



SoHe 2023
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Arcetri (Florence, Italy)

Accordo ASI - INAF n. 2020-35-HH.0



CAESAR prototype for ASPIS

from Space Weather chains of phenomena
through resource management
to user interfaces

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on behalf of the CAESAR Team

Project Prime:



Project Partners:



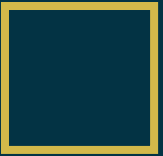
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CAESAR overview

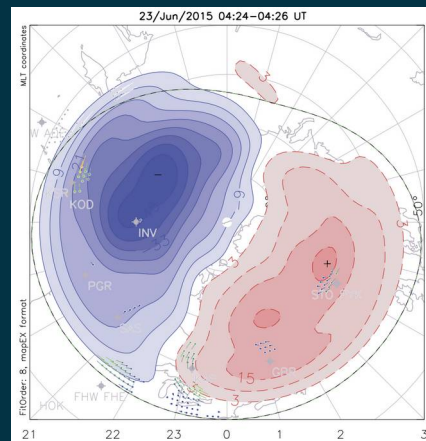
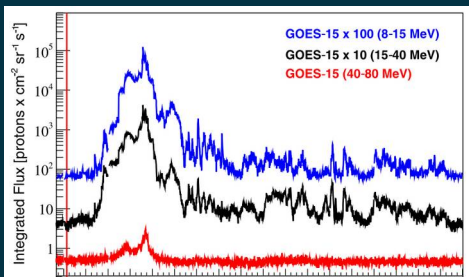
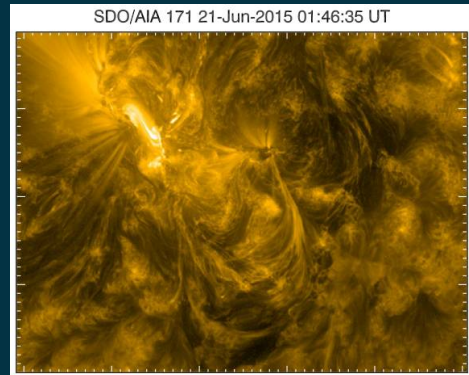
CAESAR brings together **10 Italian institutions** as partners, **95 researchers**, and tackles **the main relevant aspects of SWE science**. It is also devoted to realize the **prototype** of the scientific data centre for Space Weather of the Italian Space Agency (ASI) called **ASPIS** (ASI SPace Weather InfraStructure).



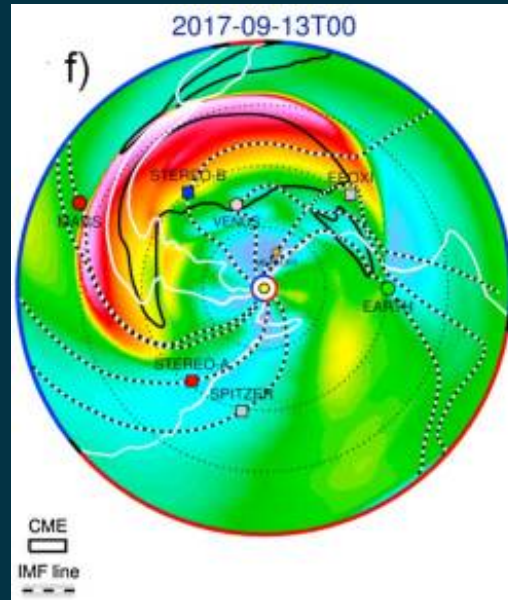
CAESAR approach

CAESAR adopts an unprecedented, comprehensive, multidisciplinary and integrated approach, encompassing the **whole chain of phenomena from the Sun to the Earth up to planetary environments.**

Geoeffective event



Widespread event



CAESAR investigates a number of well-observed “**target SWE events**” (geoeffective, widespread), exhibiting moderate to extreme SWE characteristics from several perspectives, for detailed case studies.

CAESAR investigations synergistically exploit different products, that will be made available in ASPIS.

