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HIGH SPEED SOLAR WIND STREAMS INFLUENCE ON NAM

Asenovska Y., Georgieva K., Asenovski S.

Space Research and Technology Institute, Bulgarian Academy of Sciences
Sofia 1113, Acad. G. Bonchev Str., bl 1

ABSTRACT

The most important role in the atmospheric circulation in the Northern hemisphere plays the Northern Annular Mode (NAM). The NAM index changes the surface air temperature in a typical pattern. This research is about high speed solar wind streams (HSS) and their influence on the atmospheric circulation in winter months (November - February). The NAM index during HSS follows different trends in positive and negative solar cycles and in periods with negative and positive QBO.

INTRODUCTION

The Northern Annular Mode (NAM-index) stands for the whole Northern hemisphere and for different altitudes. It characterizes the variations in the strength of the polar vortex. The NAM is a hemispheric-scale pattern, characterized by synchronous fluctuations in pressure of one sign over the northern polar cap and of opposite sign at lower latitudes.

This study is for the influence of the high speed solar wind streams on the NAM index. HSS come from solar coronal holes – open magnetic field regions. The plasma of these streams (mainly consisting of electrons, protons and helium nuclei) is characterized by high speed, low temperature and low density. When facing the Earth, the HSS cause long but not very strong geomagnetic storms.

