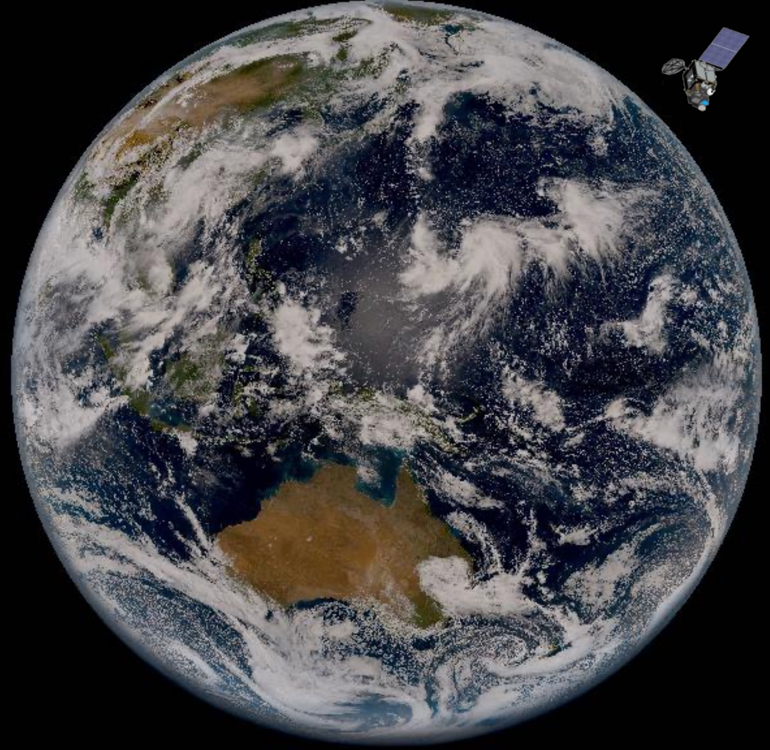
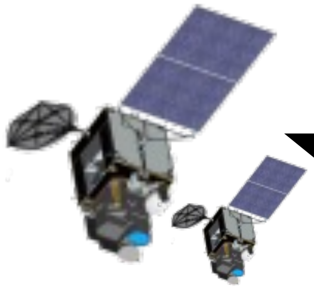


Current status of AMV at JMA/MSC

Meteorological Satellite Center
JMA

Kazuki Shimoji



2014 Himawari-8

2016 Himawari-9

Contents

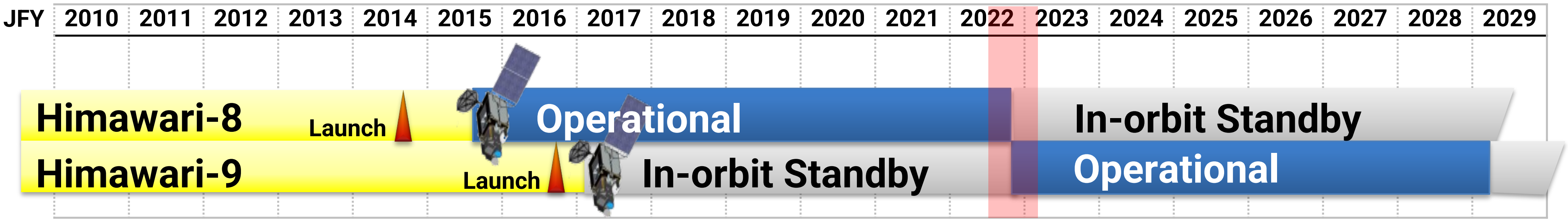
- Switchover of operational satellite from Himawari-8 to -9

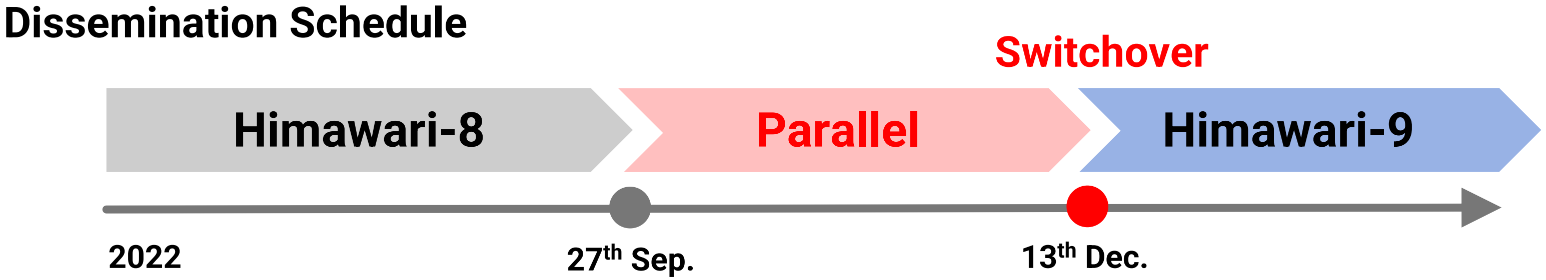
- Upcoming changes to Himawari AMV

- Preparations for Himawari-10

Mission Overview of Himawari

- Himawari-8 and -9 are the third generation geostationary meteorological satellites operated by Japan Meteorological Agency (JMA).

