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

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Background

Cloud effect in the microwave regions

<table>
<thead>
<tr>
<th>Increasing of MW radiation</th>
<th>Decreasing of MW radiation</th>
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<tbody>
<tr>
<td>Absorption &amp; Emission</td>
<td>Scattering</td>
</tr>
<tr>
<td>Surface radiation</td>
<td>Surface radiation</td>
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</table>

Ocean surface

- 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
- 1st term: 165.5 GHz is more sensitive to the scattering than 88.2 GHz.
- 2nd term: corrects the atmospheric impact limitation

- The 2nd 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: ±52.725°)

Korea Integrated Model (KIM)

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

Experiment design

<table>
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<tr>
<th>O-B</th>
<th>Scattering Index</th>
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<tr>
<td>CNTL</td>
<td>[(O-B)<em>{50.3,65} &gt; 5 K] ( SI = OBS</em>{88.2} - OBS_{165.5} - (-46.94 + 0.248 \times \theta) &gt; 10 K )</td>
</tr>
<tr>
<td>EXP (SI)</td>
<td>[(O-B)<em>{50.3,65} &gt; 5 K] ( SI</em>{new} = OBS_{88.2} - OBS_{165.5} - (BGR_{88.2} - BGR_{165.5}) &gt; 10 K )</td>
</tr>
</tbody>
</table>

- 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.

Results

Cloud detection

Case study


- 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 ± 7 GHz) than the original method.

Statistical check

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

Impact on the analysis field (comparing to ECMWF IFS)

- 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.

- 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.

References


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