International Space Weather Initiative (ISWI) Data Policy

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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 should 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 should 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 should 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.

Figure 1. ISWI Organizational structure

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 should 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
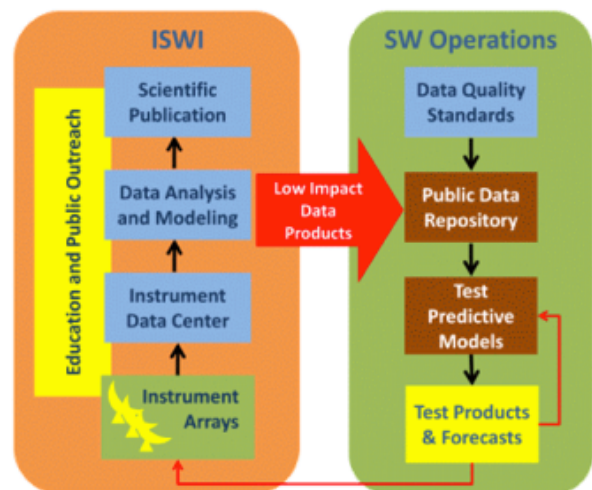
Figure 2. ISWI Implementation

- o Input instrument array data into physical models of heliophysics processes
- o Provide data products in a form useful for modelling
- o Enable Space Weather forecasting
- Promote Education, Training and Outreach
  - o Encourage and support space science courses and curricula in Universities that provide instrument support
  - o Develop public outreach materials unique to the ISWI, and coordinate the distribution

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*>[this page shows only 15 instruments]. 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 should 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 instruments 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, should provide adequate data services in order to ensure the success of ISWI. In addition, instruments that produce real-time data should 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 and data users 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 freely without cost and restriction 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. In the absence of instrument-specific language of acknowledgments from the pertinent instrument PDMPs (see Appendix A), 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 inform the relevant ISWI instrument PI/team members about the preparation of a potential publication or presentation involving the use of their instrument data, solicit their concurrence regarding the proper use of the data, and offer co-authorship on any formal or informal communications prior to submission or presentation. The relevant ISWI instrument PI/team members shall have the right to decline co-authorship.

Appendix A: ISWI Instrument Data Management Plans

This Appendix is a part of the data policy of the ISWI project. It provides the plans by which all ISWI instrument teams manage the data and metadata generated by their instruments. It describes how the teams will handle and process the data from the point when the data have been taken by the instrument. The plans will also describe the various data products to be produced by the instruments. The goal of a data management plan is to describe and explain the many aspects of data management, metadata generation, and data preservation, so that data users will have understanding of how they may access and use the data products produced by the instrument. The plan ensures that data are well-managed in the present, and are prepared for preservation and use in the future.

A data management plan defines and describes all the data products to be produced from the instrument. It also describes the data format, parameter organization, processing procedures, and other information needed to understand and use the instrument data. The plan should also document the development of different versions of the data so details about how a given data product came about can be traced. Well-documented data will

ensure understandability of the data, which is important for ensuring proper use of the data by both data collectors and researchers worldwide.

Another component of data management is the data archiving plan. Long-term data can be used for model construction and trend analysis. Data that are documented and preserved have the potential to lead to new, unanticipated discoveries. Archiving of data at dedicated data storage facilities also provides insurance against loss of the data.

For understanding of the instrument data, each data product should have clear and complete descriptions (metadata). Metadata, commonly referred to as "data about data", are the contextual details about the data, including any information important for the correct use of the data. This may include descriptions of instrument setup, operational details, measured parameters, temporal and spatial performance characteristics, units, files, caveats, etc. The metadata for the data products from each ISWI instrument may consist of three parts:
(1) Descriptive metadata that provides high-level instrument and contact information,
(2) Structural metadata that documents the relationships within and among data resource objects or terms; and
(3) Administrative metadata that helps manage and distribute information resources through elements such as version number, archiving date, and other technical information for purposes of file management, rights management and preservation.

Instrument Name: The Atmospheric Electric Field Network in South America (AFINSA)

Part 1: Instrument and personnel information

- **Current PI:** Dr. Jean-Pierre Raulin (raulin@craam.mackenzie.br)
- **Other responsible personnel:** M.Sc. José Carlos Tacza Anaya (josect1986@gmail.com)
- **Instrument Website:** https://theafinsa.wordpress.com/
- **Instrument Information:**

  - **Science and measurement objectives:**

    ➢ The main objective is to obtain a daily variation curve of the atmospheric electric field (**AEF**) under fair weather conditions (standard curve) based on means on different time scales, such as monthly, seasonal and annual.
    ➢ To characterize deviations from the standard curves in relation to the occurrence of external phenomena such as solar events (flares, proton events), geomagnetic storms, solar eclipse and seismic activity.
    ➢ Characterization and interpretation of the variations of the **AEF** along with increases in cosmic ray count, in order to understand if the former could be effective in accelerating secondary cosmic particles.
    ➢ To infer a possible causal relation between monthly means of daily variation of the fair weather **AEF** and monthly averages of the occurrence of lightning.

  - **Instrument descriptions**

  Each sensor consists of a commercially manufactured (Boltek Corporation EFM100-1000120-050205) electric field mill (**EFM**).
  The EFM senses electric field by repeated exposing and shielding a series of sense electrodes. An EFM uses a mechanical chopper to alternately shield and expose several sense plates to an electric field. When the sense plates are exposed to the electric field an electric charge is drawn from ground to the plates through a sense resistor. When the sense plates are shielded from the field the charge flows back to ground, again through the sense resistor. This moving charge is an electric current which is measured as an AC voltage across the sense resistor. The size of the voltage is proportional to the size of the electric field applied to the plates. Charge flowing onto and off of the sense electrodes will develop a voltage across the sense resistor. This voltage is amplified and fed into an analog switch along with an out of phase version of the signal.

  - **Instrument performance specifications**

Electric Field Range	-20 kV/m to + 20 kV/m
Response Time	0,1 s

Resolution	0,01 kV/m
RS 232	9600 baud, 8 bits, 1 stop bit, no parity
DC / AC Power Supply	12 VDC, 0,5 A / 120 VAC, 60 Hz
Dimensions	17 cm diameter x 13 cm altitude
EFM Weight	1 kg

- **Key/representative publications or references**

Rycroft, M. J., Harrison, R. G., Nicoll, K. A. and Mareev, E. A. An overview of Earth's global electric circuit and atmospheric conductivity. Space Science Reviews, 137 (1-4). 83-105. ISSN 0038-6308 DOI:10.1007/s11214-008-9368-6, 2008.
Harrison,R.G. The Carnegie Curve. Surveys in Geophysics, 34, 2, 209-232. DOI:10.1007/s10712-012-9210-2, 2013.
Tacza, J.C., Raulin, J.-P., Macotela, E.L., Norabuena, E., Fernandez, G., Correia, E., Rycroft, M.J., Harrison, R.G. A new South American network to study the atmospheric electric field and its variations related to geophysical phenomena. J. Atmos. Sol. Terr. Phys. 120, 70–79, 2014.

- **Instrument locations**

Station	Latitude (°)	Longitude (°)	Height (m)
CAS	-31,799	-69,297	2480
SAV	-31,800	-69,293	2480
ICA	-14,089	-75,736	402
PLO	-12,504	-76,798	85
ROR	2,87	-60,71	78
HUA	-12.042	-75.32	3350
CGR	-7.209	-35.915	550

- **Station data availability intervals at this time**

  ➢ CAS: 12/01/2008 – 31/12/2013*
  ➢ SAV: 01/01/2010 – 31/12/2013*
  ➢ PLO: 11/11/2011 – 31/01/2013*
  ➢ ICA: 19/12/2011 – 29/05/2013*

*More recent data will be distributed in near future

Part 2: Data and Format
2.1 Measurements and data products
- **Measured parameters**

  - ➢ The measured parameter is the atmospheric electric field (AEF).
  - ➢ The unit of the measure is kV/m.
  - ➢ The temporal resolution of the recorded data is 2 Hz.
  - ➢ The recorded electric field values (EFM) need to be corrected by the height factor, using the following equation:

    Value Corrected = (EFM-c)/m

    The values m and c (kV/m), for each of the stations are:

    CAS: m: 9.8774809 c: 0.29986058
    SAV: m: 7.3559111 c: -0.094422940
    PLO: m: 5,4118941 c: 0,28464718
    ICA: m: 4,8953412 c: -0,083670597

- **Data quality and caveats**

The recorded electric field values need to be corrected by the height factor as explained above.

2.2 Data file format and metadata
- ➢ The files are in Interactive Data Language (IDL) EFMSC-XXXYYYMMDD.save format. XXX stands for the station (i.e. CAS), YYYMMDD is the date. Data are compressed within monthly directory
- ➢ Each file has the following variables

  T_EFM: Time (millisecond) since 00 UT (dblarr format)
  EFM: Electric field values (kV/m) (dblarr format)
  DI: Initial day and Time (strarr format)
  DF: Final day and Time (strarr format)

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management
- ➢ The data are freely available for download at https://theafinsa.wordpress.com/
- ➢ Data do not require re-processing.
- ➢ The person responsible for the archived data is Msc. José Tacza (josect1986@gmail.com)

3.2 Data distribution plan
- ➢ The data is freely available as explained above. Update of the data availability in the near future for CAS, SAV, PLO, ICA stations. Soon, data from the new sensors ROR, HUA, CGR will be also available.
- ➢

Instrument Name: African Dual Frequency GPS Network (AMMA)

PDMP to be furnished

Instrument Name: African Meridian B-field Education and Research (AMBER)

Part 1: Instrument and personnel information

- Current PI and contact info: Endawoke Yizengaw, The Aerospace Corporation, endawoke.yizengaw@aero.org
- Other responsible personnel and contact info (e.g., instrument scientist/manager, if different from PI)Instrument website: http://magnetometers.bc.edu/index.php/amber2 Instrument information: Magnetometer Science and measurement objectives: *To filling the largest land-based gap in global magnetometer coverage, the AMBER array will address two fundamental areas of space physics: (1) the processes governing electrodynamics of the equatorial ionosphere as a function of latitude (or L-shell), local time, longitude, magnetic activity, and season, and (2) ULF pulsation strength and its connection with equatorial electrojet strength at low/mid-latitude regions.*
    - Instrument descriptions: Fluxgate magnetometer
    - Instrument performance specifications: Sampling rate of 2Hz and sensitivity of 0.01nTKey/representative publications or references: Yizengaw, E., and M. B. Moldwin (2009), African Meridian B-field Education and Research (AMBER) Array, *Earth MoonPlanet,104(1), 237-246, doi:10.1007/s11038-008-9287-2.*Instrument locations (longitudes and latitudes) and local points of contact (name, title, mailing and email addresses) [If it is more convenient to do so, this information can be provided in a separate document linked to the PDMP.]: Detail information about this can be found here http://magnetometers.bc.edu/index.php/people
    - Station data availability intervals: Most of the stations are realtime

Part 2: Data and format
2.1 Measurements and data products

- Measured parameters and data products
    - How will the measured parameters be acquired or recorded?
        - Units? Temporal & spatial resolutions?: in nT and 0.5sec temporal resolution.
    - How will physical parameters be derived from measured parameters?
        - Units? Temporal & spatial resolutions?
    - Processing and calibration procedures: Data transferred to from the site in binary format and it will be processed and calibrated and become available to the community in ASCII format.
    - Coordinate systems, software, and models used? Both geographic and geomagnetic coordinates are used. IDL software is used. Quality assurance & quality control measures: Quality control code is included in the calibrated data (detail can be found here http://magnetometers.bc.edu/index.php/dataformat)

- Definitions and descriptions of higher-level instrument data products
    - Numerical: Daily numerical data in ASCII format.
    - Graphical: Daily summary plots
- Real-time space weather data products
    - Product descriptions: geomagnetic field data
    - Method of acquisition and processing: Most of them realtime
    - Data format: Calibrated data format in ASCII
    - Storage, distribution and access methods: Data is accessible online
- Data quality and caveats

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?: ASCII
- Organization and range of data/parameters in data files?: Daily
- Information on how metadata will be provided with the data?: Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.: http://magnetometers.bc.edu/

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management
How and where will instrument data be stored and managed long-term?:
http://magnetometers.bc.edu/

- Data re-processing requirements and version control: none
- Data back up plan: Through SuperMAG
- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data): Endawoke Yizengaw (endawoke.yizengaw@aero.org)

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?: AMBER data is already open access

3.3 Policies for data access and sharing
    All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Instrument name: Atmospheric Weather Electromagnetic System for Observation Modeling and Education (AWESOME)

Part 1: Instrument and personnel information

Prof Morris Cohen
School of Electrical and Computer Engineering
Georgia Institute of Technology
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http://LF.gatech.edu and http://WALDO.world

AWESOME conducts broadband and narrowband capture of the VLF/LF (0.5-470 kHz) radio environment. The instrument consists of two orthogonal air-core loop antennas, sensitive to the magnetic field, typically in the two horizontal directions, but the vertical electric or magnetic field can be recorded as an option. System records broadband data that includes the entire spectrum 0.5-470 kHz, with 1 MHz sampling rate, 16-bits of dynamic range. Sensitivity is as low as 0.03 fT/rt-Hz. Timing accuracy is 15-20 ns. System also provides the amplitude and phase of select frequencies corresponding to radio stations in this frequency band.

Sources of VLF/LF waves are predominantly lightning-generated radio atmospherics, and a small number of VLF/LF radio stations. VLF/LF waves travel to global distances in the Earth-ionosphere waveguide, bounded by the ground and the D-region ionosphere (60-90 k, altitude). Some VLF/LF energy also escapes into the space environment, impacting space weather and radiation belt electrons.

Scientific uses include global lightning detection, characterization and geolocation, D-region ionospheric remote sensing, detection and characterization of lightning-induced electron precipitation, detection of natural magnetospheric emissions like chorus, hiss, and whistlers.

The instrument was originally designed and built at Stanford University, then transferred to Georgia Tech and upgraded A detailed instrument description can be found in these two papers:

Cohen M. B., R. K. Said, E. W. Paschal, J. C. McCormick, N. C. Gross, L. Thompson, U. S. Inan, J. C. Chang (2018), Broadband Longwave Remote Sensing Instrumentation, *Reviews of Scientific Instruments*, 89, 094501

Cohen M. B., U. S. Inan, and E. W. Paschal (2010), Sensitive Broadband ELF/VLF Radio Reception with the AWESOME Instrument, *IEEE Transactions on Geoscience and Remote Sensing*, 48, 1, 3-16, doi:10.1109/TGRS.2009.2028331

Part 2: Data and format
2.1 Measurements and data products

There are two primary types of data that will be collected. Narrowband data are the amplitude and phase of specific transmitter frequencies received at a given location. This dataset is modest, on the order of 100 MB per day per site, and can be fairly easily transmitted from remote field sites over the internet. This data can be archived continuously.

Broadband data are complete 1 MHz samples of the data, with 16-bit accuracy on two antenna channels, amounting to 350 GB per site per day (LF). It is difficult to store this amount of data continuously. Data will instead be archived in `synoptic' form, with snippets every 15 minutes saved. Continuous data are kept by the software and then automatically deleted at the local site after 7-10 days, so for special events like a solar eclipse, we will be able to save all he continuous broadband data.

Data are saved in an arbitrary/uncalibrated format. However, conversion to magnetic flux density units (typically picoTeslas) is possible by calibrating the receiver. This is done by recording data while a special signal is injected at the front end.

The data are saved in a Matlab v4 format, which can be easily read in Matlab. The format consists of a header with basic information, followed by the data itself. Matlab v4 is an easy format. The specific format is detailed below, so that it is machine-readable in any digital application.

2.2 Data file format and metadata

Narrowband data file naming convention:

XXYYMMDDHHMMSSZZZ_ACCT.mat

XX – Station ID
YY – Year
MM — Month
DD — Day
HH — Hour
MM — Minute
SS — Second
ZZZ — Transmitter Callsign
A — Not relevant
CC — 00 for N/S channel, 01 for E/W channel
T — Type of data
      A is low resolution (1 Hz sampling rate) amplitude

B is low resolution (1 Hz sampling rate) phase
C is high resolution (50 Hz sampling rate) amplitude
D is high resolution (50 Hz sampling rate) phase
F is high resolution (50 Hz sampling rate) effective group delay

Broadband data file naming convention:

XXYYMMDDHHMMSS_ACC.mat
XX – Station ID
YY – Year
MM — Month
DD — Day
HH — Hour
MM — Minute
SS — Second
A — 0 for 100 kHz sampled data, 1 for 1 MHz sampled data.
CC — 00 for N/S channel, 01 for E/W channel

Description of data file format

The file format for the AWESOME LF receiver is very similar to the Matlab v4 format. {\bf Data files can therefore be directly loaded into Matlab with the load comment}. The only difference is that the Matlab v4 format normally does not allow int16s when the user directly saves from Matlab, but broadband data are nonetheless saved as in16s. The files can be loaded directly into Matlab, however if the file size is larger than ~100 MB, Matlab cannot read it in. For these cases, the user can use the matGetVariable.m function (and also need matReadHeader.m), which allow the user to extract specific variables from the file, or a specific portion of the data (and it may be quicker than loading the whole file, anyways).

matGetVariable is used like this:
Output = matGetVariable('C:\PathToFile\Filename.mat','variable name',length,offset);

Which will load the variable 'variable name' from the file, skipping the number of samples given by offset, and a length given by offset. To extract the entire variable, run it like this:

Output = matGetVariable('C:\PathToFile\Filename.mat','variable name');

The list of variables is below.

The file format can also be read into other programs if needed, as the format is fairly simple. The files consist of a series of variable in order. The last variable is the actual data. The list of variables, in order, is:

  start_year
  start_month
  start_day

start_hour
start_minute
start_second
latitude
longitude
altitude
Fs
gps_quality
adc_channel_number
adc_sn
adc_type
antenna_bearings
antenna_description
cal_factor
computer_sn
gps_sn
hardware_description
is_broadband
station_description
station_name
VERSION
is_amp
is_msk
Fc
call_sign
filter_taps
data

NOTE: The five variables is_amp, is_msk, Fc, call_sign, and filter_taps are only present in narrowband data. Fs is the sampling rate of the data, usually 100 kHz or 1 MHz. Fc is the center frequency of the VLF transmitter (for narrowband data).

Times are given in UT, frequencies in Hz.

Variables (apart from broadband data) are stored either as unsigned character strings or doubles, depending on what the variable is. Far instance, hardware-description is a character string, but Fs (the sampling rate) is a double.

Broadband data are saved as int16. Narrowband data are saved as doubles.

Each variable is specified as follows:

1. An int32 that says the type of data stored. 0 for double, 10 for single, 30 for int16, 50 for uchar
2. An int32 that gives the length of the variable

3. An int32 that gives the number of columns (set to 1, as all data is assumed to be just one long column)
4. An int32 set to 0 to indicate that variable is NOT a complex number
5. An int32 that gives the length of the NAME of the variable
6. The variable name stored as a character string
7. An empty character (0 in ascii)
8. The variable, stored in the format specified in #1

Python tools

A set of useful tools has been curated into a python library, made publicly available at https://lf.readthedocs.io/en/latest/

Sample MATLAB scripts

On the repository, WALDO, described below, a set of Matlab scripts are provided for the purpose of quickly plotting/analyzing large amounts of data for easy viewing. These items are provided as is, and the hope is that users may find any one of them useful enough, and you can use it as a base to build your own data analysis tools. If a user do not have access to Matlab, there is a free open-source program can Octave with replicates many of its functions.

Please also note that the detailed format of the data is described in the "format" page, and reading in the data is very simple and can be done in other languages, too.

To get started, the user should move all the files in the package to the work directory underneath the Matlab folder. From Matlab, a user can run one of scripts for data analysis, by simply typing its name into Matlab (the other files in the package are just supporting scripts for the five main ones):

- vlf_spec: Used to make a plot and spectrogram of a single segment of time, 30 seconds or less in length.narrowqplot – intended to make a single amplitude/phase plot from a single pair of amplitude/phase data files
- makespectrograms: Used to take a longer file of data and create a bunch of two-channel spectrograms of each piece of the data, and saving each spectrogram to a jpeg
- makenarrowplots: Used to take a long narrowband file and create a bunch of plots of each piece of the data, and saving each plot to a jpeg.
- soundiscool: Used to create a .wav sound file from a piece of broadband data
- MapMaker: Used to visualize locations of VLF transmitters, receivers, and great circle paths
- matGetVariable.m: Lower-level scrips used to extract a selected variable from a data file. See the "Format" page for details on its usage and the variables available in each file. The user also needs the matReadHeader.m file to use it.

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management

All data will be made available to colleagues and to the public, as well, in keeping with recent OSTP policies on data sharing and broad availability. The PI is committed to free and open publication of results and data resulting from this program. The PI previously served as a AAAS Science Policy Fellow at the NSF (ENG/ECCS), where among his projects was work on expanding public access to research results, namely publications and data, in support of the Office of Science and Technology Policy's Memorandum on Open Access dated February 22, 2013.

All broadband data, both synoptic and continuous, are transferred to a hard drive and mailed to Georgia Tech as they fill. Narrowband data are sent over an internet link to a Georgia Tech server. These data will be archived on a large 150 TB server with RAID backup.

After a nominal period, data are then transferred to a public repository hosted on a Google Drive that does not have a storage limit and already runs in the many 100s of TB. The cost of this repository is currently supported on an ongoing basis by ongoing NSF grants.

The datasets have the following DOIs associated with them. The first one is VLF and LF data from more recent times (2000 and later). The second one has VLF data from the Siple Station experiments in the 1970s and 1980s. The third one is narrowband data from more recent time (2000 and later).

Cohen, M. B. (2020). AWESOME receiver system broadband VLF/LF data [Data set]. Worldwide Archive of Low frequency Data and Observations (WALDO). https://doi.org/10.48322/fwte-dv13

Inan, U. S., Cohen, M. B., & and Golkowski, M. A. (2020). AWESOME receiver system broadband VLF data [Data set]. Worldwide Archive of Low frequency Data and Observations (WALDO). https://doi.org/10.48322/fzcf-f191

Cohen, M. B., Inan, U. S., & and Golkowski, M. A. (2020). AWESOME receiver system narrowband VLF data [Data set]. Worldwide Archive of Low frequency Data and Observations (WALDO). https://doi.org/10.48322/6t7b-s324

3.2 Data distribution plan

All data can be directly accessed and downloaded at http://WALDO.world, where WALDO is known as the World Archive of Low-frequency Data and Observations. WALDO was announced and described in the following *Eos* article:

Morris Cohen (2020), Returning lightning data to the cloud, *Eos, 101*, http://doi.org/10.1029/2020EO142801

WALDO is a joint effort between Georgia Tech and CU-Denver, using data collected by Stanford University from the 1970s until 2016, and then by both Georgia Tech and CU-Denver starting in 2014.

These data will include many valuable recordings, amongst them

- Antarctic recordings at Palmer Station and South Pole over decades
- Siple Station Antarctica experiment recordings from 1974-1986
- Alaska VLF recordings in conjunction with HAARP experiments
- VLF/LF Data from the 2017 Great American Solar Eclipse
- Narrowband data from global IHY/ISWI/AWESOME receivers
- VLF recordings preceding the 2011 Tohoku M9.0 earthquake

Our hope is for the broader community to think of new ways to analyze these datasets that have not been previously considered.

With the menus on the WALDO website, any user can directly access all the raw data, including (1) Broadband VLF data, (2) Broadband LF data, (3) Narrowband data. Quick-look summary plots are available if desired. The "What's available?" link allows a user to see maps calendars, and charts showing what data is currently on WALDO. Users can navigate a large folder directly and download files either one at a time, or a whole folder at a time.

