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

KOYAMATSU Shin

Numerical Prediction Division,

Japan Meteorological Agency (JMA)

International Ocean Vector Winds Science Team (IOVWST) Meeting 2021

Outline

JMA began to assimilate scatterometer winds from Metop-C/ASCAT on 11 Dec 2019, ScatSat-1 on 29 Jul 2020, and EARS-ASCAT on 23 Mar 2020 in the global NWP systems. The impacts of these ocean vector winds are introduced in this presentation.

Contents:

- Introduction of JMA's global NWP system
- Implementation of Metop-C/ASCAT and ScatSat-1 winds
- Implementation of EARS-ASCAT winds
- Summary & Future Works

JMA'S NWP SYSTEMS

Global NWP System in JMA

	Global NWP System
Purposes	Daily forecasts Tropical cyclone information One-week forecasts
Forecast: Global Spectral Model (GSM)	
Grid size	0.1875 deg. (TL959)
Vertical levels/Top	100 / 0.01 hPa
Forecast range (Initial time)	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)
Analysis: Hybrid LETKF/4D-Var assimilation	
Grid size	Outer: TL959 (~20 km) Inner: TL319 (~55 km)
Vertical levels/Top	100 / 0.01 hPa + surface
Iterations	Outer: 2 Inner: Approx. 35
Ensemble size for LETKF	50 members
Data cut off time	Early Analysis: +2h20m Cycle Analysis: +7h50m (06, 18 UTC) +11h50m (00, 12UTC)

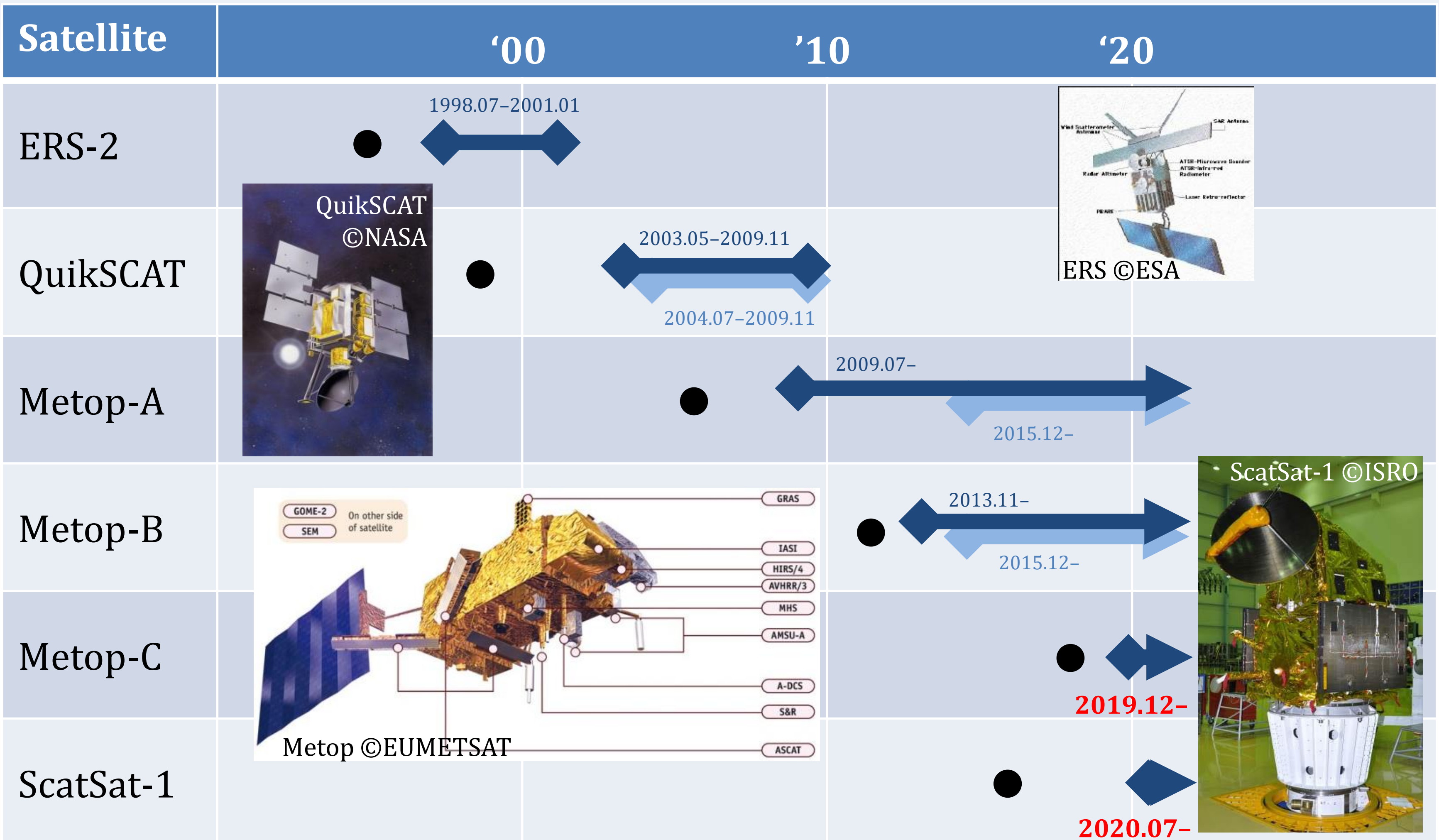
Recent Update in Global Model/Analysis

- 2019 December
  - Hybrid LETKF/4D-Var data assimilation
  - Metop-C/ASCAT winds
- 2020 February
  - EARS-ASCAT winds
- 2020 March
  - Model upgrade
- 2020 July
  - GOES-16 AMV, ScatSat-1 winds
- 2020 September
  - Metop-C/AMSU-A, MHS

Today's topics are shown in red.

Scatterometer Implementation History in JMA's NWP systems

● Launch — Use in Global analysis (dark blue bar) — Use in Meso-scale analysis (light blue bar)



Pre-Analysis Procedure for Scatterometer Winds

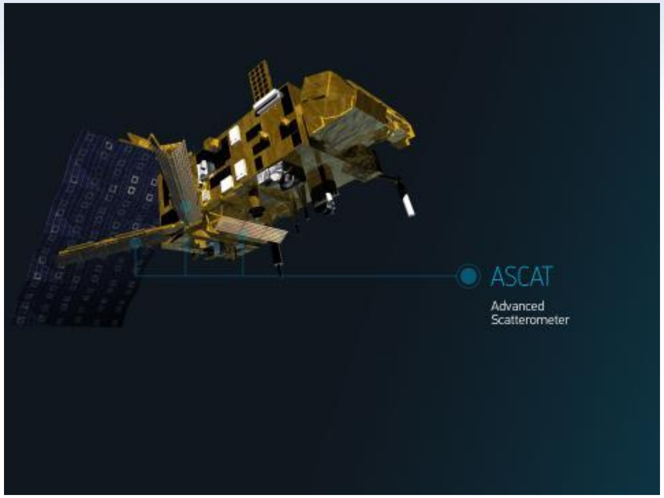
Flag check	Check provided flags (rain, land/sea, sea ice etc.)
Gross error check	Reject large |O-B| data
Group QC	Reject large |O-B| averaged by an area including similar wind vector observation Prevent over rejection in and around severe weather condition
Ambiguity removal	Select the closest wind to JMA's forecast by median filter after nudging
Thinning	1 deg x 1 deg box Eliminate spatial observation error correlation Reduce calculation cost

IMPLEMENTATION OF METOP-C/ASCAT AND SCATSAT-1 WINDS

New Scatterometers in JMA's Global NWP system

Metop-C/ASCAT

Launch: 2018-11-07
Organization: EUMETSAT
Antenna: Fan Beam
Frequency: C-band



Metop-C/ASCAT (©EUMETSAT)


ScatSat-1 (©ISRO)

