ISWI Data Coordination & Usage

Shing F. Fung

ISWI Data Coordinator

ITM Physics Laboratory, NASA Goddard Space Flight Center
Greenbelt, Maryland USA

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Abstract

The **International Space Weather Initiative (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 to communicate the results to the public and students. To enable open data access and effective use of ISWI data by the international community, careful and deliberate coordination and collaborations between data providers are essential. This presentation will consider the challenges confronting users in accessing and using ISWI instrument data and how those challenges might be mitigated in the future.

Outline

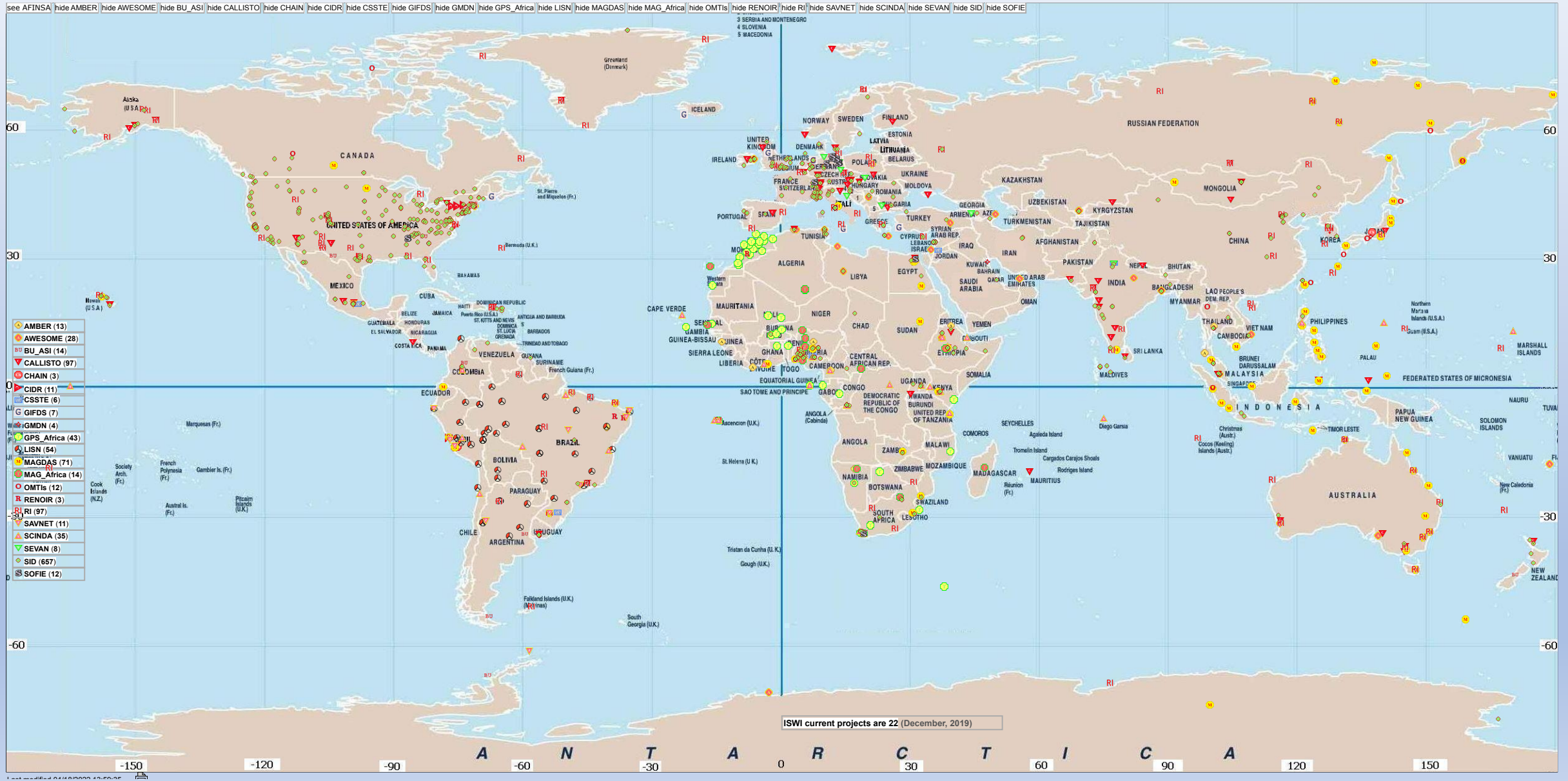
- ISWI Instrument Networks as rich data sources
- Data coordination requirements
  - ISWI open data policy
  - Current status of ISWI data access
- Broadening ISWI data Use
  - Adopting FAIR Principles for data
  - Adopting a standard metadata model
  - Middleware: a common interface to data services
  - Dataset citation and referencing
  - Increase data use through collaborations
- Summary

