Linking the uncertainty of low frequency variability in tropical forcing to regional climate change

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Research Goals

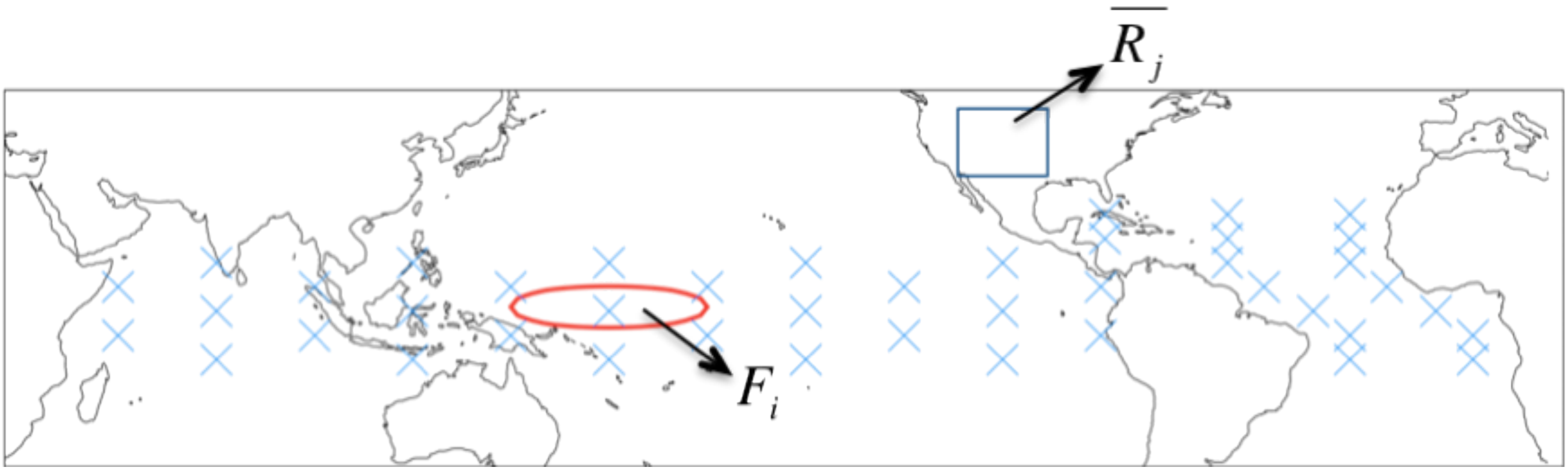
1. Explore **model uncertainty** using regional climate change from atmospheric GCM response to SST patterns (i.e., ignore local forcing)
2. Define Global Teleconnection Operator, **GTO**, to compare model responses at multiple scales
3. Introduce **Random Perturbation Method** as an alternative to the **Patch Method** to estimate GTO
4. **Identify model structural differences** that lead to different GTO patterns (convection, resolution, etc.) and influence predictability

Can we quantify uncertainty in model response at ***regional scales***?

- Create ***idealized*** experiments with "known" surface forcings to provide metrics (or framework) for comparing model response *at regional scales*
- Two options:
  - Patch Experiments (indiv. tropical SST anomalies)
  - Random SST anomalies applied across both tropical and extratropical oceans (Random Patch Method, **RPM**)

Basic Method:

Estimate the ensemble-mean response, R_j, to the ΔSST forcing, F_i



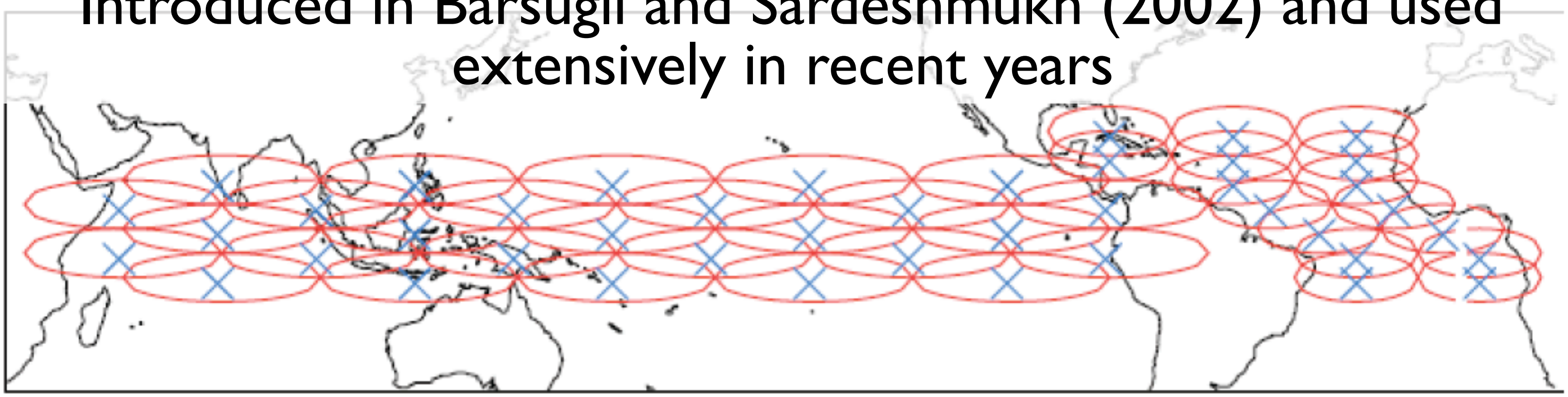
Estimate Global Teleconnection Operator, $\mathbf{K_{ij}}$, from:

$$\overline{R_j} = K_{ij} \cdot F_i + \varepsilon$$

Repeat this estimate for all SST anomaly locations.

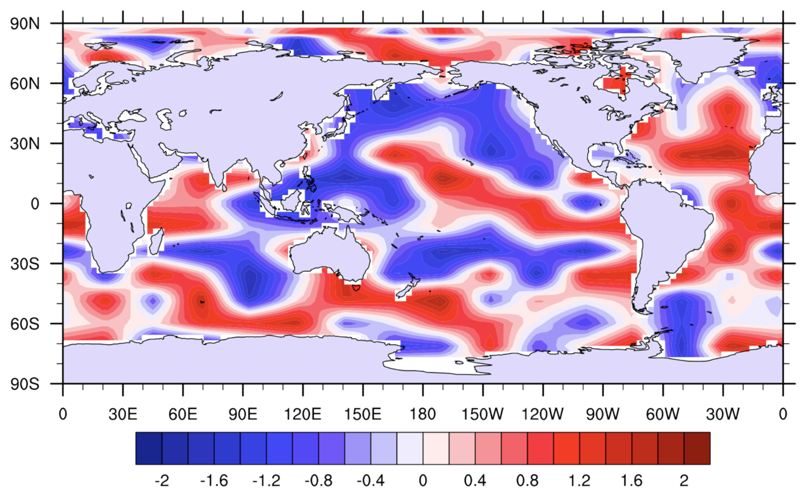
Follows: Barsugli and Sardeshmukh (2002, J. Climate)

