

Contribution of the geomagnetic activity monitoring by the Athens Space Weather Forecasting Center to the Hellenic National Meteorological Service



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p-Poster Number: 3
Session: 3
SPACE CLIMATE

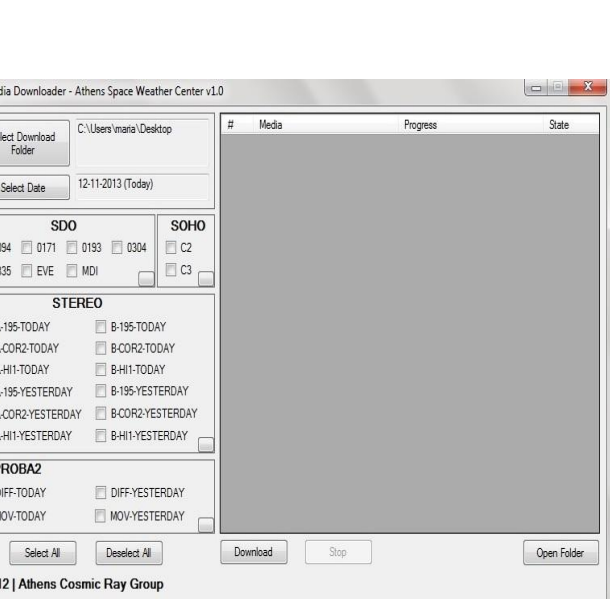
Abstract: During the last years the Athens Space Weather Forecasting Center (ASWFC) provides a Space Weather report on a daily basis (<http://cosray.phys.uoa.gr/index.php/space-weather-report>) giving information about the solar activity, the solar wind geomagnetic activity, the solar energetic particle events (SEPs), the coronal holes (CHs) and a three-day geophysical activity forecast as well. It is noted that the disturbed periods and the recorded geomagnetic storms with their characteristics, such as the scale level and the origin of the storm (CME or CIR), are also determined. In this work an evaluation of the predicted results of the geomagnetic index Ap obtained from the Athens Space Weather Forecasting Center in comparison to the observed ones for the years 2014-2016, is presented. Furthermore, a statistical analysis of these events and a comparative study of the forecasting and the actual geomagnetic conditions using data from the NOAA space weather forecasting center and from the ASWFC as well are performed. Finally, a potential association of this Space Weather report to the products provided by the Hellenic National Meteorological Service is discussed.

