A Prototype Precipitation Retrieval Algorithm Over Land Using Passive Microwave Observations Stratified by Surface Condition and Precipitation Vertical Structure

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Background

- We have developed a prototype precipitation algorithm by considering both surface condition and precipitation vertical structure.
- This prototype algorithm is applied to SSMIS (imager) and ATMS (sounder).
- Results based on this prototype algorithm greatly outperform the traditional single database algorithm.

Methodology

- The Linear Discriminant Analysis (LDA) is used for precipitation (rainfall/snowfall) detection.
- The Bayesian algorithm based on the Principal Component Analysis (PCA) is employed for precipitation retrieval.
- The PCA is applied to TBs, corresponding to same surface rainrate, which guarantee that the covariance matrix is diagonal.

Database construction

- Ground radar observations over Continental United States (CONUS) with radar quality index greater than 0.5.
- SSMIS and ATMS brightness temperatures (TBs).
- Applied this database over CONUS and globally over land.

Database stratification

- Using the following four parameters to stratify the single database:
- **Surface type (e.g., forest vs. desert)**
- **Surface temperature**
- **Elevation**
- **Ice layer depth**
- One more parameter (**beam position**) is added to further stratify the databases for ATMS to consider the varying FOV and mixed polarization.
- The essential idea is to: stratify the single database into smaller but more homogenous databases. By doing so, both the surface condition and precipitation vertical structure is similar in each smaller databases.

Effect of stratification on detection

POD (%) for rainfall detection

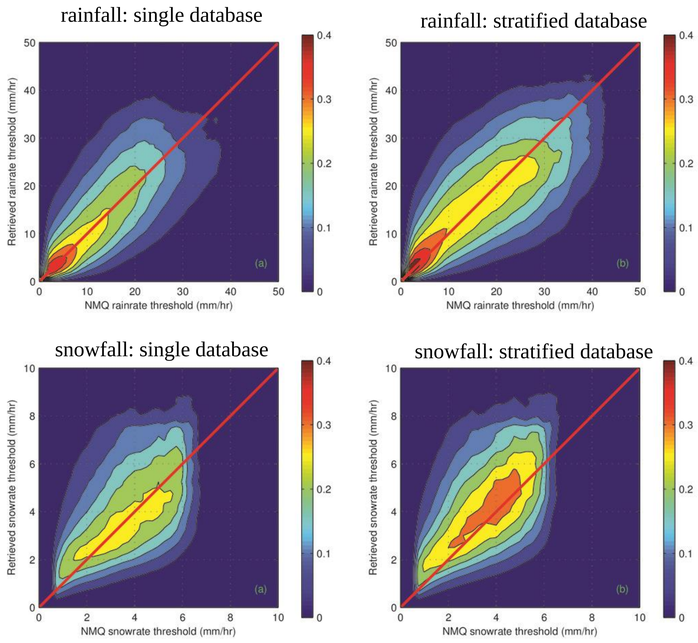
	Only TBs	TBs *rh* and *w*
Single database	75.9	78.5
Stratified database	84.0	85.1

POD (%) for snowfall detection

	Only TBs	TBs *rh* and *w*
Single database	56.0	67.2
Stratified database	68.0	76.4

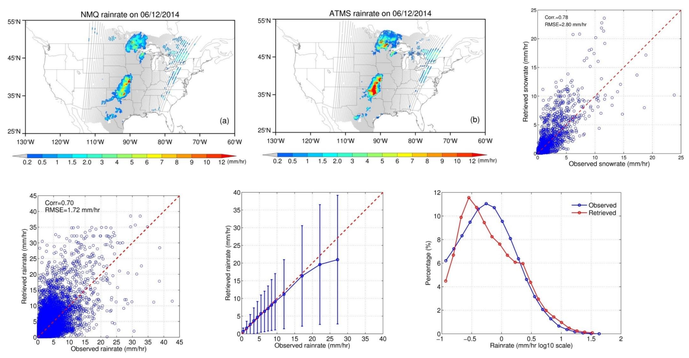
- Using databases, the POD increases 8.1% and 12.0% for rainfall and snowfall detection.
- POD further increases to 76.4 by adding relative humidity (*rh*) and vertical velocity (*w*) for snow detection

Effect stratification on retrieval



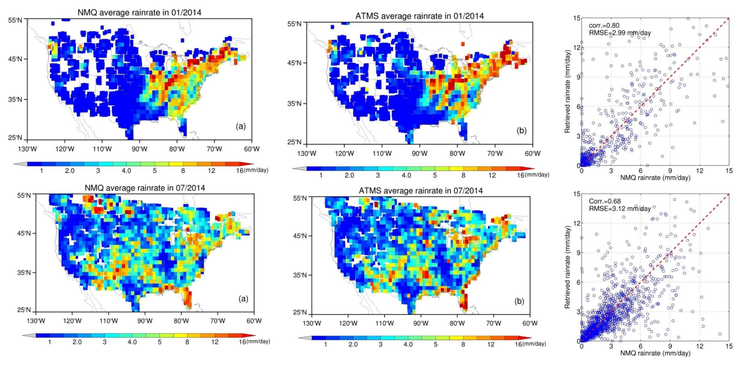
- Using stratified databases: larger Heidke Skill Score (HSS) for both rainfall and snowfall retrieval results.

