Upgraded usage of MODIS-derived polar winds in the JMA operational global 4D-Var assimilation system

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Outline

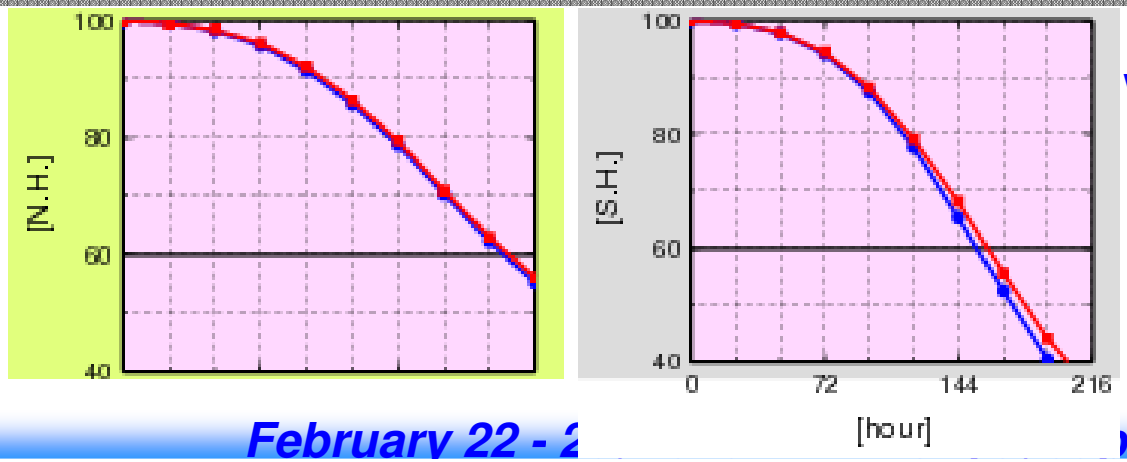
- Background
- Objectives
- Quality of MODIS/NESDIS and MODIS/CIMSS DB polar winds data (new AMVs)
- Saving computational cost and investigations of OBS. Err. Corr.
- Trial of thinning and QC for new AMVs
- Results of OSE
- Summary and Future plan

Background

- CIMSS/MODIS polar winds have been assimilated in the JMA operational system since 2004.
- Recently, MODIS polar winds delivered through GTS are produced operationally by NOAA/NESDIS.
- To reduce the entire processing time, CIMSS also produces direct broadcast (DB) MODIS data.

