Space Weather
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Feature Article

The International Space Weather Initiative (ISWI)

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Article first published online: 4 JUN 2013
DOI: 10.1002/swe.20048

Issue

Space Weather
Early View (Online Version of Record published before inclusion in an issue)

Additional Information(Show All)
How to Cite Author Information Publication History

How to Cite

Guhathakurta, M., J. M. Davila, and N. Gopalswamy (2013), The International Space Weather Initiative (ISWI), Space Weather, 11, doi:10.1002/swe.20048.

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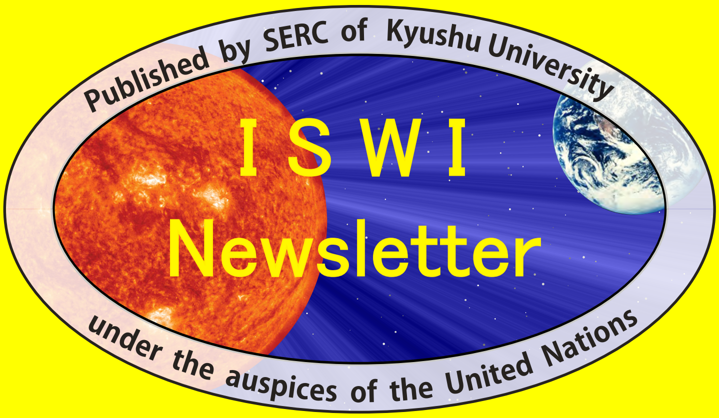
Publication History

Article first published online: 4 JUN 2013
Accepted manuscript online: 11 APR 2013 01:43PM EST

This pdf circulated in Volume 5, Number 69, on 9 June 2013.



SPACE WEATHER, VOL. 11, 1–3, doi:10.1002/swe.20048, 2013

The International Space Weather Initiative (ISWI)

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Citation: Guhathakurta, M., J. M. Davila, and N. Gopalswamy (2013), The International Space Weather Initiative (ISWI), *Space Weather*, *11*, doi:10.1002/swe.20048.

The effects of solar activities and space weather phenomena on daily lives, environment, and space systems are becoming more apparent, and the need to collaborate and cooperate with the international community to reach a greater understanding of these consequences is urgent. Strong solar storms can knock out power, disable satellites, and scramble GPS. To that effect, in 2003, NASA's Sun-Earth Connection Division led an initiative known as the "International Living With a Star" (ILWS) consisting of more than 25 of the world's most technologically advanced space agencies to contribute towards the scientific goal for understanding Space Weather through observations made in space [*Withbroe et al*., 2005].

A few years later, scientists coined the term "Heliophysics" to describe the emerging science of the Sun-Earth system [*Schrijver and Siscoe*, 2009]. As a nod to the importance of the topic, NASA has set up a dedicated Heliophysics Division at Headquarters in Washington DC, and the United Nations declared 2007 the "International Heliophysical Year" (IHY) in hopes of spurring global involvement in this new field.

When a big geomagnetic storm is underway, waves of ionization ripple through Earth's upper atmosphere, electric currents flow through the topsoil, and the whole planet's magnetic field begins to shake. As these are global phenomena, we need to be able to monitor them all around the world. Industrialized countries tend to have an abundance of monitoring stations. They can keep track of local magnetism, ground currents, and ionization, and provide the data to researchers. Developing countries are where the gaps are. A key challenge is to fill many gaps in our solar and geomagnetic storm coverage around the planet. The goal is that by observing in new geographical regions, a more global picture of Earth's response to solar wind and coronal mass ejections (CMEs) inputs can be obtained. In the long term, these networks will provide real-time data valuable for forecasting and nowcasting. Modeling improvements will allow better exploitation of existing data sets. IHY galvanized the entire world community to contribute key ground-based measurements that are missing and provided a successful model for the deployment of arrays of small scientific instruments in new and scientifically interesting geographic locations [*Thompson et al*., 2009].

The new International Space Weather Initiative (ISWI) is designed to build on this model to promote the observation, understanding, and prediction of the space weather phenomena, and to communicate the scientific results to the public. The ISWI continued the study of Universal Processes in the solar system that affect interplanetary and terrestrial environments by (1) continuing to deploy new instrumentation, (2) developing data analysis processes, (3) developing predictive models using data from the instrument arrays, and (4) continuing to promote knowledge of heliophysics through education and public outreach (Figure 1). Additional information on the ISWI is available at http://iswi-secretariat.org.

