Historical estimates of terrestrial vegetation and carbon dynamics using millennial scale soil moisture reconstructions.

Benjamin I Cook[1] and Jed O Kaplan[2]

[1]Ocean and Climate Physics, Lamont-Doherty Earth Observatory

[2]Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Lausanne, Switzerland

Introduction

The terrestrial biosphere is increasingly being recognized as a vital component of the climate system, both as a passive responder and interactive component. Models of terrestrial vegetation and the carbon cycle are useful tools for investigating the distribution and response of ecosystems, vegetation, and carbon pools to climate change and variability. For many of these modeling studies, however, the initial values or starting points are often simply based on datasets of 20th century climate, run repeatedly until the carbon and vegetation come to equilibrium (e.g., Lucht et al, 2002; Schaphoff et al, 2006). Initial carbon pools and vegetation distributions therefore represent a hypothetical case of hundreds of years of 20th century climate. This is problematic on two levels. First, the climate and boundary conditions of the 20th century are significantly different than other periods in the recent past. This includes patterns of temperature, precipitation, ENSO variability, and atmospheric carbon dioxide concentrations, all of which exert a significant influence on ecosystem structure and functioning. Secondly, ecosystem and terrestrial carbon dynamics can have timescales on the order of centuries to millennia. This is especially true for slowly decomposing soil carbon pools, such as those associated with permafrost at high Northern latitudes. It is therefore apparent that current ecosystem states and trajectories undoubtedly reflect climatic conditions prior to 1900. Ignoring this influence, and relying only on recent climate to spin up the model could lead to erroneous starting points and biased predictions of the biophysical and biogeochemical role of the land surface in the climate system.

Despite its importance, terrestrial ecosystem and carbon cycle modeling is an area of research that is poorly represented at Lamont-Doherty. The paleoclimate program at Lamont, however, is one of the strongest in the country, including two major research groups (Paleoclimatology and the Tree Ring Lab). This project is designed to facilitate collaborative efforts between an ecosystem modeling group (as represented by Dr Kaplan) and the Tree Ring Lab at Lamont-Doherty. The end goal will be to use climate reconstructions to force an ecosystem model, providing second order model estimates of past ecosystem and terrestrial carbon variability. The proposed work would expand the scope of research at Lamont-Doherty Earth Observatory, while simultaneously taking advantage of the expertise we already have at present.

Research Plan

Researchers at the Tree Ring Lab have recently completed a reconstruction of the Palmer Drought Severity Index (PDSI) for North America. The latest version of this dataset extends back in time ~1400 years before present at a monthly timescale with a horizontal resolution of 0.5°x0.5°. PDSI is a metric of drought severity, incorporating both temperature and precipitation information. An intermediate product in the calculation of PDSI is soil moisture. We will use soil moisture estimates from the PDSI reconstruction in a data assimilation technique to force the Lund-Potsdam-Jena Dynamic Global Vegetation Model (LPJ-DGVM; Sitch et al, 2003) for the last 1000 years. The LPJ-DGVM is a well validated and widely used model of the terrestrial carbon cycle and vegetation dynamics, and is an ideal tool for addressing the research questions posed. This work will provide insight into how drought dynamics over the last millennium have influenced ecosystem dynamics and carbon cycle processes. Additionally, this will provide the modeling community with a new set of initial conditions for present and future modeling experiments over this region.

Assimilating soil moisture data into the LPJ-DGVM will require substantial adjustments to portions of the model code. To accomplish this, we will use the expertise of Dr. Jed O Kaplan of the Swiss Federal Institute WSL. Dr Kaplan is an expert in ecosystem and vegetation modeling who has been intimately involved in the development, validation, and improvement of two of the most widely used models in the Earth System Science Community-BIOME4 and the LPJ-DGVM.

Budget Request: $6000

Trip 1:	
Airfare (1 RT Geneva to New York)	$1000
7 days Per Diem and Lodging, Palisades	$1000
Trip 2:	
Airfare (1 RT New York to Geneva)	$1000
7 days Per Diem and Lodging, Lausanne	$1000
Trip 3:	
Airfare (1 RT New York/Geneva)	$1000
7 days Per Diem and Lodging (NY or Lausanne)	$1000
TOTAL	**$6000**

Budget Justification

The budget will be used to pay for travel to facilitate collaboration between the two research groups. In the first trip, Dr Kaplan will come to Lamont-Doherty. While Dr Kaplan is visiting, we will 1) setup and configure computer systems at Lamont-Doherty to effectively run the LPJ-DGVM and 2) work on translating the PDSI soil moisture estimates into usable input for the model. All of the necessary data and computing resources are already available and in place at Lamont-Doherty. Once things are initially up and running, we anticipate the bulk of the rest of the work can be done remotely. In the second trip, Dr Cook will visit Dr Kaplan's lab in Switzerland. The goal of this trip will be to 1) analyze and discuss initial results, 2) discuss possible improvements, and 3) begin work on the initial manuscripts and full proposal. The third and final meeting will occur either here at Lamont or in Lausanne, and will serve to finalize the manuscripts and future proposals.

This work will serve to substantially expand the research focus at Lamont in an area of active interest that has not been previously served well at the Observatory. We anticipate, within a year, at least two manuscripts and the basis for a longer grant proposal aimed at incorporating additional climate reconstructions from different regions.

References

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