SoHe 2023
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Arcetri (Florence, Italy)

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

CAESAR
COMPREHENSIVE SPACE WEATHER STUDIES FOR THE ASPIS PROTOTYPE REALIZATION

CAESAR prototype for ASPIS

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

Marco Molinaro [INAF]

on behalf of the **CAESAR** Team

Project Prime:

INAF ISTITUTO NAZIONALE DI ASTROFISICA

Project Partners:

INFN Istituto Nazionale di Fisica Nucleare
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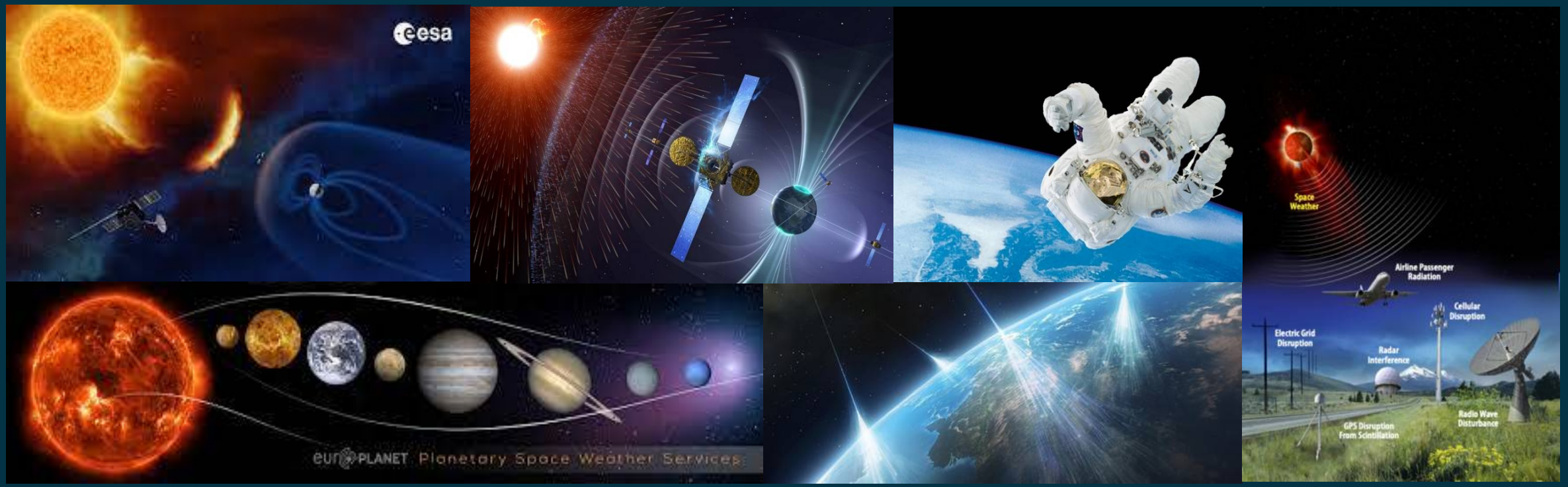
UNIVERSITÀ DELLA CALABRIA
Università di Catania
UNIVERSITÀ DI TRENTO

CAESAR overview

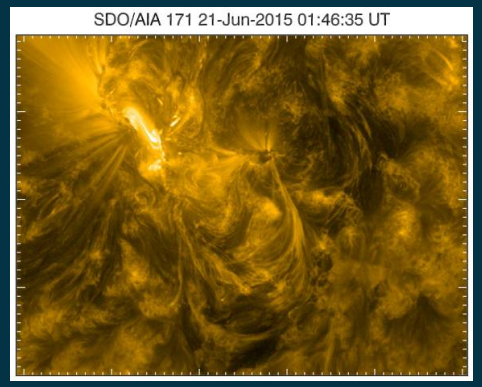
CAESAR brings together **10 Italian institutions** as partners, **95 researchers**, and tackles **the main relevant aspects of SWE science.** It is also devoted to realize the **prototype** of the scientific data centre for Space Weather of the Italian Space Agency (ASI) called **ASPIS** (ASI SPace Weather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

