Solar UV irradiation and solar wind effects in the polar cap magnetic activity (PC) index: distinctive features of the last cycle of solar activity

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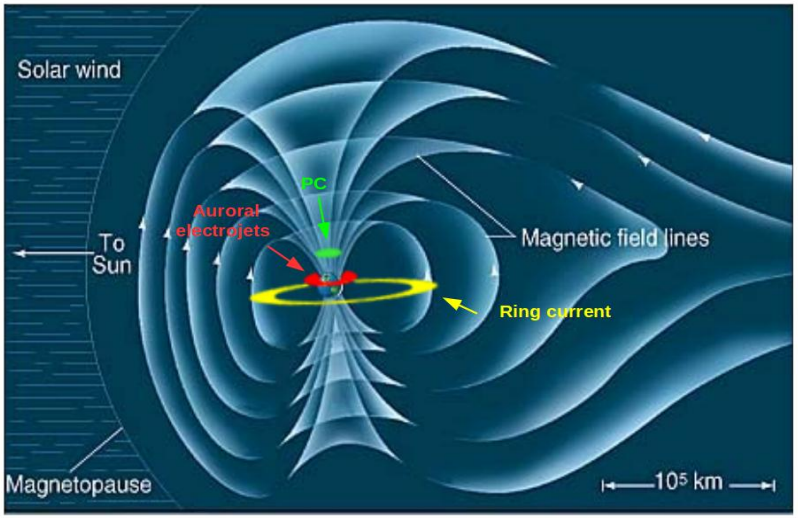
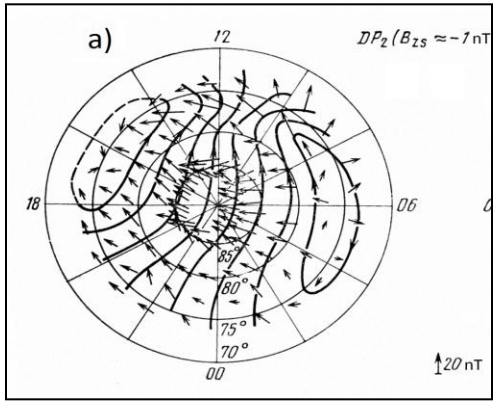
PC index as an indicator of the solar wind energy that entered into the magnetosphere:

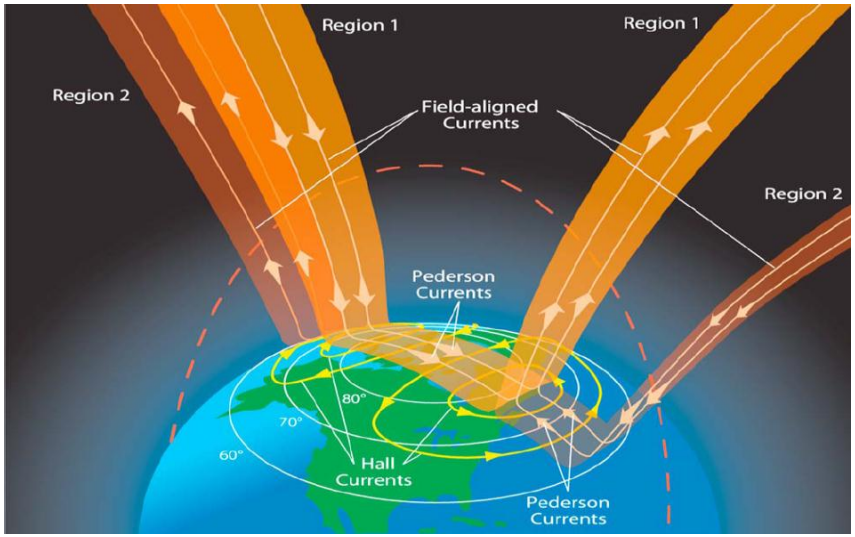


The PC index has been introduced [*Troshichev and Andrezen*, 1985; *Troshichev et al.*, 1988] to characterize magnetic activity in the polar caps generated by the solar wind coupling with the magnetosphere**.**

Experimental data are evidence that the field-aligned currents are permanently presented on the poleward boundary of the auroral oval. They are strongly dependent on interplanetary electric field (Langel, 1975; McDiarmid et al.,1977; Iijima & Potemra, 1982; Bythrow & Potemra, 1983).

These currents generate the cross-polar cap potential difference and the appropriate magnetic activity in the polar cap (Troshichev and Tsyganenko, 1979; Troshichev et al., 1979).





The concept of the magnetic disturbances in the polar cap, controlled by the interplanetary electric field *EKL* determined by Kan and Lee (1979), served as a basis for the method of the PC index calculation.

The technique of *PC* index derivation consists of two separate procedures:

(1) derivation of the statistically justified regression coefficients α (slope) and β (intersection) and angle φ determining relationship between the vector of polar cap magnetic disturbance δF and interplanetary electric field *EKL* and

(2) calculation of *PC* indices by data on current δF values with use of the regression coefficients established in course of the first procedure.

