Indian Ocean SST variability: Causes, Feedbacks, and Consequences for Model Simulations

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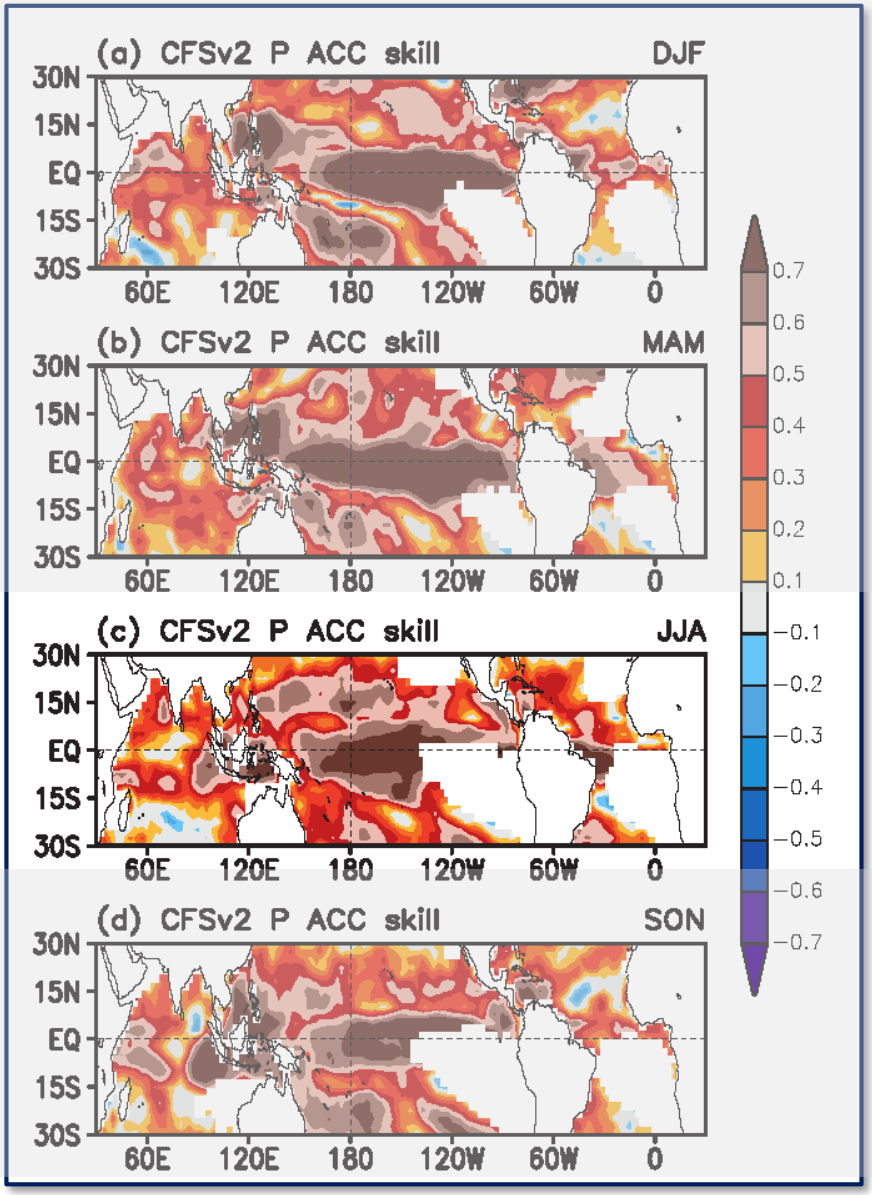
Outline

- Background
  - Spatial variations in skill of sea surface temperature and Precipitation
  - What is the cause spatial variability in skill?
- Possible explanation
- What are the implications for
  - Skill of long-range predictions?
  - Climate model simulations?
- Summary

Air-Sea interaction control…

- …several aspects of weather and climate variability on different time-scales
  - Weather: Cyclones & hurricanes
  - Intraseasonal: MJO
  - Seasonal: ENSO and its Global teleconnections
  - Climate Change: Trends in SSTs and precipitation
- Air-sea interaction also determine predictability on different time scales

Precipitation Skill for Seasonal Forecasts



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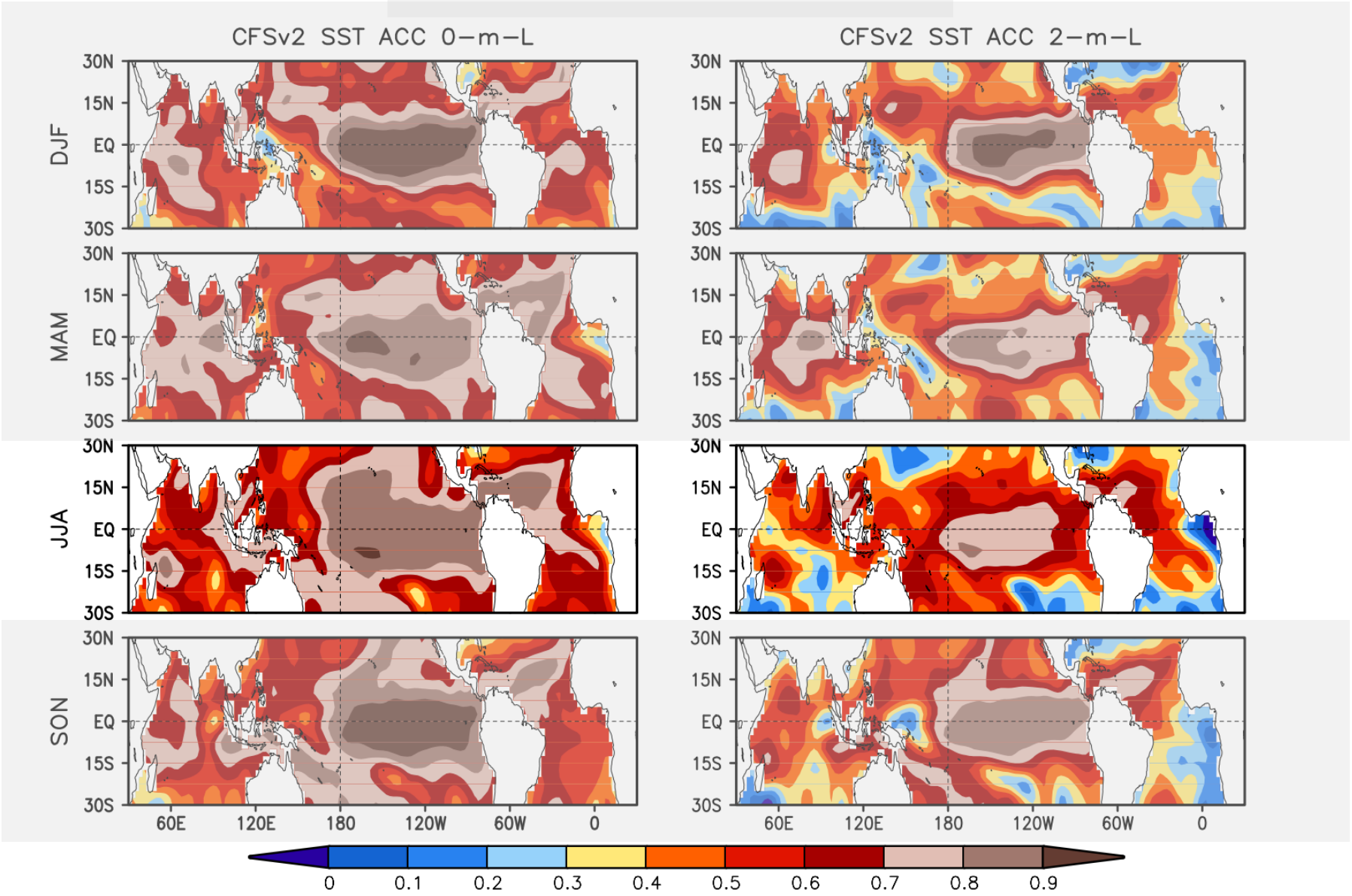
SST Skill for Seasonal Forecasts



Question

- What is the cause for spatial variation in skill?
  - Model biases?
  - Deficiencies in the specification of initial conditions?
  - Predictability limits due to some physical constraints?

