Operational and Verification
---A coupled forecasting system for the seas off China

Guansuo Wang, Fangli Qiao,
Xunqiang Yin, Changshui Xia and Yongzeng Yang

Key Laboratory of Marine Science & Numerical Modeling (MASNUM)
The First Institute of Oceanography (FIO), State Oceanic Administration (SOA), China

Outline

1. Introduction of the coupled forecast system for the seas off China

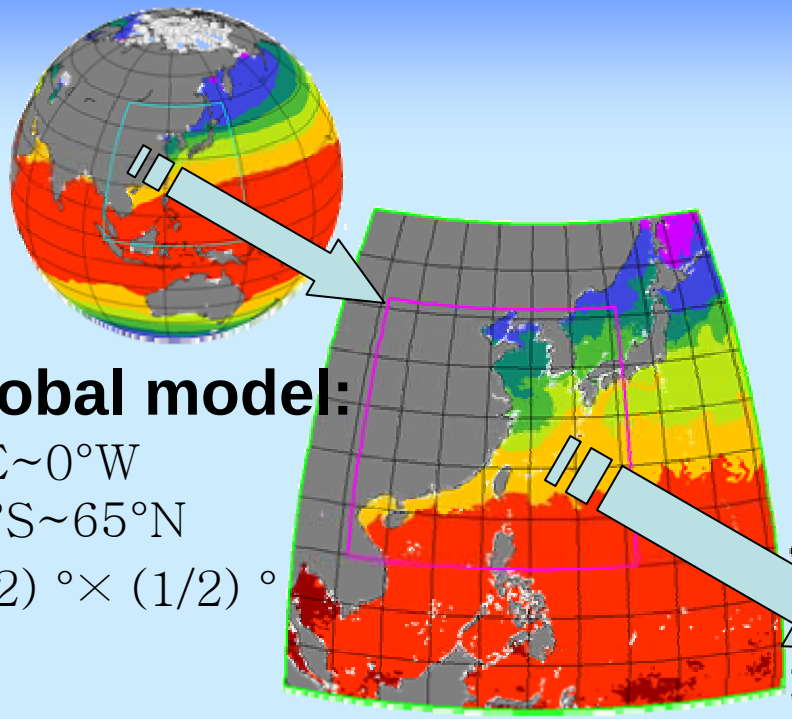
2. Applications of this forecast system

3. Verification

4. Conclusion

Introduction

- The circulation part is the improved POM adding the wave-induced mixing coefficient
- The wave part is MASNUM -WAV model
- The tidal current is included
- The Model is parallelized using MPI method
- The meteorological model is MM5 for regional and NCEP products for the global

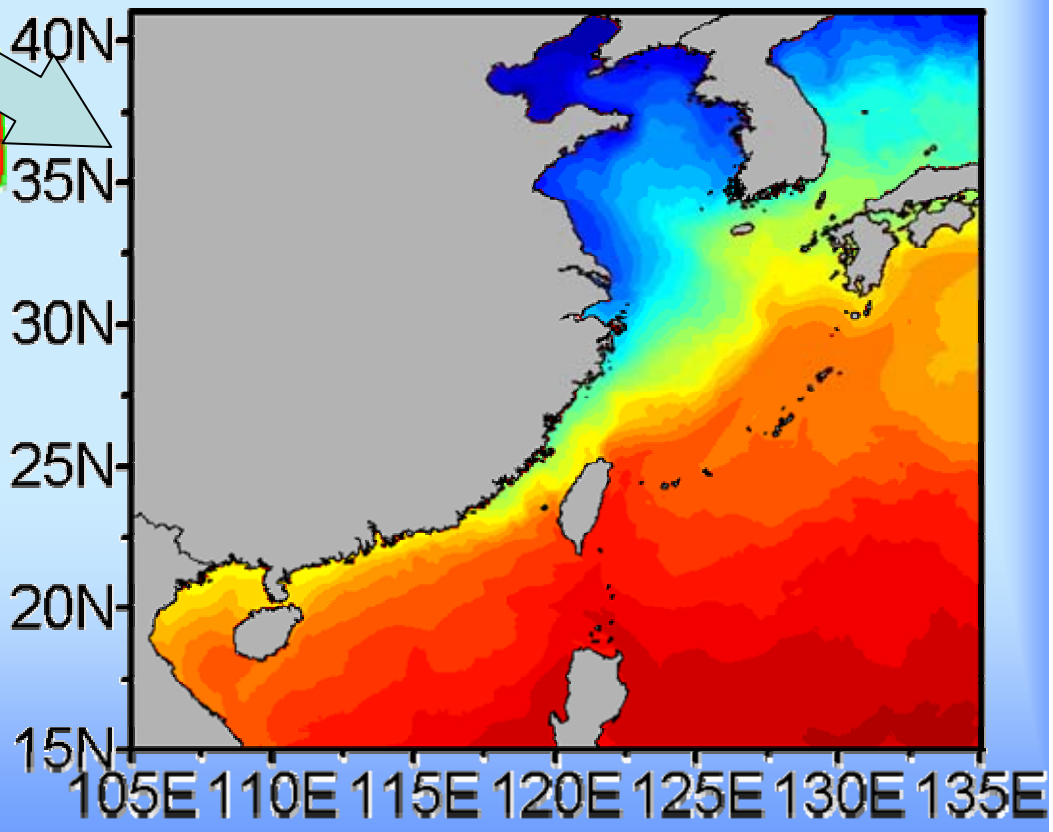


Global model:

0°E~0°W
78°S~65°N
(1/2) °× (1/2) °

Focused section
China Seas Model:

105°E~135°E,
15°N~41°N
(1/24) °X(1/24)° fine



Northwest pacific model:

99°E~150°E
0°N~50°N
(1/8) °X (1/8)°

3 nested layers
One way
55km-13km-3.5km

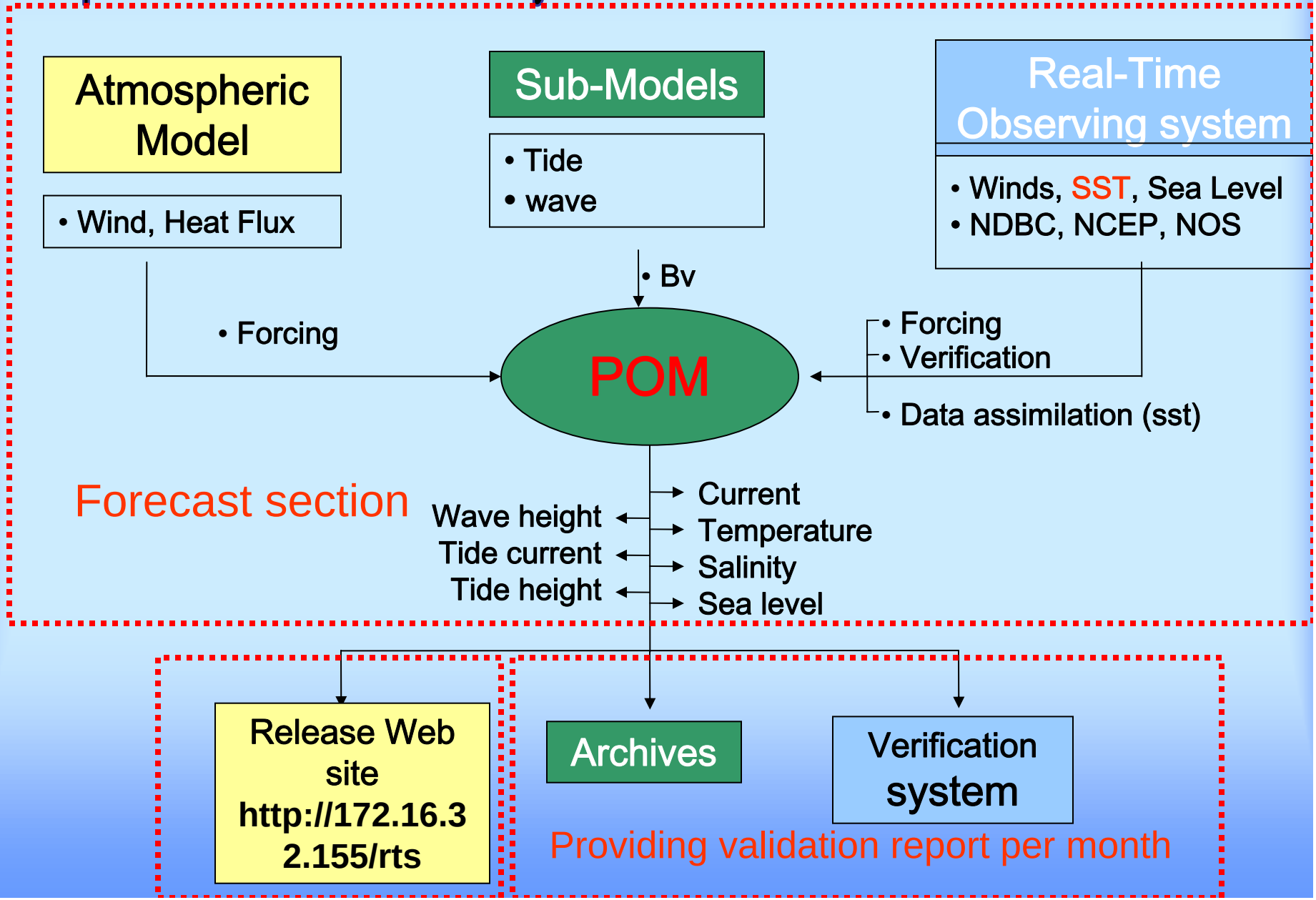
Data assimilations

SST is assimilated in mixing layer using Nudging method:

$$\frac{\partial TD}{\partial t}+\frac{\partial TUD}{\partial x}+\frac{\partial TVD}{\partial y}+\frac{\partial T\omega}{\partial \sigma}=\frac{\partial}{\partial \sigma}\left[\frac{K_H}{D}\frac{\partial T}{\partial \sigma}\right]+F_T-\frac{\partial R}{\partial z}+\frac{T_{obs}-T}{\tau}$$

Where T is forecast SST, Tobs is observed SST, τ is relaxation time scale.
The advantage of Nudging is less simple ,affective and low time costing
The observed SST is obtained from the NEAR-GOOS real time regional ocean data base under Japanese meteorological society web site:
http://goos.kishou.go.jp

Operational forecast system



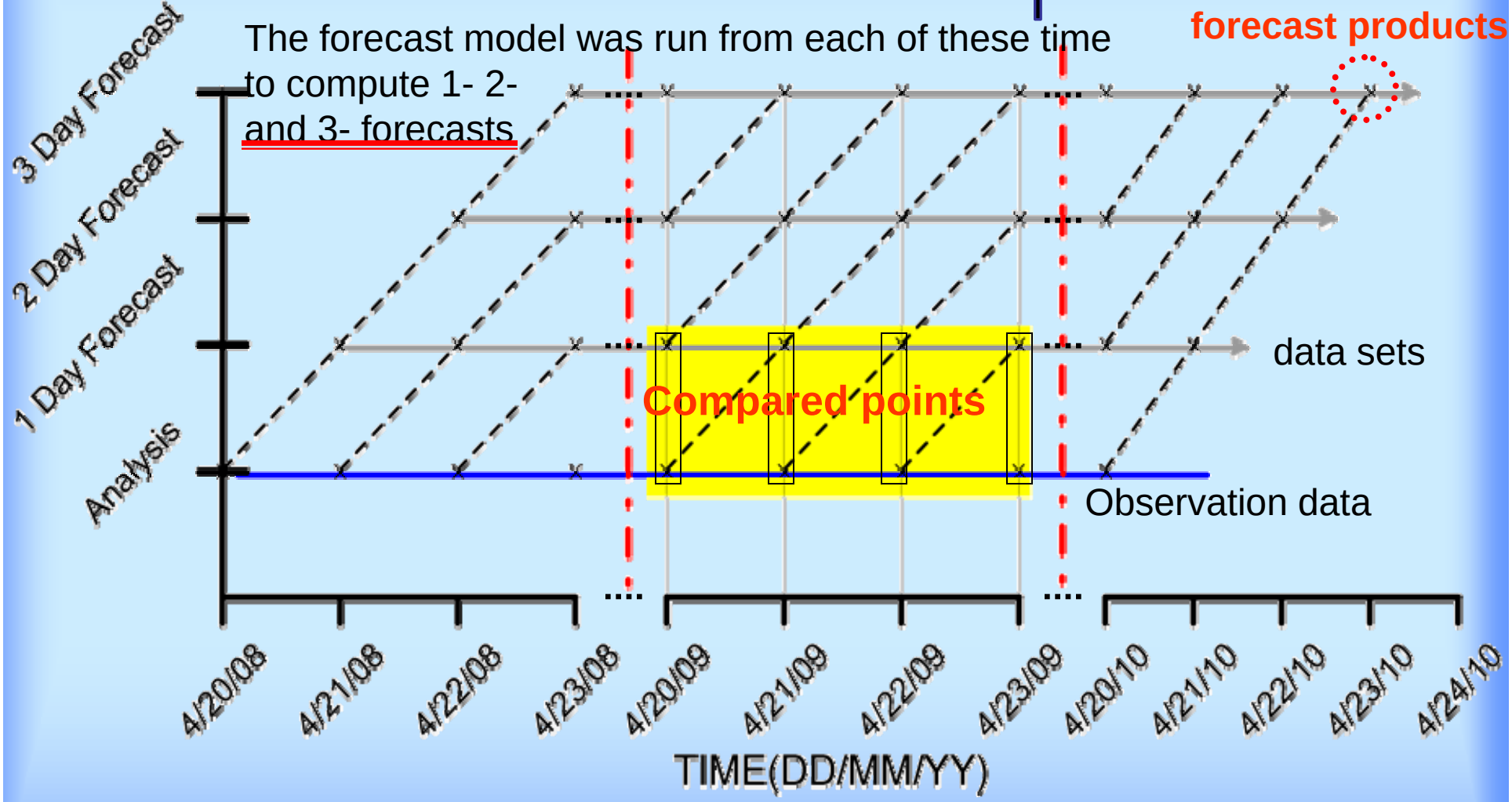
Applications

Focused section

Validation for this coupled forecast system

Verification is an indispensable part of ocean research and operational forecasting activities.