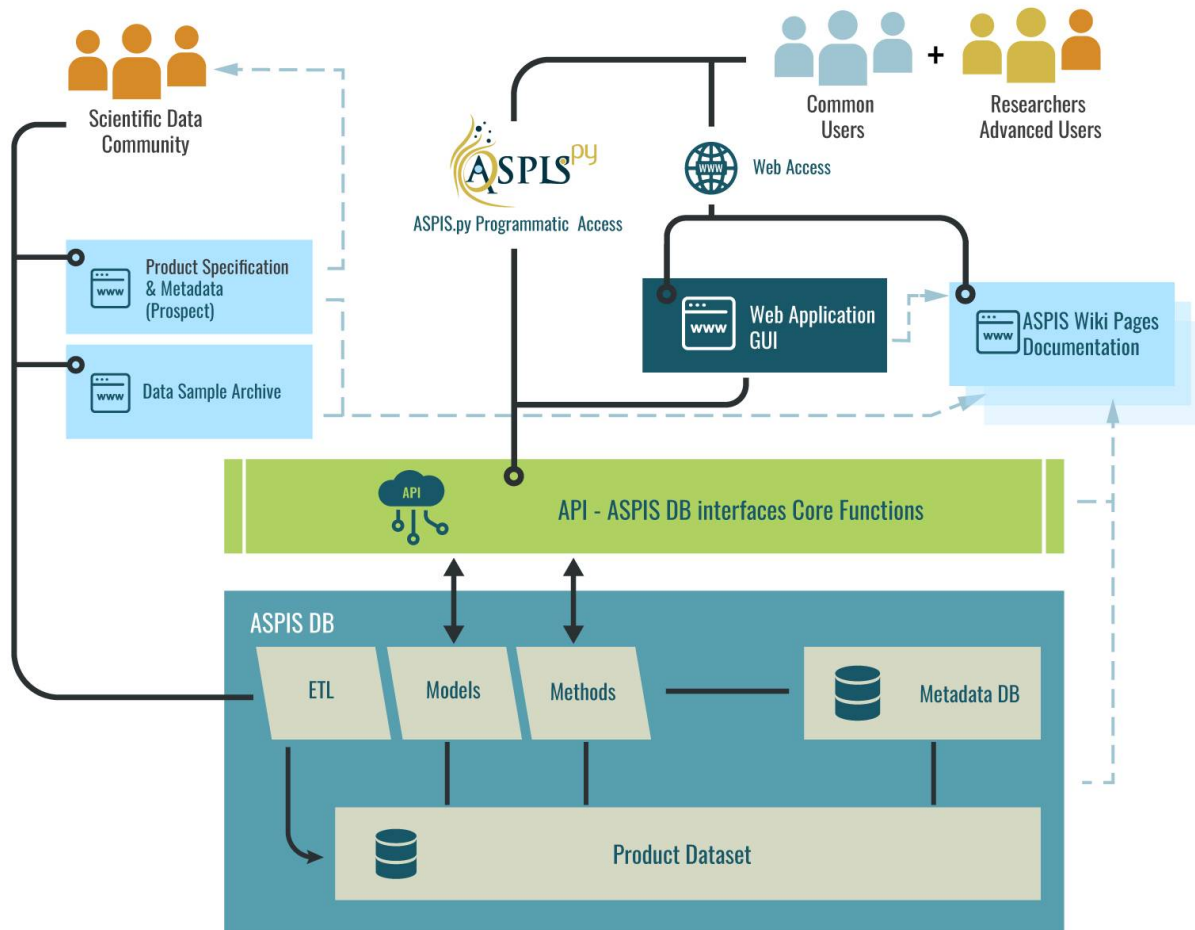




CAESAR objectives

- 1) Advance the understanding of the origin and evolution of SWE phenomena;
- 2) provide novel and longstanding data, codes and models;
- 3) design, implement and populate with such products the ASPIS prototype in a flexible user-friendly infrastructure;
- 4) pave the way to future advanced SWE forecasting capabilities;
- 5) ensure efficient dissemination and foster future studies.

