

Next Generation Global Ocean Data Assimilation System (NG-GODAS): reanalysis and applications

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NOAA/NCEP/CPC

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Support from GOMO and CVP/CPO is acknowledged for the work

Outline

- Background
- A pilot 40-year reanalysis
- Two application examples:
 - OSSEs for Tropical Pacific Observing System
 - Sea ice hindcasts
- Summary

Current NOAA operational ODA systems

- ❑ **GODAS and CFSR:** 2 different, but related systems;
- ❑ **Supports various climate services**
 - **Monitoring:** **GODAS** is used for ocean/ENSO and MJO monitoring
 - **Prediction:**
 - Foundational for supporting climate predictions (e.g., ENSO, Hurricane outlook, T/P seasonal predictions, drought outlook)
 - **CFSR** is used for initializing the climate prediction system (i.e., CFSv2)

Ocean monitoring



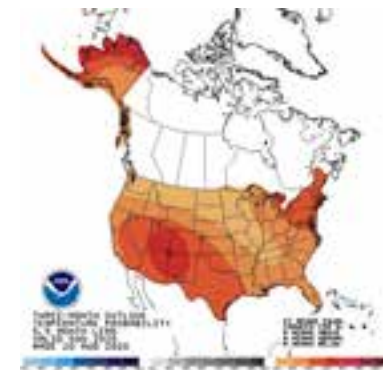
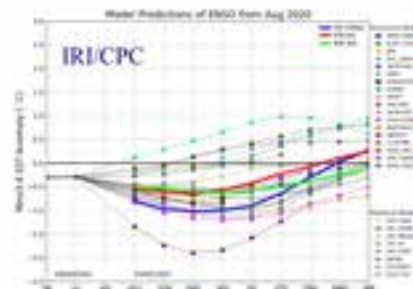
ENSO

ENSO: Recent Evolution, Current Status and Predictions



T/P Seasonal predictions

ENSO predictions



Hurricane



NOAA predicts above-normal 2022 Atlantic Hurricane Season

Ongoing La Niña, above-average Atlantic temperatures set the stage for busy season ahead

The NCEP is the first center that used ocean data to initialize a coupled global climate model-based operational system (Ji, Kumar and Leetmaa 1994).

Current NOAA operational ODA systems

Limitations of GODAS/CFSR (motivation for NG-GODAS):

- ✓ **No major upgrade since 2003** (2011 for CSFR)
- ✓ Old model system: MOM3/4
- ✓ Univariate background error covariance
- ✓ Only assimilates in situ temperature
- ✓ Lack of realistic salinity variability
- ✓ limited observation types: no altimetry, no sea-ice for GODAS
- ✓ low resolution: 1degree (GODAS)/0.5 degree (CFSR)
- ✓

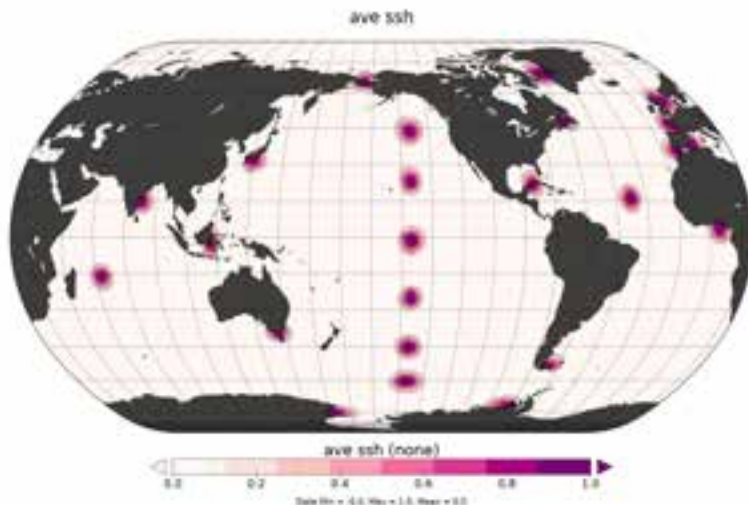
A JEDI-based Ocean Data Assimilation System: *next generation Global Ocean Data Assimilation System (NG-GODAS)*

- Model: DATM-MOM6-CICE6 (1/4 and 1-degree)
- DA algorithm: JEDI-SOCA 3D-Var

B-matrix in SOCA is given by $\mathbf{B} = \mathbf{KDC}_V\mathbf{C}_H\mathbf{C}_V^T\mathbf{DK}^T$

- \mathbf{K} : balance operators (e.g., T-S relationship);
- D : standard deviation of background error for T/S;
- C_V : a vertical correlation operator;
- C_H : a horizontal correlation operator (an external package BUMP with length scale scaled by the Rossby radius of deformation).

