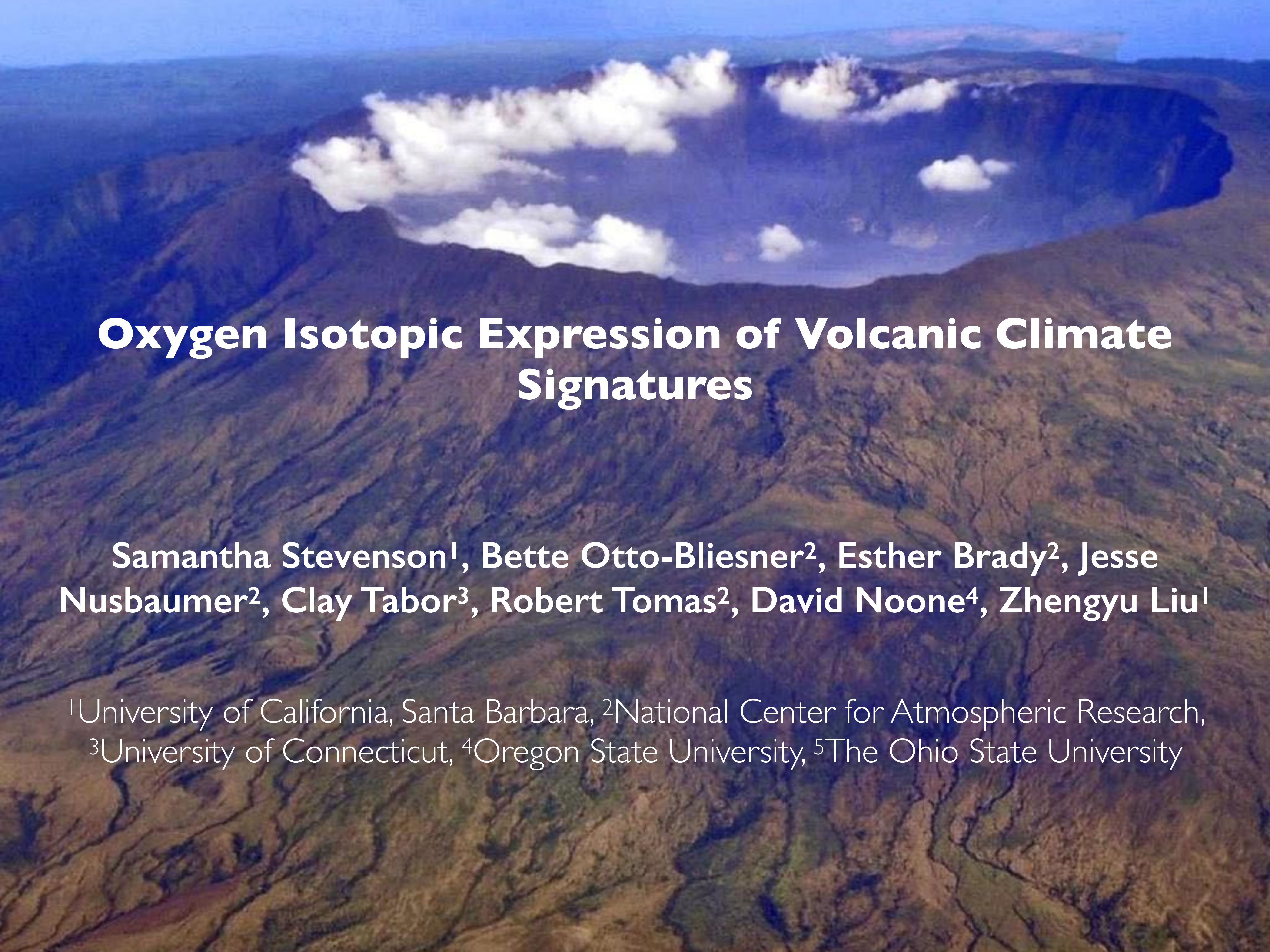
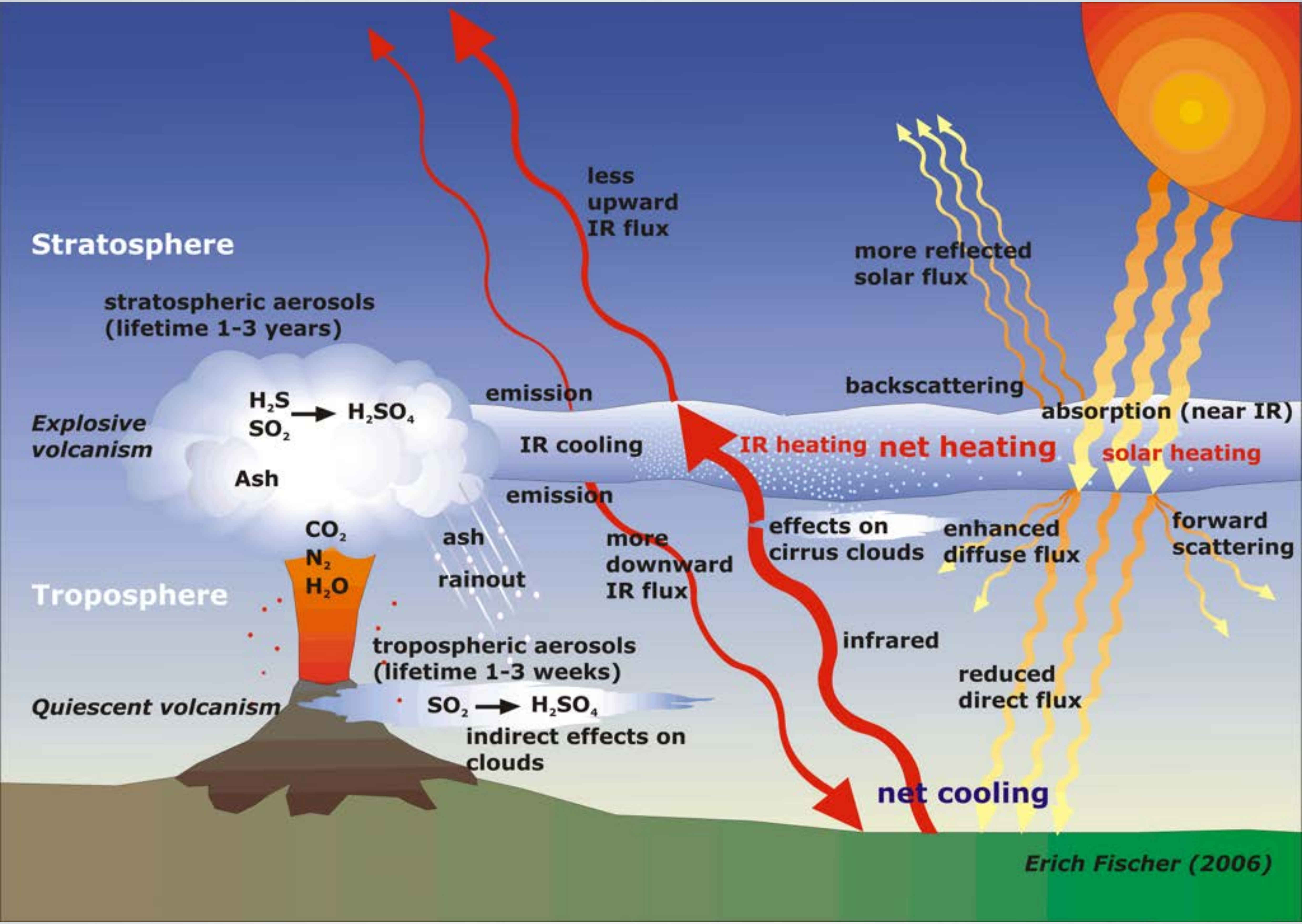


