PIRATA-24/TAV
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El Niño-Southern Oscillation Evolution Modulated by Atlantic Forcing

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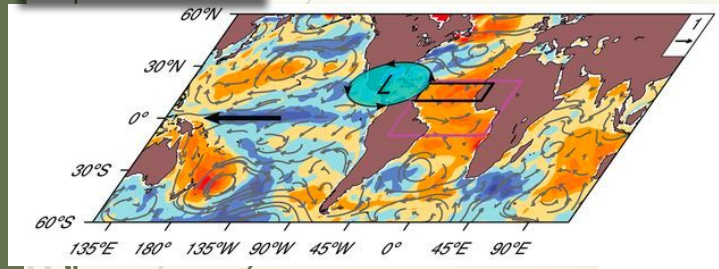
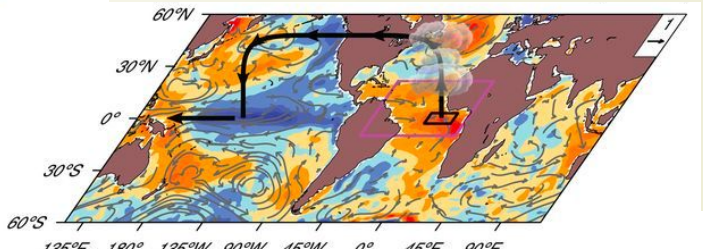
Which part of the Atlantic Ocean is most important for modulating the interannual ENSO evolution without seasonality and what is the mechanism?

MAM(0)

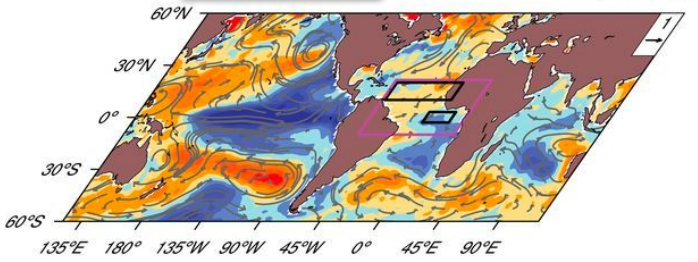


JJA(0)



Atlantic Niño:
(Ding et al., 2012; Keenlyside et al., 2013; Martín-Rey et al., 2014; Polo et al., 2015; Rodríguez-Fonseca et al., 2009)

DJF(1)



North tropical Atlantic:
(Ham, Kug, Park, & Jin, 2013; Ham, Kug, & Park, 2013; Wang et al., 2017)

Entire tropical Atlantic:
(Chikamoto et al., 2015; Kucharski et al., 2011, 2016; Li et al., 2015; McGregor et al., 2014; Ruprich-Robert et al., 2017)

Cai et al., (2019)

