



# Isotopic Signatures of Last Millennium Volcanic Eruptions in CESM

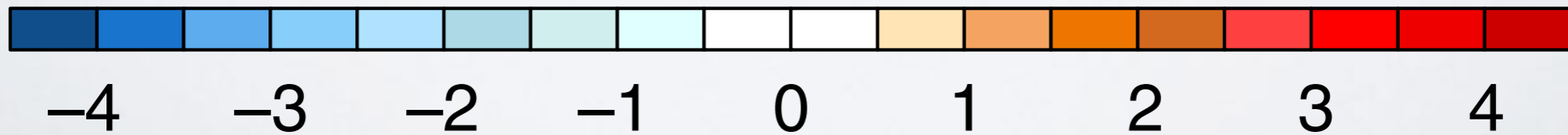
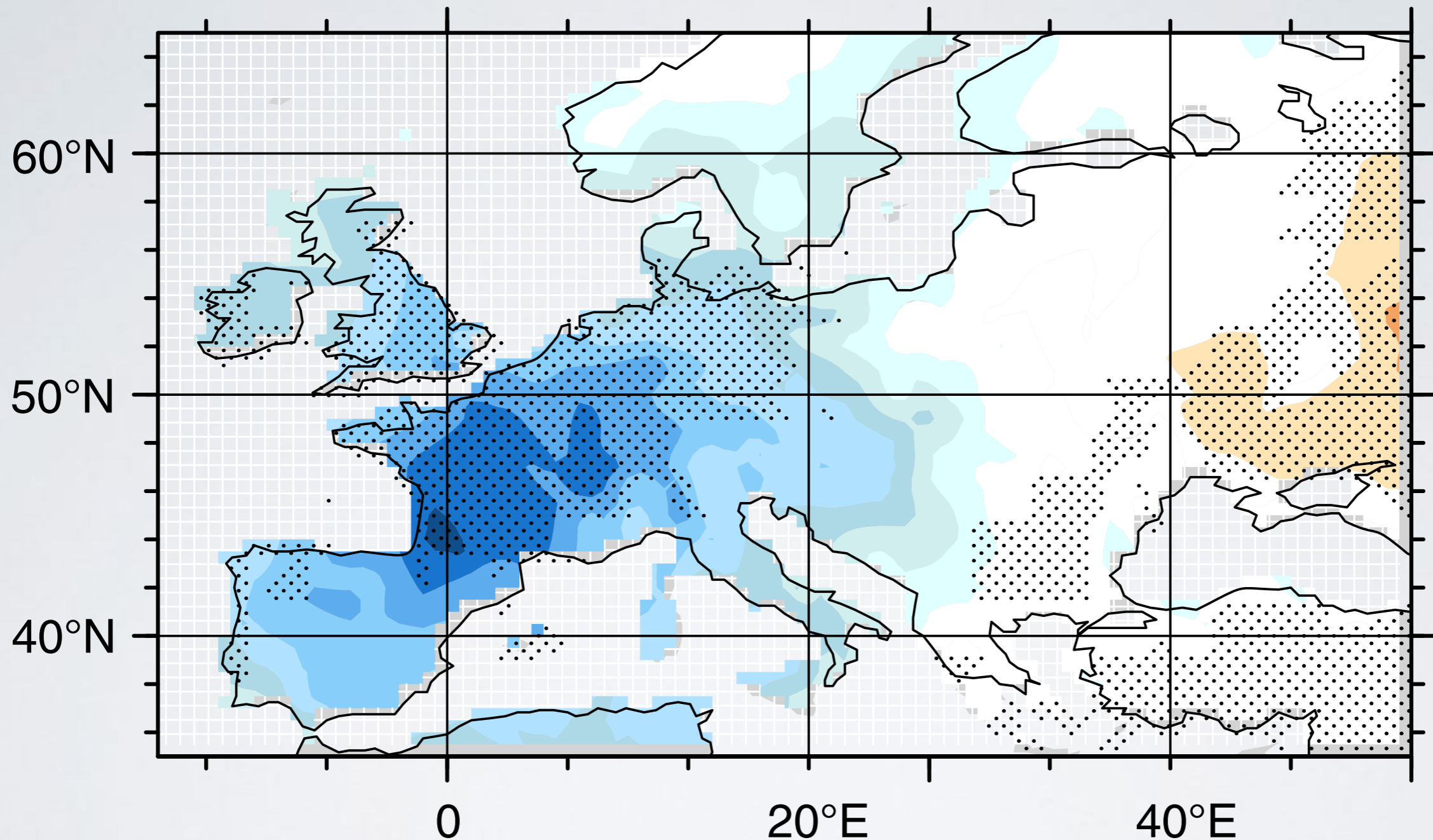
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Robert Tomas<sup>2</sup>, David Noone<sup>5</sup>, & Zhengyu Liu<sup>6</sup>

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<sup>3</sup>NASA Goddard Institute for Space Studies; <sup>4</sup>University of Connecticut;  
<sup>5</sup>Oregon State University; <sup>6</sup>The Ohio State University

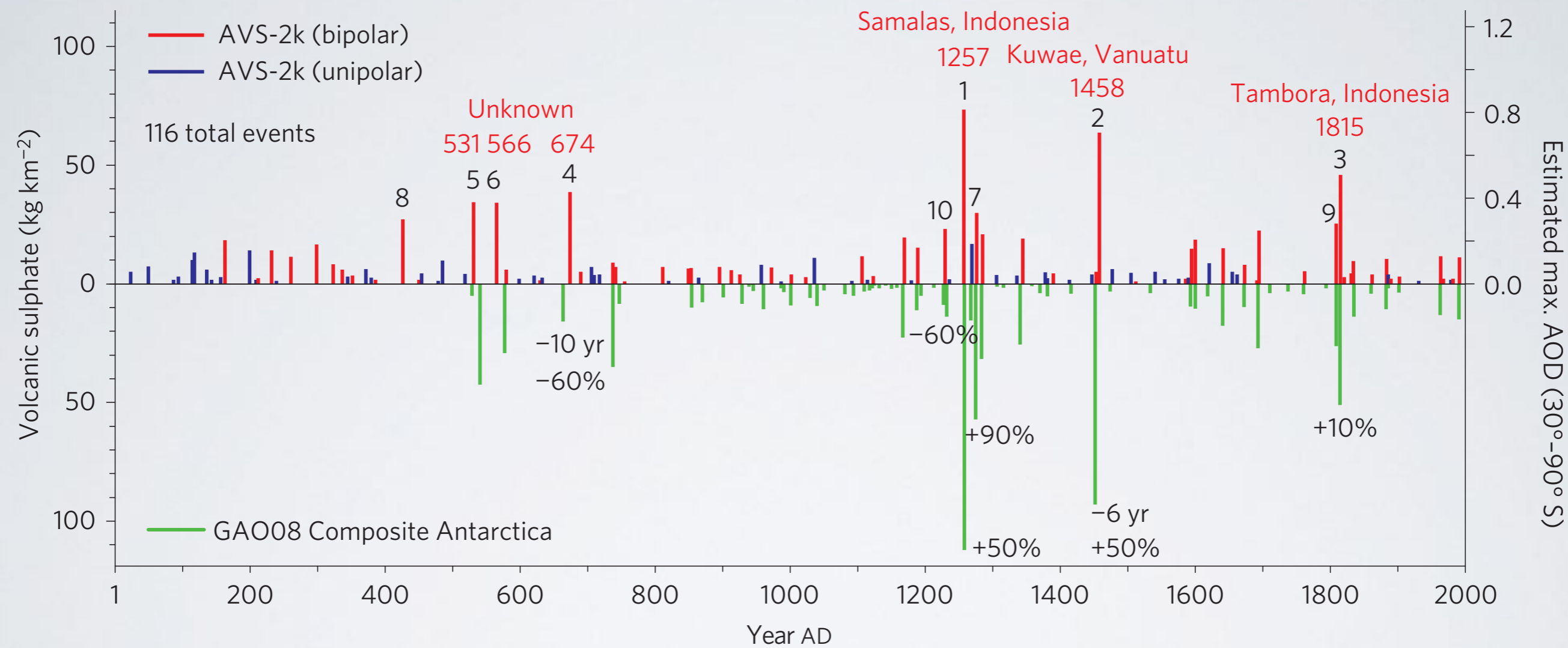
# Regional impacts of volcanism are severe

Luterbacher et al. (2004) 1816 summer Anom (vs. 1990s)



Fasullo et al. (2017)

# Properties of eruptions often uncertain



# CESM Last Millennium Ensemble

**TABLE 1. CESM-LME simulations. Additional information about the simulations including the forcing datasets, saved variables, diagnostics, model support and known issues can be found at the CESM-LME website ([www2.cesm.ucar.edu/models/experiments/LME](http://www2.cesm.ucar.edu/models/experiments/LME)).**

<b>Expt</b>	<b>No. of runs</b>	<b>Solar variability</b>	<b>Volcanic eruptions</b>	<b>Land use</b>	<b>GHGs</b>	<b>Orbital changes</b>	<b>Ozone–aerosols</b>
Full forcings	10	Transient 850–2005	Transient 850–2005	Transient 850–2005	Transient 850–2005	Transient 850–2005	Transient 1850–2005
Solar only	4	Transient 850–2005	None	*	*	*	1850
Volcanic only	5	*	Transient 850–2005	*	*	*	1850
Land use only	3	*	None	Transient 850–2005	*	*	1850
GHG only	3	*	None	*	Transient 850–2005	*	1850
Orbital only	3	*	None	*	*	Transient 850–2005	1850
Ozone–aerosol only	2	*	None	*	*	*	Transient 1850–2005

\* Fixed at 850 values.

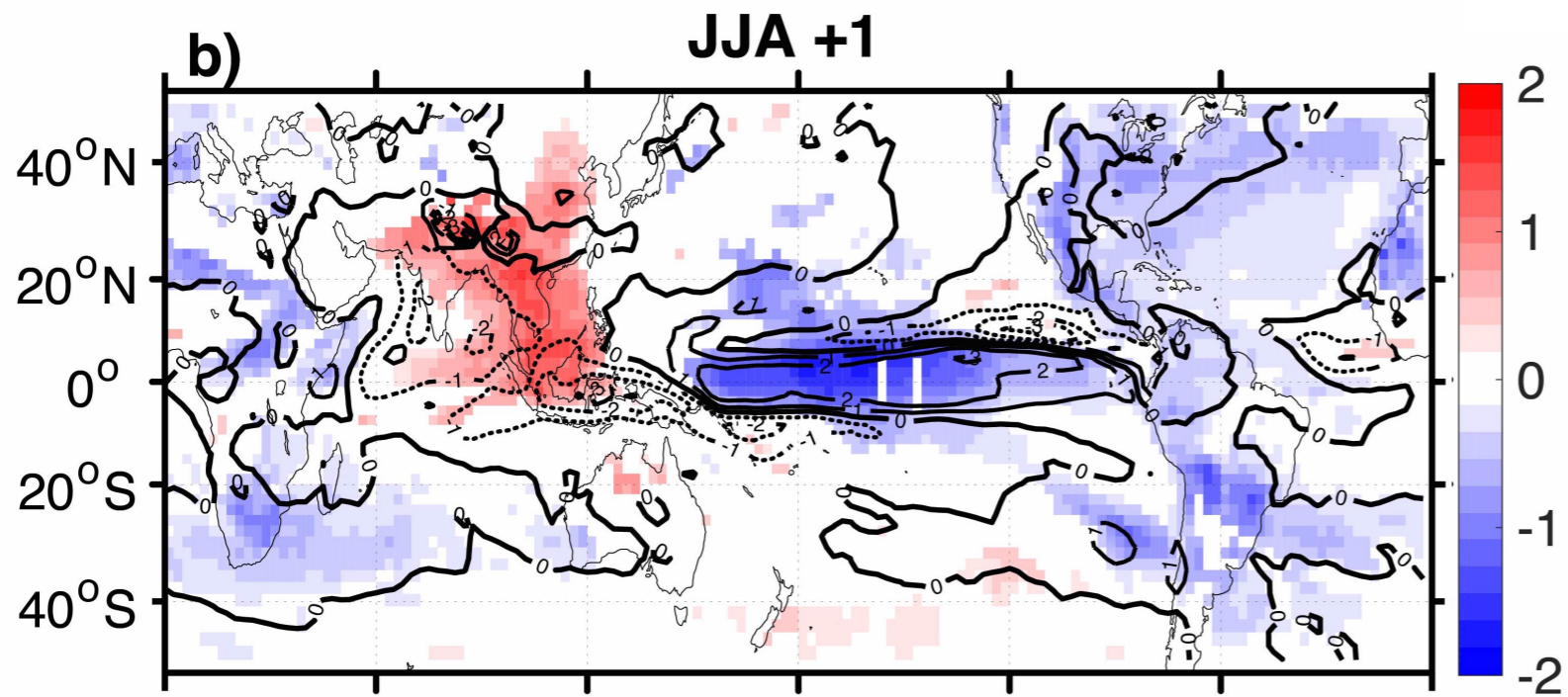
# Isotope-enabled CESM: “iLME”

