



Plasmasphere Ionosphere Thermosphere Integrated Research Environment and Access services: a Network of Research Facilities



PITHIA-NRF Goals and Outcomes

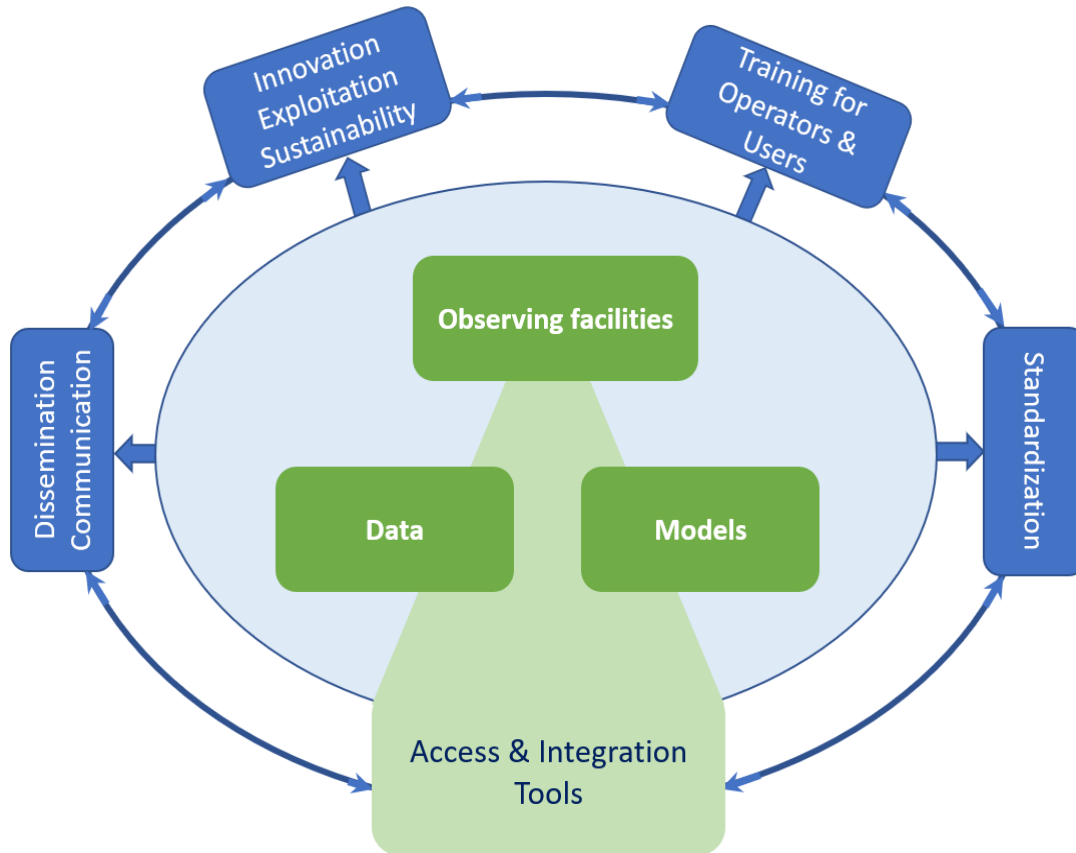
Anna Belehaki
National Observatory of Athens, Greece

Third Innovation Day
12 June 2024, CBK, Warsaw



Overview & Ambition

PITHIA-NRF aims at building a European distributed network that **integrates** observing facilities, data processing tools and prediction models dedicated to ionosphere, thermosphere and plasmasphere research.

