



M. Gerontidou, E. Paouris, P. Paschalis, A. Papaioannou, H. Mavromichalaki
 National and Kapodistrian University of Athens, Physics Department, Athens, GREECE

Space Weather Forecast
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Abstract: Enhancements of geomagnetic activity resulted from the interaction of solar wind originated from solar flares, coronal mass ejections and coronal holes at the Earth magnetosphere have been studied in the frame of Space Weather. The space weather effects can roughly be divided into two categories: those effects quickly and directly associated with solar activity, and those effects resulting from the impact of solar activity-generated interplanetary coronal mass ejections on Earth's magnetosphere. The scientific community managed to implement centers for the continuous monitoring of the geomagnetic conditions which resulted into short and long term forecasting of the planetary geomagnetic activity such as Ap index. A new forecasting center at the Athens Neutron Monitor Station (A.Ne.Mo.S.) has been established from 2012. A first estimation of the accuracy of the predicted Ap index which provided by the Athens Forecasting Center is calculated about 82% during the first year of its operation. In this work a statistical treatment of crucial parameters of about 119 X-class and 1408 M-class solar flares as well as their associated coronal mass ejections during the time period 2000-2012 has been performed. These results have been used in order to have a first estimation of the geomagnetic Ap index. This method has been applied on the Space Weather Forecasting Center of University of Athens and these results are briefly discussed.

