Recent Update on Operational Use of Scatterometer Winds in JMA's Mesoscale NWP System

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Outline

JMA began to assimilate scatterometer winds from Metop-C/ASCAT on 8 Dec 2021 in the Meso-Scale NWP system.

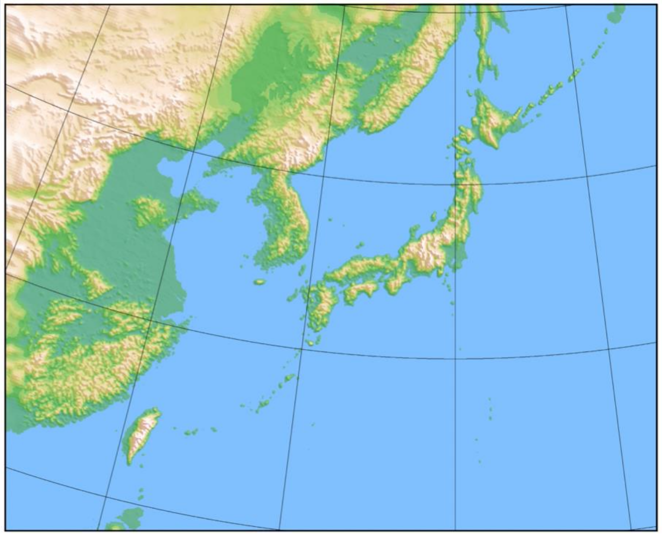
The impacts of these ocean vector winds on the system are introduced in this presentation.

Contents:

- Introduction of JMA's Meso-Scale NWP system
- Implementation of Metop-C/ASCAT winds
- Summary

JMA'S MESO-SCALE NWP SYSTEM

Meso-Scale NWP System in JMA



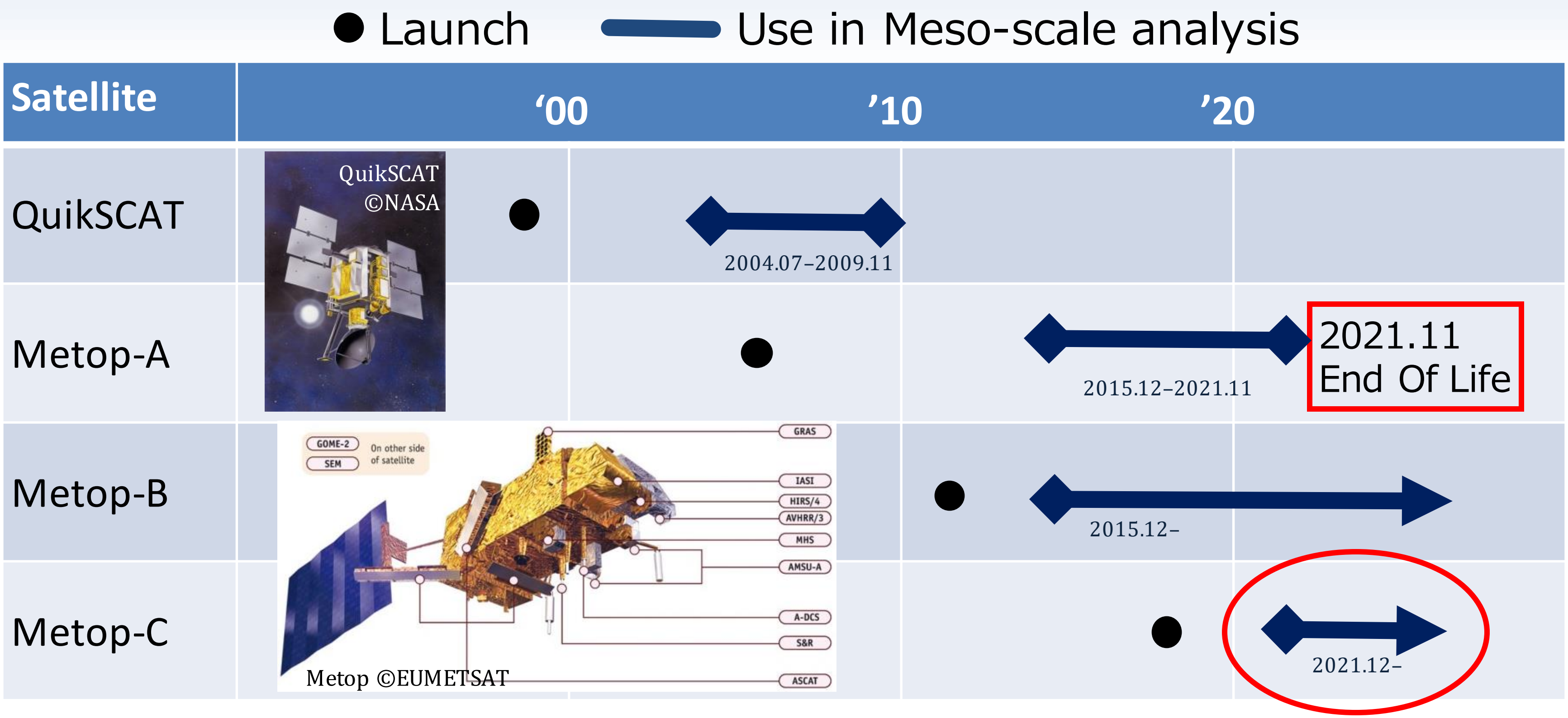
Domain of Meso-Scale Model

As you can see, domain of MSM is covered by ocean broadly.
Therefore, information of sea surface wind from scatterometer is important for JMA Meso-Scale Model.

	Meso-Scale NWP System
Purposes	Weather warnings/advisories Very short-range forecast of precipitation Aviation forecast
Forecast: Meso-Scale Model (MSM)	
Grid size	5 km (817 x 661 grids)
Vertical levels/Top	76 / 21.8 km
Forecast range (Initial time)	39 hours (03, 06, 09, 15, 18, 21 UTC) 51 hours (00, 12 UTC)
Analysis: 4D-Var assimilation	
Grid size	(Outer step) 5 km (817 x 661 grids) (Inner step) 15 km (273 x 221 grids)
Vertical levels/Top	(Outer step) 76 levels up to 21.8 km (Inner step) 38 levels up to 21.8 km
Time window	3 hours (ended at nominal analysis time, e.g. 06-09 UTC for 09 UTC run)
Iterations	50 times (Max)
Data cut off time	50 minutes

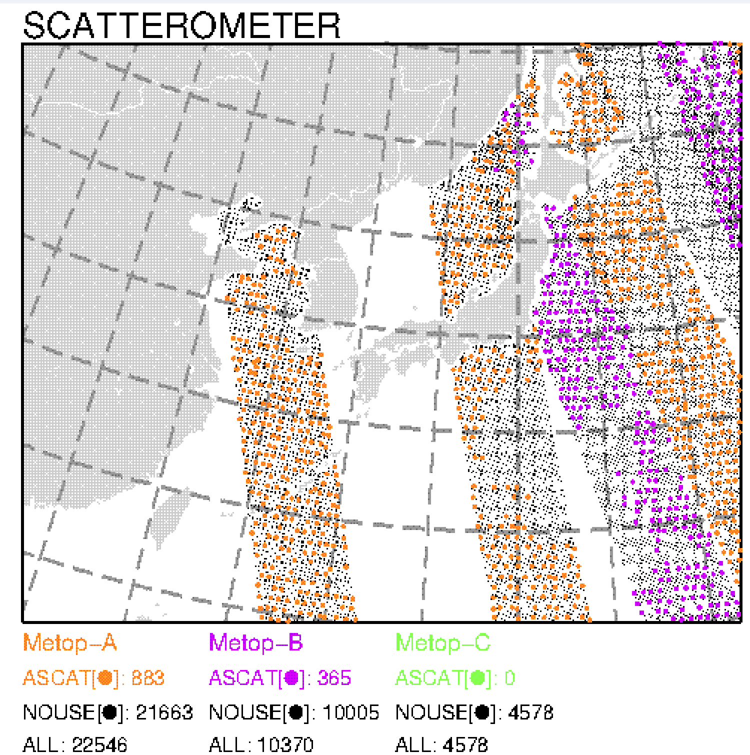
As of Mar 2022

Scatterometer Implementation History in JMA's Meso-Scale NWP system



In this presentation, I will introduce about this implementation of Metop-C/ASCAT winds on JMA's Meso-Scale NWP system.

