Letters

Relations between the Dawn Minimum in the Equatorial Radius of the Plasmapause and *Dst*, K_p, and Local *K* at Byrd Station

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The equatorial geocentric distance to the plasmapause is known to be sensitive to the level of worldwide magnetic activity, decreasing during periods of increasing magnetic disturbance [*Carpenter*, 1963, 1966; *Taylor et al.*, 1965]. The purpose of the present note is to clarify this relationship by providing statistics relating the plasmapause position to three different magnetic indices, *Dst*, K_p, and local *K* at Byrd Station in the auroral zone.

Dst, reported on an hourly basis by *Sugiura and Hendricks* [1966], is based upon observations at a series of stations near the magnetic equator and provides a measure of ring current activity. The well-known 3-hour K_p planetary index draws upon observations in the latitude range 48–63°. Byrd Station, used for local *K*, lies in the southern auroral zone at about 71°S geomagnetic ($L \sim 7$). Eights Station, which with Byrd provided the whistler information on plasmapause position, is located at about 64°S geomagnetic ($L \sim 4$), and is about 1 hour ahead of Byrd in magnetic local time.

The present study involved a measurement of the equatorial radius of the plasmapause, or knee, near local dawn. (The method of measurement has been described by *Carpenter* [1966].) Whistler data from 60 days in the period June–August 1963 were examined, and on 48 days information identifying both sides of the plasmapause could be scaled. In a typical case, the knee position was determined to within about ± 0.2 R_E (earth radii). Centered dipole coordinates were employed in the calculations. Observations within two hours of local dawn were used to avoid confusion with the diurnal variation of the knee position. (On most days of moderate but steady geomagnetic agitation with K_p in the range 2–4, the equatorial radius of the plasmapause exhibits a broad diurnal minimum near dawn. A maximum of the radius near 2000 LT involves a bulging outward of the plasmapause some 1.5–2.0 R_E beyond the minimum radius [*Carpenter*, 1966].)

Figures 1, 2, and 3 are plots of the equatorial radius of the plasmapause calculated in dipole coordinates versus, respectively; hourly *Dst* at the time of the position measurement; maximum K_p in the preceding 24 hours; and maximum 3-hour *K* value at Byrd Station in the preceding 12 hours (choice of magnetic indices explained below). It is clear that the spread in observed plasmapause positions is larger for a given value of *Dst* than for given values of either K_p or local *K*, being about 2.0 R_E for the former and 1.0–1.2 R_E for the latter. The product moment correlation coefficients relating the plasmapause position and *Dst* (minus values upward), K_p, and *K* are −0.55, −0.67, and −0.76, respectively. Note that the plasmapause-local *K* correlation (Figure 3) is relatively high in spite of the restriction of *K* to integral values.

The figures show clearly that the plasmapause is a middle-latitude phenomenon with an equatorial radius that is typically in the range 3–5 R_E and thus in the invariant latitude range of roughly 54–63°. Additional comments on the figures will be made following some remarks on the choice of magnetic indices for comparison.

REMARKS ON THE MAGNETIC INDICES USED IN THE STUDY

As viewed near the Eights-Byrd meridians, the plasmapause boundary exhibits inward radial velocities ranging up to 0.5 R_E/hour between the hours of about 2200 LT and dawn

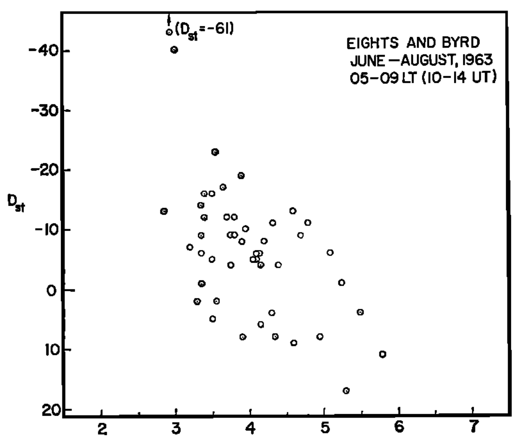

Fig. 1. The geocentric equatorial distance to the plasmapause near local dawn versus hourly *Dst* at the time of the distance measurement. The whistler data were recorded in the Antarctic at Byrd and Eights and represent a roughly 30° range of longitudes near the prime geomagnetic meridian. *Dst* values were obtained from the report by *Sugiura and Hendricks* [1966]. Centered dipole coordinates were employed in the calculations of geocentric distance.

[*Carpenter*, 1966; *Carpenter and Stone*, 1967]. The most rapid motions are not usually sustained for more than 2 hours, however, and thus significant changes in position, say of 1–2 R_E, require roughly 3–10 hours to achieve. This time requirement has partially motivated the choice of magnetic indices for the present study.

In the case of Figure 1, the hourly value of *Dst* nearest the time of the plasmapause measurement was used in recognition of *Dst* as an integral effect, dependent upon the development of a ring current. Other possible choices such as minimum (most negative) value in the preceding 24 hours did not appear to yield significantly different results.

In the case of Figure 2, the choice of maximum K_p in the preceding 24 hours was based on the time requirement mentioned, and in particular on the 1963 data showing a phase lag of roughly 6 hours between the initial K_p increase and inward plasmapause motion during weak magnetic storms [*Carpenter*, 1966]. The convenient, uncritical, value of 24 hours allows additional time for the condition of local dawn to obtain, and for possible longer term cumulative effects, such as additional compression or erosion of the plasmasphere during prolonged periods of agitation.

