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Symmetry of the Atlantic Niño mode

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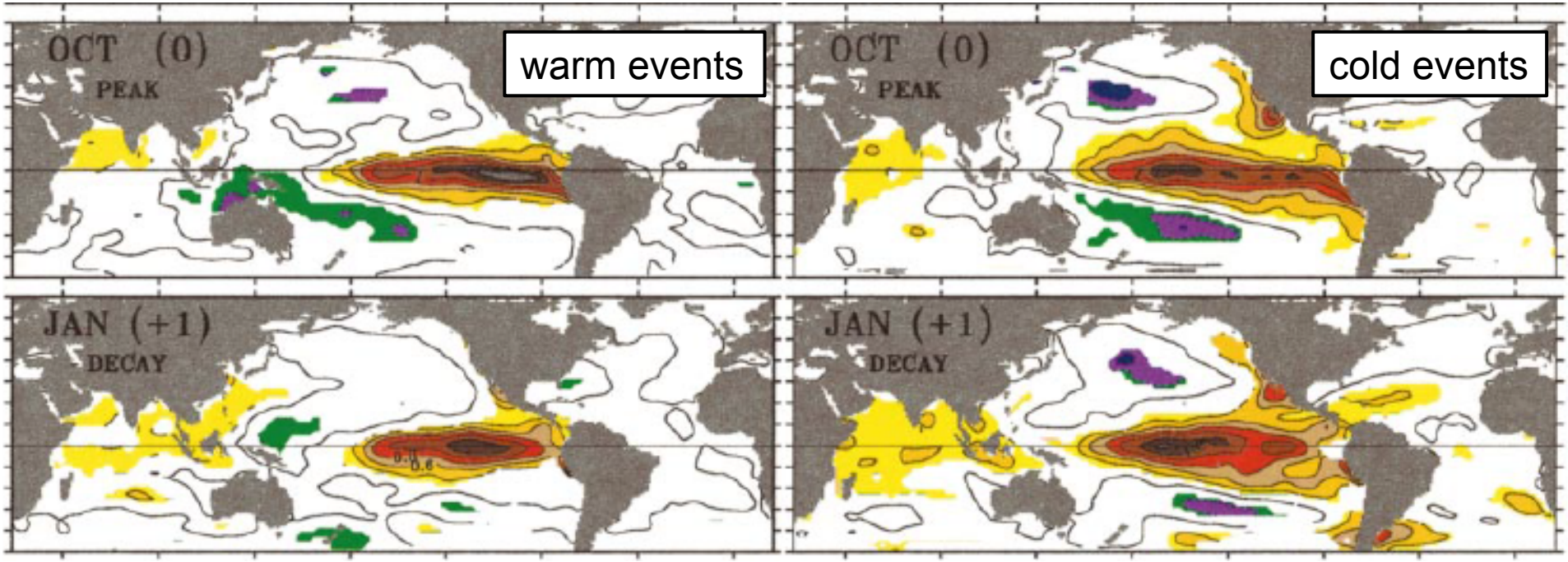
ENSO asymmetry



(Larkin and Harrison, 2002)

- La Niña is not just the mirror image of El Niño

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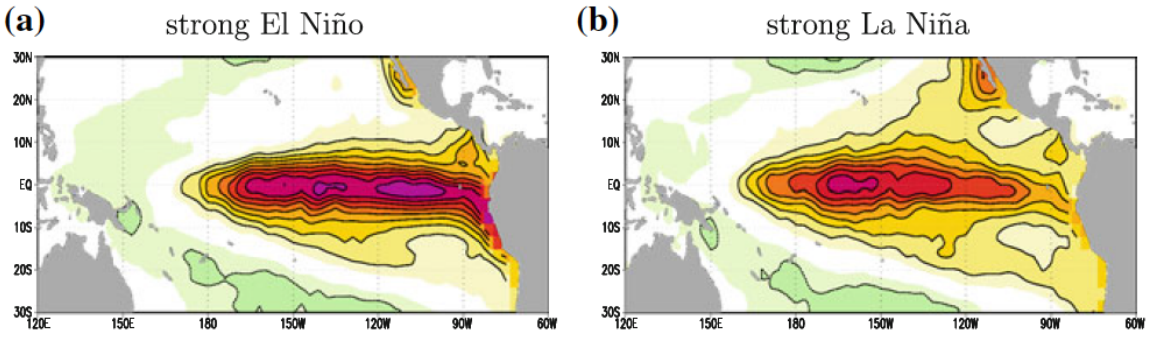
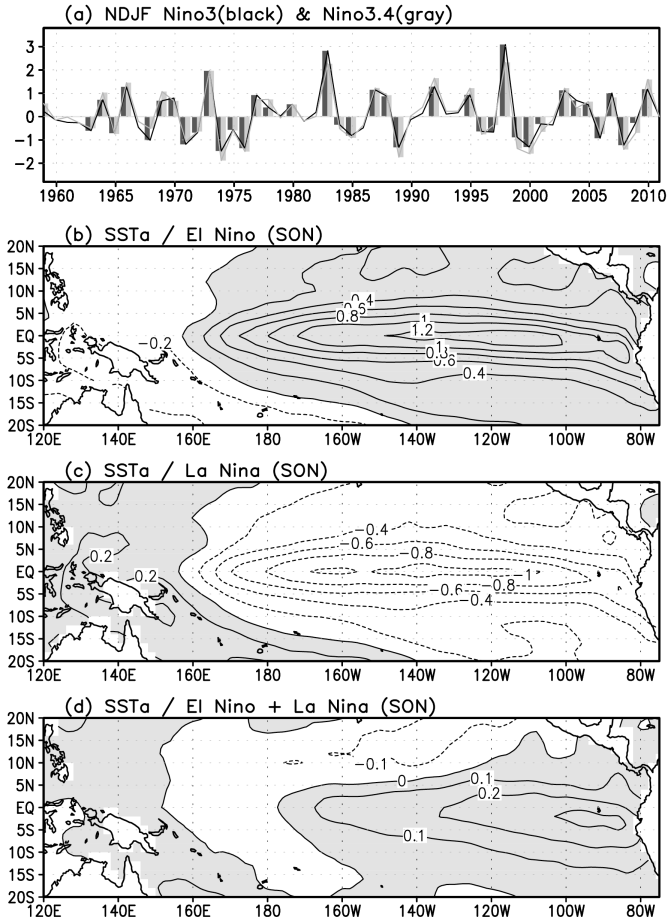
ENSO asymmetry