Pre-Analysis Procedure for Scatterometer Winds



Assimilation data coverage map of scatterometer on 12UTC 6 Aug 2020

Orange dots: Metop-A/ASCAT(passed pre-analysis)
Purple dots: Metop-B/ASCAT(passed pre-analysis)
Black dots: Rejected data (In this figure, all of Metop-C/ASCAT data is also included)

Flag check	Check provided flags (rain, land/sea, sea ice etc.) and reject flagged data
Gross error check	Reject large |O-B| data
Group QC	Reject large |O-B| averaged by an area including similar wind vector observation Prevent over rejection in and around severe weather condition
Ambiguity removal	Select the closest wind to JMA's forecast by median filter after nudging
Thinning	0.5 deg x 0.5 deg box Eliminate spatial observation error correlation Reduce calculation cost Overlapping data rejection

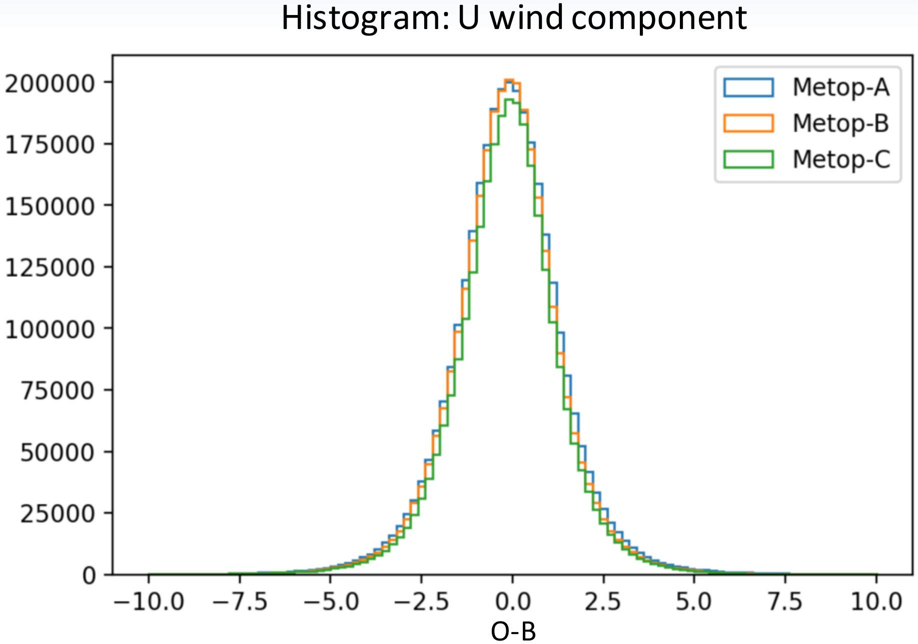
IMPLEMENTATION OF METOP-C/ASCAT WINDS

In this section, these research results will be presented.

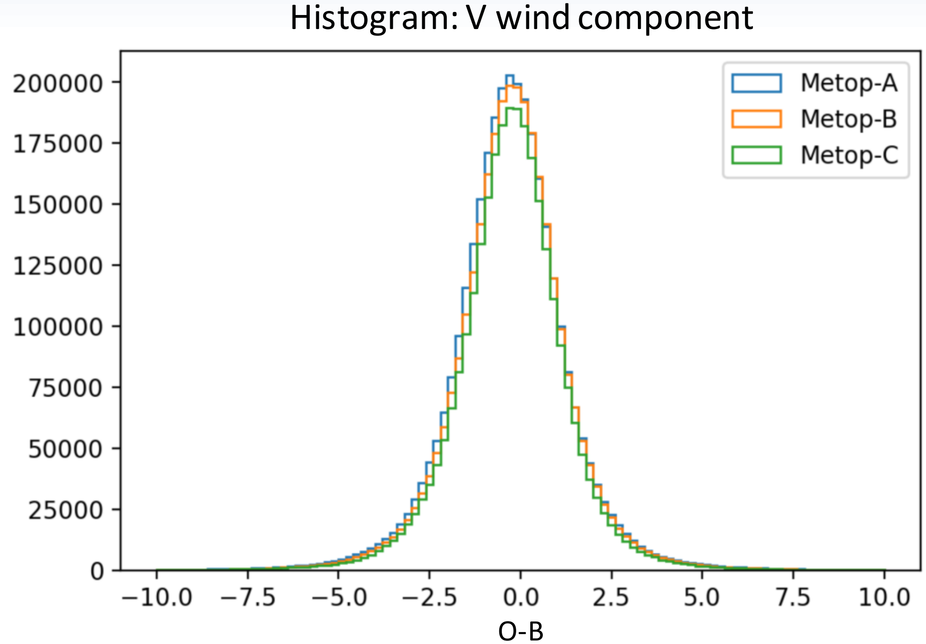
- Investigation of data quality on JMA’s Meso-scale analysis
- Observing system experiments(OSEs) result
- Examples of forecast experiment result

Investigation of data quality of Metop-C/ASCAT on JMA's Meso-scale analysis

From 00UTC 26 Jun 2020 to 21UTC 31 Jul 2020



Satellite	BIAS(m/s)	STDV(m/s)
Metop-A	-0.141	1.60
Metop-B	-0.180	1.51
Metop-C	-0.151	1.49



Satellite	BIAS(m/s)	STDV(m/s)
Metop-A	-0.296	1.69
Metop-B	-0.255	1.60
Metop-C	-0.261	1.56

Metop-C/ASCAT wind product shows similar characteristic to Metop-A,B/ASCAT wind product against JMA Meso-scale first guess.

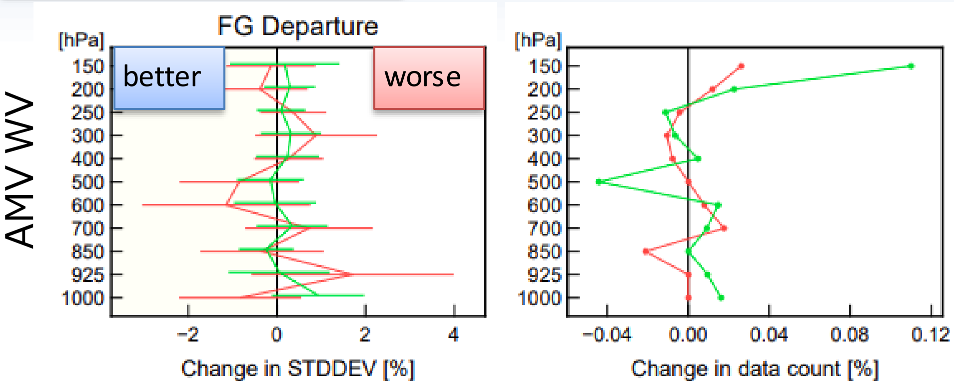
Observing System Experiments

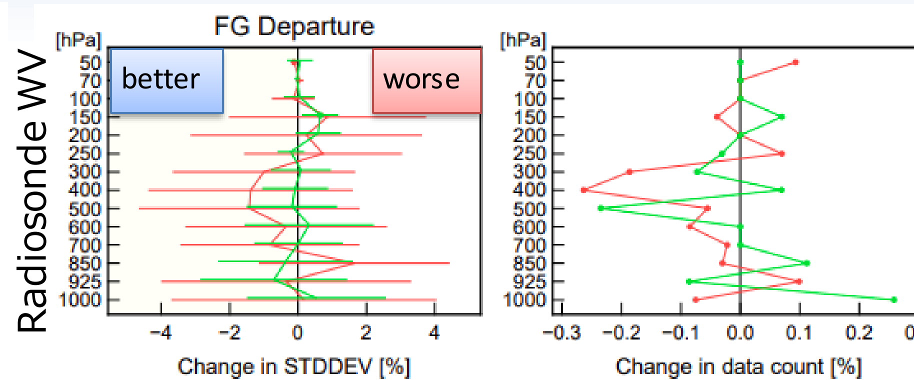
- Control experiment (CNTL)
  - Assimilate Metop-A,B/ASCAT winds
  - Same as of Oct 2020 mesoscale assimilation system of JMA
- TEST
  - Assimilate Metop-B,C/ASCAT winds
  - Preprocessing system is unchanged from CNTL.
- Experiment period
  - 2020Winter : From 20 Jan 2020 to 25 Feb 2020
  - 2020Summer : From 1 Jul 2020 to 31 Jul 2020

