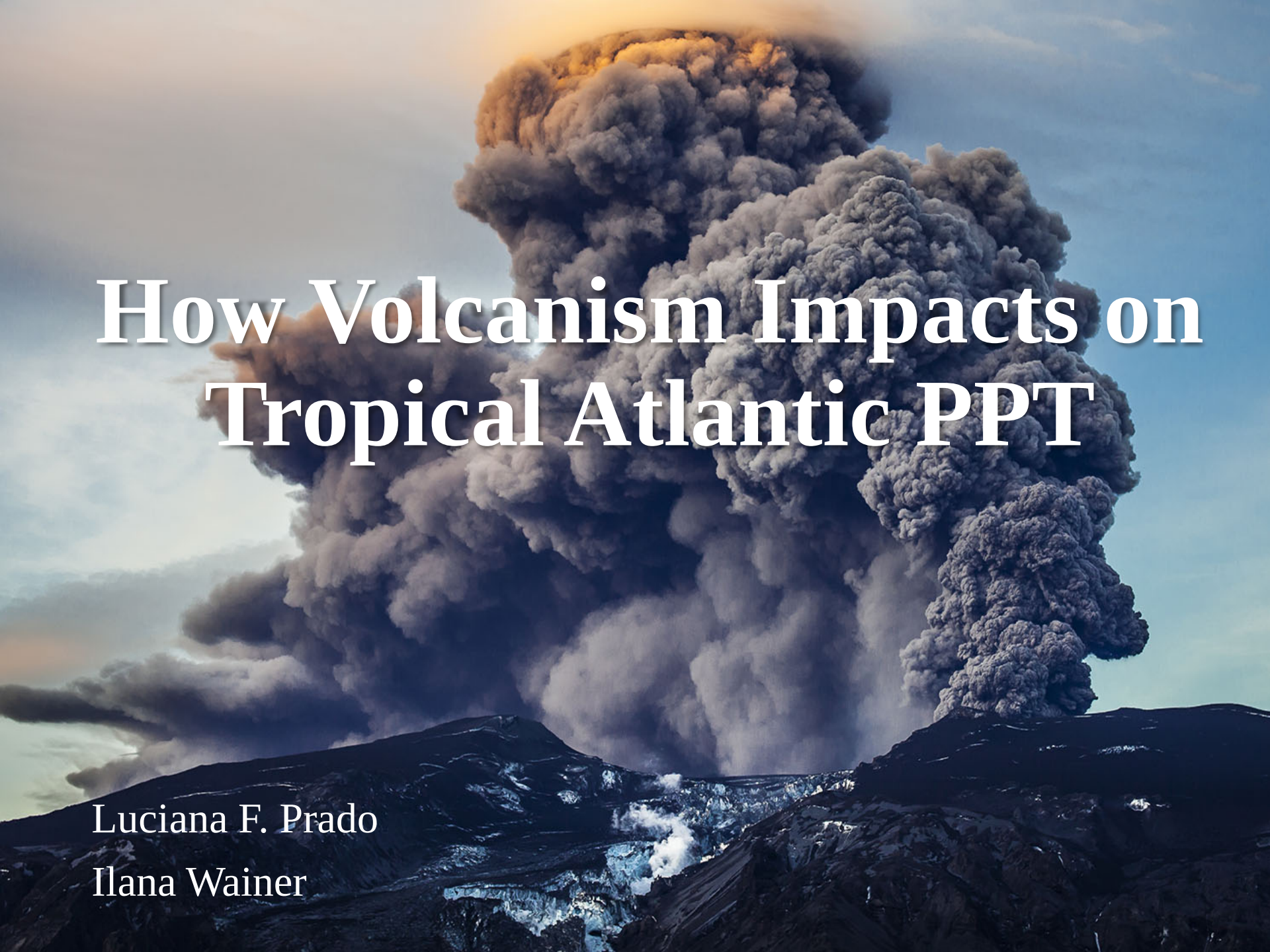


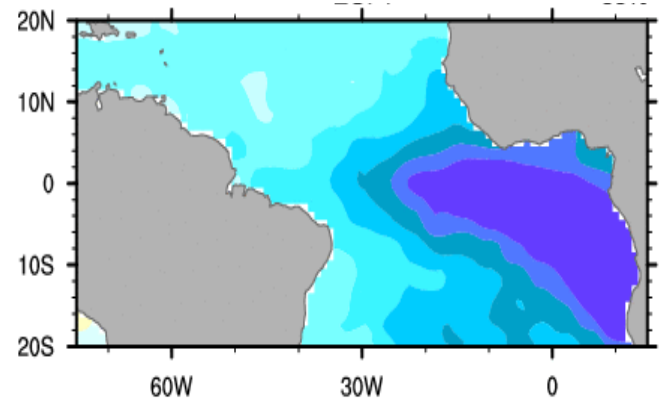
How Volcanism Impacts on Tropical Atlantic PPT

Luciana F. Prado

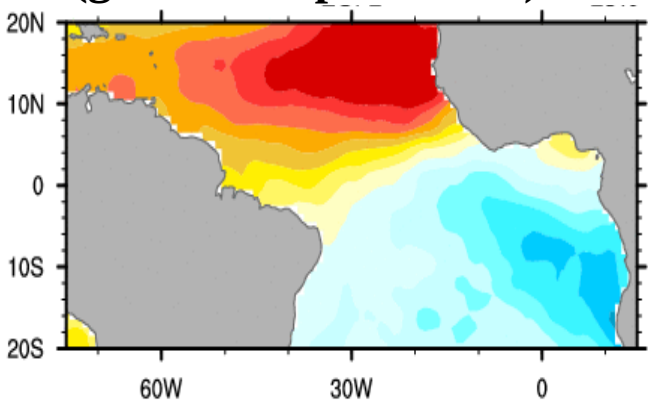
Ilana Wainer

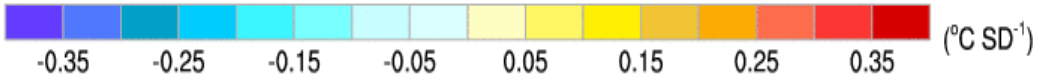
Two leading modes of Tropical Atlantic SST variability

Equatorial (zonal) Mode ~38%

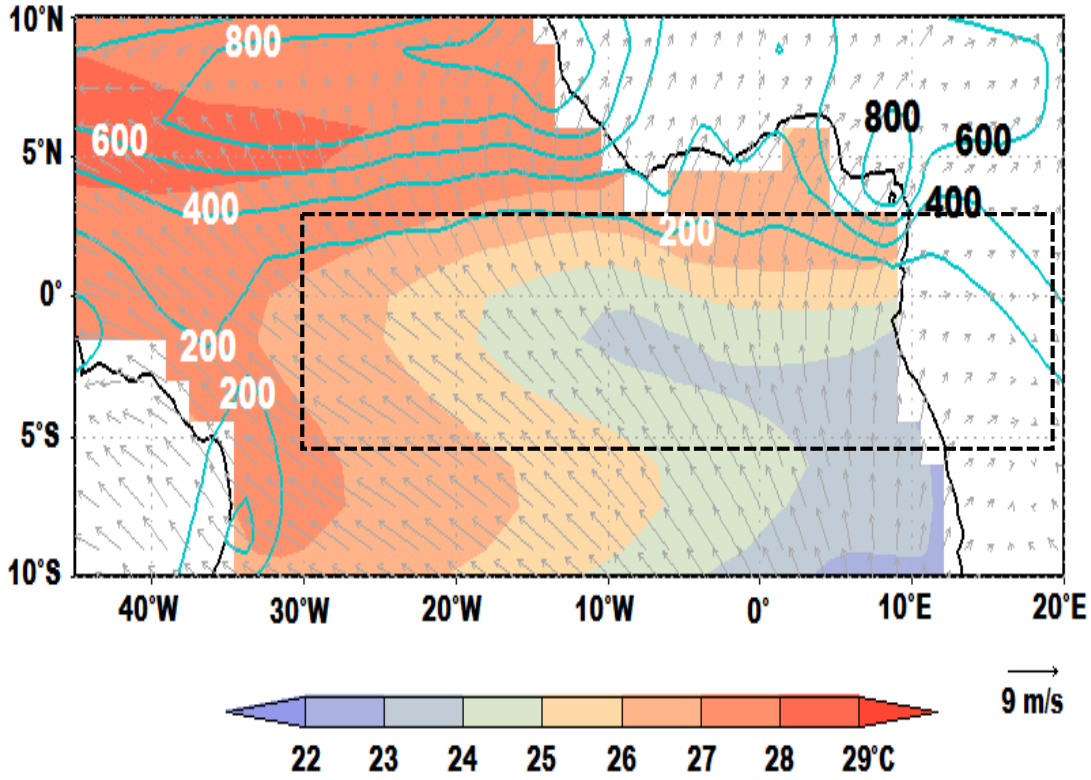


Meridional Mode ~25%
(gradient/dipole mode)