The rainfall retrieval performance



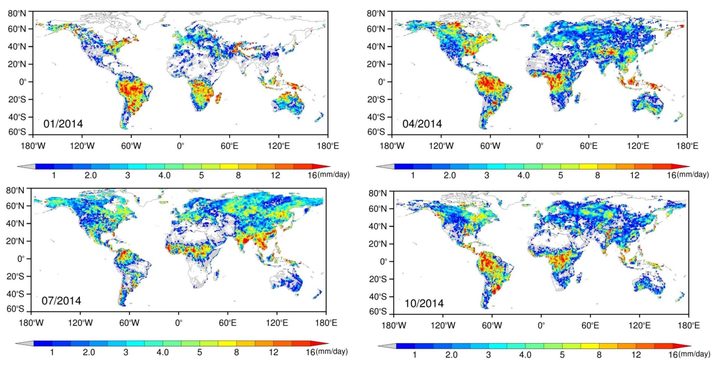
- rainfall retrieval results agree well with the NMQ ground radar observations.

CONUS Rainfall Seasonal Variation



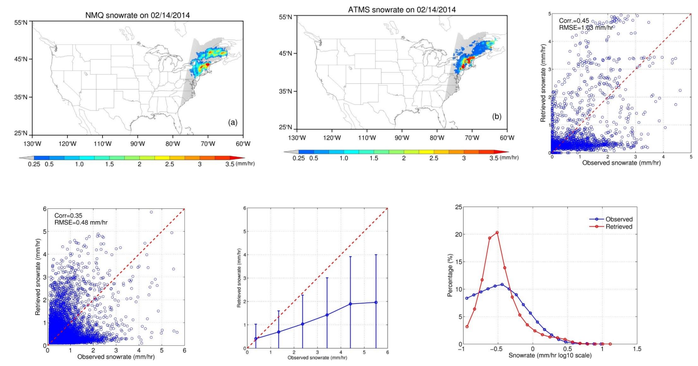
- The seasonal variation of the rain pattern is well captured over the CONUS.

Global Rainfall Seasonal Variation



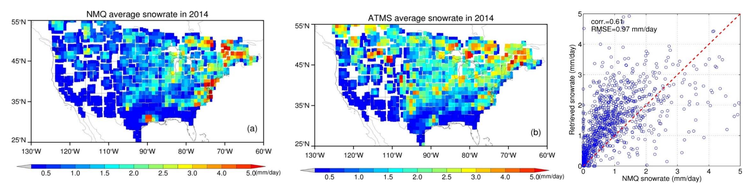
- Only use the CONUS data, the major rain band (e.g., ITCZ) movement is well demonstrated.
- **Local database (e.g., over CONUS) could be "transferred" to the global coverage.**

The snowfall retrieval performance



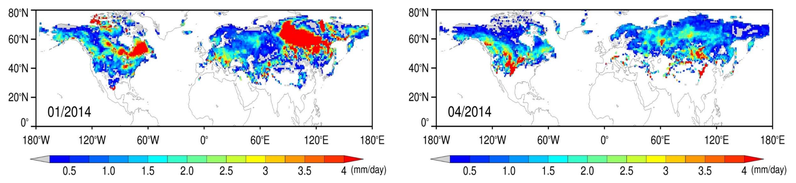
- large errors for shallow snowfall with little ice scattering signature.
- Strong surface contamination (ice covered surface) also contributes greatly to the poor retrieval results, compared with rainfall.

CONUS snowfall



- NMQ and ATMS agree well over Eastern United Sates.
- Large discrepancy between NMQ and ATMS over Rocky mountains. Terrain blockage accounts for the missing snowfall from NMQ ground radars over this region.

Snowfall over Northern Hemisphere



- Only use the CONUS data, the snowfall progress and retreat in Jan. and Apr. is demonstrated.
- Artificial large snowfall rate (e.g., Siberia) is caused by the database completeness issue.
- Validation from other data sources (e.g., CloudSat and surface station observations) is needed.

In summary:

- **This prototype algorithm works reasonably well for both rainfall and snowfall.**
- **The lack of scattering signature in some snowfall events and strong surface contamination make it difficult to estimate snowfall rate accurately.**
- **The ancillary parameters make it possible to "transfer" a local database to the global coverage.**
- **This algorithm has the potential to be applied for all GPM constellation radiometers.**

- Reference: You, Y., N.-Y. Wang, and R. Ferraro (2015), A Prototype Precipitation Retrieval Algorithm Over Land Using Passive Microwave Observations Stratified by Surface Condition and Precipitation Vertical Structure, J. Geophys. Res. Atmos., 120, DOI: 10.1002/2014JD022534
- You, Y., N.-Y. Wang, and R. Ferraro (2016), A prototype precipitation retrieval algorithm for ATMS. J. Hydrometeor., doi:10.1175/JHM-D-15-0163.1.