

Emergence of an equatorial mode of climate variability in the Indian Ocean under altered mean states

Martin Puy¹, P. DiNezio¹, Kaustubh Thirumalai²

CVCWG Winter Meeting
February 27th, 2019

¹U. of Texas Institute for Geophysics, ²Brown University



An Indian Ocean El Niño

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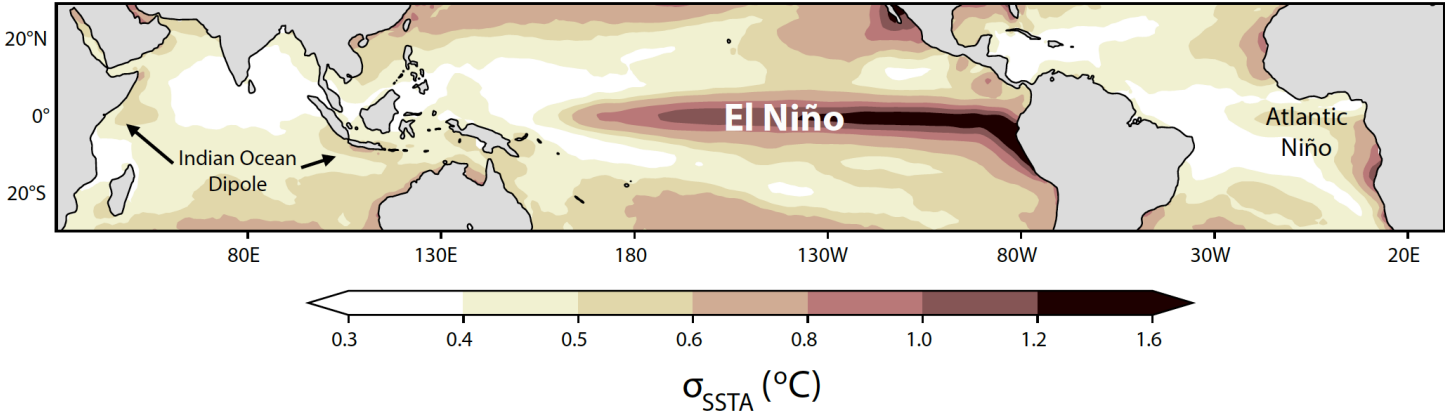
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Modern climate of the tropical oceans

a

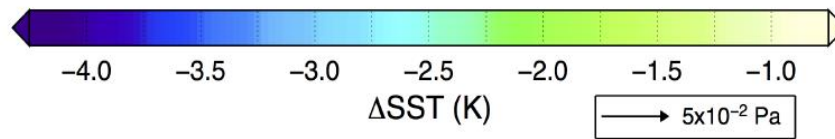
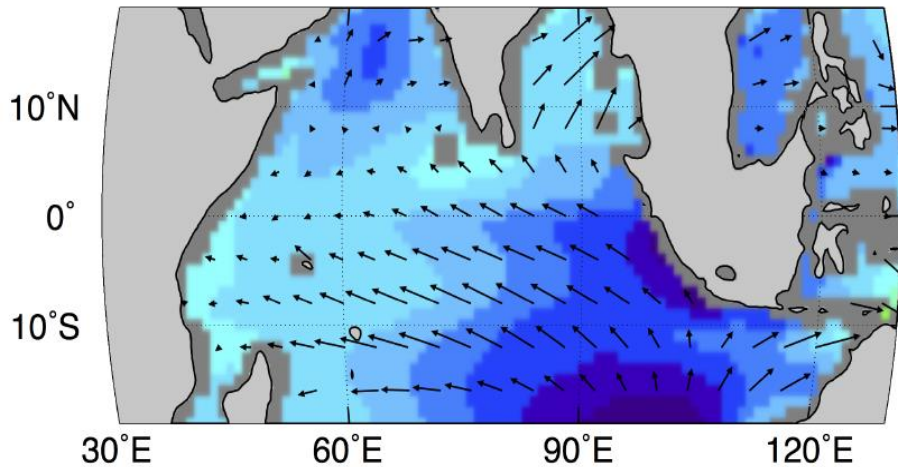
sea-surface temperature variability



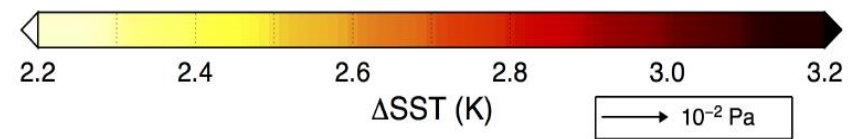
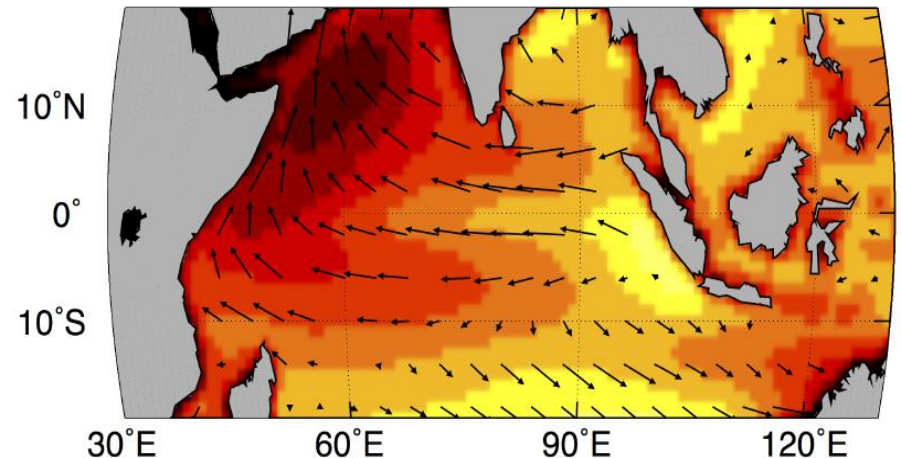
Past and future mean states conducive for stronger variability in the IO?

Last Glacial Maximum

Future



CESM1



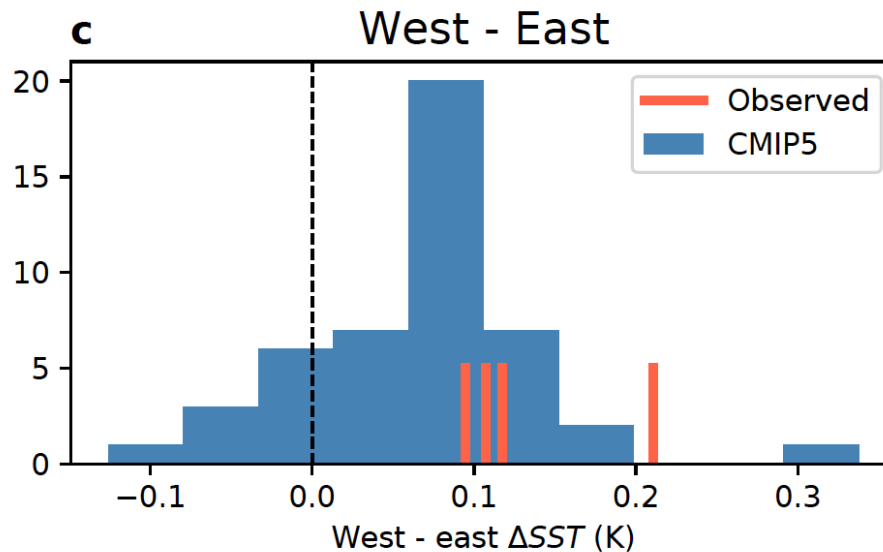
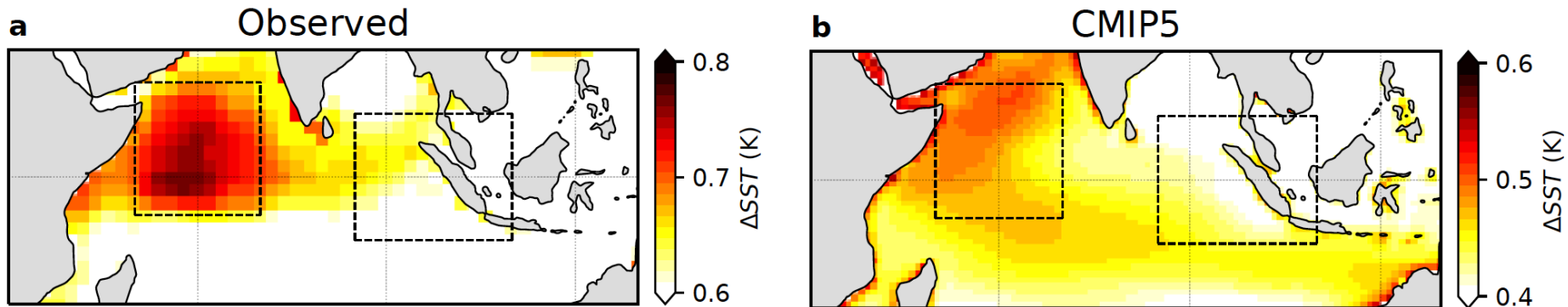
CMIP5