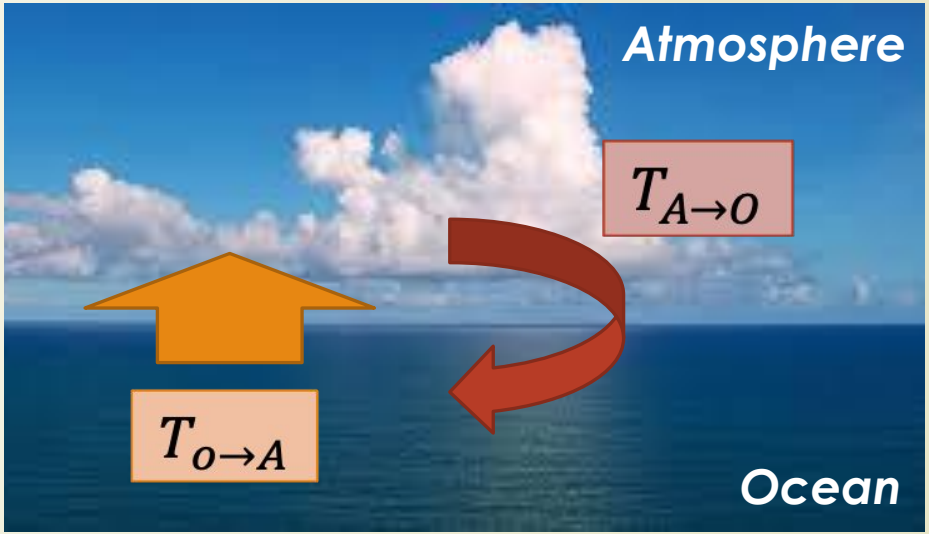
A problem in AMIP-type experiment

AMIP

$$T_{obs} = T_{o \to A}$$

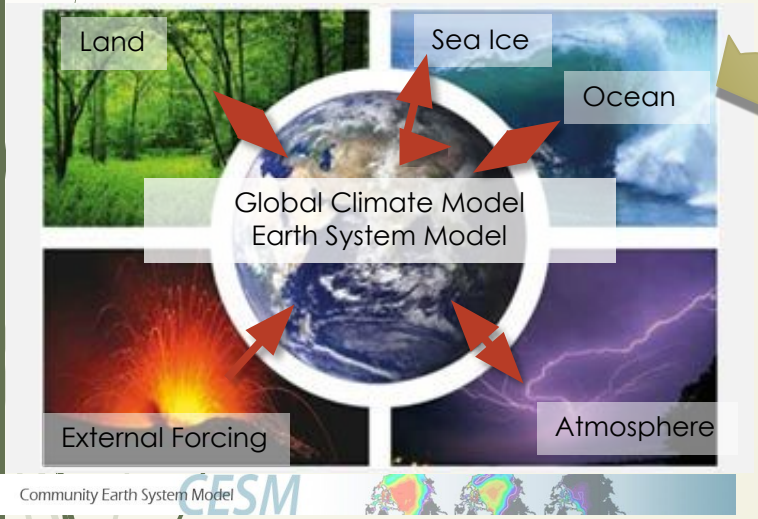
Reality

$$T_{obs} = T_{o \to A} + T_{A \to O}$$

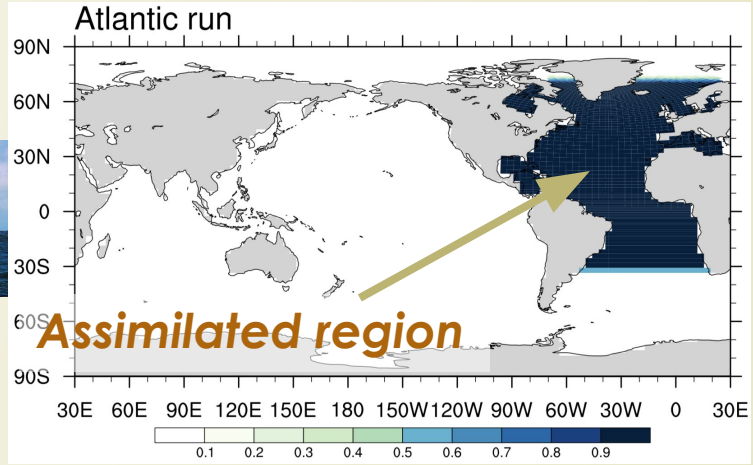


The ENSO evolution requires a fully coupled climate dynamics

Partial ocean assimilation approach



