Doppler velocities at orthogonal polarizations in radar echoes from birds, insects, and precipitation

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WSR-88D weather radar

Radar moments/parameters

Moment	Polarization
Reflectivity	Horizontal
Doppler Velocity	Horizontal
Spectral Width	Horizontal
ZDR	Horizontal & Vertical
Differential Phase	Horizontal & Vertical
Correlation Coefficient	Horizontal & Vertical

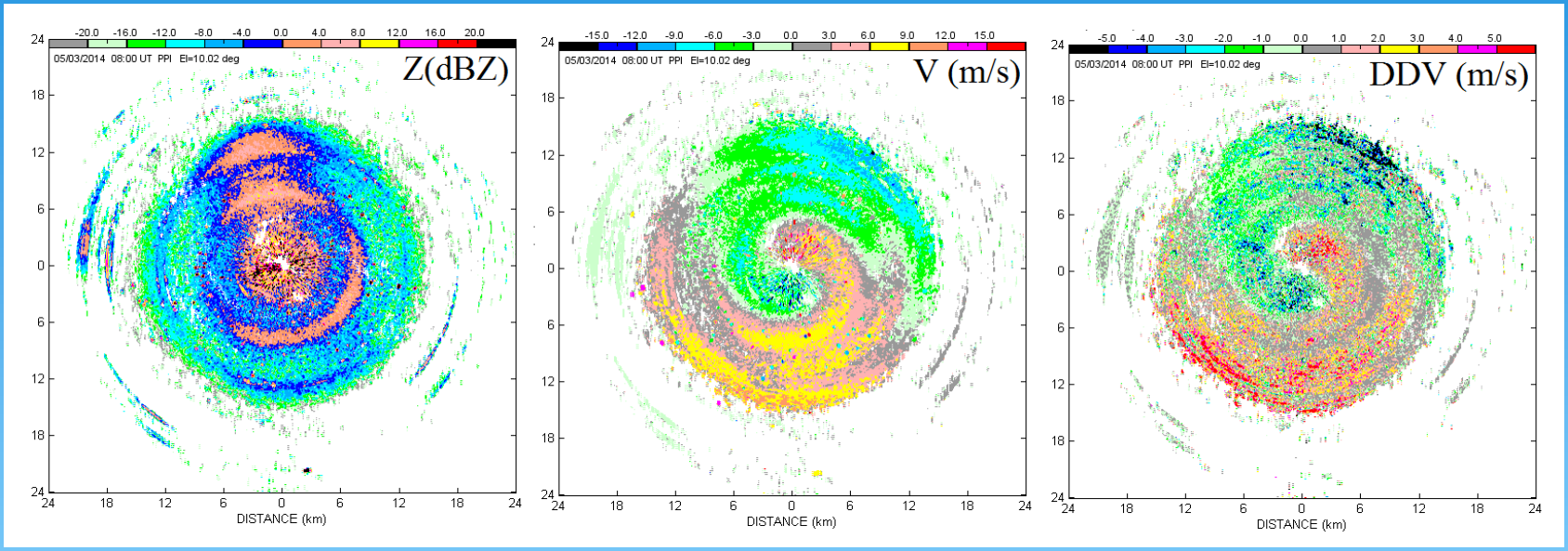
On KOUN, the Doppler velocity at vertical polarization is available.

What information can be obtained from the difference of Doppler velocities at horizontal and vertical polarizations?

