11.B.5: Monitoring radar calibration using ground clutter

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Motivations

The WSR-88D radars feature built-in hardware and program routines to calibrate reflectivity (Z) and differential reflectivity (ZDR).

To verify system Z_{DR} calibration, three methods are used:

Measurements in light rain/drizzle
Measurements in snow
Measurements in clear air (Bragg scatter)

All three methods take time to produce estimates and are not always available because they require special weather conditions.

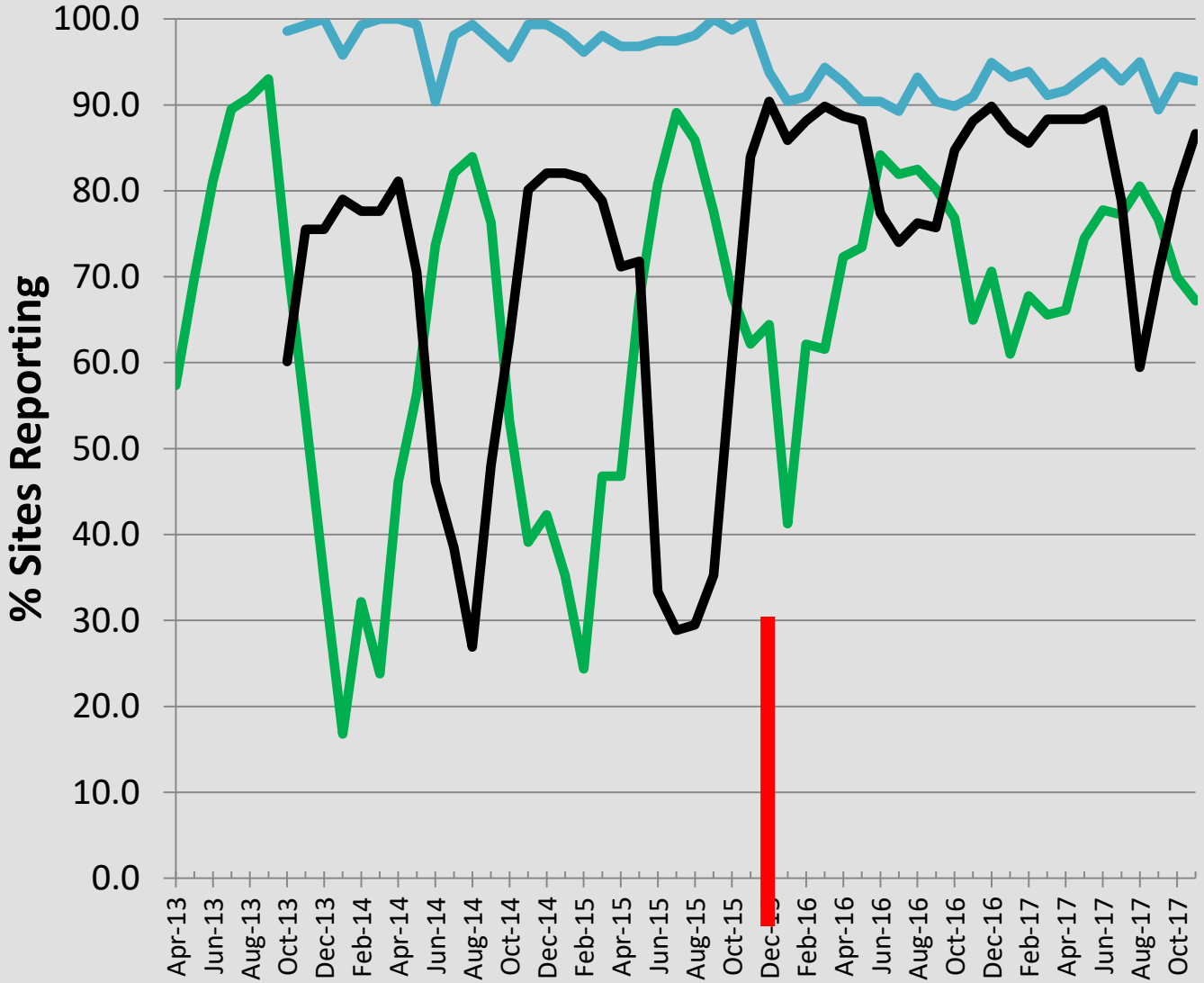
Continuous Z and Z_{DR} monitoring is needed.

