

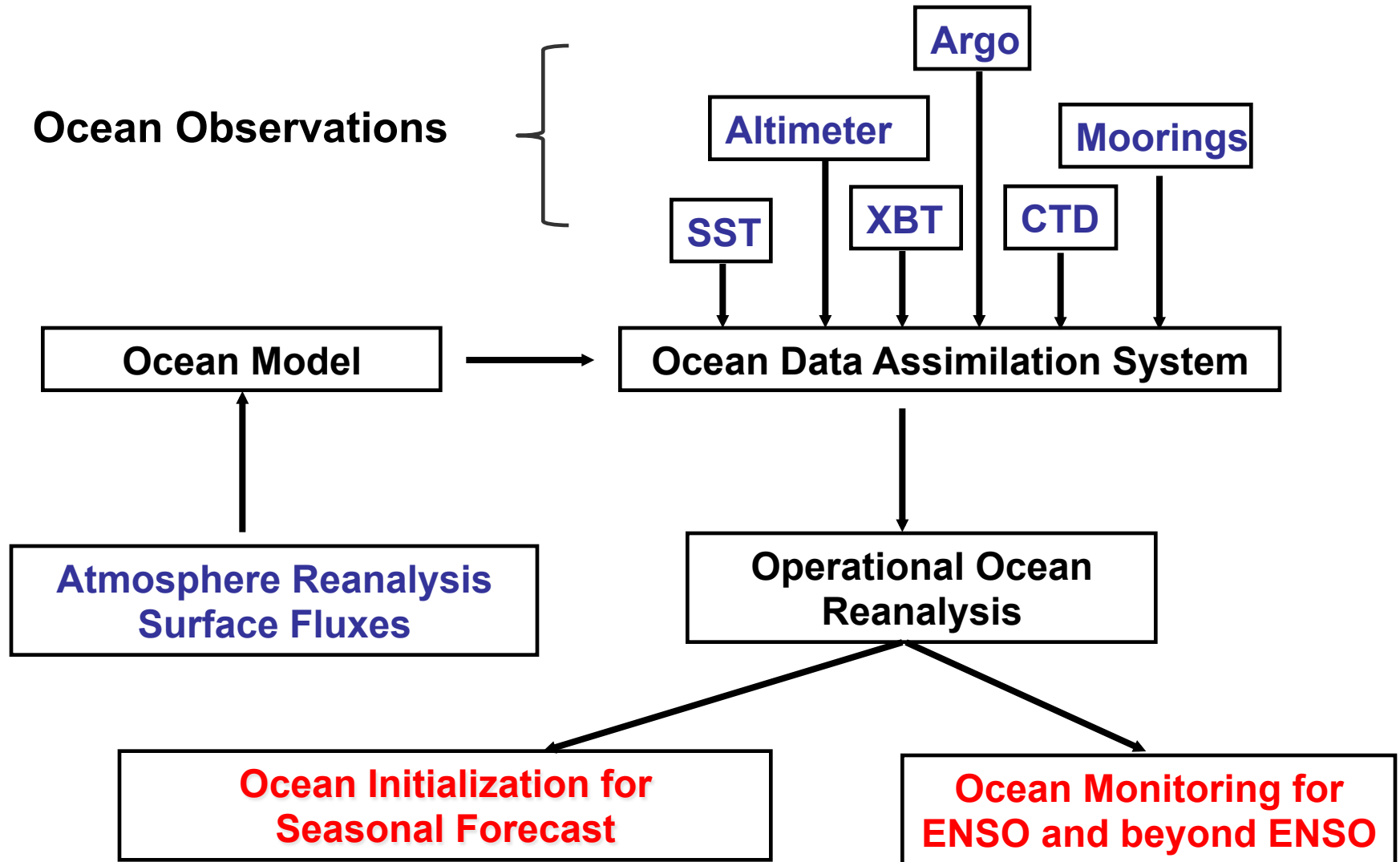
# **Ocean Initializations for Seasonal Predictions**

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# Operational Ocean Reanalysis