Definition of Differential Doppler Velocity (DDV): DDV = V_h - V_v

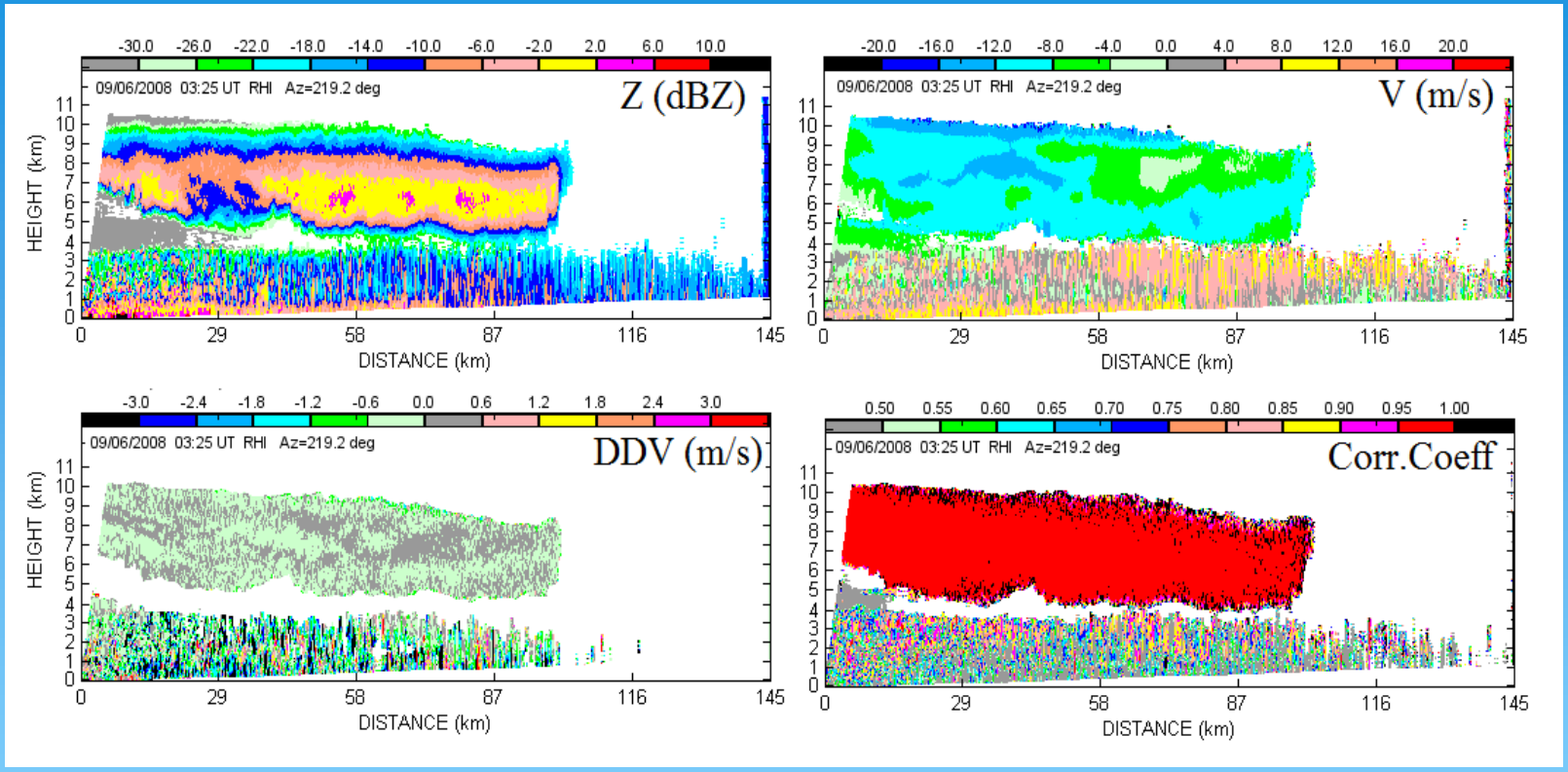
It is known that rain drops, snowflakes, and ice cloud crystals are good wind tracers so the Doppler velocities are almost equal at horizontal and vertical polarizations. Absolute DDV values in weather echoes are typically less than 0.5 m/s

