High-latitude & Equatorial Ionospheric Scintillation Based on An **Event-Driven Multi-GNSS** Data Collection System

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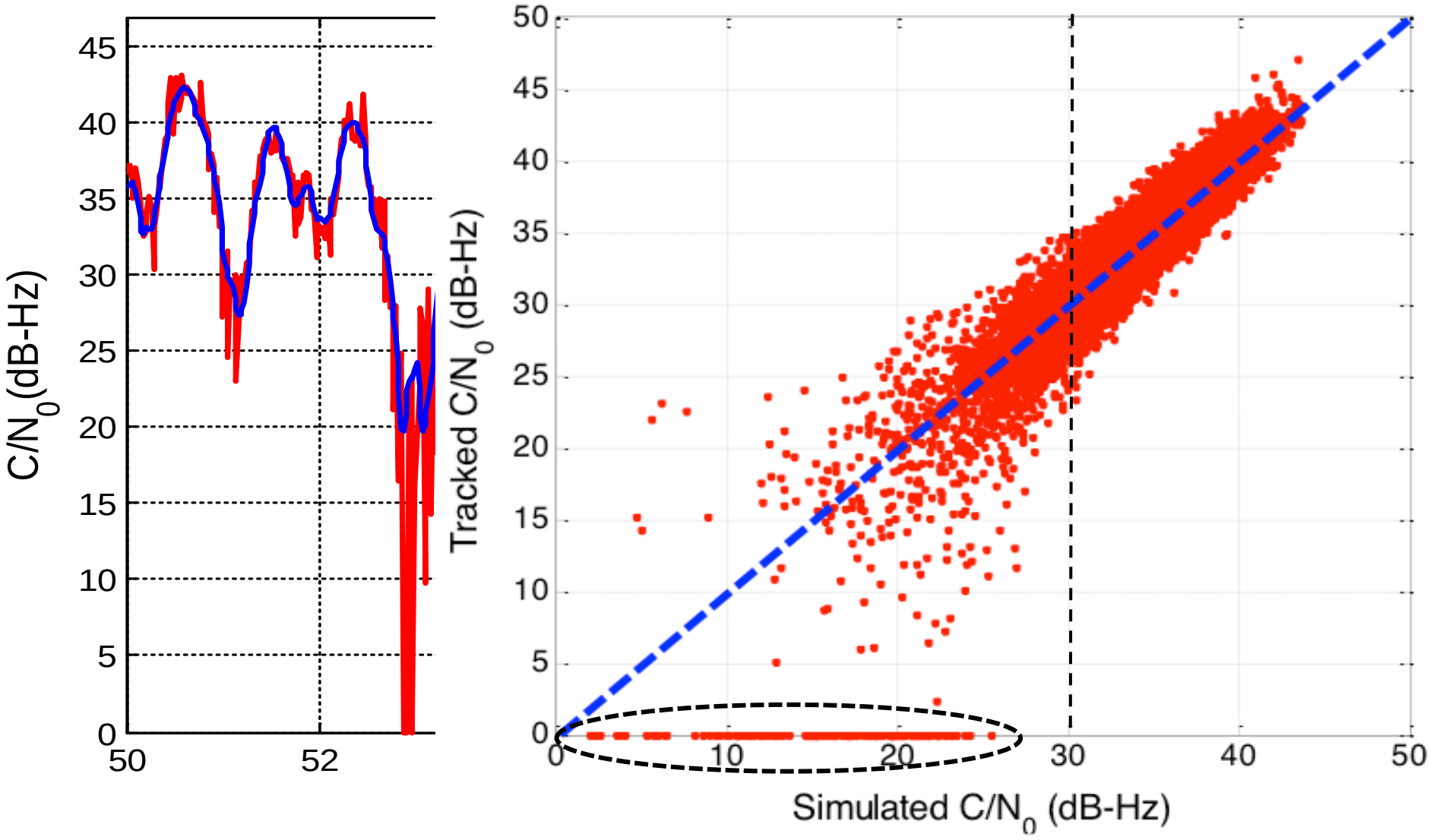
Outline

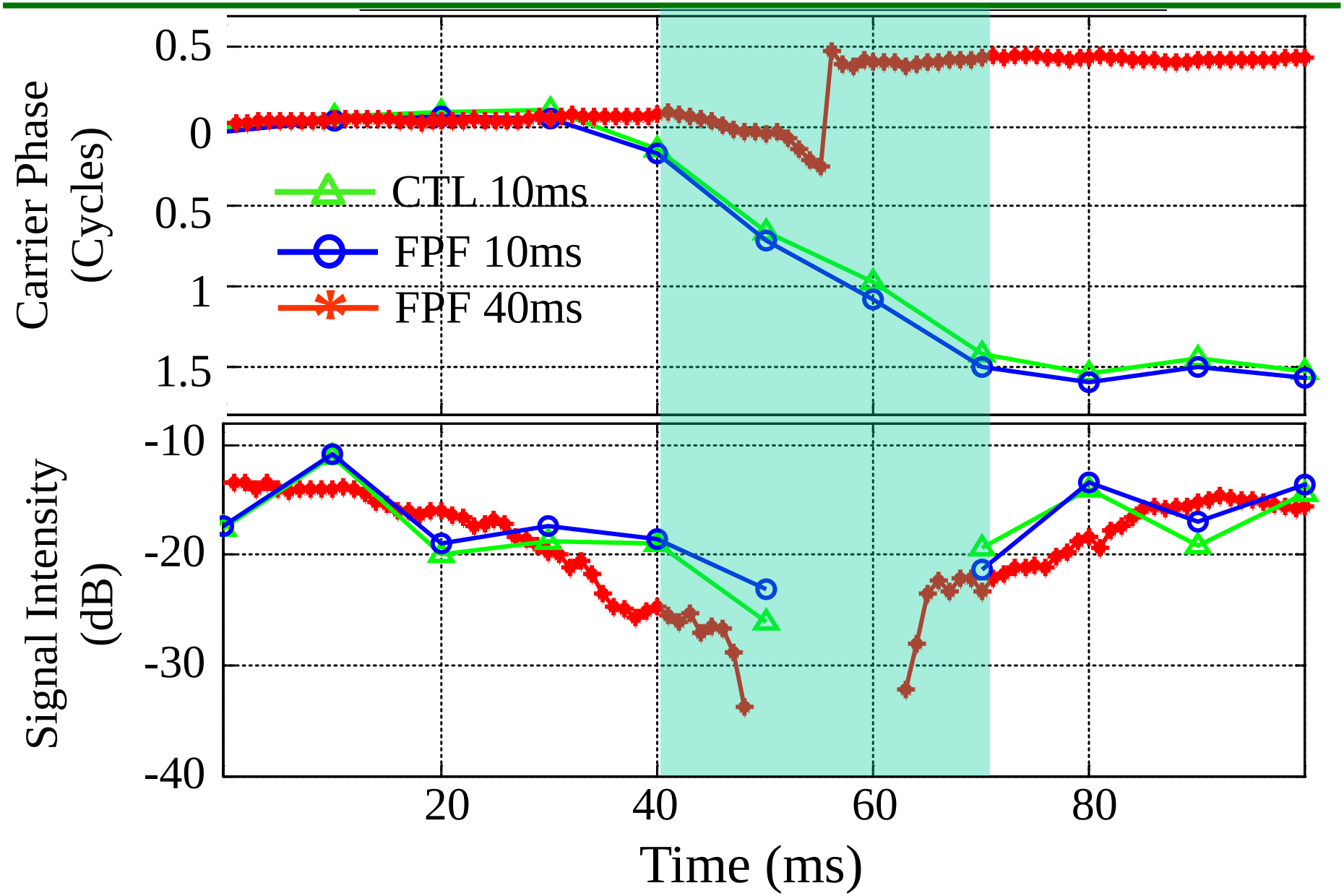
1. Why Event-Driven Multi-GNSS ?

