Real-time Ocean Reanalyses Intercomparison Project (RT-ORA-IP)

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Why RT-ORA-IP?
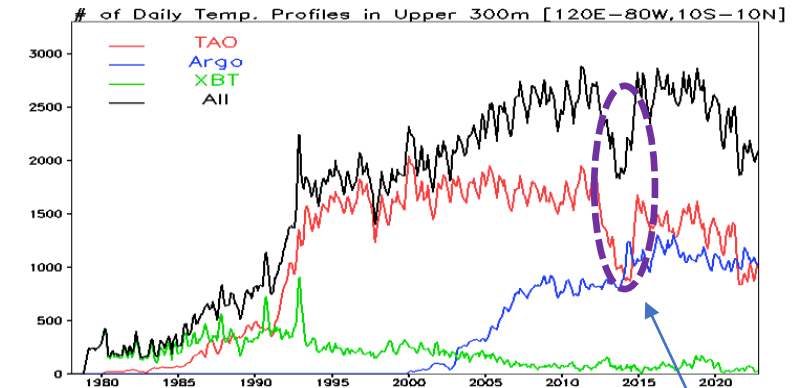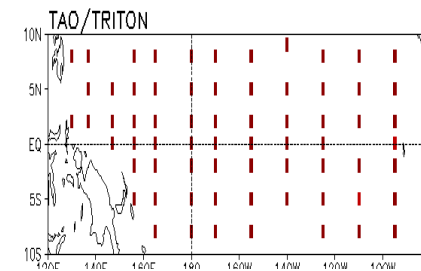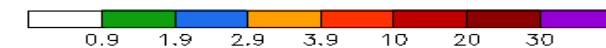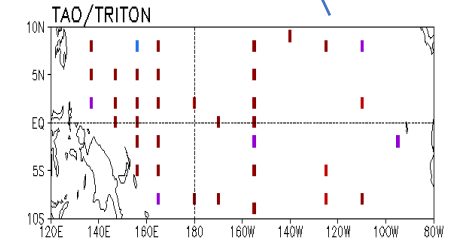
- How do variations in Tropical Pacific Observing System (TPOS) influence the ocean reanalysis and ENSO predictions?
- Extend CLIVAR-GSOP/GODAE OceanView Ocean Reanalyses Intercomparison Project (ORA-IP) to real time.

Objectives

- **Deliver ensemble ocean monitoring products in real time**

- **Quantify uncertainties in temperature analysis of tropical Pacific in support of ENSO monitoring and prediction**

- **Understand how variations in observing systems influence uncertainties in ocean reanalyses**

- **Provide support for the TPOS 2020 project on the design of the future tropical Pacific observing system**

- **Provide a sanity check for potential issues among various ocean reanalysis**
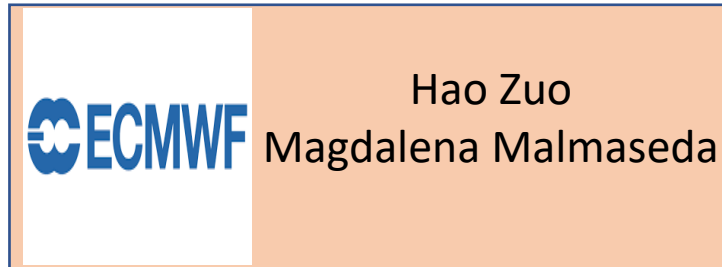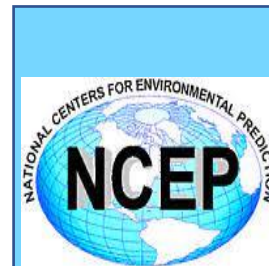
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Operational Ocean Reanalyses

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
NCEP (CFSR)	3D-VAR	T/SST	No	0.5°x1/4°	1979-present	2011	Xue et al. (2011
✴ ECMWF (ORAS5)	3D-VAR-FGAT	T, S, SST	Yes	0.25°x0.25°	1979-present	2019	Zuo et al. (2019)
✴ JMA (MOVE-G2)	3D-VAR	T, S, SST	Yes	1°x0.5°	1979-present	2009	Toyoda et al. (2013)
✴ GFDL (SPEAR-ECDA)	EnKF coupled	T, S, SST	Yes	1°x 1° (1/3° near Eq)	1993-present	2021	Lu et al. (2020)
NASA	EnOI Partially coupled	T, S, SST	Yes	1/2°x 1/2° (1/4° near Eq)	1980-present	2011	Rienecker at al. (2011)
✴ BOM (ACCESS-S2)	EnKF	T, S, SST	No	1/4°x 1/4 °	1981-preesnt	2022	Cowan et al. (2022)
✴ 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	??	??

