Current status of GK-2A AMV algorithm in NMSC/KMA

23 April 2018

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NMSC/KMA

국가기상위성센터
National Meteorological Satellite Center

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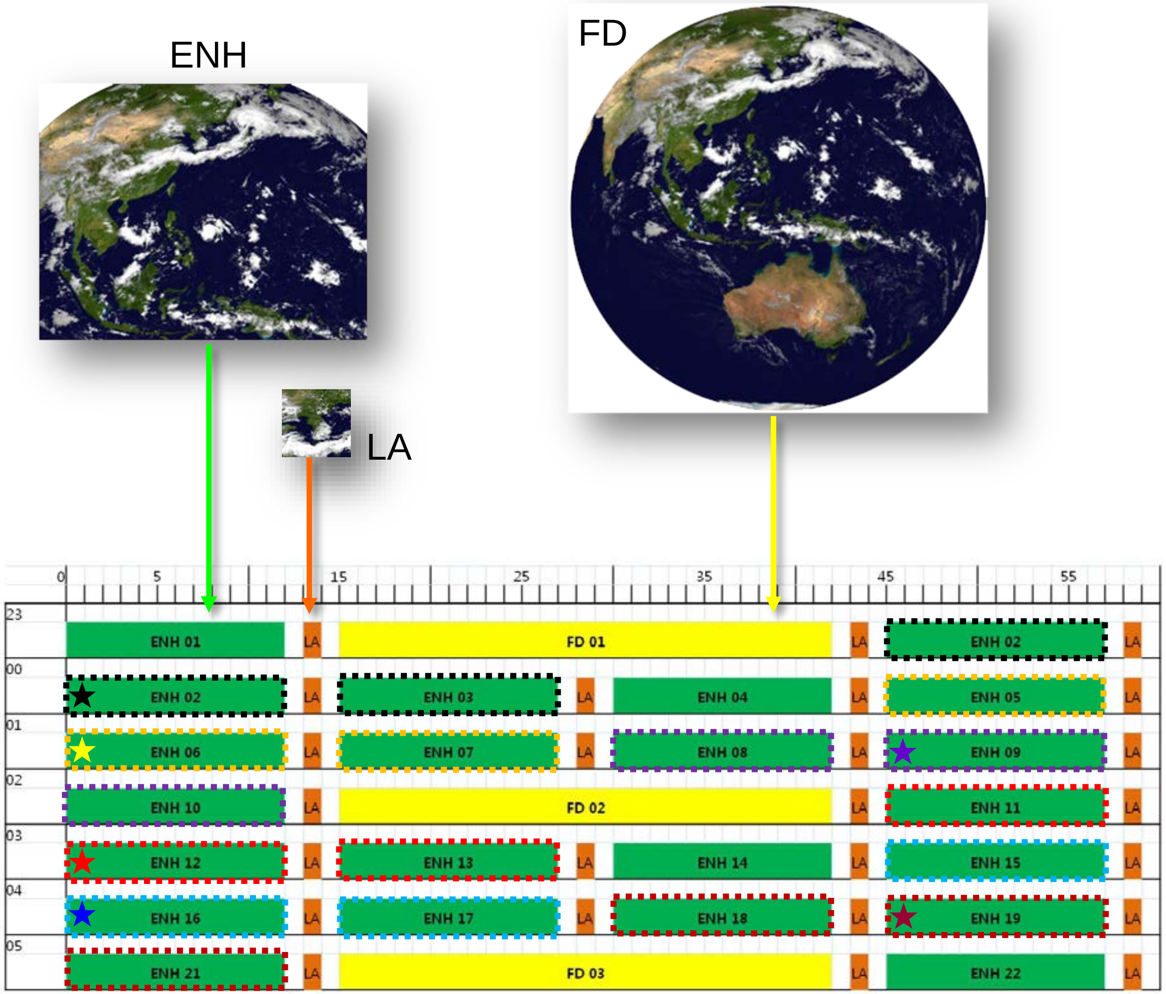
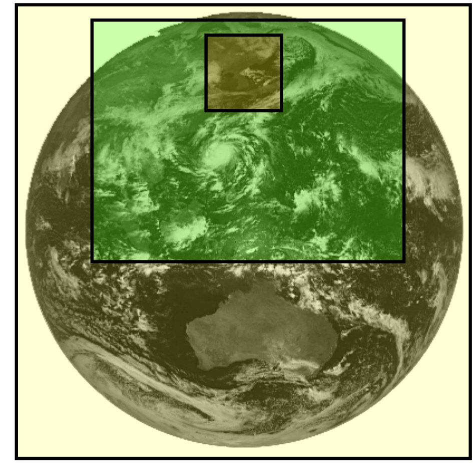
❖ Observation Schedule



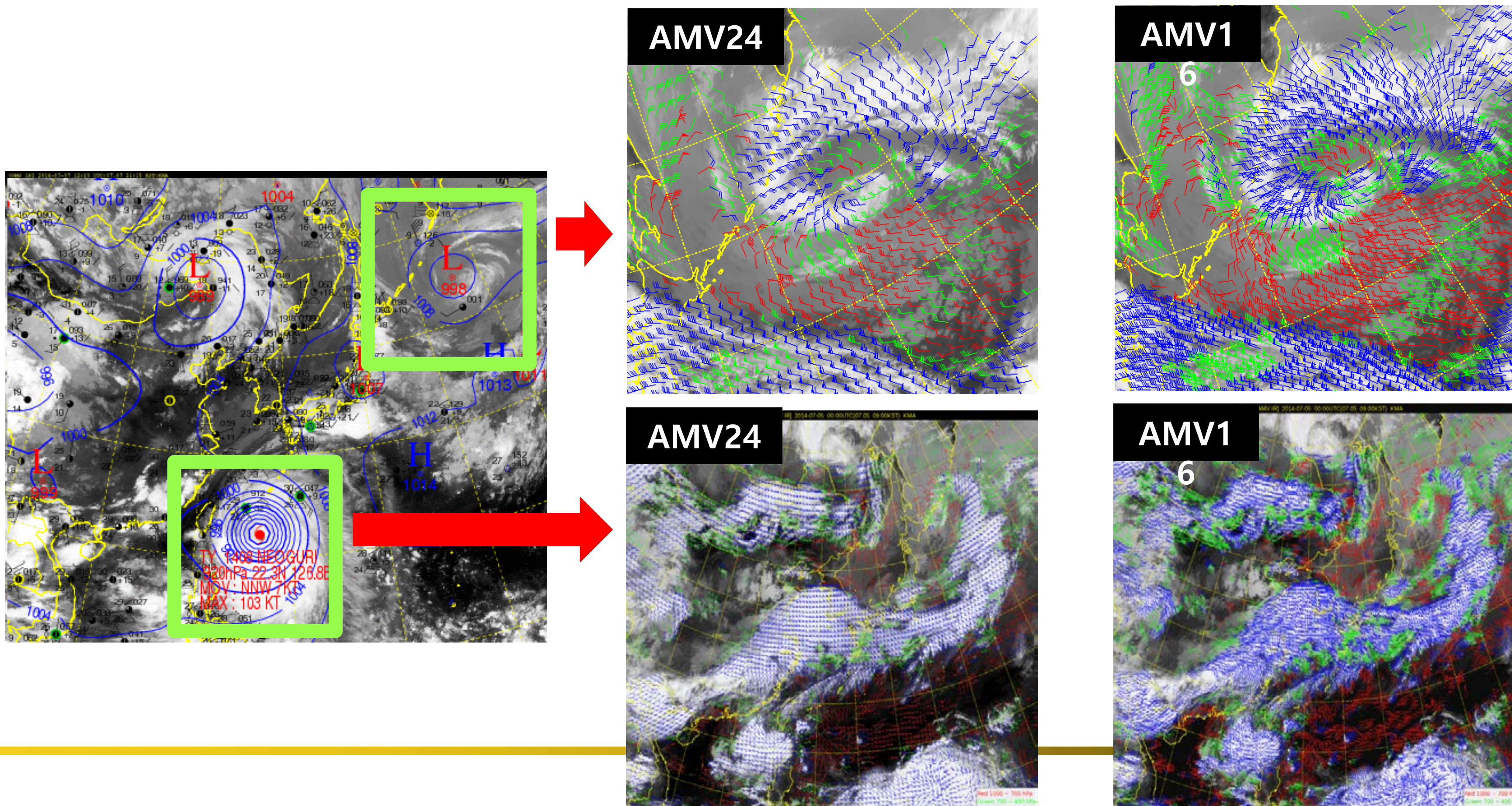


- AMV's are **produced every 1 hour** (but not regularly)
- using 3 consecutive 15 min interval ENH observations
- **disseminate by GTS**

