

An Ensemble of Simulations for the Last Millennium with CESM



Bette Otto-Bliesner

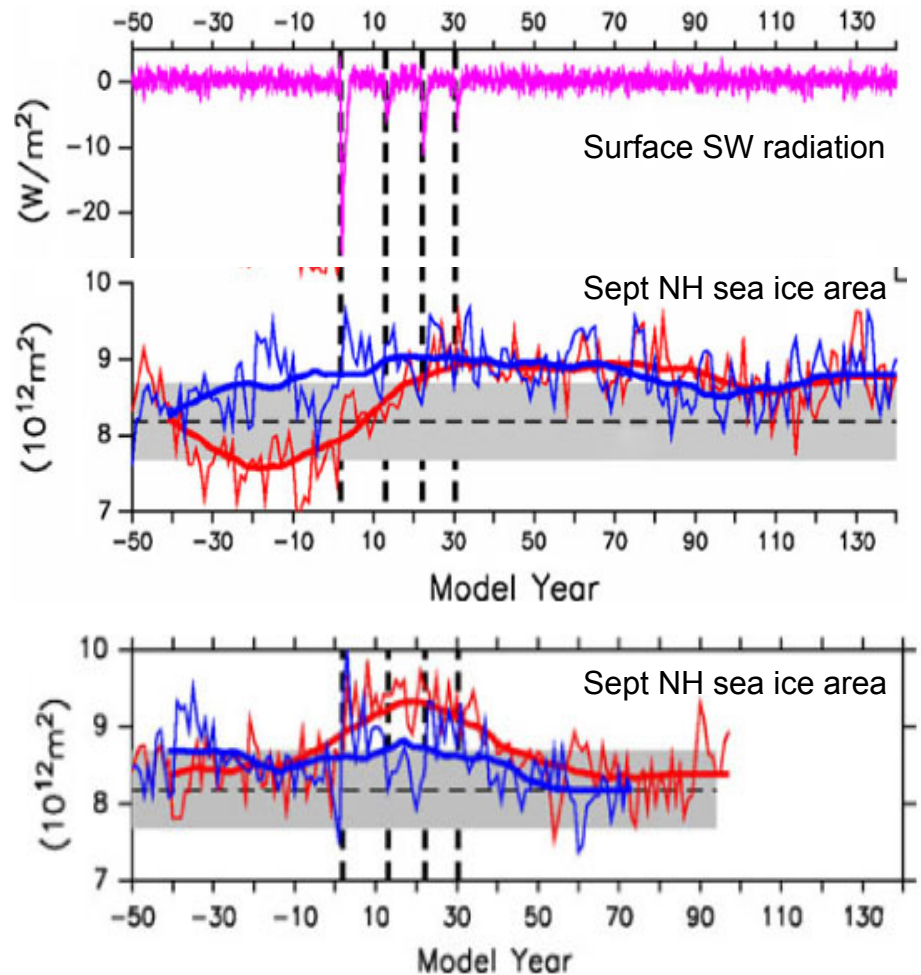
Esther Brady, Toby Ault

John Fasullo, Alexandra Jahn, Laura Landrum, Samantha Stevenson

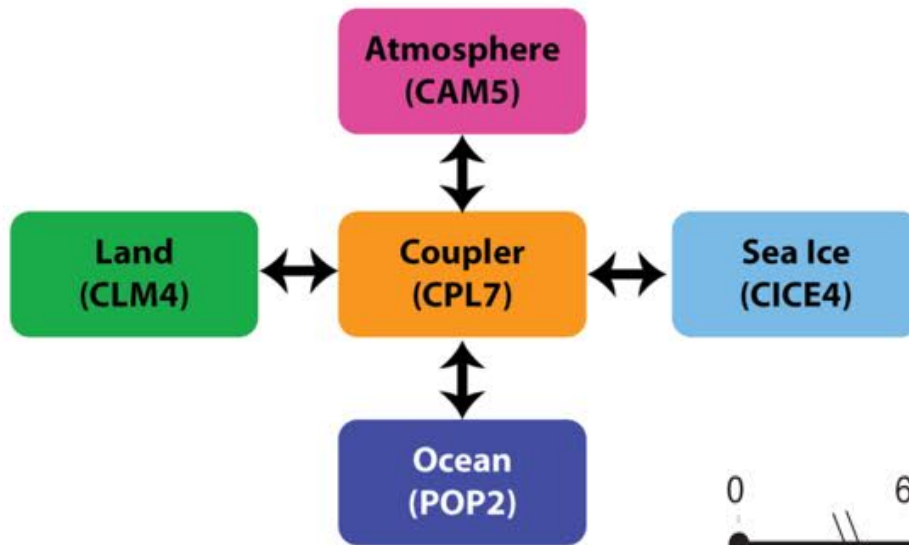
Andy Mai, Nan Rosenbloom, Gary Strand

Motivation

- Need for ensembles at regional and local scales (Goosse et al., 2005; Deser et al., 2012; Crespin et al., 2013, ...)
- **Initial state** can affect memory of system (Schneider et al., 2009; Zhong et al., 2010, ...)
- Roles and attributions to individual forcings (Phipps et al., 2013; Schurer et al., 2013; PAGES2K, 2013, ...)

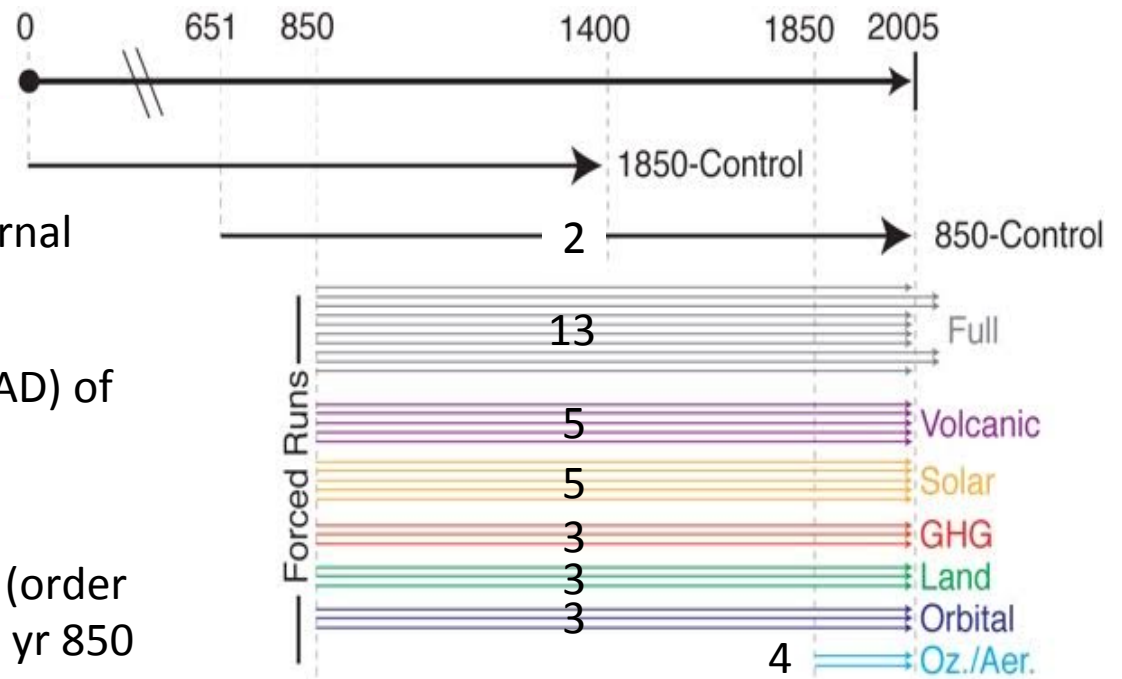


CESM1 Last Millennium Ensemble (LME)



CESM1 component models

Atmosphere and land components were run at $\sim 2^\circ$ resolution. Ocean and sea ice components were run $\sim 1^\circ$ resolution.