Deliver monthly subsurface temperature, 300m heat content and D20 anomaly at the beginning of each month

Project Web Site

Realtime updates for

- **Tropical Pacific Ocean**
- Tropical Atlantic Ocean
- Global Ocean

Plots include

- Spatial distribution
- Hovemoller diagram
- ENSO precursors
- x-z cross-sections
- Time series of climate indices
- Influence of ocean observations on spread among ocean reanalyses

https://www.cpc.ncep.noaa.gov/products/GODAS/
multiora93_body.html

Real Time Multiple Ocean Reanalysis Intercomparison

(with contributions from NCEP, ECMWF, JMA, GFDL, NASA, BOM, MET, MERCATOR, based on 1993-2013 Climatology)

(Background Information , Reference)

Tropical Pacific Ocean

- **Spatial Maps**
  - Temperature anom. in 1S-1N (X-Z section): last month   month before last month   1993-present
  - Temperature anom. tendency in 1S-1N (X-Z section): last month   month before last month   1993-present
  - Temperature anom. in 5S-5N (X-Z section): last month   month before last month   1993-present
  - Temperature anom. at z=5m(X-Y section): last month   month before last month   1993-present
  - Depth of 20C isotherm anomaly: last month   month before last month   1993-present
  - Upper 300m heat content anomaly: last month   month before last month   1993-present
  - Tropical Cyclone Heat Potential anomaly: last month   month before last month   1993-present

- **Hovemoller Plots**
  - Upper 300m heat content anomaly in 5S-5N: last month   1993-present
  - Depth of 20C isotherm anomaly in 5S-5N: last month   1993-present

- **ENSO Precursors** (Description)
  - Last three month Ensemble Mean D20 anomaly
  - Equatorial zonal wind stress, D20 and off-equatorial D20 anomaly : last four years   1993-present
  - WWV and CTP time series: last four years   1993-present   WWV Data   CTP Data
  - WWV, CTP and ENSO: 1993-present   Latest Predictions

- **Climate Indices**
 - Upper 300m heat content anomaly average in Pacific: last 4 years   1993-present

