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Applications of Microwave Satellite Data to KMA LDAPS

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Objectives

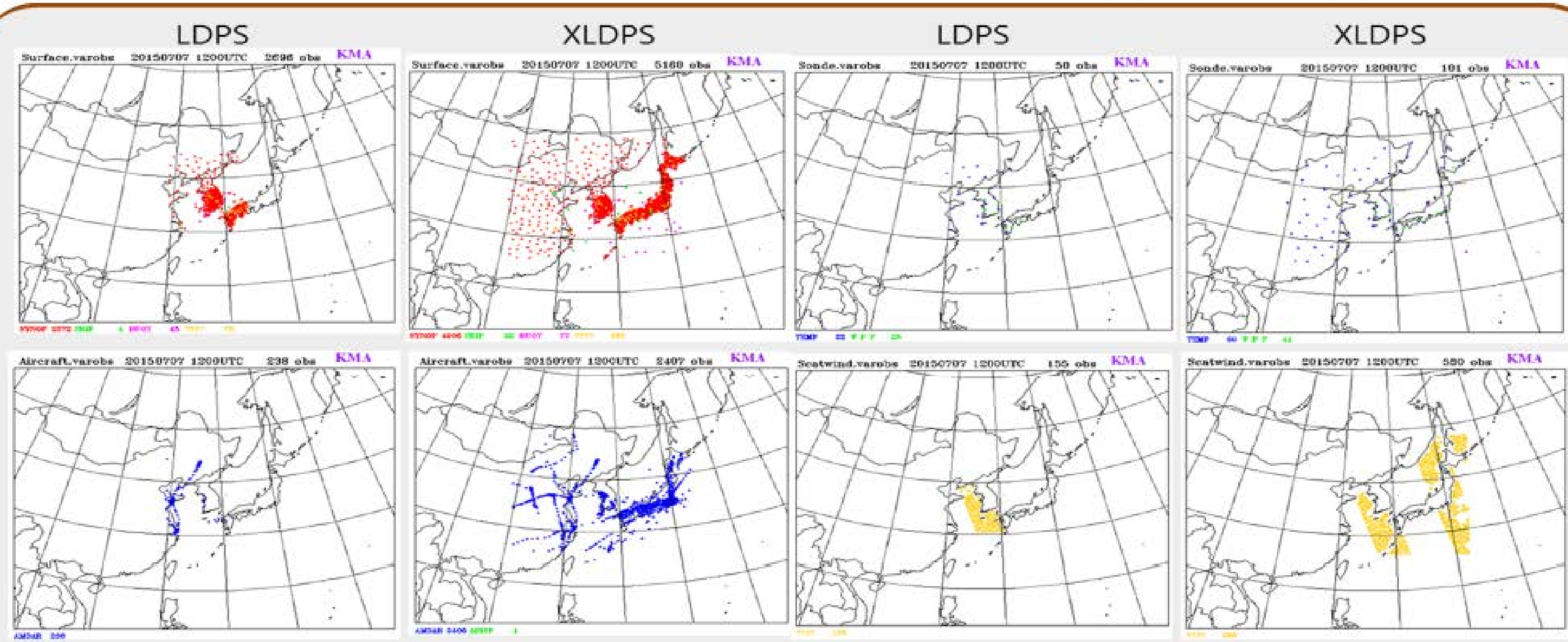
❖ **Introducing satellite data for synoptic information around sparse data area**

❖ **Assimilation of moisture information to the convective-scale model**

Observation current usage in LDAPS

- SONDE(temp, pilot, windprofiler), **SURFACE**(synop, ship, buoy, metar), **AIRCRAFT**(amdar), **RADAR**(radial velocity)**, SCATWIND**(ASCAT)

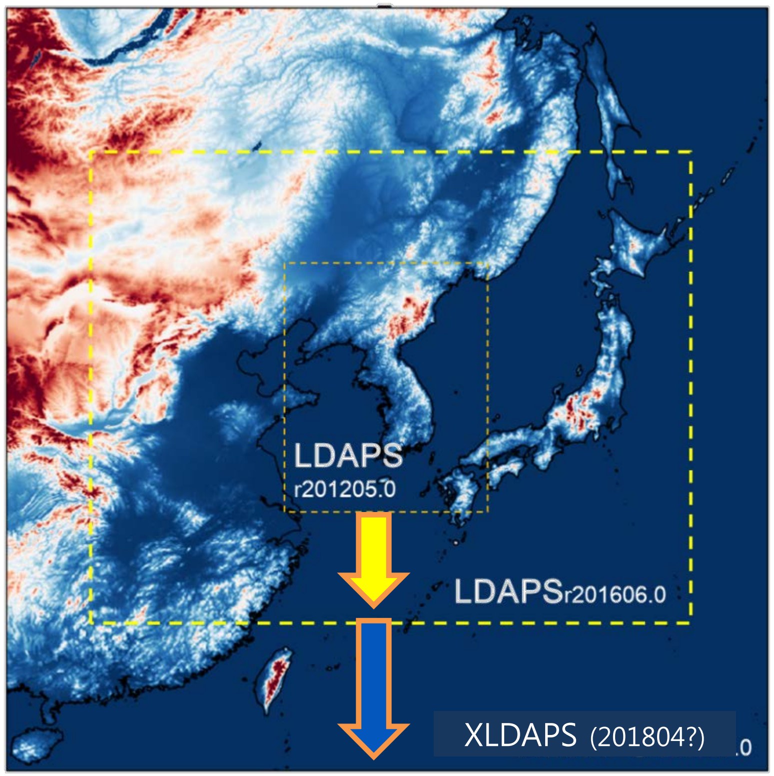
Lack of available observation, needs of satellite DA



- Surface : 2696 ➔ 5160 : 1.9 times increased
- Sonde : 50 ➔ 101 : 2 times increased
- Aircarft : 238 ➔ 2407 : 10 times increased
- Scatwind : 155 ➔ 580 : 3.8 times increased

