

Climatic impacts of the largest volcanic eruption of the last millennium

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David P. Schneider
Caspar M. Ammann
Bette Otto-Bliesner

National Center for Atmospheric Research
Climate and Global Dynamics Division
Boulder, CO

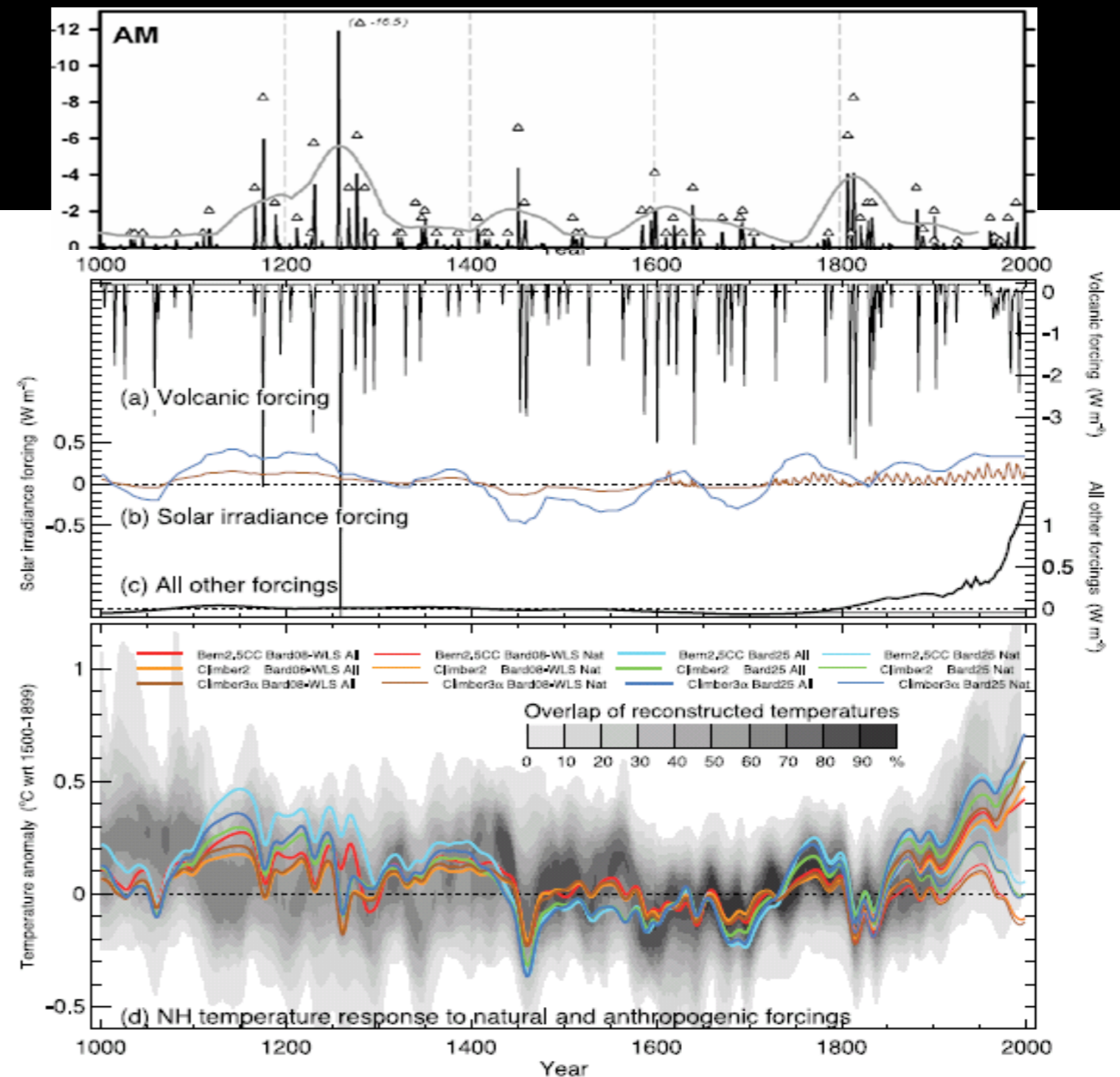
+University collaborators (Darrell Kaufman, Northern Arizona U, PI)