Atlantic Equatorial Mode (AEM)
Bjerknes feedback (delayed oscillator) mechanism

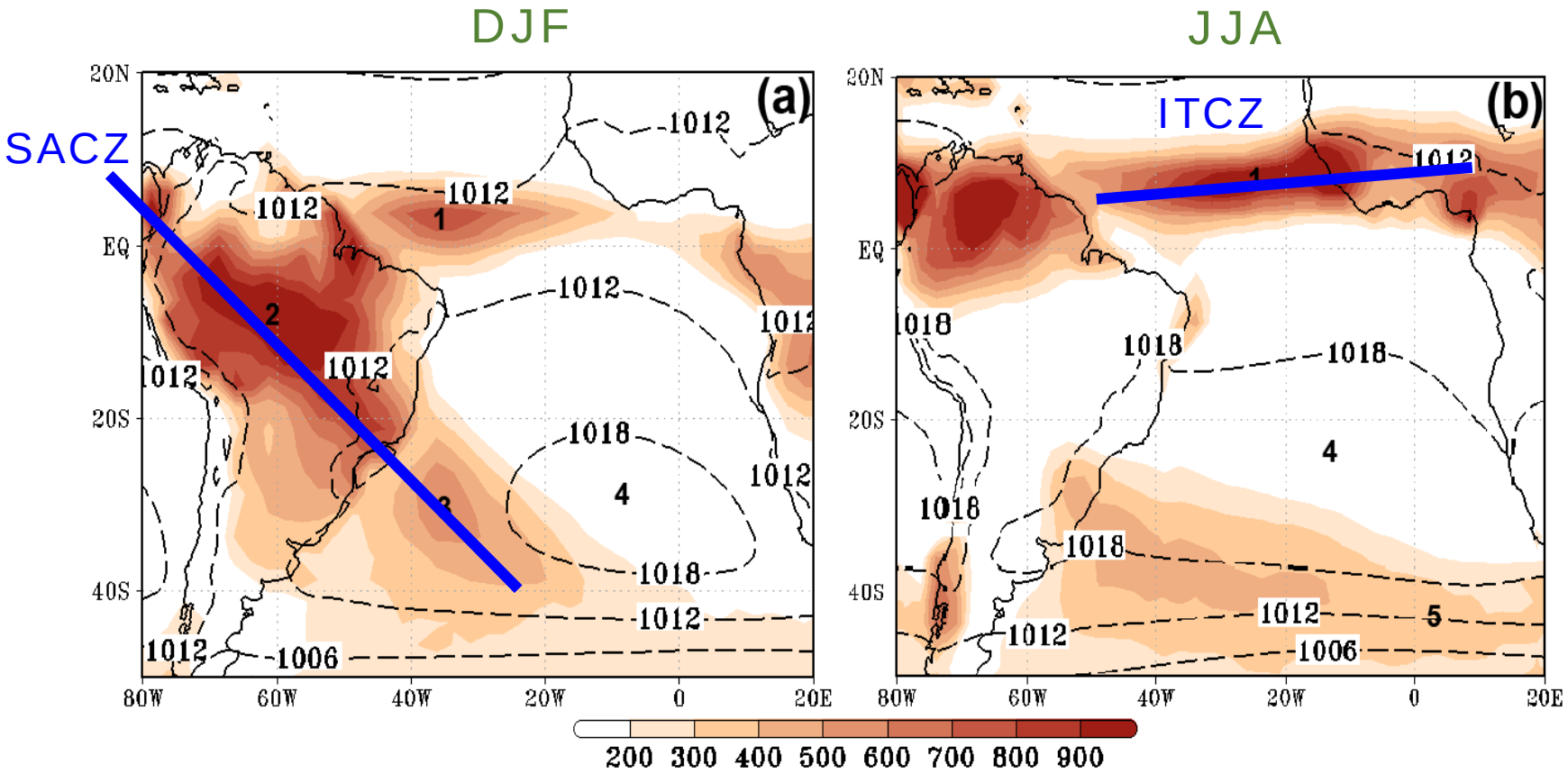


JJA climatology: SST (°C) in colors and winds (m/s) in arrows (both from Dee et al., 2011), PPT (mm/month) in green lines (Adler et al. 2003).

Interannual mode of variability: tongue-shaped spatial pattern in tropical Atlantic SST that peaks during JJA.

The AEM mechanisms is similar to ENSO [Bjerknes feedback]

South America PPT



Color: mean precipitation during season (mm3/mo); dashed lines: mean SLP (hPa). Data from Dee et al. (2011), Adler et al. (2003).

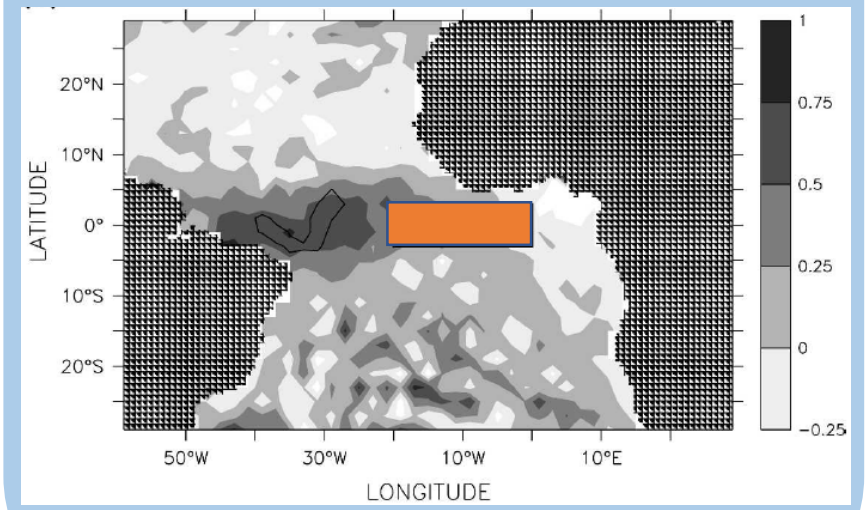
Data

- **CESM LME (*Otto-Bliesner et al., 2016 BAMS*)**
- **Monthly anomalies (850 – 1850 C.E.)**

Indices:

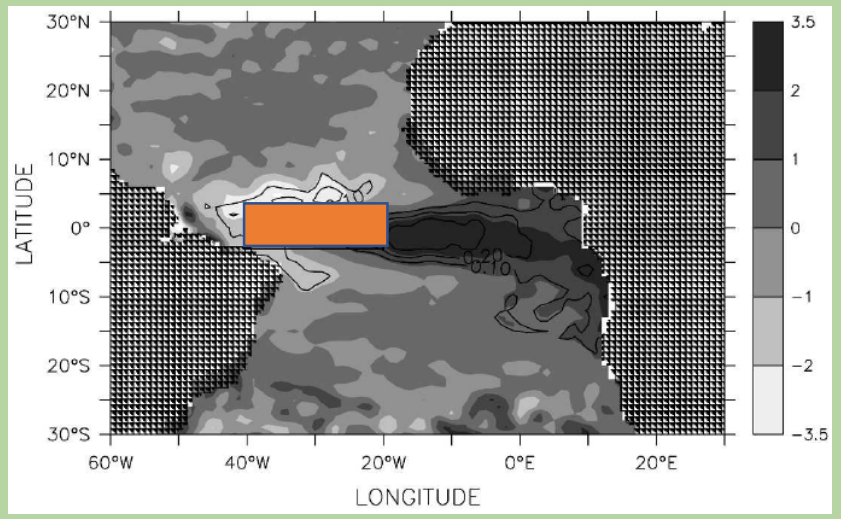
ATL3 index *(Zebiak, 1993)*

SST averaged → [3°N – 3°S/20°W – 0°]



τ_X **index** *(Keenlyside and Latif, 2007)*

τ_X averaged → [3 °N – 3 °S; 40 °W – 20 °W]



Adapted from Keenlyside and Latif (2007)

Composites:

1. Select the years according to the region of the eruption (*North*, *South*, *Tropical)* after *Stevenson et al., 2016*

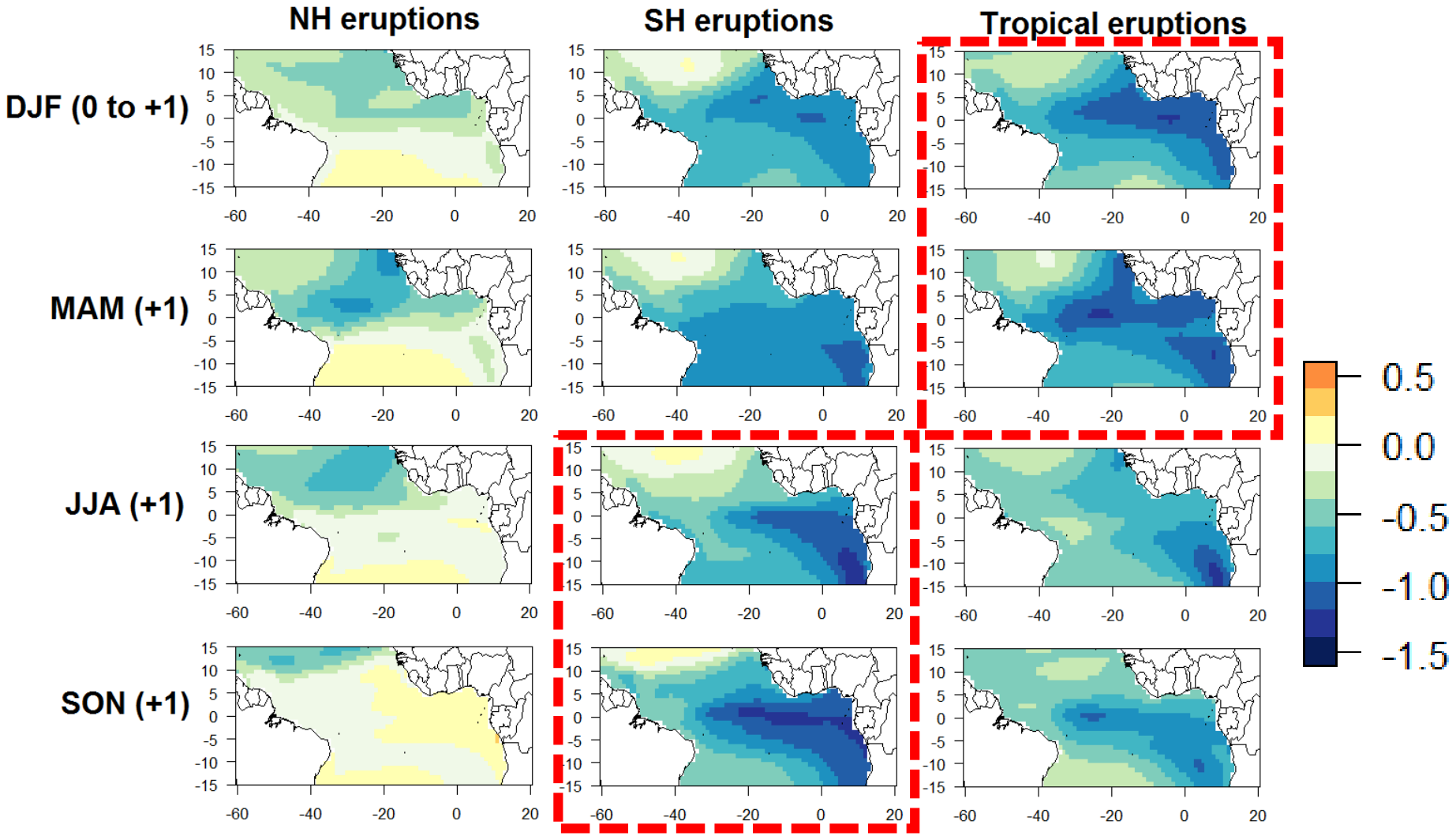
2. Volcanic events of interest: the year before (-1) , the eruption year (0), and six years after the eruption (+1 to +6 years)

