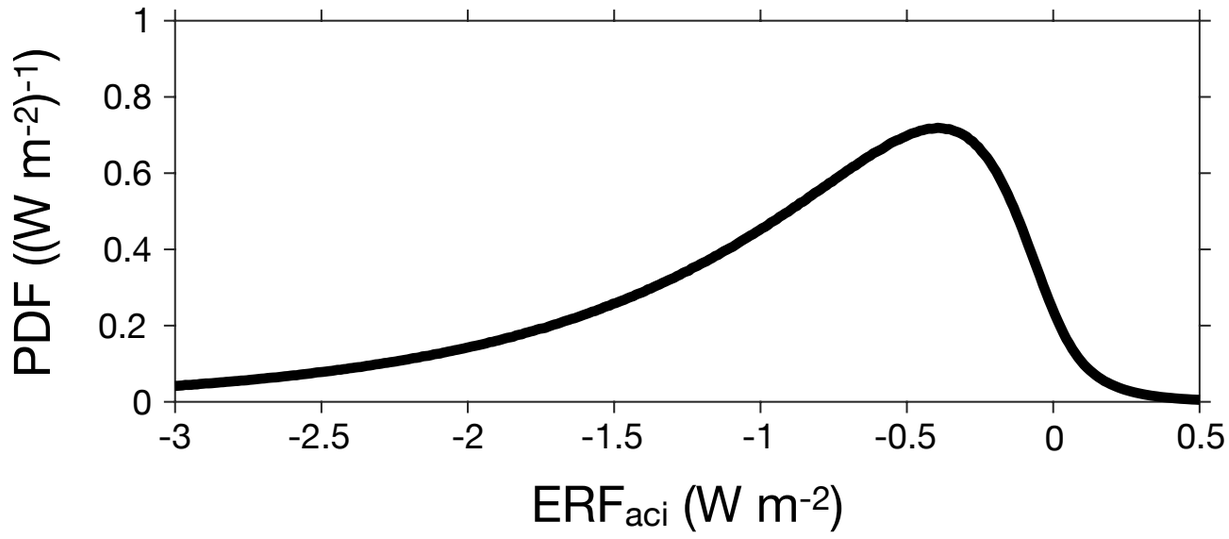
Assessing Aerosol-Cloud Interaction and Effective Radiative Forcing over the Global Ocean

Casey Wall[1], Joel Norris[1], Anna Possner[2],
Daniel McCoy[3], Isabel McCoy[4], Nick Lutsko[1]

[1]Scripps Institution of Oceanography, [2]Goethe University, [3]University of Wyoming, [4]University of Miami

Aerosol Forcing is Uncertain



We want to *constrain aerosol forcing* using "cloud-controlling factor" analysis.

