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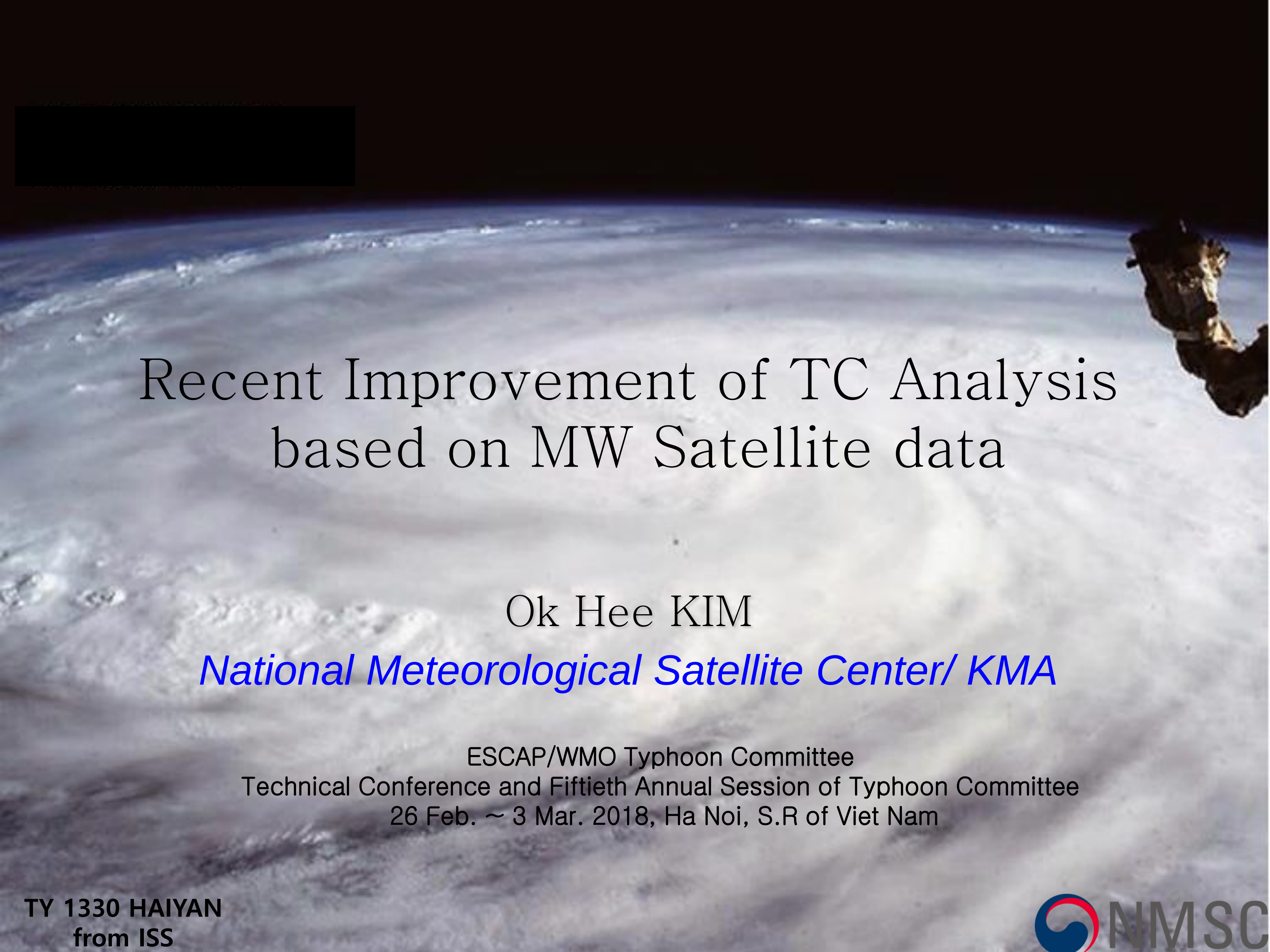
Recent Improvement of TC Analysis based on MW Satellite data

Ok Hee KIM

National Meteorological Satellite Center/ KMA

ESCAP/WMO Typhoon Committee
Technical Conference and Fiftieth Annual Session of Typhoon Committee
26 Feb. ~ 3 Mar. 2018, Ha Noi, S.R of Viet Nam



TY 1330 HAIYAN from ISS

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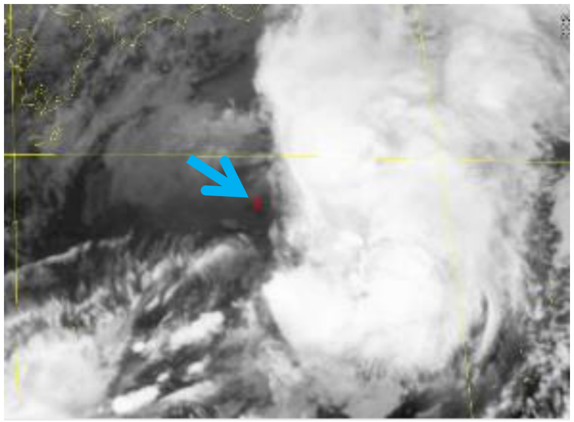
CONTENTS

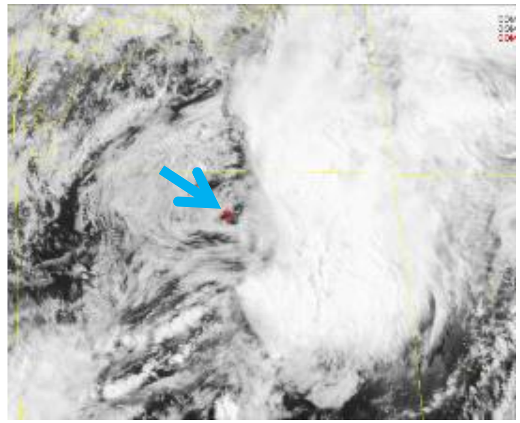
Basic images for TC Center analysis

- Basic channel Images to decide TC center: IR, SWIR & VIS of COMS, Geo, Sat.
- Limitations of analysis of low level cloud by IR1 and VIS
- At night it is highly dependent on IR images

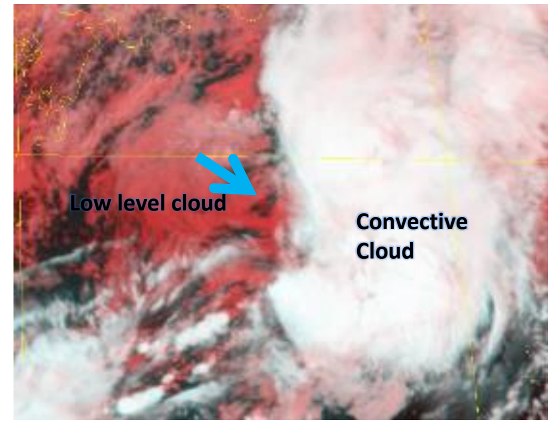
Day



IR1

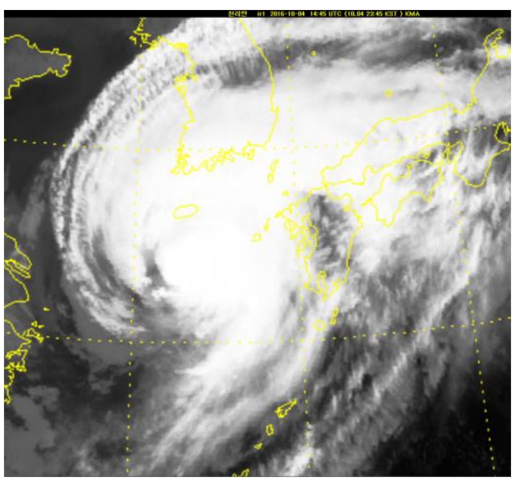


VIS

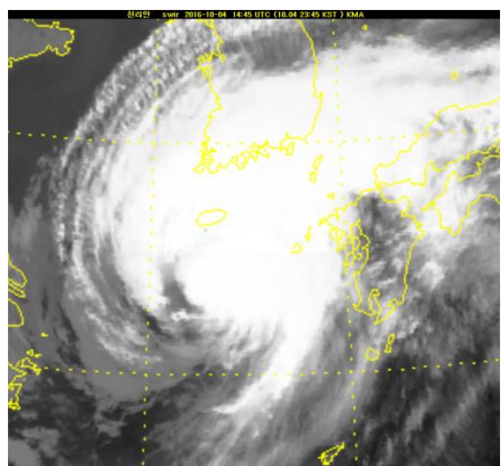


RGB Composite IR1+VIS

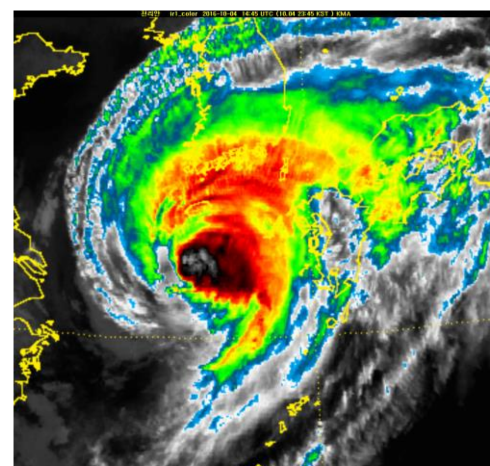
Night



IR1



SWIR



Enhanced IR1

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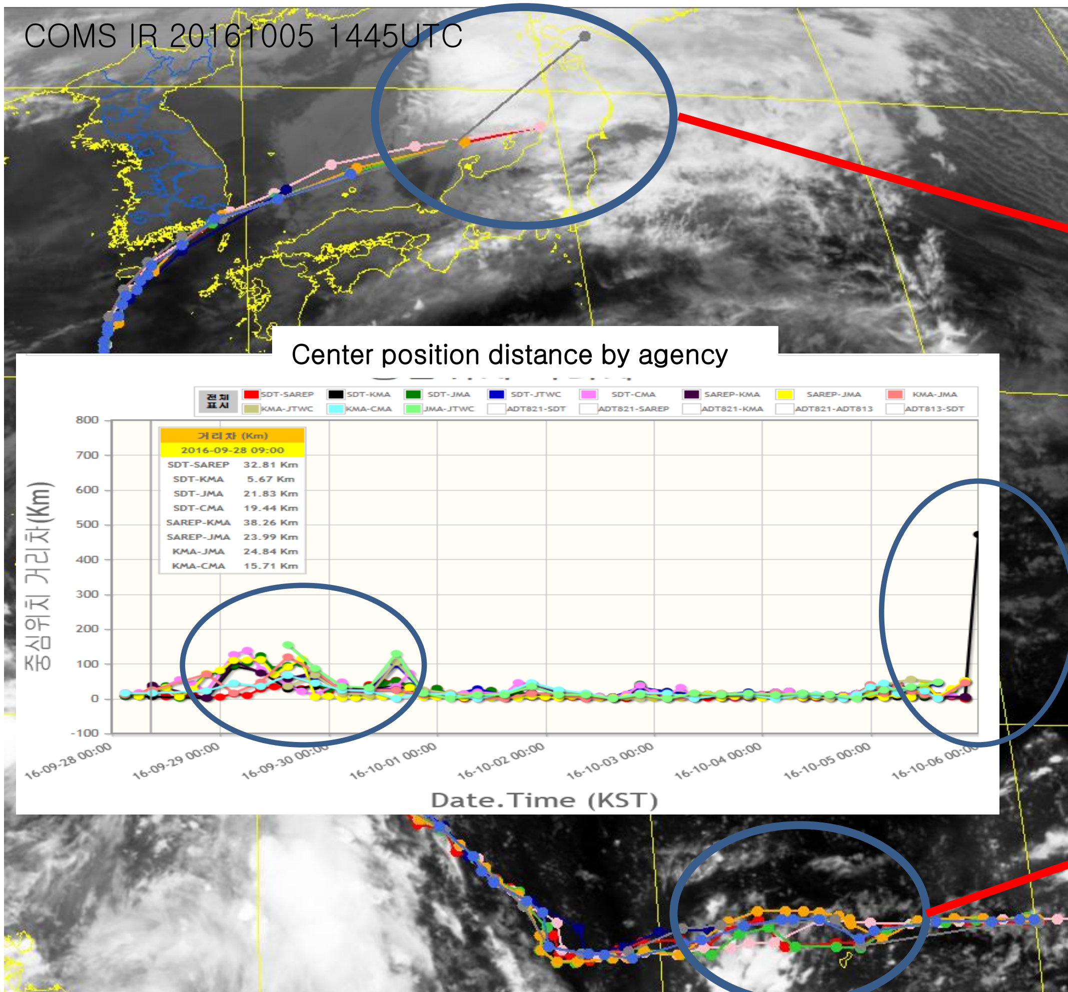
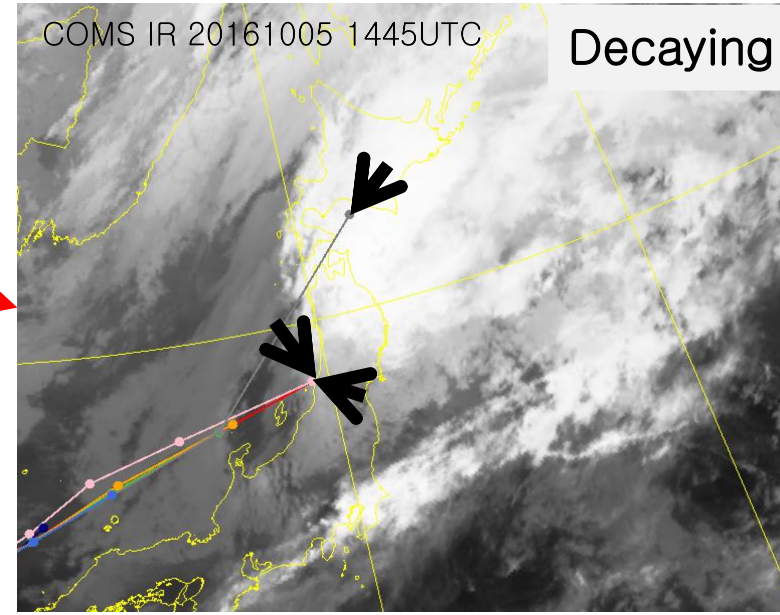
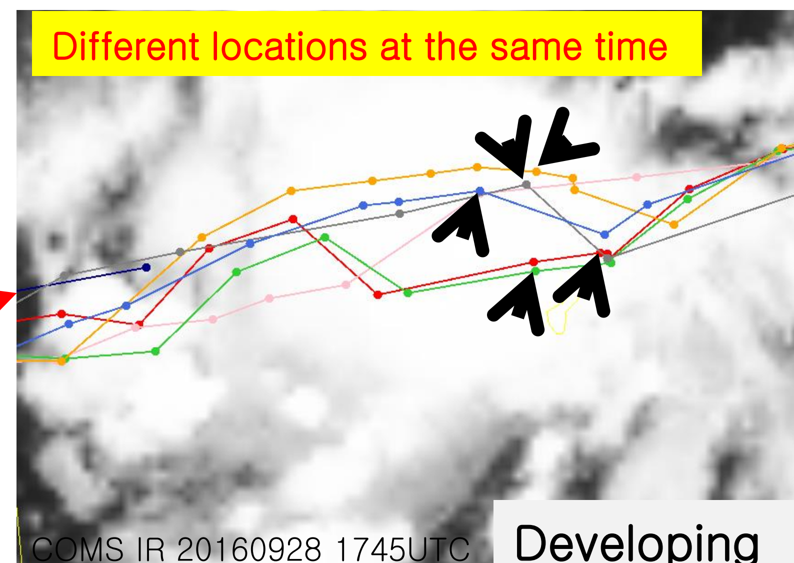
Comparison of TC positions

