The High Resolution Global Ocean Forecasting System in the NMEFC and its Intercomparison with the GODAE OceanView IV-TT Class 4 Metrics

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System design
&
Model testing
&
Numerical products application

System assessment

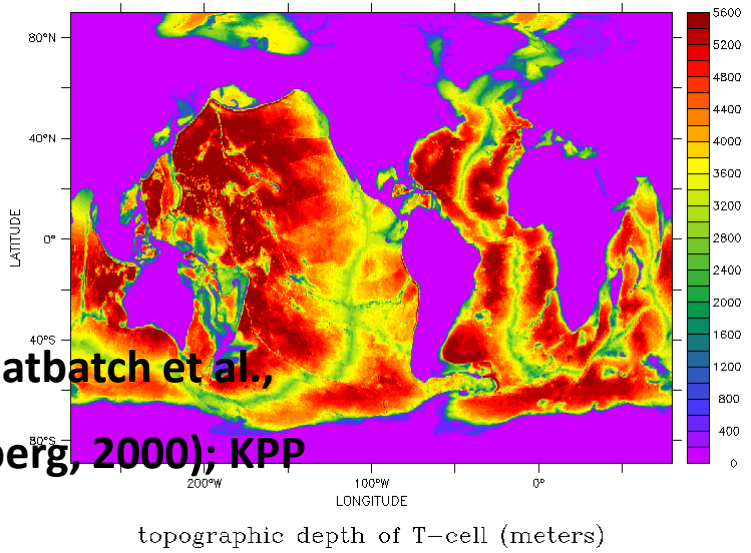
Data assimilation

Content

- **Background**
- **Development of NMEFC-NEMO**
- **Assessment of NMEFC-NEMO**
- **Conclusion**
- **Any suggestions**

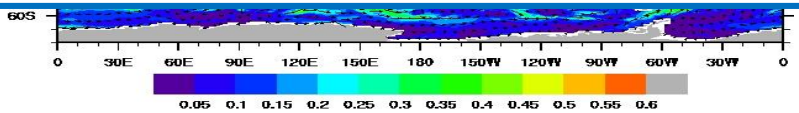
First Generation of Global Ocean Forecasting System based on MOM4

- **Grid**: Global 1/4° ×1/4°; 50 levels
- **Bathymetry**: OCCAM 0.2
- **Initialization**: OMIP_NCAR
- **Data Assimilation**: 3DVar
- **Parameterizations**: non-Boussinesq approximation (Greatbatch et al., 2001); Smagorinsky viscosity scheme (Griffies and Hallberg, 2000); KPP scheme (Large et al., 1994)
- **Atmospheric forcing**: GFS (Global Forecast System) 6-hour data



topographic depth of T−cell (meters)

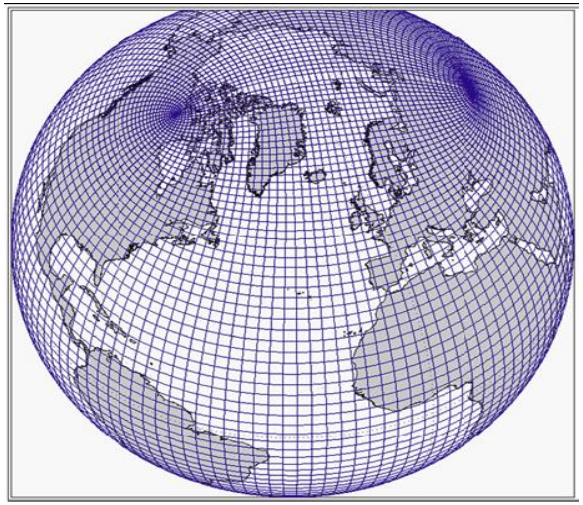
- With the higher requirement for the ocean forecasting products, we further developed a high resolution global ocean forecasting system to provide the higher standard, more sophisticated and qualified products.



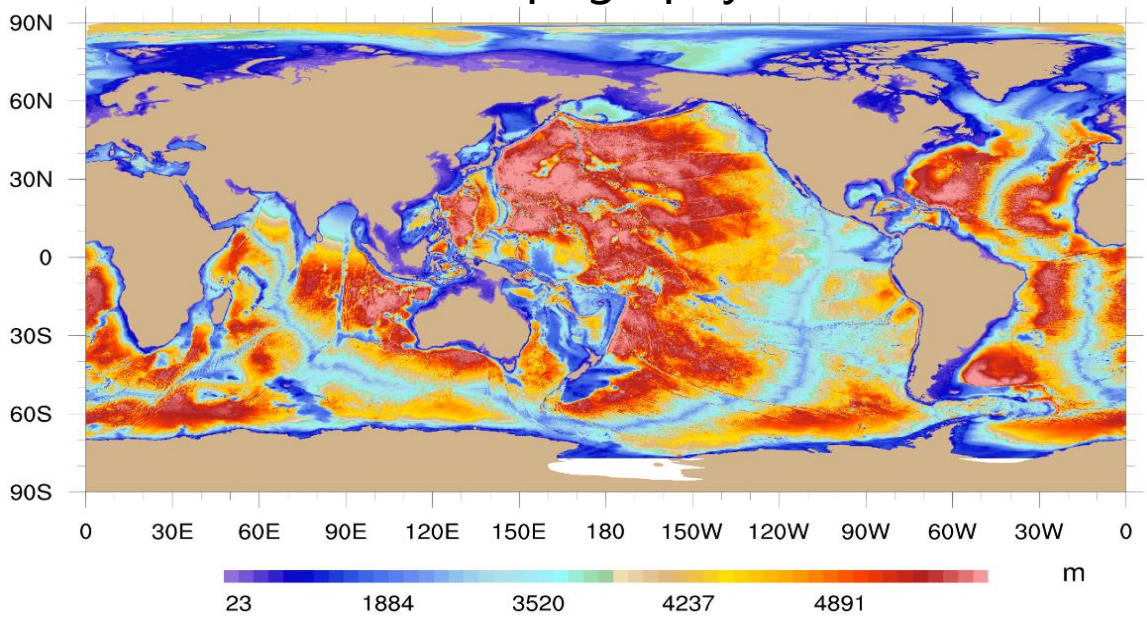
NMEFC High Resolution Forecasting System based on NEMO

Model configuration

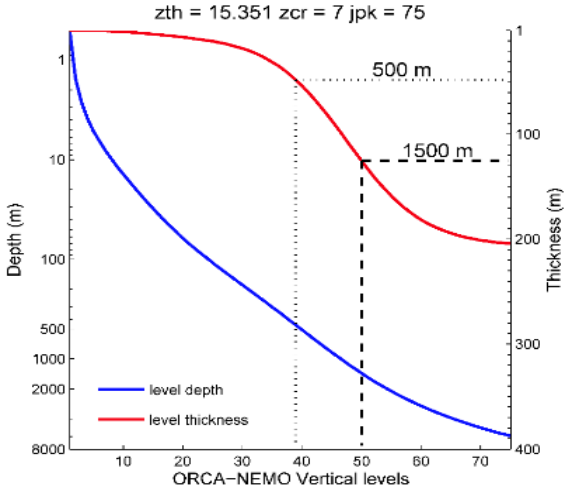
Horizontal grid



Topography



Levels depth and thickness



Code --NEMO3.6 + LIM3

Grid-- ORCA tripolar grid (Madec and Imbard [1996])

Horizontal resolution

– 4322 x 3059 horizontal grid points

– Grid spacing from 10 km at equator down to 3 km at high latitudes

Vertical grid

– 75 levels, with a resolution of 1m near the surface and 200m in the deep ocean，0-6000m

