

International Space Weather Initiative (ISWI)

(Annual Report 2015) 2016/02/19

Nat Gopalswamy

1. **The goal of the ISWI** is to develop the scientific insight necessary to understand the science, and to reconstruct and forecast near-Earth space weather. This includes instrumentation, data analysis, modeling, education, training, and public outreach.

2. ISWI Steering Committee:

Christine Amory-Mazaudier	France	GPS
Jean Lilensten	France	J Space Weather& Space Climate
Sharafat Gadimova	Austria	UNOOSA
Katya Georgieva	Bulgaria	SCOSTEP/VarSITI
Nat Gopalswamy	US	Chair
Keith Groves	US	Scintillation Networks
Lika Guhathakurta	US	NASA HQ
Norbert Jakowski	Germany	SOFIE and GIFDS
Ian Mann	Canada	U. Alberta
Christian Monstein	Switzerland	CALLISTO
Terry Onsager	US	ISES
Babatunde Rabi	Nigeria	NASRDA
Jean-Pierre Raulin	Brazil	SAVNET
Deborah Scherrer	US	SID Monitor Network
Kazunari Shibata	Japan	CHAIN project
Chi Wang	China	Space Weather Meridian
Akimasa Yoshikawa	Japan	MAGDAS

3. Instrument Arrays:

3.1 African Dual Frequency GPS Network (AMMA)

Lead Scientist: *Dr. Christine Amory-Mazaudier* (CETP&CNRS) **France**

Objective: To increase the number of real-time dual-frequency GPS stations worldwide for the study of ionospheric variability, response of the ionospheric total electron content (TEC) during geomagnetic storms over the African sector.

3.2 African Meridian B-field Education and Research (AMBER)

Lead Scientist: *Lead Scientist: Dr. Endawoke Yizengaw* (Boston College) and *Dr. Mark Moldwin* (University of Michigan) **United States**

Objective: Understand low latitude electrodynamics, ULF pulsations, effect of Pc5 ULF on MeV electron population in inner radiation belts

3.3 Atmospheric Weather Education System for Observation and Modeling of Effects (AWESOME) and SID (Sudden Ionospheric Disturbance Monitor)

Lead Scientist: *Dr. Umrans S. Inan, Dr. Morris Cohen and Dr. Deborah Scherrer* (Stanford) **United States**

Objective: Lightning, sprites, Elves, relation to terrestrial Gamma Ray flashes, whistler induced electron precipitation, conjugate studies

3.4 Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO)

Lead Scientist: *Dr. Arnold Otto Benz and Dr. Christian Andreas Monstein* (ETHZ) **Switzerland**

Objective: Study the magnetic activity of a wide range of astrophysical objects with emphasis on the Sun and cool stars

3.5 Continuous H-alpha Imaging Network (CHAIN)

Lead Scientist: *Dr. Kazunari Shibata and Dr. Satoru UeNo* (Kyoto U) Japan

Objective: Solar activity, flares, filaments, filament eruptions

3.6 Coherent Ionospheric Doppler Receivers (CIDR)

Lead Scientist: *Prof. Ayman Mahrous* (Helwan University, Egypt) and *Dr. Trevor W. Garner* (U Tex) **United States**

Objective: To tomographically reconstruct the ionosphere and to provide input to Data Assimilation models

3.7 Global Ionosphere Flare Detection System (GIFDS)

Lead Scientist: *Dr. Norbert Jakowski and Daniela Wenzel* (German Aerospace Center) Germany

Objective: To issue warnings for mitigating space weather impact on sensitive technologies

3.8 Global Muon Detector Network (GMDN)

Lead Scientist: *Dr. Kazuoki Munakata* (Shinsu U) Japan

Objective: 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 coronal mass ejection

3.9 Low-latitude Ionosphere Sensor Network (LISN)

Lead Scientist: *Dr. Cesar Valladares* (Boston College) United States

Objective: To monitor and specify the conditions of the equatorial and low-latitude ionosphere over South America.

