Measurements of the radar differential phases upon transmission and reception on WSR-88Ds

3rd Weather Radar Calibration Workshop

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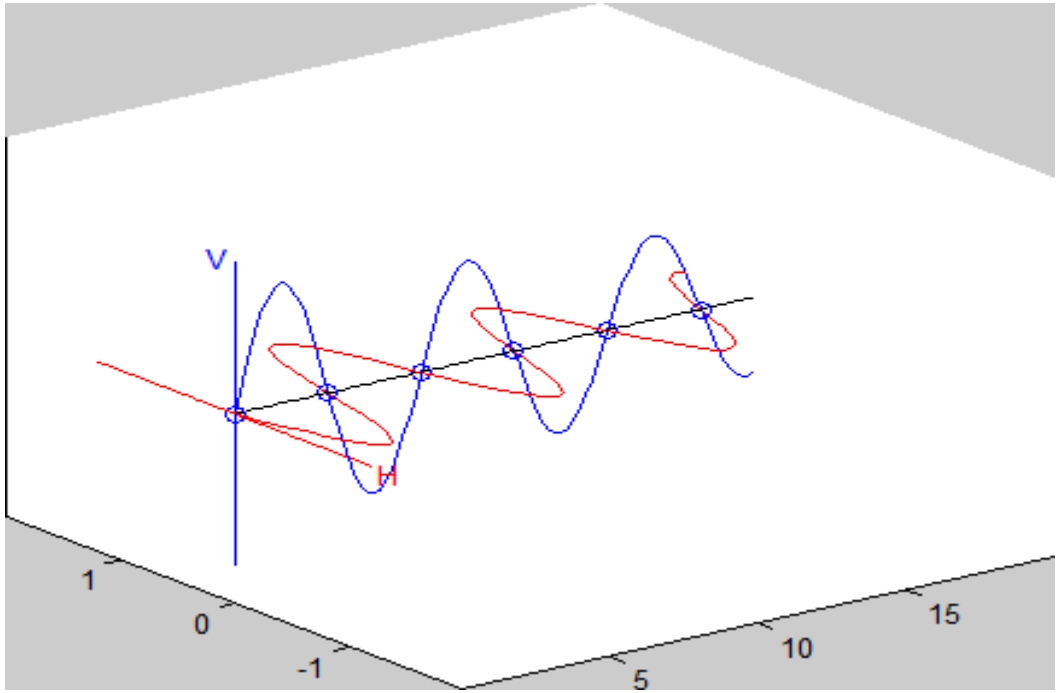
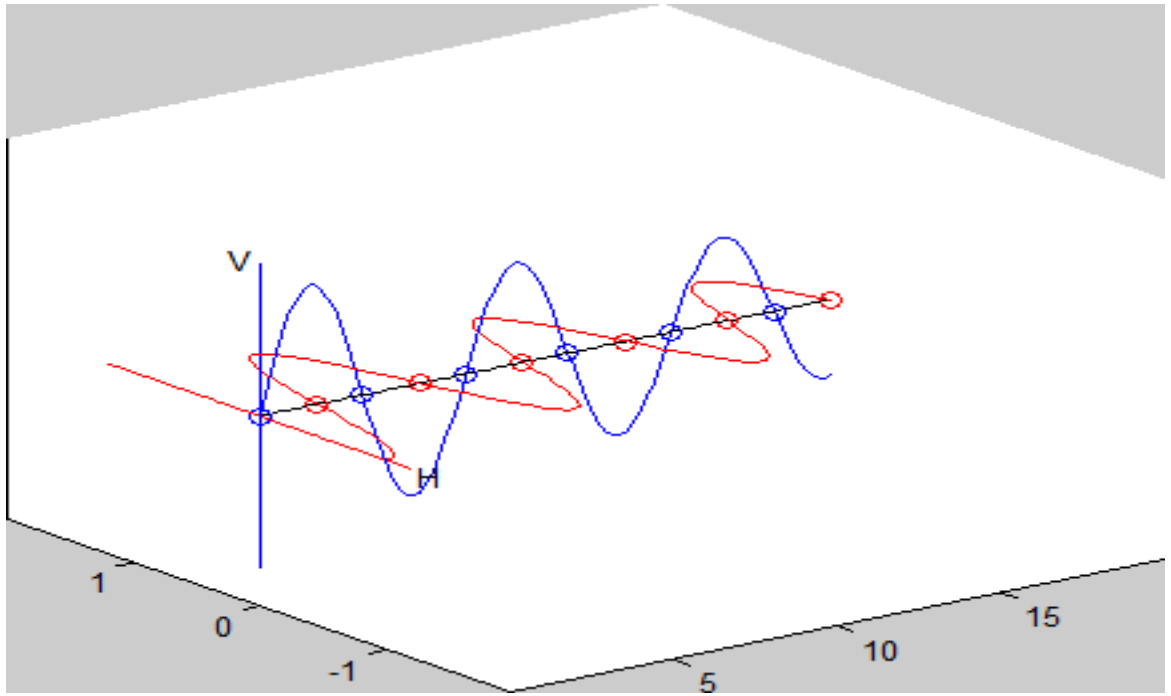
Differential phase in transmit ψt