Ground clutter can be observed continuously.

Can ground clutter be used for the calibration purposes?

Method Availability

Histogram Summary: 3 Methods



% Sites Reporting

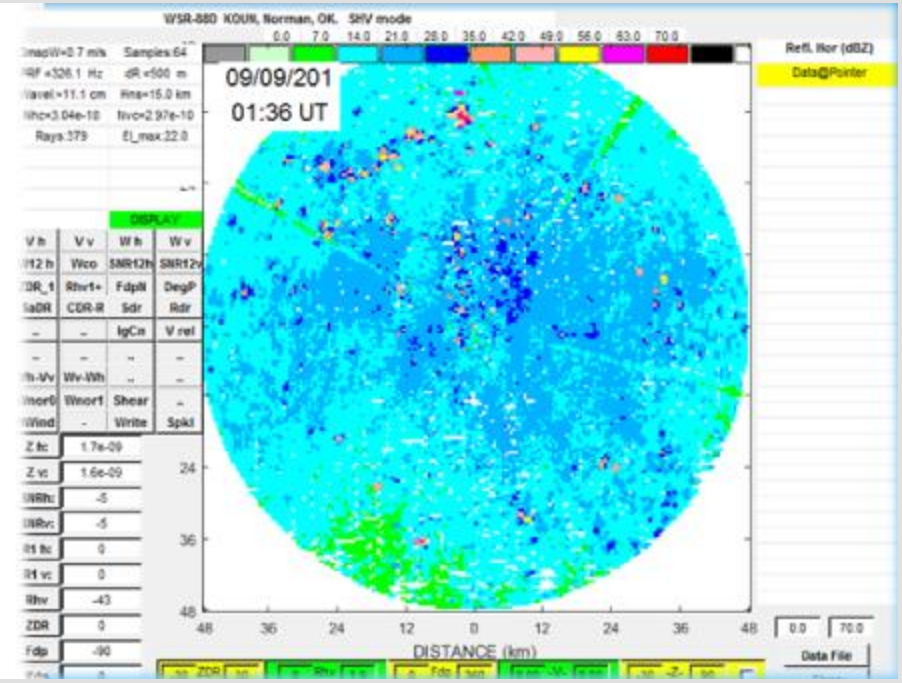
% Sites Light Rain

% Sites Dry Snow

% Sites Bragg

Daily Median Stats & redundant sites since Dec 2015

Contributors to radar echoes at the lowest antenna elevation angle



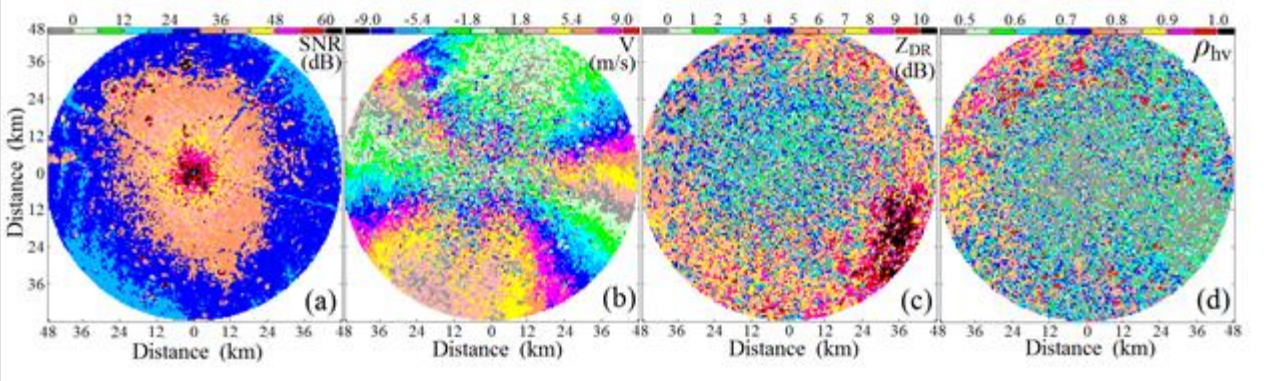
WSR-88D KOUN (Norman, OK).
Ground clutter filter is on.

