Assimilating clear-sky radiance of SSMIS humidity sounding channels in the JMA global NWP system with newly developed cloud detection algorithm

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1. Introduction
- In March 2017, JMA begun operational utilization of clear-sky radiance of SSMIS humidity sounding channel in the NWP system.
- Quality Control algorithm dedicated for SSMIS channel configuration was newly developed from a physically-based approach.
- Since SSMIS covers wide range of microwave frequency, the algorithm can discriminate liquid and frozen particles. It is useful not only for the accurate detection of cloud-precipitation affected data, but also for obtaining knowledge useful to develop all-sky assimilation.

2. Cloud detection algorithm
- Clouds are classified into 3 types based on the composing hydrometeor

(1) Cloud Liquid Water (CLW)
- Indicator: CLW calculated based on ‘cloud’ amount defined as follow. (Geer and Bauer, 2011)
  \[ \text{cloud amount} = \frac{T_b(37V)_{\text{obs}} - T_b(37H)_{\text{obs}}}{T_b(37V)_{\text{clr}} - T_b(37H)_{clr}} \]
- Threshold: 100 (g/kg)

(2) Snow Crystal
- Indicator: Polarization-corrected Temperature (PCT; Spencer et al., 1986)
- Coefficients targeting mid-latitude are adopted from Liu et al.(1998)
  \[ 1.5 \times dT_b(91V) - 0.5 \times dT_b(91H) < -3K \]
  \[ dT_b(91V) < -5K \]
- Melting layer (CLW emission) is also considered
  \[ dT_b(91V) < 0K \]
  \[ dT_b(37H) > 1.5K \]
- Positive bias of \( dT_b(91V) \) appears at west coast of South America and Africa.
- Suggesting negative (positive) bias of lower tropospheric humidity temperature.

(3) Ice Crystal
- Indicator: Scattering Index (SI; Ferraro et al., 2000)
- Due to malfunction of 150 GHz onboard F18, 183 ± 6.6 GHz (sensitive to lower troposphere) is selected as high frequency channel. This channel has the best correlation with 150GHz among 3 sounding channels.
  \[ dT_b(183 \pm 6.6) - dT_b(91V) < -10K \]

3. Result of Quality Control
- Snow Crystal QC detects data with large variance seen around \( dT_b(183 \pm 6.6) - dT_b(91V) = 0 \).
- Reduce overlooking of cloud affected data mainly at relatively thick cloud (ex. cumulus, stratocumulus) area.

4. Impact on the JMA NWP system
4.1 Assimilation Experiment Setup
**Control:**
JMA operational global DA system as of Mar. 2016 (plus minor upgrade)

**Test:**
Control + SSMIS-UPP radiance (3ch.(ch9/10/11), clear-sky, open-ocean)

Experiment Period:
10 Jul. to 11 Sep., 2015 (Assimilation), 21 Jul. to 11 Sep.2015 (Forecast)

**Figure 6:** DMSP-37F18 data fill the data gap between METOP-A/1 and NOAA-18/19.

4.2 Analysis and Forecast Field
- Improved fits in FG departure of water vapor field. Mean analysis field is almost unchanged.
- Positive impact for the prediction of Z and T at Southern Hemisphere.

5. Summary
- Newly developed cloud detection algorithm has a wider detection area mainly at where relatively thick cloud (ex. cumulus, stratocumulus) exists.
- The algorithm is implemented to JMA global data assimilation system. Experiment results show positive impact on water vapor analysis field globally, and on temperature and geopotential height forecast field at the southern hemisphere.