WESTERN NORTH PACIFIC (WNP) AS AN ENSO PRECURSOR AND ITS CHANGE UNDER GLOBAL WARMING

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MANY THANKS TO MY CO-AUTHORS
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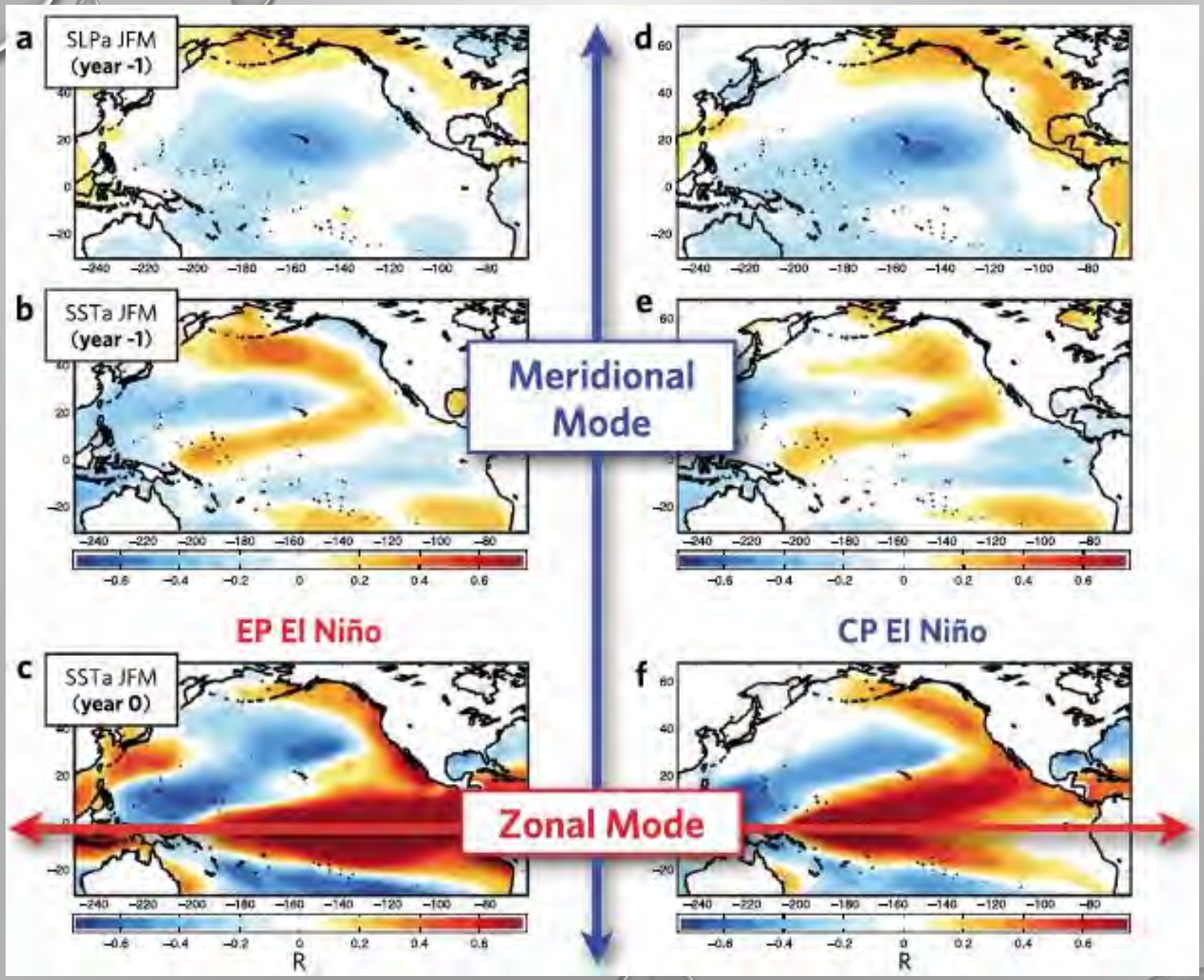
MICHELLE L'HEUREUX @CPC/NOAA

S.-Y. WANG, M. L'HEUREUX, AND J.-H. YOON, 2013: ARE GREENHOUSE GASES CHANGING ENSO PRECURSORS IN THE WESTERN NORTH PACIFIC?, J. CLIMATE (CESM SPECIAL ISSUE), DOI:10.1175/JCLI-D-12-00360.1

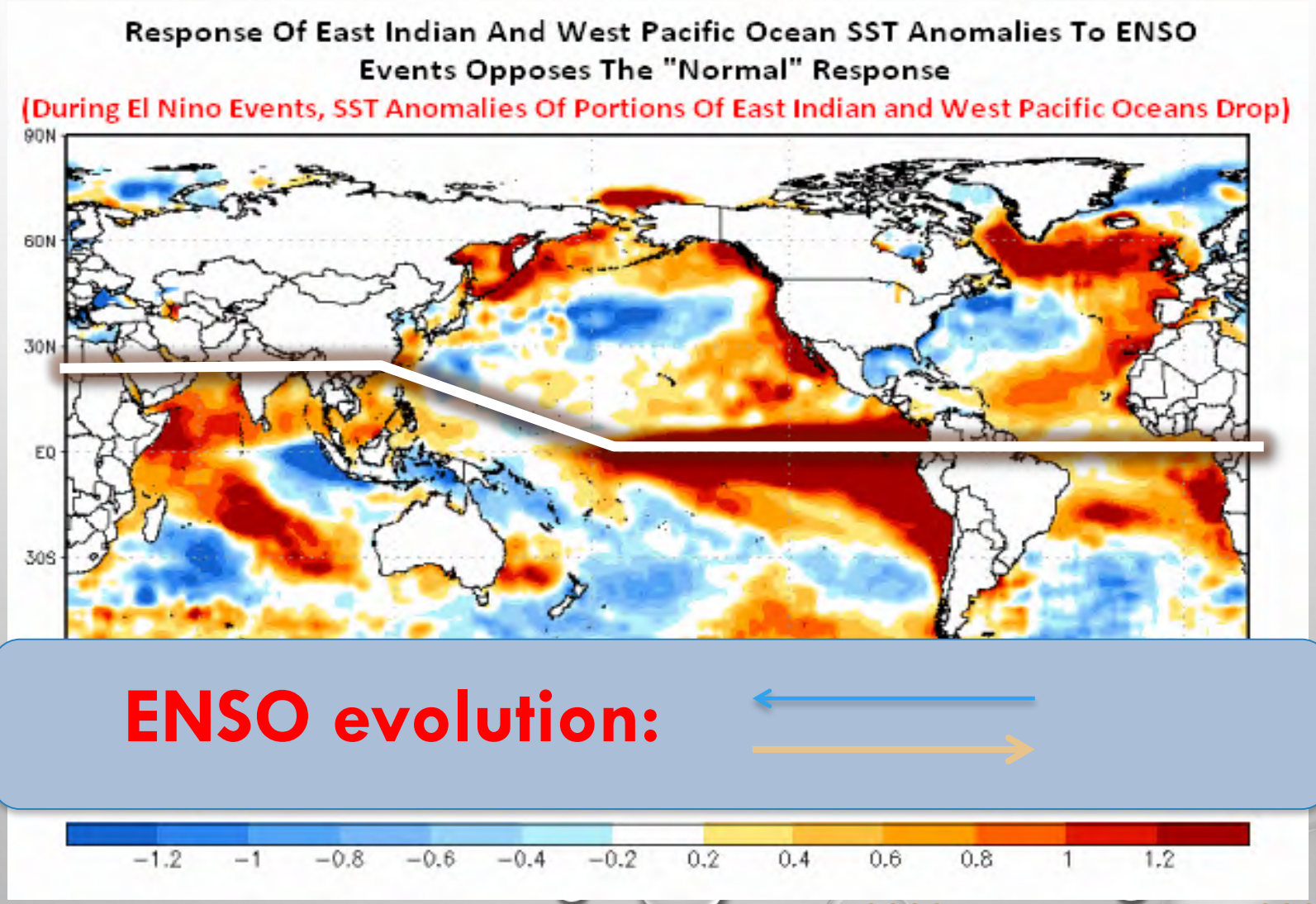
WHAT ARE "PRECURSORS" OF ENSO?

- WESTERLY WIND BURST ➔ POSITIVE FEEDBACK SUCH AS ZONAL CURRENT AND THERMOCLINE FEEDBACK ➔ LEAD TO ENSO
- NPO (NORTH PACIFIC OSCILLATION) – THROUGH 'SEASONAL FOOTPRITING MECHANISM'
- PMM (PACIFIC MERIDIONAL MODE) – SIMILAR TO NPO TYPE BUT INVOLVES 'WIND-EVAPORATION-SST FEEDBACK'

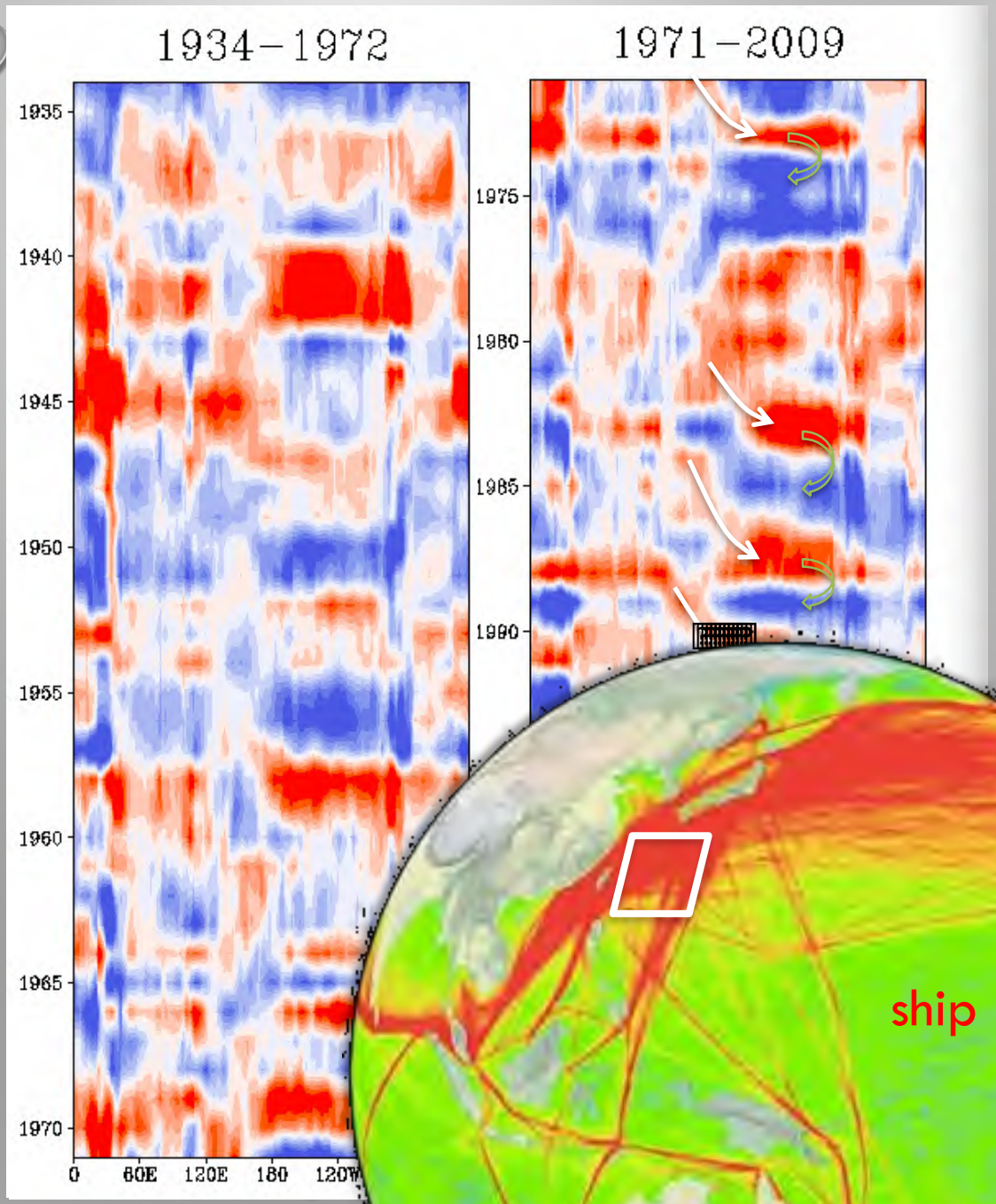


Lorenzo et al. (2015; GRL)