Oxygen Isotopic Expression of Volcanic Climate Signatures

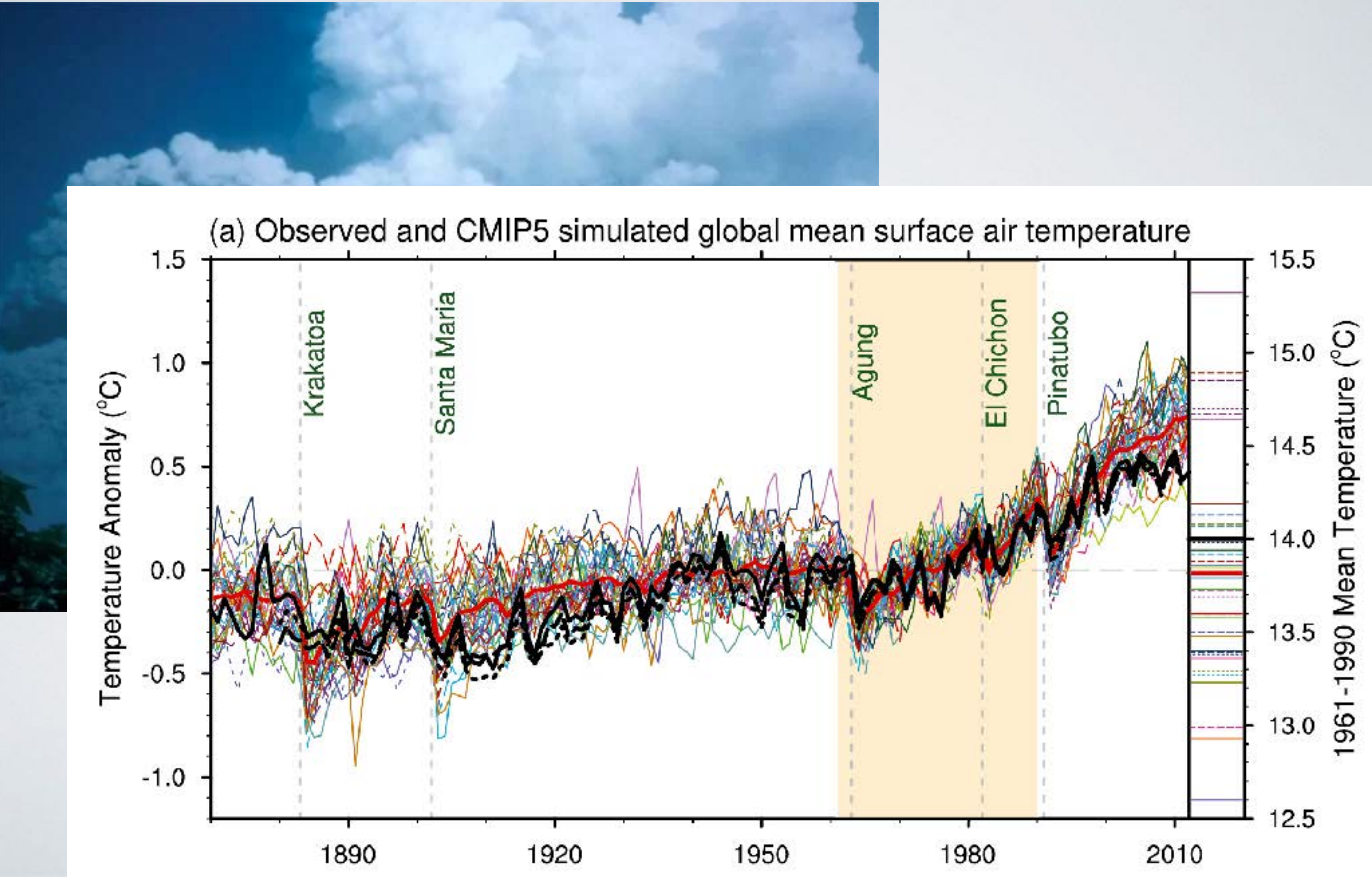
Samantha Stevenson[1], Bette Otto-Bliesner[2], Esther Brady[2], Jesse Nusbaumer[2], Clay Tabor[3], Robert Tomas[2], David Noone[4], Zhengyu Liu[1]

[1]University of California, Santa Barbara, [2]National Center for Atmospheric Research, [3]University of Connecticut, [4]Oregon State University, [5]The Ohio State University

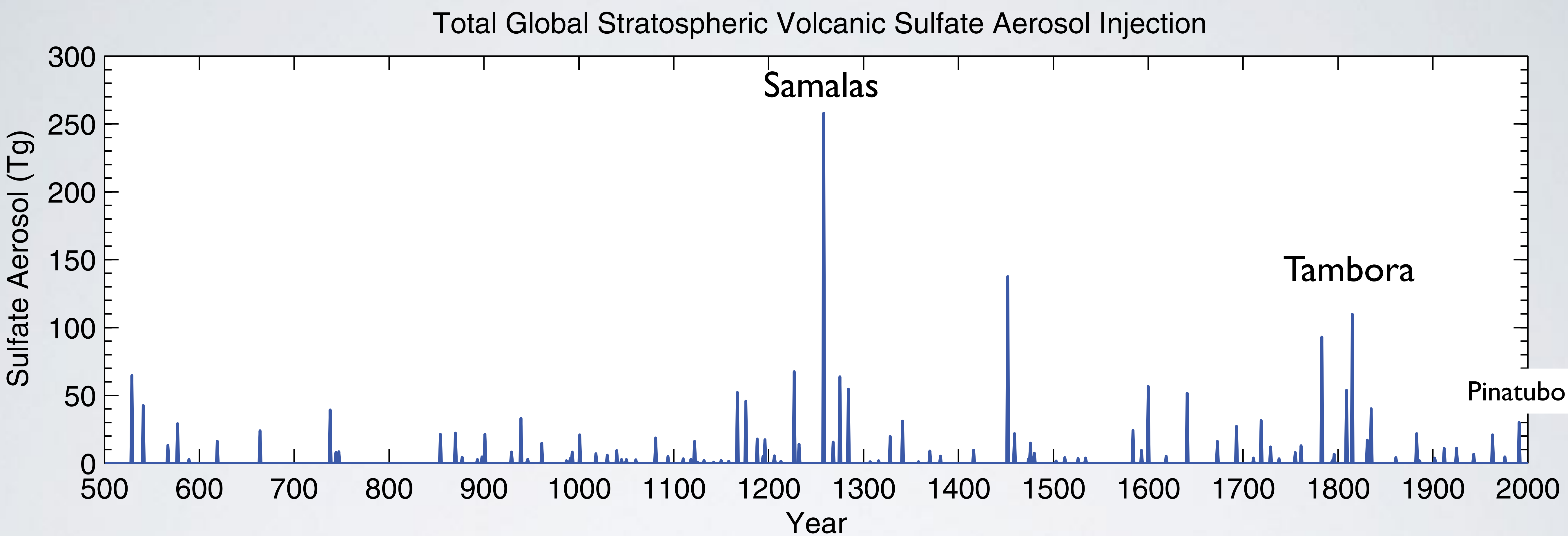


Stratosphere
stratospheric aerosols
(lifetime 1-3 years)
less
upward
IR flux
more reflected
solar flux
backscattering
absorption (near IR)
Explosive
volcanism
H_2S
SO_2 → H_2SO_4
Ash
emission
IR cooling
emission
IR heating net heating
solar heating
CO_2
N_2
H_2O
ash
rainout
more
downward
IR flux
effects on
cirrus clouds
enhanced
diffuse flux
forward
scattering
Troposphere
infrared
tropospheric aerosols
(lifetime 1-3 weeks)
reduced
direct flux
Quiescent volcanism
SO_2 → H_2SO_4
indirect effects on
clouds
net cooling
Erich Fischer (2006)

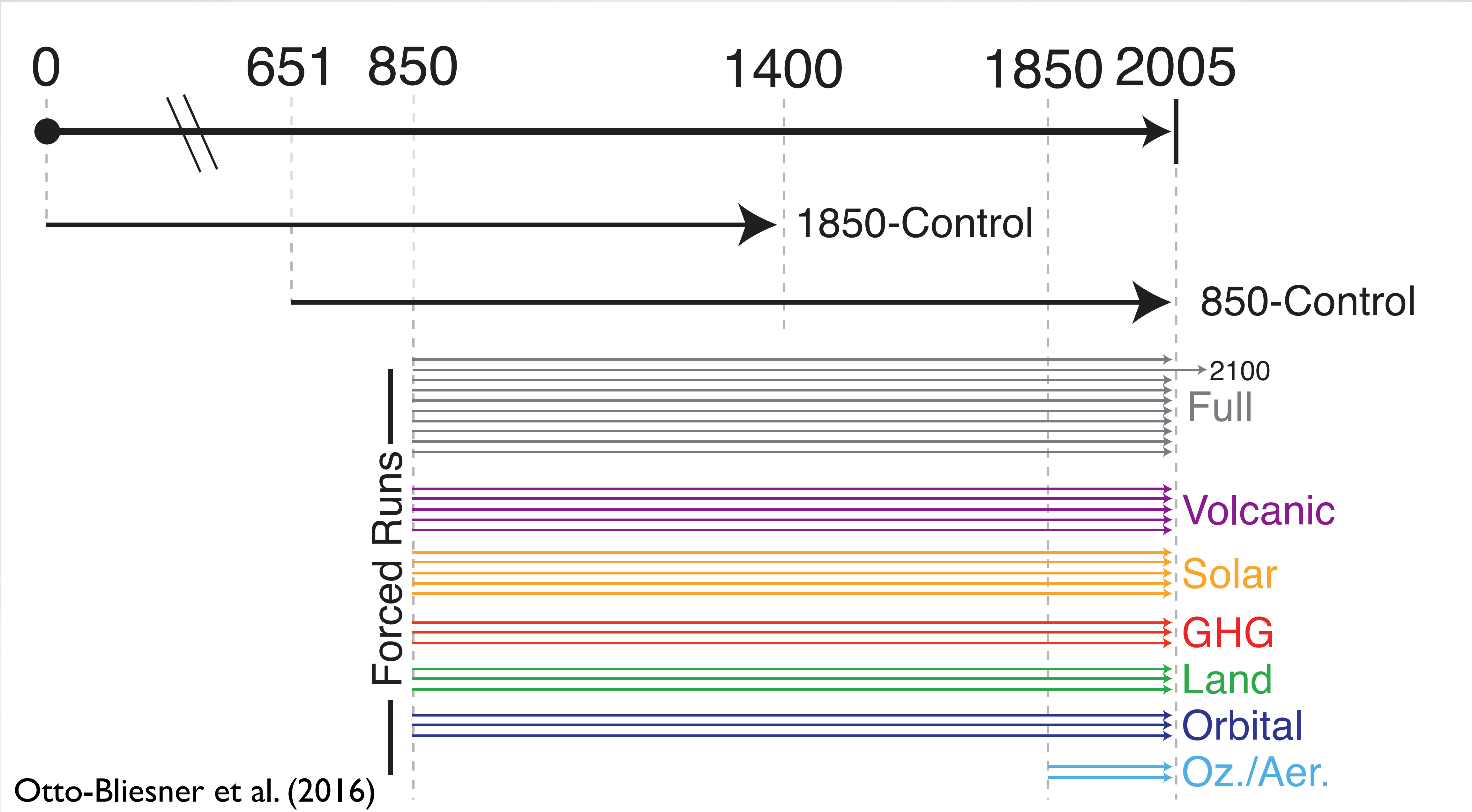
Mt. Pinatubo, Philippines, 1991



Past eruptions: even larger than Pinatubo



Information on pre-industrial volcanoes: reconstructions from ice cores



NCAR Community Earth System Model Last Millennium Ensemble (LME)
Multiple ensembles, varying sizes: different combinations of climate forcings
850-2005 for most ensembles, 1850-2005 for ozone/aerosol only
Some extensions to 2100 (full-forcing ensemble)

