Seasonal Prediction of Atmospheric Rivers and the ENSO

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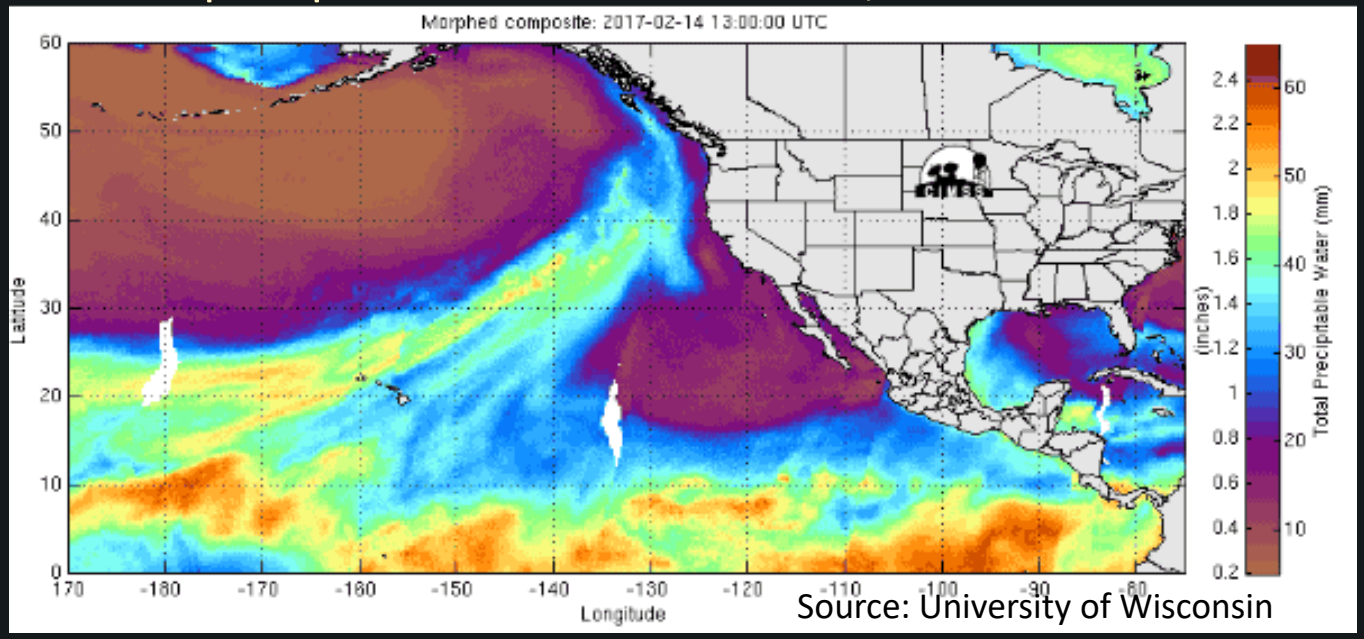
Total precipitable water: Feb. 14-17, 2017



Source: University of Wisconsin

MAPP
Modeling, Analysis, Predictions, and Projections

ENSO induced circulation change

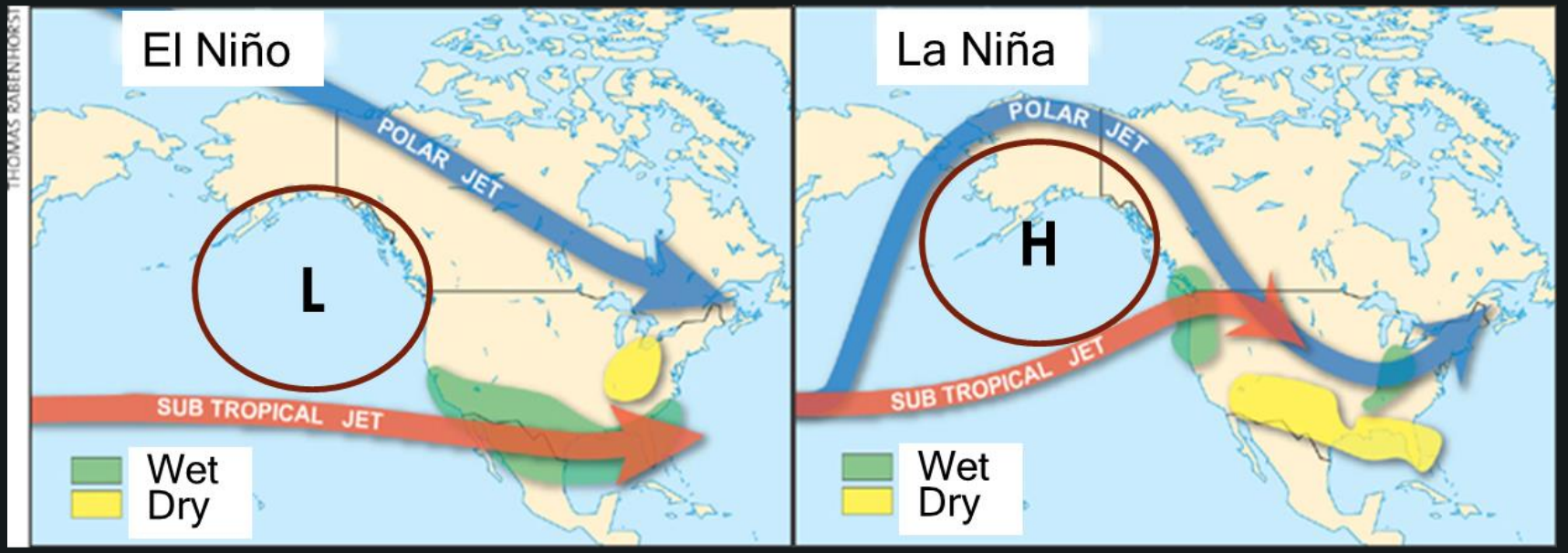
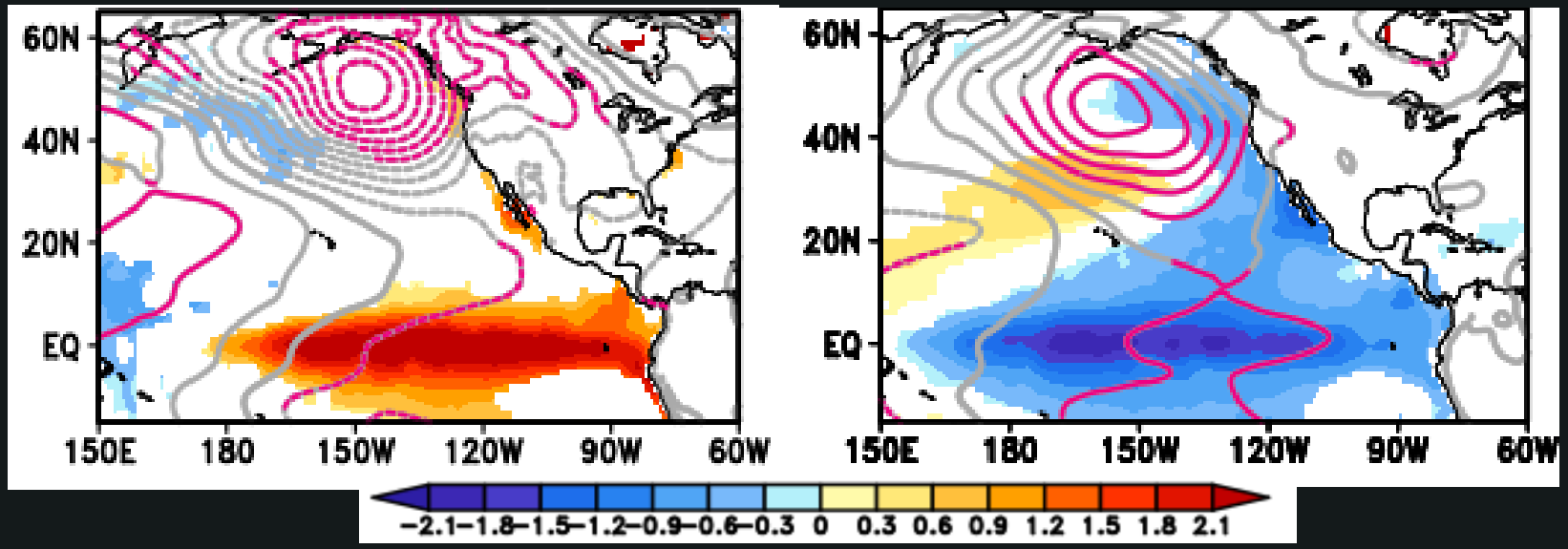


Figure: http://www.weatherwise.org/

ERAI: SST & SLP (DJF)



Questions

- **How does ENSO impact on Atmospheric Rivers?**

(Kim and Alexander 2015, Kim et al. 2017)

- **How well do models predict the AR-ENSO relation?**

"Will this winter be dry or wet?"

(Kim and Zhou 2016, Zhou and Kim submitted)

Data and method

- Atmospheric River (Rutz et al. 2014)

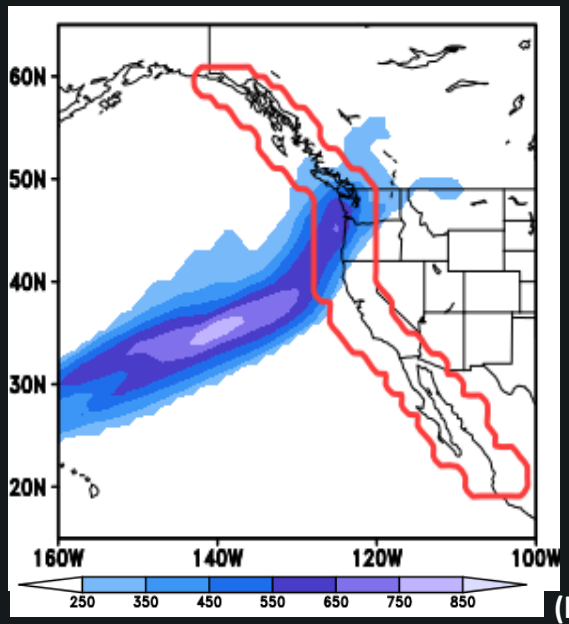
$$Q = \frac{1}{g}\int_{Ps}^{300} \vec{V} \cdot q \, dP$$

$|Q| \geq 250$ kg m^{-1} s^{-1}

L≥2000km

ERA-Interim:

1979-2017 daily, Dec-Feb



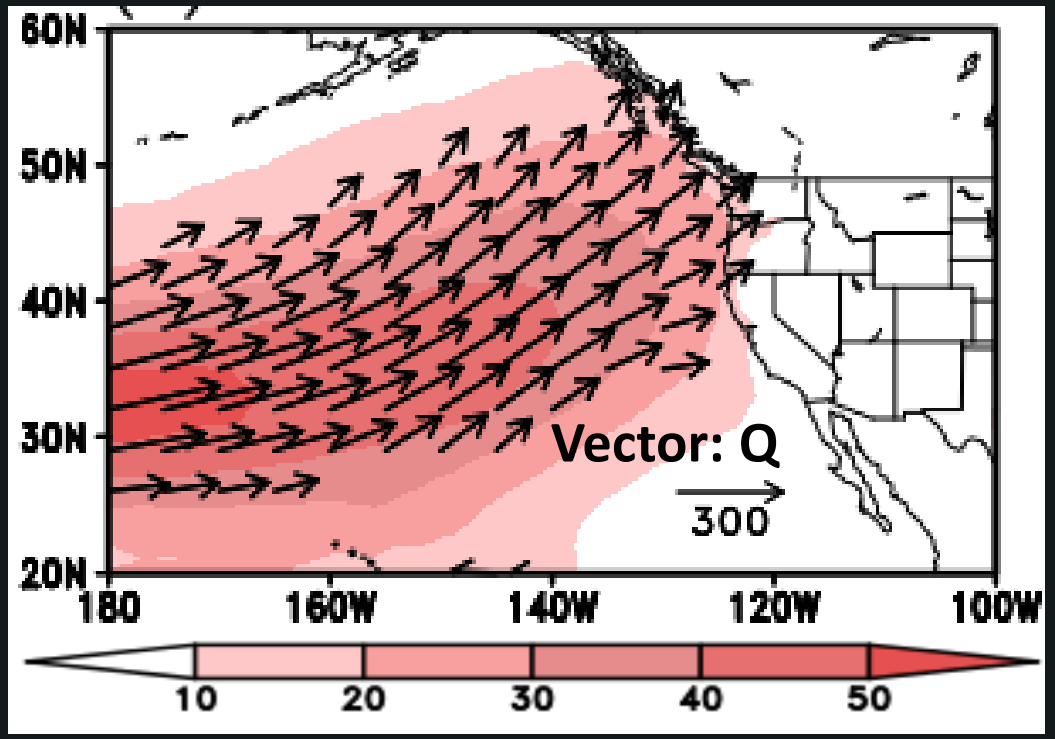
(kg m^{-1} s^{-1})

Moisture Flux (Q)

Jan-28, 2016

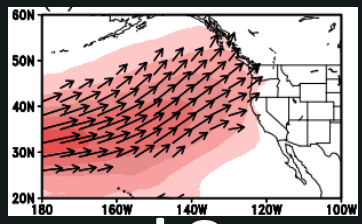
Climatology

Seasonal AR frequency



AR frequency: Number of days when an AR is detected at a given grid point during DJF

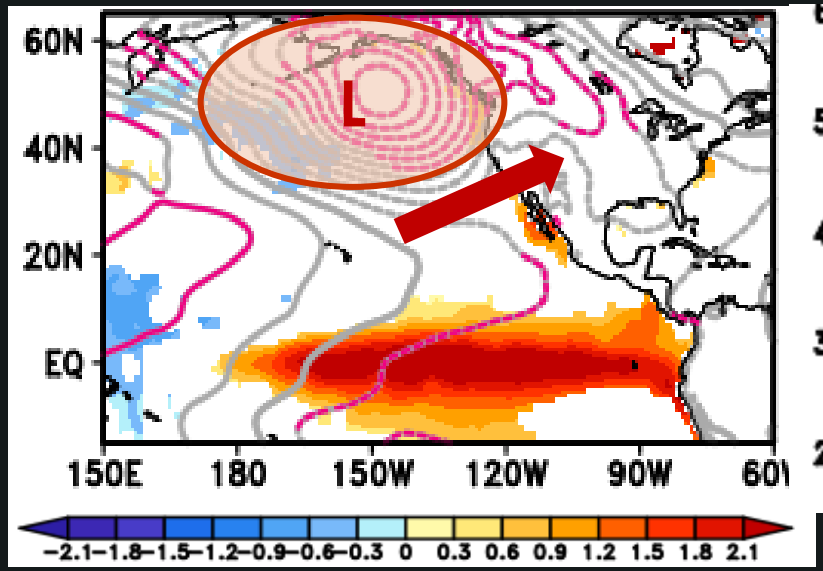
ARs and ENSO

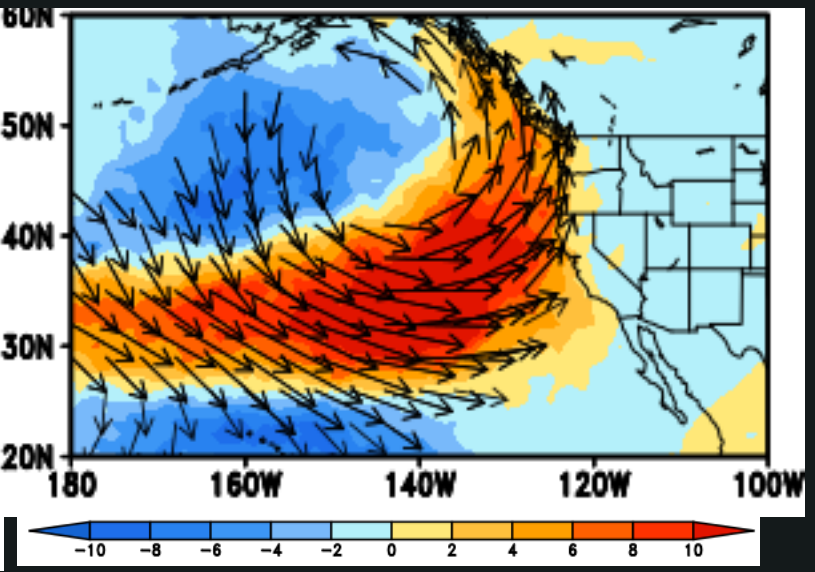


SST and SLP

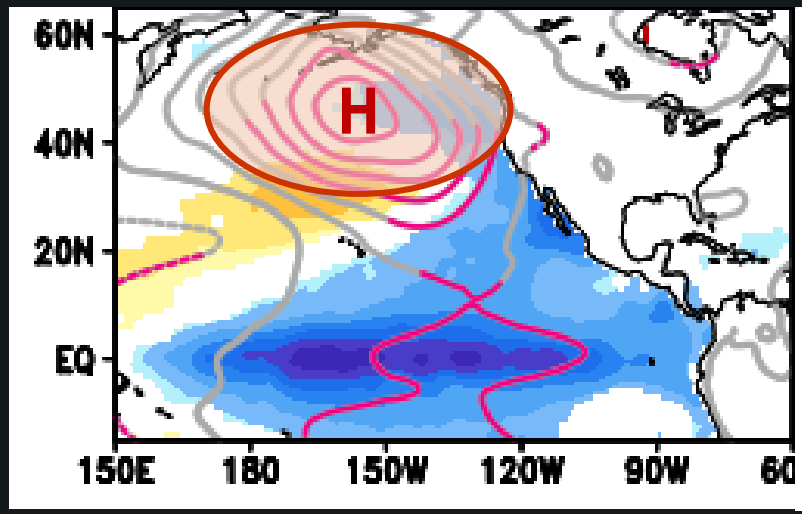
AR frequency and Q

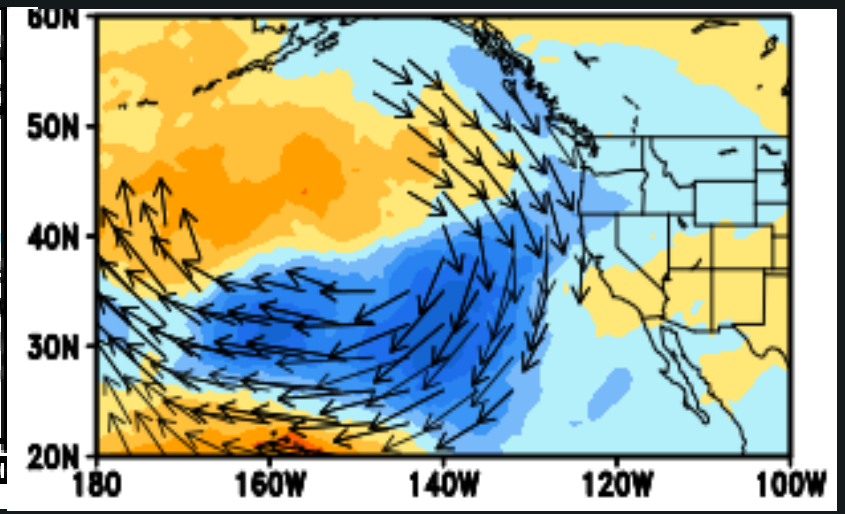
El Nino





La Nina

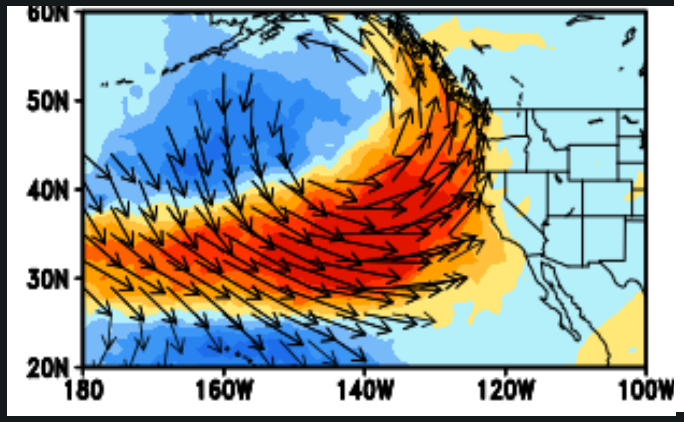




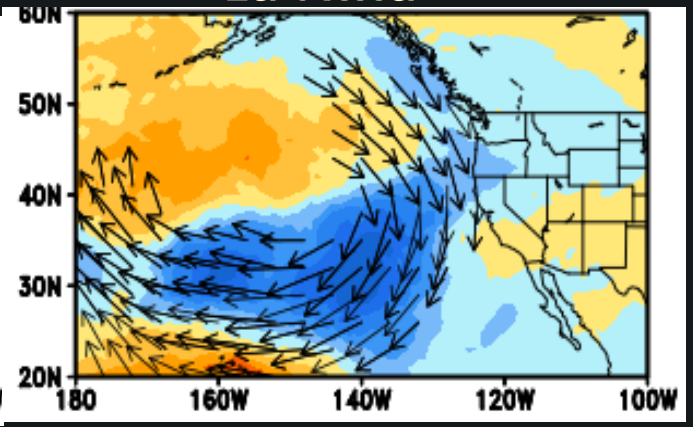
* Shadings, magenta line, vectors: values > 95% significant level