Patch Method: SST Anomaly Patches added to Climatology. Estimate response to 43 patches individually via ensemble. Introduced in Barsugli and Sardeshmukh (2002) and used extensively in recent years

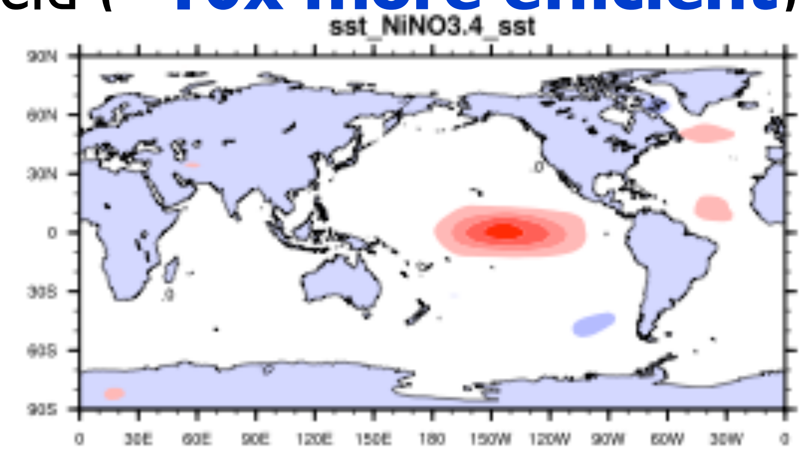


Random Perturbation Method (RPM)

Ensemble response to random field (**~10x more efficient**)



Individual Random Field



Correlation of 200 random fields with Nino3.4 Region

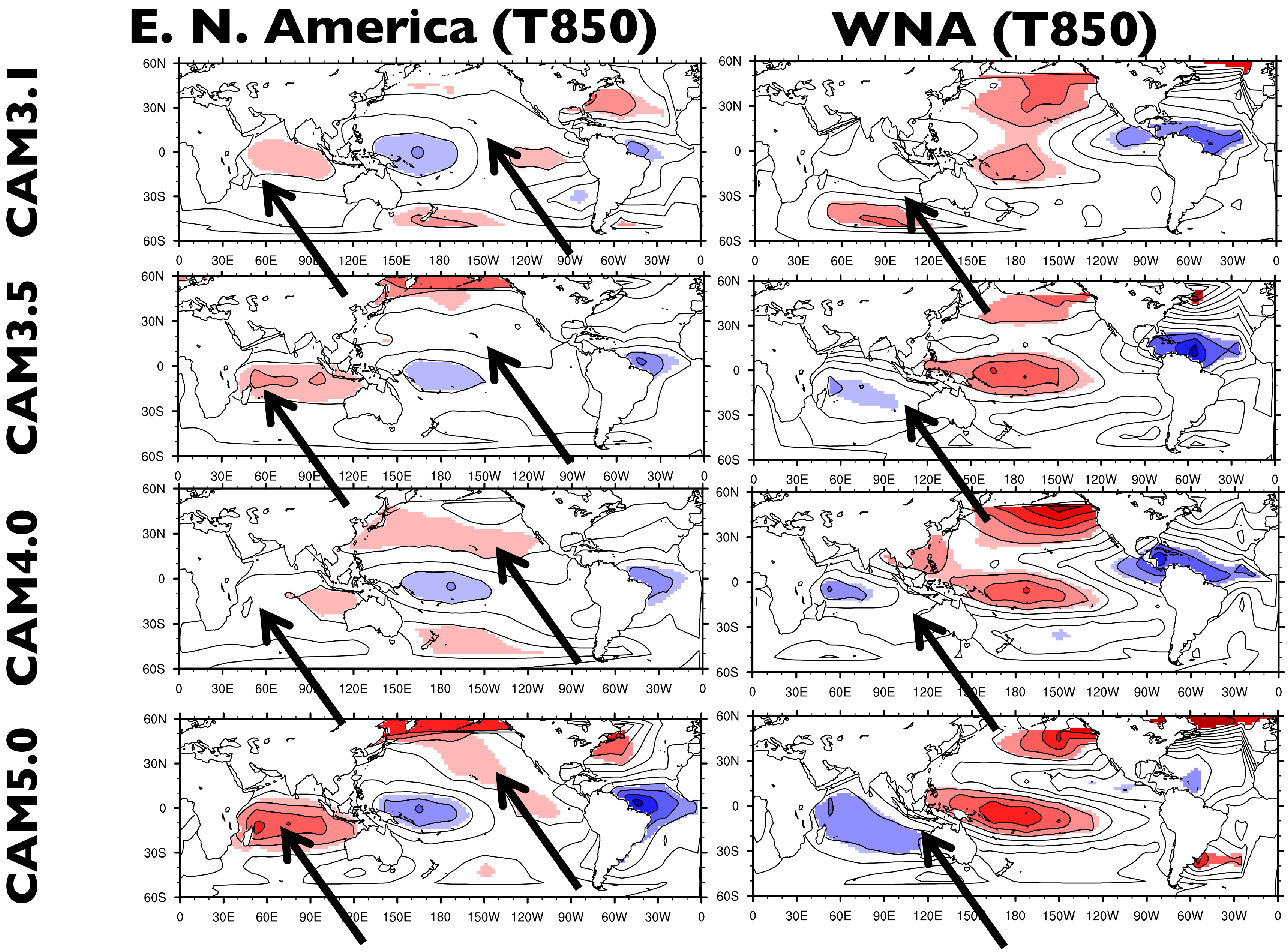
Experiments

Resolutions	Models					
	NCAR CAM3				*GFDL AM2 FV2.0x2.5*	*HadAM3*
	CAM3.1	CAM3.5	CAM4.0	CAM5.0		
T42	X				O	O
T85	X					
FV1.9x2.5	X	X	X	X		
FV4x5				O		

x: done o: To be done

SST Scenario	SST patterns	Source
C20C	CMIP3 Ensemble –mean AOGCM response to Climate of the 20^{th} century runs	PCMDI CMIP3 archive
future	CMIP3 Ensemble-mean SST(SRES A1B)	PCMDI CMIP3 archive