The Forecasting System Design

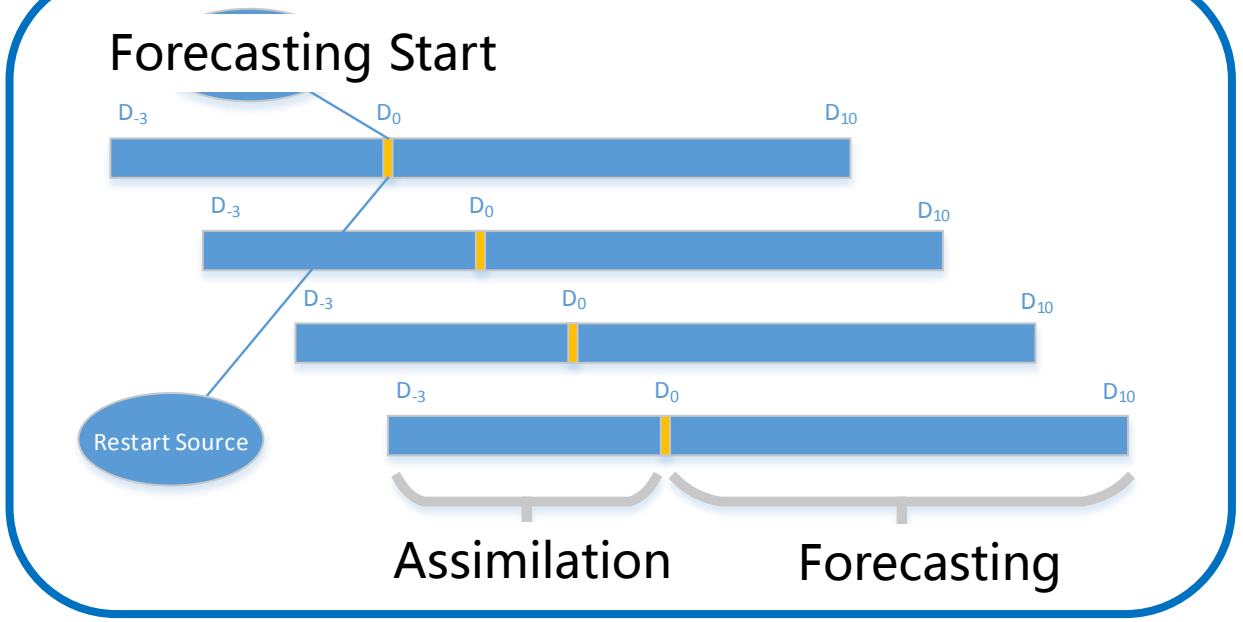
Data collection system

NCEP GFS | ECMWF GFS | Argo | Satellites | Drifts | Reanalysis

Data assimilation system

Nudging

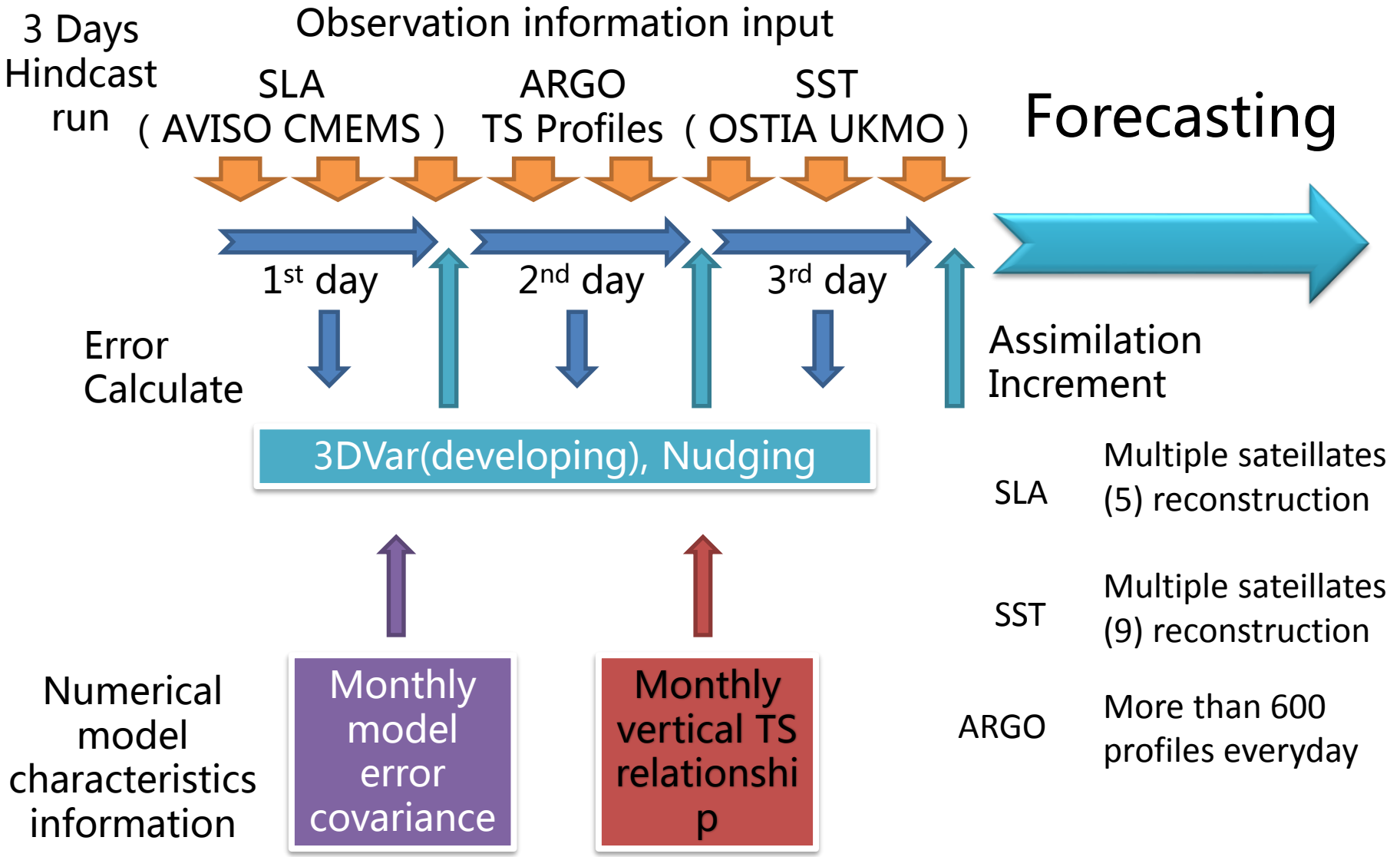
3DVAR



Forecast products release system

IVTT Products | Compress Archives | Static Forecast figures | Site and Regional improved products | Animation Products

Data Assimilation System



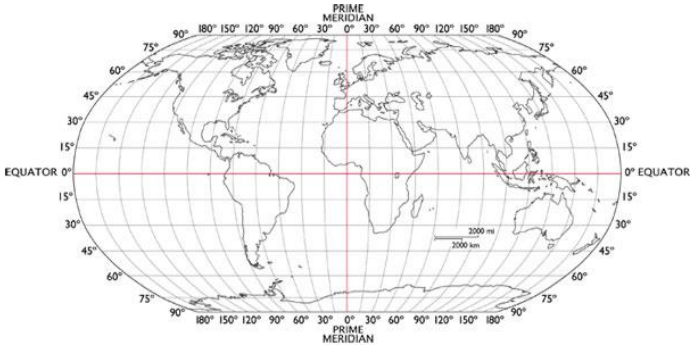
History Forecast

F_{-60} F_{-59} F_{-58} ..... F_{-2} F_{-1}

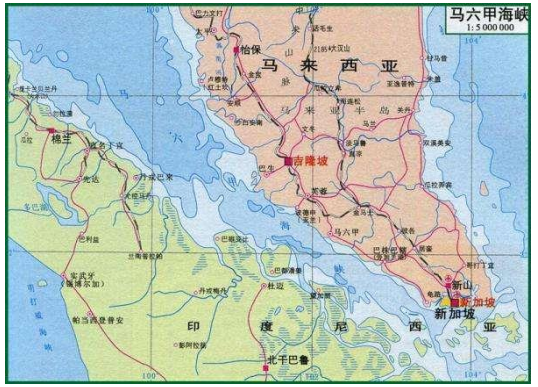
History Observation

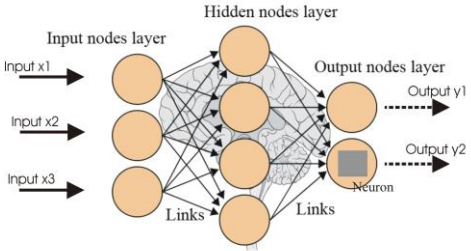
O_{-60} O_{-59} O_{-58} ..... O_{-2} O_{-1}