KMA Convective-scale Model

❖ **LDAPS (Local Data Assimilation and Prediction System)**

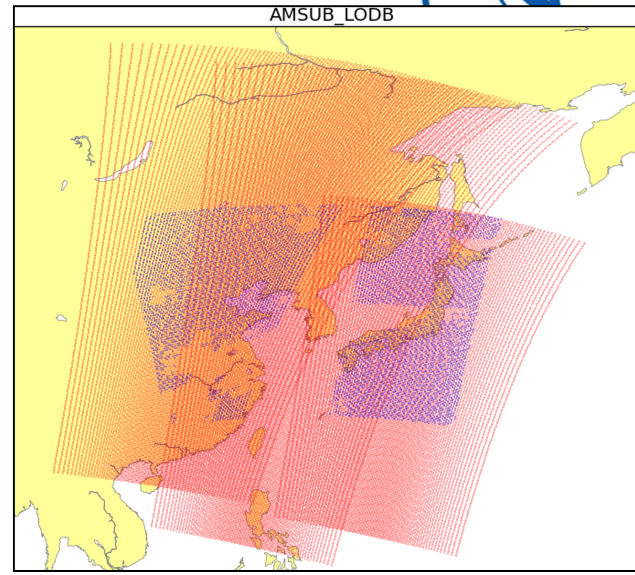


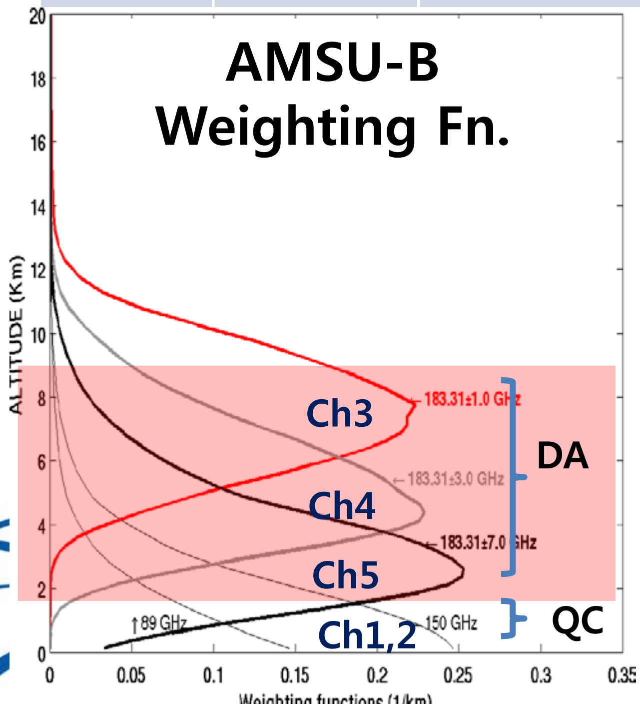
- **Model**
  - UM **vn10.1k** (ENDGame)
- **Area, resolution**
  - grid number : 1,598 (E-W) X 1,718 (S-N)
  - resolution : 1.5 ~4 km (Variable grid), 70 levels
    DA 3 km
- **Forecast length (cycle)**
  - **36 hours** (3 hourly)
- **DA system:** 3DVAR(FGAT) with IAU
  - surface, sonde, wind profiler, aircraft, radar, scatwind (current) ± 90 min cutoff time
  - **AMSU-B, ground GNSS, TC Bogus** will be added next operation
- **In Operation** since July 2017

AMSU-B Data

ATOVS(MHS) on board NOAA-18, 19, METOP-A, B

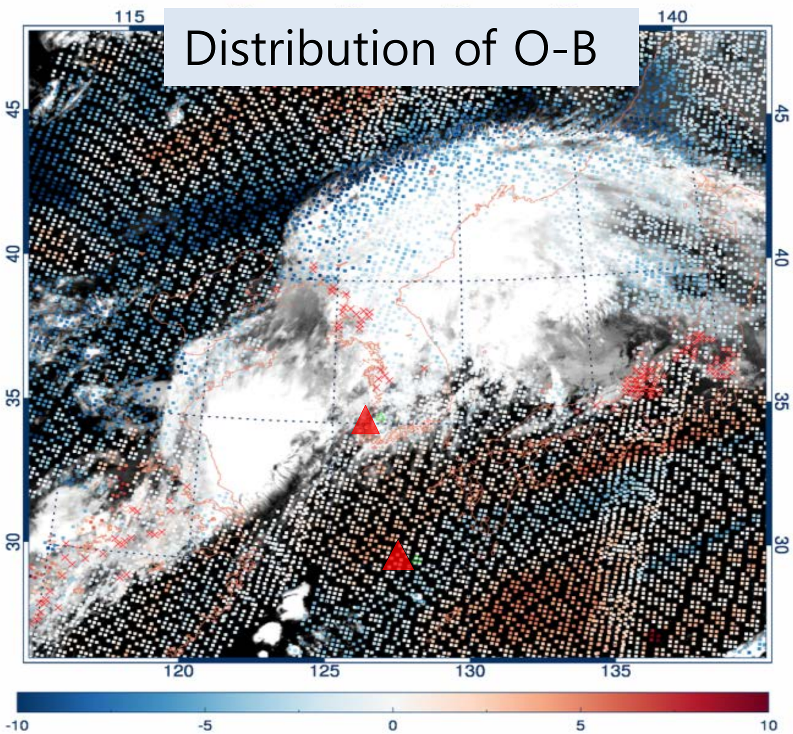
Sensor		FOV [km] (at nadir)	Distance [km]	
ATOVS	HIRS	10.0	42.2	IR Sounder
	AMSU-A	47.6	52.7	MW Temp Sounder
	AMSU-B (MHS)	15.9	17.6	MW Humidity Sounder



