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AN OPERATIONAL HYBRID 3DVAR/ ENKF OCEAN DATA ASSIMILATION SYSTEM AT NCEP

Image source: NASA Goddard

NGGPS R2O
Jul 16, 2015

MAIN GOALS

Starting from the operational Global Ocean Data Assimilation System (GODAS) baseline:

1. Apply a new scalable ensemble-based ocean data assimilation approach

2. Assimilate new observation data types and improve assimilation of present data

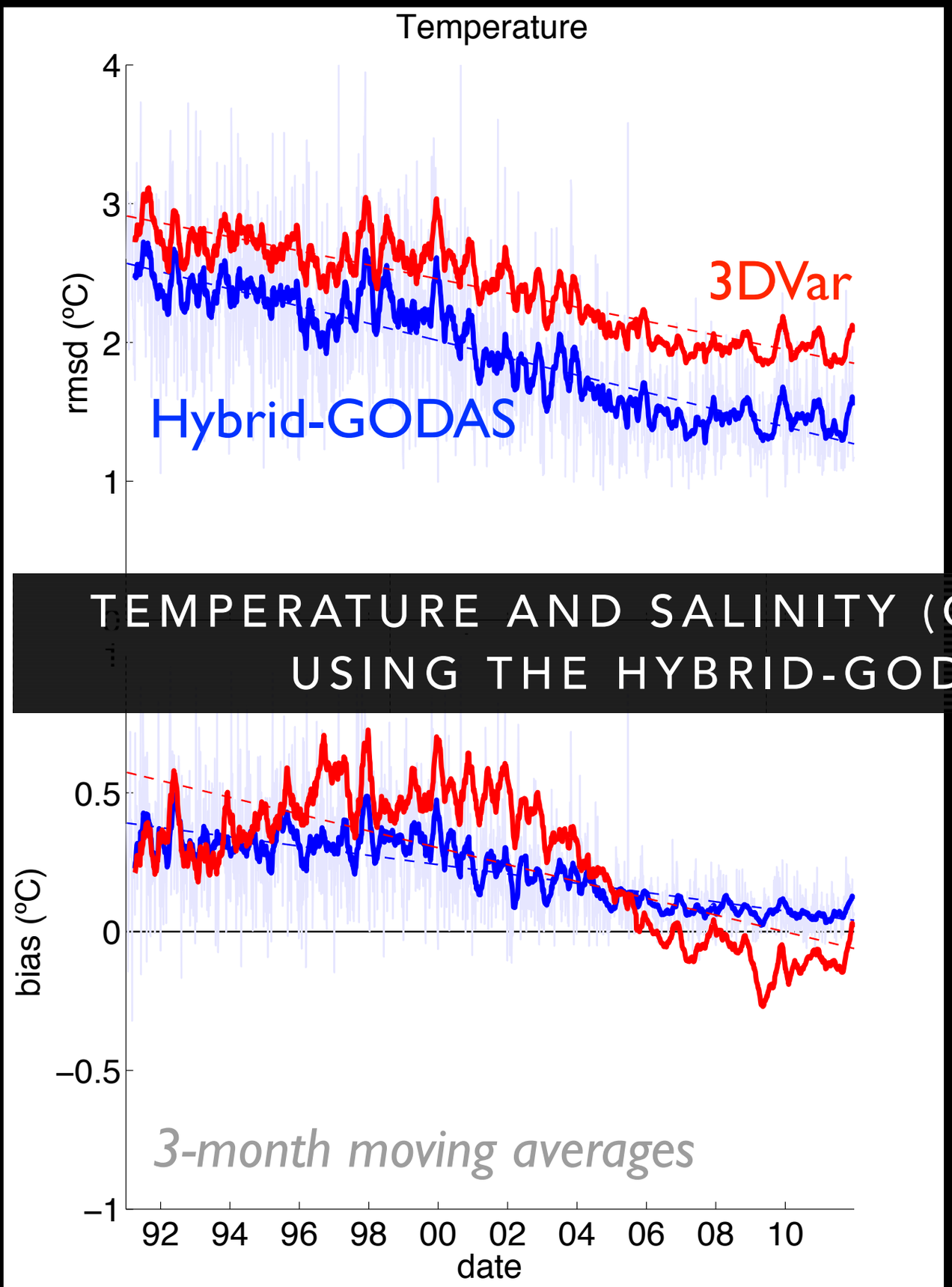
3. Integrate new models at higher resolution