Three long control runs to assess internal variability.

36-member ensemble set (850-2005 AD) of single and full forcing runs (4 through 2100 for RCP8.5 scenario).

Perturbation: small random round-off (order 10^{-14}°C) differences in the air temps at yr 850



Available on the NCAR Gateway to the Earth System Grid

Dataset

CCSM4/CESM Model Output

CESM1 Last Millennium Ensemble Project

Description

See Last Millennium Ensemble Project web page for information on this set of experiments.

Identifier

ucar.cgd.cesm4.CESM_CAM5_LME

Date Created

2015-02-16 14:01:44

Date Last Updated

2015-02-17 15:41:29

https://www.earthsystemgrid.org/dataset/ucar.cgd.cesm4.CESM_CAM5_LME.html

10 entries

CESM1 Last Millennium Ensemble Project [Atmosphere Post Processed Data, Monthly Averages](#)

CESM1 Last Millennium Ensemble Project [Atmosphere Post Processed Data, Daily Averages](#)

CESM1 Last Millennium Ensemble Project [Atmosphere Post Processed Data, 6-Hourly Instantaneous Values](#)

CESM1 Last Millennium Ensemble Project [Ice Post Processed Data, Monthly Averages](#)

CESM1 Last Millennium Ensemble Project [Ice Post Processed Data, Daily Averages](#)

CESM1 Last Millennium Ensemble Project [Land Post Processed Data, Monthly Averages](#)

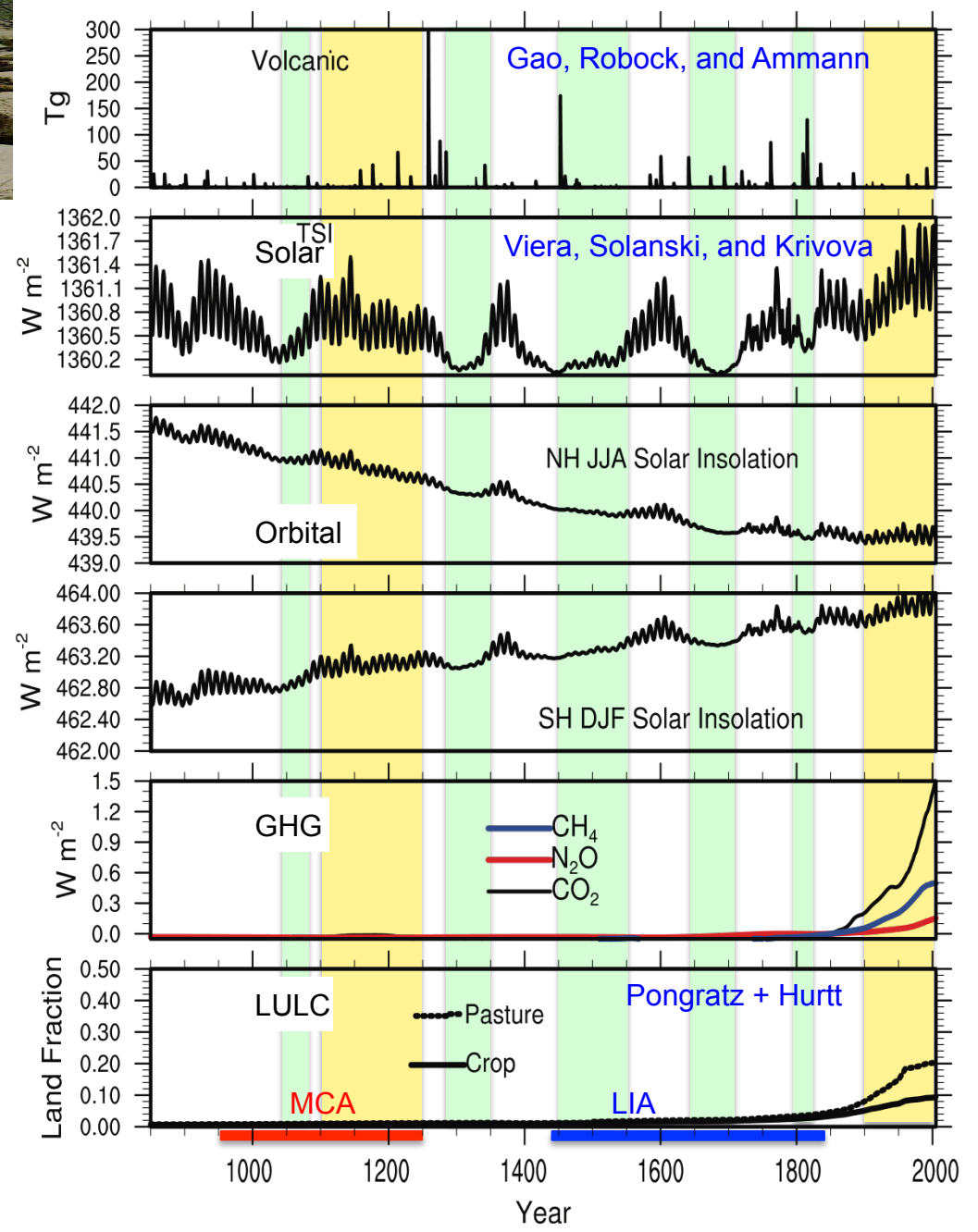
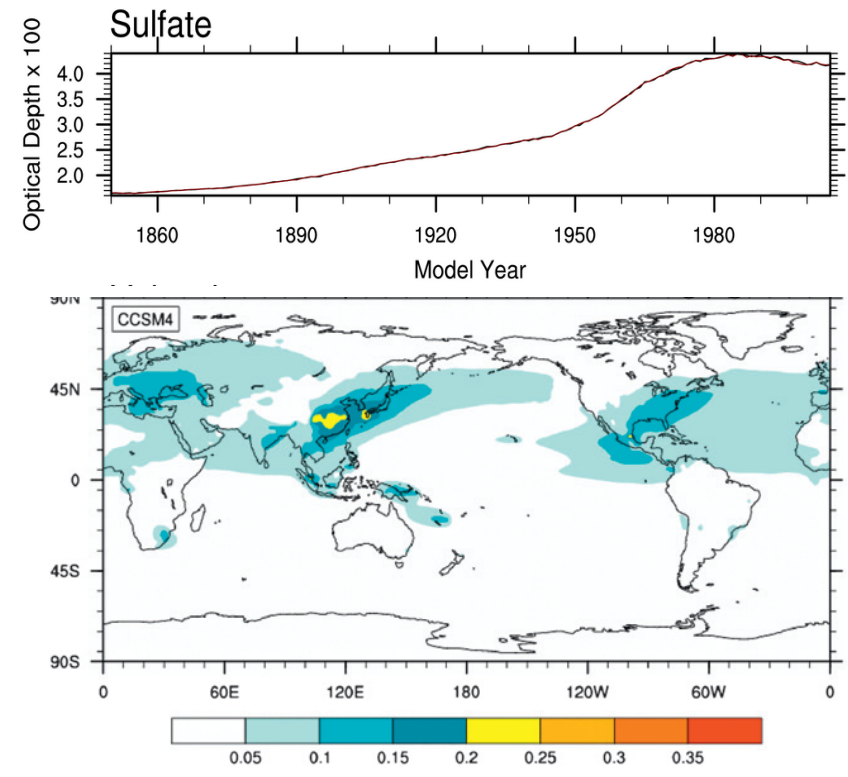
CESM1 Last Millennium Ensemble Project [Land Post Processed Data, Daily Averages](#)

