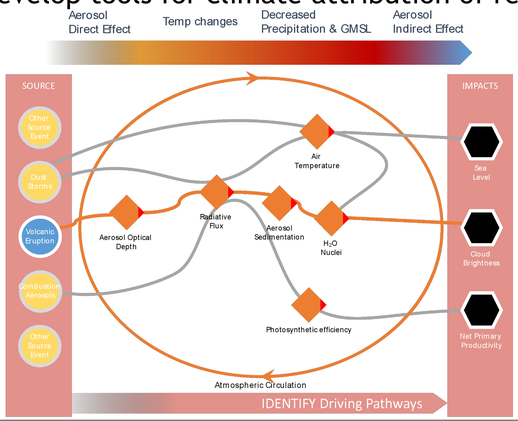
SAND2022-11899C

Sandia Academic Alliance - Fall 2022 - University of Illinois LDRD Mini-Conference

Modeling Spatiotemporal Trends following the Mt. Pinatubo Eruption

Motivation

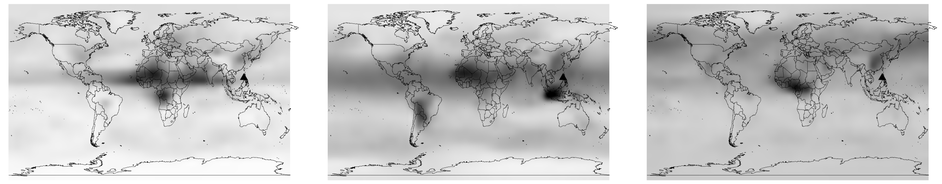
- Effects of solar climate intervention (SCI) efforts are confounded with climate change and natural variability
- The Mt. Pinatubo eruption (an SCI analog) presents a chance to develop tools for climate attribution of regionalized sources



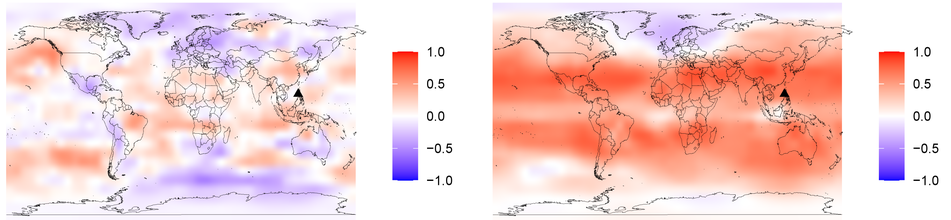
Goal: develop a model for characterizing dynamic space-time correlations between climate effects following an event.

Climate Data Exploration

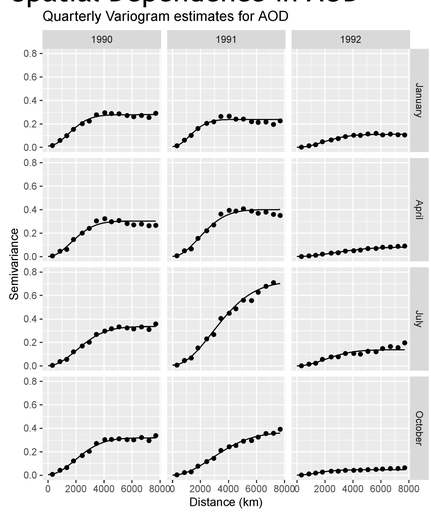
Aerosol Optical Depth (AOD) following the Mt. Pinatubo Eruption



Correlation between AOD and (50mb) Stratosphere Temperature



Spatial Dependence in AOD

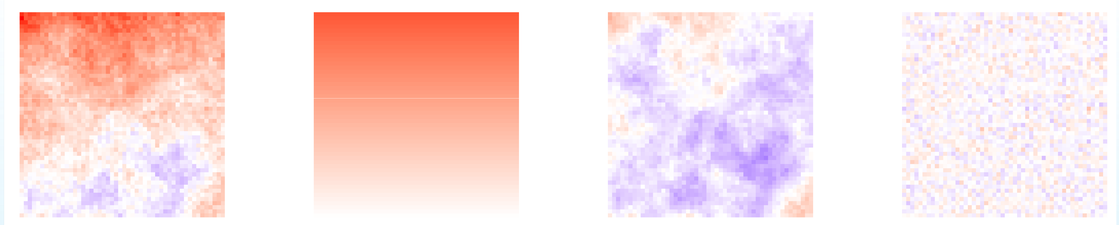


Modeling Approach

We adopt a space-time dynamic model for AOD and temperature. The dynamic formulation of the model coefficients allows for flexibility during extreme events while providing full characterizations of spatial dependence during each observed period.

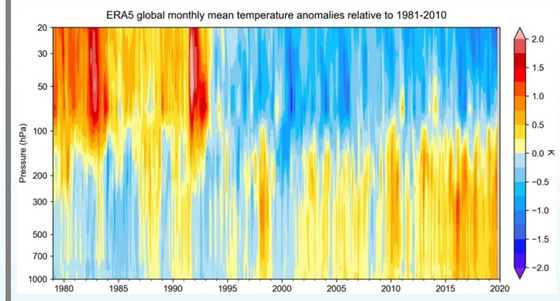
$$Y_t(s) = X_t(s)^T \beta_t + u_t(s) + \epsilon_t(s), \qquad \epsilon_t(s) \sim_{ind} N(0, \tau_t^2)$$
$$\beta_t = \beta_{t-1} + \eta_t, \qquad \eta_t \sim_{iid} N(0, \Sigma_\eta)$$
$$u_t(s) = u_{t-1}(s) + w_t(s), \qquad w_t(s) \sim_{ind} NNGP(0, \tilde{C}(\cdot|\theta_t))$$

This model allows us to isolate trends from different sources of variability in climate observations, making it possible to study each component individually.



Challenges

- Global area of focus presents challenges for model specification and computation
- Complex model requires custom Gibbs sampler implementation
- Choosing coarseness for space, time, and pressure levels



Temperature across the atmosphere. Source: ECMWF

Next Steps

- Testing dynamic model on individual climate variables to assess choice of design matrix
- Building the theory and Gibbs sampler for the multivariate extension of the model
- Evaluating model fit and running diagnostics
- Implementing sensitivity analysis with simulated data

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