ScatSat-1/OSCAT

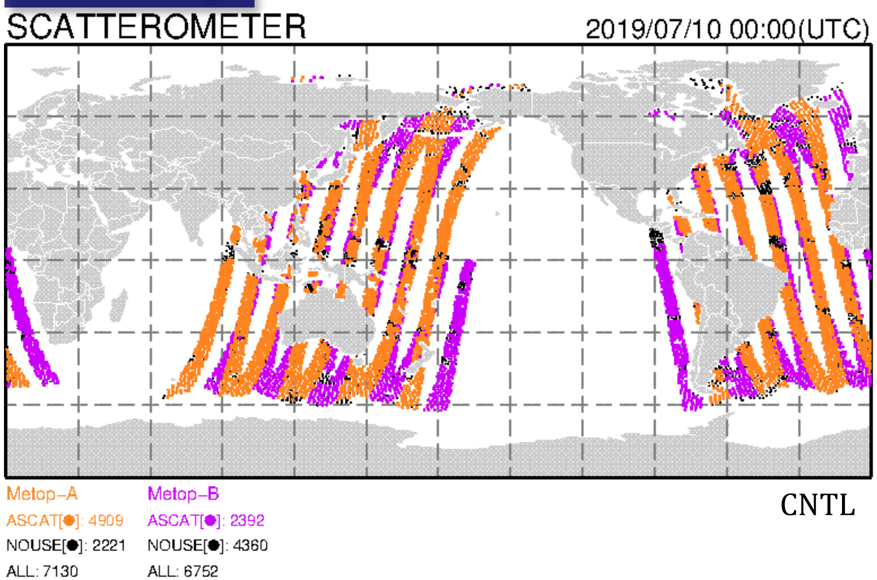
Launch: 2016-09-26
Organization: ISRO
Antenna: Pencil Beam
Frequency: Ku-band

Observing System Experiments

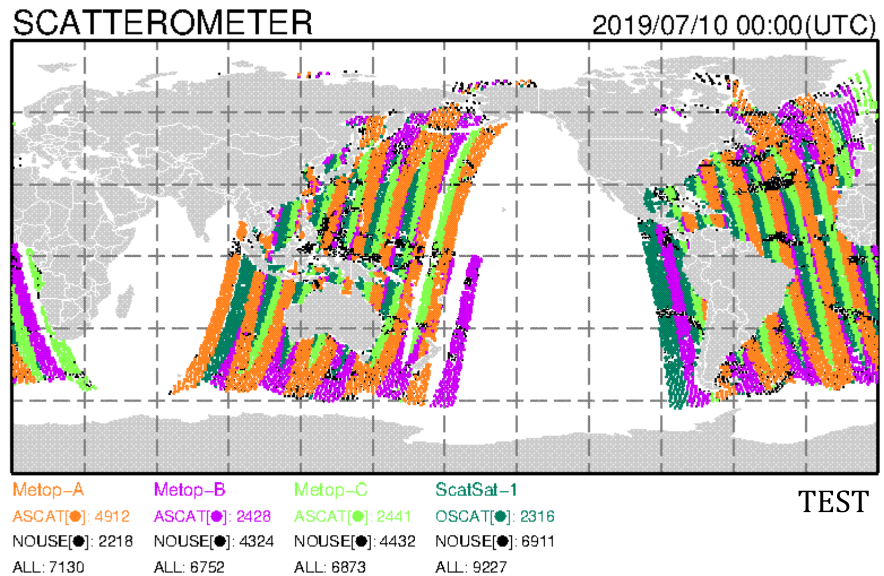
CNTL: Metop-A, B/ASCAT
TEST: Metop-A, B, C/ASCAT & ScatSat-1
Periods: Aug 2019 & Jan 2020

▼ Data distribution of scatterometer winds used for CNTL and TEST experiments in the analysis at 00 UTC 10 Jul 2019.

Data Coverage



CNTL



TEST

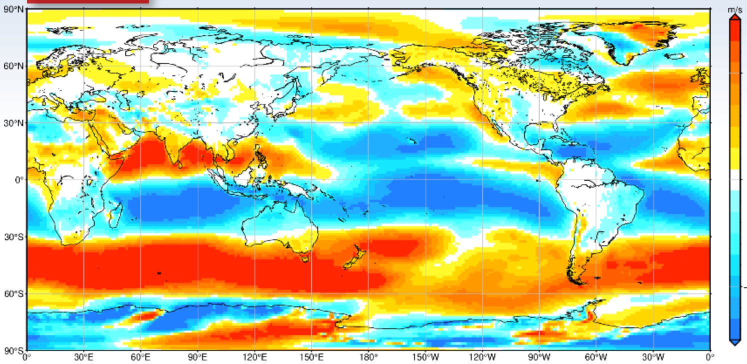
Metop-C/ASCAT (light green) & ScatSat-1 (green) winds fill the gaps among Metop-A, B swaths.

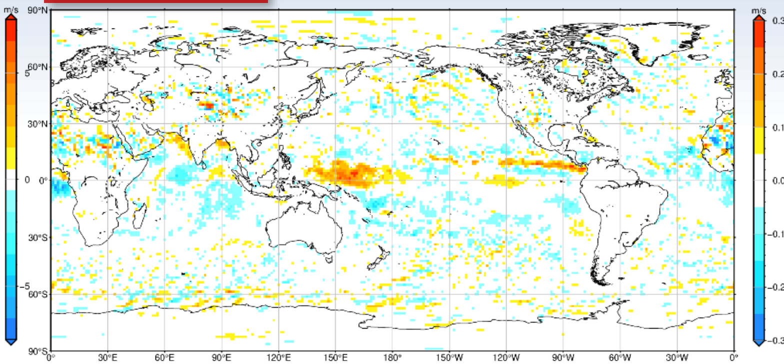
Mean Analysis Field

Aug 2019

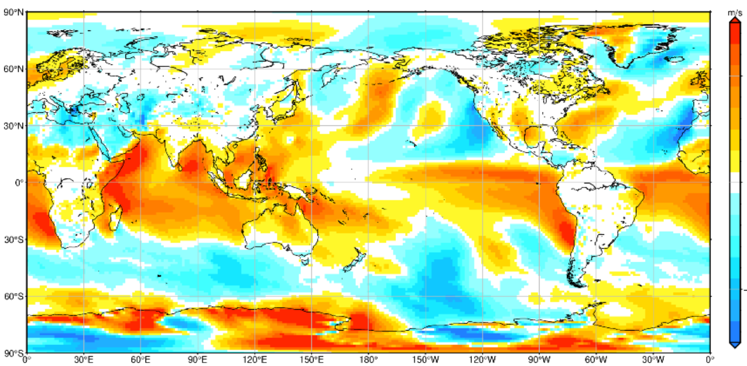
TEST | **TEST – CNTL**

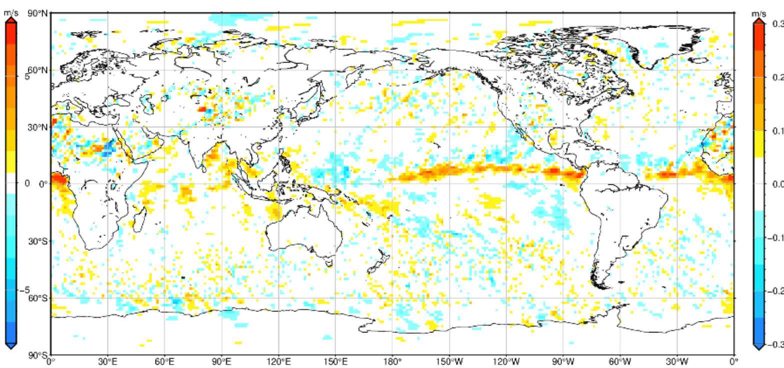
U SURF





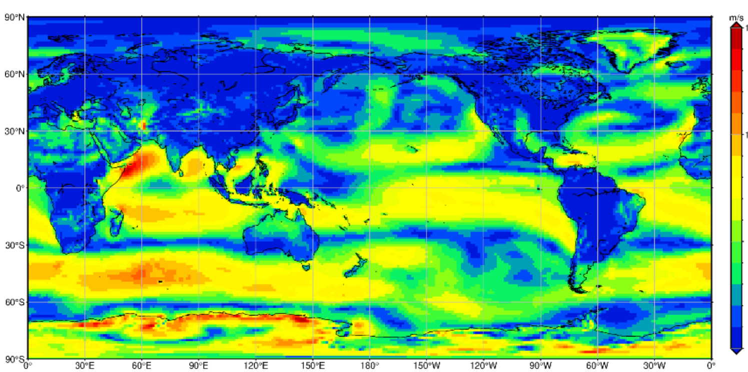
V SURF

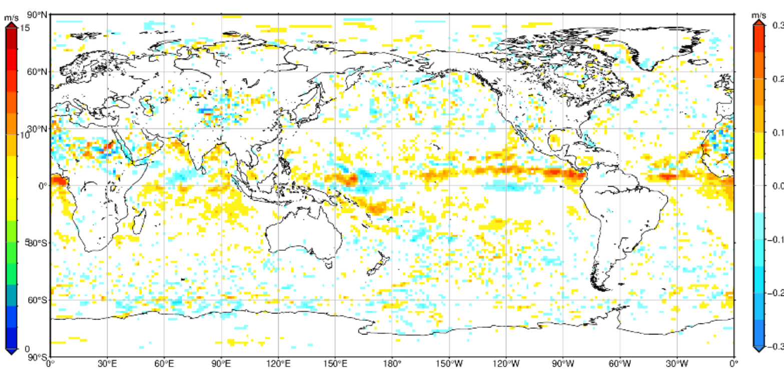




Absolute values of U SURF and V SURF are increased, particularly in tropics.