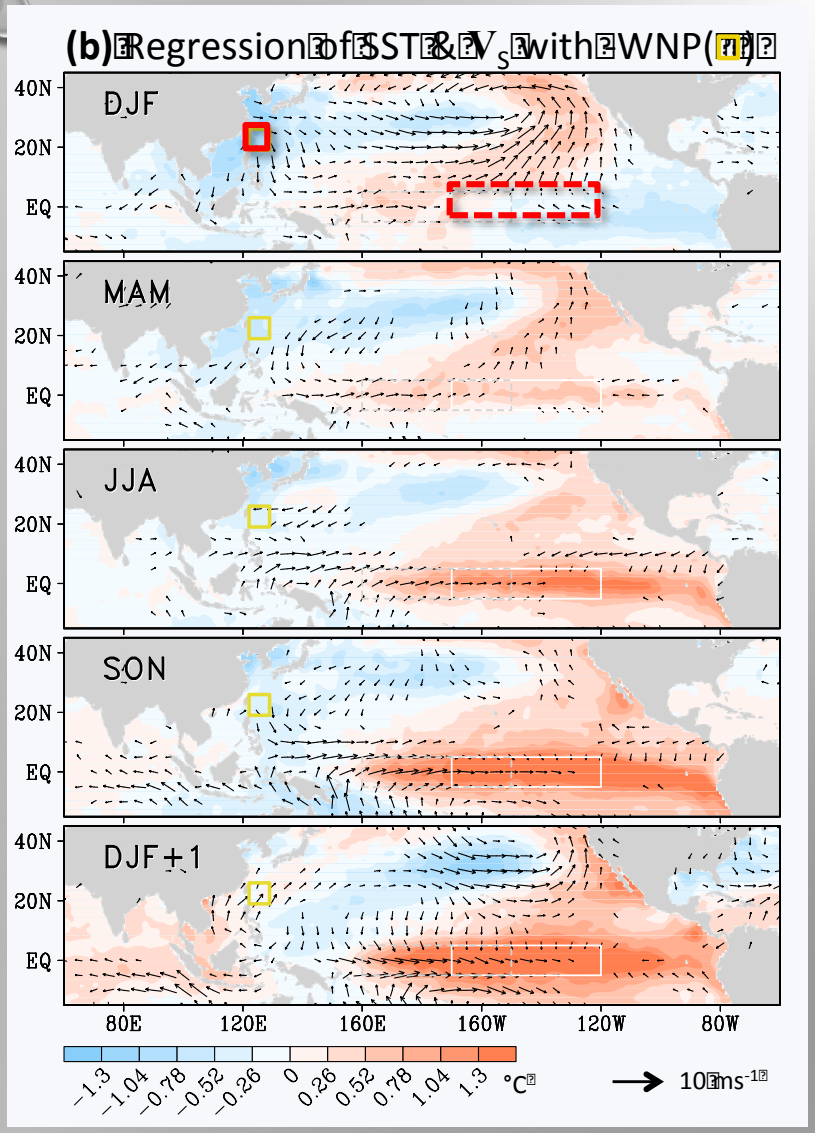
EVOLUTION OF ENSO



(Wang and An 2002; Guan and Nigam 2008)

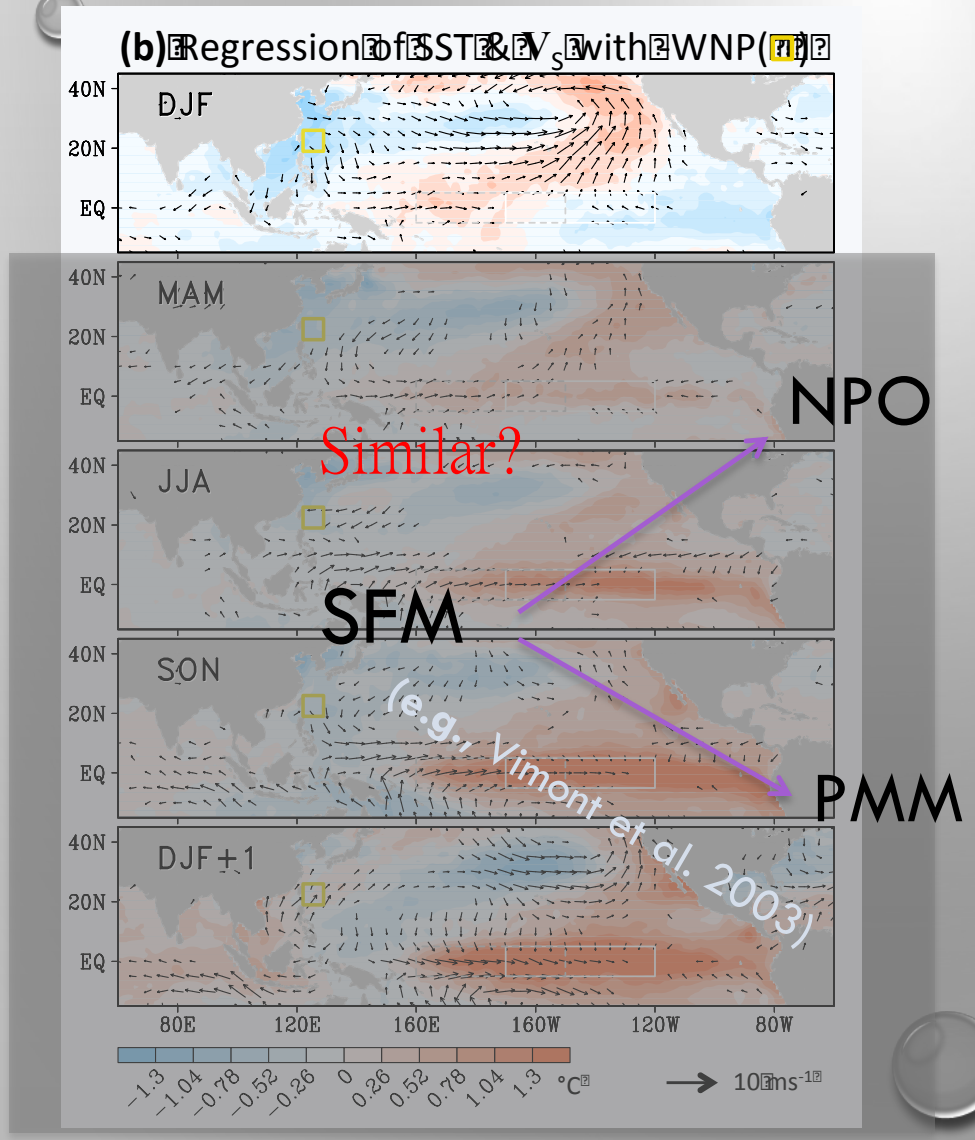

1934–1972
1971–2009
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
0
60E
120E
180
120W
earlier
later
ship routes