For users needing larger-scale access for studies like long-term data trends, machine learning training, there are ways to arrange more direct access via a mounted Google Drive. WALDO maintainers only need a Gmail address in order to share specific years, folders, or the entire database, as needed. Apart from this, however, access to WALDO is possible with no account, and no permission needed from the PIs.

On WALDO there are also some tools to help anyone use the data. The format page goes over the file format and the naming convention of the files. The scripts page contains Matlab-ready scripts to analyze the data in various way, and we note that the format is simple enough that utilities in any language or platform can easily be written to read the data files. The usage page details restrictions on the data usage (spoiler: there aren't many). And finally, there is a page with some occasional updates as WALDO adds more data and features.

Here is a PARTIAL map of some of the sites that will be on WALDO. To keep the map from being too busy, we skipped some (for now), and compressed some "clusters" of receivers into one. To get a better idea of what sites are available, a user can look in the "What's Available" page, and find the "Availability Maps" which show precisely what sites are available for each day. Or, click on the "World map" link in the above menu, and a user can find out how much data is available for each site that is currently on WALDO.
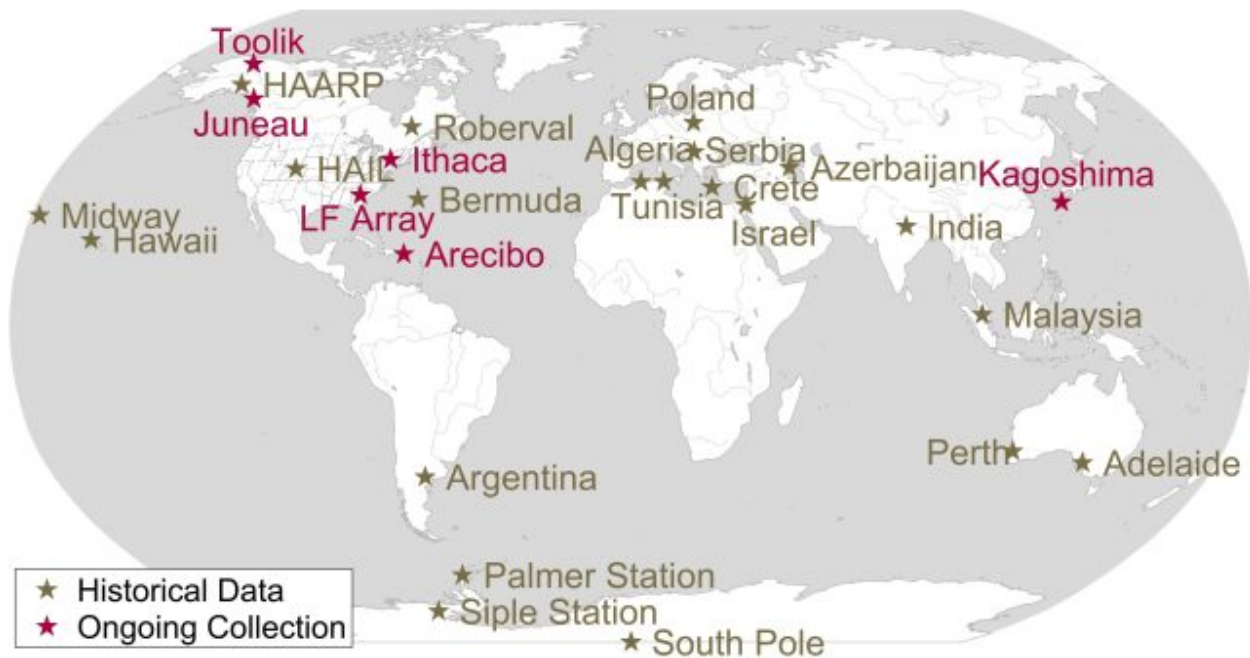
3.3 Policies for data access and sharing

The data in the WALDO database have been collected by Stanford University, the Georgia Institute of Technology, and the University of Colorado Denver. Funding has been provided by the United States government under various basic science research grants over many years.

To maximize the benefit of those investments, WALDO data are released without restriction, and can be freely analyzed or published.

The curators of WALDO are Morris Cohen (Georgia Tech) and Mark Golkowski (CU-Denver). The curators request the following acknowledgement added in any publication using WALDO data

"VLF data are provided by the WALDO database (https://waldo.world), operated jointly by the Georgia Institute of Technology, and the University of Colorado Denver, using data collected from those institutions as well as Stanford University, and has been supported by various US government grants from the NSF, NASA, and the Department of Defense."

In addition, the appropriate DOI should be cited in any publication, from the three DOIs described earlier.

If extensive amounts of WALDO data are used in a publication, the curators request, but do not require, to be contacted to discuss the possibility of joint authorship, with the WALDO curators providing help analyzing and interpreting the large dataset.

Instrument name: Sudden Ionospheric Disturbance Monitors (SID)

Part 1: Instrument and personnel information

- PI: Deborah Scherrer - dscherrer@solar.stanford.edu
- Additional contacts: Professor Philip H. Scherrer: pscherrer@solar.stanford.edu (group PI); The Society of Amateur Radio Astronomers (SARA): http://radio-astronomy.org/
- Instrument website: http://sid.stanford.edu/
- Data website: http://sid.stanford.edu/
- Instrument information: For more complete information about the project, see http://solar-center.stanford.edu/SID/DOC/SuperSID-Manual.pdf
  - Science and measurement objectives: See the website http://sid.stanford.edu

    The Stanford Solar Center has developed an education project to build and distribute inexpensive scientific instruments to students around the world. These instruments track the Sun's influence on the Earth's ionosphere by detecting solar flares and other ionospheric disturbances, called Sudden Ionopsheric Disturbances (SIDs). Two versions of the monitor exist - the original SID instruments, and a new, lower-cost SuperSID instrument. The monitors are distributed to teachers and students at no cost. The goal is to give students experience with authentic scientific data and the processes to use that. Students learn much about the Sun and the Earth's ionosphere.

    Earth's ionosphere reacts strongly to the intense X-ray and ultraviolet radiation released by the Sun during a solar flare. By using a receiver to monitor the signal strength from distant VLF transmitters, and noting unusual changes as the waves bounce off the ionosphere, students around the world can directly monitor and track these SIDs.

    Stanford's Solar Center and local educators developed these inexpensive instruments for students to install and use at their local high schools. Students "buy in" to the project by building their own antenna, a simple structure costing less than $10 and taking a couple hours to assemble. Data collection and analysis are handled by a local PC, which need not be fast nor elaborate. Because there are VLF transmitters scattered around the world, the monitors can be placed virtually anywhere there is access to power. Stanford provides a centralized data repository where students can deposit, share, and extract data. One need not have an instrument to obtain and analyze the data.

    The package comes with complete documentation, a Teacher Guide for using in schools, and a research guide for understanding SID data and suggested research projects.   http://solar-center.stanford.edu/SID/DOC/

  - Instrument descriptions: The original SID instruments were primarily an amplifier for the VLF waves and a sound sampling unit. The SuperSID instruments use the sound card of the local computer for sound sampling, so

primarily serve as an amplifier. See http://solar-center.stanford.edu/SID/sidmonitor/
- o Instrument performance specifications: see the website above
- o Key/representative publications or references:
  - o Distributing space weather monitoring instruments and educational materials worldwide for IHY 2007: The AWESOME and SID project Deborah Scherrer, Morris Cohen, Todd Hoeksema, Umran Inan, Ray Mitchell, and Philip Scherrer; *Advances in Space Research*(COSPAR), Volume 42, Issue 11, 1 December 2008, Pages 1777-1785. (http://www.sciencedirect.com/science/article/pii/S0273117707011775)
  - o The SuperSID Manual: http://solar-center.stanford.edu/SID/DOC/SuperSID-Manual.pdf
  - o Samples of other publications: http://solar-center.stanford.edu/SID/publications/
- o Instrument Locations: There have been more than 900 SID monitors distributed throughout the world, with an emphasis on Developing Nations. The complete list is available through the Society of Amateur Radio Astronomers (SARA): http://www.radio-astronomy.org/ . Specific data is not always available for every instrument since many were distributed through other groups.
- o Station data availability interval: SIDs and SuperSIDS sample VLF data every 5 seconds, 24 hours a day. However, most of the VLF transmitters go down for maintenance about once a week, and occasionally for months at a time.

Part 2: Data and format

2.1 Measurements and data products

- Collected SID data are freely available at: http://sid.stanford.edu/database-browser/
- SID software at each site samples signal strength of the signal transmitted from one to five VLF transmitters. Provided software automatically collects the data, then ftps a daily data file to Stanford. Users can also access their data locally.
- Once Stanford receives the files, they are slightly modified to add additional metadata, making the files more easily readable and graphable.   Stanford also rates the data for quality, i.e. the amount of noise vs. data.   This ranking is available to users of the data website.
- The data files at Stanford are also downloadable.
- The SID Project has no real-time data.   As noted above, data are collected by each system and once per day ftp'ed to the Stanford SID Database.

2.2 Data file format and metadata

- The SID data are in .cvs format, meaning they are both human-readable and graphable by Excel, although better graphing software is provided with the package. (Note: although Excel can graph the files, it gratuitously changes them, making them unusable for the SID software provided.)
- Each data file represents one day of data from one site monitoring one specific VLF transmitter.
- A local user-configurable file contains *keyword=value* pairs. This file is initially set up by the user when installing their SID software. These pairs identify the site name, instrument number, latitude & longitude of the site, transmitter being monitored, etc. Additional metadata is added when Stanford receives and processes the files. The metadata stays with the file, appearing at the beginning.
- The raw SID data are archived in a hierarchical data structure at Stanford, primarily as a backup for the SQL-maintained data. Users general do not access these files.
- SID data are also ingested into Stanford's Joint Science Operations Center (JSOC), which maintains data products from the Solar Dynamics Observatory, as well as certain other missions and instruments. See http://jsoc.stanford.edu/. The SID Data Access page provides a convenient interface to the data in JSOC: http://sid.stanford.edu/database-browser/
- The data are also accessible via a tool using SQL queries: http://jsoc2.stanford.edu/ajax/lookdata.html This user interface requires a password that must be obtained from the Solar Group at Stanford.

2.3 Sample Data
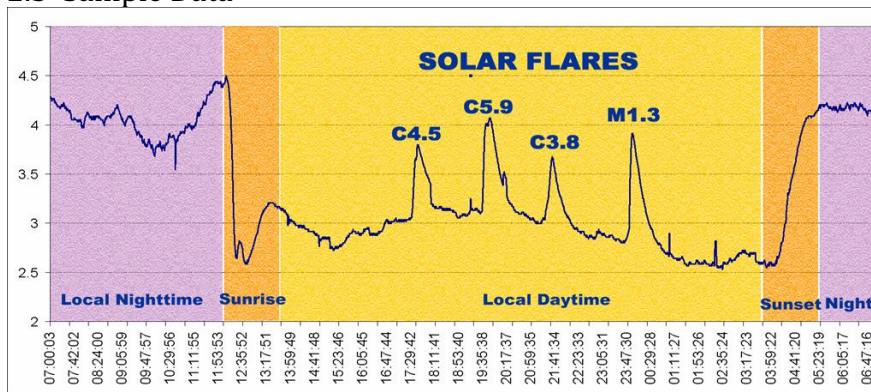
Solar SID data are easy to understand and somewhat similar to those from a seismograph. On the graph the horizontal axis represents time, in this case about 24 hours. The vertical axis represents strength of the VLF signal being received. (The actual measured values of this aren't important, only the amount of change.) The strength of the VLF signal changes depending upon the ionization of the Earth's ionosphere, and that depends upon what is happening on the Sun! Solar flares dramatically increase the ionization in the lower layers of the ionosphere, thus giving VLF waves a clean bounce point and hence showing up as an increase in signal strength. Indications of solar flares show up in SID data as spikes above (or occasionally below) the normal signal strength level. Four solar flares are labeled on the data graph below. The colors and labels were added for clarity.

Part 3: Archiving and distribution plans

3.1 Long-term data storage and management

- Stanford no longer has a director for the SID project nor an individual responsible for maintenance of the data. Changes and fixes are made available through volunteers, as time allows. However, because the JSOC system that houses the data is primarily used for NASA's SDO mission, it is expected that the data system will remain in place as long as funding is available to maintain it. Because of the immense amount of SDO data, this database cannot be backed up at additional sites.

3.2 Data distribution plan: The data are available via the website to anyone interested.
3.3 Policies for data access and sharing: All SID data at Stanford are freely available.

Instrument name: Boston University All-Sky Imaging Network (BU_ASI)

Part 1: Instrument and personnel information

- Current PIs and contact info

  Michael Mendillo
  Center for Space Physics, Boston University
  725 Commonwealth Ave, Boston, MA 02215
   tel: (617) 353-2629
   e-mail: mendillo@bu.edu

  Carlos Martinis
  Center for Space Physics, Boston University
  725 Commonwealth Ave, Boston, MA 02215
  Tel: (617) 353-5258
  Email: martinis@bu.edu

- Instrument website
  www.buimaging.com

- Instrument information
  o Science and measurement objectives

  The BU all-sky imager network has been built to study magnetically conjugate processes in the thermosphere-ionosphere from low latitudes to sub-auroral latitudes. In addition, mesospheric dynamics can be studied with each ASI in the network. The processes include Equatorial spread F (ESF), Medium scale travelling ionospheric disturbances (MSTIDs), Stable auroral red (SAR) arcs, and brightness waves (BW) in the thermosphere/ionosphere region. At lower altitudes in the mesosphere the processes include gravity waves, bores, and tidal waves.

  o Instrument descriptions
  The BU ASI Network consists of 14 all-sky imagers. Each imager measures up to 6 different airglow emissions originating at different heights in the upper atmosphere. Each emission is the result of specific chemical reactions involving charged and neutral atoms and molecules.

  o Instrument performance specifications
  Airglow emissions are measured using interference filters that can isolate light coming from a specific wavelength. The system takes images at several wavelengths for the duration of the night on nearly every night in a given month. Thermospheric emissions of neutral oxygen are measured at

wavelengths of 630.0 nm and 557.7 nm (emissions due to dissociative recombination of O_2^+), 777.4 nm (due to radiative recombination of O^+). Mesospheric processes are studied by measuring emissions at 589.3 nm (neutral Na emissions), 557.7 nm (via the three-body Barth reaction), and lines with λ > 695.0 nm (OH Meinel band emissions). Background filters at 644.4 nm or 605.0 nm, chosen to avoid thermospheric and mesospheric emission lines, are used as control filters. Exposure times are 90-120 seconds for all the filters except hydroxyl, which has an exposure time of 15-30 seconds. An entire cycle of observations takes ∼10 minutes.

- o   Key/representative publications or references

Mendillo, M., Hickey, D., Martinis, C., Wroten, J., & Baumgardner, J. Space weather nowcasting for area-denied locations: Testing all-sky imaging applications at geomagnetic conjugate points. Space Weather, 16. https://doi.org/10.1002/2017SW001741, 2018.

Martinis, C., Baumgardner, J., Wroten, J., and Mendillo, M. All-Sky-Imaging Capabilities for Ionospheric Space Weather Research Using Geomagnetic Conjugate Point Observing Sites, Advances in Space Research, DOI:10.1016/j.asr.2017.07.021, 2017.

J. Baumgardner, J. Wroten, J. Semeter, J. Kozyra, M. Buonsanto, P. Erickson, and M. Mendillo, A very bright SAR arc: implications for extreme magnetosphere-ionosphere   coupling, Ann. Geophys., 25, 2593–2608, 2007.

- o   Instruments locations

Site	GLat	GLon	Hosted by
Millstone	42.64	-71.45	USA
Pisgah[1]	35.20	-82.88	USA
McDonald	30.67	-104.02	USA
Arecibo	18.30	-66.80	Puerto Rico
V.Leyva	5.60	-73.52	Colombia
Jicamarca	-11.95	-76.87	Peru
El Leoncito	-31.80	-69.30	Argentina
Mercedes	-34.51	-59.40	Argentina
Rio Grande	-53.79	-67.75	Argentina
Rothera[2]	-67.50	-68.10	BAS- Antarctica
Mt John	-43.99	170.46	New Zealand
Asiago	45.87	11.53	Italy
Sutherland	-32.37	20.81	South Africa
Kuhlungsborn[3]	54.15	11.74	Germany

[1] operated by SRI; [2] operated by USU/BAS; [3] operated by IAP.

- Station data availability intervals

  Raw data is transferred to Boston University servers daily from each remote station upon completion of data-taking. Data is processed and made available online within 12 hours, in the form of contrast-enhanced GIF images.

Part 2: Data and format
2.1 Measurements and data products
Measured parameters and data products

- How will the measured parameters be acquired or recorded?
  - Units? Temporal & spatial resolutions?

    The raw data all-sky images are in brightness units of data number. The images are contrast-enhanced for easy feature identification and presented online in this "relative brightness" capacity. Exposure time is noted on each image, along with the universal time at which the exposure began. Spatial resolution is presented in x-y pixel and altitude/azimuth.

- How will physical parameters be derived from measured parameters?
  - Units? Temporal & spatial resolutions?

    All-sky images are routinely presented in data number units and can be calibrated to Rayleighs by request. Pixel location and altitude/azimuth can be converted to geographic coordinates upon request.

- Processing and calibration procedures

  Daily routine processing is done automatically on a linux OS, utilizing IDL in-house routines written specifically for BU ASI Network data. Calibration is done upon request.

- Coordinate systems, software, and models used?

  Pixel location and azimuth/altitude can be converted to geographic coordinates using in-house IDL routines written specifically for BU ASI Network data. An airglow code can be used to compute theoretical volume emission rates and brightness   values.

- Quality assurance & quality control measures

  Quick-look images posted online daily in several wavelengths allows for quality control on a regular basis during routine data acquisition. Restricting

calibration to non-automated, by-request-only status further contributes to quality assurance and control.

- Definitions and descriptions of higher-level instrument data products
  - Numerical

    All-sky images are routinely presented in data number units and can be calibrated to Rayleighs by request.

  - Graphical

    Quick-look images and movies are available at
    www.buimaging.com/dataview

- Real-time space weather data products
  - Product descriptions

    Raw data is transferred to Boston University servers daily from each remote station upon completion of data-taking. Data is processed and made available online within 12 hours

  - Method of acquisition and processing
  - Data format
  - Storage, distribution and access methods

- Data quality and caveats

  All-sky image calibration is vulnerable to sources of error and contamination including (but not limited to) light scattering and clouds, therefore we do not automatically calibrate our data and strongly recommend contacting the PI when attempting calibration or interpretation of data.

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?

  Data is saved as raw binary, 16-bit images along with corresponding ASCII file metadata. Processed GIF images are made available online daily.

- Organization and range of data/parameters in data files?

  Data image files are one image per file in raw binary 16-bit format.

- Information on how metadata will be provided with the data?

  ASCII text files with metadata are stored with raw data images located on BU servers. Processed GIF images presented online include overlaid text that offers information about the image.

- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.

  On BU servers, BU ASI Network data is stored in a directory structure with a naming convention as such:

  /Site name/year/MMMDDYY/

  ASCII text files containing metadata are stored within each /MMMDDYY directory along with the raw data images from that day. Within the ASCII metadata files is the following information:

  Image filename, year, month, day, filter wavelength, exposure time (s), x binning of CCD chip, y binning of CCD chip, x image size, y image size, camera temperature.

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?

  Both raw data and processed images are stored at Boston University on servers maintained by the College of Arts and Sciences Information Technology.

- Data re-processing requirements and version control

  ASCII files are produced concurrent with image processing that preserve relevant parameters.

- Data backup plan

  Data backup plan is executed and maintained by College of Arts and Sciences Information Technology at Boston University.

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)

  Joei Wroten
  Center for Space Physics (CSP), Boston University
  725 Commonwealth Ave., Boston, MA 02215

tel: (617) 353-7429
e-mail: jwroten@bu.edu

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?

  Processed images with overlaid metadata are posted daily and made freely accessible at www.buimaging.com/data. Raw data and calibrated data are made available upon request.

3.3 Policies for data access and sharing
All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Instrument Name: e-Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (e-CALLISTO)

Part 1: Instrument and personnel information

- Current PI and contact info: Christian Monstein. No affiliation. Retired cmonstein(at)swissonline.ch
- Co-PI: Javier Bussons, Physics and Mathematics Department, Universidad de Alcalá (UAH). Facultad de Educación, C/ Madrid, 1, ES-19001 Guadalajara, Spain. Javier.bussons(at)uah.es

- Other responsible personnel and contact info (e.g., instrument scientist/manager, if different from PI):
  - Prof. Dr. André Csillaghy, University of Applied Sciences, Bahnhofstrasse 6, CH-5210 Windisch, Switzerland, andre.csillaghy(at)fhnw.ch
  - Prof. Dr. Arnold Benz, Wolfgang-Pauli-Strasse 27, CH-8093 Zurich, Switzerland, benz(at)astro.phys.ethz.ch
  - Prof. Manuel Prieto, Universidad de Alcalá, manuel.prieto(at)uah.es

- Instrument website: https://e-callisto.org/
  Alternative websites to directly access data:
  https://soleil.i4ds.ch/solarradio/ hosted by FHNW, Switzerland
  https://astrodoncel.uah.es/ Spanish Data Center hosted in Sigüenza by UAH

- Instrument information
  - Science and measurement objectives: 24h/7d observation at different latitudes of solar radio bursts in the frequency range 45 MHz…. 870 MHz (wavelength 34.5 cm … 6.67 m) or any other frequency range by switching in a heterodyne up- or down-converter

  - Instrument descriptions
    - Software setup and user manual including specification (~5.2 MB):
    https://www.reeve.com/Documents/CALLISTO/CALLISTOSoftwareSetup.pdf

    - Hardware and construction manual (~8.2 MB):
    https://www.reeve.com/Documents/CALLISTO/CALLISTOConstruction.pdf

    - General information and articles: https://e-callisto.org/GeneralDocuments/Callisto-General.html

o Instrument performance specifications:
https://e-callisto.org/Qualification/applidocs.htm

o Key/representative publications or references:
https://arxiv.org/abs/astro-ph/0410437
https://link.springer.com/article/10.1007/s11207-005-5688-9

o Instrument locations (longitudes and latitudes) and local points of contact:
https://e-callisto.org/Callisto_DataStatus_Vwww.pdf

o Station data availability intervals: Each operational location sends data in 15-minute intervals between local sun-rise and sun-set. Current situation about availability of data here: https://e-callisto.org/daynight_mill.png This website is updated once every 15 minutes during 24h/7d.