Wind Speed SURF





Assimilation of Metop-C/ASCAT and ScatSat-1 tend to increase surface wind speed in analysis, particularly in tropics.

Mean Analysis Field

Jan 2020

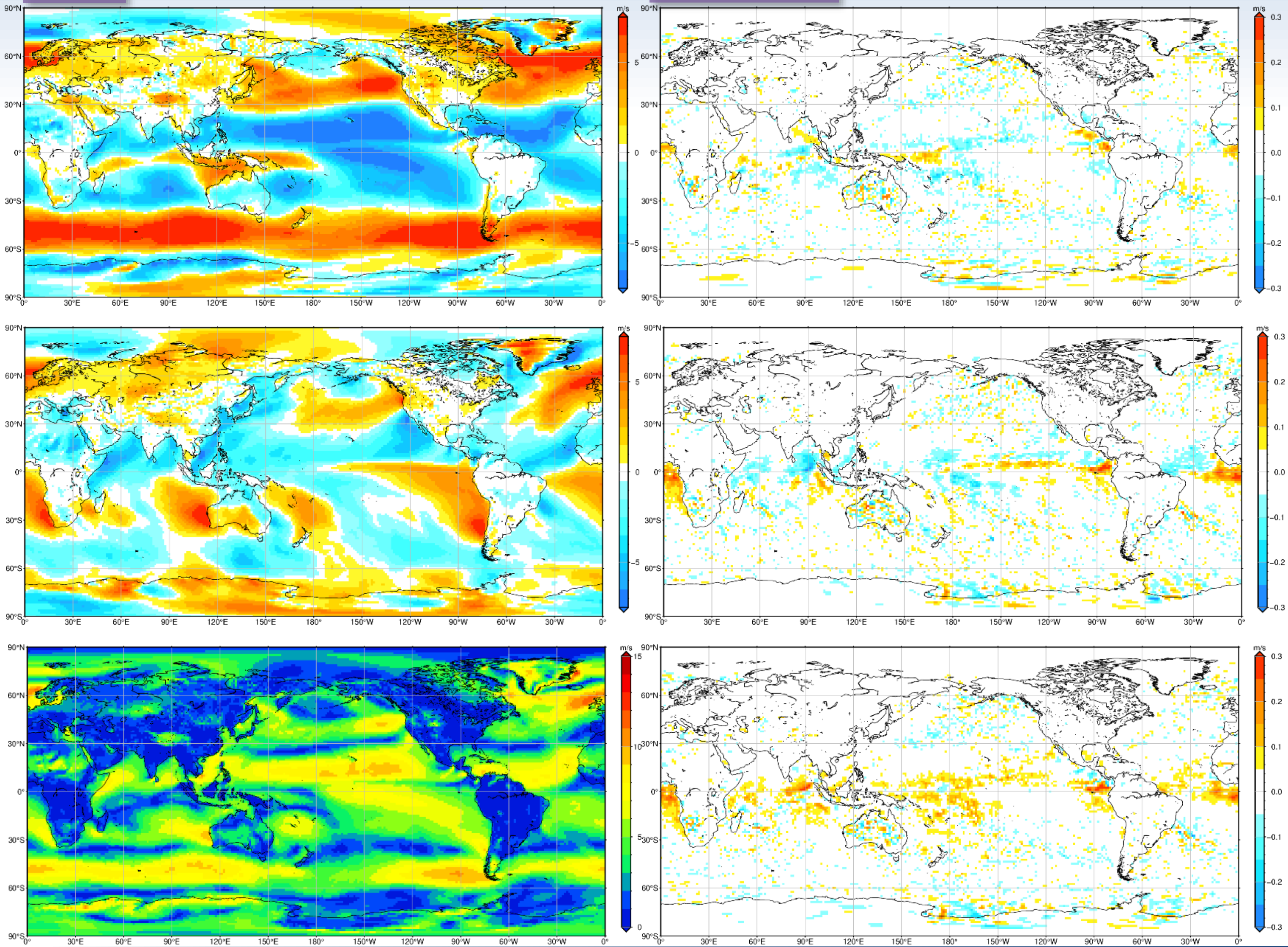
TEST

TEST – CNTL

U SURF

V SURF

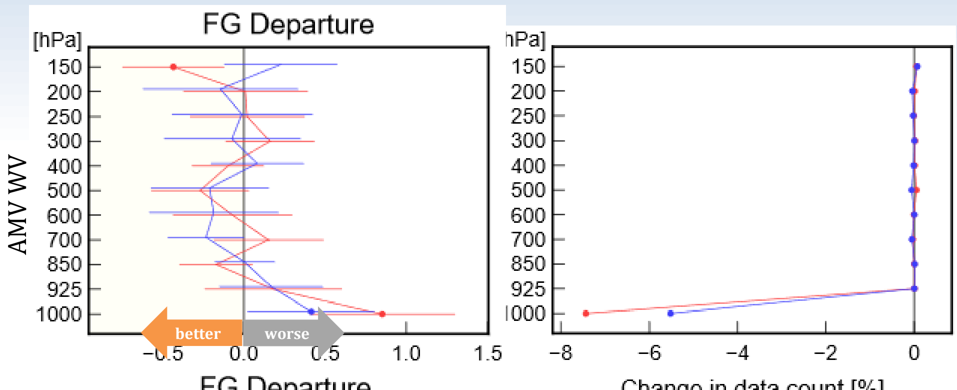
Wind Speed SURF

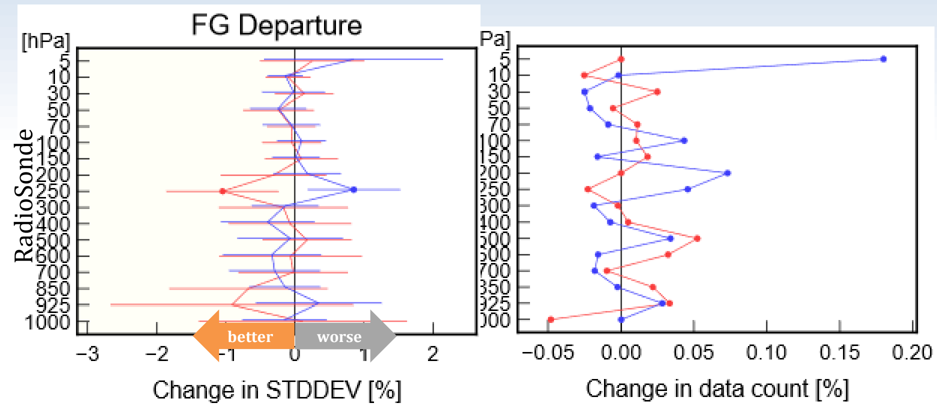


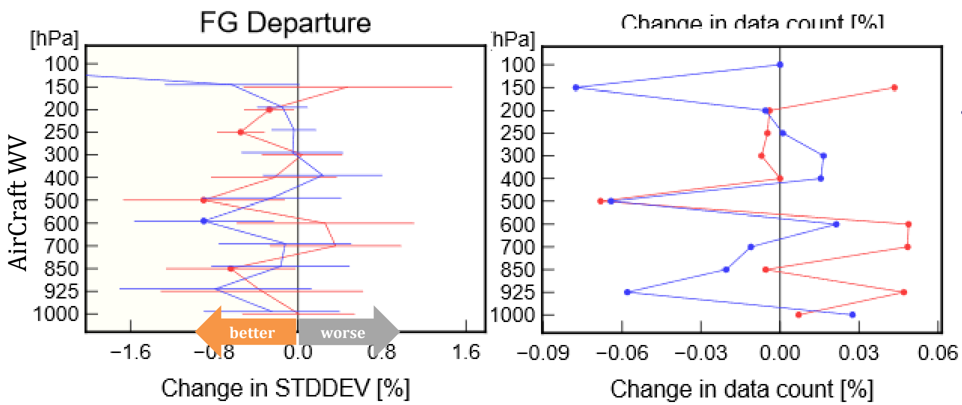
Impacts are similar to Aug 2019.