Illustration of how verification were compared



Verification the differences between observation data and the forecast products (sea surface temperature, subsurface temperature and mixed layer depth, wind) of 24 hour,48hour and 72 hour

The statistical metrics

Mean error (ME) = $\frac{1}{N}\sum_{1}^{N}(O_i - F_i)$

Mean absolute error (MAE) = $\frac{1}{N}\sum_{1}^{N}|O_i - F_i|$

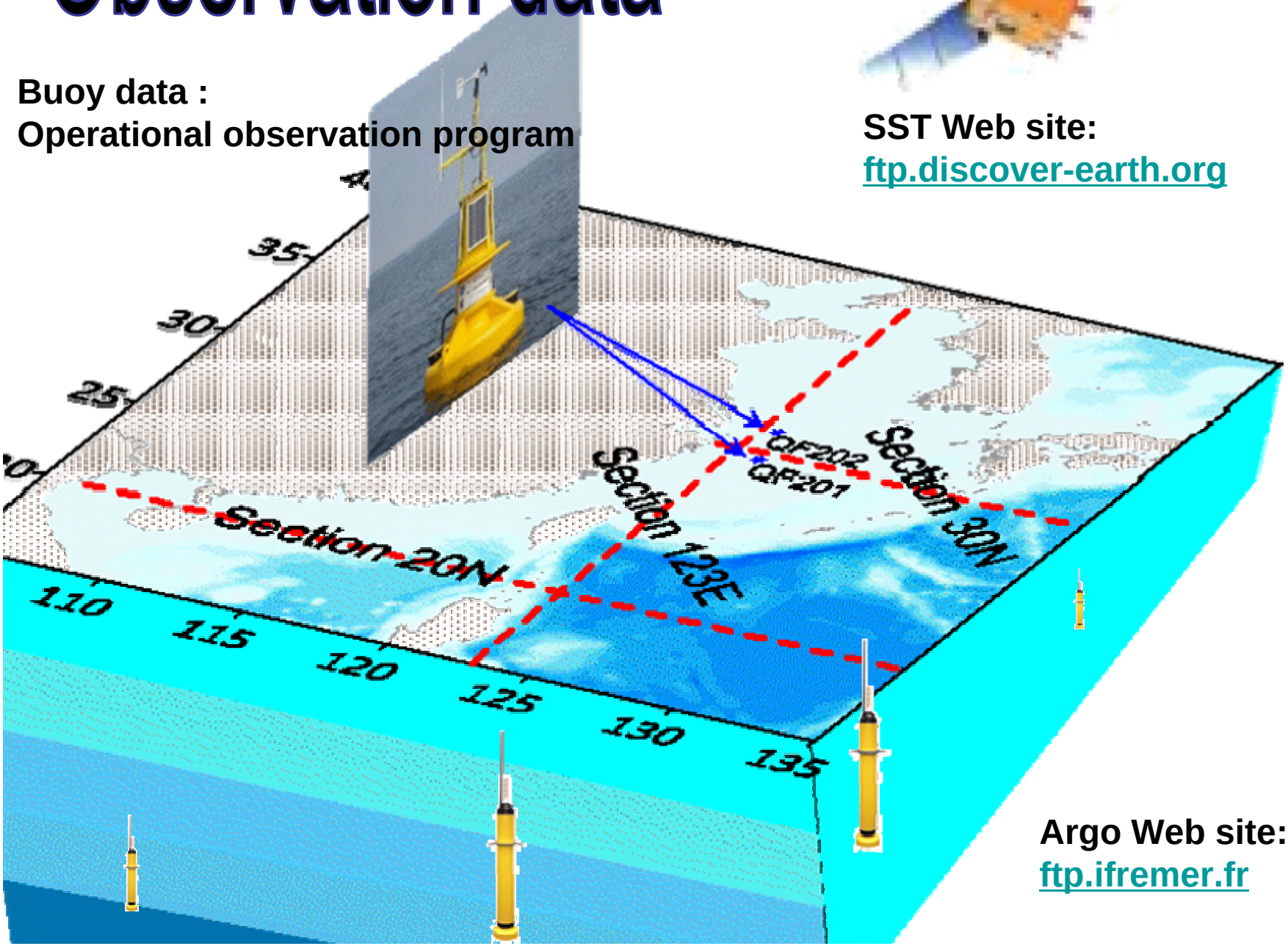
Root mean absolute error (RMSE) = $\sqrt{\frac{1}{N}\sum_{i=1}^{N}(O_i - F_i)^2}$

Correlation coefficient (R) = $\frac{\sum_{i=1}^{N}\left(F_i - \overline{F}\right)\left(O_i - \overline{O}\right)}{\sqrt{\sum_{i=1}^{N}\left(F_i - \overline{F}\right)^2}\sqrt{\sum_{i=1}^{N}\left(O_i - \overline{O}\right)^2}}$