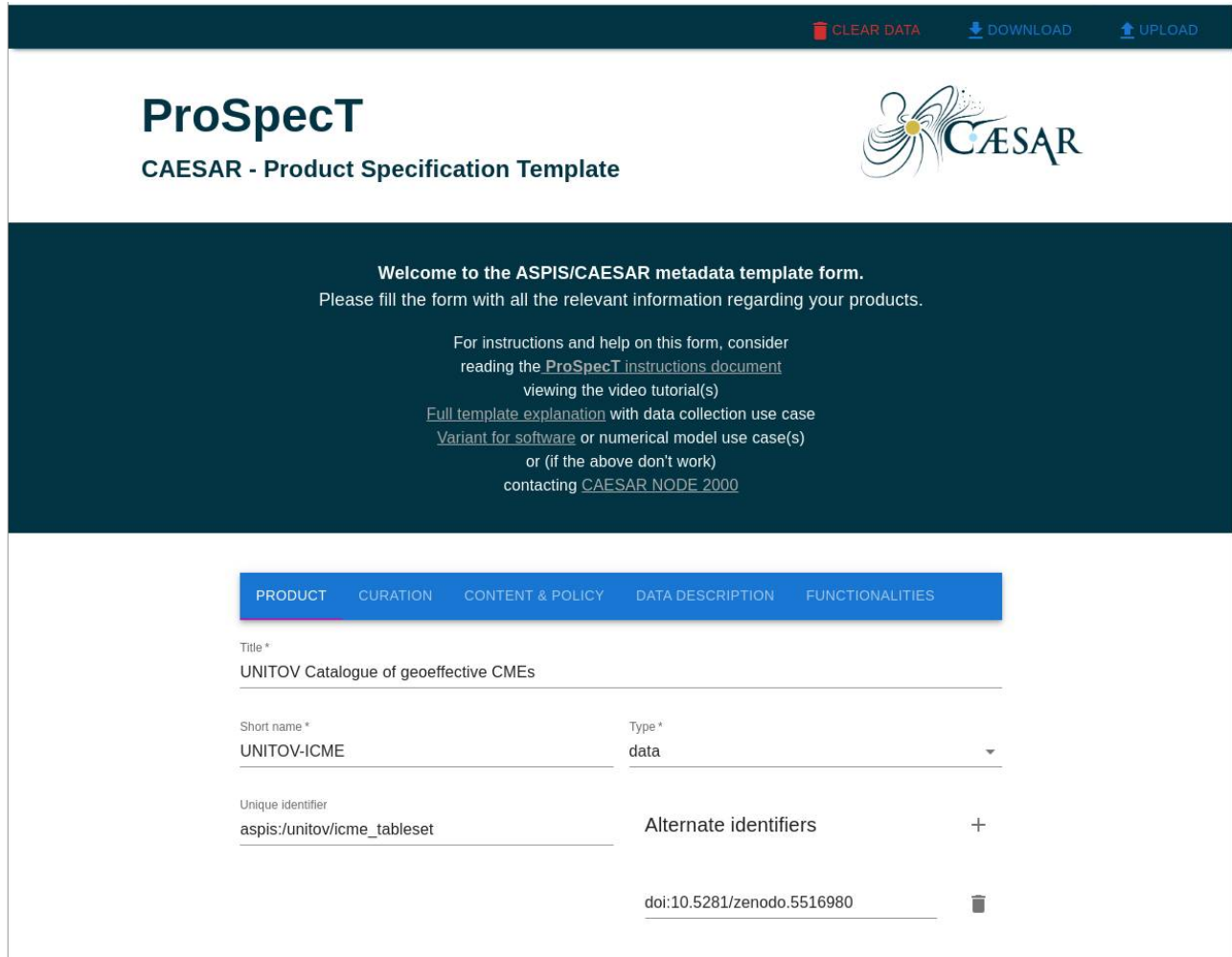
CAESAR prototype – High Level Architecture



Working Packages are responsible for

- **WP2100**
 - Designing the DB
 - Database in its general meaning
 - Implement it
 - Empty → preliminary → final prototype
 - Ingest product data/models
 - Incorporate models/tools
- **WP2200**
 - Define the archive's API
 - Provide a GUI (available to all users)
 - Develop ASPIS.py (for advanced researchers)
- **WP2300**
 - Templating product descriptions and collecting them from NODE 1000
 - Map metadata content and formats for internal/external usage
 - Document all the activities and processes


Product Specification Template – metadata schema & tool



CLEAR DATA DOWNLOAD UPLOAD

ProSpecT

CAESAR - Product Specification Template



Welcome to the ASPIS/CAESAR metadata template form.
Please fill the form with all the relevant information regarding your products.

