Study for utilizing high wind speed data in the JMA's Global NWP system

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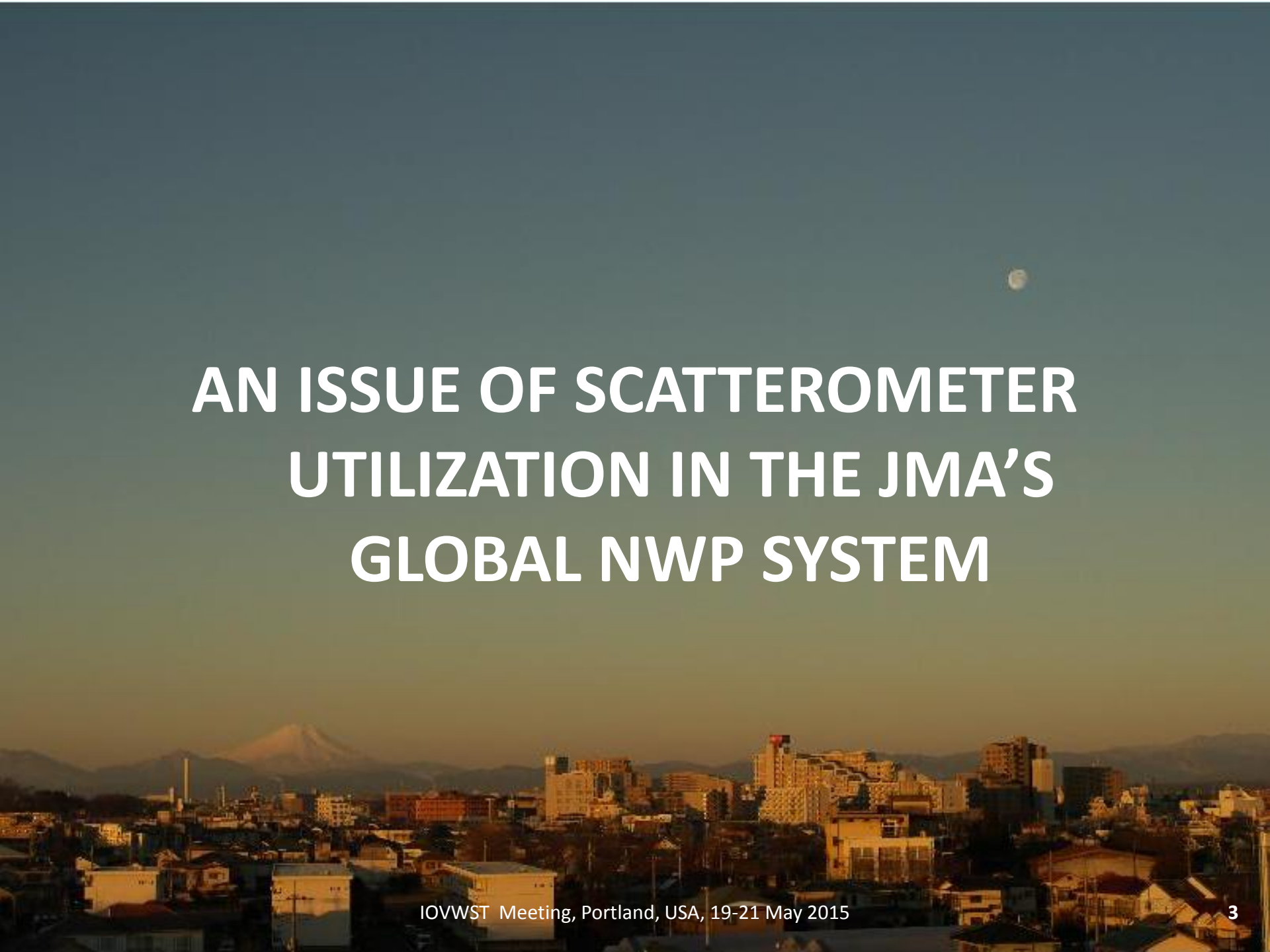
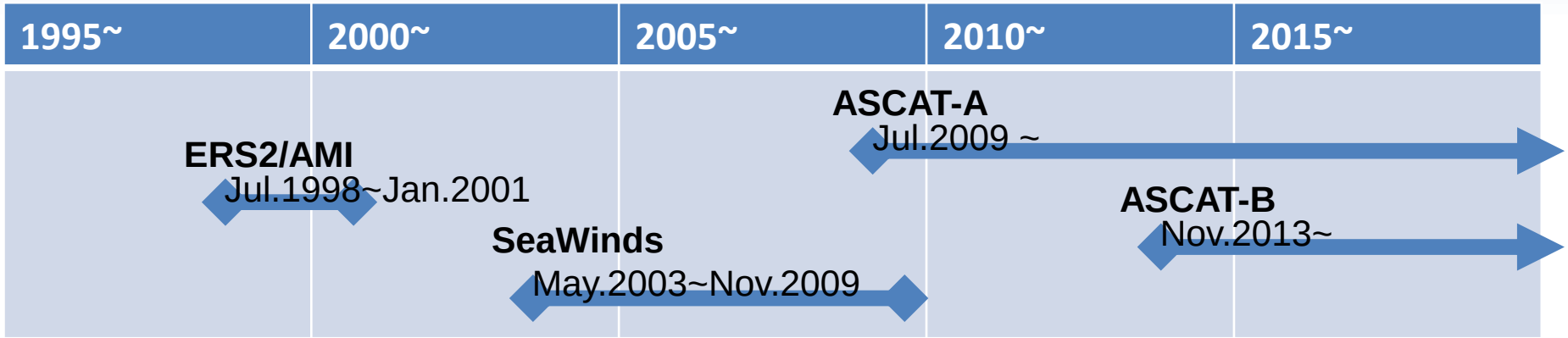
AN ISSUE OF SCATTEROMETER UTILIZATION IN THE JMA'S GLOBAL NWP SYSTEM



History of scatterometer utilization in the JMA's global NWP system



- JMA have been utilizing scatterometer OVW data for numerical weather prediction (NWP)
  - Since Jul. 1998 (ERS2/AMI)
  - At present, ASCAT-A and B OVW data retrieved by OSI-SAF are assimilated in the JMA's global NWP system

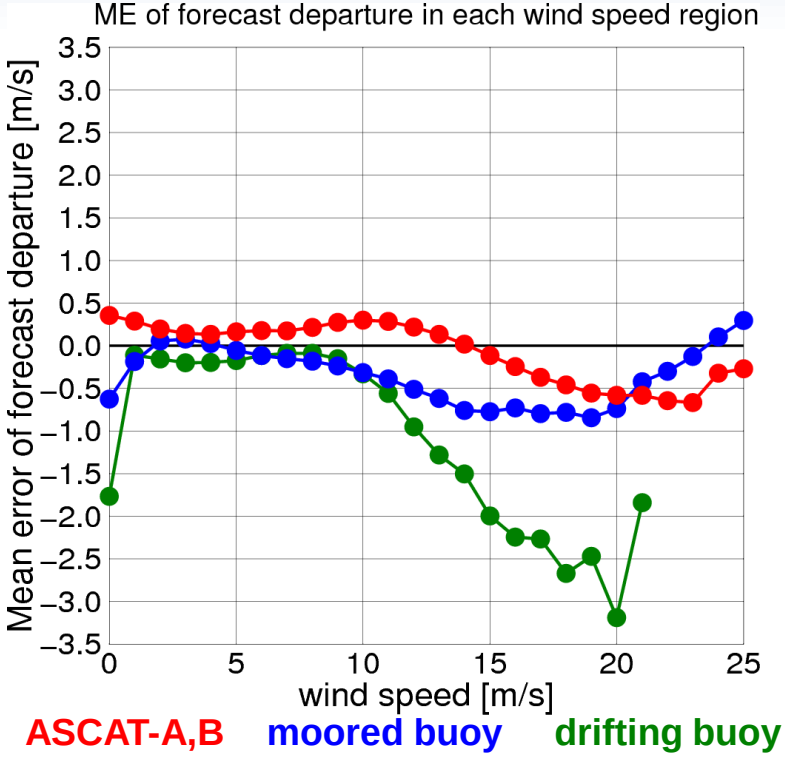
Pre-analysis procedure for scatterometer OVW

- Quality Control
  - Flag check(Rain, Land/Sea, Sea Ice, etc.)
  - Gross error check
    - Reject large |obs. – forecast| (called **O-B**)
  - Group QC
    - Reject large O-B averaged by a area including similar wind vector observation. It works as gross error check avoiding to reject many data in and around severe weather systems
  - Special treatment relevant to positive bias of the JMA's global model in high wind speed range
    - Reject data above 15 m/s
    - Inflate observational error in the south of 30S

Today's topic

- Ambiguity removal
  - Select the closest wind to JMA's forecast by median filter after nudging
- Data Thinning(100 km x 100 km box)
  - To reduce calculation cost in the data assimilation system (4D-Var)
  - Not to introduce spatial observation error correlation