1. Sample High-Lat & Equatorial Results

Amplitude Fading: Receiver Processing Artifacts



GPS Carrier Phase During Deep Fading: An Example



Issues: Conventional ISM Receivers

1. Accuracy

$$(Iono + other) \otimes h(t) = Observed\ Effects$$

$$Iono\ \text{effects} \neq Observed\ Effects$$

2. Availability

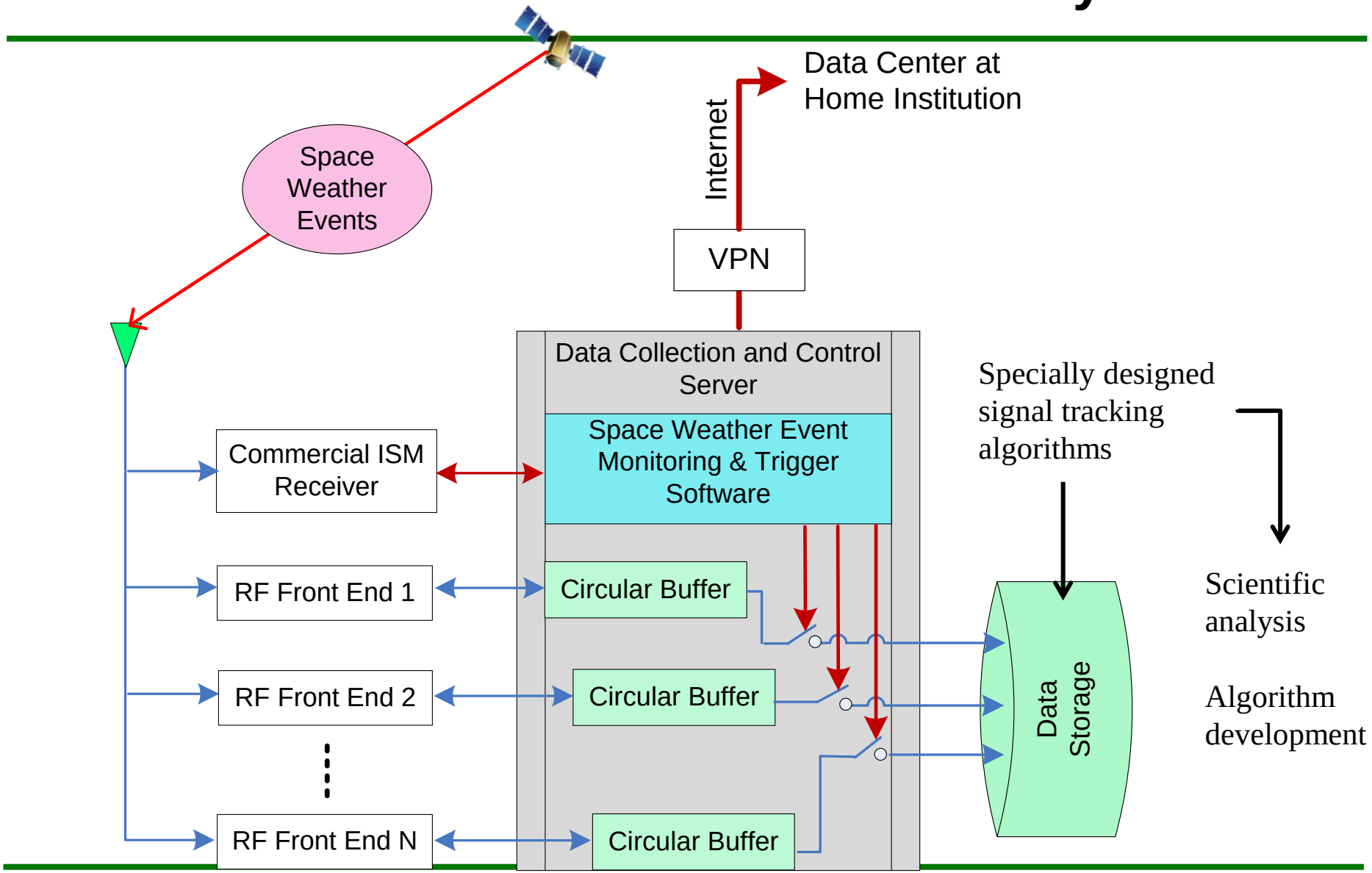
Receivers cease to function during strong space weather events → Data are not available when needed most!

3. Repeatability

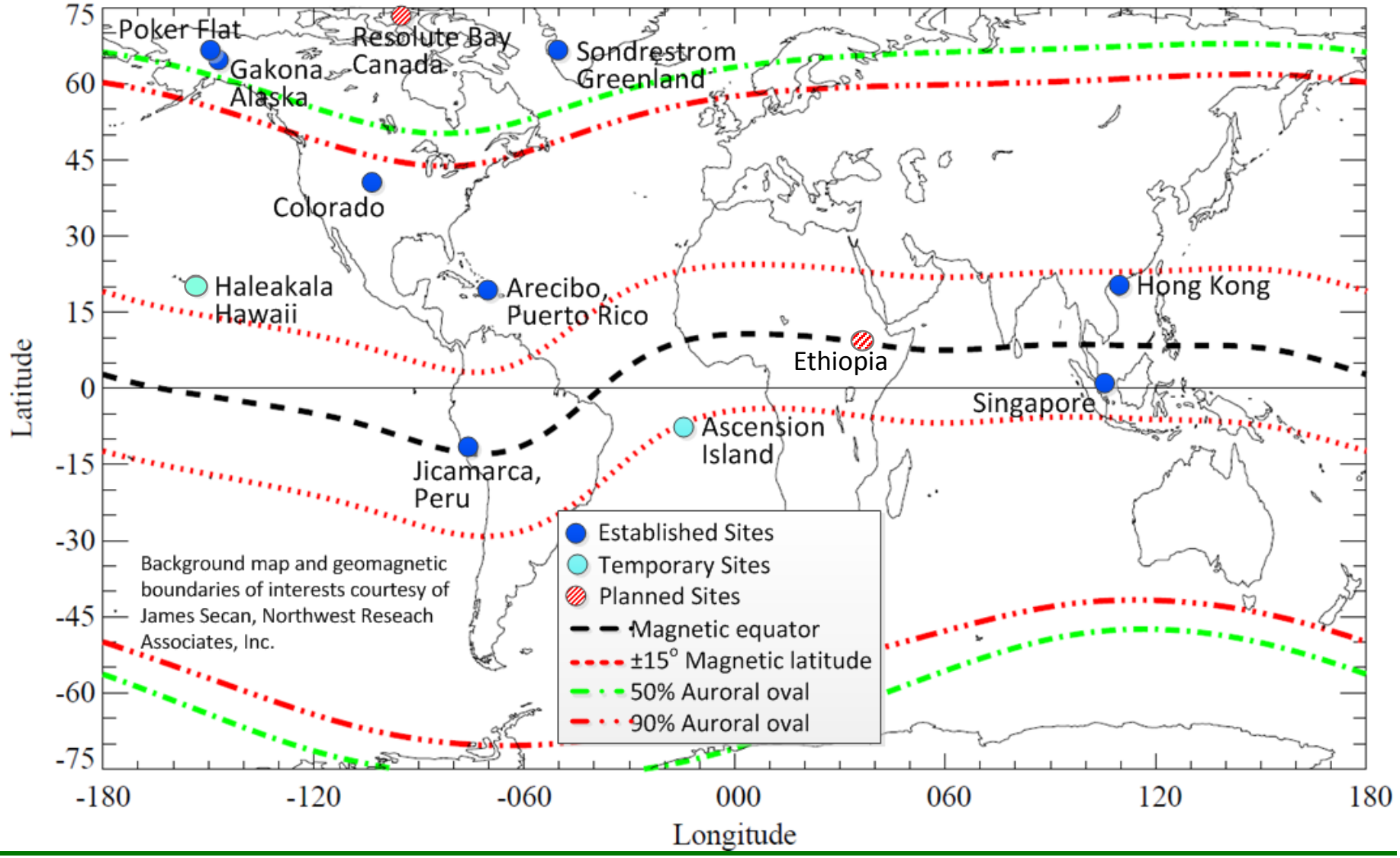
Receiver processing is irreversible → Ionosphere effects are wiped out during processing

High quality, raw GNSS signals are needed for space weather studies and robust GNSS receiver development

