ESPAS, Near-Earth space data infrastructure for e-science

Anna Belehaki , National Observatory of Athens

Near-Earth space data infrastructure for e-science

A platform to integrate heterogeneous data from earth's thermosphere, ionosphere, plasmasphere & magnetosphere

- Supports the systematic exploration of multipoint measurements from the near-Earth space through homogenised access to multi-instrument data
- Provides access to 40+ datasets from : Cluster, EISCAT, GIRO, DIAS, SWACI, CHAMP, SuperDARN, FPI, magmetometers INGV, SGO, DTU, IMAGE, TGO, IMAGE/RPI, ACE, SOHO, PROBA2, NOAA/POES, etc.
- Supports data visualization, search, statistics, modelling

ESPAS User Interface is accessible through
https://www.espas-fp7.eu/portal

Space observatories in the near-Earth space

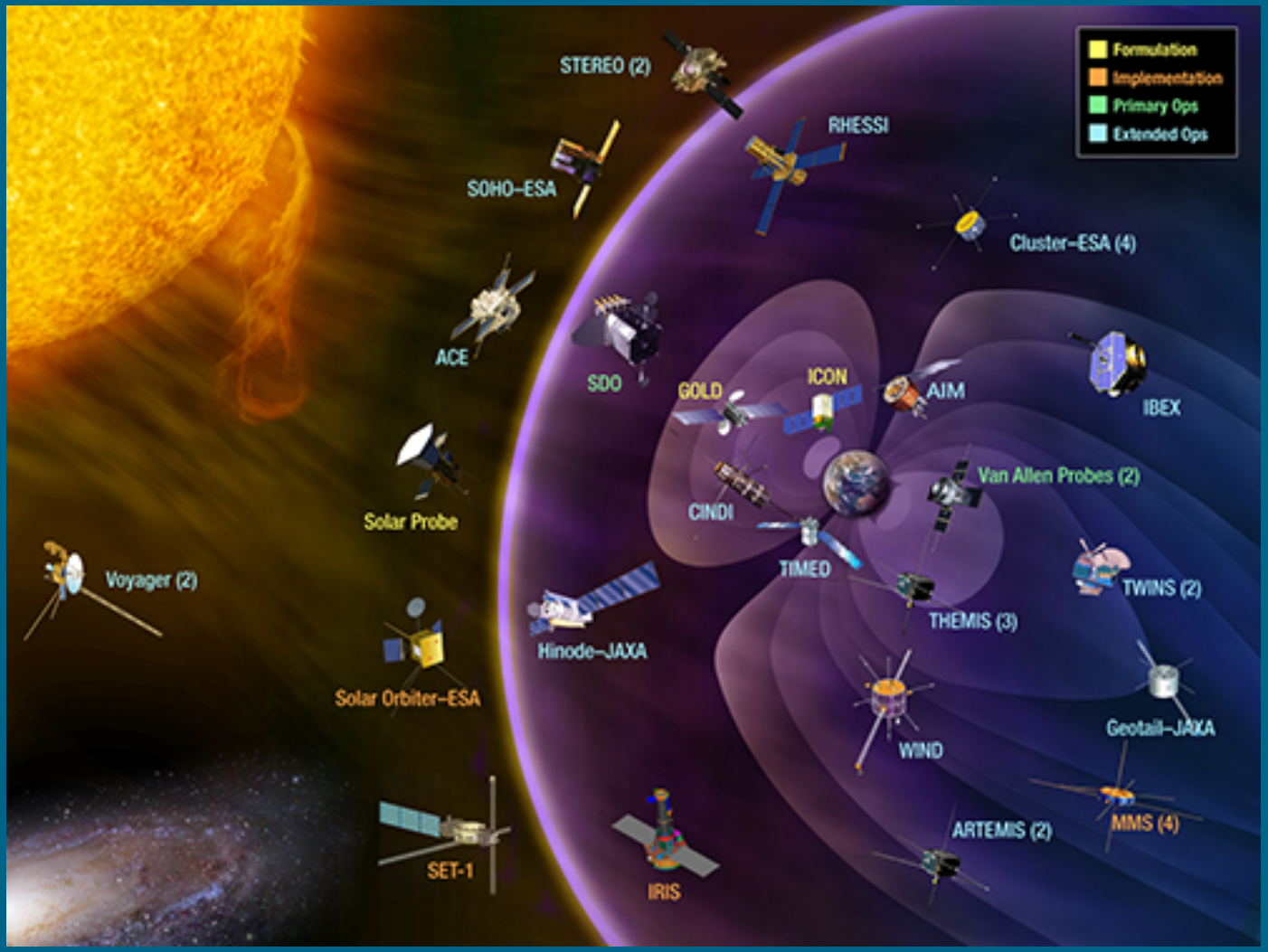
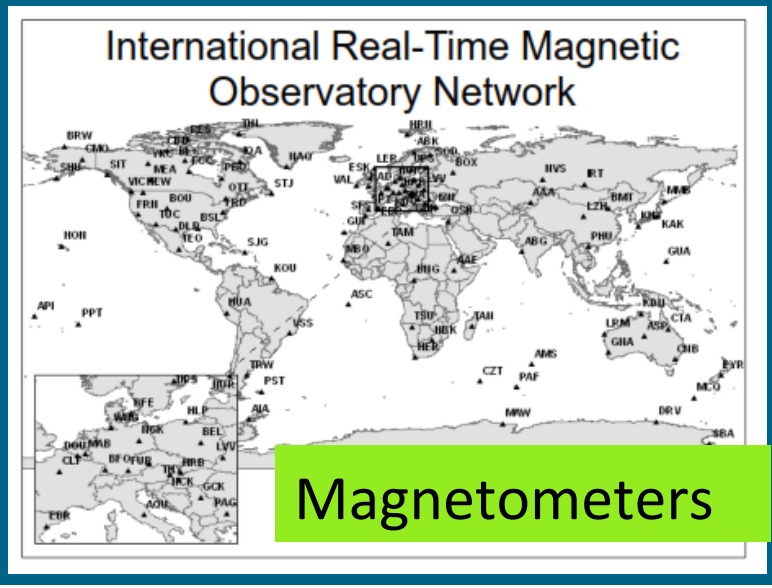


image credit: smdepo.org

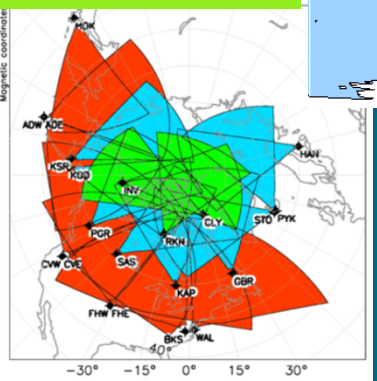
Ground-based instruments observing the near-Earth space

