Operational Use of Scatterometer Winds at JMA

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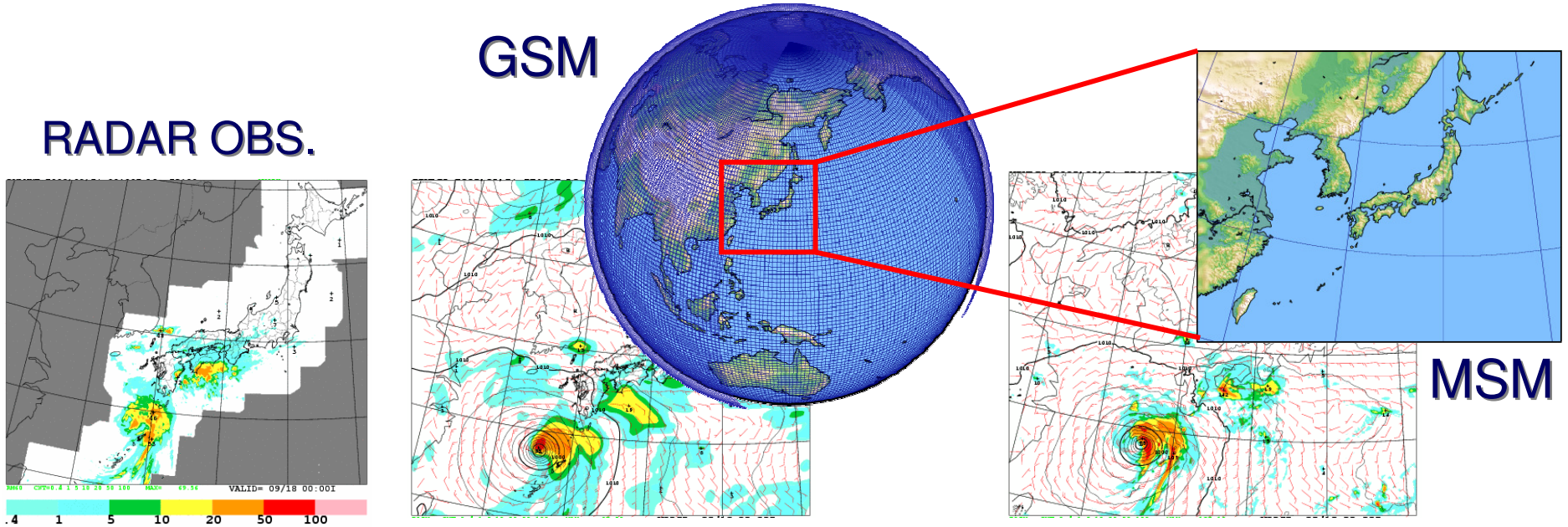
Outline

- JMA's Numerical Weather Prediction models
  - Status of NWP models
  - History and use of scatterometer winds
- Ongoing development
  - Observing System Experiment of bias corrected ASCAT data assimilation (DA) in a global NWP model
- Summary

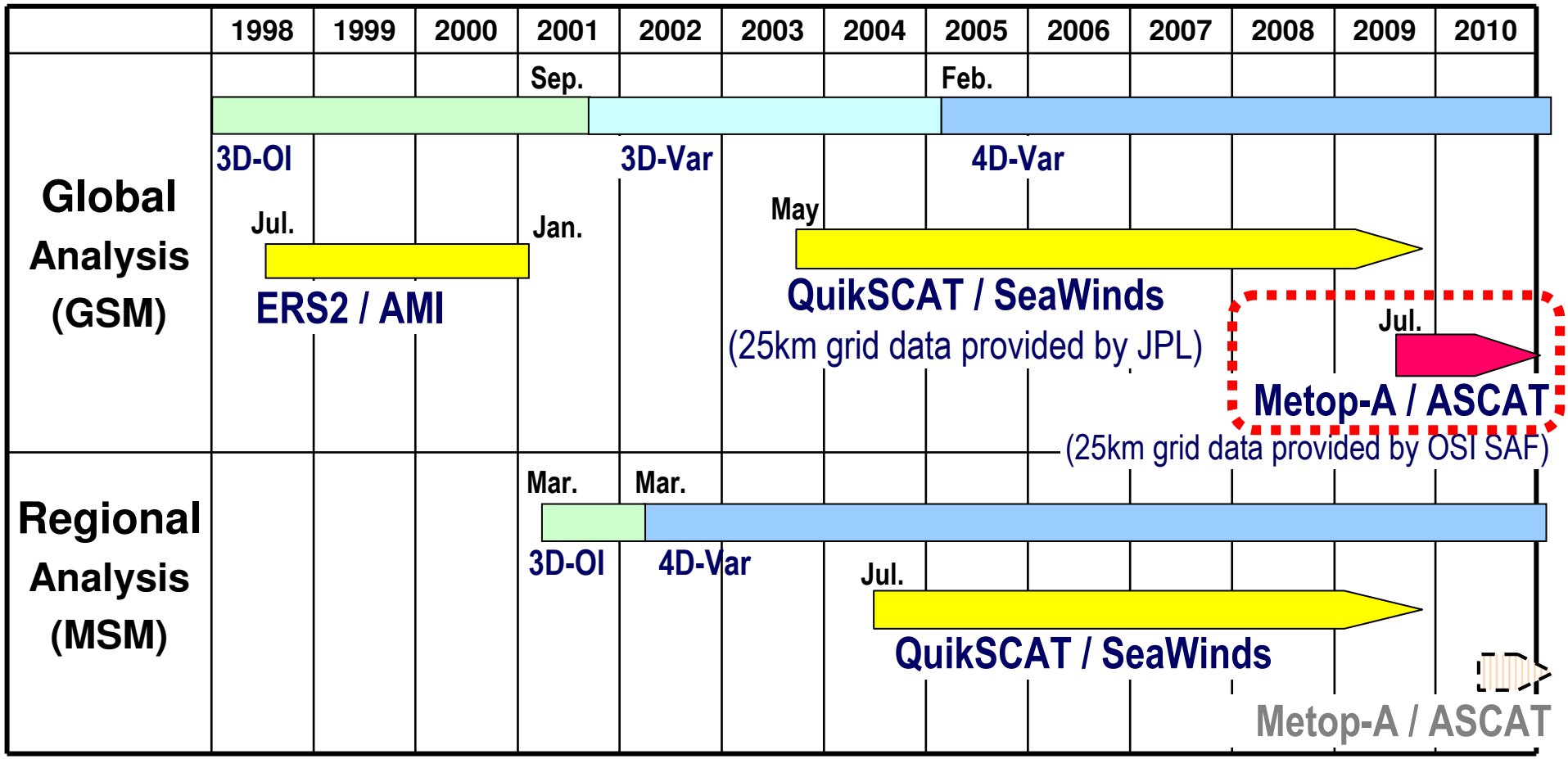
Status of JMA's operational NWP models



Model	Global Model (GSM)	Mesoscale Model (MSM)
Resolution H/V(top height)	**TL959 (20km) / 60 (0.1hPa)**	**5km / 50 (21.8km)**
Forecast range (Initial time)	**84**h (00,06,18UTC) **216**h (12UTC)	**15**h (00,06,12,18UTC) **33**h (03,09,15,21UTC)
Target	**1~7 day forecast** **Aeronautical forecast**	**Disaster prevention information**
Data Assimilation (outer/inner loop)	4D-Var (TL959/T159 or 20km/80km)	4D-Var (5 / 15km)

History of scatterometer wind use in NWP at JMA

◆ Operational use of Metop-A/ASCAT in GSM has started in July 2009.

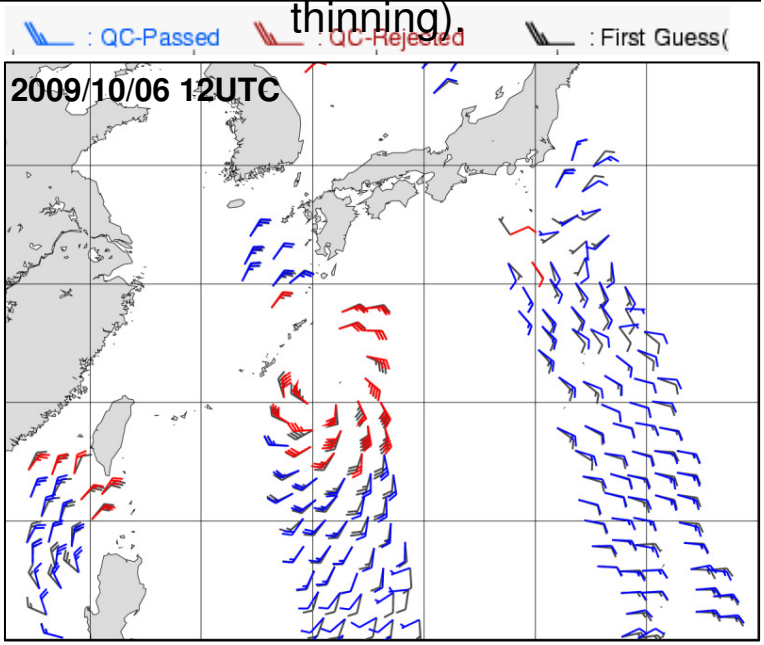


4D-Var, 3D-Var: Four or Three dimensional variational scheme
3D-OI: Three dimensional optimum interpolation

Usage of scatterometer winds in DA

◆ Quality controlled and thinned scatterometer winds are assimilated in 4D-Var DA system.

25km-grid ASCAT winds after preprocessing (QC and data thinning).



Quality Control

- Flag check (Rain, Land/Sea, Sea Ice, etc.)
- Ambiguity removal
  - Select the closest wind to JMA's forecast (implement median filter after nudging)
- Gross error check
  - Reject large |**Obs. – Background (forecast)**| winds w.r.t. wind speed, direction

Data Thinning (100km x 100km in GSM)

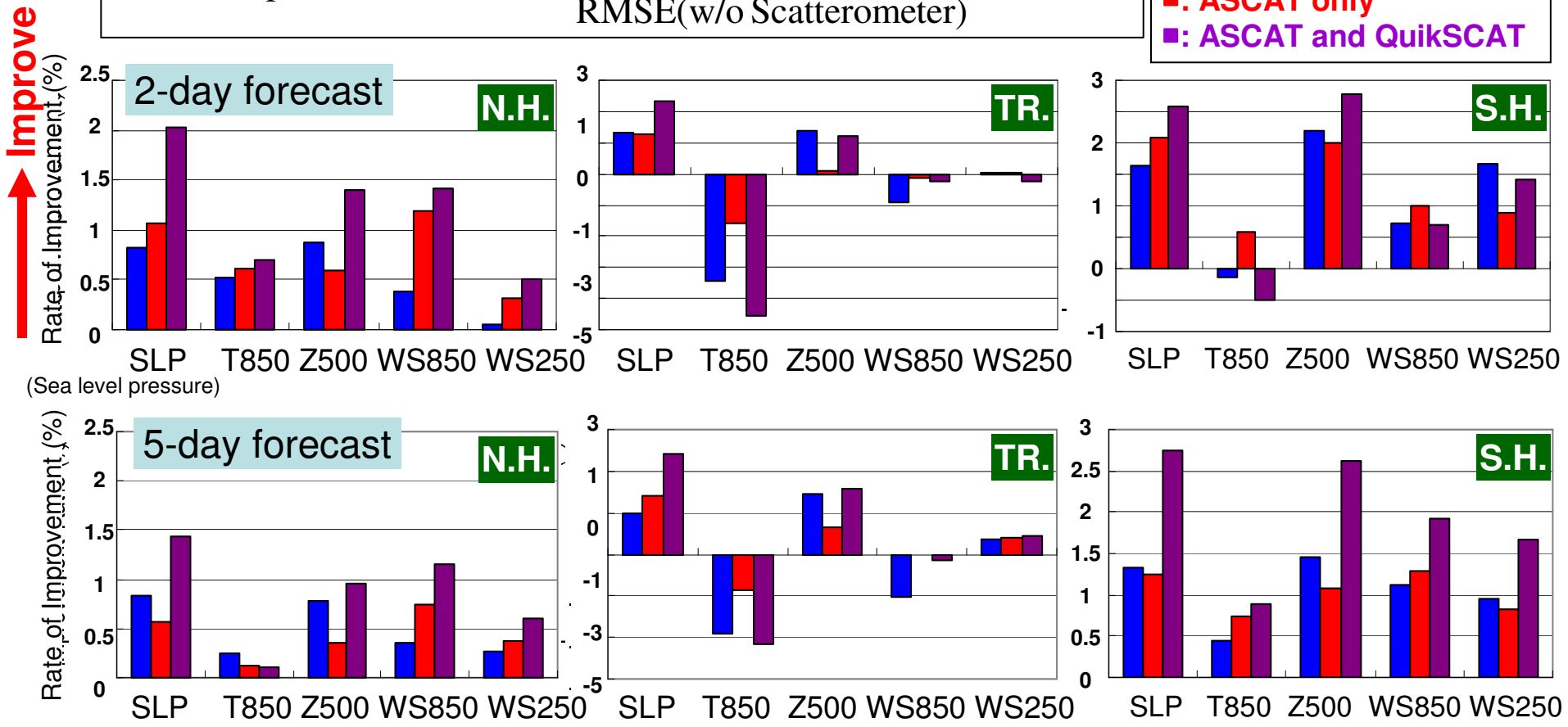
- To reduce calculation cost in 4D-Var.
- Not to introduce spatial observation error correlation which our current data assimilation algorithm does not deal with.