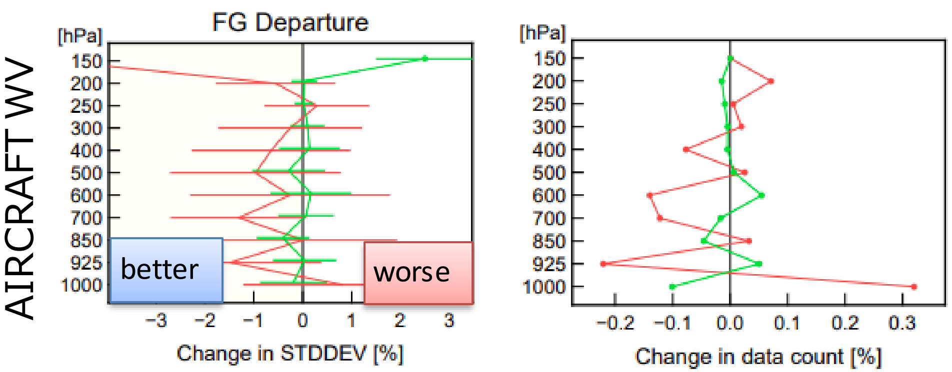
The impact of using both Metop-B/ASCAT and Metop-C/ASCAT winds in the mesoscale assimilation (TEST)was verified by observing system experiments (OSEs) .

Comparison of First-Guess Field (Wind field)

Red: 2020Summer
Green: 2020Winter



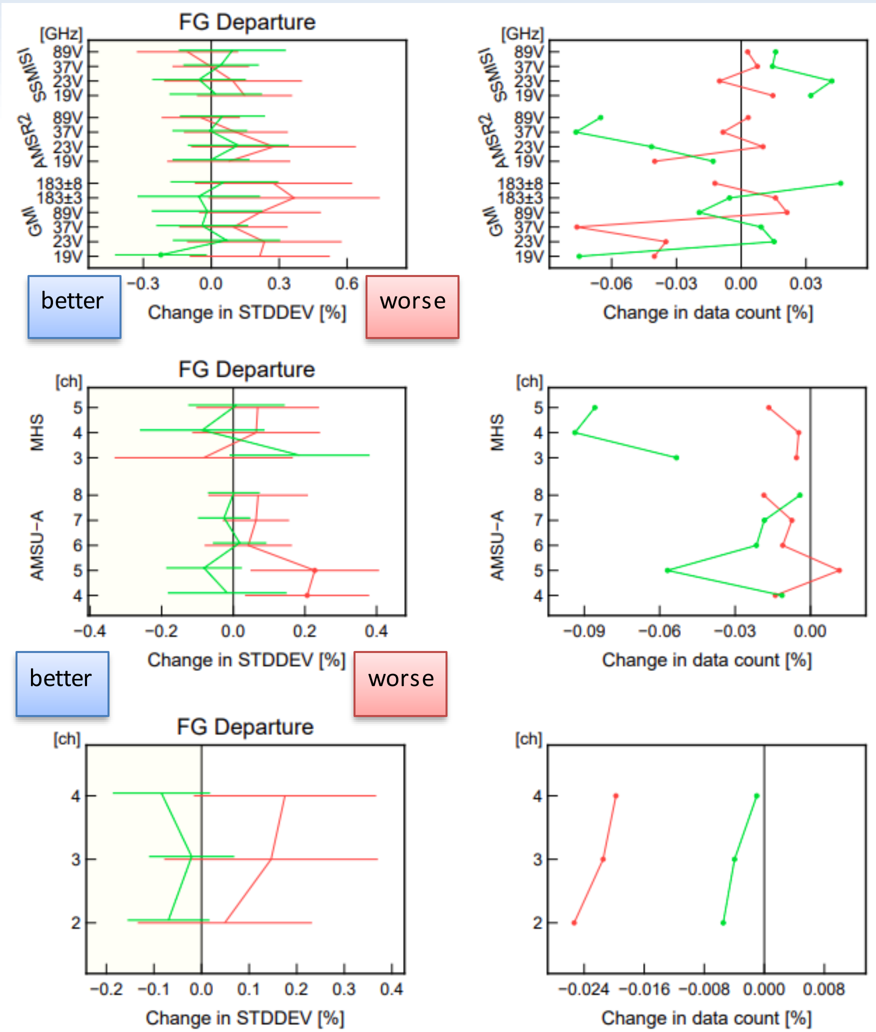




- Change in normalized standard deviation (STDDEV) of the first-guess departure $(STDDEV_{TEST} - STDDEV_{CNTL})/STDDEV_{CNTL}$ and assimilated data count for various wind observations. Error bars represent 95% confidence intervals, and dots show values are statistically significant.

Standard deviations of first-guess departure and data count do not change significantly from control experiment.
That shows accuracy of first-guess field on test experiment is equivalent to control experiment.

Comparison of First-Guess Field (Water vapor field)



Red: 2020Summer
Green: 2020Winter

Water vapor field do not change significantly from control experiment either.

That also shows accuracy of first-guess field on test experiment is equivalent to control experiment.

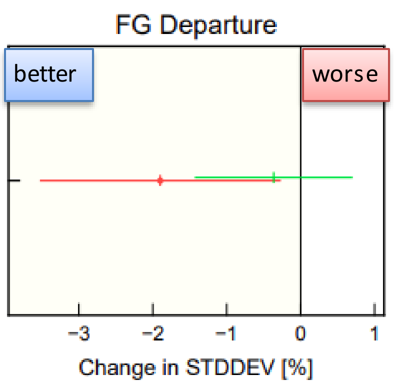
The impact of using Metop-C/ASCAT winds instead of Metop-A/ASCAT winds for analysis result is thought of as small.

▲ Same figures as the previous page but for microwave imager, sounder and CSR product for infrared imager.

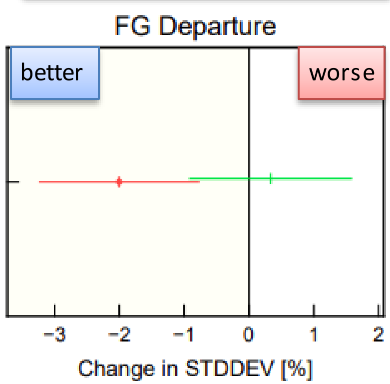
Comparison of First-Guess field(scatterometer)

