CURRENT STATUS AND PLANS OF OPERATIONAL HIMAWARI-8/9 WIND PRODUCTS AT MSC/JMA

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Japan Meteorological Agency (JMA)

12-16 April, 2021
15th International Winds Workshop

Contents

- Curent operational status for Himawari-8 and future plan to switch over to Himawari-9
- Progress from the last workshop
- Planed upgrade for Himawari-AMV
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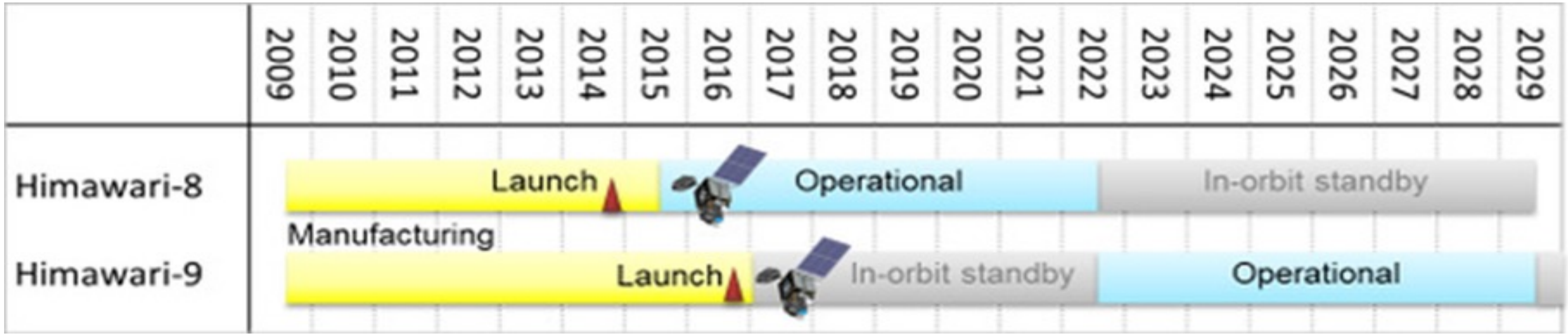
Status of JMA's current GEO satellite systems

