The Characteristics of the Real-time Land Surface Emissivity of ATMS

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Introduction

◆ Background
  - Utilization of satellite observation to numerical weather prediction models improves the forecast skill.
  - However, assimilation of microwave observations over land and near-surface channels is restricted due to uncertainties in land surface emissivity and surface temperature.
  - ϵ/emissivity = (E_R)/E_m(T) = (E_R) / σT^4
  - MW emissivity is depending on scan angle, frequency and the surface characteristics (i.e. vegetation types, soil moisture contents)
  - Difficulties in estimating MW land surface emissivity: High variability

◆ Objective
  - To better estimate the MW land surface emissivity using ATMS observation
  - To better utilize the MW observations over land.
  - To improve NWP skills.

Data

◆ The Advanced Technology Microwave Sounder (ATMS)
  - A cross-track scanning MW sounder with 22 channels onboard the Suomi-NPP.*
  - To estimate the atmospheric temperature/humidity vertical profiles.

<table>
<thead>
<tr>
<th>ATMS (SDR)</th>
<th>Brightness Temperature (TB)</th>
<th>Satellite Zenith/Azimuth Angle</th>
<th>Solar Zenith/Azimuth Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>UM model of KMA</td>
<td>Temperature/Humidity profile</td>
<td>Surface Temperature/Pressure/Humidity</td>
<td>2m Temperature/Pressure/Humidity</td>
</tr>
<tr>
<td>Period</td>
<td>201410, 201501, 201504, 201516 (each 15 days)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Method

◆ Method
  - Real-time emissivity retrieval
    - Up-welling, down-welling radiances and transmittance are estimated with RTTOV using the spatio-temporally collocated analysis data.
    - The real-time emissivity at window channels can be calculated with the equation [2].
  - The emissivity at temperature sounding channels is estimated by interpolating the emissivity of the window channels.
  - The emissivity of the window channel (Ch16 or 17) is directly assigned to humidity sounding channels.
  - Comparison with TELSEM.*

*TELSEM: A Tool to Estimate Land Surface Emissivities at Microwave frequencies

Results & Discussion

◆ Angular and Frequency Variation (31.4 GHz)
  - Angular Variation: Frequency Variation
  - As the satellite zenith angle increases, the decrement of the real-time emissivity increases.
  - The emissivity over each vegetation types shows different variation with regard to satellite zenith angle and the channel frequency.
  - These variations correspond with other microwave emissivities.

◆ Diurnal Variation
  - Monthly averaged real-time emissivity.
    - (Left) The real-time emissivity describes the diurnal/seasonal variation of surface states and atmospheric condition better.
    - (Right) As a result, the variation of C-B with regard to solar zenith angle decreased.
  - Solid line (SZA = 40°), dashed line (SZA < 40°)
  - Obs: Background TB
  - C-B: Bias Corrected observation TB

◆ Emissivity sensitivity to errors in the parameters
  - The emissivity estimation is most sensitive to the surface temperature errors (followed by observation errors) at CH3.
  - Obs Mean (STDV)
    - Ch01: 0.29(0.34) - 0.36(0.30)
    - Ch02: 0.89(0.75)
    - Ch03: 0.30(1.11)
    - Ch16: 0.30(1.11)
  - Tb Chan Mean (STDV)
    - Ch01: -0.89(0.75)
    - Ch02: 0.54(0.40)
    - Ch03: -0.50(0.38)
    - Ch16: -0.74(0.58)
  - Th Chan Mean (STDV)
    - Ch01: 0.30(1.11)
    - Ch02: 0.30(1.11)
    - Ch03: 0.30(1.11)
    - Ch16: 0.30(1.11)

◆ Estimation with VIIRS land surface temperature
  - The diurnal variation of emissivity decreased.
  - UM T_sfc induced the diurnal variation of emissivity (actual emissivity value doesn’t show diurnal variation).
  - Mean bias and STDV of C-B at sounding channels decreased.

Conclusion

◆ By utilizing the real-time emissivity estimated with ATMS observations to pre-processing process, mean bias and STDV of O-B improved especially for near-surface channels over land.
◆ Thereby, we expect more land observations to be assimilated for data assimilation system.
◆ However, relatively high biases are shown over high altitude and arctic regions.
◆ These can be refined by improved pre-processing method (cloud screening and bias-correction) or by more accurate land surface temperature data.

References


This study was supported by “A study on the Development of Observation Parameter of Low Earth Orbit Satellite Data and Pre-processing” under the KMA/NMSC’s R&D project(NMSC-2016-3137).