



ESPAS

near earth space data infrastructure for e-science

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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

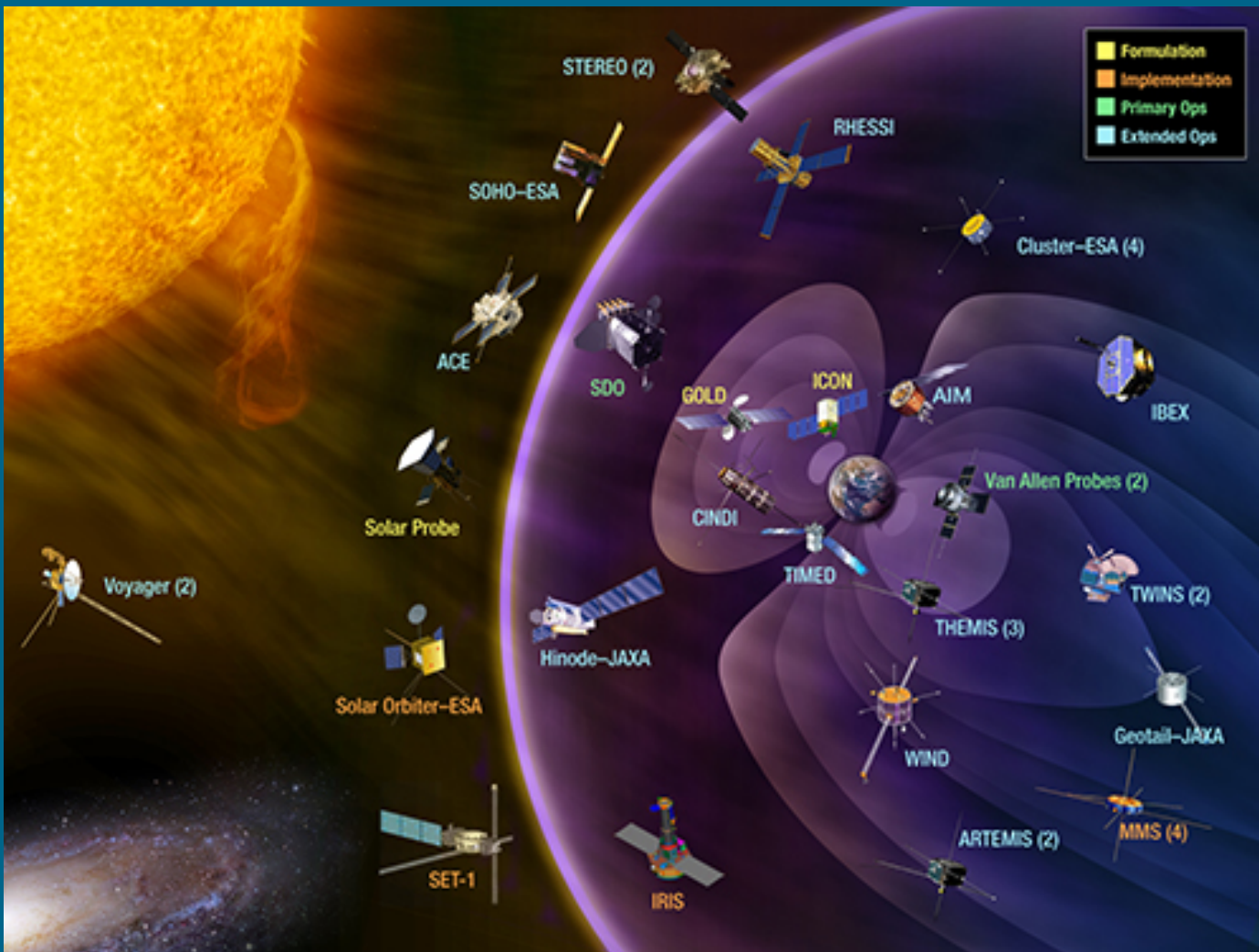
- Supports the systematic exploration of multipoint measurements from the near-Earth space through homogenised access to multi-instrument data
- Provides access to 40+ datasets from : Cluster, EISCAT, GIRO, DIAS, SWACI, CHAMP, SuperDARN, FPI, magnetometers INGV, SGO, DTU, IMAGE, TGO, IMAGE/RPI, ACE,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

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



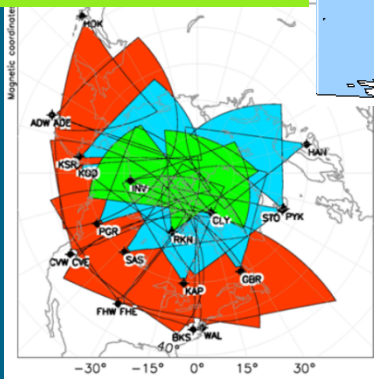
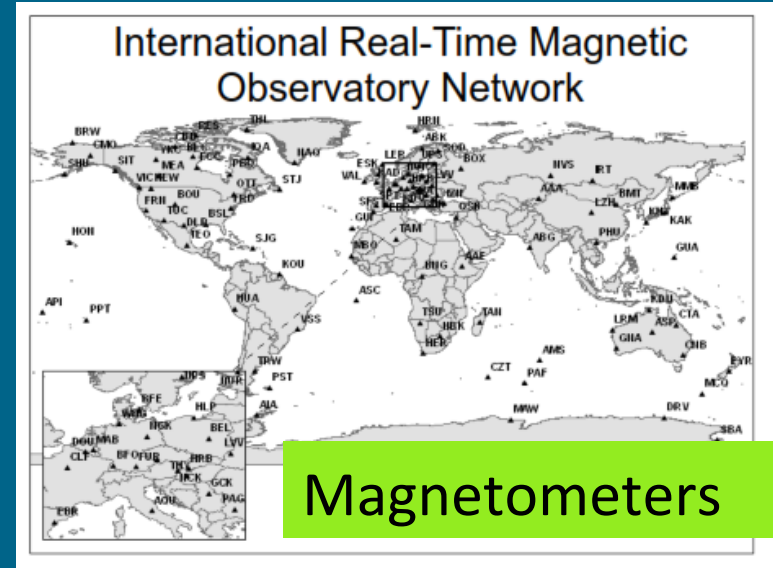