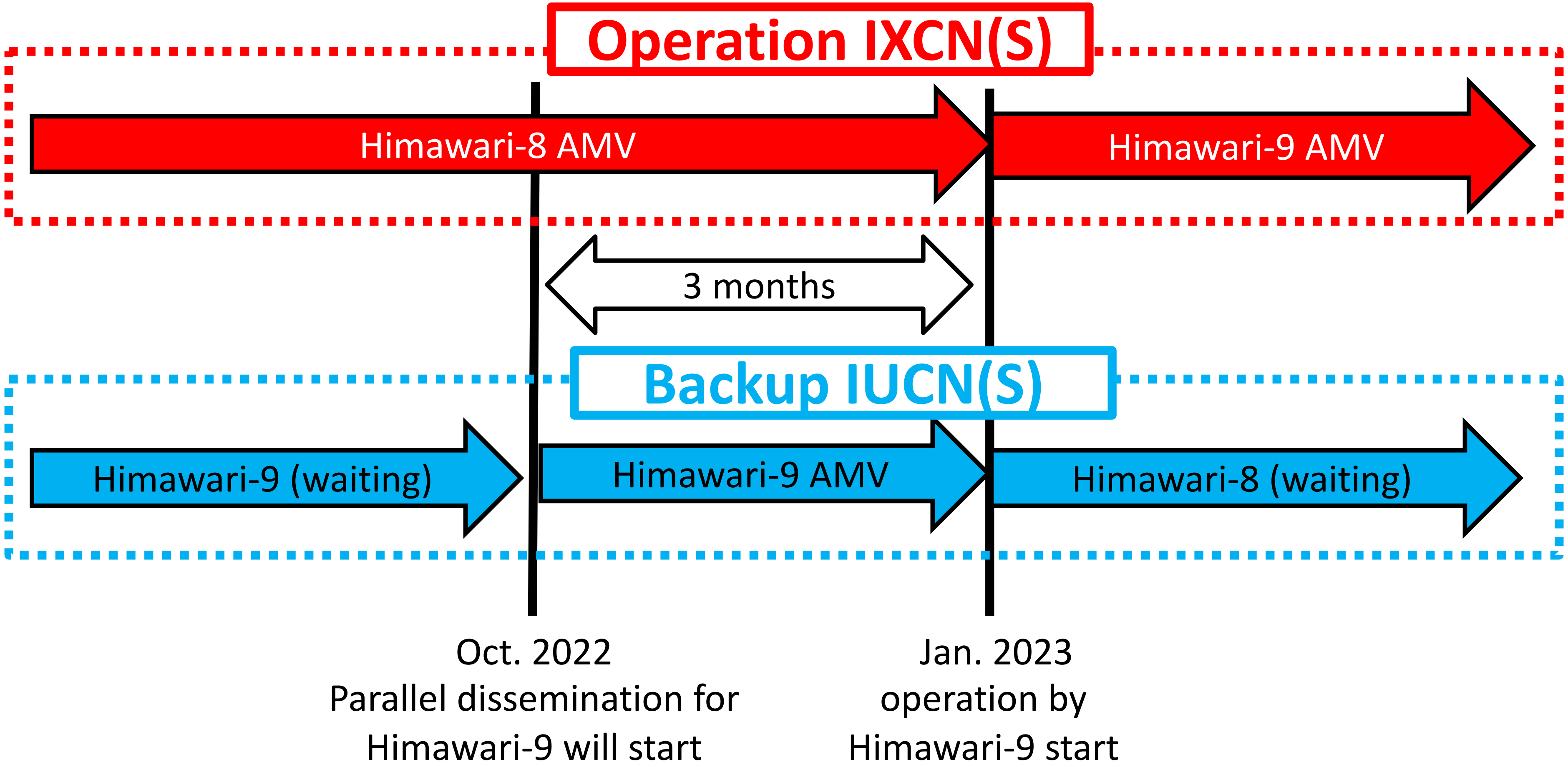


The Japan Meteorological Agency (JMA) operates two geostationary meteorological satellites, Himawari-8 and -9, equipped with Advanced Himawari Imager (AHI) units. JMA has established a satellite observation system with redundancy based on twin satellite operation, which is expected to contribute to disaster risk reduction in Asia and the western Pacific until 2029. Himawari-8 will chiefly be used for observation during the early part of this period, with Himawari-9 in a back-up role. Their operation will be switched in 2022 to place Himawari-9 in the main observation role with Himawari-8 as back-up.

There are no major problems with Himawari-8, and the focus is on the switch over from Himawari-8 to Himawari-9, which is scheduled in 2022.

Switch over from Himawari-8 to -9

- Operation by Himawari-9 will start around Jan. 2023
- Himawari-9 AMV will be disseminated from Oct. 2022
- Parallel dissemination period for the switch over to Himawari-9 is about 3 months



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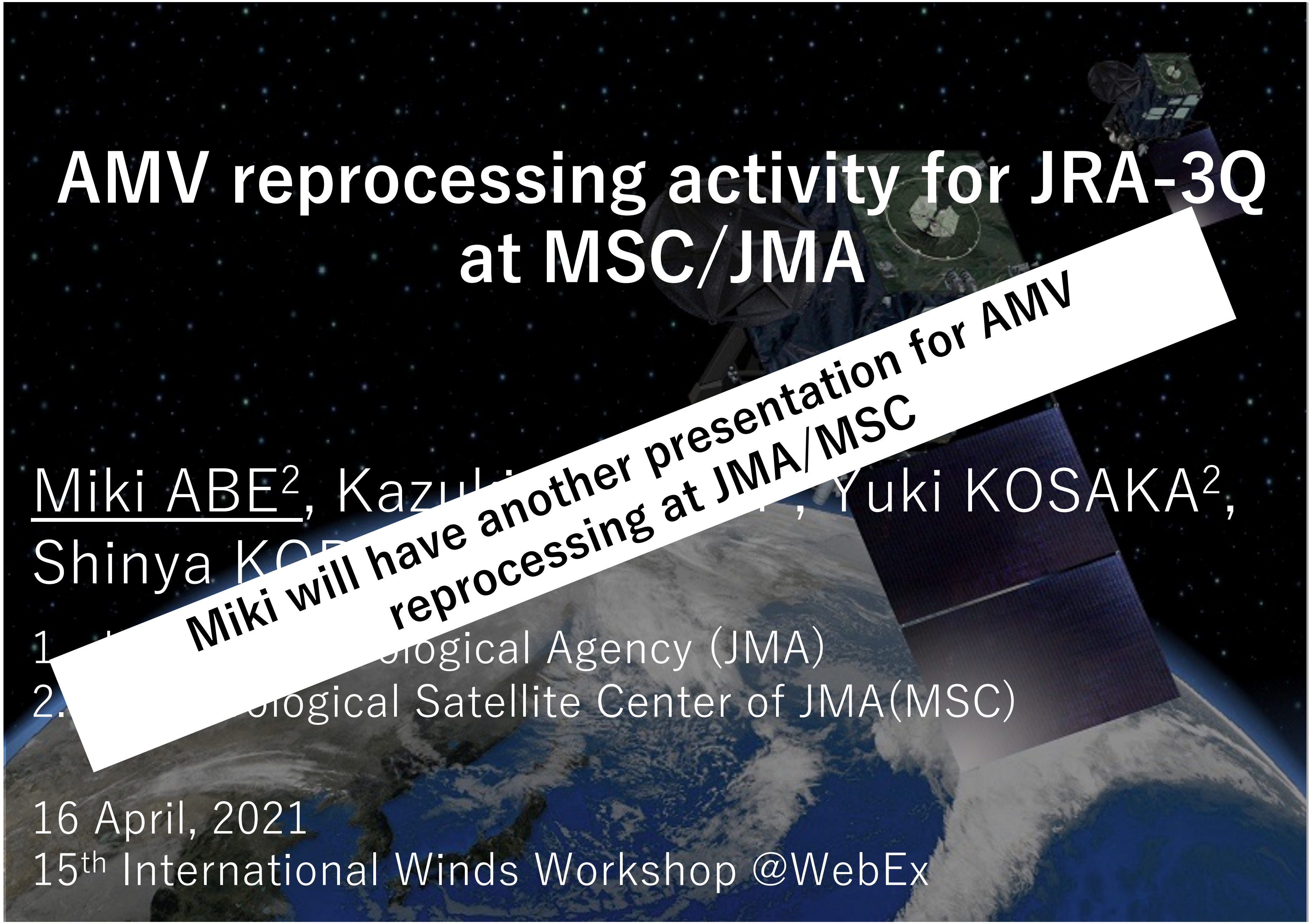