Observation data

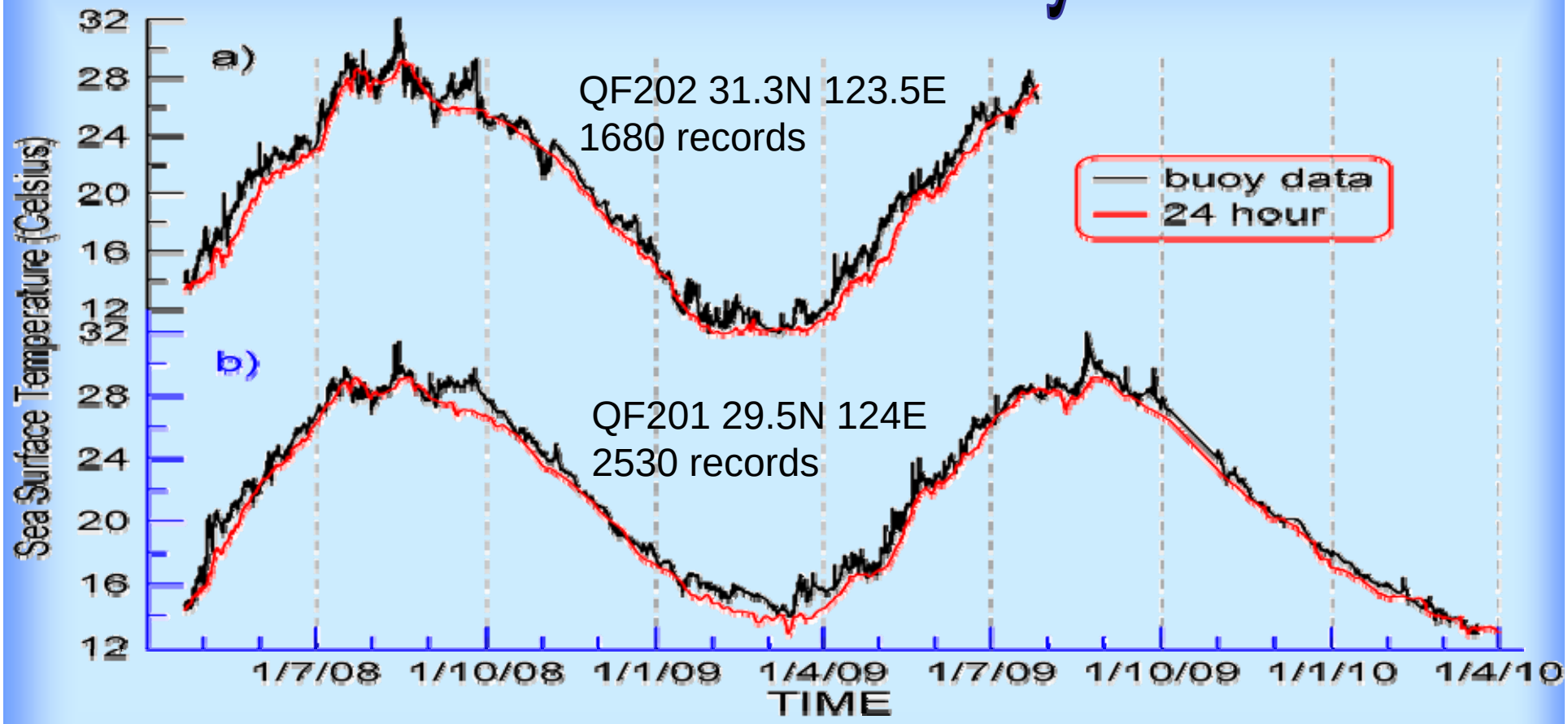
Buoy data :
Operational observation program

SST Web site:
ftp.discover-earth.org



Argo Web site:
ftp.ifremer.fr

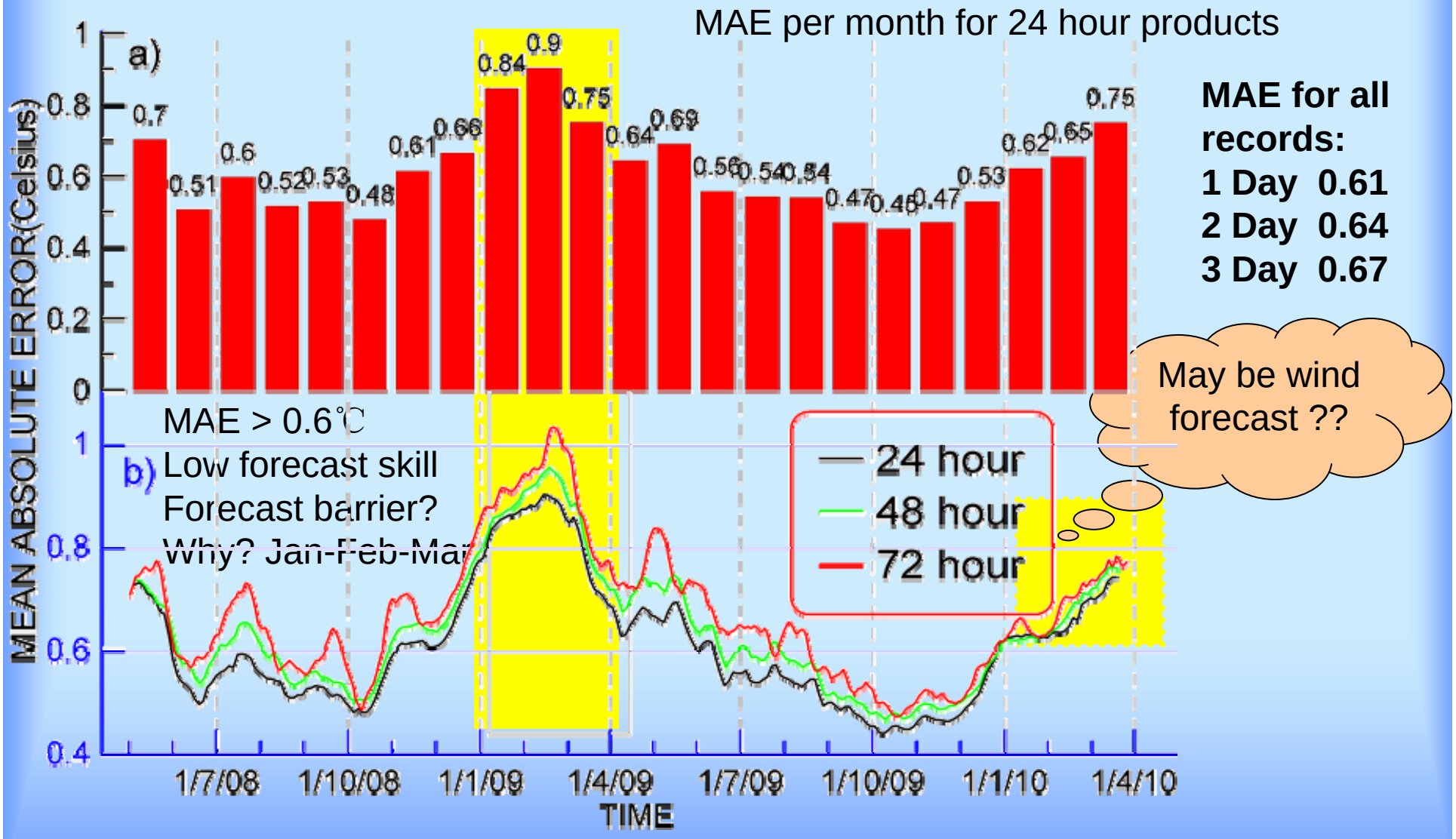
Verification of SST with Buoy data



SST time series obtained from buoy and 24 hour forecast product since Apr 20. 2008

Buoy	ME	MAE	RMSE	R
QF201	0.60	0.70	0.90	0.92
Qf202	0.80	0.95	1.2	0.95

Verification of SST with satellite data



b. Variation of MAE with time, All statistic results are obtained with respect to daily-averaged satellite data and model data