Athens Space Weather Forecasting Center

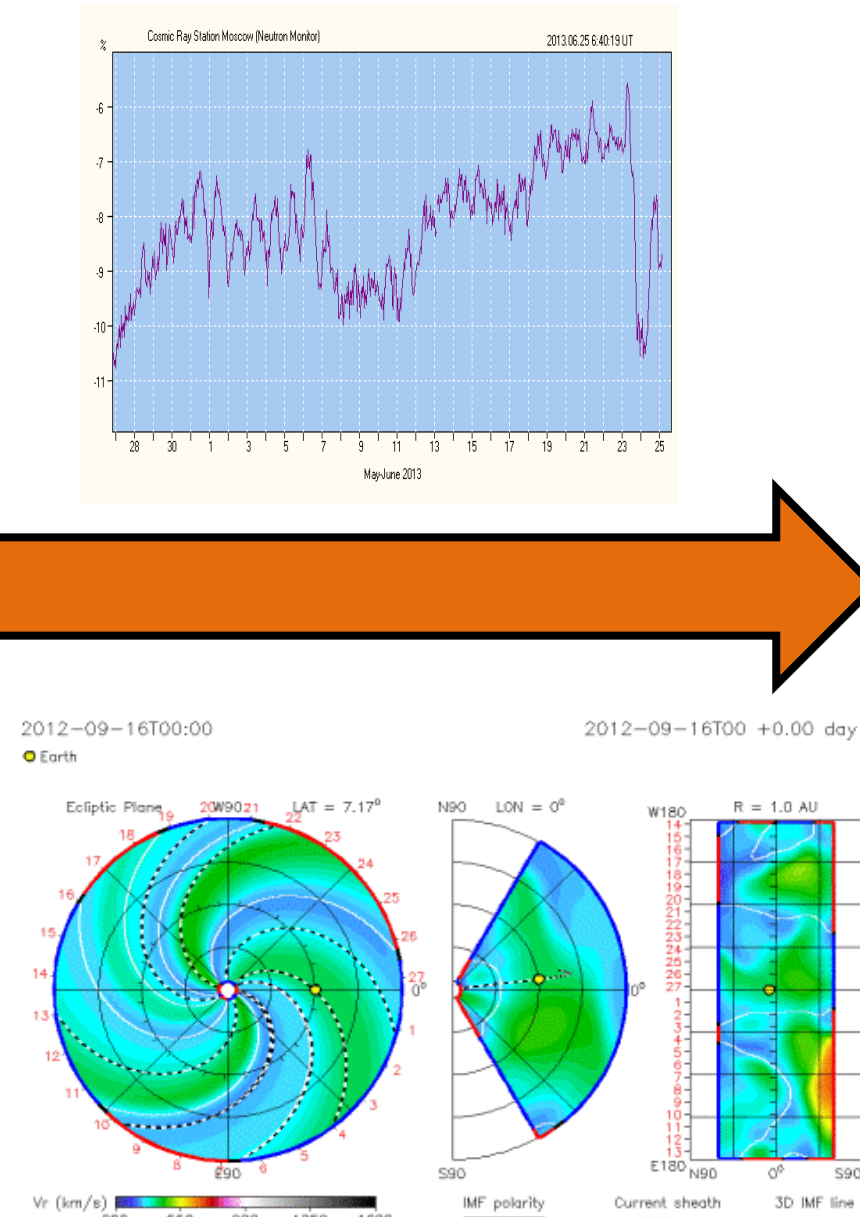
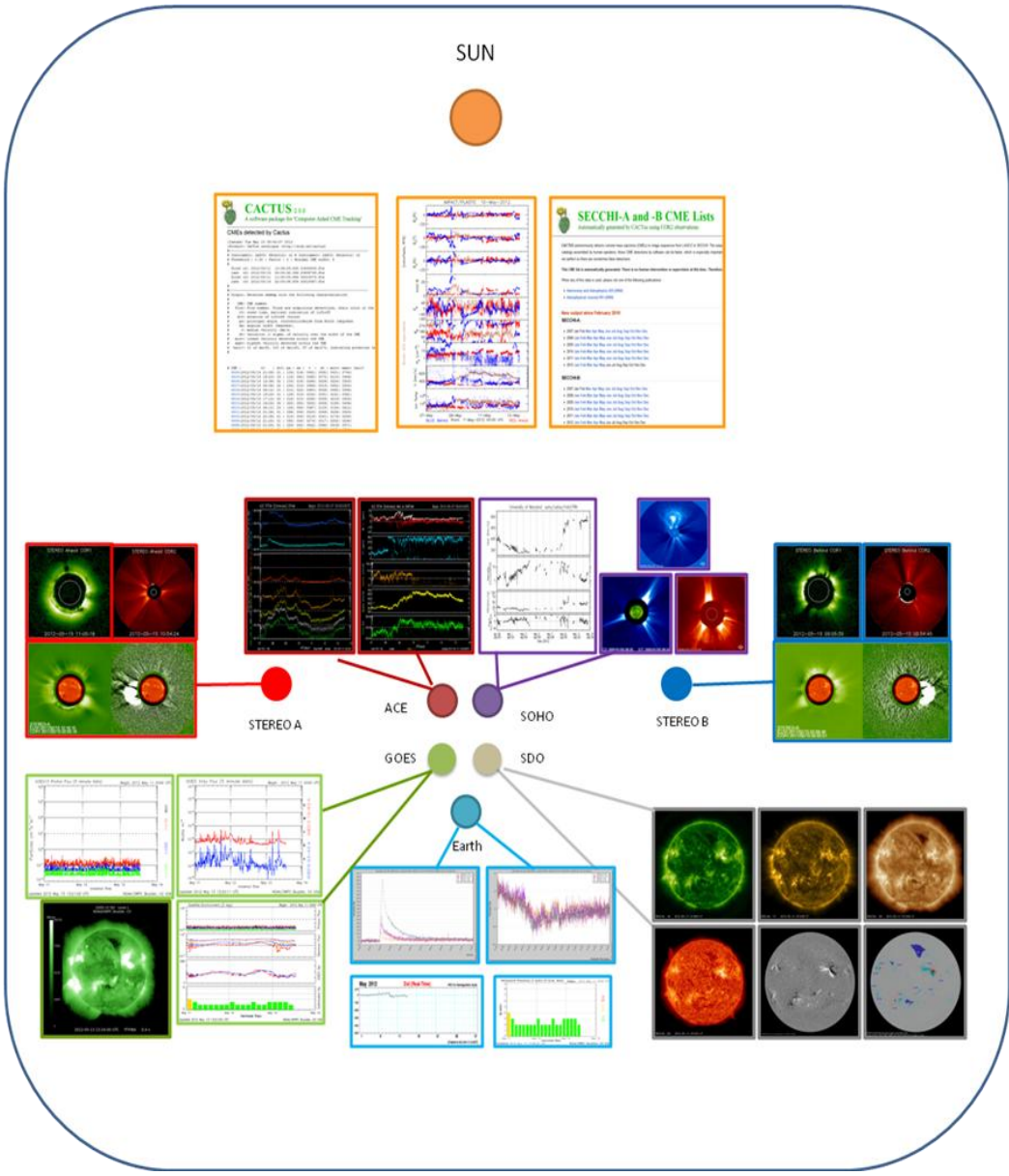
From the beginning of the year 2012 a new service named “*Athens Space Weather Forecasting Center*” is operated at the Athens Neutron Monitor Station. The product of this service is a 3-day geomagnetic activity forecast report (Abunina *et al.*, 2013), which is provided on daily basis at the website of the station (<http://cosray.phys.uoa.gr>). Due to the fact that the space environment and the conditions that are prevalent on 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 (Paouris *et al.*, 2013), 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 (McPherron, 1999). 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)**

