16th International Winds Workshop, May 8-12, 2023, Montréal, Québec

Upgrades of Polar AMVs Use in JMA's Global NWP System

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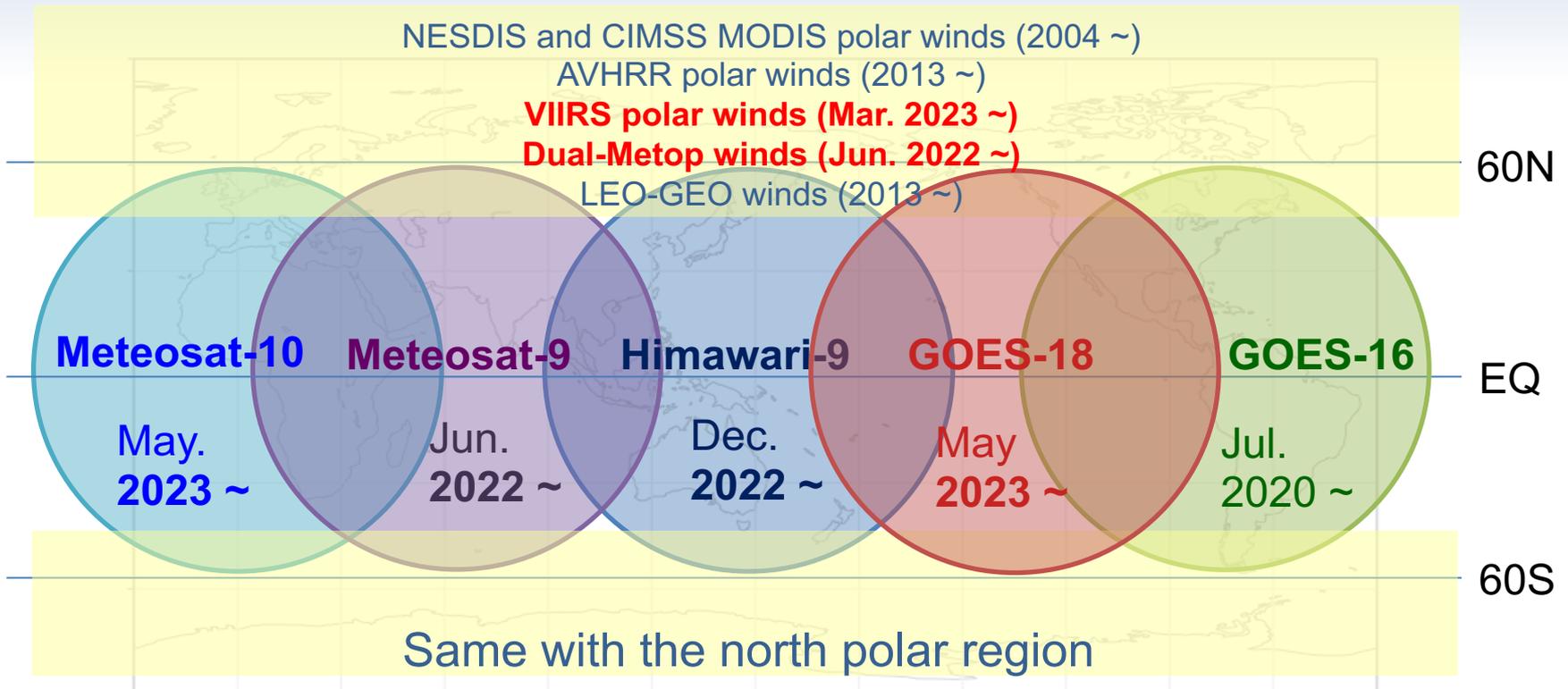**Numerical Prediction Development Center**

Tsukuba, Japan

気象庁　Japan Meteorological Agency

Outline

- Status of operational AMVs use in JMA's global NWP system (update from the previous workshop)

- Newly added LEO AMVs
  - Dual-Metop
  - S-NPP and NOAA-20/VIIRS

- Summary

Status of operational AMVs usage in JMA's global NWP

May 2023 (IWW16)

NESDIS and CIMSS MODIS polar winds (2004 ~)
AVHRR polar winds (2013 ~)
VIIRS polar winds (Mar. 2023 ~)
Dual-Metop winds (Jun. 2022 ~)
LEO-GEO winds (2013 ~)

60N

Meteosat-10   **Meteosat-9**   **Himawari-9**   **GOES-18**   **GOES-16**

EQ

May.
2023 ~

Jun.
2022 ~

Dec.
2022 ~

May
2023 ~

Jul.
2020 ~

60S

Same with the north polar region

- 4 GEO AMVs had replaced during this two years.
- 2 LEO AMVs (VIIRS and Dual-Metop) newly started using in DA.