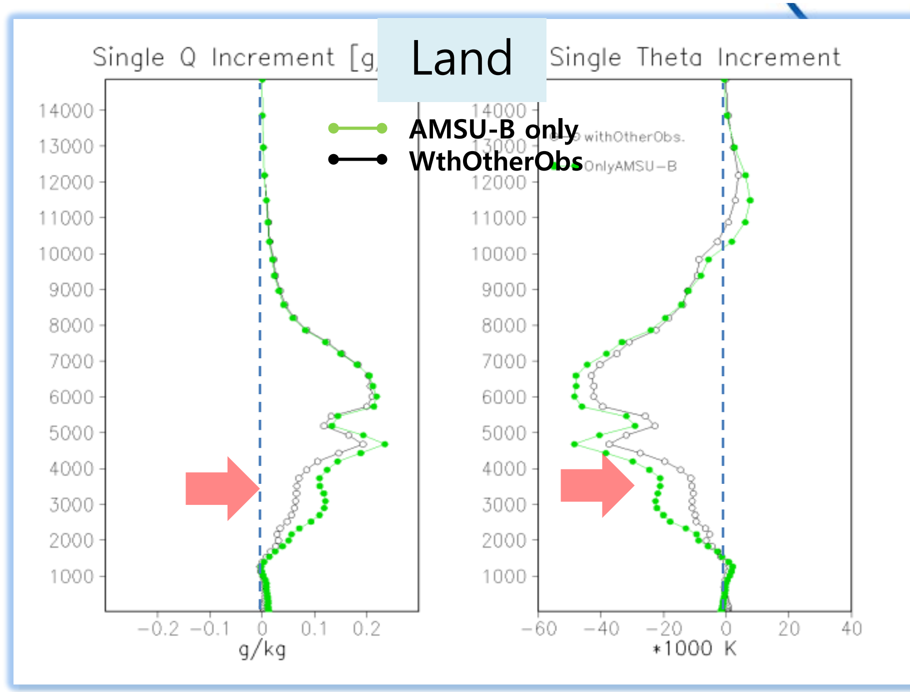


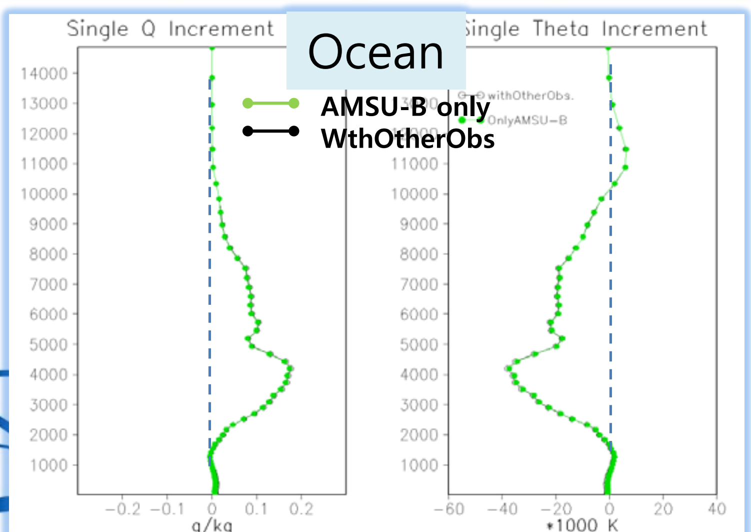
- ✓ Full-resolution AMSU-B received directly from NMSC of Korea
- ✓ Channel 1, 2 – semi-window channels, affected from surface and ice phased cloud (using for QC)
- ✓ Channel 3, 4, 5 – near 183GHz H2O absorption line (Profiling the WV in troposphere)

AMSU-B Single Observation Test



Analysis Increments Profiles of single AMSU-B with or without conventional data





- ✓ O-B<0 → Humidity(+), Temp.(-)
- ✓ The impact of AMSU-B is decreased but charged over 90 % of total increments over land.
- ✓ Over ocean and upper troposphere, the influence of AMSU-B is dominant.

→ We need accurate preprocess to get uncontaminated data.

OPS - Cloud Detection

Preprocess in OPS

- AMSU-B Level1d
- Sanity Check Thinning
- Bias Correction
- QC
- Cloud Detection
- 1D VAR QC
- Thinning

Cloud Detection

- QC algorithm for detecting cloud-affected radiances is limited by MHS data itself

1. Detect Cirrus : reject CH4, 5

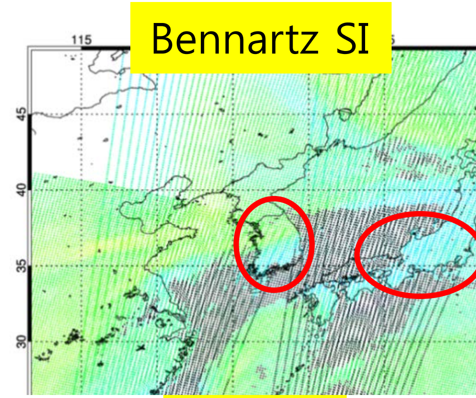
Cloud Cost Fn. $J_c = \frac{1}{2}\Delta T \cdot \{HBH^T + R\}^{-1}(\Delta T)^2$

(ΔT : O-B ch3,4,5 , H : TL Operator,
B: BgErr Cov., R: ObsErr Cov.)

2. (EXP1) Detect rain : reject all

Ocean $SI = T_{b,1} - T_{b,2} - (a + b \times \theta)$ (θ : latitude)