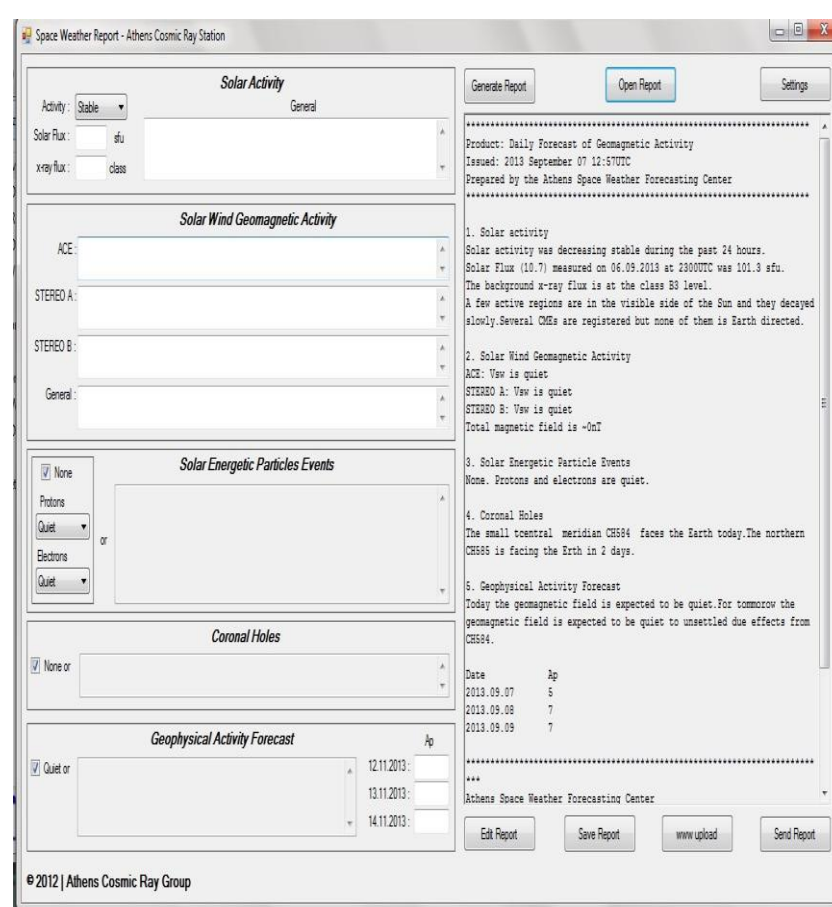
➤ **Autoregressive model (AR model)**
a) Solar events, CMEs and Coronal holes
b) Magnetic activity 27-days before
c) Phase of solar cycle