Isotope-Enabled Last Millennium Ensemble (iLME)

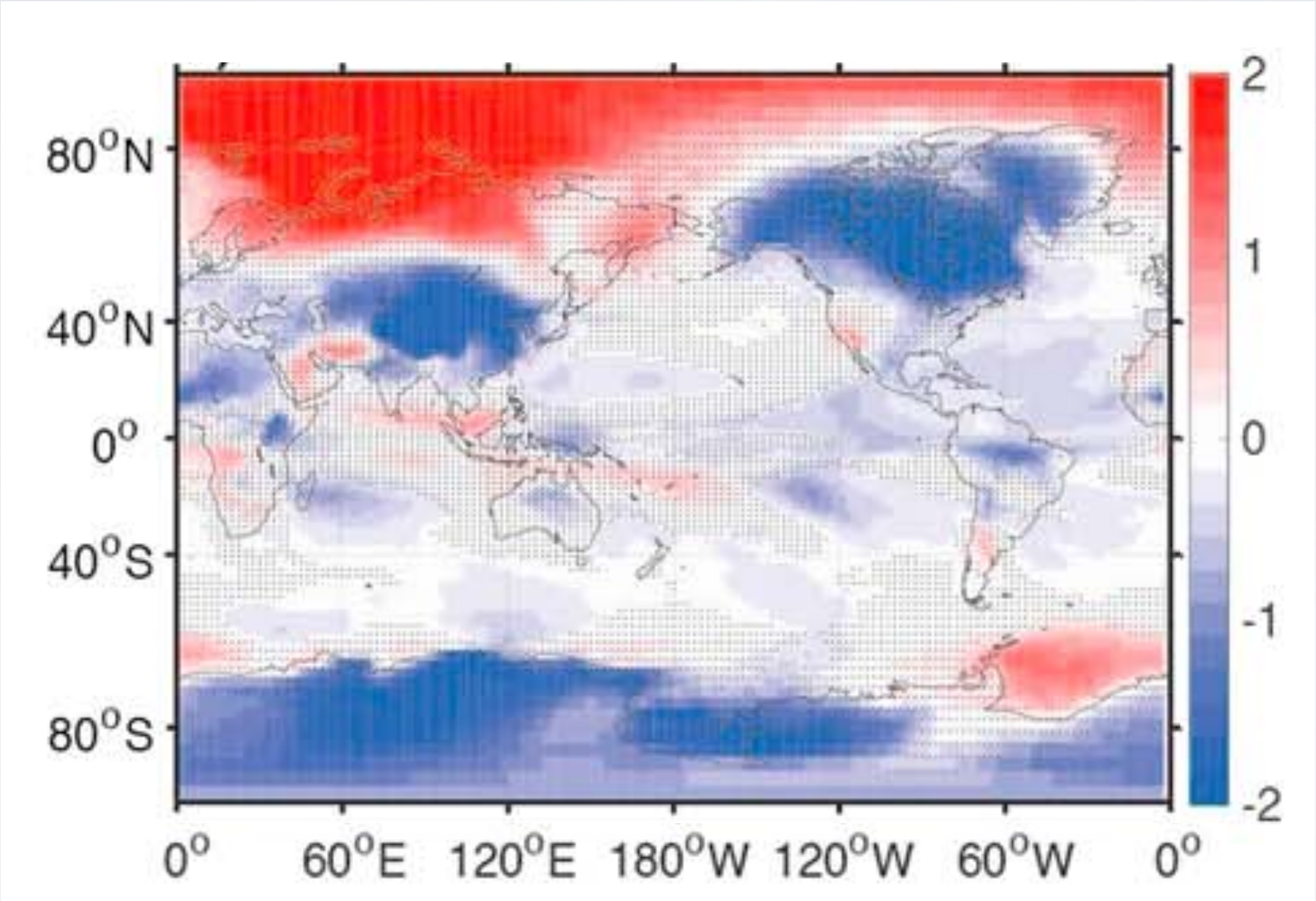
Table 1
Simulations Completed to Date as Part of the Isotope-Enabled Last Millennium Ensemble

Ensemble	Size
Full forcing	3
Volcano only	2
Orbital only	1
Solar only	1
Greenhouse gas only	1

Note. All simulations cover the 850–2005 period.

Stevenson et al. (2019)

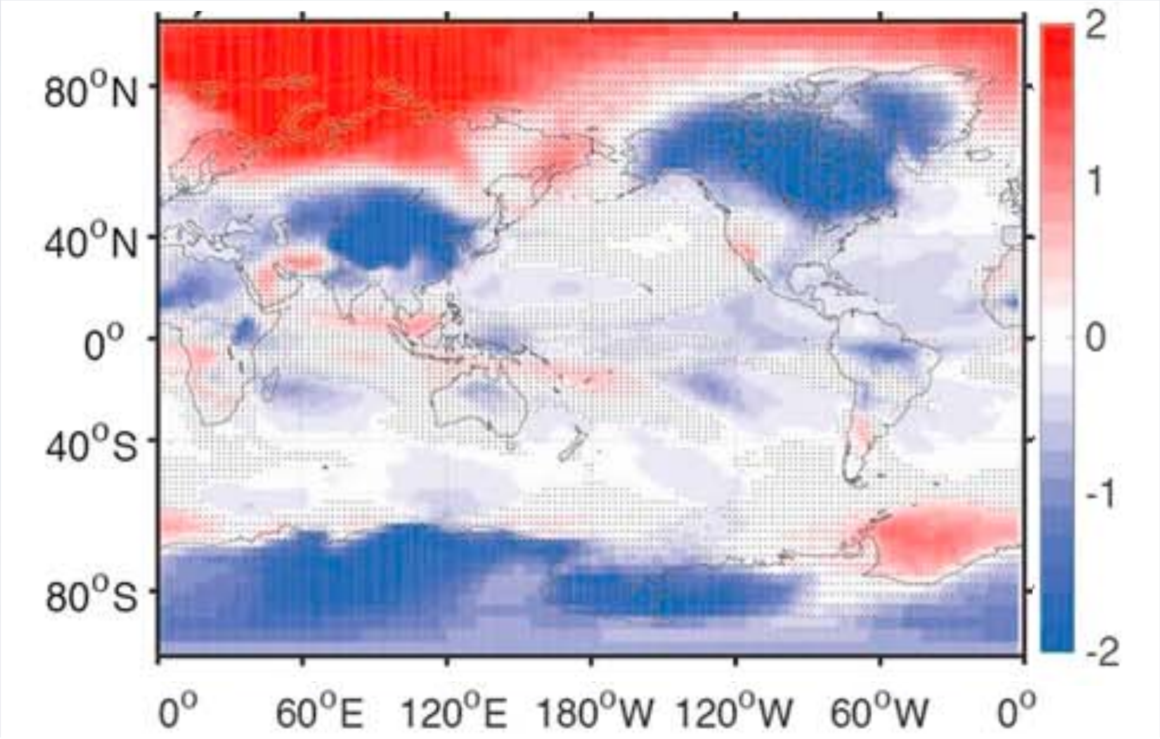
Precip $\delta^{18}O$: DJF following tropical eruptions (Year 0-1)

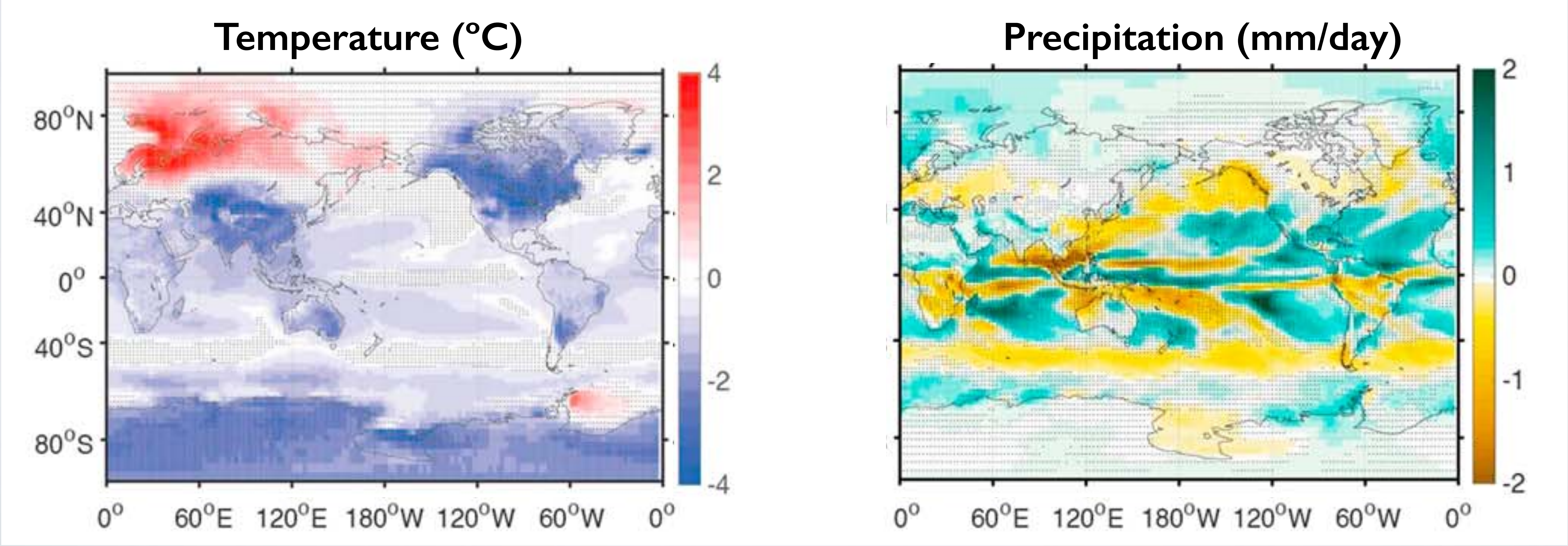


Stevenson et al. (2019)

