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# A Comparative Study of Time Domain and Joint Time-Frequency Domain Methods for Ionospheric Irregularity Drift Velocity Estimation from a GNSS Receiver Array during High Latitude Ionospheric Scintillation

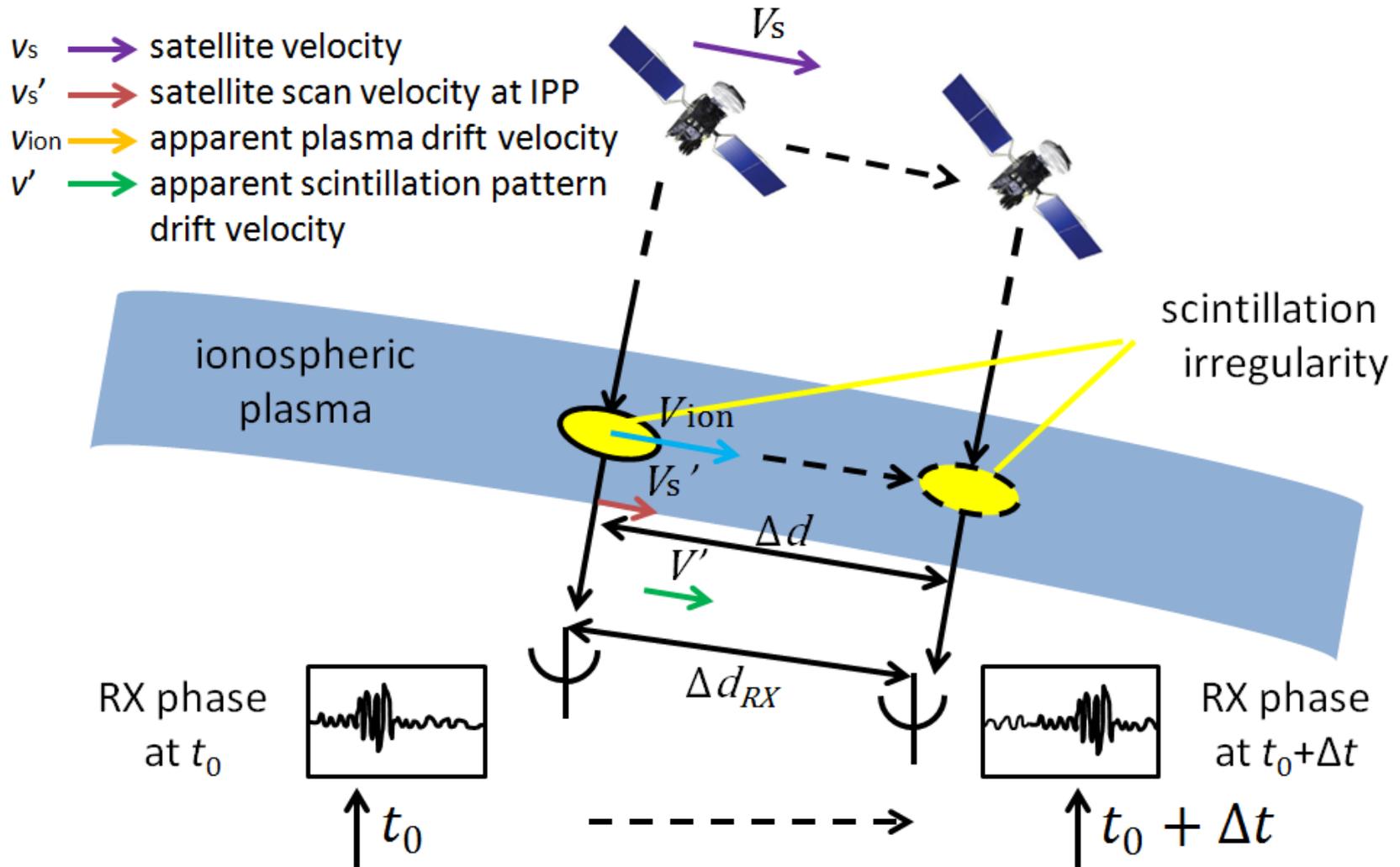
Jun Wang, Yu (Jade) Morton  
*Colorado State University*

# Outline

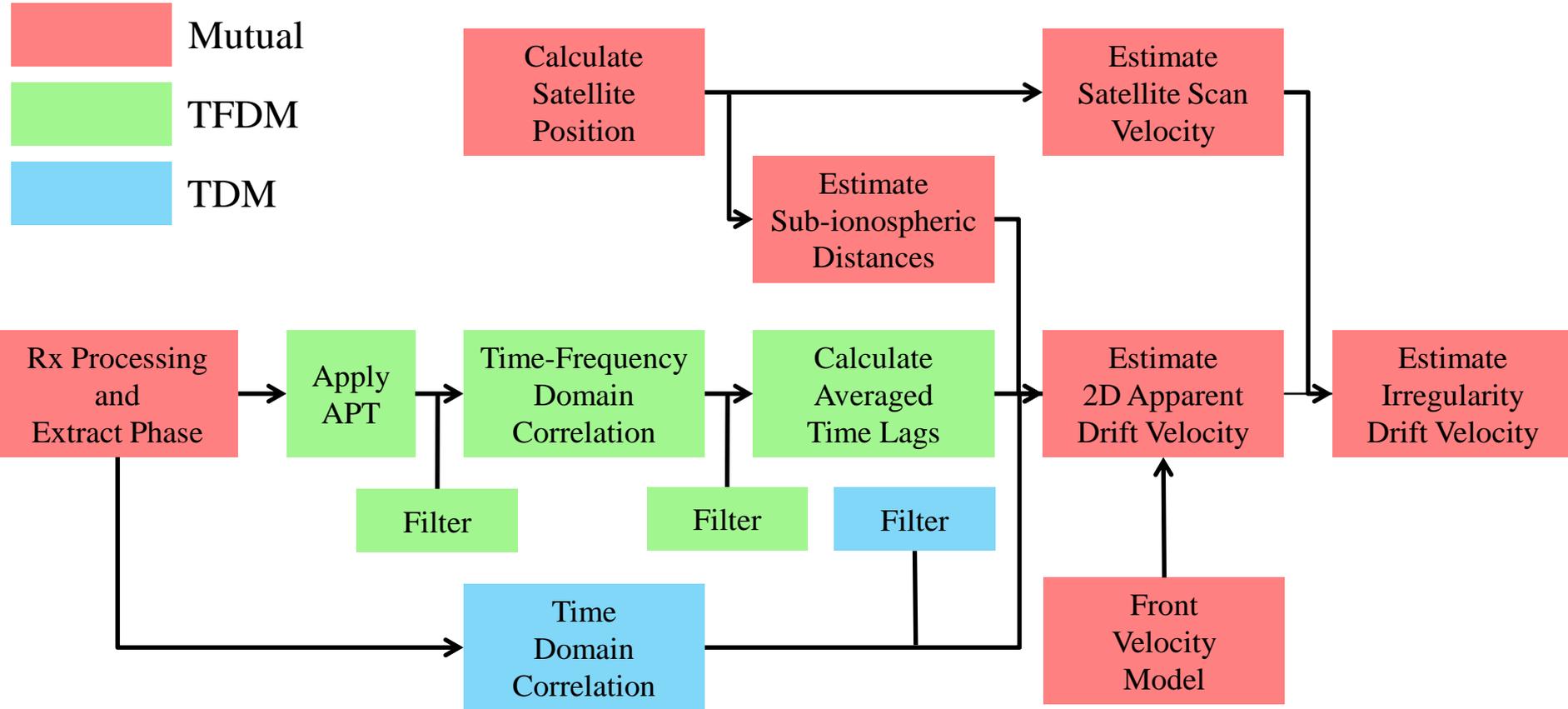
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- Introduction
- Methodology
- Case Study
- TDM vs. TFDM
- PFISR vs. GNSS
- Conclusions