- SST anomaly associated with El Niño typically larger than that associated with La Niña
- SST anomalies are located further to the east for strong El Niños than for strong La Niñas



(Dommenget et al., 2012)



(Im et al., 2015)

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Explanations

- differences in state-dependent noise forcing (Levine et al., 2016)
- nonlinearities in the the heat flux damping (e.g. Hoerling et al., 1997)
- nonlinearities in the components of the Bjerknes feedback
  - different wind response to warm and cold SSTs in the eastern equatorial Pacific (Kang and Kug,2002; Dommenget et al., 2012)
  - larger dynamical ocean response per unit anomalous zonal wind stress during El Niño compared to La Niña phases (Im et al., 2015)
  - positive anomalies in warm water volume (WWV) are associated with larger SST anomalies than negative WWV anomalies (Meinen and McPhaden, 2000)

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What about the Atlantic Niño?

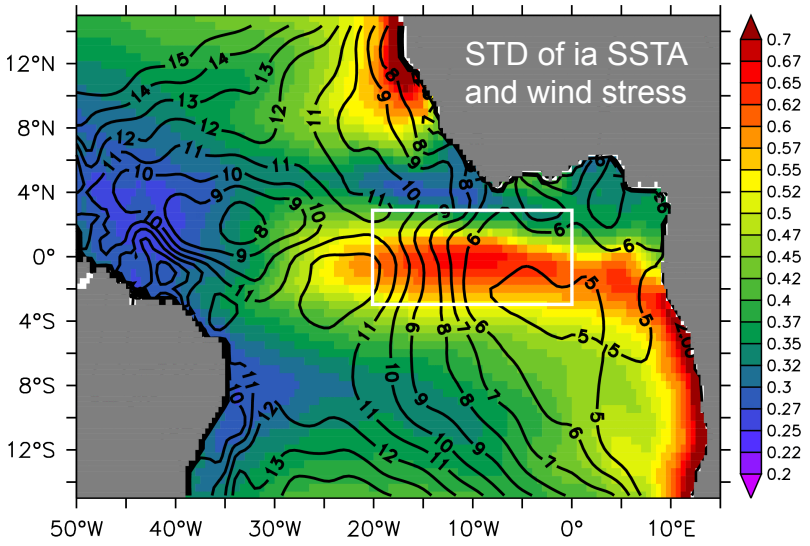
- Argued to be governed by atmosphere-ocean dynamics similar to those of ENSO:
  - Thermal damping
  - Bjerknes feedback:

  (1) SSTAs (E) drive τ_{an} (W)

  (2) τ_{an} (W) drive upwelling and thermocline depth (E)

  (3) Thermocline depth and upwelling an. result in local SSTAs

➢asymmetric as well?