## Runs completed:

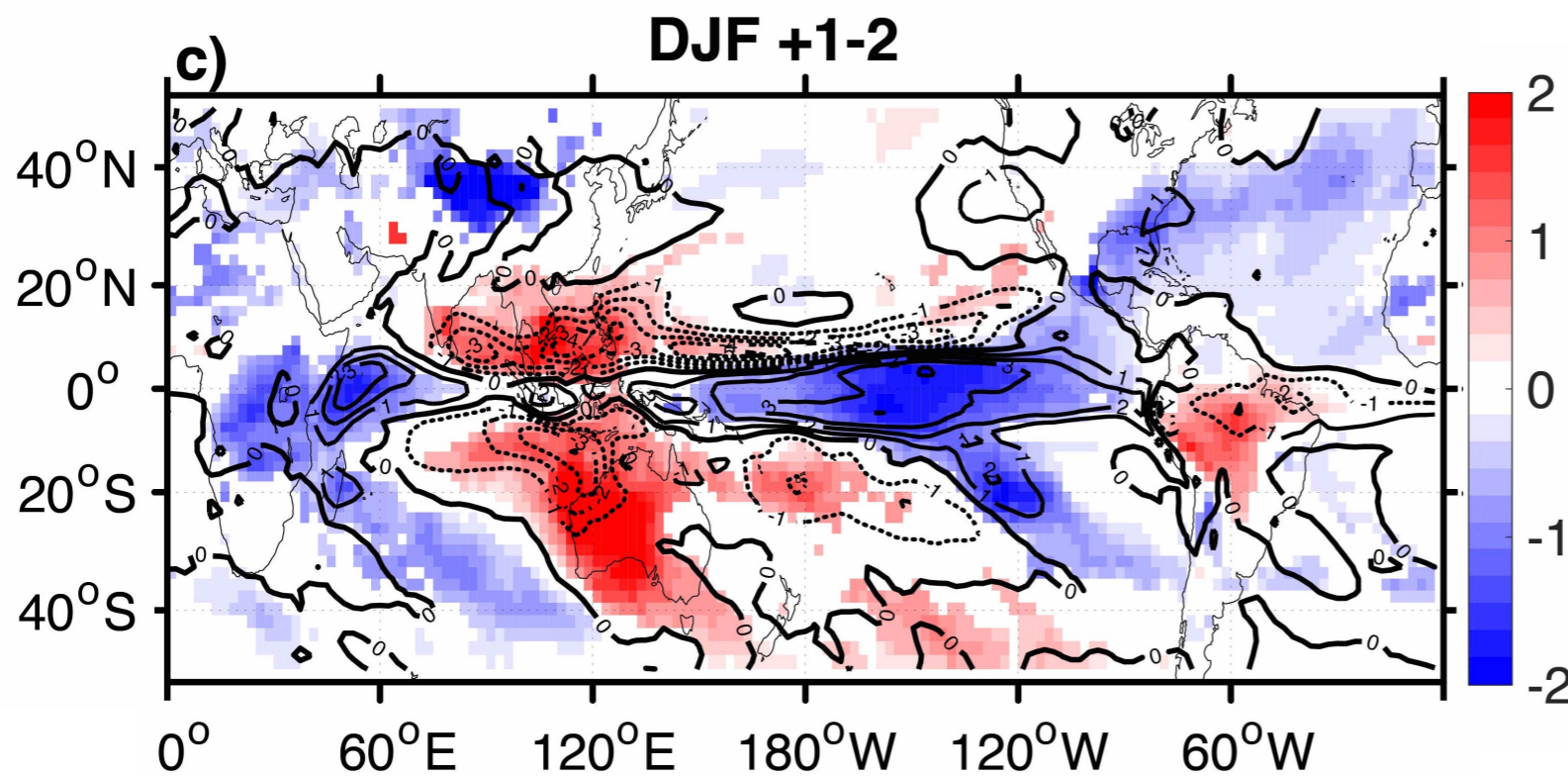
- Greenhouse gas only (1)
- Volcanic aerosols only (2)
- Orbital forcing only (1)
- Solar insolation changes only (1)
- Full forcing (3)

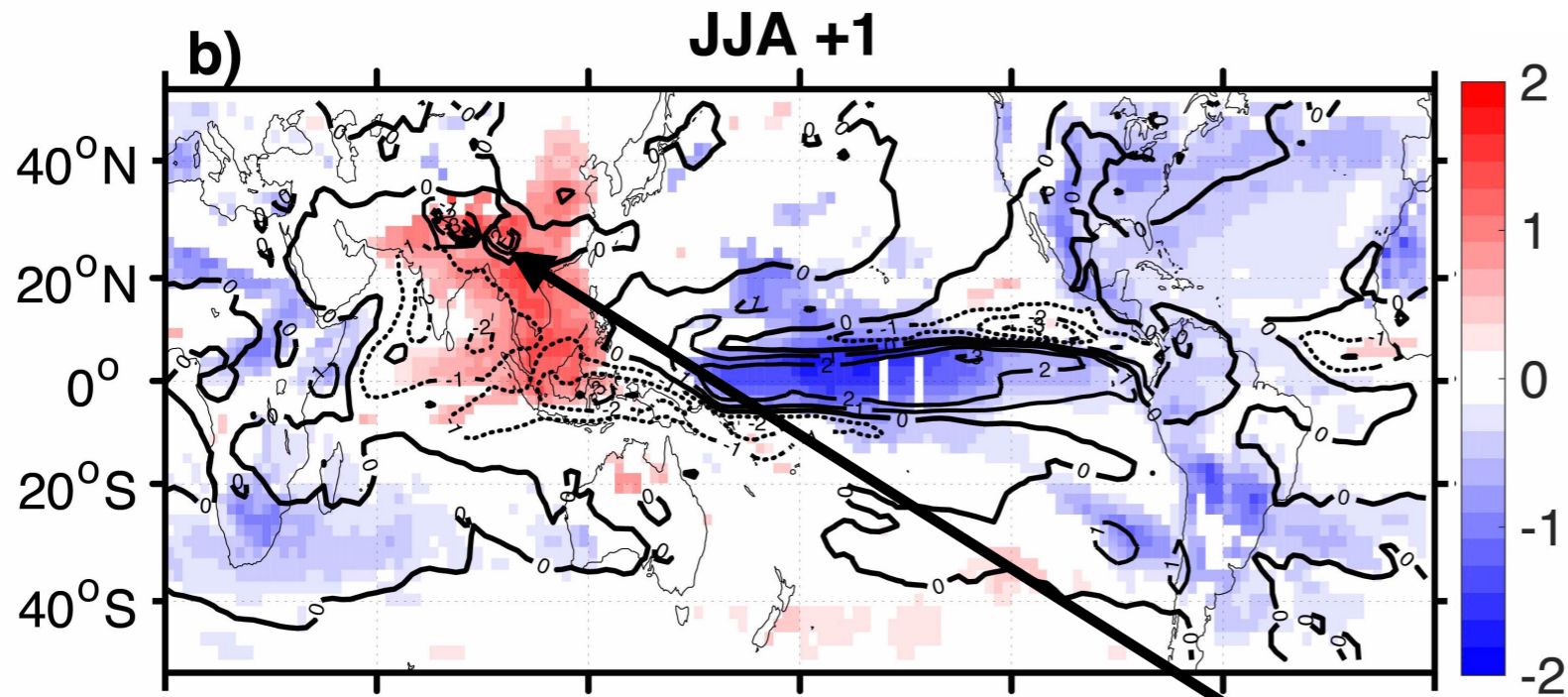
*iCESM description paper: Brady et al. (2019),  
submission to JAMES this month!*

*iLME “first results” paper: Stevenson et al. (2019),  
submission to Paleoceanography & Paleoclimatology  
this month!*

