WP2:Fine-scale rainfall data acquisition and prediction

Range super-resolution at the UK Met Office

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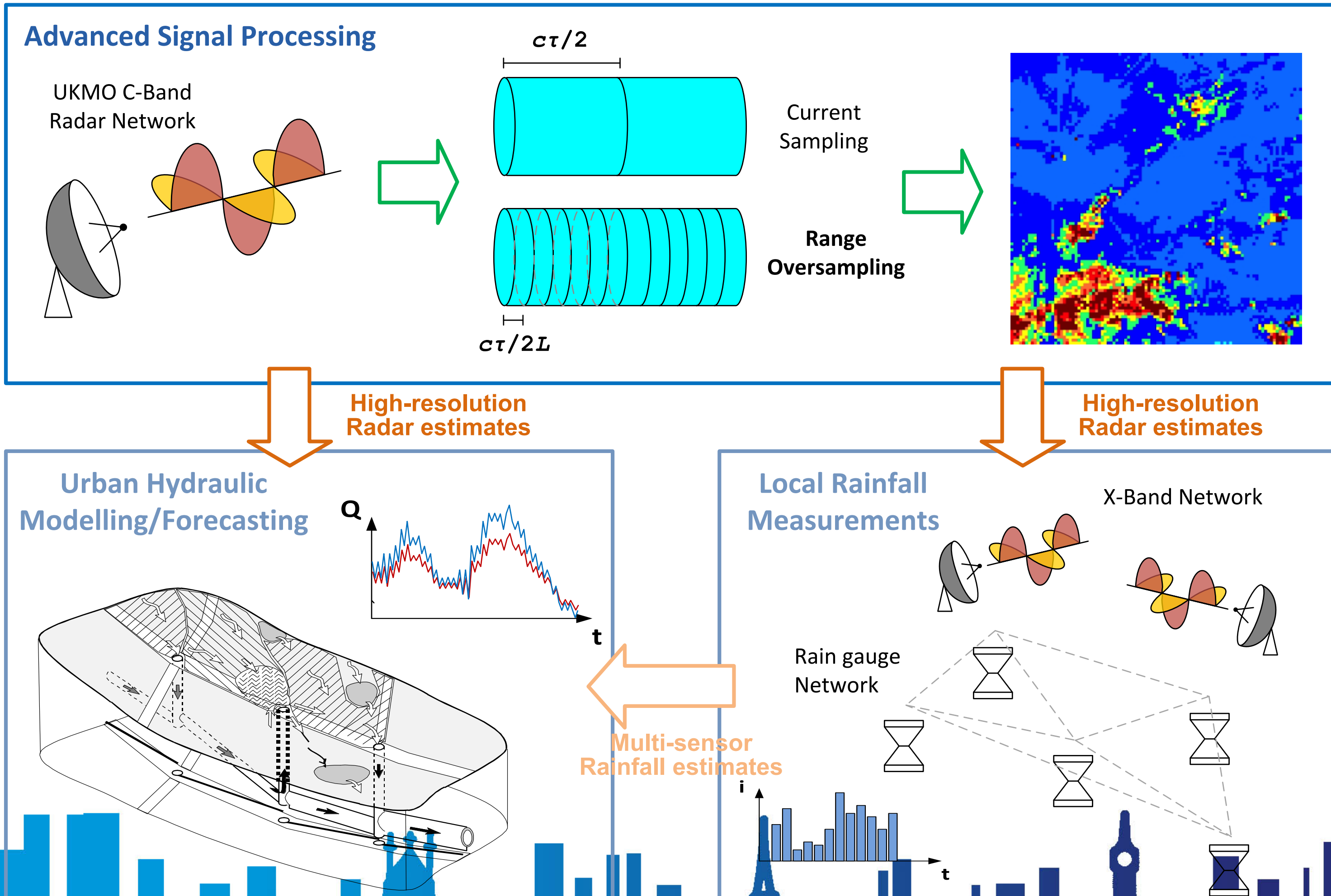
Advanced signal processing to improve the resolution of C-band radar measurements