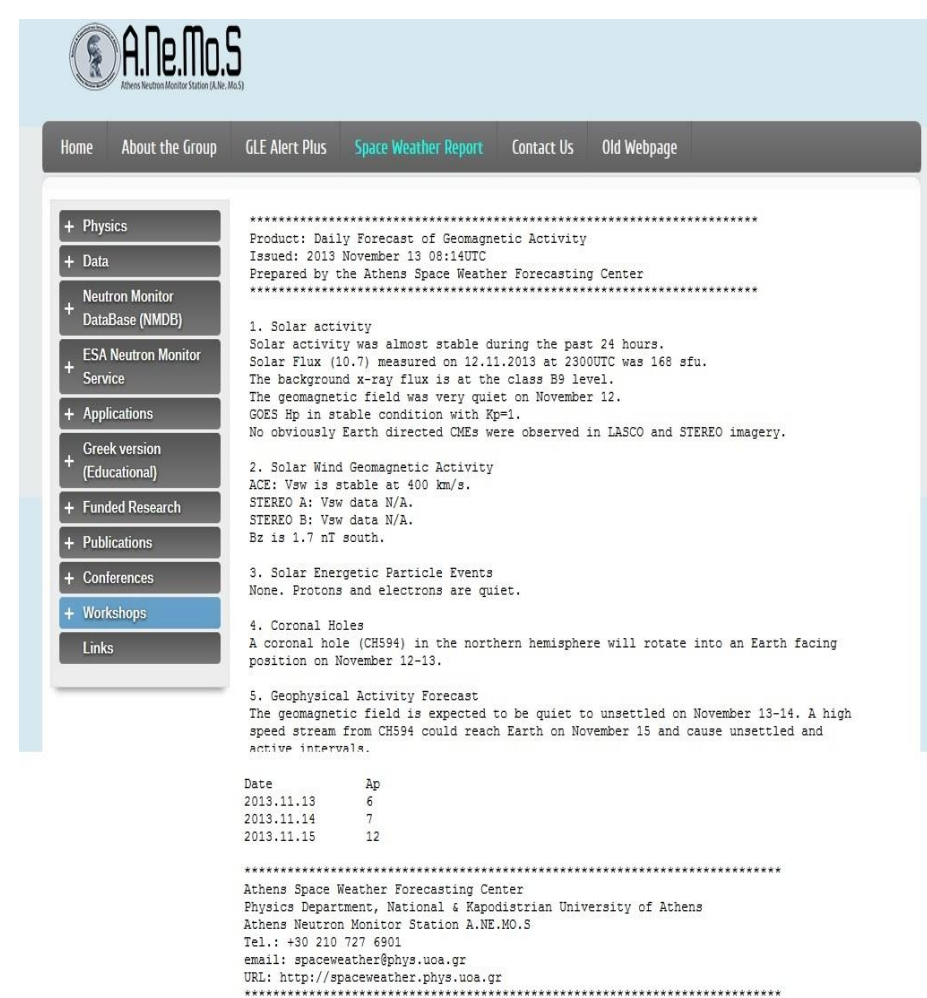
Real time MPEG movies from five satellites via **Media Downloader** developed by Athens Cosmic ray group