Space observatories in the near-Earth space



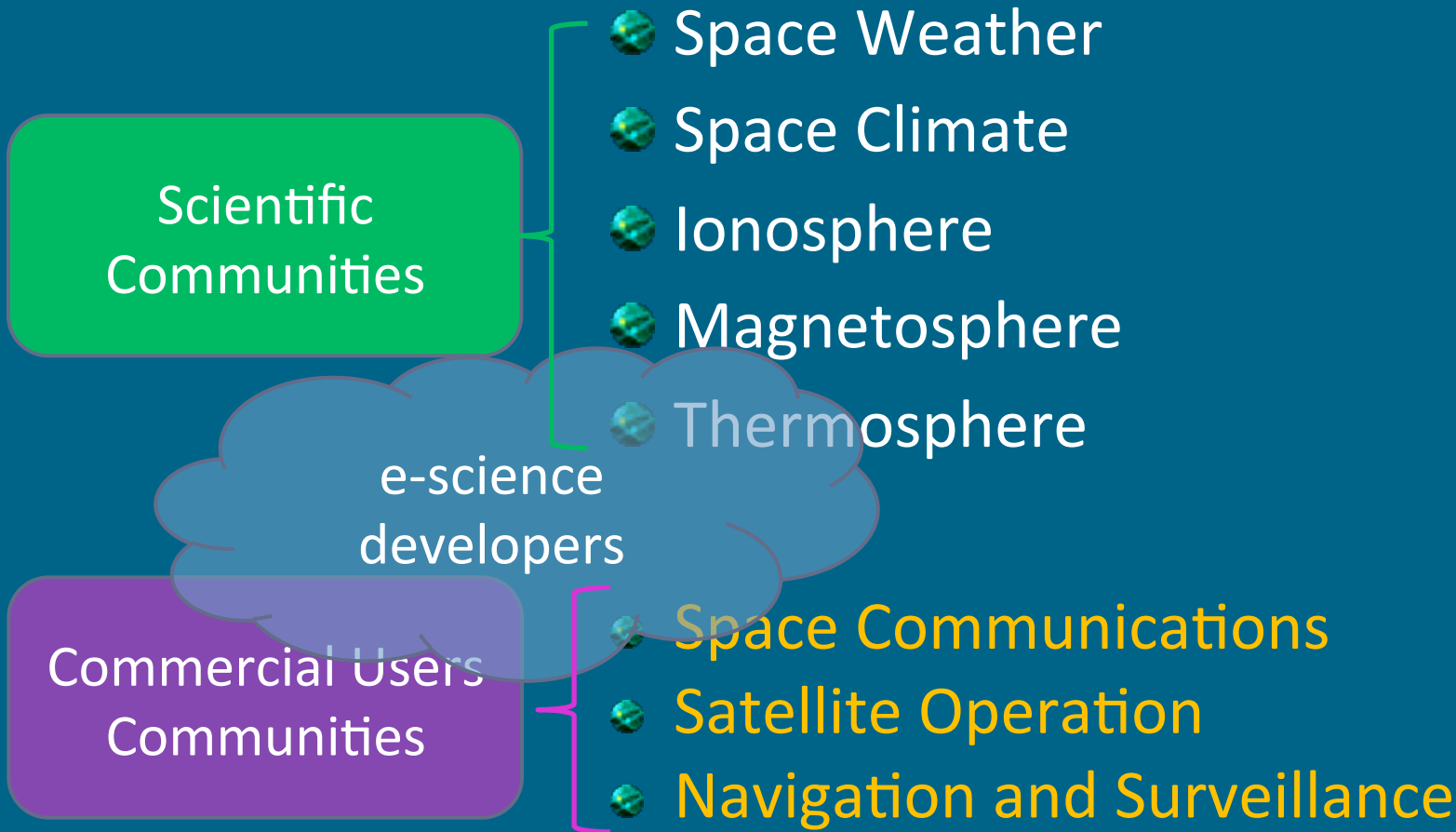


Ground-based instruments observing the near-Earth space



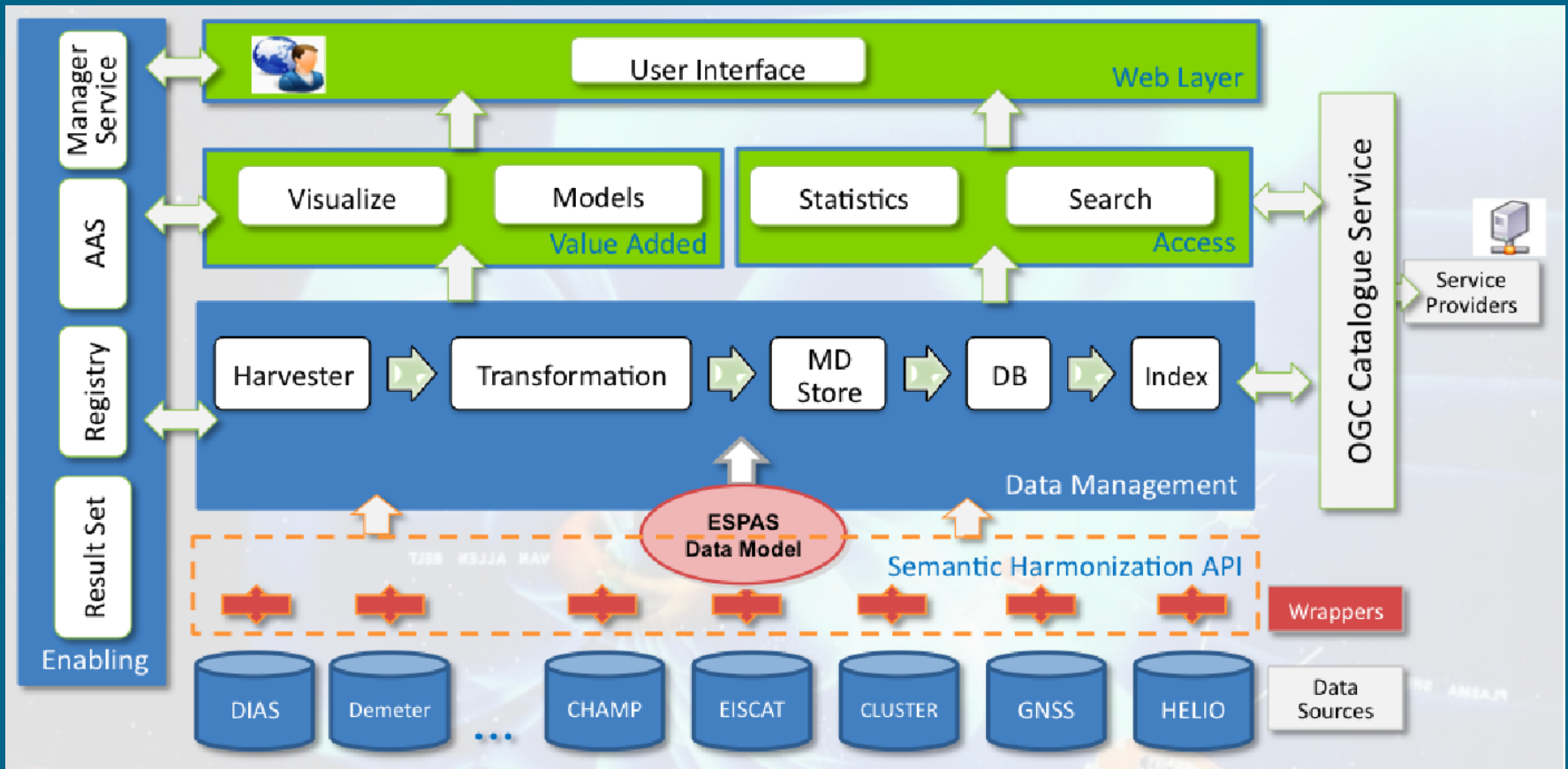


ESPAS is made out of several disparate but interrelated communities





General Architecture



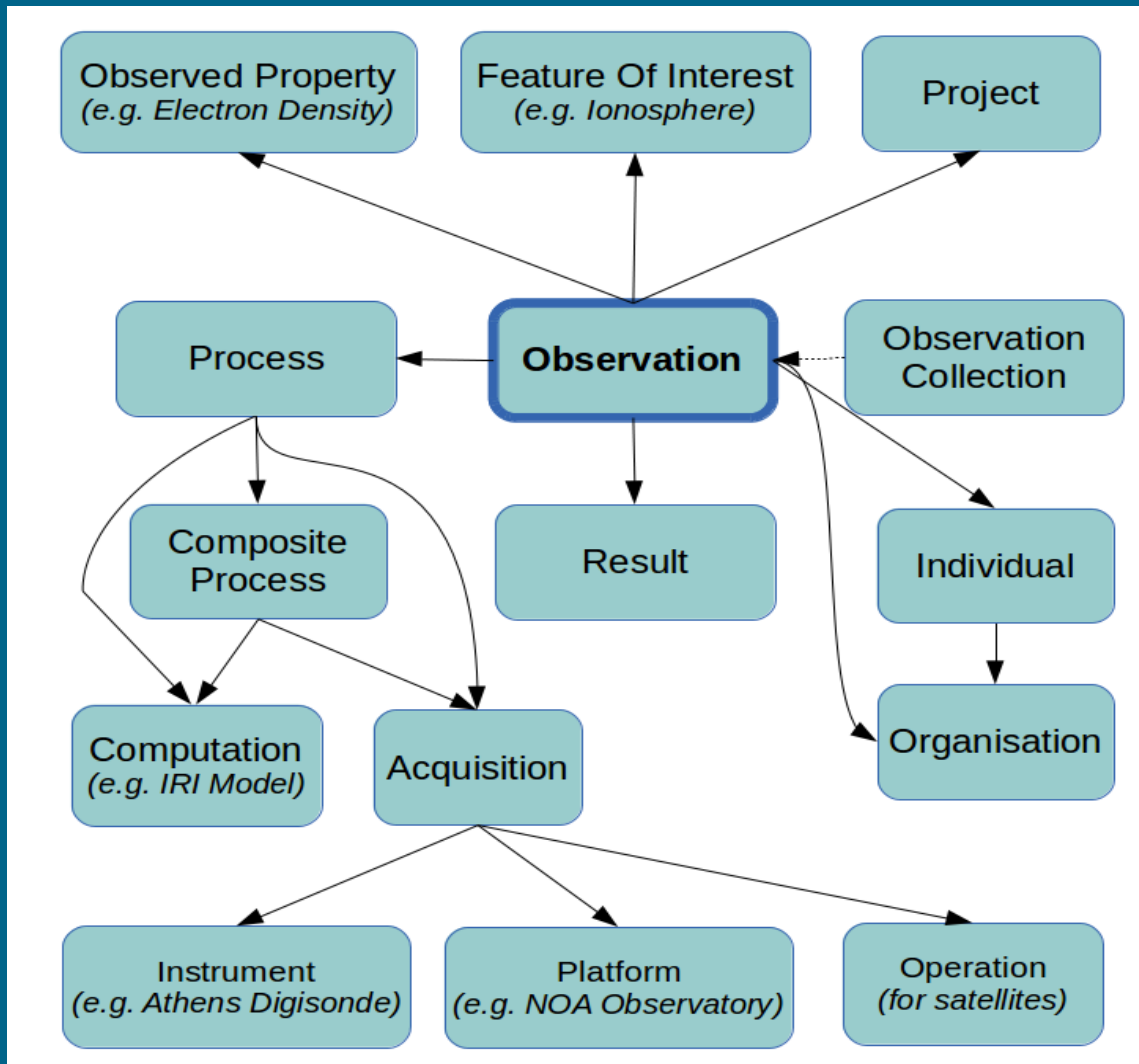
Semantic Harmonization Layer: harmonization of the data sources and their adoption of the ESPAS data model; **Data and Semantic Integration Layer:** (meta)data harvesting and basic content management services;