First-Guess Departure

Red: Aug 2019
Blue: Jan 2020





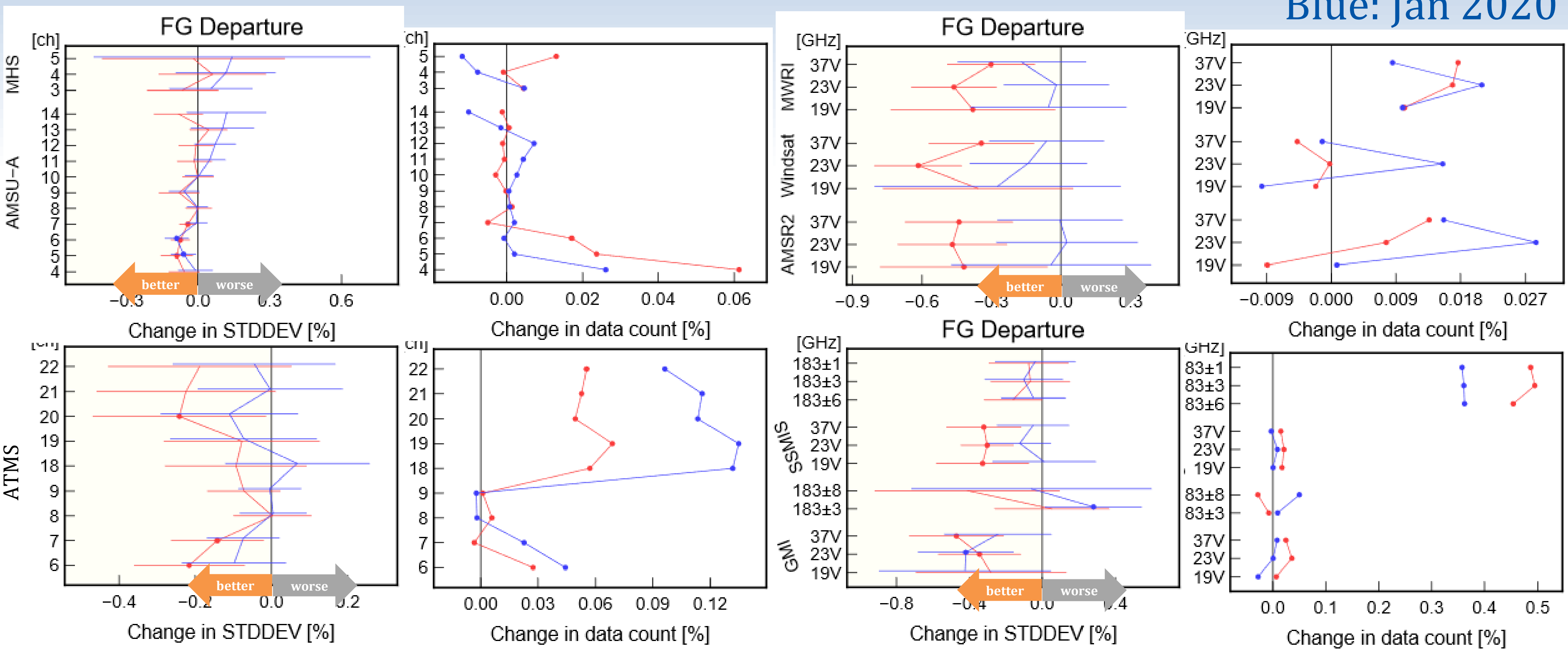


Change in normalized standard deviation (STDDEV) of the first-guess departure ($STDDEV_{TEST}$ -$STDDEV_{CNTL}$)/$STDDEV_{CNTL}$ and assimilated data count for various wind observations. Error bars represent 95% confidence intervals, and dots shows values are statistically significant.

Standard deviations of first-guess departure for Aircraft observations tend to decrease.

First-Guess Departure

Red: Aug 2019
Blue: Jan 2020



▲ Same figures as the previous page but for microwave radiance observations.

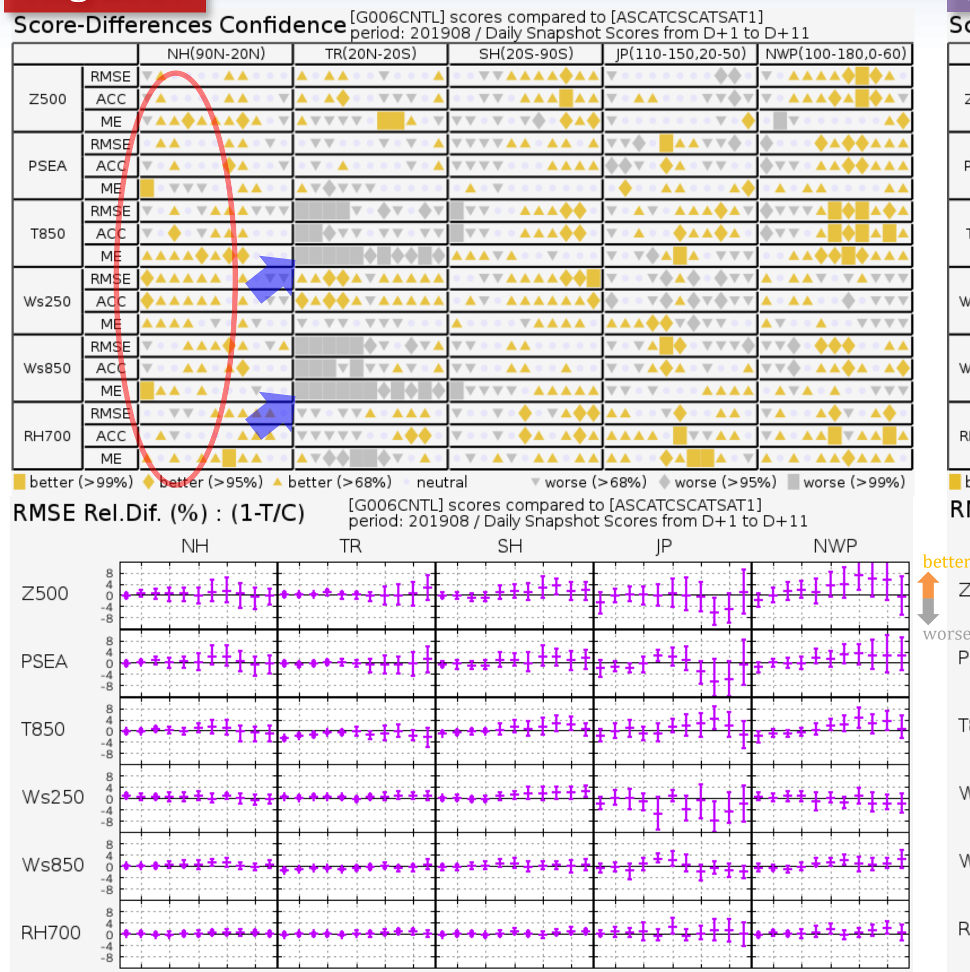
Standard deviations of first-guess departure for microwave radiance are reduced.

- This is probably because improvement of ocean surface winds improve the accuracy of the ocean ocean surface emissivity.
- The radiative transfer calculation is improved through improved ocean surface emissivity.