Rejection experiment of MODIS AMVs in January 2006

Anomaly Corr. of Z500



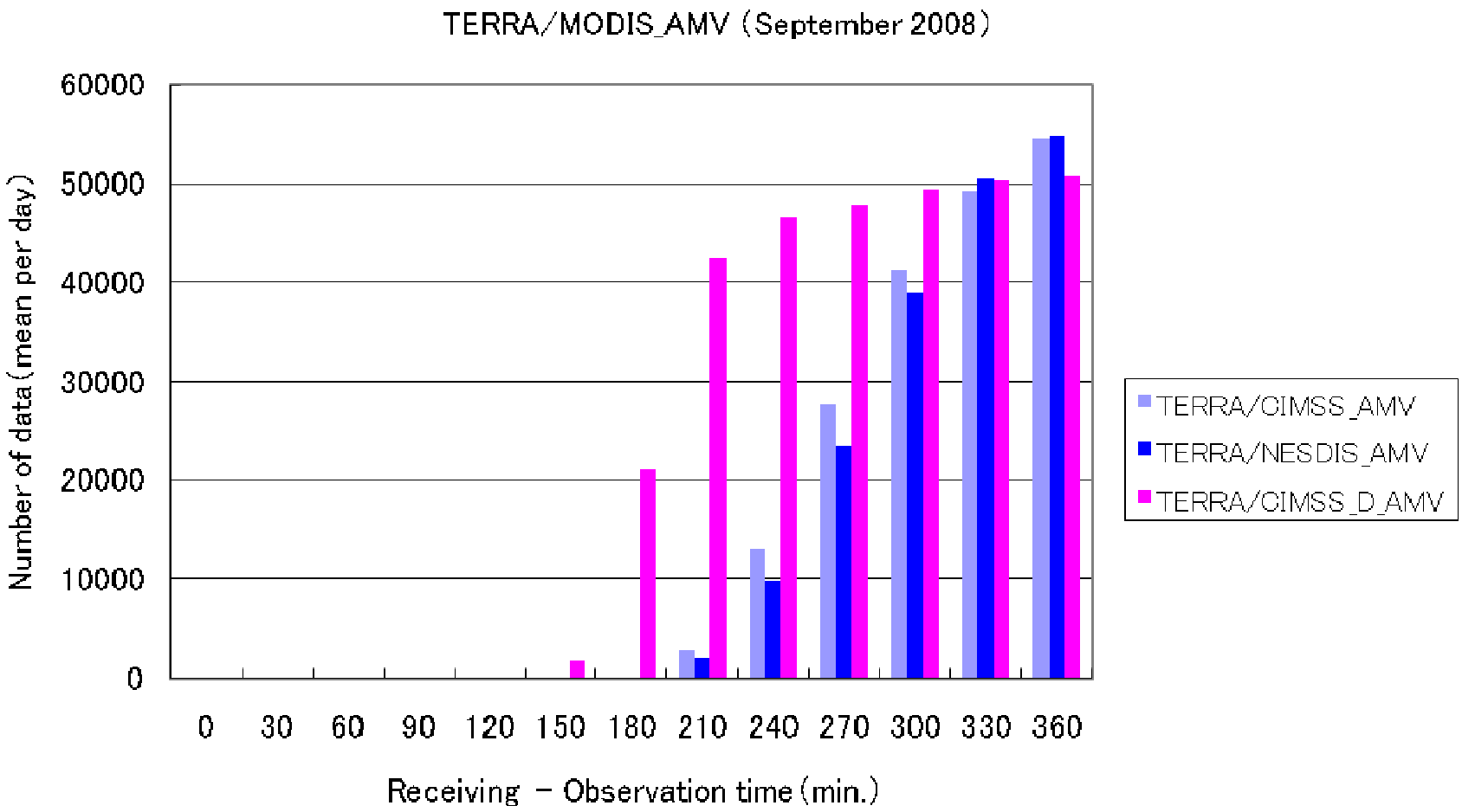
Without MODIS AMVs

With MODIS AMVs

Objectives

- To acquire the new MODIS polar winds data stably and early via GTS and to use them in the JMA operational system .
- To revise our quality control (QC) system for the new data.

MODIS winds receiving time



Quality of NESDIS & CIMSS DB MODIS polar AMVs (New data) comparison

Terra/CIMSS AMVs (SH-WV)
(Operational use: After QC)

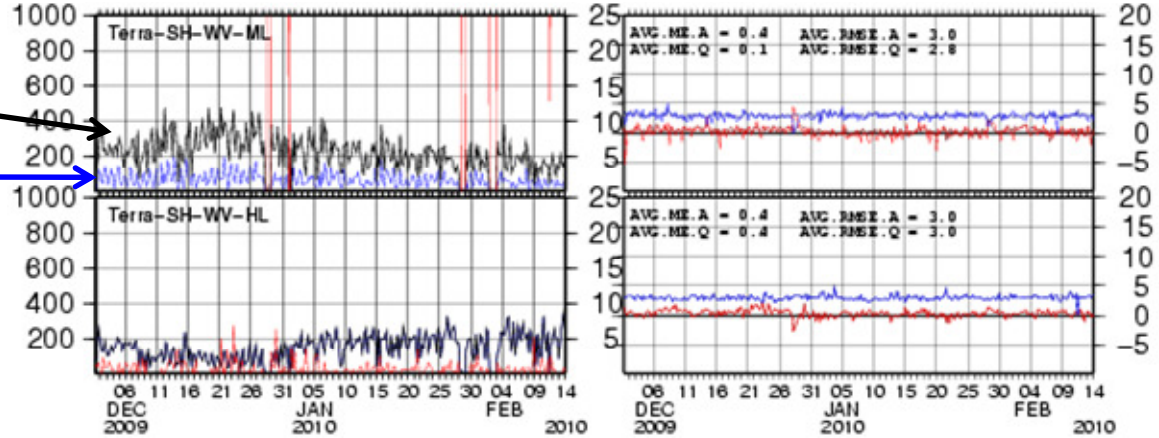
The accuracy of new AMV data bears comparison with MODIS/CIMSS AMV data used in JMA.

