A Bird's Eye View of Operational ENSO Prediction: Methods, Challenges, and Paths Forward

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Acknowledgements: Tony Barnston, Emily Becker, Gerry Bell, Tom Di Liberto, Mike Halpert, Zeng-Zhen Hu, Jon Gottschalck, Nat Johnson, Wanqiu Wang, Yan Xue, Mike Tippett, Geert Jan van Oldenborgh

Methods to Assemble NOAA ENSO Updates

- Each month an 11-member team is responsible for (a) updating the status of ENSO (the Alert System) and (b) probabilistic forecast for the coming 9 months.

- This team is composed of forecasters from NOAA CPC (+ ENSO bloggers) and Tony Barnston at the International Research Institute for Climate and Society (IRI).

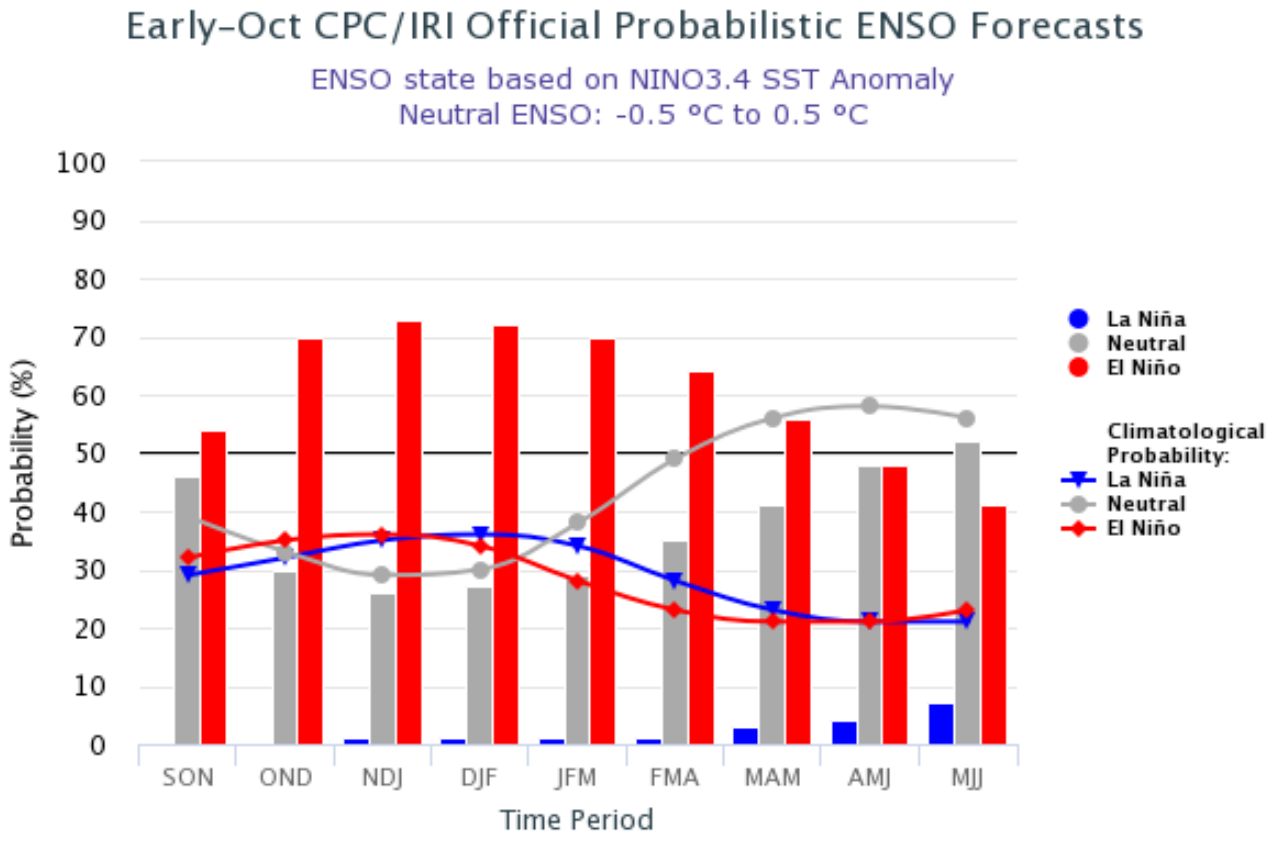
<u>El Niño or La Niña Watch</u>: Favorable for development of ENSO within the next six (6) months.

<u>El Niño or La Niña Advisory</u>: conditions are observed and expected to continue.

<u>Final El Niño or La Niña Advisory</u>: conditions have ended.

Probabilistic ENSO Outlooks

- At NOAA, have been routinely assembled since January 2012 for three categories (El Niño – Neutral – La Niña).
- An average of team member inputs, who are looking at model output from:
  - IRI/CPC ENSO Prediction Plume (national/international dynamical and statistical models),
  - North American Multi-Model Ensemble (NMME),
  - Various statistical combinations (e.g. CPC Consolidation).

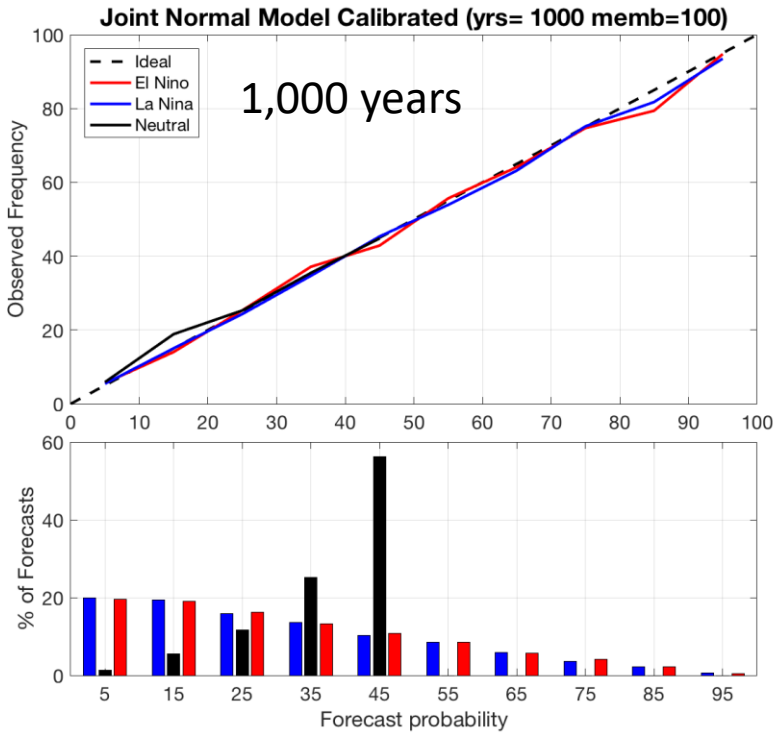


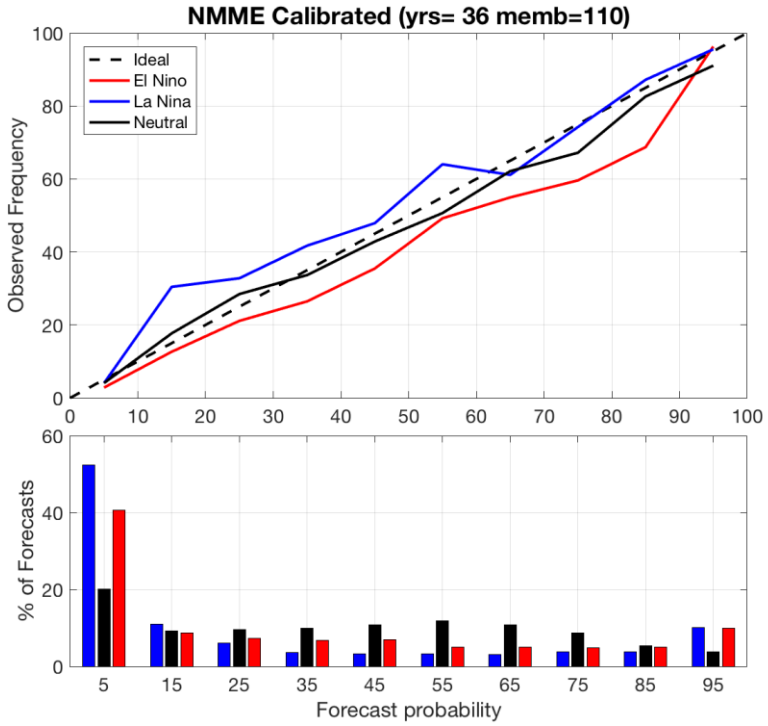
Why Don't You Just Use A Single Objective Technique?