DDV in echoes from birds



DDV in bird echoes can exceed 5 m/s

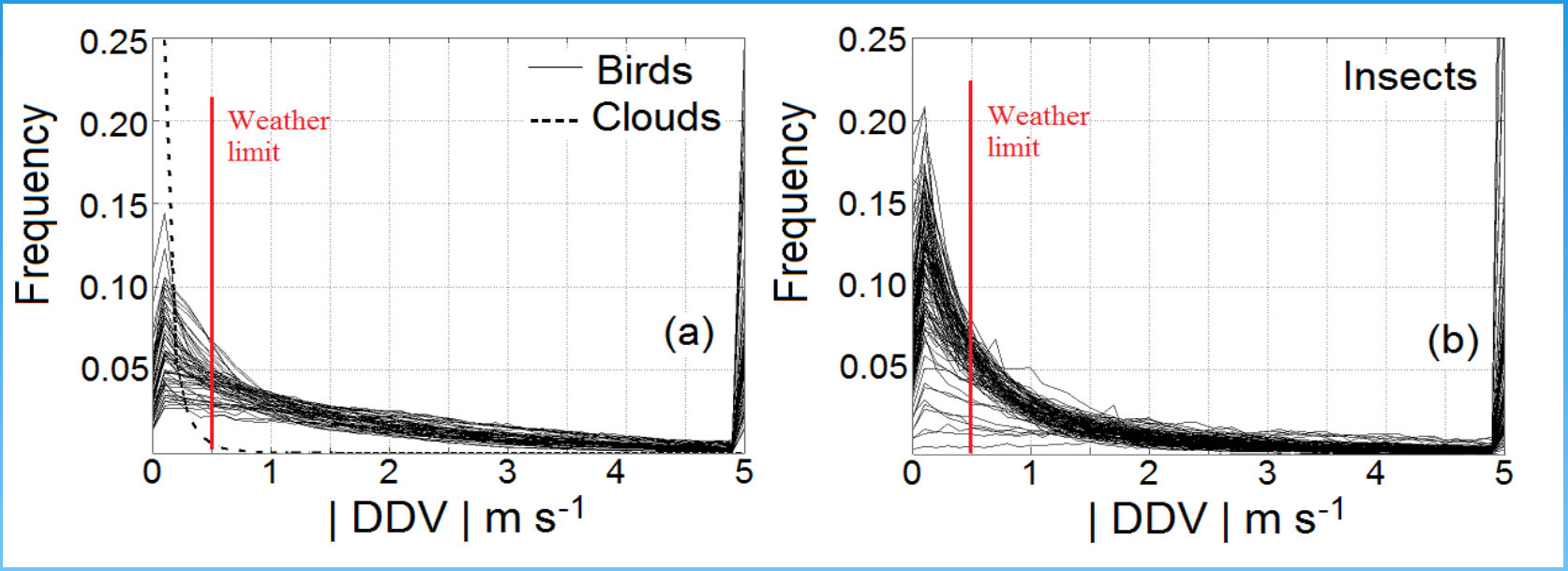
Birds & clouds



DDV fields in echoes from birds are granular with many values above 0.5 m/s typical of weather.

DDV can be used for recognition of biological echoes in a single resolution volume.

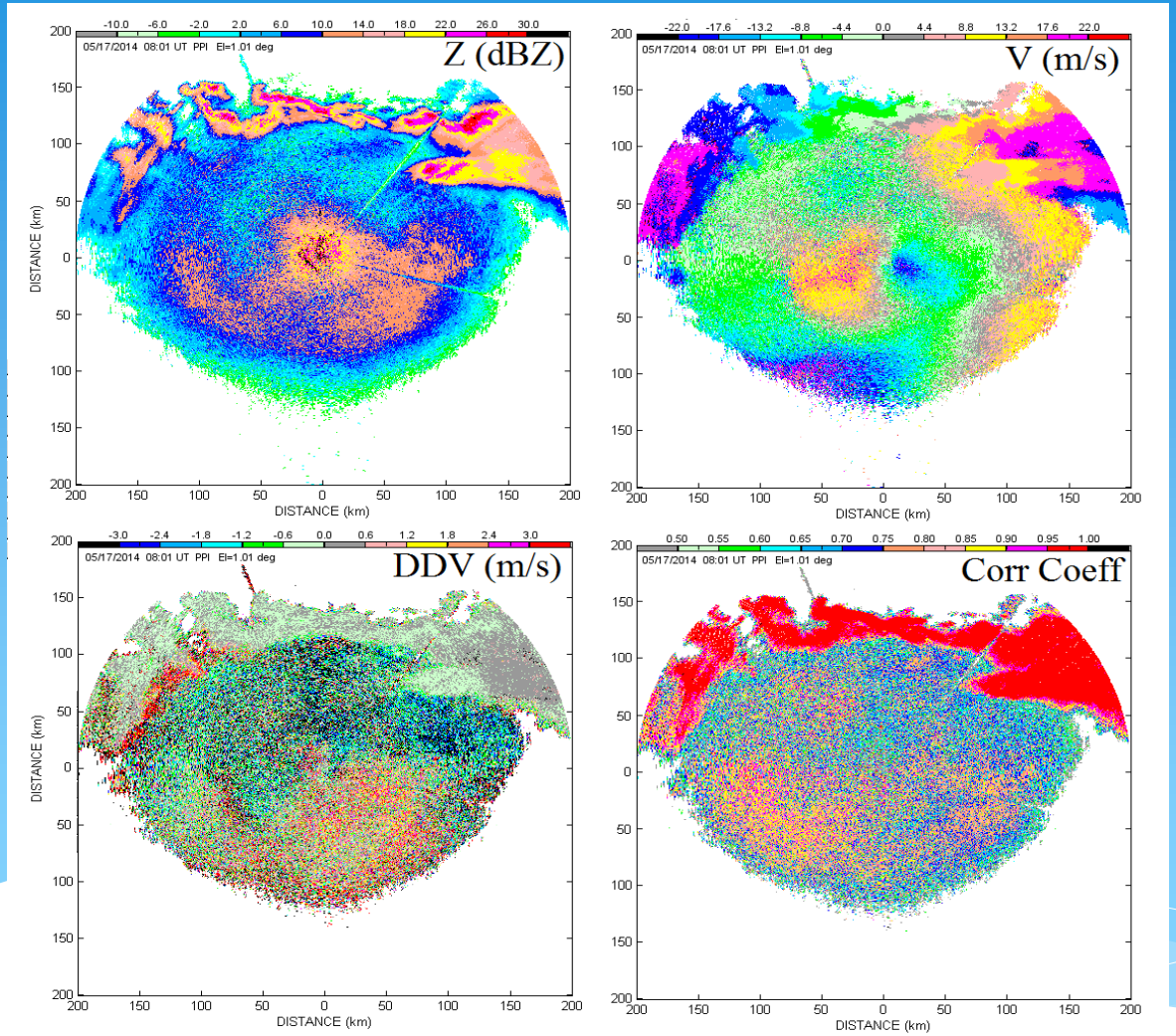
Distributions of DDV values in echoes from birds and insects