RCP8.5 scenario
Multi-model mean

CMIP5 projections supported by historical observations

SST change

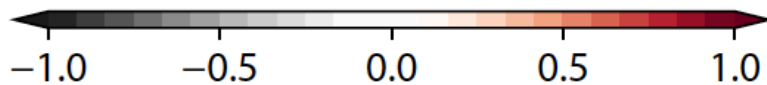
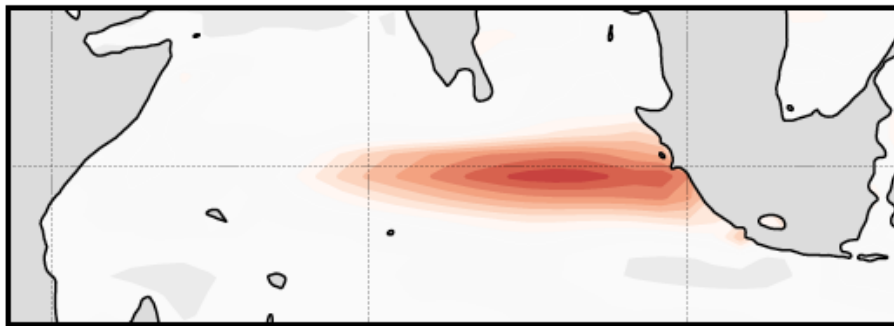
1980-2017 epoch minus 1901-1950 epoch



Both mean states are conducive for stronger equatorial SST variability

Change in SST variability July-August-September

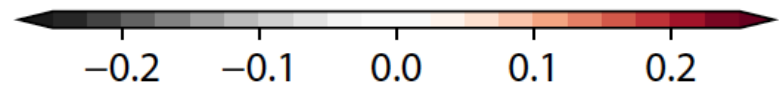
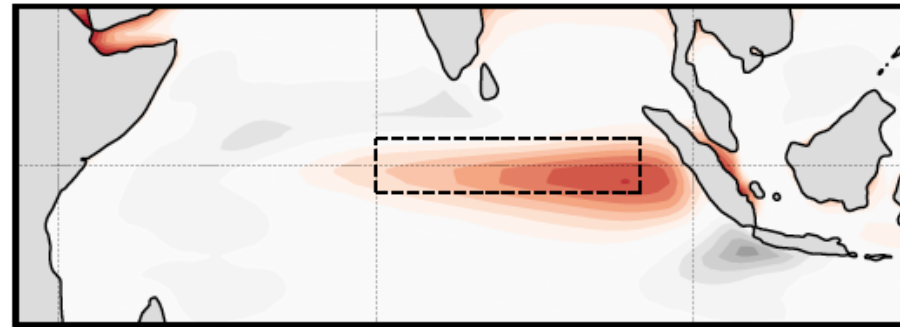
Last Glacial Maximum



$\Delta\sigma_{SST}$ (K)

CESM1
LGM

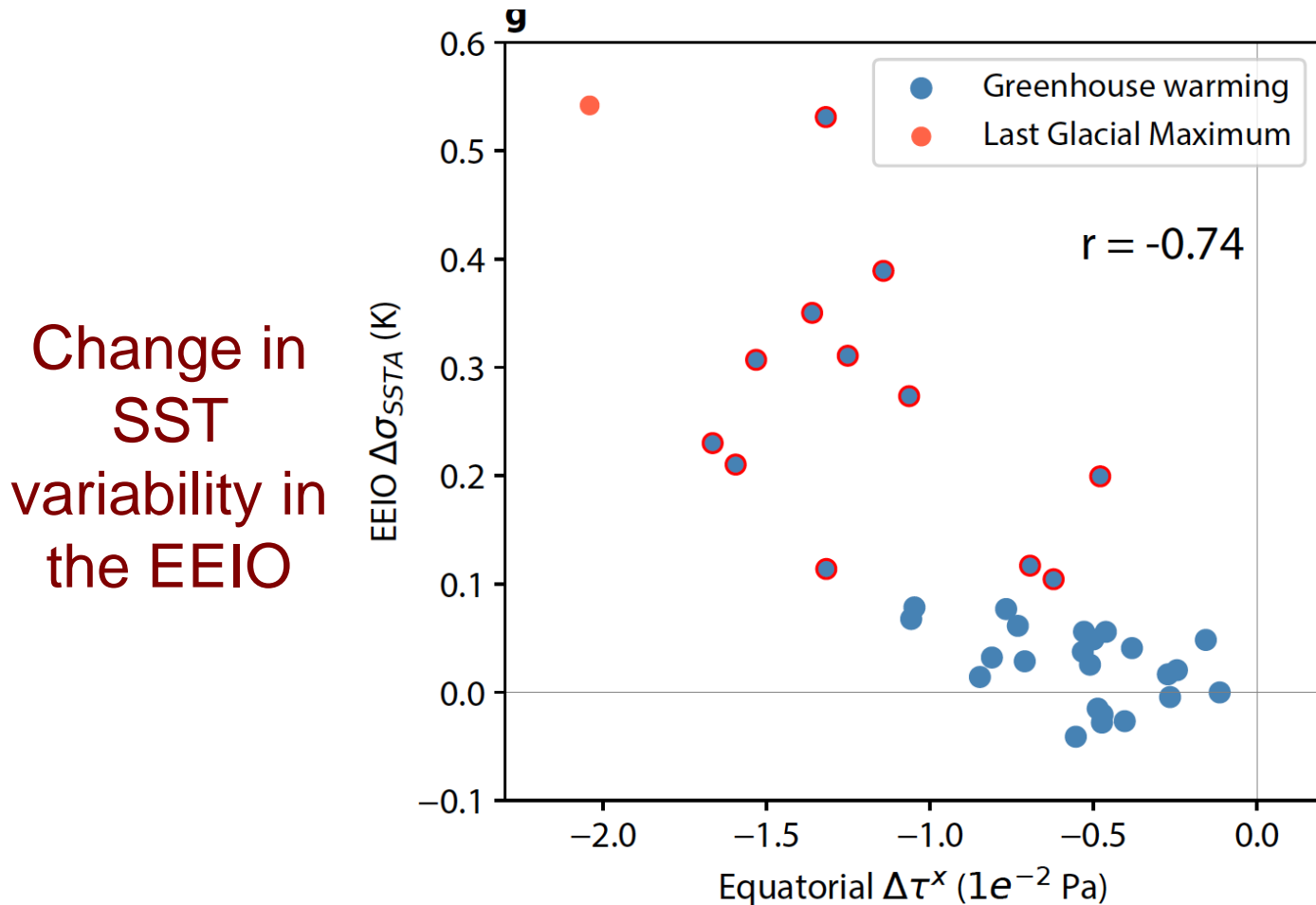
Future



$\Delta\sigma_{SST}$ (K)

