Effects of ENSO-induced extremes on terrestrial ecosystems

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Conclusions and Discussions
Model and methodology

DOE Energy Exascale Earth System Model (E3SM) model v0.3
- 1-degree (ne30np4) F-compset configuration:
  - active atmosphere model (CAM5-SE)
  - active land (ELM) with the biogeochemical model on
  - data ocean (DOCN)
  - thermodynamic sea ice (CICE)
- Data ocean reads NOAA Optimum Interpolation (OI) version 2 daily sea surface temperature (SST) (1981 to present)
- Ice fractions are also provided in the OI SST data set
- Future SST projections come from 9-month seasonal forecasts of the NOAA Climate Forecast System (CFSv2)
- Beyond 9 months from present, SSTs and ice fractions are estimated from historical OI SST data to complete simulations to 2020

The model spin-ups to reach the model equilibrium state

Our analysis here utilized one of the ensemble results simulated from the DOE Energy Exascale Earth System Model (E3SM) model v0.3 1-degree (ne30np4) F-compset configuration:
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The model spin-ups to reach the model equilibrium state

Our future plan is as follows:
- Do the 182 model years.
- Continue the above simulation to 2020 from the quasi-equilibrium state
- Recycle the 1982–1994 OISST data to drive the model till it reaches the quasi-equilibrium state
- Remap the above initial condition to the spectral element grid
- Use the land initial condition for the 20th century simulations
- Identify ENSO-induced extremes over the Tropics
- Study impacts of climate extremes on terrestrial ecosystem and biogeochemical extremes

Identification of extremes

El Niño-Southern Oscillation (ENSO) includes its warm (El Niño) and cold (La Niña) phases, can significantly alter precipitation and air temperature patterns locally and globally by teleconnections. It normally causes drought (flood) and excessively hot (cold) weather over Tropics during El Niño (La Niña), respectively. Drought is one of climate anomalies and its intensity and duration depend not only on the current weather conditions, but also on the cumulative effects of previous months. The short-term of water deficit due to lack of precipitation may not cause the plant hydraulic imbalance large enough for plants to respond. In this study, we use 3-month SPI and SPEI to find short-term drought (index less than -1.5) and scPDSI (index less than -3) to find long-term droughts caused by ENSO using model results. We use 95% and 5% percentiles for monthly mean of daily maximum and minimum temperature to identify heat and cold waves respectively. All biogeochemical variables are considered as extremes if they are less than their 5% percentiles.

Conclusions and Discussions

Drought and heat wave affect terrestrial ecosystem severely during the El Niño events
- The losses of GPP, autotrophic and heterotrophic respirations caused by short and long-term droughts are similar
- Approximately 18-43% of total GPP/respiration losses are caused by rare climate extremes
- Climate extremes lead to about 20-79% of BGC extremes in Tropics, Amazon, West and East Africa and Indonesia respectively. The losses on ENSO sensitive grids and months are computed by subtracting their corresponding monthly climatology calculated among all neutral years.

Figure: The percentages of the extremes in the biogeochemical variables (GPP, NEP, AR and HR) coincided with the climate extremes to the total BGC extremes.

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