Status of COMS AMV

❖ AMV T24(Operation) → ❖ AMV T16(Tested)

- Target size : 24x24 (96 X 96km) → 16x16 (56 X 56km)
- Target selection : Regular (REG) → Optimal target selection
- Target interval : 12 pixels → 8 pixels



Status of COMS AMV

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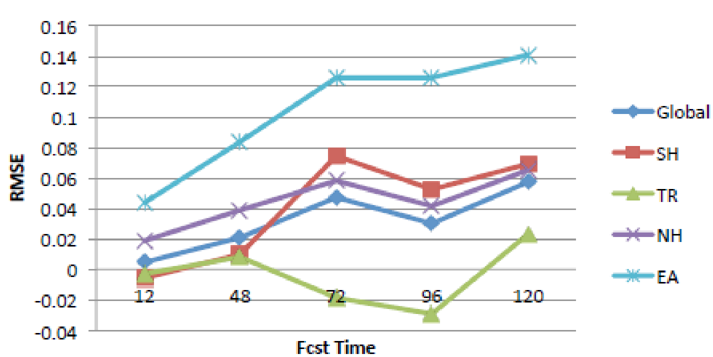
❖ Accuracy of COMS AMV (April 1 - 24, 2016)

Sonde(IR)	All level		High level		Middle level		Low level	
	T24	T16	T24	T16	T24	T16	T24	T16
Number	37940	**76507**	33601	**67665**	3190	**6216**	1149	**2626**
MVD	**5.62**	5.75	5.80	**5.57**	**4.71**	4.77	3.02	**2.98**
RMSVD	6.73	**6.69**	6.91	**6.86**	**5.60**	5.71	**3.60**	3.57
BIAS	-1.74	**-1.23**	-1.88	**-1.34**	-0.83	**-0.50**	-0.23	**-0.17**
RMSE	5.27	**5.14**	5.41	**5.27**	**4.50**	4.51	**2.54**	2.57

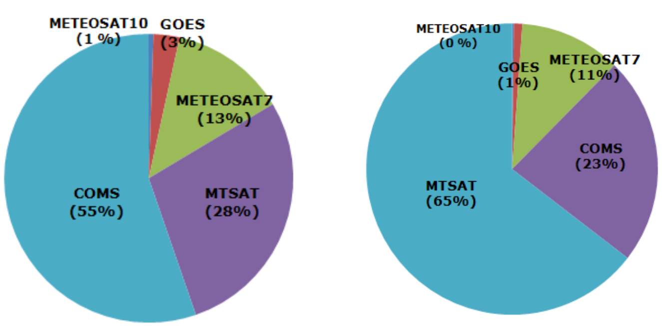
❖ Assimilate(24x24, VIS, IR, WV) in KMA global system since Dec. 2011. Positive impact especially in East Asia *[NWP Center]*

500GPH RMSE diff(Cntl-COMS)-00UTC



<September~ October in 2011>

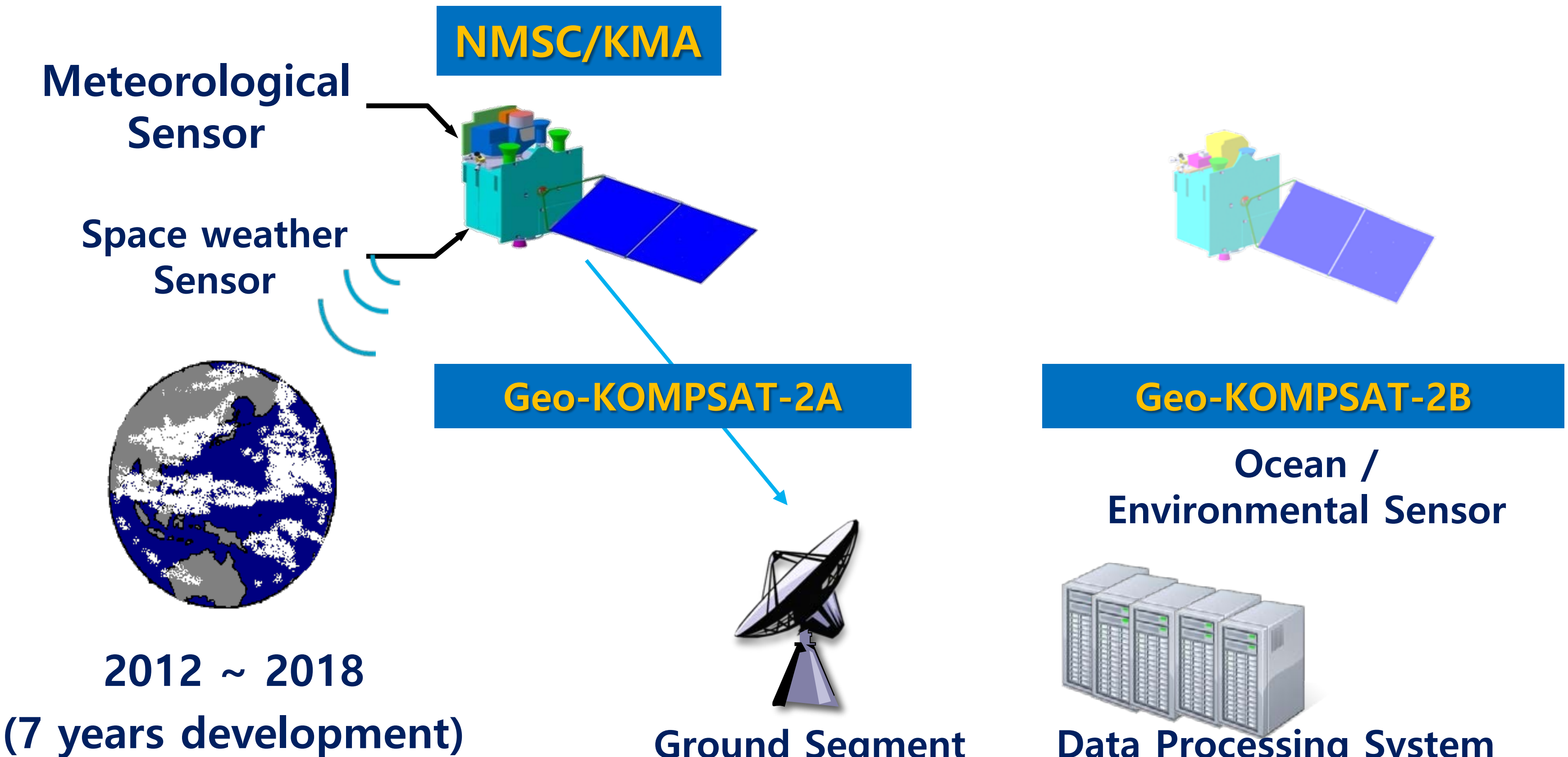
FSO of Satwind data in East Asia



<Winter & Summer in 2013>

Geo-KOMPSAT-2A Programs

- **KMA** plans to launch the next Korean geostationary meteorological satellite **GEO-KOMPSAT-2A (GK-2A) in Nov. 2018**
  - **GK-2A** for the next generation **Meteorological Imager and SWx monitoring**
  - **GK-2B** for the **Ocean Color(GOCI2) and Atmospheric Trace Gas(GEMS)** monitoring