- **Influences of ocean observations on spread among ocean reanalyses**
  - Spread of D20 anomaly and Spatial distribution of temperature profile #: last month   month before last month   1993-present
  - Spread of upper 300 heat content anomaly and spatial distribution of temperature profile #: last month   month before last month   1993-present
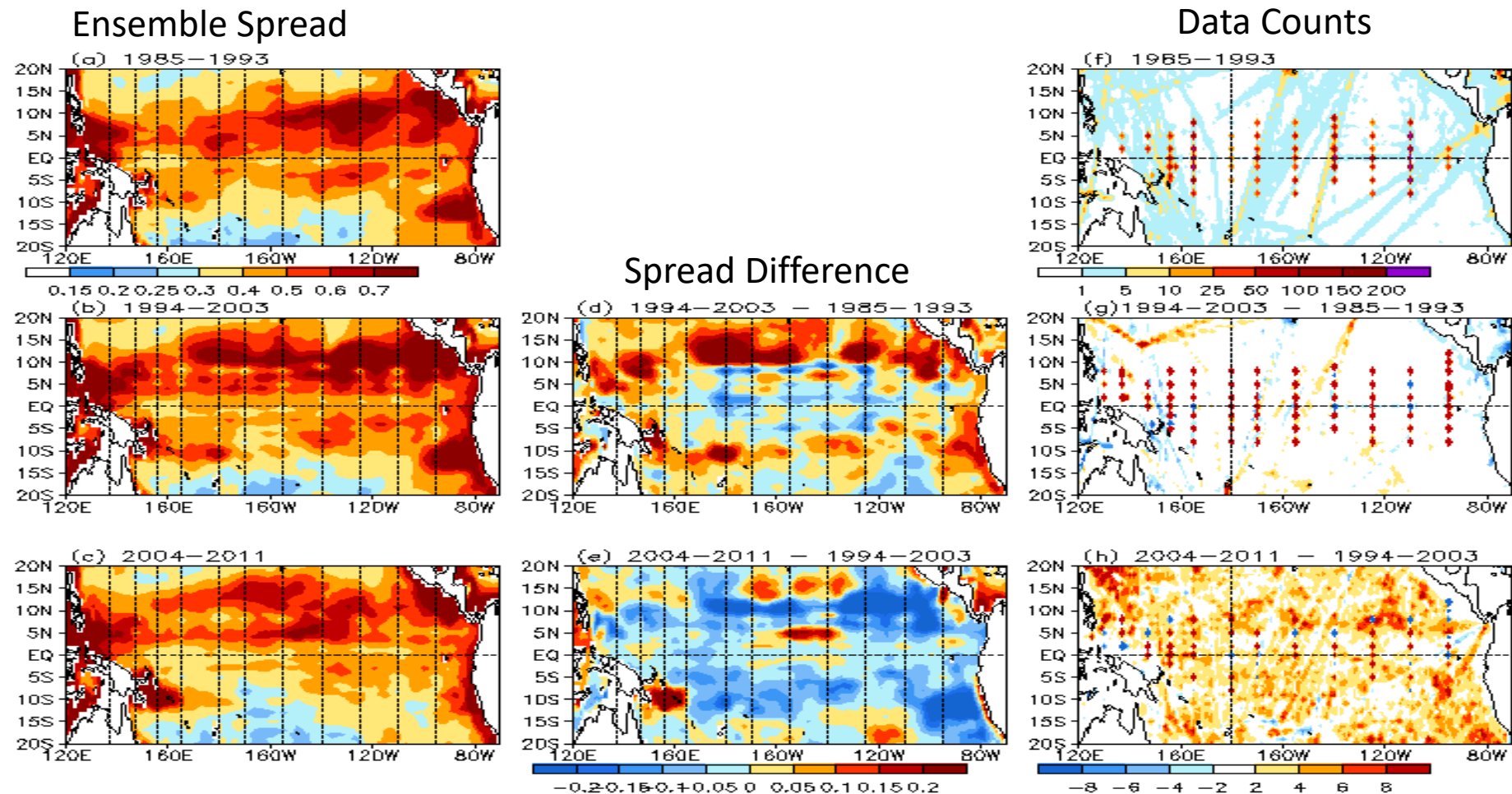
Uncertainties in Ocean Reanalyses

