URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Leveraging Geodetic GPS Receivers for Scintillation Science

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We demonstrate scintillation analysis from a network of geodetic Global Positioning System (GPS) receivers which provide data at 1-second resolution. The GPS receivers are operated by UNACVO inc., and provide continuous, near real-time coverage of the USA, Central America, and the Caribbean. The networks consist of several different hardware versions and receiver makes. The data is publicly available through UNAVCO's FTP data repository and goes back to 2012 with about 200 receivers whereas it consists of almost 1000 such receivers today. Due to the fact, the receivers are not "scientific-grade", we describe substantial post-processing routines to extract geophysically meaningful information.

We introduced proxy phase (σTEC) and intensity (SNR4) scintillation indices and validate them against the rate of change of TEC index (ROTI) and S4 [1]. Additionally, we validate the scintillation observations against a CASES scintillation receiver. We developed a receiver-dependent scintillation event thresholding algorithm using hardware-dependent noise variance. We analyze six-days adjacent to the 7-8 September 2017 geomagnetic storm, using 169 receivers covering magnetic latitudes between 15-degree and 65-degrees in the American longitude sector. We leverage the available spatial sampling coverage to construct 2-D maps of GPS scintillations and present episodic evolution of scintillation intensifications during the storm. Due to the data quality constraints, this data-source should be considered as an opportunistic distributed observatory measuring scintillation-producing irregularities. Thereby, the confidence in results is based on the collective behavior of observations from nearby receivers using 2-D maps, not in stand-alone measurements of line-of-sight signals.

This one storm is used as an example to show that low-latitude and high-latitude scintillation morphology match well-established scintillation climatology patterns. At mid-latitudes, spatiotemporal evolution of scintillation partially agrees with documented scintillation morphology. The results reveal previously undocumented mid-latitude scintillation-producing ionospheric structures. The results provide an unprecedented view into the spatiotemporal development of small-scale plasma irregularities and provide a valuable resource to further exploit scintillation evolution at large spatial scales.

References

[1] Mrak, S., Semeter, J., Nishimura, Y., Rodrigues, F. S., Coster, A. J., & Groves, K. (2020). Leveraging geodetic GPS receivers for ionospheric scintillation science. Radio Science, 55, e2020RS007131. https://doi.org/10.1029/2020RS007131