## Status of Ocean Initializations for Seasonal Predictions

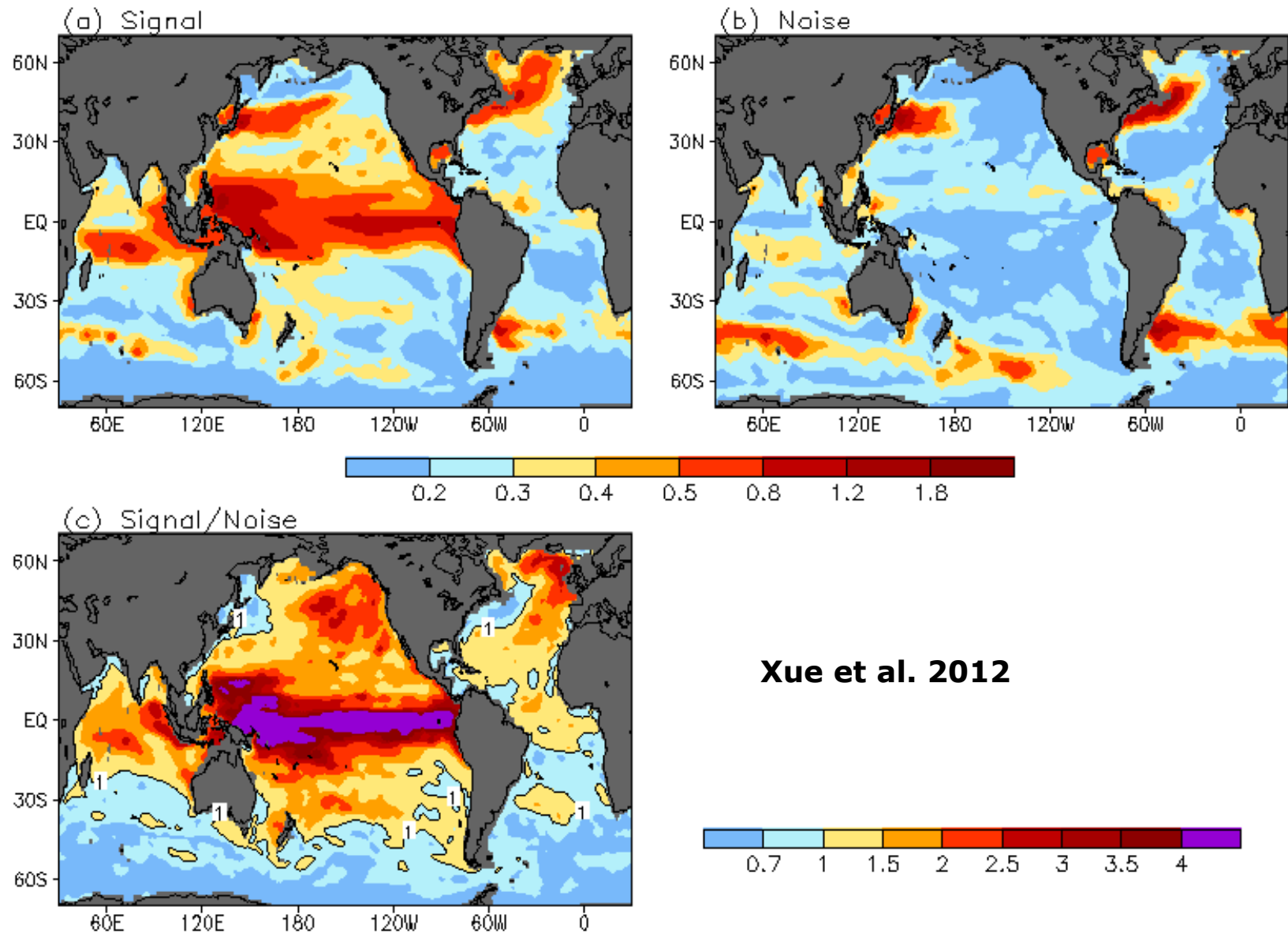
Name	Method & Forcings	In Situ Data	Altimetry Data	Resolution	Period	Vintage	Reference
<b>GODAS</b>	3D-VAR	No XBT corrections	NO (Yes in real time)	1°x 1° (1/3° near Eq), 40 Levels Pentad, Monthly	1979-present	2003	Behringer and Xue (2004)
<b>ECMWF (S3)</b>	OI	No XBT corrections	Yes	1°x1° (1/3° near Eq), 29 Levels Daily, Monthly	1959-present	2007	Balmaseda et al. (2008)
<b>JMA</b>	3D-VAR	No XBT corrections	Yes	1°x1° (1/3° near Eq), 50 Levels Pentad, Monthly	1979-present	2009	Usui et al. (2006)
<b>CFSR</b>	3D-VAR Partially coupled	No XBT corrections	No (Yes in real time)	1/2°x 1/2° (1/4° near Eq), 40 Levels Daily, Pentad, Monthly	1979-present	2010	Xue et al. (2011)
<b>GFDL</b>	EnKF Fully coupled	XBT corrections	Yes	1°x 1° (1/3° near Eq), 50 Levels Daily, Pentad, Monthly	1970-present	2010	Zhang et al. (2009)
<b>GMAO</b>	EnOI Partially coupled	XBT corrections	No	1/2°x 1/2° (1/4° near Eq), 40 Levels Daily, Monthly	1980-present	2011	Rienecker et al. (2011)
<b>MERCATOR (PSY2G2)</b>	KF-SEEK	No XBT corrections	Yes	2°x 2° (1/2° near Eq), 31 Levels Daily, Pentad, Monthly	1979-present	2007	Drévillon et al. (2008)
<b>BOM (PEODAS)</b>	EnKF	No XBT corrections	No	2°x 1.5° (1/2° near Eq.), 25 Levels Daily, Monthly	1980-present	2009	Yin et al. (2010)

Xue et al. 2012

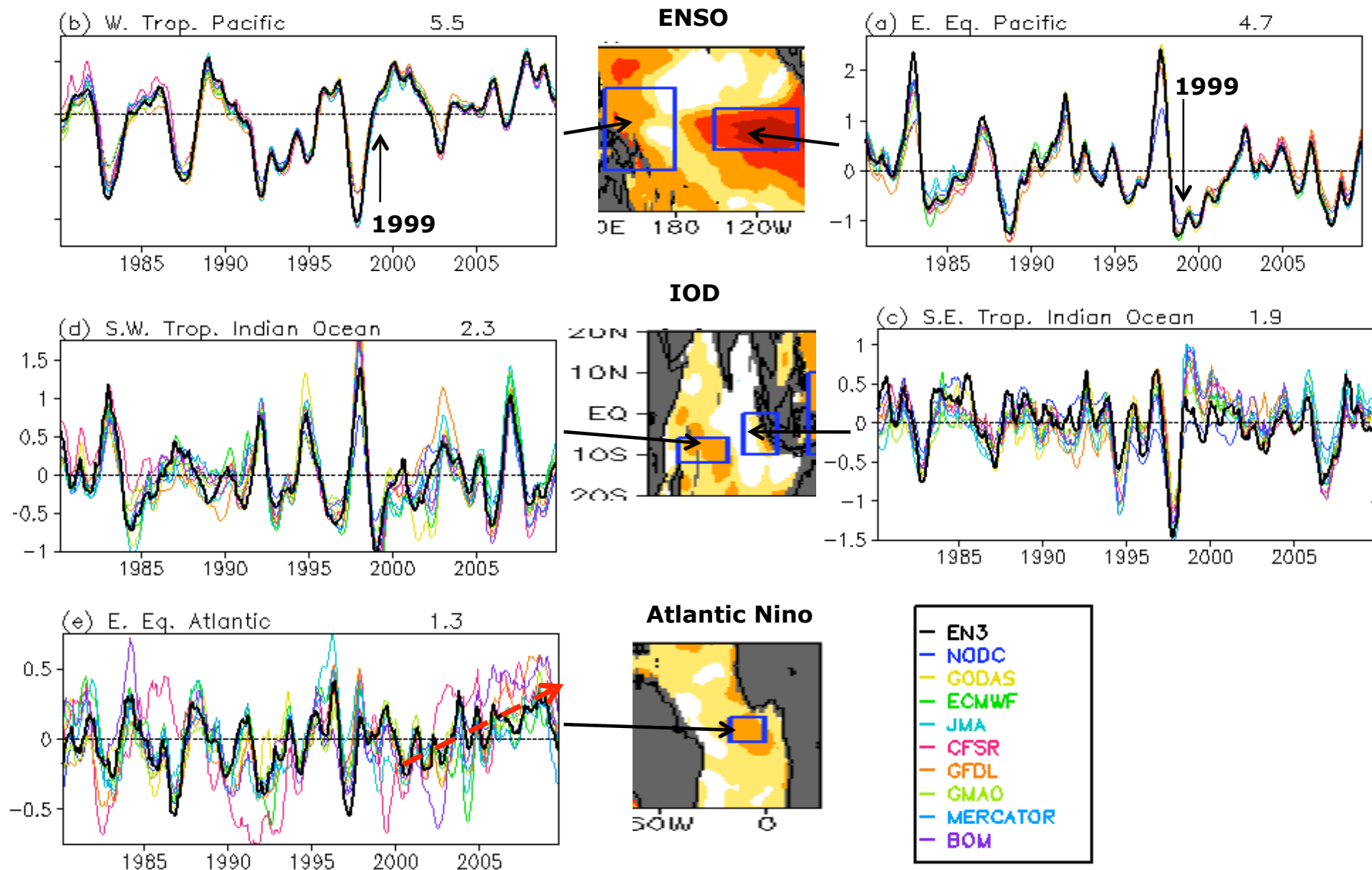
# Methodologies for Ocean Initializations