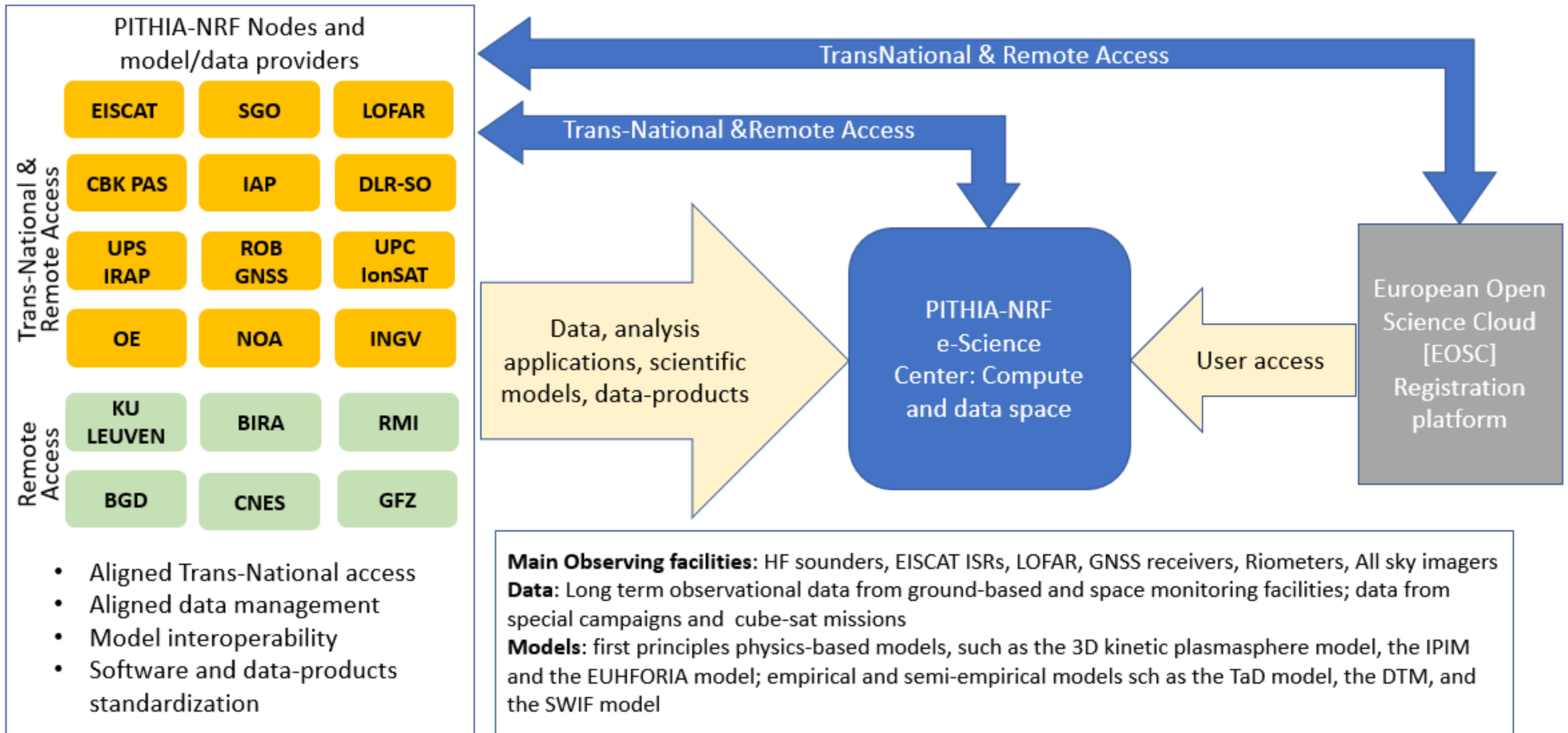


PITHIA-NRF through **standardization**, open access to relevant **e-services** and **trans-national access** to experimental facilities, has the ambition to become the European hub that will act as facilitator:

- for coordinated observations
- for data processing tools and modelling advances
- for software and data-products standardization,
- for advising on the transitioning of models to operations providing e-science supporting tools so that models can reach the desired accuracy and standards.