Improvement of forecast against w/o scatterometer run

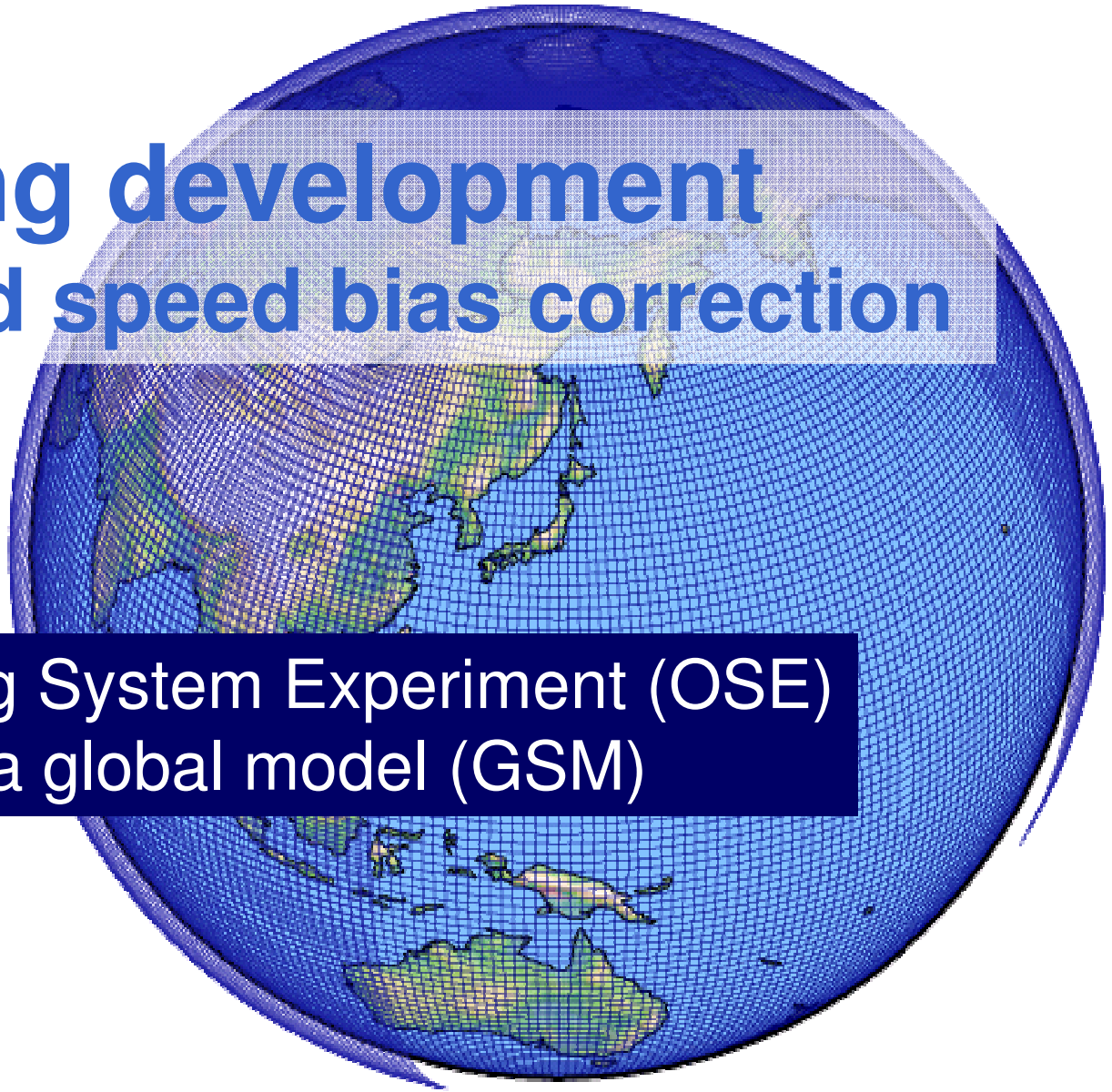
- **Observing System Experiments in low resolution GSM (Fcst period: 2008/09/01-09/30).**
- **Best improvement: ASCAT and QuikSCAT run**
- **Increase of data coverage provides more reliable analysis field, and it leads to improvement of forecast.**

$$\text{Rate of Improvement} = \frac{\text{RMSE(w/o Scatterometer)} - \text{RMSE(Test)}}{\text{RMSE(w/o Scatterometer)}} [\%]$$

■: QuikSCAT only
■: ASCAT only
■: ASCAT and QuikSCAT



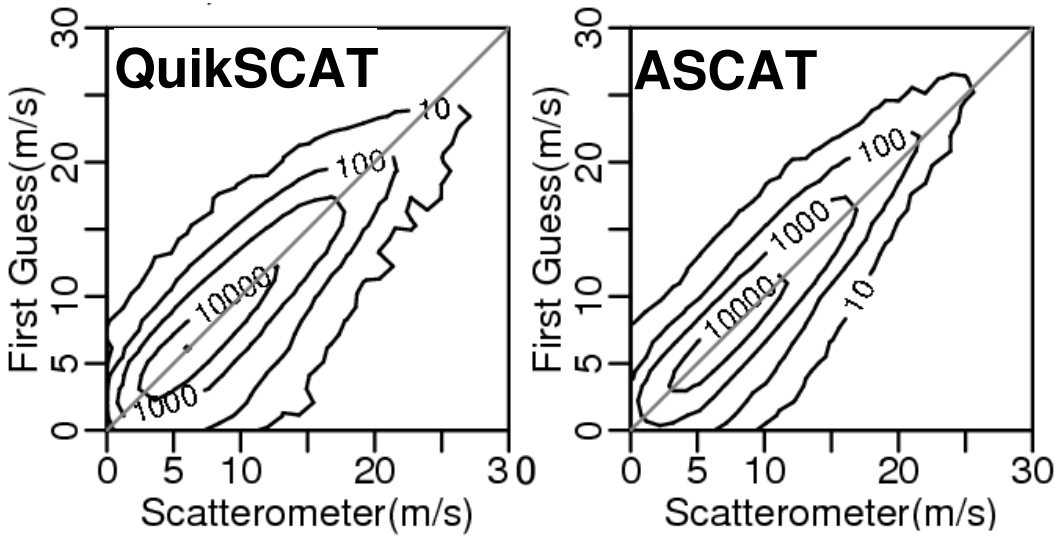
Ongoing development
- ASCAT wind speed bias correction



Observing System Experiment (OSE)
in a global model (GSM)

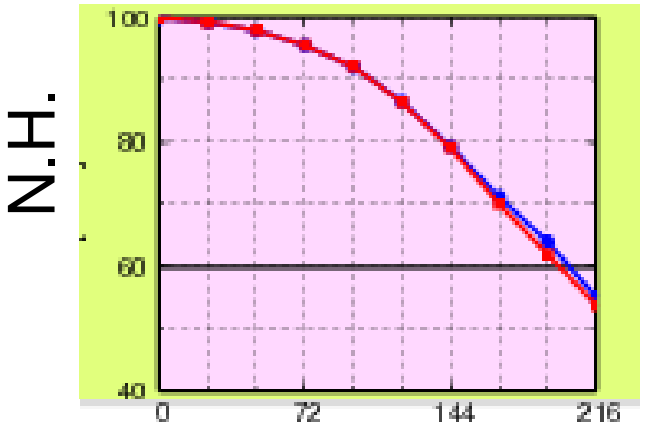
Wind speed difference between ASCAT and QuikSCAT

- Assimilation of ASCAT winds without any bias correction disimproved forecast scores due to the difference between ASCAT and QuikSCAT.
- In order to start the operational use of ASCAT data promptly, present DA system uses them of which speed are slower than 15m/s.
- End of nominal mission of QuikSCAT last November points to a need for assimilating high speed ASCAT data.



Two dimensional histogram of scatterometer wind speed vs. JMA first guess (2009/01/01 - 01/31).

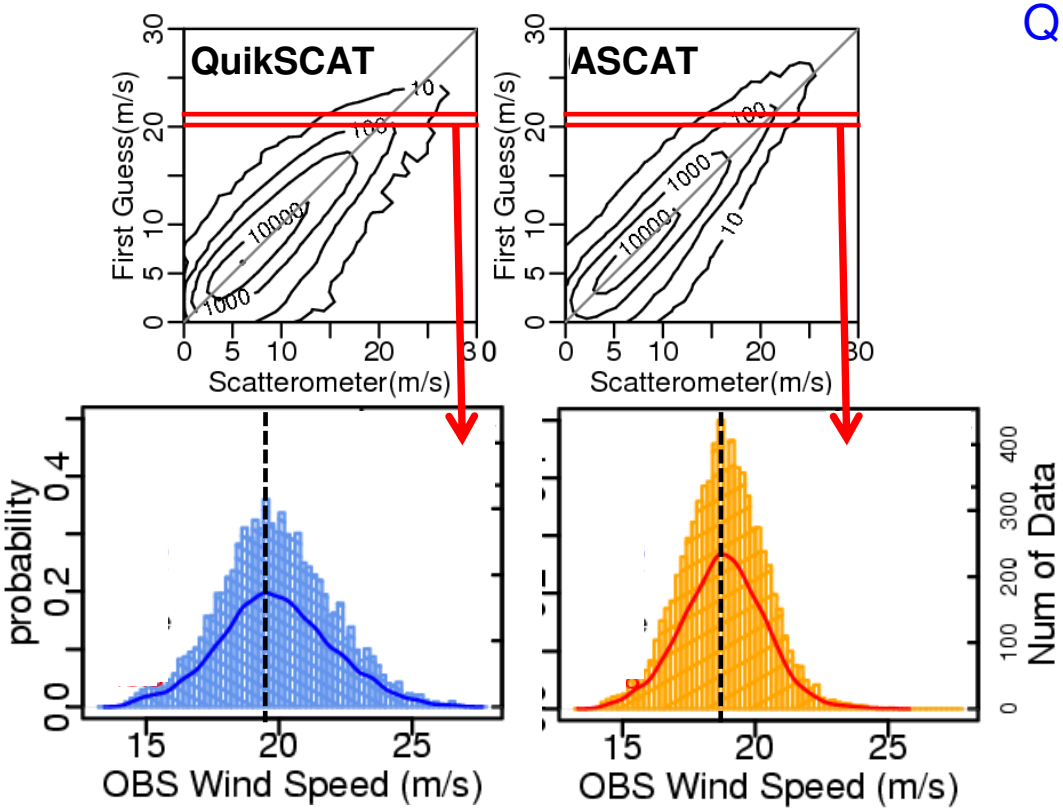
Anomaly correlations
of sea level pressure
(average of 31 days in Jan. 2009)



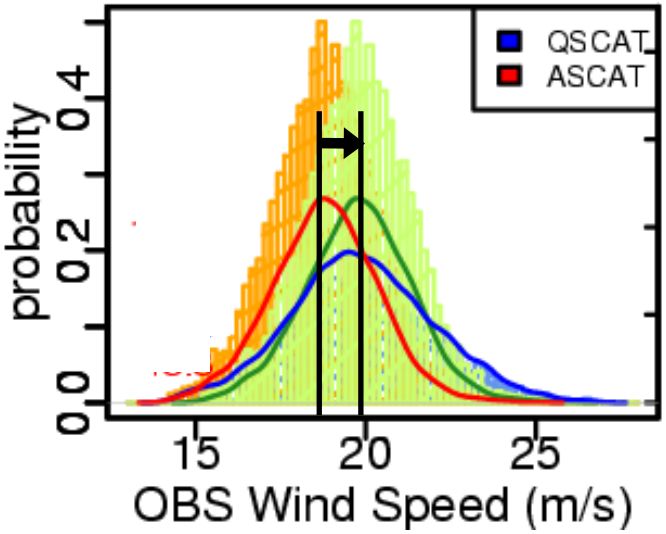
Bias correction of ASCAT wind speed

- To research the impacts of consistent scatterometer winds on NWP model, we tried to apply a wind speed bias correction method to ASCAT data under the assumption that QuikSCAT winds (25km grid data provided by JPL) represent the truth.