Callisto Day/Night Map for 13 Jan 2025 19:20:02 (UTC), blue=no data, orange=data two days ago, red=current data
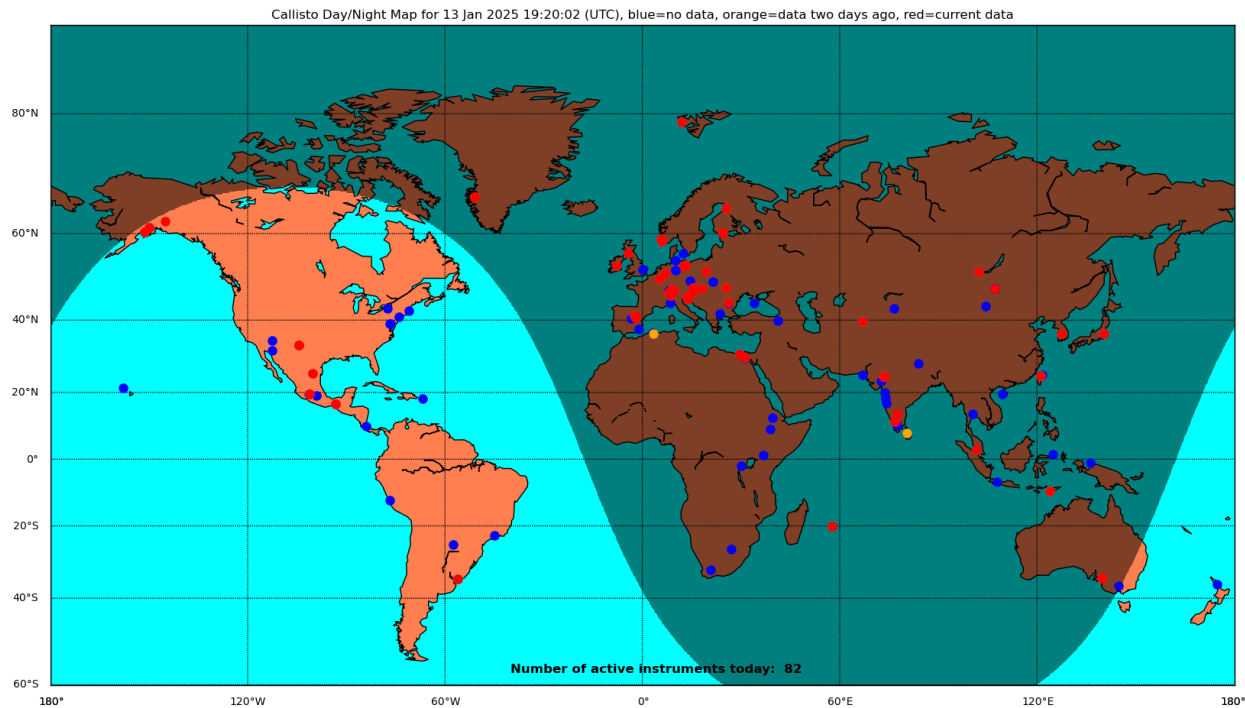
Fig. 1: Example of station availability on Monday, Jan 13, 2025. Plot is updated every 15 minutes on the main website: https://e-callisto.org/

Part 2: Data and format

2.1 Measurements and data products

- Measured parameters and data products
  - o How will the measured parameters be acquired or recorded?
    Data are acquired via a 10-bit ADC of an Atmel RISC processor ATmega16 inside the Callisto instrument. Data are then reduced to 8 bits to save memory space. Data are then transferred via RS-232 to a standard Windows

PC and stored on a local disc or on a network-drive. A PERL or PYTHON script transfers the FIT-files every 15 minutes to the central server in Switzerland. The very latest details about how acquisition is performed can be found in the firmware of Callisto here: https://e-callisto.org/Software/Callisto-Software.html

- Units? Temporal & spatial resolutions?
  In case of calibrated data the units are solar flux units (SFU) but the majority of the instruments is not calibrated in intensity, therefore the units are either 'nil' or 'digits'. Temporal resolution is programmable by the user as number of spectra per second (1….200), depending on the size of the spectrum (4…400 bins). Spatial resolution depends on the individual antenna type. The majority uses a logarithmic periodic dipole array (LPDA) with angular resolutions in the order of 70°…120°. Instruments based on long wavelength antennas (LWA) have a spatial resolution up to 180°. Images of the individual antennas can be found here: https://e-callisto.org/coverage/coverage.html

Fig. 2: Typical example of a logarithmic periodic dipole array (LPDA) in Ahmedabad, India.

- How will physical parameters be derived from measured parameters?
  Physical parameters are usually derived by generating plots of the bursts, typically in IDL, SSW-IDL, MATLAB or PYTHON.

- Units? Temporal & spatial resolutions?
  Most relevant are duration of the bursts in seconds, drift-rate in MHz per second, bandwidth in MHz and structure of the burst which is a purely visual identification which requires some experience.
- Processing and calibration procedures
  Currently none of the instruments is able to make use of a calibration unit because such a device is extremely expensive compared to the instrument itself. Intensity calibration is anyway not required for burst-analysis and of second order interest. In case calibration is required then usually post-calibration is performed by comparing with other instruments which are able to calibrate (cross-calibration with Nançay, Humain (ROB) or Nobeyama)
- Coordinate systems, software, and models used?
  The instrument coordinate system is given by time (UTC), longitude, latitude and altitude. In most cases the antenna is pointing to zenith, therefore the declination is always equal to the latitude and the hour angle is equal to 0h because the antennas are mostly oriented in north-south direction. Only very few instruments allow to track the Sun. Software (firmware and PC-firmware as well data analysis tools in IDL and PYTHON) can be found here: https://e-callisto.org/Software/Callisto-Software.html
- Quality assurance & quality control measures
  Quality assurance is done by visual inspection of the data at least once a day by the PI. Control measures are performed every few years by collecting spectra which are fed into a dedicated Python tool. As long as the system noise is below ~1000 Kelvin the system is seen as functional. In case of bad sensitivity, the instrument owner is contacted by email to identify the problem. An overview about sensitivity and rfi of most of the stations can be found here: https://e-callisto.org/OVS/Spectral%20Overview.html
  Not all stations provide their spectral overview, possibly due to internal or political reasons.
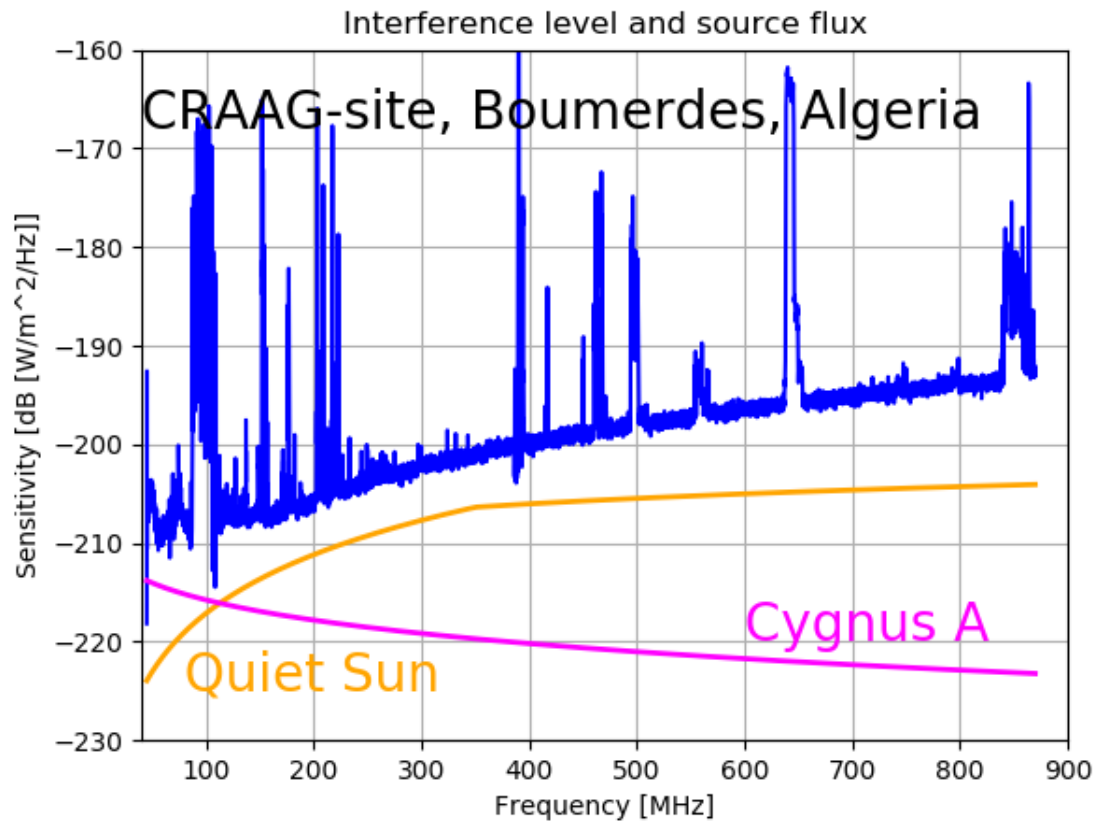
Fig.3: Typical example of a spectral overview (OVS), here from CRAAG, Algeria.

- Definitions and descriptions of higher-level instrument data products
  - Numerical: none
  - Graphical: We provide on the central archive quick-views (QV) for every 15 minute FIT-file here: https://soleil.i4ds.ch/solarradio/callistoQuicklooks/
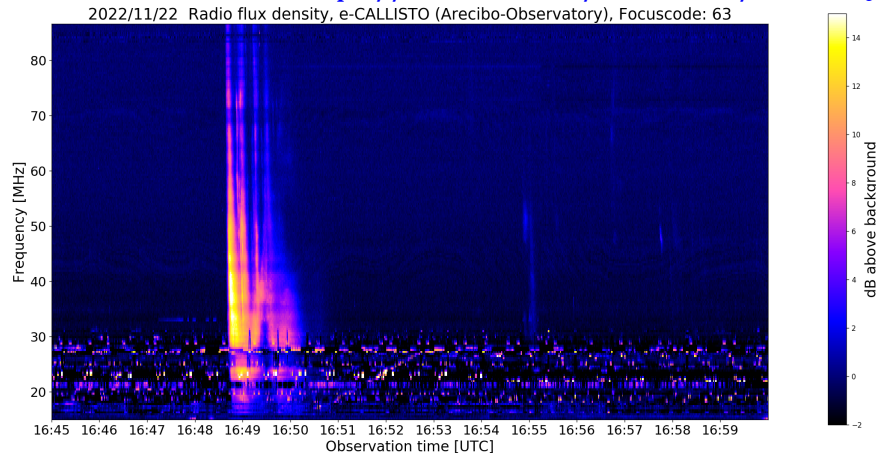
Fig. 4: Typical example for a quicklook or quickview, here a type III burst from Arecibo Observatory, Puerto Rico.

In addition we also provide a daily overview per location here:
http://soleil.i4ds.ch/solarradio/data/1998-2009_quickviews/
In addition, a daily light curve per station is available, presenting frequencies which are internationally protected by ITU here:
http://soleil.i4ds.ch/solarradio/data/Lightcurves/
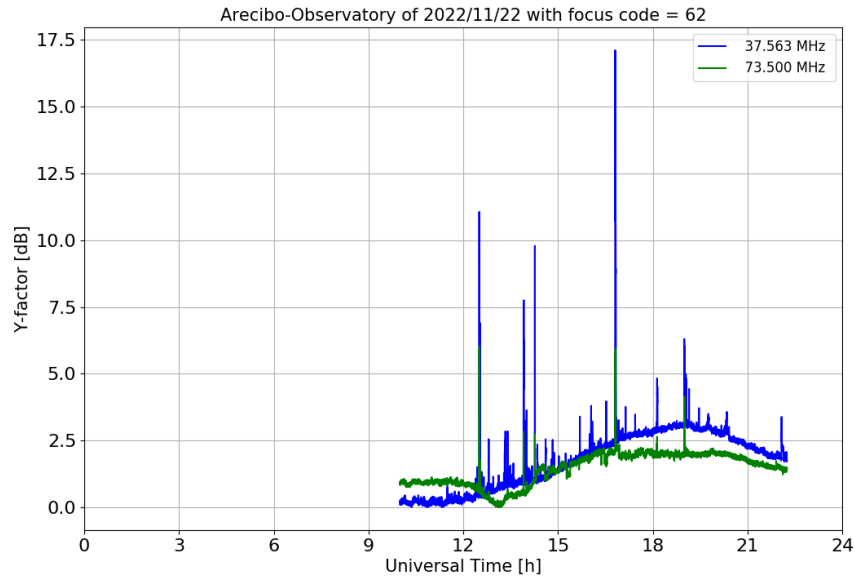
Fig. 5: Example of a daily light curve, here from Switzerland. We can see the burst as in figure 4 above at 16:49UT (blue peak).

o   From January 2021 onwards we also provide daily maximum observation time of the Sun for instruments providing data to the archive.
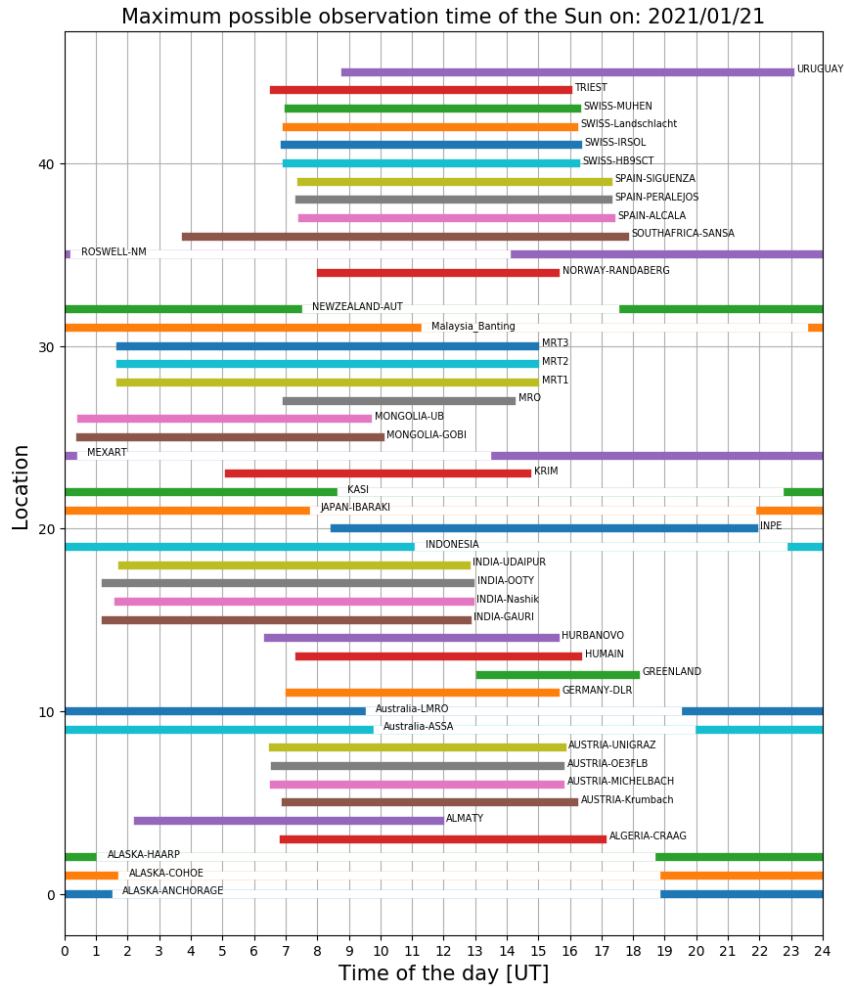
Fig. 6: Daily observation time for all hosts which provided data on January 21, 2021. It is updated every 24h around midnight CET.

- Real-time space weather data products
  - o Product descriptions: We provide FIT-files covering 15minutes of observation to the central archive in Switzerland as described above. Due to the internet speed of the instrument-hosts, the files may appear on the archive website up to 30 minutes later. Every instrument can also provide a set of light curves locally on the computer of the host in a faster cadence, every ~10 seconds. But these files are currently not available on the central server. But in addition we also provide a daily spectral overview per location with an update every hour 24h/7d, see: https://soleil.i4ds.ch/solarradio/data/1998-2009_quickviews/

Full day spectra 2020/11/22 station: GLASGOW with focus-code: 59
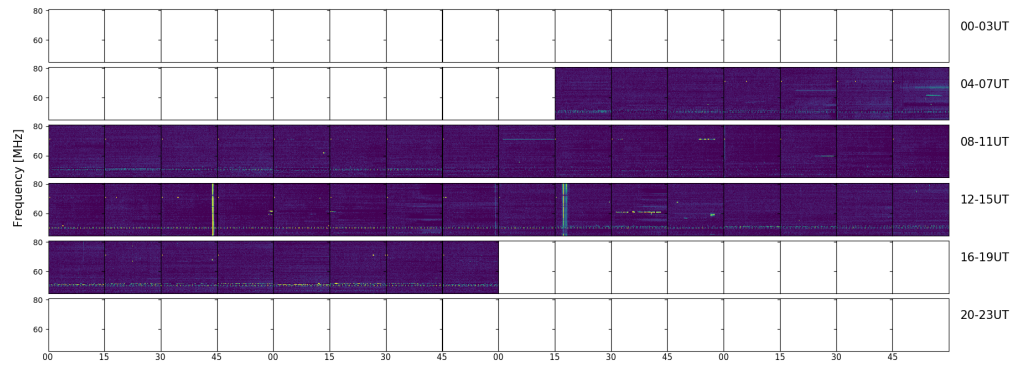
Fig. 5: Example of a daily spectral overview, here from University of Glasgow, UK. We can see the same burst as in figure 3 above at 12:44UT

- Event lists/reports: starting in Jan 1st 2025 daily burst reports are no longer made through visual inspection; instead, automatic Solar Radio Burst (SRB) identification, based on Machine Learning, is used.
- Coincidence plot: https://astrodoncel.uah.es/dashboard/xmatch.php
- Monthly plot of the number of SRBs detected per station

Number of solar radio bursts observed in Dezember 2024 within the ISWI instrument network e-Callisto

Total contributing stations: 70/236
Total reported observations: 1735
Total bursts detected: 318
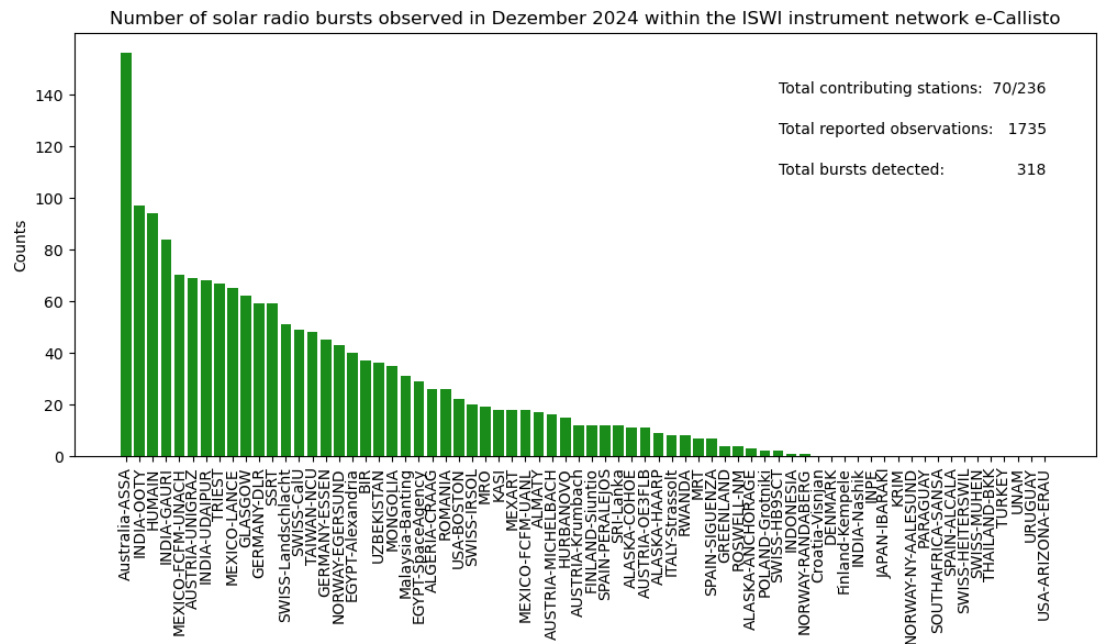
- Method of acquisition and processing: See paragraph 2.1 above
- Data format: See paragraph 2.1 above
- Storage, distribution and access methods: See paragraph 2.1 above and paragraph 2.2 below.

- Data quality and caveats
  Each instrument owner is responsible to provide best quality data possible and we cannot take over any responsibility to guarantee 100% perfect data quality. The scientist has to check if he/she can trust the data by comparing results with data from other, nearby locations. If at least two stations (coincidence criterion) observe the same event, we can assume it's a solar burst. If only one station observes a dynamic structure, one has to be careful. A catalog with natural and man-made dynamic spectra to get acquainted with dynamic spectral structures can be found here:
  https://e-callisto.org/GeneralDocuments/BurstCatalog.pdf

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?
  Main data output is stored as FIT-files and it's header is described in detail in appendix 'F' here:
  https://www.reeve.com/Documents/CALLISTO/CALLISTOSoftwareSetup.pdf
- Organization and range of data/parameters in data files?
  Parameters of observation are stored individually in a configuration file named 'callisto.cfg'. It's content and ranges are described in detail in software setup manual here: https://www.reeve.com/Documents/CALLISTO/CALLISTOSoftwareSetup.pdf
- Information on how metadata will be provided with the data?
  There are three types of metadata available:
  - A log-file in real-time where all actions and errors of the instruments are stored. The file is simple text-file (ASCII) and a description can be found here:
  https://www.reeve.com/Documents/CALLISTO/CALLISTOSoftwareSetup.pdf
  - An integrated light-curve file is also provided to produce real-time plots on a website. Details and tools available are described here:
  https://www.reeve.com/Documents/CALLISTO/CALLISTOSoftwareSetup.pdf
  - A spectral overview file can be generated manually or automatically and it is described in detail here:
  https://www.reeve.com/Documents/CALLISTO/CALLISTOSoftwareSetup.pdf
- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.
  Not applicable in the current network system.

  All meta data can be downloaded from here: https://soleil.i4ds.ch/solarradio/
  See 'Ancillary data' for plots and raw-files.

Part 3: Archiving and distribution plans

3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?
  All data (FIT-files, log-files, weather-data and reports) are stored on our central servers at campus Brugg-Windisch of University of Applied Sciences (FHNW) and at campus Casa del Doncel – Sigüenza (UAH, Spain). Storage devices are configured as RAID6 and Synology Hybrid RAID, respectively.
- Data re-processing requirements and version control
  Data processing (quick views) is performed with scripts in combination with IDL, PERL and Python, while daily overviews are executed in Python on the central server in Python3.
- Data backup plan
  Every 3 hours an automatic backup is generated on a separate disc-system in the same server room. Every 1-2 weeks all data are copied onto a tape and stored in a separate building at FHNW campus.
- Once a month the PI copies all raw-files of previous month to an external USB-disc.
- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data).
  Server administrators are Mr. Bernhard Schindler (FHNW) and Dr. Manuel Prieto (UAH):
  https://www.fhnw.ch/personen/bernhard-schindler
  https://www.uah.es/es/estudios/profesor/Manuel-Prieto-Mateo/
- Responsible group leaders are Prof. Dr. André Csillaghy (FHNW) and Dr Javier Bussons (UAH):
  https://www.fhnw.ch/people/andre-csillaghy/
  https://www.uah.es/es/estudios/profesor/Javier-Bussons-Gordo

3.2 Data distribution plan

How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?
All data are freely available any time here:
http://soleil.i4ds.ch/solarradio/callistoQuicklooks/
https://astrodoncel.uah.es/
Or, as an alternative way here: http://soleil.i4ds.ch/solarradio/
Logbooks about our own instruments here: http://soleil.i4ds.ch/solarradio/data/Journals/
Environmental data about our own instruments here:
http://soleil.i4ds.ch/solarradio/data/1998-20yy_EnvironmentalData/

We expect to be invited as co-author in case Callisto data are used for any publication. And we expect credit given to FHNW Brugg/Windisch, Switzerland.

In case Callisto data are used for any publications, the instrument PI expects to be invited

to be a co-author of the paper. For this purpose, the paper must be sent to the PI at least two weeks prior to submission, so that he can review it, possibly give comments, and decide whether he chooses to be a co-author. Note that the explicit confirmation from the PI is needed for him to appear as a co-author on any such publication.

