Impact of *in-situ* Ocean Observations

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Objective:

To quantify the impact of T&S observations from moored buoy, profiling floats and ship-based network on the global ocean analysis

Assimilation system used for the study: INCOIS-GODAS

- **MOM4p0**
  - Resolution
    - Zonal 0.5 °
    - Meridional : 0.25° within 10 ° of the equator, exponential decrease from 10°S (10°N) to 30°S (30°N), 0.5 ° from 30°.
    - Vertical: 40 layers with vertical resolution 10 m from the surface to the 240 m depth and 511m near bottom layers.
  - FORCING: NCMRWF
    - Daily Momentum
    - Daily P-E
    - Daily Radiation fluxes
    - Annual River runoff

- **3D VAR**
  - Assimilates
    - Temperature
    - Salinity
  - Assimilation window :10 days
  - Assimilates at every 6th hour
  - Background variances cycle: 5 days
  - Assimilates upto 750m depth and within +/- 63 degrees

- **Ocean Analysis (outputs)**
  - Temperature, Salinity, SSH, and Currents at all applicable ocean depths

Experiments performed for the OSE study

Experiment	Moored Buoy	Argo	Ship-based
Observation System Experiments			
REF	Yes	Yes	Yes
XBU	No	Yes	Yes
XPR	Yes	No	Yes
XSH	Yes	Yes	No
Special Experiments			
XA	No	No	No
MBU	Yes	No	No
PRF	No	Yes	No
SHIP	No	No	Yes

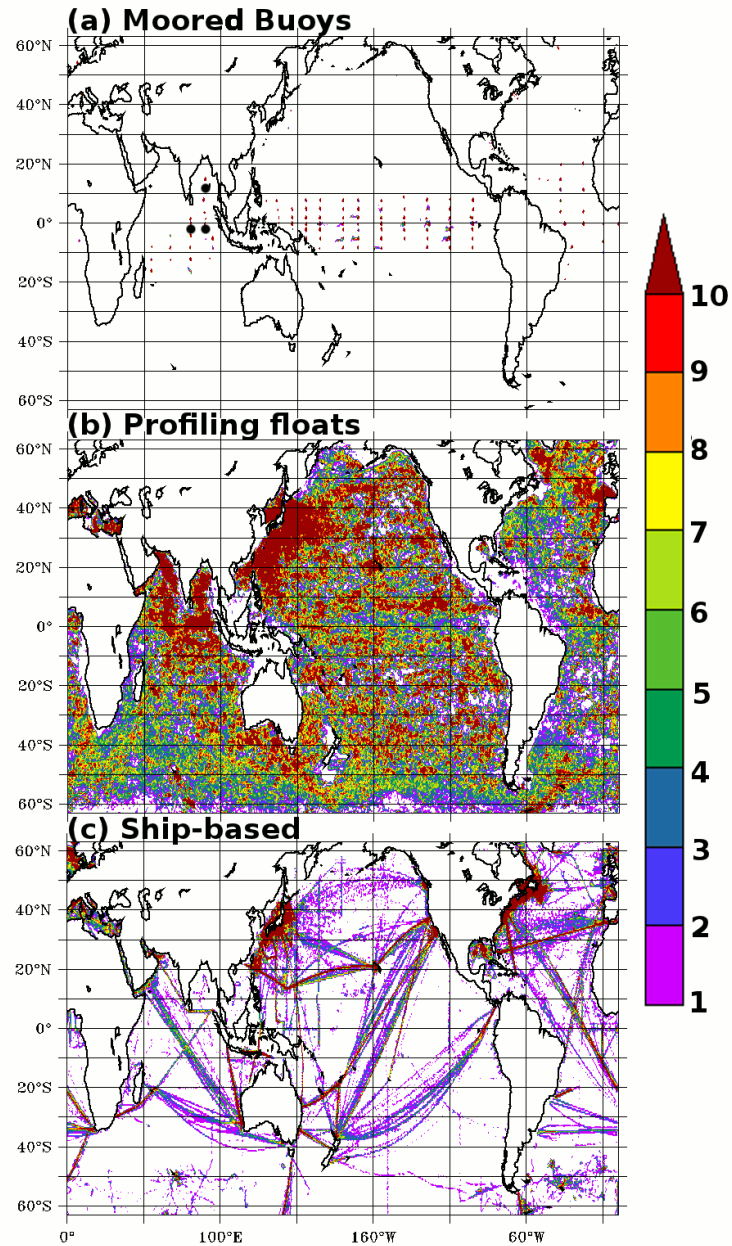
Notes:
Moored Buoy: TAO/TRITON, PIRATA, RAMA
Profiling Floats: Argo
Ship-based: CTD, XBT, XCTD, MBT etc.
No relaxation of SST and SSS is used.

