Review of GODAE OceanView Symposium 2013 and Real-time Ocean Reanalyses Intercomparison to Quantify Uncertainties in Ocean Reanalyses

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US CLIVAR Summit, POS Breakout Session, July 10, 2014

GODAE OceanView Symposium 2013
4 - 6 November, Baltimore, Maryland

Advancing Operational Oceanography

"5 years of GODAE OceanView - current progress and future priorities"

GODAE OceanView (GOV, 2009-2013)

following Global Ocean Data Assimilation Experiment (GODAE, 1997-2008)

- **Development of operational ocean analysis and forecasting systems**
- **Utilization of operational ocean analysis and forecast products**
- **Demonstration of value of sustained ocean observing systems**

Challenges and Opportunities for GODAE OceanView

- To develop coupled ocean-atmosphere data assimilation system for improved weather and climate prediction
- To develop ecosystem forecast products for coastal regions
- To demonstrate benefits and optimize use of ocean observations
- To improve ocean reanalyses for monitoring climate variability and climate change

CLIVAR-GSOP/GODAE OceanView Ocean Reanalysis Intercomparison (ORA-IP, 2013-2014)

- **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 and extended 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**

Courtesy of M. Balmaseda

ORAIP Variables and processing agents

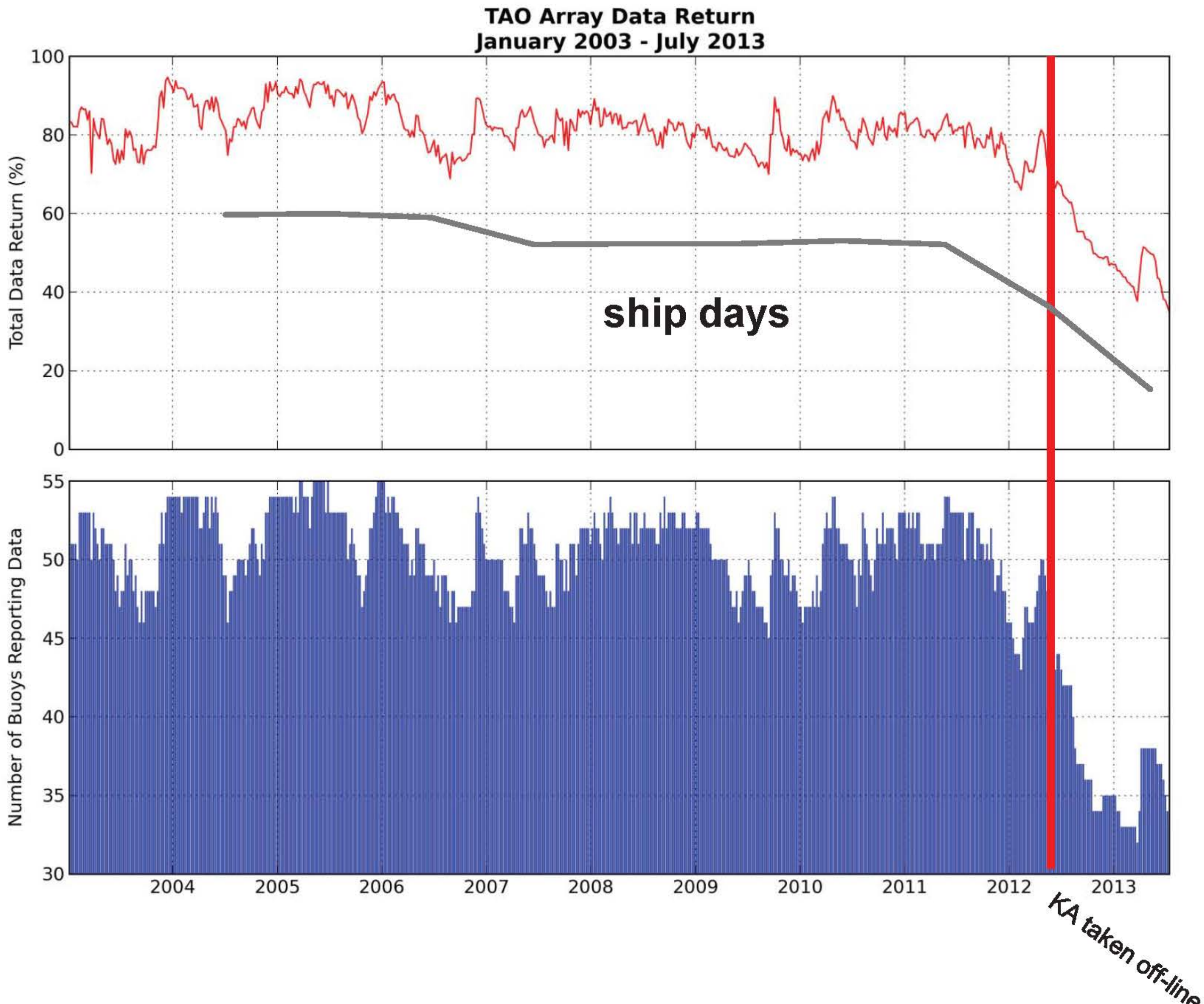
Variable	Responsible	Institution
Steric Height	Andrea Storto	CMCC
Sea Level	Fabrice Hernandez	Mercator Ocean
Ocean Heat Content	Matthew Palmer	UK MetOffice
Depth of 20 degree Isotherm	Fabrice Hernandez	Mercator Ocean
Mixed Layer Depth	Takahiro Toyoda	MRI-JMA
Salinity	Li Shi	BMRC
Surface fluxes and transports	Maria Valdivieso	University of Reading
Atlantic Meridional Overturning at 26N	Vladimir Stepanov/Keith Haines	University of Reading
Sea Ice	Gregory Smith	Environment Canada

Reanalyses Products entering ORAIP

Product	Institution	Product	Institution
CFSR	NCEP	**ECCO-v4**	NASA/JPL
GODAS	NCEP	**GECCO2**	Hamburg University
Glosea5	UK MetOffice	**MOVE-C**	MRI/JMA
ORAS4	ECMWF	**MOVE-G2**	MRI/JMA
PEODAS	BMRC	**MOVE-CORE**	MRI/JMA
GLORYS	Mercator	**K7-ODA**	JAMSTEC
C-GLORS	CMCC	**K7-CDA**	JAMSTEC
UR025.4	Reading University		
GEOS5	NASA/GMAO	**ARMOR3D**	CLS (T/S/SLA)
ECDA	GFDL	**NODC**	NOAA (T/S)
SODA	University Meryland	**EN3**	MetOffice (T/S)
ECCO-NRT	NASA/JPL	**LEGOS**	LEGOS (SLA)