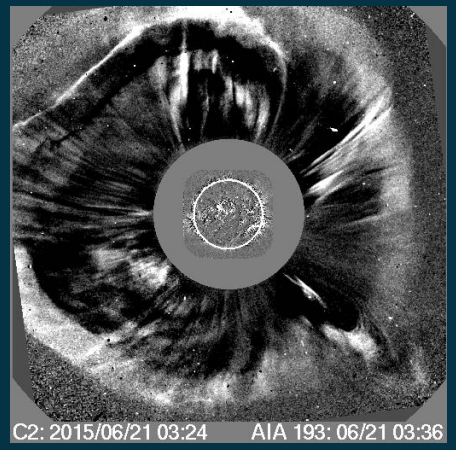


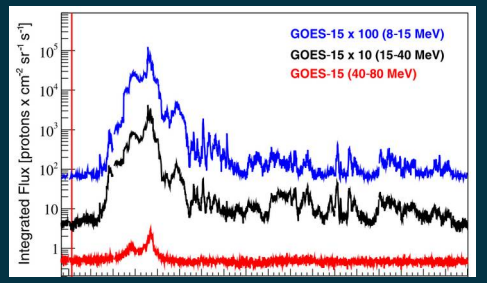
CAESAR approach

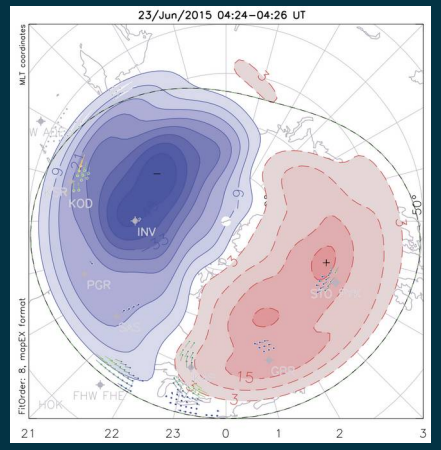
CAESAR adopts an unprecedented, comprehensive, multidisciplinary and integrated approach, encompassing the **whole chain of phenomena from the Sun to the Earth up to planetary environments.**

Geoeffective event

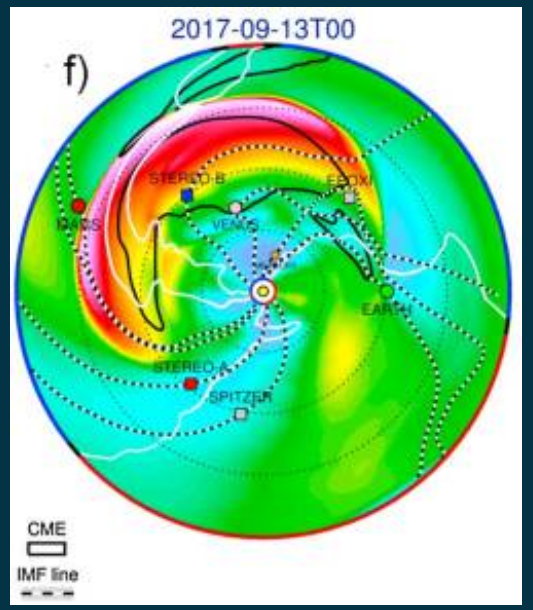








Widespread event



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;