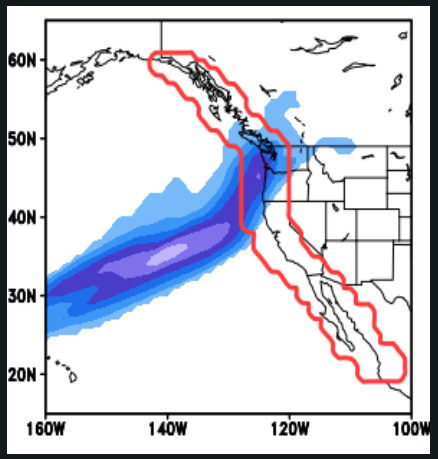
Landfalling ARs

El Nino

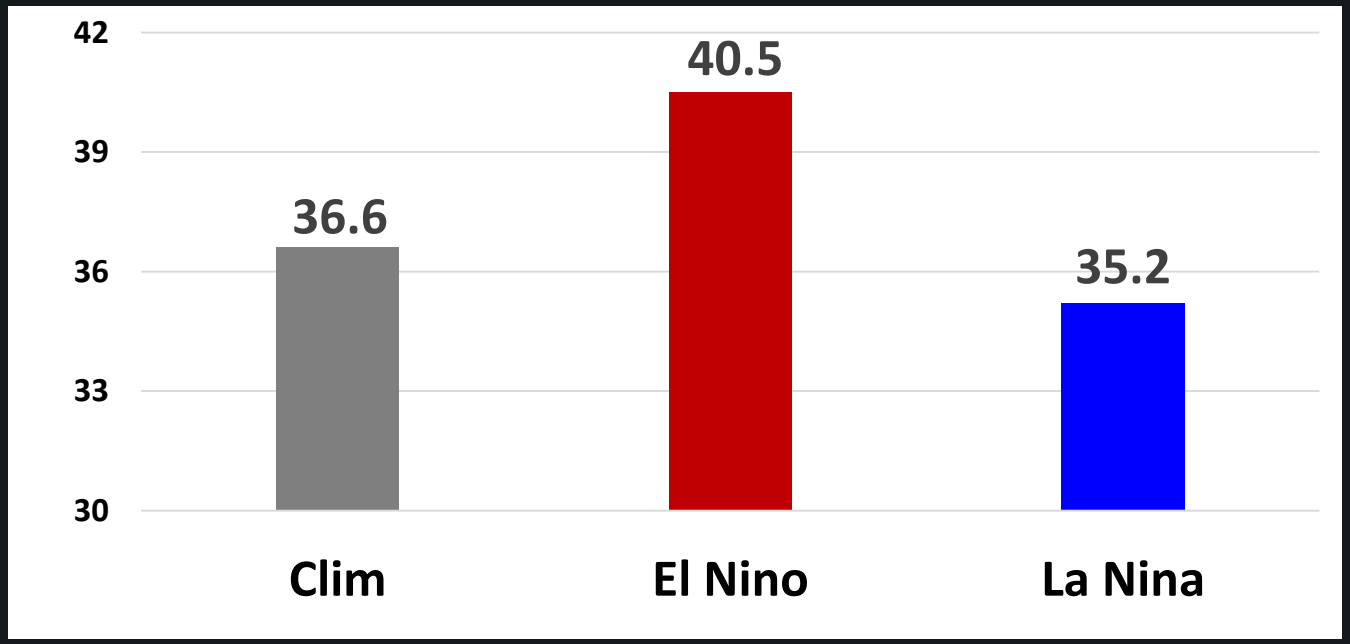


La Nina





Landfalling AR frequency



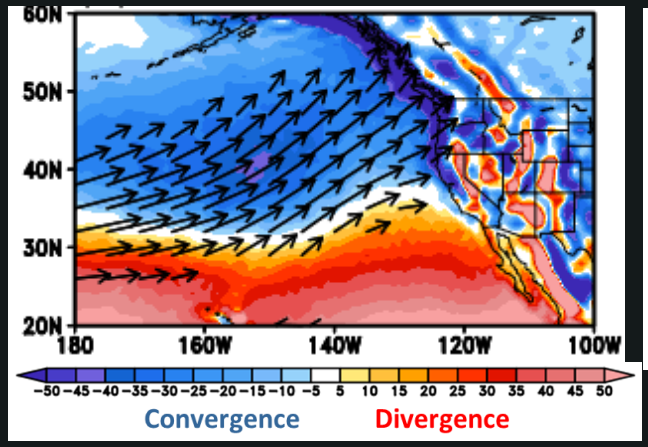
Moisture Flux Convergence

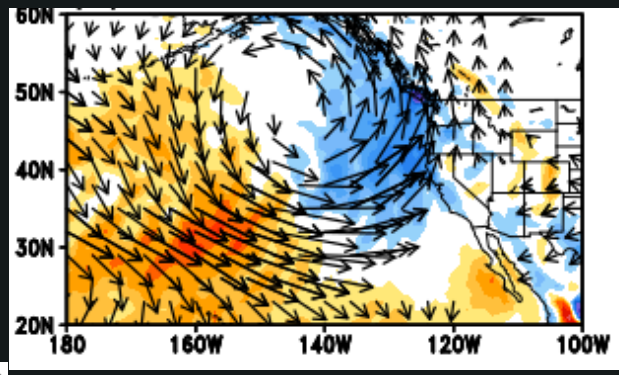
Climatology

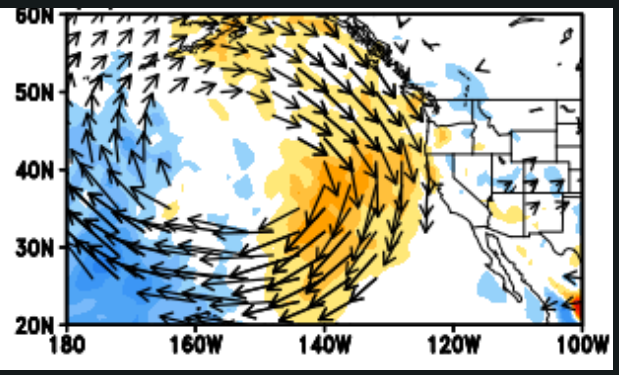
El Nino

La Nina

Moisture flux convergence

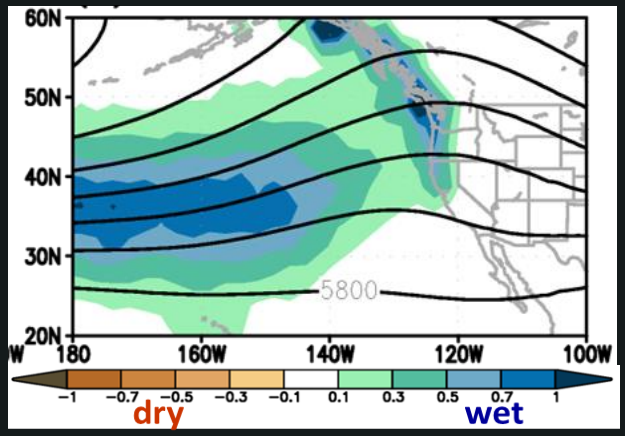


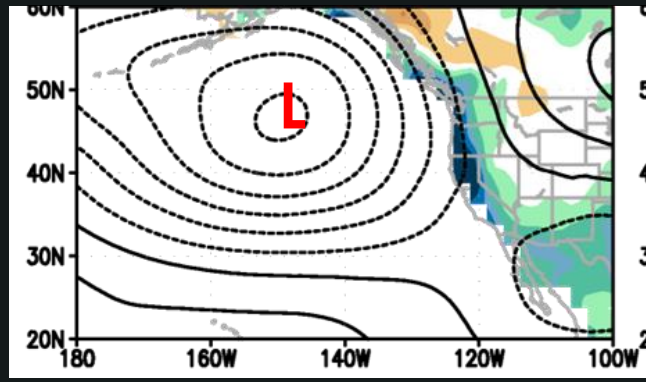


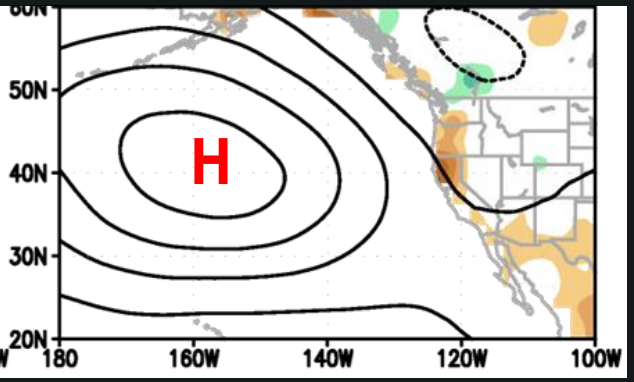


$-\nabla \cdot Q \sim P$ (*moisture budget equation*)

Precipitation and 500GPH





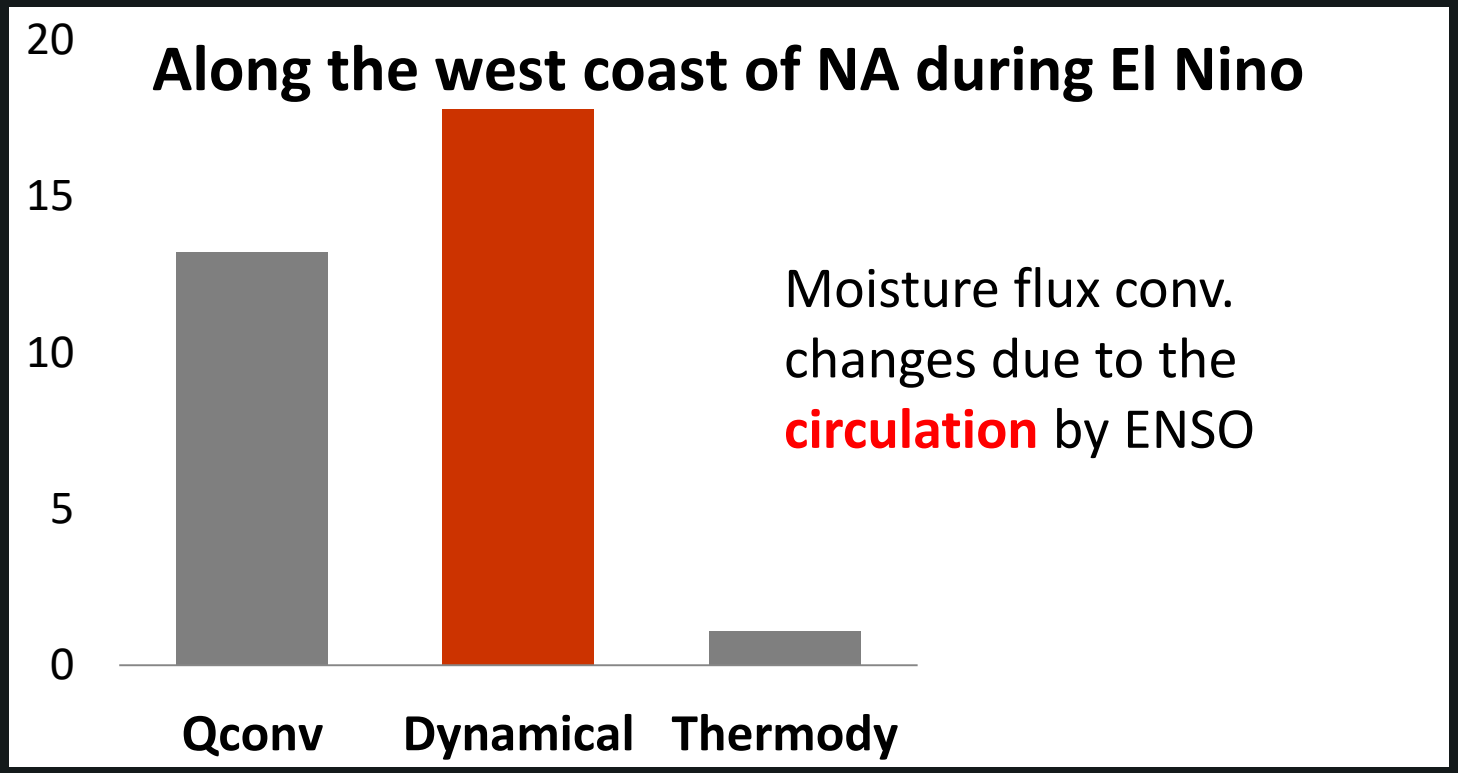


Relative Contributions

$$\nabla \cdot Q^{LF} \sim \nabla \cdot (\overline{q} V^{LF}) + \nabla \cdot (q^{LF}\, \overline{V})$$