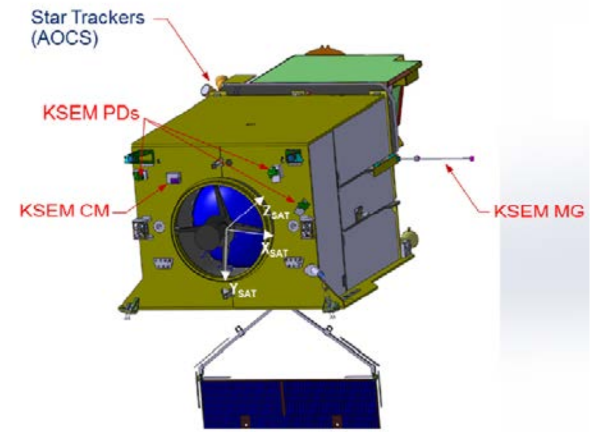


Payloads for Geo-KOMPSAT-2A

❖ AMI (Advanced Meteorological Imager)

Center wavelength (µm)			
AMI (Resolution)		**ABI**	**AHI**
1 blue	**0.47 (1km)**	**0.47**	**0.46**
2 green	**0.511 (1km)**		**0.51**
3 red	**0.64 (0.5km)**	**0.64**	**0.64**
4	0.856 (1km)	0.865	0.86
5	1.38 (2km)	1.378	
6	1.61 (2km)	1.61	1.6
		2.25	2.3
7	3.830 (2km)	3.90	3.9
8	6.241 (2km)	6.185	6.2
9	6.952 (2km)	6.95	7.0
10	7.344 (2km)	7.34	7.3
11	8.592 (2km)	8.50	8.6
12	9.625 (2km)	9.61	9.6
13	10.403 (2lkm)	10.35	10.4
14	11.212 (2km)	11.2	11.2
15	12.364 (2km)	12.3	12.3
16	13.31 (2km)	13.3	13.3

<Space weather Sensor>



KSEM(Korea Space wEather Monitor)

- PD : Particle Detector
- MG : Magnetometer
- CM : Charging Monitor

vs. AHI : addition : 1.38 µm (NIR), subtraction 2.3 µm (NIR)

- **1.38 µm** : favorable for cirrus cloud detection, cloud type and amount
- **2.3 µm** : favorable for Land/cloud Properties

52 Meteorological Products

23 Primary Products & 29 Secondary Products

Scene & Surface Analysis (13)	Cloud & Precipitation (14)	Aerosol & Radiation (14)	Atmospheric condition & Aviation (11)
Cloud detection	**Cloud Top Temperature**	**Aerosol Detection**	**Atmospheric Motion Vector**
Snow Cover	**Cloud Top Pressure**	**Aerosol Optical Depth**	**Vertical Temperature Profile**
Sea Ice Cover	**Cloud Top Height**	**Asian Dust Detection**	**Vertical Moisture Profile**
Fog	Cloud Type	**Asian Dust Optical Depth**	**Stability Index**
Sea Surface Temperature	**Cloud Phase**	Aerosol Particle Size	Total Precipitable Water
Land Surface Temperature	Cloud Amount	**Volcanic Ash Detection and Height**	Tropopause Folding Turbulence
Surface Emissivity	Cloud Optical Depth	Visibility	**Total Ozone**
Surface Albedo	Cloud Effective Radius	**Radiances**	SO_2 Detection
Fire Detection	Cloud Liquid Water Path	Downward SW Radiation (SFC)	**Convective Initiation**
Vegetation Index	Cloud Ice Water Path	Reflected SW Radiation (TOA)	Overshooting Top Detection
Vegetation Green Fraction	Cloud Layer/Height	Absorbed SW Radiation (SFC)	Aircraft Icing
Snow Depth	**Rainfall Rate**	Upward LW Radiation (TOA)	
Ocean Current	Rainfall Potential	Downward LW Radiation (SFC)	
	Probability of Rainfall	Upward LW Radiation (SFC)	

GK-2A AMV algorithm

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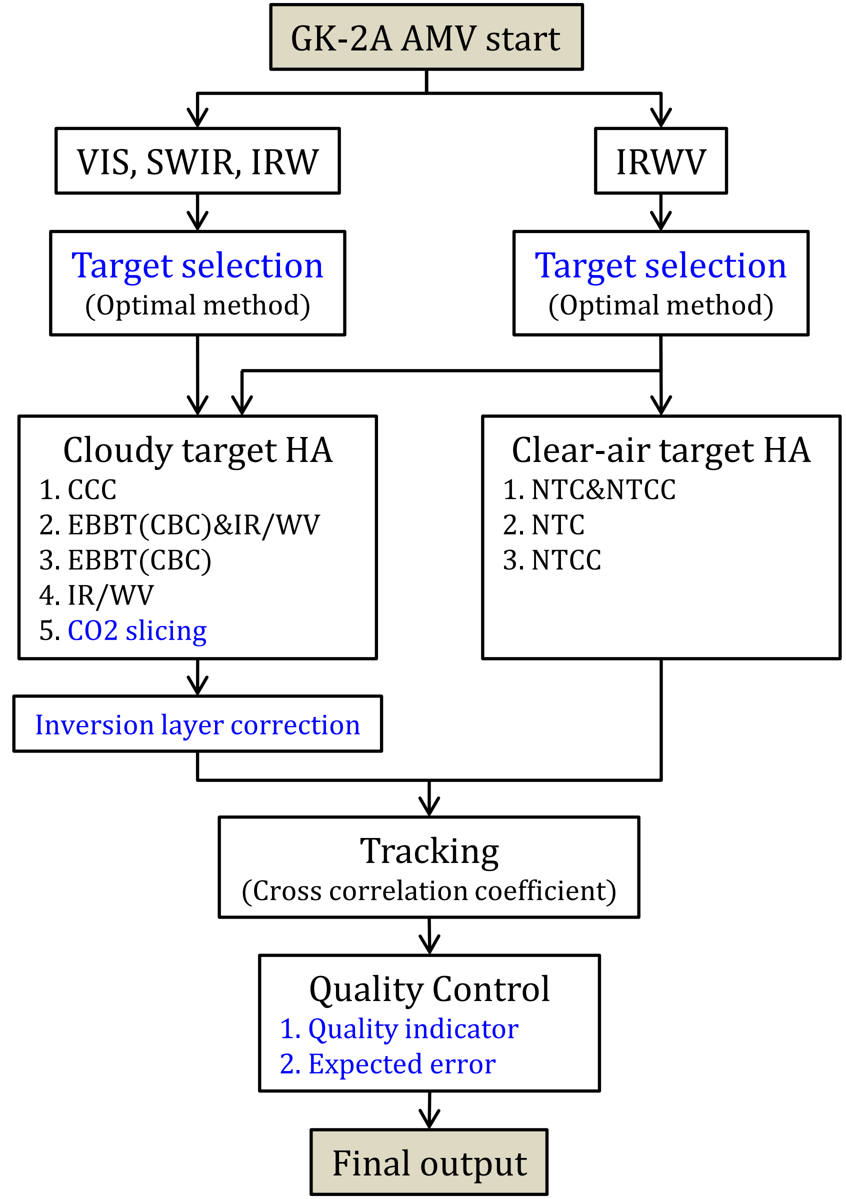
❖ Specification and flow chart