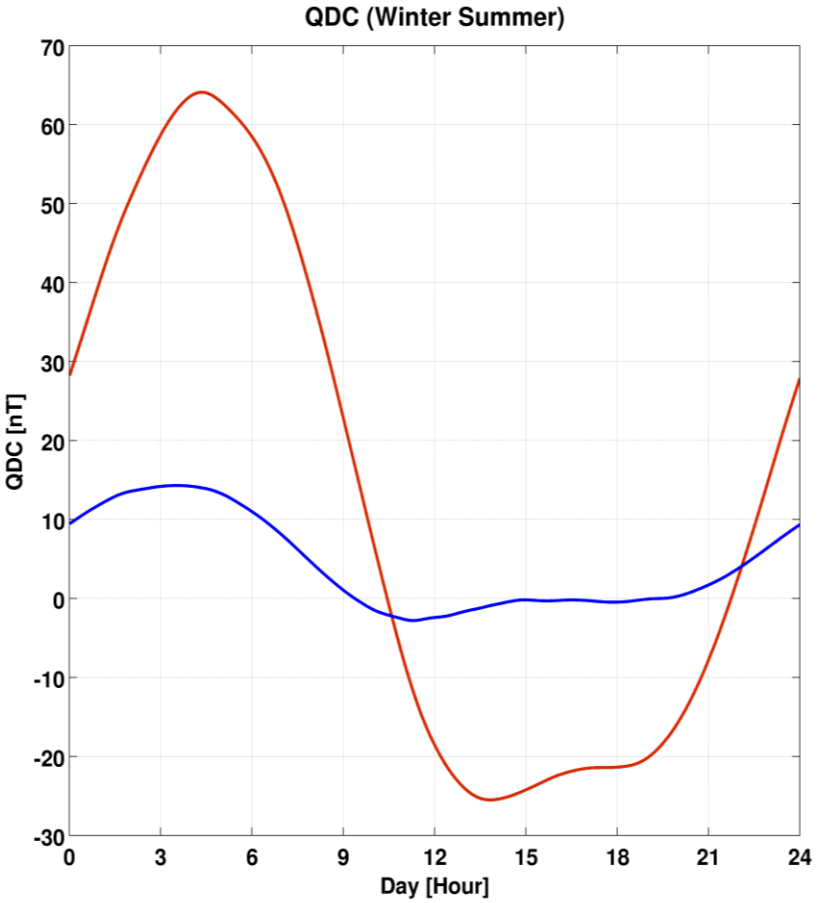
The magnitude of the polar cap magnetic activity is counted from level of the quiet daily geomagnetic field variation (QDC) to make allowance for the ionospheric conductivity changes caused by variable solar UV irradiation.

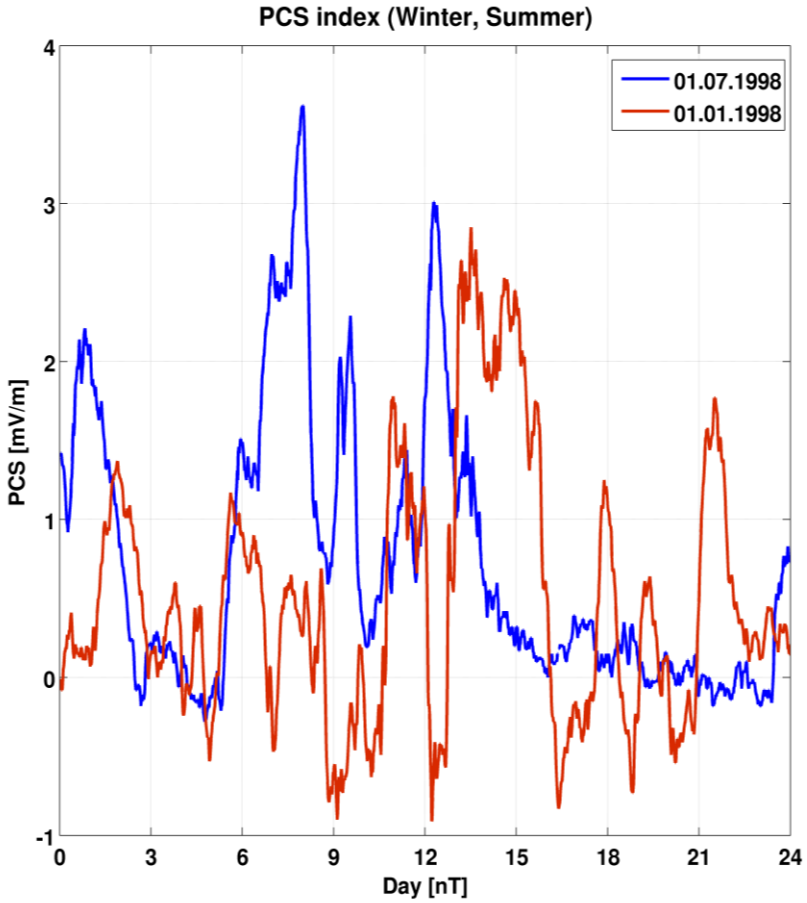
Usage of a proper QDC, as a level of reference for values of the polar cap magnetic disturbance, leads to invariance of the parameters α, β and ϕ determining relationship between the EKL and polar cap magnetic activity irrespective of solar activity epoch. Thus, once derived parameters of α, β and ϕ can be regarded as valid forever, whereas the magnitude of the corresponding QDCs changes from year to year.