- Have you ever seen a room full of scientists/managers agree to use just ONE forecast model/strategy?
- Models are always evolving! Through the years, older models get supplanted by newer versions.
- MANY different ways to compute probabilities from finite number of members. A single model can result in several different sets of probabilities.
- Each forecaster has their favorite strategy or models. By averaging everyone together we aim to arrive at the best consensus forecast.

Verify, Verify, Verify

- Build trust with users and partners if you grade the forecast.
- Real-time forecasts are the only truly *independent* test of how well a model or forecast strategy has performed.
- Verification/skill depends on the sample (# of members, number of years)





Challenge #1: Forecast "Busts" are highly visible. We like to avoid them.

future tense ASU | NEW AMERICA | SLATE

future tense THE CITIZEN'S GUIDE TO THE FUTURE APRIL 7 2014 11:23 AM

El Niño Could Grow Into a Monster, New Data Show

By *Eric Holthaus*

3.7k

EL NIÑO: IS 2014 THE NEW 1997?

Like 3.7k Tweet 447 Share 56 Pin it

NASA NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

By Ma Evelyn Castino Quilas | May 20, 2014 2:46 PM EST

Int'l Business Times

National Aeronautics and Space Administration (NASA) has issued a warning regarding El Niño 2014 that will be most likely similar to the 1997 phenomenon.

theguardian

US world opinion sports soccer tech culture life fashion business money travel environment all sections

home › environment development cities

Environment

How El Niño will change the world's weather in 2014

With a 90% chance of the global weather phenomenon striking this year, impacts both devastating and beneficial will be felt from India to Peru

90% chance of El Niño!!

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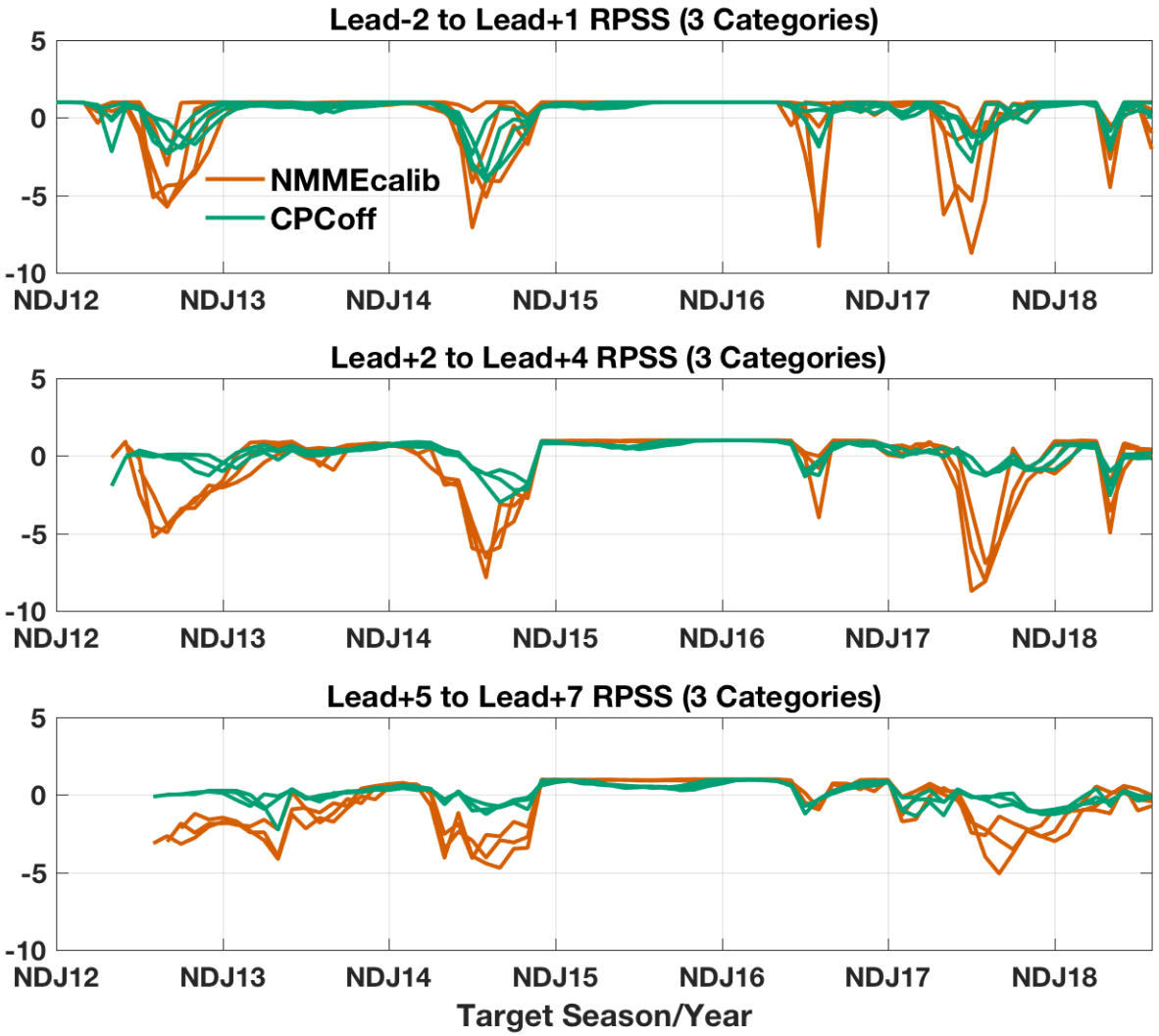
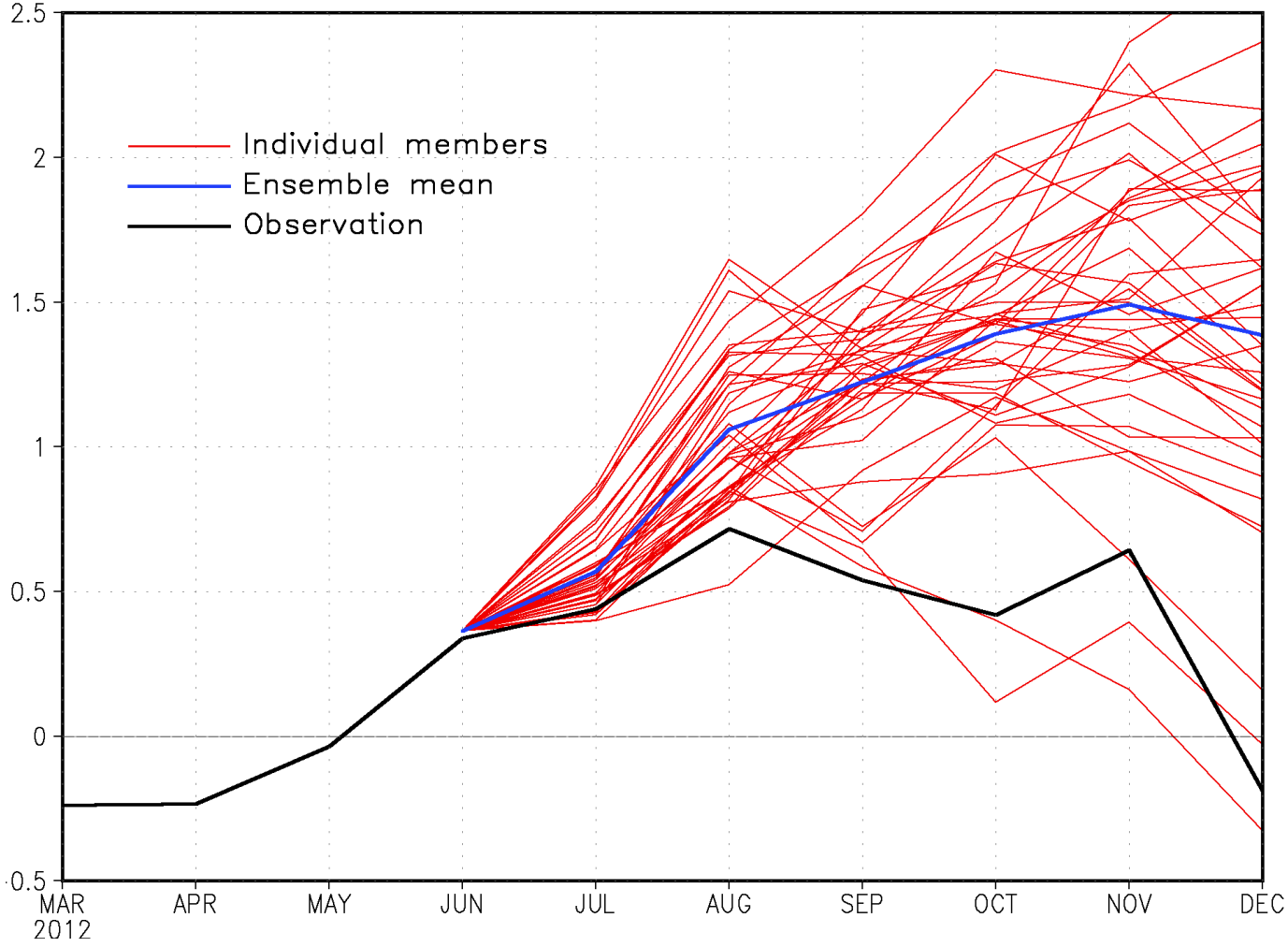