CMIP5
RCP8.5 scenario
Multi-model mean

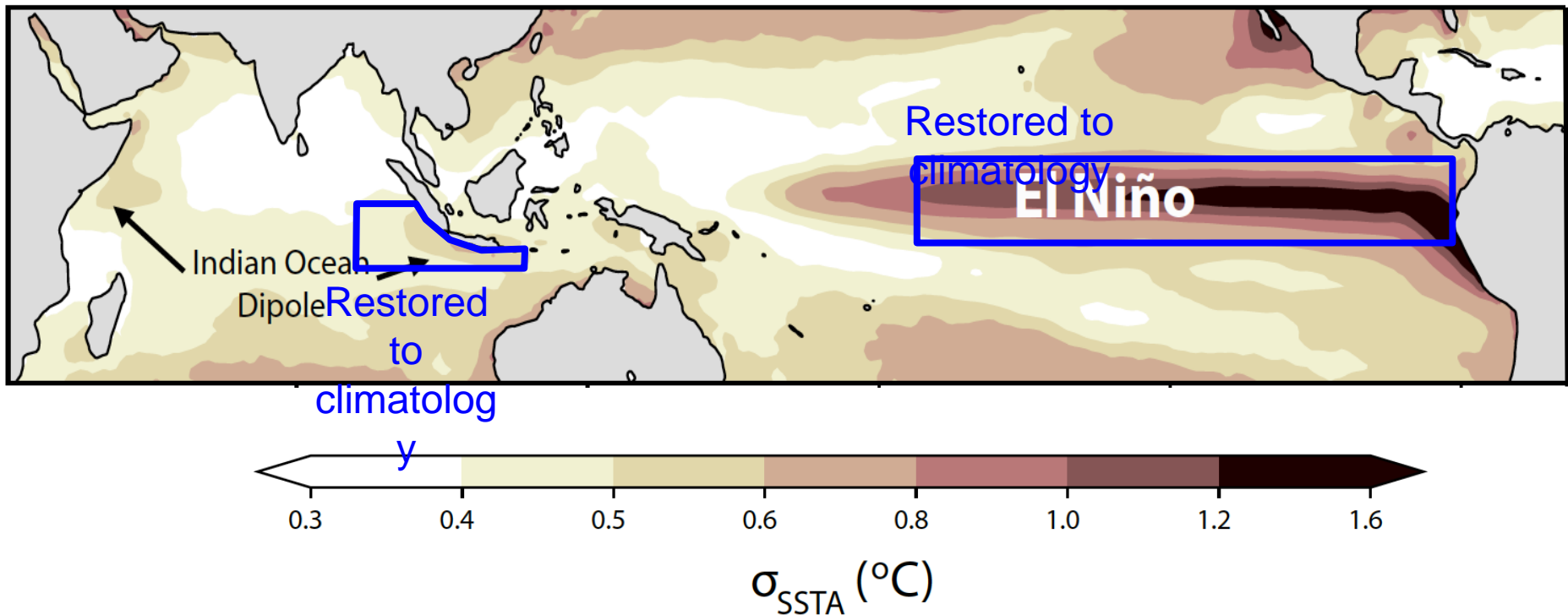
Consistent link between changes in mean state and variability among models



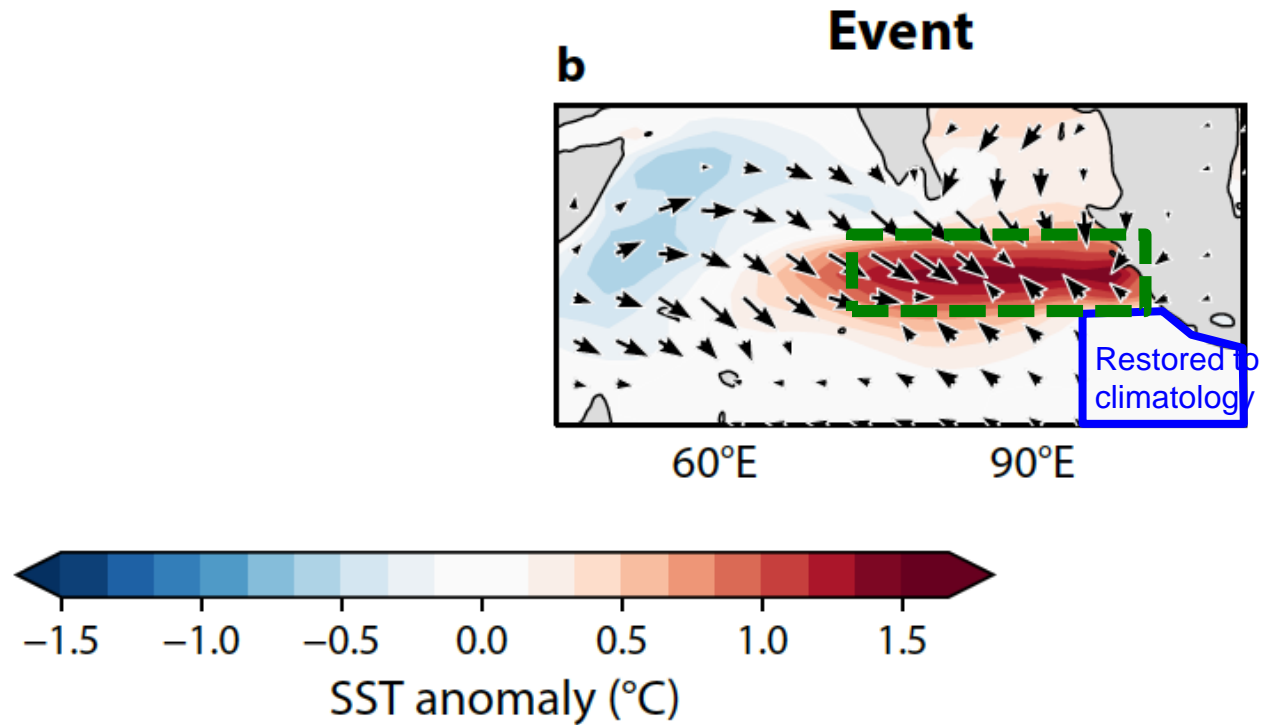
Change in surface wind stress along the equator

Additional LGM simulations:

- **ENSO disabled**
- **ENSO and IOD disabled**

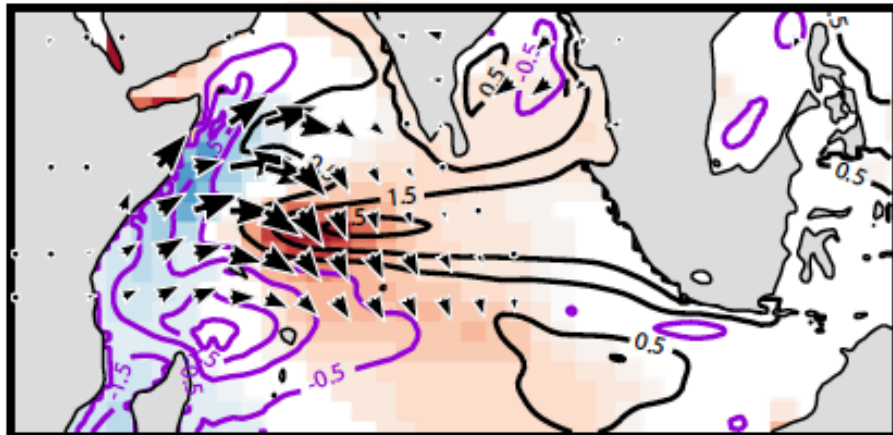


Equatorial variability independent from ENSO and IOD

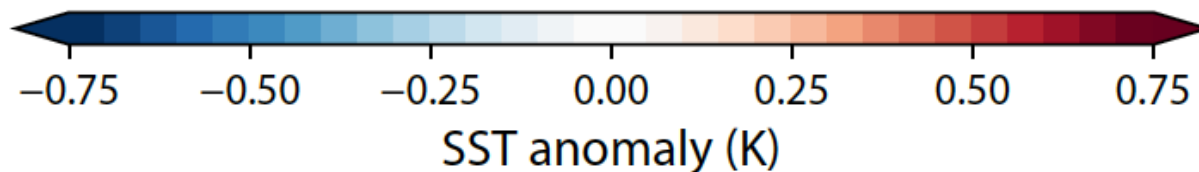
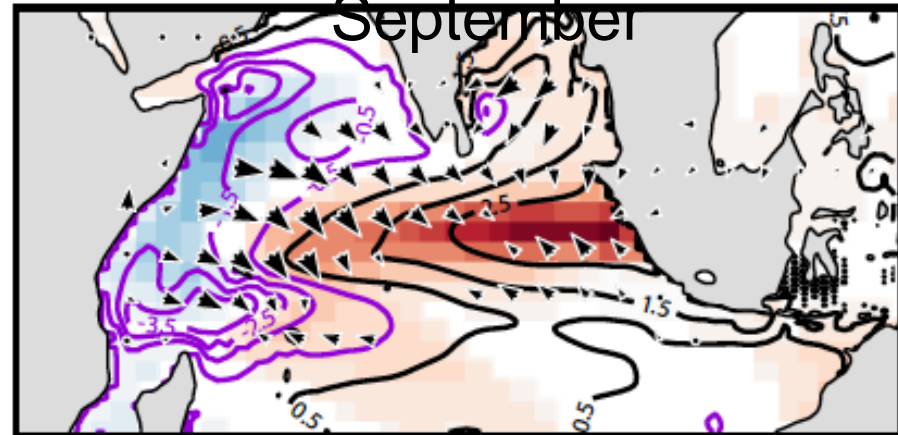


