The separation of noise and signal components in Doppler RADAR returns

SIGNAL PROCESSING
SP 078

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Mike Dixon and John Hubbert

National Center for Atmospheric Research
Boulder, Colorado

Why do we need to identify the noise on a beam-by-beam basis?

Clutter, weather and water vapor emit radiation at all wavelengths, and these emissions will add to the thermal noise.

Knowing the correct noise value in a Doppler radar return is useful for:

- computing moments with good data quality (Ivic and Torres 2010)
- optionally censoring (i.e. setting to missing) data which contains noise only
- contributing to a data quality metric (Friedrich et. al 2006, Osrodka et. al 2010).
- estimating attenuation.

Moments most sensitive to noise value

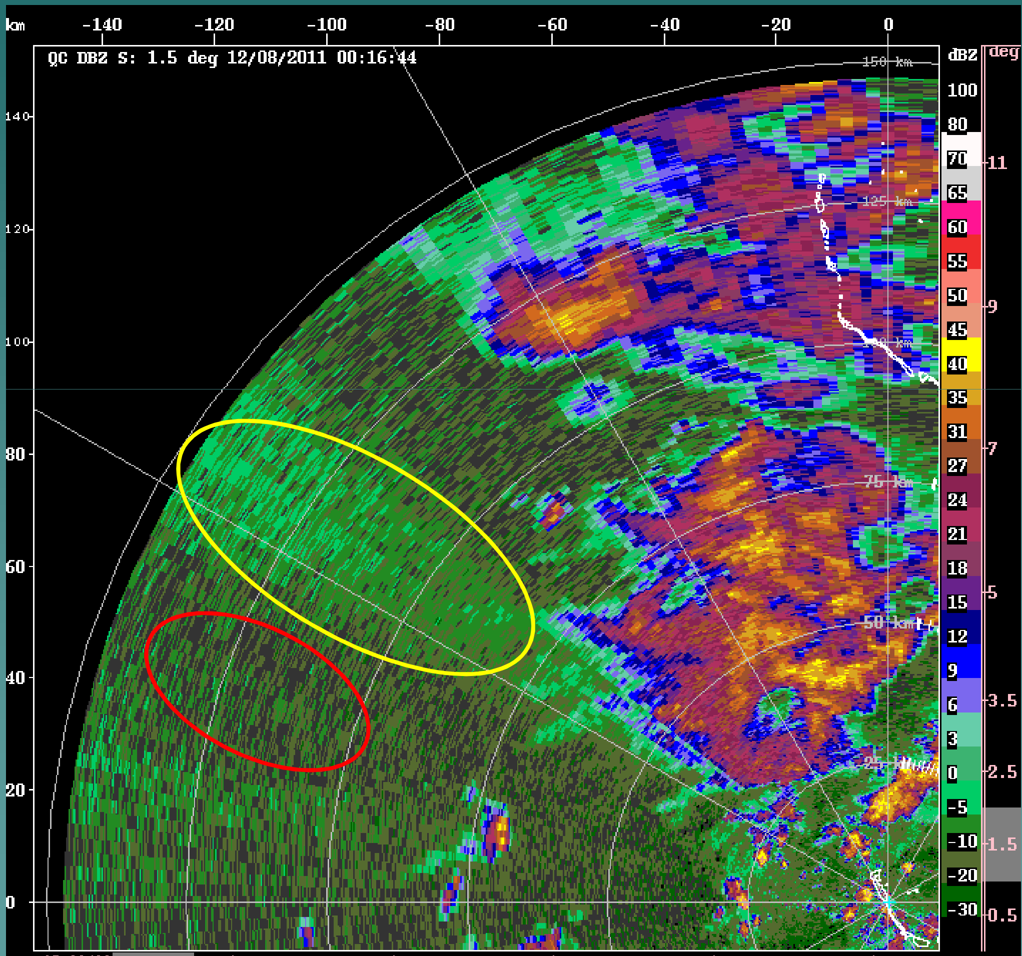
The following moments are sensitive to the noise value, especially at low SNR:

- Spectrum Width
- RHOHV
- ZDR

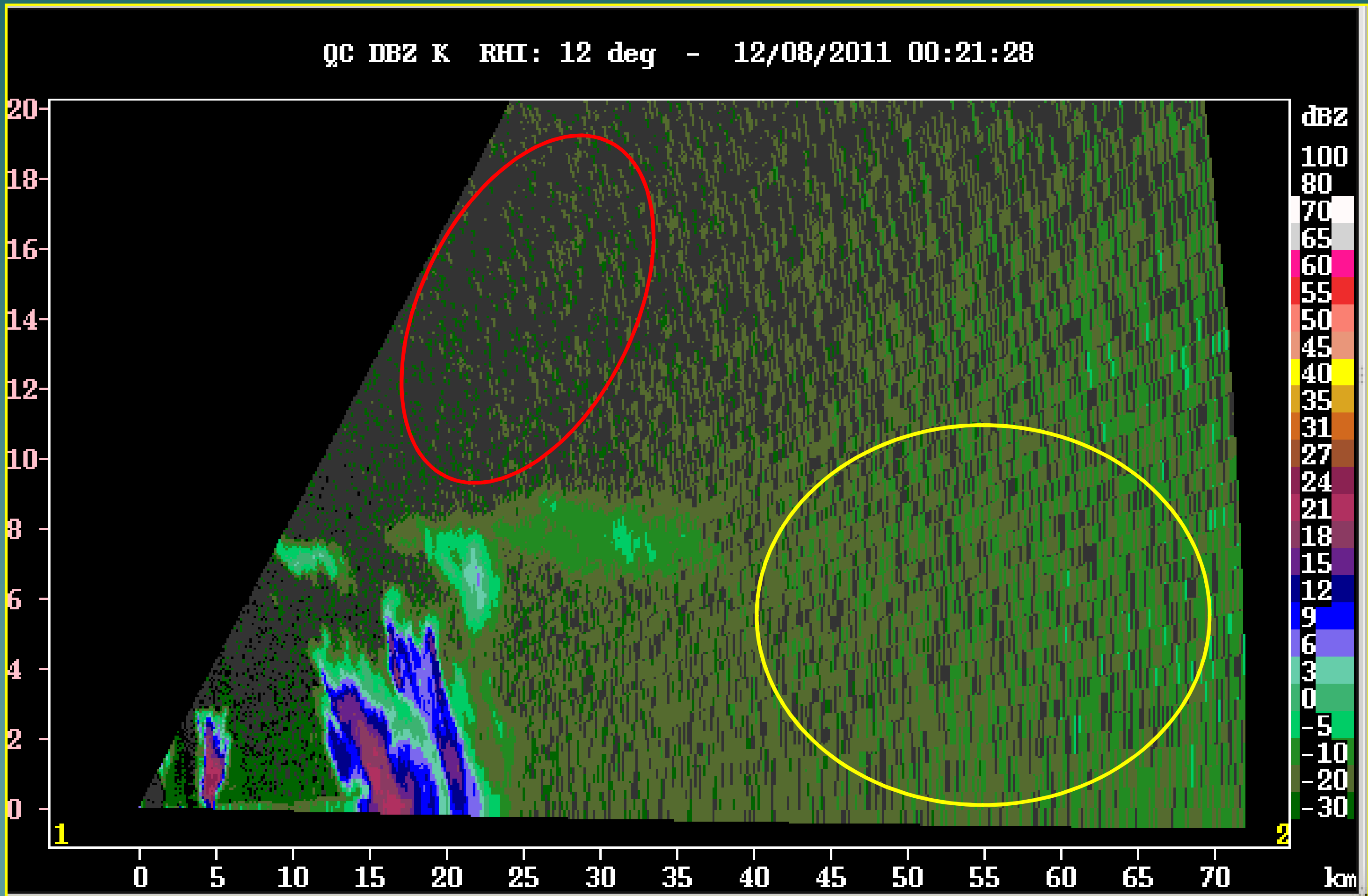
Demonstration of the method

We will demonstrate the method using S-band and Ka-band data from DYNAMO. The Ka-band radar is mounted on the side of the S-band antenna.

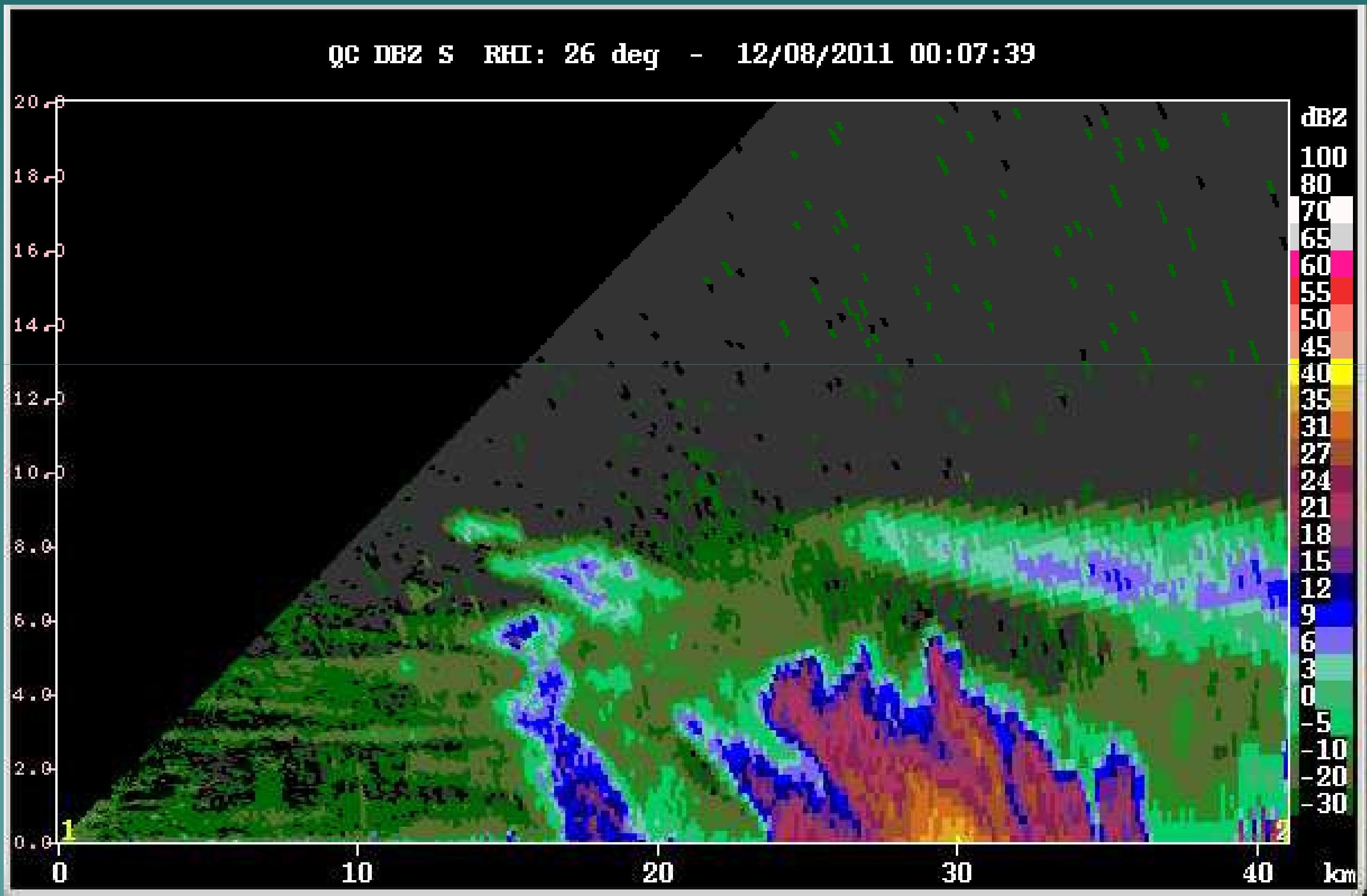
S-band low level scan showing increased, caused by ground clutter