DJF following tropical eruptions (Year 0-1)

Precip $\delta^{18}O$

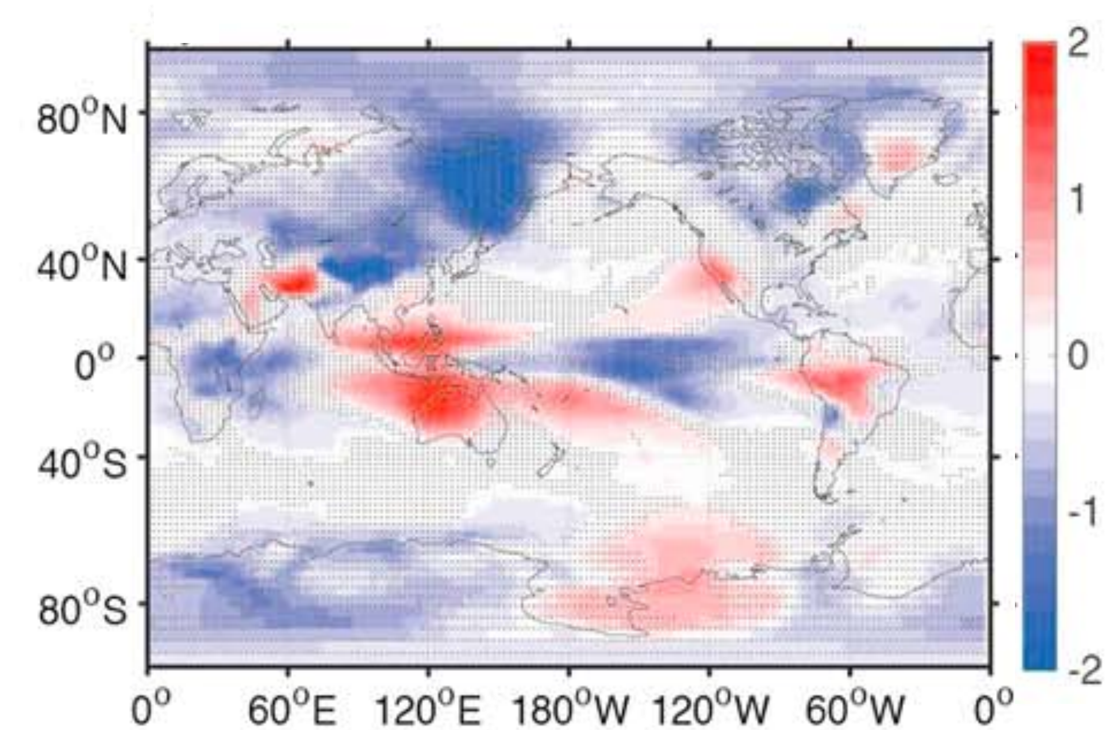




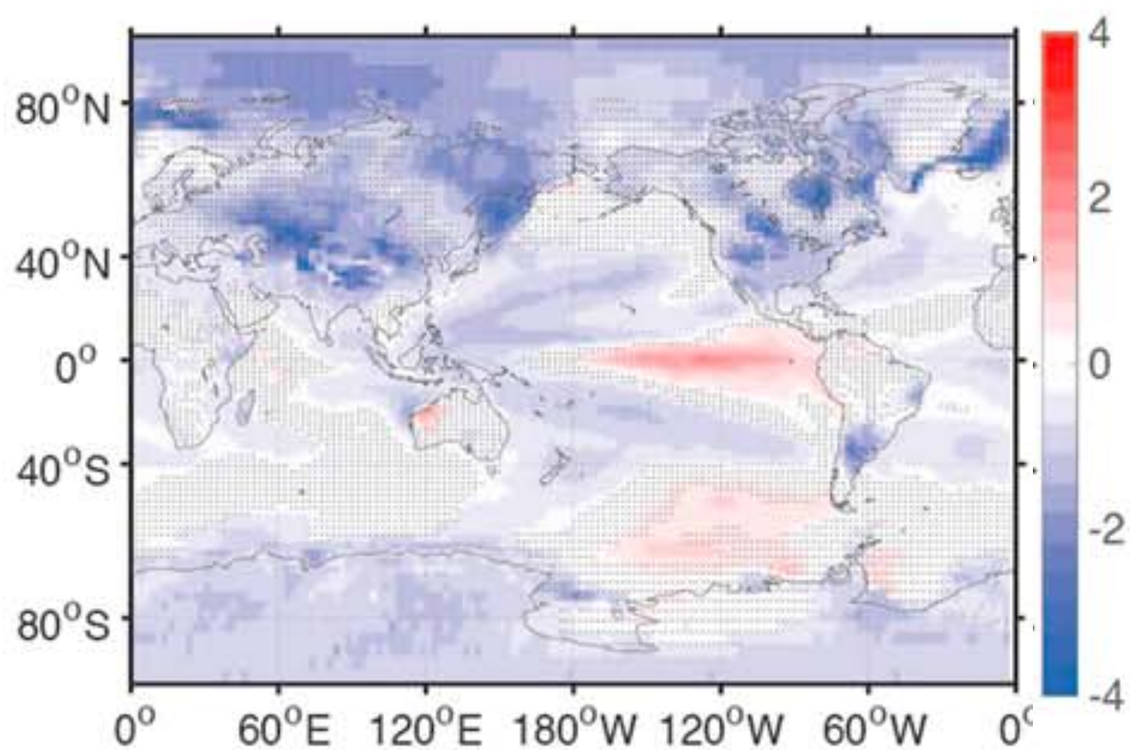
Stevenson et al. (2019)

DJF following tropical eruptions (Year 1-2)

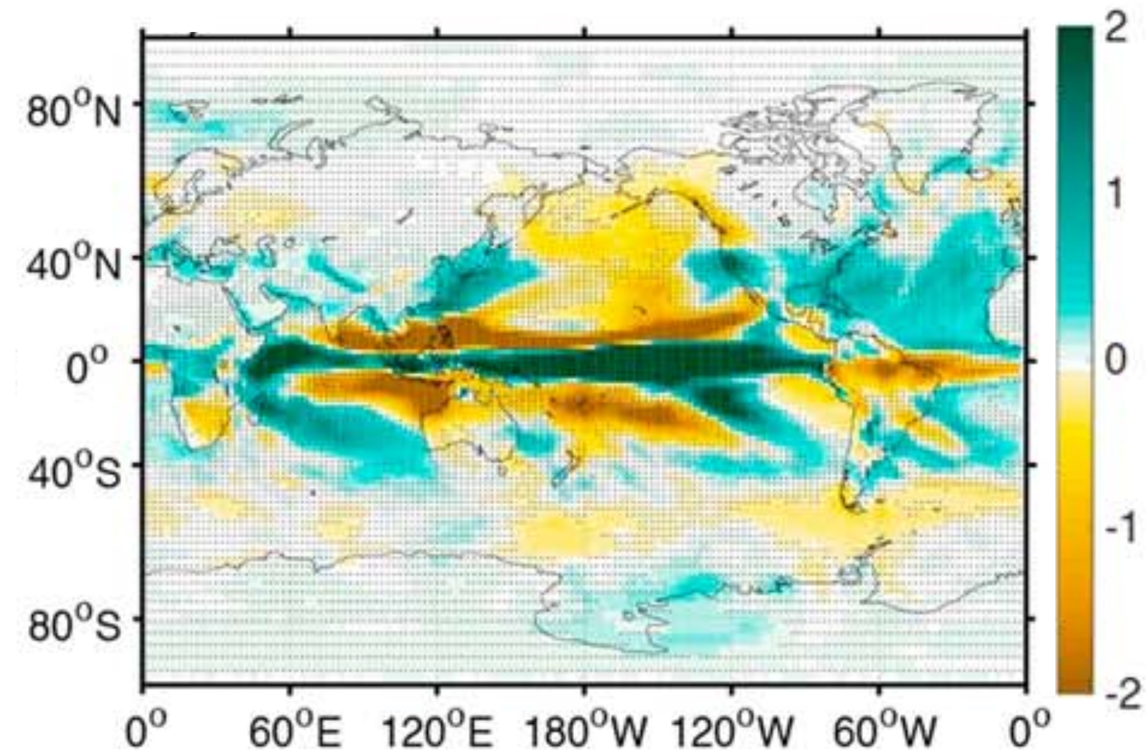
Precip $\delta^{18}O$



Temperature (°C)