ISWI Instrument Networks (https://iswi-secretariat.org/home-page/projects/)

ISWI Instruments	Measurements	Science Objectives
AFINSA	Atmospheric electric field	Atmosphere-ionosphere coupling
AMBER	Ground magnetic perturbations	Low-latitude plasma dynamics; ULF waves at low latitudes
AMMA	TEC, atmospheric water vapour	Atmospheric and ionospheric studies; Geodesy
AWESOME & SID	ELF & VLF emissions at 300 Hz - 50 kHz	Lightning-induced radio events (sferics, whistlers, chorus, hiss); Track changes in ionosphere caused by solar activity
BU_ASI	14 all-sky imagers, each with up to 6 different airglow emissions from the upper atmosphere	Magnetically conjugate processes in the thermosphere-ionosphere from low latitudes to sub-auroral latitudes
CALLISTO	Radio spectrograms, 45-870 MHz	Solar radio bursts
CHAIN	Solar images in H-alpha	Solar activity, flares, filaments, filament eruptions
CIDR	Relative TEC profile along the path of a beacon satellite	Tomographic reconstruction of ionospheric structures
GIFDS	Ionospheric effects on VLF propagation	Solar flare detection

ISWI Instruments	Measurements	Science Objectives
GMDN	Cosmic ray muon detection	Detection of cosmic ray intensity decrease ~ one day prior to ICME-driven shock arrival at Earth
LISN	GPS, magnetometers & vertical ionosondes	Low-latitude ionospheric irregularities & scintillation conditions in South America
MAGDAS	Magnetometers	Geospace plasma dynamics during geomagnetic storms & substorms; ionosphere-magnetosphere responses to solar wind variability; penetration & propagation of DP2-ULF disturbances
OMTIs	Nocturnal airglow emissions	Upper atmospheric dynamics
RENOIR	Ionospheric imaging system, Fabry-Perot interferometry (FPI), a dual-frequency and single-frequency GPS receivers	Storm-time response and irregularities of equatorial/low-latitude ionosphere/thermosphere system
RION	Ionosonde coordinated network providing near-real-time, low-latency measurements of subpeak ionospheric plasma density	Nowcast of the 3D global plasma density distribution in the subpeak ionosphere
SAVNET	Propagation of VLF waves (amplitude and phase velocity) in the Earth-ionosphere waveguide	Study of the SAMA region at low ionospheric altitudes, its structure and dynamics during geomagnetic perturbations
SCINDA	Scintillation intensity, ionospheric drift velocity, TEC	Specification and prediction of ionospheric scintillation in the earth's equatorial region
SEVAN	Changing secondary cosmic ray fluxes from different altitudes and latitudes; Particle bursts from thunderclouds	Provide short and long-term forecasts of dangerous consequences of space storms; Thunderstorm Ground Enhancements
SOFIE	Ionospheric effects on VLF propagation	Solar flare detection

ISWI Ground Instrument Distributions



Data Coordination Requirements

- A network dataset needs
  - To have sufficient temporal and spatial (global) coverage
  - To be calibrated with measurement errors characterized across network
- Data are collected continuously and made generally available
  - Data should flow freely across international boundaries to support research
- Data obtained across the globe should generally follow the FAIR Principles:
  - Findable, so required data can be found/discovered
  - Accessible, so data can be accessed & retrieved
  - Interoperable, so data can be served, processed, or analyzed along with other datasets
  - Reusable, so data is well-documented to support independent use