3.3 Policies for data access and sharing

All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Document Information

Author: Christian Monstein, Istituto ricerche solari Aldo e Cele Daccò (IRSOL), Faculty of Informatics, Università della Svizzera italiana (USI), CH-6605 Locarno, Switzerland.
monstein(at)irsol.ch

Filename: ISWI Instrument Data management plan_CALLISTO_V??.docx
Revision: 0.0 (Initial draft, 02 Dec 2016)
0.1 (Draft major revisions, 05 Dec 2016)
0.2 (Final draft, 30 Sep 2017)
0.3 (Final, 14 Feb 2018)
0.4 (Lost affiliation, 14 Nov 2018)
0.5 (New affiliation, 01 Feb 2019)
0.6 (22.01.2021)
0.7 (Update affiliation, http->https, 09.12.2022)
0.8 (Updated AstroDoncel server, Event Lists: visual → automatic, Event list updated hourly, 04.02.2025)

Instrument name: CHAIN (Continuous H-Alpha Imaging Network)

Part 1: Instrument and personnel information

- Current PI and contact info :
    Prof. K. Ichimoto (ichimoto@kwasan.kyoto-u.ac.jp)
    Mr. Satoru UeNo (ueno@kwasan.kyoto-u.ac.jp)

- Other responsible personnel and contact info (e.g., instrument scientist/manager, if different from PI):
    Contact point for data-request: data_info@kwasan.kyoto-u.ac.jp
    Contact point about IDL programs for deriving velocity fields of solar filaments:
      kenichi.otsuji@gmail.com

- Instrument website:
    http://www.kwasan.kyoto-u.ac.jp/CHAIN/

- Instrument information
    - Science and measurement objectives:
      The science target is to monitor solar flares, erupting filaments and shock waves (Moreton waves) continuously all over the solar disk and to investigate the correlation between the characteristics of the erupting phenomena and the geoeffectiveness of the corresponding CMEs.
      Moreover, by estimating solar UV radiation from solar chromospheric images, to compare it with the ionospheric variation.

    - Instrument descriptions:
      The aim of this project is reinforcement of multi-wavelength H-alpha observations of the full-disk Sun by formation of an international network of ground-based solar stations.
      As part of this project, we moved a Flare Monitoring Telescope (FMT) from Hida Observatory to Ica University of Peru in 2010 as the 1st oversea CHAIN's instrument, and King Saud University built the 2nd oversea FMT in Saudi Arabia under this project in 2015.
      By using these FMT telescopes and SMART telescope at Hida Observatory in Japan, we are able to observe solar active phenomena for 24 hours continuously.
      Moreover, in the Peru station, we are developing spectroheliograph in order to detect larger Doppler-shift event (high-speed filament eruption) than the FMT can detect. On the other hand, in Hida Observatory, we already installed a quite wide-range tunable filter on the SMART telescope for the same purpose in 2016.

    - Instrument performance specifications:
      Main instruments at oversea stations are Flare Monitoring Telescopes (FMT). They have five solar imaging telescopes that simultaneously observe the full-

disk Sun at different wavelengths around H-alpha absorption line or in different modes. Therefore, the FMT can measure the three-dimensional velocity field (Doppler velocity & transversal velocity) of moving structures on the full solar disk.

The SMART (Hida Observatory) has a wide-range tunable filter at present. It can observe full-disk solar images at 73 wavelengths between H-alpha – 0.9 nm and +0.9 nm for 12 s. Therefore, it can measure Doppler velocity of high-speed filament eruptions up to about 400 km/s with 12 s time-cadence.

On the other hand, the spectroheliograph that we are developing in Peru can cover very wide-range wavelength from H-alpha -1.6 nm to +1.6 nm, therefore, it will also be able to detect very large Doppler shift, though the FOV is smaller than existing FMT.

- o Key/representative publications or references:
  UeNo S., et al., 2007, Bull. Astr. Soc. India 35, 697
  UeNo S., et al., 2009, Data Science Journal 8, 51
  UeNo S., et al., 2010, African Skies 14, 17
  UeNo S., et al., 2014, Sun and Geosphere 9, 97
  Ichimoto K., et al., 2017, Solar Physics, 292, 63
  Asai A., et al., 2012, Astrophysical Journal 745, L18
  Ishitsuka J., et al., 2014, Sun and Geosphere 9, 85
  Cabezas D. P., et al., 2017, Astrophysical Journal 836, id. 33
  Seki D., et al., 2017, Astrophysical Journal 843, id. L24
  Seki D., et al., 2018, Sun and Geosphere, 13, 157
  Cabezas D.P., et al., 2019, Astrophysical Journal, 883, 32
  Seki D., et al., 2019, Sun and Geosphere, 14, 93
  Seki D., et al., 2019, PASJ, 71, 56

- o Instrument locations (longitudes and latitudes) and local points of contact (name, title, mailing and email addresses) [If it is more convenient to do so, this information can be provided in a separate document linked to the PDMP.]:
  1) Japan/Takayama/Hida Observatory: Longitude=E137o 19', Latidude=N36o 15', Contact point=Mr. S. UeNo (ueno@kwasan.kyoto-u.ac.jp)
  2) Peru/Ica/National Ica University: Longitude=W075o 44', Latitude=S14o 04', Contact point=Mr. Y. Buleje (yovanny_buleje@yahoo.es)
  3) Saudi Arabia/Riyadh/King Saud University: Longitude=E046o 37', Latitude=N24o 43', Contact point=Dr. A. Ibrahim (ahabdalla@ksu.edu.sa)

- o Station data availability intervals:
  1) Hida Observatory: 1992 May – 2009 Aug. (FMT),
                        2005 Jul. – 2014 Oct. & 2016 Mar. – Present (SMART)
  2) National Ica University: 2010 Mar. – Present
  3) King Saud University: 2015 Oct. – Present

Part 2: Data and format
2.1 Measurements and data products

- Measured parameters
  - How will the measured parameters be acquired or recorded?
    1) FMT (at Hida Obs. -> Ica Univ.):
    Solar full-disk images at three wavelengths [H-alpha – 0.08 nm, H-alpha, H-alpha + 0.08 nm] have been acquired with the time cadence of 1 min (before 2006 May) and 20 s (after 2006 May).
    Spatial resolution of the telescope is about 2 arcsec.
    2) SMART (at Hida Obs.):
    Solar full-disk images at five wavelengths [H-alpha, H-alpha +-0.05 nm, H-alpha +-0.08 nm](2005 Jul. – 2011 Feb.), 7 wavelengths [H-alpha, H-alpha +- 0.05 nm, H-alpha +- 0.08 nm, H-alpha +- 0.12 nm](2011 Mar. – 2015 Oct.), 65 wavelengths [from H-alpha – 0.80 nm to H-alpha + 0.80 nm](2016 Mar. – Present) have been acquired with the time cadence of 2 min (2005 Jul. – 2014 Oct.) and 12 s (after 2016 Mar. – Present).
    Spatial resolution of the telescope is about 0.6 arcsec.
    3) FMT (at King Saud Univ.):
    Solar full-disk images at five wavelengths [H-alpha, H-alpha +– 0.06 nm, H-alpha +- 0.12 nm] (2015 Oct. – Present) have been acquired with the time cadence of 20 s.
    Spatial resolution of the telescope is about 2 arcsec.

  - How will physical parameters be derived from measured parameters?
    The most important physical parameters that can be derived from CHAIN's data are Doppler velocity and transversal velocity of filament motions. Therefore, we developed IDL programs for deriving them from the acquired imaging data obtained with each telescope (using Beckers' cloud-model fitting method and Local correlation tracking method).
    If researchers who want to calculate velocity fields of solar filaments will contact to the above-mentioned contact point, we can provide those IDL programs to them.

  - Processing and calibration procedures
    Calibration procedures are also included the above-mentioned IDL programs.

  - Coordinate systems, software, and models used?
    As we already described, IDL and Beckers' cloud-model and Local correlation method are used for deriving velocity fields of filament motions.

  - Quality assurance & quality control measures
    <u>Imaging data that are covered with clouds more than a certain criterion are excluded from data archives automatically.</u>
    <u>However, if researchers need more strict judgment on the quality, they have</u>

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to check the data by their eyes.

- Definitions and descriptions of higher-level instrument data products
    - Numerical: Original imaging data that are acquired by each telescope are all 2-D "numerical" data.
    - Graphical: As for the SMART data, we have opened "graphical" data in the JPEG format also on the web for the sake of quick-look.

- Real-time space weather data products
    - Product descriptions
      Multi-wavelength H-alpha solar quick-look images obtained with the SMART telescope at Hida Observatory and preliminary Doppler velocity maps.

    - Method of acquisition and processing
      Observed original FITS data are converted to quick-look JPEG images and Doppler velocity maps by using IDL procedures and these are automatically transferred from Hida Observatory to Kwasan Observatory where the web-server is installed.

    - Data format
      JPEG & Java-script movie

    - Storage, distribution and access methods
      Real-time quick-look images and movies are stored in the RAID that is connected with the web-server in Kwasan Observatory, Kyoto, Japan. Everyone can watch these images and movies on the web-site of Kyoto University.

- Data quality and caveats
  If it is difficult for you to judge the data quality under your scientific purposes, please ask above-mentioned contact points.

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?
  1) FMT (at Hida Obs. -> Ica Univ.):
      TIFF (1992 May – 1996 Aug.)
      PGM (1996 Sep. – 2006 May)
      RAW (2006 May – Present)
  2) SMART (at Hida Obs.):
      FITS & JPEG (2005 Jul. – Present)
  3) FMT (at King Saud Univ.):
      RAW (2015 Oct. – Present)

- Organization and range of data/parameters in data files?
  2-D Numerical data [TIFF, PGM, RAW, FITS] and Display data (Graphical data) for quick-look [JPEG] are opened on the web-site of Hida Observatory, Kyoto University, Japan. (A part of data are not opened yet because of the limit of current capacity of our data storage.)

- Information on how metadata will be provided with the data?
  We have proceeded to register our metadata to metadata-database of IUGONET (http://search.iugonet.org/) in Japan.

- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.
  SPASE

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?
  At first, original data at each station are locally stored in the RAID at each station. Finally, all data are gathered in the RAID of web-server in Kwasan Observatory, Kyoto University, Japan.
  Regarding Hida Observatory, we have high-speed network-line between Hida Observatory and Kwasan Observatory. So, we can daily transfer data files from Hida to Kwasan via Internet.
  As for Ica University and King Saud University, however, the network-lines between there and Kwasan are very slow. So, we have to manually transport data files by copying them in portable HDDs.
  On the other hand, the capacity of the RAID of web-server in Kwasan Observatory is recently not so enough, because especially the amount of SMART's data has drastically increased recently.
  Therefore, improving network-lines between Ica Univ., King Saud Univ. and Kwasan Obs. and obtaining more data storage devices and budget for them are our current issues.

- Data re-processing requirements and version control
  As for the CHAIN's data, we basically open original imaging data, and the calibration-process are done by each researcher by using provided IDL programs. So, in principle, the version of open data files will be not changed. However, if some change will be performed (for example, data format will be converted), the version that is described in "metadata" will be renewed.

- Data backup plan
  All original imaging data are stored not only in the RAID of web-server, but also in

portable HDDs. These HDDs have the role of data-backup.

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)
  The same as contact point for data-request: data_info@kwasan.kyoto-u.ac.jp

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?
  In principle, all data files will be open and metadata for them will be made. However, it needs some staffs, enough network-lines, data storage devices and appropriate budget for keeping them. These points are current our issues.

3.3 Policies for data access and sharing
All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Yes. We are looking forward to support by UN in order to get appropriate budget for it.

Instrument Name: Coherent Ionospheric Doppler Receivers (CIDR)

PDMP to be furnished

Instrument Name: Global Ionosphere Flare Detection System (GIFDS)

Part 1: Instrument and personnel information

- Current PI and contact info

  Daniela Banys
  German Aerospace Center (DLR)
  Kalkhorstweg 53
  17235 Neustrelitz
  Tel.   : +49 3981 480 214
  Mail : Daniela.Banys@dlr.de

- Other responsible personnel and contact info

  Team leader:
  Dr. Jens Berdermann
  German Aerospace Center (DLR)
  Kalkhorstweg 53
  17235 Neustrelitz
  Tel.   : +49 3981 480 106
  E-Mail   : Jens.Berdermann@dlr.de

  Scientific advisor:
  Dr. Norbert Jakowski
  German Aerospace Center (DLR)
  Kalkhorstweg 53
  17235 Neustrelitz
  Tel.   : +49 3981 480 151
  E-Mail   : Norbert.Jakowski@dlr.de

- Instrument website

  TBD: impc.dlr.de

  Currently only raw plots:

  http://swaciweb.dlr.de/fileadmin/PUBLIC/VLF/VLF_NTZ.png

  http://swaciweb.dlr.de/fileadmin/PUBLIC/VLF/VLF_NTZ.svg
  (svg doesn't work with Internet Explorer)

- Instrument information
  - Science and measurement objectives

A continuous monitoring of the lower dayside ionosphere is aimed via four globally distributed VLF receivers (Global Ionospheric Flare Detection System - GIFDS). Therefore, stations in Neustrelitz/Germany, Boston/USA, Stanford/USA and Chungli/Taiwan are installed. Near real-time alerts will be provided for sudden ionospheric disturbances in the D-layer, mainly caused by solar flares. As strong solar flares can disturb communication as well as navigation signals, users of such systems shall receive alerts via Email. Selected data and further information will be integrated into the Ionospheric Monitoring and Perdiction Center (IMPC) currently under development based on the project Space Weather Application Center (SWACI).

o   Instrument descriptions

Each receiving station consists of a Perseus SDR (Software Defined Radio) receiver equipped with a MiniWhip antenna. Reliable detection of solar flares is ensured by recording multiple frequency channels ranging from 0 to 500 kHz.

o   Instrument performance specifications

The Perseus SDR is capable of providing an up to 2MHz wide part of the spectrum. The corresponding output of complex I/Q samples is processed on a PC where signal amplitudes and phases of each frequency channel are determined. For this, the I/Q samples (digitized by the SDR, port with 500 kS/s) are provided as a data stream centered around 220 kHz. A multi down-convert processor cuts selected segments out of the spectrum. This is based on overlap-save finite impulse response (FIR) filter banks that are used to obtain multiple channels of different spectral ranges. The selected spectral ranges are shifted and down-sampled to I/Q data streams at 1 kHz. Due to the smaller sampling rate and a fraction of the full bandwidth provided by the SDR, the demodulation of Minimum Shift Keying (MSK) modulated VLF signals is computationally more efficient. For demodulating MSK signals, the squared I/Q samples are locked with two PLLs onto the two signal carriers. As this is a coherent demodulation, the resulting carrier can be used for getting the bitstream and, moreover, no time synchronization is needed. Nevertheless, we are using an additional frequency clock in order to avoid thermal drifts by the internal quartz oscillator of the Perseus receiver. The resulting amplitude measurement of a VLF transmitter is stored into daily files of 1 Hz sampling rate.

o   Key/representative publications or references

Jakowski, N., Wenzel, D. (1 May 2014), Global Ionospheric Flare Detection System (GIFDS), ISWI Newsletter, Vol. 6 No. 34

Wenzel, D., Jakowski, N., Berdermann, J., Mayer, C., Valladares, C., & Heber, B. (2016). Global ionospheric flare detection system (GIFDS). Journal of Atmospheric and Solar-Terrestrial Physics, 138, 233-242.

Hoque, M. M, Wenzel, D. , Jakowski, N., Gerzen, T., Berdermann, J., Wilken, V., Kriegel, M., Sato, H., Borries, C., Minkwitz, D. (2016), Ionospheric response over Europe during the solar eclipse of March 20, 2015, Journal of Space Weather Space Climate, 6, A36, DOI: 10.1051/swsc/2016032

- o Instrument locations (longitudes and latitudes) and local points of contact (name, title, mailing and email addresses) [If it is more convenient to do so, this information can be provided in a separate document linked to the PDMP.]

  <u>Instrument location:</u> 53.33 °N, 13.07 °E

  <u>Neustrelitz / Germany (DLR Neustrelitz)</u>:

  Daniela Wenzel
  German Aerospace Center (DLR)
  Kalkhorstweg 53
  17235 Neustrelitz
  Tel.   : +49 3981 480 214
  Mail   : <u>Daniela.Wenzel@dlr.de</u>

- o Station data availability intervals

  15 min updates of daily files

Part 2: Data and format
2.1 Measurements and data products

- Measured parameters
  - o How will the measured parameters be acquired or recorded?
    - Units? Temporal & spatial resolutions?

      Smoothed 1-sec data of 8 different transmitters measured at DLR Neustrelitz (in dB)

Frequency [kHz]	Call sign	Location
20.90	HWU	46.7131 °N, 1.2444 °E
22.10	GQD	54.7318 -2.8830
23.40	DHO38	53.0789 7.6150
24.00	NAA	44.6449 -67.2816

26.70	TBB	37.4127 27.3233
37.50	NRK	63.8503 -22.4668
45.90	NSY	37.1257 14.4364
62.60	FUG	43.3868 2.0974

- o How will physical parameters be derived from measured parameters?
  - ▪ Units? Temporal & spatial resolutions?

  No derived information.

- o Processing and calibration procedures

  Measurements are calibrated in time by using an external frequency standard (LPFRS). As the measured VLF amplitude is not corrected by the sensitivity of the antenna, all measurements are relative values of the electromagnetic field at the antenna. The calibration of this measure is handled internally in the SDR.

- o Coordinate systems, software, and models used?

  Monitoring software: https://github.com/hcab14/HFMonitor

- o Quality assurance & quality control measures

  TBD

- Definitions and descriptions of higher-level instrument data products
  - o Numerical
  - o Graphical

  Not applicable.

- Data quality and caveats

  The monitoring software starts via cronjob automatically after reboot. The status of each station is saved in log-files.

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?

  ASCII

- Organization and range of data/parameters in data files?

  Daily files of 15-min updates with a sampling rate of 1 Hz are stored for each transmitter.

  Example file of NAA received in Neustrelitz (NTZ):

  ```
  # Station  = NTZ
  # Computer = Latitude E6430 : N-Series Base
  # Frequency =   24000.000 [Hz]
  # Bandwidth =   200.000 [Hz]
  # Time_UTC strength_dBm averageStrength_dBm strengthRMS_dBm
  2016-06-01 00:00:00.181283  -54.09  -96.13 -159.28
  2016-06-01 00:00:01.181312  -54.10  -96.13 -159.28
  2016-06-01 00:00:02.181106  -53.81  -95.84 -159.28
  2016-06-01 00:00:03.181148  -53.71  -95.75 -159.28
  ...
  ...
  ...
  2016-06-01 23:59:58.145200  -55.19  -97.23 -159.28
  2016-06-01 23:59:59.145206  -54.96  -97.00 -159.28
  ```

  Each file consists of a header and the measured data. The header, denoted by "#" at line begin, contains key values like receiving station (NTZ: Neustrelitz), transmitter frequency and its bandwidth. The measurements are given below. Beginning with the time stamp, referred to UTC, the signal strength, its average, as well as its RMS are listed.

- Information on how metadata will be provided with the data?

  TBD

- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.

  TBD

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?

  IMPC server at DLR Neustrelitz

- Data re-processing requirements and version control

    TBD: Version control in meta-file.

- Data back up plan

    TBD: Data is mirrored at DLR Oberpfaffenhofen

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)

    TBD

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?

    TBD: IMPC website

3.3 Policies for data access and sharing

All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Instrument Name: Global Muon Detector Network (GMDN)

Part 1: Instrument and personnel information
    Current PI and contact info
      Professor Chihiro Kato
      Physics Department, Faculty of Science, Shinshu University
      3-1-1 Asahi, Matsumoto Nagano, 390-8621
      Phone: (0263) 35-4600
      Email: ckato@shinshu-u.ac.jp

    Instrument website
      http://cosray.shinshu-u.ac.jp/crest/index.php
      http://polaris.nipr.ac.jp/~cosmicrays/en.php
      *) for Syowa station

    Instrument information
      on the web page
    Science and measurement objectives :
      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.

    Instrument descriptions
      Global Network of Muon Detectors (GNMD) is a network of
      multi-directional muon telescopes distributed in four
      countries, covering global rage of asymptotic telescope
      views.

    Instrument locations (longitudes and latitudes) and local points
    of contact (name, title, mailing and email addresses) [If it is
    more convenient to do so, this information can be provided in a
    separate document linked to the PDMP.]
      The muon telescopes that compose the GNMD are installed in
      Nagoya (Japan), Hobart (Australia), Martinho da Serra
      (Brazil) and Kuwait (Kuwait).
      Set of muon telescope and NM is installed at Syowa station (the Antarctic).

    Station data availability intervals

Part 2: Data and format
    2.1 Measurements and data products
      Data is simple count rate in counts/hour.
    2.2 Data file format and metadata
      Data is stored as ASCII format.
      Basic descriptions are on the web page

Part 3: Archiving and distribution plans
    3.1 Long-term data storage and management
        There is no definite plan for long-term data management.
    3.2 Data distribution plan
        Data is distributed as text files on the web page.
        We plan to add the information of each directional channel such
        as the barometric and temperature coefficients for the
        atmospheric corrections. We also plan to add the energy
        response and the so-called coupling coefficients which are
        necessary for deriving the cosmic ray anisotropy from the
        observed count rate data.

    3.3 Policies for data access and sharing
        Terms and conditions of data usage are described on the web page.

Instrument Name: Low-latitude Ionosphere Sensor Network (LISN)

Part 1: Instrument and personnel information

- **Current PI:** Dr. Cesar E Valladares (cev160230@utdallas.edu)
- **Other responsible personnel:** Cesar delaJara (cesar.delajara@jro.igp.gob.pe)
- **Instrument Website:** http://lisn.igp.gob.pe/
- **Instrument Type: Distributed Observatory**
- **Instrument Information:**

  LISN stands as a DASI-type array of small instruments that operates continuously as a real-time distributed observatory. The LISN observatory presently consists of 35 GPS receivers, 6 magnetometers, and 4 VIPIR ionosondes.

  Several analysis programs were implemented to identify TIDs, equatorial plasma bubbles, conjugate mid-latitude MSTIDs and large-scale TEC enhancement structures that occur during quiet and disturbed conditions.

  The association of LISN with several local universities in South America brought access to process TEC data from many GPS receivers that were deployed within the Continent under different scientific projects.

  - **Science and measurement objectives:**

    ➢ LISN was built to understand the complex day-to-day variability and the extreme state of disturbance that occurs in the South American low-latitude ionosphere.
    ➢ To assess and understand the drivers of the day-to-day variability of TEC maps over Central and South America and the Caribbean region.
    ➢ To obtain the climatology of TIDs and the range of its variability including the TID's lifetime, velocities, scale sizes, spatial extensions and other morphological parameters during tropical storms, deep convection, and jet streams.
    ➢ To examine in detail the role, if any, of GWs on seeding equatorial plasma bubbles and MSTIDs.

  - **Instrument descriptions**

    Three-axis, flux gate magnetometers
    The Vertical Incidence Pulsed Ionospheric Radar (VIPIR) ionosondes
    GPS and GNSS receivers

  - **Key/representative publications or references**

    - Valladares, C. E., and J. L. Chau (2012), The Low-Latitude Ionosphere Sensor Network: Initial results, *Radio Sci.*, 47, RS0L17, doi:10.1029/2011RS004978.
    - Valladares, C. E., and M. A. Hei, (2012), "Measurement of the Characteristics of TIDs Using Small and Regional Networks of GPS Receivers during the Campaign of 17–30 July of 2008," *International Journal of Geophysics,* vol. 2012, Article ID 548784, 14 pages, 2012. doi:10.1155/2012/548784.
    - Carrano, C. S., C. E. Valladares, and K. M. Groves, (2012) Latitudinal and Local Time Variation of Ionospheric Turbulence Parameters during the Conjugate Point

Equatorial Experiment in Brazil, *International Journal of Geophysics*, vol. 2012, Article ID 103963, 16 pages, 2012. doi:10.1155/2012/103963.