WNP AS AN ENSO PRECURSOR

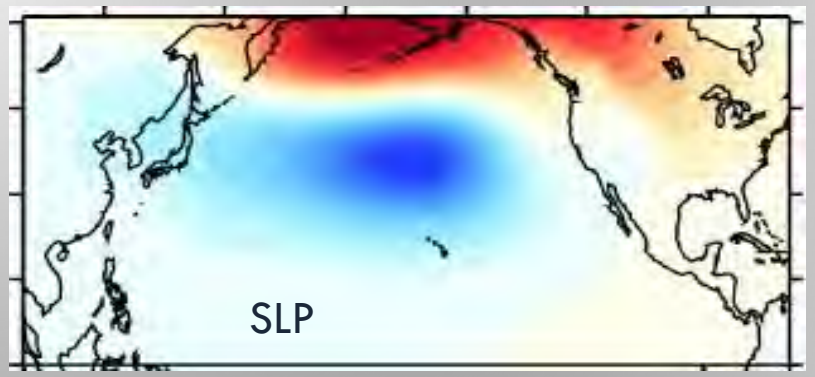


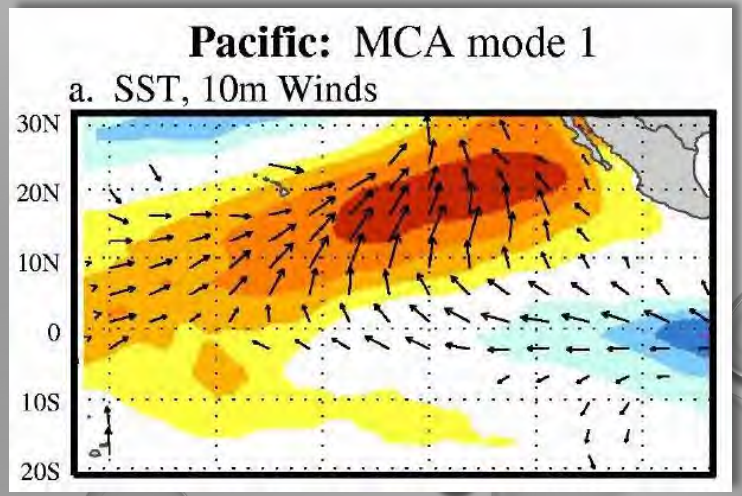
Western North Pacific

WNP AS AN ENSO PRECURSOR

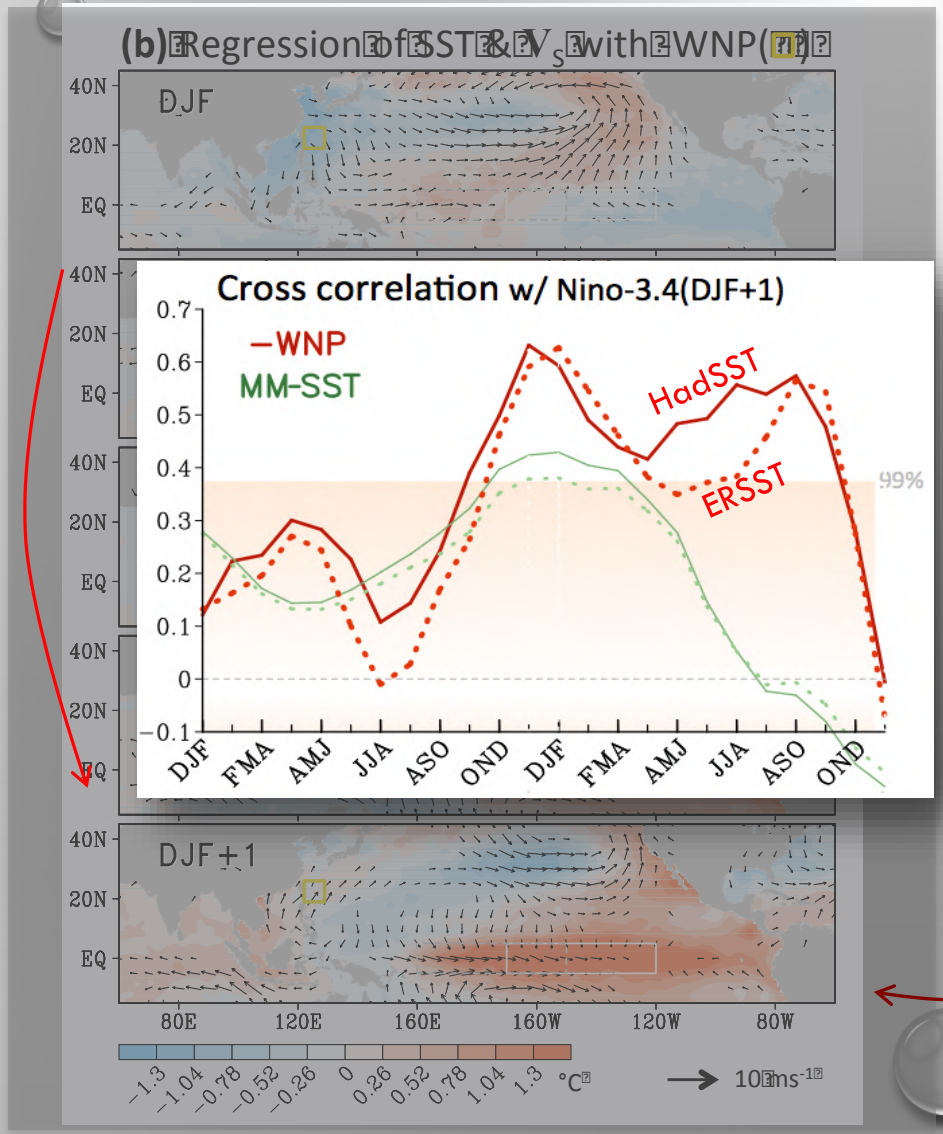


Western North Pacific

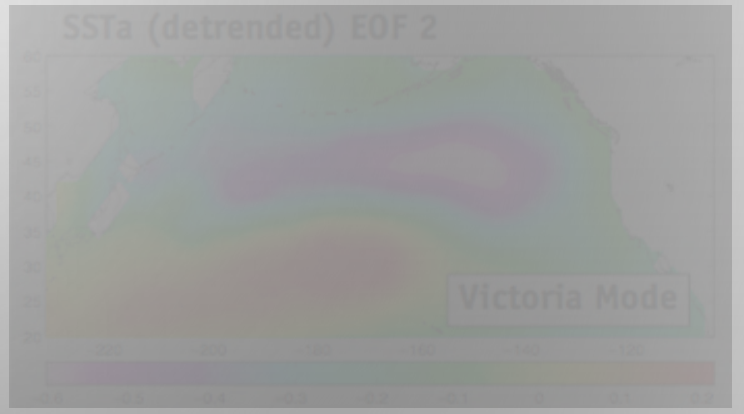


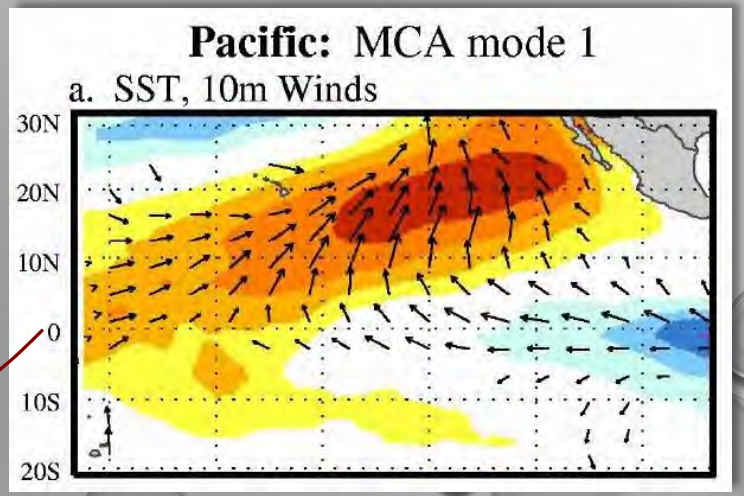


WNP AS AN ENSO PRECURSOR



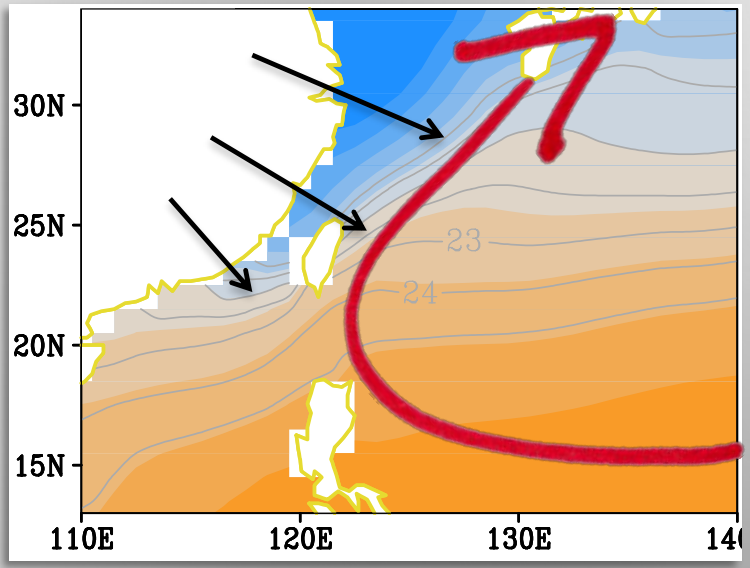
Western North Pacific





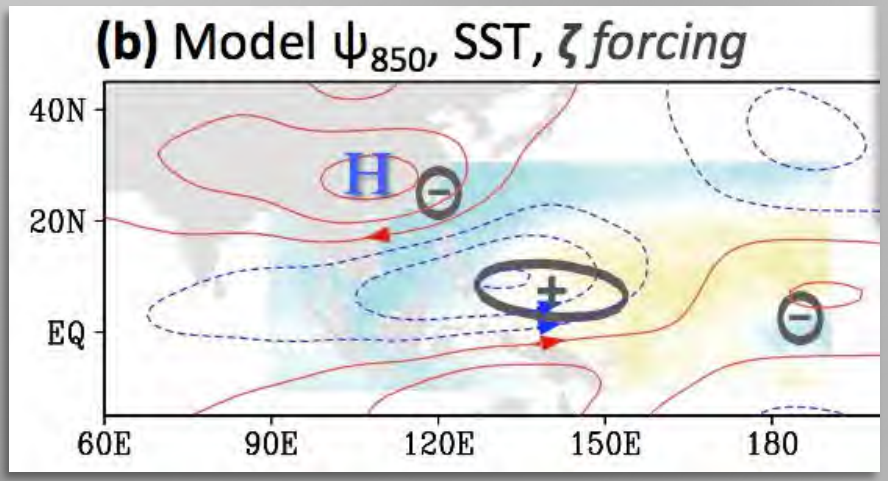
WHY WESTERN NORTH PACIFIC (WNP)?

SST DJF Mean



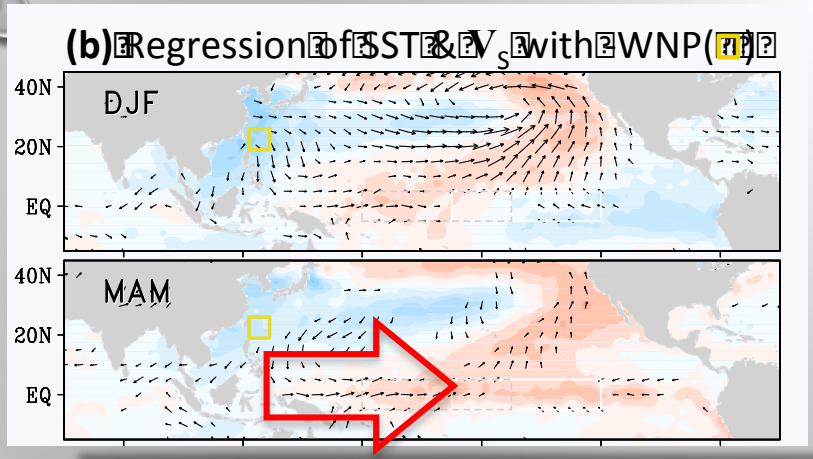
(1) East Asian Winter Monsoon impact

Kuroshio Current

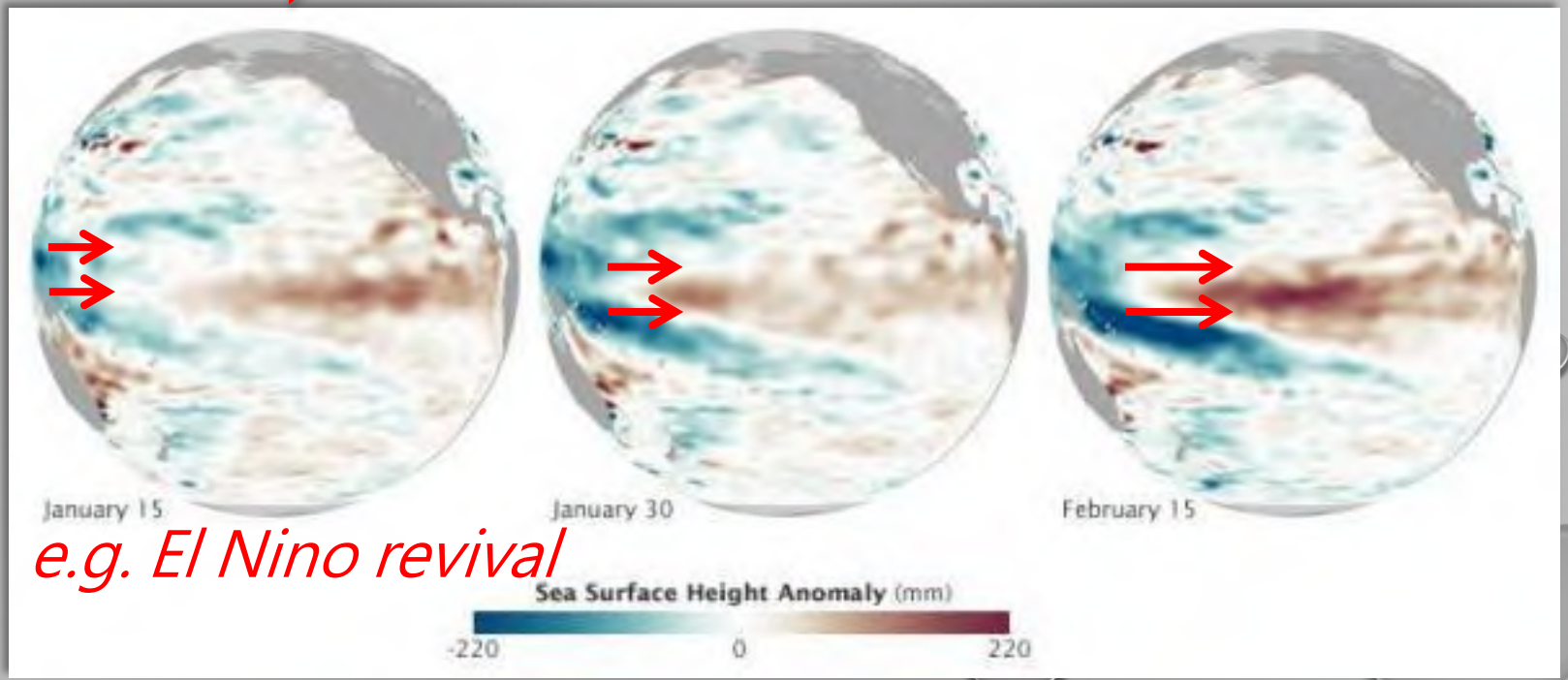


Barotropic model w/ composite WNP heat source/sink

WHY WESTERN NORTH PACIFIC (WNP)?