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3

Update from IWW15

Status of operational AMV usage in JMA's global NWP

GEO AMVs replacement

- Meteosat-8 to Meteosat-**9** (2022)
- Himawari-8 to Himawari-**9** (2022)
- GOES-17 to GOES-**18** (2023)
- Meteosat-11 to Meteosat-**10** (2023)

LEO AMVs new use

- **Dual-Metop AMVs** began operational use at high latitudes (poleward of 50 deg. N/S) from June 2022.
- **S-NPP and NOAA-20/VIIRS AMVs** began operational use from March 2023.

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Dual-Metop AMVs O-B

U- component O-B dependence on QIs (Quality Indicators)

QI1

QI2
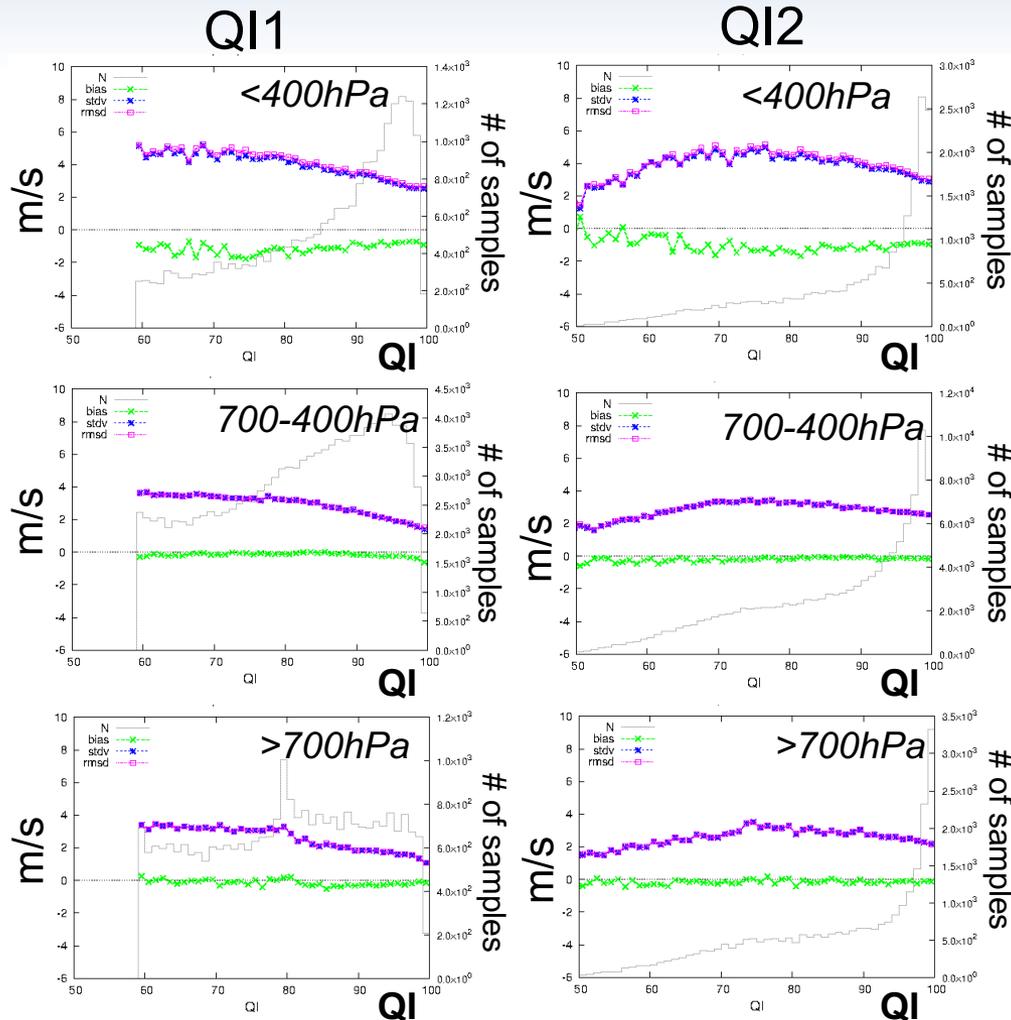
Dependence of u-wind O-B (Dual-Metop - first-guess) on QI1/QI2 over North pole (poleward of 60N). (July 10, 2019 – August 19, 2019)

These are classified into 3 levels by assigned height, upper (<400hPa), middle (700-400hPa) and lower (>700hPa).

RMSD and bias are reduced with increasing QI1 (QI with forecast test) values compared to QI2 (QI without forecast test) for each level.

