Air-Sea Interaction in the South Atlantic Convergence Zone

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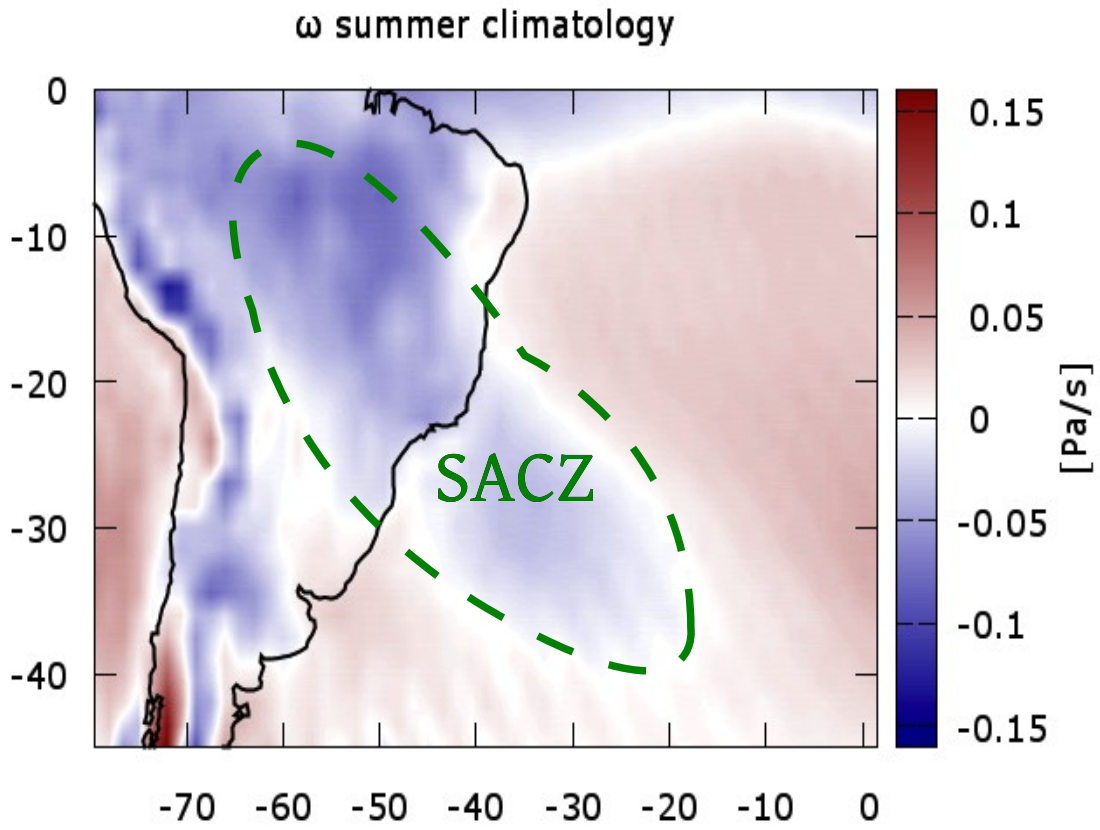
Outline

- The Problem: how to quantify the influence of the ocean over the South Atlantic Convergence Zone (SACZ) ?
- The Methods:
  - Granger Causality
  - Maximum Covariance Analysis
  - Climate Networks
- Results

The SACZ

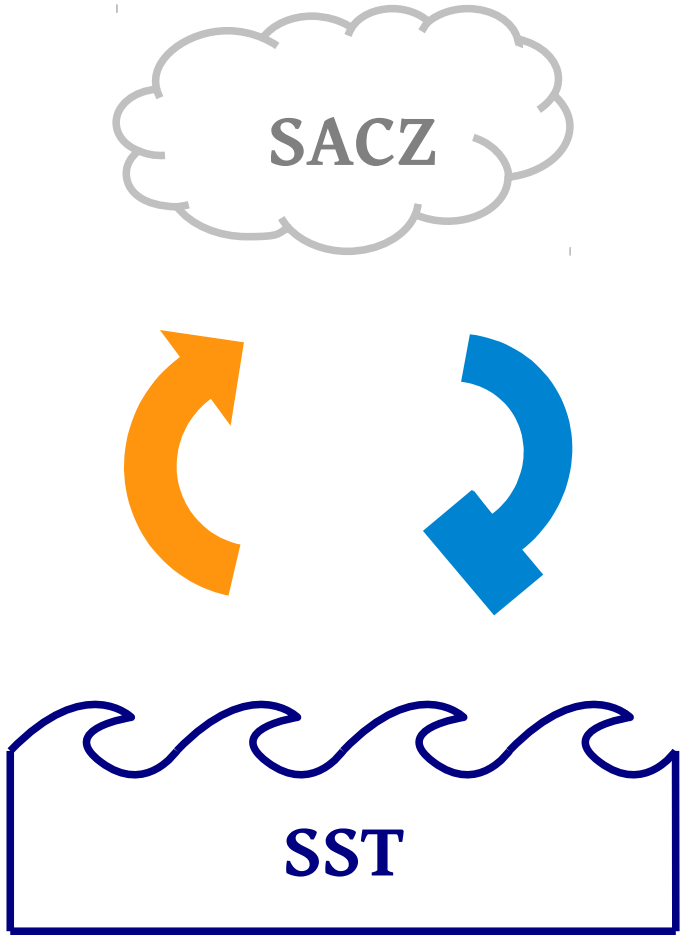
- The South Atlantic Convergence Zone is a convective pattern, NW-SE oriented, over Southern Brazil
- It has a maximum in austral summer