❖ Large distance between central positions of TC by agency in generating, developing & decaying time





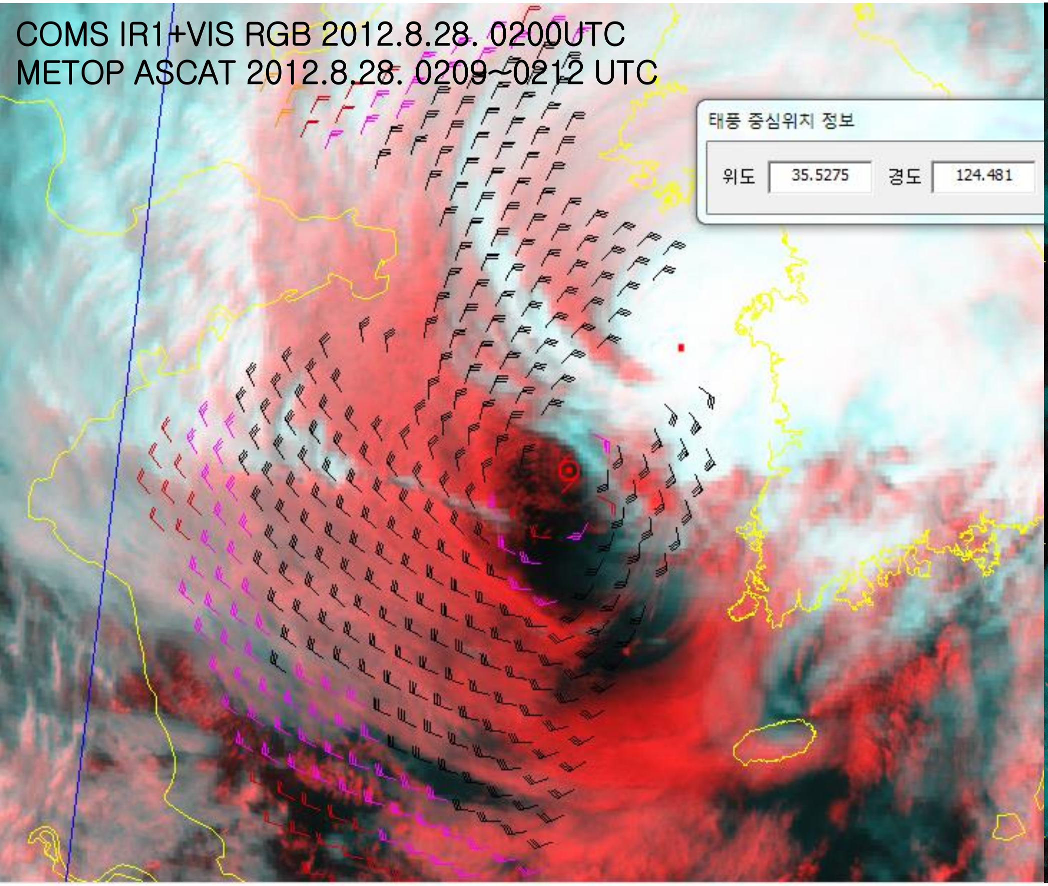


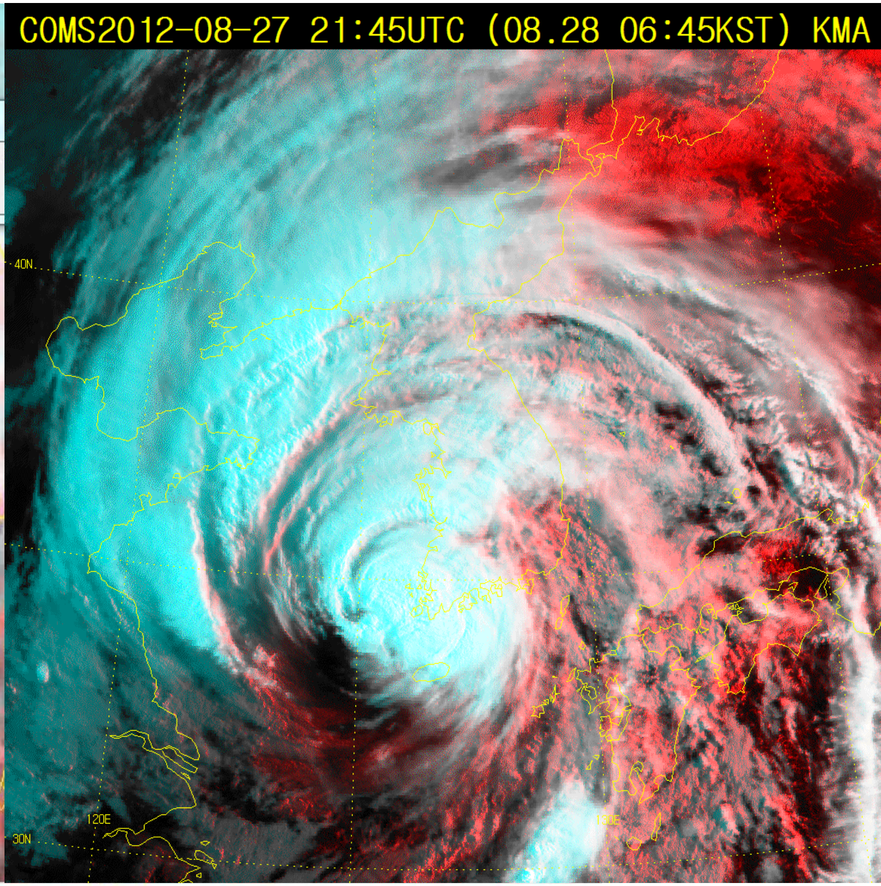
1618 CHABA

<TC Center estimation using ASCAT wind vector>

Overlapping ASCAT wind with COMS image

- Overlap wind vector of ASCAT over the cloud image of COMS
- RGB composite images with IR & VIS at day and IR & SWIR at night with COMS
- Animated images for several hours



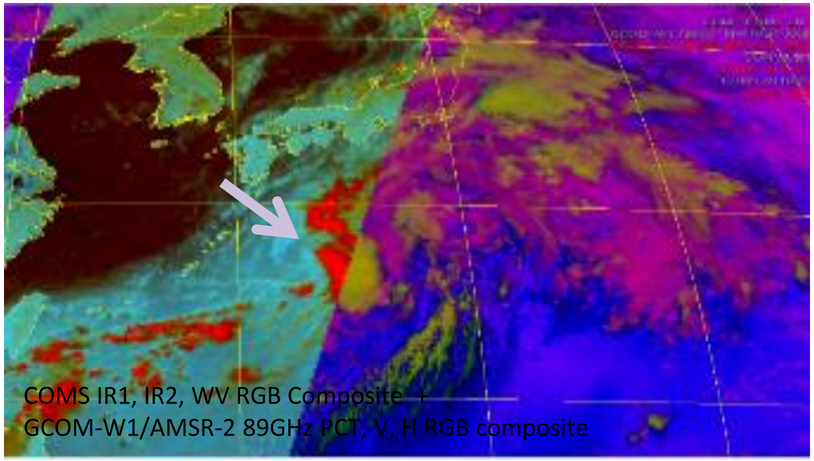


1215 VOLABEN

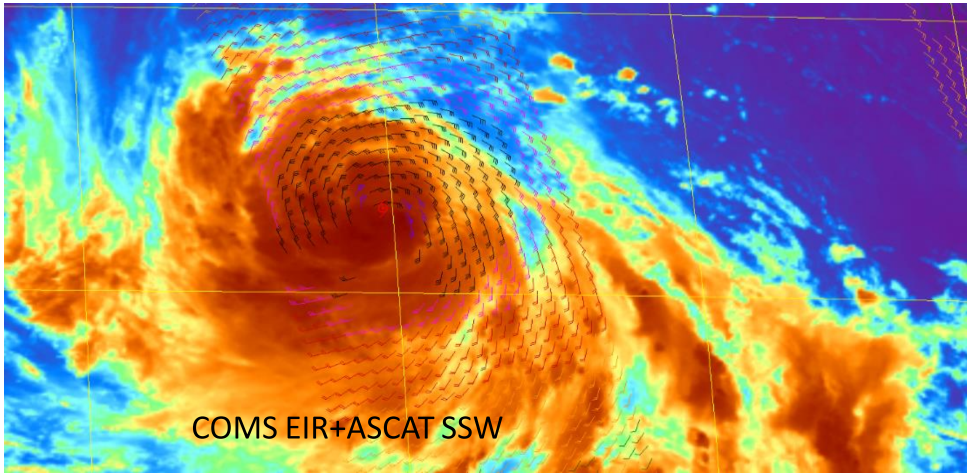
Overlapping multi channels with COMS data

- To estimate TC position more clearly, we use many RGB composite
- Overlapping multi-MW data over convective cloud images

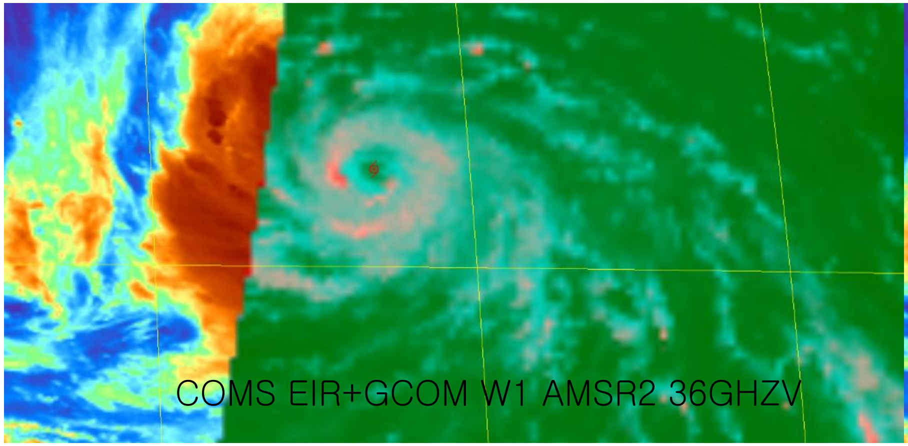
Center of cyclonic vorticity of convective cloud



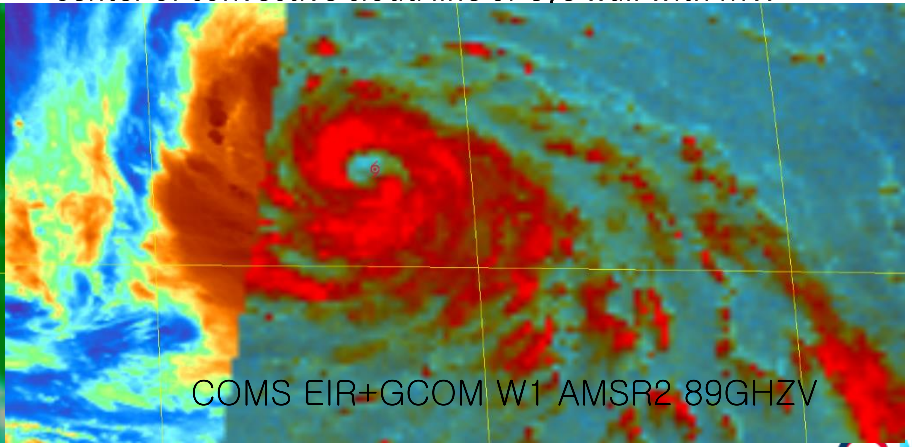
Center of ASCAT SSW with convective cloud



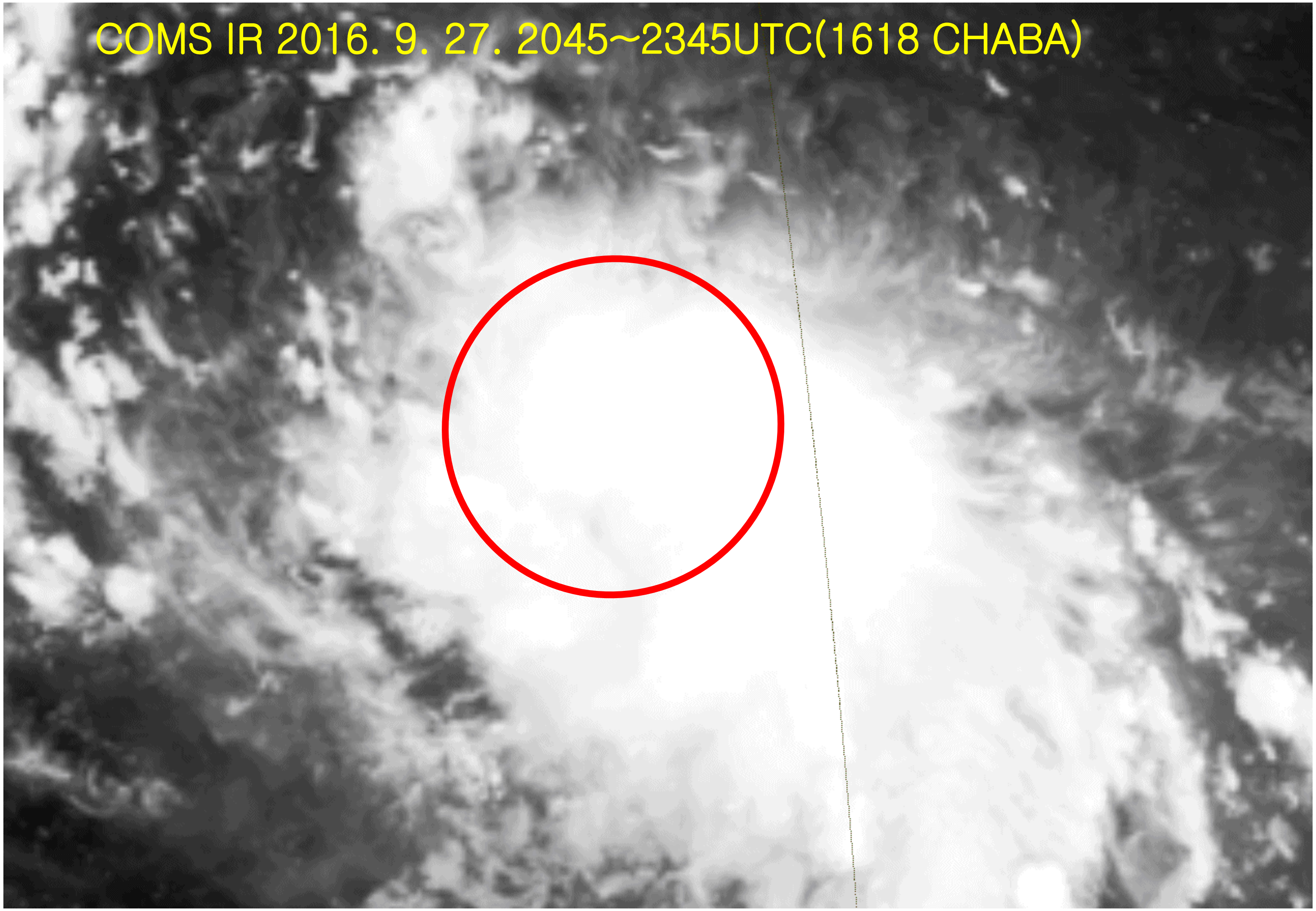
Center of convective cloud line or eye wall with MW