3.10 Magnetic Data Acquisition System (MAGDAS)

Lead Scientist: *Dr. Kiyohumi Yumoto and Dr. Akimasa Yoshikawa* (Kyushu U) Japan

Objective: Study of dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electromagnetic response of iono-magnetosphere to various solar wind changes, and the penetration and propagation mechanisms of DP2-ULF range disturbances

3.11 Optical Mesosphere Thermosphere Imager (OMTIs)

Lead Scientist: *Dr. Kazuo Shiokawa* (Nagoya U) Japan

Objective: Dynamics of the upper atmosphere through nocturnal airglow emissions

3.12 Remote Equatorial Nighttime Observatory for Ionospheric Regions (RENOIR)

Lead Scientist: *Dr. Jonathan J. Makela* (U Illinois) **United States**

Objective: Study the equatorial/low-latitude ionosphere/thermosphere system, its response to storms, and the irregularities that can be present on a daily basis.

3.13 Solar Flares detected by Ionospheric Effects (SOFIE)

Lead Scientist: *Dr. Norbert Jakowski* (Institute of Communications and Navigation and the School-Lab at DLR Neustrelitz) Germany

Objective: To detect solar radio bursts (solar flares) by measuring continuously the intensity of VLF radio signals considering ionospheric propagation effects on radio waves

3.14 South America Very Low frequency Network (SAVNET)

Lead Scientist: *Dr. Jean-Pierre Raulin* (U Presbiteriana) Brazil

Objective: Study of the SAMA region at low ionospheric altitudes and its structure and dynamics during geomagnetic perturbations

3.15 Scintillation Network Decision Aid (SCINDA)

Lead Scientist: *Dr. Keith Groves* (Boston College) **United States**

Objective: Study equatorial ionospheric disturbances to aid in the specification and prediction of communications degradation due to ionospheric scintillation in the earth's equatorial region

3.16 Space Environment Viewing and Analysis Network (SEVAN)

Lead Scientist: *Dr. Ashot Chilingarian* (Aragats) **Armenia**

Objective: To improve short and long-term forecasts of dangerous consequences of space storms

3.17 ULF/ELF/VLF network

Lead Scientist: *Prof. Colin Price* (Tel Aviv University) Israel

Objective: To monitor geomagnetic storms, ionospheric Alfvén resonances, and ULF pulsations

4. Secretariat: Solar Physics Laboratory, NASA/GSFC, Greenbelt, MD 20771, USA

4.1 Personnel:

Nat Gopalswamy (Executive Director), NASA/GSFC

Shing Fung (Director for Data Coordination) NASA/GSFC

George Maeda (ISWI Newsletter Editor), Kyushu University, Japan

Katya Georgieva and Mitko Danov (Web Service) Bulgarian Academy of Sciences

Sharafat Gadimova (UNOOSA), UN Liaison

ISWI workshops and ISWI schools will be run with support from Boston College (BC, contact: Pat Doherty) and Ikuze in Kyushu University (contact: Aki Yoshikawa). BC has been subcontracted to support the travel of US scientists to ISWI activities. BC may also raise additional funds from NSF and international organizations such as ICTP, COSPAR, and SCOSTEP.

5. Recent Activities:

The most recent ISW meeting was the United Nations/Japan Workshop on Space Weather: Science and Data Products from International Space Weather Initiative Instruments (Fukuoka, Japan, 2-6 March 2015)

The Workshop, which was organized in the framework of the Basic Space Science Initiative of the United Nations Program on Space Applications. The aim was to follow up on the achievements of the

International Heliophysical Year 2007 and ISWI and to maintain the capacity-building momentum established by these initiatives. The Workshop was also aimed at providing a global forum for space weather experts from developed and developing countries, including representatives of the major instrument operators and data providers, to discuss the latest results of space weather research, global observation, space weather data policy and use, and education on space weather, as well as to identify opportunities to expand ISWI activities, including from an operational point of view. There were three key outcomes of the Fukuoka Workshop.