See a summary at http://www.clivar.org/sites/default/files/Exchanges/Exchanges_64.pdf

Climate Observation Division
Historical TAO reporting + ship resourcing



Tropical Pacific Observing System (TPOS) 2020 Workshop

(January 27-30, 2014, La Jolla, CA)

- **Highlight the impacts** of the tropical Pacific observing system on information/services of societal relevance – **ENSO monitoring and prediction**
- **Evaluate existing and potential requirements** for sustained observations of ocean variables in tropical Pacific Ocean – **uncertainties in ocean estimation in tropical Pacific**
- **Evaluate the adequacy of existing observing strategies**
- **Recommend revisions and/or adjustments** to enhance resilience, efficiency, integration.
- **Evaluate logistical requirements** for implementation of the recommended Tropical Pacific Observing System.
- **Assess readiness of new technologies**, their potential impact and feasibility in addressing requirements, and/or lowering costs per observation.

Courtesy of David Legler

Operational Ocean Reanalyses

Name	Method & Forcings	In Situ Data	Altimetry Data	Resolution	Period	Vintage	Reference
EN3.v2a	Analysis Correction Scheme	No XBT corrections	No	1° x 1°, 42 Levels Monthly Temp.	1950-present	2009	Ingleby and Huddleston (2007)
NODC	Objective Analysis	No XBT corrections	No	1° x 1°, 16 Levels, 0 to 700m Seasonal Temp.	1955-present	2010	Levitus et al. (2009)
GODAS	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
ECMWF (S3)	OI	No XBT corrections	Yes	1° x1° (1/3° near Eq), 29 Levels Daily, Monthly	1959-present	2007	Balmaseda et al. (2008)
JMA	3D-VAR	No XBT corrections	Yes	1° x1° (1/3° near Eq), 50 Levels Pentad, Monthly	1979-present	2009	Usui et al. (2006)
CFSR	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. (2010)
GFDL	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)
GMAO	EnOI Fully coupled	XBT corrections	No	1/2° x 1/2° (1/4° near Eq), 40 Levels Daily, Monthly	1980-present	2011	Rienecker at al. (2011)
MERCATOR (PSY2G2)	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)
BOM (PEODAS)	EnKF	No XBT corretions	No	2° x 1.5 ° (1/2° near Eq.), 25 Levels Daily, Monthly	1980-present	2009	Yin et al. (2010)

Xue et al. 2012, J. Climate

Real-Time Ocean Renalyses Intercomparison

- **Extend CLIVAR-GSOP/GODAE OceanView 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 TPOS2020**

- **Monitor signal-to-noise ratio in the global ocean temperature, 300m heat content, depth of 20C isotherm** http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

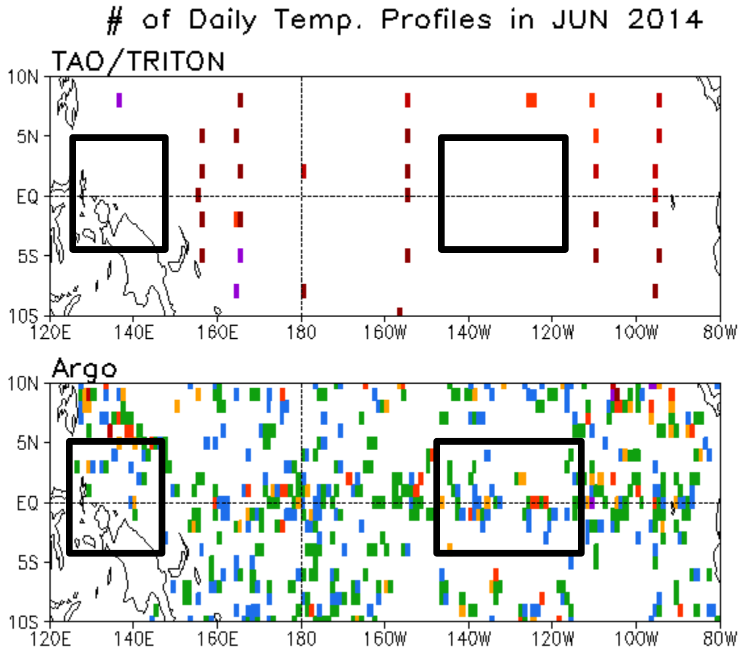
Real Time Multiple Ocean Reanalysis Intercomparison