Ocean 3D T&S Assimilation

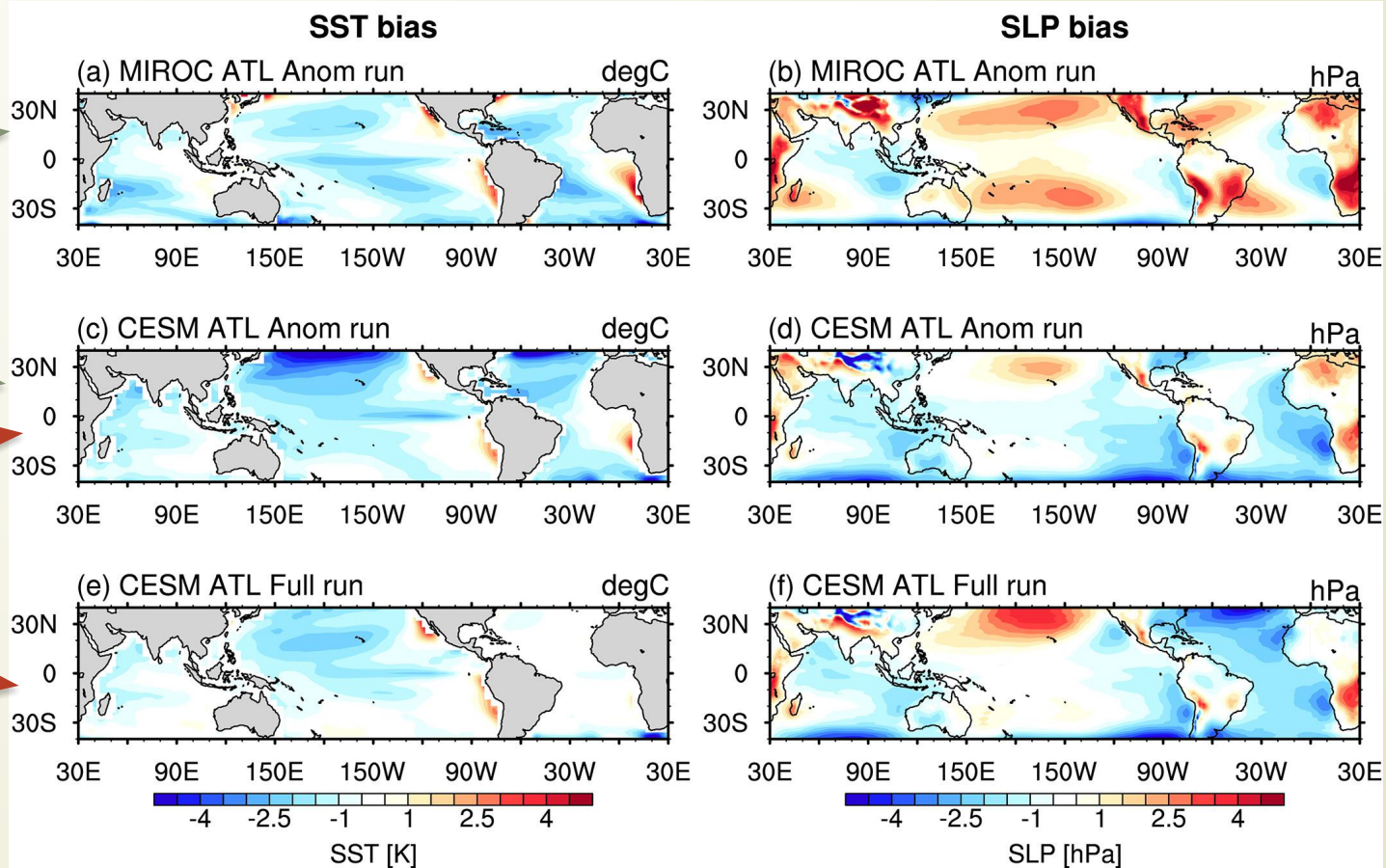


Name	Model	Method	Ocean OBS	Radiation	Ens	Period
MIROC ATL anomaly	MIROC3.2	Anomaly	JMA ProjD	Hist + A1B	10	1950-2009
CESM ATL anomaly	CESM1.0	Anomaly	ECMWF ORAS4	Hist + RCP4.5	10	1960-2014
CESM ATL full	CESM1.0	Full	ECMWF ORAS4	Hist + RCP4.5	10	1960-2014

