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Solar Wind Parameters in Positive and Negative Polarity Solar Cycles

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Abstract

Solar wind streams reach the Earth's magnetosphere and may cause essential physical processes on it. They are not associated with large geomagnetic storms which are usually caused by CME but nevertheless solar wind streams are important drivers of the geomagnetic activity. Statistical investigation of the solar wind parameters can give some guidelines for understanding of Solar - Terrestrial relationship. In the present investigation we compare different solar wind parameters during positive and negative polarity solar cycles since 1964.

Introduction

The solar wind streams, directed away from the Sun, are not uniform. They rapidly change their basic parameters – speed V [km/s], temperature T [K], direction and magnitude of the carried magnetic field B [nT], density ρ [N/cm^3], pressure P [nPa], etc. Studies of the physical processes related to these changes or just observational and statistical comparison for different periods of the Sun's activity, have significant importance for understanding how the Sun's momentum state can influence on the Earth's environment.

There are several catalogues for solar wind parameters, covering the last four solar cycles. Using the experimental data presented in OMNIWeb Data Explorer (omniweb.gsfc.nasa.gov), we can study different parameters characterizing solar wind state near the Earth.

Data processing

From a physical point of view we separate the data according to the Sun's magnetic field reversal. The polar fields reverse polarity during each cycle at about the time of cycle maximum. In Figure 1 and Table 1 are presented the last four reversals.

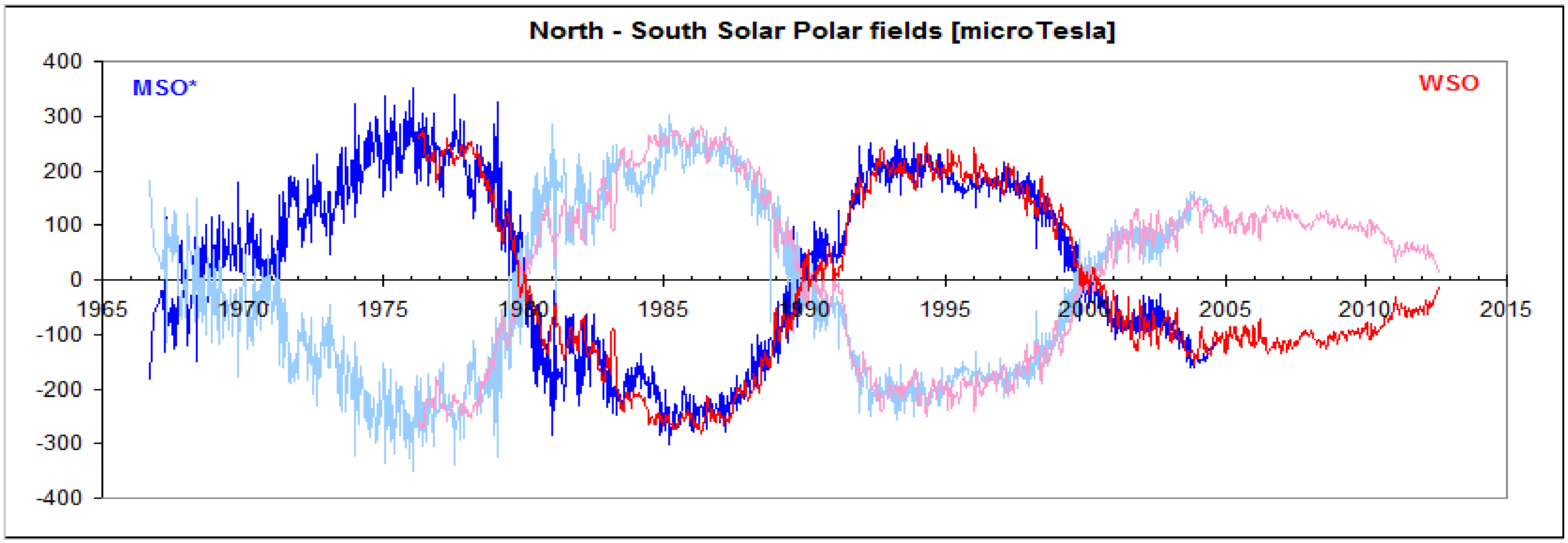


Figure 1. The North and South Sun's magnetic fields reversing (Chart by Leif Svalgaard).