- It influences very populated areas of South America such as Minas Gerais, Sao Paulo and Rio de Janeiro

The Role of the Ocean

- How does the ocean impact over the SACZ?
- And the SACZ over the ocean?
- Barreiro at al. (2002) showed in models that SST can force a dipole of precipitation
- Chabres and Nobre (2004) showed the presence of a SACZ-induced cooling of the SST anomalies (negative feedback)



Granger Causality

- Having two processes X and Y we want to understand which is the master and which is the slave
- We write the two processes as autoregressive

$$Y_t = \sum_{j=1}^{D} a_j Y_{t-j} + \sum_{j=1}^{D} b_j X_{t-j}$$

- With this assumption we fit the parameters a_j and b_j under two hypothesis:
  - Forced: $b_j \neq 0$, with residuals R_f
  - Unforced: $b_j = 0$, with residuals R_u

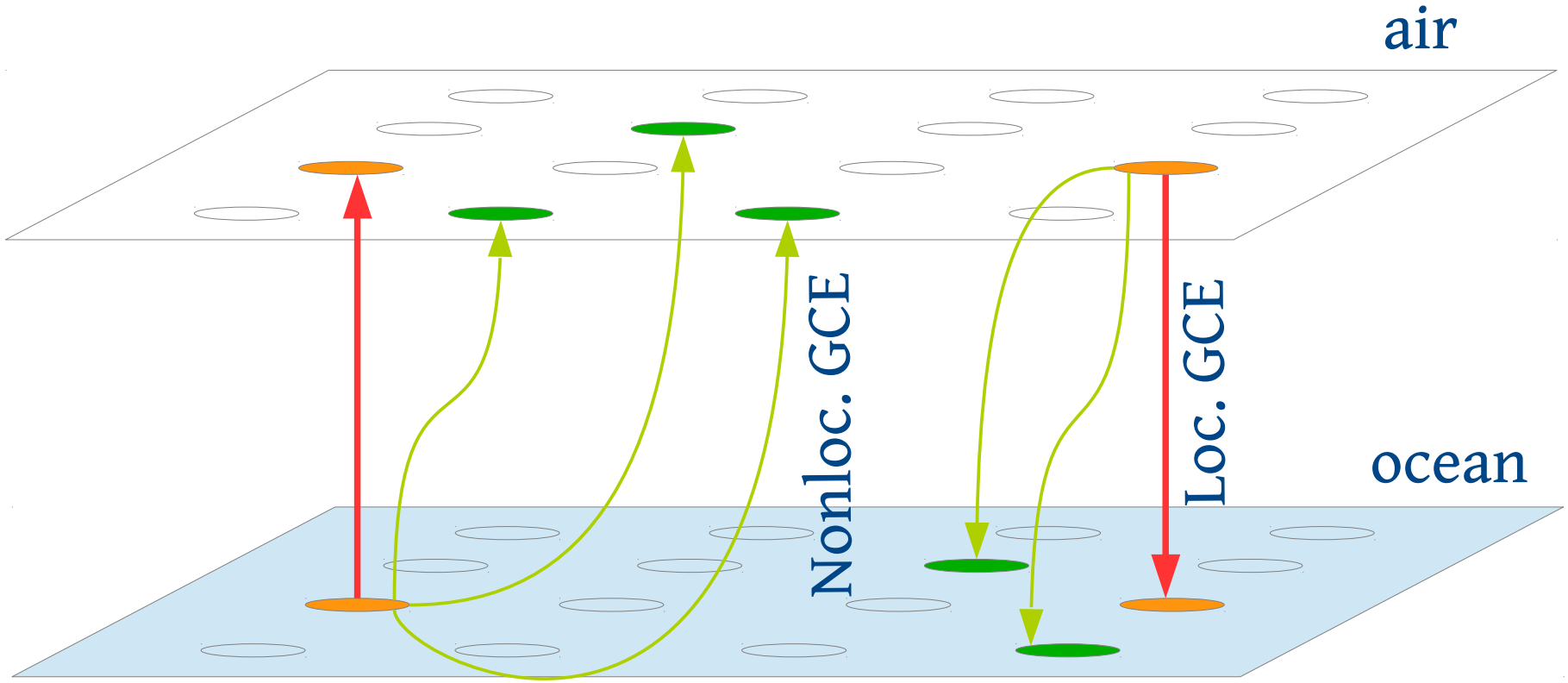
$$GCE = (R_u - R_f)/R_u$$

- If GCE > 0 X is said to be Granger causal of Y ($X \rightarrow Y$)