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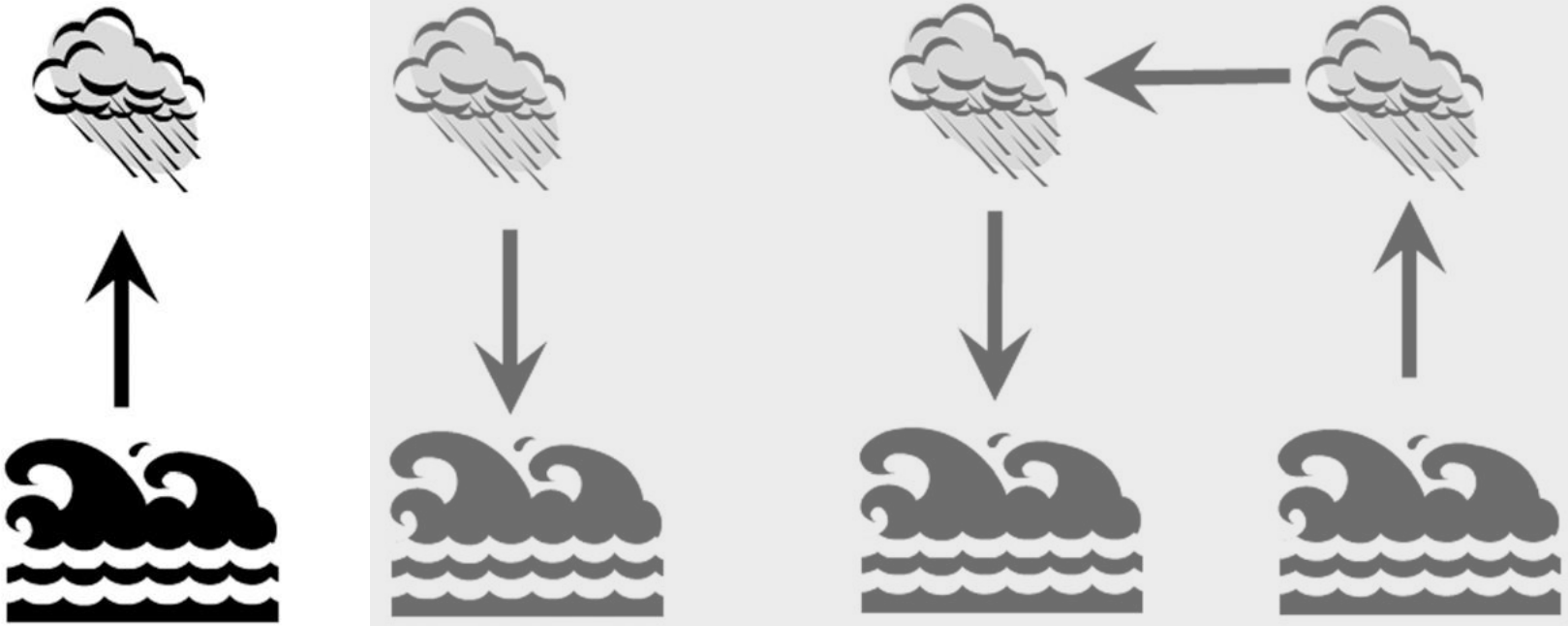
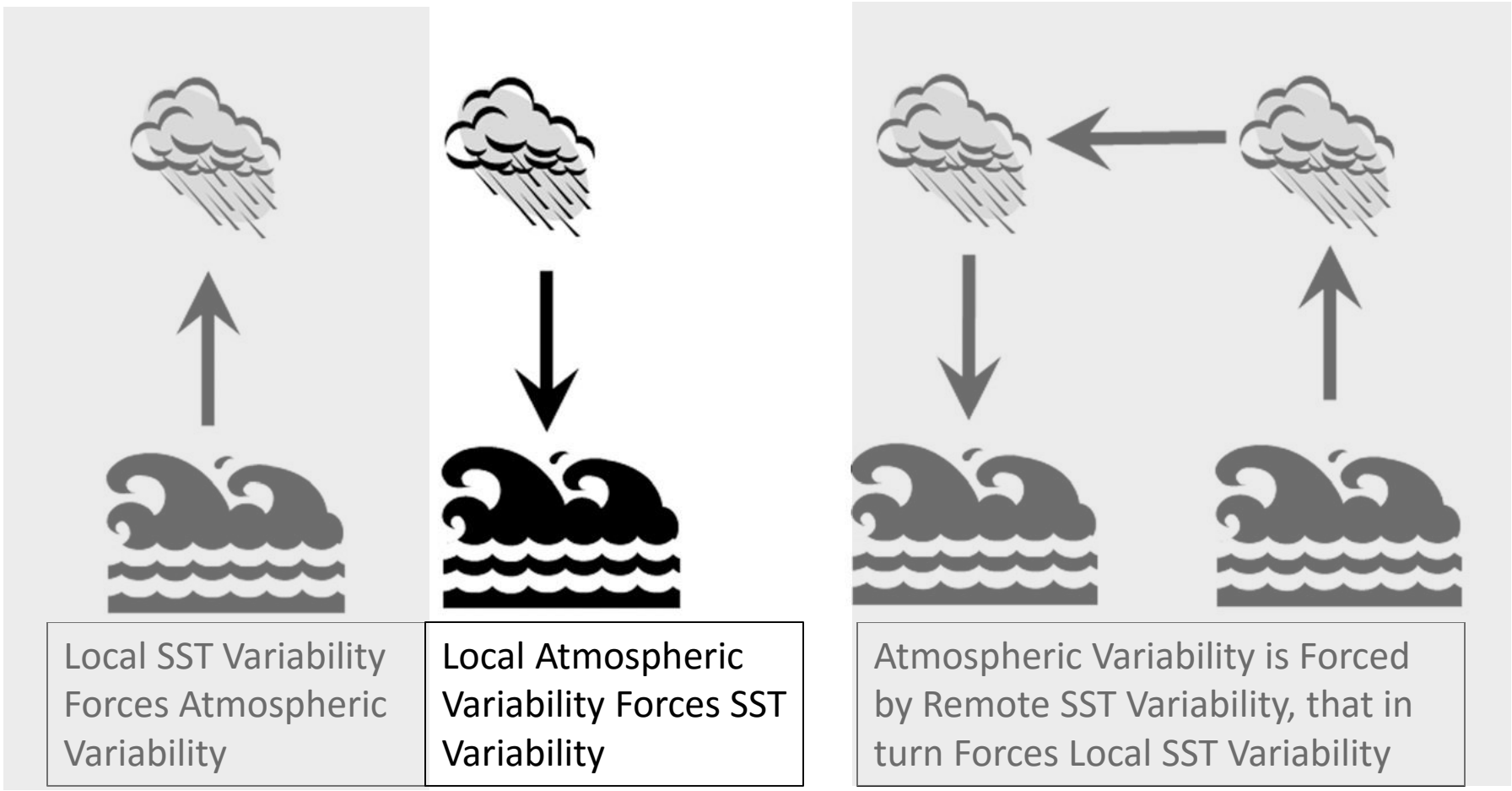
Three regimes for ocean-atmospheric interaction…
#1: Ocean forces atmosphere variability



