Recurrent high-speed solar wind co-rotating interaction region imprint on the ionosphere and atmosphere: GPS TEC variations and atmospheric gravity waves

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High-speed streams (HSS) from coronal holes dominate solar wind structure in the absence of coronal mass ejections during solar minimum and the descending branch of solar cycle. Prominent and long-lasting coronal holes produce intense co-rotating interaction regions (CIR) on the leading edge of high-speed plasma streams that cause recurrent ionospheric disturbances and geomagnetic storms. Through solar wind coupling to the magnetosphere-ionosphere-atmosphere (MIA) system they affect the ionosphere and neutral atmosphere at high latitudes, and, at mid to low latitudes, by the transmission of the electric fields [1] and propagation of atmospheric gravity waves from the high-latitude lower thermosphere [2].
The high-latitude ionospheric structure, caused by precipitation of energetic particles, strong ionospheric currents and convection, results in changes of the GPS total electron content (TEC) and rapid variations of GPS signal amplitude and phase, called scintillation [3]. The GPS phase scintillation is observed in the ionospheric cusp, polar cap and auroral zone, and is particularly intense during geomagnetic storms, substorms and auroral breakups. Phase scintillation index is computed for a sampling rate of 50 Hz by specialized GPS scintillation receivers from the Canadian High Arctic Ionospheric Network (CHAIN). A proxy index of phase variation is obtained from dual frequency measurements of geodetic-quality GPS receivers sampling at 1 Hz, which include globally distributed receivers of the RT-IGS network that are monitored by the Canadian Geodetic Survey in near-real-time [4]. Temporal and spatial changes of TEC and phase variations following the arrivals of HSS/CIRs [5] are investigated in the context of ionospheric convection and equivalent ionospheric currents derived from the ground magnetometer network using the spherical elementary current system method [6,7].
The Joule heating and Lorentz forcing in the high-latitude lower thermosphere have long been recognized as sources of internal atmospheric gravity waves (AGWs) [2] that propagate both upward and downward, thus providing vertical coupling between atmospheric layers. In the ionosphere, they are observed as traveling ionospheric disturbances (TIDs) using various techniques, e.g., de-trended GPS TEC maps [8].
In this paper we examine the influence on the Earth’ s ionosphere and atmosphere of a long-lasting HSS/CIRs from recurrent coronal holes at the end of solar cycles 23 and 24. The solar wind MIA coupling, as represented by the coupling function [9], was strongly increased during the arrivals of these HSS/CIRs.

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