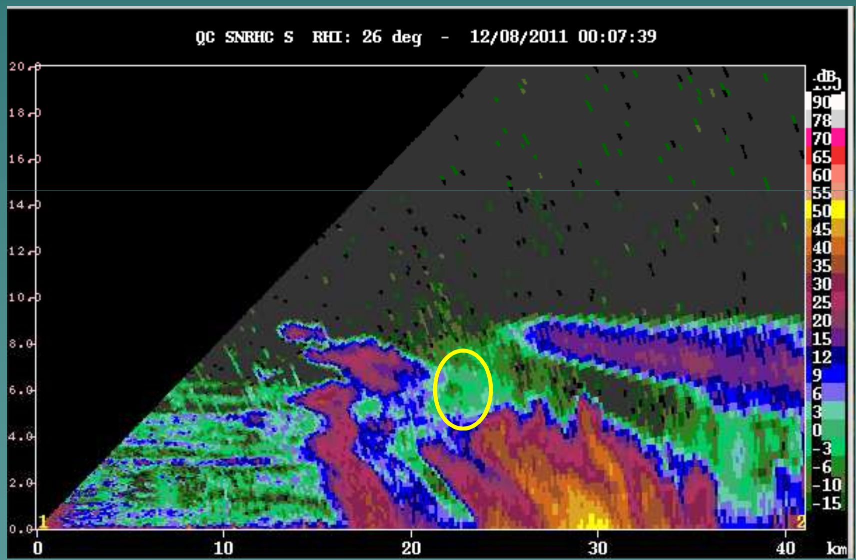
Ka-band RHI showing increased noise in the lower levels due to thermal emissions from storms and water vapor



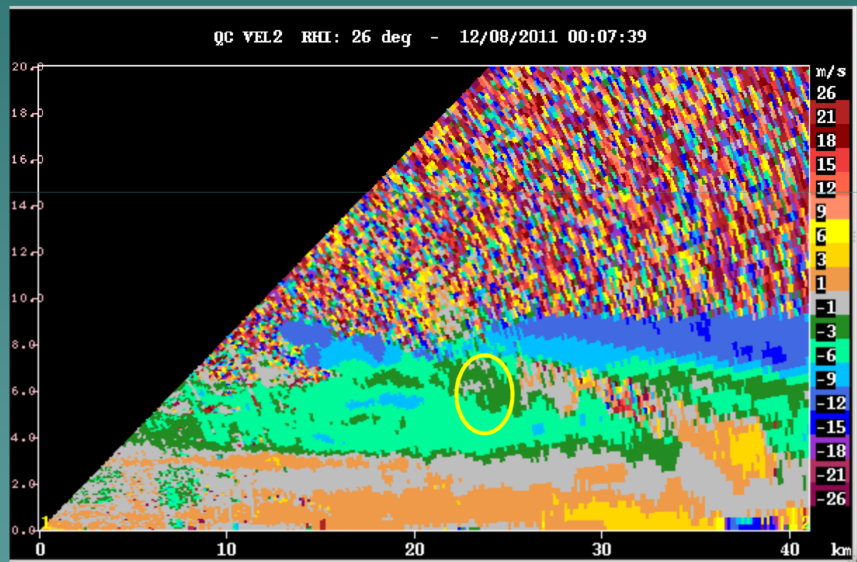
S-band RHI reflectivity for example case



RHI at S-band, showing the random nature of velocity in noise, even at low SNR values

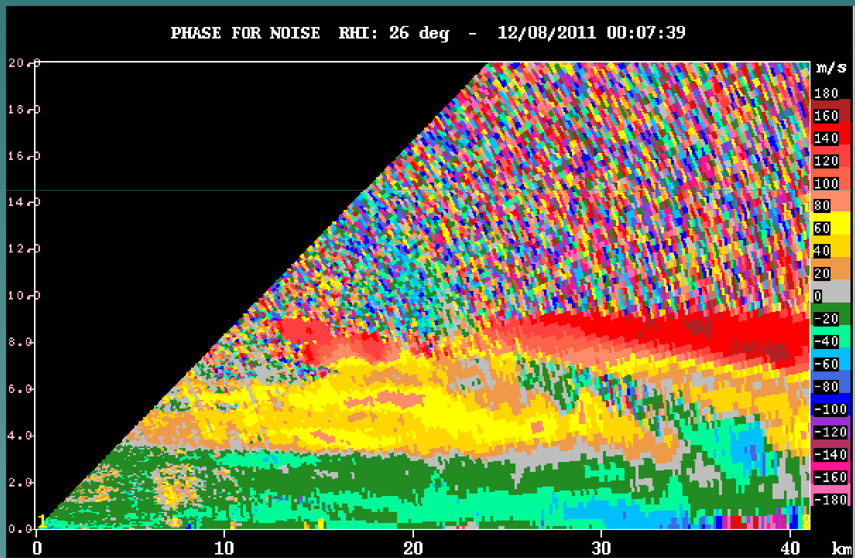


SNR

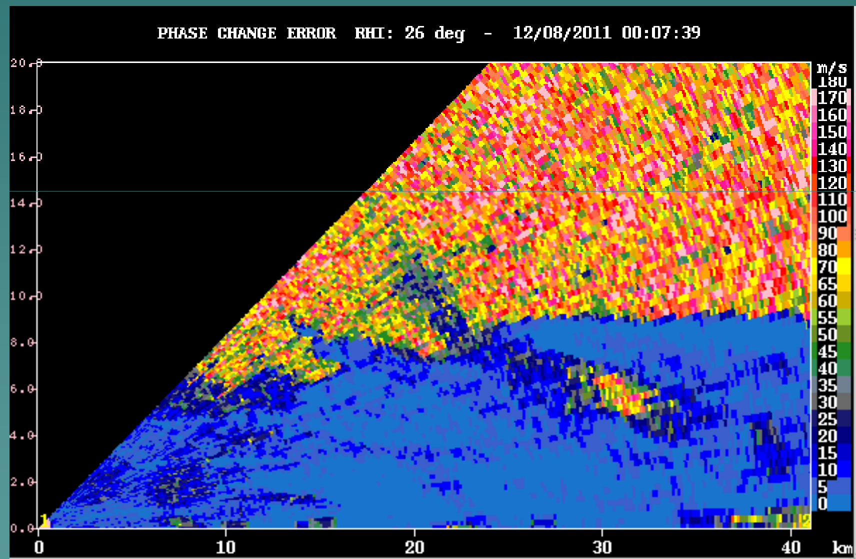


Radial Velocity

PHASE_SDEV – standard deviation of Doppler phase, computed over 9 gates in range. This is a so-called ‘feature field’.