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Data and Methods

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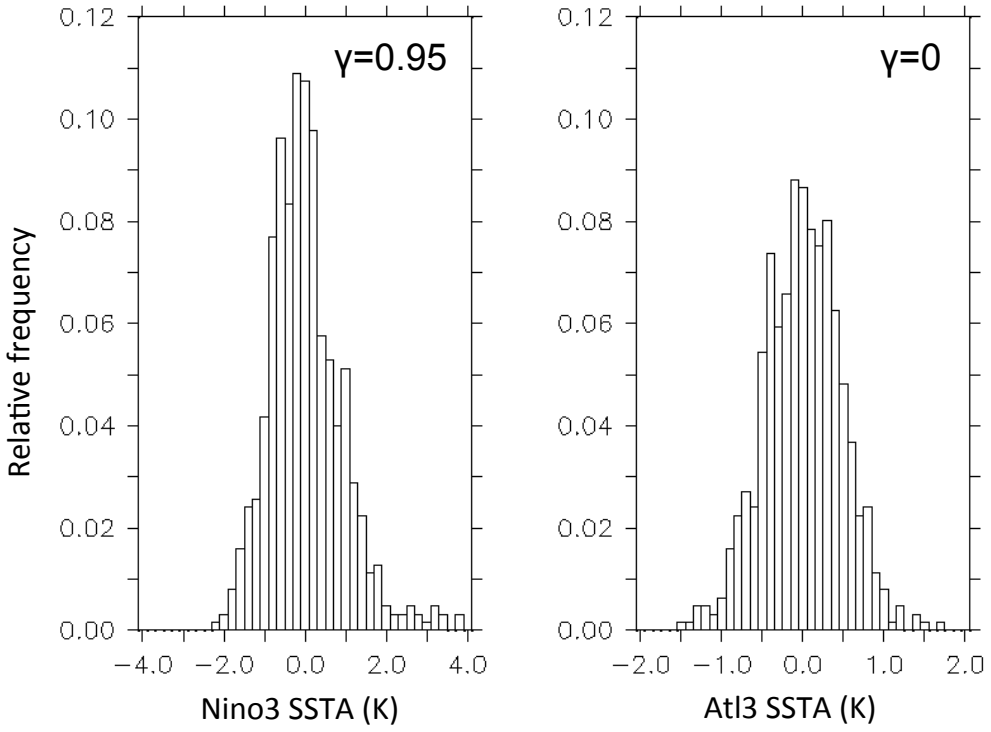
- Reanalysis products
  - ✧ ORA-S4
    - 1958 to 2009
    - forced with ERA-40 and ERA-Interim
    - 1º horizontal resolution
  - ✧ SODA2.2.4
- Composite analysis
  - 14 warm and 15 cold events
  - defined as years in which the detrended interannual Atl3 SST anomalies exceed 1 std for at least two months between May and September
- Bjerknes feedback components separately for warm and cold phases
  - focus on boreal summer months
  - compare to Pacific

Skewness

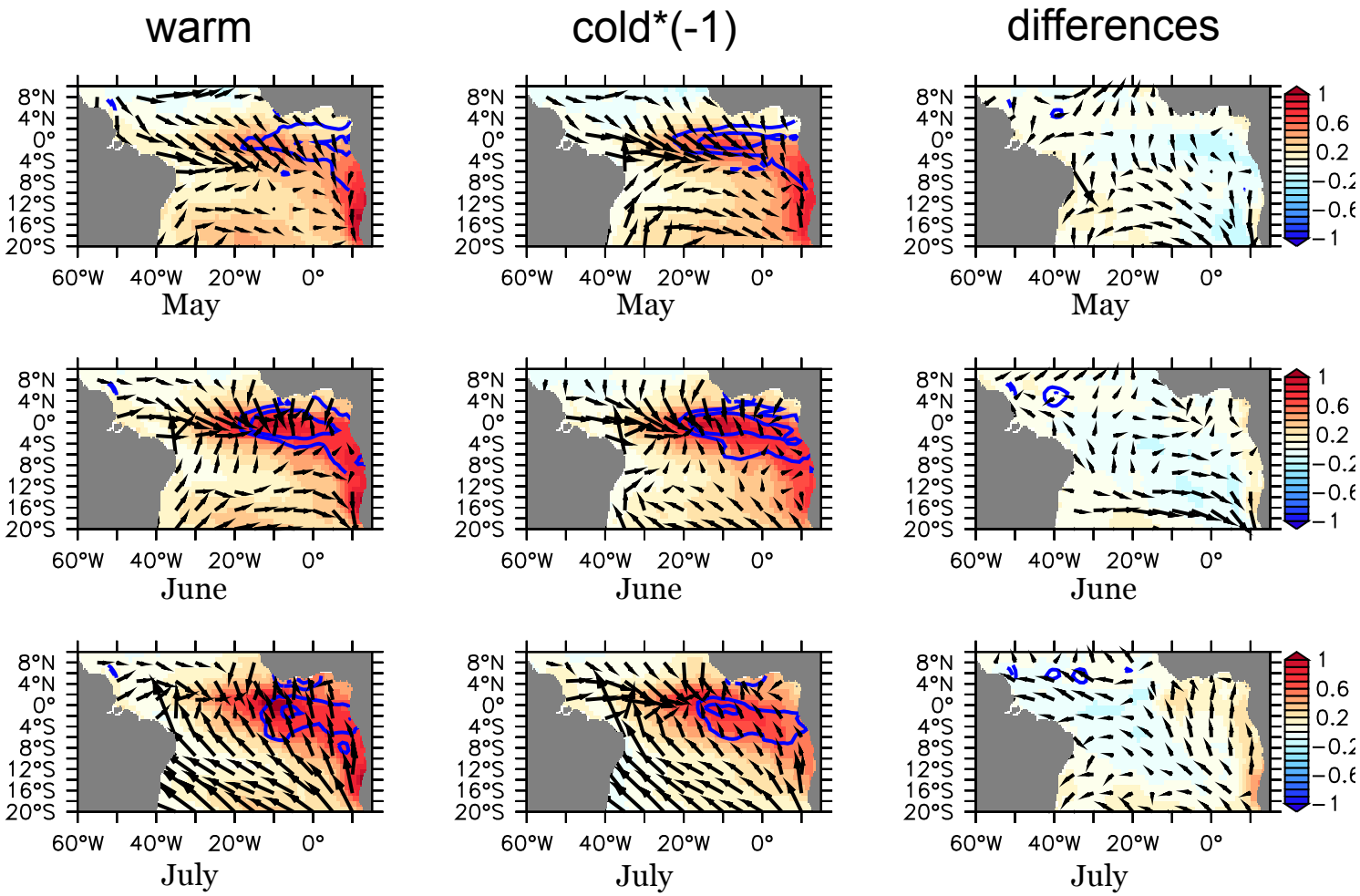


Frequency distribution for Nino3 and Atl3 SST anomalies from ORA-S4 for 1958 to 2009