Center of convective cloud line or eye wall with MW

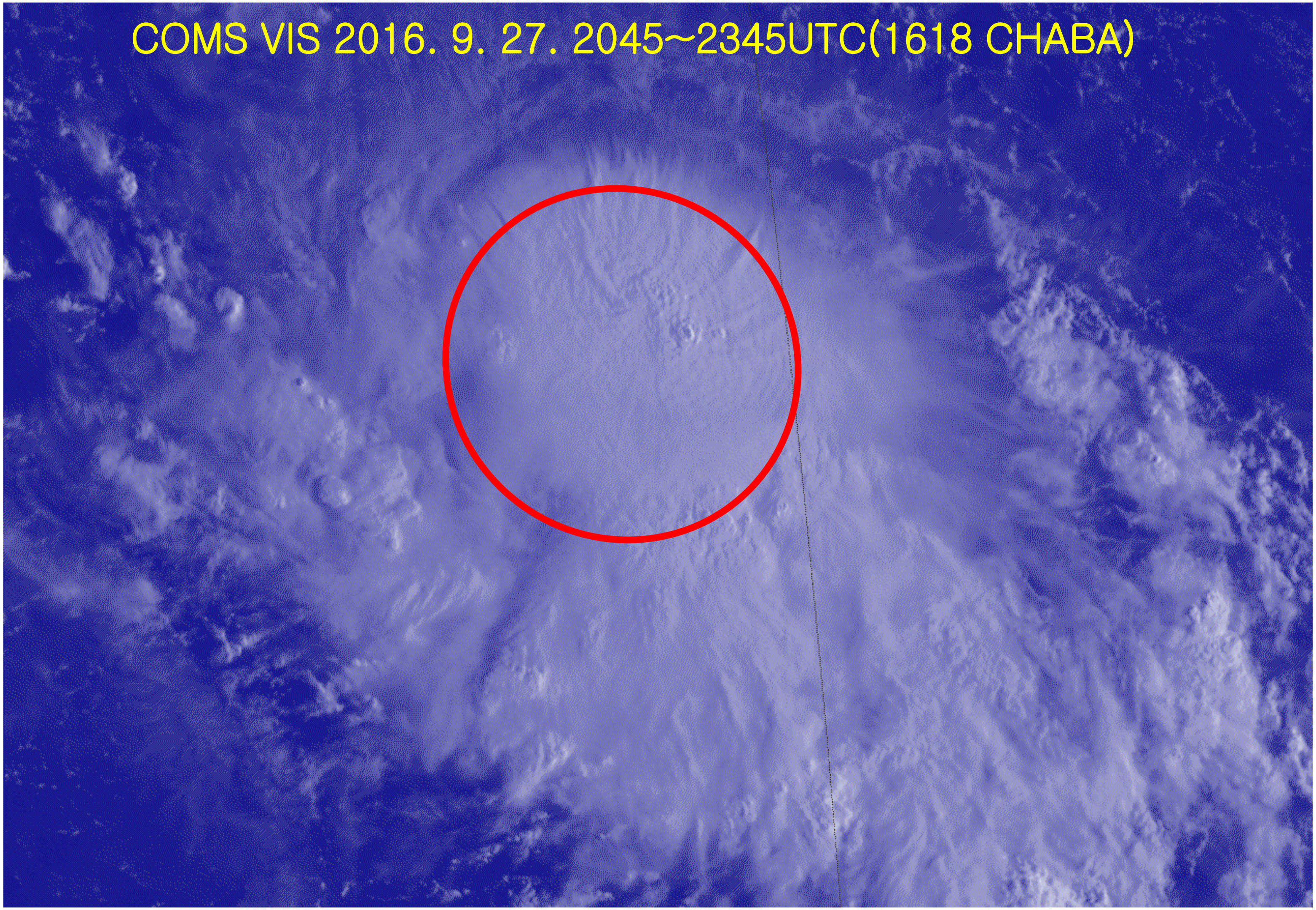


TC Center estimation in generating time



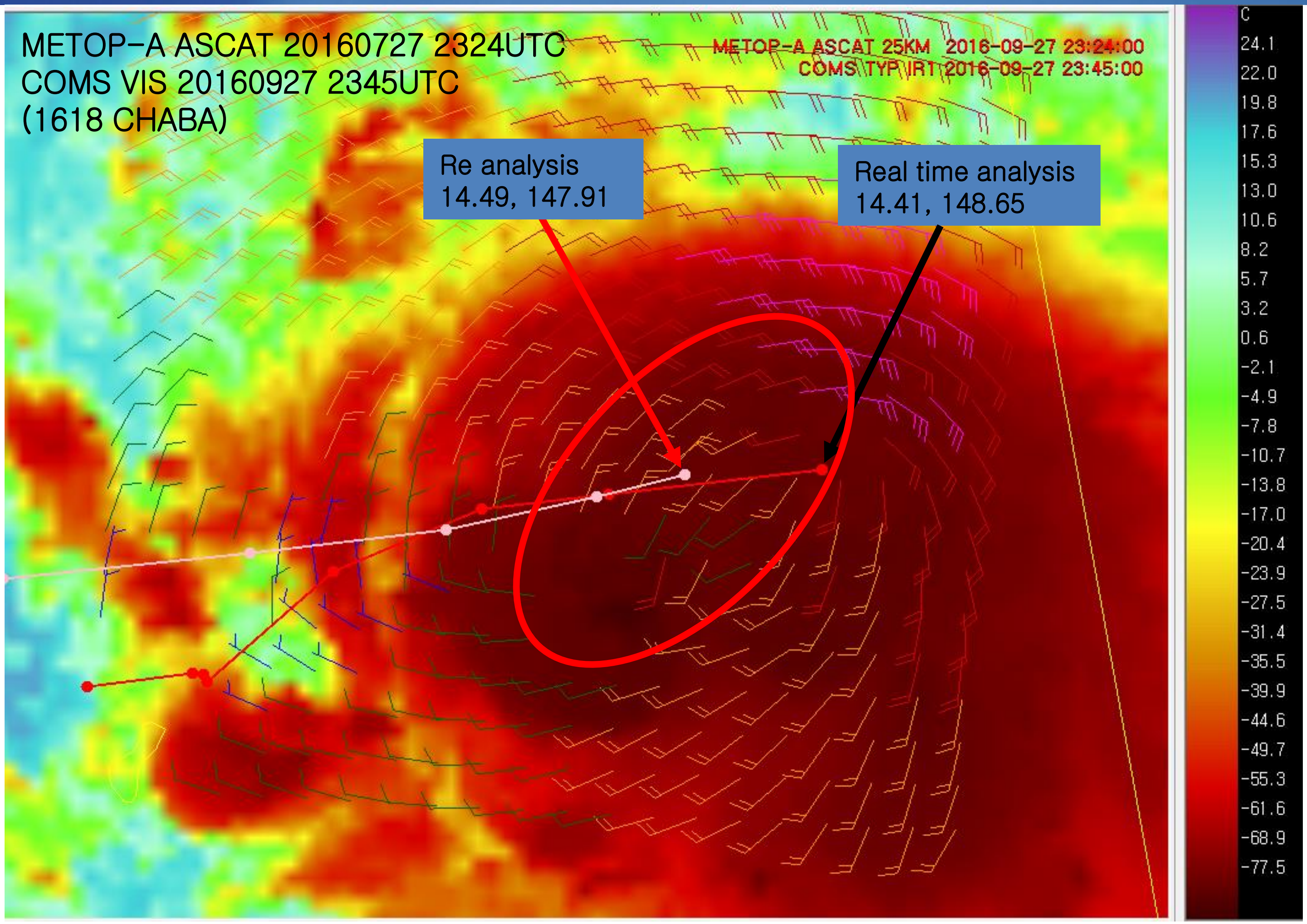
- ❖ Possibility that the center is located inner red circle
- ❖ It is difficult to decide one point using IR images only

TC Center estimation in generating time



- ❖ Possibility that the center is located inner red circle
- ❖ It is still difficult to decide one point inside Cb cluster using VIS images

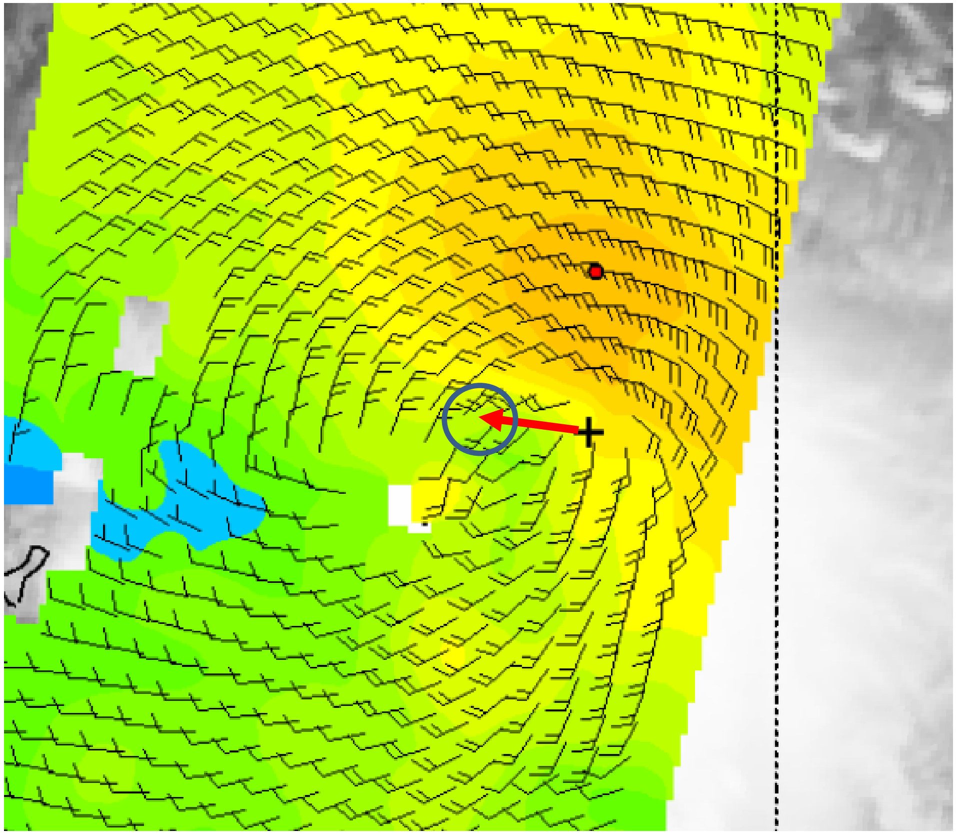
TC Center estimation using ASCAT wind



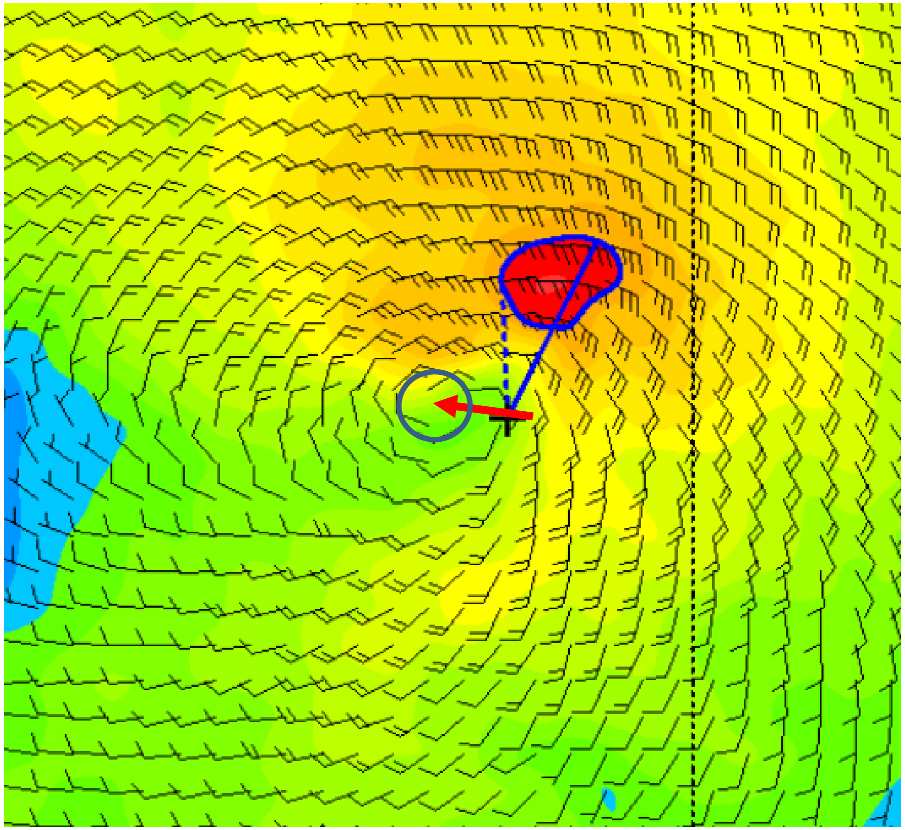
- ❖ We can estimate almost certain TC center position with ASCAT wind vector
- ❖ It is located at the intersection area bt. northeasterly and southwesterly wind around TC center => **Re analysis point: 14.49, 147.91**