(Normalized RMSD (%) against TAO/TRITON Temp)
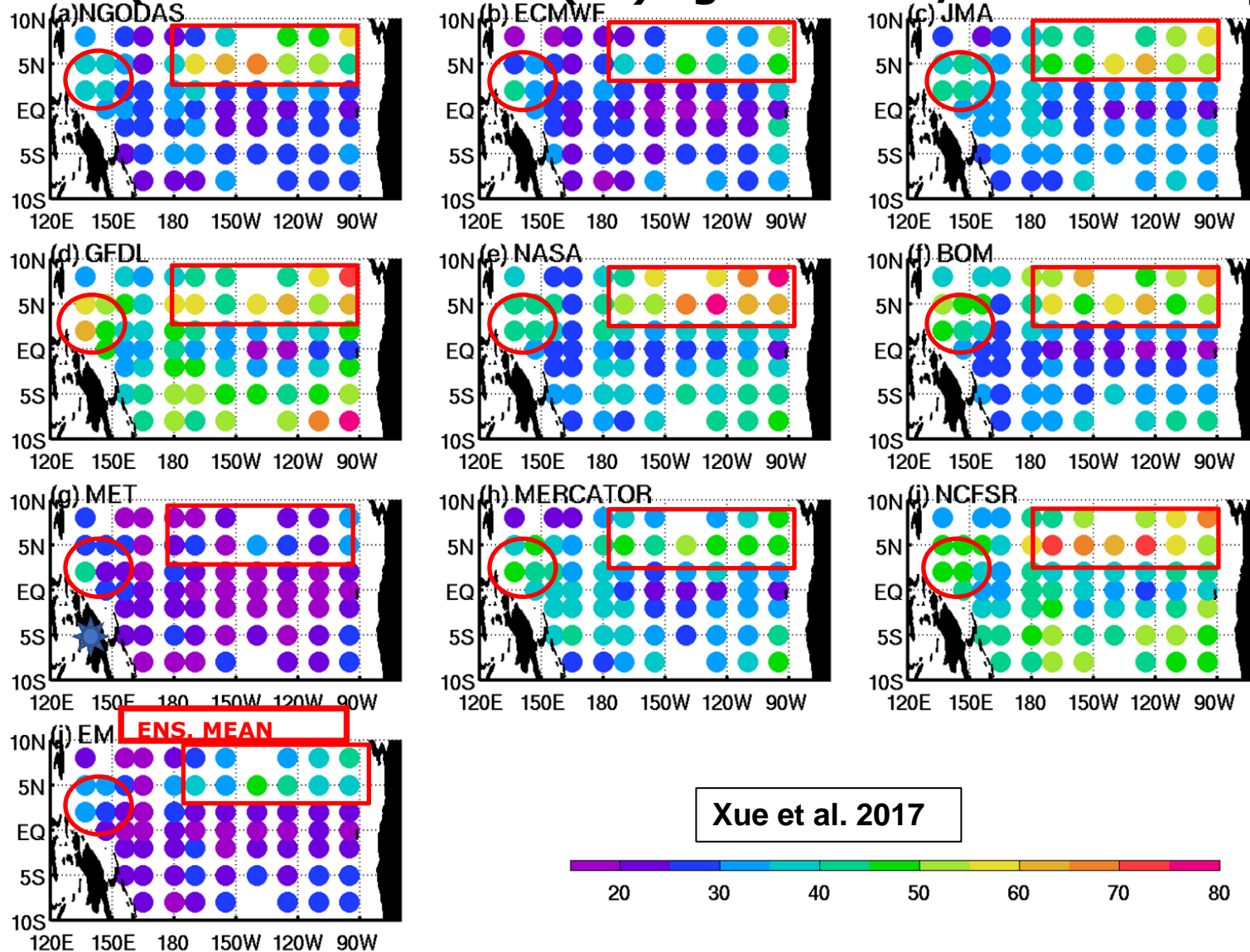
- The ensemble mean among ocean reanalyses provides a more reliable estimate of climate signal.

- The ensemble spread provides an estimate of uncertainties.

