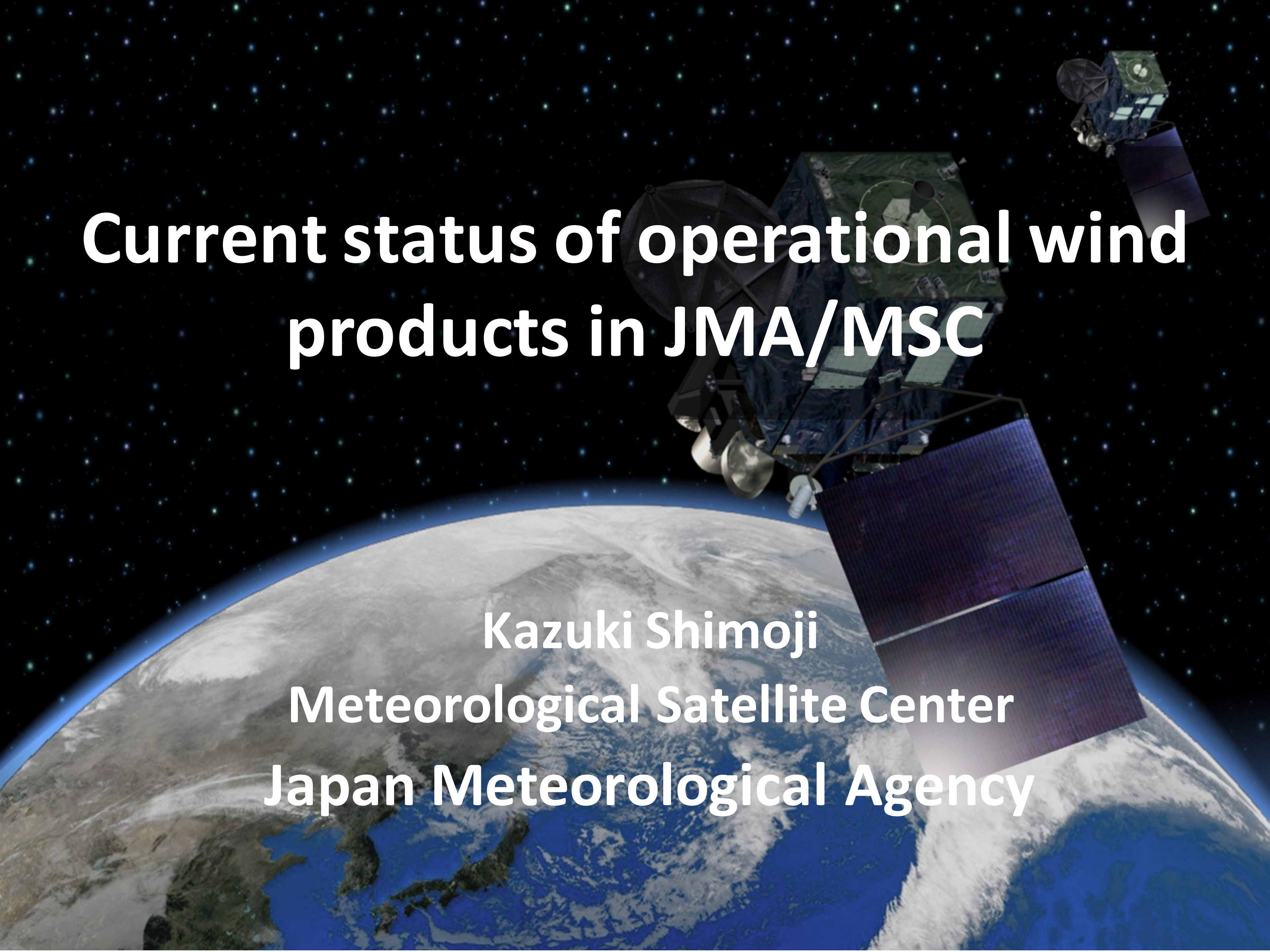

Current status of operational wind products in JMA/MSC

Kazuki Shimoji
Meteorological Satellite Center
Japan Meteorological Agency

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1. Replacement from MTSAT-1R and 2 to Himawari-8 and -9

2. Statistical characteristic of Himawari-8 AMV

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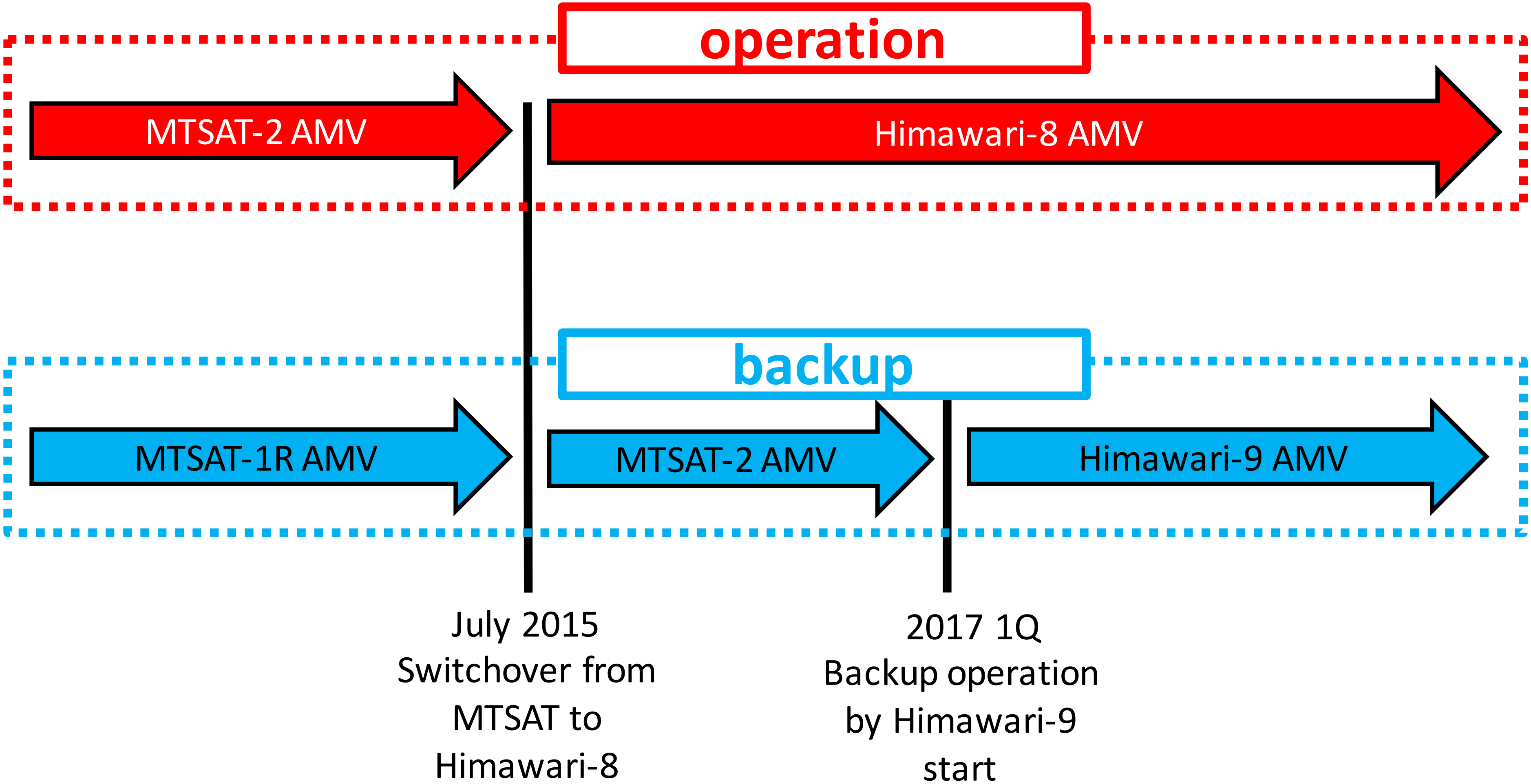
4. Summary

Replacement from MTSAT-1R and 2 to Himawari-8 and -9

- JMA will launch Himawari-9 in FY 2016
- Backup operation by Himawari-9 will start around 2017 Q1
- Derivation system for H-9 AMV is the same as H-8 AMV except SRF difference
- Disseminated BUFR will be the same as Himawari-8 except satellite ID etc.



Specification of current operational Himawari-8 AMV

- **Himawari-8 AMV for global NWP model**
  - Hourly disseminated in BUFR via Global Telecommunication System (GTS)
  - 10.4 (IR), 6.2, 6.9, 7.3 (WV) and 0.6 (VIS) winds are available
  - Spatial resolution : 17 pixel grid (34 km resolution at nadir)
  - Target box size : 7x7 and 31x31
  - Time interval of input imagery : 10 minutes (from full disk observation mode)

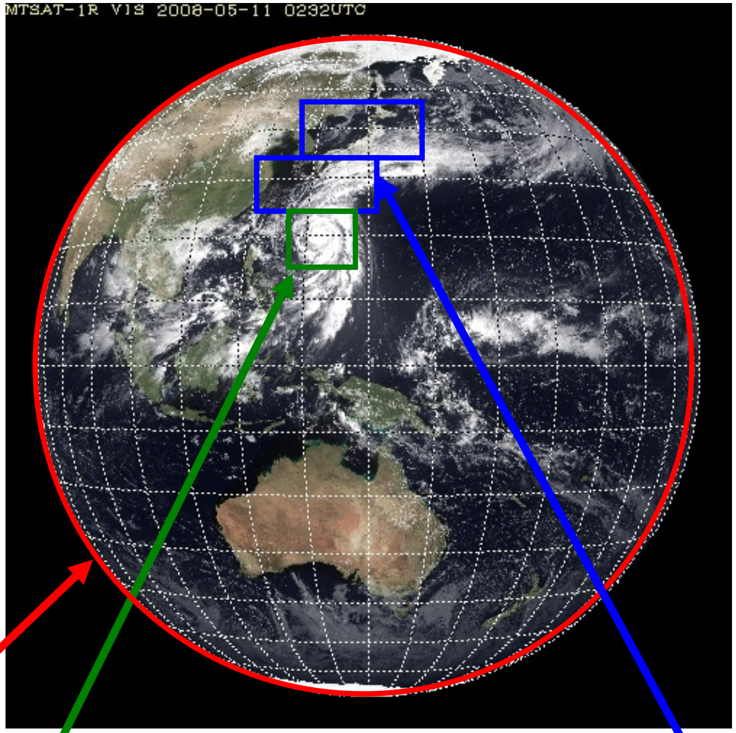
> I. spatial resolution may be upgraded to 9 pixel (27km at nadir)
> II. Dissemination frequency may be every 30 minutes
> after line speed problem is resolved (hopefully at 2018 or 2019)

- **Himawari-8 AMV for meso-scale NWP model**
  - Currently not disseminated to overseas
  - 3.7, 10.4 (IR), 6.2, 6.9, 7.3 (WV) , 0.6 (VIS) winds are available
  - Spatial resolution : 10 pixel grid (20 km resolution at nadir)
  - Target box size : 7x7 and 31x31
  - Time interval of input imagery : 10 minutes (from full disk observation mode)
  - Japan area only

Himawari-8/9: Specification of Observation

Channels of the Advanced Himawari Imager (AHI) to be carried by Himawari-8/9

Channel	Central Wavelength [µm]	Spatial Resolution	
1	0.43 – 0.48	1 km	RGB Composited True Color Image
2	0.50 – 0.52	1 km	
3	0.63 – 0.66	0.5 km	
4	0.85 – 0.87	1 km	
5	1.60 – 1.62	2 km	
6	2.25 – 2.27	2 km	
7	3.74 – 3.96	2 km	
8	6.06 – 6.43	2 km	Water Vapor
9	6.89 – 7.01	2 km	
10	7.26 – 7.43	2 km	
11	8.44 – 8.76	2 km	SO_2
12	9.54 – 9.72	2 km	O_3
13	10.3 – 10.6	2 km	Atmospheric Windows
14	11.1 – 11.3	2 km	
15	12.2 – 12.5	2 km	
16	13.2 – 13.4	2 km	CO_2



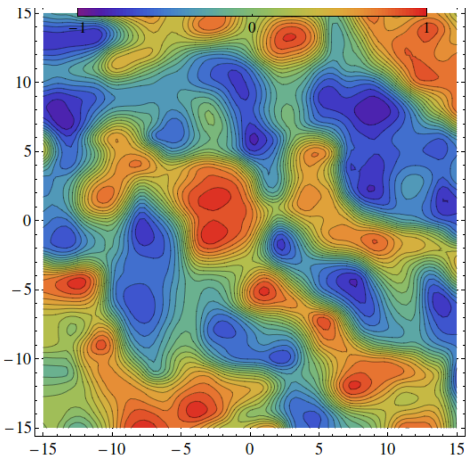
Full disk
Interval: **10 minutes** (6 times per hour)

Region: Japan
Interval: **2.5 minutes** (4 times in 10 minutes)
Dimension: EW x NS: 2000 x 1000 km x 2

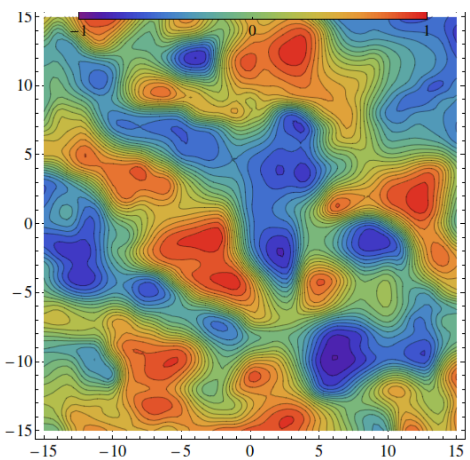
Region: Typhoon
Interval: **2.5 minutes** (4 times in 10 minutes)
Dimension: EW x NS: 1000 x 1000 km

Maximum Likelihood Estimation Approach for small Scale AMV

1. To equate cross-correlation with log likelihood function
2. To compute average of two log likelihood function surface from forward and backward matching
3. To search vector which maximize the averaged log likelihood function

