Evaluation of Tropical Pacific Observing Systems Using NCEP and GFDL Ocean Data Assimilation Systems

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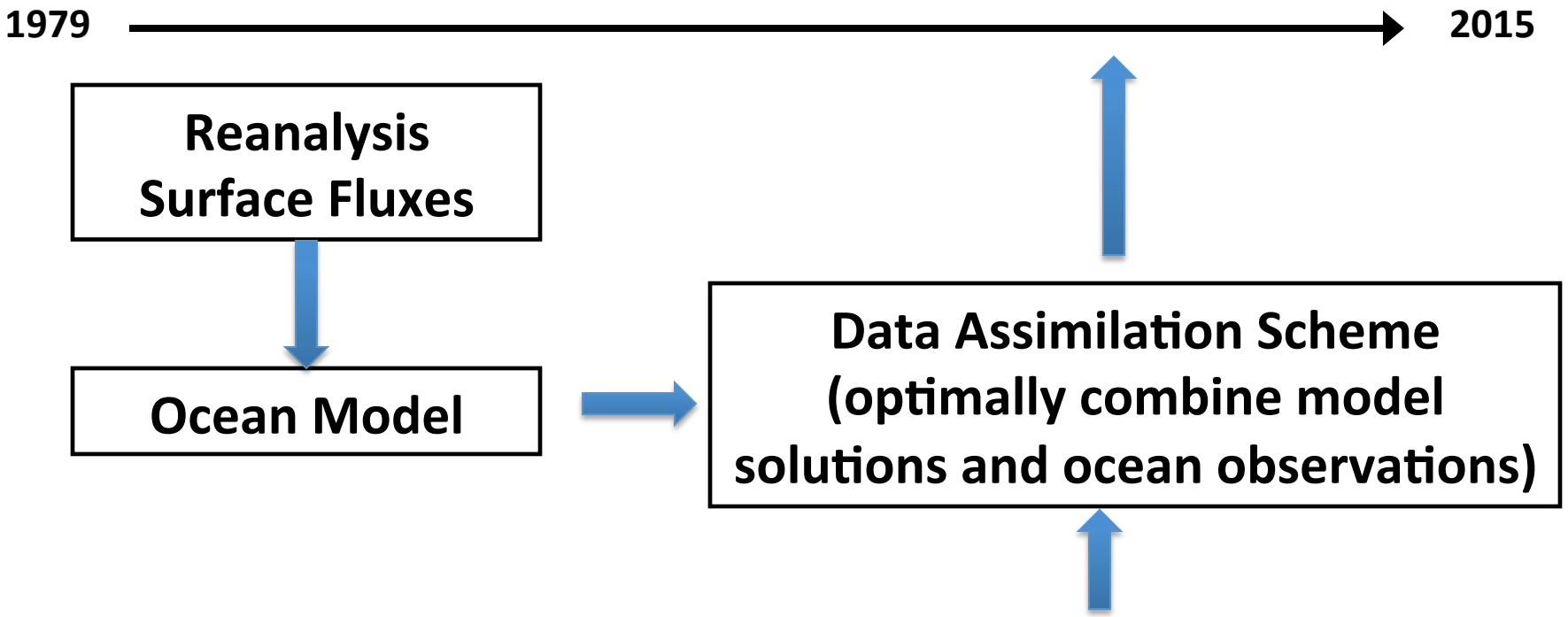
What is Ocean Reanalysis?