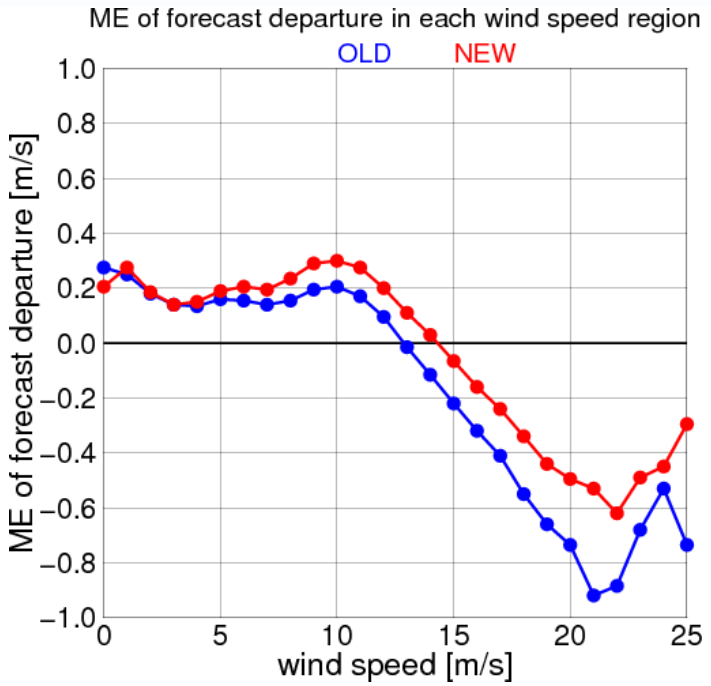
Wind speed O-B bias on scatterometer and other sensors



- Statistics of ASCAT-A,B
  - –Period is Jul. 2014
  - –F.G. is form DA cycle utilizing wind data above 15m/s
- Statistics of moored buoy and drifting buoy
  - –Period is 2014 (whole)
  - –F.G. is from routine DA cycle not utilizing wind data above 15m/s

- A similar bias trend of the model wind speed exits against various observation in high wind speed range
- A major cause of O-B bias in high wind speed range seems to be from model bias

Changes of wind speed O-B bias at recent global NWP system update



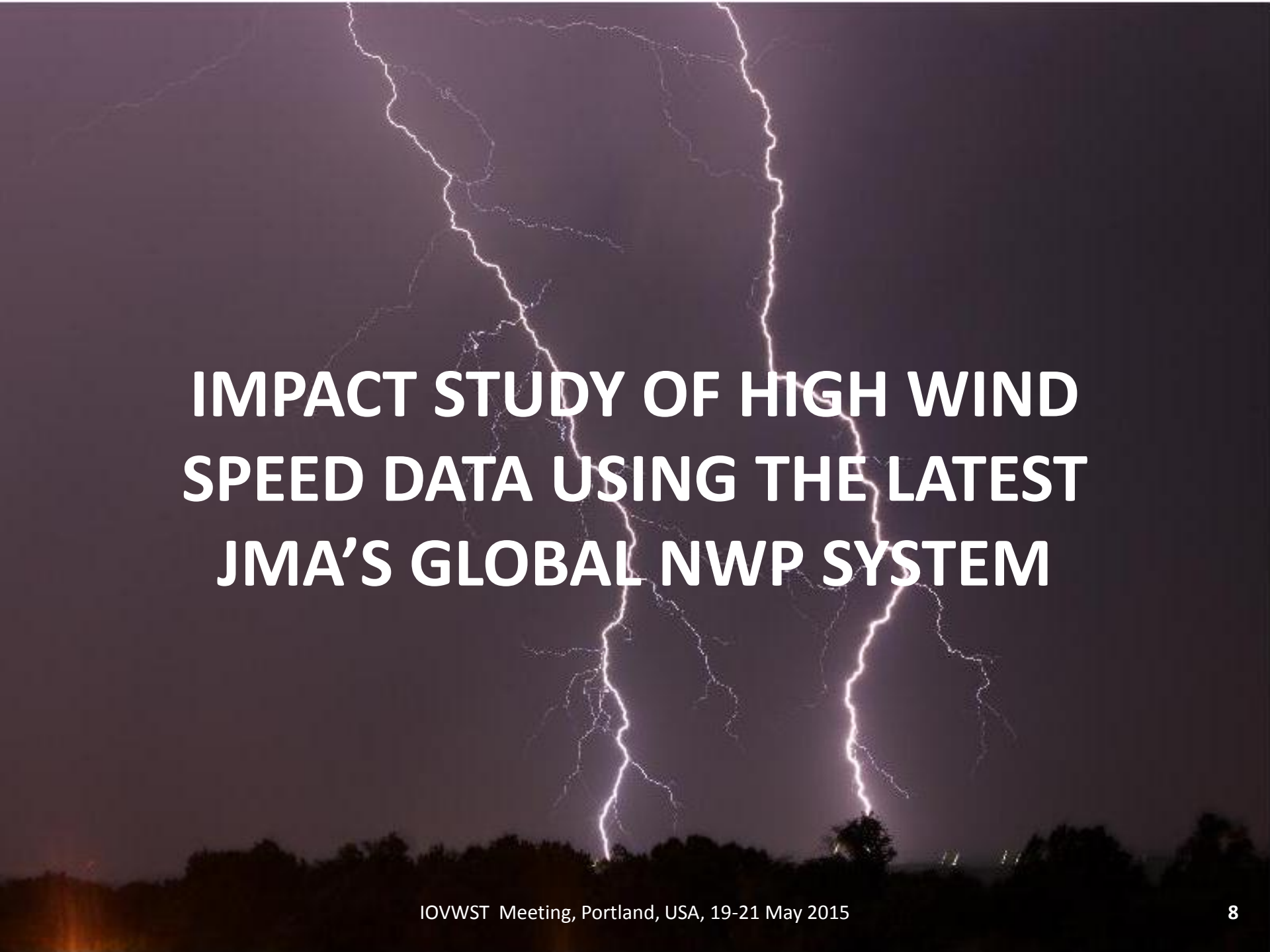
On New NWP system On old NWP system

- Statistic period: Aug. 2013
- The statistics uses F.G. derived from each DA cycle utilizing wind data above 15m/s

- JMA's global NWP system is upgraded on 18 Mar. 2014
  - Enhancement of the vertical resolution
  - Revise of several physical processes
  - Utilization of high altitude observational data

Yonehara, H., M. Ujiie, T. Kanehama, R. Sekiguchi, Y. Hayashi: Upgrade of JMA's Operational NWP Global Model. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.

- Wind speed biases in high wind speed region on new NWP system are mitigated in comparison with that on old one
- Especially, biases at 21 and 25 m/s get smaller by 0.4 m/s, and they correspond to 42 and 60 % bias reduction, respectively



IMPACT STUDY OF HIGH WIND SPEED DATA USING THE LATEST JMA'S GLOBAL NWP SYSTEM

Setup of experiment

- An Experiment to investigate the impact of utilizing high wind speed data in the latest DA system
- Configuration
  - CNTL: the current operational system
  - TEST: CNTL + [extension of utilized wind speed range (from up to 15 m/s to up to 25 m/s)] + [discontinuance of observational error inflation in the south of 30S]
- Period
  - Jan. 2014
  - Jul. 2014

Number of data

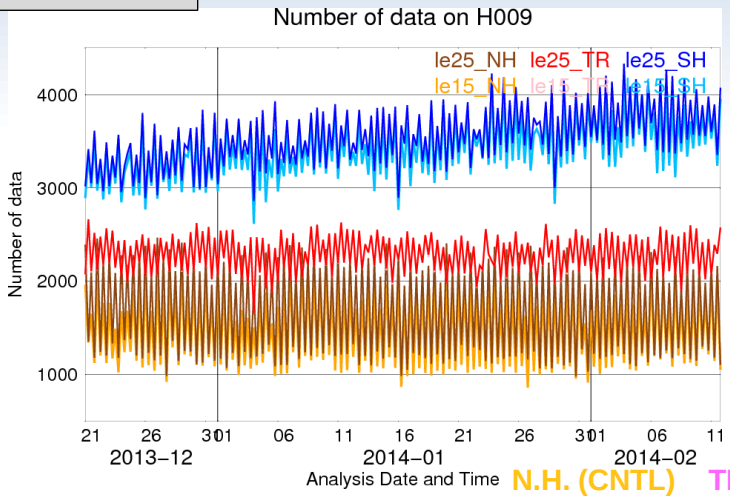
Jan. 2014

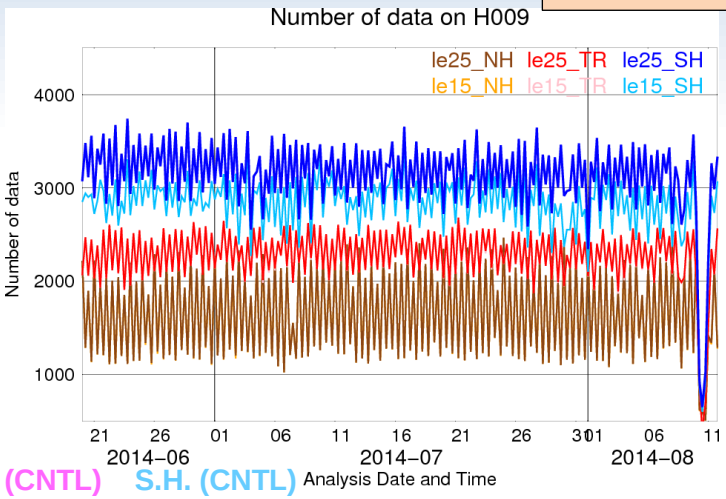
Jul. 2014

+3.5%

+0.1%

+13.8%



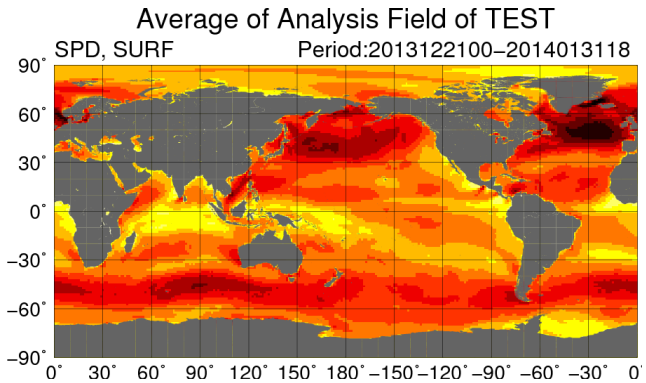


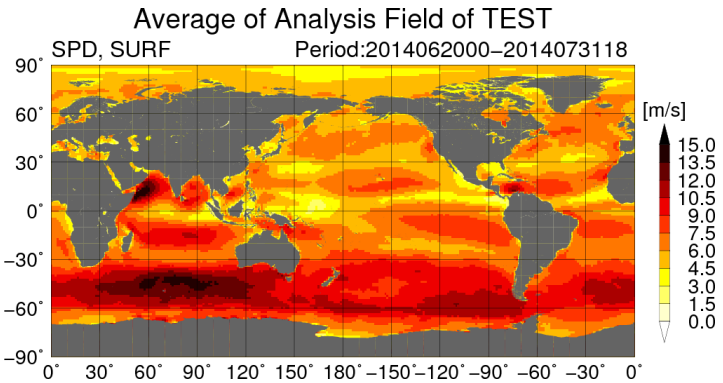
+11.4%

+0.2%

+0.3%

N.H. (CNTL) TR. (CNTL) S.H. (CNTL)
N.H. (TEST) TR. (TEST) S.H. (TEST)