In review at *Weather & Forecasting*. "Strength Outlooks for ENSO" by M. L'Heureux, M. Tippett, K. Takahashi, A. Barnston, E. Becker, G. Bell, T. DiLiberto, J. Gottschalck, M. Halpert, Z-Z. Hu, N. Johnson, Y. Xue, and W. Wang.

Challenge #2: Tropical Convection in Models

Analysis by Wanqiu Wang (NOAA CPC)

Nino 3.4 index from CFSv2 (June 2012 Forecast)

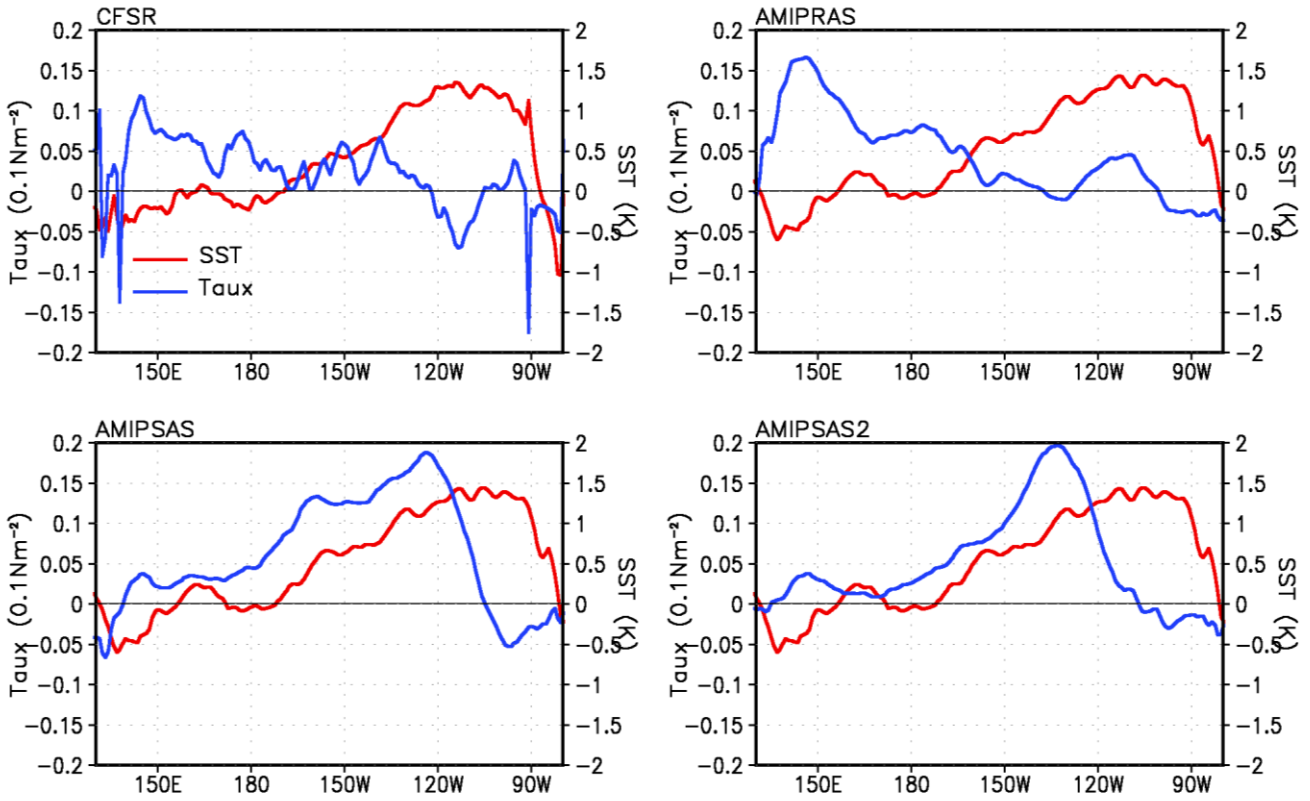


After September, most runs were warmer than observations

Challenge #2: Tropical Convection in Models

Analysis by Wanqiu Wang (NOAA CPC)

Equatorial zonal wind response to observed July 2012 SST anomalies (model with different convection schemes)



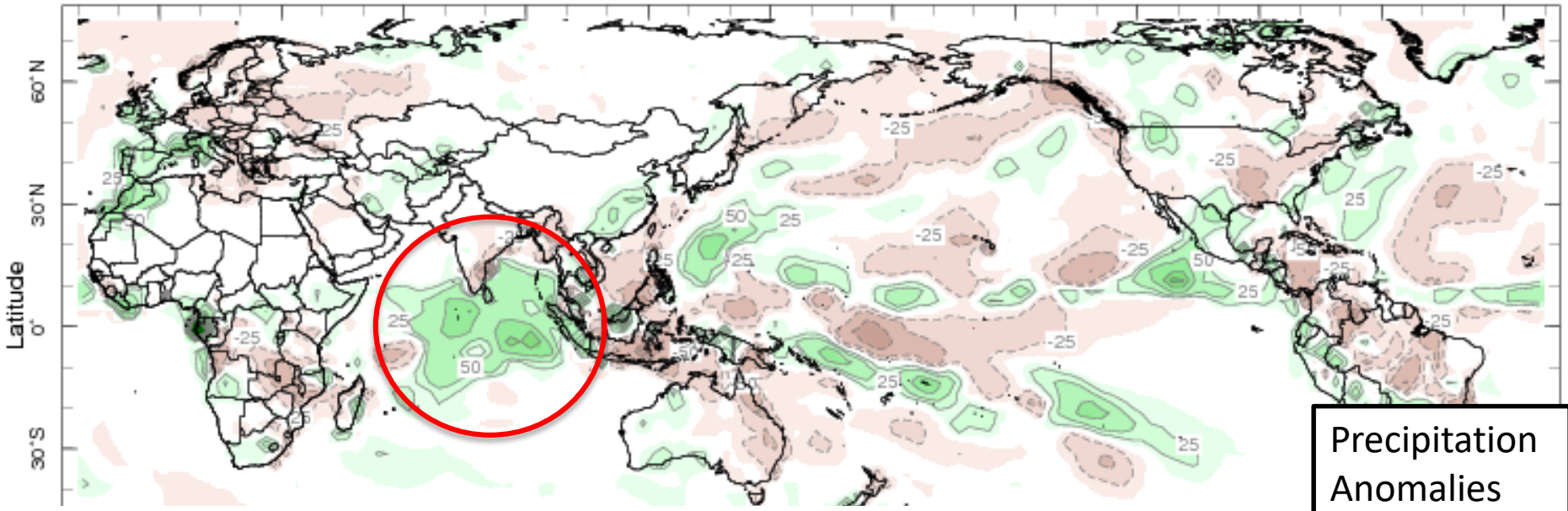
- Too strong Taux in central-eastern Pac with SAS and SAS2
- More reasonable Taux with RAS