Number of Data

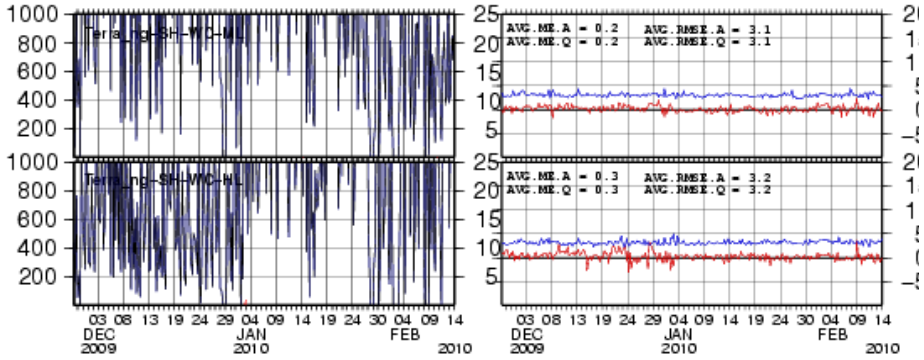
Wind-speed (O-B) ME/RMSE

All data

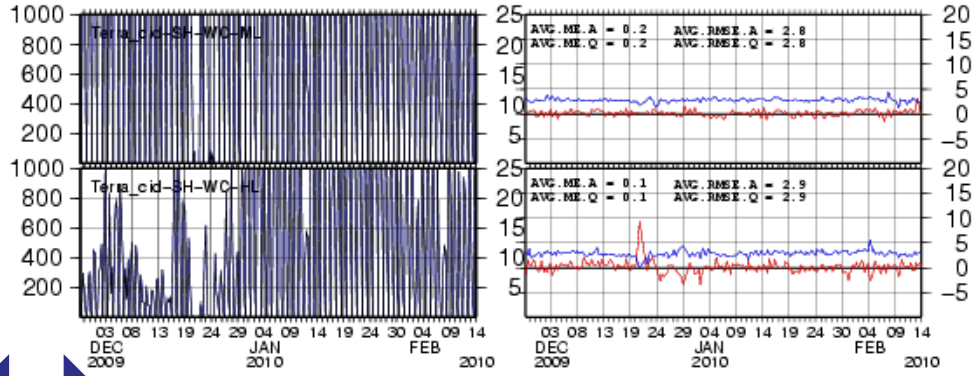
Used data



Terra/NESDIS AMVs (SH-WV) **No QC**



Terra/CIMSS DB AMVs (SH-WV) **No QC**



Saving computational cost

~ Handling of OBS. Error Cov.~

- Cost Function J for 4D-Var

$$J = \frac{1}{2}(\mathbf{x}-\mathbf{x}_{\mathrm{B}})^{\mathrm{T}}\mathbf{B}^{-1}(\mathbf{x}-\mathbf{x}_{\mathrm{B}}) + \frac{1}{2}(\mathbf{y}-\mathcal{H}\mathcal{M}(\mathbf{x}))^{\mathrm{T}}\mathbf{R}^{-1}(\mathbf{y}-\mathcal{H}\mathcal{M}(\mathbf{x})) + J_P$$

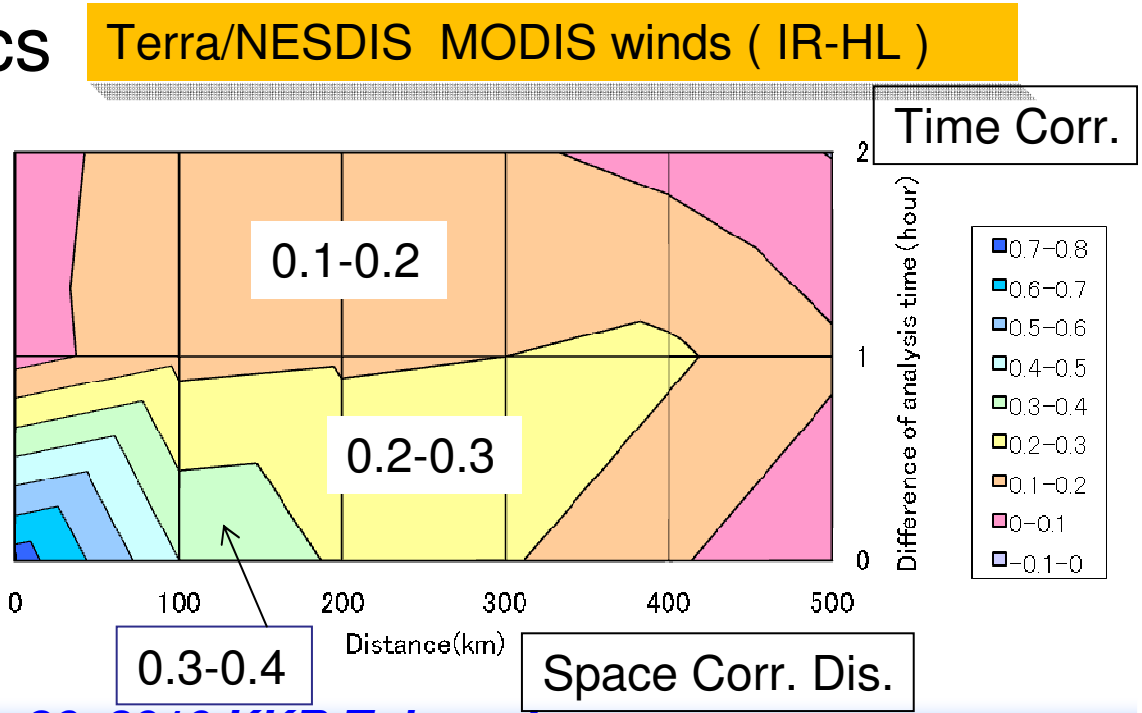
- To save the computational cost of 4D-Var, the AMV data should be thinned to ignore observation error covariance terms in the matrix.

$$\begin{pmatrix} \sigma & & 0 \\ & \ddots & \\ 0 & & \end{pmatrix}^{-1}$$

- The AMV thinning procedure is important.

Investigation of Observation Error Correlation

- Departure (O-B) Err. Corr. was statistically examined.
  - O-B Err. Corr. is empirically good indicator to decide the thinning distance.
- Statistical relationship of space and time correlation distance.
- Conditions of statistics
  - AMV with QI>=60
  - Against 20km-GSM
  - Duration
    - **May 2009**



Results of O-B error correlation in NH

Terra/NESDIS	Space Corr. Dis. (~0.2)	Time Corr. (0hr)	Time Corr. (1hr)	Time Corr. (2hr)
IR-HL	300km	0.75	0.06	0.04
WV-HL	300km	0.77	0.15	0.16
CWV-HL	200km	0.72	0.31	0.28
IR-ML	100km	0.71	0.13	0.17
WV-ML	350km	0.85	0.08	-0.19
CWV-ML	150km	0.74	0.29	0.32
IR-LL	150km	0.81	0.38	0.37
Terra/CIMSS DB	**Space Corr. Dis. (~0.2)**	**Time Corr. (0hr)**	**Time Corr.**	**Time Corr. (2hr)**
IR-HL	150km	0.65	0.28	0.01
WV-HL	150km	0.66	0.25	0.04
CWV-HL	200km	0.82	0.31	0.27
IR-ML	150km	0.73	0.23	0.20
WV-ML	150km	0.76	0.25	0.09
CWV-ML	Grater than 500km	0.82	0.35	0.33
IR-LL	Grater than 500km	0.79	0.26	0.12

