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Does Space Weather Matter to Astrobiology? The International Space Weather Initiative

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Space weather events can have significant effects all the way from the Sun to Earth. They have been implicated in the depletion of ozone and cloud formation, and their signatures may even be seen in ice core records spanning more than 400 years into the past. Solar activity at other planets, and elsewhere in the solar system, can be important, and violent flare activity can even be observed at other stars. Economically, these events may have severe consequences ranging from human exposure to increased radiation to disruption of communications, navigation and timing, and electrical power.

This short communication summarizes briefly the current status of the International Space Weather Initiative (ISWI) implemented in the spirit of the continuation of the International Heliophysical Year 2007 (IHY), facilitated by the United Nations (UN) [1,2]. This short communication is calling on the astrobiology community to explore avenues for cooperation in basic space science in terms of data analysis and modeling, specifically focusing on issues common to astrobiology and space weather [3-6]. Data emanating from more than 1000 space weather instruments operating in more than 112 nations (at this point of time) may also be utilized for the benefit of astrobiology.

UN Basic Space Science Initiative (Unbssi)

Basic space science initiative

The basic space science initiative of the United Nations is a long-term effort for the development of astronomy and space science through regional and international cooperation in these disciplines on a worldwide basis, particularly in developing nations (Figure 1). Basic space science workshops were co-sponsored and co-organized by the National Aeronautics and Space Administration (NASA) of the United States, the Japan Aerospace Exploration Agency (JAXA), and the European Space Agency (ESA). The Committee On Space Research (COSPAR) and the International Astronomical Union (IAU) acted as co-organizers of UNBSSI. A UN document containing the full report on UNBSSI is available at http://www.unoosa.org/pdf/limited/l/AC105_2013_CRP11E.pdf .

A series of workshops on basic space science was held from 1991 to 2004 (India 1991, Costa Rica and Colombia 1992, Nigeria 1993, Egypt 1994, Sri Lanka 1995, Germany 1996, Honduras 1997, Jordan 1999, France 2000, Mauritius 2001, Argentina 2002, and China 2004; http://neutrino.aquaphoenix.com/un-esa/) and addressed the status of astronomy in Asia and the Pacific, Latin America and the Caribbean, Africa, and Western Asia. Through the lead of Professor Dr. Masatoshi Kitamura (1926-2012) from the National Astronomical Observatory Japan, astronomical telescope facilities were inaugurated in seven developing nations and planetariums were established in twenty developing nations based on the donation of respective equipment by Japan.

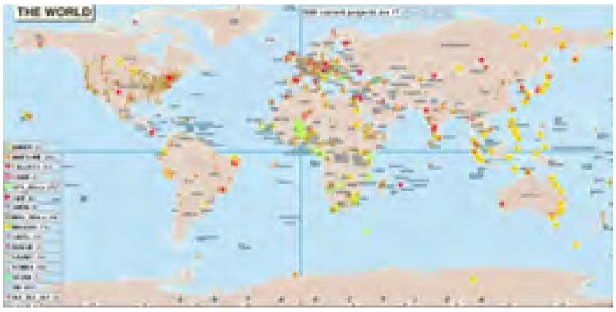

Figure 1: The Figure illustrates the worldwide current distribution of space weather instrument arrays in operation.

International heliophysical year

Pursuant to resolutions of the Committee on the Peaceful Uses of Outer Space of the United Nations (COPUOS) and its Scientific and Technical Subcommittee, since 2005, these workshops focused on the preparations for and the follow-ups to the International Heliophysical Year 2007 (UAE 2005, India 2006, Japan 2007, Bulgaria 2008, South Korea 2009; http://www.unoosa.org/oosa/SAP/bss/ihy2007/index.html). IHY's legacy is the current operation of 17 worldwide instrument arrays with more than 1000 instruments recording data on solar-terrestrial interaction from coronal mass ejections to variations of the total electron content in the ionosphere (http://iswi-secretariat.org/). Instruments are provided to hosting institutions by entities of Armenia, Brazil, France, Israel, Japan, Switzerland, and the United States.

International Space Weather Initiative

Number of nations/instruments

Starting in 2010, the workshops focused on the International Space Weather Initiative (ISWI) as mandated in a three-year-work plan as part of the deliberations of COPUOS [7,8]. Workshops on ISWI were scheduled for Egypt in 2010 for Western Asia, Nigeria in 2011 for Africa, and Ecuador in 2012 for Latin America and the Caribbean. The International Center for Space Weather Science and Education at Kyushu University, Fukuoka, Japan (http://www.serc.kyushu-u.ac.jp/index_e.html), was established through ISWI in 2012. Similar research and education centers were also established in Nigeria (http://www.cbssonline.com/aboutus.html) and India (http://www.cmsintl.org/). Table 1 provides an overview on the 17 space weather instrument arrays/networks taking data in more than 112 nations with a total number of more than 1000 instruments.