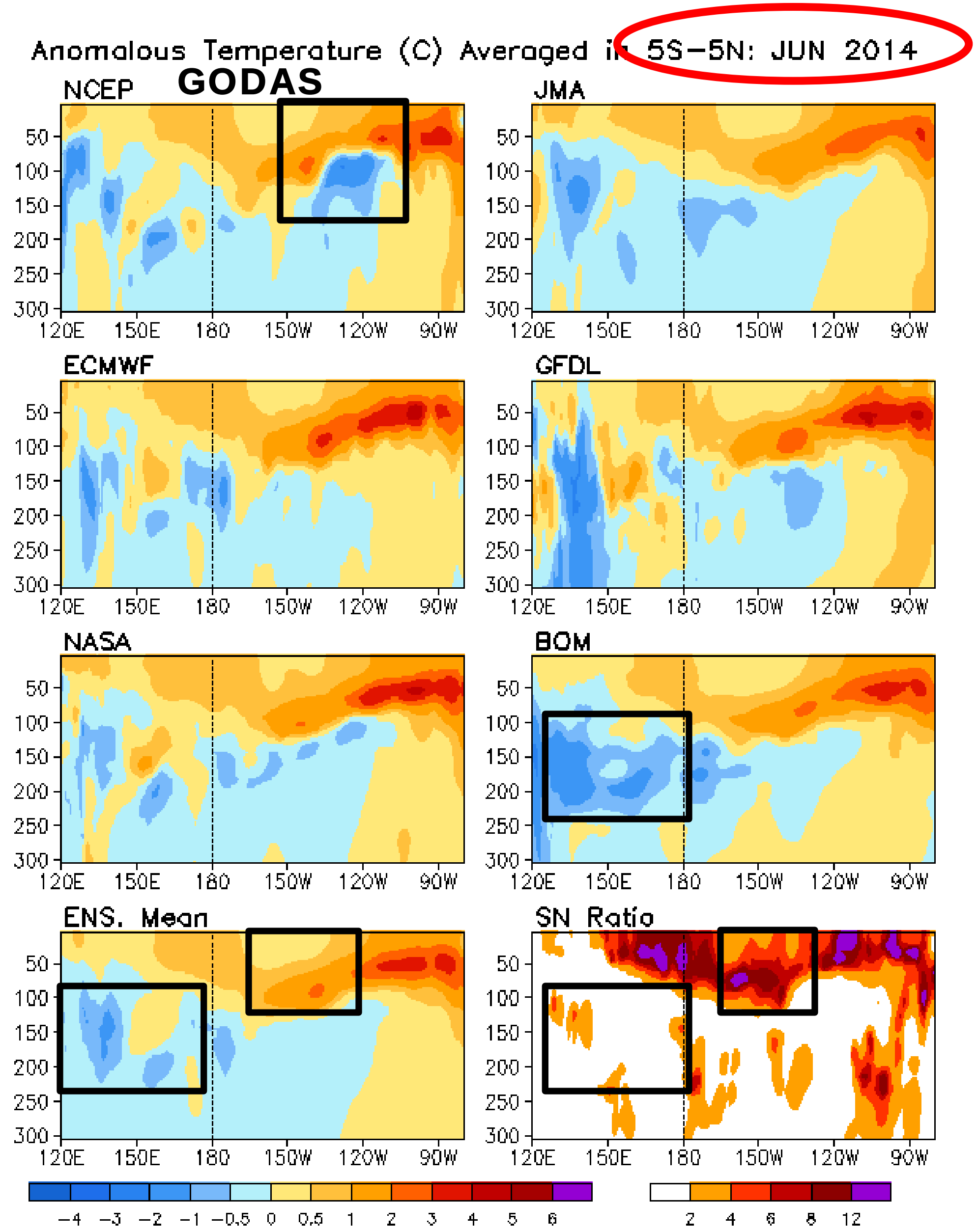
(with contributions from NCEP, ECMWF , JMA , GFDL , NASA , BOM based on 1981-2010 Climatology)

(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



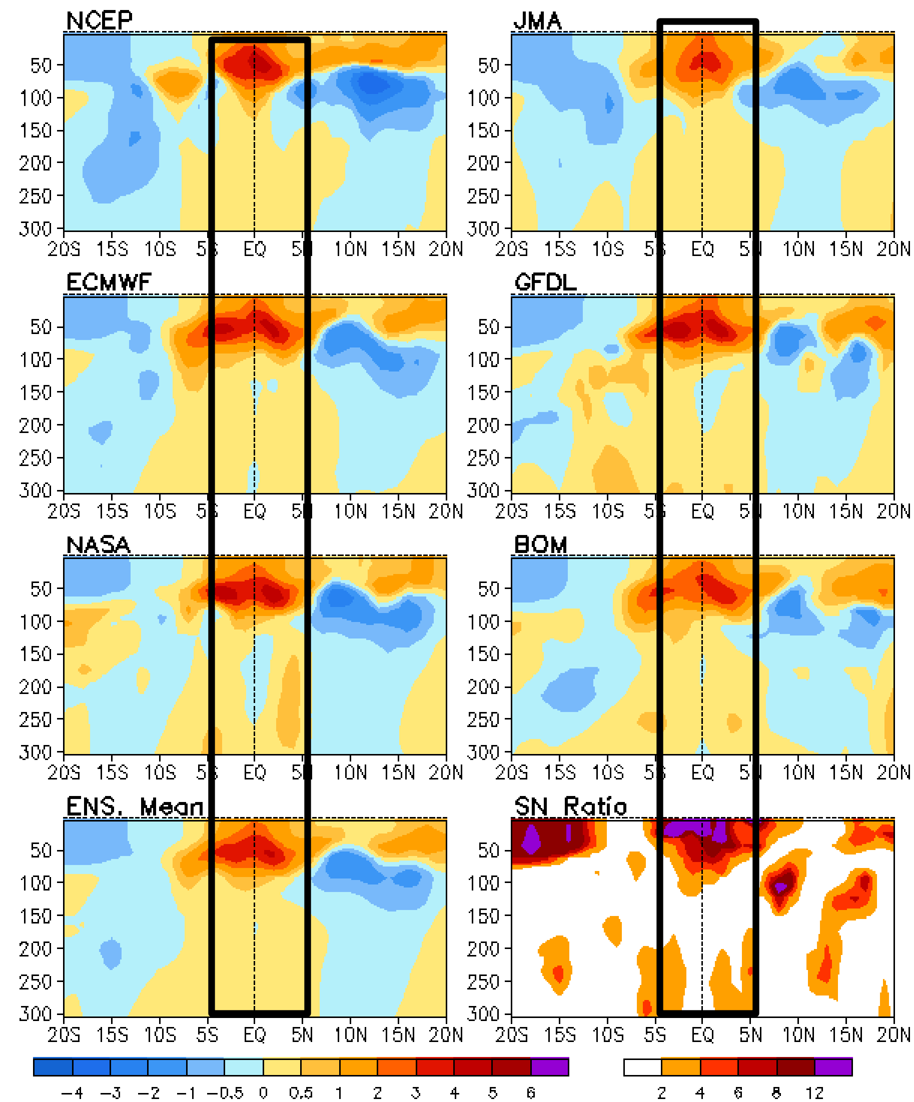


-The ensemble mean (ensemble spread) can be used to measure signal (noise).