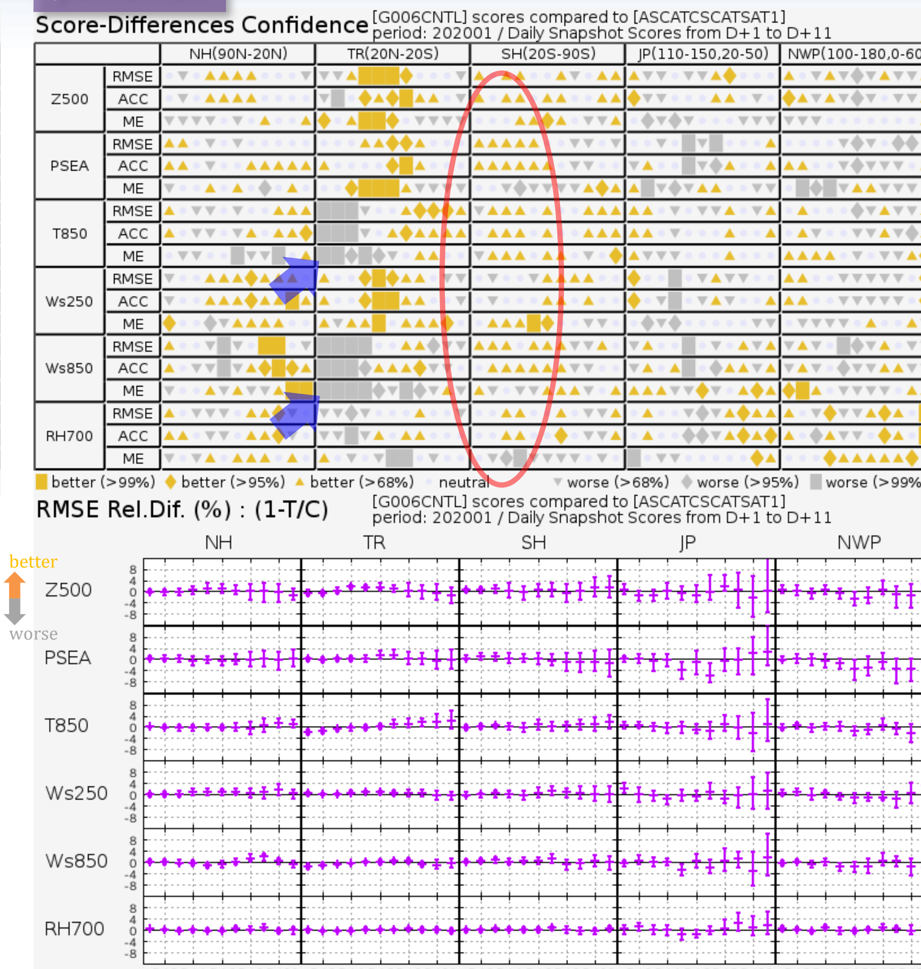
Forecast Score

Forecast scores against own analysis look getting worse in the lower troposphere of tropics.
This is probably "artefacts" caused by the change in analysis fields.
Forecasts in the summer hemisphere tend to be improved.

Aug 2019



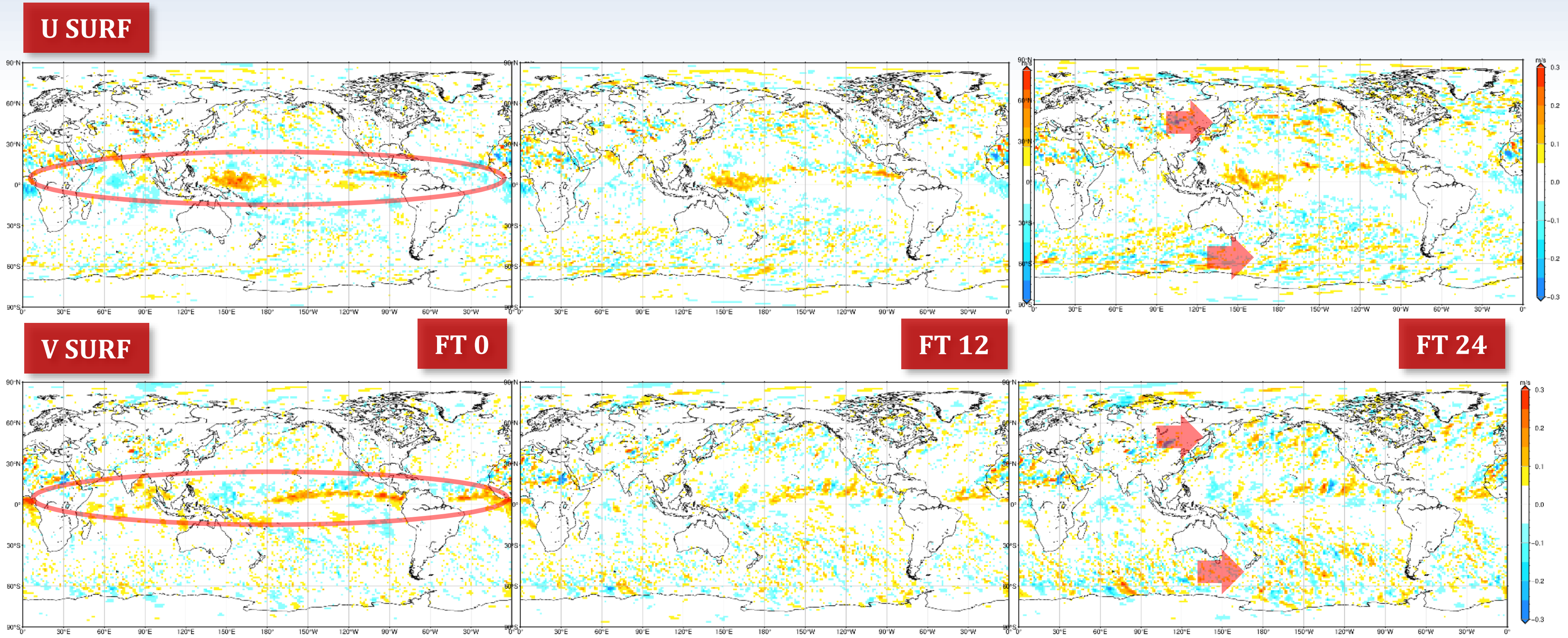
Jan 2020



▲ Forecast scores (upper panels) and relative differences of RMSE (lower panels) for each element and region against own analysis. The vertical axis of each panel ranges from Day 1 to Day 11. Orange symbols mean improvement in score cards.

Forecast Field

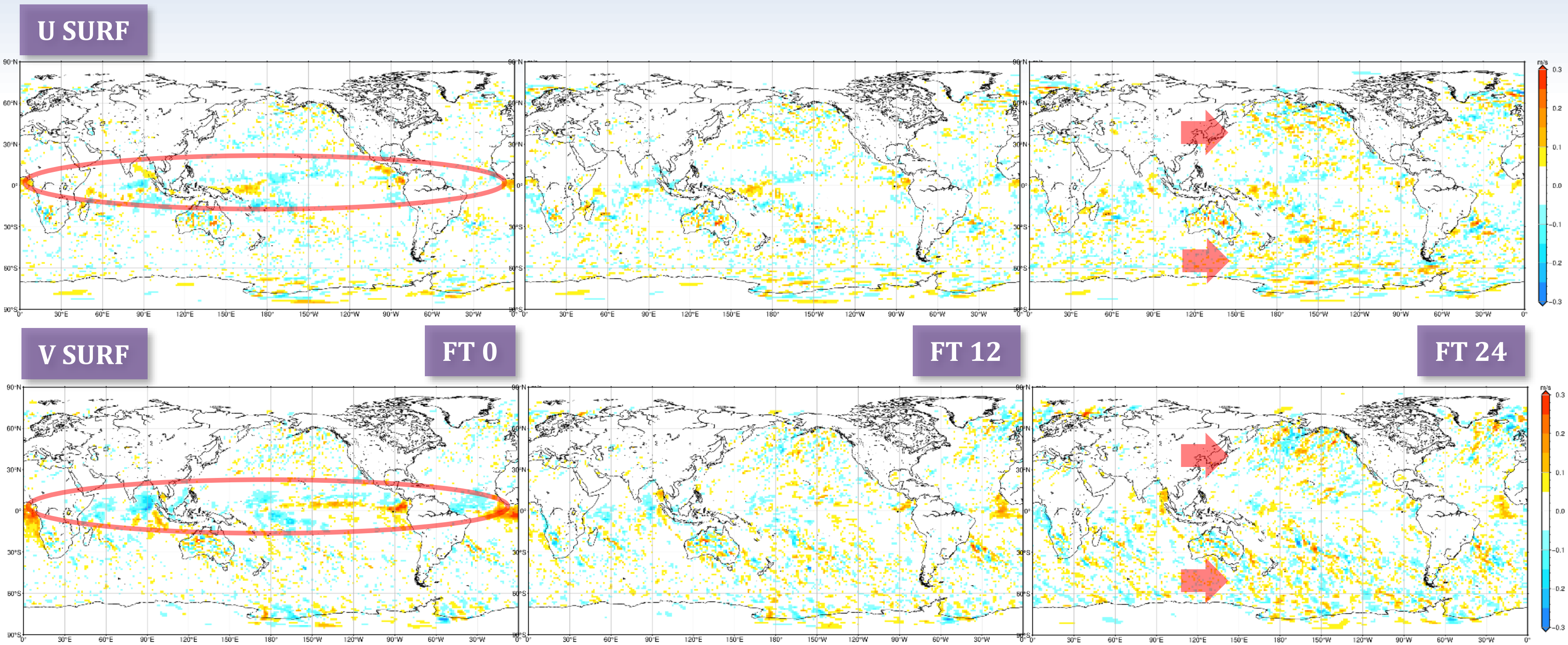
Aug 2019



Changes in the tropics in U SURF analysis affect on forecast fields over 2 days, while those in V SURF get unclear in forecast fields.
Changes in the tropics spread to middle latitudes through the data assimilation cycle.

