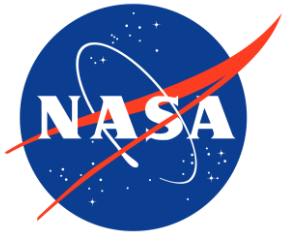



Jet Propulsion Laboratory
California Institute of Technology

# Ocean dynamic persistence provides substantial predictability for El Niño-Southern Oscillation (ENSO)

*Tony Lee and Ou Wang*
*NASA Jet Propulsion Laboratory, California Institute of Technology*

# Motivation

ENSO prediction skill from coupled models

←

Accuracy of the initial ocean state

+

Fidelity of coupled models in depicting air-sea coupling

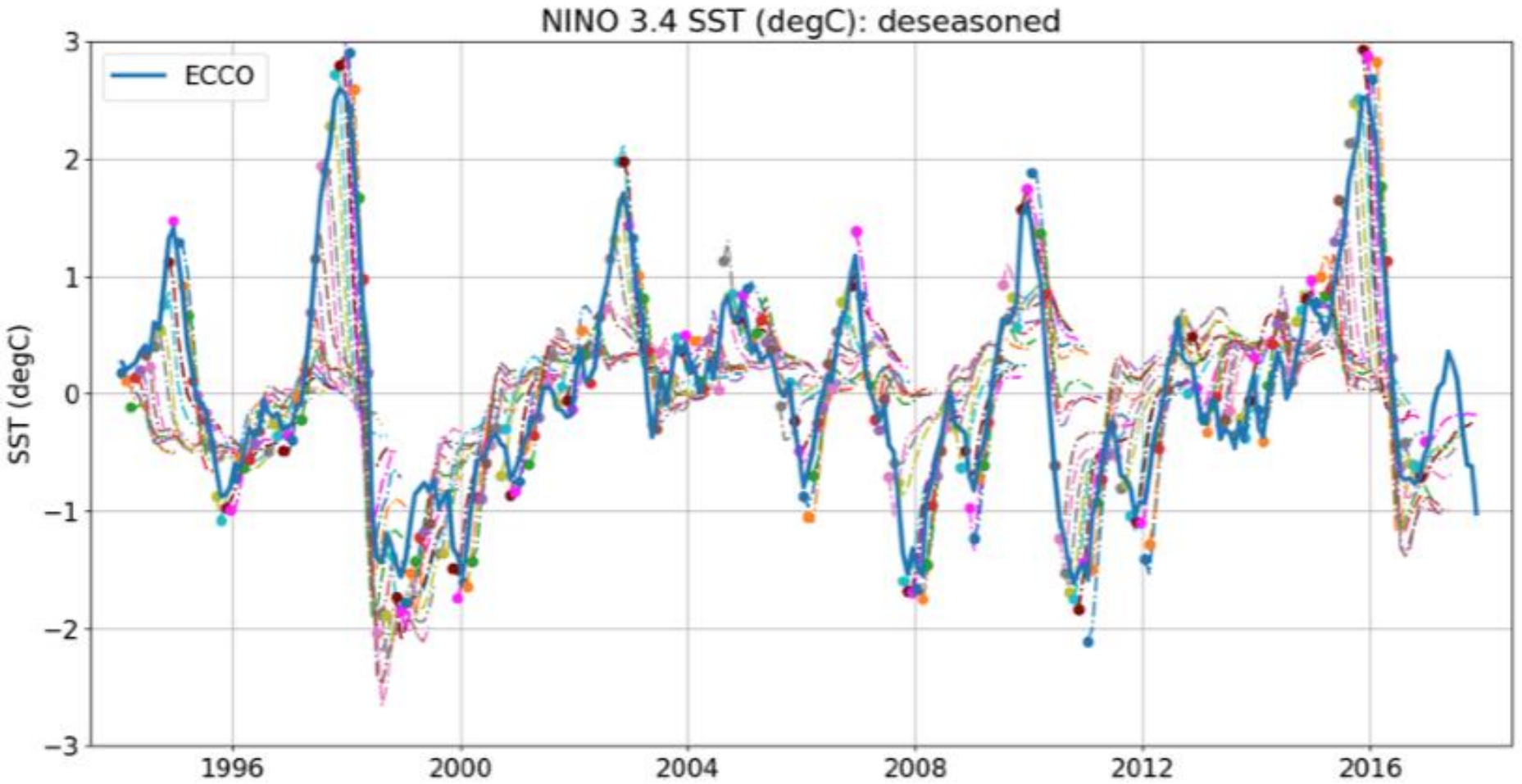
How much predictability does the initial ocean state provide w/o considering subsequent air-sea coupling?

Coupled-model initialization shock or drift can limit the contribution of an accurate initial ocean state to ENSO prediction skill.

# Method

- Perform a set of 12-month forward integration of a global ocean model forced by climatological seasonal atmospheric forcings, initialized from **ECCO** ocean state estimate monthly from 1994 to 2017.
- Interannual ocean anomalies in the 12-month hindcasts are solely due to the evolution of the initial ocean state without air-sea coupling - referred to as **ocean dynamic persistence**.
- It **contrasts statistical persistence**, a typical baseline metrics for evaluating prediction skill, where the initial anomaly is damped statistically as a function of prediction lead time.