Data for assimilation

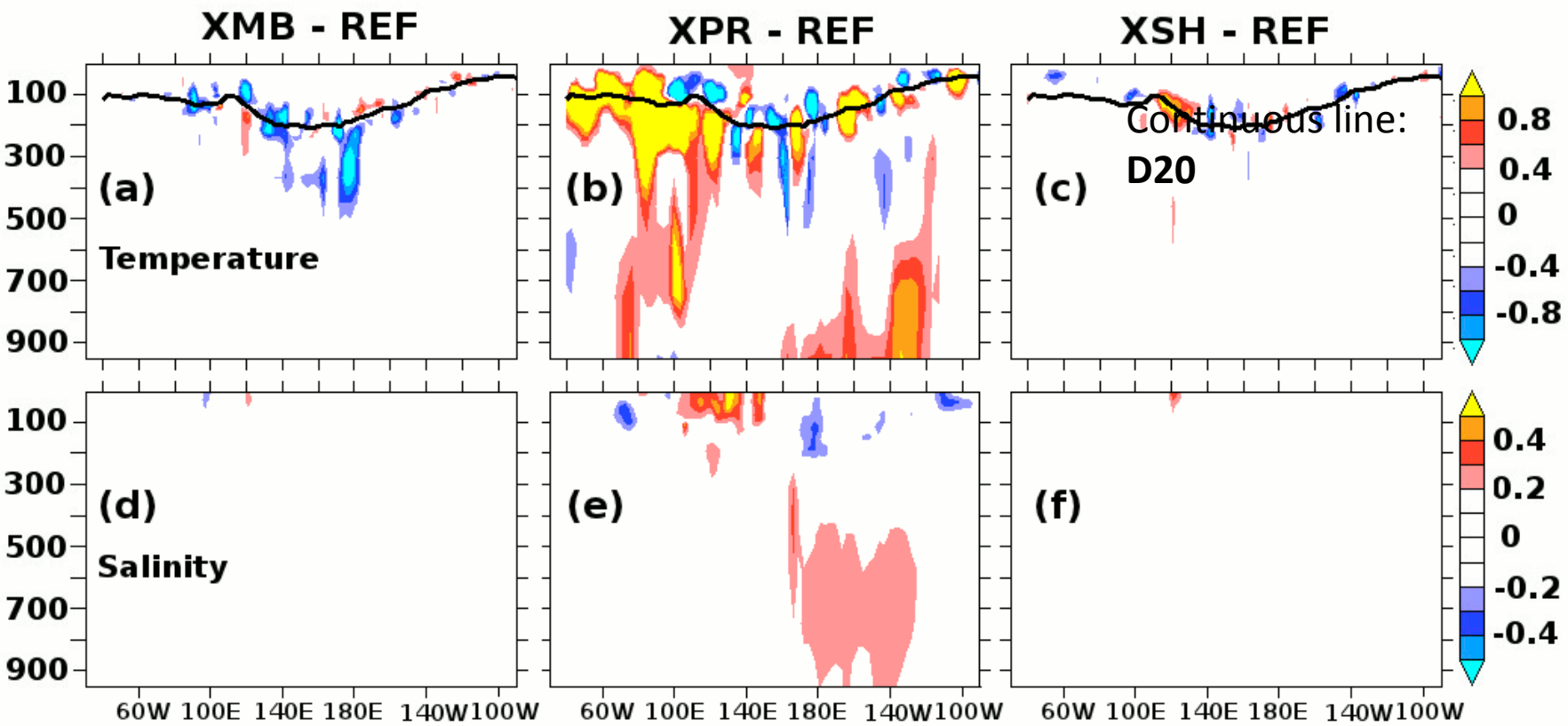
Distribution of temperature profiles available for assimilation during 2004-2011.