3. Seasonal analysis (DJF, MAM, JJA, SON)

Location	Years
Tropical	1258 (Samalas), 1284, 1809, 1815 (Tambora)
Northern	1176, 1213, 1600, 1641, 1762 (Laki), 1835
Southern	1275, 1341, 1452 (Kuwae)

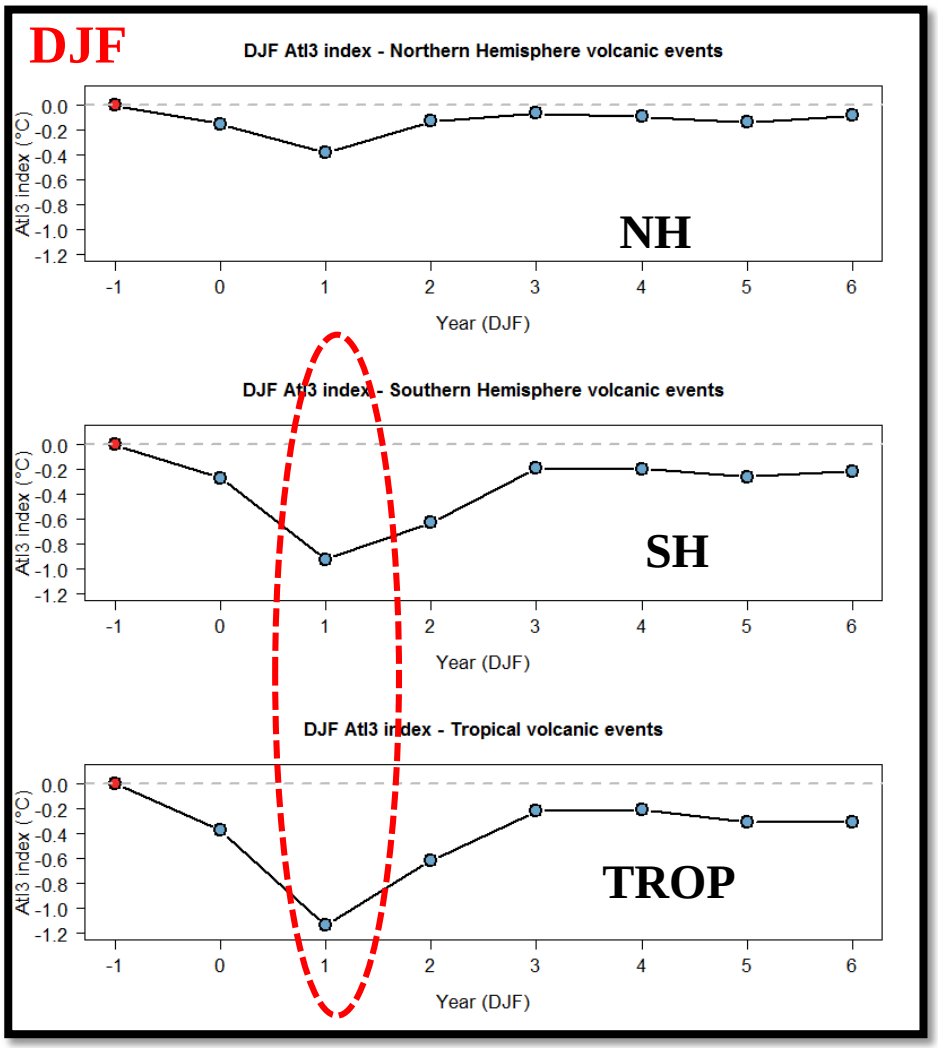
from Stevenson et al. (2016)

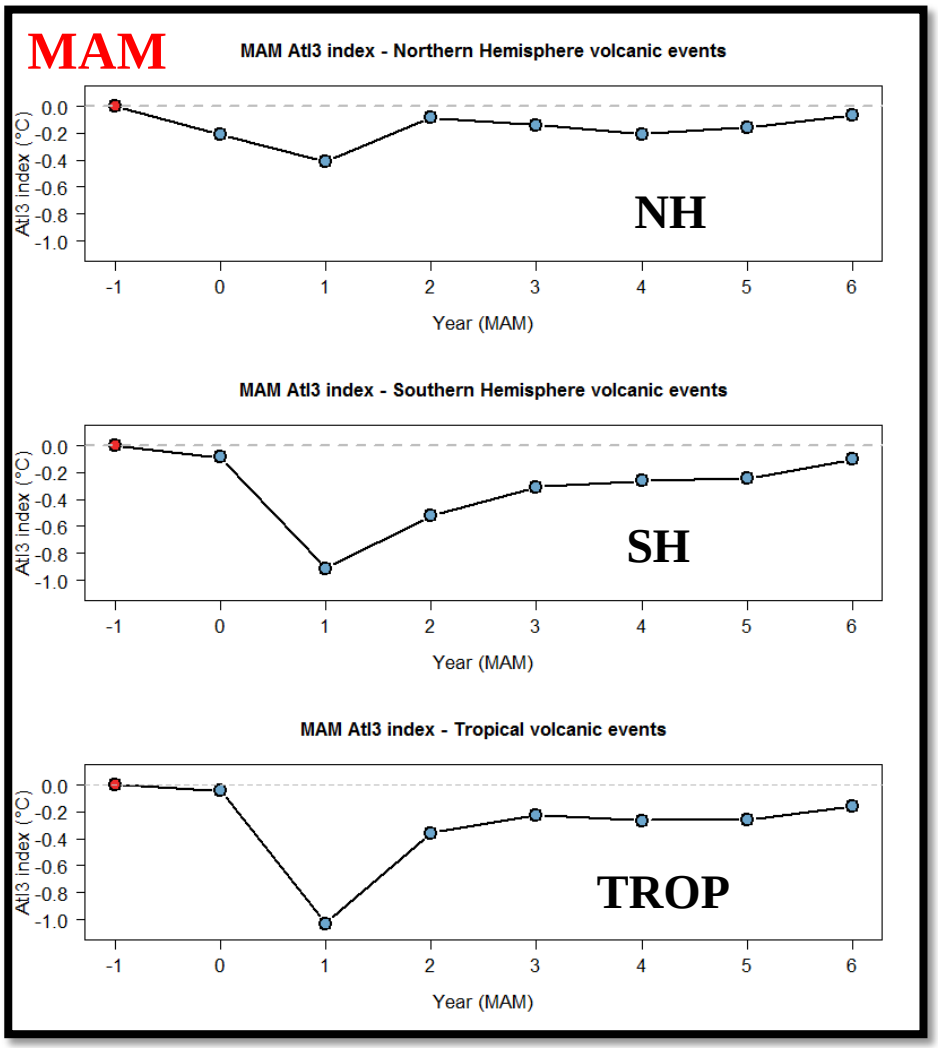
SST response



- Intensification of the cold-tongue pattern during DJF (0 to +1) and MAM (+1) → Tropical eruptions
- Intensification of the cold-tongue pattern during JJA (+1) and SON (+1) → SH eruptions

ATL3 index Superposed Epoch Analysis (SEA)



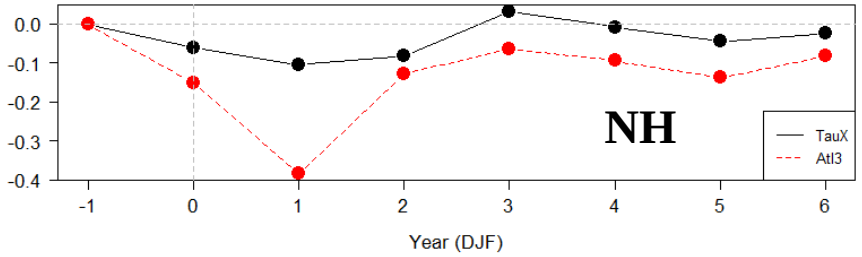


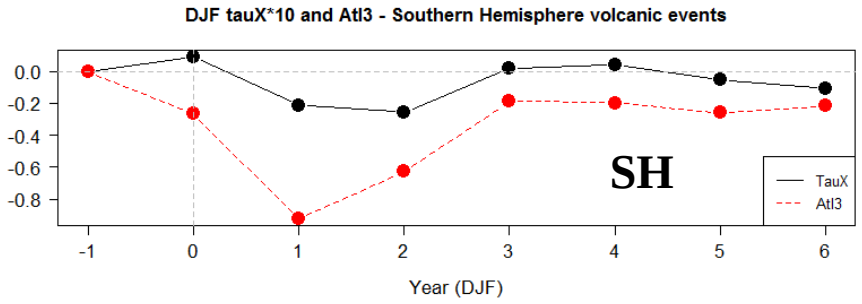
- Greater impact of **TROPICAL** followed by **SH** volcanism, mainly during (+1) season
- Decrease in SST anomalies up to -1.2 °C