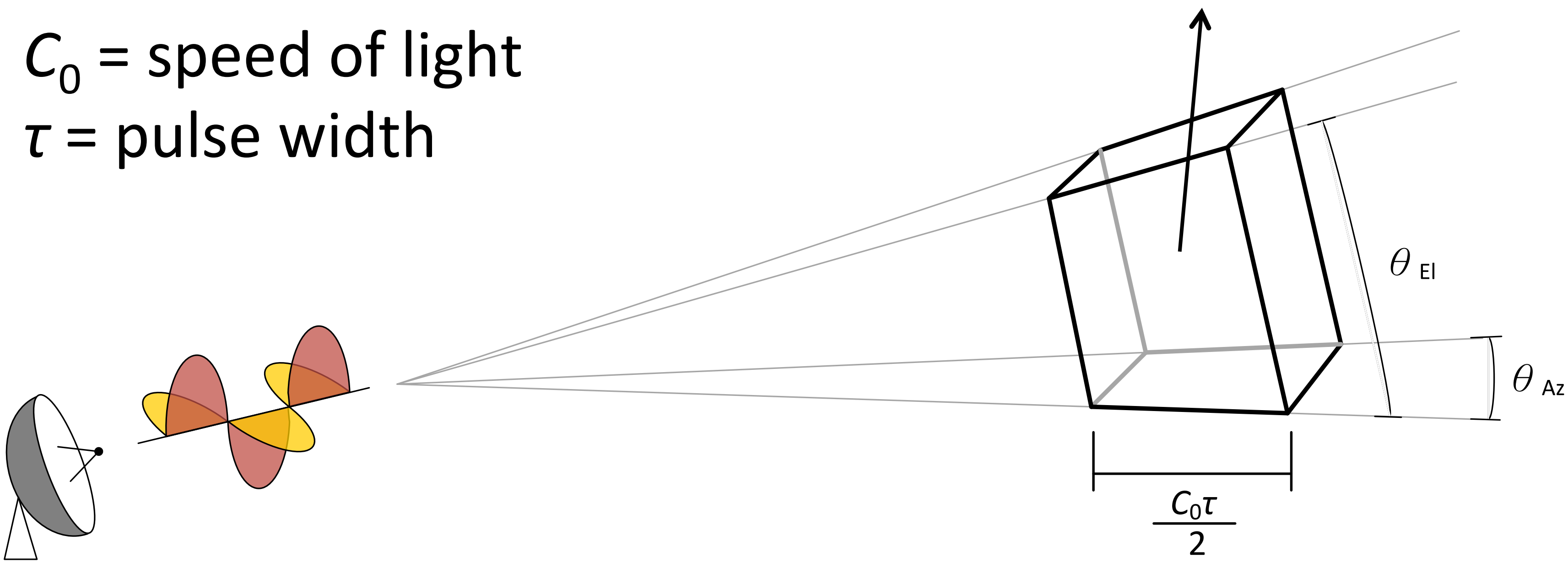


Range Resolution

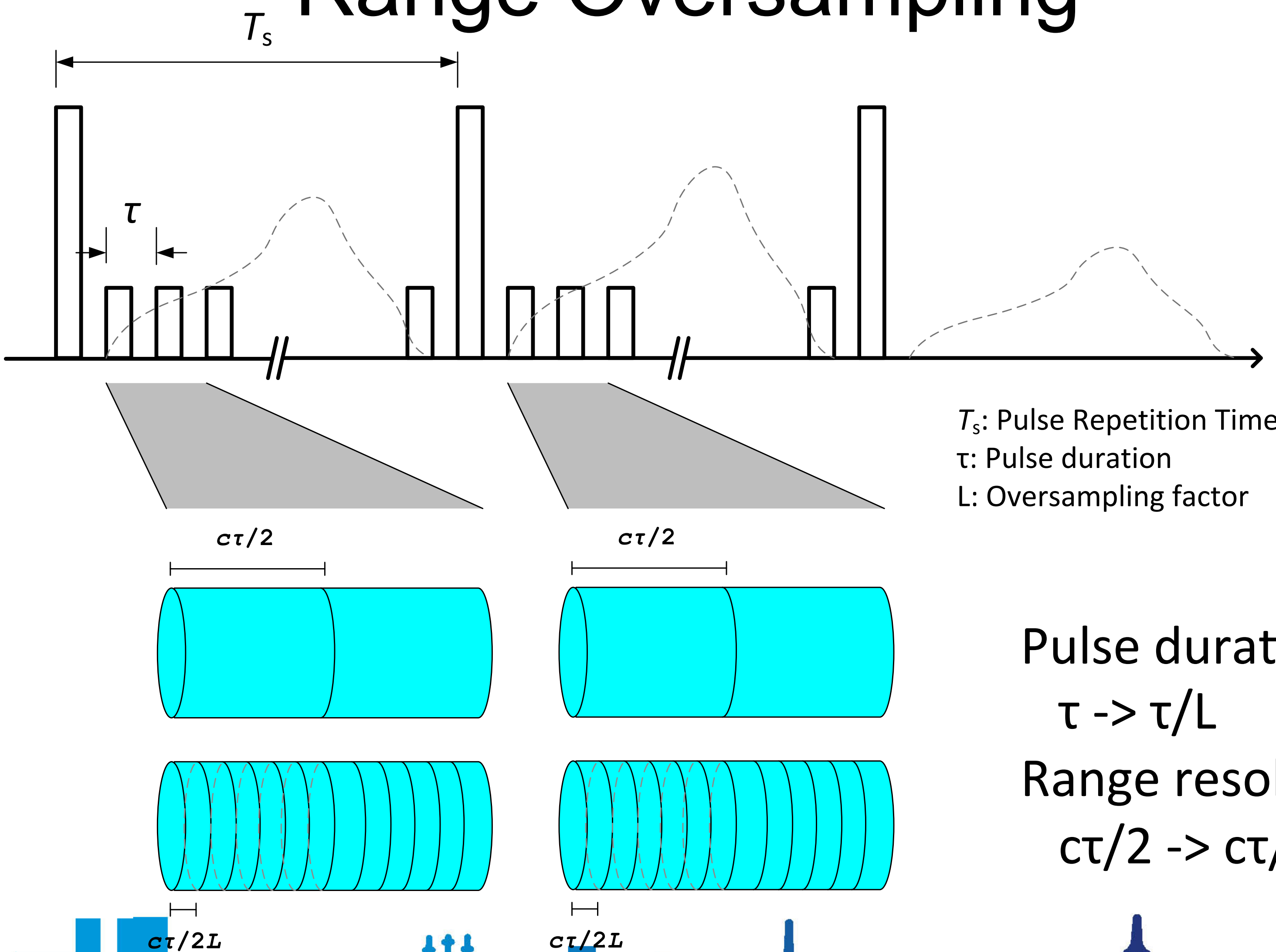
$$S_r = \frac{C_0 \tau}{2} \text{ [m]}$$

C_0 = speed of light
τ = pulse width

Resolution Cell Volume:
two separate objects that lie within the same resolution cell cannot be distinguished by radar



