

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

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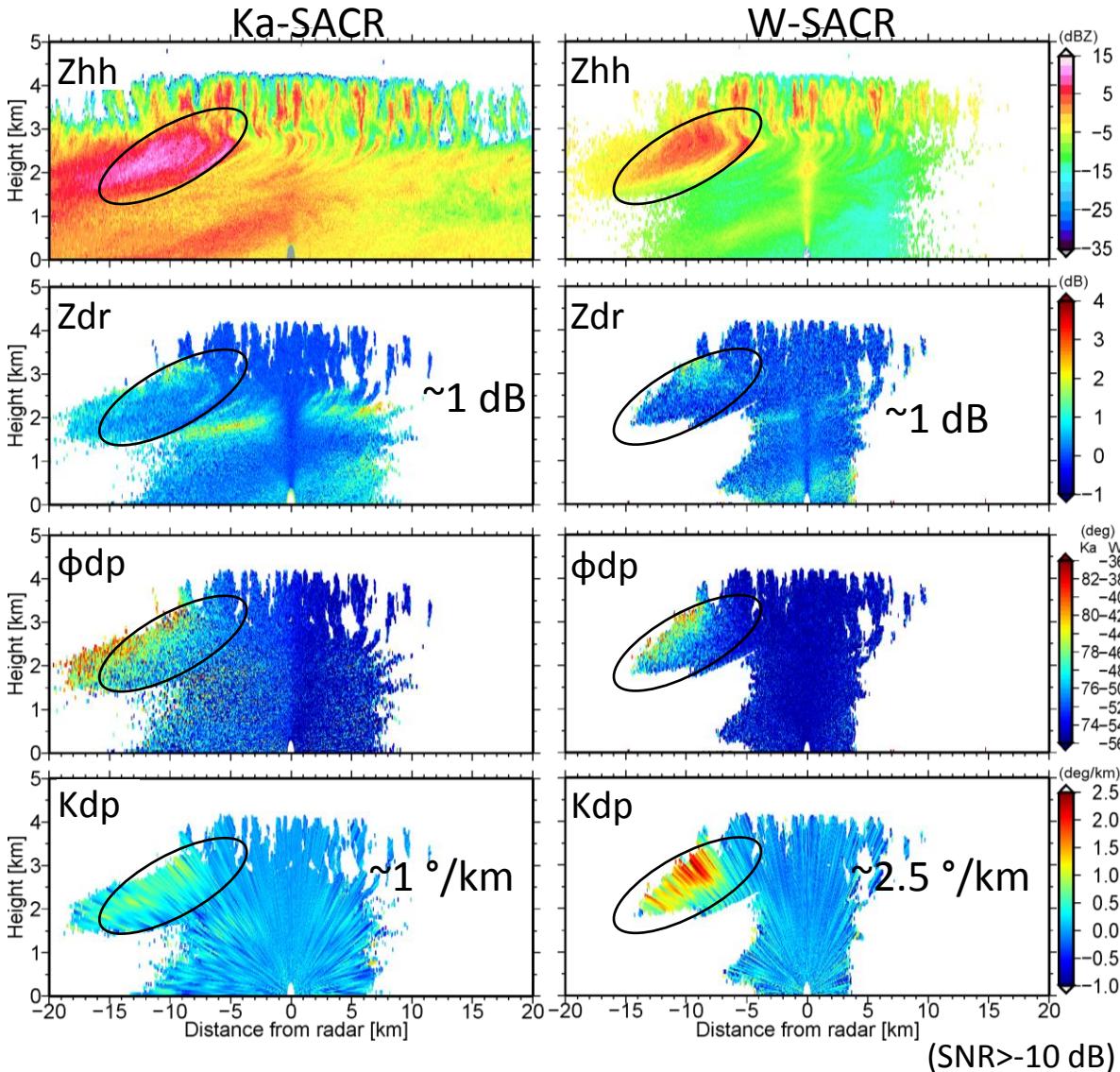
*Stony Brook University*