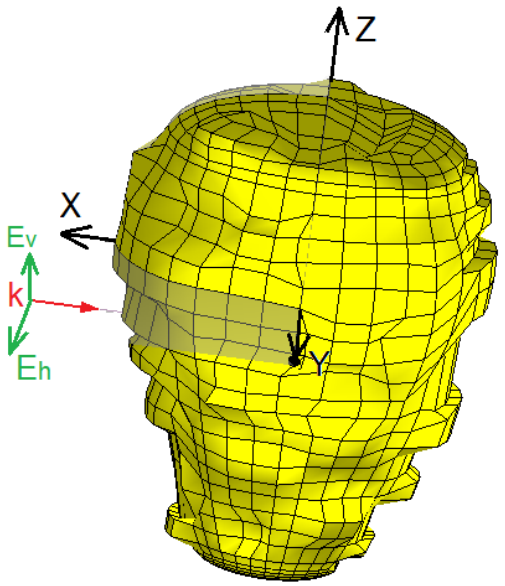
ψt = 0 deg



ψt = 90 deg

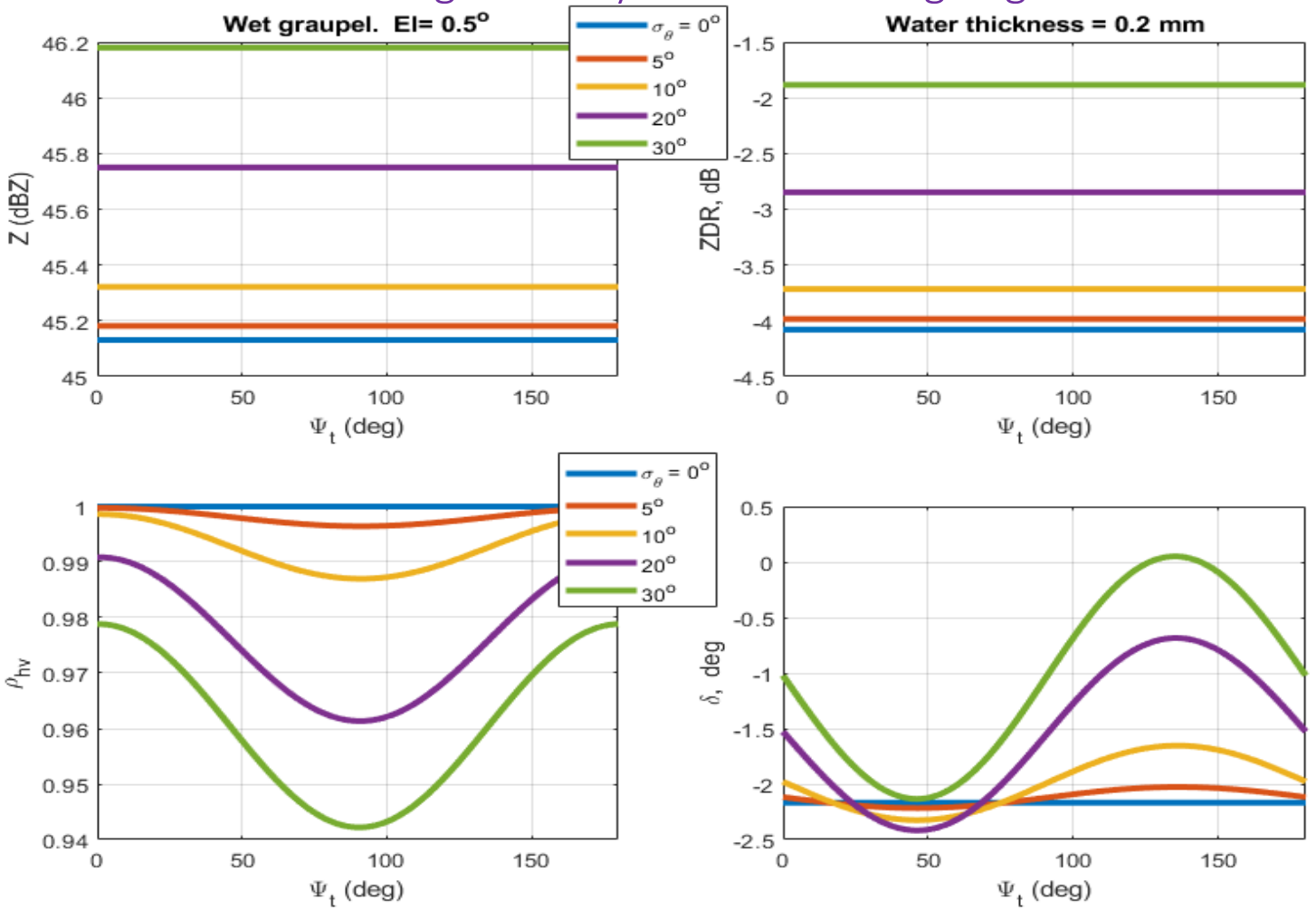
The differential phase ψt between incident orthogonally polarized waves impacts the radar variables.