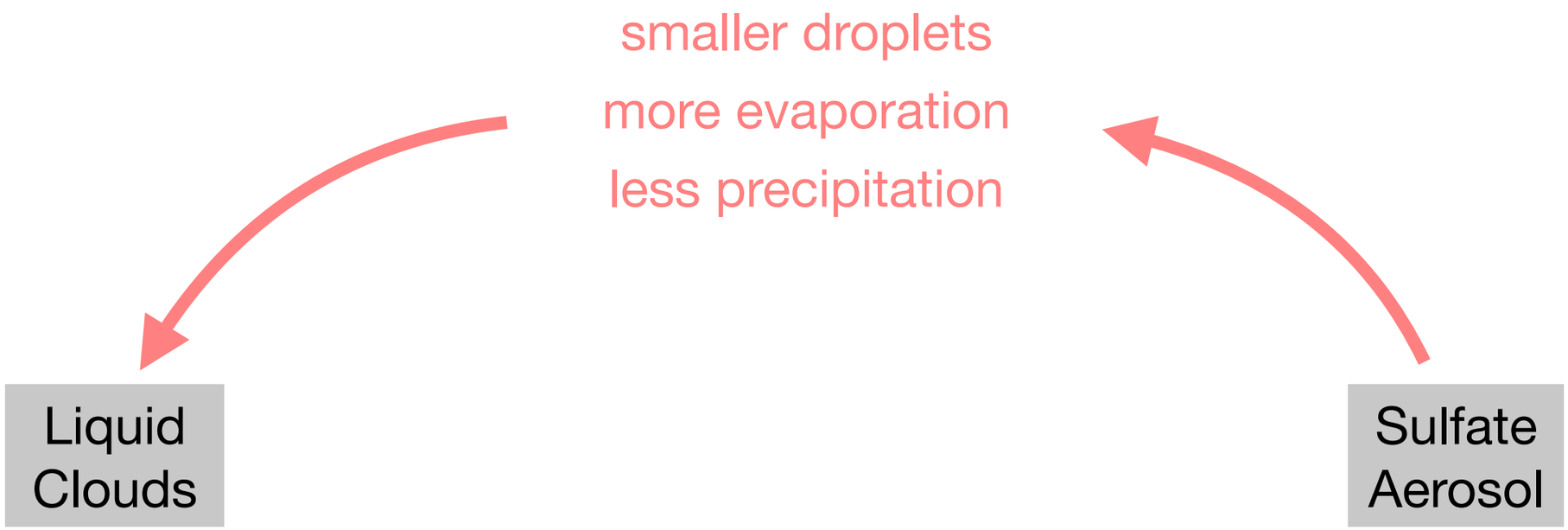
Bellouin et al. 2020

Mechanisms of Aerosol-Cloud Interaction

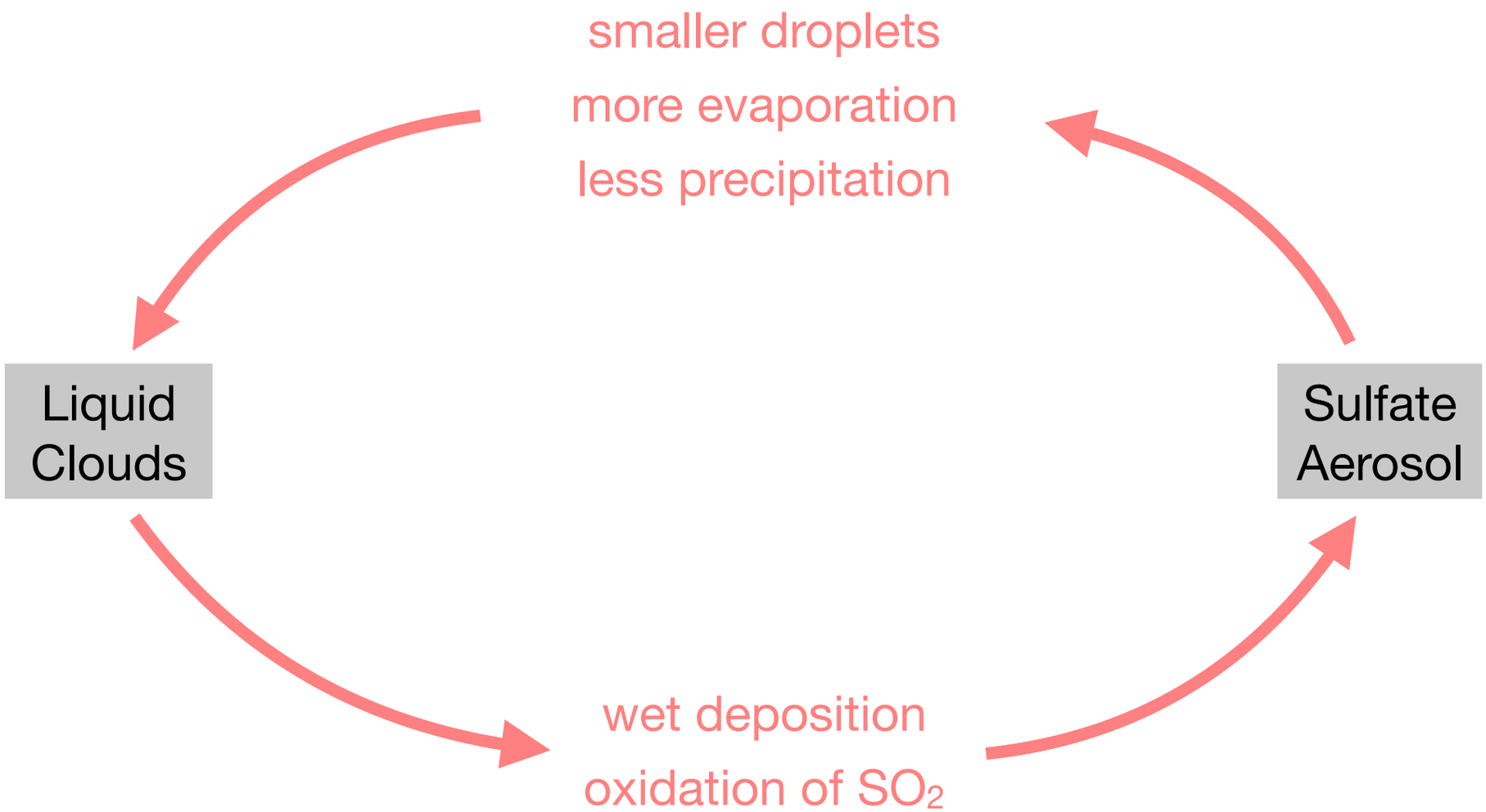
Liquid Clouds

Sulfate Aerosol

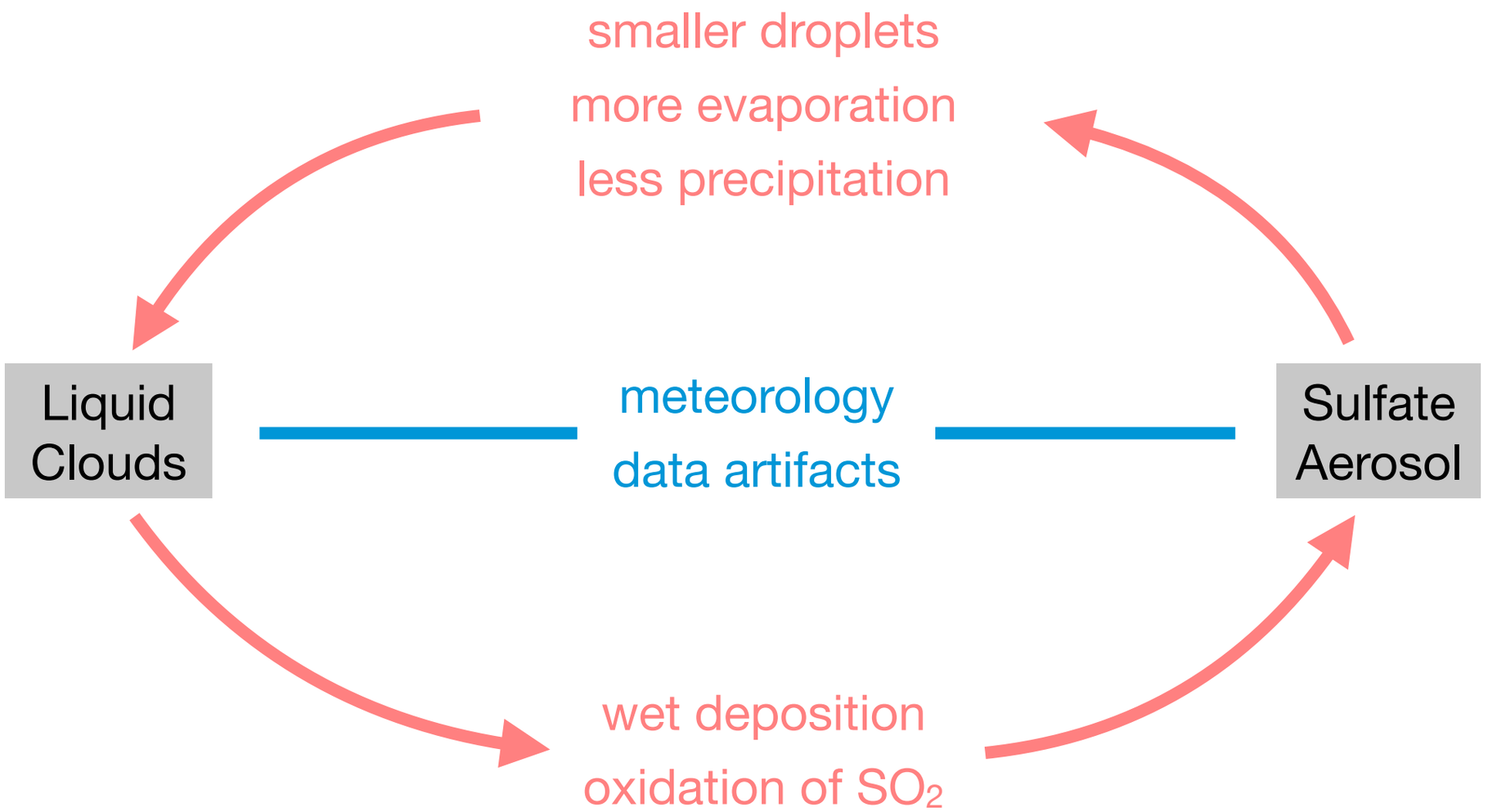
Mechanisms of Aerosol-Cloud Interaction



Mechanisms of Aerosol-Cloud Interaction



Mechanisms of Aerosol-Cloud Interaction



Goals

1. Remove confounding factors and quantify aerosol-cloud relationships
2. Test predictive skill
3. Estimate aerosol forcing