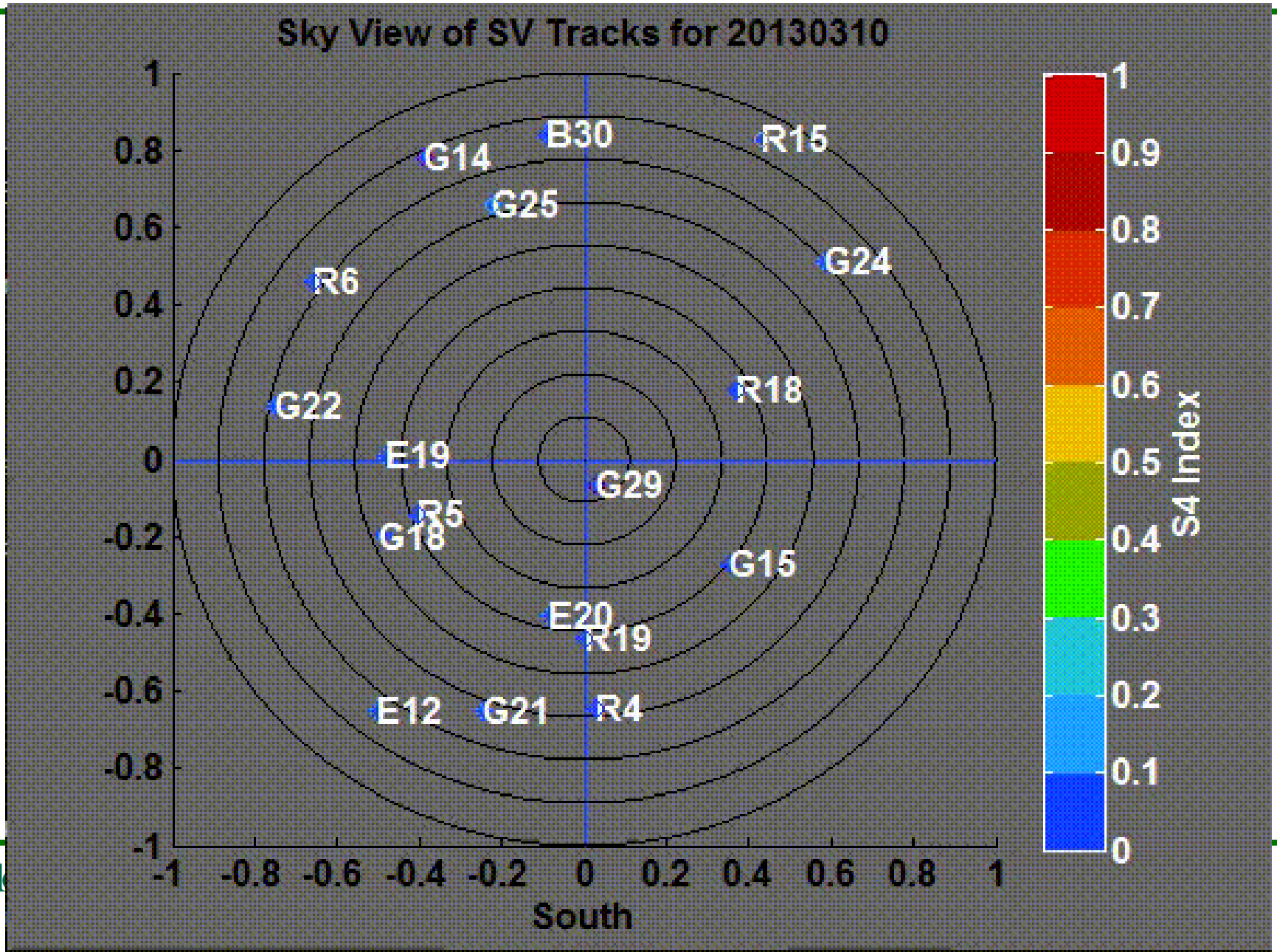
Event Driven Raw Data Collection System



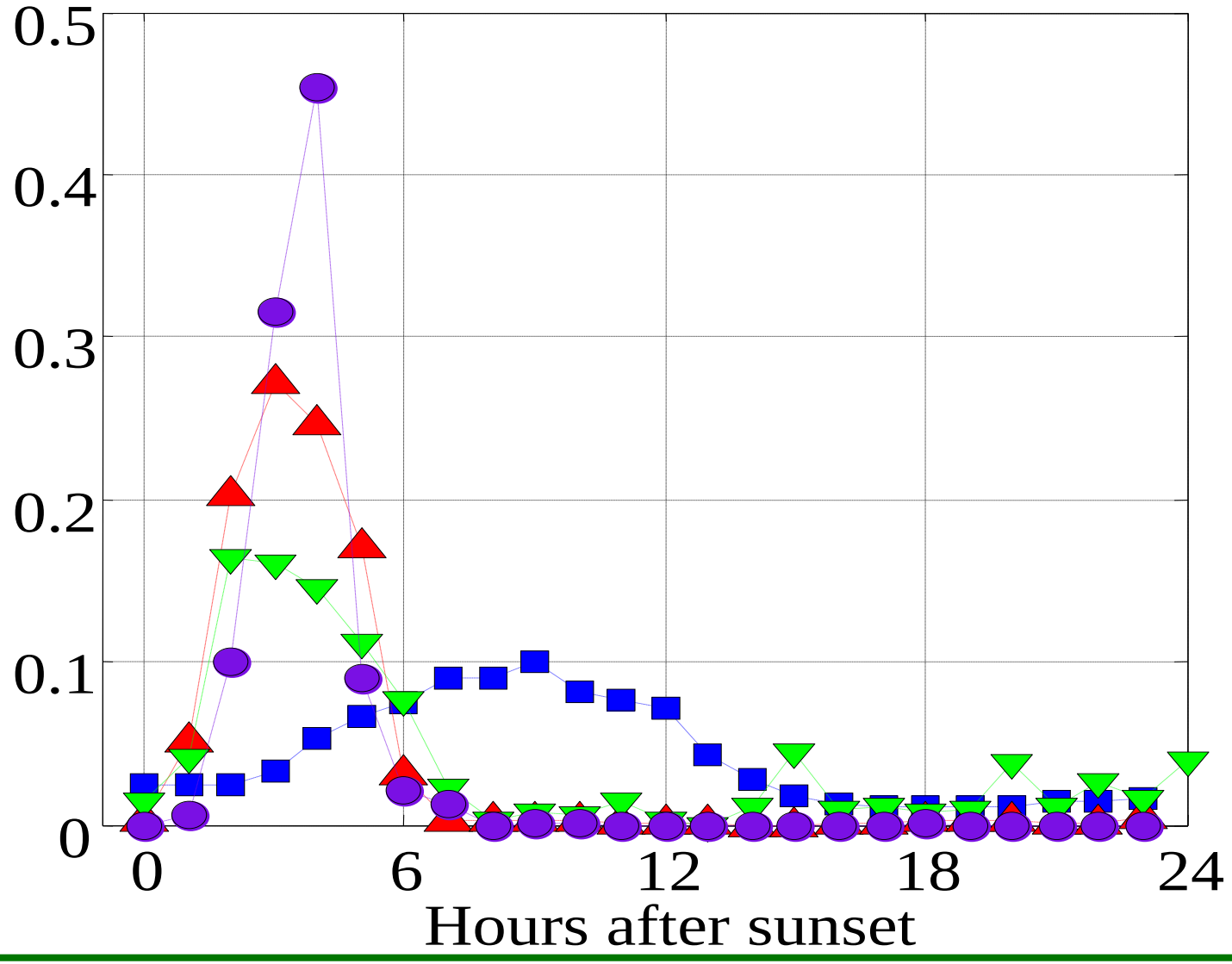
Event-Driven Multi-Constellation GNSS Network



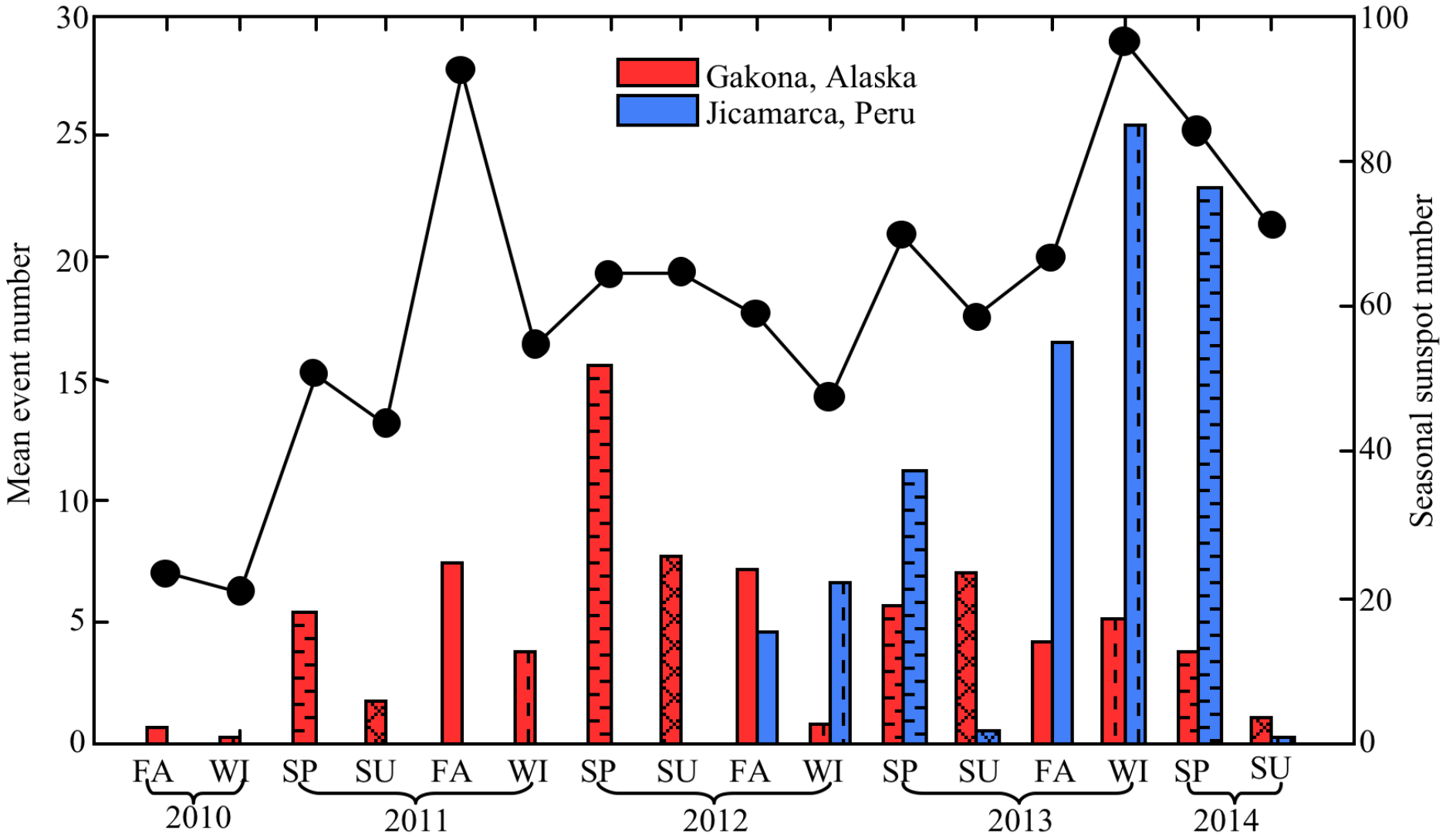
Equatorial Scintillation Spatial Distribution