➡ QI1 values are used for screening low quality vectors in analysis.

O-B U wind Bias (m/s)
O-B U wind Stdv (m/s)
O-B U wind RMSD (m/s)

Dual-Metop O-B Bias (u-component wind)

2019 summer (10 Jul. - 19 Aug.)
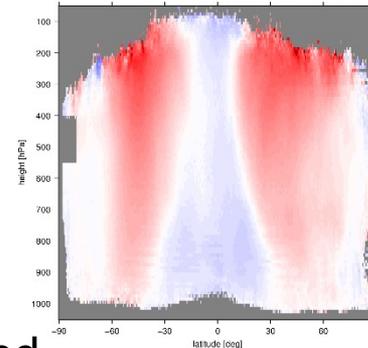
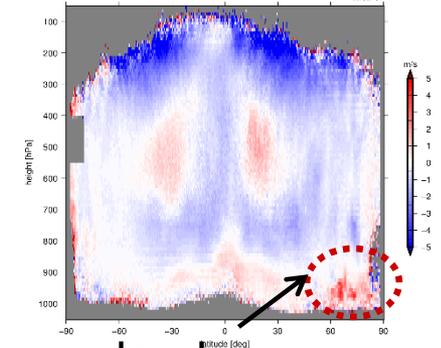**2020 winter** (10 Dec. – 11 Feb.)

w/o QI screening

Mean U (Dual-Metop)   O-B Bias U
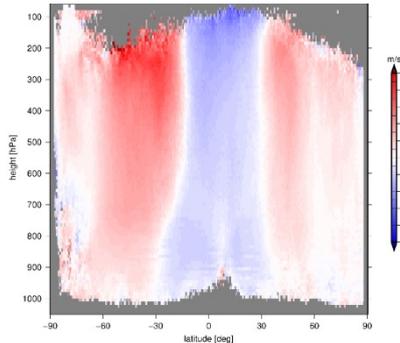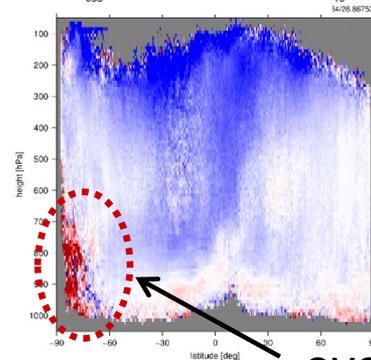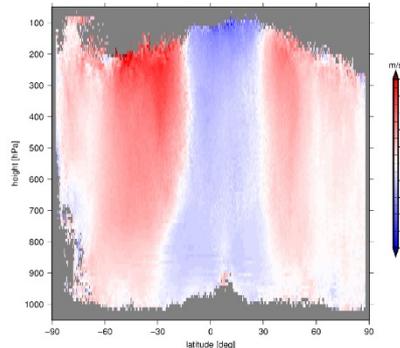
Mean U (Dual-Metop)   O-B Bias U

over land

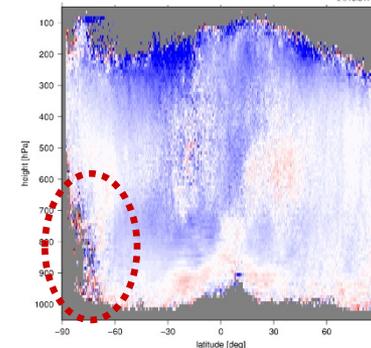over land

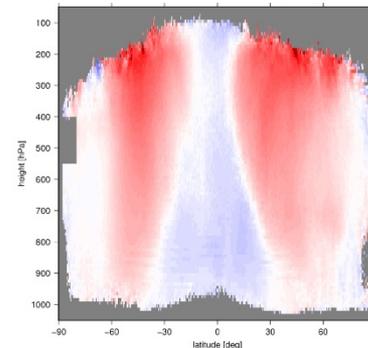w/ QI screening (QI1 > 85)
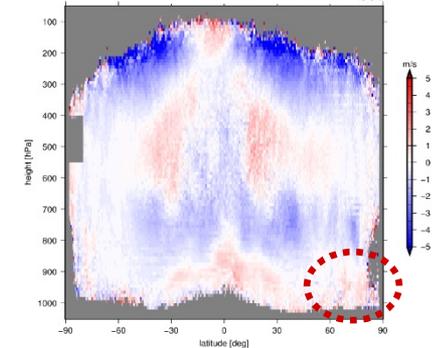
Mean U (Dual-Metop)   O-B Bias U

Mean U (Dual-Metop)   O-B Bias U

U-wind biases are mitigated by QI screening. In particular, positive biases are reduced over land. Biases remain above 300hPa and in lower layer over land. These altitude data are not use for analysis.