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DATA AND METHODS

For identifying the HSS, Richardson catalogue of the structure of the solar wind was used. The catalogue starts from 1963 and ends in 2012. 150 HSSs that meet the following criteria:

- take place during the winter (from November to February)
- last at least 4 days
- at least 2 days before the HSS, the solar wind was slow, no CMEs or another HSS

were separated.

Using this list of HSS and the catalogue of Baldwin and Dunkerton for the daily NAM at 17 altitudes, a script in MatLab was written. The script extracts the values of NAM for 13 days for each HSS – 2 days before the HSS, the day of the HSS and 10 days after that. Because the data for the NAM ends in July 2006, the final number of investigated HSS dropped to 126.

To the data two more fields were added – for the polarity of the solar magnetic cycle and for the QBO. Both these fields have only two possible values – positive and negative. The polarity cycles are:

- before January 1969: negative
- January 1969 – December 1979: positive
- January 1980 – December 1989: negative
- January 1990 – December 1999: positive
- after January 2000: negative.

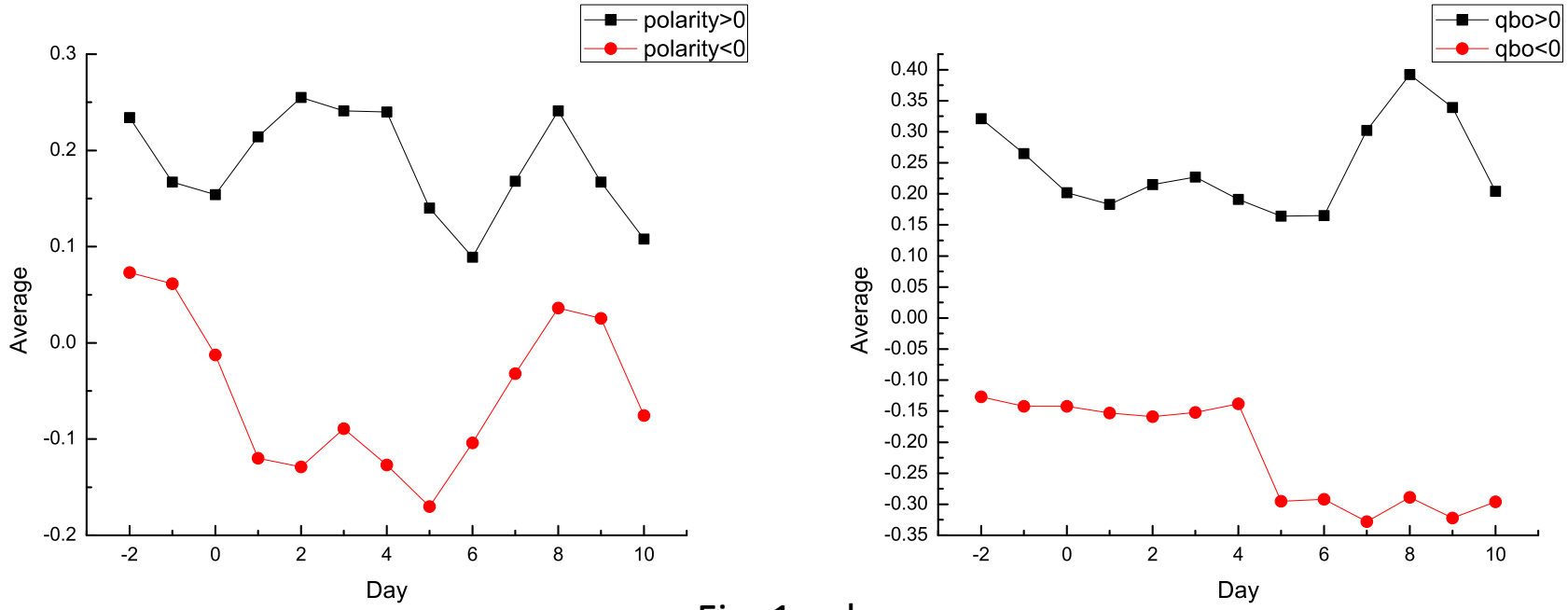
The list for the monthly QBO values at 7 different altitudes for years 1953 - 2013 was downloaded from the website of the Free University, Berlin. It was used only the sign of the QBO at 50 hPa altitude.