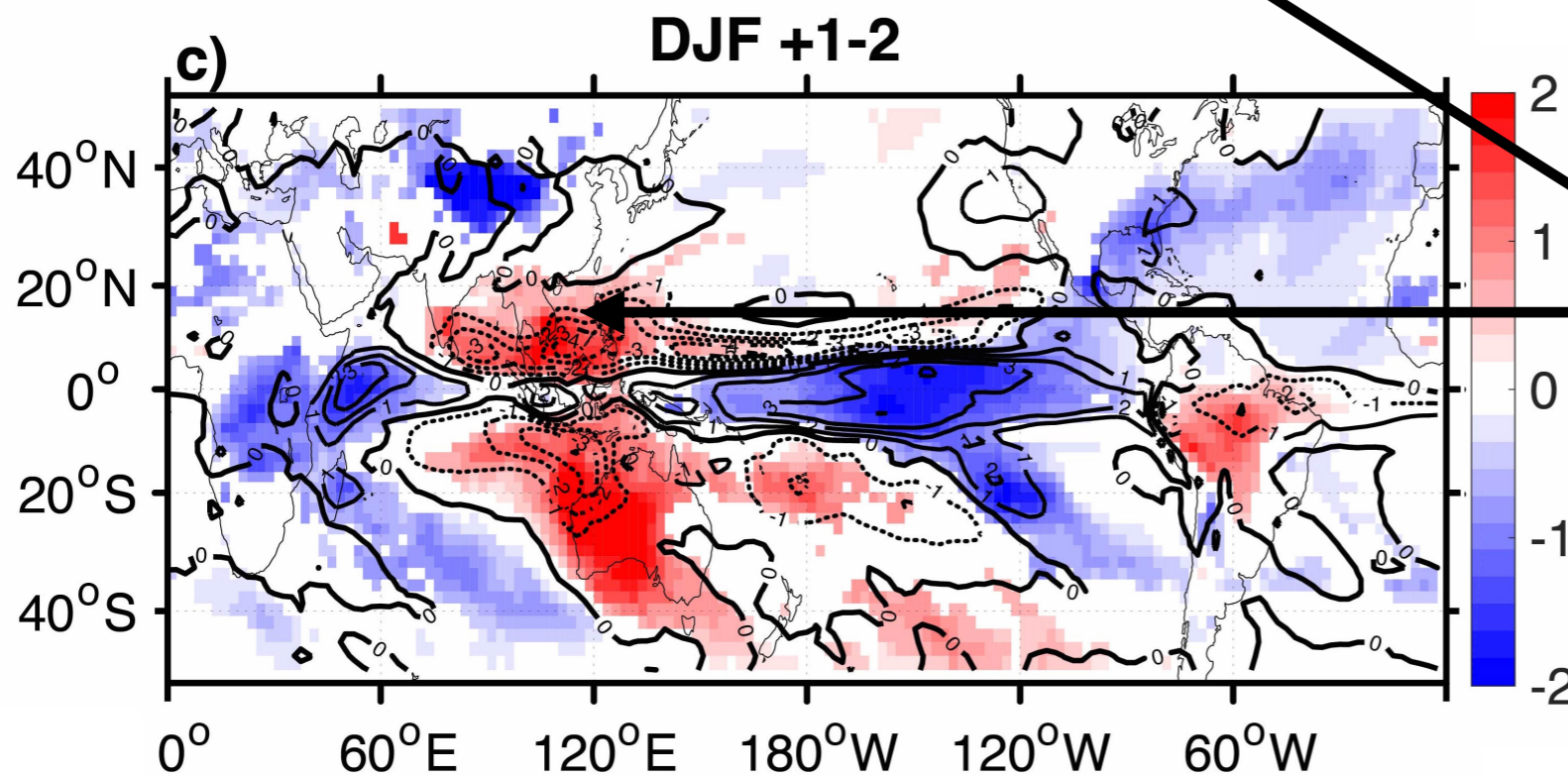


Precipitation amount  
(contours) and  
precipitation  $\delta^{18}\text{O}$   
(colors) anomalies  
following tropical  
eruptions

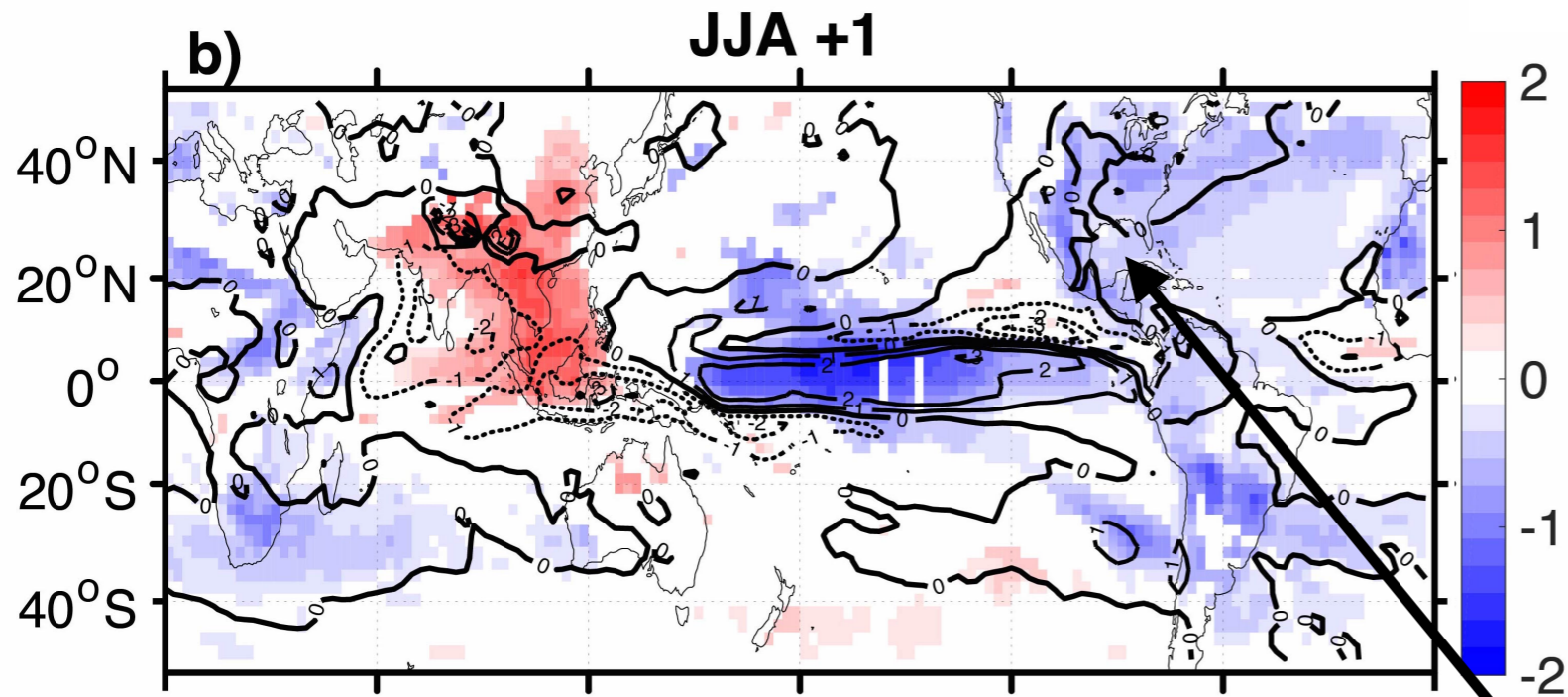




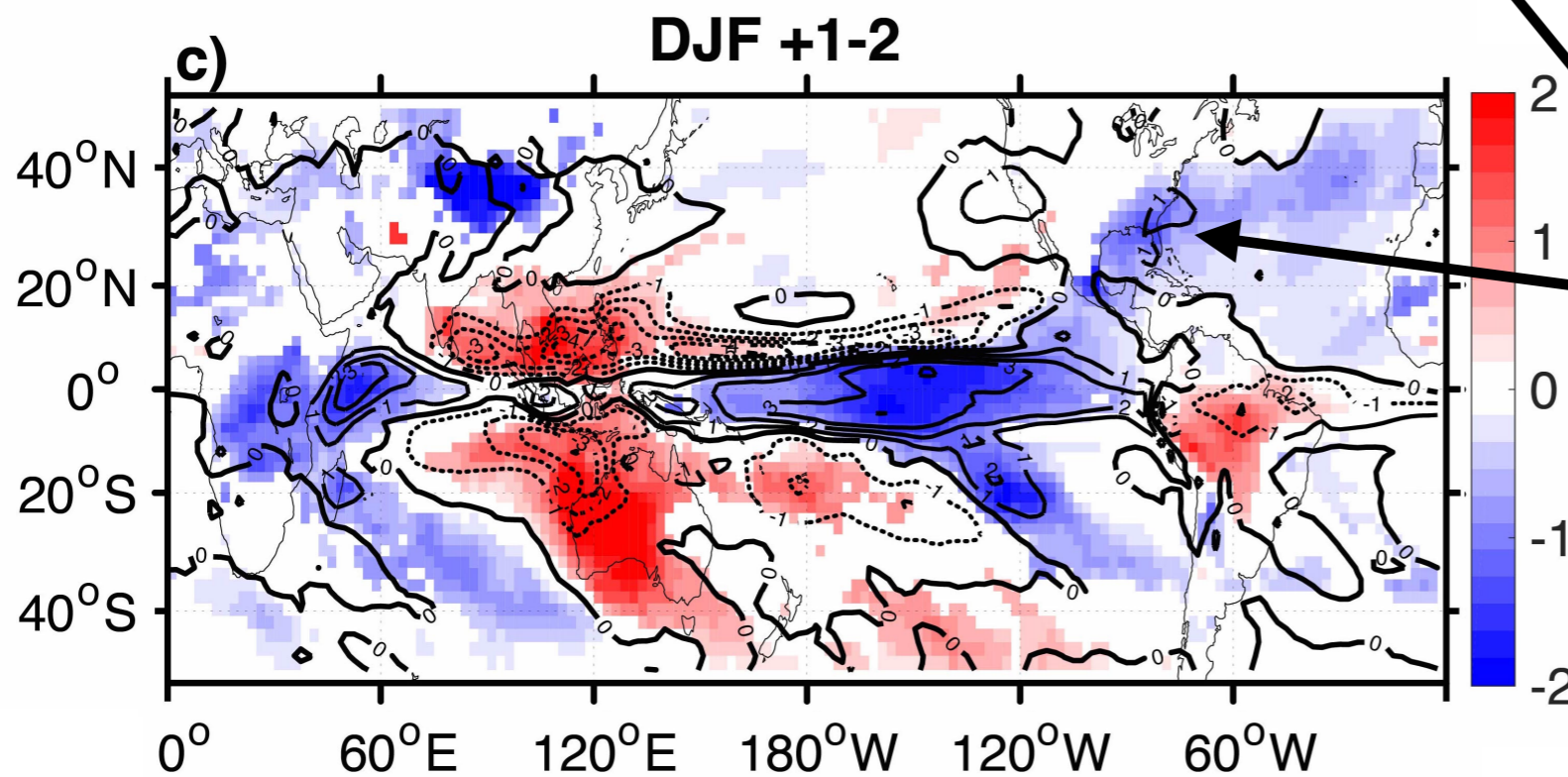
Precipitation amount  
(contours) and  
precipitation  $\delta^{18}\text{O}$   
(colors) anomalies  
following tropical  
eruptions



*Enriched signature in Asian  
monsoon region;  
not entirely coincident with  
precipitation response*



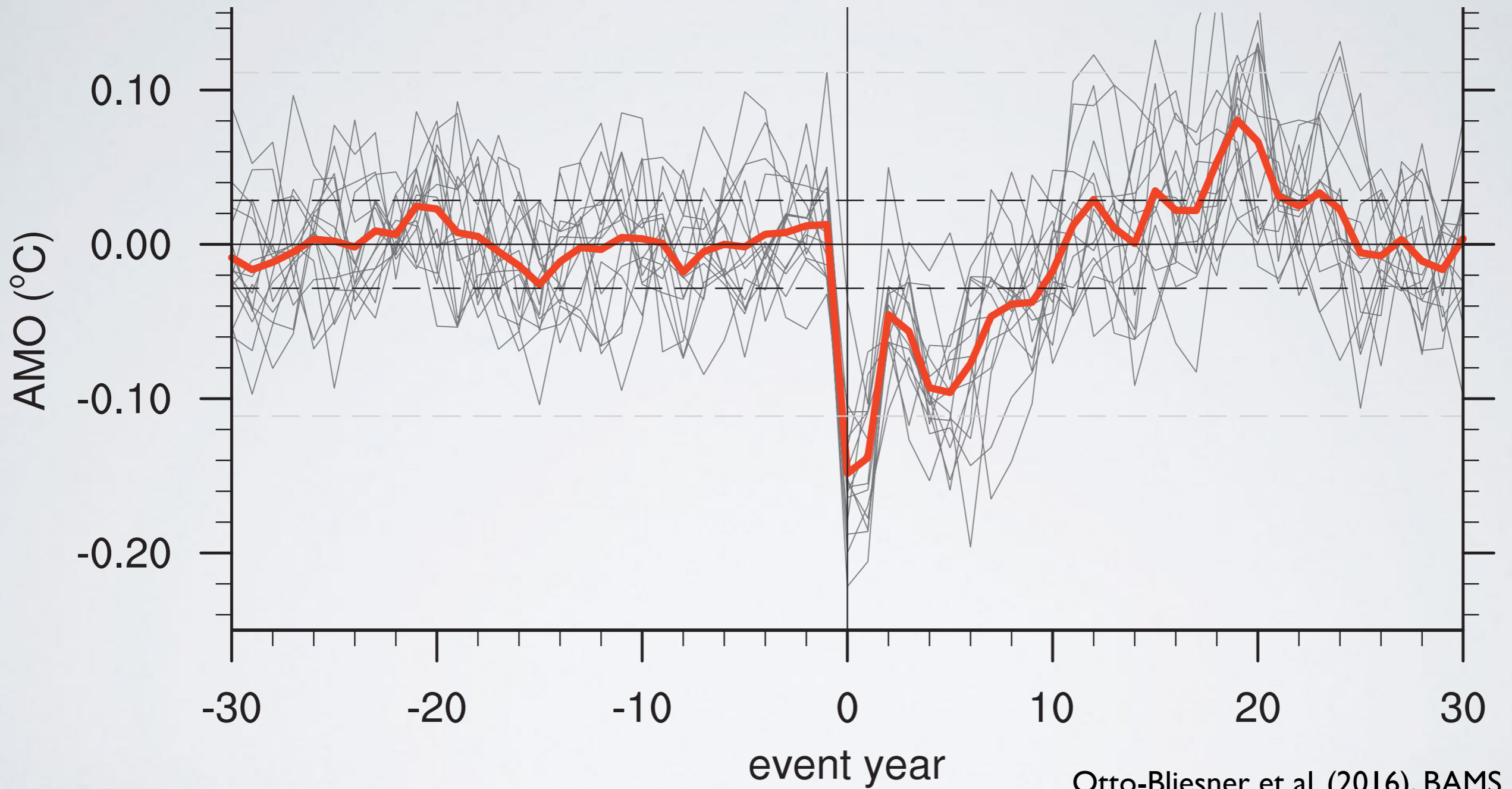
Precipitation amount  
(contours) and  
precipitation  $\delta^{18}\text{O}$   
(colors) anomalies  
following tropical  
eruptions