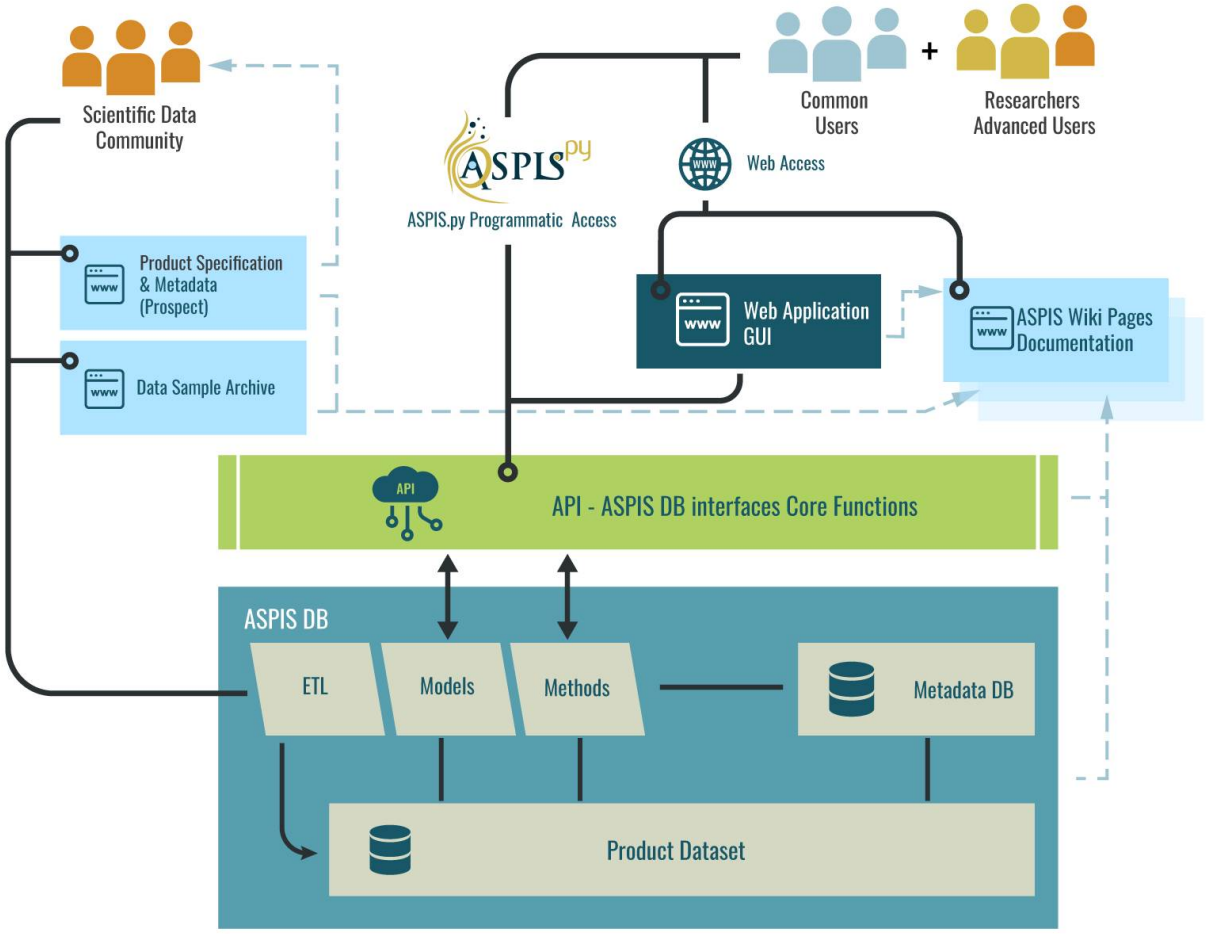
2) provide novel and longstanding data, codes and models;

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.