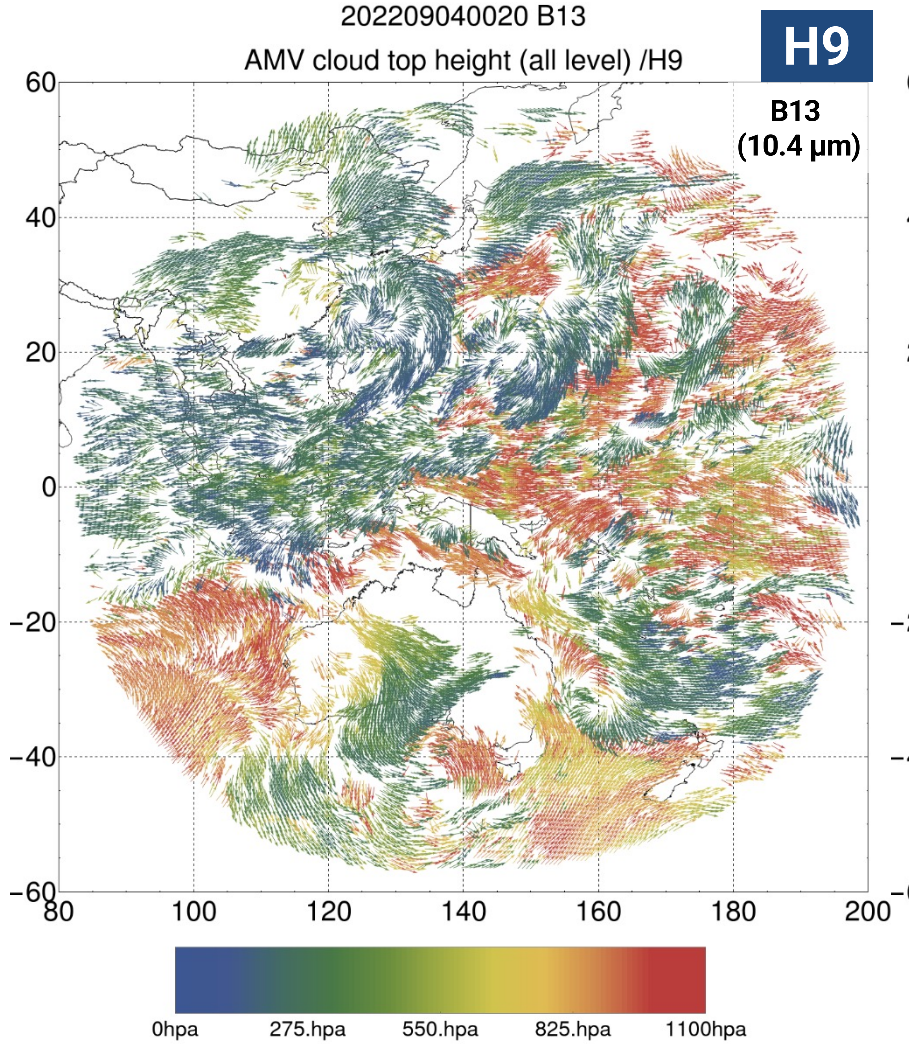


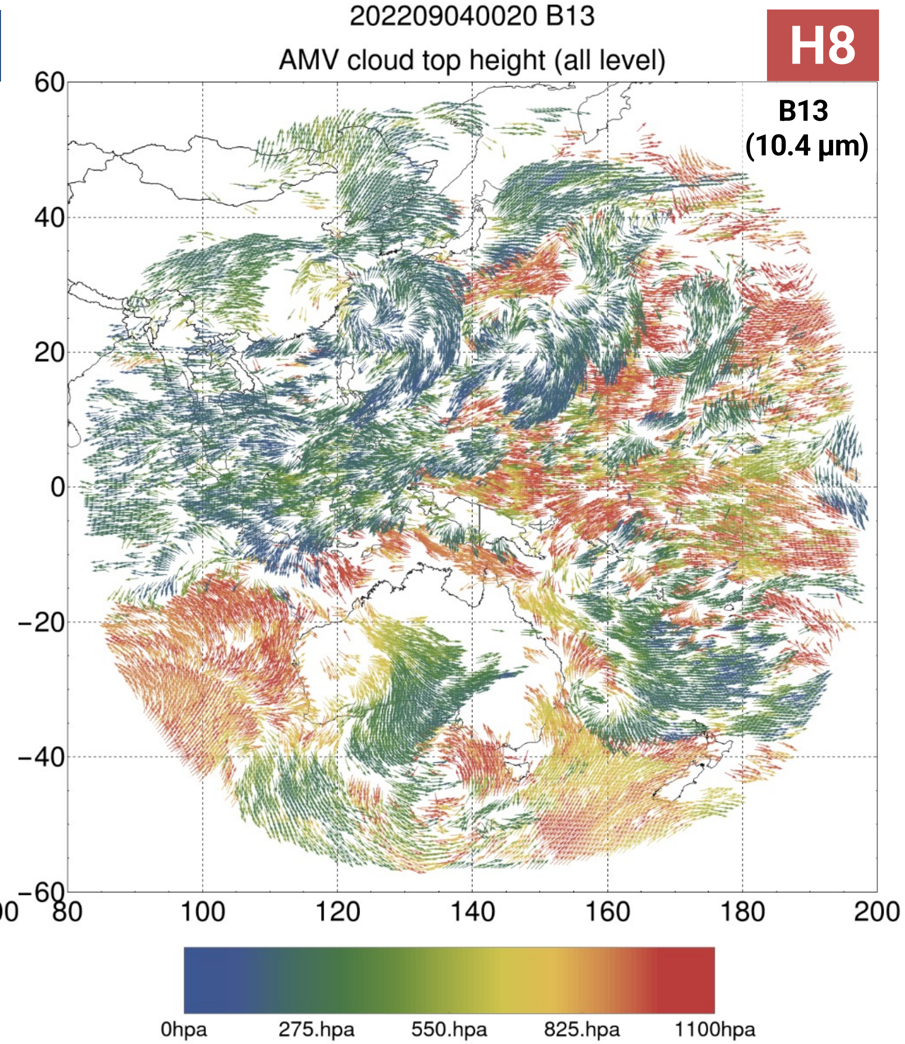


- Switchover of operational satellite from Himawari-8 to -9 was done on 13th December 2022.
- Before the switchover, parallel dissemination of Himawari-9 AMV via ftp server began on 27th September.

