Improving Earth Systems Models Through Research in the Tropics

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A guest post from PLOS Ecology Reporting Fellow, Daniel E. Winkler, on research from the Ecological Society of America Scientific Meeting in Ft. Lauderdale, Florida, August 7-11, 2016.

Forests of the Amazon and in tropical systems around the globe cycle more carbon than any other ecosystem on Earth. Tropical forests play a critical role in determining much of the Earth's energy balance. Furthermore, it is estimated that forests of the tropics are the Earth's largest carbon sink. However, to date little research has uncovered the processes controlling carbon cycling in the tropics. As a result, Earth system models (ESMs) have suffered and often perform poorly because of this substantial knowledge gap. This has made forecasting future climate and cycling under global change scenarios difficult and sometimes unreliable. The Department of Energy is funding a $100 million project (yes! I said $100 MILLION) called NGEE-Tropics–next-generation ecosystem experiments project in the tropics.

Above the Amazonian canopy. Photo courtesy of NGEE-Tropics (http://eesa.lbl.gov/ngee-tropics/)

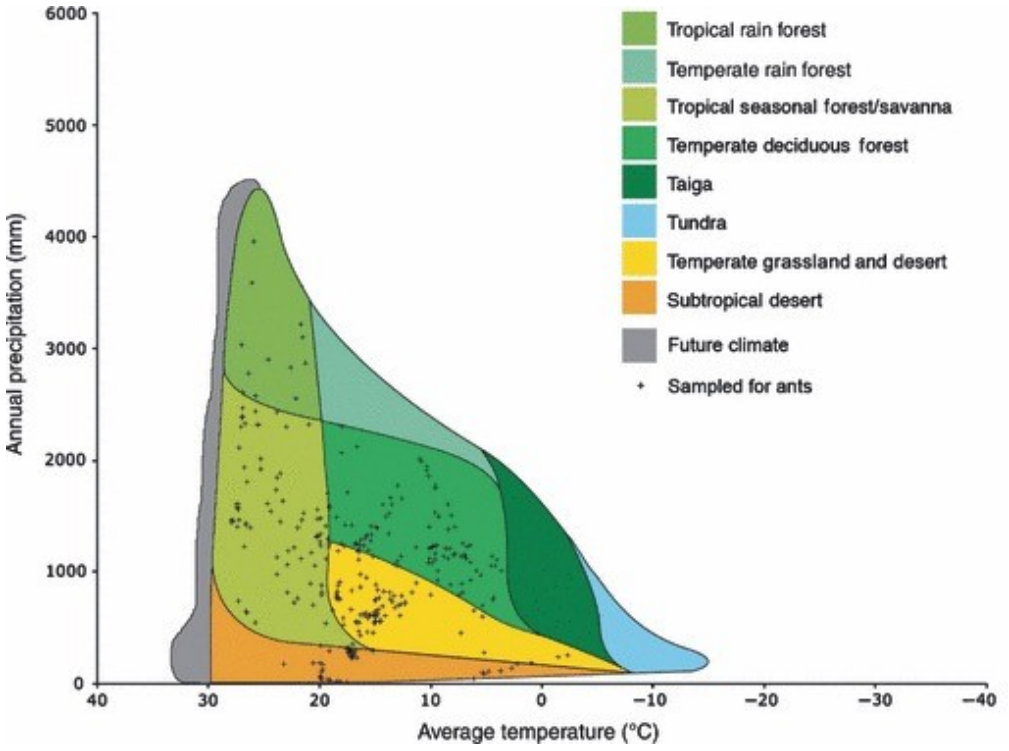
This funding will span 10 years of research. The project's overarching goal is to improve ESMs by developing "a predictive understanding of how tropical forest carbon balance and climate system feedbacks will respond to changing environmental drivers over the 21st century."