- Pradipta, R., C. E. Valladares, and P. H. Doherty (2014), GPS observation of continent-size traveling TEC pulsations at the start of geomagnetic storms, *J. Geophys. Res. Space Physics*, 119, 6913–6924, doi:10.1002/2014JA020177.

- Yizengaw, E., M. B. Moldwin, E. Zesta, C. M. Biouele, B. Damtie, A. Mebrahtu, B. Rabiu, C. E. Valladares, and R. Stoneback, (2014) The longitudinal variability of equatorial electrojet and vertical drift velocity in the African and American sectors, *Ann. Geophys.,* 32, 231-238, doi:10.5194/angeo-32-231-2014.

- Pradipta, R., C. E. Valladares, and P. H. Doherty (2015), An effective TEC data detrending method for the study of equatorial plasma bubbles and traveling ionospheric disturbances, *J. Geophys. Res. Space Physics,* 120, 11,048–11,055, doi:10.1002/2015JA021723.

- Carter, B. A., E. Yizengaw, R. Pradipta, J. M. Retterer, K. Groves, C. Valladares, R. Caton, C. Bridgwood, R. Norman, and K. Zhang (2016), Global equatorial plasma bubble occurrence during the 2015 St. Patrick's Day storm, *J. Geophys. Res. Space Physics,* 121, 894–905, doi:10.1002/2015JA022194.

- Pradipta, R., C. E. Valladares, B. A. Carter, and P. H. Doherty (2016), Interhemispheric propagation and interactions of auroral traveling ionospheric disturbances near the equator, *J. Geophys. Res. Space Physics*, 121, 2462–2474, doi:10.1002/2015JA022043.

- Pradipta, R., C. E. Valladares, and P. H. Doherty (2015), Ionosonde observations of ionospheric disturbances due to the 15 February 2013 Chelyabinsk meteor explosion, *J. Geophys. Res. Space Physics*, 120, 9988–9997, doi:10.1002/2015JA021767.

- Khadka, S. M., C. Valladares, R. Pradipta, E. Pacheco, and P. Condor (2016), On the mutual relationship of the equatorial electrojet, TEC and scintillation in the Peruvian sector, *Radio Sci.,* 51, 742–751, doi:10.1002/2016RS005966.

- Maruyama, N., Y.-Y. Sun, P. G. Richards, J. Middlecoff, T.-W. Fang, T. J. Fuller-Rowell, R. A. Akmaev, J.-Y. Liu, and C. E. Valladares (2016), A new source of the midlatitude ionospheric peak density structure revealed by a new Ionosphere-Plasmasphere model, *Geophys. Res. Lett.,* 43, 2429–2435, doi:10.1002/2015GL067312.

- Valladares, C. E., and R. Sheehan (2016), Observations of conjugate MSTIDs using networks of GPS receivers in the American sector, *Radio Sci.,* 51, doi:10.1002/2016RS005967.

- Valladares, C. E., , J. V. Eccles, Su. Basu, R. W. Schunk, R. Sheehan, R. Pradipta, J. M. Ruohoniemi, (2016), The magnetic storms of August 3-4, 2010 and August 5-6, 2011: 1. Ground and space-based observations, accepted for publication *J. of Geophys. Res*.

- Valladares, C. E., R. Sheehan, and E. E. Pacheco (2017), Observations of MSTIDs over South and Central America, *Ionospheric Space Weather Longitude and hemisphere dependences and Lower Atmosphere Forcing, Geophysical Monograph*

220, First edition. Edited by Fuller-Rowell, Yizengaw, Doherty and Basu. Published by John Wiley & Sons, Inc.

- **VIPIR ionosonde locations**

Station	Latitude (°)	Longitude (°)	Height (m)
Jicamarca	-11.950	-76.887	495
P. Maldonado	-12.590	-69.193	195
Tupiza	-21.430	-65.732	2910
Tucuman	-26.804	-65.231	453

Part 2: Data and Format
2.1 Measurements and data products

Sensor	Geophysical quantity	Associated with
GPS receiver	TEC	N
GPS receiver	Amplitude and phase scintillations	ESF
GPS receiver	TEC depletion	ESF
GPS receiver	TEC perturbation	TID, AGW
Dynasonde	Virtual height vs. frequency	dh/dN, AGW
Dynasonde	Ordinary and extraordinary modes	N, redundantly
Dynasonde	Echo-locations	dN/dx, dN/dy
Dynasonde	Vector Velocity	Ex, Uy, Ez
Dynasonde	Phase structure function	$dN/N_{1\ km}$, spectral index ν
Fluxgate magnetometer	3D magnetic field	B

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management
  ➢ The data are freely available for download at http://lisn.igp.gob.pe

3.2 Data distribution plan
  ➢ The datasets are freely available. Data are uploaded in a near-real-time basis. GPS, magnetic field and ionosondes files are available on-line and off-line basis.

Instrument Name: Magnetic Data Acquisition System (MAGDAS)

Part 1: Instrument and personnel information

- Current PI(s) and contact info

  Names: Prof. Dr. Akimasa Yoshikawa & Dr. Shuji Abe

  Affiliation: International Research Center for Space and Planetary Environmental Science (i-SPES), Kyushu University

  Address: 744, Motooka, Nishi-ku, Fukuoka, 819-0395, Japan

  Tel/Fax: +81-92-802-6240

  E-mail(s): yoshikawa.akimasa.254@m.kyushu-u.ac.jp & abeshu@i-spes.kyushu-u.ac.jp

- Other responsible personnel and contact info (e.g., instrument scientist/manager, if different from PI)

  Dr. Kirolosse Girgis

  International Research Center for Space and Planetary Environmental Science (i-SPES), Kyushu University

  744, Motooka, Nishi-ku, Fukuoka, 819-0395, Japan

  Tel/Fax: +81-92-802-6240 744

  E-mail: girgiskirolosse@i-spes.kyushu-u.ac.jp

- Instrument website

  http://data.icswse.kyushu-u.ac.jp/

- Instrument information
  - Science and measurement objectives

    MAGDAS Project is established to carry out various space weather studies. We aim to elucidate:

(1) the dynamics of the geospace plasma changes during magnetic storms and auroral substorms,
(2) the electromagnetic response of the ionosphere-magnetosphere coupling to solar wind variations, and
(3) the penetration and propagation mechanisms of the equatorial electrojet from the solar wind into the equatorial ionosphere.

o   Instrument descriptions

MAGDAS magnetometer is a three-axis ring-core type fluxgate magnetometer.

o   Instrument performance specifications

MAGDAS magnetometers measure magnetic field variations through the horizontal (H), declination (D), and vertical (Z) components. The total field (F), available at several stations since 2015, is derived from these components. GPS signals are utilized to synchronize the standard time within the data logger and transfer unit.

o   Key/representative publications or references

Yumoto, K., and the 210MM Magnetic Observation Group, The STEP 210 magnetic meridian network project, J. Geomag. Geoelectr., 48, 1297-1310., 1996.

Yumoto, K. and the CPMN Group, Characteristics of Pi 2 magnetic pulsations observed at the CPMN stations: A review of the STEP results, Earth Planets Space, 53, 981-992, 2001.

Yumoto K. and the MAGDAS Group, MAGDAS project and its application for space weather, Solar Influence on the Heliosphere and Earth's Environment: Recent Progress and Prospects, Edited by N. Gopalswamy and A. Bhattacharyya, ISBN-81-87099-40-2, pp. 309-405, 2006.

Yumoto K. and the MAGDAS Group, Space weather activities at SERC for IHY: MAGDAS, Bull. Astr. Soc. India, 35, pp. 511-522, 2007.

o   Instrument locations (longitudes and latitudes) and local points of contact (name, title, mailing and email addresses) [If it is more convenient to do so, this information can be provided in a separate document linked to the PDMP.]

The MAGDAS network stations are deployed globally. For more detailed information, please visit the project homepage:

http://data.icswse.kyushu-u.ac.jp/

o   Station data availability intervals

The station data availability intervals will be publicly accessible soon on the project homepage. In the meantime, real-time 1-day quick-look data plots are regularly available at:

http://magdas2.i-spes.kyushu-u.ac.jp/realtime/index.php .

Part 2: Data and format

2.1 Measurements and data products

- Measured parameters
  - o   How will the measured parameters be acquired or recorded?
    - ▪   Units? Temporal & spatial resolutions?

    The MAGDAS magnetometer is a fluxgate magnetometer. It initially measures the electric current in the secondary coil of the sensor. Instead of recording all measured parameters, the system converts them into physical parameters within the magnetometer's mainboard. The converted data are then recorded on compact flash data cards and transmitted online to the center's server.

  - o   How will physical parameters be derived from measured parameters?
    - ▪   Units? Temporal & spatial resolutions?

    The measured physical parameter is the ground magnetic field, representing geomagnetic field perturbations. Data are recorded in binary format using a Unix/Linux-based data logger. The MAGDAS system provides a temporal resolution of one second and a magnetic sensitivity of 0.01 nanotesla.

  - o   Processing and calibration procedures

    The instruments are calibrated by the magnetometer manufacturer, maintained through long-term operation, and validated by comparison with reference magnetometer data from Kakioka Magnetic Observatory, Japan Meteorological Agency. Data processing is conducted using UNIX/Linux systems in our laboratory when necessary.

  - o   Coordinate systems, software, and models used?

The geomagnetic coordinates system is used. Dip latitudes are calculated, based on the IGRF-12 model as of January 1, 2017, 00:00UT at an altitude of 100 km.

- Quality assurance & quality control measures

  The real-time quick-look plots (ordinary and time derivative) of the active stations are available at:

  http://magdas2.i-spes.kyushu-u.ac.jp/realtime/index.php

  These plots allow for monitoring MAGDAS data quality. The data loggers transmit measured geomagnetic field data to the center's data acquisition server every 10 minutes.

- Definitions and descriptions of higher-level instrument data products
  - Numerical

    The measured physical parameter is the ground magnetic field, representing geomagnetic field perturbations. Data are recorded in binary format using a Unix/Linux-based data logger. The MAGDAS system provides a temporal resolution of one second and a magnetic sensitivity of 0.01 nanotesla.

  - Graphical

    The daily real-time quick-look plots of the active stations are publicly available at http://magdas2.i-spes.kyushu-u.ac.jp/realtime/index.php.

- Data quality and caveats

  The real-time quick-look plots (ordinary and time derivative) of the active stations are available at:

  http://magdas2.i-spes.kyushu-u.ac.jp/realtime/index.php

  These plots allow for monitoring MAGDAS data quality. The data loggers transmit measured geomagnetic field data to the center's data acquisition server every 10 minutes.

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?

We adopt the IAGA 2002 Data Exchange Format (for more details, please visit https://www.ngdc.noaa.gov/IAGA/vdat/IAGA2002/iaga2002format.html).

- Organization and range of data/parameters in data files?

  The magnetometer data from each station is recorded in a single file per day.

- Information on how metadata will be provided with the data?

  We adopt the IUGONET metadata format (Inter-university Upper Atmosphere Observation NETwork. For more details, please visit http://www.iugonet.org/).

- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.

  The IUGONET metadata format is based on the SPASE format.

Part 3: Archiving and distribution plans

3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?

  MAGDAS data are stored in RAID servers of the International Research Center for Space and Planetary Environmental Science (i-SPES), Kyushu University.

- Data re-processing requirements and version control

  The data are re-processed if required. The version control is unimplemented.

- Data backup plan

  Data are backed up in several media, mirrored RAID server, external HDDs, and optical disks.

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)

  PI Names: Prof. Dr. Akimasa Yoshikawa & Dr. Shuji Abe

  Affiliation: International Research Center for Space and Planetary Environmental Science (i-SPES), Kyushu University

  Address: 744, Motooka, Nishi-ku, Fukuoka, 819-0395, Japan

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E-mail(s): yoshikawa.akimasa.254@m.kyushu-u.ac.jp & abeshu@i-spes.kyushu-u.ac.jp

3.2 Data distribution plan

How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?

The real-time quick-look plots (ordinary and time derivative) are publicly available at http://magdas2.i-spes.kyushu-u.ac.jp/realtime/index.php. All MAGDAS data are available upon request. We are currently developing web-based data sharing system which will be accessible in the near future. A subset of MAGDAS data had been accessible through the ERG Science Center (for more details, please visit http://ergsc.isee.nagoya-u.ac.jp/), recorded as CDF format. Metadata of MAGDAS data had been publicly available through IUGONET.

3.3 Policies for data access and sharing

All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Instrument Name: Optical Mesosphere Thermosphere Imager (OMTIs)

Part 1: Instrument and personnel information

- Current PI and contact info

  Kazuo Shiokawa

  Institute for Space-Earth Environmental Research (ISEE), Nagoya University

  Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan

  tel: +81-52-747-6419   fax: +81-52-747-6323

  e-mail: shiokawa@nagoya-u.jp

- Other responsible personnel and contact info (e.g., instrument scientist/manager, if different from PI)

  Yuichi Otsuka

  Institute for Space-Earth Environmental Research (ISEE), Nagoya University

  Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan

  tel: +81-52-747-6317   fax: +81-52-747-6323

  e-mail: otsuka@isee.nagoya-u.ac.jp

- Instrument website

    https://stdb2.isee.nagoya-u.ac.jp/omti/

- Instrument information
    - Science and measurement objectives

      The Optical Mesosphere Thermosphere Imagers (OMTIs) are introduced to understand dynamical variations of the Earth's mesosphere, thermosphere and ionosphere on global scale from polar to equatorial regions.

    - Instrument descriptions

      The OMTIs consist of more than twenty all-sky airglow/aurora imagers, five Fabry-Perot interferometers (FPIs), three meridian scanning photometers, and four airglow temperature photometers.

- Instrument performance specifications

  The OMTIs instruments measure two-dimensional pattern, Doppler wind, and temperature through airglow emissions from oxygen (wavelength: 557.7 nm) and OH (near infrared band) in the mesopause region (80-100 km) and from oxygen (630.0 nm) in the thermosphere/ionosphere (200-300 km).

- Key/representative publications or references

  Shiokawa, K., Y. Katoh, M. Satoh, M. K. Ejiri, T. Ogawa, T. Nakamura, T. Tsuda, R. H. Wiens, Development of optical mesosphere thermosphere imagers (OMTI), Earth, Planets, and Space, 51, 887-896, 1999.

  Shiokawa, K., T. Kadota, Y. Otsuka, T. Ogawa, T. Nakamura, and S. Fukao, A two-channel Fabry-Perot interferometer with thermoelectric-cooled CCD detectors for neutral wind measurement in the upper atmosphere, Earth Planets Space, 55, 271-275, 2003.

  Shiokawa, K., Y. Otsuka, S. Suzuki, T. Katoh, Y. Katoh, M. Satoh, T. Ogawa, H. Takahashi, D. Gobbi, T. Nakamura, B. P. Williams, C.-Y. She, M. Taguchi, and T. Shimomai, Development of airglow temperature photometers with cooled-CCD detectors, Earth Planets Space, 59, 585-599, 2007.

  Shiokawa, K., Y. Otsuka, and T. Ogawa, Propagation characteristics of nighttime mesospheric and thermospheric waves observed by optical mesosphere thermosphere imagers at middle and low latitudes, Earth Planets Space, 61, 479-491, 2009.

  Shiokawa, K., Y. Otsuka, S. Oyama, S. Nozawa, M. Satoh, Y. Katoh, Y. Hamaguchi, Y. Yamamoto and J. Meriwether, Development of low-cost sky-scanning Fabry-Perot interferometers for airglow and auroral studies, Earth Planets Space, vol.64, no.11, 1033-1046, 2012.

- Instrument locations (longitudes and latitudes) and local points of contact (name, title, mailing and email addresses) [If it is more convenient to do so, this information can be provided in a separate document linked to the PDMP.]

  The OMTIs are in automatic operation at various countries, e.g., at Norway, Australia, Indonesia, Thailand, Russia, Japan, Canada, and Nigeria. Detailed locations and points of contact are available at https://stdb2.isee.nagoya-u.ac.jp/omti/.

  Station data availability intervals

This information is available at https://stdb2.isee.nagoya-u.ac.jp/omti/, including quick-look data plots and 1-hour values of sky conditions.

Part 2: Data and format
2.1 Measurements and data products

- Measured parameters and data products
  - How will the measured parameters be acquired or recorded?
    - Units? Temporal & spatial resolutions?

    All the original measured parameters are recorded by Windows PC in binary format. Temporal and spatial pixel information are available at https://stdb2.isee.nagoya-u.ac.jp/omti/.

  - How will physical parameters be derived from measured parameters?
    - Units? Temporal & spatial resolutions?

    The airglow images are originally in unit of count, and can be converted to the unit of Rayleighs. The Fabry-Perot interferometer data are in ASCII, in unit of m/s (wind) and Kelvin (temperature).   The photometer data are in unit of Rayleighs. The rotational temperature is in unit of Kelvin. Temporal and spatial pixel information are available at https://stdb2.isee.nagoya-u.ac.jp/omti/.

    Processing and calibration procedures

    Calibration of the instruments are done by using optical calibration facilities in the National Institute of Polar Research, Japan. The data are automatically processed by UNIX/Linux computers.

  - Coordinate systems, software, and models used?

    The raw airglow image data are in all-sky coordinates.   They can be converted to the geographical coordinates.

  - Quality assurance & quality control measures

    Quick-look plots and 1-hour sky condition status are available at https://stdb2.isee.nagoya-u.ac.jp/omti/ as measures of data quality.

- Definitions and descriptions of higher-level instrument data products
  - Numerical

    The airglow images are originally in unit of count, and can be converted to the unit of Rayleighs. The Fabry-Perot interferometer data are in ASCII, in

unit of m/s (wind) and Kelvin (temperature). The photometer data are in unit of Rayleighs. The rotational temperature is in unit of Kelvin.

- o Graphical

  Quick-look plots are available at https://stdb2.isee.nagoya-u.ac.jp/omti/. They are one plot per one-day for each instrument.

- Real-time space weather data products
  - o Product descriptions
  - o Method of acquisition and processing
  - o Data format
  - o Storage, distribution and access methods

  OMTI data is not real-time data products. It usually takes 1-2 days after the observation to produce quick-look plots.

- Data quality and caveats

  Quick-look plots and 1-hour sky condition status are available at https://stdb2.isee.nagoya-u.ac.jp/omti/ as measures of data quality.

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?

  All-sky imager data are available in both binary and CDF format. Other instrument data are in ASCII format.

- Organization and range of data/parameters in data files?

  All-sky imager data are one file per one image. Other instruments are one file per one night data.

- Information on how metadata will be provided with the data?

  Metadata of OMTIs is opened through IUGONET at http://www.iugonet.org/.

- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.

  The IUGONET metadata format including that of OMTIs is basically compatible to the SPASE format.

Part 3: Archiving and distribution plans

3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?

    The OMTIs data are stored in a data server (raid storages) of the Institute for Space-Earth Environmental Research (ISEE), Nagoya University.

- Data re-processing requirements and version control

    CDF data of airglow images are version controlled.

- Data back up plan

    Data are backed up in several outside media, such as optical disks.

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)

    Kazuo Shiokawa

    Institute for Space-Earth Environmental Research (ISEE), Nagoya University

    Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan

     tel: +81-52-747-6419   fax: +81-52-747-6323

     e-mail: shiokawa@nagoya-u.jp

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?

    Metadata of OMTIs have been opened through IUGONET at http://www.iugonet.org/. The quick-look plots of the OMTIs have been opened through https://stdb2.isee.nagoya-u.ac.jp/omti/.   The CDF data of airglow images have been opened through the ERG Science Center at http://ergsc.isee.nagoya-u.ac.jp/.   Other digital data are available on request.

3.3 Policies for data access and sharing

All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Instrument Name: Realistic Ionosphere (RI)

Part 1: Instrument and personnel information

- Current PIs and contact info

  Ivan Galkin

  University of Massachusetts Lowell

  Lowell GIRO Data Center

  600 Suffolk Street, Suite 315

  Lowell, MA 01854

  Tel. (978) 934-4912

  e-mail: Ivan_Galkin@uml.edu

  Bodo Reinisch

  Lowell Digisonde International, LLC

  175 Cabot St, Suite 200

  Lowell, MA 01854

  Tel. (978) 735-4752

  e-mail: Bodo.Reinisch@digisonde.com

- Instrument website

  http://giro.uml.edu

- Instrument information
  - *Science and measurement objectives*
    The Realistic Ionosphere (RI) provides accurate and prompt 24/7 nowcast of the 3D global plasma density distribution in the subpeak ionosphere

  - *Instrument descriptions*
    RI includes several sensing, modeling, and computer science components:

    - ❖ **GIRO: Global Ionosphere Radio Observatory [1]**

      A multi-nation coordinated network of ionosondes providing near-real-time (nRT) low-latency measured data of the subpeak ionospheric plasma density, including raw and derived data products:
      - vertical and oblique ionogram data and displays,
      - ionogram-derived autoscaled and validated records of electron density profiles, and standard URSI characteristics (foF2, hmF2, etc.),
      - skymaps of signal propagation,
      - plasma drift bulk velocities,
      - local tilts of the ionosphere, and
      - measurements of Traveling Ionospheric Disturbances (TIDs).

      Open Data Portal: giro.uml.edu

    - ❖ **IRTAM 3D: IRI-based Real-Time Assimilative Model [2]**

A global 3D empirical nowcast of the subpeak ionospheric plasma density based on a Real-Time IRI technique of smooth transformation of the background International Reference Ionosphere (IRI) climatological model into the optimal match with GIRO measurements. The IRTAM 3D updates are issued every 15 minutes with a 7.5 minute latency from the GIRO start of ionogram measurements.

Latest 24 hours of IRTAM Ionosphere: http://giro.uml.edu/IRTAM
Retrospective IRTAM database: http://giro.uml.edu/GAMBIT

❖ **TID Explorer (TIDx) [3,4]**

Based on Doppler-Frequency-Angular Sounding (FAS) sensing method [5] between two Digisonde DPS4D instruments, TID Explorer provides nowcast and forecast of traveling ionospheric disturbances: natural or artificial phenomena associated with the wave-like perturbation of plasma density in response to propagation of the acoustic gravity waves in the neutral atmosphere. The FAS method allows full specification of the TID ensemble, including its amplitude, period, and the K vector of propagation.

TID Explorer: https://lgdc.uml.edu/tidx
Pan-European TID Warning System: http://tid.space.noa.gr

❖ **Sky-LITE: Skymapping for Local Ionosphere Tilt Evaluation [6]**

Use of HF skymapping technology for a wide-angle sensing of the ionospheric plasma structures to determine local tilts of isodensity surfaces in the ionosphere and bulk velocity of plasma drift.

Plasma Drift Database: http://ulcar.uml.edu/DriftBase

❖ **RayTRIX: Ray-Tracing through Realistic Ionosphere eXplorer [6]**

HF signal raytracing through the ionospheric channel specified by IRTAM, Sky-LITE and TIDx

RayTRIX Oblique Ionogram Synth: http://giro.uml.edu/rix/oi-synth/
RayTRIX AoA computer: http://giro.uml.edu/rix/ff-aoa/

❖ **LGDC: Lowell GIRO Data Center**

A collection of computer software, database engines, and computer infrastructure for computations associated with ReI nowcast and warning services, and open international data access for academia, students, radio enthusiasts, and space weather applications. Over 600 million records of

sounding data available over GIRO Web Portal. Online interactive data explorer workstations with capability to submit derived and annotation value-added information to LGDC.

o Instrument performance specifications

Ionosondes of various instrument designs and models comprise GIRO network. All of the systems operate in the vertical-incidence ionogram mode and automatically scale recorded ionogram images to extract standard URSI characteristics for subsequent near-real-time assimilation at LGDC into IRTAM 3D model: (a) critical frequency foF2, (b) F2 layer peak height hmF2, and electron density profile shape parameters (c) B0 and (d) B1.