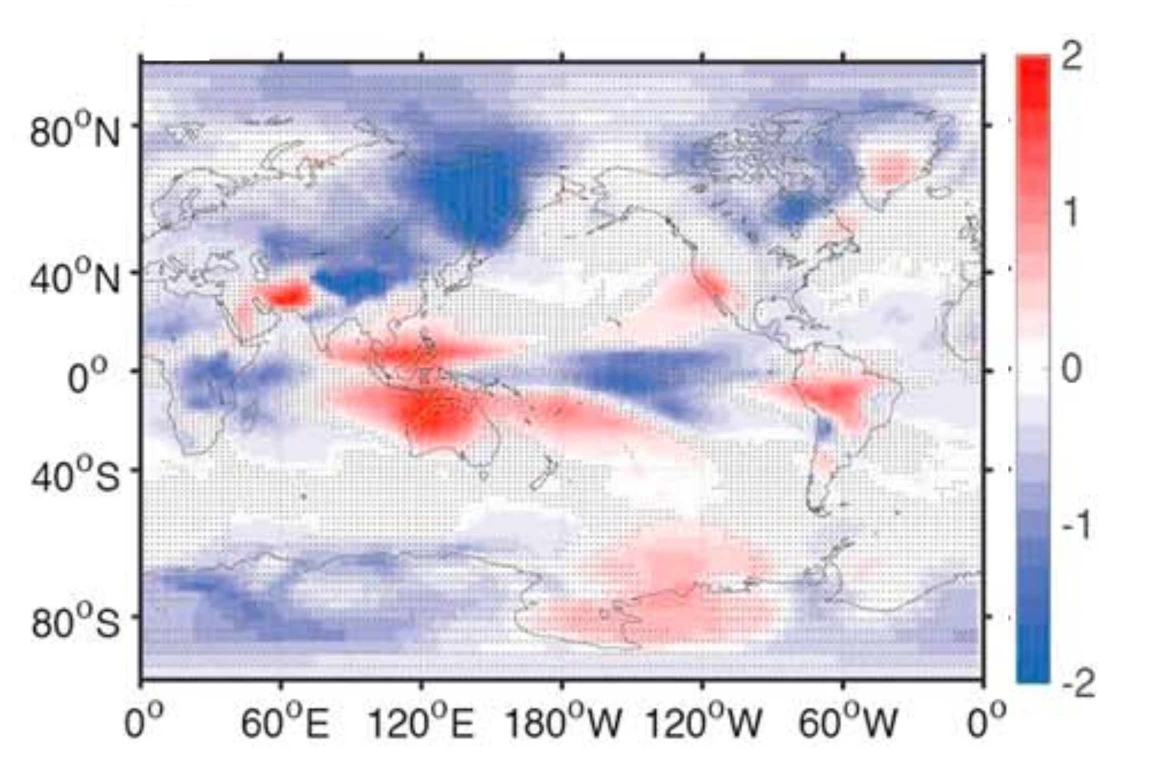
Precipitation (mm/day)



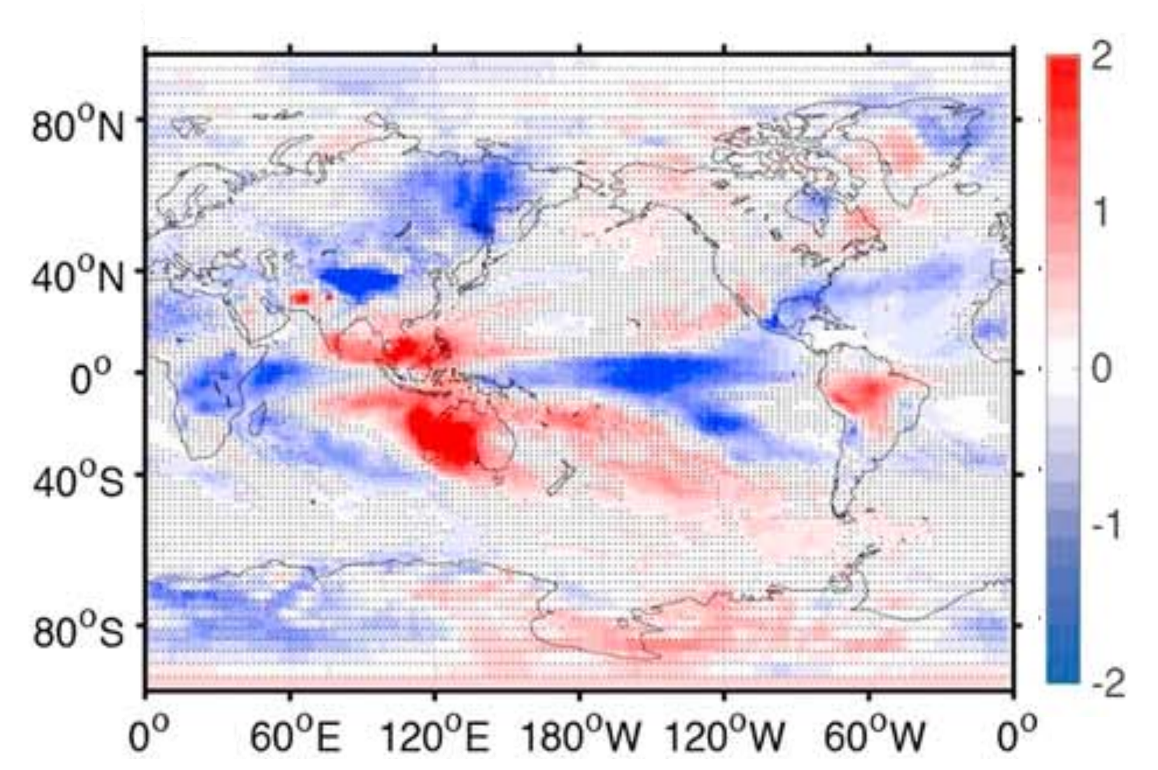
Stevenson et al. (2019)

DJF following tropical eruptions (Year 1-2)

