Overview of scintillation events due to E region and F region as inferred from SAGA

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Introduction

Scintillation

- Rapid fluctuation in power and/or phase in received signals
- Caused by: variation in electron density in the ionosphere
- May be correlated across multiple receivers in space-time
- Allows characterization of ionosphere by observation of signal on ground that produce it

Previous Work

- Identified a phase/amplitude case [1]
- Only study of cases with phase data [2]

Objective: Use spaced-receiver method with amplitude data at high latitudes to calculate properties of irregularities. Compare to phase analysis and PFSIR data.

Background

SAGA

- SAGA: Scintillation Auroral GPS Array
- Collects: 100 Hz power and phase
- Scintillation signal
- Signals are then detrended and filtered [2]

Velocity estimation

- Internal turbulent motion + bulk drift motion: characterized by drift velocity (v)
- Bulk movement velocity
  - "Frozen-in" irregularities velocity
- Internal turbulent motion
  - Characteristic velocity (v_i)
- Assumptions made (verified afterwards analysis):
  - \( v_i < v \)
  - Correlation peak-correlation threshold
  - One irregularity layer

- Spaced-receiver method [4]:
  - \( s_i, s_j(t) \): Scintillation signal in receivers i and j
  - \( x_{ij}, y_{ij} \): 2D distance between pair of receivers i and j
  - \( \theta \): Direction of velocity from East
  - \( y \): Measurements
  - \( x \): System State
  - \( f(\theta) = f(x, y_\theta) \)
- \( v \): Noise (Monte Carlo simulation)

Height (z) and thickness (L) of scattering layer

- Comparison between observed (Ro) and theoretical (R_L) scintillation phase and amplitude signal ratio
- Theoretical ratio based on Rytov weak scatter theory

Cross correlation analysis

- \( S_p \): Amplitude spectrum
- \( S_p \), Phase spectrum
- \( S_{p, x} \): Electron density change spectrum (not known)
- \( S_{p, x} \)
- \( S_{\phi} \)
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Phase analysis

- \( T \): 400/500 km
- \( \phi \): 300/400 km
- \( F \): Layer in all receivers in both

Amplitude analysis

- \( T \): 400/500 km
- \( \phi \): 300/400 km
- \( F \): Layer in all receivers in both

Conclusion

- Velocity, height and thickness are calculated with SAGA amplitude data
- Amplitude estimation agrees with phase analysis and PFSIR results
- Amplitude analysis more cases with discarded estimations compared with phase analysis

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References

1. CV. Sreenivas, Y. Su, and S. Datta-Barua. "Detection, Classification, and Attribution of Auroral GPS Scintillation to Ionospheric Scattering Layer," in revision

Results

CASE: L1 Amplitude and Phase Case: F-region case, 16th November 2014 (DOY 320) 0:59-1:25 AM, PRN 32

- 5 operational receivers
- Elevated power and phase scintillation values
- Velocity correlation in signals
- Study of time period 1:15-1:51 UT for velocity and height estimation

Phase correlation analysis

- \( T \): 400/500 km
- \( \phi \): 300/400 km
- \( F \): Layer in all receivers in both

Amplitude analysis

- \( T \): 400/500 km
- \( \phi \): 300/400 km
- \( F \): Layer in all receivers in both

Conclusion

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