Data and Methods

Data

CERES FBCT and MODIS

R — low-cloud radiative effect

r_{eff} — cloud effective radius

$\mathscr{L}$ — liquid water path

L_n — low-cloud fraction

MERRA2

s — sulfate concentration (910 hPa)

meteorological variables

Resolution

monthly 5°x5° grid over ocean

"Cloud-Controlling Factor" Analysis

$$R' = \sum_{i=1}^{7} \frac{\partial R}{\partial x_i} x_i' + \epsilon$$

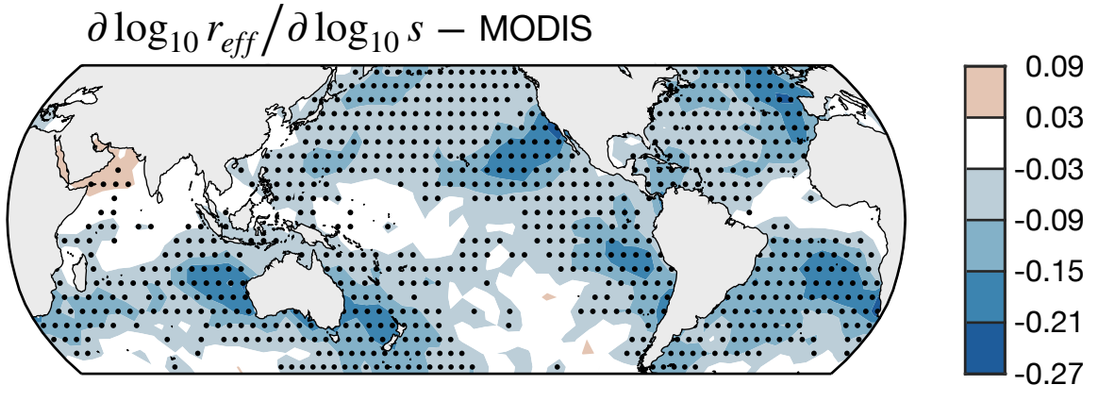
x_i — 6 meteorological variables and $\log_{10} s$

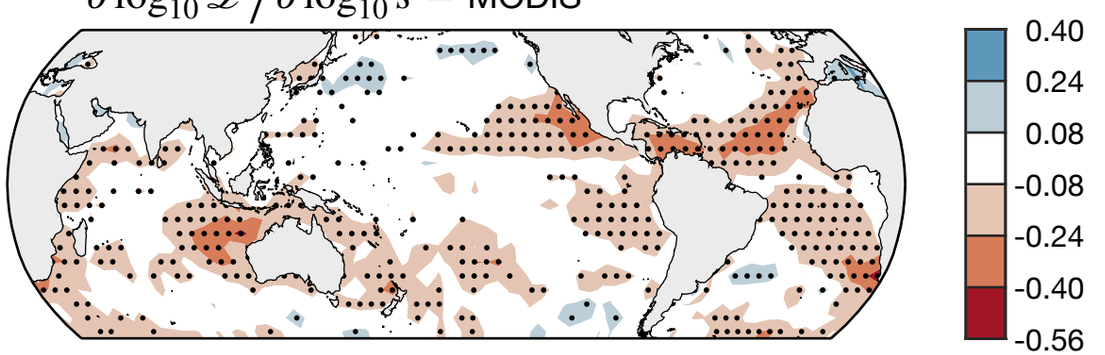
References

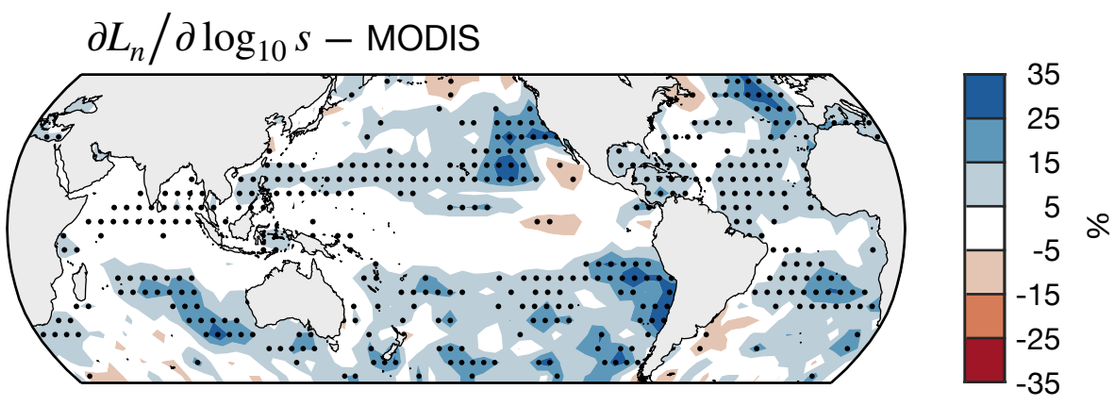
Scott et al. 2020

Myers et al. 2021

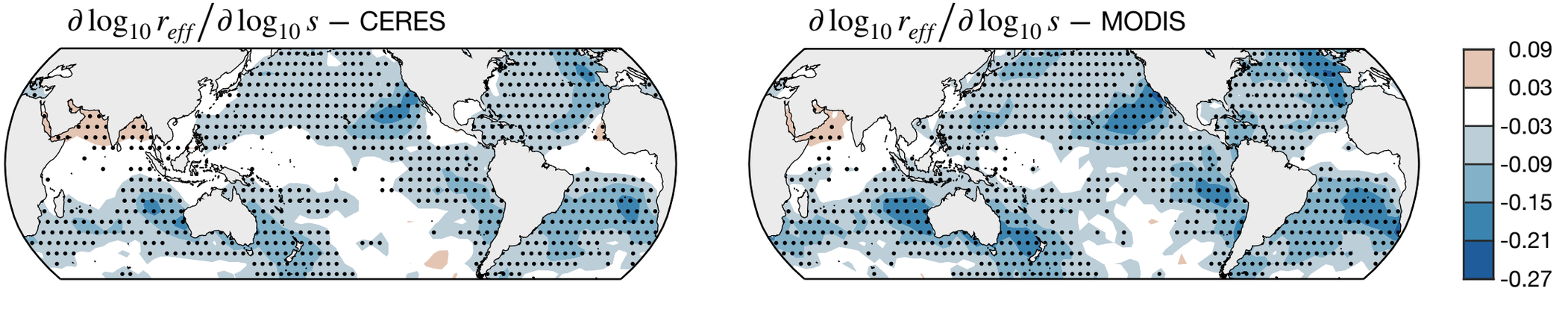
Relationships Among Aerosol and Cloud Properties