Solar cycle	Period	Magnetic field strength in the poles of the Sun
20	Jan. 1969 - Dec. 1974	decrease
20	Jan. 1975 - Nov. 1979	increase
21	Dec 1979 - Dec 1984	decrease
21	Jan. 1985 - Feb. 1990	increase
22	Mar. 1990 - Dec 1994	decrease
22	Jan 1995 - Dec 1999	increase
23	Jan 2000 - Nov 2008	decrease

Table 1. Periods of solar cycles for which the experimental data of the parameters are separated.

After separating the data to measured during negative polarity solar cycles (NPSC) and positive polarity solar cycles (PPSC), we found their monthly average daily values. In this way we can find the differences between NPSC and PPSC using the obtained values for the components of the magnetic field, plasma temperature, plasma density, plasma speed, flow pressure, respectively.

Examination of monthly average daily values suggests that we are looking for differences between NPSC and PPSC during the seasonal Earth's rotation.

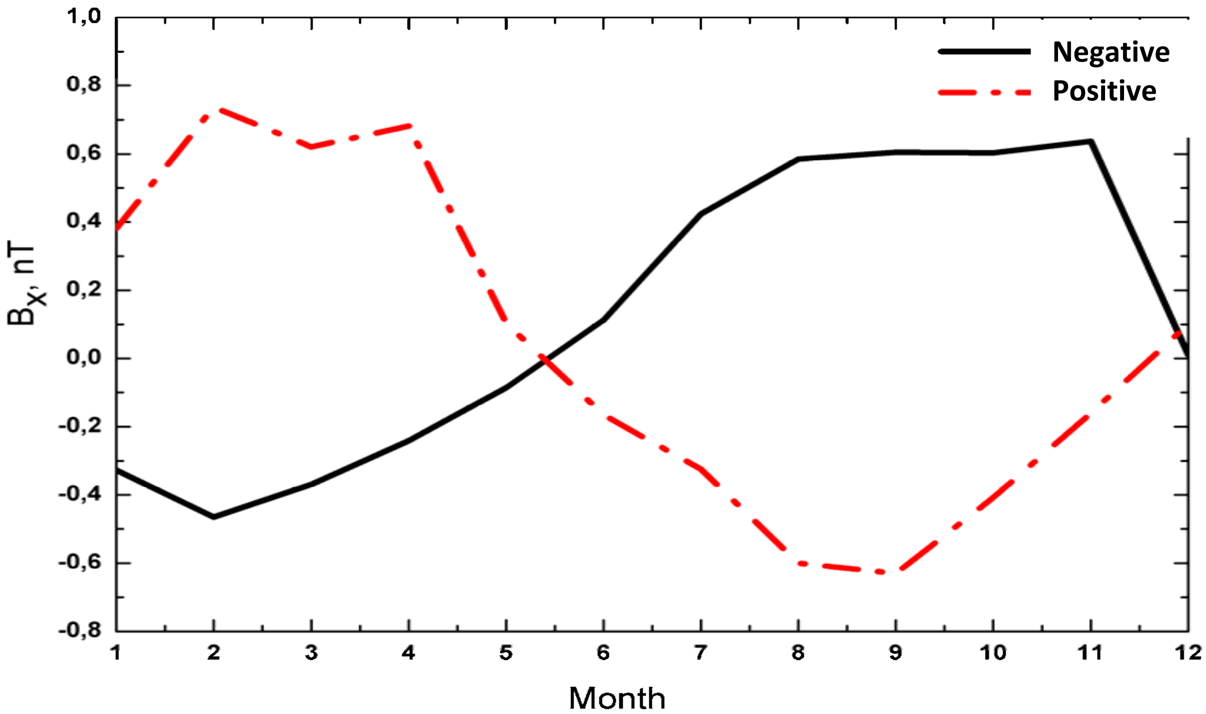


Figure 2. Annual cycle of the IMF B_x component in PPSC (broken line) and NPSC (solid line).

In spring the Earth is at highest Southern heliolatitudes and in PPSC, in the Southern solar hemisphere the magnetic field is toward the Sun, so IMF B_x component near the Earth is positive.