Global Grid Mapping

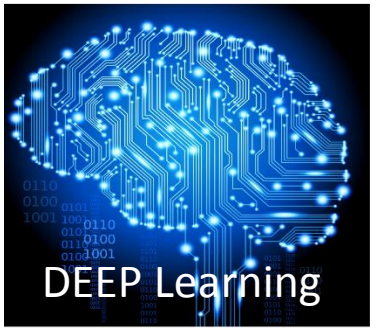


Regional and site bias relationship build



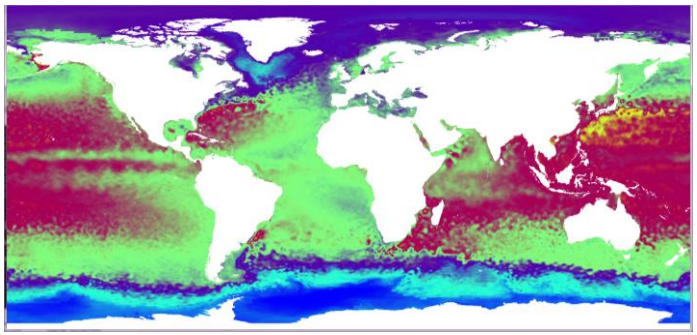


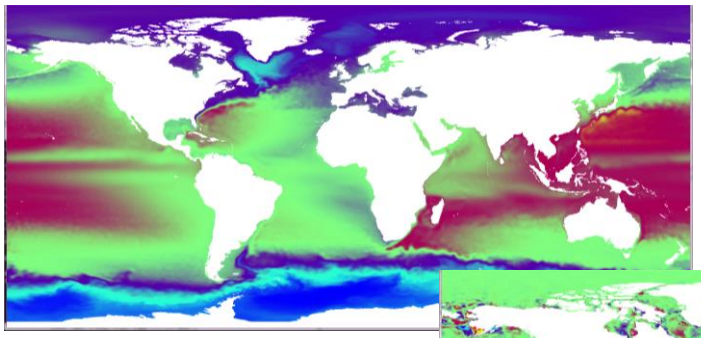
Artificial Neural Networks



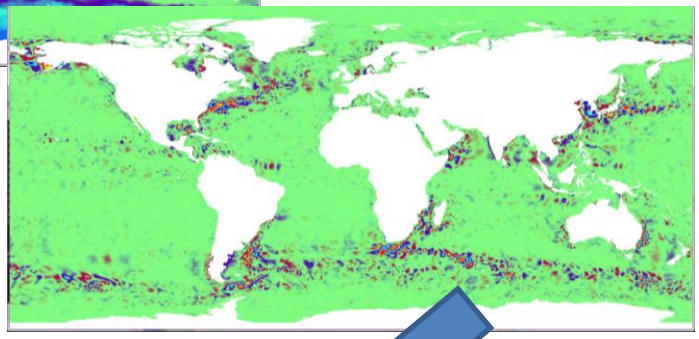
Improved Forecasting Products

Example for SLA

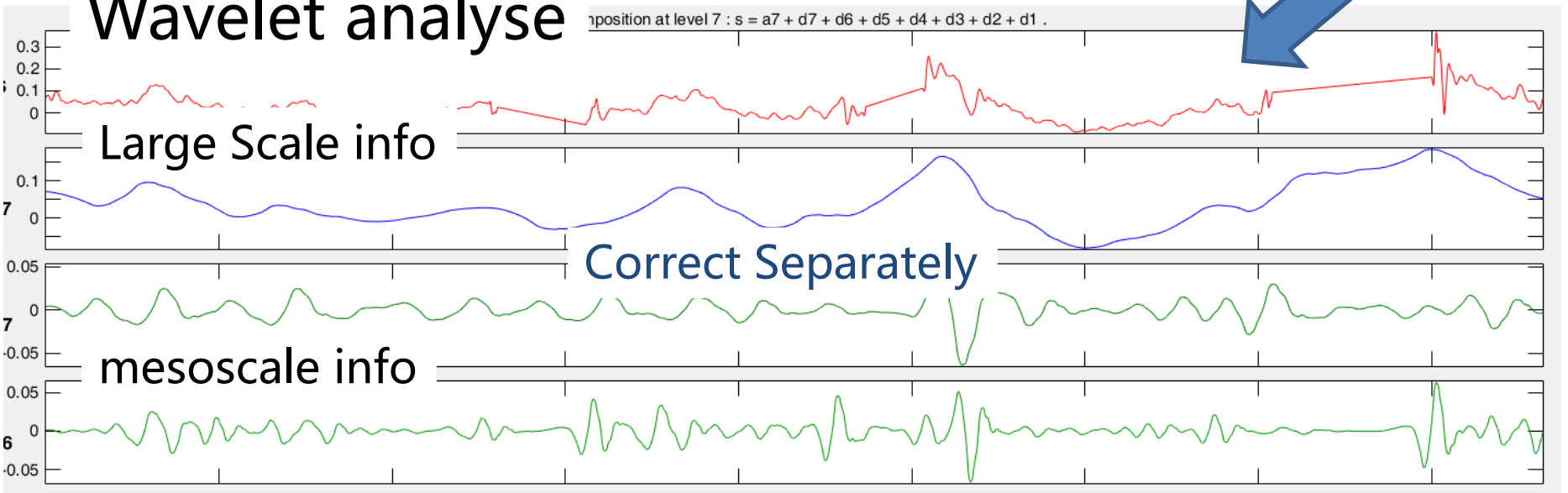




SSH — SDH =



Wavelet analyse

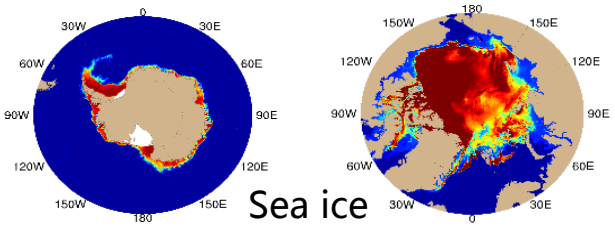


Forecast products release system

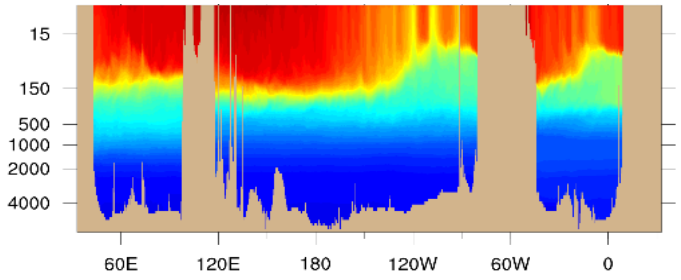
Products part one:

GODAE-IVTT standard products
Class 1 : gridded model output
Class 2 : time series of specified locations and sections
Class 3 : transport through sections and other quantities
Class 4 : metrics of forecast capability