Forecast Field

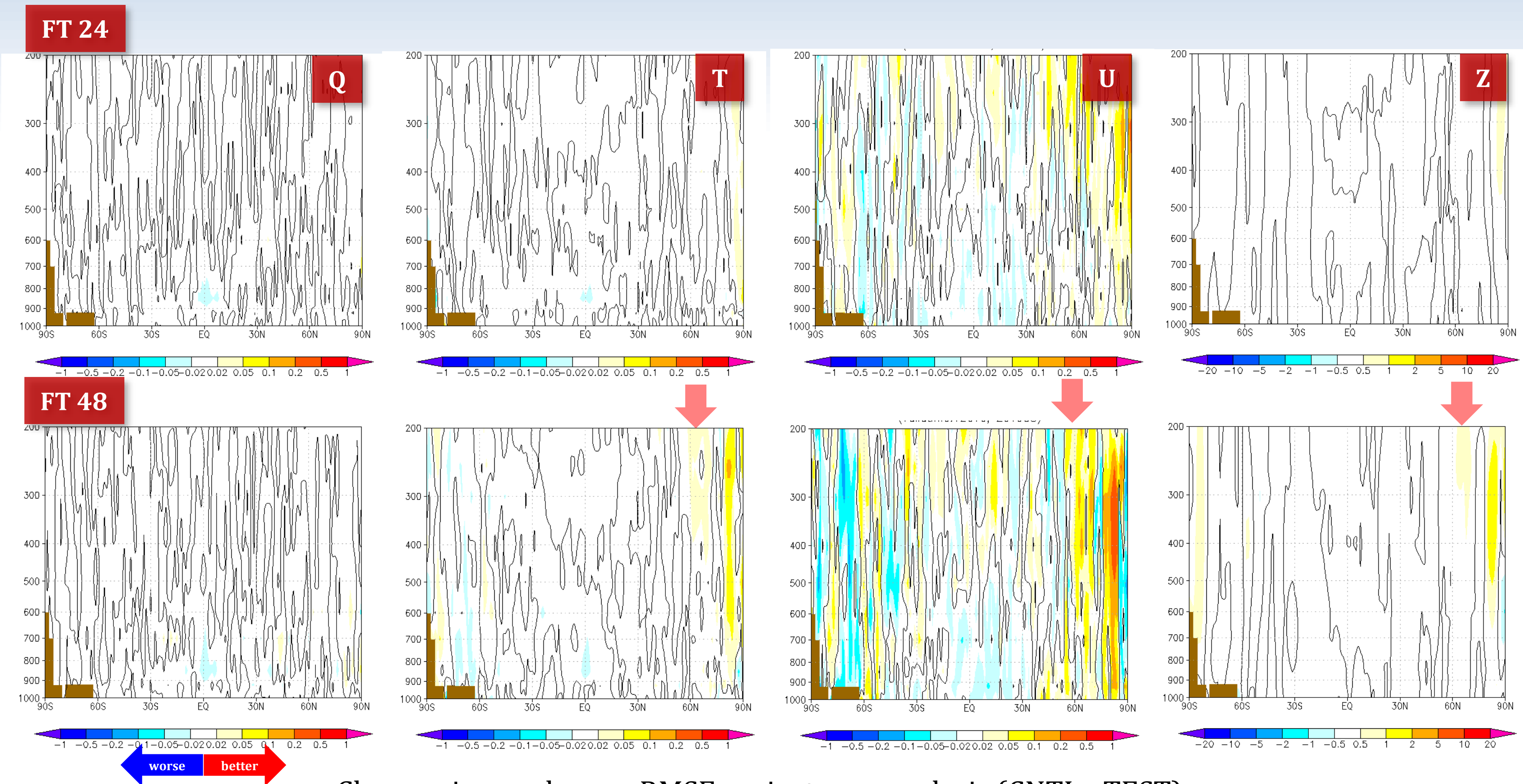
Jan 2020



Impacts are similar to Aug 2019.

Zonal Mean

Aug 2019



▲ Changes in zonal mean RMSE against own analysis (CNTL - TEST)

Zonal mean RMSEs in Northern hemisphere tend to be reduced.

IMPLEMENTATION OF EARS-ASCAT

EARS-ASCAT

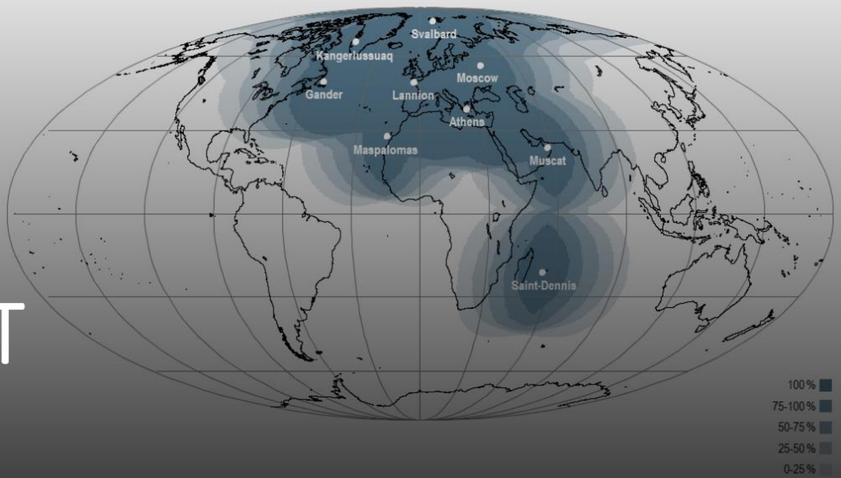
- Data delivery service provided by EUMETSAT
- Expected to increase data number available in early analyses with its high timeliness

https://www.eumetsat.int/ears-ascat

EUMETSAT IMAGES SATELLITES ABOUT US NEWS & FEATURES

EARS-ASCAT

Measuring wind speed and direction over the oceans



EARS-ASCAT collects ASCAT instrument data from Metop passes, via a network of HRPT stations, and re-transmits Level 2 products via EUMETCast.

Last Updated
07, December 2020

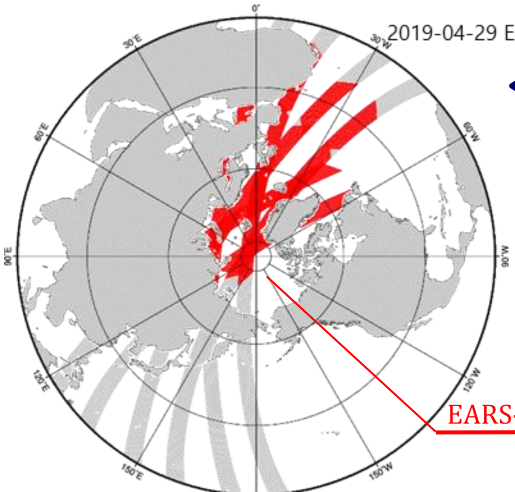
The prime objective of the Advanced Scatterometer (ASCAT) instrument is to measure wind speed and direction over the oceans. Scatterometer data has also proved to be very useful in a variety of studies, including polar ice and tropical vegetation.