CESM1 Last Millennium Ensemble Project [Ocean Post Processed Data, Monthly Averages](#)

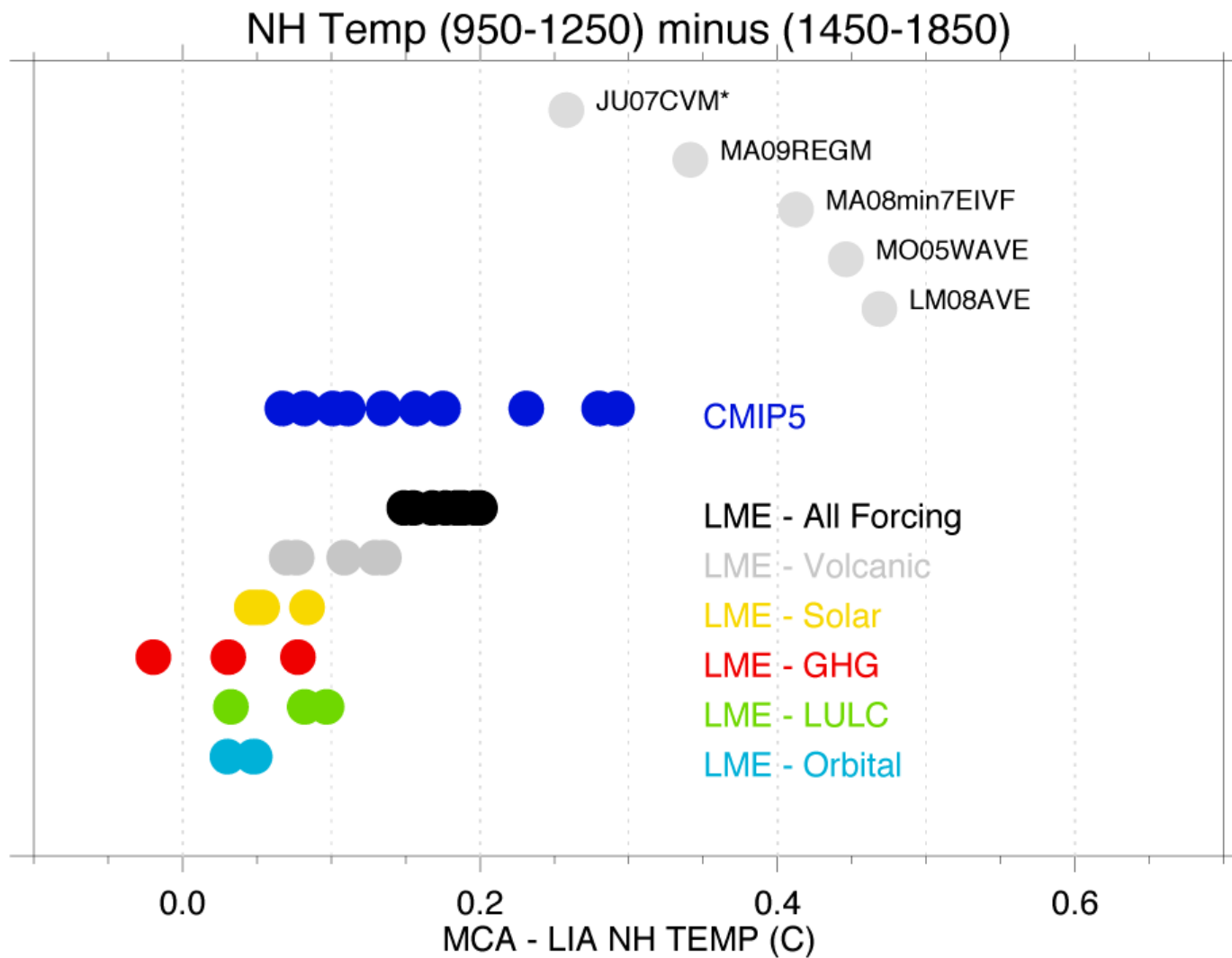
CESM1 Last Millennium Ensemble Project [Ocean Post Processed Data, Daily Averages](#)

CESM1 Last Millennium Ensemble Project [River Post Processed Data, Monthly Averages](#)

LME Forcings

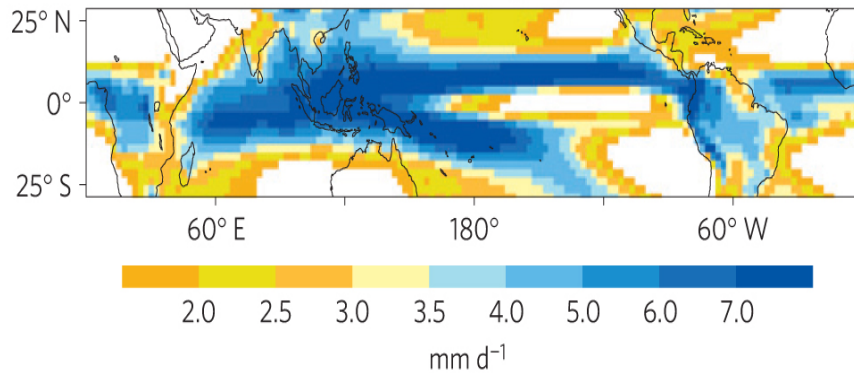


NH Temperature: MCA minus LIA

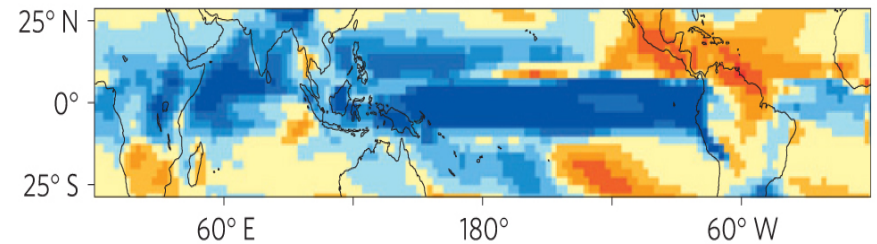


Regional response of precipitation

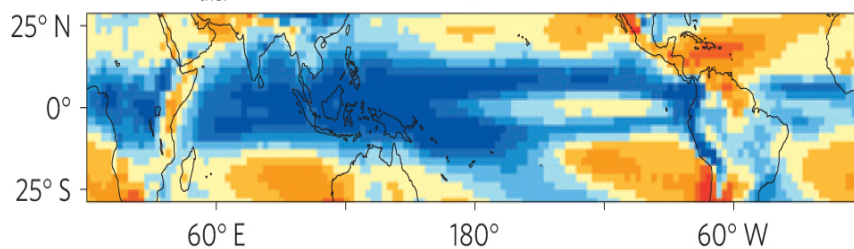
a Precipitation climatology P (pre-industrial)