- **OI or 3-D VAR ocean-alone data assimilations**
  - NCEP GODAS, ECMWF
- **Ensemble Kalman filter ocean-alone data assimilation**
  - MERCATOR, BOM
- **Partially coupled ocean and atmosphere data assimilation**
  - NCEP CFSR, GMAO
- **Fully coupled ocean and atmosphere data assimilation**
  - GFDL
- **Assimilation of SST only using a coupled model**
  - Japan Frontier Coupled Model

# Signal to Noise Ratio of 300m Heat Content

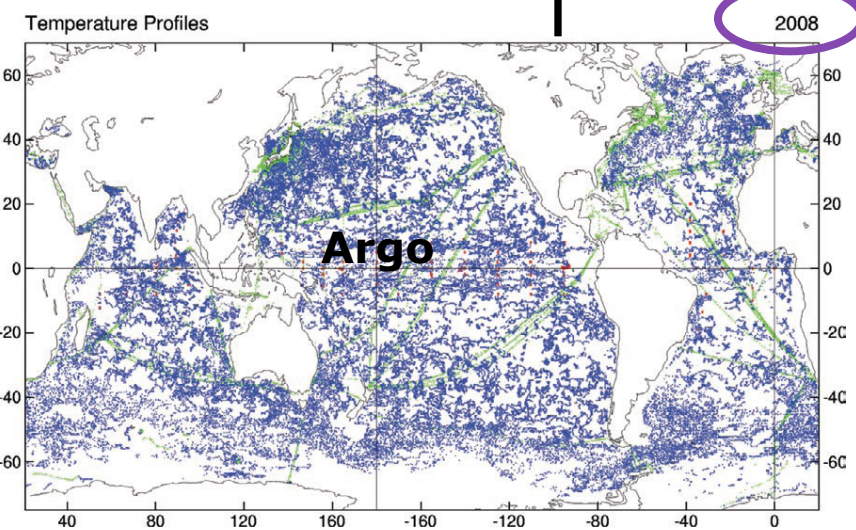
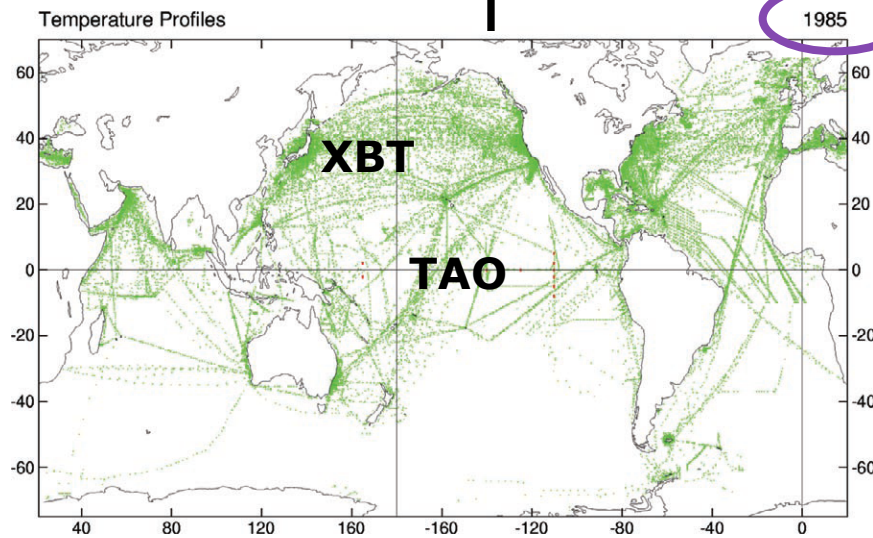
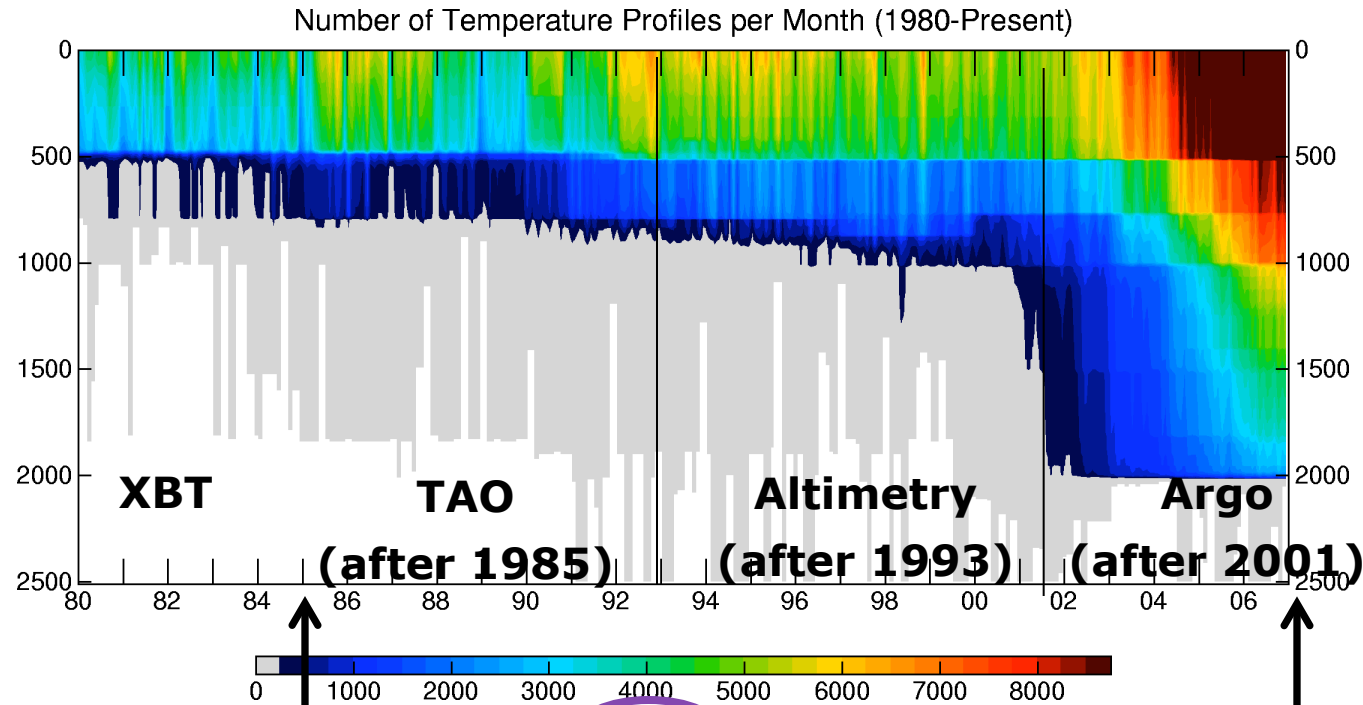