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**

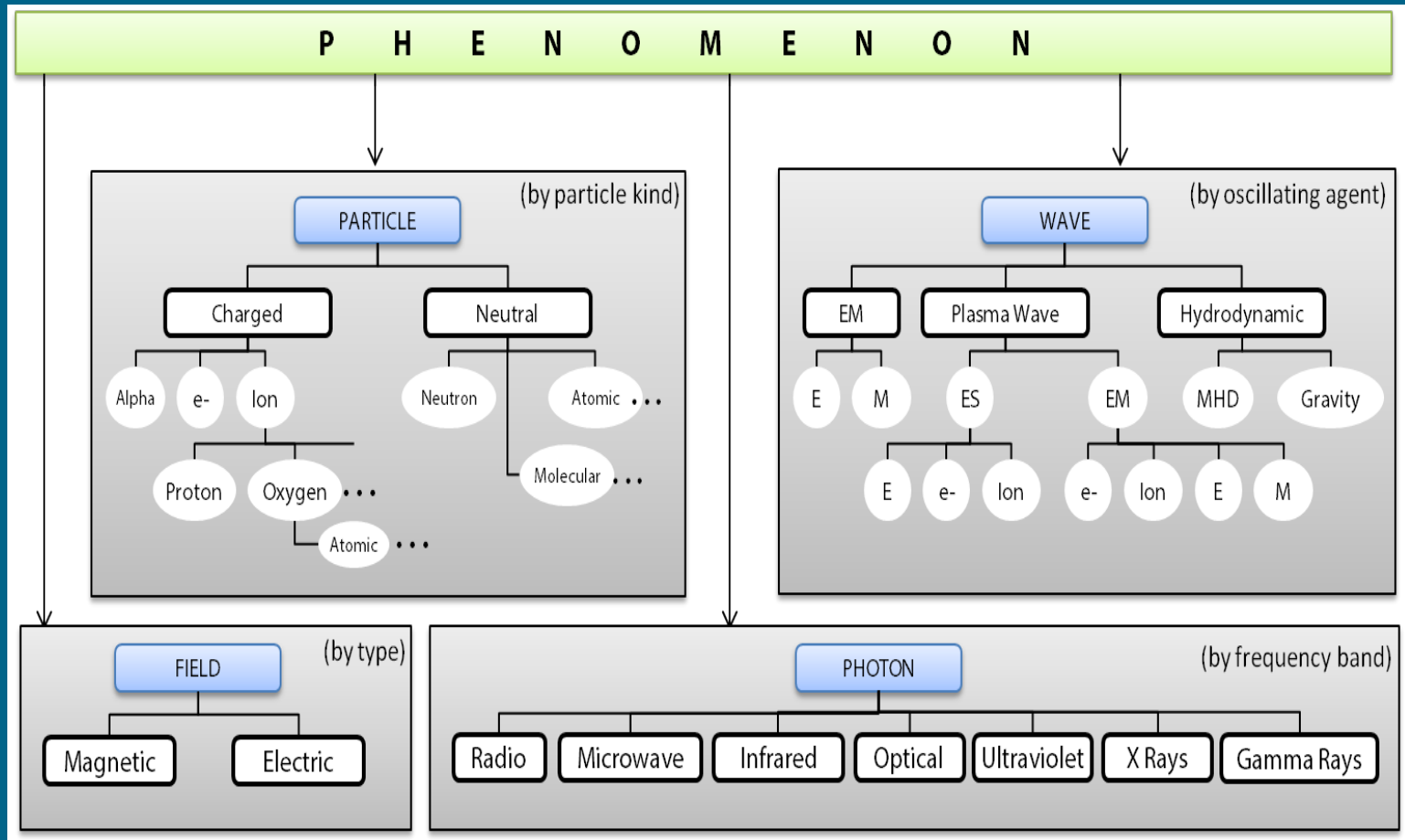


The Observed Property is defined in ESPAS as a forest of 6 trees:

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

M E A S U R A N D

Distance
--Altitude
--Scale Height
--Thickness
--Semi-thickness

Flux
--Transport
--Particle
--Energy
--Surface Integral
--Poynting
--Electric
--Magnetic

Spectral Density
--Power
--Amplitude
--Voltage

Frequency
--Doppler Shift
--Resonance
--Critical
--Cutoff
--Collision
--Blanketing
--Band
--Top