Step-1:
Make scatterometer wind speed histograms binned by interpolated JMA first guess.

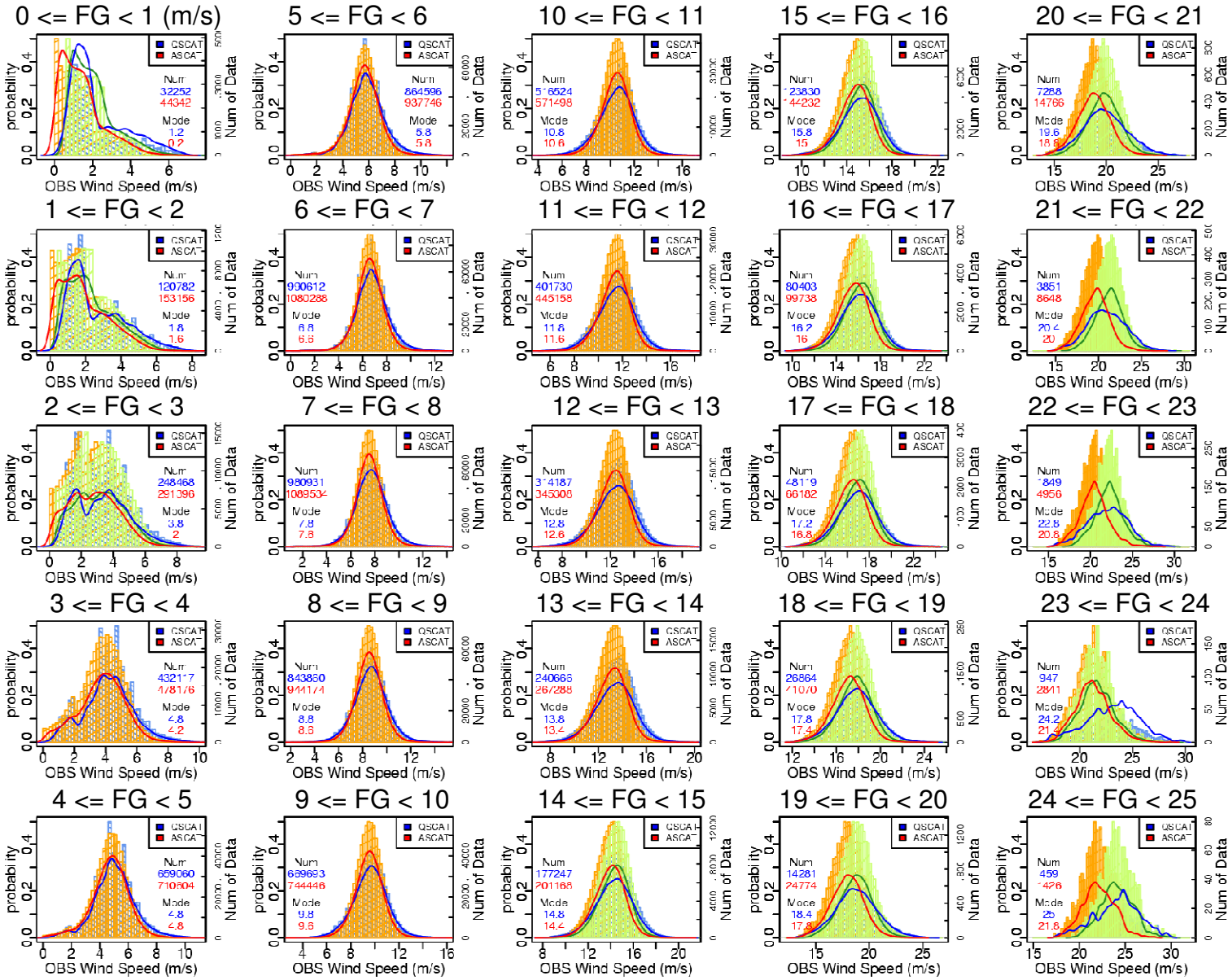


Step-2:
If the mode of ASCAT is different from that of QuikSCAT, adjust to QuikSCAT.



In this case, 2m/s is added to ASCAT wind speed.

Bias correction using 6 months (Jan.-Jun. 2009) data



QuikSCAT
ASCAT
Bias corrected ASCAT

Observing System Experiments in GSM

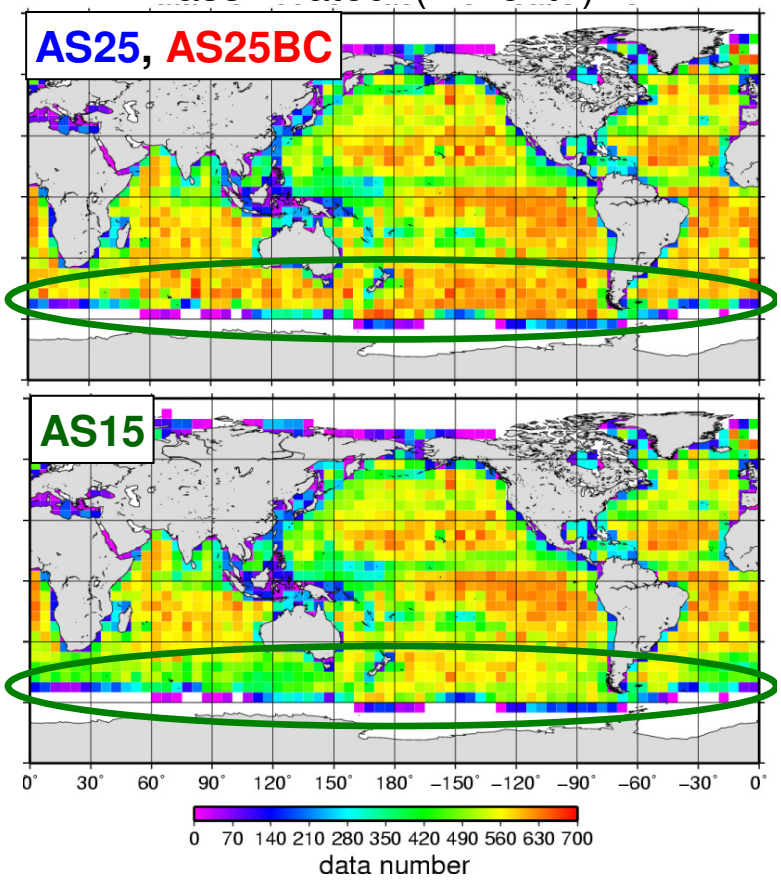
- Three experiments were carried out in low resolution GSM. (1-month data assimilation and forecast, 2009/08/01-08/31)

Experiment name and usage of scatterometer winds

Expname	**ASCAT**	**QSCAT**	
AS15 (control run)	0-15m/s	0-30m/s	same as operational setup
AS25	0-25m/s	0-30m/s	without bias correction
AS25BC	0-25m/s	0-30m/s	bias correction to ASCAT is applied

Over the Southern Ocean, **AS25** and **AS25BC** led to about 10% increase in the number of ASCAT winds assimilated than **AS15**.

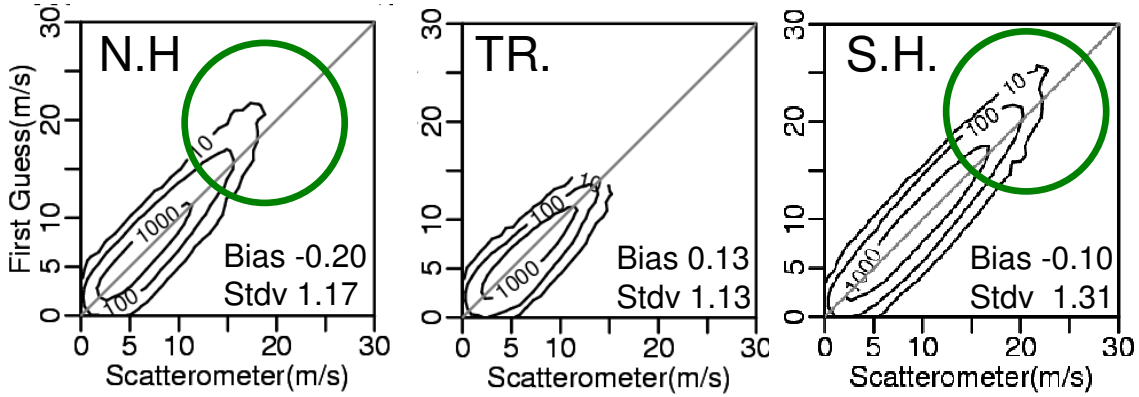
Total ASCAT data number assimilated (1 month).



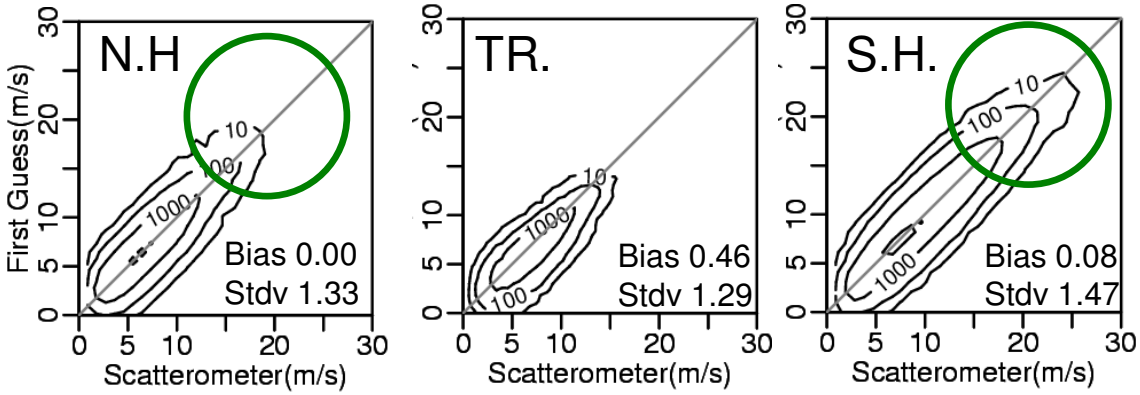
2-D wind speed histogram and averaged O-B map

- Wind speed inconsistency between ASCAT and QuikSCAT
- Large difference of O-B is remarkable over tropics and the Southern Ocean.

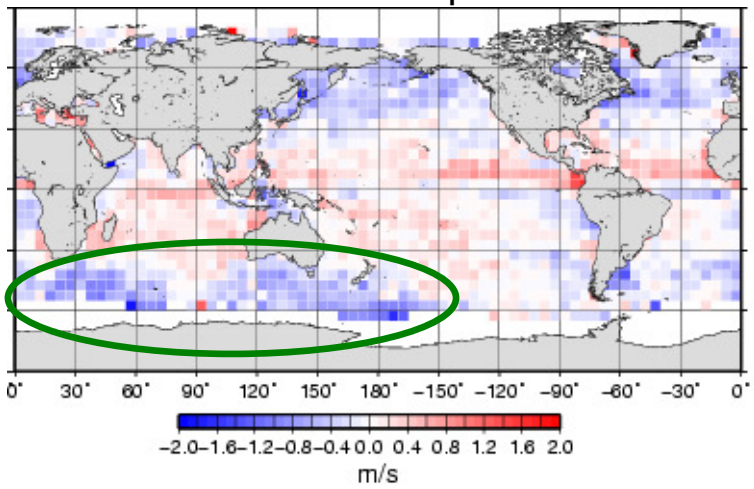
ASCAT (AS25, w/o bias correction)