TC Center estimation using NWP wind vector

2016. 9. 27. 2345UTC COMS IR
2016. 9. 27. 2324UTC METOP ASCAT SSW

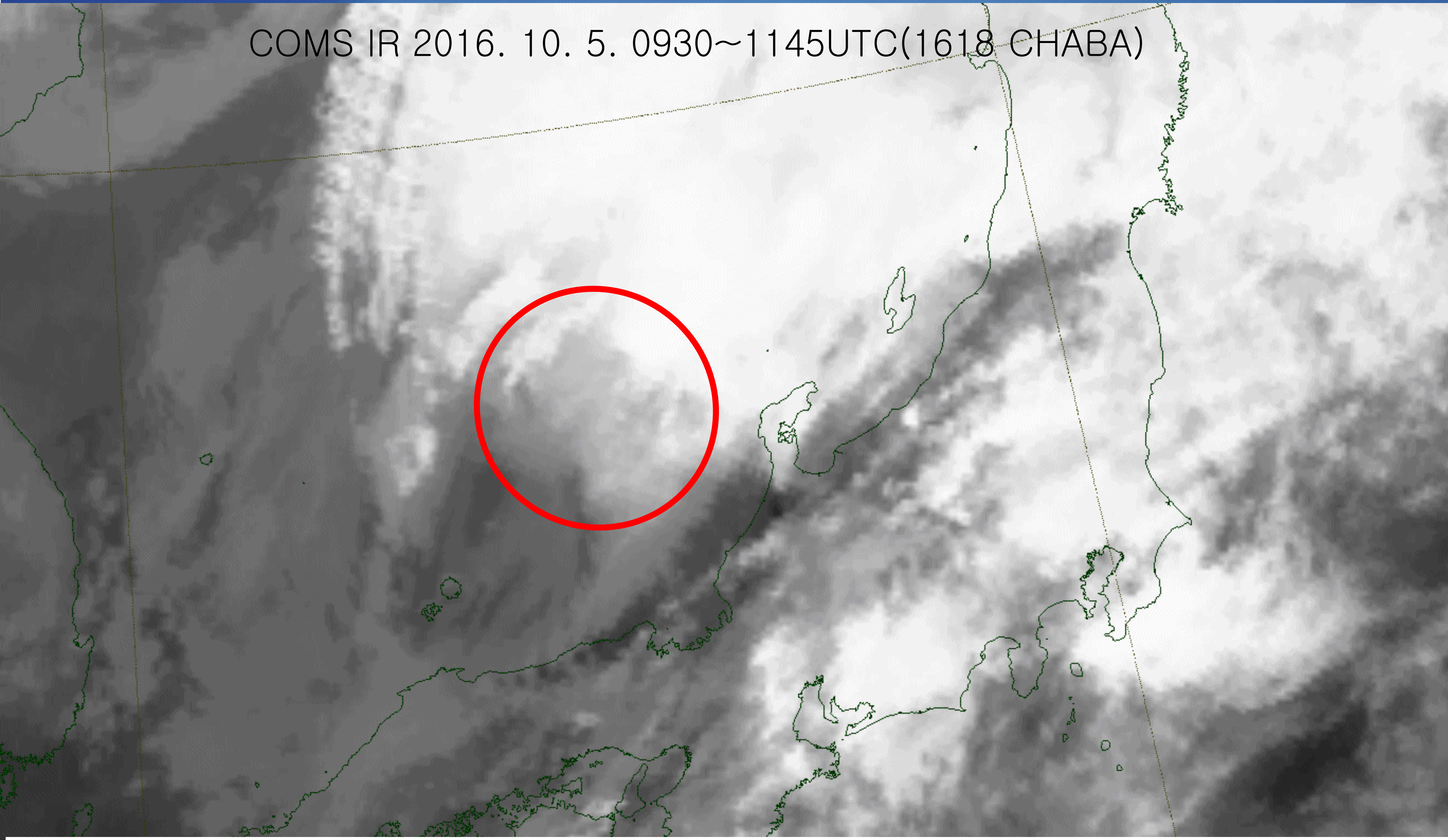


2016. 9. 28. 00UTC ECMWF wind vector



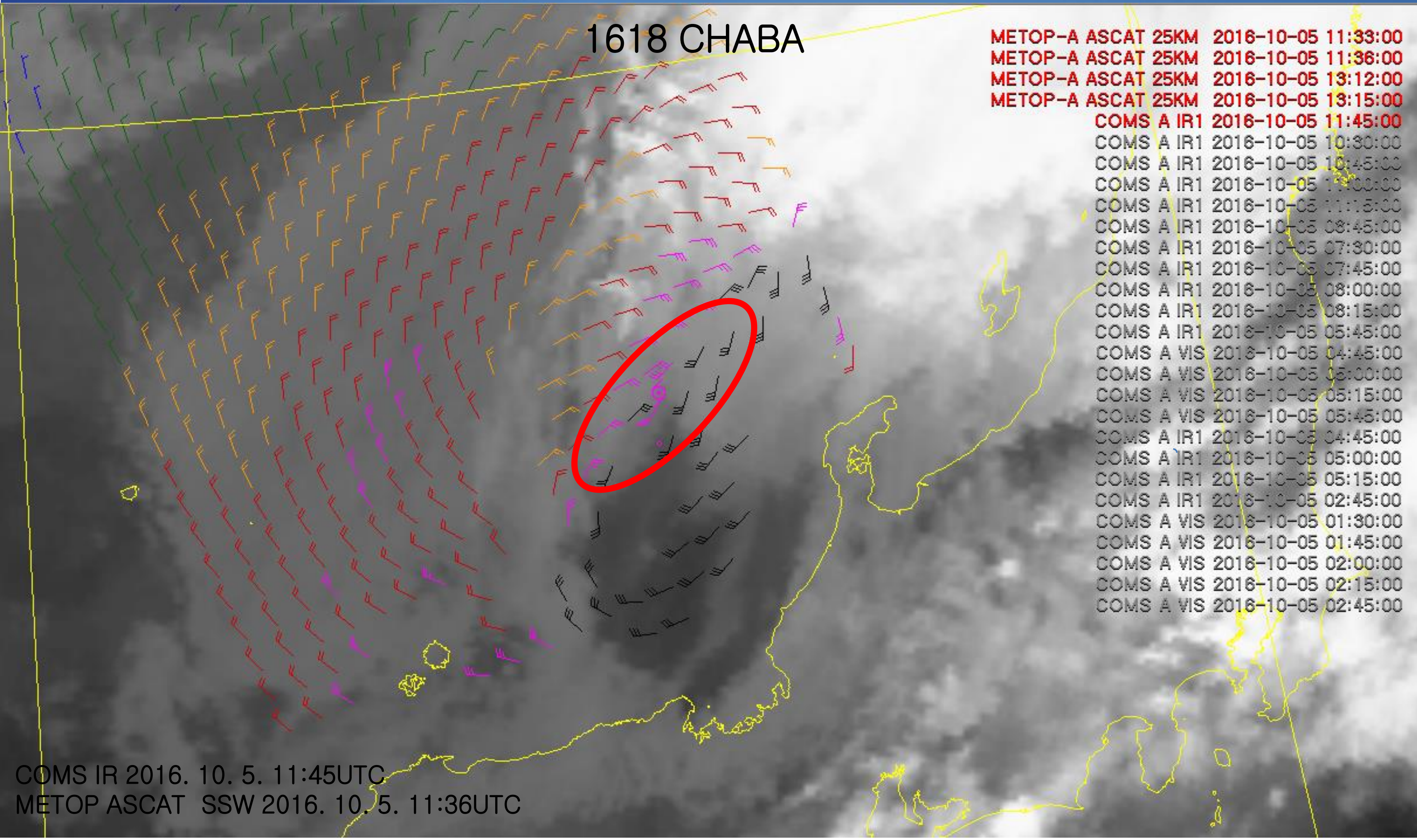
- ❖ We need to move westward from real time position(+) of TC center using ASCAT and ECMWF, re-analysis wind vector(red area: strong wind(over 15m/s))
- ❖ Real time: 14.41, 148.65 => re-analysis: 14.49, 147.91

TC Center estimation in decaying time with IR



- ❖ Center of cyclonic vorticity of low level cloud on IR image
- ❖ Possibility that the center is located inner red circle
- ❖ It is difficult to decide one point using IR images only

Center estimation in decaying time with wind



- ASCAT wind vector help us clearly to find center
- TC Center can be estimated at the intersection area btw. northeasterly and southwesterly wind based on ASCAT wind vector

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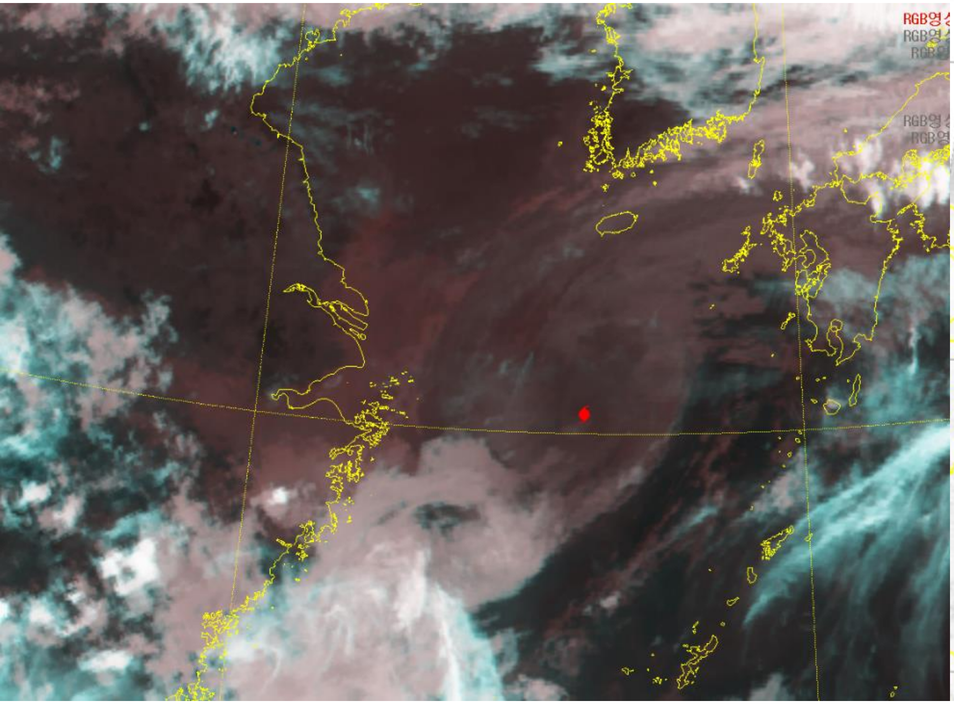
<using SNPP/VIIRS DNB image at night>

Decision of Center position at night

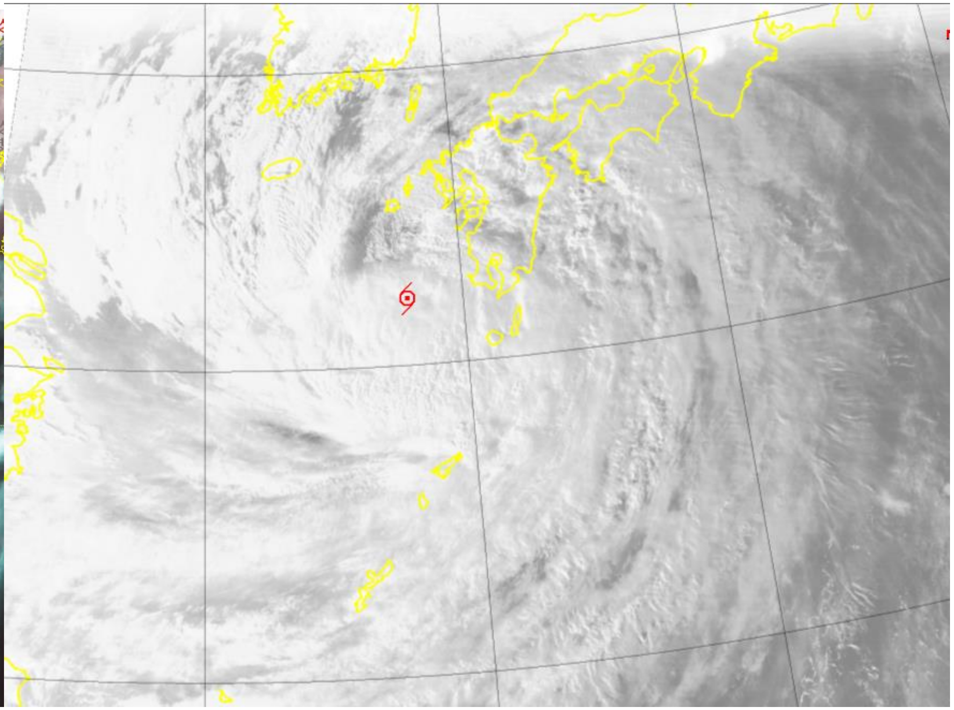
- ❖ Low level Cloud can be detected better in SWIR than IR1 channel at night
- ❖ Insufficient channel images at night except IR and SWIR
- ❖ Suomi NPP/DNB image show us cloud line curvature clearly at night