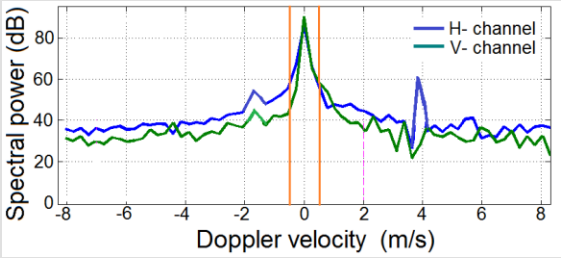
- Reflections from the ground, manmade structures, vegetation.
- Echoes from precipitation.
- Echoes from flying birds and insects.
- Reflections from moving vehicles.

Need to filter out reflections from moving scatterers and select signals from stable objects (ground, manmade structures, big tree trunks, etc.).

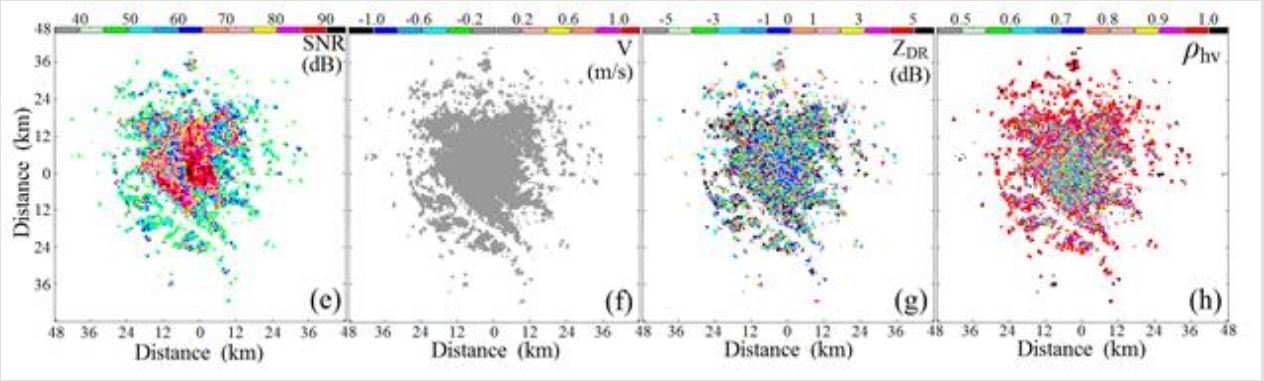
This approach is the opposite of normal ground clutter filtering.

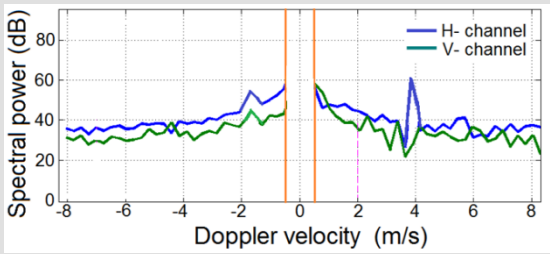
Signal processing to select stable ground clutter



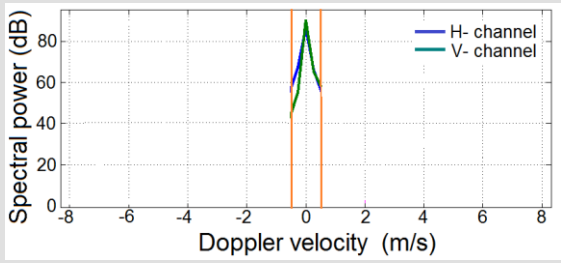


Typical Doppler spectrum of "clear air"