# Ocean dynamic persistence hindcasts of Niño3.4 SST index



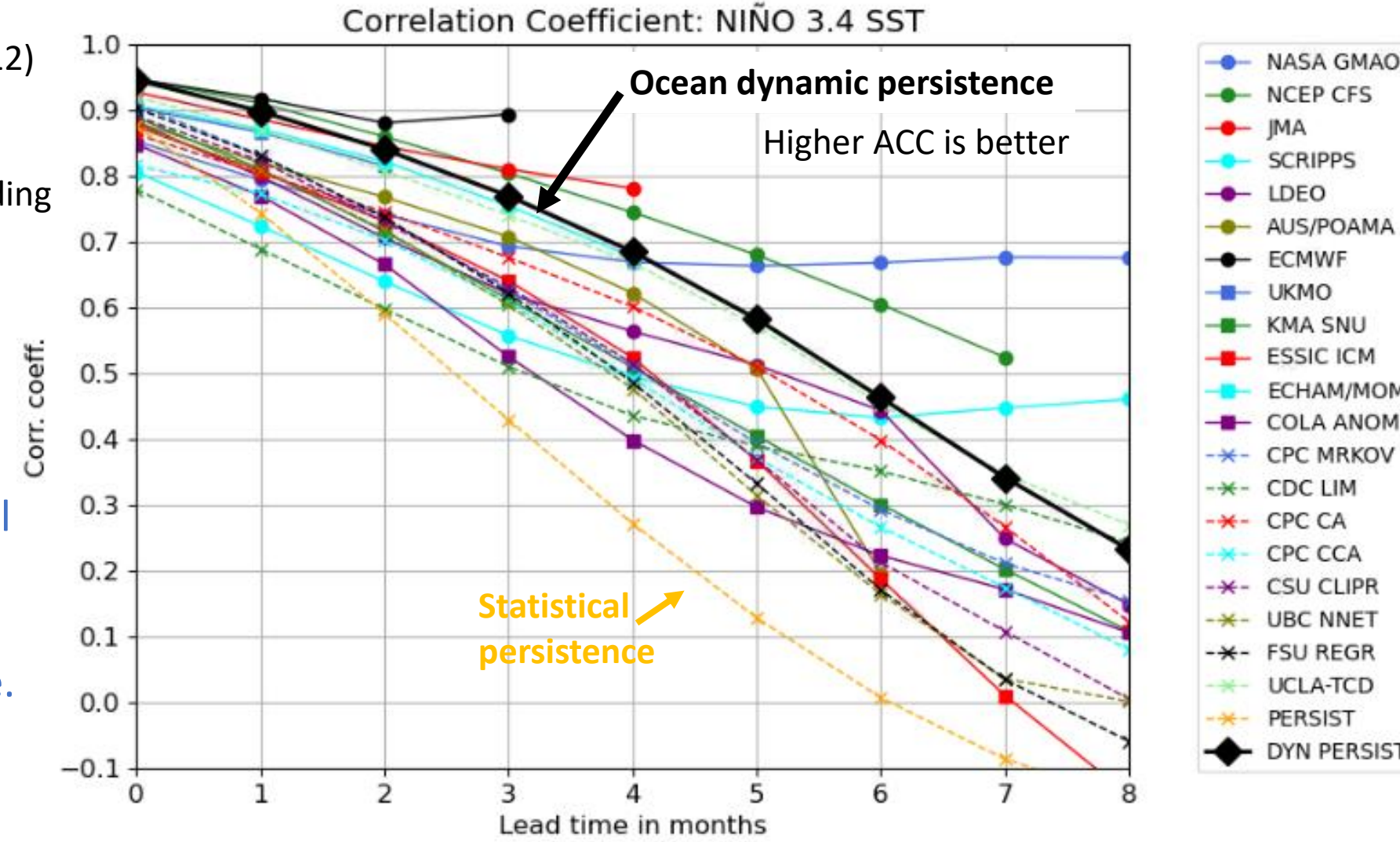
# Prediction skill: Anomaly Correlation Coefficient (ACC) of predicted vs. observed Niño3.4 SSTA

(for the 2002-2011 period as in Barnston et al. 2012, BAMS)

**Color curves:** from Barnston et al. (2012)
Solid – coupled models.
Dashed – statistical models.
(Thanks to Dr. Tony Barnston for providing the model forecast data)

## Findings:

Ocean dynamic persistence skill
> skill of most coupled and statistical forecast models;
>> skill of statistical persistence.




Lead time month 0 represents the average for predictions in the first 3 months (Barnston et al. 2012)

# Prediction skill: Root Mean Squared Error (RMSE) of predicted vs. observed Niño3.4 SSTA

(for the 2002-2011 period as in Barnston et al. 2012, BAMS)

**Color curves:** from Barnston et al. (2012)
Solid – coupled models.
Dashed – statistical models.
(Thanks to Dr. Tony Barnston for providing the model forecast data)

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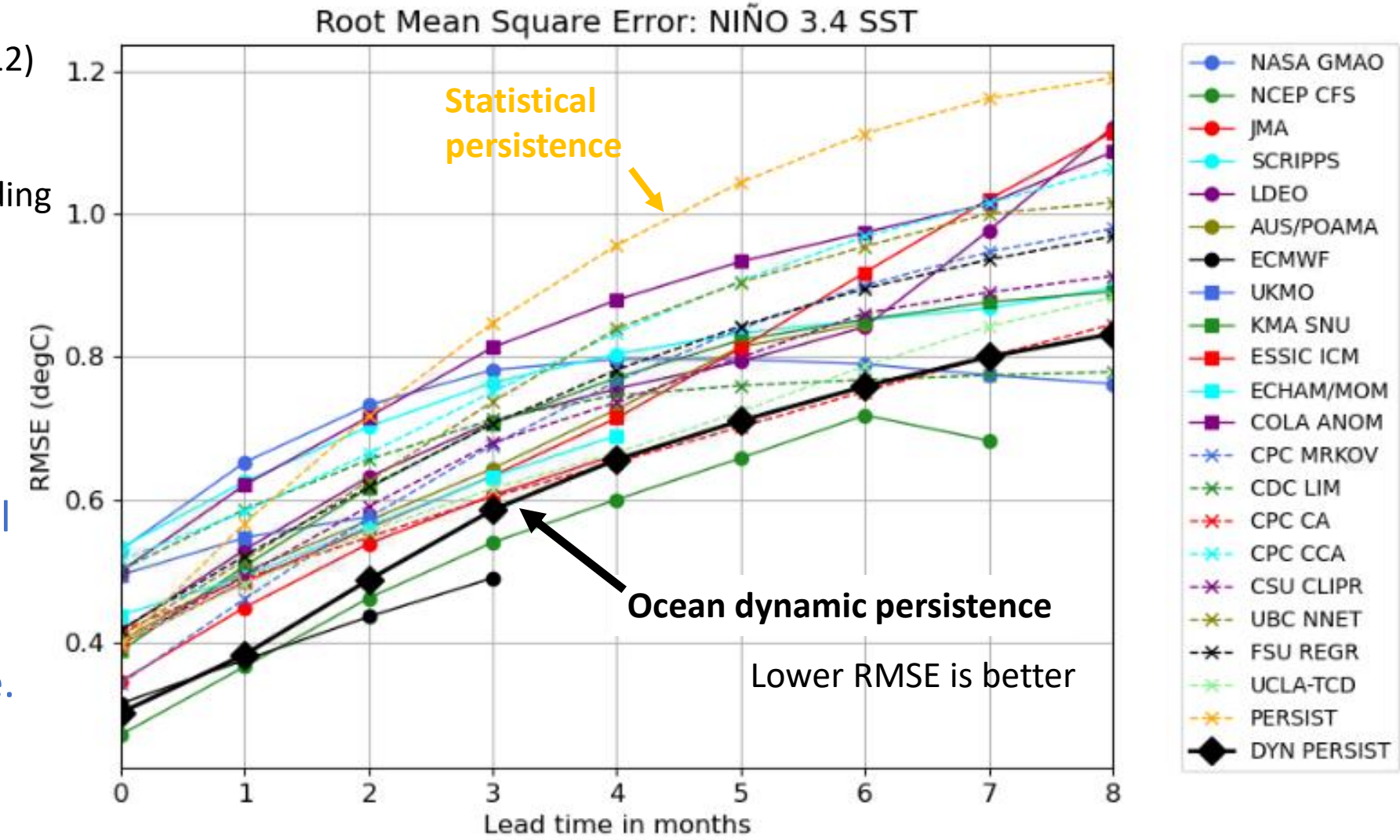