To see the influence of the HSS on the NAM, we used the superimposed epoch analysis method. For each of the 17 altitudes of the NAM, the data was organized in tables with 126 rows and 18 columns. The rows are for the 126 HSS described above, and the columns are as follows:

- the first three are for the date on which the HSS reaches the Earth: year, month, day
- the next two are for the polarity and QBO
- the last 13 are the values of the NAM for 2 days before the HSS, the day of the HSS and 10 days after that.

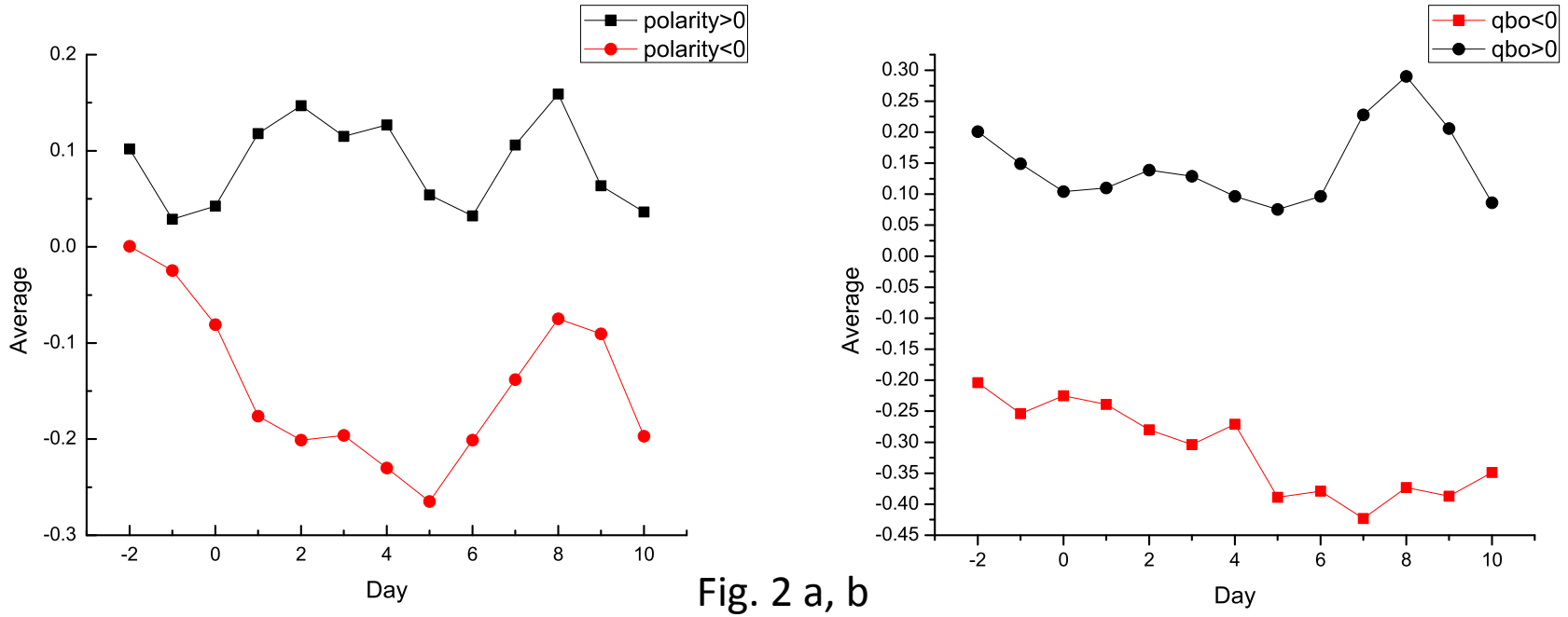
Plots of the average values of NAM for each of the 13 days of the HSS for different values of the solar cycle polarity and QBO were made from the final 17 tables.

