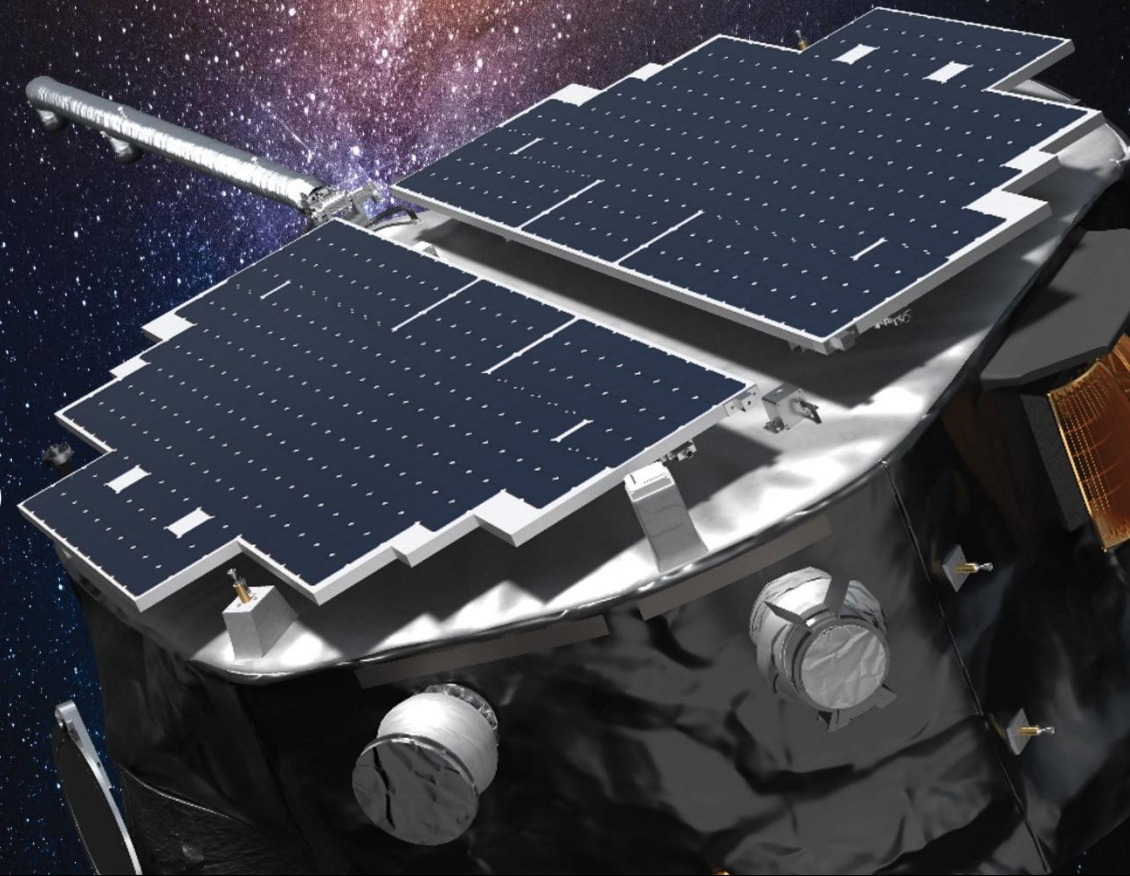


IMAP Active Link for Real-Time (I-ALiRT) Overview

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I-ALiRT Deputy Lead

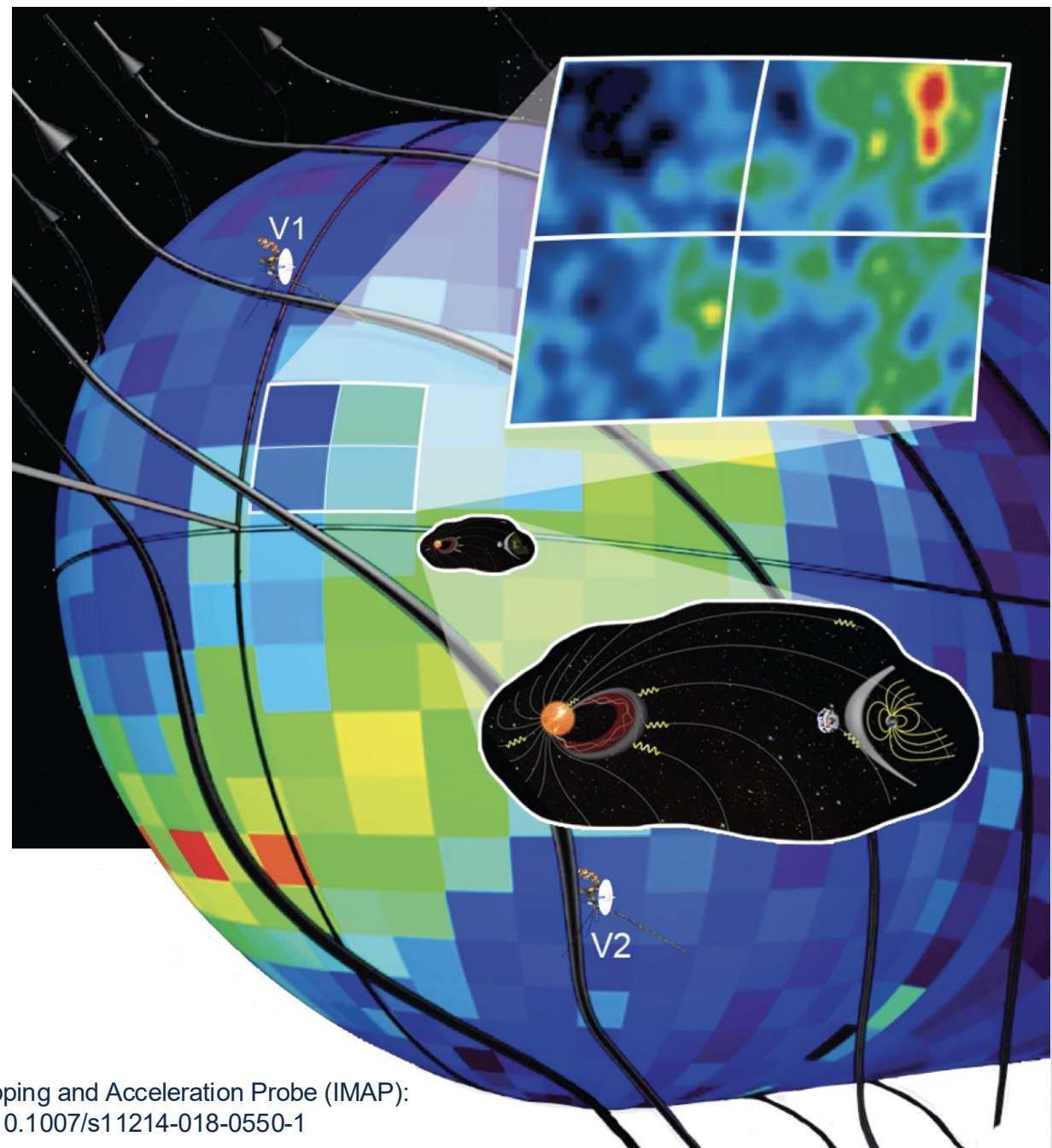


IMAP mission in a nutshell

- ❑ IMAP launches is expected to launch NET Sept 23 2025, on a two-stage Falcon-9 rocket from Kennedy Space Center and reaches its final orbit at L1 using onboard propulsion.
- ❑ 10 instruments working together to:
 - ❑ understand the **acceleration** of particles expelled from the Sun to high energies
 - **I-ALiRT architecture:** IMAP provides near real-time observations of solar wind, energetic particles and magnetic fields at L1, measurements necessary for space weather applications.
 - ❑ **map** the interaction of these high energy particles with the local interstellar medium by remotely sensing the boundary of our solar system (~ 100 AU).
 - ❑ provide precise measurements of the interstellar neutral flow and composition, interstellar dust composition, and complementary ionization rates/radiation pressure

