Linking Biogeochemistry and Atmospheric Transport in the NCAR CSM

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The Climate System Model (CSM) at the National Center for Atmospheric Research (NCAR) is a modular system of state-of-the-science components for the simulation of processes and interactions in the Earth system that determine our climate (Boville and Gent, 1998). CSM components have been used to simulate biogeochemical cycles on land (Bonan, 1995) and in the ocean (S. Doney, personal communication), and these simulations have been compared to appropriate local or regional data. I propose an exploratory study linking the biogeochemistry modules of the NCAR Climate System Model (CSM) with the atmospheric transport code in CCM3, and comparing the results to available observations. A first step will be to evaluate the passive chemical tracer transport of CCM3 by repeating an SF_6 experiment recently completed by other major models in an international intercomparison (TransCom 2, Denning *et al*, 1999). Assuming this is successful, a full follow-on proposal will be submitted to develop improved biogeochemical linkages among the CSM components, and to test these flux simulations against atmospheric data.

Some simulations of atmospheric CO_2 have been performed with the CCM. Erickson (1996) performed seasonal simulations with CCM2 using prescribed surface fluxes and found reasonable agreement with observations. CCM2 was also a participant in the first phase of the TransCom intercomparison, in which it was found to exhibit a strong interhemispheric gradient of CO_2 due to seasonal exchange with vegetation (Law *et al*, 1996). This "rectifier effect" arises from seasonal covariance between CO_2 fluxes and atmospheric transport (Denning *et al*, 1995, 1996). Some effort has also been made to test CSM-simulated CO_2 fluxes against atmospheric CO_2 data (Craig and Holmen, 1998; Craig *et al*, 1999), but these simulations lacked realism because the carbon budget was badly out of balance in many parts of the world. The size of carbon pools in soils and vegetation in LSM were prescribed a priori and were not allowed to adjust to simulated fluxes, leading to very strong regional sources and sinks and regional anomalies in the simulated atmospheric CO_2 concentration field that were not consistent with observations.

The work proposed here is envisioned as the first step in a broad effort to (1) link biogeochemical fluxes and concentrations across modules in the CSM; (2) use resulting simulated atmospheric concentration fields to pinpoint model deficiencies; and (3) work with both NCAR and University colleagues to address and correct these deficiencies if possible. Obviously, such extensive collaboration will not be possible with the very limited support of an SGER award. This proposal seeks funds to begin this collaboration by bringing the CSM to CSU and performing a preliminary evaluation of the problem. A

Research Associate will be recruited to work with the CSM, this individual will be trained in the use of the model and the structure of the code, and a simple tracer experiment will be performed.

The specific tasks to be performed under the SGER grant will be:

1) Obtain the CSM1 code, relevant data sets, and output processing software, and implement them on the SGI Origin computers at CSU

2) Modify the CCM3 code to include tracer transport diagnostics required for the TransCom 2 protocol. This will allow quantitative evaluation of both the resolved and parameterized transport characteristics of the model (see http://transcom.colostate.edu/Transcom_2/T2_Protocol/protocol.pdf for a complete description of these diagnostics).

3) Perform a 5-year sulfur hexafluoride simulation with emissions prescribed according to the TransCom 2 protocol, and compare the resulting concentrations to observations.

This preliminary experiment will bring the CSM up to date with respect to the international TransCom intercomparison and will pave the way for NCAR participation in the upcoming carbon cycle inversion intercomparison (TransCom 3). More importantly, it will facilitate the recruitment and training of a research associate who will continue to work with the CSM on the larger collaborative efforts mentioned above. This further collaboration will require significant additional resources beyond the SGER grant, which will be provided through other currently funded projects and possibly through a follow-on proposal submitted to NSF.

Resources required for the exploratory work include 3.5 months of support for the new Research Associate, and small amounts of salary support for coordination of the activity by the PI, a systems programmer, and a support scientist in our group. A personal computer is requested for the use of the new RA, and small amounts are requested to support computing use, long-distance telephone, and photocopy expenses. The total budget for this activity is $24,981.

Follow-on work will be partially supported by the PI's other research projects (TransCom inversion intercomparison project, NSF-MMIA stable isotope inversion project, and NASA EOS-IDS Biosphere-Atmosphere Interactions project), and/or a probable further submission to NSF. This work will build on the resources and experience provided under the SGEr program, and will include (1) development, implementation, and testing of a new soil carbon cycling parameterization for LSM; (2) the implementation of algorithms for predicting the stable isotopic composition of water and CO_2 in the CSM; (3) coupled prediction of atmospheric CO_2 using biogeochemical fluxes from both the land and ocean components of the CSM with transport by CCM3; and (4) inverse calculation of the global carbon budget from atmospheric data with the CSM.

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