Dynamical — circulation anomalies

Thermo-dynamical — moisture anomalies



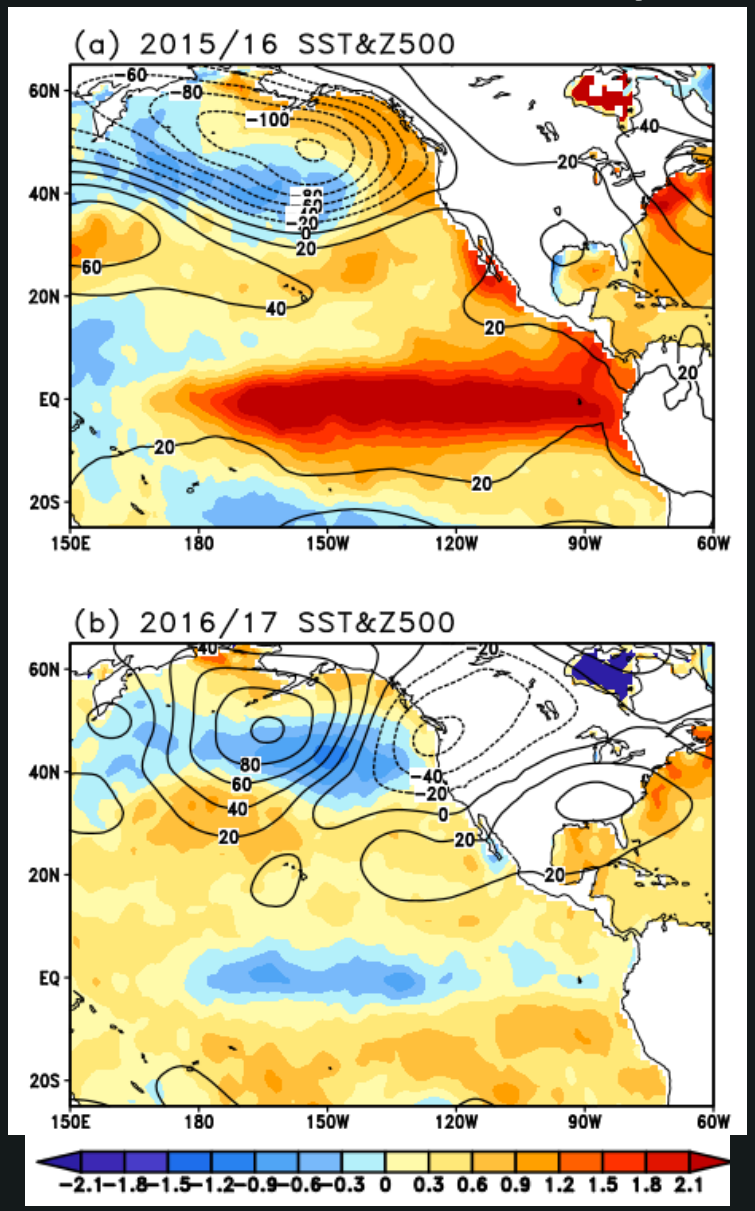
Recent winters

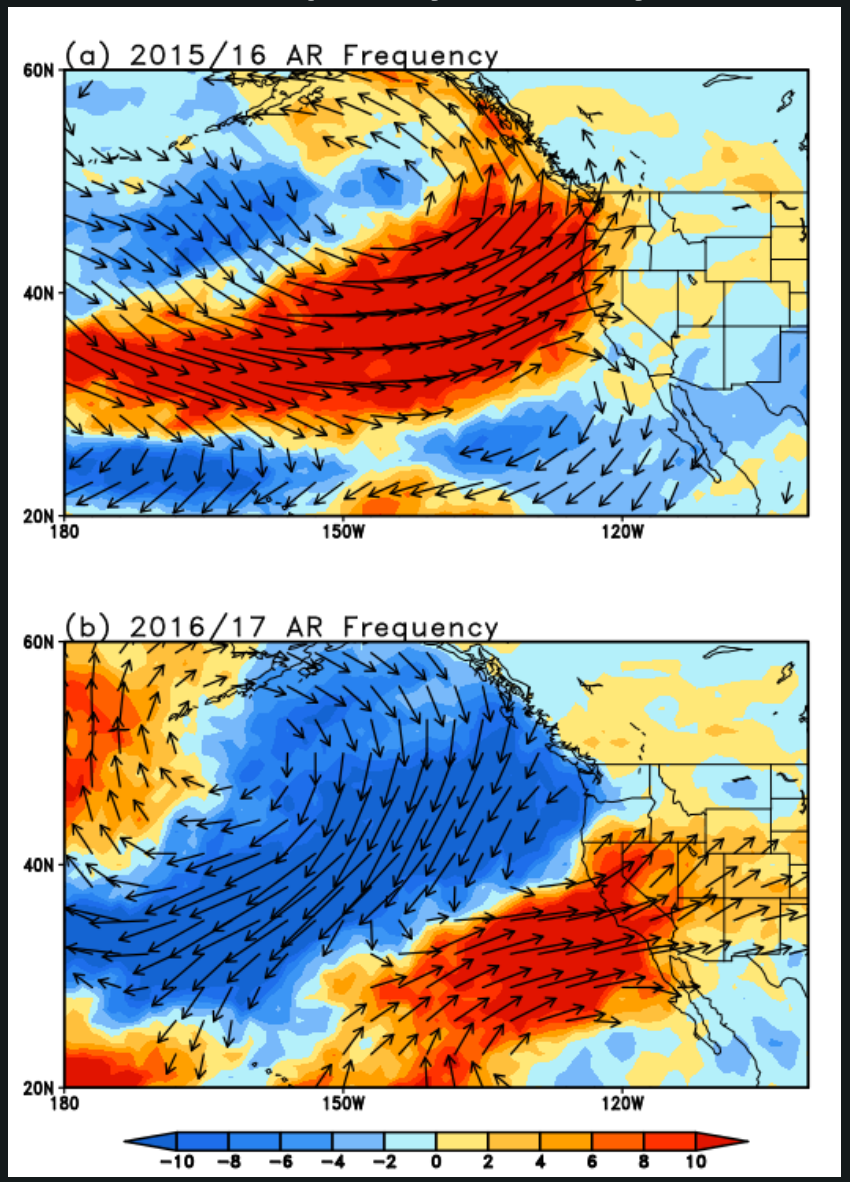
SST & 500GPH anomaly

AR Frequency anomaly

2015/16 DJF

2016/17 DJF





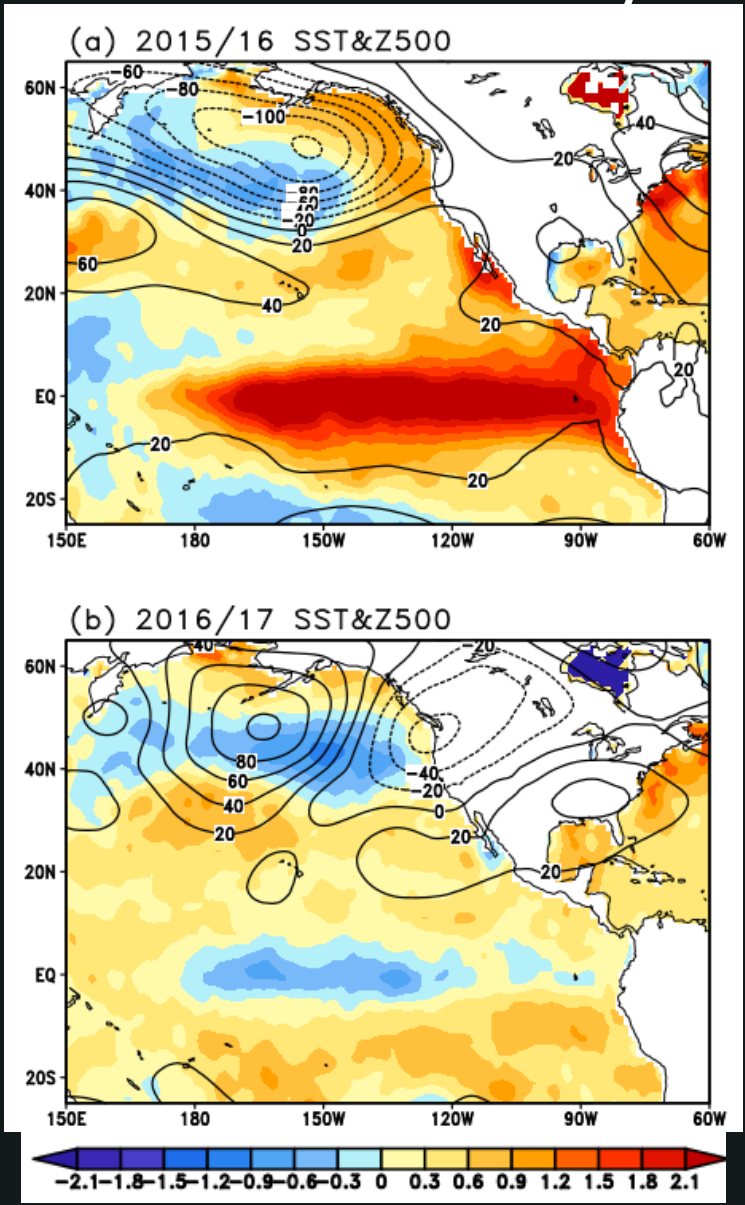
Recent winters

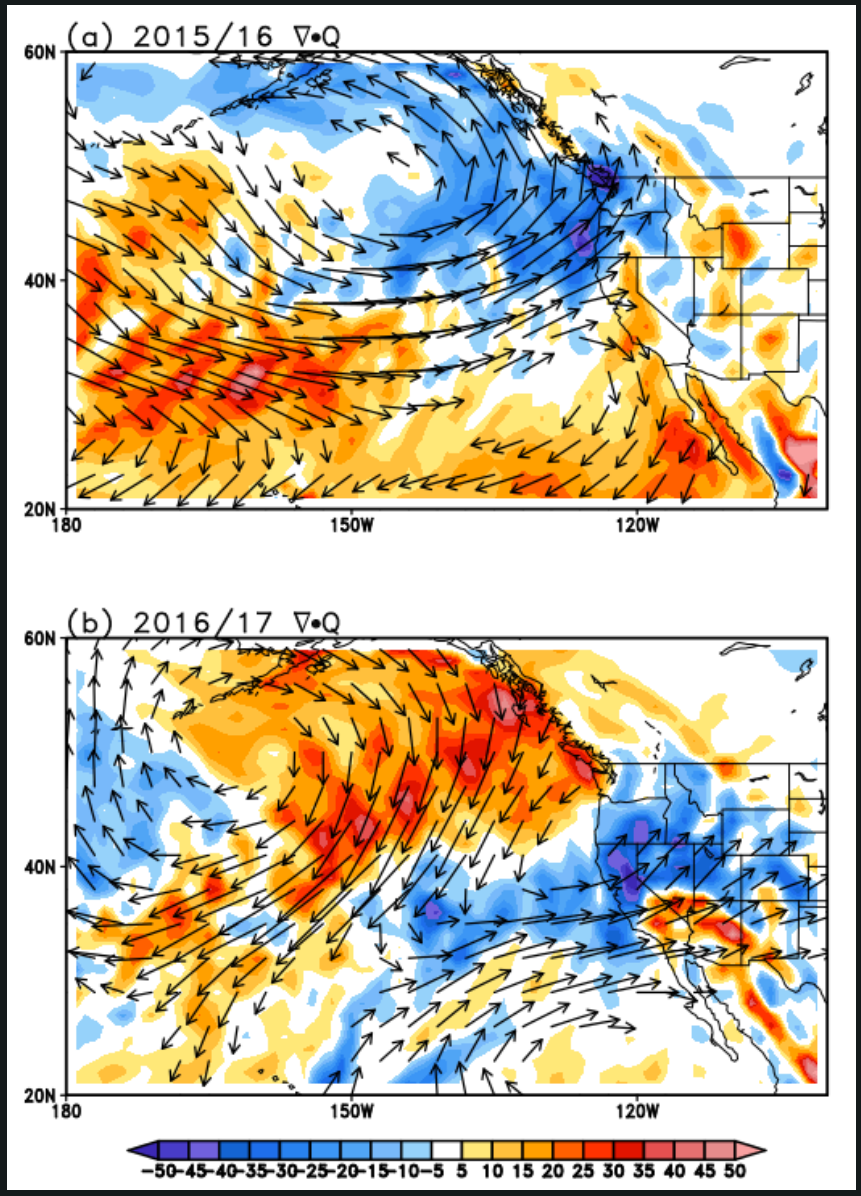
SST & 500GPH anomaly

Moisture flux conv anomaly

2015/16 DJF

2016/17 DJF





Questions

- How does ENSO impact on Atmospheric Rivers?
- **How well do models predict the AR-ENSO relation?**

NMME seasonal hindcasts

- **ENSO prediction**
