TESTING MAGNETOSPHERIC MODELS BY MEASURING THE STATISTICAL PROPERTIES OF SOLAR WIND AND MAGNETOSPHERIC PLASMAS.

Mervyn P. Freeman[(1)], Gary Abel[(2)], and Nicholas Watkins[(3)]

[(1)] British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, U. K. E-mail: mpf@bas.ac.uk

[(2)] As (1) above, but E-mail: gaab@bas.ac.uk

[(3)] As (1) above, but E-mail: nww@bas.ac.uk

ABSTRACT

Analysis of the spatio-temporal structure of ionospheric plasma velocity fluctuations measured by HF radars and of associated ground magnetic fluctuations measured by magnetometers reveals that convection fluctuations are primarily characterised by a scale-free property (no preferred frequency over the observed range), similar to that of the turbulent solar wind [5, 6]. We consider the implications of this on (a) the interpretation of finite-range and spatially-averaged observations, (b) forecasting space weather from solar wind observations, and (c) the Dungey reconnection model of magnetospheric convection.

INTRODUCTION

It is now generally accepted that the system-scale plasma convection cycle in the Earth's magnetosphere is driven by magnetic reconnection at the magnetopause interface between the interplanetary and terrestrial magnetic fields [1]. For example, numerous studies have confirmed the fundamental prediction that the strength and pattern of system-scale convection are closely related to the strength and direction of the interplanetary magnetic field (IMF) [2]. The system-scale convection has been shown to react to changes in the IMF on a characteristic time scale of 10-20 min [3], and a low-pass filter with this time scale has been invoked to describe the relationship between temporal fluctuations of the IMF and system-wide convection strength [4].

In contrast, the relationship between the IMF and magnetospheric convection on sub-system scales is not well understood. Numerous studies have analysed examples of transient and/or spatially localised convection phenomena in the magnetosphere and ionosphere. Commonly, typical temporal and spatial scales are quoted and attempts are often made to correlate the phenomena with prevailing IMF fluctuations measured by a spacecraft in the solar wind.

However, statistical analysis of the spatio-temporal structure of ionospheric plasma velocity fluctuations measured by HF radars and of associated ground magnetic fluctuations measured by magnetometers reveals that convection fluctuations are primarily characterised by a scale-free property (no preferred frequency over the observed range), similar to that of the turbulent solar wind [5, 6]. We consider several implications of these observations: (a) The effect of finite-range time samples and spatial averaging on the perceived character of long correlation length processes. (b) To what extent sub-system scale magnetospheric convection can be related to single point IMF measurements in the same way as at the system scale. The implications of this for forecasting space weather phenomena from solar wind observations is discussed. (c) A generalised, multi-scale version of the Dungey magnetospheric convection model is proposed and its properties considered.

REFERENCES

[1] J. W. Dungey, Interplanetary magnetic field and the auroral zones, Phys. Rev. Lett., vol. 6, pp. 47-49, 1964.

[2] P. H. Reiff, R. W. Spiro, and T. W. Hill, Dependence of polar cap potential drop on interplanetary parameters, J. Geophys. Res., vol. 86, pp. 7639-7648, 1981.

[3] M. P. Freeman, A unified model of the response of ionospheric convection to changes in the interplanetary magnetic field, J. Geophys. Res., submitted, 2002.

[4] L. F. Bargatze, D. N. Baker, R. L. McPherron, and E. W. Hones, Jr., Magnetospheric impulse-response for many levels of geomagnetic-activity, J. Geophys. Res., vol. 90, pp. 6387-6394, 1985.

[5] G. A. Abel and M. P. Freeman, A statistical analysis of ionospheric velocity and magnetic field power spectra at the time of pulsed ionospheric flows, J. Geophys. Res., submitted, 2002.

[6] M. P. Freeman, N. W. Watkins, and D. J. Riley, Evidence for a solar wind origin of the power law burst lifetime distribution of the AE indices, Geophys. Res. Lett., vol. 27, pp. 1087-1090, 2000.