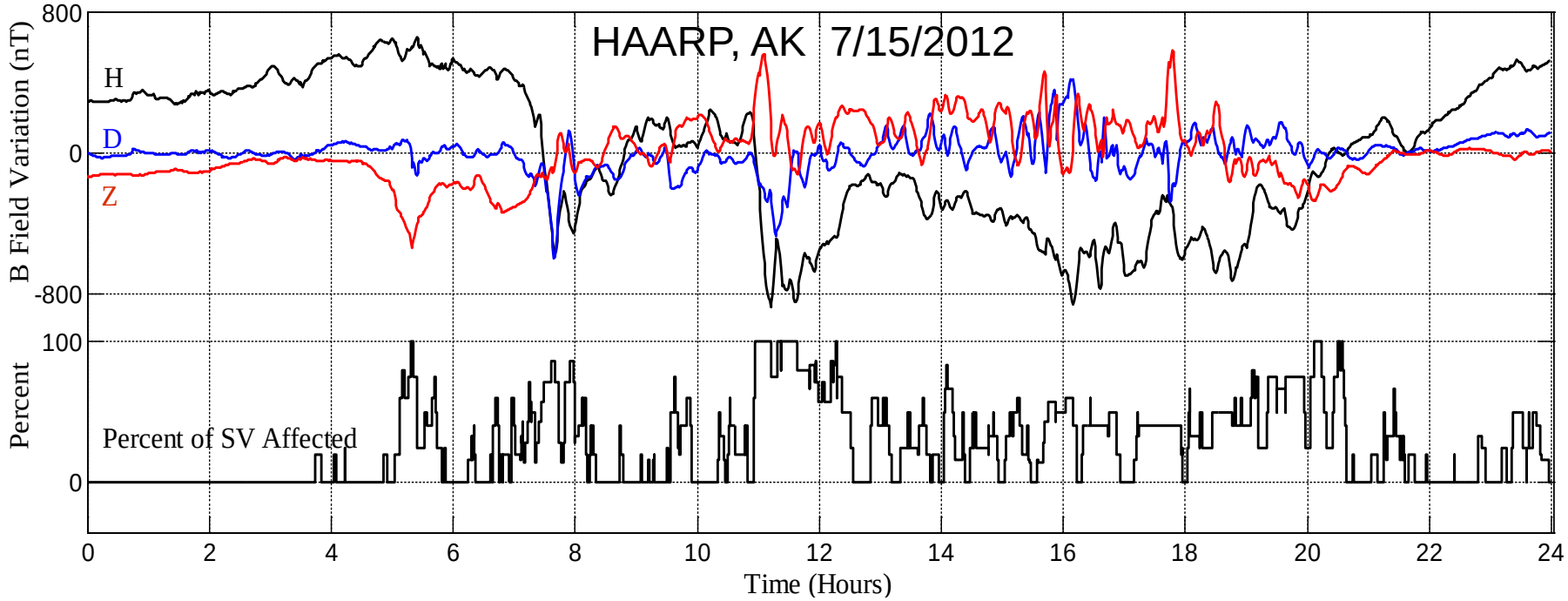
Diurnal Patterns

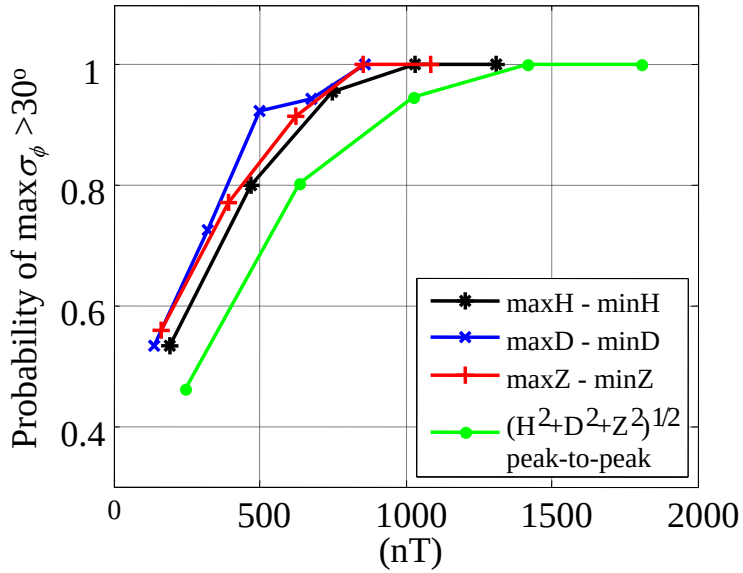


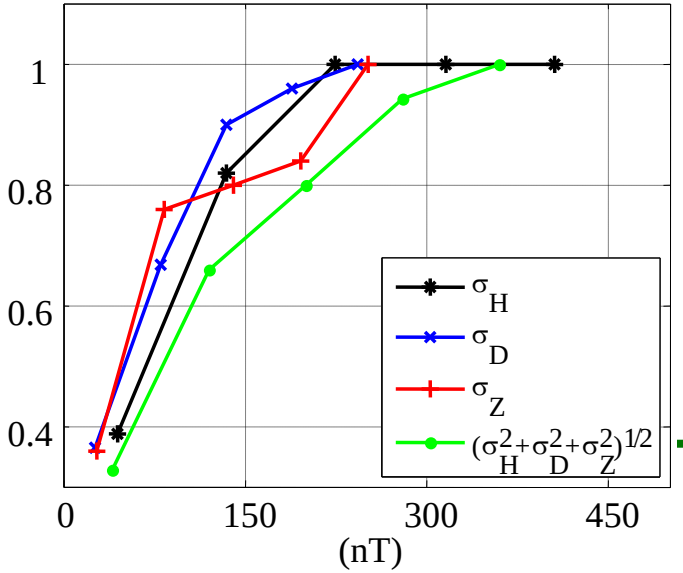
Solar Cycle Dependence: High vs. Low Lat



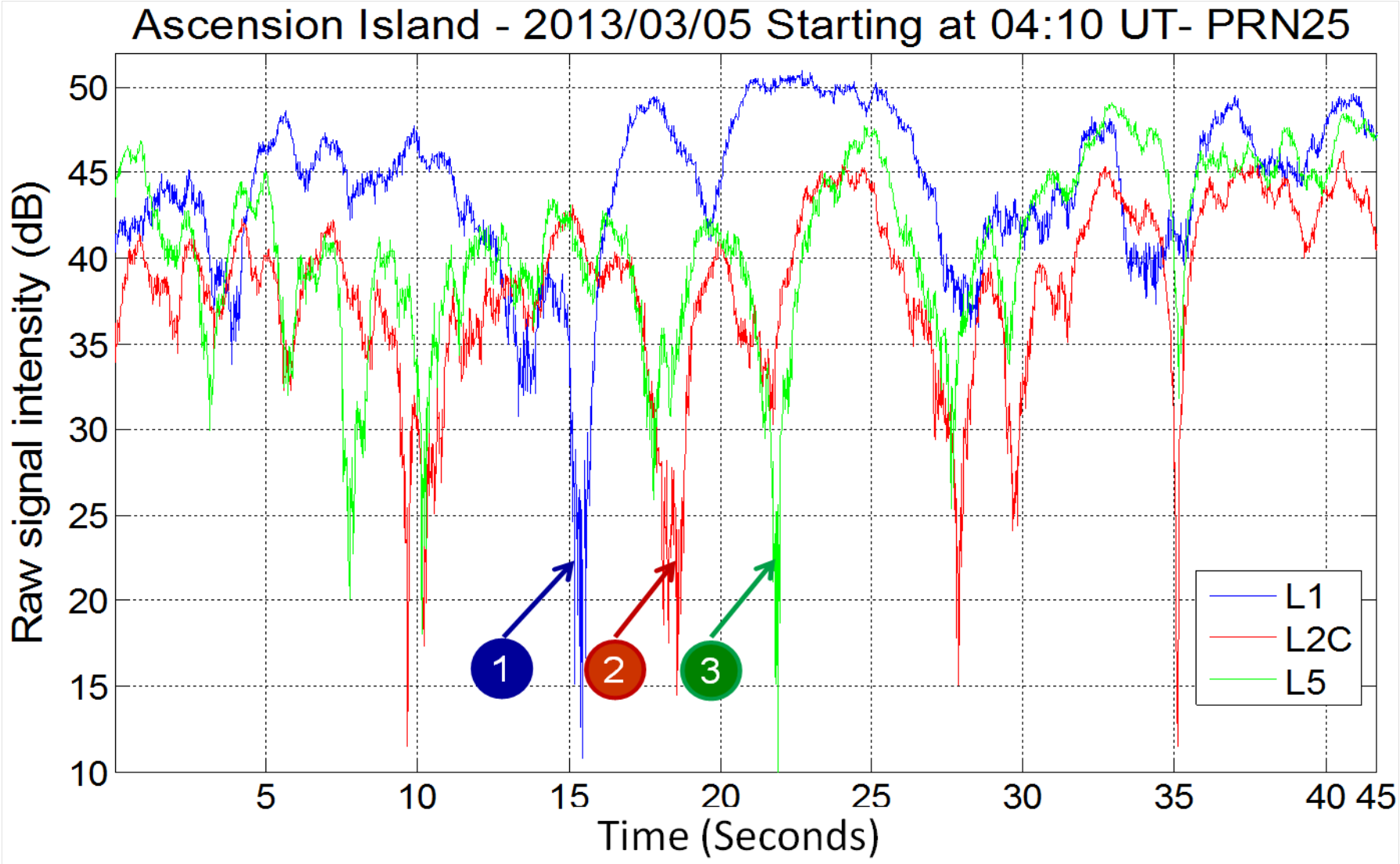
Geomagnetic Disturbance Impact on High Latitude