For instructions and help on this form, consider
reading the [ProSpecT instructions document](#)
viewing the video tutorial(s)
[Full template explanation](#) with data collection use case
[Variant for software](#) or numerical model use case(s)
or (if the above don't work)
contacting [CAESAR NODE 2000](#)

PRODUCT CURATION CONTENT & POLICY DATA DESCRIPTION FUNCTIONALITIES

Title *
UNITOV Catalogue of geoeffective CMEs

Short name *
UNITOV-ICME

Type *
data

Unique identifier
aspis:/unitov/icme_tableset

Alternate identifiers +

doi:10.5281/zenodo.5516980

- JSONForms
- JSON metadata document
- VOResource-like
- Combine
 - Technical work requirements
 - Scientific user impact when collecting/curating metadata
 - Ease of use in prototype development



Product Specification Template – stored result

```
1
{
  "product": {
    "title": "UNITOV Catalogue of geoeffective CMEs",
    "shortname": "UNITOV-ICME",
    "type": "data",
    "identifier": "aspis:/unitov/icme_tableset",
    "altidentifier": [
      "doi:10.5281/zenodo.5516980"
    ],
    "status": "Active",
    "created": "2022-04-08T11:24:13+02:00",
    "updated": "2023-10-01T12:00:00+02:00"
  },
  "template": {
    "version": 1
  },
  "curation": {
    "publisher": "UNITOV - Università degli Studi di Roma Tor Vergata",
    "publisherID": "aspis:/unitov",
    "creator": [
      "Dario Del Moro",
      "Raffaello Foldes",
      "Gianluca Napoletano"
    ],
    "contributor": [
      "Ronish Mugatwala",
      "Simone Chierichini"
    ],
    "contact": [
      {
        "name": "Dario Del Moro",
        "email": "delmoro@roma2.infn.it"
      }
    ]
  },
  "content": {
    "subject": [
      "I - Solar Physics",
      "II - Sun-Earth Relationship",
      "III - Geomagnetism"
    ],
    "description": "A database associating L1 Time of Arrival and Speed of an interplanetary CME to the kinematic characteristics of the corresponding CME, covering the period 1996-2020.",
    "referenceURL": "https://zenodo.org/record/5516980#.YK_Kjz00V4",
    "relationship": [
      {
        "type": "related-to",
        "description": "P-DBM model can ingest part of the table to simulate the ICME propagation ",
        "relatedproduct": "UNITOV-PDBM",
        "relatedproductid": "aspis:/unitov/p-dbm"
      }
    ]
  },
  "policy": {
    "type": "public",
    "description": "Other"
  },
}
```

**machine-readable
information**



CAESAR Documentation Wiki

JSON (ProSpecT)

Sphinx

Wiki

Caesar 0.1 documentation » Welcome to CAESAR documentation!

Table of Contents

Welcome to CAESAR documentation!
CAESAR in brief
Contents

Next topic

CAESAR

This Page

Show Source

Quick search

Welcome to CAESAR documentation!

This is the CAESAR Project live documentation. Here you can learn how to use CAESAR v aspis.py library and have a look about the informations of the data products hosted in CAESAR

CAESAR in brief

CAESAR (Comprehensive Space Weather Studies for the ASPIS Prototype Realization) is a project led by the Italian Space Agency and the National Institute of Astrophysics through the ASI-INA agreement for the development of the ASPIS prototype of scientific data centre for Space Weather



Check out the CAESAR section for further information, including the details on ASPIS the project

To read about the latest news of the project please, visit the website [CAESAR project](#)

Contents

next | index

Caesar documentation » Product Catalogue » INGV ROTEI ionospheric index global maps from ESA Swarm satellites

Table of Contents

INGV ROTEI ionospheric index global maps from ESA Swarm satellites

- Data Description
- Capabilities

Previous topic

INGV ROTEI ionospheric index time series at 1Hz from ESA Swarm satellites

Next topic

INGV ROTEI ionospheric index time series at 1Hz from ESA Swarm satellites (A, B, and C)

This Page

Show Source

Quick search

INGV ROTEI ionospheric index global maps from ESA Swarm satellites

The tiny table of contents

- INGV ROTEI ionospheric index global maps from ESA Swarm satellites
 - Data Description
 - Capabilities

Global maps of ROTEI (Rate Of change of electron TEMperature Index) ionospheric index, as derived by in-situ electron temperature observations from the Swarm satellites (A, B, and C) at 1Hz rate, from 1 January 2014 to 31 December 2020.