Additionally, Digisonde DPS4D models are operating in the synchronized bistatic mode to measure properties of the oblique-sounding signal to then detect and evaluate TID activity at the mid-point between cooperating instruments. Local Doppler skymap measurements are made by Digisonde 256, DPS4, and DPS4D models for computation of ionosphere tilt and overhead bulk drift velocity.

All model computations are performed by real-time processors at LGDC.

o Key/representative publications or references

1. *Reinisch, B. W., and I. A. Galkin*. **Global ionospheric radio observatory (GIRO)**, EPS, 63, 377-381, doi:10.5047/eps.2011.03.001, 2011.
2. *Galkin, I.A., B.W. Reinisch, X. Huang, and D. Bilitza*. **Assimilation of GIRO Data into a Real-Time IRI** Radio Science, 47, RS0L07, doi:10.1029/2011RS004952, 2012.
3. *Reinisch, B.W., I.A. Galkin, A. Belehaki, et al.* **Pilot ionosonde network for identification of travelling ionospheric disturbances**, accepted to Radio Science (2018).
4. *Verhulst, T., D. Altadill, J. Mielich, B. Reinisch, I. Galkin, A. Mouzakis, A. Belehaki, D. Buresova, S. Stankov, E. Blanch, D. Kouba*. **Vertical and oblique HF sounding with a network of synchronised ionosondes**, Adv. Space Res., doi:10.1016/j.asr.2017.06.033, 2017.
5. *Paznukhov, V.V., V.G. Galushko, and B.W. Reinisch*. **Digisonde observations of TIDs with frequency and angular sounding technique**, Adv. Space. Res., 49(4), 700-710, doi:10.1016/j.asr.2011.11.012, 2012.
6. *Huang, X. and B.W. Reinisch*. **Real time HF raytracing through a tilted ionosphere**, Radio Sci., 41(5), RS5S47, 10.1029/2005RS003378, 2006.

o Instrument locations (longitudes and latitudes) and local points of contact (name, title, mailing and email addresses)

GIRO station list (see Appendix A) grows continuously as new instruments join the observatory. Up-to-date list (100 locations as of March 2018) is available at

♦ https://lgdc.uml.edu/common/DIDBFastStationList

Local point of contact can be found in

- ♦ http://umlcar.uml.edu/DIDBase/Acknowledgements.htm

- o Station data availability intervals

Data availability varies per instrument; up-to-date calendar lists and date intervals are available at LGDC via database servlet calls to

- ♦ https://lgdc.uml.edu/common/DIDBStationList
- ♦ https://lgdc.uml.edu/common/DFDBStationList

and database browsing queries in SAO and Drift Explorer software.

Part 2: Data and format
2.1 Measurements and data products

- Measured parameters and data products

Instrument Model	Raw measurement	Raw data product	Data products derived automatically onsite
Digisonde DPS4D	Signal amplitude, phase, angle of arrival (AoA), virtual height, Doppler frequency, polarization for the strongest Doppler line of spectrum	Vertical-incidence (VI) Ionogram	Autoscaled standard URSI characteristics, ionogram traces, vertical Electron Density Profile (EDP), vertical ionospheric TEC, Table of Maximum Usable Frequencies (MUF)
		Oblique-incidence (OI) Ionogram	(In progress)
	Amplitude, phase, virtual height, polarization for full Doppler Spectra in 4 channels of reception	VI Doppler spectra	Vertical Echo Skymap (AoA), Bulk drift velocity for E and F regions, Local Tilt Angle of ionosphere
		OI Doppler spectra	Narrowband HF CW beacon signal properties: Doppler frequency, AoA
Digisonde DPS4	Same as DPS4D	VI Ionogram	Same as DPS4D
	Same as DPS4D	VI and OI Doppler spectra of signal	Same as DPS4D
Digisonde 256	Same as DPS4D	VI Ionogram	Same as DPS4D
INGV-AIS	-	-	Autoscaled standard URSI characteristics, ionogram traces, vertical EDP
IPS-5A	-	-	
VISRC2	-	-	
Dynasonde	-	-	

- o How will the measured parameters be acquired or recorded?
  - ▪ Units? Temporal & spatial resolutions?

Measurement schedules vary by location; 15 minute cadence of VI ionograms is nominal, but 5 minute resolution is getting common. Combined VI and OI ionograms are recorded by DPS4D. TID detection requires 20-sec measurements at high cadences of 2 or 2.5 min. Local tilt and plasma velocities are commonly measured at 5-15 minute cadence.
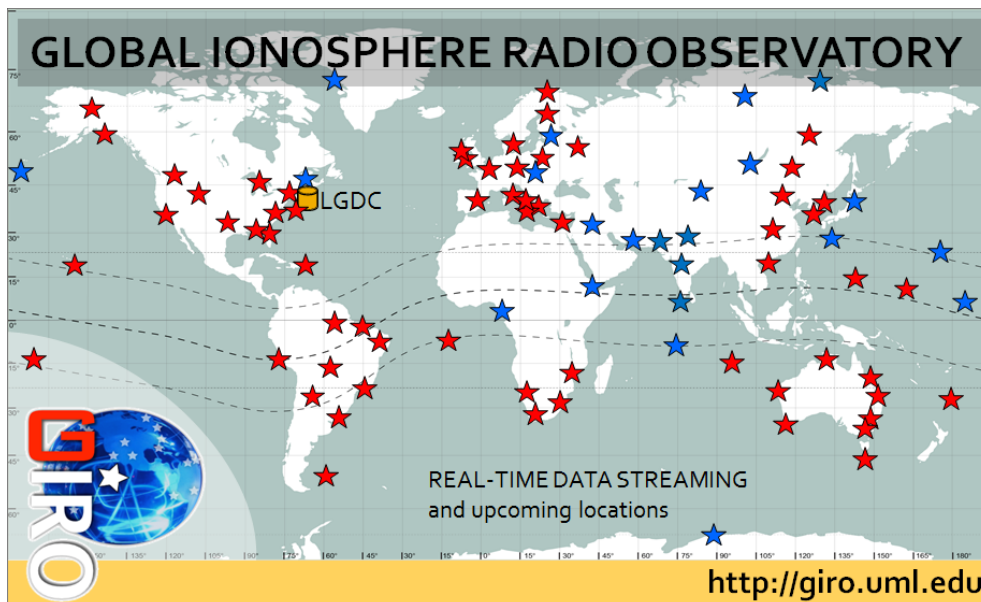
Fig. Spatial resolution of GIRO observations: currently operating real-time systems (red stars) and upcoming locations (blue stars)

- o How will physical parameters be derived from measured parameters?
  - ▪ Units? Temporal & spatial resolutions?

  RI is a fully automated facility with physical parameters derived using intelligent computer systems for data interpretation and real-time processors running both onsite and at LGDC. Data assimilation, ray-tracing, and TID warning algorithms operate at LGDC.

- o Processing and calibration procedures

Instrument	Data product	Software	Operating mode
Digisondes	Autoscaled standard URSI characteristics, ionogram traces, vertical Electron Density Profile (EDP)	ARTIST	Onsite
INGV-AIS		AUTOSCALA	
IPS-5A			
VISRC2			
Dynasonde		DSND	
Digisondes	Manual validation of VI ionogram autoscaling	SAO Explorer	Office workstation
	ARTIST error bar evaluation	ASQ	
Digisondes	Vertical Echo Skymap (AoA)	DriftExplorer	Onsite
	Bulk drift velocity for E and F regions	DDAV	
	Local Tilt Angle of ionosphere	SkyLITE	

All systems	IRTAM-3D plasma density distribution	IRTAM RealTimer	LGDC / GAMBIT
Digisonde DPS4D	TID detection, evaluation, and warning report	TID RealTimer	LGDC / TIDBase

- o Coordinate systems, software, and models used?

  IRI and IGRF models are used during data analysis for background specification.

- o Quality assurance & quality control measures

  Incoming data dispatcher uses QA test and checks for all incoming measurement data. Database ingestion software checks values for allowed range of variability.

- Definitions and descriptions of higher-level instrument data products
  - o Numerical

Data Product	Access Level	Software
Digisonde ionograms in DIDBase and Mirror GIRO servers	Expert read/write, interactive, editor function	SAO Explorer
Ionogram-derived data in DIDBase (standard URSI characteristics, ionogram traces, vertical EDP, MUF)	Expert read/write, interactive	SAO Explorer
	Automatic dissemination	FTP
	Online retrieval	DIDBGetValues applet with access via http://giro.uml.edu/didbase/scaled.php
IRTAM 3D in GAMBIT database	User, interactive	GAMBIT Explorer UserApp
	Expert, interactive	GAMBIT Explorer MasterApp
	Online retrieval	gambit-coeffs applet
Plasma drift data in DriftBase	Expert, interactive	Drift Explorer
TID records in TIDBase	User, interactive, online	TID Explorer
	Online retrieval	tid-detector and track-info applets
RayTRIX: oblique ionogram synthesizer	Online retrieval	rix/oi-synth applet
RayTRIX: OI skymapping	Online retrieval	rix/ff-aoa applet

- o Graphical

Data Product	Visualization	Software or Webpage
Digisonde ionograms and ionogram-derived data in DIDBase	Ionogram images, contour plots, directograms, profilograms, time series	SAO Explorer
	Ionogram image browser	DIDBase Web Portal, http://ulcar.uml.edu/DIDBase/
	Latest 24-hour ionogram animations	GIRO Ionogram Movies page at http://giro.uml.edu
IRTAM 3D in GAMBIT Database	Interactive Earth globe views and animations	GAMBIT Explorer
	IRTAM latest 24-hour animations	IRTAM home page at http://giro.uml.edu/IRTAM/

Data Product	Visualization	Software or Webpage
Plasma drift data in DriftBase	Raw data 4-channel charts and waterfalls, skymaps, drift velocity charts	Drift Explorer
	Skymap and drift velocity chart browser	DriftBase Web Portal at http://ulcar.uml.edu/DriftBase/
RayTRIX: oblique ionogram synthesizer	Synthesized OI ionogram image	rix/oi-synth applet at http://giro.uml.edu/
RayTRIX: OI skymapping	Synthesized OI skymap image	rix/ff-aoa applet at http://giro.uml.edu/
OI skymaps in D2Dbase for TID analysis	Recorded OI skymap image	DUX and Sky6
TID records in TIDBase	Track and TID timelines	TID Explorer at https://lgdc.uml.edu/tidx
	TID Warning system	http://tid.space.noa.gr

- Real-time space weather data products
  - Product descriptions
    - **Realistic Ionosphere weather maps**: 2D global IRTAM surface maps of critical frequency foF2, peak height hmF2, and profile shape parameters B0 and B1, released at 15 minute cadence with 7.5 minute latency from the sensor measurement start; download the 2D map expansion coefficients from LGDC for input to IRI-2017 model to produce 3D volume electron density nowcast.
    - **TID Detection, Evaluation, and Warning Report:** pilot Pan-European TID Warning and Mitigation project "TechTIDE" at http://techtide.space.noa.gr/.
    - **GIRO Data Repositories in real-time:** access to raw and derived ionosonde data products for the real-time subset of GIRO network locations using LGDC databases access portals and software.
    - **RayTRIX:** raytracing numerical modeling applications based on Realistic Ionosphere nowcast.
  - Method of acquisition and processing

    Data analysis requires intelligent systems and numerical computations too resource-demanding to operate at the instrument locations. Data are therefore delivered over FTP/SFTP protocols to Lowell GIRO Data Center for post-processing using its computing facilities. Data latency varies by location and usually does not exceed a few minutes. Releases of IRTAM nowcast are done at 7.5 minute of each quarter of the hour.

  - Storage, distribution and access methods

    All real-time weather records are kept at LGDC in various databases and provided with an applet server for client-pull distribution over HTTPS using RESTFul resource locators.

  - Data format

For compatibility with commonly used IT regulations, real-time data products are released in plain ASCII over HTTPS in form of expansion coefficients (maps) or tabulations (characteristics). Release of the binary GIRO data products is possible in limited quantities via LGDC ftp server for download per user selection. These data products are stored in digisonde-specific format (raw data) or standard URSI format for ionosonde data exchange (ionogram-derived data).

- Data quality and caveats

Over 90% of all ionogram-derived records in GIRO are produced by intelligent computer systems for ionogram autoscaling, known for their occasional mistakes of the image interpretation, especially during periods of elevated geospace activity. It is recommended to use GAMBIT database at LGDC that holds maps of ionospheric characteristics computed using custom data conditioning algorithms for protection against autoscaling data noise. In those applications that demand high resolution and accuracy of the ionospheric specification, and especially for case-by-case comparison studies involving Realistic Ionosphere as the ground truth reference, the users are strongly advised to manually validate the automatic ionogram interpretation and then request reanalysis of RI to avoid discrepancies.

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?

LGDC does not maintain data file repositories; all records are stored in databases. Software tools and online web portals are used to access the database contents:

The ionogram-derived data can be provided in two different flavors of the SAO standard for ionosonde data exchange, SAO 4 and SAO 5; see format descriptions at http://ulcar.uml.edu/SAOXML and http://ulcar.uml.edu/~iag/SAO-4.3.htm.

Most of other public data distributions are arranged via HTTPS downloads rather than files, in which case plain ASCII format is used. This includes IRTAM coefficients in GAMBIT database, time series of ionospheric characteristics, RayTRIX simulations, and TID detection/warning reports.

Expert-level explorer software can be used to export various data presentations in text form and save copies of raw and derived ionosonde data. Binary ionosonde formats are proprietary, see http://digisonde.com/dps-4dmanual.html for their descriptions. For software downloads, see http://ulcar.uml.edu/downloads.html.

- Organization and range of data/parameters in data files?

All data are stored in relational databases at LGDC and provided with software for access over the Internet. Organization of data in databases allows automatic quality control of information for range, content, and integrity at the time of ingestion. Comprehensive descriptions of data content are stored in the auxiliary tables and dictionaries of the databases that can be queried by identificator labels attached to the measurement records.

- Information on how metadata will be provided with the data?

  Self-describing data model and format (XML) are used where possible. Ionogram-derived data records underwent comprehensive parameter-level ISO 19156 Observations and Measurements registration. Custom metadata dictionaries for these records are stored at http://espas.spaceweatherservices.com.

- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.

  ISO 19156 space physics domain ontology and specific metadata descriptions for ionogram-derived data records were developed during ESPAS project, available at https://www.espas-fp7.eu/portal/ (select Assets – Vertical Ionosonde – Observed Properties).

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?

  Lowell GIRO Data Center manages all RI data collections:
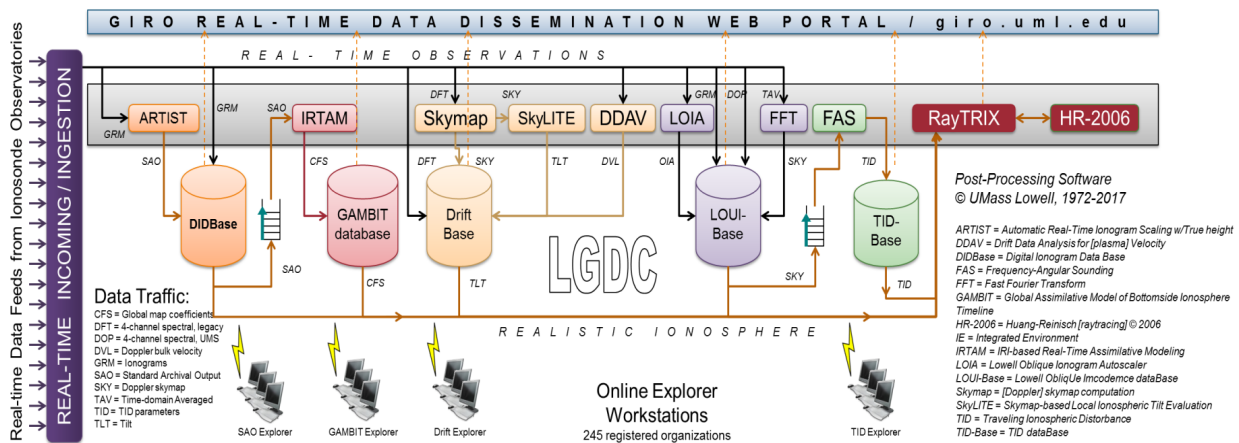
- Data re-processing requirements and version control

As new analysis algorithms emerge, reanalysis of original measurements to produce new releases of higher-level data products is conducted. LGDC databases are designed to keep multiple versions of reprocessing results for comparisons. Each derived product is tagged with analysis software version, human/robot tag, and in most cases, an estimated confidence level and uncertainty metrics.

- Data back up plan

  Incoming raw data files are preserved and delivered to GIRO Mirror sites in Europe, Africa, and China. Weekly local backups of LGDC databases are made to preserve raw and automatically-derived data products. Manual analysis results are copied daily.

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)

  LGDC Primary contact: Dr. Ivan A. Galkin, up-to-date SPASE record at VHO.

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?

  Multiple ways to publicly access RI data over the Internet using GIRO web portal at http://giro.uml.edu and expert-level explorer software available for download at http://ulcar.uml.edu/downloads.html. RI access license is "Free for academic use, with attribution", see LGDC Rules of the Road for additional details on co-authorship clause and acknowledgements:

  http://umlcar.uml.edu/DIDBase/RulesOfTheRoadForDIDBase.htm

3.3 Policies for data access and sharing
All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Appendix A. GIRO Station List as of March 12, 2018

#	URSI	STATION NAME	CITY	COUNTRY	LAT	LONG	CONTACT PERSON
1	AH223	AHMEDABAD	AHMEDABAD	INDIA	23	72.5	Prof. D. Pallamraju Physical Research Laboratory (PRL), Navrangpura, Ahmedabad 380 009, India raju@prl.res.in
2	AL945	ALPENA	ALPENA, MI	USA	45.07	276.44	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
3	AN438	ANYANG	ANYANG	SOUTH KOREA	37.39	126.95	Radio Research Laboratory (RRL) site decomissioned, archived data only
4	AS00Q	ASCENSION ISLAND	GEORGETOWN	ASCENSION ISLAND	-7.95	345.6	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
5	AT138	ATHENS	ATHENS	GREECE	38	23.5	Dr. Ioanna Tsagouri National Observatory of Athens (NOA), Metaxa and Vas. Pavlou Str., P. Penteli 15236, Greece tsagouri@space.noa.gr
6	AU930	AUSTIN	AUSTIN, TX	USA	30.4	262.3	Dr. Terence Bullett AFWA DISS Program, NGDC/CIRES: Space Weather Observations and Applications 325 Broadway Str, Boulder, CO, 80305, USA terry.bullett@noaa.gov
7	BP440	BEIJING	BEIJING	CHINA	40.3	116.2	Dr. Baiqi Ning Institute of Geology and Geophysics (IGG) CAS No. 19, Beitucheng Western Road, Chaoyang District, 100029, Beijing, P.R.China nbq@mail.iggcas.ac.cn
8	BLJ03	BELEM	BELEM	BRAZIL	1.43	48.44	Dr. Inez Staciarini Batista National Institute for Space Research (INPE) Av. dos Astronautas, 1758 Jardim da Granja 12201-970 Sao José dos Campos, SP, Brazil inez.batista@inpe.br
9	BJJ32	BERMUDA	ST. DAVID'S IS.	BERMUDA	32.4	295.3	Air Force Weather Agency (AFWA) site decomissioned, archived data only
10	BVJ03	BOA VISTA	BOA VISTA	BRAZIL	2.8	299.3	Dr. Inez Staciarini Batista National Institute for Space Research (INPE) Av. dos Astronautas, 1758 Jardim da Granja 12201-970 Sao José dos Campos, SP, Brazil inez.batista@inpe.br
11	BC840	BOULDER	BOULDER, CO	USA	40	254.7	Dr. Terence Bullett AFWA DISS Program, NGDC/CIRES: Space Weather Observations and Applications 325 Broadway Str, Boulder, CO, 80305, USA terry.bullett@noaa.gov
12	BR52P	BRISBANE	BRISBANE	AUSTRALIA	-27.06	153.06	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
13	BV53Q	BUNDOORA	MELBOURNE	AUSTRALIA	-37.7	145.05	La Trobe University site decomissioned, archived data only
14	CXM9B	CACHIMBO	CACHIMBO	BRAZIL	-9.5	305.2	Dr. Inez Staciarini Batista National Institute for Space Research (INPE) Av. dos Astronautas, 1758 Jardim da Granja 12201-970 Sao José dos Campos, SP, Brazil inez.batista@inpe.br
15	CAJ2M	CACHOEIRA PAULISTA	CACHOEIRA PAULISTA	BRAZIL	-22.7	315	Dr. Inez Staciarini Batista National Institute for Space Research (INPE) Av. dos Astronautas, 1758 Jardim da Granja 12201-970 Sao José dos Campos, SP, Brazil inez.batista@inpe.br
16	CN53L	CAMDEN	CAMDEN	AUSTRALIA	-34.05	150.67	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
17	CGK21	CAMPO GRANDE	CAMPO GRANDE	BRAZIL	-20.5	305	Dr. Inez Staciarini Batista National Institute for Space Research (INPE) Av. dos Astronautas, 1758 Jardim da Granja 12201-970 Sao José dos Campos, SP, Brazil inez.batista@inpe.br
18	CB53N	CANBERRA	CANBERRA	AUSTRALIA	-35.32	149	Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
19	CH833	CHERRY	CHERRY, NM	USA	32.9	253.59	Dr. Torreon Creekmore IARPA HFGeo Program Manager Intelligence Advanced Research Projects Activity (IARPA) 5850 University Research Court, Riverdale Park, MD 20737, USA torreon.creekmore@iarpa.gov
20	RL052	CHILTON	CHILTON	UK	51.5	359.4	Dr. Ruth Bamford Rutherford Appleton Laboratory (RAL) : RAL Space : STFC Chilton, Oxfordshire OX11 0QX, United Kingdom R.A.Bamford@rl.ac.uk
21	CS31K	COCOS ISLAND	COCOS ISLAND	AUSTRALIA	-12.18	96.83	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
22	CO764	COLLEGE	COLLEGE, AK	USA	64.9	212	Air Force Weather Agency (AFWA) site decomissioned, archived data only