One scene of H8 and H9 AMVs

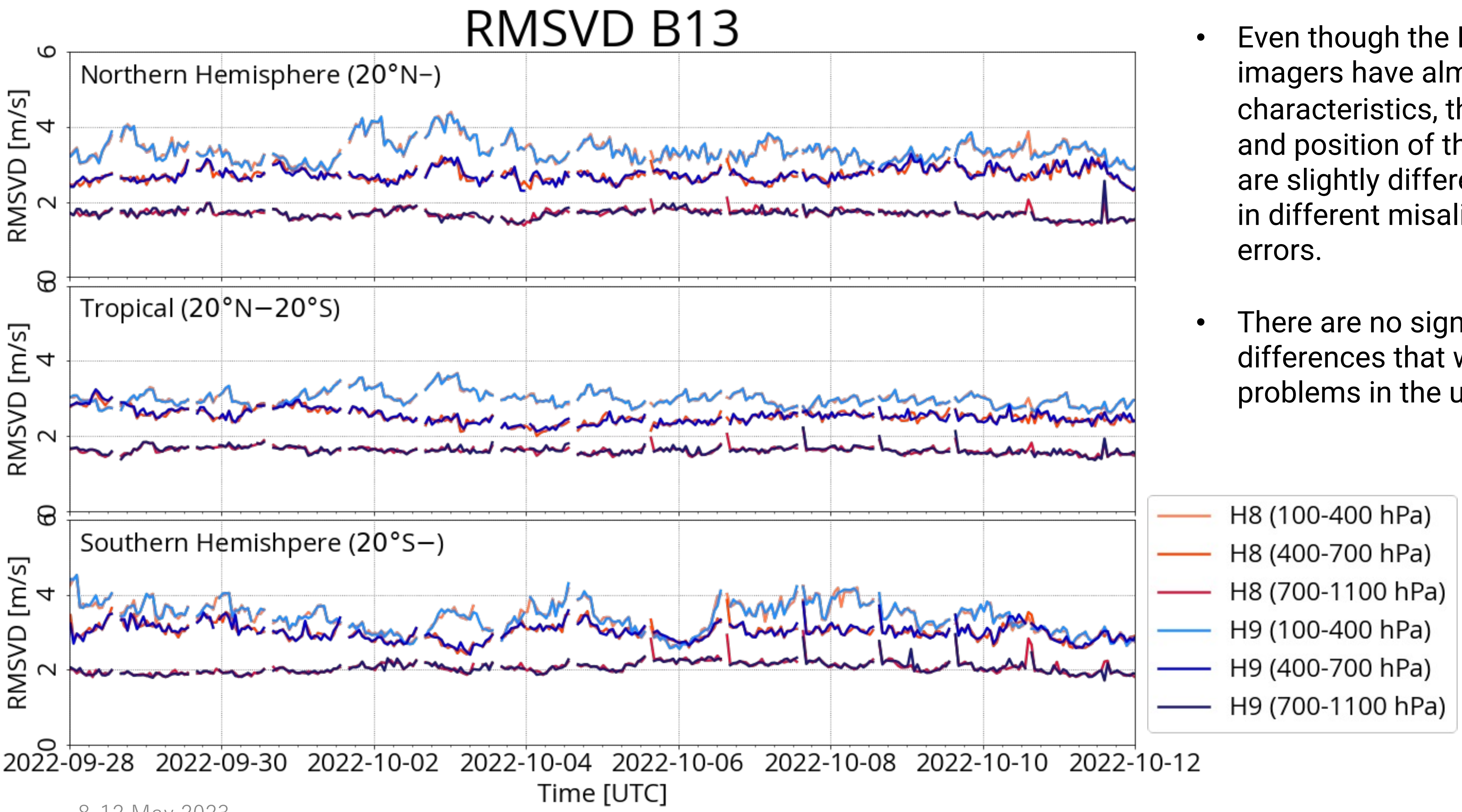
- Atmospheric Motion Vector (AMV) product derived from Himawari-9 is almost identical to the one from Himawari-8.
- One-scene comparison shows no significant difference between Himawari-8 and -9 AMV products.





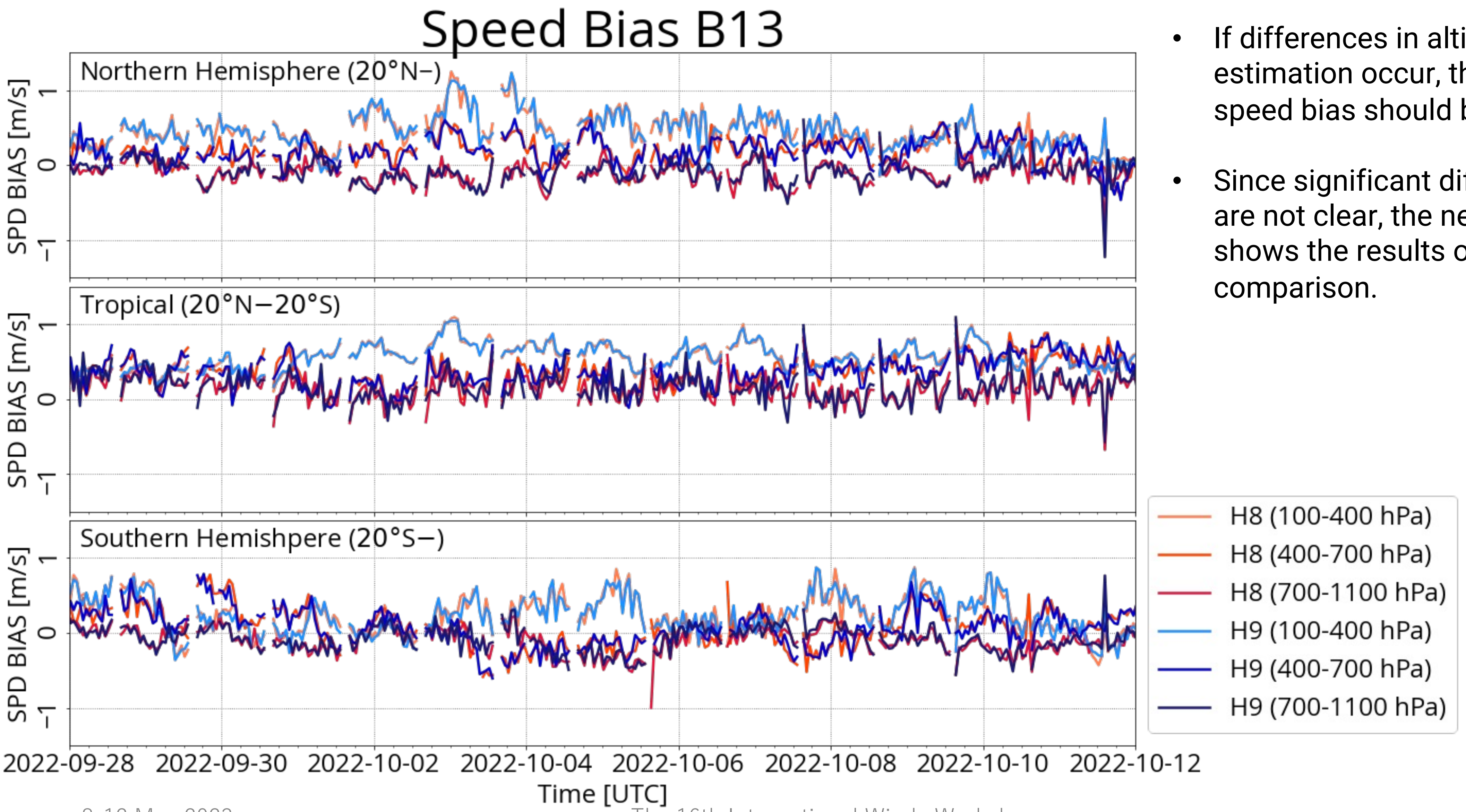
Color: Estimated cloud top height
Date: 2022-09-04 00UTC