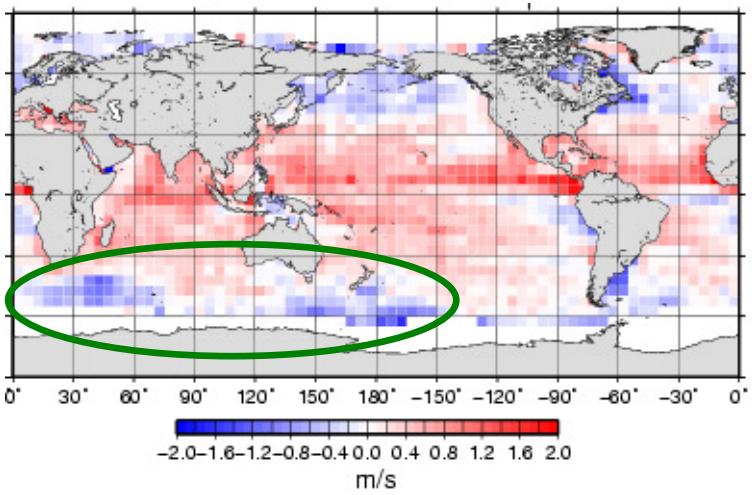


QuikSCAT



O-B of wind speed

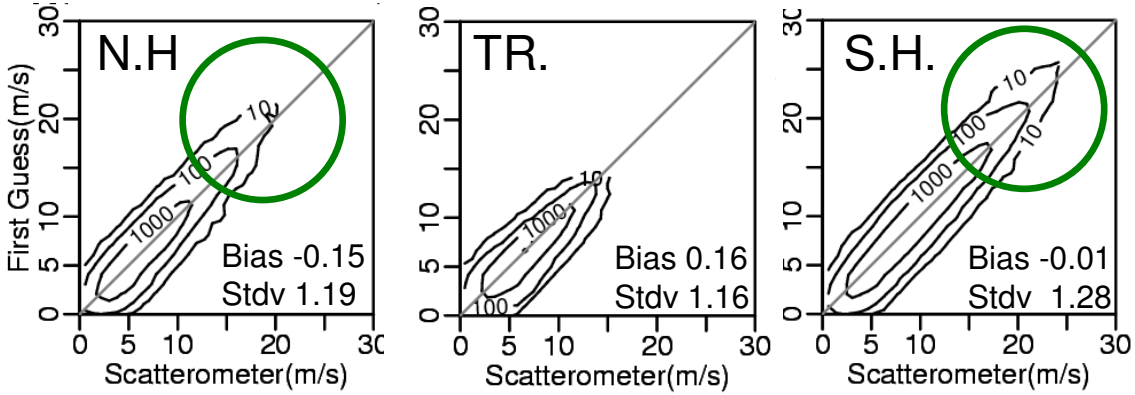




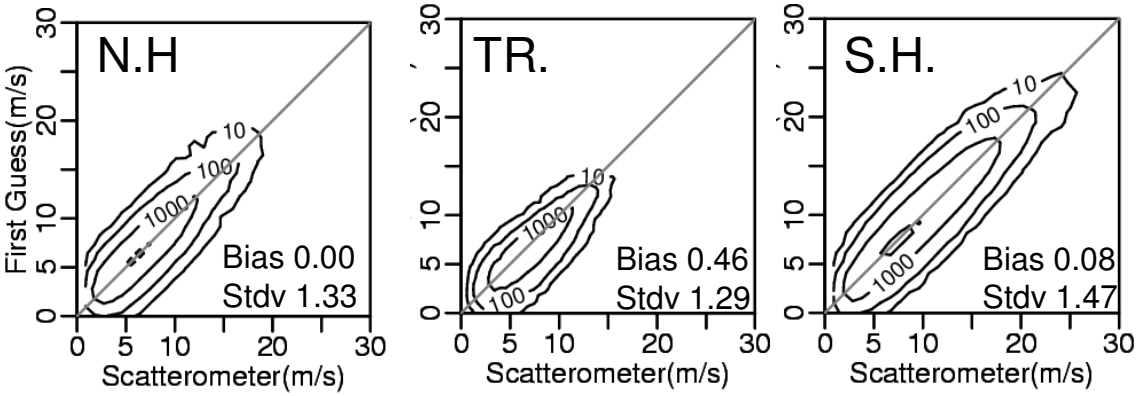
2-D wind speed histogram and averaged O-B map

- Wind speed difference between ASCAT and QuikSCAT is reduced over the Southern Ocean (although that in tropics still remains).

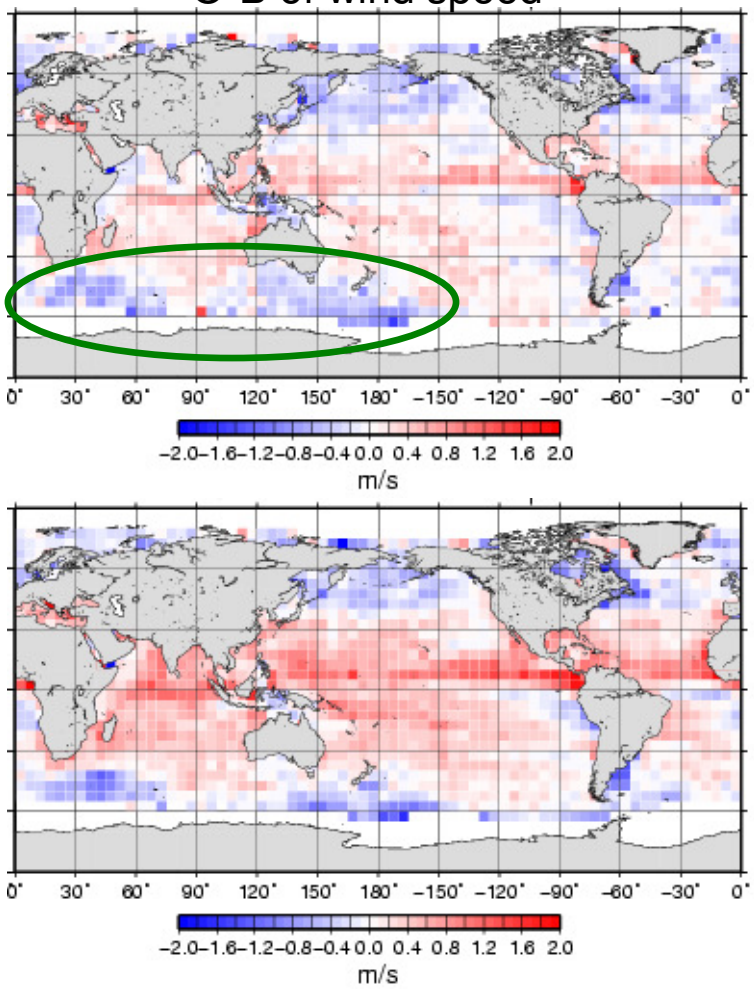
ASCAT (AS25BC, w/ bias correction)



QuikSCAT



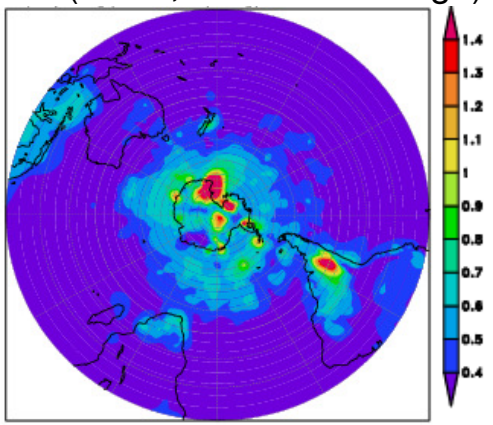
O-B of wind speed



Impact of high speed ASCAT winds on analysis

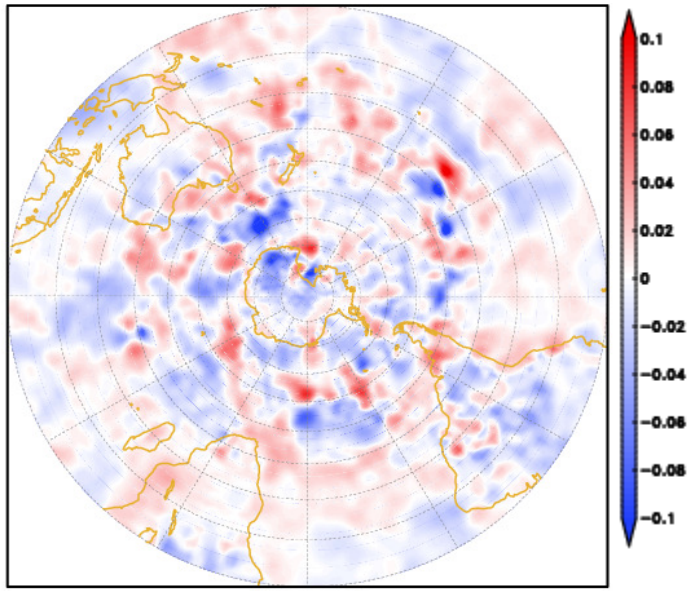
	ASCAT usage
AS25BC	0-25(m/s) w/ bias correction
AS25	0-25 (m/s)

RMS of analysis increment of SLP (AS25, 1-month average).

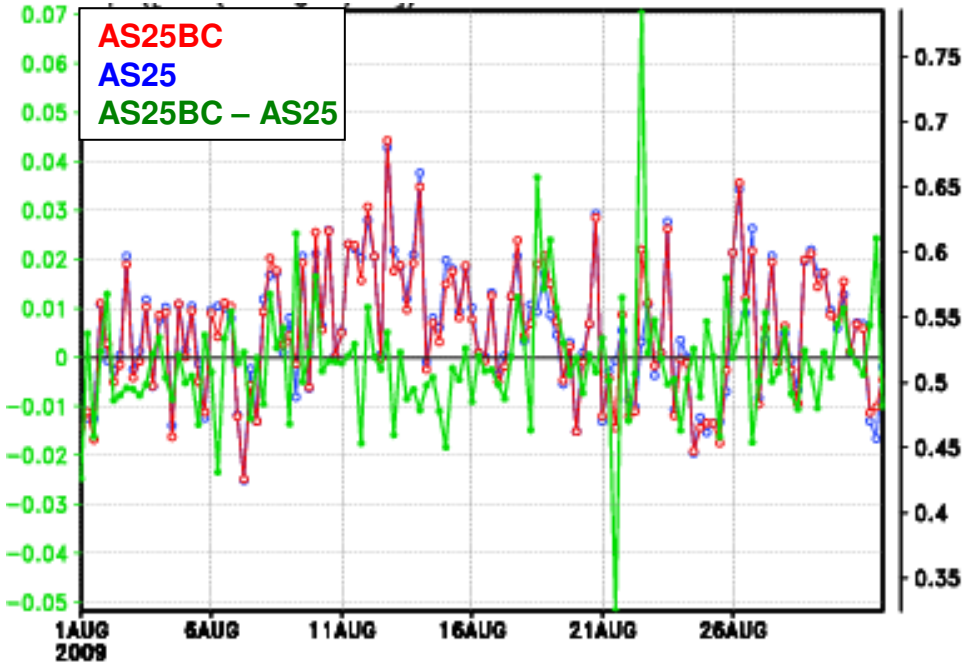


- Analysis increment (analysis – first guess) of AS25BC was generally smaller than that of AS25.
- This decrease indicated that stable field was analyzed in AS25BC. On the other hand, the gap of wind speed between ASCAT and QuikSCAT in AS25 made its analysis filed somewhat noisy.

Difference of averaged RMS of analysis increment of SLP (AS25BC-AS25).



Time series of analysis increment RMS of sea level pressure and its difference in S.H.(AS25BC-AS25).