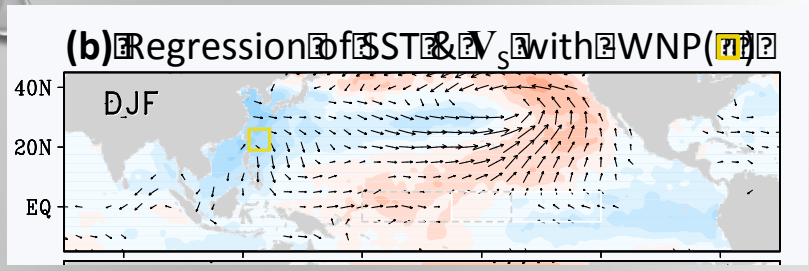


(2) Oceanic Kelvin wave - zonal wind triggered



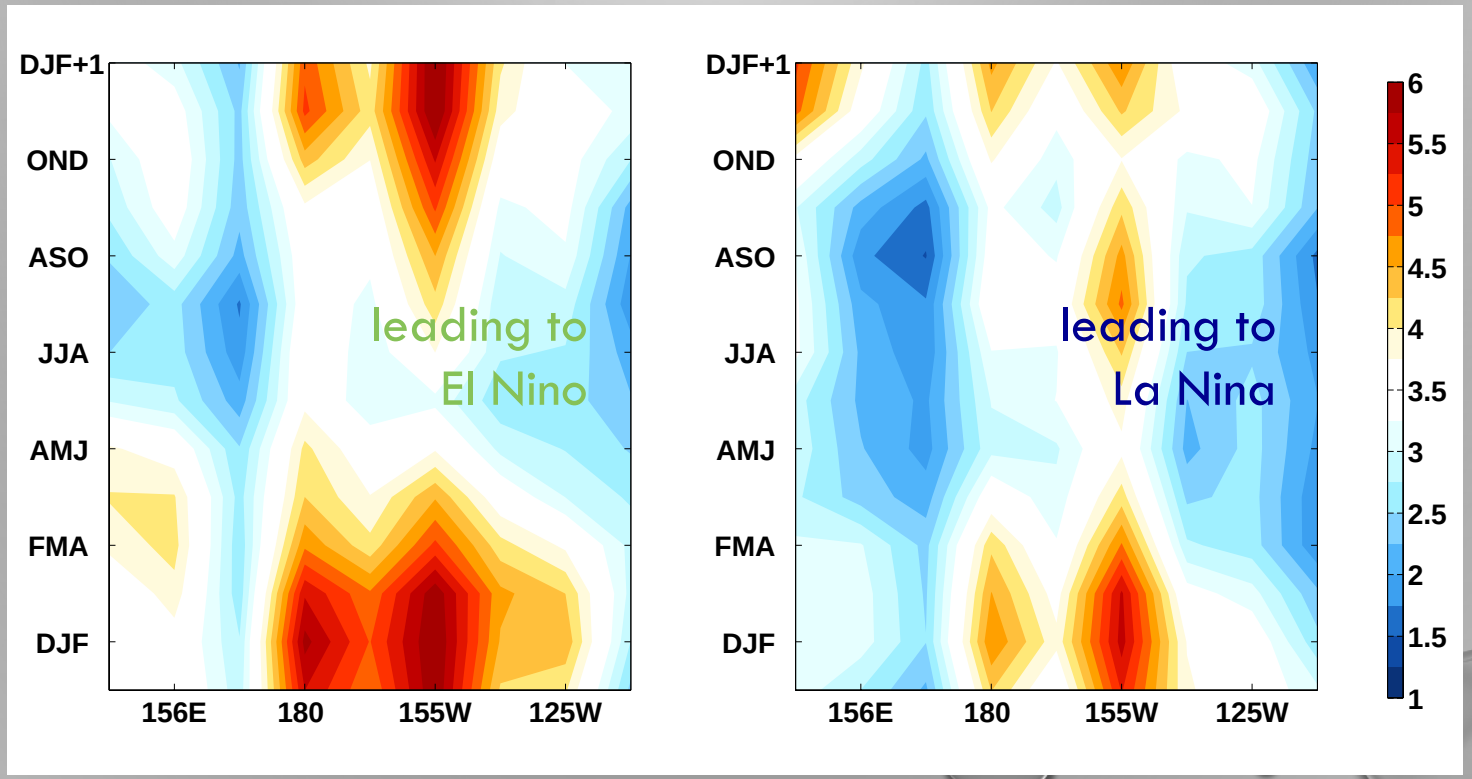
e.g. El Nino revival

WHY WESTERN NORTH PACIFIC (WNP)?

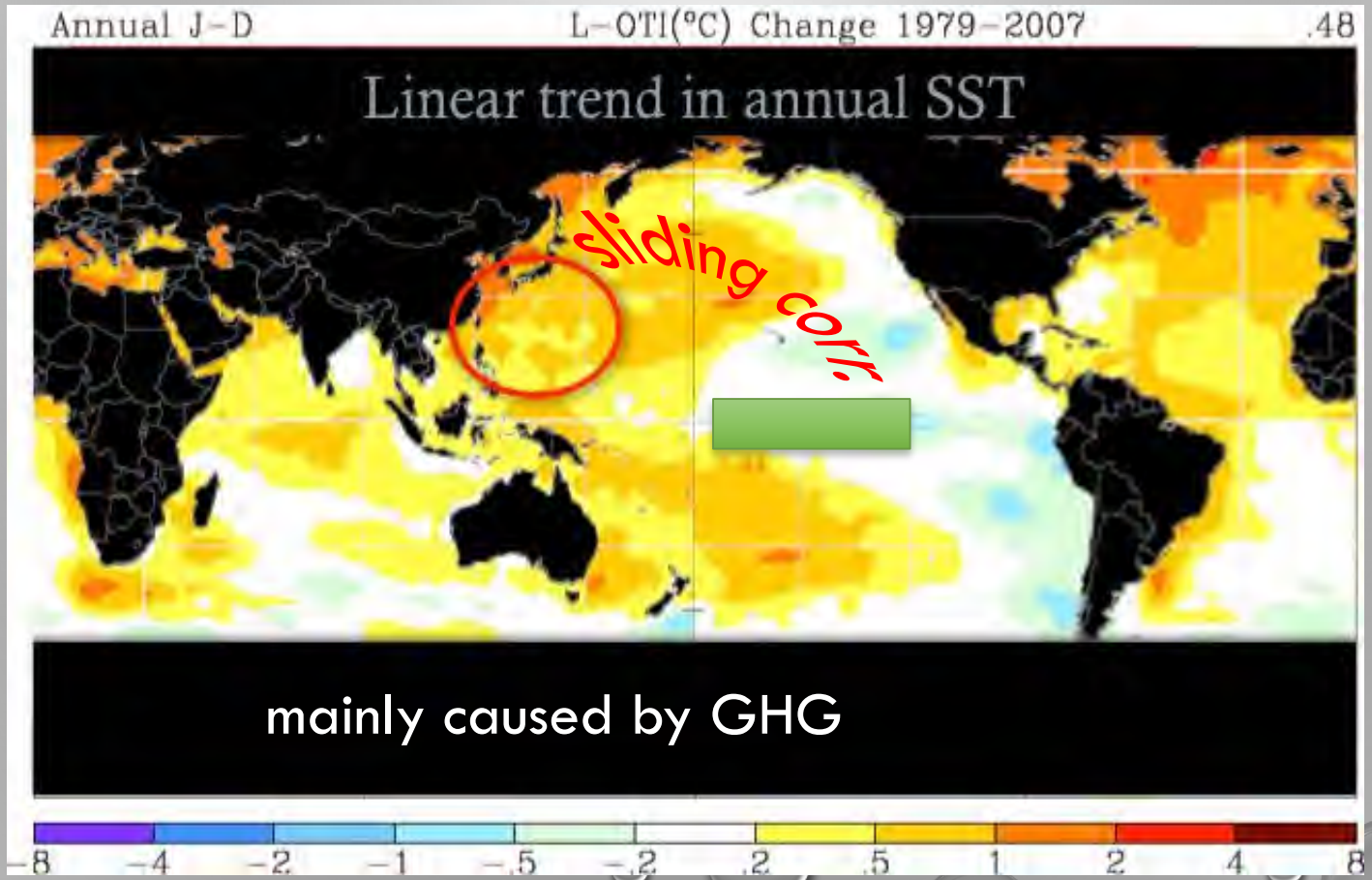


KW dynamic height composite

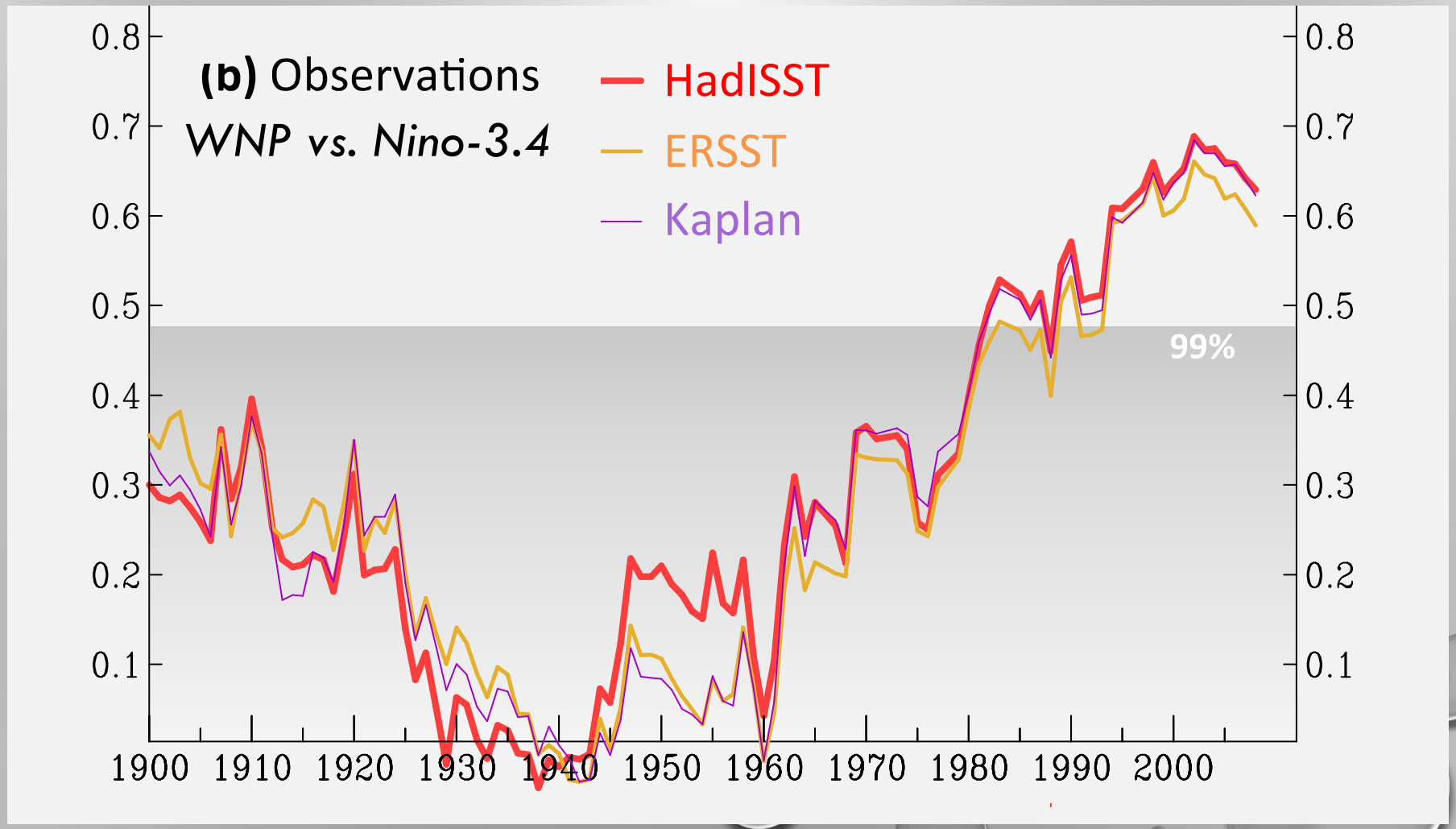
(2) Oceanic Kelvin wave - zonal wind triggered