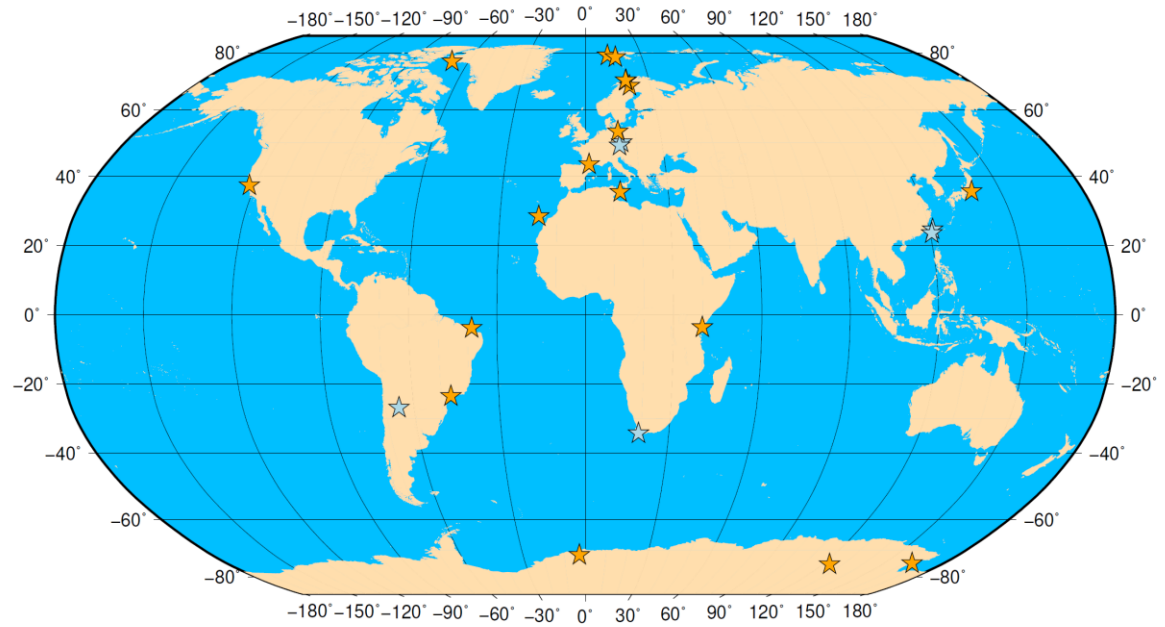
Integrating facilities, data and models



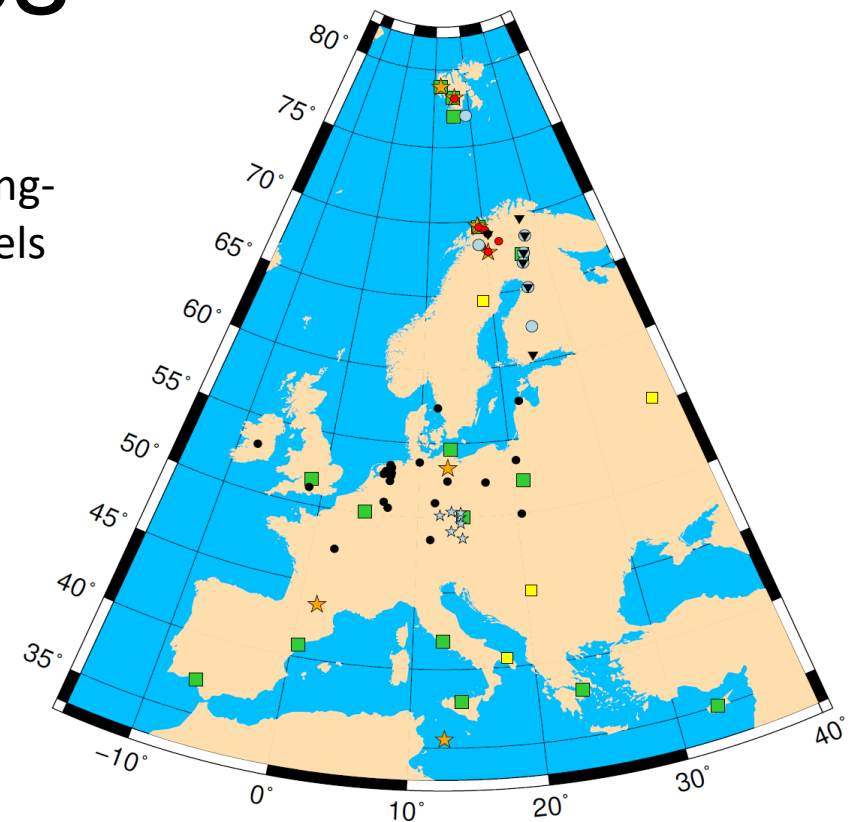


Observing facilities

PITHIA-NRF participating organizations offer access to observing facilities, long-term observational data from ground-based and space experiments, and to models



The World map shows GNSS high sampling rate and CDSS sites only.



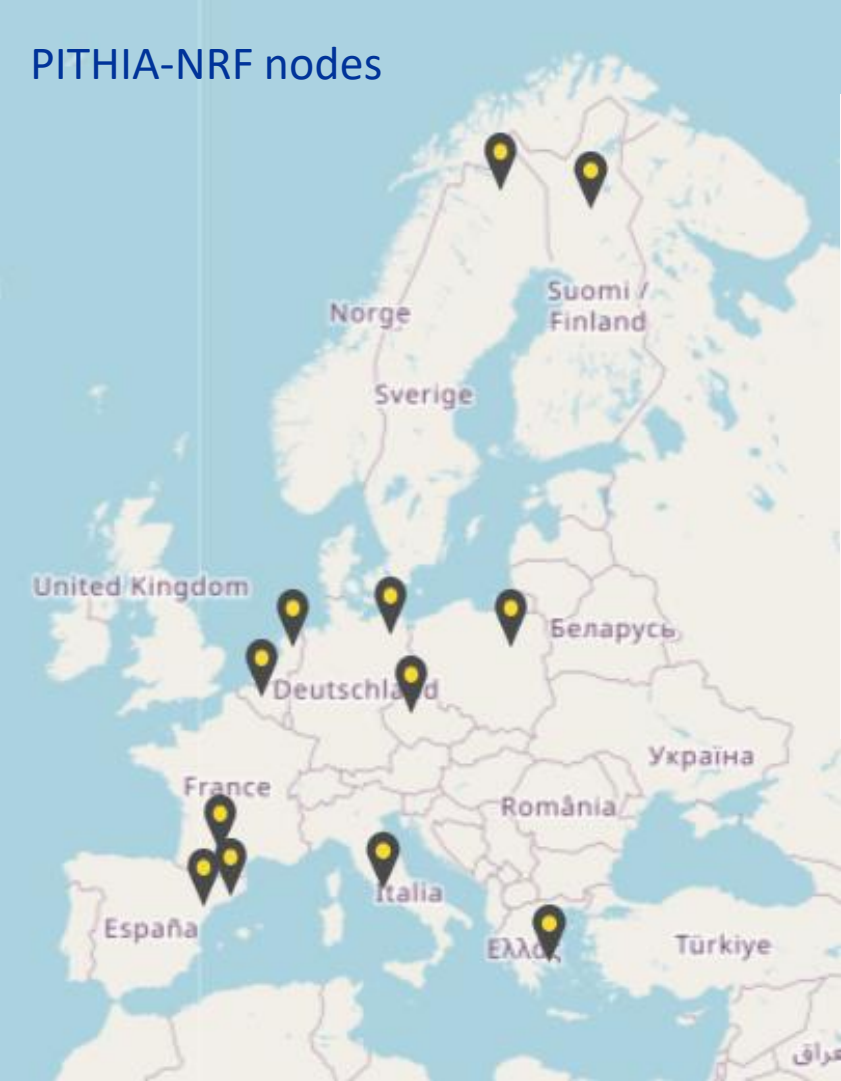
- ionosondes with real-time data delivery ■
- ionosondes without real-time data delivery ■
- IAP CDSS transmitters and receivers (on both maps) ★
- INGV + DLR GNSS scintillation receivers (on both maps) ★
- EISCAT transmitters and receivers light blue circles: SGO riometer chain ●
- SGO pulsation magnetometer chain ▼
- LOFAR sites and sites associated with LOFAR ●