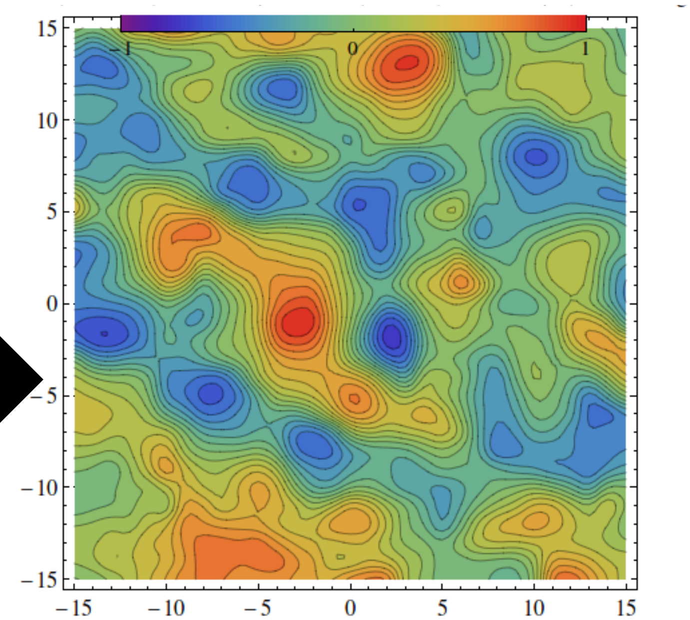


auxiliary information
Correlation surface from backward motion



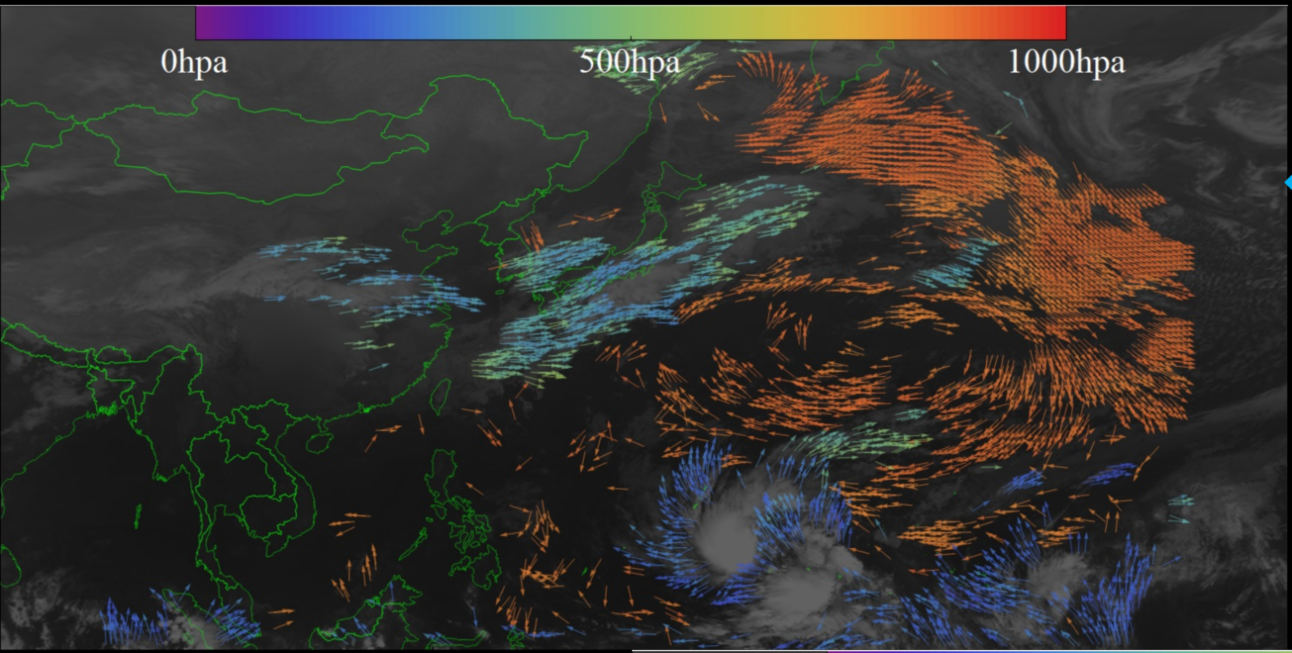
prior information
Correlation surface from forward motion

probabilistic inference
to regard correlation surface as log likelihood function



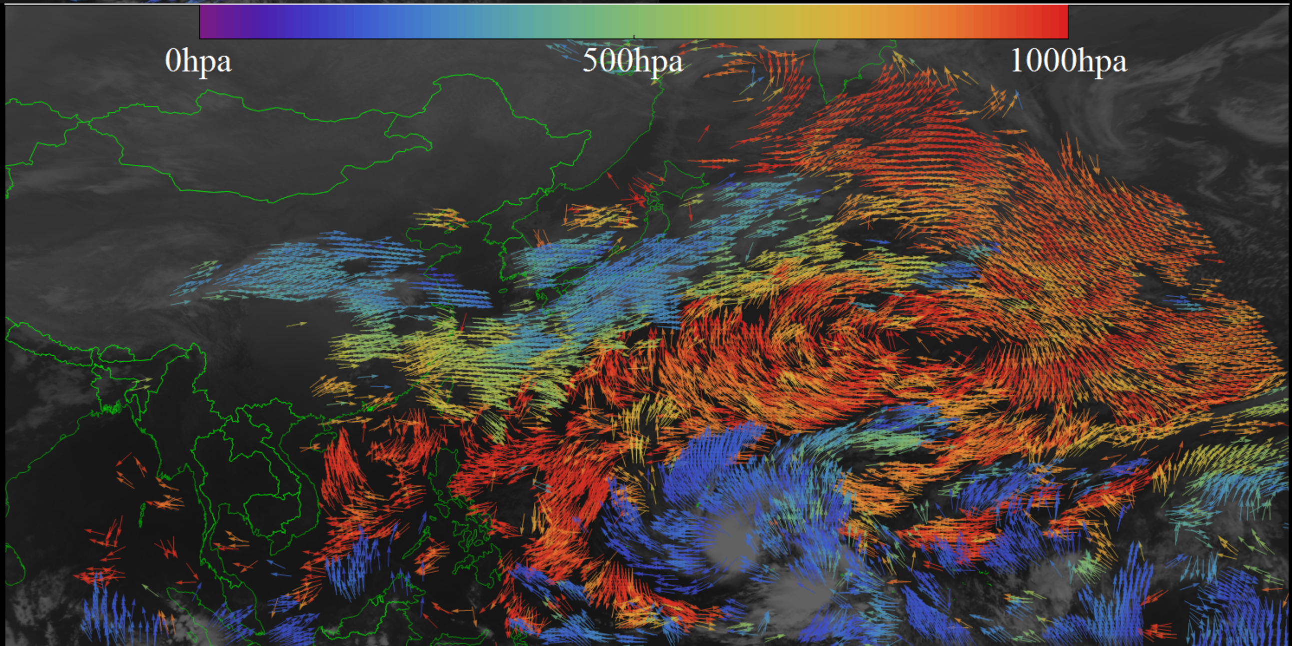
posterior information
averaged correlation surfaces

Changes of AMV derivation software for Himawari-8

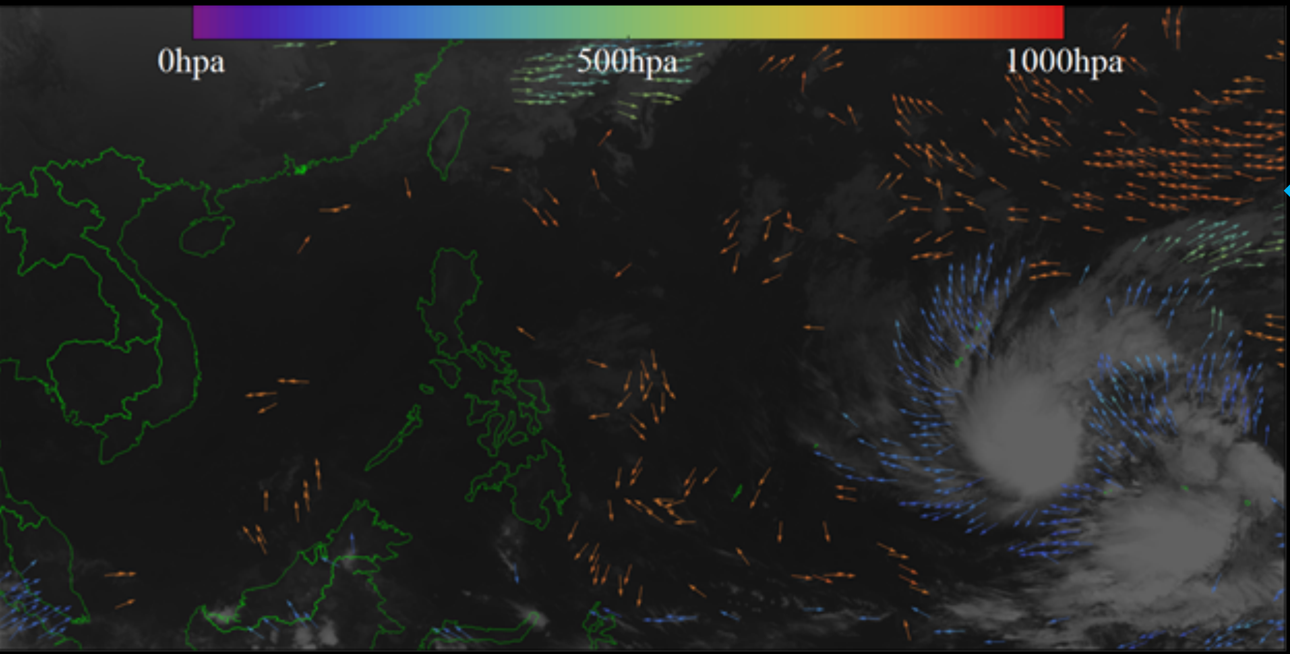


MTSAT IR AMV computed by **MTSAT AMV software** (QI>80) for 00UTC 02 March 2014

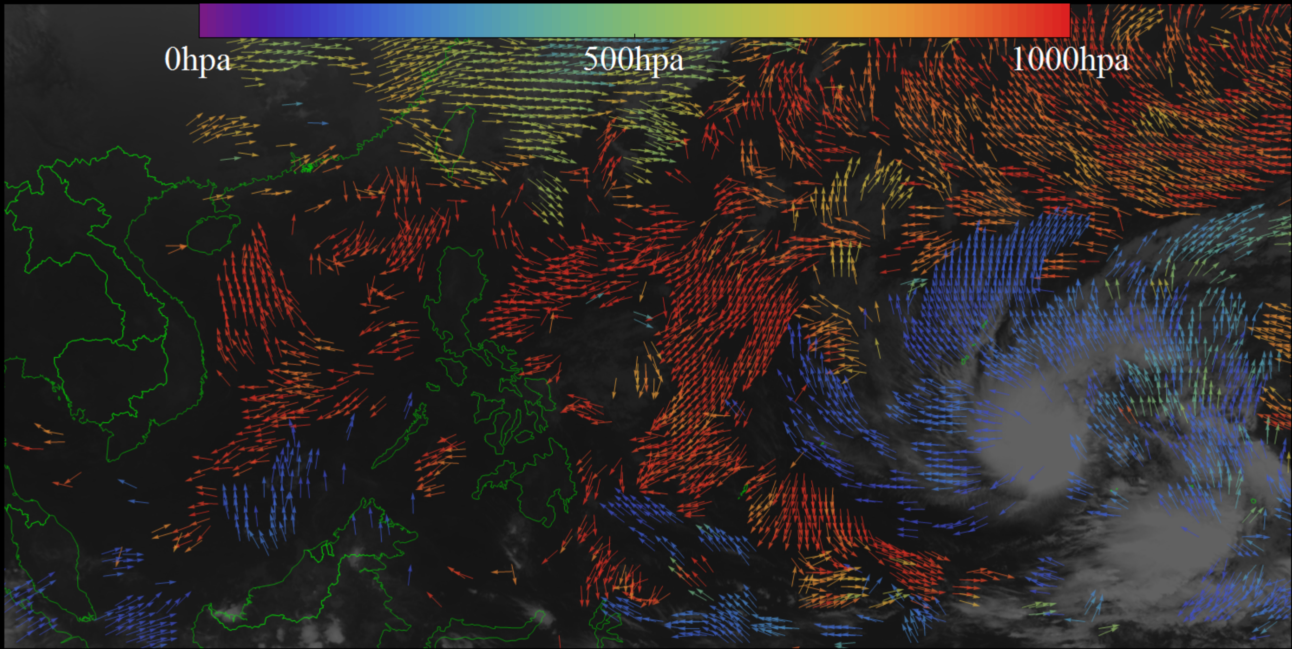
MTSAT IR AMV computed by **H-8 AMV software** (QI>80) for 00UTC 02 March 2014