Time series comparison of RMSVD (O-B) for IR winds



- Even though the H8 and H9 imagers have almost the same characteristics, the attitude and position of the satellites are slightly different, resulting in different misalignment errors.
- There are no significant differences that would cause problems in the use of AMVs.

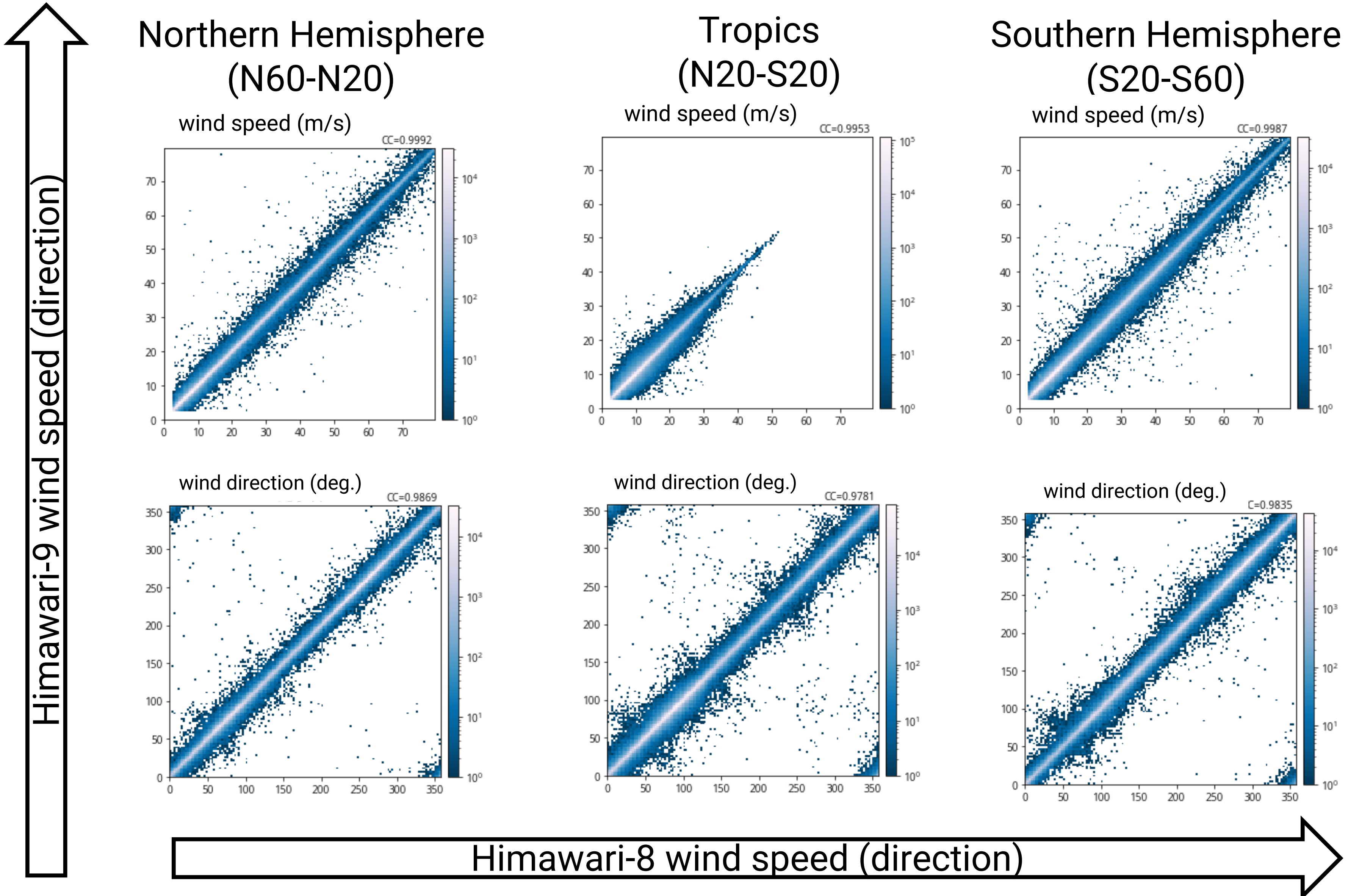
Time series comparison of wind speed biases (O-B)



- If differences in altitude estimation occur, then the wind speed bias should be affected.
- Since significant differences are not clear, the next slide shows the results of a direct comparison.

Comparison of collocated wind vectors from Himawari-8 and -9 AMVs (IR winds)

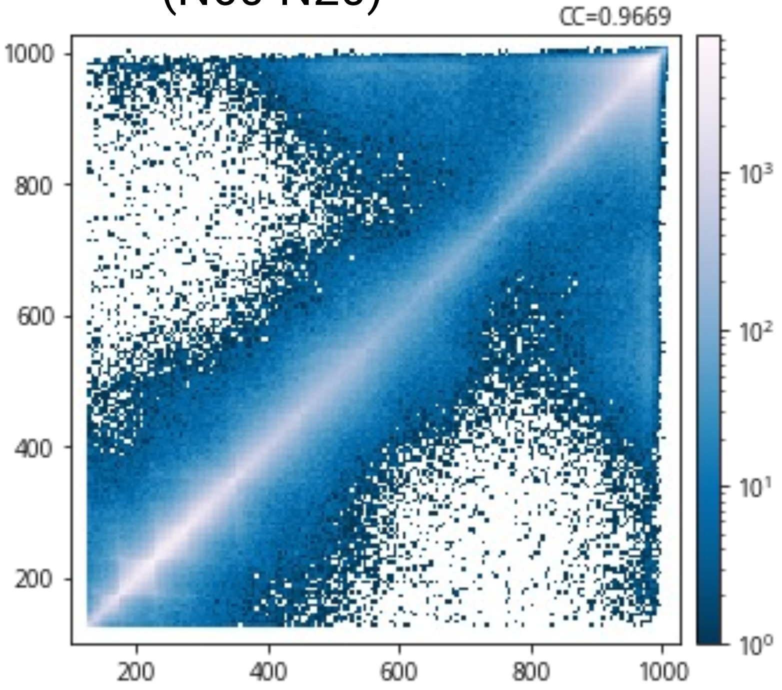
Northern Hemisphere (N60-N20) | Tropics (N20-S20) | Southern Hemisphere (S20-S60)