PC index is calculated independently for northern (*PCN*) and southern (*PCS*) hemispheres by magnetic data from two near-pole magnetic observatories: Thule (now Qaanaaq) in Greenland at 86.5° corrected geomagnetic (CGM) latitude, and Vostok in Antarctica at –83.4°. Two sets of 1-min indices (*PCN* and *PCS*) and corresponding QDC values have been calculated for every day of the last cycle of solar activity (1998-2012).

In this study the daily mean QDC were examined to estimate the effect of the solar UV irradiation and its change in course of the last solar cycle, whereas the daily mean PC quantities estimate the solar wind effect and it's changes in different epochs of solar activity.

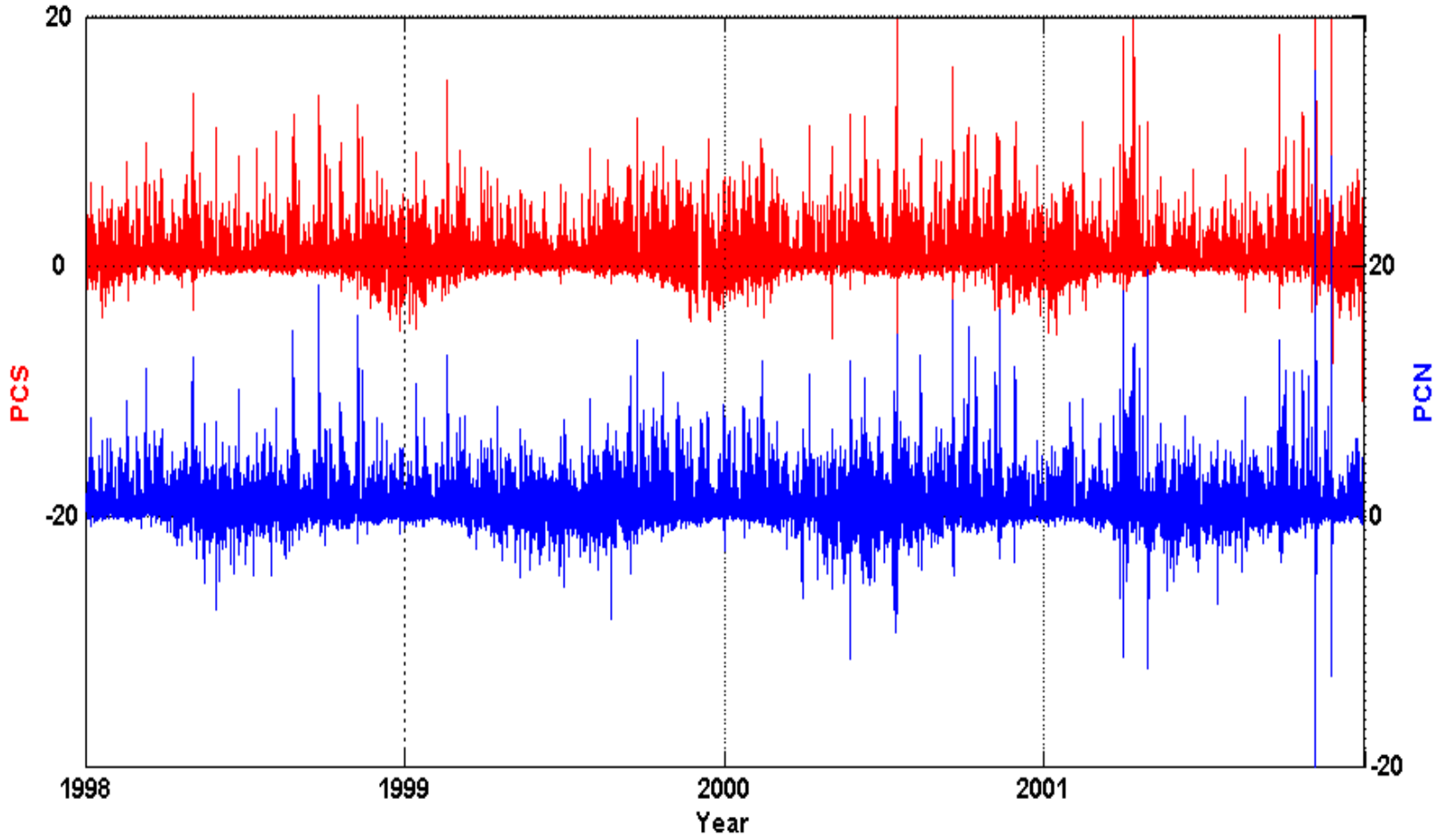
Quiet Daily Curves for summer and winter days (1 January and 1 July 1998) and run of the PCS index counted from QDC level





Magnitude of QDC under conditions of high conductive ionosphere in summer polar cap (red line) is much larger than that in the winter polar cap (blue line).