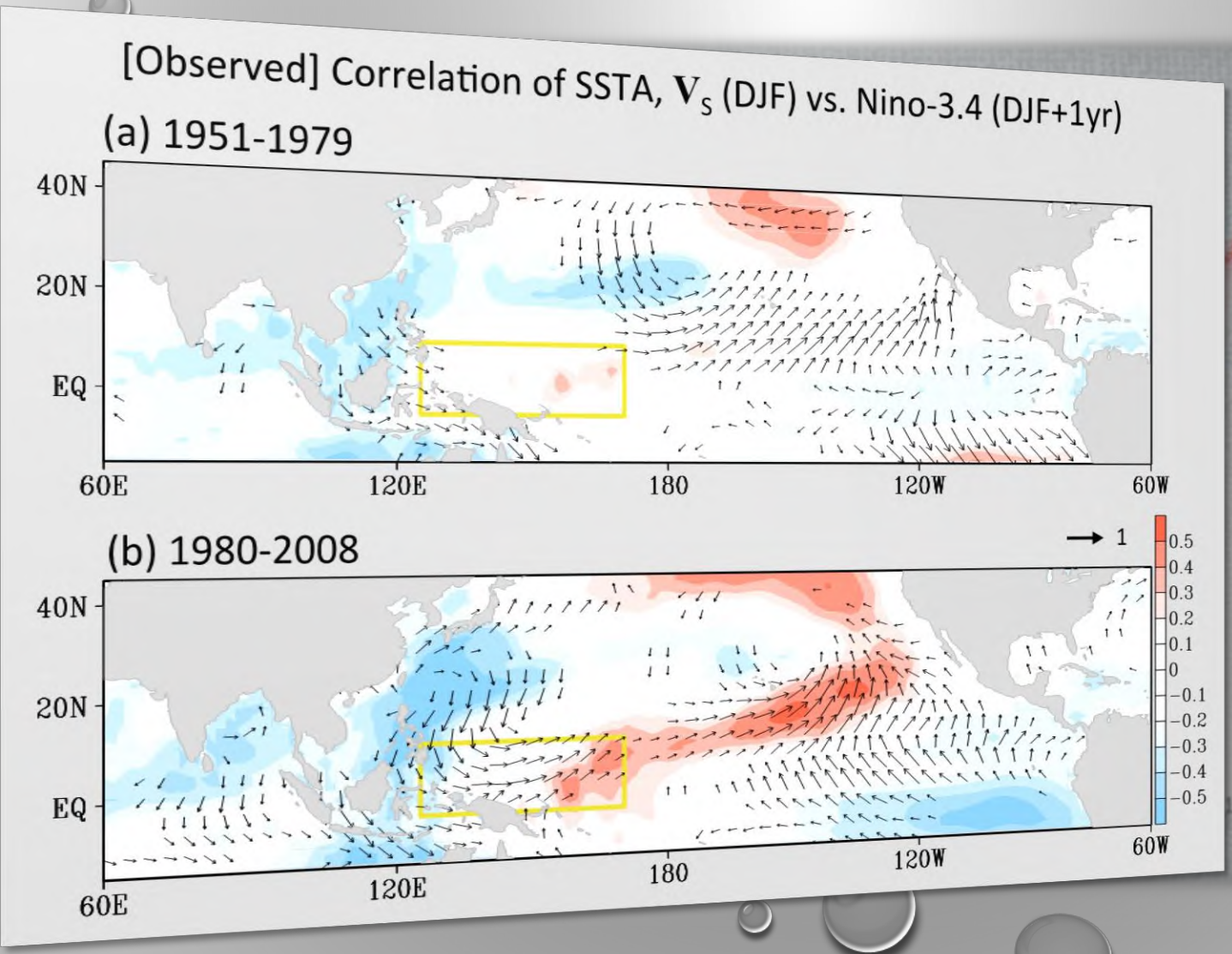
IS GHG forcing ENHANCING ENSO PRECURSORS IN THE WESTERN NORTH PACIFIC?



25-YR SLIDING CORRELATION OF SSTA



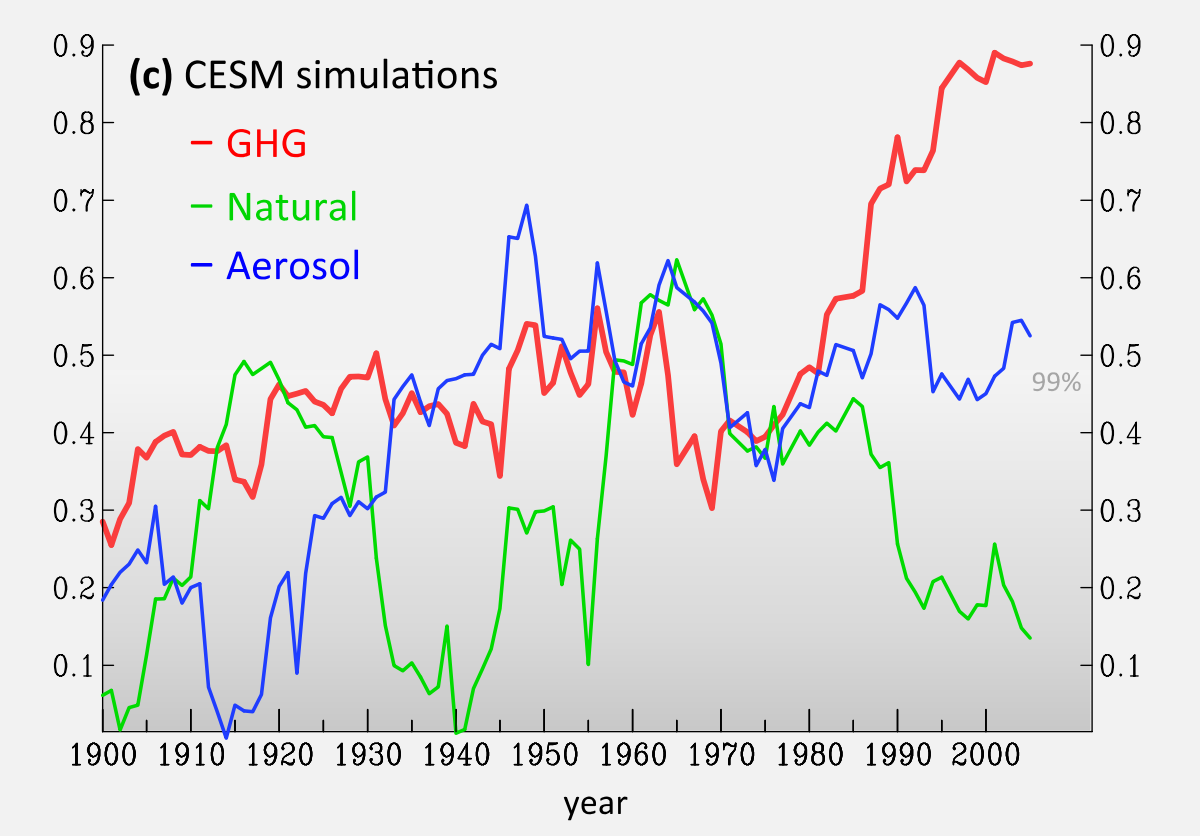
CORRELATION FOR ENSO PRECURSORS



USING EARTH SYSTEM MODEL (ESM) – CESM1

25-YR SLIDING CORRELATION OF SSTA

Historical forcing experiments (1850-2005):

