



Real-time Ocean Reanalyses Intercomparison for Quantifying Uncertainties in Ocean Reanalyses and Monitoring Climate Variability

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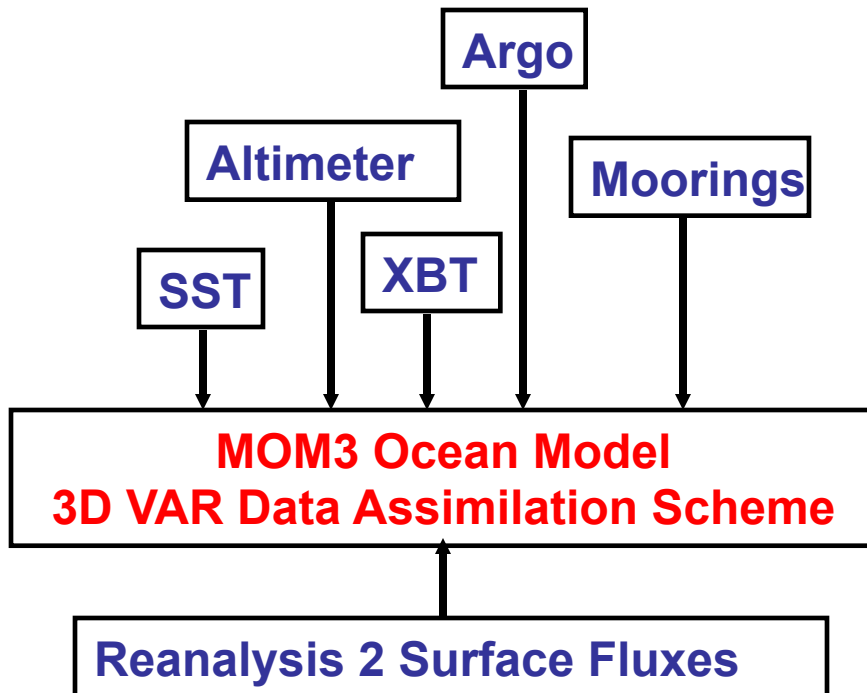
Climate Prediction Center, NCEP/NOAA

Applications of seasonal to decadal climate predictions for marine resource management workshop,
Princeton University, NJ, June 3-5, 2015

NCEP Operational Ocean Reanalyses

Ocean-alone

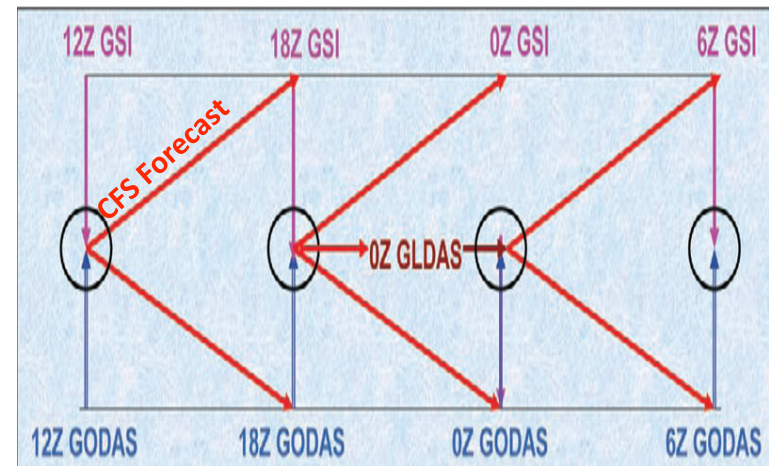
Global Ocean Data Assimilation System
(**GODAS**, implemented in **2003**)



Partially Coupled System

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

Atmosphere Data Assimilation System
(**T382L64 GSI**)