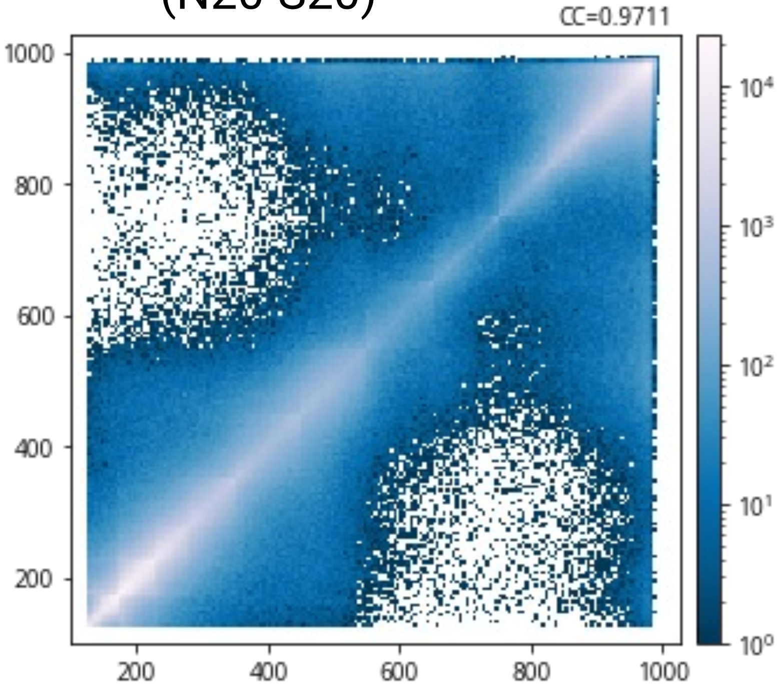
- The correlation coefficient of wind speed between Himawari-8 and -9 AMVs are more than 0.995 at all areas.
- As for wind direction, 0.978 or higher.
- Little significant difference between H8 and H9 AMVs is expected in the AMV tracking process.
- Similar results for other bands

Comparison of collocated pressure heights from Himawari-8 and -9 AMVs

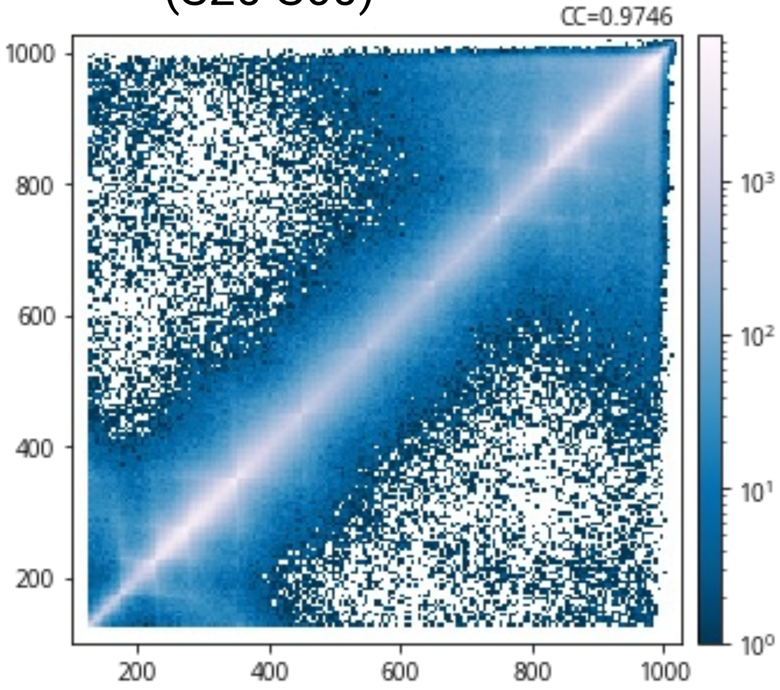
Northern Hemisphere
(N60-N20)



Tropics
(N20-S20)



Southern Hemisphere
(S20-S60)



- The correlation coefficient of wind speed between Himawari-8 and -9 AMVs are more than 0.966. Both exhibit nearly identical characteristics.
- Differences in heights are greater than differences in wind vectors. The differential evolution method used for height assignment is an algorithm that uses random numbers and terminates the calculation after a finite number of times, leaving a random factor in the results.
- The reason for the noticeable difference in AMV heights between H8 and H9 in the lower troposphere is thought to be that the water vapor band has little information about the lower layers, making it difficult to converge to an optimal solution.

Summary of Transition from Himawari-8 to -9

- **Parallel dissemination for Himawari-9 AMV via ftp server began on 27th September.**

- **The quality of Himawari-8 and -9 AMVs are statistically almost identical. For practical purposes, it was considered unlikely that the same treatment would make a significant difference in the results.**

- **Switchover from Himawari-8 to -9 was done on 13th December 2022.**

- **Himawari-9 is currently an operational satellite and Himawari-8 is a backup satellite.**