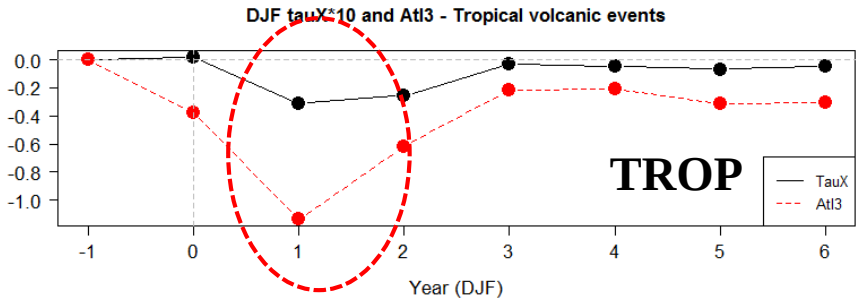
ATL3 and τ_x

- If the cold tongue **cools,** there is an intensification of the equatorial temperature gradient and a **strengthening** of the easterly trade winds → ***ITCZ moves north***

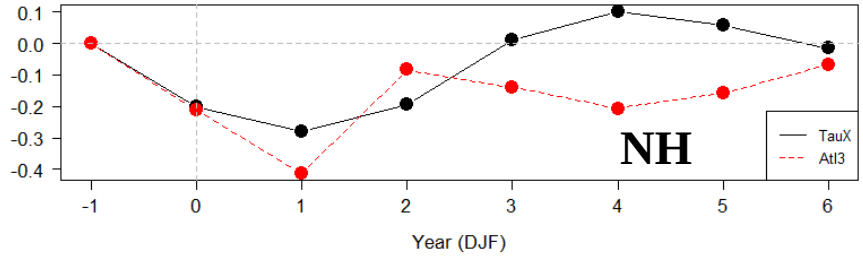
DJF

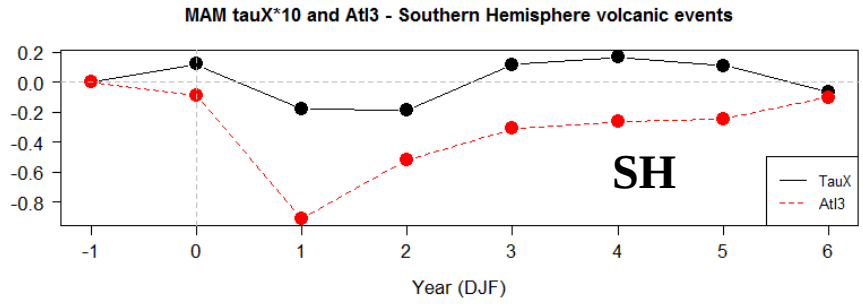


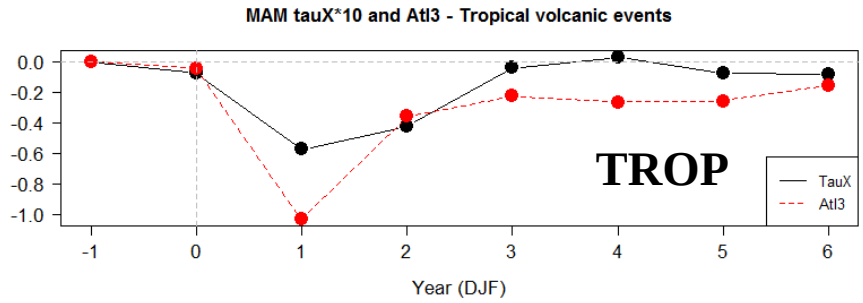




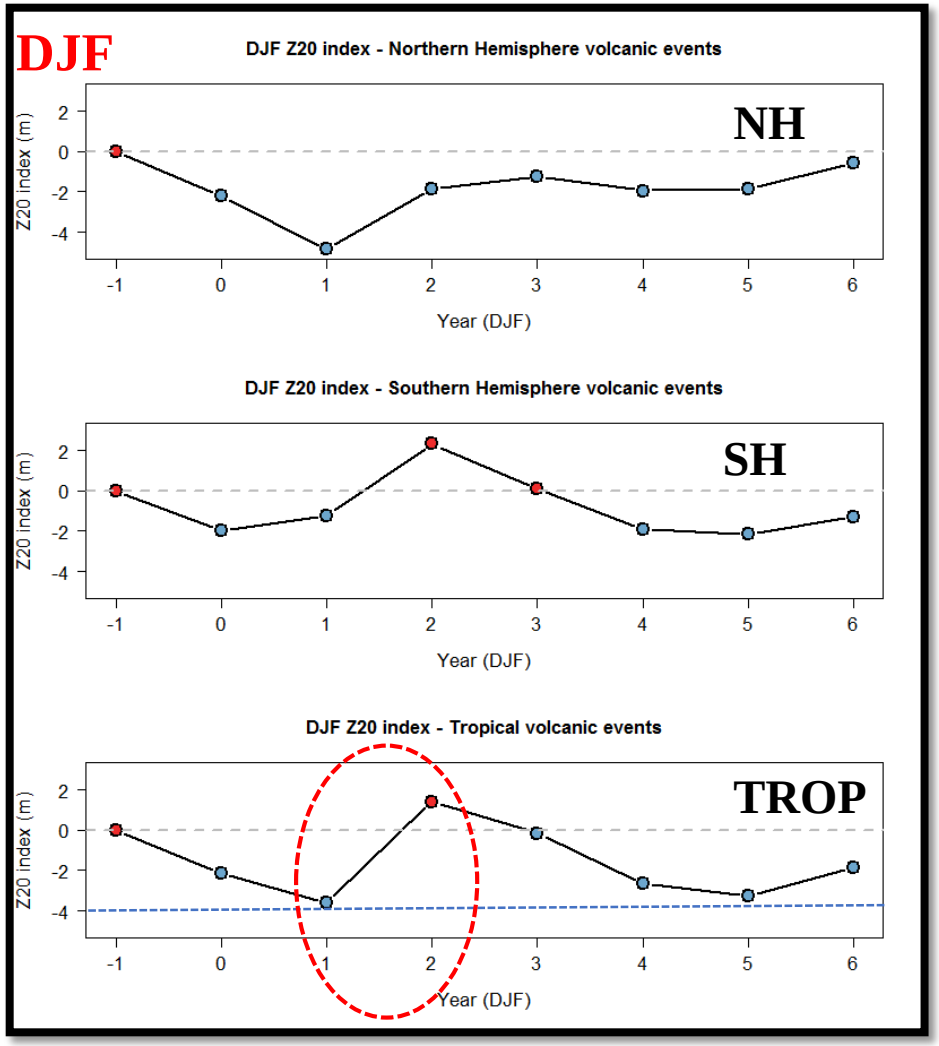
MAM

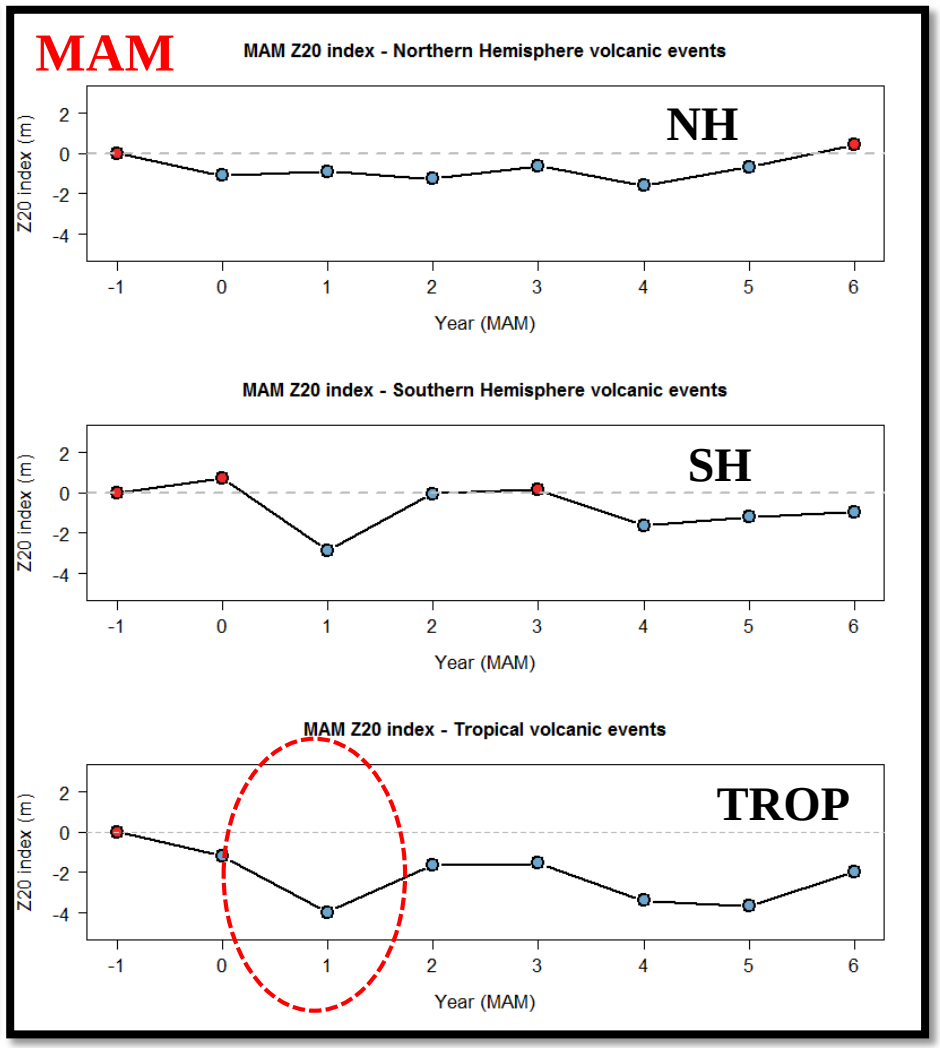






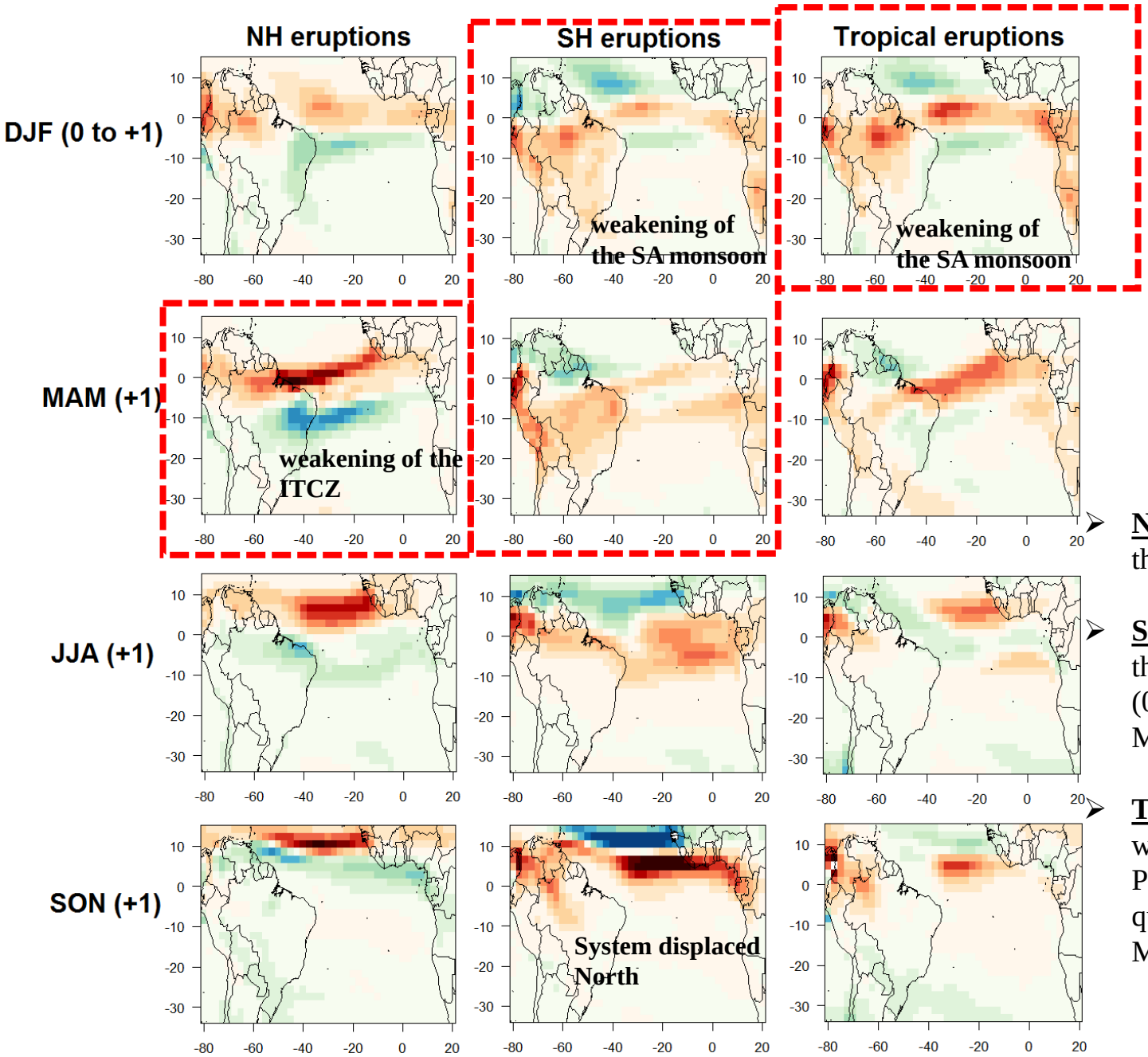
Z20





- Greater impact of **NH** and **TROPICAL** volcanism during **DJF**, and of **TROPICAL** volcanism during **MAM**