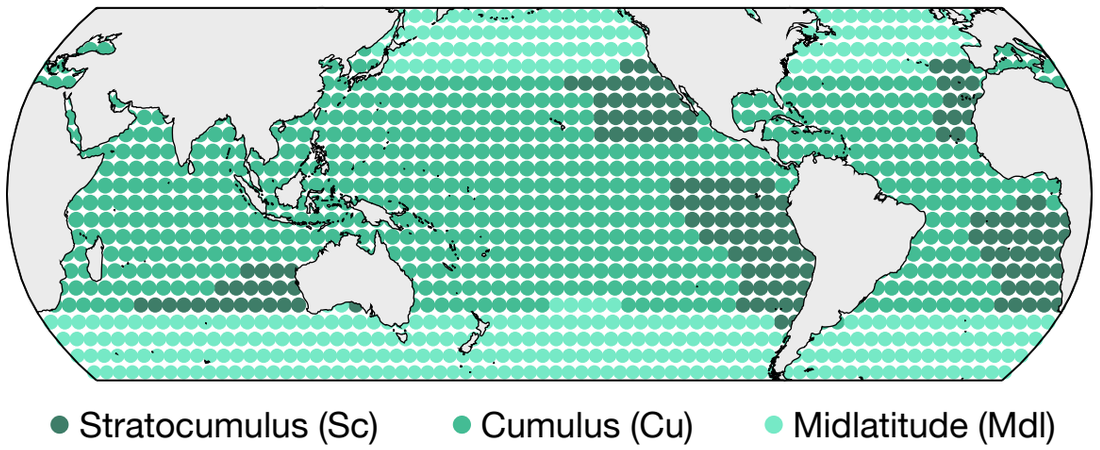


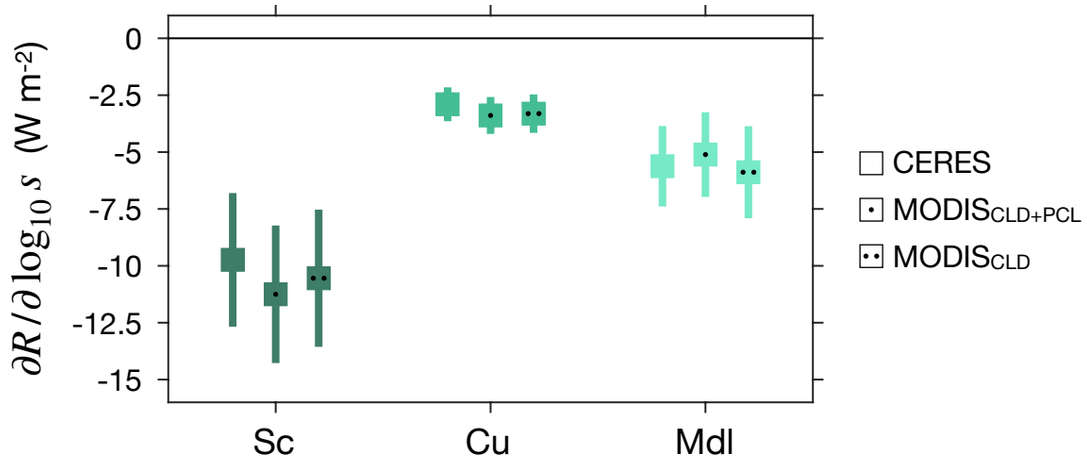


Relationships Among Aerosol and Cloud Properties

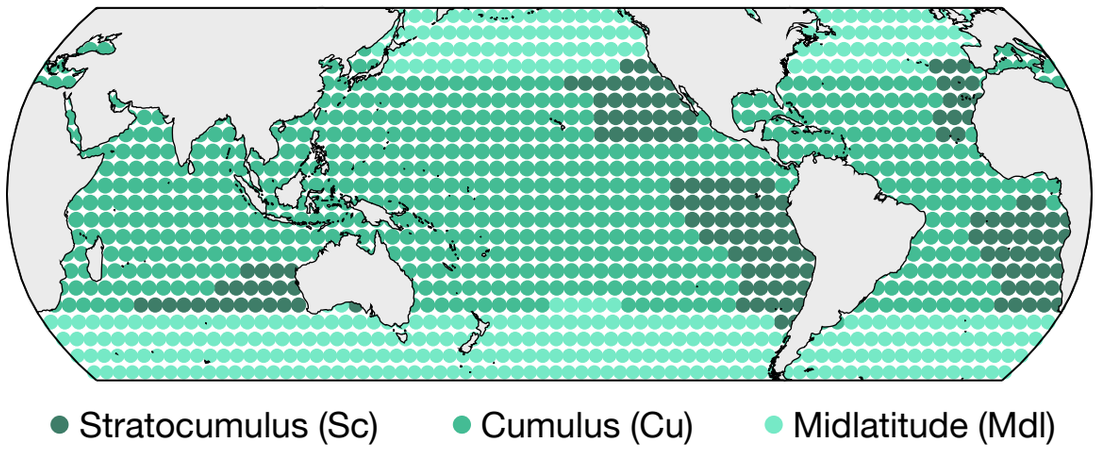


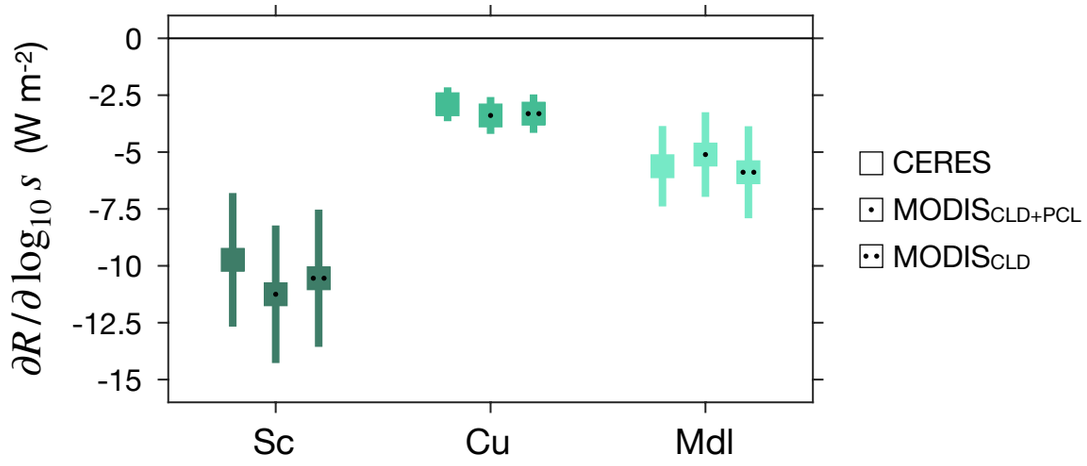
Relationships Among Aerosol and Cloud Radiative Effects