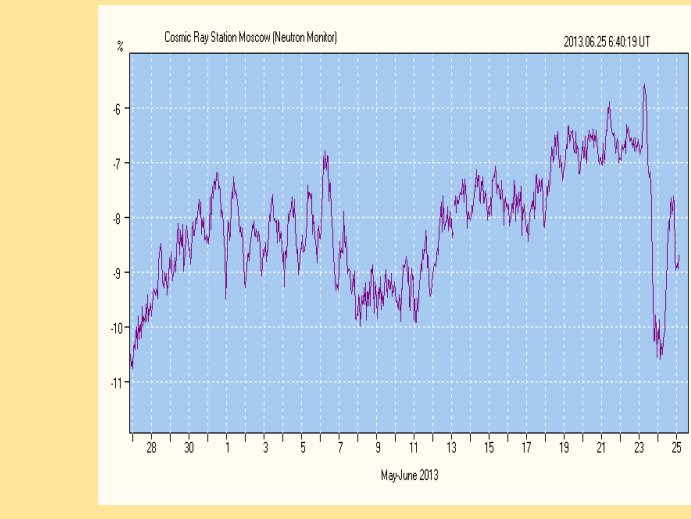
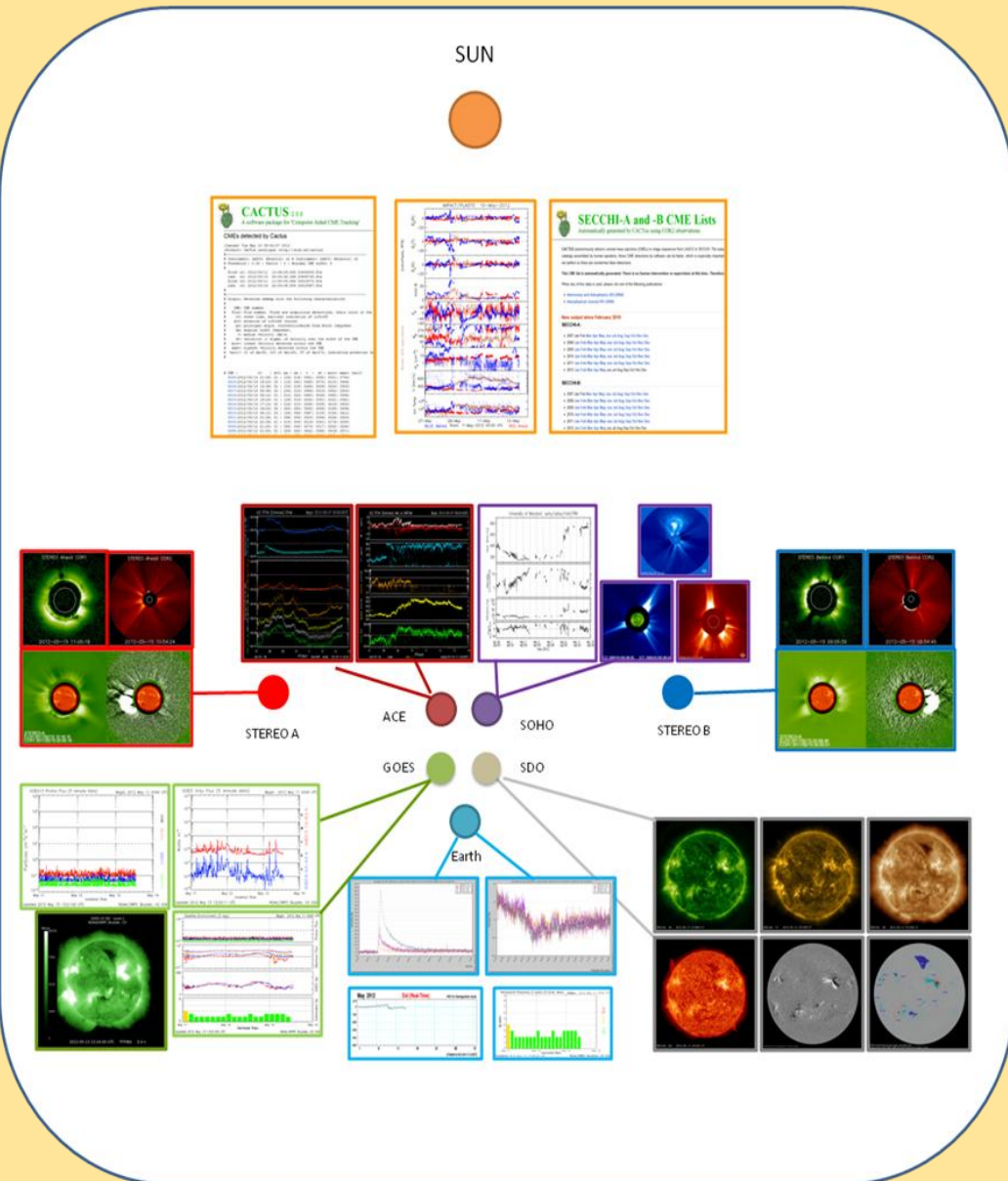
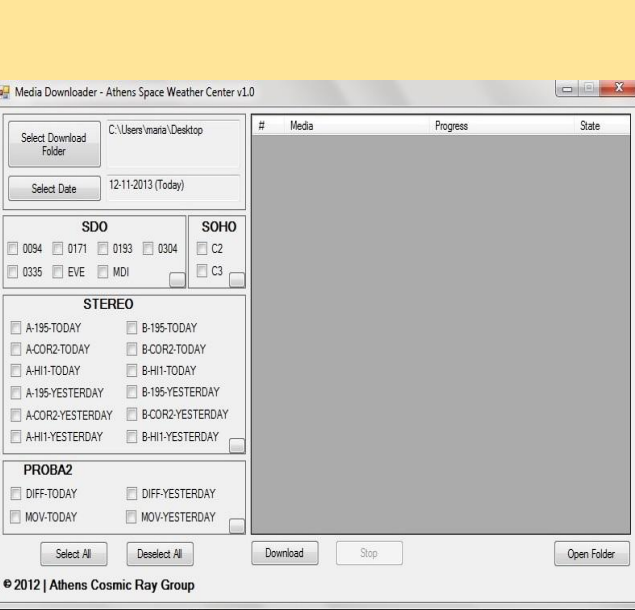
Athens Space Weather Forecasting Center

From the beginning of the year 2012 a new service named "Athens Space Weather Forecasting Center" is operated at the Athens Neutron Monitor Station (Abinina et al., 2012). The product of this service is a 3-day geomagnetic activity forecast report, which is provided on daily basis at the website of the station (<http://cosray.phys.uoa.gr>). Due to the fact that the space environment and the conditions that are prevalent in it, result into disturbances at the Earth's magnetosphere and ionosphere, which are the direct consequences of the interaction of solar wind and transient magnetic fields of coronal mass ejections (CMEs) with the Earth's magnetic field, an estimation of the disturbances of the Earth's magnetic field are usually being quantified with indices. The Ap index is a measure of the magnetic activity and is the only global planetary magnetic index. The estimation of the Ap index in the Athens forecasting center is based on:

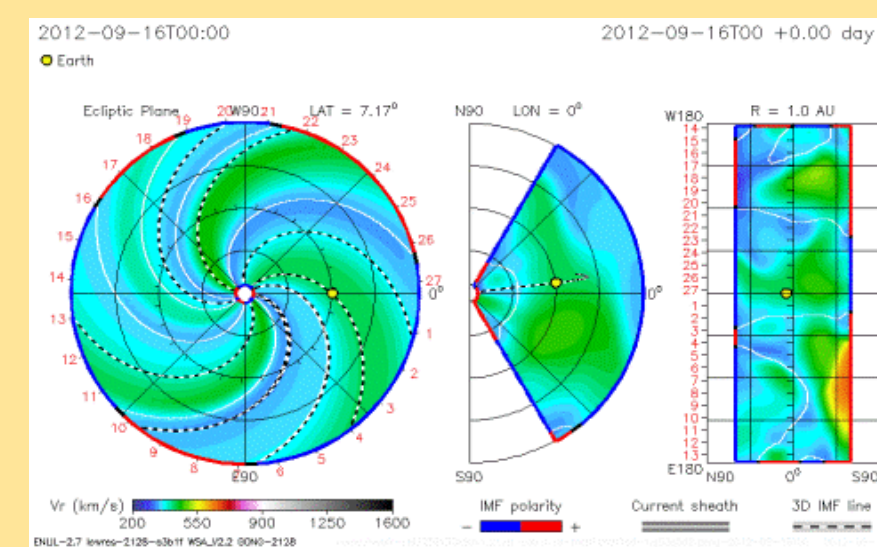
➤ Current observations of the Sun and near-Earth space from several satellites covering a wide range of Sun (SDO, SOHO/LASCO, STEREO A and B, ACE)

➤ Autoregressive model (AR model)

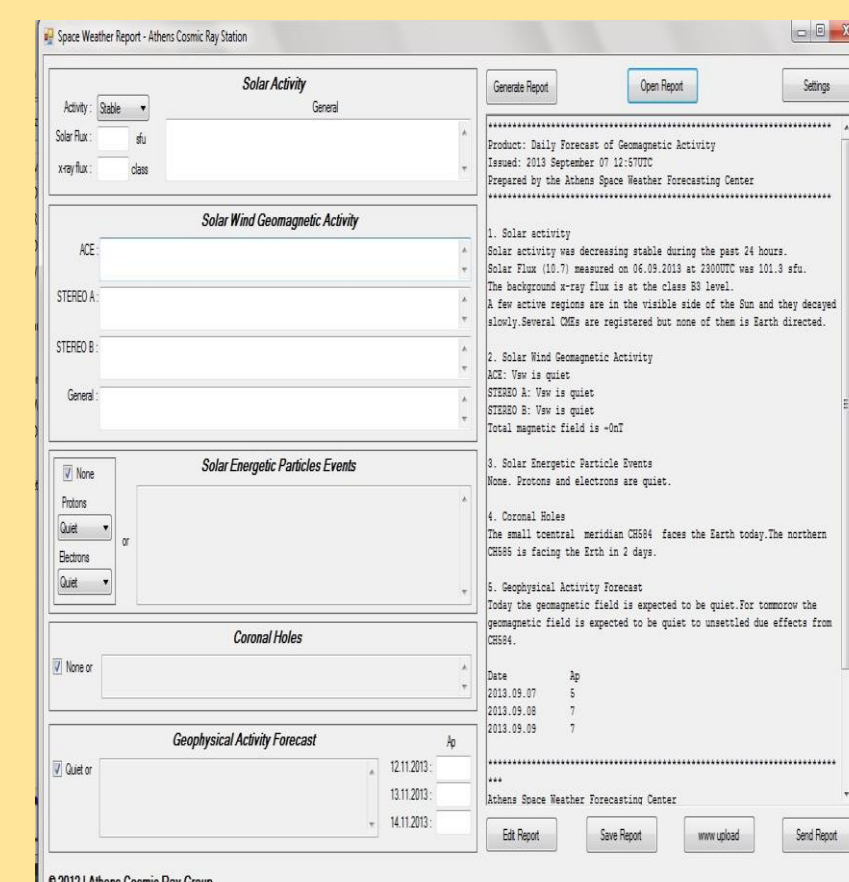
- a) Solar events, CMEs and Coronal holes
- b) Magnetic activity 27-days before
- c) Phase of solar cycle