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

Ocean Initial Conditions for CFSv2

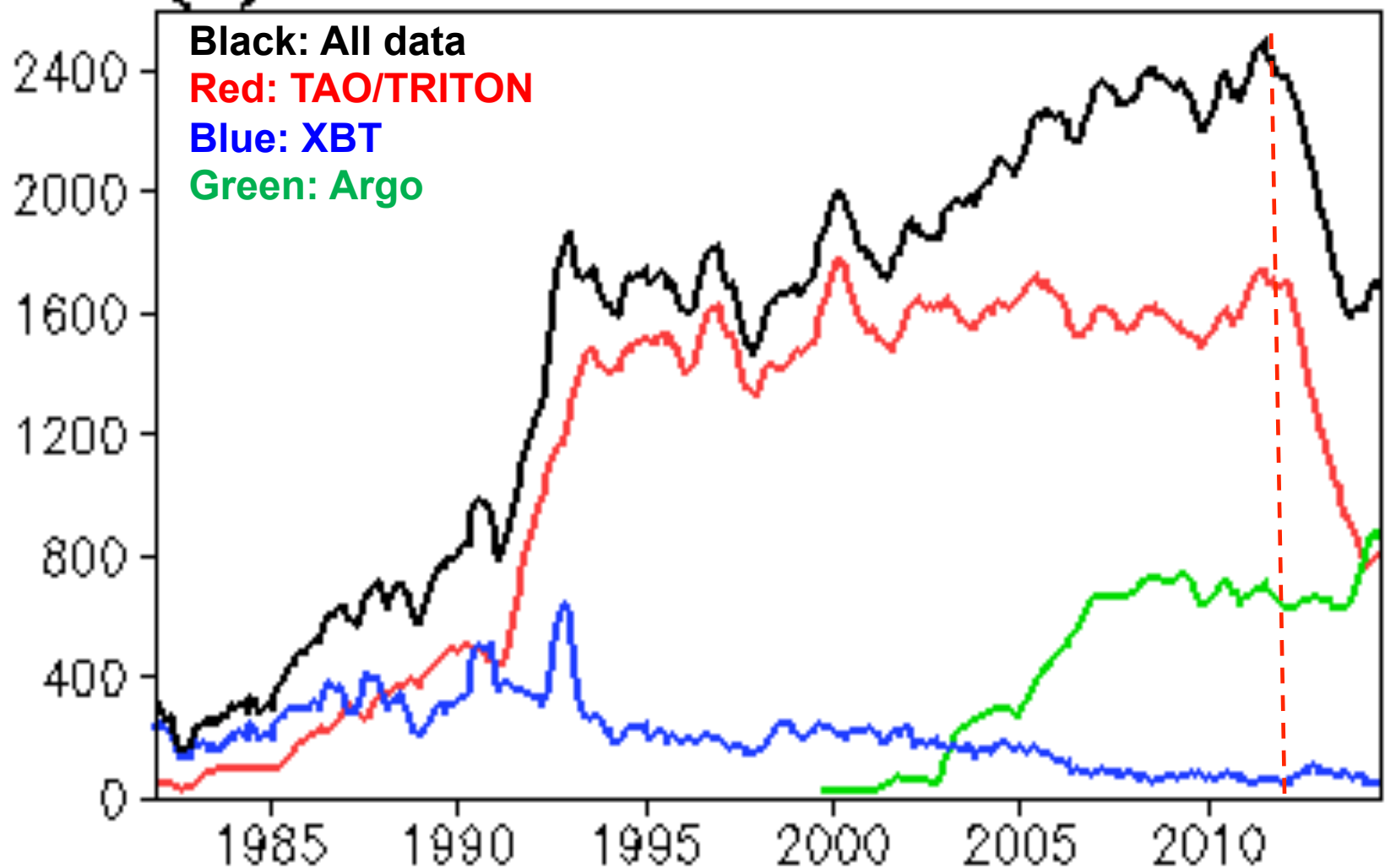
Ocean Reanalyses Intercomparison (ORA-IP)

Coordinated by CLIVAR-GSOP/GODAE OceanView

- **Ocean reanalysis production is an on-going activity**
- **New vintages are produced approximately every 5 years**
 - **Improved quality controlled observations (XBT corrections, Argo corrections and black lists)**
 - **Improved forcing fluxes**
 - **Improved models and methods**
- **We need to **assess uncertainties** among ocean reanalyses (through intercomparison and validation with independent data)**
- **We need to **facilitate the use of ocean reanalyses** by other communities**
- **We need to prepare for **quasi-real time monitoring of the ocean****

Tropical Pacific Observing Systems

Number of daily temperature profiles in 8S-8N



Real-Time Ocean Reanalyses Intercomparison Project

- **Extend Ocean Reanalyses Intercomparison Project (ORA-IP) into **real time****
- **Assess uncertainties** in temperature analysis of tropical Pacific in support of **ENSO monitoring and prediction**
- **Explore any connections between gaps in ocean observations and spreads among ensemble ORAs**
- **Articulate needs for sustained ocean observing systems in support of design of Tropical Pacific Observing Systems in 2020**
- **Monitor signal-to-noise ratio** in the global ocean temperature, 300m heat content, depth of 20C isotherm

Real-Time Ocean Reanalyses

Name	Method & Forcings	In Situ Data	Altimetry Data	Resolution	Period	Vintage	Reference
NCEP (GODAS)	3D-VAR	T, SST	NO (Yes since 2007)	1°x 1° (1/3° near Eq)	1979-present	2003	Behringer and Xue (2004)
ECMWF (S4)	OI	T, S, SST	Yes	1°x1° (1/3° near Eq)	1959-present	2011	Balmaseda et al. (2012)
JMA	3D-VAR	T, S, SST	Yes	1°x1° (1/3° near Eq)	1979-present	2009	Usui et al. (2006)
GFDL (ECDA)	EnKF coupled	T, S, SST	Yes	1°x 1° (1/3° near Eq)	1970-present	2010	Zhang et al. (2009)
NASA	EnOI Partially coupled	T, S, SST	Yes	1/2°x 1/2° (1/4° near Eq)	1980-present	2011	Rienecker et al. (2011)
BOM (PEODAS)	EnKF	T, S, SST	No	2°x 1.5 ° (1/2° near Eq.)	1980-present	2009	Yin et al. (2010)
UK Met (GLOSEA5)	3DVAR	T, S, SST	Yes	1/4°x 1/4°	1993-present	??	Waters et al. (2014)
MERCATOR (GLORYS2)	KF-SEEK	T, S, SST	Yes	1/4°x 1/4°	1993-present	??	??