- EN3V2a temperature and salinity profiles [*Ingleby and Huddleston, 2007*]
  - Rich collection of data (WOD05, GTSPP, Argo, and ASBO)
  - XBT corrected profiles[*Wijffels et al., 2008*]
  - QC'd
- Further QC
  - Delayed mode profiles
  - Reject profiles having large vertical gaps

With-held some locations (50km radius) in the BoB and EEIO



Depth-Longitude differences w.r.to REF for October, 2008

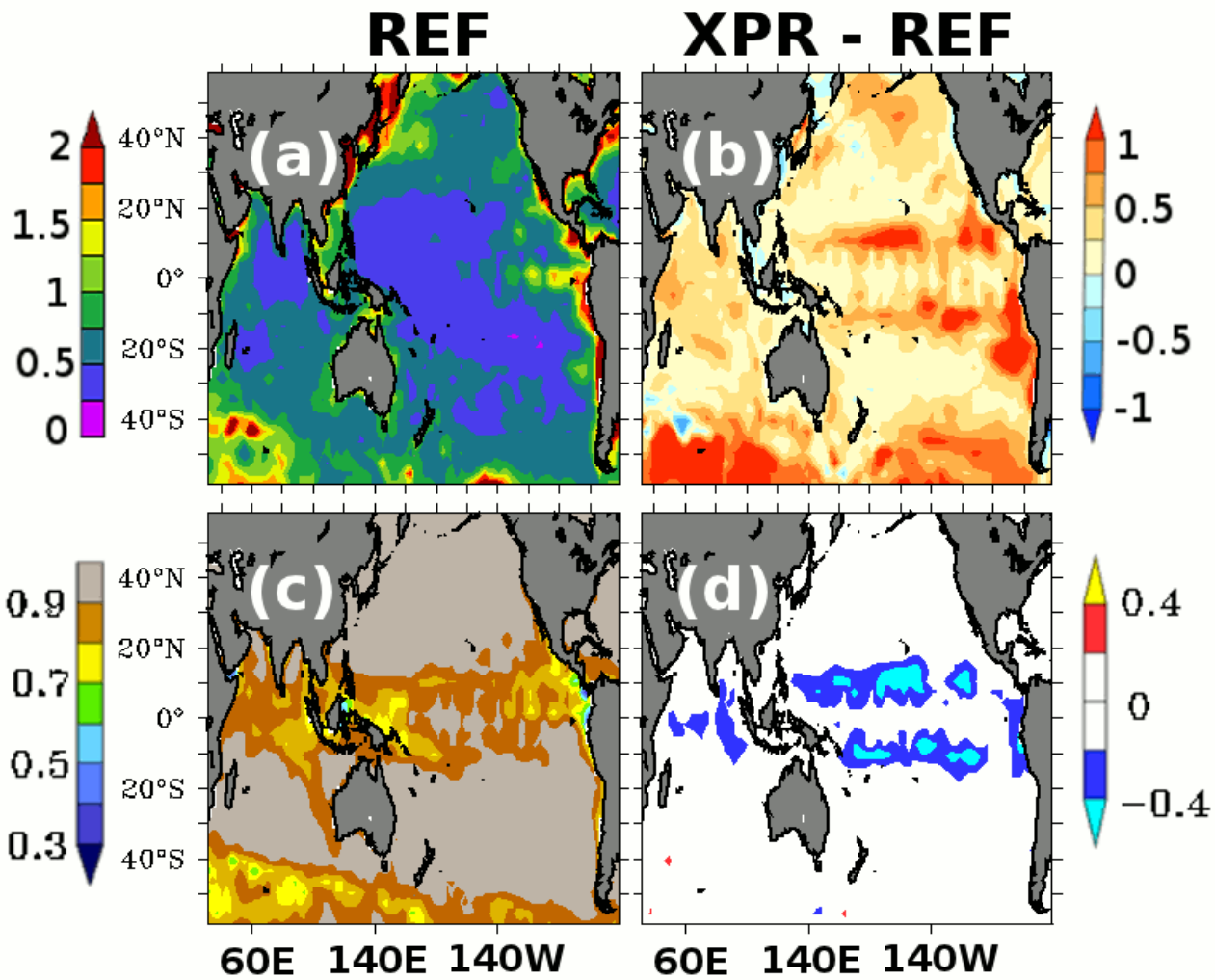


5S to 5N - averaged

Sea Surface Temperature

(a) RMSD

(c) Correlation

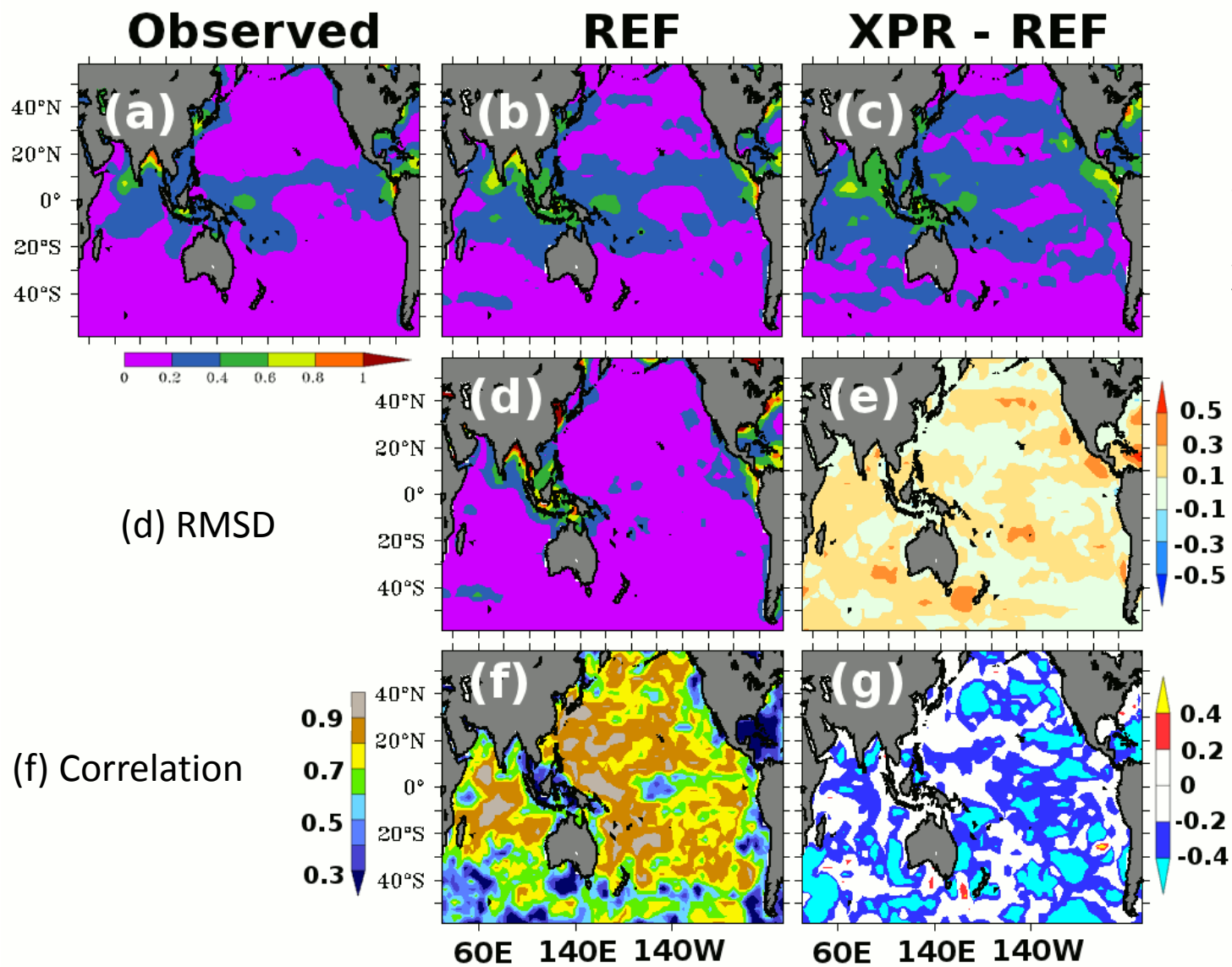


(b) Difference in RMSD

(d) Difference in Correlation

RMSD are w.r.to Observation: TMIAMSRE

Sea Surface Salinity



Panels a, b, & c show STD of observed, REF and XPR respectively

(d) RMSD