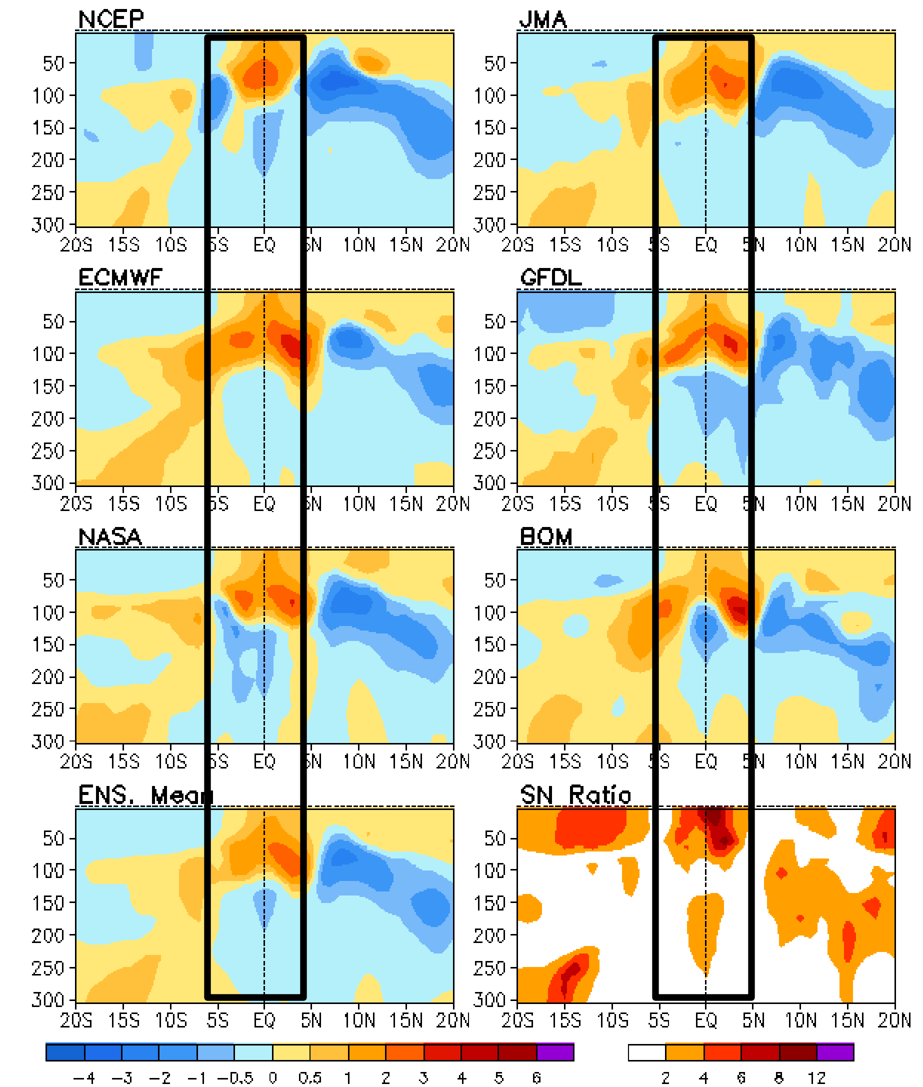
- The signal-to-noise (SN) ratio is relatively low in the western (central-eastern) Pacific where negative (positive) anomalies presented.

- The low signal-to-noise ratio may be partially attributed to the sparse observations in those regions.