Dynamics of equatorial mode resembling El Niño

Precursor
April-May-June



Event peak
July-August-
September



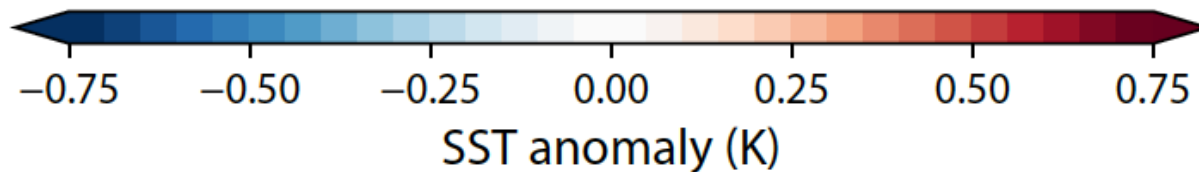
Composite event based on peak SSTA over the eastern equatorial IO from CESM1 LGM run with ENDO and IOD disabled

Equatorial mode currently inactive

Precursor
April-May-June



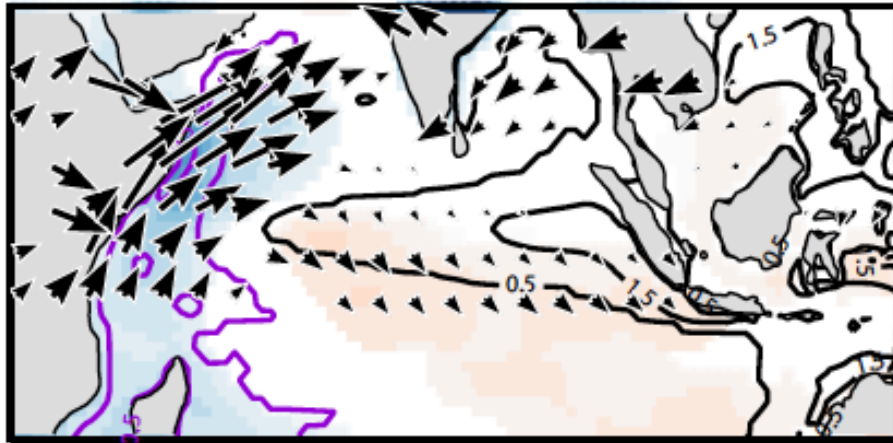
Event peak
July-August-
September



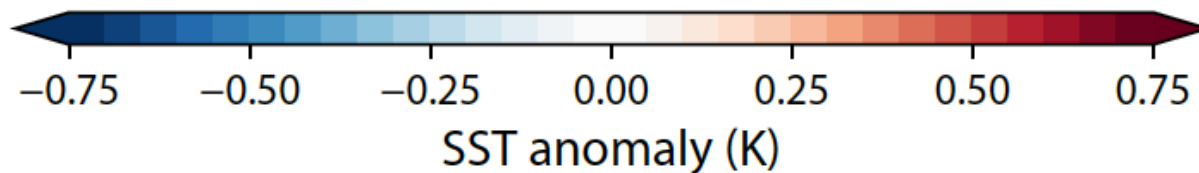
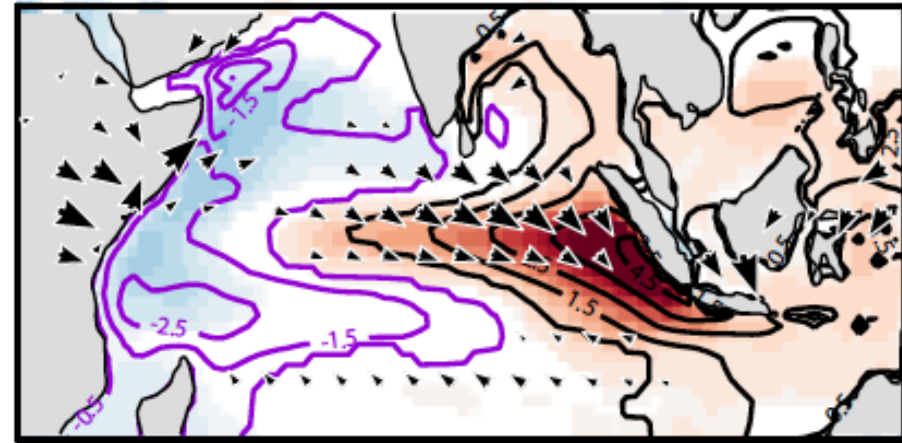
Composite event based on western IO zonal wind precursor from ERA40 reanalysis. Thermocline depth anomalies from OBAS4 ocean reanalysis

Equatorial mode also active under greenhouse warming

Precursor
April-May-June



Event peak
July-August-

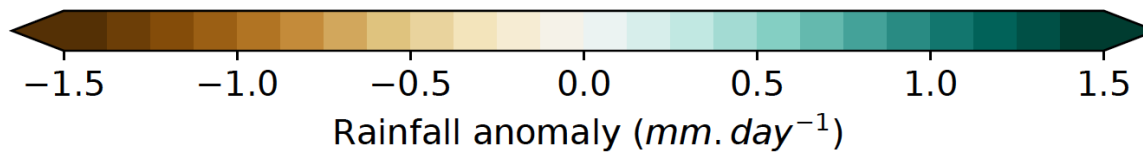
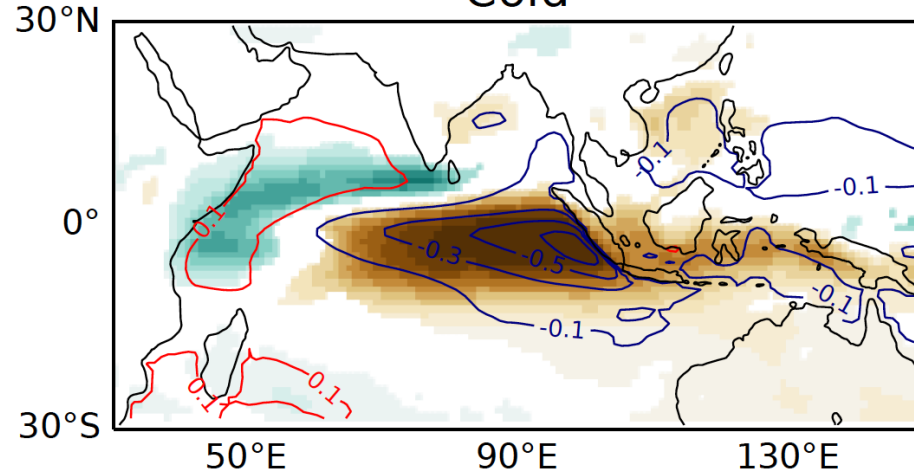
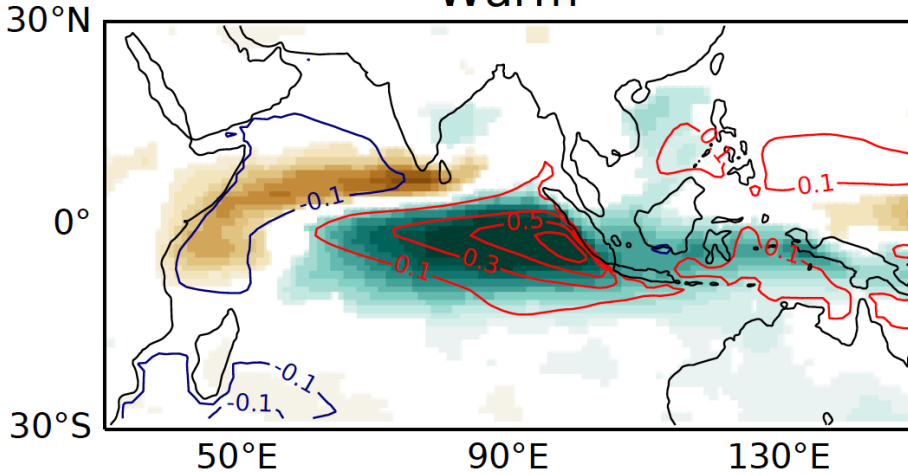


Composite event based on western IO zonal wind precursor in RCP8.5 climate (2050-2100) from a subset of CMIP5 models.