*Strong depletion over  
Atlantic basin, eastern  
North America; not driven  
by precipitation amount*



# Atmospheric responses: likely AMO-related

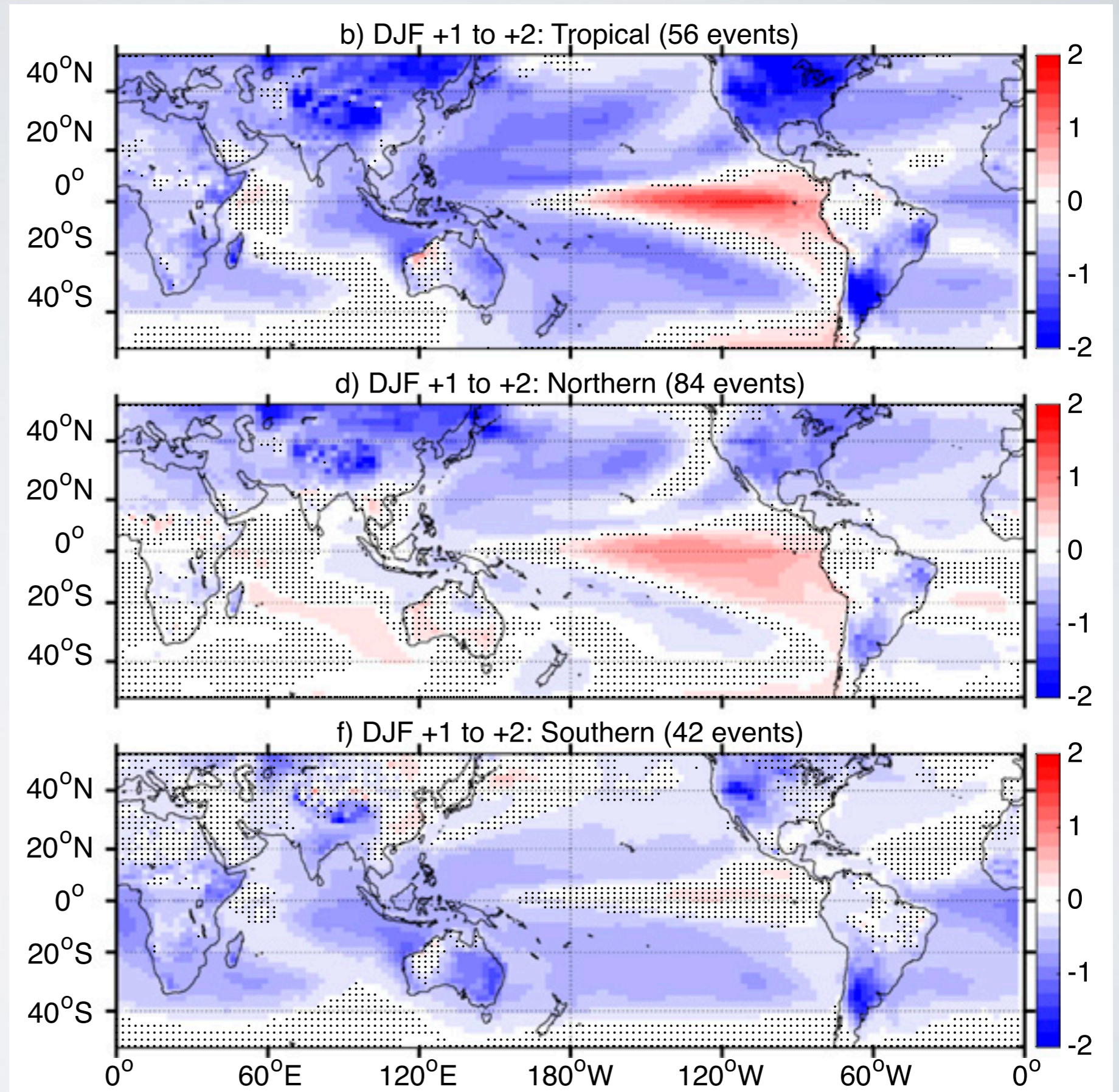


Otto-Bliesner et al. (2016), BAMS

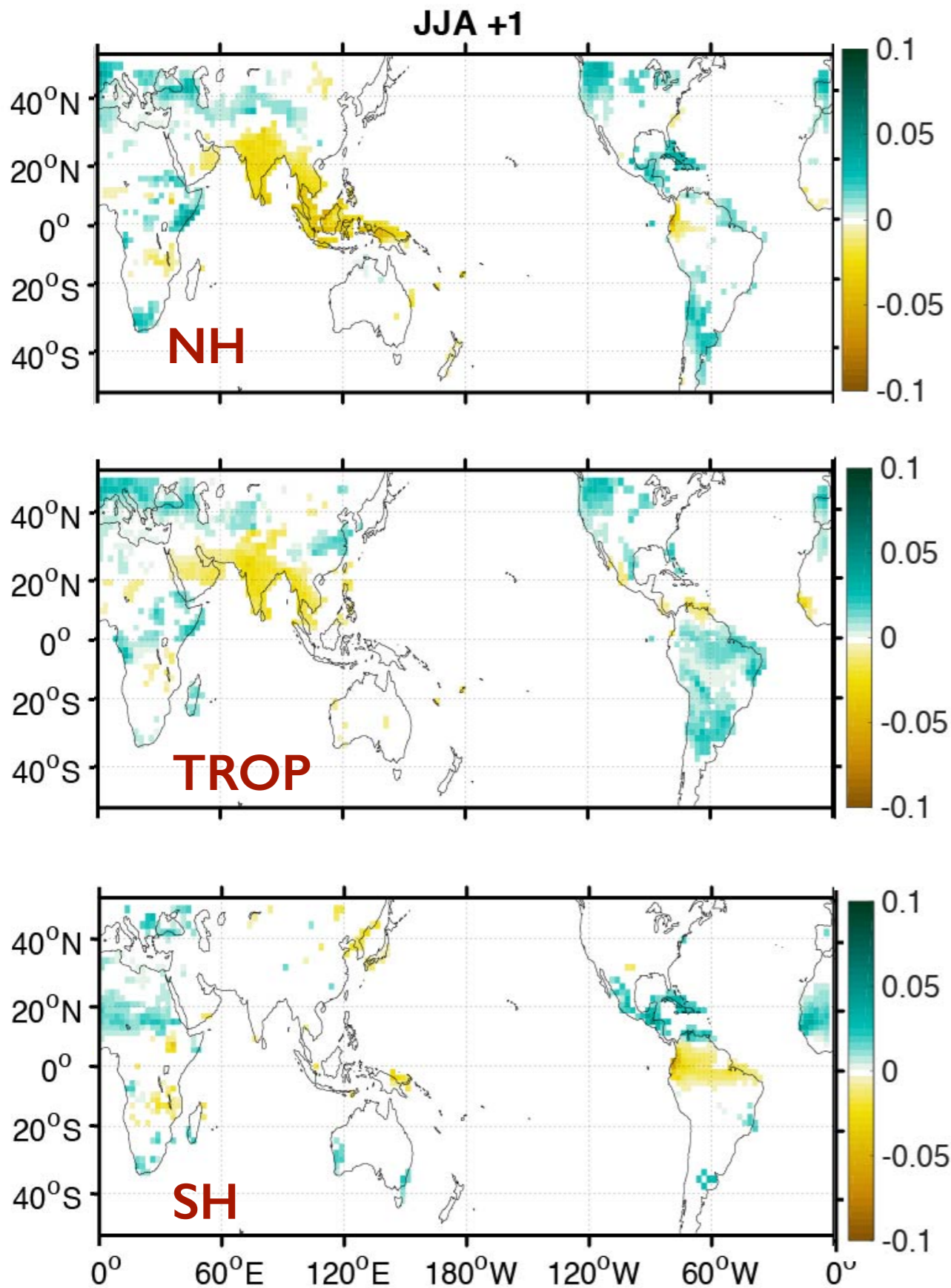
# LME: AMO, ENSO responses latitudinally dependent