Local SST variability forces atmospheric variability	Local Atmospheric Variability Forces SST Variability	Atmospheric Variability is Forced by Remote SST Variability, that in turn Forces Local SST Variability

Three regimes for ocean-atmospheric interaction…
#2: Atmosphere forces ocean variability



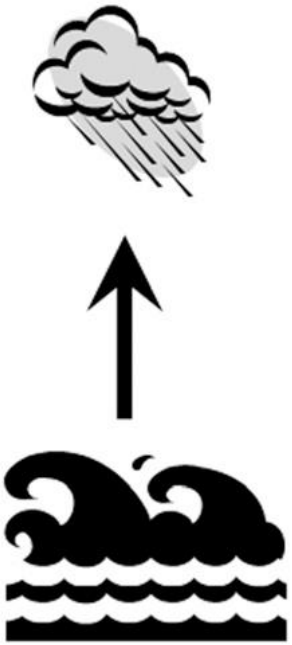
Local SST Variability Forces Atmospheric Variability

Local Atmospheric Variability Forces SST Variability

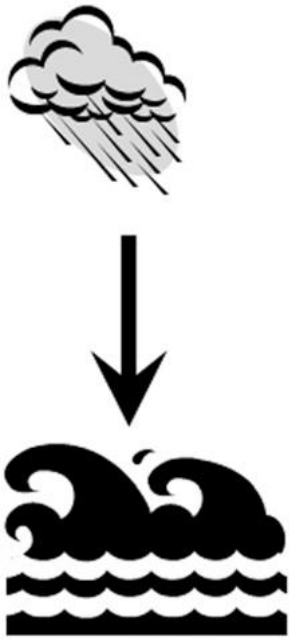
Atmospheric Variability is Forced by Remote SST Variability, that in turn Forces Local SST Variability

What are the consequences for different regimes?

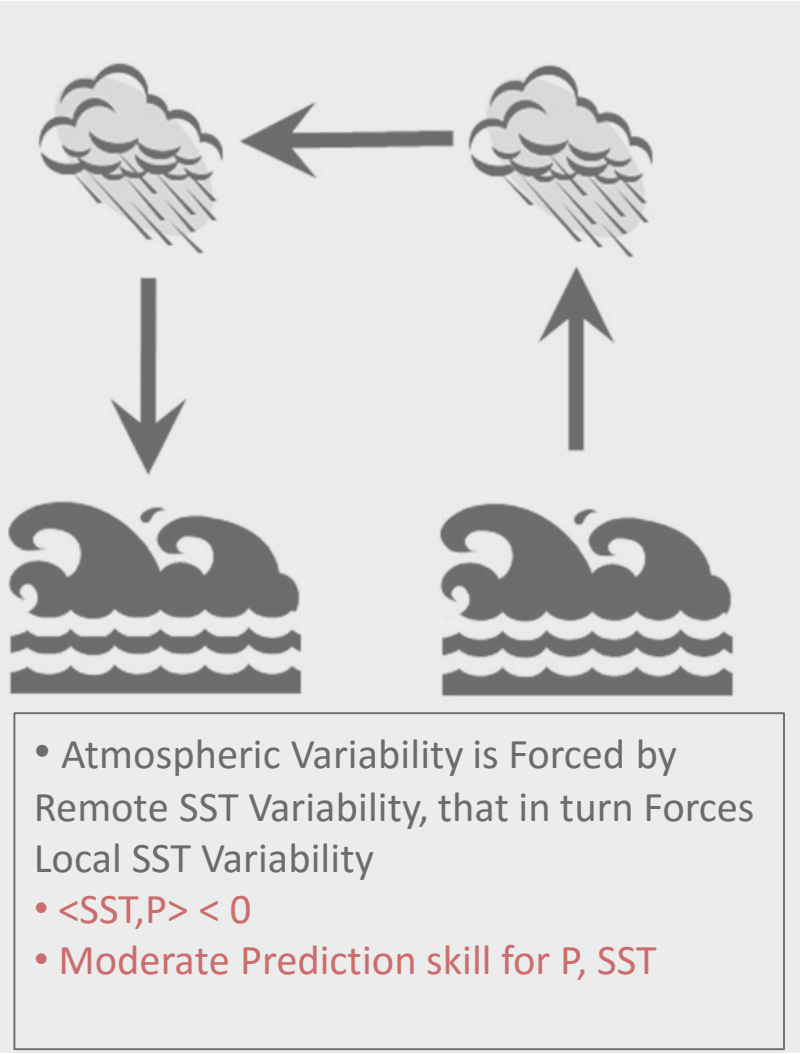
Implications for Local SST-P Relationship



- Local SST Variability Forces Atmospheric Variability
- <SST,P> > 0
- High Prediction skill for P, SST