Challenge #3: ENSO is not just the Niño-3.4 Index

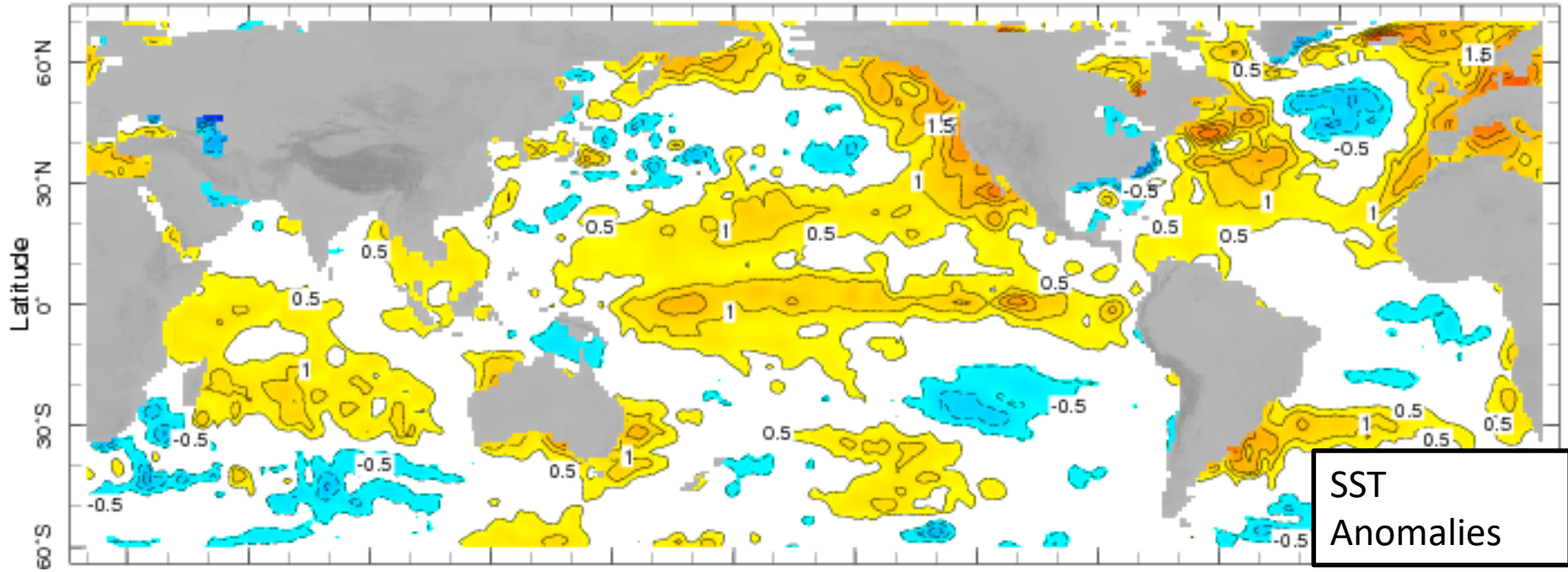
"All Models are Wrong, but some are useful." - Box, G. and Draper. N.

"All Indices are Wrong, but some are useful." - Me

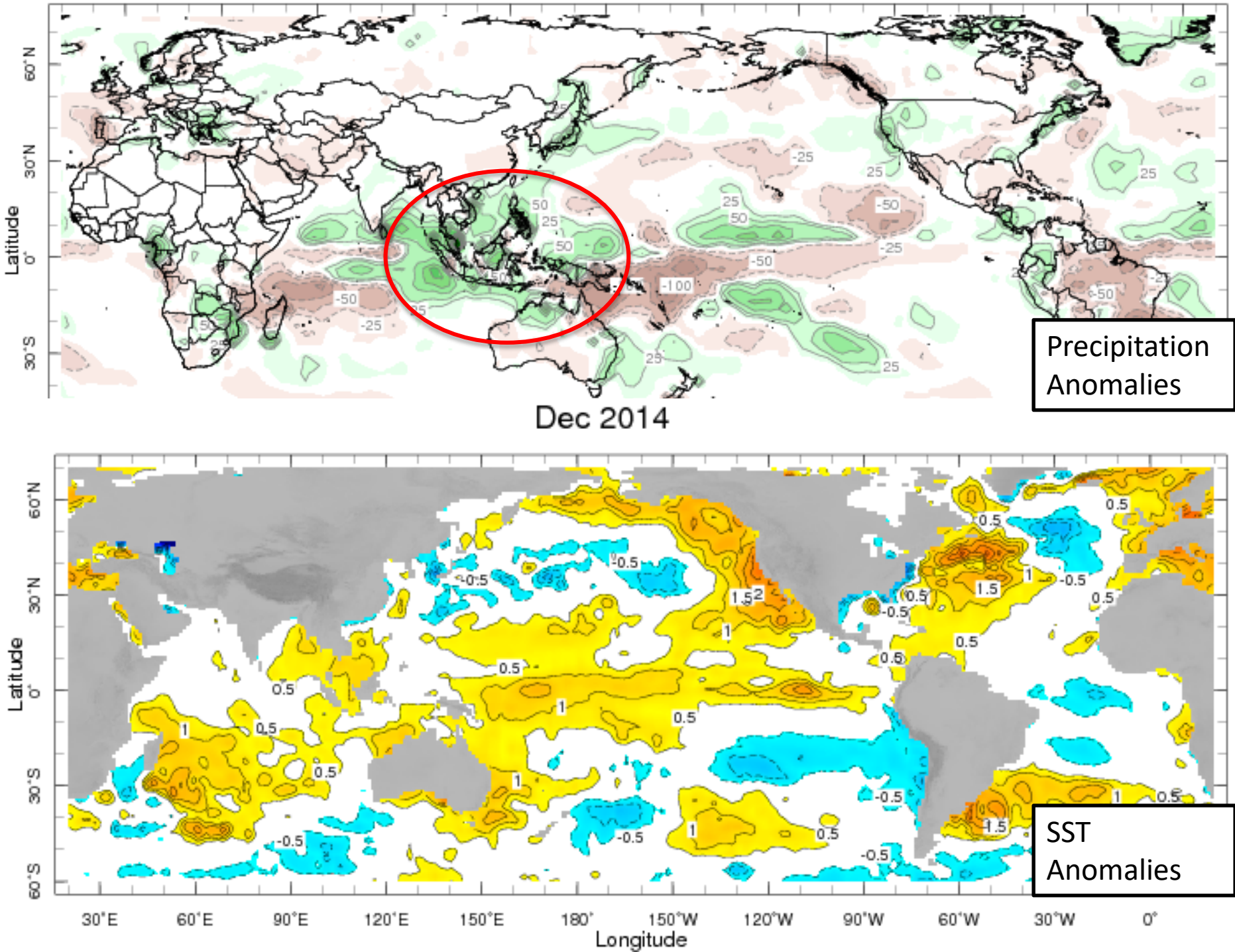
- The Niño-3.4 SST index is emphasized because of ***strong correlations*** with overlying atmosphere (SOI, winds, OLR).
- SST based indices (vs. atmospheric indices) are formed from ***climate quality*** SST datasets, which are adjusted and homogenized (e.g. ERSSTv5, HadISST, COBE)
- Therefore, Niño-3.4 is useful as a baseline for ENSO forecasts and verification.
- **But ENSO is a coupled ocean-atmosphere phenomenon…. let's look back at boreal winter 2014-15**