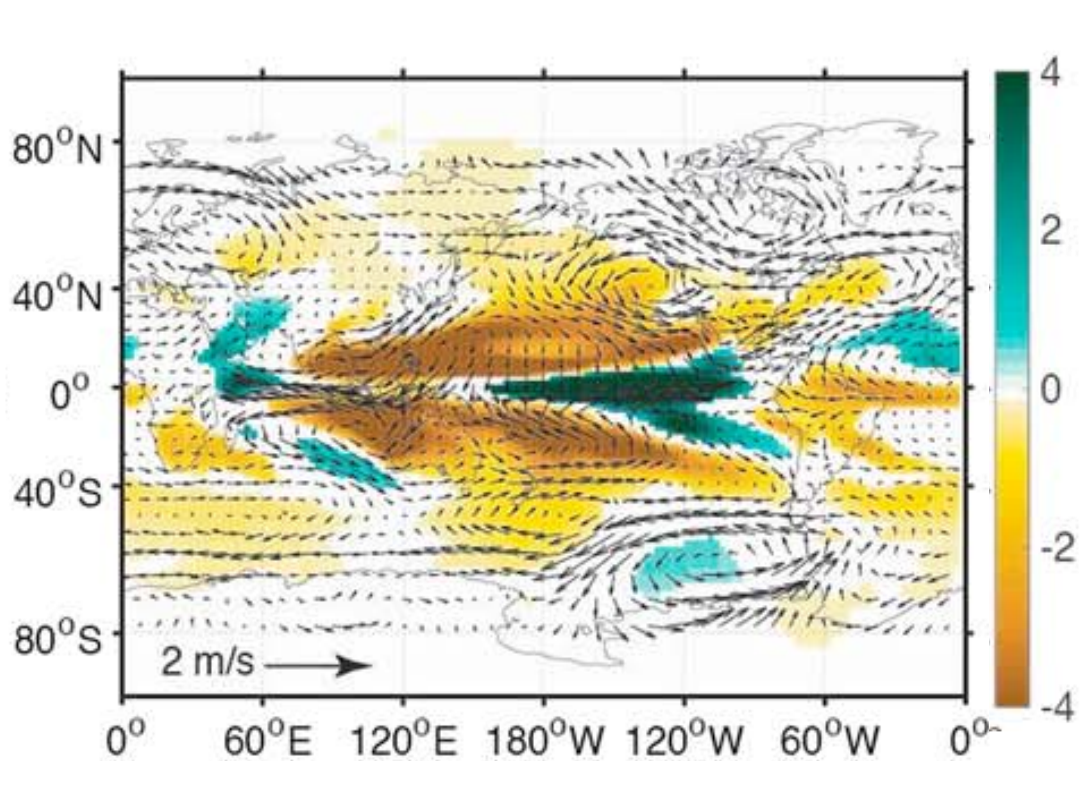
Precip δ^{18}O



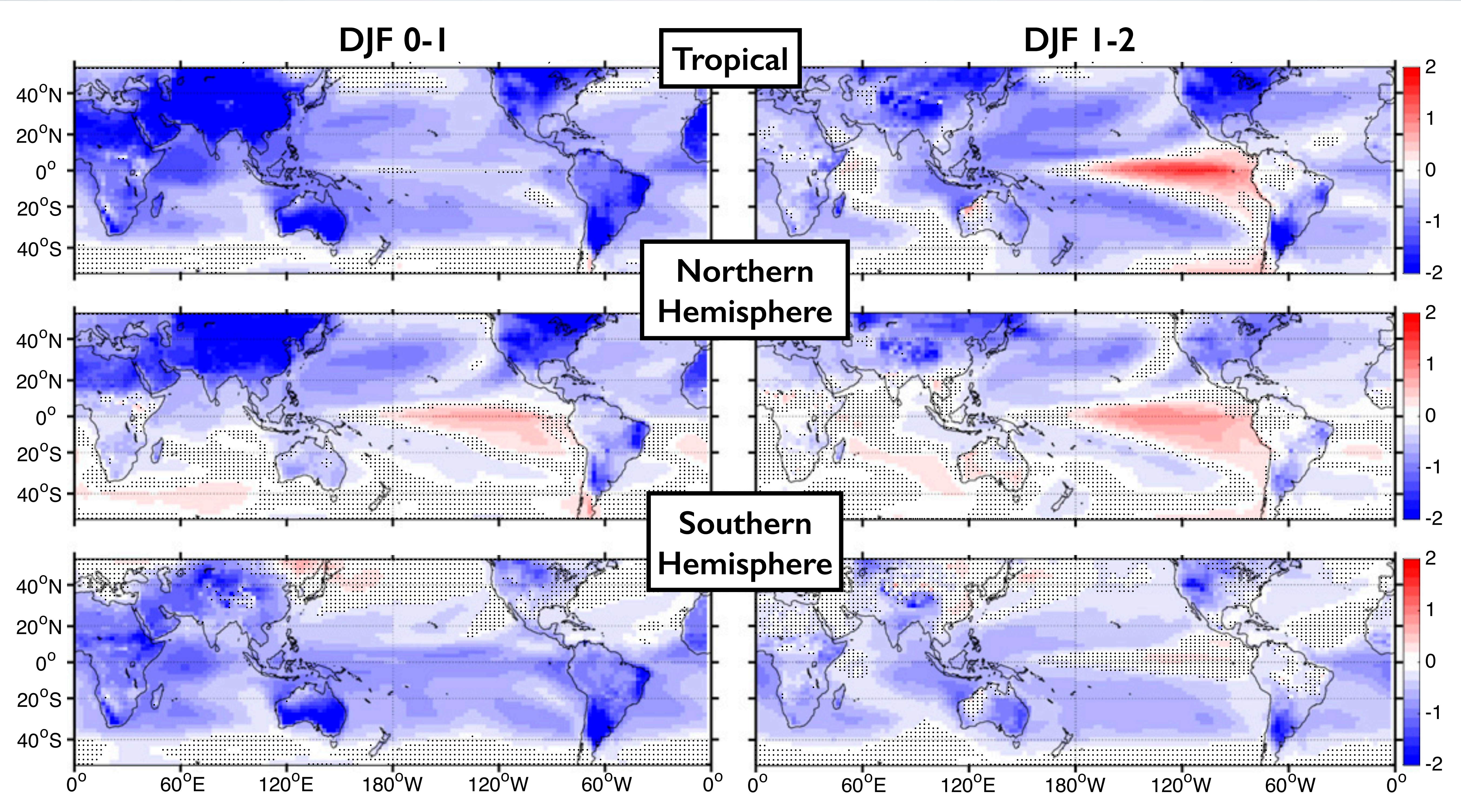
Vapor δ^{18}O



850 hPa wind (vectors), total precipitable water (colors)



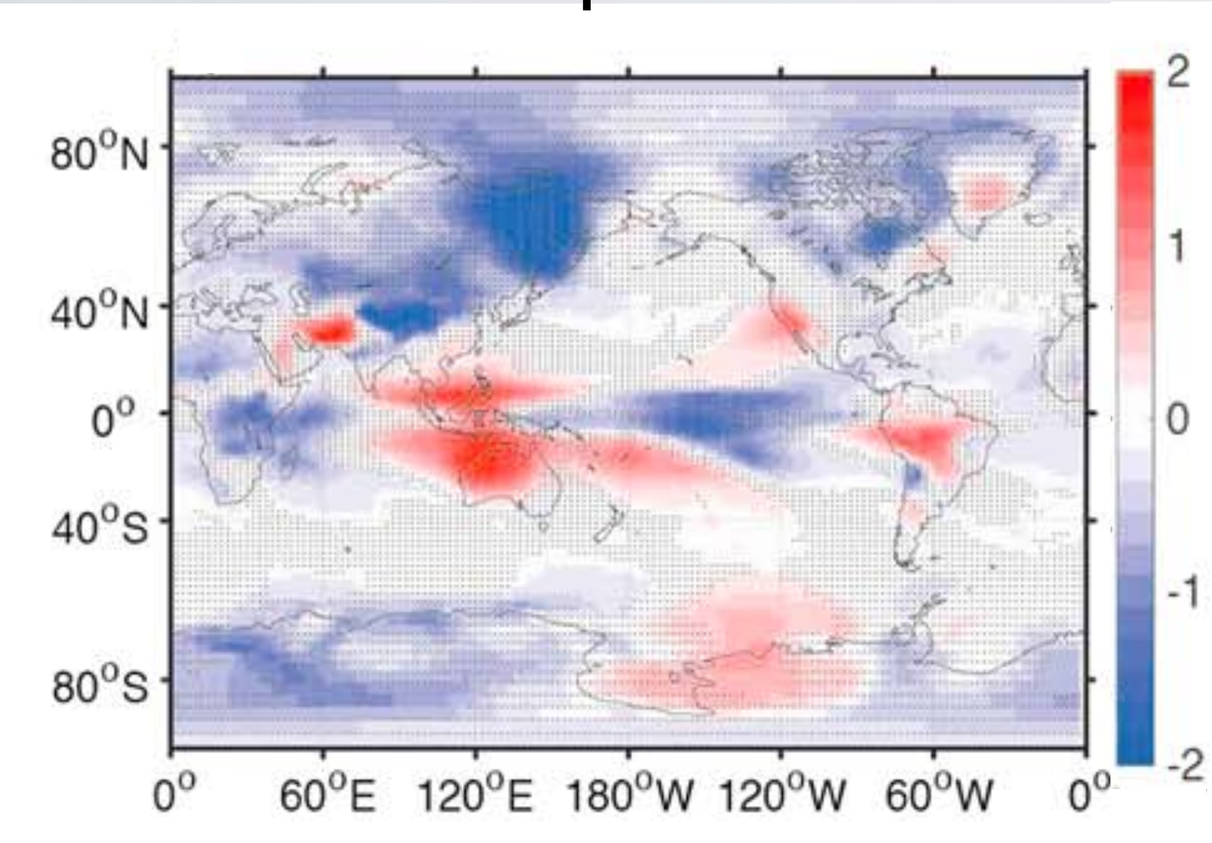
El Niño initiation after eruptions depends on latitude



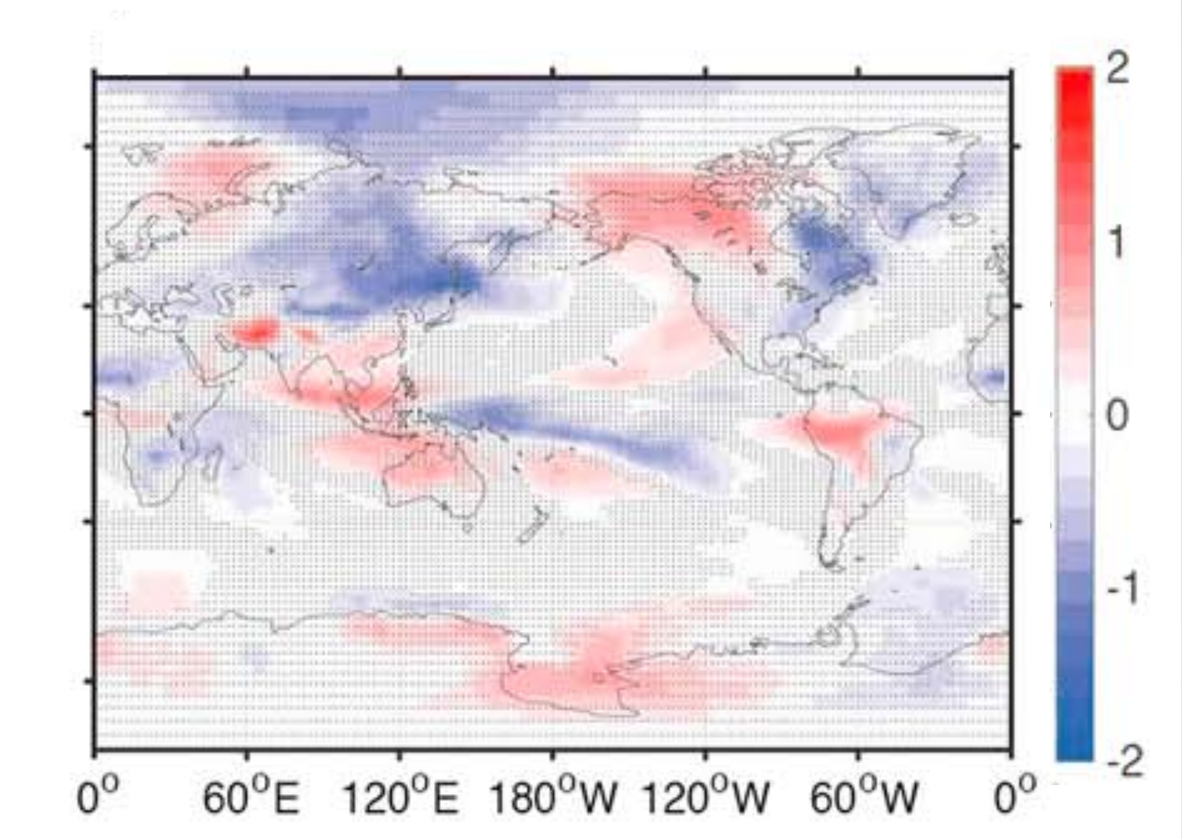
Stevenson et al. (2016), J. Clim.