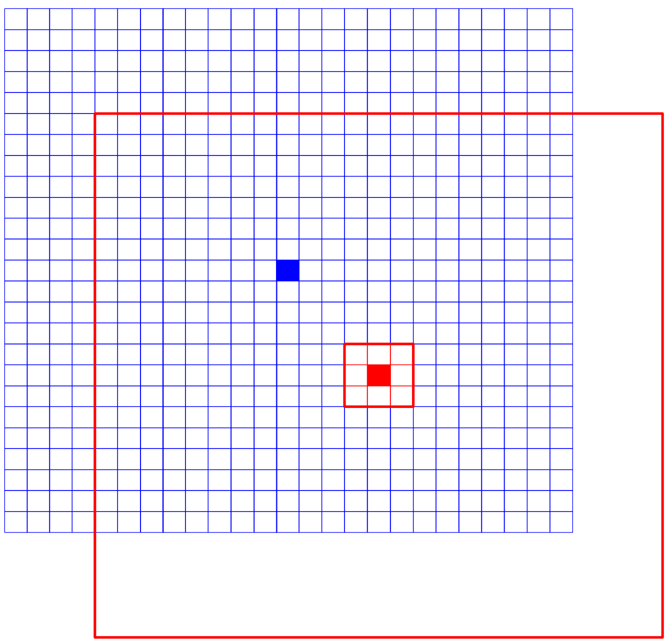
	GK-2A AMV	
Channels	VIS(03), SWIR(07), IR(13, 14), WV(08, 09, 10)	
Input L1b images	3 images (proxy: Himawari8/AHI)	
Time interval	Normal scan(FD)	10 minute
	Rapid scan	2 minute
Model / RTM	UM N768/rttov 11.2	
Target box size	Cloudy target	VIS : 32by32 SWIR : 16by16 IR : 16by16 WV : 16by16
	Clear-air target	WV : 16by16
Target selection	Optimal (Statistic)	
Grid step size	Same with target box size	
Search box size	Cloudy target	VIS : 185by185 SWIR : 54by54 IR : 54by54 WV : 54by54
	Clear-air target	WV : 54by54
Center of search area	Regular	
Target tracking	CC	
Height assignment	Cloudy target	1. CCC 2. EBBT(Cloud base correction) 3. IR/WV rationing 4. CO2 slicing (+Inversion layer correction)
	Clear-air target	1. NTC 2. NTCC
Quality control	QI, EE	



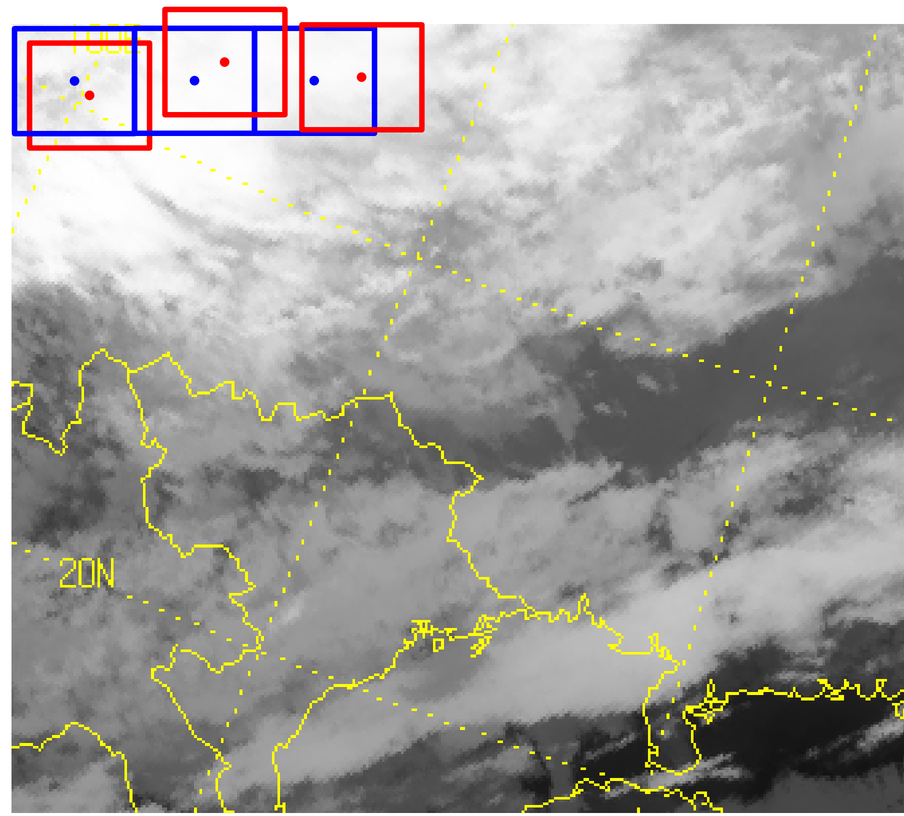
Step1: Target selection

❖ Optimal target selection

- **Cloud Target: 03, 07, 08, 09, 10, 13, 14 (Using cloud mask)**
- **Clear Target: 08, 09, 10**



$$STD_{m,n} = \sqrt{\frac{1}{9}\sum_{i=-1}^{1}\sum_{j=-1}^{1}\left(BT_{m+i,n+j} - \overline{BT}_{m,n}\right)^2}$$



Step1: Target(search) size and temporal gap

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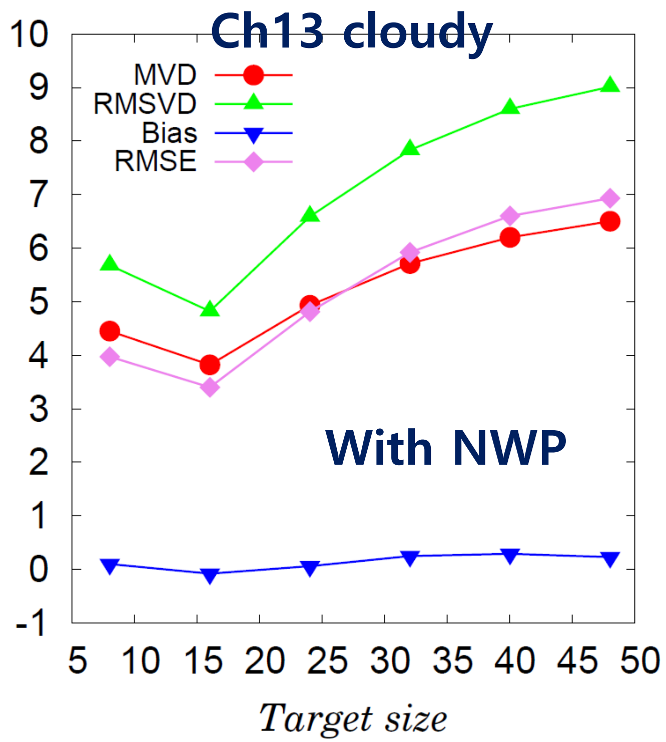
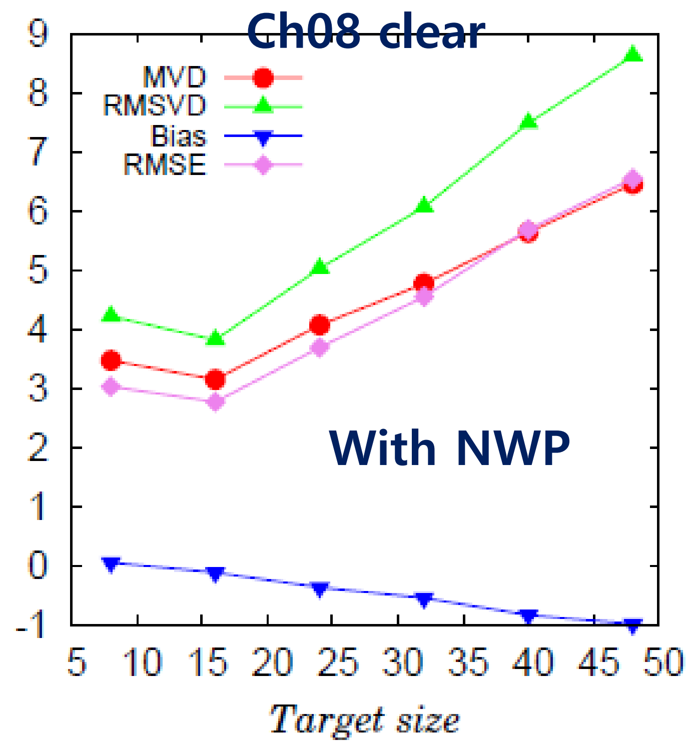
❖ Preliminary Results for GK-2A

[P10: Sensitivity Tests]