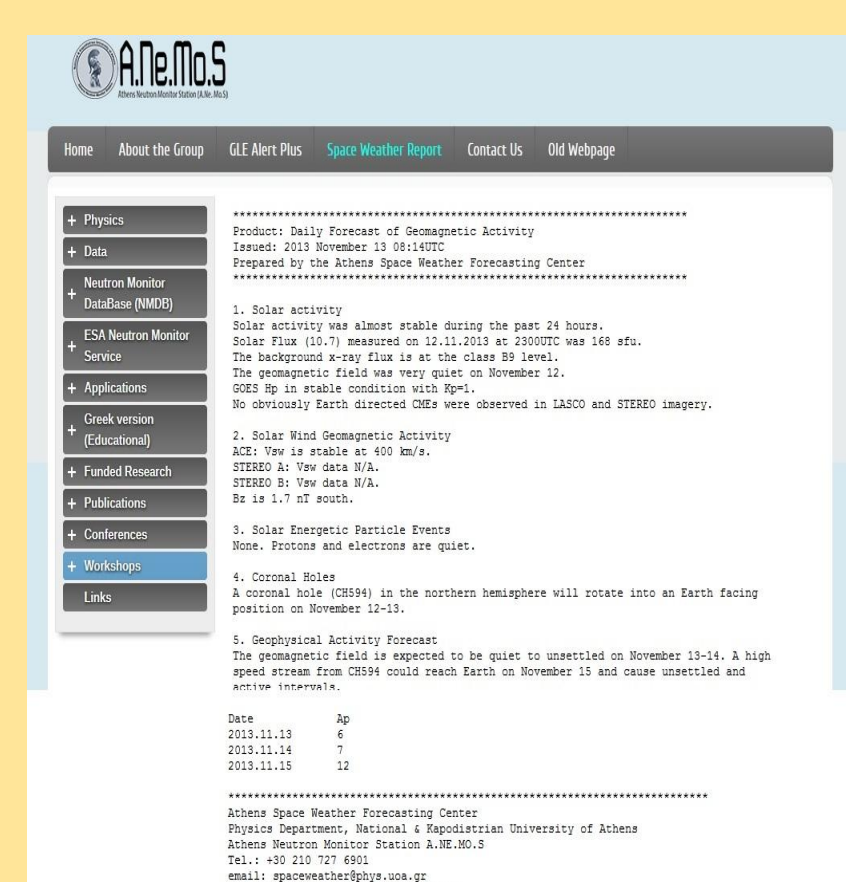
Neutron Monitor Data



WSA-ENLIL model-CME evolution



Application for the daily report developed by Athens Cosmic Ray group



Report as provided at the website <http://cosray.phys.uoa.gr/index.php/space-weather-report>