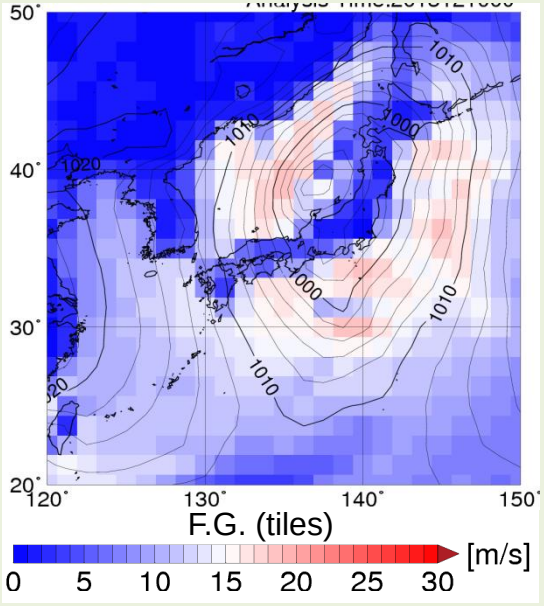




- Data increase corresponds to high wind speed area

The first analysis in DA cycle

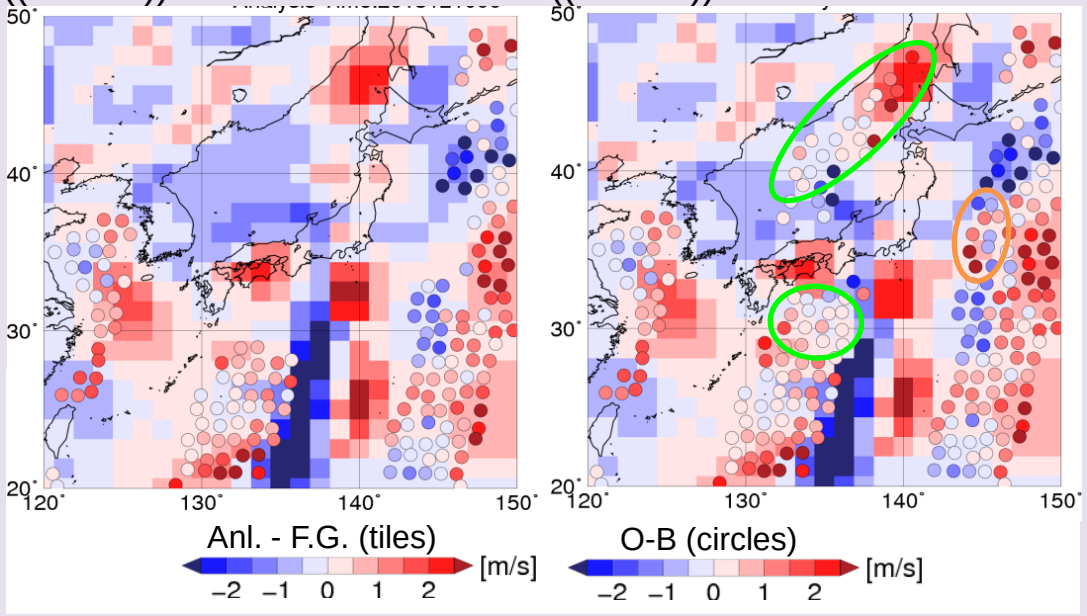
F.G.



Anl. - F.G. and O-B

((CNTL))

((TEST))

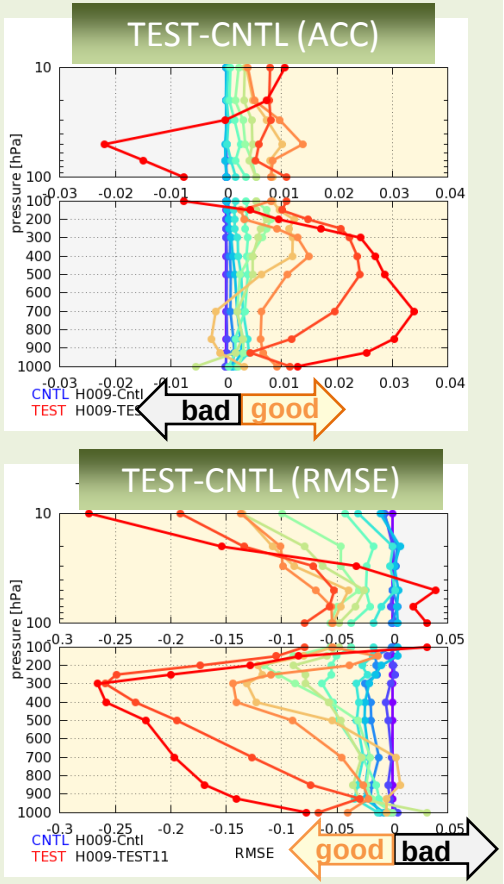


- Data are added anew in the Sea of Japan, the south of Shikoku and the east of Kanto
- The Sea of Japan, The south of Shikoku
  - Around area of $O - B \approx 0$, modification to weaken wind speed on CNTL is restrained
- The east of Kanto
  - Positive O-B bring modification to strengthen wind speed

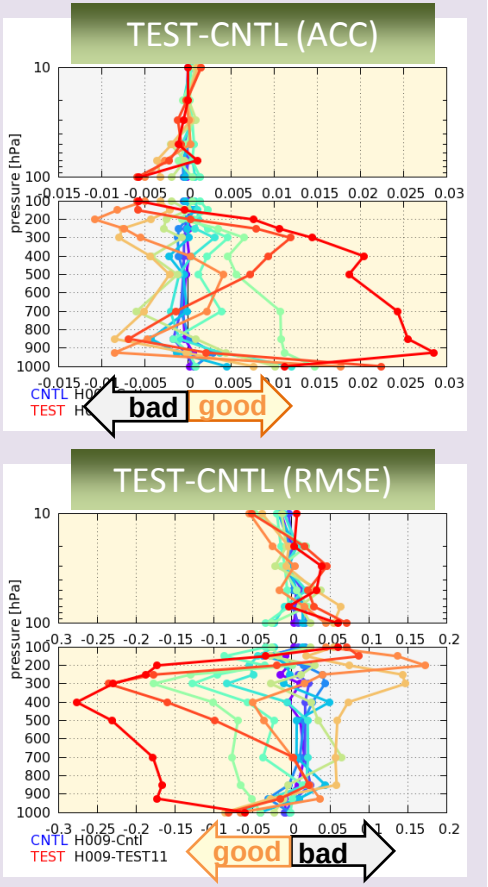
Forecast score statistics

ACC and RMSE of U in global area

Statistics of U in compared with own analysis



Statistics of U in compared with sonde obs.



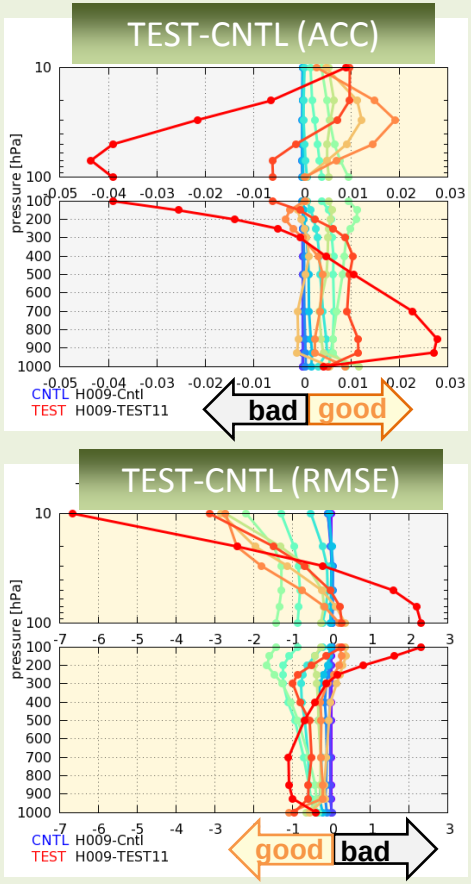
- In case of comparing with own analysis, good results can be seen on many layers and lead time.
- In case of comparing with sonde obs., RMSE above 850 hPa in the first half lead time get worse. still, that near surface shows good.