Run of the PCN and PCS indices counted from QDC

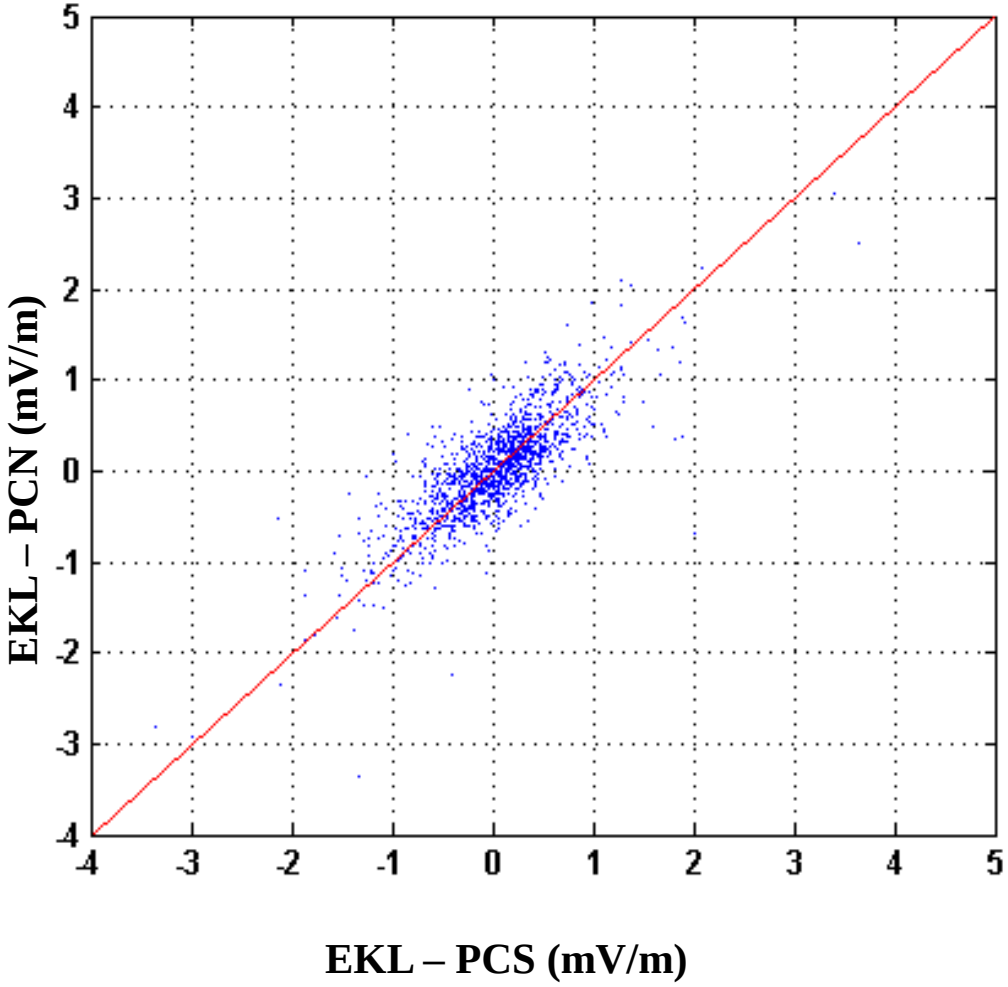


There is a remarkable agreement in behavior of the positive northern (PCN) and southern (PCS) indices counted from QDC as a level of reference.

The positive PC indices increase simultaneously (up to 20 mV\m) in both hemispheres.

The negative PC indices related to the specific NBZ field-aligned current system are observed only in summer season owing to high conductivity of the sunlit ionosphere.

Relationship between values of the PCN/PCS index and interplanetary electric field EKL influencing the magnetosphere.



The relationship between differences (*EKL-PCS*) and (*EKL-PCN*) for 2000 is shown in Figure.