- Decrease in depth anomalies up to **4 m**

PPT response

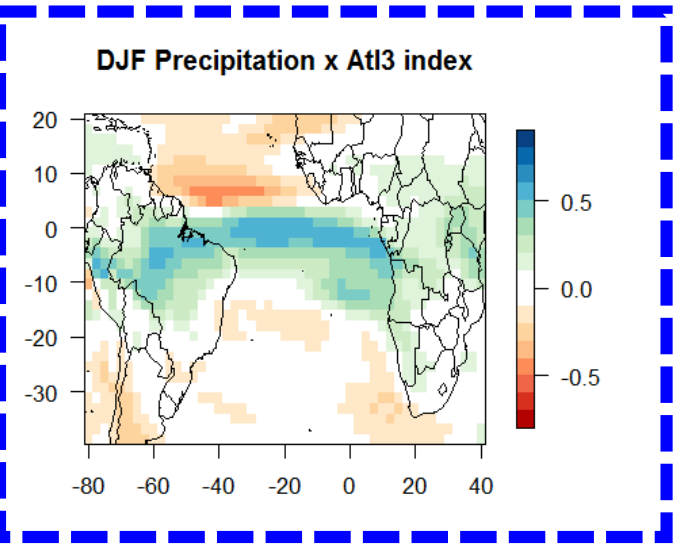


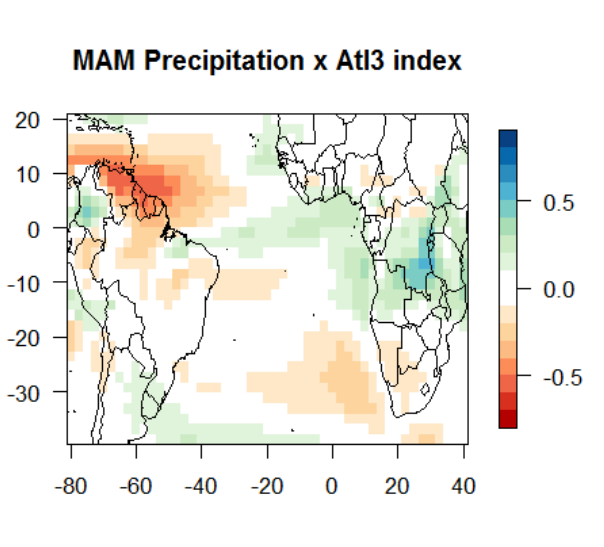
NH eruptions: weakening of the ITCZ during MAM (+1)

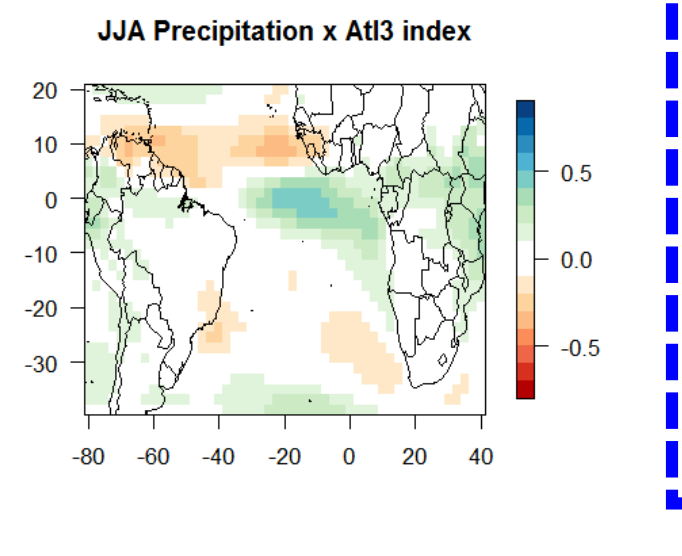
SH eruptions: weakening of the monsoon PPT during DJF (0 to +1), less PPT during MAM (+1)

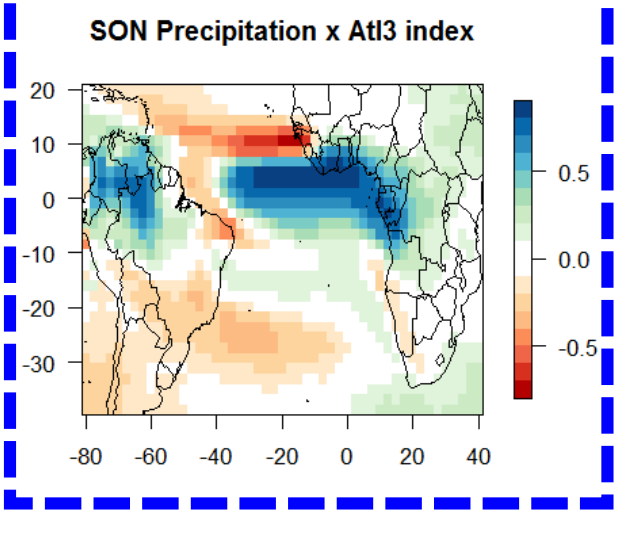
Tropical eruptions: weakening of the monsoon PPT during DJF (0 to +1), quadripole pattern during MAM (+1)

Correlation ATL3 and PPT (850 – 1850 C.E.)