L.T.=0
L.T.=24
L.T.=48
L.T.=72
L.T.=96
L.T.=120
L.T.=144
L.T.=168
L.T.=192
L.T.=216
L.T.=240
L.T.=264

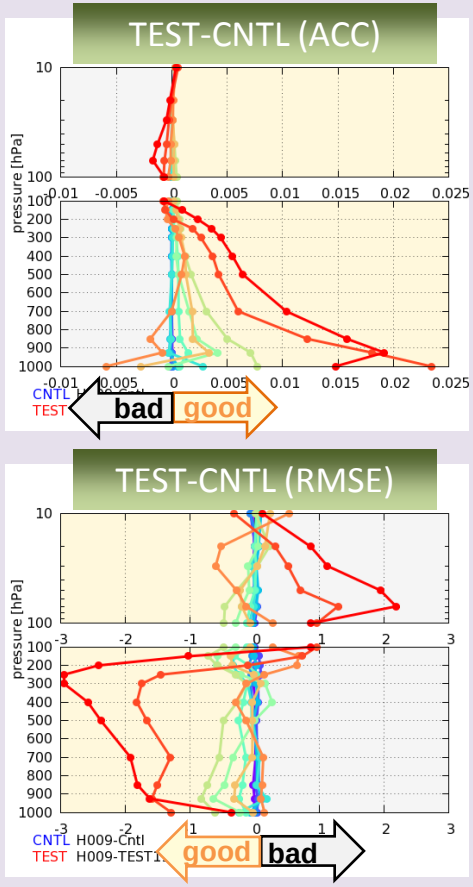
Forecast score statistics

ACC and RMSE of Z in global area

Statistics of Z in compared with own analysis



Statistics of Z in compared with sonde obs.



- In case of comparing with both own analysis and sonde obs., good results can be also seen about geopotential height and other major elements

- L.T.=0
- L.T.=24
- L.T.=48
- L.T.=72
- L.T.=96
- L.T.=120
- L.T.=144
- L.T.=168
- L.T.=192
- L.T.=216
- L.T.=240
- L.T.=264

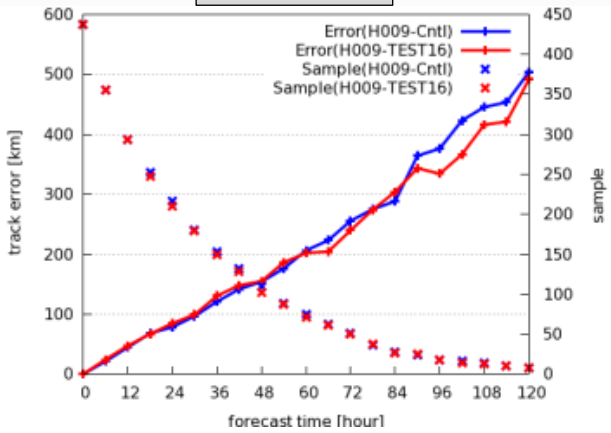
Verification of low forecast

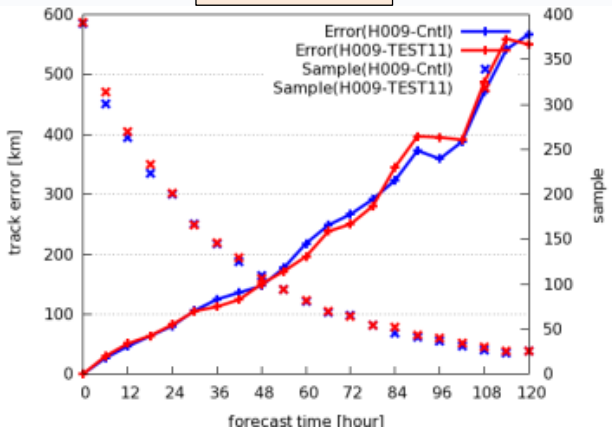
central position

Jan. 2014

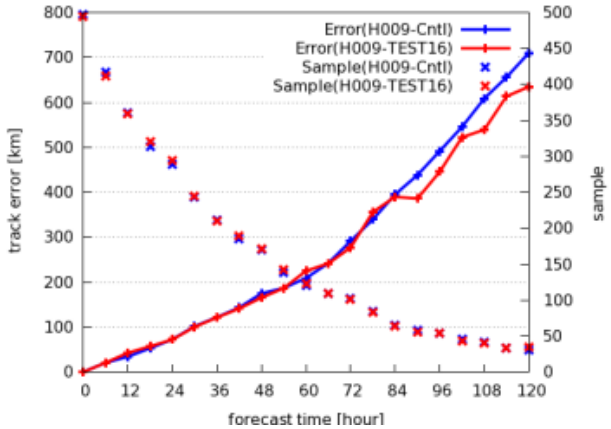
Jul. 2014

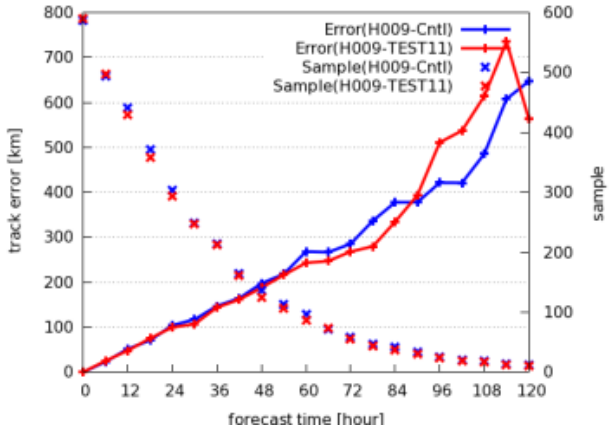
N.H.





S.H.





- Evaluate RMSE and/or ME of
  - central position
  - central pressure
  - maximum wind speed
- Clear improvement is not showed about both central position and central pressure
- Figures shows RMSE of central position

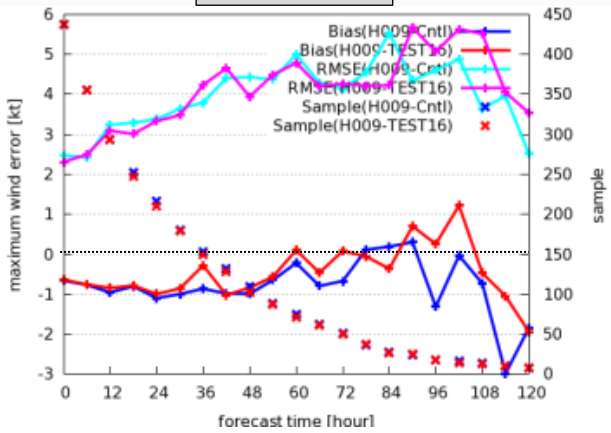
RMSE(CNTL)
RMSE(TEST)

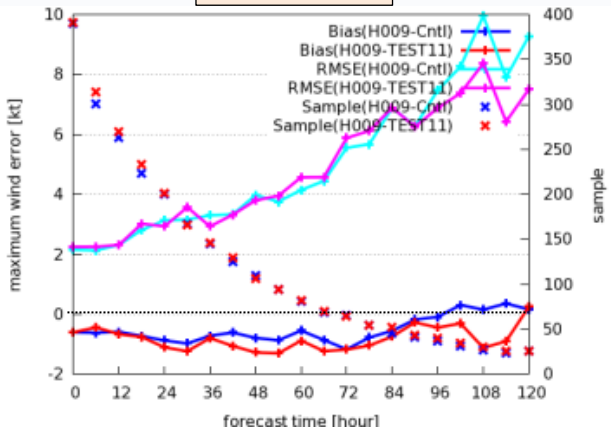
Verification of low forecast

maximum wind speed

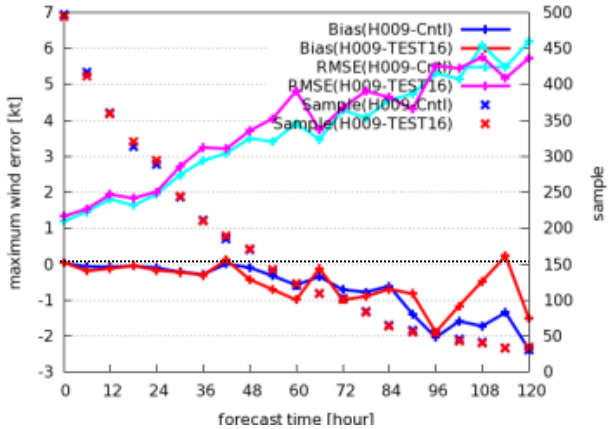
Jan. 2014 | **Jul. 2014**

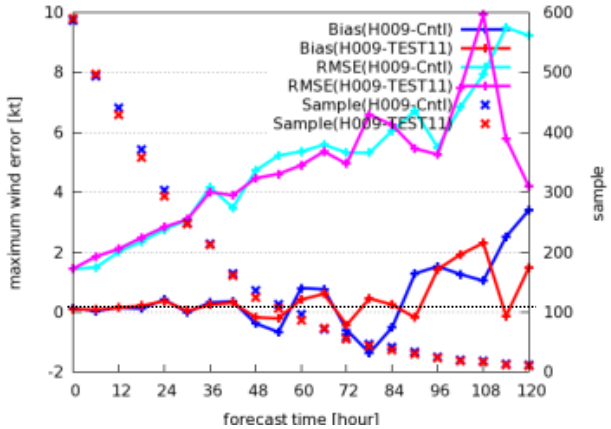
N.H.





S.H.