At first the separation was only for positive or negative magnetic polarity solar cycles, then for positive or negative QBO. After that we added 4 cases: positive polarity and positive QBO, positive polarity and negative QBO, negative polarity and positive QBO and negative polarity and negative QBO. Finally we separated from each other the 5 solar magnetic cycles (not only in positive and negative).



1000 hPa

Fig. 1 a, b



850 hPa

Fig. 2 a, b

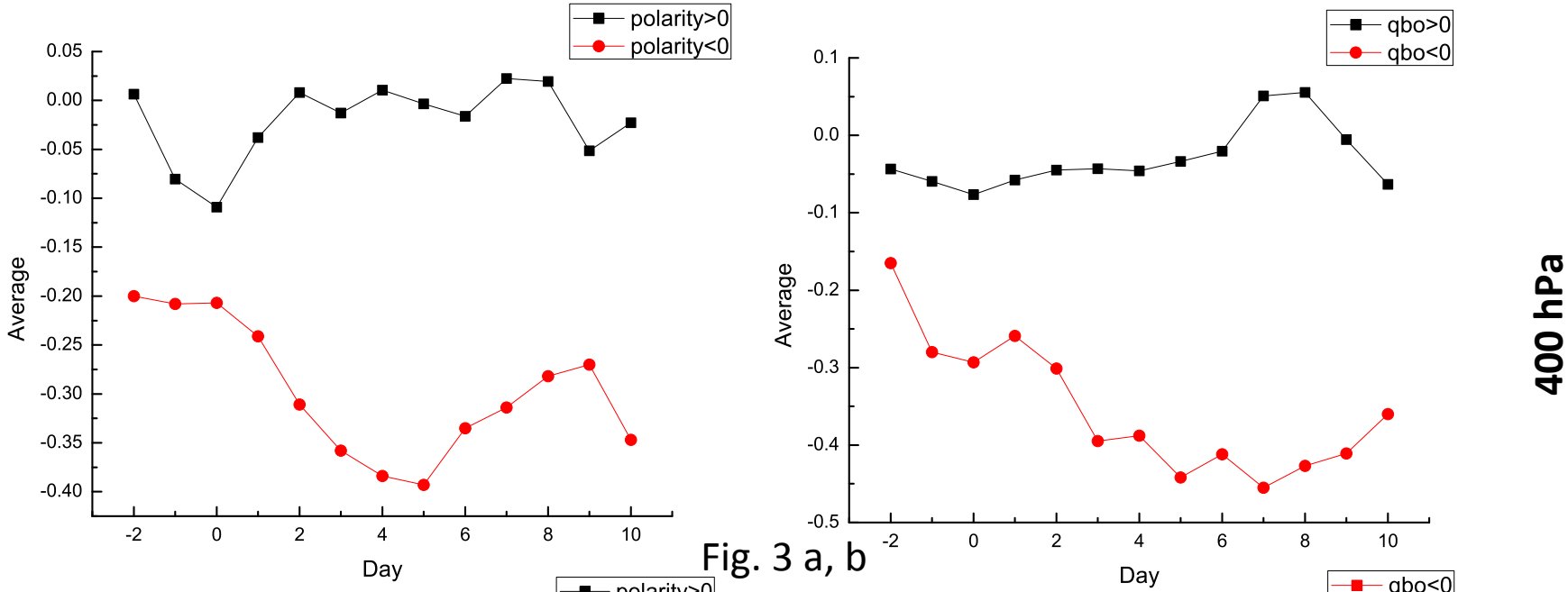


Fig. 3 a, b

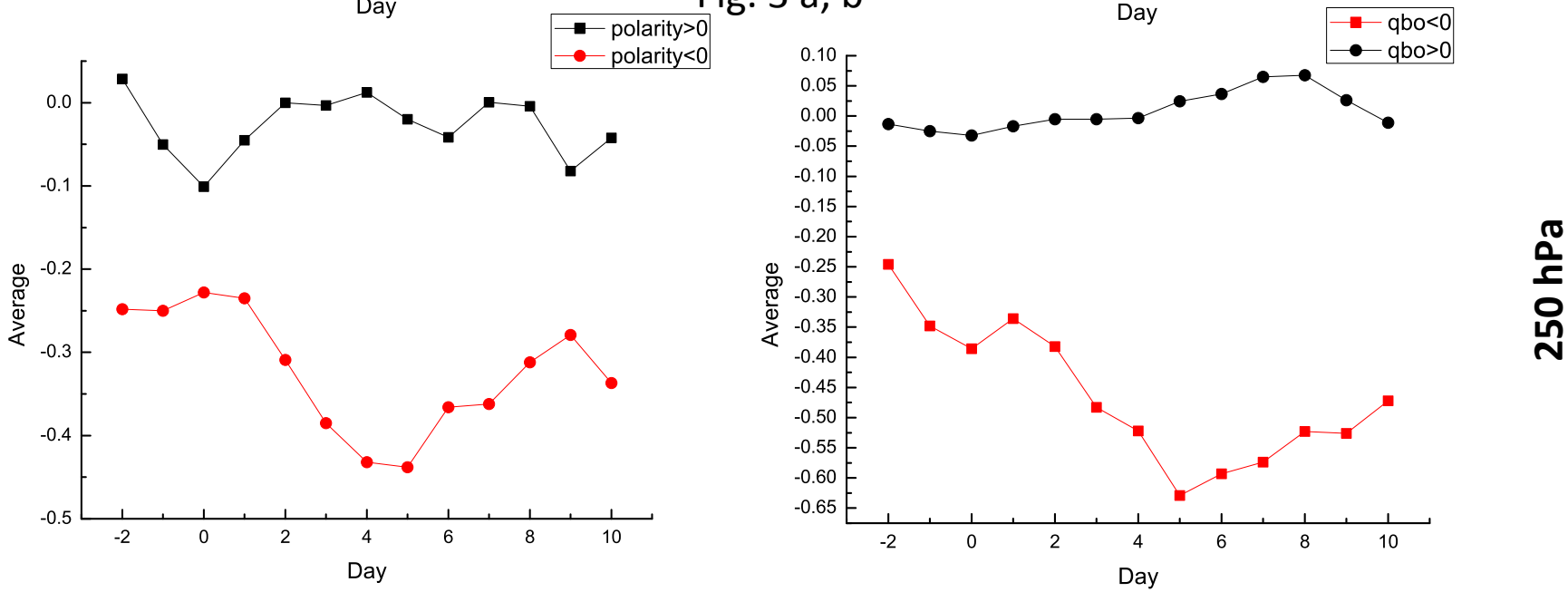
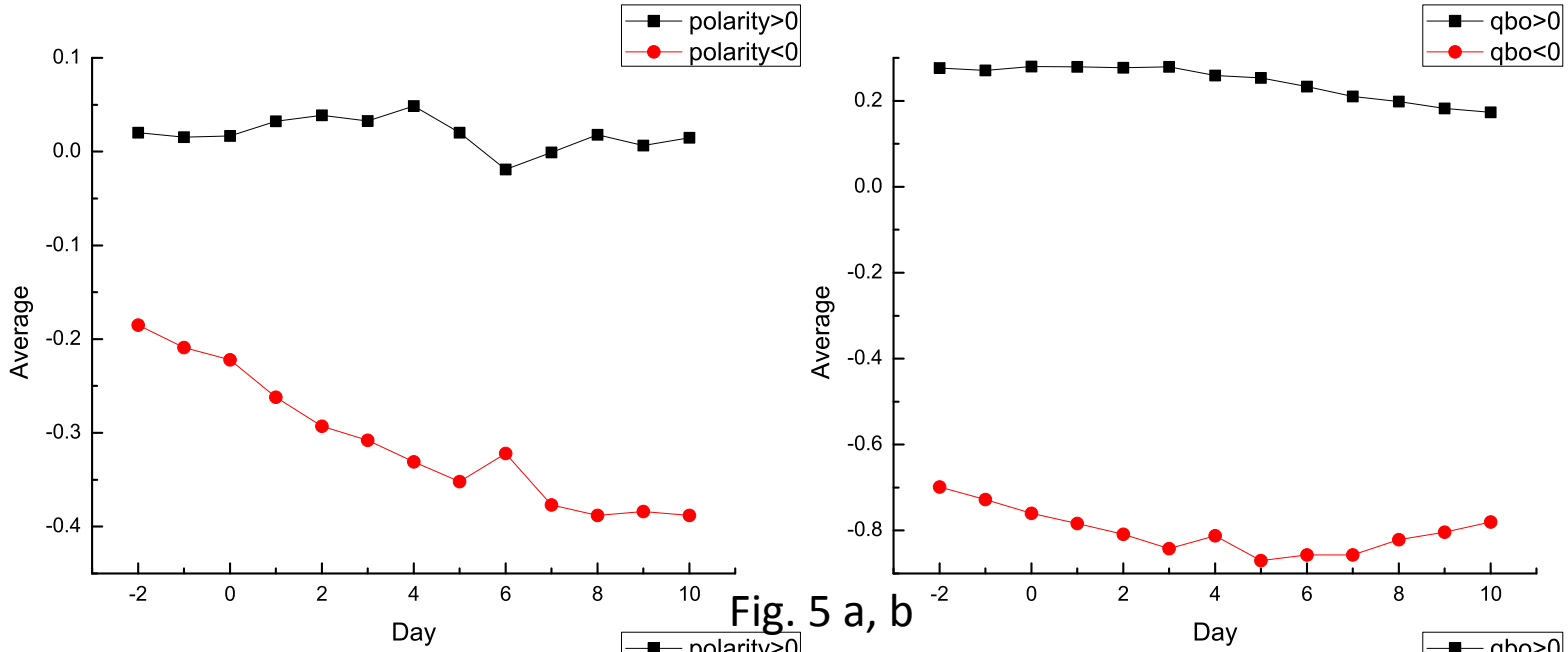
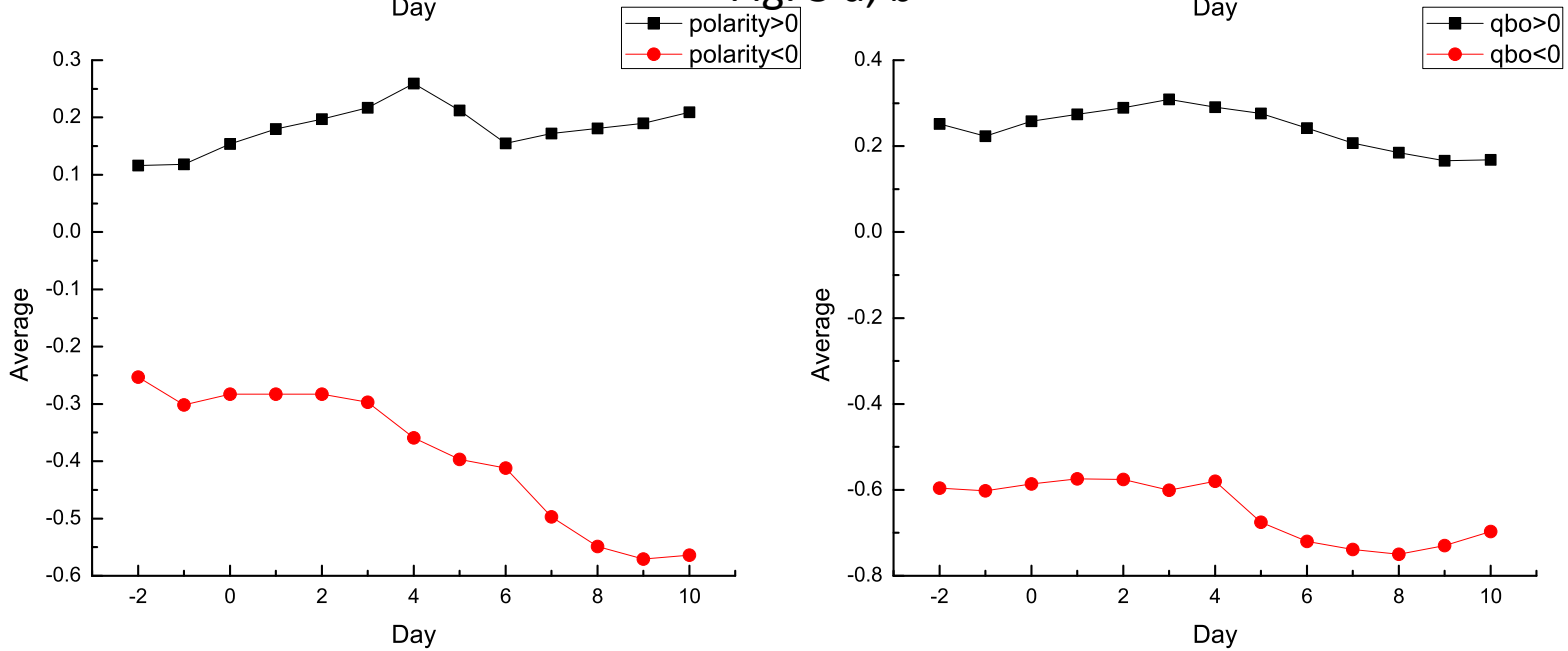