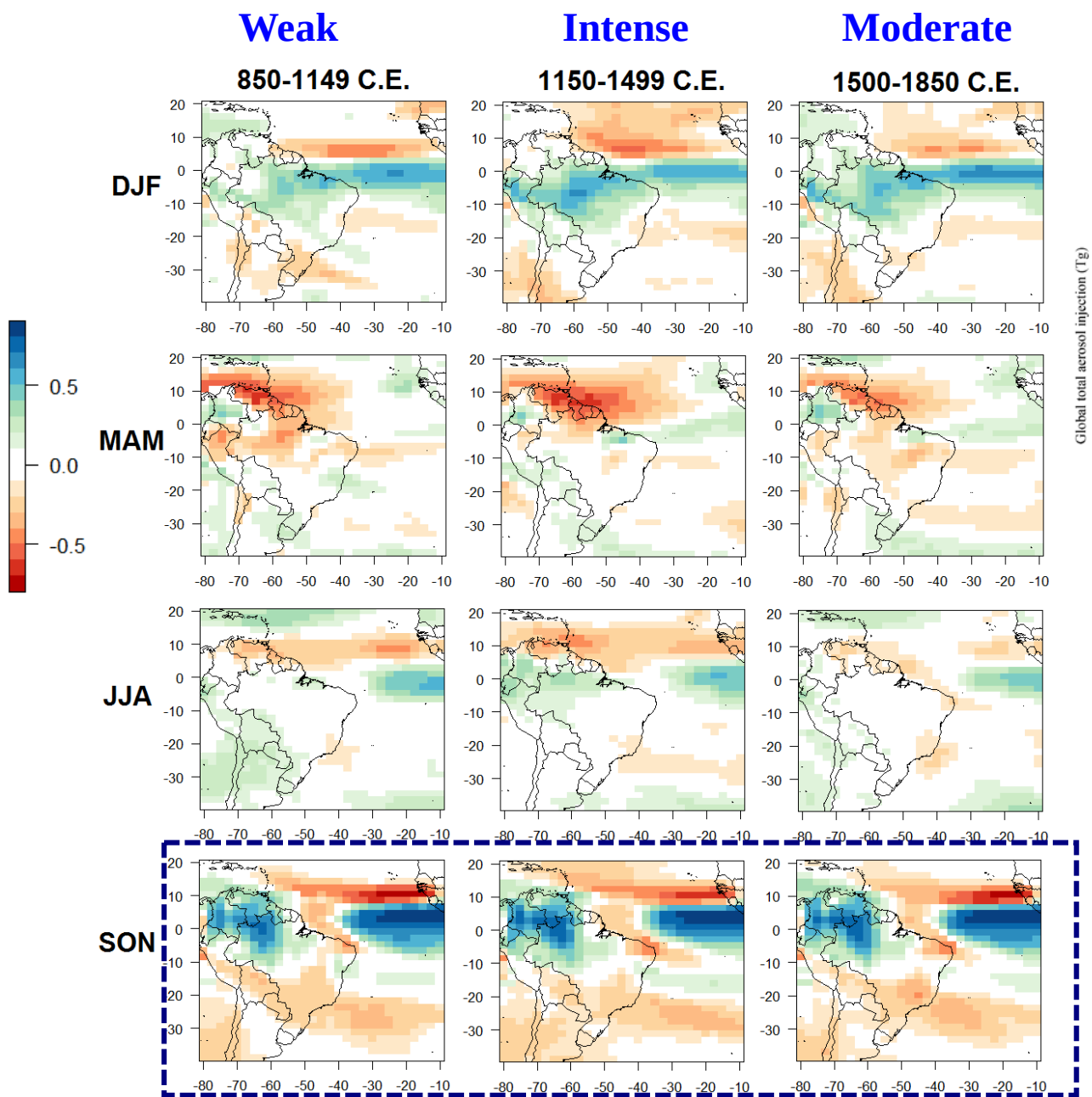


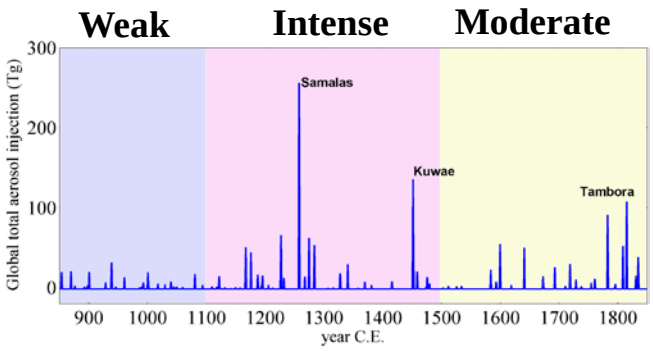
[95 % significance]

SOUTH AMERICA:

- Positive correlation during DJF (Monsoon season) and SON.
- Negative correlation during MAM

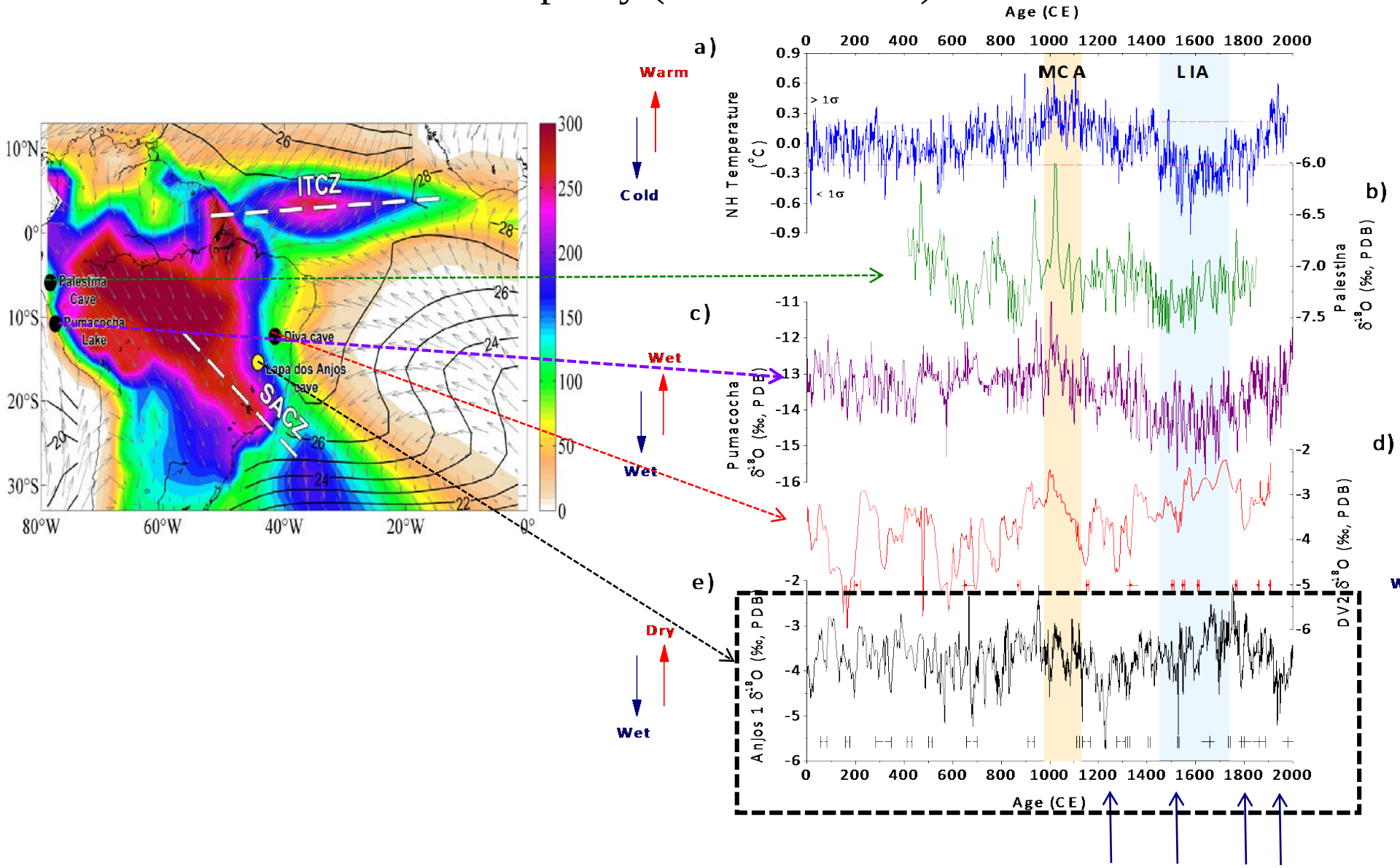
ATL3 and PPT (850 – 1850 C.E.) by intensity





- **Stronger correlation during SON**
- **ATL3 x PPT same pattern regardless of volcanism intensity**

PPT from proxy (South America)



Sirkis et al. (in preparation)

Conclusions – part 1

- **Tropical** eruptions: Intensification of **cold**-tongue pattern during **DJF** (0 to +1) and MAM (+1) and **easterly** trade winds.

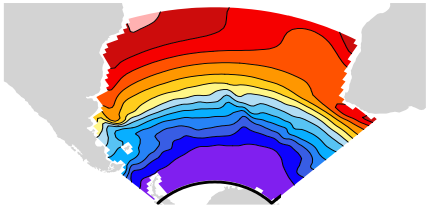
Cooling → stronger easterlies → ***ITCZ moves north → less PPT***

- **SH eruptions** → Intensification of the **cold-**tongue pattern during **JJA** (+1) and SON (+1) ***ITCZ moves north → less PPT***

SW radiation deficit on the surface : Weakens the evaporation

- ATL3 x PPT relationship is independent of volcanism intensity.

South-Atlantic LM mean (850-1850)



How does the South Atlantic Ocean Respond to Volcanism?