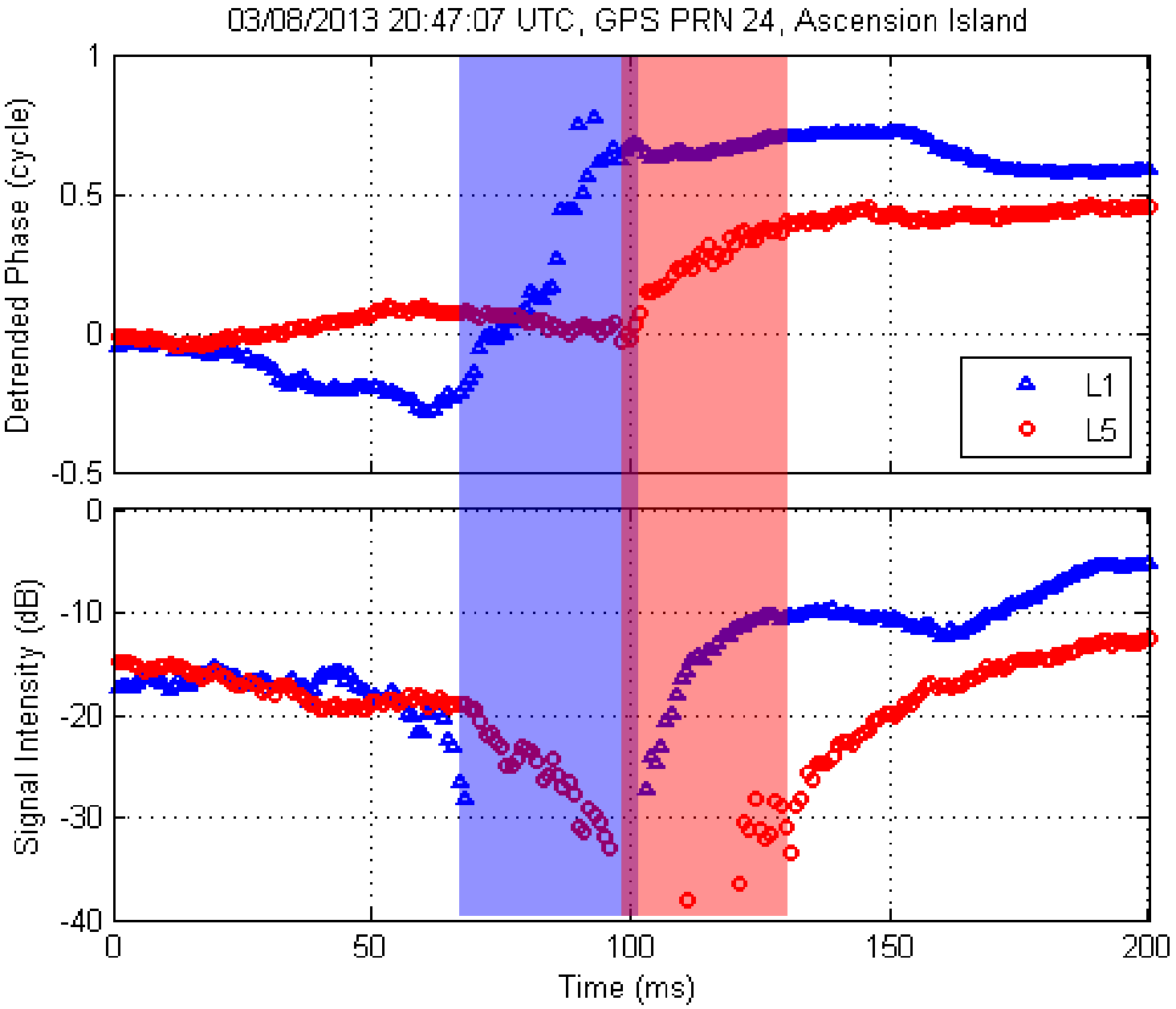


Frequency Diversity: Selective Fading



Multi-Frequency Deep Fading

Carrier Phaser Reversal During Deep Fading



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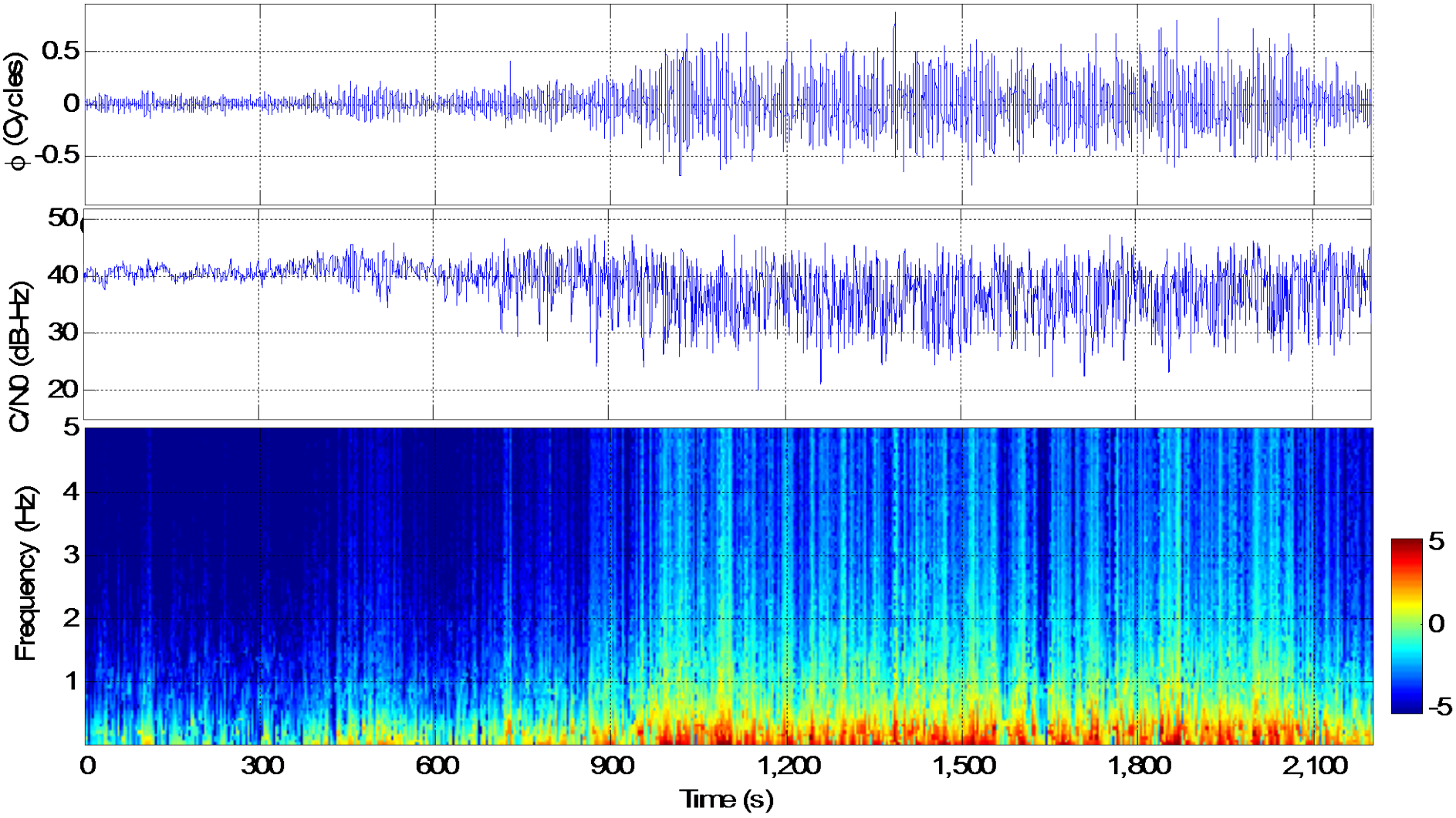
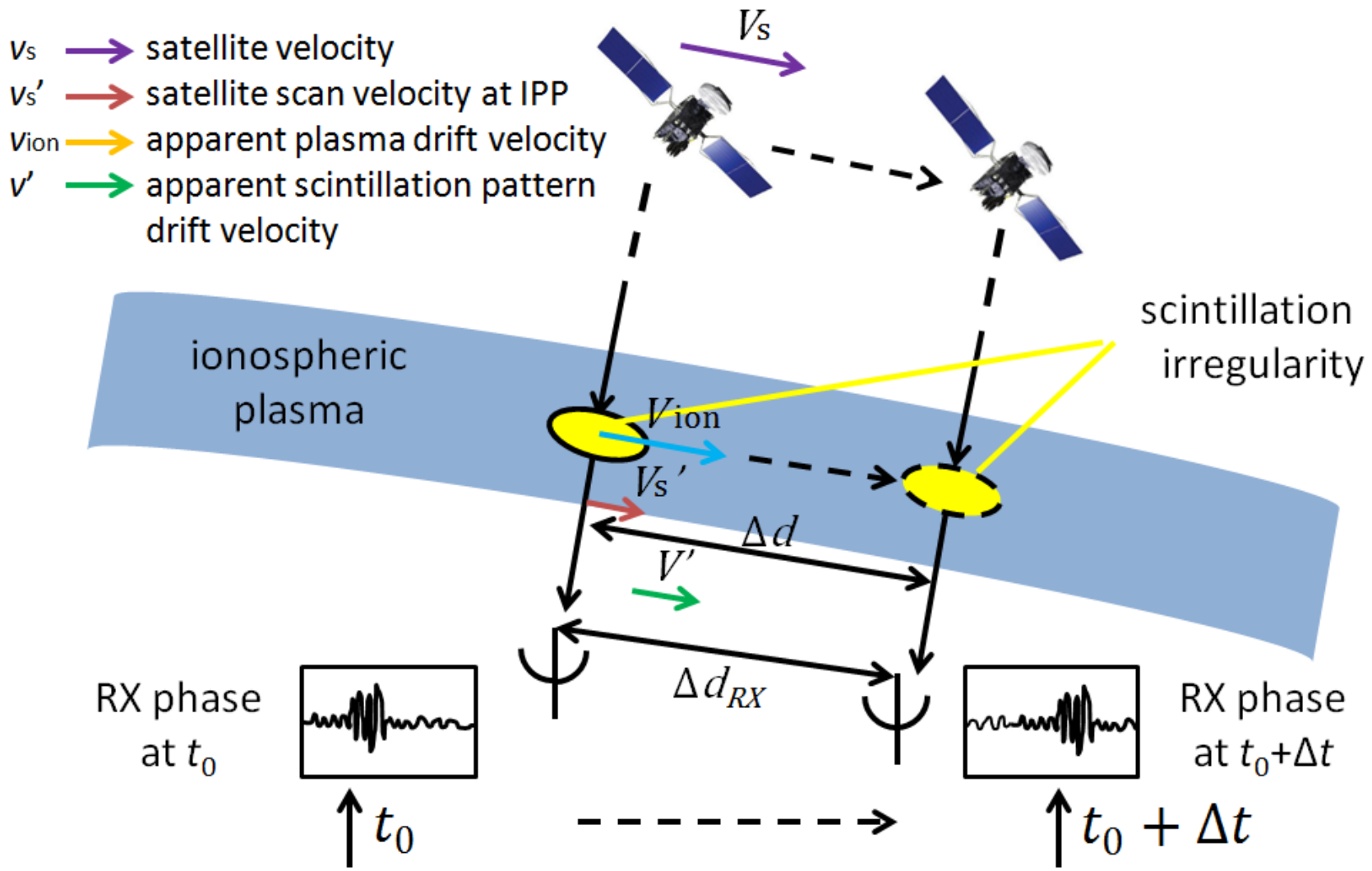
Adaptive Joint Time-Frequency Analysis