Products pat two：Conventional static visualization products

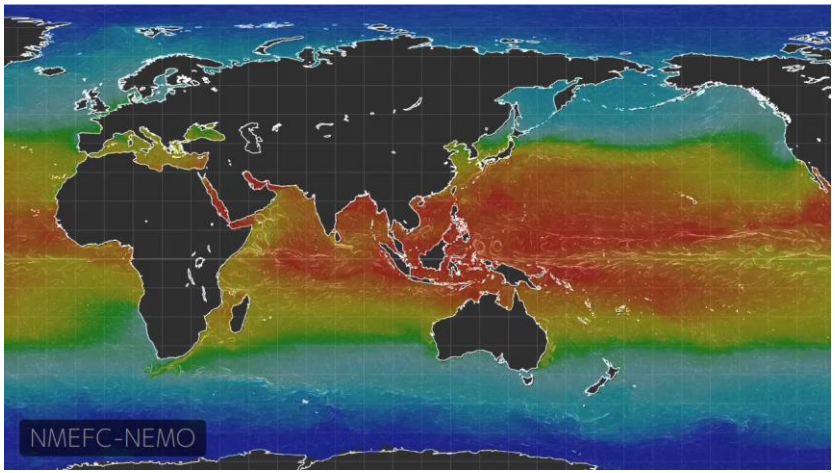


Sea ice

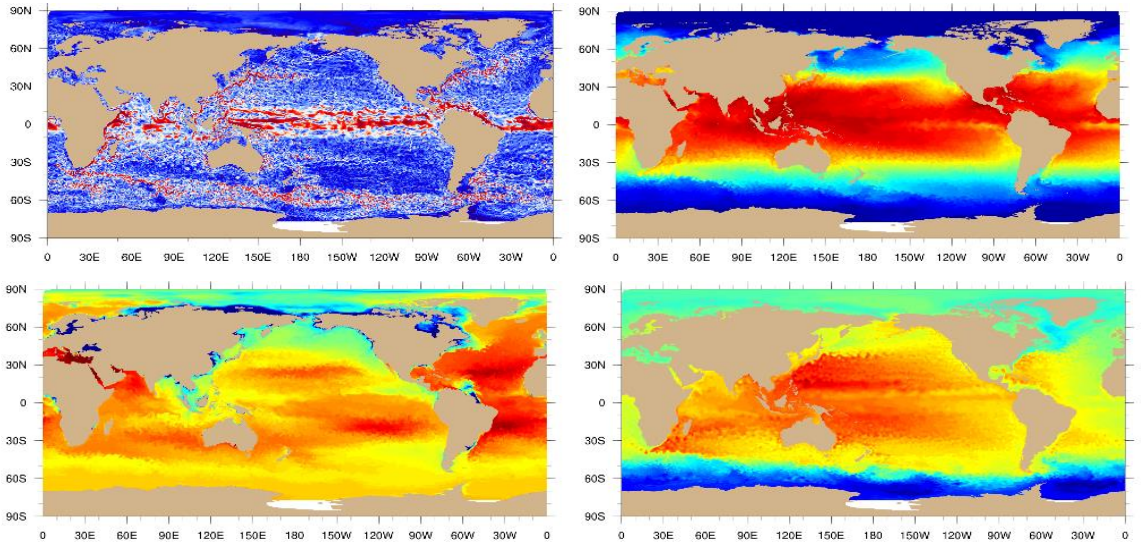


Vertical profile

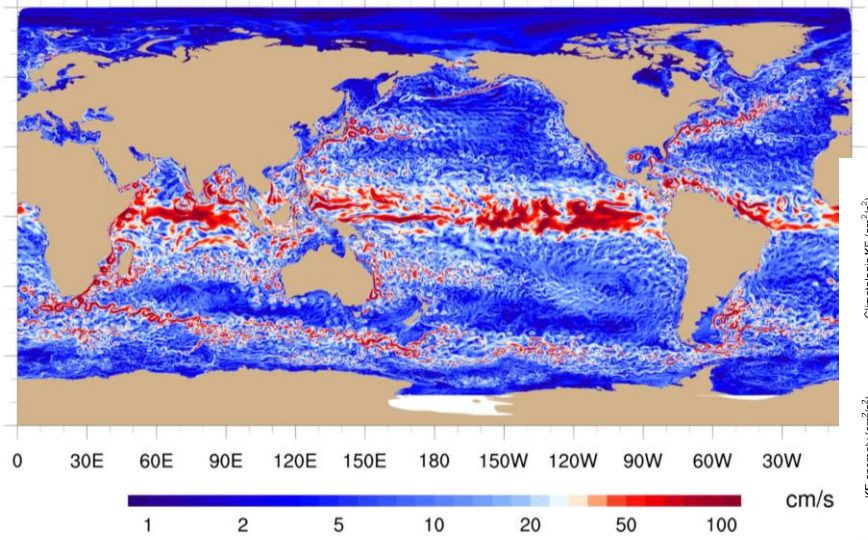
Products part three： Animation products



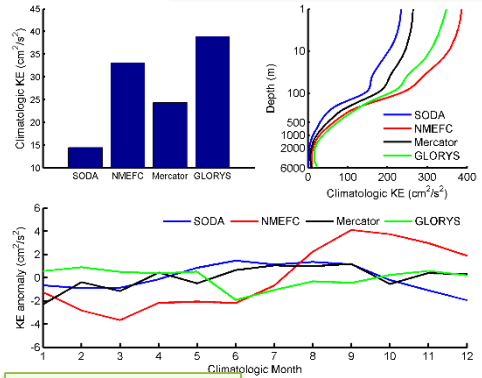
Eddies activities and variation

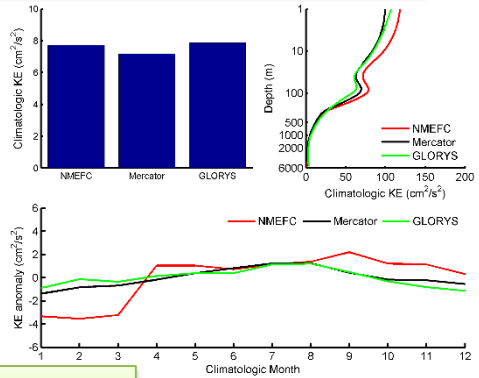


Temperature, salt, current, and SSH



Climatologic kinetic energy with and without eddy



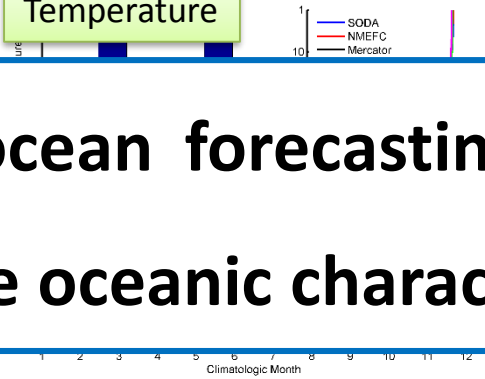


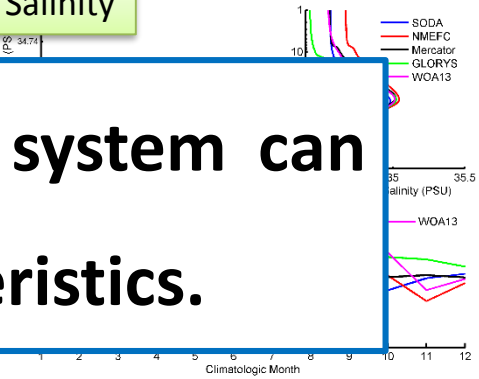
NMEFC-NEMO

Temperature

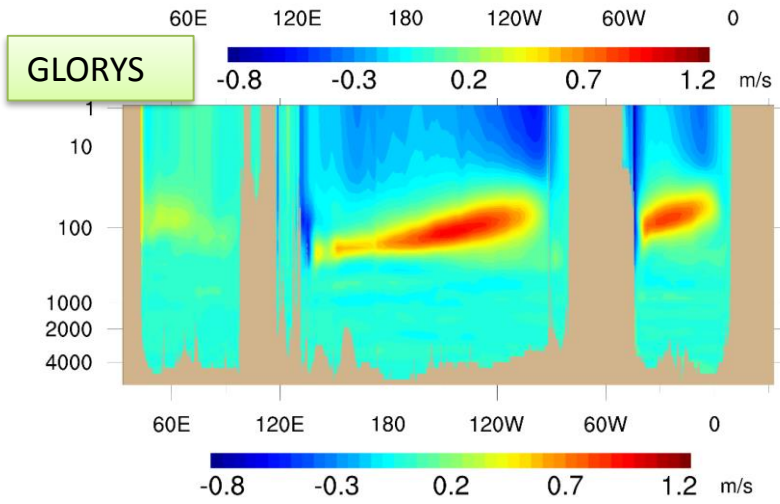
Salinity

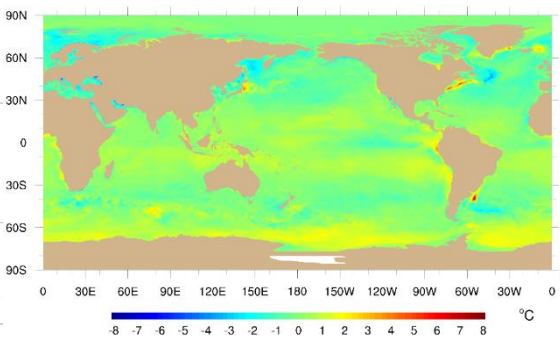
- **This high resolution ocean forecasting system can basically reproduce the oceanic characteristics.**