Surface air temperature anomalies, full (non-isotope-enabled) LME

Stippling = insignificant



# Soil moisture



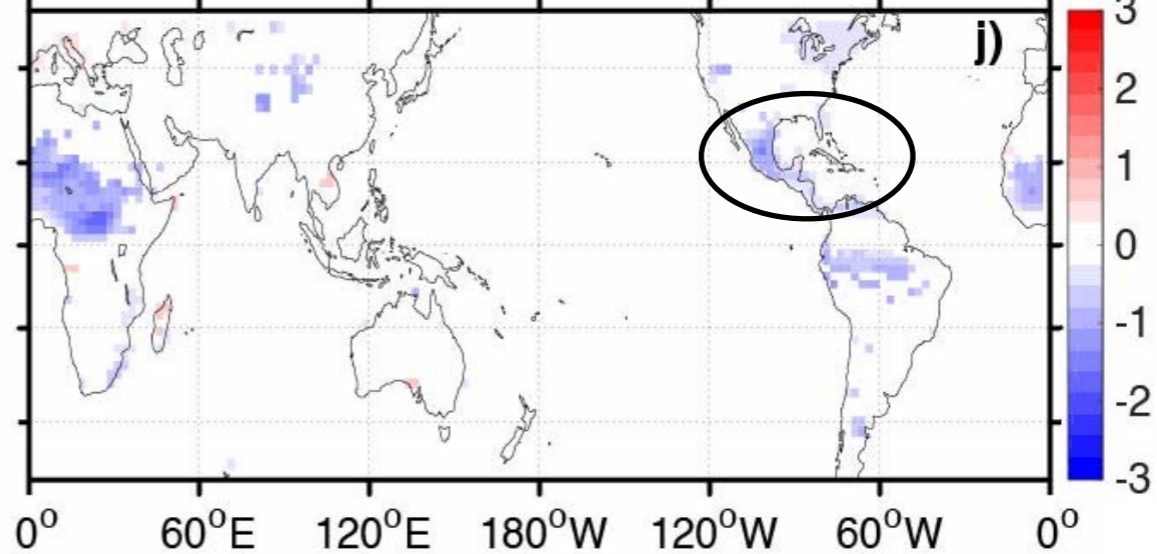
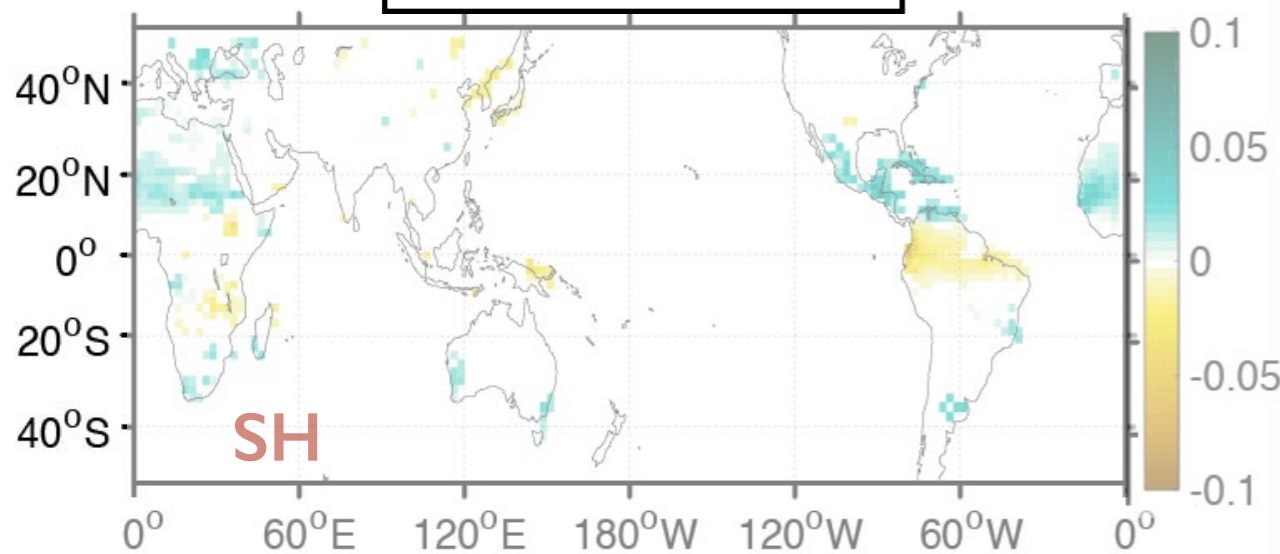
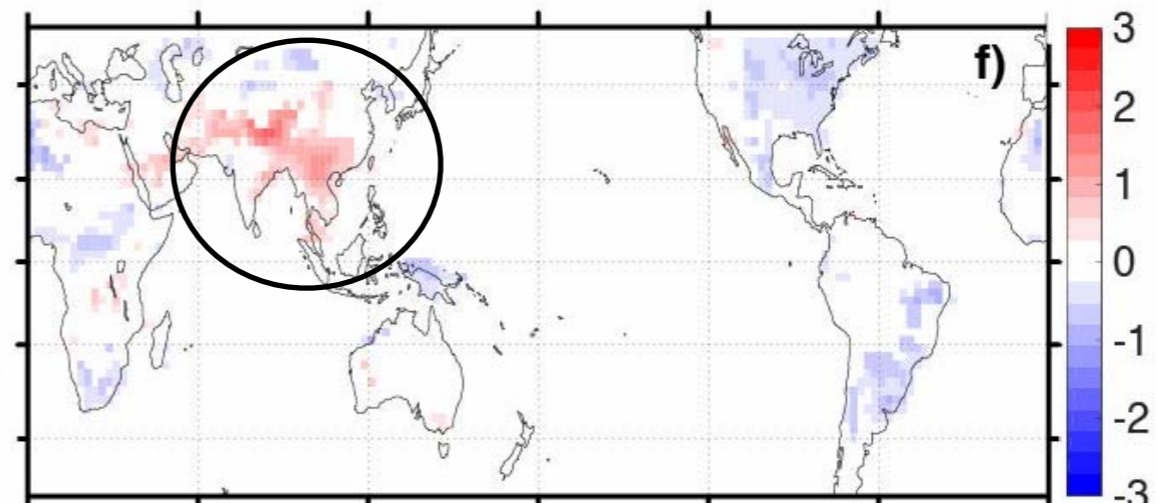
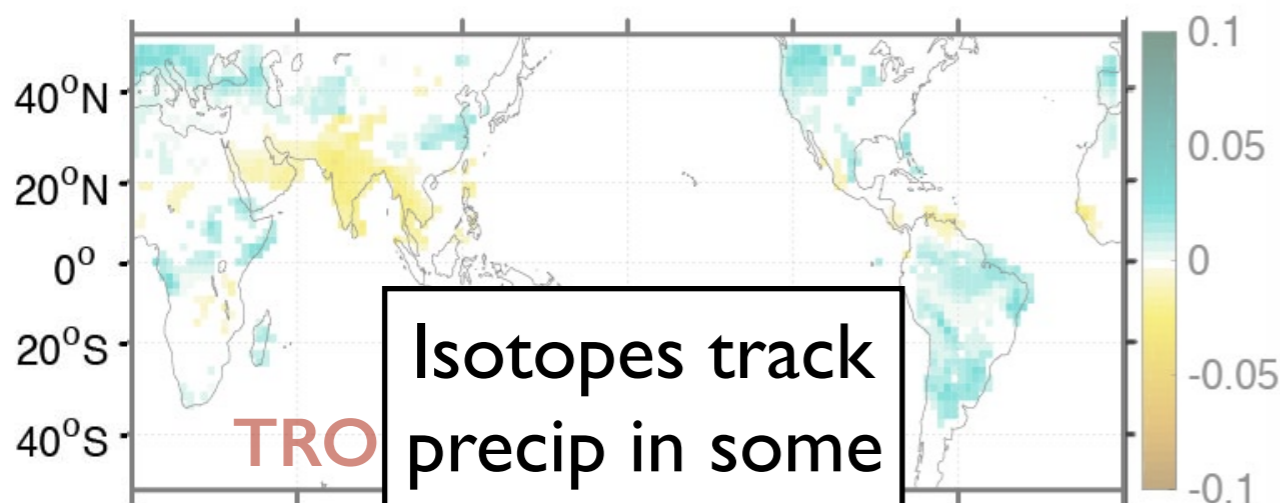
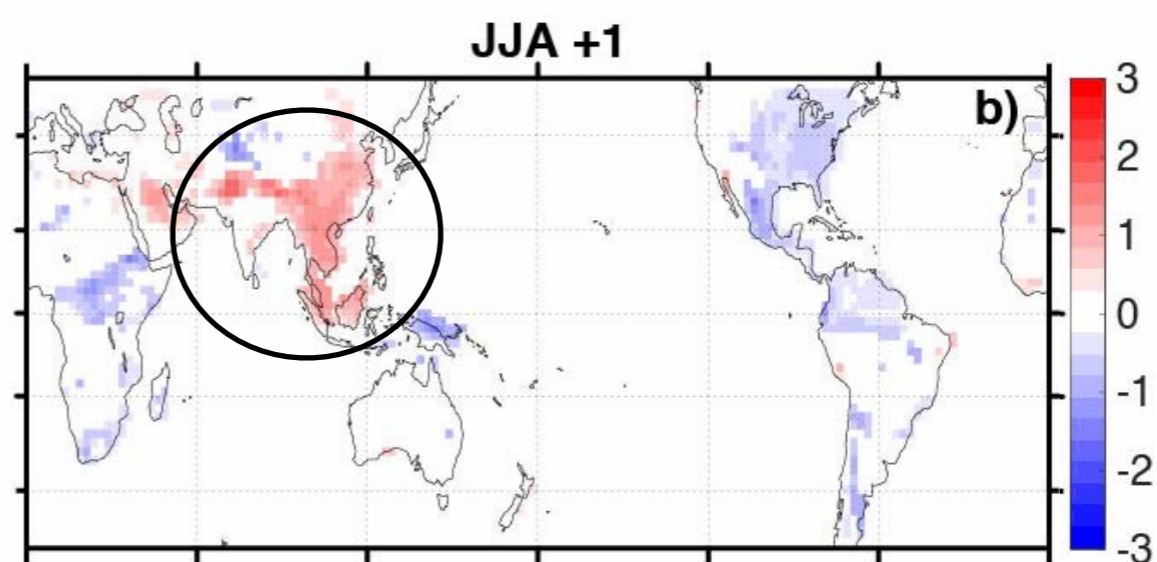
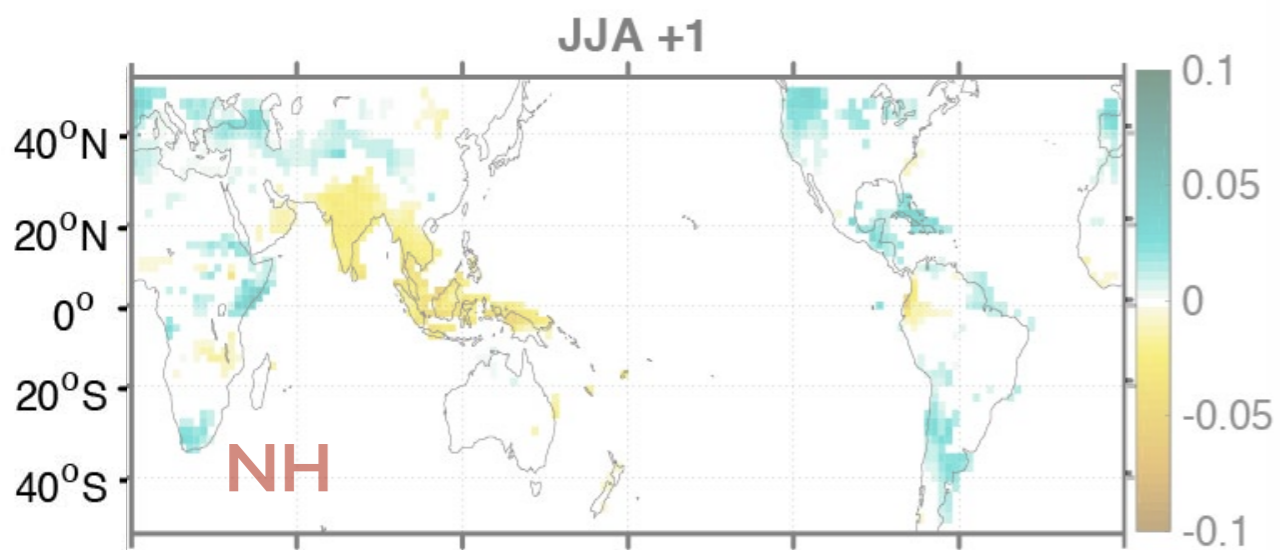
0-30cm soil moisture anomalies,  
JJA +1 after eruptions in different  
hemispheres