Selected instrument concepts

The current instrument concepts can be grouped into four

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Abbreviation	Name of Array	Number of Nations/ Instrument
AMBER	African Meridian B-field Education and Research	5/5
AWESOME	Atmospheric Weather Education System for Observation and Modeling of Effects	21/24
CALLISTO	Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory	27/51
CHAIN	Continuous H-alpha Imaging Network	3/3
CIDR	Coherent Ionospheric Doppler Network	3/11
GMDN	Global Muon Detector Network	4/4
GPS_ Africa	African Dual Frequency GPS Network	16/43
MAGDAS	Magnetic Data Acquisition System	27/71
MAG_ Africa	Magnetometers in Africa	11/14
OMTIs	Optical Mesosphere Thermosphere Imager	7/12
RENOIR	Remote Equatorial Nighttime Observatory for Ionospheric Regions	2/3
SAVNET	South America Very Low frequency Network	4/11
SCINDA	Scintillation Network Decision Aid	22/34
SEVAN	Space Environment Viewing and Analysis Network	5/7
SID	Sudden Ionospheric Disturbance Monitor	75/657
ULF/ELF/VLF	Magnetic observations utilizing ultralow, extremely low, very low frequency signals	1/3
CSSTE	Regional Centres for Space Science and Technology Education, affiliated to the United Nations	6/6

Table 1: Space Weather Instrument Arrays.

classes: (i) solar telescope networks, (ii) ionospheric networks, (iii) magnetometer networks, and (iv) Particle detector networks.

Solar telescope networks

The solar telescope network consists of radio telescopes that can observe solar eruptions of concern to various destinations in heliospace. Of particular importance are shocks and particle beams produced at the Sun, which can be remote sensed by the radio telescopes. The telescopes have been deployed at several locations in the world, so that a continuous coverage of the Sun will be possible. CALLISTO is a dual-channel frequency-agile receiver based on commercially available consumer electronics. The complete spectrometer is very compact, very cheap and easy to replicate for deploying in many locations.

Ionosphere networks

The AWESOME instrument is an ionospheric monitor that can be operated by students. The monitors detect solar flares and other ionospheric disturbances. AWESOME monitors have been deployed in many African and Asian nations, so that the current data obtained in the western hemisphere can be combined with other data. Africa GPS is an effort to link many GPS networks in Africa. The overarching plan is to increase the number of real-time dual-frequency GPS stations world-wide for the study of ionospheric variability. Of particular interest is the response of the ionospheric Total Electron Content (TEC) during geomagnetic storms over the African sector. This program is particularly compatible with magnetometry. SCINDA is a real-time, data driven, communication outage forecast and alert system. Its purpose is to aid in the specification and prediction of communications degradation due to ionospheric scintillation in the equatorial region of Earth. Scintillation affects radio signals up to a few GHz frequencies and seriously degrades and disrupts satellite-based navigation and communication systems. SCINDA consists of a set of ground-based sensors and quasi-empirical models, developed to provide real-time alerts and short-term (< 1 hour) forecasts of scintillation impacts on UHF satellite communication and L-Band GPS signals in the Earth's equatorial regions. SCINDA was deployed near the magnetic equator of Earth (within 20 degrees on either side). The RENOIR is a suite of instruments dedicated to studying the equatorial/low-latitude ionosphere/thermosphere system, its response to storms and the irregularities that can be present on a daily basis. Through the construction and deployment of a RENOIR station, it is possible to achieve a better understanding of the variability in the nighttime ionosphere and the effects this variability has on critical satellite navigation and communication systems. SAVNET is for monitoring the solar activity on long and short time scales and ionospheric perturbations over the South Atlantic Magnetic Anomaly (SAMA). The network is also be used for studying Earth's atmosphere. The basic data output is composed of these phase and amplitude measurements of VLF signals.

Magnetometer network

Magnetometer network is a relatively low-cost method for monitoring solar-terrestrial interaction. Multi-continental networks provide an excellent basis for meso- and global-scale monitoring of magnetospheric-ionospheric disturbances and provide scientific targets for mid- and low-latitudes and opportunities for developing nations to host instruments and participate in the science investigations. MAGDAS is being deployed for space weather studies. The MAGDAS data will be used to map the ionospheric equivalent current pattern every day. The current and electric fields at all latitudes are coupled, although those at high, and middle and low latitudes are often considered separately. By using the MAGDAS ionospheric current pattern, the global electromagnetic coupling processes at all latitudes will be clarified. MAGDAS will utilize the Circum-Pan Pacific Magnetometer Network involving several nations around the globe (Australia, Indonesia, Japan, The Philippines, Russian Federation, United States of America, and Taiwan Province of China).

Particle detector networks

Particle detectors have a wide range of applications: They can detect energetic particles from the Sun, galactic and extra-galactic sources and from the heliosphere. They can also indirectly observe large magnetic structures such as magnetic clouds and shocks from the Sun through the well-known process of Forbush decrease. These particles also interact with Earth's atmosphere and produce air-showers (secondary particles). They are also linked to ozone depletion and the cloud-cover variation. The SEVAN world-wide particle detector network is a combined neutron–moon detecting system. Flexible 32-bit microcontroller-based data acquisition electronics is utilizing the correlation information from cosmic ray secondary fluxes, including environmental parameters (temperature, pressure and magnetic field). The high precision time synchronization of the remote installations via Global Positioning System (GPS) receivers is crucial ingredients of the new detector. The GMDN collaboration consists of institutes from several nations. Many of the nations are already operating muon detectors and some have recently installed them. The precursory decrease of cosmic ray intensity is seen more than one day prior to the arrival of shock driven by coronal mass ejection at Earth. This is an important forecasting tool for predicting space weather attributed to energetic solar eruptions.

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ISWI Beyond 2013

COPUOS has adopted "Space Weather" as a regular agenda item from 2013 onwards. ISWI will be one of the elements of this topic and it will continue to support deployment of space weather instruments, the inclusion of space science education curricula covering heliophysics in universities, and initiate public outreach projects in UN Member States.

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