5.1. Science: There were keynote talks, invited talks, and poster presentations involving science and applications of Space Weather. Selected papers were submitted to the online journal, “Sun and Geosphere” and after the review process, 14 papers have been published within 9 months after the workshop. The published papers are available online: <http://www.sungeosphere.org/>.

5.2. UN Report: Details on the deliberations of the Workshop have been published as A/AC.105/1096 by the United Nations Committee on Peaceful Uses of Outer Space (UNOPUOS) for the benefit of the international community. The report contains the observations and recommendations that are helpful in furthering the space weather agenda.

5.3. ISWI’s Open Data Policy: During the Workshop, there were three panel discussions on the data distribution and utility for space weather research and forecasting. The participants overwhelmingly supported the idea of open data policy and making the data from ISWI instruments available in real time. With NASA support, ISWI has initiated an effort to develop a mechanism to make the data available from as many networks as possible. The PIs of the ISWI instruments will benefit greatly if their data are used widely because they can participate in more collaborations or their data are widely acknowledged.

The ISWI Steering Committee established a subcommittee to deal with the data issues immediately after the Fukuoka meeting. The charter of the subcommittee is to develop a data policy and rules of the road for data usage. The members of the subcommittee are:

Shing Fung (Chair) shing.f.fung@nasa.gov

Christine Amory <christine.amory@lpp.polytechnique.fr>

Keith Groves <keith.groves@bc.edu>

Christian Monstein <monstein@astro.phys.ethz.ch>

Terry Onsager <Terry.Onsager@noaa.gov>

Babatunde Rabiou <tunderabiou@yahoo.com>

George Maeda <maeda@serc.kyushu-u.ac.jp>

Jesper Gjerloev <Jesper.Gjerloev@jhuapl.edu>

The data subcommittee submitted its report including the data policy, rules of the road, and recommendations to implement them. One of the major items in the ISWI Steering committee meeting on February 19, 2016 is to discuss this report, approve it, and implement the recommendations as soon as possible. The draft report is attached as Annexure I.

6. Future activities:

6.1. ISWI/SCOSTEP School: Following the successful International Space Science Schools held in Indonesia (2012), Kenya (2013), and Peru (2014), the next one will be held in Sangli in India during November 7-17, 2016. The School will be organized in collaboration with the Scientific Committee On Solar Terrestrial Physics (SCOSTEP) as in the past. In 2016, The Institute for Space-Earth Environmental Research (ISEE) of Nagoya University will cosponsor the School with substantial financial support. The

school will feature advanced training for PhD students and young scientists in the field of Solar Terrestrial Physics.

6.2. UN/ISWI Workshop: Following the successful Workshop in Fukukoka, the next workshop will be held in the United States in April 2017, adjacent to the Space Weather week in Boulder Colorado. The Workshop will be held under the auspices of the UN Office of Outer Space Affairs (UNOOSA) under the Basic Space Sciences initiative. Even though both IHY and ISWI have been initiated in, and supported by, the United States, no workshop was held there. This will be the first UN/ISWI workshop in the United States.

6.3 Data Infrastructure: Once the ISWI data policy and rules of the road are implemented, efforts will be made to develop infrastructure to support data distribution for those networks that are unable to provide data due to limitations on such facilities.

6.4 Outreach Activities: Two total solar eclipses will occur in the near future: On 9 March 2016 in Indonesia and 21 August 2017 in the United States. ISWI is planning outreach activities to explain how Sun affects life on Earth to the public.

Annexure I
International Space Weather Initiative (ISWI) Data Policy

Version 1.0 (Draft)

October 21, 2015

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Executive Summary

ISWI is a program of international cooperation. The success of ISWI depends on unrestricted flow of data across geo-political and organizational boundaries. In support of an open data environment, ISWI data must remain freely available, accessible and usable to all users. The ISWI data policy described below is a result that follows the recommendations from the UN/Japan Workshop on Space Weather: “Science and Data Products for ISWI Instruments” (held on 2-6 March, 2015, in Fukuoka, Japan) that the ISWI Steering Committee should address data sharing issues as a priority item. The policy describes the roles and responsibility of both data providers and users and the guidelines (rules of the road) by which all ISWI participants are expected to follow.