NH/TROP events:  
Monsoon suppression, western  
US wetting

SH events:  
Amazon drying, Caribbean/  
African wetting

# Soil moisture

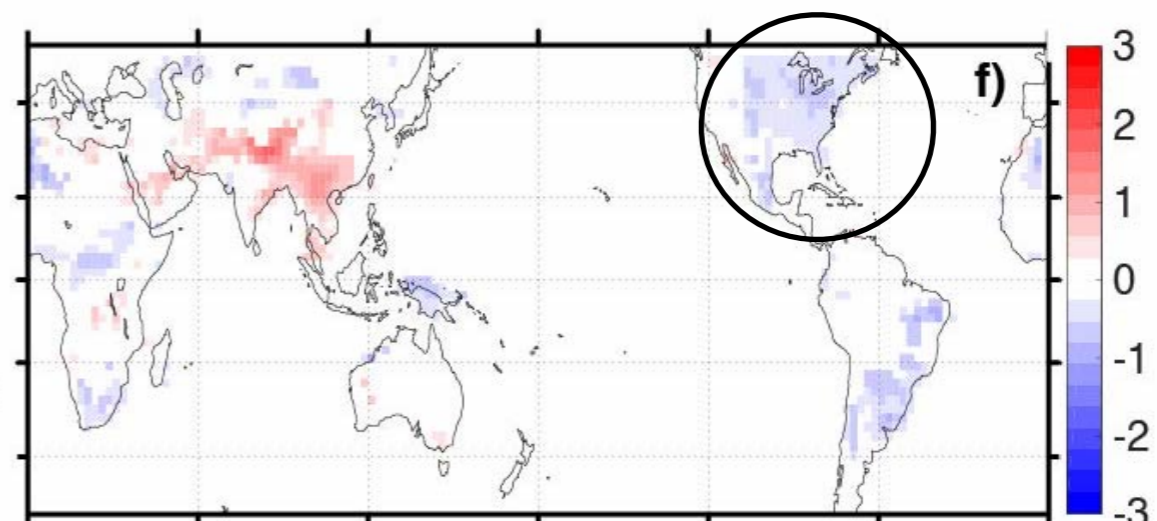
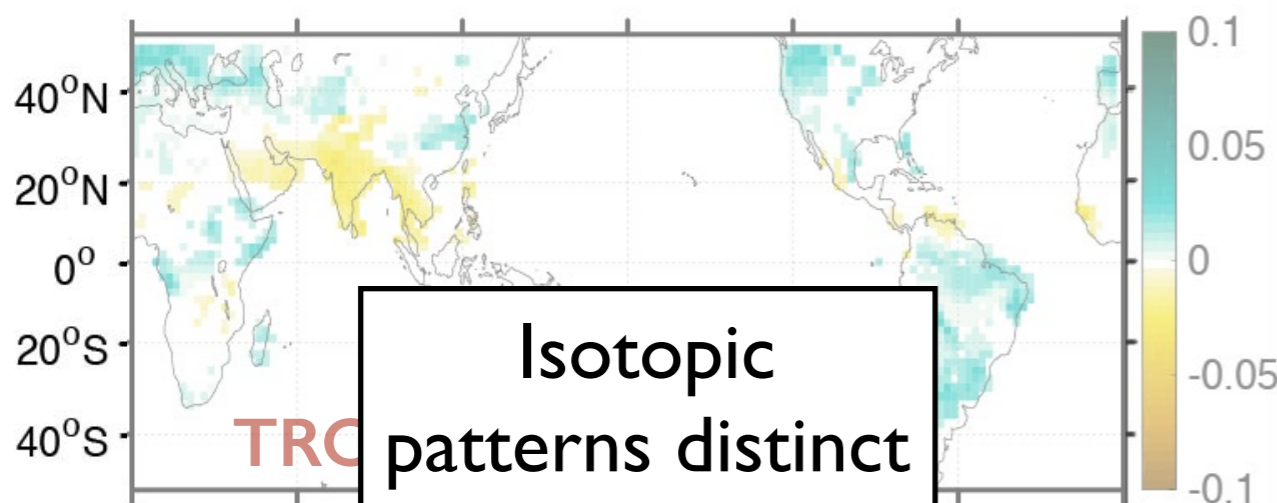
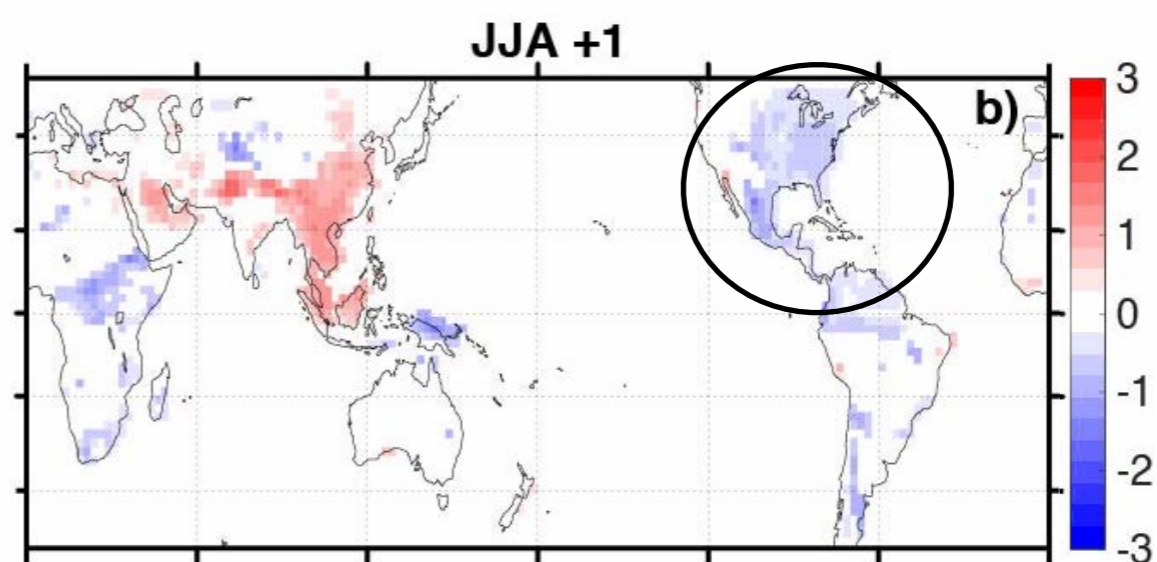
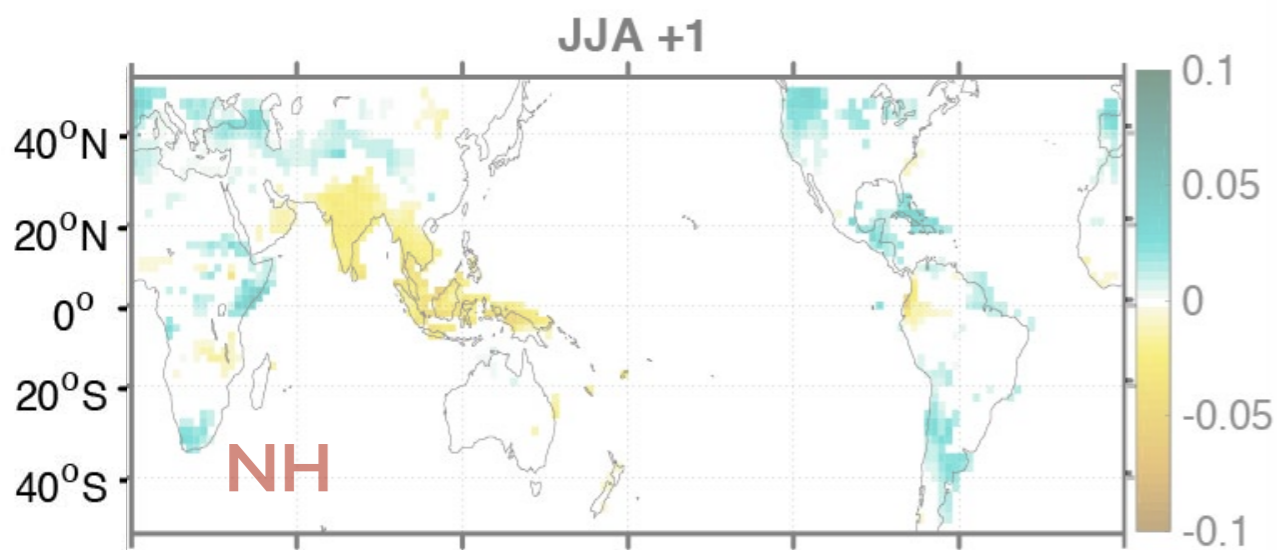
# Soil $\delta^{18}\text{O}$



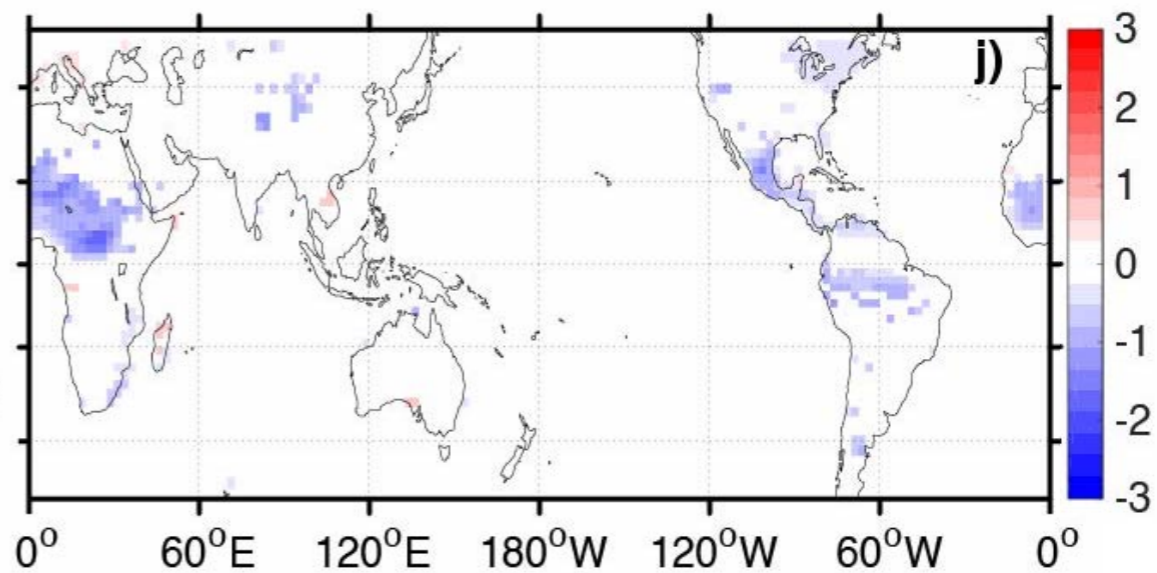
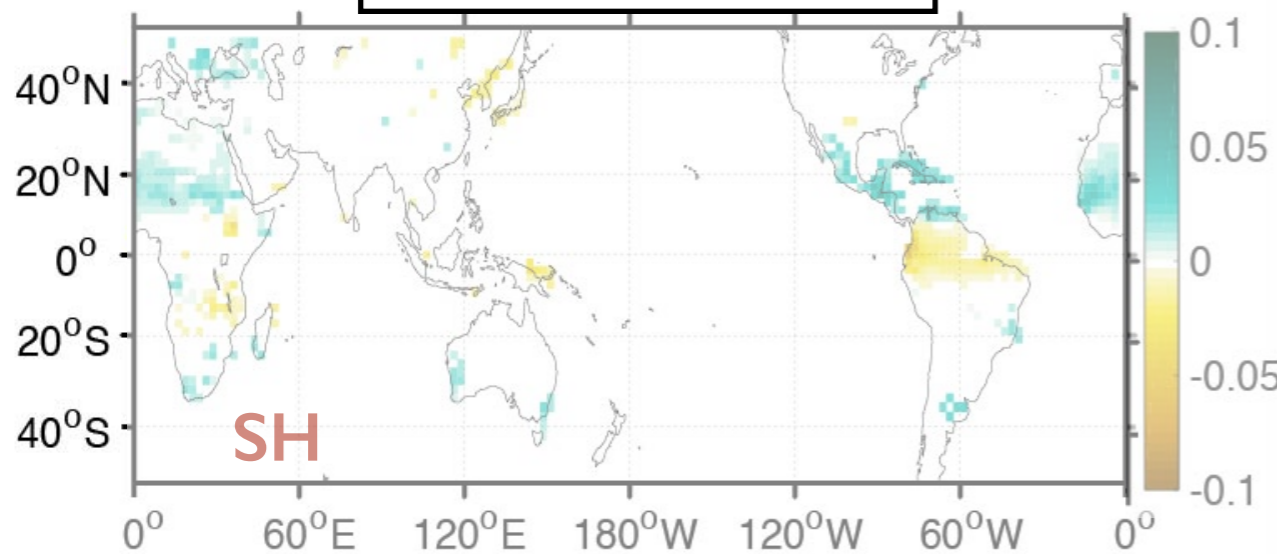
Isotopes track precip in some areas