# Methodology: Illustration



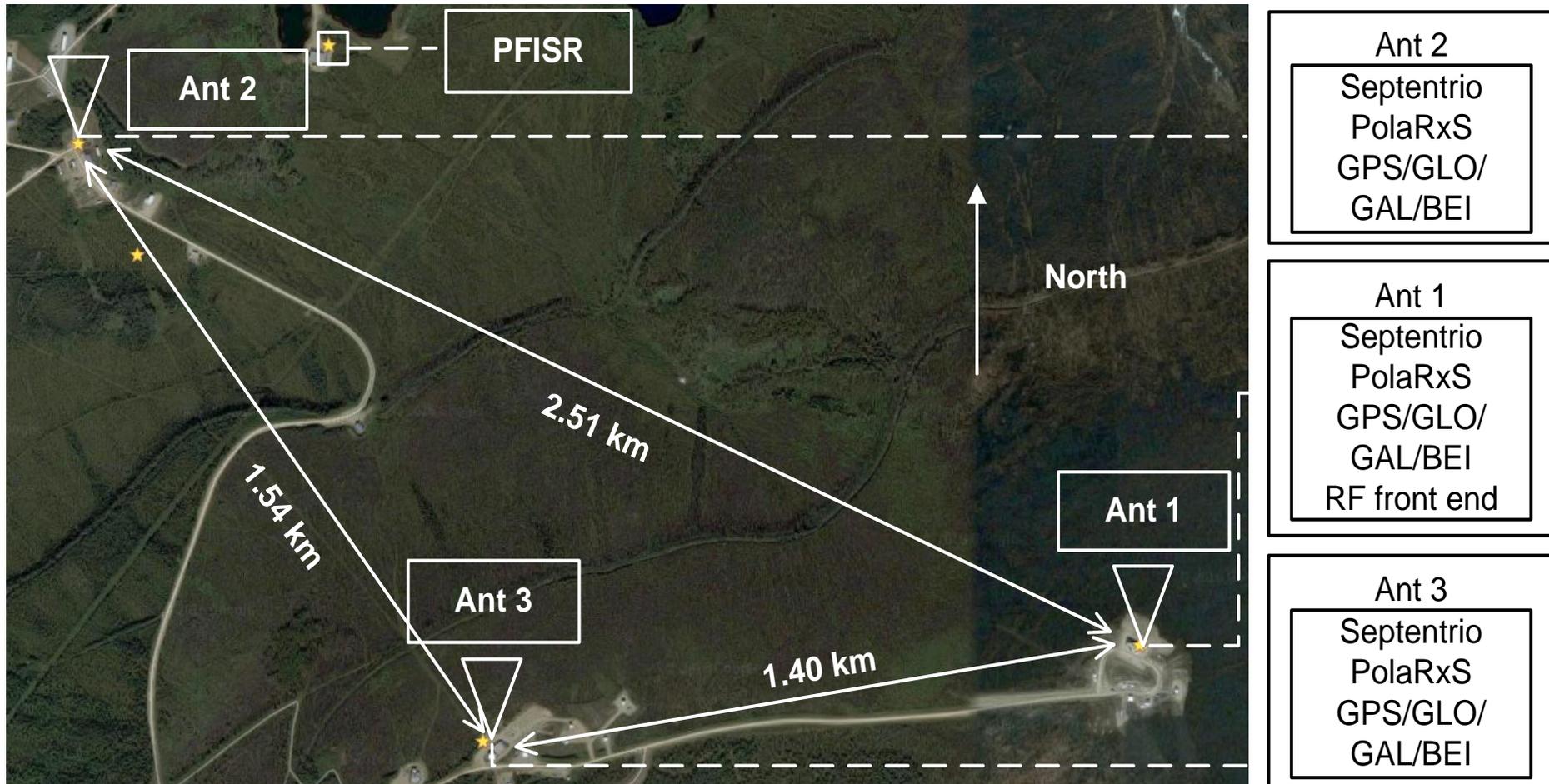
# Methodology: Block Diagram



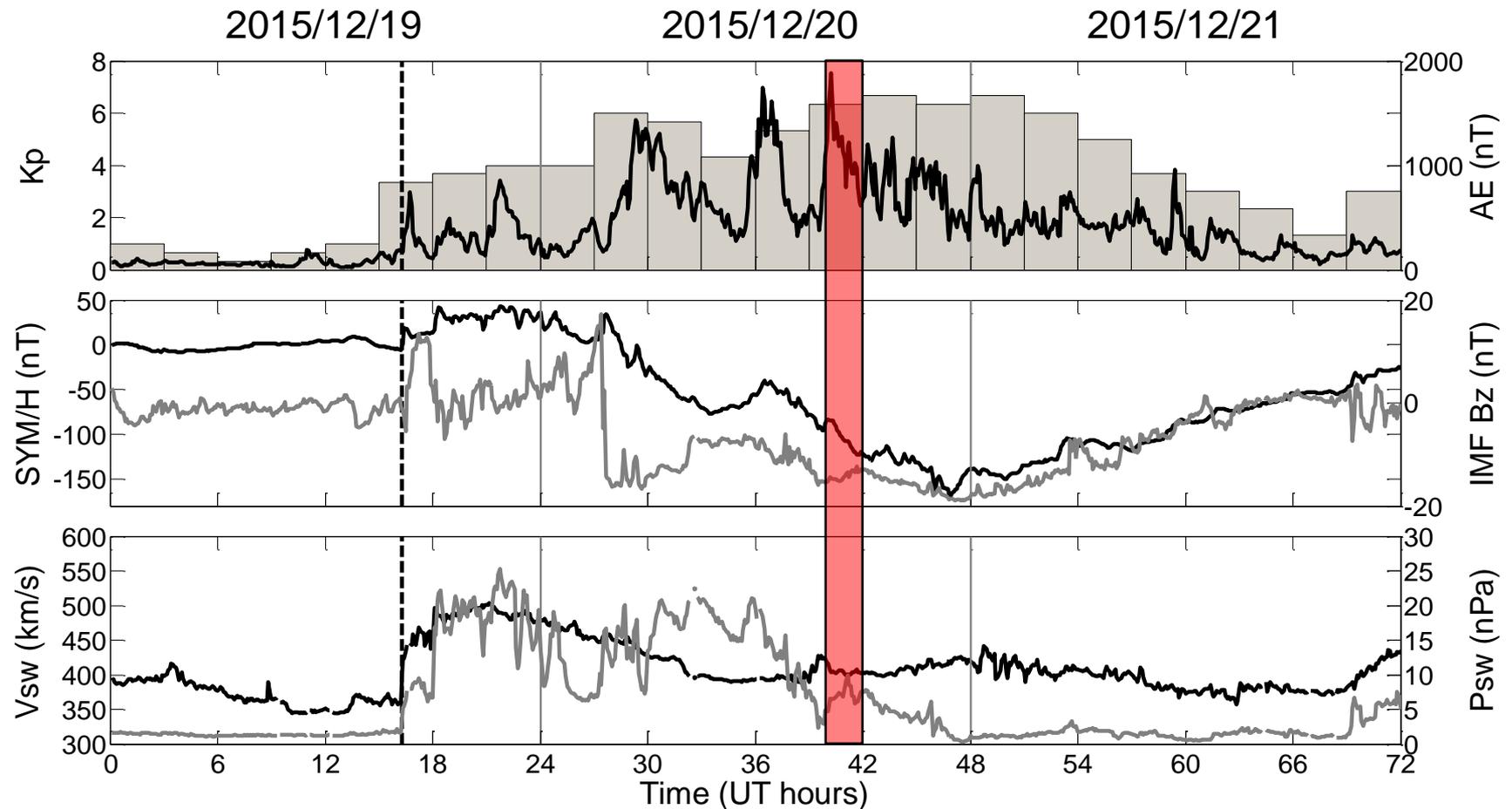
Wang, J., and Morton, Y. T. (2015). High-Latitude Ionospheric Irregularity Drift Velocity Estimation Using Spaced GPS Receiver Carrier Phase Time-Frequency Analysis. *IEEE Transactions on Geoscience and Remote Sensing*, 53(11), 6099-6113

Wang, J., and Morton, Y. T. (2017). A Comparative Study of Ionospheric Irregularity Drift Velocity Derived from a GNSS Receiver Array and PFISR Measurements during High Latitude Ionospheric Scintillation. Minor revision with *Journal of Geophysical Research - Space Physics*