1. Preamble: Purpose, General ISWI Guidelines, Justification, and Scope

The purpose of this document is to establish the guidelines that govern the ISWI data access and distribution rights and protocol. Anyone who participates in the ISWI project or seeks to use ISWI instrument data understands that he or she must fully abide by the ISWI data policy and rules of the road as stipulated in this document.

A key goal of the ISWI project is to produce and disseminate high-quality data from its network of instruments (see sect. 2.2) to support research, operations, and education. Since space weather applications and heliophysics research in general often require an integration of data from many instrument platforms (ground-based and space-based), the success of ISWI depends on unfettered flow of data at all stages of data production, dissemination, and archiving, with a close collaboration between scientific and technical teams. The ISWI data policy is guided by two overarching principles:

1. Access to the data obtained under the auspices of ISWI should be open and freely available for the betterment of the world society. ISWI data will be made *independently usable* and *publicly accessible* as soon as practical; and
2. To encourage continued ISWI operations and availability of data, support of ISWI and efforts to produce and make ISWI data usable and accessible must be formally acknowledged. To that end, users of ISWI data are expected to follow the rules of the road and protocol described in Section 8 of this document.

Justification. Space weather analysis and modeling, for both research and operations, require the use of observations (data) to assess the potential impact of space weather events. Availability and accessibility of data are thus critical for continued operations of ISWI. Through international cooperation, ISWI can strengthen the capacity and resilience of data services by ensuring adequate observing infrastructure and global coordination, and that data requirements are met. The ISWI data policy will provide the guidelines and general protocol with which ISWI instrument data access, distribution and use are permitted under international space weather cooperation. Such cooperation will contribute to more efficient sharing of data, better coordination of observations, creation of an international space weather roadmap and framework, and the promotion of education and capacity building.

Scope. This ISWI data policy applies broadly to all ISWI participants and data users.

2. Roles and Responsibilities of ISWI Participants

2.1 ISWI Overview

ISWI is a program of international cooperation to advance the space weather science by a combination of instrument deployment, analysis and interpretation of space weather data from the deployed instruments in conjunction with space data, and communicate the results to the public and students. Information about ISWI can be found on the ISWI Secretariat website <<http://www.iswi-secretariat.org/>>.

The goal of the ISWI is to develop the scientific insight necessary to understand the science, and to reconstruct and forecast near-Earth space weather. This includes instrumentation, data analysis, modeling, education, training, and public outreach.

The oversight and operational components and their relationships are shown in **the ISWI organizational chart** in Figure 1. The ISWI data policy being described in this document serves to provide the guidelines that must be subscribed by each of the ISWI components and data users.

2.2 ISWI projects and instrument teams

ISWI program implementation is schematically represented in Figure 2. Program success clearly depends critically on having continuous (unfettered) data flow beginning from the instrument arrays to users.

- Instrumentation and data analysis
 - Expand existing instrument arrays
 - Deploy of new arrays
 - Expand data analysis effort for ISWI data and other relevant data bases
- Coordinate data products to provide input for physical modeling of the Sun-Earth System
 - Input instrument array data into physical models of heliophysics processes
 - Provide data products in a form useful for modelling
 - Enable Space Weather forecasting
- Promote Education, Training and Outreach
 - Encourage and support space science courses and curricula in Universities that provide instrument support
 - Develop public outreach materials unique to the ISWI, and coordinate the distribution