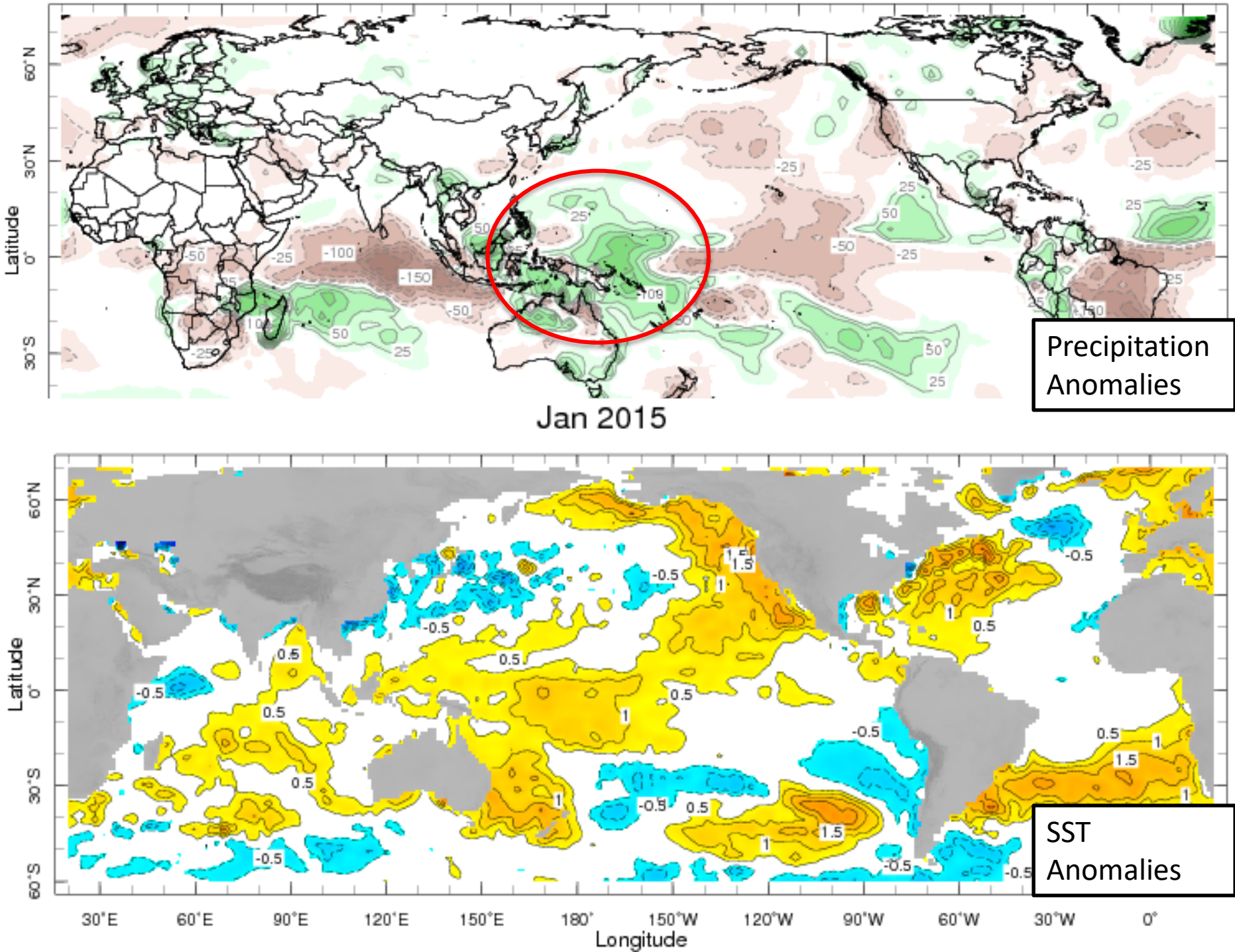


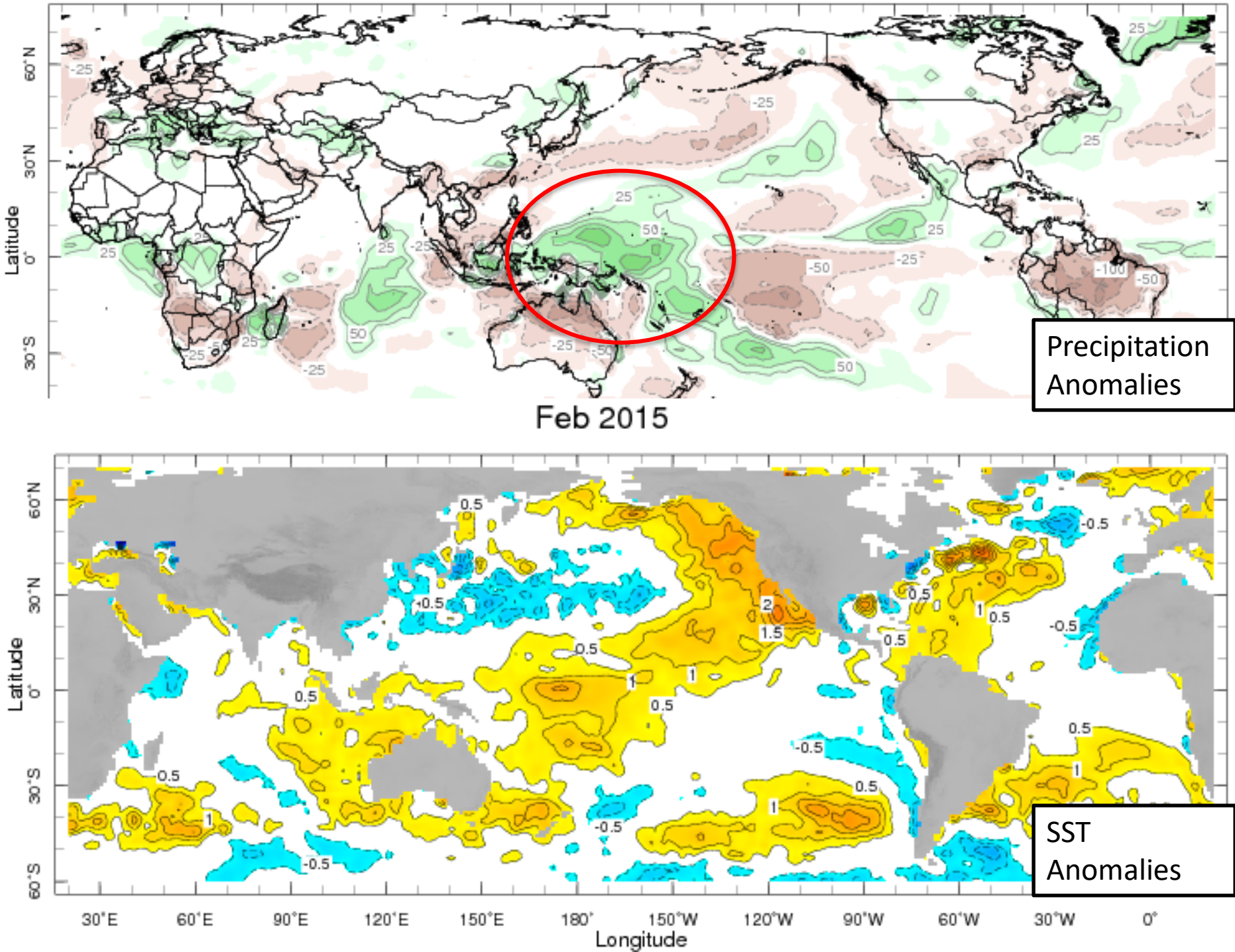
Nov 2014

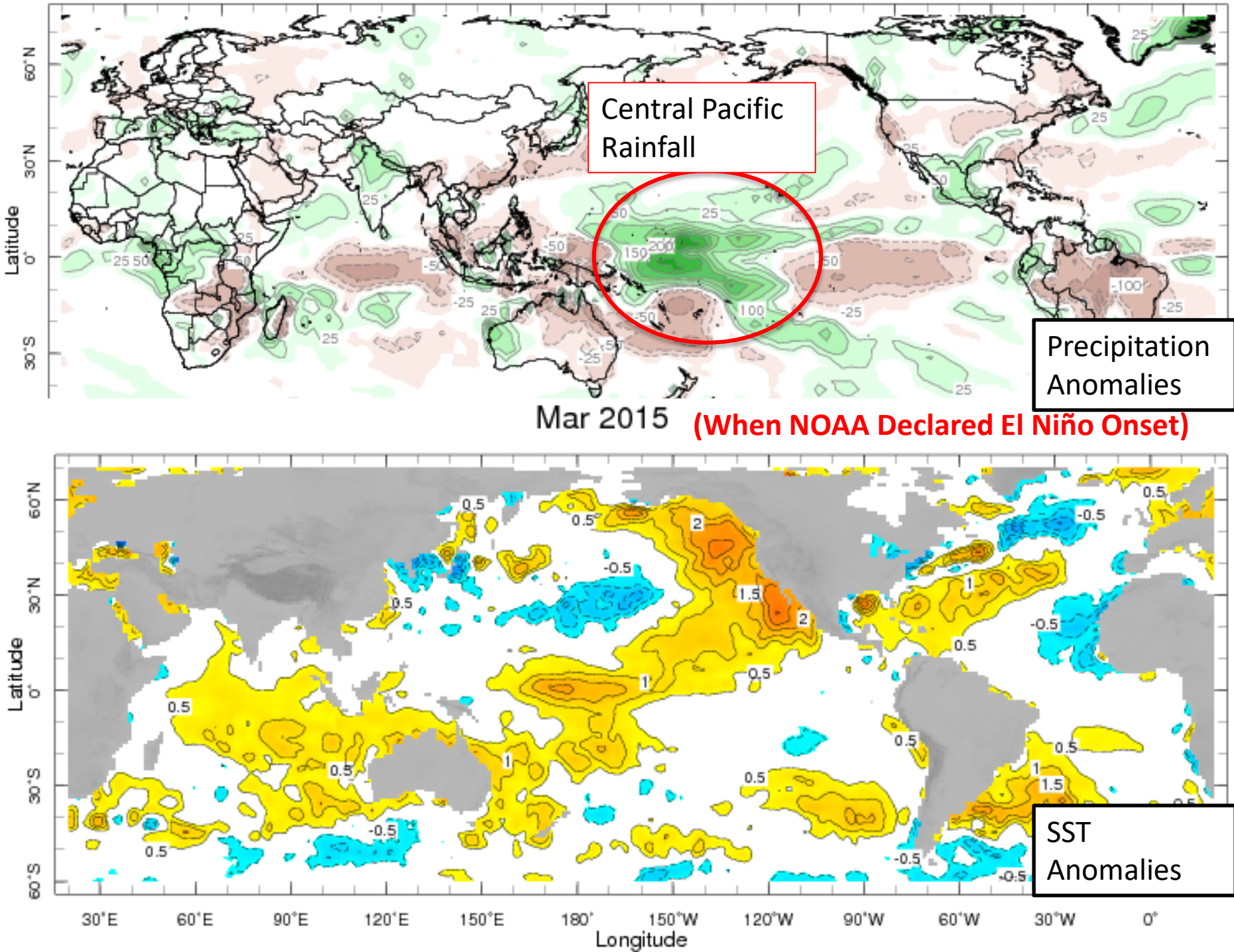


Graphics from IRI Data Library


Precipitation Anomalies
Dec 2014
SST Anomalies
Latitude
Longitude
60°N
30°N
0°
30°S
60°S
30°E
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W
0°


Latitude
60°N
30°N
0°
30°S
Precipitation Anomalies
Jan 2015
Latitude
60°N
30°N
0°
30°S
60°S
SST Anomalies
30°E
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W
0°
Longitude


Latitude
