Building Algorithm Components for GPM Snowfall Retrieval

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Introduction The goal is to develop algorithm components for snowfall detection and retrieval using GPM/GMI (as well as other microwave radiometers in the constellation) observations. Toward this goal, currently we are working on the following: (1) develop a snow-rain separation algorithm using data of surface observations; (2) examine the sensitivity of microwave channels to snowfall using radar-radiometer matchups; (3) build scattering database for aggregate snowflakes; (4) develop an empirical snowfall detection/retrieval algorithm over land; and (5) study snowing cloud profile characteristics for snowfall over ocean.

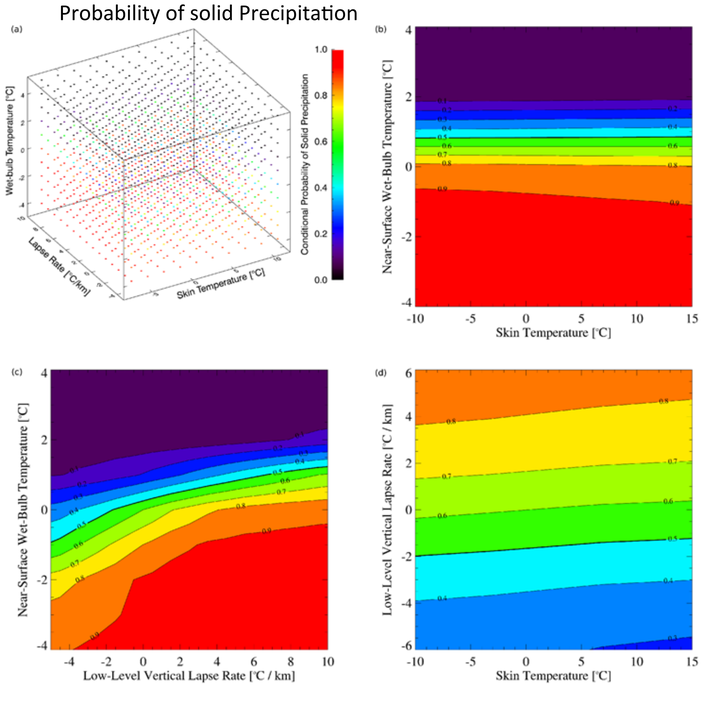
Snow-Rain Separation

Data Used:
Land: NCEP ADP Operational Global Surface Observations, 1997-2007
Ocean: International Comprehensive Ocean-Atmosphere Data Set (ICOADS), 1995-2007
Upper Air: Integrated Global Radiosonde Archive (IGRA)

Sensitive Variables

- Air temperature (2 m)
- Humidity (2 m)
- Low-level (0 - 500 m) lapse rate
- Surface skin temperature
- Land or ocean

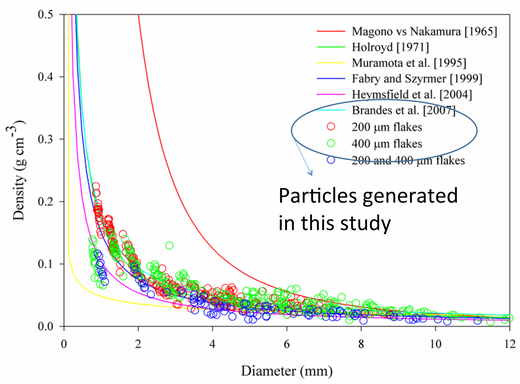
Probability of solid Precipitation



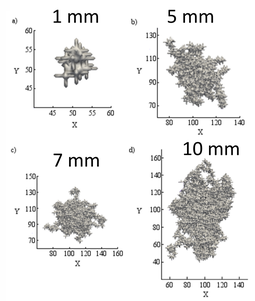
(Sims and Liu, 2015, JHM)

Scattering Database for Aggregates

Aggregate snowflakes have been created with their dimension-mass/density relation constrained by consensus of observations. Their scattering properties have been calculated using DDA and scattering table is archived on the web. With the addition of table to the earlier table for crystal type particles, we now have the scattering table for full range of ice/snow particles, with types of "rounded", "oblate" and "prolate" aggregates. (Nowell, 2015; Nowell et al., 2013)

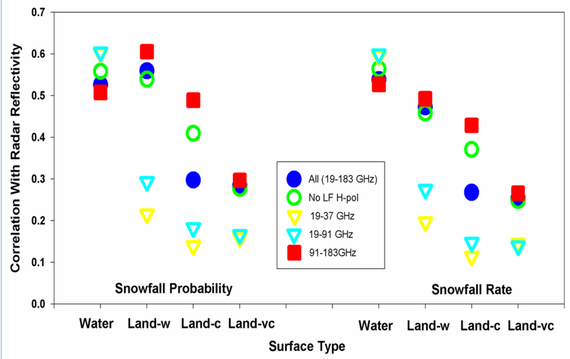


Exemplar particles



Sensitivity of MW Signature to Snowfall Over Land

Method:
- Collocate SSMIS and NMQ:
  SSMIS: 19,22,37,91,150,183±1,3,7 GHz; NMQ: U.S. + Canada Radar networks
- Select snow-possible scene only using "snow-rain separation" algorithm
- Use "Empirical method" for snowfall detection and retrieval
- Compare with NMQ (truth)