Annual mean climatological biases

Model systematic error

Mean state bias



Atlantic precursors for ENSO evolution

Lag correlation of SST (shade) & SLP (contour) with Nino3.4 index

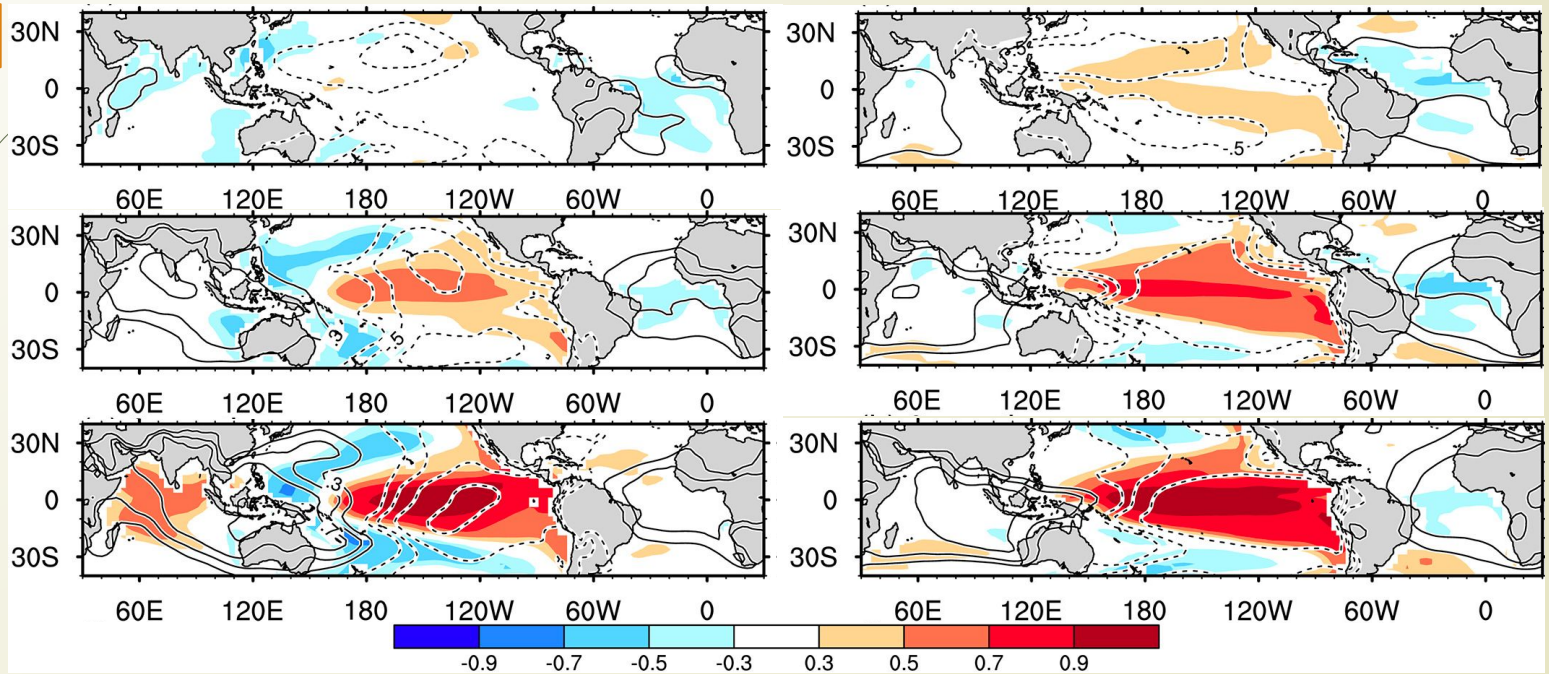
Observation

Multi-model

12-month before

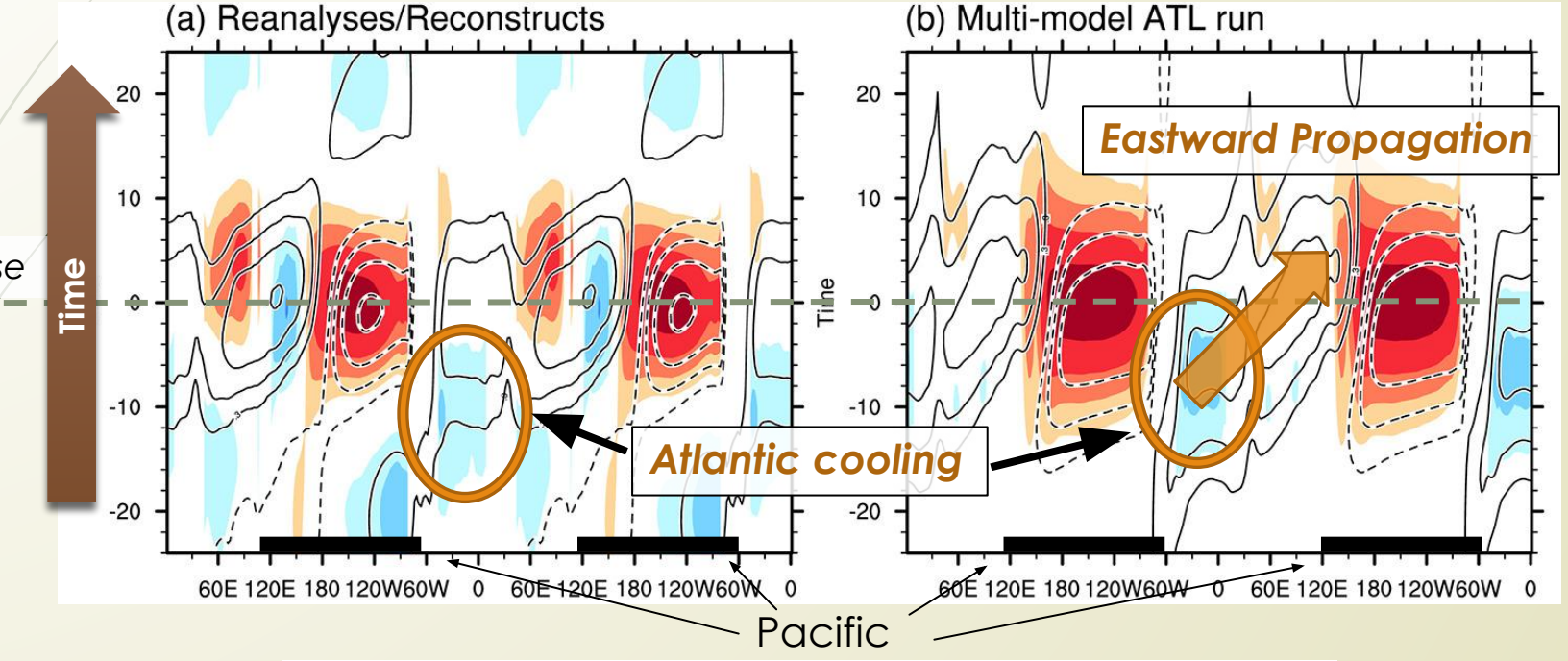
6-month before

