Polar Cap (PC) Magnetic Activity Index

O. A. Troshichev¹, O. Rasmussen², and V. O. Papitashvili³

¹ Department of Geophysics, Arctic and Antarctic Research Institute, St. Petersburg, Russia
² Solar-Terrestrial Physics Division, Danish Meteorological Institute, Copenhagen, Denmark
³ Space Physics Research Laboratory, University of Michigan, Ann Arbor, Michigan, U.S.A.

The PC-index has been introduced by Troshichev et al. [1979, 1988] as an index for monitoring geomagnetic activity over the polar caps caused by changes in the interplanetary magnetic field (IMF) and solar wind. Troshichev and Andrezen [1985] have shown that ground geomagnetic disturbances measured at a single near-pole station highly correlate \( r > 0.8 \) with the “merging electric field” \( E_m \) applied to the Earth’s magnetosphere [Kan and Lee, 1979]:

\[
E_m = V_{SW} B_T \sin^2 (\theta/2) = V_{SW} (B_y^2 + B_z^2)^{1/2} \sin^2 (\theta/2)
\]

Here \( V_{SW} \) is the solar wind velocity, \( B_y \) and \( B_z \) are the IMF azimuthal and vertical components, respectively, and \( \theta \) is the IMF “clock-angle” measured between the Earth’s magnetic field vector and \( B_T \).

The algorithm to derive the PC-index is based on a statistical analysis of the relationship between variations in \( E_m \) and geomagnetic perturbations \( \Delta F \) at the Earth’s surface. Two near-pole magnetic observatories were proposed for derivation of the index: Qaanaaq (Thule) in Greenland at 85.4° corrected geomagnetic (CGM) latitude and Vostok in Antarctica at –83.4°. Since a near-pole station is located under the sunward, transpolar portion of the two-cell ionospheric current system DP2, observed magnetic perturbations point approximately towards dusk. The exact direction is slightly varying in time because DP2 is somewhat skewed with respect to the noon-midnight meridian. Thus, the transverse magnetic perturbation caused by the DP2 transpolar current can be written as:

\[
\Delta F_{PC} = \Delta H \sin \gamma \pm \Delta D \cos \gamma
\]

where \( \gamma = \lambda \pm D_E + \phi + UT \cdot 15^\circ \). Here \( \Delta H \) and \( \Delta D \) are deviations in the ground horizontal \( H \) and \( D \) magnetic field components from the pre-selected quiet level, \( D_E \) is the station’s average declination angle, \( \lambda \) is its geographical longitude, and \( \phi \) is the UT-dependent angle between the DP2 transpolar current and the noon-midnight meridian. “+” is used for Vostok, and “−” for Qaanaaq. The quiet level is deduced for Qaanaaq by interpolating between field’s values determined at nighttime hours of quiet winter days in the two consecutive years. The quiet level for Vostok is determined from quiet days for the examined month.

The “true” angle \( \phi \) is obtained through a correlation analysis relating \( E_m \) and horizontal magnetic perturbations projected on various directions; the direction where correlation is maximal is then used for derivation of the index. Figure 1 shows optimal directions obtained at Vostok and Qaanaaq (Thule).

**Figure 1.** The CGM latitude - MLT diagram for the selection of optimal directions in the PC index derivation [after Vennerstrøm et al., 1994].
for June and December. It was found that these optimal directions vary with UT and season; therefore, the projected horizontal perturbation $\Delta F_{PC}$ should be normalized with respect to $E_m$:

$$\Delta F_{PC} = \alpha E_m + \beta$$

and

$$PC = (\Delta F_{PC} - \beta) / \alpha \eta$$

where $\alpha$ (slope) and $\beta$ (intercept) are functions of local time and month, and $\eta = 1 \text{ mV/m}$ is a normalization coefficient required to make the PC index dimensionless. The PC index is now calculated from a set of 12 (months) by 24 (hourly) values of the coefficients $\alpha$ and $\beta$ and angles $\phi$. These coefficients have independently been determined for Qaanaaq and Vostok for the period when good coverage of the IMF data has been available. For example, Figure 2 shows contour plots of the coefficients $\alpha$ and $\beta$ obtained for Thule as functions of the months and UT hour. Further investigation of the PC-index is underway [e.g., Papitashvili and Rasmussen, 1999; Troshichev et al., 2000]

The World Data Center B2 (Moscow, Russia) and the NOAA National Geophysical Data (Boulder, Colorado, U.S.A.) have published the index catalogs [e.g., Troshichev et al., 1991; Vennerstrøm et al., 1994]; NGDC has also made PC-index available through regular publications. Currently the Northern PC index is continuously derived from geomagnetic data obtained at Qaanaaq; the Southern PC index – from geomagnetic data obtained at Vostok. Both indices are available on-line from the Danish Meteorological Institute (Copenhagen, Denmark, http://www.dmi.dk/projects/wdcb1/pcn) and from the Arctic and Antarctic Research Institute (St. Petersburg, Russia, http://www.aari.nw.ru).

The International Association of Geomagnetism and Aeronomy (IAGA) has officially adopted the Polar Cap (PC) Magnetic Activity Index at the 22nd General Assembly of International Union of Geodesy and Geophysics (IUGG, Birmingham, UK, July 1999). It has been recommended by IAGA that the service should be continued for both the Northern and Southern polar caps in near future upon availability of resources at DMI and AARI.

References