Rainfall impacts

Warm

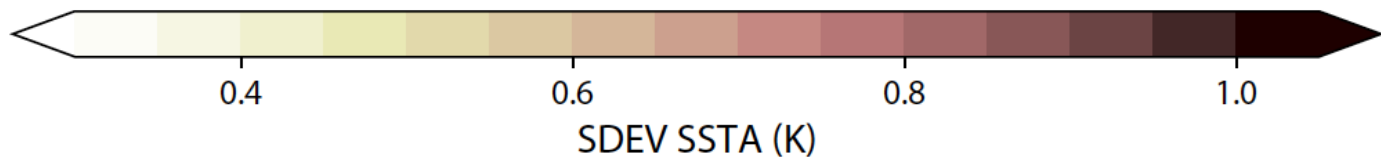
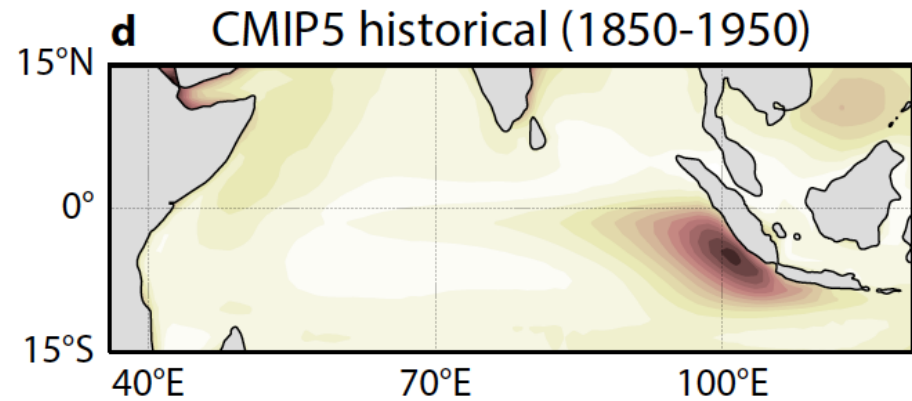
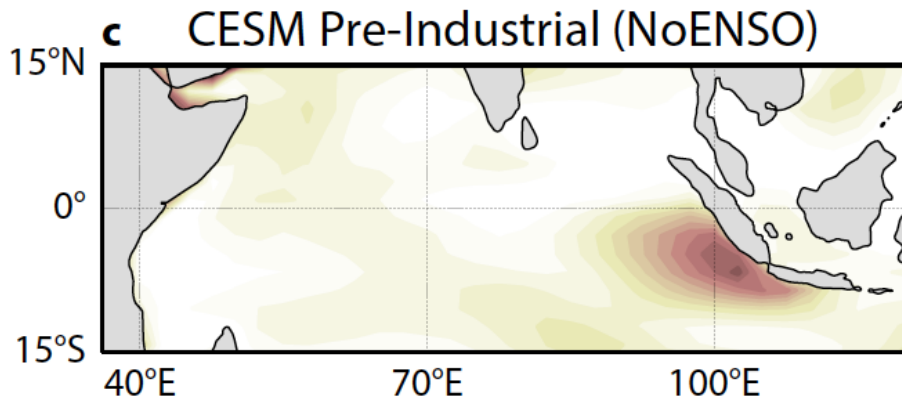
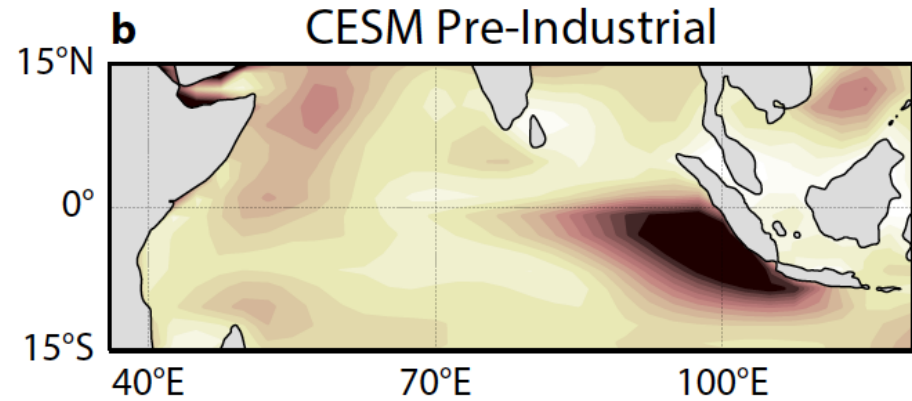
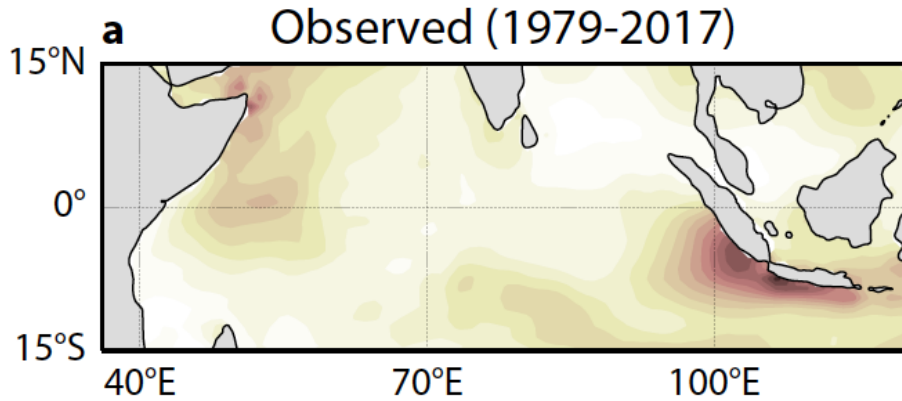
Cold