Water plays a unique role at microwave frequencies at which scatterometers are operated. It is the only naturally abundant medium with a high dielectric constant, so increasing the fraction of liquid water contained in soil, snow and vegetation increases the dielectric properties of these media, thereby significantly altering their scattering and absorption behaviour.

The backscattering coefficient, measured with scatterometers, is dependent on the dielectric properties of the soil surface layer, surface roughness, and vegetation. Thus, ASCAT provides useful data for ice and land applications, such as sea ice extent, permafrost boundary, desertification, etc. Because the scatterometer radar signal can penetrate the surface, ASCAT can also observe subsurface/subcanopy

EARS (regional) vs. OSI-SAF (global)

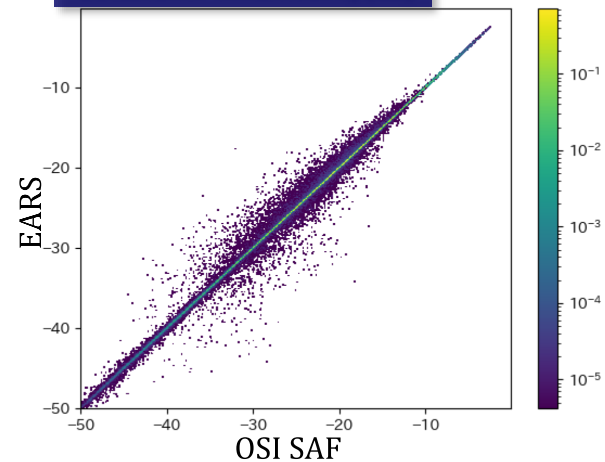
- EARS-ASCAT winds are distributed around 9 ground receiving stations located around North Atlantic Ocean.
- Collocated data comparison shows regional EARS-ASCAT products have almost the same quality as global OSI SAF.



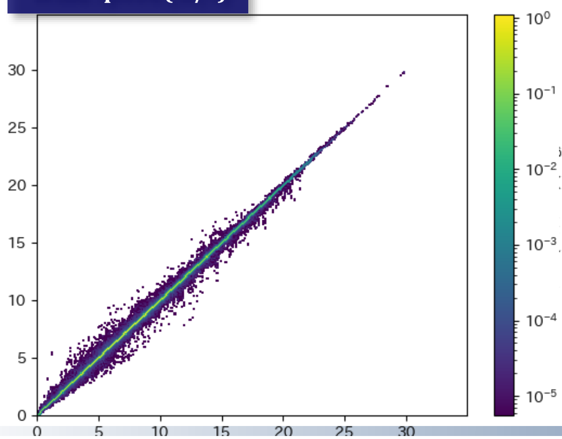
◀ Metop-B/ASCAT wind data available in the JMA's early analysis at 2019-04-29 12UTC
Gray: OSI SAF (global) ASCAT winds
Red: EARS (regional) ASCAT winds

Comparison between OSI SAF (global) and EARS (regional) ASCAT winds in backscatter coefficient, wind speed, and wind direction. Data with the same observation time and along track cell number were regarded as identical. ▶ ▼

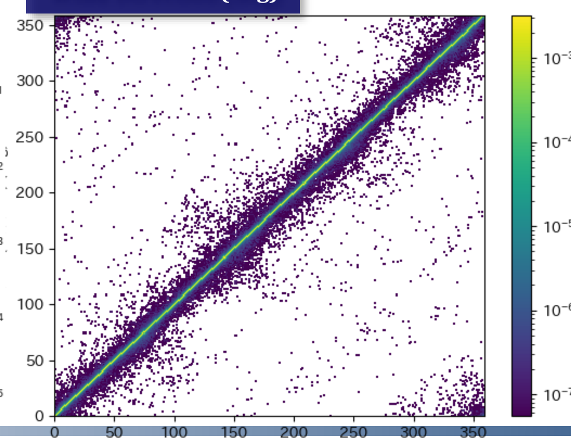
Backscatter coefficient σ_0 (dB)



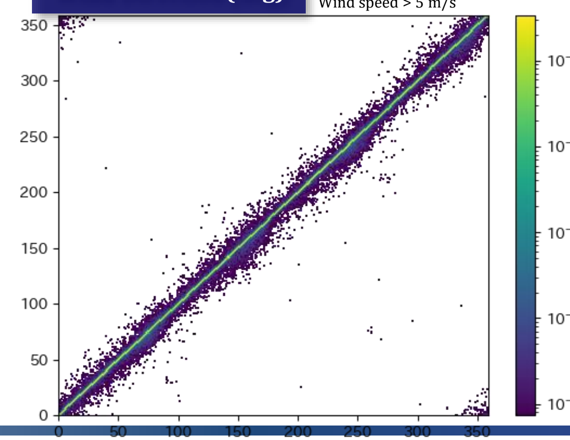
Wind Speed (m/s)



Wind Direction (deg)



Wind Direction (deg) Wind speed > 5 m/s

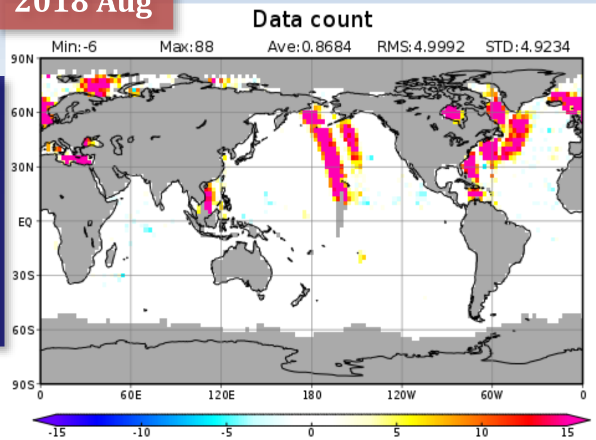


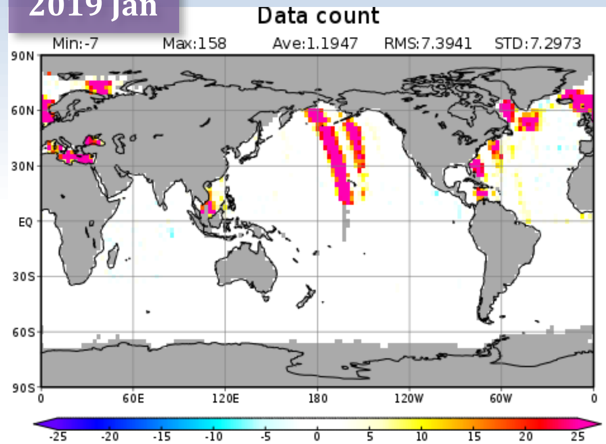
Impacts of EARS-ASCAT

2018 Aug

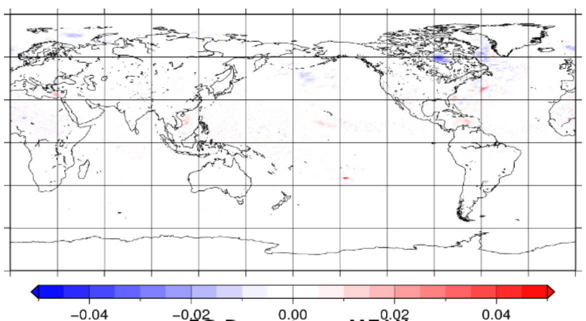
2019 Jan

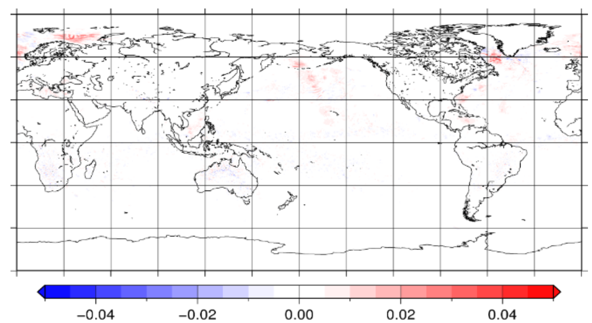
Data Count Diff.