COMS/SWIR+IR1 RGB Composite



COMS/SWIR, IR1 2013-06-20 15:00UTC

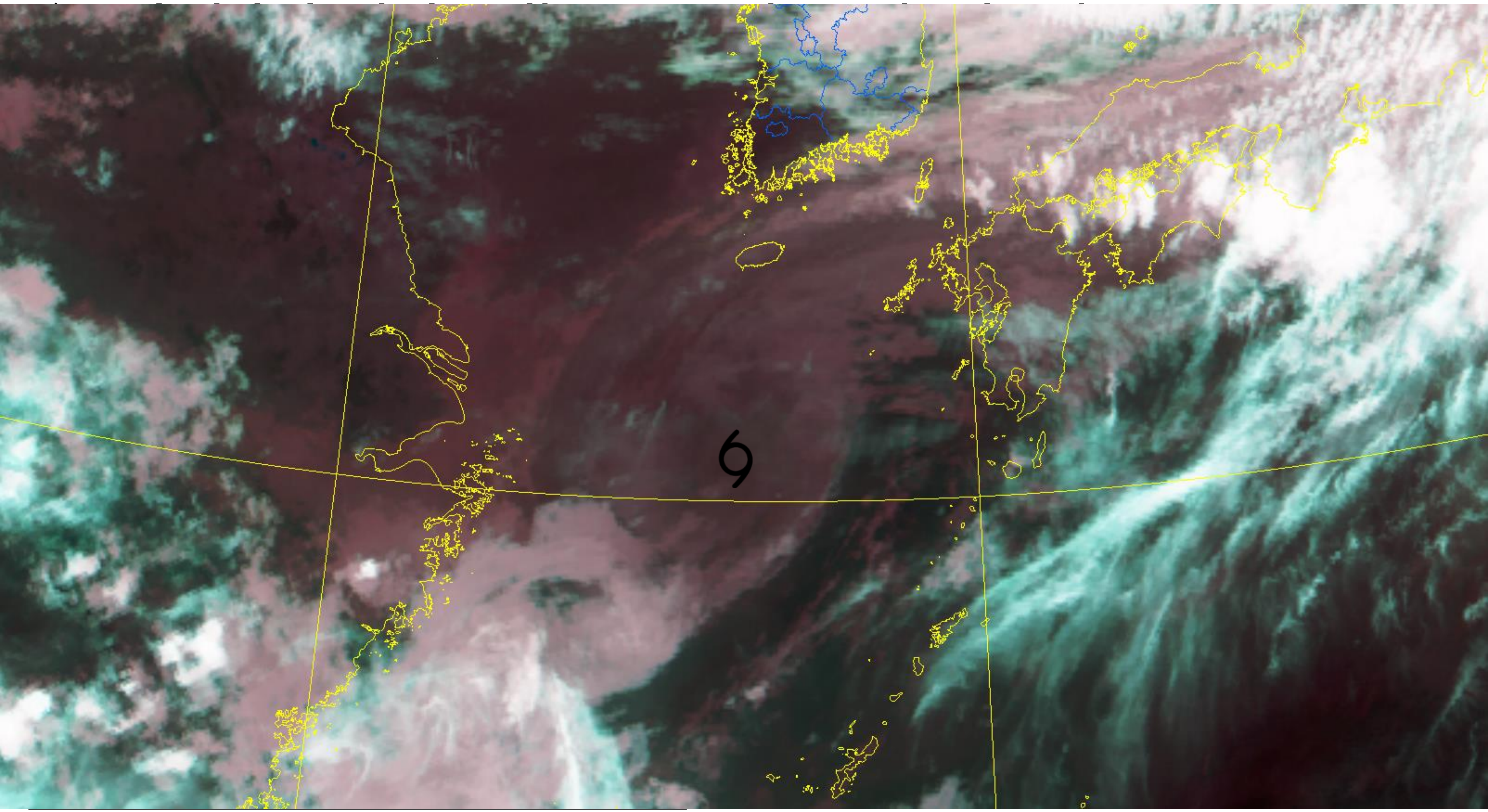
Suomi NPP/DNB



Suomi NPP/DNB 2014-07-09 16:37UTC

SWIR: Short Wave Infrared

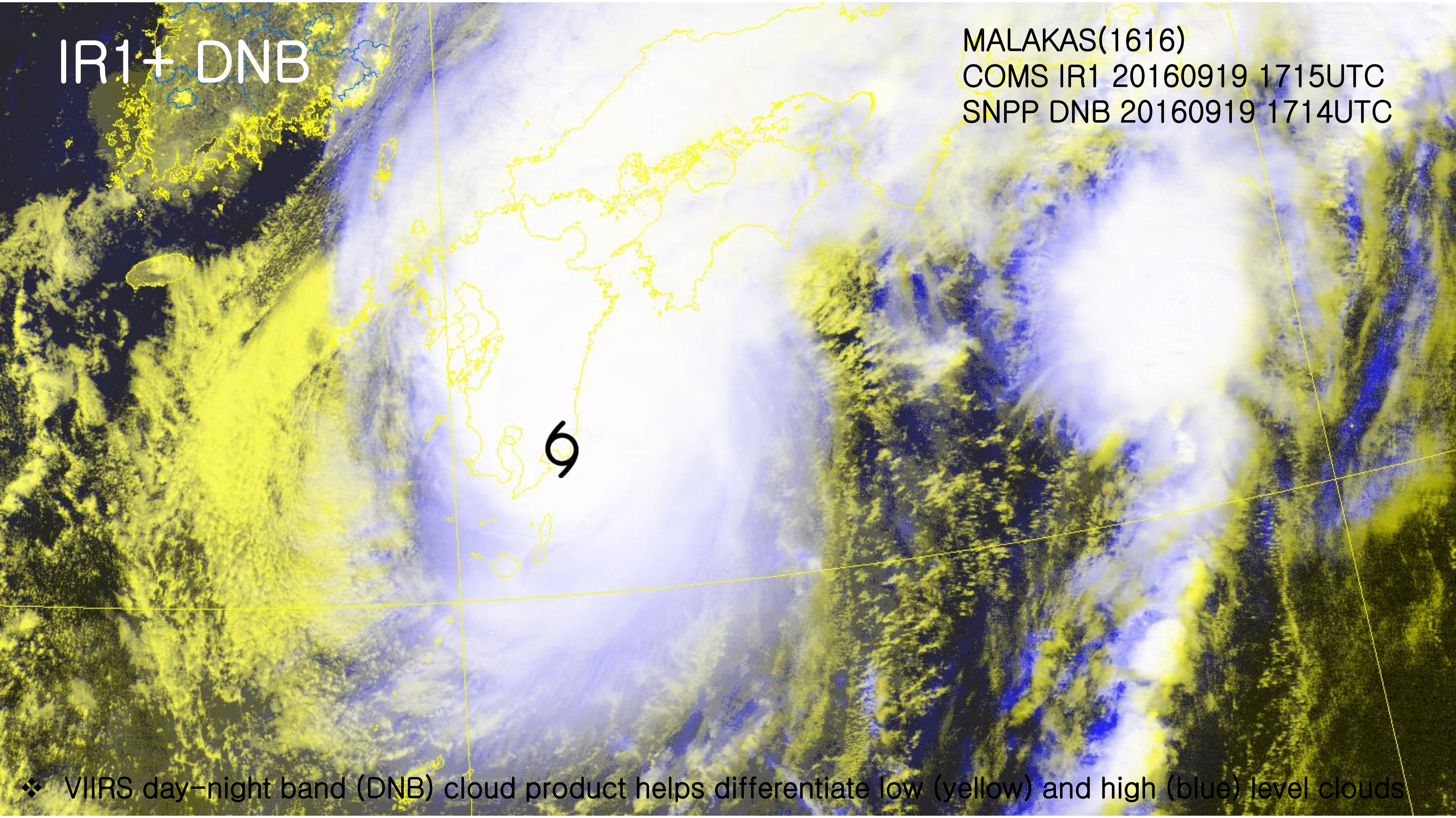
Decision of Center position at night



❖ RGB composite image with SWIR show us Low level Cloud at night

SWIR: Short Wave Infrared

Night Time: Overlapping Cloud



Moonlight probes cirrus (optically thick at IR wavelengths, but optically *thin* at VIS wavelengths), reflects off low-level liquid clouds, enabling superior low-level circulation analysis

=> TC position can be estimated more correctly with DNB visible image at night

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< Using ATOVS vertical profile of temperature >

ATOVS and ATMS sensor

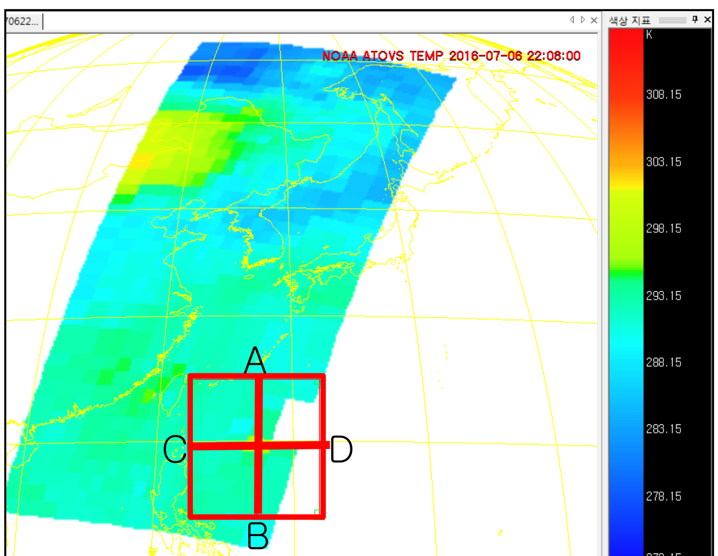
	NOAA	Metop	NPP
Sensor	ATOVS	ATOVS	CrIS & ATMS
Spatial resolution	48km	48km	50km
Vertical resolution	42 levels	42 levels	100 levels
Swath	2200km	1650km	2300km
Frequency	23~183GHz, V polarization	23~183GHz H & V polarization	23~183GHz H & V polarization

- Advanced TIROS Operational Vertical Sounder (ATOVS) consists of High Resolution Infrared Radiation Sounder (HIRS), the Advanced Microwave Sounding Unit-A (AMSU-A) and AMSU-B for retrieving temperature, humidity and ozone sounding in all weather conditions
- Vertical Profile of temperature of ATOVS and ATMS
- Warm core of vertical temperature in TC

Vertical Profile of Tb: Warm core in TC

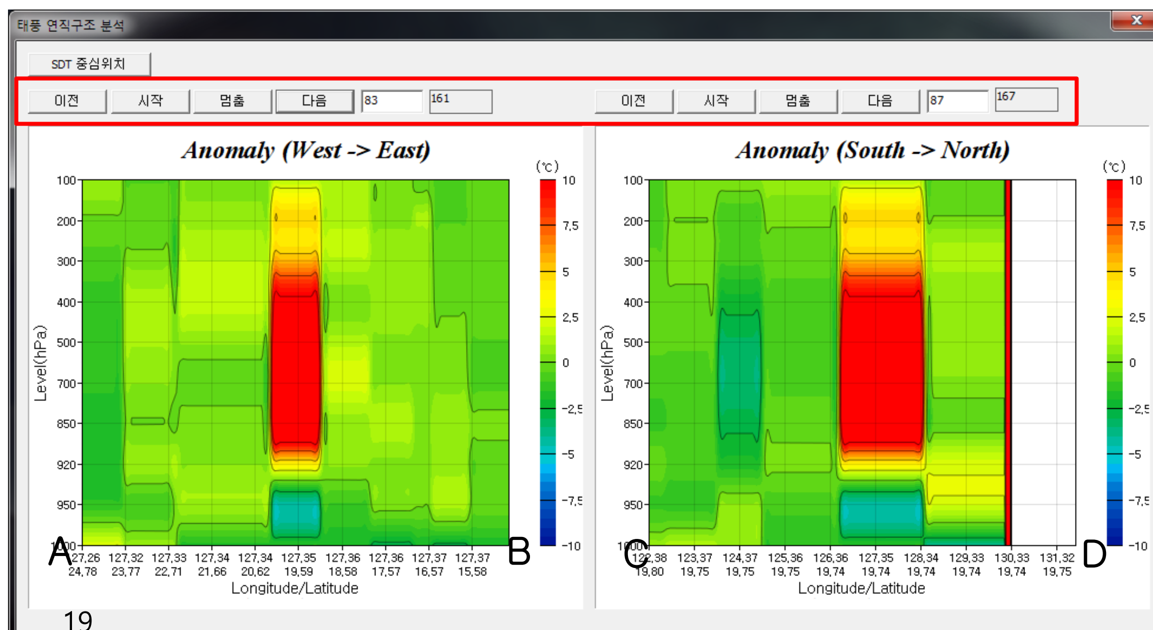
- NOAA/ATOVS, S-NPP/ATMS Temperature :
  Temperature of 1000hPa~100hPa levels, Interpolation Tb between levels
- Product Tb anomaly around TC center position in a selected area
  Tb anomaly : $\Delta T_i = T_i - \overline{T_i}$
- Product Warm core from Tb anomaly around TC center
- **Useful to analysis TC center tilted TC with vertically**

NOAA ATOVS Temp. (2016.07.06 22:08 UTC)



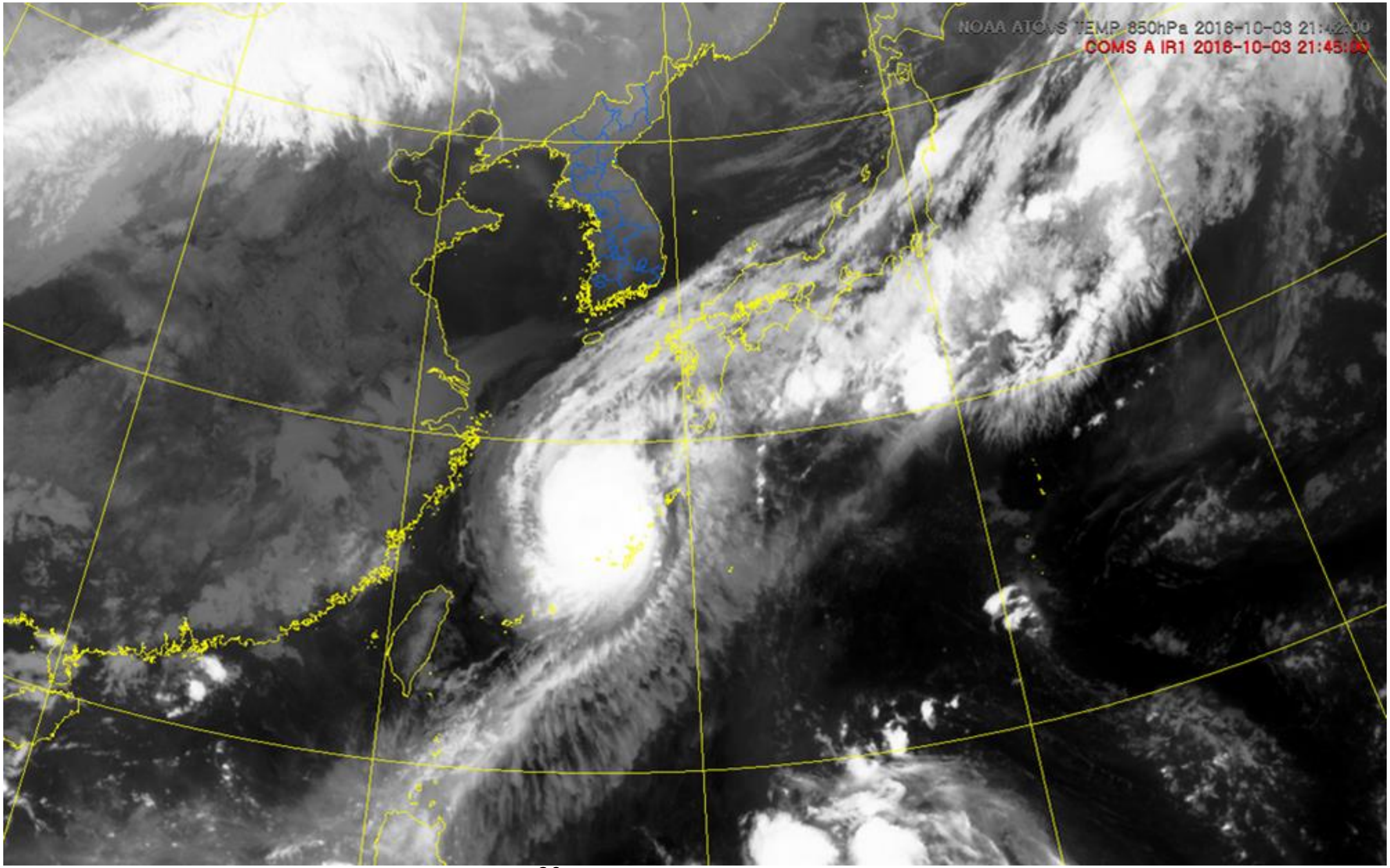
Auto scan in selected area

Tb anomaly Cross Section



Vertical Profile: Warm core in TC

❖ NOAA/ATOVS Temperature : Warm core(anomaly) with vertical profile in TC



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<Wind radius of 15m/s based on multi-Microwave>