23	CS839	COLORADO SPRINGS	COLORADO SPRINGS, CO	USA	39	255.12	Air Force Weather Agency (AFWA) site decomissioned, archived data only
24	DW41K	DARWIN	DARWIN	AUSTRALIA	-12.45	130.95	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
25	DB049	DOURBES	DOURBES	BELGIUM	50.1	4.6	Dr. Stanimir Stankov Royal Meteorological Institute, RMI Geophysical Center (IRM-CPG) R Centre Physique 1, B-5670 Dourbes-Viroinval, Belgium s.stankov@meteo.be
26	DS932	DYESS AFB	ABILENE, TX	USA	32.4	260.2	Air Force Weather Agency (AFWA) site decomissioned, archived data only
27	EG931	EGLIN AFB	VALPARAISO, FL	USA	30.5	273.5	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
28	EI764	EIELSON AFB	MOOSE CREEK, AK	USA	64.66	212.93	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
29	TR170	EISCAT TROMSO	TROMSO	NORWAY	69.6	19.2	Dr. Mike T Rietveld University of Tromso, EISCAT Tromso Site Ramfjordmoen N-9027 Ramfjordbotn, Norway mike.rietveld@eiscat.uit.no
30	EA036	EL ARENOSILLO	EL ARENOSILLO	SPAIN	37.1	353.3	Dr. Benito De la Morena Carretero Instituto Nacional de Technica Aeroespacial (INTA), Área de Investigación e Instrumentación Atmosférica Ctra. San Juan del Pto - Matalascañas, Km. 34, 21130 - Mazagón, Huelva, Spain morenacb@inta.es
31	FF051	FAIRFORD	FAIRFORD	UK	51.7	358.5	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
32	FZA0M	FORTALEZA	FORTALEZA	BRAZIL	-3.9	321.6	Dr. Inez Staciarini Batista National Institute for Space Research (INPE) Av. dos Astronautas, 1758 Jardim da Granja 12201-970 Sao José dos Campos, SP, Brazil inez.batista@inpe.br
33	GA313	GADANKI	GADANKI	INDIA	13.46	79.17	Dr. Amit Kumar Patra National Atmospheric Research Laboratory Gadanki, Pakala Mandal, Chittoor District, Andhra Pradesh, 517122 India patra.narl@gmail.com
34	GA762	GAKONA	GAKONA, AK	USA	62.38	215	Mr. Marty Karjala HAARP Research Supervisor, University of Alaska Fairbanks (UAF) Geophysical Institute U102 GAKO Gakona (IAC), Gakona AK 99586, USA dkarjala2@alaska.edu
35	GM037	GIBILMANNA	GIBILMANNA	ITALY	37.9	14	Mr. Enrico Zuccheretti Istituto Nazionale di Geofisica e Vulcanologia (INGV), Via di Vigna Murata, 605 - 00143 Rome, Italy enrico.zuccheretti@ingv.it
36	GSJ53	GOOSE BAY	GOOSE BAY	CANADA	53.3	299.7	Air Force Weather Agency (AFWA) site decomissioned, archived data only
37	GR13L	GRAHAMSTOWN	GRAHAMSTOWN	SOUTH AFRICA	-33.3	26.5	Dr. John Bosco Habarulema South African National Space Agency (SANSA), Hospital Street, Hermanus, South Africa jhabarulema@sansa.org.za
38	GU513	GUAM	AGAFO GUMAS	USA	13.62	144.86	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
39	HA419	HAINAN	HAINAN IS.	CHINA	19.4	109	Dr. Jiankui Shi National Space Science Center (NSSC), Chinese Academy of Sciences 1 Nanertiao, Zhongguancun, Haidian District, Beijing 100190, P.R.China jkshi@nssc.ac.cn
40	HAJ43	HANSCOM AFB	BEDFORD, MA	USA	42.5	288.7	Air Force Weather Agency (AFWA) site decomissioned, archived data only
41	HE13N	HERMANUS	HERMANUS	SOUTH AFRICA	-34.42	19.22	Dr. John Bosco Habarulema South African National Space Agency (SANSA), Hospital Street, Hermanus, South Africa jhabarulema@sansa.org.za
42	HO54K	HOBART	HOBART	AUSTRALIA	-42.92	147.32	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
43	IC437	I-CHEON	I-CHEON	SOUTH KOREA	37.14	127.54	Mr. Sun-hak Hong Radio Research Agency (RRA), I-Cheon branch 370-9, Sinpil-ri, Seolseong-myeon, I-Cheon-si, Gyeonggi-do, 467-881, Korea sunhakhong@korea.kr
44	IF843	IDAHO NATIONAL LAB	IDAHO FALLS, ID	USA	43.81	247.32	Mr. James R. Hanneman Idaho National Laboratory (INL), Idaho Falls, Idaho 83415, USA james.hanneman@inl.gov
45	IL008	ILORIN	ILORIN	NIGERIA	8.5	4.5	Prof. J.O. Adeniyi University of Ilorin, P.M.B. 1515 Ilorin, Kwara State, Nigeria segun47@yahoo.com
46	IR352	IRKUTSK	IRKUTSK	RUSSIA	52.4	104.3	Dr. Konstantin G. Ratovsky Institute of Solar-Terrestrial Physics (ISTP), RAS, 126A Lermontov St., Irkutsk 664033, Russia ratovsky@iszf.irk.ru

47	JJ433	JEJU IS.	JEJU IS.	SOUTH KOREA	33.43	126.3	Mr. Sun-hak Hong Radio Research Agency (RRA), I-Cheon branch 370-9, Sinpil-ri, Seolseong-myeon, I-Cheon-si, Gyeonggi-do, 467-881, Korea sunhakhong@korea.kr
48	JI91J	JICAMARCA	JICAMARCA	PERU	-12	283.2	Digisonde Station Jicamarca Radio Observatory, P.O. Box 13-0207, Lima 13, Perú Operations@jro.igp.gob.pe
49	JR055	JULIUSRUH	JULIUSRUH	GERMANY	54.6	13.4	Mr. Jens Mielich Leibniz-Institut für Atmosphärenphysik (IAP) Hinter der Düne 3, Ortsteil Drewoldke, 18556 Altenkirchen, Germany mielich@iap-kborn.de
50	KS759	KING SALMON	KING SALMON, AK	USA	58.4	203.6	Air Force Weather Agency (AFWA) site decomissioned, archived data only
51	KI167	KIRUNA	KIRUNA	SWEDEN	67.9	20.4	Dr. Thomas Leyser The Swedish Institute of Space Physics, Box 812, SE-981 28 Kiruna, Sweden thomas.leyser@irfu.se
52	KR835	KIRTLAND AFB	ALBUQUERQUE, NM	USA	35	253.47	Dr. Eugene Dao Air Force Research Laboratory, AFRL/RVBXI, Kirtland Air Force Base 2000 Wyoming Blvd SE, Albuquerque, NM 87123, USA eugene.dao@us.af.mil
53	TO535	KOKUBUNJI	KOKUBUNJI	JAPAN	35.7	139.5	National Institute of Information and Communications Technology (NICT) site decomissioned, archived data only
54	KJ609	KWAJALEIN	KWAJALEIN	REP.MARSHALL IS.	9	167.2	Dr. Eugene Dao Air Force Research Laboratory, AFRL/RVBXI, Kirtland Air Force Base 2000 Wyoming Blvd SE, Albuquerque, NM 87123, USA eugene.dao@us.af.mil
55	LM42B	LEARMONTH	LEARMONTH	AUSTRALIA	-21.8	114.1	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
56	LV12P	LOUISVALE	LOUISVALE	SOUTH AFRICA	-28.5	21.2	Dr. John Bosco Habarulema South African National Space Agency (SANSA), Hospital Street, Hermanus, South Africa jhabarulema@sansa.org.za
57	LL721	LUALUALEI	LUALUALEI, HW	USA	21.43	201.85	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
58	MU12K	MADIMBO	MADIMBO	SOUTH AFRICA	-22.39	30.88	Dr. John Bosco Habarulema South African National Space Agency (SANSA), Hospital Street, Hermanus, South Africa jhabarulema@sansa.org.za
59	ME929	MELROSE	MELROSE, FL	USA	29.71	278	Prof. Robert Moore University of Florida, Dept. Electrical and Computer Engineering 557 New Engineering Building, Gainesville, FL 32611, USA rcmoore@ufl.edu
60	MHJ45	MILLSTONE HILL	WESTFORD, MA	USA	42.6	288.5	Dr. Bodo Reinisch Lowell Digisonde International, University of Massachusetts Lowell 175 Cabot St, Suite 200, Lowell, MA 01854 USA bodo.reinisch@digisonde.com
61	MH453	MOHE	MOHE	CHINA	52	122.52	Dr. Baiqi Ning Institute of Geology and Geophysics (IGG) CAS No. 19, Beitucheng Western Road, Chaoyang District, 100029, Beijing, P.R.China nbq@mail.iggcas.ac.cn
62	MO155	MOSCOW	MOSCOW	RUSSIA	55.47	37.3	Dr. Valery Panchenko IZMIRAN RAS, Kaluzhskoe Hwy 4, Troitsk, Moscow 108849, Russia panch@izmiran.ru
63	MU834	MUNYO	MUNYO, NM	USA	33.56	253.35	Dr. Torreon Creekmore IARPA HFGeo Program Manager, Intelligence Advanced Research Projects Activity (IARPA) 5850 University Research Court, Riverdale Park, MD 20737, USA torreon.creekmore@iarpa.gov
64	NQJ61	NARSSARSSUAQ	NARSSARSSUAQ	GREENLAND	61.2	314.6	Air Force Weather Agency (AFWA) site decomissioned, archived data only
65	NI135	NICOSIA	NICOSIA	CYPRUS	35.03	33.16	Dr. Haris Haralambous Frederick University, 7 Y. Frederickou Str., Pallouriotisa, Nicosia 1036 Cyprus eng.hh@frederick.ac.cy
66	ND61R	NIUE	ALOFI	NIUE	-19.07	-169.93	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
67	NDA81	NORD	NORD	GREENLAND	81.4	342.5	Air Force Weather Agency (AFWA) site decomissioned, archived data only
68	NI63_	NORFOLK	CASCADE, NORFOLK IS	AUSTRALIA	-29.03	167.97	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
69	NO369	NORILSK	NORILSK	RUSSIA	69.2	88	Dr. Konstantin G. Ratovsky Institute of Solar-Terrestrial Physics (ISTP) RAS, 126A Lermontov St., Irkutsk 664033, Russia ratovsky@iszf.irk.ru
70	OK426	OKINAWA	OKINAWA	JAPAN	26.68	128.15	National Institute of Information and Communications Technology (NICT) site decomissioned, archived data only
71	OL246	OLSZTYN	OLSZTYN	POLAND	53.8	20.5	Prof. Andrzej Krankowski University of Warmia and Mazury (UWM) in Olsztyn 2 Michała Oczapowskiego Str, 10-719 Olsztyn, Poland kand@uwm.edu.pl
72	SN437	OSAN AB	OSAN AB	SOUTH KOREA	37.1	127	Air Force Weather Agency (AFWA) site decomissioned, archived data only

73	PE43K	PERTH	PERTH	AUSTRALIA	-32	116.13	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
74	PSJ5J	PORT STANLEY	PORT STANLEY	FALKLAND ISLANDS	-51.6	302.1	Dr. Ruth Bamford Rutherford Appleton Laboratory (RAL) : RAL Space : STFC Chilton, Oxfordshire OX11 0QX, United Kingdom R.A.Bamford@rl.ac.uk
75	PQ052	PRUHONICE	PRUHONICE	CZECH REPUBLIC	50	14.6	Dr. Dalia Buresova Institute of Atmospheric Physics, Acad. Sciences Czech Republic, Bocni 1401a Prague, 14131 Czech Republic buresd@ufa.cas.cz
76	PA836	PT ARGUELLO	LOMPOC, CA	USA	34.8	239.5	Mr. Marc Leahy NEXION Program Manager, USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
77	THJ77	QAANAAQ	QAANAAQ	GREENLAND	77.5	290.8	Air Force Weather Agency (AFWA) site decomissioned, archived data only
78	PRJ18	RAMEY AFB	AQUADILLA	PUERTO RICO	18.5	292.9	Dr. Terence Bullett AFWA DISS Program, NGDC/CIRES: Space Weather Observations and Applications 325 Broadway Str, Boulder, CO, 80305, USA terry.bullett@noaa.gov
79	RM041	ROME	ROME	ITALY	41.8	12.5	Mr. Enrico Zuccheretti Istituto Nazionale di Geofisica e Vulcanologia (INGV) Via di Vigna Murata, 605 - 00143 Rome, Italy enrico.zuccheretti@ingv.it
80	RO041	ROME	ROME	ITALY	41.9	12.5	Mr. Enrico Zuccheretti Istituto Nazionale di Geofisica e Vulcanologia (INGV), Via di Vigna Murata, 605 - 00143 Rome, Italy enrico.zuccheretti@ingv.it
81	EB040	ROQUETES	ROQUETES	SPAIN	40.8	0.5	Dr. David Altadill Observatori de l'Ebre, Universitat Ramon Llull, CSIC, Ionospheric Department Horta Alta #38, E43520 Roquetes, Tarragona, Spain David_Altadill@obsebre.es
82	VT139	SAN VITO	BRINDISI	ITALY	40.6	17.8	Mr. Marc Leahy NEXION Program Manager USAF 557th Weather Wing SMC/RSSE, 250 S. Peterson Blvd, Bldg 1470, Peterson AFB, CO 80914, USA mark.leahy@us.af.mil
83	SMK29	SANTA MARIA	SANTA MARIA	BRAZIL	-29.73	306.29	Mr. Chunxiao Yan National Space Science Center (NSSC), Chinese Academy of Sciences 1 Nanertiao, Zhongguancun, Haidian District, Beijing 100190, P.R.China cxyan@nssc.ac.cn
84	SA418	SANYA	SANYA	CHINA	18.34	109.42	Dr. Baiqi Ning Institute of Geology and Geophysics (IGG) CAS No. 19, Beituicheng Western Road, Chaoyang District, 100029, Beijing, P.R.China nbq@mail.iggcas.ac.cn
85	SAA0K	SAO LUIS	SAO LUIS	BRAZIL	-2.6	315.8	Dr. Inez Staciarini Batista National Institute for Space Research (INPE) Av. dos Astronautas, 1758 Jardim da Granja 12201-970 Sao José dos Campos, SP, Brazil inez.batista@inpe.br
86	SMJ67	SONDRESTROM	SONDRESTROM	GREENLAND	66.98	309.06	Air Force Weather Agency (AFWA) site decomissioned, archived data only
87	SQ832	SQUIRT	SQUIRT, NM	USA	32.42	253.71	Dr. Torreon Creekmore IARPA HFGeo Program Manager, Intelligence Advanced Research Projects Activity (IARPA) 5850 University Research Court, Riverdale Park, MD 20737, USA torreon.creekmore@iarpa.gov
88	TV51R	TOWNSVILLE	TOWNSVILLE	AUSTRALIA	-19.63	146.85	Mr. Kehe Wang Space Weather Services (SWS), Bureau of Meterorology (BOM) Level 15 Tower C, 300 Elizabeth Street, Surry Hills NSW 2010, Australia kehe.wang@bom.gov.au
89	TM308	TRIVANDRUM	TRIVANDRUM	INDIA	8.54	76.87	Dr. Tarun Kumar Pant Space Physics Laboratory Vikram Sarabhai Space Centre, Trivandrum, India tarun_kumar@vssc.gov.in
90	TR169	TROMSO	TROMSO	NORWAY	69.6	19.2	Prof. Chris Hall Tromsø Geophysical Observatory, University of Tromsø, N-9037 Tromsø, Norway chris.hall@uit.no
91	TUJ2O	TUCUMAN	TUCUMAN	ARGENTINA	-26.9	294.6	Air Force Weather Agency (AFWA) site decomissioned, archived data only
92	TNJ20	TUCUMAN AIS-INGV	TUCUMAN AIS-INGV	ARGENTINA	-26.9	294.6	Dr.Eng. Miguel Angel Cabrera Universidad Nacional de Tucumán, Avda. Independencia 1800 - C.P. 4000 - Tucumán, Argentina mcabrera@herrera.unt.edu.ar
93	WP937	WALLOPS IS	WALLOPS IS	USA	37.9	284.5	Dr. Terence Bullett AFWA DISS Program, NGDC/CIRES: Space Weather Observations and Applications 325 Broadway Str, Boulder, CO, 80305, USA terry.bullett@noaa.gov
94	WI937	WALLOPS IS	WALLOPS IS	USA	37.9	284.5	Dr. Terence Bullett NGDC/CIRES: Space Weather Observations and Applications, 325 Broadway Str, Boulder, CO, 80305, USA terry.bullett@noaa.gov
95	MZ152	WARSAW	WARSAW	POLAND	52.2	21.1	Dr. Iwona Stanislawska Space Research Centre, Polish Academy of Sciences, 18A Bartycka Str., 00-716 Warsaw, Poland stanis@cbk.waw.pl

96	WU430	WUHAN	WUHAN	CHINA	30.5	114.4	Dr. Baiqi Ning Institute of Geology and Geophysics (IGG) CAS No. 19, Beitucheng Western Road, Chaoyang District, 100029, Beijing, P.R.China nbq@mail.iggcas.ac.cn
97	XI434	XINXIANG	XINXIANG	CHINA	35.3	113.92	Research Institute of Radiowave Propagation site decomissioned, archived data only
98	YA462	YAKUTSK	YAKUTSK	RUSSIA	62	129.6	Dr. Alexander E. Stepanov Institute of Cosmophysical Research and Aeronomy (IKFIA) RAS, 31 Lenin Ave., Yakutsk 677908, Russia a_e_stepanov@ikfia.sbras.ru
99	ZH466	ZHIGANSK	ZHIGANSK	RUSSIA	66.8	123.4	Dr. Alexander E. Stepanov Institute of Cosmophysical Research and Aeronomy (IKFIA) RAS 31 Lenin Ave., Yakutsk 677908, Russia a_e_stepanov@ikfia.sbras.ru
100	ZS36R	ZHONG SHAN	ZHONG SHAN	ANTARCTICA	-69.4	76.4	Dr. Beichen Zhang Polar Research Institute of China, 451 Jinqiao Road, Shanghai, 200136, P.R.China zhangbeichen@pric.gov.cn

Instrument Name: Remote Equatorial Nighttime Observatory for Ionospheric Regions (RENOIR)

PDMP to be furnished

Instrument Name: Solar Flares detected by Ionospheric Effects (SOFIE)

Part 1: Instrument and personnel information

- Current PI and contact info

  Alexander Kasten
  German Aerospace Center (DLR)
  Kalkhorstweg 53
  17235 Neustrelitz
  Tel.   : +49 3981 480 204
  E-Mail   : Alexander.Kasten@dlr.de

- Other responsible personnel and contact

  Instrument manager:
  Lutz Heinrich
  17255 Wustrow
  E-Mail   : neuhein.electronic@gmail.de

  Scientific advisor:
  Dr. Norbert Jakowski
  German Aerospace Center (DLR)
  Kalkhorstweg 53
  17235 Neustrelitz
  Tel.   : +49 3981 480 151
  E-Mail   : Norbert.Jakowski@dlr.de

- Instrument website

    o   http://www.projectlab-neustrelitz.de/index_en.php
    o   http://www.projectlab-neustrelitz.de/sofie/eng/daten.php

- Instrument information

    The objective is to detect solar flare events(sfe) by continuously measuring
    the intensity of VLF radio signals and observing ionospheric propagation
    effects on radio waves. The high-energy radiation of solar flares (e.g. X-rays)
    modifies the structure of the lower ionosphere at an altitude of 60 - 150 km/
    35-95 miles. The changed conditions for radio wave propagation are
    immediately measurable as variations of the signal strength at the SOFIE-

receiver. Apart from possible signal interferences, the recorded signal strength maps directly the temporal variation of solar flares, with a remarkable precision. So, by simple measurements of the signal strength at the carrier frequency, it is possible to detect and monitor solar flares, which are often a precursor of space weather storms. Due to the simplicity of the measuring method, SOFIE is perfect as an educational project. Not only does it introduce interesting scientific problems, but also had and has great potential for the development of working and thinking scientifically.

To record solar flares (sfe) the DLR_Project_Lab Neustrelitz in collaboration with the company Neuhein GbR developed a specific VLF receiver named SOFIE RX
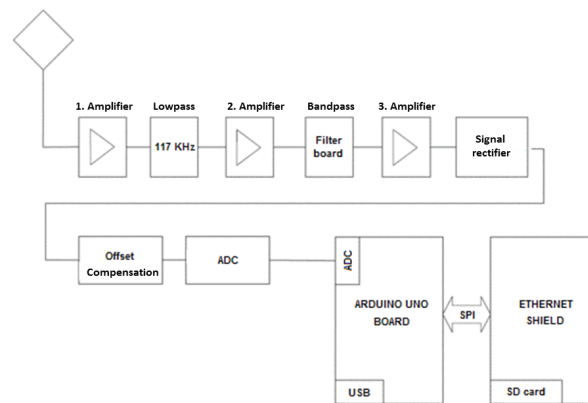
Main purpose is flare detection, by this we observe the sfe only during daytime (ionized atmosphere between transmitter and receiver) for this project.

o Key/representative publications or references

German ISWI Newsletter - Vol. 3 No. 66 09. July 2011 (Project SIMONE (Solar & Ionospheric - MOnitoring NEtwork) at the Ernst-Moritz-Arndt-Gymnasium (High school) at Bergen/Rügen)

German ISWI Newsletter - Vol. 6 No. 34 01. May 2014 (SOFIE (Solar Flares detected by Ionospheric Effects))

o Instrument and local points of contact

Neustrelitz / Germany (DLR Neustrelitz):

Alexander Kasten
German Aerospace Center (DLR)

Kalkhorstweg 53
17235 Neustrelitz
Tel.   : +49 3981 480 204
Mail   : Alexander.Kasten@dlr.de

http://www.projectlab-neustrelitz.de/data/look_up_table.xlsx

o Station data availability intervals

Daily files, uploaded to the FTP-Server by the stations

Part 2: Data and format
2.1 Measurements and data products

- Measured parameters

  5-sec data of signal strength in mV, corresponding to the ionized status of the atmosphere

RX	TX
DLR_Project_Lab Neustrelitz 53.362242,13.069807	NAA Cutler, ME, USA; 24.0Hz Rev.2 Test 5 44.643403, -67.281857
DLR_School_Lab Braunschweig 52.3156322,10.5605167	GQD Skelton, UK; 22.1kHz Rev.2 Test 5 54.731742, -2.883020
Friedrich-Franz-Gymnasium Parchim 53.42199,11.82723	GQD Skelton, UK; 22.1kHz Rev.2 Test 5 54.731742, -2.883020
Neuhein GbR Canow (MV) 53.2012163,12.9103479	GQD Skelton, UK; 22.1kHz Rev.2 Test 5 54.731742, -2.883020
SANSA (Hermanus) -34.4236333,19.1515275	GQD Skelton, UK; 22.1kHz Rev.2 Test 5 54.731742, -2.883020

o How will physical parameters be derived from measured parameters?
  ▪ Units? Temporal & spatial resolutions?

  SOFIE provides only direct signal strength information at a selected VLF frequency.

o Processing and calibration procedures

Time adjustment via NTP once at midnight and manual adjustment of amplitude level of the receiver

- o Coordinate systems, software, and models used?

  Software available on the FTP-Server (for registered user) or using the SOFIE-website for display (http://www.projectlab-neustrelitz.de/sofie/eng/daten.php)

- o Quality assurance & quality control measures

  TBD

- Definitions and descriptions of higher-level instrument data products
  - o Numerical
  - o Graphical

  Not applicable.

- Data quality and caveats

  Recording of station outages, respectively malfunction of the data transmission by a daily controlling subroutine of the data files on the FTP-Server

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?

  ASCII

- Organization and range of data/parameters in data files?

  Uploaded daily files on the FTP-Server and locally real time-data for participating stations. Daily files contain new measurements every 4/5 sec.

  Example file:

  UTC: 1 1
  2209 00:00:15
  2209 00:00:20
  2262 00:00:25
  2258 00:00:29

In the first line of a SOFIE-data file you find some information regarding the time difference between the local time at the receiver site and Greenwich time (UTC). In this example the first "1" tells you, that the receiver is located eastward from Greenwich (true). Otherwise you would see a "0" (false), which means the station is located westward. The second "1" tells you the time difference between receiver and Greenwich in hours. Daylight savings time isn't considered.

Following the file head, you see the measurements of the signal strength (in millivolts) and the corresponding timestamp (local time in hh:mm:ss).

- Information on how metadata will be provided with the data?