- Maximum wind speed forecast is improved especially in winter hemisphere (high wind speed region)
- This result is consistent with additional utilization of high wind speed data

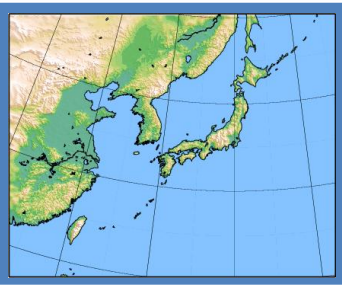
BIAS(CNTL)
BIAS(TEST)
RMSE(CNTL)
RMSE(TEST)

Summary

- Wind speed O-B bias in high wind speed range is reduced in the latest JMA's NWP system
- Experiments utilizing ASCAT high wind speed data show
  - High wind speed data modify F.G. reasonably according to O-B
  - Statistics in comparison with own analysis and sonde observation indicate forecast field improvement in major atmospheric elements including wind
  - Maximum wind speed forecast around lows is improved
- JMA plans to utilize ASCAT high wind speed data


THANK YOU

JMA's Global and Mesoscale NWP systems

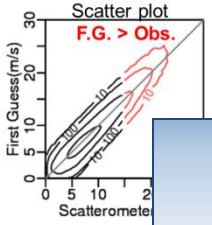
	Global NWP system 	**Mesoscale NWP system** 
Purpose	Short and medium range forecast	Disaster reduction, short range forecast
Forecast		
Model resolution	TL959(20 km), 100 Layers up to 0.01 hPa	5 km, 50 Layers up to 22 km
Forecast range	84-hours at 00, 06, 18UTC, 264-hours at 12UTC	39-hours at 00,03,06,09,12,15,18,21UTC
Data Assimilation(DA)		
Data assimilation scheme	4D-Var Outer: TL959(20 km) Inner: TL319(55 km)	4D-Var Outer: 5 km Inner: 15 km
Data cut off time	Early Analysis: +2h20m Cycle Analysis: +11h50m(00,12), +7h50m(06,18)	+0h50m

To utilize high wind speed

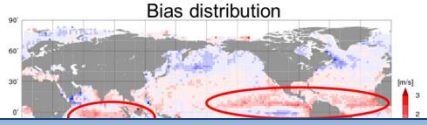
Wind speed bias problems

Wind speed First Guess departure (statistical period : Aug. 2013)

Scatter plot



Bias distribution



- Wind speed b
  - These data a operational u
- Positive bias i
  - Only gross er

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Trial bias correction

- 3rd order polynomial fitting

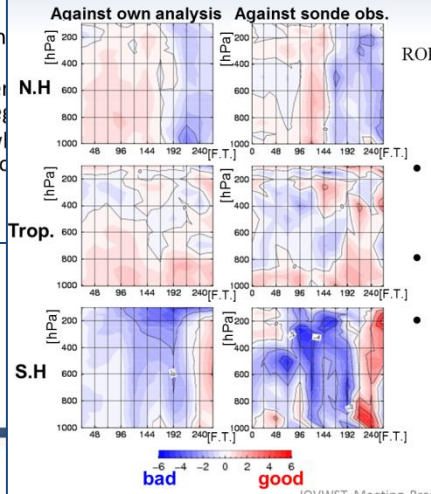
$$spd' = C0 + C1(spd)^1 + C2(spd)^2 + C3(spd)^3$$

spd':corrected wind speed spd: observed wind speed

(Cotton, J., 2009: A comparison of QuikSCAT with buoy, ship and radar altimeter wind speeds and evaluating the need for a new bias correction. Met Office Forecasting Research Technical Report 538.)

- Pairs of Obs. and F.G. value averaged by bo F.G. bins are use samples
- This correction observed wind
  - greater in high region
  - slightly smaller wind speed reg
  - smaller as a wi of number of c

Rate of improvement of Wind speed



$$ROI[\%] = (RMSE_{CNTL} - RMSE_{TEST})/RMSE_{CNTL}$$

$$RMSE = \sqrt{\sum (Fcst - ref.)^2}/N$$

ref. : own analysis or sonde obs.)

- In the N.H., wind field on almost all layers were improved in first half forecast time
- In the Trop., wind field on low level layers were improved
- In the S.H., worse result was noticeable. It may be due to the bias change for worse on middle level layers

IOVWST Meeting, Brest, France, 2-4 June 2014 18

- Currently, Wind speed data above 15 m/s are rejected in JMA's DA because of wind speed O-B bias since the beginning of utilization of ASCAT-A, B
- We have studied some methods to utilize those data (for example, my presentation at IOVWST2014)
- But any method has not brought good analysis and/or forecast yet

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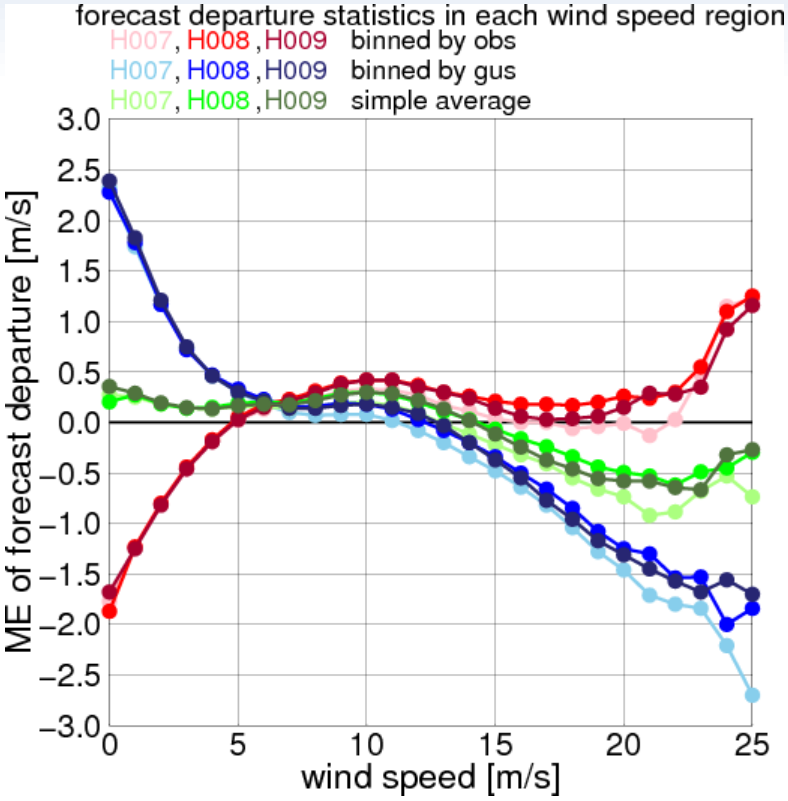
Changes of wind speed O-B statistics between Da system versions