AMV reprocessing activity for JRA-3Q at MSC/JMA

Miki will have another presentation for AMV reprocessing at JMA/MSC

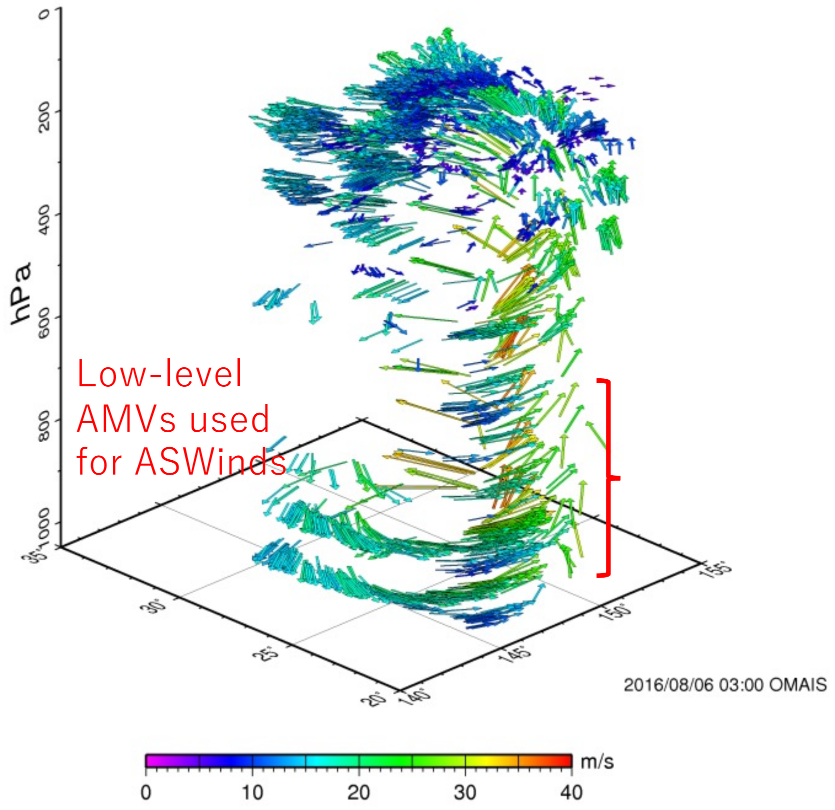
Miki ABE[2], Kazu… , Yuki KOSAKA[2],
Shinya KO…

1. … ological Agency (JMA)
2. … ological Satellite Center of JMA(MSC)