Example 1: wet graupel



WIPL model of a natural graupel

σ_θ is the standard deviation in the canting angle, it is a measure of the tumbling intensity. θ is the canting angle of a scatterer

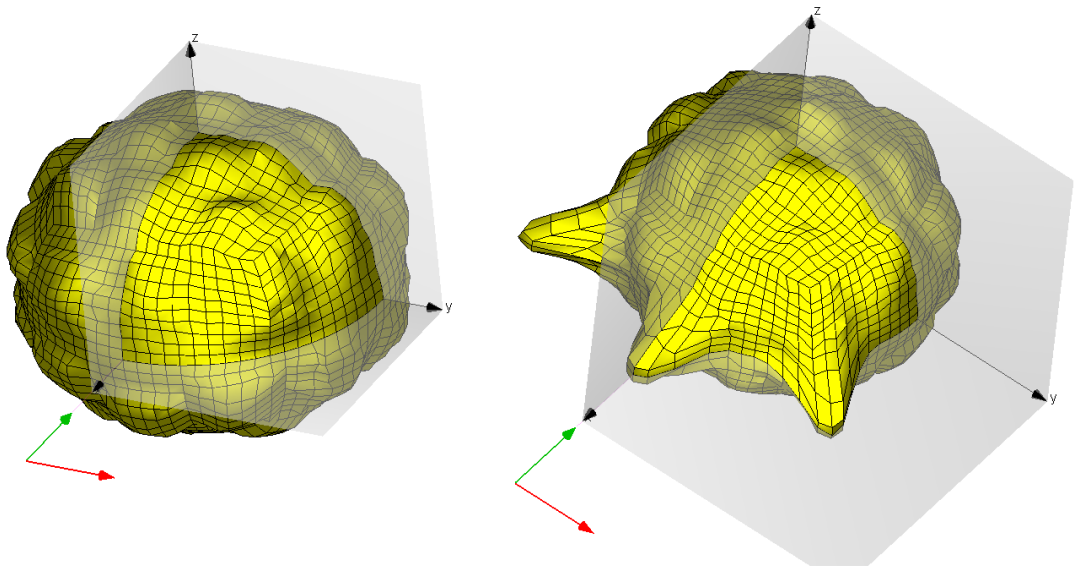


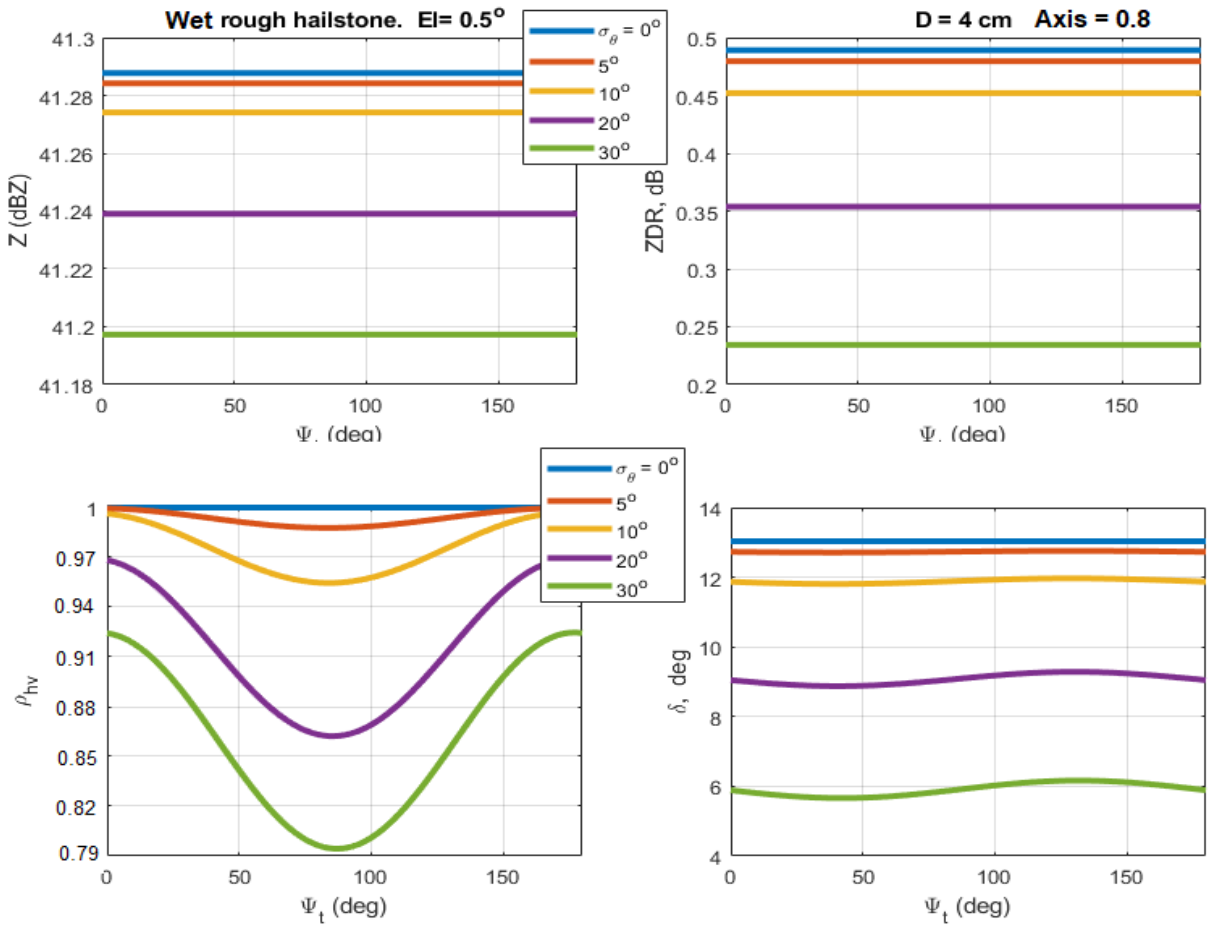
Reflectivity Z and ZDR do not depend on ψt. The correlation coefficient ρ_{hv} and phase upon scattering δ depend on ψt. Tumbling affects ZDR, ρ_{hv} , and δ.