Precip $\delta^{18}O$ during DJF following eruptions (Year 1-2)

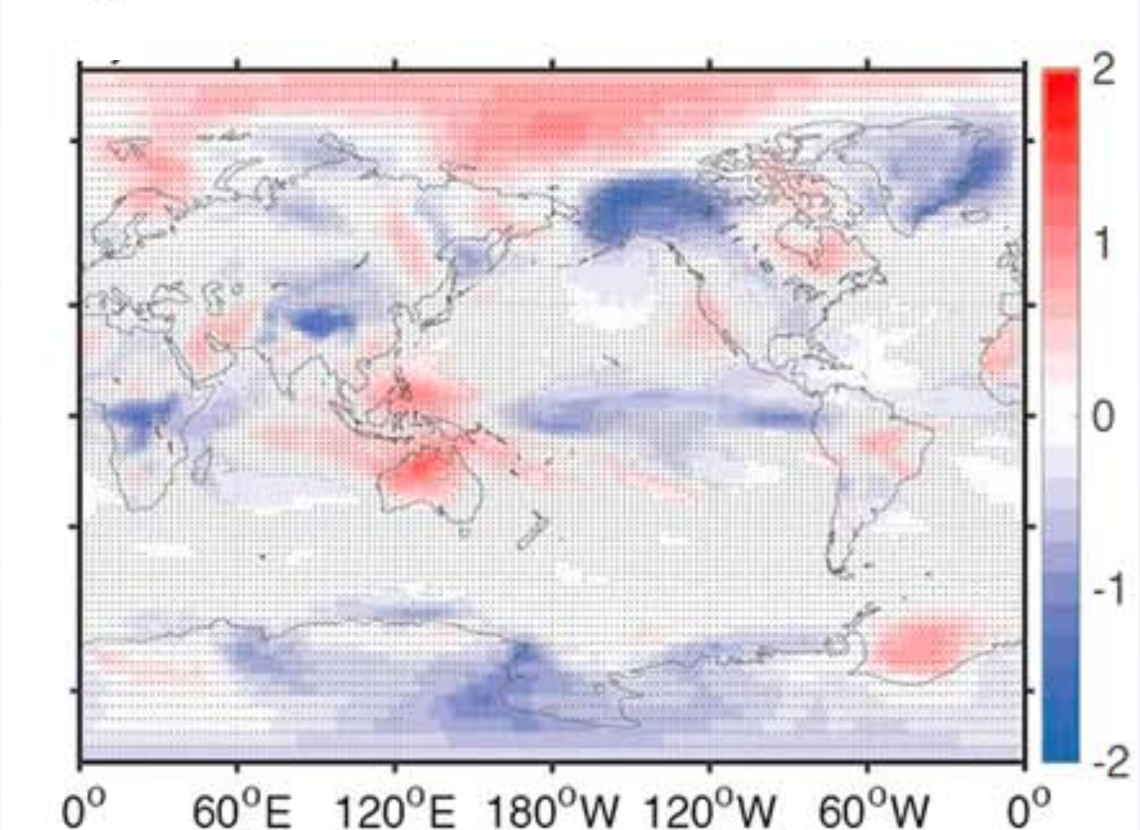
Tropical



Northern

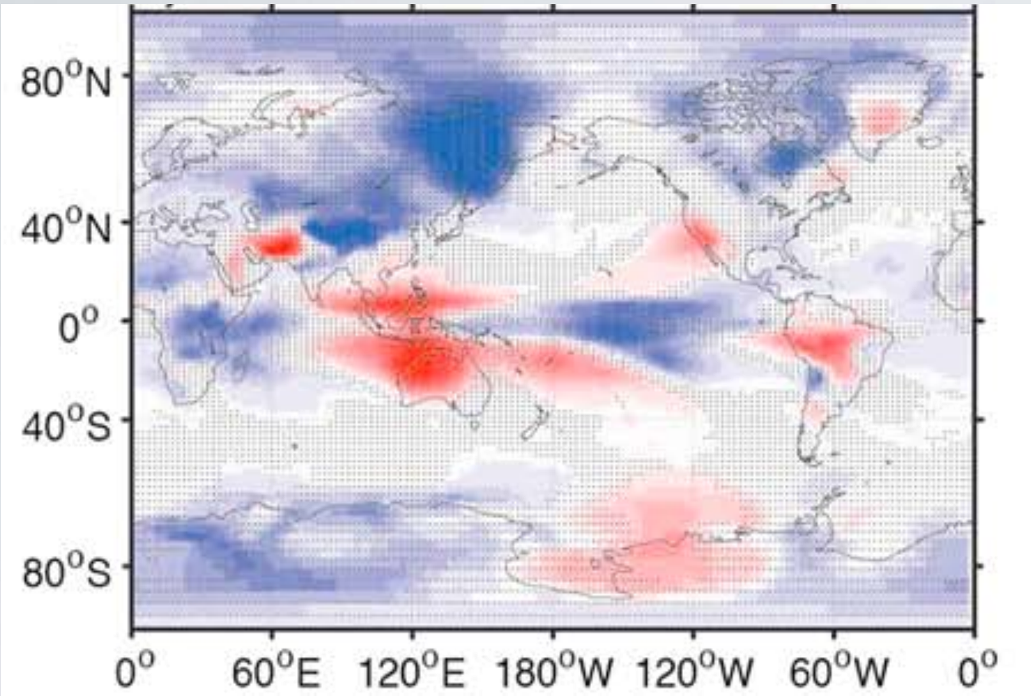


Southern



Stevenson et al. (2019)

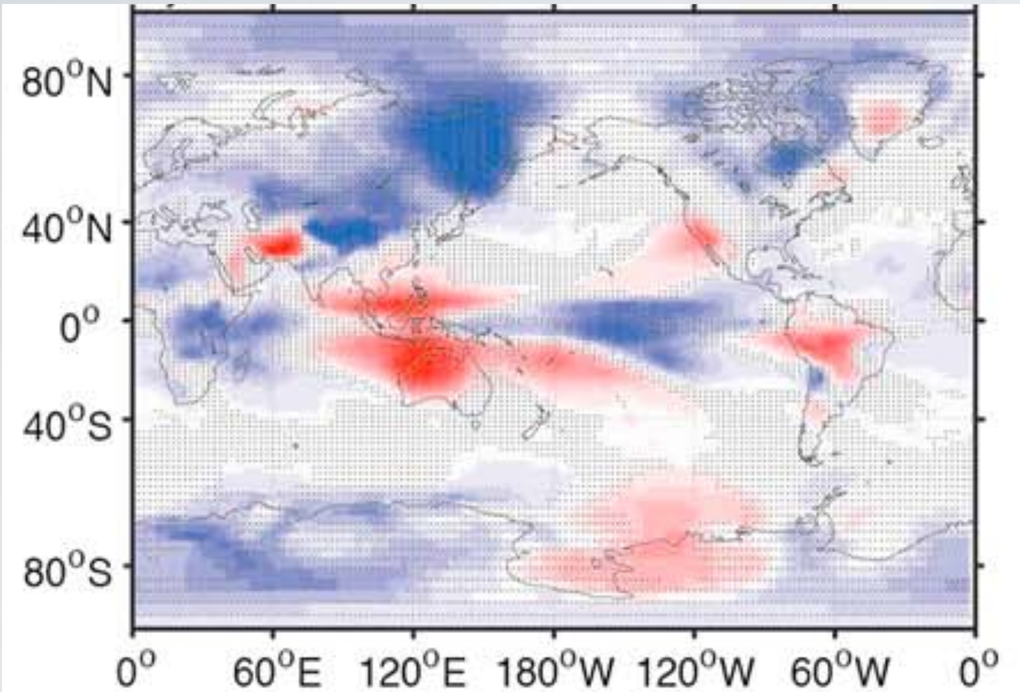
Precip δ^{18}O: a volcano fingerprinting tool??



x [all data in iLME simulations]

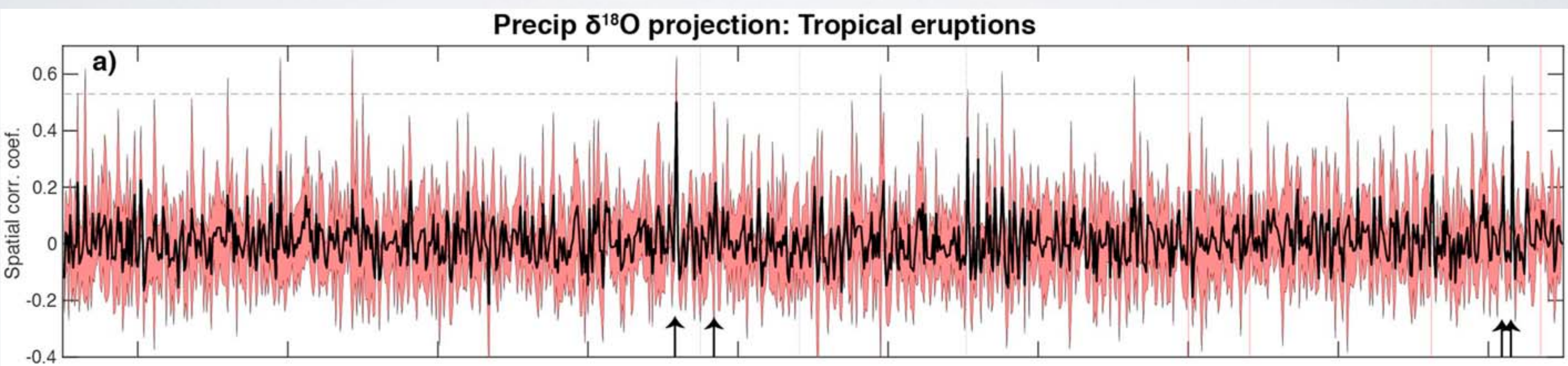
Stevenson et al. (2019)

Precip $\delta^{18}O$: a volcano fingerprinting tool??