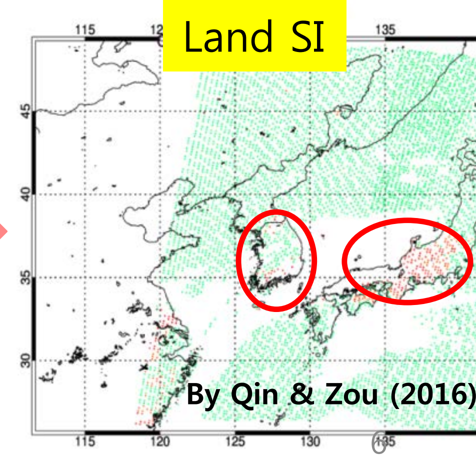
- It is not working on land



2-1. Detect Rain over Land

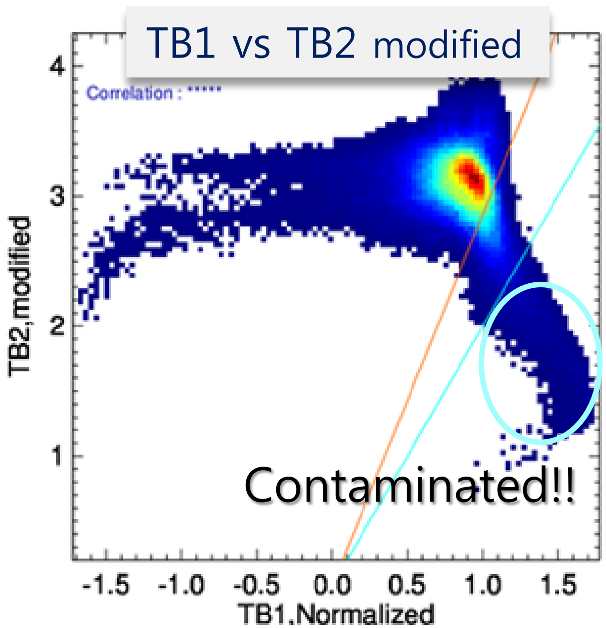
(EXP2) If cirrus detected, reject all channels

(EXP3) Detect rain using Land SI*



* Qin & Zou(2016)-Development and Initial Assessment of a New Land Index for Microwave Humidity Sounder Cloud Detection

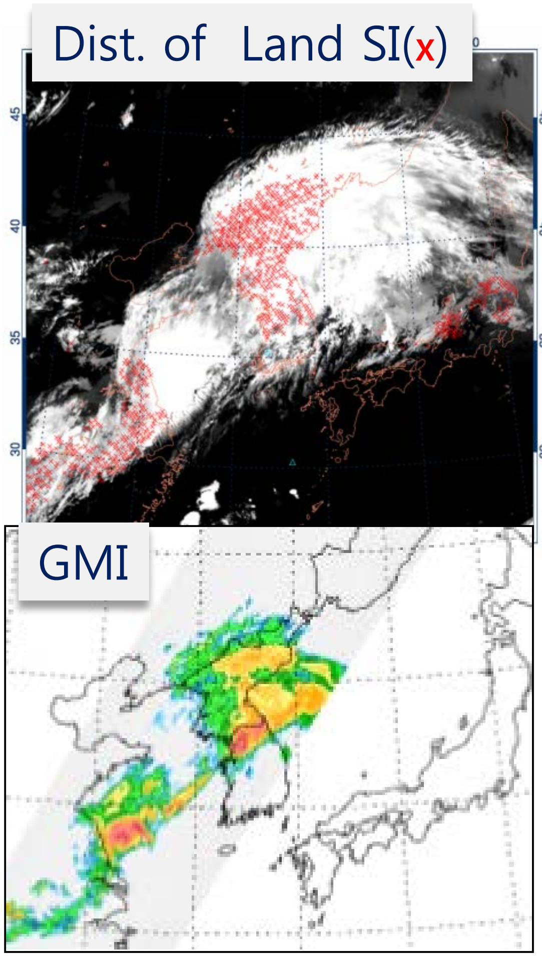
Land Scattering Index

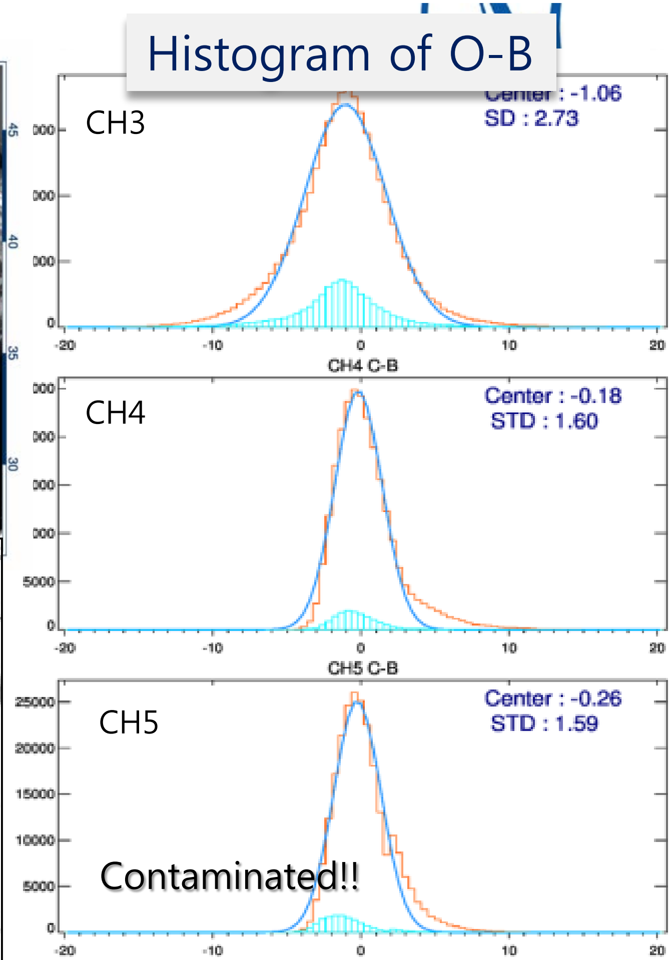


$$L_{index} = \frac{T_{b,1}^{normalizd}}{\left(\frac{1}{2}\left(\frac{T_{b,2}^{obs}}{100} - 1\right)\right)^{3}},$$

$$\left(T_{b,1}^{Normalized} = \frac{T_{b,1} - \mu}{\sigma},\right.$$

$$\left.\mu = \frac{1}{5}\sum_{i=1}^{5} T_{b,i},\ \sigma = \sqrt{\frac{1}{5}\sum_{i=1}^{5}\left(T_{b,i} - \mu\right)^{2}}\right)$$