Results of O-B error correlation in SH

Terra/NESDIS	Space Corr. Dis. (~0.2)	Time Corr. (0hr)	Time Corr. (1hr)	Time Corr. (2hr)
IR-HL	250km	0.81	0.25	0.33
WV-HL	Grater than 500km	0.77	0.39	0.41
CWV-HL	200km	0.79	0.29	0.26
IR-ML	350km	0.78	0.30	0.32
WV-ML	250km	0.60	0.38	0.37
CWV-ML	250km	0.80	0.36	0.31
IR-LL	200km	0.82	0.41	0.40

Terra/CIMSS DB	Space Corr. Dis. (~0.2)	Time Corr. (0hr)	Time Corr.	Time Corr. (2hr)
IR-HL	200km	0.82	0.13	0.21
WV-HL	250km	0.79	0.36	0.24
CWV-HL	Grater than 500km	0.82	-0.14	0.37
IR-ML	200km	0.76	0.23	0.30
WV-ML	250km	0.79	0.40	0.37
CWV-ML	250km	0.79	0.29	0.31
IR-LL	200km	0.79	0.26	0.12

Trial of thinning and QC for MODIS/NESDIS and MODIS/CIMSS AMVs

Operational method (CIMSS winds : CNTL)	Trial method : TEST (NESDIS&CIMSS DB winds)
• Thinning 1.Thinning interval : 150 km. 2.One AMV selected per box in the 6 hour time window.	1.Thinning interval : 150 (250) km for NH (SH). 2.Priority of AMVs with short space correlation distance. 3. One AMV selected per box in the 6 hour time window.
•QC(**Blacklisting in space**) 1. All winds over land below 400 hPa 2. All WV winds below 550 hPa over sea 3. All IR winds below 600 hPa over sea	1. IR wind speeds less than 10m/s below 650hPa for NH. 2. 300 – 900 hPa : IR winds for NH. 3. 300 – 600 hPa : WV/CWV winds for NH 4. 300 – 600 hPa : All winds for SH.

Global Experiments Specification

- Hydrostatic Global Spectral Model (GSM)

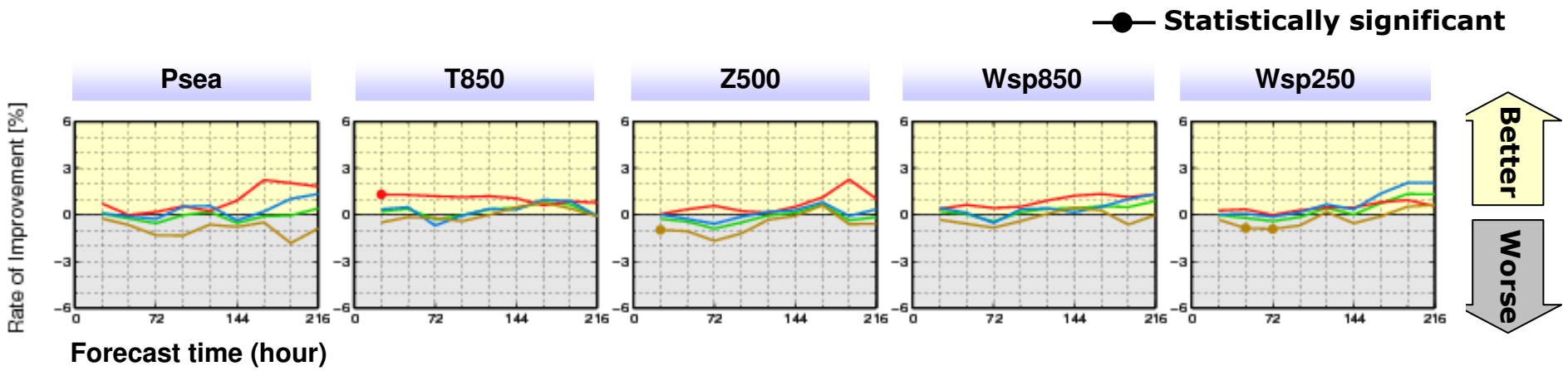
Horizontal rez./ Vertical rez.	60 km / 60 level
Top	0.1 hPa
Inner-loop model rez. for DA	120 km
Assimilation method	4D-Var
Time windows	6-hour
Forecasts	216 hours (Init. 12UTC)

- Experimental duration
  - Data Assimilation
    From 00UTC 20/08/2008 to 00UTC 09/10/2008
  - Forecast
    From 01/09/2008 to 30/09/2008

Normalized score against initial forecast (FT=0)