ISWI Open Data Policy

- Established since November 2017, the policy stipulates that
  - ISWI data are openly shared, exchanged, accessed and used
  - All ISWI instruments agree with policy by providing their project data management plans (PDMPs)
  - ISWI will promote international collaborations & coordination to facilitate space weather research and capacity building
- Latest version 1.3.9 revised on January 3, 2023
  - Posted on ISWI website (https://iswi-secretariat.org/) under both Steering Committee and Projects

Current Status of ISWI Data Access

- As per ISWI data policy, ISWI instrument data should be freely accessible from instrument team websites (see ISWI Projects page) as described in instrument PDMPs.
- Several instrument PDMPs are still missing; some instrument websites are also not current/available.
- ISWI instrument data are not generally FAIR-compliant.

Broadening ISWI Data Use

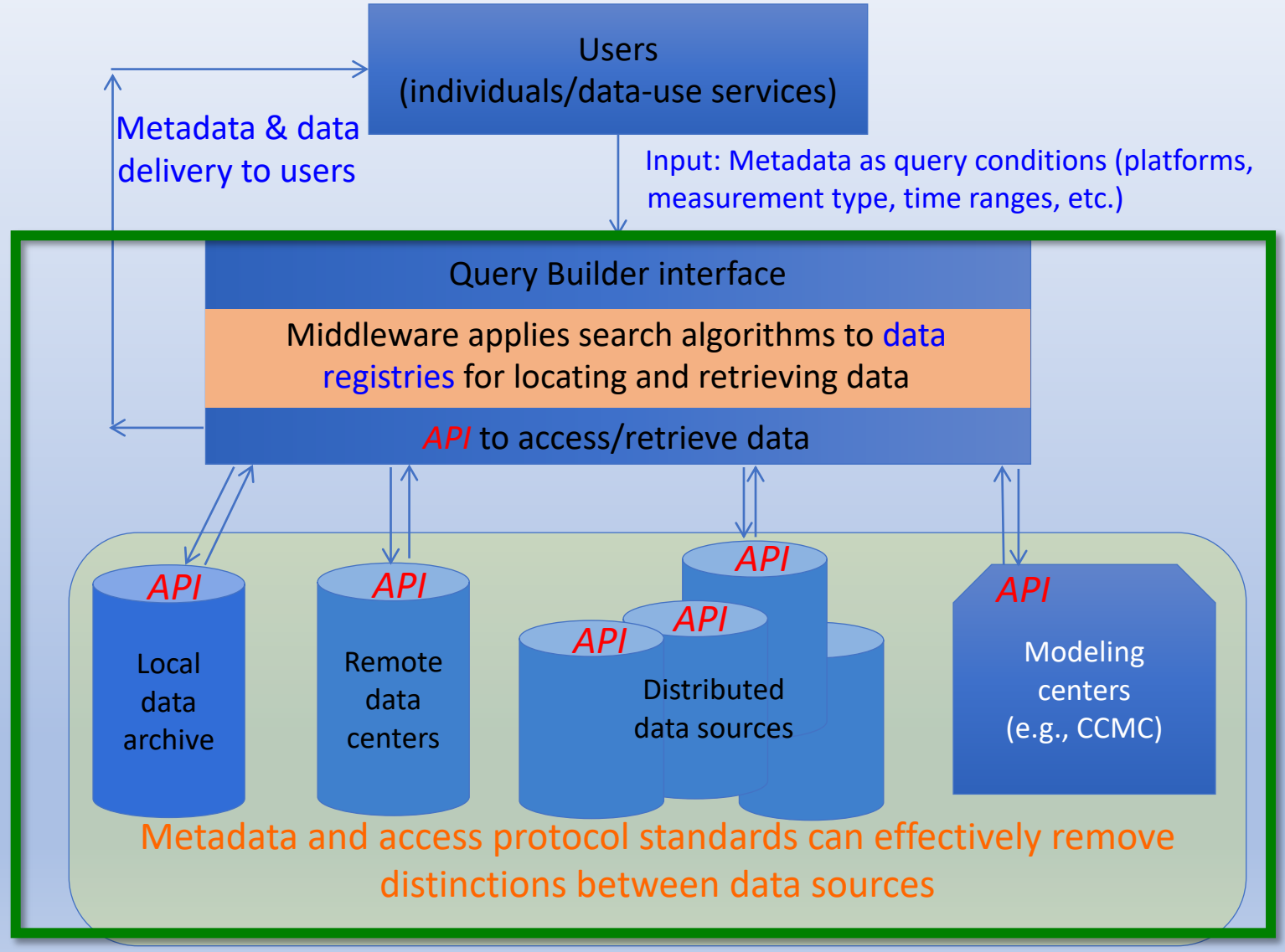
- ISWI data utilization can be broadened if instrument data become FAIR-compliant.
  - ISWI data can become interoperable with other data
- This can be facilitated by adopting a standard metadata model, enabling the use of a common data service interface
  - Useful in supporting cross-disciplinary research and capacity building
- The *Space Physics Archive Search and Extract* (*SPASE*) is a metadata model
  - Developed specifically for describing heliophysics and space weather resources (data, model, model data, software, etc.).
  - Recommended as a metadata standard by COSPAR Panel on Space Weather