BUMP based Correlation modelling



Correlation similar to diffusion operator,
but perfectly normalized correlation
operator

**BUMP (Benjamin Menetrier) Correlation on
the 1/4 degree MOM6 tripolar grid**

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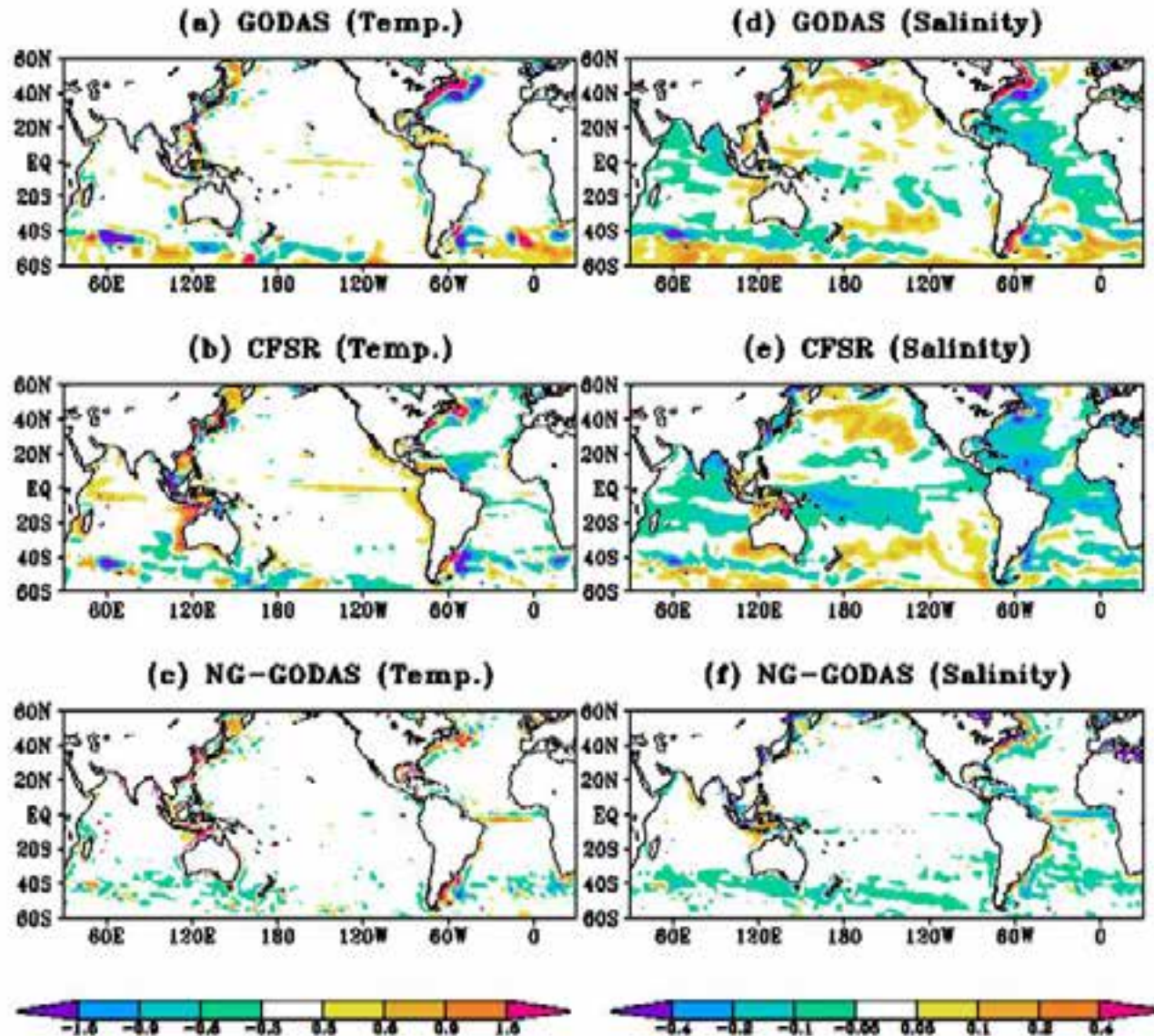
A pilot reanalysis run

- A joint effort of EMC/CPC/JCSDA
- Model: DATM-MOM6-CICE6 (1-degree)
- DA algorithm: JEDI-SOCA 3D-Var
- Atmospheric forcing: CFSR (1979/01-2000/12)+GEFS (2001/01-2019/08);
- Ocean/sea ice obs.:

Obs type	Date
ADT	1993-2020 (NESDIS)
Satellite SST (AVHRR)	1981-200208 (ESACCI L3U), 200208-201811 (NESDIS L3U)
Insitu (T&S)	1979-2020 (WOD)
SSS	SMOS ESA L2 (2010-2020), SMAP RSS/JPL L2 (2015-2020)
Sea ice Conc	NSIDC L3 SSMR, SSMI (1979-200305), EMC L2 (200306-2020 SSMI, SSMIS)