Range Oversampling



T_s: Pulse Repetition Time, PRT
τ: Pulse duration
L: Oversampling factor

Pulse duration:
τ -> τ/L
Range resolution:
cτ/2 -> cτ/2L

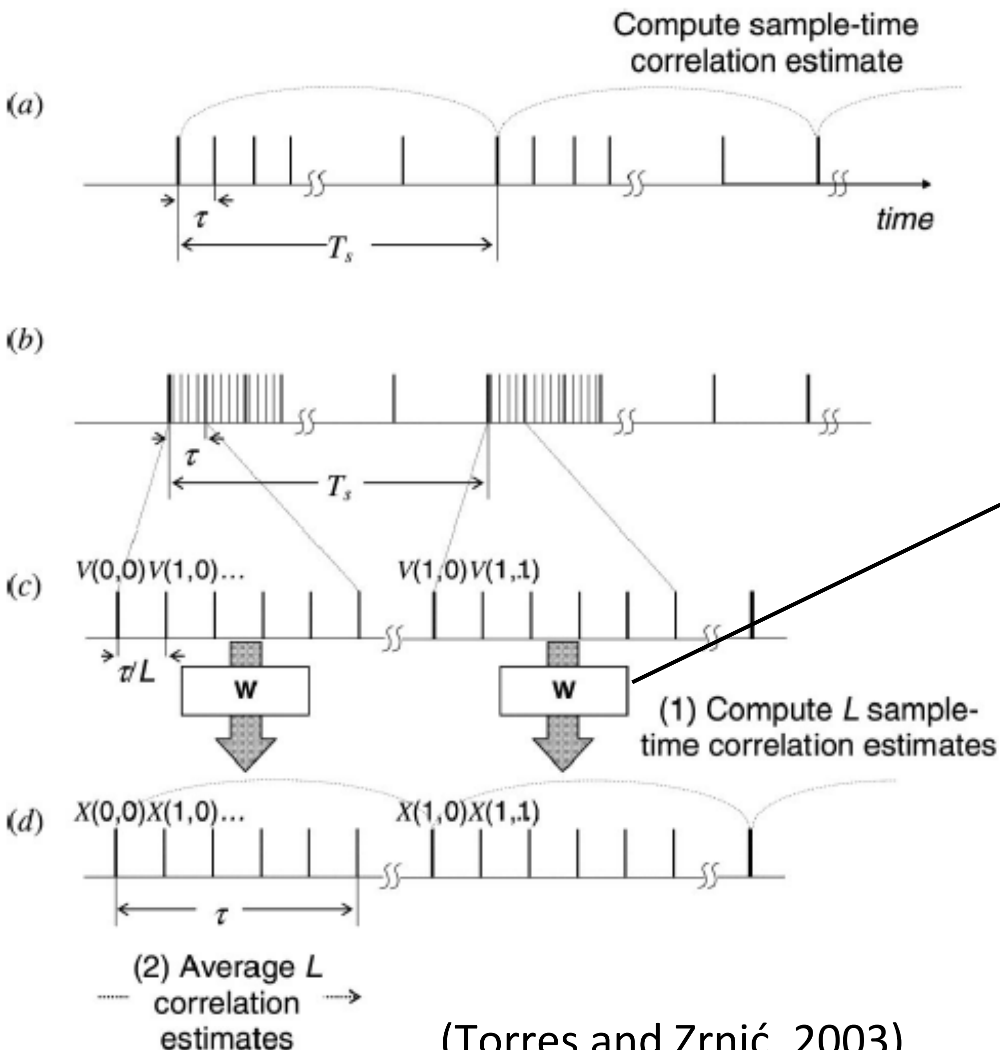
Range Oversampling Techniques

- **Whitening transformation**
  – Produce more independent samples to compensate for effects of angular windowing reduce variance again
- De-convolutional processing
  – Could give improved range and azimuth processing , in one.
  – Highly sensitive to noise – research required

Whitening Transformation

- De-correlates oversampled received signals and therefore improves the estimation of spectral moments and polarimetric variables
- Has been implemented on the National Weather Radar Testbed in the United States
- Has proven to be computationally efficient for real-time operation
- Has been tested on CASA X-band radar and verified to able to improve the estimation of polarimetric variables.

Whitening Transformation



(Torres and Zrnić, 2003)

1. Construct correlation matrix

$$\mathbf{C}_v$$

2. Compute Whitening matrix by decomposition techniques

$$\mathbf{C}_v = \mathbf{H}*\mathbf{H}^T$$

$$\mathbf{W} = \mathbf{H}^{-1}$$

3. Whiten oversampled signals

$$\mathbf{X}_n = \mathbf{W}\ \mathbf{V}_n$$

4. Estimate spectral moments

Decomposition

- Cholesky Decomposition (WTB)