Verification of SST with satellite data

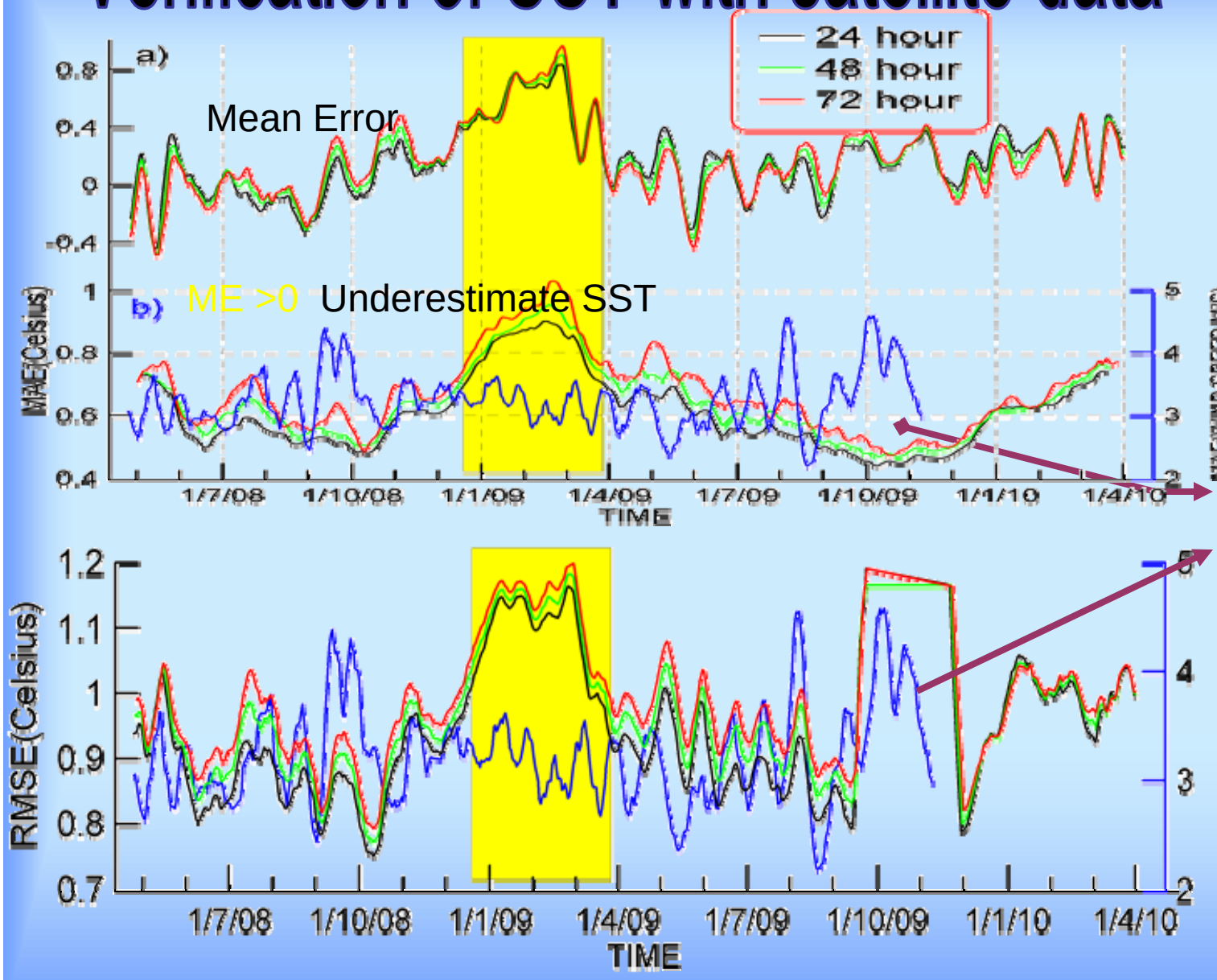


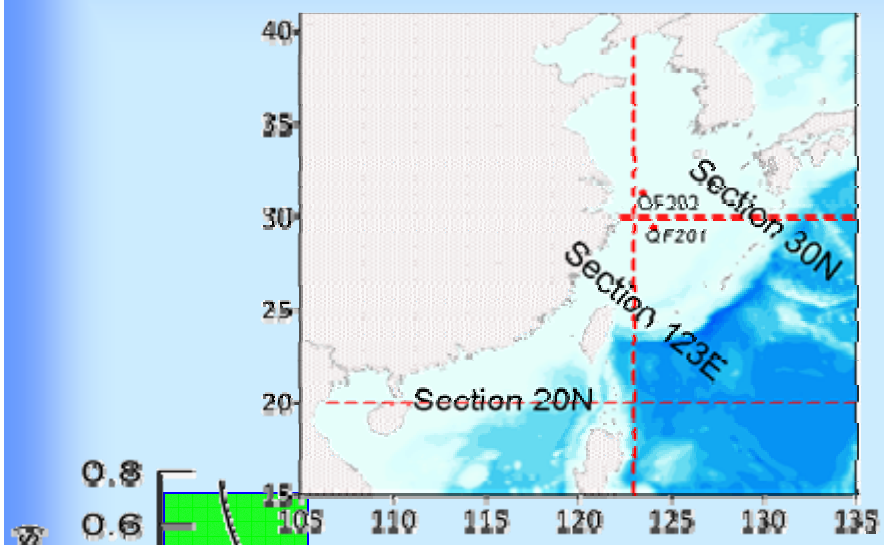
Fig. a show that MAE of wind Values is about 3m/s

WIND MAE with per 5 day data

SST RMSE
0.97 ℃
0.99 ℃
1.01 ℃

Variation of RMSE,MAE and ME for SST with time, All statistic results are obtained with respect to daily-averaged satellite data and model data