TransNational Access

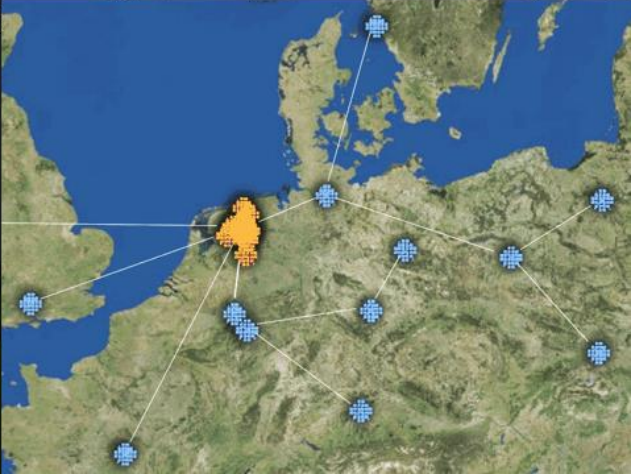
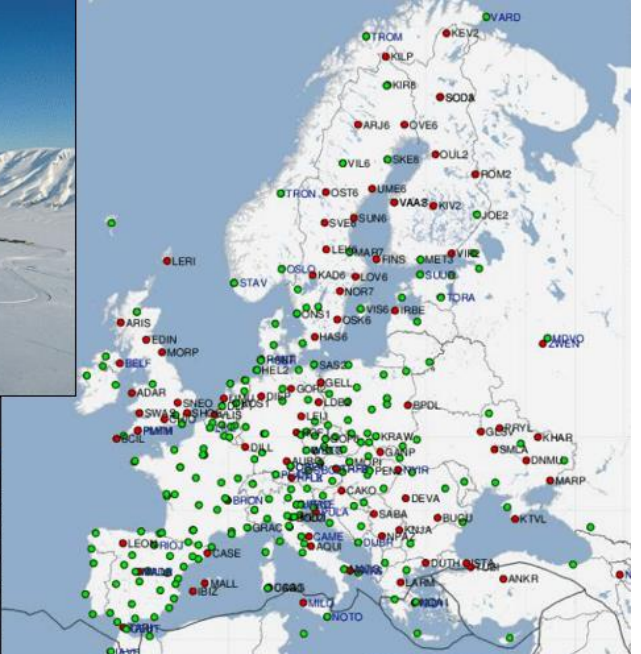


PITHIA-NRF nodes



TNA Calls

- First TNA Call
- Second TNA Call
- Third TNA Call
- Fourth TNA Call
- Fifth TNA Call
- Sixth TNA Call





Indicative nodes activities



Multiple ionosondes
Observation possibilities

The case of Hunda-Tonga volcano explosion: a multi-node collaboration
Verhulst et al.: J. Space Weather Space Clim. 2022, 12, 35