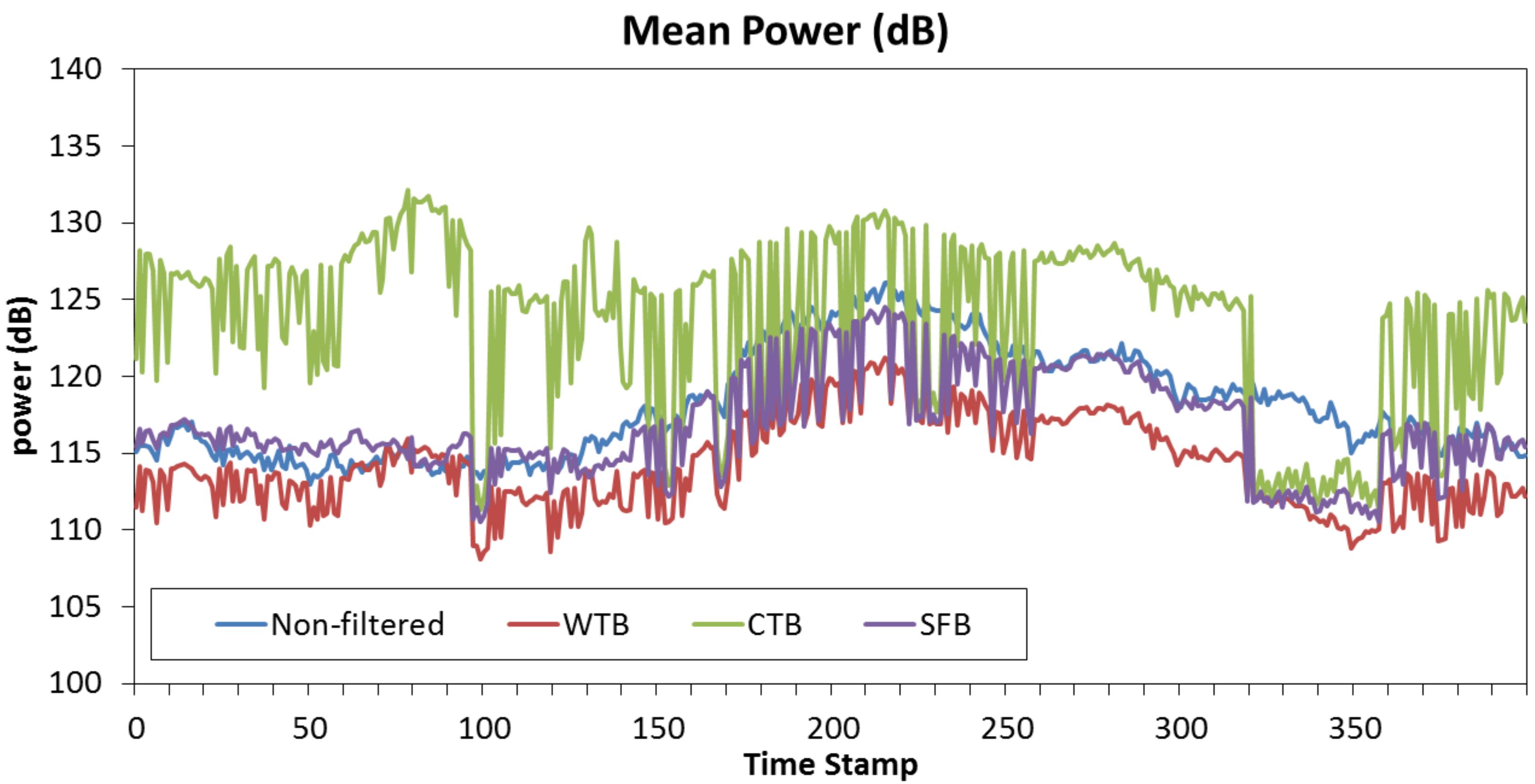
$$\mathbf{W} = \mathbf{H}^{-1}$$

- Singular Value Decomposition

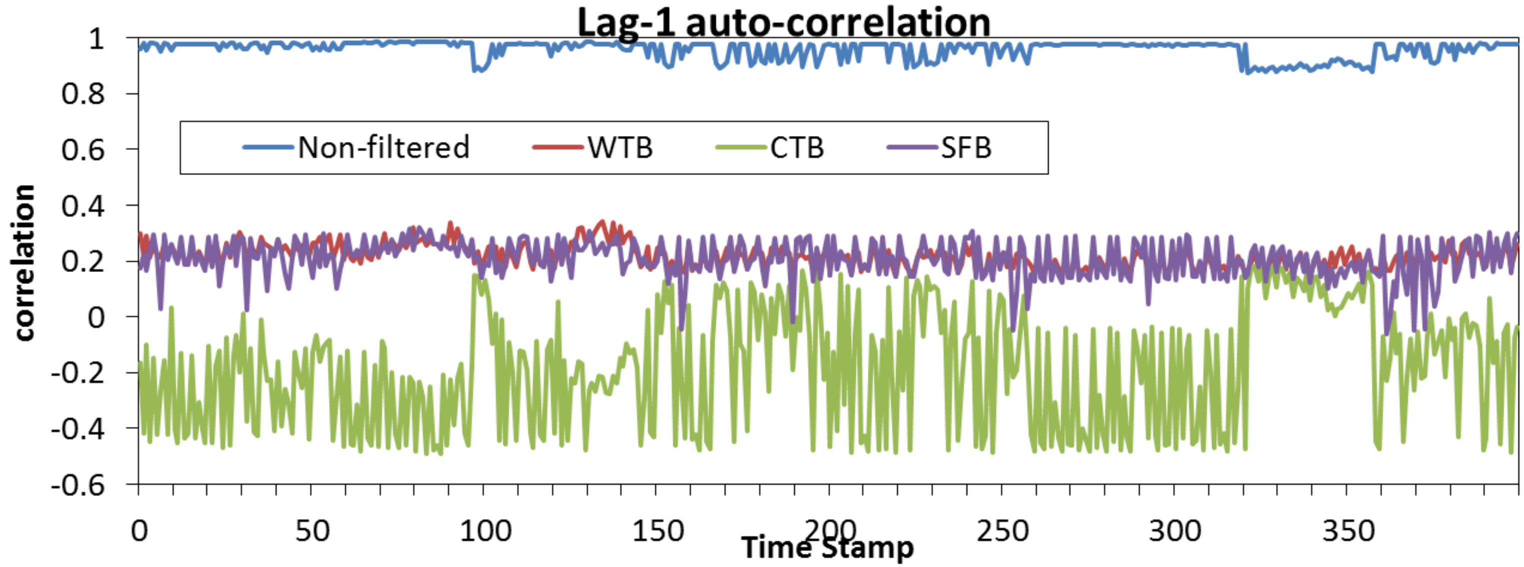
$$\mathbf{W} = \gamma \mathbf{Q} \mathbf{\Sigma}^{+} \mathbf{P}^{*T}$$