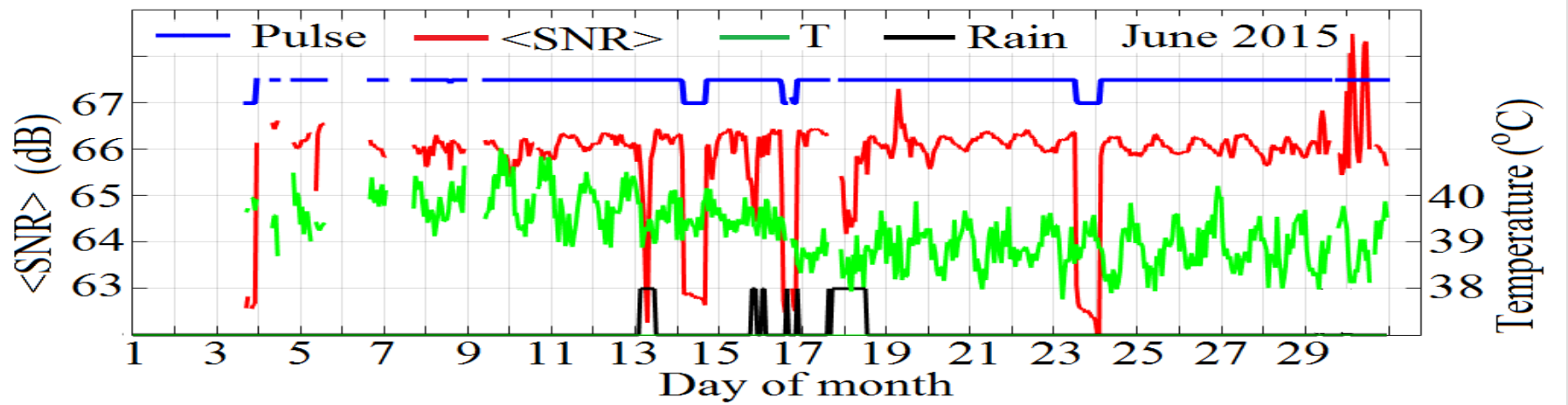
Standard processing: suppress ground clutter



Calibration monitoring: Leave 3 central spectral lines

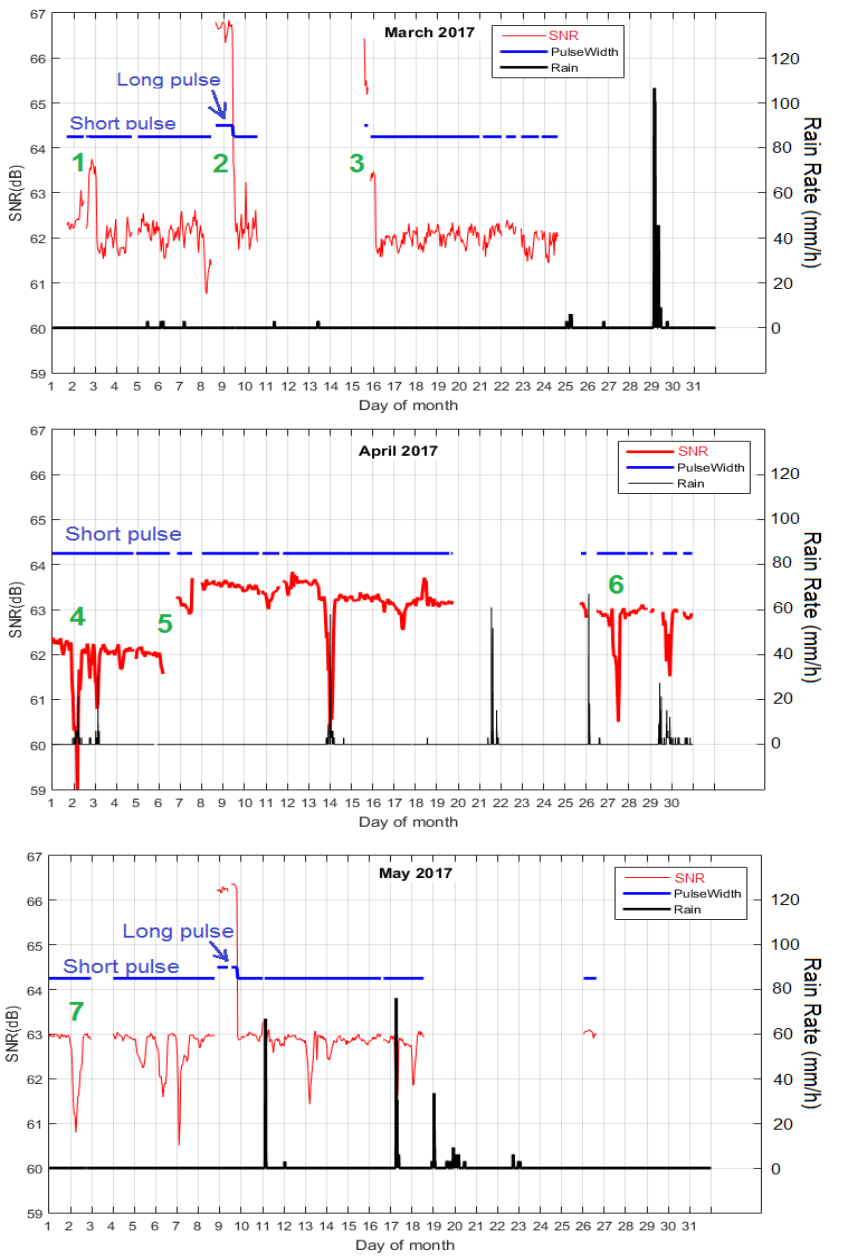
Is the signal with 3 central spectral lines stable enough to be used for monitoring the radar calibration?