Red: 2020Summer
Green: 2020Winter

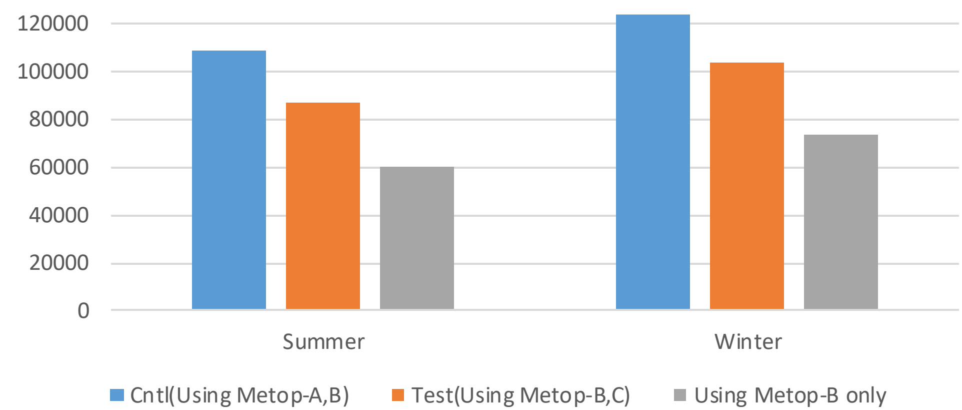
Compared to CNTL



Compared to experiment using only Metop-B



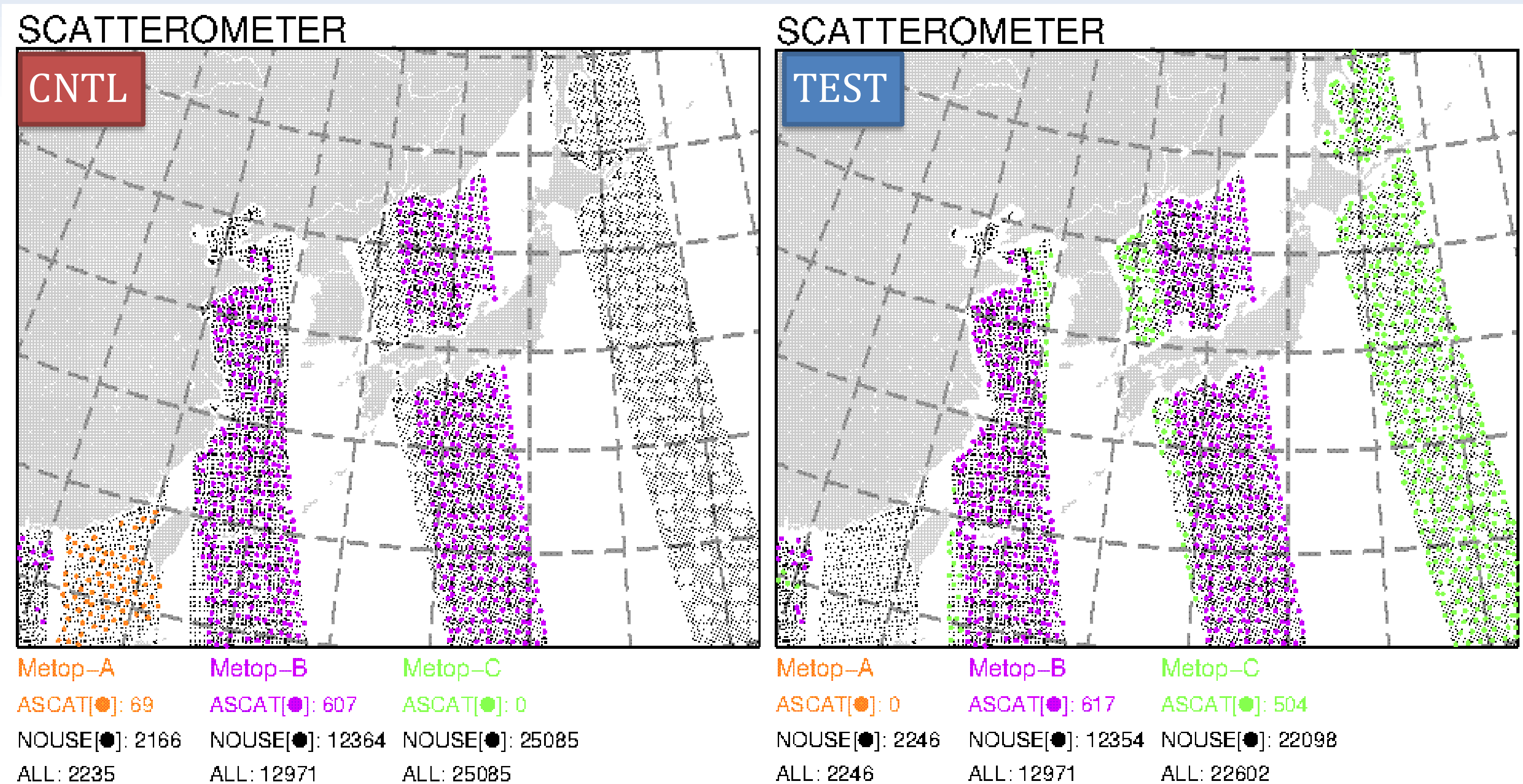
Changes in data count



▲ Same figures as the previous pages but for scatterometer observations.

- Standard deviations of first-guess departure is slightly improved.
- Assimilated data numbers of scatterometers increased by about 40 percent compared with OSE that uses only Metop-B/ASCAT winds.
- Assimilated data numbers of scatterometers decreased by about 20 percent compared with control experiment that uses Metop-A/ASCAT and Metop-B/ASCAT winds.
- Result of comparison of first-guess field shows that adding Metop-C/ASCAT does not make significant changes from control experiment except for assimilated data numbers.

Forecast improvement example
15UTC 23 Jul 2020initial

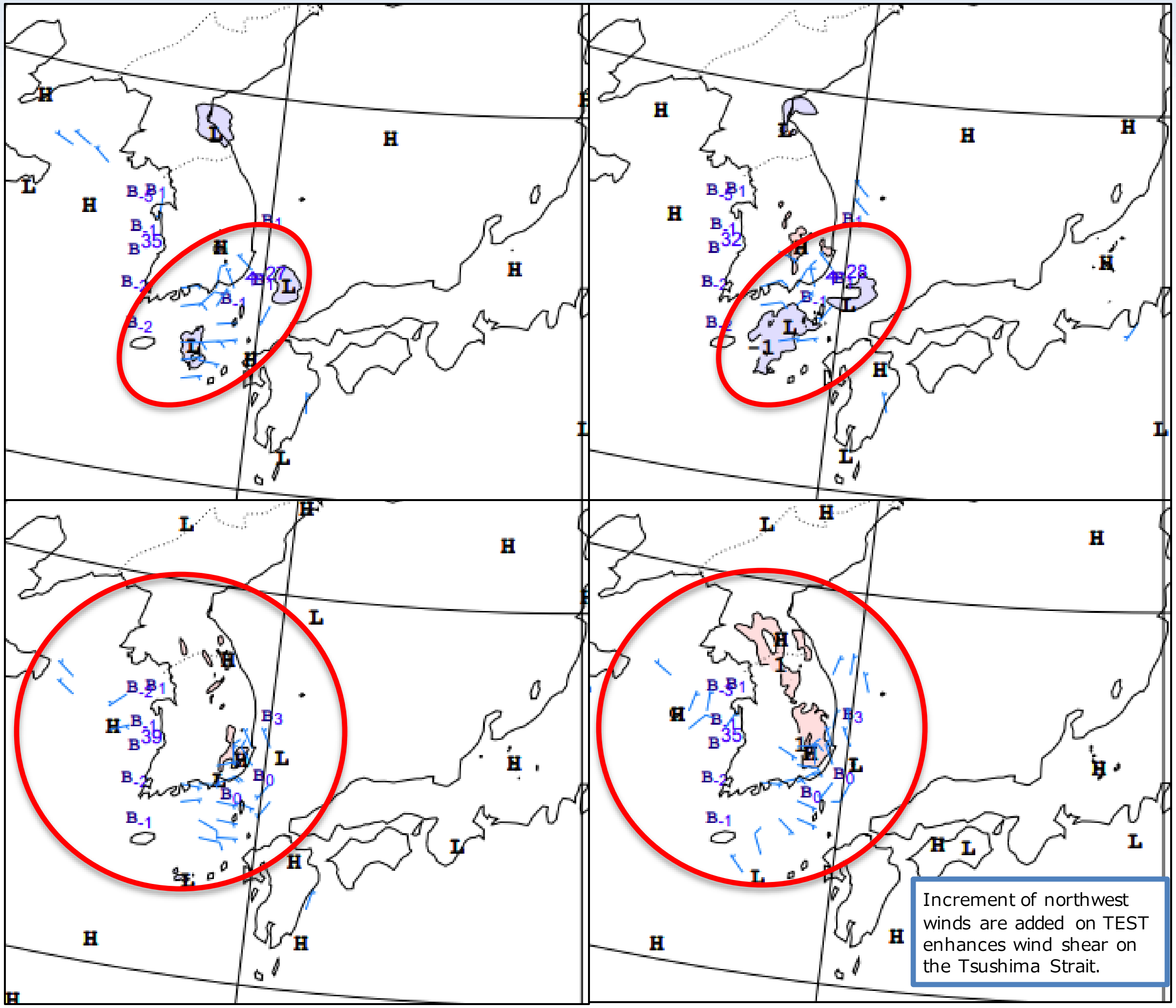


- Data distribution of scatterometer winds used for this initial shows that coverage of TEST experiment is wider than CNTL.