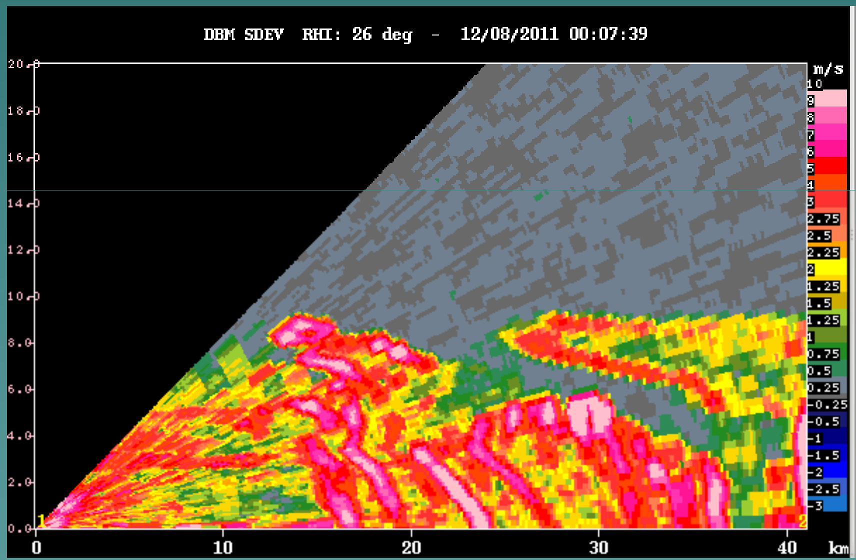


Doppler phase in degrees

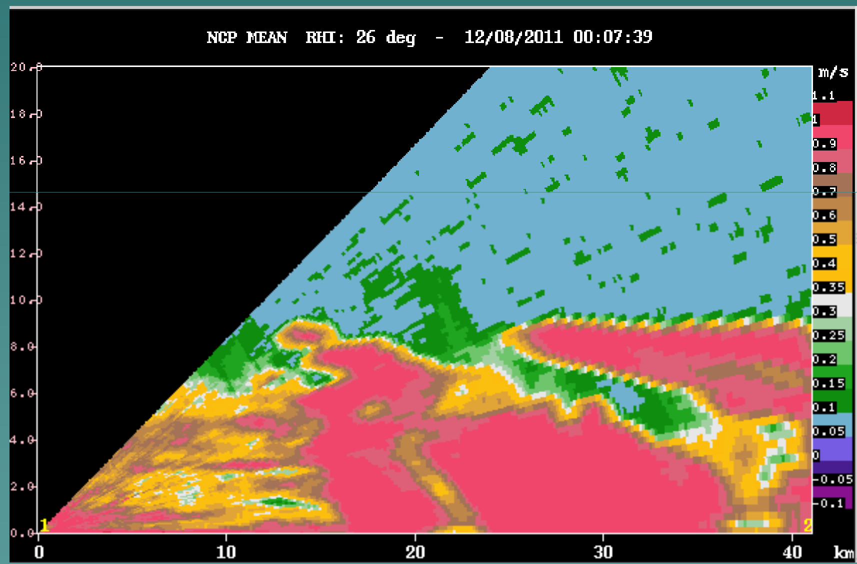


SDEV of phase

DBM_SDEV - standard deviation of power
NCP_MEAN – mean of NCP
Feature fields computed over 9 gates



DBM SDEV



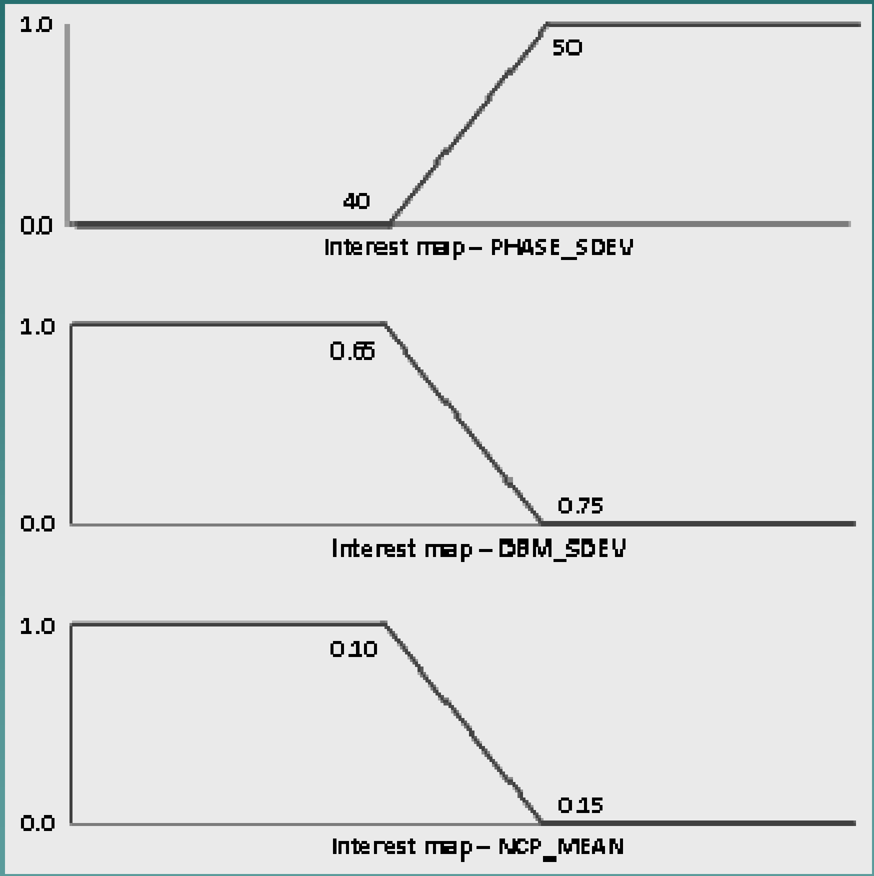
MEAN NCP

Converting feature fields into interest fields and combining

We convert each feature field into an ‘interest field’ ranging from 0 to 1 by applying an ‘interest map’ transfer function.