Time-series of Signal-to-Noise ratio from ground clutter



- SNR depends on the width of radar pulse (short, 1.5 μs or long, 4.5 μs).
- Diurnal variations are obvious (they are within ± 1 dB).
- If no rain is observed within a distance of 30 km, the SNR from ground clutter can be used to monitor Z calibration.

Features of SNR from the ground observed in March-May 2017



(1): The antenna positioned a bit low.

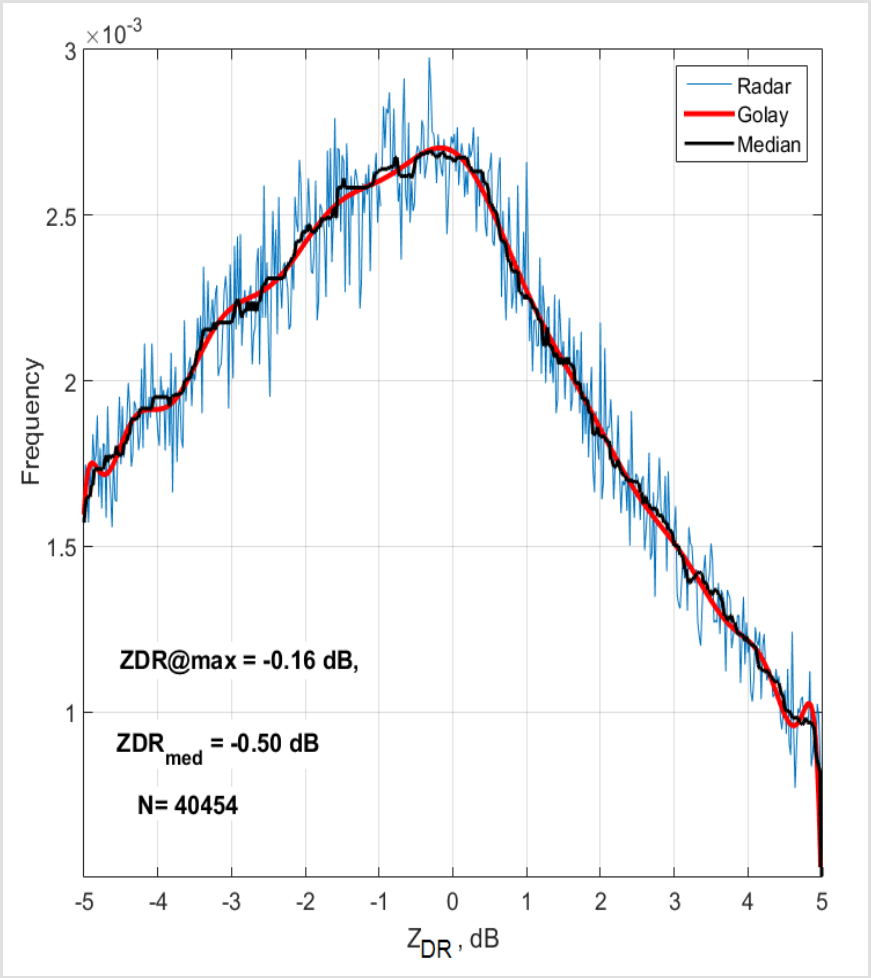
(2,3) Switching to the long pulse.

(4 and similar) Wet radome.

(5) Tuning the transmitter.