Zhiyuan Jiang, Kultegin Aydin, Eugene Clothiaux, and Johannes Verlinde

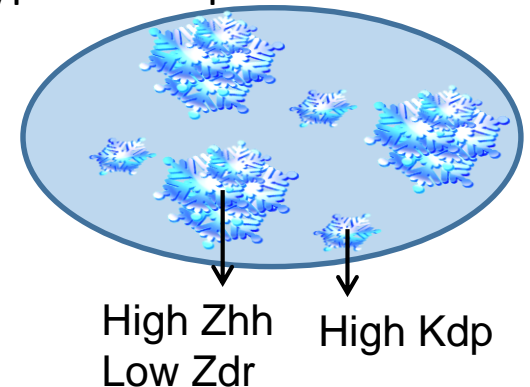
*Pennsylvania State University*

# Ka/W-SACR2 polarimetric data

Case: Mixed-phase cloud on November 29, 2015

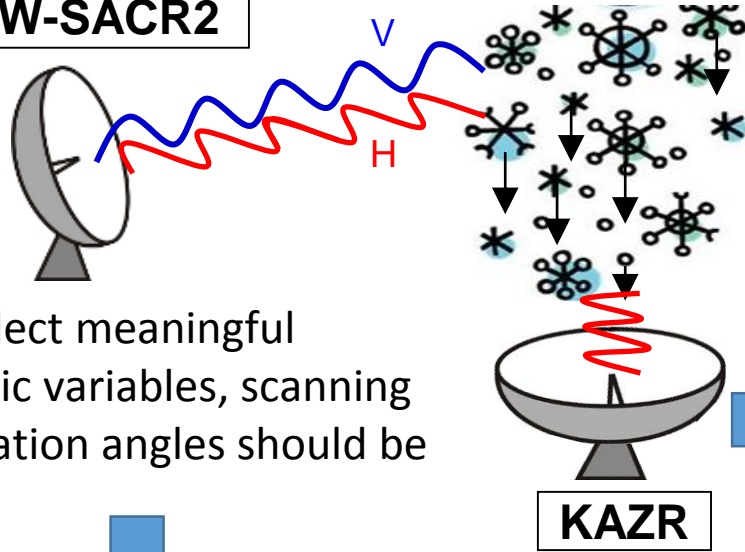


- Kdp is a good indicator of oblate ice particles (dendrites, early aggregates), especially at W band.
- Kdp values were consistent with scattering calculations for dendrites, while Zdr values were lower than scattering calculations.
- Low Zdr values indicate that spherical particles dominated the total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



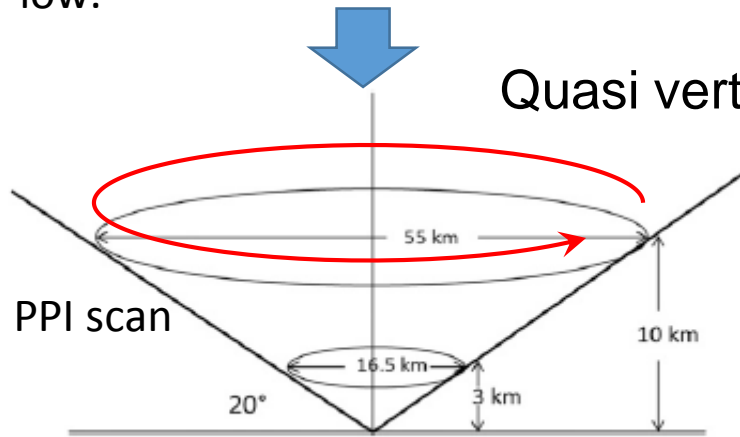
# Ka/W SACR2 and KAZR measurements

**Ka/W-SACR2**



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)

FIG. 2. Conical volume representing azimuthally averaged quasi-vertical profiles of radar variables.

*Ryzhkov et al. (2016)*

Azimuthal averages of polarimetric variables at each level from PPI.