NG-GODAS/NOAA-ODAs: compared with UK-MET EN4

Mean Diff. w.r.t EN4 during 2001–2019: 0–300m

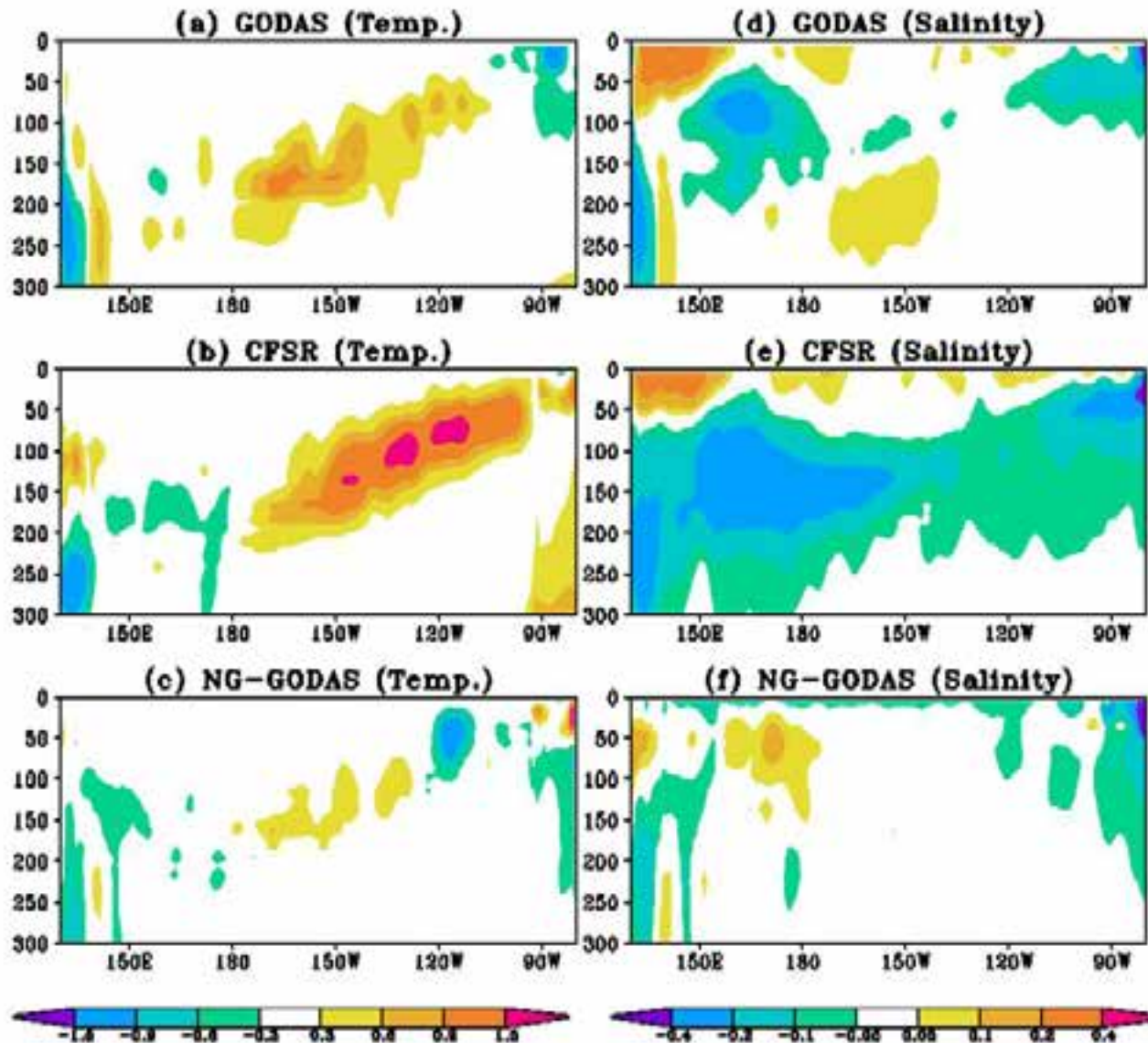


- Mean biases **at upper ocean** (particularly in salinity):