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Observing System Experiments (OSEs) with Dual-Metop AMVs

CNTL No polar AMVs (baseline)	**GA/GSM; operational global NWP system as of September, 2020** • 6-hourly cycle analysis and forecast • **w/o all polar AMVs** (MODIS and AVHRR), assuming the end of the missions
TEST Dual-Metop	CNTL + • **w/ Dual-Metop AMVs at high latitudes** (Not use between 50N and 50S) • QC of Dual-Metop: QI screening (QI1 > 85), not use upper layer (< 300hPa) and lower layer (>700hPa) vectors over land

Experimental periods: for a month each in winter and summer
- December 21, 2019 – February 11, 2020 (**January 2020**)
- July 21, 2020 – September 11, 2020 (**August 2020**)

We considered using Dual-Metop AMVs in global analysis to supplement high latitude coverage where GEO AMVs are not available.

Change of standard deviation of O-B (%)
(microwave radiances)
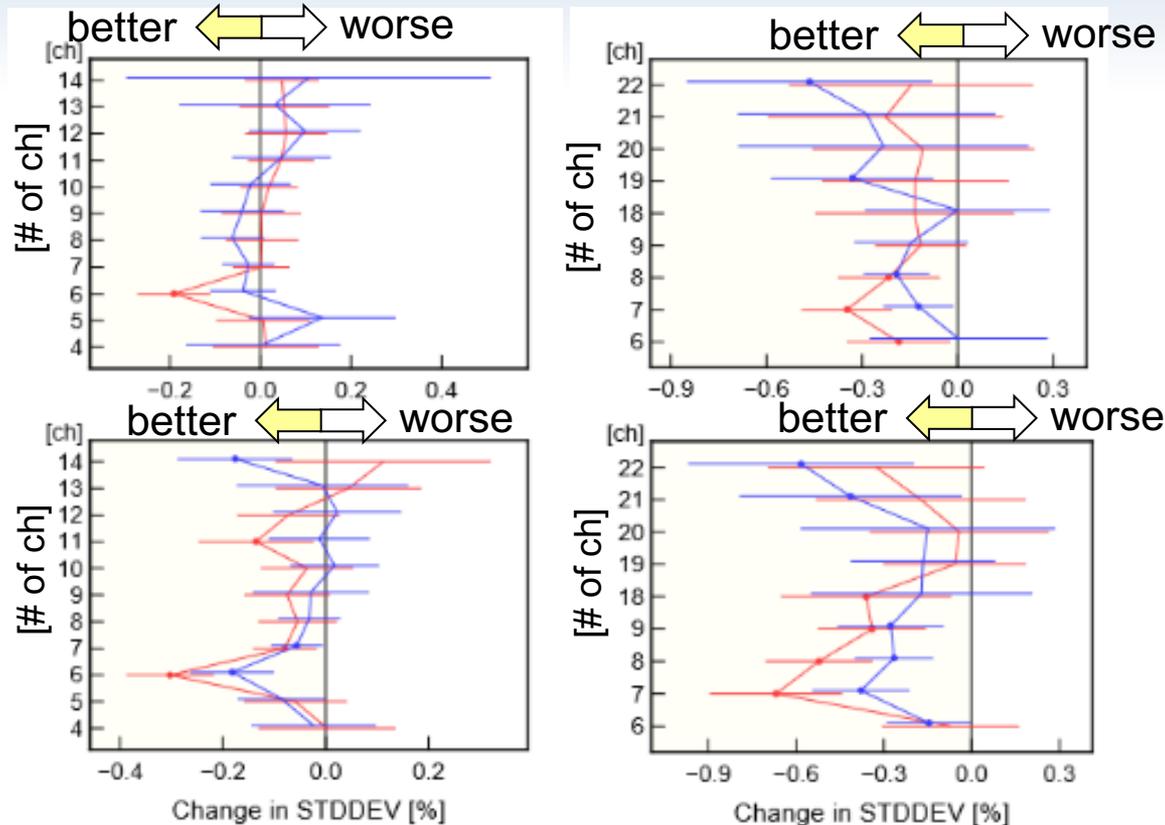
AMSU-A   ATMS

Northern Hemisphere

Southern Hemisphere

Consistency between the first guess and AMSU-A and ATMS temperature sounding channel observations is improved.

=> It is suggested that the analysis temperature fields in the lower to middle troposphere are improved by use of Dual-Metop AMVs.