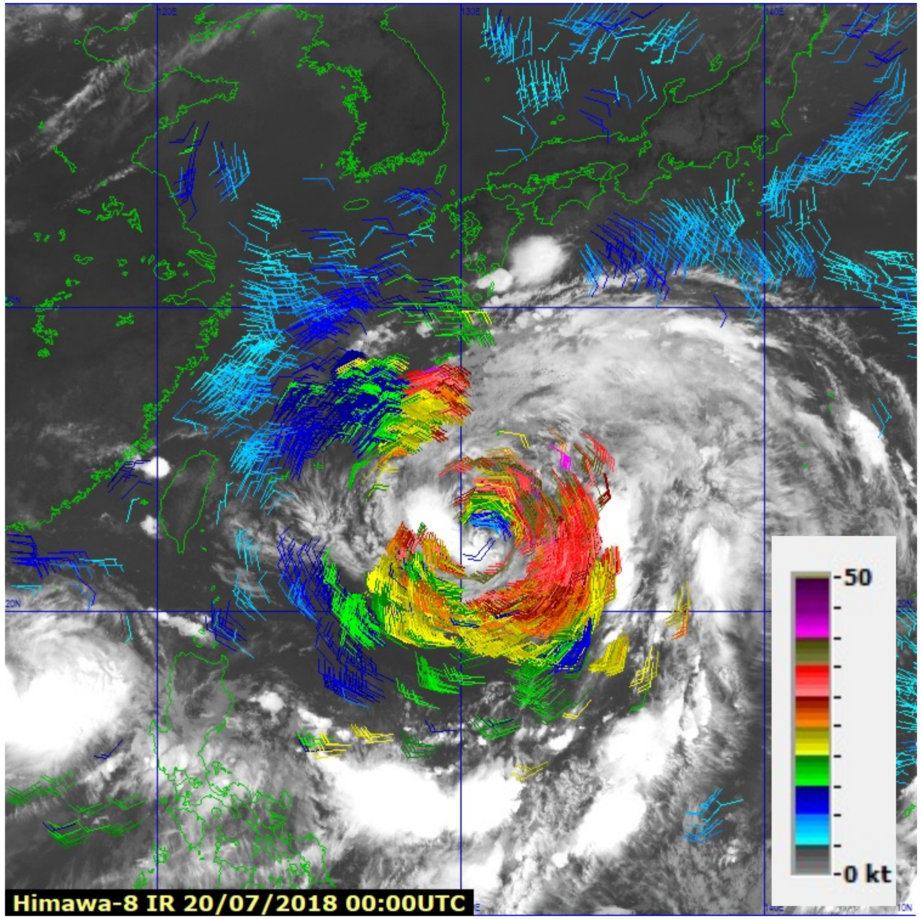
16 April, 2021
15th International Winds Workshop @WebEx

Application of AMV to real-time typhoon monitoring

Started using Rapid-Scan AMV for operation



3-D image of Himawari-8 VIS AMVs derived from target obs. images around typhoon Omais (1605) .



ASWinds from FD and TG AMVs (every 10-min) July 20 00UTC to 12UTC, Typhoon Ampil (T1810)

- JMA developed AMV based Sea-surface Winds (AS Winds), a satellite product that estimates sea wind speed using RS-AMV as an input.
- ASWinds has been used at JMA's RSMC Tokyo-Typhoon Center since 2017, and began distribution to overseas in 2019.

ASWind Monitor for Tropical Cyclone Monitoring on MSC's web site;
https://www.data.jma.go.jp/mscweb/en/product/product/aswind/monitor/aswind.php

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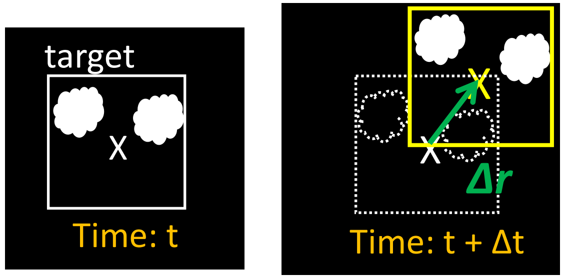
Overview of Himawari-8/9 AMV Derivation

Step 1：Motion Vectors (Tracking Process)

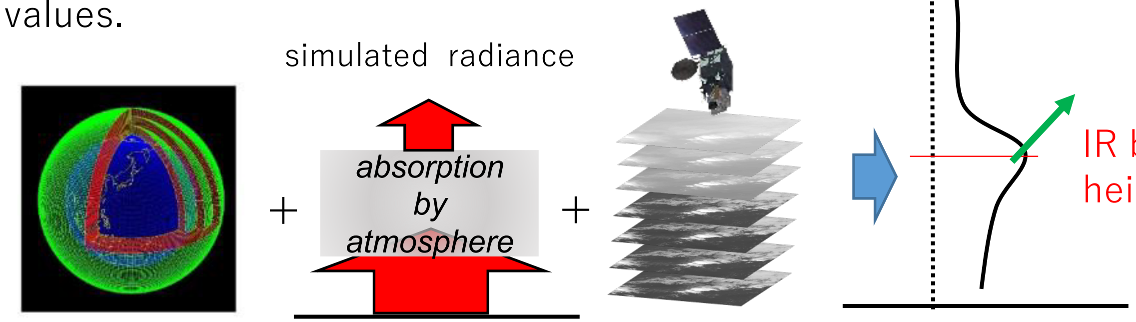
Similarity cloud patterns are tracked by a cross correlation method from sequential satellite images, and motion vectors are derived.