60°N
30°N
0°
30°S
Precipitation Anomalies
Feb 2015
Latitude
60°N
30°N
0°
30°S
60°S
SST Anomalies
30°E
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W
0°
Longitude

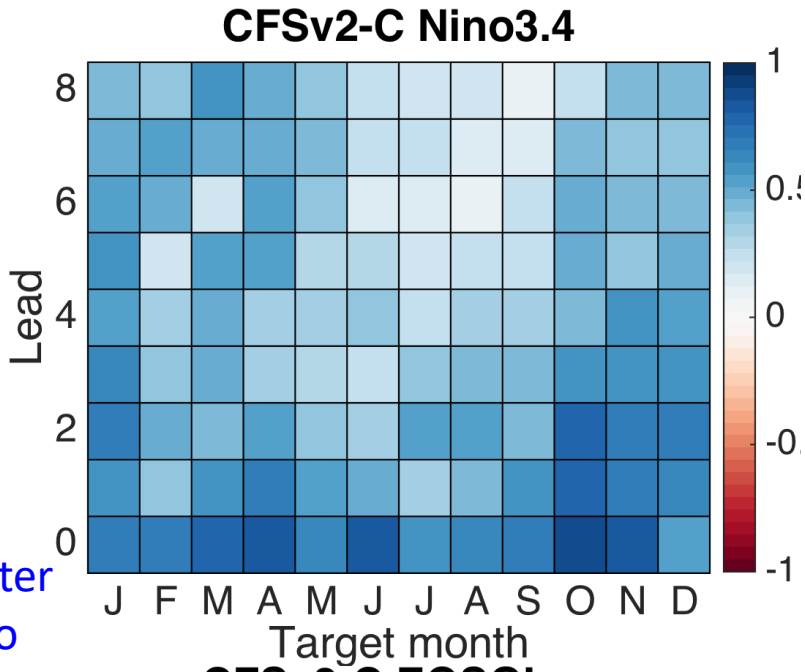

Central Pacific Rainfall
Precipitation Anomalies
Mar 2015
(When NOAA Declared El Niño Onset)
SST Anomalies
Latitude
Longitude
60°N
30°N
0°
30°S
60°S
30°E
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W
0°

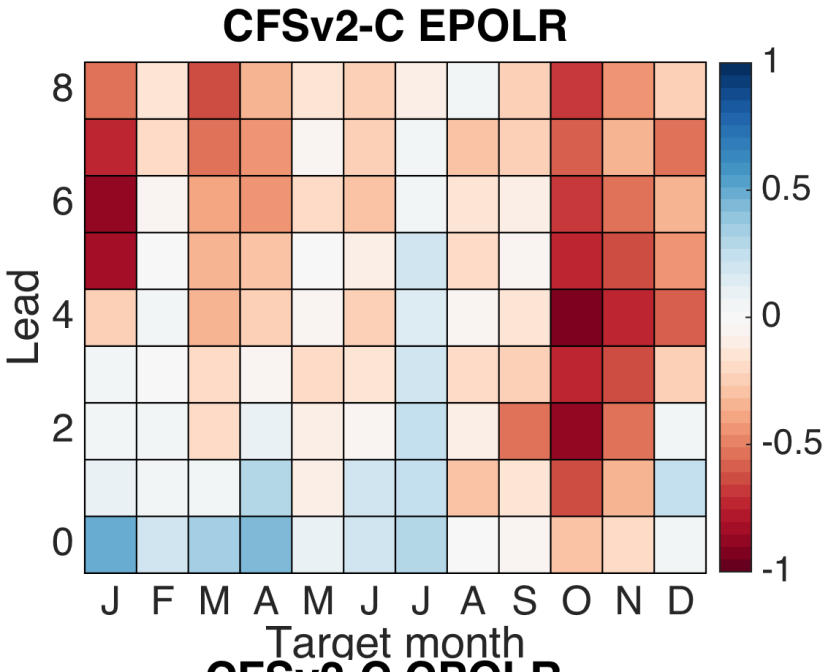
Challenge #3: ENSO is not just the Niño-3.4 Index