RMSE improvement percent
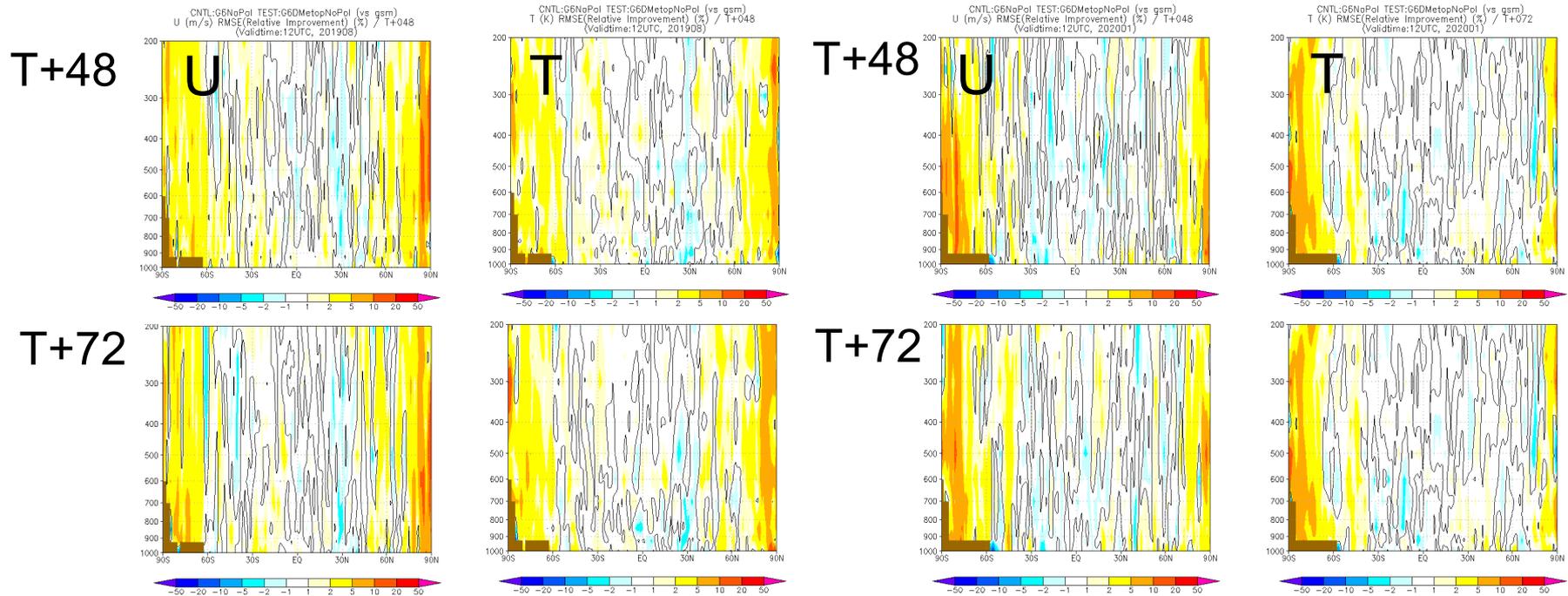
Dual-Metop vs no polar AMVs against own analysis

Verification is calculated using forecasts from 12 UTC initials and own analysis.

degraded ⬅️➡️ improved

$$\frac{RMSE_{cntl} - RMSE_{test}}{RMSE_{Cntl}} \times 100\ (\%)$$

August 2019

January 2020

T+48

T+48

T+72

T+72

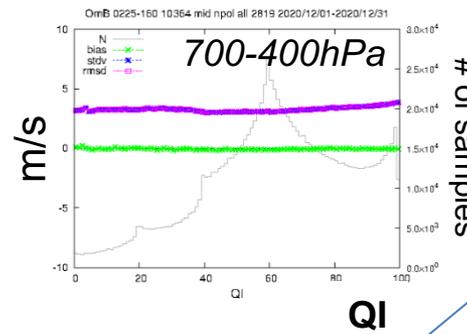Dual-Metop AMVs have significant positive impact on wind and temperature forecast fields.
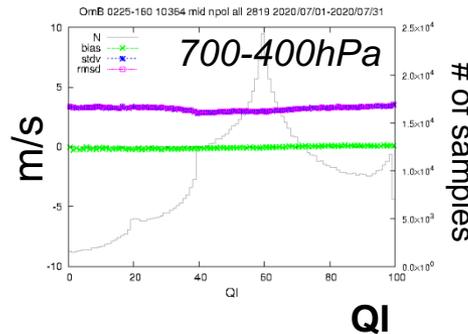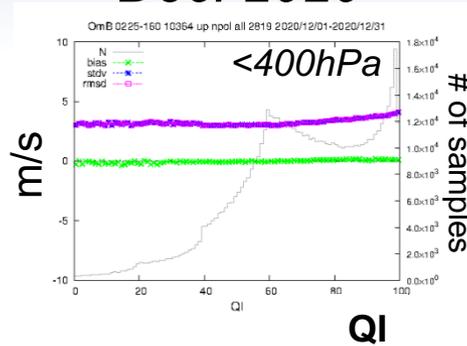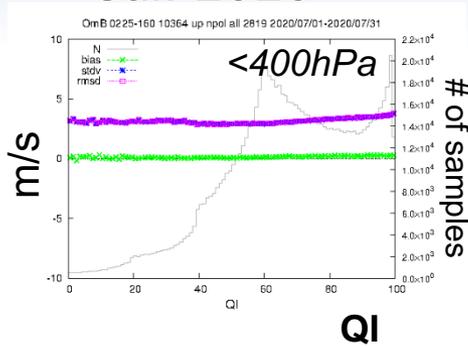
Outline