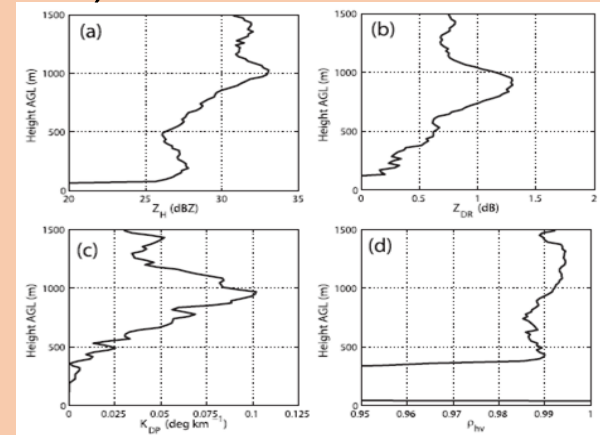
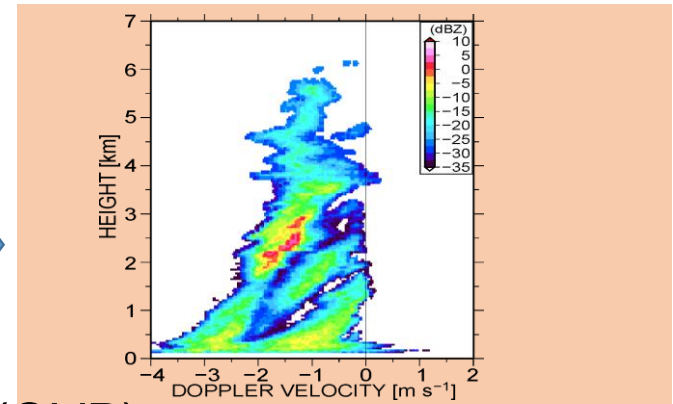
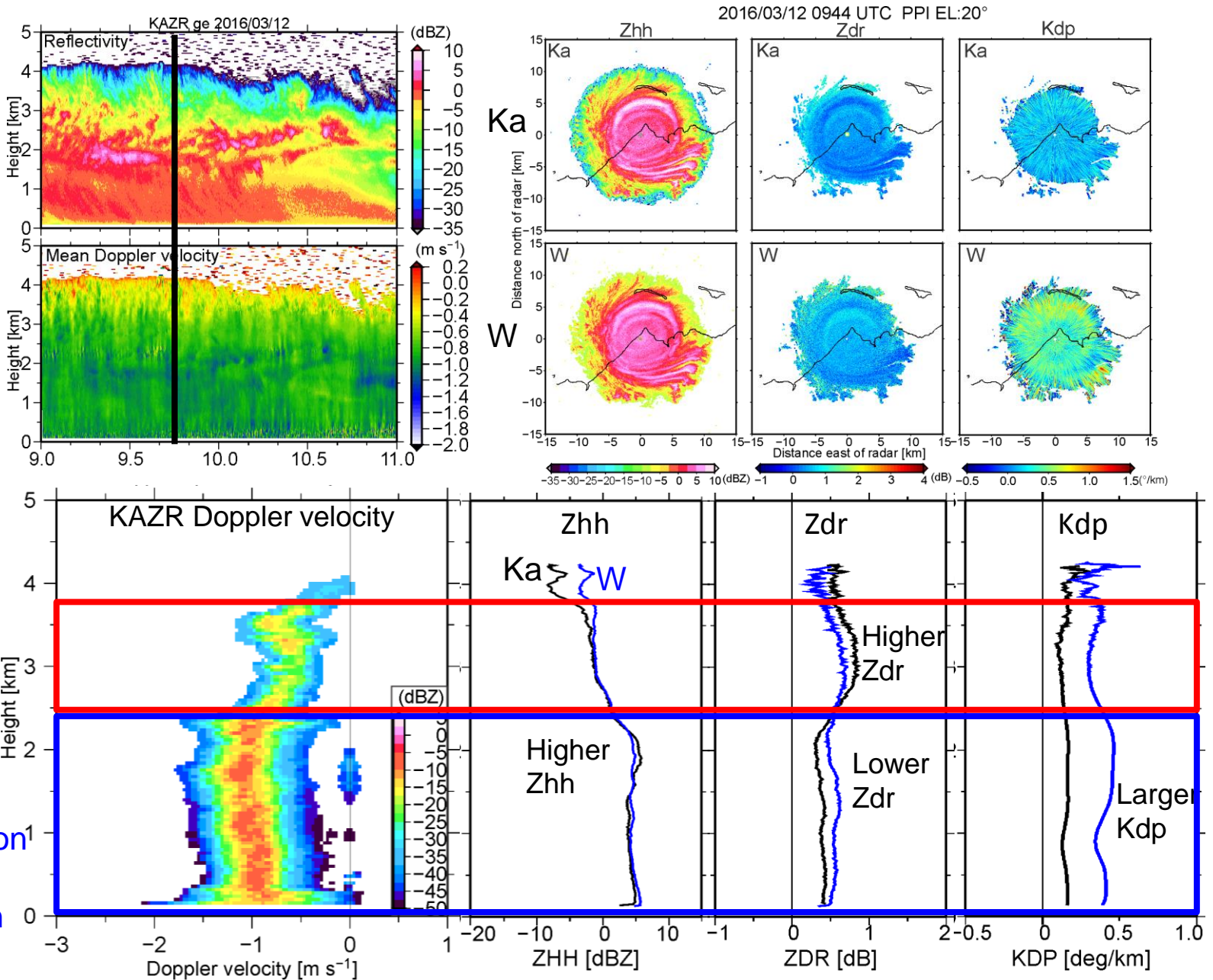


FIG. 4. Quasi-vertical profiles of (a)  $Z_H$ , (b)  $Z_{DR}$ , (c)  $K_{DP}$ , and (d)  $\rho_{hv}$ , taken from the S-band KOUN 4.3° elevation angle PPI scan shown in the previous figure (1406 UTC 30 Nov 2006).