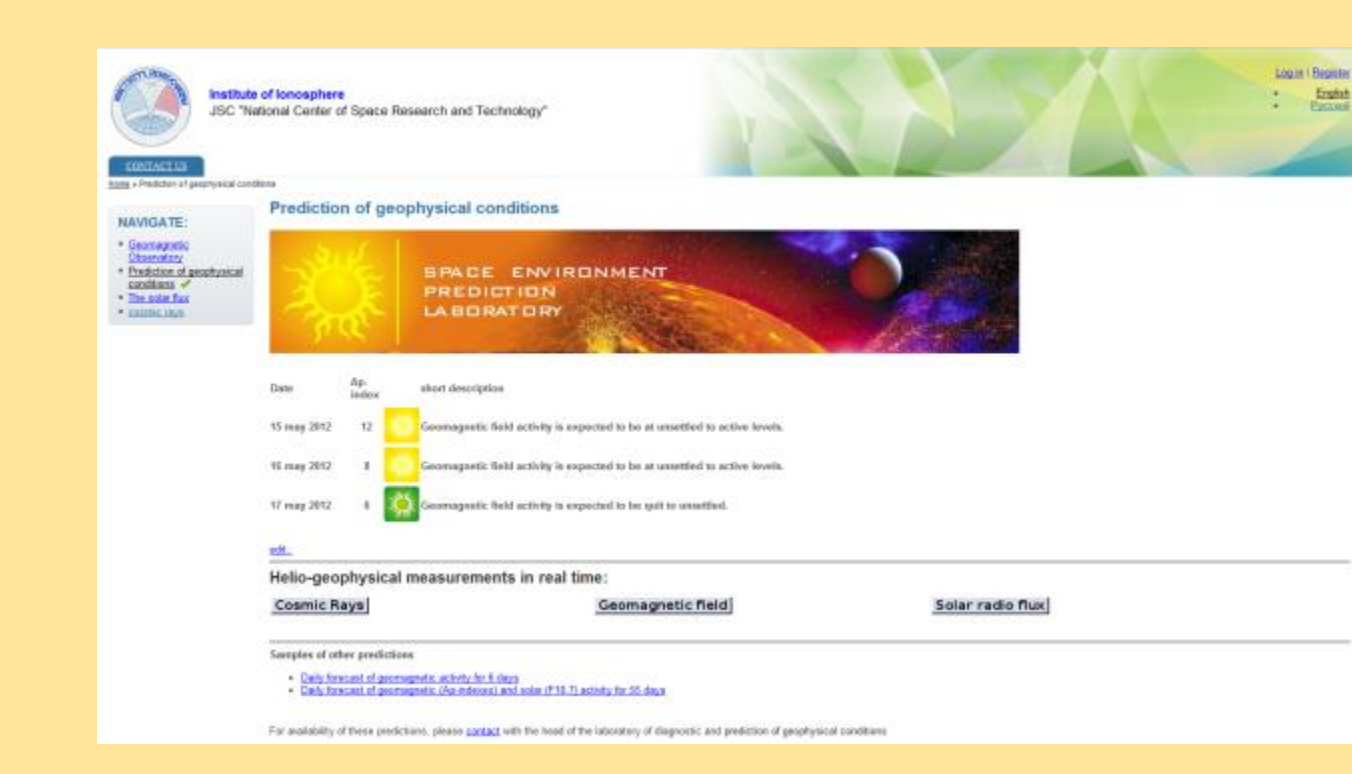
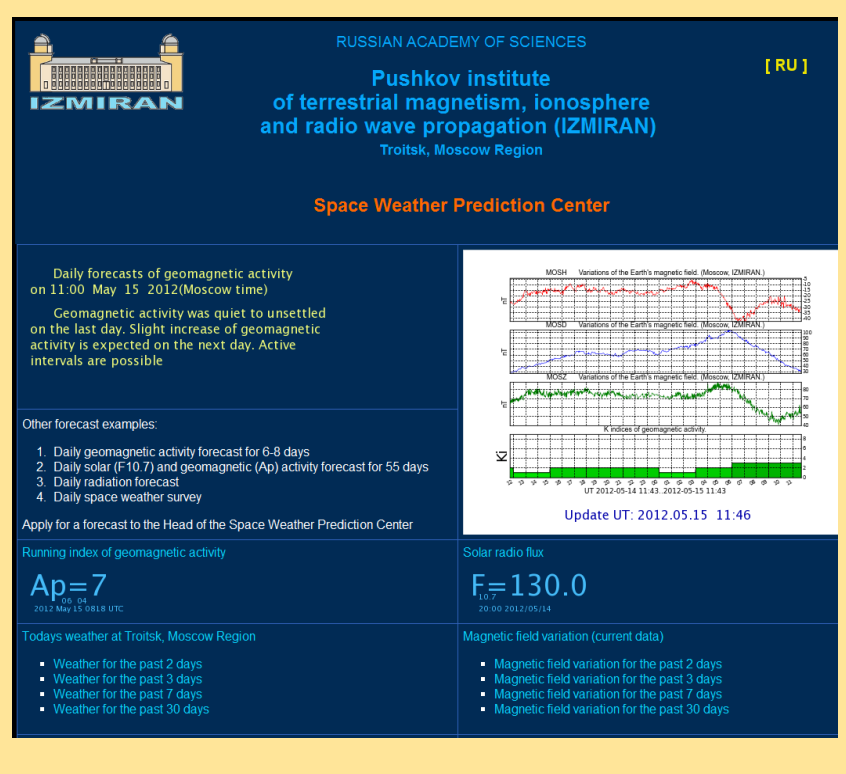