The differential phase between incident orthogonally polarized waves impacts the radar variables

Example 2: Hail

σ_θ is the standard deviation in the canting angle

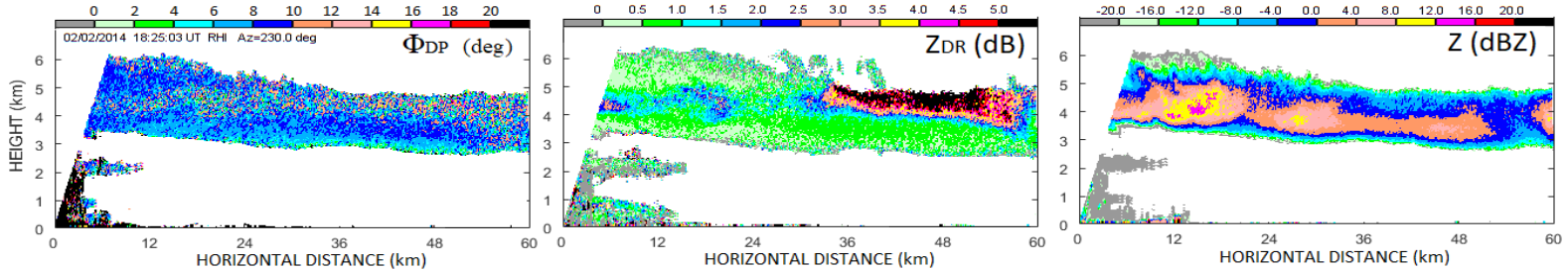




Reflectivity Z and ZDR do not depend on ψ_t. The correlation coefficient ρ_{hv} and phase upon scattering δ depend on ψ_t. Tumbling affects ZDR, ρ_{hv} , and δ.