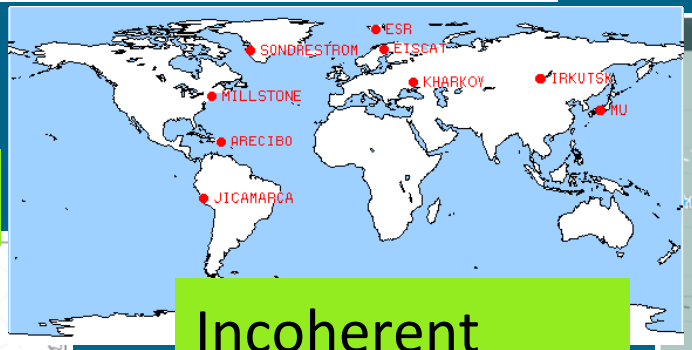
GNSS receivers



Magnetometers

SuperDARN

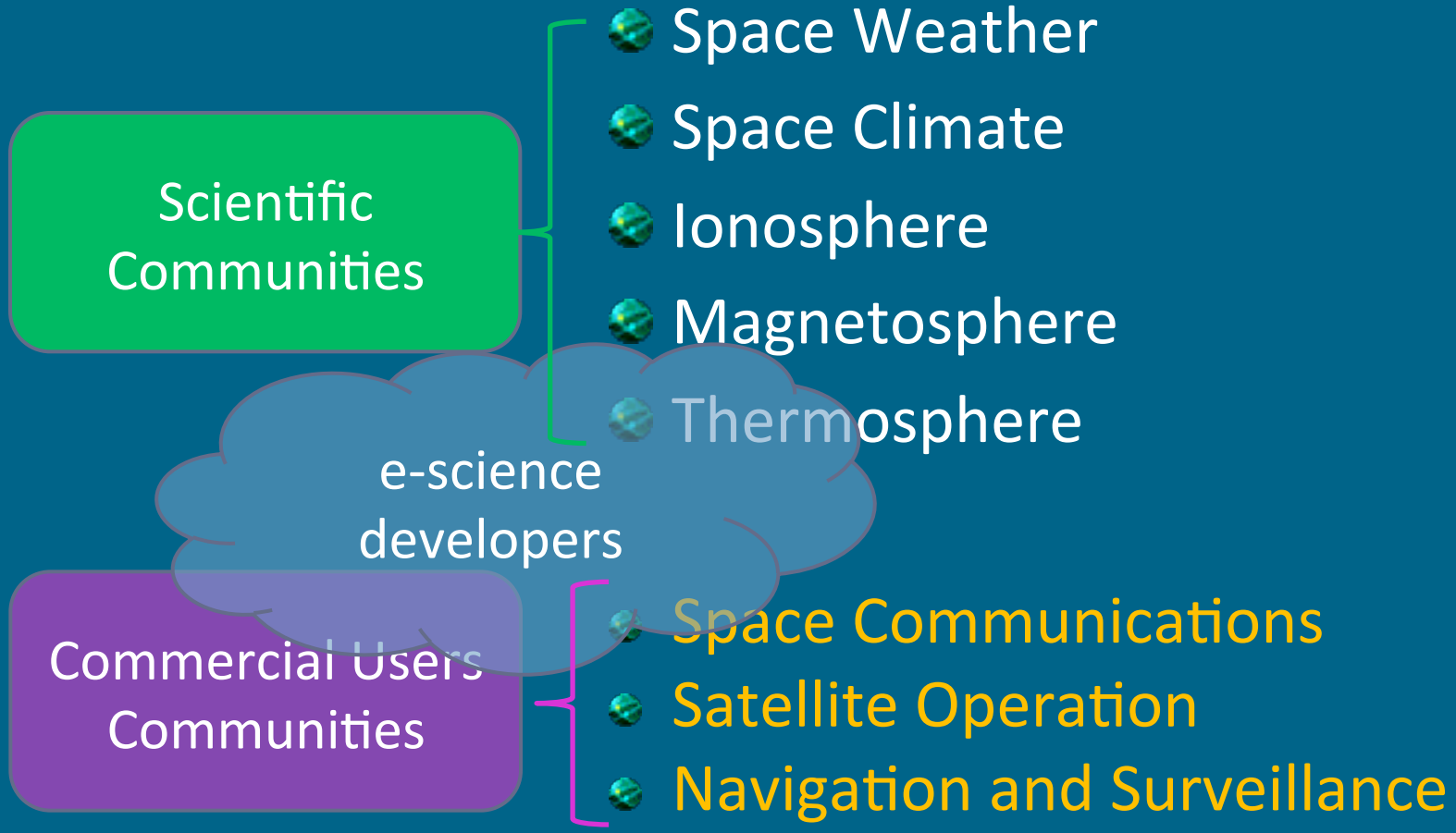




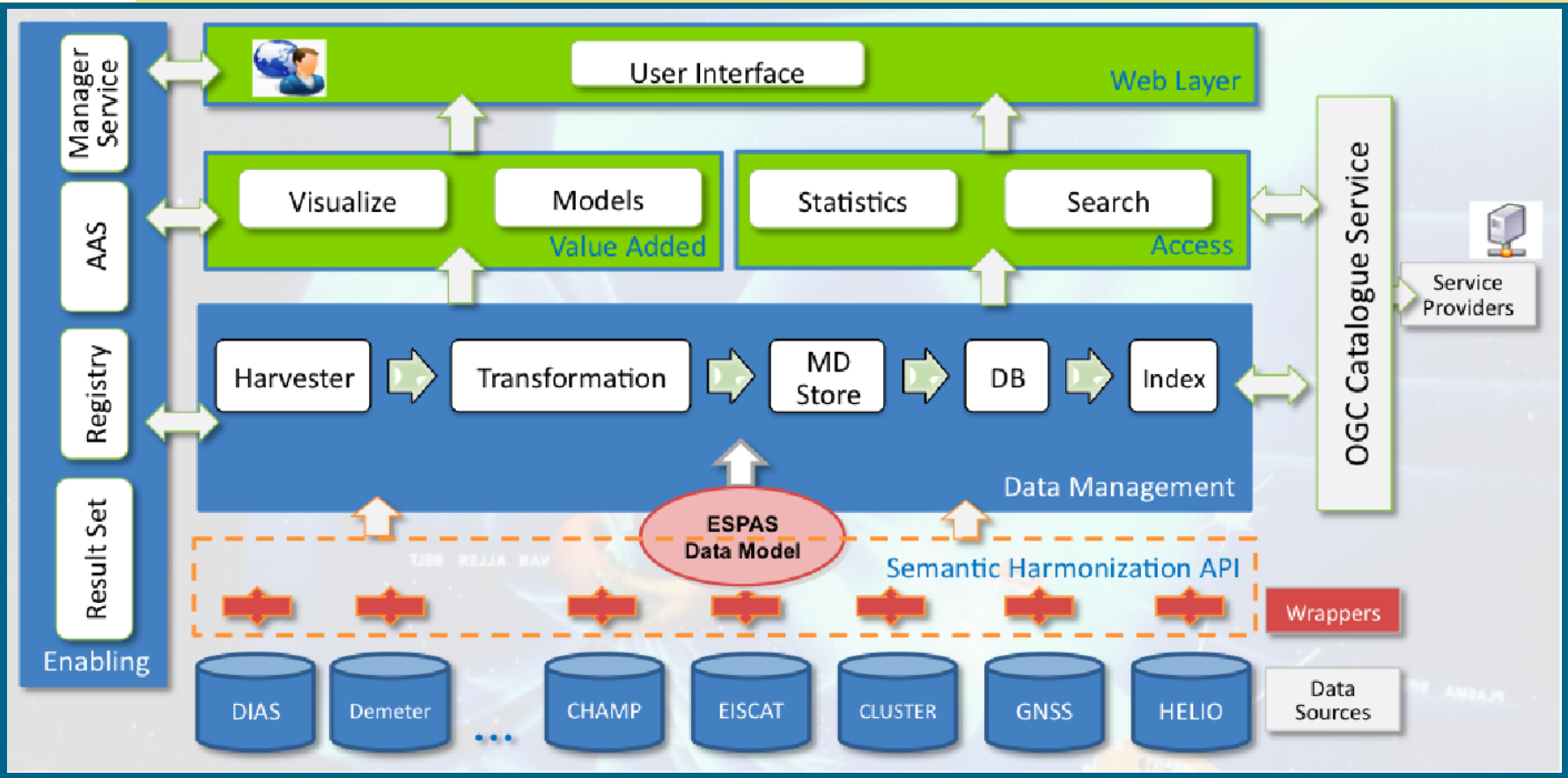
Incoherent Scatter Radars

Digisondes

ESPAS is made out of several disparate but interrelated communities



General Architecture

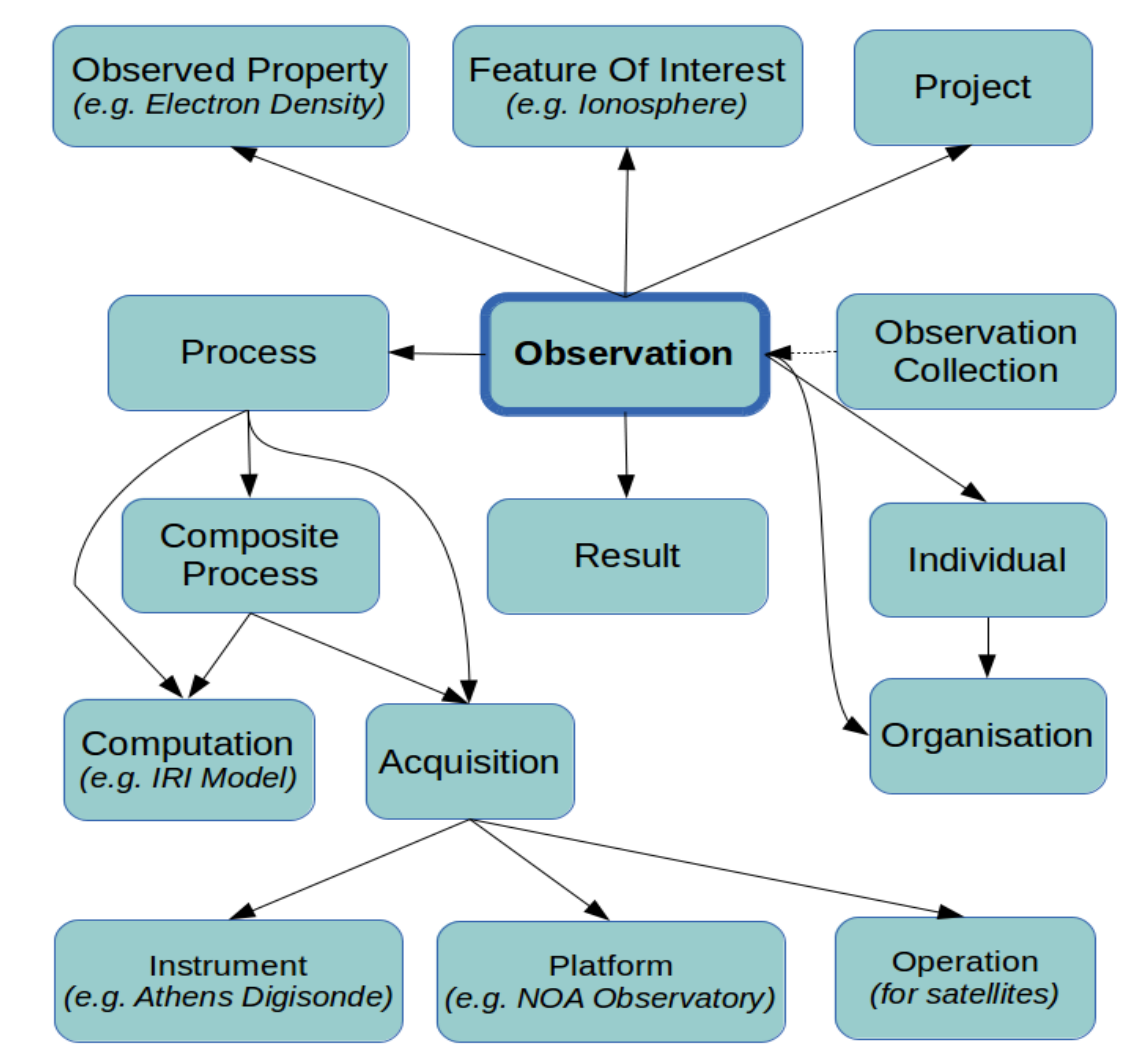


Semantic Harmonization Layer: harmonization of the data sources and their adoption of the ESPAS data model; **Data and Semantic Integration Layer**: (meta)data harvesting and basic content management services;

Value-added Services Layer: provides the services built on; **Web Layer** : Graphical User Interface;

Binding Layer : components that glue, manage and organize all the services in a SOA

ESPAS data model – high level overview



International Organization for Standardization

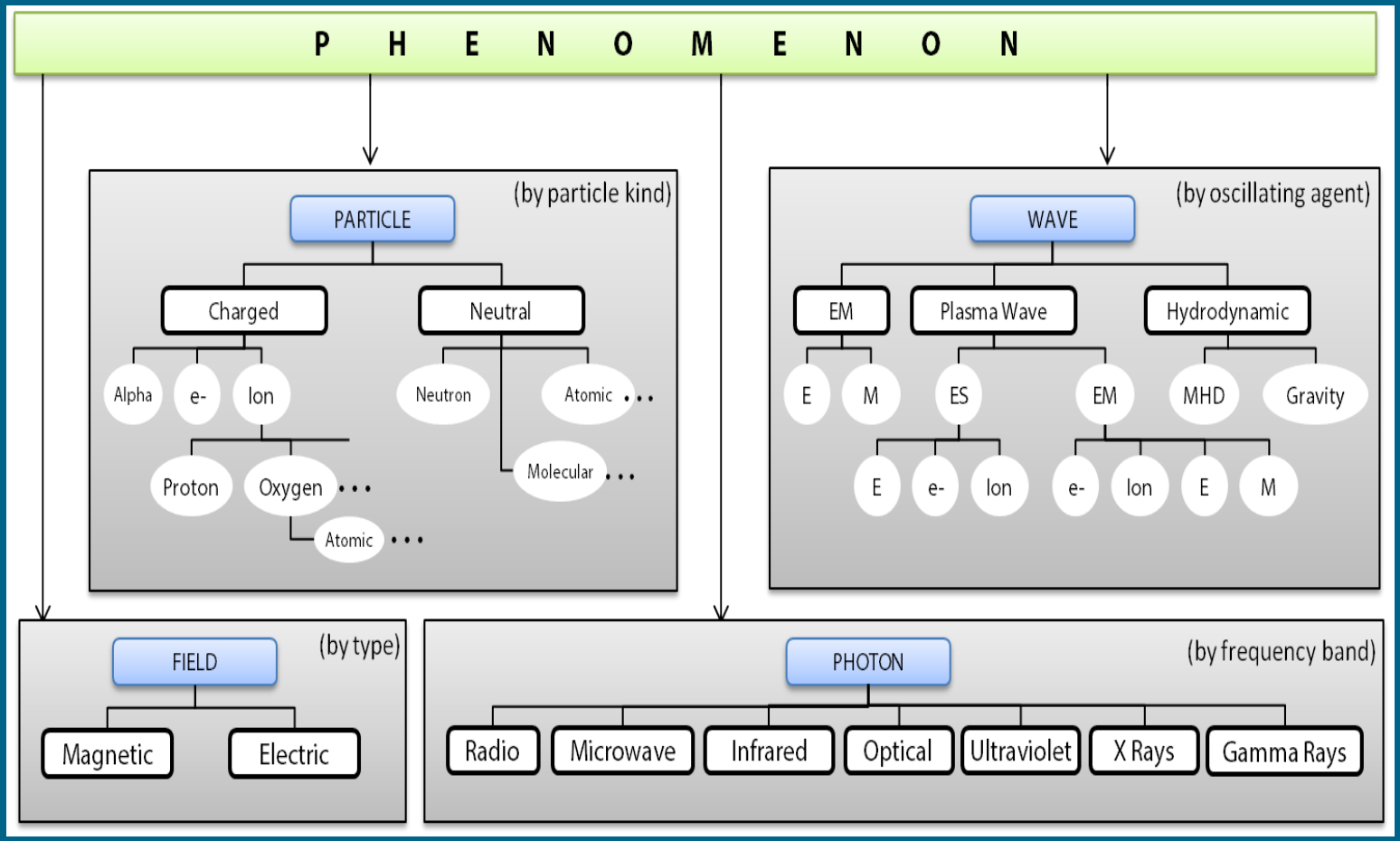
ISO Open Geospatial Data Model

ESPAS ontology

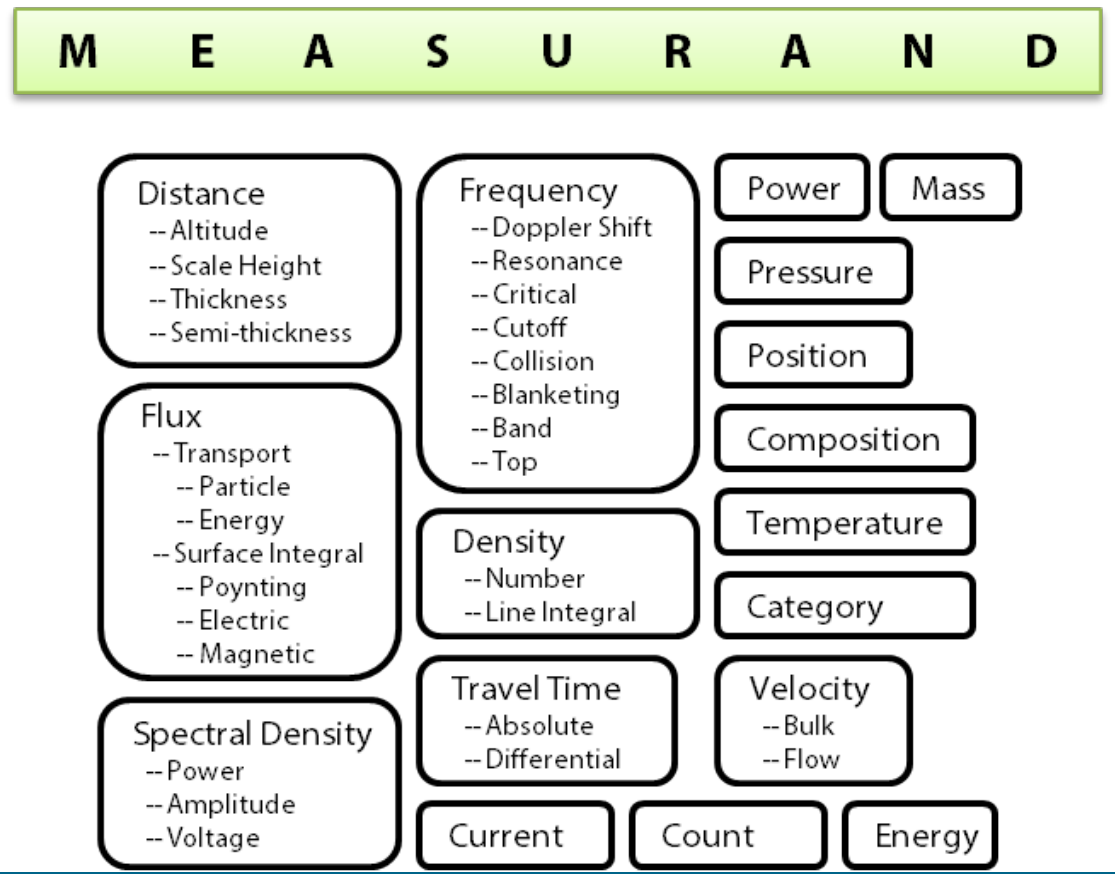
The Observed Property is defined in ESPAS as a forest of 6 trees:

1. Phenomenon
2. Measurand
3. Feature of Interest
4. Propagation Mode (wave phenomena only)
5. Interaction (wave phenomena only)
6. Qualifier

