Polarimetric radar analysis using Oliktok Ka/W-band SACR2: Mixed-ice particles in Arctic mixed-phase clouds
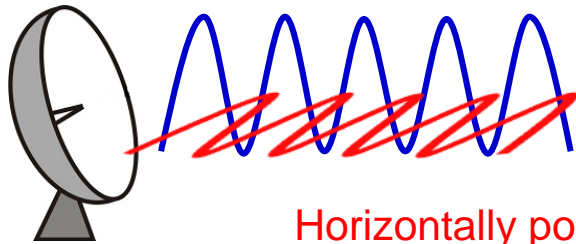
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Pennsylvania State University

Polarimetric radar measurements

Ka/W-SACR2 polarimetric measurements provide information about ice particles (e.g., ice crystal habit, size, number concentration).
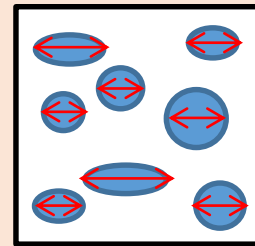
Vertically polarized microwave (V)

Horizontally polarized microwave (H)
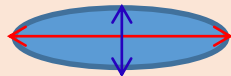
Ka/W-SACR2

Z_{HH}: **Radar reflectivity (dBZ)**

→ Mass, size, number concentration

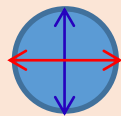Z_{DR}: **Differential reflectivity (dB)**
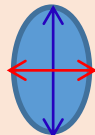
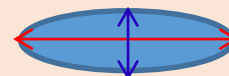$$Z_{DR} = Z_H - Z_V$$

Oblate — Positive

Sphere — ~0 dB

Prolate — Negative

→ Aspect ratio, bulk density

Very sensitive to size

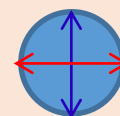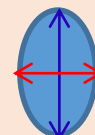K_{DP}: **Differential propagation phase shit ($°$ km^{-1})**

Oblate — Positive

Sphere — ~0 $°$ km^{-1}
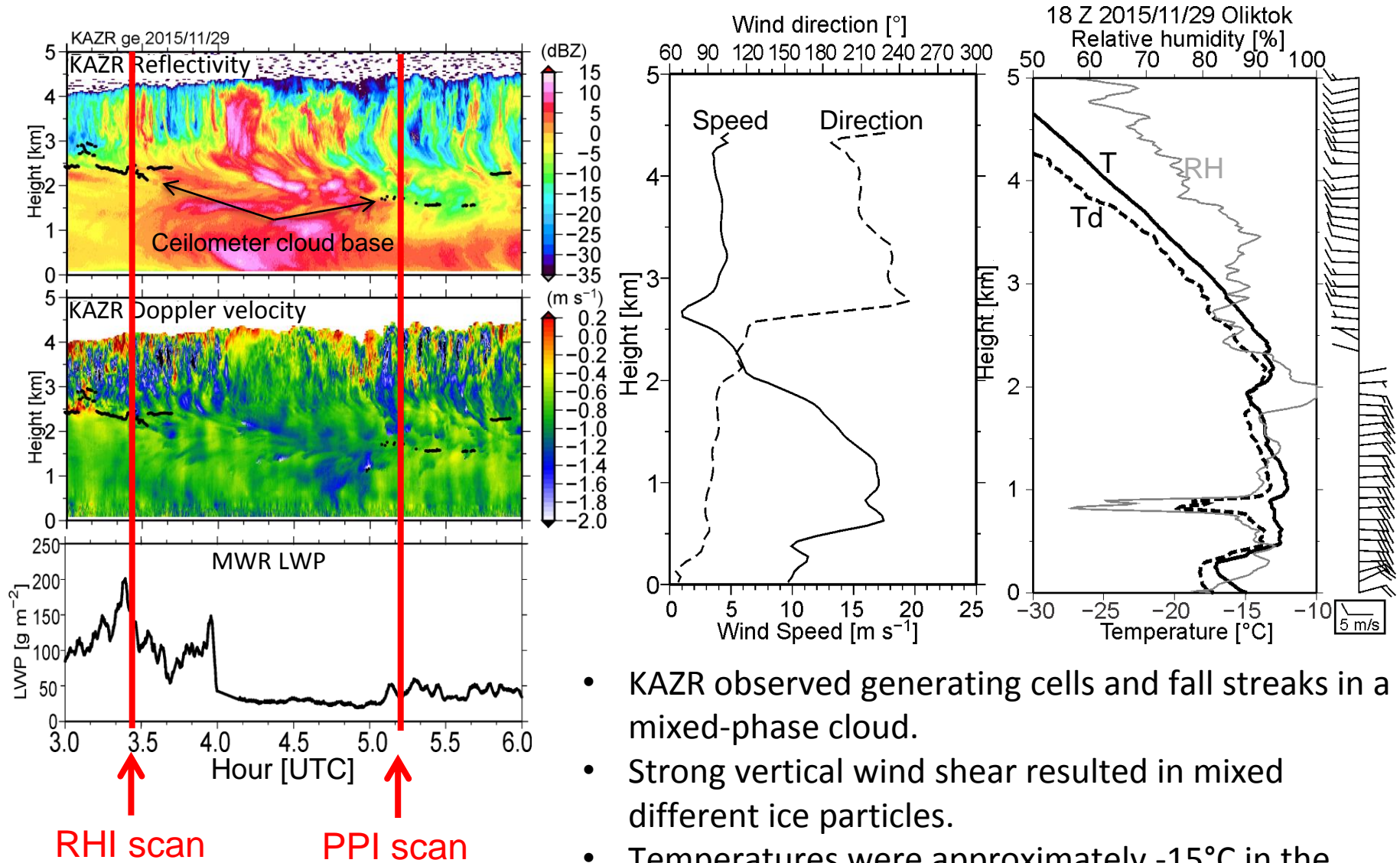
Prolate — Negative