DDV values in weather echoes are typically less than 0.5 m/s. Seldom, they can reach 1 m/s.

DDV values in echoes from birds and insects frequently exceed 5 m/s. This can be used as an additional parameter in recognition this type of radar echoes.

Where are fringes of weather echoes?



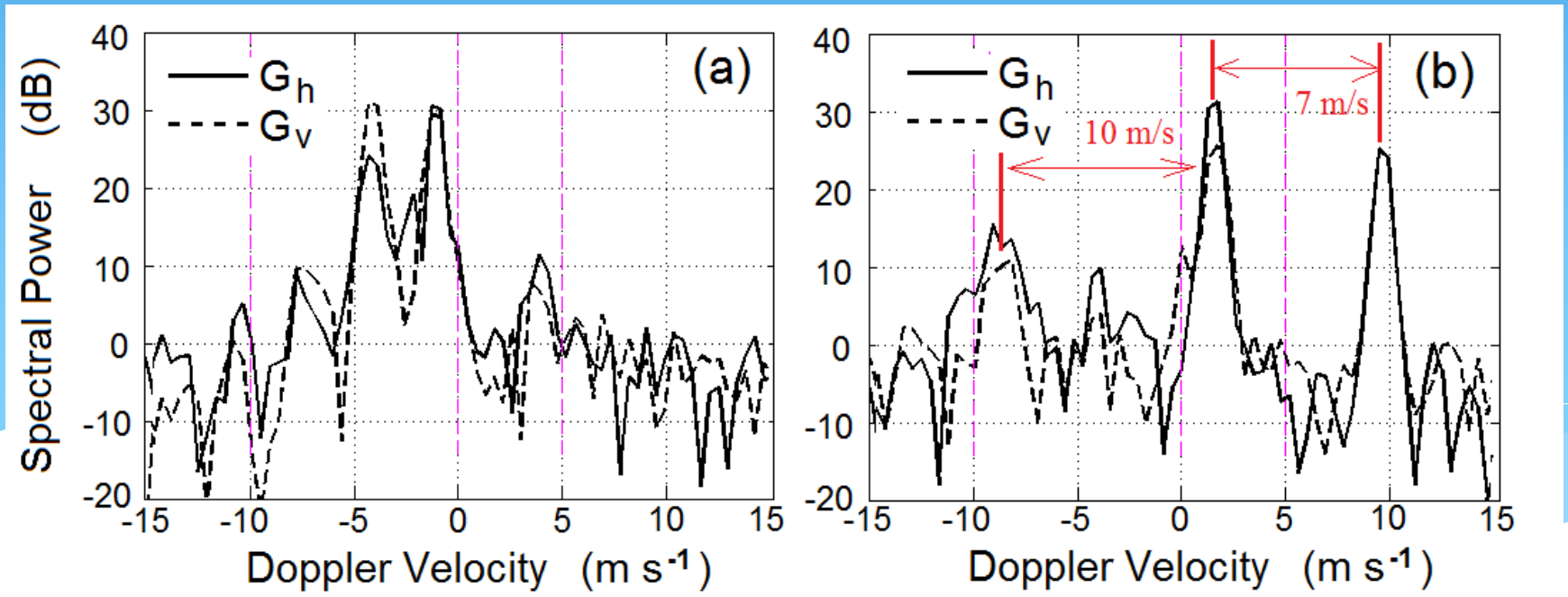
The DDV field shows large values at the fringes of weather echoes.