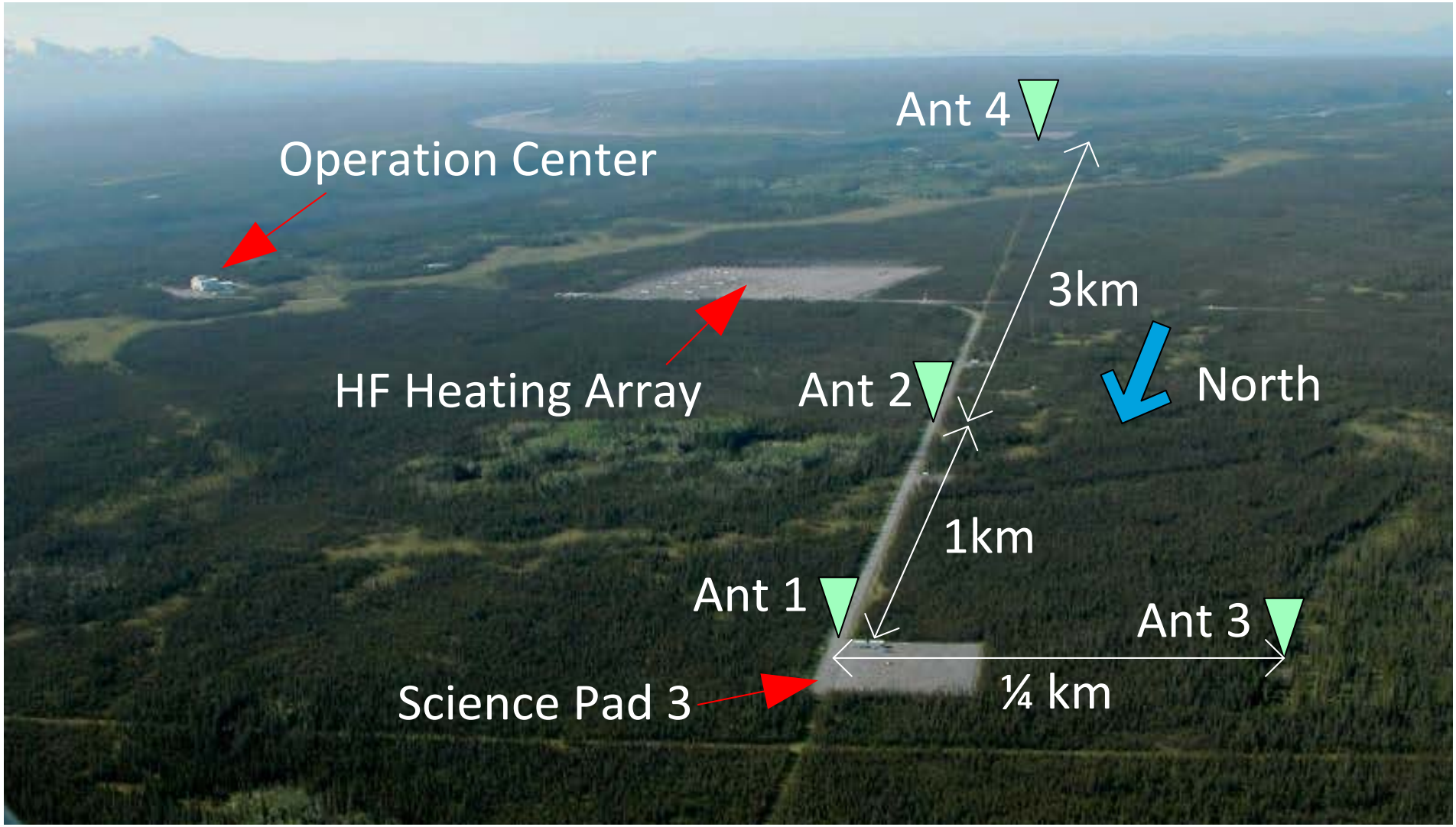


Irregularity Dynamics Sensing Using GNSS Array

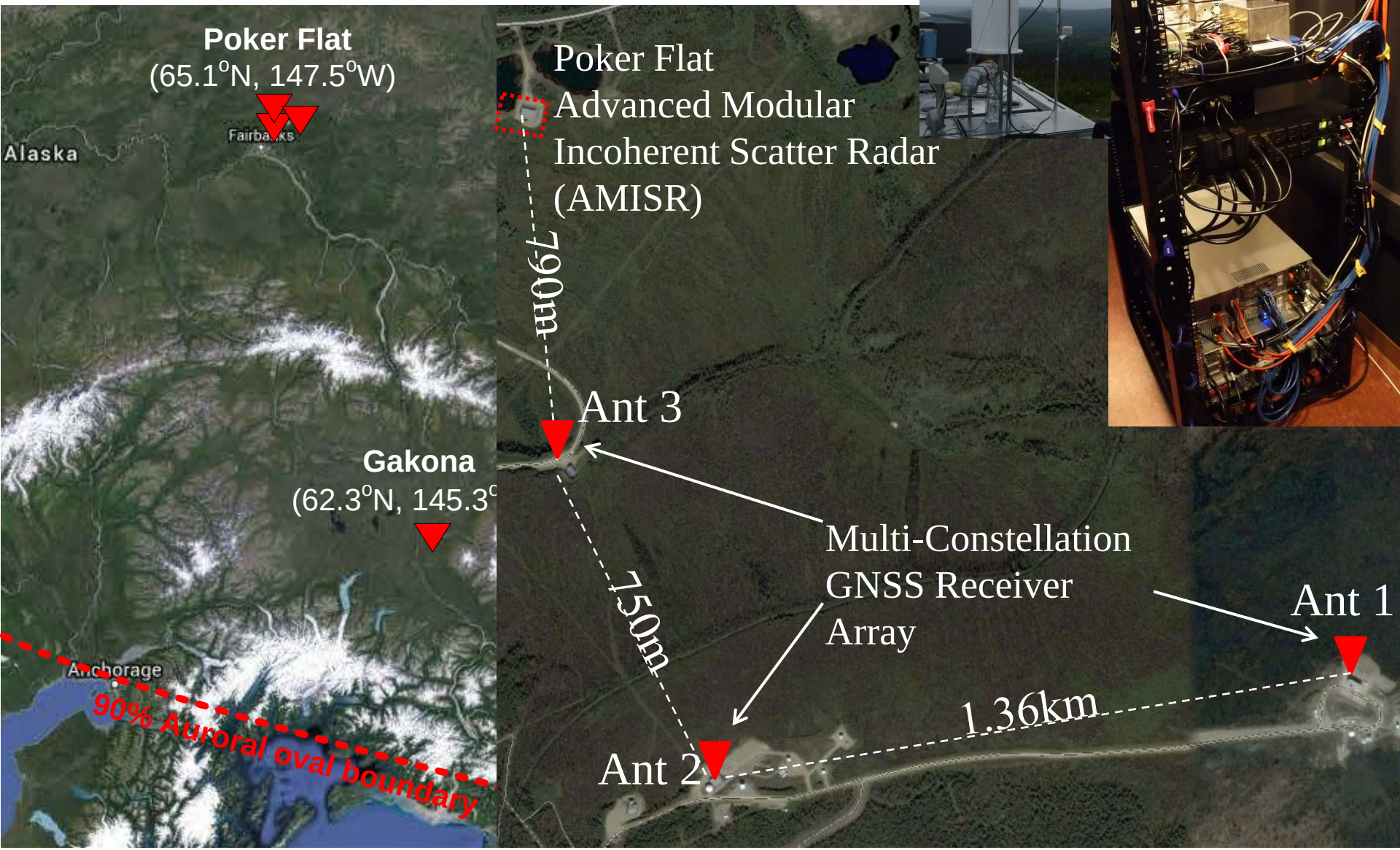


Array Processing: HAARP (Gakona, Alaska)