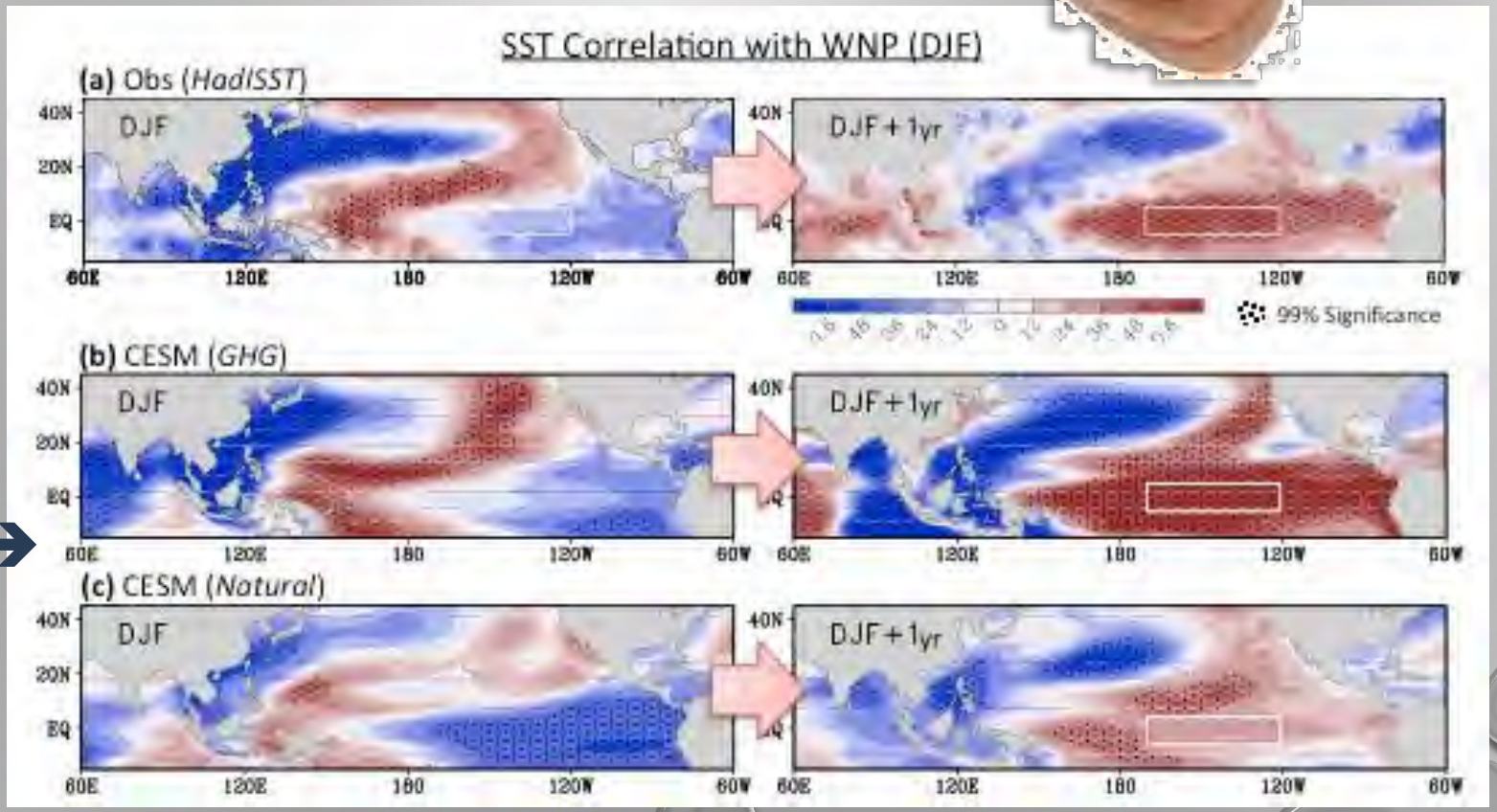


← holy cow

HOW GOOD IS CESM
REALISTIC ENSO PRE-CON

OBS ➔

CESM1 ➔

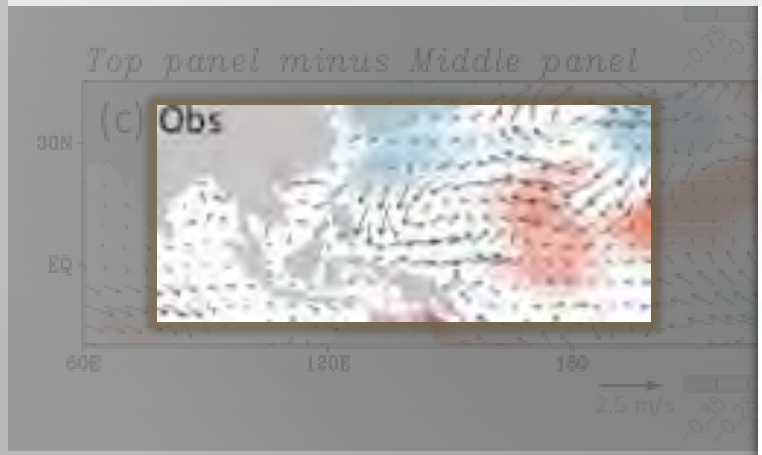


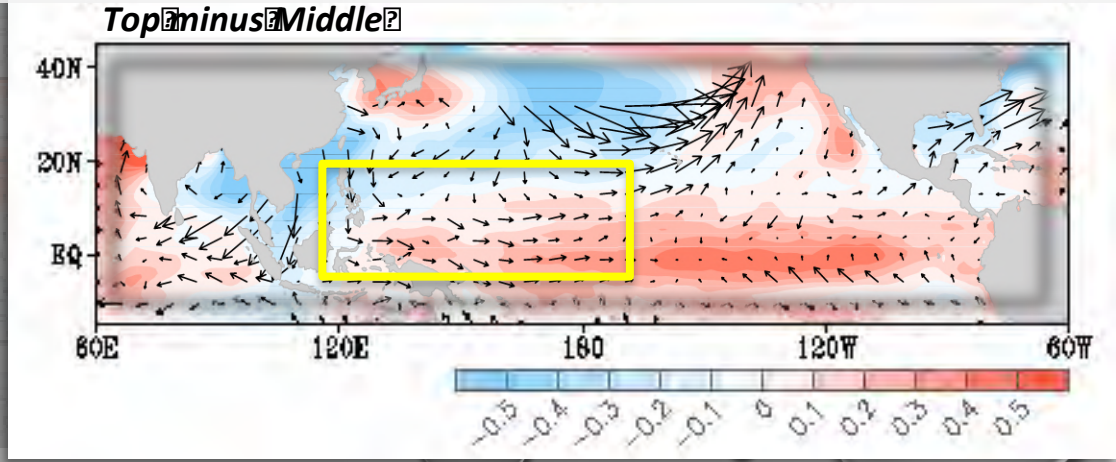
WNP warming & dynamics

CESM free run

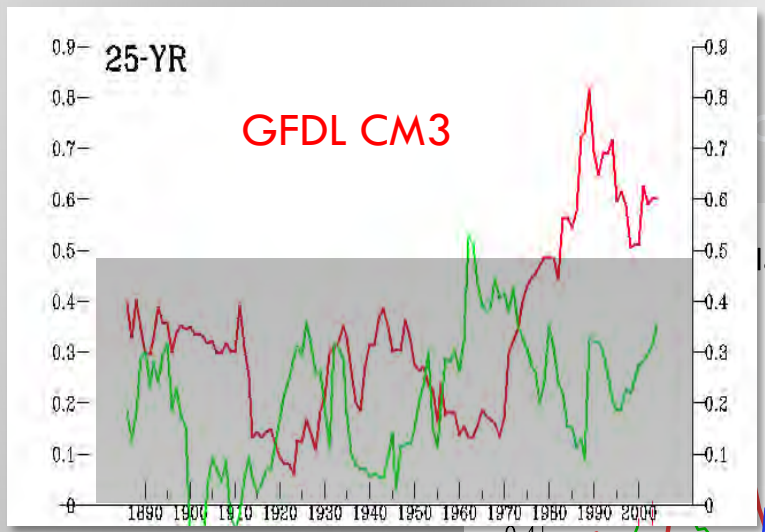
Community Earth System Model

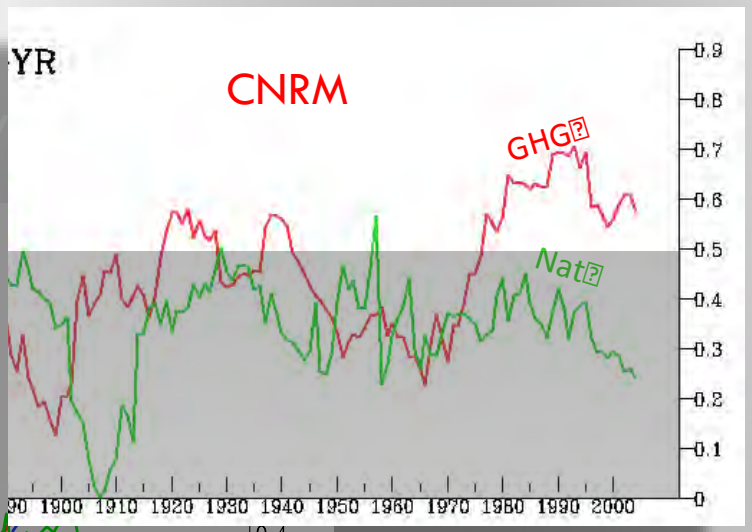
CESM 350-year control run (natural variability)

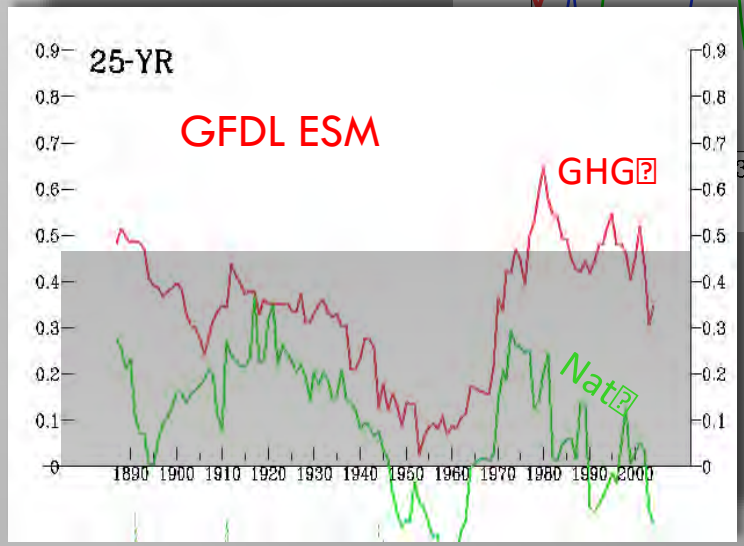


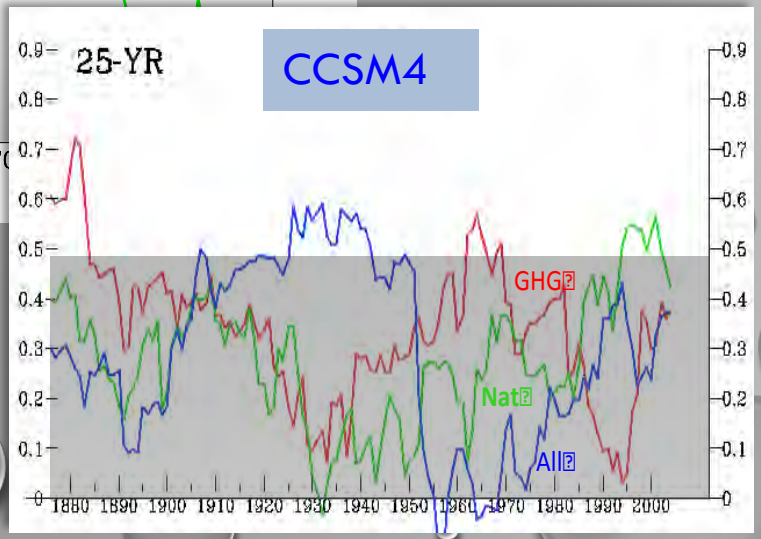


OTHER MODELS (FROM CMIP5)