IMAP paper

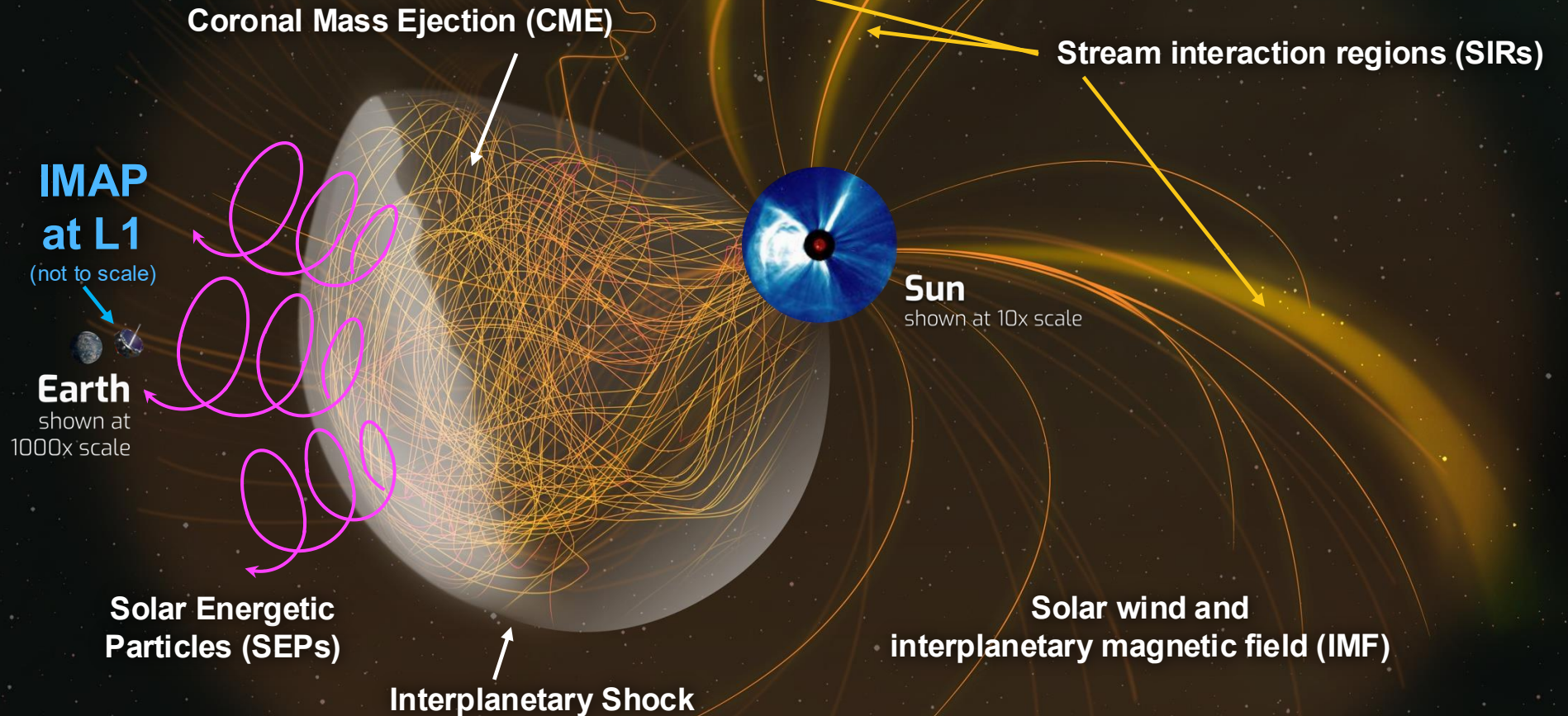
McComas, D.J., Christian, E.R., Schwadron, N.A. *et al.* Interstellar Mapping and Acceleration Probe (IMAP): A New NASA Mission. *Space Sci Rev* **214**, 116 (2018). <https://doi.org/10.1007/s11214-018-0550-1>