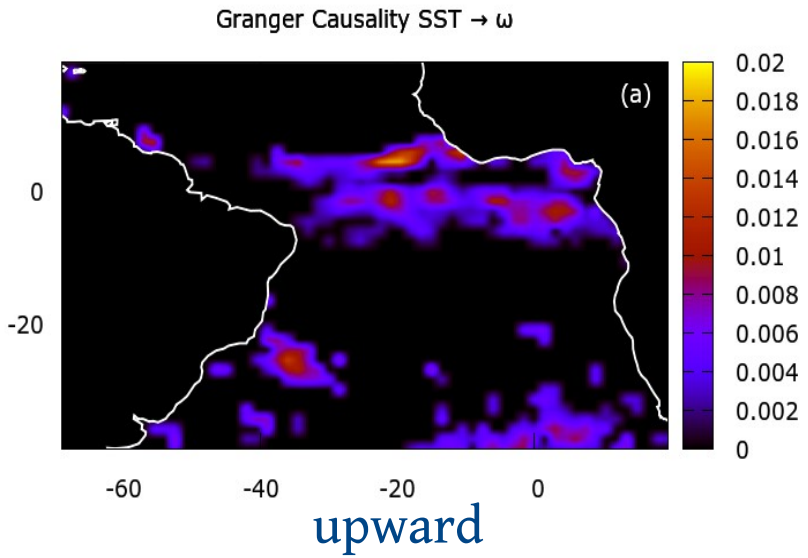
Data

- ERA Interim Reanalysis ranging from Dec 1979 to Mar 2013
- Only austral summers
- 1.5 degrees of spatial resolution and 1 day of temporal resolution
- ω anomalies at 500 mbar as proxy for the SACZ
- Sea Surface Temperature anomalies for the state of the ocean

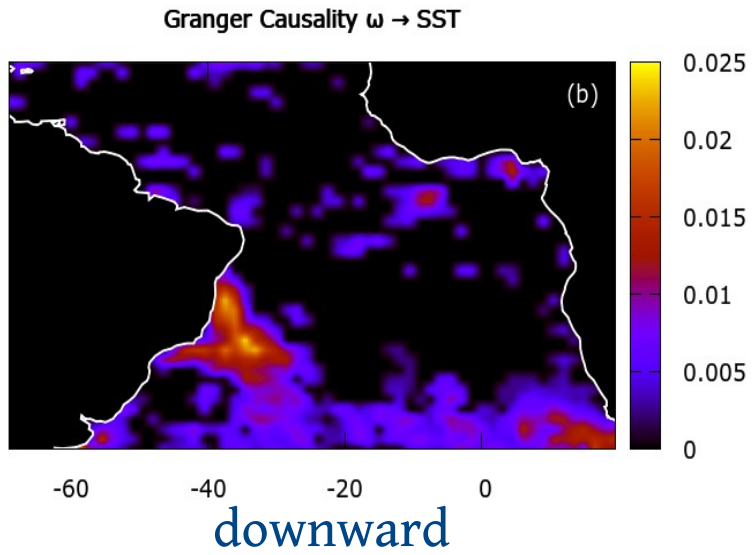
Local and Global Granger Causality



LOCAL GCE (direct upward/downward forcing)