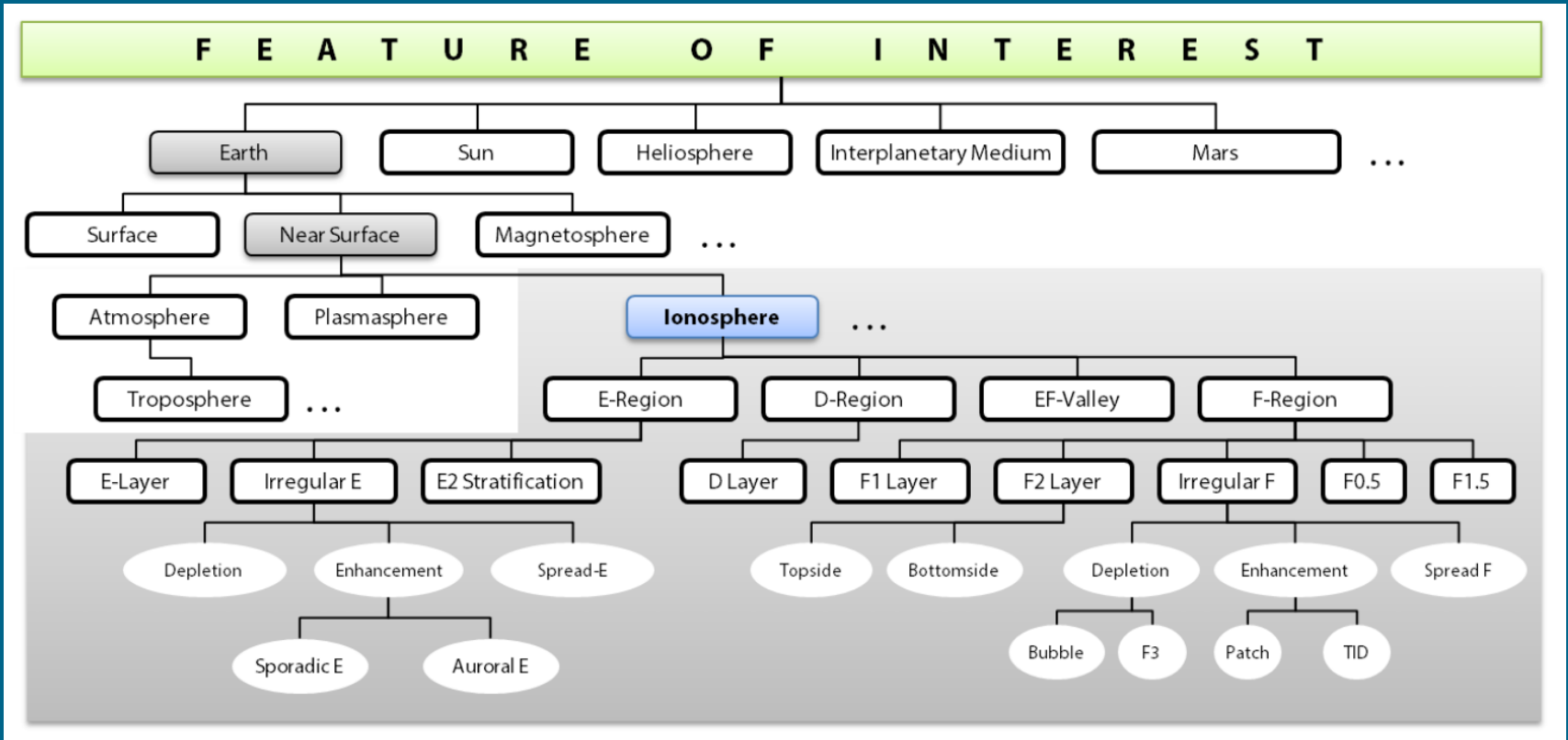
Phenomenon vocabulary



Measurand vocabulary



Feature of interest vocabulary



ESPAS services

- **Metadata search**
  - Time period
  - Assets
  - Observed properties
  - Observation collections
  - Location (of the instrument)

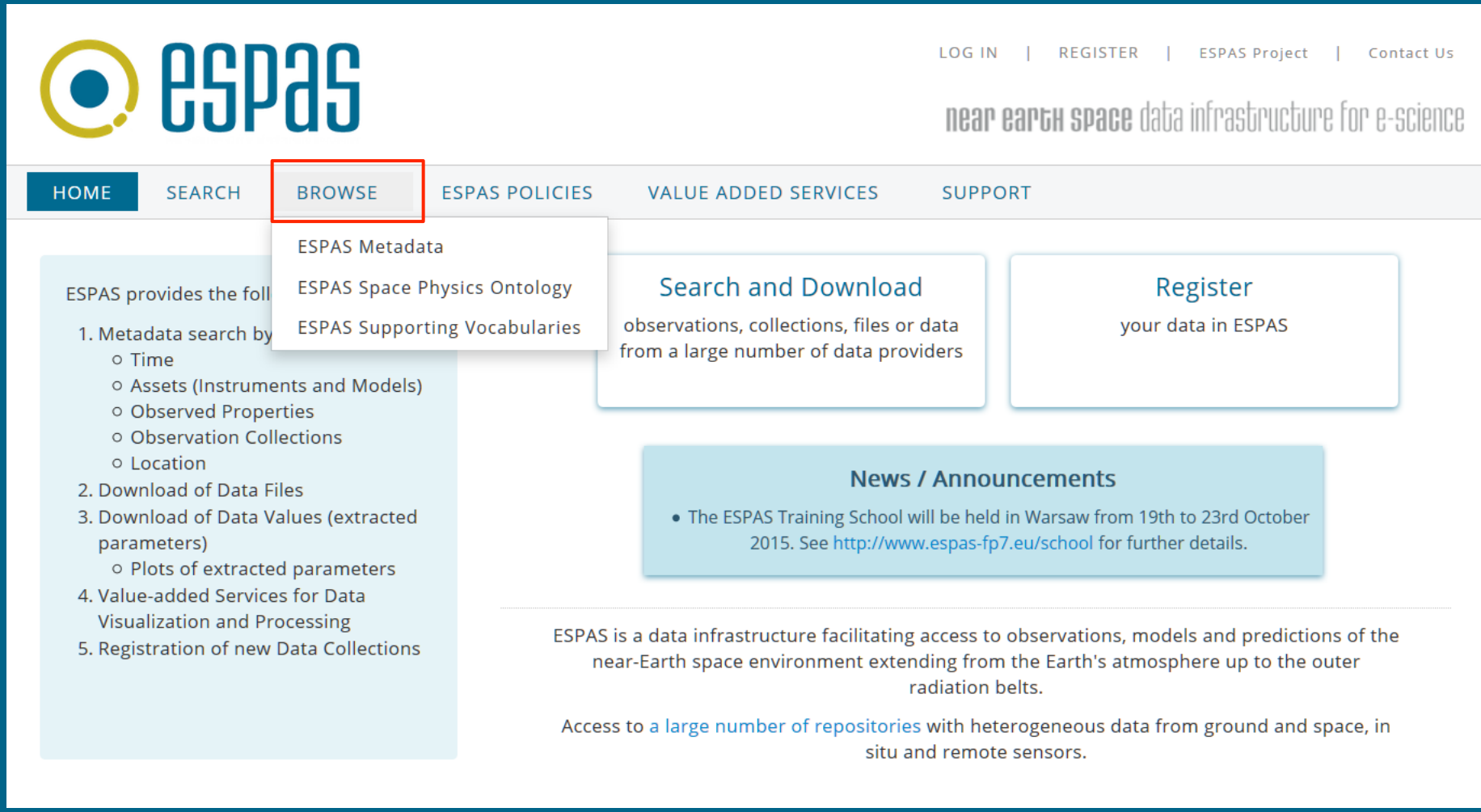
- **Download of data files**: the user gets the available datafiles in their original format

- **Download of data values** (extracted parameters), the user gets as a result a text file (csv or XML format)

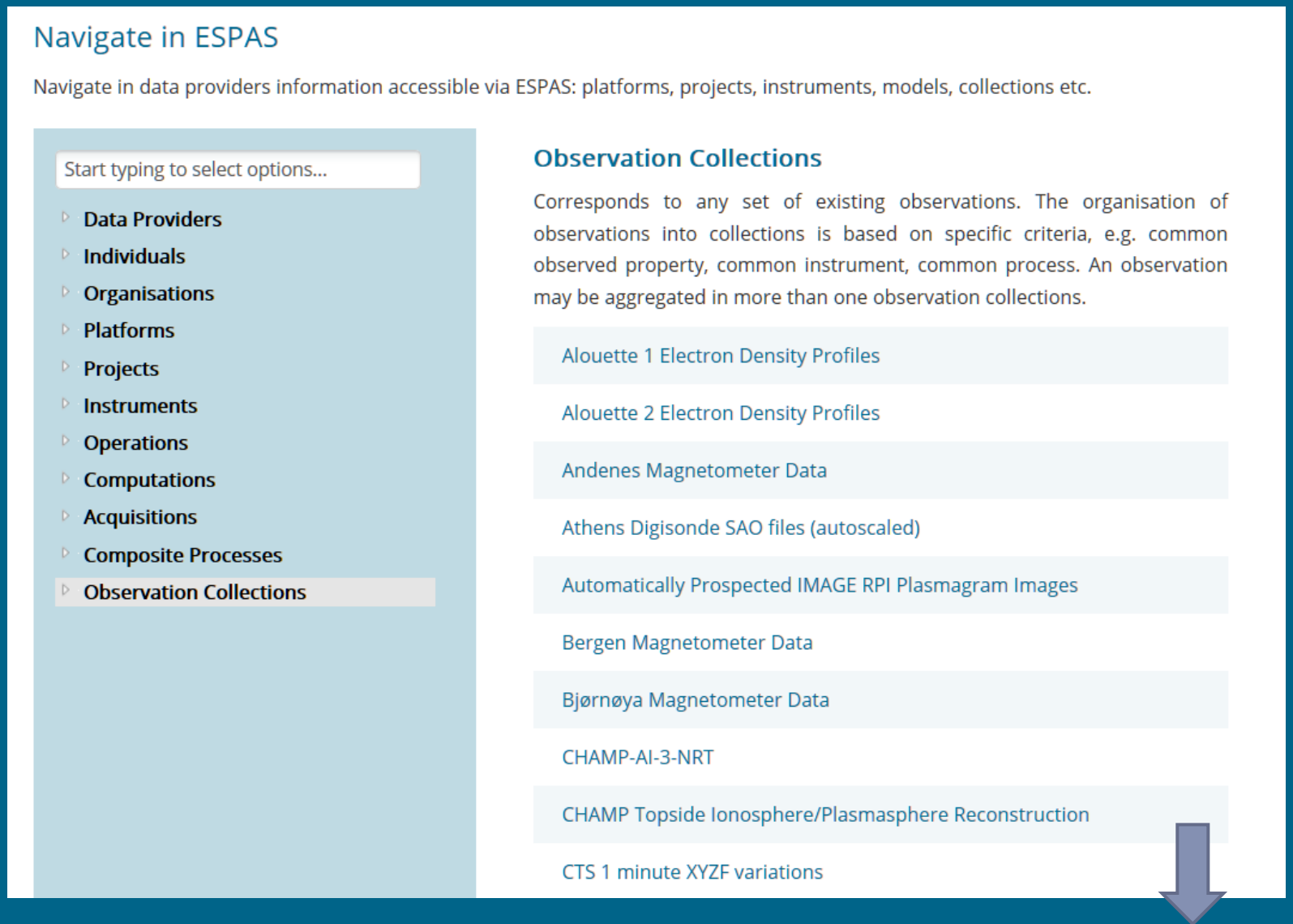
- **Plotting tools**: Downloaded data values can be plotted using either the quick plot of the ESPAS platform or the most advanced IDL-based plotting tool for OGC data files.

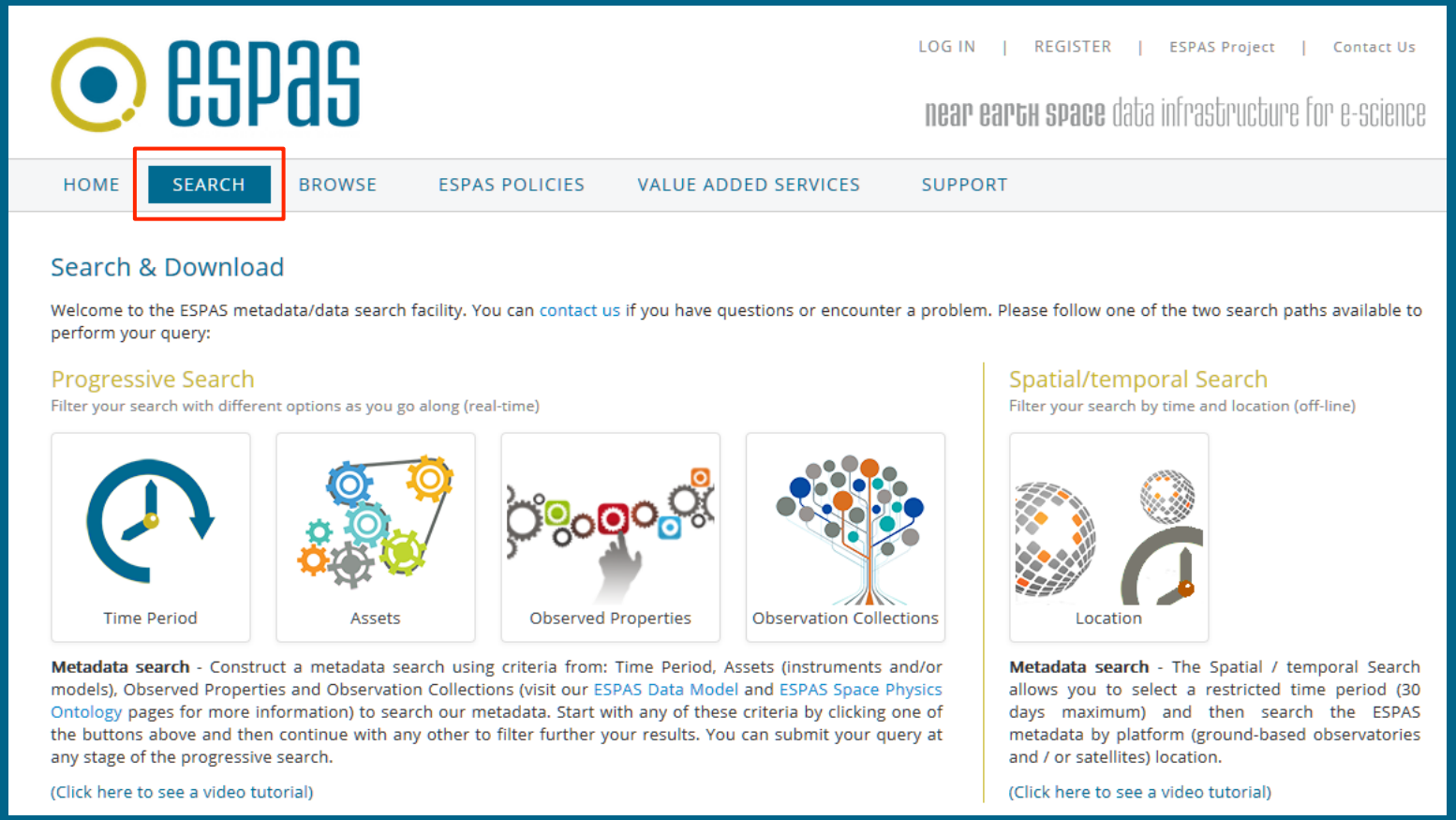
- **Registration and validation of data**: Data collections from space missions and ground-based instruments can be registered in ESPAS following the standards of the ESPAS data model and domain ontology. The service is available to the scientific community upon request.