Density
--Number
--Line Integral

Travel Time
--Absolute
--Differential

Power

Mass

Pressure

Position

Composition

Temperature

Category

Velocity

--Bulk
--Flow

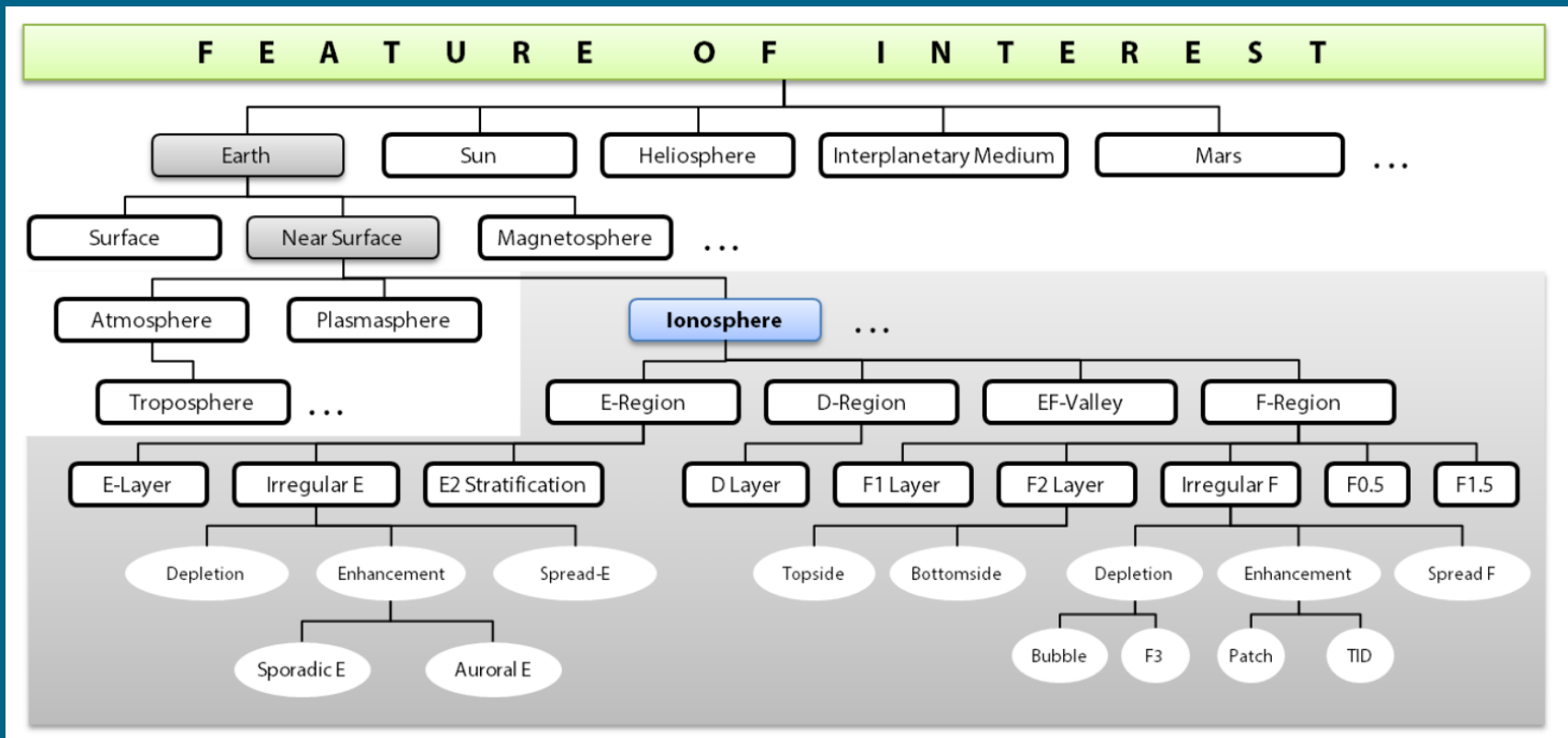
Current

Count

Energy



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.



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ESPAS POLICIES

VALUE ADDED SERVICES

SUPPORT

ESPAS Metadata

ESPAS Space Physics Ontology

ESPAS Supporting Vocabularies

ESPAS provides the following services:

1. Metadata search by
 - o Time
 - o Assets (Instruments and Models)
 - o Observed Properties
 - o Observation Collections
 - o Location
2. Download of Data Files
3. Download of Data Values (extracted parameters)
 - o Plots of extracted parameters
4. Value-added Services for Data Visualization and Processing
5. Registration of new Data Collections

Search and Download

observations, collections, files or data from a large number of data providers

Register

your data in ESPAS

News / Announcements

- The ESPAS Training School will be held in Warsaw from 19th to 23rd October 2015. See <http://www.espas-fp7.eu/school> for further details.

ESPAS is a data infrastructure facilitating access to observations, models and predictions of the near-Earth space environment extending from the Earth's atmosphere up to the outer radiation belts.

Access to a [large number of repositories](#) with heterogeneous data from ground and space, in situ and remote sensors.



Navigate in ESPAS

Navigate in ESPAS

Navigate in data providers information accessible via ESPAS: platforms, projects, instruments, models, collections etc.

Start typing to select options...

- ▶ **Data Providers**
- ▶ **Individuals**
- ▶ **Organisations**
- ▶ **Platforms**
- ▶ **Projects**
- ▶ **Instruments**
- ▶ **Operations**
- ▶ **Computations**
- ▶ **Acquisitions**
- ▶ **Composite Processes**
- ▶ **Observation Collections**

Observation Collections

Corresponds to any set of existing observations. The organisation of observations into collections is based on specific criteria, e.g. common observed property, common instrument, common process. An observation may be aggregated in more than one observation collections.

Alouette 1 Electron Density Profiles

Alouette 2 Electron Density Profiles

Andenes Magnetometer Data

Athens Digisonde SAO files (autoscaled)

Automatically Prospected IMAGE RPI Plasmagram Images

Bergen Magnetometer Data

Bjørnøya Magnetometer Data

CHAMP-AI-3-NRT

CHAMP Topside Ionosphere/Plasmasphere Reconstruction

CTS 1 minute XYZF variations



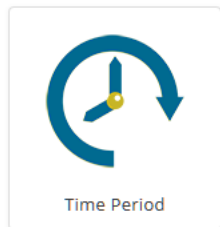


Search & Download

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

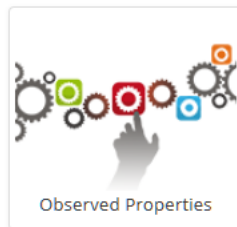
Filter your search with different options as you go along (real-time)



Time Period



Assets



Observed Properties



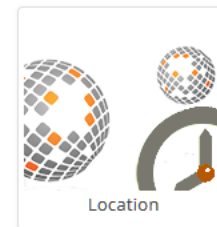
Observation Collections

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)

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Current Selections

Time Periods: 2005-01-01 00:00 - 2015-07-01 05:00 [00:00 - 23:59] UTC

[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

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Current Selections
Assets: Electron Density Assimilative Model
Time Periods: 2012-10-08 09:45 - 2012-10-18 00:00 [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
- Observation Collection
- Region of Space
- Model
- Dimensionality Instance

Number of Observations : 878

Download Data Providers' status Share your results

Dataset files
Data values

Observation Collections

- EDAM grids of electron density

espas Dataset Files Download

You can give a name to your download request. If you leave it empty the default name will be the date of the request.

Request name EDAM-Oct2012

Licences

- I agree to all the Licences
- I agree to the UBIRM's Terms of Reference licence

Download

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



LOG IN | REGISTER | ESPAS Project | Contact Us

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ESPAS POLICIES

VALUE ADDED SERVICES

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 - o Plots of extracted parameters
4. Value-added Services for Data Visualization and Processing
5. Registration of new Data Collections

Search and Download

observations, collections, files or from a large number of data providers

News

- The ESPAS Training School was held in 2015. See <http://www.ESPAS.org>

- About ESPAS
- ESPAS Data Model
- ESPAS Space Physics Ontology
- Glossary
- ESPAS User's Manual
- For Data Providers
- Data Providers' Status
- Contact Us

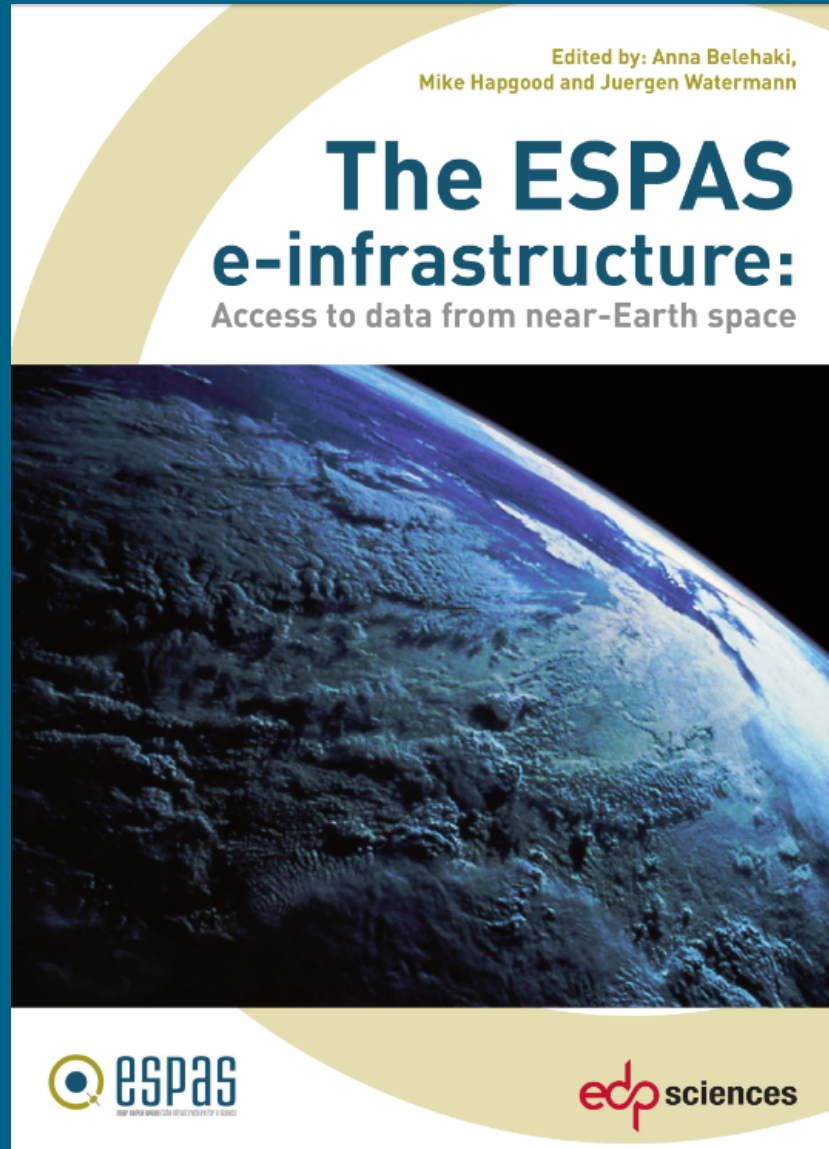
ESPAS is a data infrastructure facilitating access to observations, models and predictions of the near-Earth space environment extending from the Earth's atmosphere up to the outer radiation belts.