Forecast improvement example 15UTC 23 Jul 2020initial

FT -02

FT -01



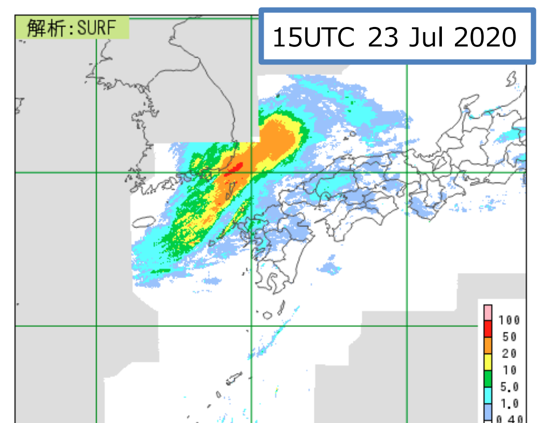
CNTL

TEST

Analysis increment of 15UTC 23 Jul 2020 FT-02,FT-01(Psea)

Blue area shows increment of surface pressure distribution(<-1 hPa).
Red area shows increment of surface pressure distribution(>1 hPa).
H and L letters show increments of surface pressure(-1 hPa≦ or ≦1hPa).
Blue arrows show increment of surface wind vector(> 5 knot).

Increments of surface pressure and wind vector was changed around the Korean Peninsula. This region is correspond to precipitation area on observation (the figure below).

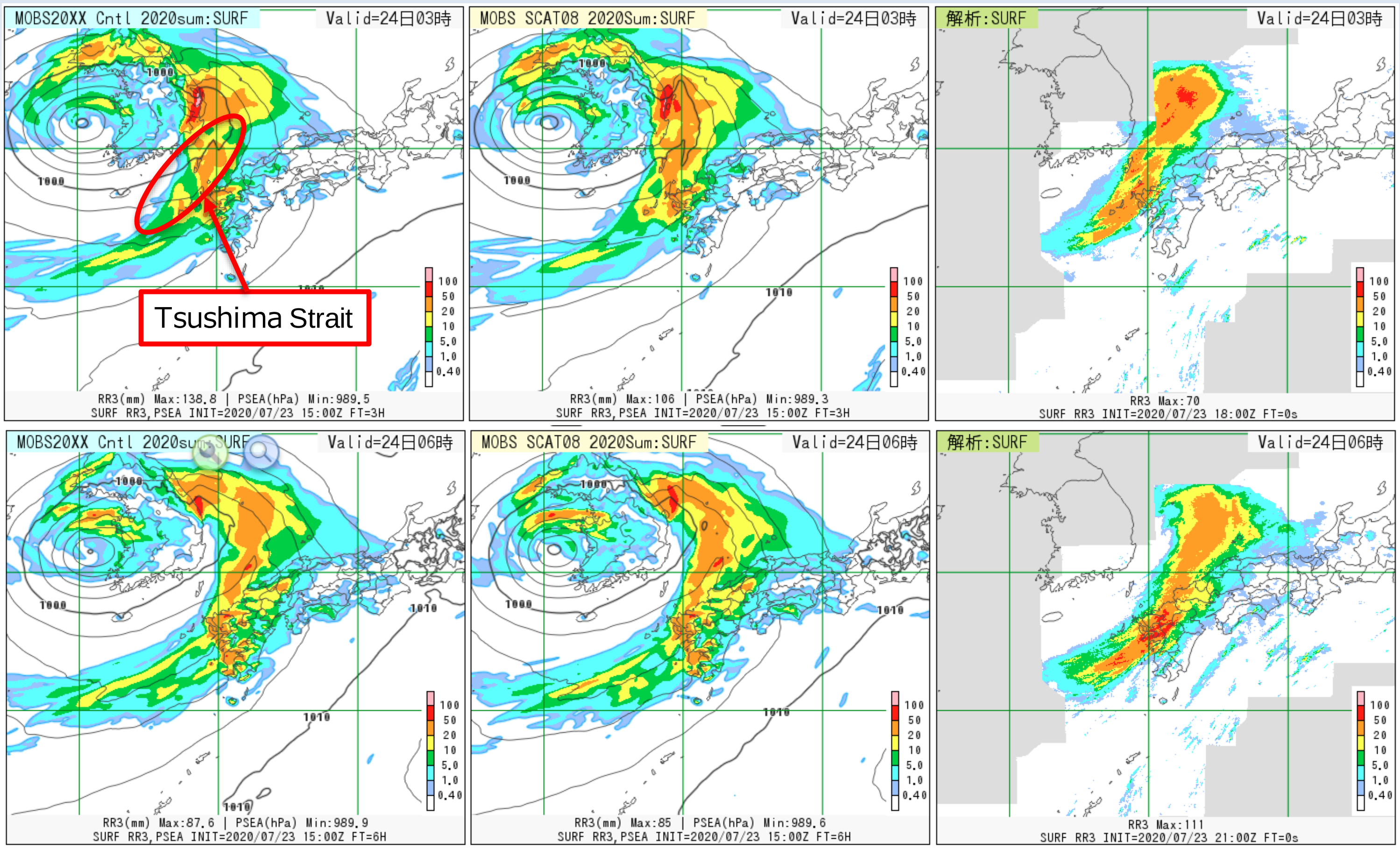


Radar/Raingauge-Analyzed Precipitation

Forecast improvement example
15UTC 23 Jul 2020initial FT03,FT06

FT 03

FT 06



[mm/3H]