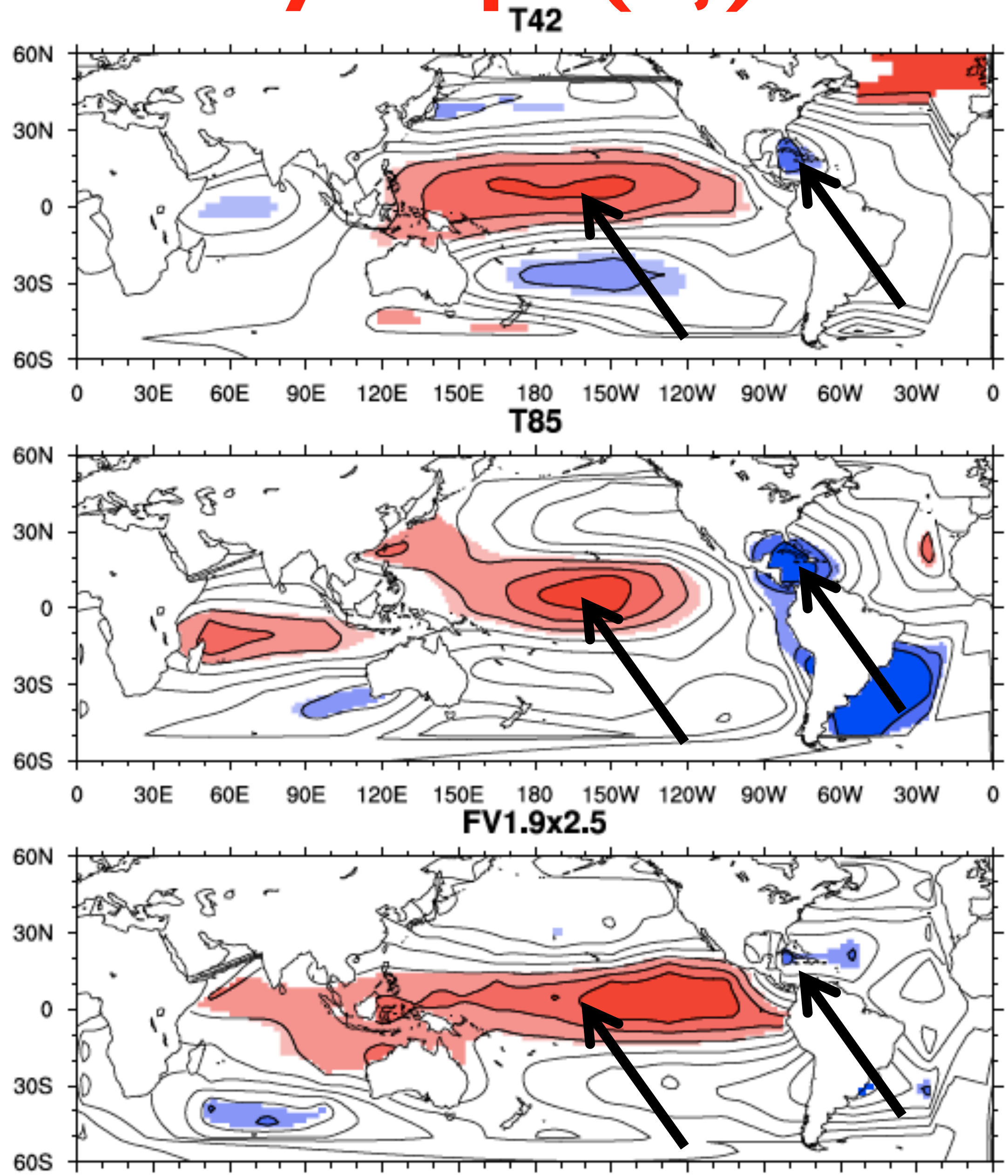
GTO: Sensitivity Maps (K_{ji})



GTO: Sensitivity Maps (K_{ji})

CAM3.1
Central North America (Precip)

Three Resolutions:
T42, T85, FV1.9x2.5



Summary of Results so far

- **Estimated GTO for multiple CAM models**
  - **Structure**: CAM3.1, CAM3.5, CAM4.0 and CAM5.0 (FV1.9x2.5)
  - **Resolution**: CAM3.1 @ T42, T85, and FV1.9x2.5
- **Sensitivity of larger scales is more robust**
  - Global, Tropical, and Extra-tropical targets
  - Unforced variability contributes significantly at regional scales and more at high latitude
  - Verified with linear reconstruction via AMIP runs and observed SST
- **Resolution & Grid <u>may</u> be more important than model physics**

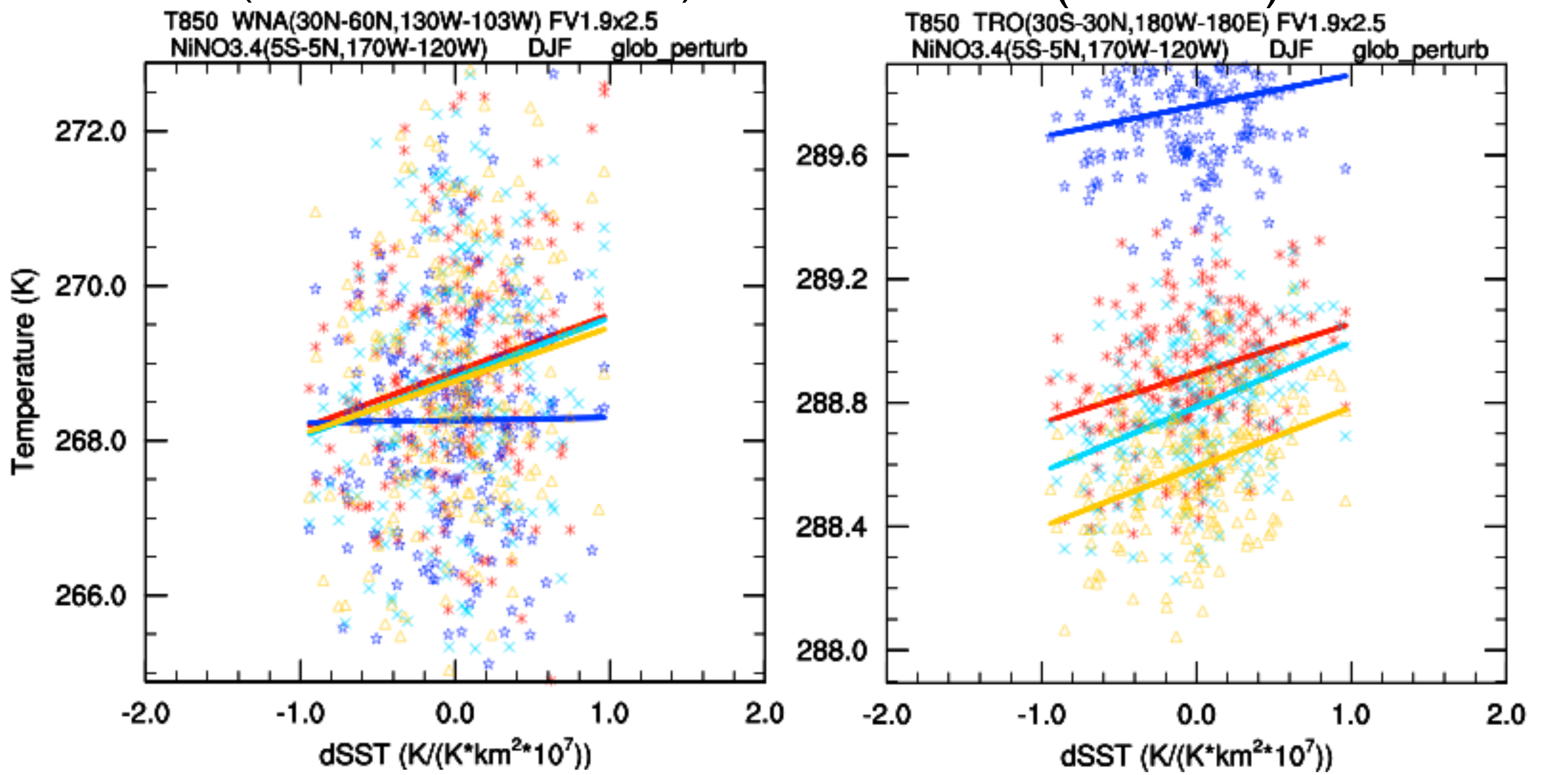
Extra slides

NCAR CAM Inter-Comparison:

CAM3.1 (blue), CAM3.5 (cyan)
CAM4.0 (red), CAM5.0 (orange)

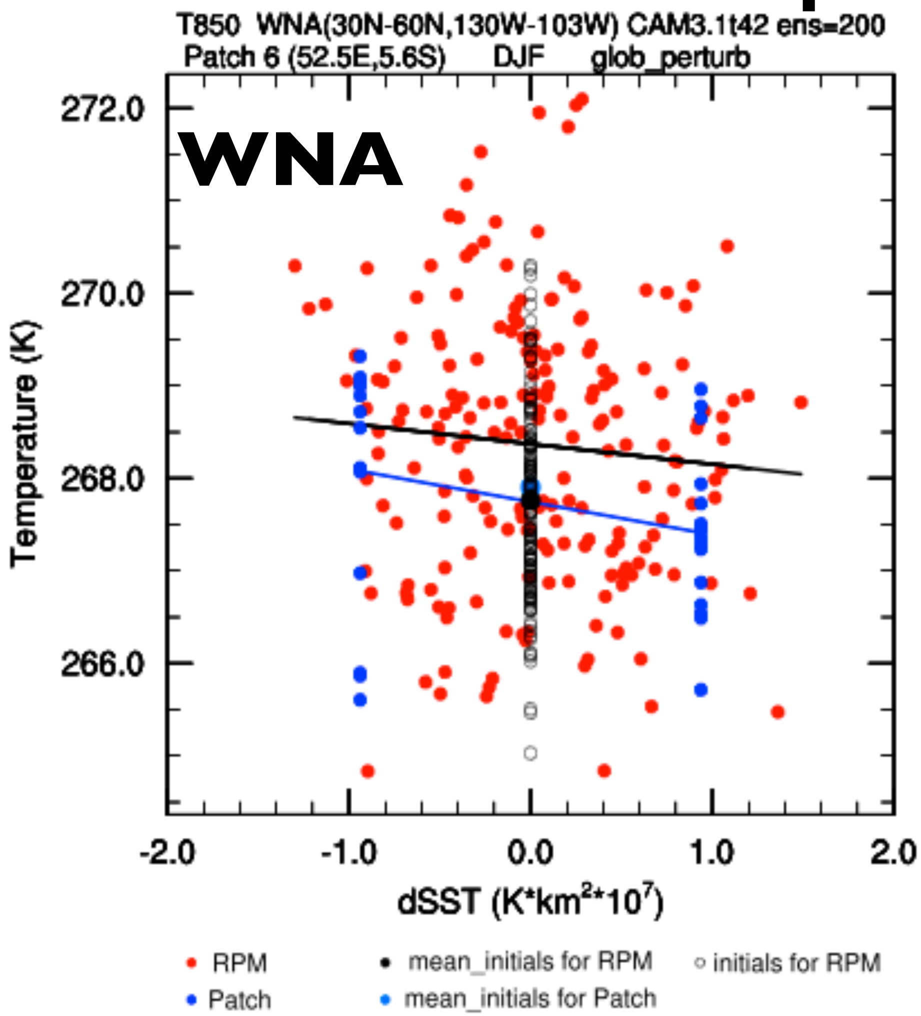
DJF T850 response to Nino3.4 SST location

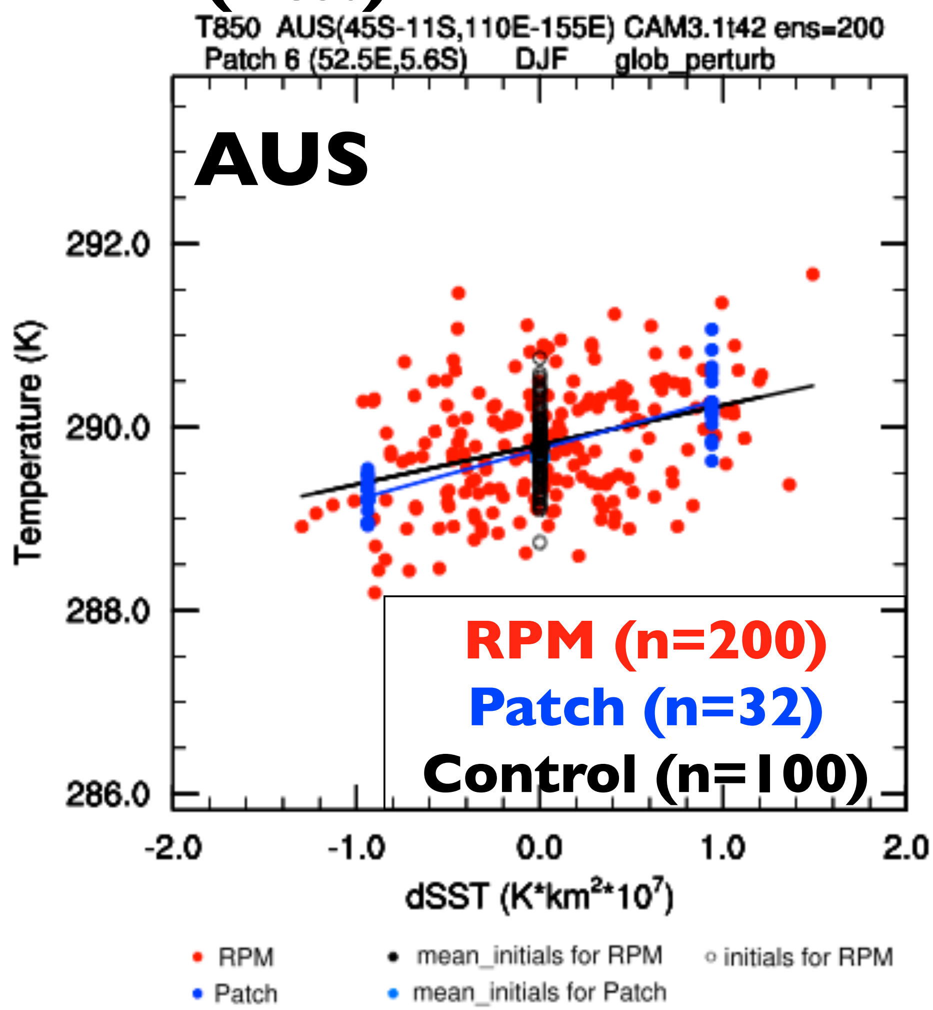
W. North America (30-60N, 170-103W) | **Tropics** (30S-30N)



GTO: RPM versus Patch

Temperature (T_{850})





Patch Region: 52.5E, 5.6S (Indian Ocean)
Response: WNA (left), Australia (right)

Define metric: GTO
Global Teleconnection Operator

- Estimate $\mathbf{K_{ji}}$ from the following linear relation:
- $$R_j = K_{ji} F_i + b_{0j} + \varepsilon$$
- where $\mathbf{R_j}$ is the model response of targeted region of interest, $\mathbf{F_i = (\Delta SST)_i}$ is the SST anomaly at a given location, $\mathbf{b_{0j}}$ is the intercept and ε is the error.

