The ANeMoS federated products to the SSA Space Radiation Expert Service Centre (R-ESC)

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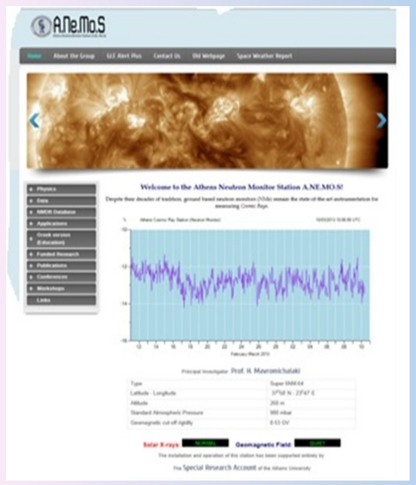
Abstract: Within the segment of Space Weather (SWE) of the Space Situational Awareness (SSA) Program of the European Space Agency (ESA) in particular on the topic of Space Radiation, the expert group of the Athens Neutron Monitor Station (ANeMoS) has been developed the Neutron Monitor (NM) Service, which is available via ESA portal (http://swe.ssa.esa.int/web/guest/space-radiation). Two distingue products named Multi-station Data and Ground Level Enhancement Alert Plus (GLE Alert Plus) have been implemented and are continuously provided via ESA portal. The first one is an interface, which provides an easy way to access the data that are stored in the Neutron Monitor Database (NMDB).The interface connects to the NMDB slave server located at the ANeMoS. On the other hand the GLE alert Plus system relies upon the availability of high resolution data (e.g. with 1-min cadence rate) made available in the NMDB at every minute of time (e.g. 1-min resolution). When indentifying a clear enhancement in at least three neutron monitors distributed at different geographical points around the world within a narrow time window, a GLE Alert is issued. The role of the ANeMoS, as an expert group, is to maintain and operate the above mentioned two products as part of the SSA SWE federated network including incident management, service requests, access requests and provision for eventual service closure. Additionally, the production of monthly statistics about federated products including visit statistics, most popular product, user feedback or specific user interaction (e.g. outreach activity) is also provided. Moreover, the execution of the service test campaign of in orbit environment and effects monitoring for spacecraft operation in low earth and geostationary orbit (SCO/orb) as well as the service to airline (NSO/air) will be also supported. Recently, an ongoing service named DYASTIMA-R, which constitutes a successor of the Dynamic Atmospheric Shower Tracking Interactive Model Application (DYASTIMA) is being developed. This new simulation tool will be used for the calculation of the equivalent dose during flights scenario in the lower or higher atmosphere, characterized by different altitudes, different geographic latitudes and different solar and galactic cosmic ray intensity.

Athens Neutron Monitor Station (ANeMoS)

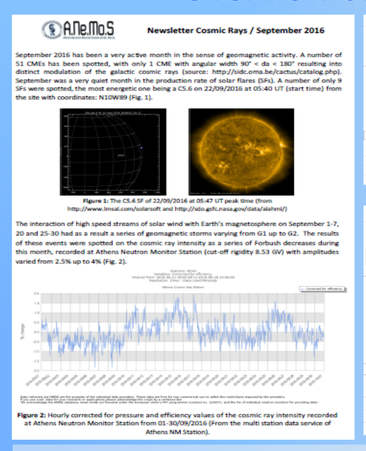


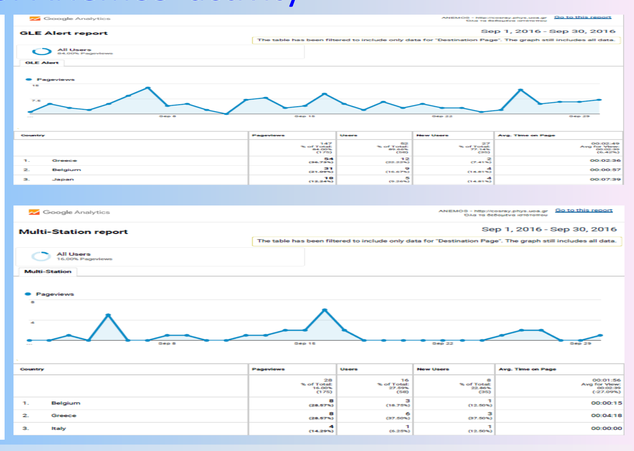
The Athens Neutron Monitor (6NM-64) provides data in real time with minimum resolution of 1 minute. The measurements can be obtained via the internet in several formats and resolutions.

Since 2008 a database collecting the high resolution measurements of neutron monitors is in operation, with the participation of 12 countries and more than 50 Neutron Monitor Stations. ANeMoS sends real time data to the European Neutron Monitor Database (NMDB) every 1 minute. A mirror server of the NMDB database has been set up and is in operation at the Athens NM station [1].