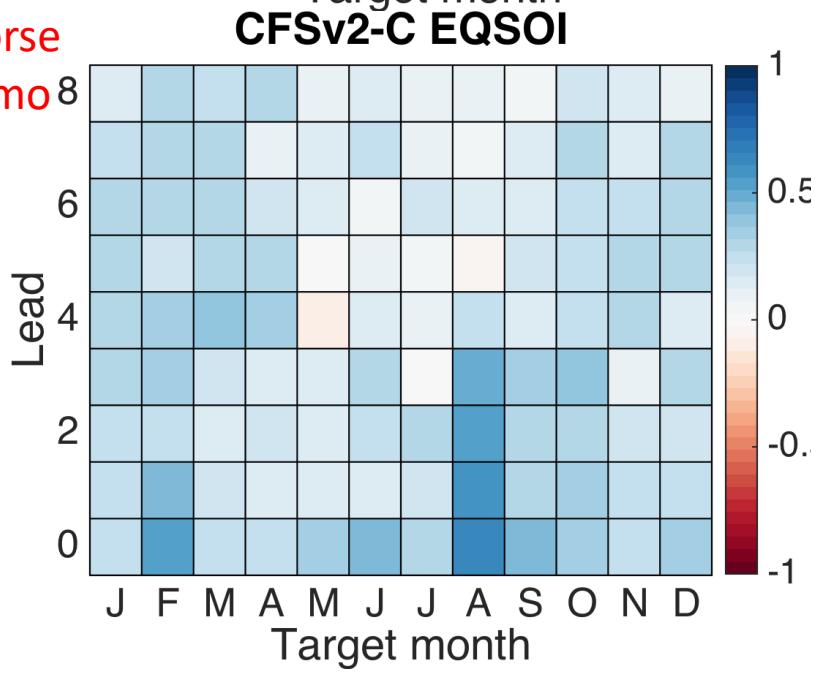
Log Skill Score

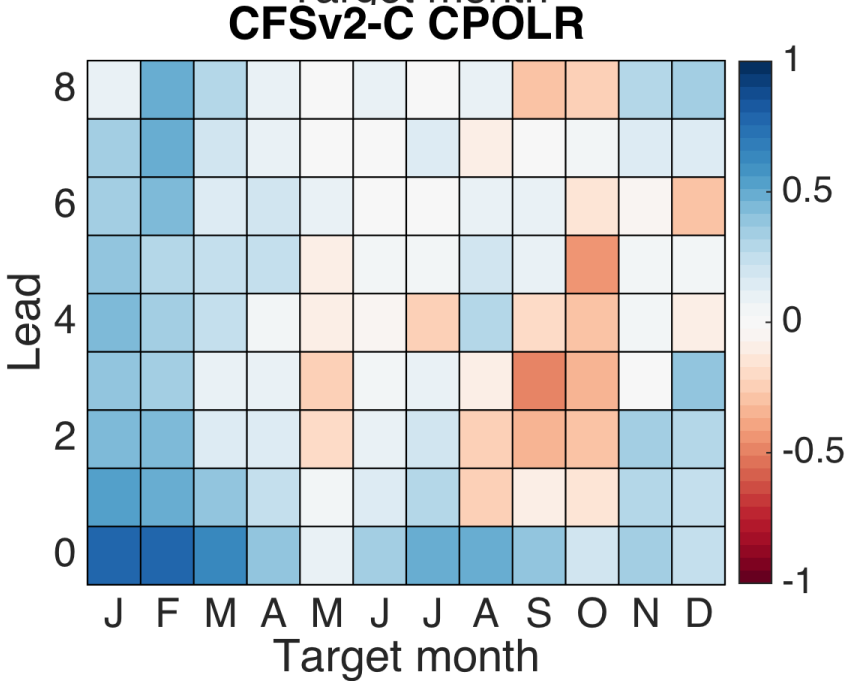
Blue : better than climo

Red: worse than climo



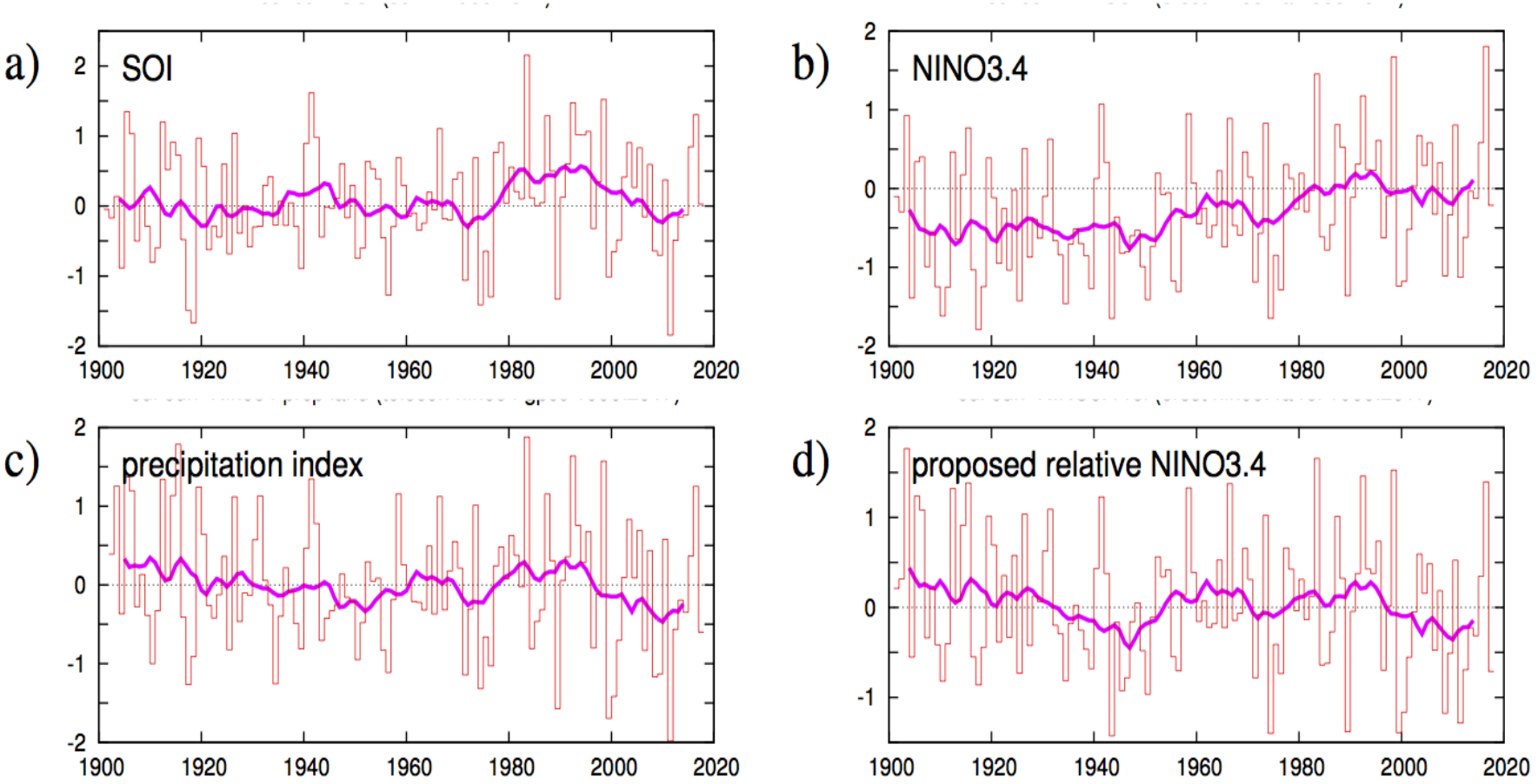






Challenge #4: Is that ENSO or is that Trend?

Analysis by Geert Jan van Oldenborgh (KNMI)



Proposed Relative SST index (in progress): "**Defining El Niño indices in a warming climate**" by Geert Jan van Oldenborgh, Harry Hendon, Tim Stockdale, Michelle L'Heureux, Erin Coughlan de Perez, Roop Singh, Maarten van Aalst

Suggested Paths Forward

- In skill evaluation, don't always focus on the average/median. Also pay attention to the ***variance in skill*** (busts matter!).

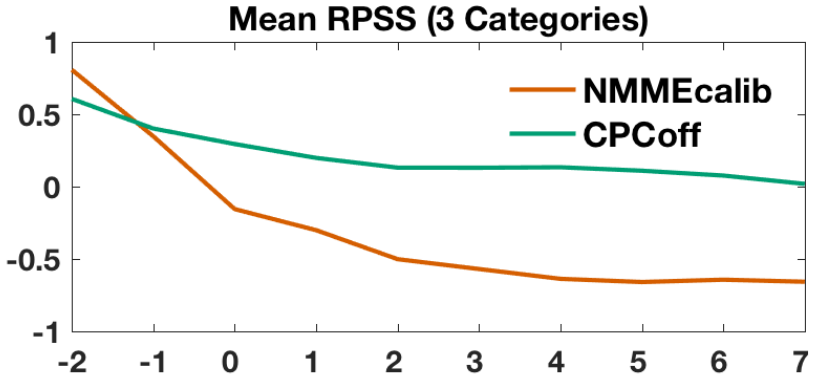
- ***In prediction mode***, evaluate model's forecasts of ENSO: their physics (process metrics) and skill (verification).