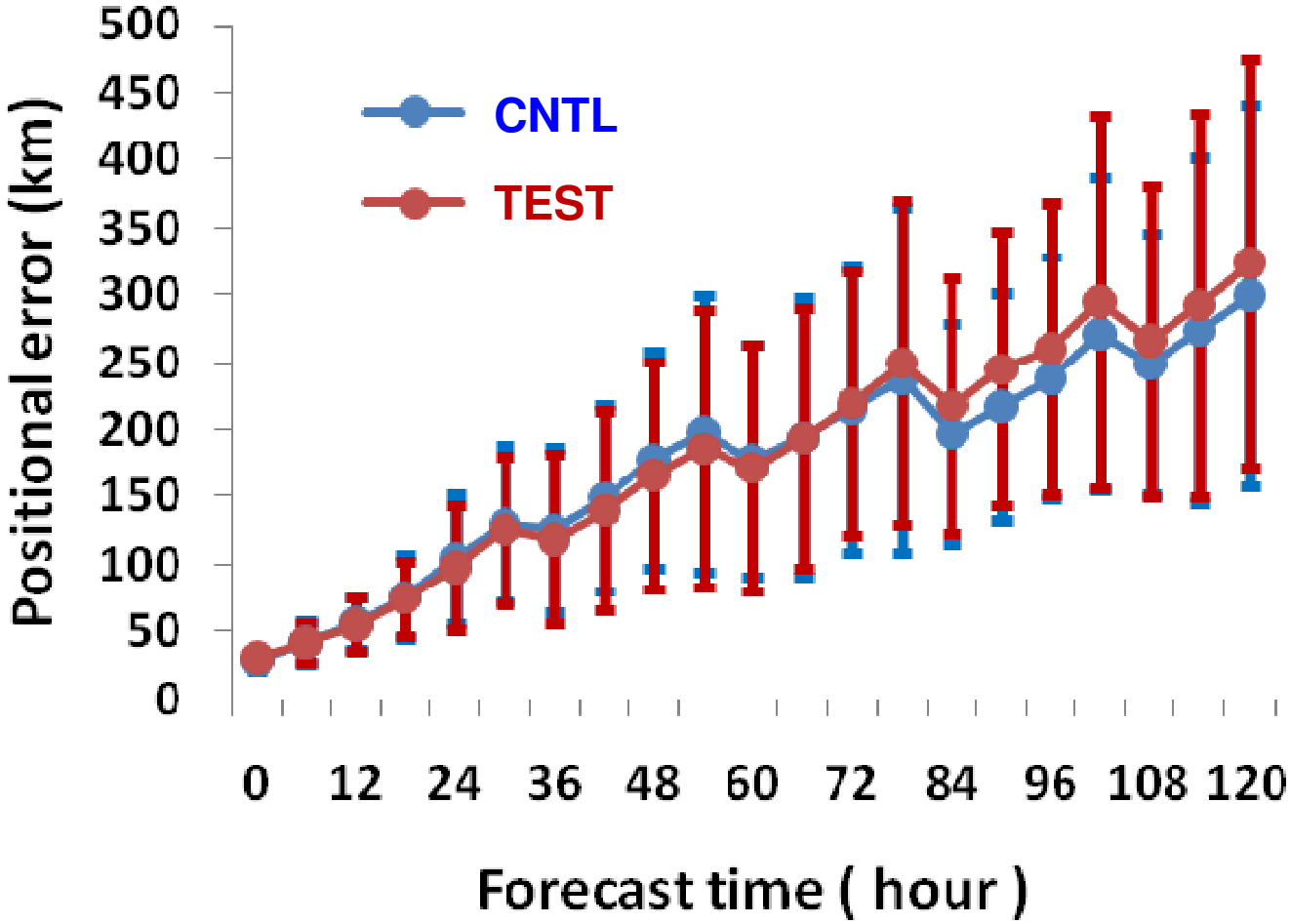
- Slightly positive impacts on nine-day GSM forecast in the Southern Hemisphere.
- Negative impacts (Ave. 1~2 %) in the Northern Hemisphere.

Ex. **Forecast Improvement Rate wrt RMSE for 1-9 day forecasts**
(CNTL-TEST)/CNTL in September 2008.



Mean TC Track Forecast Error

- Five TC track predictions were slightly worse in the late-forecast time.



Summary

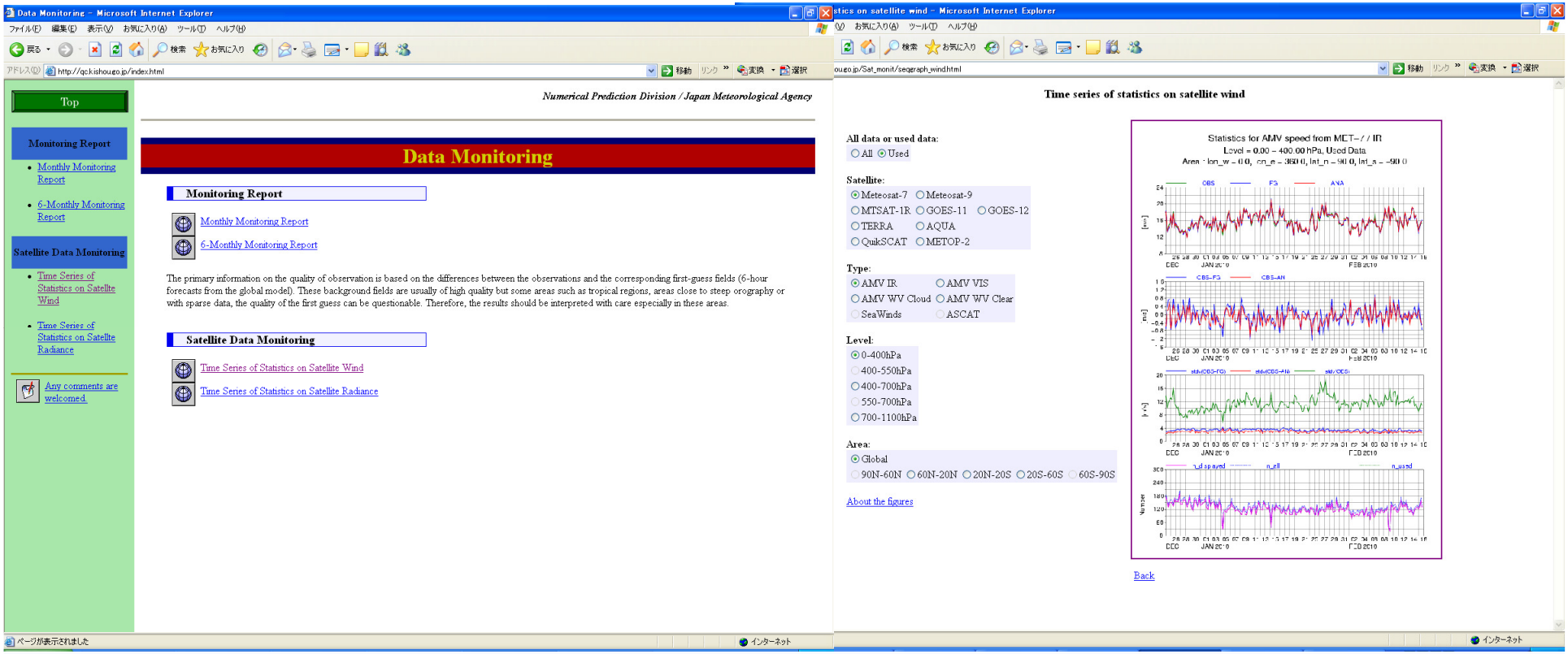
- OSEs for new NESDIS & MODIS DB AMVs using the global NWP system were conducted.
- The trial of QC system for the new AMVs was performed.
- The thinning was decided under consideration of O-B error correlation.
- Slightly positive impacts on nine-day GSM forecast in the Southern Hemisphere.
- Negative impacts (Ave. 1~2 %) in the Northern Hemisphere.
- Five TC track predictions were slightly worse in the late-forecast time.

