Snowfall Retrieval from Space

Guosheng Liu
Florida State University

• Mid-latitudes vs. Polar regions
• Radars vs. Radiometers
The difference between mid-latitudes and polar regions
- surface & airborne radar obs

Barrow—Alaska (71°N)
2002-2005 winters

Wakasa Bay—Japan (~35°N)
2001&2003 January

MMCR

\[ Z_e = 56S^{1.2} \] (Matrosov 2006)

APR-2 & Obama Doppler

![Graphs showing snowfall rates and relative frequency at different altitudes and snowfall rates.](image-url)
Snowfall examples from CloudSat
Ze-R relationships for Solid Precipitation

Ze (mm$^6$m$^{-3}$) vs. Precipitation (mm/h)

 depend on:
- Size Distribution +
- particle shape

(Dependent on: Wakasa snow (Aonashi, 2003), Snow_dry (Puhakka, 1975), Snow (Sekhon & Srivastava, 1970), Snow_dry (Imai, 1960), Plate, column (Ohtake & Henmi, 1970), Single crystals (Carlson & Marshall, 1972), Snow_dry (Fujyoshi et al., 1990) - 9.4 GHz, Graupel_13.4GHz, den=0.25 (Mie), Graupel_35.6GHz, den=0.25 (Mie), Graupel_94.0GHz, den=0.25 (Mie))
High frequency measurement of snowfall

![Graphs and images related to snowfall measurements.]

- δTB (K) measurements plotted over time and height.
- AMSUB (A1-B1) data shown with temperature (TB) values at various latitudes.
- Color-coded maps indicating temperature variations at different altitudes and latitudes.
Snowfall Retrieval From High –Frequency Microwave Satellite Observations

- Use surface and airborne radar snowfall observations as the basis to build the a-priori database
- Radiative transfer model utilizes nonspherical snowflakes scattering calculations

A Case Study (Jan 14 2001)

Compare AMSU-B Retrieval with AMeDAS radar (3 cases, correlation coefficient: 0.79)

Noh, Liu, et al. (2006)
Below 60°N

Winter Snowfall Distribution

SSM/T-2 snowfall

COADS snow fraction

Winter Rainfall Distribution

SSM/I rainfall

COADS rain fraction

Liu & Curry (1996)
SSM/I 85GHz $\Delta T_B$ 92/12/

Detecting Snowfall From Space
- what we knew and what we do not know

- From space radar (CloudSat, future new radars)
  - Pros: physically direct, only need Z to R conversion
  - Cons: CloudSat - spatial coverage, only a 1.4 km wide strip per orbit
  - Future radar? (GPM radars can go up to ~67 degree latitudes), how about polar regions?
  - Need minimum detectable dBZ value -10 dBZ or smaller

- From High-Frequency Microwave Radiometers (AMSU-B, SSMIS, GMI)
  - Pros: More spatial and temporal coverage (4~6 satellites)
  - Cons: 1. weaker signature, 2. physically less direct, 3. surface contamination
  - Below ~60N degree, particularly over ocean, there have been attempts in retrieving snow from HF-Microwave radiometer obs,
  - Above ~60 degree latitudes, ???

- Polar Regions:
  - Satellite radars see snow;
  - Radiometers? Need to explore
    - Studies shows increase of TB associated with cloud/snow at 85, 37 GHz
    - How about even higher frequencies?