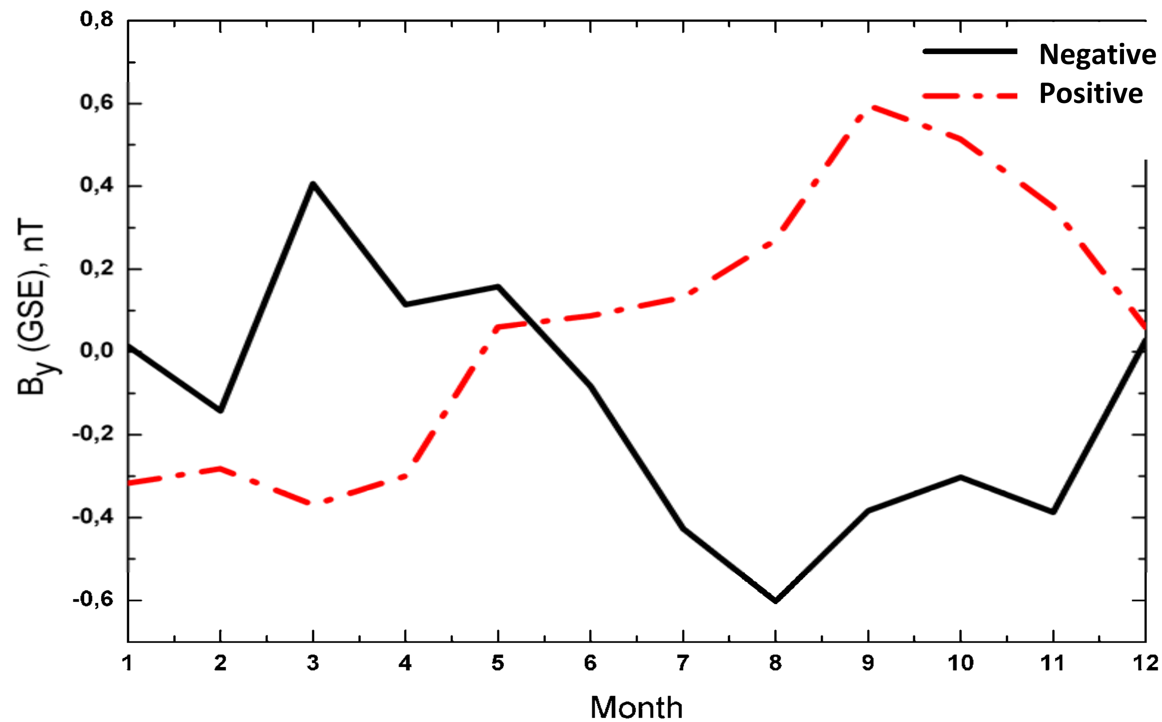
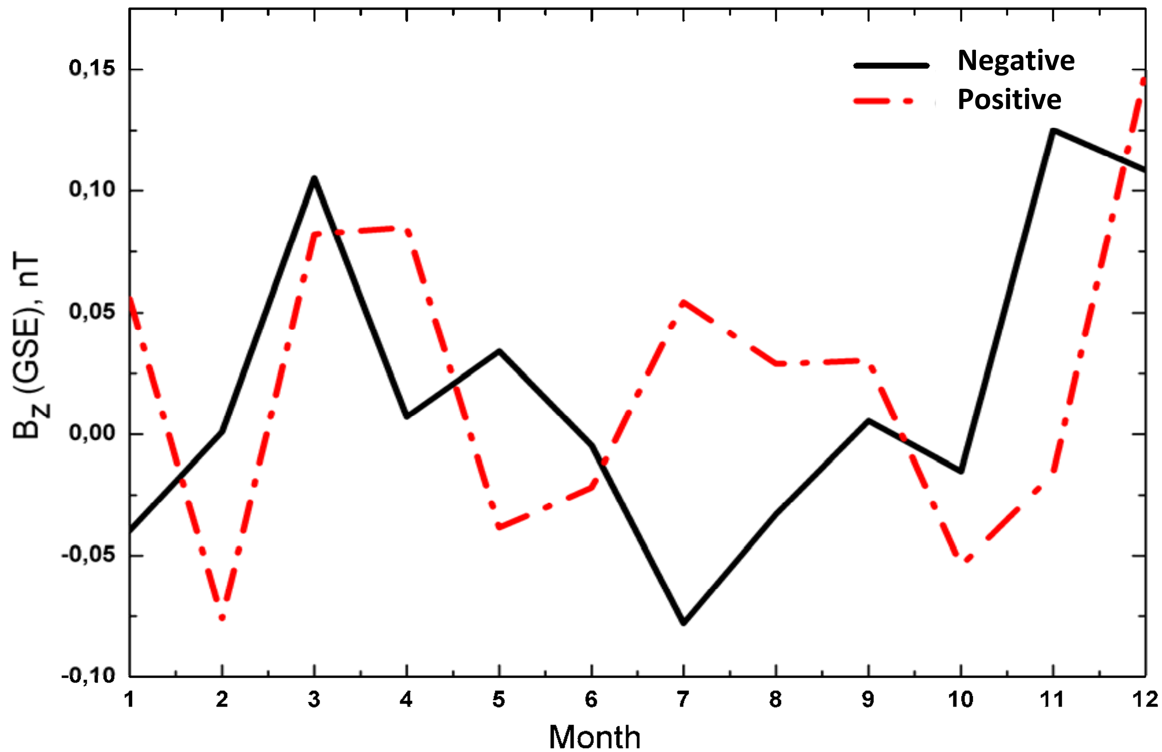