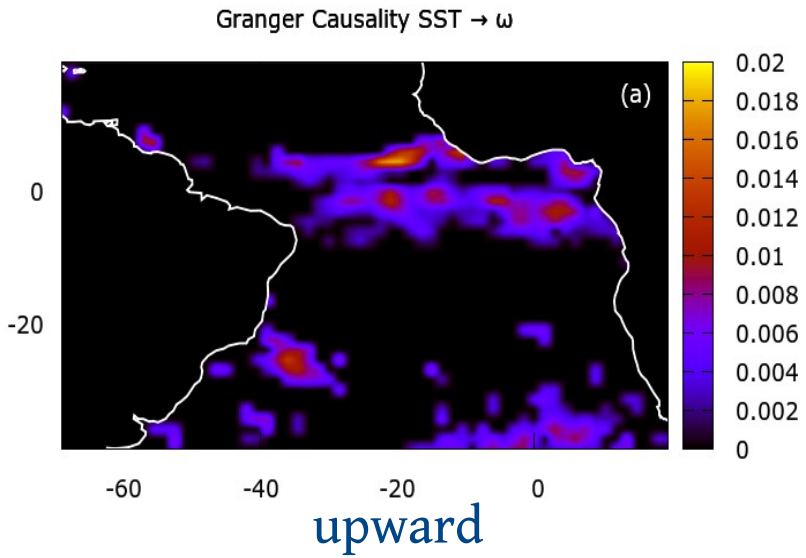


upward

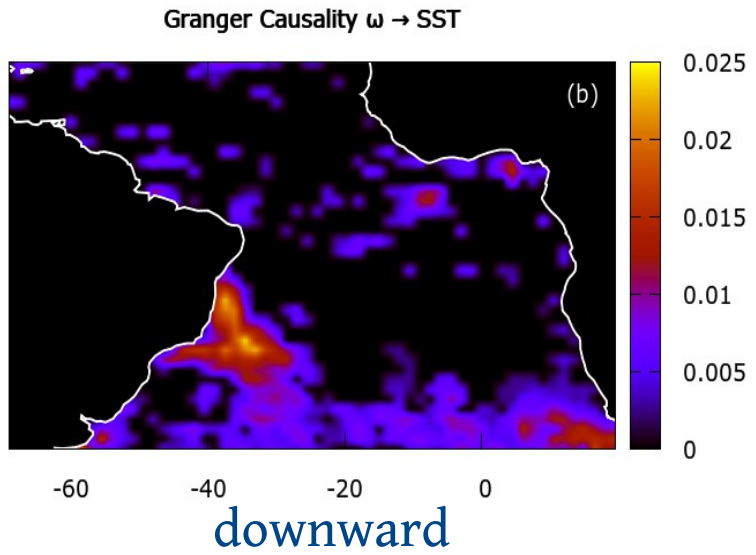


downward

LOCAL GCE (direct upward/downward forcing)