Data for ionospheric indices calculation are collected by the ESA Swarm satellites mission. Swarm is a constellation constituted by three low-Earth-orbit satellites launched at the end of 2013, and still operating, in a circular near-polar orbit. Two of them (Swarm A and C) have the same orbit configuration (inclination of 87.4°, initial altitude of about 460 km, east-west separation of about 1°-1.5° in longitude). The third (Swarm B) has a different orbital configuration (inclination of 88°, initial altitude of about 520 km) compared to the couple Swarm A and C. In-situ electron density (Ne) and electron temperature (Te) observations are collected by Langmuir Probes (LP). Precise Orbit Determination (POD) antennas are GPS receivers from which the TEC is determined, both vertical and slant, for each GPS satellite in view. Swarm's data are freely downloadable at <ftp://swarm-diss.eo.esa.int>.

References:

- De Michelis et al. (2020), Journal of Geophysical Research: Space Physics, 125, e2020JA027934. <https://doi.org/10.1029/2020JA027934>
- De Michelis, et al. (2021a), Remote Sensing, 13, 759. <https://doi.org/10.3390/rs13040759>
- De Michelis, et al. (2021b), Scientific Reports, 11, 6183, <https://doi.org/10.1038/s41598-021-84985-1>
- De Michelis et al. (2022), Remote Sensing, 14, 918. <https://doi.org/10.3390/rs14040918>
- Pignalberi (2021), Computers and Geosciences, 48, 104675, <https://doi.org/10.1016/j.cageo.2020.104675>
- Pignalberi et al. (2021), Universe, 7, 290. <https://doi.org/10.3390/universe7080290>

Providers:

- Swarm A satellite - source:
 - ESA Swarm A Electric Field Instrument - Langmuir Probe, <https://swarm-diss.eo.esa.int/>
- Swarm B satellite - source:
 - ESA Swarm B Electric Field Instrument - Langmuir Probe, <https://swarm-diss.eo.esa.int/>
- Swarm C satellite - source:
 - ESA Swarm C Electric Field Instrument - Langmuir Probe, <https://swarm-diss.eo.esa.int/>

Product Type: data

Status: Active

Creation date: 2022-04-26T16:16:20+02:00

Last Update: 2023-10-01T12:00:00+02:00



Data - Metadata - Formats :: project requirements

- Homogenising submitted data and metadata always involves a critical balance
 - Lessen work to be done
 - Homogenise formats (dataset format, metadata content, ...)
- Find ways to “standardise” following community needs

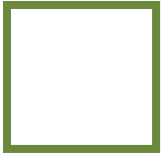
prototype



solution

- file formats (for datasets, type based)
- data/dataset collection metadata preparation
- units
- datetime format
- coordinate frames