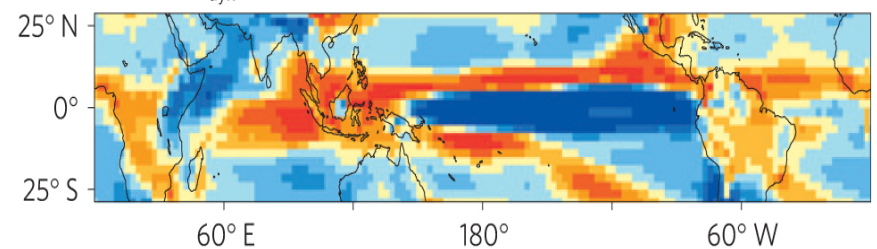
b ΔP (RCP8.5, end of twenty-first century: pre-industrial)



c ΔP_{ther} (RCP8.5, end of twenty-first century: pre-industrial)

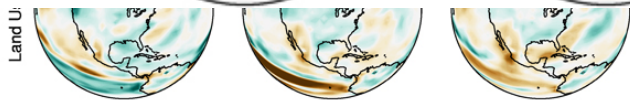
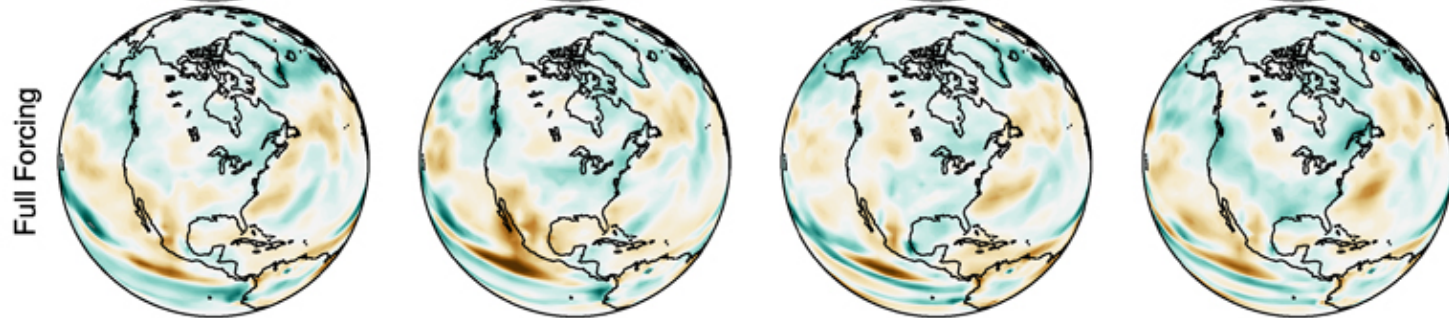
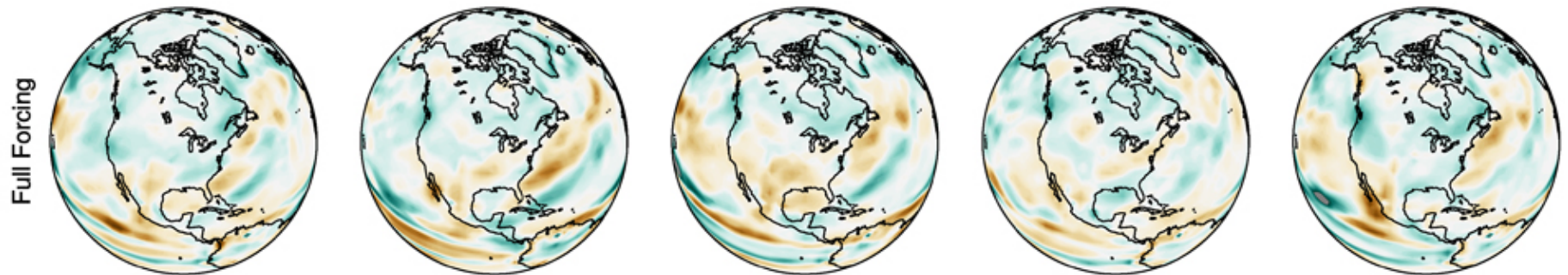


d ΔP_{dyn} (RCP8.5, end of twenty-first century: pre-industrial)



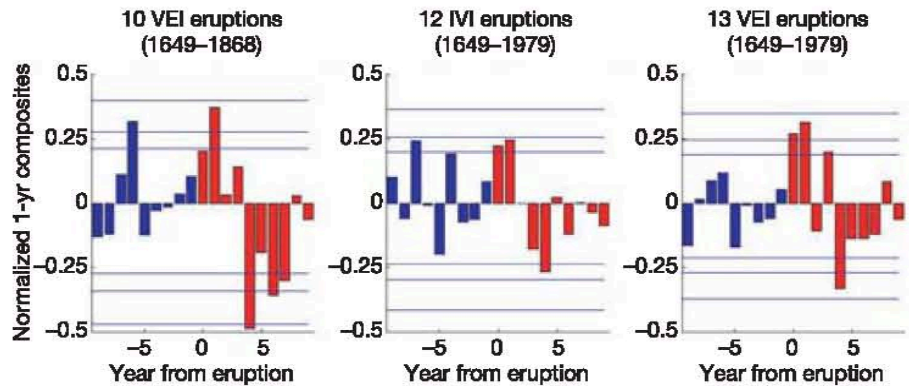
-0.9 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.9
 mm d^{-1}