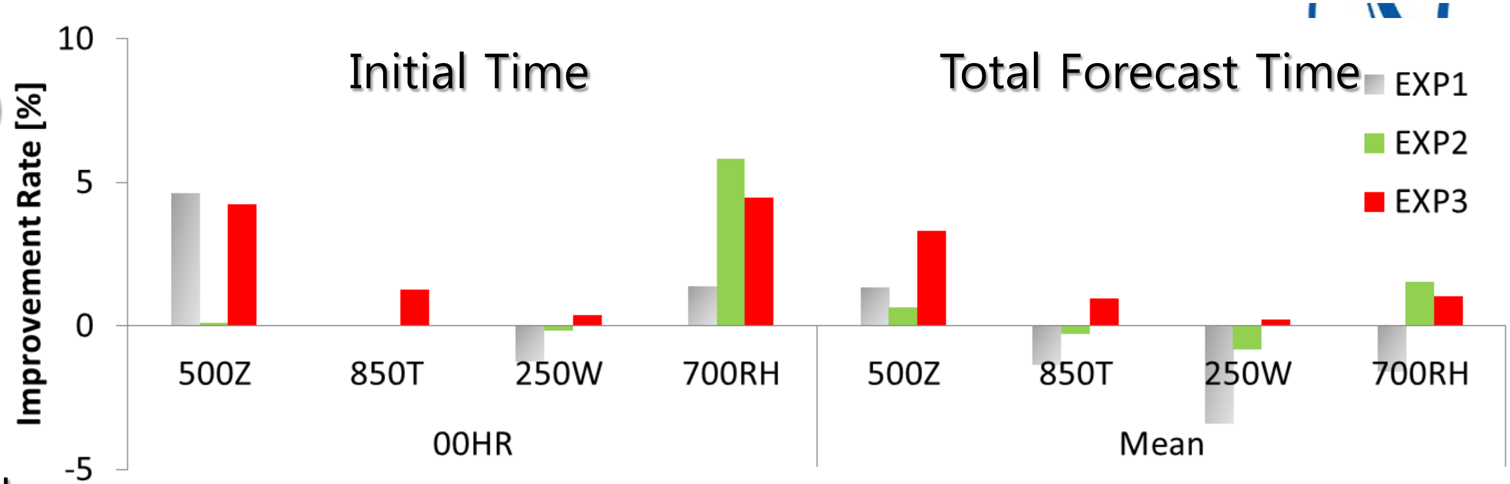




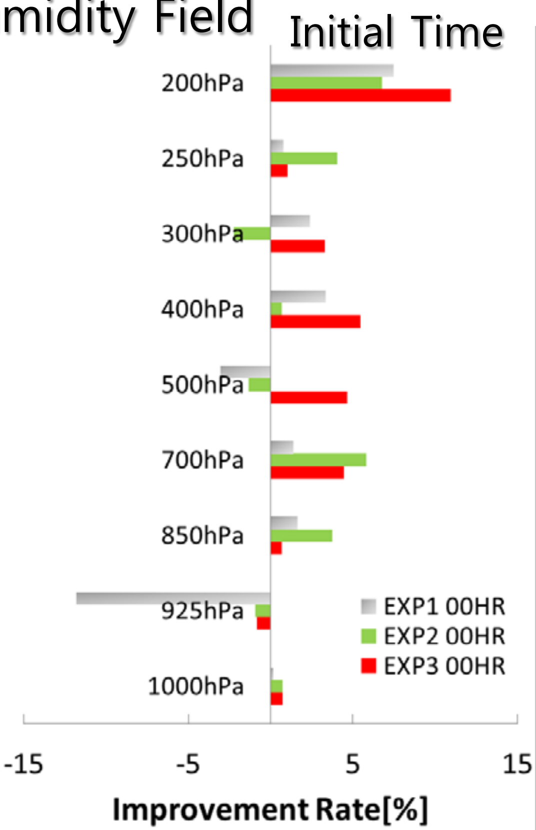
- In cloudy area, the standard deviations(σ) of MHS channel become smaller and the TB1-μ are not lower than clear sky. → Land SI increased
- The contaminated data show negative O-B signals at lower channel.
- When remove it, the STD of departure become 1.59 to 1.55 at CH5 and the bias of departure closes to 0 at CH3 (-1.06 →-0.28)

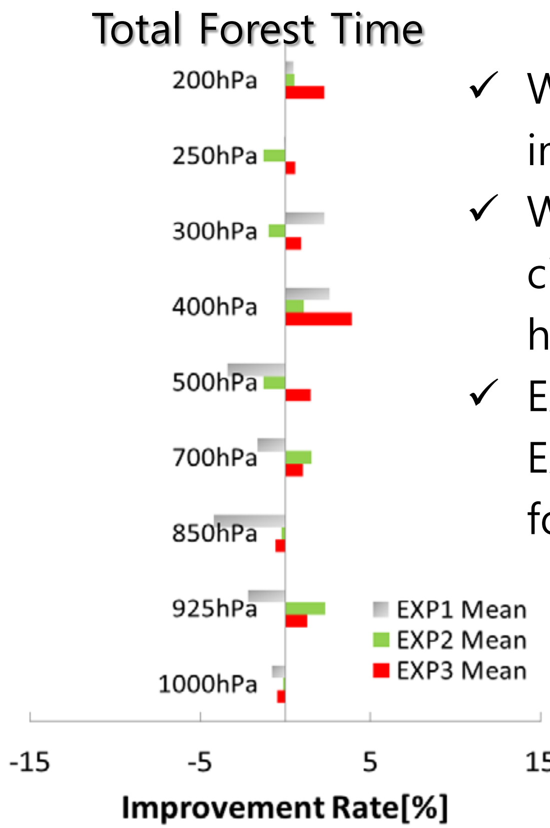
Model Impact Result

Verification (with Sonde)



Humidity Field





- ✓ When adding Land SI(EXP3), it shows improvements of main fields.
- ✓ When rejecting all channel under cirrus(EXP2), it shows improvement of humidity fields at lower troposphere.
- ✓ EXP3 shows better performance than EXP2 in humidity fields with total forecast time and all height.