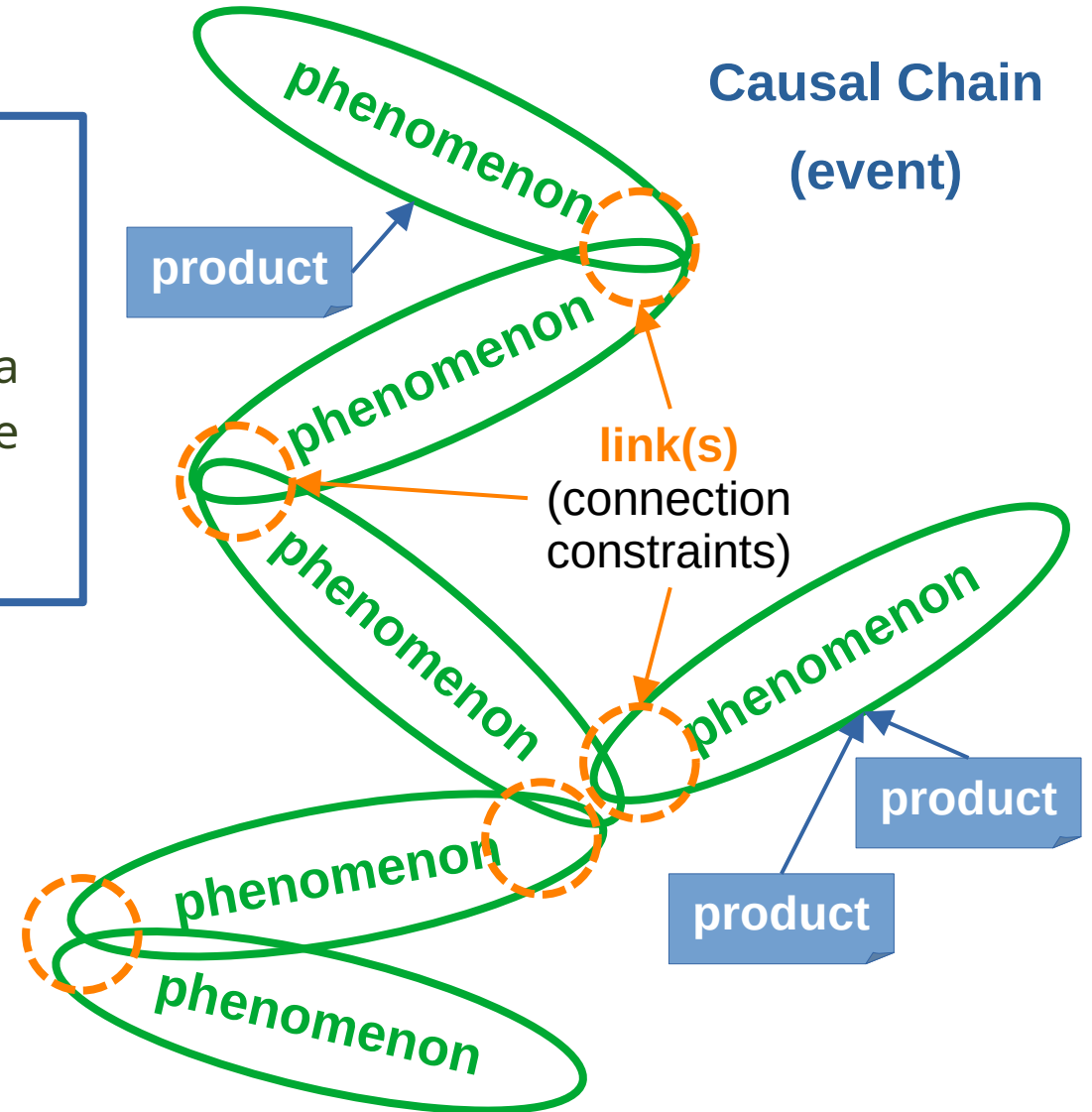
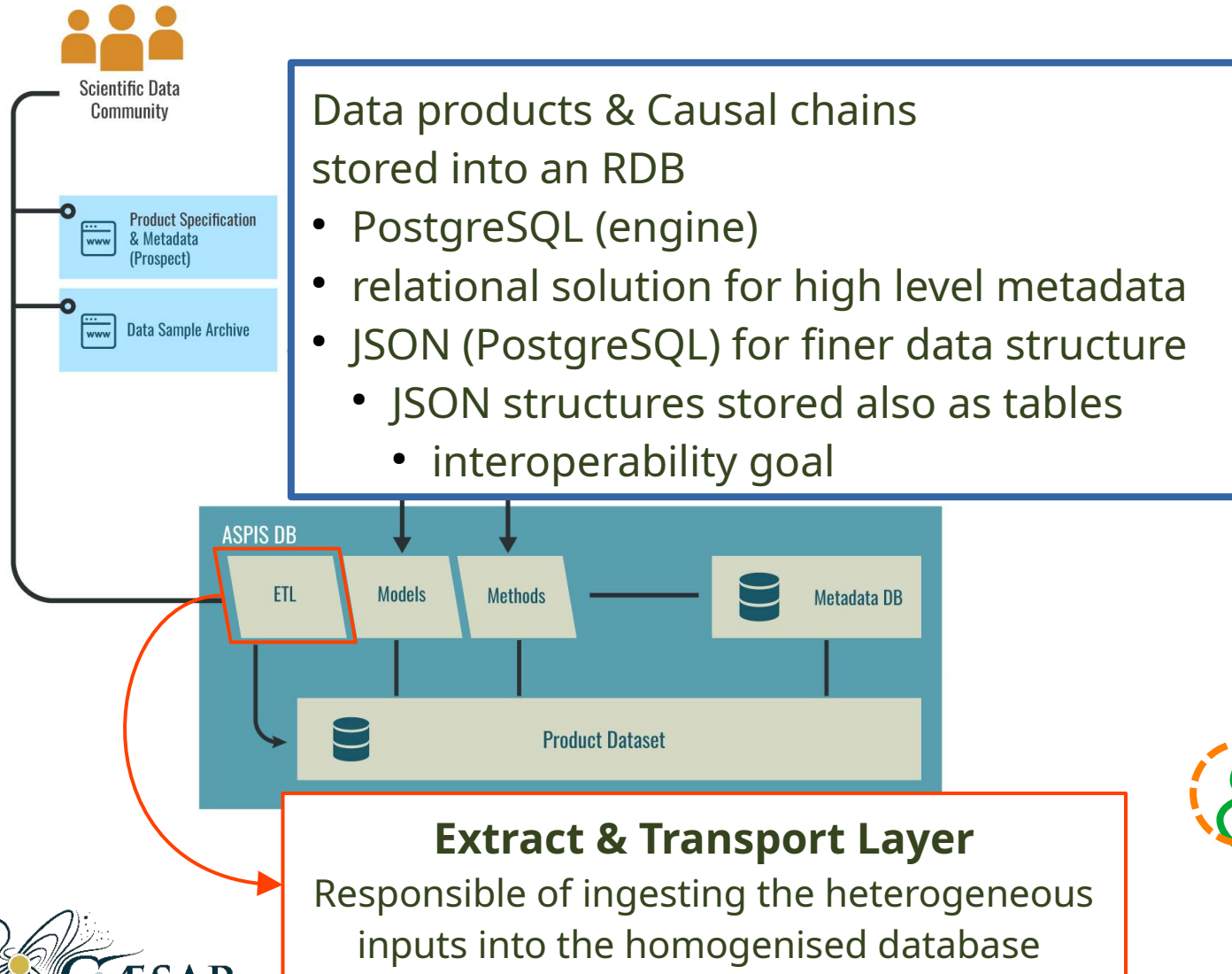
	FITS	netCDF	CSV	JSON
timeseries	✓	✓	✓	✓
tablesets	✓	✓	✓	✓
images	✓	✓		
datacubes	✓	✓		