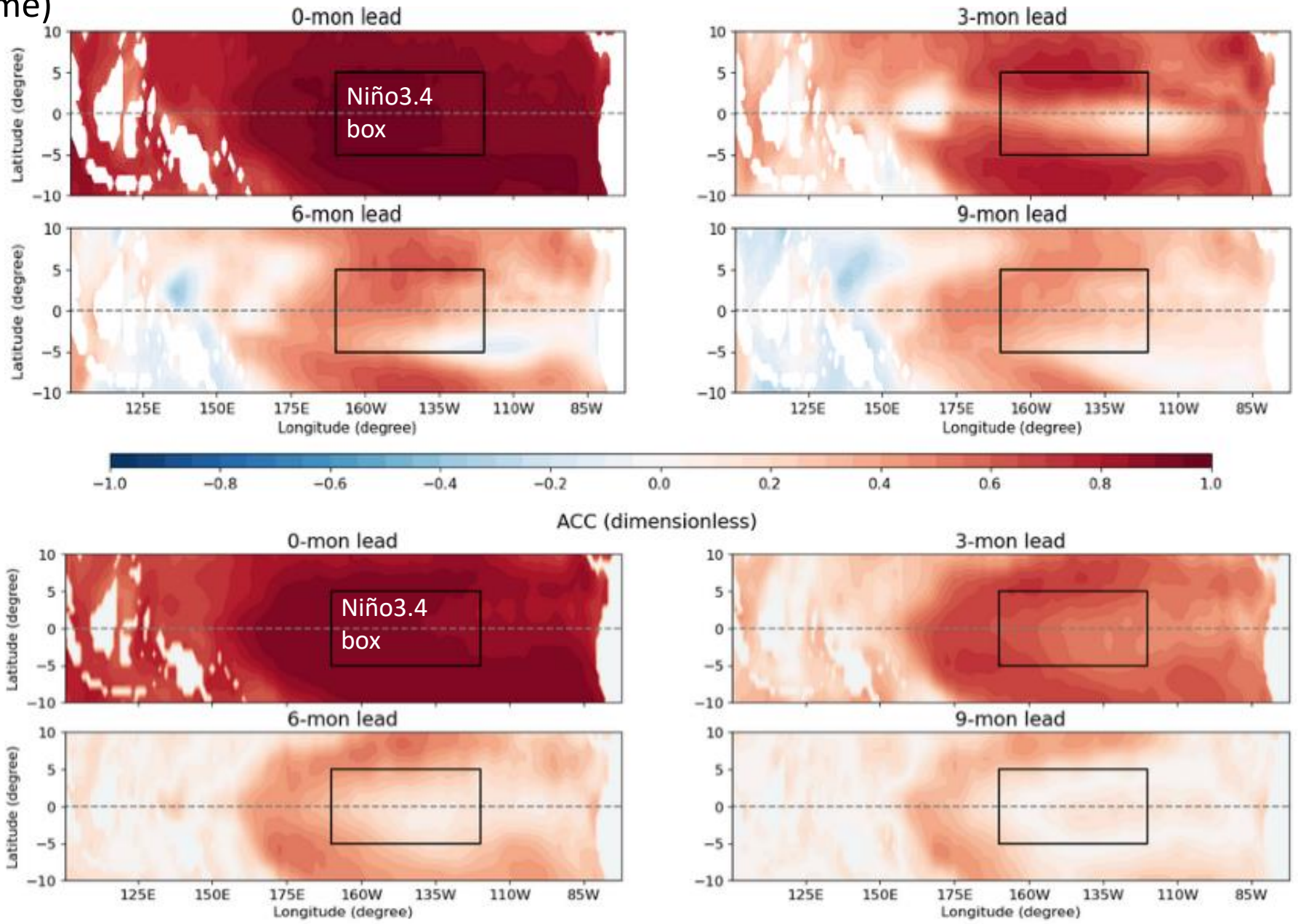

Lead time month 0 represents the average for predictions in the first 3 months (Barnston et al. 2012)

# Contrasting prediction skills by ocean dynamic persistence & statistical persistence

(as a function of space and lead time)