K is the linear operator that estimates the local climate change response to an SST anomaly over a specified region.

We call **K** the Global Teleconnection Operator, **GTO**.

- The GTO can be used to **estimate the response to observed SST patterns via K*SST(obs)**. (i.e., an empirical Green's function)

"Giorgi" Regions

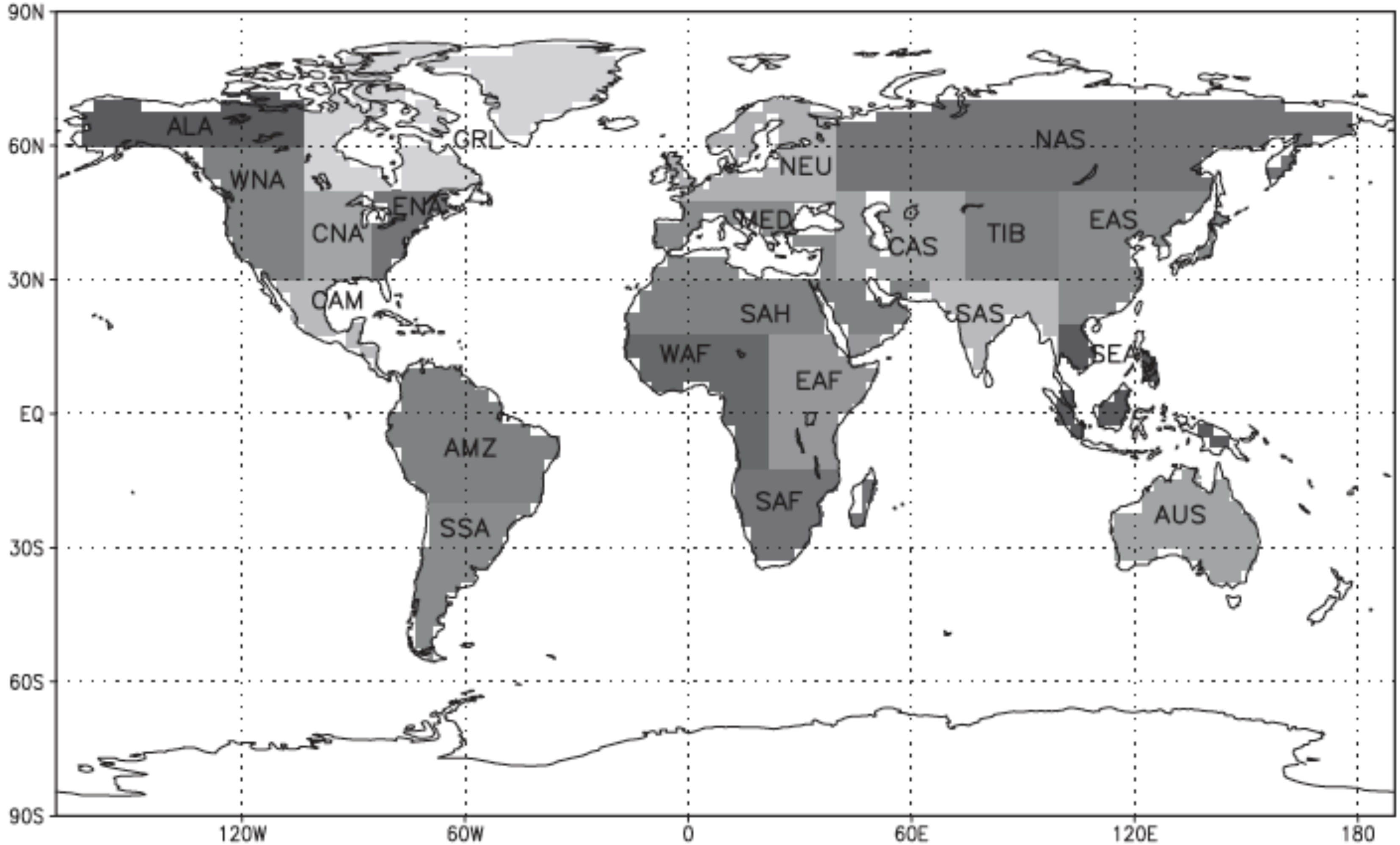
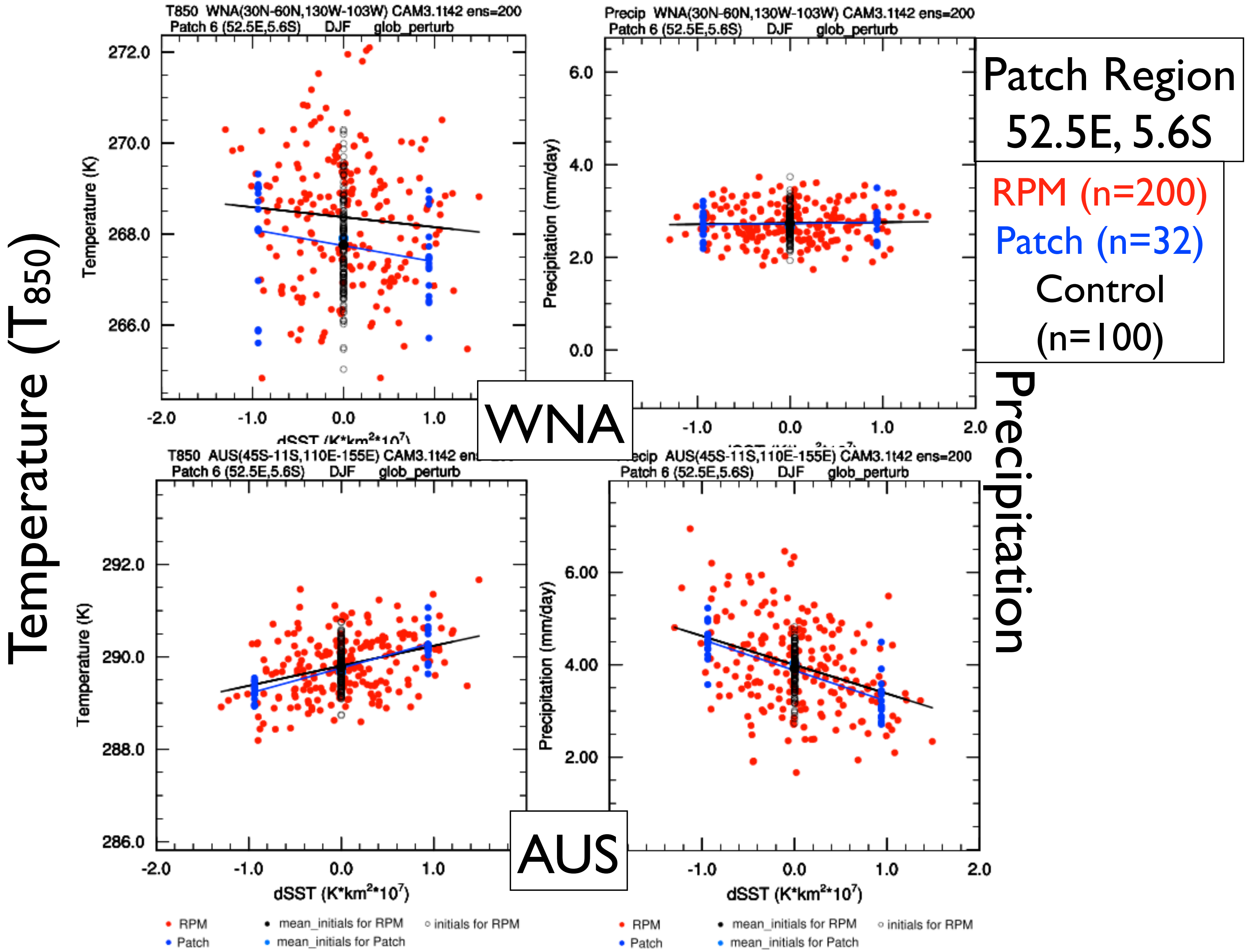
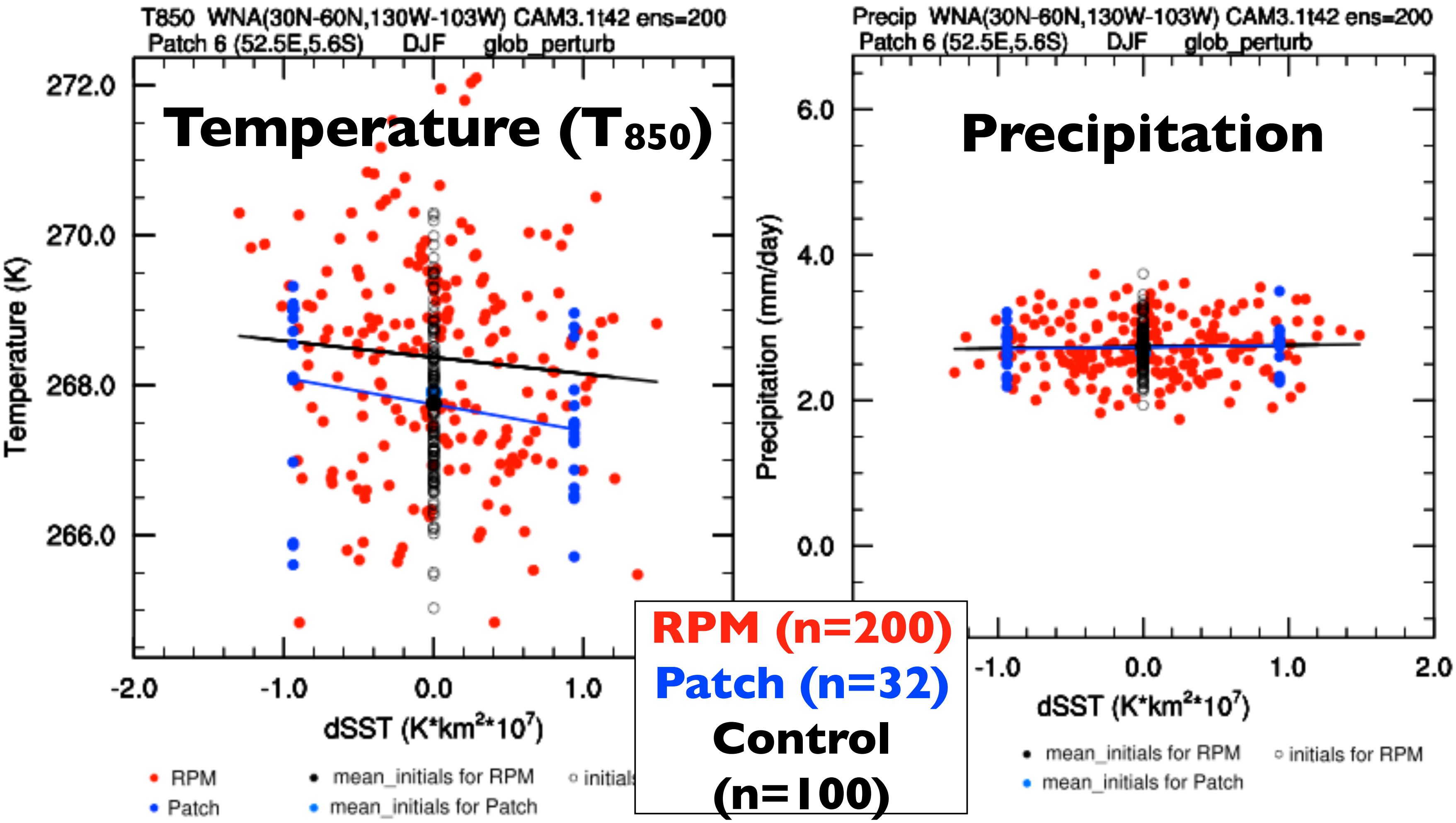