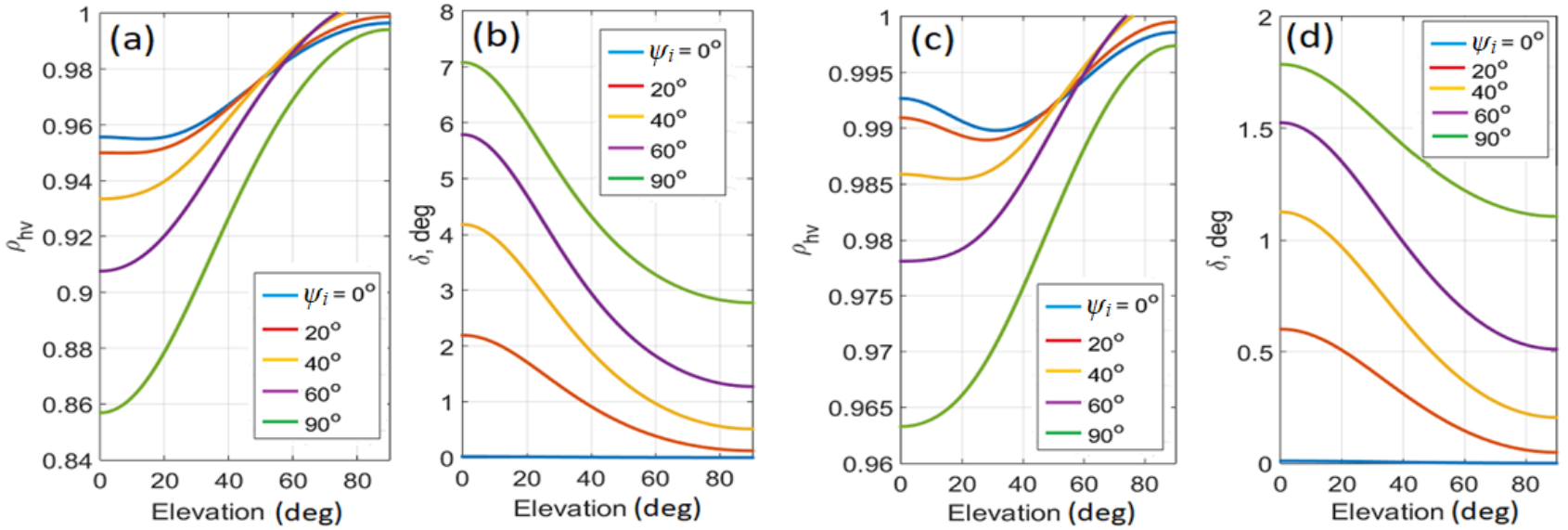
The differential phase between incident orthogonally polarized waves impacts the radar variables

Example 3: Ice clouds



Elevation dependence of ρ_{hv} and δ at various ψ_t.

Phase upon scattering δ can be nonzero at vertical incidence if $\psi_t > 0$.