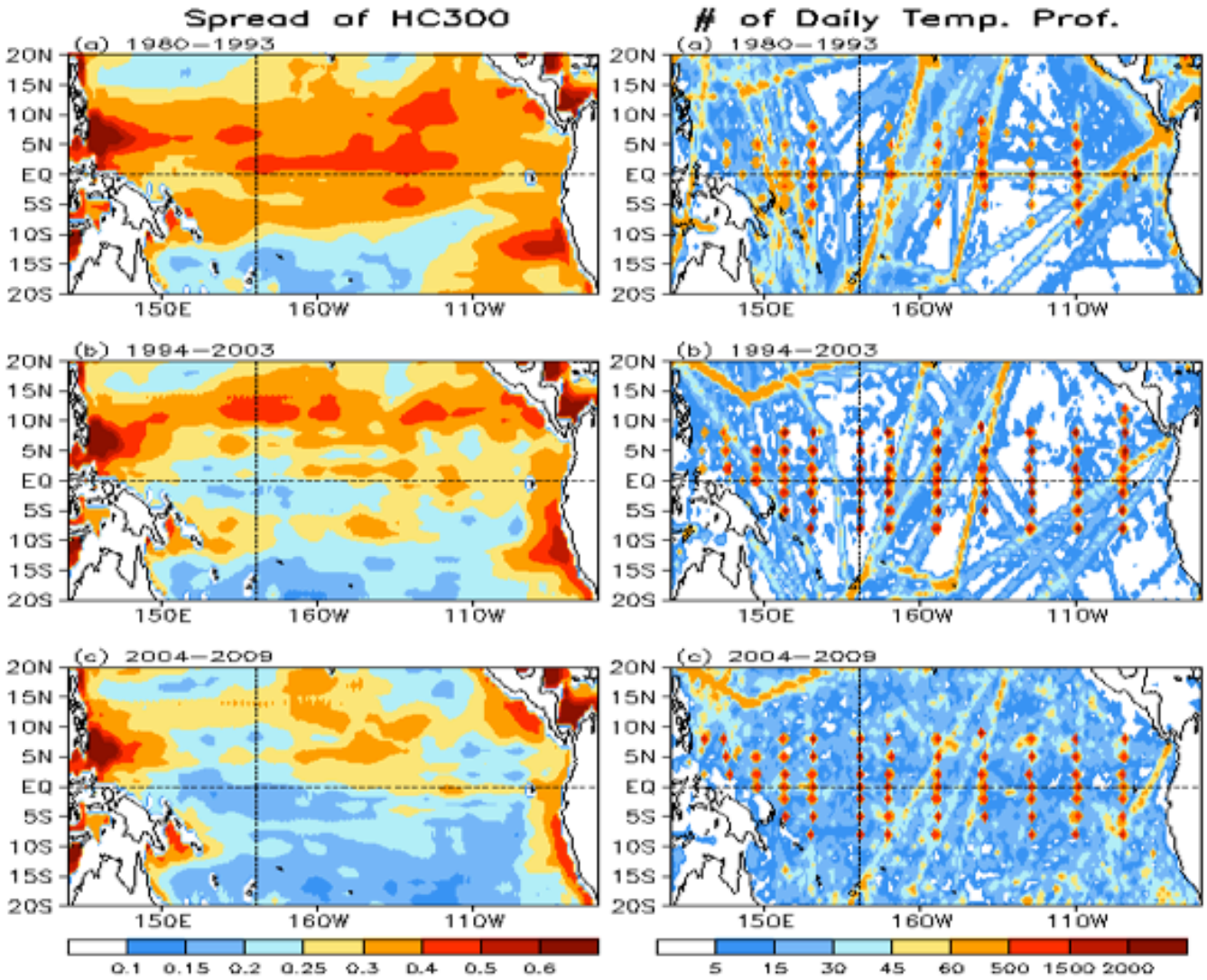
OSE is an ocean reanalysis experiment in which observations from one particular observing platform is withheld.

Is the Quality of Ocean Reanalysis Sensitive to Data Distribution?