Anomalous Temperature (C) Averaged in 120W−90W: JUN 2014

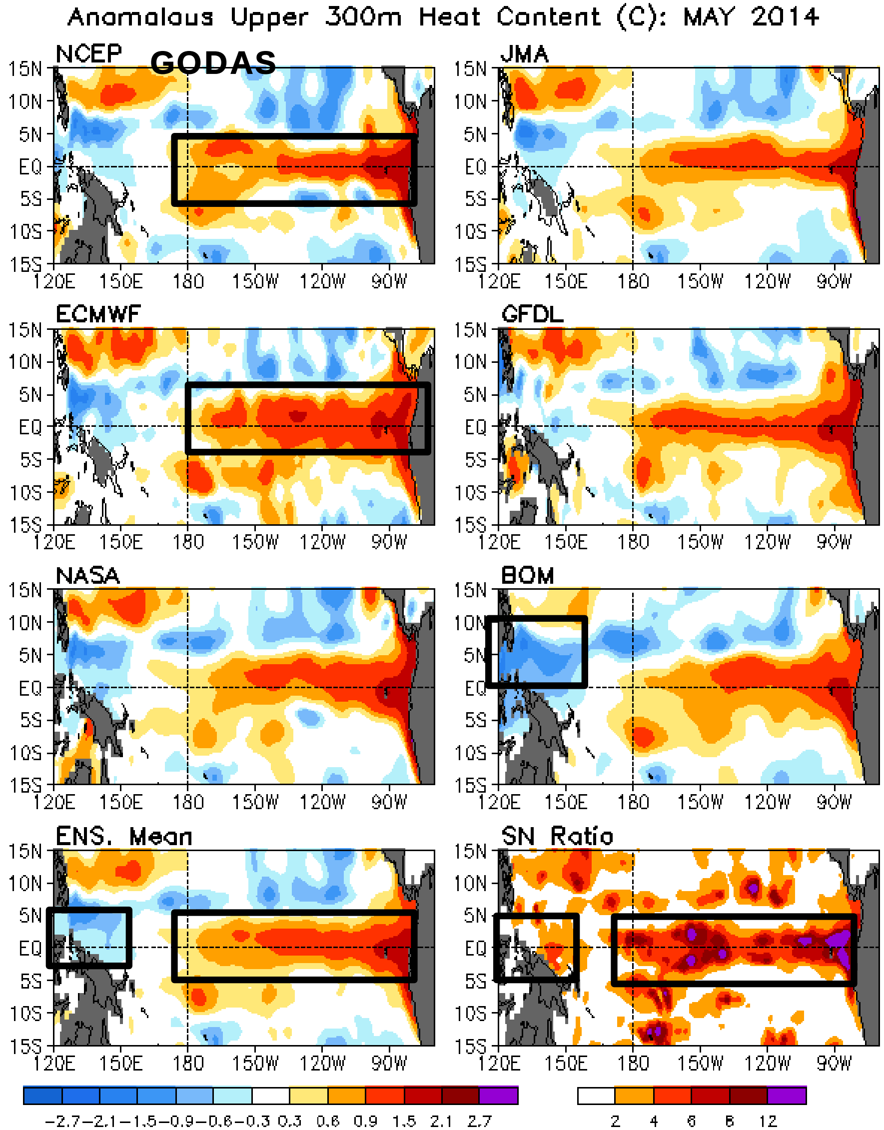


Anomalous Temperature (C) Averaged in 150W−120W: JUN 2014

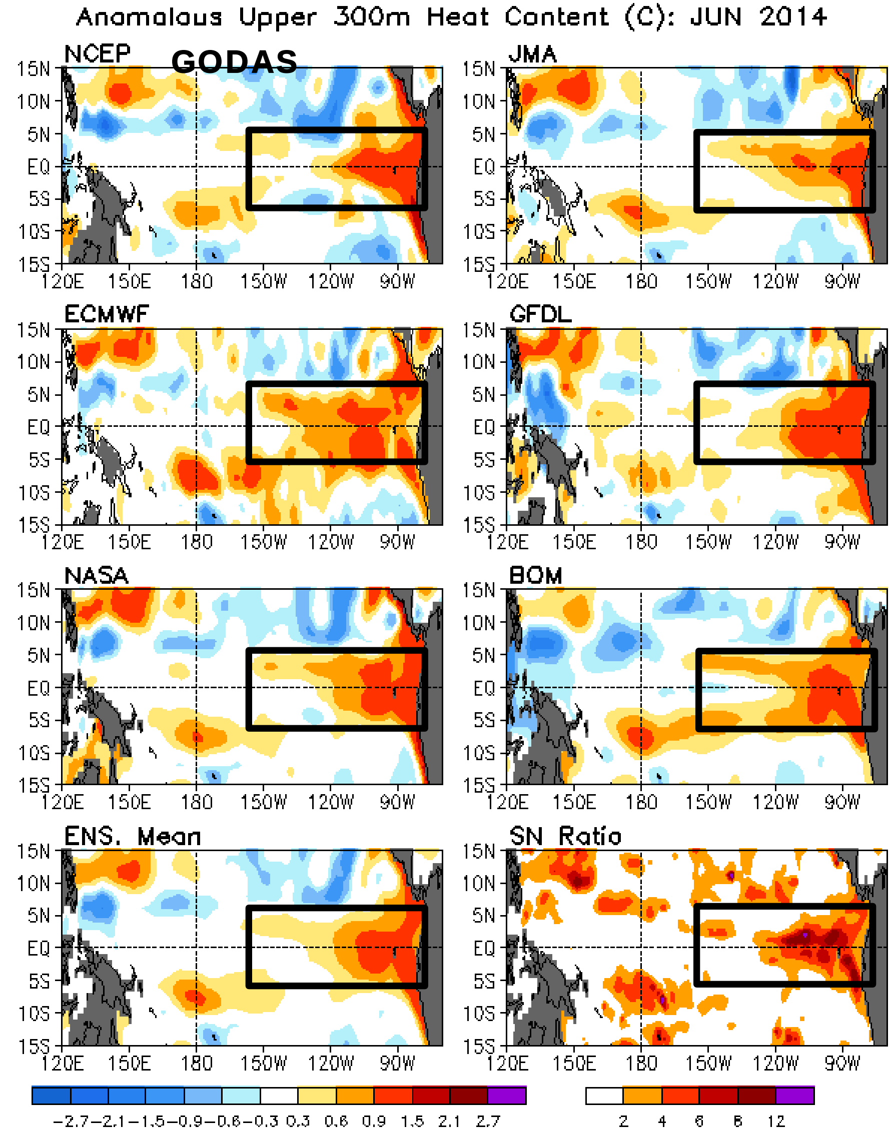


Upper 300m Heat Content Anomaly

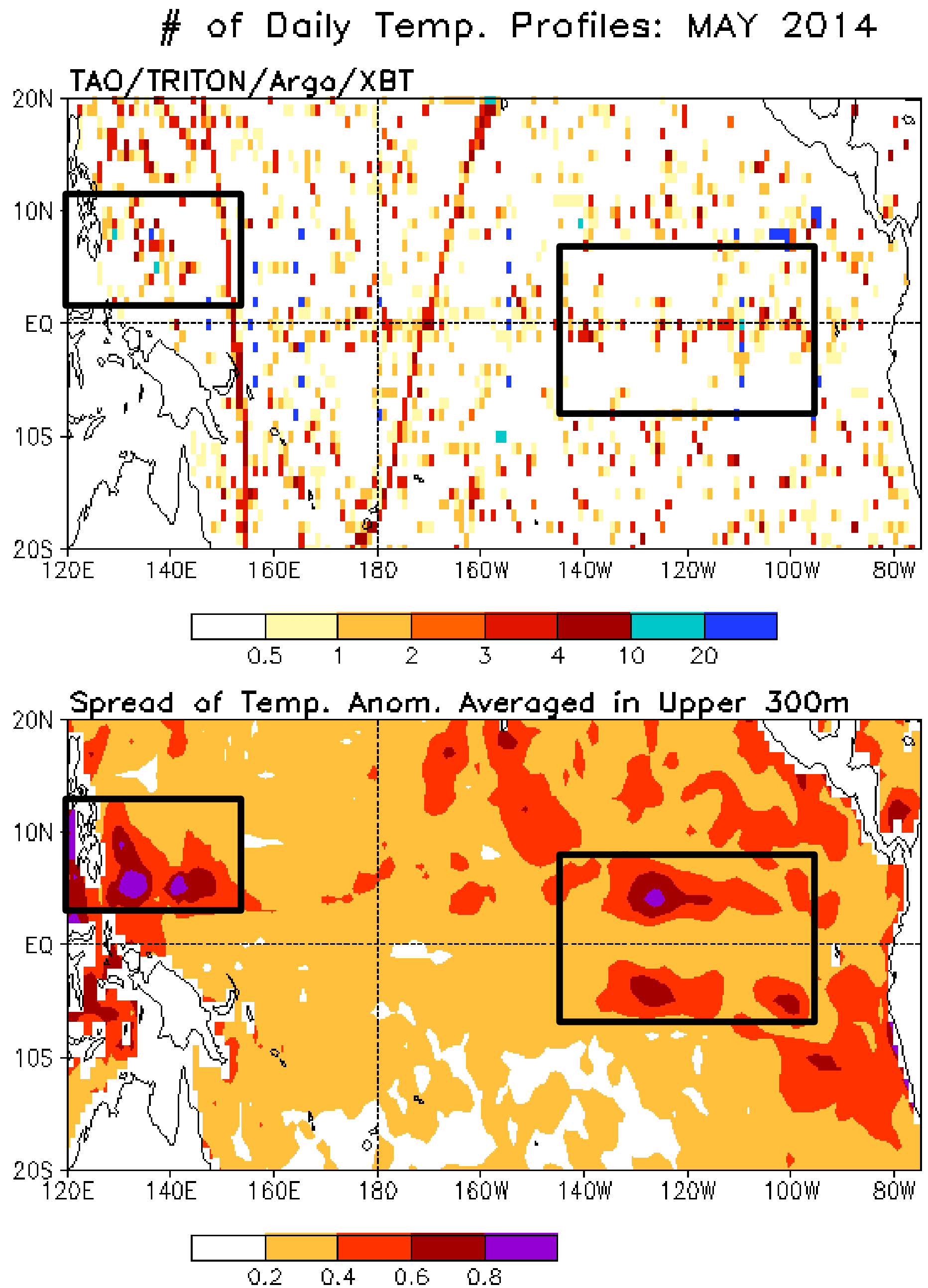
May

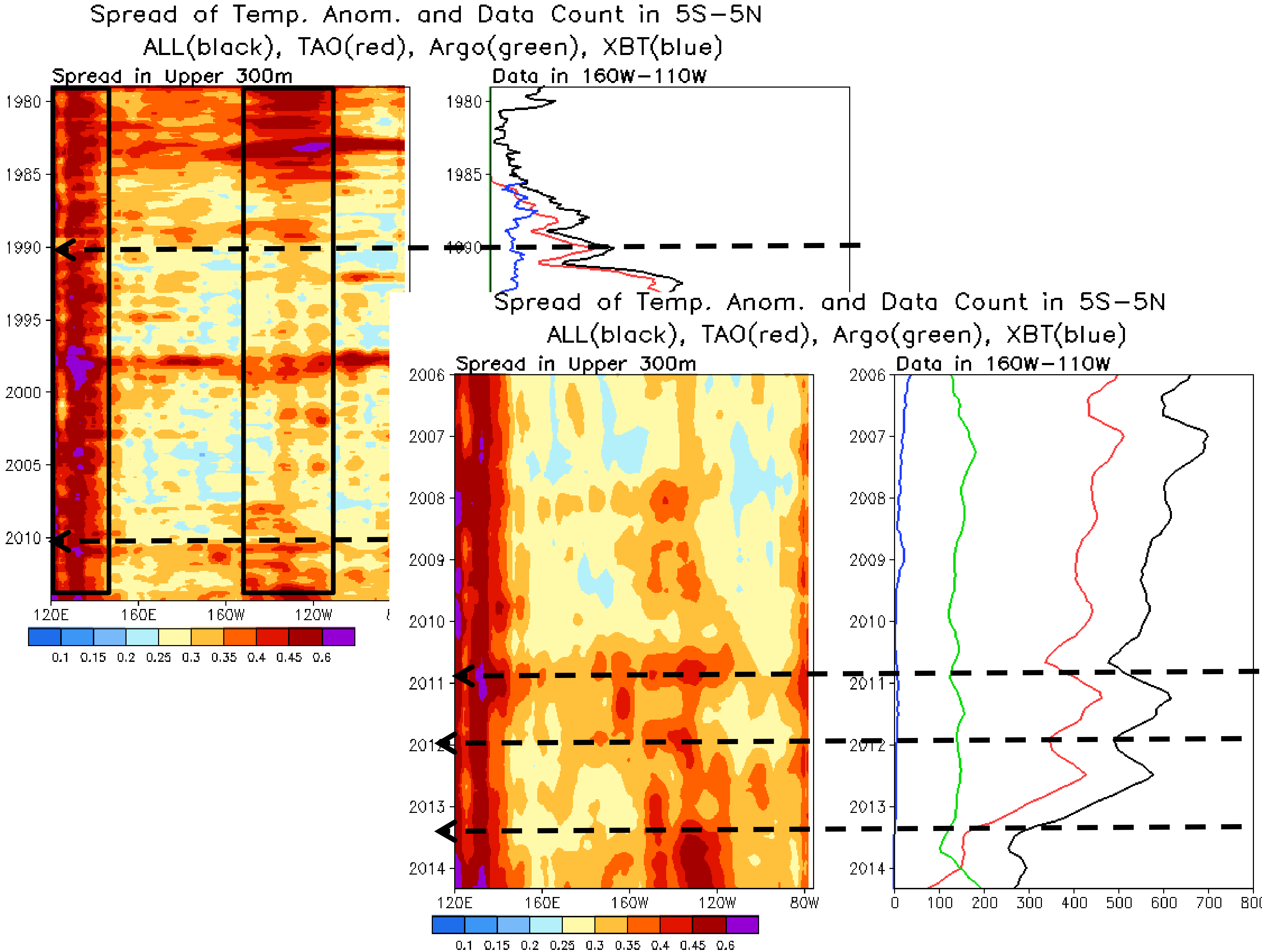


June



Influences of ocean observations on spread among ocean reanalyses





Spread of Temp. Anom. and Data Count in 5S-5N
ALL(black), TAO(red), Argo(green), XBT(blue)
Spread in Upper 300m
Data in 160W-110W
1980
1985
1990
1995
2000
2005
2010
120E
160E
160W
120W
0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.6
Spread of Temp. Anom. and Data Count in 5S-5N
ALL(black), TAO(red), Argo(green), XBT(blue)
Spread in Upper 300m
Data in 160W-110W
2006
2007
2008
2009
2010
2011
2012
2013
2014
120E
160E
160W
120W
80W
0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.6
0 100 200 300 400 500 600 700 800