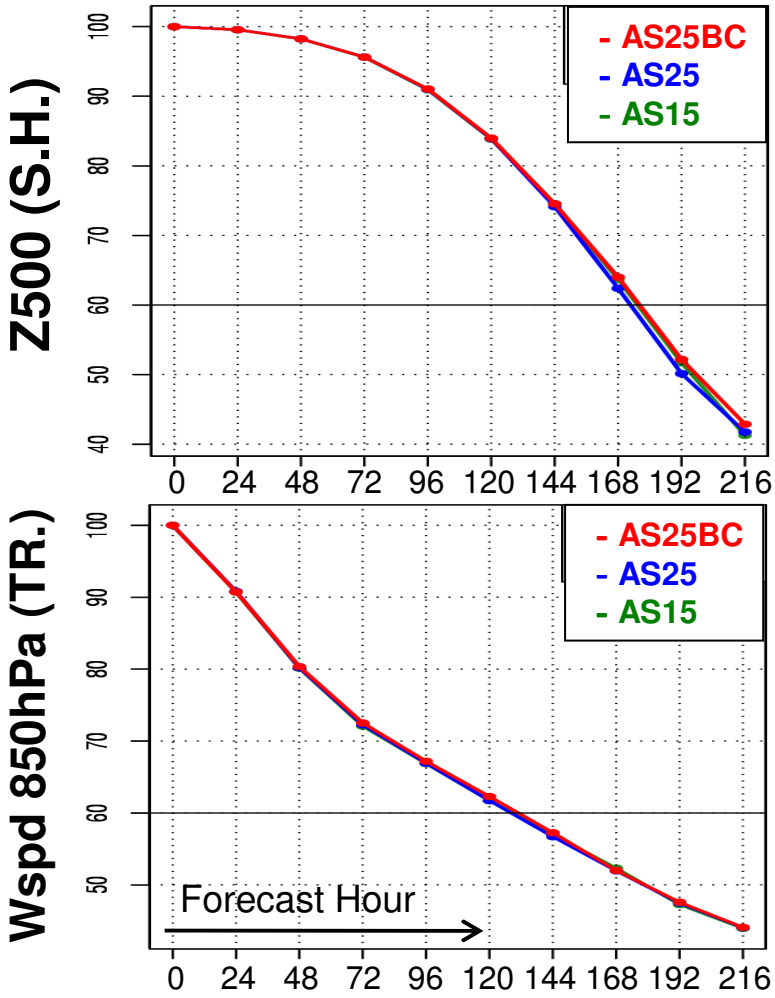


Impact of high speed ASCAT winds on forecast

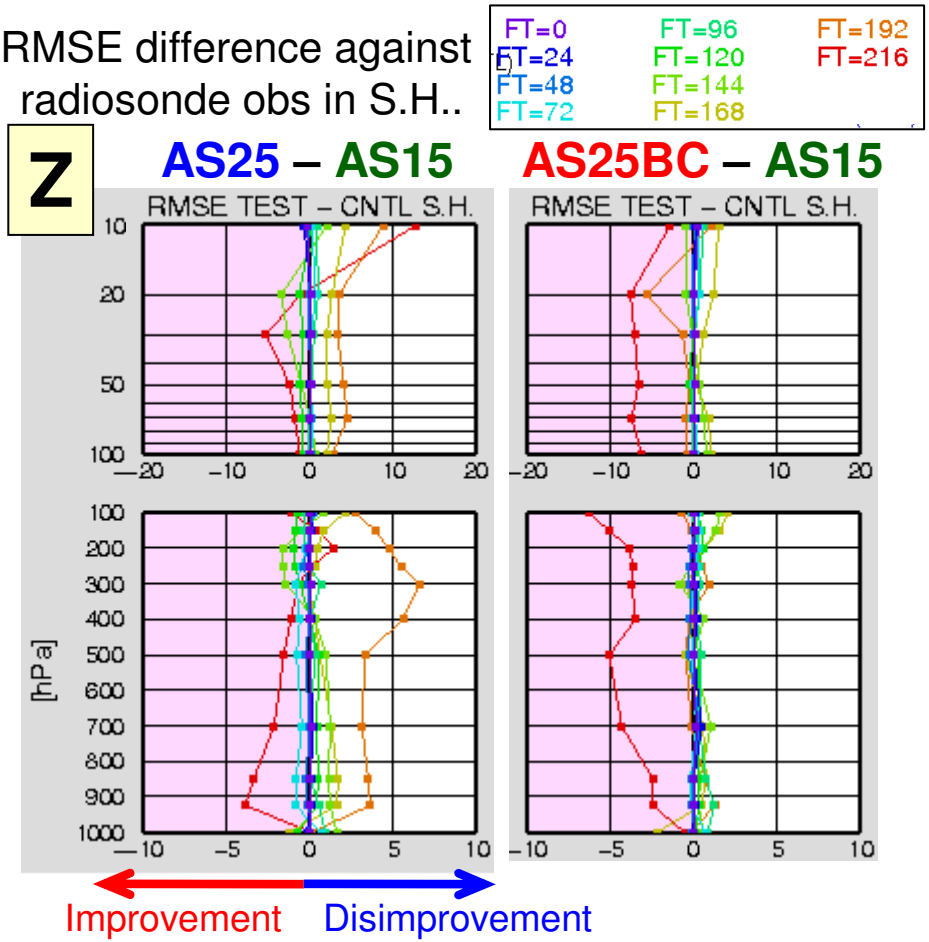
- Forecast scores of AS25BC were comparable with AS15, however, AS25 disimproved them.

	ASCAT usage
AS25BC	0-25(m/s) w/ bias correction
AS25	0-25 (m/s)
AS15	0-15 (m/s)

Anomaly correlations (average of 31 days)

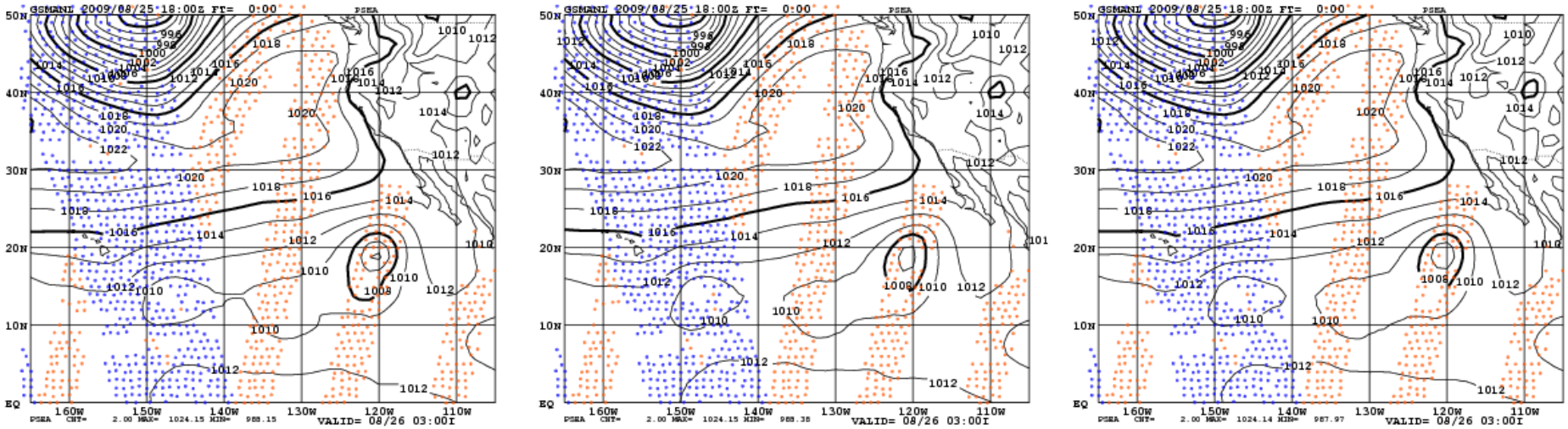


RMSE difference against radiosonde obs in S.H..



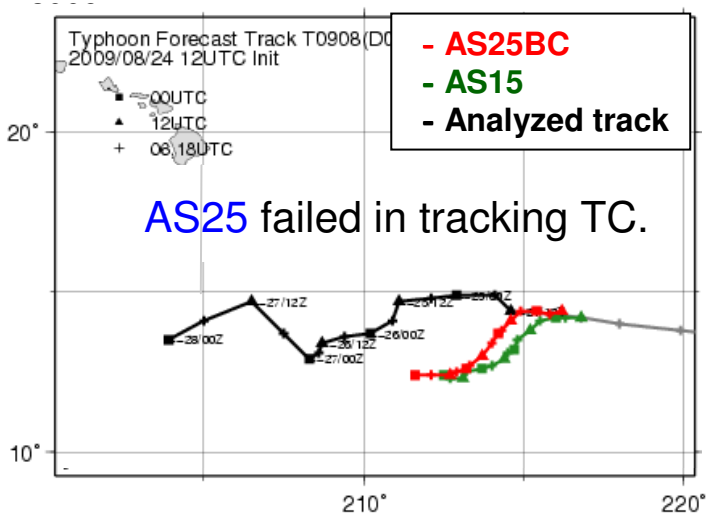
Impact on TC forecast

2009/08/25 18UTC



- TC intensities analyzed in AS25BC and AS25 were slightly stronger than AS15.
- To the contrary of QuikSCAT winds, ASCAT data in AS25 sometimes weakened TCs.
- Analyzed position of TC center in AS25BC was better than that of AS15, and it let to the improvement of TC track forecast.

TC track forecast (TS Hilda) at 12UTC 24 Aug.

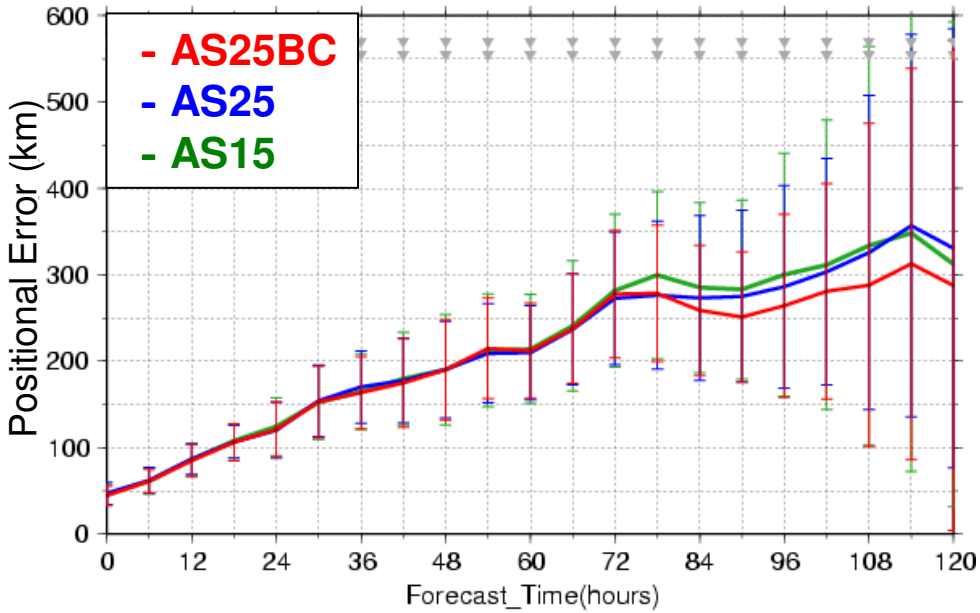


Averaged positional error of TC track forecasts

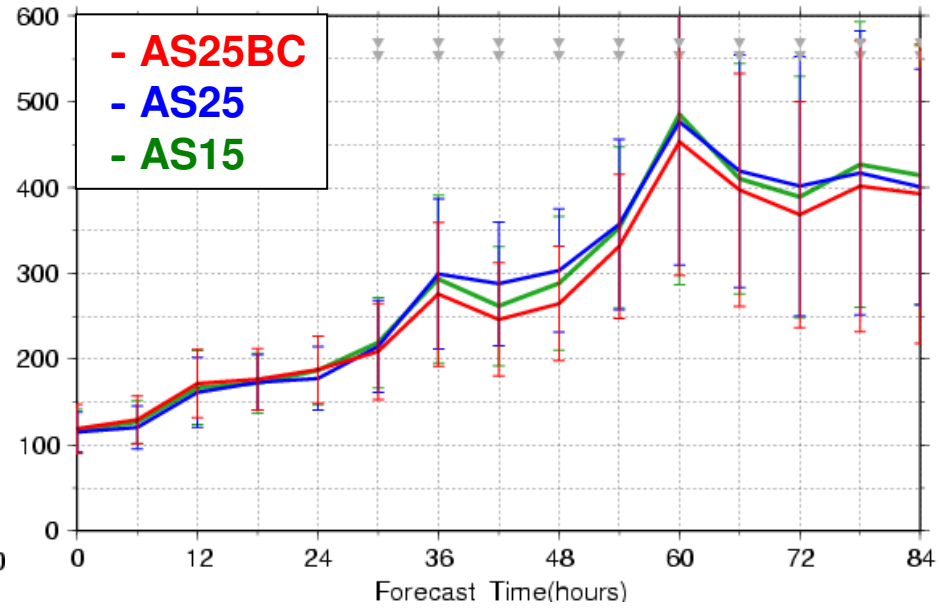
- AS25BC improved TC track forecast (but not statistically significant).

	ASCAT usage
AS25BC	0-25(m/s) w/ bias correction
AS25	0-25 (m/s)
AS15	0-15 (m/s)

North Western Pacific (31 initials).



East Pacific and North Atlantic



Error bar: 95% confidence interval.

Summary

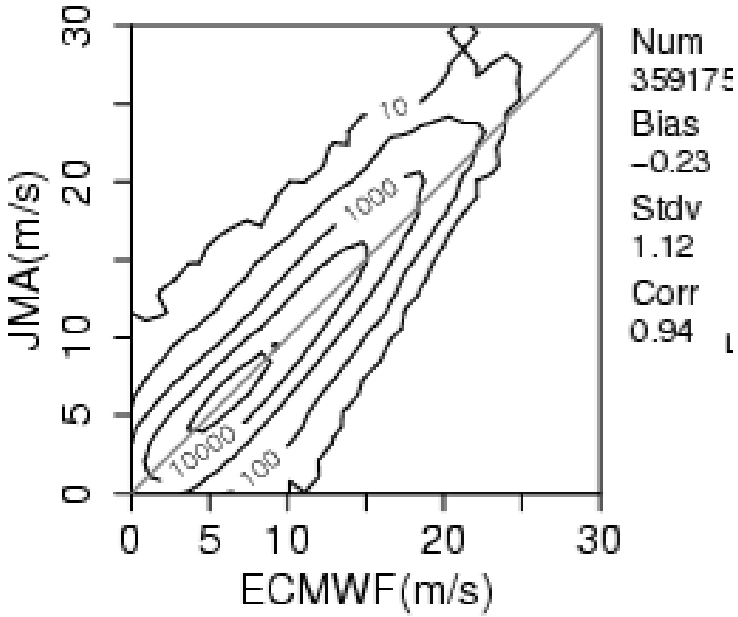
- JMA has used scatterometer winds in the operational GSM and MSM. In July 2009, we have started to use Metop-A/ASCAT winds in GSM. In 2010, operational use of ASCAT in MSM is planned.