Figure 3. Annual cycle of the IMF B_y component in PPSC (broken line) and NPSC (solid line).

The behavior of the B_y component is the opposite to the one of B_x. In autumn, when the Earth is at highest Northern heliolatitudes, the field is away from the Sun and B_y is positive

Figure 4. Annual cycle of the IMF Bz component in PPSC (broken line) and NPSC (solid line).



The basic geometry of the heliospheric magnetic field is described by the Archimedean spiral model of Parker. In-situ measurements confirmed this general picture, and some differences were found between the calculated parameters and the measured ones.

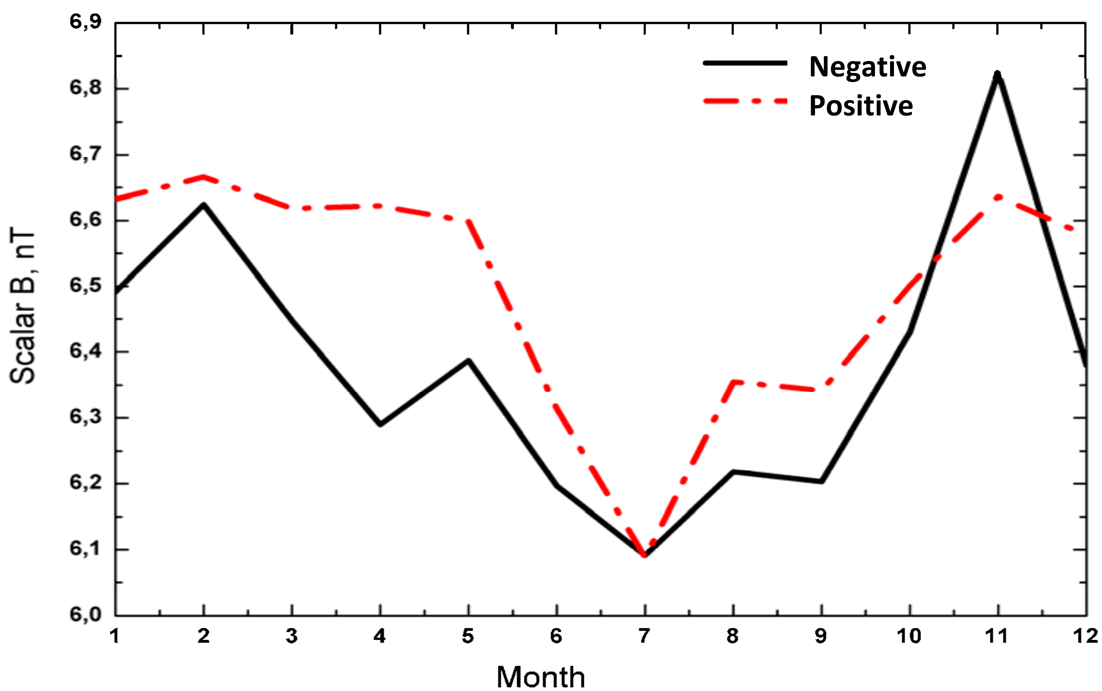


Figure 5. Annual cycle of the IMF Scalar B in PPSC (broken line) and NPSC (solid line).