Future Plan

- We will do the re-examination of QC for new NESDIS & CIMSS(DB) MODIS AMVs.
- We will consider using the other polar satellite winds (NOAA/AVHRR, Metop/AVHRR etc.) to defend the lack of data in the north & south pole areas.

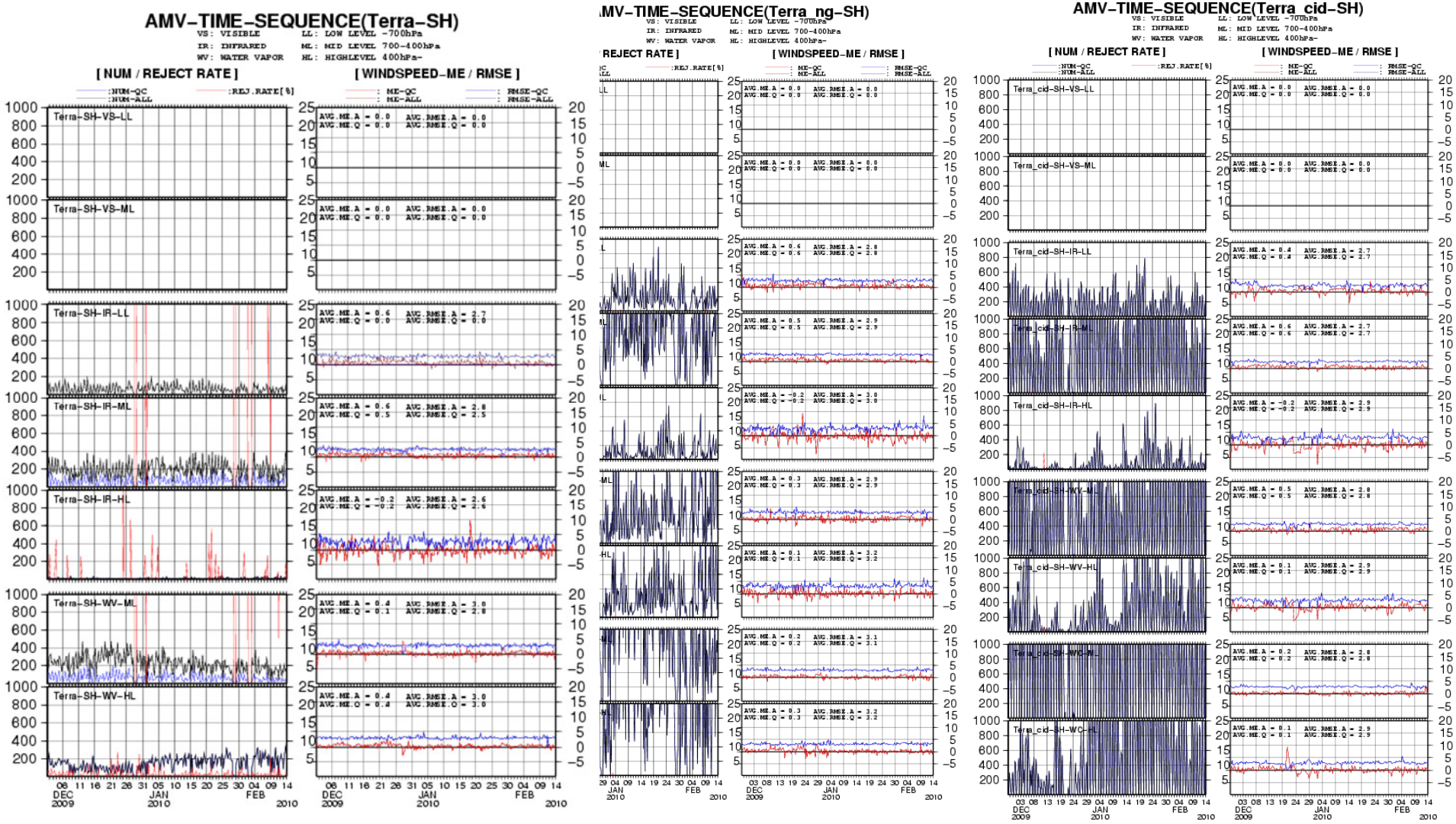
Web site page for Satellite Data Monitoring

