A Prototype Precipitation Retrieval Algorithm Over Land for SSMIS and ATMS

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Background

- Our group provided the **level-2 rainfall estimation** over land for **TRMM** (2A12).

- The **Bayesian algorithm** is and will be applied to all **GPM constellation** radiometers.

- This work has been done in the **NASA GPM** retrieval algorithm framework and supports **NOAA's (partial) contribution** to GPM.

- Algorithm is applied to **SSMIS** (imager) and **ATMS** (sounder).
Bayesian Algorithm

\[ f(x|T) = f(T|x) \times f(x) \]

- **posterior** is proportional to **likelihood** times **prior**

- \( x \): rainrate
- \( T \): brightness temperature (TB)

Database Stratification

• The fundamental problem for the precipitation retrieval: non-unique solution (one set of TB associated with many different surface rainrates).

• To alleviate this problem: use ancillary parameters to stratify the single database.

• Two most important factors affecting TB: surface condition and precipitation vertical structure.
Land Surface Parameters

- **Elevation** (NOAA)
- **Surface Emissivity Class** (TELSEM)
- **Surface Temperature** (MERRA)
Precipitation vertical structure parameter

- **Ice layer thickness**: the difference between the freezing level height (FLH) and storm height (SH).
- FLH: estimated from MERRA
- SH: estimated from TBs

Credit: NASA TRMM Science Team
Primary datasets

• Special Sensor Microwave Imager/Sounder (SSMIS)
  ▪ TB observations

• Advanced Technology Microwave Sounder (ATMS)
  ▪ TB observations

• Multi-Radar/Multi-Sensor System (MRMS)
  ▪ Surface precipitation observations

• Modern Era Retrospective-analysis for Research and Applications (MERRA)
  ▪ Ancillary information

• Integrated Surface Datasets (ISD)
  ▪ Ground gauge observations
## Precipitation Detection Results

### POD (%) for rainfall

<table>
<thead>
<tr>
<th></th>
<th>Only TBs</th>
<th>TBs $rh$ and $w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single database</td>
<td>75.9</td>
<td>78.5</td>
</tr>
<tr>
<td>Stratified database</td>
<td>84.0</td>
<td>85.1</td>
</tr>
</tbody>
</table>

### POD (%) for snowfall

<table>
<thead>
<tr>
<th></th>
<th>Only TBs</th>
<th>TBs $rh$ and $w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single database</td>
<td>56.0</td>
<td>67.2</td>
</tr>
<tr>
<td>Stratified database</td>
<td>68.0</td>
<td>76.4</td>
</tr>
</tbody>
</table>

- Using stratified databases, the POD increases **8.1%** and **12.0%** for rainfall and snowfall detection, respectively.
- POD further increases to 76.4 by adding **relative humidity** ($rh$) and **vertical velocity** ($w$) for snow detection.
Comparison between observed and retrieved rainfall

Using Stratified database:
- Larger correlation and smaller RMSE
- Similar features for other seasons and snowfall
Larger HSS from stratified databases, indicates better performance.
• The **seasonal variation** of the rain pattern is well **captured** over the CONUS.

• Over-estimation in summer over central United States is evident.

• The NMQ radar-only data is biased compared with gauge data, particularly over central United States.
Using only CONUS data, the **rainfall geo-spatial pattern** retrieved from ATMS agrees well with that from GPCC gauge observations.

- The **major rain band (e.g., ITCZ) movement** is clearly demonstrated.

- The ATMS retrieved rainfall is larger. (1) ATMS instantaneous observation vs. GPCC gauge accumulated observation (2) regional database applied globally.
• Snow case on 02/01/2014
• **Magenta cross: snow gauge report**
• Ground radar misses almost all the snowfall over the Rock mountain region due to terrain blockage.
• Snow case on 02/14/2014
• Ground radar and satellite are in better agreement over eastern United States.
• NMQ and ATMS agree well over Eastern United States
• Large discrepancy between NMQ and ATMS over Rocky mountains
• Using only CONUS data, the retrieved snowfall over Tibetan Plateau and Siberia regions is greatly over-estimated.
Conclusions

• A prototype precipitation algorithm is developed and applied to SSMIS and ATMS.

• The retrieved precipitation rate is in good agreement with radar observations.

• Using only CONUS data, the retrieved rainrate agrees well with ground observation in the 60S-60N region.

• The stratification scheme could help NASA’s future GPM algorithm development.

• We are working to include the precipitation features and develop better snowfall detection/retrieval methods.
Questions and comments
Some backup slides
Precipitation retrieval error

- **One-standard deviation error bar** adds valuable extra information.