# GNSS System Setup

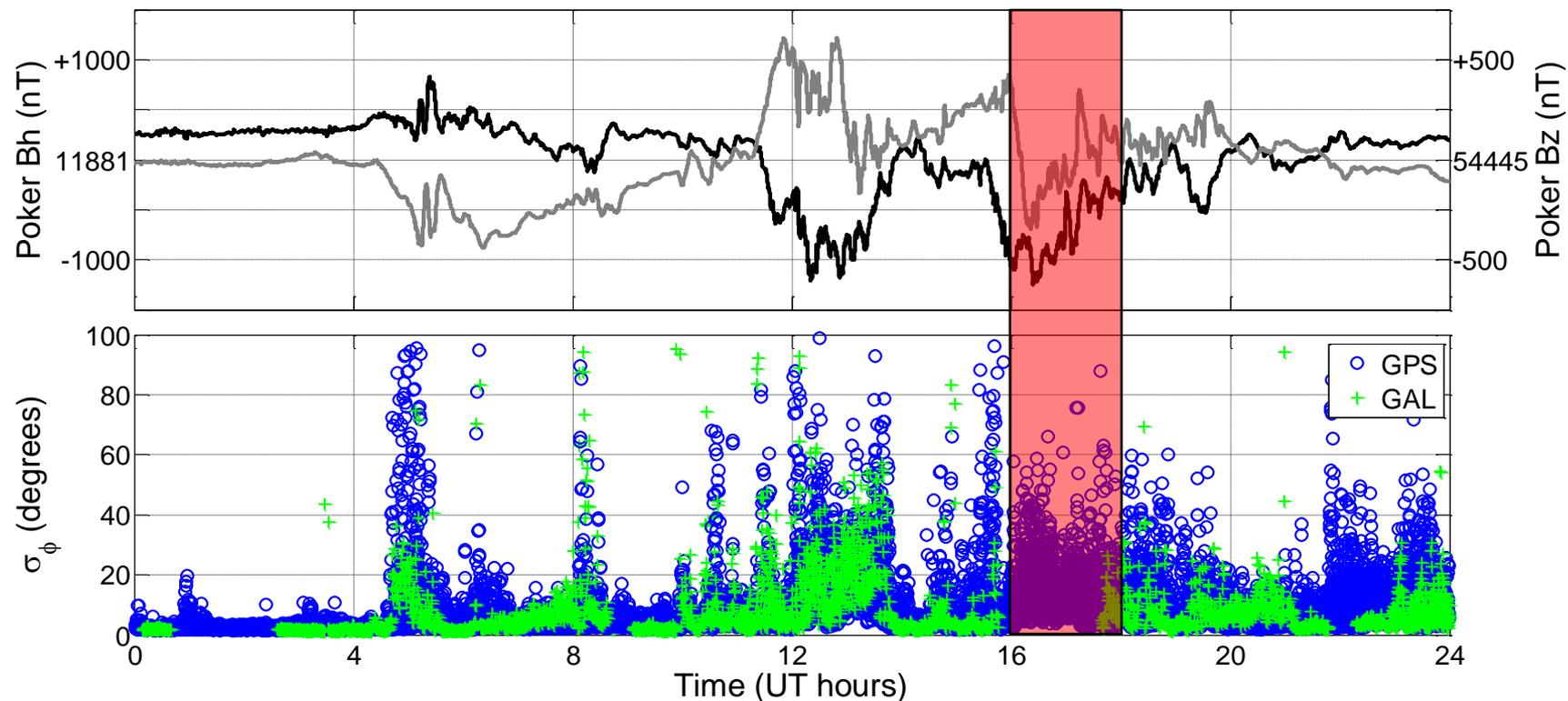


# Case Study: Geomagnetic and IMF Parameters

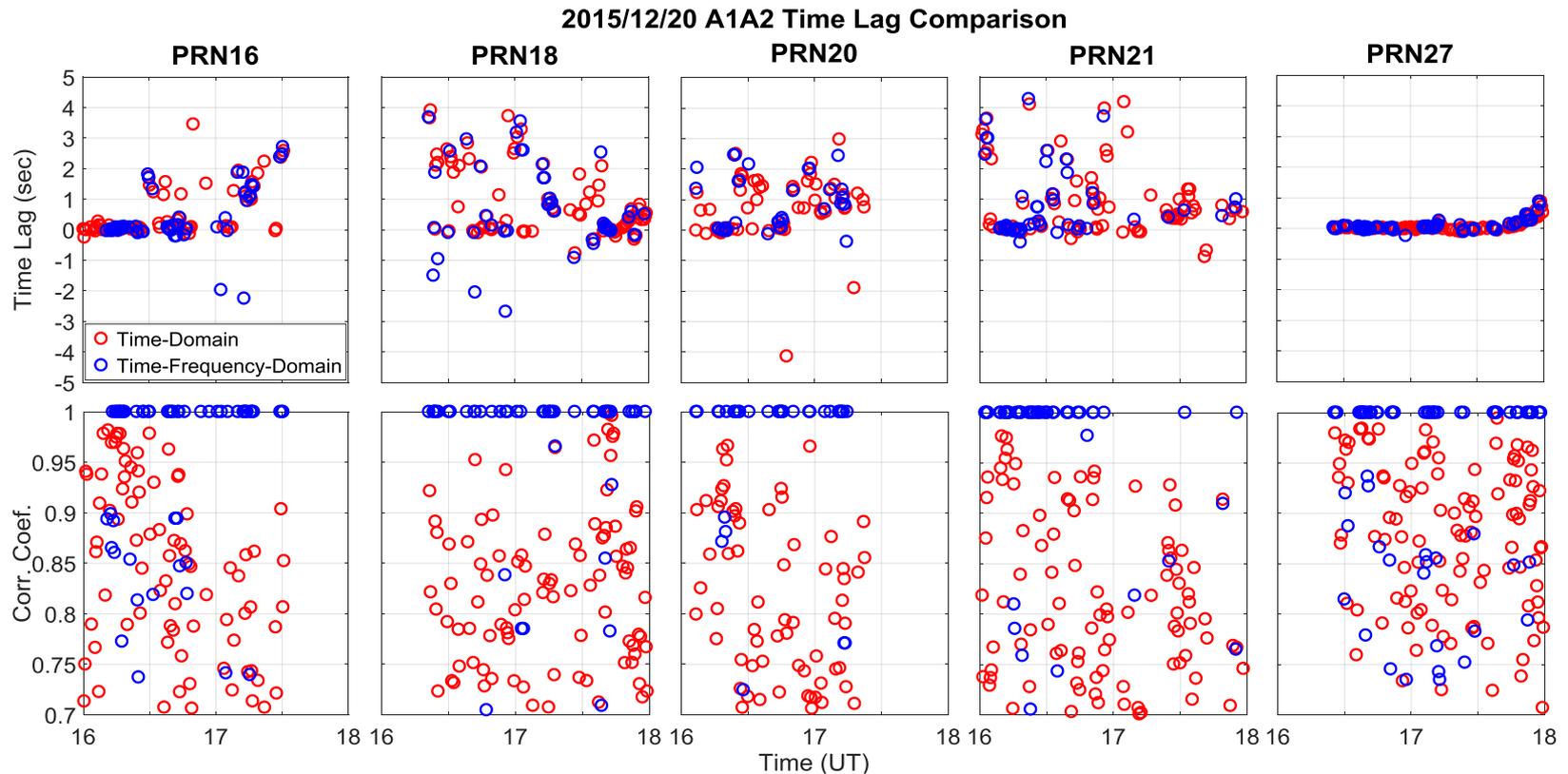


# Case Study: Magnetometer and GNSS $\sigma_\phi$ Measurements