Changes of AMV derivation software for Himawari-8



MTSAT IR AMV computed by **MTSAT AMV software** (QI>80) for 00UTC 02 March 2014

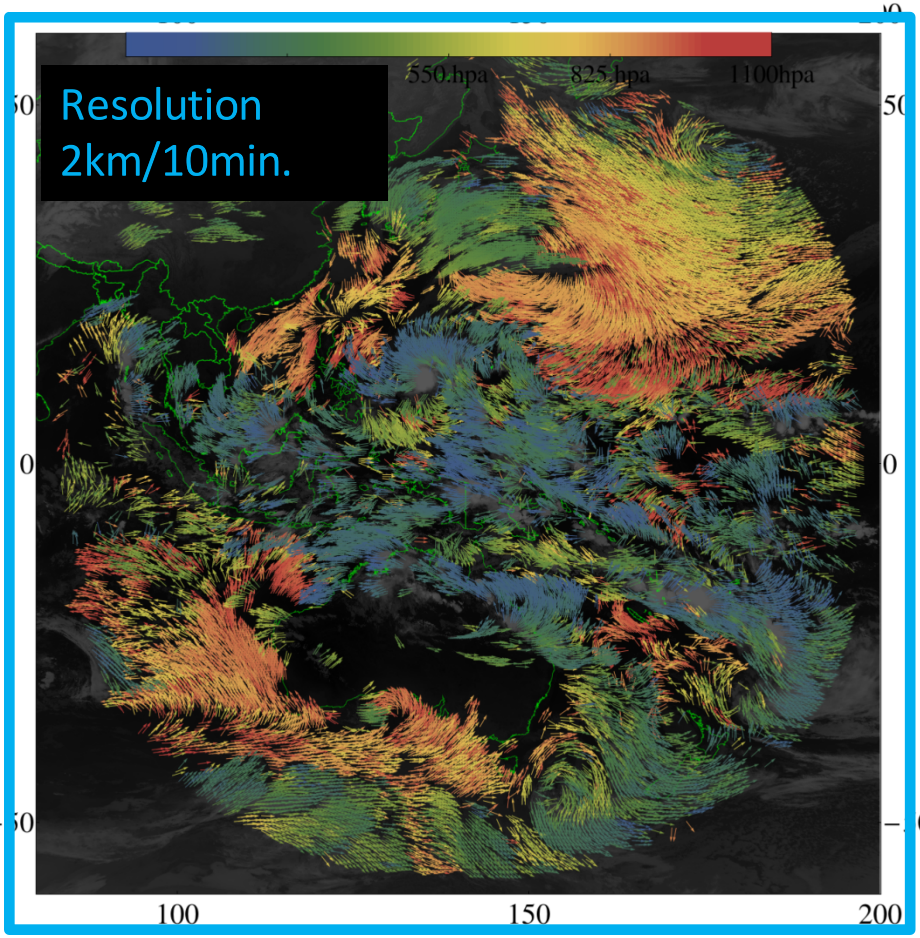


MTSAT IR AMV computed by **H-8 AMV software** (QI>80) for 00UTC 02 March 2014

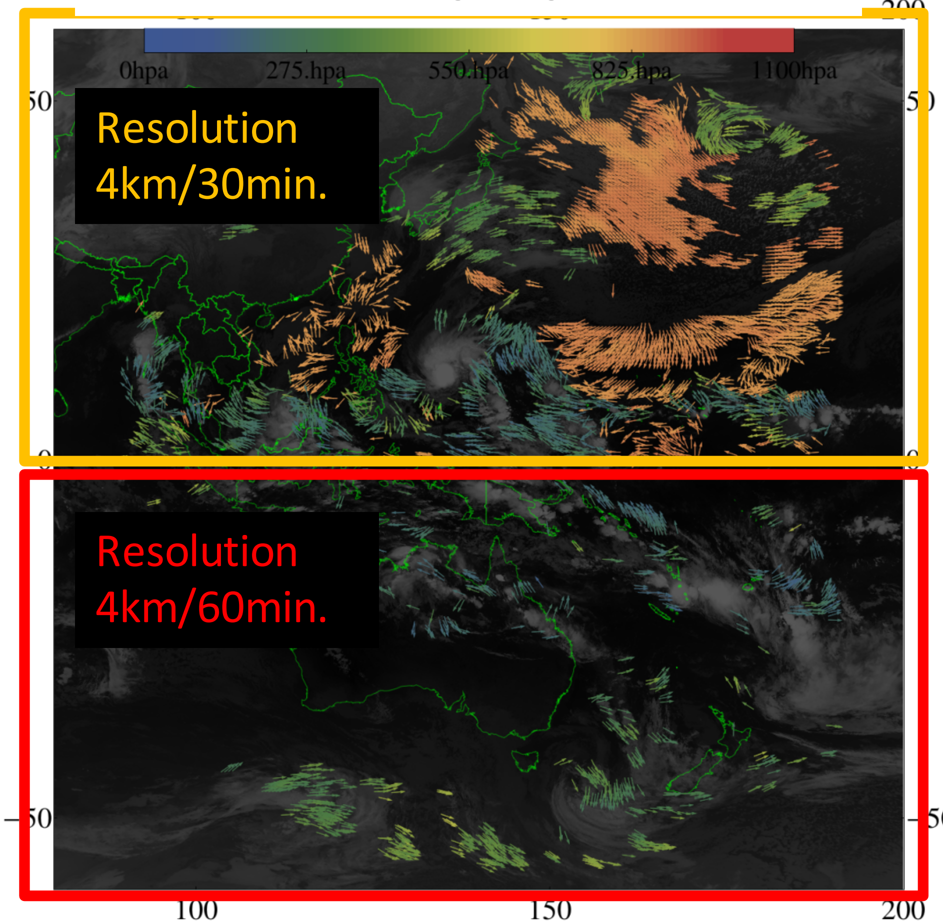
Synergy between new tracking algorithm and improvement to spatial/temporal resolution of AHI

Himawari-8 B13 and MTSAT-2 IR AMV (QI>60, 2015 01 14 1700UTC)

Himawari-8 AMV using Himawari-8 imagery and new algorithm



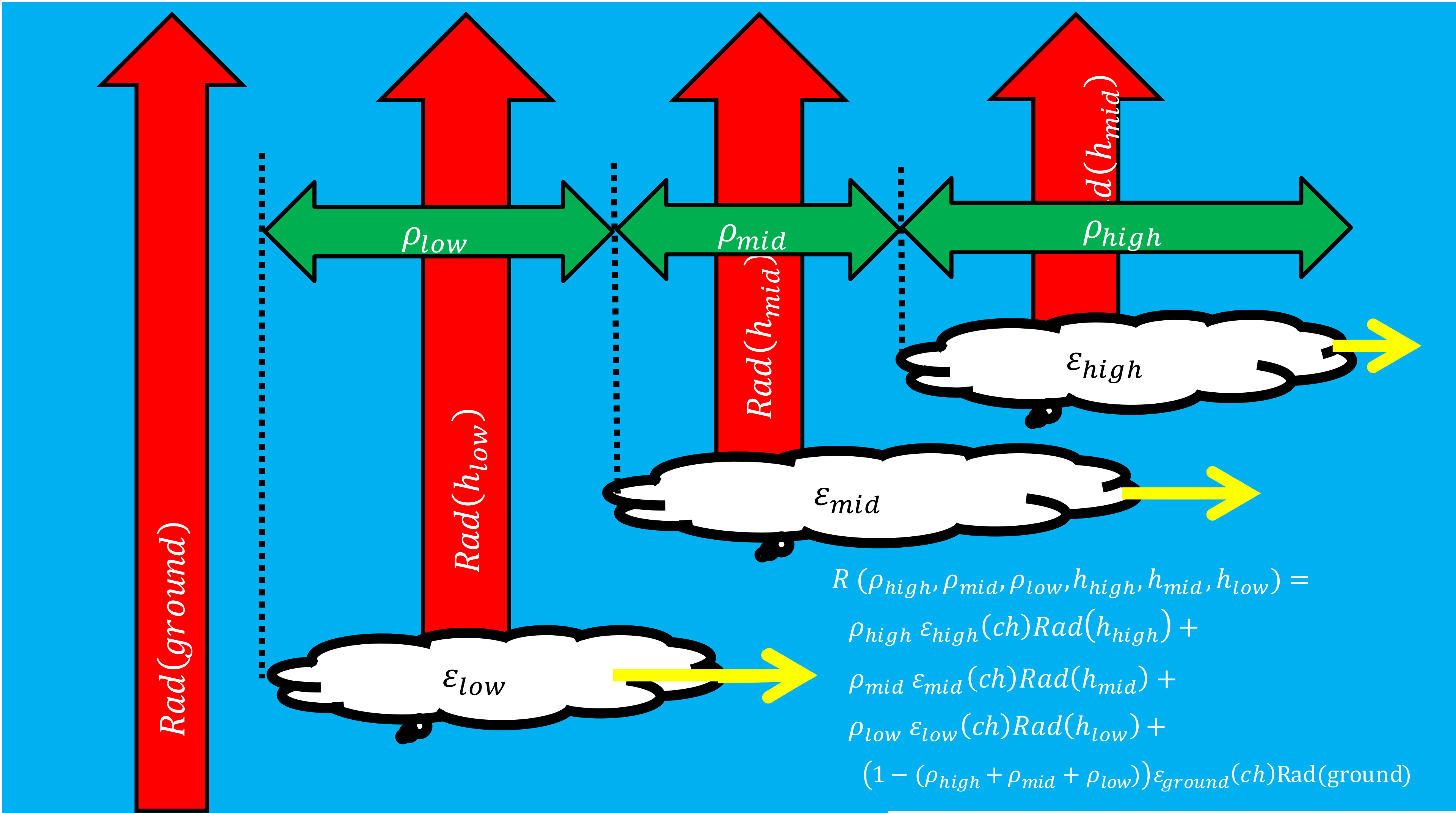
MTSAT-2 AMV using MTSAT-2 imagery and heritage algorithm



Colder color : upper level wind

warmer color : low level wind

Optimal estimation method using radiance rationing model



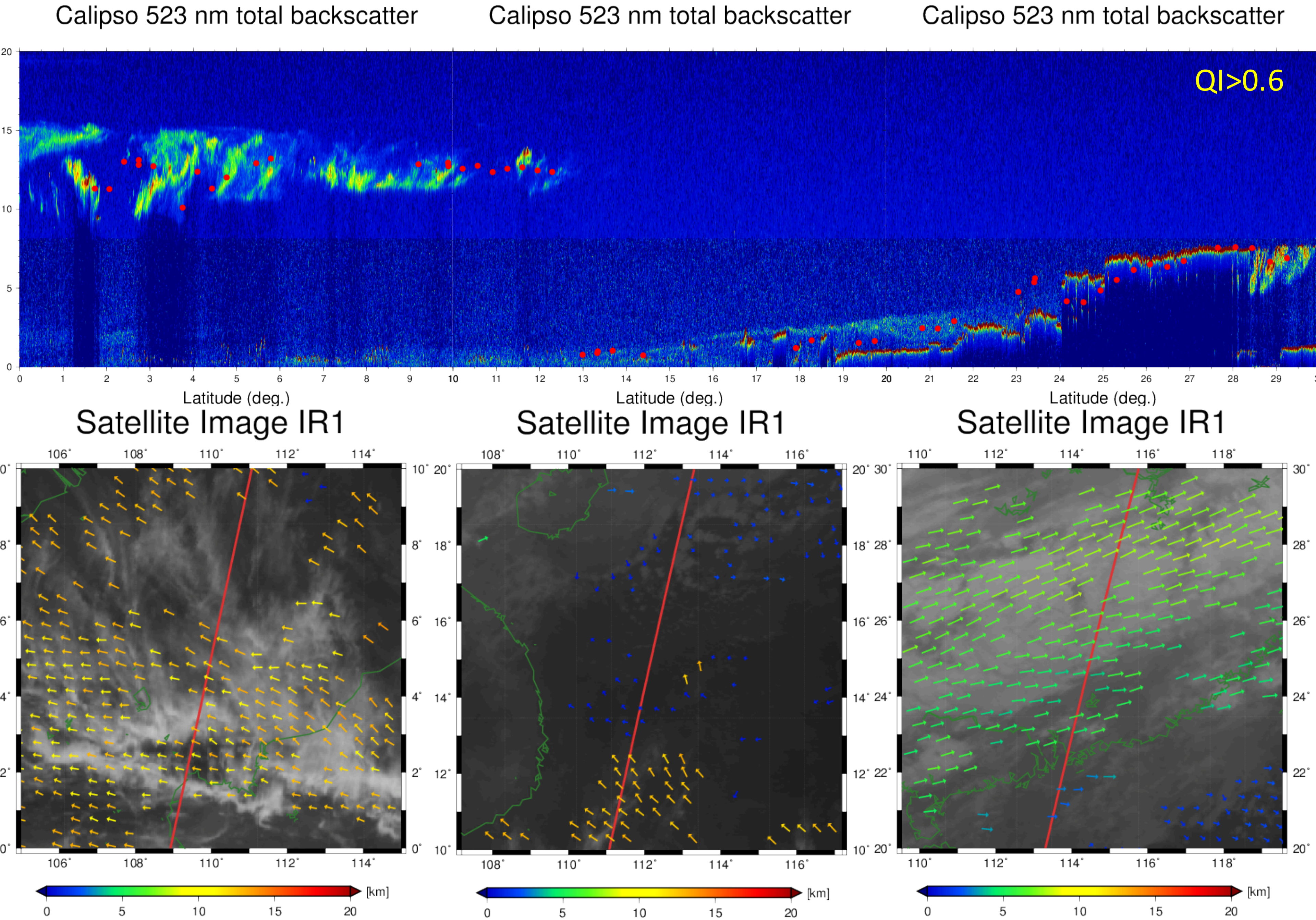
$$R\,(\rho_{high}, \rho_{mid}, \rho_{low}, h_{high}, h_{mid}, h_{low}) =$$
$$\rho_{high}\,\varepsilon_{high}(ch)Rad(h_{high}) +$$
$$\rho_{mid}\,\varepsilon_{mid}(ch)Rad(h_{mid}) +$$
$$\rho_{low}\,\varepsilon_{low}(ch)Rad(h_{low}) +$$
$$(1-(\rho_{high}+\rho_{mid}+\rho_{low}))\varepsilon_{ground}(ch)\mathrm{Rad(ground)}$$