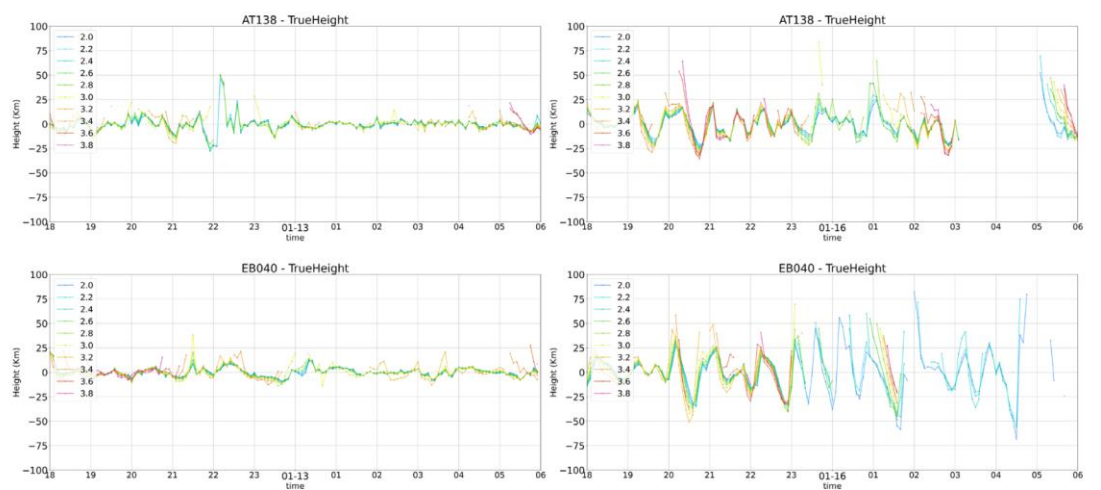
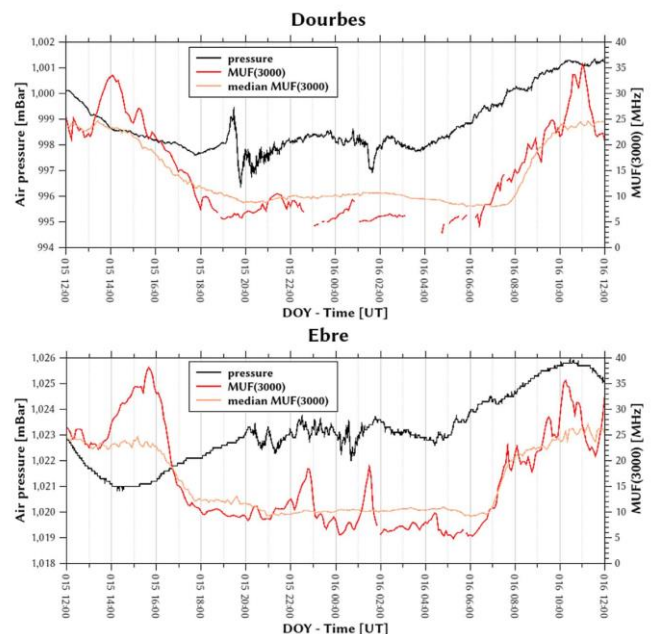
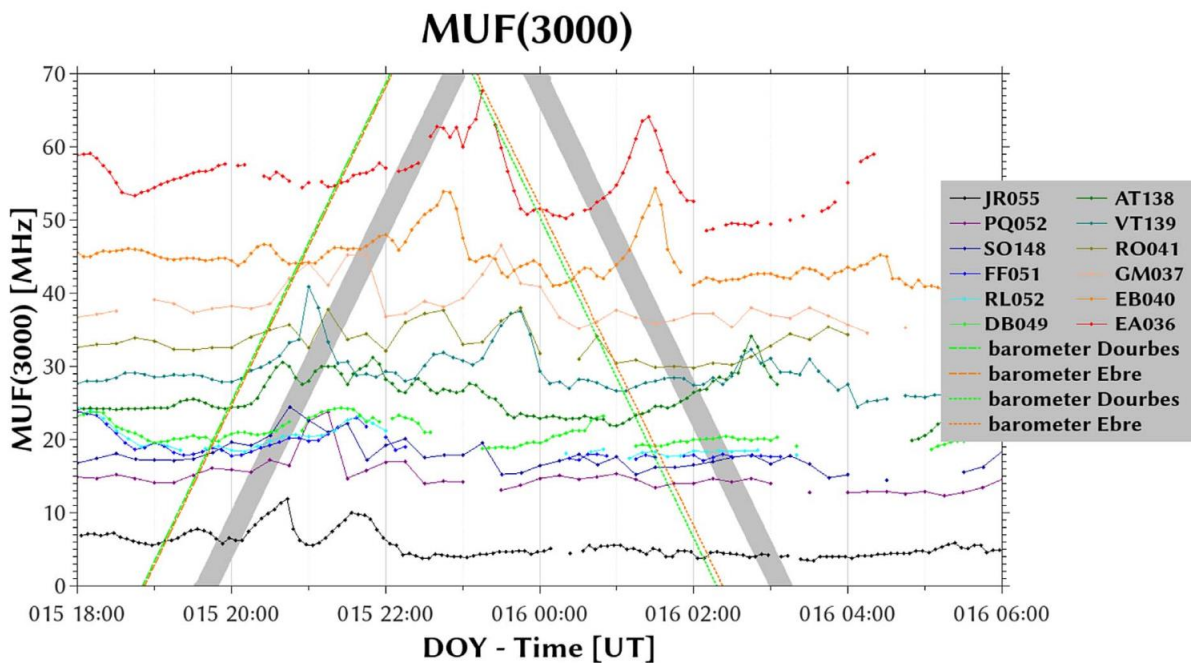


Fig. The maximum usable frequency (MUF) calculated from different sounders indicating ionospheric disturbances caused by the 15 January 2022 eruption of the Hunga volcano.



Indicative nodes activities



TNA projects at EISCAT

Measure the emission of the thermosphere and ionosphere (O and N₂⁺) in the same volume as the EISCAT antennas from three distant sites (50 to 100 km apart) so as to retrieve the vector polarisation, i.e. its angle in 3D.