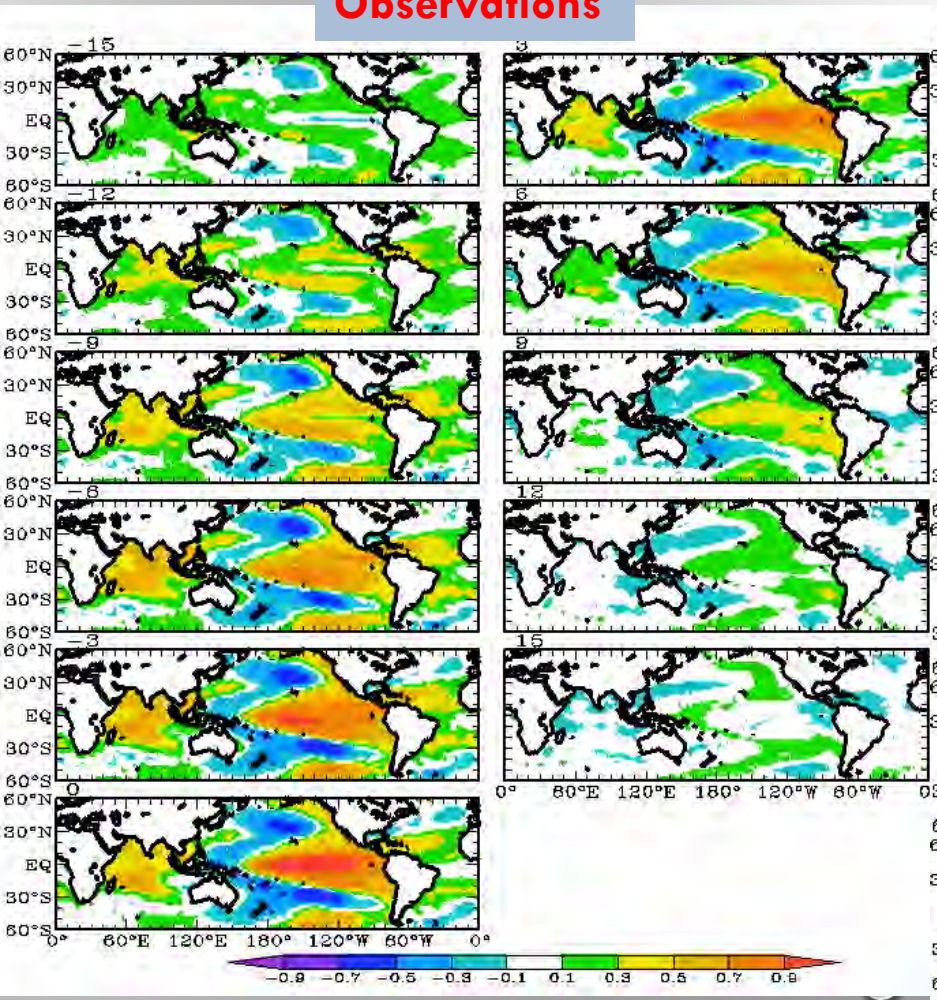


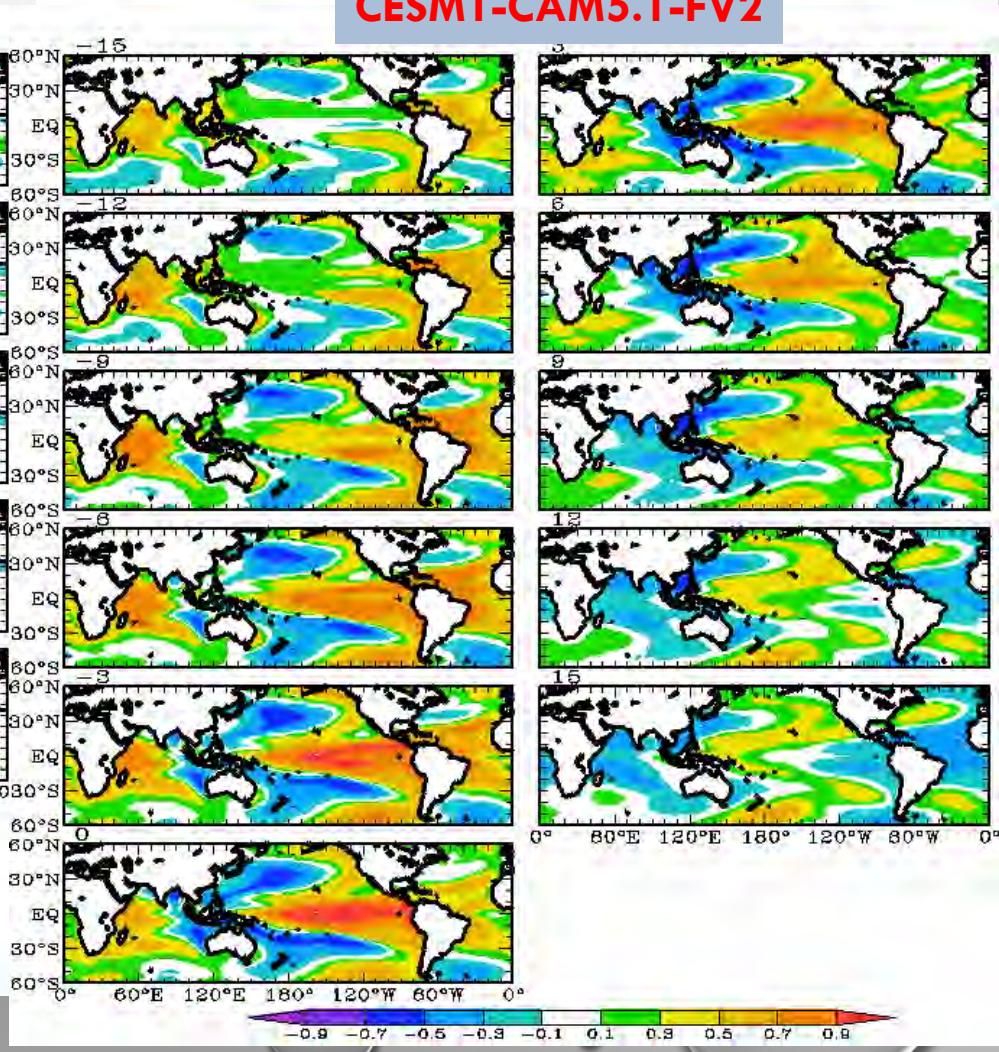


LEAD-LAG CORRELATION OF NINO3.4 WITH SST

Observations

CESM1-CAM5.1-FV2



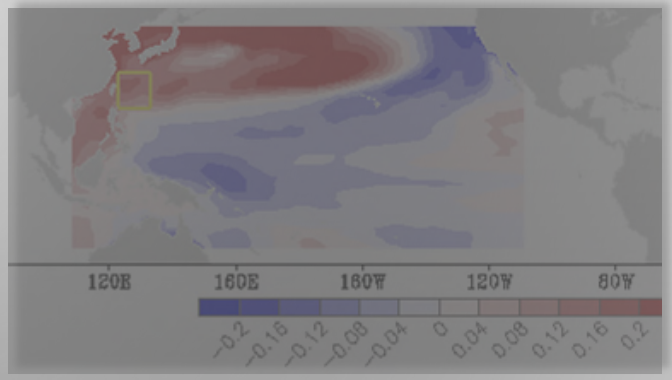


CAM - the Atmospheric Component of CCSM/CESM

Model	CCSM3 (2004)	CCSM3.5 (2007)	CCSM4 (Apr 2010)	CESM1 (Jun 2010)
Atmosphere	CAM3 (L26)	CAM3.5 (L26)	CAM4 (L26)	CAM5 (L30)
Boundary Layer Turbulence	Holtslag-Boville (93) Dry Turbulence	Holtslag-Boville	Holtslag-Boville	Bretherton-Park (09) Moist Turbulence
Shallow Convection	Hack (94)	Hack	Hack	Park-Bretherton (09) Shallow Convection
Deep Convection	Zhang-McFarlane (95)	Zhang-McFarlane Neale et al.(08) Richter-Rasch (08)	Zhang-McFarlane Neale et al.(08) Richter-Rasch (08)	Zhang-McFarlane Neale et al.(08) Richter-Rasch (08)
Cloud Macrophysics	Zhang et al. (03)	Zhang et al. with Park & Vavrus' mods.	Zhang et al. with Park & Vavrus' mods.	Park-Bretherton-Rasch (10) Cloud Macrophysics
Stratiform Microphysics	Rasch-Kristjansson (98) *Single Moment*	RK *Single Moment*	RK *Single Moment*	Morrison and Gettelman (08) *Double Moment*
Radiation / Optics	CAMRT (01)	CAMRT	CAMRT	RRTMG Iacono et al.(08) / Mitchell (08)
Aerosols	Bulk Aerosol Model (BAM)	BAM	BAM	Modal Aerosol Model (MAM) Liu & Ghan (2009)
Dynamics	Spectral	Finite Volume (96,04)	Finite Volume	Finite Volume
Ocean	POP2 (L40)	POP2.1 (L60)	POP2.2 - *BGC*	POP2.2
Land	CLM3	CLM3.5	CLM4 - *CN*	CLM4
Sea Ice	CSIM4	CSIM4	CICE	CICE

SUMMARY

- NPO-*like* mode leads WNP to trigger ENSO



- GHG appears to enhance (accelerate) this process

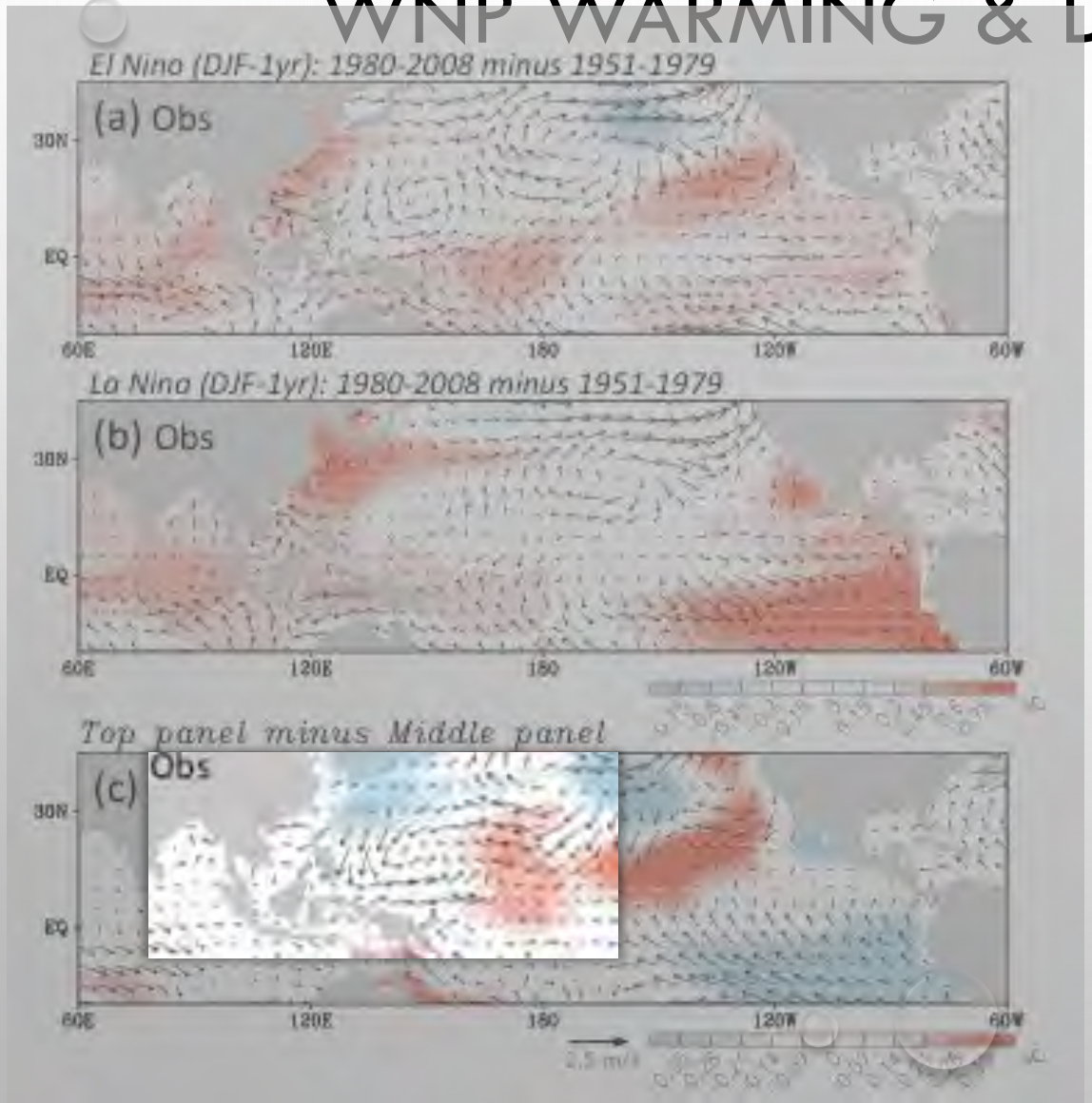
THANKS TO…

- MANY DISCUSSIONS WITH B. ANDERSON (BU), K. BALAGURU (PNNL), AND MORE.

- SUPPORT FROM EARTH SYSTEM MODELING PROGRAM/OFFICE OF SCIENCE/US DOE.