Relationships Among Aerosol and Cloud Radiative Effects

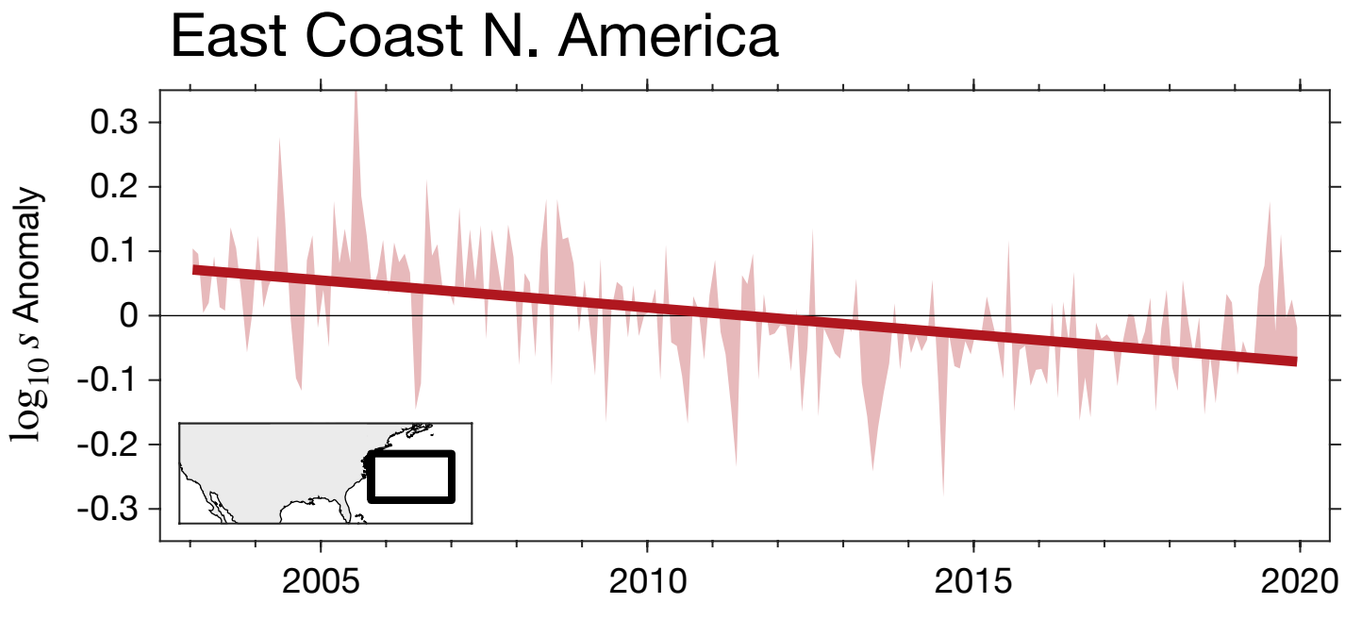


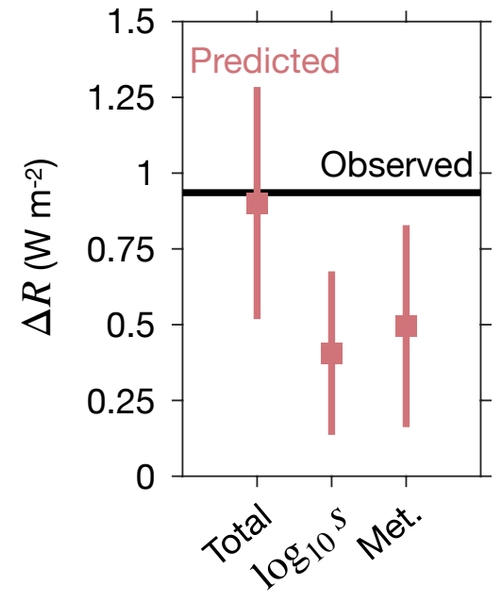


Goals

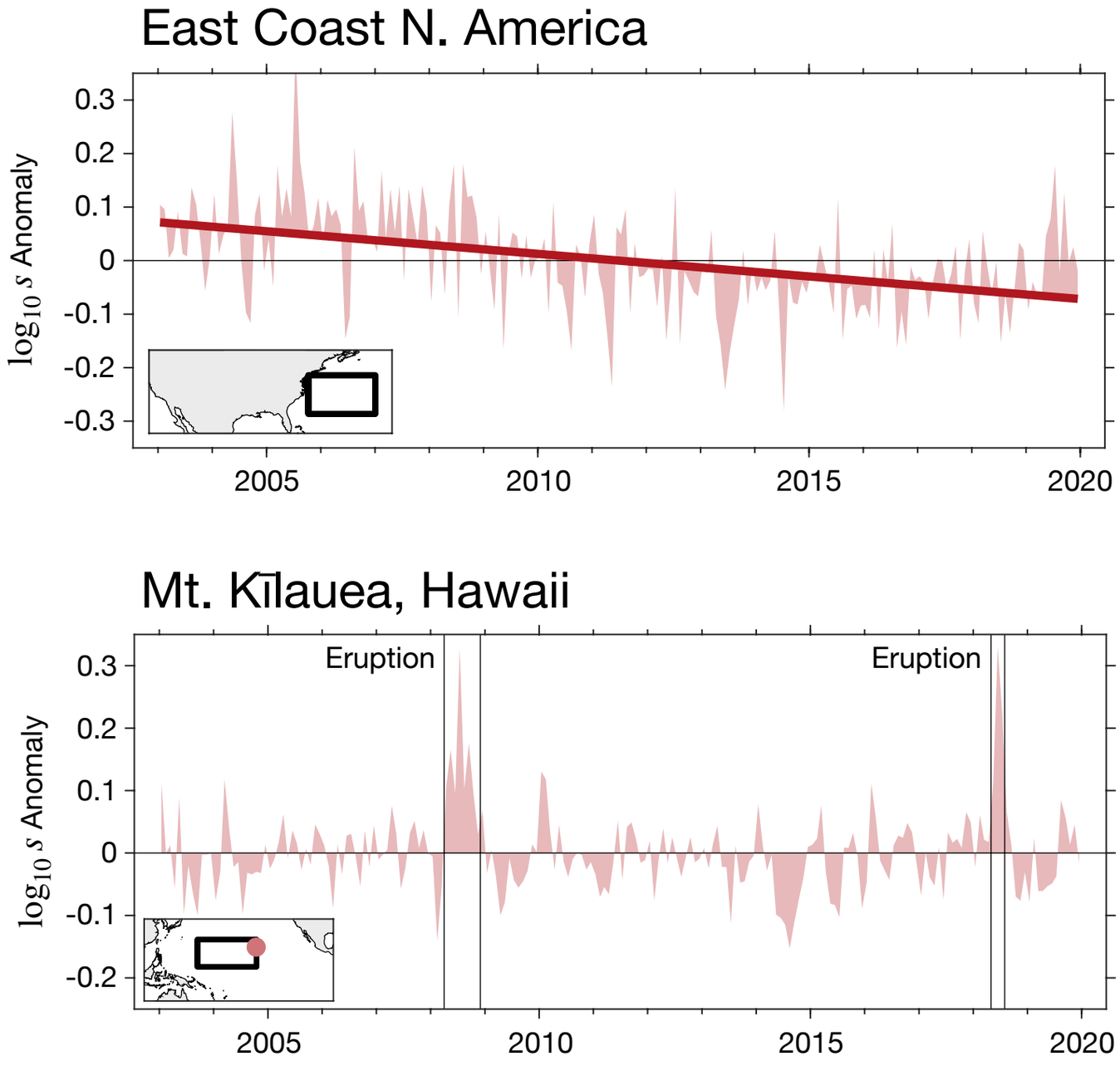
1. Remove confounding factors and quantify aerosol-cloud relationships ✓
2. Test predictive skill