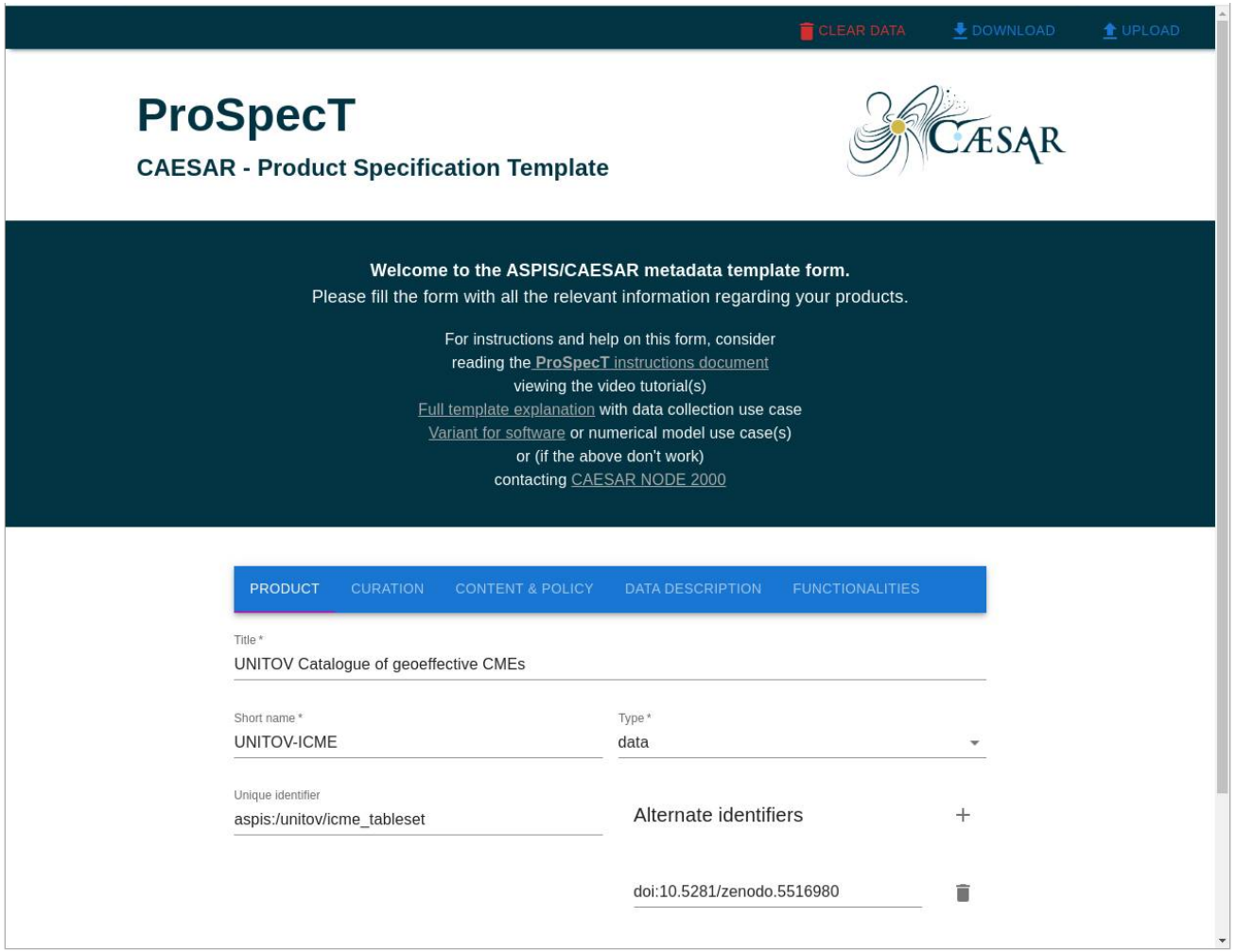
CAESAR prototype – High Level Architecture



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



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

CÆSAR

Product Specification Template – stored result


```
{
  "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__KjzOOV4",
    "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"
  },
```