We then combine the interest fields into a single decision field, by computing a weighted mean.

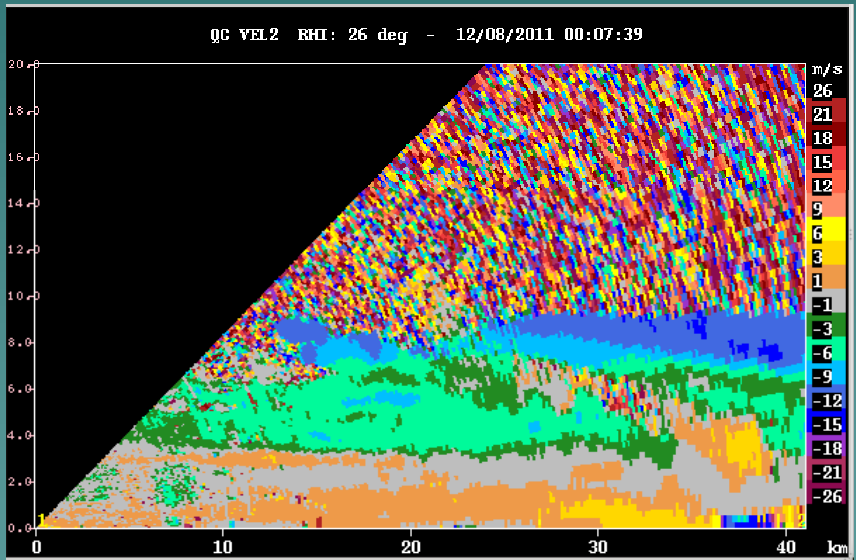
Interest maps for converting feature fields to interest fields



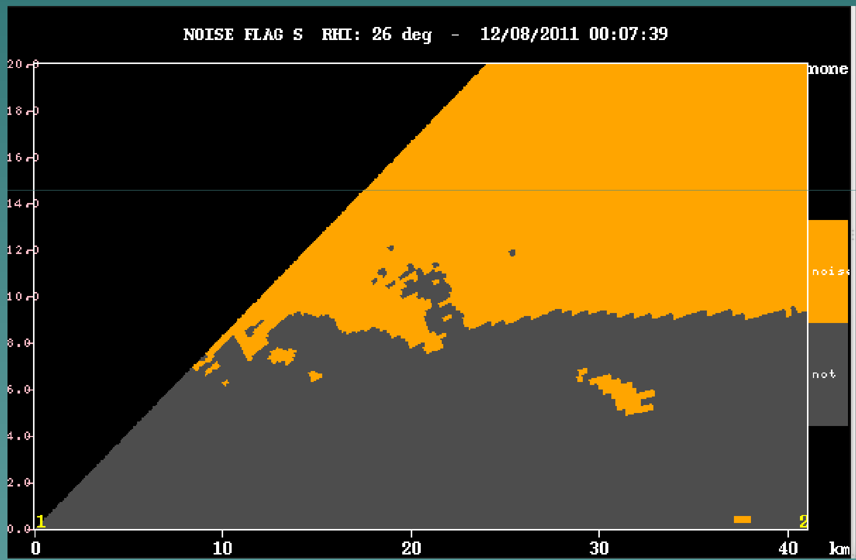
Interest map weights and thresholds

	S-band	Ka-band
Weight for PHASE_SDEV	1.0	1.0
Weight for DBM_SDEV	1.0	1.0
Weight for NCP_MEAN	0.65	1.0
Interest threshold for noise	0.65	0.9

