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On the nature of DP fields during disturbances in geospace - Characterization and Modelling

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This dissertation investigates Disturbance Polar (DP) fields during geospace disturbances, that are coherent on a global scale and shows modulation under the electrojet in the dip equatorial region.

This study was motivated mainly by the global (high- to low-) latitudinal coverage offered by the Japanese 210deg magnetic meridian (210MM, hereafter) chain of magnetometers, and in part by the wealth of available experimental measurements pertaining to geospace. The investigation of geospace disturbances using ground magnetic observations form the oldest branch of Space Physics, and is more than a century old.

In this paper, we study the effect of storms, substorms, storm sudden commencements and the prompt penetration of convection electric field (quasiperiodic DP 2 fluctuations), using 3 sec magnetic H,D,Z data covering high- to low-latitudes in both hemispheres, for specific events recorded along the 210deg magnetic meridian. The analysis requires accounting for various external (ionospheric and magnetospheric) current systems as well as the internal (inside the Earth) currents. The ground magnetic observations are the integrated effect of these various current systems, including solar regular variations, symmetric and asymmetric ring currents, tail, magnetopause, field aligned and induction currents. But their separation is a difficult task. One has to resort to case based arguments as the situation warrants. Our aim in revisiting the study of DP fields is two fold: (1) the excellent spatio-temporal coverage offered by the 210MM chain allows us to investigate these fields for the above mentioned phenomena in detail (2) to use these disturbance fields for deriving the sheet currents that flow in the E-region of the ionosphere, which in turn will pave the way for future investigations of electrodynamic coupling between high- and low-latitudes, during times of penetration of electric fields and currents of magnetospheric origin to the low-latitude ionosphere.

Once DP fields have been derived, we can investigate their structure in detail. The dense array of magnetometers helps us to elucidate the effect of various current systems along the meridian as a function of geographic and geomagnetic location of the observatory.

Using formulations based on potential theory, we construct a new regional model to separate the ground magnetic field into external and internal components. This is followed by using the external field component to continue towards the electrojet altitude (~110km) to arrive at the sheet currents. This will help us to investigate the nature of the DP current along the chain of magnetometers spanning both hemispheres. For testing the model, we apply the DP fields of a DP 2 event in both hemispheres, as well as that of a substorm event in the northern hemisphere to the model. The model could extract the main morphological features of the currents associated with such disturbances, besides providing current density values along the meridian. It is hoped that the model will provide a starting point for further investigation of electrodynamical coupling between high- and low-latitudes during such disturbances in geospace. Besides, one can derive true ionospheric currents, using the model computed currents in conjunction with measurements of ionospheric electric fields and information about the conductivity. Such studies involving electrodynamics of the low latitudinal ionosphere is very important from the space weather perspective.