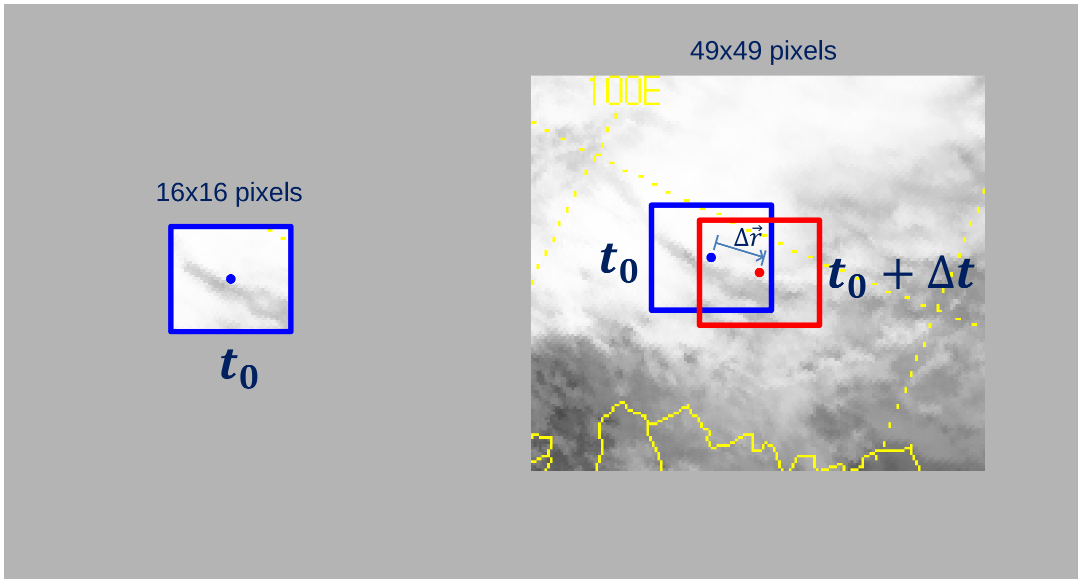
Periods	2016.07.21. 00:00 ~23:00 (UTC)
Channel	Ch. 13 cloudy target, Ch. 08 clear target
Time interval	**10 minute**
Target(Search) box size	**8(46), 16(54), 24(62), 32(70), 40(78), 48(86)**





Step2: Target tracking

❖ Cross Correlation Coefficient



Caluated vector : $\vec{v} = \dfrac{\vec{r}}{\Delta t}$

$$CC_{m,n} = \frac{1}{N_x N_y} \sum_{i=1}^{N_x} \sum_{j=1}^{N_y} \left(\frac{a_{m+i,n+j} - \bar{a}_{m,n}}{(\sigma_a)_{m,n}} \frac{b_{i,j} - \bar{b}}{\sigma_b} \right)$$

$a_{i,j}$: BT value in ith row and jth column of N_x by N_y target box in search area at time $t_0 + \Delta t$.

$\bar{a}$: Average of $a_{i,j}$.

σ_a : Standard deviation of $a_{i,j}$.

$b_{i,j}$: BT value in ith row and jth column of N_x by N_y target at time t_0.

$\bar{b}$: Average of $b_{i,j}$.

σ_b : Standard deviation of $b_{i,j}$.

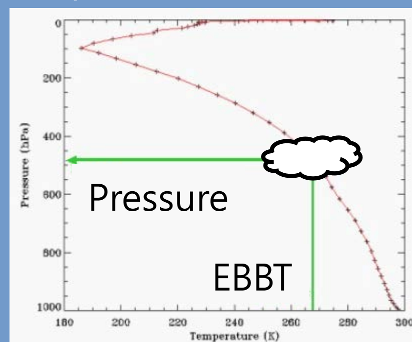
N_x, N_y : Size of target box.

Step3: Height assignment(Cloud Target)

❖ Cloud Target: 4 methods + 2 combinations

EBBT

- **E**quivalent **B**lackbody **T**emperature
- Opaque Clouds
- NWP Temp. Profile
  + RTM simulation
- Coldest 15% temp.
  : Dominant motion
  level of targets

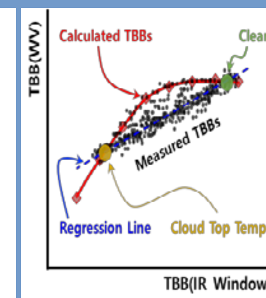


IR/WV Intercept

- Semi-transparent Clouds Optically Thin Clouds (e.g., cirrus)

$$\frac{R_{cld}(WV)-R_{clr}(WV)}{R_{cld}(IR_\lambda)-R_{clr}(IR_\lambda)} = \frac{\cancel{\varepsilon(WV)}\,[R_{bcd}(WV,P_{cd})-R_{sfc}(WV)]}{\cancel{\varepsilon(IR_\lambda)}\,[R_{bcd}(IR_\lambda,P_{cd})-R_{sfc}(IR_\lambda)]}$$

R_{clr}: Measured cloudy radiance
R_{cld}: Measured cloud free radiance
R_{sfc}: Calculated Planck blackbody radiance for a cloud at level P_{cd}
R_{bcd}: Calculated clear air radiance



CO_2 Slicing Method

- Similar to IR/WV intercept, but use CO_2 channel

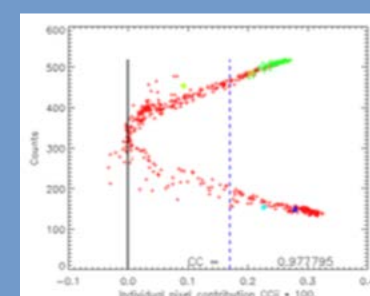
$$\frac{R_{clr}(CO_2)-R_{cld}(CO_2)}{R_{clr}(IR_\lambda)-R_{cld}(IR_\lambda)} = \frac{\cancel{\varepsilon(CO_2)}\,[R_{sfc}(CO_2)-R_{bcd}(CO_2,P_{cd})]}{\cancel{\varepsilon(IR_\lambda)}\,[R_{sfc}(IR_\lambda)-R_{bcd}(IR_\lambda,P_{cd})]}$$

R_{clr}: Measured cloudy radiance
R_{cld}: Measured cloud free radiance
R_{sfc}: Calculated Planck blackbody radiance for a cloud at level P_{cd}
R_{bcd}: Calculated clear air radiance

CCC

- **C**ross-**C**orrelation **C**ontribution
- Every Cloud
- Depends on CTP

$$P = \frac{\sum_{cc_{i,j} > cc_{i,j}thres} CC_{i,j}\, CTP_{i,j}}{\sum_{cc_{i,j} > cc_{i,j}thres} CC_{i,j}}$$



Step3: Height assignment(Clear Target)

