Response of Polar Cap Convection to the Interplanetary Magnetic Field

F. S. MOZER AND W. D. GONZALEZ*

Physics Department and Space Sciences Laboratory
University of California, Berkeley, California 94720

Evidence has been accumulated for several years to show the control by the interplanetary magnetic field of energy transfer to the magnetosphere and substorm phenomena. This control is most clearly evidenced during periods when the southward component of the interplanetary magnetic field is enhanced, which offers strong support for reconnection theories of the solar wind interaction with the magnetosphere [*Dungey*, 1961]. Although some of this evidence has been obtained from electric field measurements [*Mozer*, 1971*b*; *Haerendel*, 1972], the most recent such data have revealed no apparent correlation between the southward component of the interplanetary magnetic field and polar cap convection [*Heppner*, 1972].

Because of the above differences and because the relationship between convection and the interplanetary magnetic field is of crucial importance to the understanding of the large-scale interaction between the solar wind and the earth's magnetic field, 227 hours of polar cap balloon electric field measurements have been examined in search of such relationships, with the conclusion that magnetic field reconnection dominates viscous interaction or any other mechanism for transferring energy to the magnetosphere. The data of greatest interest to this study were obtained on balloons flown from Resolute Bay (magnetic latitude ≈83°) and Thule (magnetic latitude ≈87°) during a 4-day interval in early September 1971 [*Mozer et al.*, 1973]. Because these data and their implications for reconnection theories are also described elsewhere [*Mozer et al.*, 1973], it suffices for present purposes to plot the measured dawn to dusk component of the electric field in Fig- ure 1 along with the components of the inter- planetary magnetic field measured on Imp (Fairfield, private communication, 1972). The theoretical electric field of the bottom curve this figure will be considered after several fea- tures of the experimental data are discussed.

The magnitude of the sun to tail compone of the polar cap electric field (not shown) w generally small as compared with that of th dawn to dusk component of Figure 1 [*Moz et al.*, 1973]. The two electric field measure- ments of this figure are linearly correlated wit a correlation coefficient of +0.35, which is pr sumably less than 1, both because the larg scale polar cap electric field is not spatial uniform [*Heppner*, 1972; *Mozer et al.*, 197 and because of local turbulence [*Moz* 1971*a*]. Nevertheless, there is general agreeme between the two sets of electric field data, an it is the comparison of these general trends w the interplanetary magnetic field data that the topic of this letter.

The most obvious relationship between th magnetic and electric field data is the anticor lation of the electric field (especially that Thule) with B_z, the northward component the interplanetary magnetic field. This an correlation is best evidenced by three seve hour intervals of large northward magn field that are accompanied by small elec fields and three intervals of southward magn field that are associated with large electric fi This relationship offers strong evidence th polar cap convection is largely controlled by magnitude of the southward component of interplanetary magnetic field.

Since the magnetic field reconnection impl by this relationship also occurs with the y co ponent of the interplanetary magnetic field cause reconnection occurs for any nonzero

---

* Also at the Institute for Plasma Research, Stanford University, Via Crespi, Stanford, California 94305.

between the two reconnecting fields, a more quantitative discussion of reconnection and the electric field data requires inclusion of this component, as is done in the bottom curve of Figure 1. This theoretical polar cap electric field curve is obtained from the interplanetary magnetic field data and a three-dimensional model of reconnection that assumes that the efficiency of reconnection is unity and simplifies certain geometric aspects of the problem. Details of this model are beyond the scope of the present paper but will be discussed in future publications. The average magnitude of the theoretical curve agrees with either set of experimental data to better than a factor of 2, and the time variations of the theoretical and experimental curves are very similar. The linear correlation coefficient between the theoretical curve and the Thule data is +0.66, while that for the theoretical curve and the Resolute Bay data is +0.52. Thus, the magnitudes and time variations of these measured polar cap electric fields are adequately explained by magnetic field reconnection theories.

