

# Impacts of cloud screening algorithm of the ATMS on numerical weather prediction model: Scattering index

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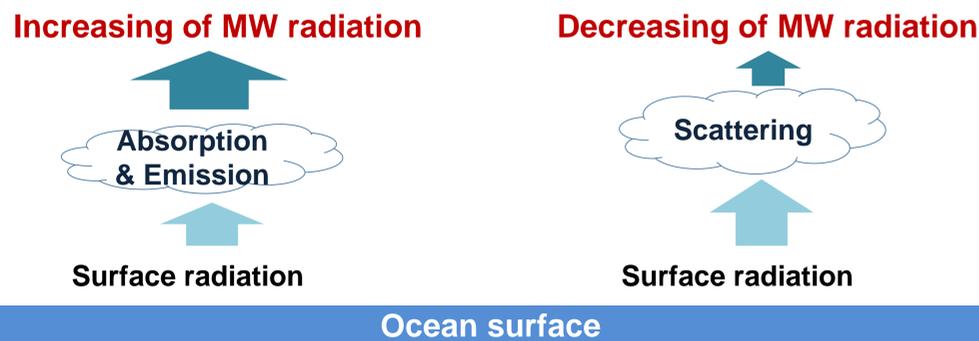
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## Background

### ◆ Cloud effect in the microwave regions



- The cloud detection in the pre-processing of satellite observation for NWP model plays a significant role in selecting quality controlled data.

## Data & methods

### ◆ Scattering Index (SI)

- SI can be calculated by utilizing the differential scattering effects of large hydrometeors to the different channel frequencies (Bennartz, R., et al. (2002)).

$$SI = (Obs_{88.2} - Obs_{165.5}) - (-46.94 + 0.248 \times \theta)$$

- Obs: observed brightness temperature (TB),  $\theta$ : satellite zenith angle
- 1<sup>st</sup> term: 165.5 GHz is more sensitive to the scattering than 88.2 GHz.
- 2<sup>nd</sup> term: corrects the atmospheric impact limitation
- The 2<sup>nd</sup> term is limited in describing the temporal-spatial variation.
- Using the simulated TB in the clear sky condition, this limitation can be resolved.

$$SI_{new} = Obs_{88.2} - Obs_{165.5} - (Bgr_{88.2} - Bgr_{165.5})$$

- Bgr: background TB simulated by the RTTOV using the atmospheric information from the NWP model.

### ◆ Advanced Technology Microwave Sounder (ATMS)

- On board on Suomi-NPP (and on NOAA-20)
- A cross-track scanner (scan angle:  $\pm 52.725^\circ$ )

CH	Frequency [GHz]
1	23.8
2	31.4
3	50.3
4	51.76
5	52.8
6	53.596 ± 0.115
7~15	54.4~60
16	88.2
17	165.5
18~22	183.31

### ◆ Korea Integrated Model (KIM)

- Korea's next operational NWP model
- H4DEnVar
- 10 Km resolution (L91), Cubed-sphere

### ◆ Experiment design

	O-B	Scattering Index
CNTL	$ (O - B)_{50.3GHz}  > 5 \text{ K}$	$SI = Obs_{88.2} - Obs_{165.5} - (-46.94 + 0.248 \times \theta) > 30 \text{ K}$
EXP (SI)	$ (O - B)_{50.3GHz}  > 5 \text{ K}$	$SI_{new} = Obs_{88.2} - Obs_{165.5} - (Bgr_{88.2} - Bgr_{165.5}) > 10 \text{ K}$

- KIM3.3, 4DCLV, KPOP\_v3.3.04
- Initial: 2018.01.01 (00 UTC), UM background
- Spin-up period: 2018.01.01 (00 UTC) ~ 2018.01.10 (00 UTC)
- Experiment period: 2018.01.10 (06 UTC) ~ 2018.01.25 (18 UTC)
- The thresholds are empirically determined.