# 300m Heat Content Indices for ENSO, IOD and Atlantic Nino



# Ocean Observations

from Saha et al. (2010)



## **Impacts of Ocean Initialization on ENSO Forecast Skill**

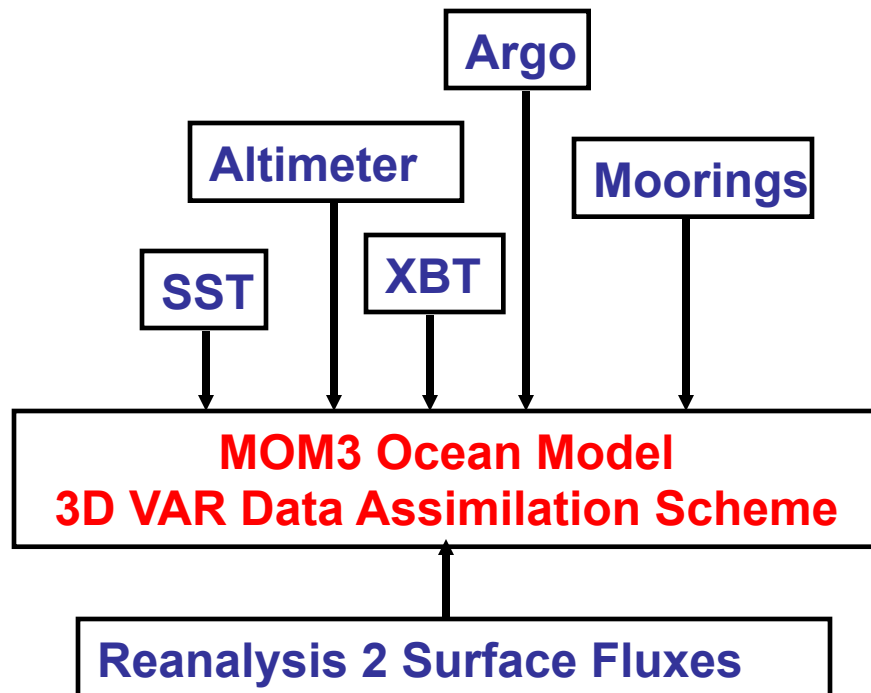
- **Assimilation of upper ocean temperature improves long-lead ENSO forecast skill**
  - Ji et al. 1998; Alves et al. 2003; Balmaseda et al. 2007
- **Implementation of the TAO array contributed to a significant improvement in ENSO forecast skill**
  - Stockdate et al. 2011
- **TAO and Argo data are complementary for ENSO forecast skill**
  - Balmaseda and Anderson 2009; Fuji et al. 2011
- **A discontinuity in ocean initialization led to a sudden shift in model systematic bias and a lower ENSO forecast skill**
  - Kumar et al. 2012; Xue et al. 2013



# Initialization of Seasonal Predictions at NCEP

## Ocean-alone

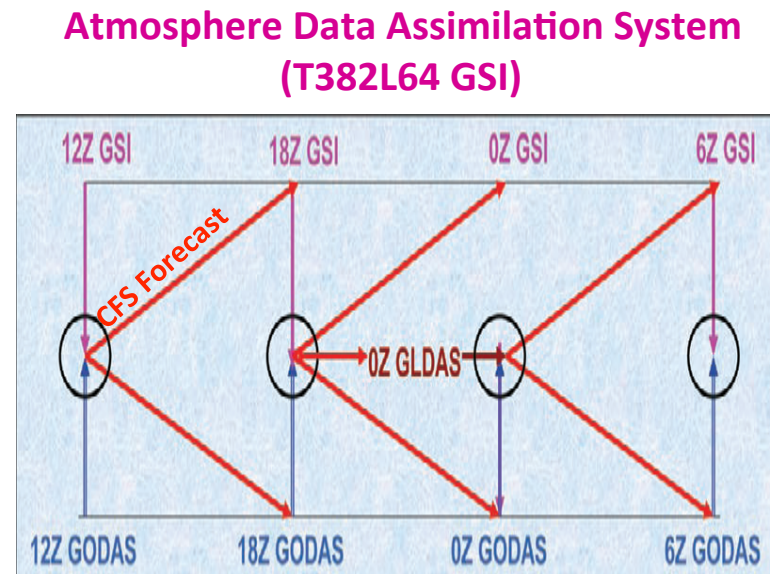
Global Ocean Data Assimilation System  
(**GODAS**, implemented in **2003**)