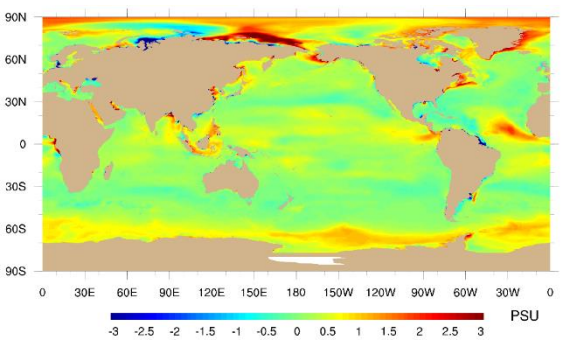




GLORYS







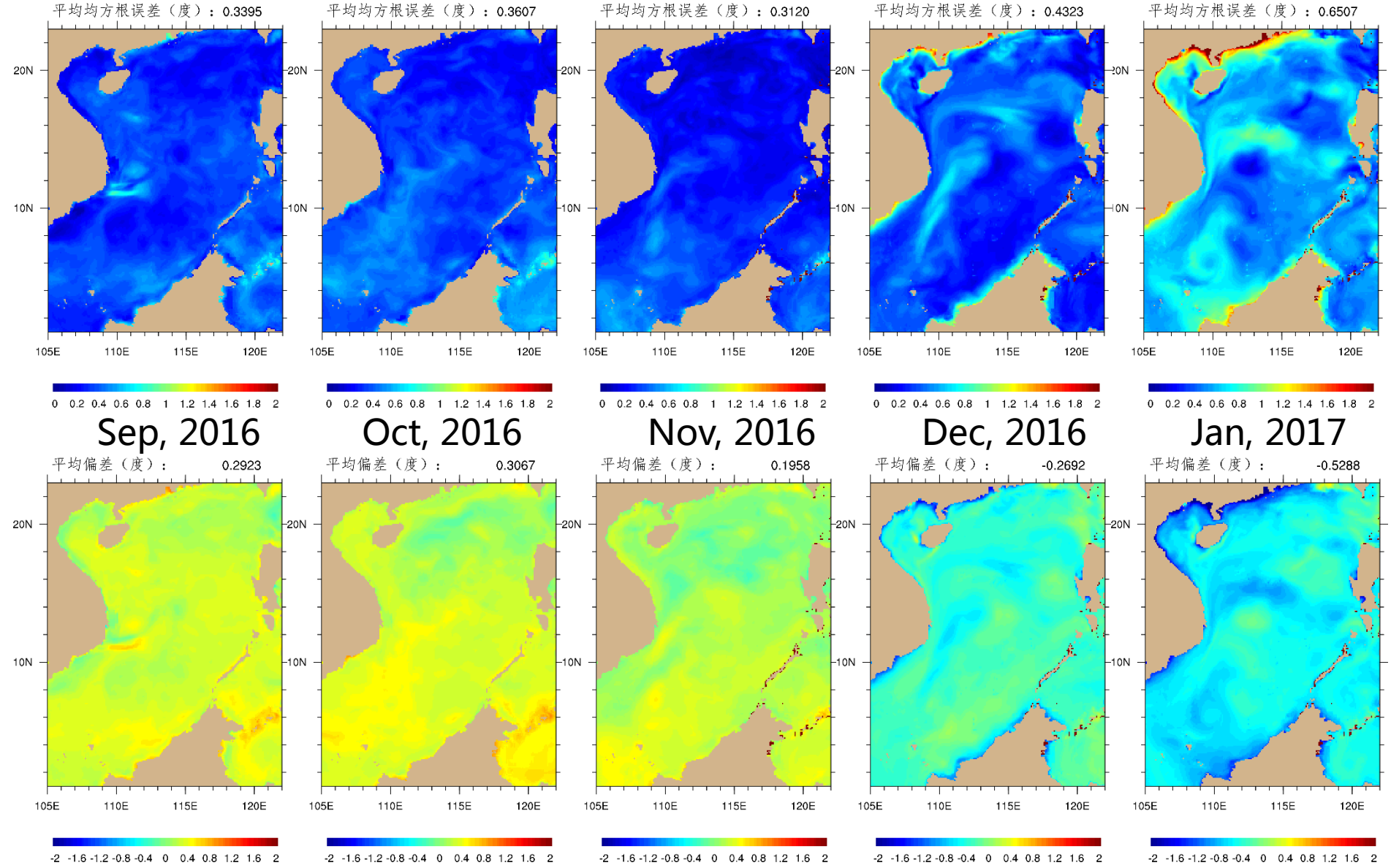
SST（NEMO-GLORYS）

SSS（NEMO-GLORYS）

Ten years climatologic assessment

Regional comparison of operational system

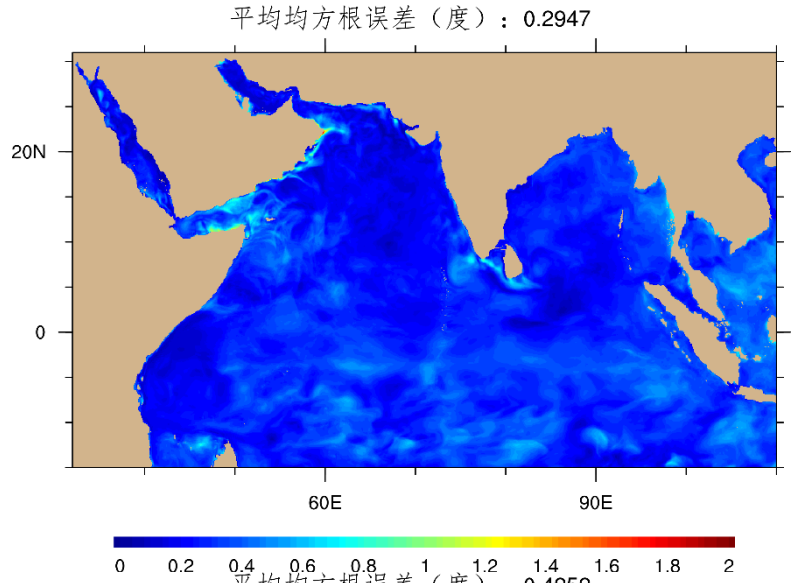
SST of South China Sea：RMSE 0.4℃，Bias ±0.3 ℃, against PSY Reanalysis Data



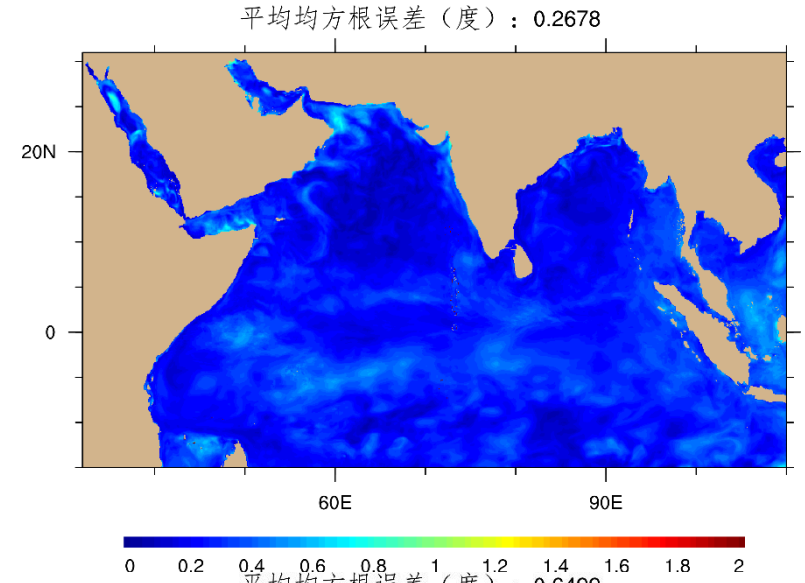
Regional comparison of operational system