# Soil moisture

# Soil $\delta^{18}\text{O}$

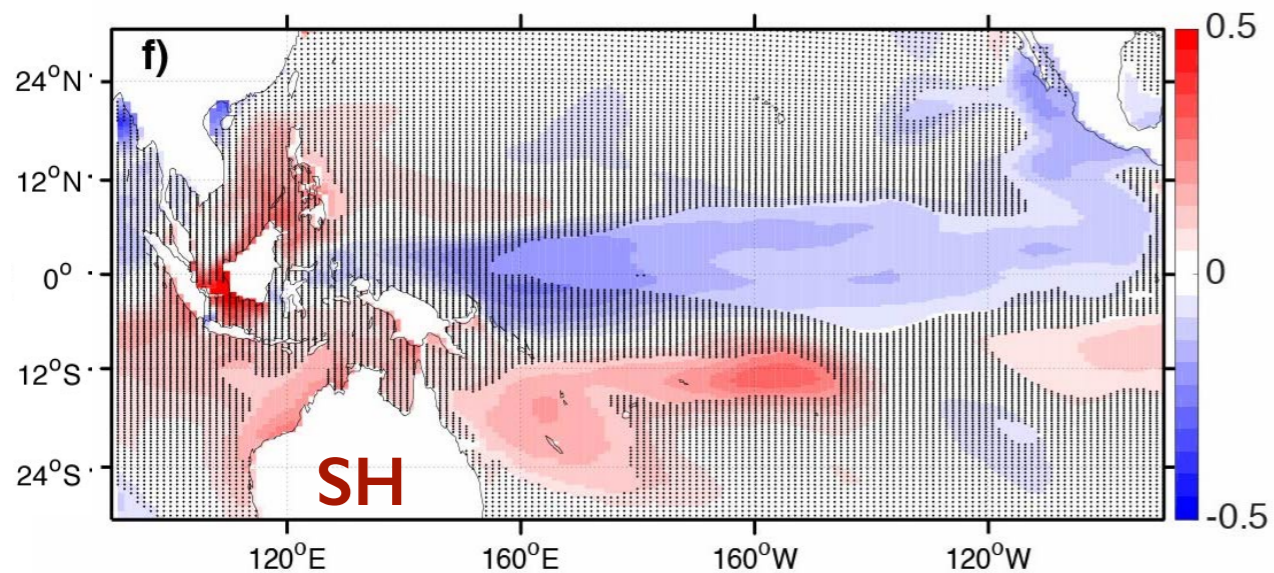
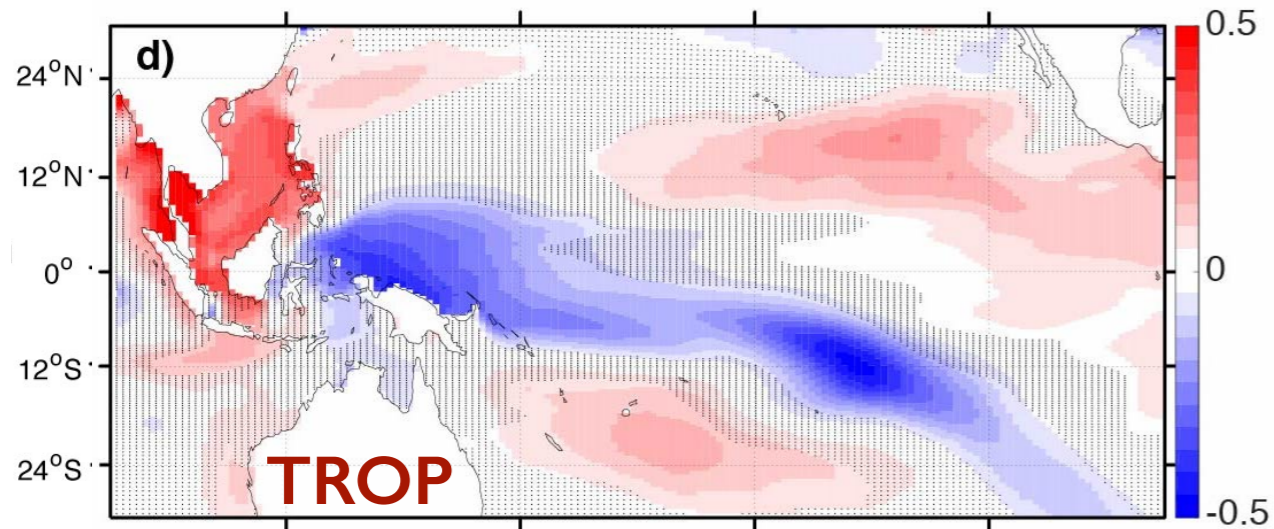
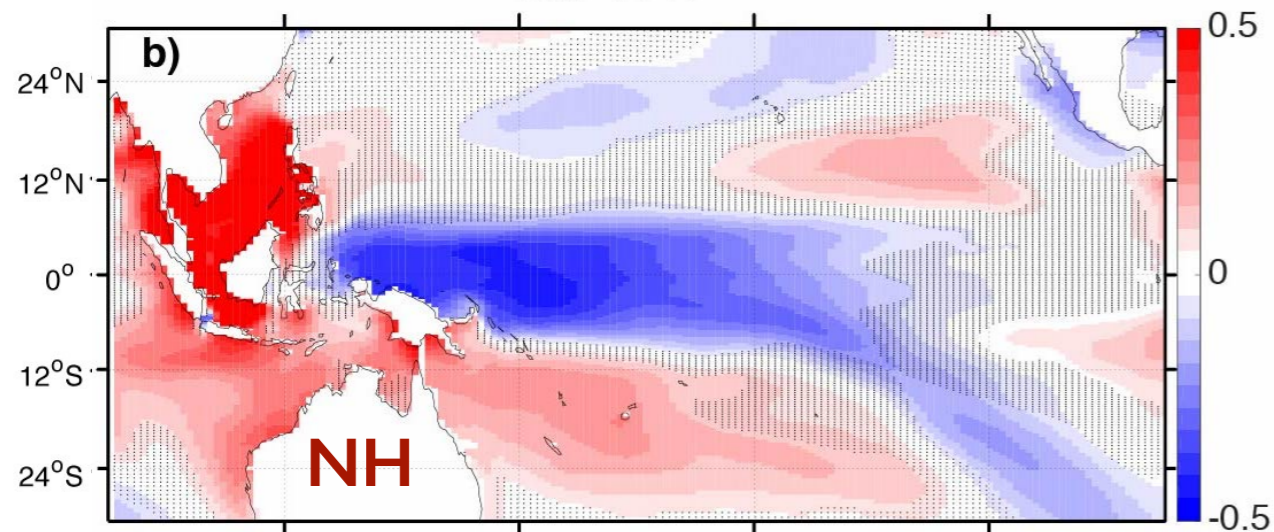