- Status of operational AMVs use in JMA's global NWP system (update from the previous workshop)

- **Newly added LEO AMVs**

  - Dual-Metop

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- Summary

VIIRS AMVs O-B

U-component O-B dependence on QI (Quality Indicator)

Jul. 2020   *Dec. 2020*
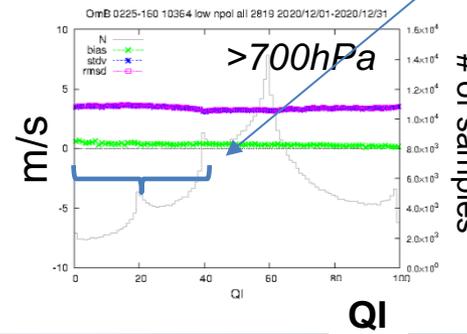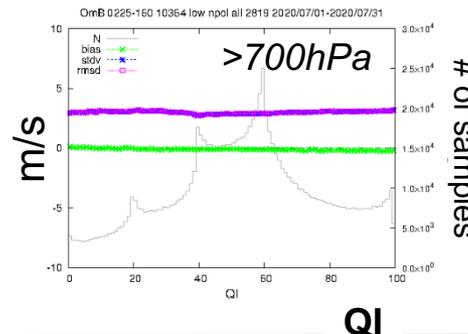
Dependence of u-wind O-B (NOAA-20/VIIRS - first-guess) on QI2 over North pole (poleward of 60N).
(July 1 – 31, 2020 and December 1 – 31, 2020)

These are classified into 3 levels by assigned height, upper (<400hPa), middle (700-400hPa) and lower (>700hPa).

Bias is slightly large at low QI values.

Dependence of O-B differences on QI2 (QI without forecast test) values is small for each level.

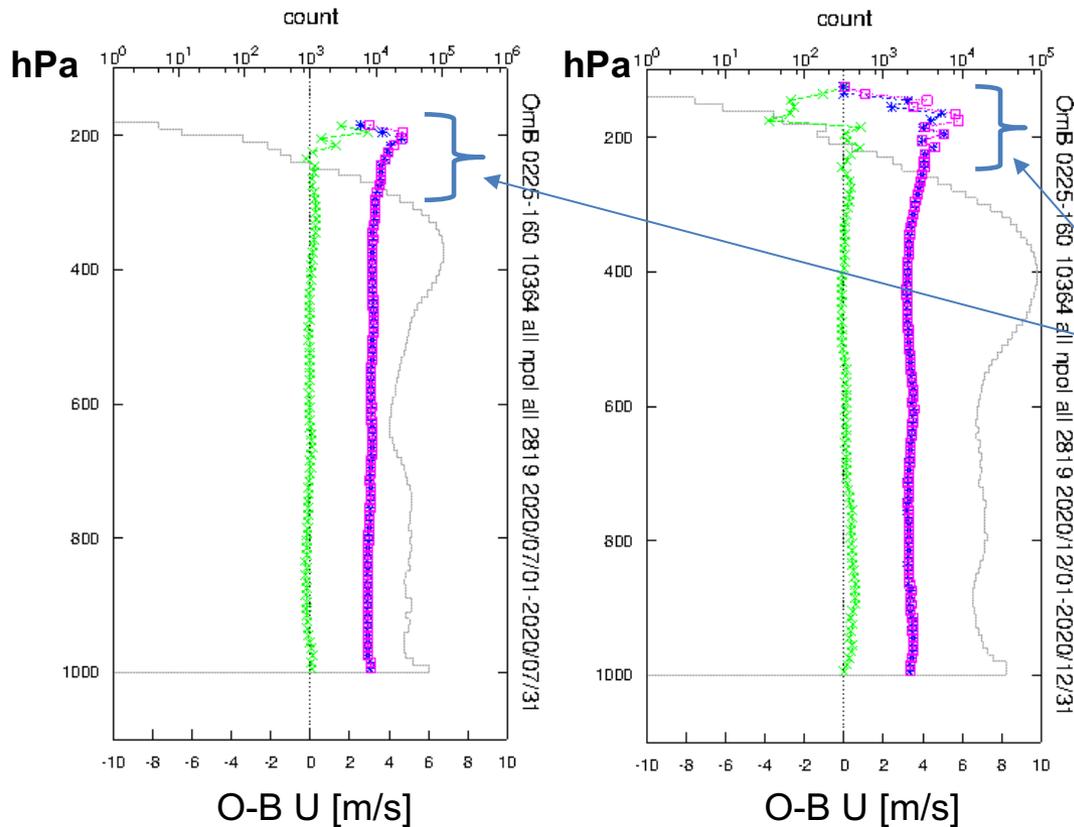O-B U wind Bias (m/s)
O-B U wind Stdv (m/s)
O-B U wind RMSD (m/s)