Xue et al. 2017

Impacts of TPOS Data on Ensemble Spread

Ensemble Spread
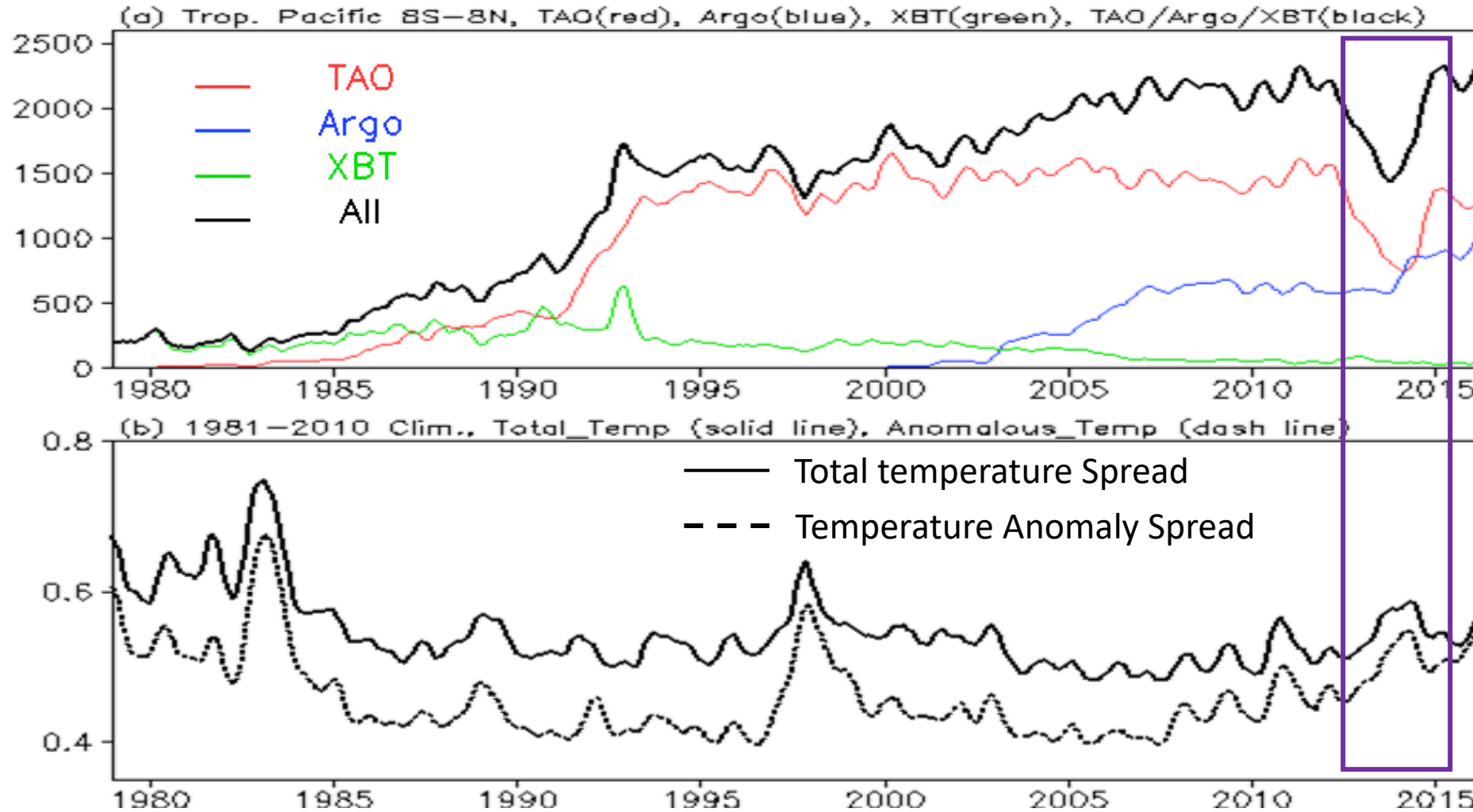
Data Counts

Spread Difference

Xue et al. 2017

- **The full deployment of TAO array significantly reduced the analysis uncertainty in the deep tropics.**
- **Argo data helped to reduce the analysis uncertainty between 9º-15º.**

Impacts of TPOS Data on Ensemble Spread

(a) Trop. Pacific 8S-8N, TAO(red), Argo(blue), XBT(green), TAO/Argo/XBT(black)