The basic principles of the ISWI model are simple. Each instrument team is led by a single scientist. The lead scientist or principal investigator, funded by his/her country, provides instrumentation (or fabrication plans) and data distribution. In a few cases, where resources allow, the hosting country will pay for the instrument. The host country provides the workforce, facilities, and operational support necessary to operate the instrument. This is typically at a local university or government laboratory. Host scientists become part of science team. All data and data analysis activity is shared within the science team, and all scientists participate in publications and scientific meetings where possible.

The ISWI program promotes the coordination of data products in a form useful for input into physical models of heliophysics processes. These data are being used for both retrospective analysis aimed at physical understanding of space weather, and for models that predict future space weather. Eventually, as internet connectivity improves, these data will be made available in near real time in a form where they can be ingested into predictive models. In the near term, other strategies like data transfer during selected time periods, or on recorded media like DVDs and tapes are adequate for the retrospective scientific studies of space weather events, and the development of physical models. Figure 2 below shows the countries participating in this effort.

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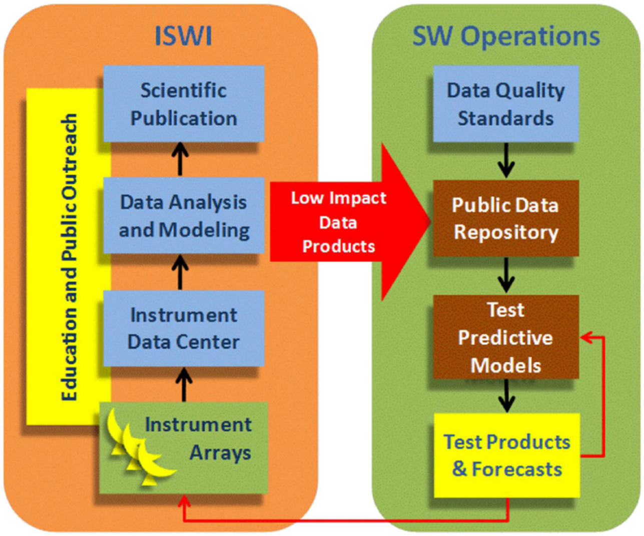

Figure 1. The instruments deployed in the ISWI provide data useful for Space Weather research and for forecasting.

With the support of the United Nations Office of Outer Space Affairs (OOSA), the IHY/ISWI has facilitated the operation of nearly 600 instruments operating in more than 95 countries. Some examples of the type of instruments are: African GPS Receivers for Equatorial Electrodynamics Studies (AGREES) to understand the unique structures of equatorial ionosphere, which has been reported from satellite observations data in the African sector; African Dual Frequency GPS Network (AMMA), to increase the number of real-time dual-frequency GPS stations worldwide for the study of ionospheric variability and total electron content (TEC); African Meridian Bfield Education and Research (AMBER), to understand low latitude electrodynamics; Atmospheric Weather Education System for Observation and Modeling of Effects (AWESOME) and SID (Sudden Ionospheric Disturbance Monitor) to study lightning, sprites, Elves, relation to terrestrial Gamma Ray flashes, and others; Continuous H-alpha Imaging Network (CHAIN) to study solar activity, flares, filaments, filament eruptions etc.; Coherent Ionospheric Doppler Radar (CIDR) to tomographically reconstruct the ionosphere and to provide input to Data Assimilation models; Global Muon Detector Network (GMDN) to identify the precursory decrease of cosmic ray intensity that takes place more than one day prior to the Earth-arrival of shock driven by an interplanetary CME; Magnetic Data Acquisition System (MAGDAS) to study dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electromagnetic