CFSR > GODAS > NG-GODAS

NG-GODAS/NOAA-ODAs: compared with UK-MET EN4

Mean Diff. w.r.t EN4 during 2001–2019: Eq

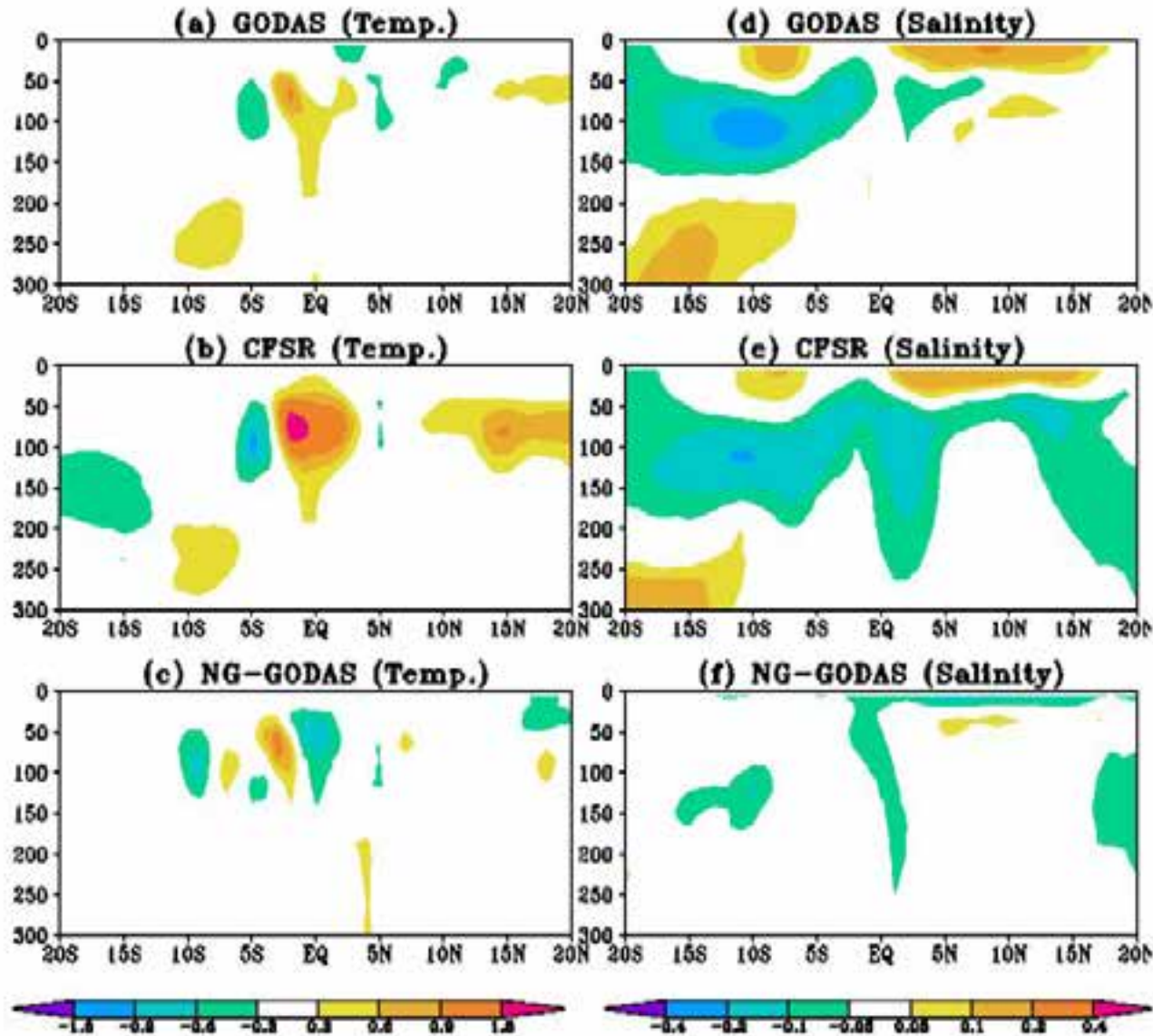


- Mean biases along the equatorial Pacific:

CFSR > GODAS > NG-GODAS

NG-GODAS/NOAA-ODAs: compared with UK-MET EN4

Mean Diff. w.r.t EN4 during 2001–2019: 115°W



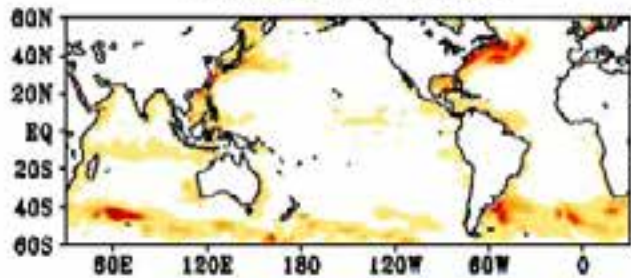
- Mean biases along a meridional section in the eastern Pacific:

CFSR > GODAS > NG-GODAS

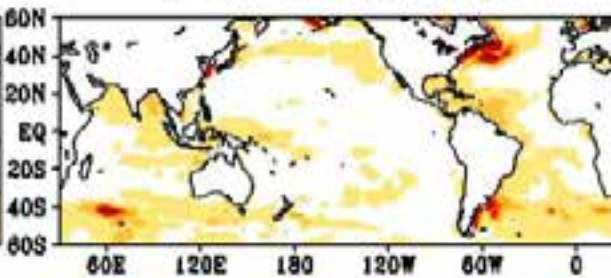
NG-GODAS/NOAA-ODAs: compared with UK-MET EN4

RMSE w.r.t EN4 during 2001–2019: 0–300m

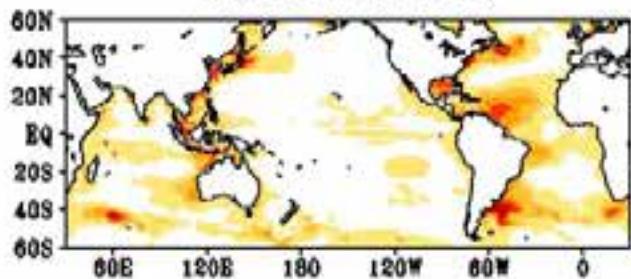
(a) GODAS (Temp.)



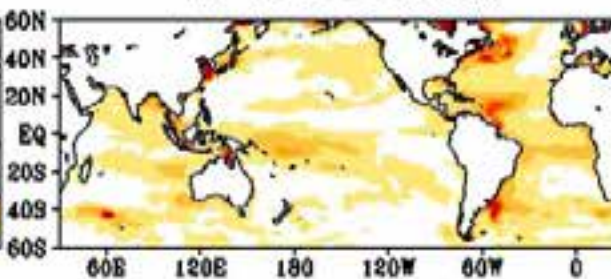
(d) GODAS (Salinity)



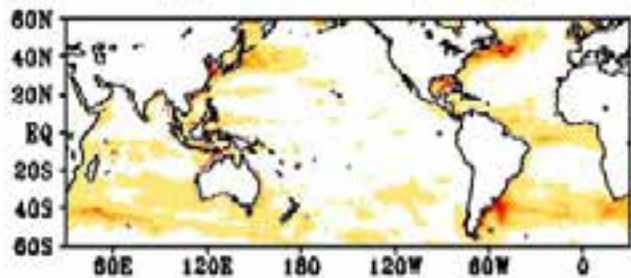
(b) CFSR (Temp.)