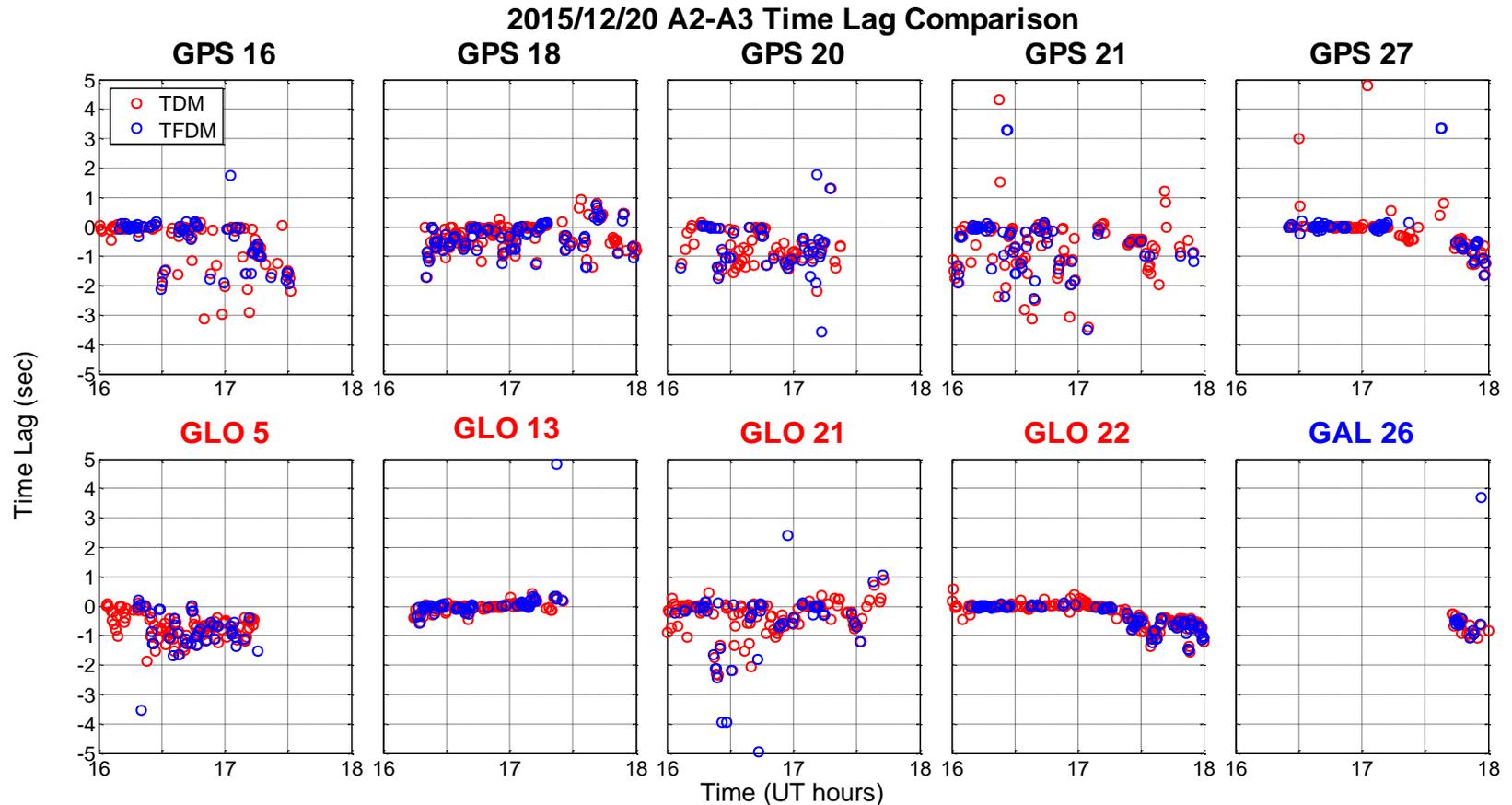
2015/12/20



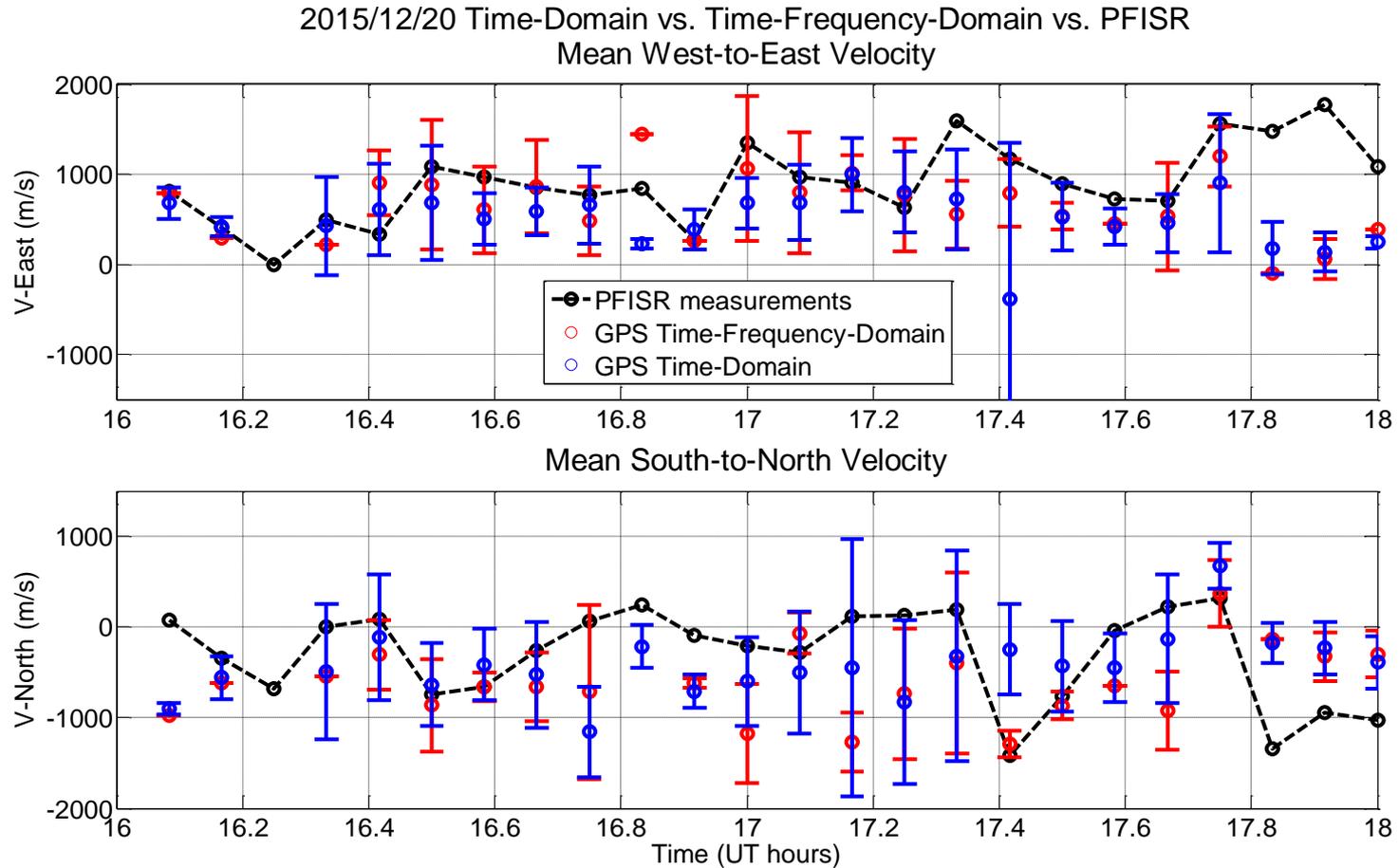
# TDM vs. TFDM: Time Lag Estimations



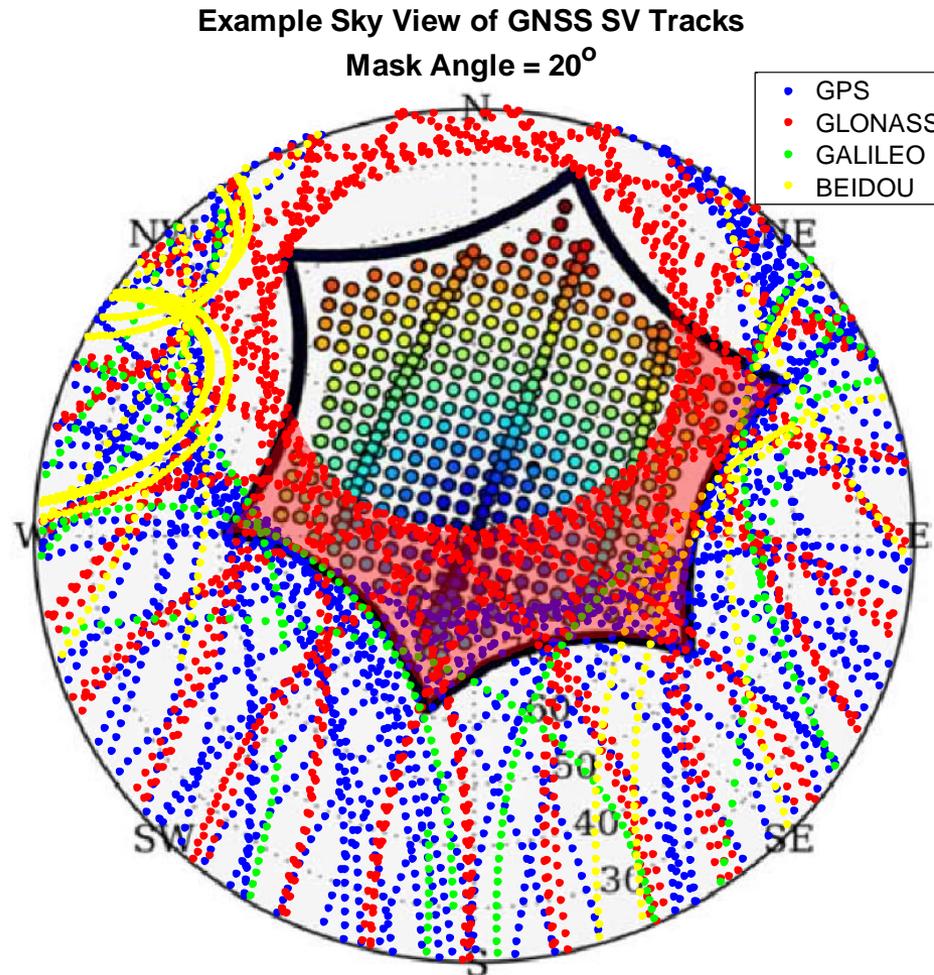
# TDM vs. TFDM: Time Lag Estimations (GNSS)