1258 AD volcanic eruption(s)



Climate forcing over last 1000 years

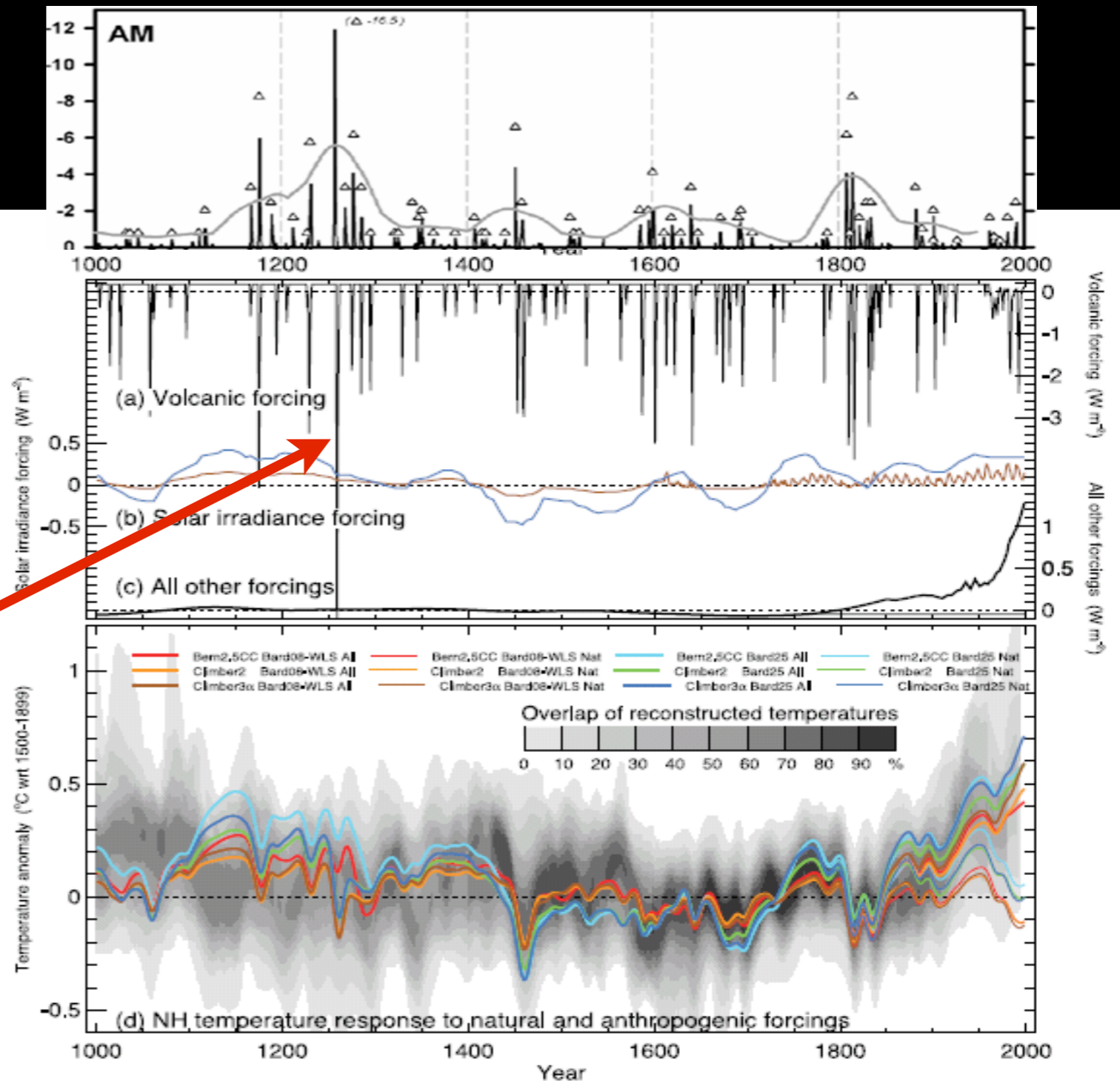


1258 AD volcanic eruption(s)



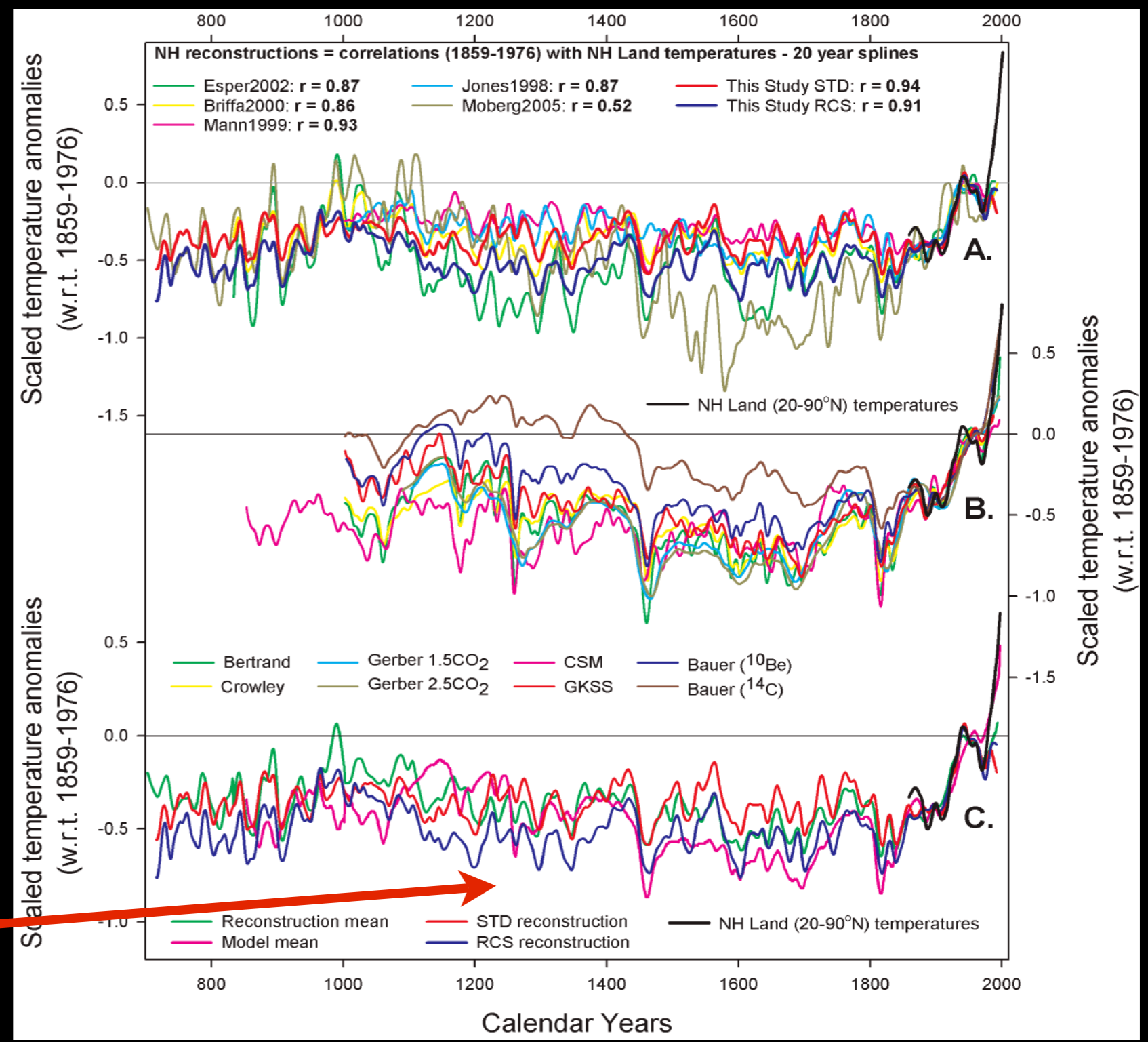
Climate forcing over last 1000 years

presumed huge
tropical
eruption



1258 AD volcanic eruption(s): Was it actually tropical?

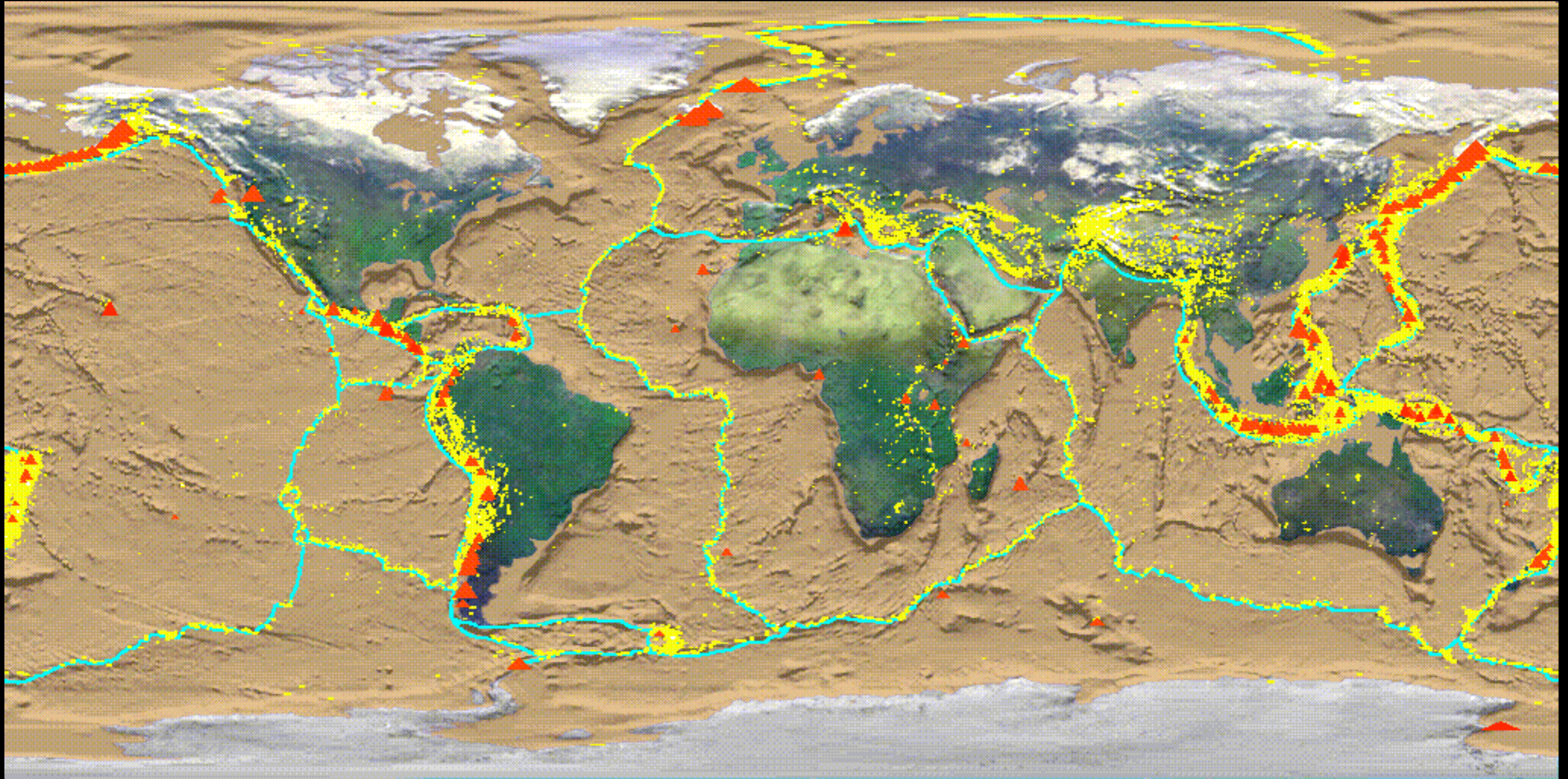