Mature stage



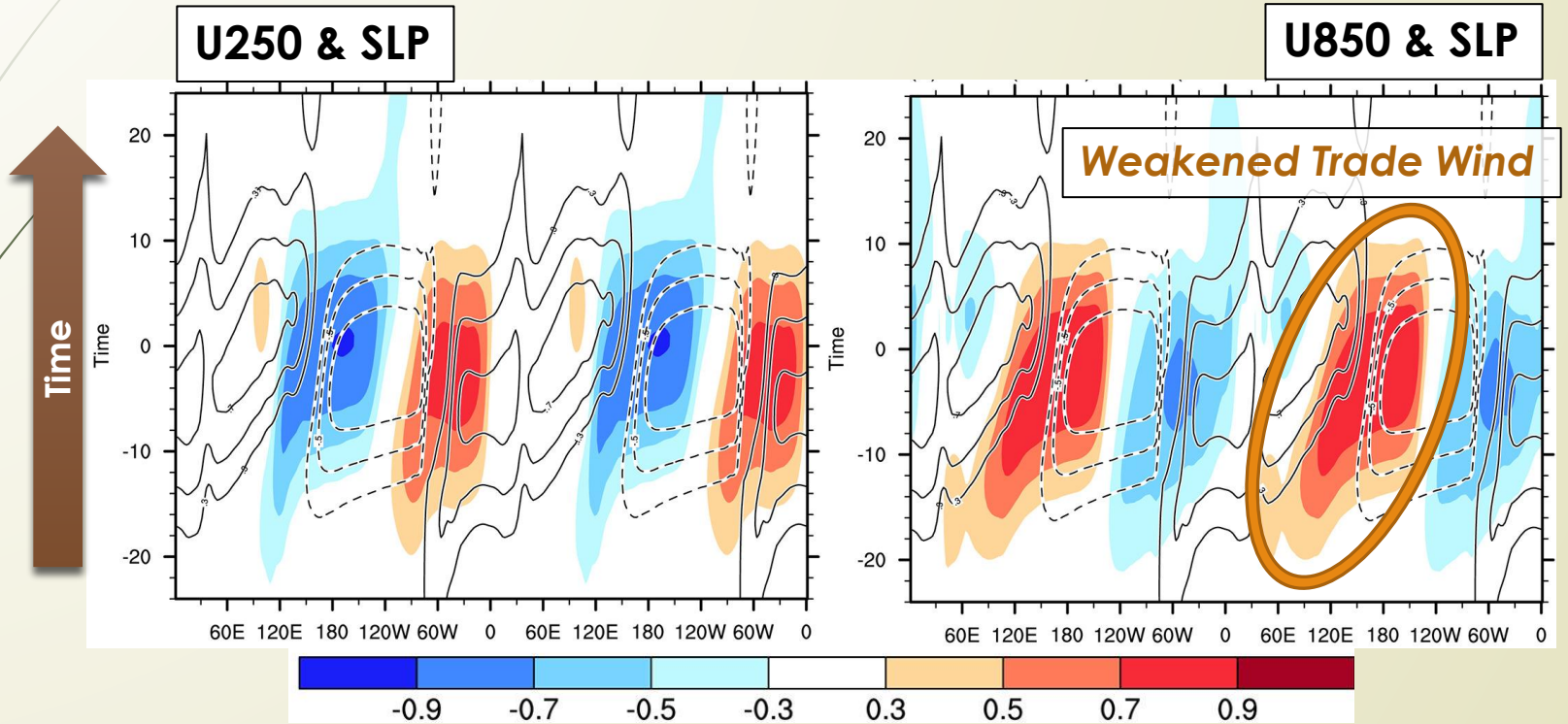
SSTA and SLPA evolutions at the equator

SST (shade) & SLP correlations (contour) with the Niño3.4 index



Upper and lower zonal winds in multi-Model

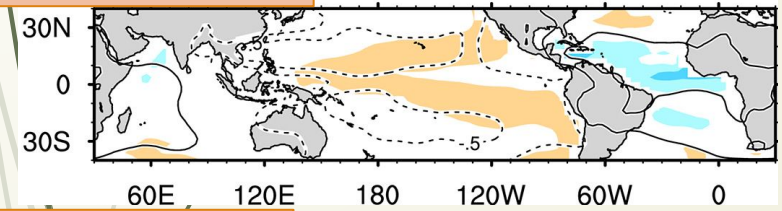
U250/U850 (shade) & SLP correlations (contour) with the Niño3.4 index