Access to a large number of repositories with heterogeneous data from ground and space, in situ and remote sensors.



ESPAS Data Portal

<https://www.espas-fp7.eu/portal/>





BACKUP SLIDES

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
			<i>O-TRACE POINTS - F2 LAYER</i>
7	xx	15F8.3	VIRTUAL HEIGHTS
8		15F8.3	TRUE HEIGHTS
9		40I3	AMPLITUDES
10		120I1	DOPPLER NUMBERS
11	xx	15F8.3	FREQUENCIES
			<i>O-TRACE POINTS - F1 LAYER</i>
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**

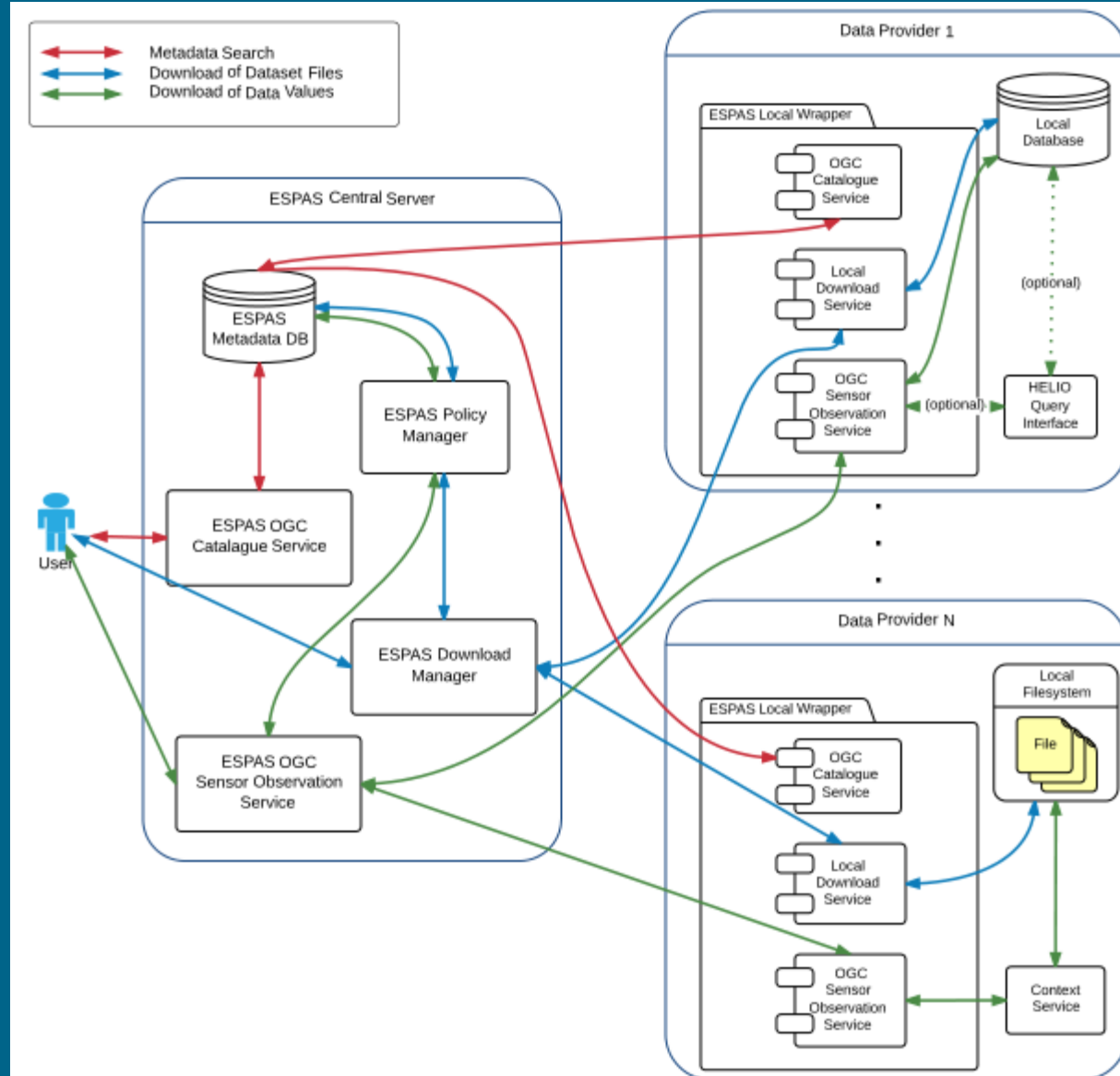
Search fields:

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



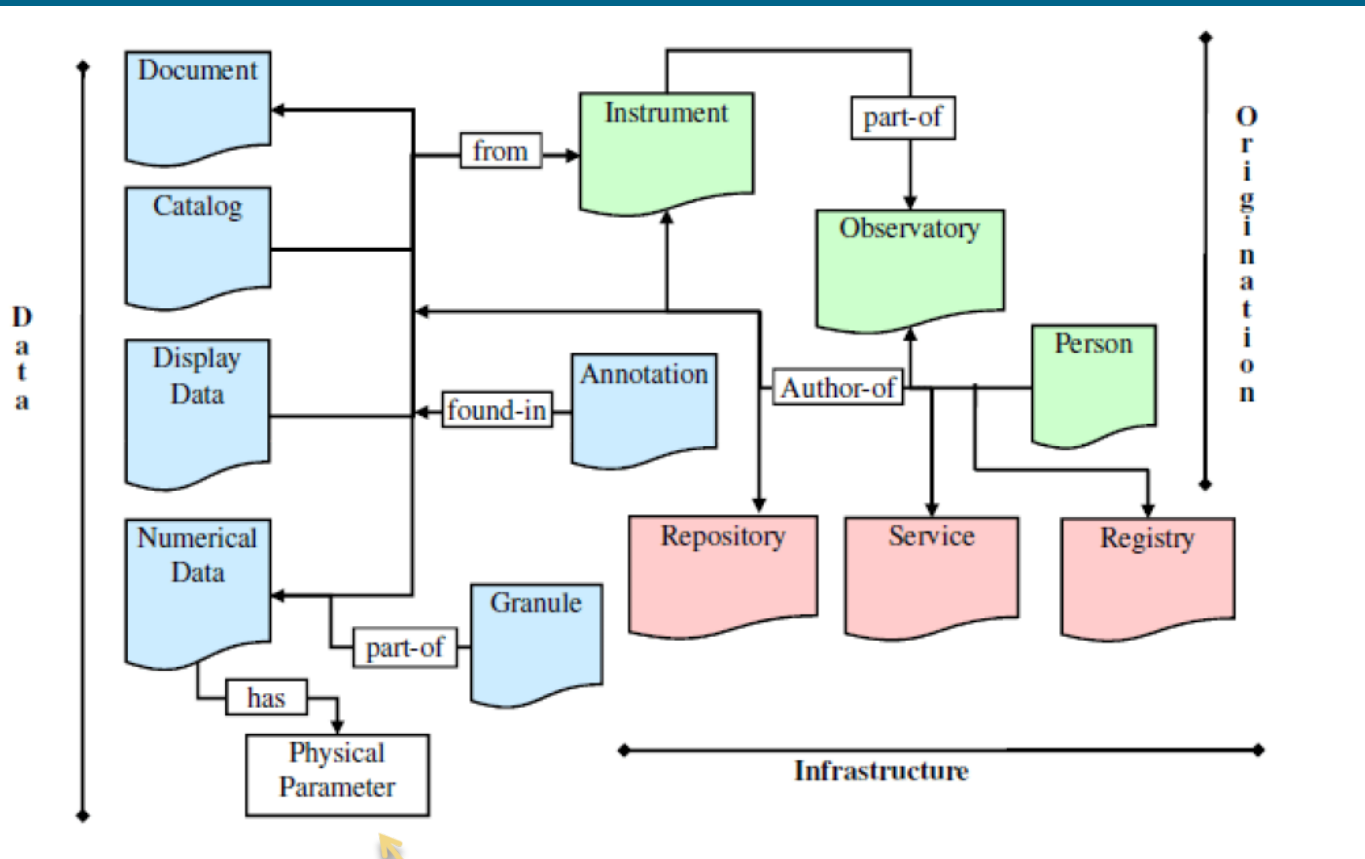
Interoperability services

- 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



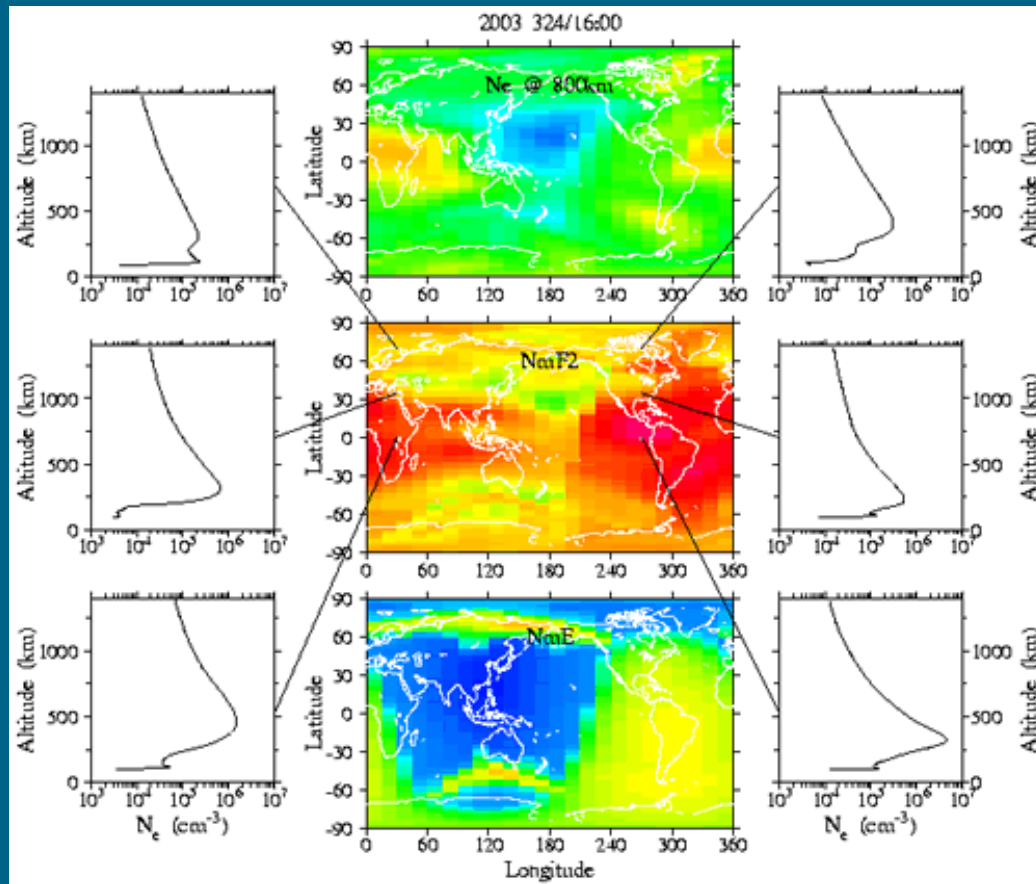
Some science cases
and the implications to collect
the required data



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?

Madrigal DB

<http://www.openmadrigal.org/>

EISCAT ISRs Ne

DIDB ionograms scaled characteristic

<http://giro.uml.edu/didbase/scaled.php>

Ne profiles from ionosondes and Digisondes extrapolated to the topside ionosphere

CHAMP Radio occultation profiles

<http://sisko.colorado.edu/sutton/data.html>

CHAMP Radio occultation profiles

International Reference Ionosphere – IRI

<http://www.irimodel.org>

IRI Ne for background values

IMAGE RPI Ne profiles

<http://ulcar.uml.edu/rpi.html>

IMAGE RPI Ne profiles

ISIS and Alouette topside data

<http://nssdc.gsfc.nasa.gov/space/isis/isis-status.html>

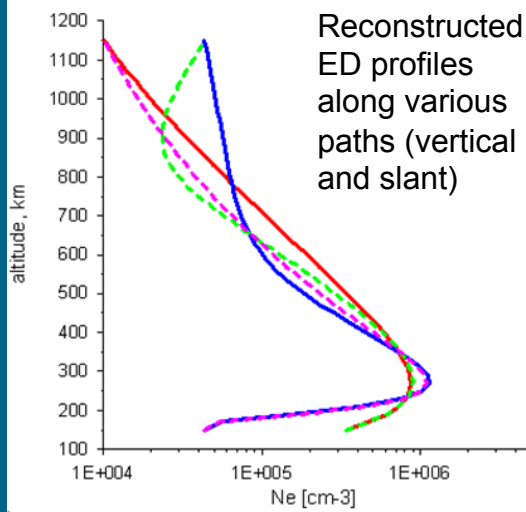
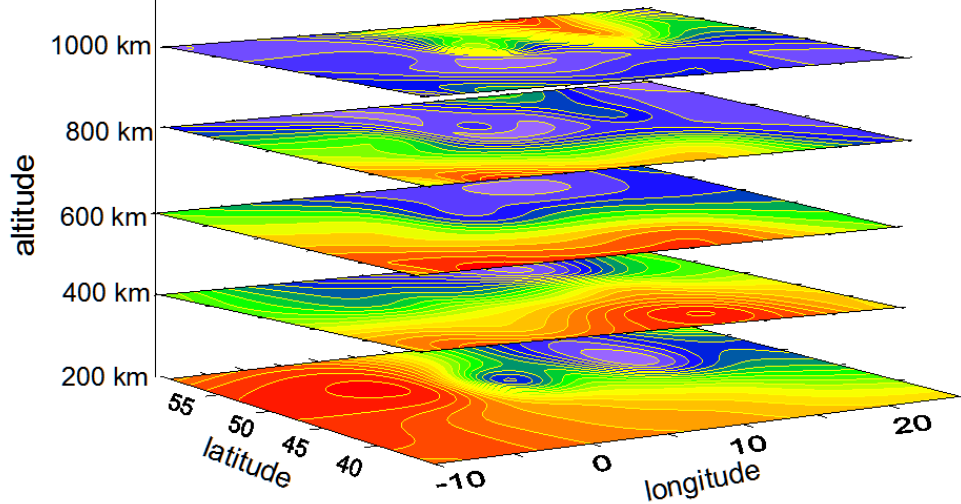
ISIS and Alouette topside Ne profiles



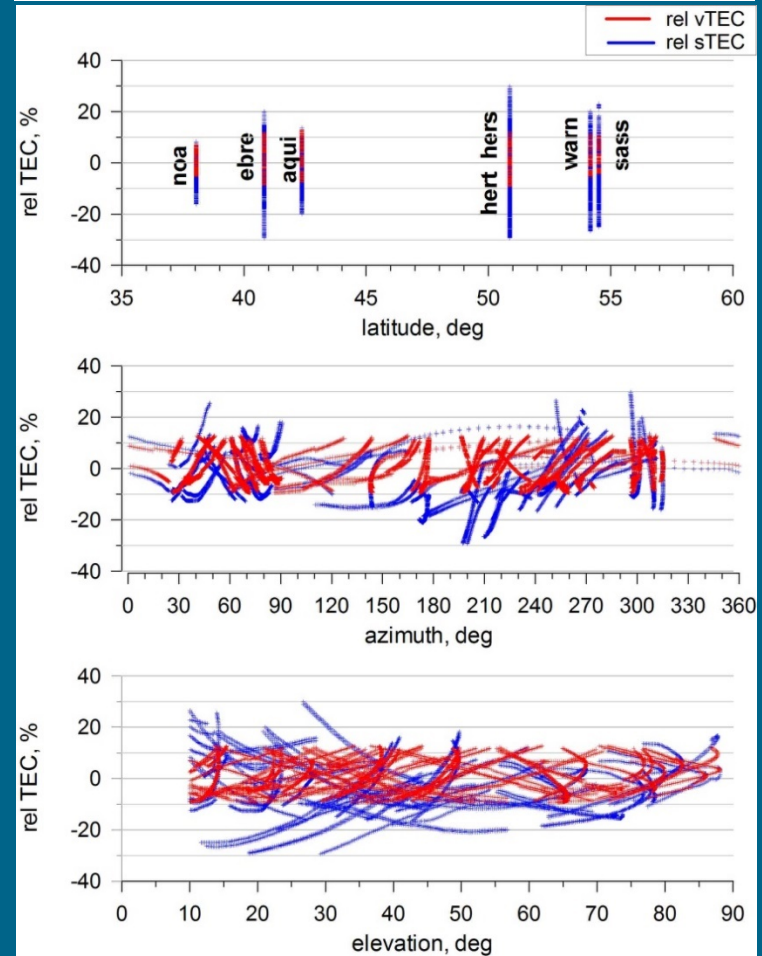
Validation of a 3D electron density model