NH temperature over last 1000 years



lack of
temperature
signal

1258 AD volcanic eruption(s): UNKNOWN source volcano

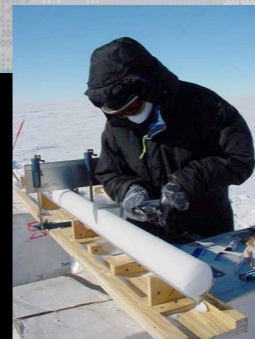
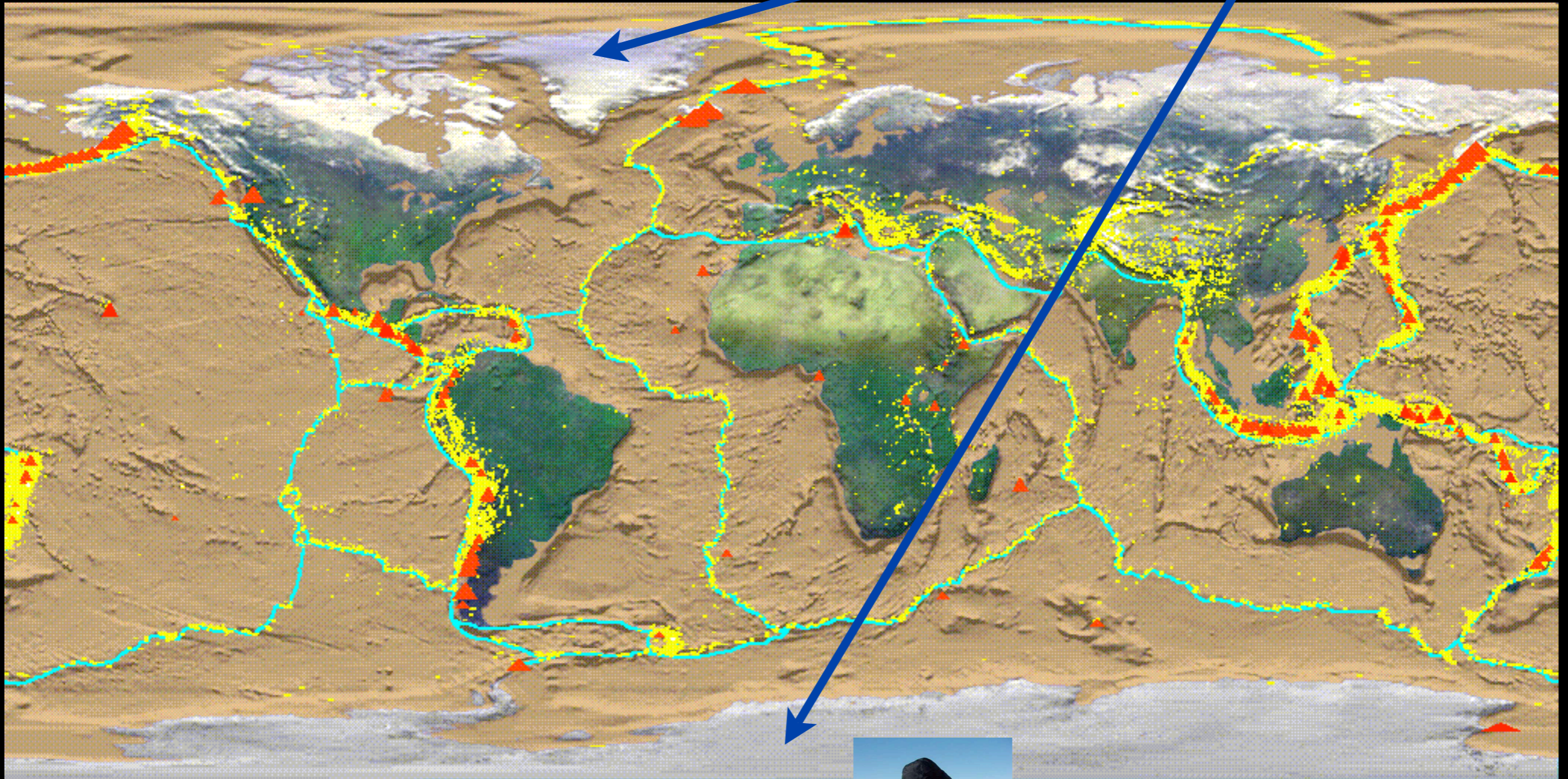
Distribution of volcanic activity



(http://www.uwsp.edu/geol/faculty/ritter/images/lithosphere/tectonics/Vol_eq_plates_GSFC.gif)