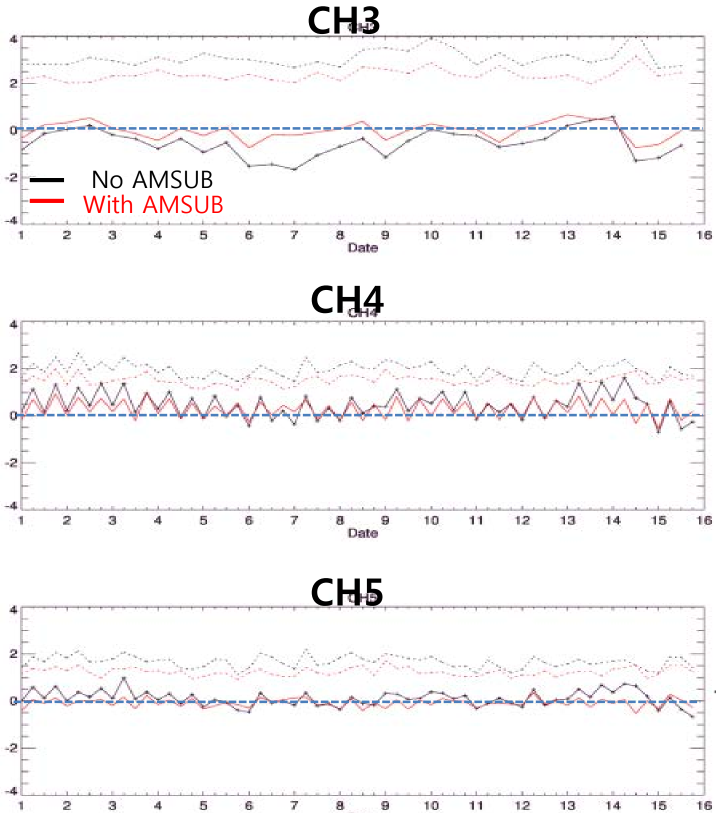
Improvement Rate [%]

$$= [1-\frac{RMSE(EXP)}{RMSE(OPER)}] \times 100$$

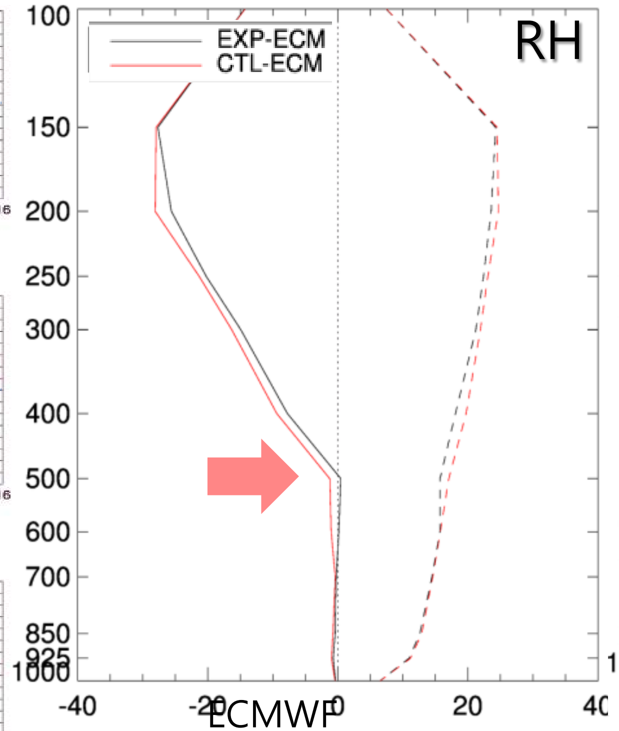
+ : improved , - : degraded

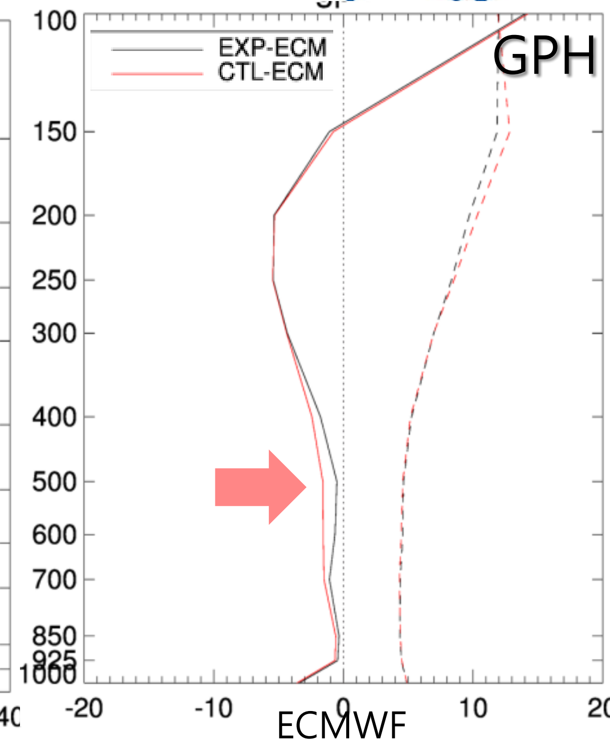
Model Impact Result

O-A (cold vs AMSU-B)



Comparison with ECMWF





- Comparing the O-A, the change is biggest at CH3 after assimilating AMSU-B.
- It influences strongly on humidity and GPH fields near 500 hPa.