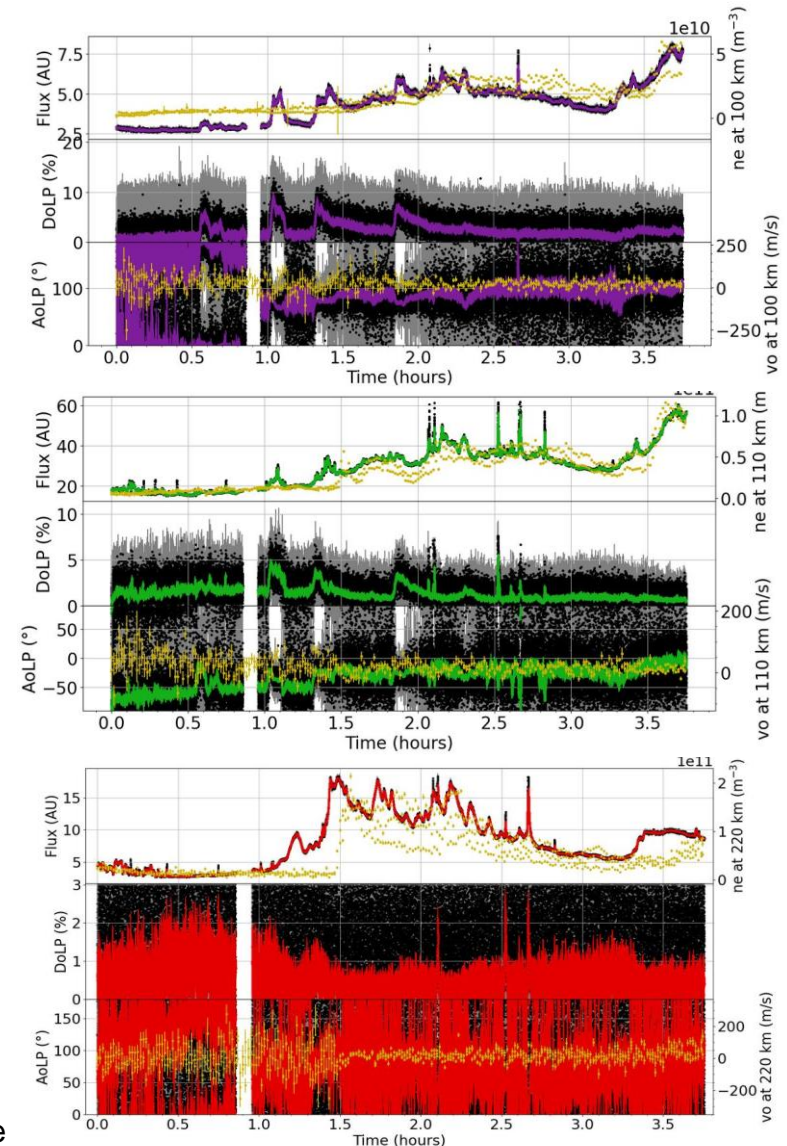


The 3 polarimeters used in this study 3 March, 2022. From left to right, Grand Cru, Carmen Cru and Corbel Cru. In this configuration, Grand Cru and Carmen Cru are looking in the EISCAT direction while Corbel Cru points 90° apart

This campaign confirms that the polarisation of the auroral emissions is a new tool to monitor the ionospheric electron density and the ionospheric currents at different altitudes, allowing drawing their profiles.

Electron densities measured around 100, 110 and 220 km to the purple, green and red lines respectively (upper panels). Degree of Linear Polarization (DoLP) and Angle of Linear Polarization (AoLP) in lower panels.

Acknowledgements: Jean Liliensten, IPAG, France





Indicative nodes activities

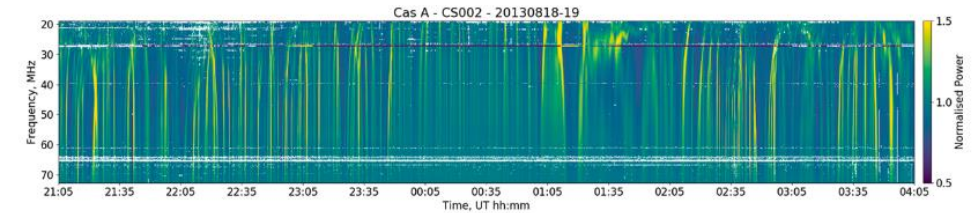


LOFAR: low frequency radio telescope

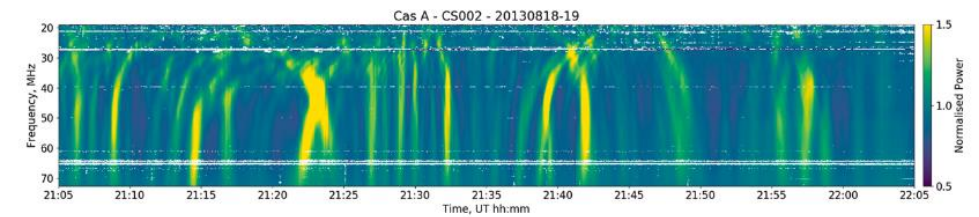
Two TNA projects are performed in LOFAR by researchers coming from Bulgarian Academy of Sciences and University of Warmia and Mazury in Olsztyn, Poland



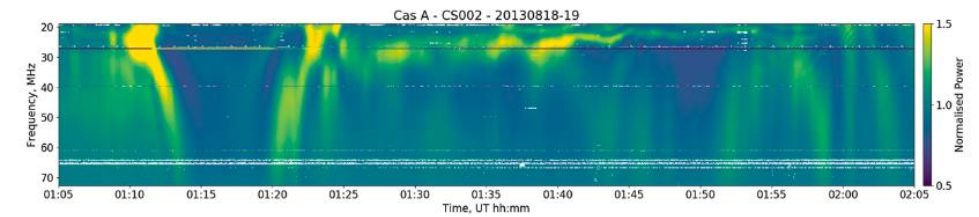
Database of **ionospheric amplitude scintillation data** of a bright radio source. Single station data of multiple stations. Access to small scale structures and velocities thereof, by combining data from multiple core stations (python scripts).