TaD electron density model

Ne [sm⁻³] 13:45 UT, 08 March 2012

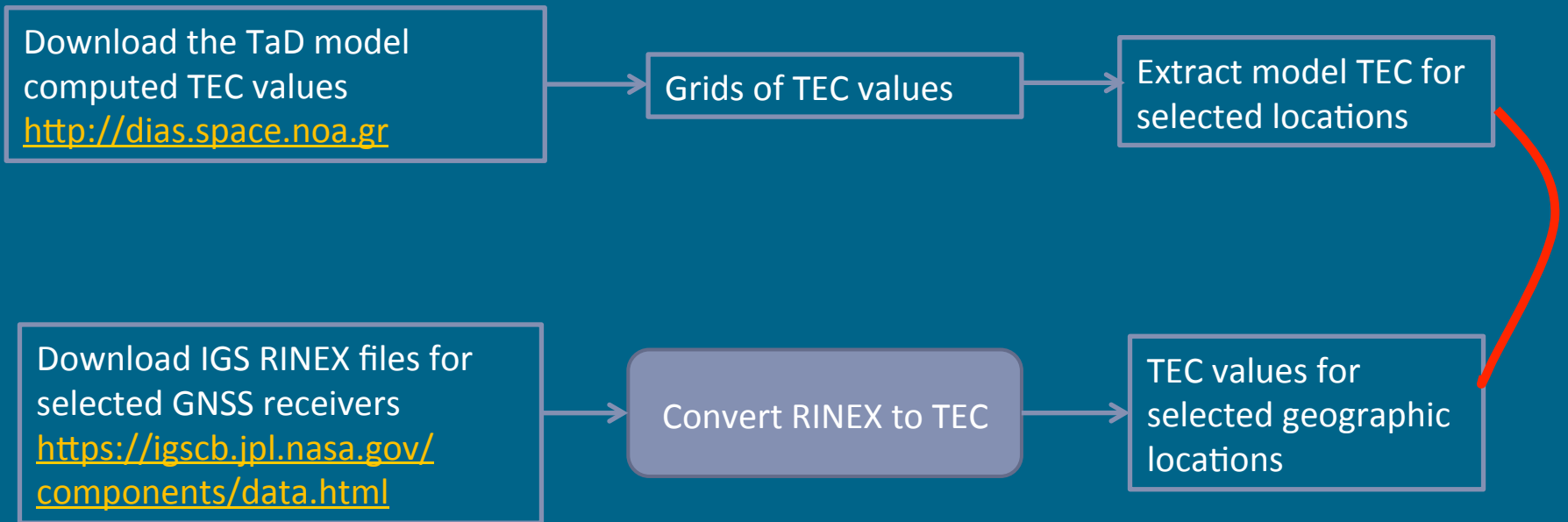


Comparison with vertical and slant TEC from IGS GNSS receivers





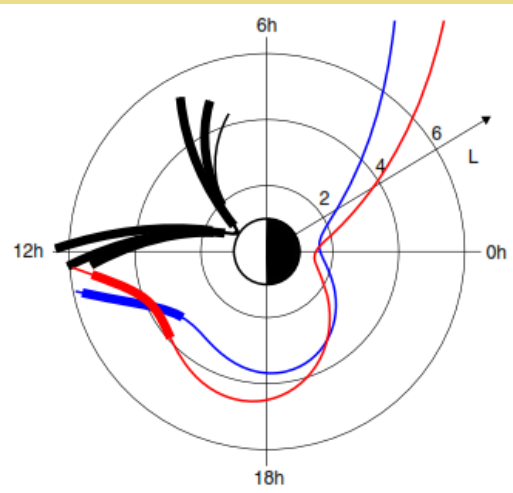
What needs to access the required data?



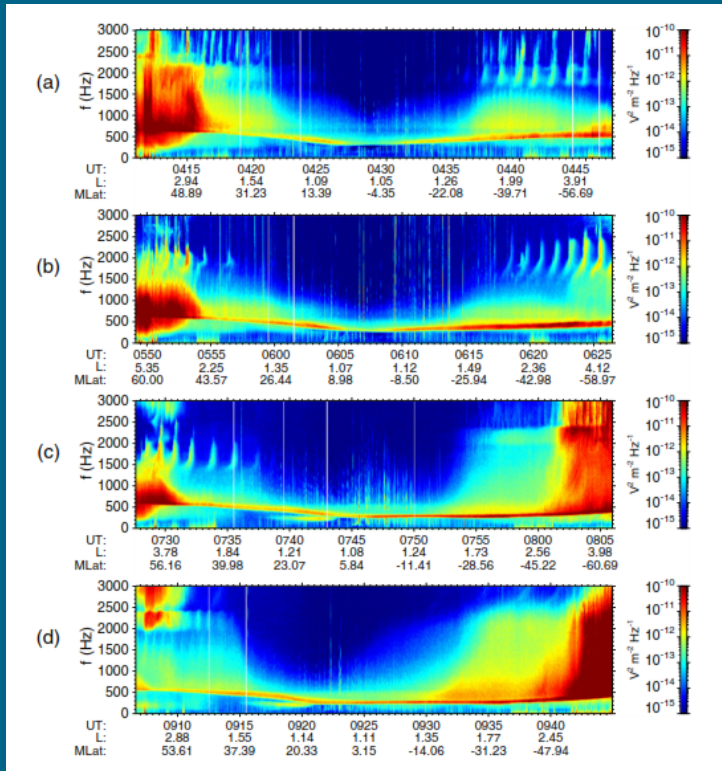


QUASI-PERIODIC EMISSIONS by CLUSTER and DEMETER spacecraft (Nemec et al., JGR, 2013)

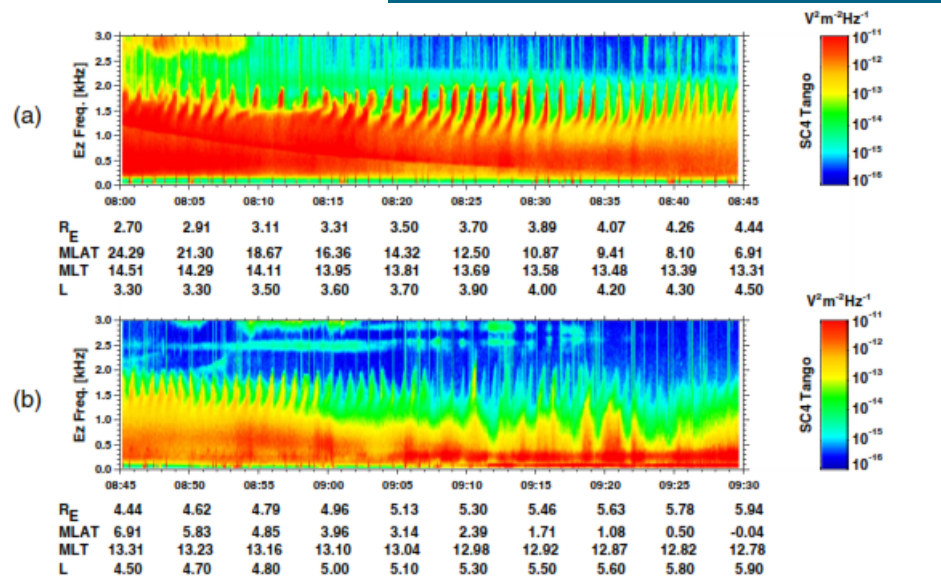
Cluster satellites are in a highly elliptic orbit which is evolved with time.
 Demeter's orbit is a quasi Sun-synchronous circular orbit with an inclination of about 98.23° and an altitude of about 660 km.