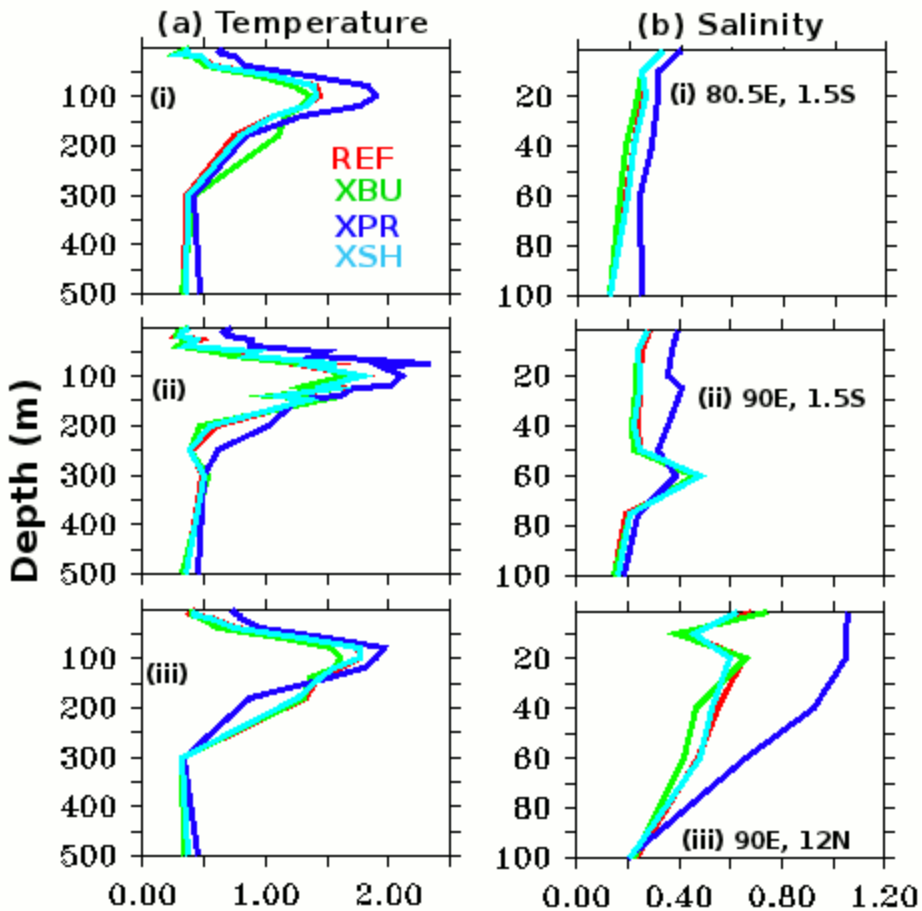
(e) Difference in RMSD

(f) Correlation

(g) Difference in Correlation

RMSDs are w.r.to Observation: EN3V2a salinity

Depth-wise RMSD at Independent locations



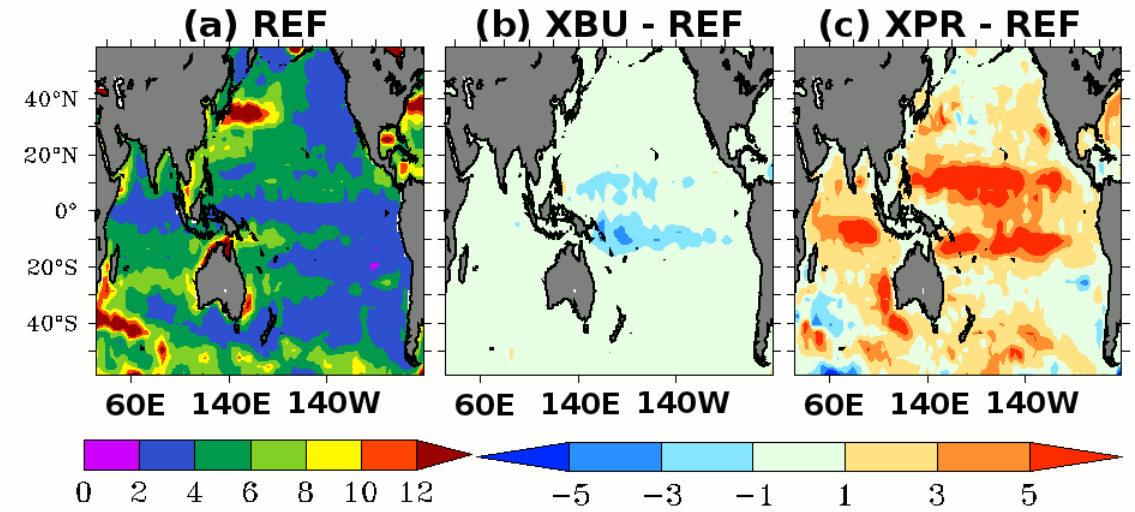
Removal of Argo observation degrades the quality of temperature and salinity upto 0.5 degC (~27%) and 0.6 (~66%) PSU respectively.