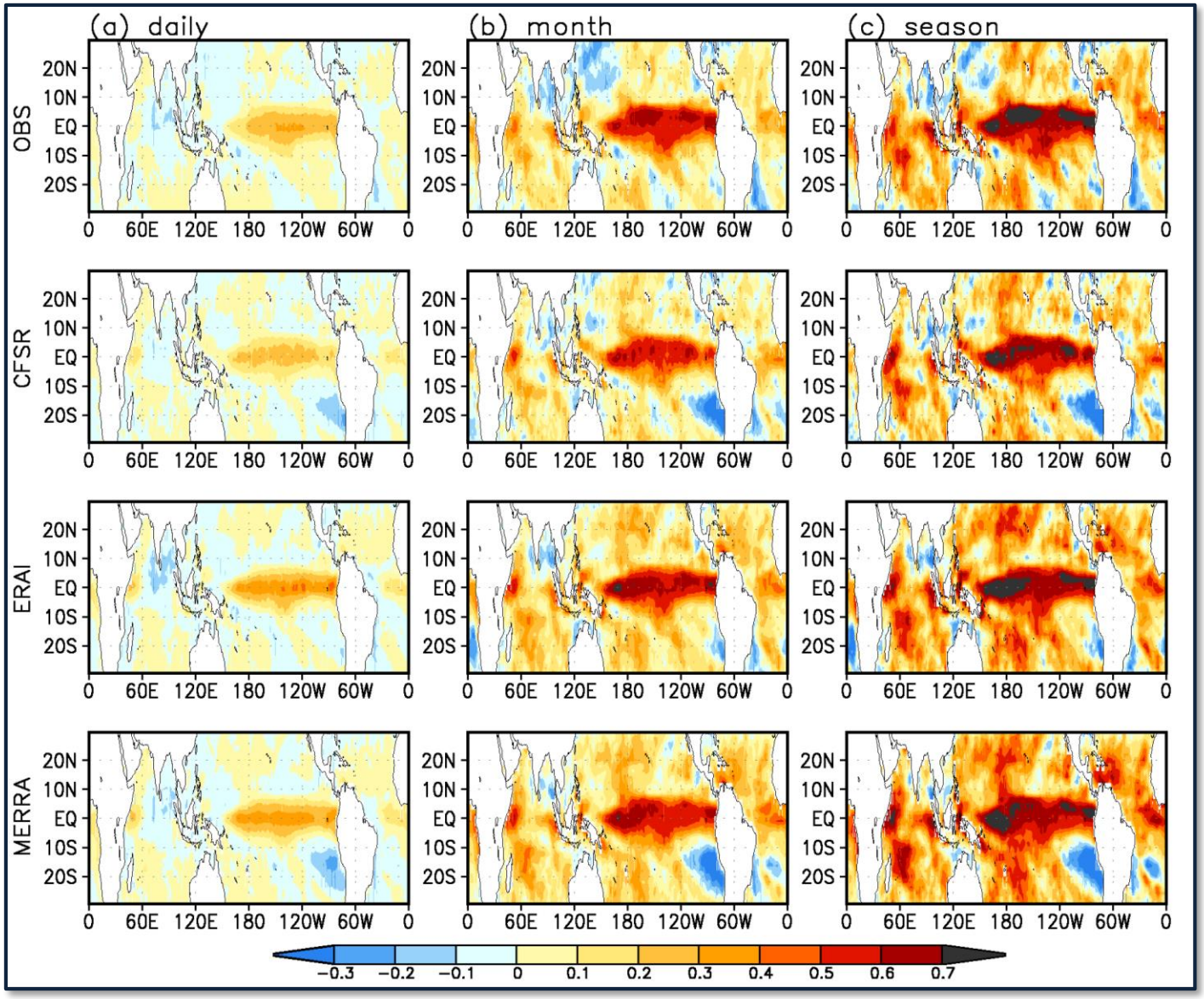


- Local Atmospheric Variability Forces SST Variability
- <SST,P> < 0
- Low Prediction skill for P, SST



- Atmospheric Variability is Forced by Remote SST Variability, that in turn Forces Local SST Variability
- <SST,P> < 0
- Moderate Prediction skill for P, SST