Data set	Skewness Atl3 SSTA	Skewness Nino3 SSTA
ORA-S4	0.00	0.95
COBE SST2	0.00	0.85
ERSSTv3	-0.09	0.80
HadISST	0.00	0.93
KAPLAN	-0.12	0.82

- Atlantic Niño mode much more symmetric than Pacific ENSO in terms of amplitude

Composites



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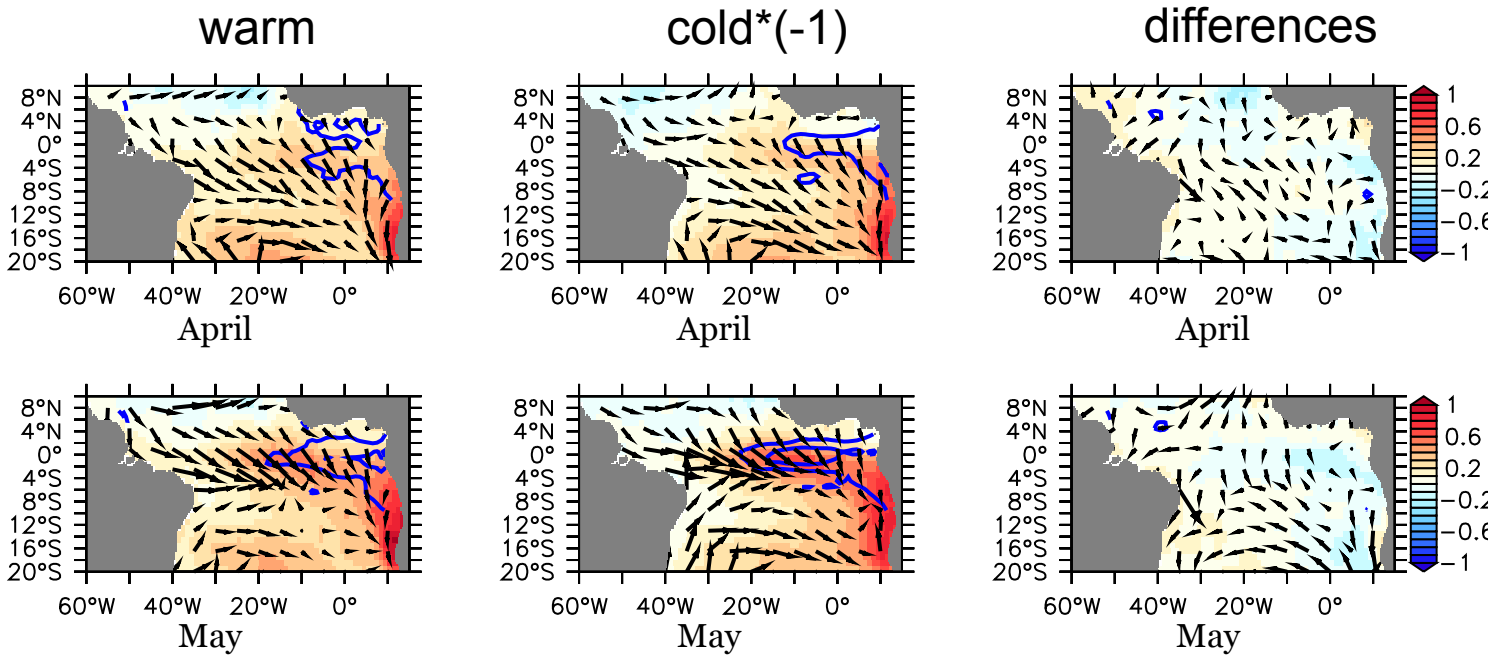
Onset of warm/cold events



- weaking/strengthening of trades
- SST anomaly first at African coast, then in eastern equatorial Atlantic
- accompanied by deepening/shoaling of thermocline