Conclusions

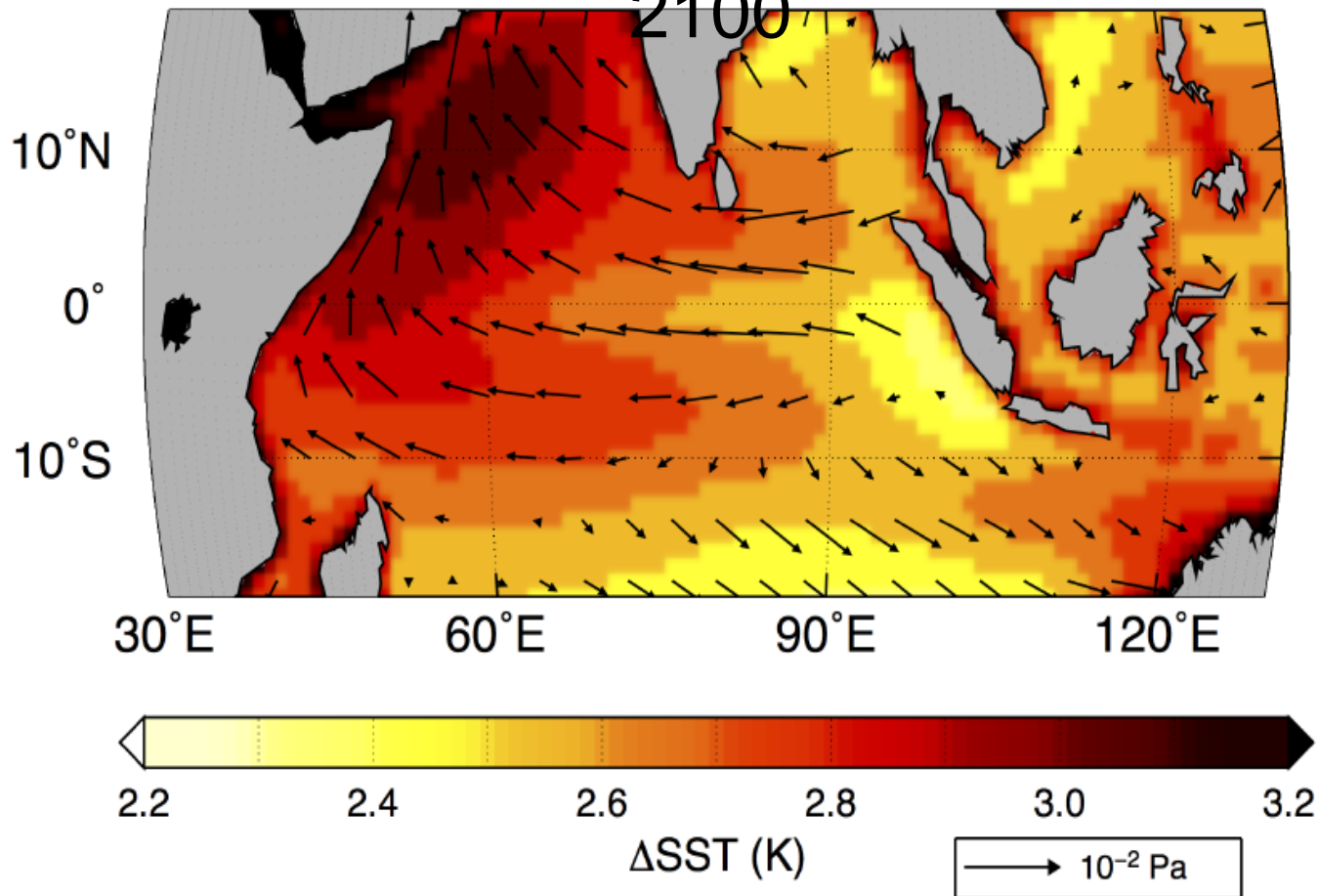
- Indian ocean capable of stronger SST variability,
- Associated with an equatorial mode resembling the Pacific El Niño:
 - Triggered by wind precursor in the western IO,
 - Communicated to eastern IO via Kelvin waves,
 - Amplified by a favorable mean state with equatorial upwelling and shallow

