DUAL POLARIZATION

Mitigation of Ambiguities in Range and Velocity

Clutter Filtering
Processing of Single Polarization Signals

H - Digital Receiver oversampled

Processing of oversampled (pseudo whitening?)
Autocovariances or spectra
Clutter Filtering
R/V mitigation

Quality control: choice of valid autocovariances and spectra (50 m spacing)

Combining autocovariances and spectra for 250 m spacing

Computation of spectral moments
Processing of Dual Polarization Signals

- **H - Digital Receiver oversampled**
  - Processing of oversampled (pseudo whitening?)
  - Autocovariances or spectra
  - Clutter Filtering
  - R/V mitigation
  - Quality control: choice of valid autocovariances and spectra (50 m spacing)
  - Combining autocovariances and spectra for 250 m spacing
  - Computation of spectral moments

- **V - Digital Receiver oversampled**
  - Processing of oversampled (pseudo whitening?)
  - Autocovariances or spectra
  - Clutter Filtering
  - R/V mitigation
  - Quality control: choice of valid autocovariances and spectra (50 m spacing)
  - Combining autocovariances and spectra for 250 m spacing
  - Computation of spectral moments

**Dual Polarization**

- Dual Polarization Cross covariances or cross spectra
  - Quality control: choice of valid cross spectra and cross coavariances (50 m apart)
  - Combining cross spectra and cross covariances for 250 m resolution
  - Computation of polarimetric variables
Mitigation of Ambiguities in Range and Velocity

• Phase Coding (SZ-2)
  – Surveillance Scan
    • Standard Processing to obtain Polarimetric Variables as demonstrated in JPOLE
    • Clutter Filtering – Filters must be identical in H and V channels. Trivial modification of GMAP then Spectral processing to obtain Polarimetric variables
  – Doppler Scan
    • Overlaid echoes: Spectral processing of the weaker signal
    • No overlay: Processing of Auto and Cross-covariances to obtain Polarimetric variables
    • Clutter Filtering – Filters must be identical in H and V channels. Trivial modification of GMAP then Spectral Processing
Use of the GMAP

- For Reflectivity in H channel use GMAP as is.
- For \( \sigma_v \) use the same GMAP filter in both channels or same notches?
- For the polarimetric variables use GMAP on the H channel to select the notch width. Then use the same notch on both H and V channels. Do not interpolate across the notch.
The Systematic Phase Coding Technique

- Transmitted pulses are phase-encoded with \( \text{SZ}(8/64) \) switching code

- Recovery of the weak-trip velocity is not always possible

- Phase-coded scan can be preceded by long-PRT scan
Mitigation of Ambiguities in Range and Velocity

- Staggered PRT

- Processing in the long PRT interval $T_2$ region III
  - Standard Processing to obtain Z and Polarimetric Variables
Mitigation of Ambiguities in Range and Velocity

• Staggered PRT

– Processing samples in regions I and II of $T_1$ and $T_2$
  • Either standard or autocovariance estimates to obtain polarimetric variables
  • Clutter Filtering
    – Use GMAP to identify clutter spectrum
    – Sachi’s filter to remove clutter
    – Spectral processing to obtain Polarimetric variables
Spectrum: Staggered PRT Clutter and Signal

clutter + signal before filtering

Log Magnitude

Phase (deg.)

clutter + signal before filtering

0 100 m/s
Spectrum: Staggered PRT Signal
Spectrum after Filtering Clutter

Phase recovery approach – 2

$M = 64$, $v_a = 50 \text{ m s}^{-1}$, $CNR = 60 \text{ dB}$, $CSR = 30 \text{ dB}$

$w_c = 0.28 \text{ m s}^{-1}$, $v = 20 \text{ m s}^{-1}$, $w = 4 \text{ m s}^{-1}$, $n_c = 11$

(a) Magnitude

(b) Phase (deg.)
Clutter Filter Map
Reflectivity Field no GCF (Stag. PRT)
Reflectivity Filed after GCF (Stag. PRT)
Staggered PRT GCF Suppression
Velocity Field no GCF (Stag. PRT)
Velocity Field after GCF (Stag. PRT)
Spectrum Width no GCF (Stag. PRT)
Spectrum Width after GCF (Stag. PRT)
Differential Reflectivity no GCF
$Z_{DR}$ after GCF (Stag. PRT)
Differential Phase no GCF (St. PRT)
$\Phi_{DP}$ after GCF (Stag. PRT)
Correlation $\rho_{hv}$ no GCF (Stag. PRT)
$\rho_{hv}$ after GCF (Stag. PRT)
Receiver Sensitivity in the dual polarization WSR-88D
Signal to Noise Ratio - SNR

Dual pol SNR ~ \( P/(2N) \)
Single pol SNR ~ \( P/N \)
Effects of the 3 dB loss

• Increased errors in estimates of reflectivity, velocity, and spectrum width
• More data are below the SNR threshold and thus could be lost
• On the current WSR-88D (Legacy)
  – SNR threshold for velocity is 3.5 dB
  – SNR threshold for reflectivity is 2 dB
  \[10\log(P-N) > 10\log(N) + 2 \text{ dB}\]
Recommendation

• Use thresholds on the magnitude of the autocorrelation instead of the signal power on Z, \( \nu \) and \( \sigma_\nu \)

• Combine the autocorrelations (pulse pair) from the two channels (Horizontal and Vertical) to obtain estimates of \( \nu \) and \( \sigma_\nu \)
Recommendation

-For velocity and spectrum width estimates sum the two autocovariances:
  \[ v = \nu_a \arg\{R_h(T)+R_v(T)\}/\pi \]
  and use the following thresholds

  for 0.5 dB < SNR < 3.5 dB take data which has
  \[ |R_h(T)+R_v(T)|/2 > T_a = 0.25 \text{ N} \]
  for SNR > 3.5 dB take all the data

-For reflectivity estimates use the following thresholds
  for -1 dB < SNR < 2 dB take data which has
  \[ |R_h(T)+R_v(T)|/2 > T_a = 0.5 \text{ N} \]
  for SNR > 2 dB take all the data

Choose \( T_a \) which produces acceptable probability of false alarm, similar to the current Legacy system (i.e., with a 2 dB SNR threshold!).
Spectral Processing of Staggered PRT

Frequency domain, DFT of the coded signal – has 5 replica
Replicas can overlap
Perfect reconstruction is possible if the replicas occupy less than
$\frac{2}{(5T_u)}$, or 40% of extended Nyquist interval

At frequencies $f_1$ and $f_2$ the computed complex spectrum coefficients are

\[
V(f_1) = C(2) E(f_1,2) + C(3) E(f_1,3) \quad E(f_1) \text{ is Green, } E(f_2) \text{ is Blue}
\]
\[
V(f_2) = C(4) E(f_1,2) + C(5) E(f_1,3)
\]

Solve for the two complex spectral components $E(f_1)$ and $E(f_2)$