Improving over land precipitation retrieval by brightness temperature temporal variation

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Motivation:

- The primary precipitation signal over land is the brightness temperature (TB) depression at high frequency channels caused by the ice scattering.

- A common and serious issue is the cold land surface contamination (e.g., snow-covered land), which is particularly problematic for rainfall/snowfall retrieval in winter.

- To mitigate this problem, this study proposes to use TB temporal variation (ΔTB), which is derived from eight polar-orbiting satellites, including GPM, F17, F18, S-NPP, NOAA-18, NOAA-19, Metop-A and Metop-B.

- MRMS precipitation data is taken as reference.

Basic idea: Make satellites “talk” to each other. When doing retrieval, one satellite should “consult” what happened previously from another satellite.
Why these 8 satellites:

GPM, F17, F18, S-NPP, NOAA-18, NOAA-19, Metop-A and Metop-B.

Because:

Radiometers onboard these satellites all have frequencies from ~89 GHz to ~183 GHz.

<table>
<thead>
<tr>
<th>Satellite name</th>
<th>Radiometer name</th>
<th>Frequency</th>
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<th>Resolution</th>
<th>ECT</th>
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<tbody>
<tr>
<td>GPM</td>
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<td>166.0 (V/H)</td>
<td>183.3±3, ±7 (V)</td>
<td>6 or 7 km</td>
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“Convert” TBs from other radiometers to GMI

- **Simultaneous Conical Overpass (SCO):** simultaneous measurements at a location from two different sensors at a similar frequency should be highly correlated.
  1. regress SSMIS(F17)-V91.7 against GMI-V89, using SCO pairs between F17 & GPM.
  2. apply this relation to all pixels.

- **Sounder (ATMS & MHS):** SCO pairs dependent on scan position.

- By doing so, it is as if that we have eight sensors measuring TBs at GMI frequencies, which are 89.0 (V/H) 166.0 (V/H), 183.3±3 (V), and 183.3±7 (V).

“Convert” TBs from other radiometers to GMI

- There are no obvious outliers observed when pooling data from all eight sensors together.
- Our method can effectively convert TBs from other sensors to GMI channels.
**TB temporal variation (ΔTB):**

\[ \Delta TB = TB_{t_0} - TB_{t-1} \]

- \( TB_{t_0} \) is the current TB associated with precipitation.
- \( TB_{t-1} \) is the preceding TB at the same location without precipitation.
- \( \Delta TB \) is not the difference between two temporally consecutive TB observations.

\[ \Delta t = t_0 - t_{-1} \]

- \( \Delta t \) time difference between these two observations.
- The shorter the revisit time (\( \Delta t \)), the better the correlation between TB temporal variation (\( \Delta TB \)) and precipitation intensity is.
Correlation from TB vs. from $\Delta$TB

- $\Delta$TB correlates more strongly with precipitation rate.
- Especially, over Rocky Mountains and northeast CONUS.
Why ΔTB is better

Because:

Surface contamination from snow cover is greatly mitigated by ΔTB due to the frequent re-visit (every 2hr) from these eight satellites.
A blizzard case: Mid-Atlantic and Northeast on 23 Jan 2016

- Over-estimation for light precipitation (<2 mm/hr) is greatly alleviated for all sensors.
- Because: if ΔTB is 0, the retrieval can only be 0.
Retrieval results:

- Using all channels from 89 to 183 GHz.

- Largest improvement is at the lower end of the precipitation intensity.
Summary:

• ΔTB correlates more strongly with precipitation rate than TB itself.
• ΔTB greatly mitigates snow-cover contamination.
• Largest improvement is found for the cold season precipitation.

Acknowledgement:

• Dr. Wesley Berg for SSMIS data status.
• Dr. Joe Munchak for reading/discussing the original draft.
• Dr. Eric Nelkin for providing the equatorial crossing time.
• Over the targeted region, the daily re-visit frequency is from 10 to 16 times (on average, every ~2-hr), depending on latitudes.

• The frequent revisit for a certain location enables us to find a non-cloudy background accurately, therefore $\Delta TB$ mostly contains the precipitation information, instead of surface and environmental contamination.
Retrieval results:

- Only using 89 GHz channel, AMSR2-type sensor (highest freq. \sim 89 GHz).

- Largest improvement is at the lower end of the precipitation intensity.
Shorter $\Delta T$, better correlation

- Correlation substantially weakens with longer $\Delta T$ over the Northeast region (37-47N, 65-80W).
- With these 8 satellites, almost all $\Delta T$ (94.6%) is less than 24 hrs.
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- $\Delta t$ time difference between these two observations.
- We show later that the shorter the revisit time ($\Delta t$), the better the correlation between TB temporal variation ($\Delta TB$) and precipitation intensity is.