➢ symmetric in timing and amplitude

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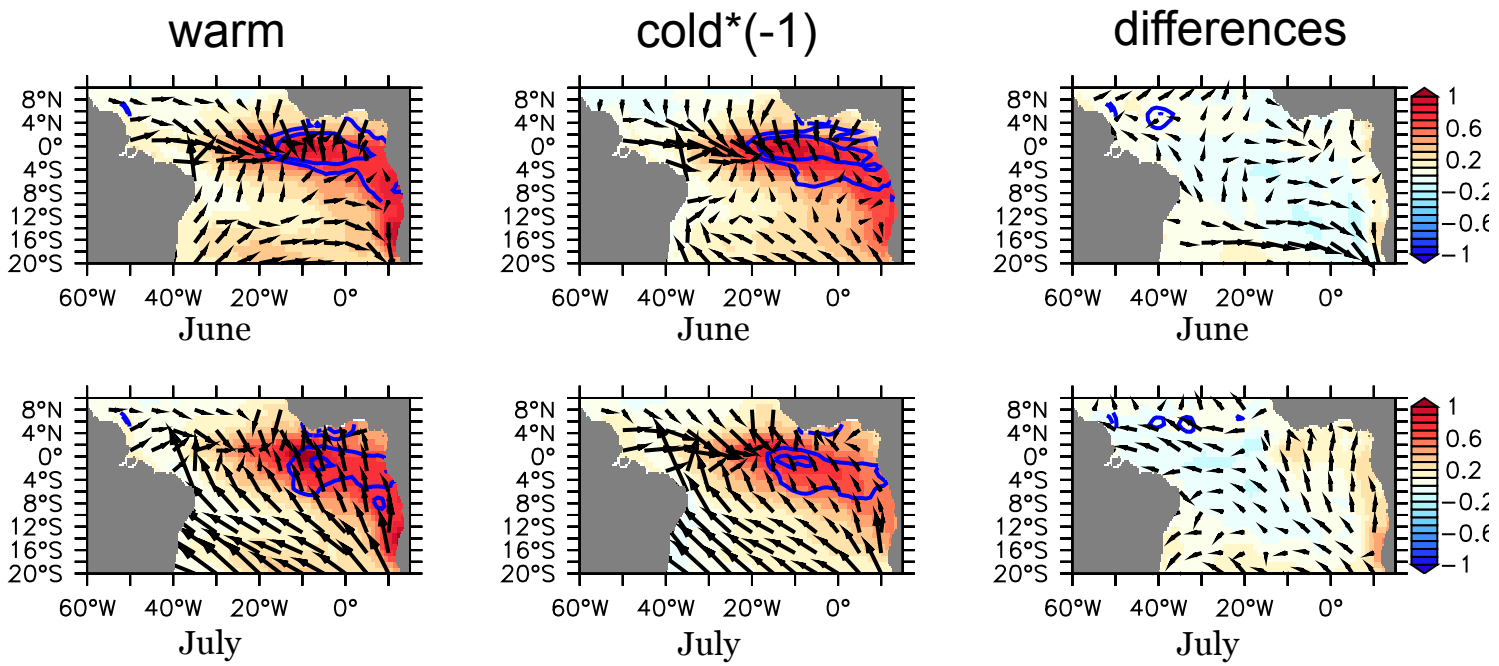
Peak of warm/cold events



- SST anomaly reaches peak in June
- accompanied by deepening/shoaling of thermocline

➢ symmetric in timing and amplitude

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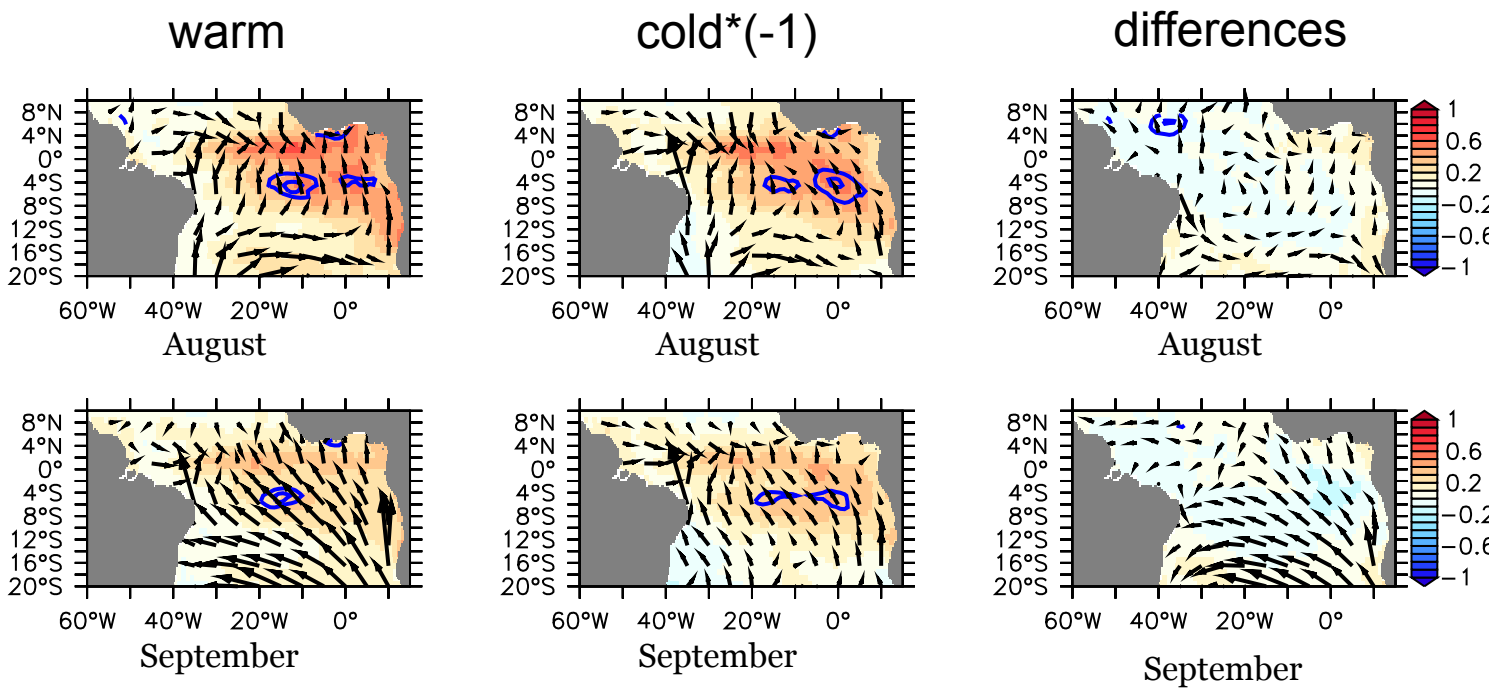
Decay of warm/cold events