Noise flag decision flag, shown alongside the original velocity field



Radial Velocity



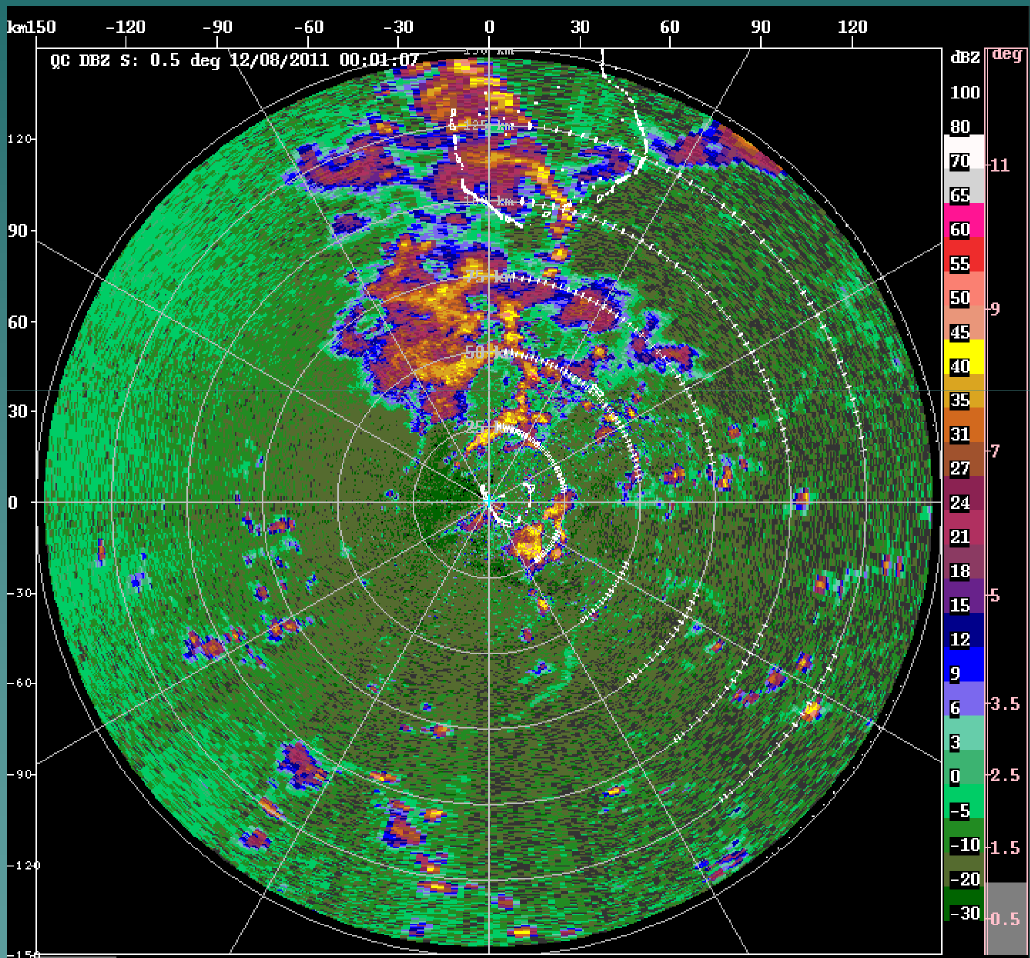
Noise Decision Flag

Computing noise bias and applying censoring

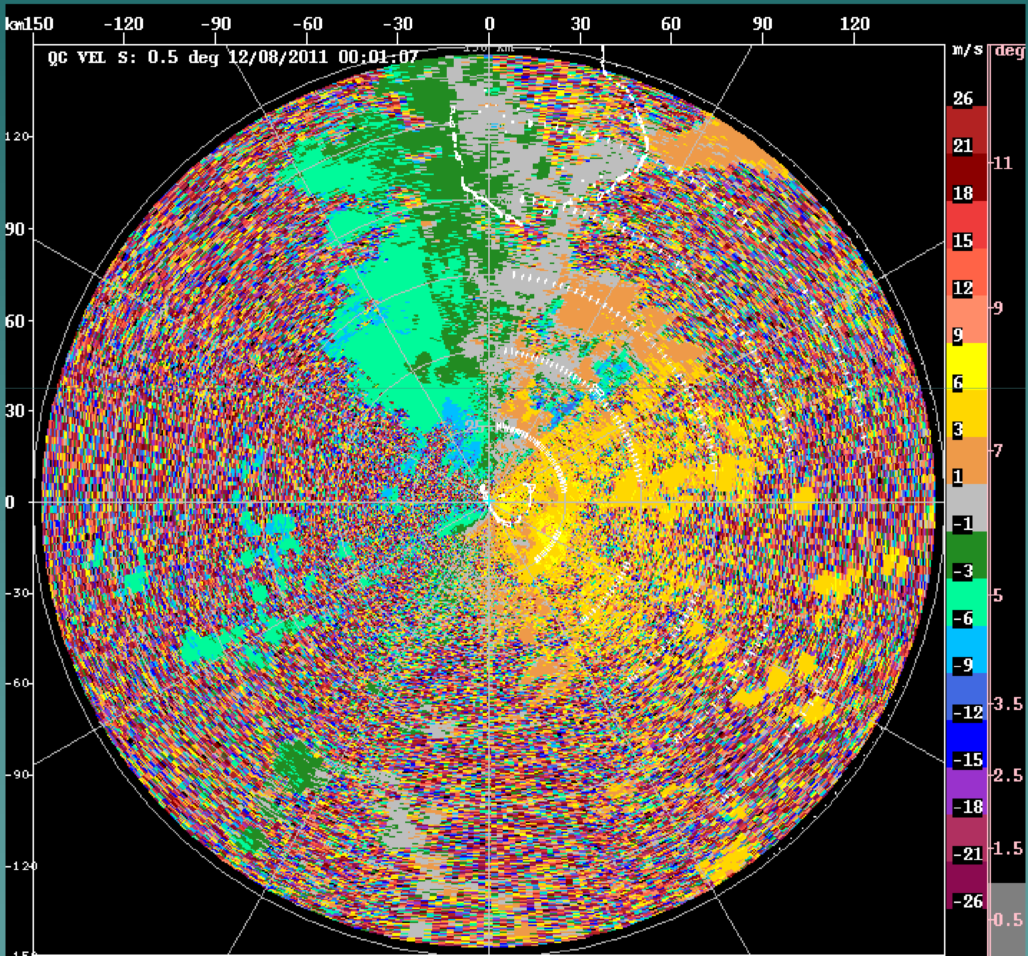
Having identified the noise-only gates, we can then:

- Compute the mean noise for the beam
- Censor data at the noise-only gates

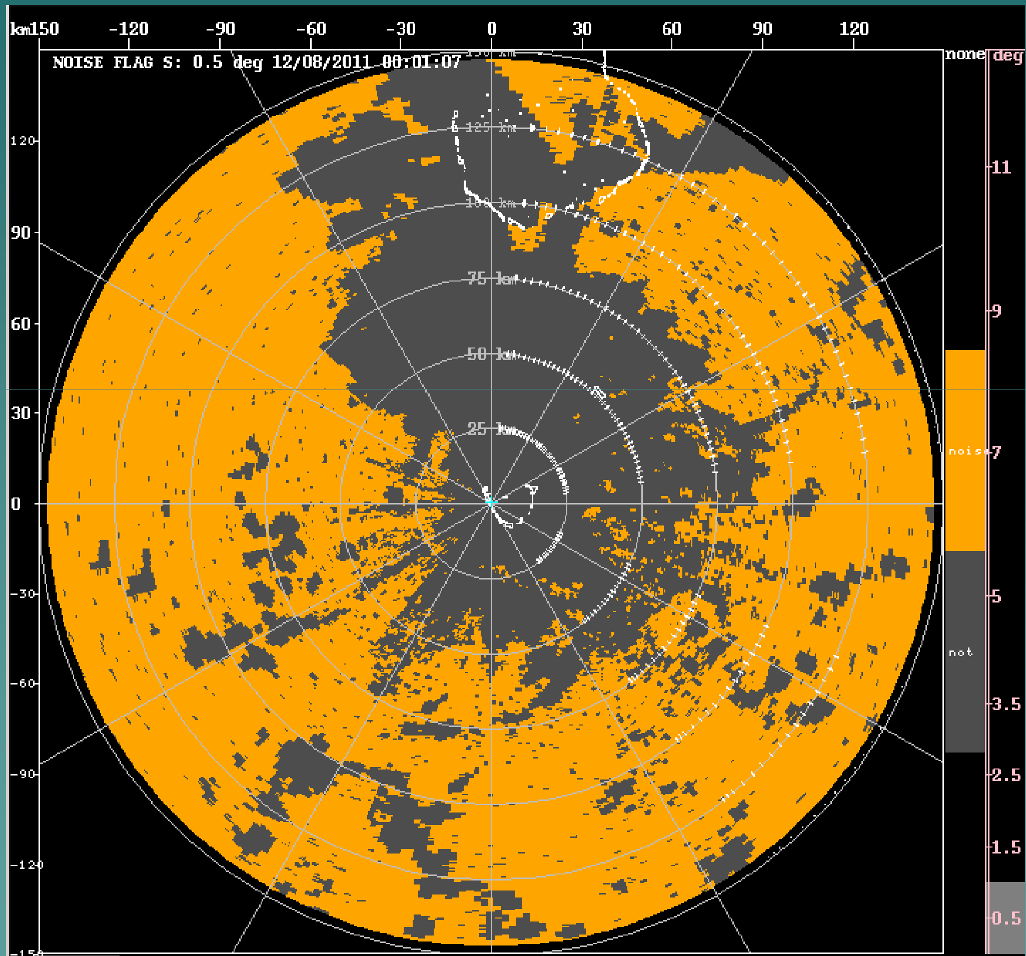
S-band DBZ PPI at 0.5 degrees. No censoring is applied. Note increased noise to NW.



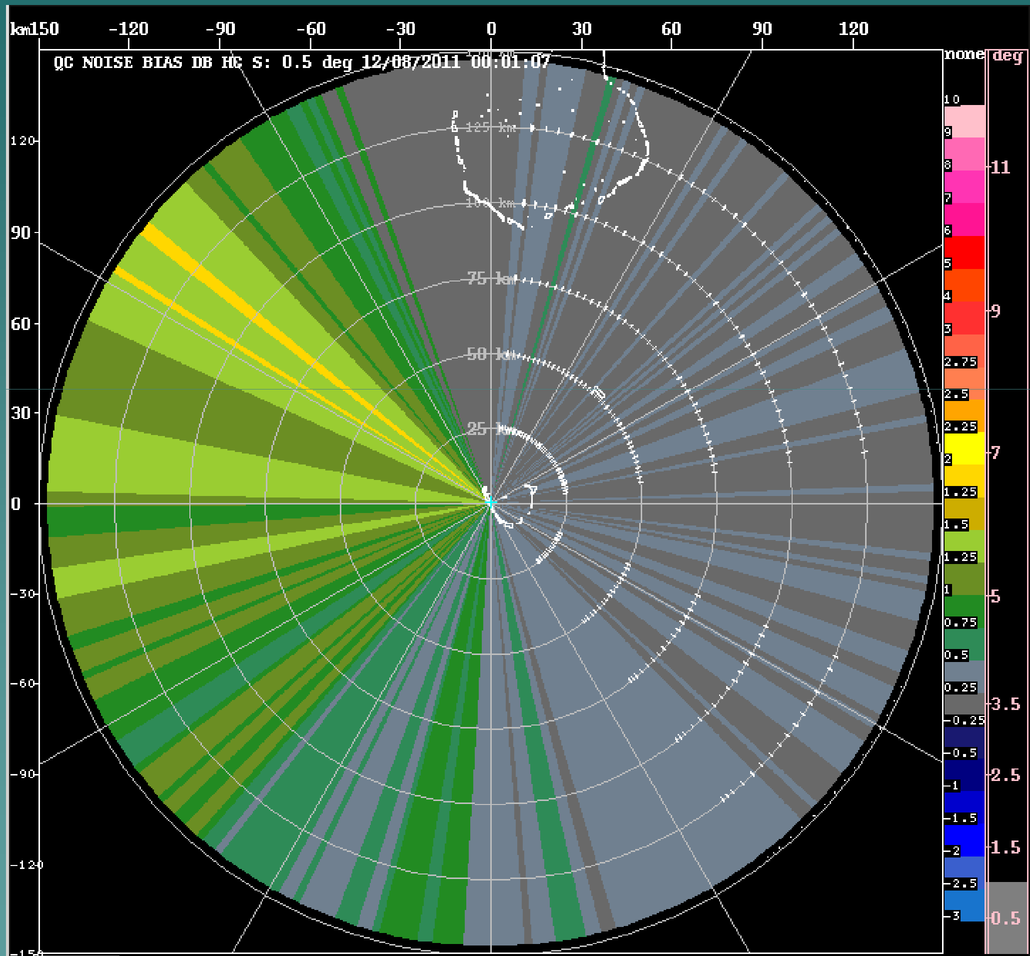
S-band VEL PPI at 0.5 degrees. Note noise as random velocity