1980-1993

1994-2003

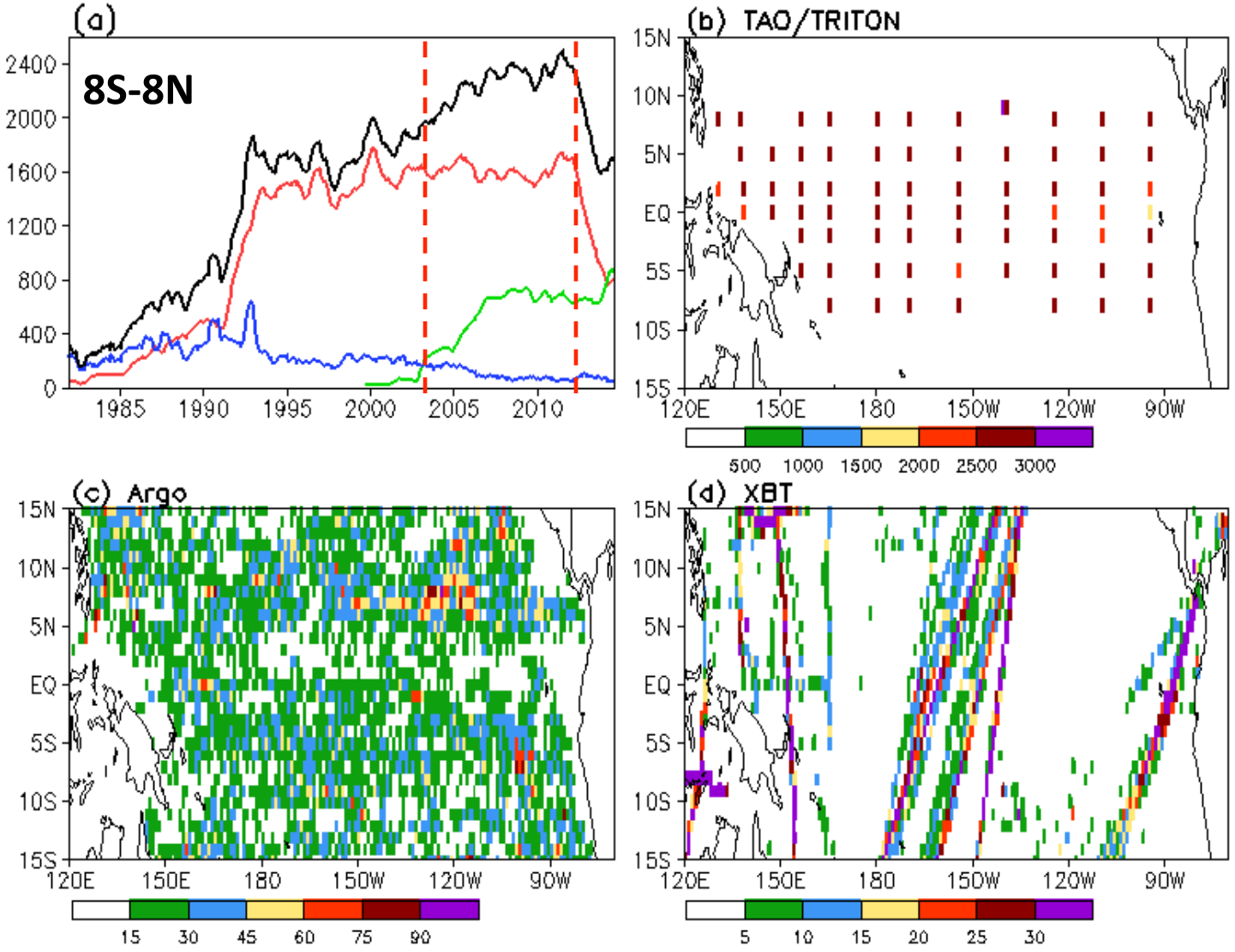
2004-2009



Xue et al. 2012

Tropical Pacific Observing Systems

Black: All data
Red: TAO/TRITON
Blue: XBT
Green: Argo



2004-2011

Coordinated Observing System Experiments at NCEP and GFDL (2004-2011)

	CTL	ALL	noMoor	noArgo
In situ data included	no profiles	all profiles	all except moorings	all except Argo
XBT	×	√	√	√
TAO	×	√	×	√
Argo	×	√	√	×

- What are the mean biases and RMSE (monthly anomalies) in the control simulations when no in situ observations are assimilated?
- How well are mean biases and RMSE constrained by assimilation of all in situ observations?
- What are influences of withholding mooring or Argo data on mean biases and RMSE?

NCEP's Global Ocean Data Assimilation System

- MOM4p1, 0.5° resolution, 1/4° in 10°S-10°N, 40 levels
- Daily fluxes from NCEP Reanalysis 2
- 3D-VAR, Univariate in temperature and salinity (Behringer 2007)
- Horizonal covariance with scale elongated in zonal direction, vertical covariance as function of local vertical temperature gradient
- Temperature profiles and OISST assimilated
- Synthetic salinity derived with climatology T/S relationship and temperature profiles from XBT and moorings, observed salinity from Argo assimilated
- Altimetry SSH not assimilated
- Temperature (salinity) at 5m is relaxed to daily OISST (Levitus salinity climatology) with 10 (30) day relaxation time scales.

GFDL's Ensemble Coupled Data Assimilation System

- **MOM4, 1° resolution, 1/3° in 10°S-10°N, 50 levels**
- **Coupled model CM2.1**
- **Ensemble Kalman Filter with 12 ensembles (Zhang et al 2007)**
- **Flow-dependent ensemble covariance of temperature and salinity**
- **3-D air temperature and wind from NCEP renalyses assimilated**
- **Observed temperature and salinity profiles and observed SST assimilated**
- **Altimetry SSH not assimilated**

Evaluation of OSEs

- **Validation data**
  - **TAO temperature and current**
  - **Altimetry SSH from AVISO**
  - **Surface current from OSCAR**
  - **EN4 temperature and salinity analysis (objective analysis based on in situ data only) is used as reference but not the "truth"**