- weaker wind anomalies, southerly/northerly in EEA
- SST anomaly decays

➢ symmetric in timing and amplitude

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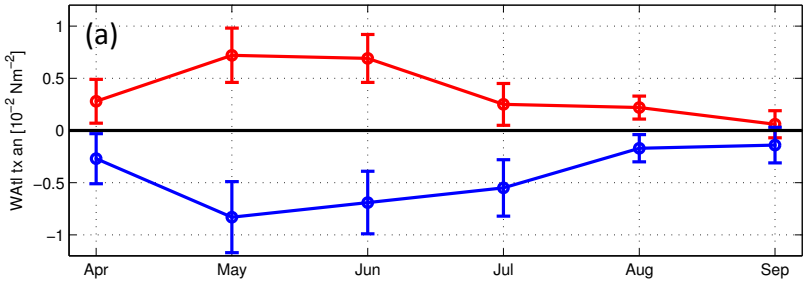
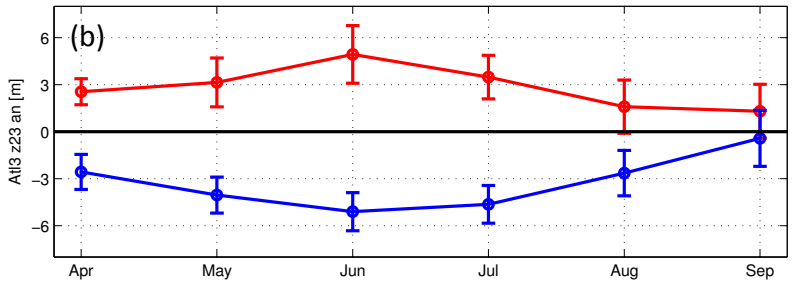
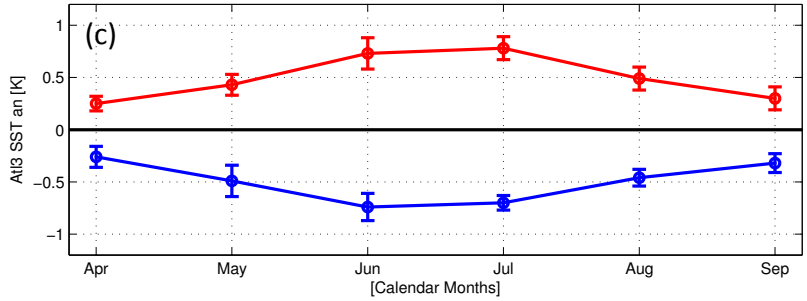
Composites



Western equatorial Atlantic zonal wind stress anomalies



Eastern equatorial Atlantic thermocline depth anomalies



Eastern equatorial Atlantic SST anomalies

Bjerknes feedback

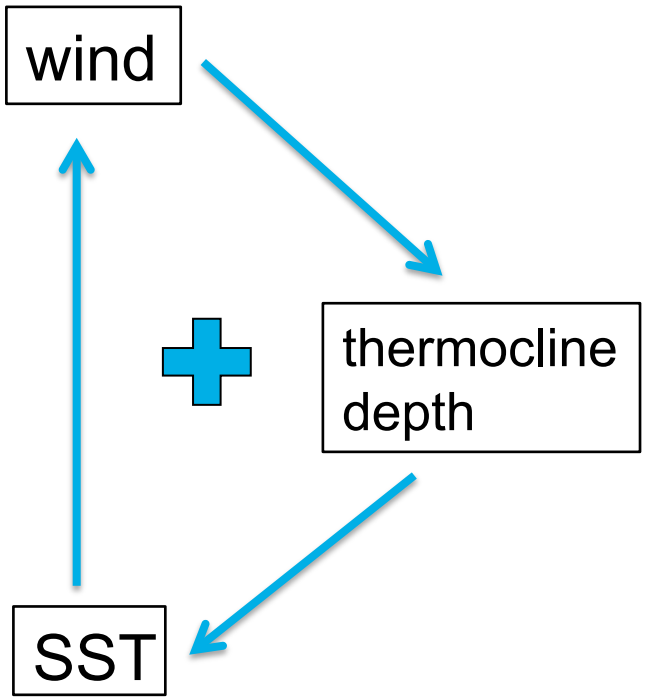
Why is the Atlantic Niño mode much more symmetric than ENSO?

➢ check symmetry of individual components of the Bjerknes feedback:

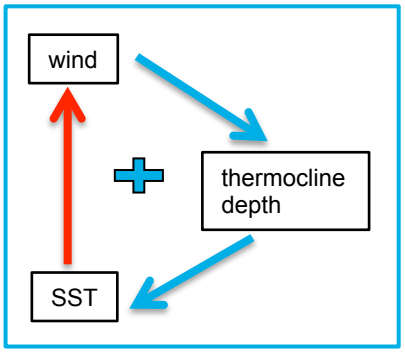
(1) SSTAs (E) drive τ_{an} (W)

(2) τ_{an} (W) drive upwelling and thermocline depth (E)