→ Aspect ratio, bulk density

Sensitive to oriented particles

# Case overview: Mixed-phase cloud 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.
- Temperatures were approximately -15°C in the most of cloud, corresponding to dendritic crystal growth regime.

Ka/W-SACR2 polarimetric data in RHI

Ka/W-SACR2 RHI

Scattering calculation for dendrites (IWC=0.04g/m³)
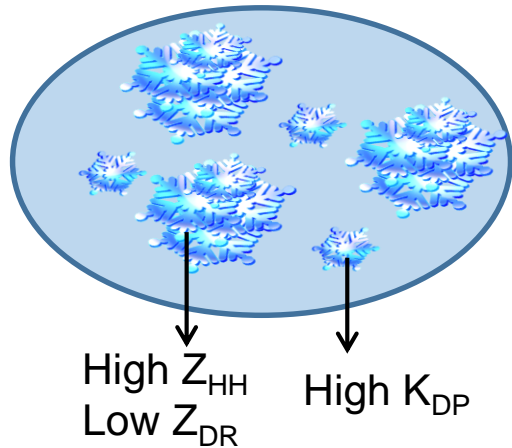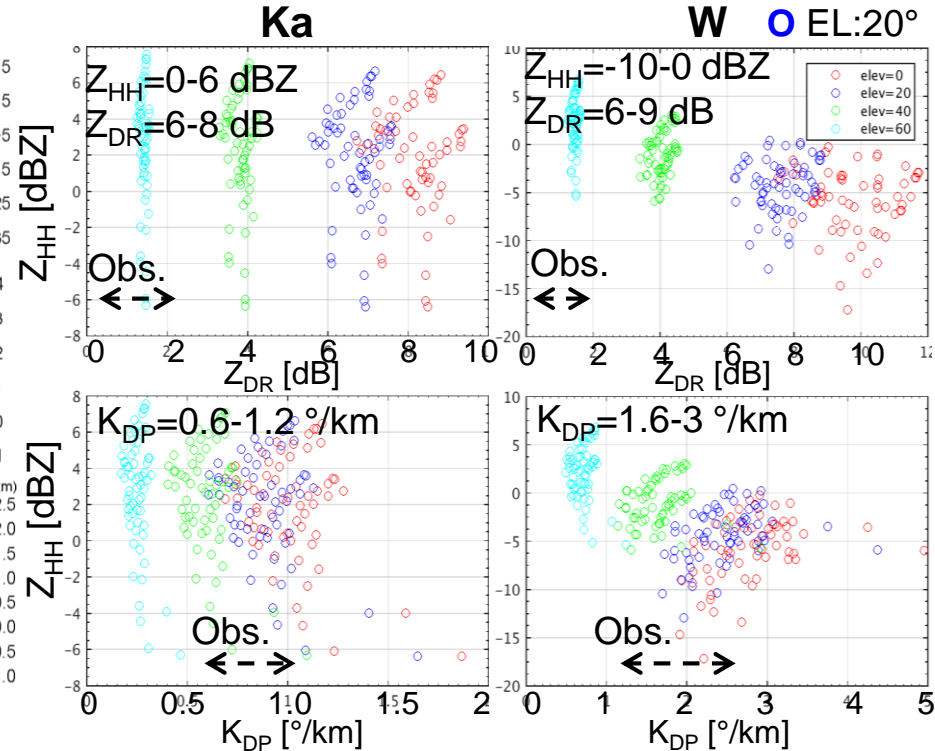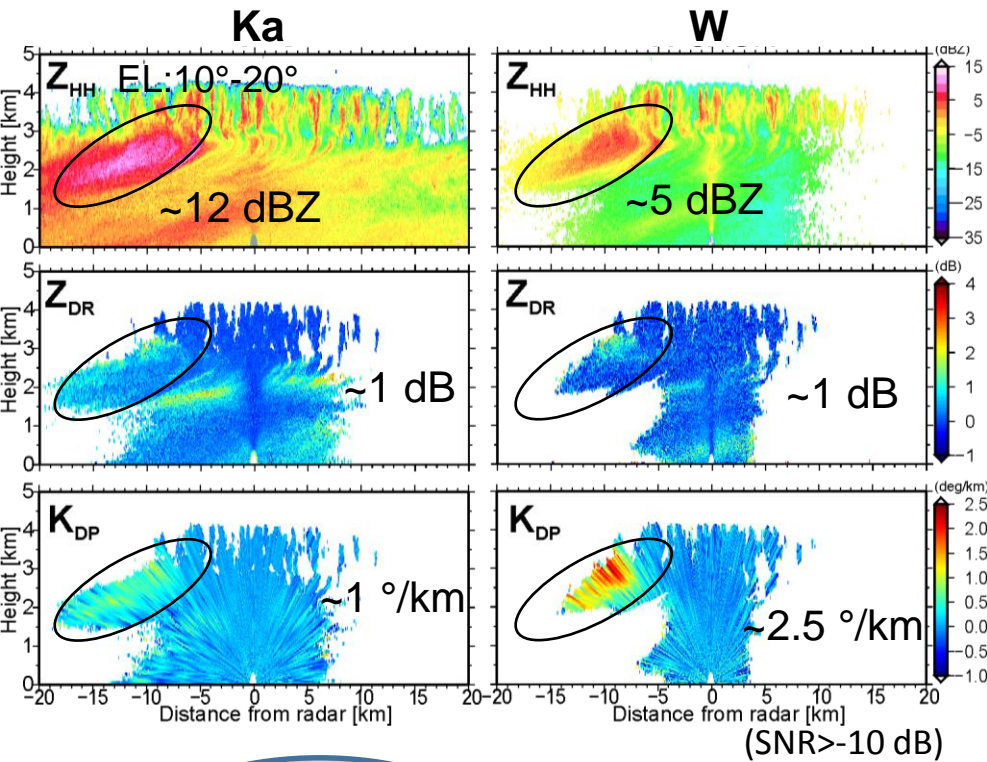
- K_{DP} is a good indicator of oblate ice particles, especially at W band.
- K_{DP} values were consistent with scattering calculations for dendrites, while Z_{DR} values were lower than scattering calculations.
- Low Z_{DR} values indicate that spherical particles dominated the total reflectivity.
- Inconsistency between K_{DP} and Z_{DR} suggests mixed different types of ice particles.