- **Seasonal ARs prediction**

$$Q = \frac{1}{g}\int_{Ps}^{200} \vec{V} \cdot q \, dP$$

Daily output (850, 500, 200 hPa)

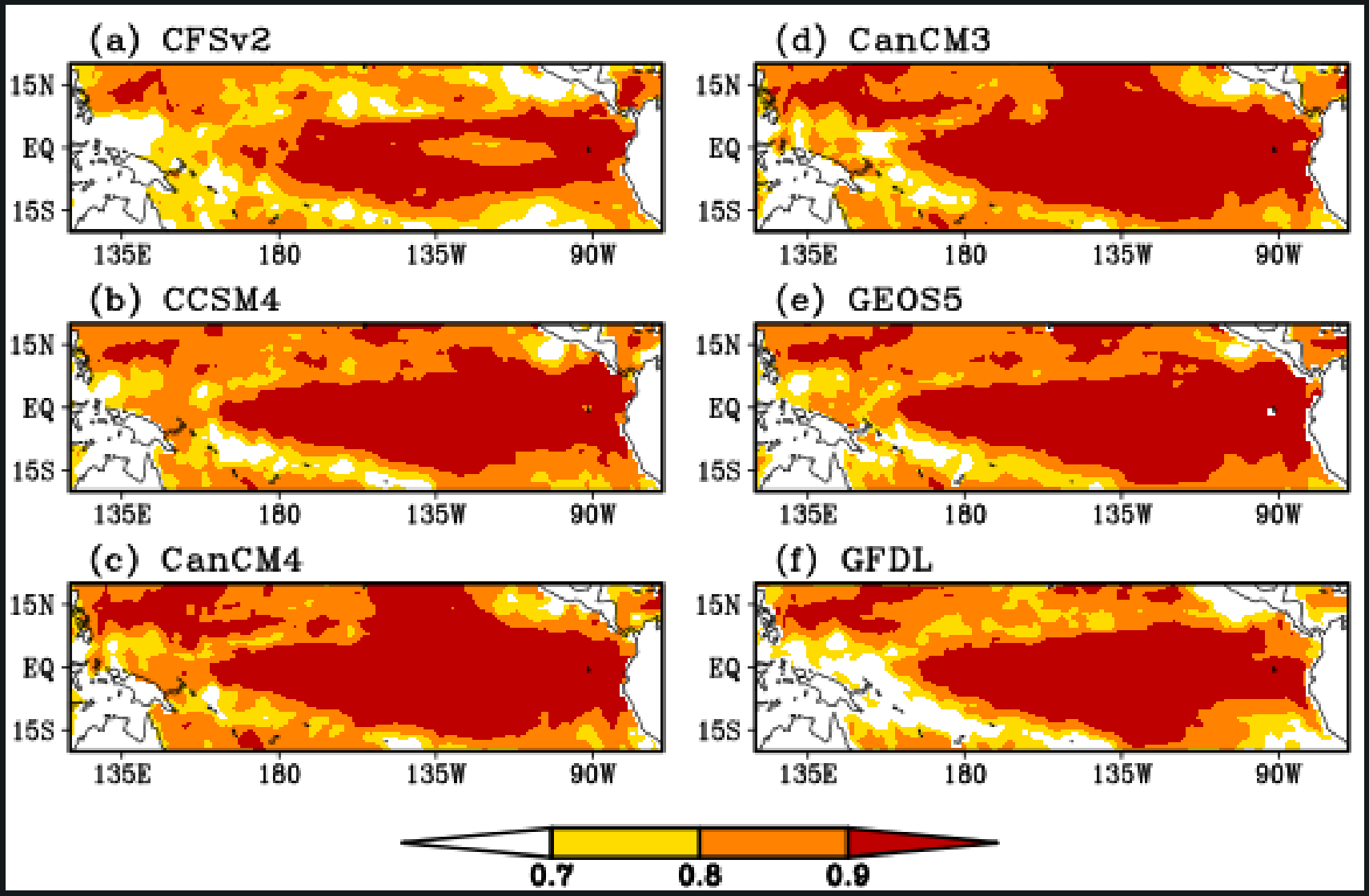
Target season: **DJF**

Initial condition: early Nov.

Models	Period (monthly)	Ensemble #
CFSv2	1982-2010	12
GDFL CM2.1	1982-2015	10
CCSM4	1982-2015	10
GEOS5	1982-2015	10
CanCM4	1981-2011	10
CanCM3	1981-2011	10

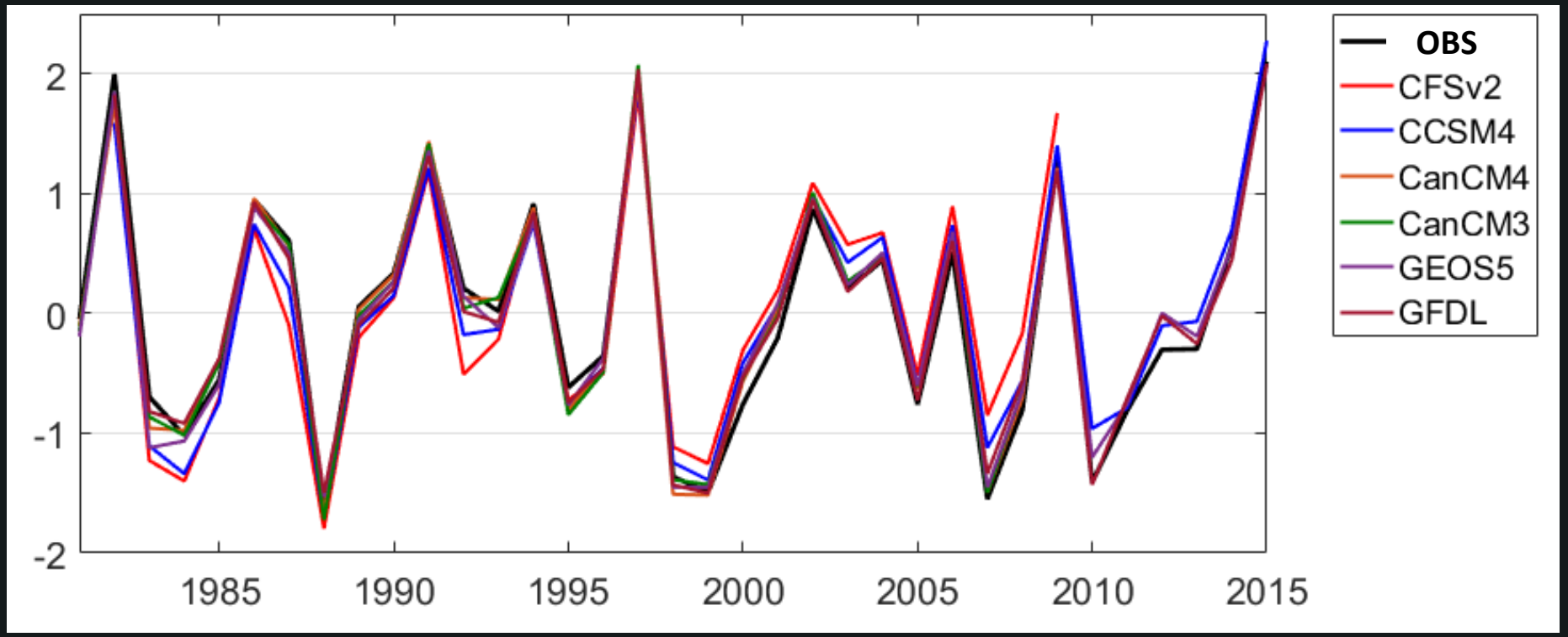
Prediction skill: SST

Correlation coefficient



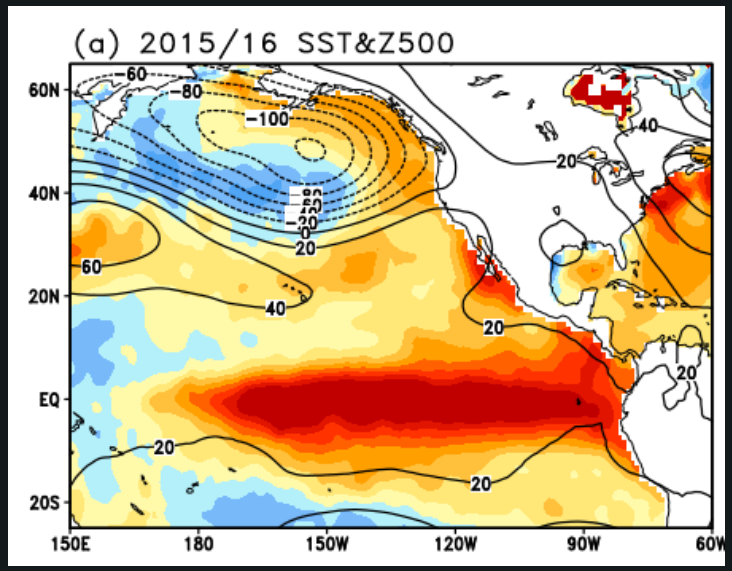
Prediction: ENSO index

Nino 3.4 index (SST averaged over the ENSO region)