Multi – Microwave Sensors

❖ **6 MW Sensors :** METOP-A/ASCAT, METOP-B/ASCAT,GCOM-W1/AMSR2, GPM/GMI, CORIOLIS/WINDSAT, DMSP/SSMIS

Sensor description

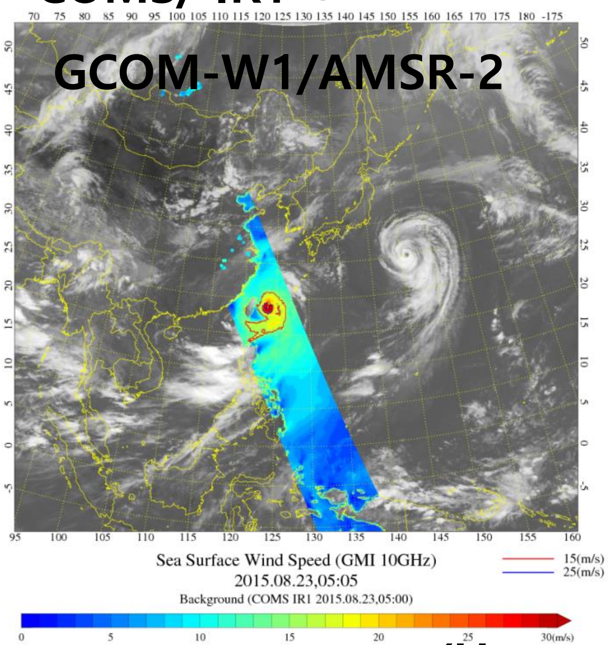
Sensors	**ASCAT**	**AMSR2**	**GMI**	**SSMIS**	**WINDSAT**
Type	Active Scatterometer	Passive radiometer	Passive radiometer	Passive radiometer	Passive radiometer
Frequency	5.255GHz, V polarization	6.93GHz H & V polarization	10.65GHz H & V polarization	18.7GHz ~, V polarization	10.7GHz~, H & V polarization
Swath	500km, 2path	1450km	931km	1700km	980km
Resolution	25km	50km	32km	25km	25km
fundamental conception to produce SSW	backscattered signal is spectrally analysed and detected	Reflectance signal depended on sea surface roughness	Reflectance signal depended on sea surface roughness	Reflectance signal depended on sea surface roughness	Reflectance signal depended on sea surface roughness
wind	10-m wind speed and direction	10-m wind speed	10-m wind speed	10-m wind speed	10-m wind speed and direction
Range of wind speed	0 ~ 50m/s	0 ~ 40m/s	0 ~ 40m/s	0 ~ 50m/s	3 ~ 25m/s

(http://www.remss.com/missions, Hong and Shin, 2013)

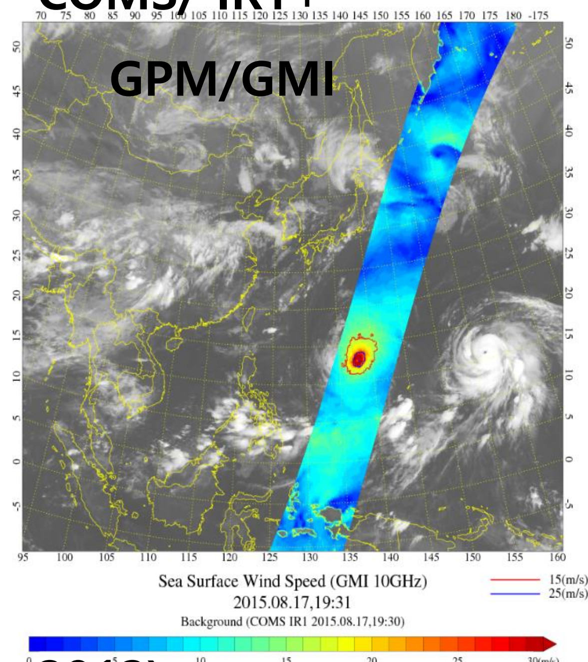
SSW based on MW Satellite

- ❖ Retrieved sea surface wind(SSW) speed
  - under rain-free and rain conditions using the low frequency bands of passive microwave(PMW) satellite observations
  - GCOM-W1/AMSR-2(6.9 GHz), GPM/GMI(10.7 GHz)

COMS/ IR1 +



COMS/ IR1+



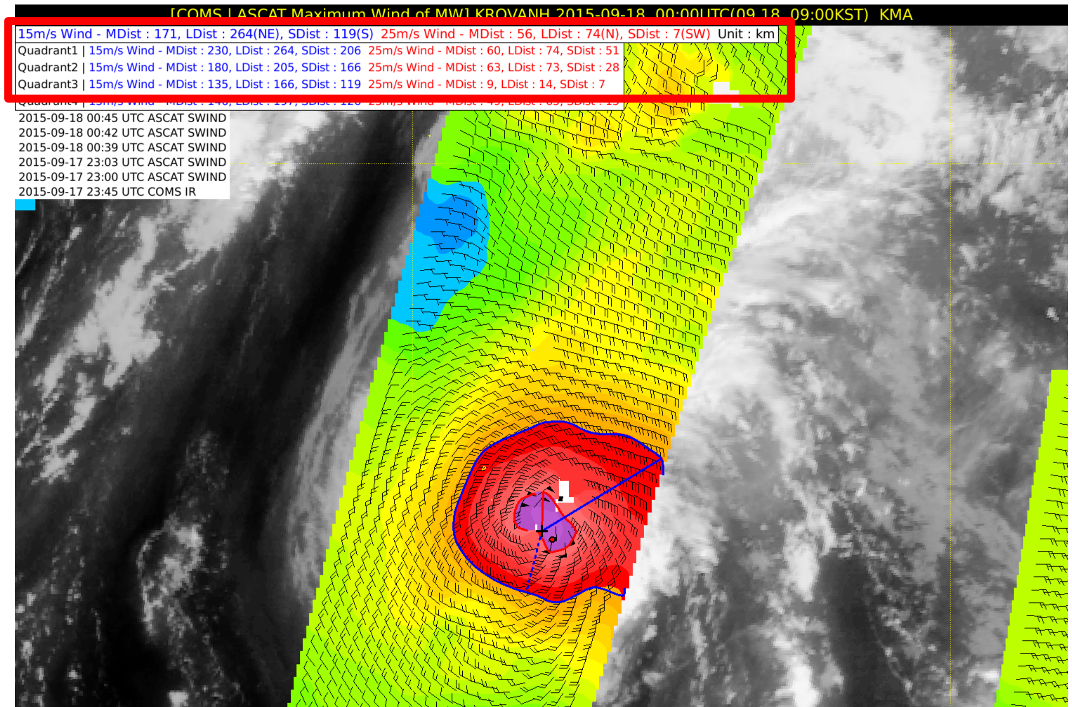
(Hong and Shin, 2013)

1515 GONI & 1516 ATSANI
(20150821 00UTC)

•MW: Microwave

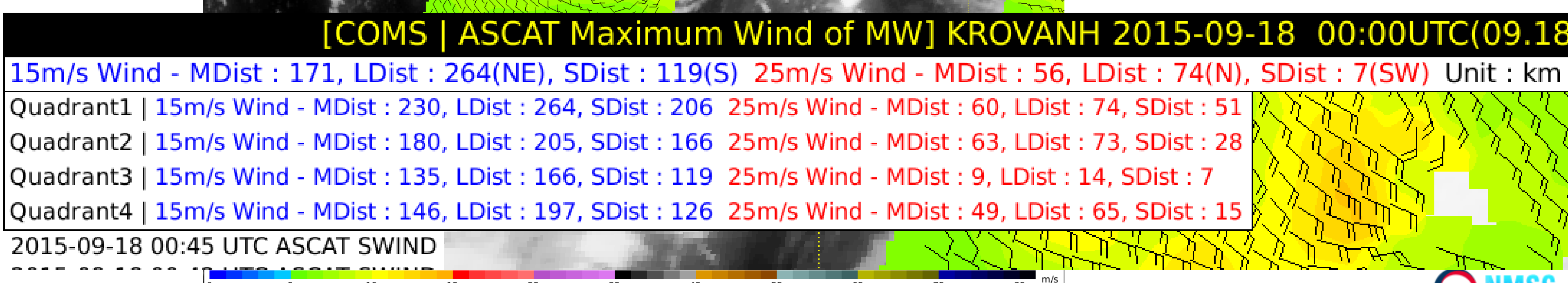
R15 & R25 based on multi-MW

❖ R15 & R25 products based on multi-MW satellite available
- AMSR2, GMI, ASCAT, WINDSAT, SSMIS



METOP-A/ASCAT
2015.9.17. 2303UTC

Red : R15m/s wind
Purple : R25m/s wind



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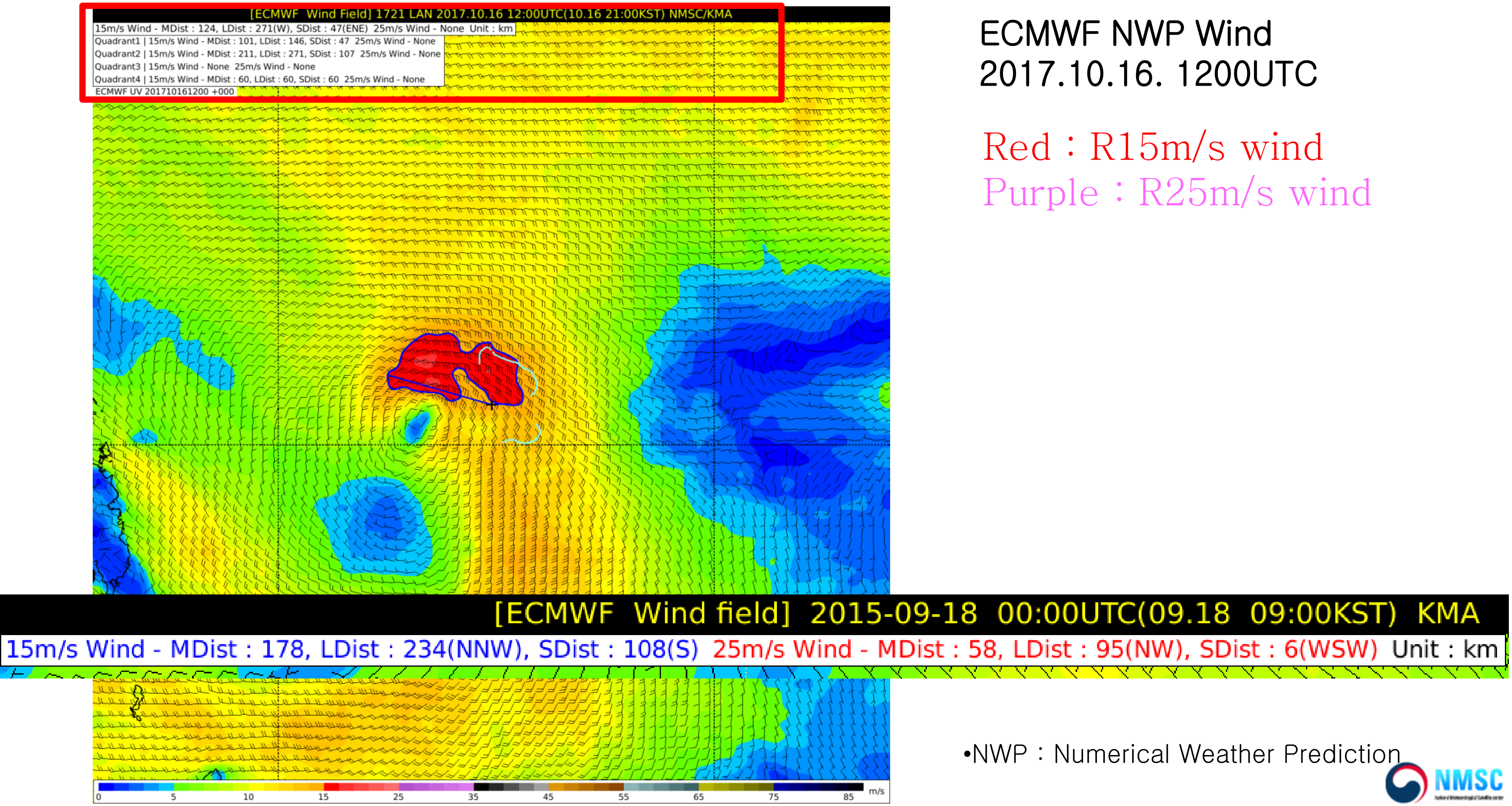
R15 & R25 based on NWP

- ❖ R15 & R25 based on MW are similar to NWP
  - – TC size and azimuth of long and short distance
- ❖ Estimated SSW of NWP in empty and no observation based on MW