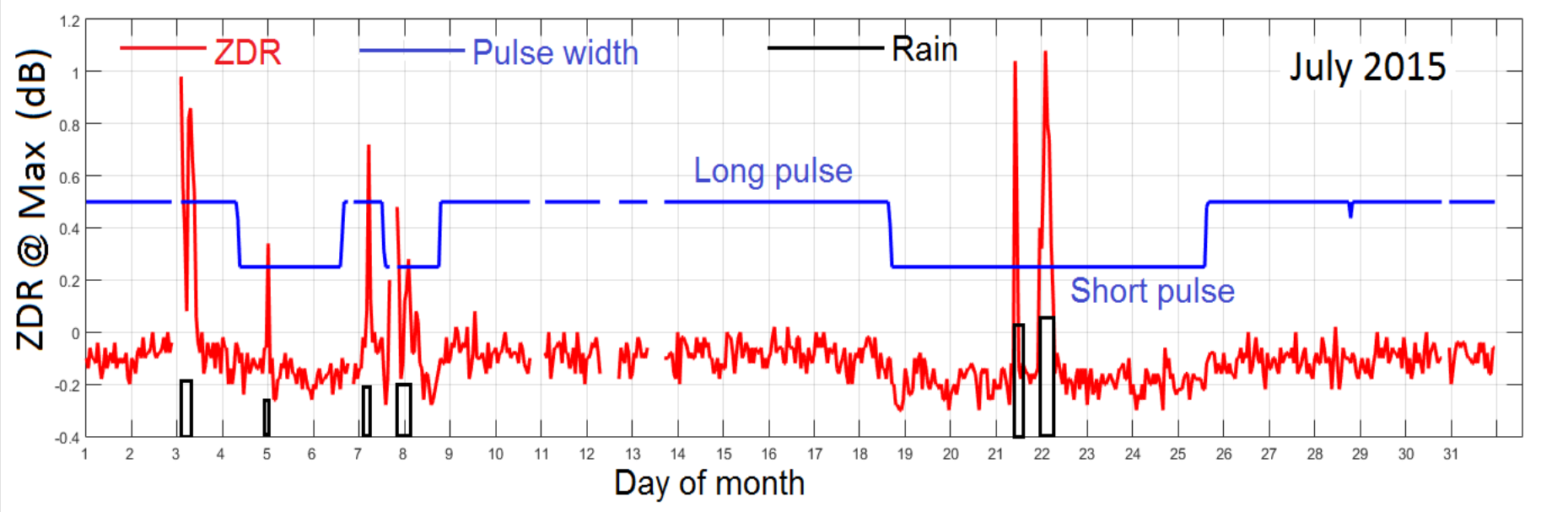
(6, 7) Unknown.