Ka/W-SACR2 polarimetric data in PPI and KAZR

Quasi vertical profiles (QVP)
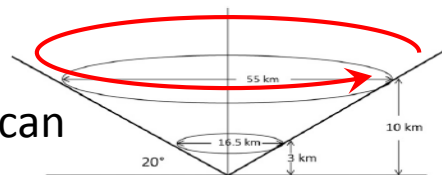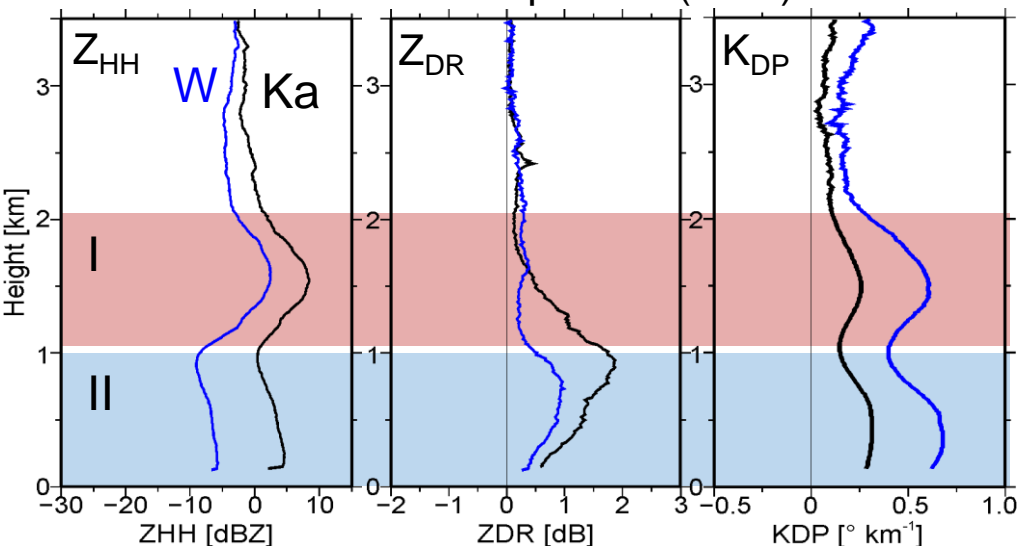

KAZR Doppler spectra

PPI scan

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

Azimuthal averages of polarimetric variables at each level from PPI (*Ryzhkov et al. 2016*)

Region I:

High Z_{HH} with high K_{DP} but weakly positive Z_{DR},

→mixture of large, spherical particles (high Z_{HH}, low Z_{DR}), and plate-like crystals (high K_{DP}).

Faster-falling population (**d**) has higher or equal contribution than slower population (**a**)

→Population **a** corresponds to plate-like crystals; population **d** corresponds to spherical particles.
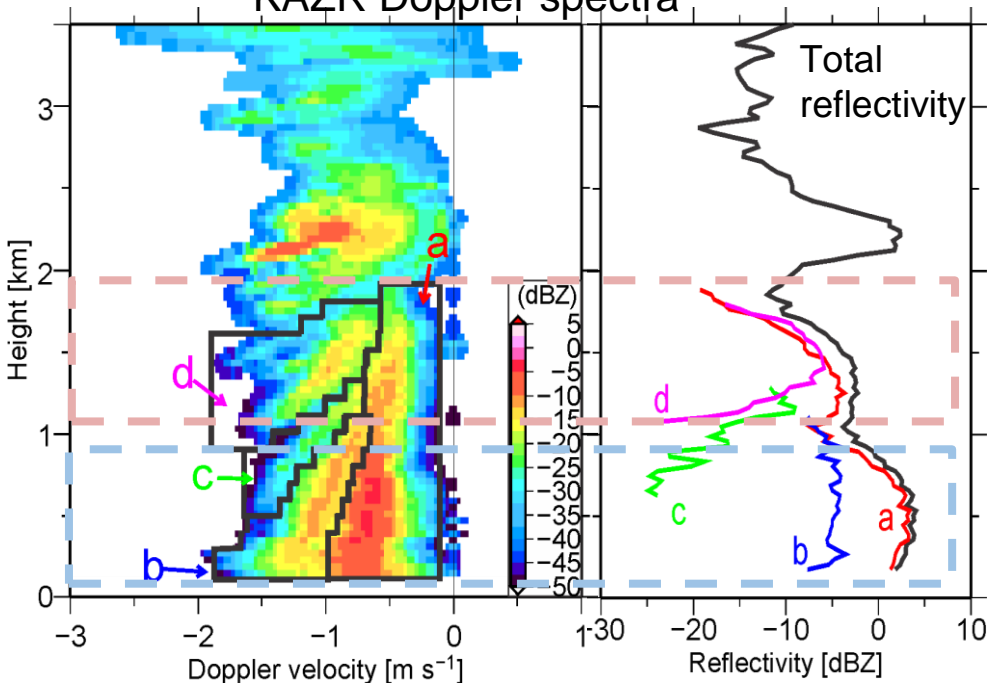
Region II:

Decreasing Z_{DR} downward with higher K_{DP},

→Increase of number concentration and aggregation.

Slower-falling population (**a**) dominates the total reflectivity.

→Population **a** corresponds to plate-like crystals, growing into aggregates toward the ground.

Summary

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

  ➢ K_{DP} is a good indicator of oblate ice particles, especially at W band.