(3) Thermocline depth and upwelling an. result in local SSTAs

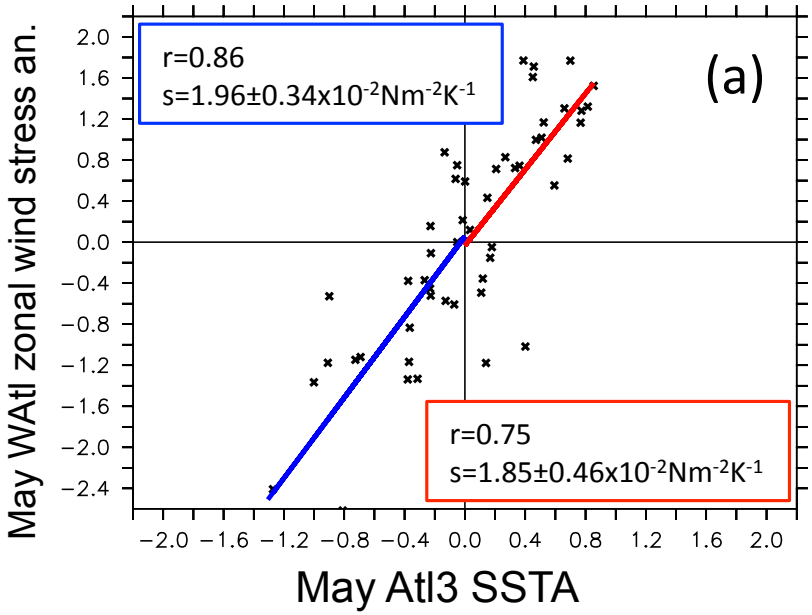


Bjerknes feedback

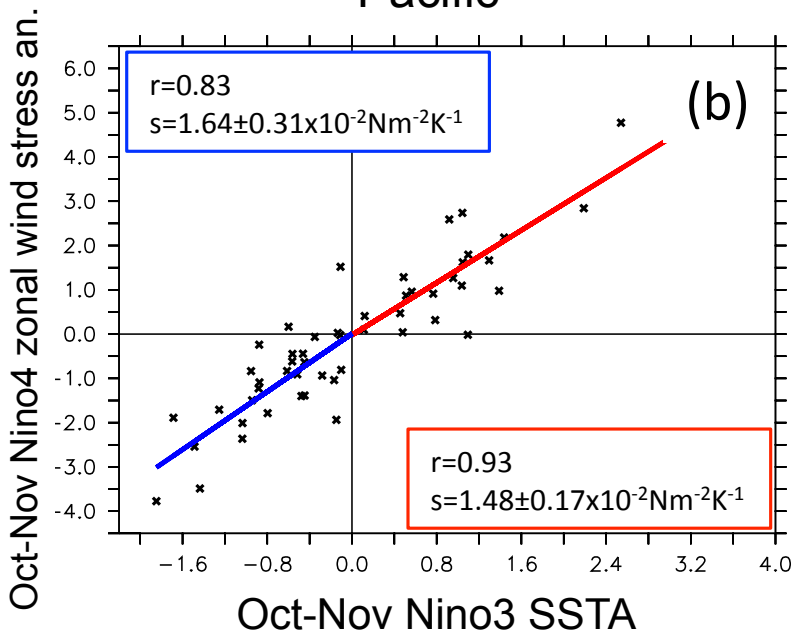


Relationship between eastern equatorial SST anomalies and western equatorial wind stress symmetrical for warm and cold SSTAs in both Atlantic and Pacific