**Ocean Initial Conditions for CFS**

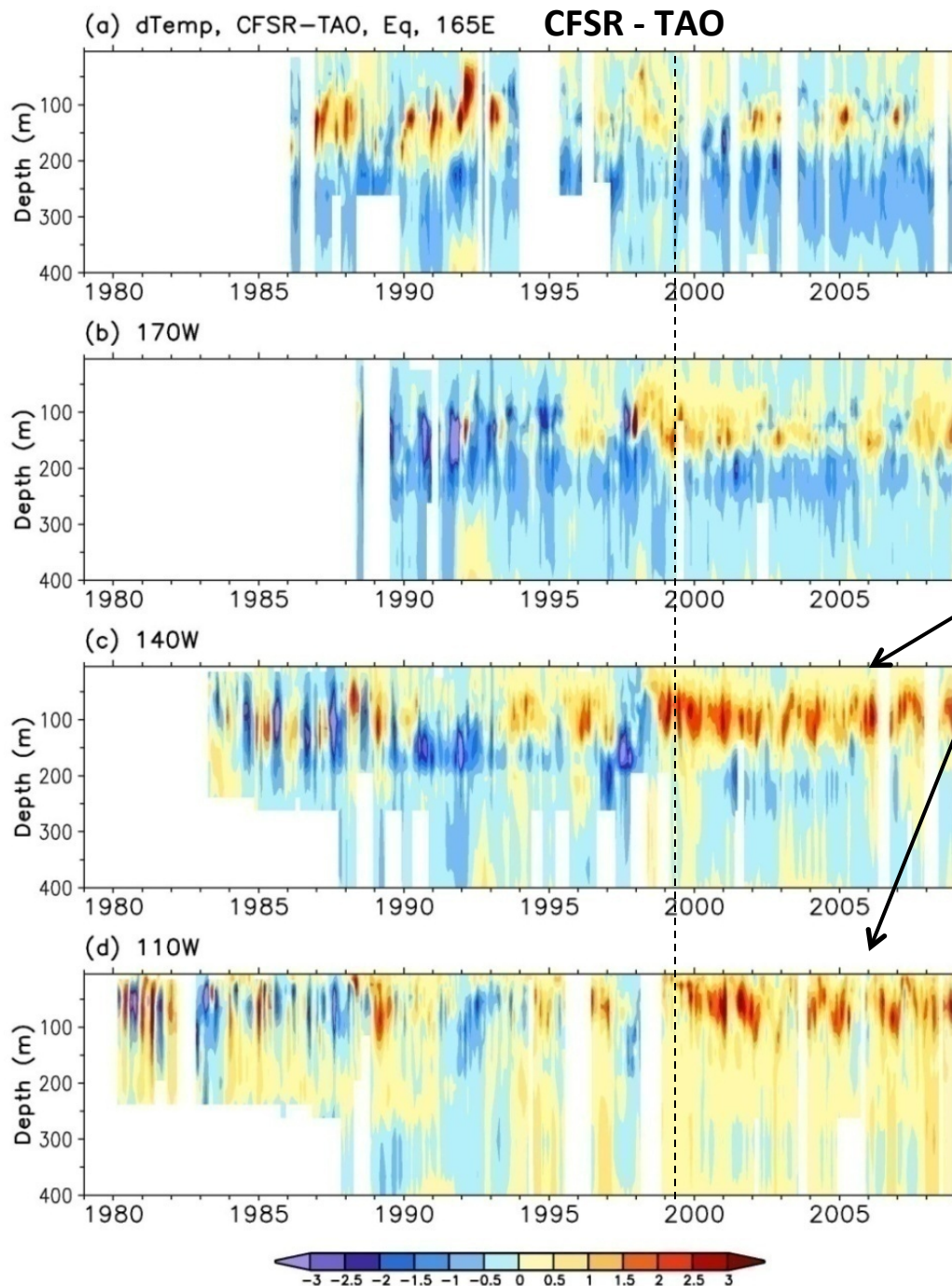
## Partially Coupled System

Climate Forecast System Reanalysis  
(**CFSR**, implemented in **2011**)



Ocean Data Assimilation System  
(**MOM4 Ocean Model and 3D VAR**)