Middleware: A Common Interface to Data Services

All resources described in SPASE can leverage middleware data services, such as

- NASA Heliophysics Data Portal
- NASA Heliophysics Digital Observatory

designed to expose/serve data from distributed data sources or repositories.



[adapted from Fung et al., 2023]

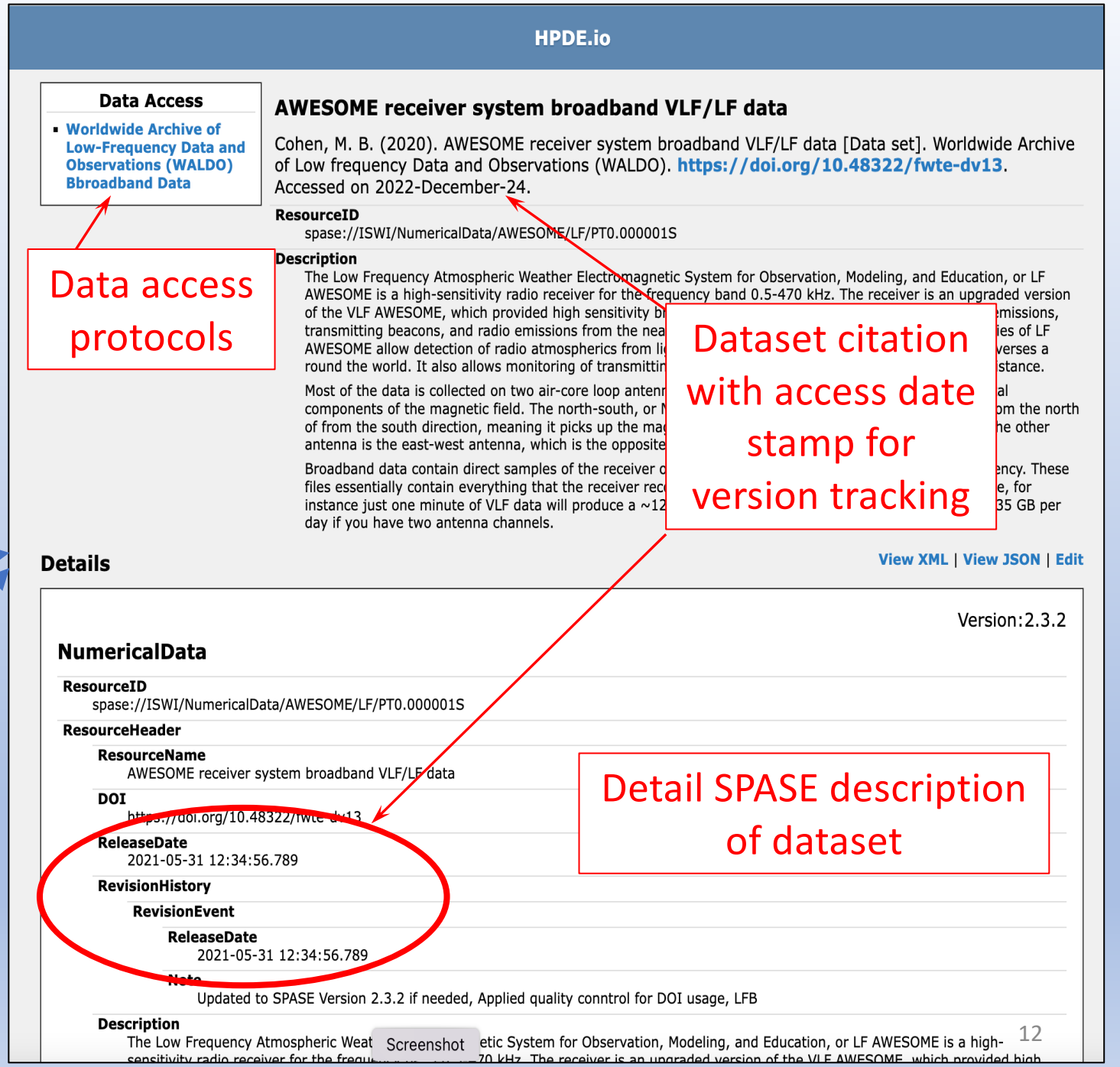
Dataset Citation & Referencing

DOI can be minted and used as a persistent reference to a dataset.

AWESOME Example: SPASE registry landing page, https://hpde.io/ISWI/NumericalData/AWESOME/LF/PT0.000001S.html

DOI URL, https://doi.org/10.48322/fwte-dv13

Both AWESOME & e-Callisto are now SPASE-registered with DOI references.



Increase Data Use Through Collaborations

- Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)
  - ISWI shares similar goals in science, international collaboration, and capacity building.
  - ISWI instruments are valuable data resources for PRESTO, the current SCOSTEP project (2020-2024).
- COSPAR International Space Weather Action Teams (ISWAT) initiative
  - Community-driven, self-guided efforts to form a global hub for collaborations to address challenges across the field of space weather
  - Basis and framework for formulating the next COSPAR space weather roadmap
- NASA Geospace Dynamics Constellation (GDC) and **other space missions**
  - Launch no earlier than 2029
  - Studying processes that govern the dynamics of upper atmosphere, mesosphere, thermosphere, and ionosphere (~80-450 km)
  - Expects to collaborate with international ground-based observational community

[NASA SMD, March 14, 2023]

Heliophysics Missions

Heliophysics Mission Fleet