Fig. 4 a, b



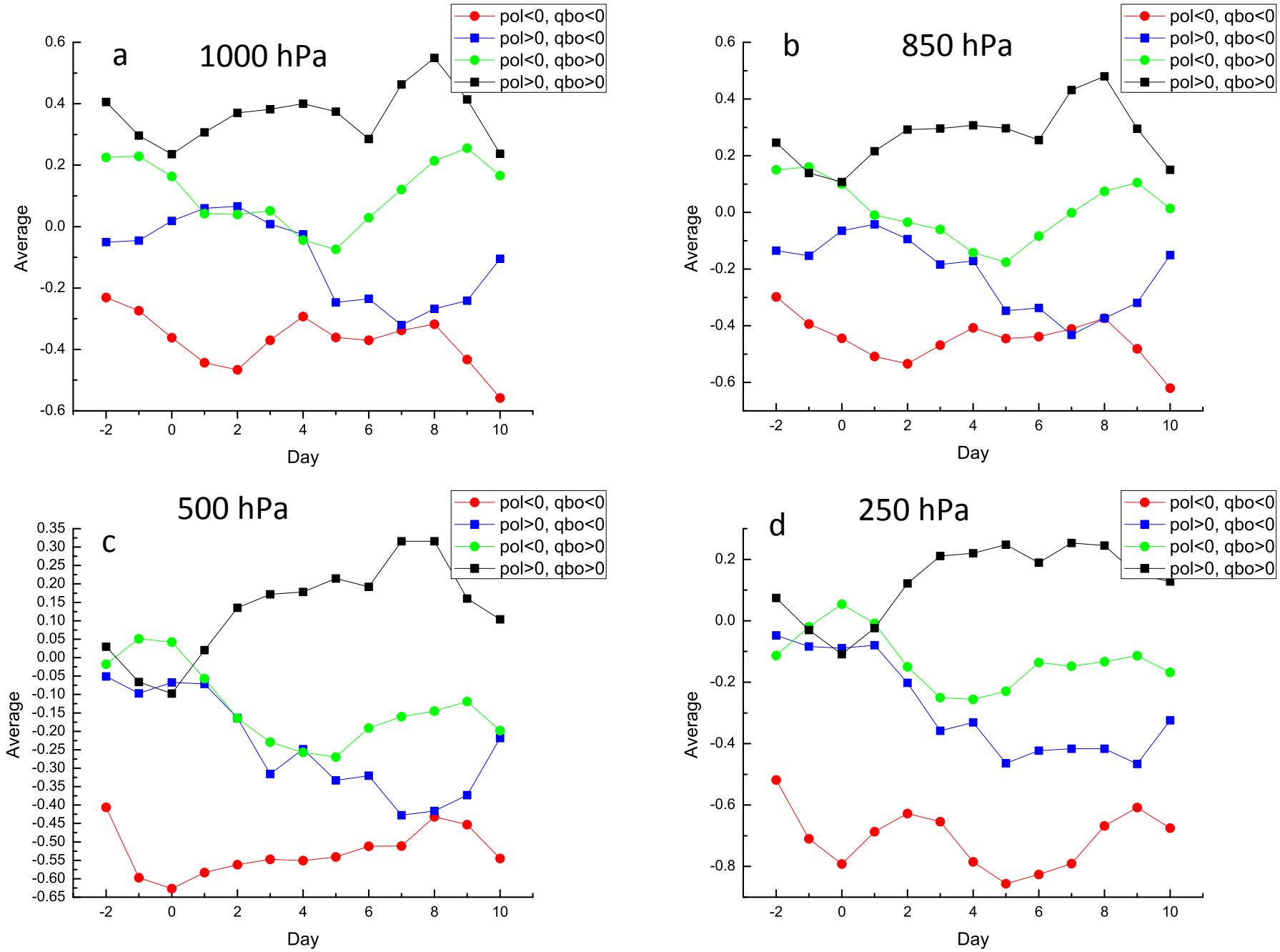
50 hPa

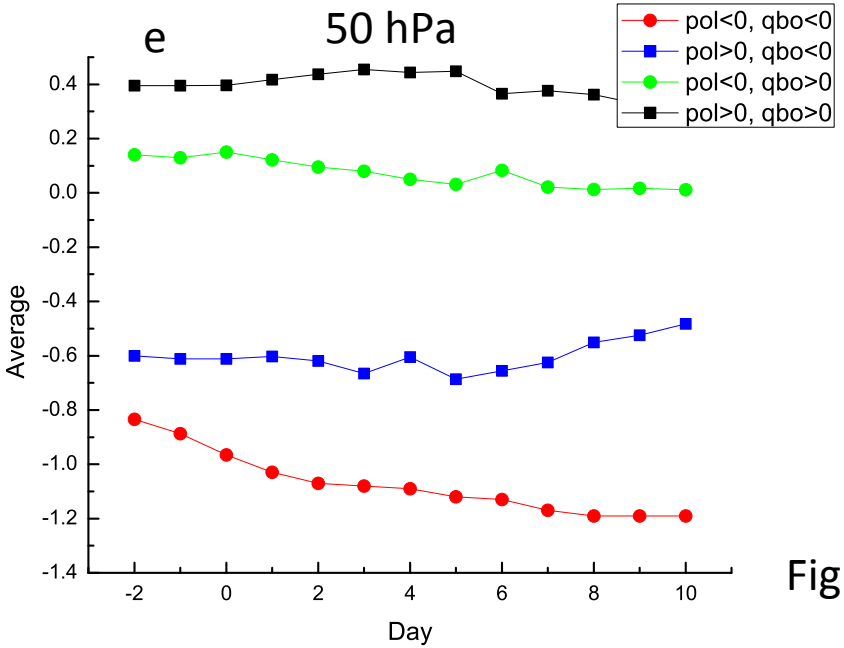
Fig. 5 a, b



10 hPa

Fig. 6 a, b


a
1000 hPa
b
850 hPa
c
500 hPa
d
250 hPa
pol<0, qbo<0
pol>0, qbo<0
pol<0, qbo>0
pol>0, qbo>0
Average
Day



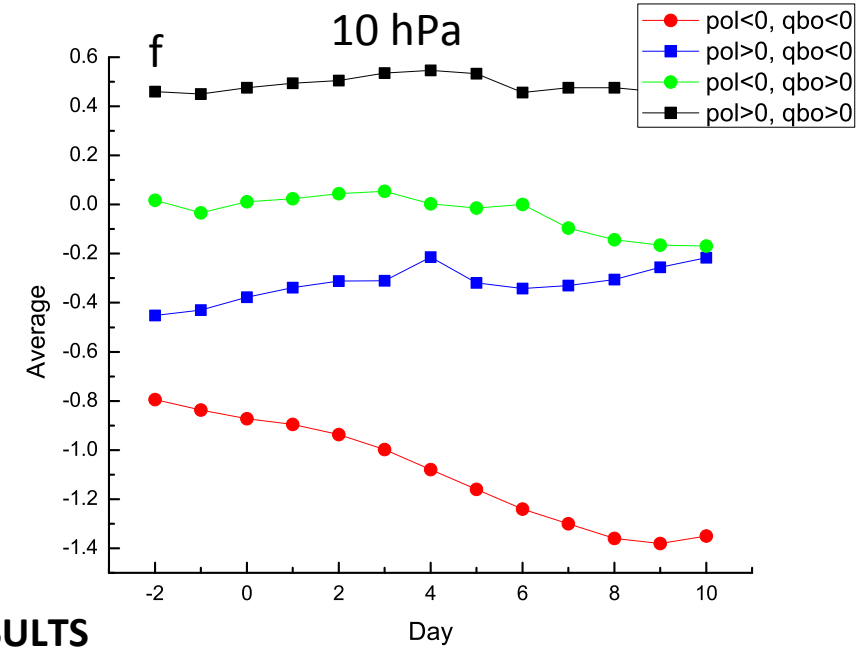


Fig. 7

From figures 1 – 6 we see that the values of the NAM are greater in periods with positive polarity of the solar magnetic cycle (a) and in periods with positive QBO (b). It is also observed a slight decrease of the NAM after a HSS hits the Earth in cases with negative polarity of the solar magnetic cycle, but this decrease is statistically insignificant.
Figure 7 shows that the phase of the QBO influences the NAM more than the polarity of the solar cycle and this is best seen at higher altitudes.

RESULTS

- The values of the NAM for positive magnetic polarity solar cycles/ QBO are greater than the values for negative polarity/ QBO.
- When the polarity of the solar cycle is negative, the HSS seems to lower the NAM.
- The QBO seems to have a greater influence on NAM than the polarity
- Factor analysis shows statistical difference in the reaction of the NAM index to HSS in positive and negative polarity solar cycles.

FUTURE

Comparing the results with these from random days from the same periods (positive/negative magnetic polarity/QBO).