ε_{ground}

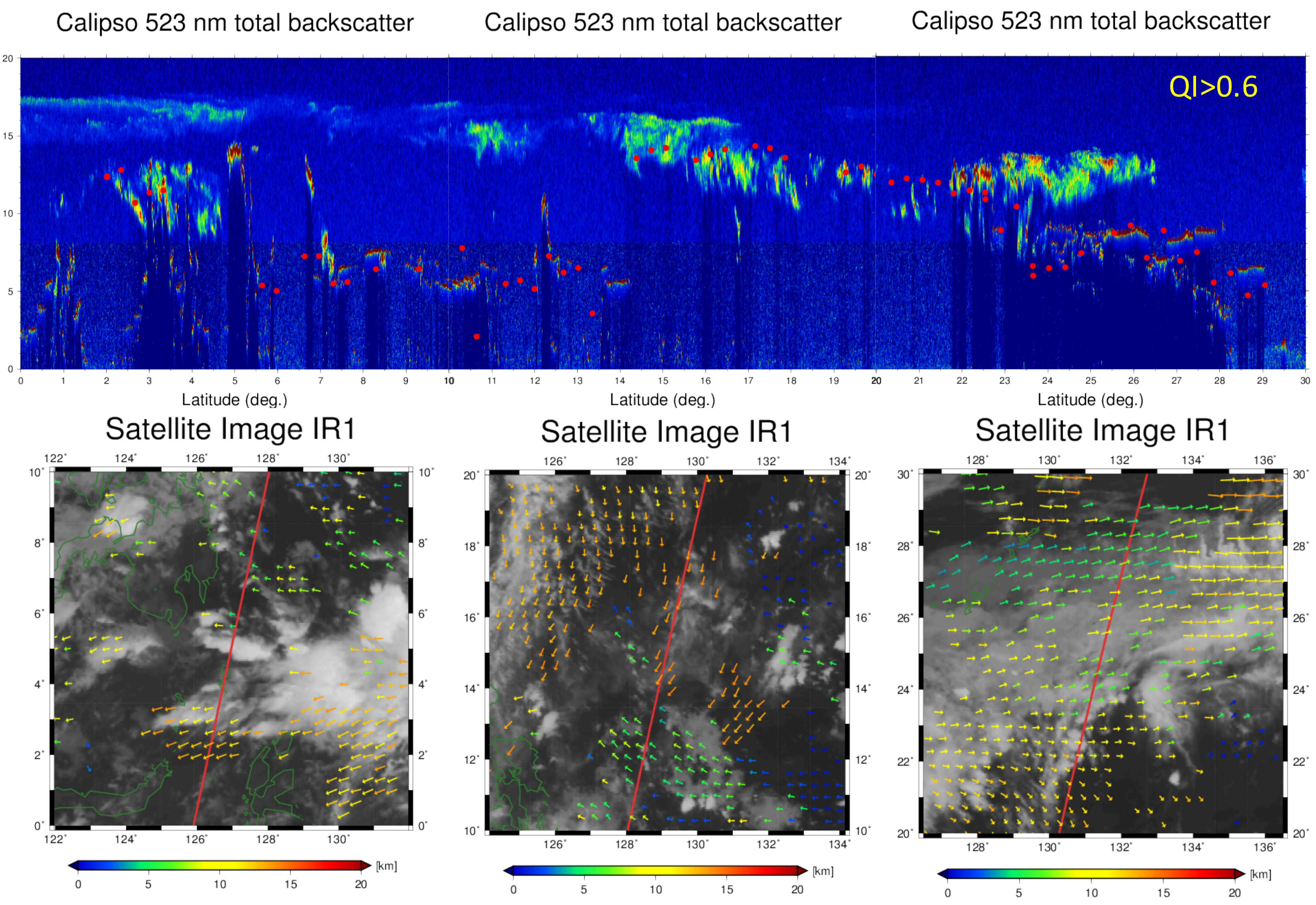
$$\prod_{ch}^{N} e^{-\frac{(R_{obs}-R\,(\rho_{high},\rho_{mid},\rho_{low},h_{high},h_{mid},h_{low}))^{2}}{2\,\sigma^2}}$$

$$\prod_{ch}^{N_{ch}}\left(1-\prod_{layer}^{N_{layer}}\left(1-e^{-\frac{\left(\overrightarrow{v_{obs}}-\overrightarrow{v_{nwp}}(h_{layer})\right)^2}{2\,\sigma^2}}\right)\right)$$

MTSAT IR AMVs by H8 software (vs CALIPSO at 2014-02-18 18UTC)



MTSAT IR AMVs by H8 software (vs CALIPSO 2014-06-13 18UTC)



Himawari-8 channels for AMV height estimation

Channels of the Advanced Himawari Imager (AHI) to be carried by Himawari-8/9

Channel	Central Wavelength [µm]	Spatial Resolution
1	0.43 – 0.48	1 km
2	0.50 – 0.52	1 km
3	0.63 – 0.66	0.5 km
4	0.85 – 0.87	1 km
5	1.60 – 1.62	2 km
6	2.25 – 2.27	2 km
7	3.74 – 3.96	2 km
8	6.06 – 6.43	2 km
9	6.89 – 7.01	2 km
10	7.26 – 7.43	2 km
11	8.44 – 8.76	2 km
12	9.54 – 9.72	2 km
13	10.3 – 10.6	2 km
14	11.1 – 11.3	2 km
15	12.2 – 12.5	2 km
16	13.2 – 13.4	2 km

- 6 bands are simultaneously used for HA
- averaged radiance in target box is used

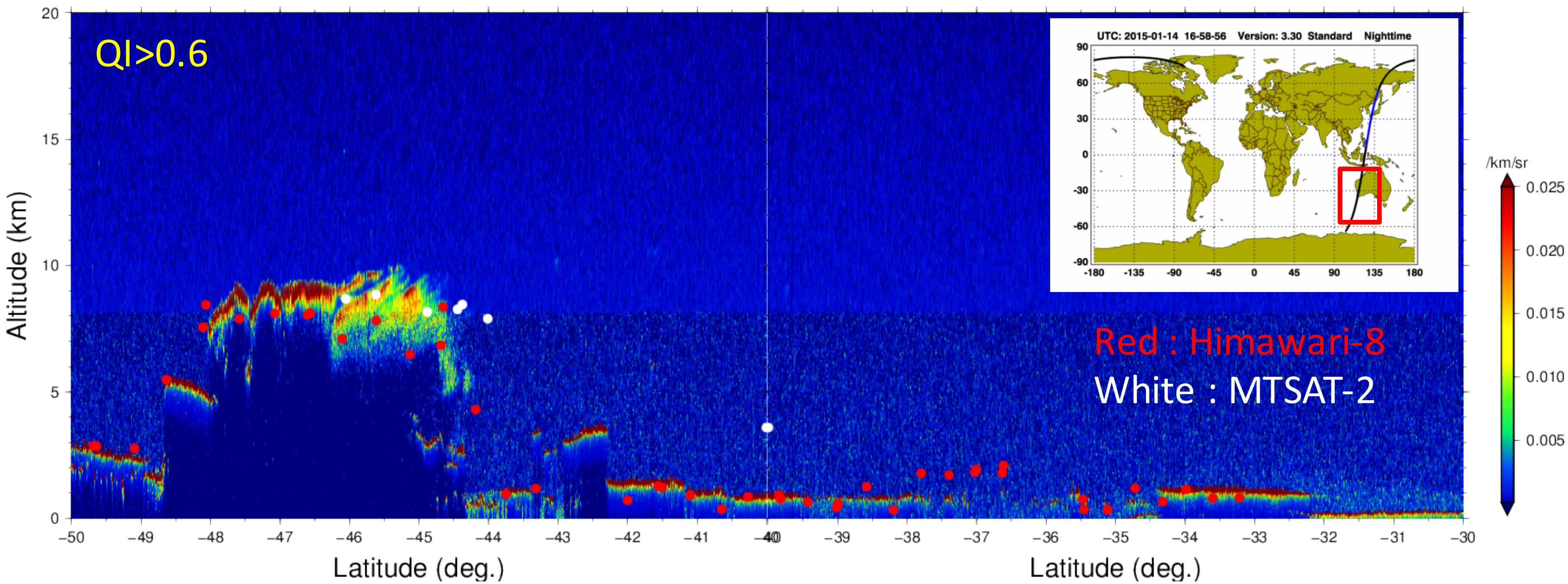
WV bands : including upper level information

window bands : all level information

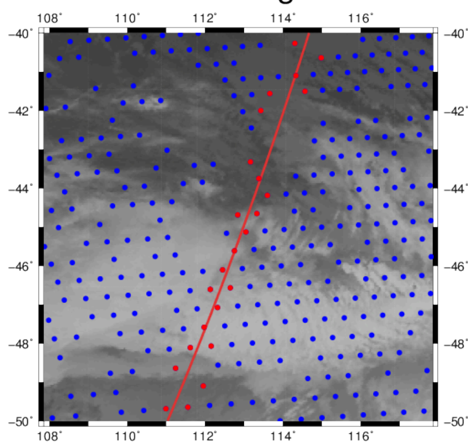
CO2 band : upper and middle level information

Collocation study (B13/IR1 wind with CALIPSO) (2015 01 14 1700UTC)

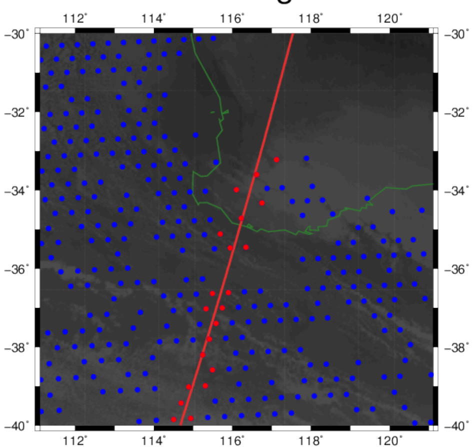
Calipso 523 nm total backscatter　　Calipso 523 nm total backscatter



Satellite Image B13

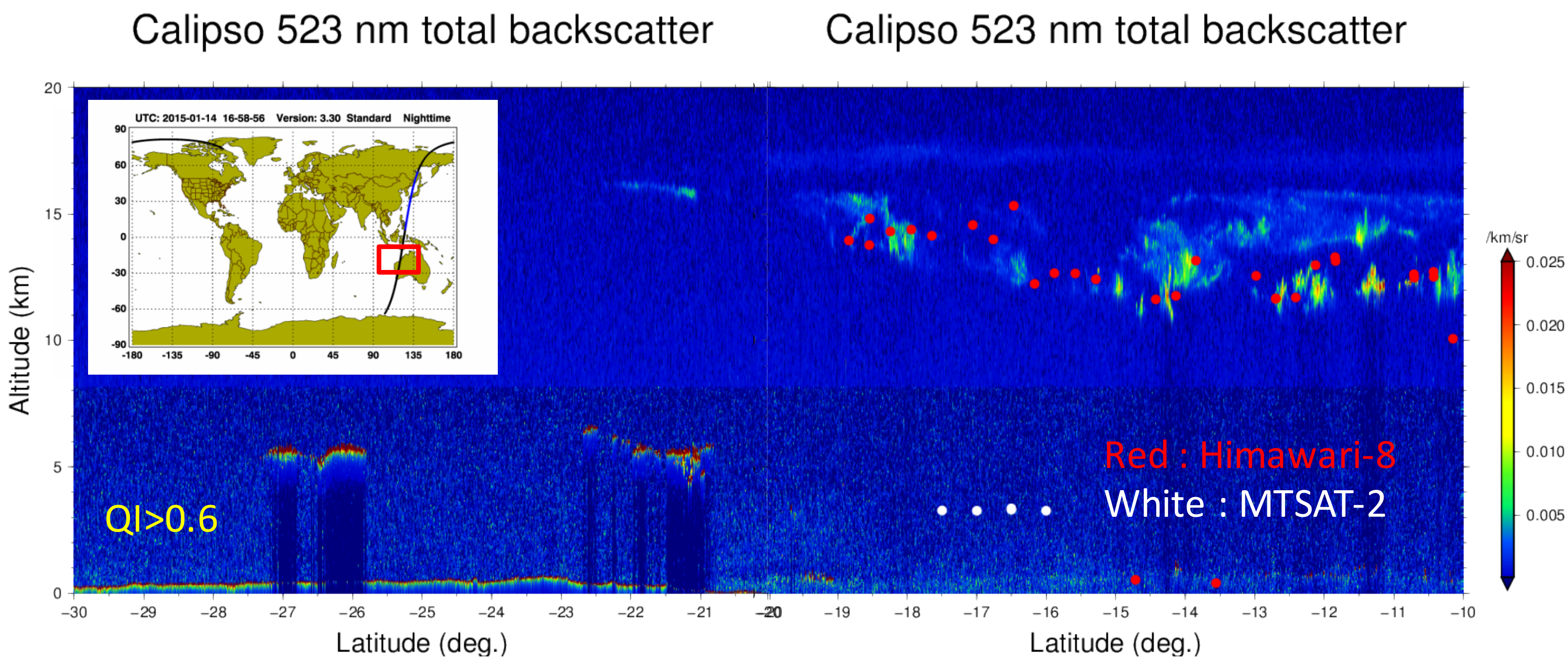


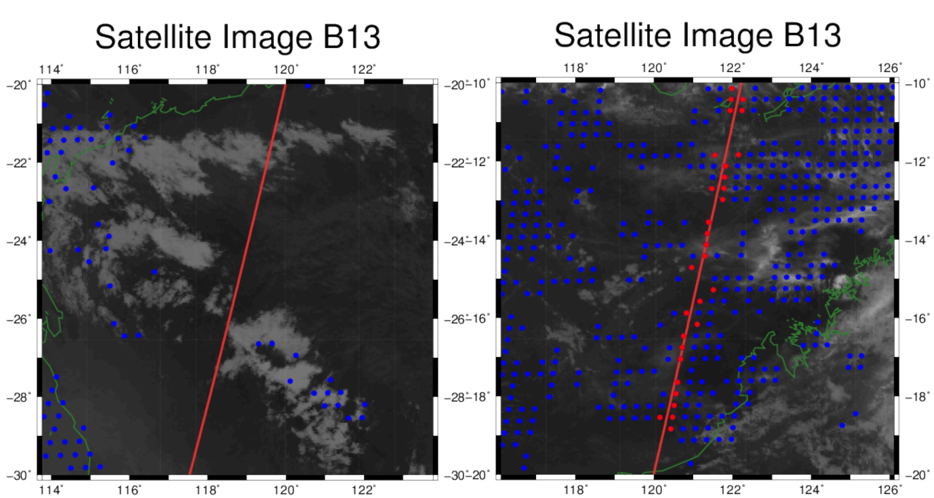
Satellite Image B13



- Dense cloud height on middle and high level correspond to CALIPSO well
- Height error of low level cloud is larger than that of high and middle cloud

Collocation study (B13/IR1 wind with CALIPSO) (2015 01 14 1700UTC)