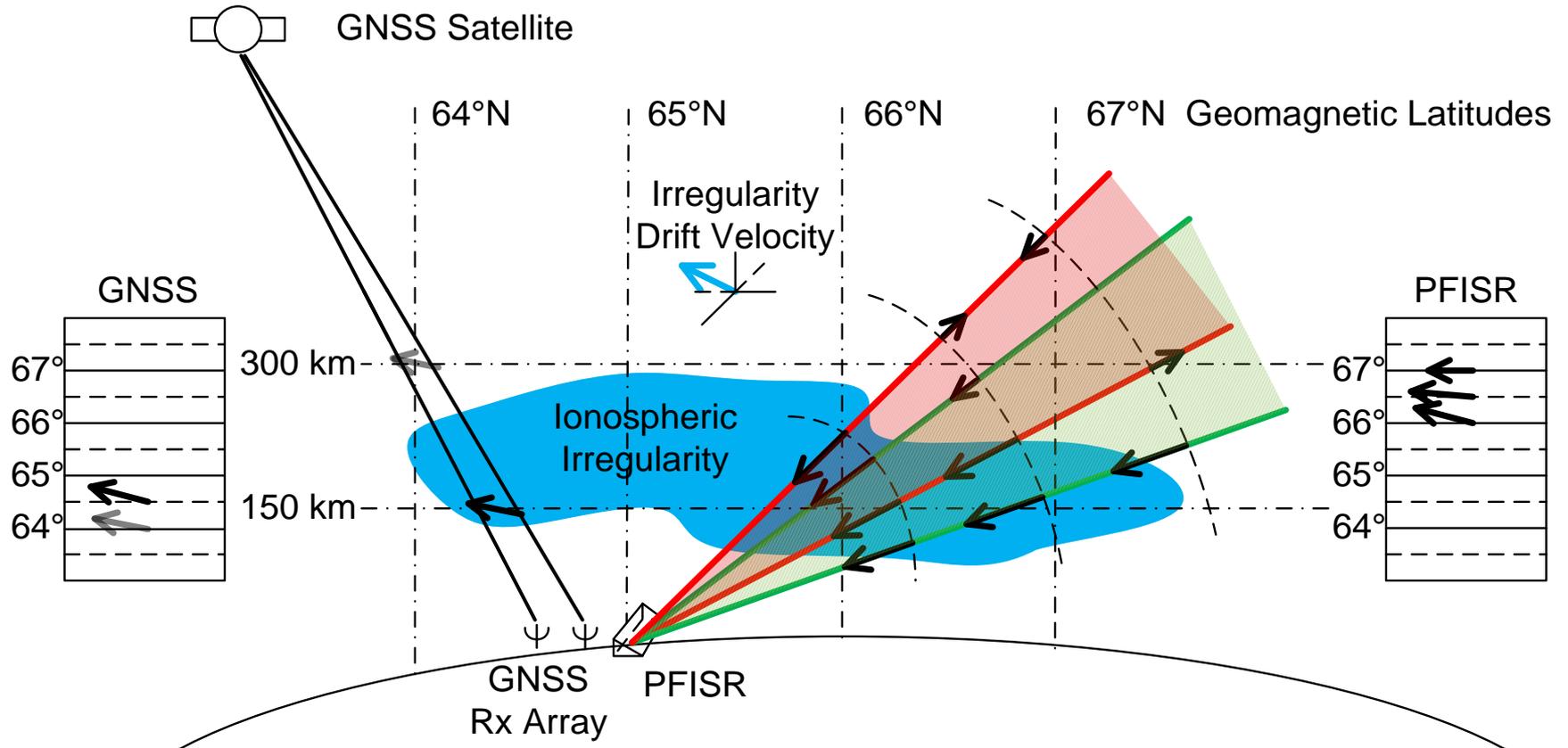
# TDM vs. TFDM: Velocity Estimations



# System Coverages

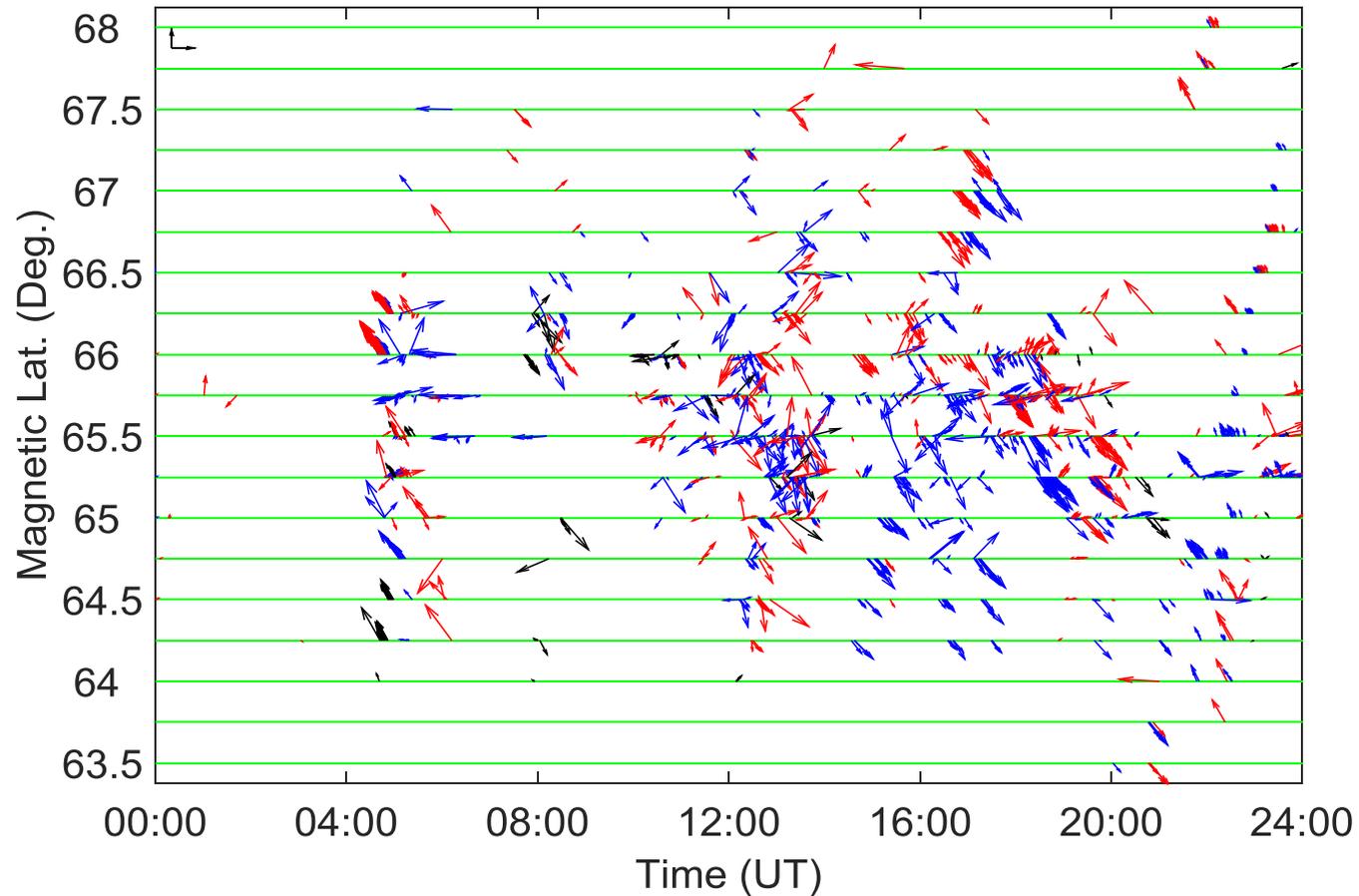


# Drift Velocity Estimation Schemes: PFISR vs. GNSS

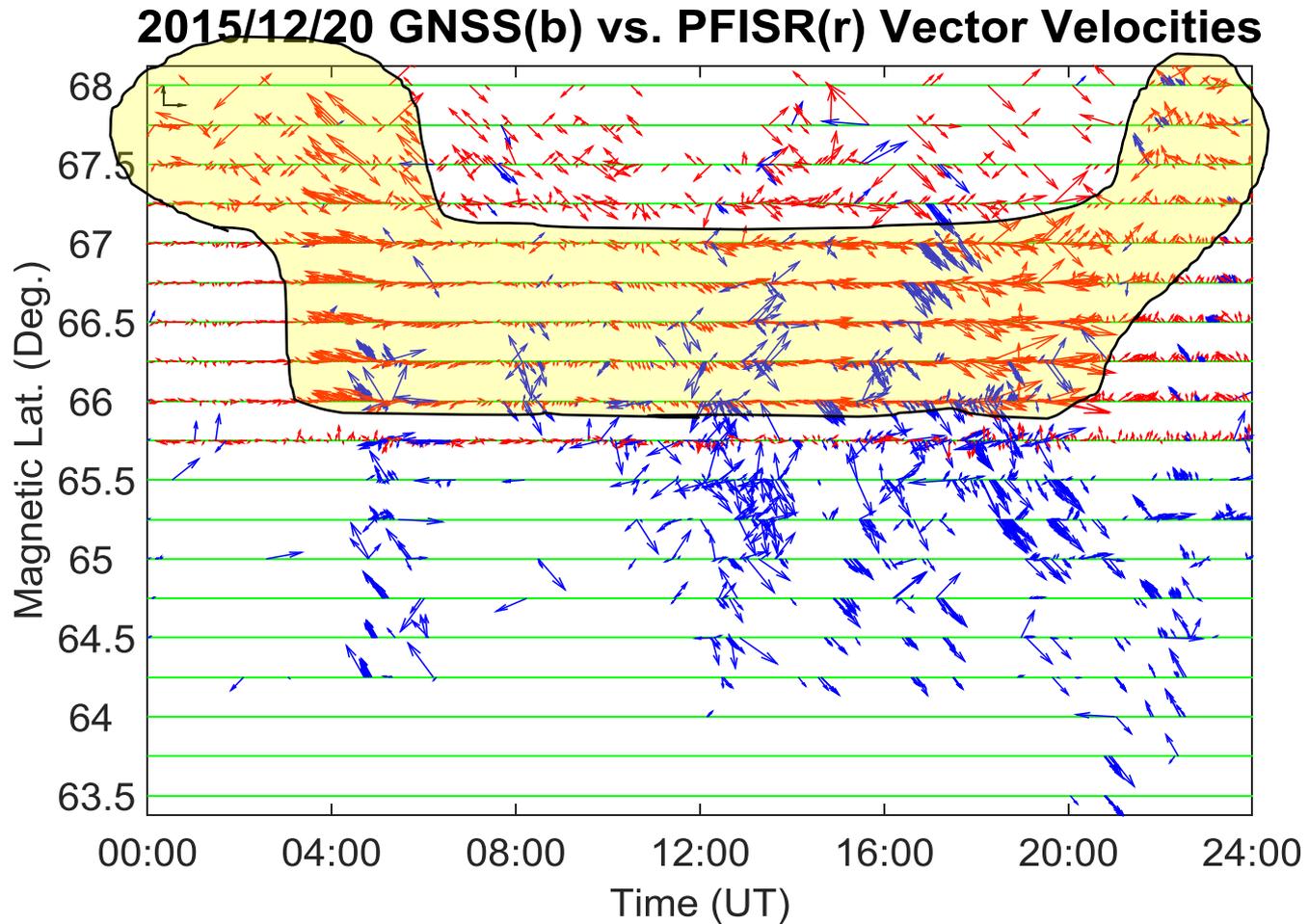


# GNSS: Projected Vector Velocities

2015/12/20 GPS(b) vs. GLO(r) vs. GAL(k) Vector Velocities

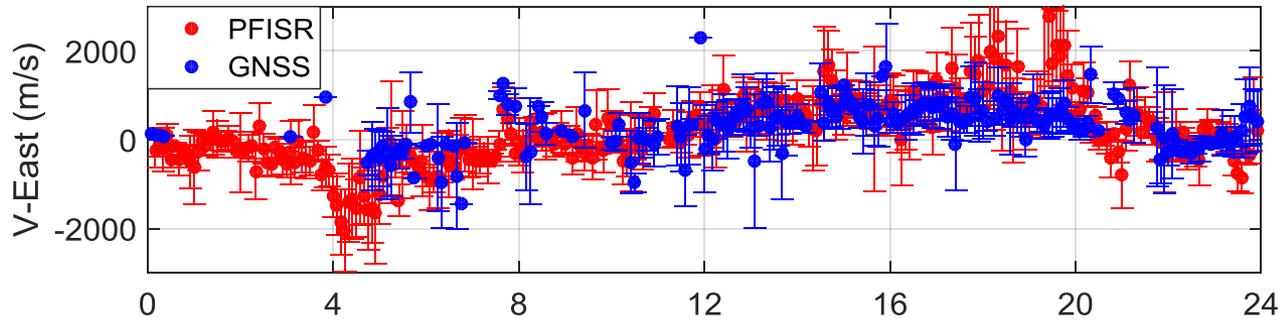


# PFISR vs. GNSS: Vector Velocities

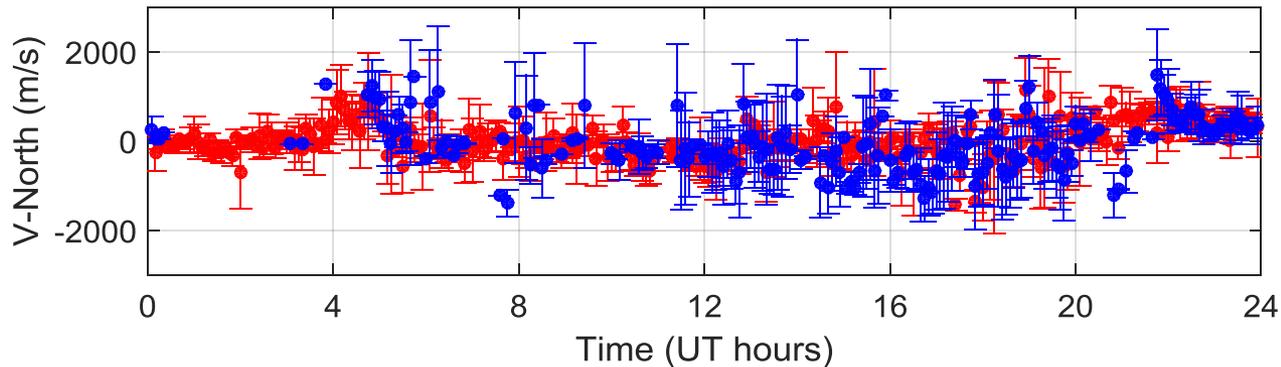


# PFISR vs. GNSS: Mean and Standard Deviations

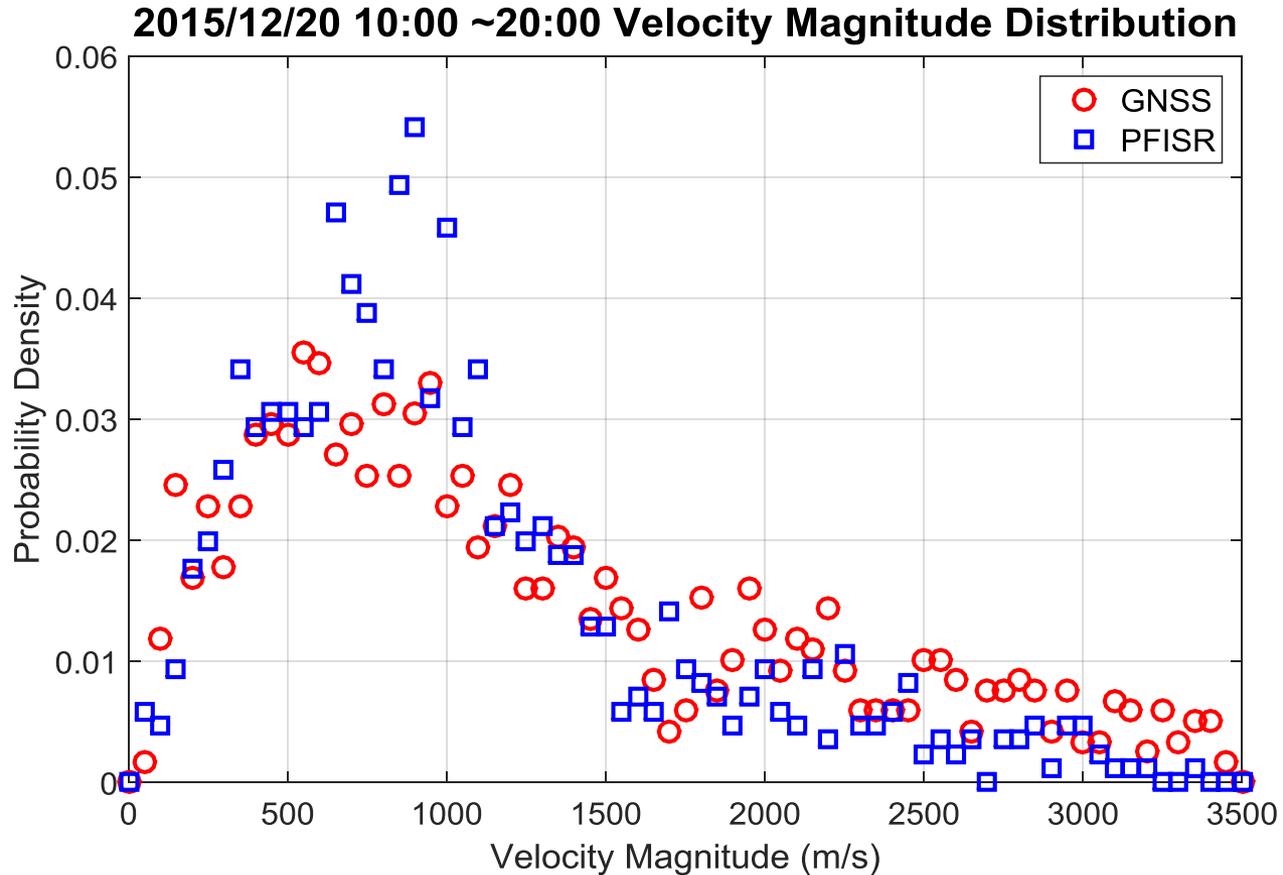
2015/12/20 PFISR vs. GNSS Mean Drift Velocities  
Mean West-to-East Velocity