Sea-surface temperature variability in boreal summer

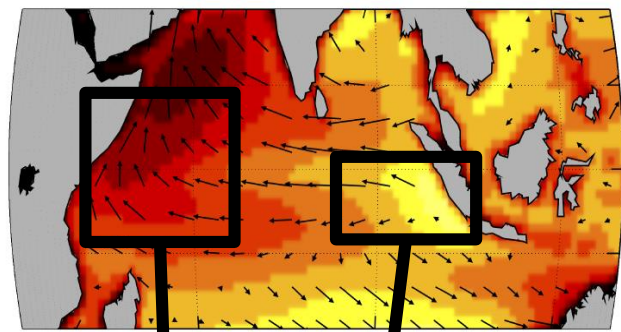


Pattern of warming explains rainfall predictions

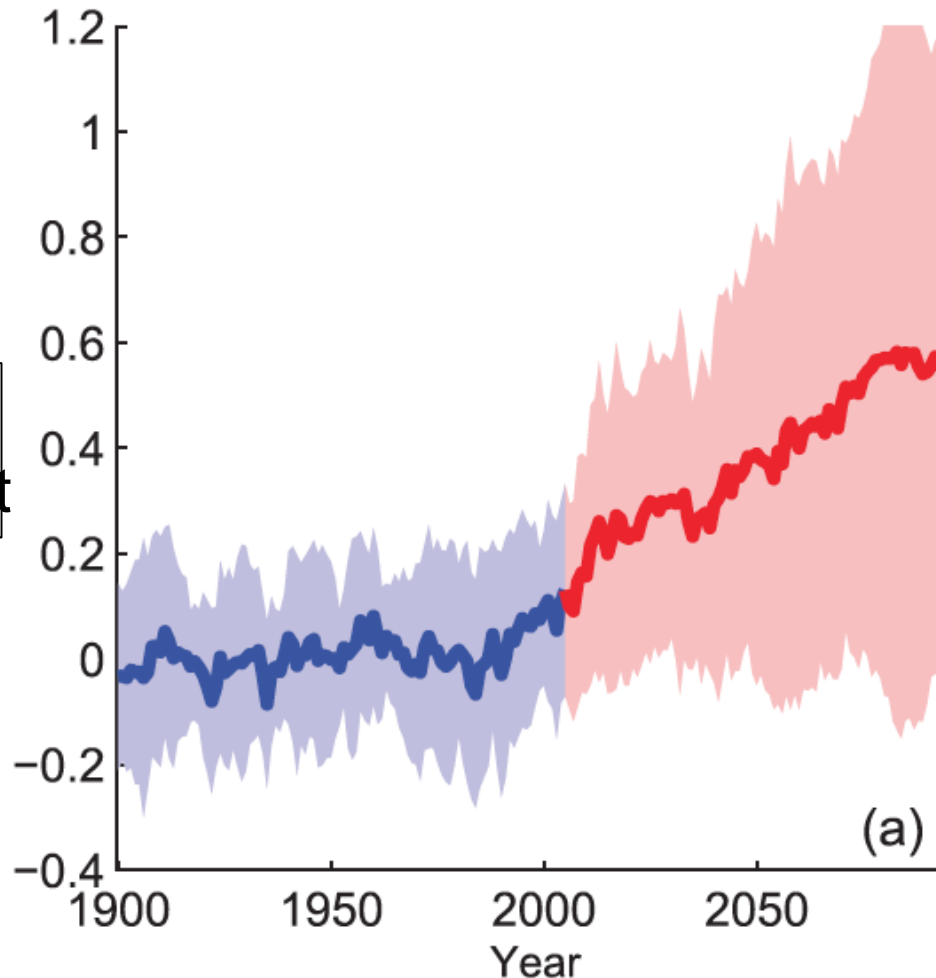
Multi-model prediction for year
2100



Large uncertainty among models



SST difference
West minus East

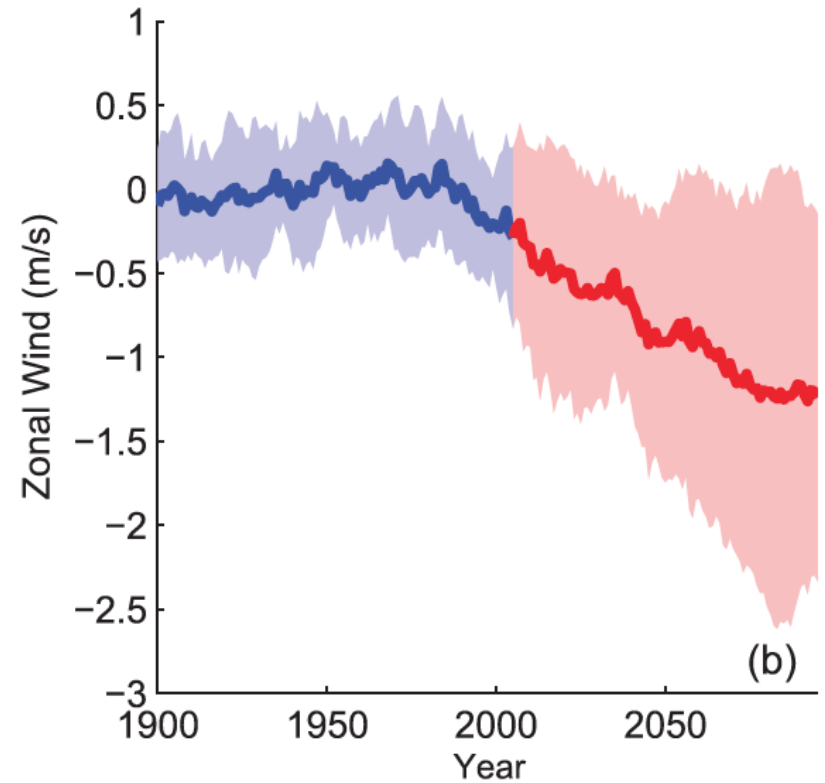
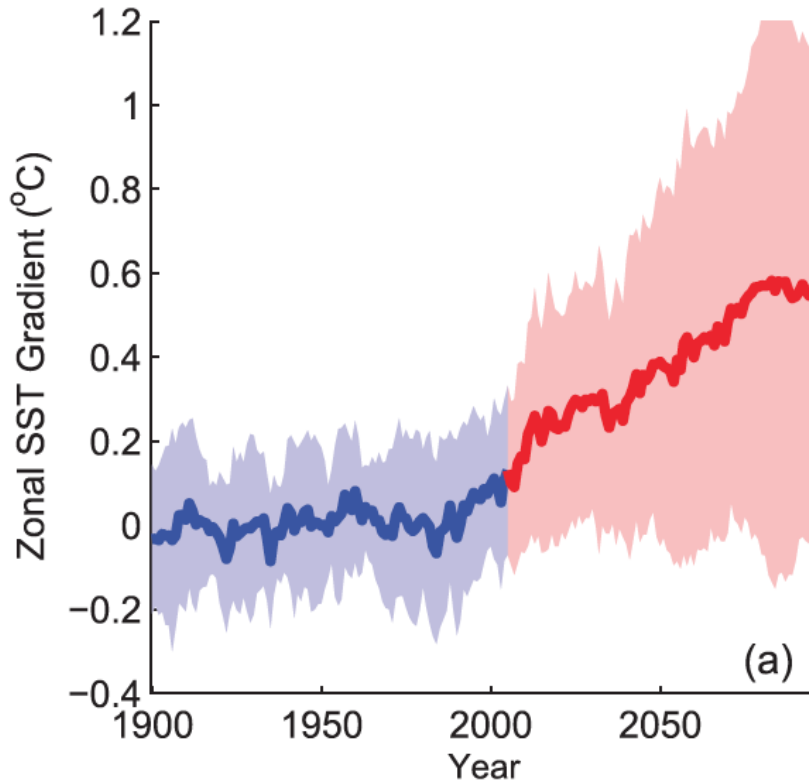


West
warms
faster

West and
East warm
at the
same rate

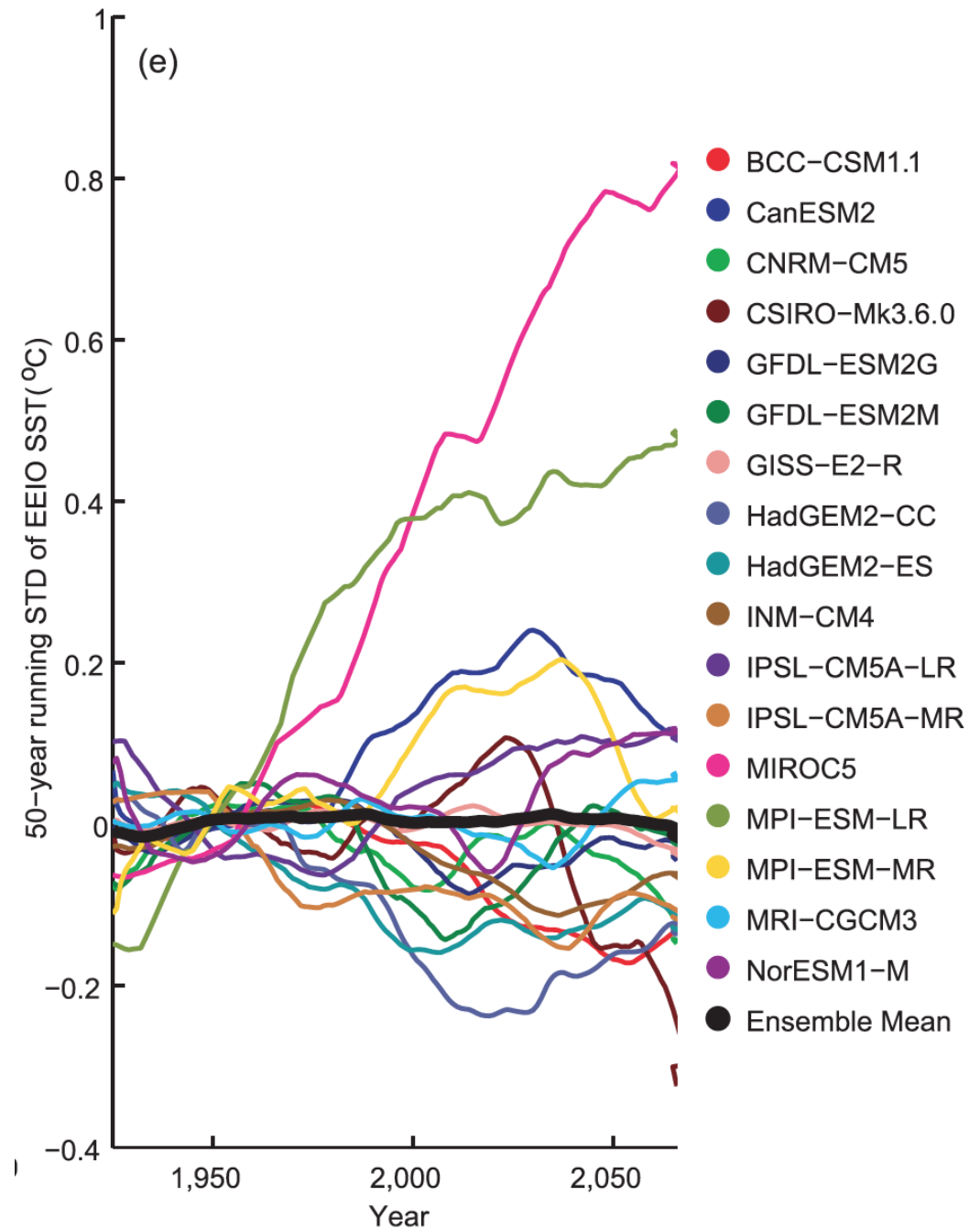
Shading shows
spread among

Large uncertainty among models



Shading shows one standard deviation of inter-model spread

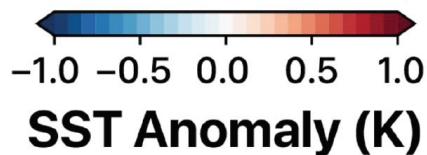
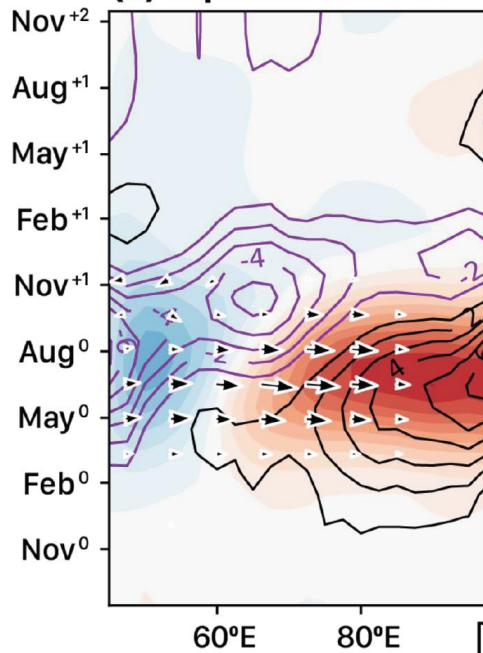
Large uncertainty in variability change