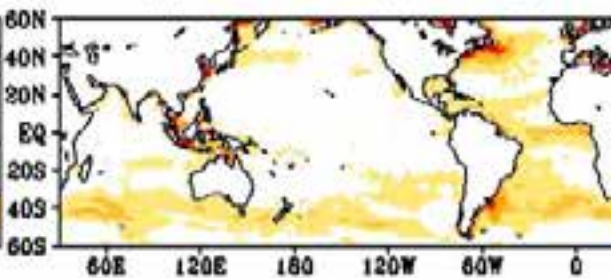
(e) CFSR (Salinity)



(c) NG-GODAS (Temp.)



(f) NG-GODAS (Salinity)

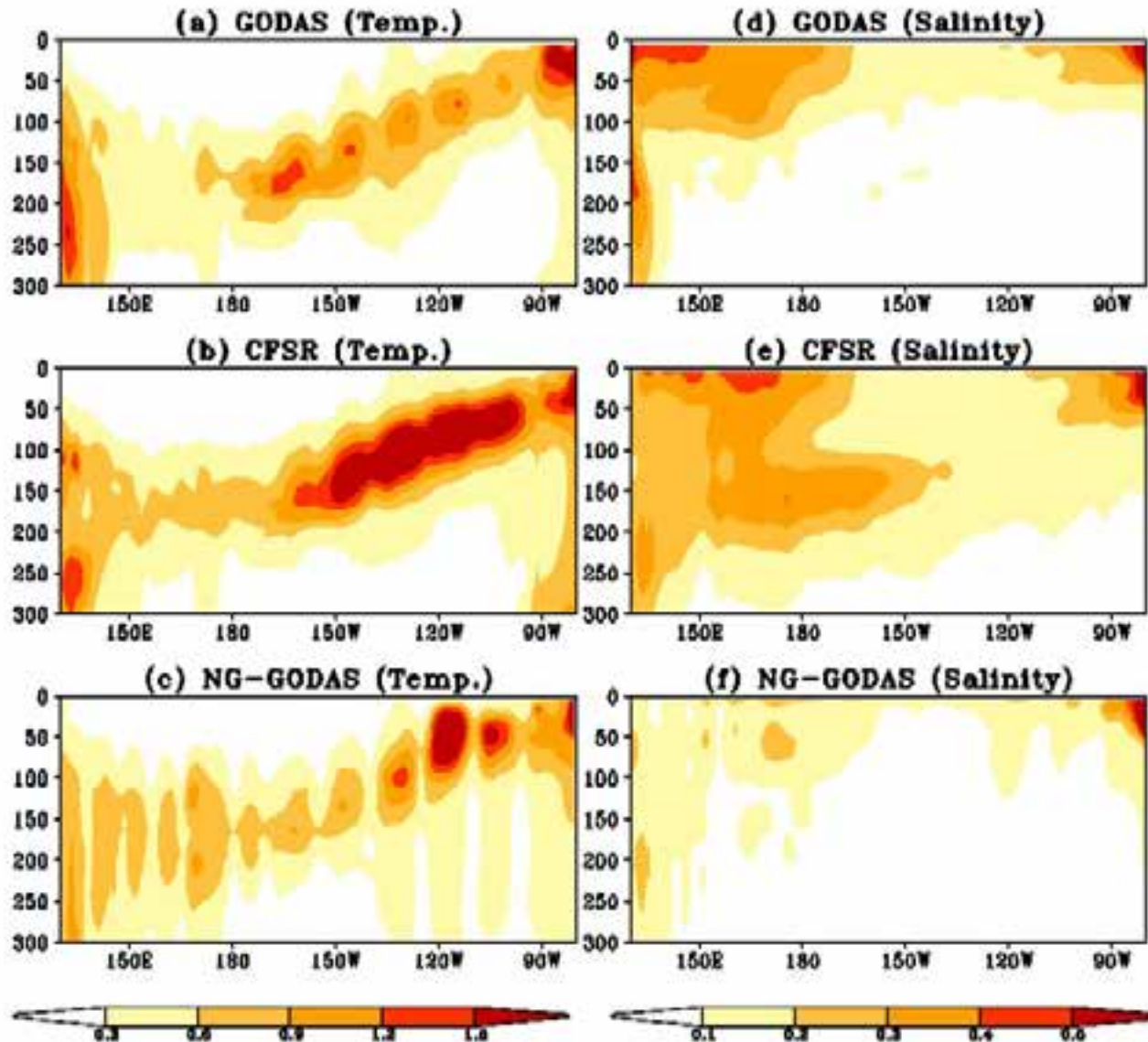


- RMSE at upper ocean (particularly in salinity):