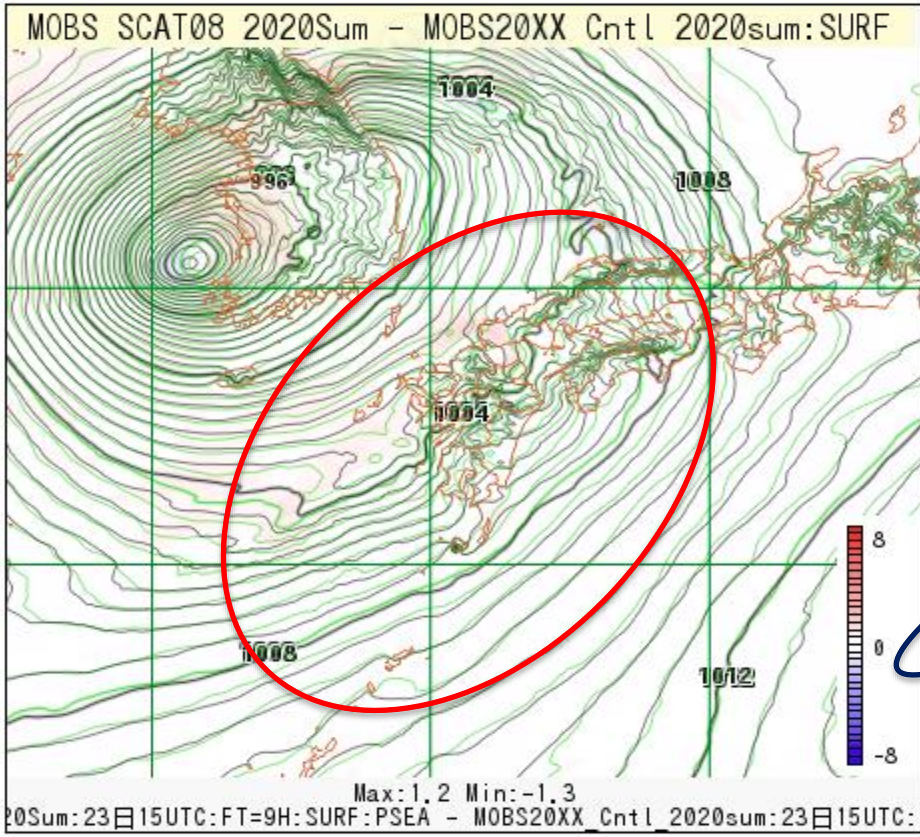
CNTL

TEST

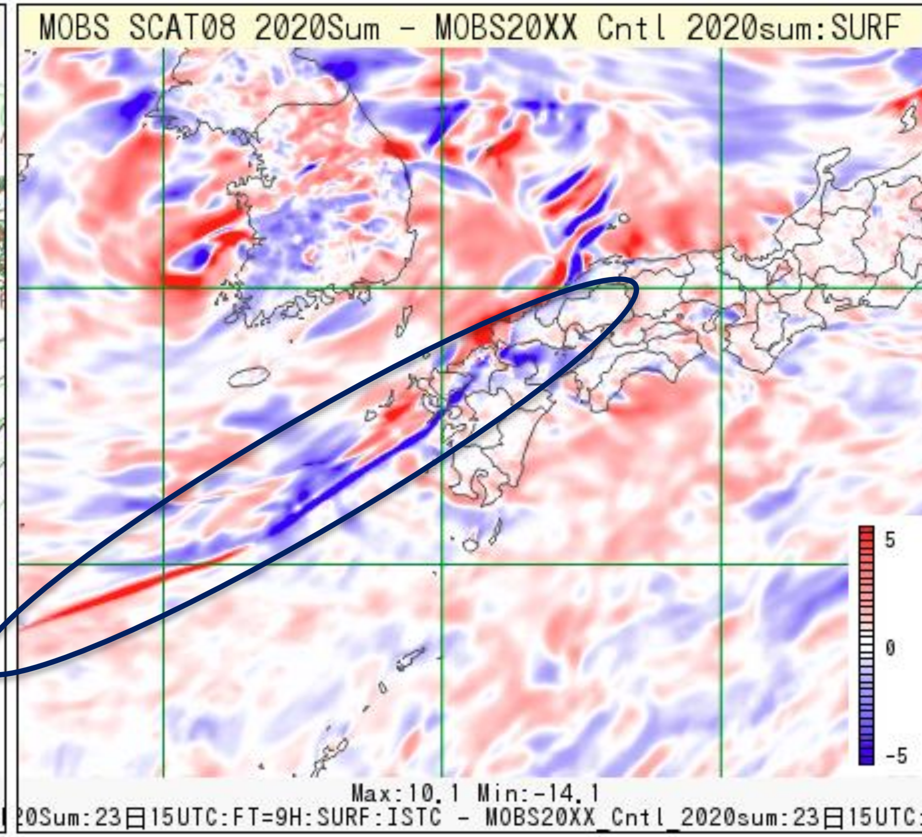
Radar/Raingauge-Analyzed Precipitation

According to forecast time advance, precipitation area on Tsushima Strait that related to analysis increment changes moves toward southeast. These results show precipitation area of TEST is stronger than CNTL and it is more consistent to observation.

Forecast improvement example
15UTC 23 Jul 2020initial FT09



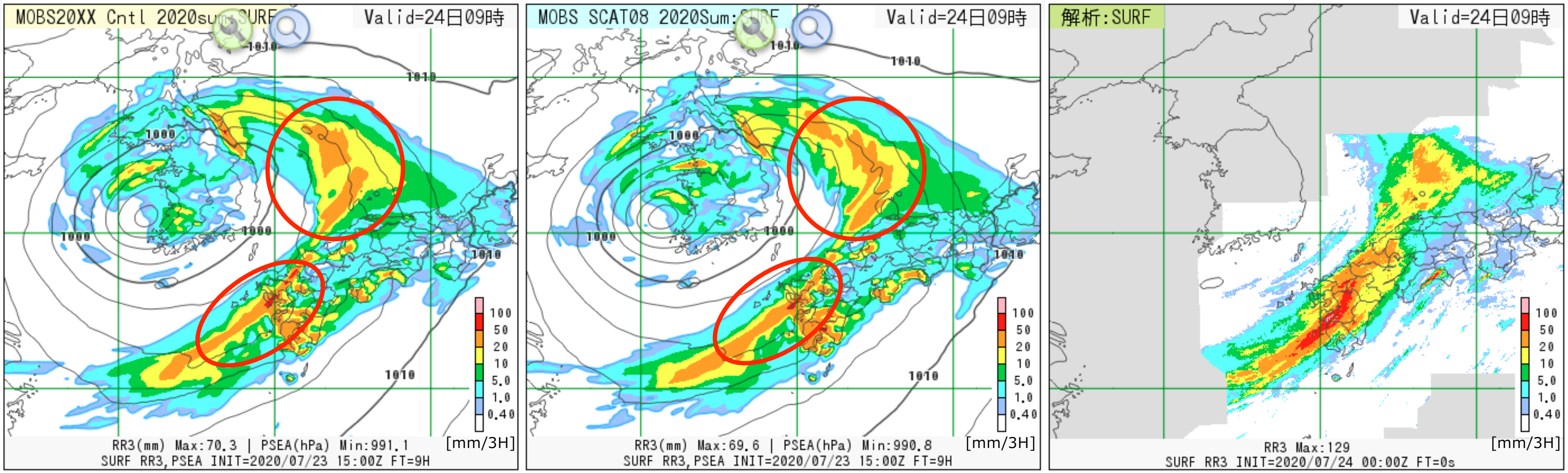
Sea surface pressure（black line :CNTL, green line: TEST）



Wind speed(TEST-CNTL)

Distribution of sea surface pressure (left figure) on forecast was also changed.
Right figure also shows shifting of convergence zone along cold front.