Taking into account that both IMF components B_x and B_y demonstrate a clear 22 – year periodicity while B_z doesn't show such trend.

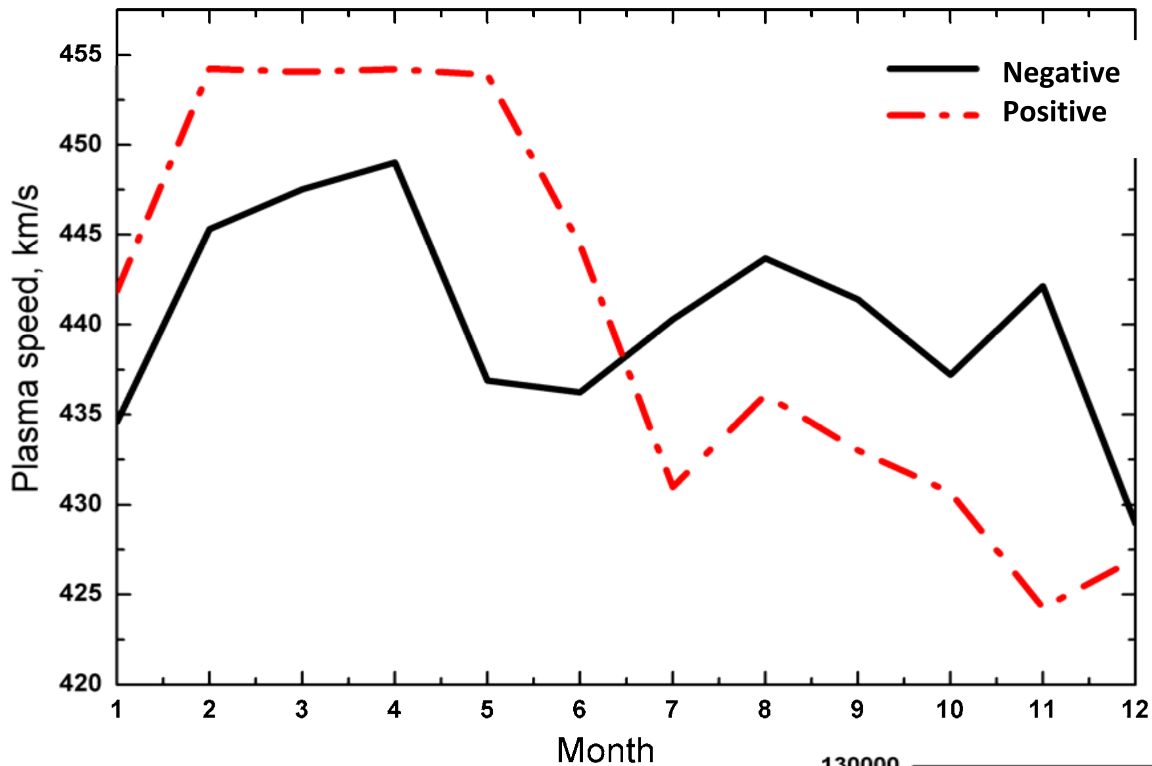


Figure 6. Annual cycle of the Plasma speed in PPSC (broken line) and NPSC (solid line).

The monthly average daily values of plasma speed for both negative and positive periods show an identical trend.

Plasma temperature is not appropriate for such type of analysis. In Figure 7 we can notice that the average temperature during positive periods is higher than in negative periods.