Do birds fly in clouds?

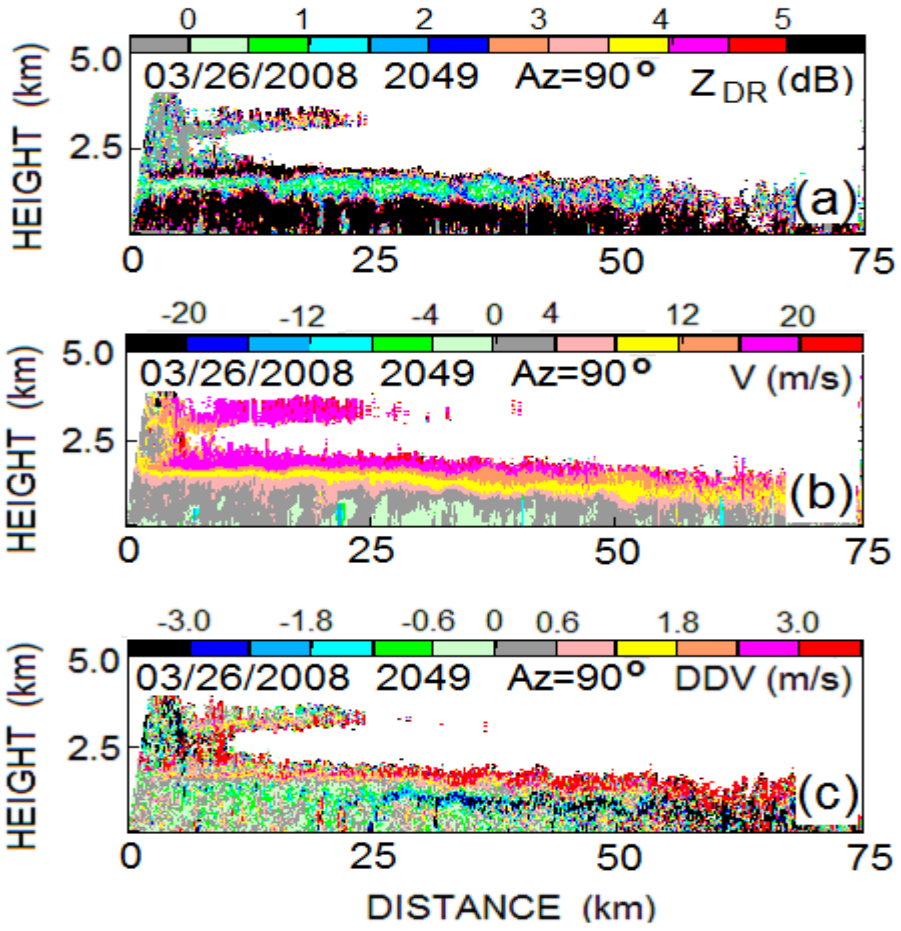
DDV is a spectral parameter

Large DDV values pertain to multi-peak Doppler spectra with large differential reflectivities at the peaks.

Frequently, the velocity difference between the spectral peaks is large. Most likely, the peaks are formed by different species or group of species. So DDV could be used to detect the presence of multiple species in the resolution volume.