IMAP will continuously broadcast the I-ALiRT space weather data to ground stations around the world

I-ALiRT can:

- Support the safety of satellites and astronauts, in the event of CMEs and SEPs from solar eruptive activity
- Provide up to ~ 45 min warning of the solar wind that cause hazardous space weather effects in the geospace environment (e.g., geomagnetically induced currents, communications and navigation disruptions, thermospheric drag)

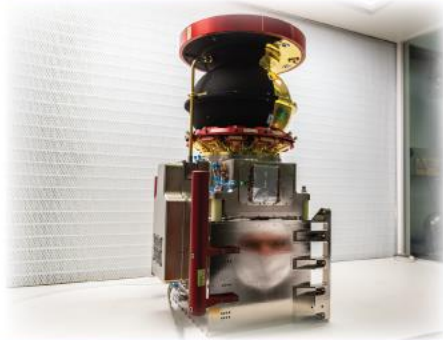


SWAPI

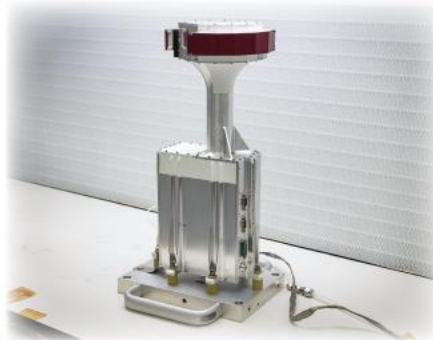


Solar Wind, Pickup, Suprathermal, and Energetic Ions;
Energetic Electrons

CoDICE



HIT

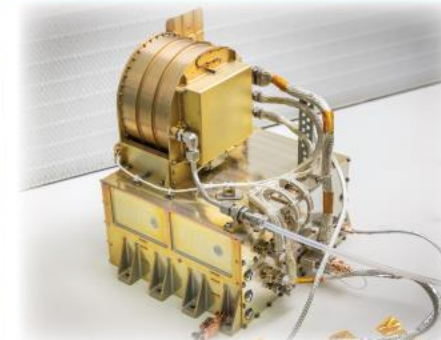


MAG



Magnetic Fields

SWE



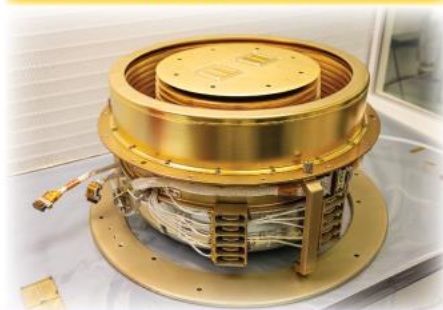
Solar Wind Electrons

Space Weather: I-ALiRT

IMAP-Lo



IMAP-Hi

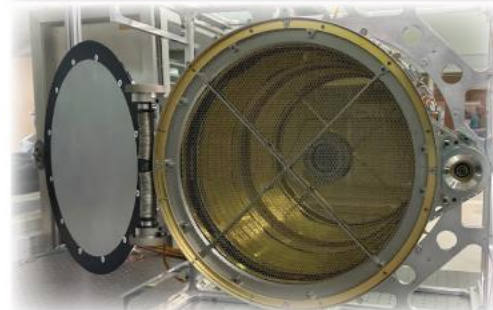


IMAP-Ultra



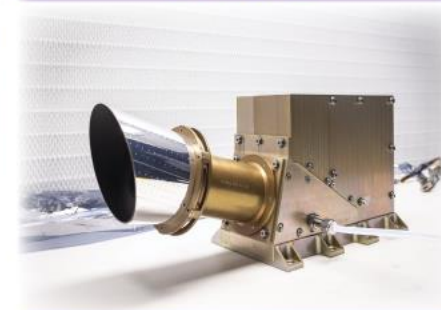
Energetic Neutral Atoms (Increasing Energy);
Interstellar Neutral Atoms