ANeMoS participates as an expert group at the Space Situational Awareness (SSA) program of European Space Weather Agency (ESA), with the development of the interface of Neutron Monitor (NM) Service (http://swe.ssa.esa.int/web/guest/space). The NM Service provides a) timely and accurate warning for GLE (GLE Alert) and b) real and near real time data from multiple NM stations (Multi Station). The services of ANeMoS are provided via the portal of ESA (http://swe.ssa.esa.int/web/guest/space-radiation).

Overview of ANeMoS activity

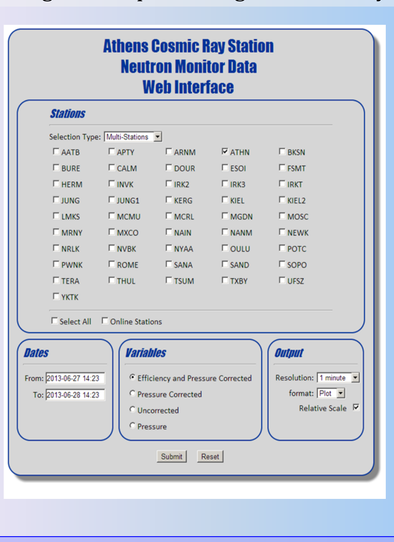




Monthly Solar and Cosmic ray activity Newsletter (left panel) and Statistics of the ANeMoS Federated Products to the ESA SSA Space Radiation Coordinating Center (right panel)

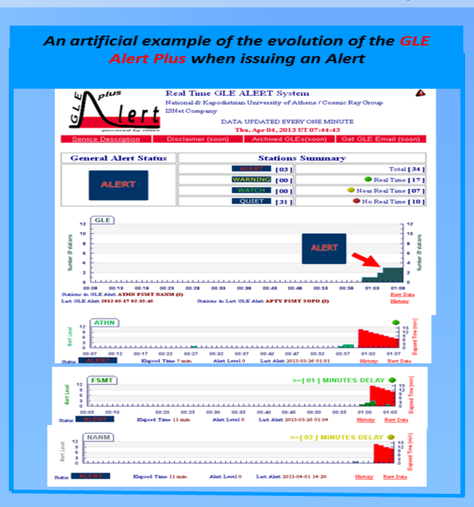
Multi –Station Neutron Monitor Data

The multi-station interface provides an easy way to access the data that are stored in the NMDB database. The interface connects to the NMDB slave server located at the Athens station. The user has to select the stations, the variables, the time interval and the resolution of the exported data. The output can be obtained in both plot and ascii format. Moreover, a feature that allows the retrieval of data in csv file has been implemented, allowing further processing of the data by the user.



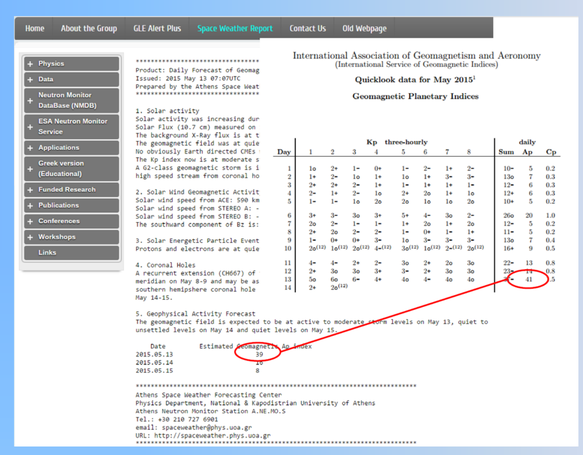
Ground Level Enhancement Alert (GLE Alert Plus)

The recordings of each NM station providing data to the NMDB are the input ones for the GLE Alert Plus. For every 1 minute it calculates the moving average of the previous hour (i.e. 60 1-min measurements) and the threshold that represents the upper limit for which each NM station is considered to be at 'Quiet' mode. If three consecutive 1-min measurements exceed this threshold, the particular NM station is considered to be at a 'Station Alert' mode and an elapsed time window of 15 min is being triggered. In case 3 NM stations, independently of each other, enter the 'Station Alert' mode within the aforementioned time window a General 'GLE Alert' is being marked and an Alert is issued.



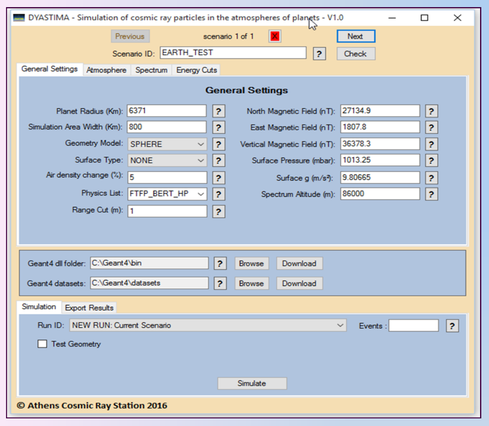
Athens Space Weather Forecasting Center (ASWFC)

The continuous space measurements by ACE, SOHO, GOES, SDO, PROBA, STEREO A and B, together with ground based observatories as neutron monitors and magnetometers has led to the implementation of Space Weather Centers for the short and long term forecasting of the planetary geomagnetic index Ap. The Athens Space Weather Forecasting Center (ASWFC) provides a daily report that includes current geomagnetic conditions in near-Earth space [2], [3] as well as a 3-day forecast of the planetary geomagnetic index Ap. This estimation of the Ap index is based on a set of rules that includes a number of known parameters/properties of Ap index [3].