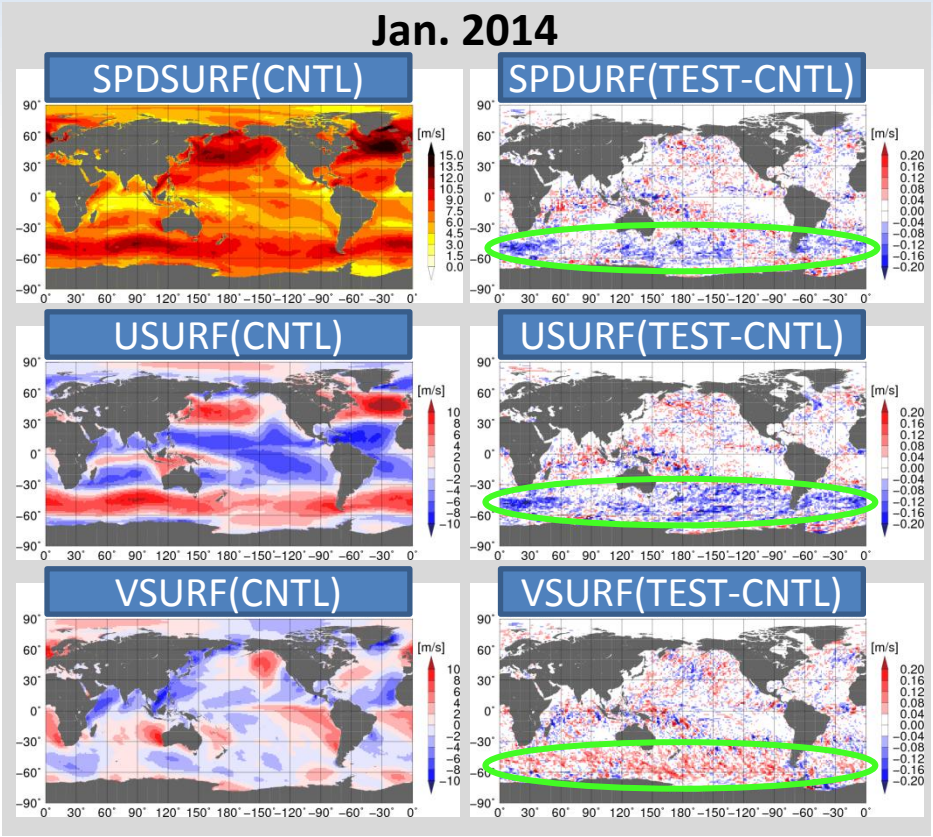


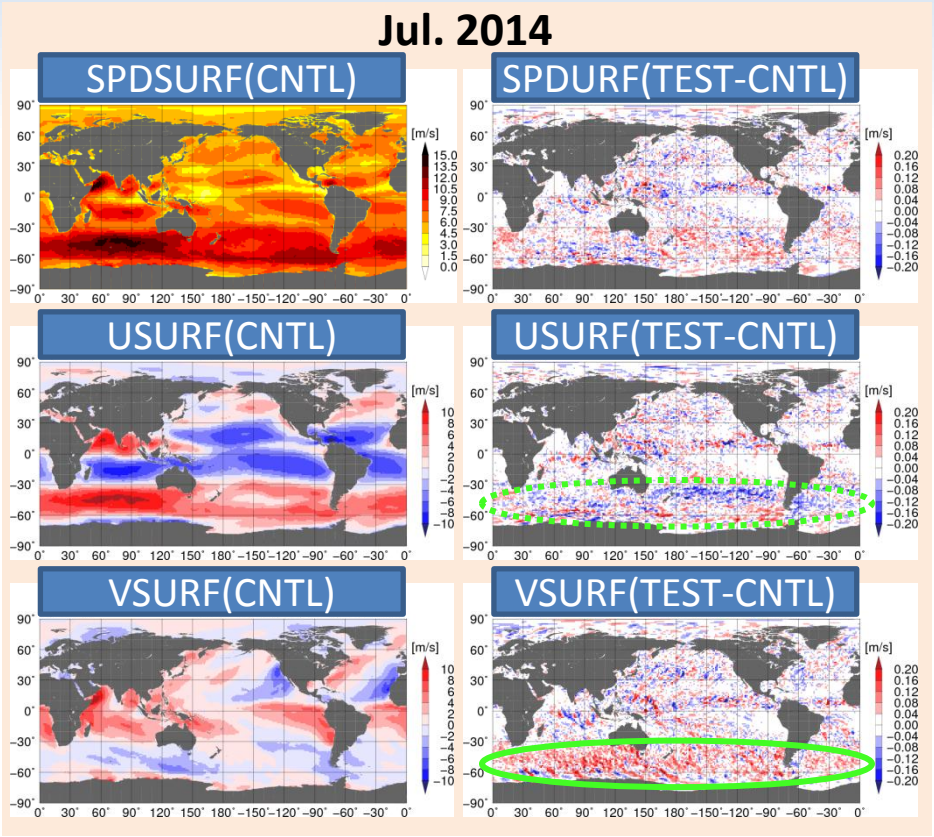
- Wind speed biases in high wind speed region on H008 and H009 are mitigated in comparison with that on H007
- Especially, biases at 21 and 25 m/s get smaller by 0.4 m/s according to averages of biases binned by obs. and F.G. (green lines), and they correspond to 37 and 63 % bias reduction respectively
- All past study to utilize high wind speed data is conducted before on H007

H009=(H009+H009)/2
H008=(H008+H008)/2
H007=(H007+H007)/2

H009: mean of O-B binned by obs. on H009
H008: mean of O-B binned by obs. on H008
H007: mean of O-B binned by obs. on H007
H009: mean of O-B binned by F.G. on H009
H008: mean of O-B binned by F.G. on H008
H007: mean of O-B binned by F.G. on H007

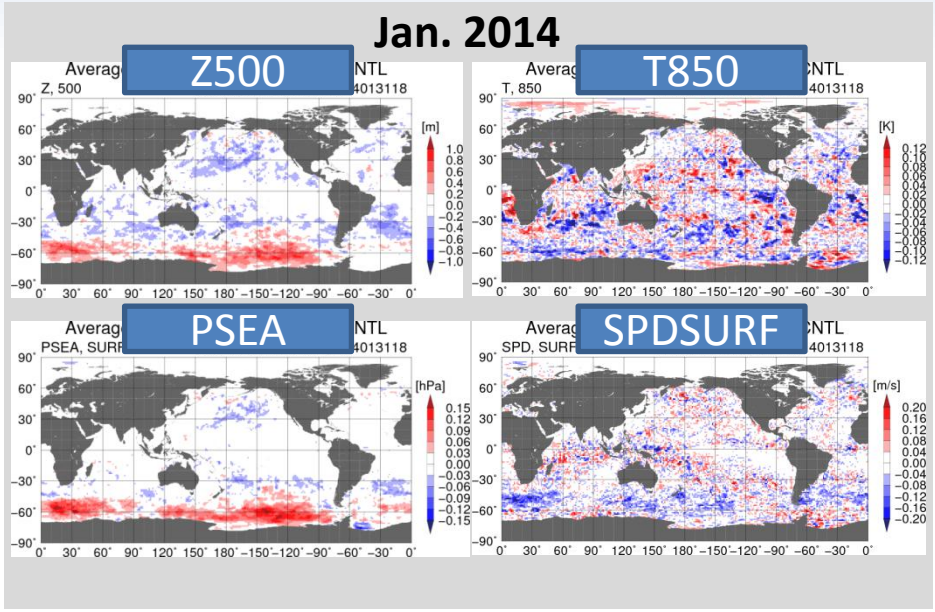
Change of wind analysis fields

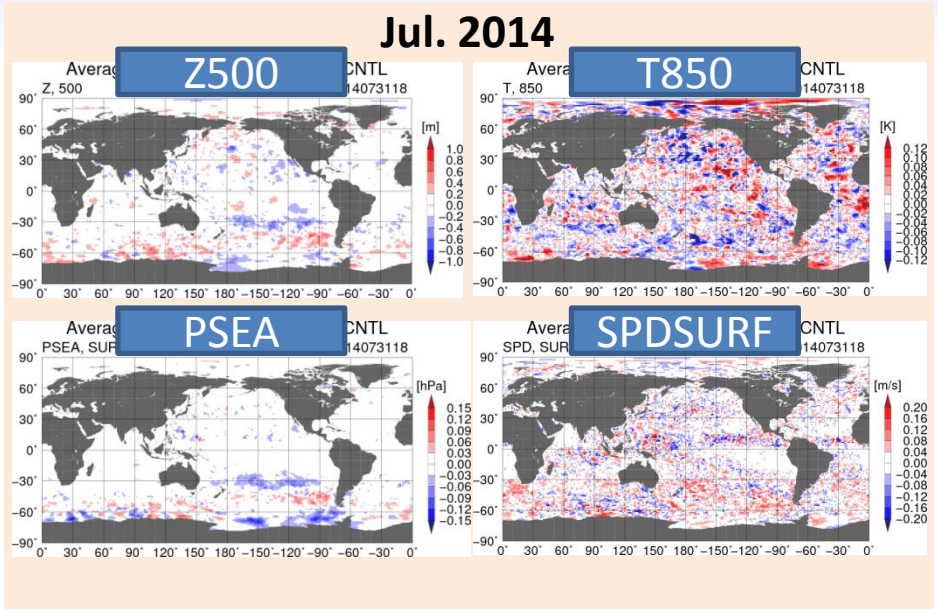




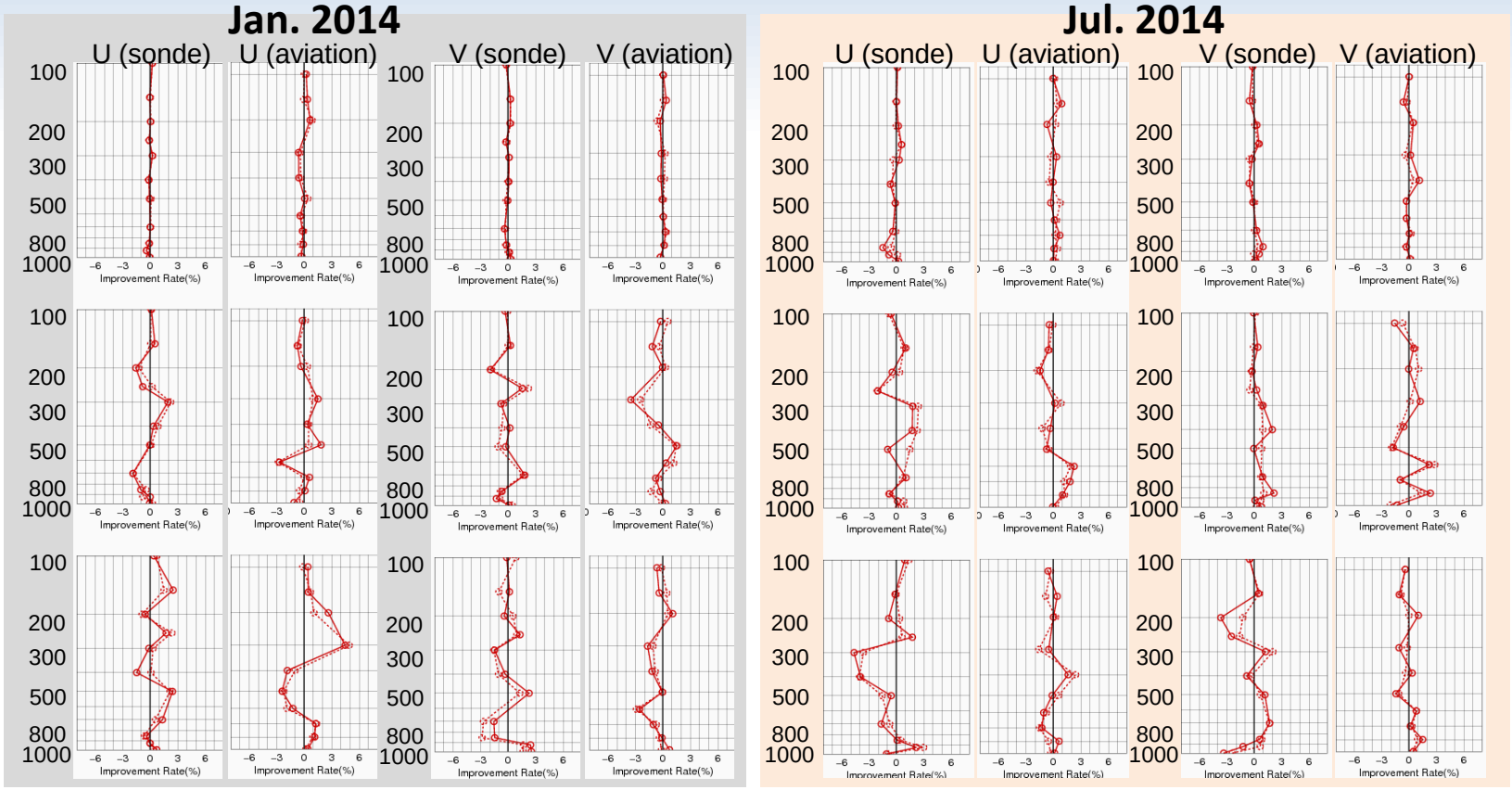
- Regular wind flow in mid-latitude area in S.H. get weaker, especially on Jan. 2014 experiment

Change of Analysis fields





Change of wind analysis and F.G.