Mean South-to-North Velocity



# PFISR vs. GNSS: Velocity Magnitude Distribution



# Conclusions

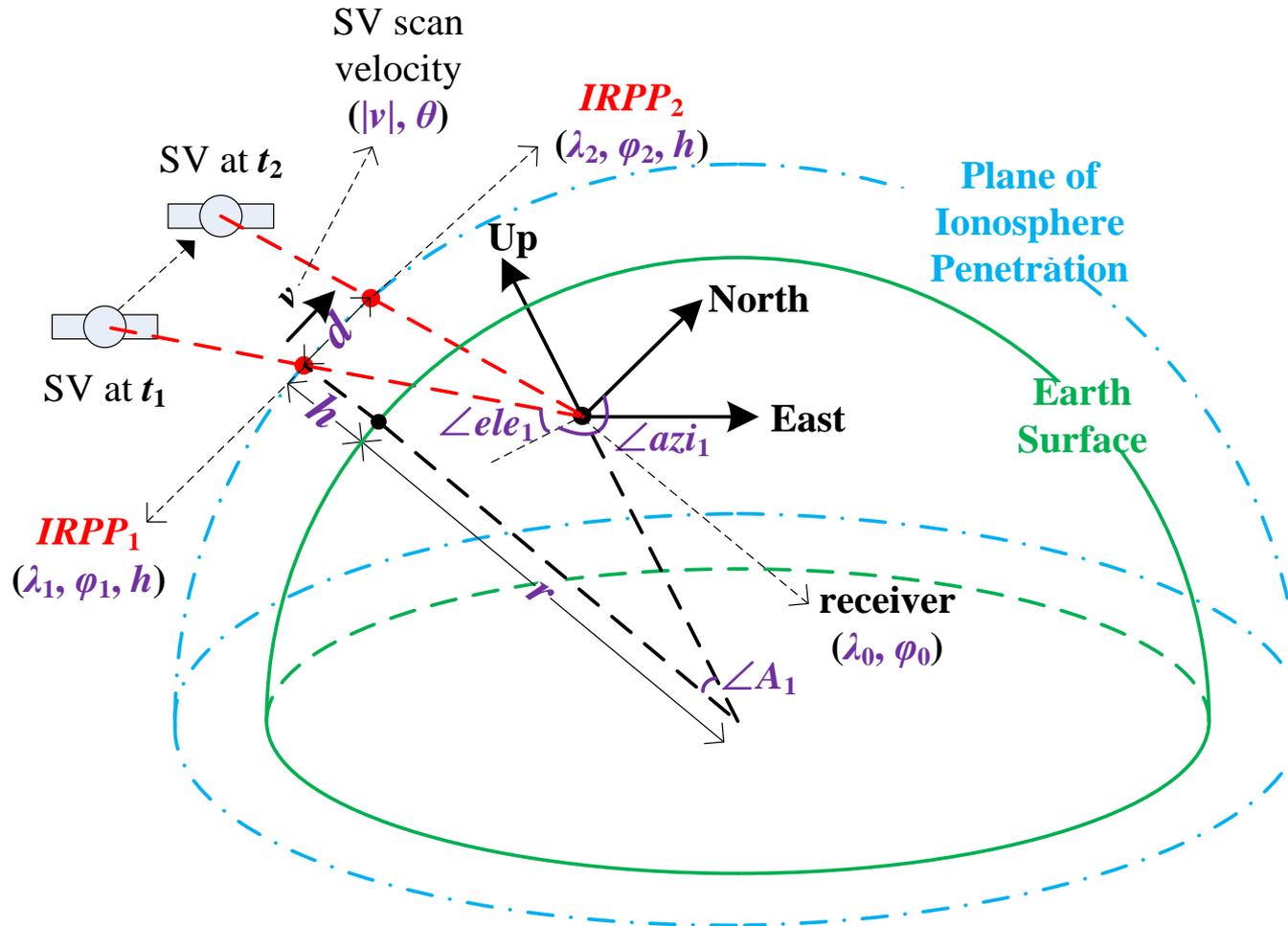
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- GNSS phase measurements can be used for drift velocity estimation from a spaced-receiver array during high latitude scintillation
- Overall, TDM and TFDM demonstrate good agreement
- The TFDM exhibits slightly better consistency and reliability over the TDM due to spectral filtering
- Cross-Comparison between the GNSS array and the PFISR is favourable
- GNSS and PFISR can be used to compliment each other