IDEX



Dust

GLOWS



UV

IMAP



IMAP



Near real-time space weather data products from I-ALiRT

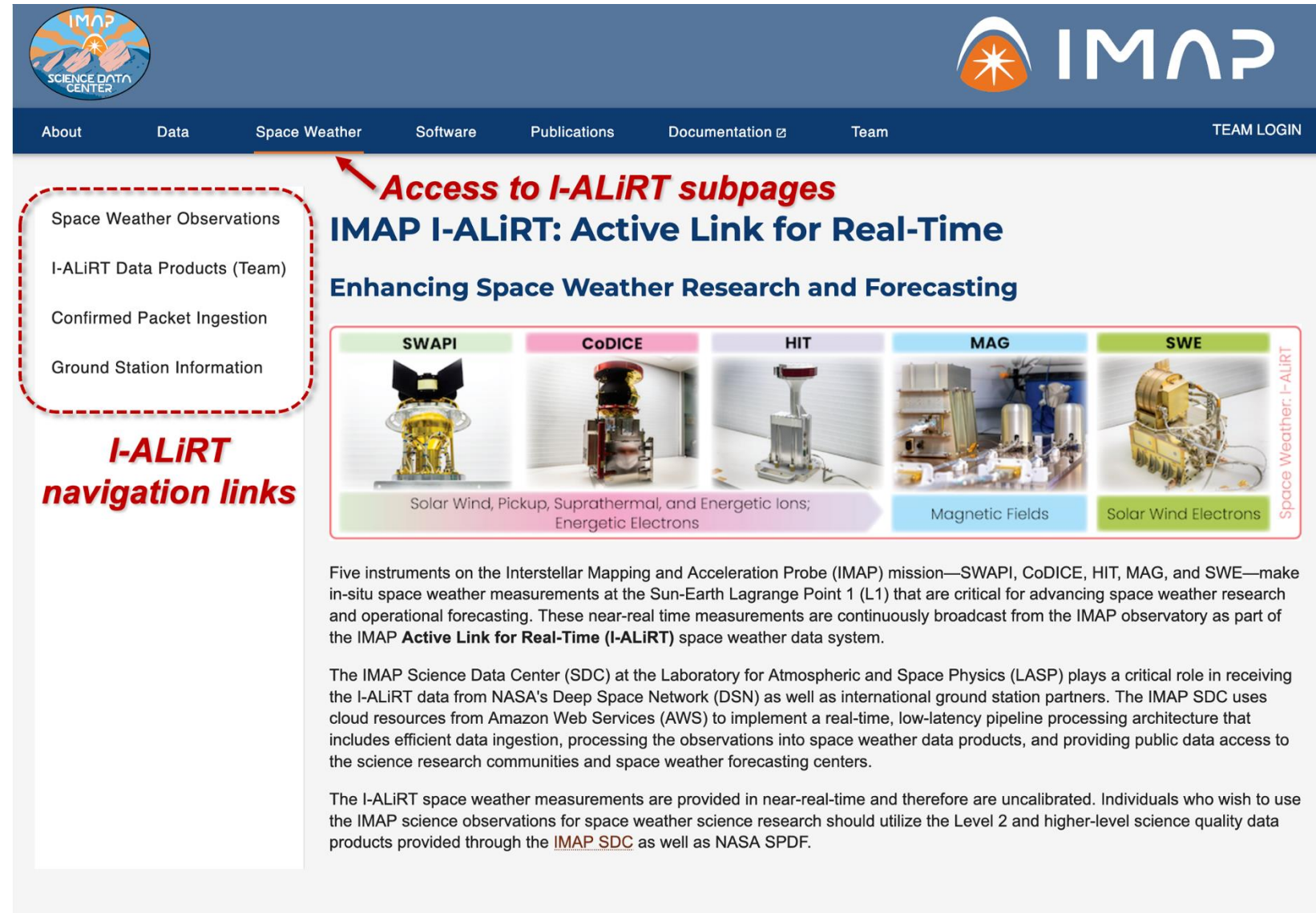
Continuation of ACE Data with Significantly Higher Cadences