  ➢ K_{DP} values were consistent with scattering calculations for dendrites, while Z_{DR} values were lower than scattering calculations.

  ➢ Low Z_{DR} values indicate that spherical particles dominated the total reflectivity.

  ➢ In conjunction with KAZR Doppler spectra, quantitative analysis of mixed ice particles will be available.

Quasi-vertical profiles from PPI
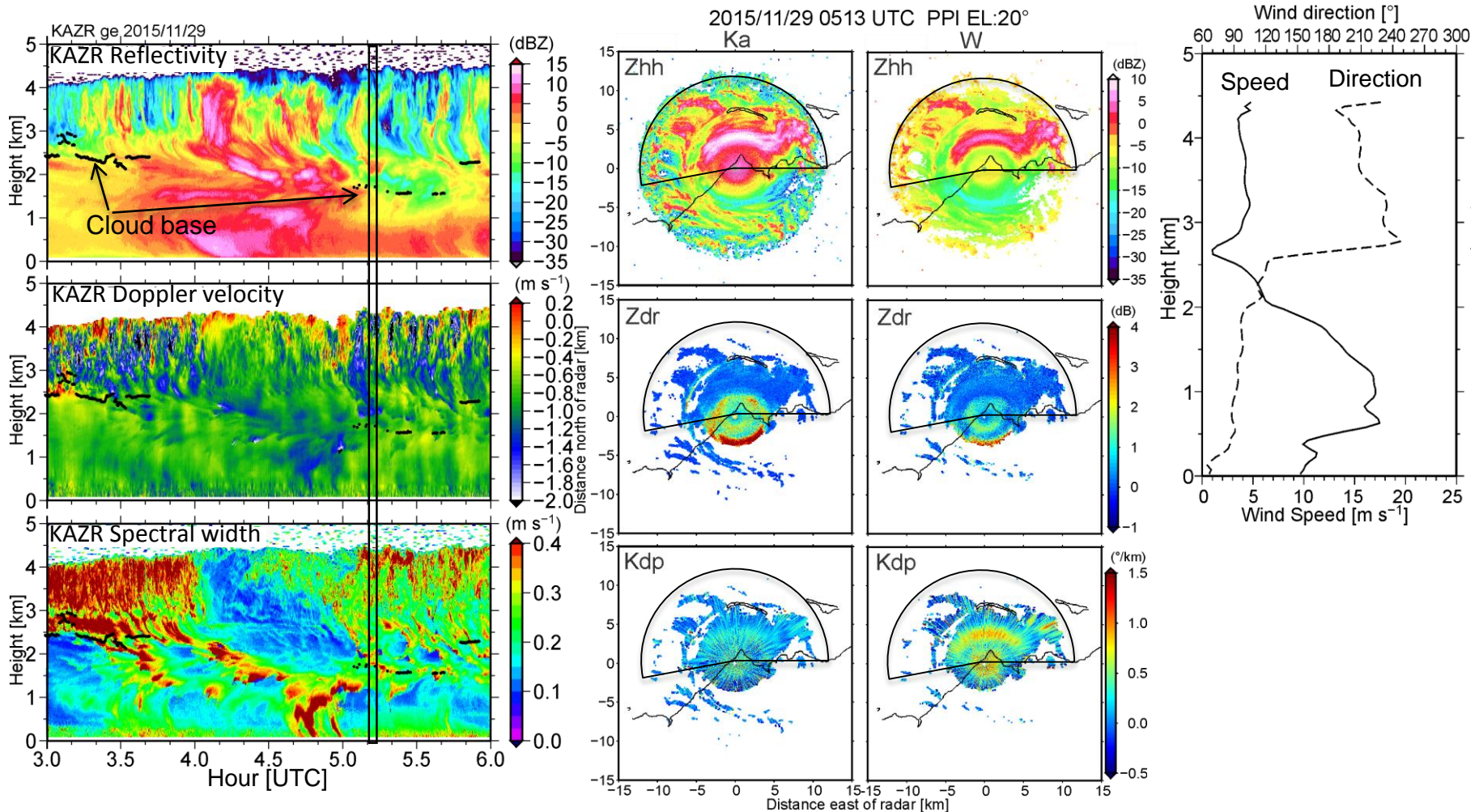
- Vertical profiles from azimuthal average of PPI measurements can be compared with vertically-pointing radar (KAZR). --- Quasi-vertical profile method (Ryzhkov et al. 2016).
- QVP was applied to the northern sector of PPI observations.