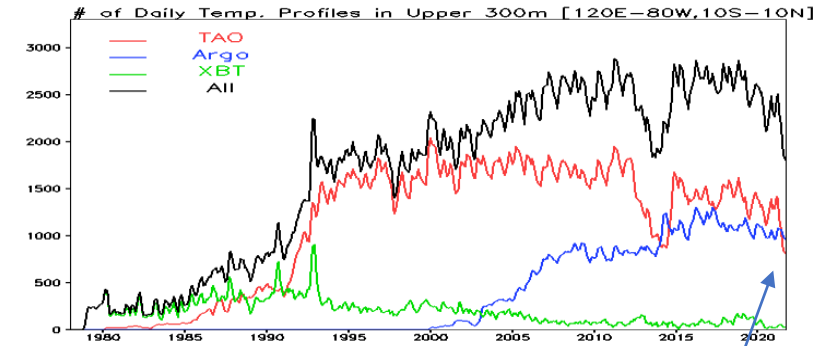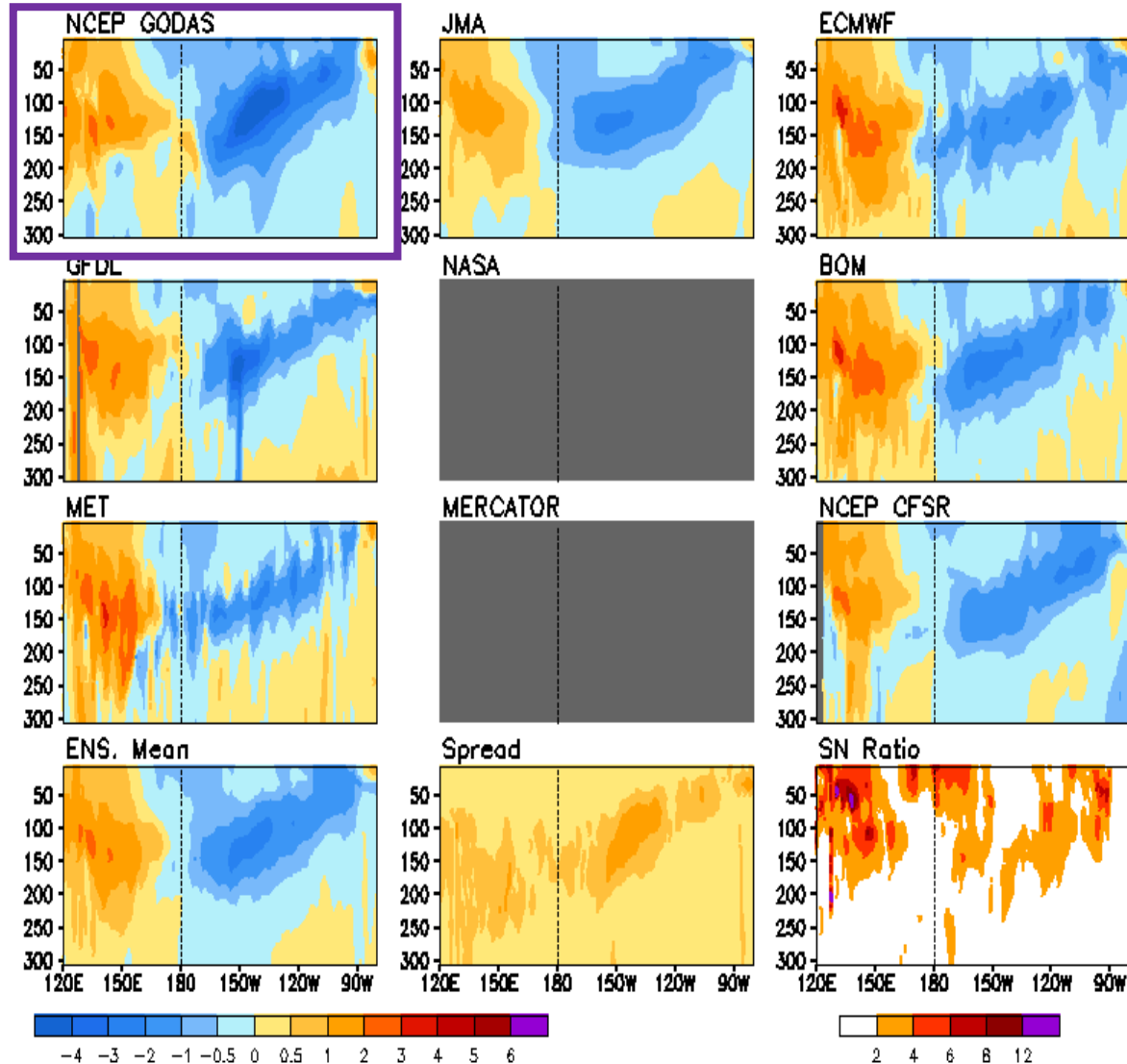(b) 1981-2010 Clim., Total_Temp (solid line), Anomalous_Temp (dash line)