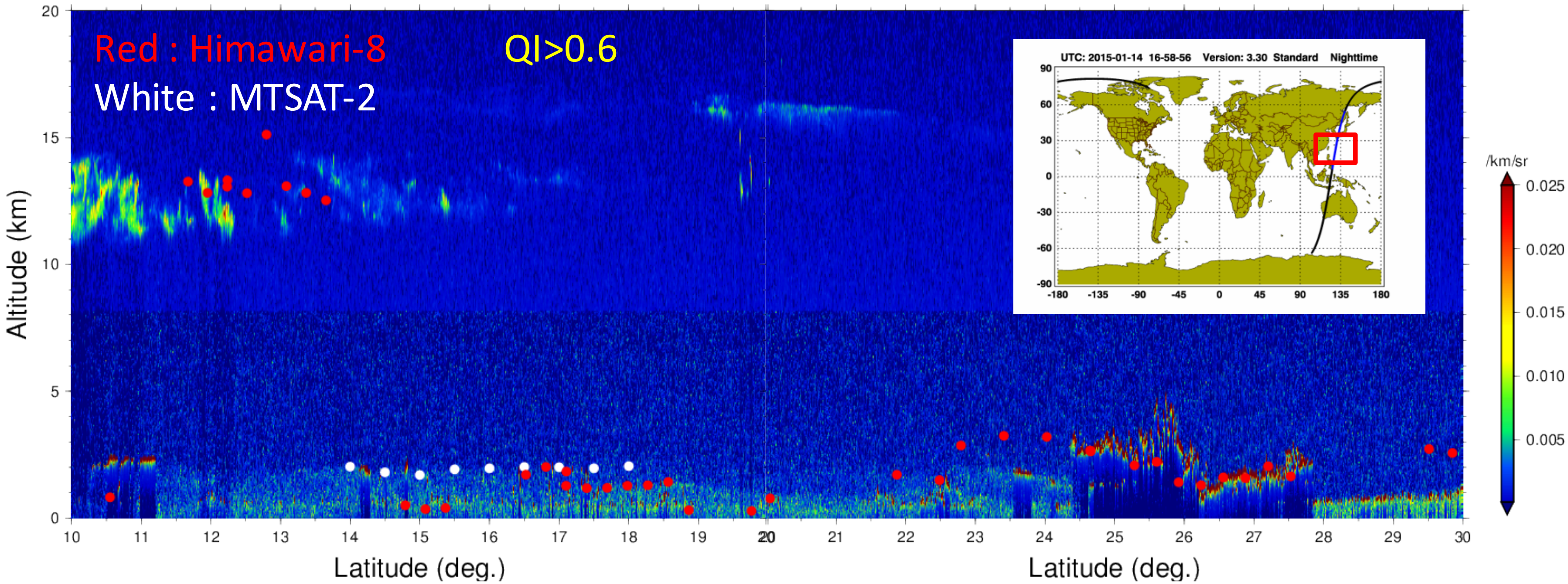


- Height of semitransparent cirrus over cumulus is generally consistent with CALIPSO
- Sophistication for optimal layer selection method in multiple layer situation required

Collocation study (B13/IR1 wind with CALIPSO) (2015 01 14 1700UTC)

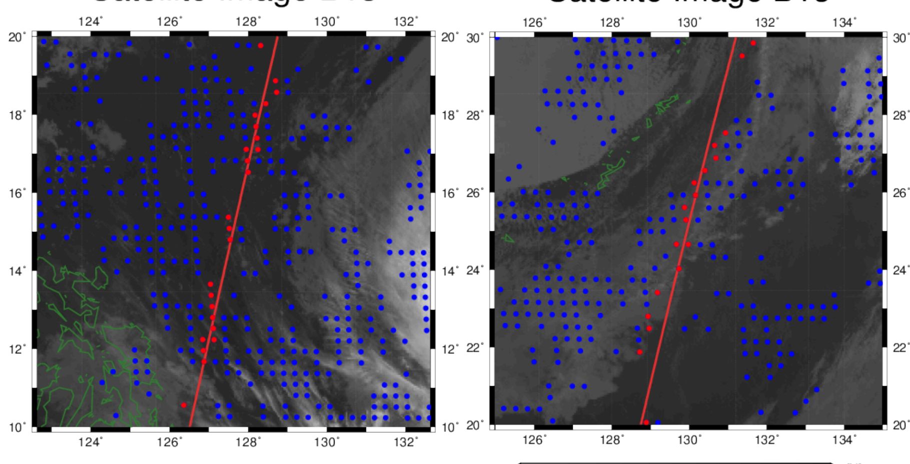
Calipso 523 nm total backscatter

Calipso 523 nm total backscatter



Satellite Image B13

Satellite Image B13



- Very mall fractional clouds at low level are sometimes assigned to lower than MTSAT AMV

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IR AMV sonde statistic for summer season（Himawari-8 vs MTSAT ）

Period : August 1 – August 31 2015 (QI > 0.85）

Himawari-8 AMV using Himawari-8 imagery and new algorithm

HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	4.88	5.25	4.52	5.25
RMSVD	5.82	6.20	5.40	6.50
BIAS	−0.1	0.04	−0.23	−0.16
SPD	19.07	22.08	15.93	29.89

MED-LEVEL (400-700hPa)	ALL	NH	TROP	SH
MVD	3.97	4.05	3.42	4.81
RMSVD	4.67	4.75	4.00	5.59
BIAS	−0.12	0.03	−0.28	−0.28
SPD	12.28	12.23	8.94	19.24

LOW-LEVEL (700hpa -)	ALL	NH	TROP	SH
MVD	3.22	2.99	3.21	3.44
RMSVD	3.86	3.71	3.8	4.08
BIAS	0.54	0.04	0.84	0.45
SPD	8.85	8.26	8.23	10.55

MTSAT-2 AMV using MTSAT-2 imagery and heritage algorithm

HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	5.11	5.71	4.4	5.68
RMSVD	6.17	6.84	5.26	6.99
BIAS	−0.66	−0.87	−0.36	−1.83
SPD	18.07	21.55	13.56	27.11

MED-LEVEL (400-700hPa)	ALL	NH	TROP	SH
MVD	4.96	4.81	4.11	5.76
RMSVD	6.05	5.66	4.91	7.21
BIAS	−0.35	0.07	−0.39	−0.99
SPD	16.52	14.3	11.87	23.04

LOW-LEVEL (700hpa -)	ALL	NH	TROP	SH
MVD	3.32	3.04	3.27	3.62
RMSVD	3.95	3.86	3.88	4.17
BIAS	0.26	−0.43	0.52	0.23
SPD	8.12	7.44	8.05	8.78

- BIAS (AMV-sonde) is mitigated on high and middle level
- Improvement to RMSVD can be seen in middle level.

Red : improved (over 0.5 m/s)
Green : neutral
Blue : debased (over 0.5 m/s)

Note: AMV minus ground truth (RAWIN)
MVD = Mean Vector Difference
RMSVD = Vector Difference RMS
BIAS = Speed Bias
SPD = Wind Speed

IR AMV sonde statistic for winter season（Himawari-8 vs MTSAT）

Period : December 1 – December 31 2015 (QI > 0.85）

Himawari-8 AMV using Himawari-8 imagery and new algorithm

HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	4.77	5.73	4.10	5.08
RMSVD	5.72	6.75	4.87	6.07
BIAS	−0.32	−0.38	−0.34	0.04
SPD	24.2	40.49	12.96	27.57

MED-LEVEL (400-700hPa)	ALL	NH	TROP	SH
MVD	4.58	4.74	3.72	4.32
RMSVD	5.48	5.65	4.55	5.05
BIAS	−0.19	−0.24	−0.16	0.52
SPD	19.69	21.78	8.56	15.37

LOW-LEVEL (700hpa -)	ALL	NH	TROP	SH
MVD	3.39	3.57	3.01	3.60
RMSVD	4.06	4.28	3.60	4.19
BIAS	0.22	−0.14	0.84	0.38
SPD	9.90	10.46	9.09	9.12

MTSAT-2 AMV using MTSAT-2 imagery and heritage algorithm

HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	4.90	6.56	3.78	5.71
RMSVD	5.99	7.80	4.42	6.77
BIAS	−0.74	−1.4	−0.47	−0.28
SPD	18.8	33.32	9.43	23.93

MED-LEVEL (400-700hPa)	ALL	NH	TROP	SH
MVD	5.79	5.94	5.67	4.78
RMSVD	7.03	7.21	6.99	5.56
BIAS	−1.76	−1.79	−2.6	−1.21
SPD	21.45	22.32	11.97	18.5

LOW-LEVEL (700hpa -)	ALL	NH	TROP	SH
MVD	3.62	4.04	2.95	3.88
RMSVD	4.25	4.69	3.48	4.41
BIAS	−0.13	−0.57	0.39	0.02
SPD	9.55	10.49	8.66	8.76

- Negative speed BIAS (AMV-sonde) in winter season is mitigated
- RMSVD is decreased in high and middle level

Red : improved (over 0.5 m/s)

Green : neutral

Blue : debased (over 0.5 m/s)

Note: AMV minus ground truth (RAWIN)
MVD = Mean Vector Difference
RMSVD = Vector Difference RMS
BIAS = Speed Bias
SPD = Wind Speed

WV AMV sonde statistic for summer season（Himawari-8 vs MTSAT ）

Period : August 1 – August 31 2015 (QI > 0.85）

Himawari-8 AMV using Himawari-8 imagery and new algorithm

HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	5.07	5.51	4.71	5.41
RMSVD	6.07	6.55	5.64	6.71
BIAS	0.4	0.72	0.16	0.16
SPD	20.27	23.52	17.43	32.37

MTSAT-2 AMV using MTSAT-2 imagery and heritage algorithm

HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	5.45	5.90	4.89	5.80
RMSVD	6.53	7.00	5.90	6.99
BIAS	0.79	0.7	0.91	0.39
SPD	19.81	23.41	15.12	28.79

- Quality is almost same for WV high level winds in summer

Red : improved (over 0.5 m/s)
Green : neutral
Blue : debased (over 0.5 m/s)

Note: AMV minus ground truth (RAWIN)
MVD = Mean Vector Difference
RMSVD = Vector Difference RMS
BIAS = Speed Bias
SPD = Wind Speed

WV AMV sonde statistic for winter season（Himawari-8 vs MTSAT）

Period : December 1 – December 31 2015 (QI > 0.85）

Himawari-8 AMV using Himawari-8 imagery and new algorithm

HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	4.81	5.8	4.2	5.29
RMSVD	5.76	6.83	4.98	6.36
BIAS	0.17	0.26	0.03	0.8
SPD	24.82	42.48	14.47	29.39

MTSAT-2 AMV using MTSAT-2 imagery and heritage algorithm

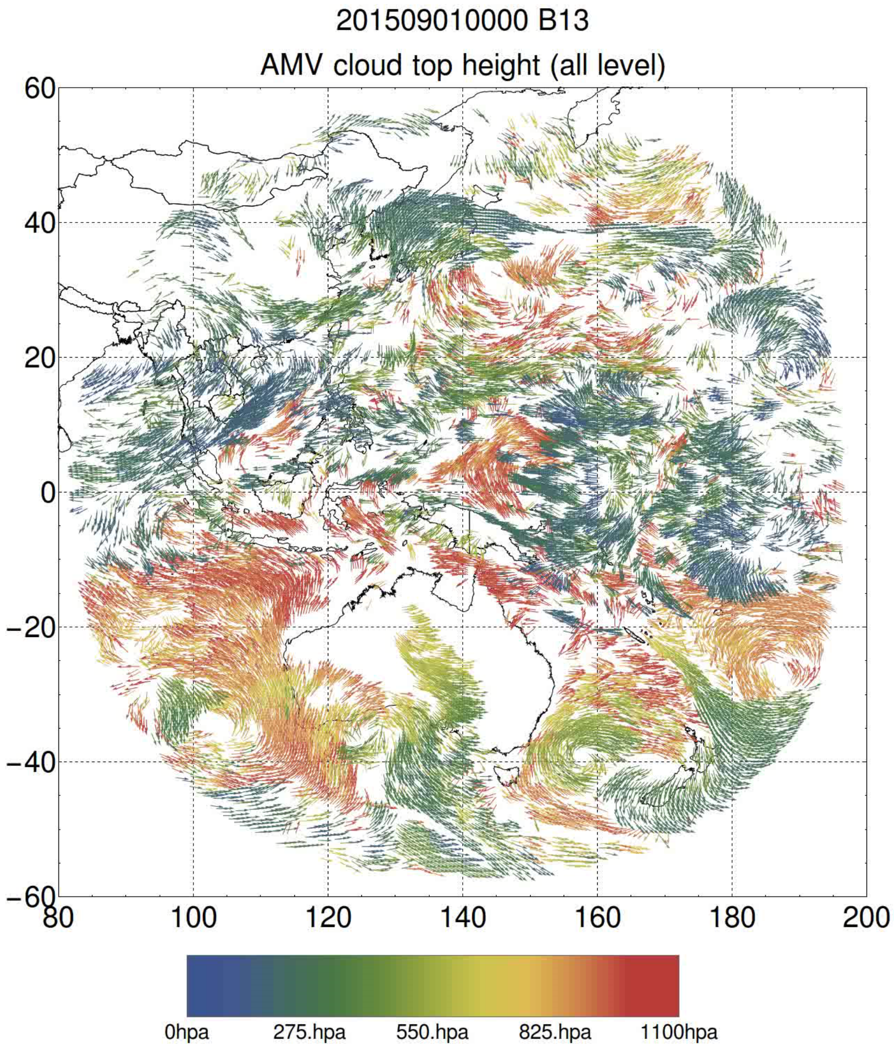
HIGH-LEVEL (-400hPa)	ALL	NH	TROP	SH
MVD	5.39	7.11	3.93	5.85
RMSVD	6.68	8.53	4.68	6.96
BIAS	0.99	1.19	0.66	1.68
SPD	23.96	40.22	10.69	26.63