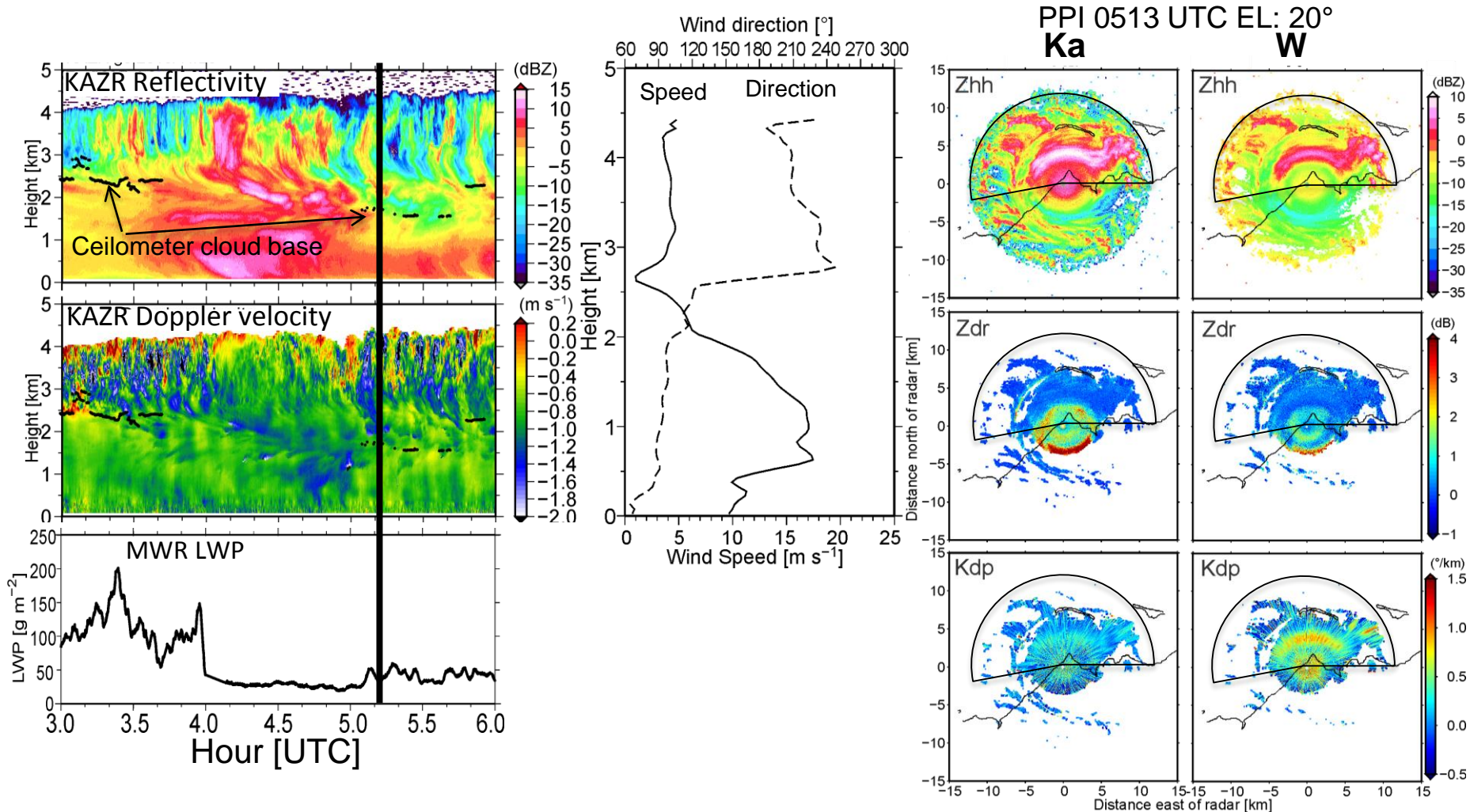
*Kumjian et al. (2013)*

Vertical profiles of polarimetric variables.