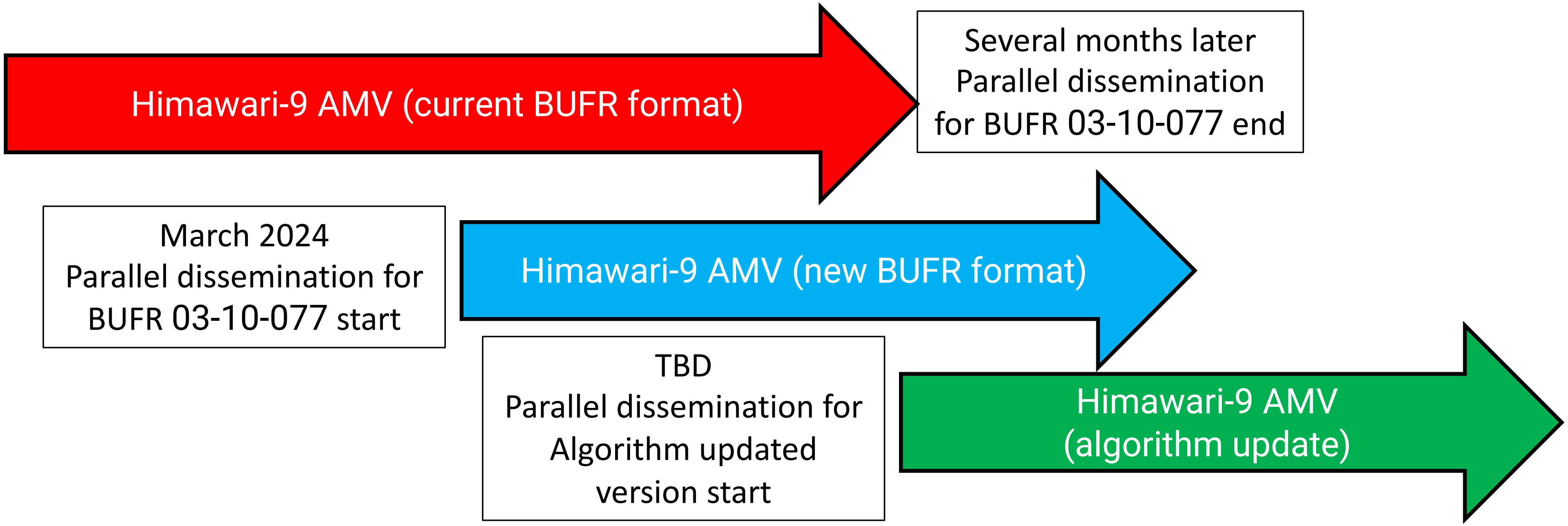
Contents

- Switchover of operational satellite from Himawari-8 to -9
- **Upcoming changes to Himawari AMV**
- Preparations for Himawari-10

Upcoming changes to Himawari AMV

- Parallel distribution and migration to the new BUFR format (03-10-077) is scheduled to begin in around March 2024 due to computer server upgrades. At this stage, the parallel distribution will be done by GTS with bulletin IUCN(S).

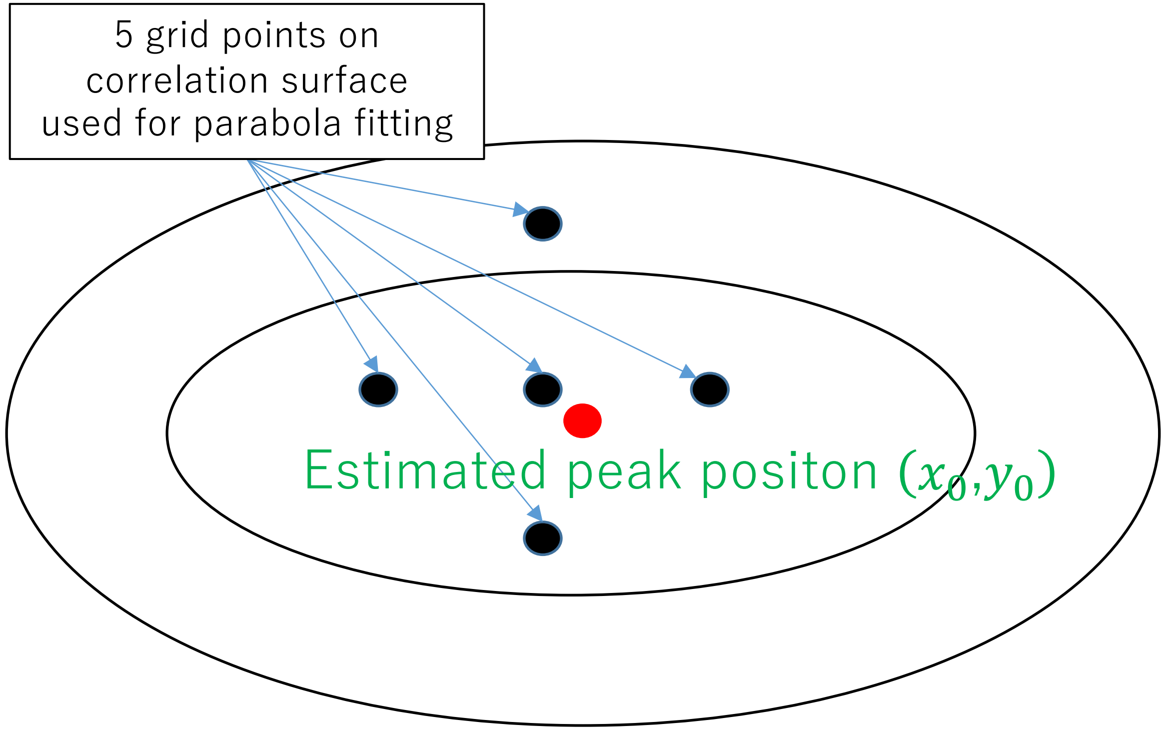
- Algorithm updates will be implemented after the migration to the new BUFR format. Details of timing to be determined. The same process is applied to the AMVs from the Himawari-8, which is now a backup.