It is especially important to consider the measured electric fields at times when either

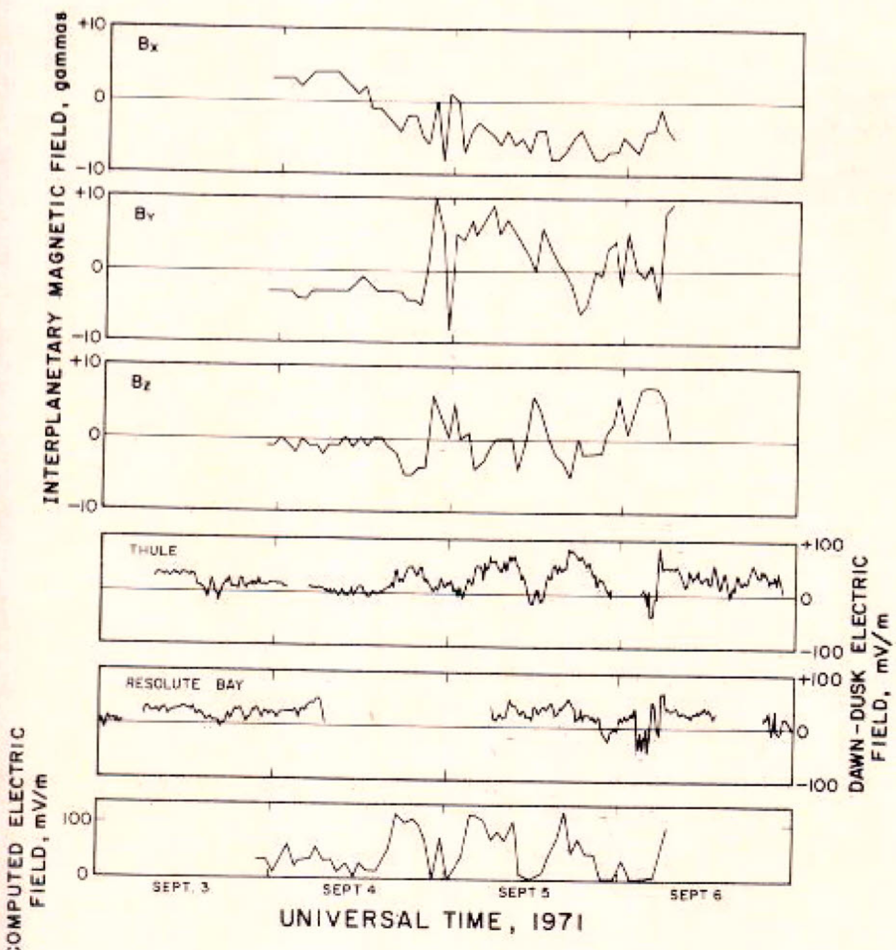

Fig. 1. Plots of the 15-min averages of the polar cap dawn to dusk electric fields measured in a nonrotating frame of reference at Thule and Resolute Bay along with 1-hour averages of the components of the interplanetary magnetic field. The bottom curve results from applying the interplanetary magnetic field data to a theoretical model of three-dimensional reconnection.

the bottom curve of Figure 1 or the interplanetary magnetic field data indicate that reconnection is not occurring. Such times, in particular the several hours of data near the middle of September 5 and the beginning of September 6, are characterized by the largest negative values of the dawn to dusk electric field that were measured during the data collection interval. Thus, abrupt termination of reconnection appears to reverse the sense of polar cap ionospheric convection. This result implies that viscous or any other interactions between the solar wind and the magnetosphere are unimportant as compared with reconnection.

Acknowledgments. This work was supported by the National Science Foundation under grant GA-33112X.

* * *

The Editor thanks J. R. Doupnik for his assistance in evaluating the letter.

REFERENCES

Dungey, J. W., Interplanetary magnetic fi[eld] and the auroral zones, *Phys. Rev. Lett.*, *6*, [...] 1961.

Mozer, F. S., W. D. Gonzalez, F. Bogott, M. [...] Kelley, and S. Schutz, High latitude elect[ric] fields and the three-dimensional interacti[on] between the interplanetary and terrestr[ial] magnetic fields, submitted to *J. Geophys. R[es.]*, 1973.

Haerendel, G., Plasma drifts in the auroral io[no]sphere derived from barium releases, in *Ear[th's] Magnetospheric Processes*, edited by B. [...] McCormac, p. 246, D. Reidel, Dordrecht, [Hol]land, 1972.

Heppner, J. P., Polar cap electric field distribu[tions] related to the interplanetary magnetic [field] direction, *J. Geophys. Res.*, *77*, 4877, 1972.

Mozer, F. S., Power spectra of the magnetosph[eric] electric field, *J. Geophys. Res.*, *76*, 3651, 19[71a].

Mozer, F. S., Origin and effects of electric [fields] during magnetospheric substorms, *J. Geo[phys.] Res.*, *76*, 7595, 1971*b*.

(Received March 7, 1973;
accepted April 2, 1973.)