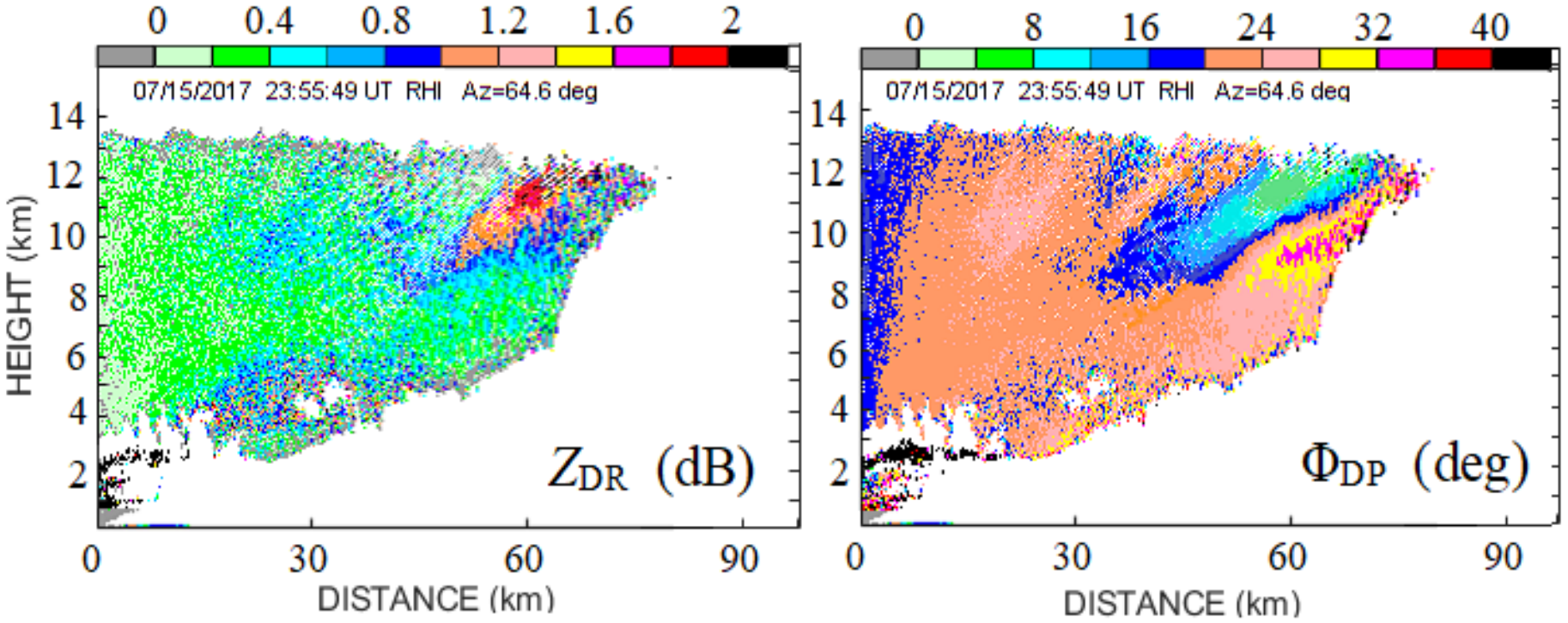


Thin ice plates

Ice plates with the axis ratio 0.3

The differential phase between incident orthogonally polarized waves impacts the radar variables

Example 4: X-band observations (Norman, OK).



Measured differential phase can drop in areas of enhanced ZDR

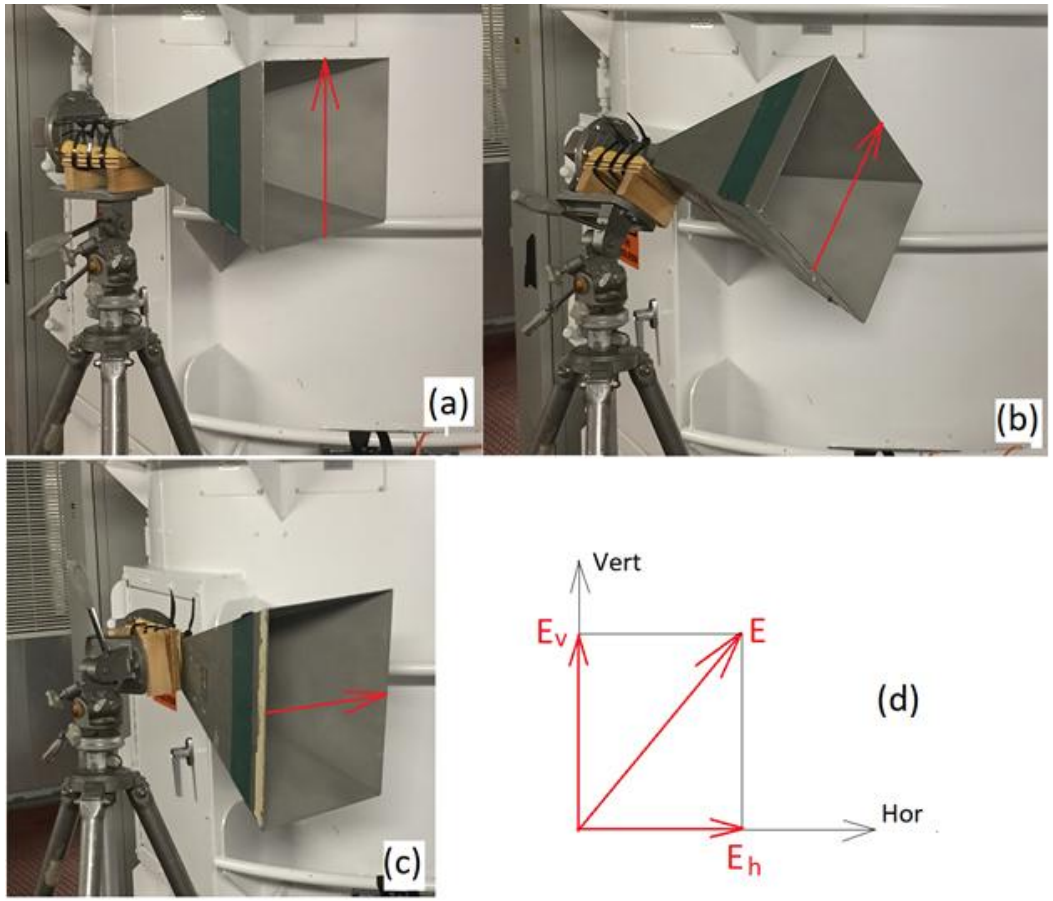
To quantitively interpret the radar variables measured from ice particles, ψ_t should be known (measured).

Measurements of the radar differential phases upon transmission ψ_t and reception ψ_r on WSR-88Ds

WSR-88D (Weather Surveillance Radar – Doppler) is the S band radar in the USA. The network contains 160+ systems.