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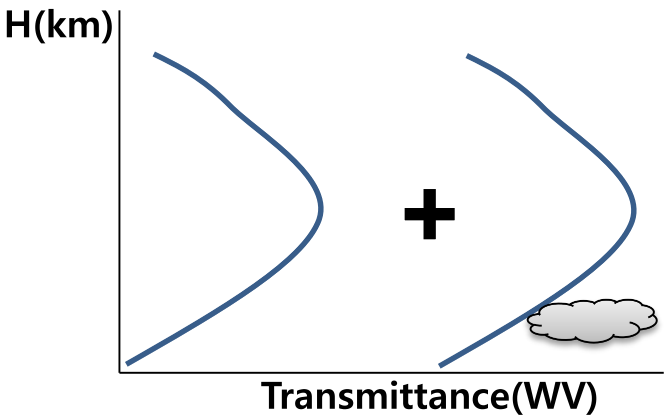
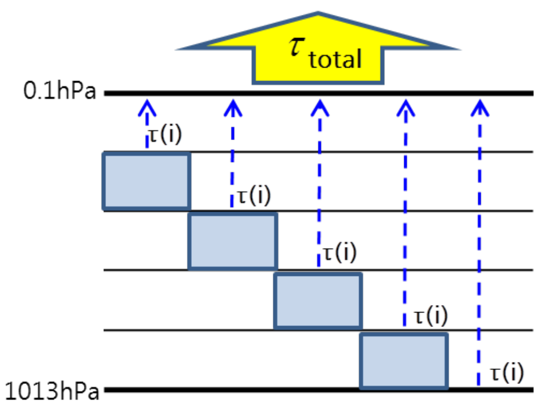
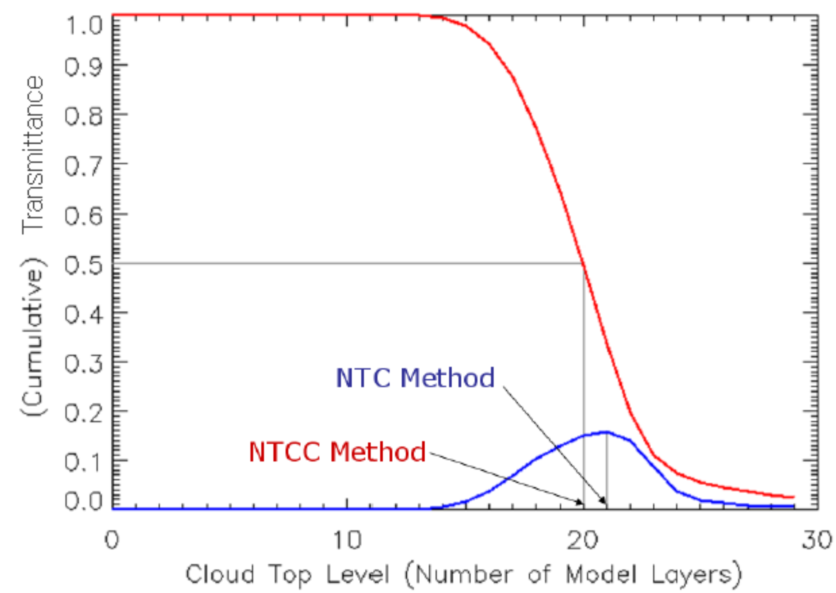
❖ Clear Target: 2 methods ➔ chose higher one

- NTC & NTCC methods. (Transmittance profile by channel.)





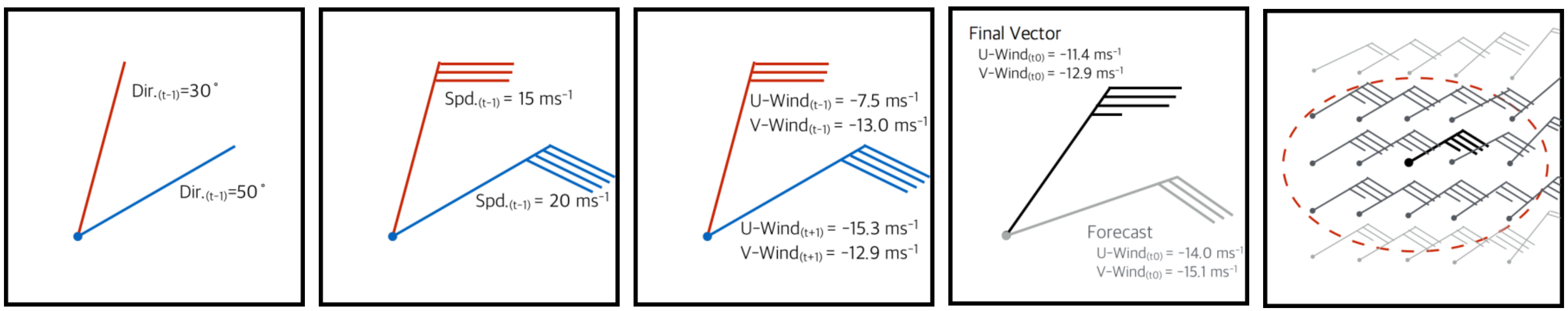


*NTC: Normalized total contribution
*NTCC: Normalized total cumulative contribution

Step4: Quality Control

❖ Quality Indicator (QI)

- **Calculation Procedure:** Calculated using weighted averaged of 5 consistencies
  1. Temporal **Direction** Consistency
  2. Temporal **Speed** Consistency
  3. Temporal **Vector** Consistency
  4. **Forecast** Consistency
  5. **Local Vector** Consistency



$$\text{QI} = \sum_{i=1}^{5} W_i \Phi_i$$

- **Direction Test**

$$\Phi_{dir.} = 1 - \left[\tanh\left\{\frac{Diff.(Dir.)}{coeff.A \cdot \exp\left(\frac{-Spd.avg}{coeff.B}\right) + coeff.C \cdot Spd._{avg} + coeff.D}\right\}\right]^{coeff.E}$$

- **Others**

$$\Phi_{other} = 1 - \left[\tanh\left\{\frac{Diff.}{MAX(coeff.A \cdot Spd._{avg},\ coeff.B) + coeff.C}\right\}\right]^{coeff.D}$$

Results: Cloudy target for 10.4㎛

❖ Validation: 4 HA methods + 2 combinations

- 2016. 7. 1. ~ 7. 7. (All level(1000~100 hPa))

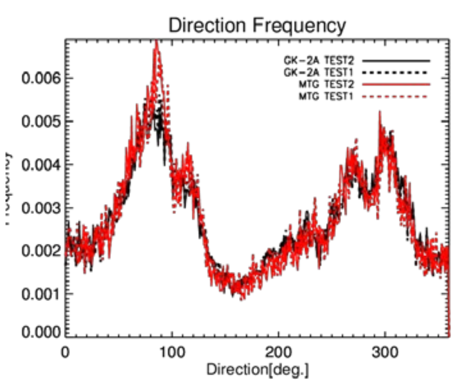
Ch13 (10.4)	GK-2A(Himawari-8)		Goes-R(Meteossat-8)	
Period	2016.7.1.~7.7.		Aug 2006	Feb 2007
HA method	EBBT&IR/WV	EBBT & CO2	GOES-R/ABI Cloud Height Algorithm (ACHA) products	
Count	17702	17345	13987	15286
MVD	**4.71**	**5.05**	**4.51**	**5.21**
RMSVD	**5.71**	6.14	-	-
Bias	**-0.67**	-1.09	0.24	-0.54
RMSE	**4.35**	4.64	5.78	6.61

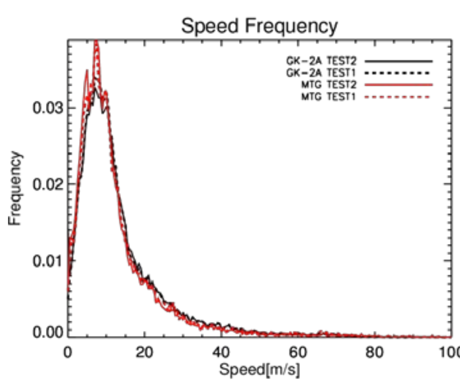
[Jaime Daniels, et al., GOES-R ATBD(2012)]

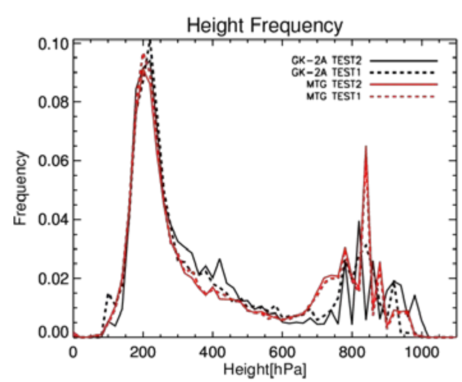
Ch13 (10.4)	GK-2A		MTG	
QI>80	> 80		> 80	
Reference	NWP	Sonde	NWP	Sonde
Count	44145	1028	45580	1035
Bias	-0.34	-1.32	-0.18	-0.80
RMSE	**4.74**	**5.92**	**4.70**	**5.91**
NBias	-0.023	-0.071	-0.012	-0.045
NRMSE	0.316	0.316	0.323	0.330