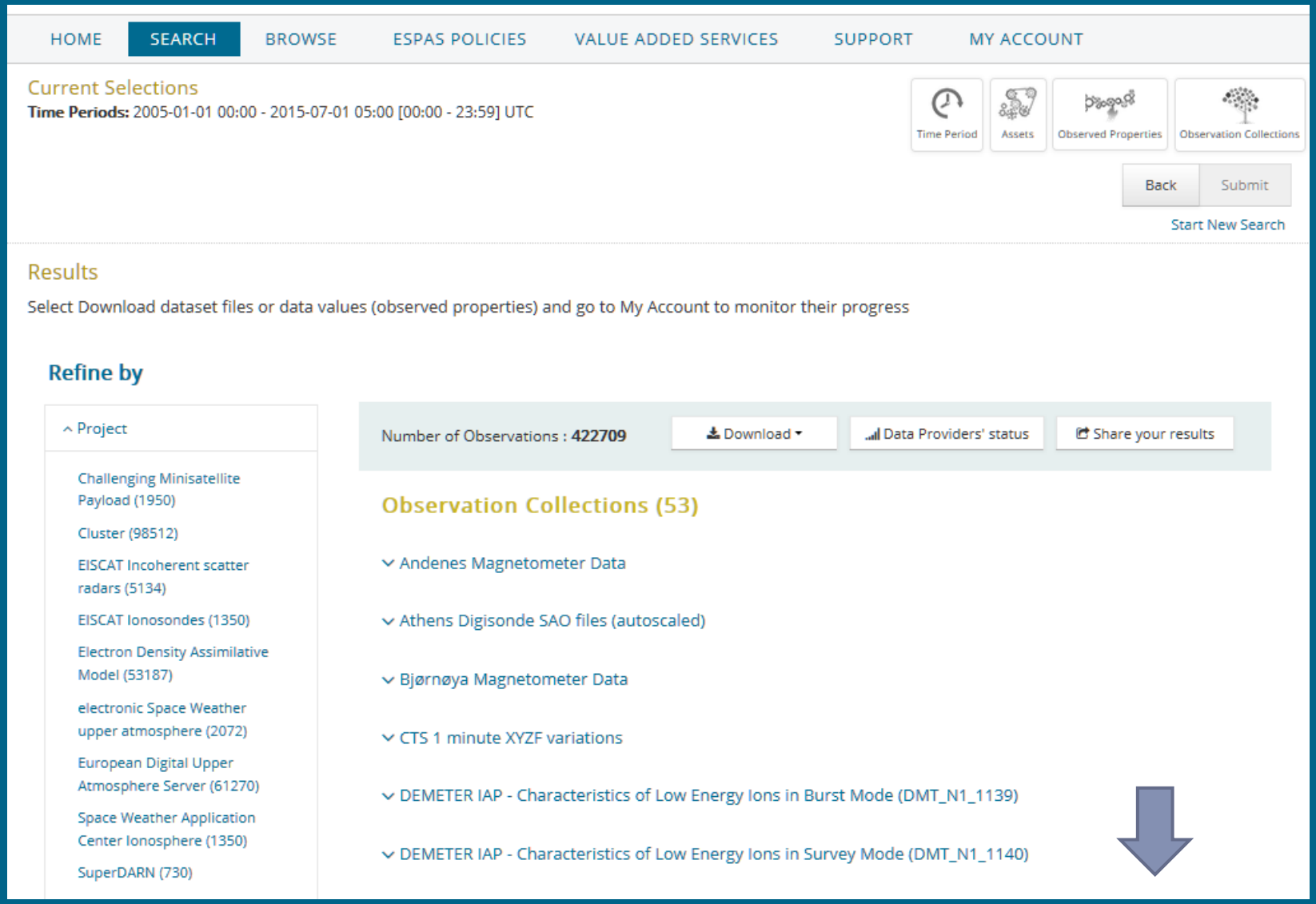
ESPAS portal

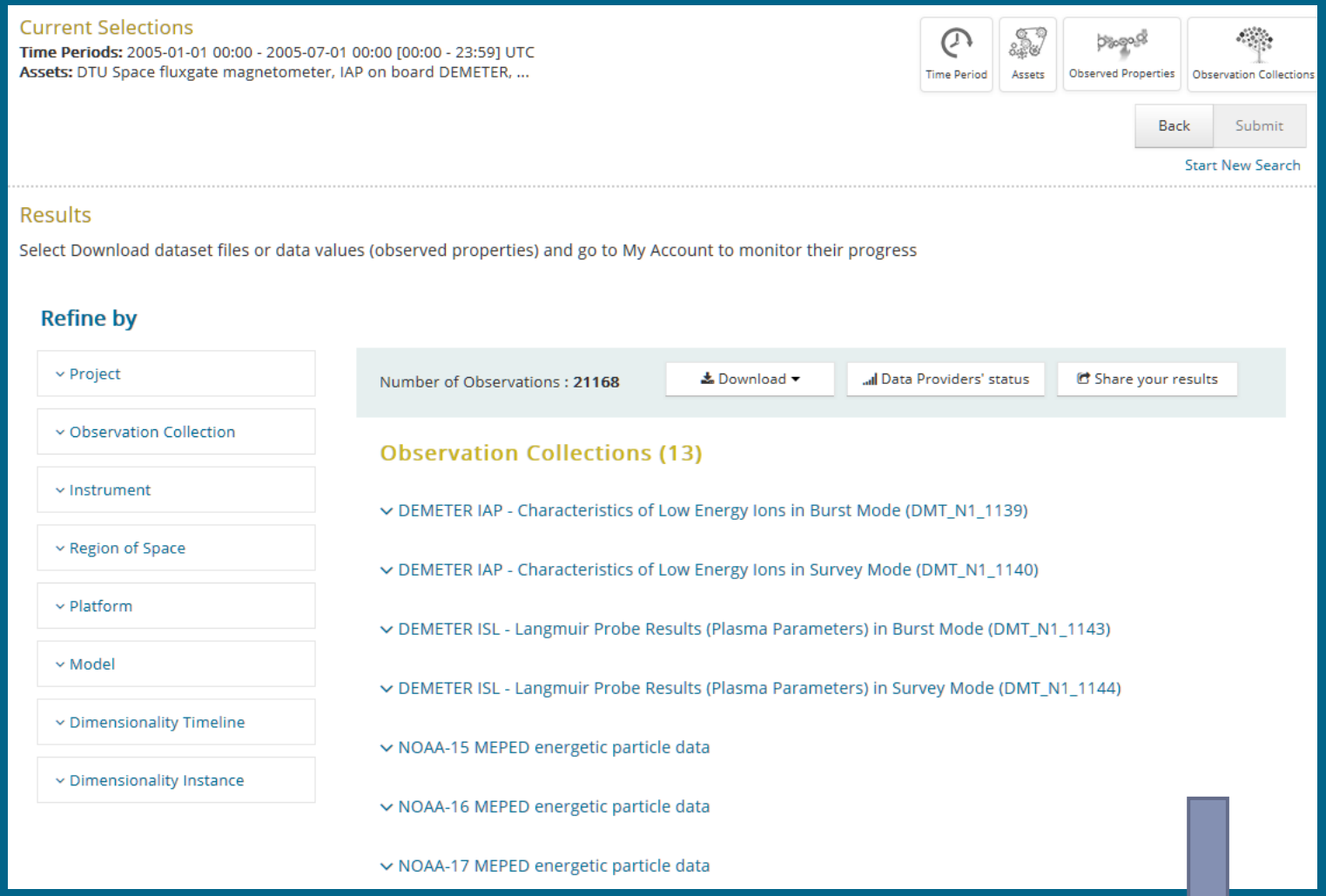


Navigate in ESPAS




espas
LOG IN | REGISTER | ESPAS Project | Contact Us
near earth space data infrastructure for e-science
HOME
SEARCH
BROWSE
ESPAS POLICIES
VALUE ADDED SERVICES
SUPPORT
Search & Download
Welcome to the ESPAS metadata/data search facility. You can contact us if you have questions or encounter a problem. Please follow one of the two search paths available to perform your query:
Progressive Search
Filter your search with different options as you go along (real-time)
Time Period
Assets
Observed Properties
Observation Collections
Metadata search - Construct a metadata search using criteria from: Time Period, Assets (instruments and/or models), Observed Properties and Observation Collections (visit our ESPAS Data Model and ESPAS Space Physics Ontology pages for more information) to search our metadata. Start with any of these criteria by clicking one of the buttons above and then continue with any other to filter further your results. You can submit your query at any stage of the progressive search.
(Click here to see a video tutorial)
Spatial/temporal Search
Filter your search by time and location (off-line)
Location
Metadata search - The Spatial / temporal Search allows you to select a restricted time period (30 days maximum) and then search the ESPAS metadata by platform (ground-based observatories and / or satellites) location.
(Click here to see a video tutorial)


HOME
SEARCH
BROWSE
ESPAS POLICIES
VALUE ADDED SERVICES
SUPPORT
MY ACCOUNT
Current Selections
Time Periods: 2005-01-01 00:00 - 2015-07-01 05:00 [00:00 - 23:59] UTC
Time Period
Assets
Observed Properties
Observation Collections
Back
Submit
Start New Search
Results
Select Download dataset files or data values (observed properties) and go to My Account to monitor their progress
Refine by
Project
Challenging Minisatellite Payload (1950)
Cluster (98512)
EISCAT Incoherent scatter radars (5134)
EISCAT Ionosondes (1350)
Electron Density Assimilative Model (53187)
electronic Space Weather upper atmosphere (2072)
European Digital Upper Atmosphere Server (61270)
Space Weather Application Center Ionosphere (1350)
SuperDARN (730)
Number of Observations : 422709
Download
Data Providers' status
Share your results
Observation Collections (53)
Andenes Magnetometer Data
Athens Digisonde SAO files (autoscaled)
Bjørnøya Magnetometer Data
CTS 1 minute XYZF variations
DEMETER IAP - Characteristics of Low Energy Ions in Burst Mode (DMT_N1_1139)
DEMETER IAP - Characteristics of Low Energy Ions in Survey Mode (DMT_N1_1140)