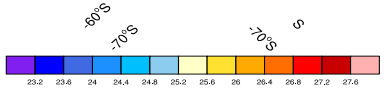
LME results
(14 ensemble members,
10 full forcing + 4 volcanic only)

Tropical + Southern eruptions

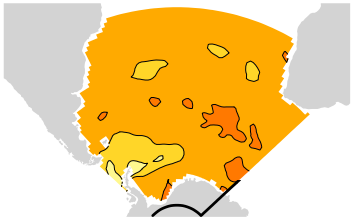
(**1258**, 1275, 1284, 1341, **1452**, 1809, **1815**)

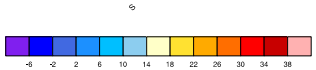
Composites for **DJF**

(after Stevenson et al. 2016)

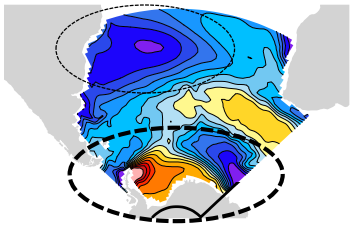


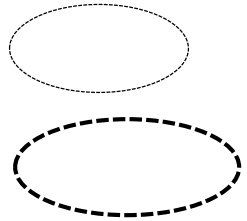
DJF - Year = 0



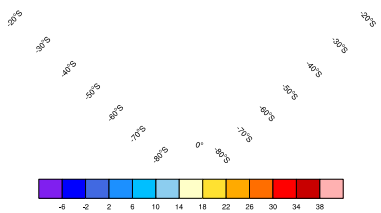


DJF - Year = +1

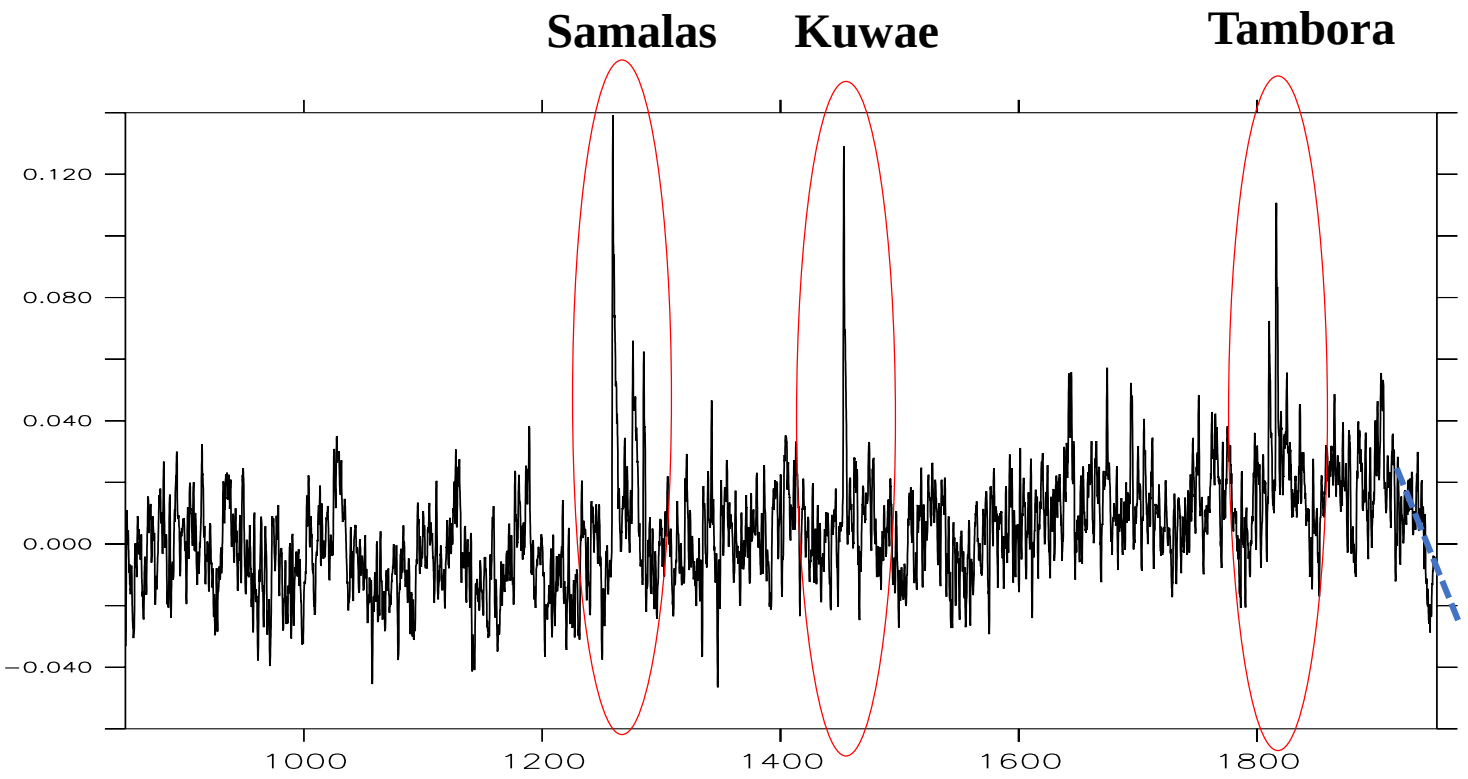


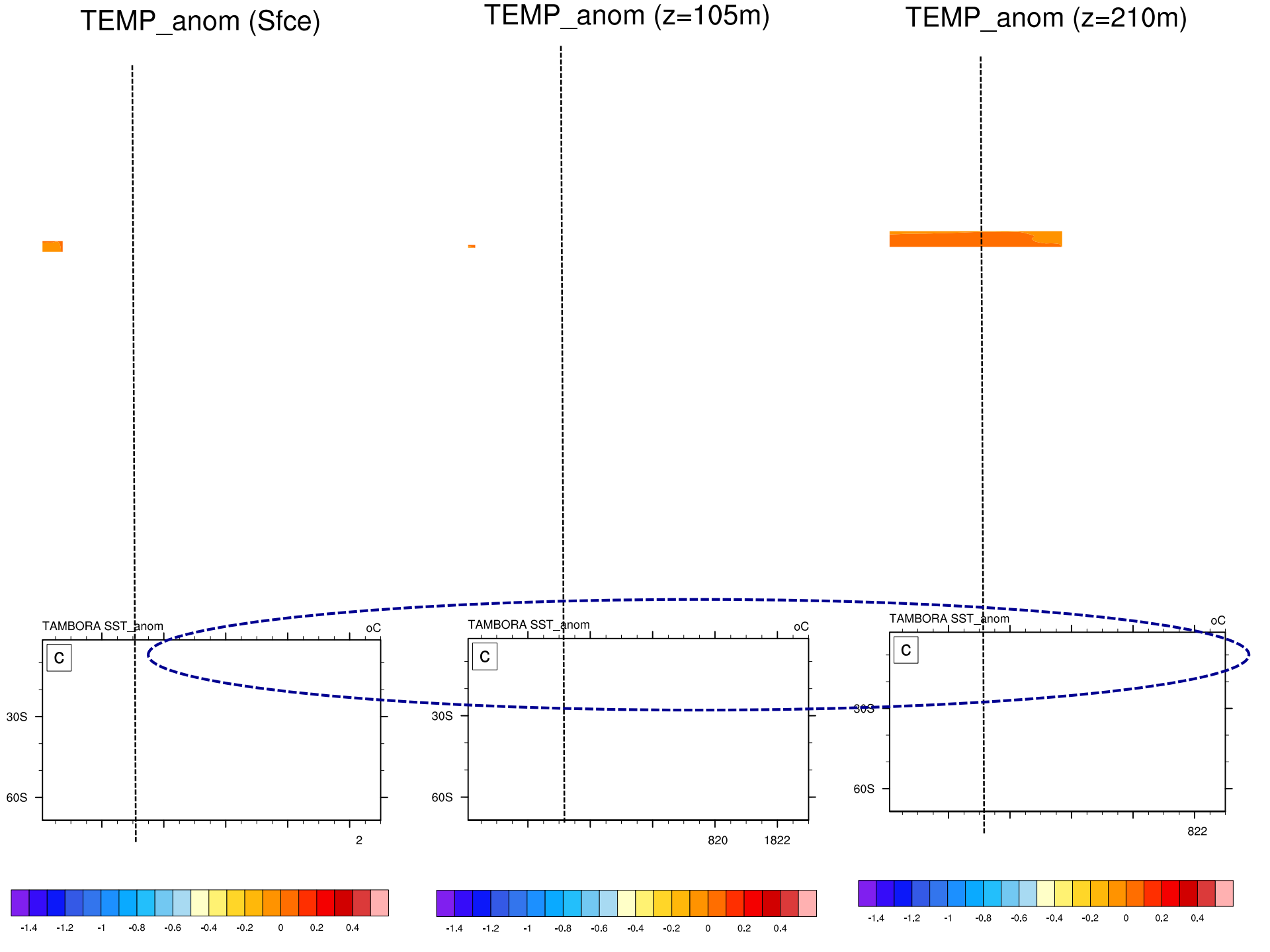


r+1)



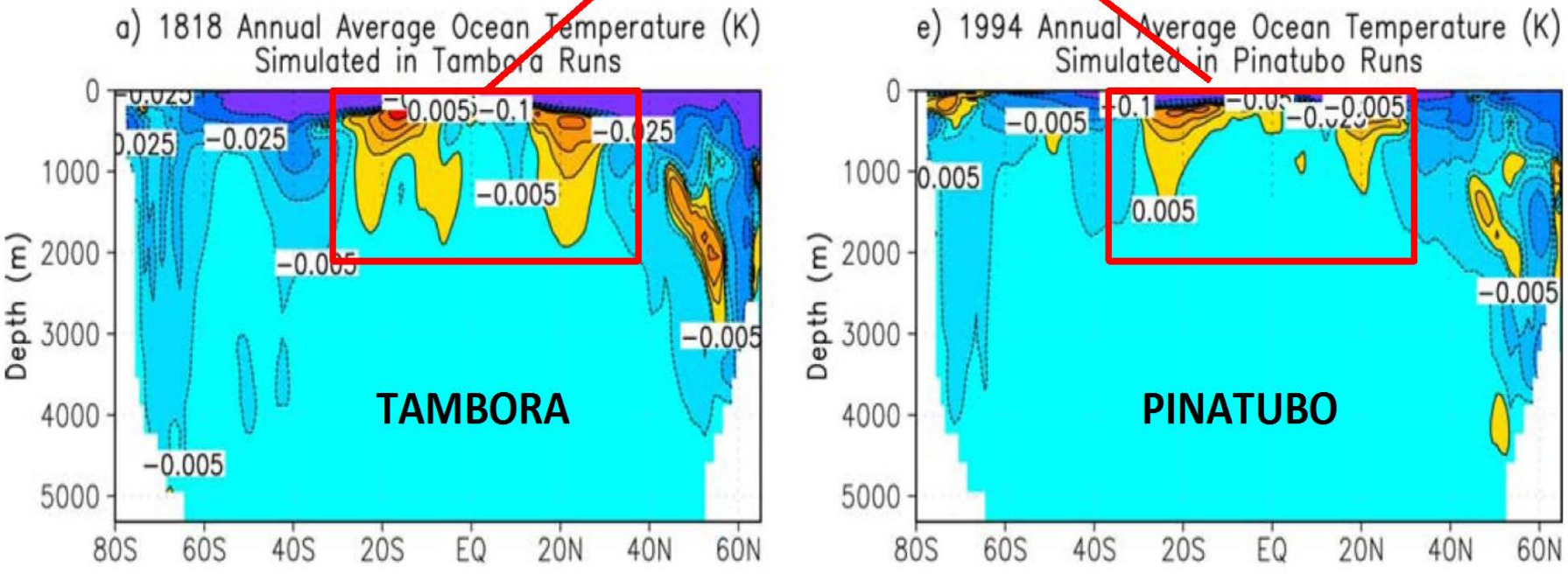
Zonal avg time-series of SSS_anom in the South Atlantic *(average between **60S-70S**)*