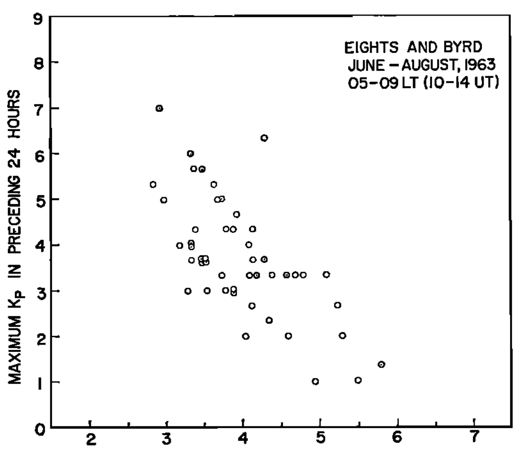

Fig. 2. The geocentric equatorial distance to the plasmapause near local dawn versus maximum 3-hour K_p value in the 24 hours preceding the distance measurement. The whistler data were recorded in the Antarctic at Byrd and Eights and represent a roughly 30° range of longitudes near the prime geomagnetic meridian. Centered dipole coordinates were employed in the calculations of geocentric distance.

In the case of Figure 3, the choice of the maximum 3-hour *K* at Byrd Station in the preceding 12 hours was based on a recent study showing that the nightside inward motion of

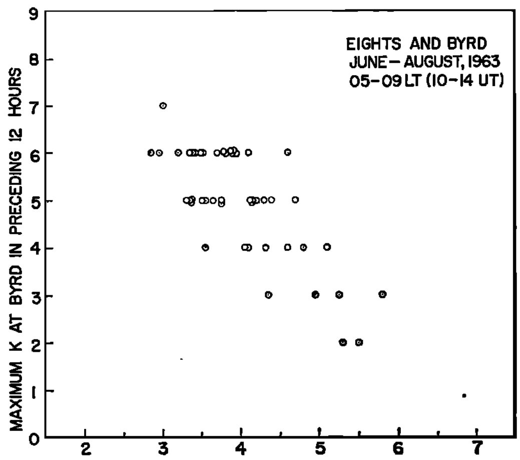

Fig. 3. The geocentric equatorial distance to the plasmapause near local dawn versus maximum 3-hour *K* value at Byrd Station in the 12 hours preceding the distance measurement. The whistler data were recorded in the Antarctic, at Byrd and Eights, and represent a roughly 30° range of longitudes near the prime geomagnetic meridian. Centered dipole coordinates were employed in the calculations of geocentric distance.

the plasmapause involves both slow, $\sim$0.1 R_E/hr, motions lasting 3 or more hours, and rapid, $\sim$0.4 R_E/hr, motions lasting 1–2 hours, the latter being associated with polar substorms [*Carpenter and Stone*, 1967]. The substorm contribution to the inward displacement is comparable to that of the slower system, and local K at Byrd directly reflects the substorm behavior, at least at the time of onset. The choice of a 12-hour period reflects both the restriction of the substorm effect in local time and the probable decoupling of night- and dayside effects by the bulge in the plasmapause near 1800–2200 LT.

Discussion

The difference between the *Dst* relation to the plasmapause position and the corresponding relations of K_p and K local appears to reflect the prominent role of substorm-associated drift motions in determining the minimum range of the plasmapause boundary. These motions and in particular the associated electric fields and current systems, probably have only a minor influence on *Dst*, while being directly reflected in K local at Byrd and somewhat less directly reflected in K_p. The close connection between K local at Byrd and the substorm is established by magnetic bay activity, which should on most occasions be reflected in the scaling of the 3-hour K value bracketing the substorm onset. The relation between substorms and K_p is less direct, involving detection of some aspect of the bay activity at subauroral latitudes by stations of which only a few are near to the substorm activity at a given time. The weakness of the *Dst*-plasmapause position relation may tentatively be ascribed to the location of the observing stations far from regions of substorm current flow in the ionosphere.

Many details of the magnetic-disturbance behavior of the plasmapause remain to be investigated. One remark for the present concerns Figure 2, in which data points for geocentric distances less than 4 R_E appear to cluster in two bands spaced about 0.7 R_E apart. This seems to be a real effect associated with the sequence of events during a protracted weak magnetic storm, such storms being typical of conditions during the June–August 1963 period. During the first 2 or 3 days of a weak storm, the data points tend to lie on the right-hand side of the distribution in Figure 2. Later in the storm the points tend to shift to the left-hand side and to remain there until a noticeable increase in the plasmapause radius begins. The author has noted a corresponding effect in electron number density, wherein the lowest observed nighttime densities just outside the plasmapause tend to be detected several days after the beginning of a weak storm (see [*Angerami and Carpenter*, 1966]). The pattern is not yet clear, but suggests that a process that eventually erodes the plasma and causes the total ionization content of the plasmasphere to be decreased is at work during the early days of a weak storm. When a significantly lower total content has been achieved, relatively moderate activity in the latter phases of the storm is sufficient to maintain the diurnal minimum radius of the knee at a given low value for an additional period.

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