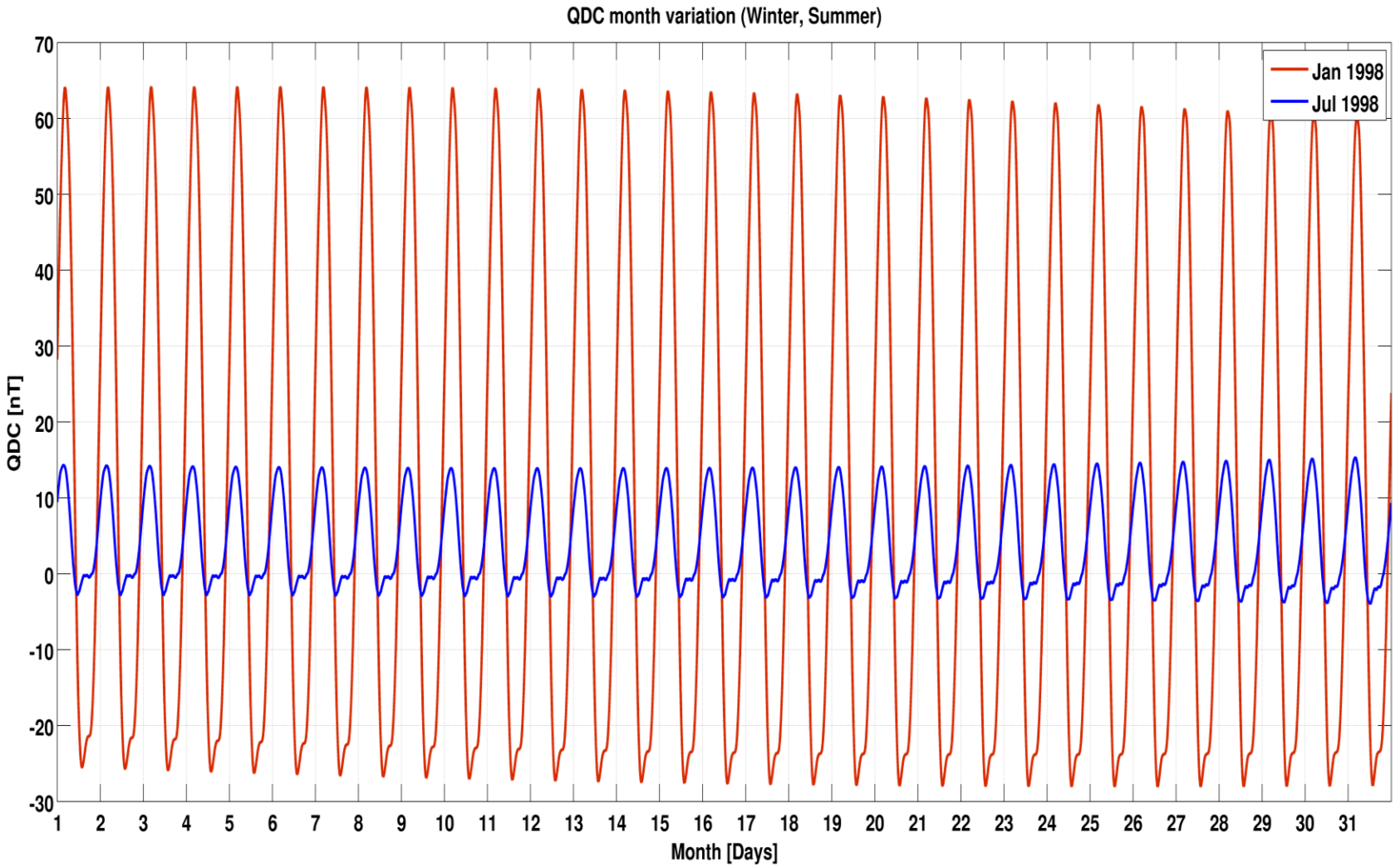
Differences (*EKL-PCS*) and (*EKL-PCN*) are in close agreement.

It is seen that values of differences (*EKL-PCS*) and (*EKL-PCN*) lie in range ± 1 mV/m.

Conclusion:

Use of QDC as a level of reference in counting off the value of the polar cap magnetic disturbances δF provides agreement between indices of the polar cap magnetic activity in the northern (*PCN*) and southern (PCS) hemispheres and their consistency with the interplanetary electric field *EKL*.

