Use of Oliktok Ka/W-band SACR2 polarimetric and KAZR Doppler spectra measurements of Arctic ice precipitation clouds

Mariko Oue and Pavlos Kollias
Stony Brook University

Zhiyuan Jiang, Kultegin Aydin, Eugene Clothiaux, and Johannes Verlinde
Pennsylvania State University
Ka/W-SACR2 polarimetric data

Case: Mixed-phase cloud on November 29, 2015

- **Kdp** is a good indicator of oblate ice particles (dendrites, early aggregates), especially at W band.
- **Kdp** values were consistent with scattering calculations for dendrites, while **Zdr** values were lower than scattering calculations.
- Low **Zdr** values indicate that spherical particles dominated the total reflectivity.
- Inconsistency between **Kdp** and **Zdr** suggests mixed different types of ice particles.
Ka/W SACR2 and KAZR measurements

KAZR (zenith pointing) collects Doppler velocities (spectra) attributed to particle fall speeds.

But, to collect meaningful polarimetric variables, scanning radar elevation angles should be low.

Quasi vertical profiles (QVP)

Azimuthal averages of polarimetric variables at each level from PPI.

Ryzhkov et al. (2016)

Kumjian et al. (2013)

Non-spherical crystals

Number concentration increased, aggregation

KAZR Doppler velocity

Higher Zhh

Lower Zdr

Larger Kdp
KAZR observed generating cells and fall streaks in a mixed-phase cloud.

Strong vertical wind shear resulted in mixed different ice particles.

QVP was applied to the northern sector of PPI observations.
Region I

Low Zdr and low Kdp, suggesting spherical ice particles (large aggregates or spherical graupel), single shape dominated, with advection.

Faster-falling (0.5-2 m/s) population suggesting large aggregates (possibly small graupel included).
Region II

High Zhh with high Kdp but weakly positive Zdr.
→ suggesting mixture of large, spherical particles (the total Zhh and low Zdr), and plate-like crystals (high Kdp).

Faster-falling population (b) has higher or equal contribution than slower population (a), then decreases as Zdr increases.
→ Population a corresponds to plate-like crystals; population b corresponds to spherical particles.
Region III

Increasing Zhh and decreasing Zdr downward with keeping higher Kdp. → suggesting increase of number concentration and aggregation. Low phv. → suggesting mixture of different types of particles

Slower-falling population (a) dominates the total reflectivity. → Population a corresponds to plate-like crystals, growing into aggregates toward the surface.
Summary

Ka/W-SACR2 polarimetric analysis in conjunction with KAZR Doppler spectra can provide information to identify precipitating ice particles in Arctic mixed-phase clouds.

Quasi-vertical profiles of polarimetric variables from PPI scans showed a presence of multiple ice particle types, consistent with KAZR Doppler spectra profile.

- Faster-falling particles at ~2.5 km corresponded to low Zdr and Kdp values, suggesting large, spherical aggregates.

- Faster-falling particles at ~1.5 km corresponded to low Zdr with high Zhh, suggesting large, spherical aggregates. Slower-falling particles corresponded to high Kdp, suggesting plate-like crystals.

- Three particle populations were suggested below 1 km, consistent with lower ρhv values. Slower-falling particles corresponded to decreasing Zdr toward the surface with keeping high Kdp, suggested aggregation process of plate-like crystals.

- Higher Zdr decreased toward the surface, suggesting oblate ice particles (plate like) growing to spatial particles, as falling speeds increased.