- **Evaluation Methods**
  - **Mean and annual cycle**
  - **Standard deviation (STD)**
  - **Root-mean-square error (RMSE) and anomaly correlation coefficient (ACC)**
  - **Integrated RMSE in upper 300m**

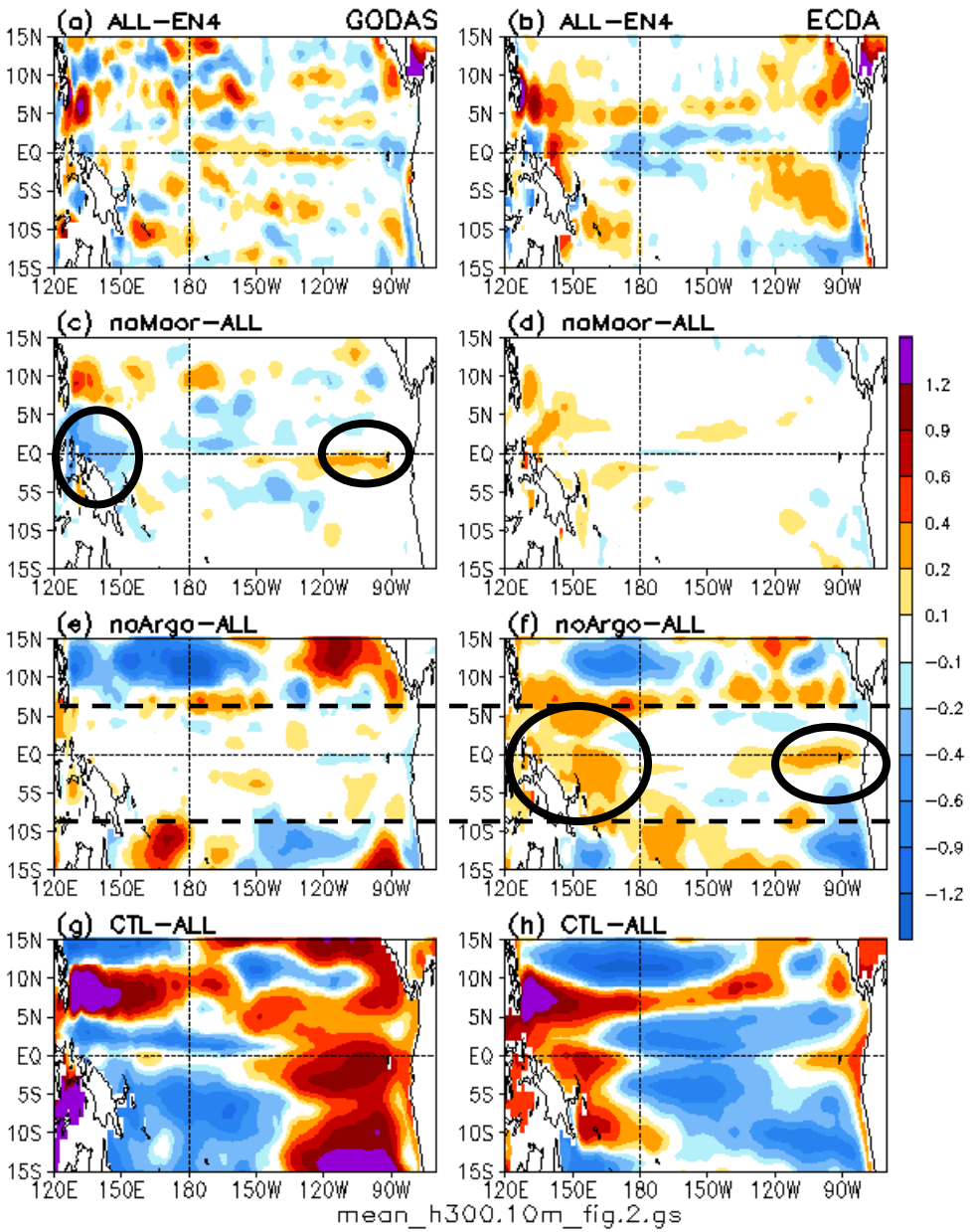
Mean Upper 300m Heat Content (HC300)