Spatio-temporal evolution of equatorial mode resembles El Niño

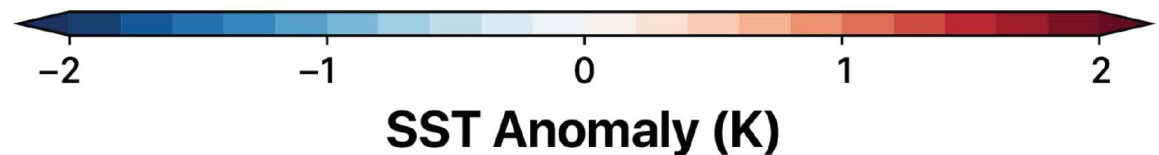
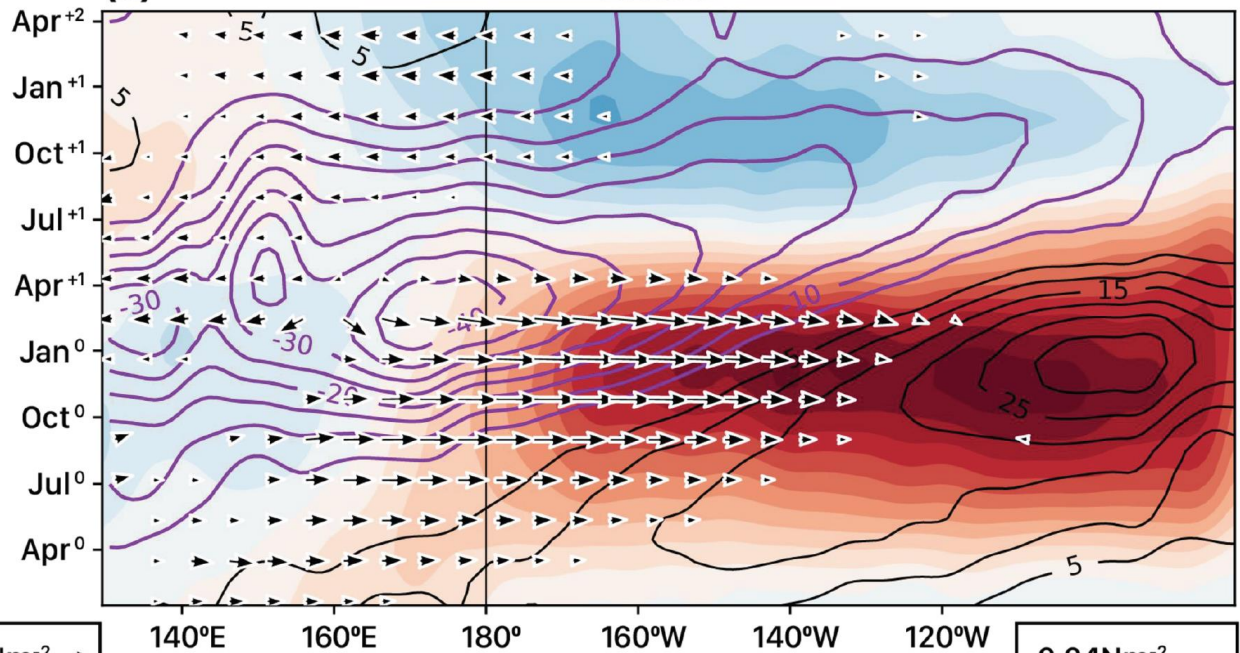
Glacial Indian Ocean

(a) Equatorial Mode



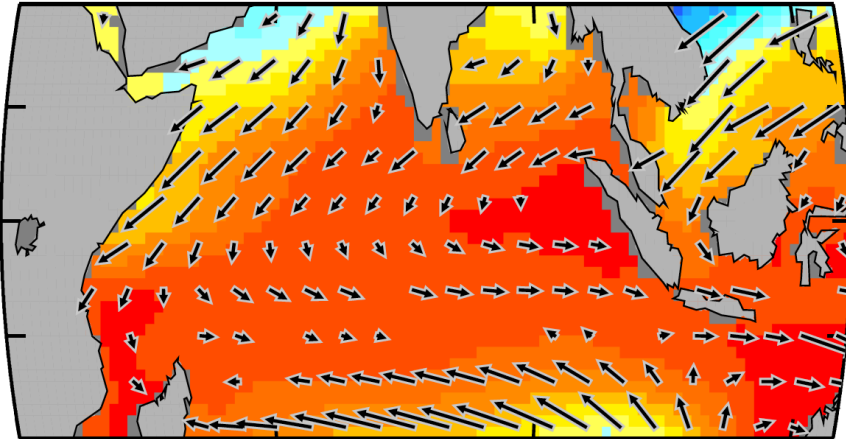
Modern Pacific Ocean

(b) El Niño

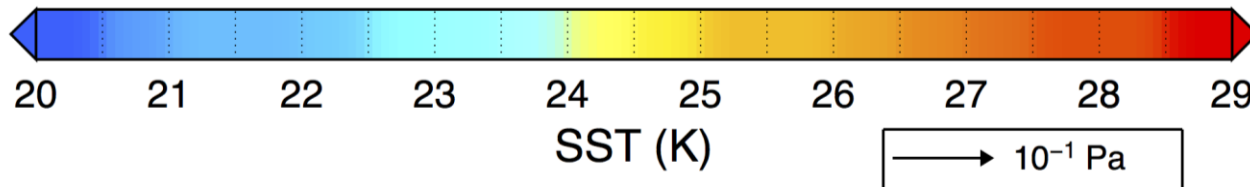
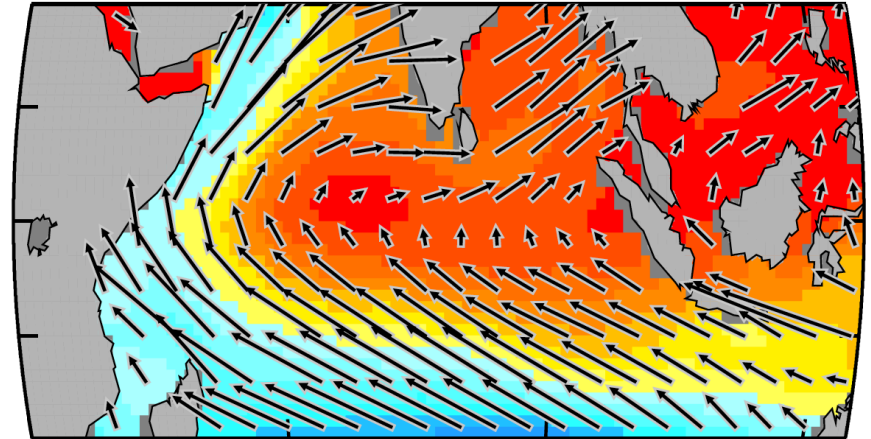


Seasonally reversing winds along the equator

January-February-
March

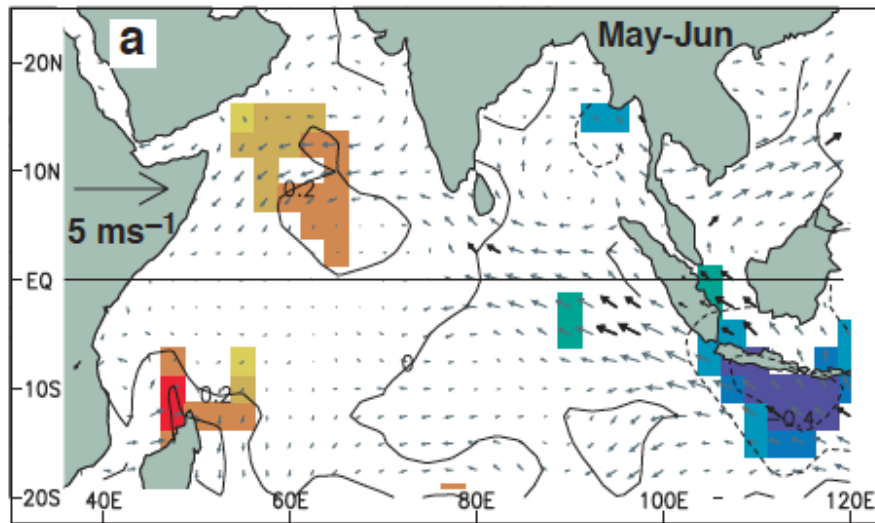


July-August-September



Strong air-sea coupling and SST variability restricted to the SE Indian Ocean

Precursor
May-June



Peak
September-October