Upgrade for Tracking Process

Improvement to Subpixel Estimation

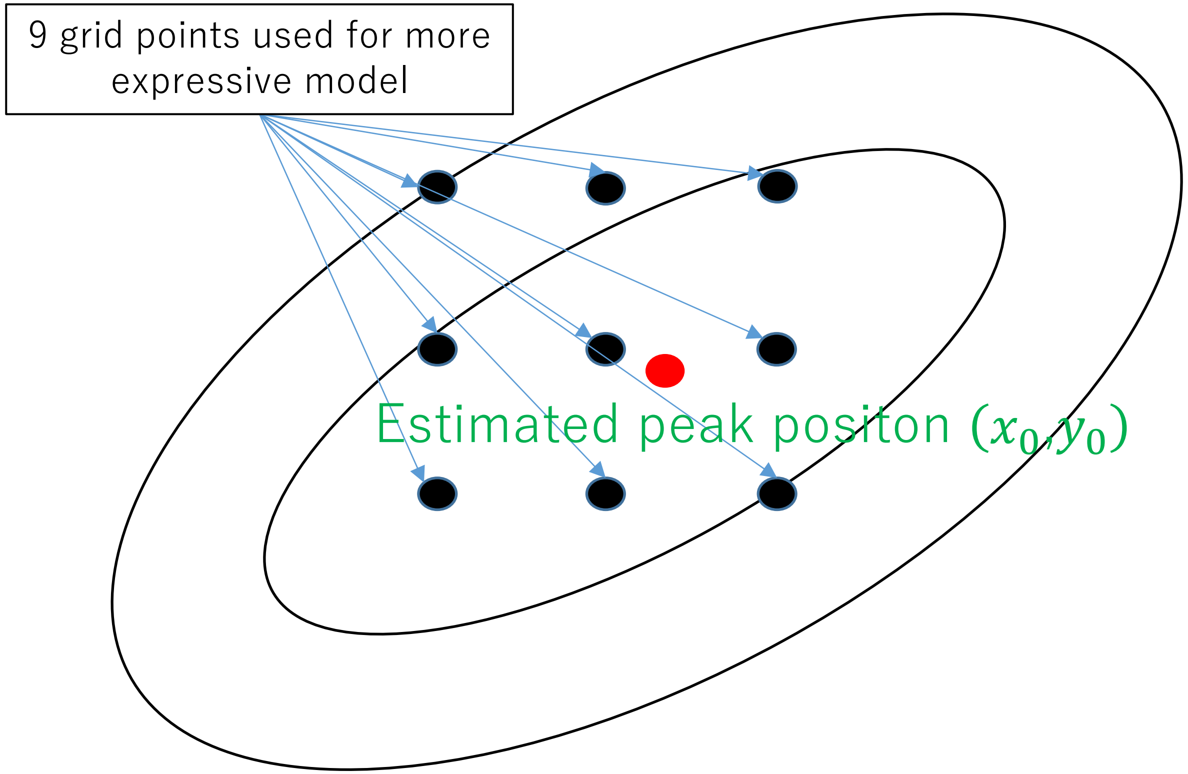
conventional method



$$C(x,y) = a(x - x_0)^2 + b(y - y_0)^2 + c$$

Cannot represent peaks tilted with respect to the horizontal axis (or vertical axis)

new method



$$C(x,y) = a(x - x_0)^2 + b(y - y_0)^2 + c$$
$$+ d(x - x_0)(y - y_0)$$

Able to represent peaks tilted with respect to the horizontal axis (or vertical axis)

Upgrade ：Height Assignment Process

Improvement to cost function for cloud height estimation

cost function for current method
simplified for understanding

$$C(x) = \sum_n t_n (\Sigma^{-1})_{nn} (R^n(x) - R^n_{\mathrm{obs}})^2$$

$$\Sigma_{mn} \equiv \langle \ (R^m(x_o) - R^m_{\mathrm{obs}}) \delta_{mn} (R^n(x_o) - R^n_{\mathrm{obs}}) \ \rangle$$

x : latent variable for cloud status
C(x) : cost function to be minimized
$R^n(x)$ ： simuilated radiance of band n under x
R^m_{obs} : observed radiance of band m
Σ_{mn} : covariance matrix
<> : statistical average
x_o : optimal x to minimize C(x)
t_n ： tuning parameter for band n
δ_{mn} : Kronecker delta

- to be assumed that the non-diagonal elements of the error covariance matrix are zero.
- In reality, there is an error correlation between the bands, so the off-diagonal elements are not zero.
- **empirical tuning is required for weighting**
- **6 IR/WV bands are being used for height assignment**

cost function for new method
simplified for understanding

$$C(x) = \sum_m \sum_n (\Sigma^{-1})_{mn} (R^m(x) - R^m_{\mathrm{obs}})(R^n(x) - R^n_{\mathrm{obs}})$$

$$\Sigma_{mn} \equiv \langle \ (R^m(x_o) - R^m_{\mathrm{obs}})(R^n(x_o) - R^n_{\mathrm{obs}}) \ \rangle$$

x : latent variable for cloud status
C(x) : cost function to be minimized
$R^n(x)$ ： simuilated radiance of band n under x
R^m_{obs} : observed radiance of band m
Σ_{mn} : covariance matrix
<> : statistical average
x_o : optimal x to minimize C(x)

- the off-diagonal elements of the error covariance matrix are considered.
- Scaling of residuals taking into account error correlations between bands.
- **empirical tuning is not required for weighting**
- **All IR/WV bands (except ozone channel) are used for height assignment**

Quality Changes in Sonde Statistics for IR winds

- RMSVD and MVD decreased in all areas and all altitudes, the quality is considered to have improved.
- BIAS increased slightly in the middle level, However, considering that RMSVD is decreasing, it is thought that the positive and negative BIASes have just canceled each other (common things in empirical tuning) in the current version.

Note: AMV minus ground truth (sonde)

MVD = Mean Vector Difference
RMSVD = Vector Difference RMS
BIAS = Speed Bias
SPD = Wind Speed
N.H = northern hemisphere (lat>20)
TROP = tropics (-20<lat<20)
S.H = northern hemisphere (lat<-20)

Period: 01-28 Feb. 2017 (winter season in N.H)
Method : Comparison of rawinsonde winds with AMV winds within 150 km radius of a RAOB site
Filters :
VERT. DIST.(>=700hPa) < 50 (hPa)
VERT. DIST.(<700hPa) < 35 (hPa)
QUALITY >= 85
0.5*0.5 deg. latitude/longitude grid point data
SPEED DIFF. < 30 (m/s)
DIRECTION DIFF. < 90 (deg)

Upper level (100-400hPa)

current version

	ALL	N.H	TROP	S.H
MVD	4.9	6.33	4.12	5.58
RMSVD	5.99	7.61	4.88	6.85
BIAS	-0.35	-0.61	-0.2	-0.5
SPD	23.76	44.52	13.08	26.8
NCMV	364012	43415	230169	90428
NC	39036	12209	24429	2398

new version

	ALL	N.H	TROP	S.H
MVD	4.7	5.7	4.02	5.16
RMSVD	5.72	6.9	4.79	6.01
BIAS	0.12	0.71	-0.22	-0.12
SPD	25.96	48.17	11.33	31.24
NCMV	1268331	151216	845168	271947
NC	32749	11654	18592	2503