SST of Indian Ocean：RMSE 0.5℃, against PSY Reanalysis Data

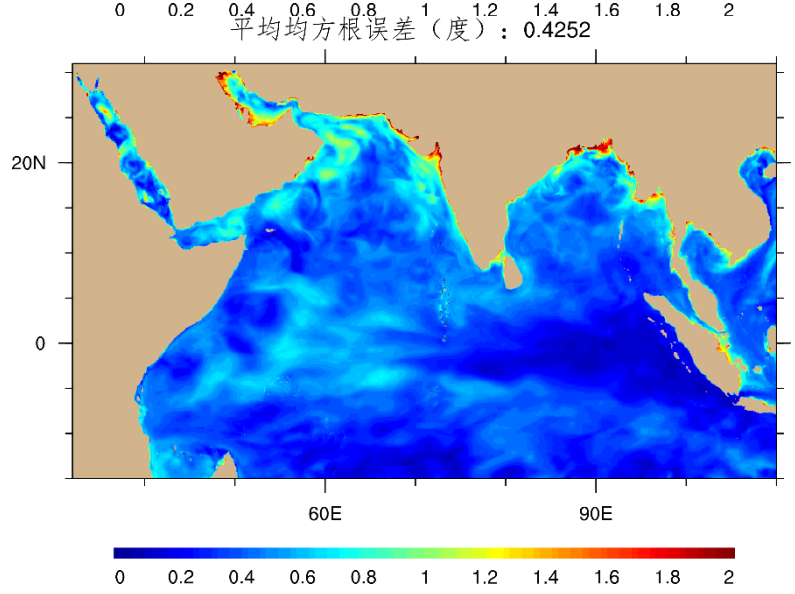
Oct, 2016



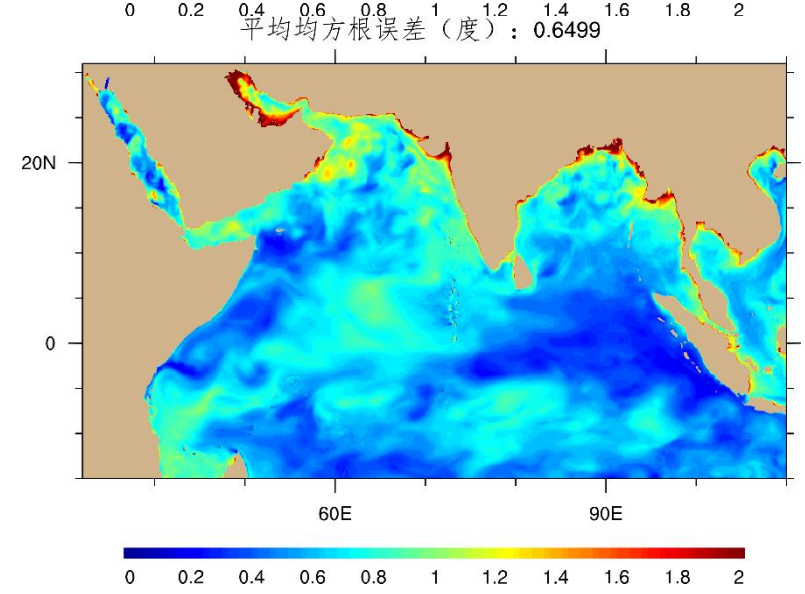
Nov, 2016



Dec, 2016

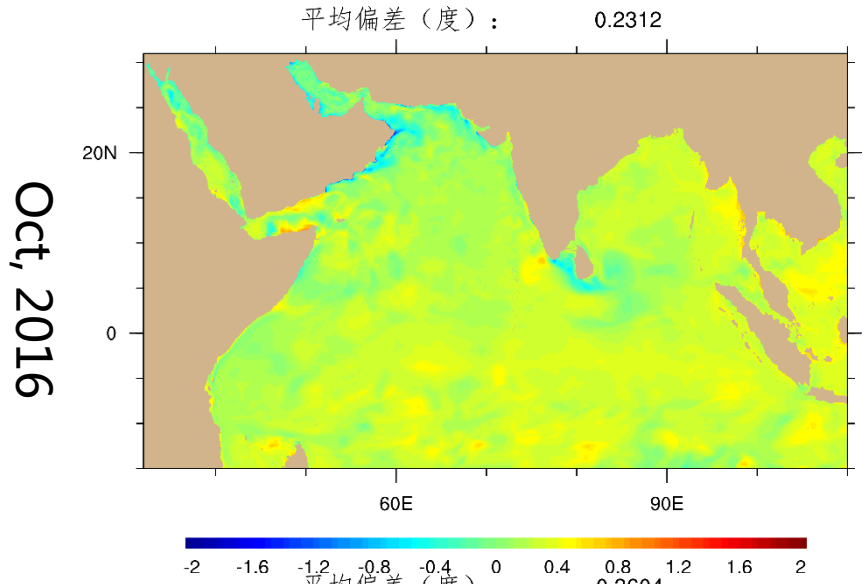


Jan, 2017

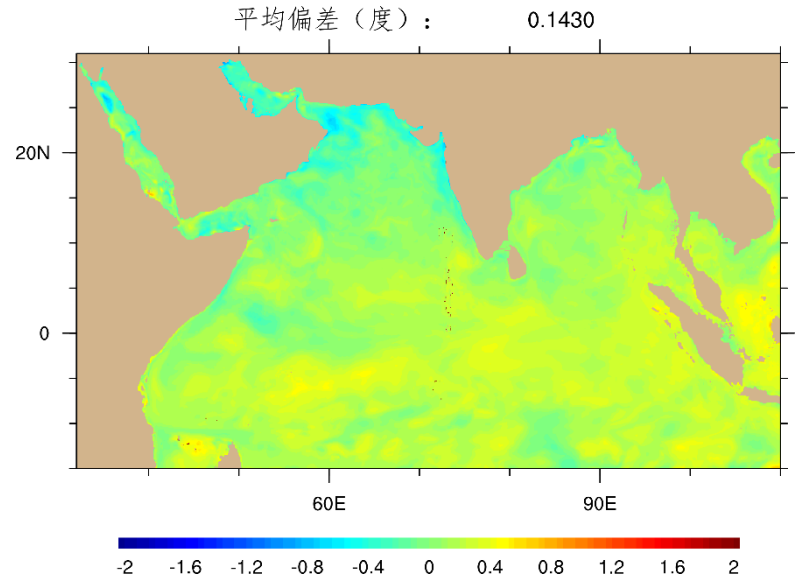


Regional comparison of operational system

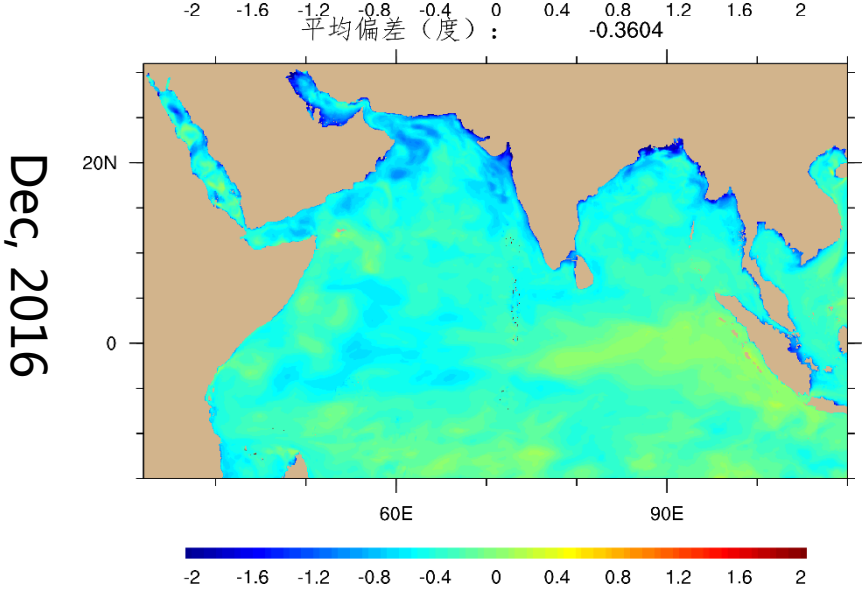
SST of Indian Ocean：RMSE -0.6-0.1℃, against PSY Reanalysis Data



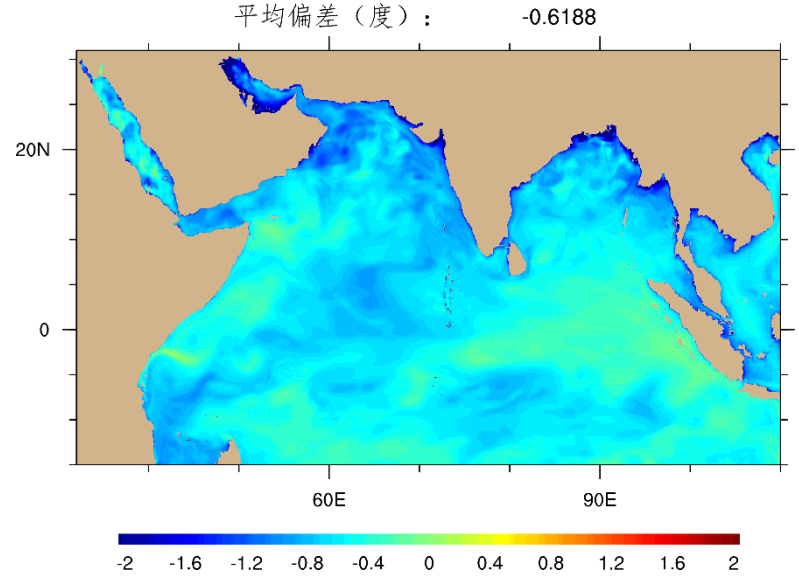
Oct, 2016



Nov, 2016



Dec, 2016



Jan, 2017

Introduction of IV-TT

- **Background:**

  The GODAE Oceanview **Intercomparison** and **Validation Task Team (IV-TT)** aims to coordinate and promote the development of **scientific validation** and **intercomparison of operational oceanographic systems**. A particular focus is a real-time intercomparison of GOV systems using the **Class 4 framework**.

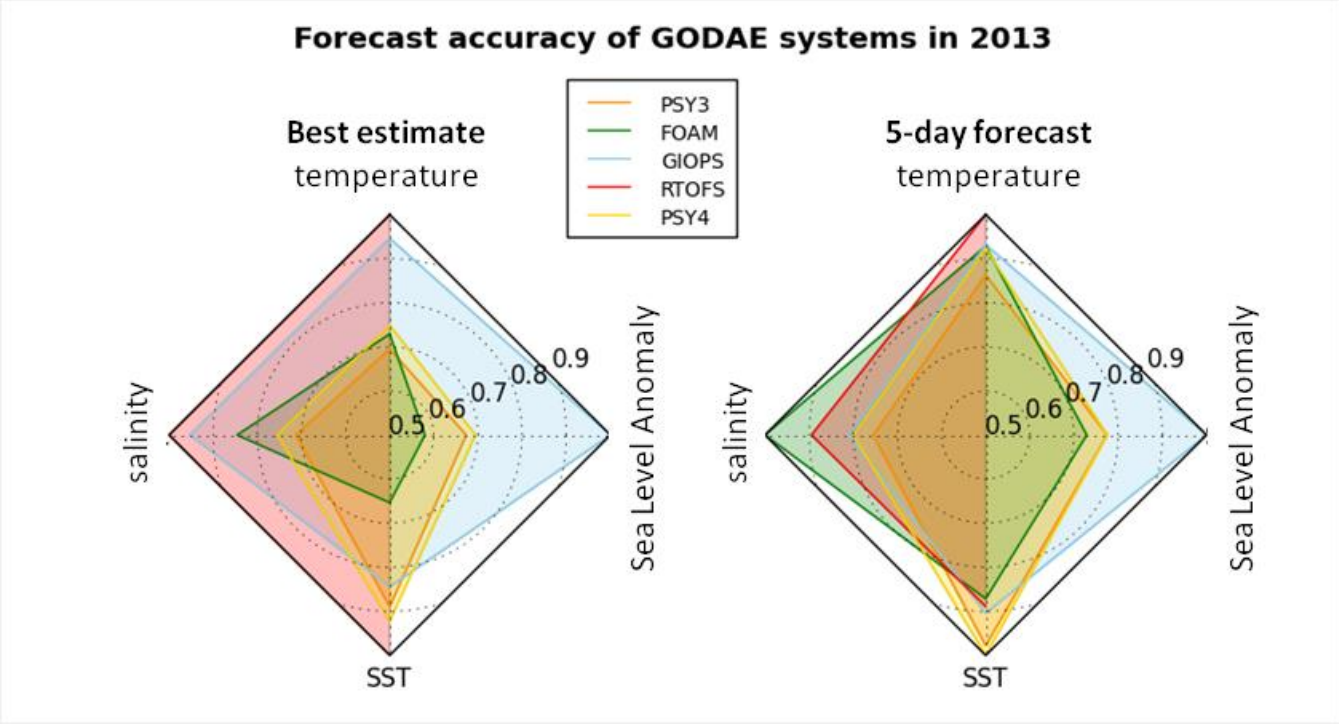
- **Workshop objectives:**

- Review the **current status** of the Class4 intercomparison and discuss outstanding issues
- Discuss the **future directions** of this intercomparison
- Discuss **ongoing initiatives** and other **additional possible assessments**
- Discuss recent **advances in evaluation** and **verification efforts**, and the **development of new metrics**

Joint systems

country	System name	model
Environment Canada	GIOPS-CONCEPTS	NEMO 1/4
Mercator Ocean	PSY3 & PSY4	NEMO 1/4 &1/12
Australian Bureau of Meteorology	BLUElink-OceanMAPS	MOM4 10km around Australia but low resolution further out
NOAA/NCEP/NWS	RTOFS Global	HYCOM 1/12
UK Met Office	FOAM	NEMO 1/4

Five systems and 6 models, 4 of the models are based on NEMO.