- **The ensemble spread is linked to the TPOS data counts, which highlights the importance of long-term stability of TPOS.**
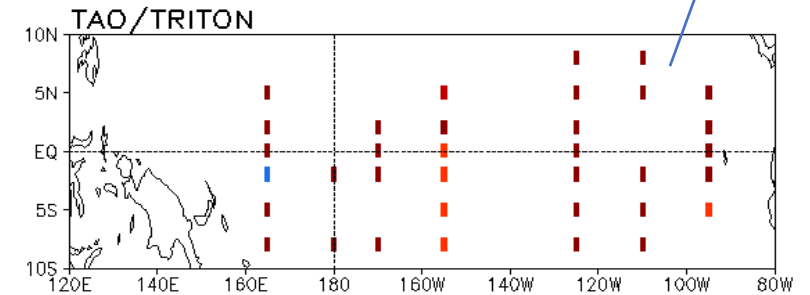
ENSO Monitoring and Prediction

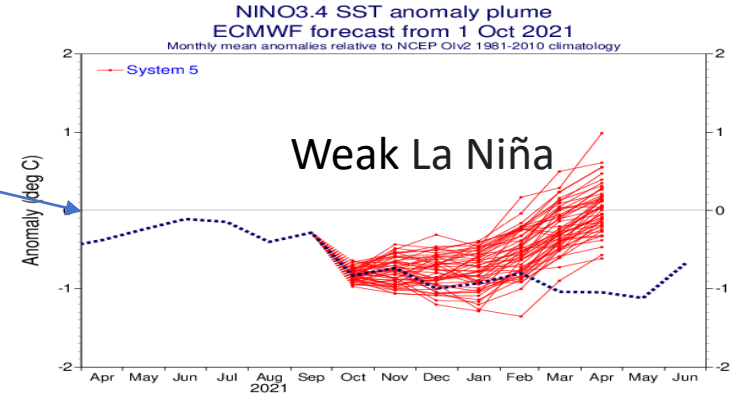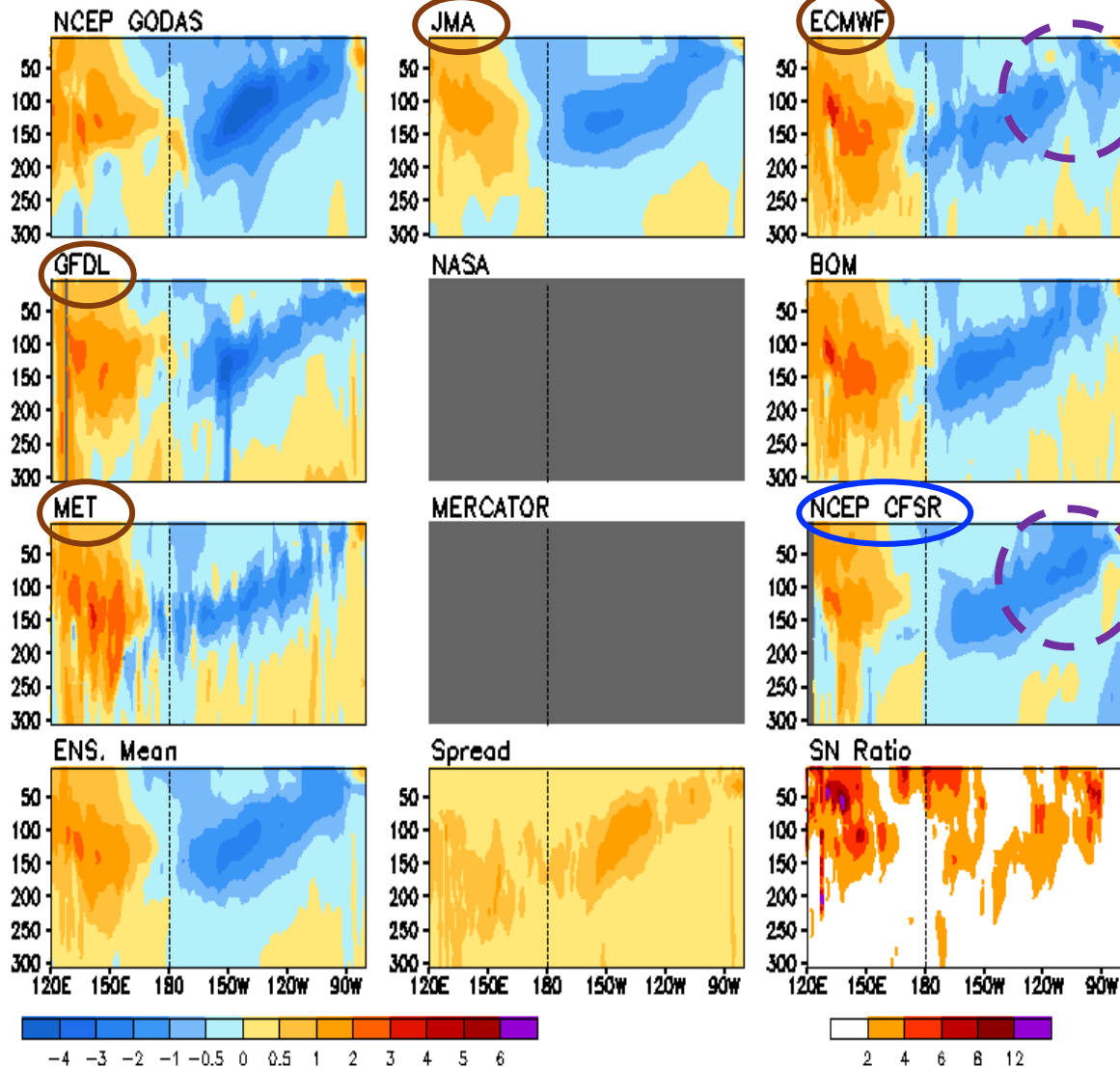Outlier