Removal of Shipbased or Moored buoy observations doesnot seem to degrade the quality of temperature and salinity analysis.

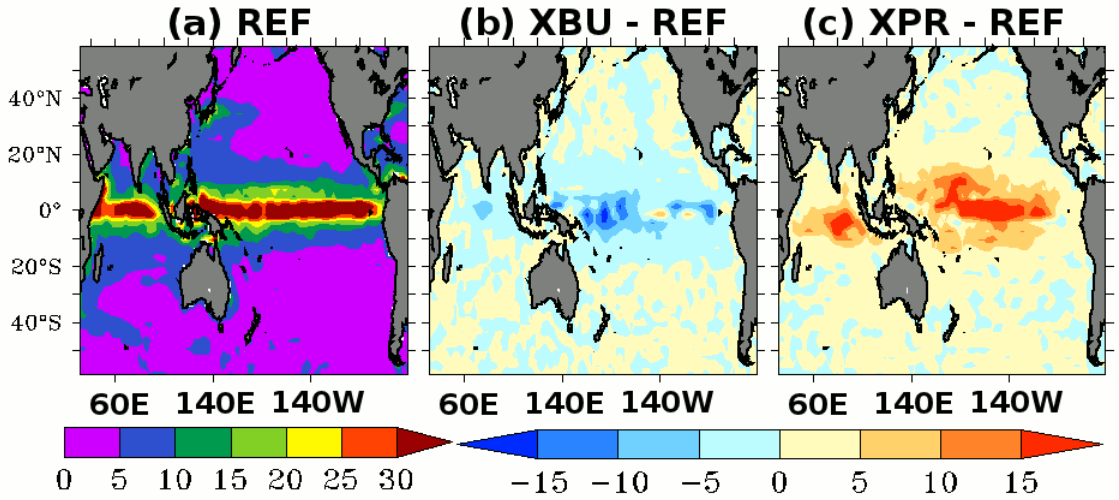
Statistics are based on daily averaged data and are w.r.to RAMA data

RMSD Difference in RMSD

Sea Surface Height Anomaly (cm)

