ABSTRACT. This paper reviews research involved with direct and inferred determinations of the polar cap size and location, as well as their relationships with the interplanetary magnetic field. "Polar cap" is defined here as the region of open geomagnetic field lines encircled by the auroral oval. The first part of the paper reports the progress in the observation and understanding of polar cap size variations as related to changes of the interplanetary magnetic field magnitude and direction obtained by scaling the global auroral distributions from DMSP auroral pictures. Some new results on configurational changes of the auroral oval (i.e., the polar cap) with different orientations of the interplanetary magnetic field are also discussed. There are indications of the dawn-dusk and sunward-tailward displacements of the auroral oval in association with the interplanetary magnetic field B_y and B_x components, respectively. It is obvious from this review that a better understanding of the interaction between the terrestrial magnetosphere and the interplanetary magnetic field requires further efforts, both observational and theoretical.

I. INTRODUCTION

In the past twenty years, various types of satellite observations have revealed that the earth's magnetosphere is open: Namely, that geomagnetic field lines from the polar cap regions extend into interplanetary space and connect with the magnetic field lines of solar origin. Variations of the solar wind and the interplanetary magnetic field will undoubtedly affect the configuration of the terrestrial magnetosphere. Associated with an increase of the solar wind dynamic pressure, compression of the dayside magnetosphere and the magnetotail has been detected. The location of the magnetopause can be accurately determined from magnetohydrodynamics by balancing the solar wind dynamic pressure in the interplanetary space with the magnetic pressure of the geomagnetic field inside the magnetosphere. However, responses of the terrestrial magnetosphere to variations of the interplanetary magnetic field are far from clear, and the importance of the interplanetary magnetic field in the solar-terrestrial interaction, especially in the energy coupling, has been just recently recognized.
One of the possible processes of the energy transfer from the solar wind into the magnetosphere to produce the magnetospheric substorm is the field line merging between the interplanetary magnetic field and the geomagnetic field. The dayside northward directed closed geomagnetic field lines near the magnetopause can be eroded away by a southward directed interplanetary magnetic field (i.e., the geomagnetic field lines are opened by and connected with the interplanetary field lines); and consequently the dayside magnetopause moves earthward (see Russell, 1979). Due to the "frozen-in" condition between the interplanetary field and the solar wind, the antisunward motion of the solar wind carries the newly merged geomagnetic field lines from the dayside magnetosphere (or the magnetosheath) across the polar cap into the magnetotail. Associated with this so-called "magnetic flux transfer" process, one of the expected configurational responses of the magnetosphere is the change in the polar cap size which is controlled by the flux of open geomagnetic field lines. The polar cap is defined as the area bounded by the auroral oval, and the bundle of the geomagnetic field lines originating in the polar cap is connected (i.e., open) to the interplanetary magnetic field of the solar origin. The purpose of this paper is to report the progress in the observation and understanding of the polar cap size variation with changes of the interplanetary magnetic field and some new results on configurational changes of the auroral oval (i.e., the polar cap) with the different orientation of the interplanetary magnetic field are also discussed.

II. DAYSIDE VARIATIONS

The polar cusp at high altitude and the dayside auroral oval in the polar ionosphere are the boundaries delineating the last closed field lines from the region of open geomagnetic lines. Thus, the effect of the earthward motion of the dayside magnetopause during the southward turning of the interplanetary magnetic field is seen as the equatorward movements of the polar cusp and the dayside auroral oval. Their locations can be determined from the particle measurements of polar orbiting satellites or from the optical auroral observations and ionosonde data by using the ground-based or airborne instruments.

The first report of the possible polar cusp motions responding to the changes of the north-south component of the interplanetary magnetic field was made by Russell et al. (1971). Based on the characteristics of particles and fields observed by the OGO-5 satellite in the dayside magnetosphere at mid-altitude (~ 2.6 to 6 Re), these authors identified the polar cusp region and compared its spatial location with simultaneous variations of the north-south component of the interplanetary magnetic field. It was concluded that the multiple detection of the identified cusp region along the OGO-5 trajectory appeared to be the effect of the interplanetary magnetic field, and also that the mid-altitude polar cusp moved equatorward or poleward when the interplanetary magnetic field turned southward or northward, respectively. The most convincing evidence of the polar cusp movements, however, comes from a statistical study of the location of the polar cusp electron precipitation measured by the low altitude polar orbiting satellite,