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 DEMETER on 13 April 2010.



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?

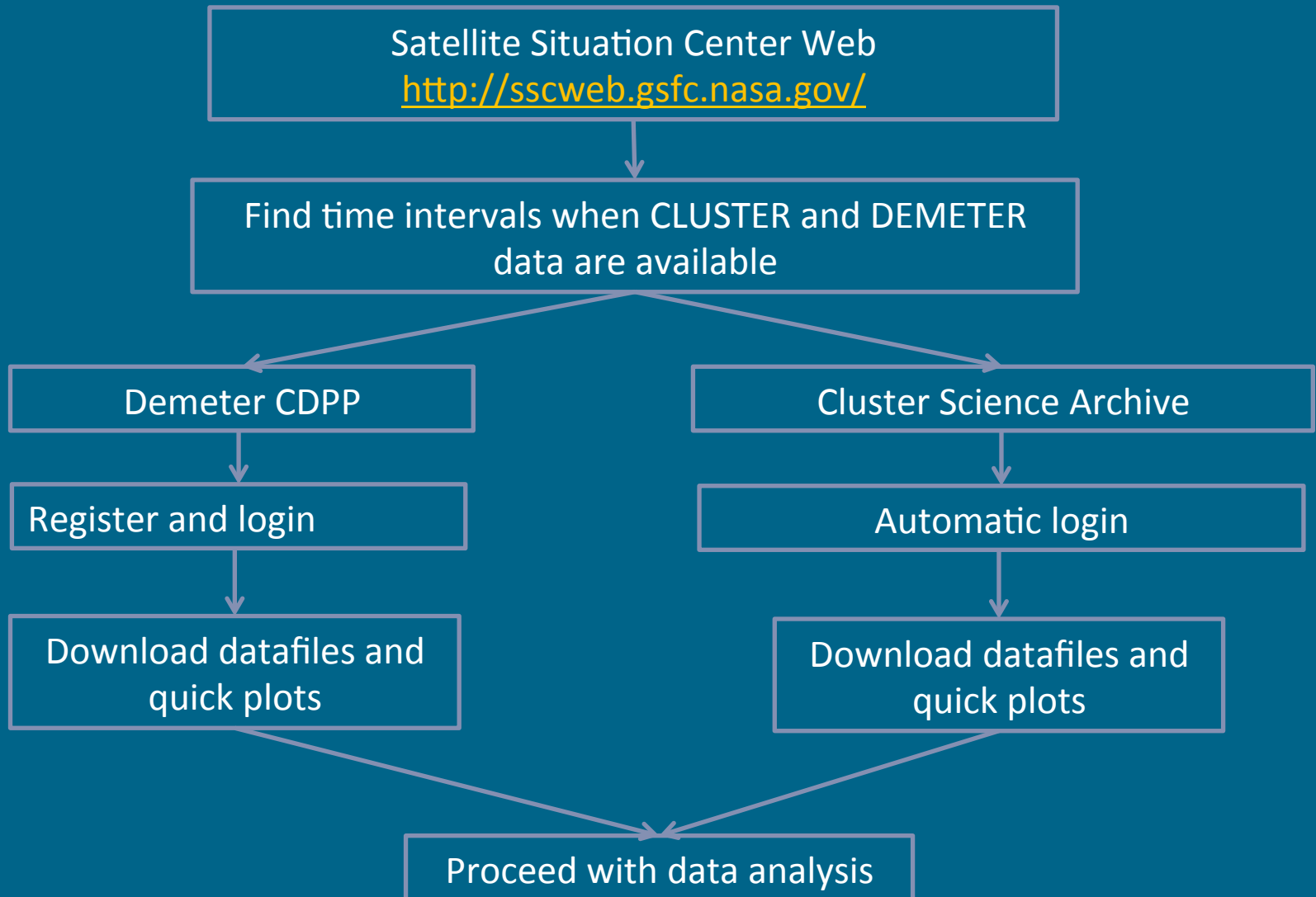
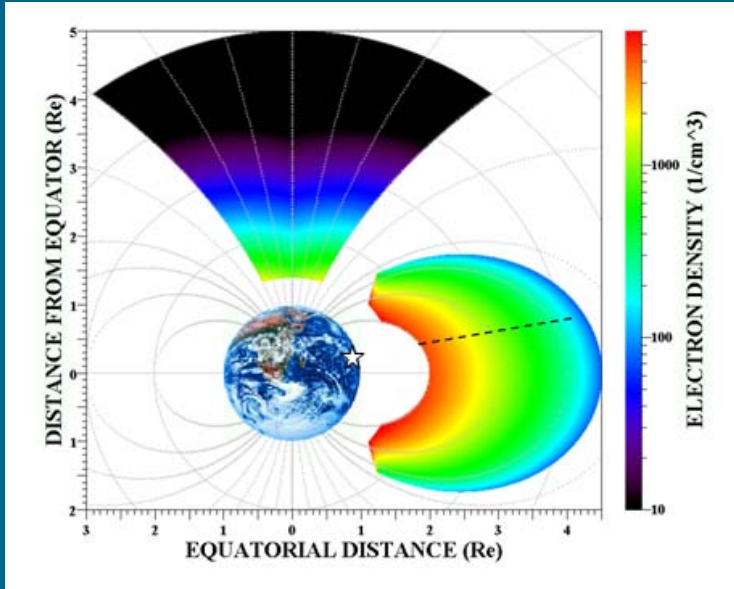


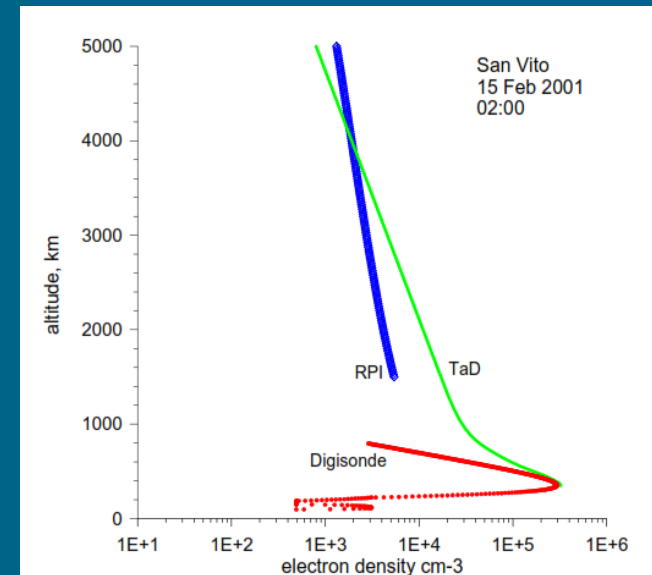
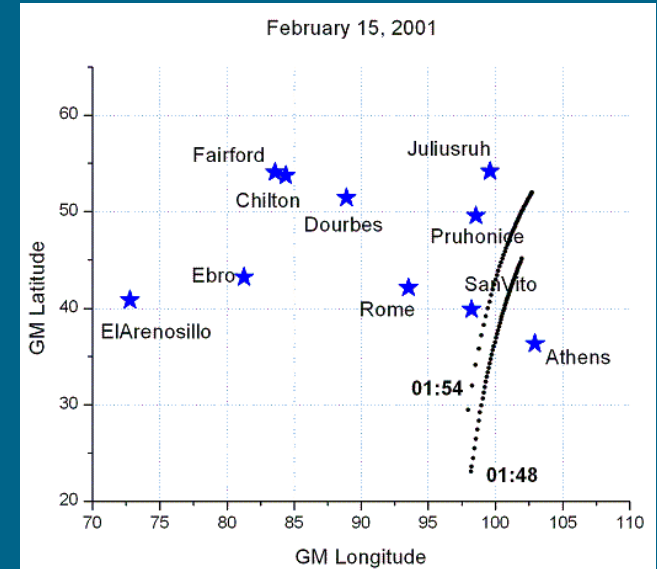


IMAGE RPI conjunctions with ground-based Digisondes (Belehaki et al 2009)



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