WSA –ENLIL CONE model-CME evolution



Application for the daily report developed by Athens Cosmic Ray group



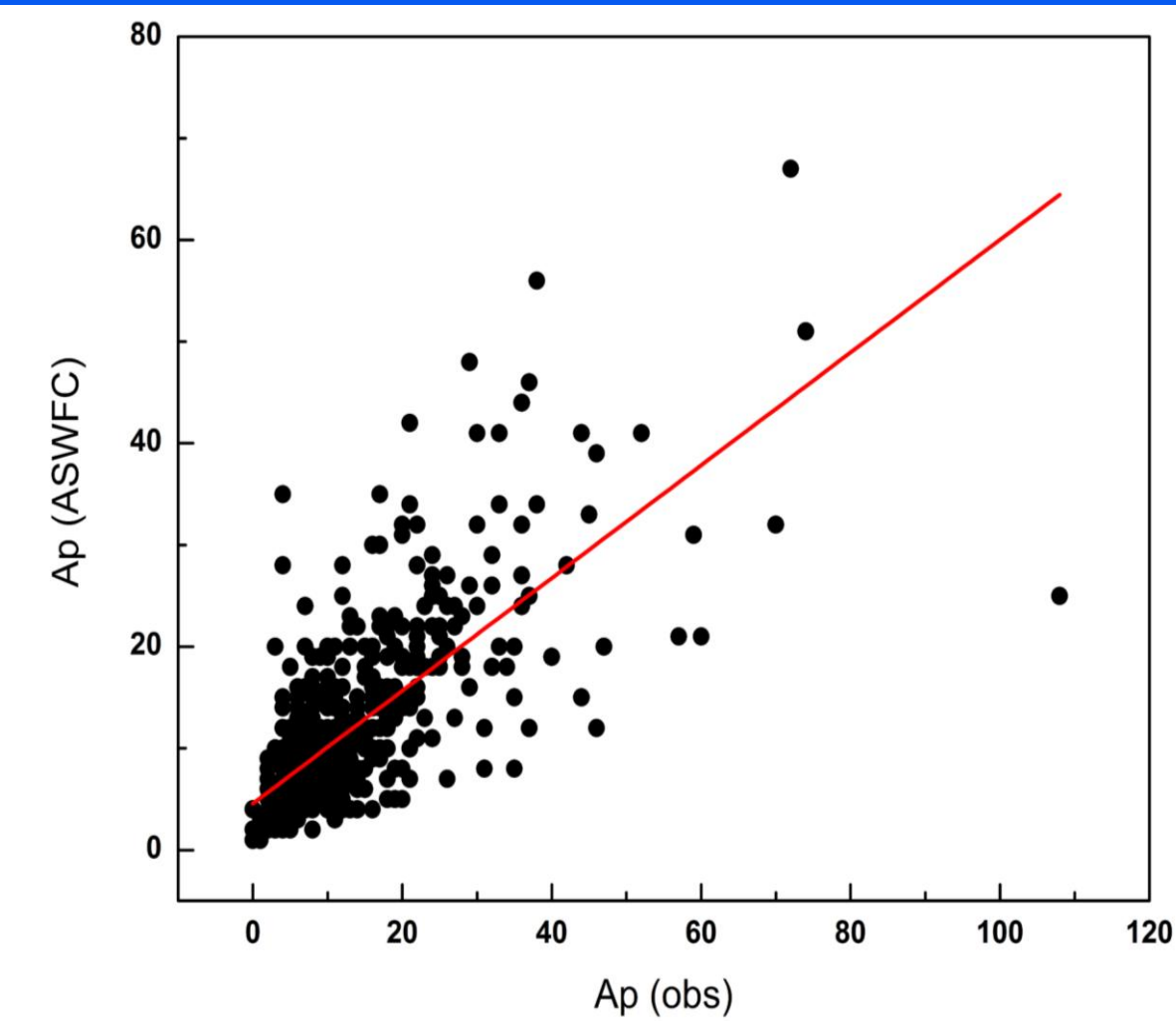
Report as provided at the website <http://cosray.phys.uoa.gr/index.php/space-weather-report>

Basic items:

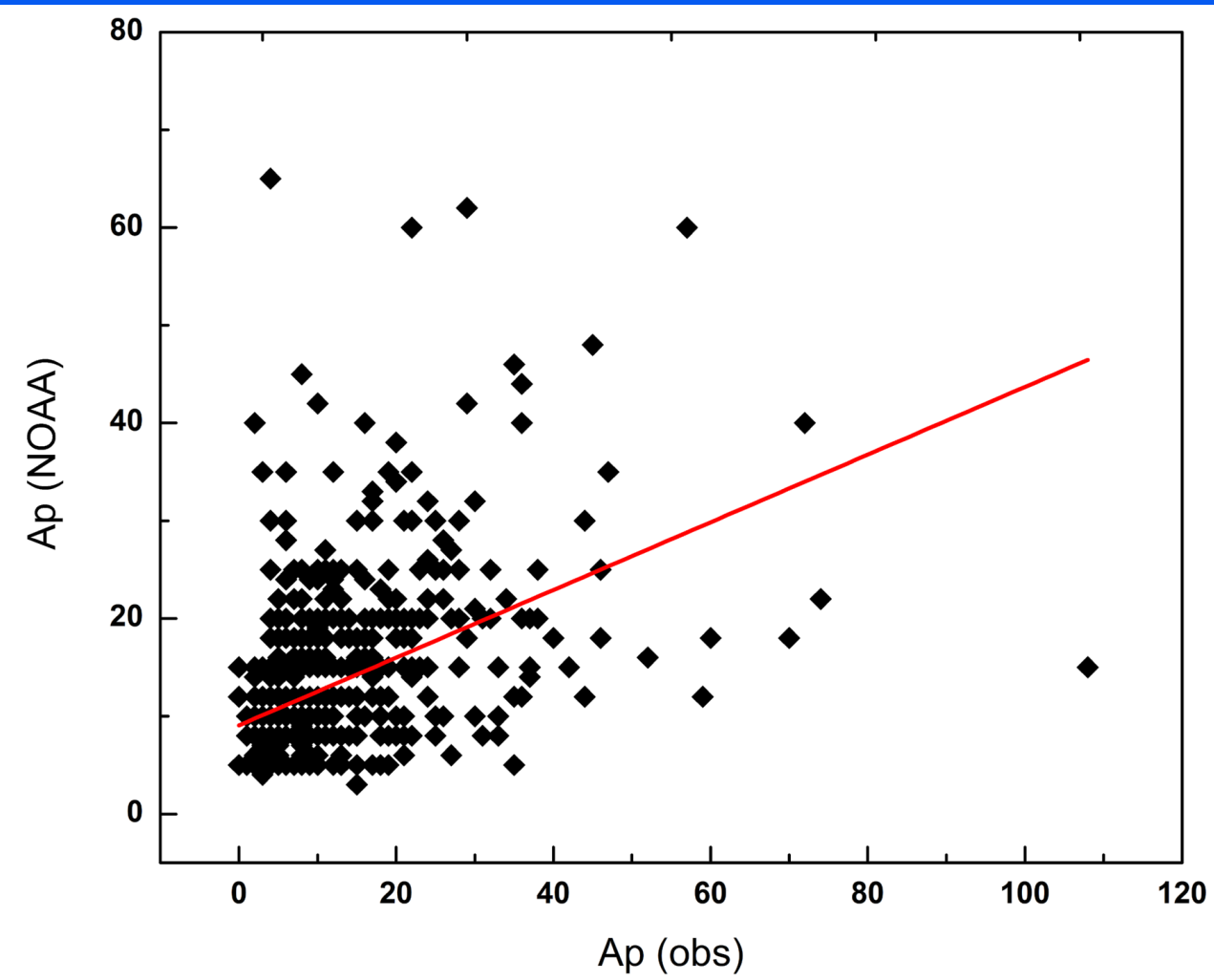
• Note the yesterday’s Ap index. This is due to the fact that Ap index seems to be persistent in the sense that yesterday’s Ap index may be the same today. Moreover, if a trend is being marked in Ap’s behaviour, i.e., if Ap is being decreasing or in contrast if it has been increasing for several days,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

- 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.

Forecasting results - Comparison



	ASWFC
RMSD	7.239
MAPE	51.8%
Pearson r	0.723



	NOAA
RMSD	10.255
MAPE	74.9%
Pearson r	0.436

RMSD : Root mean square deviation
MAPE : Mean average percentage error

Scatter plot of the observed and predicted values of the Ap index from the Athens Space Weather Forecasting Center (left panel) and from NOAA (right panel). The Pearson r coefficient reaches the value of 0.723 for the first case and 0.436 for the second.