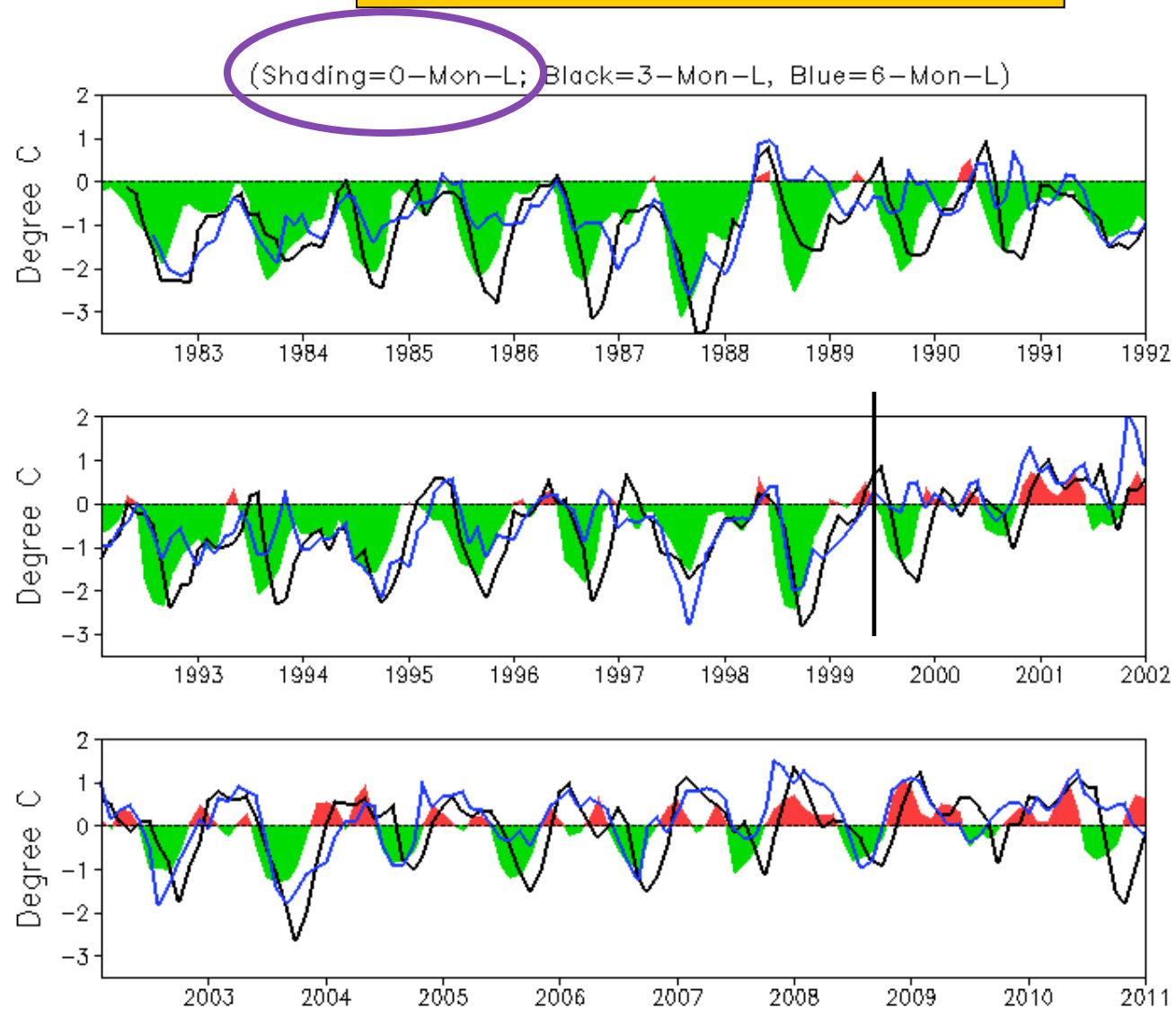
**Ocean Initial Conditions for CFSv2**



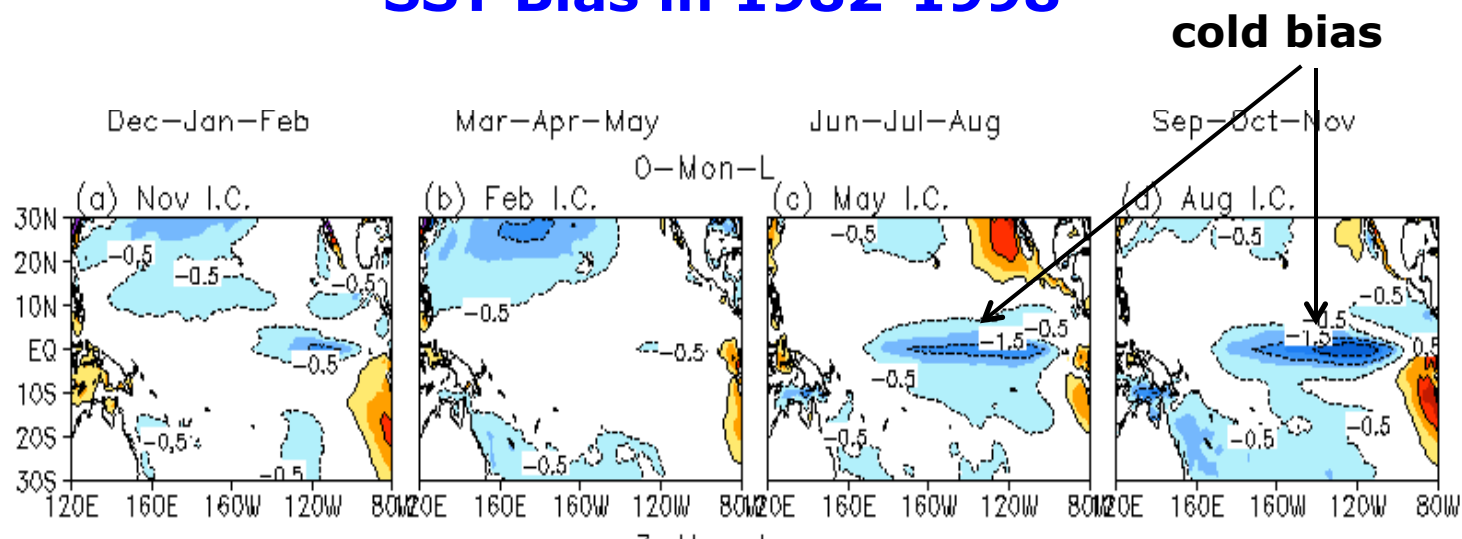
## CFSR Subsurface Temperature Bias

- Compare to TAO temperature, CFSR temperature in the Eq. E. Pacific has significant warm biases after 1999, which have significant impacts on ENSO forecast
- The warm biases after 1999 were probably caused by a sudden reduction of easterly wind biases in the central equatorial Pacific when ATOV satellite data were assimilated in 1998