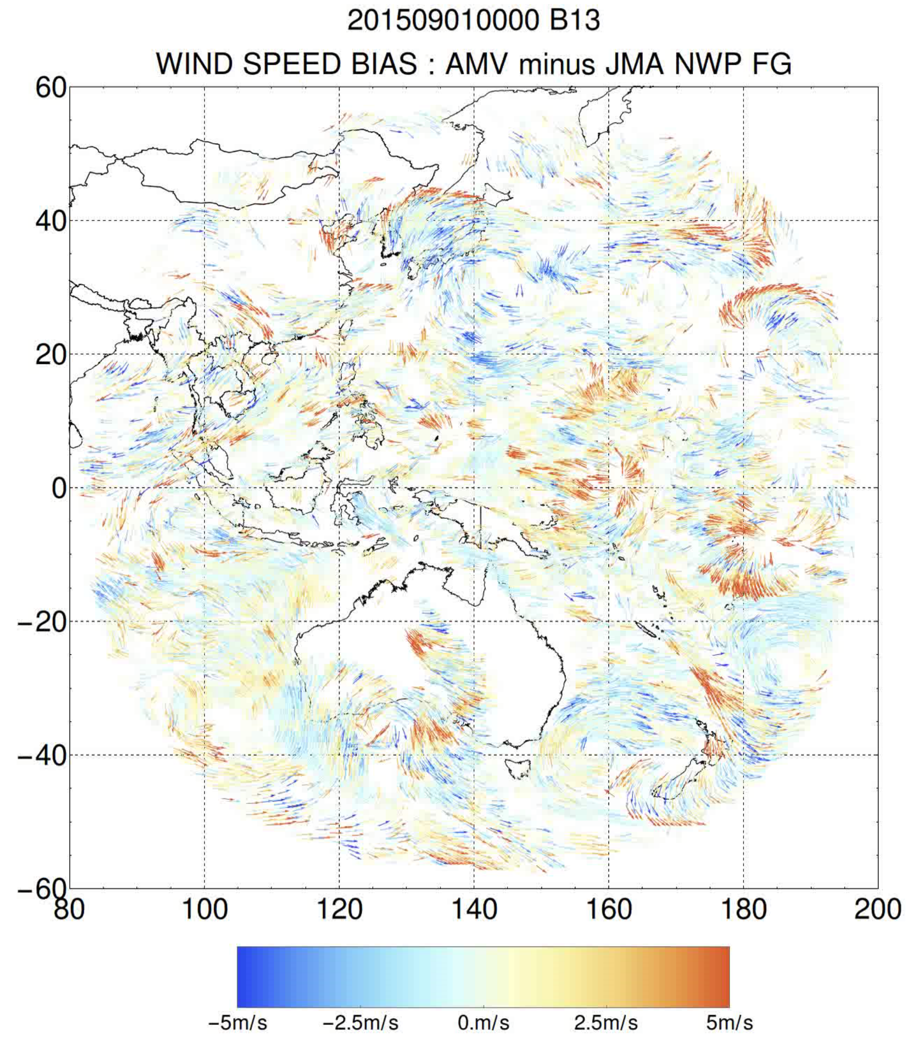
- Quality is totally improved for WV high level winds in winter season over all region

Red : improved (over 0.5 m/s)
Green : neutral
Blue : debased (over 0.5 m/s)

Note: AMV minus ground truth (RAWIN)
MVD = Mean Vector Difference
RMSVD = Vector Difference RMS
BIAS = Speed Bias
SPD = Wind Speed

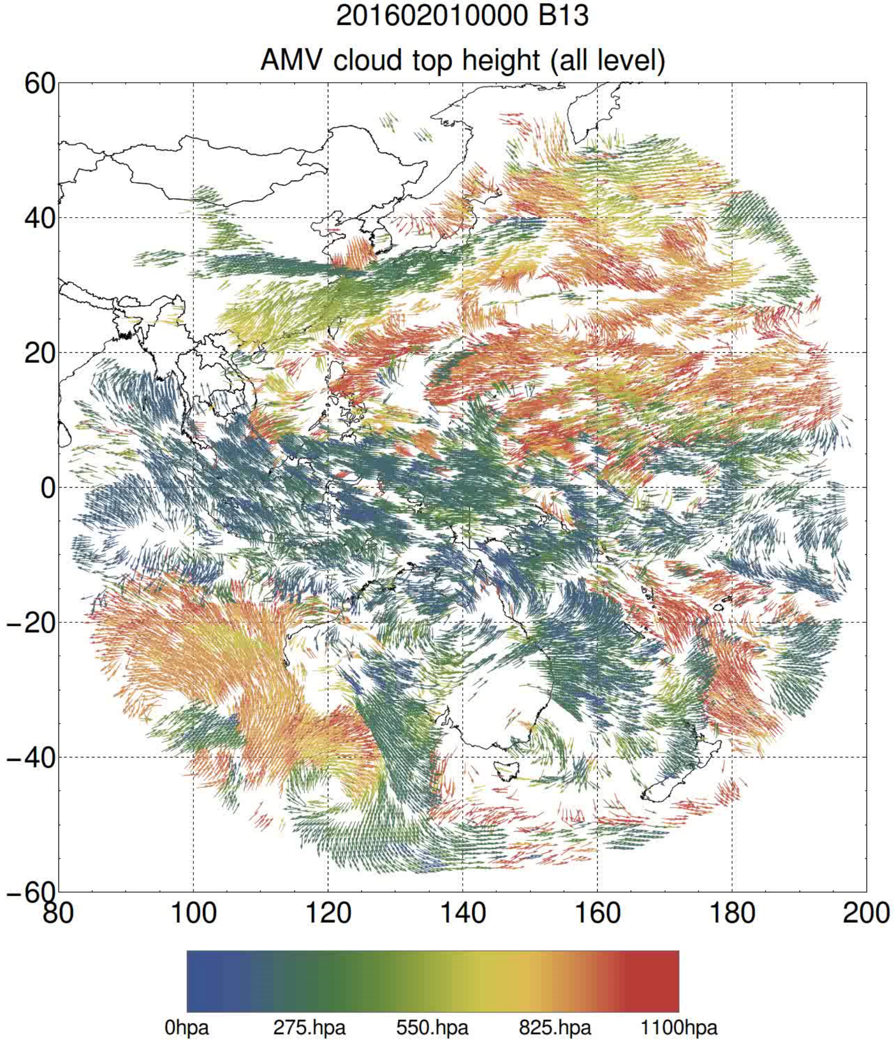
O-B analysis using JMA global model for 10.4um (IR) AMV at summer season (QI>60)

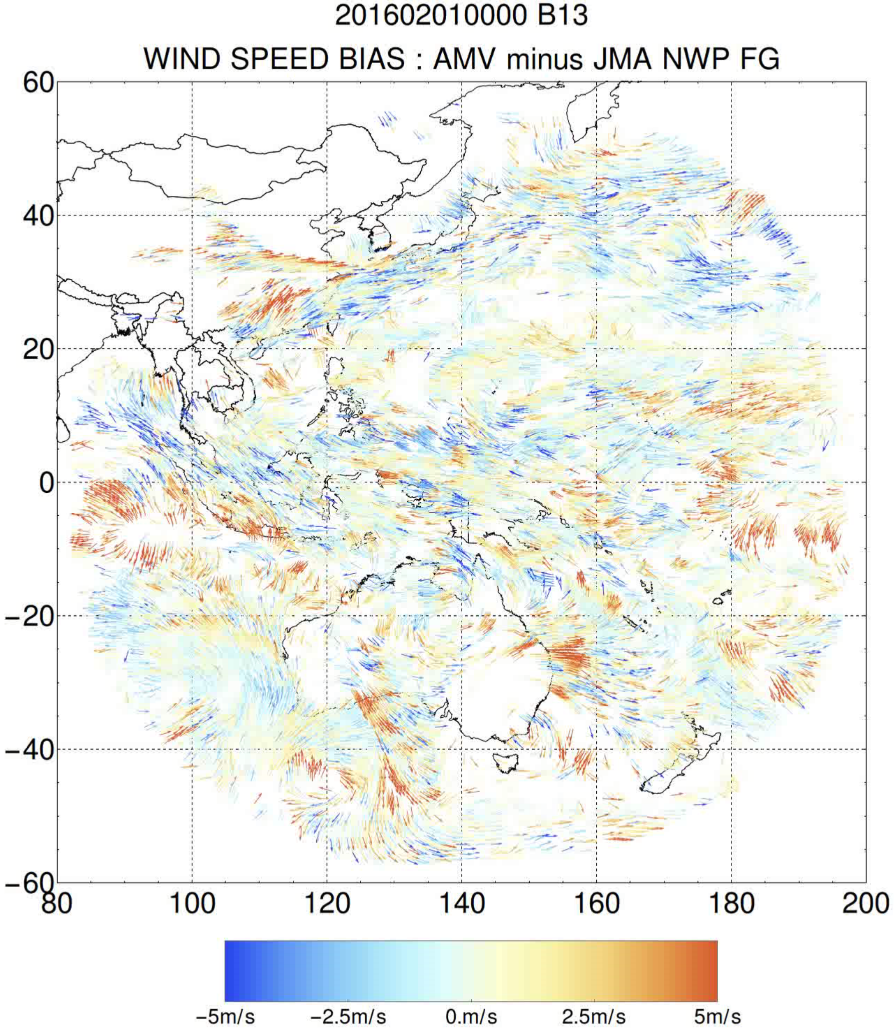




- Positive wind speed bias seen around convective area

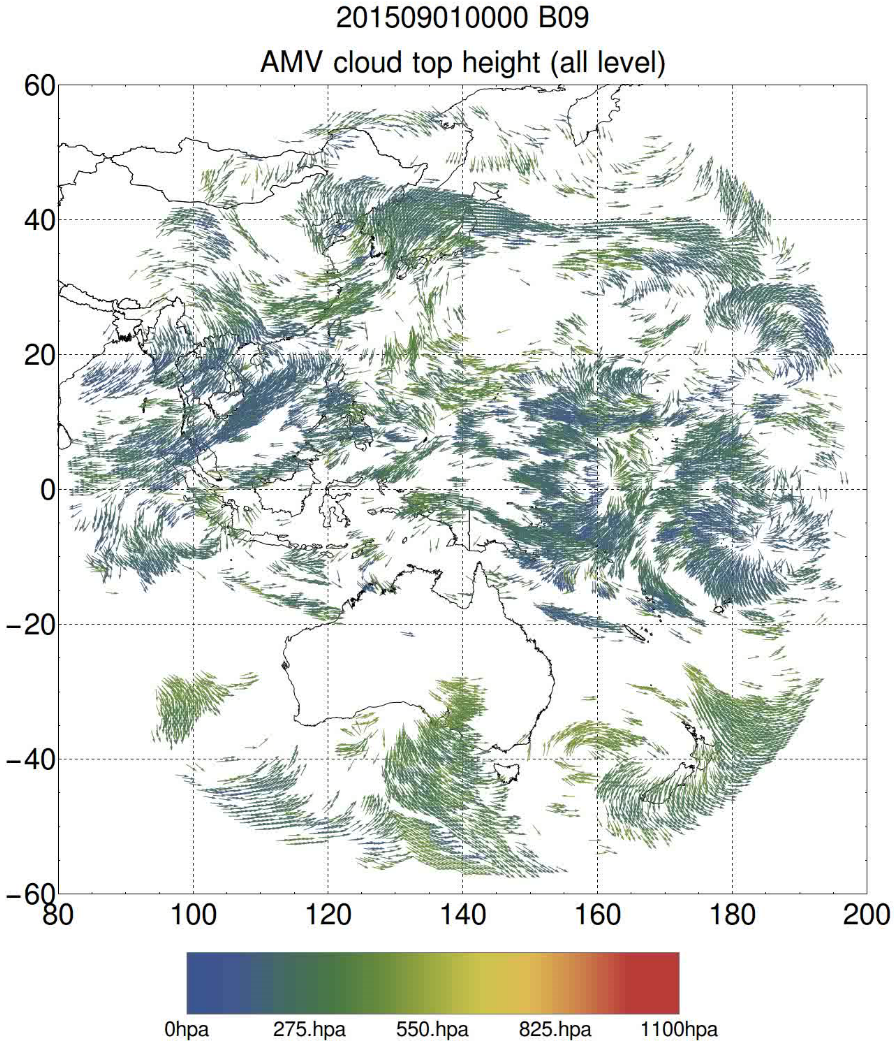
O-B analysis using JMA global model for 10.4um (IR) AMV at winter season (QI>60)

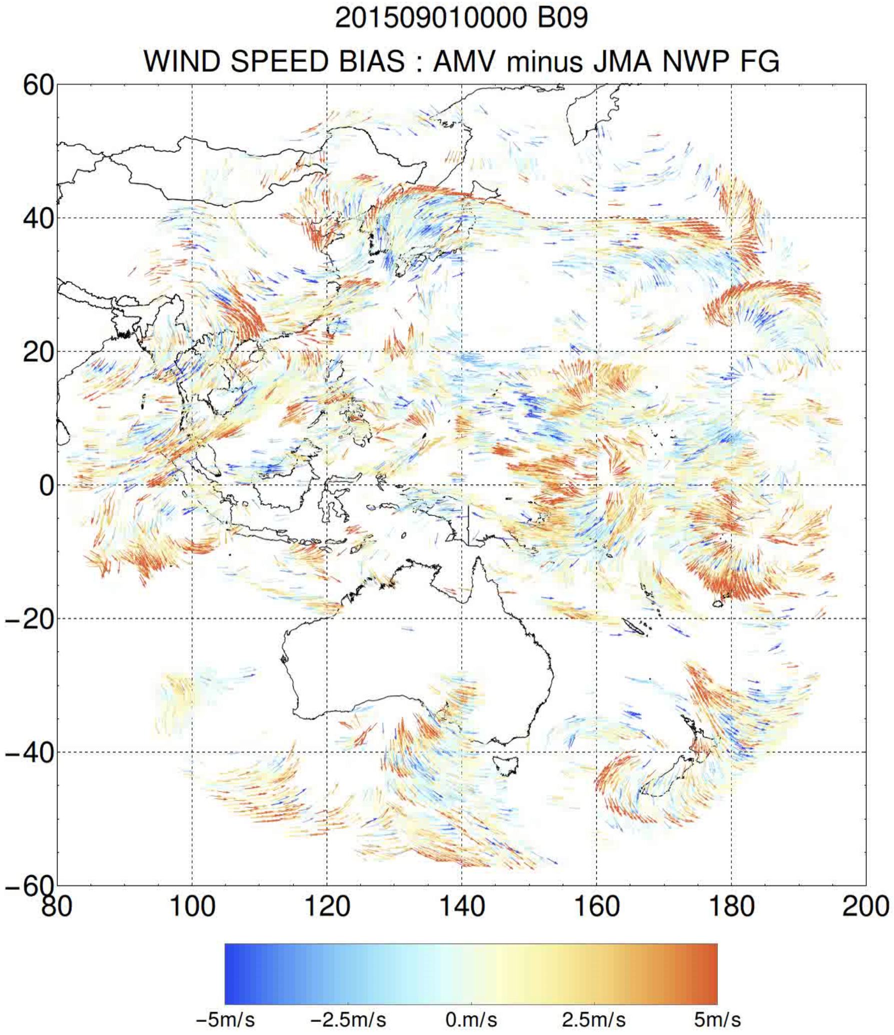




- Negative wind speed bias seen around northern hemisphere
- Negative wind speed bias around jet region on northern hemisphere
- Positive wind speed bias seen around convective area (same as summer season)