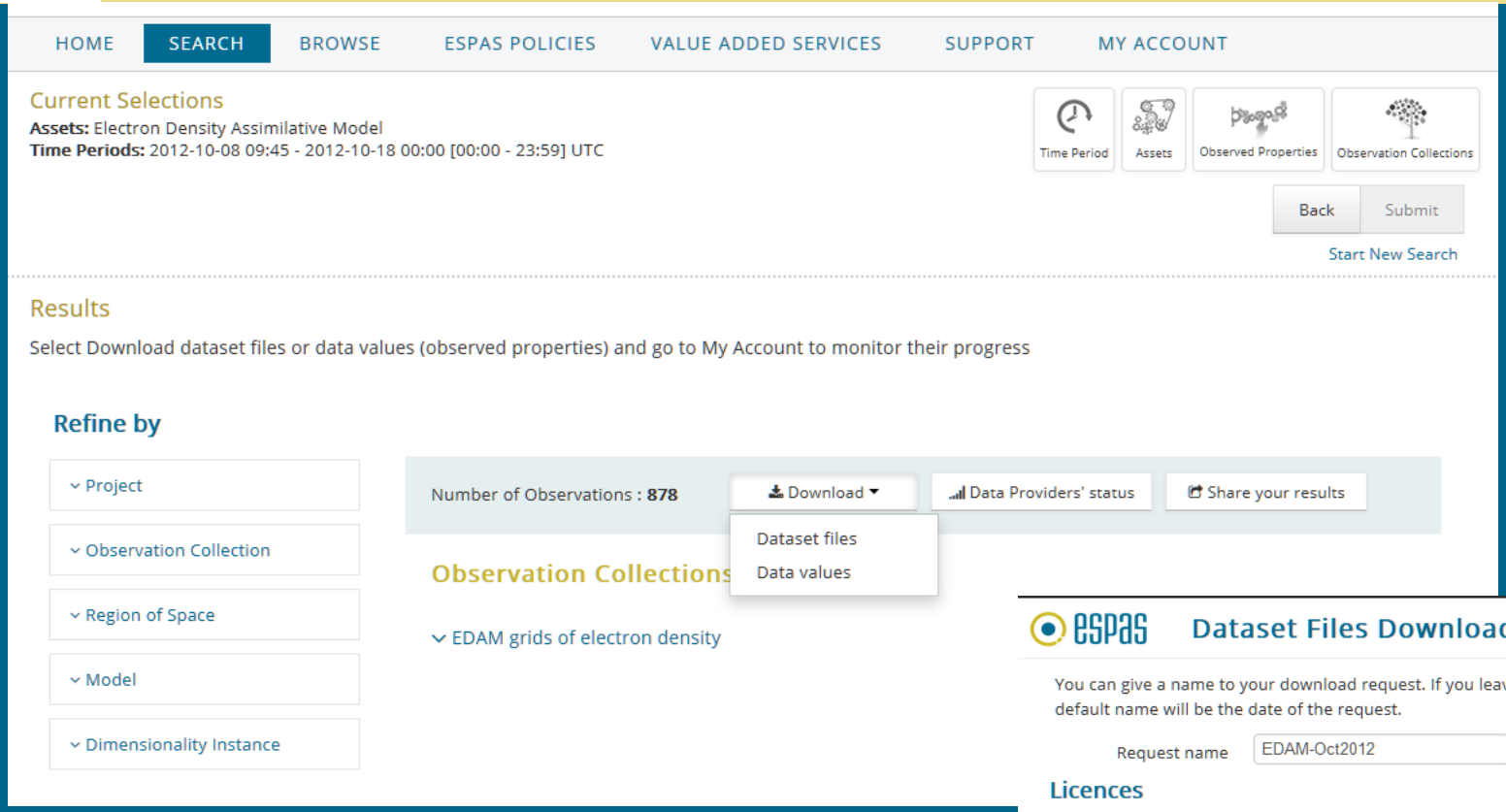

Current Selections
Time Periods: 2005-01-01 00:00 - 2005-07-01 00:00 [00:00 - 23:59] UTC
Assets: DTU Space fluxgate magnetometer, IAP on board DEMETER, ...
Time Period
Assets
Observed Properties
Observation Collections
Back
Submit
Start New Search
Results
Select Download dataset files or data values (observed properties) and go to My Account to monitor their progress
Refine by
Project
Observation Collection
Instrument
Region of Space
Platform
Model
Dimensionality Timeline
Dimensionality Instance
Number of Observations : 21168
Download
Data Providers' status
Share your results
Observation Collections (13)
DEMETER IAP - Characteristics of Low Energy Ions in Burst Mode (DMT_N1_1139)
DEMETER IAP - Characteristics of Low Energy Ions in Survey Mode (DMT_N1_1140)
DEMETER ISL - Langmuir Probe Results (Plasma Parameters) in Burst Mode (DMT_N1_1143)
DEMETER ISL - Langmuir Probe Results (Plasma Parameters) in Survey Mode (DMT_N1_1144)
NOAA-15 MEPED energetic particle data
NOAA-16 MEPED energetic particle data
NOAA-17 MEPED energetic particle data

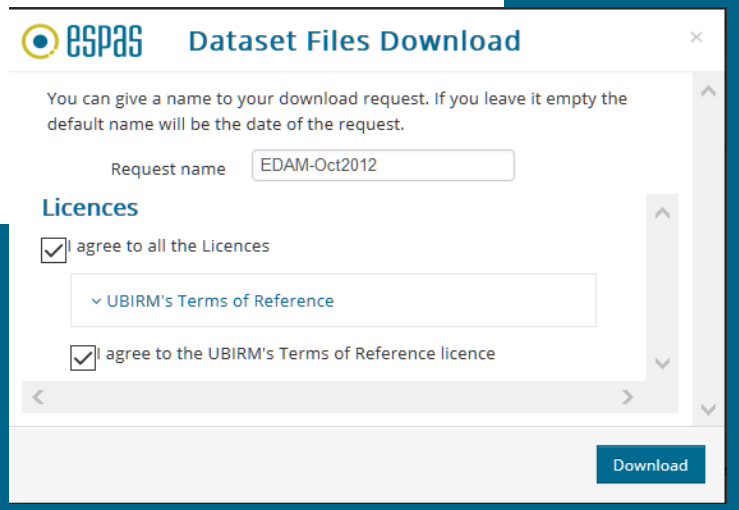
Access policy – data reuse

- ESPAS offers open access to data *
- Users must register
- Users must accept the Terms of Reference provided by each data provider

* A requirement from several journals

Data license and Terms of Reference: an example

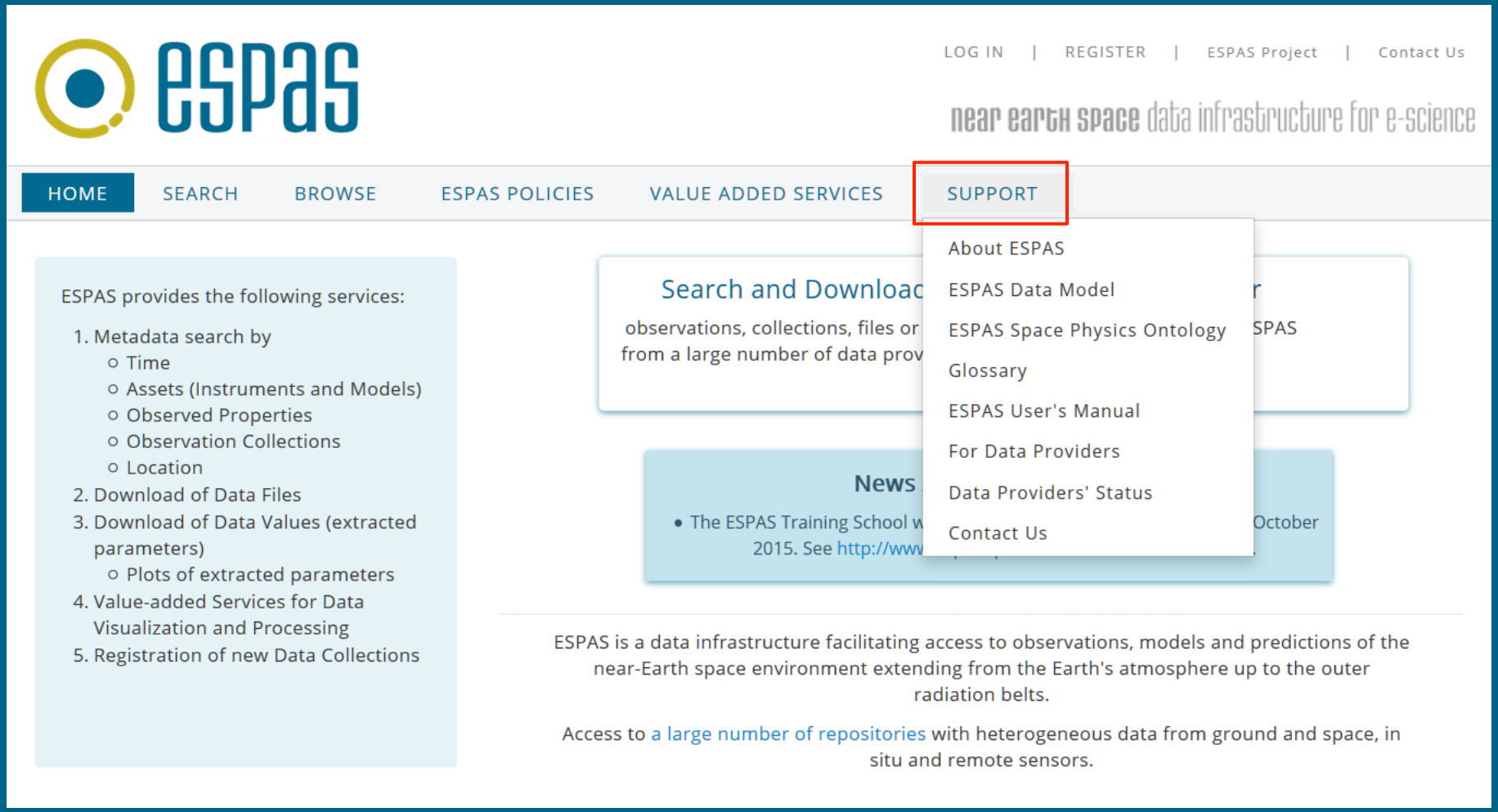




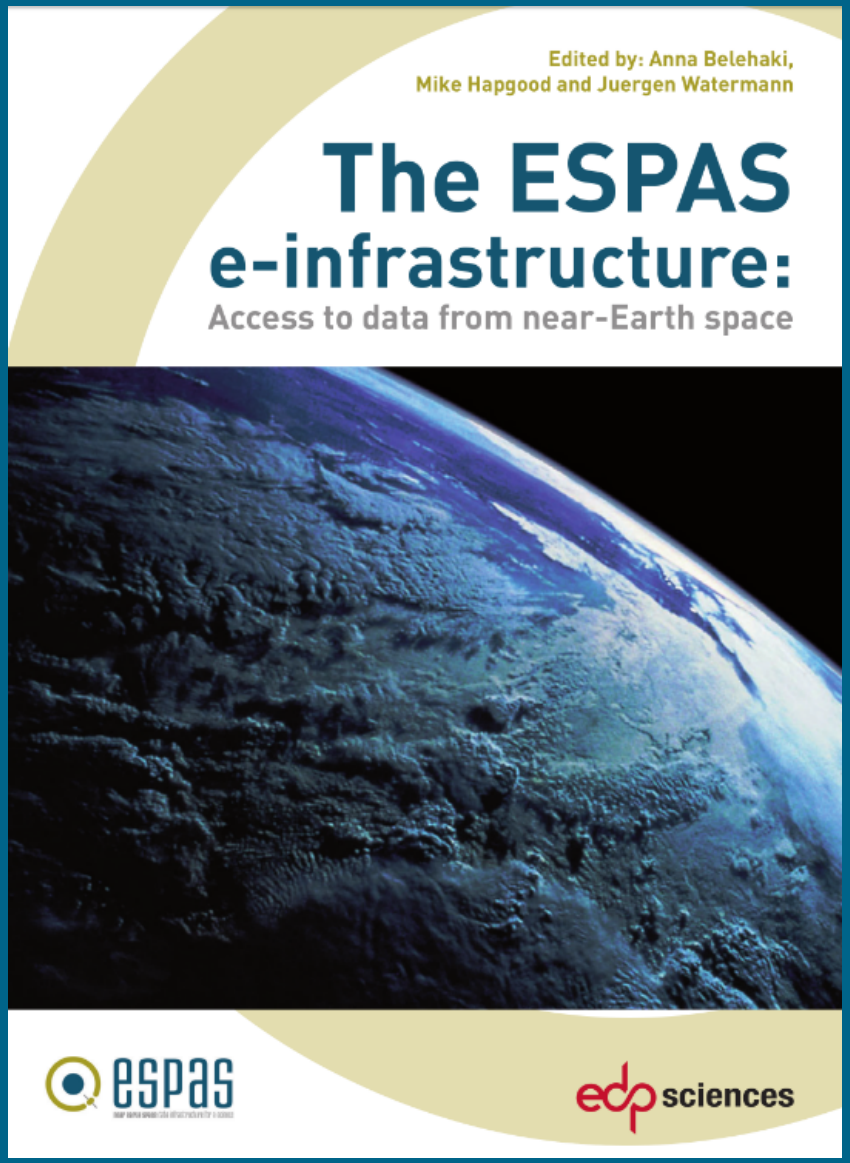
UBIRM's Terms of Reference

The data acquired from this service may be used freely for educational and **non-commercial** academic research purposes by registered users only. Redistribution of the data is subject to the same conditions of use. Please reference: Angling, M. J., and N. K. Jackson-Booth (2011), A short note on the assimilation of collocated and concurrent GPS and ionosonde data into the Electron Density Assimilative Model, Radio Sci, 46(RS0D13).