ECMWF NWP Wind
2017.10.16. 1200UTC

Red : R15m/s wind
Purple : R25m/s wind

•NWP : Numerical Weather Prediction

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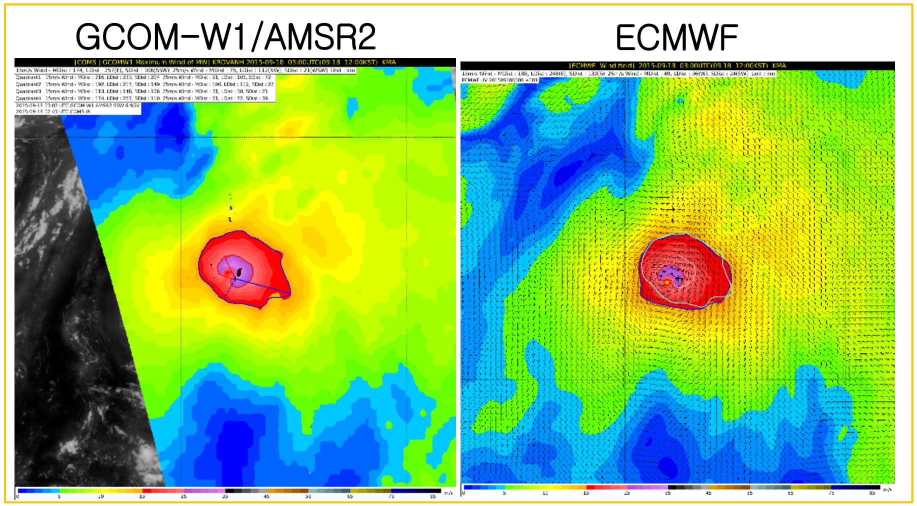
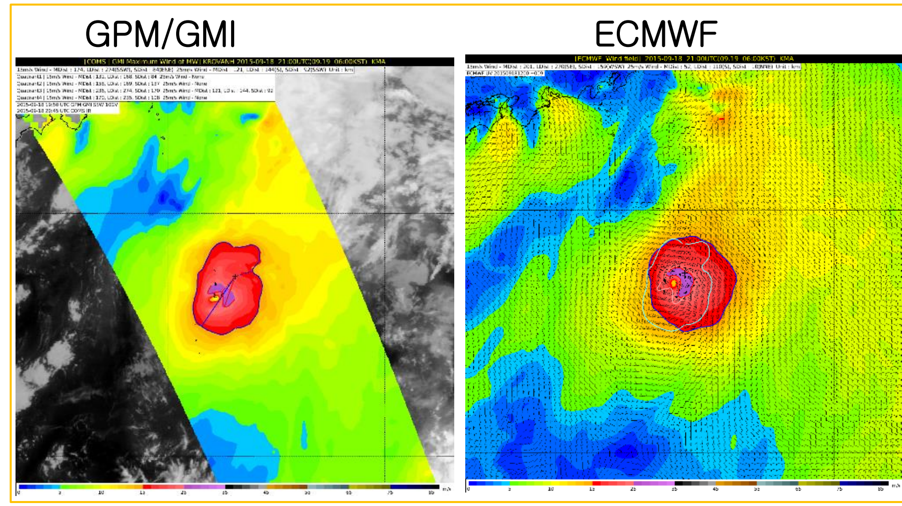
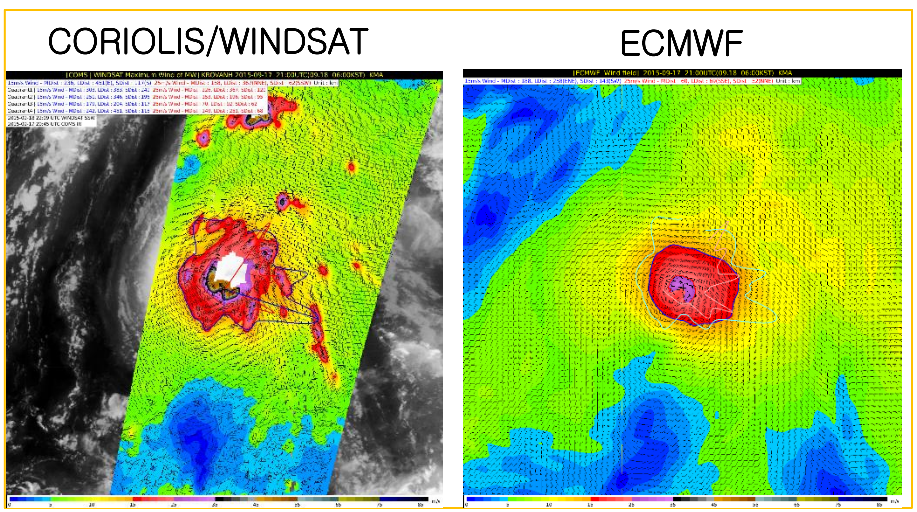
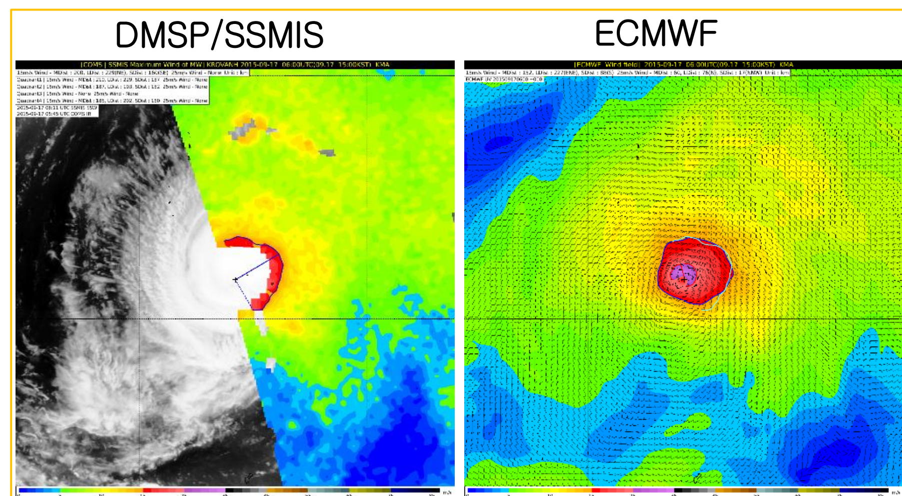
R15 & R25 based on multi-MW

- ❖ Retrieved SSW speed under rain-free and rain conditions using multi-MW
- ❖ Wind products close to observation at weaken state of TC
- ❖ Production of R15 & R25 in asymmetrical TC structure
- ❖ NWP wind data compensate the wind data of no observation area of MW





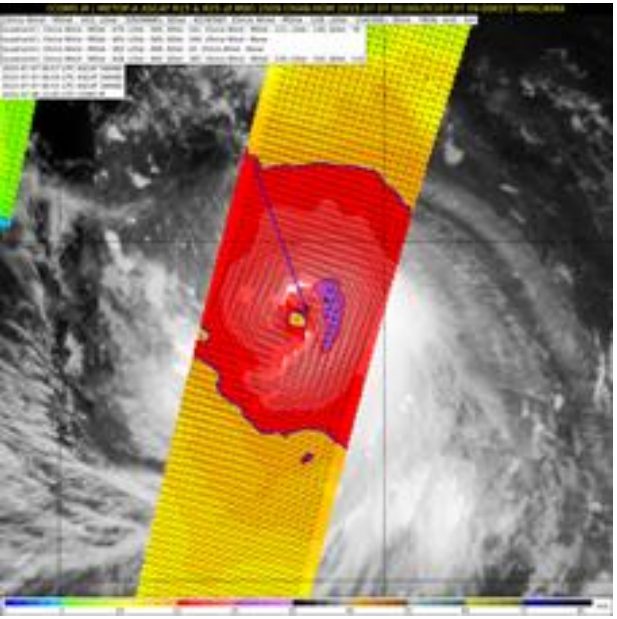




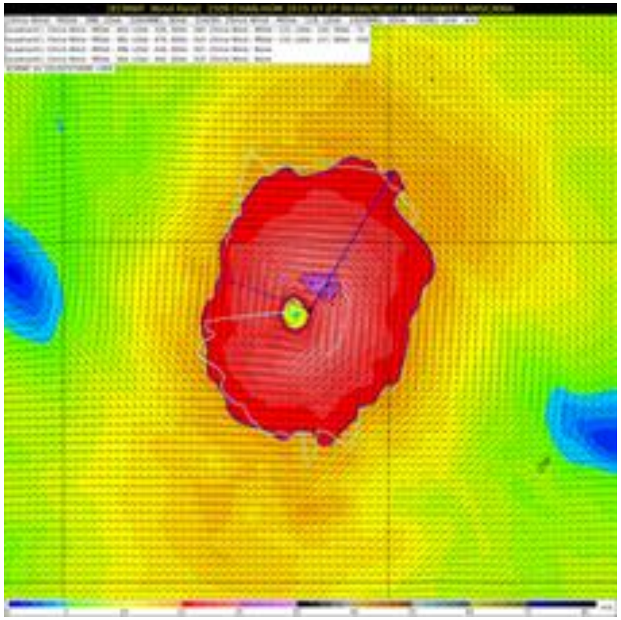
Composite Wind data between MW and NWP

❖Combine MW and NWP wind data to identify in no observation area of satellite data

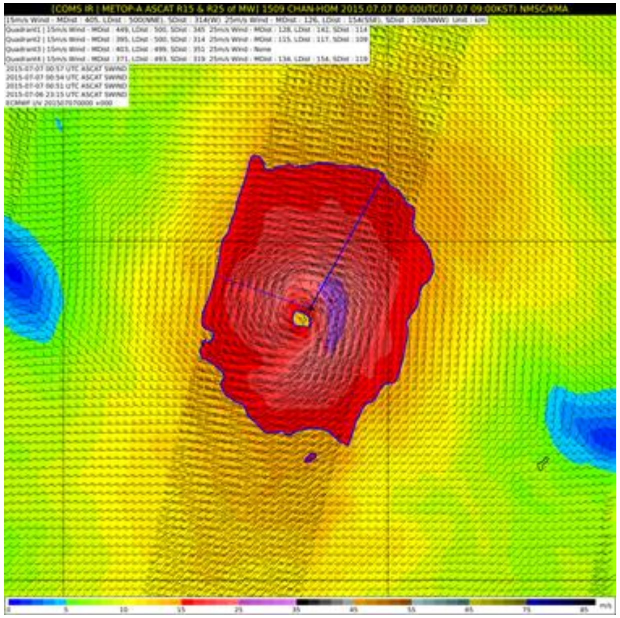
METOP/ASCAT



ECMWF



METOP/ASCAT + ECMWF



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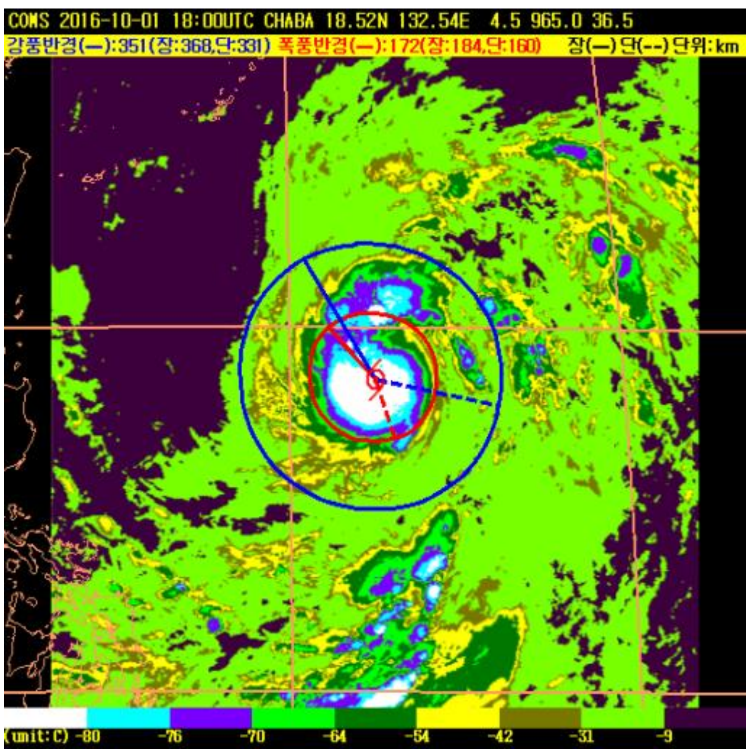
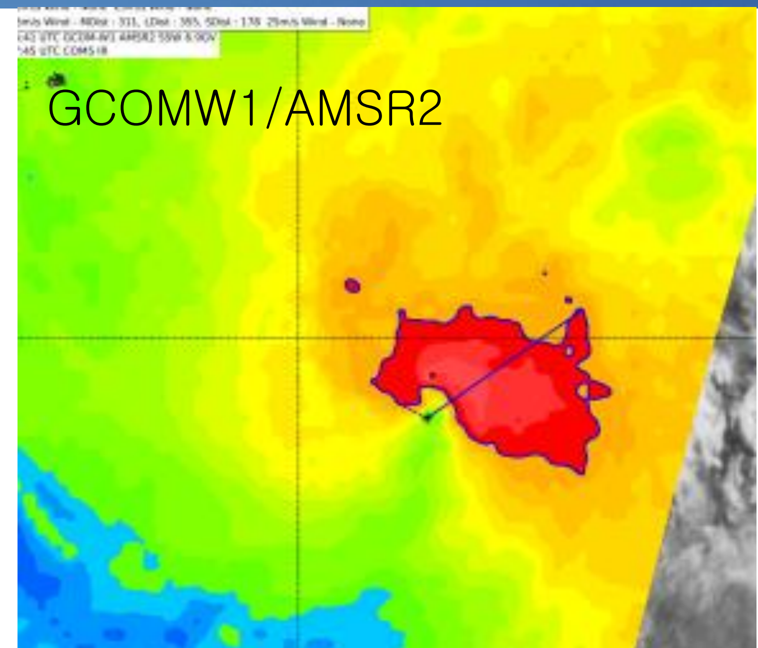
Adjustment of R15 based on multi wind data

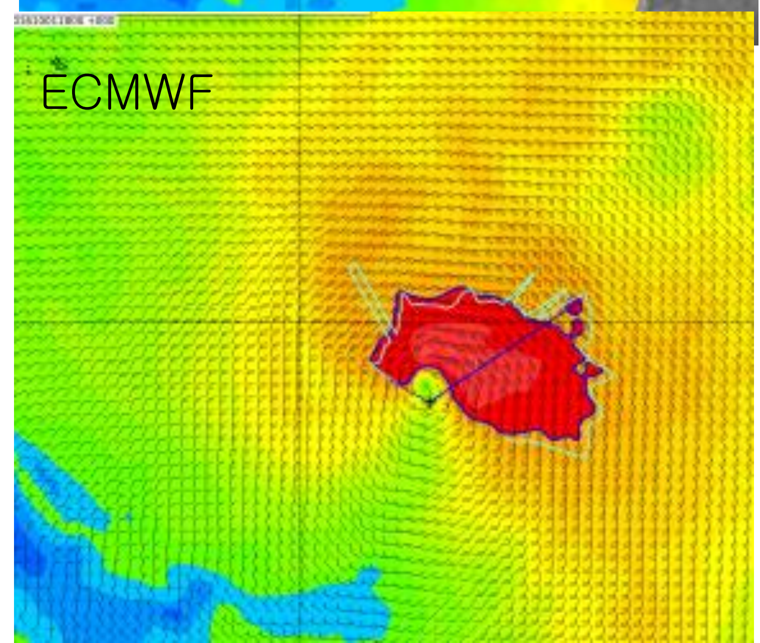
2016. 10. 1. 18UTC

COMS IR 351km(Average)
GCOMW1/AMSR2 355km(4 quadrant long axis)
ECMWF 339km(4 quadrant long axis)
=> R15 : about 350km