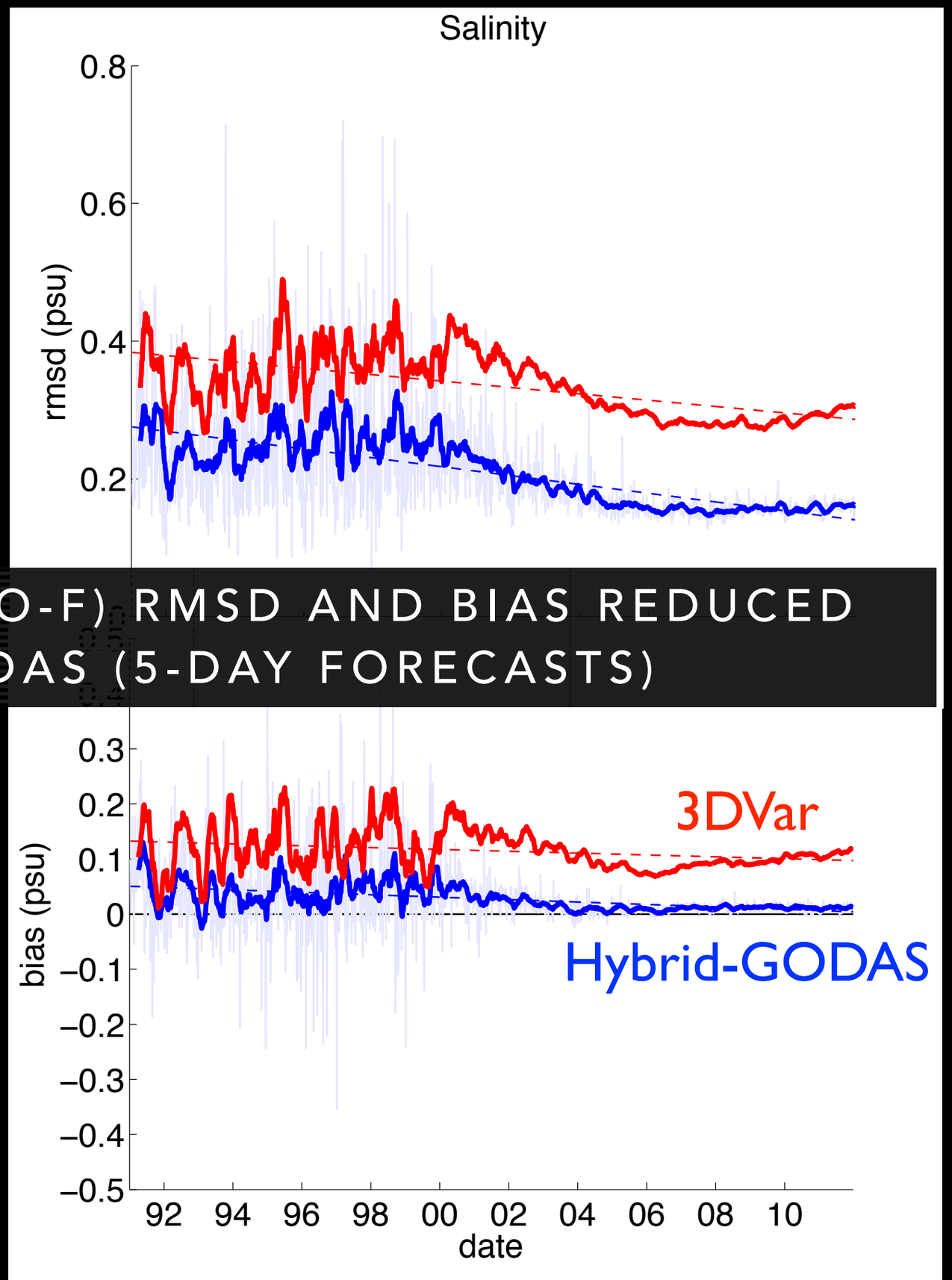
all for implementation in the Next Generation Global Prediction System

TO DATE:

- Oceanic Local Ensemble Transform Kalman Filter (Ocean-LETKF) system (Penny et al., 2013)
- Hybrid-Gain assimilation method (Penny 2014)
- Hybrid Global Ocean Data Assimilation System (Hybrid-GODAS) at NCEP (Penny et al., 2015)
- 21-Year Hybrid GODAS Reanalysis (Penny et al., in preparation)

21-YEAR HYBRID-GODAS REANALYSIS





TEMPERATURE AND SALINITY (O-F) RMSD AND BIAS REDUCED USING THE HYBRID-GODAS (5-DAY FORECASTS)