Motion Velocity = Δr / Δt

Step 2： Height Assignment Process

Height of the vector is determined by minimizing difference between observed and simulated values.



NWP's vertical profile

Radiative Transfer Model

Observed Radiance

Height of the vectors

Obs. Bands for Tracking
- Band 3 (Visible) (day time only)
- Band 7 (short wave IR)
- Band 8-10 (Water Vapor)
  → tracking upper layer clouds
- Band 13 (IR)

IR bands are used for height assignment

Himawari-8/9 Imager (AHI) Observation bands

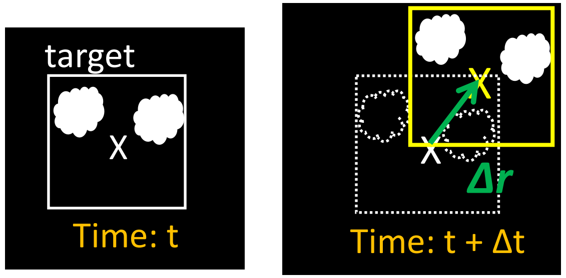
Band		Spatial Resolution	Central Wavelength
1	Visible	1 km	0.47 μm
2			0.51 μm
3		0.5 km	0.64 μm
4	Near Infrared	1 km	0.86 μm
5		2 km	1.61 μm
6			2.26 μm
7	Infrared	2 km	3.9 μm
8			6.2 μm
9			6.9 μm
10			7.3 μm
11			8.6 μm
12			9.6 μm
13			10.4 μm
14			11.2 μm
15			12.4 μm
16			13.3 μm

Upgrade for Tracking Process

Improvement to Subpixel Estimation

Step 1：Motion Vectors (Tracking Process)

Similarity cloud patterns are tracked by a cross correlation method from sequential satellite images, and motion vectors are derived.



Motion Velocity = Δr / Δt

$$\vec{v}_{AMV} = \frac{\vec{r}_{t+\Delta t} + \vec{\delta} - \vec{r}_{t}}{\Delta t} = \frac{\vec{r}_{t+\Delta t} - \vec{r}_{t}}{\Delta t} + \frac{\vec{\delta}}{\Delta t} = \vec{v}_{true} + \frac{\vec{\delta}}{\Delta t}$$

$\vec{v}$: wind vector

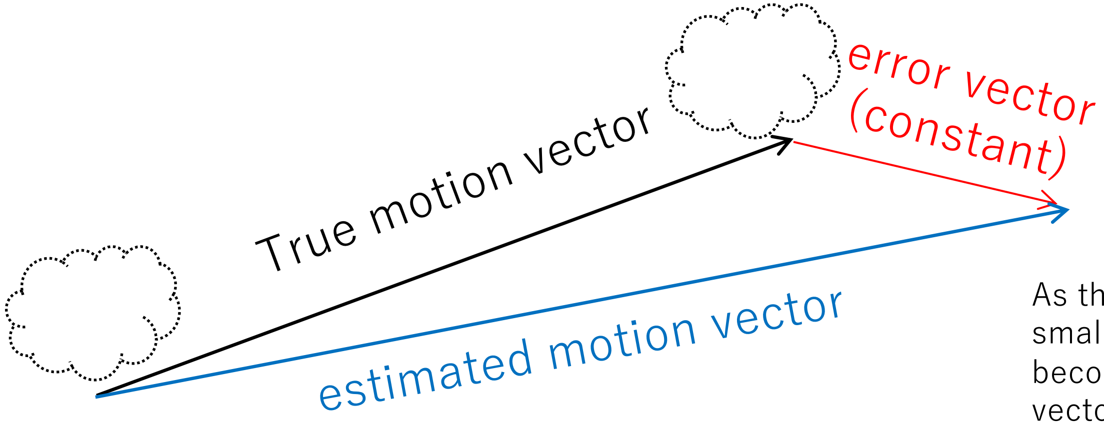
$\vec{r}$: position vector

$\vec{\delta}$: error of target's position vector

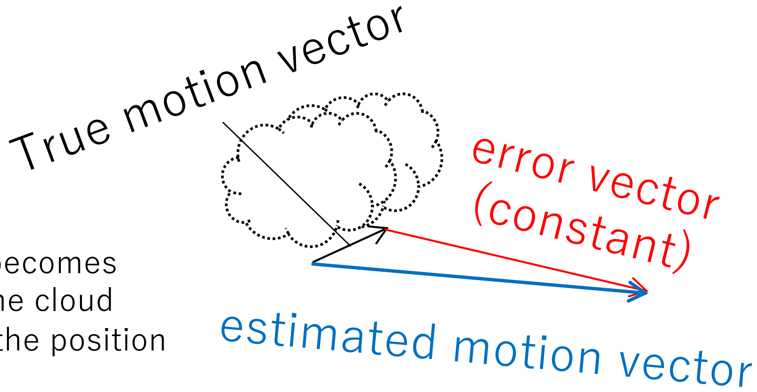
Δt : time interval of observation

- AMV error increases in inverse proportion to the observation time interval
- For RapidScan-AMV, necessary to further reduce the error of pattern matching. Subpixel level position estimation is important

Normal scan (10 min.)