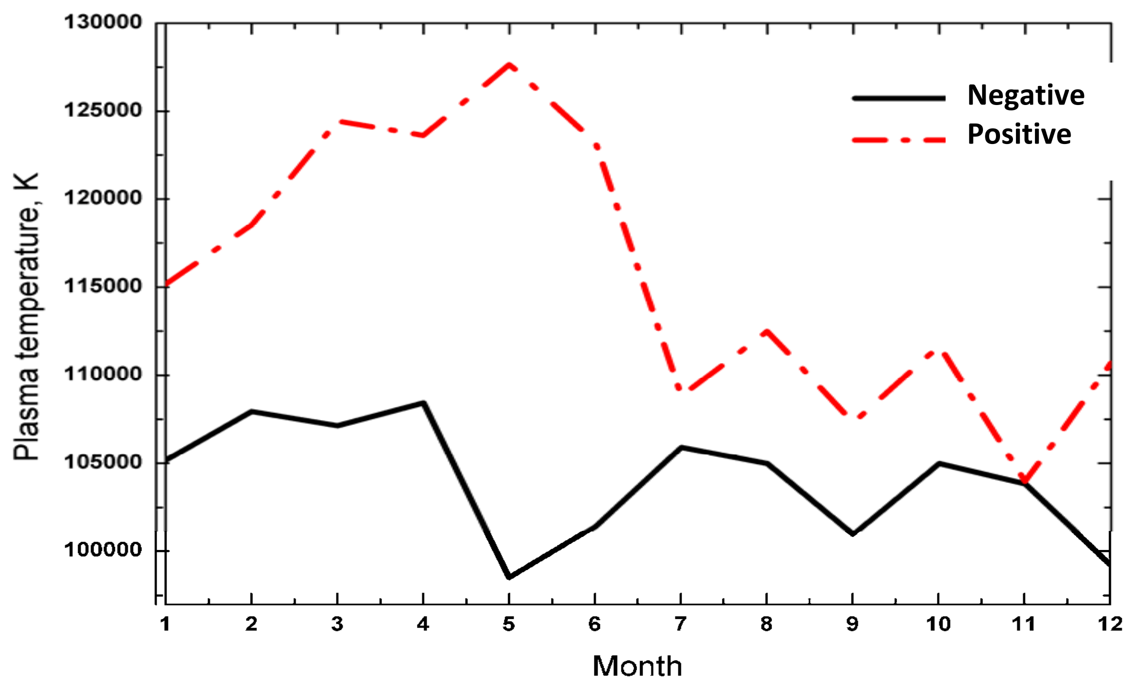
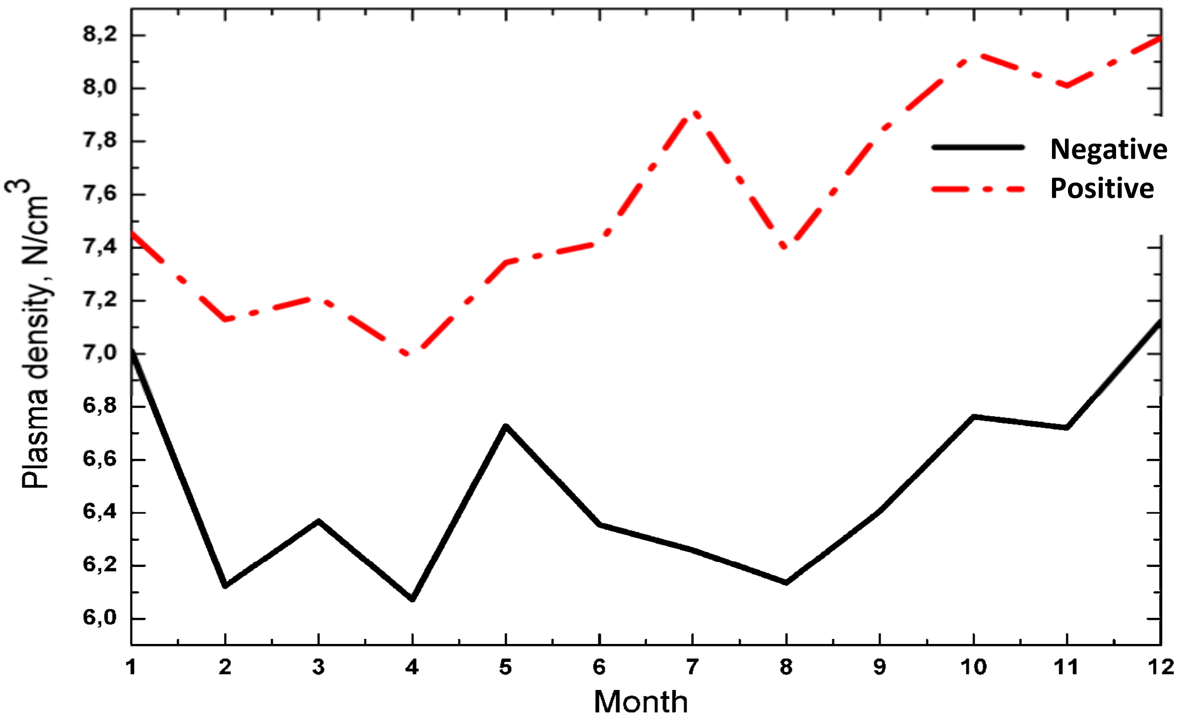