IMAP Source	I-ALiRT Data Product	Description	Units	I-ALiRT Cadence	ACE RTSW Cadence
SWAPI (§2.1)	pseudo-speed (u_p)	Coincidence counts of 0.4 to 10 keV/q solar wind H ⁺ protons grouped as a single 12-second coarse sweep (across 62 energy steps of the ESA energy range)	km/s	12 sec	64 sec
	pseudo-density (n_p)		#/cm ³		
	pseudo-temperature (T_p)		K		
CoDICE-Hi (§2.2.2)	Suprathermal proton flux	0.05 to 5 MeV H ⁺ proton (differential intensities; 15 energy ranges)	#/(cm ² -sr-s-MeV)	1 min	5 min
HIT (§2.3)	SEP proton count rates	2 to 15 MeV protons (2 energy ranges, each for sunward and antisunward look directions)	#/s	1 min	5 min
MAG (§2.4)	B vectors Azimuthal and elevation angles of B (ϕ_B , θ_B)	GSE, GSM, and RTN coordinates. Magnetic field measurements at dynamic range of ± 512 nT and resolution ≥ 16 pT	nT degrees	4 sec	60 sec

New Space Weather Data Products

IMAP Source	I-ALiRT Data Product	Description	Units	I-ALiRT Cadence
CoDICE-Lo (§2.2.1)	Solar wind charge state ratios and elemental abundances	C ⁶⁺ /C ⁵⁺ , O ⁷⁺ /O ⁶⁺ , Fe ^(low) /Fe ^(high) , C/O, Mg/O, Fe/O determined from pseudo-number densities of solar wind species	unitless	4 min
HIT (§2.3)	SEP electron count rates	0.5 to 1 MeV electrons (2 energy ranges, each for sunward and antisunward look directions)	#/s	1 min
SWE (§2.5)	Identification of counterstreaming (bidirectional) electron flow	A single number indicating whether electrons are flowing in one direction along the magnetic field or both directions (parallel and antiparallel) to the magnetic field	0 = unidirectional 1 = bidirectional	1 min
	Solar wind electron count rates	Normalized counts of 100 eV to 1 keV suprathermal electrons summed over 7 CEMs and all spin angles, at each energy channel (8 total).	Normalized #/s	

I-ALiRT plots, data access, ground station information will be accessible through the IMAP SDC website <https://imap-mission.com/>



The screenshot shows the IMAP Science Data Center website. The top navigation bar includes links for About, Data, Space Weather (highlighted with a red arrow), Software, Publications, Documentation, Team, and TEAM LOGIN. A sidebar on the left contains a dashed red box labeled "I-ALiRT navigation links" with links to Space Weather Observations, I-ALiRT Data Products (Team), Confirmed Packet Ingestion, and Ground Station Information. The main content area features the title "IMAP I-ALiRT: Active Link for Real-Time Enhancing Space Weather Research and Forecasting" and a grid of five instrument images: SWAPI (Solar Wind, Pickup, Suprathermal, and Energetic Ions; Energetic Electrons), CoDICE, HIT, MAG (Magnetic Fields), and SWE (Solar Wind Electrons). Below the grid, text describes the instruments and the data processing pipeline.

Access to I-ALiRT subpages

IMAP I-ALiRT: Active Link for Real-Time Enhancing Space Weather Research and Forecasting

I-ALiRT navigation links

- Space Weather Observations
- I-ALiRT Data Products (Team)
- Confirmed Packet Ingestion
- Ground Station Information

SWAPI
Solar Wind, Pickup, Suprathermal, and Energetic Ions; Energetic Electrons

CoDICE

HIT

MAG
Magnetic Fields

SWE
Solar Wind Electrons

Space Weather: I-ALiRT

Five instruments on the Interstellar Mapping and Acceleration Probe (IMAP) mission—SWAPI, CoDICE, HIT, MAG, and SWE—make in-situ space weather measurements at the Sun-Earth Lagrange Point 1 (L1) that are critical for advancing space weather research and operational forecasting. These near-real time measurements are continuously broadcast from the IMAP observatory as part of the IMAP **Active Link for Real-Time (I-ALiRT)** space weather data system.