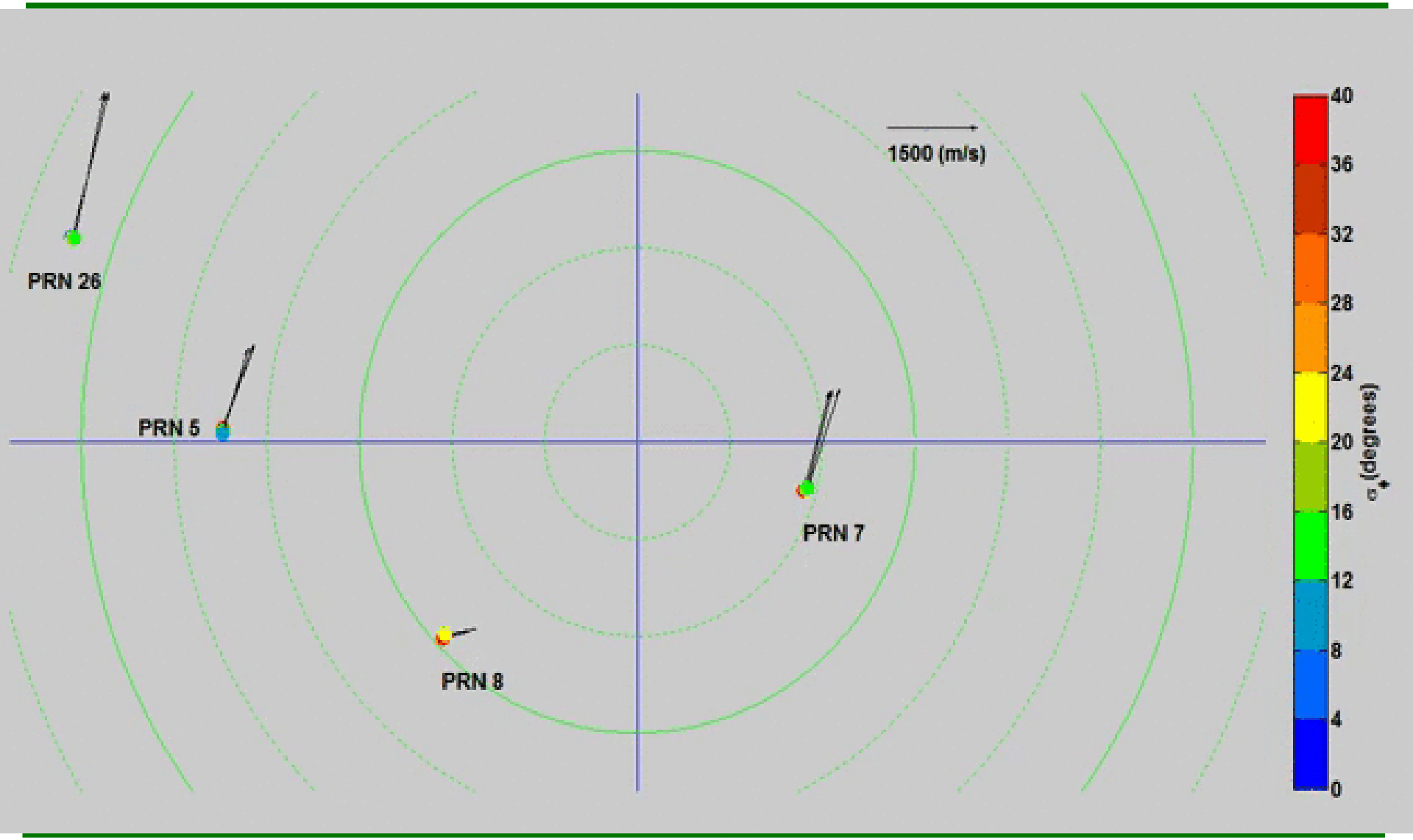
Lat: 62.39º, Lon: 145.15ºW



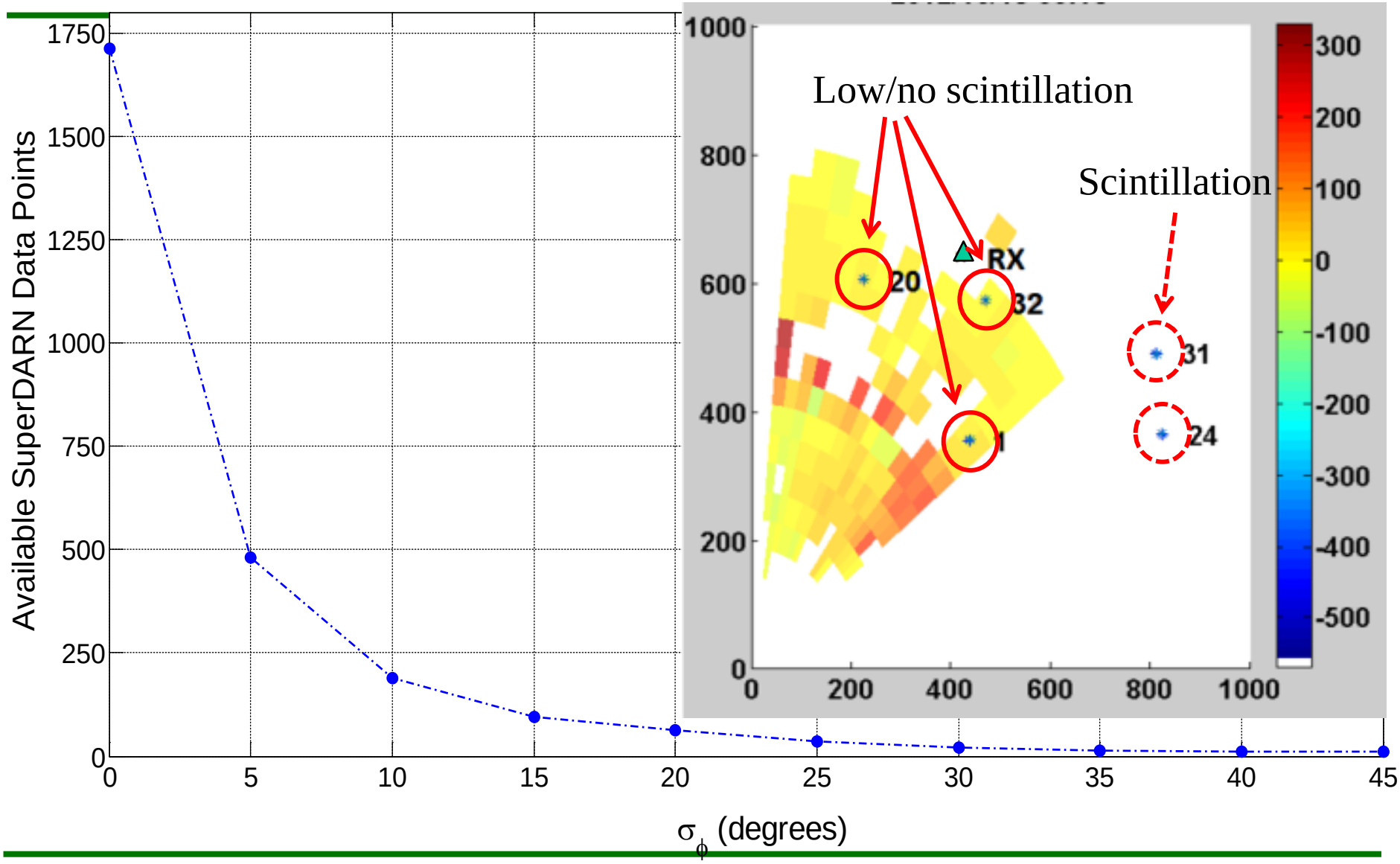
New Alaska Deployment



Plasma Structure Dynamics Monitoring



Comparison with SuperDARN



Novel GNSS Receiver Algorithms

- Adaptive Filtering
- Adaptive Inter-Channel Frequency Aiding
- Multi-Constellation Vector Processing
- Fixed Position Feedback
- Adaptive Drift Velocity Feedback

Conclusions

- High quality GNSS data is needed for
  - Continuous, accurate interpretation of ionosphere processes
  - Robust GNSS receivers development
- Successful data collection system yielding both known results as well as new observations
  - Adaptive processing is needed
  - Computation cost need to be improved