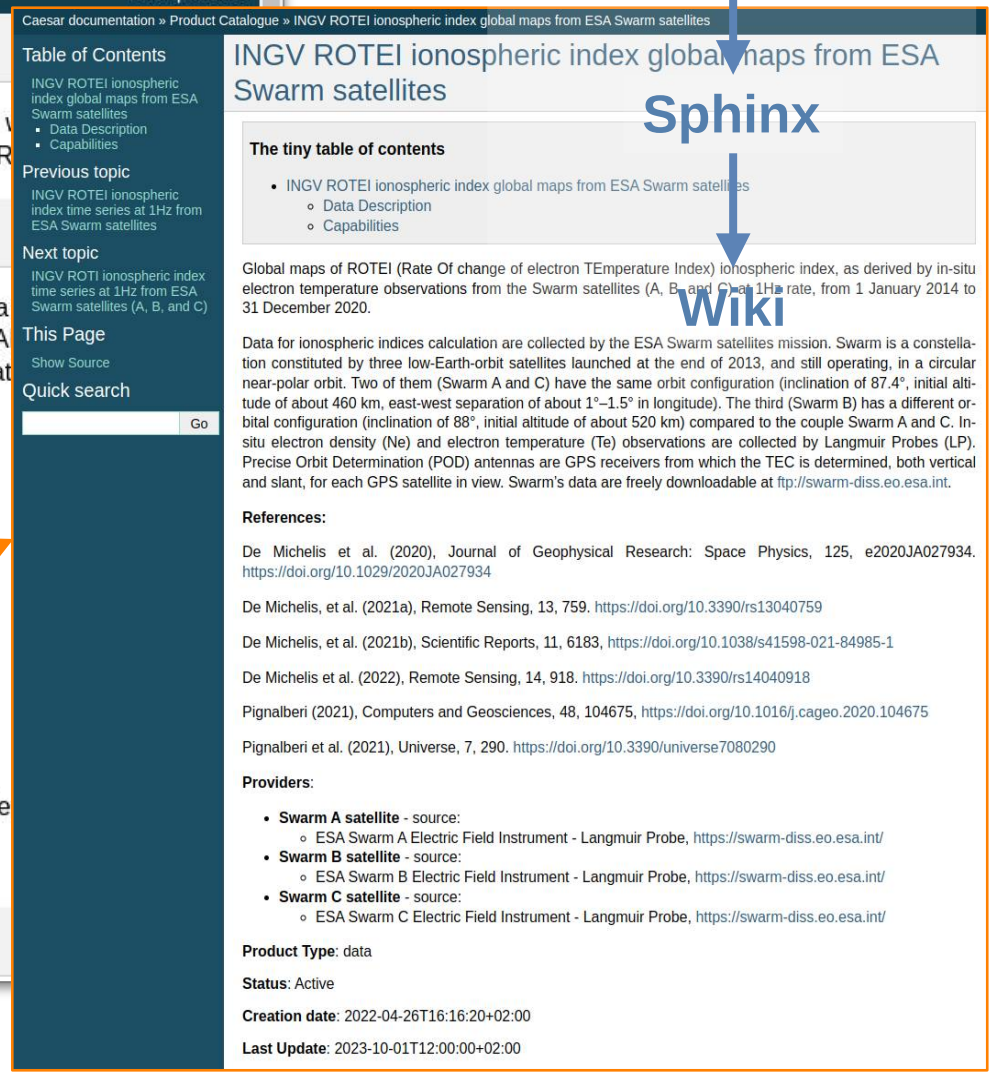

machine-readable information

CAESAR Documentation Wiki

JSON (ProSpecT)