$(\mathrm{RMSE(F.G.)_{CNTL}} - \mathrm{RMSE(F.G.)_{TEST}})/\mathrm{RMSE(F.G.)_{CNTL}}$

$(\mathrm{RMSE(Anl)_{CNTL}} - \mathrm{RMSE(Anl)_{TEST}})/\mathrm{RMSE(Anl)_{CNTL}}$

$\mathrm{RMSE(X)_E}$ meas RMSE of X against each observation on experiment E

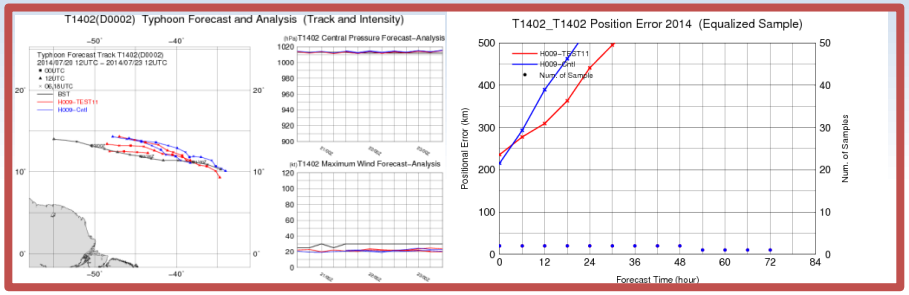
- Remarkable improvement is not showed here

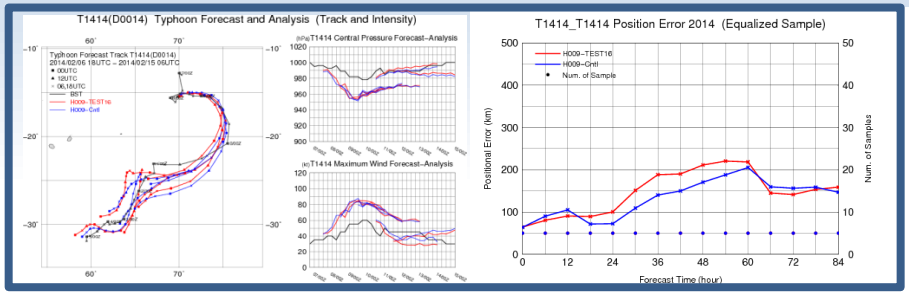
better

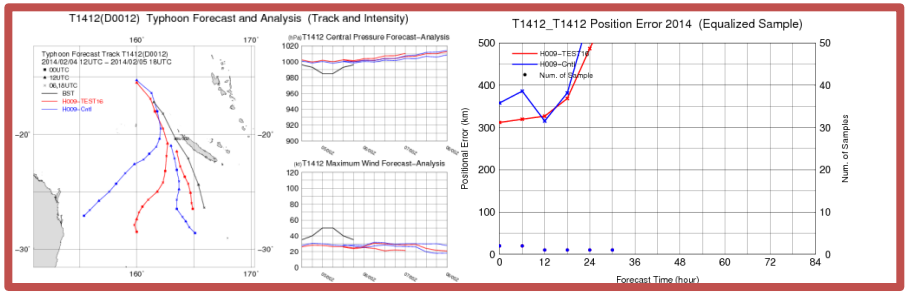
worse

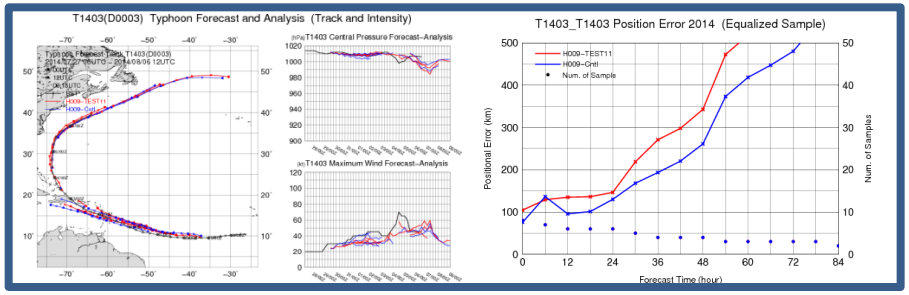
Good case and bad case

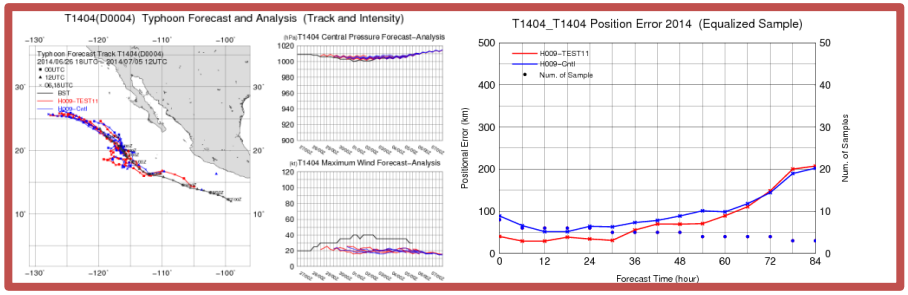
CNTL
TEST

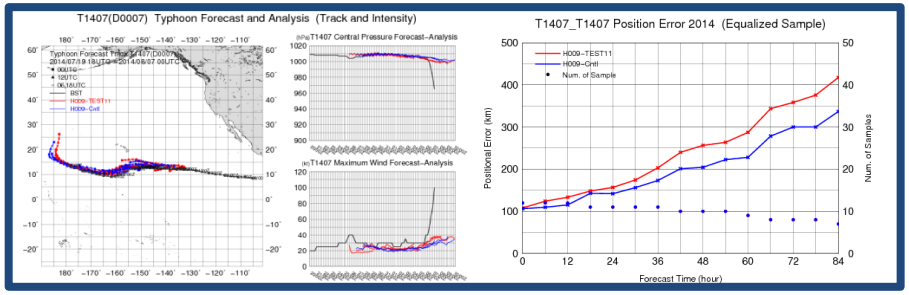












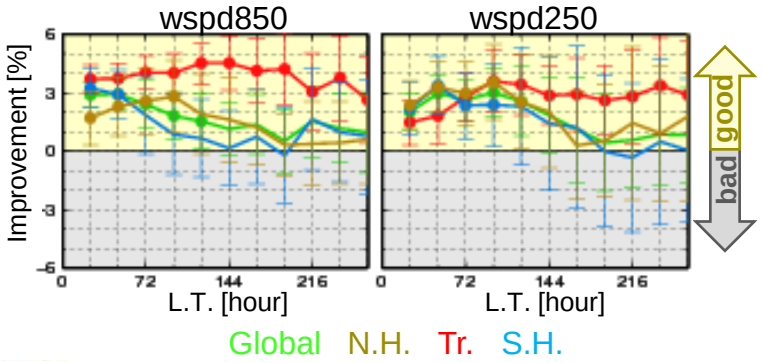
- Best tracks are simple in case positional error gets smaller
- On the other hand, best tracks are complex relatively in case positional error does not get smaller. It does not seem to be only a problem how rich observations are

JMA's global NWP system update

- H007 -> H008 (18 Mar. 2014)
  - Enhancement of the vertical resolution
  - Revise of several physical processes including **atmospheric boundary layer process**
  - Utilization of high altitude observational data
- H008 -> H009 (4 Sep. 2014)
  - Utilization of IASI data from Metop-A and Metop-B and AIRS data from Aqua

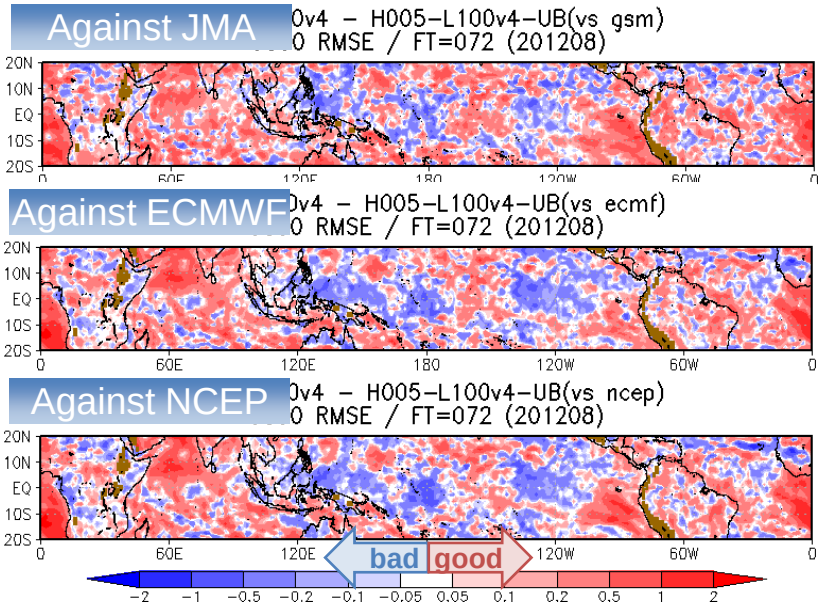
Impact study of revision of atmospheric boundary layer process showed low level wind forecast improvement