All in situ obs. included

Impacts of withholding TAO

Impacts of withholding Argo

Impacts of withholding both TAO and Argo



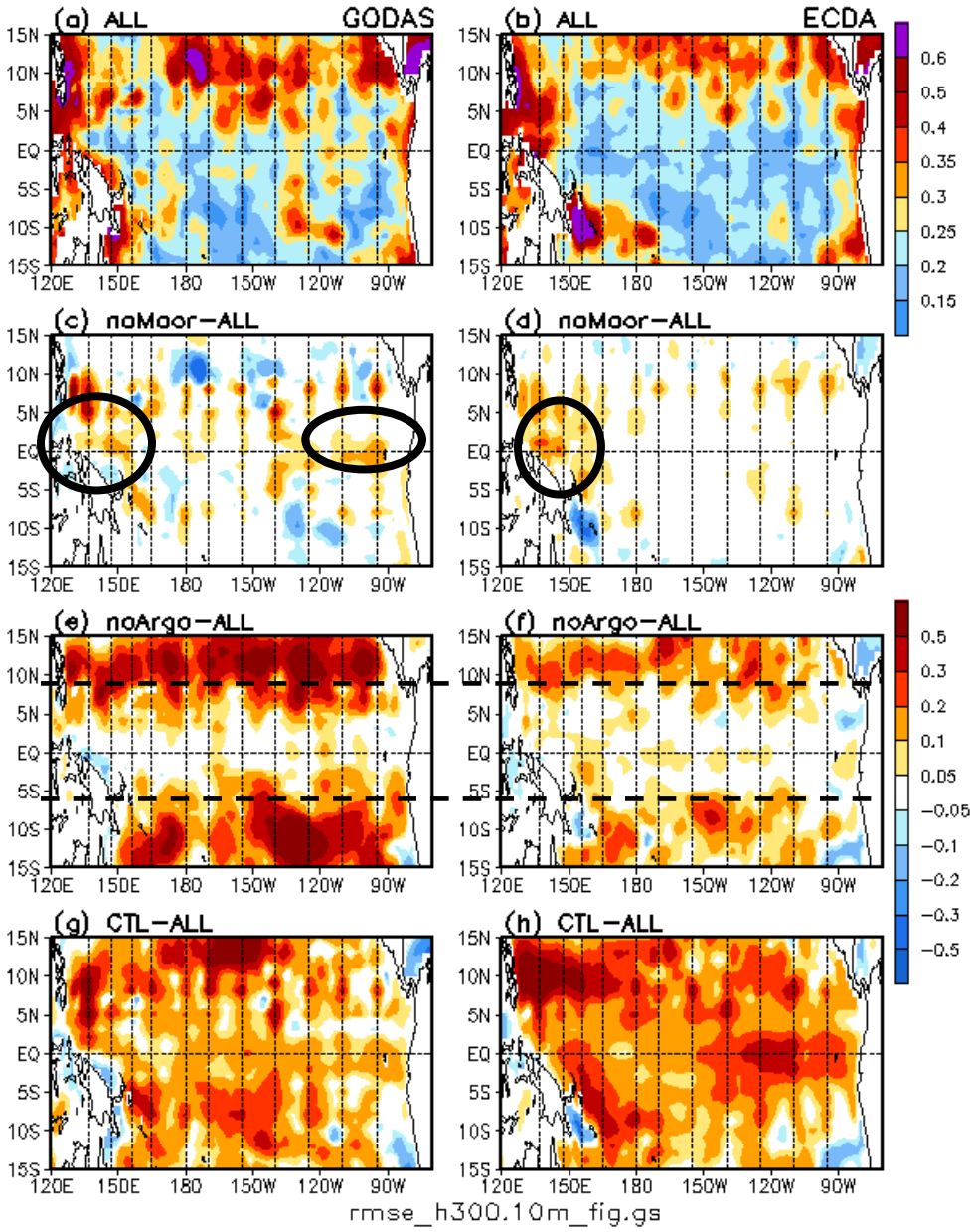
RMSE of HC300 Anomaly

All in situ obs. included

Impacts of withholding TAO

Impacts of withholding Argo

Impacts of withholding both TAO and Argo



RMSE of Salinity at Equator

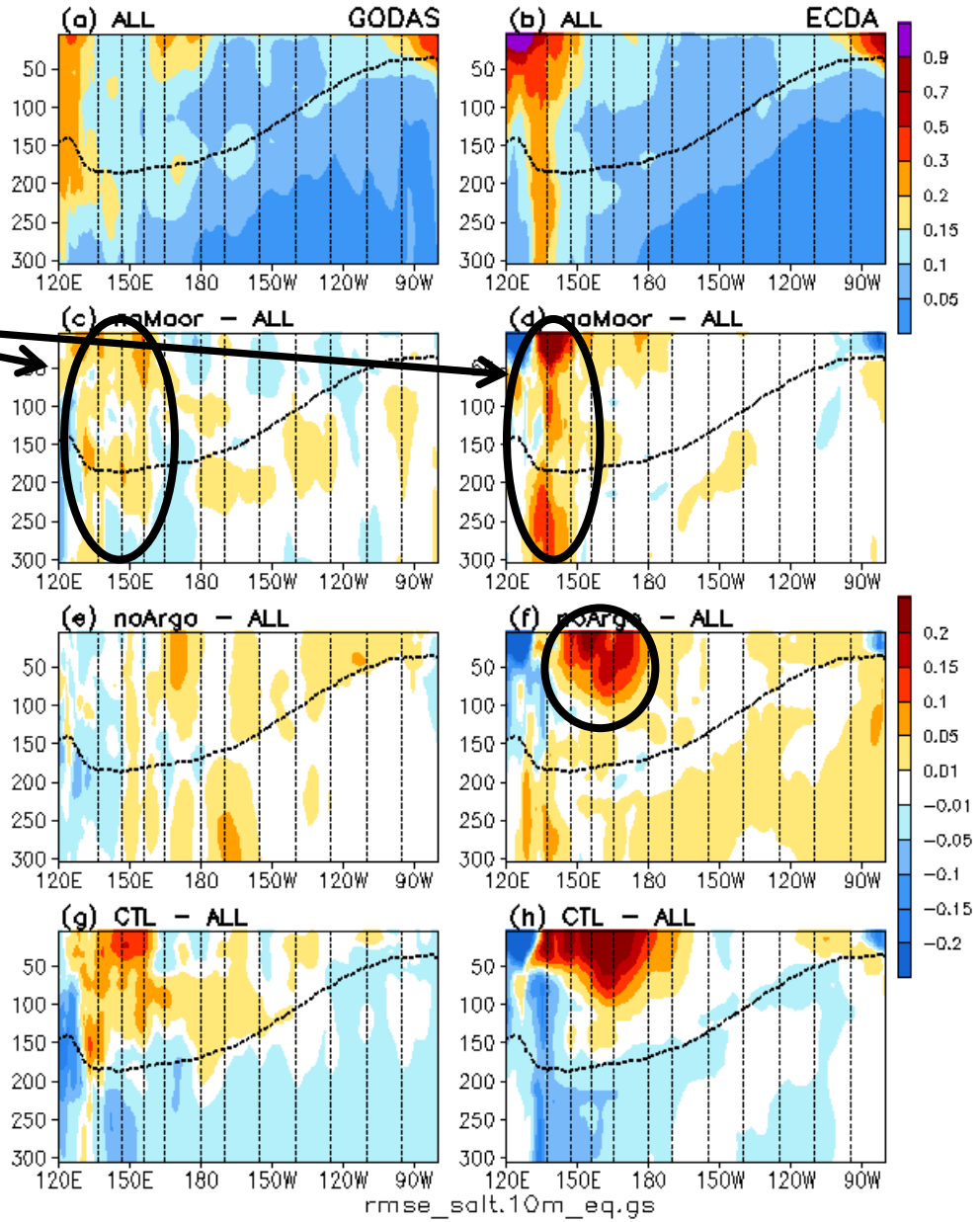
All in situ obs. included

TRITON

Impacts of withholding TAO

Impacts of withholding Argo

Impacts of withholding both TAO and Argo



RMSE of Salinity in Upper 300m

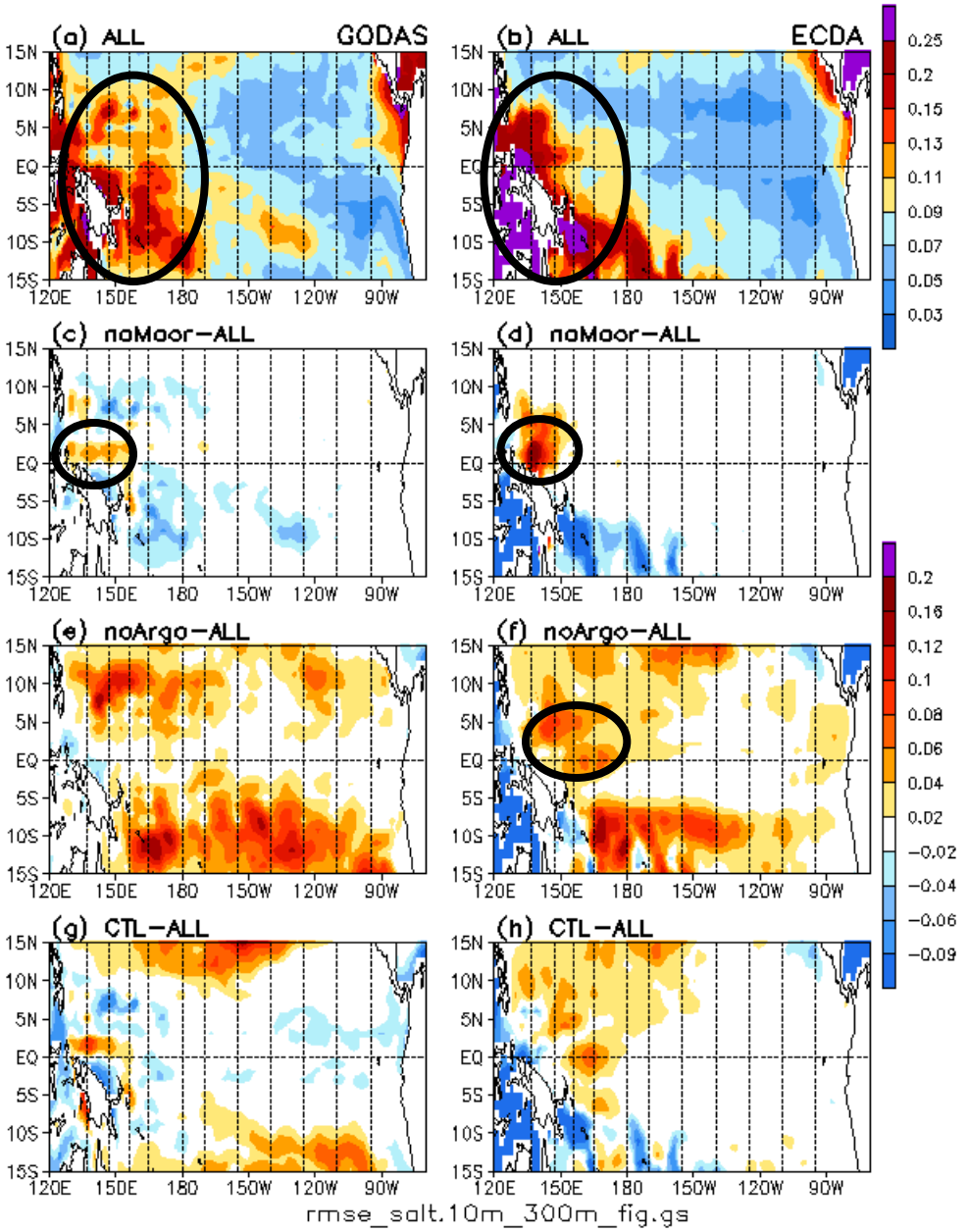
NCEP GFDL

All in situ obs. included

Impacts of withholding TAO

Impacts of withholding Argo

Impacts of withholding both TAO and Argo



RMSE of Surface Zonal Current

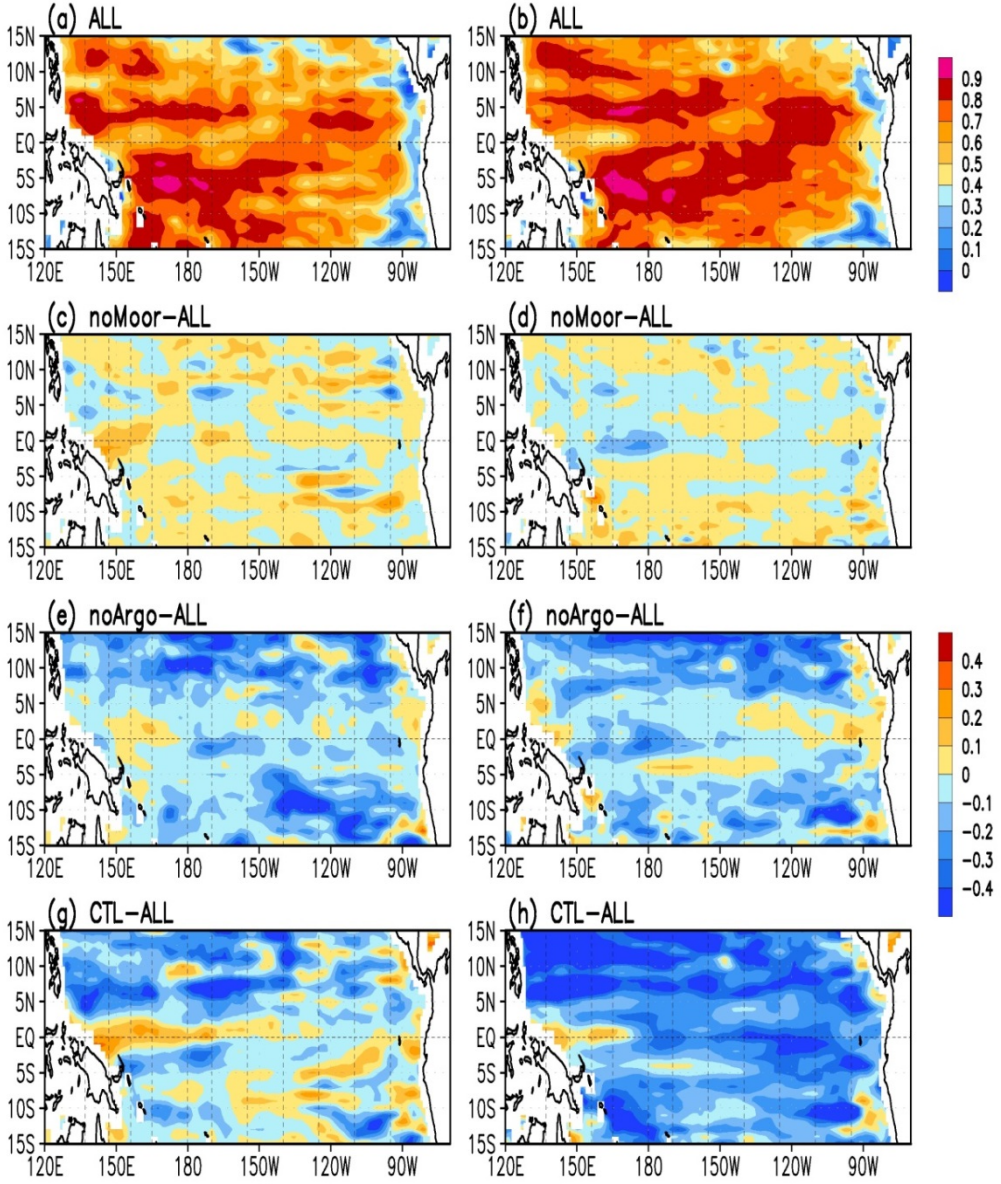
NCEP GFDL