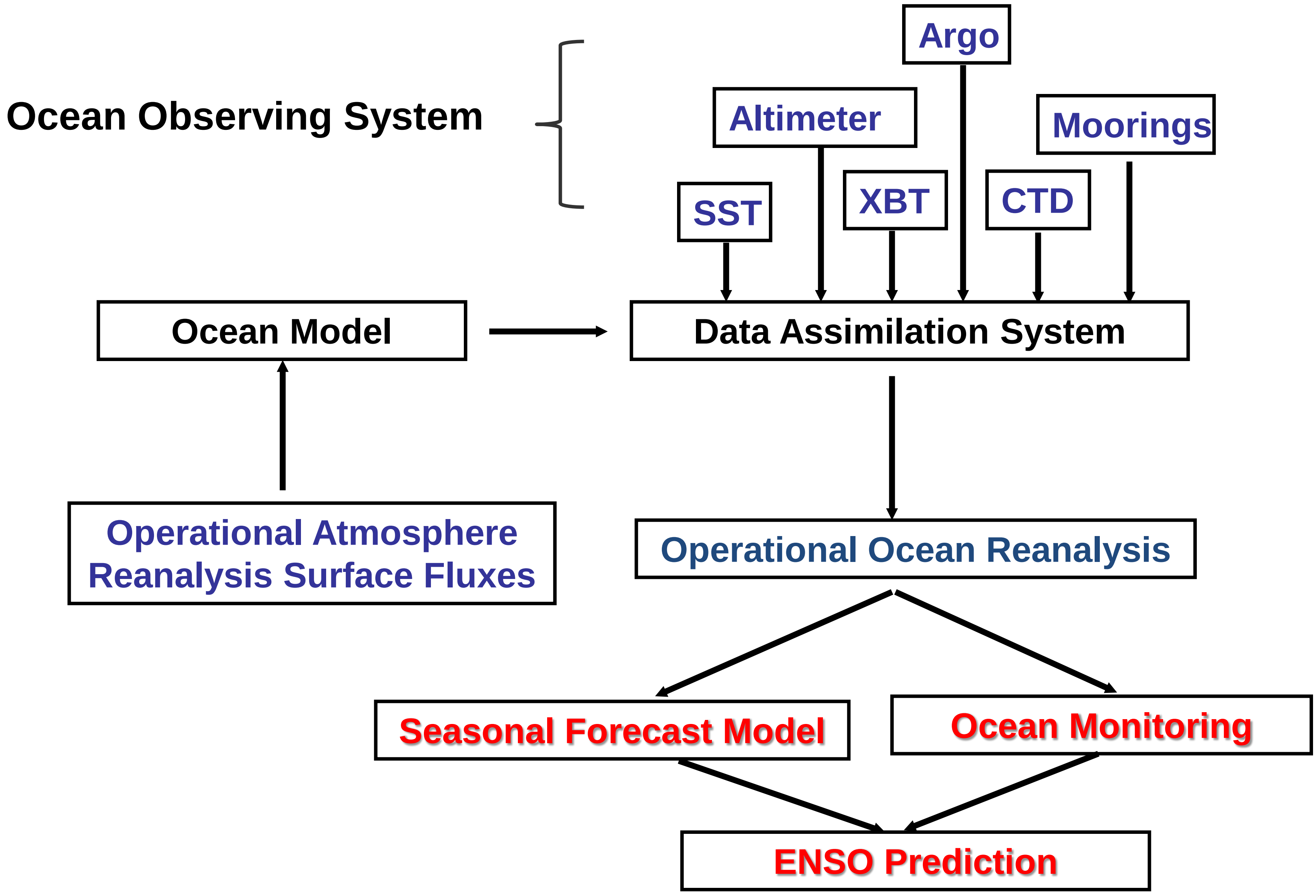
Summary

- An ensemble of six operational ORAs has been collected to assess signal (ensemble mean) and noise (ensemble spread) in upper ocean temperature analysis in near real-time
- Extensive monitoring plots have been developed to assess uncertainties in temperature analysis of tropical Pacific in support of ENSO monitoring and prediction
- We have explored connections between gaps in ocean observations and spread among ensemble ORAs
  - ✓ The spread of ensemble ORAs decreased abruptly in early 1990s when the TAO array was fully implemented.
  - ✓ The spread started to increase since 2010 and reached a peak value in 2013 when the TAO array return rate drop to 40%

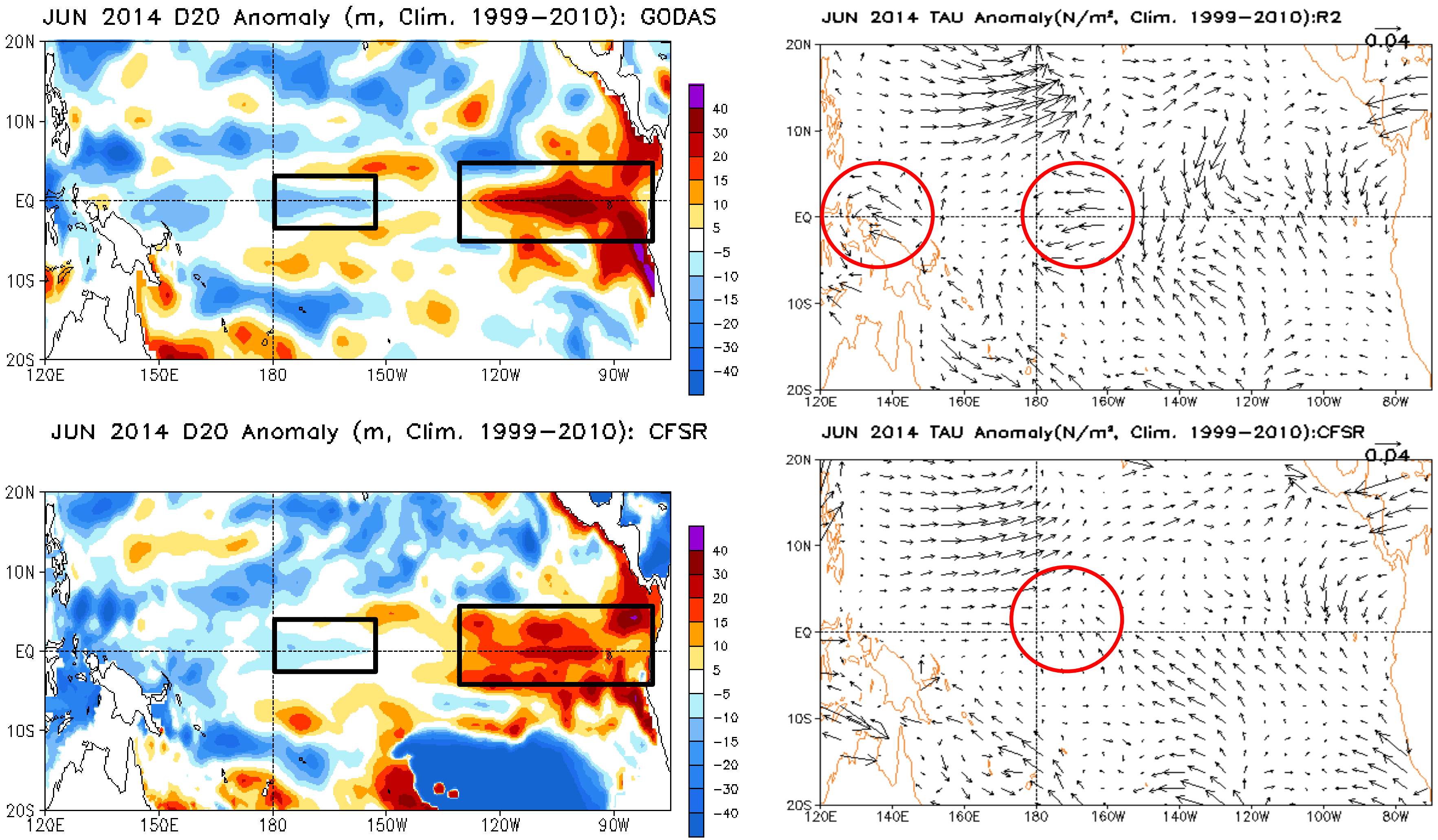
Thanks!