Real Time Multiple Ocean Reanalysis Intercomparison

(with contributions from [NCEP](#), [ECMWF](#), [JMA](#), [GFDL](#), [NASA](#), [BOM](#) based on 1981-2010 Climatology)

([Background Information](#))

Tropical Pacific Ocean

• Climate Indices

- Depth of 20C isotherm anomaly in NINO3: [last 4 years](#) [last 15 years](#) [1979-present](#)
- Depth of 20C isotherm anomaly in NINO4: [last 4 years](#) [last 15 years](#) [1979-present](#)
- Upper 300m heat content anomaly in NINO3: [last 4 years](#) [last 15 years](#) [1979-present](#)
- Upper 300m heat content anomaly in NINO4: [last 4 years](#) [last 15 years](#) [1979-present](#)
- Warm Water Volume: [last 4 years](#) [last 15 years](#) [1979-present](#)
- Warm Water Volume average in last two months ending in:
[Jan](#) [Feb](#) [Mar](#) [Apr](#) [May](#) [Jun](#) [Jul](#) [Aug](#) [Sep](#) [Oct](#) [Nov](#) [Dec](#)

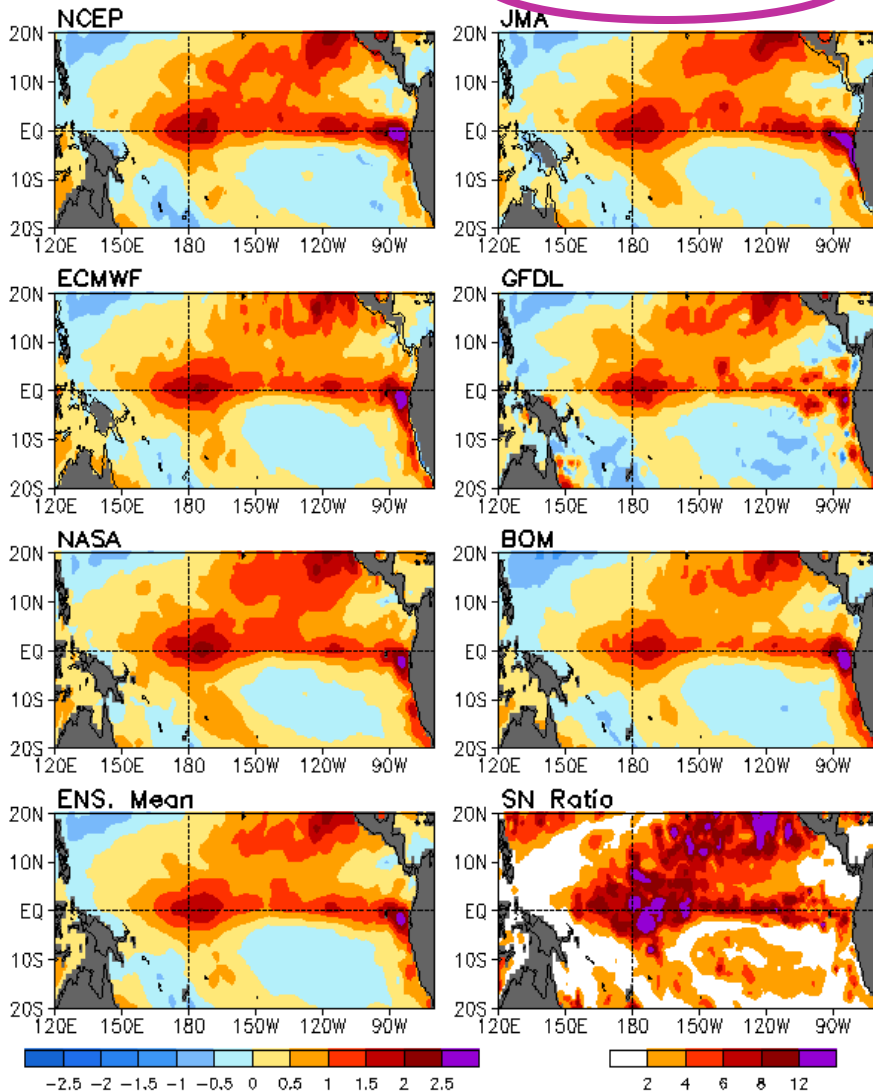
• Spatial Maps

- Temperature anom. at z=5m (X-Y section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. at z=15m (X-Y section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. at z=35m (X-Y section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. at z=55m (X-Y section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. at z=75m (X-Y section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. at z=100m (X-Y section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. at z=150m (X-Y section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. in 1S-1N (X-Z section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. in 5N-10N (X-Z section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. in 10S-5S (X-Z section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. in 120W-90W (Y-Z section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. in 150W-120W (Y-Z section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. in 160E-150W (Y-Z section): [last month](#) [month before last month](#) [1979-present](#)
- Temperature anom. in 130E-160E (Y-Z section): [last month](#) [month before last month](#) [1979-present](#)
- Depth of 20C isotherm anomaly: [last month](#) [month before last month](#) [1979-present](#)
- Upper 300m heat content anomaly: [last month](#) [month before last month](#) [1979-present](#)