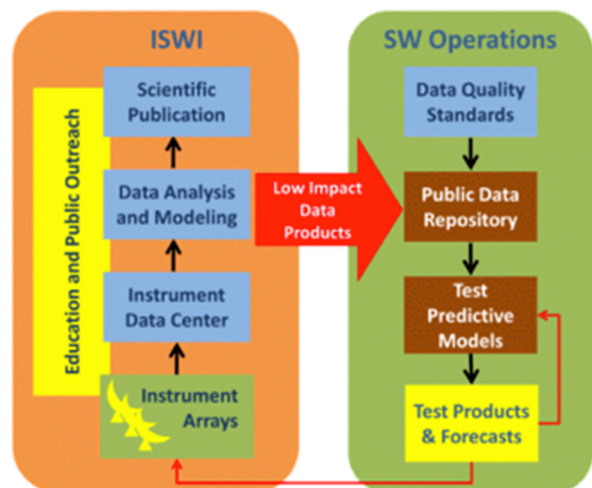


Figure 2. ISWI Implementation

There are currently 17 ISWI instrument teams. More specific information on various ISWI instrument teams can be found at <<http://newserver.stil.bas.bg/ISWI/pi-addr.html>>. In general, an ISWI instrument project functions with

- The lead scientist or principle investigator (funded by his/her country) providing the instrumentation (or fabrication plans) and data distribution
- The host country providing the workforce (host scientists, students, etc.), facilities, and operational support for the operation of an ISWI instrument project, typically at a local university.
- Host scientists becoming part of the instrument science team
- All data will be publicly shared and made accessible

ISWI teams are the generators and primary distributors of their instrument data. As data providers, they hold the key to the success of the ISWI. Due to time sensitivity of real-time data, the instrument team must also be responsible for making their real-time data available and readily accessible on near-real time basis. Data products for research and modeling purposes can be distributed from the instrument team's data facility, ISWI-designated data distribution centers, or relevant data archives.

Instrument teams' commitment to the ISWI success is important. To that end, all ISWI instrument teams shall do their best to secure the resources and support needed to provide their data at highest quality possible in terms of resolution, cadence, calibration, usability, availability, and continual accessibility. Data products to be made available to users by ISWI instruments should be specified and described in the instrument project data management plans (PDMP) included in Appendix A of this ISWI data policy.

New instrument arrays are welcome. Proposals for new instrument array should be submitted to the ISWI Executive Director <<http://www.iswi-secretariat.org/>>.

2.3 ISWI data archives and distributors

Raw data taken by an ISWI instrument is sent to the instrument's data center or facility for processing and data products generation, as indicated in Figure 2. Data processing facility here refers to a step in the data product generation pipeline rather than a specific location, so the facility can be distributed between instrument sites and any dedicated data distribution centers. For distribution of real-time data, the data processing facility should be located at/near the instrument site to minimize the delay in data distribution. Data products that are suitable for retrospective analysis or modeling, including real-time products that are suitable for space weather models development, should be adequately documented and distributed freely without unnecessary delay. The responsible instrument team should also submit the data and associated products to an ISWI-designated data distribution site for further dissemination and archiving.

[Note: ISWI needs to identify some viable options/solutions for permanent data archives.]

2.4 ISWI data users

The primary goal of ISWI is to collect and provide relevant observations to support space weather research and operations. With the necessary data and infrastructure support, ISWI instrument data can be accessed by worldwide users: scientists, operational facility, students, and the public to gain

understanding of the of space weather and increase awareness and appreciation of the impact of space weather on life on Earth.

2.5 ISWI community

ISWI is a program of international cooperation to support space weather science and operations so as to improve life on Earth. The success of ISWI depends on the collaboration of many individuals and teams, and the cooperation between different countries. For the purposes of this policy, the ISWI community refers to (1) the ISWI instrument teams that are responsible for developing, deploying and operating the instruments, and (2) the ISWI data users. **Under the auspices of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), the ISWI Steering Committee has the oversight responsibility for the maintenance of this data policy. By virtue of utilizing any ISWI infrastructures and resources, all ISWI participants have agreed explicitly or implicitly to adhere to this policy.**

3. ISWI Policy on the Exchange of Data and Related Products

All data and associated documentations and tools produced under the auspices of ISWI should be made freely and readily accessible to worldwide users. As such, there should be no restriction on data and knowledge exchange between ISWI participants, provided acknowledgments about the sources are explicitly given in the work and products being produced by the users. **Protocols for acknowledgments are stipulated in the ISWI Rules of the Road in Section 8 below.**