Data – Metadata – Formats :: enforced solution

- minimal content for tablesets and data collections descriptions:
 - all columns
 - **name, query-ability, data type, NULL values representation, quantity units**
 - following, possibly, the IVOA standard for units
 - specific columns
 - **(1) time associated** with data/event: **UTC, ISO-8601-like**
 - e.g.: '1999-01-01T00:00:00.123456789', '2010-01-01T00:00:00'
 - **(2-3) columns: coordinates** (2D o 3D)
 - accepted Coordinate Frames:
 - Sun localisation
 - (heliographic) Cartesian, **Stonyhurst**, Carrington [HPC, **HGS**, HGC]
 - Heliosphere localisation
 - (heliocentric) Cartesian, Earth Ecliptic, **Stonyhurst** [HCC, HEE, **HGS-HEEQ**]
 - Earth or near-Earth localisation
 - Geographic, (geocentric) Earth Equatorial, **Solar Ecliptic**, Solar Magnetic, Geomagnetic + McIlwain's [GEO, GEI-Mean, **GSE**, GSM]
 - Other: ICRS or planetary coordinate frames

Database Design & Causal chains





User interface – WEB app

- Visualize the data
- Compare data products
- Show checked event chains
- Download data
- Save user's views and selected products
- Build personalized events chains
- Submit events chains to community

Basic Advanced

Visualize the data	✓	✓
Compare data products	✓	✓
Show checked event chains	✓	✓
Download data	✓	✓
Save user's views and selected products		✓
Build personalized events chains		✓
Submit events chains to community		✓