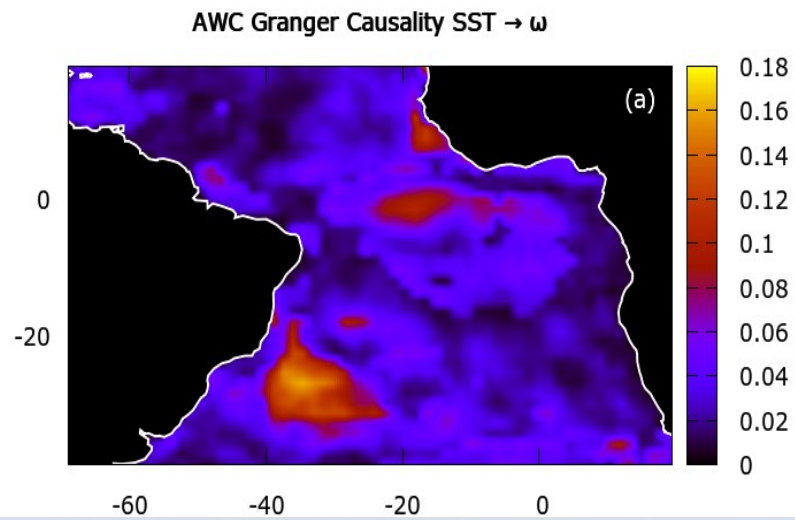


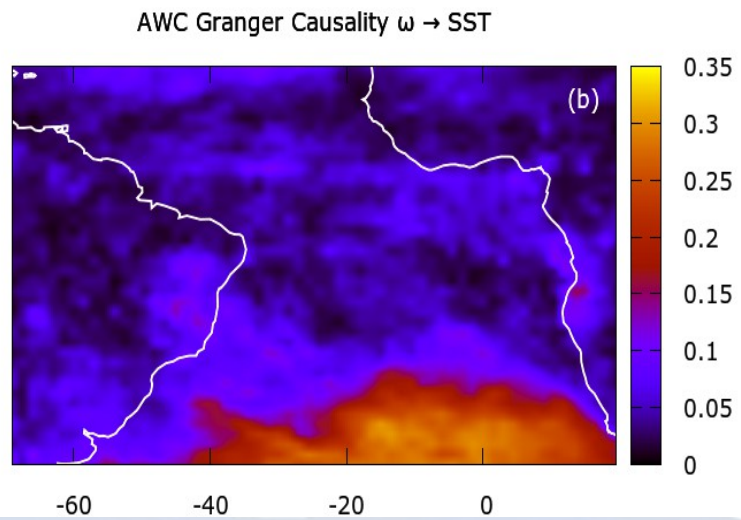
upward



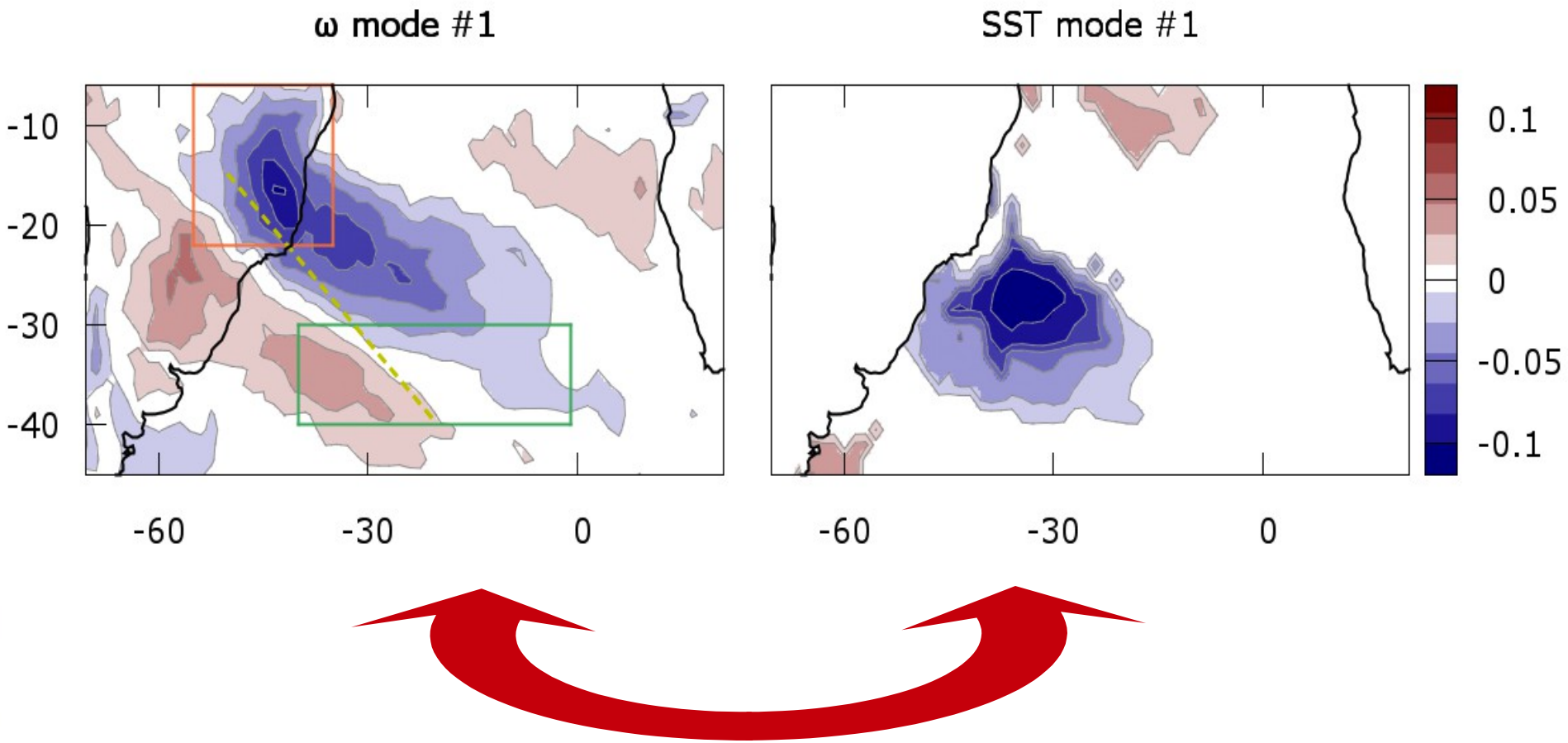
downward

NONLOCAL GCE (Area Weighted Connectivity)