IVTT Class4 assessment method

- $Bias = \frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)$
- $RMSE_{FCT} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2}$
- $RMSE_{per} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(B_i - O_i)^2}$

Model deviate from observation (smaller is good)

- $PSS = 1 - \frac{RMSE_{FCT}}{RMSE_{per}}$

Persistence skill score: numerical forecast VS analysis data extrapolation (>0 is good)

- $CSS = 1 - \frac{RMSE_{FCT}}{RMSE_{clim}}$

Climatology skill score: numerical forecast VS Climatological data (>0 is good)

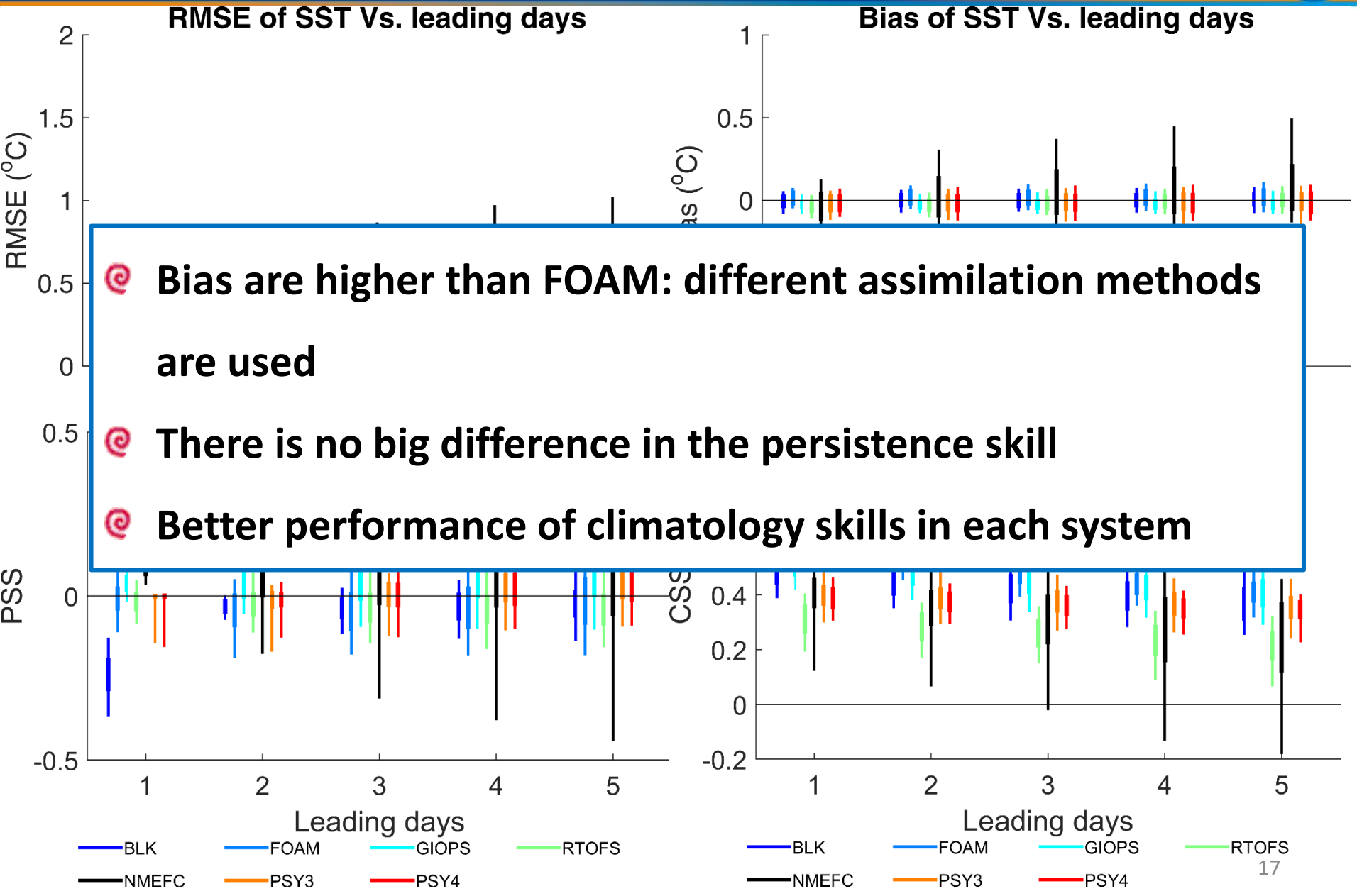
- $AC = \frac{\sum(F-C)(O-C)}{\sqrt{\sum(F-C)^2}\sqrt{\sum(F-O)^2}}$

Anomaly correlation: weather variations capture ability

F—forecast O—observation C—climatology B—Best estimate

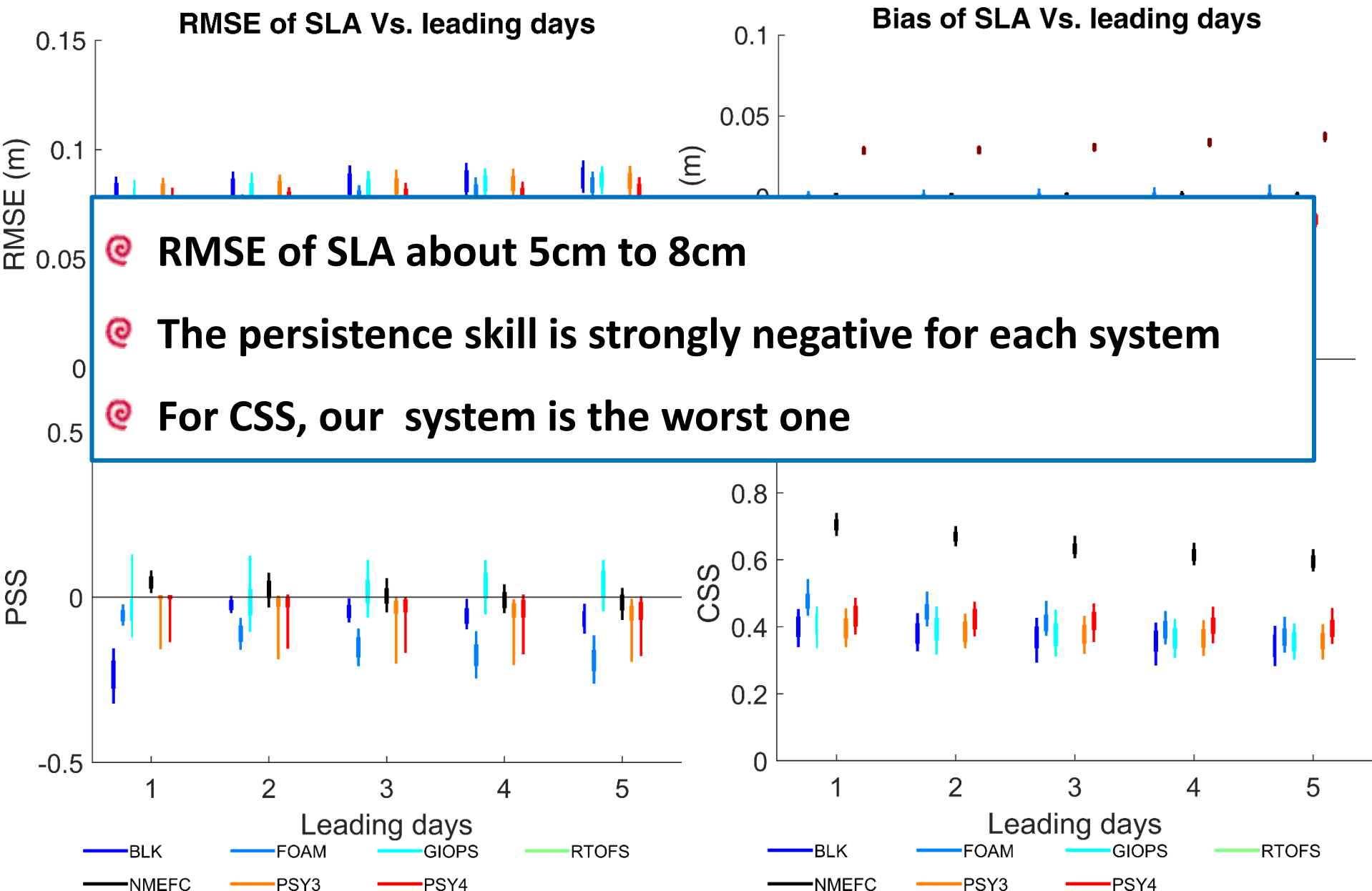
A.G. Ryan, C. Regnier, P. Divakaran, T. Spindler, A. Mehra, G.C. Smith, F. Davidson, F. Hernandez, J. Maksymczuk & Y. Liu (2015) GODAE OceanView Class 4 forecast verification framework: global ocean inter-comparison, Journal of Operational Oceanography, 8:sup1, s98-s111, DOI: 10.1080/1755876X.2015.1022330