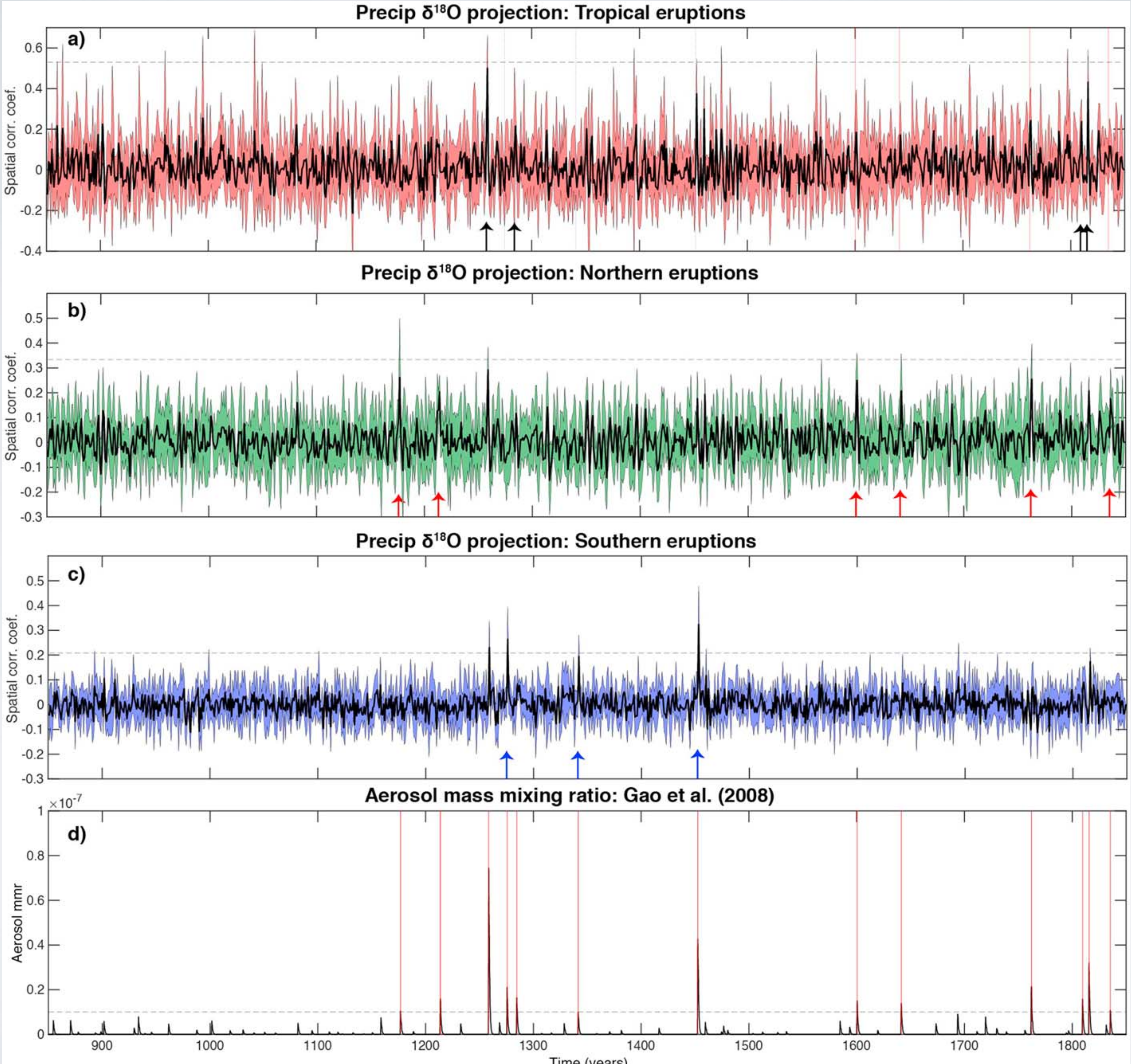


x [all data in iLME simulations]

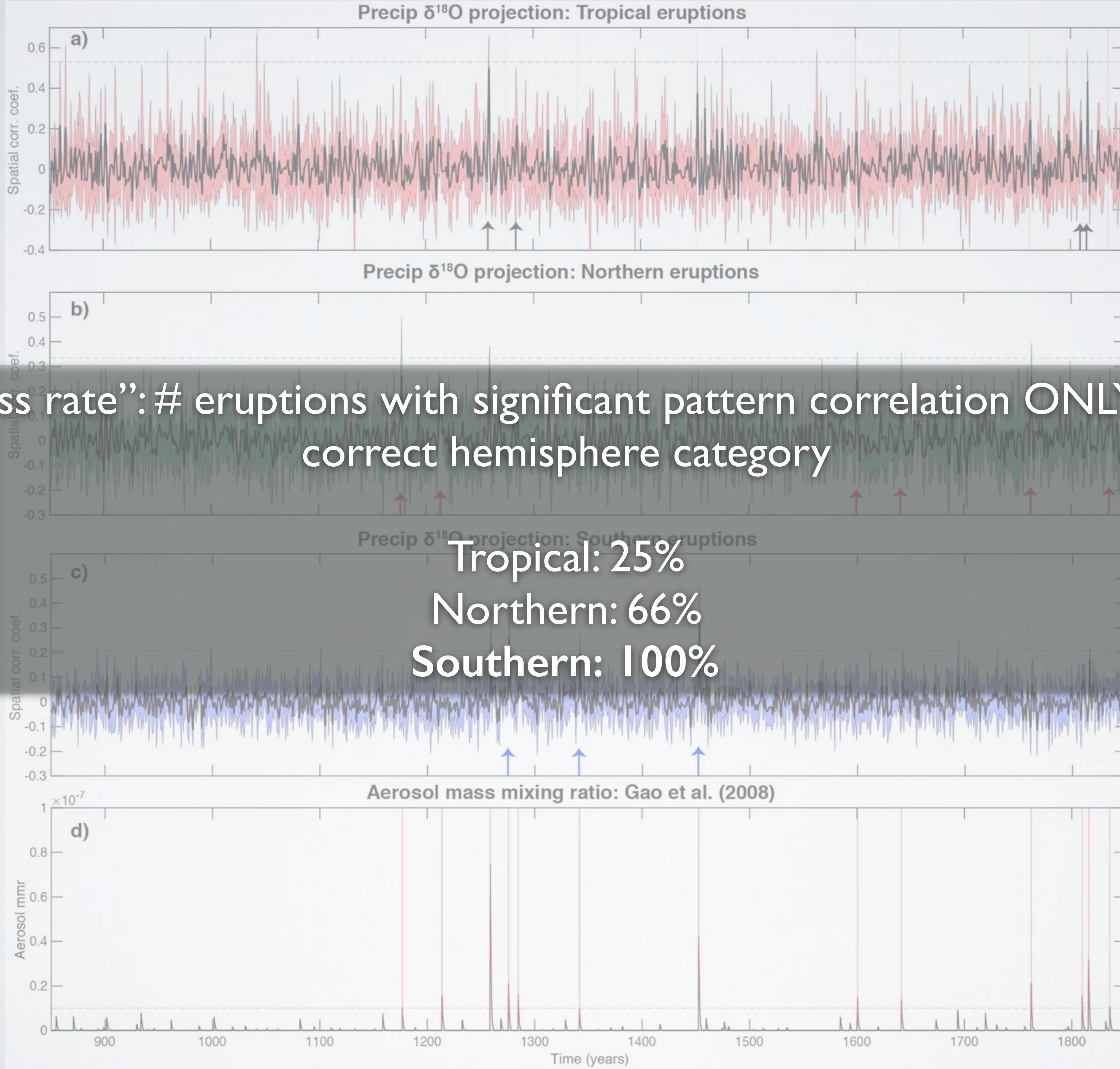
=



Stevenson et al. (2019)



Stevenson et al. (2019)



"Success rate": # eruptions with significant pattern correlation ONLY in the correct hemisphere category

Tropical: 25%
Northern: 66%
Southern: 100%

Stevenson et al. (2019)

Conclusions

- The isotope-enabled Last Millennium Ensemble will be a valuable tool for understanding LM proxy signatures (now publicly available!!)
- Oxygen isotopic anomalies record temperature, hydroclimate signatures of eruptions
- Vapor $\delta^{18}O$ significantly influences precipitation $\delta^{18}O$ in many locations, moisture source changes appear significant
- Precipitation $\delta^{18}O$ patterns can uniquely identify eruption hemisphere! (sometimes)