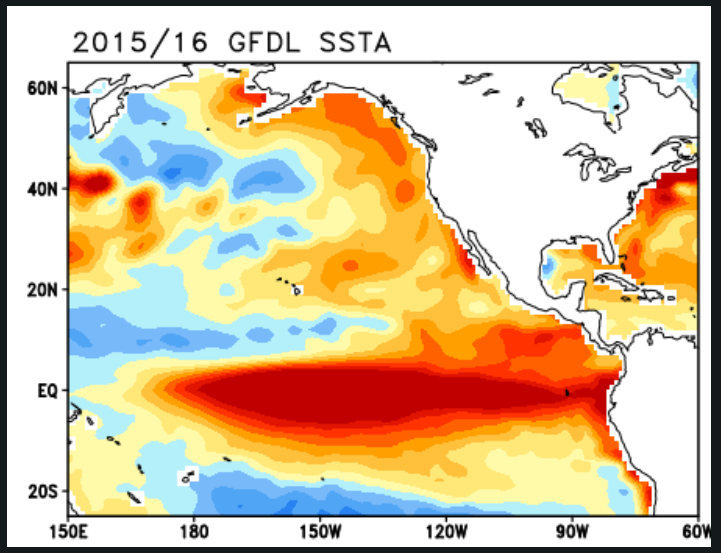


Prediction: 2015/2016 El Nino

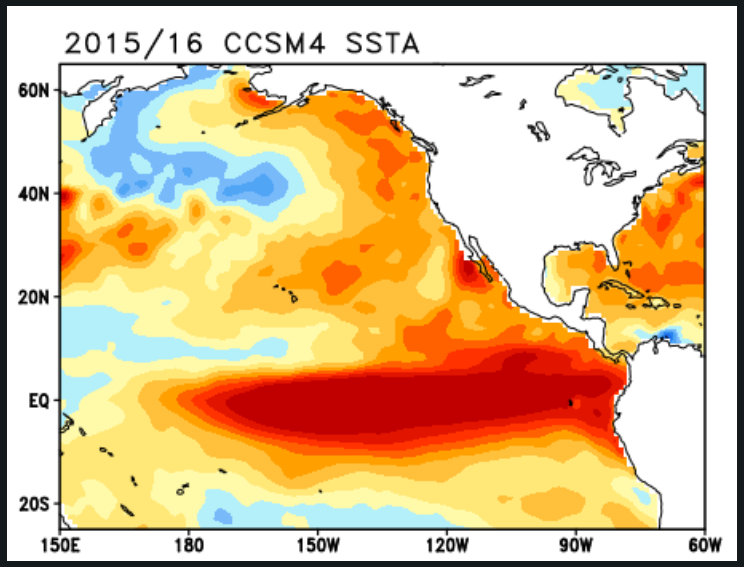
OBS



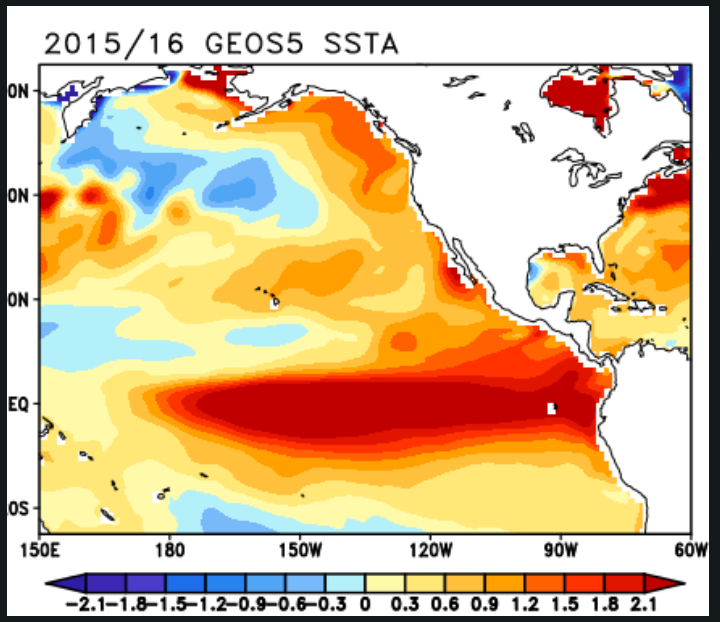
GFDL



CCSM4

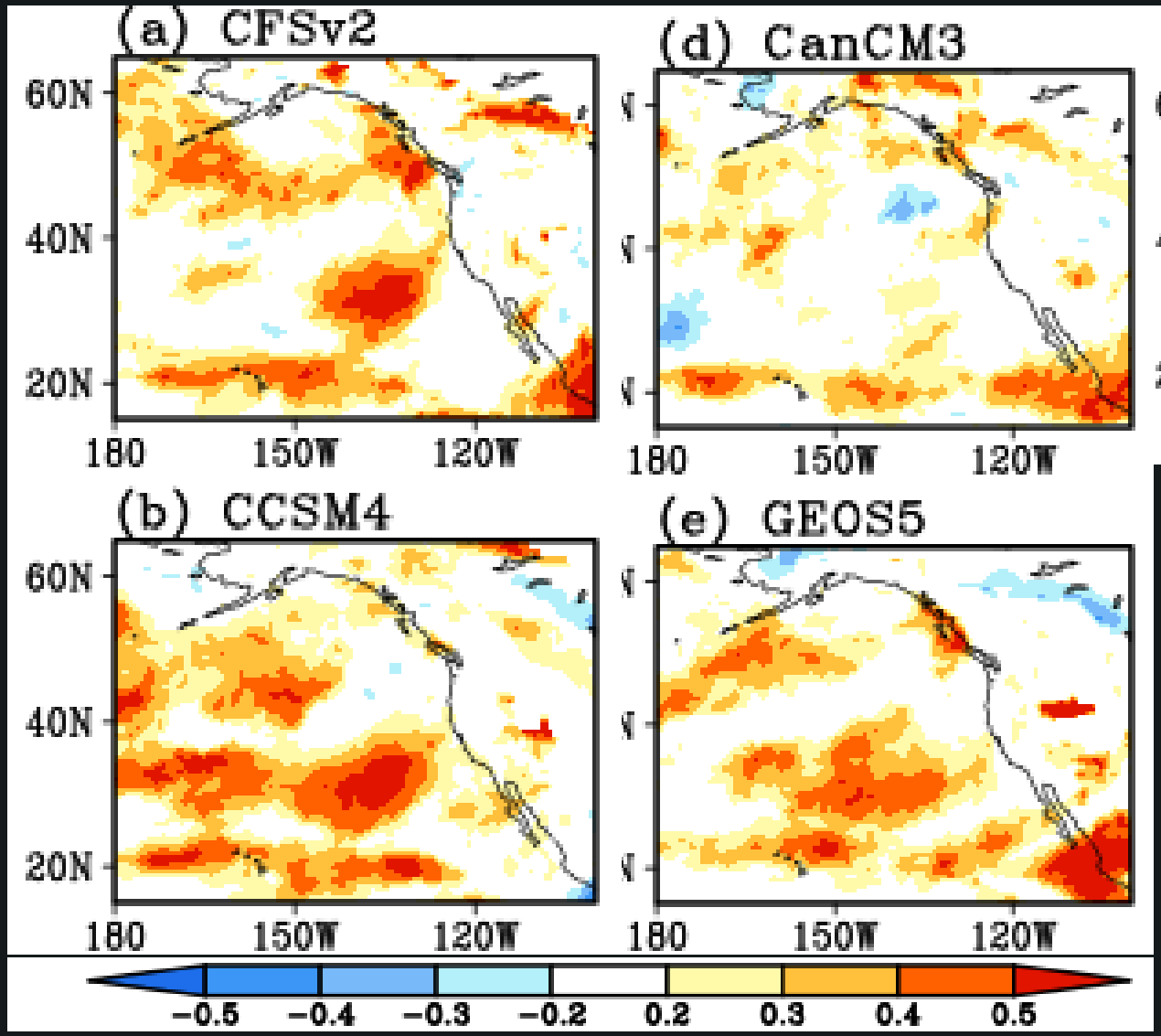


GEOS5



Prediction skill: AR frequency

Correlation coefficient



Prediction: AR Frequency and Q

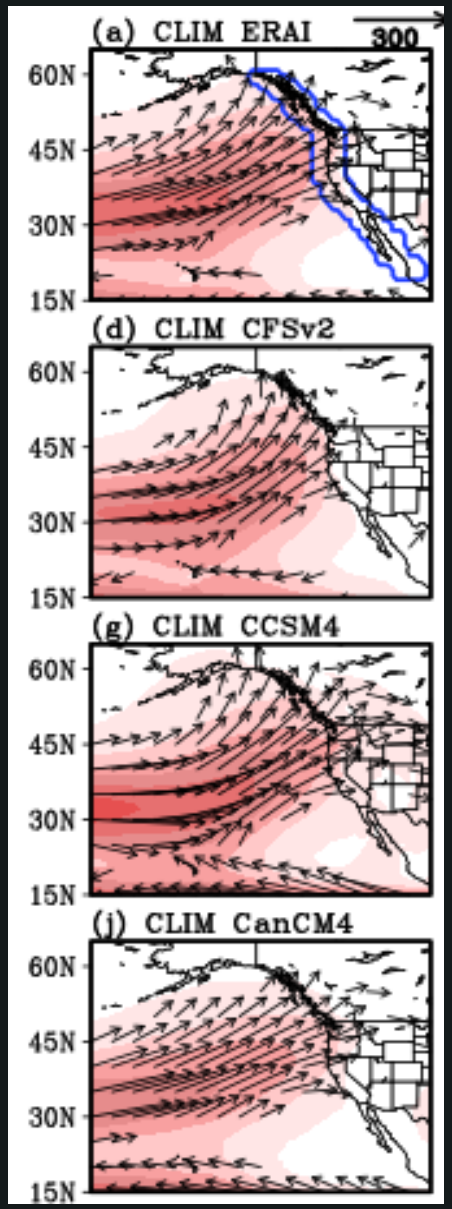
Climatology

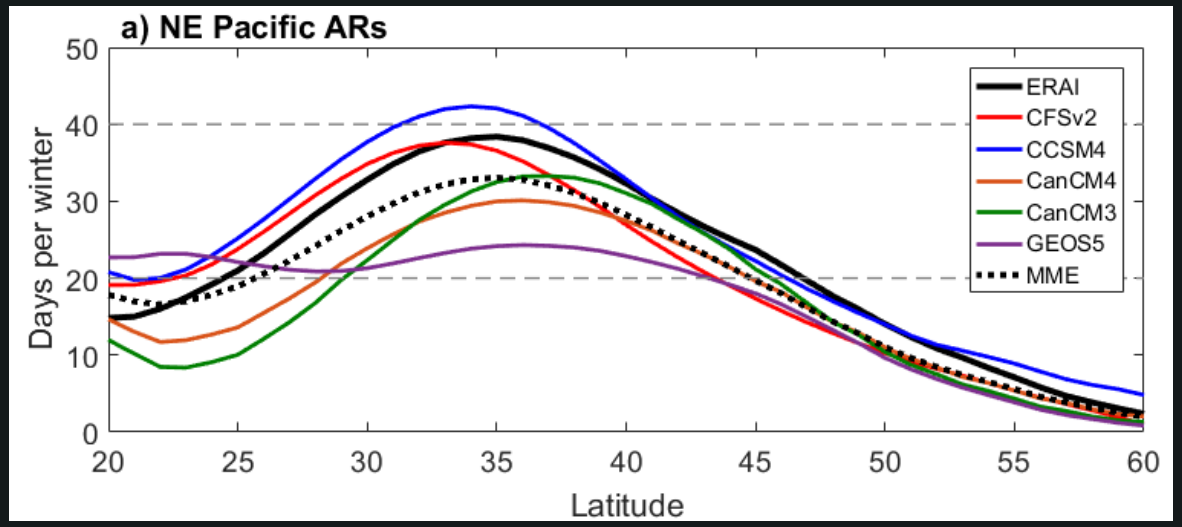
OBS

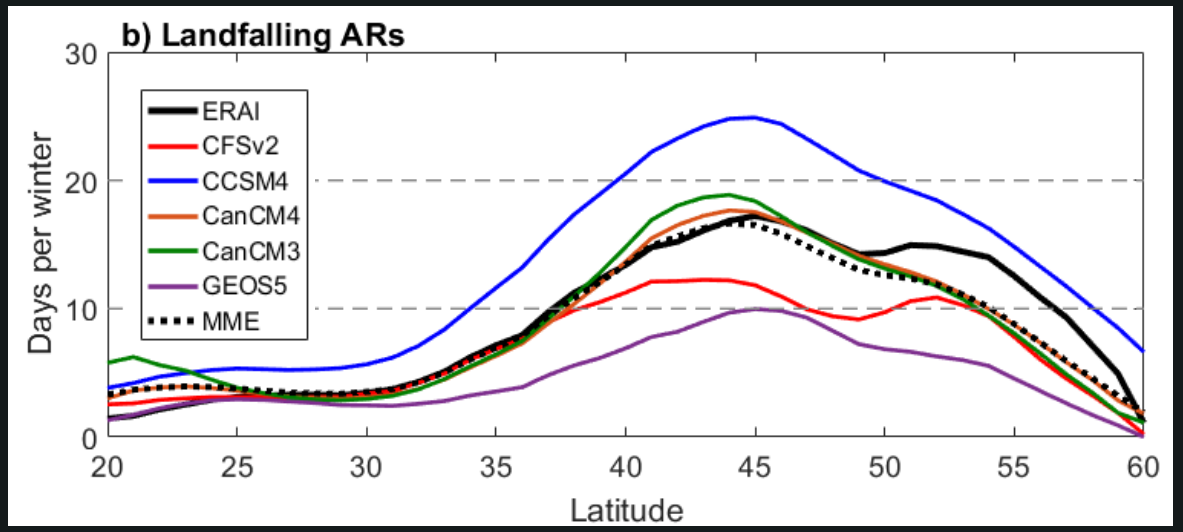
CFSv2

CCSM4

CanCM4







Prediction: AR Frequency and Q

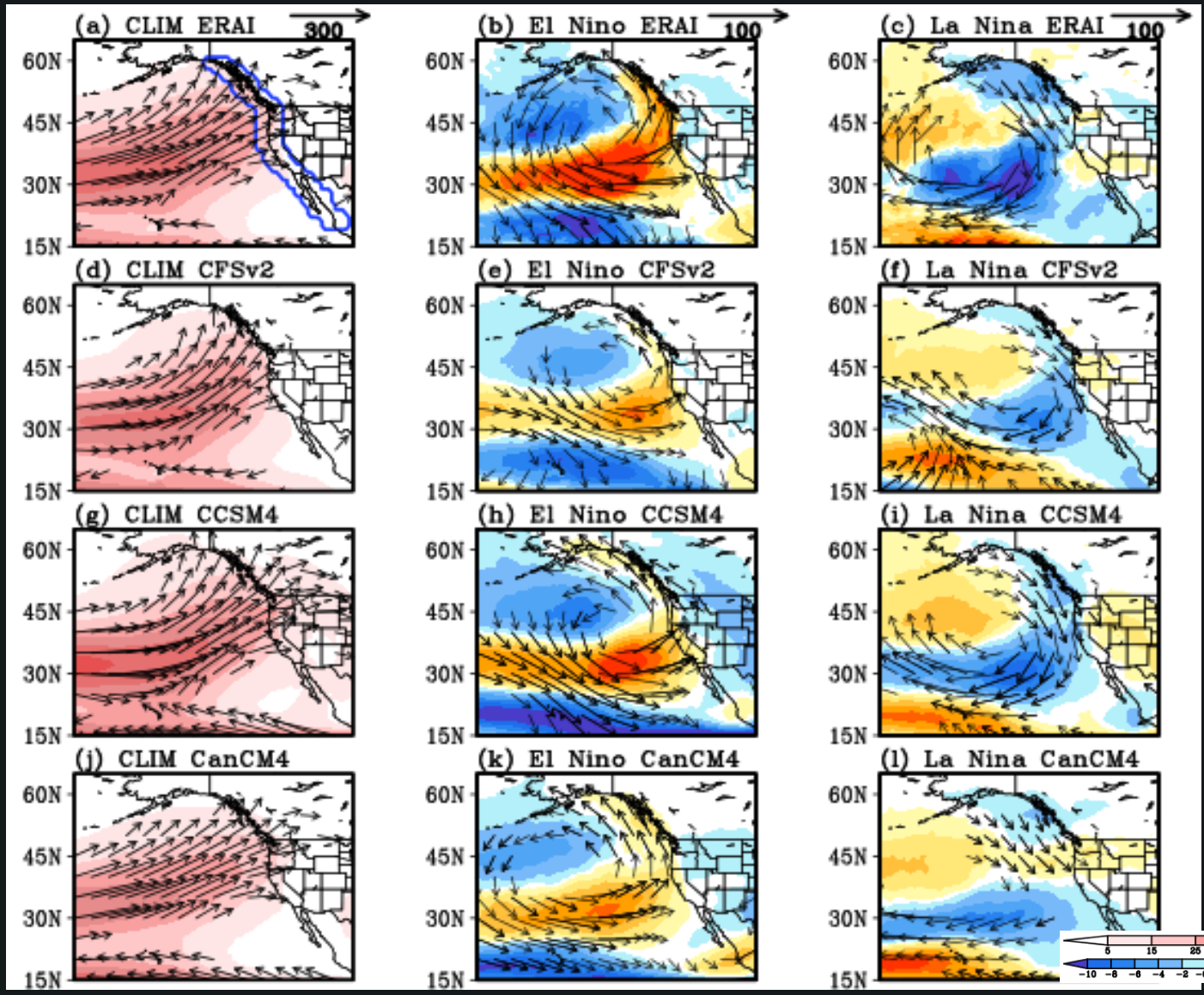
Climatology | El Nino | La Nina

OBS

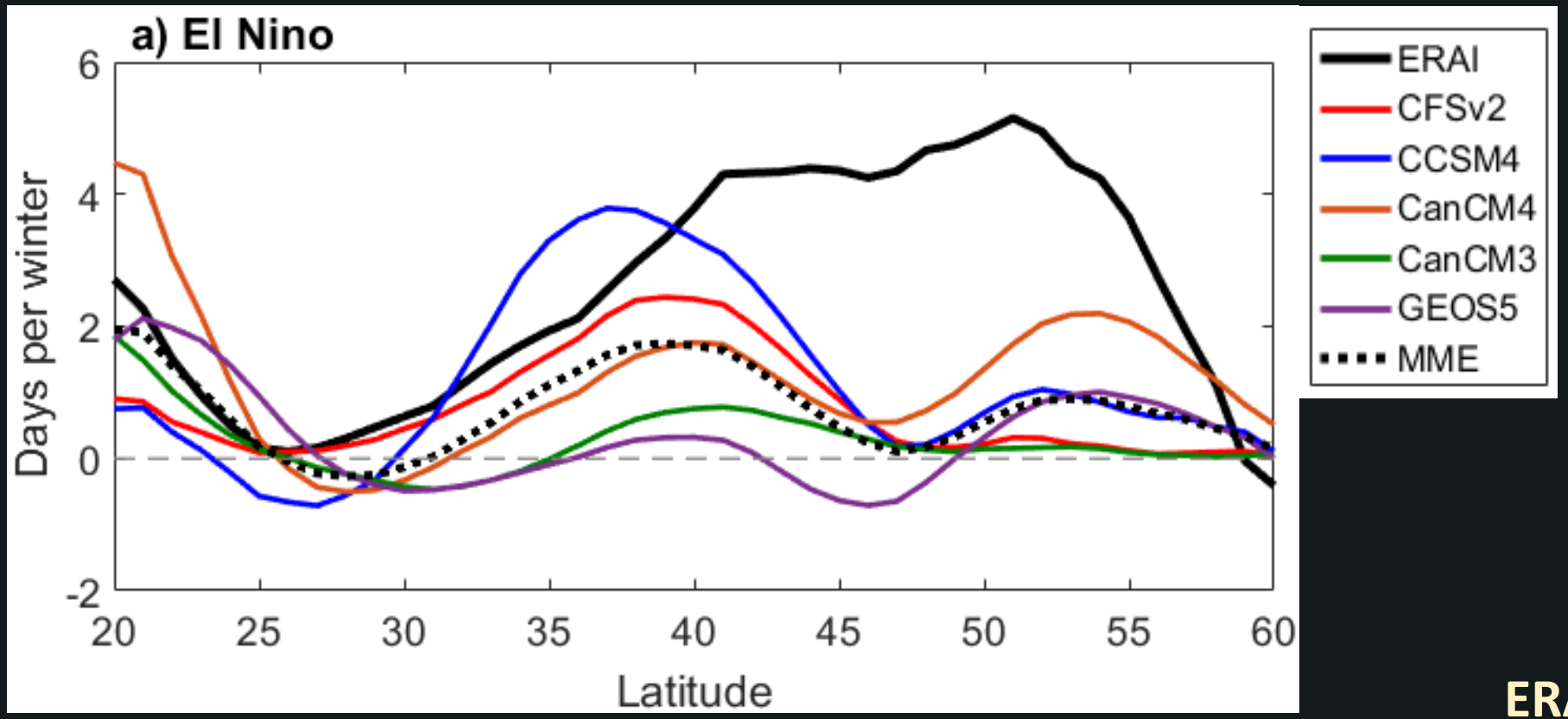
CFSv2

CCSM4

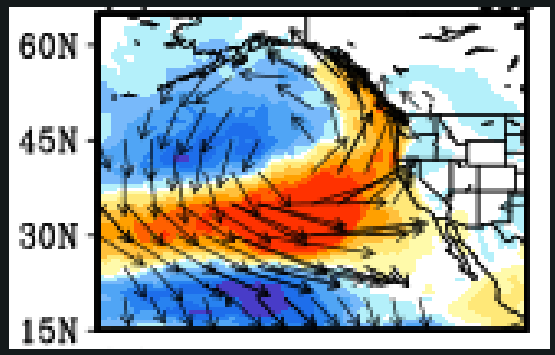
CanCM4



Landfalling AR Frequency in El Nino