# Case study (1): Single ice growth on 12 Mar. 2016

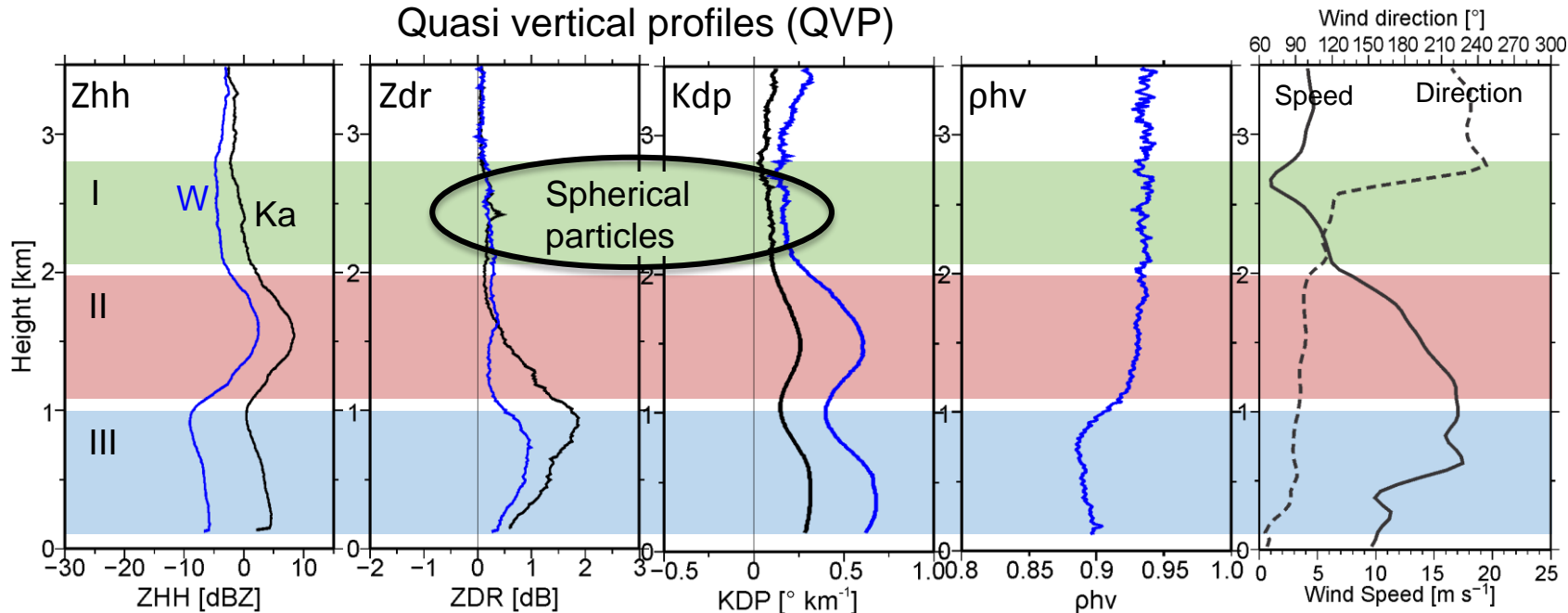


# Case study (2): Mixed ice particles on 29 Nov. 2015

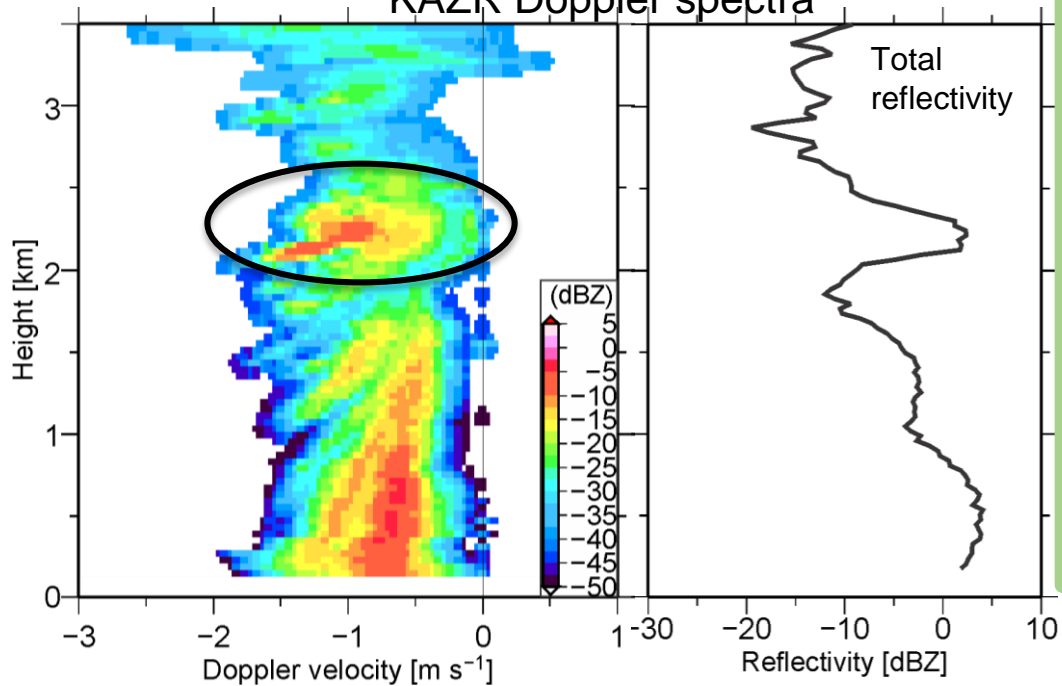


- KAZR observed generating cells and fall streaks in a mixed-phase cloud.
- Strong vertical wind shear resulted in mixed different ice particles.
- QVP was applied to the northern sector of PPI observations.