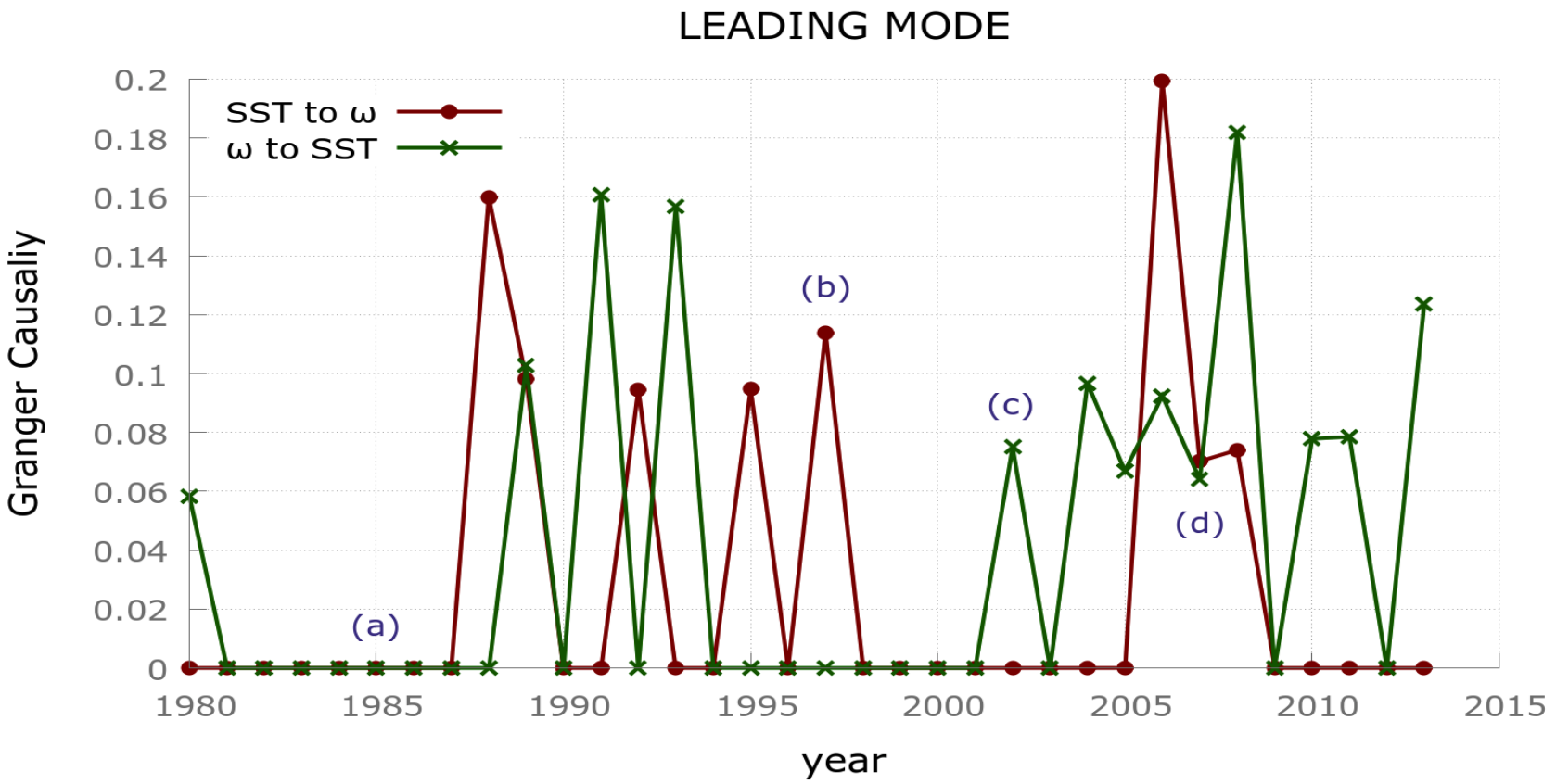


Principal Components



GCE between Principal Components

Principal Components



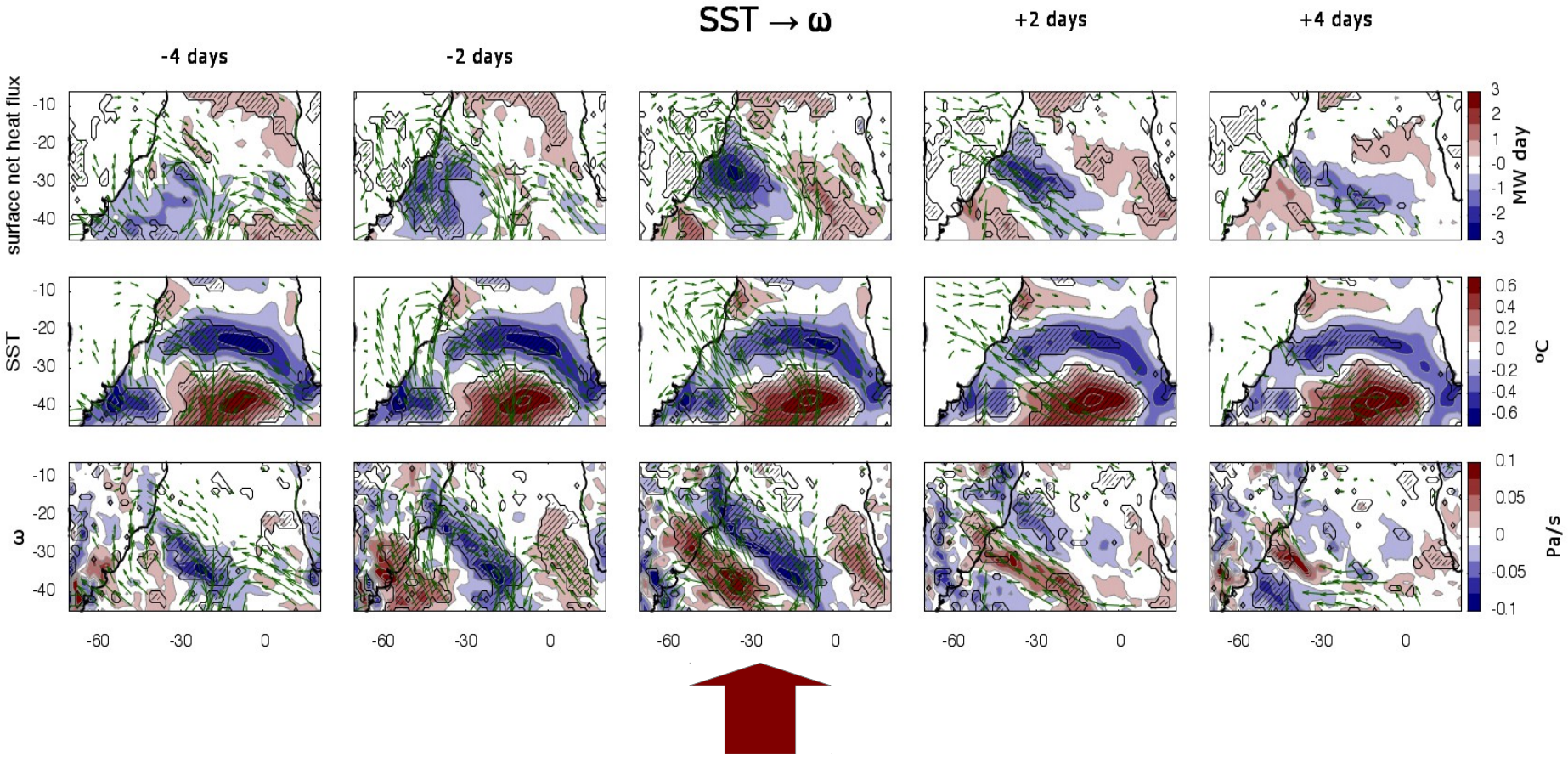
(a): NEUTRAL

(b): SST → ω

(c): ω → SST

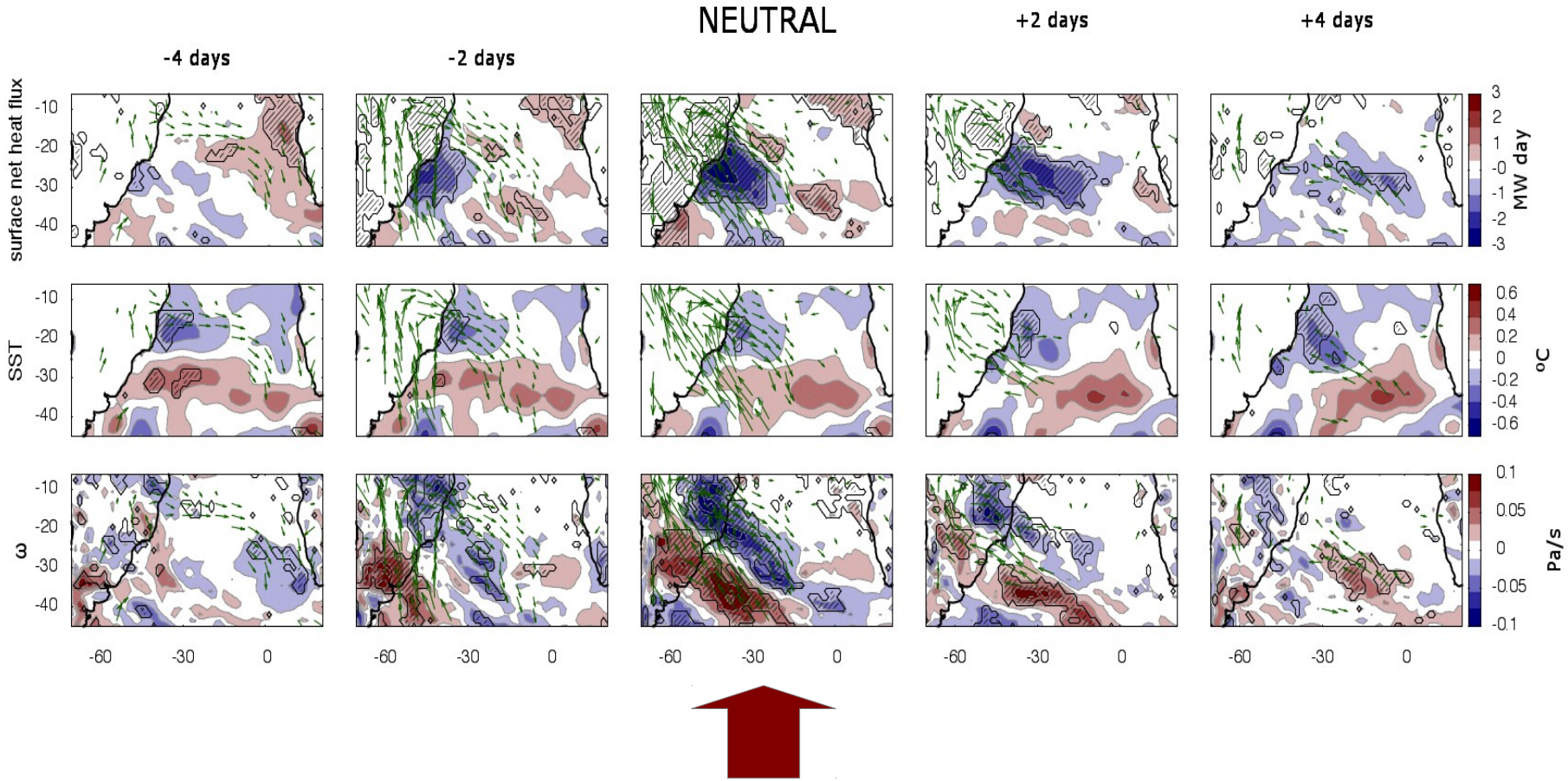
(d): SST ↔ ω

Composites SST → ω



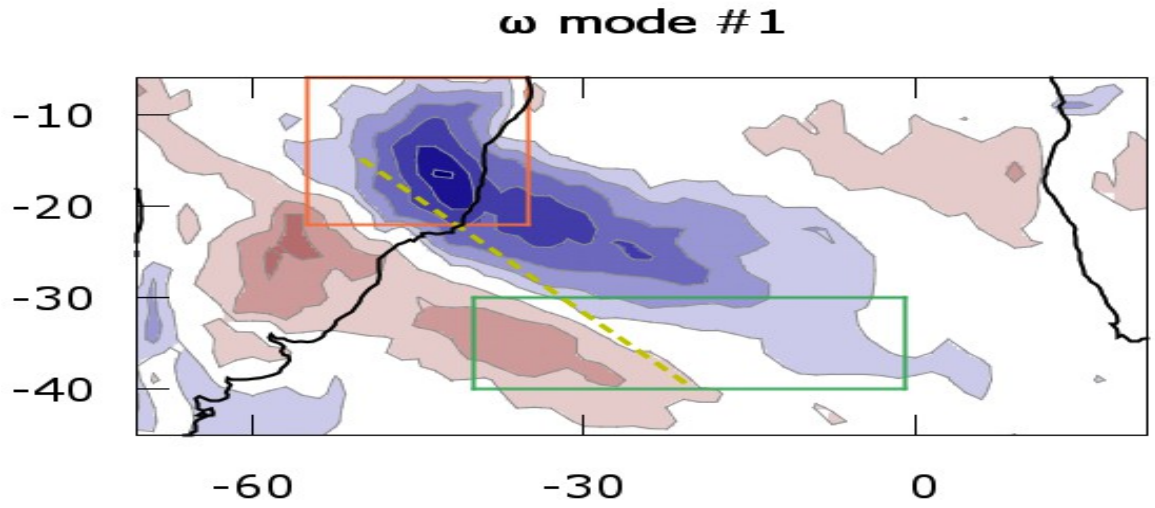