Mid. level (400-700hPa)

may just look small due to overtuning..

current version

	ALL	N.H	TROP	S.H
MVD	4.84	5.13	3.8	4.45
RMSVD	5.87	6.24	4.37	5.14
BIAS	-0.06	-0.07	-0.02	-0.02
SPD	20.98	24.52	8.94	14.35
NCMV	136383	65271	36521	34591
NC	9834	7455	1967	412

new version

	ALL	N.H	TROP	S.H
MVD	4.43	4.68	3.37	3.9
RMSVD	5.24	5.52	3.89	4.44
BIAS	-0.34	-0.42	0.15	-0.57
SPD	22.52	26.13	7.1	15.05
NCMV	459146	201744	146167	111235
NC	14704	11653	2413	638

Low level (below 700hPa)

current version

	ALL	N.H	TROP	S.H
MVD	3.6	3.8	3.39	3.47
RMSVD	4.32	4.55	4.05	4.12
BIAS	0.18	-0.63	1	0.89
SPD	10.43	10.91	10.03	9.66
NCMV	416021	135485	165970	114566
NC	14395	7132	5826	1437

new version

	ALL	N.H	TROP	S.H
MVD	3.42	3.69	3.21	3.26
RMSVD	4.08	4.39	3.84	3.74
BIAS	0.22	-0.74	1.03	0.51
SPD	9.74	10.27	9.53	8.29
NCMV	1313187	414287	540904	357996
NC	14240	6189	6818	1233

Contents

- Switchover of operational satellite from Himawari-8 to -9
- Upcoming changes to Himawari AMV
- **Preparations for Himawari-10**

Preparations for Himawari-10

- JMA plans to begin operating a successor satellite to Himawari-9 around JFY2029.
- The successor satellite will be equipped with an infrared sounder.
- The main purpose of installing infrared sounder is to improve the forecast accuracy of extreme phenomena such as linear precipitation zones and typhoons by assimilating them into numerical forecasts.
- JMA is considering developing vertical profiles of air temperature and water vapor as secondary products, as well as three-dimensional wind profiles.
- JMA/MSC is currently in the process of conducting a basic study using simulated MTG-IRS data generated from NWP data.

Geostationary HiMawari Sounder (GHMS)

- L3Harris's new infrared FTS sounder based on the same concept with its GeoXO Sounder (GXS) being proposed to NASA
- Observing sequence changed for Himawari-10
- Values in the tables show JMA requirements

GHMS Observing Area & Interval

Observing Area (minimum coverage)	Interval
Sounding Disk (LZA ≤ 60 deg)	60 min
Japan (EW 2500 km x NS 2000 km)	15 min※
Target Area (EW 1000 km x NS 1000 km)	15 min

※ Sounding Disk observation over Japan area is regarded as one of the "Japan" observations in the 60-min repeat cycle (i.e., three "Japan" observations to be conducted in 60 minutes).

GHMS Spatial & Spectral characteristics

Spatial (horizontal) resolution		≤ 4.2 km
Spectral Coverage	LWIR	680 - 1095 cm^{-1} (14.7 - 9.13 μm)
	MWIR	1689 - 2250 cm^{-1} (5.92 - 4.44 μm)
Spectral Resolution (FWHM)		≤ 0.754 cm^{-1}
Spectral Sampling Distance		≤ 0.625 cm^{-1}

Geostationary HiMawari Imager (GHMI)

- L3Harris's new 18-band imager based on the same concept with its GeoXO Imager (GXI) selected by NASA
- Observing sequence & band configuration changed for Himawari-10
- Values in the tables show JMA requirements

Improvement from Himawari-8/9

GHMI Observing Area & Interval

Observing Area (minimum coverage)	Interval
Full Disk	10 min
Japan (EW 2500 km x NS 2000 km)	2.5 min
Target Area1 (EW 1000 km x NS 1000 km)	2.5 min
Target Area2 (EW 1000 km x NS 1000 km)	2.5 min
Target Area3 (EW 1000 km x NS 1000 km	2.5 min
Target Area4 (EW 1000 km x NS 1000 km)	2.5 min
Target Area5 (*) (EW 1000 km x NS 500 km)	30 sec

*Mainly used for CAL/VAL activities

GHMI Spectral band characteristics

	Center Wavelength [μm]	Band width [μm]	Spatial resolution at nadir [km]
VIS	0.46 - 0.48	≤ 0.07	≤ 1
	0.54 - 0.56	≤ 0.05	≤ 1
	0.63 - 0.65	≤ 0.12	≤ 0.5
NIR	0.85 - 0.87	≤ 0.06	≤ 1
	1.375 - 1.385	≤ 0.04	≤ 2
	1.60 - 1.62	≤ 0.08	≤ 2
	2.24 - 2.27	≤ 0.06	≤ 2
IR	3.75 - 3.95	≤ 0.50	≤ 1
	5.10 - 5.20	≤ 0.20	≤ 1
	6.05 - 6.45	≤ 1.20	≤ 2
	6.90 - 7.00	≤ 0.50	≤ 2
	7.27 - 7.43	≤ 0.60	≤ 2
	8.44 - 8.76	≤ 0.50	≤ 2
	9.55 - 9.70	≤ 0.50	≤ 2
	10.3 - 10.5	≤ 0.90	≤ 2
	11.1 - 11.3	≤ 1.00	≤ 2
	12.25 - 12.55	≤ 1.20	≤ 2
	13.2 - 13.4	≤ 0.70	≤ 2

Summary

- Switchover from Himawari-8 to -9 was done on 13th December 2022.
- The quality of Himawari-8 and -9 AMVs are statistically almost identical. For practical purposes, it was considered unlikely that the same treatment would make a significant difference in the results.
- Parallel distribution and migration to the new BUFR format (03-10-077) is scheduled to begin in around March 2024 due to computer server upgrades. At this stage, the parallel distribution will be done by GTS with bulletin IUCN(S).
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- JMA plans to begin operating a successor satellite to Himawari-9 around 2030. The successor satellite will be equipped with both of imager and a next-generation hyperspectral infrared sounder to calculate retrieved temperature and vapor fields and wind products that can be derived from them.

Merci pour votre attention!