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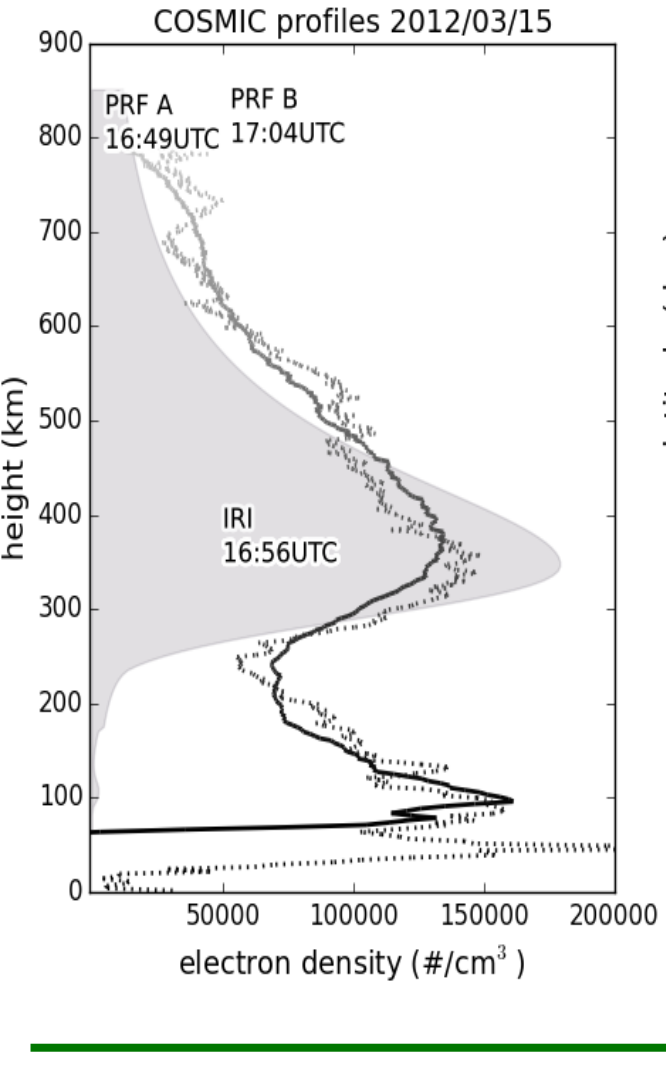
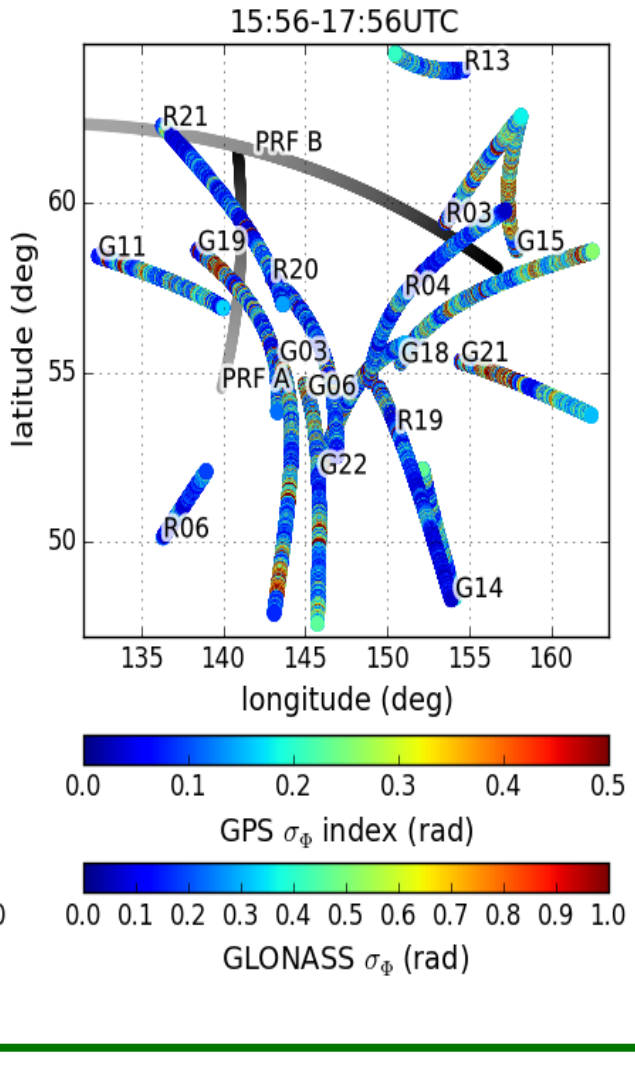
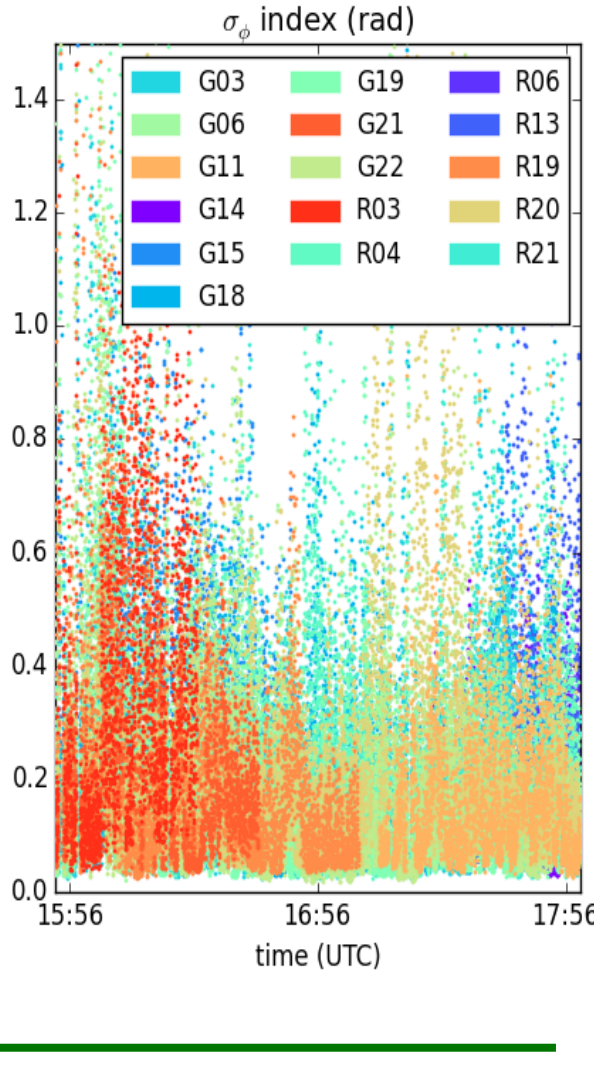
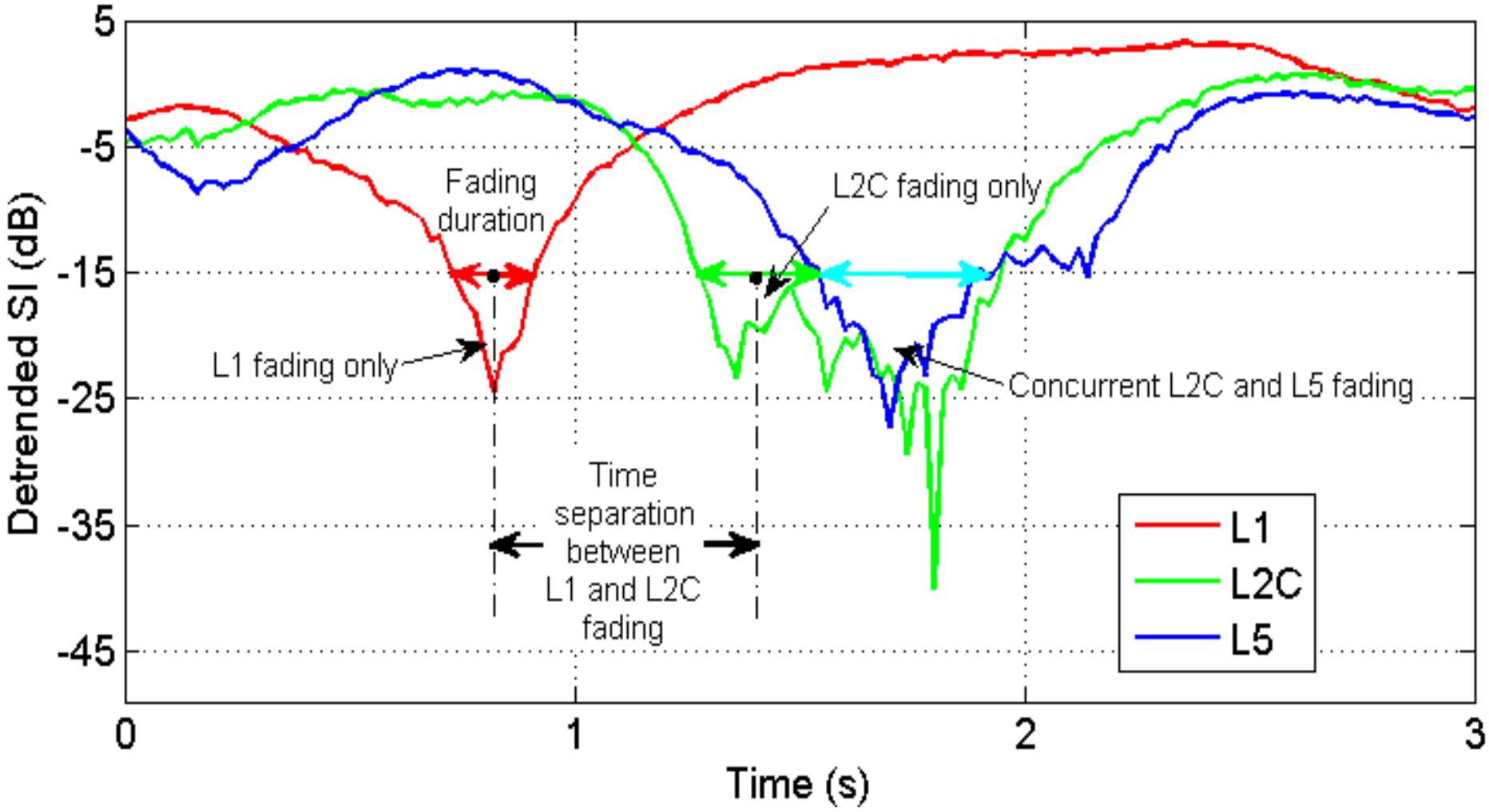
Common Volume LEO and Ground Observations







Multi-Frequency Fading Analysis



Fading Overlap: Ascension Island

Threshold of detrended signal intensity: -15dB

Fading band	L1	L2C	L5
L1 only	95.3%	/	/
L2C only	/	82.9%	/
L5 only	/	/	80.7%
Concurrent L1 and L2C	3.0%	1.3%	/
Concurrent L1 and L5	1.4%	/	0.7%
Concurrent L2C and L5	/	15.7%	18.5%
Concurrent L1, L2C and L5	**0.2%**	**0.1%**	**0.1%**

	Fading Number
L1	1,791
L2C	4,591
L5	1,584
Total	7,966

More on Hong Kong, Singapore, and Brazil

Very small percentage