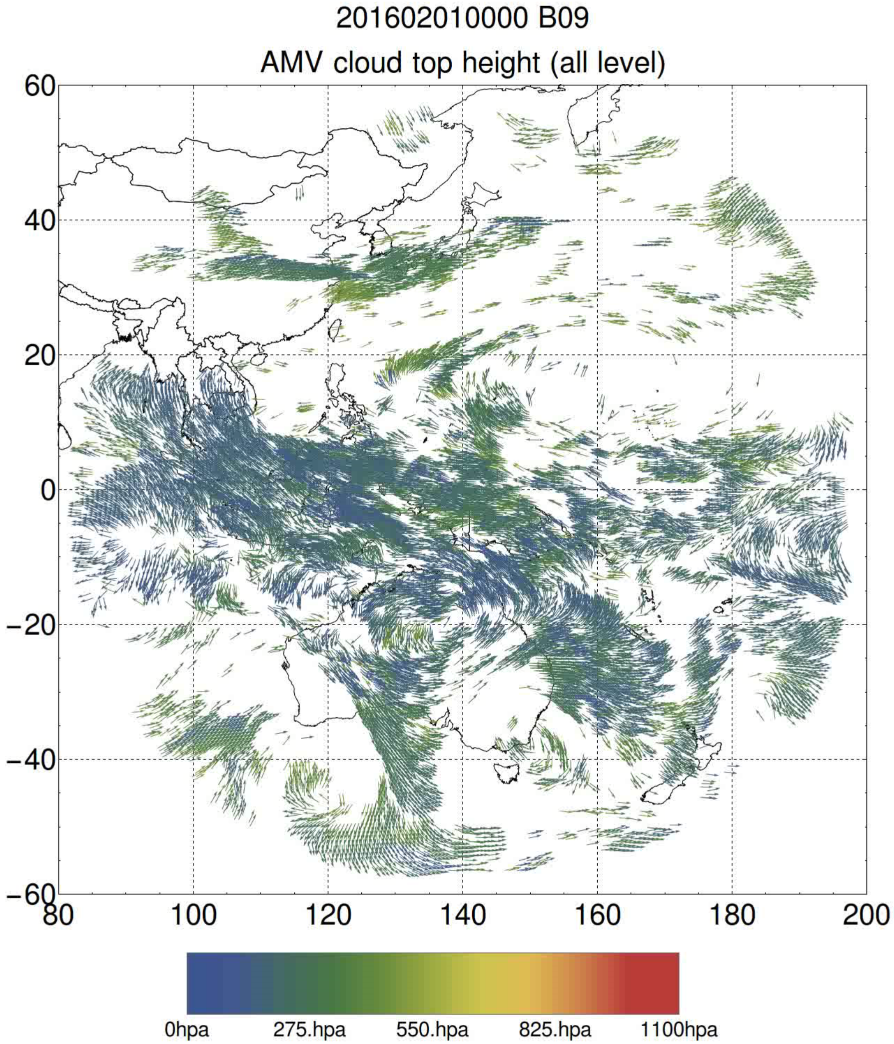
O-B analysis using JMA global model for 6.9um (WV) AMV at summer season (QI>60)

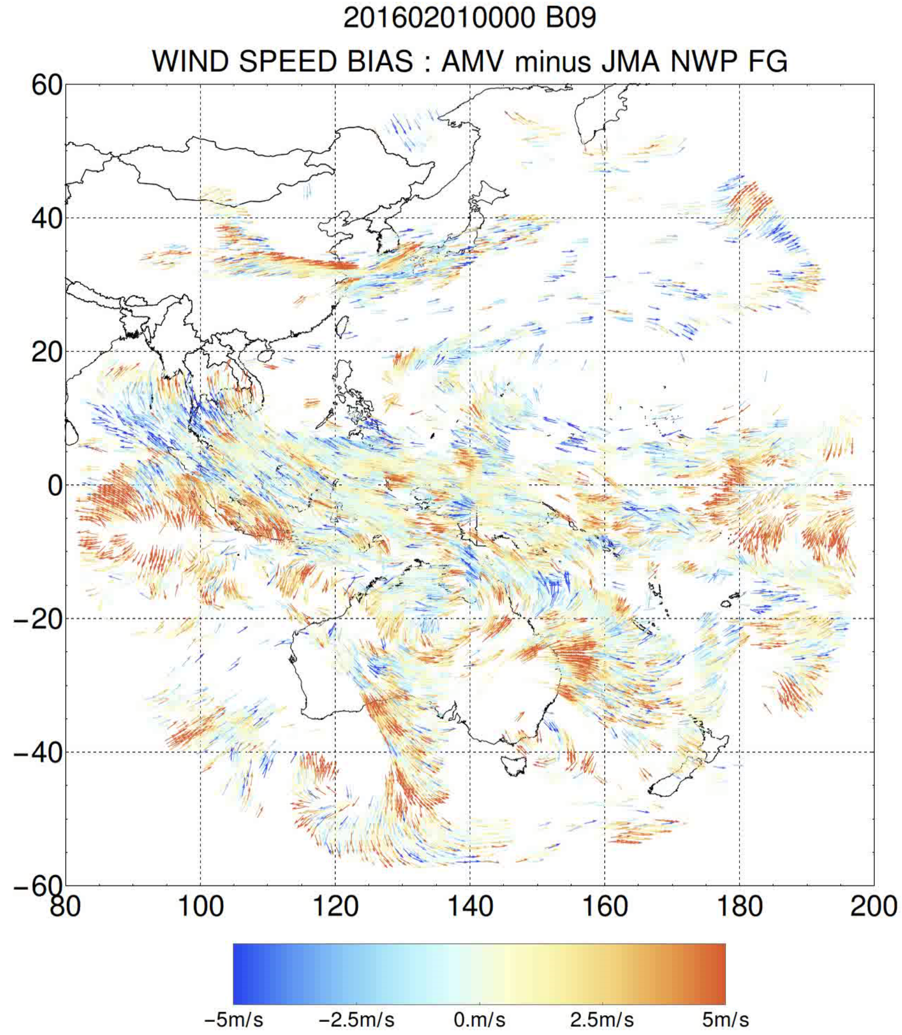




- Positive wind speed bias seen around convective area
- Totally positive wind speed bias over all area

O-B analysis using JMA global model for 6.9um (WV) AMV at winter season (QI>60)





- Positive wind speed bias seen around convective area
- Totally positive wind speed bias at all area

Contents

Future upgrade for Himawari AMV

AMV for global NWP

AMV for global NWP
- spatial density : 34 km at nadir
- temporal density : Hourly computed
- Input data resolution : 2km and 10 min.

High-resolution AMV for global NWP
- spatial density : 18 km at nadir **(x 3)**
- temporal density : half-hourly computed **(x 2)**
- Input data resolution : 2km and 10 min.

AMV for mesoscale NWP

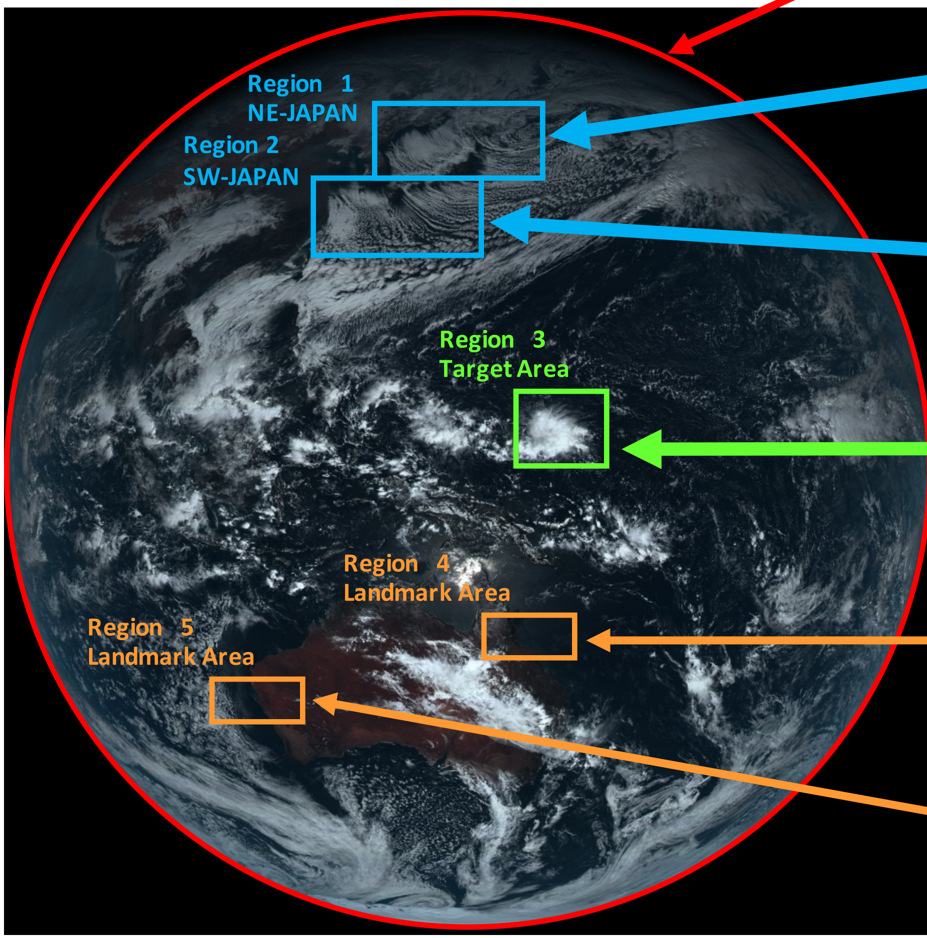
AMV for mesoscale NWP (Japan area)
- spatial density : 20 km at nadir
- temporal density : Hourly computed
- target box size : 7x7 and 31x31 pixels
- Input data resolution : 2km and 10 min.

RS-AMV for Japan area
- spatial density : 3.5 km at nadir
- temporal density : 10 min.
- target box size : 7x7 and 31x31 pixels
- Input data resolution
  - IR and WV : 2km and 5 min.
  - VIS : 0.5km and 2.5min.

RS-AMV for target observation
- spatial density : 2.5 km at nadir
- temporal density : 10 min.
- target box size : 5x5 and 31x31 pixels
- Input data resolution
  - IR and WV : 2km and 5 min.
  - VIS : 0.5km and 2.5min.

- **New AMV products will start from September 2016**
- **Dissemination of new products to overseas is planed to start after establishment of transmission way**

AHI Observation Areas and Frequencies



Full disk

Interval : **10 minutes** (6 times per hour)

Region 1 JAPAN (North-East)

Interval : **2.5 minutes** (4 times in 10 min)

Dimension : EW x NS: 2000 x 1000 km

Region 2 JAPAN (South-West)

Interval : **2.5 minutes** (4 times in 10 min)

Dimension : EW x NS: 2000 x 1000 km

Region 3 Target Area

Interval : **2.5 minutes** (4 times in 10 min)

Dimension : EW x NS: 1000 x 1000 km

Region 4 Landmark Area

Interval : **30 seconds** (20 times in 10 min)

Dimension : EW x NS: 1000 x 500 km

Region 5 Landmark Area

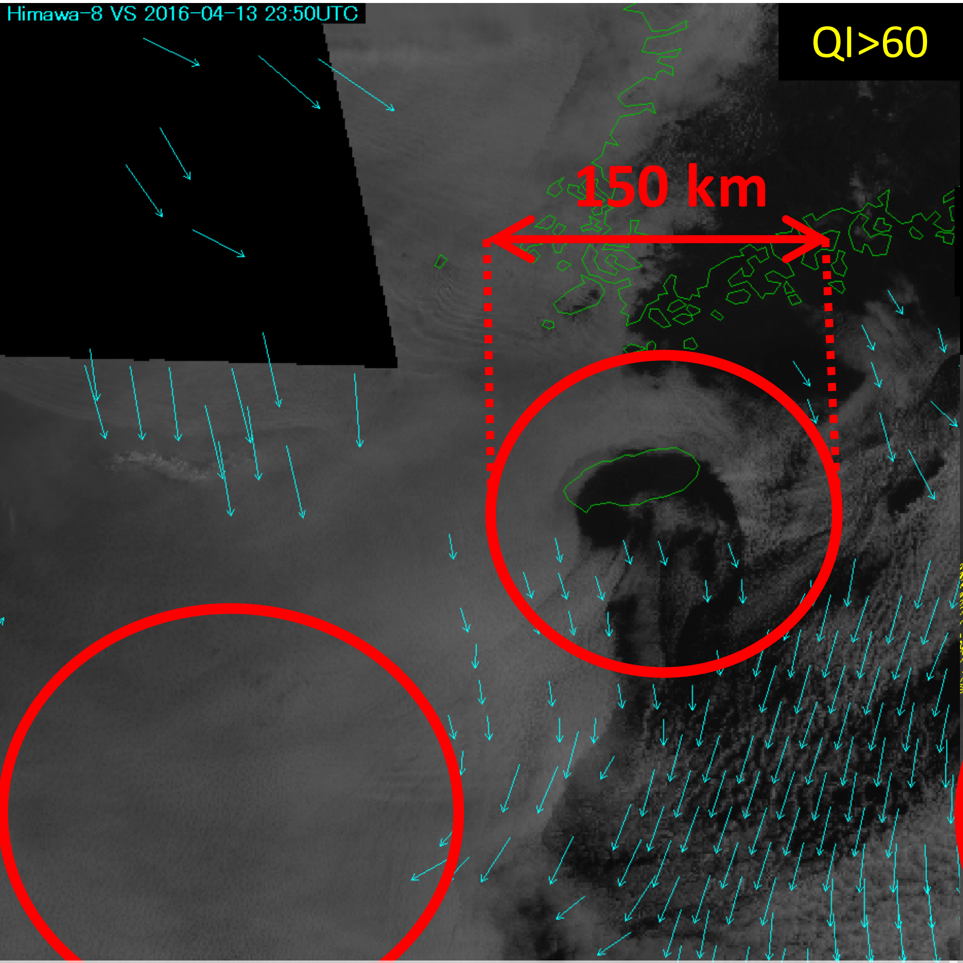
Interval : **30 seconds** (20 times in 10 min)