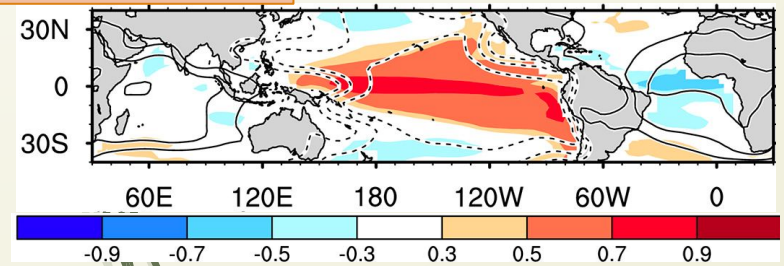
Schematic view of Atlantic impact

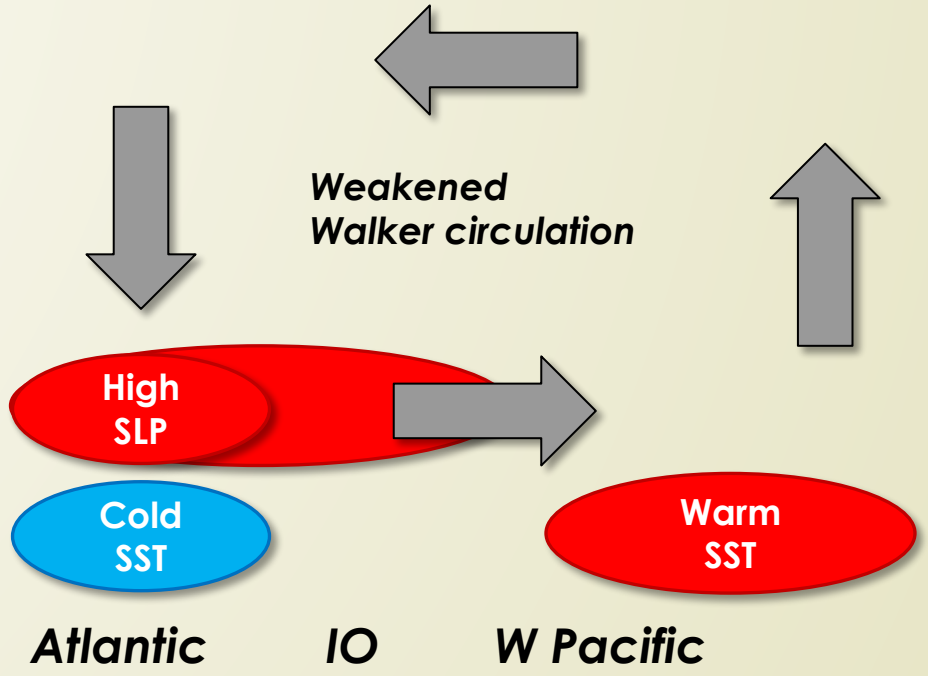
Multi-model

12-month before



6-month before





Atlantic SST

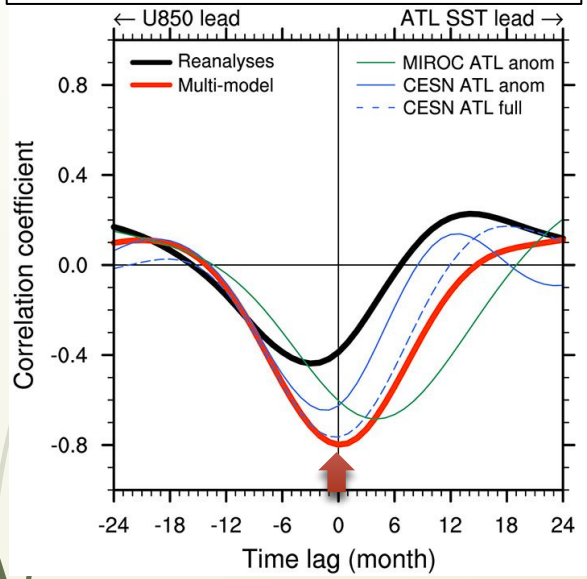
Trade wind

Nino3.4 index

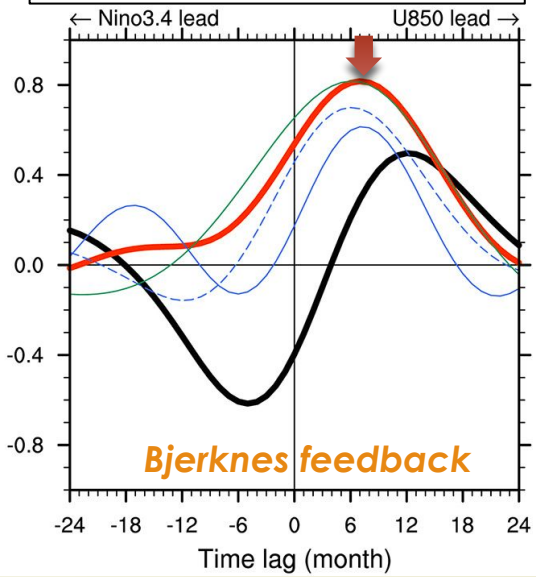
Timing for triggering the El Niño event

Lead-lag correlation

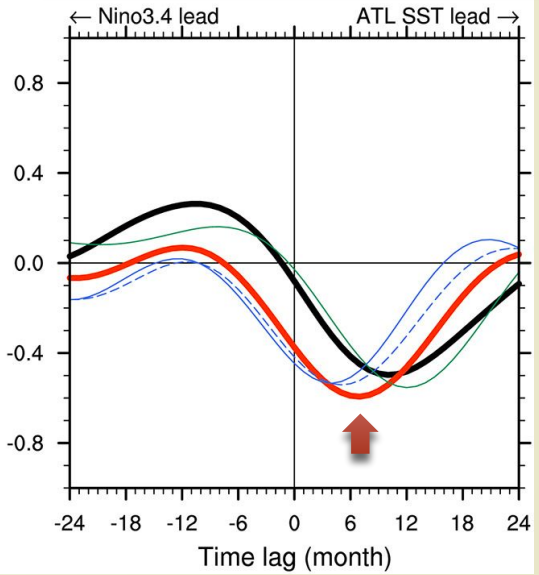
Atlantic SST vs Trade Wind