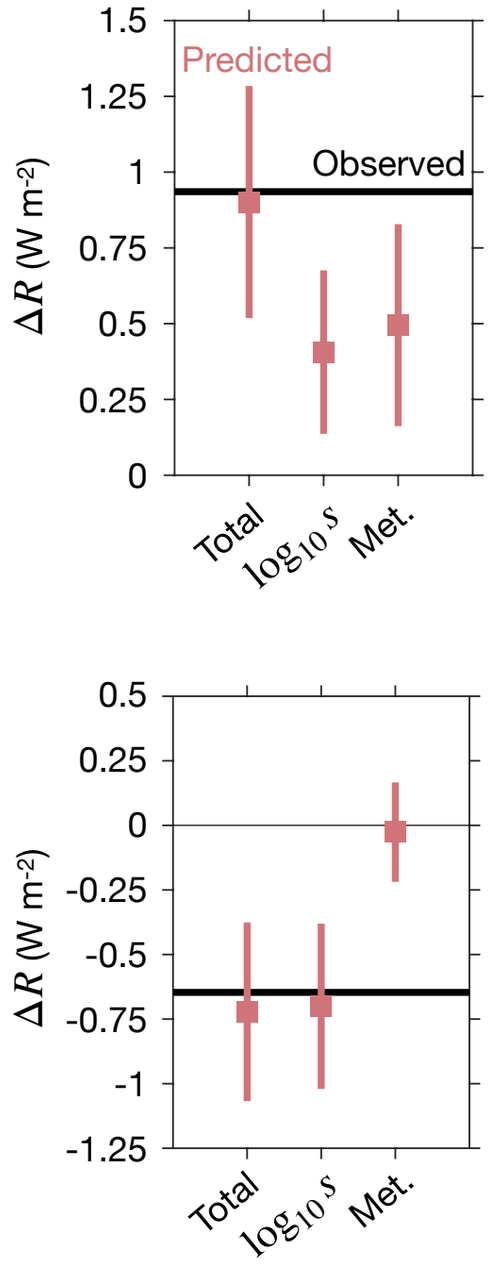
Test Cases for Validating Method





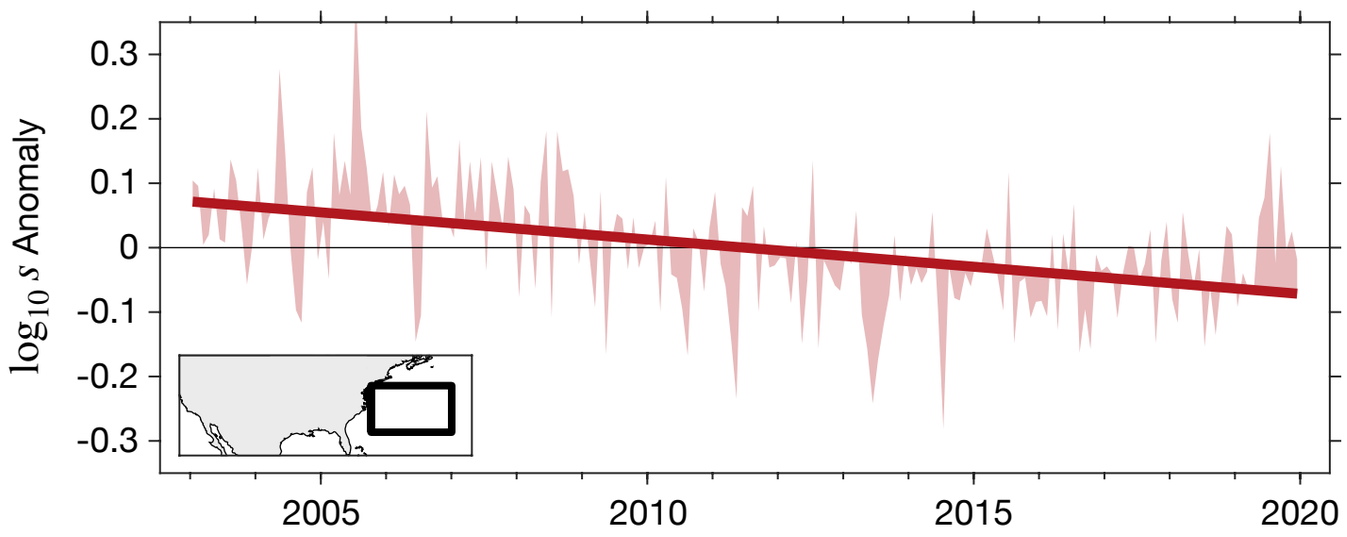
Test Cases for Validating Method

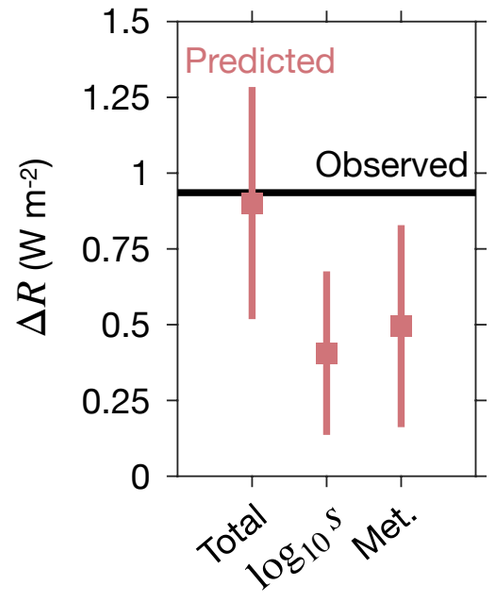




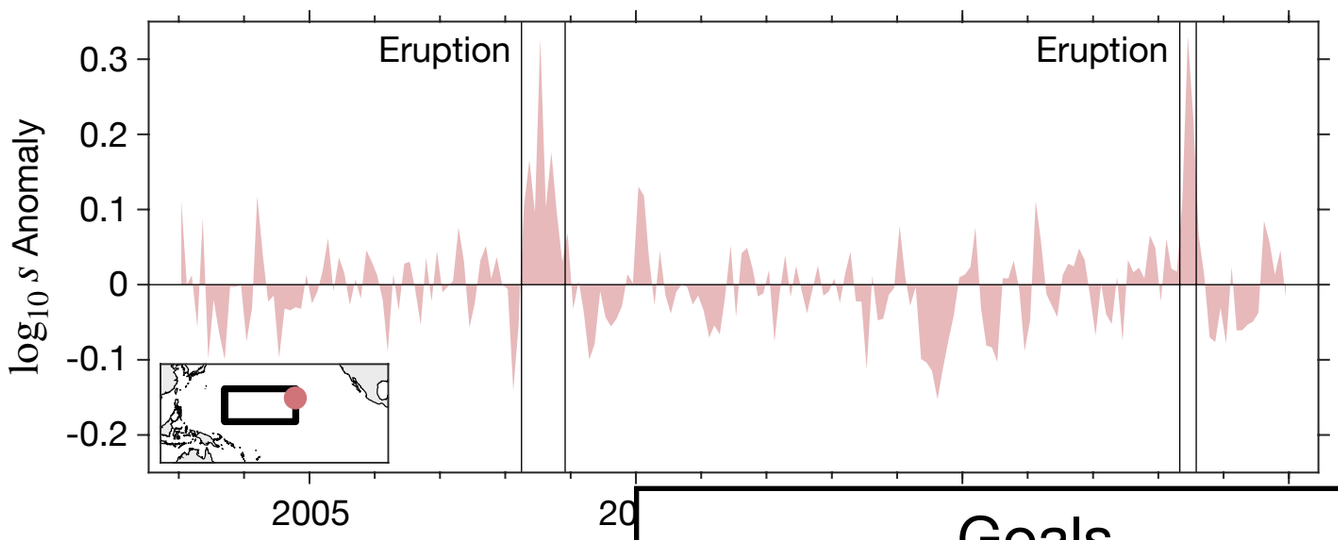
Test Cases for Validating Method

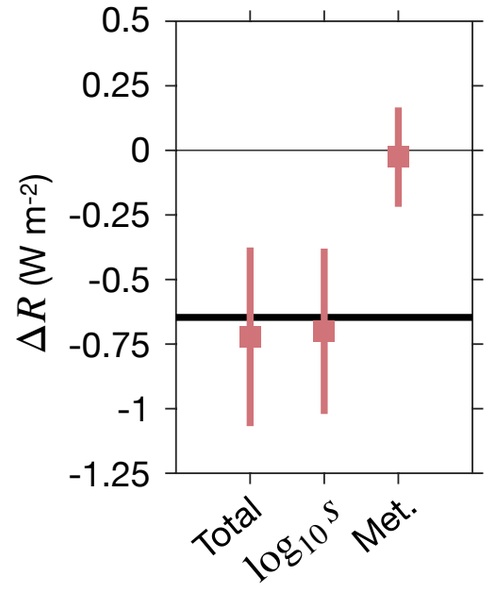
East Coast N. America