DATA ASSIMILATION PLAN

ADAPT THE LOCAL **ENSEMBLE** TRANSFORM KALMAN FILTER (LETKF) SOFTWARE TO FACILITATE QUICK ADAPTATION TO NEW DATA AND MODELS

SHIFT TO AN ‘OBSERVATION SPACE’ PARADIGM (SIMILAR TO ATMOSPHERIC DA) AND LEVERAGE THIS FOR **STRONG COUPLING** WITH OTHER COMPONENTS (SEA-ICE, LAND, WAVES, ATMOSPHERE, CHEMISTRY)

OBSERVATION PLAN

- Primary Goal: forward-operator based approach

<u>Observed field</u>:	<u>Present data</u>:
Sea Surface Temperature (SST)	Relaxation to OI analysis
Sea Surface Salinity (SSS)	Relaxation to climatology
Temperature/Salinity Profiles (T/S)	Argo/XBT/TAO/TRITON/etc. interpolated to model levels
Sea Surface Height (SSH)	AVISO TOPEX/Poseidon/ Jason1/Jason2 Altimetry

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Observed field:	Present data:
SST	Relaxation to OI analysis
SSS	Relaxation to climatology
T/S Profiles	Argo/XBT/TAO/ TRITON/etc. at model levels
SSH	AVISO Altimetry

OBSERVATION PLAN

- Primary Goal: forward-operator based approach

Observed field:	Present data:	Phase 1 data:
SST	Relaxation to OI analysis	SST (L2, along track bias corrected)
SSS	Relaxation to climatology	SSS (L3)
T/S Profiles	Argo/XBT/TAO/ TRITON/etc. at model levels	Full-depth Argo
SSH	AVISO Altimetry	SLA (L2, all altimeter satellites, along track)

OBSERVATION PLAN

- Primary Goal: forward-operator based approach

Observed field:	Present data:	Phase 1 data:	Phase 2 data:
SST	Relaxation to OI analysis	SST (L2, along track bias corrected)	SST (L1 and SVP drifters, via NSST model in GFS)
SSS	Relaxation to climatology	SSS (L3)	SSS (L2 orbital/ swath data)
T/S Profiles	Argo/XBT/TAO/ TRITON/etc. at model levels	Full-depth Argo	Full-depth Argo. Model mapped to in situ temperature and salinity
SSH	AVISO Altimetry	SLA (L2, all altimeter satellites, along track)	L1-type data to constrain Sea Level Anomaly (SLA)

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Surface winds		O-F's from diag files	
SVP Drifter			Lagrangian DA of drifter positions

And more: ocean color, gravity, near surface atmospheric measurements

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Observed field:	Present data:	Phase 1 data:	Phase 2 data:
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SSS	Relaxation to climatology	SSS (L3)	SSS (L2)

RETRIEVAL ... ... DIRECT OBSERVATION

T/S Profiles	Argo/XBT/TAO/ TRITON/etc. at model levels	Full-depth Argo	Full-depth Argo. Model mapped to in situ temperature and salinity
SSH	AVISO Altimetry	SLA (L2, all altimeter satellites, along track)	L1-type data to constrain Sea Level Anomaly (SLA)
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MODEL PLAN

ALIGNING WITH THE **NEMS** DEVELOPMENT, WE SHIFT FROM THE OPERATIONAL 1/2° CFS.V2 OCEAN (MOM4P1) TO 1/4° GLOBAL RESOLUTION FOR TWO OCEAN MODELS:

CFS.V3

MOM6-LETKF
(1/4° GLOBAL)

HYBRID-GODAS 3DVAR/LETKF

RTOFS

HYCOM-LETKF
(1/4° GLOBAL)

HYBRID-NCODA 3DVAR/LETKF

Image source: PNNL

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RTOFS

HYCOM-LETKF (1/4° GLOBAL)

HYBRID-NCODA 3DVAR/LETKF

Both have general vertical coordinates and require treatment of variable thickness layers.

Image source: PNNL

SOURCE CODE DEVELOPMENT

- The source code is being transferred to a newly established UMD Github account for UMD/NCEP collaboration and future open source development
- Concurrent Code updates:
  - Adoption of style guide for consistency and readability
  - Reorganization for improved modularity and adaptability
  - Elaboration of inline and external written documentation
  - Optimization of code and process flow for improved scalable computational performance
- At completion, a version 1.0 release of the Ocean-LETKF will be made publicly available on Github as a community code

CONCLUSION

Reiterating main goals to support NGGPS:

1. Implement *new ensemble-based* ocean data assimilation approach

2. Assimilate *new observational data types* and improve assimilation of existing data

3. Integrate new *NEMS-compatible ocean models*, at higher resolution

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