DDV in echoes from insects

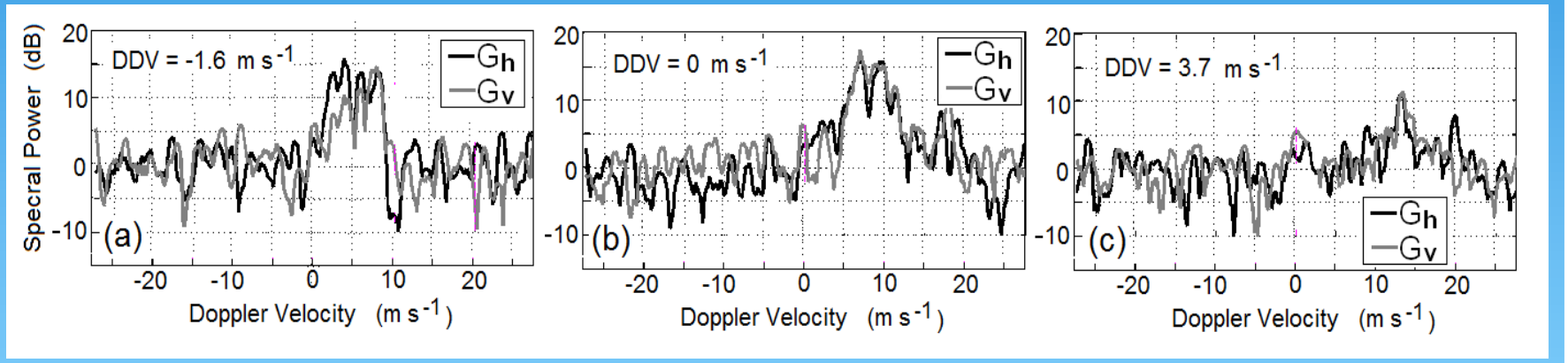


DDV values in echoes from insects can exceed 5 m/s.

DDV patterns in insect echoes sometimes exhibit layers of positive and negative values as in the figure to the left. Such patterns occur in a layer of humid air surrounded by insect echoes. A substantial wind shear in the layer plays a role as well.

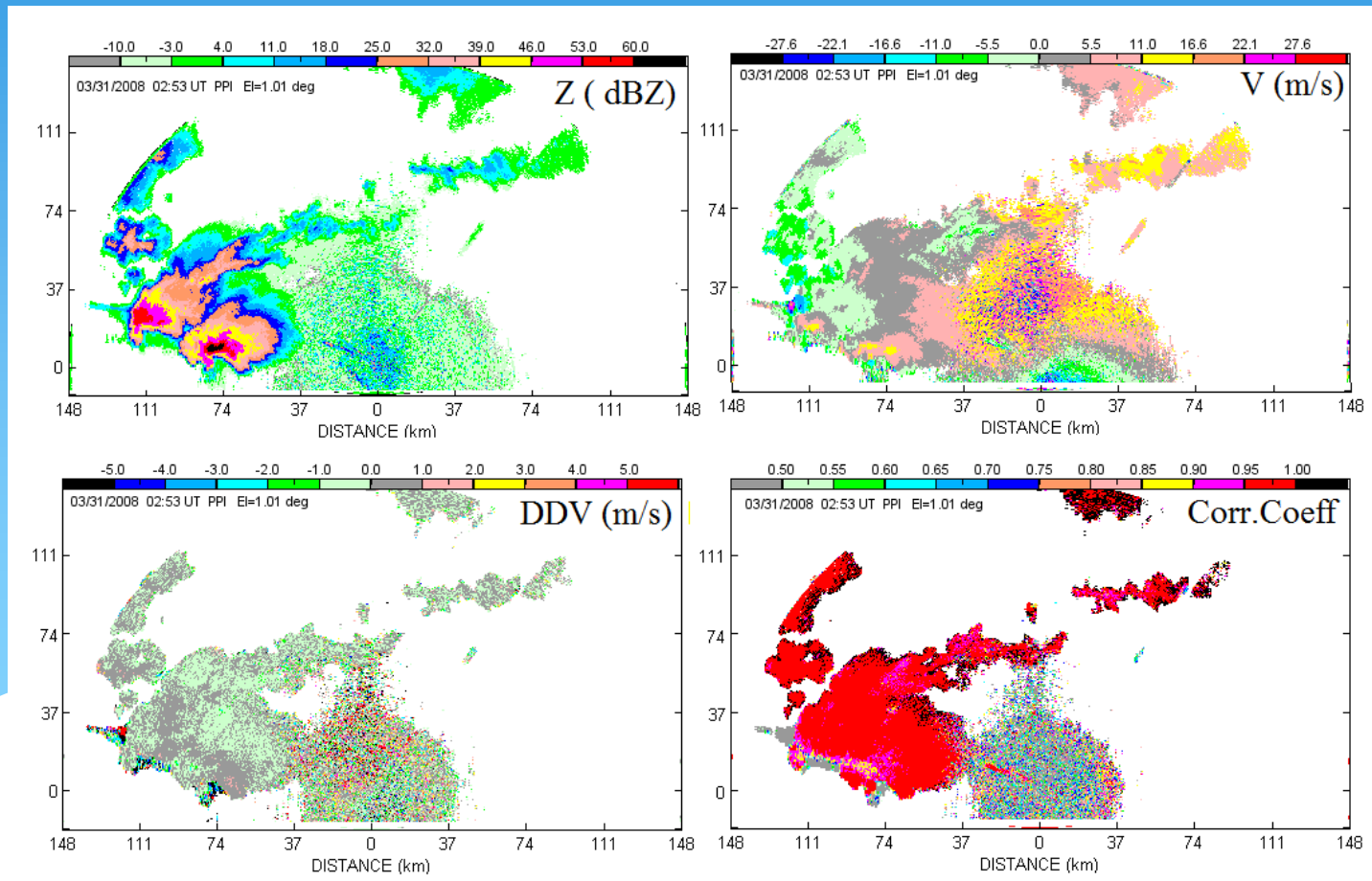
DDV is large for multi-peak Doppler spectra

These are spectra for the case shown in the previous slide. 26 march, 2008, 20:49 UTC.