Prediction skill (ACC) from **ocean dynamic persistence**

Prediction skill (ACC) from **statistical persistence**

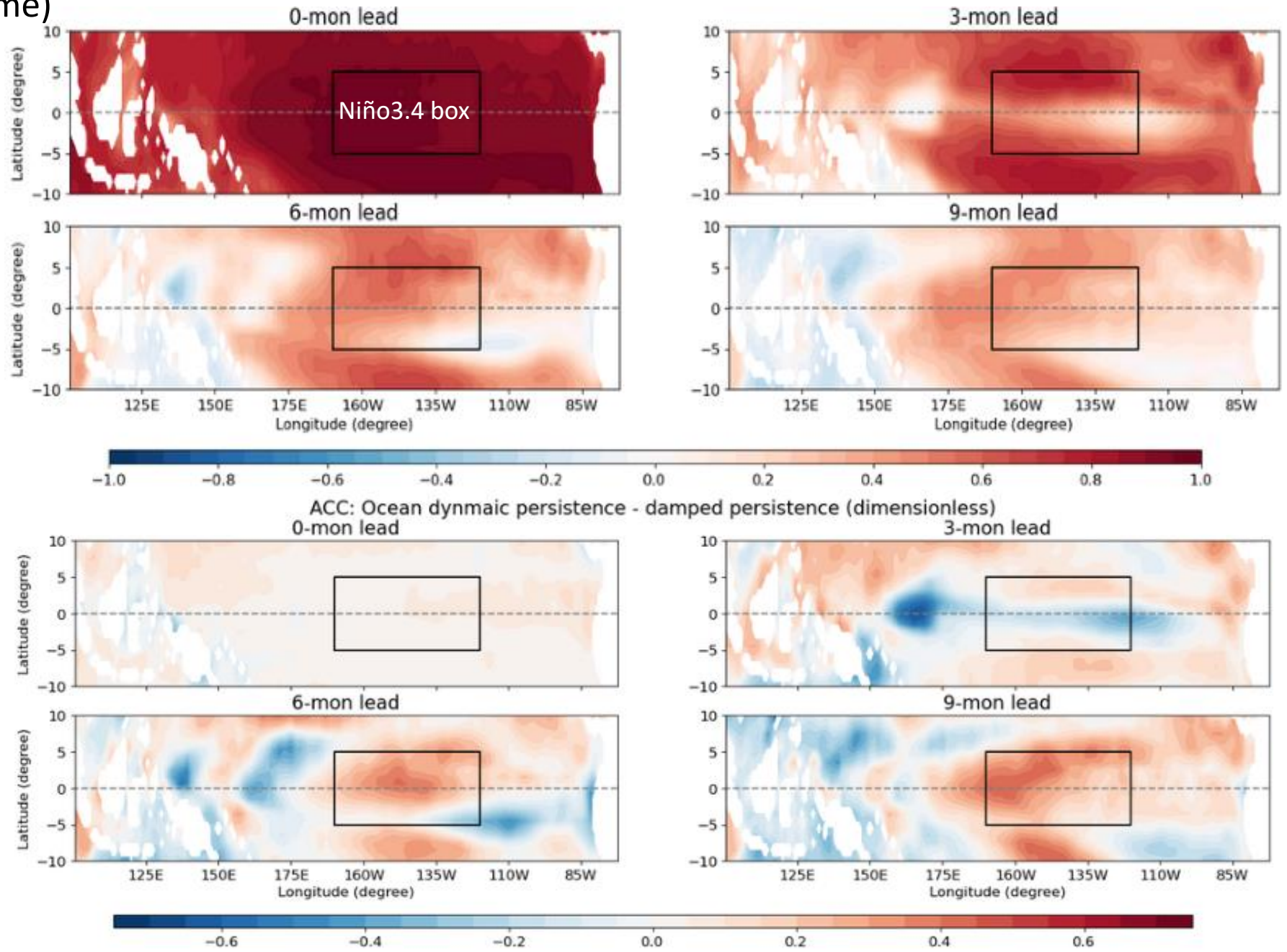


# Contrasting prediction skills by ocean dynamic persistence & statistical persistence

(as a function of space and lead time)

Prediction skill (ACC) from **ocean dynamic persistence**

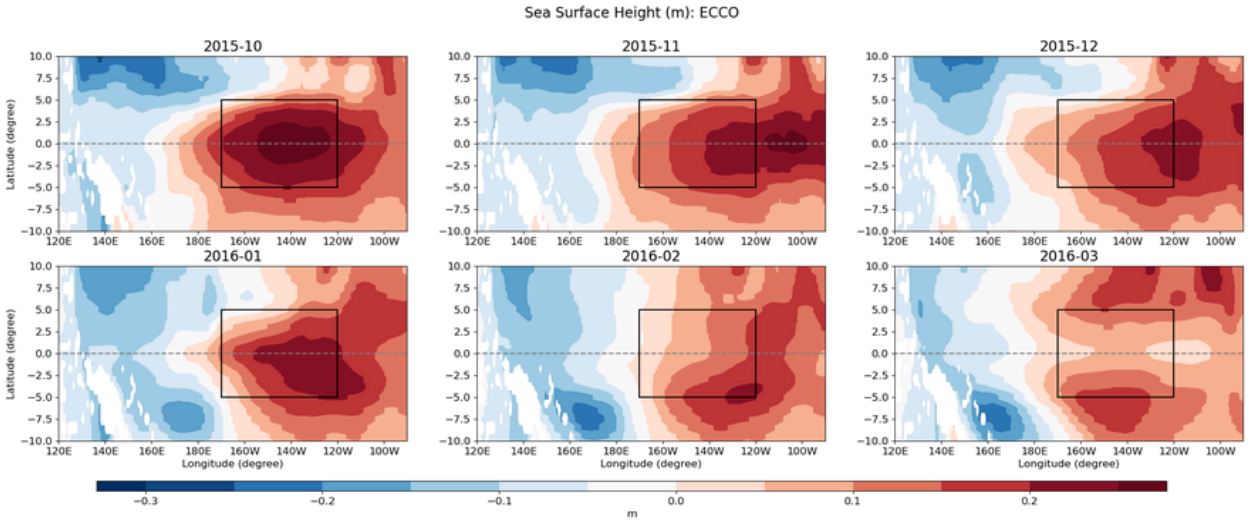
Prediction skill (ACC) difference: **dynamic-statistical persistence** (red values indicate ocean dynamic persistence having higher skill)



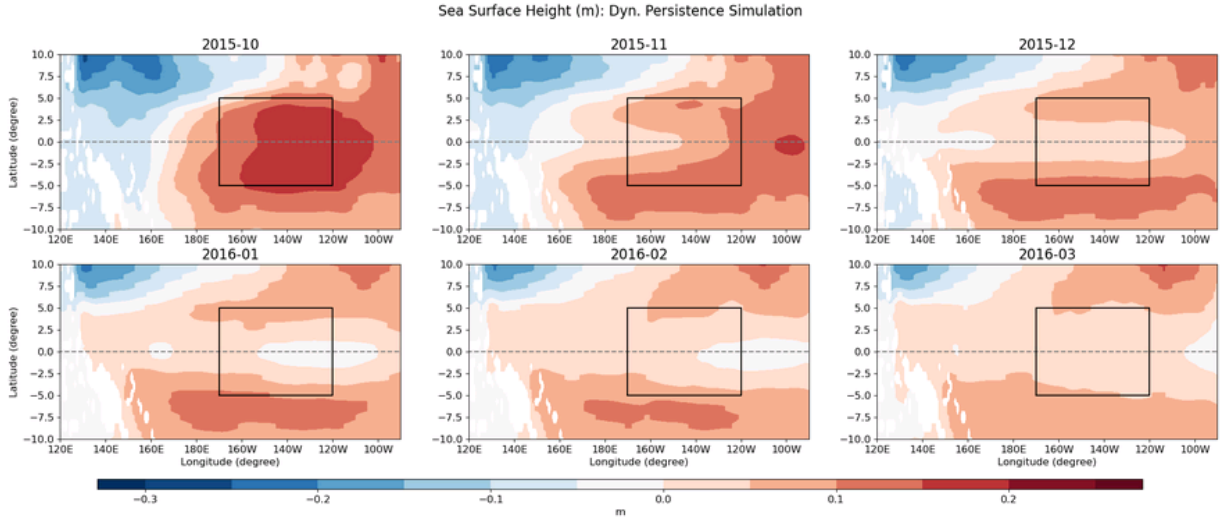
# Equatorial wave dynamics is important to ocean dynamic persistence:

## example for equatorial & off-equatorial SSHA & SSTA anomalies during the 2015 El Niño

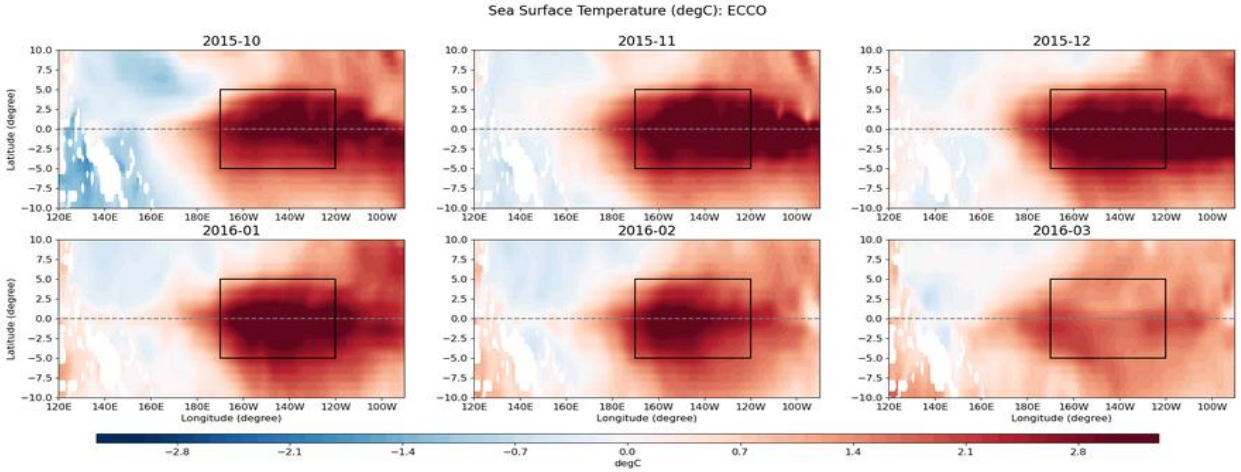
### SSHA from ECCO



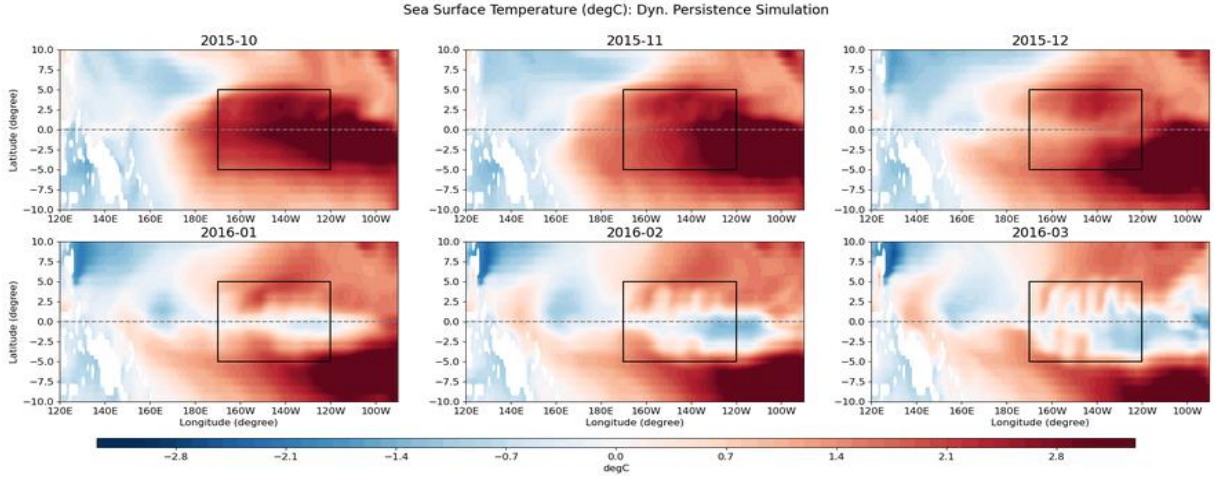

### SSHA dynamic persistence, initialized 2015-09-30, 24Z




### SSTA from ECCO




### SSTA dynamic persistence, initialized 2015-09-30, 24Z



# Summary

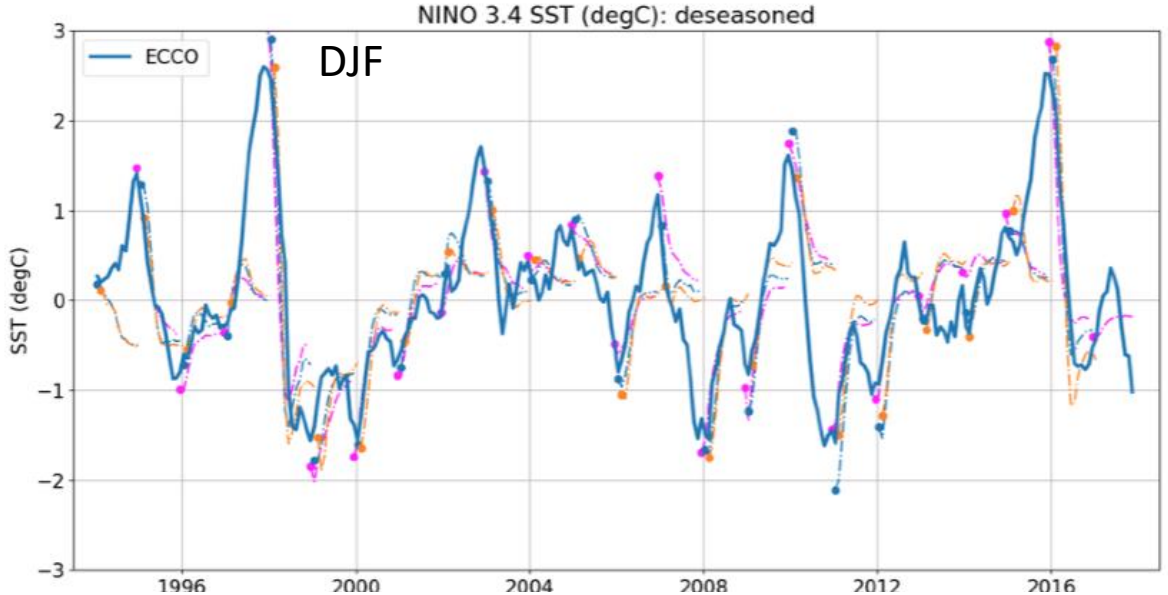
- The skill of **ocean dynamic persistence** in hindcasting Niño3.4 SST index
  - exceeds the skills of most statistical & coupled models;
  - is much better than that of statistical persistence;
  - raises the bar for baseline metrics of evaluating ENSO prediction skill.

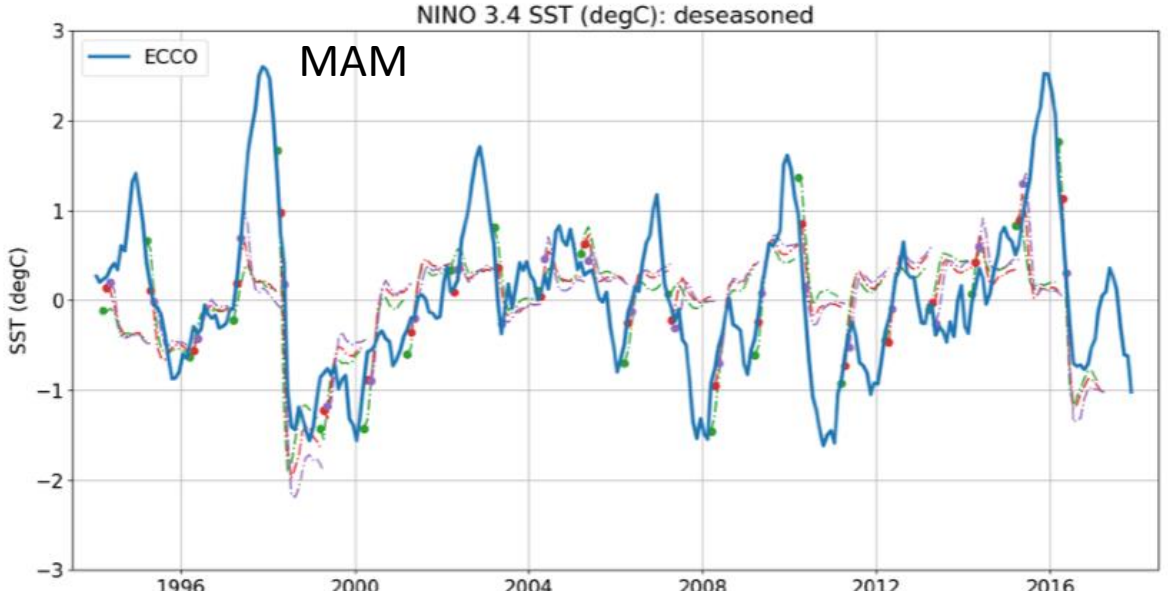
- Equatorial wave dynamics explains much of the ocean dynamic persistence.