Trade Wind vs Nino3.4



Atlantic SST vs Nino3.4



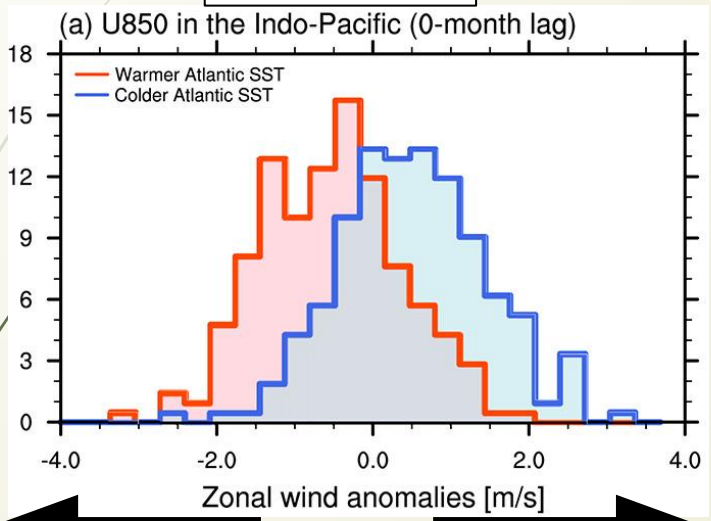
Simultaneously

7-month later

Equatorial Atlantic SST cooling ⇨ **weakened trade winds** ⇨ **El Niño**

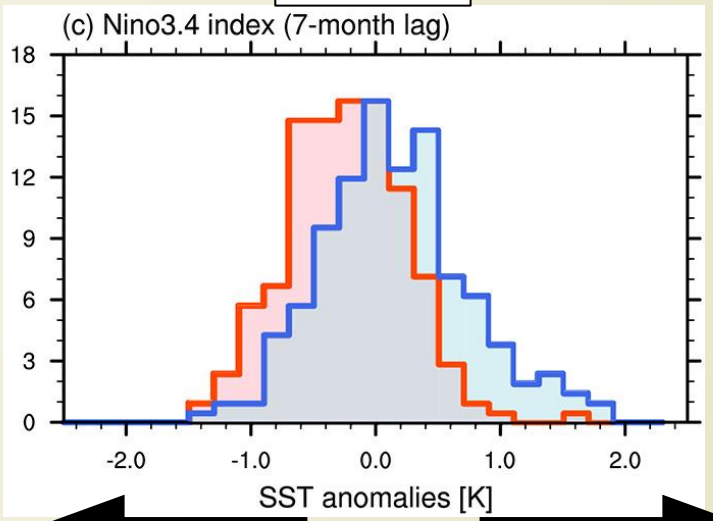
Histogram of ensemble members

Trade Wind



Strengthened ***Weakened***

Nino3.4



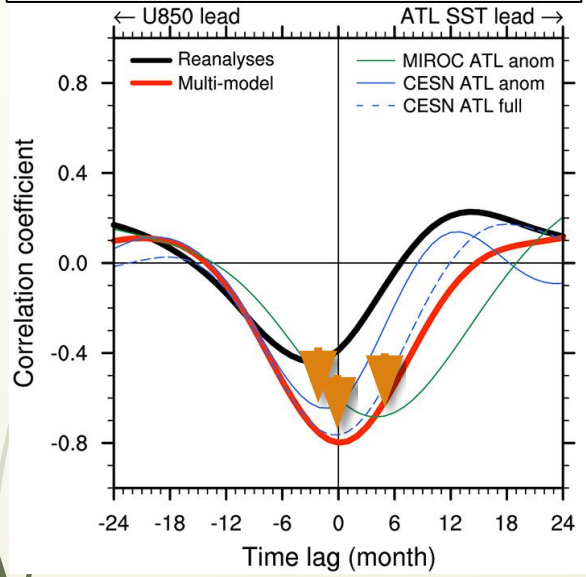
La Niña ***El Niño***

210 samplings (=7 years x 3 systems x 10 members)