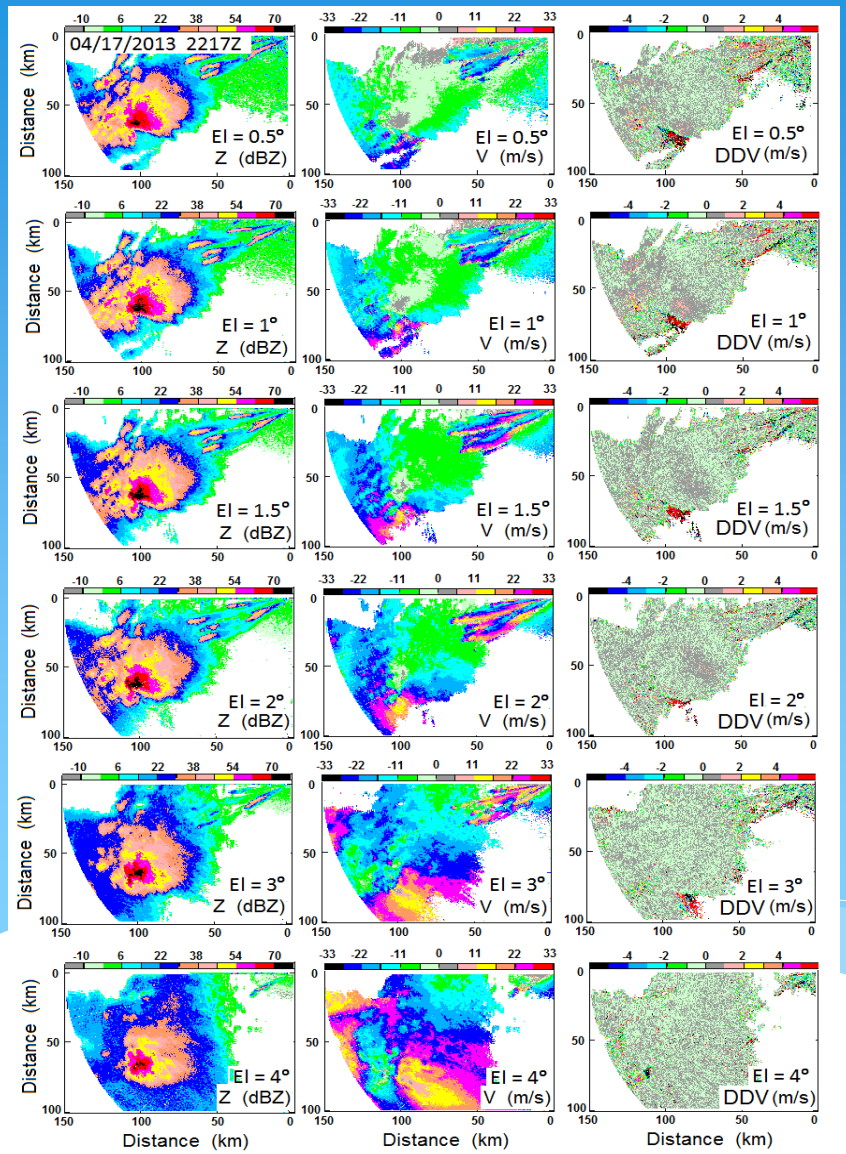
DDV in thunderstorms

Tornadic thunderstorms March 31, 2008 observed in Oklahoma. Two tornadoes were observed at the time in the hook areas (the southern parts of radar echo) . Note high DDV values in the areas. Most likely, these are areas where birds and insects have been trapped by strong inflow. So DDV could be used for identification of areas of inflow.



Corr. Coefficients are also low in the tornadic areas but it can be due to low SNR.

Height of inflow regions obtained from DDV



Series of PPIs collected 17 April, 2013 in Oklahoma.

Note areas of large DDV on the PPIs from 0.5 to 3 deg elevations. The inflow area stretches from the ground to the height of 4 km.

DDV can be used to detect inflow areas in thunderstorms.

