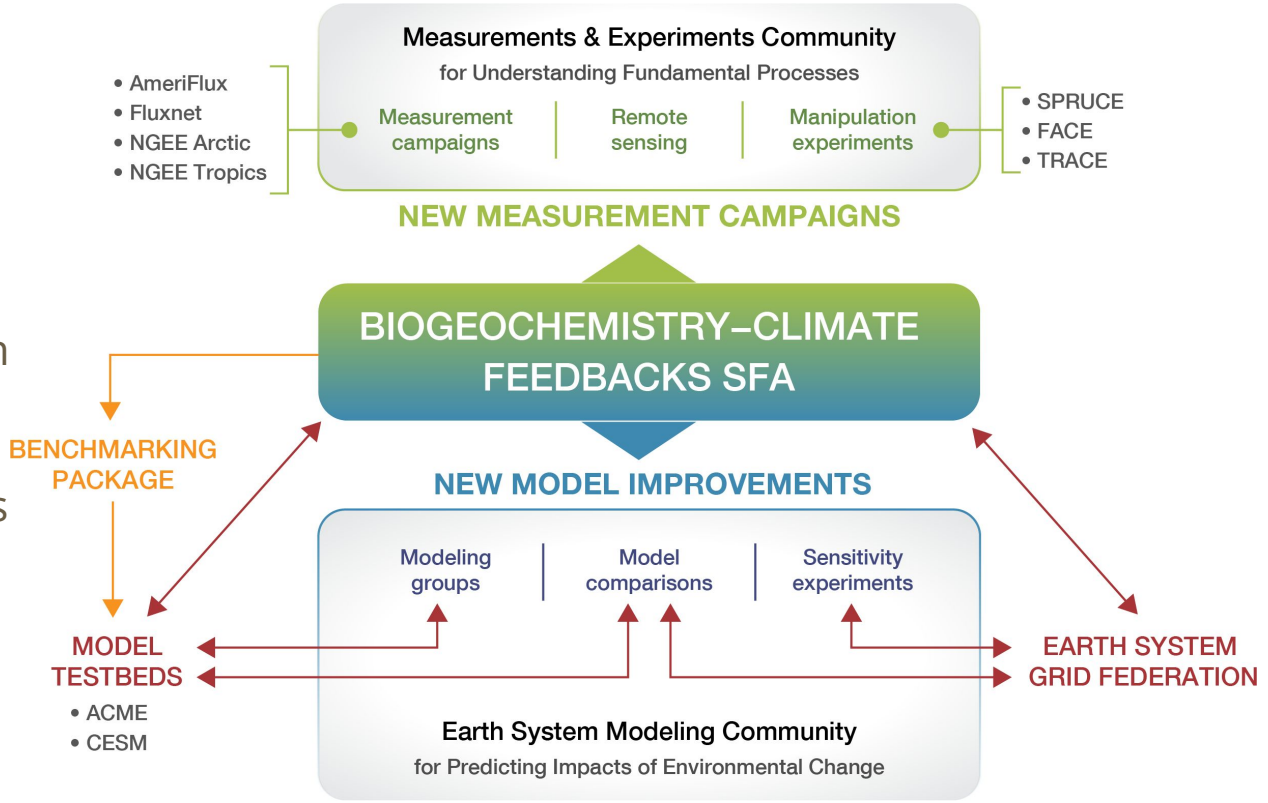
BGC Feedbacks SFA Tropical Research Agenda