Sphinx

Wiki



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**

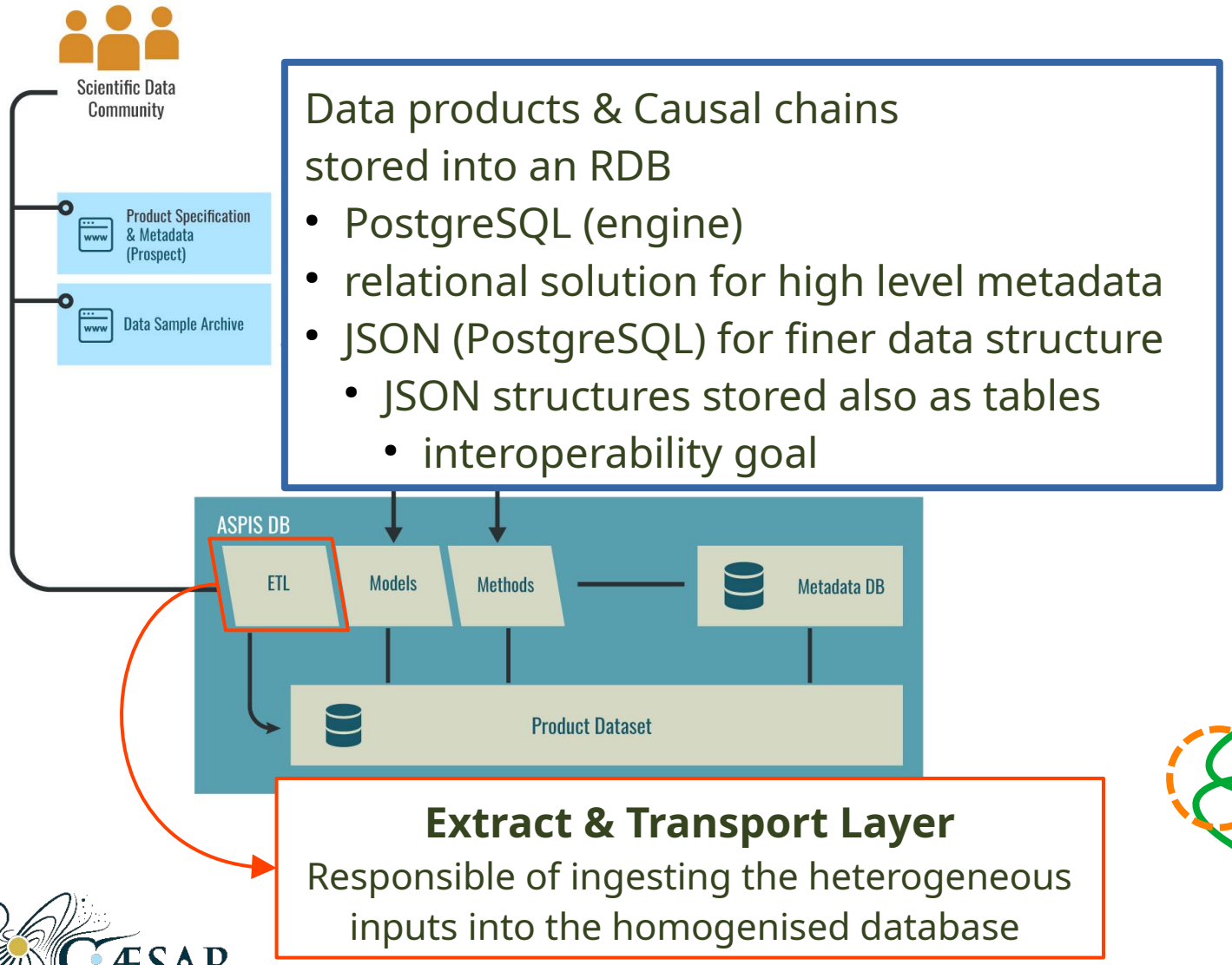
- file formats (for datasets, type based)
- data/dataset collection metadata preparation
- units
- datetime format
- coordinate frames

	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]
        - Heliopshere 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