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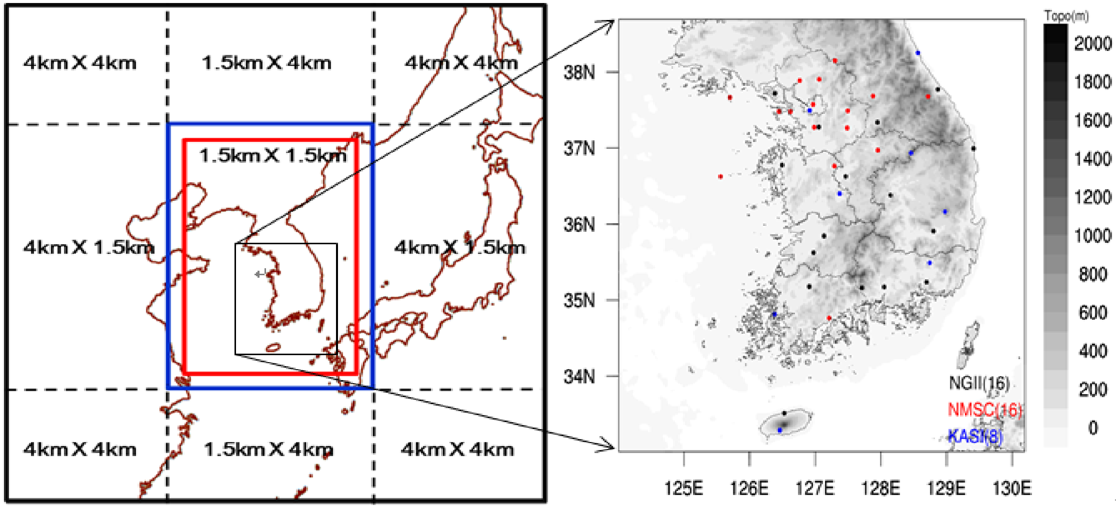
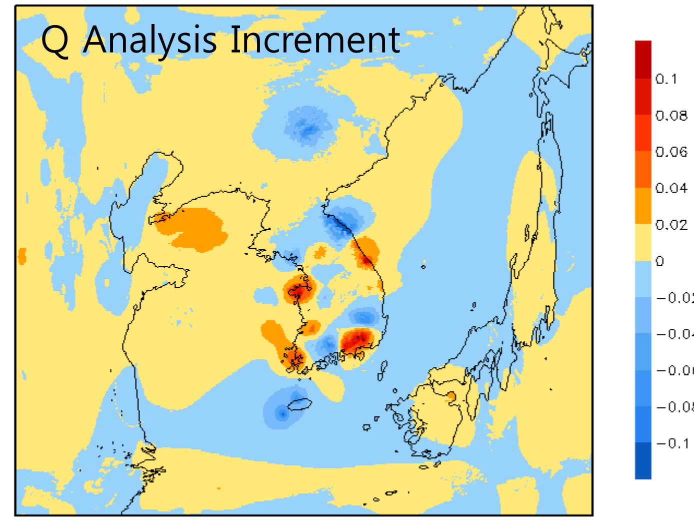
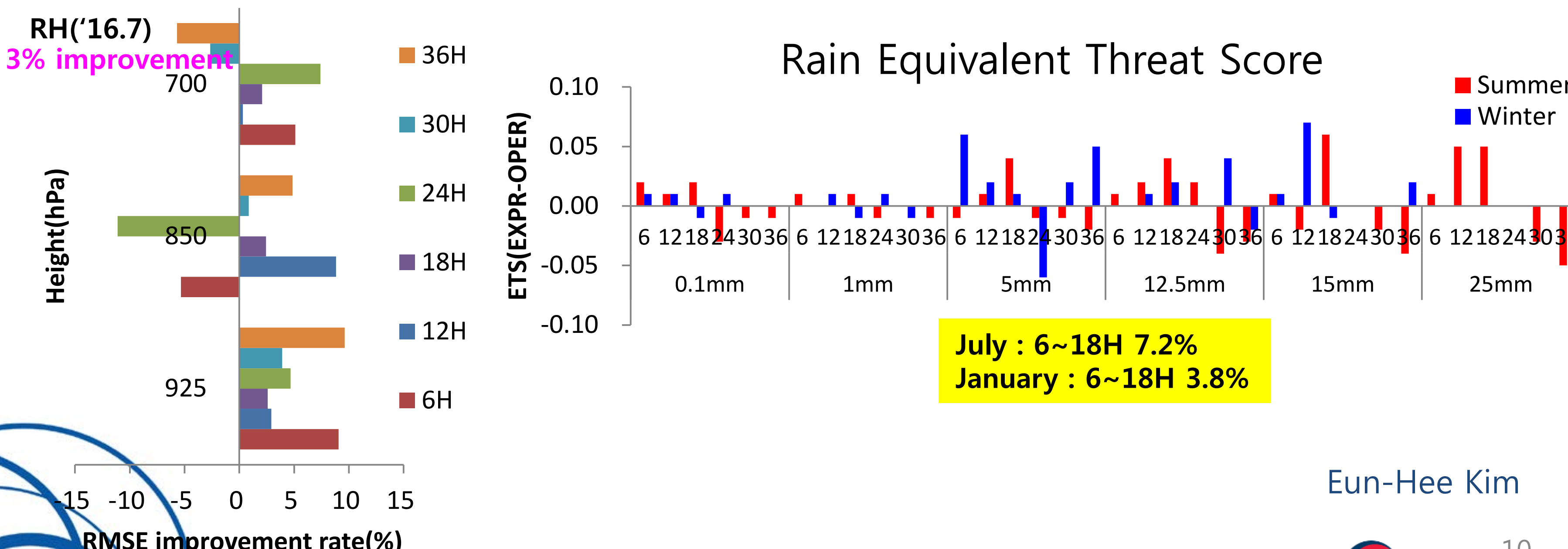
Ground-based GNSS in local model

