GPS phase scintillation at high latitudes: Dependence on the interplanetary magnetic field

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The high-latitude ionosphere dynamics is largely driven by magnetic reconnection between the interplanetary and the Earth's magnetic field on the dayside magnetopause and impulsive releases of energy in the magnetotail. The interplanetary magnetic field (IMF) controls polar cap and auroral phenomena, including auroral substorms, ionospheric convection, polar cap patches and sun-aligned auroral arcs that produce irregularities on scales ranging from hundreds of kilometers to a few meters.

Ionospheric irregularities cause rapid fluctuations of radio wave amplitude and phase that can degrade GPS positional accuracy and affect performance of radio communication and navigation systems. GPS scinitillation and total electron content (TEC) have been monitored with the Canadian High-Arctic Ionospheric Network (CHAIN). The NovAtel GSV4004B receivers that form the original CHAIN are capable of tracking up to 10 GPS signals at the L1 frequency (1575.42 MHz) and the L2 frequency (1227.6 MHz). The NovAtel receivers measure phase and amplitude at a 50-Hz rate for each satellite being tracked on L1. CHAIN has been transformed into the Expanded CHAIN (ECHAIN), adding new stations equipped with Septentrio PolaRxS multi-frequency receivers capable of tracking up to 30 satellites including GPS, GLONASS and Galileo. Each receiver records the raw phase and amplitude of the signal at up to a 100-Hz rate for scintillation measurements. TEC is computed from combined L1 and L2 pseudorange and carrier phase measurements.

Dependences on the IMF of the GPS phase scintillation level and occurrence as a function of magnetic latitude and magnetic local time are investigated. A strong dependence of scintillation on the IMF B_Z is marked by enhanced scintillation occurrence in the cusp, in the expanded auroral oval and at subauroral latitudes for strongly southward IMF. In the polar cap, scintillation is collocated with the tongue of ionization for southward IMF and with sun-aligned arcs for northward IMF. The dawn-dusk asymmetries in scintillation occurrence are controlled by the IMF B_Y polarity. The statistical results are supported by cases of IMF-dependent ionospheric convection observed by Super Dual Auroral Radar Network (SuperDARN).