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Discrepancy between summer and winter PC indices observed in the course of magnetospheric substorms: Physical implications

O. Troshichev and A. Janzhura
Arctic and Antarctic Research, Dept. of Geophysics, St. Petersburg, Russian Federation (olegtro@aari.nw.ru, 7-812-3373241)

The PC index based on a statistically justified relationship between the polar cap magnetic activity and the interplanetary electric field EKL has been derived as a value standardized for the EKL intensity regardless of season, UT and hemisphere. As a result, the summer and winter PC indices are consistent with one another under ordinary conditions. Discrepancies between the summer and winter PC indices arising in the course of magnetospheric substorms are analyzed in this paper. The magnetospheric substorms start only if the PC index reaches the definite threshold value >1.5mV/m for substorms), in case of isolated substorms the summer PC index increase being followed by a delayed growth of the winter PC index. This regularity is explained by quite different conditions in the summer and winter polar regions for closure of the Region 1 field-aligned currents (FAC), which are responsible for the cross-polar cap voltage and, correspondingly, for magnetic activity in the polar caps: the high ionospheric conductivity in summer sunlit polar cap does not limit the raise of FAC intensity in response to solar wind impact on the magnetosphere, as opposed to the winter dark low-conducting ionosphere, where the Region 1 FAC closure is dependent on the auroral ionosphere conductivity and strongly affected by the auroral particle precipitation. As conductivity in the auroral oval raises owing to growth of the particle precipitation, the conditions for closure of the Region 1 field-aligned currents in the winter dark polar region are improved and summer and winter PC indices level off.
The powerful sawtooth substorms are characterized by continuous very intense particle precipitation in the auroral zone, which supports the extreme high conductivity of the auroral ionosphere. As a result, the Region 1 FAC intensity in the winter polar cap extremely increases whereas conditions of the Region 1 FAC closure in the summer sunlit ionosphere are only trivially affected. large intensity. Since the coefficients describing the relationship between EKL and the polar cap magnetic activity were derived for statistically justified (i.e. mean) conditions, their application to such abnormal situation, as intense field-aligned currents in the winter dark polar region, should lead to overestimation of the winter PC index. It is just this regularity that typical of powerful magnetic disturbances, like to sawtooth substorms. The summer and winter PC indices decline and level off as soon as the intense auroral particle precipitation terminates and the auroral ionosphere in the winter and summer polar caps returns to the ordinary (statistically justified) state.