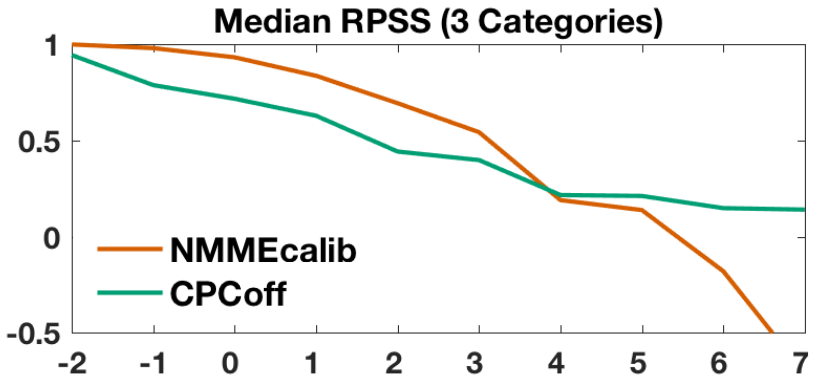
- While atmospheric indices are lower in skill, we need to cast a wider net and ***predict coupling***.

- In real-time, use methods to ***isolate long-term trends versus the seasonal ENSO cycle*** (and also understand their interactions).

EXTRA SLIDES

Challenge #1: Forecast "Busts" are highly visible. We like to avoid them.





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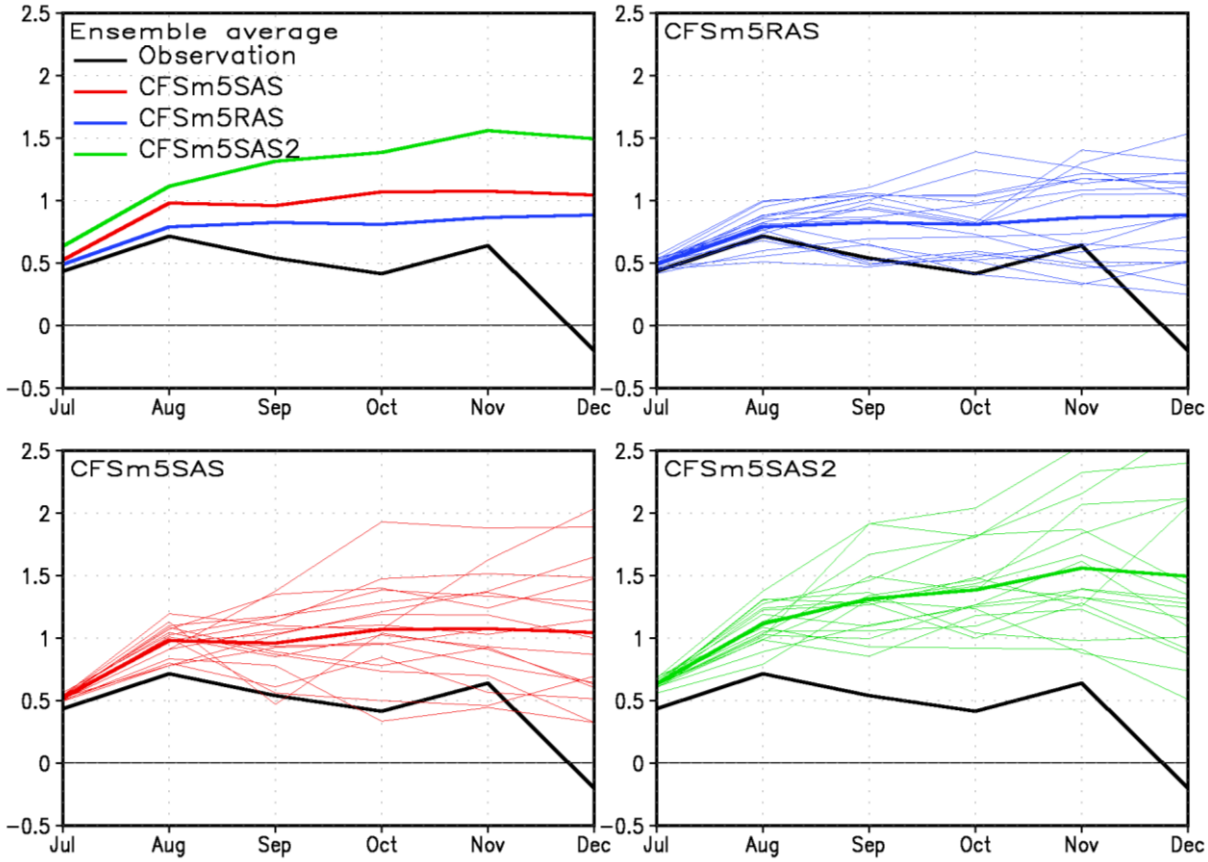

- Ensemble mean Nino3.4 most warm with SAS2 and least warm with RAS.
- Obs is more contained in CFSm5RAS
- All three convection schemes tend to produce warmer forecasts than that observed.

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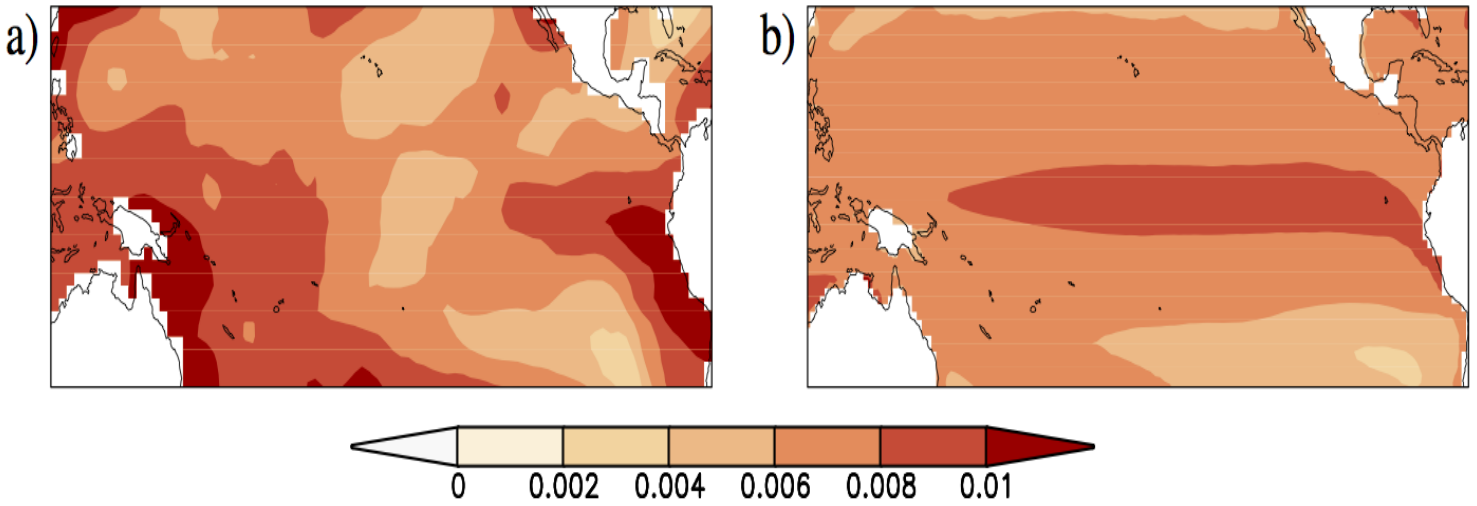

Fig. 2 *Trend in the tropical Pacific 1900–2016 (K/ppm) in a) in the ERSST v5 dataset b) the CMIP5 multi-model mean . It is clear that it does not project on El Niño (see also reference 11), with more warming both in the west and the east in the observations and along the whole equator in the models. Note that the uncertainties are so large that the two patterns are compatible.*