1258 AD volcanic eruption(s): UNKNOWN source volcano

ice core recording locations



1258 AD volcanic eruption(s): UNKNOWN source volcano

Volcanic sulfate in ice cores

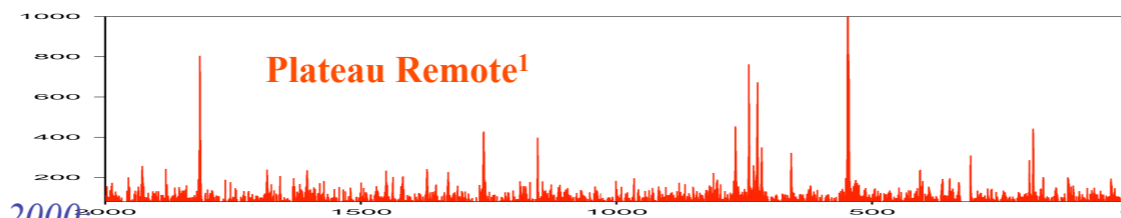
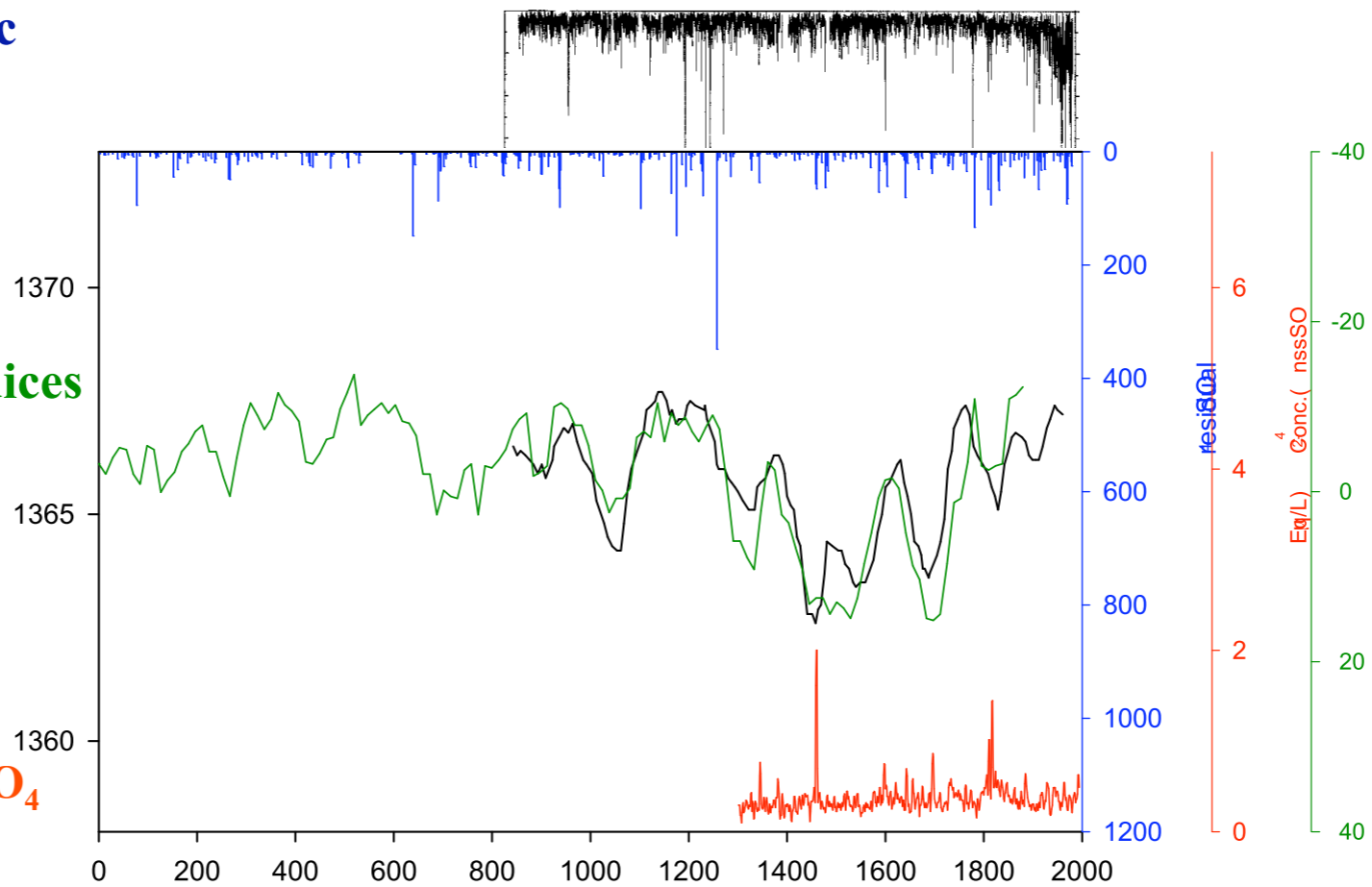
Greenland volcanic
 SO_4

(N.E. Greenland;
Summit)

“Solar activity” indices
(^{14}C , ^{10}Be)

W/m²

Antarctic volcanic SO_4



Sources:

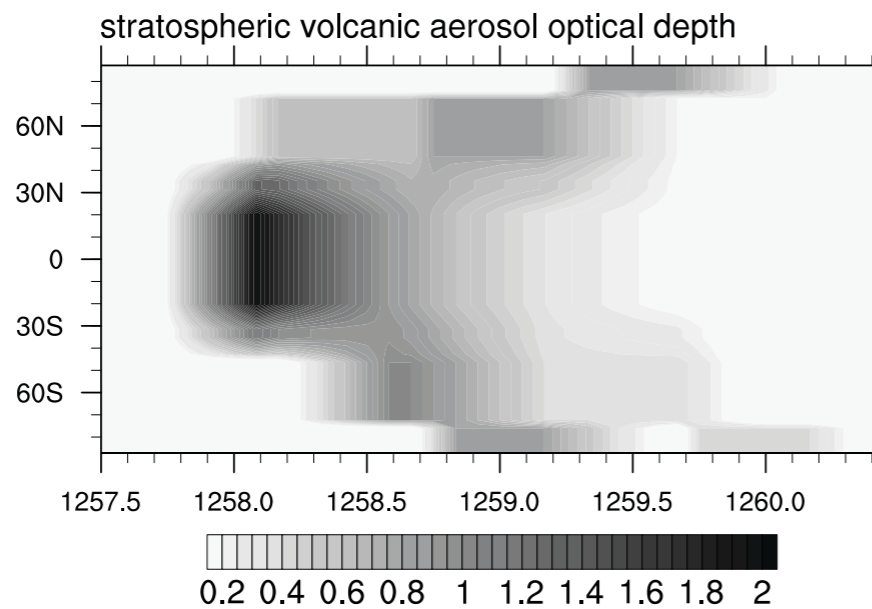
*Bigler et al., 2003; Zielinski 2000, Beer, 2002; Bard et al., 2001; *Palmer et al., 2002; ¹Cole-Dai et al., 2000*