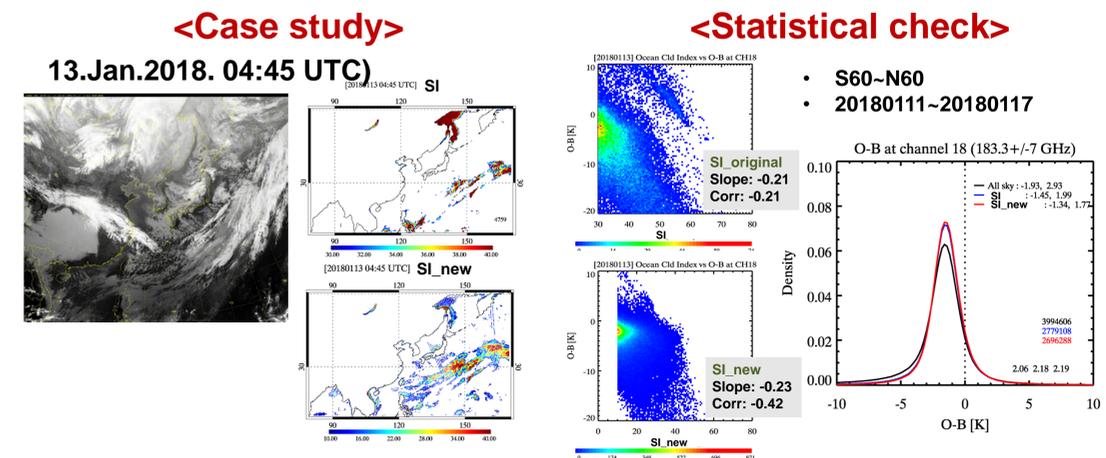
## References

- Bormann, N., et al. (2013). "Evaluation and assimilation of ATMS data in the ECMWF system." Journal of Geophysical Research: Atmospheres 118(23): 12,970-912,980.
- Bennartz, R., et al. (2002). "Precipitation analysis using the Advanced Microwave Sounding Unit in support of nowcasting applications." Meteorological Applications 9(2): 177-189.

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## Results

### ◆ Cloud detection

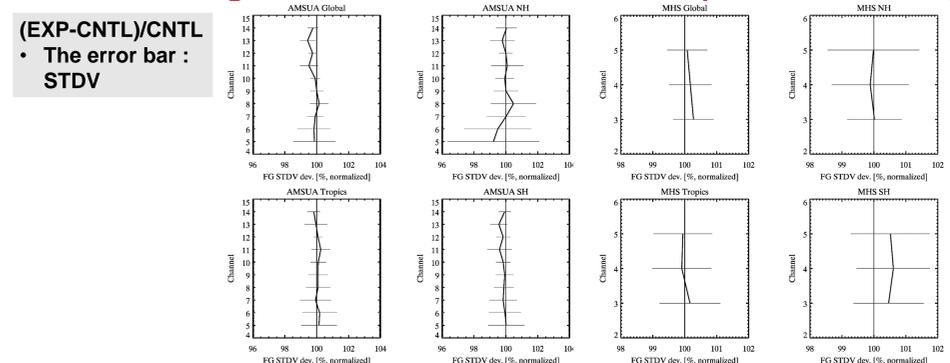


- The new SI effectively detects the scattering clouds and it reduces the O-B bias at the humidity sounding channel.
- The new SI is more correlated with the O-B at channel 18 ( $183.31 \pm 7 \text{ GHz}$ ) than the original method.

### ◆ Experiment results

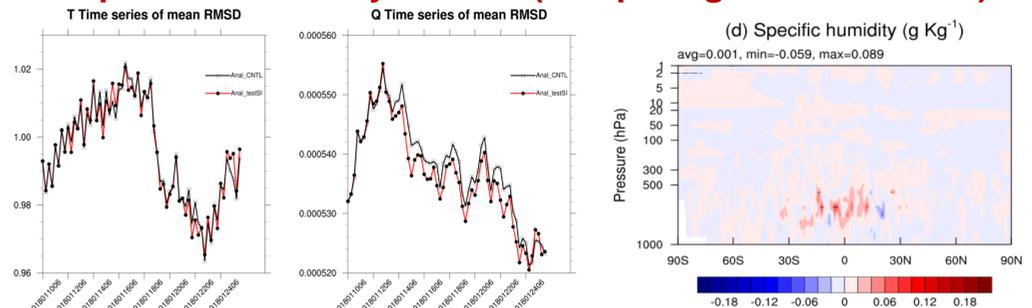
- The number of assimilated ATMS observation decreased by 2.7 %.

#### <Diagnosis on the observations (AMSU-A, MHS)>



- It has positive impact in the AMSU-A stratospheric channels (especially at the SH, where the ITCZ is located).
- But it is negative at the MHS.

#### <Impact on the analysis field (comparing to ECMWF IFS)>



- It reduces the RMSD of humidity field at the troposphere.
- But, it is neutral at temperature field. (Little changes at the upper atmosphere (5~10 hPa))

### ◆ Summary & conclusion

- The SI calculation with the real-time clear sky TB is effective in detecting the clouds with large hydrometeors.
- The effect of the improved SI is significant in humidity fields at the tropics.
- The changes in background fields do not significantly affect the first guess STDV of observations.
- It is expected to have positive impact on the assimilation of microwave observations and on the analysis/forecast fields.