4. Data Standards: Formats and Metadata Model

To facilitate data exchange and utilization, all ISWI data products and tools should be properly documented, described and stored in *standard formats*. The use of standards means that the customization of tools and interfaces for data access and exchange can be minimized. Data formats commonly used for space and Earth science data are: [CDF](#), [HDF](#), [netCDF](#), [FITS](#), and ASCII. While some data formats (e.g., CDF) are self-documenting and self-describing, it is also useful for the metadata of the ISWI data products to conform to standard metadata models, such as the Space Physics Archive, Search and Extract (SPASE) metadata model (see Appendix B). Using standard metadata dictionary and protocol will facilitate the ISWI data to be searched and accessed by existing heliophysics data systems, such as NASA's heliophysics virtual observatories (VxOs) (see Appendix C), leveraging those existing infrastructure to help disseminate the ISWI data.

5. Data Archiving

The data products available from each ISWI instrument are generally described in Appendix A and on the instrument websites. There are generally two types of ISWI instrument data products: real-time, or near real-time, data and retrospective data. Real-time (near-real time) data are produced primarily for satisfying operational needs, such as space weather forecasting or nowcasting; whereas retrospective data are used primarily for research or modeling purposes. Real-time data, if suitably adapted, can also be used for research purposes. When properly processed, documented, organized, stored and maintained, the scientific value and usability of the ISWI data are preserved. When made freely available and accessible, worldwide users will be able to use the data in endeavors (e.g., research and capacity building efforts) that cause positive societal impact. Archiving is thus important to ensure the long-term utility of ISWI instrument data.

Since ISWI is an international collaborative project, through the working of the cognizant instrument science team members, the country in which an ISWI instrument is located and operates should be substantially responsible for ensuring the data generated in their country are delivered for archiving. The final archiving location, which may change as necessary, should be specified and updated in the instrument's PDMP included in Appendix A of this policy.

6. Data Distribution and Accessibility

ISWI instrument data are useful only if they are accessible to and usable by users. The most efficient way to disseminate ISWI data is for users to access the data directly from data access portals over the internet. This implies that data distribution centers, such as data archives or instrument institutions, must provide adequate data services in order to ensure the success of ISWI. In addition, instruments that produce real-time data must have the necessary infrastructure to broadcast their real-time data products, and archive those data, if needed, for retrospective analysis. The methods by which each ISWI instrument will disseminate their data products are described in the instrument PDMP's in Appendix A.

7. ISWI Data Management Policy Review and Revision

Keeping ISWI data unrestricted with free electronic access is key to the success of ISWI. The ISWI data policy serves to provide the guidelines to which all ISWI participants should adhere with regard to the management, distribution and use of ISWI data (see Rules of the Road below). Due to changes in the world's geopolitical and economic landscapes and the disparities in technological capacity among member states and instrument teams, an ISWI Data Working Group should be established to assist the ISWI Steering Committee to ensure that the policy is being followed.

8. Rules of the Road for ISWI Data Use and Acknowledgments

ISWI participants should confirm their commitment to the ISWI data policy by providing free and unrestricted access to ISWI data and products, and using the data responsibly. In particular, all ISWI participants agree:

(1) To provide on a free and unrestricted basis essential data and products for the provision of services in support of the protection of life and property, and the well being of all nations, particularly those data and products required to describe, understand, and forecast space weather;

(2) To provide the data and products which may be required to sustain the ISWI Program at the global, regional, national and international levels and to assist other ISWI Members in their fulfillment of their ISWI responsibilities in their countries.

(3) To provide free, unrestricted electronic access to all ISWI data and products to the research and education communities, for their non-commercial activities.

(4) To acknowledge relevant ISWI instrument teams, PI and/or science team members, for providing the data and any assistance for using the data. The following standard acknowledgment should be included in any formal and informal publications, presentations, and communications.