Measurements of ZDR from ground clutter



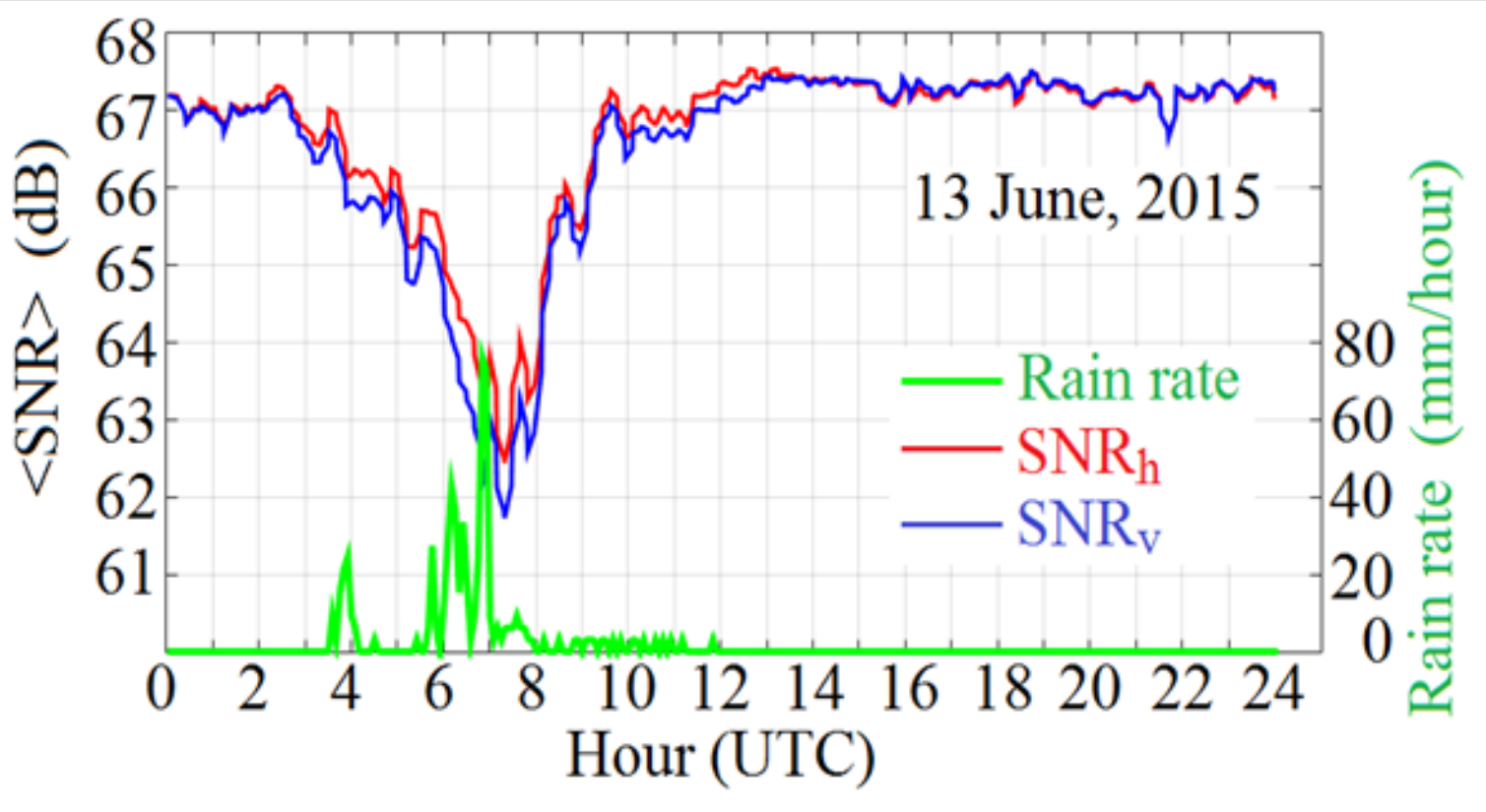
- Collect ZDR values from a single sweep.
- Make a distribution of ZDR values (result: the blue line in the figure).
- Apply the Golay filter to the distribution (result: the red curve in the figure).
- Obtain ZDR at the maximum of the filtered distribution, i.e., at the maximum of the red curve.

Time-series of Z_{DR} from ground clutter



- Diurnal variations are within ± 0.1 dB.
- ZDR for the short pulse is lower by 0.1 dB than that in the long pulse.
- Spikes in ZDR are caused by rain.

Rain impacts



SNR from ground clutter on 13 June 2015. WSR-88D KOUN.

SNR from ground clutter decreases in rain.

Water on radar radome attenuates transmitted and received radiation.

SNR from ground clutter could be used to correct for attenuation.

Conclusions

Radar returns with narrow spectra can be used to monitor the stability of reflectivity calibration within +/- 1.0 dB if no rain is observed within 30 km from radar. Some changes in Z calibration cannot be monitored without watching for changes in ground clutter (e.g., transmitter tuning)

Variations of ZDR from ground clutter are within ±0.1 dB if radar is stable and no rain is present within a distance of 30 km from radar. Ground clutter with the narrow spectra can be used to monitor the system ZDR.

SNR from the ground decreases and ZDR increases in rain.

SNR from ground clutter could be used to correct for attenuation in a wet radome, i.e., when radar is in rain.

Recommendations

- Z and ZDR monitoring by using ground clutter should be considered for operations.
  - This approach has many potential benefits in the diagnostic of radar hardware and correcting measured reflectivity for wet radome.
- More study is needed to connect some features of SNR and ZDR from the ground with changes in radar hardware.
- More study is needed to use SNR from the ground clutter to correct the drops in weather reflectivity in situations with wet radome.
- ZDR from the ground could be used to study possible dependence of system ZDR on ambient temperature.
- Calibrating reflectivity by using the consistency relations should be studied.