The IMAP Science Data Center (SDC) at the Laboratory for Atmospheric and Space Physics (LASP) plays a critical role in receiving the I-ALiRT data from NASA's Deep Space Network (DSN) as well as international ground station partners. The IMAP SDC uses cloud resources from Amazon Web Services (AWS) to implement a real-time, low-latency pipeline processing architecture that includes efficient data ingestion, processing the observations into space weather data products, and providing public data access to the science research communities and space weather forecasting centers.

The I-ALiRT space weather measurements are provided in near-real-time and therefore are uncalibrated. Individuals who wish to use the IMAP science observations for space weather science research should utilize the Level 2 and higher-level science quality data products provided through the [IMAP SDC](#) as well as NASA SPDF.



Access to quick look plots and data files (*.json, *.cdf) will be available starting on Feb 1, 2026

[About](#)
[Data](#)
[Space Weather](#)
[Software](#)
[Publications](#)
[Documentation](#)
[Team](#)

Space Weather Observations

I-ALiRT Data Products (Team)

Confirmed Packet Ingestion

Ground Station Information

IMAP I-ALiRT: Active Link for Real-Time

Enhancing Space Weather Research and Forecasting

Solar Wind, Pickup, Suprathermal, and Energetic Ions; Energetic Electrons

Magnetic Fields

Solar Wind Electrons

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Information about the I-ALiRT ground station network will be updated as NASA HQ continues to establish additional antenna partners




[About](#)
[Data](#)
[Space Weather](#)
[Software](#)
[Publications](#)
[Documentation](#)
[Team](#)

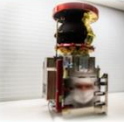
[Space Weather Observations](#)
[I-ALiRT Data Products \(Team\)](#)
[Confirmed Packet Ingestion](#)
[Ground Station Information](#)

IMAP I-ALiRT: Active Link for Real-Time Enhancing Space Weather Research and Forecasting



SWAPI

Solar Wind, Pickup, Suprathermal, and Energetic Ions; Energetic Electrons



CoDICE



HIT



MAG

Magnetic Fields



SWE

Solar Wind Electrons

Five instruments on the Interstellar Mapping and Acceleration Probe (IMAP) mission—SWAPI, CoDICE, HIT, MAG, and SWE—make in-situ space weather measurements at the Sun-Earth Lagrange Point 1 (L1) that are critical for advancing space weather research and operational forecasting. These near-real time measurements are continuously broadcast from the IMAP observatory as part of the IMAP **Active Link for Real-Time (I-ALiRT)** space weather data system.

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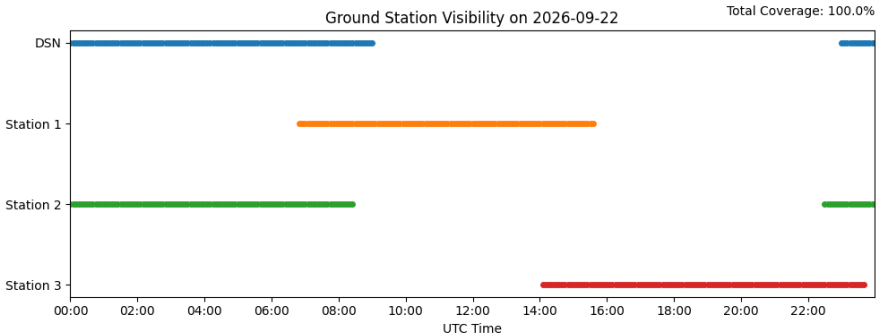
- NASA has established agreements with:

Ground Station Site Location	Institution/Agency	Coordinates (latitude, longitude)
Kiel, Germany	Christian-Albrechts-University of Kiel (CAU)	54.26°N, 10.18°W
Jeju, South Korea	Korea AeroSpace Administration (KASA)	33.25°N, 126.17°E

- Coordination and support from NOAA to utilize a few of their ground stations for I-ALiRT



- Example I-ALiRT ground station coverage plot showing 24-h coverage from DSN and NASA partner ground stations