Fig. 1 Regions used in the analysis presented in this work (see Table 2 and text)

GTO: RPM versus Patch



GTO: RPM versus Patch



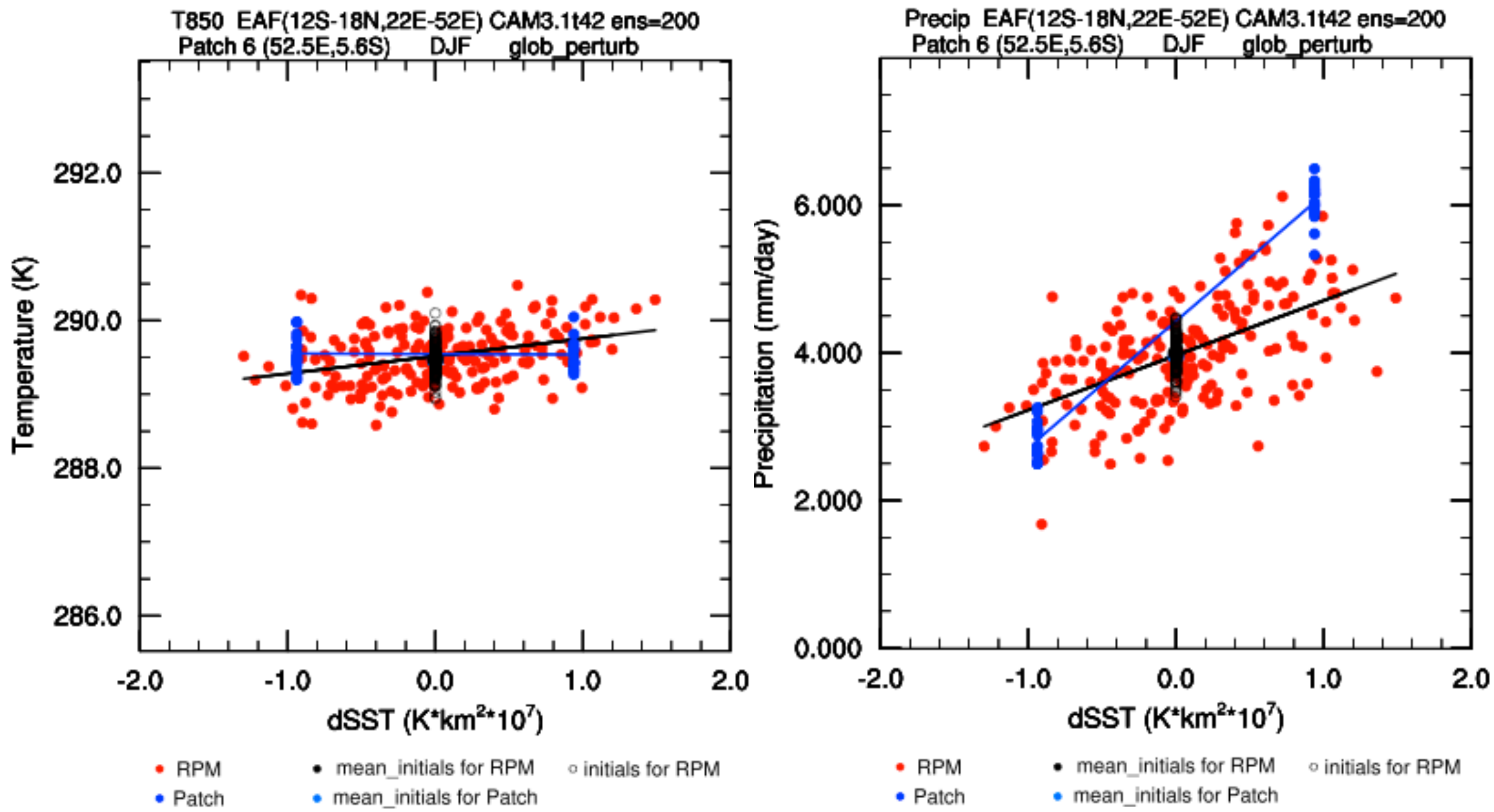
Patch Region: 52.5E, 5.6S (Indian Ocean)
Response: Giorgi Region: W. North America

GTO: RPM versus Patch
Example of Non-linear Case

Patch Region
52.5E, 5.6S

East Africa

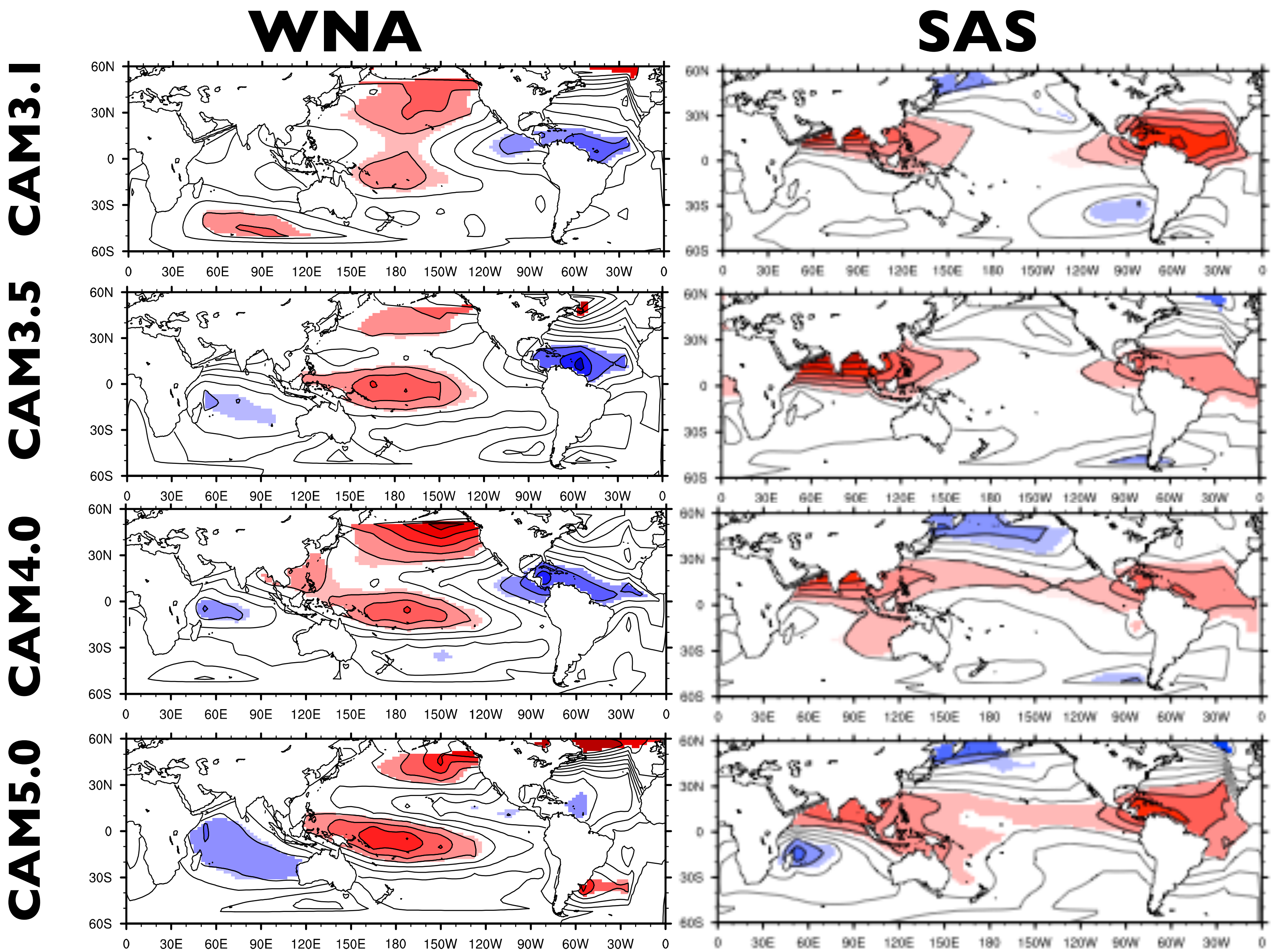
RPM (n=200)
Patch (n=32)
Control (n=100)



Temperature (T_{850})

Precipitation

GTO: Sensitivity Maps (K_{ji})



GTO: Sensitivity Maps (K_{ji})