Collaboration of the ASWFC and the Hellenic National Meteorological Service

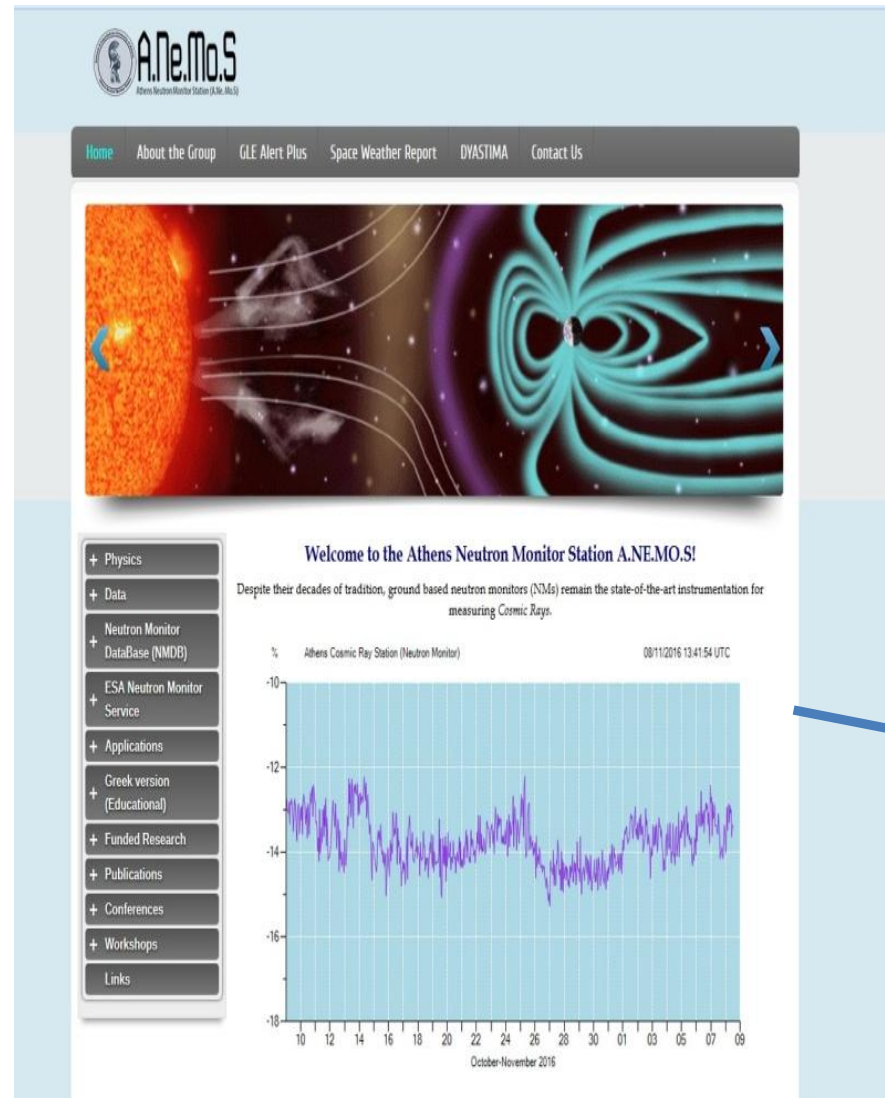
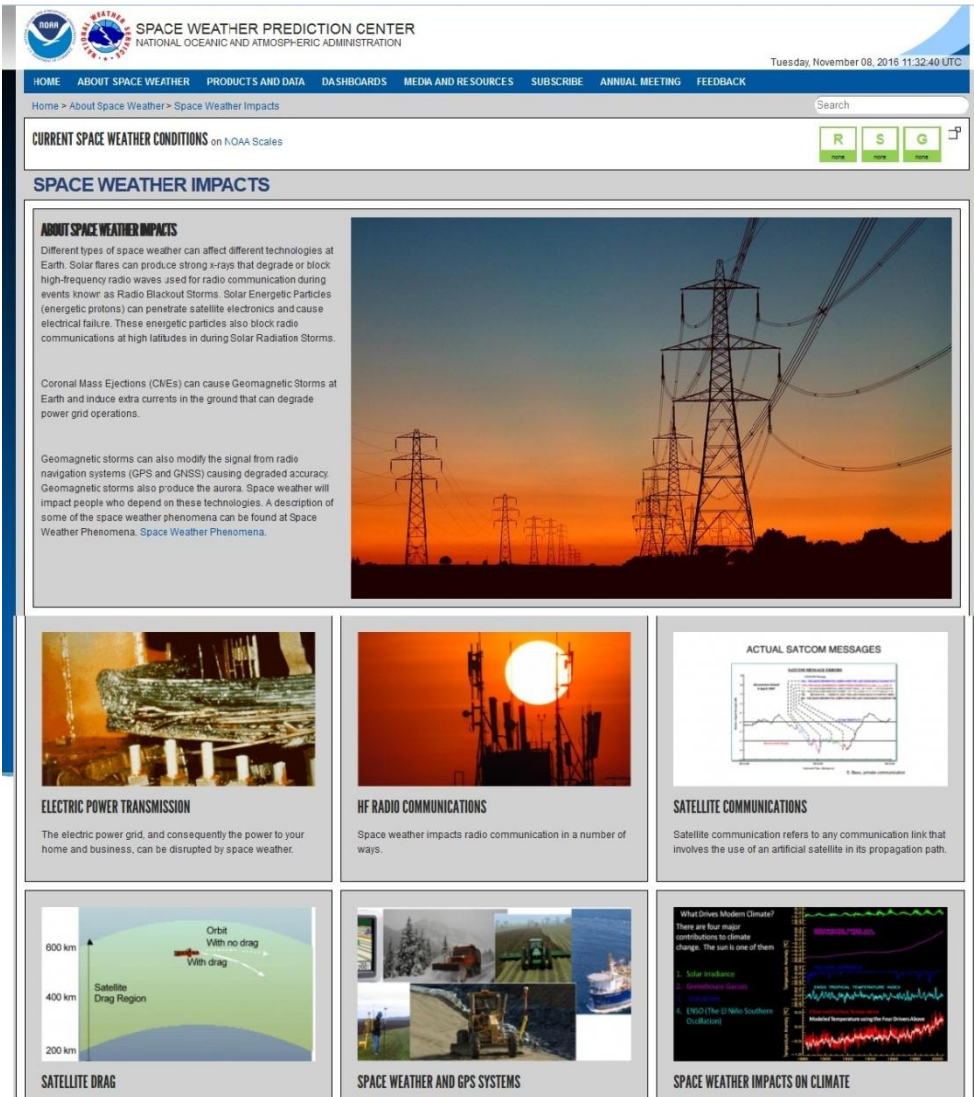
The Hellenic National Meteorological Service (HNMS) as an experienced and internationally recognized organization has the ability to carry out the requirements in the context of the North Atlantic Treaty Organization (NATO) by extending the Weather Forecast to the Space Weather Forecast.