Isotopic patterns distinct in others



# Salinity

DJF +1-2



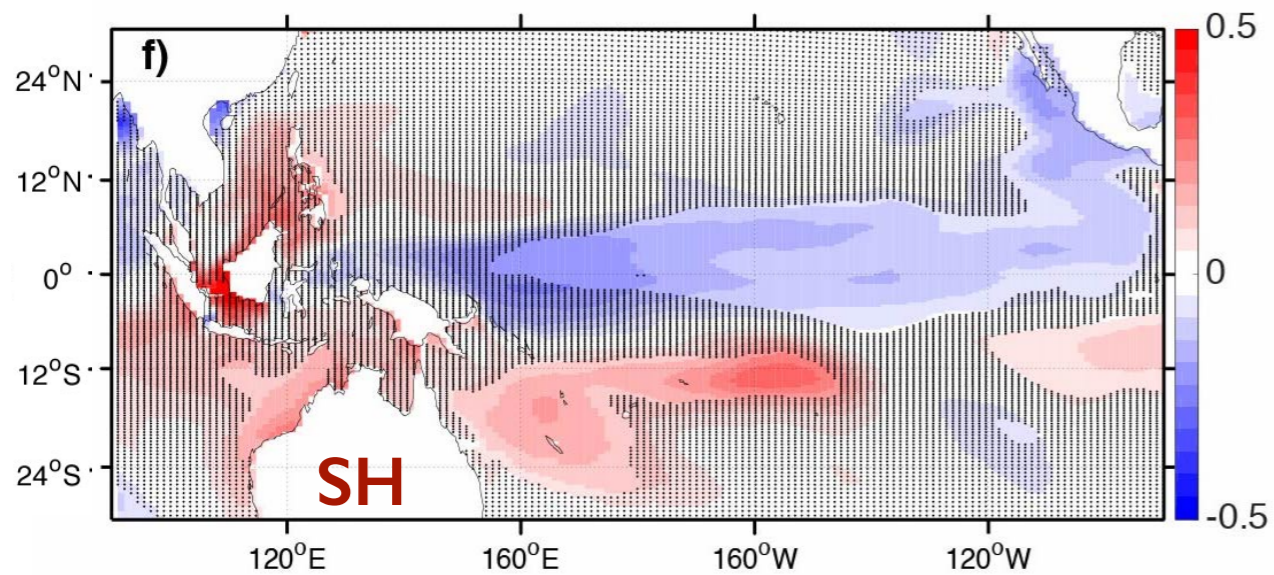
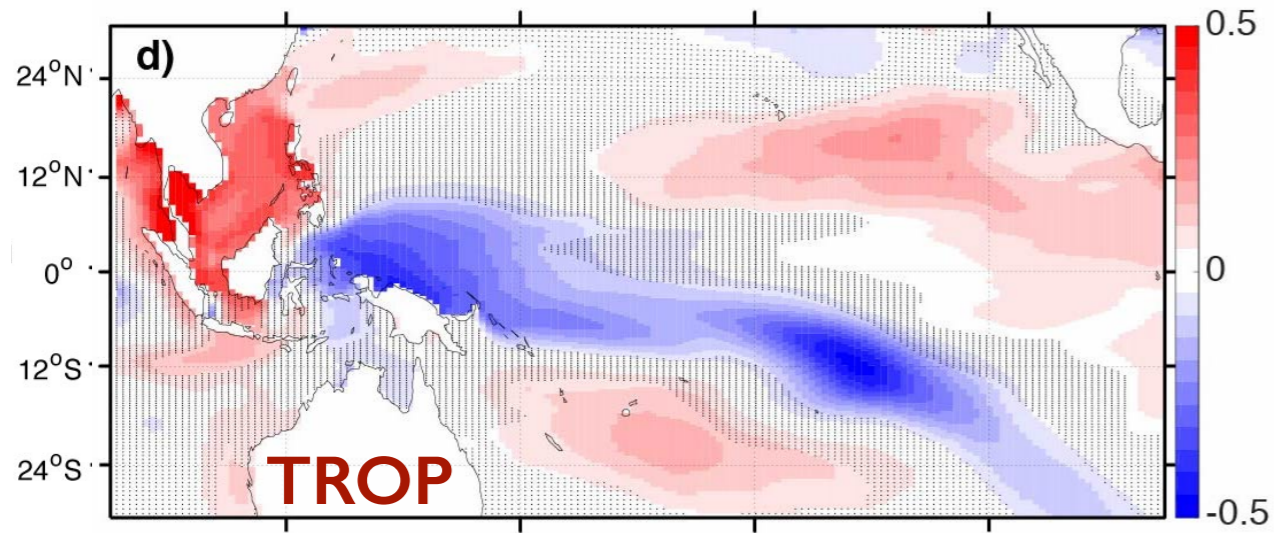
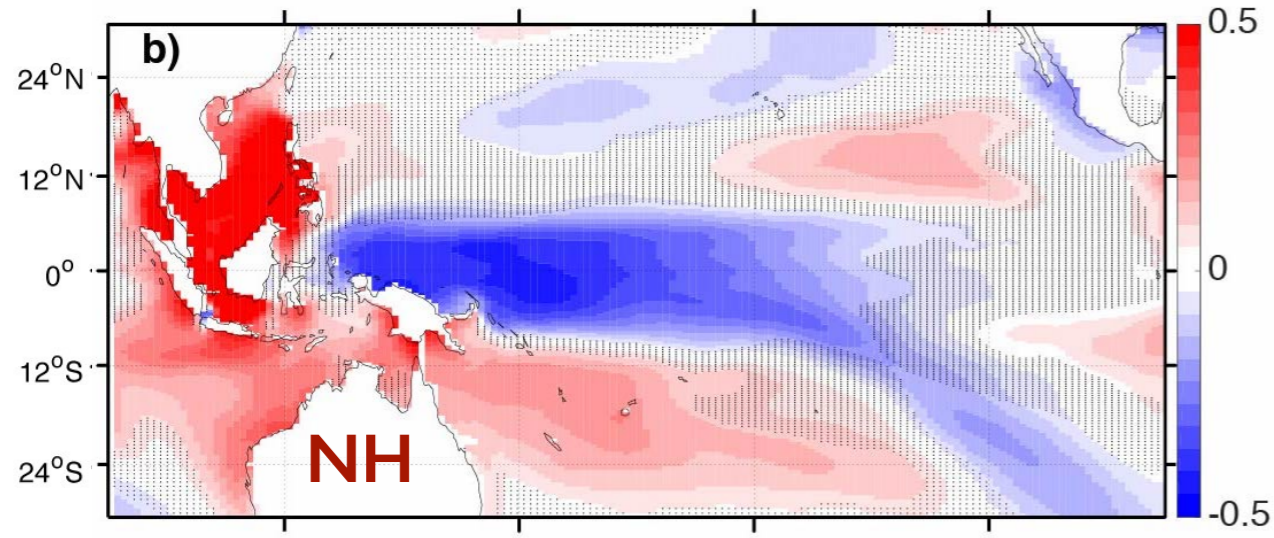
Salinity anomalies, DJF +1-2 after eruptions in different hemispheres

NH/TROP events:  
Central Pacific freshening,  
Maritime Continent saltening

SH events:  
Eastern Pacific freshening

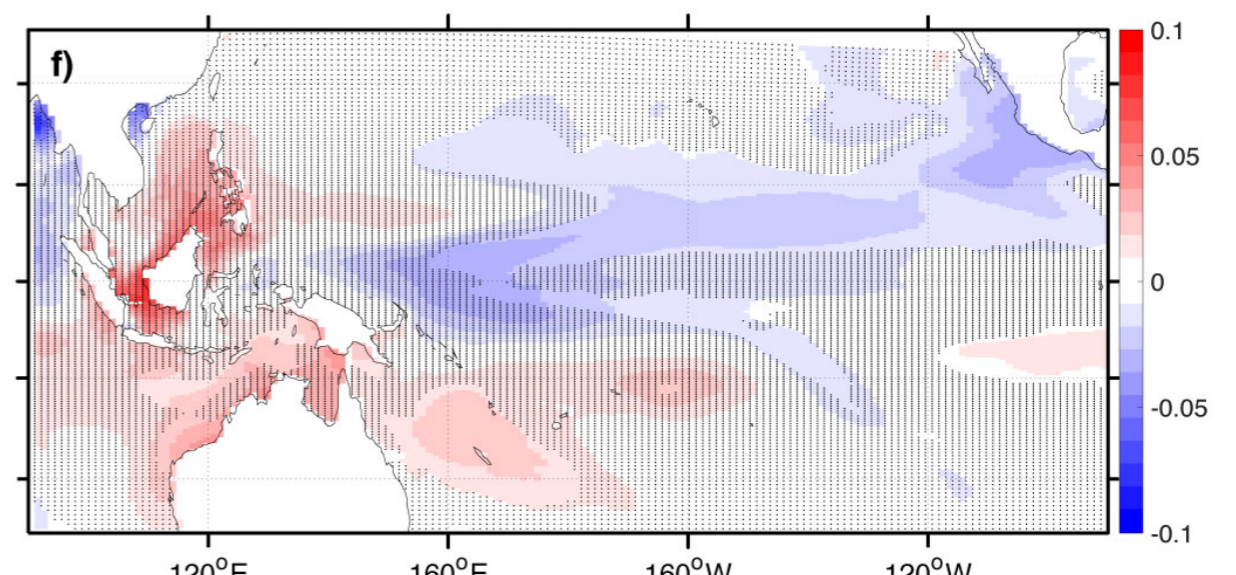
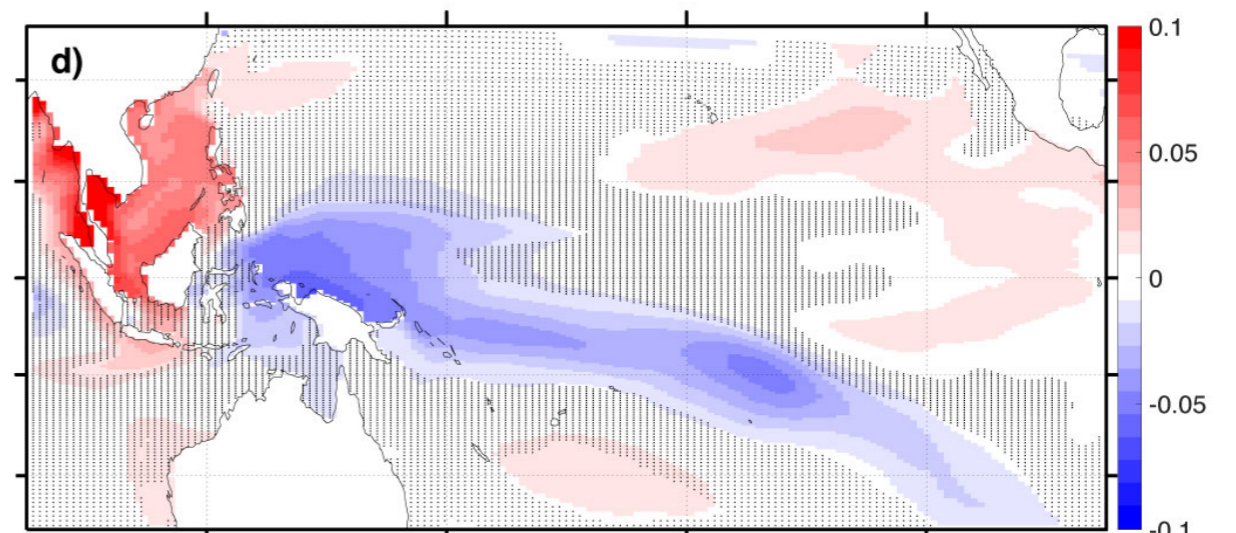
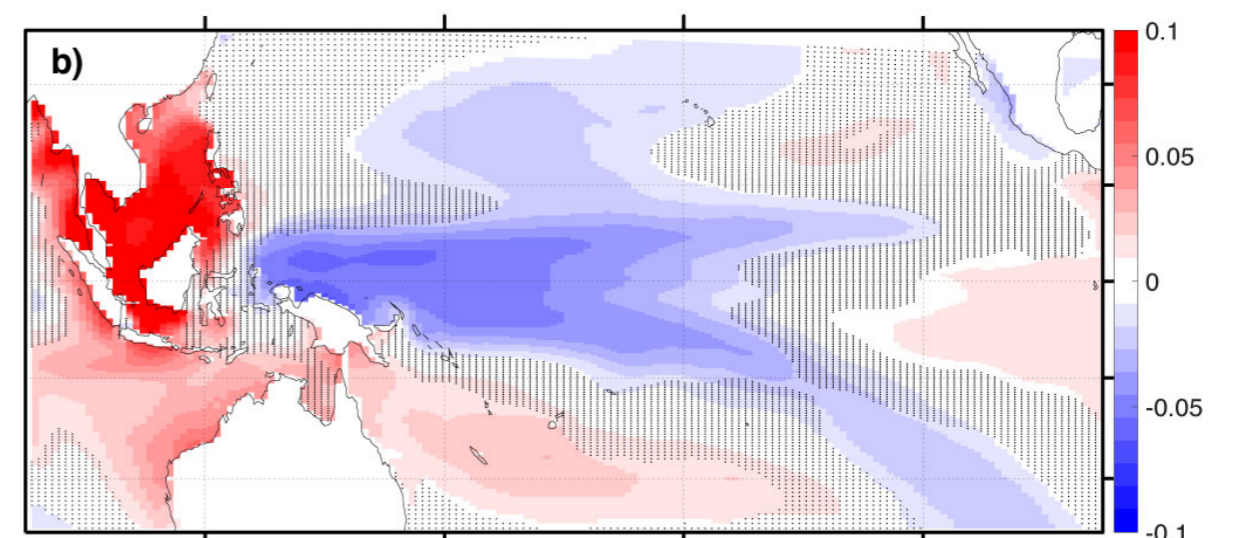
# Salinity

DJF +1-2



# Seawater $\delta^{18}\text{O}$

DJF +1-2



# Conclusions

- **Isotope-enabled LME: complete, soon to be publicly released**  
Full-forcing, single-forcing experiments included
- **Post-eruption influences on precip,  $\delta^{18}\text{O}_p$  often quite distinct: influence of AMO felt in  $\delta^{18}\text{O}_p$  throughout the Atlantic basin, eastern North America**
- **AMO responses differ depending on eruption hemisphere, as does ENSO (consistent with previous work)**
- **Isotopic anomalies in soil moisture differ hemispherically as well; anomalies sometimes quite distinct from soil moisture balance**  
**South Pacific Convergence Zone responses differ significantly between eruptions in differing hemispheres: NH eruptions have a stronger SPCZ signature**

***Possible to use isotope-enabled models to assess proxy network best suited to identify past eruption characteristics?***