CFSR > GODAS > NG-GODAS

NG-GODAS/NOAA-ODAs: compared with UK-MET EN4

RMSE w.r.t EN4 during 2001–2019: Eq

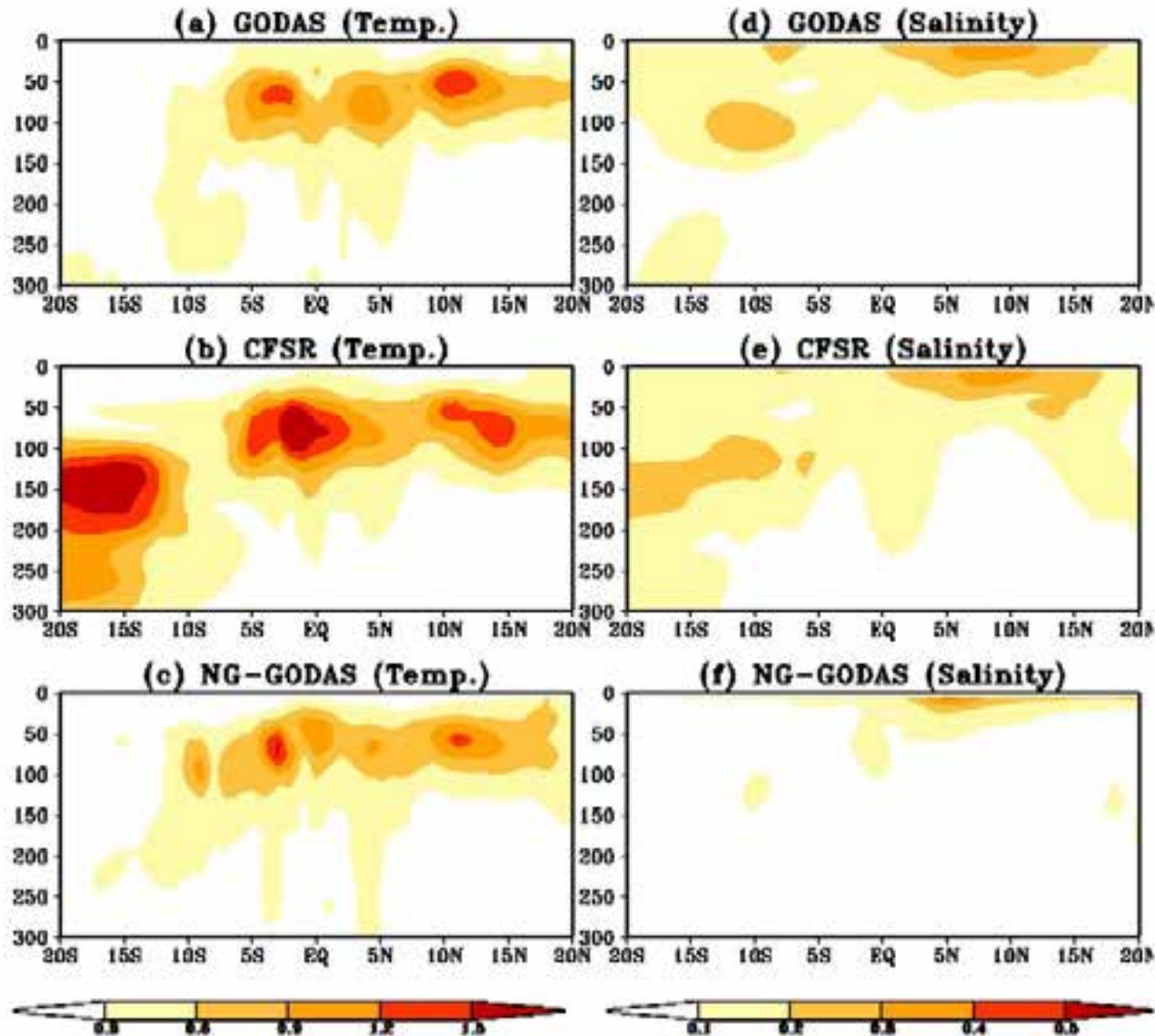


- RMSE along the equatorial Pacific (particularly in salinity):

CFSR > GODAS > NG-GODAS

NG-GODAS/NOAA-ODAs: compared with UK-MET EN4

RMSE w.r.t EN4 during 2001–2019: 115°W



- RMSE along a meridional section in the eastern Pacific (particularly in salinity):

CFSR > GODAS > NG-GODAS

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Oceanic OSSEs in support of the TPOS 2020 Project

- **TPOS 2020 Project:**

- Recommended by an international TPOS workshop in Jan. 2014, La Jolla, CA.
- To propose a redesign of TPOS that will be more effective, modern and robust.

- **OSSE:** Current Configuration of *in situ* TPOS observations (Zhu et al. 2021)

- TAO/TRITON
- Argo

15 AUGUST 2021

ZHU ET AL.

6797

Roles of TAO/TRITON and Argo in Tropical Pacific Observing Systems: An OSSE Study for Multiple Time Scale Variability

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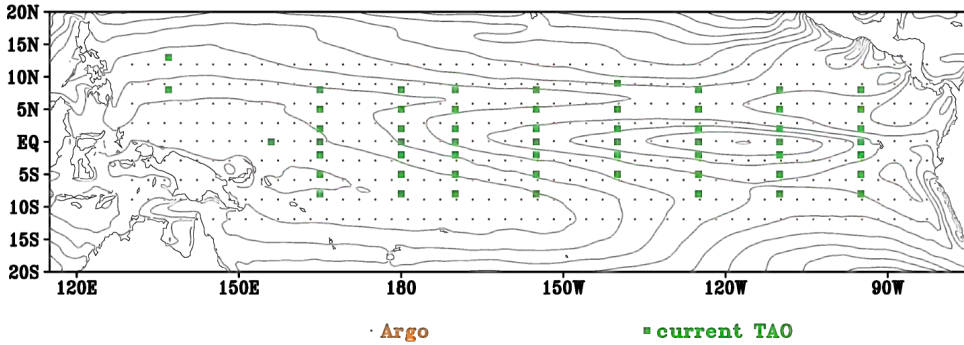
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OSSE studies for the Tropical Pacific Observing System