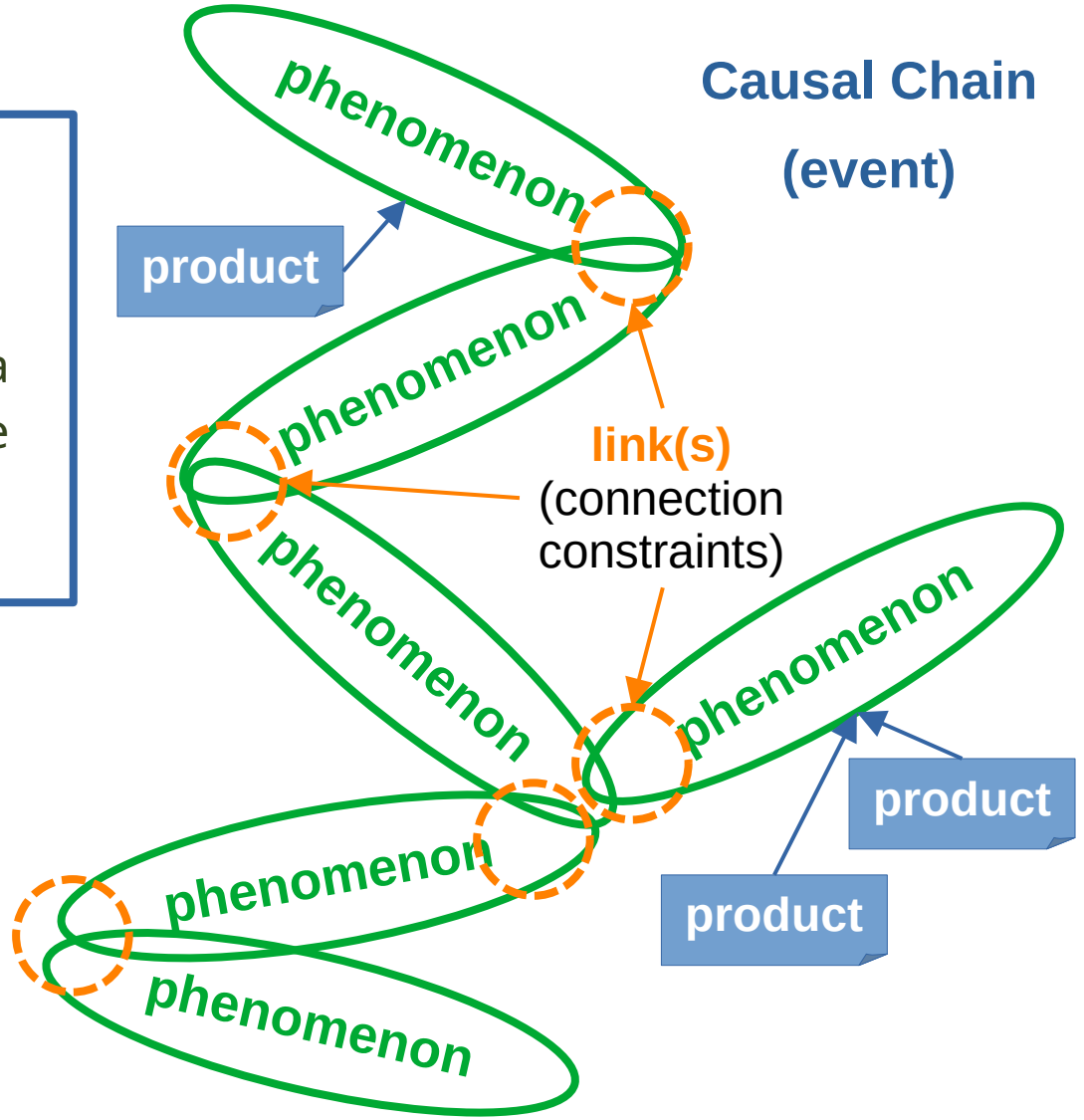


Data products & Causal chains
stored into an RDB

- PostgreSQL (engine)
- relational solution for high level metadata
- JSON (PostgreSQL) for finer data structure
  - JSON structures stored also as tables
    - interoperability goal