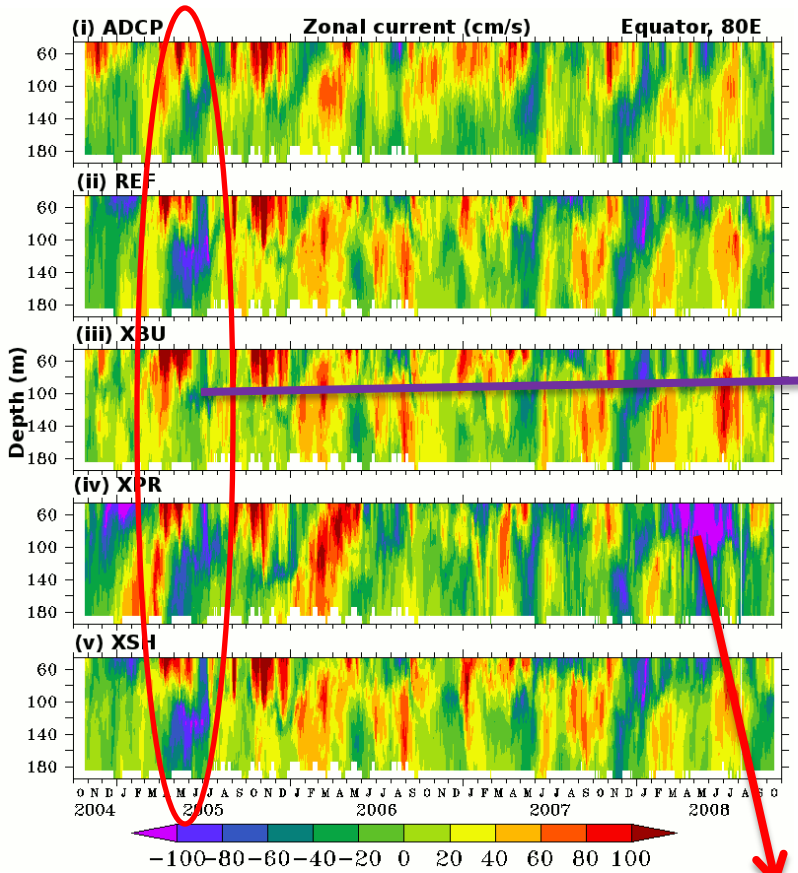


Zonal Current (cm/s)