A method to measure the differential phase upon transmission

Transmitting horn antenna



1. $\psi_{sys} = \psi_t + \psi_r$, ψ_{sys} is routinely measured in a close-to-radar edge of precipitation

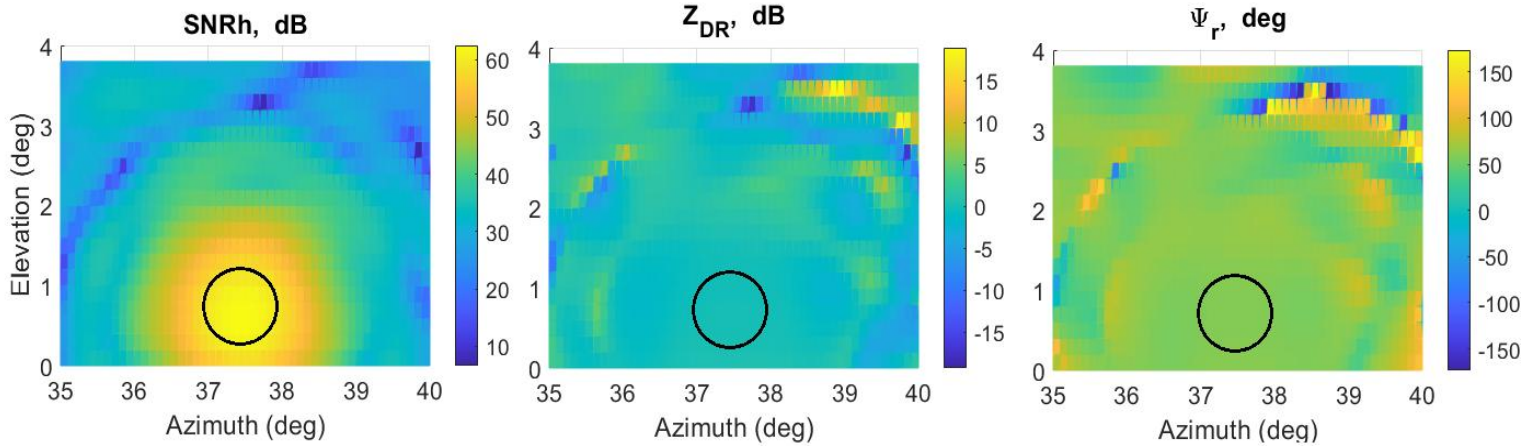
2. If ψ_r can be measured, then

$$\psi_t = \psi_{sys} - \psi_r,$$

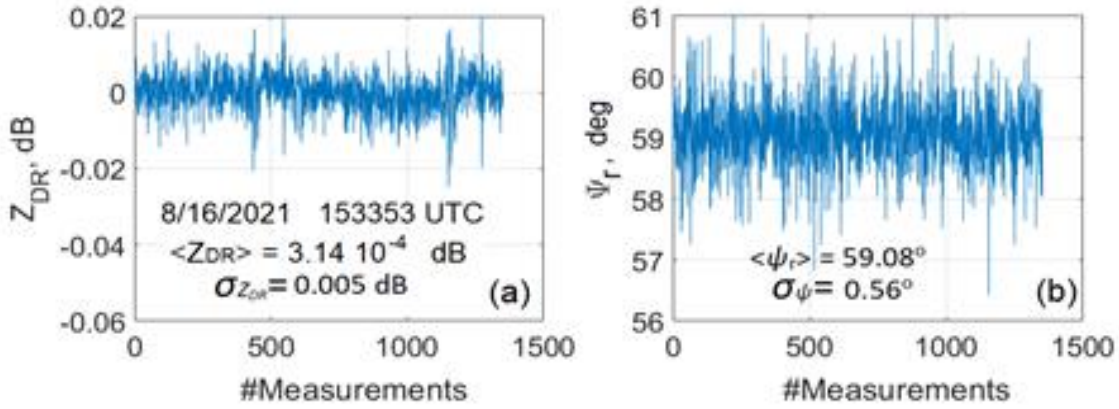
ψ_r can be measured using an external transmitting horn directed to a radar antenna. The differential phase of transmitted wave is zero, therefore, the received phase is ψ_r.