Rapid Scan (30 sec.)

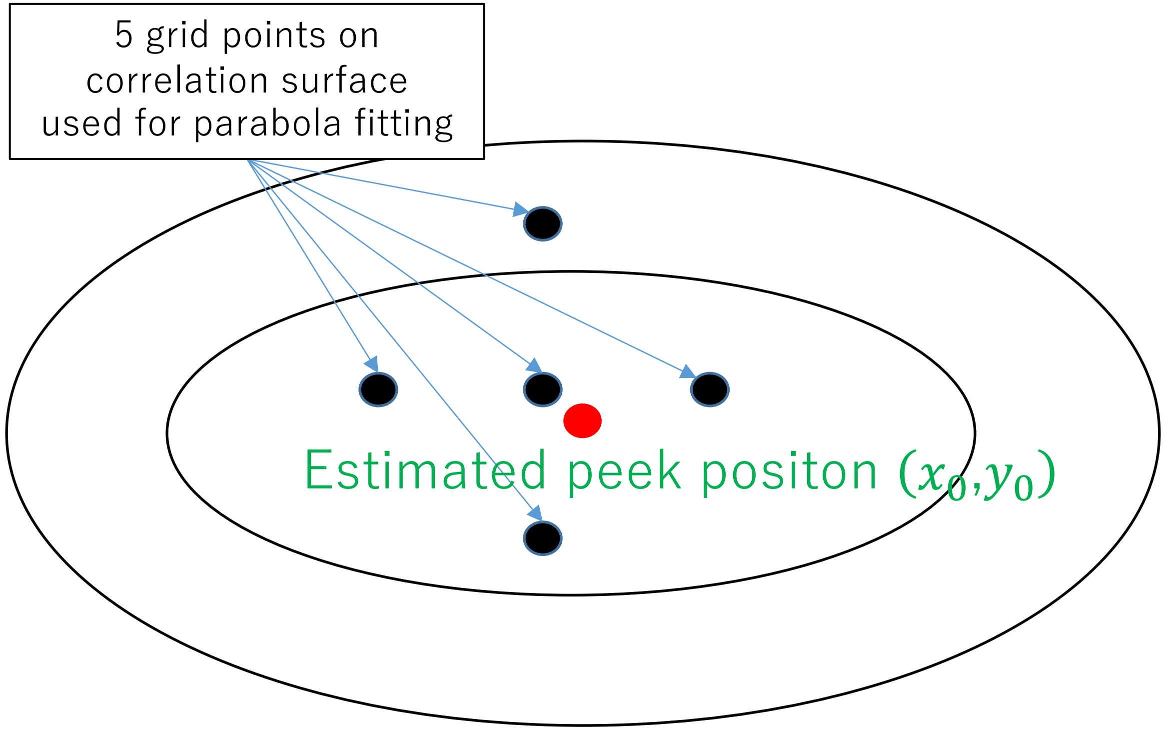


As the observation time interval becomes smaller, the moving distance of the cloud becomes smaller, so the error of the position vector increases relatively.

Upgrade for Tracking Process (2)