RMSD are w.r.to Observation: Merged SLA from AVISO, Surface Currents from OSCAR

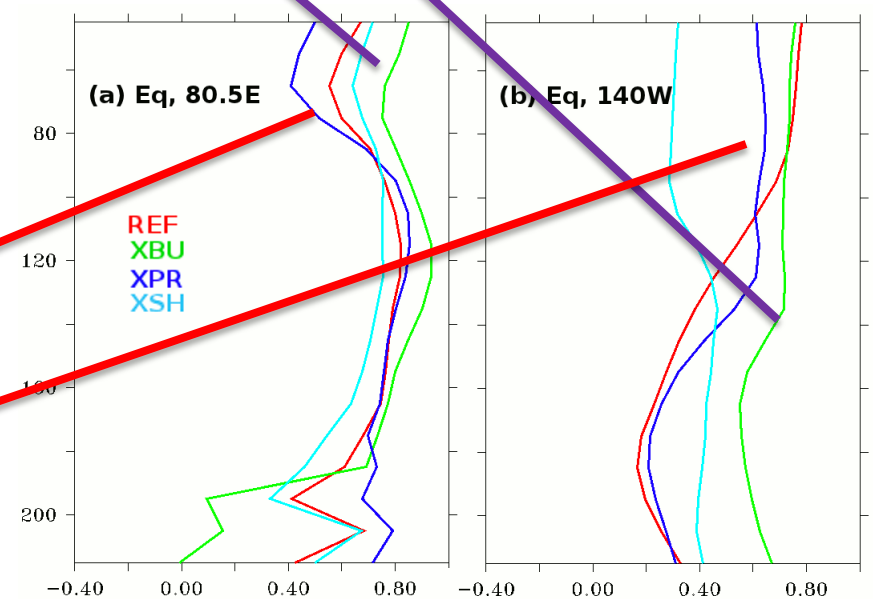
Sub-Surface currents



Improvements with the exclusion of Moored buoys

Statistics are based on daily averaged data

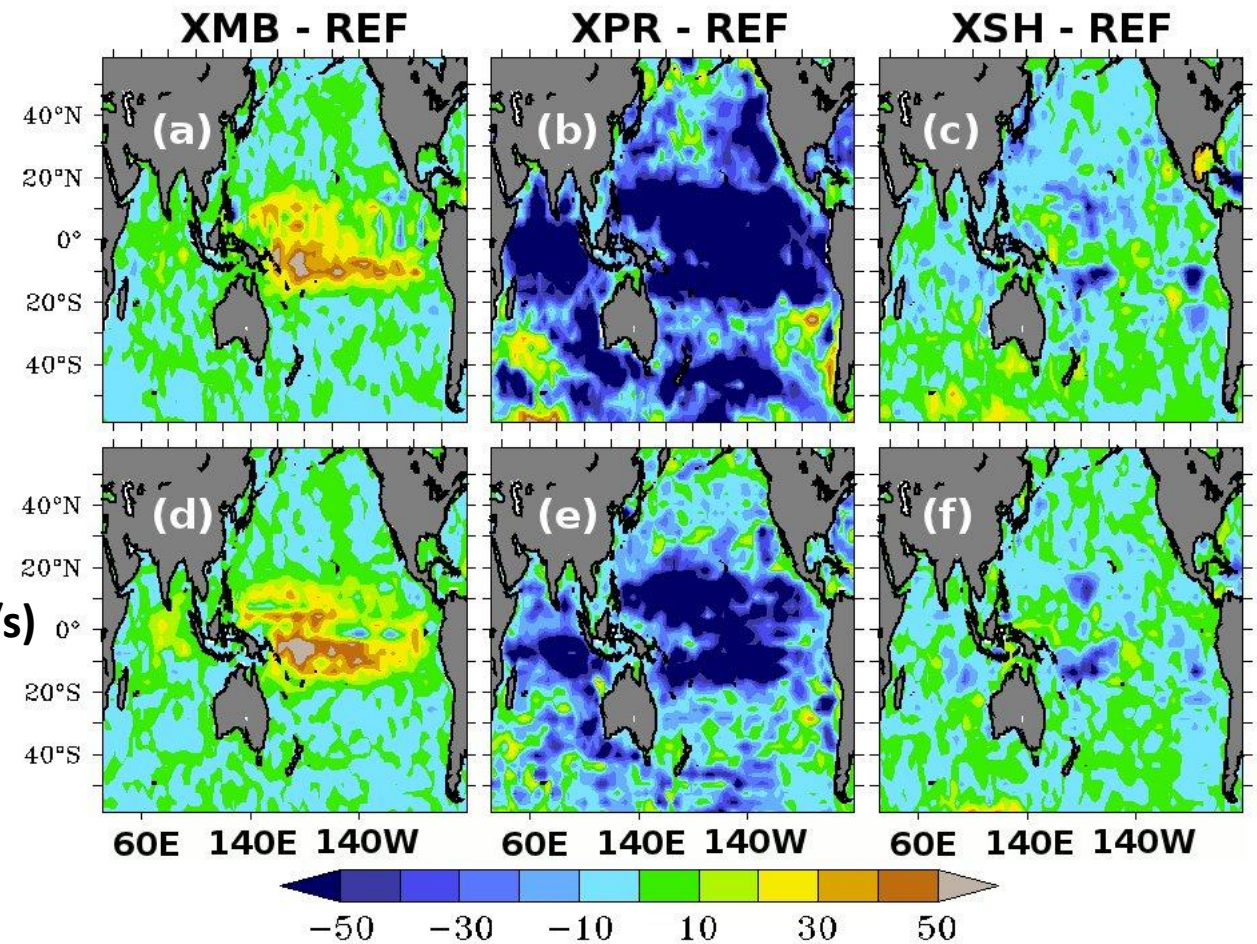
Degradations with the exclusion of Argo



Percent Degradation

Sea Surface Height Anomaly (cm)

Zonal Current (cm/s)



PD= (RMSD_ref – RMSD_exp)/RMSD_ref; +ve PD indicates improvement with the sensitivity experiment “exp” and viceversa

Percent Degradations for Climate Indices

Sea Surface Temperature (◦C)
Sea surface Height Anomaly (cm: in brackets)

	RMSD (REF)	XMB	XPR	XSH
TIO	0.5 (0.9)	0 (0)	-13 (-100)	-2 (0)
EIO	0.1 (1.0)	-1 (8)	-170 (-206)	-10 (3)
AS	0.7 (1.9)	1 (-1)	-11 (-48)	-10 (3)
BoB	0.8 (2.1)	0 (5)	-3 (-36)	2 (-1)
IOD_WEST	0.1 (1.4)	-1 (7)	-186 (-148)	-21 (1)
IOD_EAST	0.4 (1.4)	0 (15)	-7 (-213)	-1 (-5)

PD= (RMSD_ref – RMSD_exp)/RMSD_ref; +ve PD indicates improvement with the sensitivity experiment “exp” and vice-versa

Summary

- Consistent with the earlier studies, T&S observations from Argo network has strong positive impact on the quality of ocean analysis
- Although not so strong, ship-based observations have positive impact over many, if not all, regions of the world.
- Present set up of moored buoy observations does not seem to add significant value to the quality of global ocean analysis. The study hypothesize that the impact of moored buoys would turn positive with
  - vertical resolution of moored buoys
  - the improvement of spatial coverage of moored buoys in the tropical Pacific, from 10S-10N to 15S-15N
- Caveats:
  - Results are based on a single assimilation system, i.e. INCOS-GODAS
  - The results from the present study need to be confirmed by other assimilation systems before further conclusions can be drawn regarding redundancies and requirements in the observing systems