal/Arctic-Climate Positive Feedback component of the overall project. Terrestrial ecosystems north of 45°N contain more than one-third of active terrestrial organic carbon, approximately 750 petagrams (Pg) of carbon , most of which resides in the soil. In addition, there are an estimated 455 Pg of carbon in large peatland basins and an additional 1000 Pg of carbon in yedoma and non-yedoma permafrost. This region has already experienced rapid changes in environmental conditions under current global warming. In particular, the spatial distribution of boreal and arctic vegetation types has started to shift with large consequences for snow cover and regional albedo. Although some degree of boreal/arctic feedback to warming is almost certain (indeed, has already been documented), there has been no comprehensive assessment of its likely magnitude—in part because the model capability has been lacking. The capability of CCSM will be extended by incorporating additional plant functional types for high latitude into the Climate Land Model-Nitrogen Cycle (dynamic vegetation) (CLM-CNDV) land surface model. Initial Community Atmosphere Model (CAM) (coupled to a slab ocean model) runs with static current vegetation, and CLM-CNDV's dynamic vegetation will be completed to investigate the potential impact of albedo feedbacks in the climate system. The impact of fires on the soil C cycle and shrub invasion will be quantified. Finally, simulations using CCSM fully coupled to the modified land-surface model will be repeated with CLM-CNDV's dynamic vegetation dynamics included.

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SIGNIFICANCE

There is a pressing need to extend state-the-art land surface models and apply them to a global modeling evaluation of global abrupt climate change from the biophysical and greenhouse gas feedbacks generated by vegetation range shifts, biogeochemical dynamics, and climate forcing in the boreal/arctic regions. Even if these feedbacks are projected to not achieve sufficient strength and speed to cause abrupt climate change, they will still be playing an important role in future climate, and it will be valuable to quantify this amplification of anthropogenic radiative forcing.