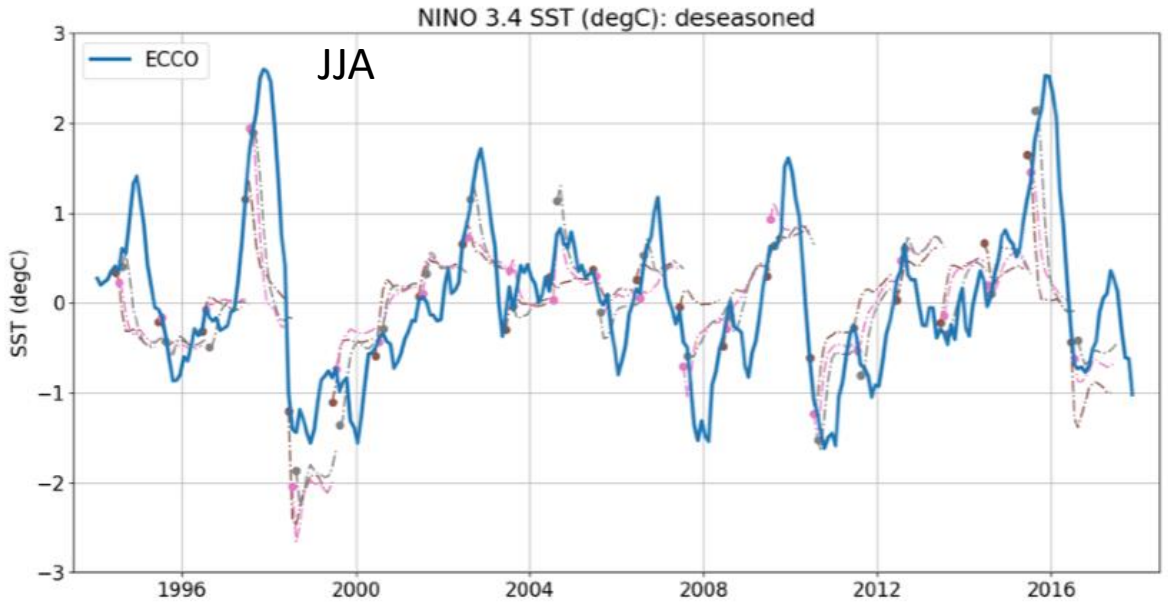
- The role of oceanic advection/diffusion at longer lead times needs to be investigated.