- OSEs of bias corrected ASCAT high winds assimilation has shown that it is very important for forecast improvement to use bias-less winds between ASCAT and QuikSCAT. We will start the operational use of high speed ASCAT data in 2010.

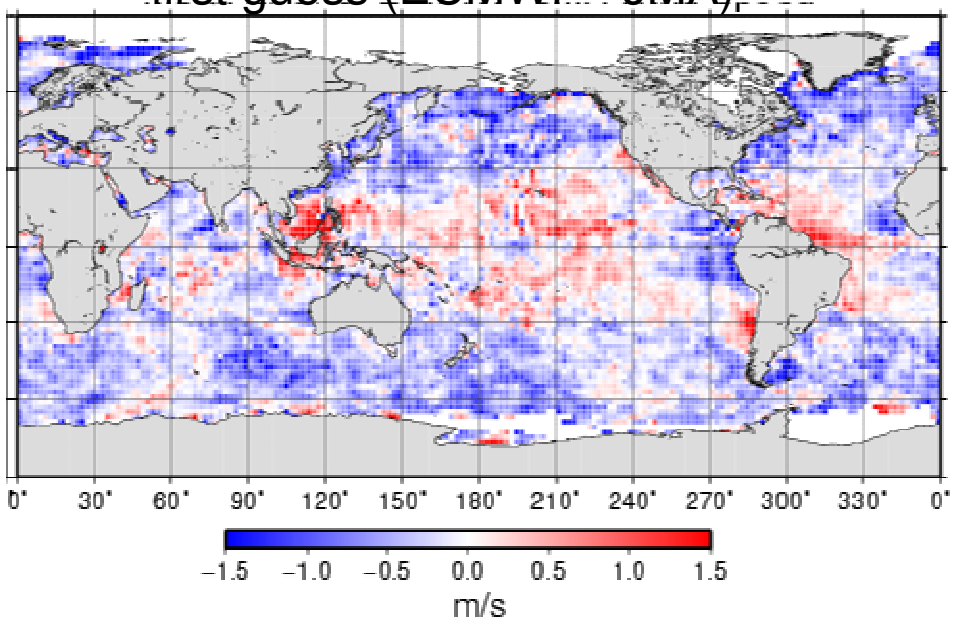
Thanks for your attention.

First Guess of Ocean Surface Wind Speed (JMA vs. ECMWF)

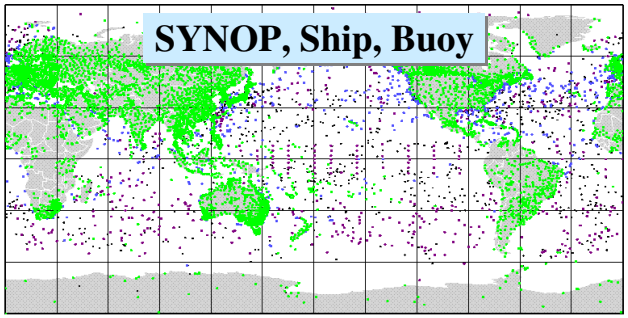
2009/01/01 - 01/10 (10 days)

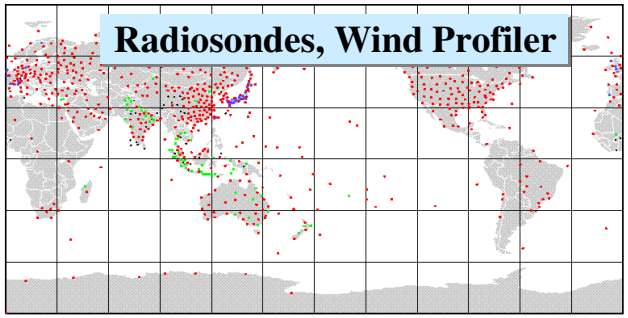


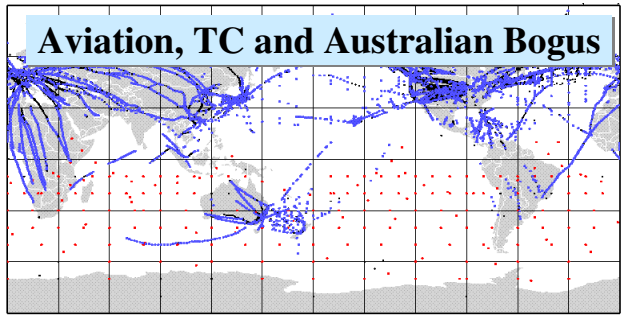
difference of ocean surface wind
first guess (ECMWF - JMA)