40 domestic sites will be used operationally in next local model







July : 6~18H 7.2%
January : 6~18H 3.8%

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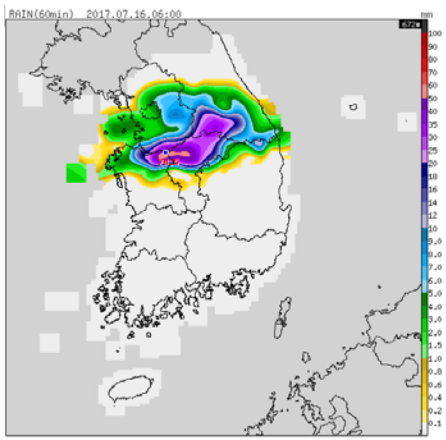
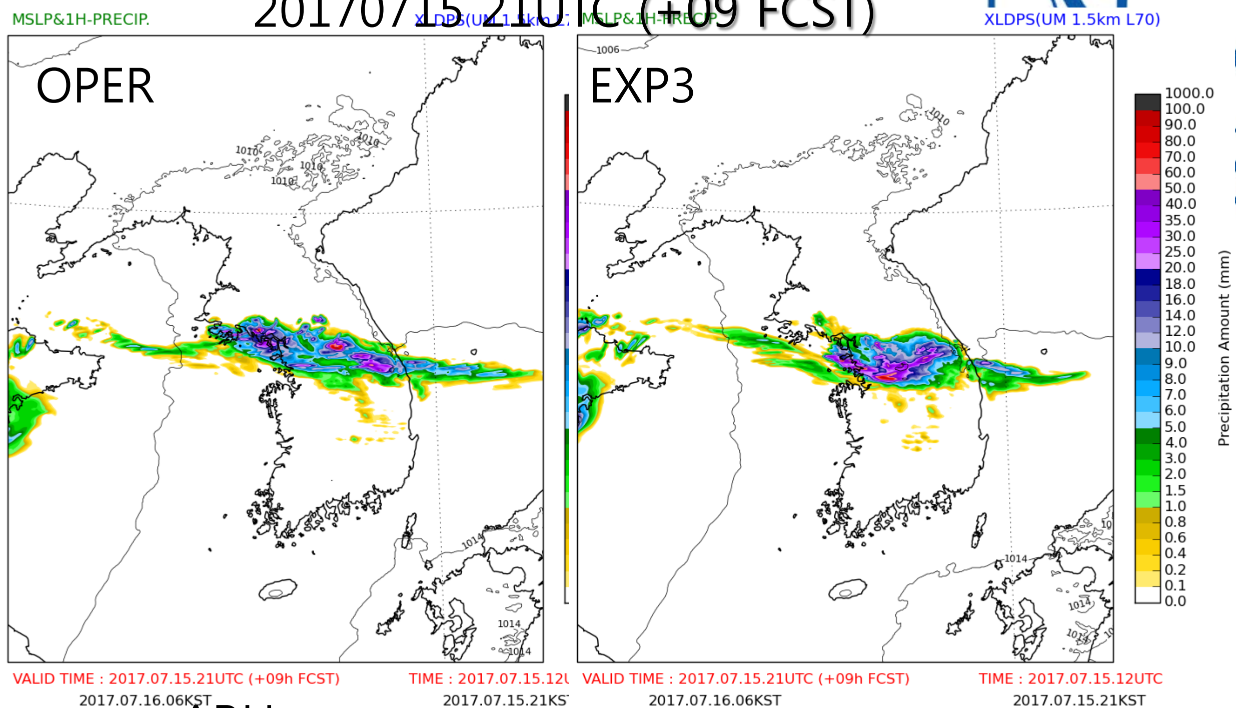
Model Impact Result-case study

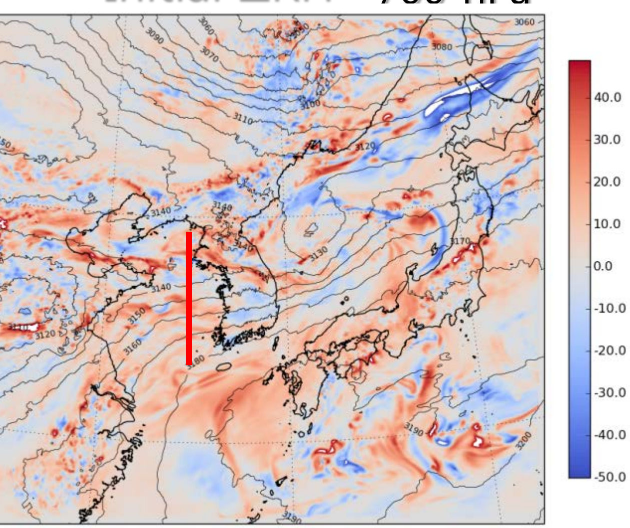
20170715 21UTC AWS



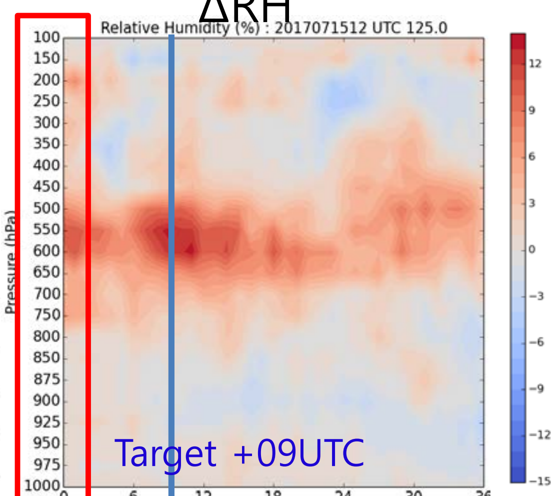
20170715 21UTC (+09 FCST)



Initial ΔRH 700 hPa



ΔRH



- When assimilating AMSU-B and groundGNSS additionally, these add humid in troposphere.
- Changes in the upper layer RH fields could affect the subsequent precipitation forecasts.

Summary and Future Plan

- KMA has been dedicating to assimilate satellite data to **fills the gap at the data sparse area** and provide **the moisture information.**
- By removing the cloud-affected radiances, the humidity and GPH field at 850~400hPa show better forecast performance.
- The skill score of precipitation forecast is improved but it is tend to overestimate the strong rainfall at the end of forecast.
- **Observation error** and **new bias correction method**
- Additional polar-orbiting satellite data - IASI, ATMS, GPSRO…

Thanks for attention.