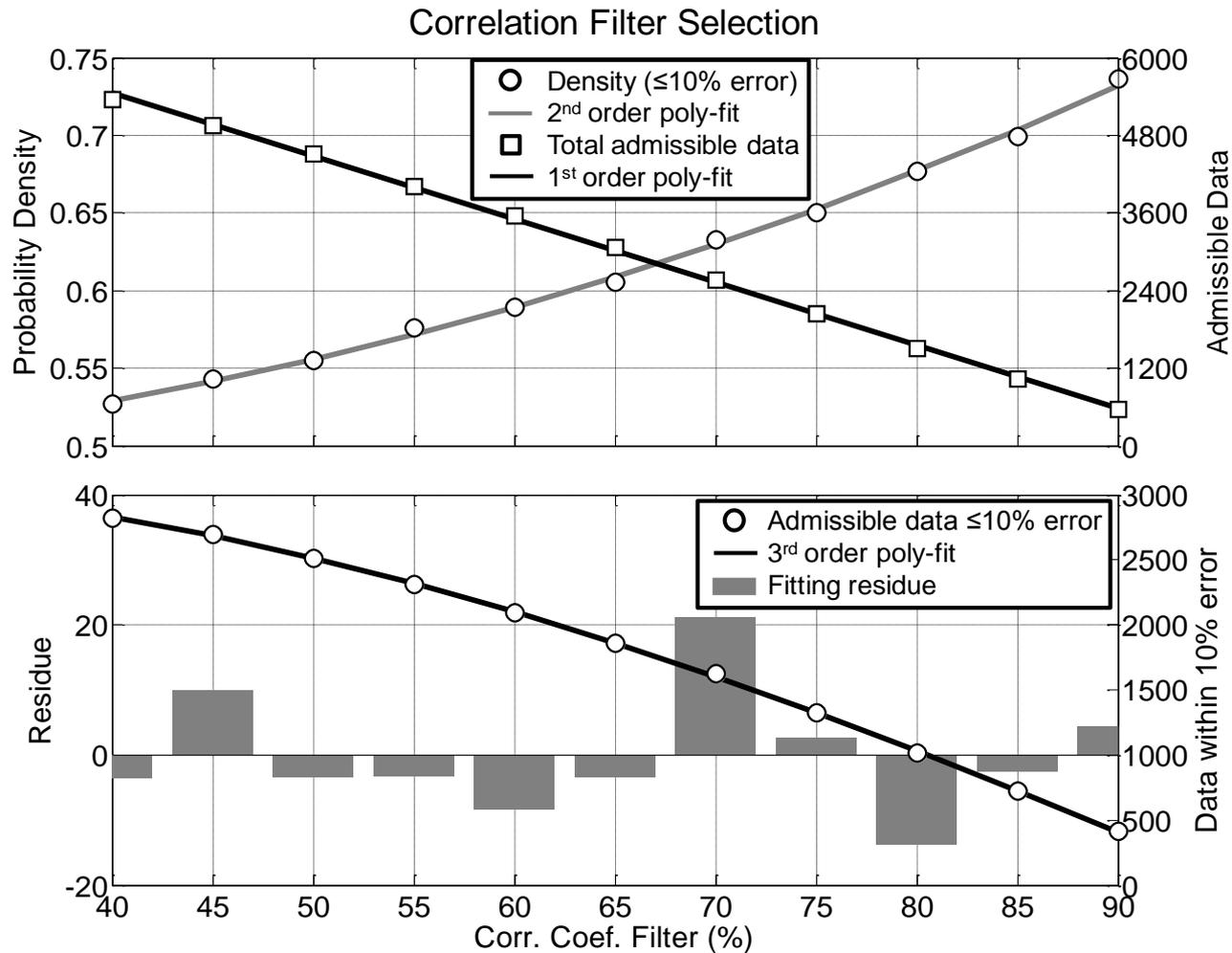
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Thank you  
and  
Questions?

# Satellite Scan Velocity Estimation



# TDM Correlation Filter Selection

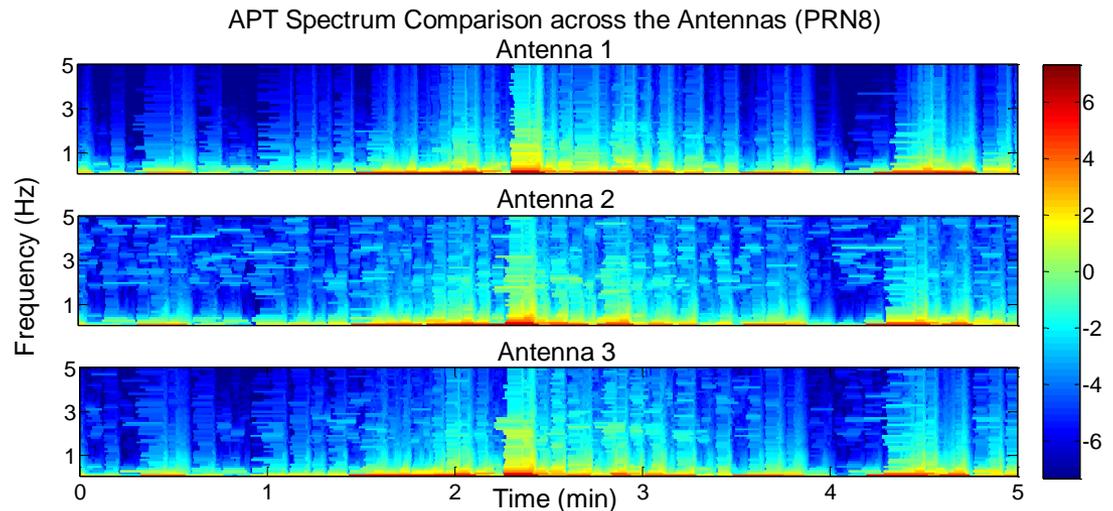
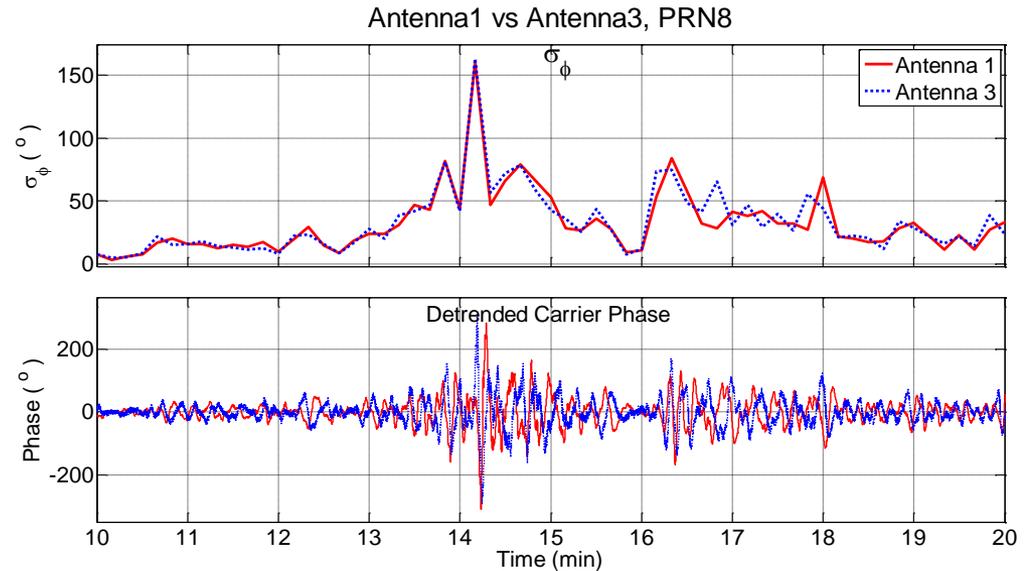