SST



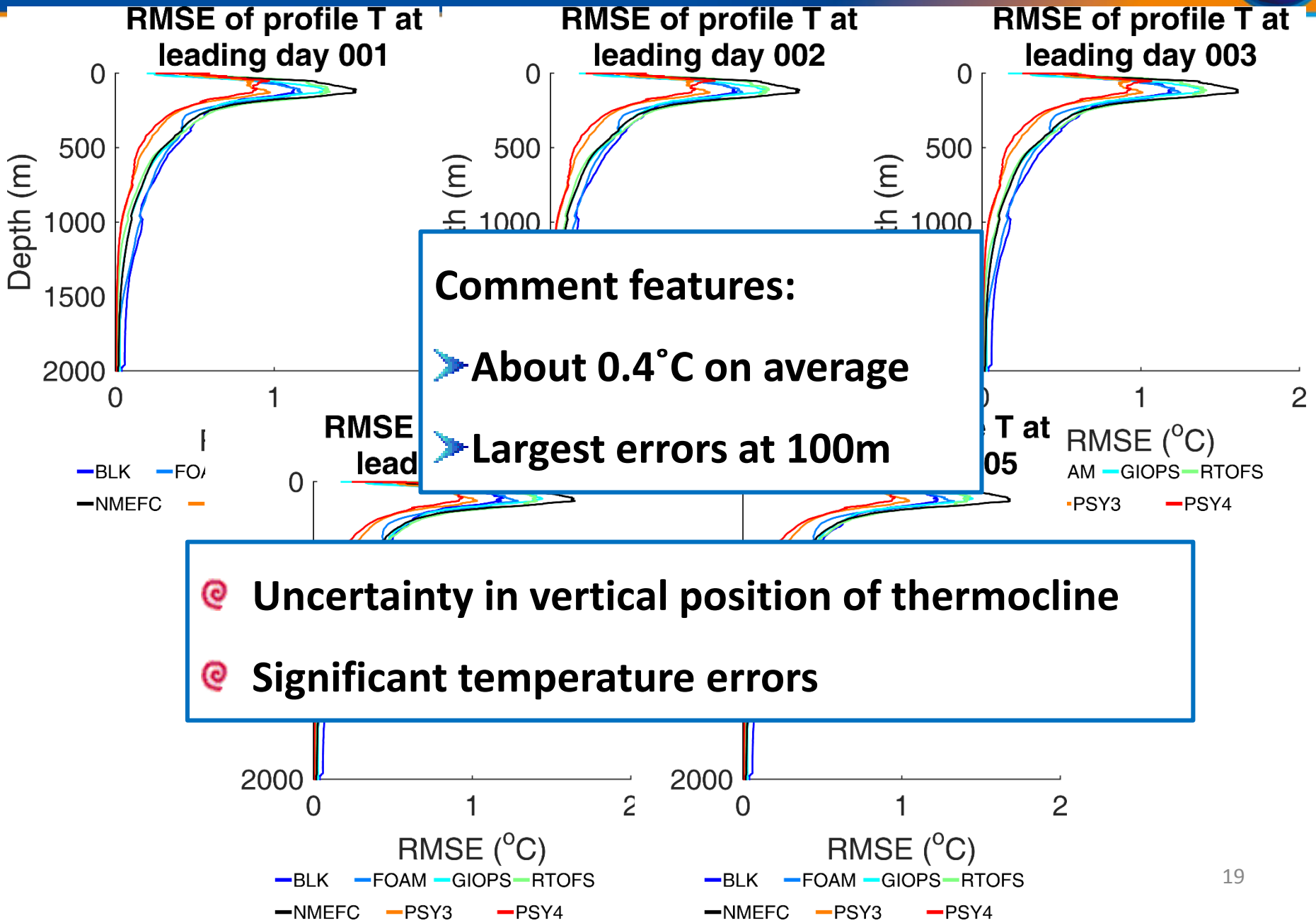
- Bias are higher than FOAM: different assimilation methods are used
- There is no big difference in the persistence skill
- Better performance of climatology skills in each system

SLA



- RMSE of SLA about 5cm to 8cm
- The persistence skill is strongly negative for each system
- For CSS, our system is the worst one

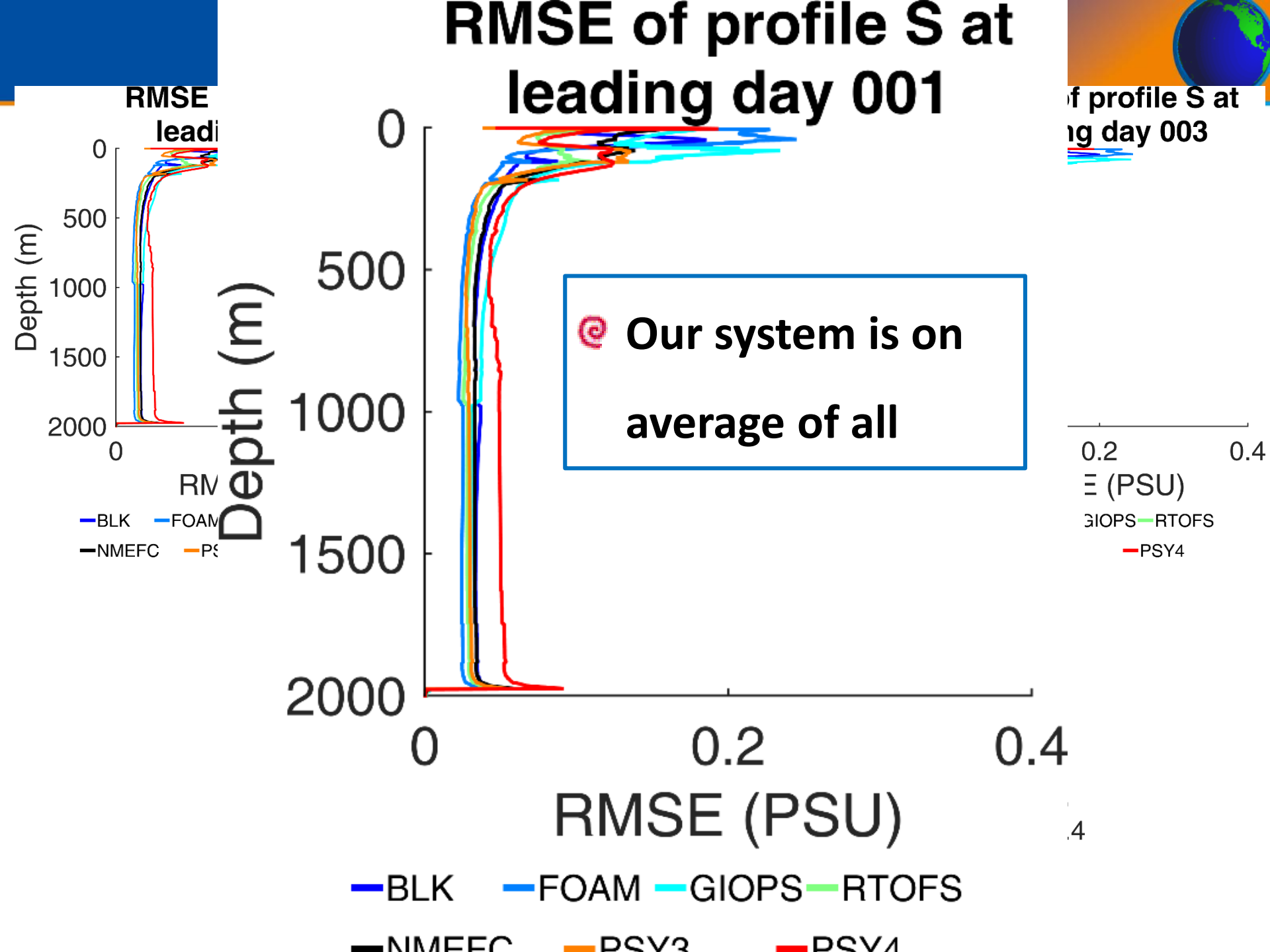
RMSE of Temperature Profile



Comment features:

- **About 0.4˚C on average**
- **Largest errors at 100m**

- **Uncertainty in vertical position of thermocline**
- **Significant temperature errors**


RMSE of profile S at leading day 001
Depth (m)
0
500
1000
1500
2000
0
0.2
0.4
RMSE (PSU)
BLK
FOAM
GIOPS
RTOFS
NMEFC
PSY3
PSY4
Our system is on average of all

Conclusion

- **NMEFC NEMO global operational forecasting system:**
  - runs stably and provides 5-day forecasting
  - working on the assimilation system and a 3-DVar assimilation schemes
- **Evaluation of the products**
  - temperature and salinity is comparable to other systems
  - improve the forecasting of thermocline by a better 3-DVar assimilation system
- **Forecasting skills:**
  - short term forecasting: data assimilation system is more important
  - longer forecasting: forecasting system with an higher frequency output plays an important role

Thanks for your attention

http://www.nmefc.gov.cn