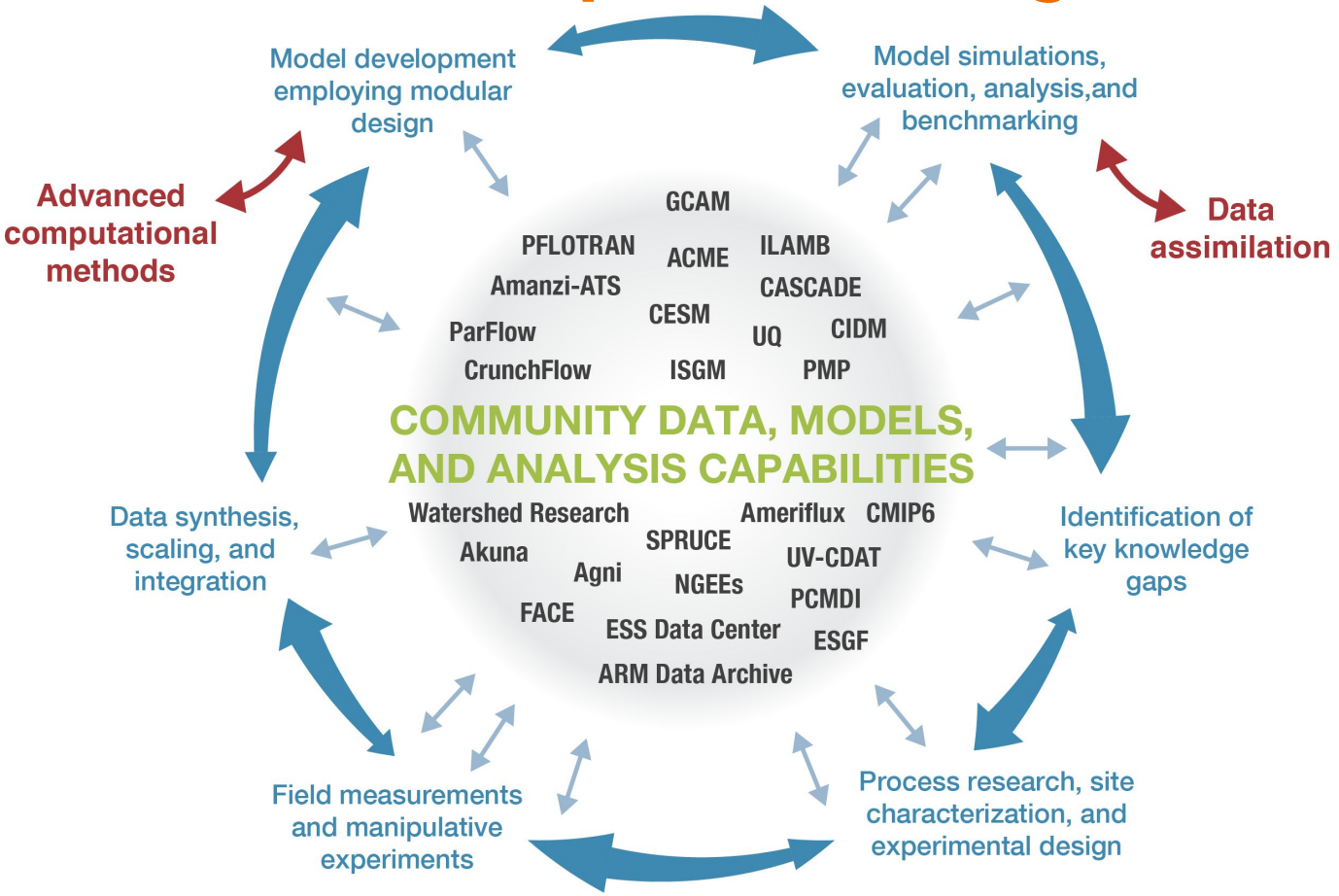
Forrest M. Hoffman (ORNL), William J. Riley (LBNL), and James T. Randerson (UCI)

Biogeochemistry Feedbacks Scientific Focus Area

- Develop new hypothesis-driven approaches for evaluating ESM processes and using observations at site, regional, and global scales
- Investigate degree to which contemporary observation may reduce uncertainties, using emergent constraints
- Create community open source benchmarking software systems
- Evaluation performance of biogeochemical processes and feedbacks in models



Model-Data-Experiment Integration



Tropical Research Objectives

- To study land–atmosphere interactions and how climate variability and change influence ecosystem responses
- To study terrestrial, marine, and atmospheric responses and feedbacks of El Niño Southern Oscillation (ENSO) and extreme events
- To support model–data integration and develop metrics for benchmarking land and ocean responses and feedbacks
- To develop benchmark datasets in collaboration with NGEE Tropics
- To leverage the ACME model for biogeochemical cycle forecasting

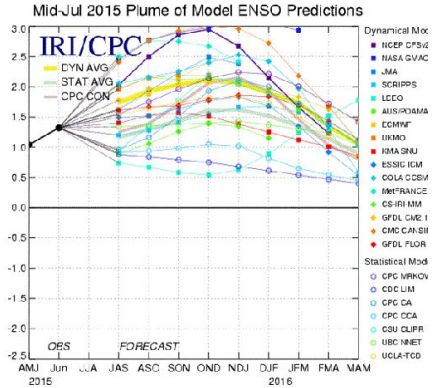
Decadal-Scale Predictability of Ecosystem Responses

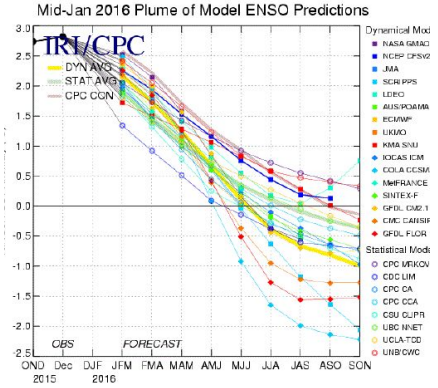
- This research leverages the **ACME model** (ESM Program) to **study ecosystem responses to climate variability** (RGCM Program) and to **support research and model development in NGEE Tropics** (TES Program)
- Objectives
  - **To study responses and feedbacks of tropical droughts** induced by 1997–1998 and 2014–2016 El Niño events in the ACME land model
  - To study model responses of the 2005 and 2010 Amazon droughts, which were a consequence of Atlantic Ocean conditions
  - **To construct meteorological forcing data**, including strong tropical land–atmosphere interactions, from CAM5-SE for use in NGEE Tropics process model development and testing for the FATES model
  - **To test the utility of the ACME framework for decadal-scale biogeochemistry predictions and tropical ecological forecasting**