Get supporting info



ESPAS Data Portal
https://www.espas-fp7.eu/portal/



BACKUP SLIDES

ESPAS basic services: Homogenized access to the main ESPAS data repositories

Observational Data

- High level metadata search: Datasets
- Granule level data search: Data

Group	Req.	FORTRAN Format	Description
	x	2(40I3)	DATA FILE INDEX
1	x	16F7.3	GEOPHYSICAL CONSTANTS
2		A120	SYSTEM DESCRIPTION AND OPERATOR'S MESSAGE
3	x	120A1	TIME STAMP AND SOUNDER SETTINGS
4	x	15F8.3	SCALED IONOSPHERIC CHARACTERISTICS
5		60I2	ANALYSIS FLAGS
6		16F7.3	DOPPLER TRANSLATION TABLE
			O-TRACE POINTS - F2 LAYER
7	xx	15F8.3	VIRTUAL HEIGHTS
8		15F8.3	TRUE HEIGHTS
9		40I3	AMPLITUDES
10		120I1	DOPPLER NUMBERS
11	xx	15F8.3	FREQUENCIES
			O-TRACE POINTS - F1 LAYER
12	xx	15F8.3	VIRTUAL HEIGHTS
13		15F8.3	TRUE HEIGHTS
14		40I3	AMPLITUDES
15		120I1	DOPPLER NUMBERS

SAO Parameters

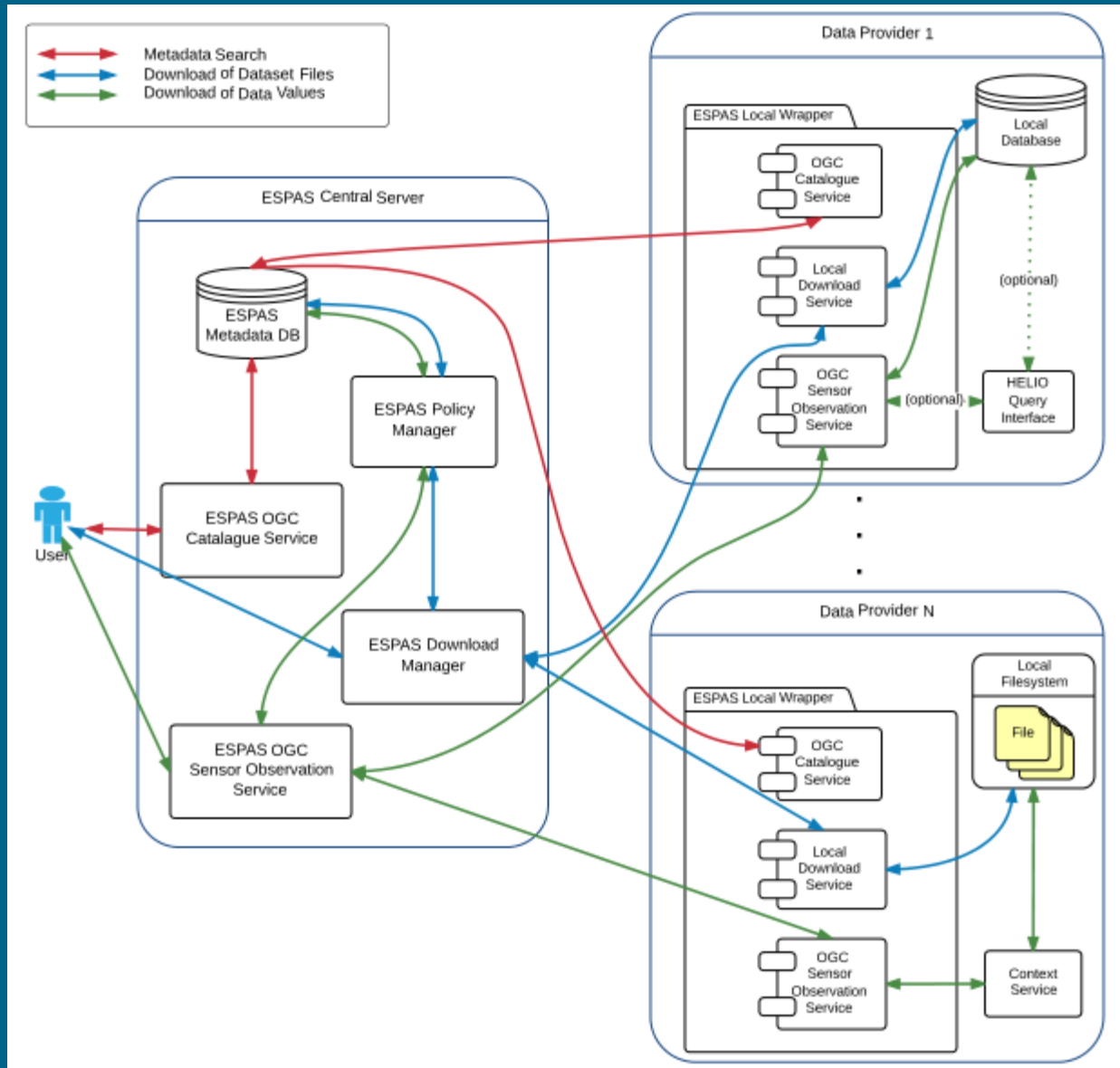
AZM	Mean azimuth angle (0=geog N,90=east) - Units: deg
ELM	Elevation angle (0=horizontal,90=vert) - Units: deg
HSA	Half scattering angle (bistatic system) - Units: deg
SYSTMP	System temperature - Units: K
POWER	Peak power - Units: kW
GDALT	Altitude (height) - Units: km
GFIT	Goodness of fit - Units: N/A
CHISQ	Reduced-chi square of fit - Units: N/A
PO+	Composition - [O+]/Ne - Units: N/A
NEL	Log10(Ne in m-3) - Units: lg(m-3)
TI	Ion temperature (Ti) - Units: K
TR	Temperature ratio (Te/Ti) - Units: N/A
COL	Log10 (ion-neutral collision frequency) - Units: lg(s-1)
VO	Line of sight ion
DNEL	Error in L
DTI	Error in Ion temp
DTR	Error in Temperature ratio (Te/Ti) - Units: N/A

Madrigal Parameters

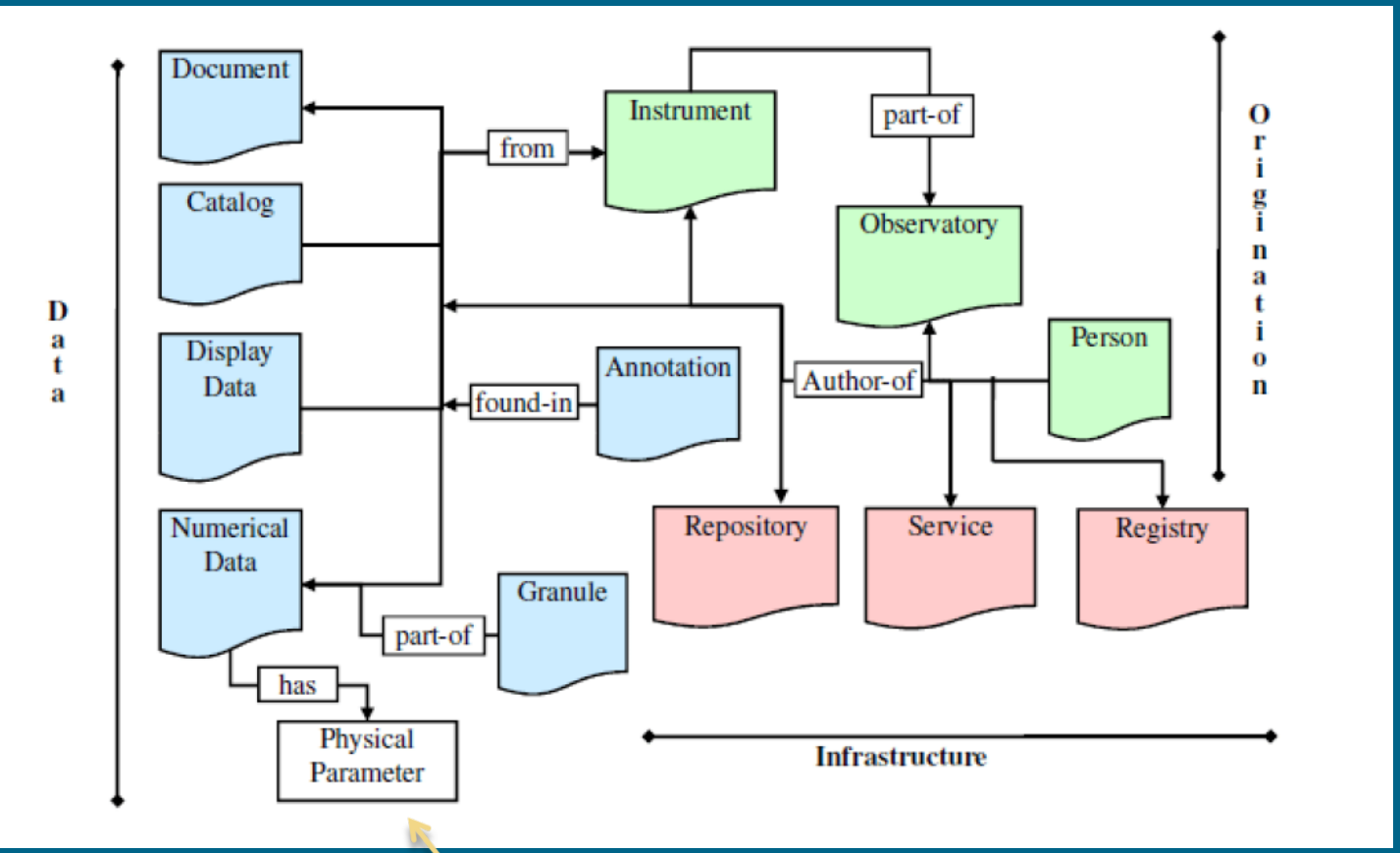
Search fields:
organization, observatory, characteristics, instruments, temporal and spatial constraints, observed vs generated data

Interoperability services

- An **OGC compliant Catalogue Service (CSW),** which supports the discovery of ESPAS resources offered by each data provider.
- A **Download Service**, that facilitates the download of data bundles in terms of data collections offered by each provider.
- An **OGC Compliant Sensor Observation Service (SOS)** with the goal to facilitate the collection of selected data parameters/values from the observations of each data provider.



SPASE and ISO OG data model



VWO and VITMO: based on SPASE model

No dictionaries for physical parameters

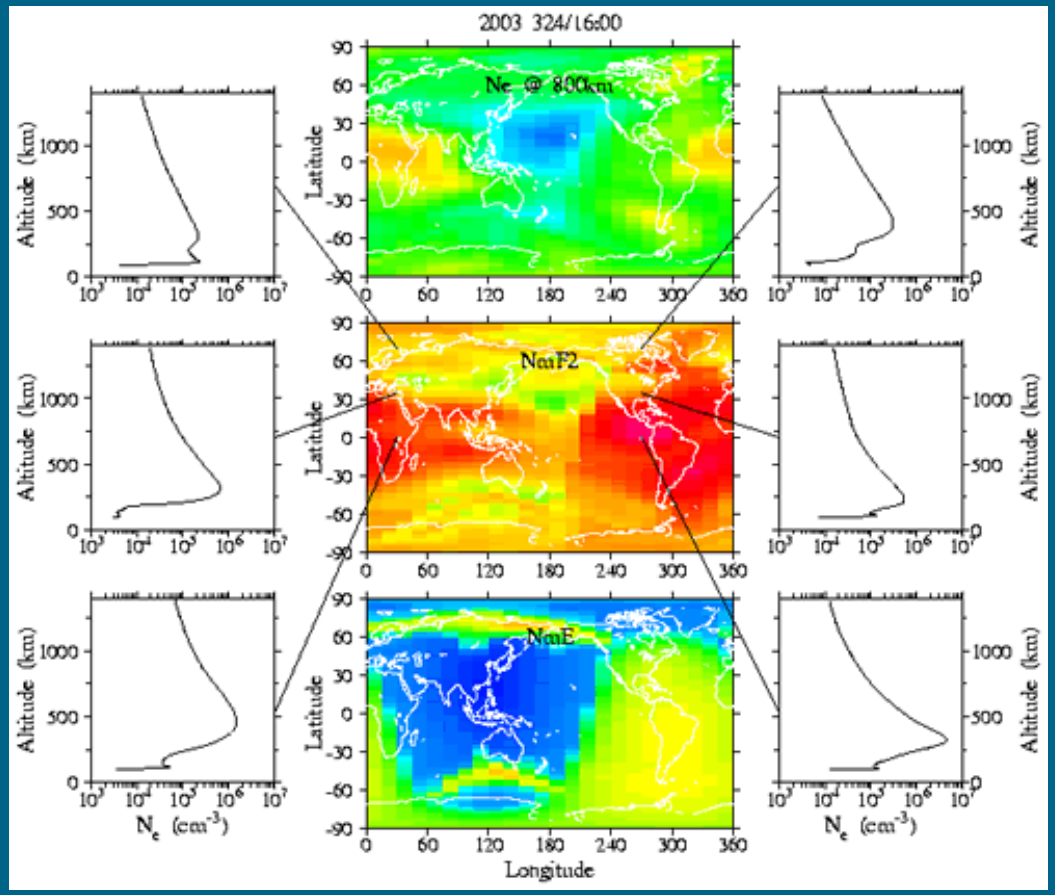
Some science cases

and the implications to collect the required data

Data assimilation into models

EISCAT ISRs Ne

Ne profiles from ionosondes and Digisondes extrapolated to the topside ionosphere