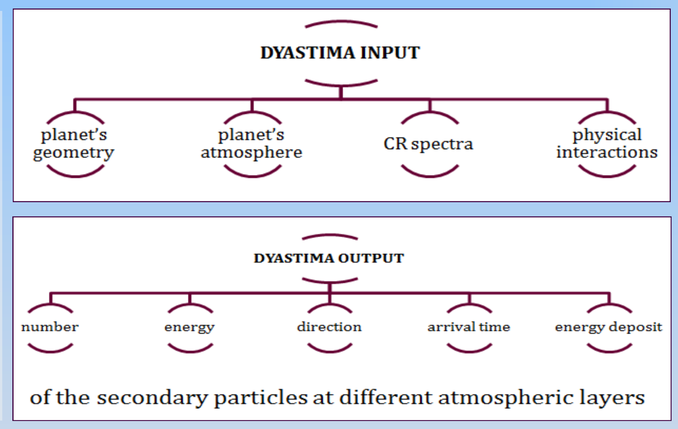


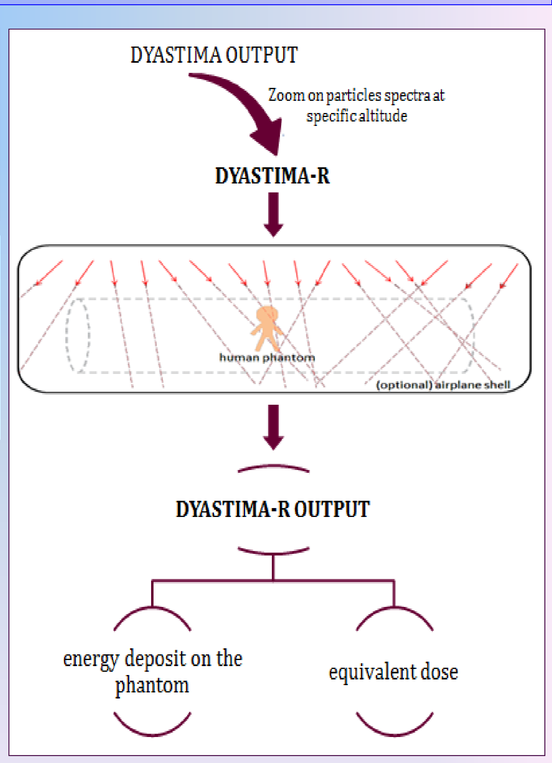
The website of ASWFC with the corresponding daily forecast. The estimated Ap index (39) and the observed value (41) by IAGA are presenting as an example of a successful forecast of a G2 geomagnetic storm of May 13th 2015.

DYnamic Atmospheric Shower Tracking Interactive Model Application (DYASTIMA) and DYASTIMA -R



In order to implement a simulation of the cosmic ray propagation through the atmosphere, there are some physical quantities and processes that must be taken into consideration. DYASTIMA is a standalone application for the simulation of the showers that are produced in the atmosphere of a planet due to the CR. The application makes use of the well known Geant4 simulation toolkit [4] [5]. The simulation scenario is described by using a graphical user interface (GUI). The output of DYASTIMA provides all the available information about the cascade and tracking. DYASTIMA is also used for cascades simulation in the atmosphere of other planets [6].





A new software application DYASTIMA-R, which constitutes an extension of DYASTIMA uses the output provided by DYASTIMA, in order to calculate the energy that is deposited on the phantom and moreover the equivalent dose. Monte Carlo simulations are made in order to describe the particle interactions and the transport of the primary and secondary radiation through matter, especially through simulated media, such as the human body (phantom) and the aircraft shielding (optional).

As DYASTIMA-R calculates the equivalent dose for various types of particles in different atmospheric altitudes and takes into account the phases of solar activity, as well as the geometry and shielding materials of the aircrafts, allowing the study of various flight scenarios. Therefore, it can be of great interest for air-craft crews (pilots, flight attendants), passengers (frequent travelers, pregnant women, children), airlines and tour operators, air-craft manufacturers, legislators and Civil Aviation. DYASTIMA-R will be combined with the GLE-Alert system operated in ANeMoS and ESA Space Radiation Center and soon will be provided as a tool for an extensive study of the radiation exposure during air-craft flights and manned space missions [7].

References:

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