Space Weather of the Heliosphere: Processes and Forecasts
Proceedings IAU Symposium No. 335, 2017
C. Foullon & O.E. Malandraki, eds.

doi:10.1017/S1743921318000054

SWERTO: a Regional Space Weather Service

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Abstract. The Space WEeatherR TOr vergata university (SWERTO) service is an operational Space Weather service based on multi-instrument data from space-based (PAMELA, ALTEA) and ground-based (IBIS, MOTHII) instruments. The service (*spaceweather.roma2.infn.it*) is located at the Physics Department of the University of Rome Tor Vergata, Italy (UTOV) and will allow registered users to access scientific data from instrumentation available to UTOV researchers through national and international collaborations. It will provide intuitive software for the selection and visualization of such data and results from prototype forecasting codes for flare probability and Solar Energetic Particle (SEP) fluxes. The service is designed to promote access to technical and scientific information by the regional industries which employ technologies vulnerable to Space Weather effects. Basically, SWERTO aims to: *i)* design and construct a data-base with particle fluxes recorded by space missions and spectro-polarimetric measurements of the solar photosphere; *ii)* allow an *Open Access* to the data-base and to prototype forecasts to regional industries involved and exposed to Space Weather effects; *iii)* implement a tutorial and a FAQ section to help decision makers to became aware of and evaluate the risks from Space Weather events; *iv)* outreach and customer products. SWERTO has been financed by the Regione Lazio FILAS-RU-2014-1028 grant.

Keywords. Space weather instrumentation, space weather data, space weather services

1. Introduction

The effects of Space Weather (SW) on human high-tech activities, infrastructures and health on the ground, in the air, and in space is well documented in a large number of technical and scientific reports (e.g., Baker *et al.* 2004, Narici 2008). The *Regione Lazio*, situated in central Italy, hosts a large number of high-tech industries and national critical infrastructures whose operators and decision makers must have situational awareness of SW events in order to be able to take actions to mitigate possible SW impacts. The SWERTO service aims to provide to registered users a series of scientific data from instruments operating within national and international programs in which UTOV researchers are involved. Moreover, it offers a user web interface consisting of a dashboard designed to present SW information in a way that is easy to read for final operational users and decision makers. The SWERTO service is constructed from a database containing space-based and ground-based data which are relevant for characterizing the space environment and solar activity. The database contains mainly particle flux data from two satellite-borne experiments (Anomalous Long Term Effects on Astronauts (ALTEA) and Payload for Antimatter- Matter and Light-nuclei Astrophysics (PAMELA)) as well as

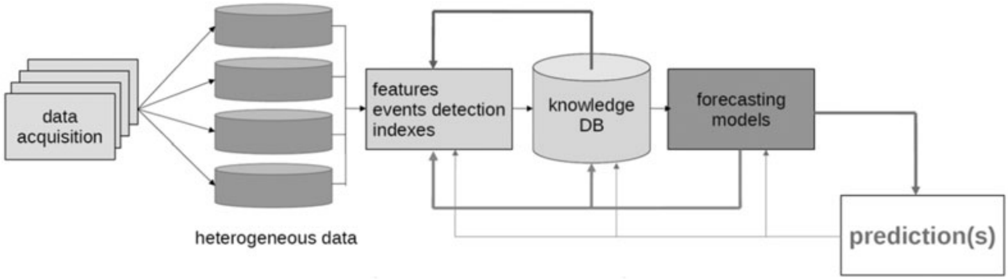

Figure 1. Scheme of the SWERTO database concept.

solar data from ground-based measurements (Interferometric BIdimensional Spectropolarimeter (IBIS) instrument, updated Magneto-Optical filters at Two Heights (MOTH II) suite of instruments). Data from these instruments feed into the second component of the SWERTO service which is the operational analysis and forecasting system. A Flowchart of the SWERTO basic concept is shown in Figure 1.

2. The database and the web interface

The SWERTO data component, the heterogeneous data layer in Figure 1, currently collects data from the four above-mentioned space-based (PAMELA and ALTEA) and ground-based (IBIS and MOTH II) observing systems. The analysis and forecasting models from these observing systems and additional instruments (e.g., SDO/HMI magnetograms or GOES X-ray fluxes) feed into the second SWERTO component which is the operational SW service. The flowchart in Figure 1 presents the different types of procedures performed in the second SWERTO component (features event detection and indexes, knowledge Data Base, forecasting models and predictions). The user web interface consists of a dashboard designed to organize and present information in a way that is easy to read for final operational users and decision makers. On the SWERTO service dashboard (Figure 2) the following information is shown:

(*a*) The latest H_a image acquired by the Global Oscillation Network Group (GONG).