MCA (950-1250) - LIA(1450-1850)



mm/year

Tropical Volcanic Eruptions and El Niño



Adams et al. Nature 2003

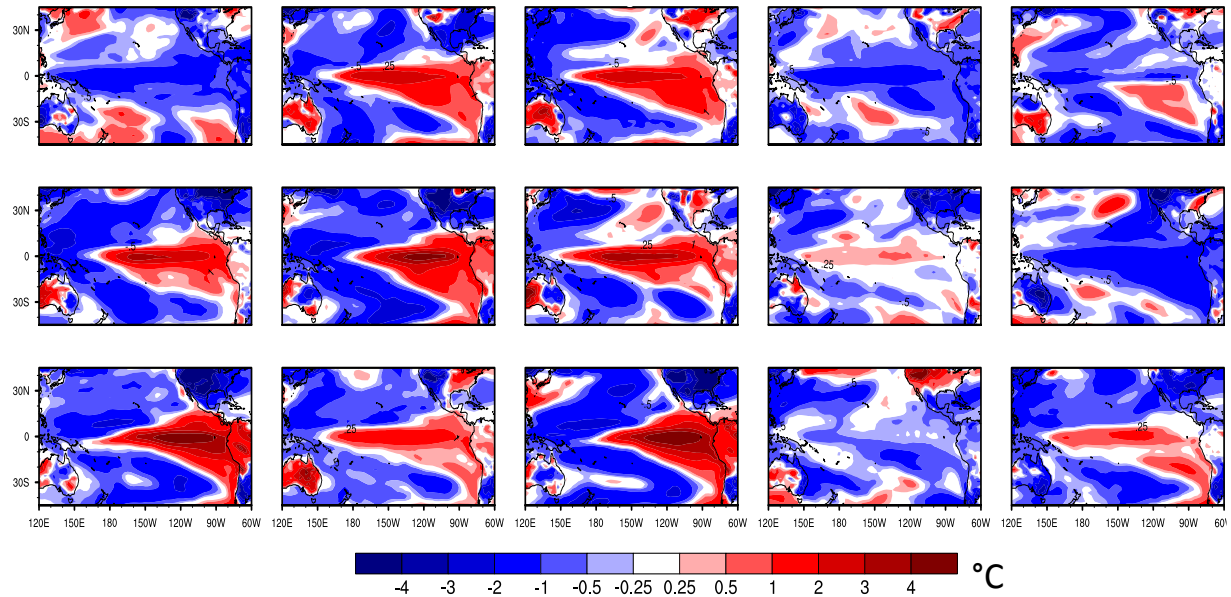
A paleoclimate proxy-based study suggested the probability for El Niño to occur following large tropical eruptions doubled.

CESM Last Millennium Ensemble find that 9 (60%) of the individual members exhibit El Niño warming after the Tambora eruption (April 1815).

This is double the average likelihood for an El Niño to occur in any given cold season.

The other 6 members show a neutral or La Niña response.