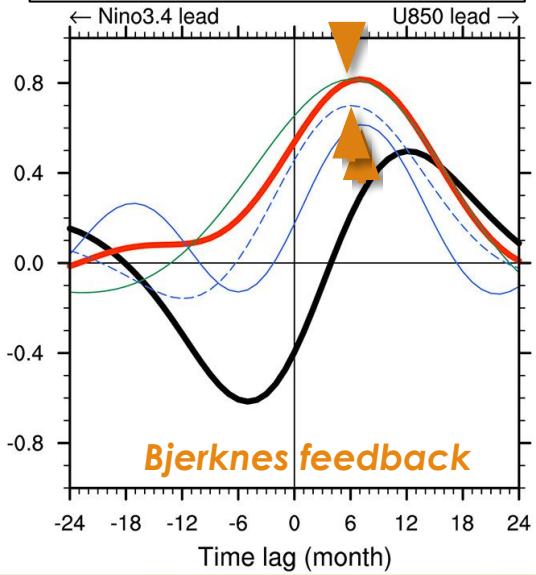
Timing for triggering the El Niño event

Lead-lag correlation

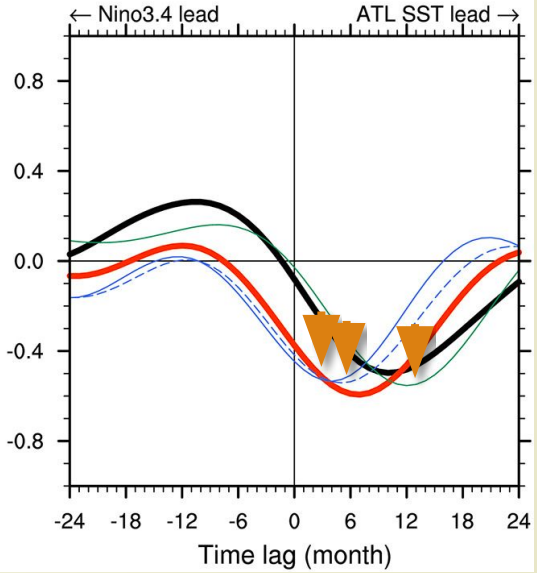
Atlantic SST vs Trade Wind



Trade Wind vs Nino3.4



Atlantic SST vs Nino3.4



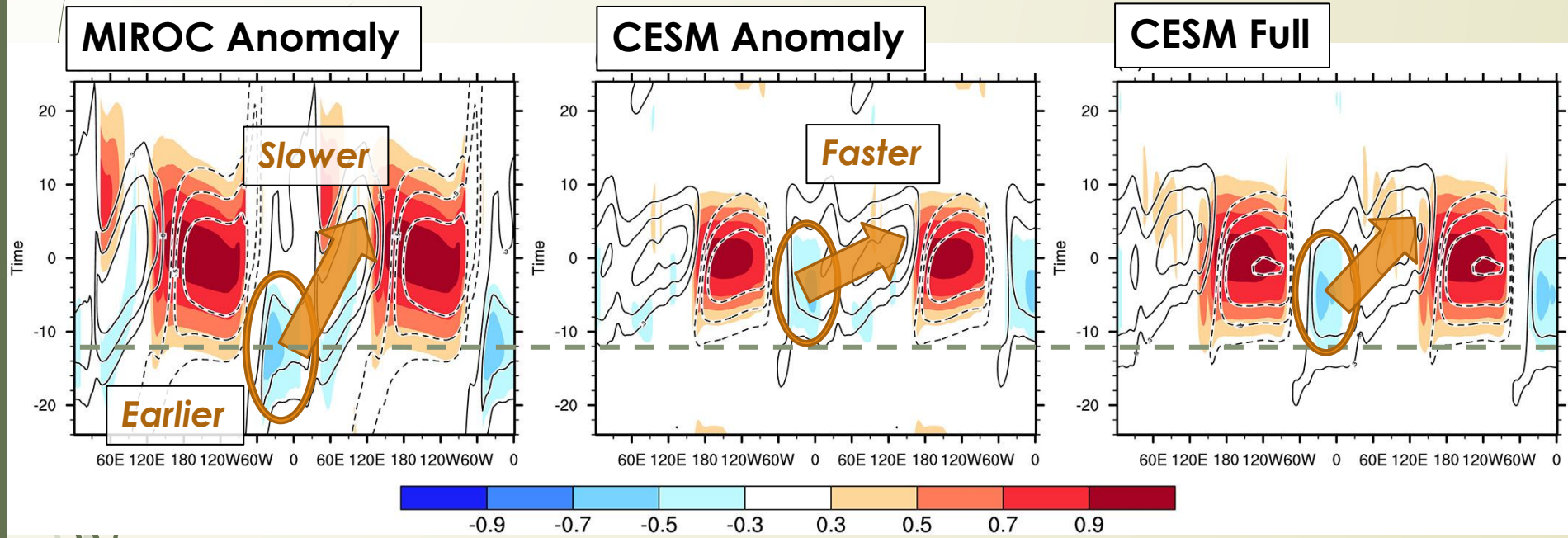
Simultaneously

7-month later

Equatorial Atlantic SST cooling ⇨ **weakened trade winds** ⇨ **El Niño**

Timing of trade wind response shows model sensitivity

Model sensitivity: SST(shade) & SLP(contour)



Model sensitivity originates from the timing of Atlantic cooling and the eastward propagation speed

Conclusions

- Our multi-model ensemble shows that the **equatorial Atlantic** plays an important role for activating ENSO dynamics.
- The Atlantic cooling (warming) causes weakened (strengthened) trade wind simultaneously and then triggers an El Niño (La Niña) event 7-month later.
- The model sensitivity is small in Bjerknes feedback but large in the timing of trade wind response.

Implication in our research

Improving the Tropical Atlantic Observing System contributes to

- enhancing climate predictability not only in the tropical Atlantic but also in the tropical Pacific
- improving performance of model climate simulation
- advancing our understanding of climate dynamics.

Thank you!

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RESEARCH ARTICLE
10.1029/2020JC016318

Key Points:

- Model runs show that equatorial Atlantic warming (cooling) triggers subsequent tropical Pacific cooling (warming) 7 months later
- Pacific wind-SST feedbacks are robust on ENSO timescales, but model sensitivity is large in Pacific wind response to Atlantic forcing

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