ACME
Accelerated Climate Modeling for Energy

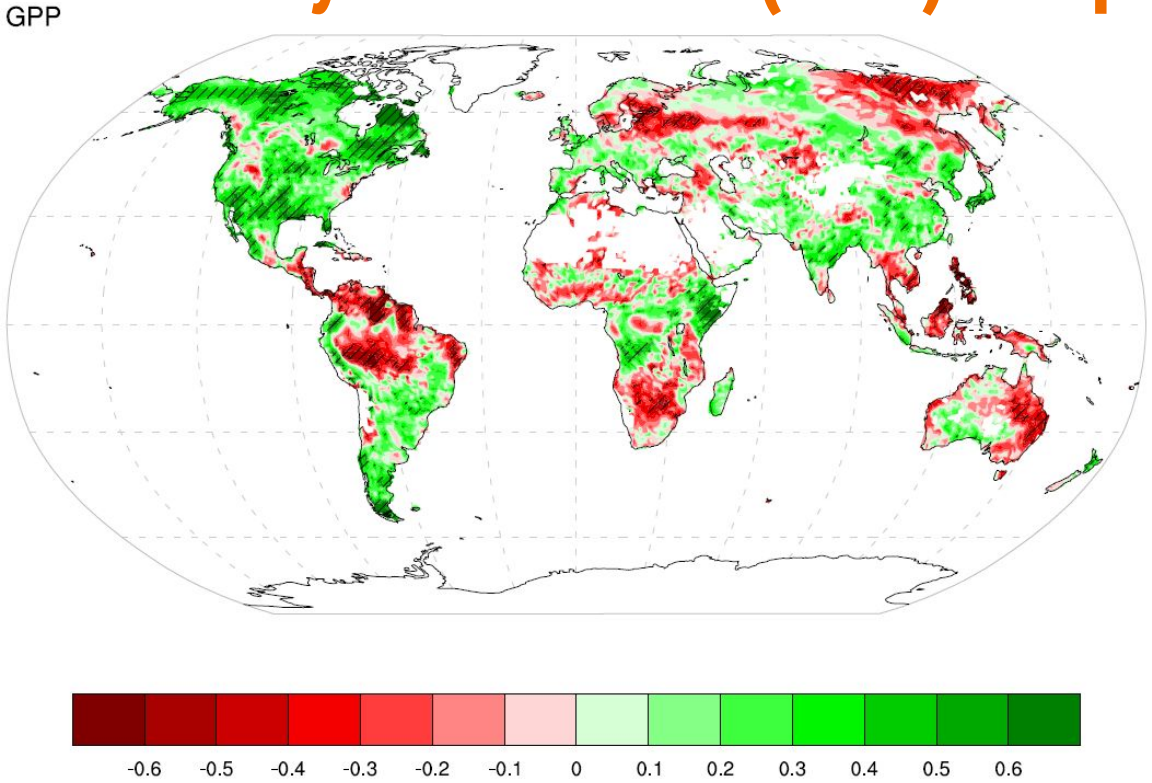
Decadal-Scale Predictability of Ecosystem Responses

- Model Configuration
  - ACME v0.3 and v1.0-pre run at 1-degree (ne30np4) AMIP-style (F compset)
  - Data ocean model reads NOAA Optimum Interpolation (OI) version 2 daily sea surface temperature (SST) (September 1981–present)
  - Sea ice fractions are also provided by the OISSTv2 data set
  - Future SST projections come from 9-month seasonal forecasts of the NOAA Climate Forecasting System (CFSv2)
  - Beyond 9 months from present, SSTs and ice fractions are drawn from historical OISSTv2 data (match SST magnitude and direction) for 5 years