Extract & Transport Layer

Responsible of ingesting the heterogeneous inputs into the homogenised database



User interface – WEB app

	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		✓

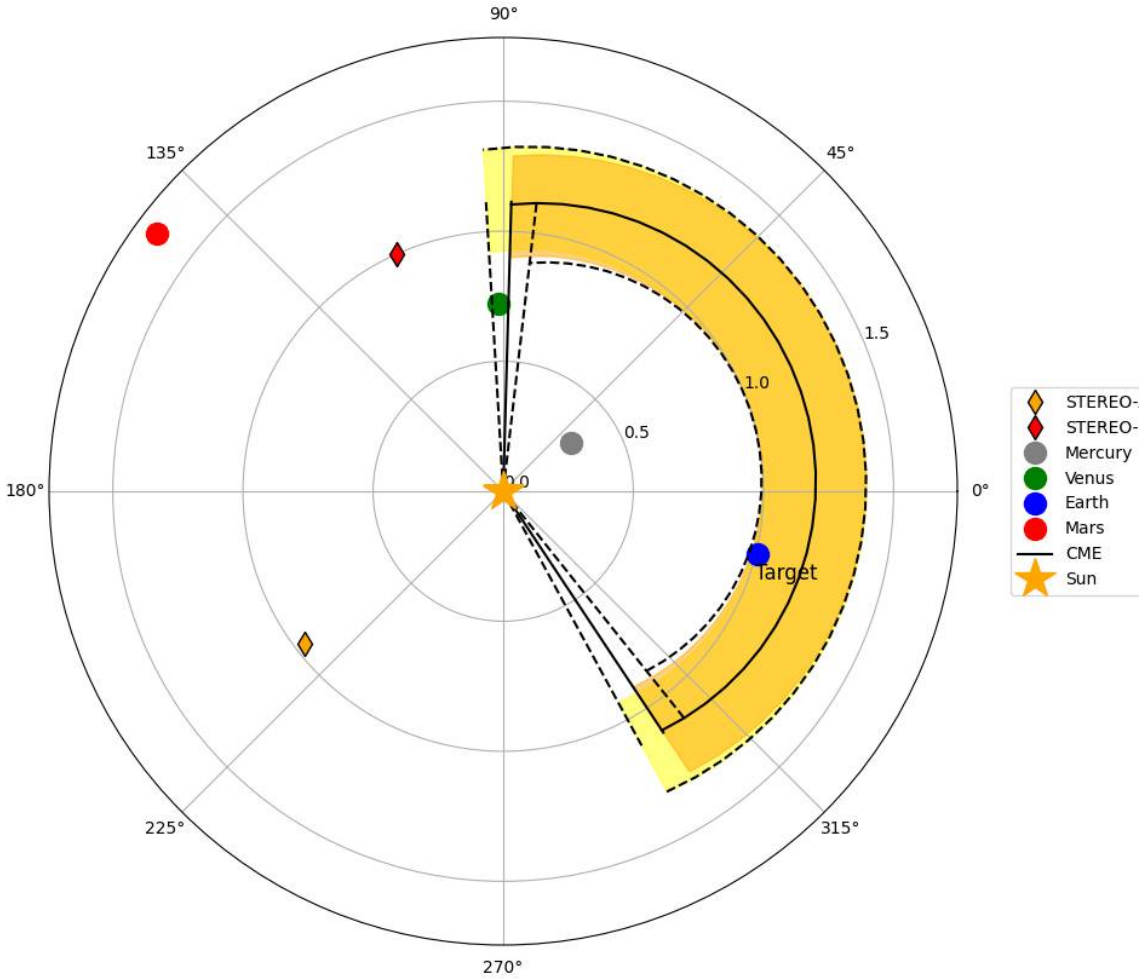
User interface – ASPIS.py

- 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

```
sunpy
numpy
pandas
scikit-learn
matplotlib
```



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.

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https://caesar.iaps.inaf.it/

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SWICO
Space Weather Italian Community

Thank you!

NODE 2000 Team
Marco Molinaro (INAF), Valerio Formato (INFN), Valeria di Felice (INFN), Dario Del Moro (UNITOV), Monica Laurenza (INAF), Cristina Campi (UNIGE), Federico Benvenuto (UNIGE), Carmelo Magnafico (INAF), Mirko Stumpo (INAF), SciGè Liu (INAF), Giuseppe di Persio (INAF), Emanuela Scalise (INAF), Rossana De Marco (INAF), Ermanno Pietropaolo (UNIAQ), Gregoire Francisco (UNITOV), Andrea Tacchino (UNIGE)

EB Team
Anna Milillo, Giuseppe Sindoni, Marco Giardino, Christina Plainaki, Alberto Bigazzi, Gianluca Polenta

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