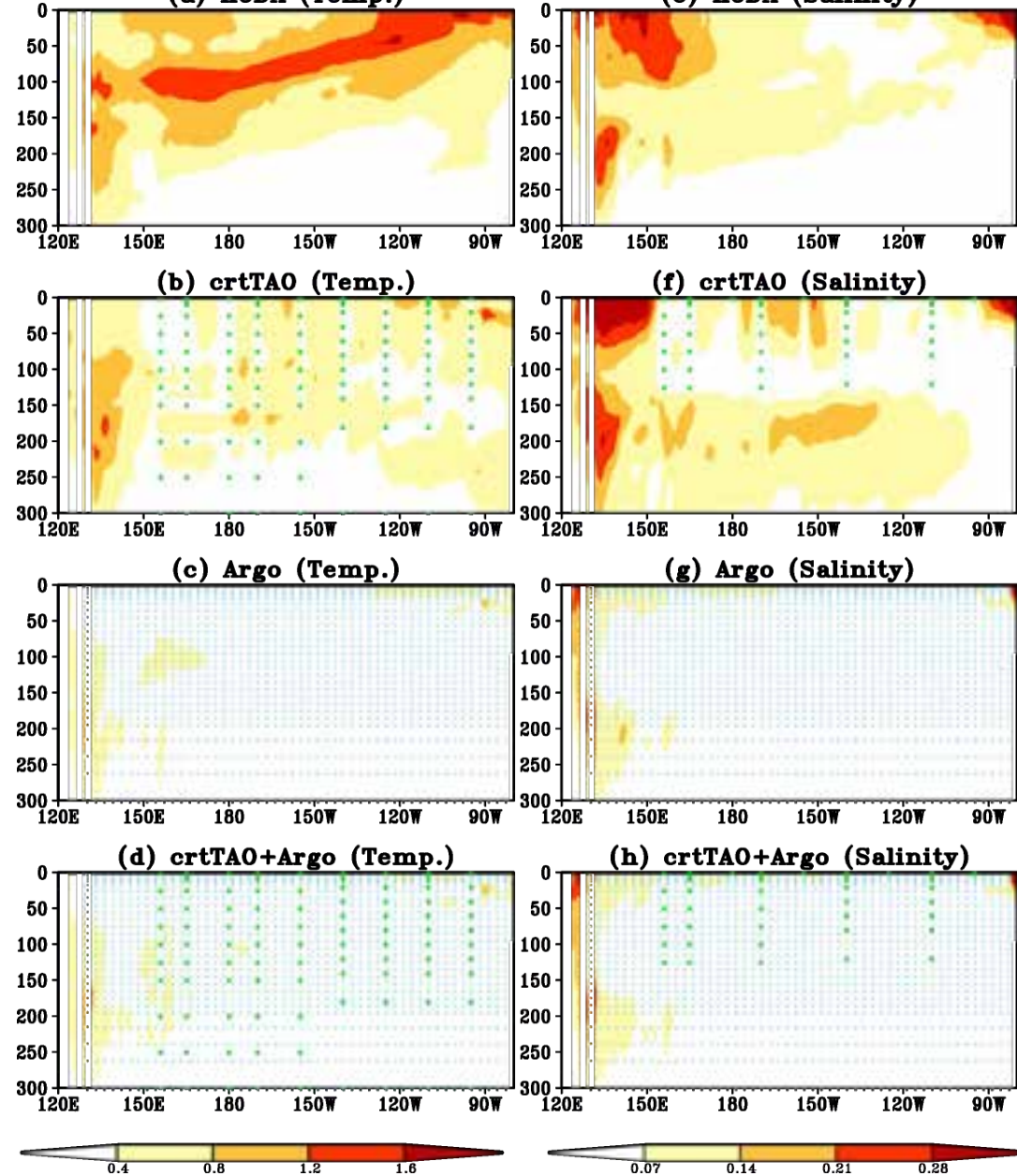
Current TPOS configuration for OSSE



Experiments	Assimilated data
noDA	none
crtTAO	T profiles (a few S) every day with current TAO configurations
Argo	T/S profiles every 3x3 box and every 10 days
crtTAO+Argo	Both TAO and Argo profiles

- **Temp.:** Both TAO and Argo improve the estimate of its LF component (Argo is better)
- **Salinity:** Argo presents the same improvement as in Temp., but TAO presents some improvement only over the upper ocean