I-ALiRT Architecture

CoDICE

- Hi: Suprathermal Ions at 1 min Cadence
- Lo: SW Charge State Ratios at 4 min Cadence

SWAPI

- Thermal Plasma at 12 sec Cadence

HIT

- Protons & Electrons at 1 min Cadence

SWE

- Low Energy Electrons at 15 sec Cadence

MAG

- Magnetic Field at 4 sec Cadence

Hi: 272 bit I-ALiRT Packet @ 1 Hz
Lo: 192 bit I-ALiRT Packet @ 1 Hz

256 bit I-ALiRT Packet @ 1 Hz

528 bit I-ALiRT Packet @ 1 Hz

384 bit I-ALiRT Packet @ 1 Hz

192 bit I-ALiRT Packet @ 1 Hz

Flight Software

- Strips headers off of incoming packets
- Integrates I-ALiRT packets into a single packet
- Estimates spin information from ACS applications
- Defines instrument status from heartbeat measured by autonomy
- Incorporates autonomy thruster flag and rule firings
- Frames packet for downlink

ACS Data

ACS

- Measure Attitude

Autonomy Data

Autonomy

- Measure Inst. Heartbeat, 1Hz
- Thruster Flags
- Rule Firings

If Observatory is placed in safe mode, instruments are turned off and I-ALiRT packets are replaced with safe mode packets

Normal Contact Downlink 375-500 kbps
I-ALiRT Packets

I-ALiRT Packets or Safe Mode Packets @ 2083 bps downlink

DSN



I-ALiRT Packets along with
Recorded Data
Real-time Housekeeping

IMAP MOC



I-ALiRT Packets

Health & Status Message or

Safe Mode Packets

IMAP SOC



Post Processed Space
Weather Data

**Space Weather
Community**



**Participating
I-ALiRT Ground Station**



I-ALiRT Packets or
Safe Mode Packets
(Each has a unique APID)

IMAP SOC post-processes space weather
data within 5 minutes of receipt of data

From Lee et al.
(submitted to SSRv, 2025)



Summary of the I-ALiRT space weather data latencies

I-ALiRT data flow process	Latency Requirements (seconds)
Generating data packet of the full cadence of measurements from CoDICE, SWAPI, HIT, MAG and SWE	240
Spacecraft FSW and RF processing of the I-ALiRT data frame	50
Ground station receiving I-ALiRT data frame that contains the full data cadence of previous measurements	300
Transferring of I-ALiRT data frame by the ground station to the SOC (or if during DSN contacts, to the SOC via the MOC)	10 <i>(not a requirement)</i>
Processing of the full measurement cadence to when the data products are available to the public	300

‘Worst case’ scenario: If all of the listed processes need to utilize their maximum latencies to fulfill the tasks, the latest data that are made publicly available would be no more than 900 seconds (15 minutes) old

I-ALiRT details can be found in the manuscript to be published in Space Science Reviews

Current status: addressing reviewers' comments

Space Weather Science to Enhance Forecasting with the NASA IMAP Active Link for Real-Time (I-ALiRT) System

Christina O. Lee¹, Eric R. Christian², Laura Sandoval³, Alastair Crabtree⁴, Mihir I. Desai⁵,
Matina Gkioulidou⁶, Bernd Heber⁷, Timothy Horbury⁴, Lynn Kistler⁸, Jenny Knuth³,
Bishwas L. Shrestha⁹, Kristopher Larsen³, Stefano Livi⁵, Greg M. Lucas³, Daniel E.
Matlin⁶, Tori Marbois³, David J. McComas⁹, John G. Mitchell², Joey Mukherjee⁵, Arik
Posner¹⁰, Jamie S. Rankin⁹, Chelle Reno⁹, Nathan A. Schwadron⁸, Ruth M. Skoug¹¹,
Evan J. Smith⁶, Michael J. Starkey⁵, Drew L. Turner⁶, Bradley D. Williams¹⁰, Eric J.
Zirnstein⁹

Teamwork makes the dream work!

IMAP pulls together an international team of 25 institutions