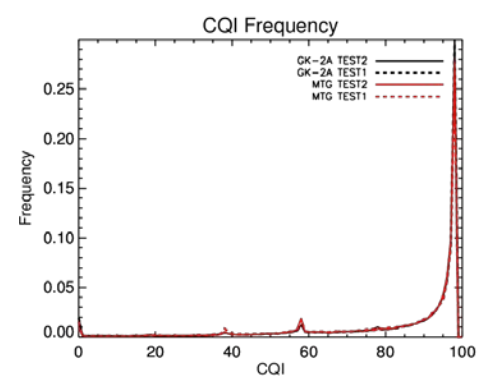
[Inter-comparison with MTG AMV]

- **Inter-comparison with MTG algorithm** *[P9: Inter-comparison results]*



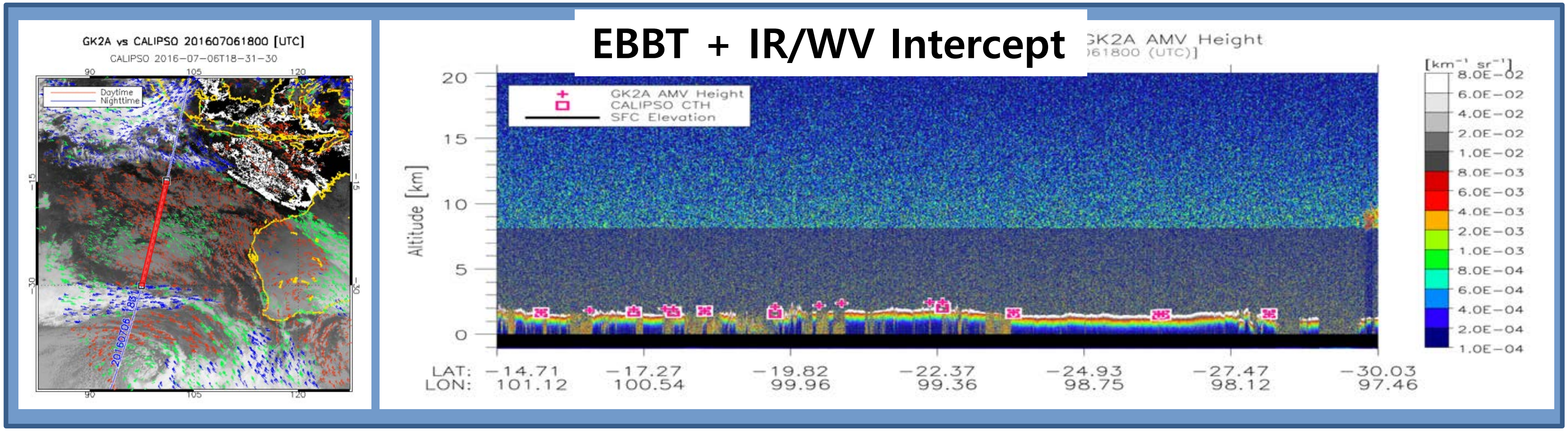


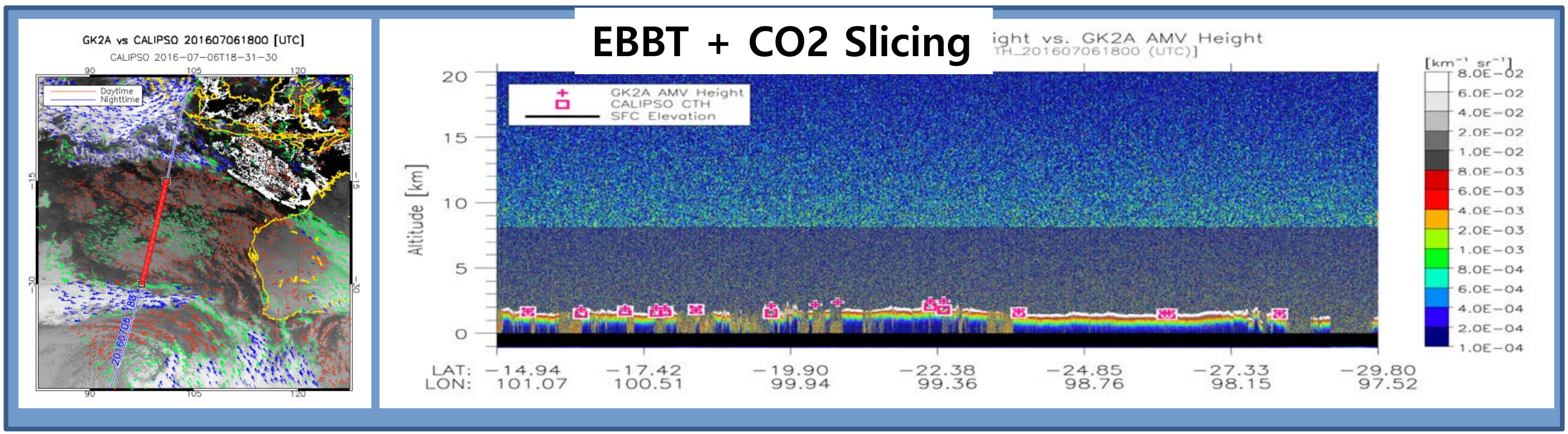




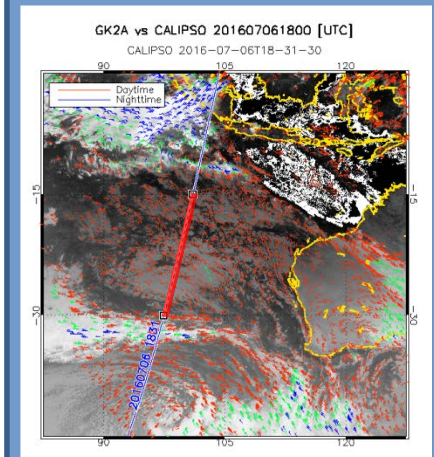
AMV height assignment methods

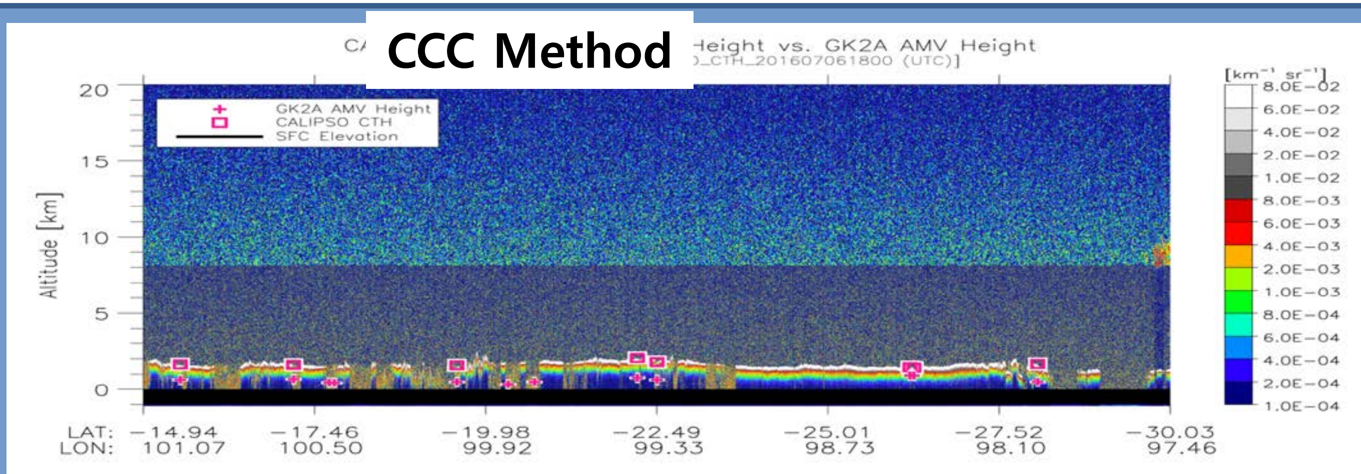
❖ Optically THICK LOW cloud case





❖ Optically THICK LOW cloud case





AMV height assignment methods

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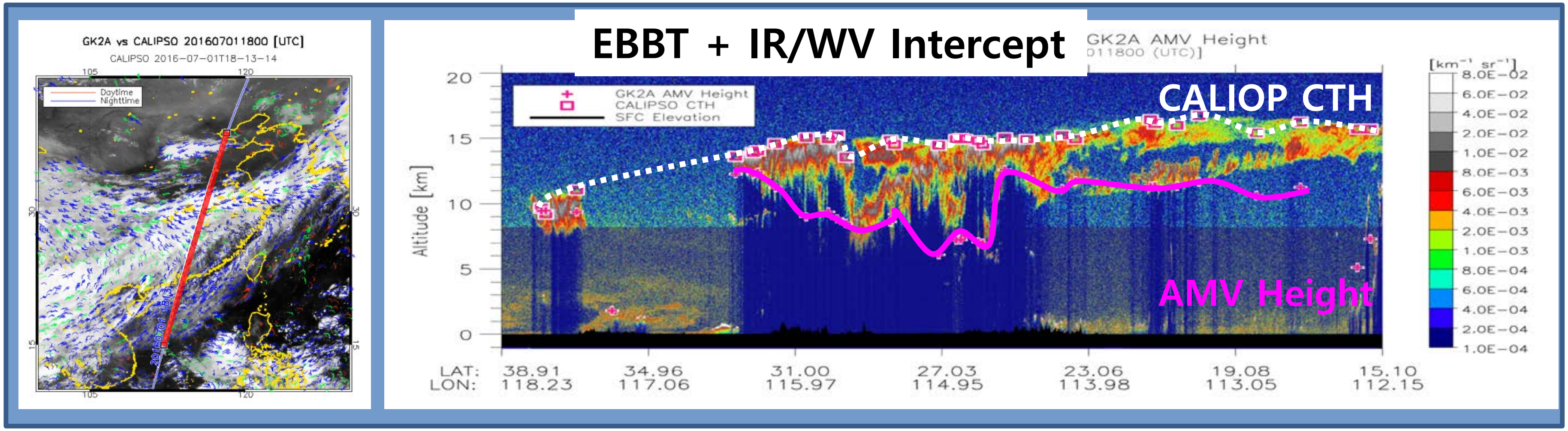
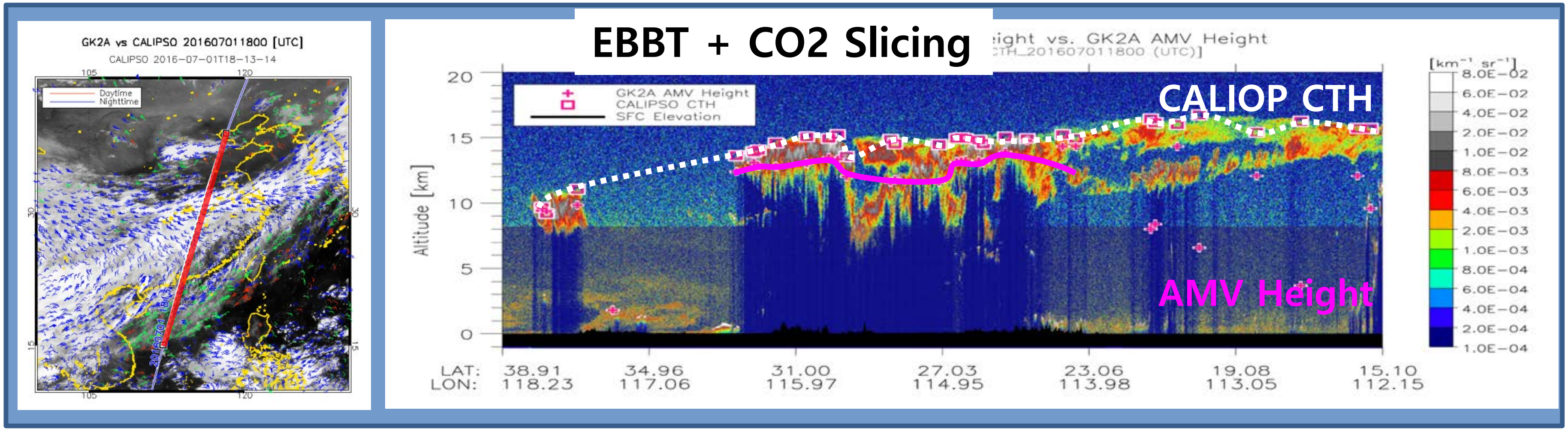
❖ Optically THIN HIGH cloud case





AMV height assignment methods

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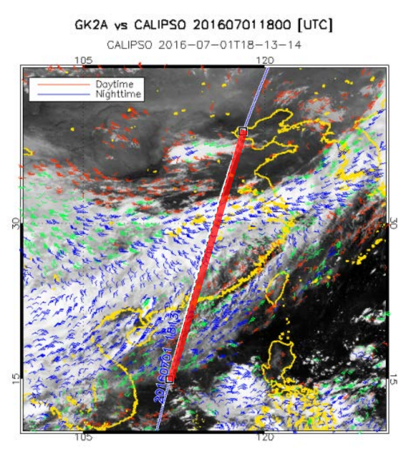