CHAMP Radio occultation profiles

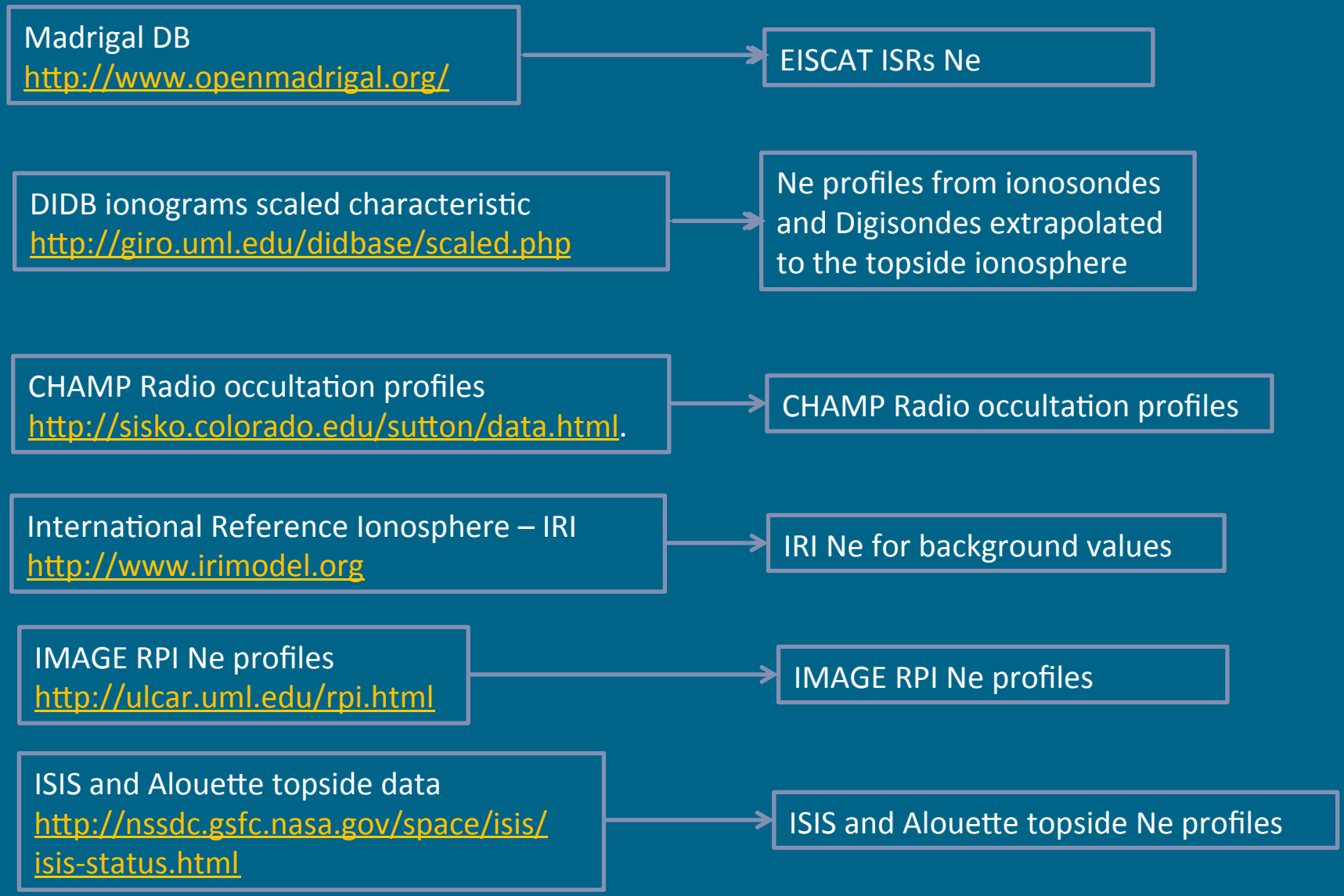
IRI Ne as background

IMAGE RPI Ne profiles

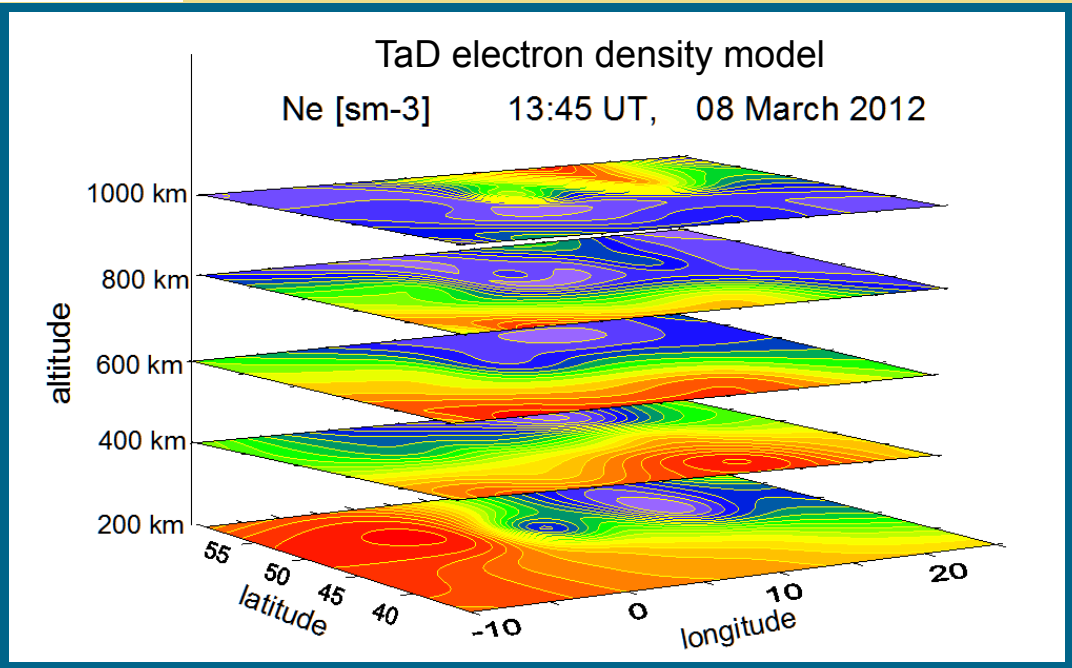
ISIS I&II and Alouette topside Ne profiles

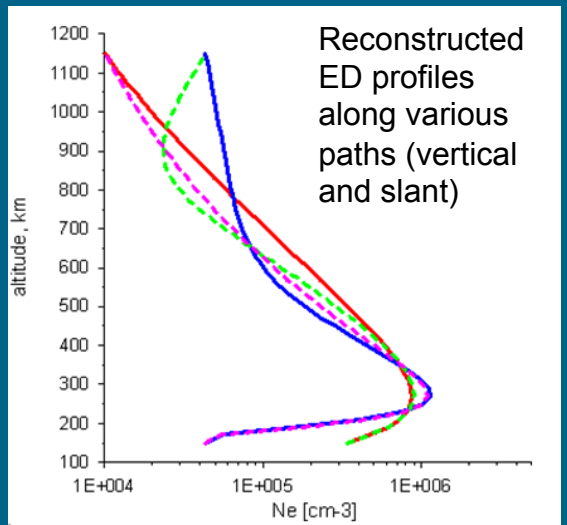
image credit: CCMC

What needs to access ED data from various sources?

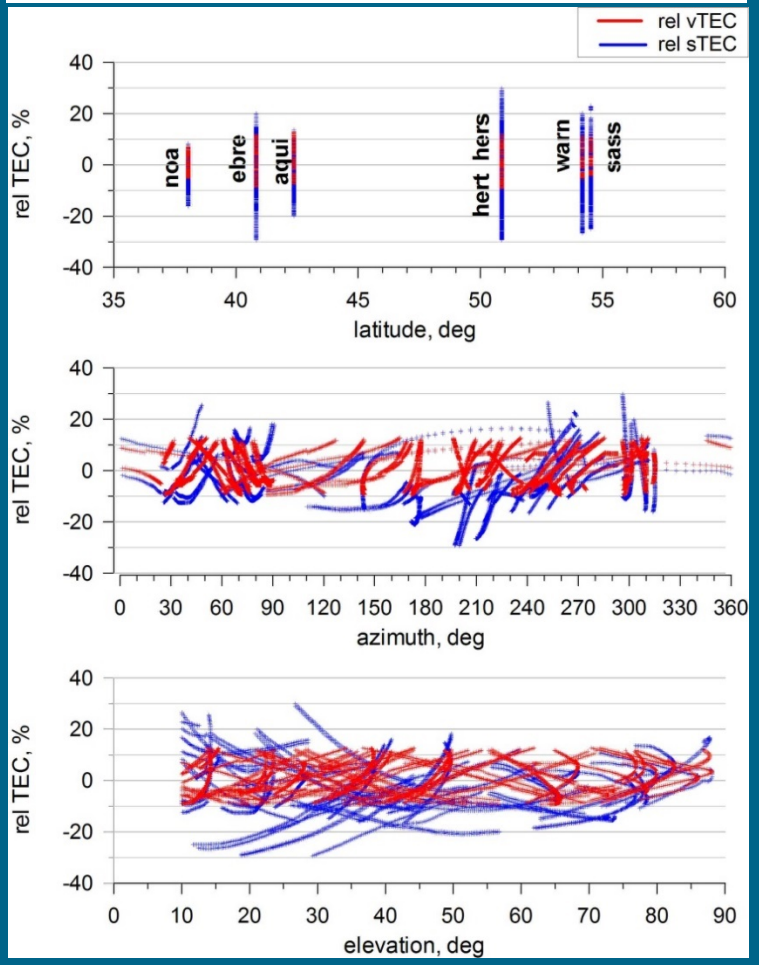


Validation of a 3D electron density model

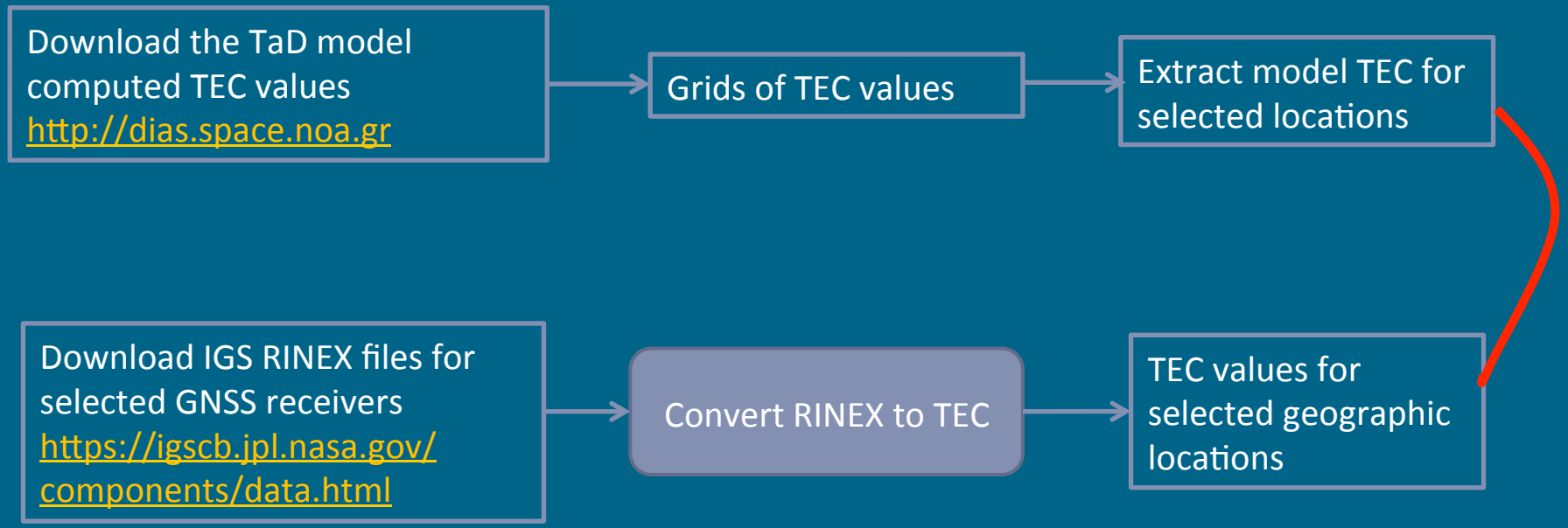




Comparison with vertical and slant TEC from IGS GNSS receivers

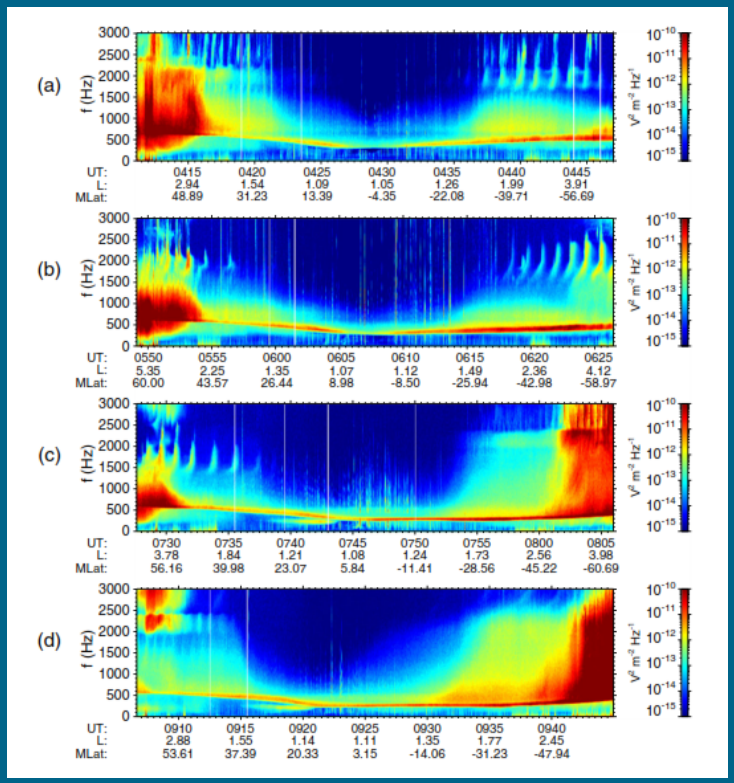


What needs to access the required data?

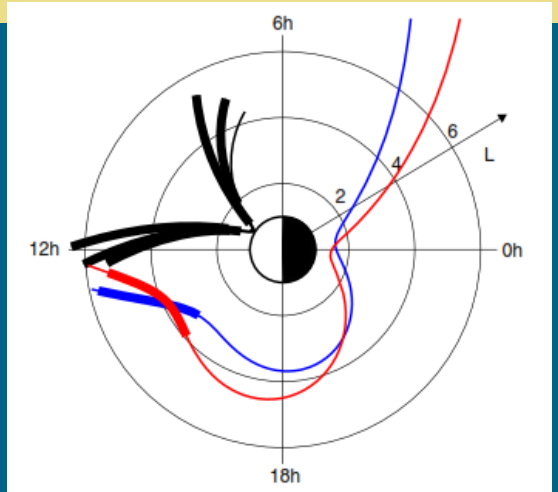


QUASI-PERIODIC EMISSIONS by CLUSTER and DEMETER spacecraft (Nemec et al., JGR, 2013)

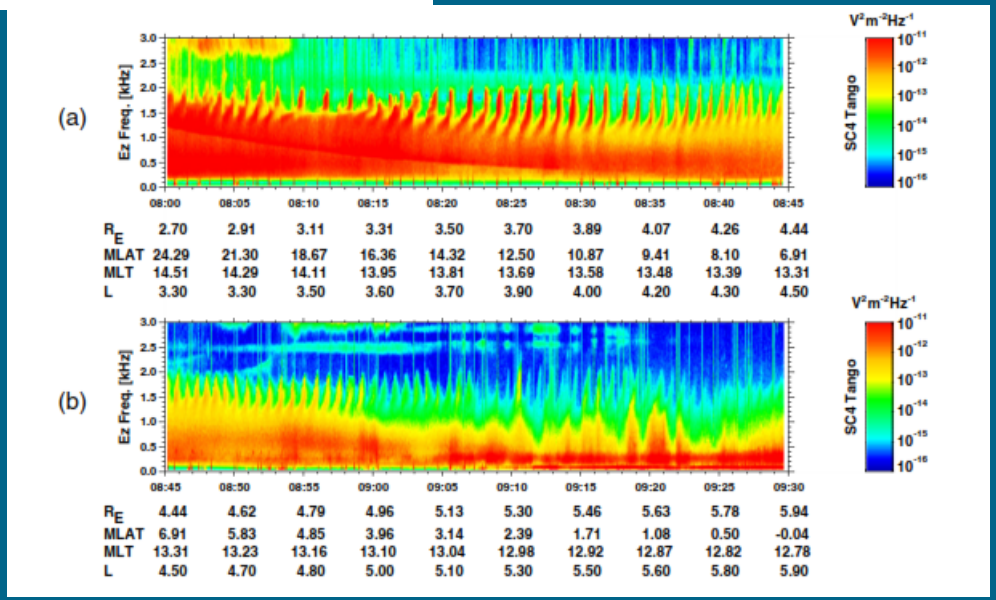
Cluster satellites are in a highly elliptic orbit which is evolved with time.
Demeter's orbit is a quasi Sun-synchronous circular orbit with an inclination of about 98.23° and an altitude of about 660 km.