Conclusions

- DDV can be used as an additional parameter in distinguishing meteorological and non-meteorological radar echoes in a single radar resolution volume.

-DDV could indicate the presence of multiple species in the resolution volume.

-DDV can be used for identification of inflow regions in thunderstorms.

Disadvantage: To obtain DDV, a low-level signal processing routine is needed. Typically, radars do not have such a routine.

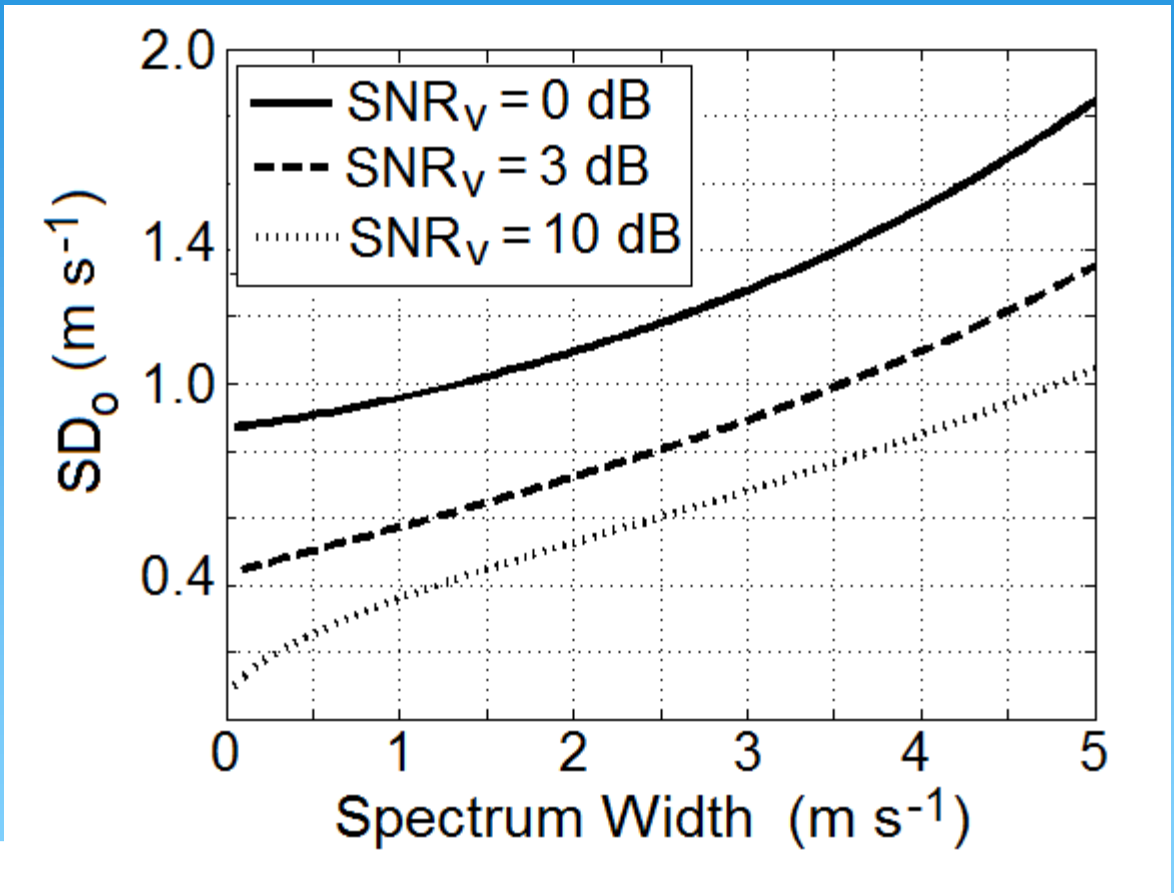
We thank the members of ENRAM working groups 1&2 for the opportunity to present and discuss our results.

Backup

Technical parameters of the WSR-88D radar

Parameter	Value
Wavelength	10 – 11 cm
Coherency	Klystron/perfect
TX Power	700 – 900 kW
Min detectable signal	-116 dBM
Beamwidth	0.95 – 1.0 deg
Height of the tower	25 – 30 m
Radial range resolution	250, 500 m
Range of observations	460 km
Dual polarization config	STAR

Standard deviation of DDV estimates



More details can be found in the journal paper:

V. Melnikov, M. Leskinen, and J. Koistinen: "Doppler velocities at orthogonal polarizations in radar echoes from insects and birds", IEEE Geoscience and Remote Sensing Letters, v. 11, no 3, March 2014, 592-596.