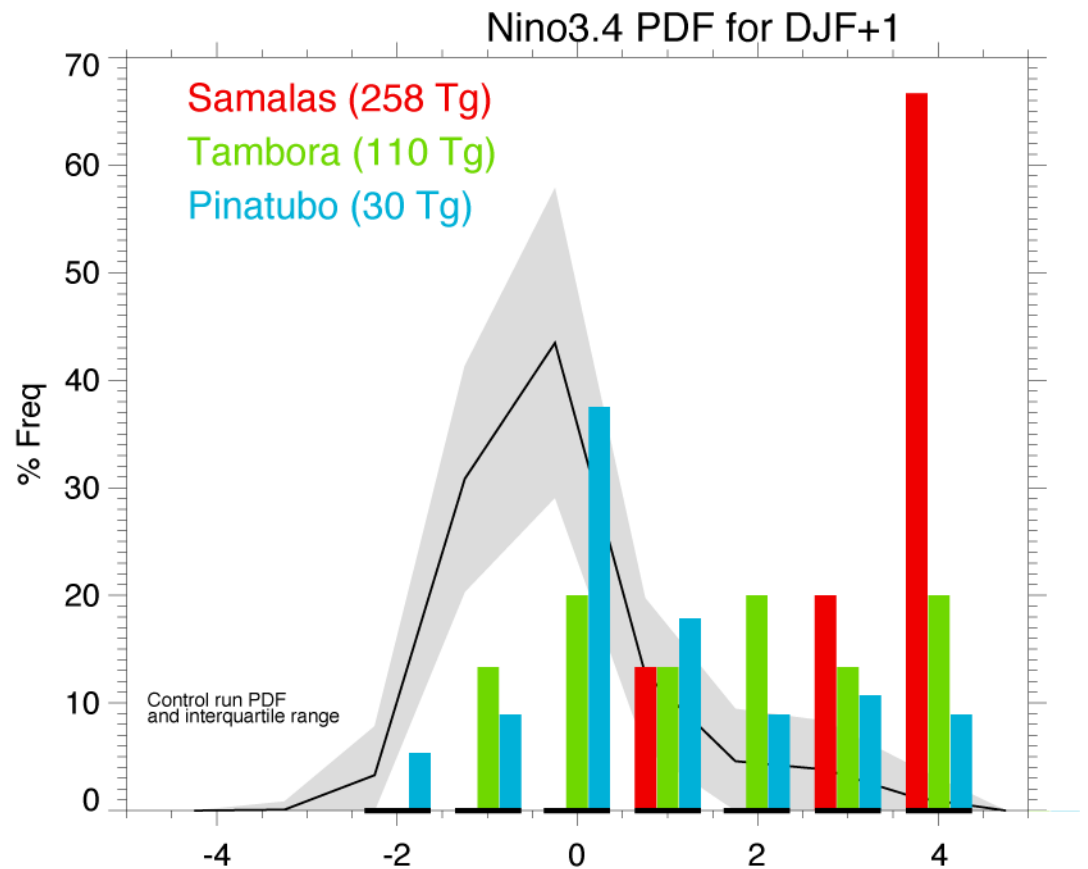
Post-Tambora, Winter 1816/1817



CESM Large and Last Millennium Ensembles

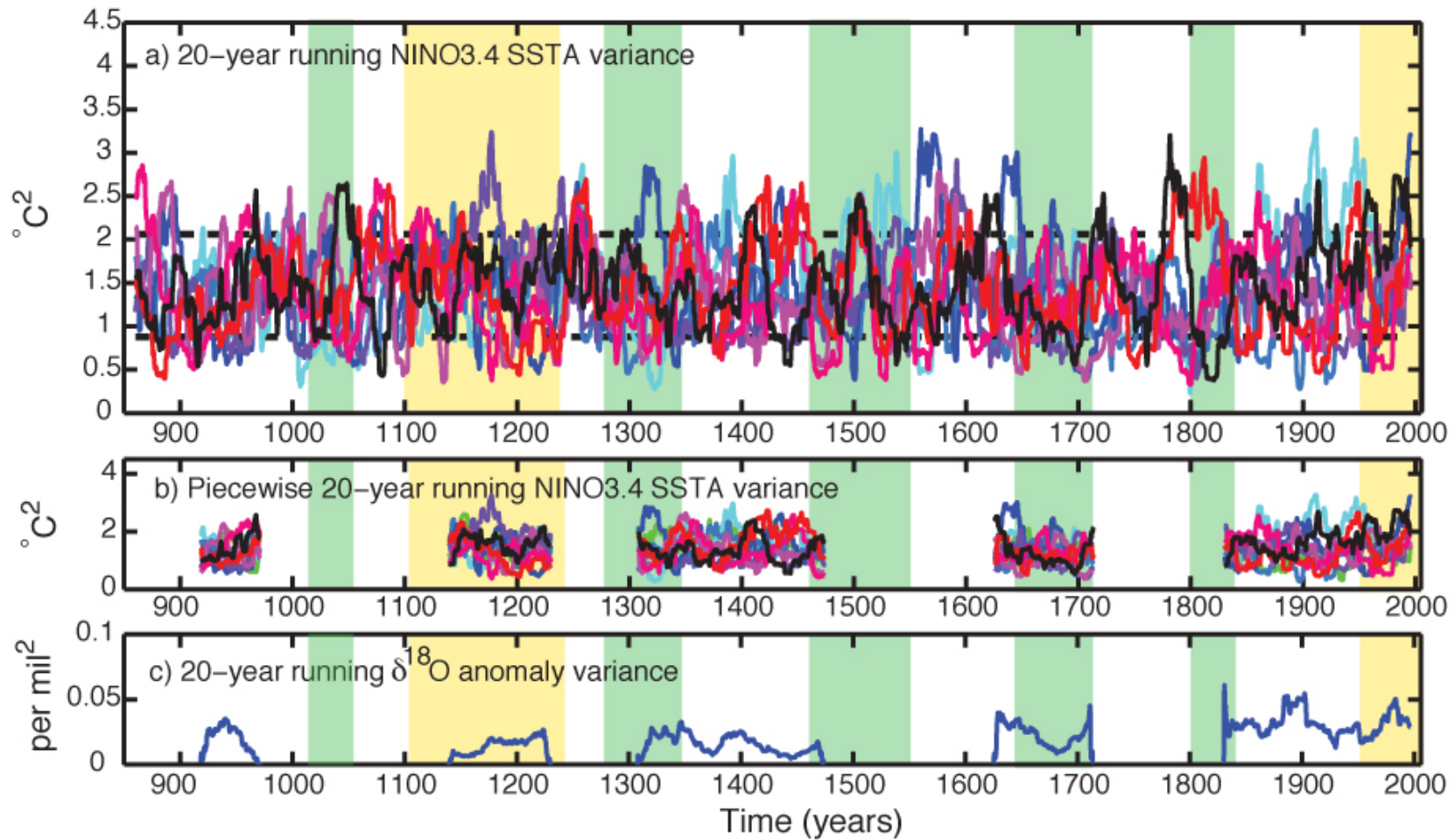
Large Ensemble (LE): 40 simulations from 1920 to 2100.