R15 and R25 by COMS IR1

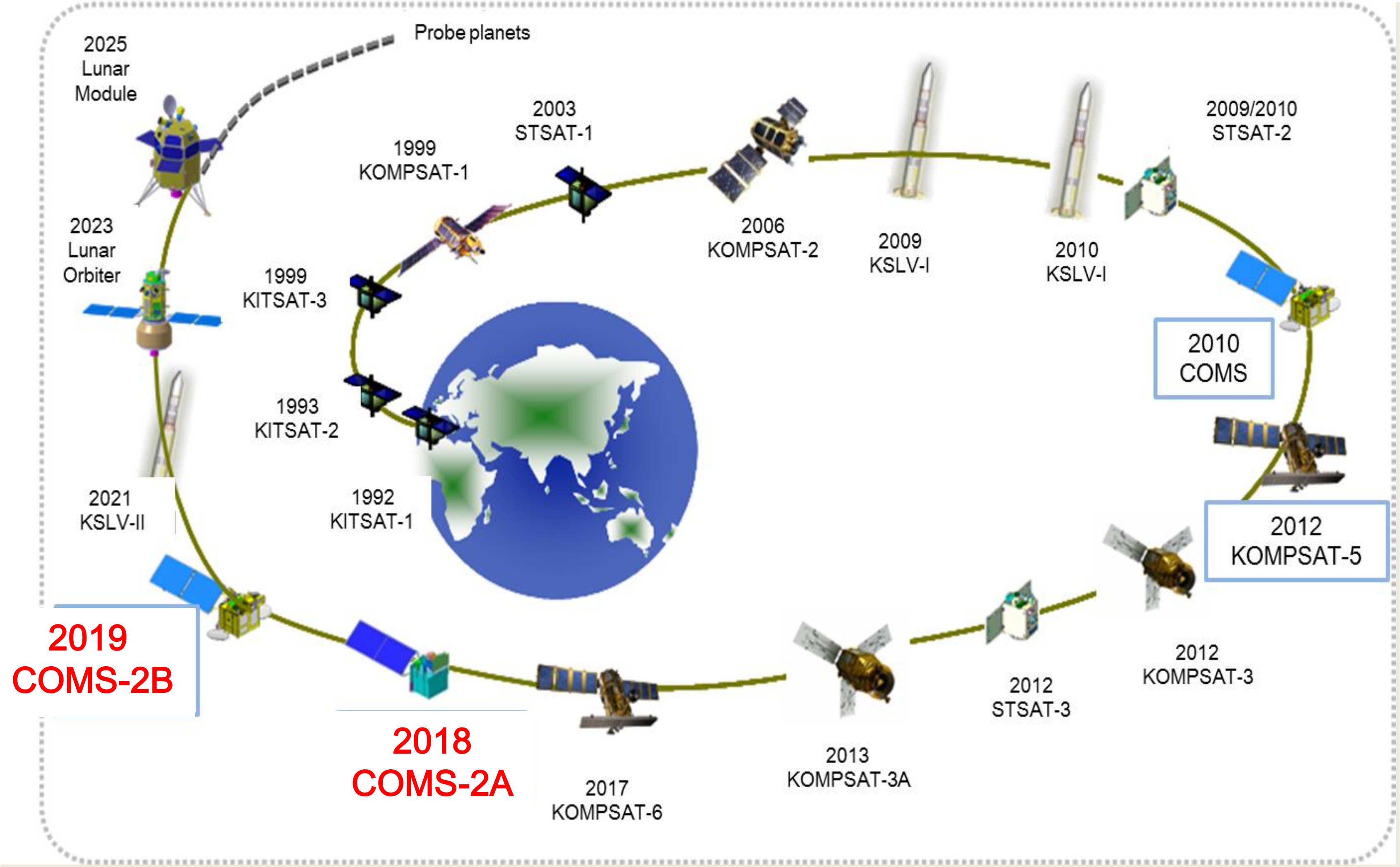




<Developing TC analysis skills with COMS-2A>

Development of the next COMS

- ❖ Development of the geo. Multi-purpose satellite based on the National Space Development Plan in S. KOREA.
- ❖ Next Meteorological Satellite is planned to be launched in 2018 and 2019



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COMS-2A AMI sensor

❖ AMI(Advanced Meteorological Imager) (cf. AHI/Himawari-8/9, ABI/GOES-R)

Channels	Wavelengh(㎛)					
	AMI (GK-2A)	ABI (GOES-R)	AHI (HW8)	MI (COMS)	SEVIRI (MSG)	MODIS
1(VIS) blue	0.470	0.470	0.46			0.466 (B03)
2(VIS) green	**0.511**		**0.51**			0.554 (B04)
3(VIS) red	0.640	0.640	0.64	0.675	0.6	0.647 (B01)
4(VIS)	0.856	0.865	0.86		0.8	0.857 (B02)
5(NIR)	**1.380**	**1.378**				1.382 (B26)
6(NIR)	1.610	1.610	1.6		1.6	1.629 (B06)
NIR		**2.250**	**2.3**			2.114 (B07)
7(IR)	3.830	3.90	3.9	3.75	3.9	3.788 (B20)
8(WV)	6.241	6.185	6.2		6.2	6.765 (B27)
9(WV)	6.952	6.95	7.0	6.75		6.765 (B27)
10(WV)	7.344	7.34	7.3		7.3	7.337 (B28)
11(IR)	8.592	8.50	8.6		8.7	8.529 (B29)
12(IR)	9.625	9.61	9.6		9.7	9.734 (B30)
13(IR)	10.403	10.35	10.4	10.8	10.8	B30+B31
14(IR)	11.212	11.20	11.2			11.019 (B31)
15(IR)	12.364	12.30	12.3	12.0	12.0	12.032 (B32)
16(IR)	13.31	13.30	13.3		13.4	13.365 (B33)

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COMS MI vs. COMS-2A AMI

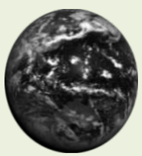
4 times spatial resolution

COMS
VI 1km
IR 4km

→

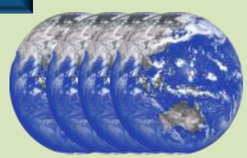
COMS-2A
VI 0.5~1km
IR 2km

6 times temporal resolution



1 FD

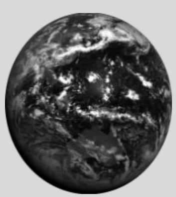
→ 1 Hr



6FD

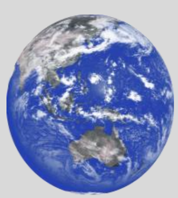
3 times number of channels

5 channel
(vis 1, IR 4)



→

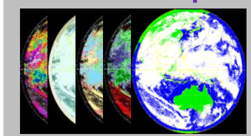
16 channels
(vis 4, NIR 2, IR 10)

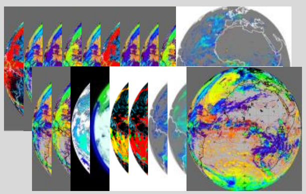


3.5 times number of products

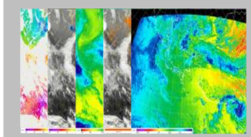
COMS	COMS-2A

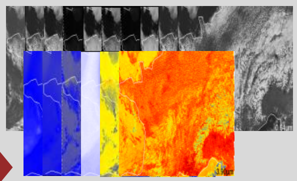
Cloud/Precipitation (5→19)



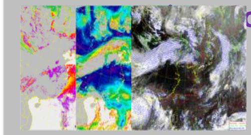


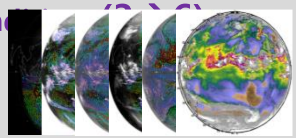
Radiation/aerosol (5→16)



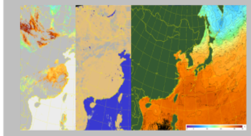


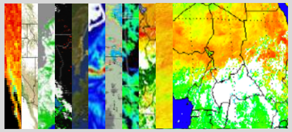
Atmospheric





Surface information(3→11)

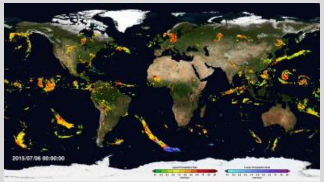




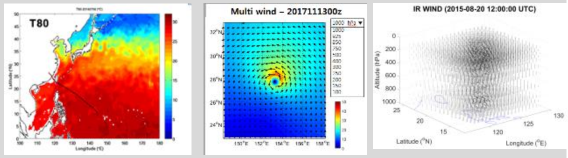
16 products → 52 products

4 Application Facilities

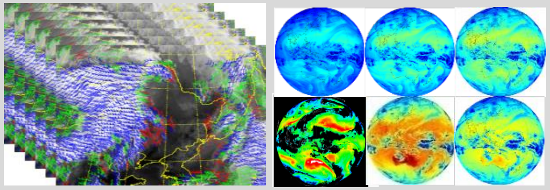
Analysis & Nowcasting



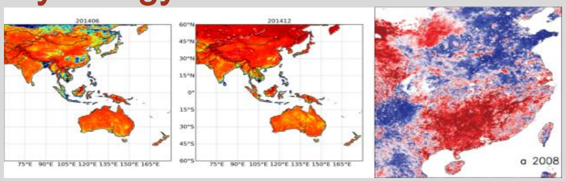
Typhoon & Ocean



Data Assimilation & NWP



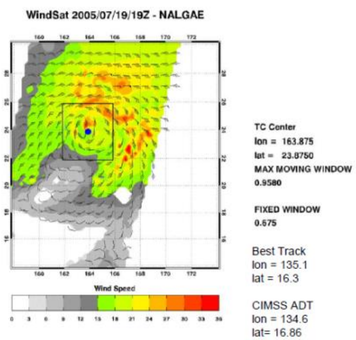
Hydrology & Environment

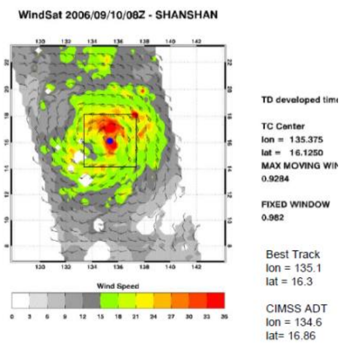


NMSC

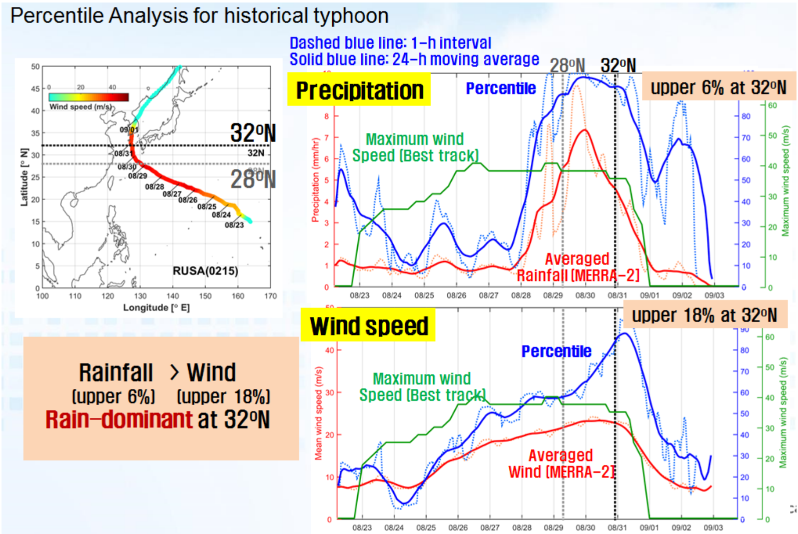
Developing TC analysis skill with COMS-2A

ADT Improvement
TC centering technique using derived winds

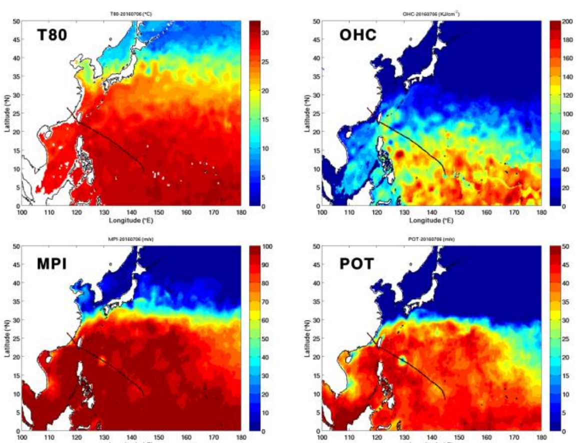




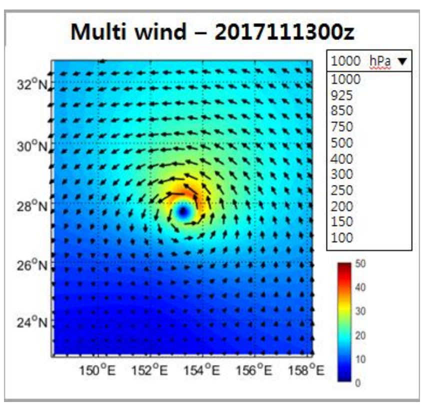
Supporting Impact forecast of TC

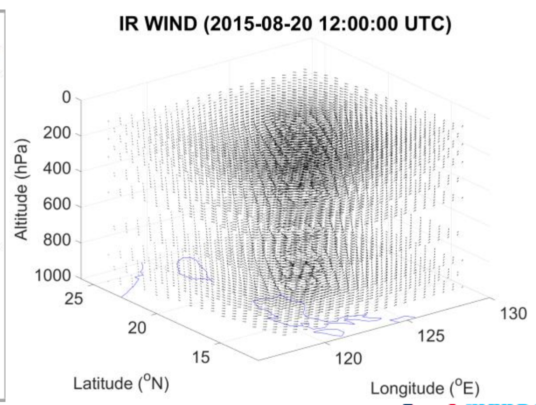


Estimating the intensity change of TC
: OHC, MPI, Vertical Shear etc.



Multi Satellite-base 3D Winds





Summary

❖ **With multi-Microwave Satellite data:**

- Low level Cloud can be detected better in SWIR than IR1 image at night
- **Overlap ASCAT and NWP wind, or MW 37 and 89Ghz with COMS images**
- Estimation certain TC center position with ASCAT **wind vector**
- Analysis convective cloud line or Eye wall with 37Ghz and 89Ghz of AMSR2 & GMI
- **Suomi NPP/DNB image show us cloud line curvature clearly at**
- **NOAA/ATOVS : warm core(anomaly) with vertical profile of temperature in TC**
- **Production of R15 & R25 based on multi-MW almost every 3 hours amd NWP**
- Wind is close to observation at weaken state of TC and in asymmetrical TC structure
- NWP data compensate the wind of no observation area of MW

❖ **With Next Meteorological Satellite data:**

- Developing typhoon analysis skills for COMS-2A satellite application
  - Supporting Impact forecast of TC
  - Estimating the intensity change of TC: OHC, MPI, Vertical Shear etc.
  - Multi Satellite-base 3D Winds

Thank you

National Meteorological Satellite Center/ KMA