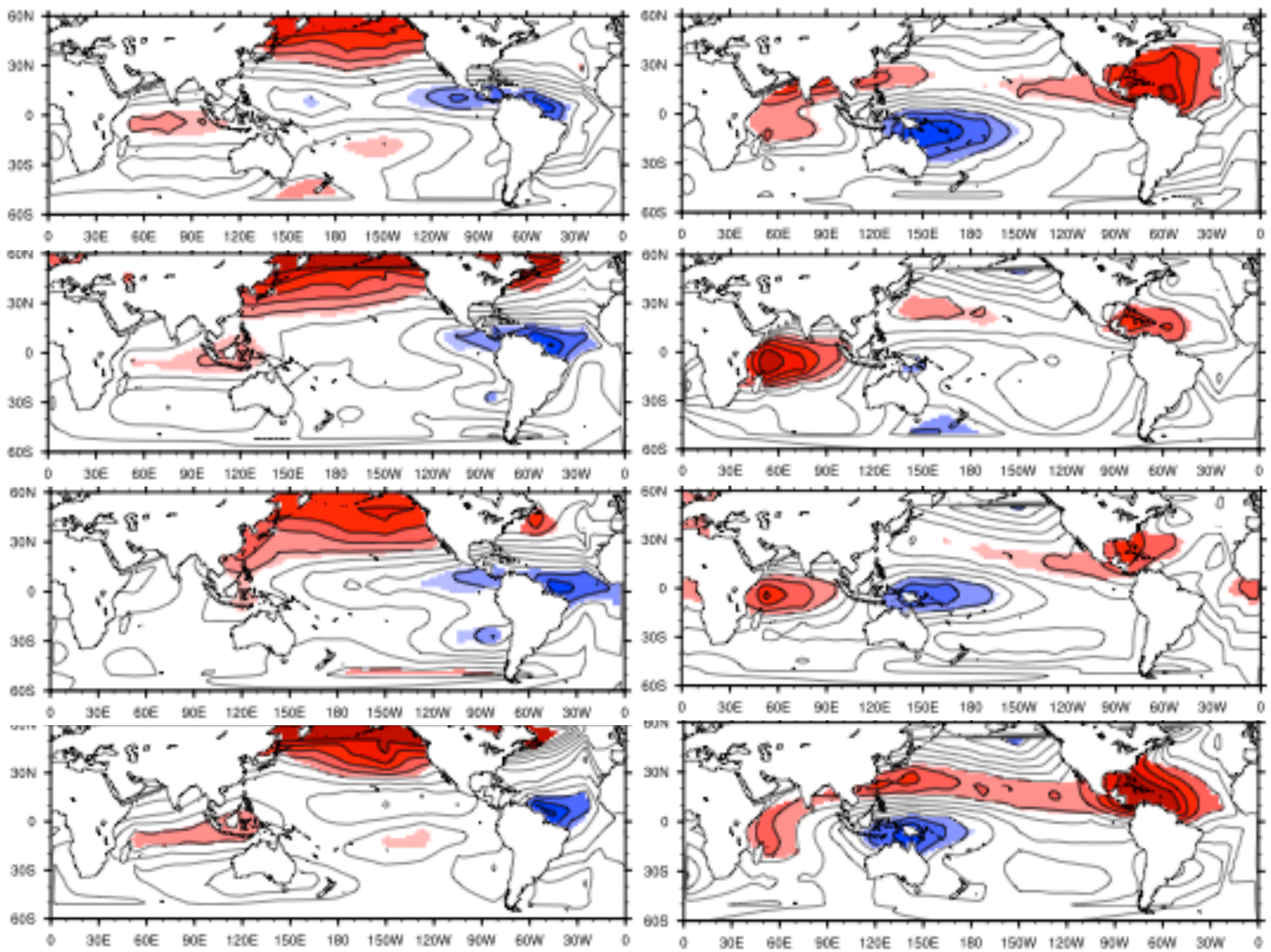
N. America | **EAS**

CAM3.1

CAM3.5

CAM4.0

CAM5.0



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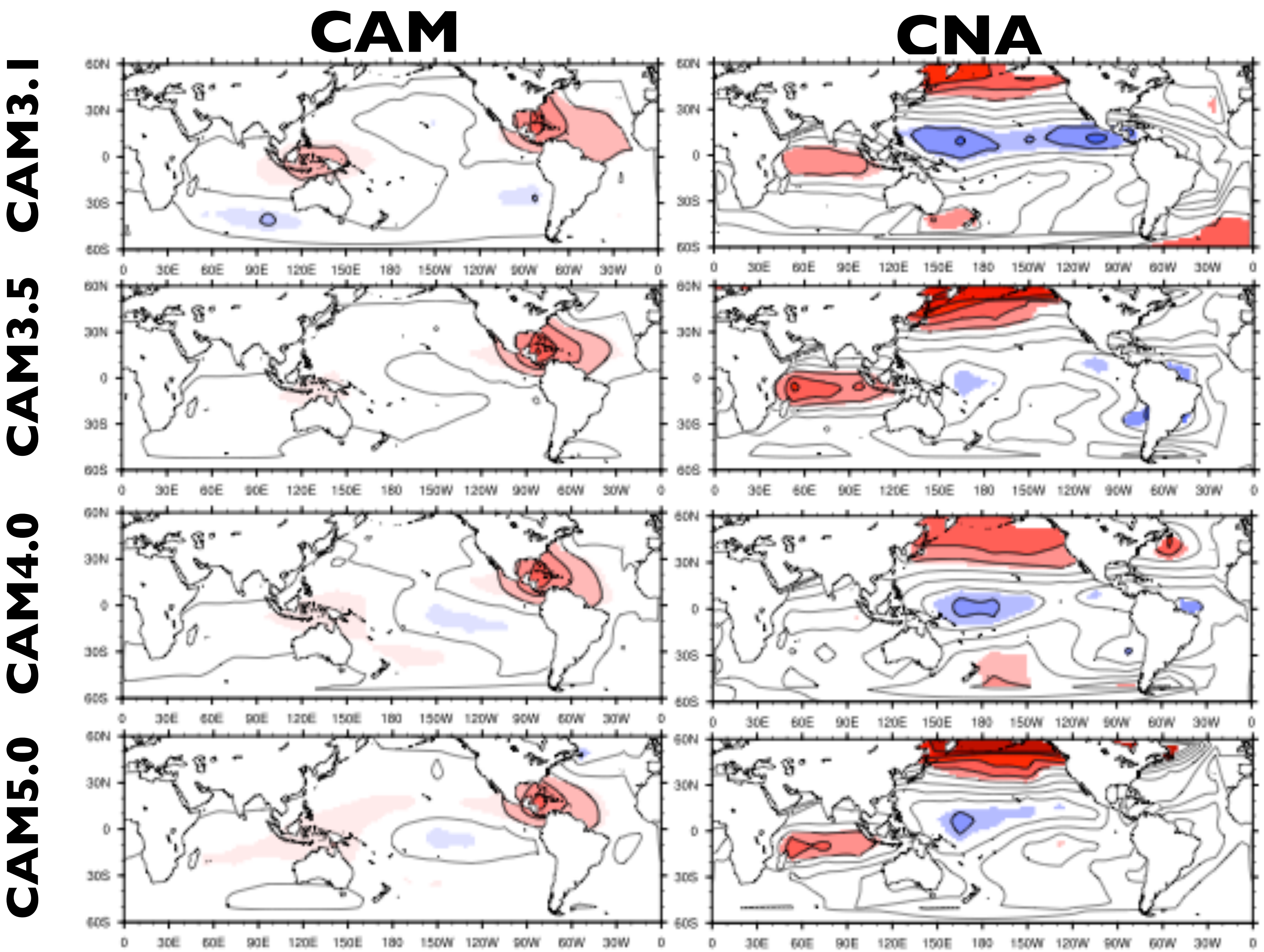

GTO: Sensitivity Maps (K_{ji})