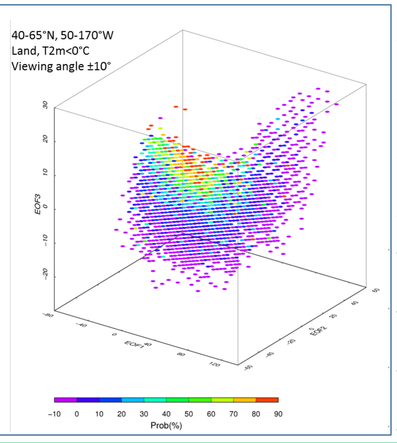
Surf Type:
1.Water; 2.Land-w:Ts>-2°C; 3.Land-c: -8°C <Ts<-2 °C; 4.Land-vc: Ts<-8 °C

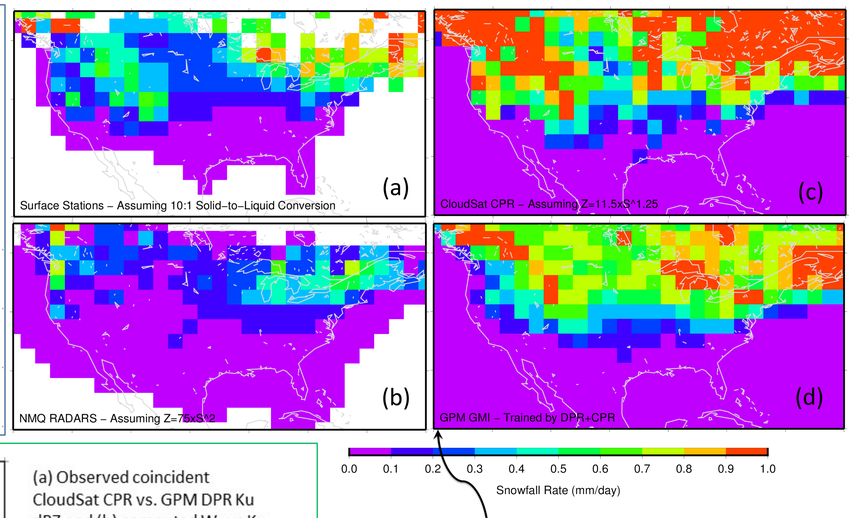
Insights:

1. High-freq (f>150 GHz) essential for snowfall detection & retrieval;
2. 91-183 GHz only as good as all 19-183 GHz channels;
3. Similar skills for detection (probability) and retrieval (snowfall rate)

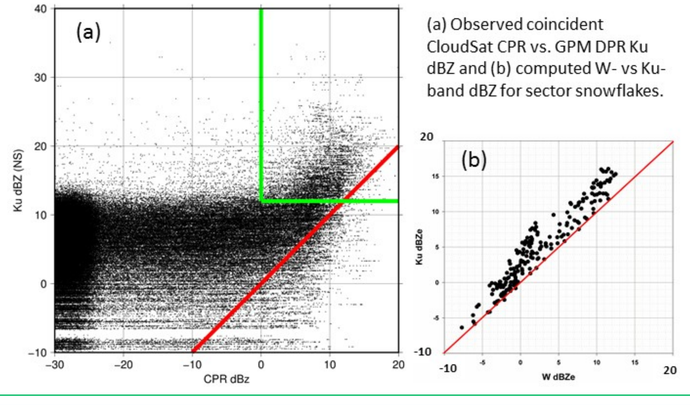
Snowfall Detection and Retrieval

METHOD: The over-land snowfall detection/retrieval algorithm is based on a lookup-table using coincident MW radiometer and radar (as truth) data pairs. From radar reflectivity, first derive snowfall rate using a Z-S relation. Then a lookup table is generated that gives snowfall probability and snowfall rate in 3-D brightness temperature EOF space. (Liu&Seo, 2013)





Use combined CloudSat/CPR and GPM/DPR as "truth": DPR (Ku or Ka) has a minimum detection of about 12 dBZ, missing most of snowfall events, while CloudSat CPR has attenuations for heavy snowfall. Combined DPR-CPR data are used as "truth" in the GPM GMI empirical algorithm. Z-S relations for DPR/CPR are derived from scattering database with assumed size distributions.



(a) Observed coincident CloudSat CPR vs. GPM DPR Ku dBZ and (b) computed W- vs Ku-band dBZ for sector snowflakes.

(a) GHCND + Canada Station observed climatology – multiple years
(b) NMQ – 6 winter (DJF) months (2011-2013), assuming other months no snow
(c) CloudSat – 4-year (2007-2010) average
(d) GMI – 2014.4-2015.3, trained by CloudSat/CPR + GPM/DPR

* Similar pattern – therefore, GMI is able to catch the snowfall signature
* Different magnitude – need more study for "truth" data, Z (radar) to S (snowfall) conversion.