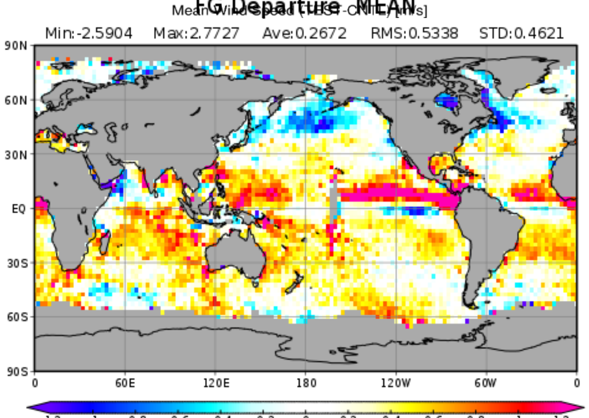


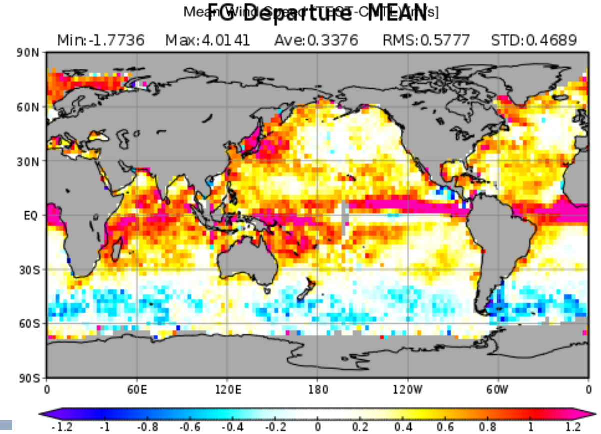
Wind Speed Diff.





Wind Speed Bias





EARS-ASCAT winds assimilated in our early analyses increased mainly in the northern hemisphere.

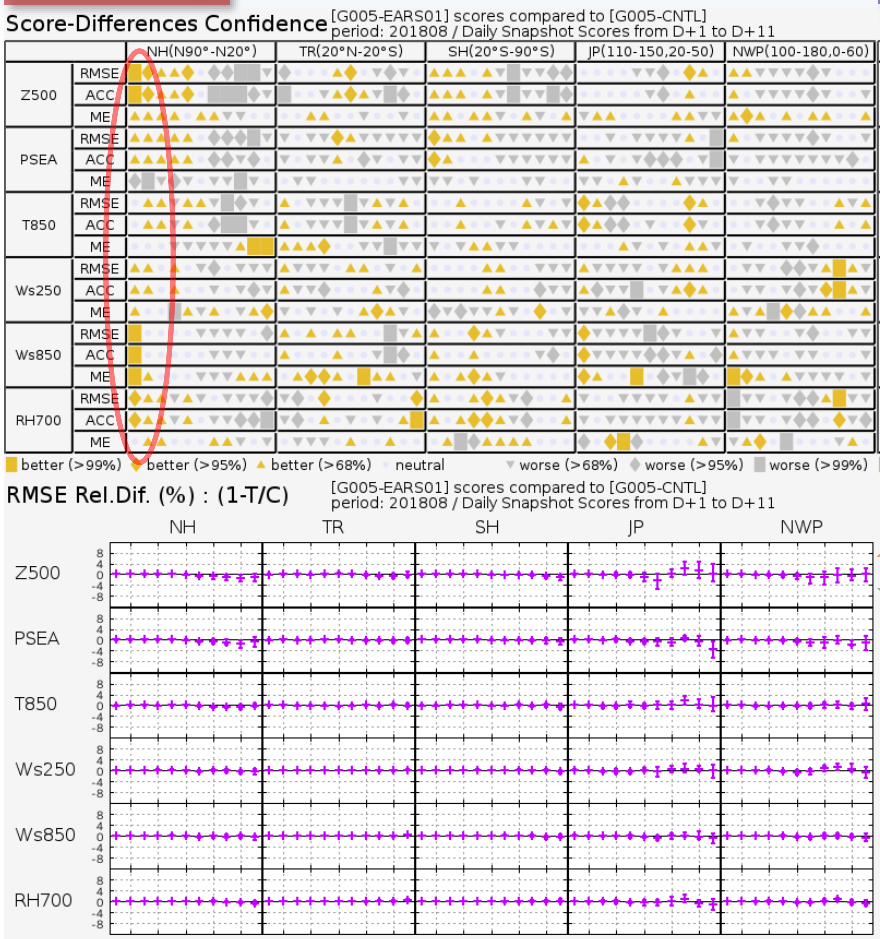
Wind speed in analysis field was changed in the region corresponding to the available data increased.

EARS-ASCAT reduced the wind speed biases in analysis field against scatterometer winds.

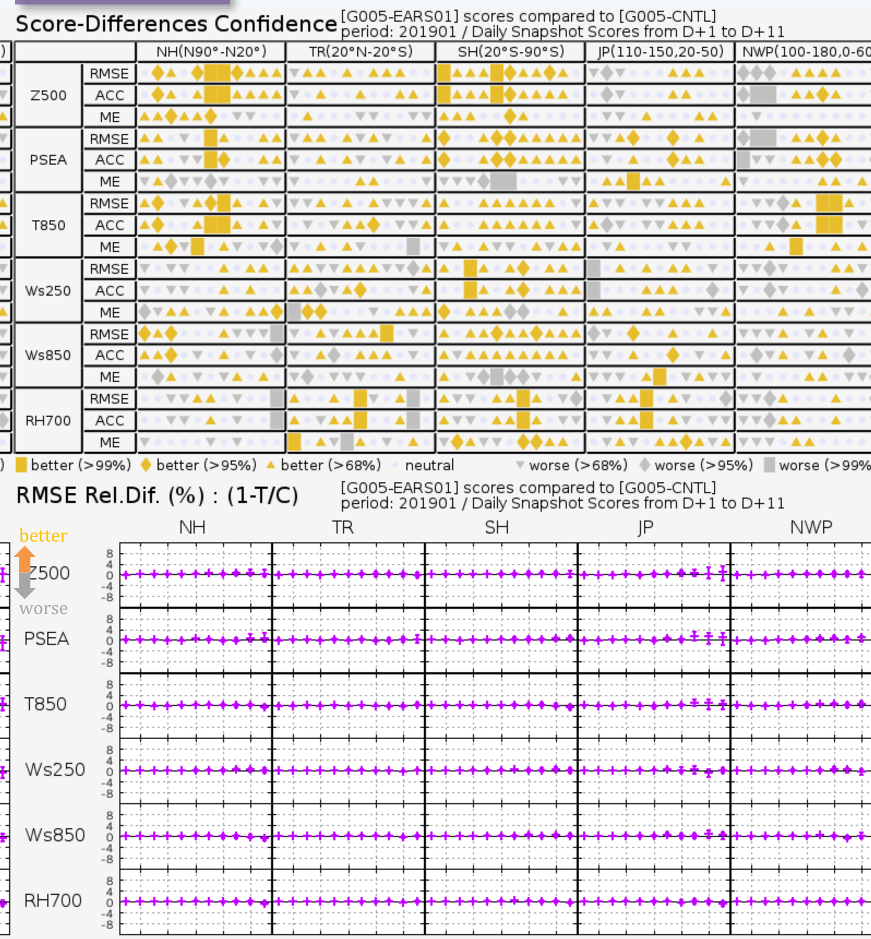
Forecast Score

Use of EARS-ASCAT improved forecast ~ 1 day in northern hemisphere.

2018 Aug



2019 Jan



▲ Forecast scores (upper panels) and relative differences of RMSE (lower panels) for each element and region against own analysis. The vertical axis of each panel ranges from Day 1 to Day 11. Orange symbols mean improvement in score cards.

Summary & Future Works

JMA began to assimilate scatterometer winds from Metop-C/ASCAT on 11 Dec 2019, ScatSat-1 on 29 Jul 2020, and EARS-ASCAT on 23 Mar 2020 in the global NWP systems.

- Metop-C/ASCAT & ScatSat-1 winds:
  - ✓ improved the analysis field by increasing absolute values of U and V components in tropics
  - ✓ reduced standard deviation of first-guess departure for other wind observations and microwave radiance observations
  - ✓ improved forecast in summer hemisphere
- EARS-ASCAT winds:
  - ✓ increased available wind data in the northern hemisphere
  - ✓ reduced the wind speed biases in analysis field against scatterometer wind
  - ✓ improved short-term forecast score

Impacts of assimilation of Metop-C/ASCAT and ScatSat-1 winds on Meso-scale analysis are under investigation.