Dimension : EW x NS: 1000 x 500 km

RS-AMV from AHI target observation (Japan area)

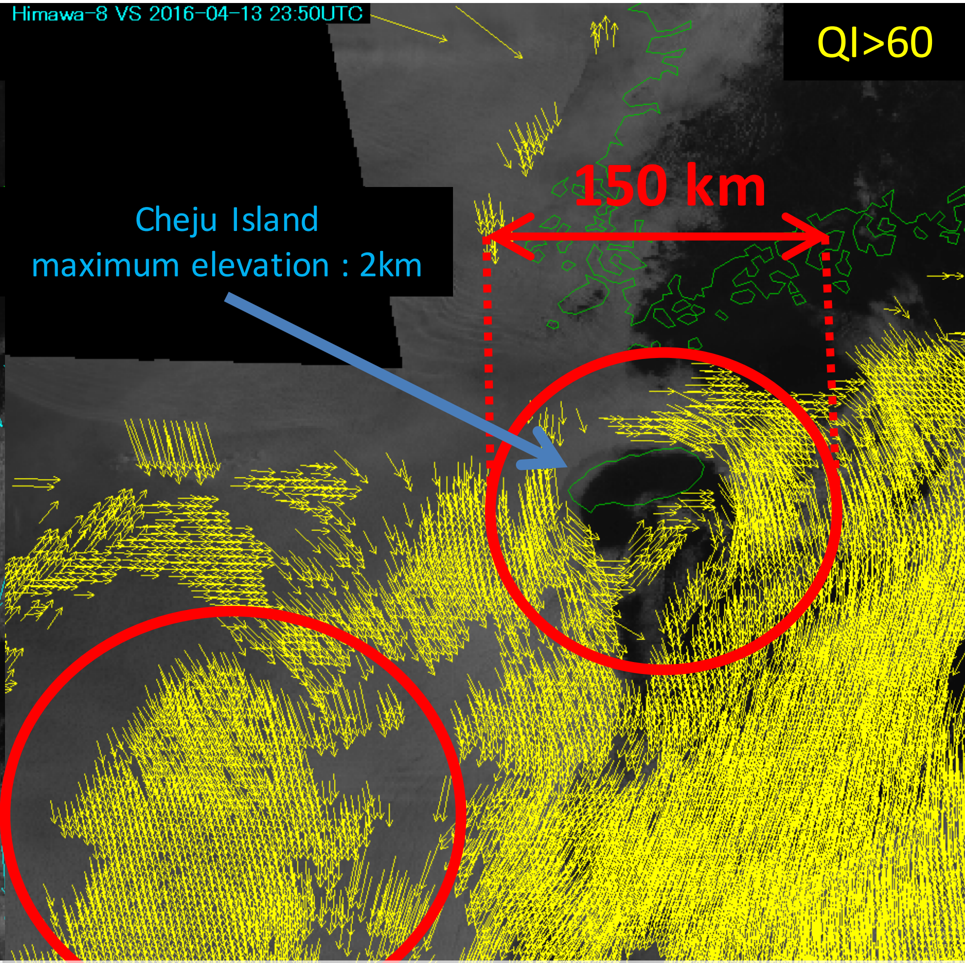
- Orographic winds can be detected
- Rapidly deforming clouds at low level can be tracked

H8 VIS AMVs from 10 minutes and 2 km VIS imagery
2016-04-13-2340UTC



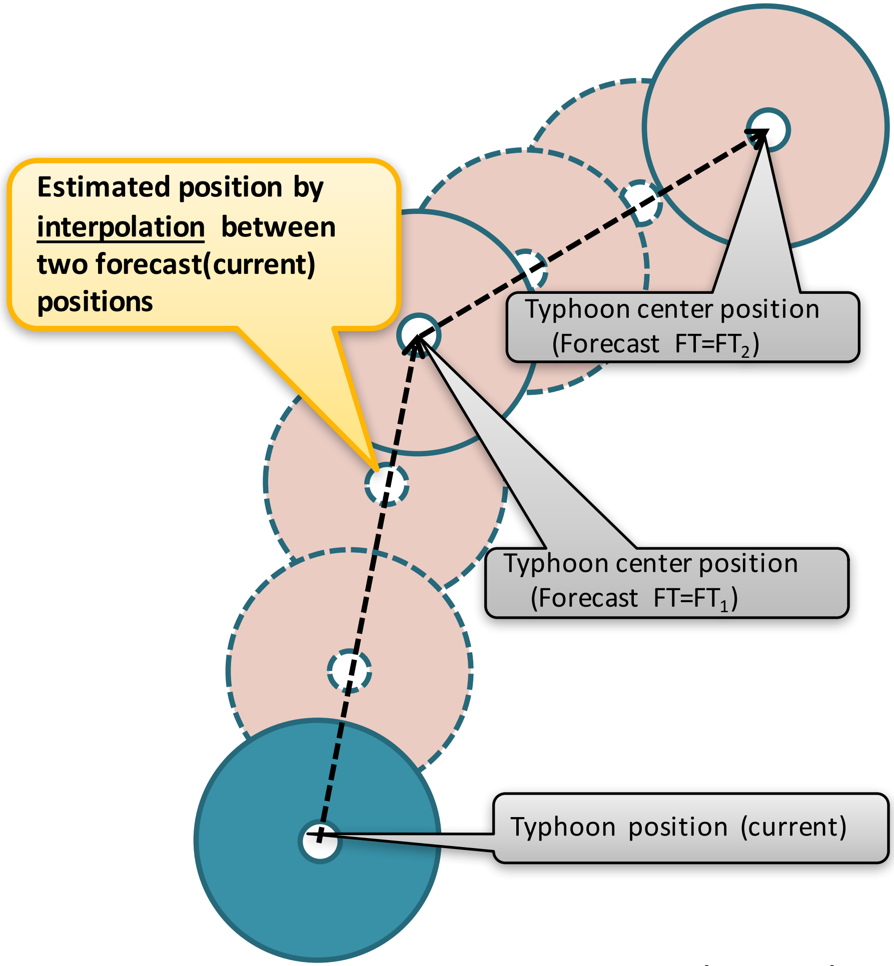
Target box size : 7x7 (14km) and 31x31 (62km) pixels

H8 VIS AMVs from 2.5 minutes and 0.5 km VIS imagery
2016-04-13-2340UTC



Target box size : 5x5 (2.5km) and 31x31 (16km) pixels

Target area observation (Typhoon)

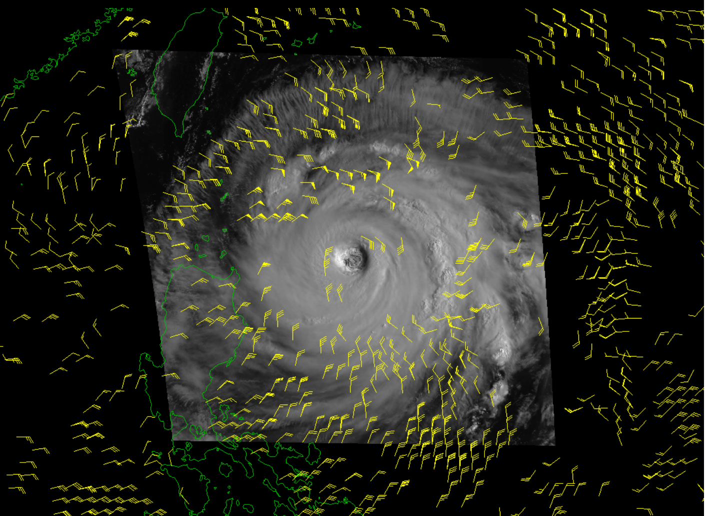


(movie)

21 UTC on 9th – 10 UTC on 10rh, May 2015
Typhoon Noul (2015) Band 03

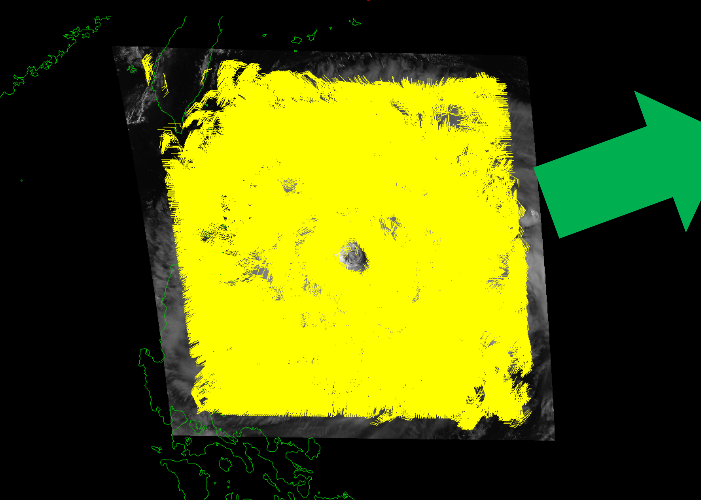
RS-AMV from AHI target observation (Typhoon)

Operational Himawari-8 AMV



Using 10 min. and 2 km resolution

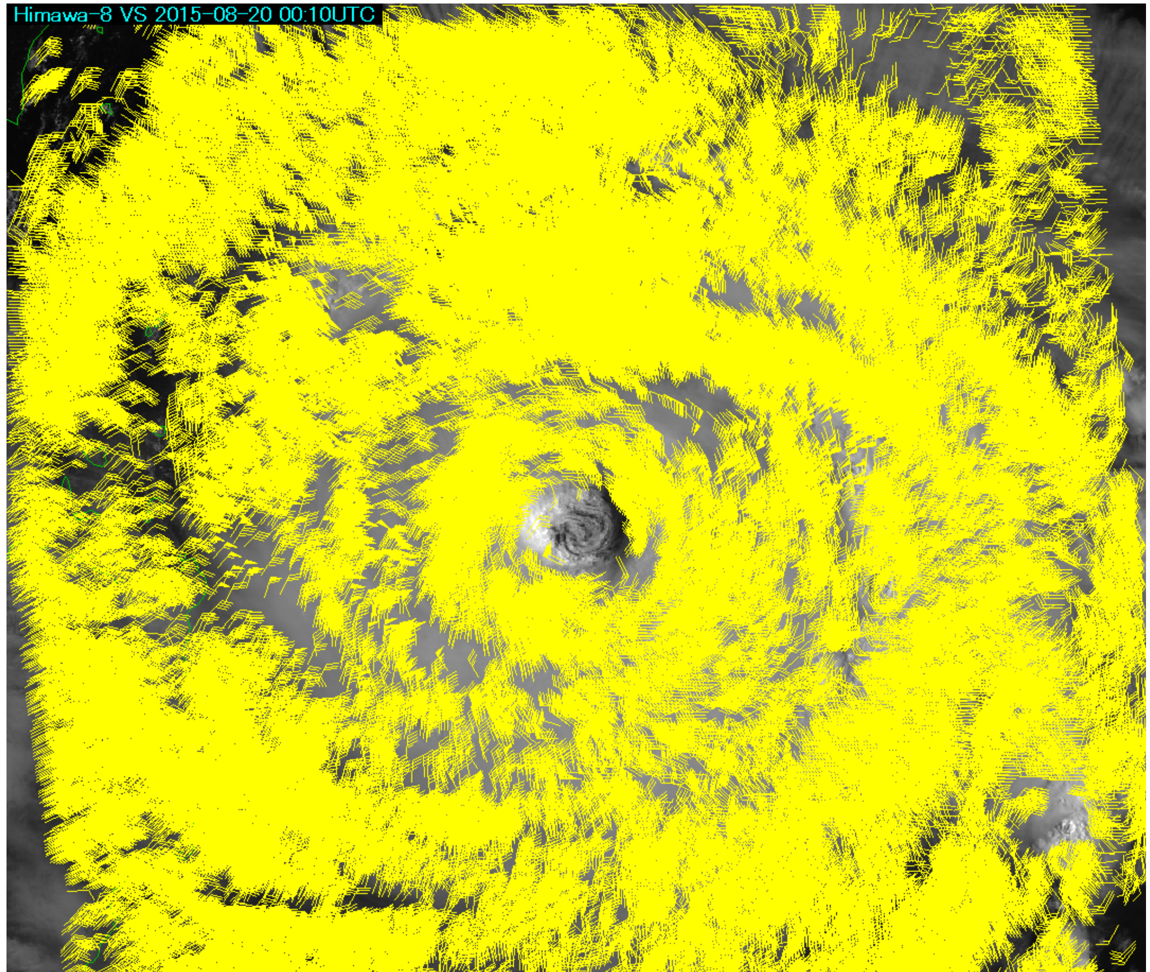
Himawari-8 Rapid Scan AMV



Using 2.5 min. and 0.5 km (2km for IR)

IR and VIS AMVs (QI>60, 00UTC August 20th 2015)

✓ Increase of data quality and quantity ->
Improvement to temporal and spatial resolution



Target box size : 5x5 (2.5km) and 31x31 (15km) pixels

Contents

Summary

- JMA replaced operational geostationary satellite from MTSAT-2 to Himawari-8 at 7th July 2015.
- Backup satellite Himawari-9 will launch in 2016 and start its backup operation from Q1 2017.
- Quality of Himawari-8 AMV is considered to be comparative to or better than MTSAT-2 AMV from sonde statistic and collocation study using CALIPSO.
- JMA plans to increase spatial/temporal density of Himawari AMV and now looking for data transmission method.