<SST-P> Between Observations and Various Reanalyses for Different Time-Scales



Various Reanalyses

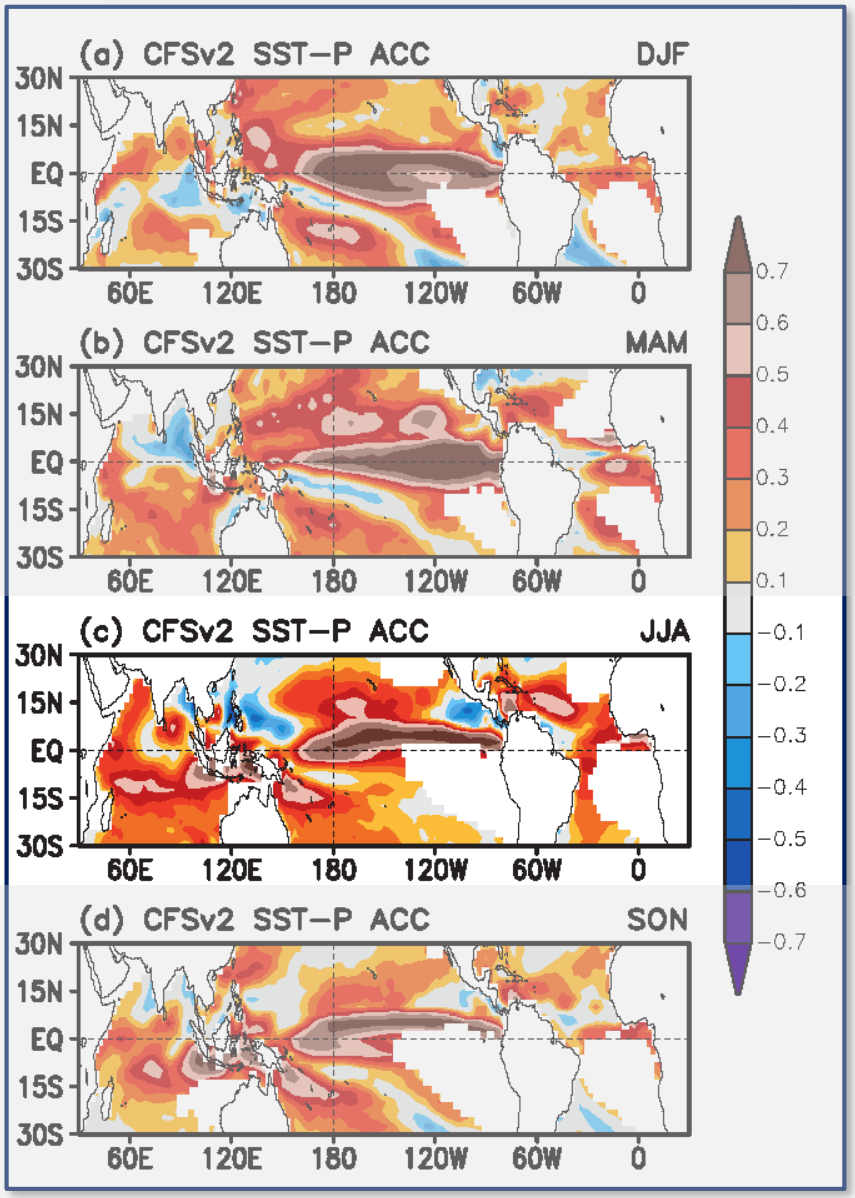
Obs

CFSR

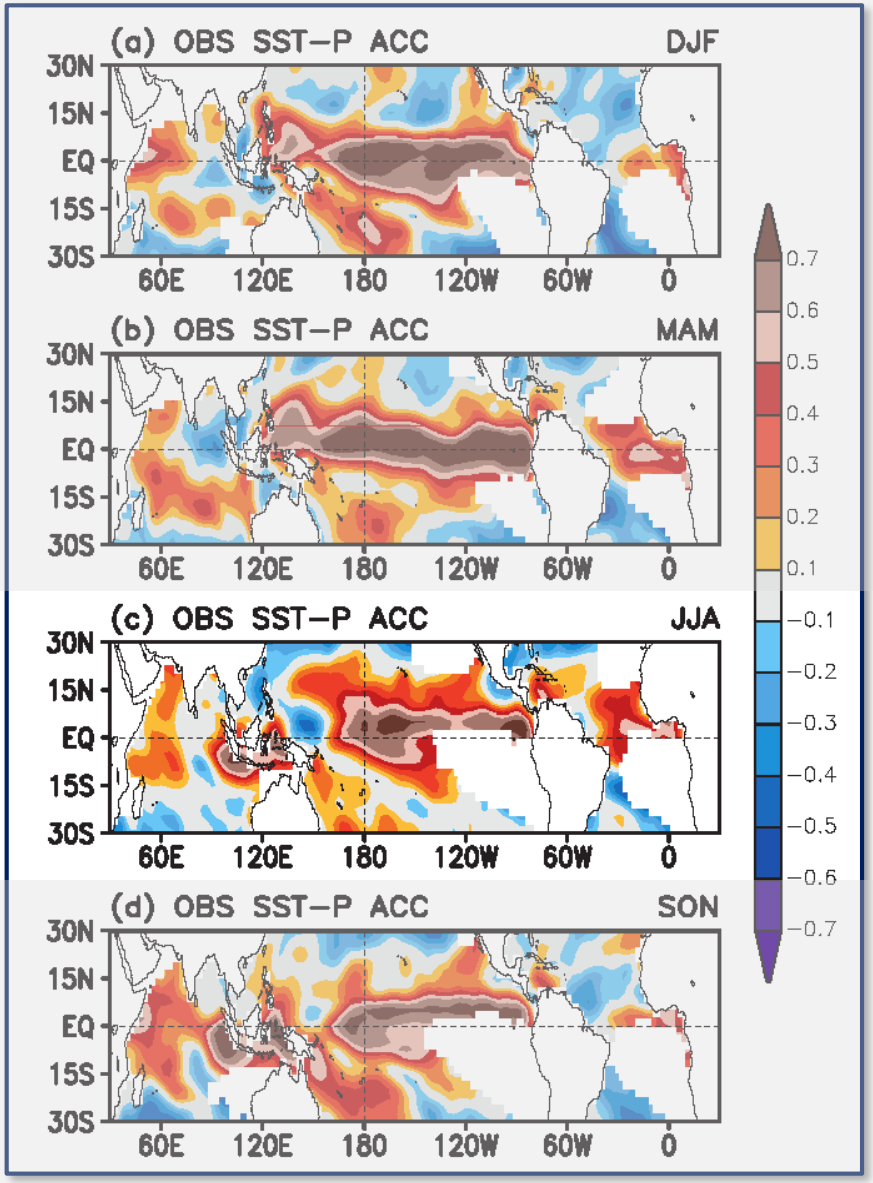
ERAI

MERRA

Model Local SST-P Correlation