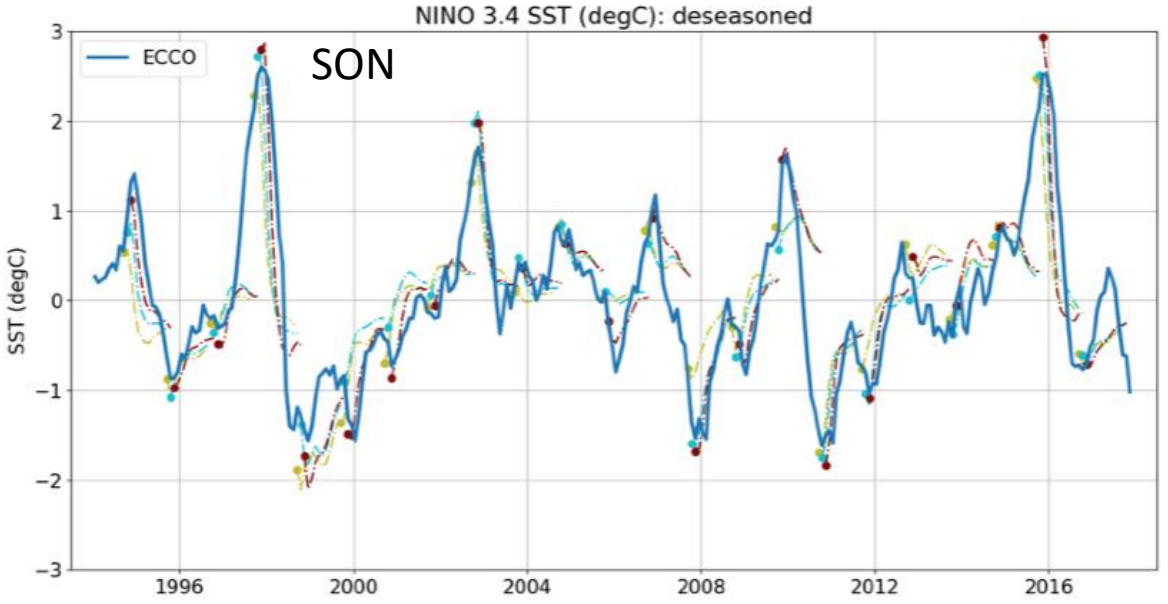
# Backup slides

# Ocean dynamic persistence hindcasts of Niño3.4 SST index: by initialization season

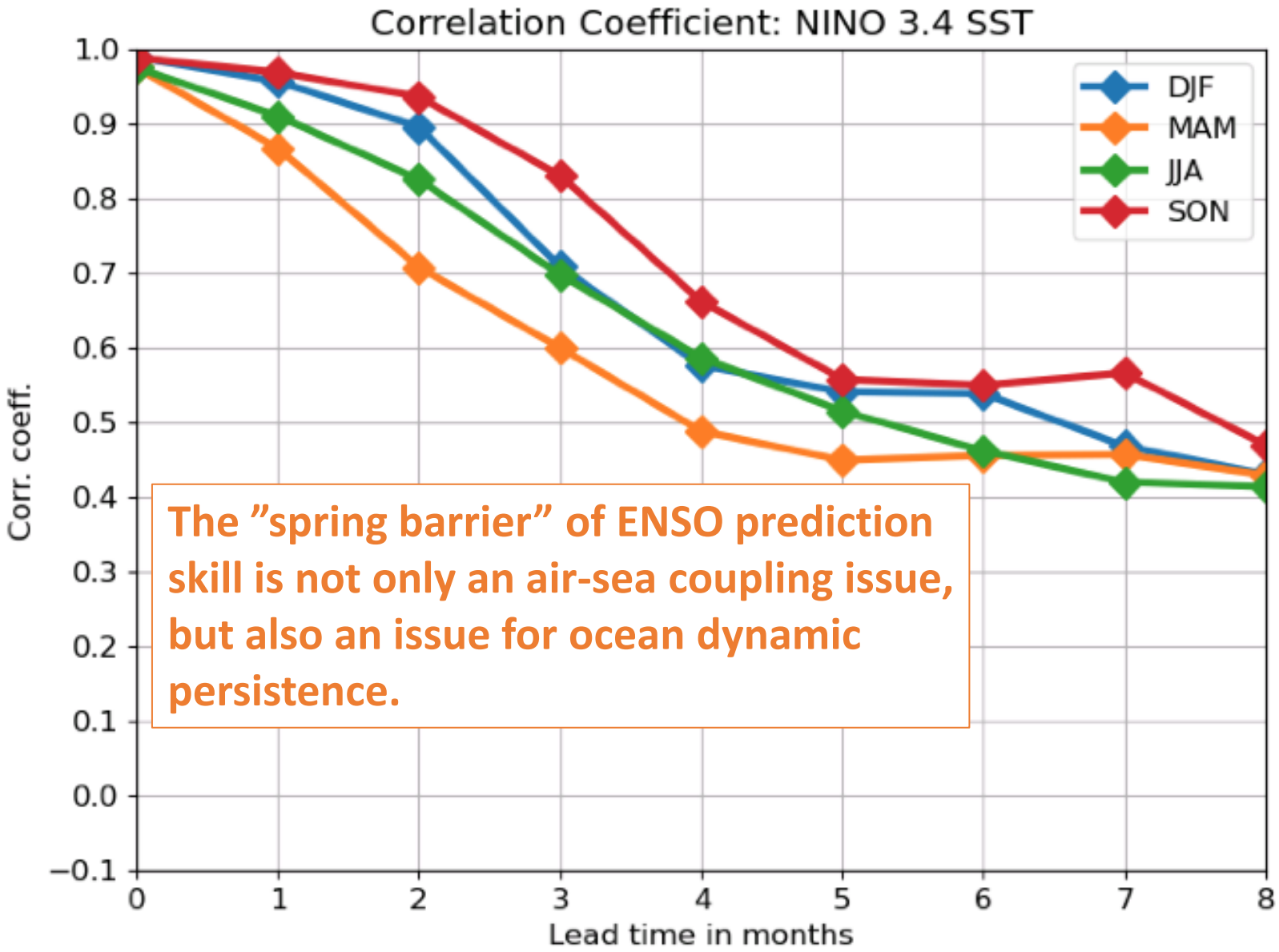


# The skill of ocean dynamic persistence in hindcasting Niño3.4 SST index by initialization season

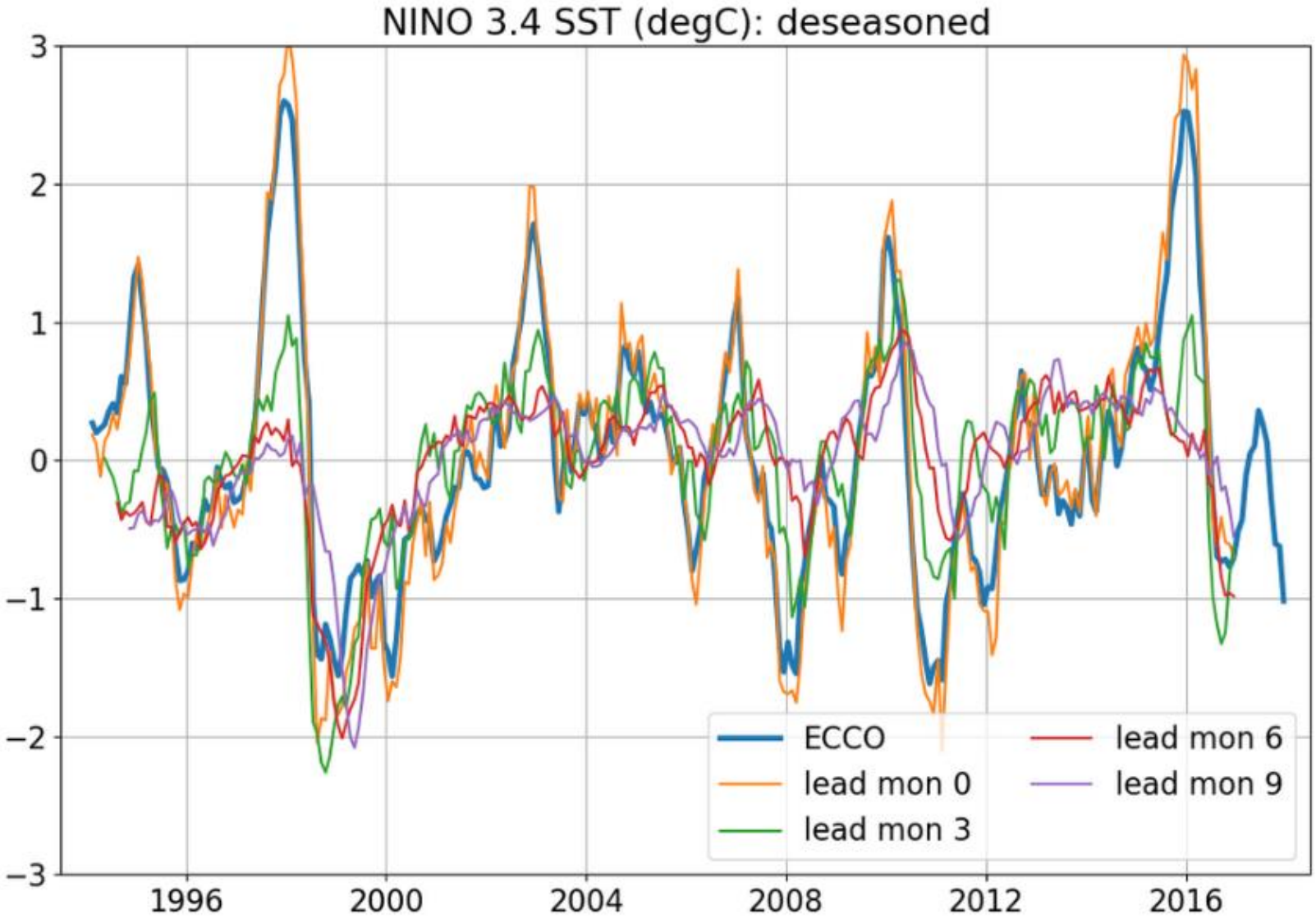



**The ”spring barrier” of ENSO prediction skill is not only an air-sea coupling issue, but also an issue for ocean dynamic persistence.**

Correlation values shown here are for 1994-2017, not 2022-2011 as in Barnston et al. (2012).