Monitoring the Tropical Pacific ENSO Variability

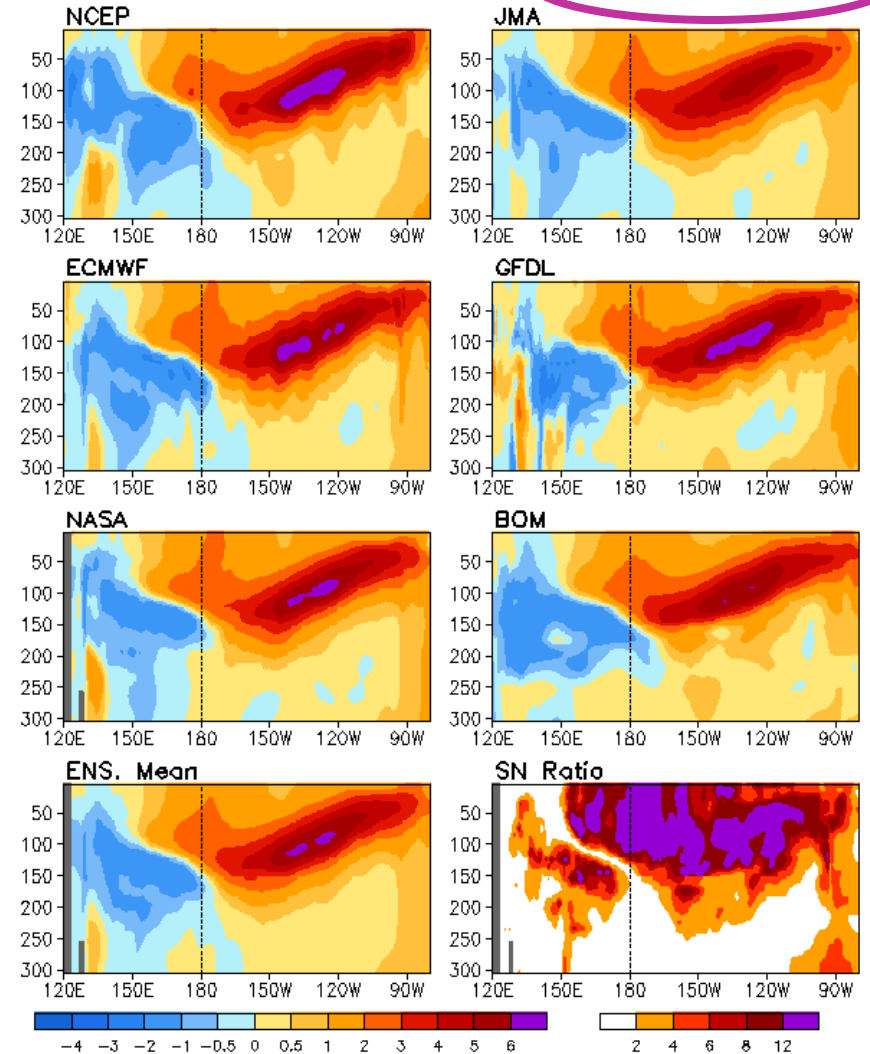
SST

Anomalous Temperature (C) at z=5m: APR 2015



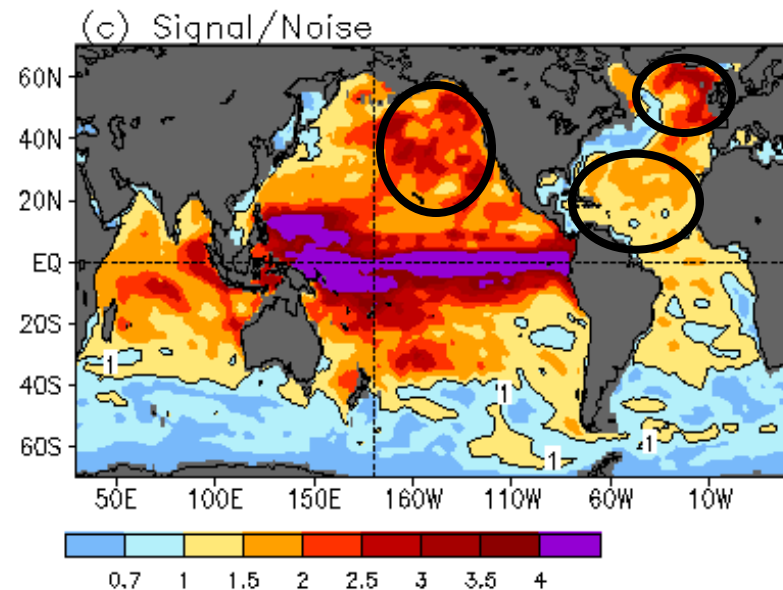
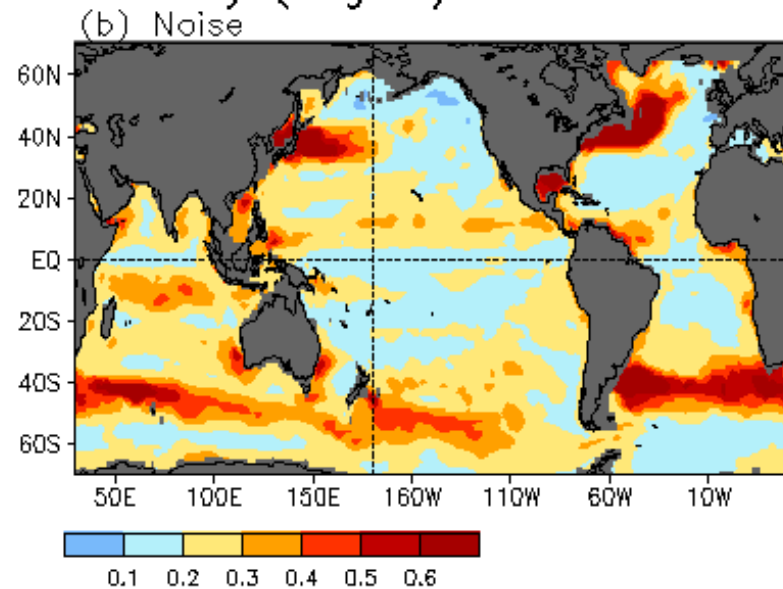
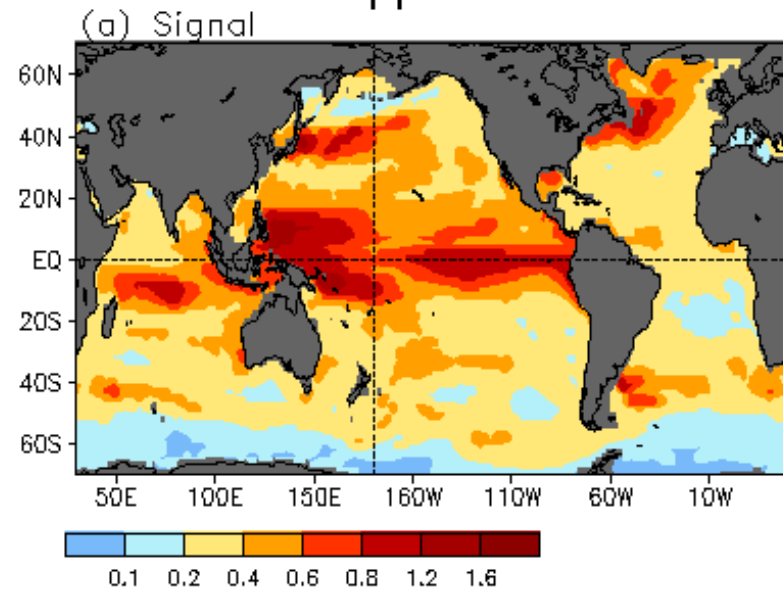
Eq. Subsurface Temp.