Comments and Suggestions?

Operational Ocean Reanalysis



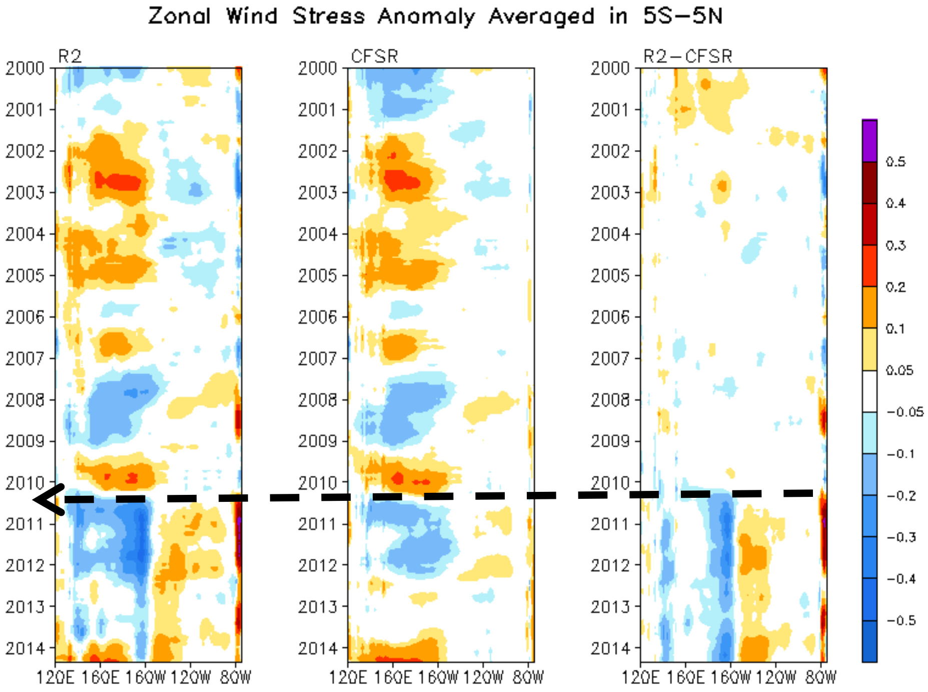
Difference between GODAS and CFSR (1999-2010 Clim.)



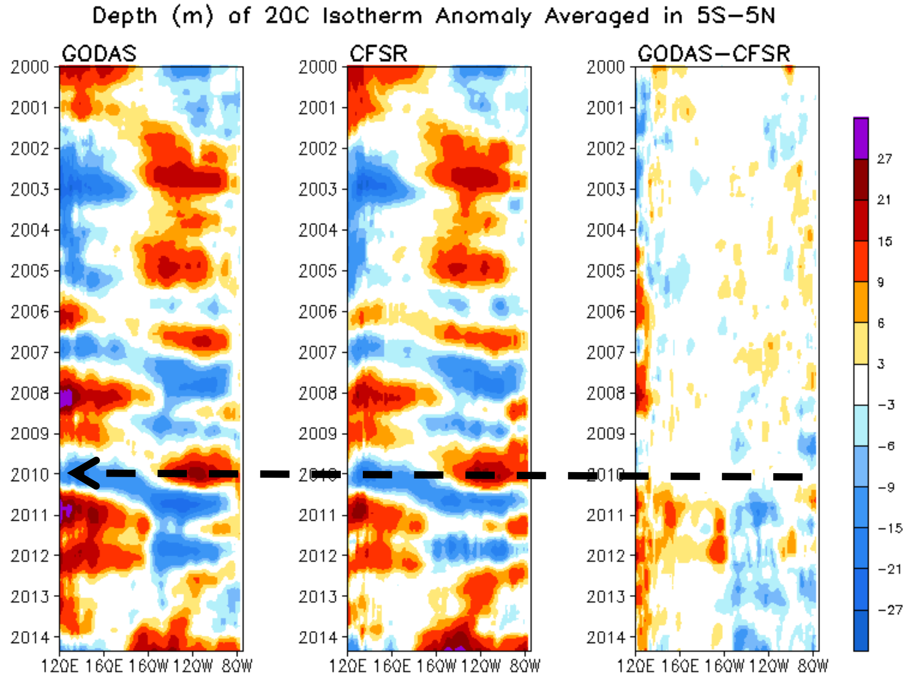
- **Positive D20 anomaly in GODAS has much narrower meridional extend than CFSR between 130W-100W, and negative D20 anomaly near Dateline was stronger than that in CFSR.**
- **Easterly wind anomaly was stronger in R2 than that in CFSR.**

Difference between GODAS and CFSR

Zonal Wind Stress Anomaly



Depth of 20C Isotherm Anomaly



- Trade winds in R2 are much stronger than those in CFSR near 170W since 2010.

- Consistent to the stronger trade winds in R2, D20 anomaly in GODAS is about 3-6m lower than that in CFSR east of 150W since 2010.

Recent Evolution of Ocean Heat Content Anomaly