Observed Local SST-P Correlation



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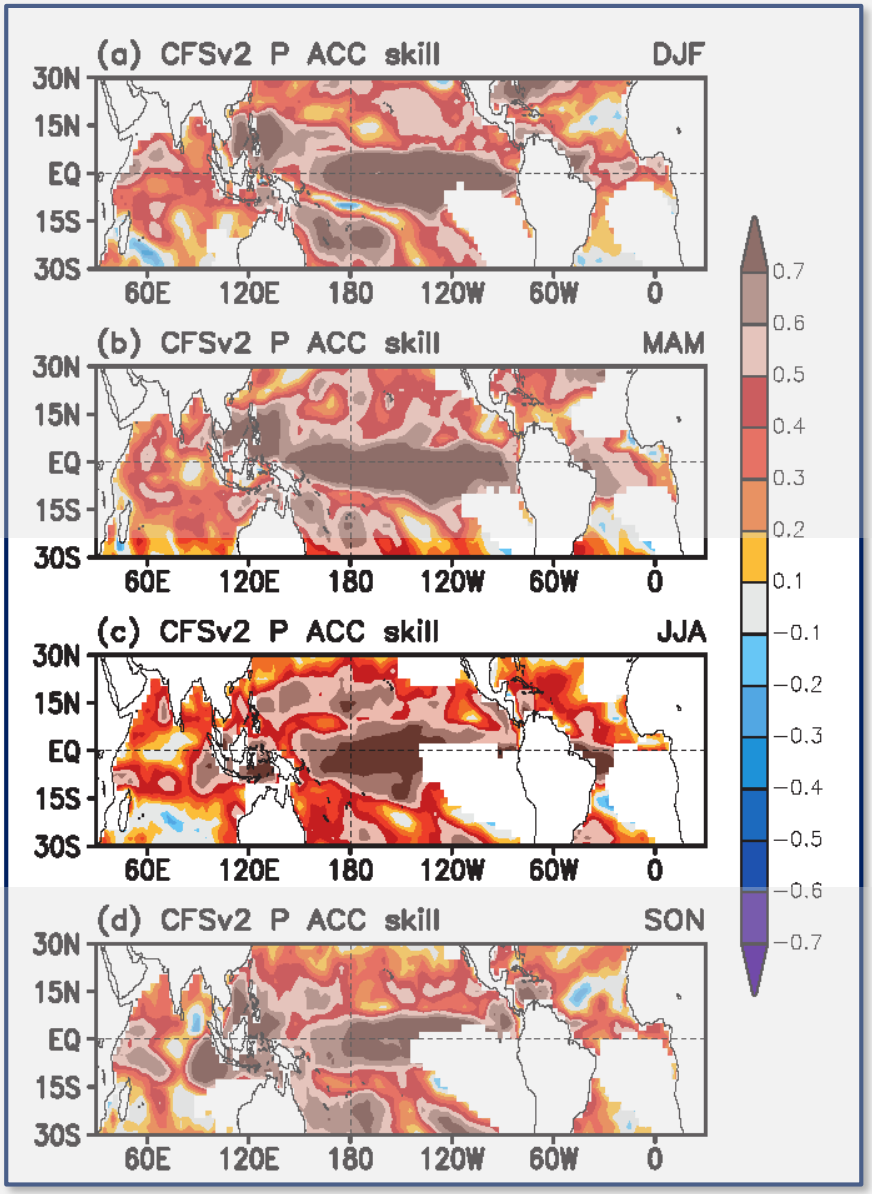
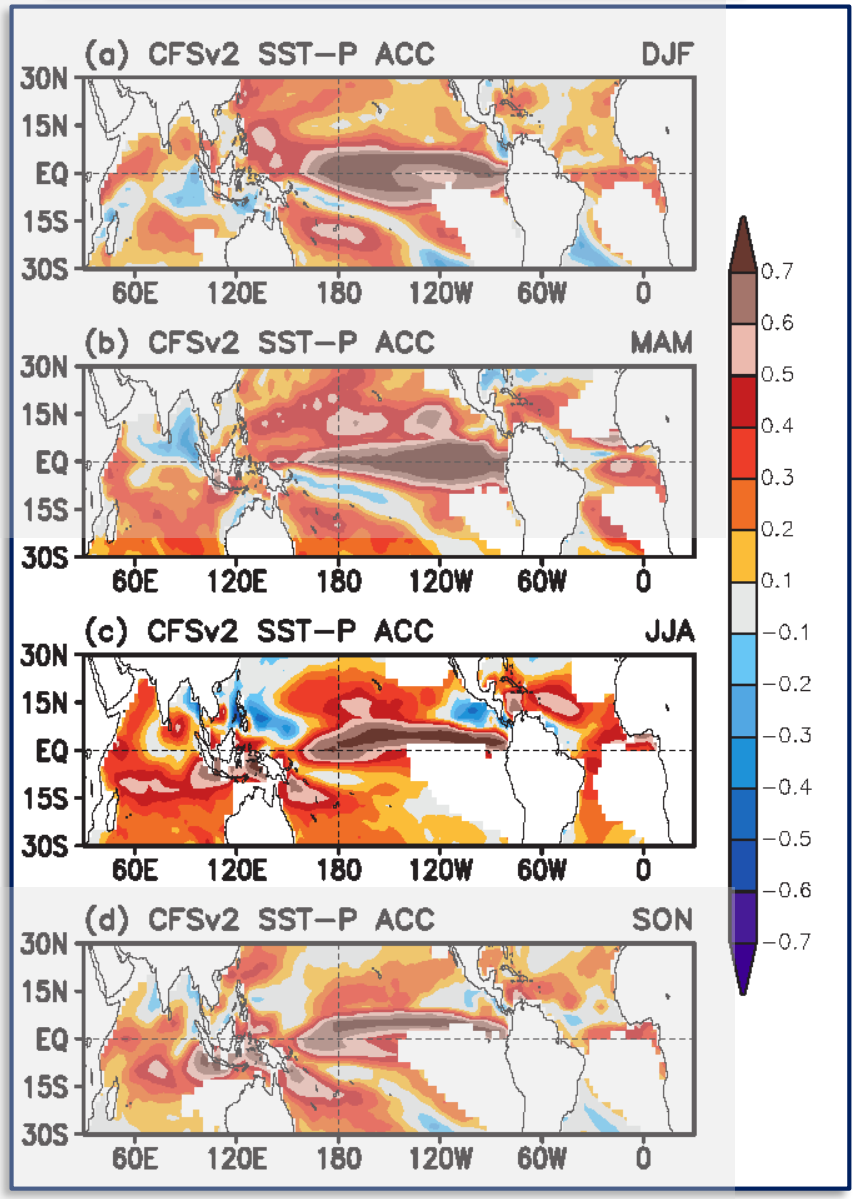
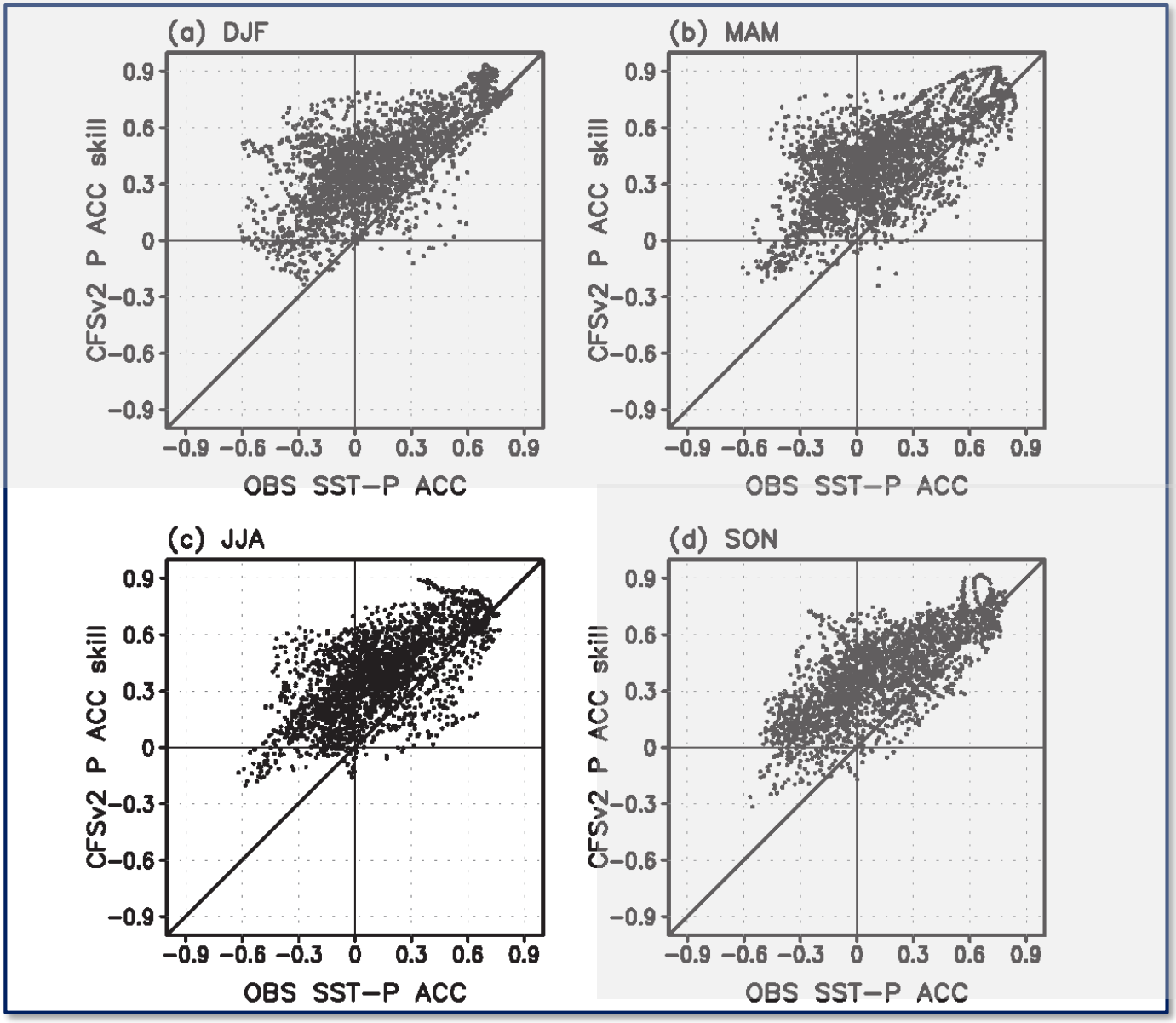
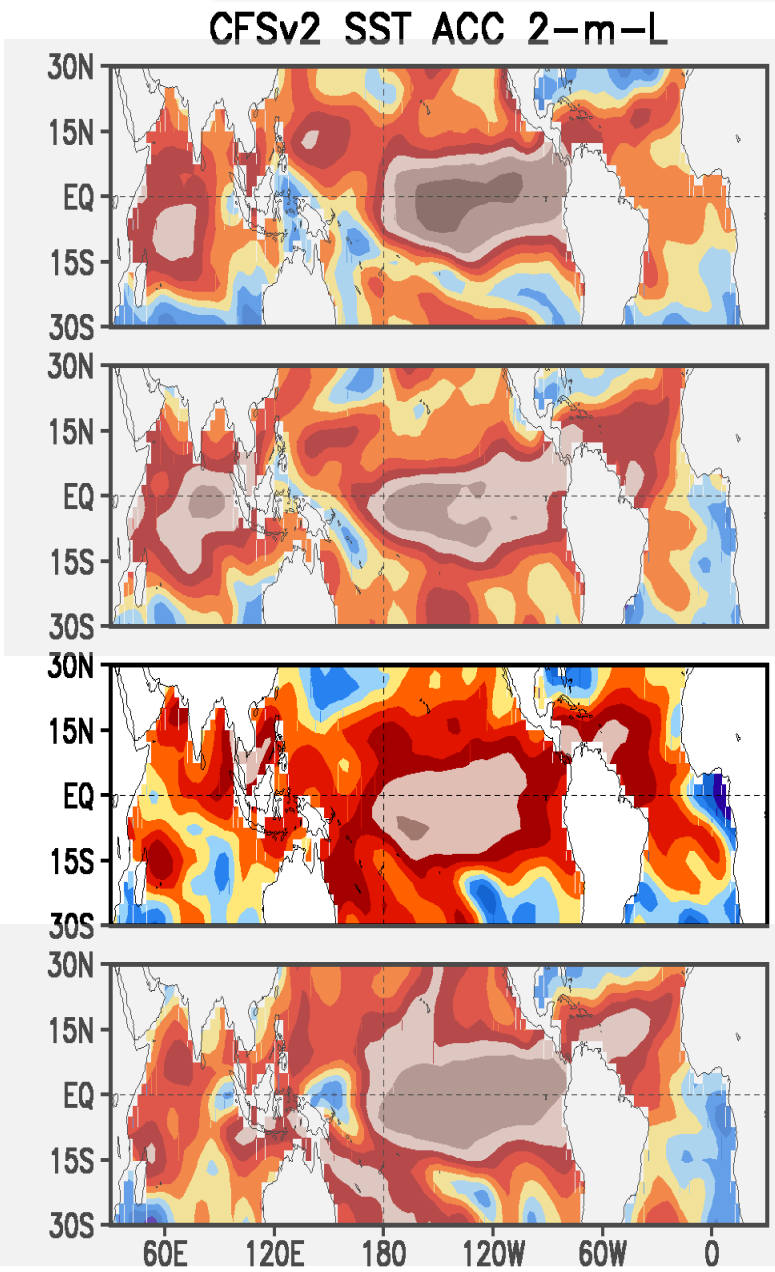