User interface – ASPIS.py

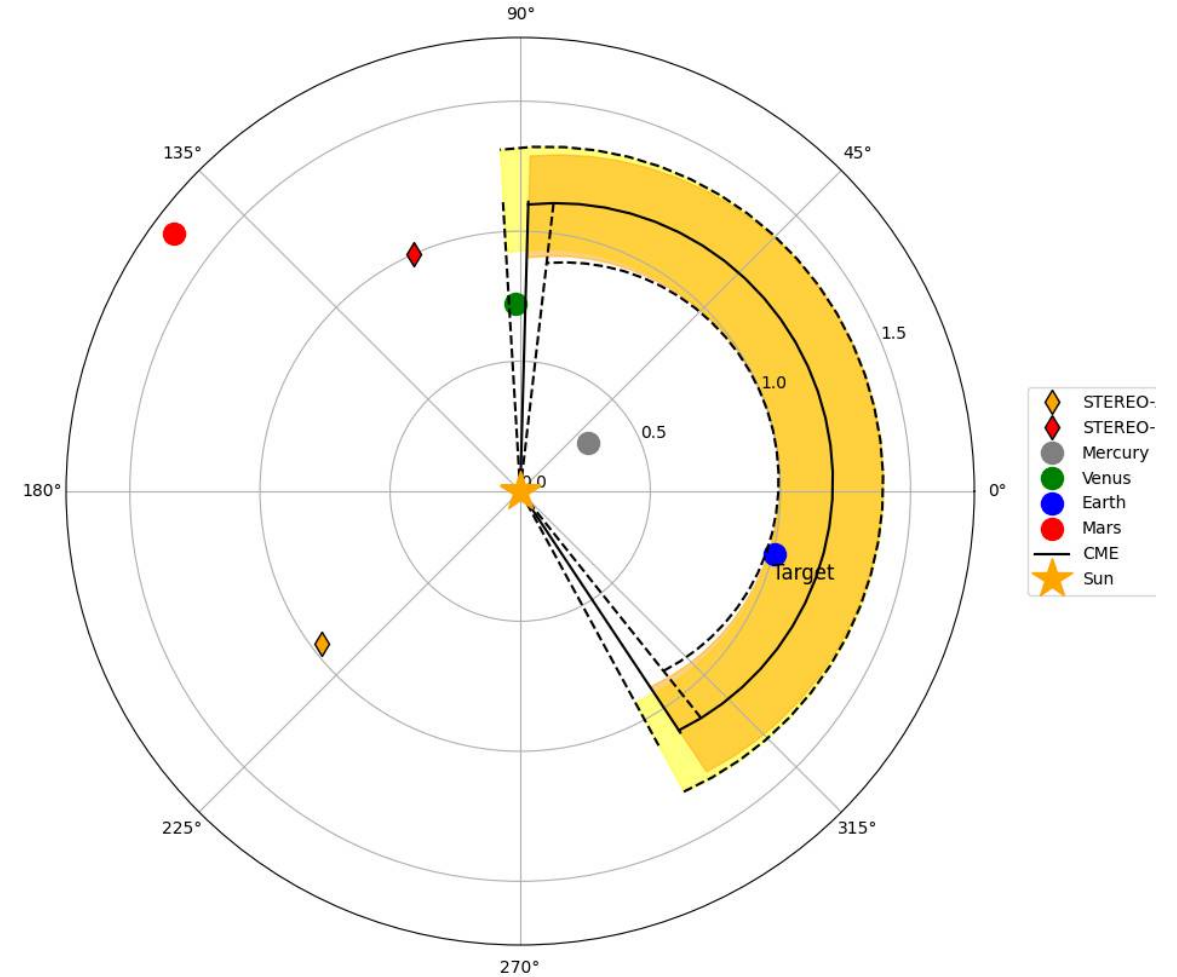
- Python module library
 - programmatic user interface
 - light-computation modules (from products)
 - data and metadata, query and access
 - events (chains)
 - phenomena (datasets)
- visualisation functions

main ▾ aspis.py / aspis.egg-info / requires.txt



requires.txt 43 B

```
1 sunpy
2 numpy
3 pandas
4 scikit-learn
5 matplotlib
6
```



Interfacing and interoperability

CAESAR lives within the Space Weather community, that is attached to Solar Physics, Planetary Science and Heliophysics in general.

On the ASPIS side, GUI and internal solutions will be driven by project identified requirements, but the goal is also to have this archive capable of connecting, interoperating at global level.

We investigated (and still doing so) previous and existing approaches of a variegated community: HELIO, SOLARNET, EuroPlaNet, VSO, HAPI, SunPy, ...

Now that we are at the implementation step we should be able to identify future steps for ASPIS:

- frameworks, standards, communities, ...

This research has been carried out in the framework of the CAESAR (Comprehensive spAce wEather Studies for the ASPIS prototype Realization) project, supported by the Italian Space Agency and the National Institute of Astrophysics through the ASI-INAf n. 2020-35-HH.0 agreement for the development of the ASPIS (ASI Space weather InfraStructure) prototype of scientific data centre for Space Weather.

Accordo ASI - INAF n. 2020-35-HH.0



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Thank you!



NODE 2000 Team

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Project Prime:



Project Partners:



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