# Extract Phase and Apply APT

Detrended Carrier  
Phase Measurement

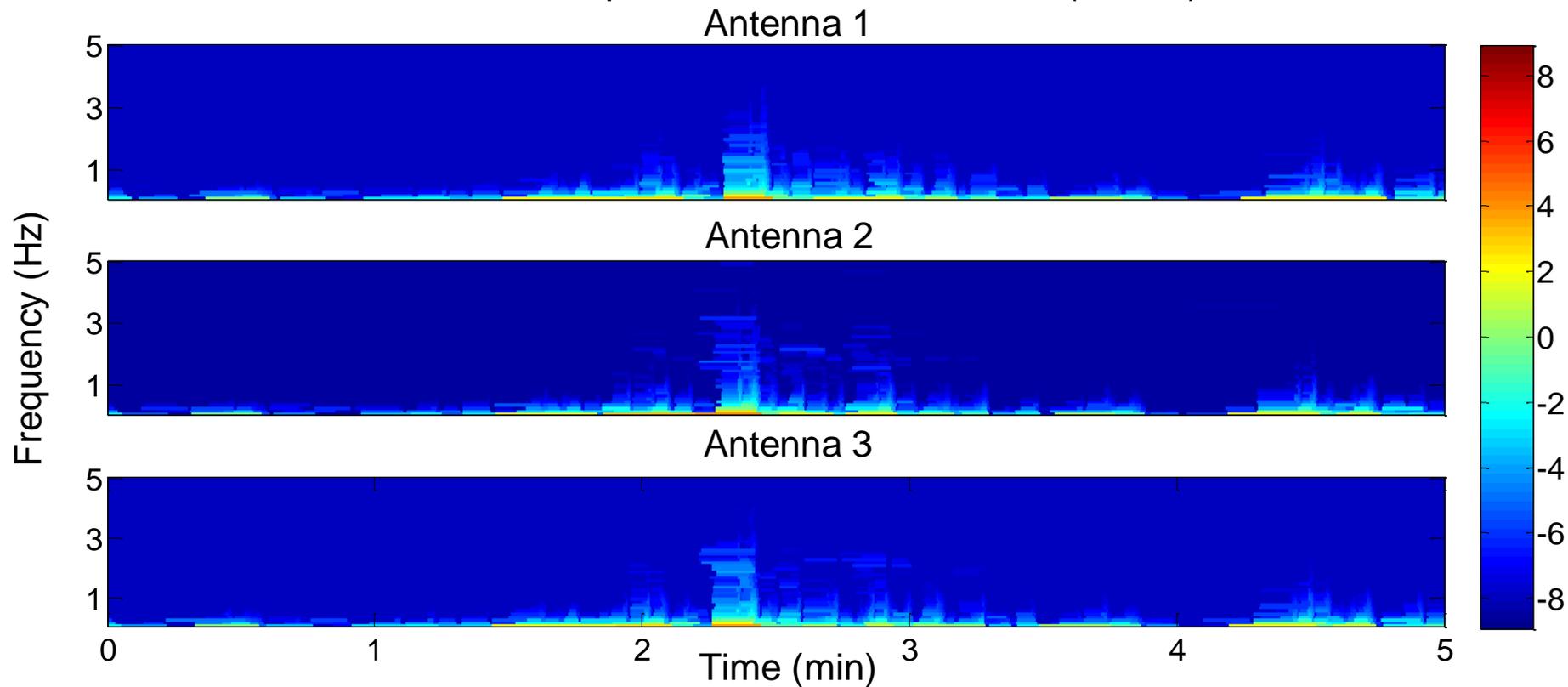


APT Spectrum



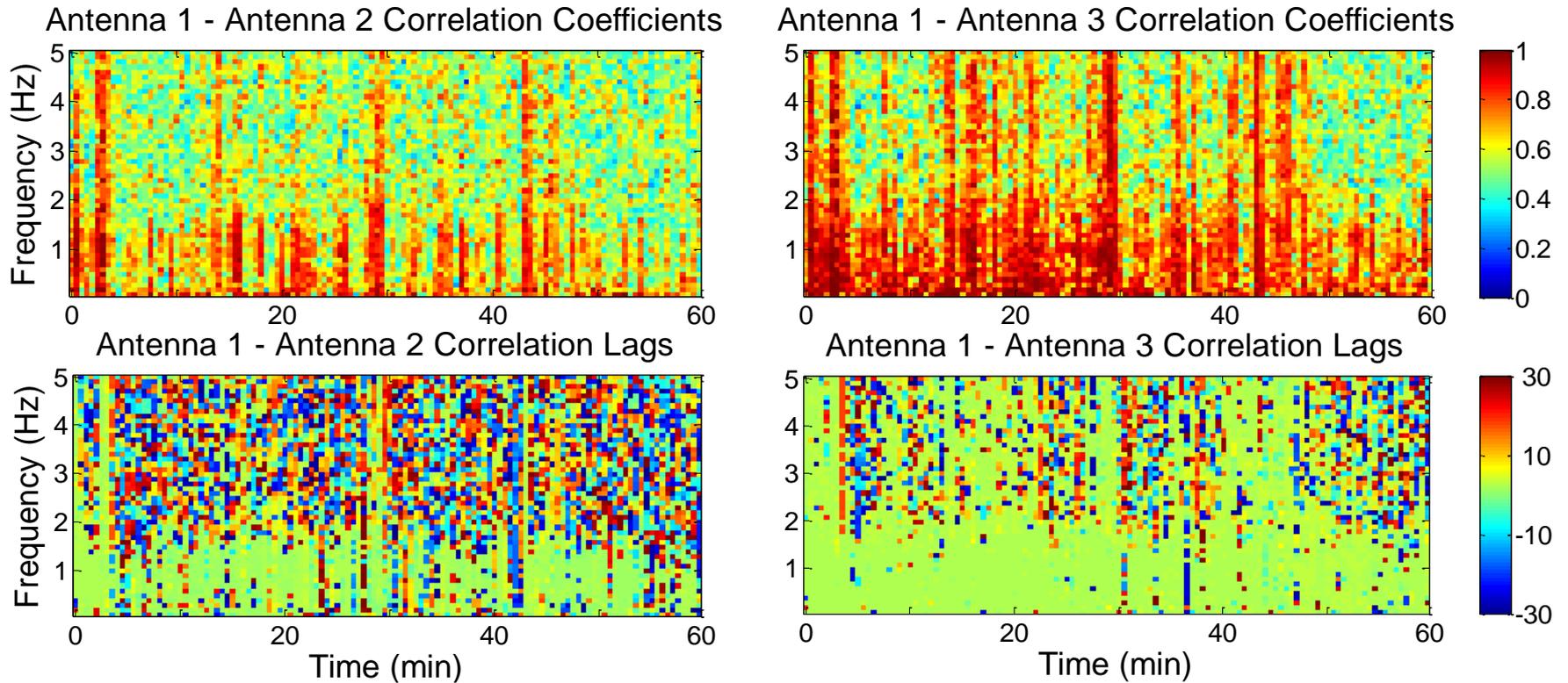
# APT Spectral Filtering

Filtered APT Spectra across the Antennas (PRN 8)



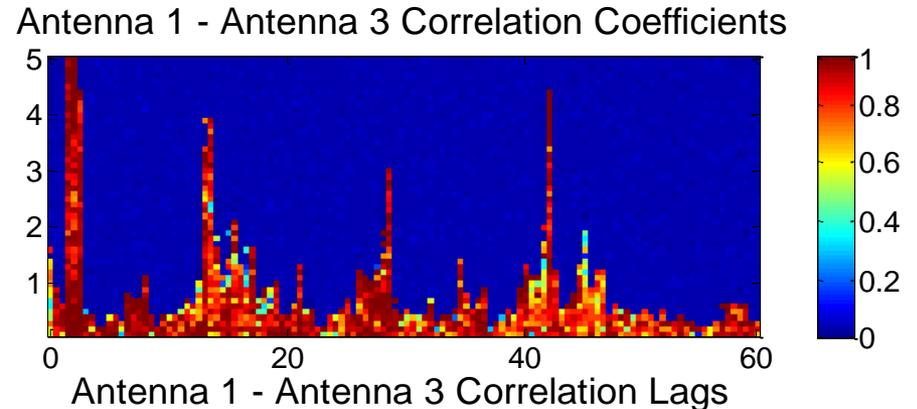
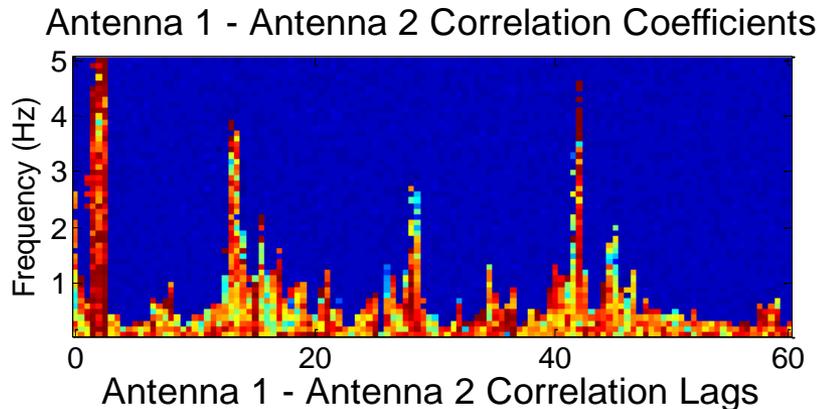
# Spectral Domain Correlation

Raw Correlation Results on PRN 8 (Correlation Time = 30 sec)



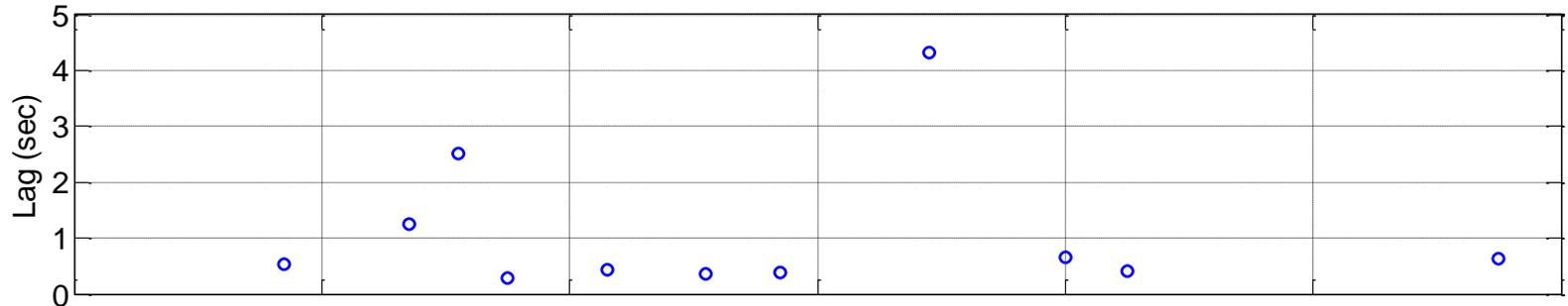
# More Spectral Filtering

Filtered Correlation Results on PRN 8 (Correlation Time = 30 sec)



# Averaged Time Lag Calculation

Averaged Lag Estimation, PRN 8  
Antenna 1 - Antenna 2, coefficient threshold = 0.9



Antenna 1 - Antenna 3, coefficient threshold = 0.9