SACZ more developed over the ocean

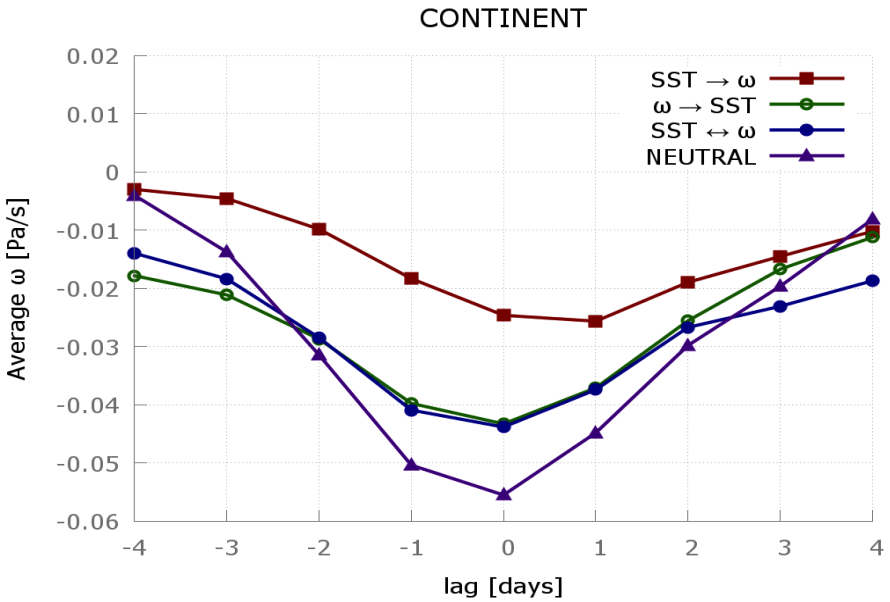
Composites NEUTRAL

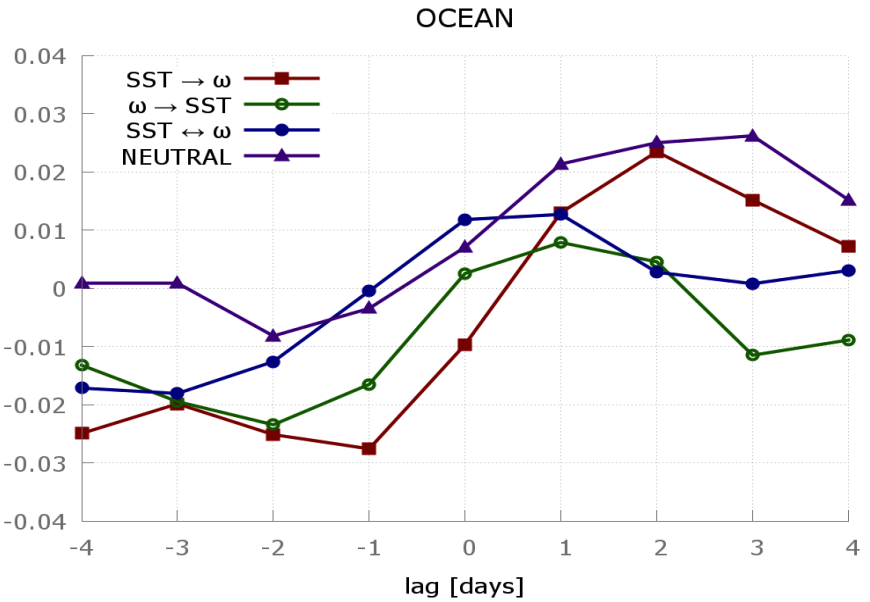


SACZ more developed over the continent

Box-Average Composites







Summary

- Using Granger causality we disentangled air-sea interaction in the SACZ area.
- We found that SACZ events can manifest in four different flavours, depending on the interaction taking place among the atmosphere and the ocean.
- When the ocean forces the atmosphere, the SACZ develops more over the sea.
- When there is no significant interaction among air and sea, the SACZ develops more over the continent.

Thank You