The responses of forest species composition and biomass to climate change

Why

- Importance of forest ecosystems
- Forest responses to climate change are of major concern
- Uncertain future of global forests

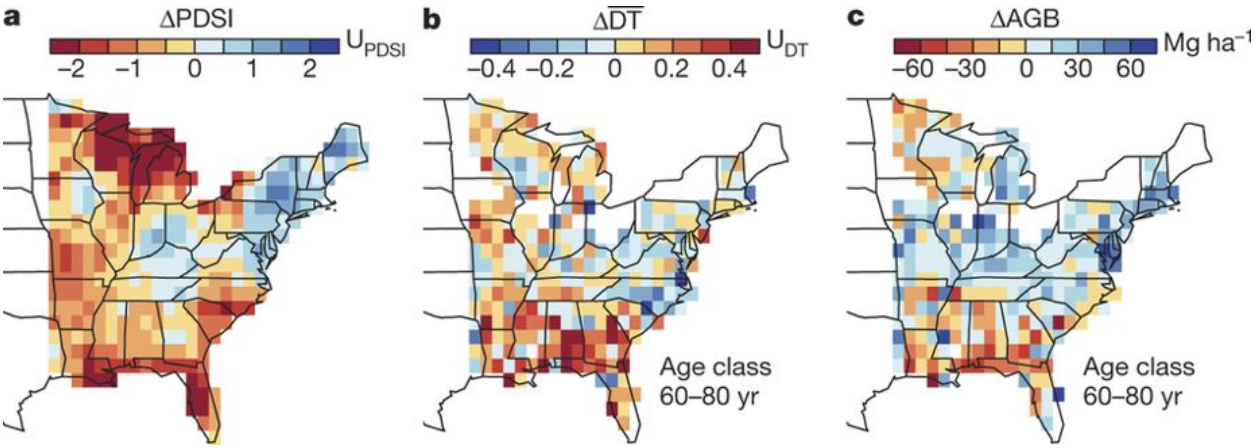
Questions

- How sensitive (or resilient) the forest ecosystems are to climate variability within ~3 decades?
  - Did forest species composition shift over the decades following the climate variability?
  - Did forest biomass or productivity respond to the climate variability over the decades?
  - Did forest biodiversity change over the decades following the climate variability?
- Does biodiversity affect forest resilience in responding to climate variability?
  - How to quantify biodiversity?
  - Which trait is the most important one whose diversity affects forest resilience?
- How to use phenology information to build predictive models of forest biomass or productivity?
  - Can phenology indicators reflect forest biomass change?
  - How do biodiversity and climate variability affect phenology indicators?
  - Is it necessary to design new phenology indicators to improve model's performance?