Mt. Kīlauea, Hawaii

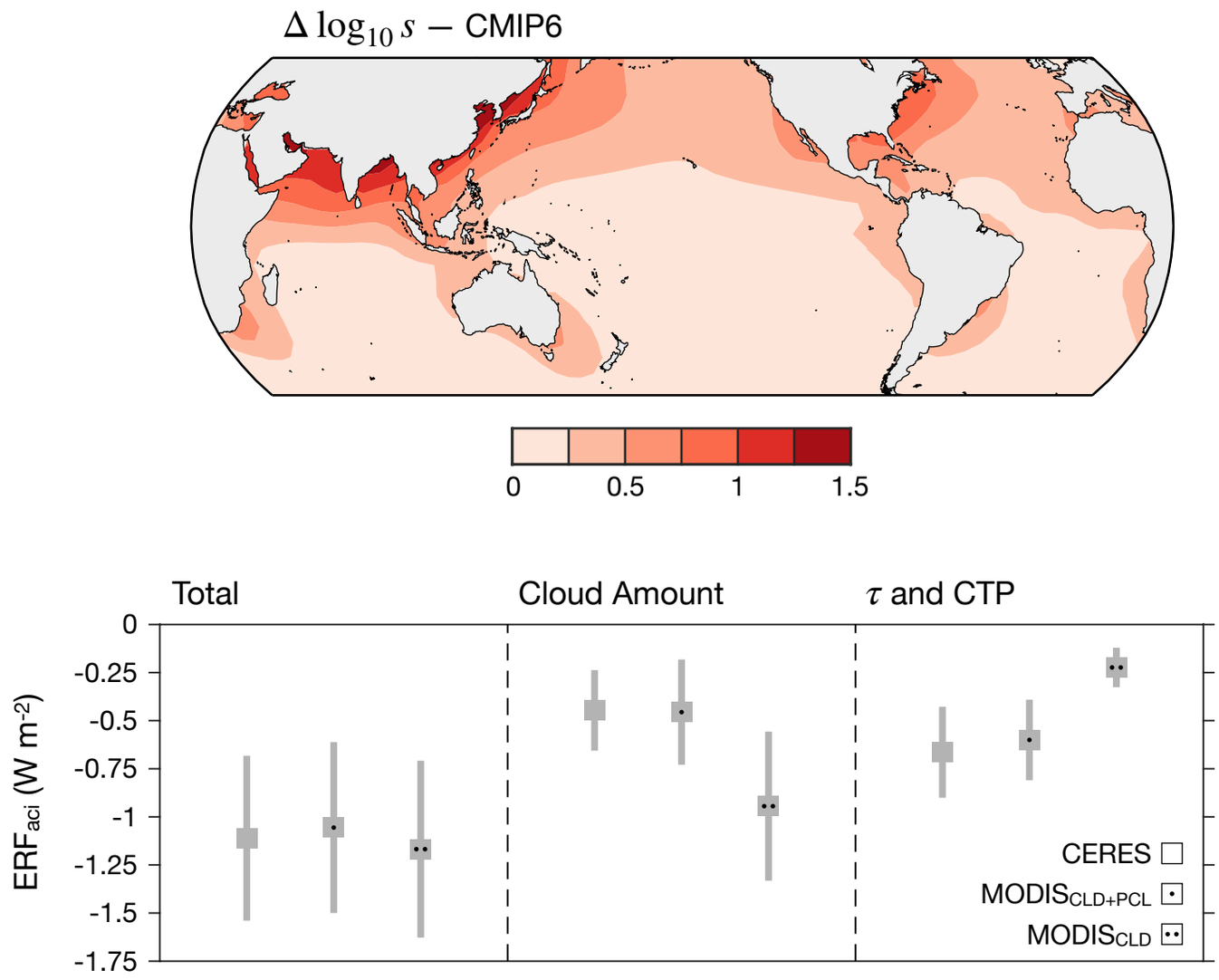




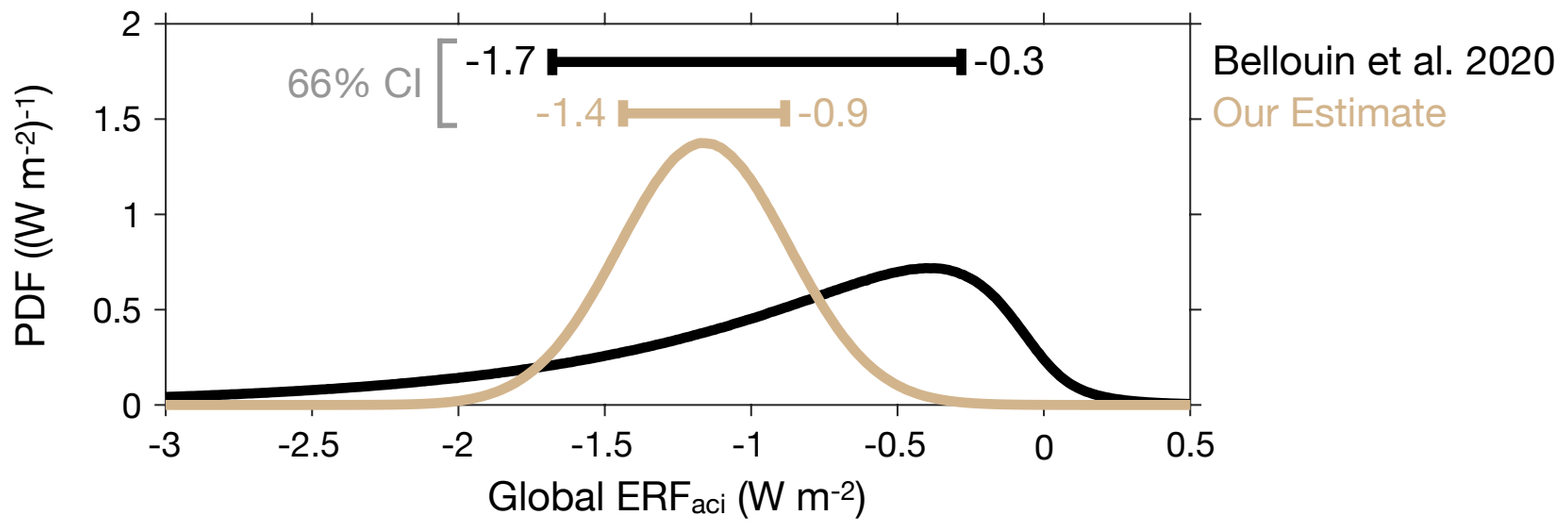
Goals

2. Test predictive skill ✓
3. Estimate aerosol forcing

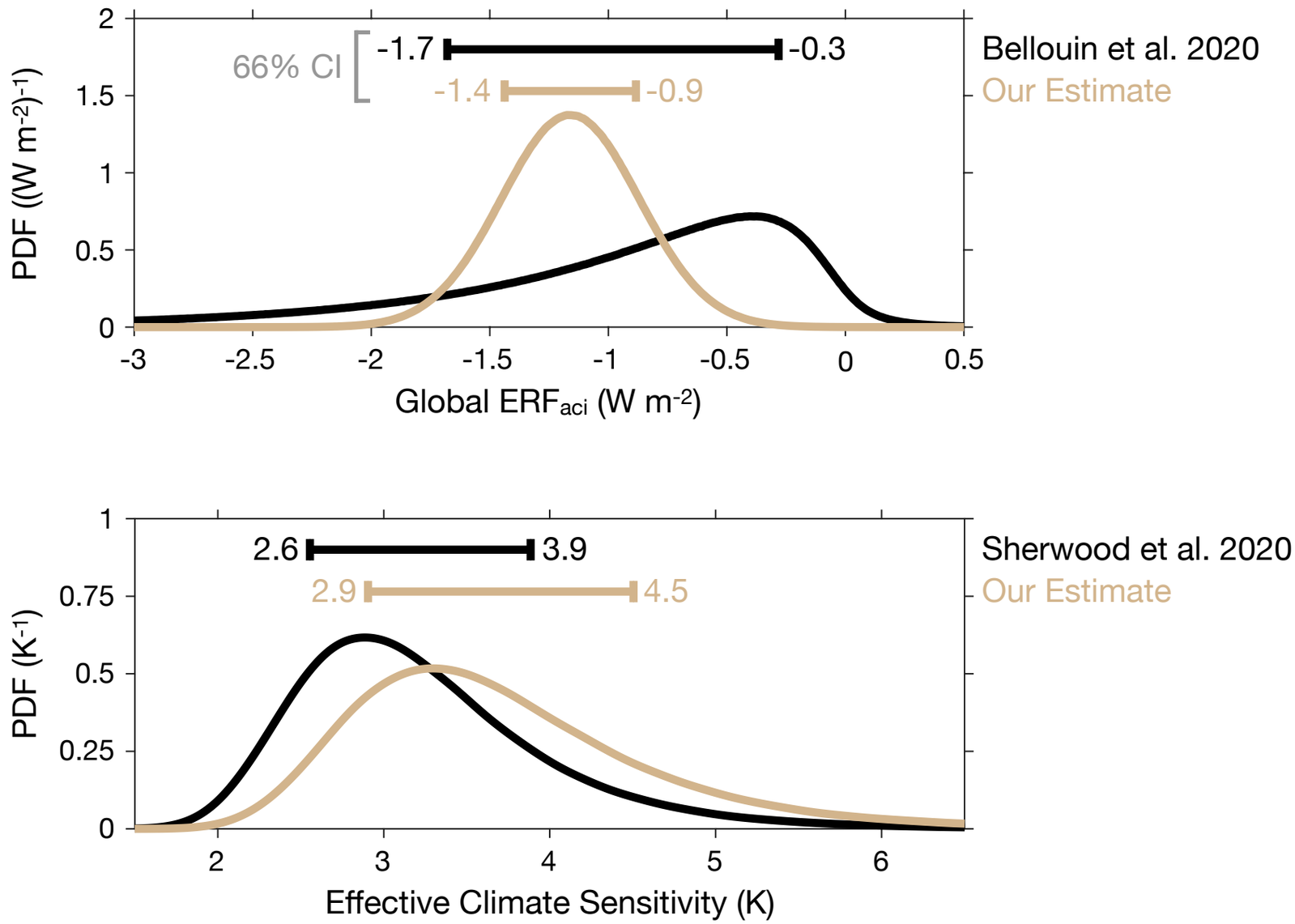
Aerosol Forcing - 1850 to 2014



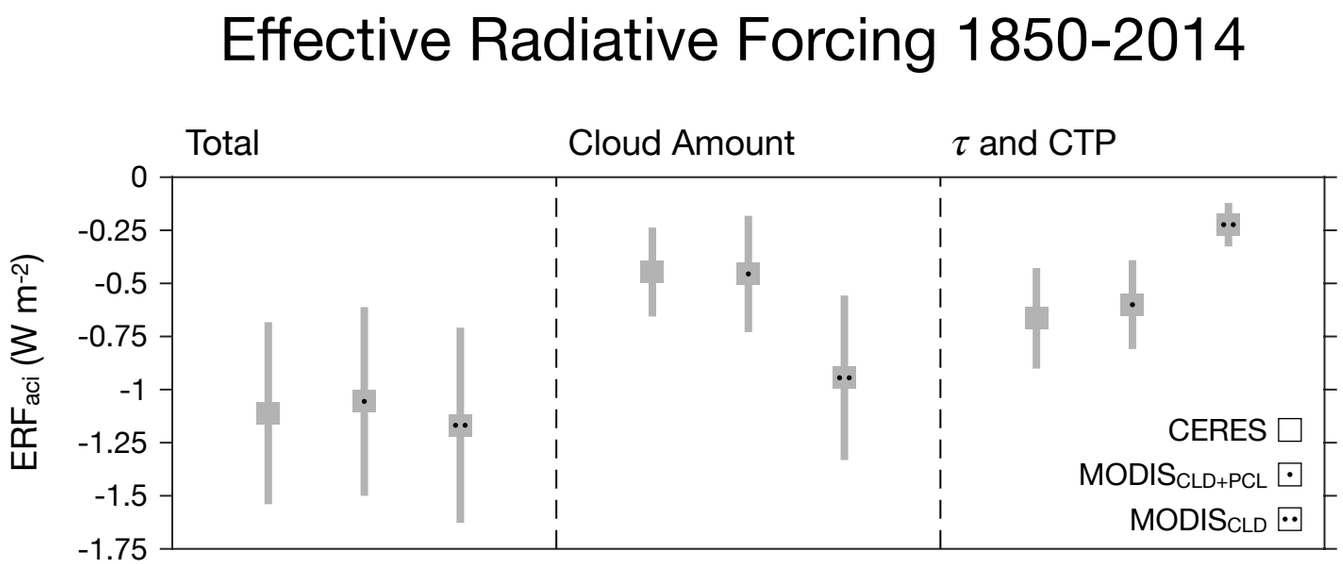
Aerosol Forcing and Climate Sensitivity



Aerosol Forcing and Climate Sensitivity



Conclusion



1. Analysis predicts stronger constraint on aerosol forcing and higher climate sensitivity than recent assessments.

2. Total forcing estimates are consistent across datasets, but cloud fraction vs. optical depth decomposition is not.

3. Cloud-fraction adjustment explains at least 20% of forcing.

email: cawall@ucsd.edu