(*b*) The latest magnetogram from Helioseismic and Magnetic Imager (HMI) instrument on board of Solar Dynamics Observatory (SDO).

(*c*) Proton and Helium counts from PAMELA. PAMELA, originally built to study antimatter in cosmic rays (Picozza *et al.* 2007), has over the years specialized in the study of the solar component of cosmic rays. The instrument measures populations of particles within the cosmic radiation, from energies of a few tens of MeV up to a few TeV.

(*d*) Averaged flux or averaged dose rate from ALTEA. ALTEA measure the radiation field (e.g., Di Fino *et al.* 2014) inside the International Space Station (ISS). It has been on-board the ISS since 2006, recording data till 2012 in different configurations. ALTEA returned to Earth in Feb. 2015 to be upgraded with a new detector entitled LIDAL (Light Ion Detector for ALTEA) and it will be back on-board the ISS in 2018.

(*e*) High resolution solar velocity or magnetic maps from the IBIS instrument, a spectro-polarimetric imager based on capacitance-stabilized piezoelectric scanned Fabry-Perot etalons. The instrument can rapidly and precisely scan solar photospheric and chromospheric spectral lines from 550 to 860 nm (e.g., Viticchié *et al.* 2009).

(*f*) Full disk line-of-sight (LOS) Doppler velocity and LOS magnetic field strength from MOTH II. MOTH II consists of two telescopes observing in the K I (769.9 nm) and Na I (589.0 nm) lines and provides observations of the velocity and magnetic filed

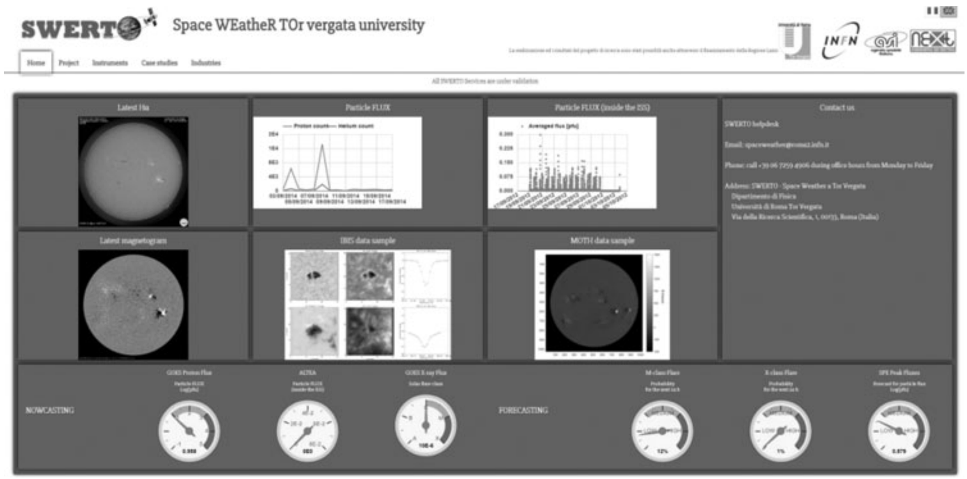

Figure 2. The SWERTO service dashboard.

at two heights of the solar atmosphere. The core of MOTH II is a tandem of magneto-optical filter (MOF) constituted by a cell containing vapours of K (or Na) immersed in a longitudinal magnetic field. The telescope is managed by the University of Hawaii's Institute for Astronomy (IfA), Georgia State University (GSU) and JPL.

Moreover, needle gauges (see lower panel on Figure 2) provide an easy graphical interface to easily obtain *nowcasting* and *forecasting* information. More in detail, they show: *i)* recent proton flux near Earth, measured for three different particle energy ranges-5-minute GOES-13 prepared by the U.S. Dept. of Commerce, NOAA, Space Weather; *ii)* particle flux inside the ISS. ALTEA will be back in orbit in 2018 (upgraded with LIDAL); *iii)* recent GOES X-ray flux near Earth; *iv)* M- and X-class flare probability for the next 24h, currently based on HMI magnetograms using the algorithm reported in Schrijver (2007), *v)* SEP flux created making use of detected CME parameters: some characteristics of the proton spectrum can be forecast in LEO orbit, using the correlation between the SEP characteristics and the CME velocity (Papaioannou *et al.* 2016, Napoletano *et al.* 2017).

3. Acknowledgments

We acknowledge the use of SDO/HMI full disk magnetograms and GONG H_a images. SDO data are courtesy of the NASA/SDO HMI science team. We acknowledge the support from Regione Lazio FILAS-RU-2014-1028 grant (November 1st, 2015 - October 31st, 2017).

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