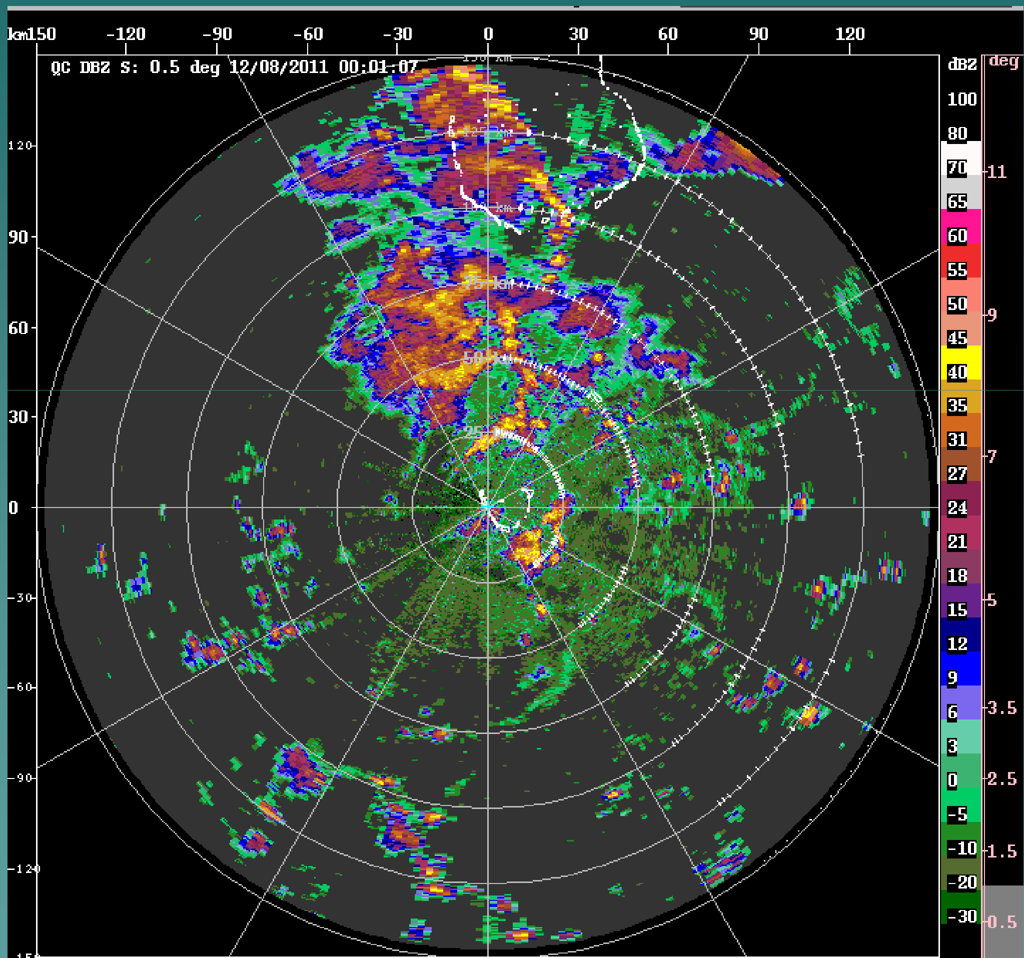
Noise flag – gates in orange have noise only



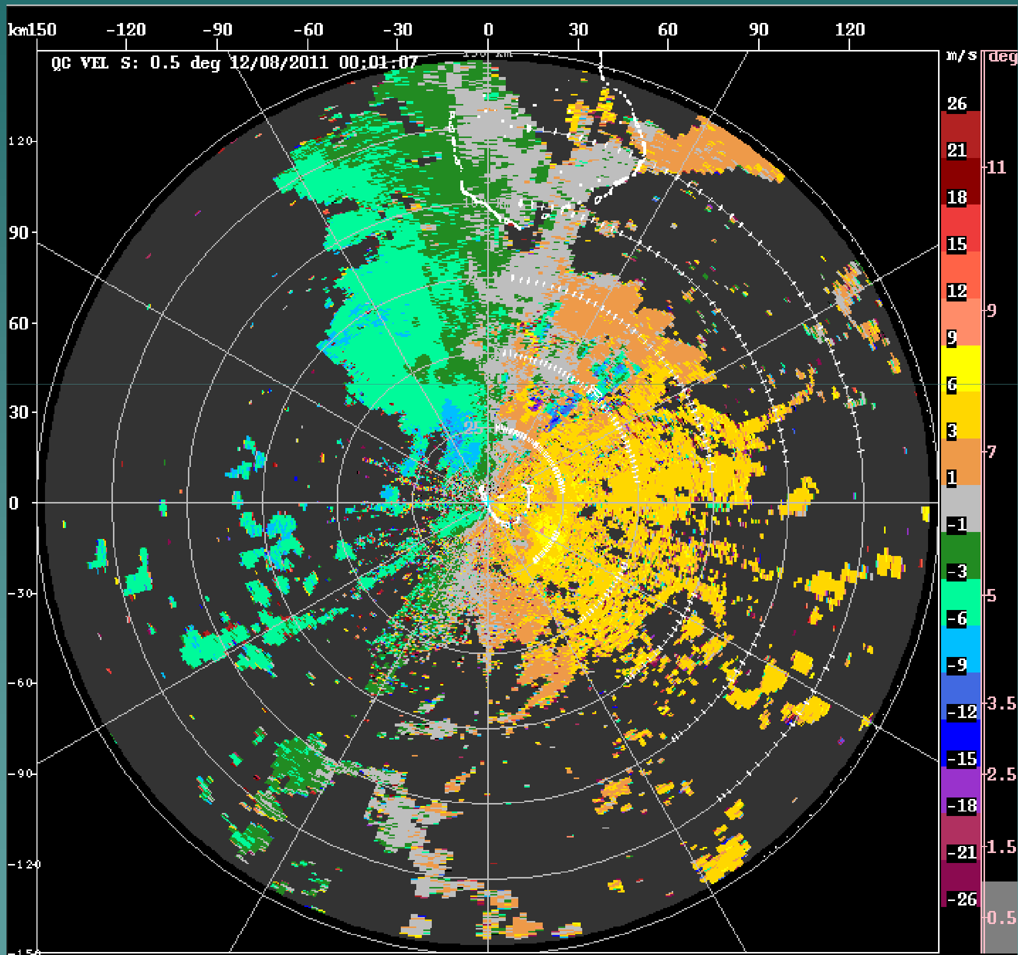
Noise bias relative to the calibrated noise



S-band DBZ PPI at 0.5 degrees. Censoring was applied at noise gates



S-band Velocity PPI at 0.5 degrees. Censoring was applied at noise gates



Merci – Thank you