All in situ obs. included

Impacts of withholding TAO

Impacts of withholding Argo

Impacts of withholding both TAO and Argo



Summary of NOAA OSE Project

- **Without assimilation of any in situ data, both GODAS and ECDA had large mean biases, STD biases and RMSE.**

- **Assimilation of in situ data significantly reduced mean biases, STD biases and RMSE in all variables except zonal current at equator.**

- **For constraining temperature analysis, the TAO/TRITON and Argo is complimentary in the equatorial Pacific, and the Argo is critical in off-equatorial regions.**

- **For constraining salinity, sea surface height and surface current analysis, the influence of Argo data is more important. The influence of the TRITON salinity data is critical.**

- **GODAS was more sensitive to withholding Argo data in off-equatorial regions than ECDA. The results suggest that multiple ocean data assimilation systems should be used to assess sensitivity of ocean analyses to changes in the distribution of ocean observations.**

Xue et al. 2015: Evaluation of Tropical Pacific Observing Systems Using NCEP and GFDL Ocean Data Assimilation Systems. Climate Dynamics, Online

Thanks!

Recommendations for Ocean Observing Systems from CPC's Perspective

- **Both mooring and Argo data are needed to constrain large model biases.**
- **The impacts of TAO/TRITON are largest in the far western and eastern equatorial Pacific based on GFDL and NCEP data assimilation systems. So the moorings in those regions are recommended to be given a high priority.**
- **Paired temperature and salinity profiles such as those from Argo are easier than temperature-alone profiles to be assimilated by data assimilation systems. So more paired T/S profiles are recommended.**
- **Salinity observations are very sparse before 2004 and continuous salinity profiles should be maintained so that a long record of high quality salinity analysis can be made.**
- **Current observations at the TAO/TRITON moorings should be continued since they are critical in validation of ocean current analysis.**
- **Surface fluxes in NCEP reanalysis products have large uncertainties. The TAO/ TRITION flux products should be continued since they are critical in validation of NCEP fluxes (SW, LW, LH, SH, humidity, surface winds).**
- **Quantities to better define mixed layer depth and ocean velocity including entrainment velocity, and to help improve ocean model parameterizations.**