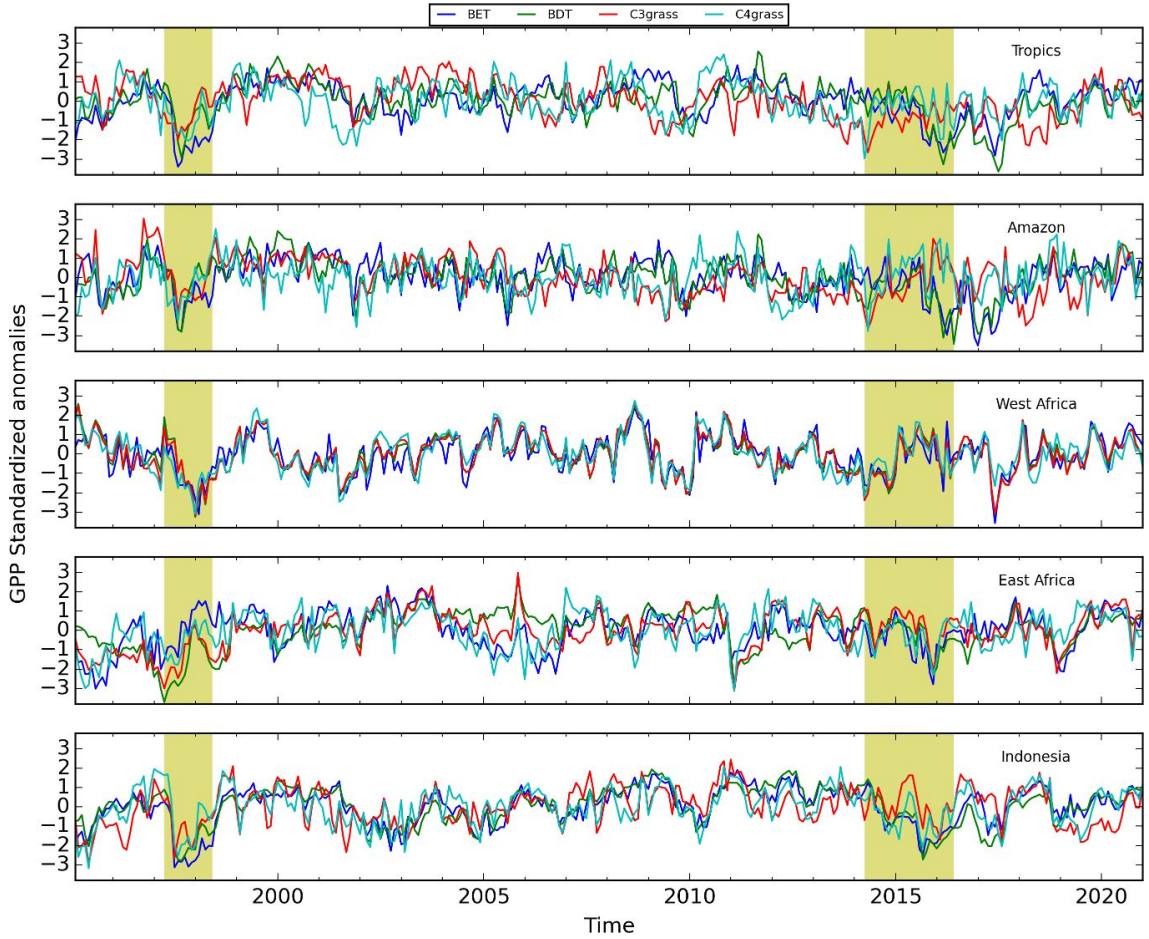


Global Gross Primary Production (GPP) Responses



Correlation of annual gross primary production with 5-month averages of sea surface temperatures over the Niño 3.4 region (November–February) during 1995–2016. The hatching indicates areas where the correlation is at a 90% confidence level or higher.

Regional PFT-level GPP Anomalies



Decadal-Scale Predictability of Ecosystem Responses

- Analysis of spin up simulation indicated that land carbon pools approached equilibrium when driven by OISSTv2 (1982–1994).
- ILAMB evaluation showed a +0.5 K bias in mean surface air temperature over land and a positive bias in mean precipitation at high elevations.
- Patterns of 2-m air temperature and precipitation correlations with Niño 3.4 SSTs were consistent with NCEP and ERA-Interim reanalyses.
- Patterns of GPP correlations with Niño 3.4 SSTs were consistent with expectations, especially GPP reductions in the Amazon and Indonesia.
- Patterns of precipitation and soil moisture for the 2010 Amazon drought were consistent with data reported by Lewis et al. (2011).
- Next: decompose carbon fluxes (growth, respiration, fire), compare atmospheric CO_2 variability with observations, and compare with site measurements.
- Ready to upgrade to ACME v1.0 model and use methodology to investigate ENSO-related energy, water, and carbon questions.

Future Tropical Research Collaboration

- Understanding how changes in water availability (thus evapotranspiration and latent heat) influence regional temperatures (Paul Levine, UCI)
- Decomposing continental influences on global precipitation (Gabe Kooperman, UCI)
- Understanding the influence of tropical biomass burning, deforestation, and afforestation on global biogeochemical cycles
- Constraining ecosystem responses by confronting models with land, ocean, and atmosphere measurements and informing field activities
- Develop tropical-specific metrics for evaluating ACME and community models