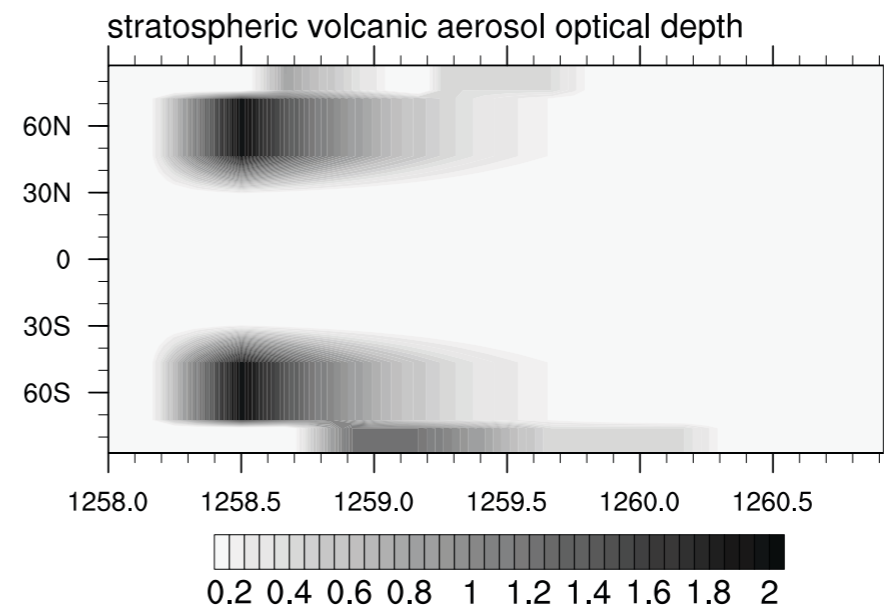
1258 AD volcanic eruption(s): Model-based experiments

Optical depths based on prescribed aerosol mass

tropical eruption



high-latitude eruptions



1258 AD volcanic eruption(s): CCSM3 experiments

- CCSM3 in fully coupled mode
- T42 resolution; 1 x 1 degree ocean
- Preindustrial “1750” control run

1258 AD volcanic eruption(s): CCSM3 experiments

- 3, 50-year long ensemble members with a sequence of 4 large tropical eruptions
- 3, 50-year long ensemble members with a sequence of 8 large high-latitude eruptions
- volcanic forcing prescribed as zonally averaged “Pinatubo-like” stratospheric aerosol load with timing & magnitude partially constrained by ice core records; other forcing held constant

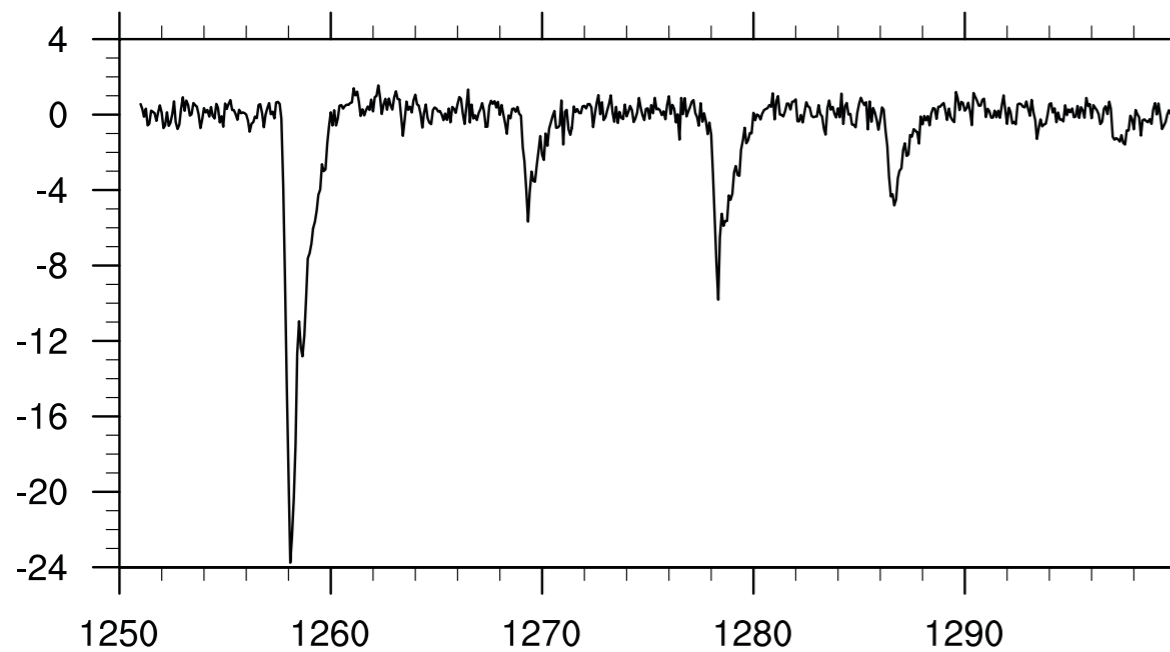
Results

Reduction in shortwave radiation at surface

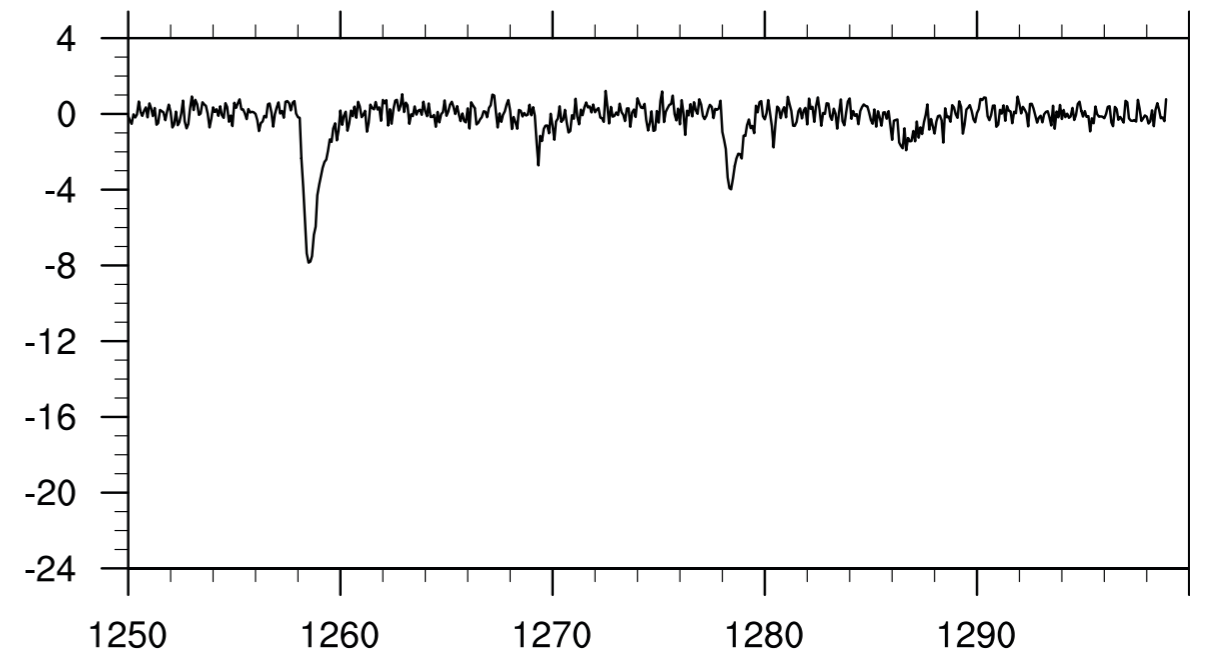
tropical eruption

high-latitude eruptions

Change in Global Surface SW (W/m^2)