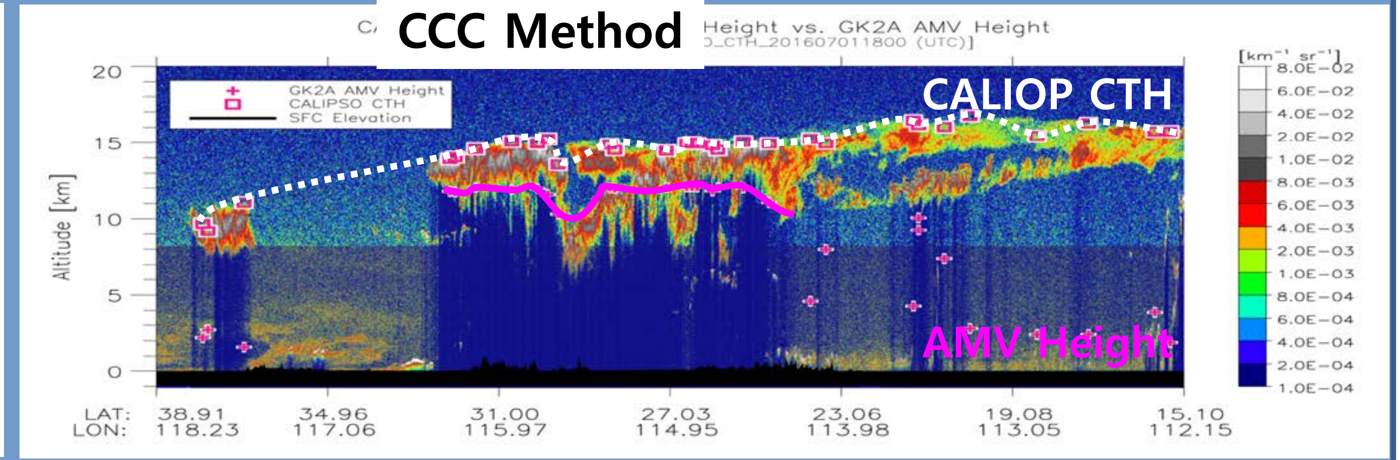
❖ Optically THIN HIGH cloud case





Summary

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- We have developed Atmosphere Motion Vector **for GK-2A/AMI** using Himawari8/AHI as proxy data.
  - Target size(Search size) : 16 X 16 (54 X 54)
  - Height Assignment : EBBT+IR/WV intercept
  - The result is comparable with other institute
  - The accuracy is better than COMS one
  - Need to validate with long term data

- **Related Posters**
  - P7: Quality Control(Quality Index and Expect Error)
  - P9: AMV Inter-comparison with EUMETSAT
  - P10: Sensitivity Tests for target size and HA methods
  - P11: Impact assessment

Thank you!!!