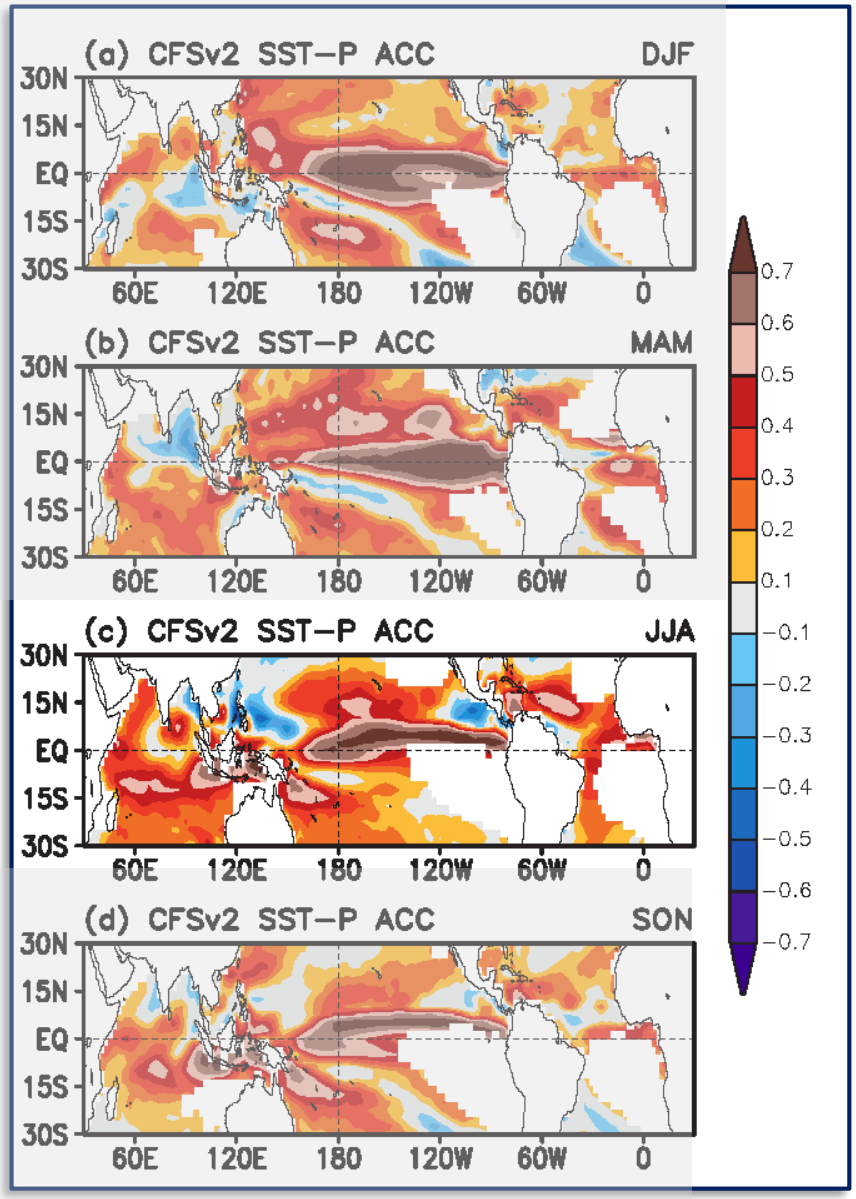
Model Local SST-P Correlation




(a) DJF
(b) MAM
(c) JJA
(d) SON
CFSv2 P ACC skill
OBS SST–P ACC
0.9
0.6
0.3
0
–0.3
–0.6
–0.9

SST Skill for Seasonal Forecasts





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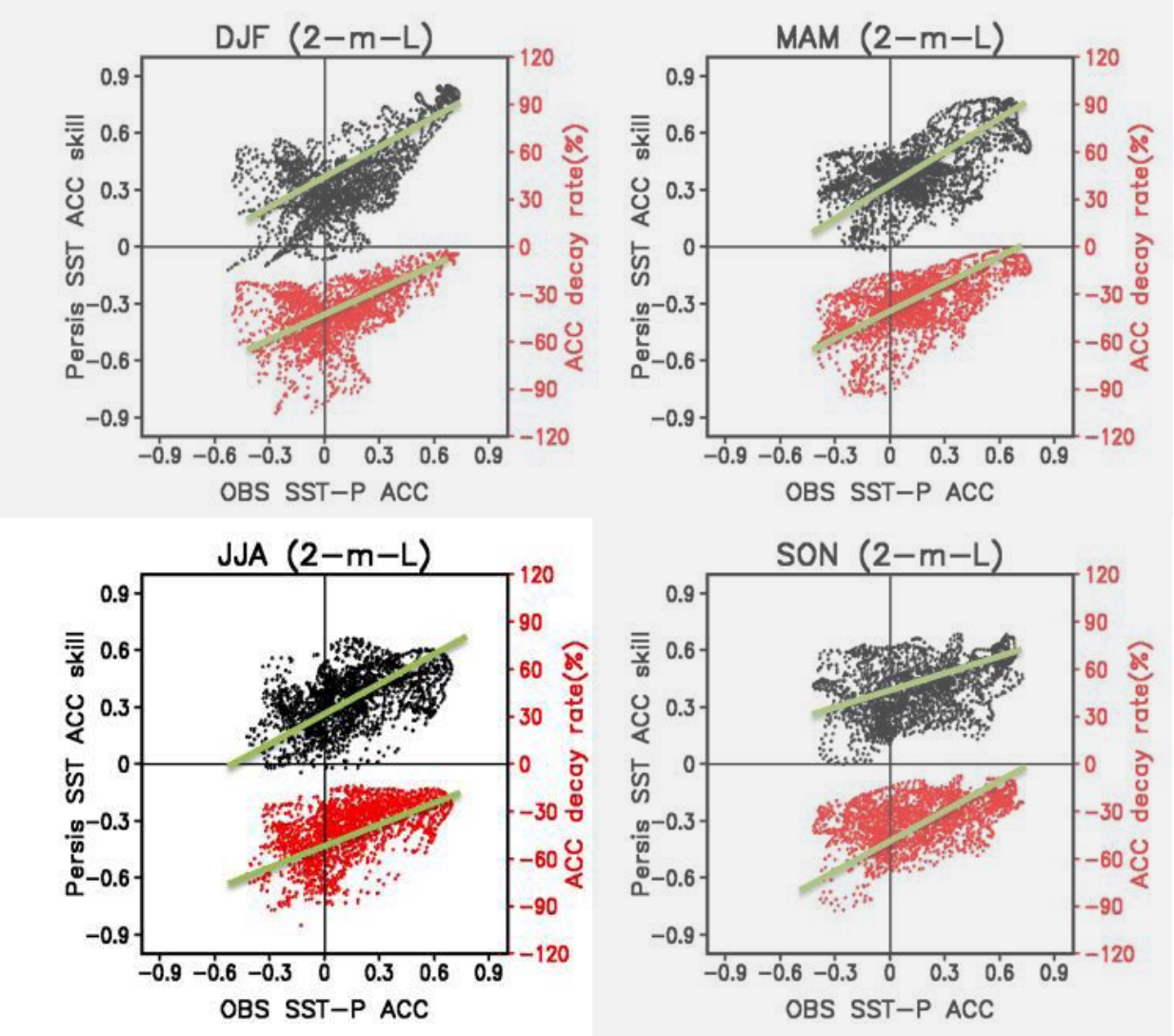