Change in Global Surface SW (W/m^2)

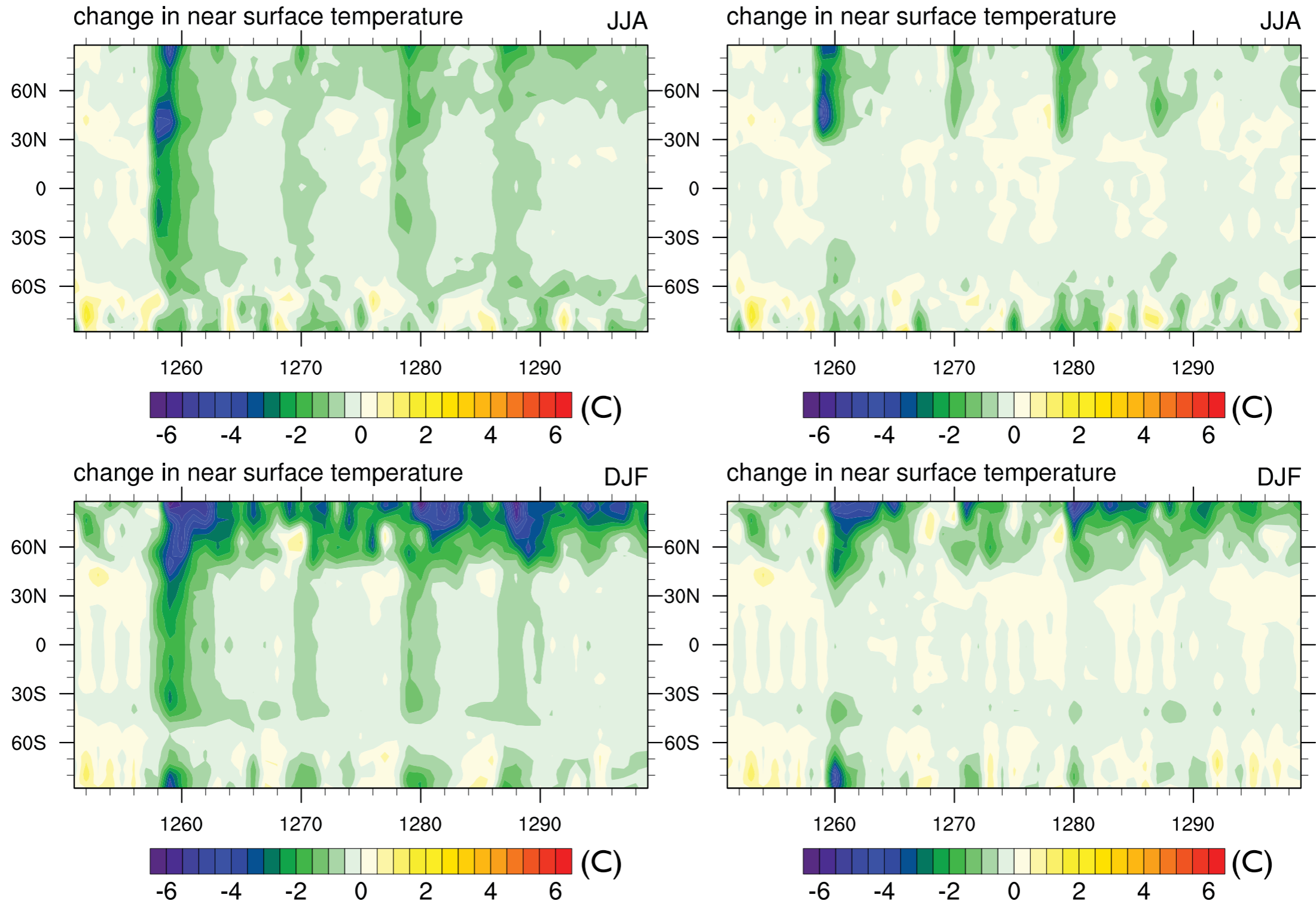


Results

Near-surface air temperature anomalies, zonal avg

tropical eruption

high-latitude eruptions

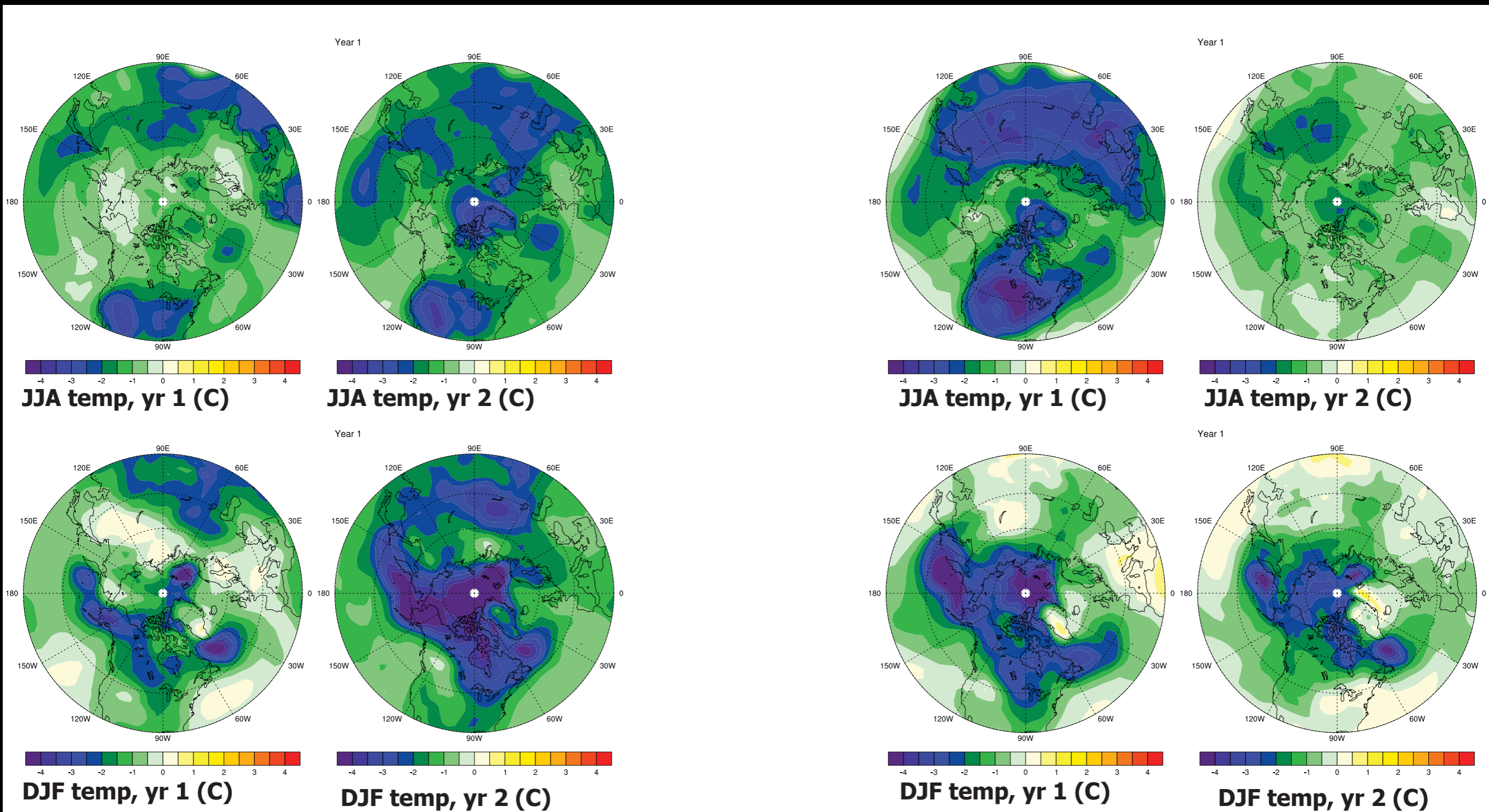


Results

Near-surface air temperature anomalies, composite

tropical eruption

high-latitude eruptions

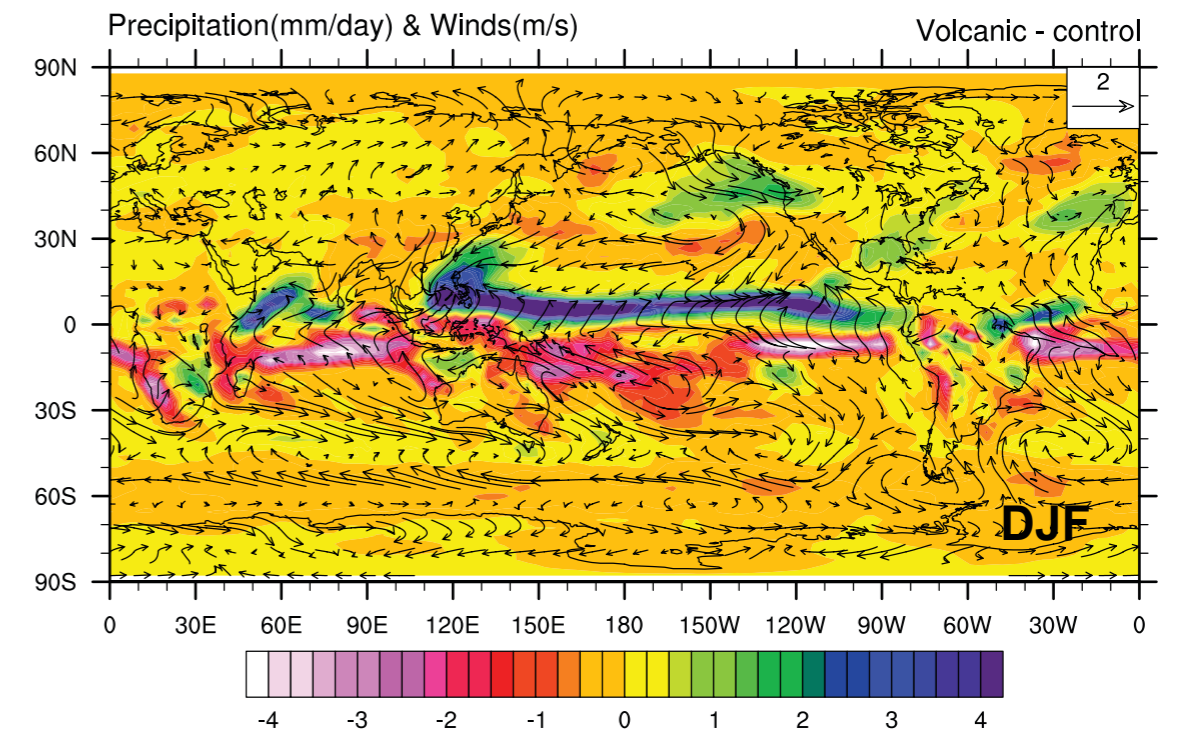
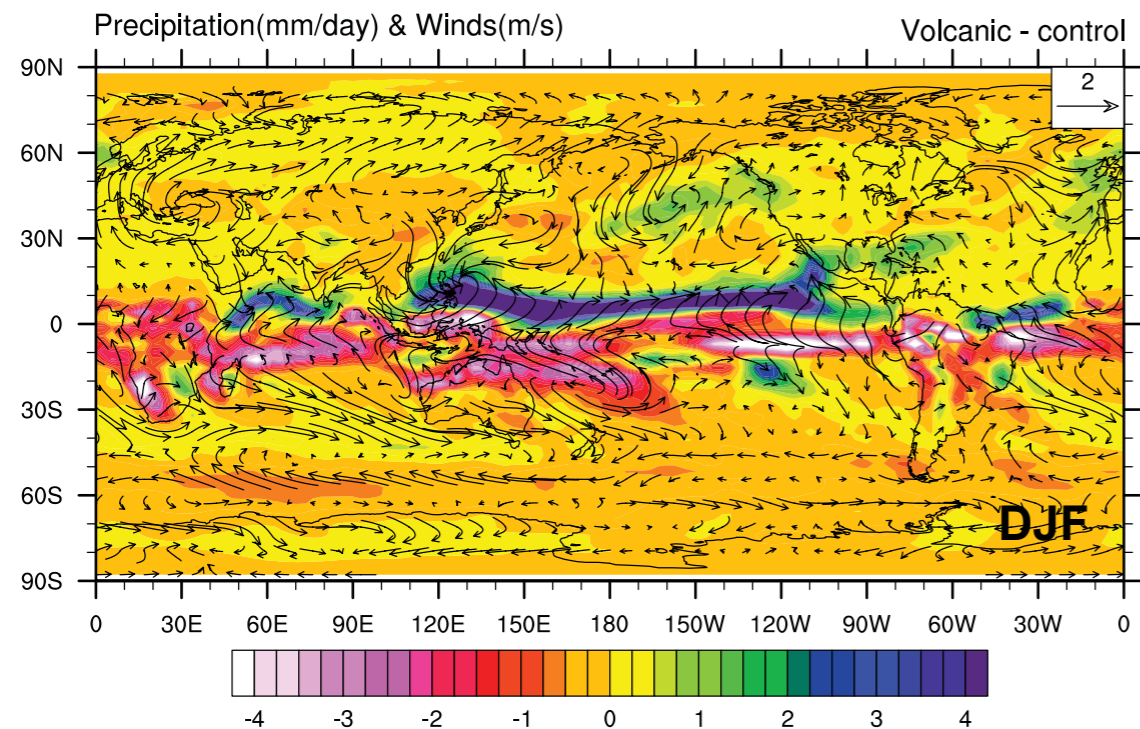
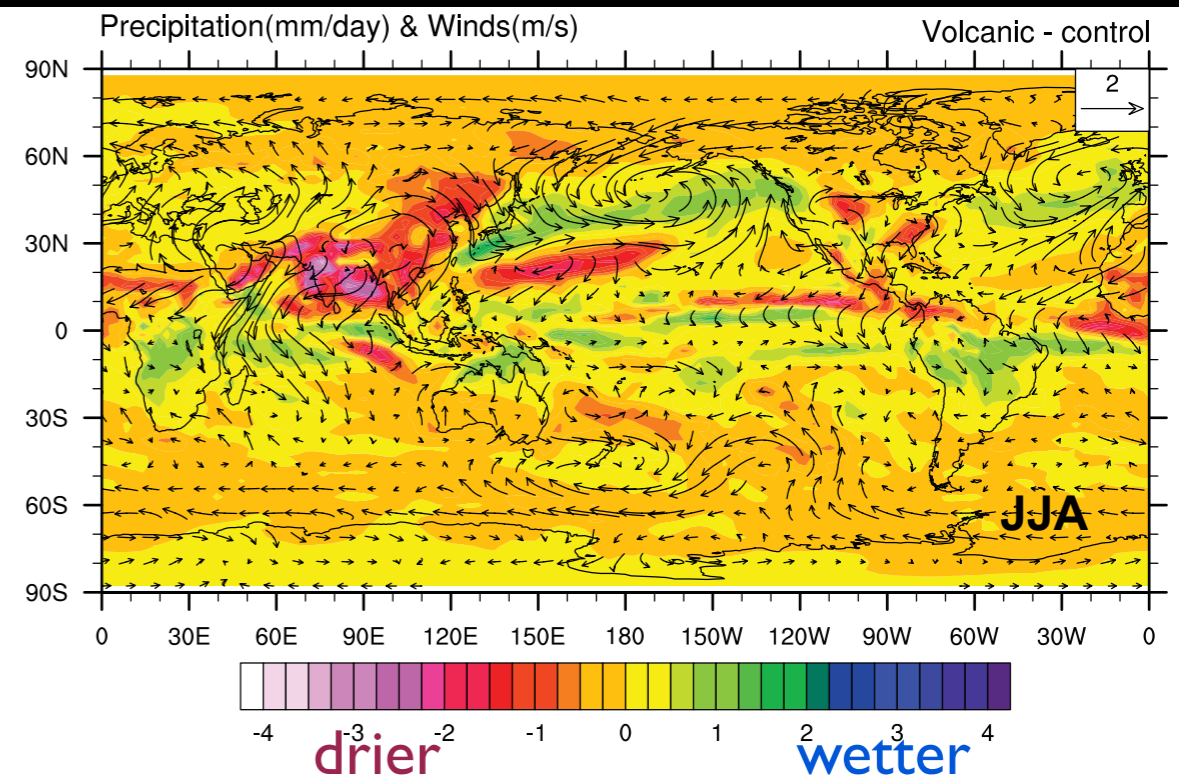