- **Main page (Free access)**
  - http://qc.kishou.go.jp/index.html
- **Time series of statistics on satellite wind**
  - http://qc.kishou.go.jp/Sat_monit/seqgraph_wind.html



Thank you for your attention

Quality of NESDIS & CIMSS DB MODIS polar winds comparison



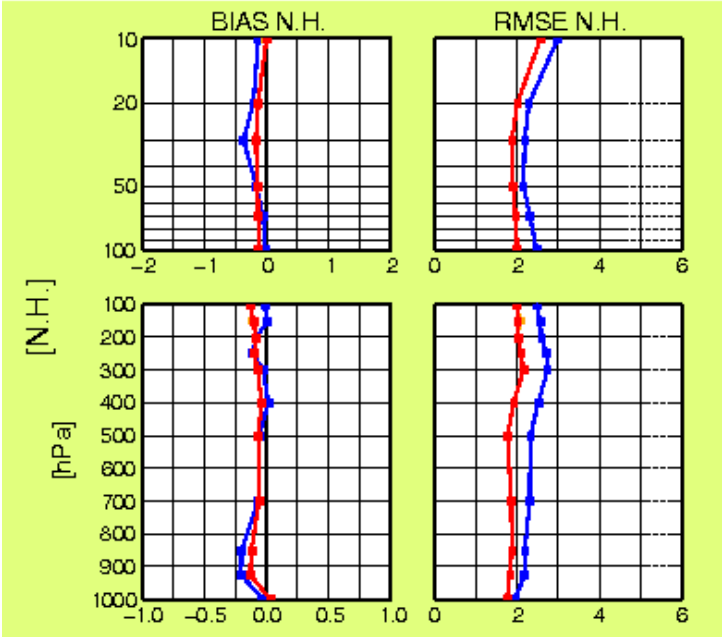
Experimental results for GSM-DA

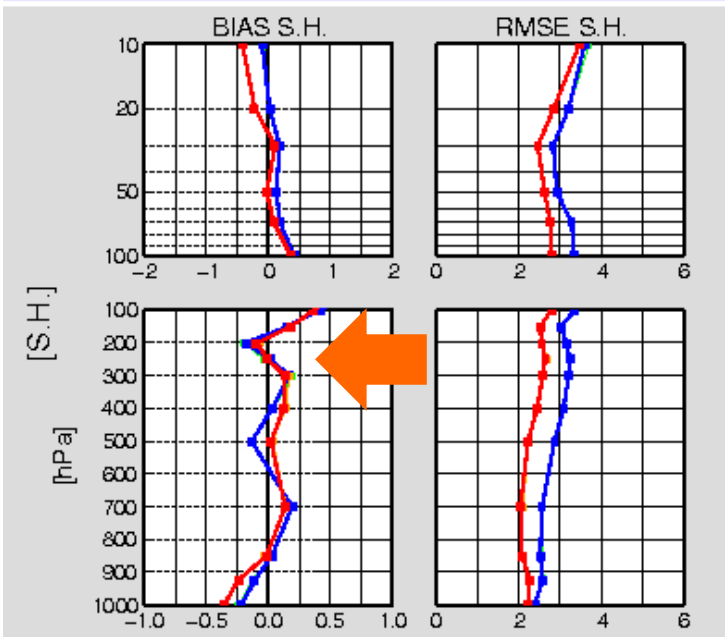
Analysis and First-guess against radiosonde observations

- BIAS of wind analysis in TEST reduced in the Southern Hemisphere. The others remained as same with CNTL.

Ex.

U-component wind speed BIAS and RMSE in the Northern and Southern Hemisphere on September 2008.





Anl TEST — Anl CNTL — Guess TEST — Guess CNTL

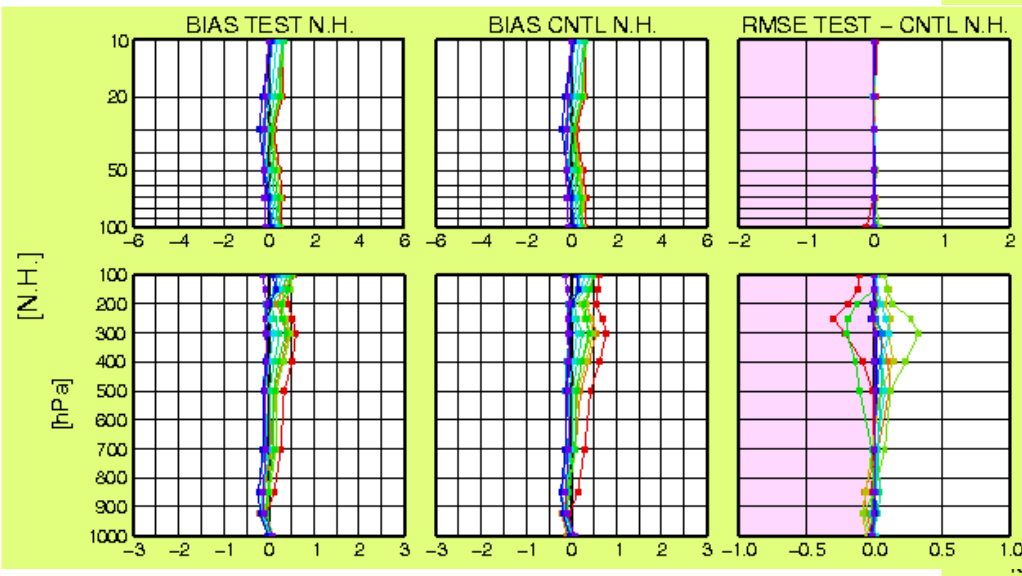
Forecast against radiosonde observations and initial forecast

- RMSE of wind forecast increased in the Northern Hemisphere especially above 500hPa.