# Quasi vertical profiles (QVP)



## KAZR Doppler spectra



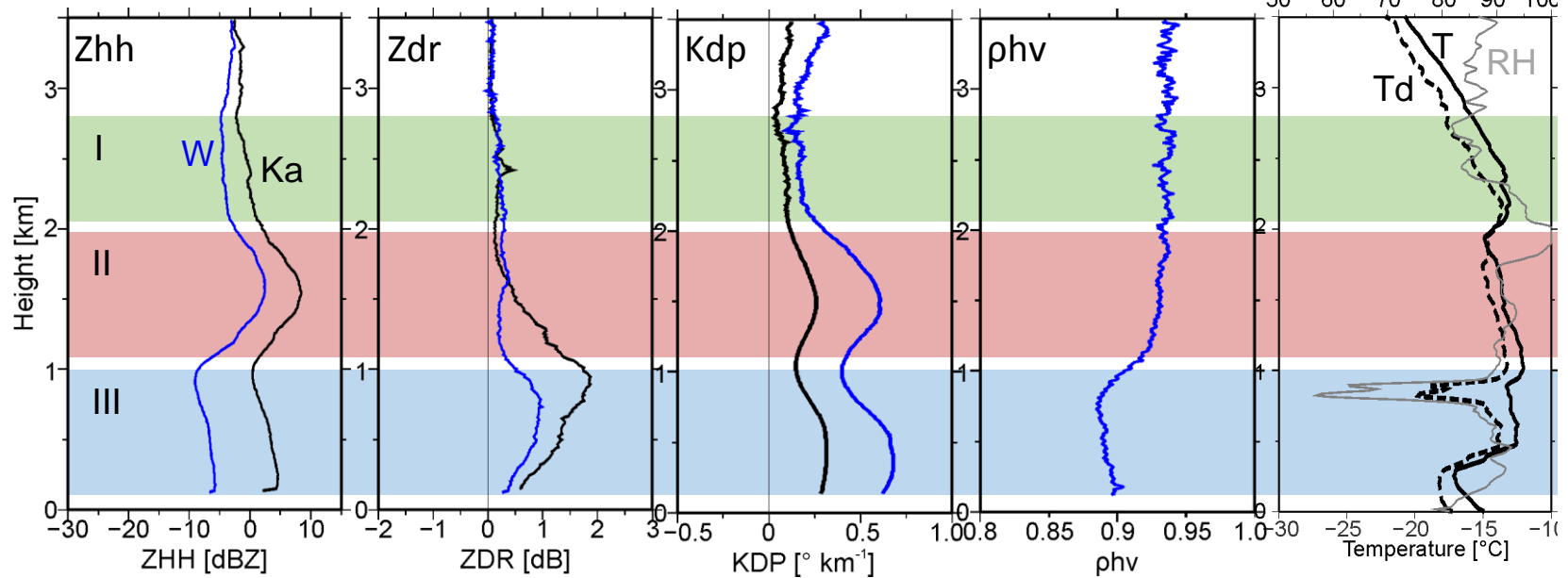
### Region I

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

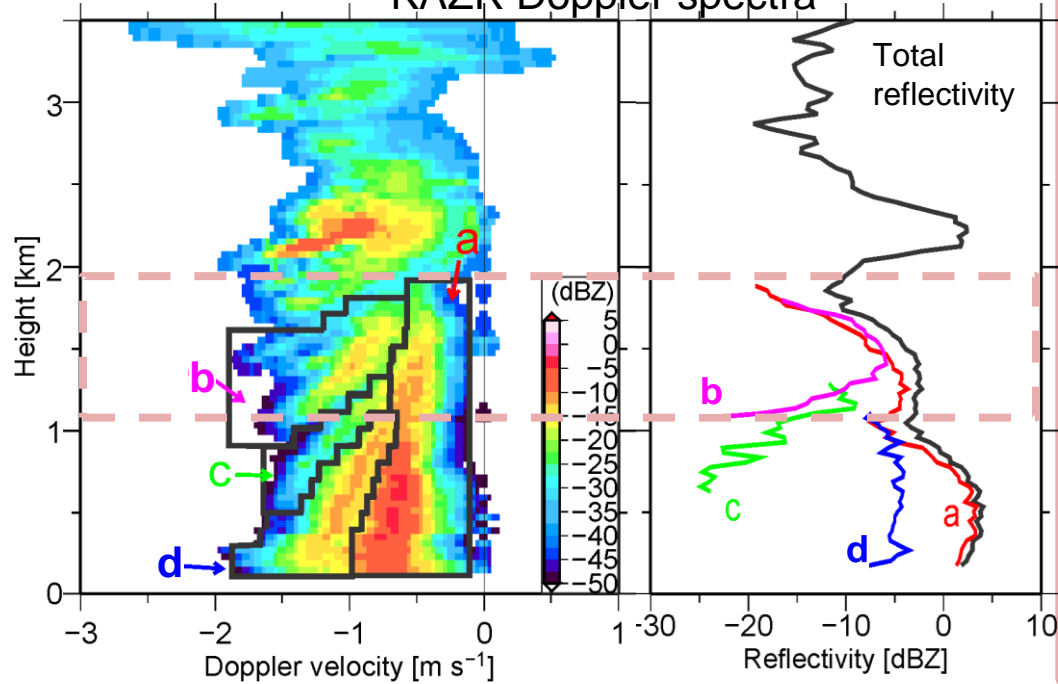
Faster-falling (0.5-2 m/s) population  
→ suggesting large aggregates  
(possibly small graupel included).