ERAI



Prediction: Circulation field in El Nino

Surface

Upper level

OBS

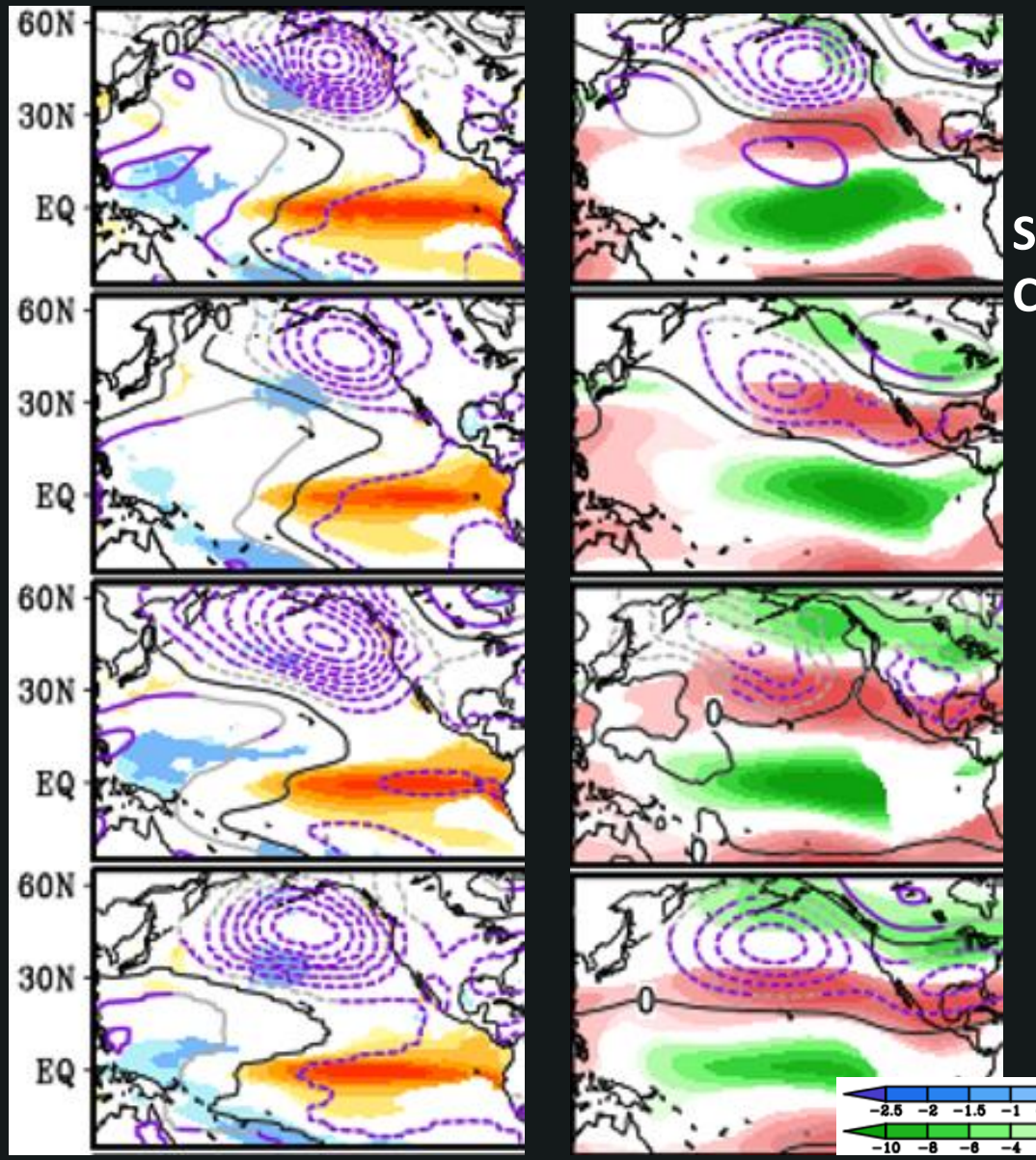
CFSv2

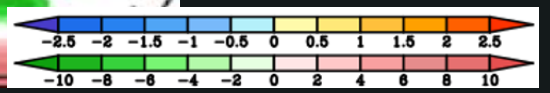
CCSM4

CanCM4

Shading: SST
Contour: SLP

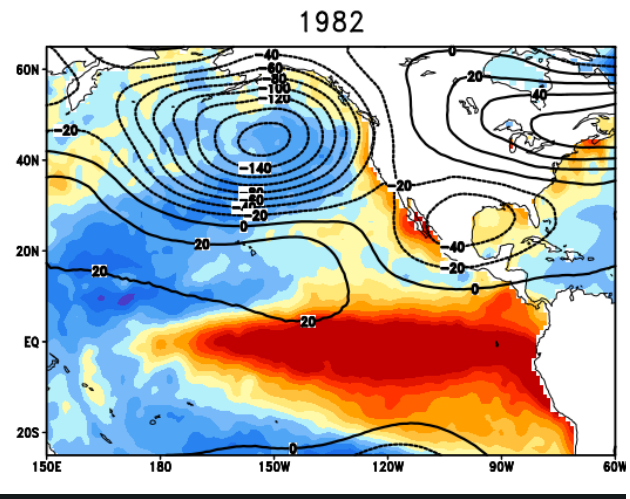
Shading: U200
Contour: Z500



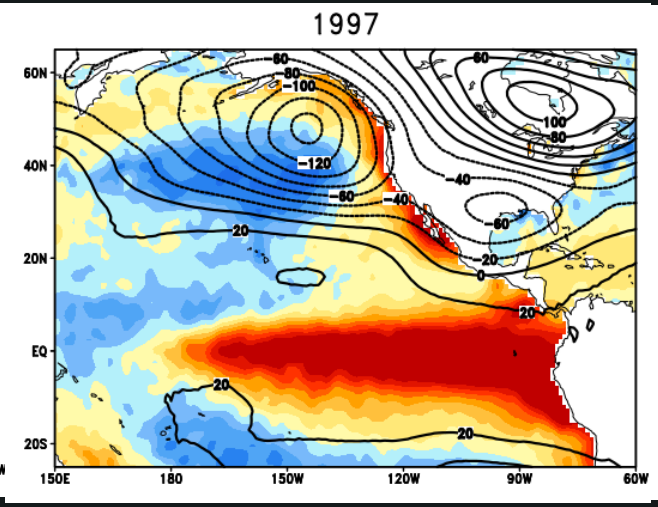


Three major El Ninos

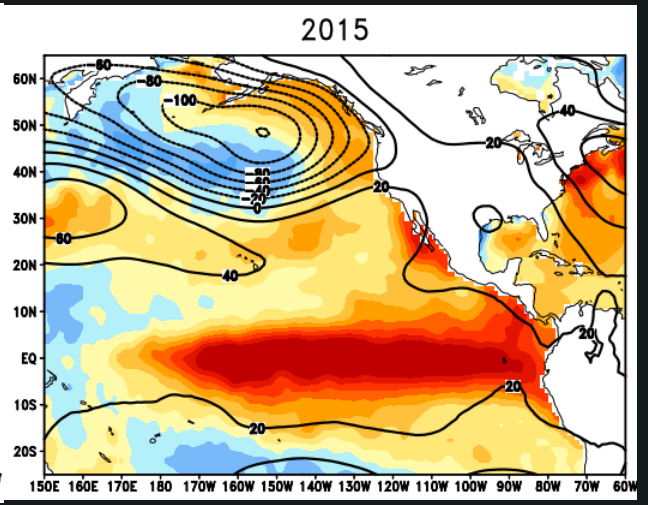
1982/83

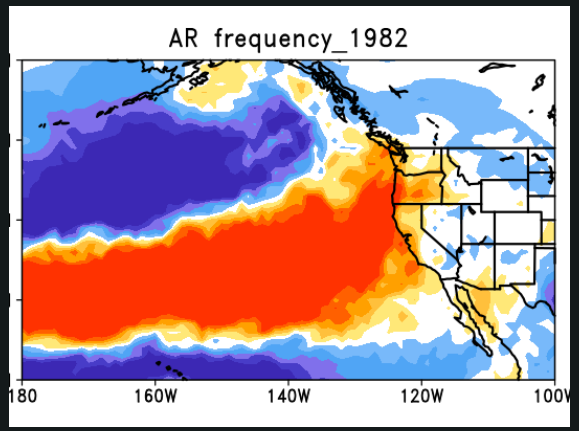


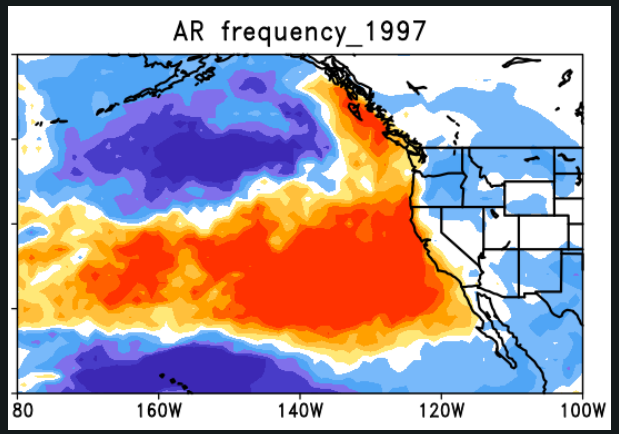
1997/98

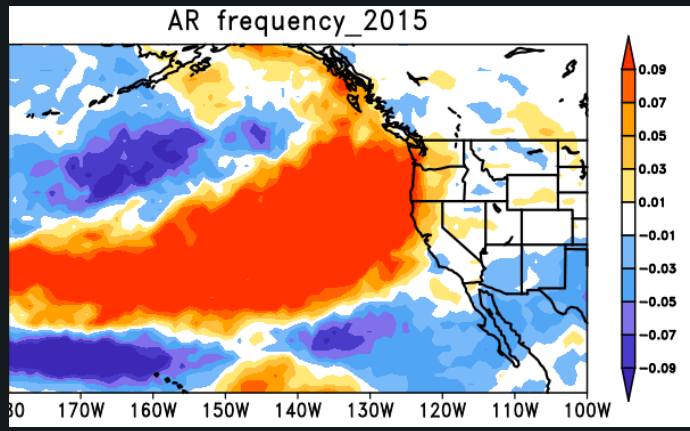


2015/16









Summary and future work

- The year-to-year changes in cool season atmospheric rivers (ARs) over the northeast Pacific is strongly modulated by ENSO.

- In El Nino winters, the Aleutian low intensify, resulting an increase in the frequency and intensity of landfalling ARs over the west coast.

- While the prediction skill is still low over the Northeast Pacific, the NMME hindcasts simulate the ENSO-AR relationship to some extent, thus have potential to predict the seasonal AR activity.

Next Steps:

- Expand evaluation to additional S2S forecast models

- Subseasonal AR variability and predictability

Thank you!

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References

Zhou, Y. and H. M. Kim: Prediction of atmospheric rivers over the North Pacific and its connection to ENSO in the North American Multi-Model Ensembles (NMME), Climate Dynamics. *(in review)*

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