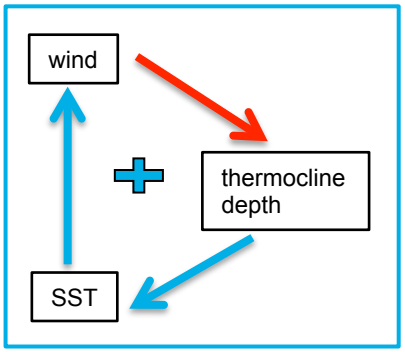
Atlantic



Pacific

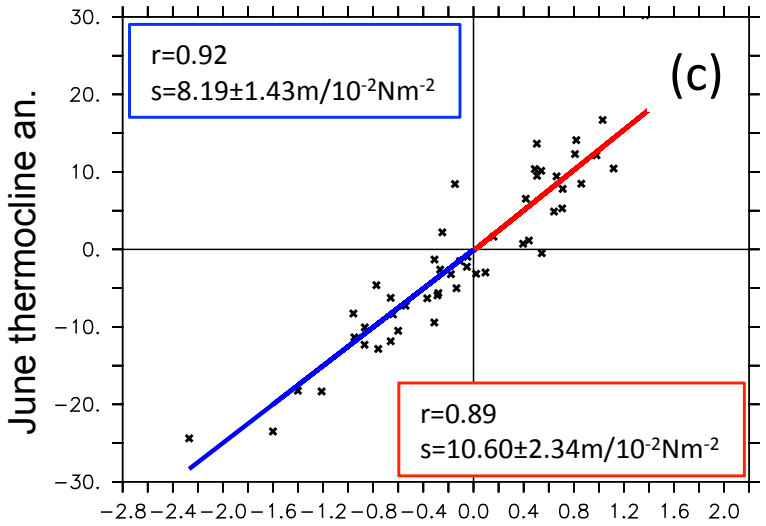


Bjerknes feedback

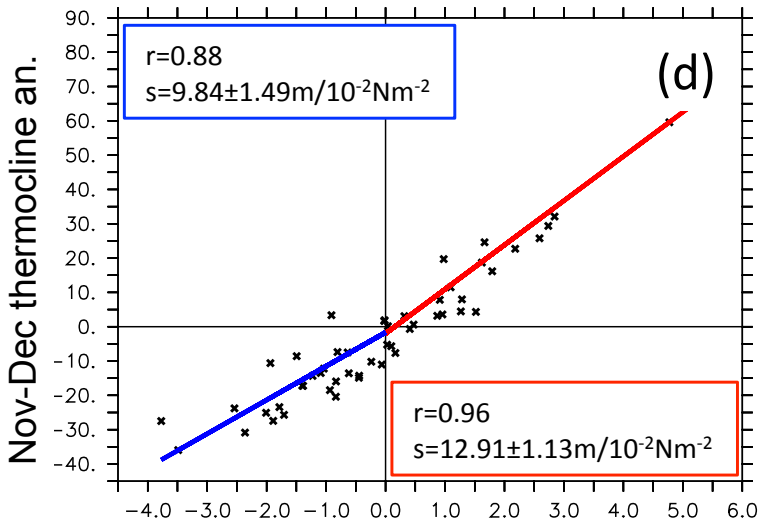


Relationship between western equatorial wind stress and equatorial thermocline slope symmetrical for Atlantic, slightly stronger for warm phase in Pacific

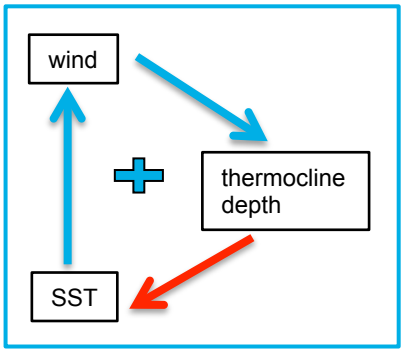
Atlantic



Pacific

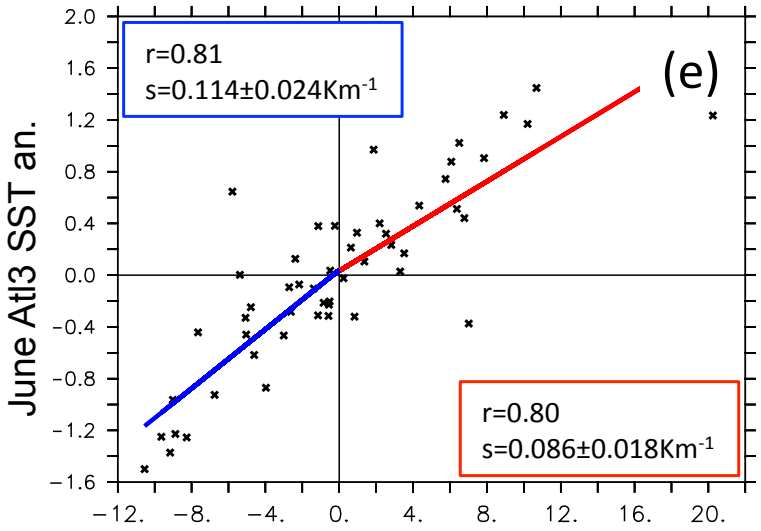


Bjerknes feedback

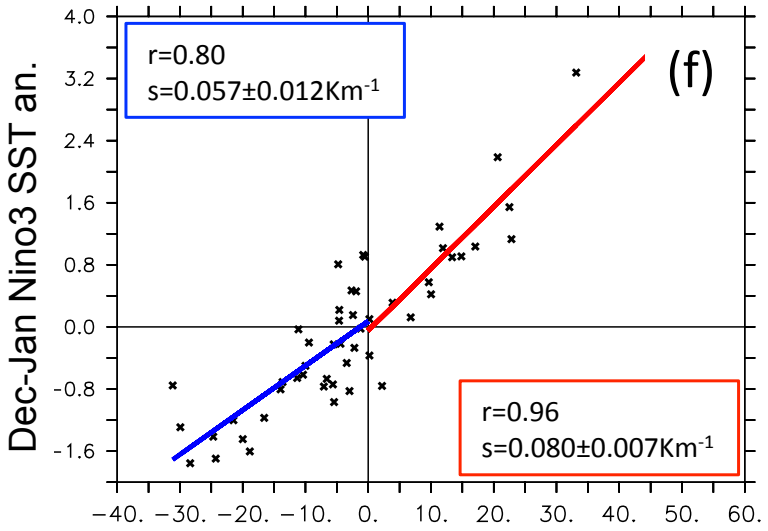


Relationship between eastern equatorial thermocline depth and SST anomalies symmetric for warm and cold SSTAs in Atlantic, but stronger response to deepening of thermocline in Pacific

Atlantic



Pacific



Conclusions

- Atlantic Niño mode much more symmetric than Pacific ENSO in terms of amplitude, timing and location of events

- Analysis of individual feedback terms suggests that all components are symmetric in the Atlantic while relationship between thermocline depth and SST anomalies stronger for warm events in Pacific

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Tropical Climate Variability and Teleconnections: past, present and future

Conveners: Joke Lübbecke, Belen Rodríguez de Fonseca , Irene Polo , Elsa Mohino , Fred Kucharski , Teresa Losada

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