Ionospheric Scintillations

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Intensity and phase scintillations are encountered in a variety of fields where electromagnetic waves propagate through a turbulent medium with fluctuations of refractive index. Tropospheric scintillation is caused by turbulent fluctuations of temperature and humidity in the neutral atmosphere, ionospheric scintillation arises from random fluctuations of electron density in the E and F regions of the ionosphere and interplanetary scintillation is caused by fluctuations of electron density in the solar wind. In each of these areas, the scintillation technique has been utilized to remotely sense the characteristics of the random medium and its dynamics. This is because the theory of wave propagation in random media is well developed. This presentation is focused on F-region ionospheric scintillation and it is shown that relatively simple receiving systems can be used to monitor signals from satellites and thereby study the global variation of ionospheric turbulence and the different instabilities that cause such turbulence. The specific characteristics of these instabilities and their impact on systems operating in the polar, auroral and equatorial regions are described. Spaced receiver scintillation measurements have been performed to determine the motion of the electron density irregularities in the ionosphere and its random variation that indicates the age of the turbulence. GPS satellites have opened up the possibility of measuring simultaneously GHz scintillation and the integrated electron density environment within which such measurements are made. In the equatorial region, during solar maximum, the integrated strength of the irregularities at the Fresnel scale (approximately 400 meters) for GPS observations becomes very large after sunset and causes signal intensity fading as large as 20 dB. In such a fading environment most receivers fail to acquire the GPS signals. At polar, auroral and middle latitudes, the ionospheric irregularities under magnetically active conditions often attain speeds as large as 1 km/sec when larger scale inhomogeneities introduce significant phase scintillations and cause GPS receivers to lose phase lock. When GPS receivers fail to acquire signals, either because of large signal intensity fadings or phase scintillations, the performance of space-based navigation systems is compromised. It is shown that by monitoring multiple GPS satellites from a station it is possible to study the variation of scintillation in space and time and their relationship to large-scale gradients in the ionosphere. Such observed relationship in the various ionospheric domains will allow the development of predictive models for the specification and forecast of this ionospheric space weather phenomenon, which creates substantial impact on communication and navigation systems.