“We gratefully acknowledge that the data used in this paper/presentation/communication has been generously provided by the ISWI XXX Team <www.ISWI_TeamWebsite>.”

(5) To include relevant ISWI instrument PI/team members as co-authors on any formal or informal communications, unless the co-authorship is declined by the team personnel.

Appendix A: ISWI Project Data Management Plans

This Appendix is an integral part of the ISWI data policy. It provides information about all the recognized ISWI instruments, their data products, and their methodology for data archiving and dissemination in accordance to the ISWI data policy.

1. African Dual Frequency GPS Network (AMMA- PI **Olivier Bock**)
Lead Scientist: *Dr. Christine Amory-Mazaudier* (LPP&UPMC) **France**
Objective: To increase the number of real-time dual-frequency GPS stations worldwide for the study of ionospheric variability, response of the ionospheric total electron content (TEC) during geomagnetic storms over the African sector.
(read [more](#))
2. African Meridian B-field Education and Research (AMBER)
Lead Scientist: *Lead Scientist: Dr. Endawoke Yizengaw* (Boston College) and *Dr. Mark Moldwin* (University of Michigan) **United States**
Objective: Understand low latitude electrodynamic, ULF pulsations, effect of Pc5 ULF on MeV electron population in inner radiation belts
(read [more](#))
3. Atmospheric Weather Education System for Observation and Modeling of Effects (AWESOME) and SID (Sudden Ionospheric Disturbance Monitor)
Lead Scientist: *Dr. Umran S. Inan, Dr. Morris Cohen and Dr. Deborah Scherrer* (Stanford) **United States**
Objective: Lightning, sprites, Elves, relation to terrestrial Gamma Ray flashes , whistler induced electron precipitation, conjugate studies
(read [more](#))
4. Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO)
Lead Scientist: *Mr. Christian Andreas Monstein* (ETHZ) **Switzerland**
Objective: Study the magnetic activity of a wide range of astrophysical objects with emphasis on the Sun and cool stars
(read [more](#))
5. Continuous H-alpha Imaging Network (CHAIN)
Lead Scientist: *Dr. Kazunari Shibata and Dr. Satoru UeNo* (Kyoto U) **Japan**
Objective: Solar activity, flares, filaments, filament eruptions
(read [more](#))
6. Coherent Ionospheric Doppler Receivers (CIDR)
Lead Scientist: *Prof. Ayman Mahrous* (Helwan University, Egypt) and *Dr. Trevor W. Garner*(U Tex) **United States**
Objective: To tomographically reconstruct the ionosphere and to provide input to Data

- Assimilation models
(read [more](#))
7. Global Ionosphere Flare Detection System (GIFDS)
Lead Scientist: *Dr. Norbert Jakowski* and *Daniela Wenzel* (German Aerospace Center) **Germany**
Objective: To issue warnings for mitigating space weather impact on sensitive technologies
(read [more](#))
 8. Global Muon Detector Network (GMDN)
Lead Scientist: *Dr. Kazuoki Munakata* (Shinsu U) **Japan**
Objective: 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 coronal mass ejection
(read [more](#))
 9. Low-latitude Ionosphere Sensor Network (LISN)
Lead Scientist: *Dr. Cesar Valladeres* (Boston College) **United States**
Objective: To monitor and specify the conditions of the equatorial and low-latitude ionosphere over South America
(read [more](#))
 10. Magnetic Data Acquisition System (MAGDAS)
Lead Scientist: *Dr. Kiyohumi Yumoto* and *Dr. Akimasa Yoshikawa* (Kyushu U) **Japan**
Objective: Study of dynamics of geospace plasma changes during magnetic storms and auroral substorms, the electromagnetic response of iono-magnetosphere to various solar wind changes, and the penetration and propagation mechanisms of DP2-ULF range disturbances
(read [more](#))
 11. Optical Mesosphere Thermosphere Imager (OMTIs)
Lead Scientist: *Dr. Kazuo Shiokawa* (Nagoya U) **Japan**
Objective: Dynamics of the upper atmosphere through nocturnal airglow emissions
(read [more](#))
 12. Remote Equatorial Nighttime Observatory for Ionospheric Regions (RENOIR)
Lead Scientist: *Dr. Jonathan J. Makela* (U Illinois) **United States**
Objective: Study the equatorial/low-latitude ionosphere/thermosphere system, its response to storms, and the irregularities that can be present on a daily basis
(read [more](#))
 13. Solar Flares detected by Ionospheric Effects (SOFIE)
Lead Scientist: *Dr. Norbert Jakowski* (Institute of Communications and Navigation and the School-Lab at DLR Neustrelitz) **Germany**
Objective: To detect solar radio bursts (solar flares) by measuring continuously the intensity of VLF radio signals considering ionospheric propagation effects on radio waves (read [more](#))