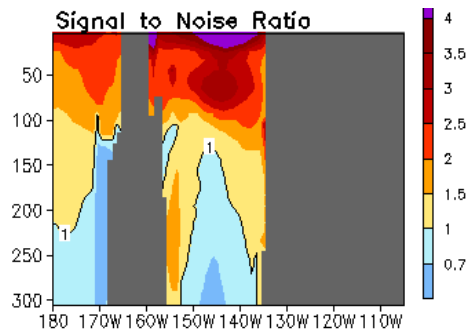
Anomalous Temperature (C) Averaged in 1S-1N: APR 2015



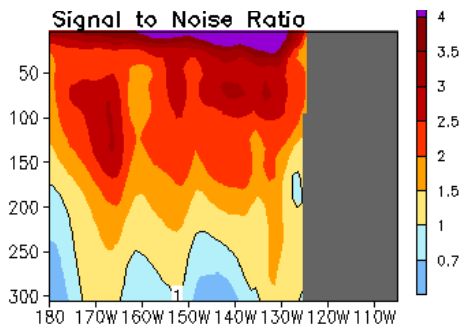
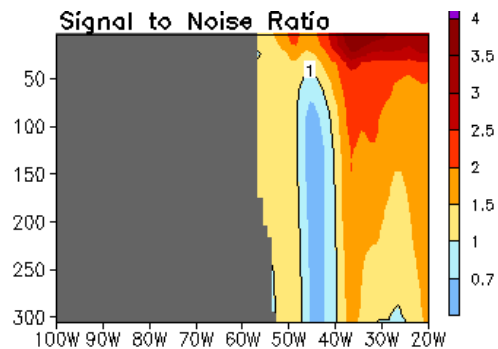
Signal, Noise and Signal-to-Noise Ratio (1985-2013)

Upper 300 Heat Content Anomaly (degree)