Figure 7. Annual cycle of the Plasma temperature in PPSC (broken line) and NPSC

Figure 8. Annual cycle of the Plasma density in PPSC (broken line) and NPSC (solid line).

The monthly average daily values of plasma density and flow pressure are higher in positive periods than in negative periods of solar cycle.



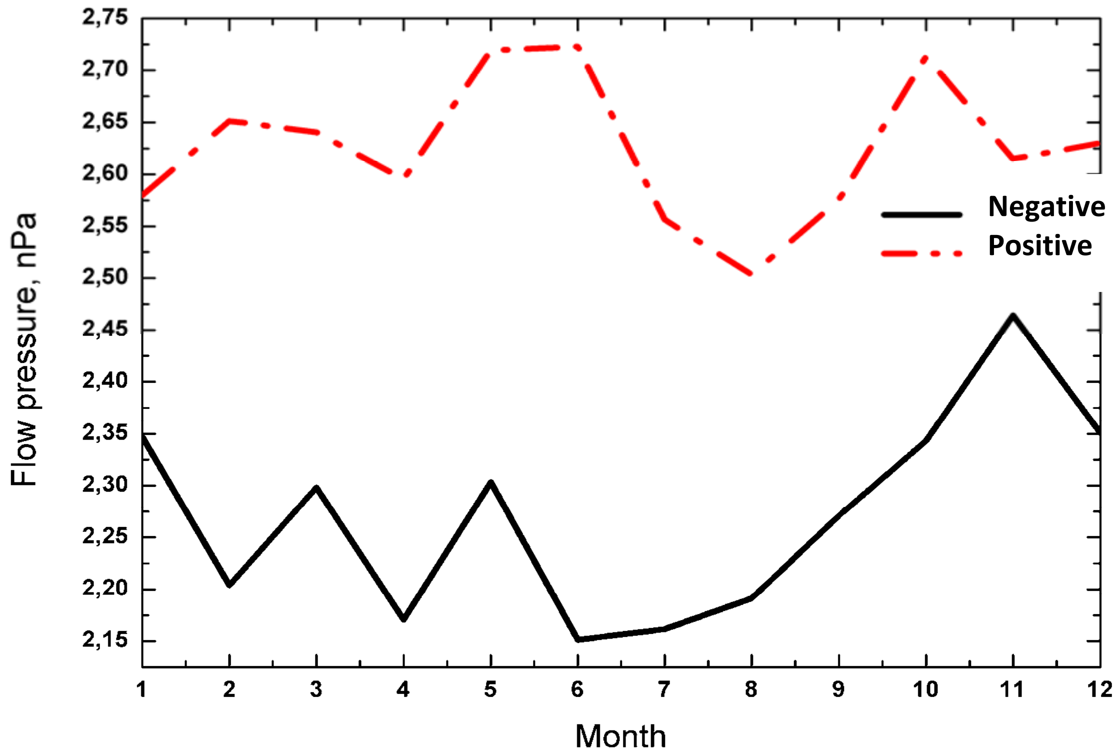


Figure 9. Annual cycle of the Flow pressure in PPSC (broken line) and NPSC (solid line).

There isn't any seasonal trend during both periods in these two parameters.

Conclusion

Statistical investigation of the parameters, which characterize the solar wind, can give some guidelines for understanding of Solar - Terrestrial relationship. In this work is presented a primarily view of possible relations between solar wind parameters in different periods of solar cycle – negative and positive polarity solar cycles.

Because of the complexity and nonlinearity of the physical processes related to them, we can see specific seasonal trends for some of the parameters only – IMF component B_x and B_y, scalar B and plasma speed. Nevertheless, the collected data for the parameters, allows applying different statistical methods for analyzing the relations between positive and negative solar cycles. One possible solution in future study is to use a nonlinear treatment of the problem.