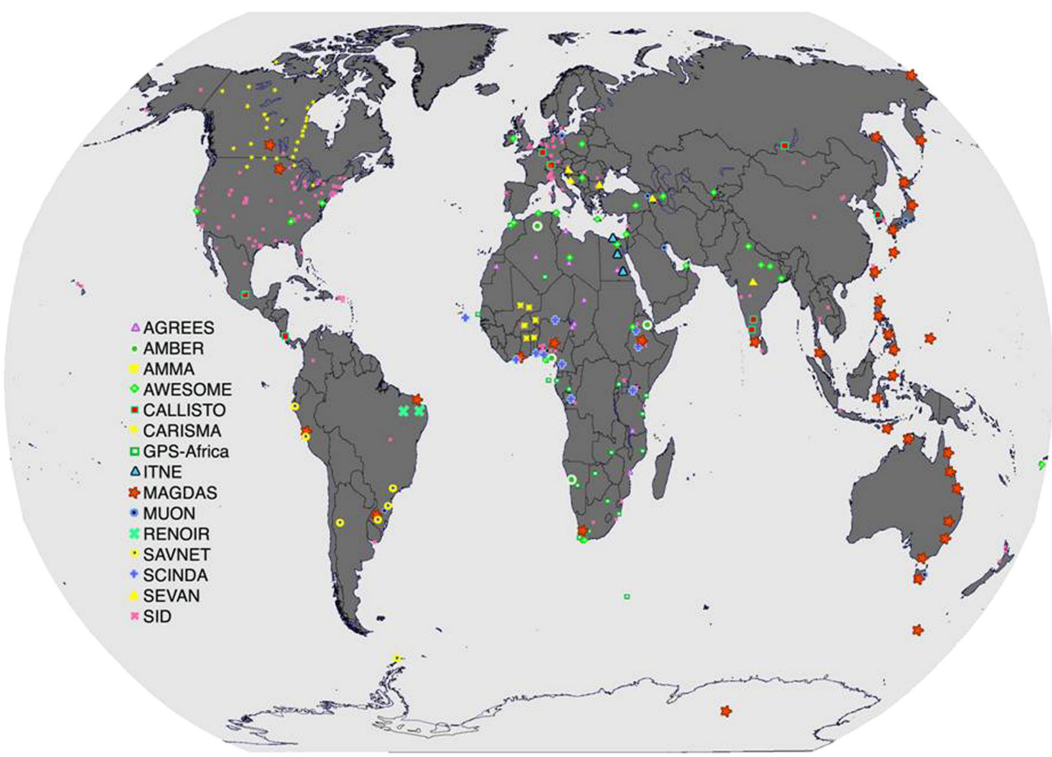

Figure 2. A map of ISWI-brokered space weather monitoring stations. Prospective participants should visit the ISWI home page (http://iswi-secretariat.org) to learn more about available projects and how to become involved.

response of iono-magnetosphere to various solar wind changes; A complete list of instruments, their coordinates, and host countries can be obtained from http://iswi-secretariat.org/.

The UN sponsored IHY and ISWI schools have trained several hundred graduate students and young scientists. Since 2005, IHY focused workshops took place in the following countries: the United Arab Emirates (2005), India (2006), Japan (2007), Bulgaria (2008), and the Republic of Korea (2009). More detailed information can be obtained from the website at http://www.unoosa.org/oosa/SAP/bss/ihy2007/index.html.

Beginning in 2010, ISWI focused workshops took place in Egypt (2010) for the benefit of developing countries in Western Asia, Nigeria (2011) for Africa, and Ecuador (2012) for Latin America and the Caribbean. Detailed information is available at (http://www.stil.bas.bg/ISWI/). In addition, there are many schools held worldwide to train graduate students; some examples of which are ISWI and Chapman Conference on Longitude and Hemispheric Dependence of Space Weather, in Addis Ababa, Ethiopia, 12–16 November 2012, ISWI and MAGDAS School on Space Science, Bandung Indonesia, 17–26 September 2012, Nigeria, Redeemer's University, Near Lagos, 15–20 August 2011, Slovakia, High Tatras, 21–27 August 2011, Democratic Republic of the Congo (RDC), Kinshasa, 11–24 September 2011, Morocco, Rabat, 5–16 December 2011, Ethiopia, Bahir Dar, 28 October–4 November 2010.

United Nation's Committee on Peaceful Use of Outer Space (UNCOPUOUS) has adopted "Space Weather" as a regular agenda item from 2013 onwards. ISWI is now one of the elements of this topic, and it will continue to promote deployment of instruments and the inclusion of space science curricula in universities and graduate schools, and to support public outreach projects worldwide.

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