NGEE-Tropics was featured in an organized oral session this year at ESA called Novel Tropical Ecosystems: Response to Global Change. Session organizers Jennifer Holm, Jeffrey Chambers, and Lara Kueppers are researchers at the Lawrence Berkeley National Laboratory (LBNL) leading the project that also includes collaborators outside of LBNL from Brookhaven, Los Alamos, Oak Ridge, and Pacific Northwest national laboratories, researchers from the Smithsonian Tropical Research Institute, U.S. Forest Service, the National Center for Atmospheric Research, NASA, and international collaborators including from Brazil's National Institute of Amazonian Research.

This work seems fitting to highlight at ESA this year given the meeting's theme: Novel Ecosystems in the Anthropocene. Novelty under future scenarios may be primarily seen in tropical systems given that they currently reside at the edge of bioclimatic life zones. Thus, global change may force shifts in processes in these systems into novel states that have no analog to compare to.

> *How will tropical systems respond when mean annual temperatures shift beyond 30°C as predicted?*

Jeffrey Chambers started the session with an overview of the current state of research examining drought and temperature responses of tropical systems, and how NGEE-Tropics aims to advance ESMs by providing a predictive understanding of tropical systems responses to change.



Classic Whittaker plot of world biomes with a future climate/no-analog state mapped in gray. How will tropical systems respond when mean annual temperatures shift beyond 30°C as predicted? Figure from Jenkins et al. 2011 exploring the diversity of ants under global climate change.

NGEE-Tropics seeks to develop a representative, process-rich tropical forest ecosystem model. The model will extend vertically from tropical bedrock to the top of the forest canopy and will allow for models of evolution and feedbacks of tropical ecosystems in a changing climate to be modeled at the super fine resolution of a next-generation ESM grid cell (i.e., 10 km^2 cells! ... most current models produce 100 km^2

resolution of a next-generation ESM grid cell (i.e., 10 km2 cells!...most current models produce 100 km2 or larger). A lofty goal indeed! One of the coolest features of the project is their integration of not just biogeochemistry and hydrologic cycles in their models, but also plant demography, ecophysiology, and plant functional traits.

Shifting north to the subtropical climate of Puerto Rico, Molly Cavaleri from Michigan Technological University presented work from the Tropical Responses to Altered Climate Experiment (TRACE) in collaboration with her institution as well as the U.S. Forest Service and USGS. Their experiment is the first warming experiment conducted in a tropical forest ecosystem and uses infrared heaters to warm soil and plants of the understory along with individual leaves and branches in the forest canopy. The project is being carried out in the Luquillo Experimental Forest in Puerto Rico.

A plot surrounded by infrared heaters at the TRACE site in the Luquillo Experimental Forest in Puerto Rico.

The experiment is about to kick into full swing when heaters are turned on over the next few months and into early next year. More information and future updates can be found on the project's website: www.forestwarming.org.

Several other exciting projects in tropical systems were showcased in the remainder of the session, including another experiment in the Luquillo Experimental Forest in Puerto Rico led by UC Berkeley Professor Whendee Silver. Postdoctoral Researcher Christine Sierra O'Connell presented results from the experiment that highlight the persistent effects of drought on soil moisture and oxygen long after the

drought itself has ended.

Site of the Silver Lab's research at the Luquillo Experimental Forest in Puerto Rico. Image courtesy of Christine O'Connell.

Their results also reveal the importance of topographic controls on soil biogeochemical responses to drought. Overall, their work and the others in this Novel Tropical Ecosystems session are helping science advance towards reducing the uncertainty of ecological processes under novel tropical climates.

Daniel Winkler is a PhD candidate at the University of California, Irvine and a recent National Park Service Young Leader in Climate Change. Daniel is a plant ecophysiologist interested in invasive species, evolutionary ecology, and climate change impacts on native communities in "extreme" environments. His field sites include much of the desert southwest, alpine regions of Colorado, the subalpine forests of Baja

California, and the tundra of northern Japan. All of Daniel's research focuses on climate change impacts on native systems, with an emphasis on parks and protected areas. You can follow him on Twitter @DanielEWinkler, his research on Facebook at www.facebook.com/GeoMustard/, or find more information on his website at www.winklerde.com.

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