Polarization detection during snowfall using ground-based passive microwave radiometry

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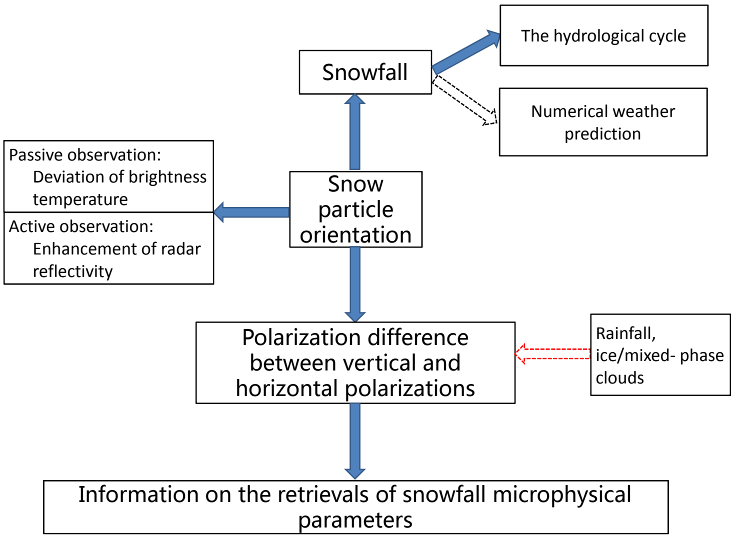
1. Introduction



2. Observation

Observations during **TOSCA** campaign----**T**owards an **O**ptimal estimation based **S**now **C**haracterization **A**lgorithm

Ground-based Dual-Polarized microwave Radiometer (DPR)

- 3 channels at 90 GHz and 150 GHz
- 2 independent channels at 150 GHz with vertical and horizontal polarizations

Case study: April 04, 2010

Snowfall duration: 11 UTC – 19 UTC

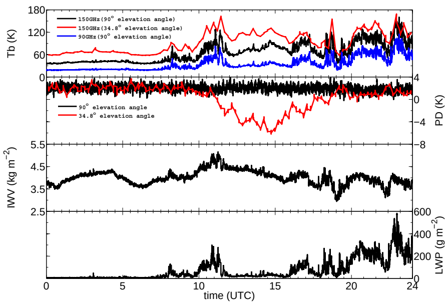


Fig. 1 Observation results on April 04, 2010. From top to bottom: brightness temperature at 150 GHz and 90 GHz; polarized signals at the elevation angle of 34.8 and 90; integrated water vapor path and liquid water path derived from HATPRO.

- Polarized Difference (PD) reaches as much as -6 K
- Brightness temperature (Tb) enhancement
- PD and Tb are sensitive to supercooled liquid water during snowfall

14-channel K-band microwave radiometer HATPRO:

- 7 channels between 22 GHz and 31.4 GHz
- 7 channels between 50 GHz and 60 GHz

- DPR PD mean error is expected to be zero in clear sky
- The clear sky was detected by Ceilometer
- PD mean error at different elevation angles in clear sky is ~2 K
- PD standard deviation in clear sky is ~1 K

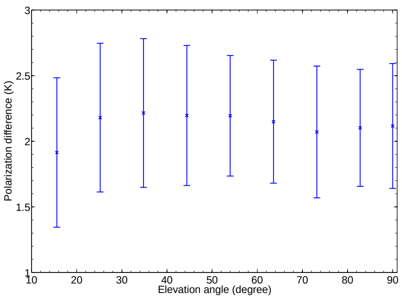
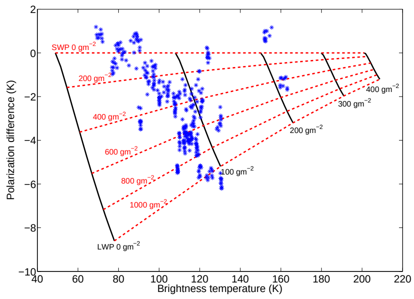


Fig. 2 DPR mean values and standard deviation of polarization difference as a function of scanning elevation angle in the clear sky

3. Radiative transfer simulations

To get a deep insight into the polarization measurements, atmospheric conditions are reconstructed (comparing the observation results with the radiative transfer simulations):

- Horizontally-oriented oblates with a fixed aspect ratio of 0.5
- Scattering properties calculated by T-matrix algorithm
- Radiative transfer model rt4



Size distribution

Snow particles—exponential size distribution

Supercooled water drops—monosize distributed sphere with the radius of 10 µm

Fig. 3 Radiative transfer simulations on April 04, 2010. Black solid lines are the contours of supercooled water path; red dotted lines are the contours of snow water path. The radiative transfer results are shown at the elevation angle of 32°. Asterisks are obtained from the observation results in Fig. 1 during 11 UTC and 19 UTC.

- **Pure effects of snow water**: the **black solid line** with the liquid water content (LWP) of 0 g/m²
- **Pure effects of supercooled liquid water**: the **red dotted line** with the snow water path (SWP) of 0 g/m²

- Effects of SWP on PD/Tb (without LWP)
  - Maximum PD up to ~9 K
  - Tb only ~80 K
- Combination effects of SWP and LWP on PD/Tb
  - PD is damped
  - Tb is enhanced

4. Conclusions and discussion

The polarized signals of observations with simulated results from radiative transfer model are shown with the combination of PD and Tb in this study,

- The observed PD during snowfall is up to -6 K.
- Supercooled water in the snow precipitation events enhances Tb and erodes PD. Tb increases while PD decreases with the increases of supercooled water.
- PD is sensitive to the supercooled water during snowfall. It could be possible to distinguish LWP and SWP by combining Tb with PD measurement.
- PD can be helpful on the retrievals of snow particle information, e.g. particle orientation, etc.

Analysis on the differences between the radiative transfer and observation results

- **Snow particle model**
  - **Snow particles, e.g. the shape, size and canting angle**, is more complicated during snowfall.
  - Particle models affect the radiative transfer results (PD and Tb!).
- **Supercooled liquid water**
  - Refractive index which affect the emission ability of the supercooled water can **shift Tb**.
  - The **location of the supercooled water** also affects Tb.
- **Surface emissivity**
  - The surface emissivity depends on the surface type & frequency.
  - During snowfall events, **the surface emissivity varies** with the snow accumulation.

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