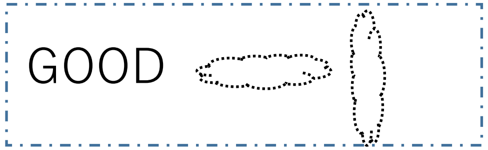
Improvement to Subpixel Estimation

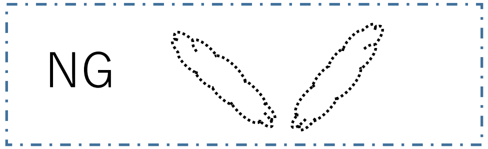
conventional method



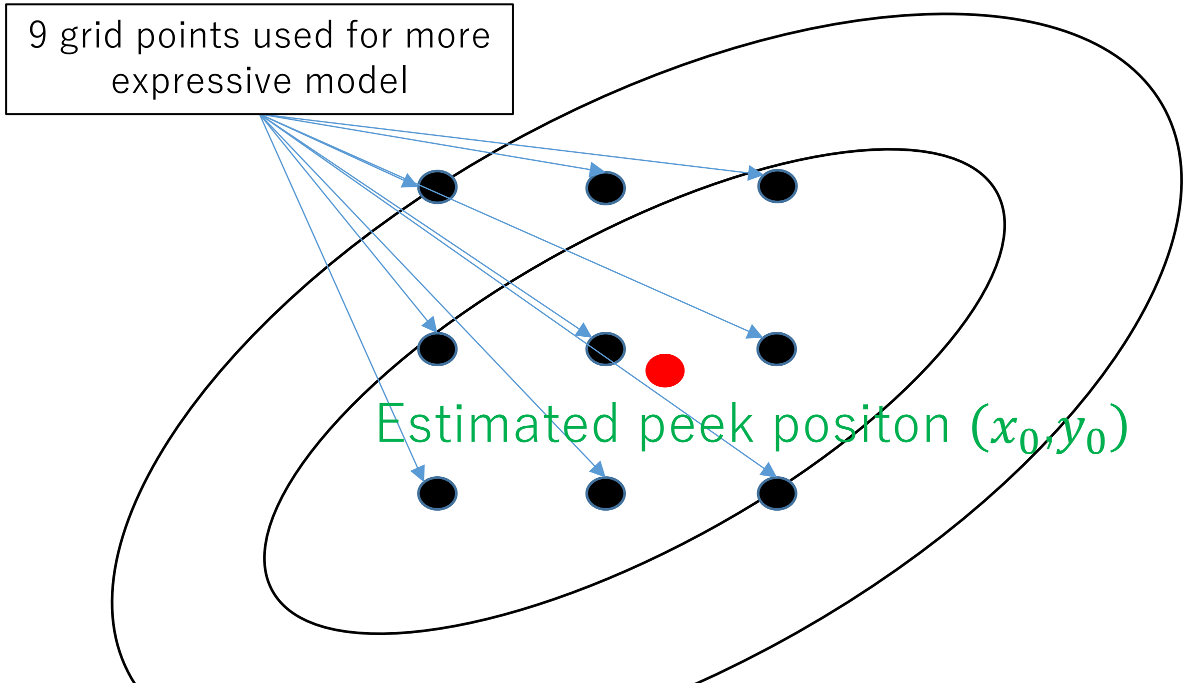
$$C(x,y) = a(x-x_0)^2 + b(y-y_0)^2 + c$$

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



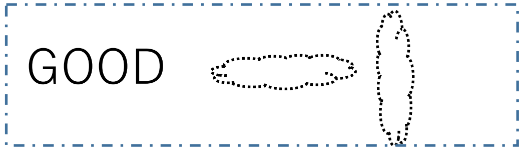


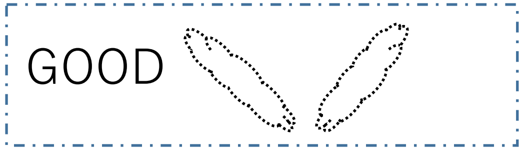
new method



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

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



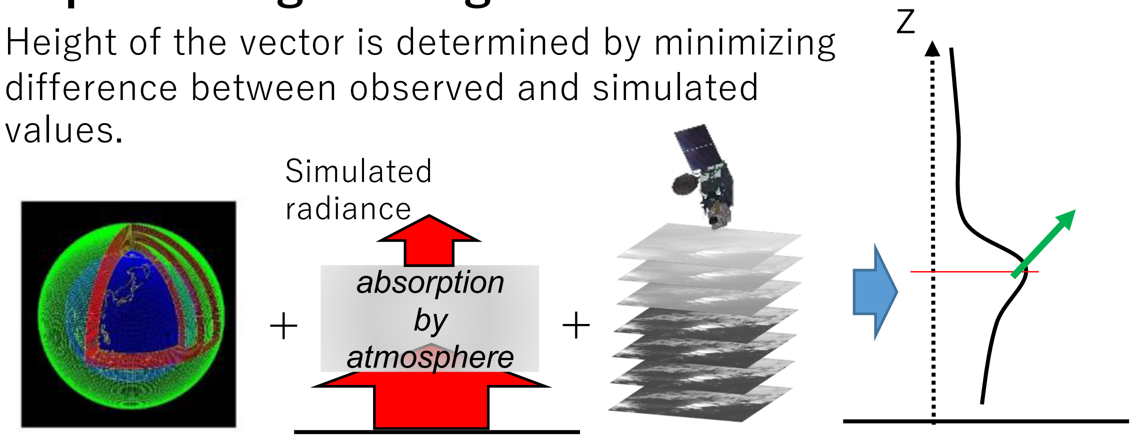


Upgrade for Step 2：Height Assignment Process

Improvement to cost function for cloud height estimation

Step 2： Height Assignment Process

Height of the vector is determined by minimizing difference between observed and simulated values.