Forecast improvement example
15UTC 23 Jul 2020initial FT09



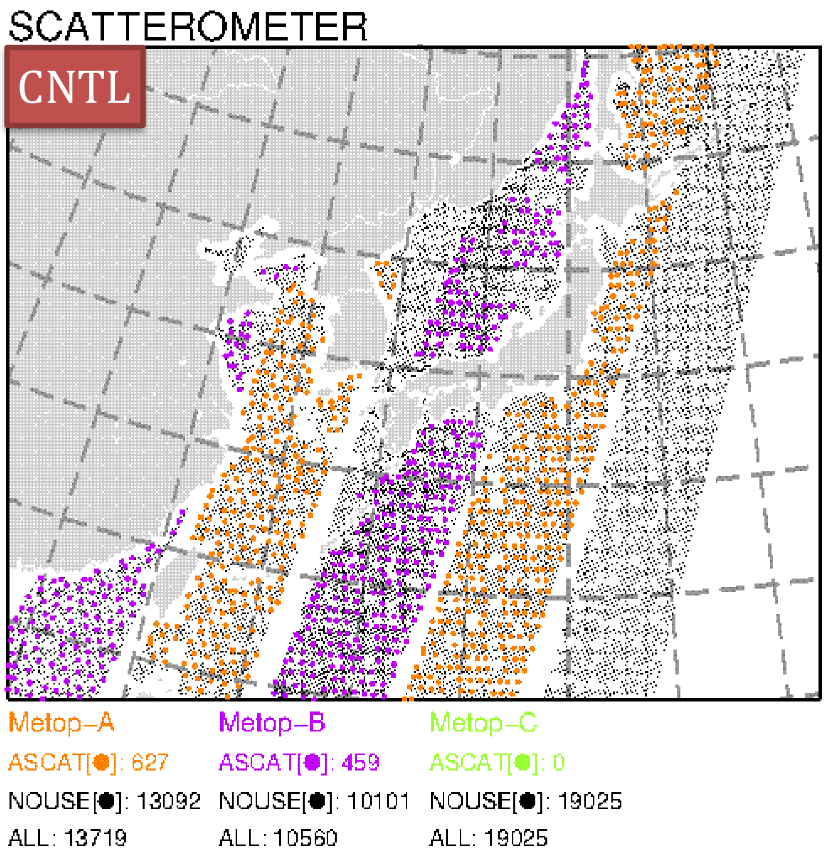
CNTL

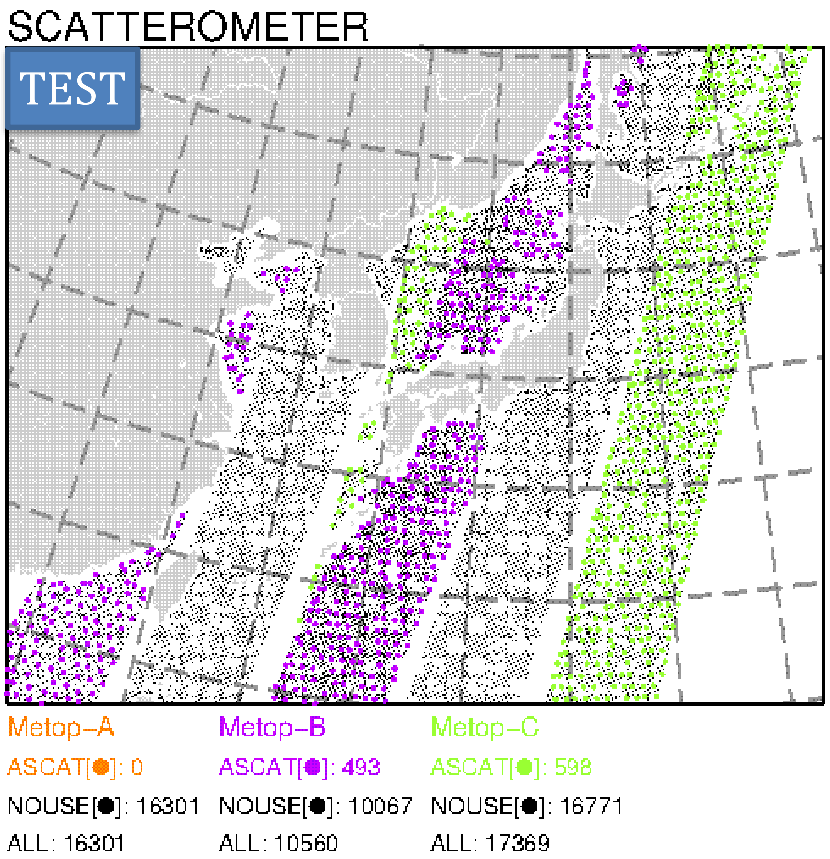
TEST

Radar/Raingauge-Analyzed Precipitation

Changes of wind field and surface pressure distribution make width of precipitation band(>20 mm/3H) and rainfall amount along cold front more consistent to Radar/Raingauge-Analyzed Precipitation.

Forecast deterioration example 03UTC 3 Jul 2020initial

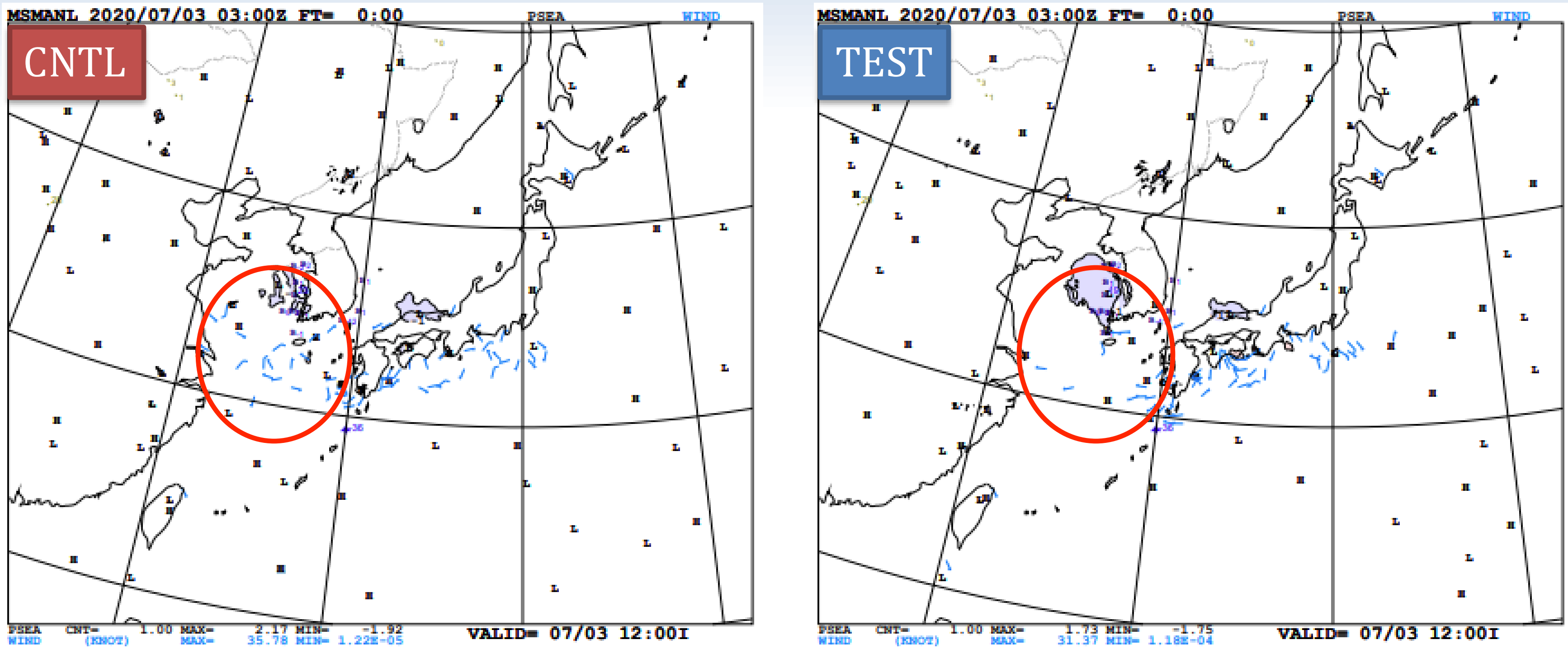




Data distribution of scatterometer winds used for CNTL and TEST experiments shows overlapping satellite path of Metop-B and Metop-C.

There is data thinning process of overlapping scatterometer datasets in the JMA's preprocessing system of assimilation. Therefore, this decreasing of assimilated data numbers seems to be caused this overlapping satellite path.

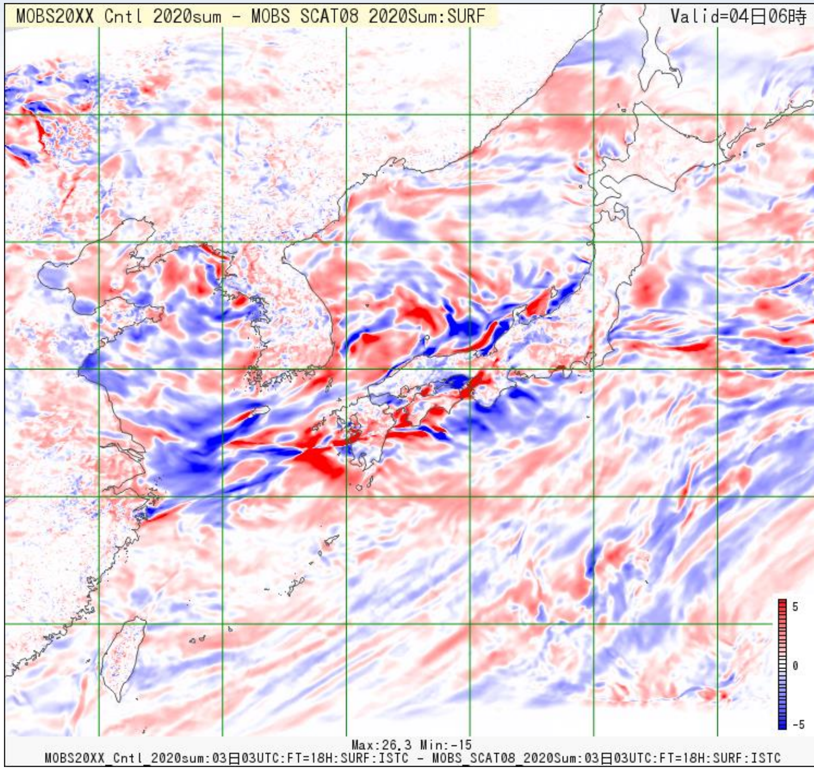
Forecast deterioration example
03UTC 3 Jul 2020initial