LME: 18 simulations with volcanic forcing from 850-2005



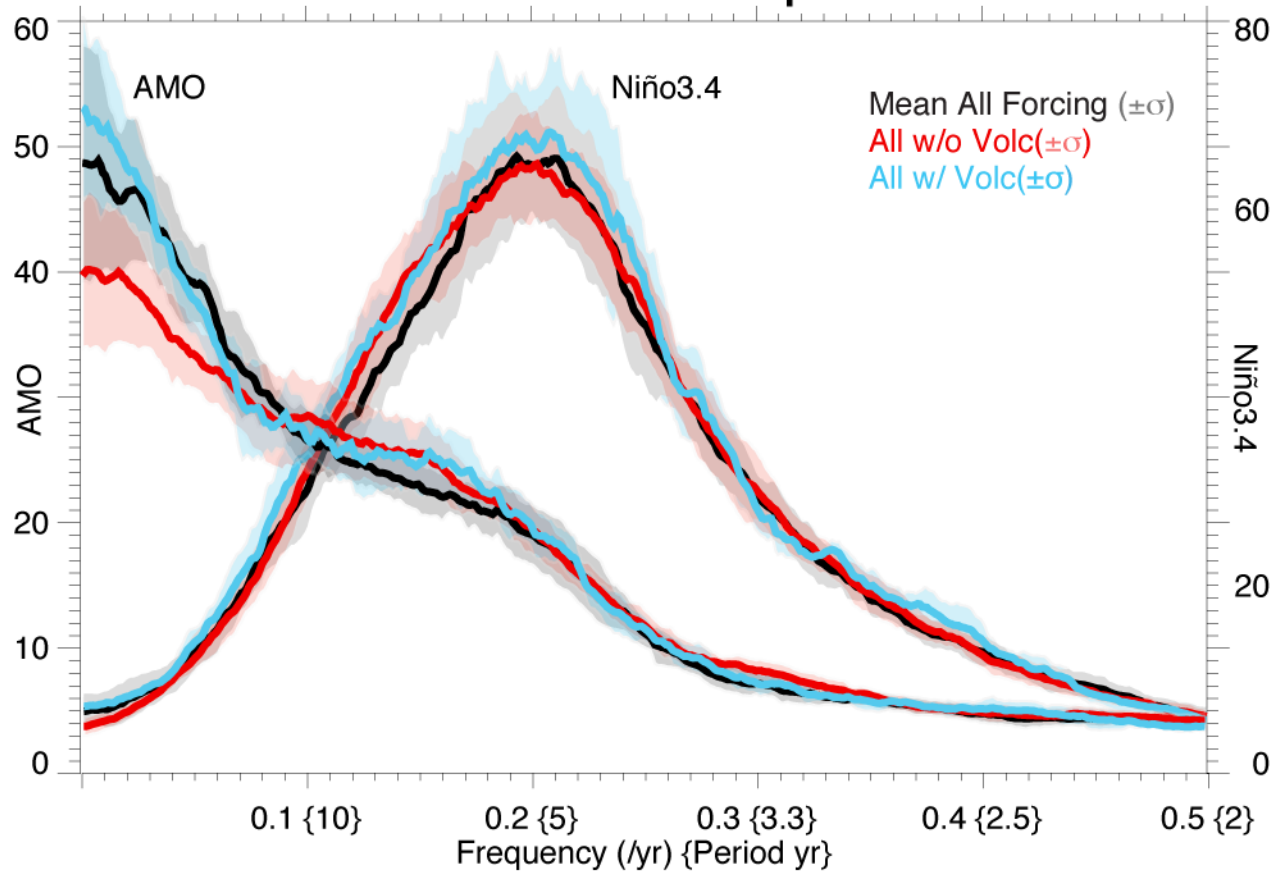
Courtesy of John Fasullo

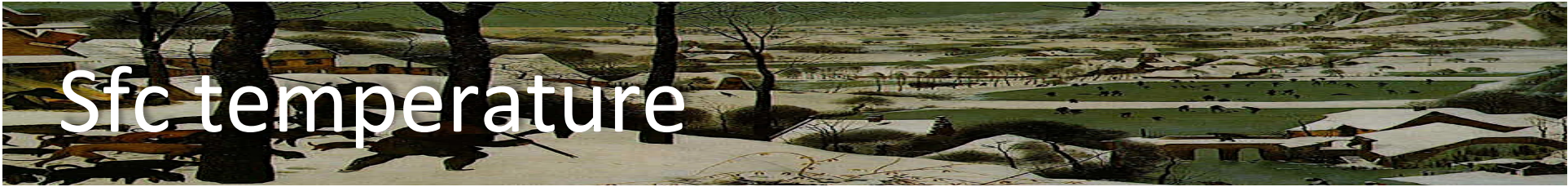
ENSO variance: CESM vs coral proxy





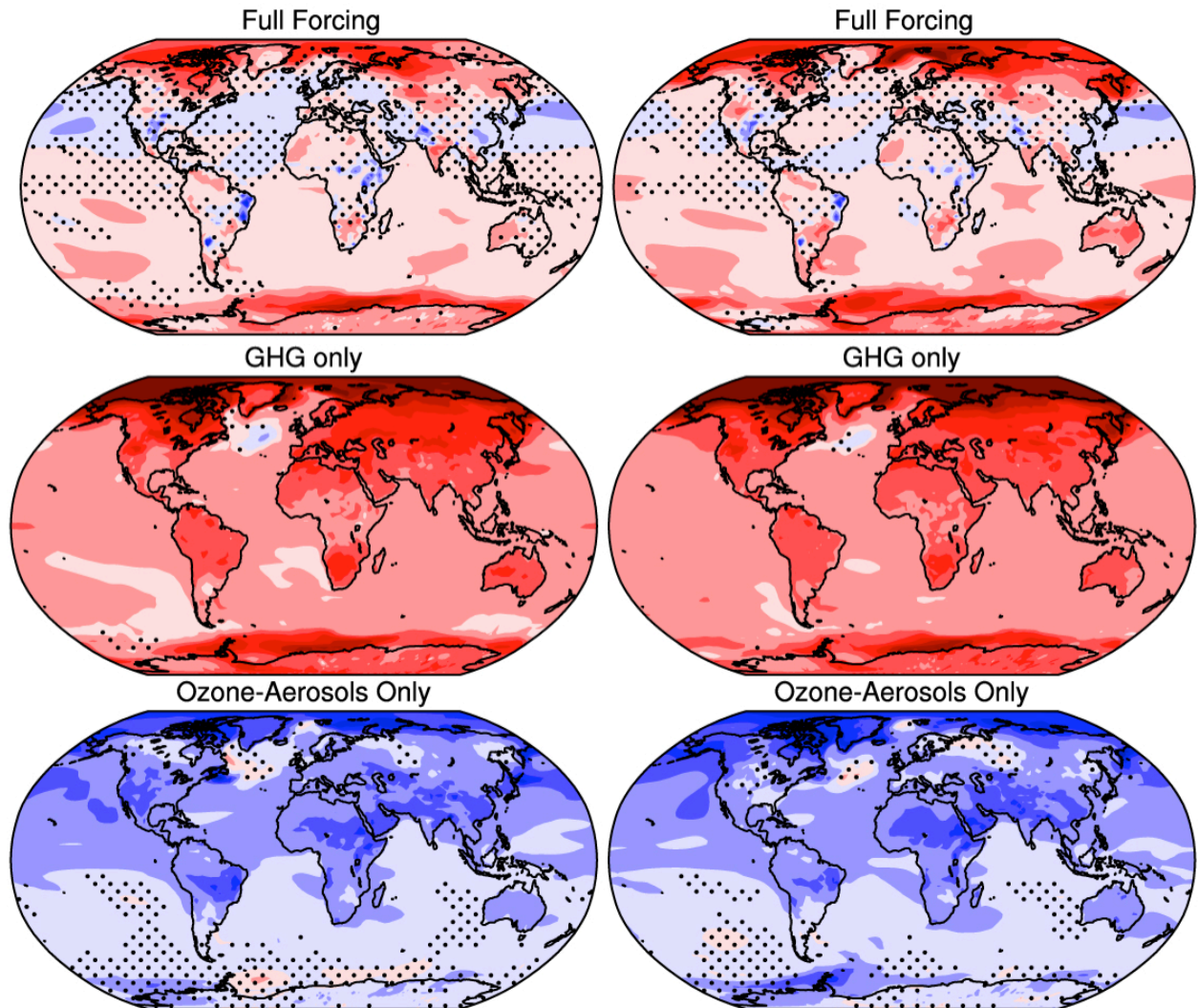
AMO and Niño3.4 Power Spectra : 850-1849





Sfc temperature

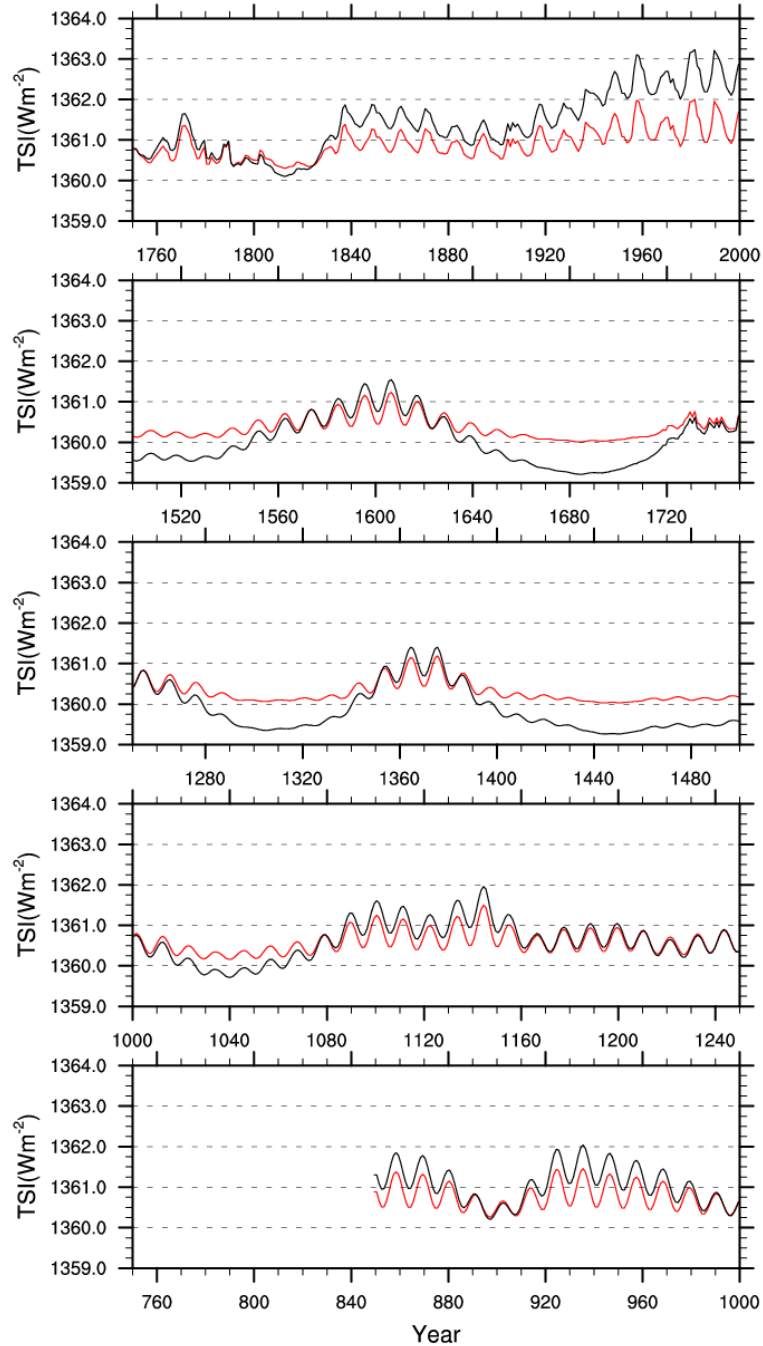
PD (1950-2005)
minus
LIA (1450-1850)



