Simulation Study of GPS Phase Scintillation

by

Charles L. Rino^{1,2}, Charles S. Carrano¹, Brian Breitsch² Jade Morton²

1 Institute for Scientific Research, Boston College, 140 Commonwealth Ave., Boston, MA, 02467, USA

² Department of Electrical and Computer Engineering, Colorado State University, Fort Collins, CO, 02467, USA

> 15th Ionospheric Effects Symposium 9-11 May 2017 Alexandria, VA





Introduction

Commercial GPS receivers measure signal intensity, delay, and phase, which are interpreted as follows: $I(t, f_{c}) = P(t) |h(t, f_{c})|^{2} + \cdots$ $[c]\tau(t, f_{c}) = r(t) - cKN(t) / (2\pi f_{c}^{2}) - c\phi(t, f_{c}) / (2\pi f_{c}) + \cdots$ $\left[c / (2\pi f_c)\right] \phi(t, f_c) = r(t) + cKN(t) / (2\pi f_c^2) + M\lambda + c\phi(t, f_c) / (2\pi f_c) + \cdots$ Nuisance factors Phase wavelength ambiguity **Total Electron Content** $h(t, f_c) = \left| h(t, f_c) \right| e^{i\phi(t, f_c)}$ True Range Scintillation





The 2D Phase-Screen Model as a Scintillation Surrogate

Advantages

- <u>All</u> nuisance factors are eliminated
- Supported by compact, efficient, complete theory
- The initiating stochastic TEC serves as truth for TEC measurements
- Noise free-scintillation is unencumbered by phase uncertainty associated with deep fades

Disadvantage

• Not yet clear how well 2D phase-screen surrogate represents real-world scintillation





Phase Screen Example



The only thing that distinguishes TEC from phase scintillation is frequency dependence.

$$TEC_{k} = \left(\left(\phi_{k}^{[2]} / f_{c2} - \phi_{k}^{[1]} / f_{c1} \right) / \left(2\pi K \left(\frac{1}{f_{c2}}^{2} - \frac{1}{f_{c2}}^{2} \right) \right) + \cdots \right)$$





TEC Moderate Scintillation









TEC Strong Scintillation







Slide 6



TEC Equatorial Data







Conclusions

- Multi-frequency two-dimensional equivalent-phasescreen realizations capture the essential characteristics of GPS phase scintillation
- The initiating phase is effectively stochastic TEC structure in that the initiating disturbance has no associated intensity scintillation
- Standard two-frequency TEC estimates have small biases common to estimates that have one common frequency
- As the L1 universal strength measure approaches *jump* changes in the TEC estimator are observed.

THANK YOU FOR YOUR ATTENTION