The red arrow shows the polarization plane of transmitted wave

Measurements of the receive phase

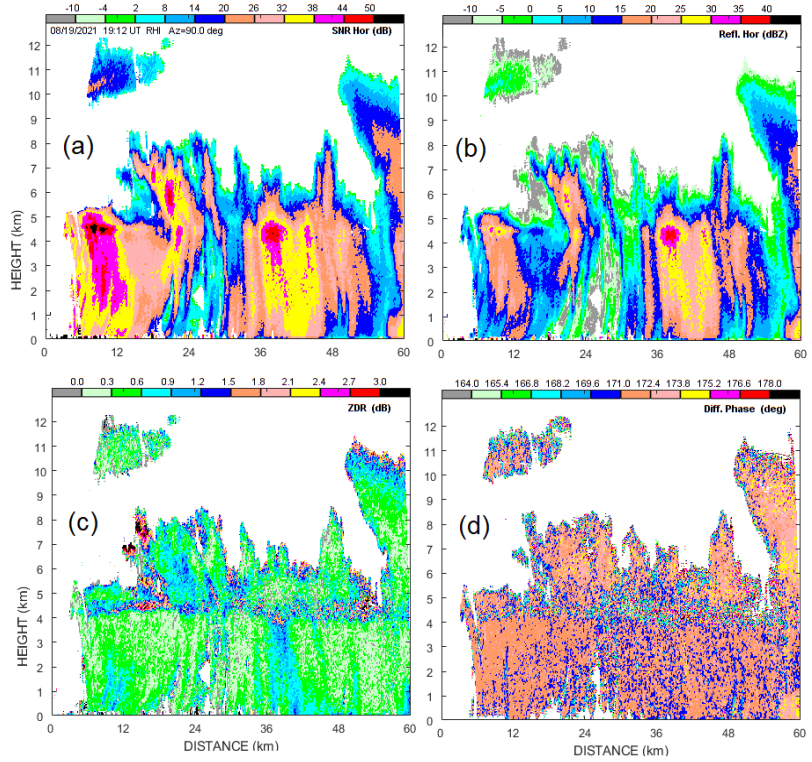


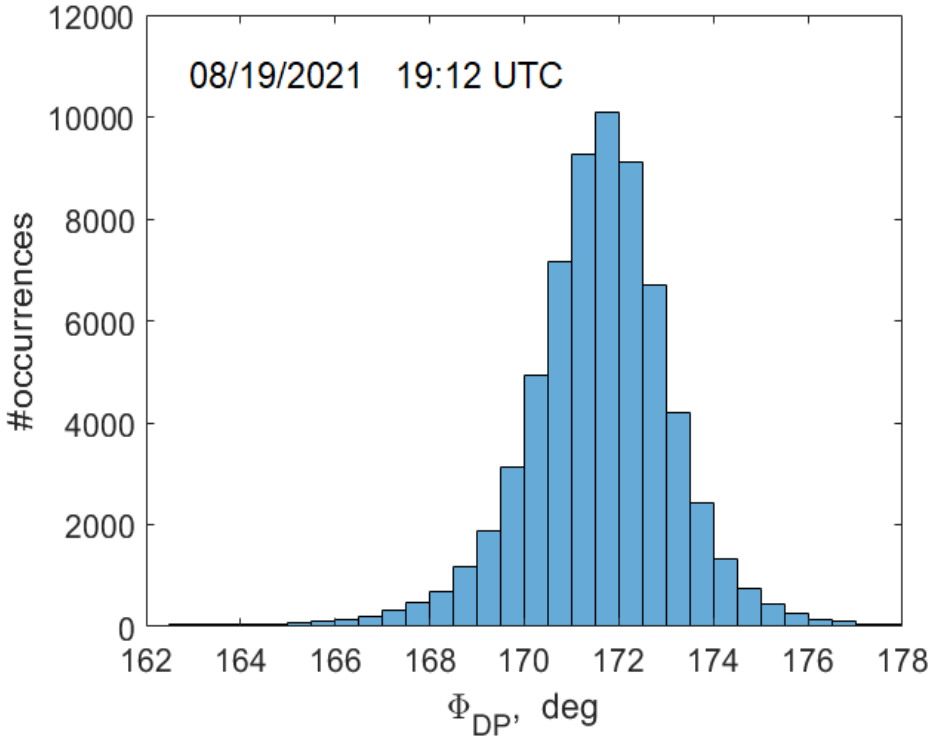
The radar antenna scans around the direction to the transmitted horn. 2D images of the horn's signal. The black circle shows the 1 deg beamwidth of WSR-88D KOUN.



Time series of ZDR and ψr of the horn's signal

Measurements of ψsys and obtaining ψt





Histogram of ψsys from precipitation. Ψsys = 171.5 deg

ψt = ψsys – ψr = 171.5 – 59.1 = 112.4 deg. The phase of transmitted horizontally polarized wave is behind the phase of vertically polarized wave (S band KOUN).

Conclusions

- The differential phase in transmit ψ_t impacts the correlation coefficient ρ_{hv} and phase upon scattering δ. This effect should be taking into considerations in hail detection and sizing as well as in the interpretation of measurements in ice clouds.

- The phase ψ_t on the WSR-88D KOUN, KIWA, and KLWX are 112.4^o, 50^o, and 10^o, respectively.

- At shorter wavelengths, the impacts of ψ_t are expected to be stronger than those at S band.