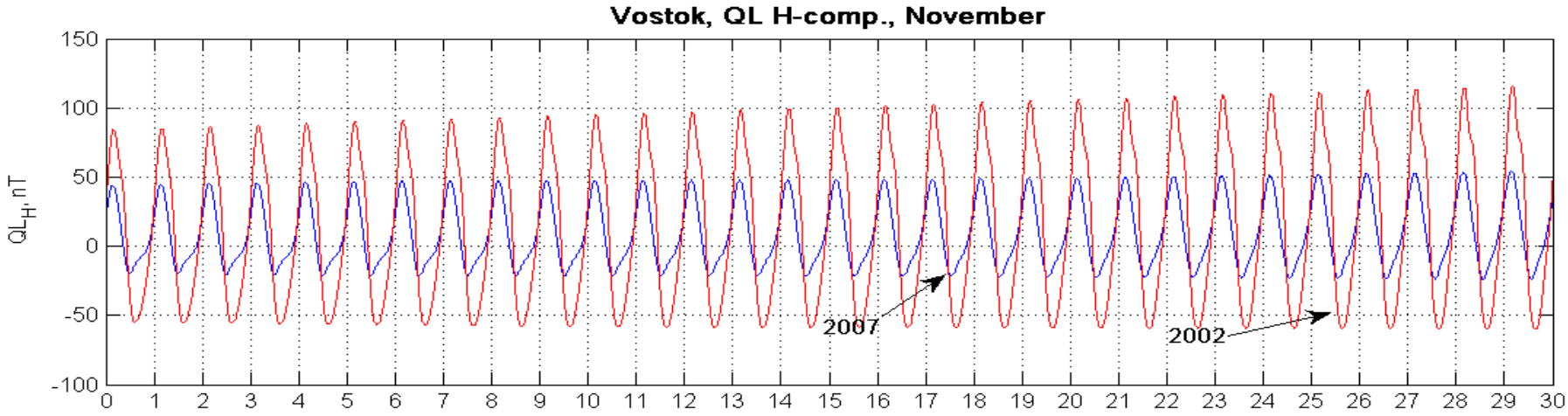
Seasonal changes of the QDC amplitude



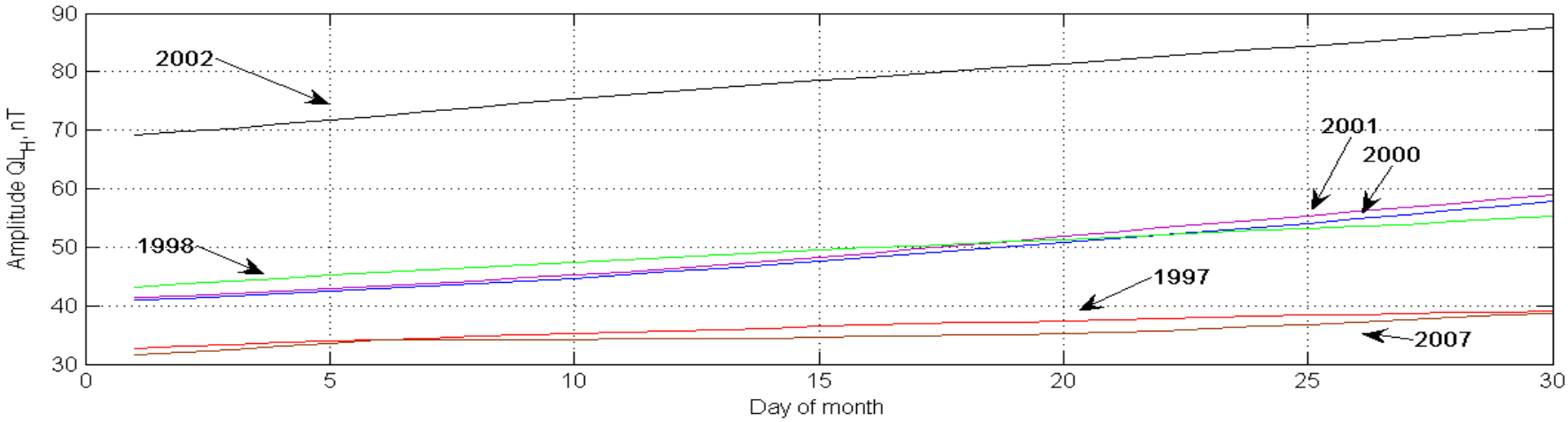
Magnitude of QDC changes from day to day and reaches the maximum in the summer solstice and minimum in the winter solstice.

Difference of the QDC amplitudes in periods of solar maximum (November 2007) and solar minimum (November 2002)

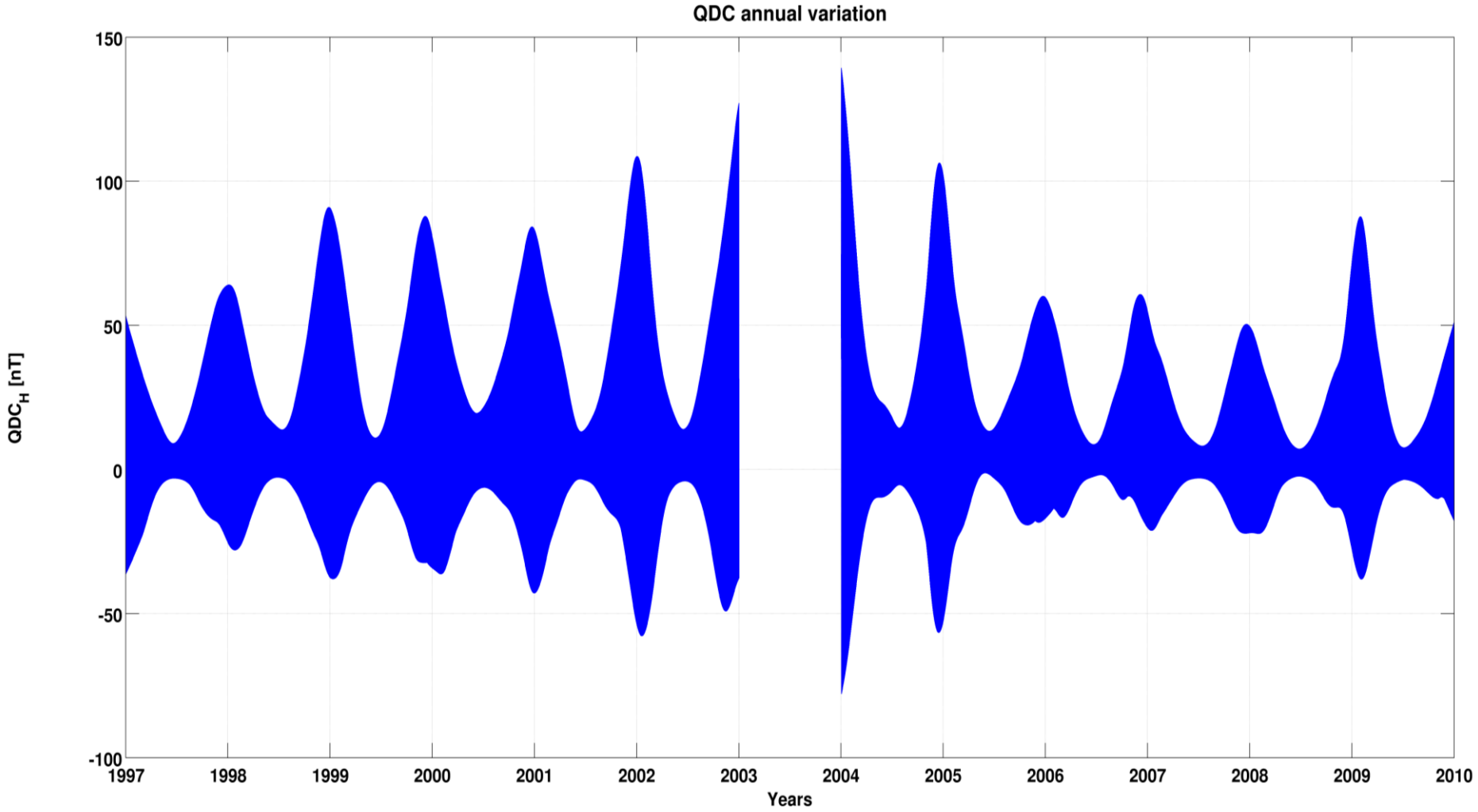
QDC in H components at Vostok station (Antarctica) in Novembers of 2002 and 2007