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Types of model simulations

- Coupled – The observed characteristics of air-sea interaction is preserved (or is more realistic)

- Atmospheric alone – The so called “AMIP” simulations where sea surface temperature is specified

AMIP Simulations

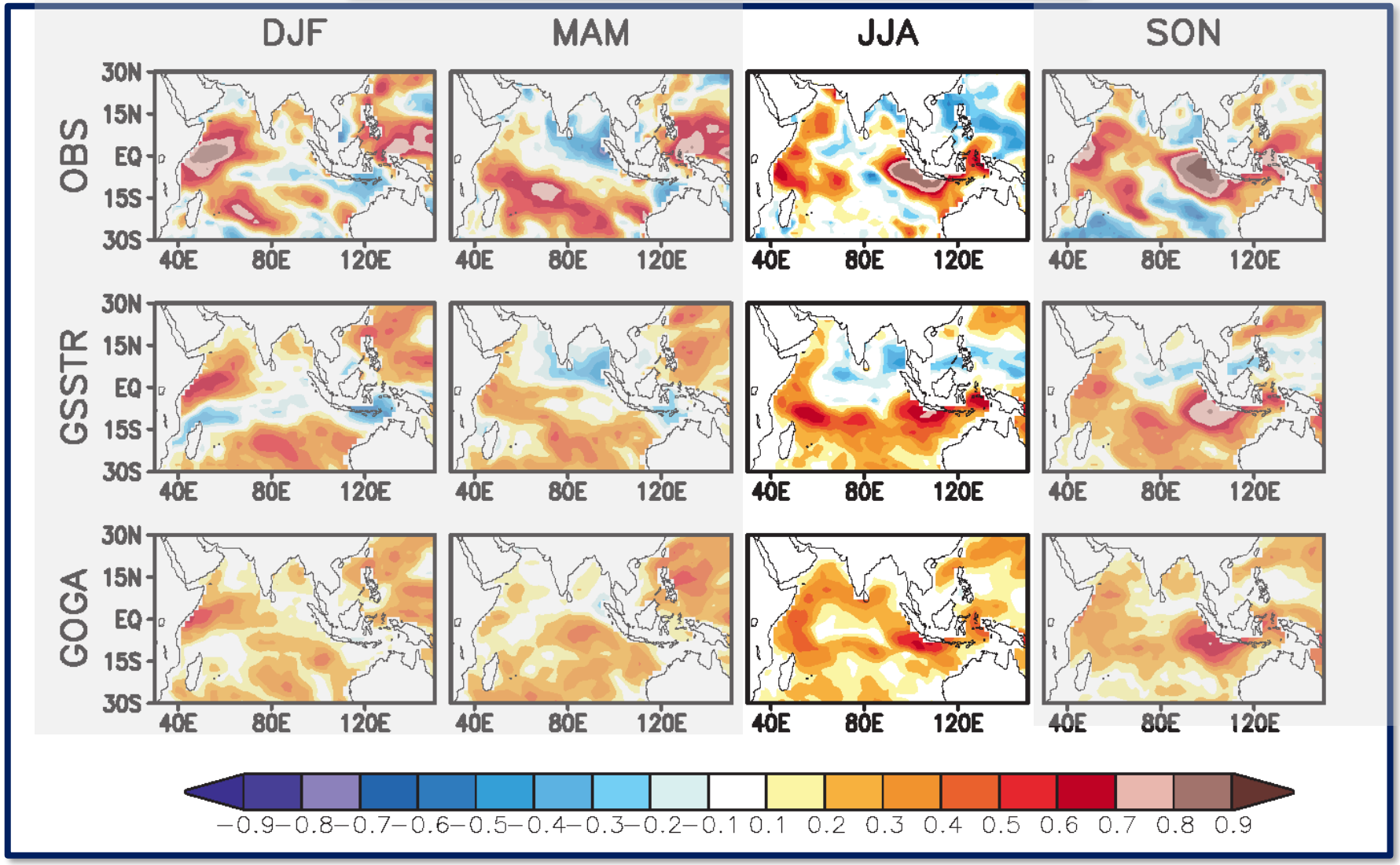
- AMIP simulations – Atmospheric general circulation model forced either with observed evolution on SSTs or with some idealized SSTs
- In AMIP simulations, atmospheric variability does not affect ocean…ocean is basically an infinite reservoir of heat. <SST-P> **>** 0

Possible Reasons for Doing Uncoupled Model Simulations

- Why use AMIP simulations?
  - Often simplifies the analysis
  - More controlled experimentation in understanding causality of observed atmospheric anomalies (aka Attribution)
  - Time-slice climate change projections for information with higher spatial resolution
- Our ability to justify AMIP simulations depends on how much atmospheric variability (and "response" to SST) differs between coupled and uncoupled (AMIP) simulations? How severe are the consequences of ignoring correct <SST-P> relationship?

Local SST-P Correlations

a. Observations
b. Coupled simulation
c. AMIP simulation



Summary

- Observed <SST-P> relationship has a large spatial variability and asymmetry in its amplitude.
- This spatial variability needs to be correctly replicated in climate model simulations.
- The spatial variability in <SST-P> can be explained by the direction of forcing, and time-scales associated with ocean and atmospheric variability.
- Decoupling the system sometimes provides a simplifying assumption, and more control in our attempts to understand the influence of ocean on atmospheric variability…However, that understanding is only as good as the extent of consequences of the approximation, which should be first assessed.