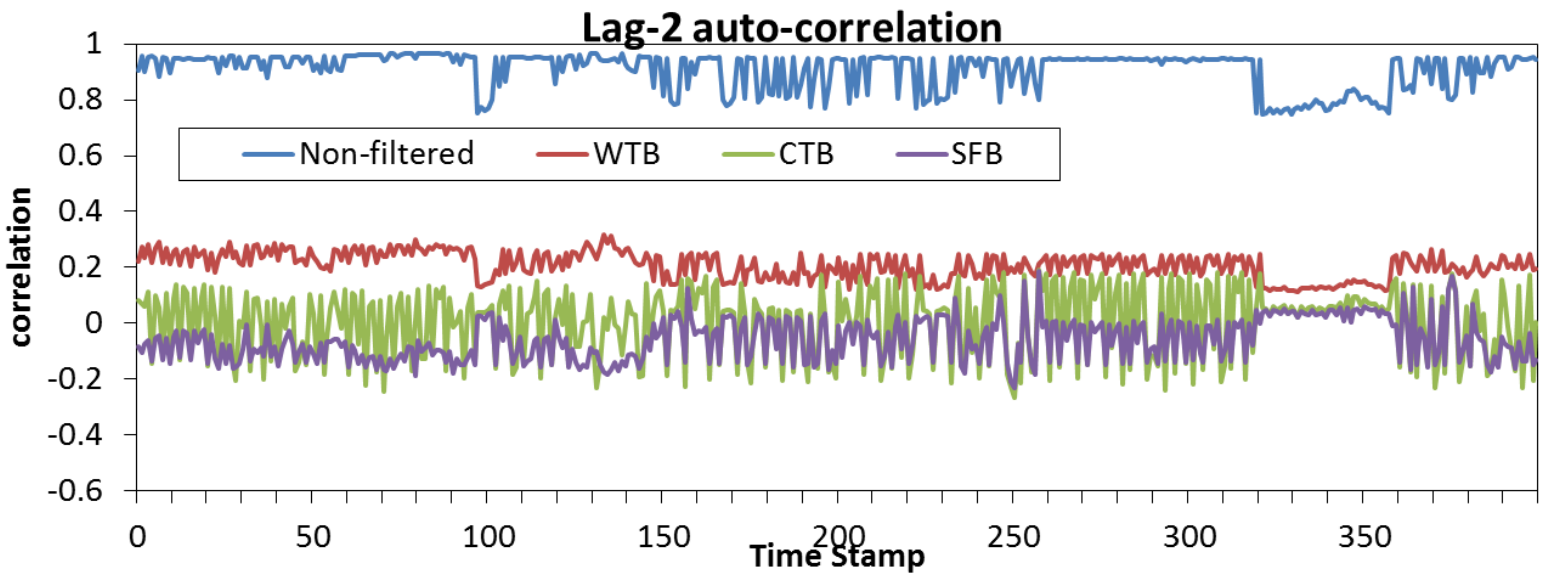
  - Truncated Singular Value Decomposition (TSVD)
  - Clipped Singular Value Decomposition (CSVD)
  - Sharpening Filter (SFB)
  - Optimal Whitening Transformation (Under implmentation)

Preliminary results (L = 5)



Preliminary results (L = 5)





Follow-up Works

- Implementation of Optimal Whitening Transformation technique
- Sensitivity analyses of key parameters (such as oversampling factor) and evaluation of the associated impact on spectral moment estimates and polarmetric variables
- Implementation of de-convolution techniques
- Results validation using ground rain-gauge data