Heliophysics missions are strategically placed throughout our solar system, working together to provide a holistic view of our Sun and space weather, along with their impacts on Earth, the other planets, and space in general. NASA's heliophysics mission fleet includes 19 operating missions using 26 spacecraft, 13 missions in development, 1 mission under study, a robust sounding rocket program and a variety of CubeSat missions.

- ESA = European Space Agency
- JAXA = Japan Aerospace Exploration Agency

*Numbers in parentheses indicate how many spacecraft each mission includes.

UNDER DEVELOPMENT

- AWE (ISS)
- Carruthers Geocorona Observatory
- ESCAPADE (2)
- EUVST (JAXA)
- EZIE (3)
- GDC (6)
- HelioSwarm (9)
- HERMES (Gateway)
- IMAP
- MUSE
- PUNCH (4)
- SunRISE (6)
- TRACERS (2)

PRIMARY OPERATION

- Parker Solar Probe
- Solar Orbiter (ESA)

EXTENDED OPERATION

- ACE
- AIM
- GOLD (SES-14)
- Hinode (JAXA)
- IBEX
- ICON
- IRIS
- MMS (4)
- RAD (Curiosity)
- SDO
- SOHO (ESA)
- STEREO
- THEMIS-ARTEMIS (2)
- THEMIS (3)
- TIMED
- Wind
- Voyager (2)

science.nasa.gov/heliophysics

Summary

Coordination is needed…

- For resources, personnel, and instrument sites to ensure that all ISWI instrument networks operate continuously as planned.
- For cross calibration and measurement error characterization of all instruments across a given instrument network.

To broaden data use, coordination & collaboration are needed to adopt

- A metadata standard (such as SPASE) for data documentation
- The FAIR Principles, so that all ISWI data can be served freely
  - By common (middleware) data services
  - Along with other space-based and ground-based datasets
  - Across international boundaries