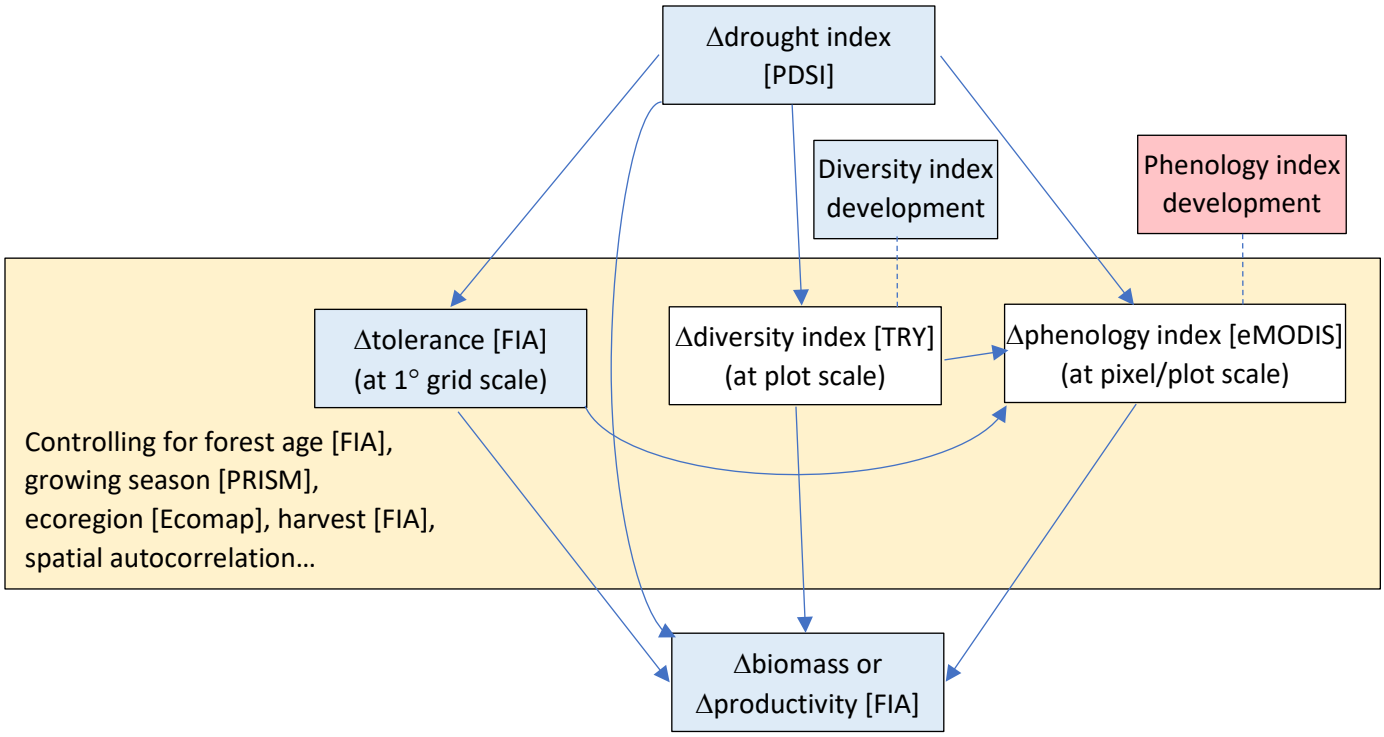
Data

- Forest inventory data (FIA – USFS): 9.92 GB in csv
- Historical climatic data (PRISM – Oregon State University): ? GB in raster bil
- Historical drought index data (PDSI – Princeton University): 143 GB in NetCDF
- Tree species trait data (TRY – Max Plank Institute): 4.23 GB in plain txt
- Phenological index data (eMODIS – USGS): 7.91 GB in raster bsq
- Ecoregion data (Ecomap – USFS): 36 MB in shp

Examples of change (more examples can be found at https://tz05.github.io/climfor.html):



Model framework



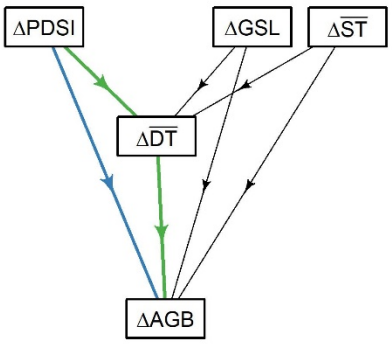
Methods

- Spatial regression modeling (with the "spautolm" function in the R "spdep" package), e.g.,

$$\mathbf{\Delta biomass} = a_0\mathbf{1} + a_1\mathbf{\Delta dought\ index} + a_2\mathbf{\Delta tolerance} + a_3\mathbf{\Delta growing\ season} + \cdots + \mathbf{u}$$

  where the bold terms are vectors (change of specific variable over decades) for the grids (inventory plots are aggregated into 1° grids); **u** is a vector of spatially autocorrelated errors.

- Structural equation modeling (with the "sem" function in the R "lavaan" package), e.g.,



- Mixed models (with the "nlme" function in the R "nlme" package)

- Other considerations: random forest (R “randomForest” package), quantile regression forest (R “quantregForest” package).
- Besides, biodiversity index design and R package development. I designed the Comprehensive Functional Diversity (CFD) and am developing an R package for its calculation. The CFD is to quantify the overall diversity of species assembly in a high-dimensional trait space.