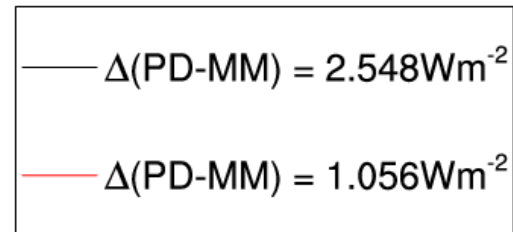
Hatched areas not significant at 95% CI



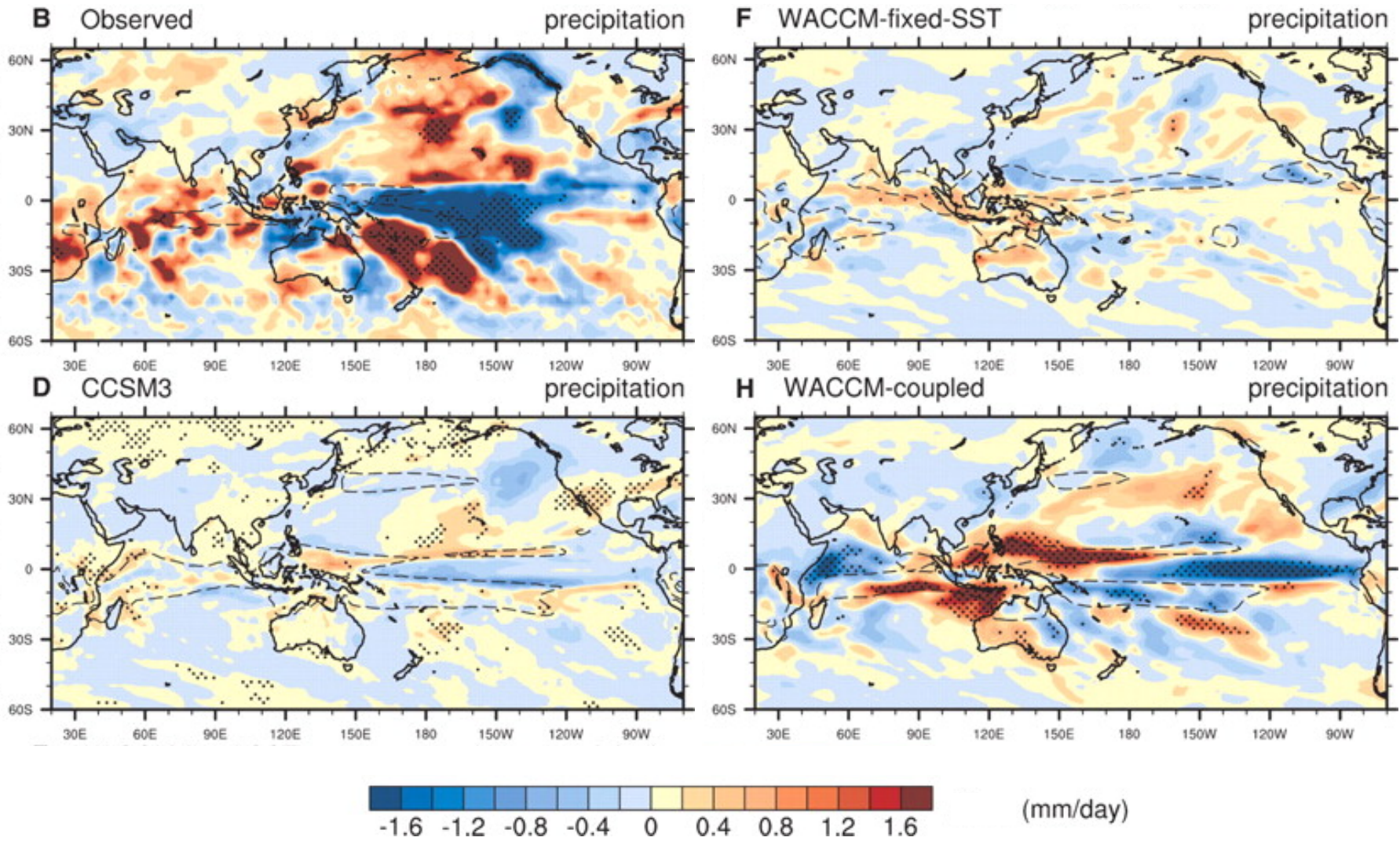
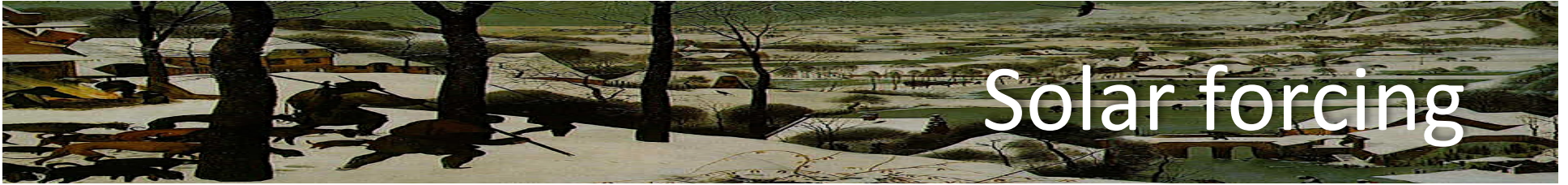
Solar forcing



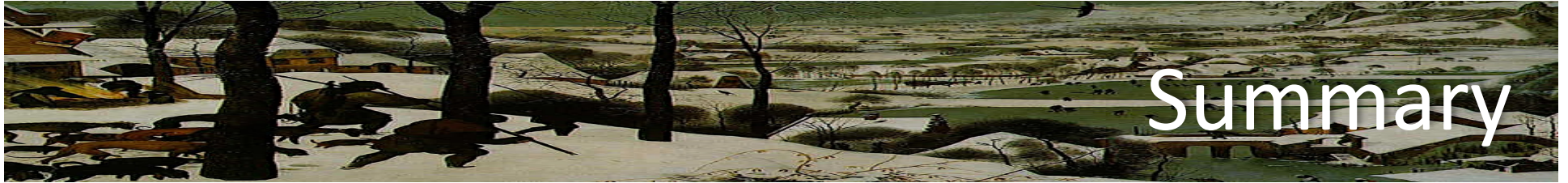
How well can we constrain the solar forcing over the past 2K?



Courtesy of Bob Tomas



Meehl et al., Science, 2009



- Last Millennium – integration of data and models
 - **Nature is one realization** of what happened; climate model simulations give us additional realizations.
 - Dynamically consistent framework within which to diagnose mechanisms of regional variability.
- CESM-Last Millennium Ensemble
 - Separation of forcings (GHG, solar, volcanic, orbital, and land use)
 - Internal variability (3 long controls)
- Some other runs
 - Enhanced solar variability forcing
 - Sensitivity to month of eruption – Tambora and Samalas
 - Solar + volcanic forcing ensemble (Rutgers)
 - [TBD] Full forcing with water isotopes and radiocarbon

Webpage: <https://www2.cesm.ucar.edu/models/experiments/LME>