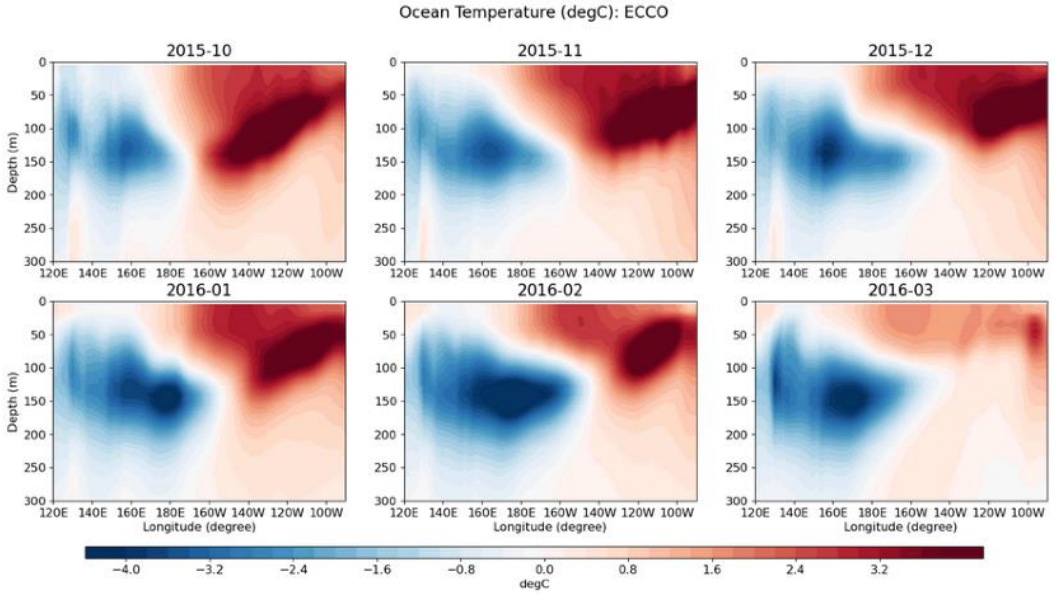
The value at each lead time represents the value for that lead-time month, not 3-month lead time average as in Barnston et al. (2012).

# NINO3.4 SST (degC): ECCO vs. Predictions

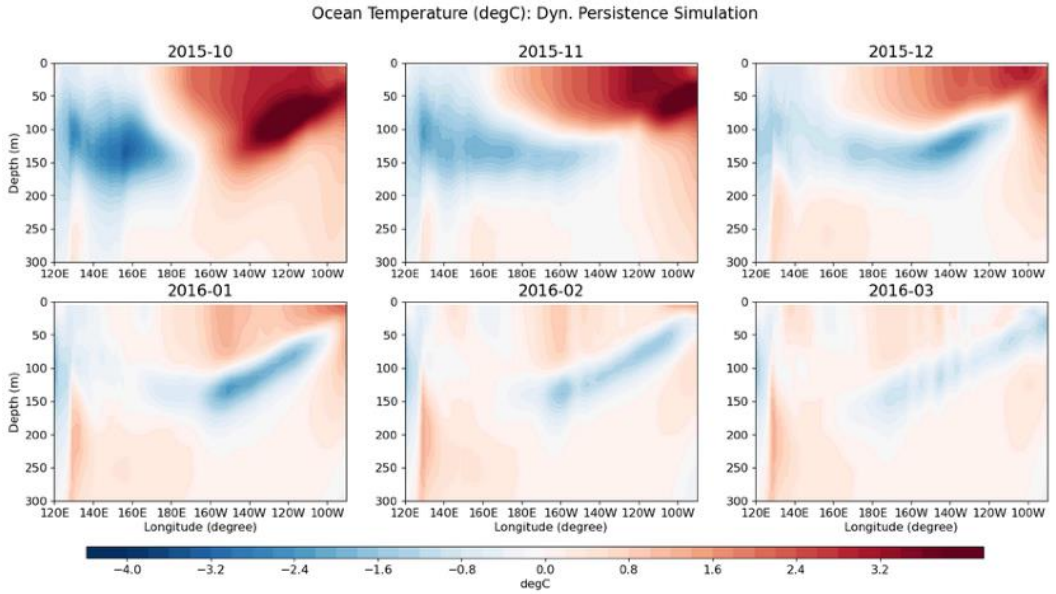


# Temperature Anomaly (degC): 5S-5N Average

## ECCO

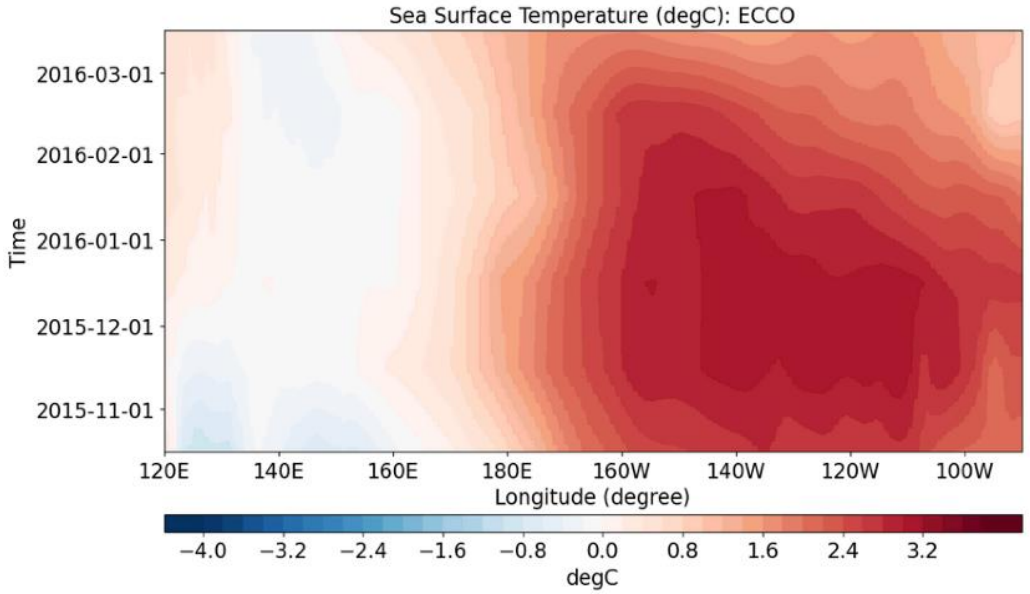



## Prediction: Initialized on 09/30/2015, 24Z



# Sea Surface Temperature Anomaly (degC): 5S-5N Average

## ECCO




## Prediction: Initialized on 09/30/2015, 24Z