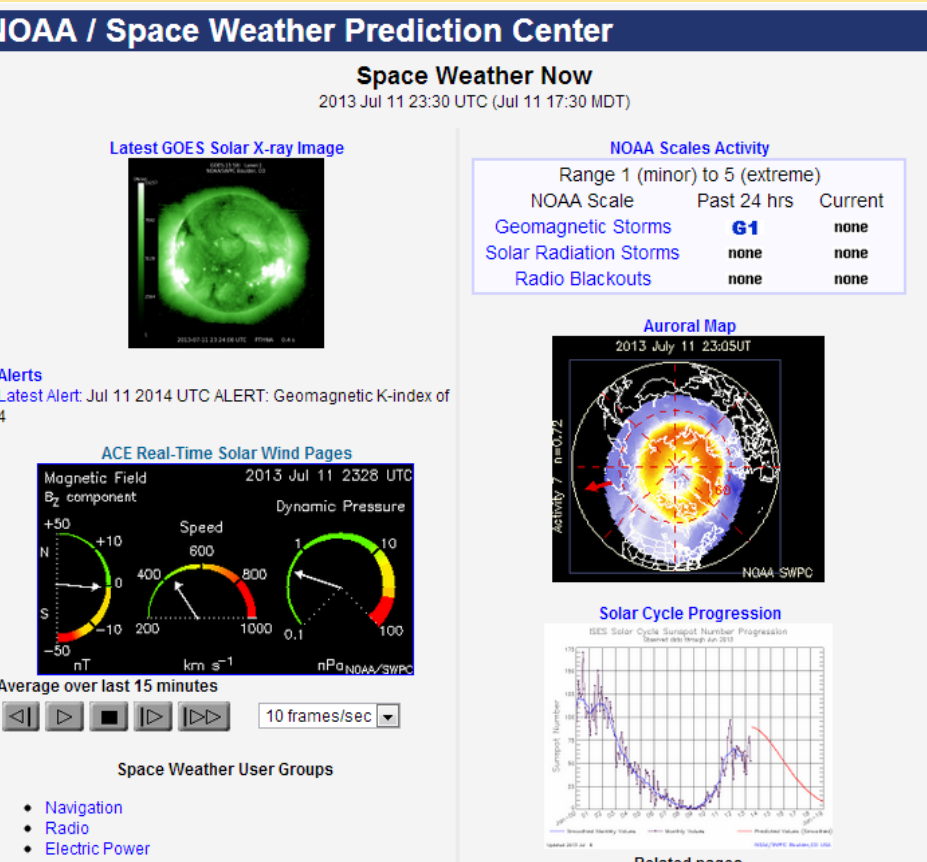
Basic items:

• Note the yesterday's Ap index. This is due to the fact that Ap index seems to be persistent in the sense that yesterday's Ap index may be the same today. Moreover, if a trend is being marked in Ap's behaviour, i.e., if Ap is being decreasing or in contrast if it has been increasing for several days, this trend may continue, as this may be due to a recurrent behaviour of the Sun or the passage of a transient magnetic field (McPherron, 1999)

• Consideration the recurrent behaviour of the Sun, which is dominant within the heliosphere and acts as the ruler of the near-Earth environment conditions. We consider the magnetic activity 27-days before, when due to the solar rotation the same active region was facing the Earth. Also, take into account the phase of the solar cycle, i.e., if they provide the forecast in solar minimum conditions, it is most likely for the Sun to produce recurrent behaviour.

• Finally, consult all available data from the Sun, near-Earth space and the Earth that may demonstrate signs of intense activity which will result into an increase of the geomagnetic conditions and the Ap index.

Operational Space Weather Centers

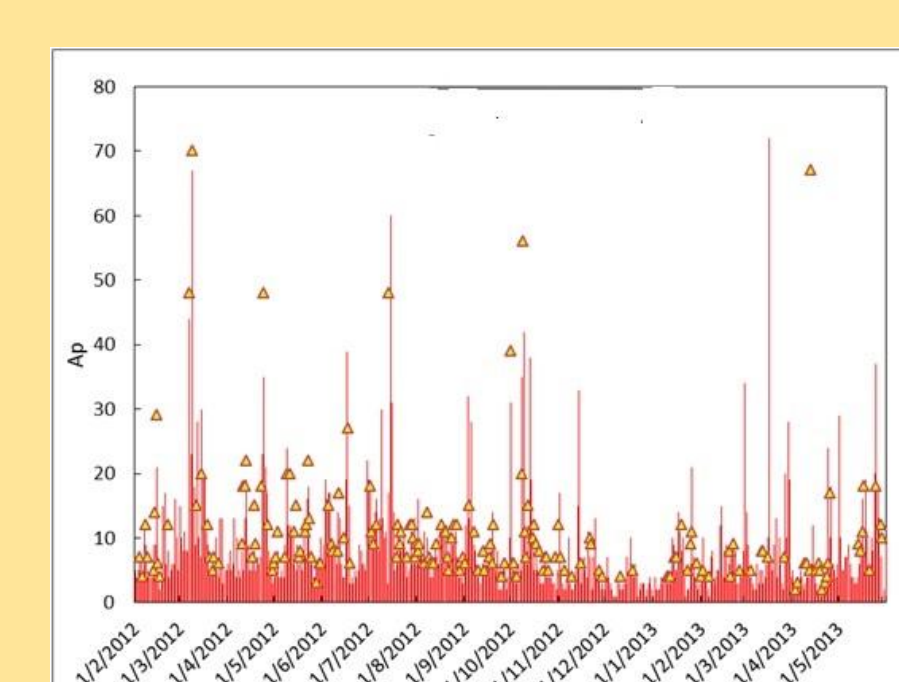


IZMIRAN Space Weather Prediction Center
<http://forecast.izmiran.rssi.ru/indexE.htm>

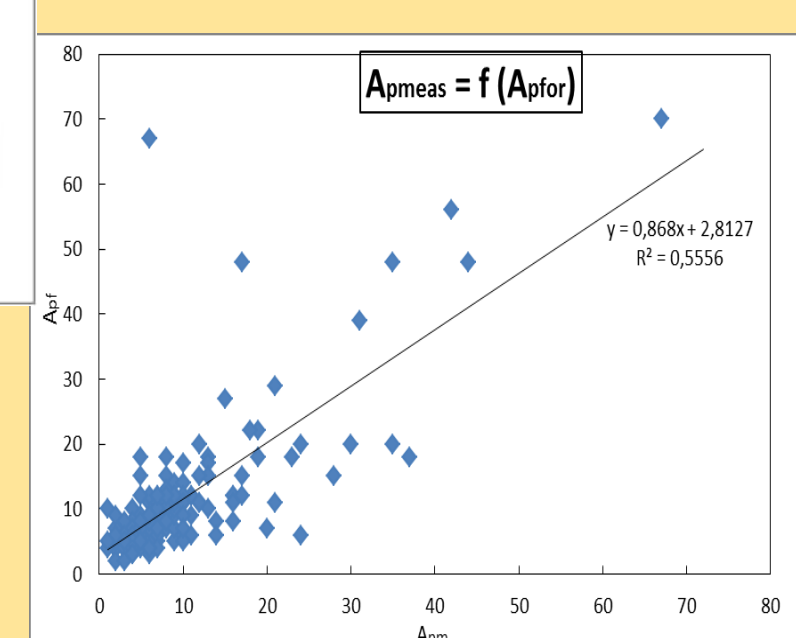
Kazakhstan Institute of Ionosphere
<http://www.ionos.kz/?q=en/node/21>

NOAA/ Space Weather Prediction Center
www.swpc.noaa.gov/SWN/

Preliminary statistical results for the Athens Forecasting Center during the first year of its operation 2012



■ Observed Ap
 ▲ Predicted Ap



Estimation of the geomagnetic index Ap from the CME-index Pi

In a previous work dedicated on CME-index (P_i), the relation of this index with the cosmic ray (CR) intensity was established (Paouris, 2013). This index have improved all the empirical models of galactic cosmic ray modulation (Mavromichalaki and Paouris, 2013). A first attempt to relate the main characteristics of the CME such as the angular width and the linear speed with the geomagnetic index Ap has already made. A case study is presented.