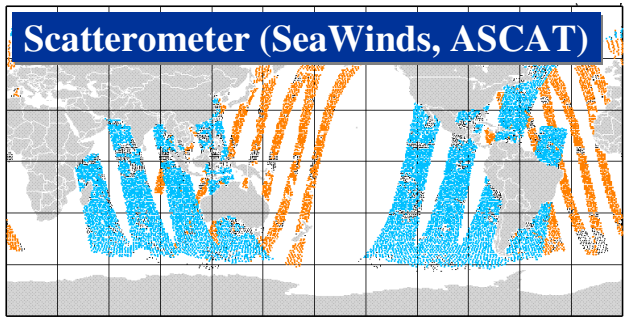


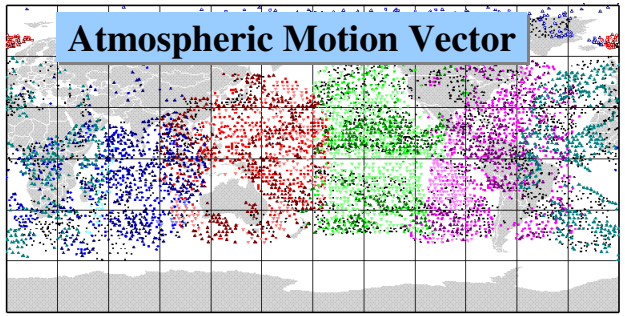
Data assimilated in global model

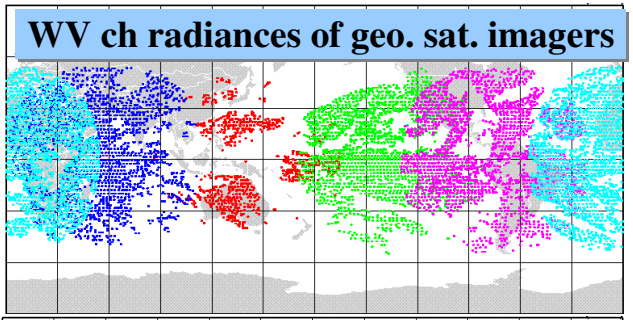


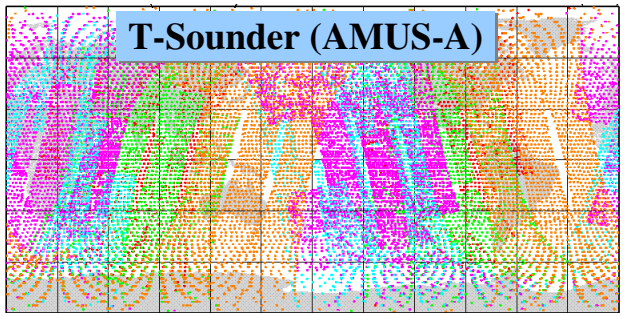


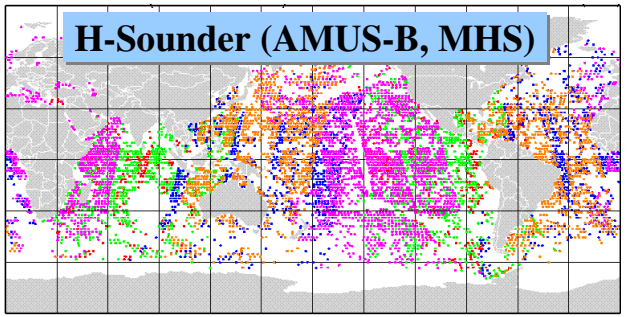


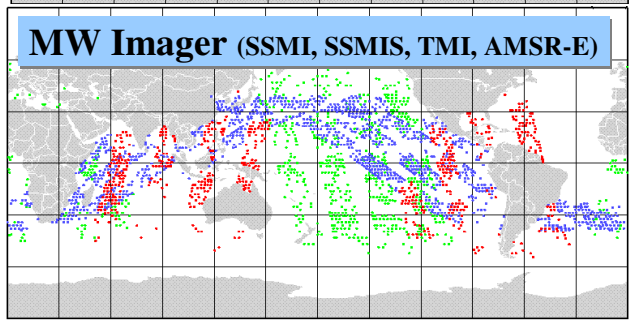


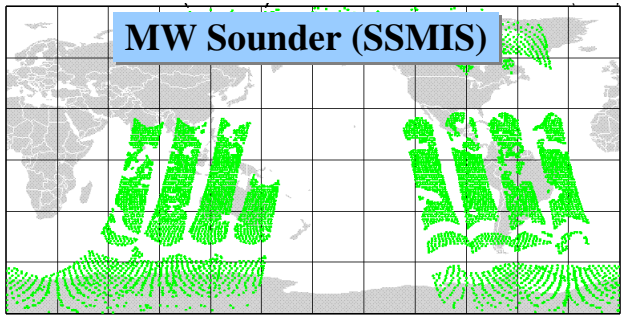


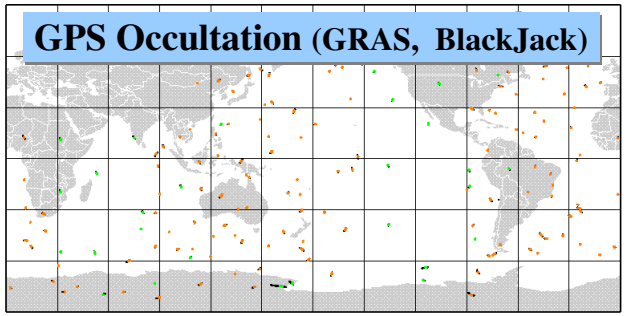






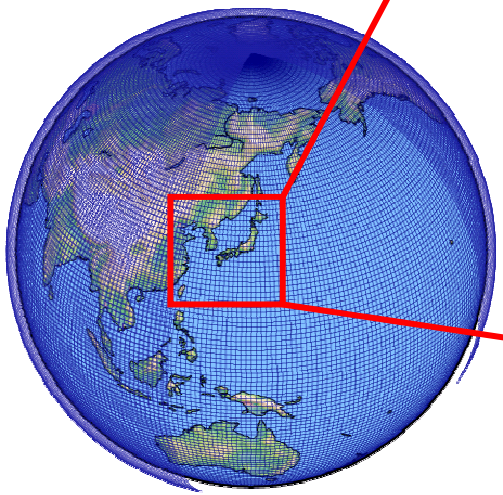


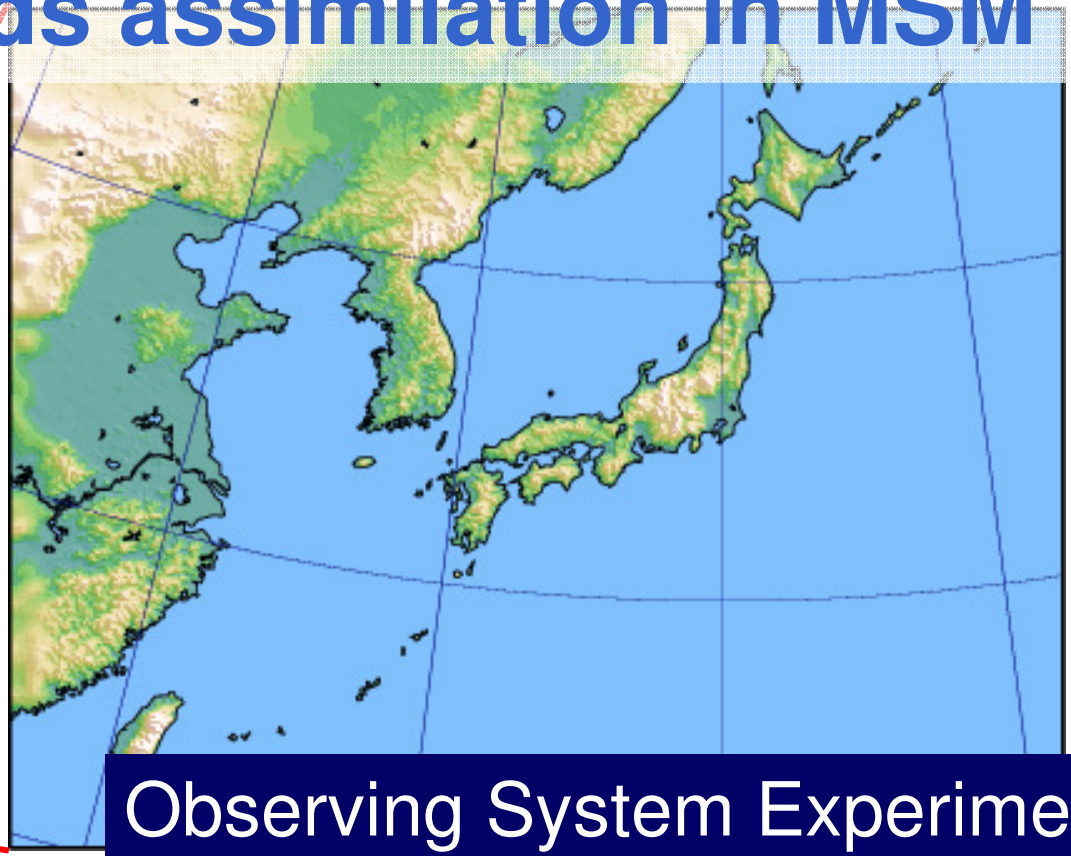




Ongoing development

- ASCAT winds assimilation in MSM



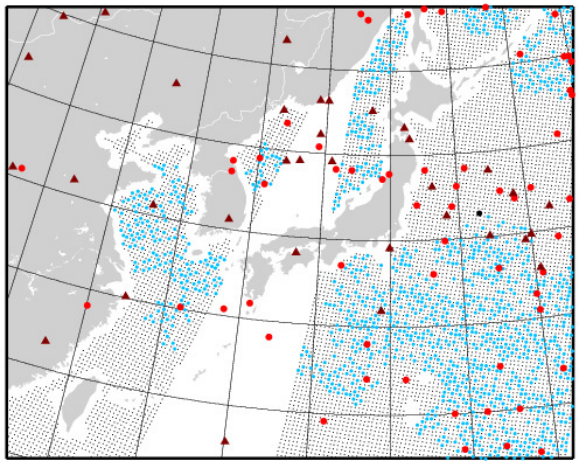


Observing System Experiment
in a regional model

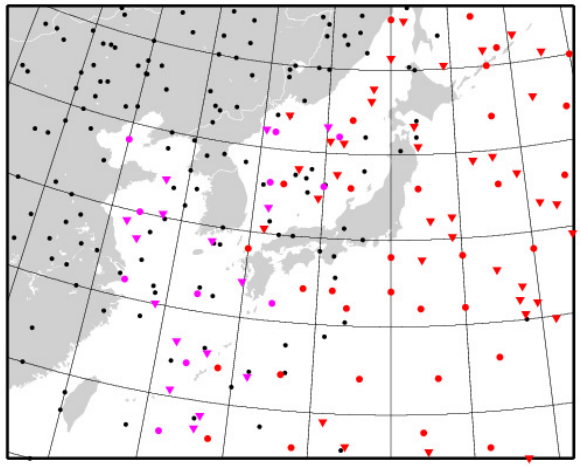
Data assimilated in regional model

- Important subject to use ASCAT in regional data assimilation system

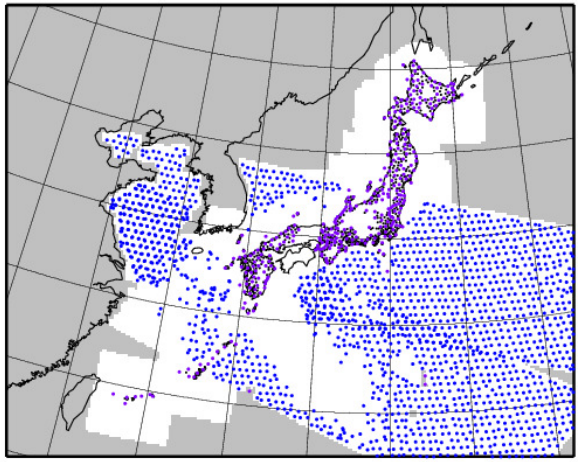
MW Scatterometer / AMV



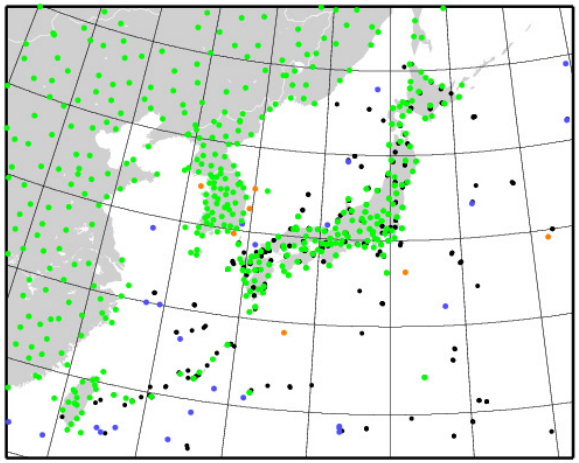
MW-Sounder



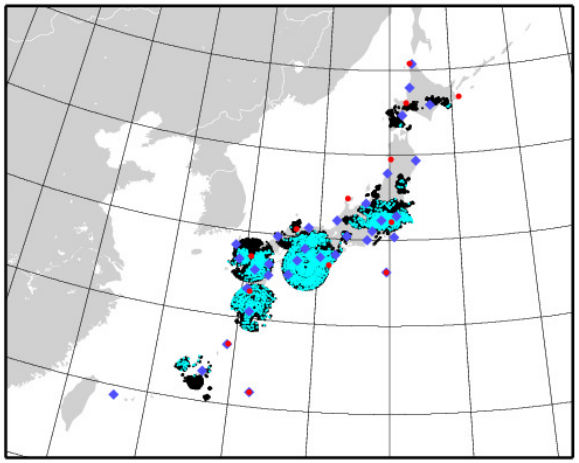
GPS-PWV, MW-Imager



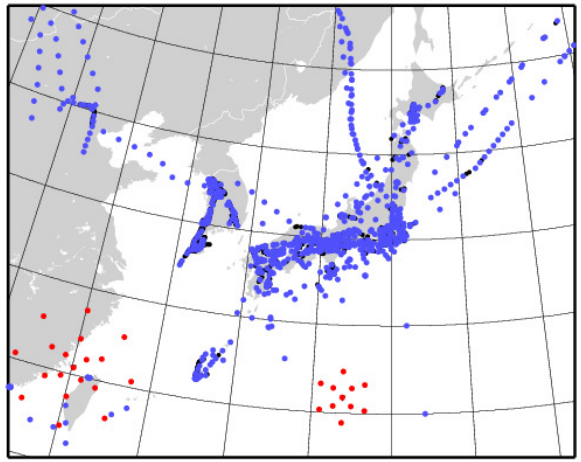
SYNOP, Ship, Buoy



Radiosonde, Wind profiler, Doppler radar

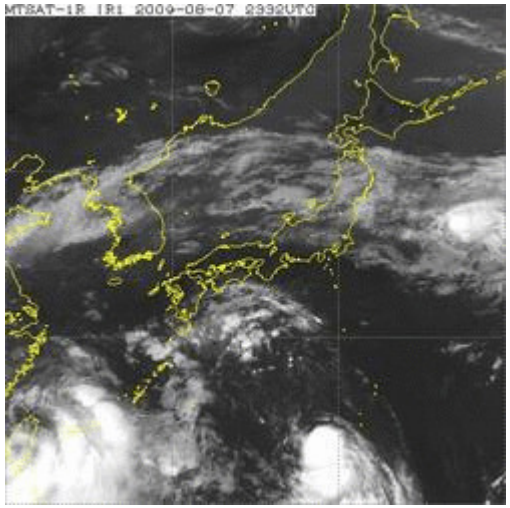


Aviation, TC bogus

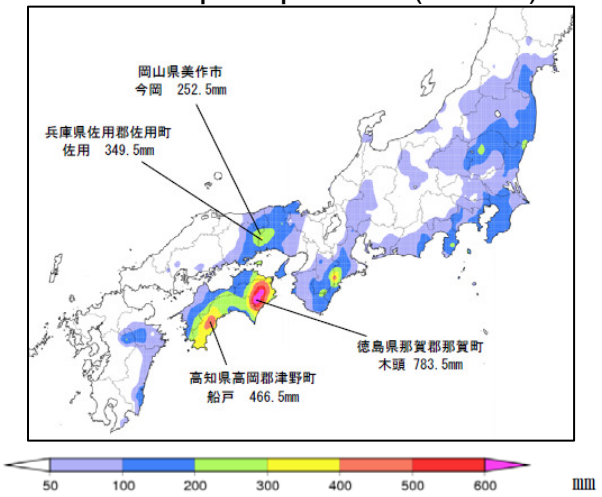


Heavy rainfall prediction in MSM

- Warm and moist outflow from TC caused heavy rainfall.
- Operational MSM did not predict that because TC position was not accurate in the model.

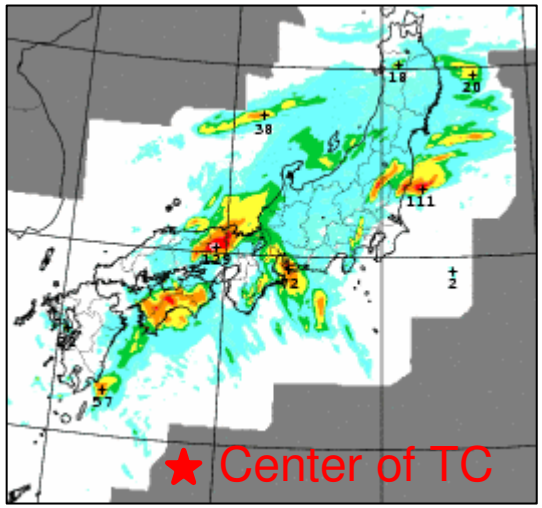


Total precipitation (8/8-11)

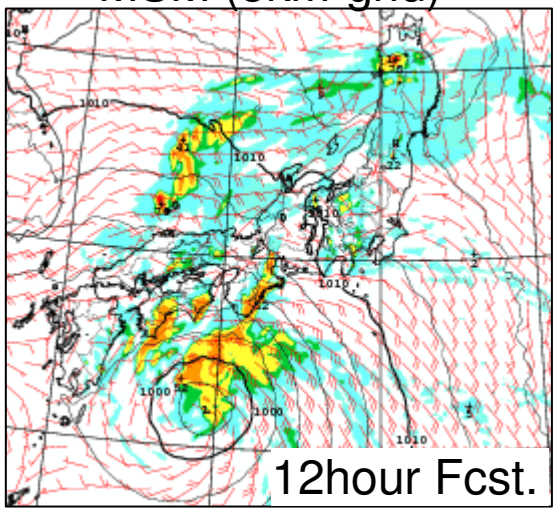


Rainfall forecast of operational nwp model (mm/3h, 2009/08/09 15UTC)

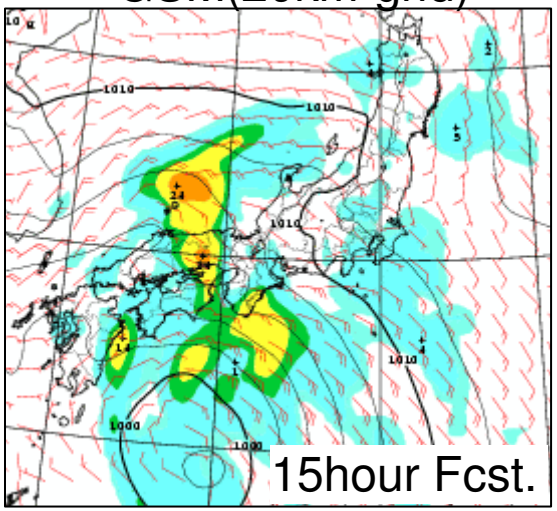
Radar Observation



MSM (5km-grid)



GSM(20km-grid)