Distribution of MAE and ME along LON/LAT

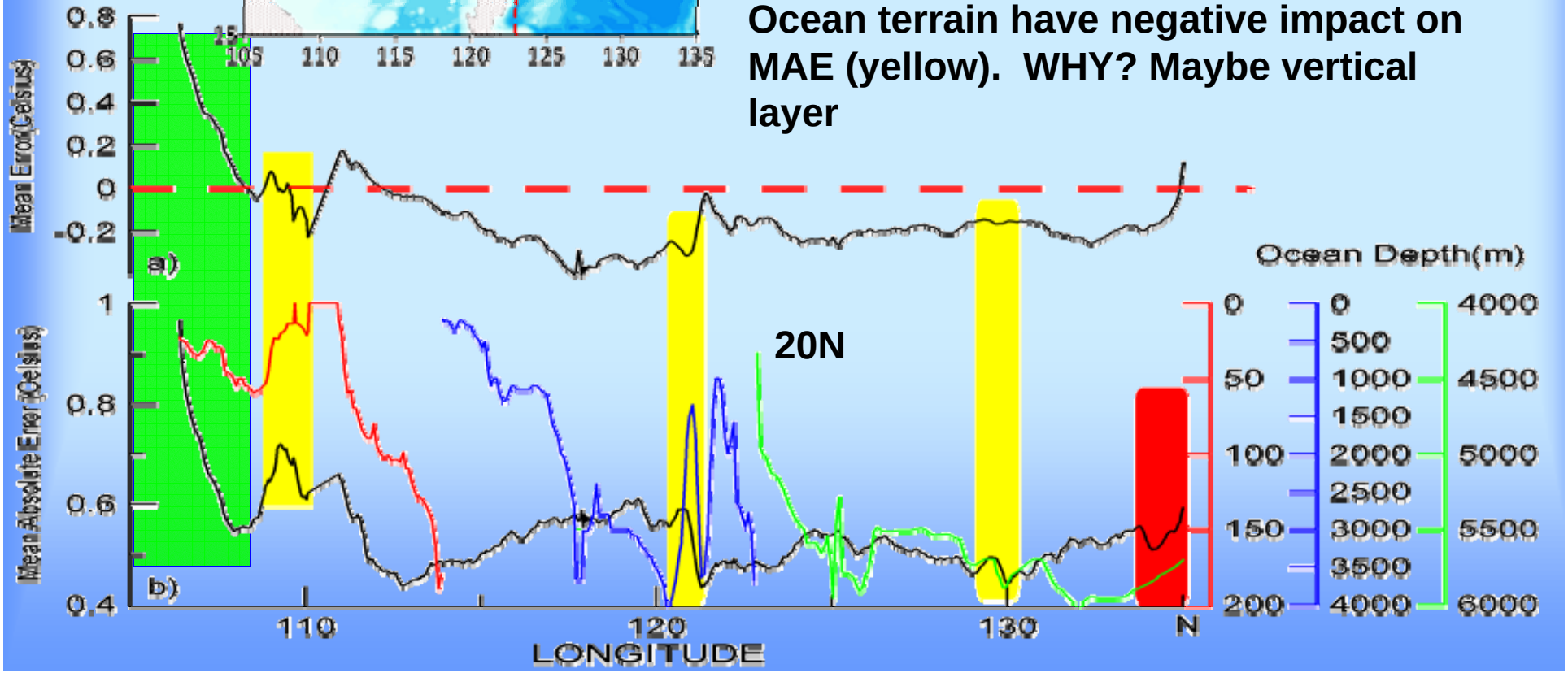


In shallow domain (green), Mean Error > zero, worse forecast skill, So forecast system undervalue SST.

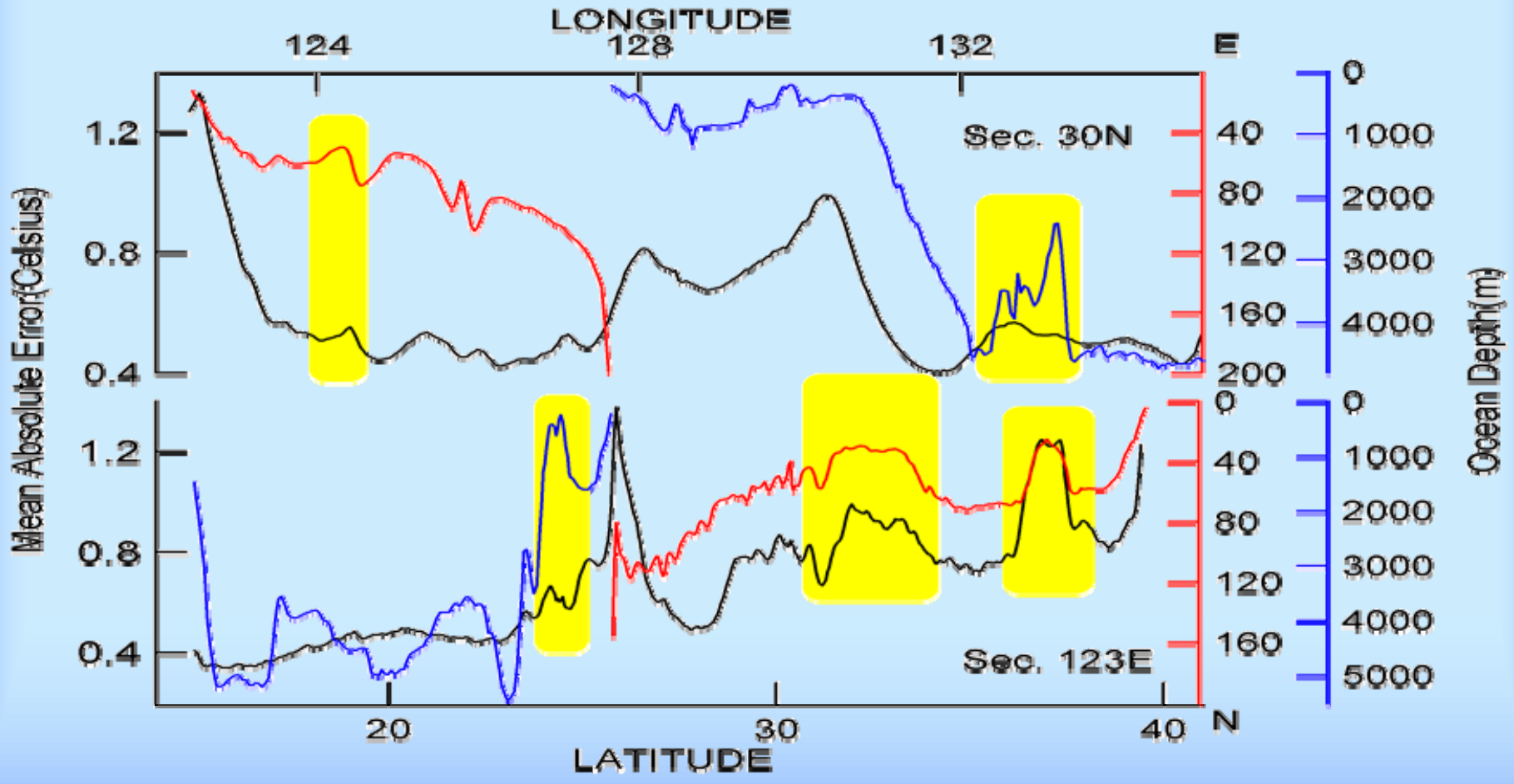
MAE of SST went down with ocean depth increasing.

MAE became larger at open boundary (red).