VIIRS AMVs O-B

U-component O-B dependence on assigned height

Jul. 2020   *Dec. 2020*

Dependence of u-wind O-B (NOAA-20/VIIRS - first-guess) on AMV height over North pole (poleward of 60N).
(July 1 – 31, 2020 and December 1 – 31, 2020)

O-B differences are large in upper layer (<~250hPa). These altitude data are not use for analysis.

Variation of O-B differences with altitude is small.

O-B U wind Bias (m/s)
O-B U wind Stdv (m/s)
O-B U wind RMSD (m/s)

Observing System Experiments (OSEs) with VIIRS AMVs

CNTL No polar AMVs (baseline)	**GA/GSM; operational global NWP system as of June, 2022** • 6-hourly cycle analysis and forecast • **w/o MODIS AMVs**, assuming the end of the missions
TEST VIIRS AMVs	CNTL + • **w/ S-NPP and NOAA-20VIIRS AMVs** (poleward of 60N/S) • QC of VIIRS AMVs: QI screening (QI2 > 60), not use upper layer (< 300hPa) and lower layer (>700hPa, >400hPa(land))

Experimental periods: for a month each in summer and winter
• July 21, 2021 – September 11, 2021 (**August 2021**)
• December 21, 2021 – February 11, 2022 (**January 2022**)

Polar AMV	
MODIS(NESDIS)	0
MODIS(CIMSS)	0
AVHRR	309
Dual-Metop	589
LEOGEO	792
VIIRS	421
Total	2111
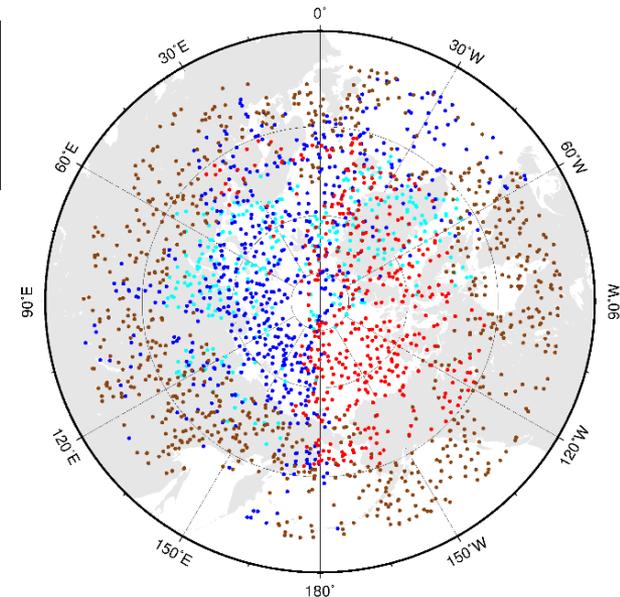
Typical north polar AMV coverage assimilated at 00Z Aug 15, 2021 (TEST).
Red is VIIRS (NOAA-20 and S-NPP) AMVs.
(Blue is Dual-Metop AMVs.)