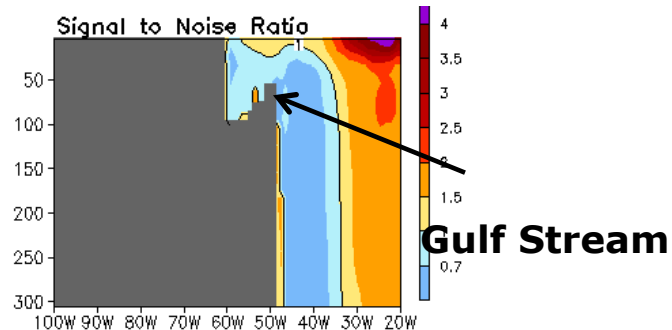




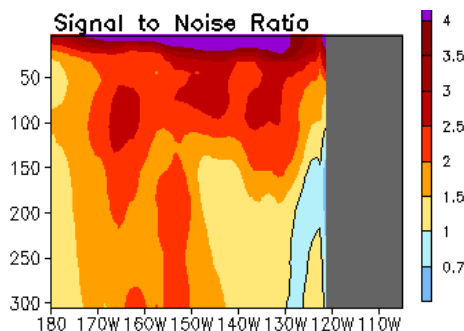
55N



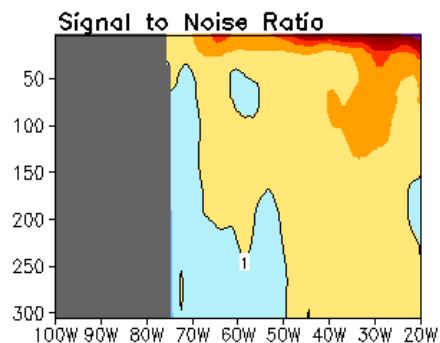
45N



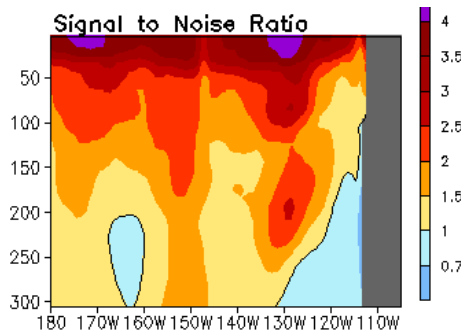
West Coast



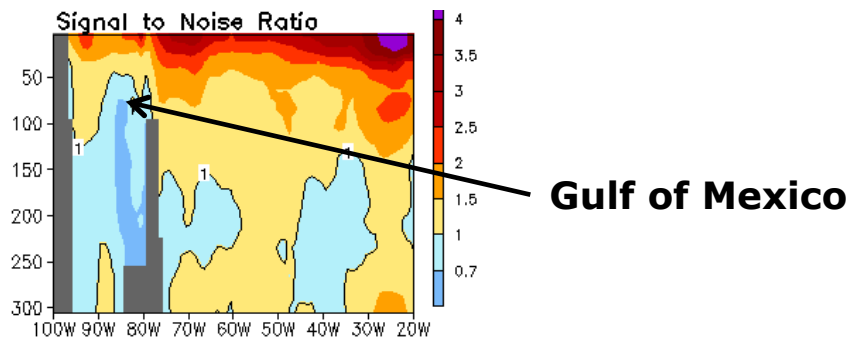
35N



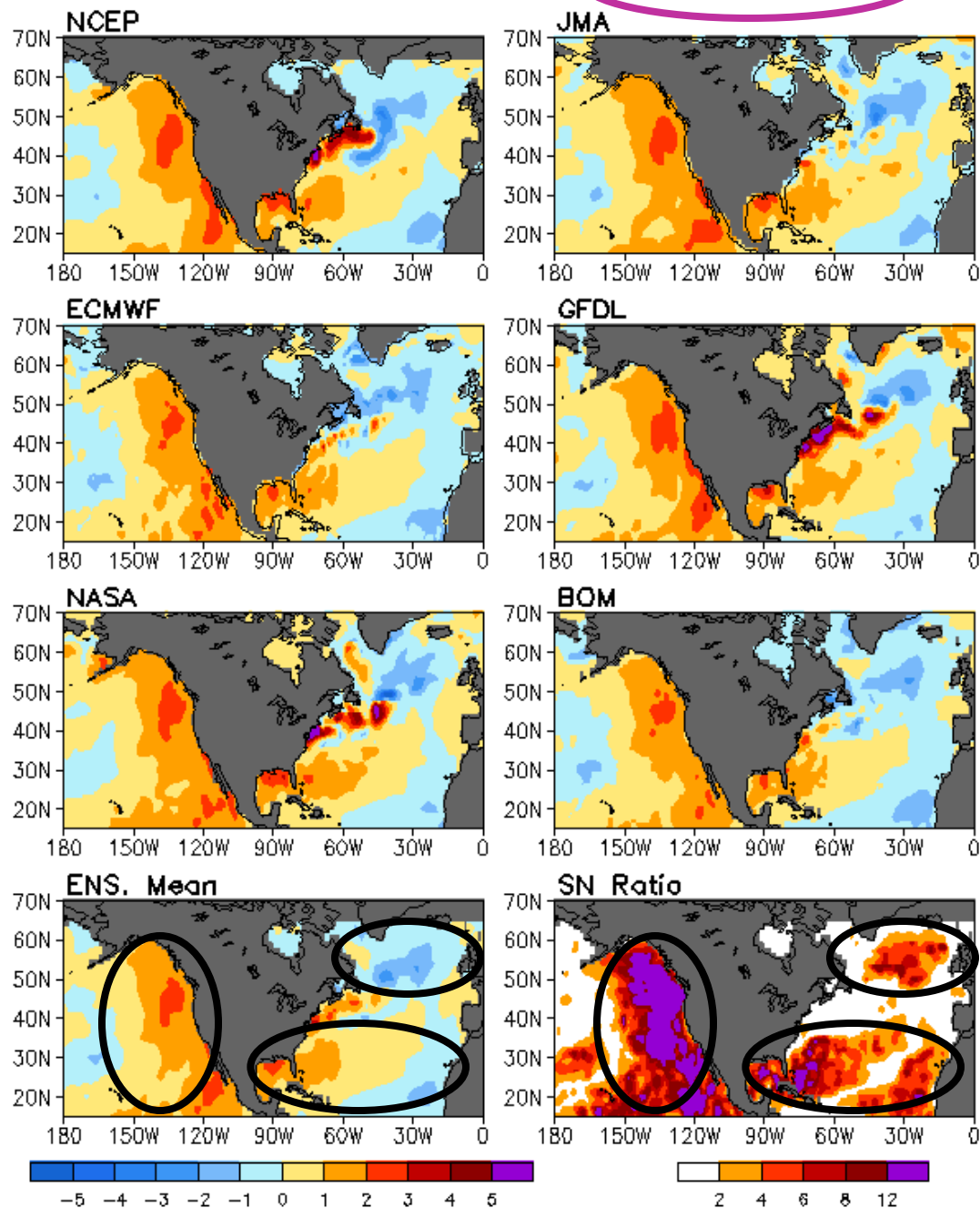
East Coast



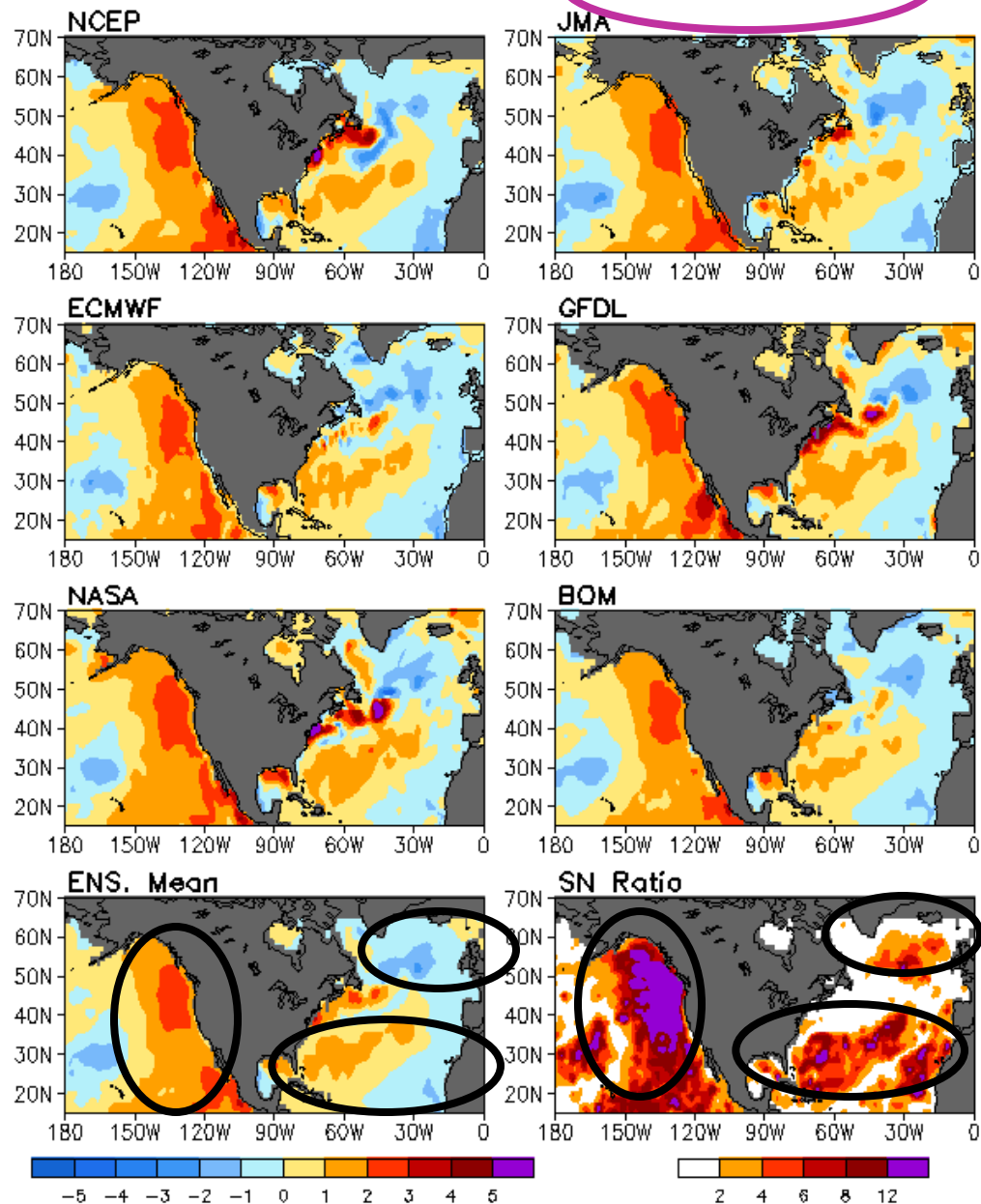
25N



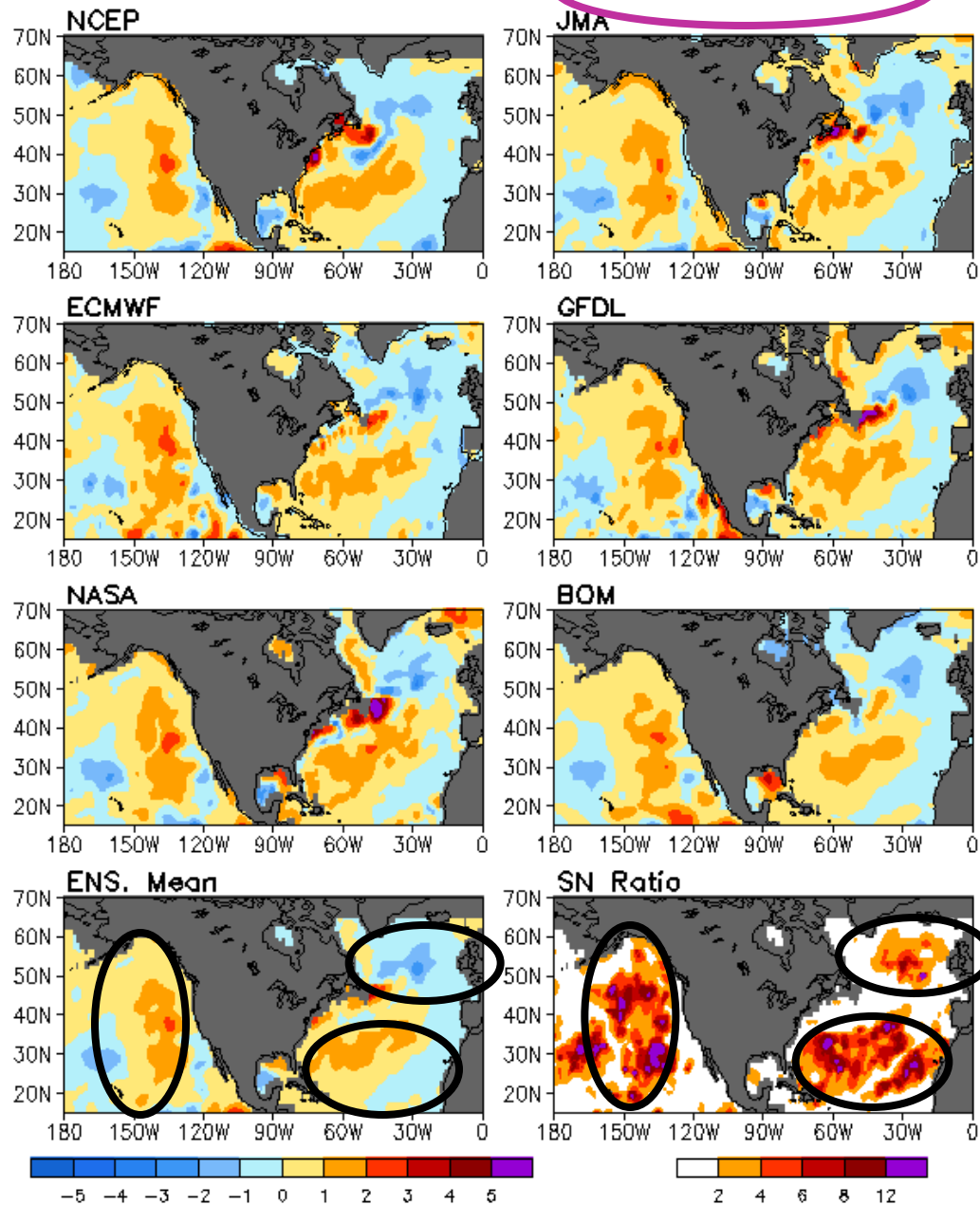
Anomalous Temperature (C) at z=5m: APR 2015



Anomalous Temperature (C) at z=55m: APR 2015



Anomalous Temperature (C) at $z=105\text{m}$: APR 2015



Summary

- An ensemble of six operational ORAs has been used to assess **signal** (ensemble mean) and **noise** (ensemble spread) in upper ocean temperature analysis in near **real-time**.
- Although there are uncertainties in ocean reanalysis products, the ensemble mean of multiple ocean reanalyses likely provides the best estimation of the state of ocean and can be used to **derive climate indicators**. The ensemble spread provides uncertainties in our estimation.
- The ensemble mean of temperature analyses from multiple ORA products has been used in **monitoring and predicting ENSO**.
- The next step is to include UK Met Office and MERCATOR ocean reanalyses and to develop an ensemble of eight ORAs.
- The analysis and monitoring products will be expanded beyond the tropical Pacific.
- There might be potential utilities for nowcasting and monitoring subsurface temperature conditions for ecosystem applications in coastal regions.