The case study of October 2003

For a case study event of October 2003 the Pi-index value was 2.45 for the event of October 28, 2003 at 11:30 U.T., as the CME was a HALO one and the linear speed was 2459 Km/s. This CME was connected with a X17.2 solar flare (Zhang et al., 2007). This event produced a strong geomagnetic storm at October 29, 2003 with a daily Ap value equal to 190 and a minimum Dst value equal to -350 nT.

$$P_i = \frac{V_p}{V_{p_{max}}} + \frac{w}{w_{max}}$$

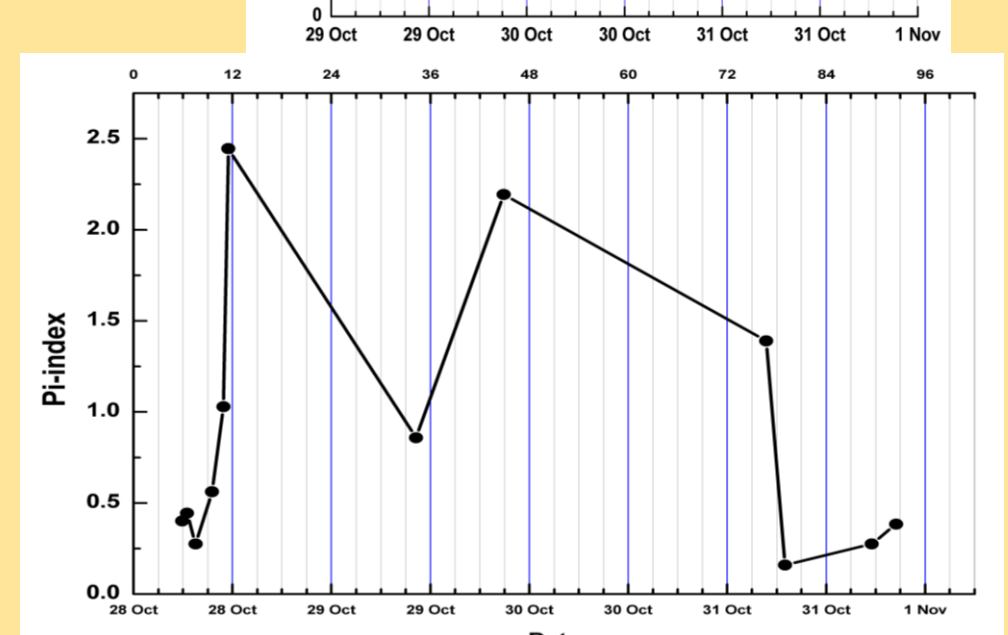
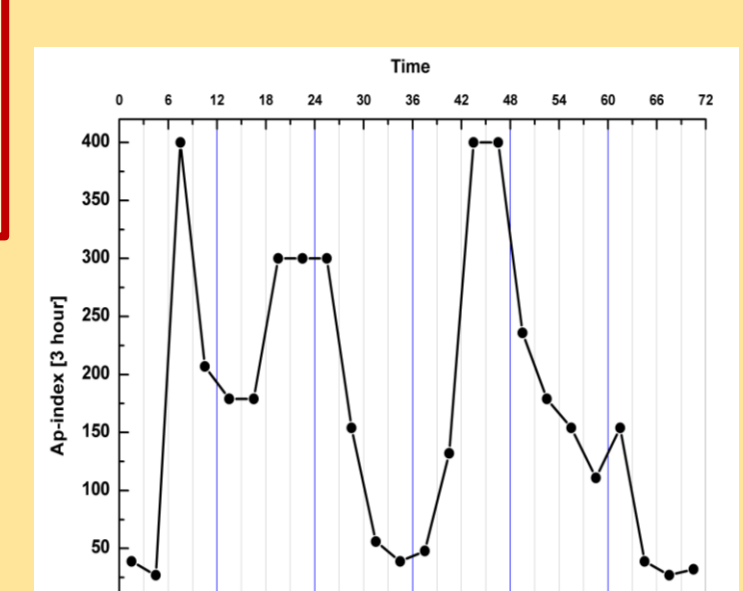


$$Ap = Ap_0 + A \cdot e^{R_0 \cdot P_i}$$

P_i : CME-index values
 V_p : Linear speed of CME
 w : Angular width of CME

Ap : calculated values
 Ap_0, A, R_0 : constant values (-226.5, 211.9, 0.43638)
 P_i : CME-index values

Ap observed = 400
Ap calculated = 390



References

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❖ Website: <http://cosray.phys.uoa.gr/>
 Contact: Prof. H. Mavromichalaki, emavromi@phys.uoa.gr