Ocean terrain have negative impact on MAE (yellow). WHY? Maybe vertical layer

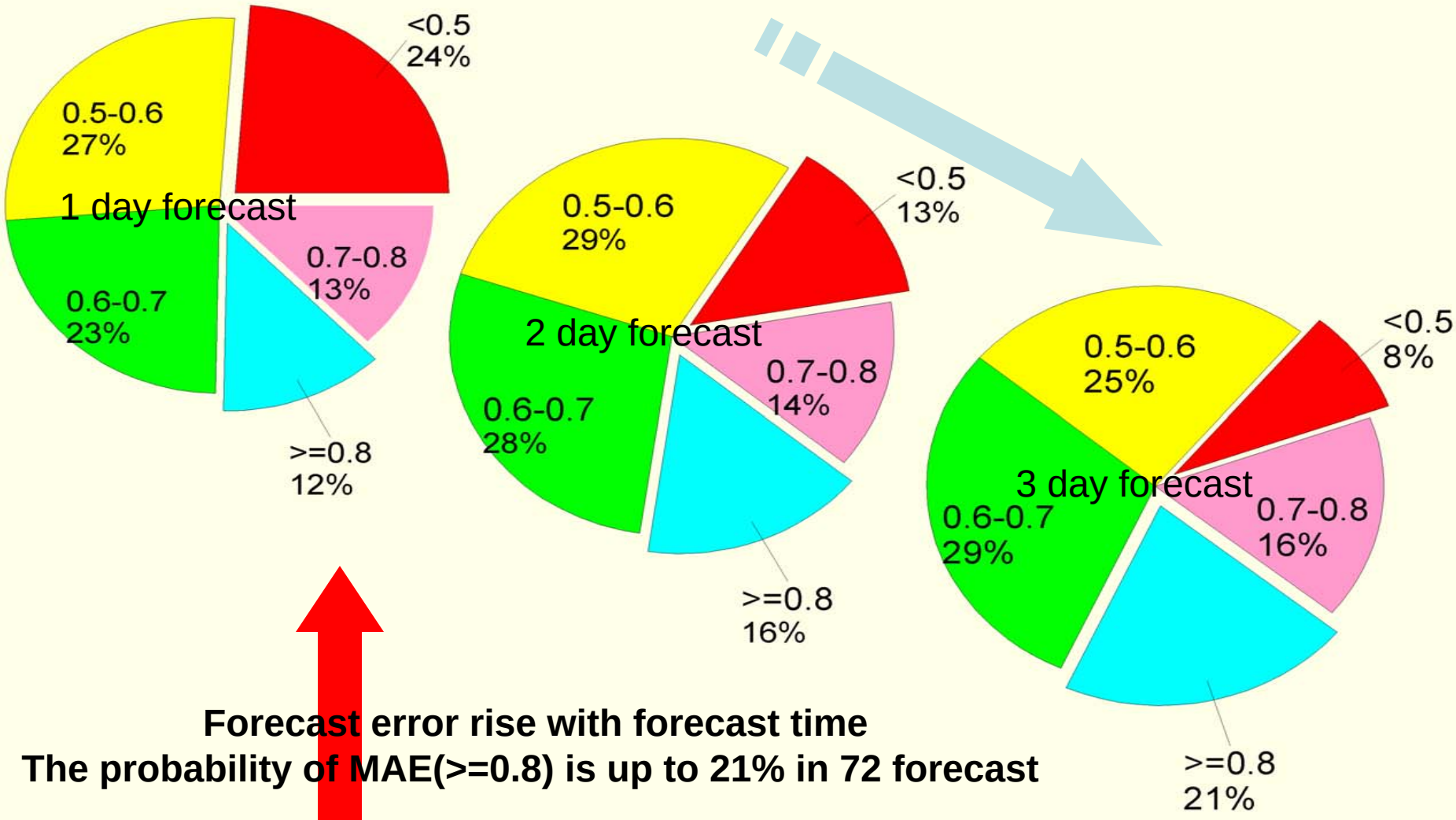


Distribution of MAE and ME along 30N/123E



There have be the same phenomena along 30N and 123E

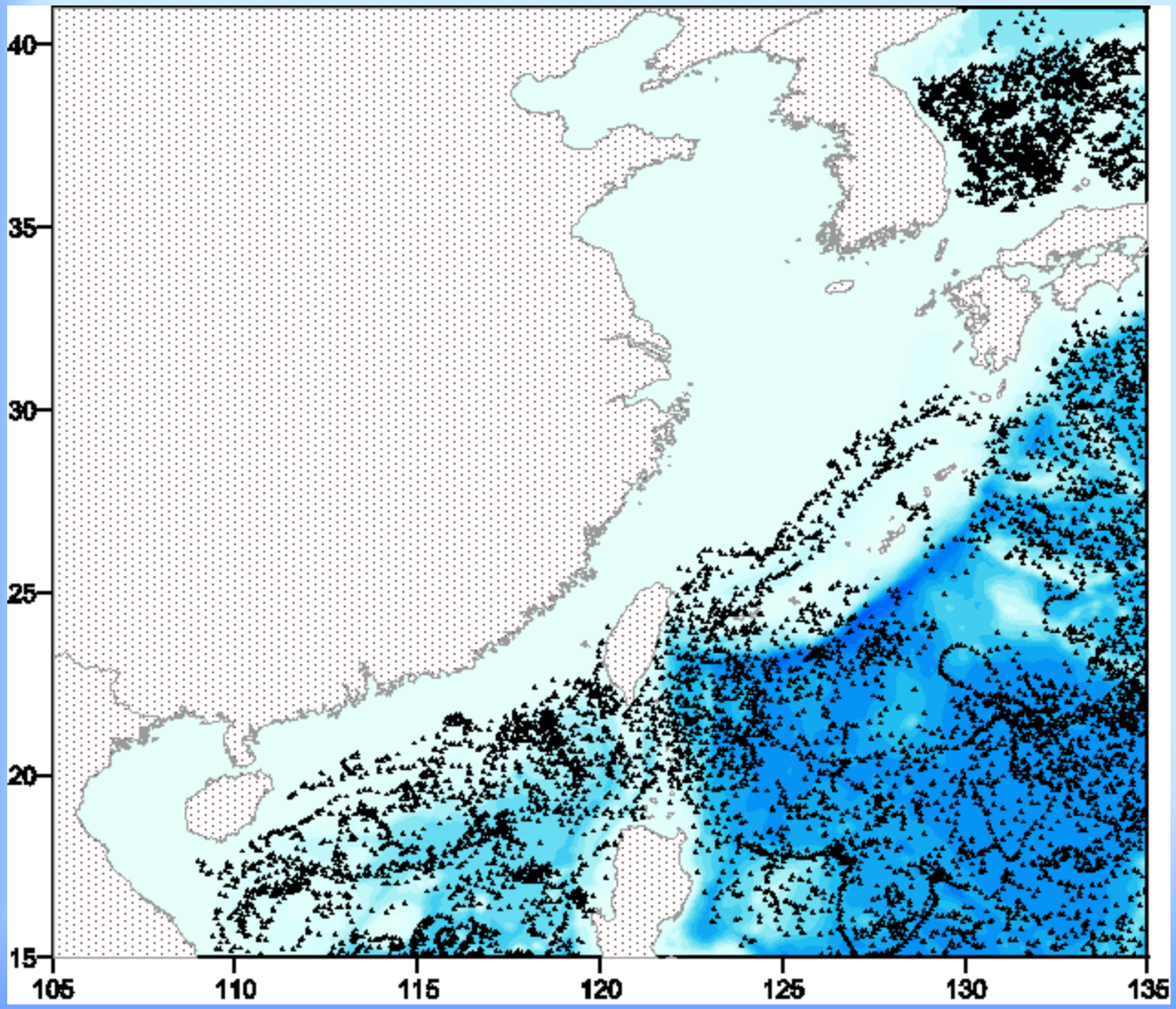
Probability of distribution of MAE for SST