Frequency-time spectrograms of power spectral density of electric field fluctuations measured by DEMETER on 13 April 2010.



The extent of the analyzed QP event from 13 April 2010 as observed by DEMETER (black), Cluster 2 (red), and Cluster 4 (blue). L-values and MLTs of the satellites between 04:30 UT and 09:30 UT are plotted in polar coordinates. The parts of the satellite orbits where QP emissions were observed are plotted in bold.



Frequency-time spectrograms of power spectral density of electric field fluctuations measured by the WBD instrument on board Cluster 4 on 13 April 2010 close to the equatorial region at radial distances 3 to 6 Re.

What needs to access CLUSTER and DEMETER data?

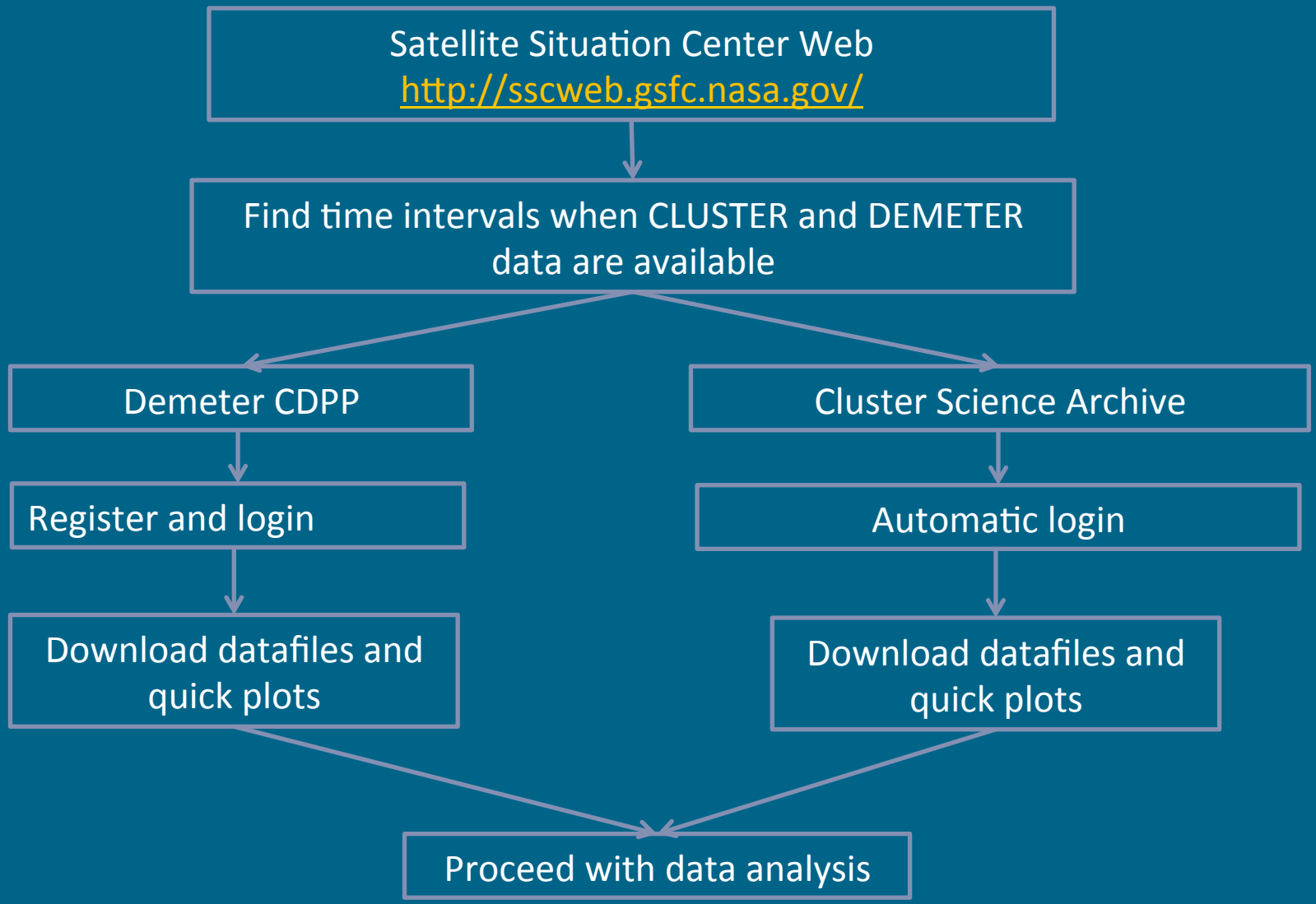
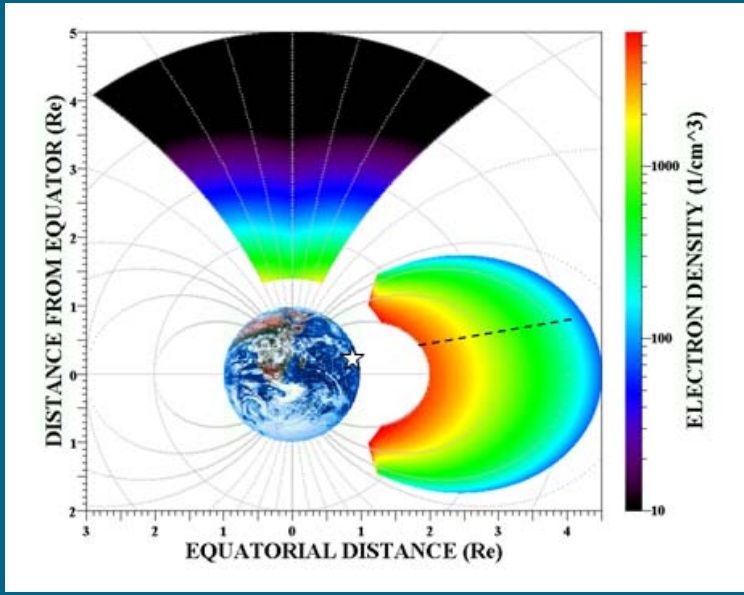
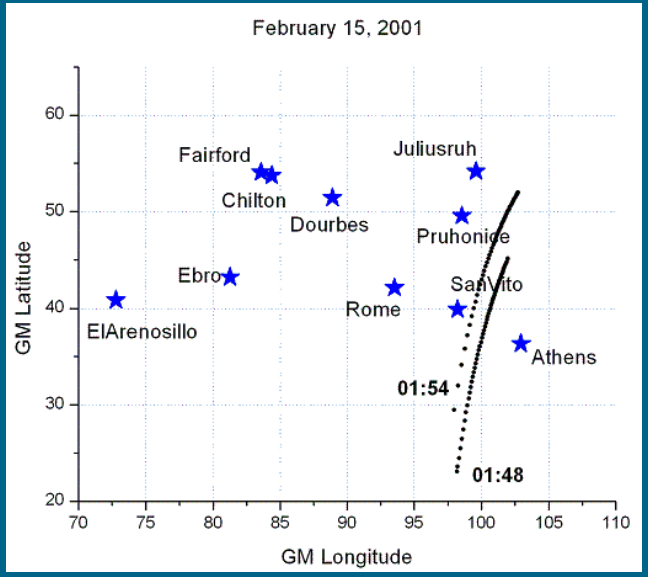


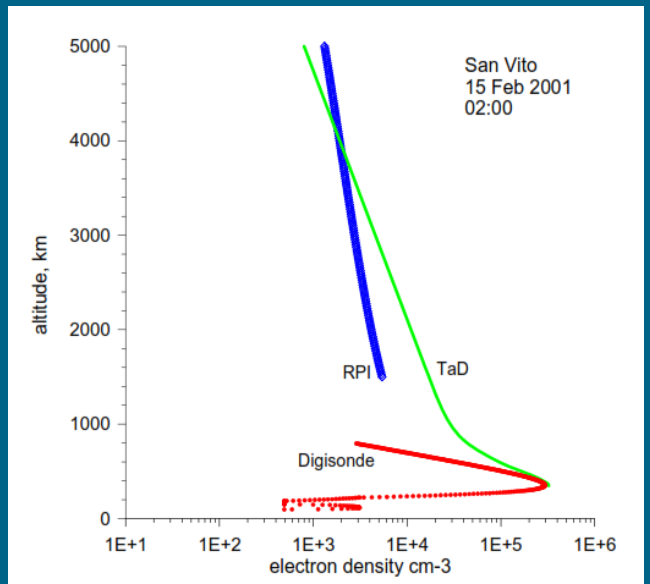
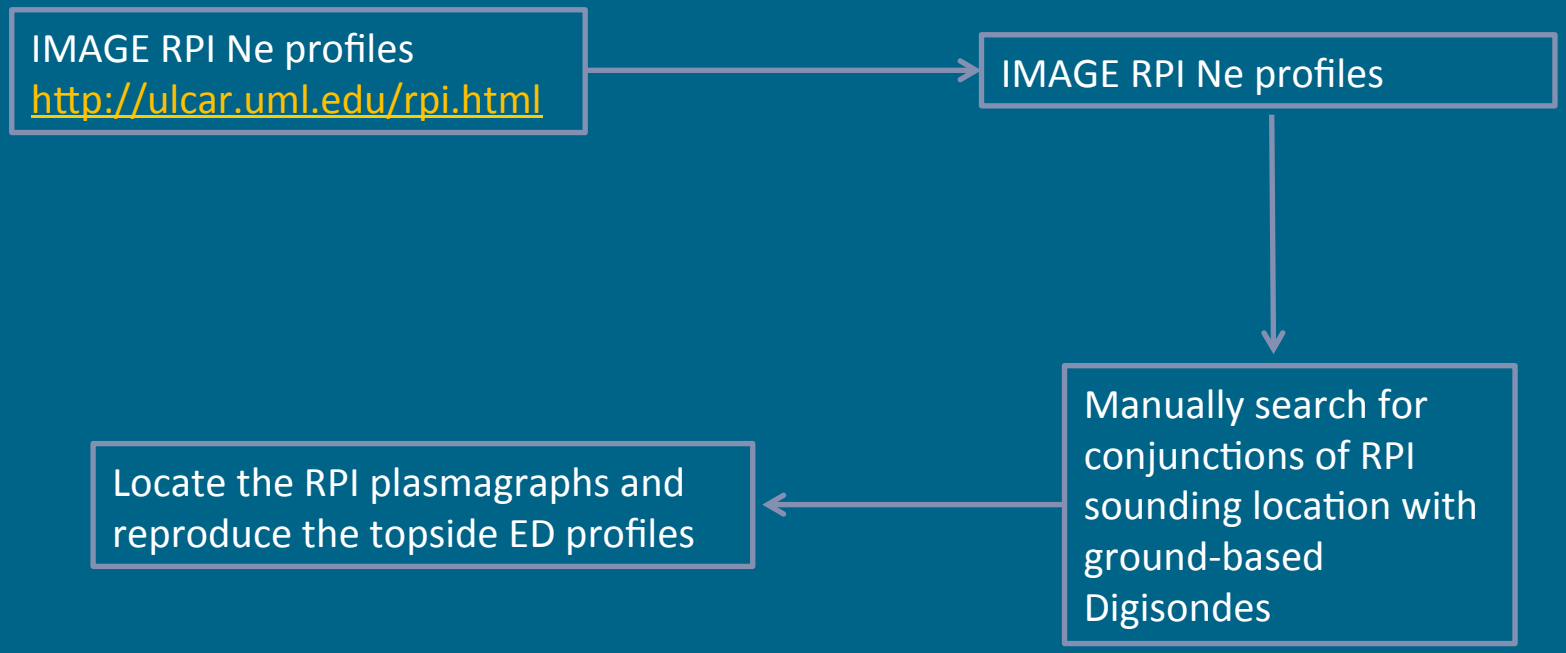
IMAGE RPI conjunctions with ground-based Digisondes (Belehaki et al 2009)





2D electron density distribution in the magnetic meridional plane derived from RPI data.

When IMAGE plane is close to a Digisonde location on the ground (star symbol), the ionogram-derived bottomside vertical EDP of ionosphere can be combined with the plasmaspheric vertical EDP from RPI data (dashed line) for comparison with a reconstruction model (TaD model in this case).



Steps required to access and collect the data