RMSE improvement percent

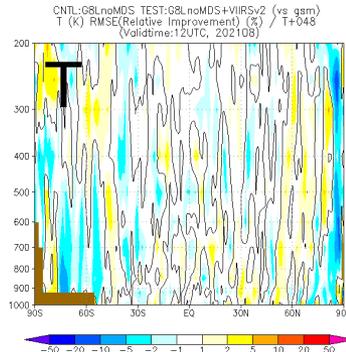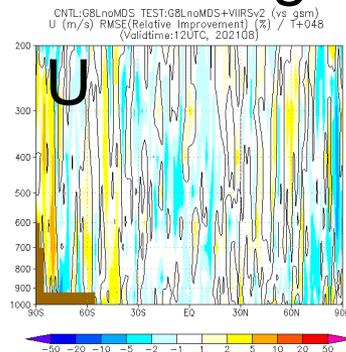## VIIRS vs no MODIS AMVs against own analysis

Verification is calculated using forecasts from 12 UTC initials and own analysis.

degraded ⬅️➡️ **improved**

$$\frac{RMSE_{cntl} - RMSE_{test}}{RMSE_{Cntl}} \times 100\ (\%)$$

August 2021

T+48

T+72

January 2022

T+48
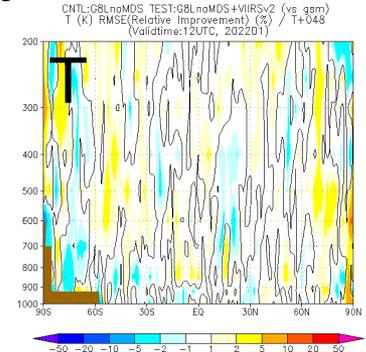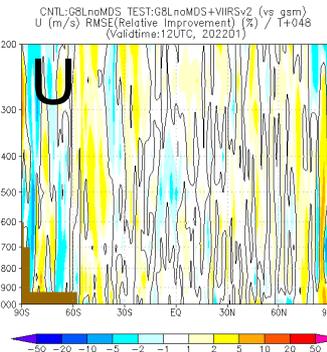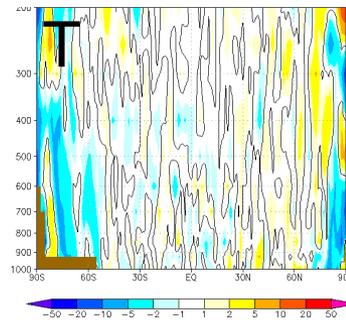
T+72

VIIRS AMVs have positive impact on wind and temperature forecast field especially in January 2022.

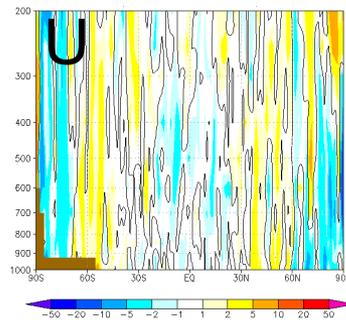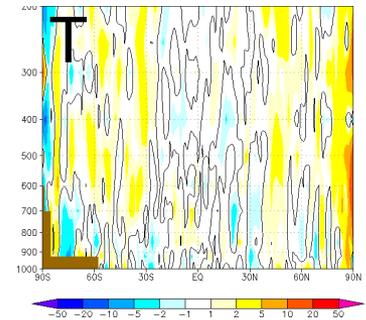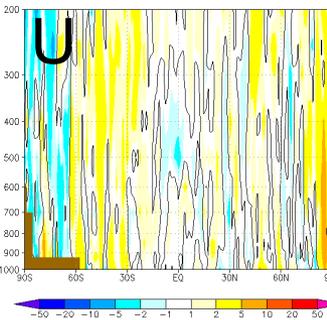# Summary

Operational use of new polar AMVs in JMA's global NWP

- Suomi-NPP and NOAA-20/VIIRS AMVs (March, 2023 ~)

- Dual-Metop AMVs at high latitudes (polarward 50deg. N/S) (June, 2022 ~)

These LEO AMVs provide valuable wind information and effectively reduce the error of analysis and forecast fields.

➢ We expect follow-on tandem products (e.g., Sentinel-3/SLSTR, NOAA-20/21 and EPS-SGs, etc) to succeed Dual-Metop AMVs.

Future work
- Satellites replacement (NOAA-21, EPS-SG/METImage, MTG/FCI, …)
- Preparation for operational use of DWL
- Exploring to use new satellite wind products

Thank you for your attention.

JMA's operational global NWP system configuration

	Global NWP System
Purposes	Daily forecasts Tropical cyclone information One-week forecasts

Forecast: Global Spectral Model (GSM)

Grid Size	~0.125 deg. (TQ959)
Vertical Levels/Top	128 / 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: TQ959 (~13 km) Inner: TL319 (~55 km)
Vertical Levels/Top	128 + surface / 0.01 hPa
Iterations	Outer: 2 Inner: Approx. 35
Ensemble Size for LETKF	100 members
Data Cut Off Time	Early Analysis: +2h20m Cycle Analysis: +7h50m (06, 18 UTC) +11h50m (00, 12UTC)