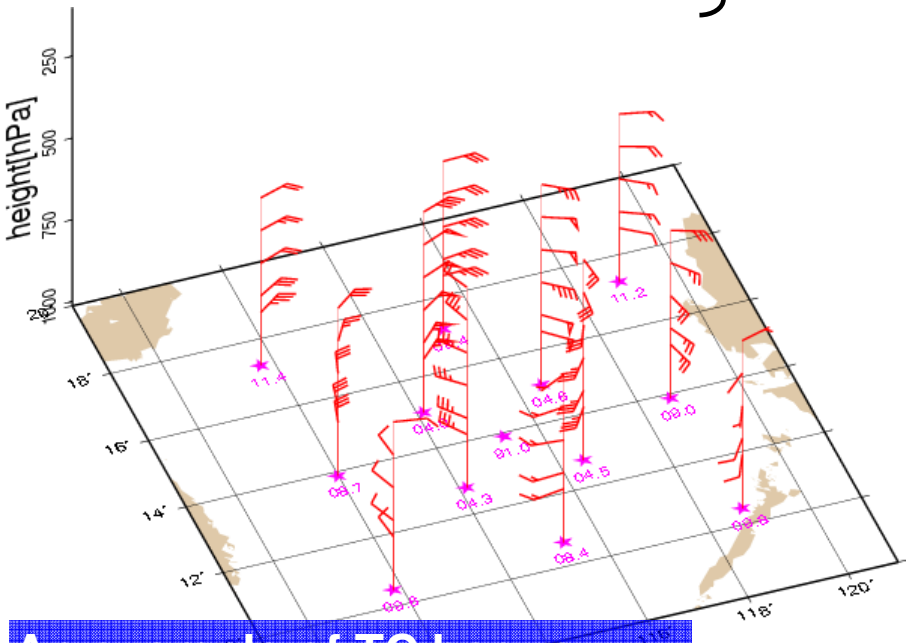


TC bogus over western North Pacific

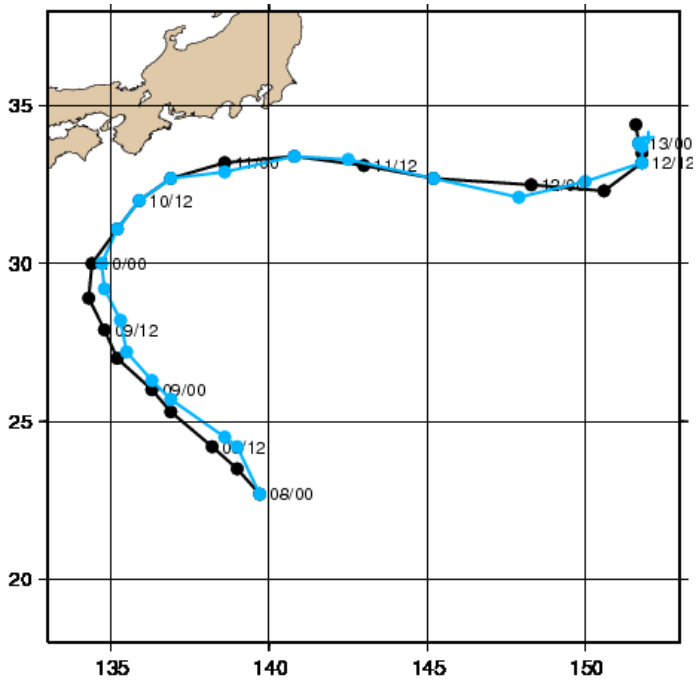
- Tropical cyclone bogus observation are assimilated to construct a realistic TC structure in the initial fields over western North Pacific.

Parameters to generate the TC bogus data
- First guess
- Central position of the TC
- Central sea level pressure
- 15m/s wind speed radius

} RSMC Tokyo (JMA) analysis



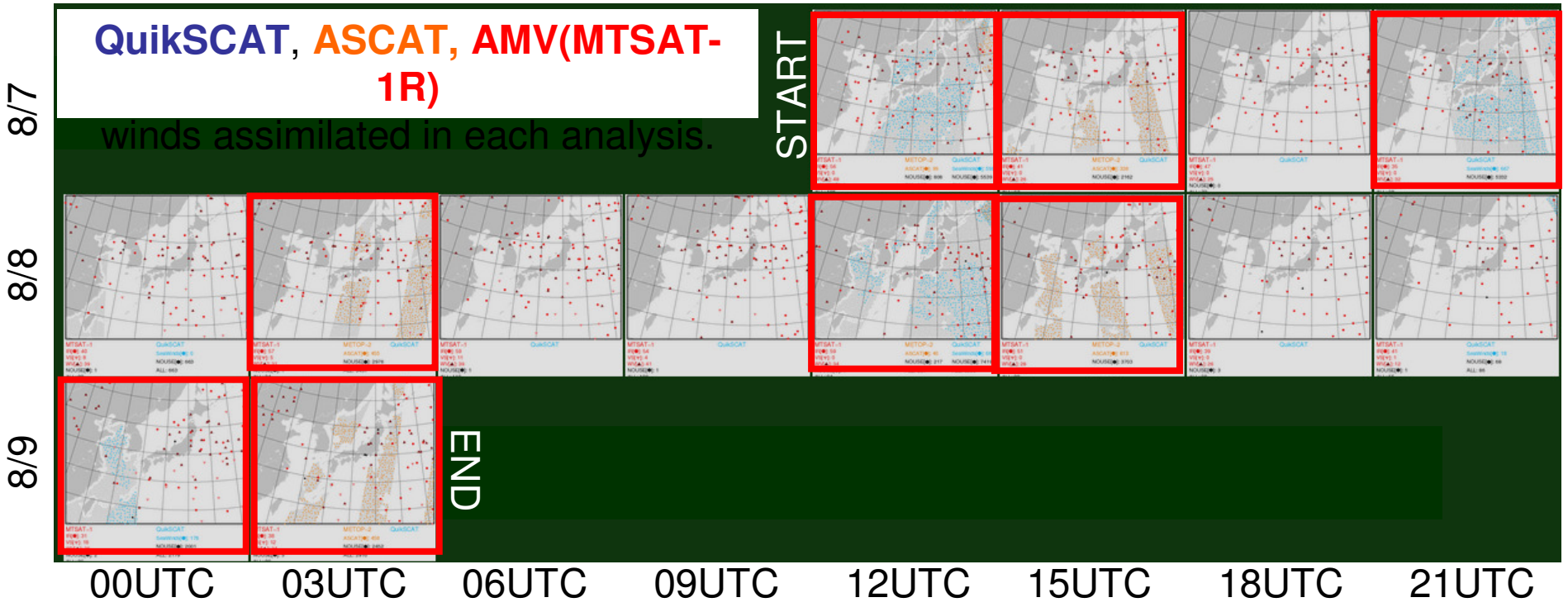
An example of TC bogus assimilated in global analysis



Observing System Experiment

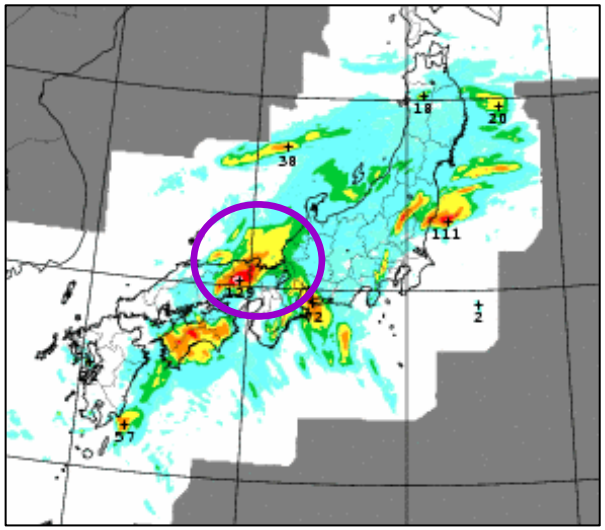
- Five experiments
  Experiment period:
  8/7 12UTC - 8/9 03UTC

ASCAT	QuikSCAT	TC bogus
use	use	Nouse
use	nouse	Nouse
nouse	use	Nouse
nouse	nouse	Nouse
nouse	use	use

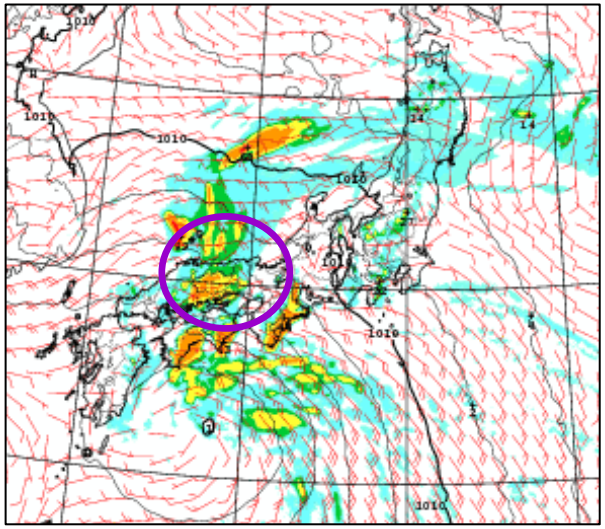


Rainfall prediction (12hour fcst.)

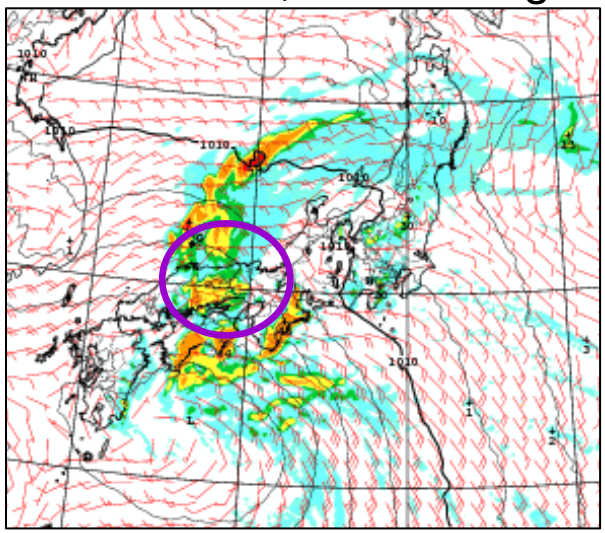
Radar OBS.



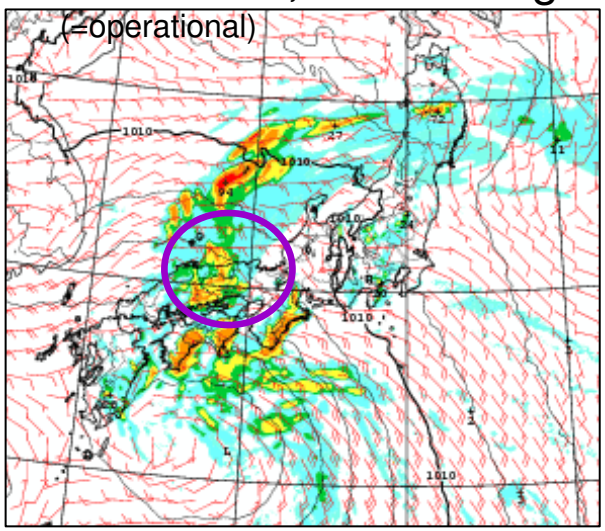
w/ ASCAT, QSCAT, w/o TC bogus



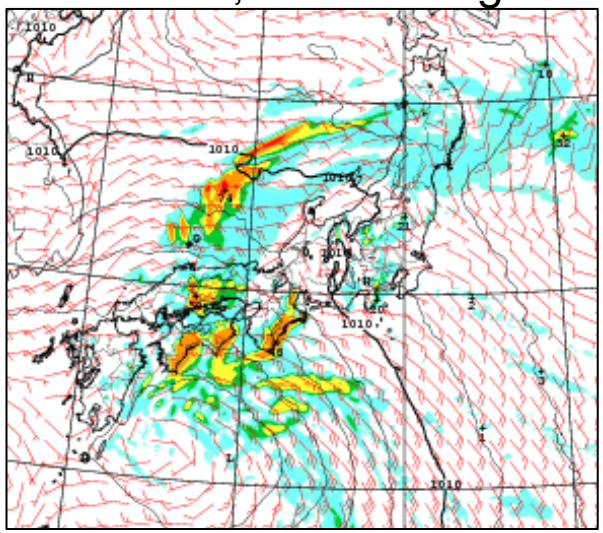
w/ ASCAT, w/o TC bogus



w/ QSCAT, w/o TC bogus (=operational)



w/o scatt, w/o TC bogus



w/ QSCAT, TC bogus