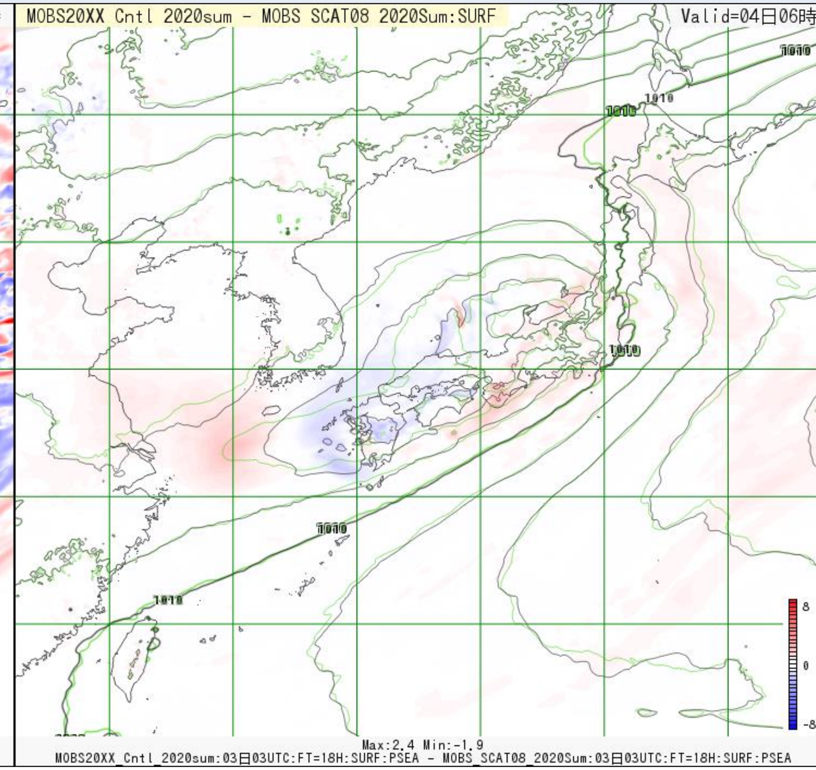
Analysis increment of 03UTC 3 Jul 2020 FT00(Psea)

- As previous slide has shown, decrease of assimilated scatterometer wind has caused by overlapping satellite path in this initial.
- As a result, analysis increment of surface winds by scatterometer also becomes narrower and decrease.

Forecast deterioration example
03UTC 3 Jul 2020initial FT18



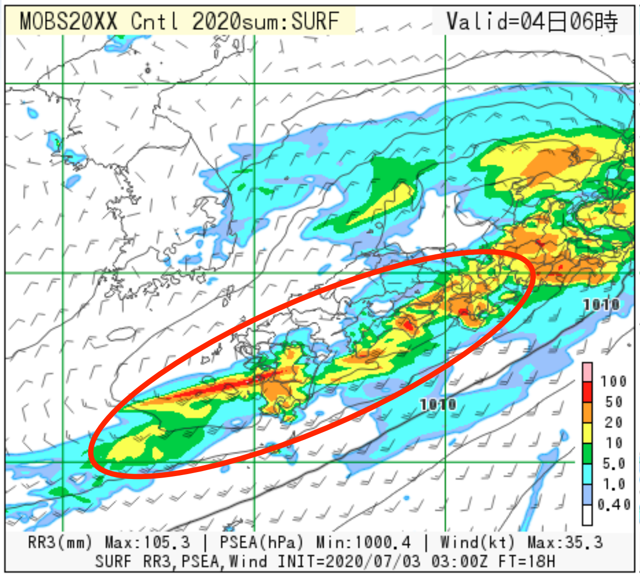
Wind speed(CNTL-TEST)



Sea surface pressure（Green line shows TEST）

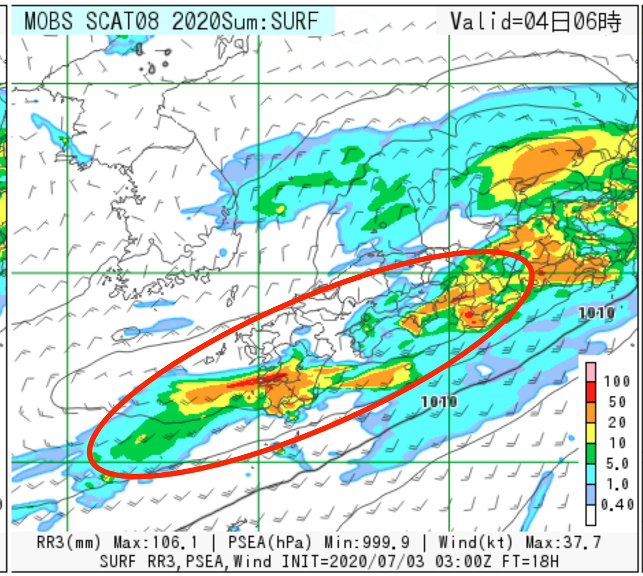
Shifting of convergence zone and surface pressure distribution on western area of Japan was caused by decreasing of analysis increment of surface wind.

Forecast deterioration example 03UTC 3 Jul 2020initial FT18



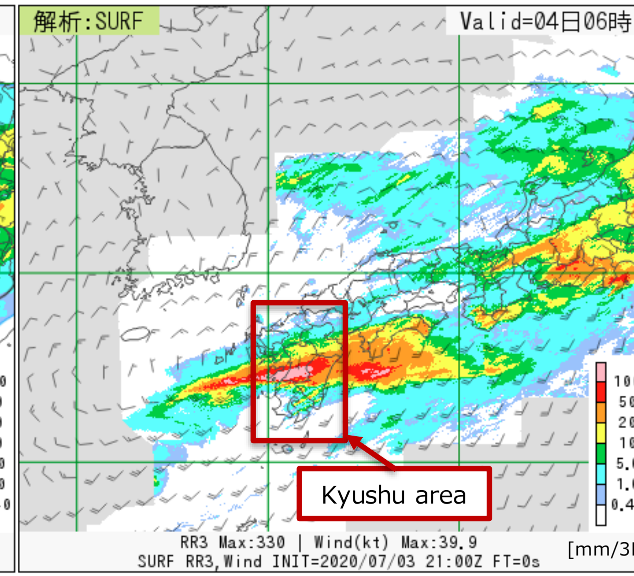
[mm/3H]

CNTL



[mm/3H]

TEST



Radar/Raingauge-Analyzed Precipitation

Shifting convergence zone and surface pressure distribution makes precipitation on Kyushu area weaker than CNTL. TEST shows less consistent result against Radar/Raingauge-Analyzed Precipitation.

As a side note, impact on forecast skills was statistically small.

Summary & Future work

Metop-A/ASCAT finished their operational mission on November 2021.
To deal with decrease of scatterometer assimilation coverage by this EOL,
JMA began to assimilate scatterometer winds from Metop-C/ASCAT on 8 Dec 2021 in the Meso-scale NWP systems.

- Before beginning to assimilate, we conducted OSEs to check the characteristics of the implementation of Metop-C/ASCAT winds.

- OSE result of using Metop-C/ASCAT winds shows:
  - ✓ Assimilated data numbers of scatterometers decreased by 20 percent compared with control experiment that uses Metop-A/ASCAT and Metop-B/ASCAT winds,
    but increased by 40 percent compared with OSE that uses only Metop-B/ASCAT winds.
  - ✓ Statistically, changes in standard deviation of first-guess departure and impact on forecast skills are relatively small. Data quality of Metop-C/ASCAT winds is equal to or greater than Metop-A,B/ASCAT winds.
  - ✓ Both of improvement example and deterioration example show that assimilation coverage of scatterometer winds is important for the forecast of rainfall event.

- As a future work, now we are planning to implement HY-2B/C winds for extending assimilation coverage of scatterometer winds.
  Real-time data availability is important for the operational NWP center, therefore beginning of data provision by OSI SAF on Nov 2021 is related to this decision.
  We have expectation that this implementation will contribute improvement of forecast skills.