Amplitude of the November QDC in different years of the solar cycle

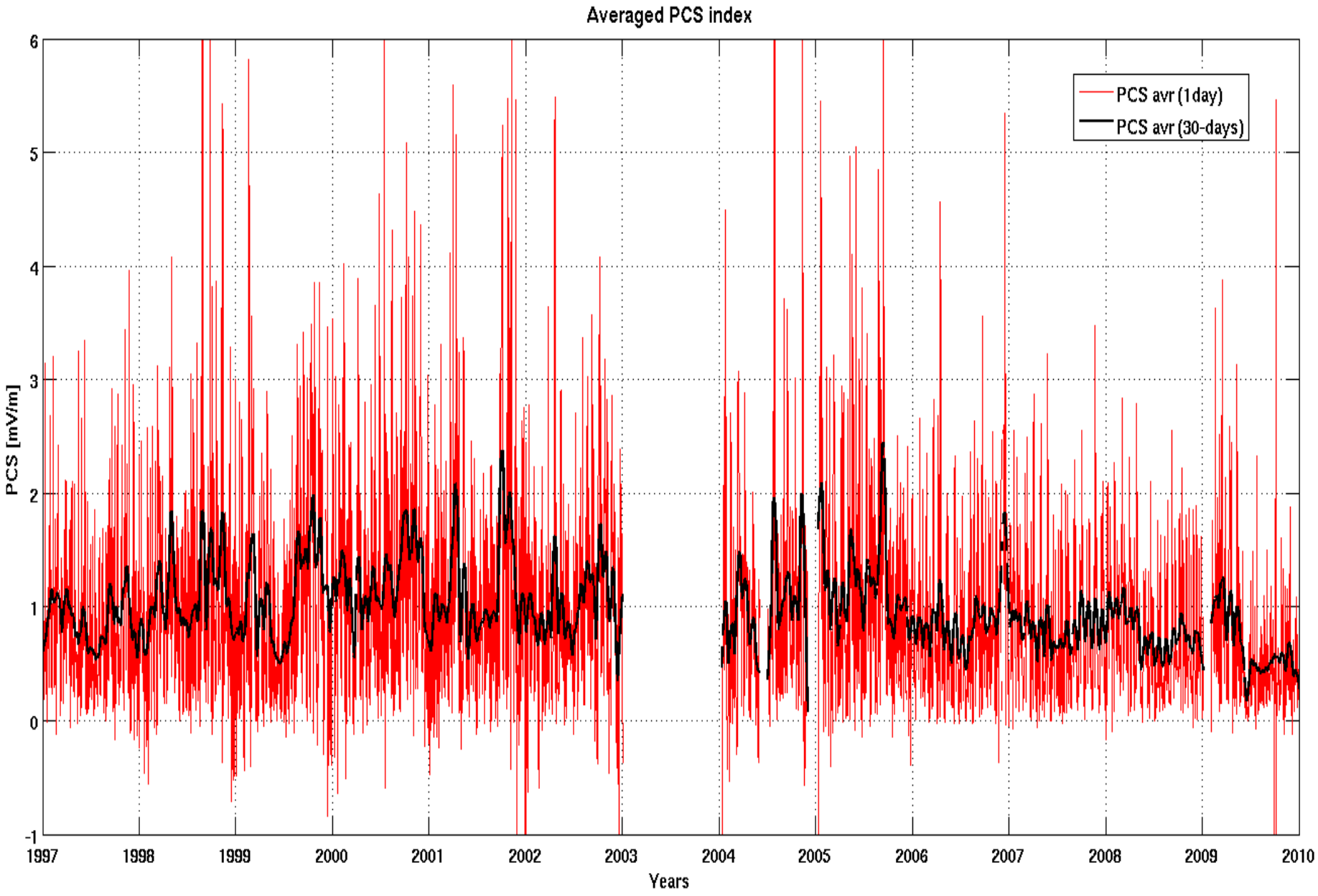


Range of QDC changes in summer and winter months in course of solar cycle

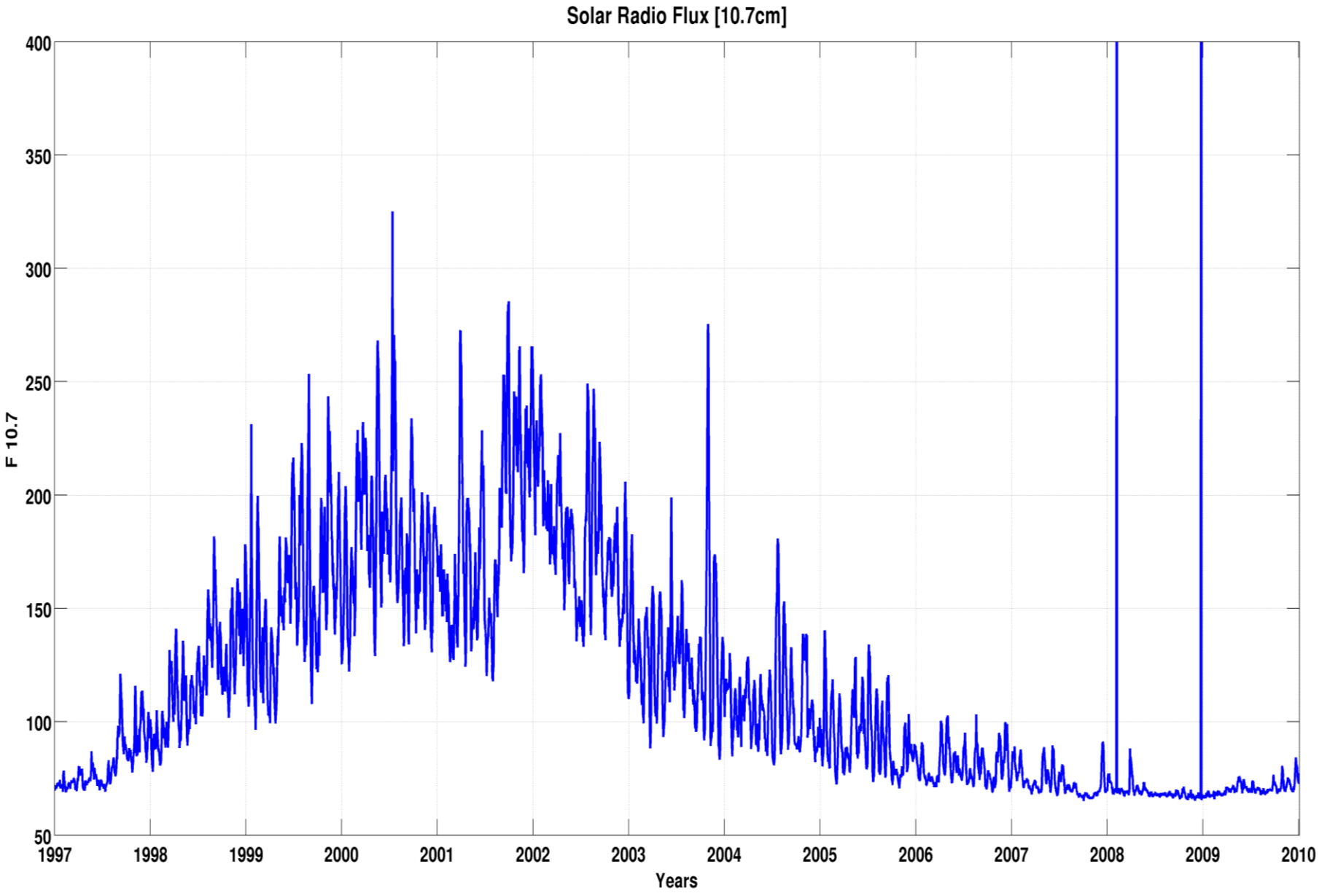


Amplitude of QDC kept the large the large values in epoch of solar maximum (1999-2001), reached the highest level by 2004 and started to decrease in 2005 down to minimum in 2008 (increase in 2009 could be regarded as a precursor of the next solar cycle beginning).

Run of the PC index in course of solar cycle



Run of the solar activity index F10.7 in course of solar cycle



Conclusions

The *PC* index has been introduced as a value of the polar cap magnetic activity generated in the polar regions under influence of the geoeffective solar wind coupling with the magnetosphere.

To make allowance for the ionospheric conductivity changes related to the solar UV variations, the value of the polar cap magnetic disturbance δF was counted from the Quiet Daily Curve (QDC), the QDC amplitude being maximum in the summer polar cap owing to high conductivity of the sunlit ionosphere and being minimum in the winter dark polar cap.

Use of QDC as a level of reference in estimating δF provides adequate response of the PCN and PCS indices to the solar wind influence irrespective of season, UT time and site of geomagnetic observations.

The QDC amplitude determined for each day in period from 1997 to 2009 demonstrate remarkable changes in course of solar cycle, as follows:

- amplitude keeps the high level in course of solar maximum (1999-2001), but reaches the largest values after the maximum (in 2004),
- amplitude quickly decreases in 2005 and remains on low level during 3 years (2206-2008), it starts to increase again in 2009.

These changes of QDC amplitude do not consistent either with variations of the solar activity (index F10.7) in course of solar cycle or with the run of the PC index.

The QDC changes could be regarded as evidence of the appropriate changes in the solar UV irradiation if they are supported by other independent data..