# Quasi vertical profiles (QVP)

18 Z 2015/11/29 Oliktok  
Relative humidity [%]



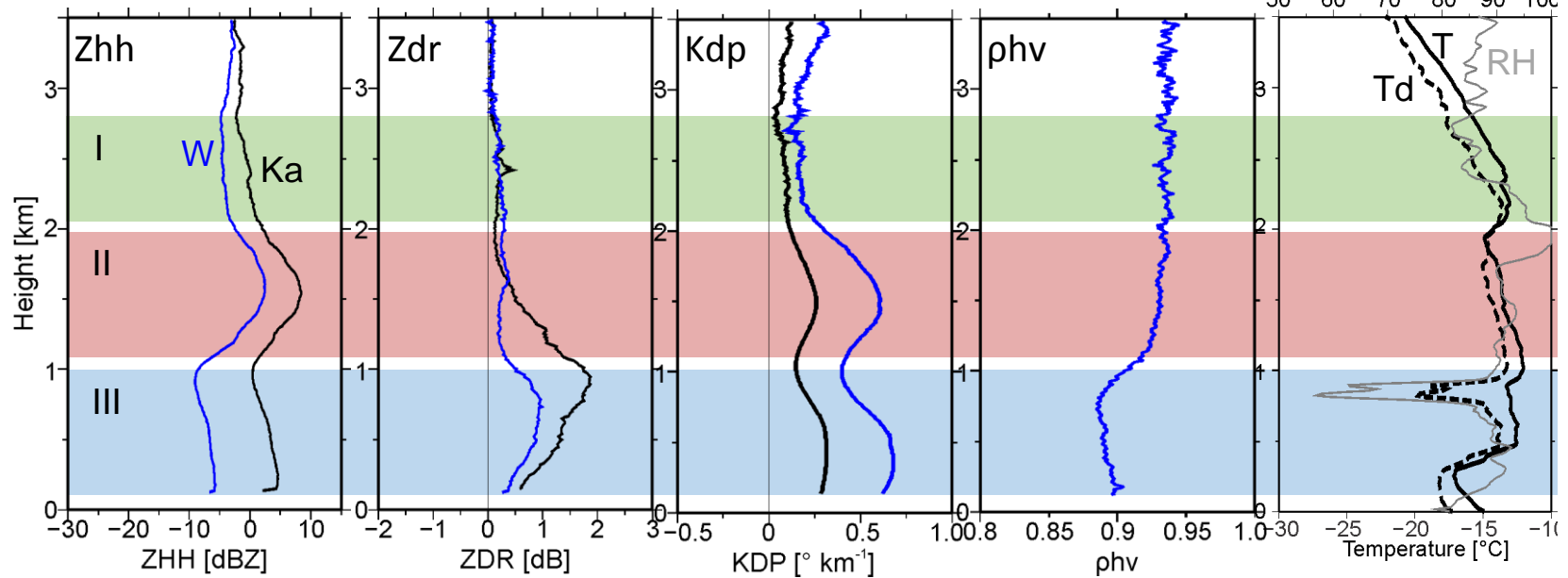
## KAZR Doppler spectra



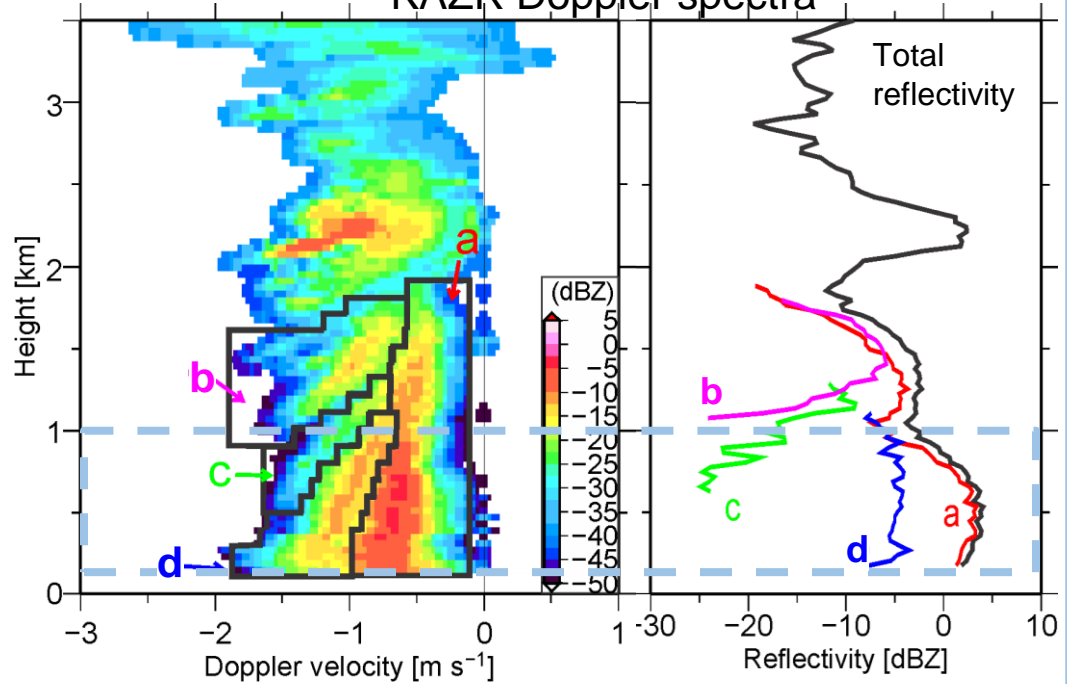
**Region II**  
 High Zhh with high Kdp but weakly positive Zdr.  
 → suggesting mixture of large, spherical particles (the total Zhh and low Zdr), and plate-like crystals (high Kdp).  
 Faster-falling **population (b)** has higher or equal contribution than slower **population (a)**, then decreases as Zdr increases.  
 → **Population a** corresponds to plate-like crystals; **population b** corresponds to spherical particles.

# Quasi vertical profiles (QVP)

18 Z 2015/11/29 Oliktok  
Relative humidity [%]



## KAZR Doppler spectra



**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  $\sim 2.5$  km corresponded to low Zdr and Kdp values, suggesting large, spherical aggregates.
  - ◆ Faster-falling particles at  $\sim 1.5$  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 phv 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 spherical particles, as falling speeds increased.