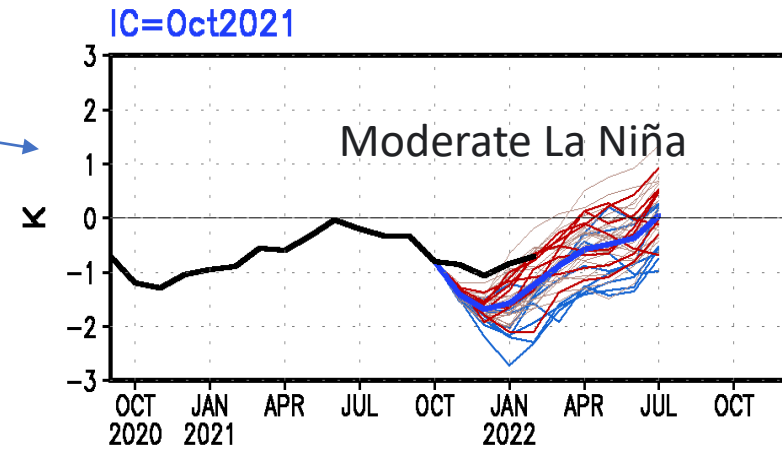Anomalous Temperature (C) Averaged in 1S-1N: SEP 2021

- **The performance of GODAS is highly dependent on the availability of TAO data.**
- **GODAS had high chance to develop large cold bias due to the rapid decline of mooring profiles.**

ENSO Monitoring and Prediction

https://charts.ecmwf.int/products/seasonal_system5_nino_plumes

https://www.cpc.ncep.noaa.gov/products/people/mchen/CFSv2FCST/verification/

ENSO Monitoring and Prediction

Oceanic ENSO Precursors

Anomalous Depth (m) of 20C Isotherm
(Hatched areas : Signal/noise >1)

Anomalous Depth (m) of 20C Isotherm Averaged in [120E–80W, 5S–5N]

Warm Water Volume
(Meinen and McPhaden 2000)

Anomalous Depth (m) of 20C Isotherm Averaged in [160W–110W, 10S–10N]

Central Tropical Pacific Index
(Wen et al. 2014, Wen et al. 2021)

Red box: Warm Water Volume Precursor   Blue box: Central Tropical Pacific Precursor

— NCEP   — JMA   — ECMWF   — GFDL   — NASA   — BOM   — MET   — CFSR   — MERCATOR   (shading) ENM

Future Work

❑ Continue to deliver real-time information to the user community for ENSO monitoring and prediction

❑ Develop real-time ensemble monitoring products to monitor climate variability beyond ENSO

❑ Develop web-based real-time interface to deliver observation-model comparison assessment

❑ Participate in collaborative efforts to assess the future design of the tropical Pacific observing system.

❑ Expand the analysis and monitoring beyond the tropical Pacific