Forecast error rise with forecast time

The probability of MAE(>=0.8) is up to 21% in 72 forecast

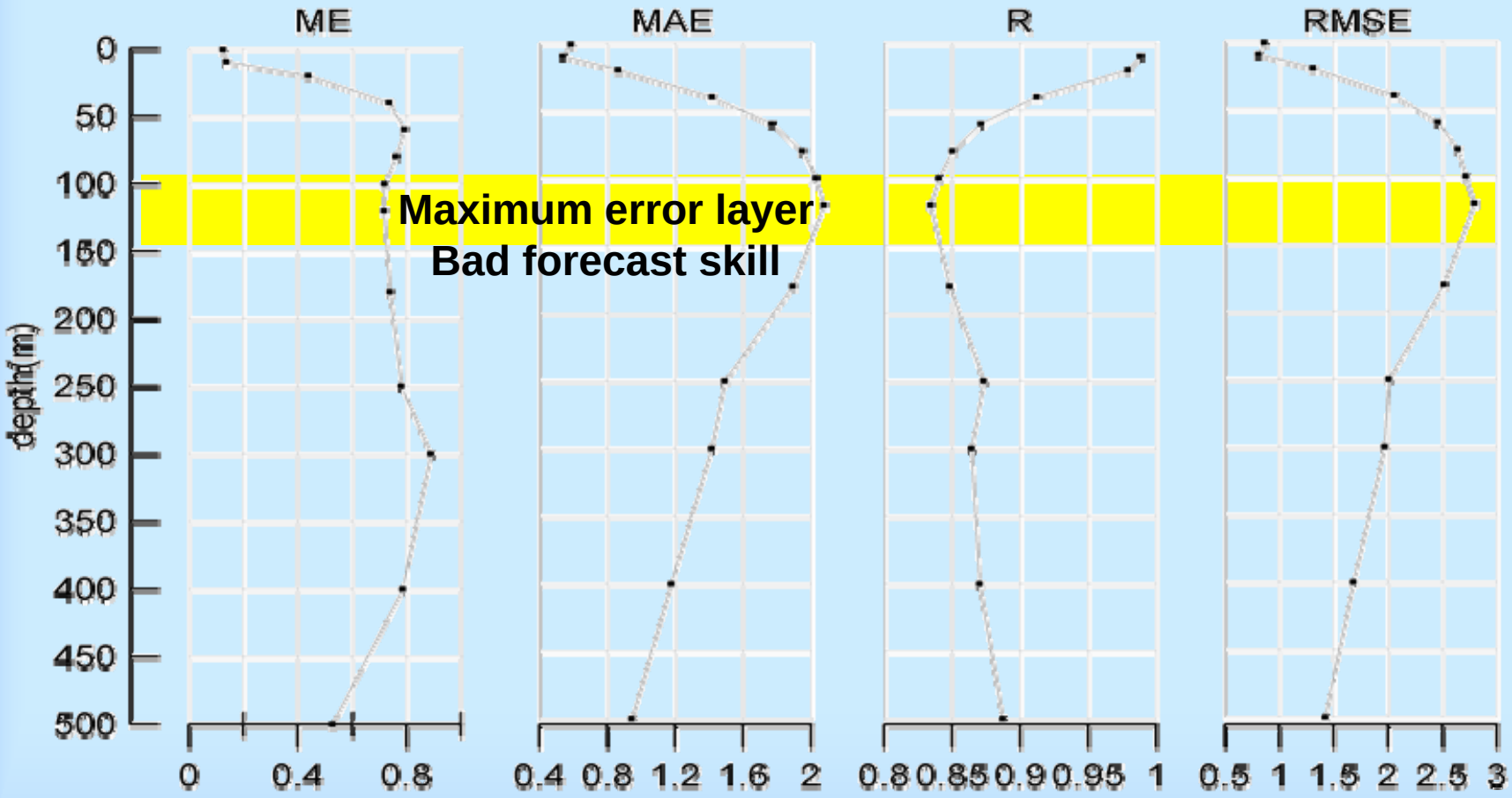
Comparison with Argo data



Profile **number**: 8036

The distribution of Argo Profile used in verification between Apr 20. 2008 to Apr 30. 2010

Subsurface temperature



Average Variations of ME, MAE, R and RMSE with depth from surface to 500m below the sea surface last 2 years.

In the layer between 100m to 150m: maximum MAE(>2℃)

minimum correlation coefficient

maximum RMSE

Mixed Layer Depth

The depth, where the temperature has changed by a variable value(0.5℃) from the temperature at a reference depth of 10 m.

Time	ME	R	MAE	RMSE
1 Day	11.8	0.54	21.6	32.3
2 Day	12.1	0.54	21.6	32.4
3 Day	12.3	0.52	21.7	33.1

Mixed layer depth was underestimated. ME value is about 12m for forecast vs Argo. Table data show that the forecast skill was reduced with time

Mixed Layer Depth

Distribution of ME for MLD

Time	<15M	15-40M	>40M
1 Day	50.3%	34.4%	15.3%
2 Day	50.4%	34.2%	15.4%
3 Day	50.4%	34.1%	15.5%

Probability of forecast accuracy for MLD

Forecast Accuracy =

1-ABS(Obs.-Fcast)/Obs

time \ acc.	>70%	50%-70%	<50%
1 Day	43.3%	27.6%	29.1%
2 Day	43.1%	27.7%	29.2%
3 Day	43.2%	27.5%	29.3%

Conclusion

1. Skill in predicting SST,MLD is expected to be improved . However this will tend to increase the shallow bias in MLD
2. Forecast skill go down with forecast time
3. Open boundary and ocean terrain have a important impact on forecast skill
4. In a period of time (Jan-Feb-Mar), Forecast skill is lost. There maybe a forecast barrier.

Overall the forecast shows reasonable accuracy over a series of studies designed to test ability to represent upper ocean condition.

Thanks!