BACK-UP SLIDES

WNP WARMING & DYNAMICS

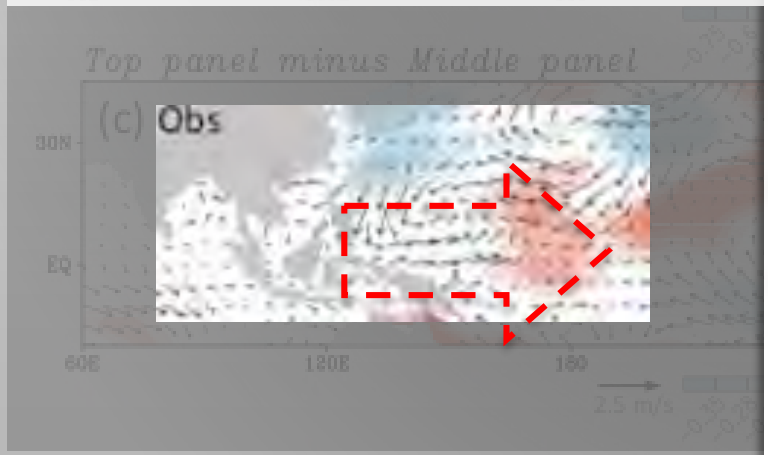


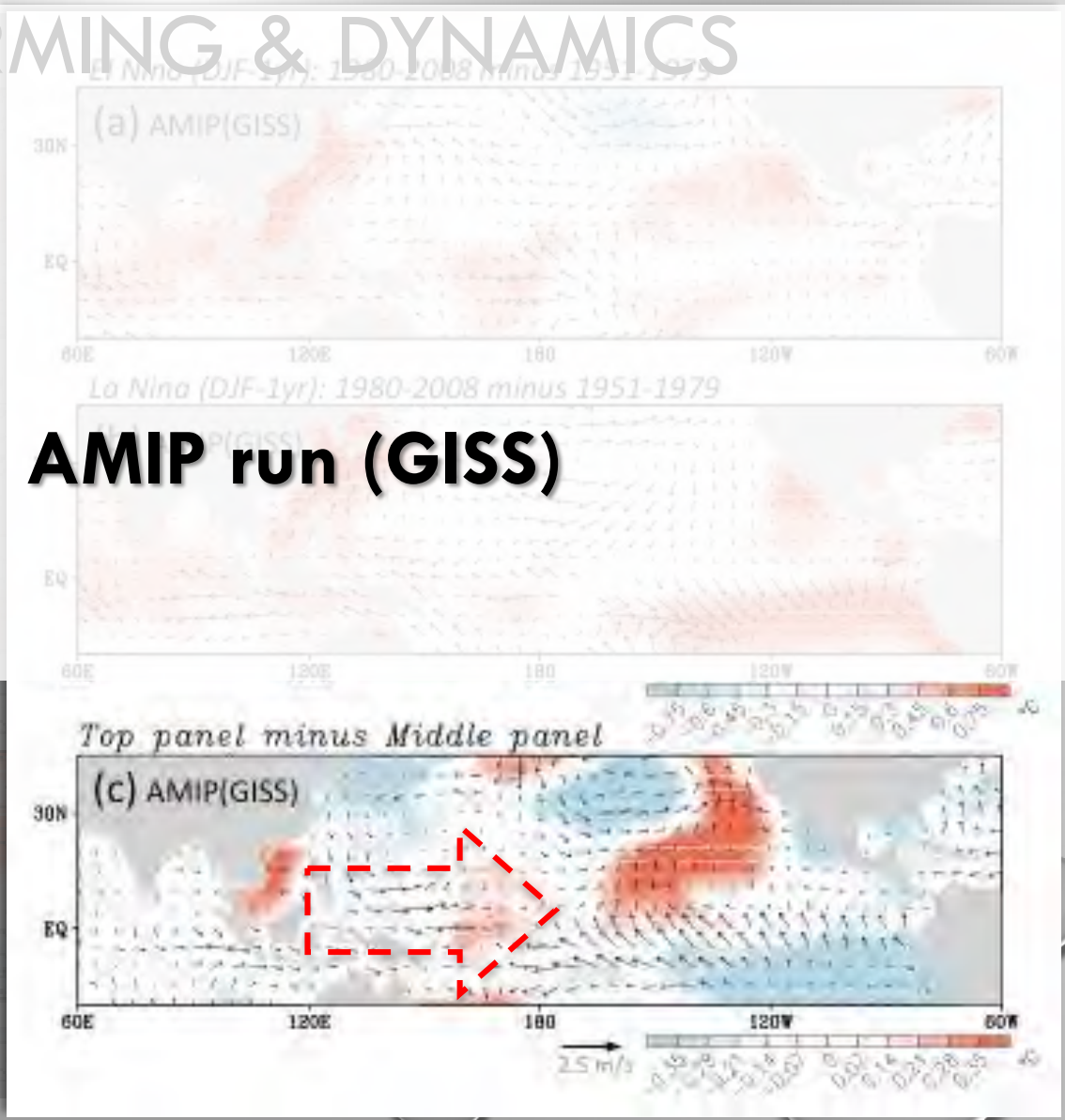
Composite analysis:

NCEP + 20CR

& HadSST

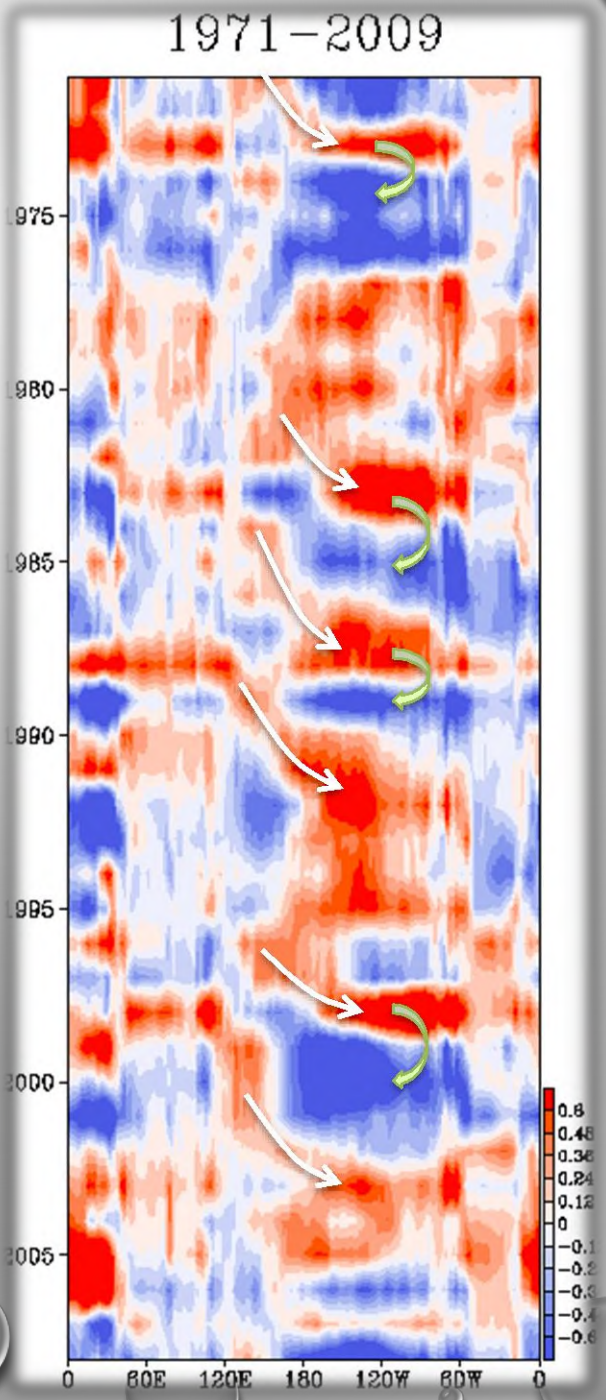
WNP WARMING & DYNAMICS





AMIP run (GISS)

And it's only half the story!



WHAT IS THE SFM (SEASONAL FOOTPRINTING MECHANICM) OR PMM (PACIFIC MERIDIONAL MODE)?

Atmo-Ocean coupled climate variability

→ MCA (Maximum Covariance Analysis, or SVD of Bretherton et al. 1992)

→ similar to Multi-variate EOF

The Seasonal Footprinting Mechanism in the Pacific: Implications for ENSO*

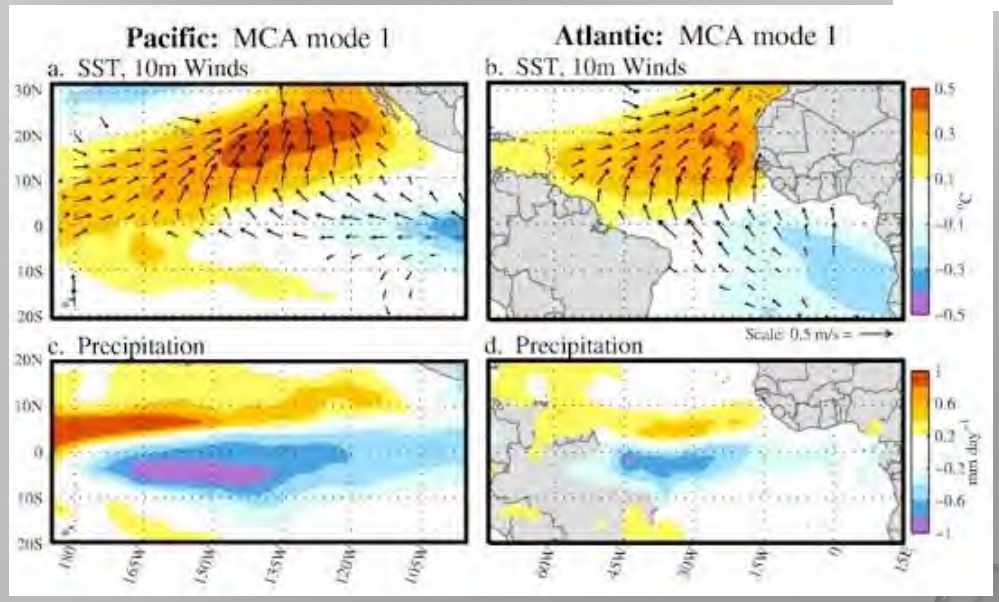
DANIEL J. VIMONT, JOHN M. WALLACE, AND DAVID S. BATTISTI

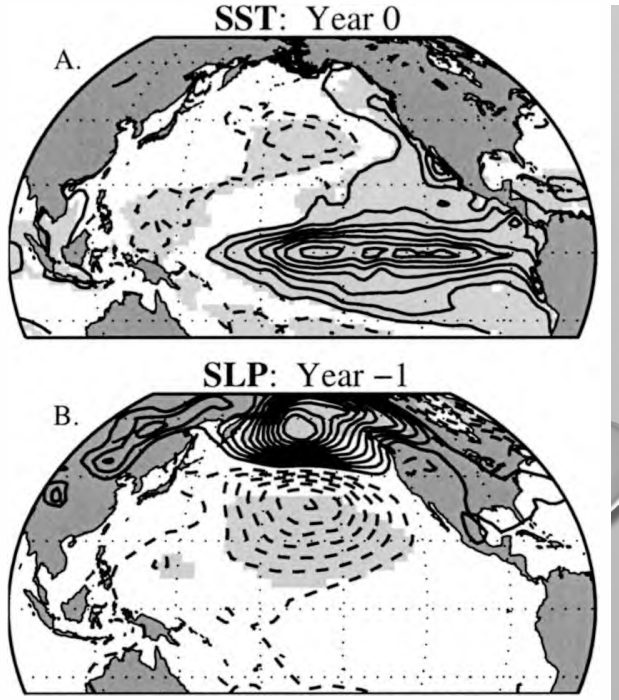
Department of Atmospheric Sciences, University of Washington, Seattle, Washington

(Manuscript received 15 February 2002, in final form 23 July 2002)

ABSTRACT

Midlatitude atmospheric variability is identified as a particularly effective component of the stochastic forcing of ENSO. This forcing is realized via a seasonal footprinting mechanism (SFM), in which the tropical atmosphere is forced during the spring and summer by SST anomalies generated by midlatitude atmospheric variability during the previous winter. The strong relationship between the SFM and ENSO may serve to enhance ENSO predictability and supports the view that ENSO is linearly stable in nature.





THANK YOU VERY MUCH!