Transmission of an ionospheric electric field to the equator during a geomagnetic impulse event

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The near instantaneous onset of a geomagnetic impulse such as the preliminary reverse impulse (PRI) of the geomagnetic sudden commencement at high latitude and at the dayside geomagnetic equator has been explained by means of the TM0 mode waves in the Earth-ionosphere waveguide (Kikuchi and Araki, J. Atmosph. Terrest. Phys., 41, 927-936, 1979). There is, on the other hand, a time lag of the order of 10 sec in the peak amplitude of the magnetic impulse at the dayside equator. To explain these two temporal aspects, we examine transmission of the TM0 mode in a finite-length Earth-ionosphere transmission line composed of a finitely conducting ionosphere and the perfectly conducting Earth, by applying a fixed electric potential at one end and null potential at the other end of the transmission line, corresponding to the foot of a field-aligned current on the dawn- or dusk-side in the polar cap and middle point on the noon-midnight meridian at low latitude, respectively. Successive reflections at both ends of the transmission line lead to that the ionospheric currents start to grow instantaneously, but approach a steady state after a time proportional to the length of the transmission line and the ionospheric conductivity. The transient time is of the order of 10 sec when we give high conductivity applicable to the equatorial ionosphere, which agrees with the observed time lag in the peak amplitude of the equatorial geomagnetic impulse. Consequently, the TM0 mode in the finite-length Earth-ionosphere transmission line explains both the instantaneous onset and time lag in the peak amplitude of the geomagnetic impulse at the dayside geomagnetic equator.