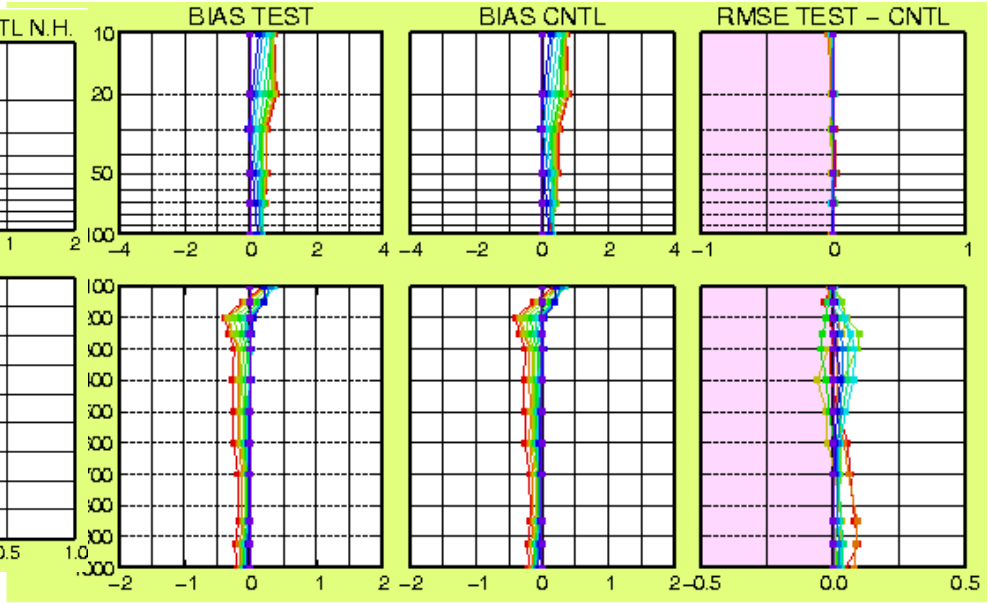
U-component wind speed BIAS and RMSE in the Northern Hemisphere on September 2008.

FT=0 FT=24 FT=48 FT=72 FT=96 FT=120 FT=144 FT=168 FT=192 FT=216

Against radiosonde observations



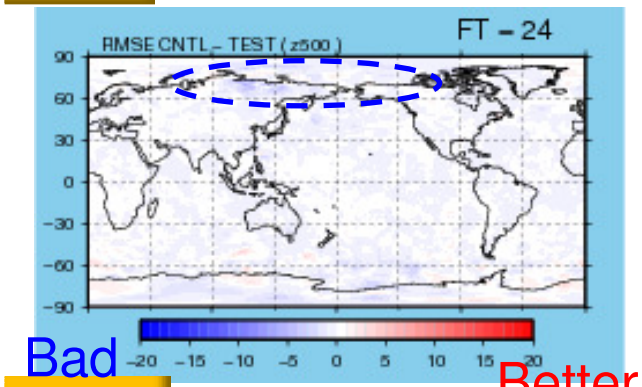
Against initial forecast

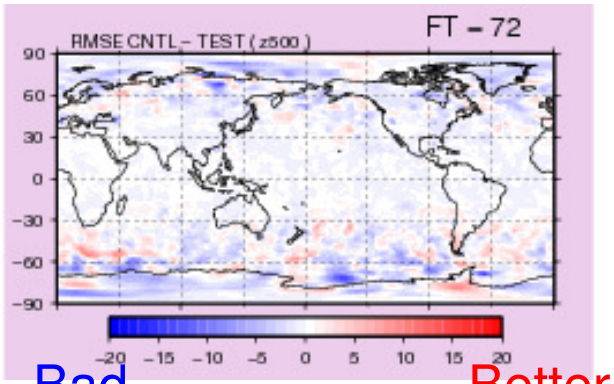


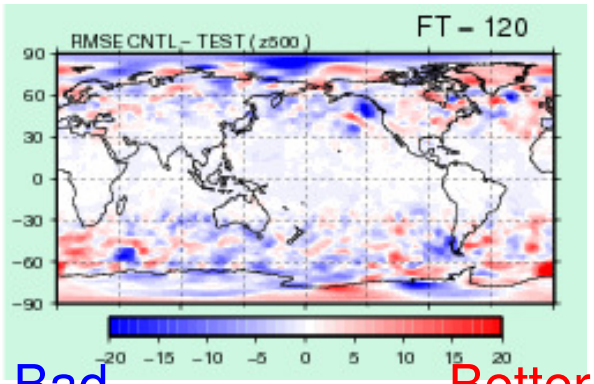
Error map & Zonal mean against initial forecast

Forecast Improvement wrt RMSE for 1-5 day forecasts
CNTL-TEST in September 2008.

Z500







Psea