- Purpose is to use as many bands as possible without empirical tuning
- Correlated error between each bands are not considered in current version.
- The weighting of each band in the cost function is not reflected mathematically properly.
  - ✓ The weight of a specific band is reduced in consideration of error correlation by empirical tuning.

Himawari-8/9 Imager (AHI) Observation bands

Band		Spatial Resolution	Central Wavelength
1	Visible	1 km	0.47 µm
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6 IR bands are used for height assignment

Upgrade for Step 2 : Height Assignment Process (2)

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 under x
R^m_{obs} : observed radiance of band n
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 non-diagonal component is not zero.
- **empirical tuning is required for weighting**
- **6 IR/WV bands will be 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 under x
R^m_{obs} : observed radiance of band n
Σ_{mn} : covariance matrix
<> : statistical average
x_o : optimal x to minimize C(x)

- the non-diagonal elements of the error covariance matrix is considered.
- Specific band not over-evaluated nor under-evaluated
- **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 decreasing 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.

may just look small due to overtuning..

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)

current version | **new version**

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)

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)

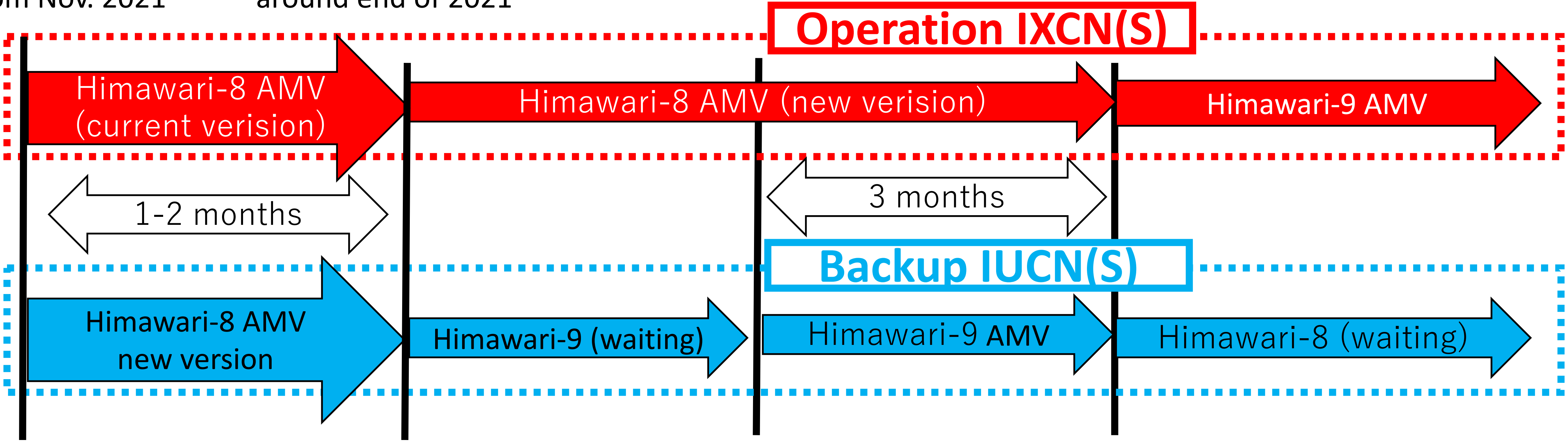
current version

	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

Schedule and Other Changes



- BUFR Sequence 310077 will be applied
- dissemination every 30 minutes
- distribution start at the 2021 fiscal second half in prospect
- parallel dissemination (BUFR designator IUCN(S) for experimental data will be used)
- Winds from 3.9 micro meter band will be available
- **We JMA wish to abolish one or two of the three water vapor AMVs currently being distributed. Please let us know if you are a NWP user who is likely to have problems.**
- **What are NWP user's thoughts on the parallel dissemination period and migration schedule? If you have any opinions, please contact me.**

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Summary

- There are no major problems with Himawari-8 currently in operation.
- Switch over from Himawari-8 to Himawari-9 is scheduled at January 2023.
- Parallel dissemination for Himawari-9 AMV will start around October 2022.
- After January 2023, Himawri-9 AMV will be in operation and Himawri-8 will be a backup.
- JMA reprocessed AMV from past JMA's operational satellites for JMA's climate reanalysis project.
- Recently, JMA was developing application of AMV to real-time typhoon monitoring and put it in operation.
- JMA will upgrade Himawari AMV algorithm for tracking and height assignment.
- It was confirmed that the quality was improved in the anti-sonde statistics due to the effect of the algorithm change.
- This change involves a transition to BUFR Sequence 310077 and change in AMV delivery frequency (every 30 minutes) and etc.
- JMA plan to start distribution of test data in November 2021 and move to new software by the end of 2021.


Thank you for your attention !

Spare Slides