## Nino 3.4 SST Bias

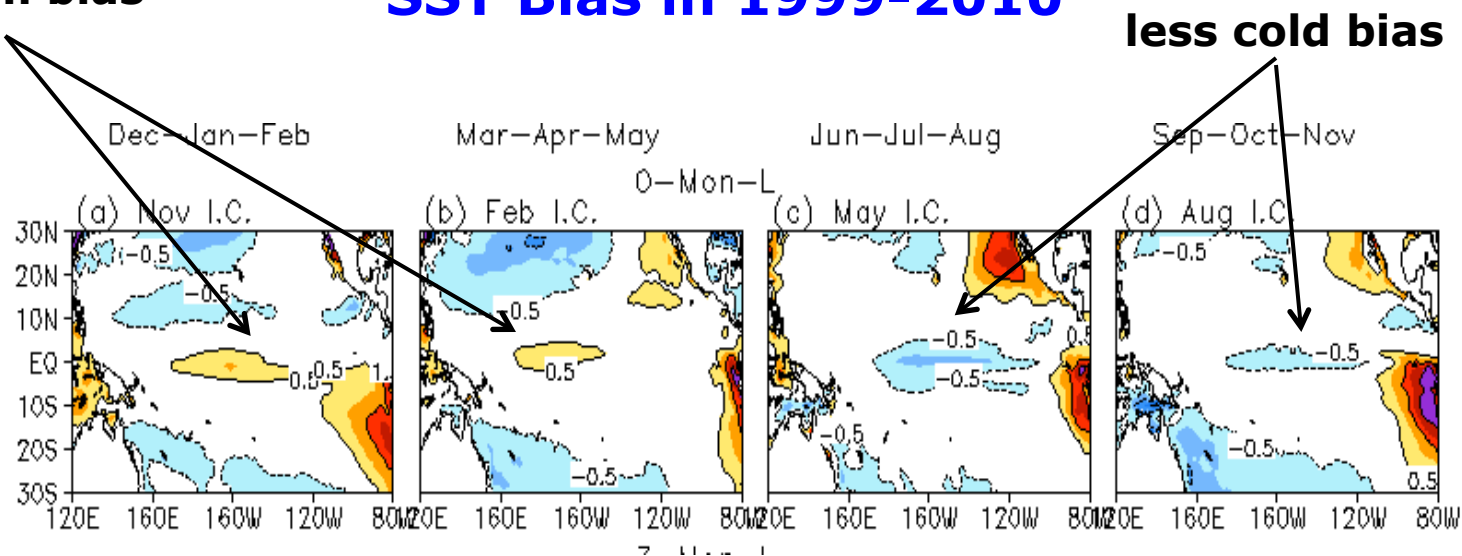


## SST Bias in 1982-1998



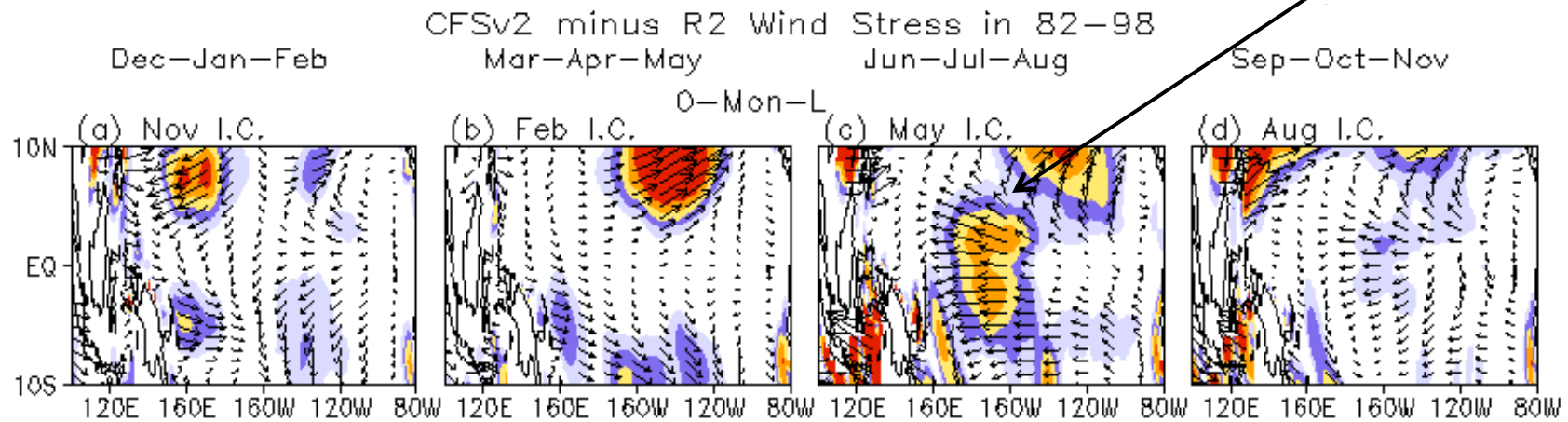
**warm bias**

## SST Bias in 1999-2010



## Wind Stress Bias in 1982-1998

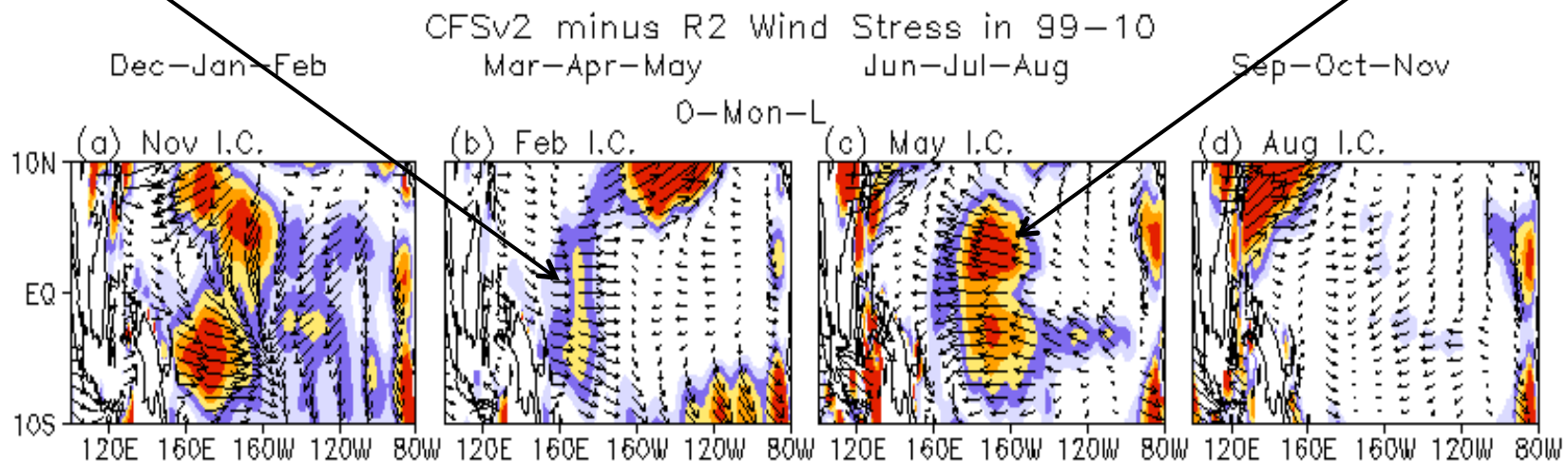
easterly bias



westerly bias

## Wind Stress Bias in 1999-2010

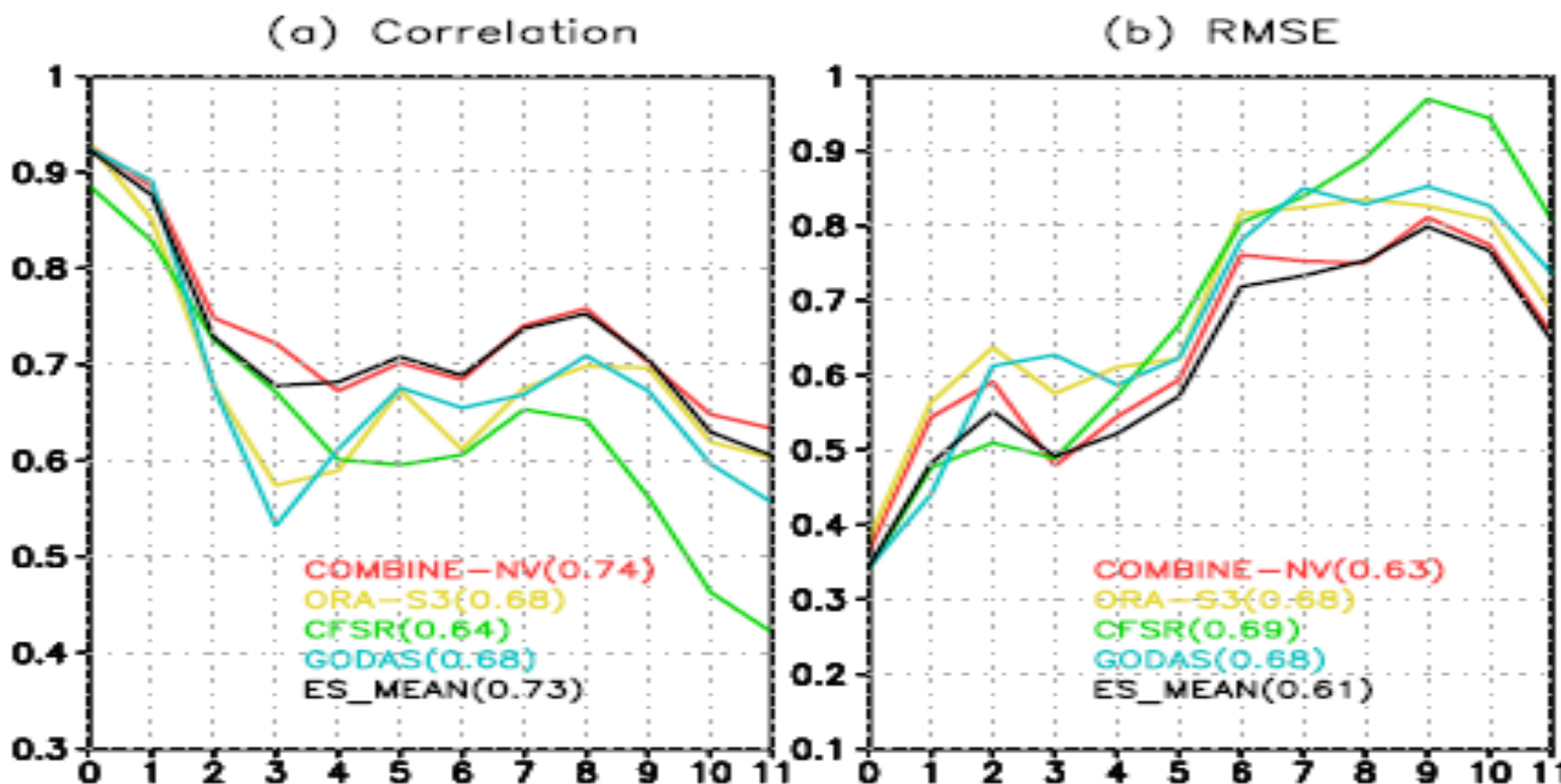
strong easterly bias





## ENSO prediction skill of CFSv2 is sensitive to ocean initializations – Zhu et al. GRL 2012

*(April ICs: 1979-2007)*



# Outstanding Questions

- **What are the sensitivities of model ENSO forecast skill to different ocean initializations?**
- **What are the sensitivities of model systematic biases to different ocean initializations?**
- **Will the coupled ocean and atmosphere data assimilations improve ENSO forecast skill?**
- **How does the ENSO forecast skill change with time due to decadal changes of ENSO characteristics?**
- **What are the influences of changing ocean observation systems on the ENSO forecast skill?**

# Outstanding Questions

- **What are the influences of changing ocean observation systems on the ENSO forecast skill?**
  - **What are the relative roles of different ocean observing systems in the ENSO forecast skill?**
  - **How did the recent failure of some TAO moorings impact the real time ENSO forecast in the past year?**
  - **Can the current ocean data assimilation systems adequately assimilate all ocean observations?**
  - **Are the current seasonal forecast models good enough to assess the value of enhanced ocean observing systems for ENSO forecast?**



**Thanks!**

**Comments and Suggestions?**