Difference (not revised result minus revised result) of RMSE normalized by RMSE of not revised result about wind speed on 850 hPa and 250 hPa



The error bars represent a 95% confidence interval, and dots mean statistically significant

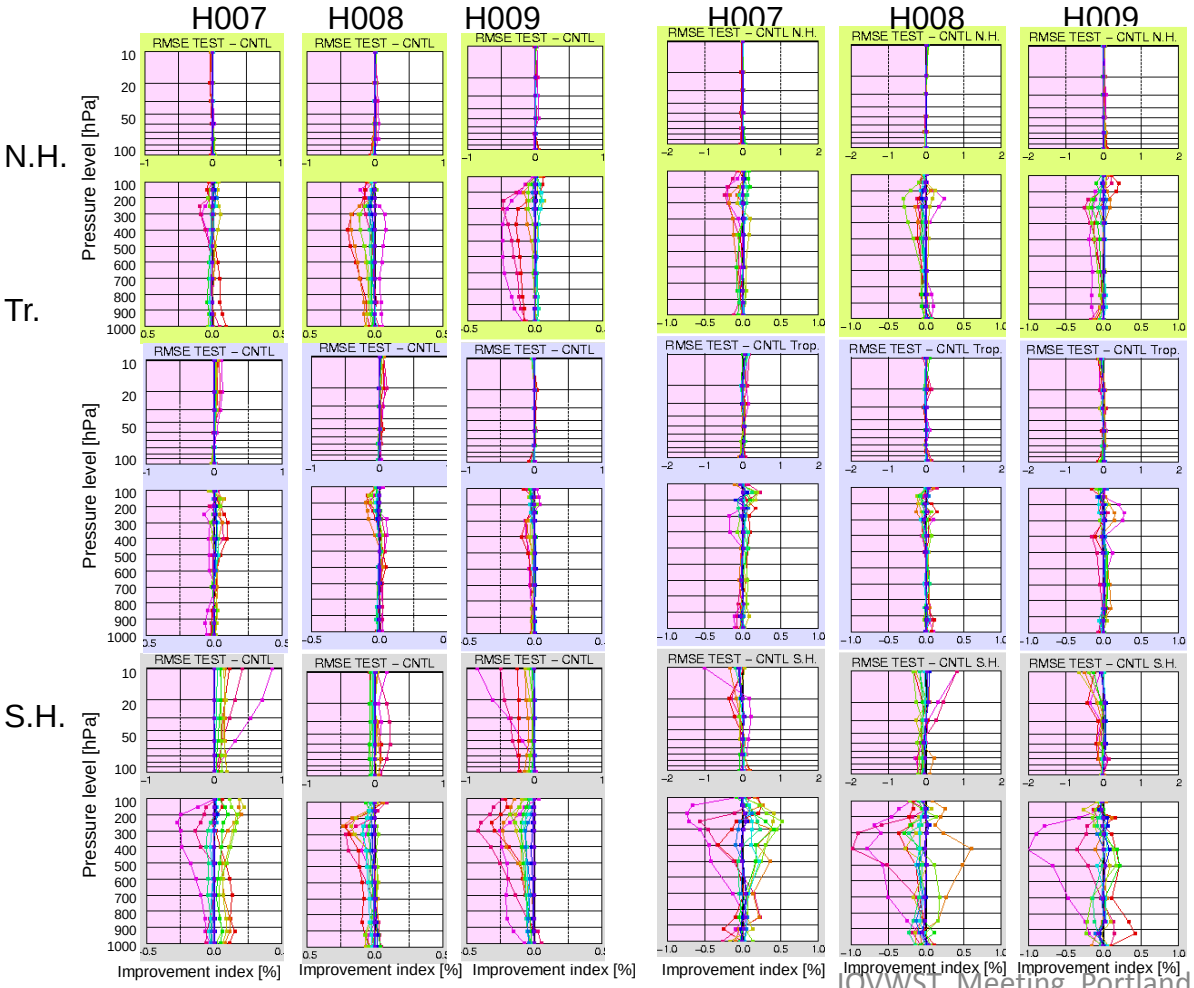
Difference (not revised result minus revised result) of U850 RMSE calculated against each NWP at L.T.=72



Forecast score on various JMA's global NWP system

Improvement index of U in compared with own analysis

Improvement index of U in compared with sonde obs.



- Forecast score improved at upgrade of H008.

Improvement index means a difference (TEST-CNTL) of RMSE normalized by CNTL RMSE, and RMSE is calculated by own analysis (left figures) and by sonde observation (right figures) as reference

- L.T.=0
- L.T.=24
- L.T.=48
- L.T.=72
- L.T.=96
- L.T.=120
- L.T.=144
- L.T.=168
- L.T.=192
- L.T.=216
- L.T.=240
- L.T.=264

Forecast score on various JMA's global NWP system

- Forecast score improved at upgrade of H008.

Improvement index means a difference (TEST-CNTL) of RMSE normalized by CNTL RMSE, and RMSE is calculated by own analysis (left figures) and by sonde observation (right figures) as reference

- L.T.=0
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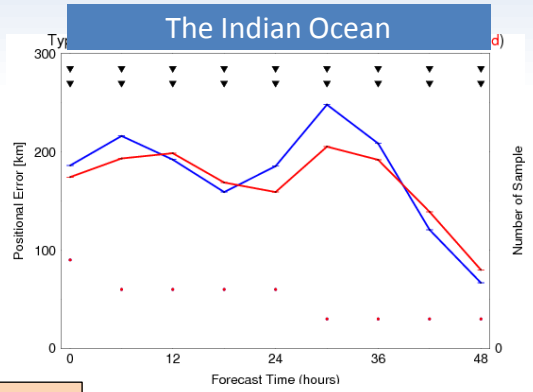
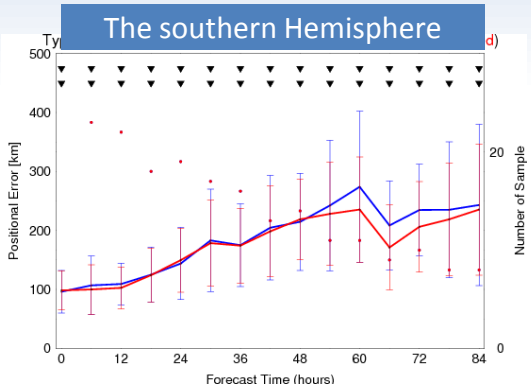
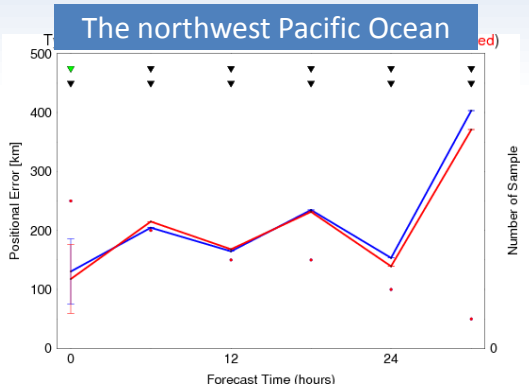
Positional error of tropical cyclones

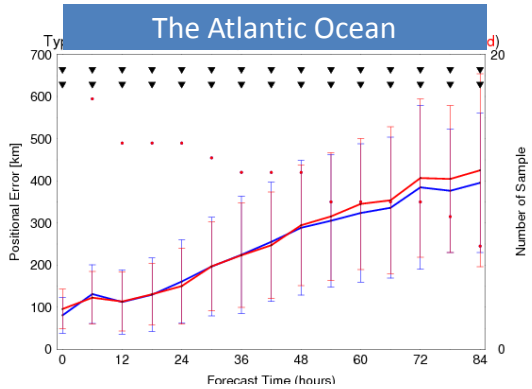
Jan. 2014

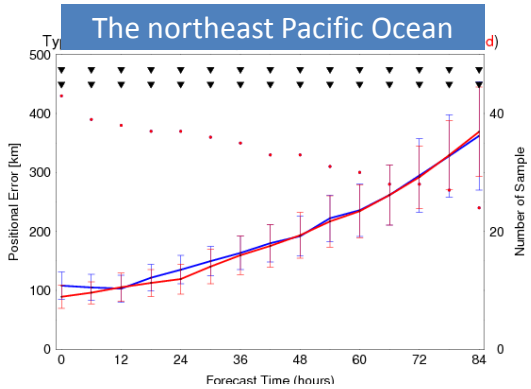


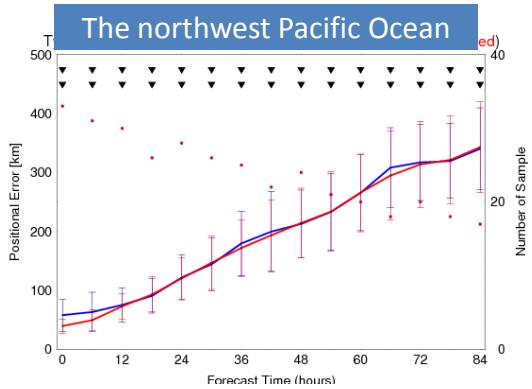




Jul. 2014







CNTL
TEST

- Positional error gets smaller in the northeast and northwest Pacific Ocean at L.T.=0
- It is almost neutral in other area