Website of HNMS

Space weather, which results from the activity of the Sun, affects technological systems and humans in space, in the atmosphere and on the ground. It also has an influence on the atmosphere itself thus influencing the terrestrial weather and climate.

Space weather events, in the form of solar flares, solar energetic particles, and geomagnetic disturbances, occur regularly, some with measurable effects on critical infrastructure systems and technologies, such as the Global Positioning System (GPS), satellite operations and communication, aviation, and the electrical power grid. Extreme space weather events -- those that could significantly degrade critical infrastructure -- could disable large portions of the electrical power grid, resulting in cascading failures that would affect key services such as water supply, healthcare, and transportation.



Website of ANeMoS

Space weather has the potential to simultaneously affect and disrupt health and safety across entire continents. Successfully preparing for space weather events is an all-of-nation endeavor that requires partnerships across governments, emergency managers, academia, the media, the insurance industry, non-profits, and the private sector.

In the frame of this collaboration the current report provided by ASWFC will be in agreement with the requirements of the Hellenic National Meteorological Service. Expert scientists from the Athens cosmic ray group and the Hellenic National Meteorological Service as well will cooperate in order to provide an advanced service within NATO requirement to benefits of national authorities and the society.



The objective of the upcoming collaboration of Athens Space Weather Forecasting Center and Hellenic Meteorological Service is the development of a new service providing an accurate information regarding the space environment and particularly regarding hazards to infrastructures in orbit and on the ground.

References:
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•McPherron R.L.: *Phys. Chem. Earth (C)* 24 45, 1999.
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Acknowledgements:
The authors thank the Special Research Account of the University of Athens for supporting the cosmic ray research. The authors thank the providers of all of the available scientific data from satellites and space missions such as SOHO, STEREO, SDO, ACE.

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