 14. South America Very Low frequency Network (SAVNET)
Lead Scientist: *Dr. Jean-Pierre Raulin* (U Presbiteriana) **Brazil**
Objective: Study of the SAMA region at low ionospheric altitudes and its structure and dynamics during geomagnetic perturbations (read [more](#))
 15. Scintillation Network Decision Aid (**SCINDA**)
Lead Scientist: *Dr. Keith Groves* (Hanscom AFRL) **United States**
Objective: Study equatorial ionospheric disturbances to aid in the specification and prediction of communications degradation due to ionospheric scintillation in the earth's equatorial region
(read [more](#))

16. Space Environment Viewing and Analysis Network (SEVAN)
Lead Scientist: *Dr. Ashot Chilingarian* (Aragats) **Armenia**
Objective: To improve short and long-term forecasts of dangerous consequences of space storms (read [more](#))
17. ULF/ELF/VLF network
Lead Scientist: *Prof. Colin Price* (Tel Aviv University) **Israel**
Objective: To monitor geomagnetic storms, ionospheric Alfvén resonances, and ULF pulsations (read [more](#))

Appendix B: Space Physics Archive Search and Extract (SPASE) Metadata Model

Standard metadata model can help reduce the complexity of the software tools with which we use to locate and query databases in order to search and retrieve the data we need for research and analysis. It would be much simpler for users to use the same data querying tools to access multi-disciplinary datasets that may be stored at different locations. Through the collaboration of the international Heliophysics community, the Space Physics Archive Search and Extract (SPASE) model has been developed with the goals of:

- Facilitating data search and retrieval across the Space and Solar Physics data environment with a common metadata language
- Defining and maintaining a standard Data Model for Space and Solar Physics interoperability, especially within the Heliophysics Data Environment
- Using the Data Model to create data set descriptions for all the important Heliophysics data sets.
- Providing tools and services to assist SPASE data set description creators as well as the researchers/users
- Working with other groups for other Heliophysics data management and services coordination as needed

The SPASE effort is implemented by the SPASE Consortium <www.spase-group.org> that consists of representatives of the international Heliophysics data community. The SPASE Consortium is currently the only international group supporting global data management for Solar and Space Physics.

Appendix C: Virtual Observatory Framework

The concept of virtual observatory was developed originally by the astronomy and astrophysics community. They recognized that published records (e.g., different types of observations) on the same astronomical object could be collected, reorganized, and served electronically to provide new insight about the object. The collected information would appear as if it were new observations on the object. The facility that provides such data services is called a virtual observatory (VO). Subsequently, the NASA Heliophysics community borrowed the term and developed various discipline-oriented virtual observatories (VxOs, with “x” representing a Heliophysics sub-discipline, see

<http://hpde.gsfc.nasa.gov/hpde_data_access.html >). The VxOs have mostly, though not uniformly, adopted SPASE (see Appendix B) as the standard metadata model. A common goal of the VxOs, however, is to provide access to data sources that are geographically distributed rather than centralized at a given data archive. The VxO data distribution model, when suitably adapted and implemented, may be effective for distributing ISWI instrument data.