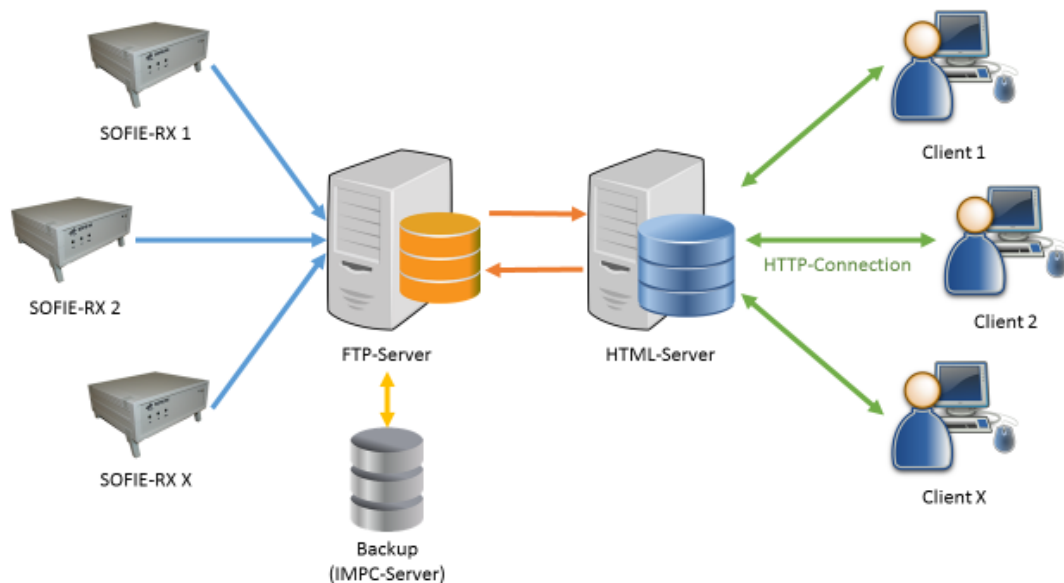 Metadata are to be found on the project website or on the FTP-Server

- Metadata format.

  TBD, probably SPASE

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?

Long term data storage → FTP-Server with weekly backup, for example on IMPC-Server at DLR Neustrelitz.

- Data re-processing requirements and version control

Not applicable.

- Data back up plan

IMPC server at DLR Neustrelitz

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)

> Alexander Kasten
> German Aerospace Center (DLR)
> Kalkhorstweg 53
> 17235 Neustrelitz
> Tel.   : +49 3981 480 204
> Mail   : Alexander.Kasten@dlr.de

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?

Provided via website or via FTP for registered users

3.3 Policies for data access and sharing
All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Instrument Name: South America Very Low frequency Network (SAVNET)

Part 1: Instrument and personnel information
- **Current PI:** Dr. Jean-Pierre Raulin (raulin@craam.mackenzie.br)
- **Other responsible personnel:** Eng. António A. S. Magalhães (asmagal@fc.up.pt)
- **Instrument Website:** https://thesavnet724.wordpress.com/
- **Instrument Information:**

  - **Science and measurement objectives:**

  ➢ The main scientific objective of SAVNET is monitoring the solar and extra-solar activity on short (sub-seconds to hours) and long (years) time scales;
  ➢ Better understanding of the spatial structure of the South Atlantic Magnetic Anomaly;
  ➢ Study of atmospheric phenomena;
  ➢ Search for genuine seismic–electromagnetic effects.

  - **Instrument description**

  Each network receiving station is composed of 3 sensors; 2 sensitive to the magnetic field of the incoming wave (square loop antennae), and 1 to its electric field (a whip antenna). Amplified signals are digitized using a commercial audio card. Design and construction of sensors and pre–amplifiers were undertaken at the Radio Observatorio do Itapetinga–INPE (Brazil). The VLF tracking receiver prototype was tested in early 2007. Early in 2008, most receivers were installed.

  - **Instrument performance specification**

  A precise and stable time reference on time scales of hours or days is needed to measure phase variations along the same time intervals. For this a GPS system providing a 1 pulse per second (1–pps) is used. Accurate phase measurements on long time scales are achieved by locking the sound card crystal to the 1–PPS. The typical error in the received signal phase is in the range of $5x\ 10^{-8}$ s which corresponds to less than 1 degree depending on the frequency of the incoming wave.

  - **Key/representative publications or references**

  RAULIN, J-P.; CORREIA DE MATOS DAVID, PEDRO; HADANO, RUBENS; SARAIVA, A. C. V. ; CORREIA, EMILIA ; KAUFMANN, PIERRE . The South America VLF NETwork (SAVNET). Earth, Moon, and Planets, v. 104, p. 247-261, 2009.

  RAULIN, J-P., BERTONI, F. C. P., GAVIlÁN, H. R., GUEVARA-DAY, W., RODRIGUEZ, R., FERNANDEZ, G., CORREIA, E., KAUFMANN, P. Solar flare detection sensitivity using the South America VLF Network (SAVNET). J. Geophysa. Res. (Space Phys.) v. 115, p.A07301, July, 2010.

TANAKA, Y. T., RAULIN, J-P., BERTONI, F. C. P., FAGUNDES, P. R., CHAN, J., SCHUCH, N. J., HAYAKAWA, M., HOBARA, Y., TERASAWA, T., TAKAHASI, T. First very low frequency detection of short repeated bursts from magnetar SGR-J1550-5418. The Astrophys. J. Let. V. 721, p. L24-L27, September, 2010.

- **Instrument locations**

SAVNET is composed of many receiver stations most of them under tests and integration. For this reason, the number of working receiver stations varied along the 2006 – 2017 period. The maximum number of receiver stations was 11, located in Brazil, Peru, Argentina and Mexico. For each receiver, a code XXX is used. CAS for CASLEO (Argentina), PLO, ICA and PIU for Punta Lobos, Ica and Piura (Peru), ATI, SMS, PAL, ROR, CPG, EACF for Atibaia, San Martinho da Serra, Palmas, Roraima, Campina Grande and Comandante Ferraz (Brazil), LAVNET (Mexico).

- **Station data availability intervals**

See webpage.

Part 2: Data and Format
2.1 Measurements and data products
- **Main Transmitter signals received**

STATION	FREQ. (KHz)	LAT. (°)	LONG. (°)	LOCAL
NAA	24.0	44.645	- 67.282	Cutler, ME
NAU	40.8	18.399	- 67.178	Aguada, PR
NDK	25.2	46.366	- 98.336	La Moure, ND
NLK	24.8	48.203	- 121.917	Jim Creek. DC
NPM	21.4	21.420	- 158.151	Lualualei, HI
NWC	19.8	-21.816	114.166	Exmouth, Australia

- **Measured parameters**

  ➢ Phase and amplitude of the incoming narrowband VLF radio signal;
  ➢ Unit of measure: Phase in Deg. ; Amplitude in dB relative to the input voltage
  ➢ Broadband (1 kHz – 50 kHz) spectra in ADC units
  ➢ The commonly used temporal resolution is 1 sec. (can be down to 0.1 s)

2.2 Data file format and metadata
  ➢ Original file format is converted to FITS format.
  ➢ Files available for download are in the form XXX-YYYY and contain (narrowband) data for the year YYYY recorded at the receiver station XXX. These are TAR compressed files.

Uncompressing under Linux OS with the command *tar –xvf XXX-YYYY*. The result will be daily gzipped FITS files in the form XXX-YYYMMDD.fits.gz for the receiver station XXX for the date YYYY (year), MM (month) and day (DD). Use then the Linux command to get the final file *gzip –d XXX-YYYMMDD.fits.gz*. The files can be easily read within IDL. The header contains all the necessary informations. For further help on the reading file process, please contact asmagal@fc.up.pt . Each user of SAVNET data is kindly invited to identify him(her)self by sending an email to asmagal@fc.up.pt and raulin@craam.mackenzie.br

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management
- ➤ Data (narrowband) are available for download at https://thesavnet724.wordpress.com/
- ➤ Data do not require re-processing
- ➤ The person responsible for the archived data is Eng. António A. S. Magalhães (asmagal@fc.up.pt).

3.2 Data distribution plan
- ➤ As a preliminary distribution plan, data are available for ATI (2006-2010), CAS (2007-2010), PIU (2007-2010) and PLO (2007-2020).

Instrument Name: Scintillation Network Decision Aid (SCINDA)

PDMP to be furnished

Instrument Name: Space Environment Viewing and Analysis Network (SEVAN)

Part 1: Instrument and personnel information

- Current PI and contact info: **A.Chilingarian, chili@aragats.am**
- Other responsible personnel and contact info (e.g., instrument scientist/manager, if different from PI): **T.Karapetyan, ktigran79@gmail.com**
- Instrument website: **http://www.crd.yerphi.am/space_environmental_viewing_and_analysis_network**
- Instrument information
    - Science and measurement objectives

SEVAN (Space Environmental Viewing and Analysis Network) is a network of particle detectors located at middle and low latitudes, which aims to improve fundamental research of space weather conditions and to provide short and long-term forecasts of dangerous consequences of space storms. 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.

With the SEVAN network it is possible to detect modulation effects solar activity pose on galactic cosmic rays and magnetosphere, i.e., Forbush decreases and post-Forbush increases of count rate due to coupling of "frozen" magnetic fields in ICMEs. Also it will be possible to detect changes in count rates during the travel of ICMEs from the sun to Earth lasting 17–50 h. Time series of different species of cosmic rays rates can be used for forecasting of the severity of upcoming Geomagnetic storm and for detection of ground level enhancements (GLEs).

For extreme GLE events like in 1956, 1989 when the counts can increase by 50% and more even at middle latitudes, GLEs will be reliably detected with one SEVAN module only. For the new emerging field of High-energy physics in atmosphere SEVAM modules can detect electron, gamma ray and neutron content of the Thunderstorm Ground Enhancements (TGEs)- intense paqrticle fluxes from the thunderclouds.

Instrument descriptions:

The SEVAN network consists of hybrid detectors registering charged and neutral components of secondary cosmic rays. The network detects changing fluxes of different species of secondary cosmic rays at different altitudes and latitudes, thus turning into a powerful integrated device used to explore solar modulation effects. To facilitate SEVAN network creation, Cosmic Ray Division (CRD) of the Yerevan Physics Institute designs the basic SEVAN particle detector module, front-end electronics and advanced data acquisition system (ADAS). The CRD provides scintillator slabs, photomultipliers, electronics and ADS the host institutions.
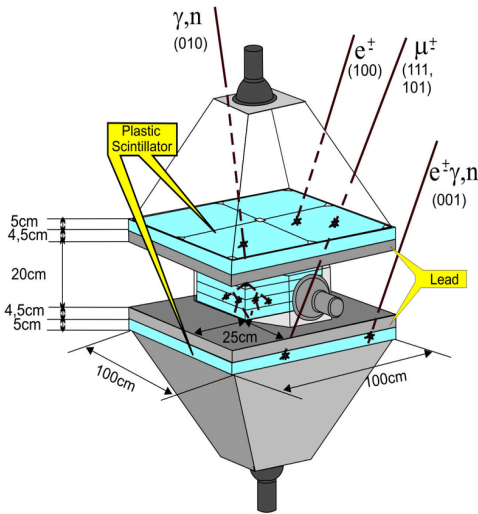
See detector design details in the following link:

http://www.crd.yerphi.am/Mechanical_Charts

    ○   Instrument performance specifications:

The basic detecting unit of the SEVAN network (see Figure) is assembled from standard slabs of 50 x 50 x 5 cm^3 plastic scintillators. Between two identical assemblies of 100 x 100 x 5 cm^3 scintillators (four standard slabs) are located two 100 x 100 x 5 cm^3 lead absorbers and thick 50 x 50 x 25 cm^3 scintillator assembly (5 standard slabs). A scintillator light capture cone and photo multiplier tube (PMT) are located on the top, bottom and the intermediate layers of detector. The detailed detector charts with all sizes are available from http://aragats.am/SEVAN.

Incoming neutral particles undergo nuclear reactions in the thick 25 cm plastic scintillator and produce protons and other charged particles. In the upper 5 cm thick scintillator charged particles are registered very effectively; however for the nuclear interactions of neutral particles there is not enough matter. When a neutral particle traverses the top thin (5 cm) scintillator, usually no signal is produced. The absence of the signal in the upper scintillators, coinciding with the signal in the middle scintillator, points to neutral particle detection. The coincidence of signals from the top and bottom scintillators indicates the traversal of high-energy muons. Lead absorbers improve the efficiency of the neutral flux detection and filtered low energy charged particles. If we denote by "1" the signal from a scintillator and by "0" the absence of a signal, then the following combinations of the 3-layered detector output are possible:

111 and 101—traversal of high energy muon; 010—traversal of a neutral particle;100—traversal of a low energy charged particle stopped in the scintillator or in the first lead absorber (energy less than *100 MeV).110—traversal of a higher energy charged particle stopped in the second lead absorber. 001—registration of inclined charged particles

For details follow the links:

http://www.crd.yerphi.am/files/Projects/SEVAN/Posters/SEVAN_2012.jpg

http://www.crd.yerphi.am/files/Projects/SEVAN/Posters/Characteristics_of_SEVAN.jpg

o Key/representative publications or references:

1. **S. Chilingaryan, A. Chilingarian, V. Danielyan, W. Eppler, The Aragats data acquisition system for highly distributed particle detecting networks, Journal of Physics: Conference Series 119 (2008) 082001**
2. **S. Chilingaryan, A. Chilingarian, V. Danielyan, et al., Advanced data acquisition system for SEVAN, Advances in Space Research 43 (2009) 717–720**

3. **A. Chilingarian and A. Reymers, Investigations of the response of hybrid particle detectors for the Space Environmental Viewing and Analysis Network (SEVAN), Ann. Geophys, 26, 249.257, 2008**
4. **A. Chilingarian, G. Hovsepyan, K. Arakelyan, et al, Space Environmental Viewing and Analysis Network (SEVAN), Earth, Moon and Planets: Volume 104, Issue 1 (2009), page 195**

5. **Chilingarian, A., and N. Bostanjyan, Cosmic ray intensity increases detected by Aragats Space Environmental Center monitors during the 23rd solar activity cycle in correlation with geomagnetic storms, J. Geophys. Res., Vol. 114, No. A9, A09107**
6. **A. Chilingarian and N. Bostanjyan, On the relation of the Forbush decreases detected by ASEC monitors during the 23rd solar activity cycle with ICME parameters, Advances in Space Research, Volume 45, Issue 5, 2010, Pages 614-621**

7. **M. Zazyan, A. Chilingarian, Calculations of the sensitivity of the particle detectors of ASEC and SEVAN networks to galactic and solar cosmic rays, Astropart. Phys, Volume 32, Issues 3-4, October-November 2009, Pages 185-192**

8. **A. Chilingarian, Statistical study of the detection of solar protons of highest energies at 20 January 2005, Advances in Space Research 43 (2009), pp. 702-707**

9. **A. Chilingarian, T. Karapetyan, Calculation of the barometric coefficients at the start of the 24th solar activity cycle for particle detectors of Aragats Space-environmental Center, Advances in Space Research, doi:10.1016/j.asr.2010.12.001**
10. **Bagrat Mailyan , Ashot Chilingarian, Investigation of diurnal variations of cosmic ray fluxes measured with using ASEC and NMDB monitors, Advances in Space Research 45 (2010) 1380–1387**

　　　　　　　　o Instrument locations (longitudes and latitudes) and local points of contact (name, title, mailing and email addresses) [If it is more convenient to do so, this information can be provided in a separate document linked to the PDMP.]

Name	Detector Type	Type of the Electronics	Type of Measurements	Number of physical Channels	Number of software Channels	Operating System type	Type of the Storing Data	Size of the Daily Data
Armenia, Mt. Aragats, 40o28'N, 44o10'E, 3200m asl, Aragats Research Station								
SEVAN-Aragats	Scintillator	Counter with coincidences	Particles	3	8	Linux	CSV	103 kB
Armenia, Mt. Aragats, 40o22'N, 44o15'E, 2000m asl, Nor-Amberd Research Station								
SEVAN NorAmberd	Scintillator	Counter with coincidences	Particles	3	8	Linux	CSV	103 kB
Armenia, Yerevan, 40o22'N, 44o15'E, 1000m asl, Cosmic Ray Division Headquarters								
SEVANYerevan	Scintillator	Counter with coincidences	Particles	3	8	Linux	CSV	103 kB
Bulgaria, Mt. Musala, 42°10'45"N, 23°35'8"E, 2925m asl								
SEVAN-Moussala	Scintillator	Counter with coincidences	Particles	3	8	Linux BusyBox	CSV	103 kB
Croatia, Zagreb, 45°49'7"N, 15°58'30"E, 160m asl								
SEVAN-Zagreb	Scintillator	Counter with coincidences	Particles	3	8	Linux	CSV	103 kB
India, Jawaharlal Nehru University, 28°32'26"N, 077°09'46"E, 258 m asl								
SEVAN-JNU	Scintillator	Counter with	Particles	3	8	Linux	CSV	103 kB

		coincidences						
Slovakia -Lomnicky Stit, 49.2 N 20.22 E, 2634 m asl								
SEVAN-Stit	Scintillator	Counter with coincidences	Particles	3	8	Linux	CSV	103 kB

- Station data availability intervals

  Armenian SEVAN's 2008-2016; other countries SEVAN's – different time spans.

Part 2: Data and format
2.1 Measurements and data products

- Measured parameters
  - How will the measured parameters be acquired or recorded?
    - Units? Temporal & spatial resolutions?

  One-minute and one-second count rates of 3 scintillators of SEVAN modules and different coincidences of these counts allowing to enrich selected time series with neutral particle, low energy charged particles and high energy muons. Counts per minute and counts per second.

  - How will physical parameters be derived from measured parameters?
    - Units? Temporal & spatial resolutions?

Particle fluxes are directly calculated from the measured time series. Forbush decreases, GLEs, geomagnetic storms TGEs and other physical processes modulated stable flux of secondary cosmic rays as well as comparisons with other detectors and space born measurements are made with Advanced Data Extraction Infrastructure (ADEI). ADEI is WEB program allowing on-line physical analysis and report preparation with various statistical analysis and multivariate visualization procedures. It has been developed to provide data exploration capabilities to a broad range of physical experiments dealing with time series. ADEI is optimized to minimize the delay between measurements and data transfer/storage, selection and generation of figures, enumeration of significances of selected events; estimation of important physical parameters and finally paper and report composing.

Streaming data is utilized in many analysis applications in user-friendly environment. Multivariate data from hundreds of measuring channels is on-line integrated in MySql databases within the constraints placed by integrated systems.

ADEI automatically handles structuring and processing of the incoming data and make it available to the statistical/physical analysis routines for instant exploration and selection of important events.

   Processing and calibration procedures

To ensure that acquired data is harmonized data-appropriate cleansing and restructuring is made involving time-gaps filling and outlier checking.

   o   Coordinate systems, software, and models used?

Following models were used to compare calculated and measured particle fluxes: CORSIKA Monte Carlo simulation code. Using CORSIKA we simulate cascades of the secondary charged and neutral particles. The threshold energies for the primary particles assumed as input for CORSIKA correspond to the rigidity cutoff of the detector locations. All secondary particles were tracked until their energy drops below a predetermined value (50 MeV for hadrons, 10 MeV for muons and 6 MeV for electrons and photons) or reached all the way to the ground level. The spectra of primary protons and helium nuclei (99% of the flux at energies up to 100 GeV) are selected to follow the proton and helium spectra reported by CAPRICE98 balloon-borne experiment.

   Among different species of secondary particles, generated in nuclear-electromagnetic cascades in the atmosphere, muons, electrons, $\gamma-$s, neutrons, protons, pions and kaons were followed with CORSIKA and stored. These particles were used as input for the CERN origin GEANT package, implemented for detector response simulation. Additionally we, also, take into account the light absorption in the scintillator.

   o   Quality assurance & quality control measures

      Continuous monitoring of measured particle fluxes; warnings and alerts on abrupt increase or decrease of count rates; comparisons with calculated theoretically expected values.

- Definitions and descriptions of higher-level instrument data products
   o   Numerical
   o   Graphical

The ADEI platform delivers following physical analysis capabilities within an intuitive modeling interface that can be easily understood by users:
- Histograms of selected time series with goodness of fit estimation;

- Scatter plots and delayed correlation analysis of time series;
- Peak and deep hunting in time series (GLEs an dFD). Calculation of the P-values for the background only hypothesis in terms of one-sided Gaussian tail significances and provided in units of standard deviation;
- Presenting of time series of count rates in percent and standard deviations (reliability estimates of FD and GLE and geomagnetic storms);
- Combination of time series (Comparisons of GLE, FD amd GM amplitudes on different altitudes, longitudes and latitudes).

- Data quality and caveats

Continuous monitoring of means and variances of measured time-series.

2.2 Data file format and metadata

For each of the instrument data products defined above, please provide:

- Description of data file format (CDF, FITS, HDF, netCDF, ASCII, etc.)?
- Organization and range of data/parameters in data files?
- Information on how metadata will be provided with the data?
- Metadata format. For example, SPASE <www.spase-group.org> is a metadata model that has been developed in recent years by the heliophysics research community for describing space-based and ground-based heliophysics data products.

Data storage and access is performed via ADEI interfaces.

The main logic of ADEI system is contained in a backend which is implemented purely in PHP programming language. The backend incorporates a data access layer, a caching daemon, an ADEI library. Communication with the web frontend and other client applications is maintained using web services. HTTP protocol is used for data exchange, XML and JSON - for data encoding.

The data access layer hides details of underlying data sources providing other components of the system with a uniform way of data access. The data is organized hierarchically. The top level of hierarchy is the data source and ADEI may underline several data sources. The time series from SEVAN modules provided by the data source are divided in time-synchronized groups, so called LogGroups.

The current version includes drivers to access data stored in:

- Relational databases accessible using PDO or ODBC modules of PHP. Most of popular databases including MySQL, PostgreSQL, Oracle, and Microsoft SQL server are supported.

- ASEC data format
- RRD (RRDtool team 2009) data format

The caching daemon is continuously running on a backend server and polls all data sources for a new data. When the data is acquired it piped through series of filters which check the data quality, apply correction coefficients and drop invalid data. Then, the data is aggregated over intervals of few different sizes. For each size, called cache level, five new time series is constructed and stored in MySQL database (caching database). This time series contain following information for each interval of aggregation:

- Number of records
- Longest time interval without valid data records
- Average value
- Minimum value
- Maximum value

The ADEI PhP library implements several classes, which are using the caching, database and data access layer to provide stored data in various forms. The plot module first selects the maximal cache level providing enough points to generate the plot of specified size. The time resolutions of caching database are selected in the way that between 1000 and 10000 data samples can be extracted for any specified interval. Such an amount of points fulfills most of plotting demands and in the same time the plots could be generated relatively fast. After selection of cache level is made, the data is extracted from correspondent caching tables and one of supported algorithms is used to convert aggregated values into the graphic points.

Part 3: Archiving and distribution plans
3.1 Long-term data storage and management

- How and where will instrument data be stored and managed long-term?

  Data are on-line transferred from on-line computers to 4 servers at CRD headquarters with large storage capacity and simultaneously to 2 additional mirror sites in Germany and Russia.

  Data re-processing requirements and version control

  ADEI versions are continuously modified and updated.

- Data back up plan

  External SSD hard drives and my iCloud.

- Primary person responsible for the archived data and contact info (must be kept up-to-date in case there are requests for data or information about data)

  T.Karapetyan

3.2 Data distribution plan

- How will instrument team support/enable instrument metadata and data access in accordance to the ISWI open data policy?

The data from SEVAN network is available from link without any restrictions.

http://adei.crd.yerphi.am/adei

The visualization and data analysis cervices are also provided for user. Users can consult WiKi site for getting instruction of reach ADEI possibilities for physical analysis.

3.3 Policies for data access and sharing
All ISWI instrument teams and users of ISWI instrument data agree to abide by the ISWI open data policy. All instrument teams also agree to maintain their data management plans to ensure their accuracy and completeness.

Agree

A.Chilingarian
Director of Yerevan Physics Institute

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 is consist 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 disciplined-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.

Change log

Version 1.3.9 Updated PDMPs for AWESOME, eCallisto and OMTIs
Version 1.3.9a Minor updates to SID and eCallisto PDMPS
Version 1.3.10 Updated eCallisto and MAGDAS PDMPs (Feb 20, 2025)