TEMP_anom (Sfce)
TEMP_anom (z=105m)
TEMP_anom (z=210m)
TAMBORA SST_anom
oC
C
30S
60S
2
820
1822
822
-1.4
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4

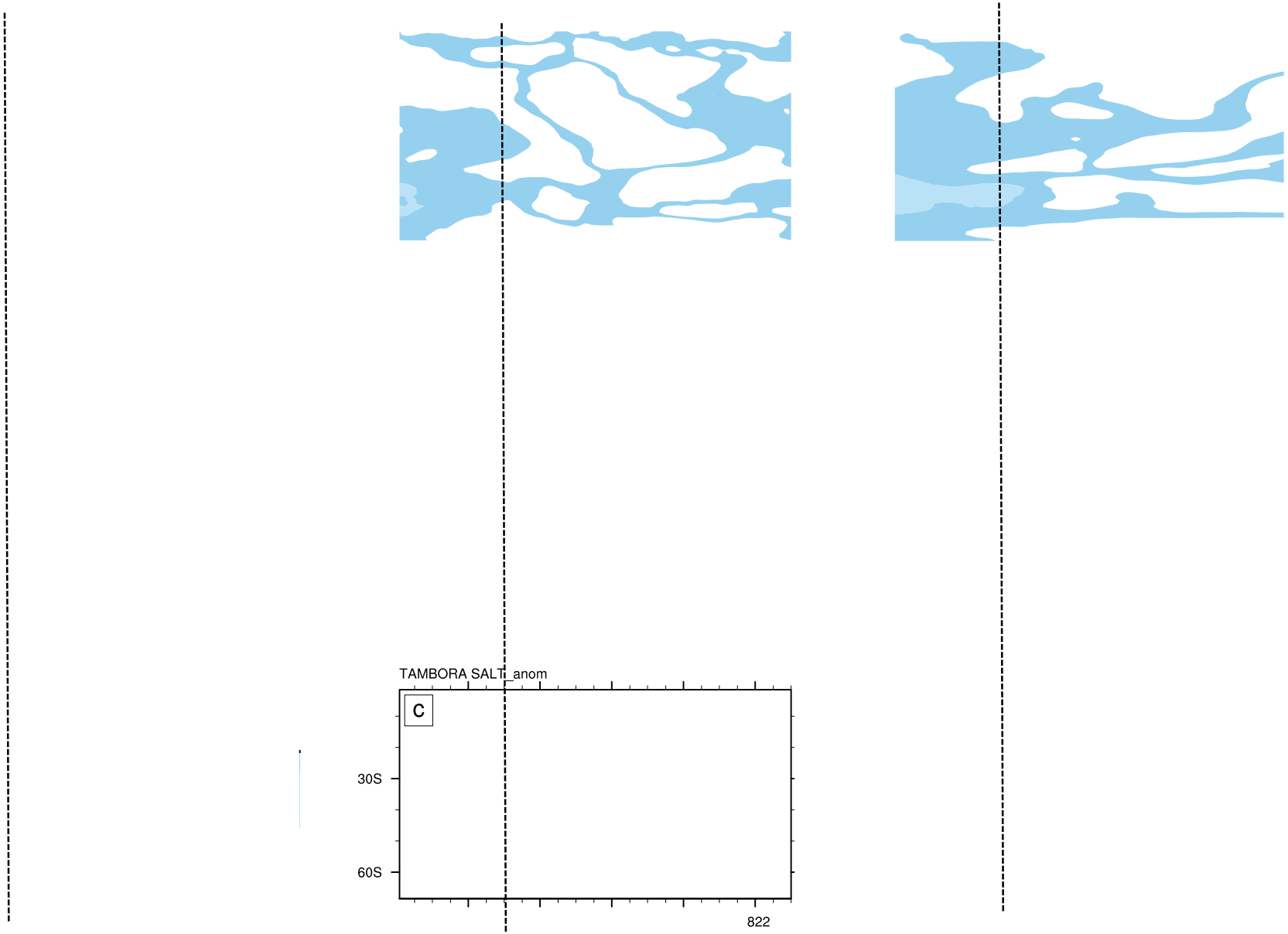
cooling at sfce and warming below is consistent with previous results

ΔT = 0.05-0.1 K



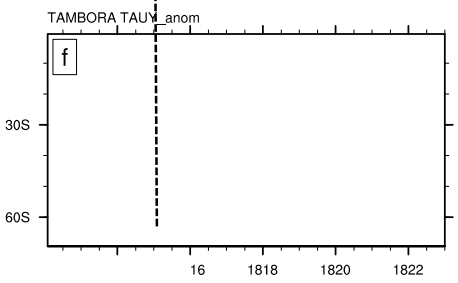
Stenchikov et al. (2009) JGR

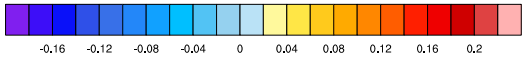
SALT anom (z=105m)



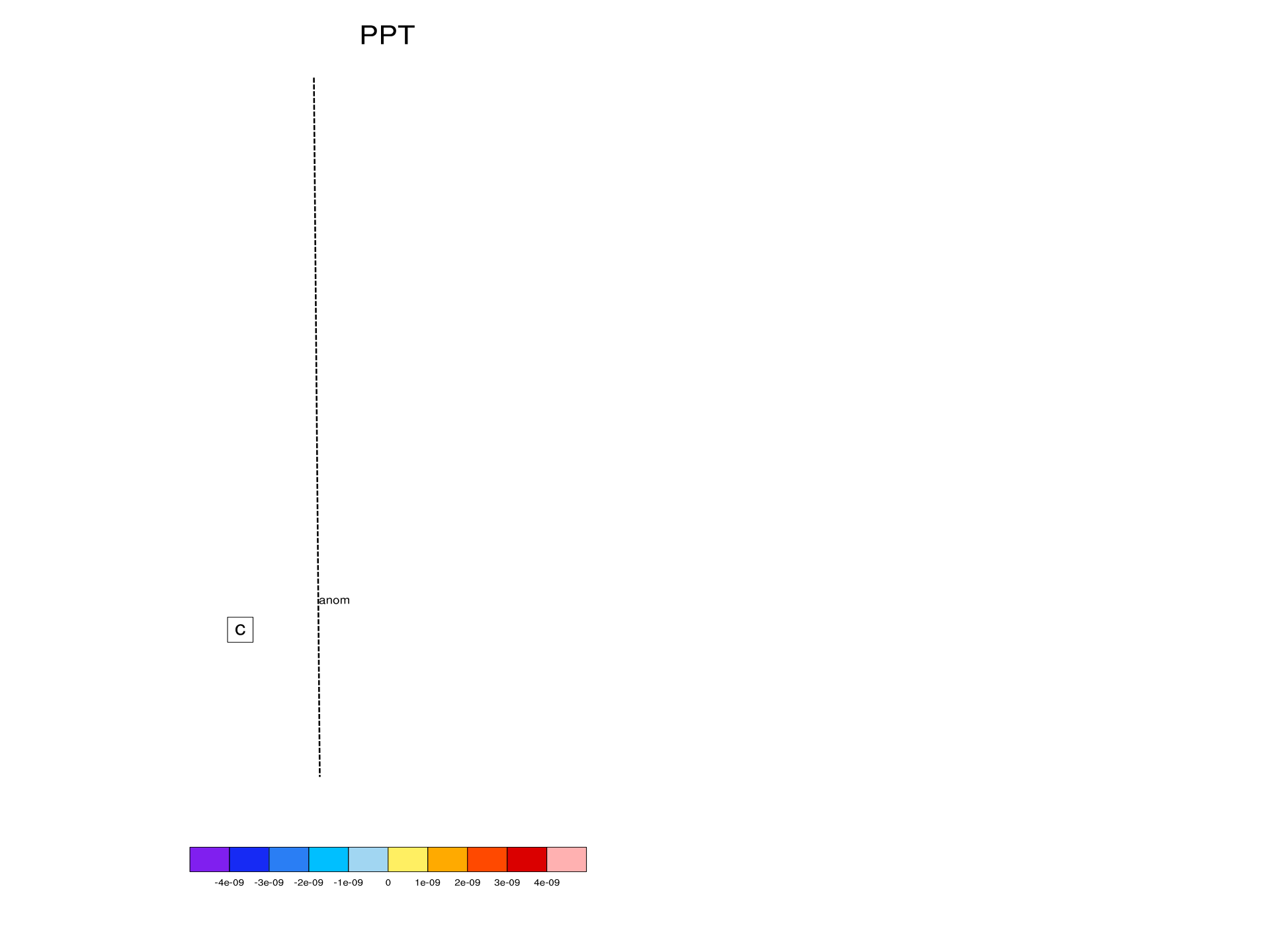
TAUx

TAUy


TAMBORA TAUY_anom
f
30S
60S
16
1818
1820
1822


-0.16
-0.12
-0.08
-0.04
0
0.04
0.08
0.12
0.16
0.2

Explosive events trigger meridionally propagating signals in the South Atlantic that are surface-driven but are seen below the surface and are being investigated.


PPT
anom
C
-4e-09
-3e-09
-2e-09
-1e-09
0
1e-09
2e-09
3e-09
4e-09

Vertical slices at 30W

Yr 0

Yr+1

Yr+2