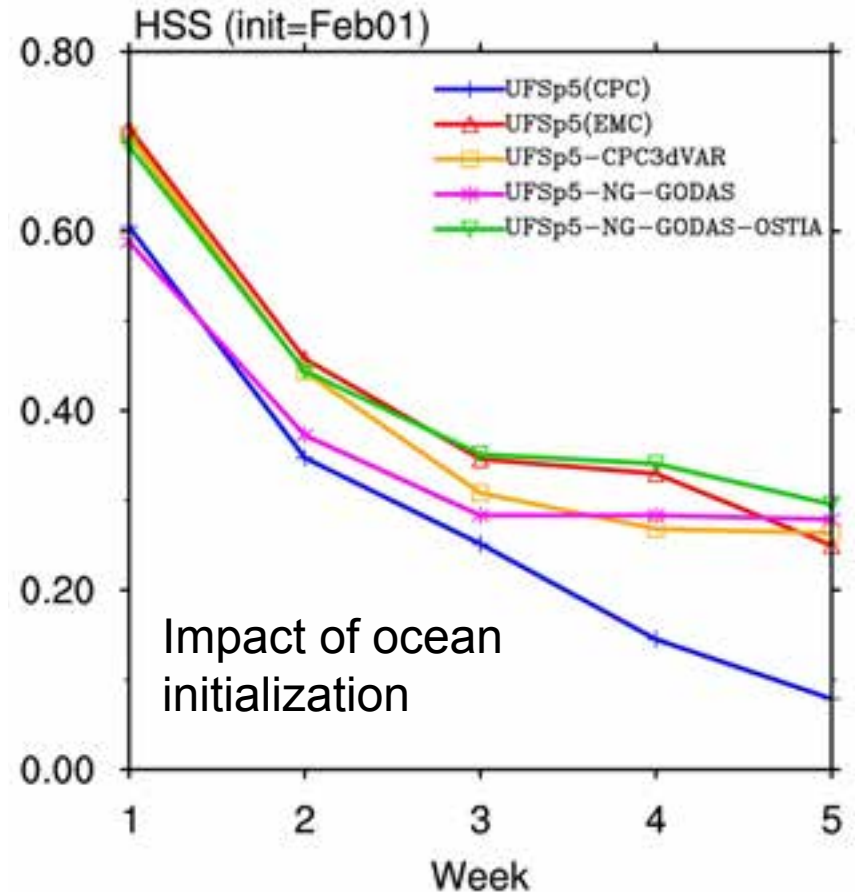
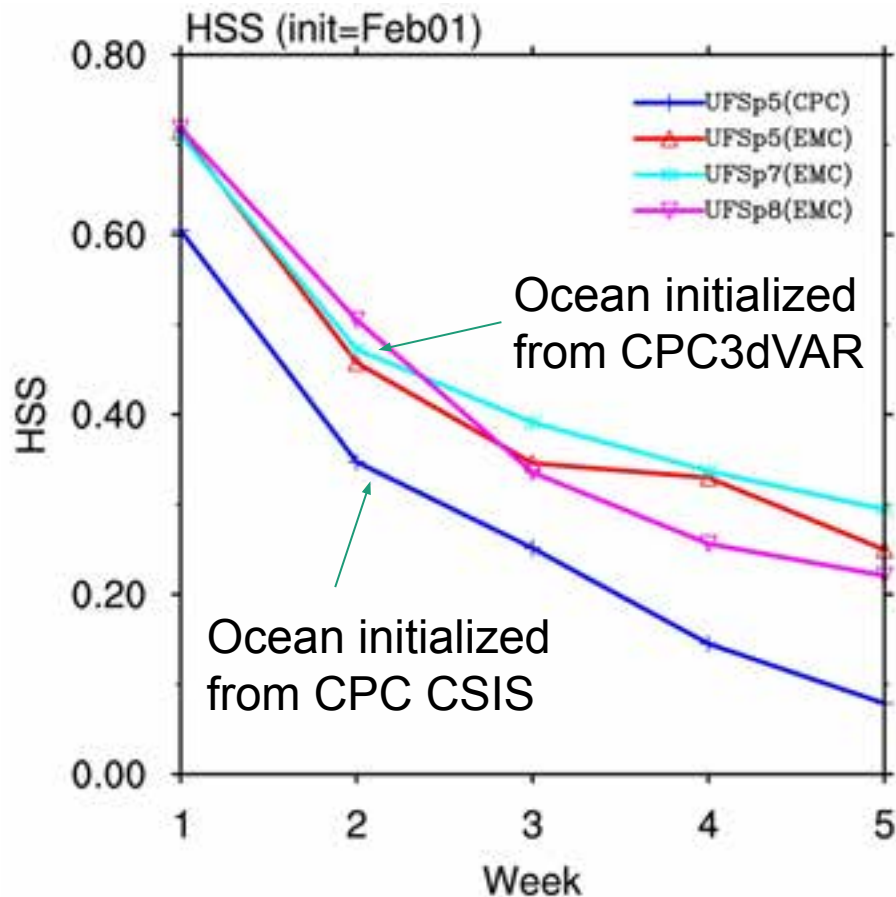
RMSD of Low-frequency component



(Zhu et al. 2021)

Sea ice predictions in UFS prototypes

Sea ice Heidke Skill Score (2012-2018)



- Sea ice forecast skill comparable among UFSp5, UFSp7, UFSp8
- The UFSp5 skill from CPC is lower

- Better skill in UFSp5, UFSp7, UFSp8 was due to the initialization from CPC2dVAR
- **Reasonable skill with initialization from NG-GODAS with OSTIA SST**

Summary...

- A pilot 40-year (1979-2019) ocean reanalysis was completed with NG-GODAS;
- NG-GODAS provides improved analysis results (especially in salinity), vs. the current NOAA operational GODAS/CFSR systems;
- An OSSE capability with NG-GODAS was set up for the tropical Pacific observing system;
- Encouraging results were shown for sea ice hindcasts with NG-GODAS.

Ongoing effort: set up a real-time configuration of NG-GODAS

Thanks!