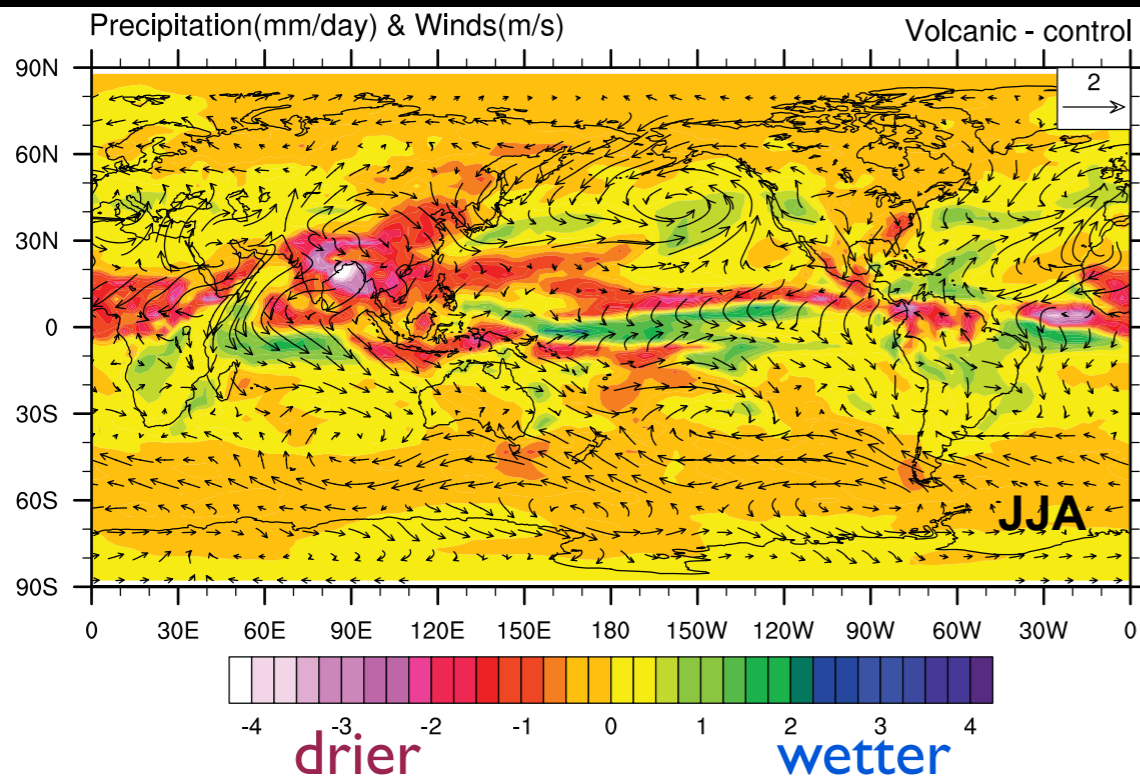


Results

Precipitation anomalies, composite

tropical eruption

high-latitude eruptions



Summary & future work

- (Surprisingly?) similar surface temperature & precipitation response to tropical vs. high-latitude volcanic forcing
- Cooling is greatest in summer over land and in winter over marginal sea-ice
- Global reduction in precipitation, especially in areas of tropical monsoon
- These results emphasize the role of the direct radiative response vs. the dynamical response (e.g. forced positive phase of Arctic Oscillation/Northern Annular Mode)

Summary & future work

- Additional experiments to include solar-only and full forcing
- Integration of paleo proxy data with model results with emphasis on the Arctic
- Re-visit ice core evidence for the 1258 AD eruption
- Further volcanic forcing experiments to elucidate the dynamical response