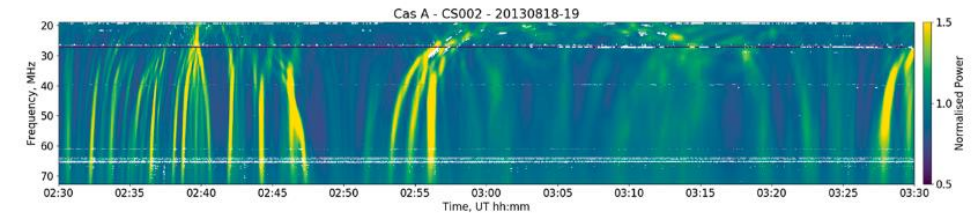
(a)



(b)



(c)



(d)

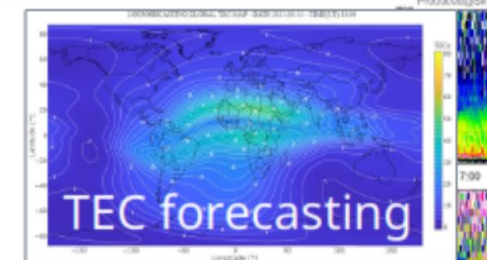
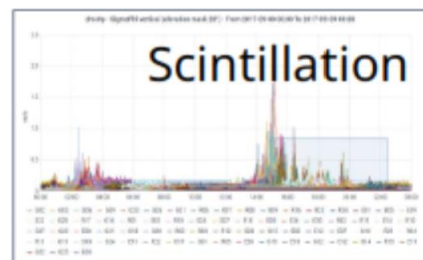
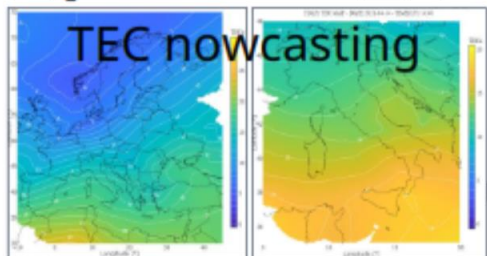
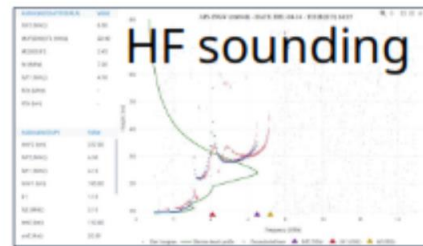


What data collections are provided in PITHIA-NRF and how to access?



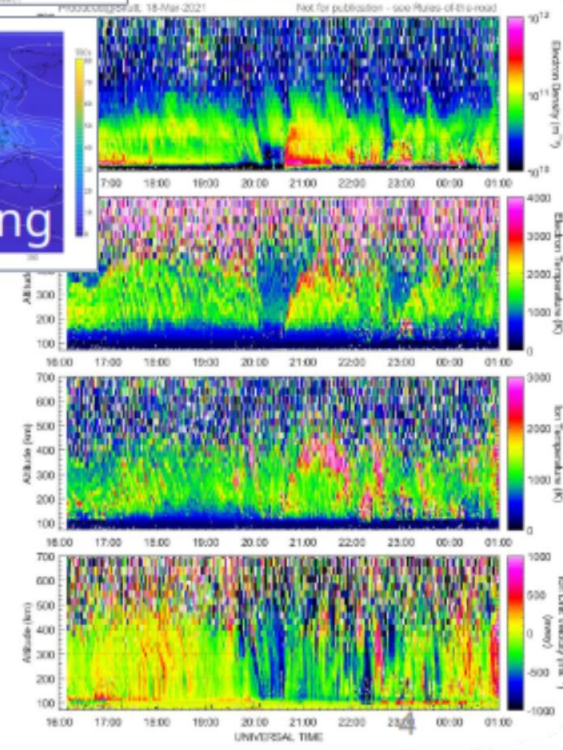
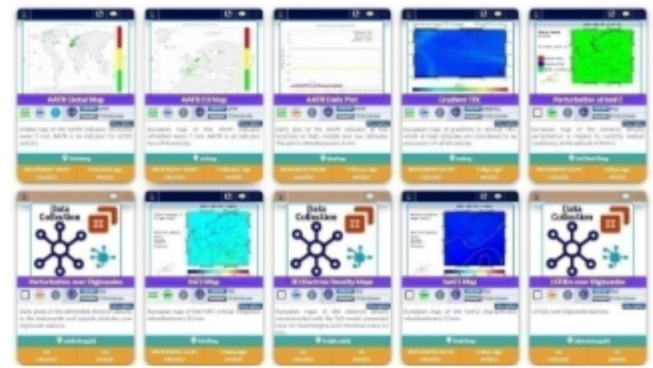
Some examples of the available data collections:

- Ionosonde parameters
 - Derived profiles, skymaps, drifts
 - Archive/Nowcasting/Forecasting
 - Models
- Doppler Sounding
 - Gravity Waves, global propagation
- Incoherent Scatter
 - Ionospheric density, temperature profiles
 - Ionospheric convection
- GNSS/LOFAR
 - TEC, Ionospheric scintillation
 - Local/global maps
- Riometer/Magnetometer networks
 - Absorption, Magnetic fields
- Interhemispheric Modelling



**High latitude
EISCAT Scientific Association
EISCAT VHF RADAR**
SP, vhf, bells, 21-22 November 2020

**Detection and prediction of
TIDs**





PITHIA-NRF e-Science center



PITHIA e-Science Centre

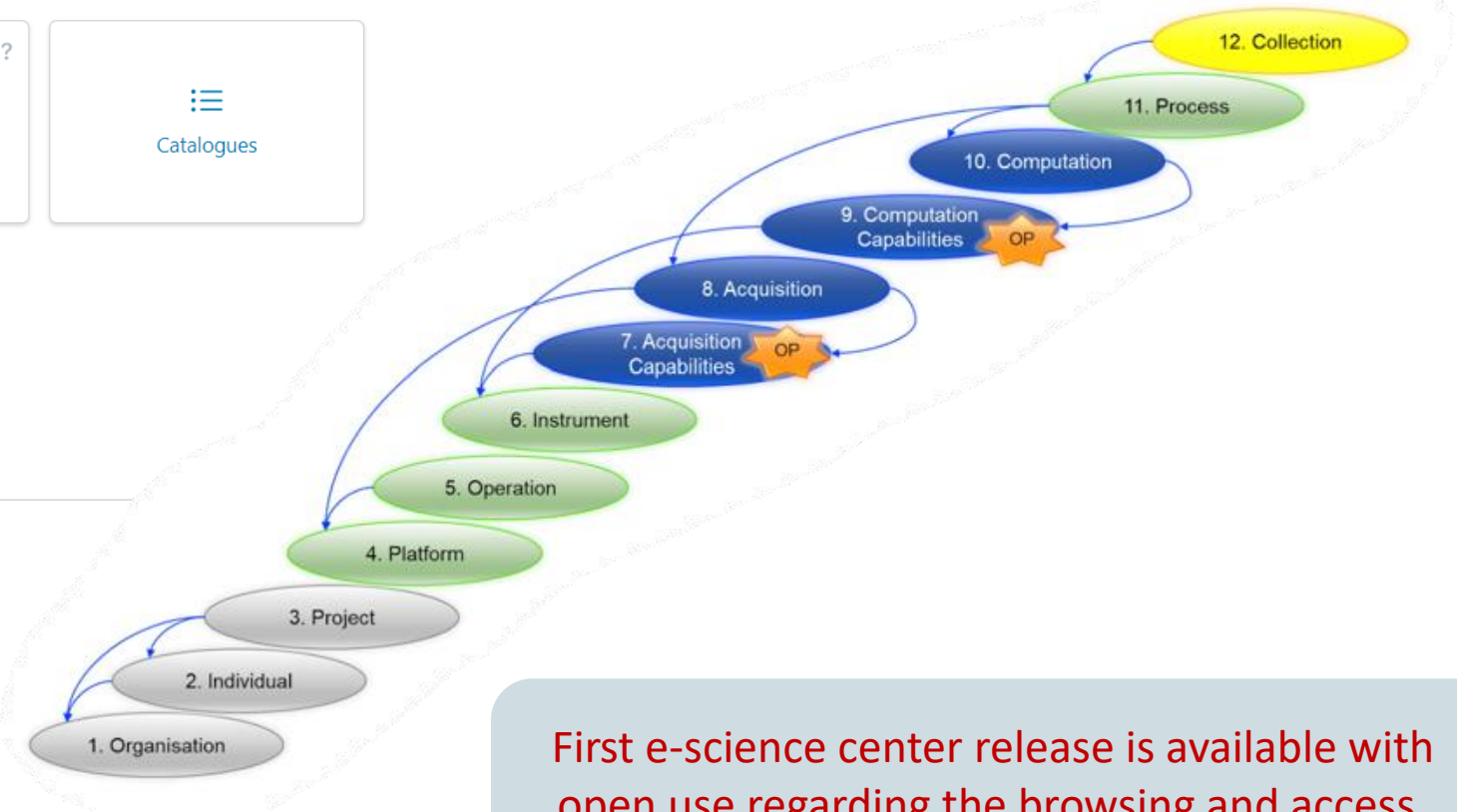
Scientific Metadata

- Search Data Collections by Content
- Data Collection Simple Search
- Data Collections
- Catalogues
- Workflows
- All Scientific Metadata

Space Physics Ontology

- Space Physics Ontology
- Space Physics Ontology Guide

12 STEPS of Registration based on the ESPAS ISO 19156 data model



First e-science center release is available with open use regarding the browsing and access. Data registration is available to authorized users



PITHIA e-Science Centre

Scientific Metadata

Search Data Collections by Content

Data Collection Simple Search

Data Collections

Catalogues

Workflows

All Scientific Metadata

Acquisitions from instruments

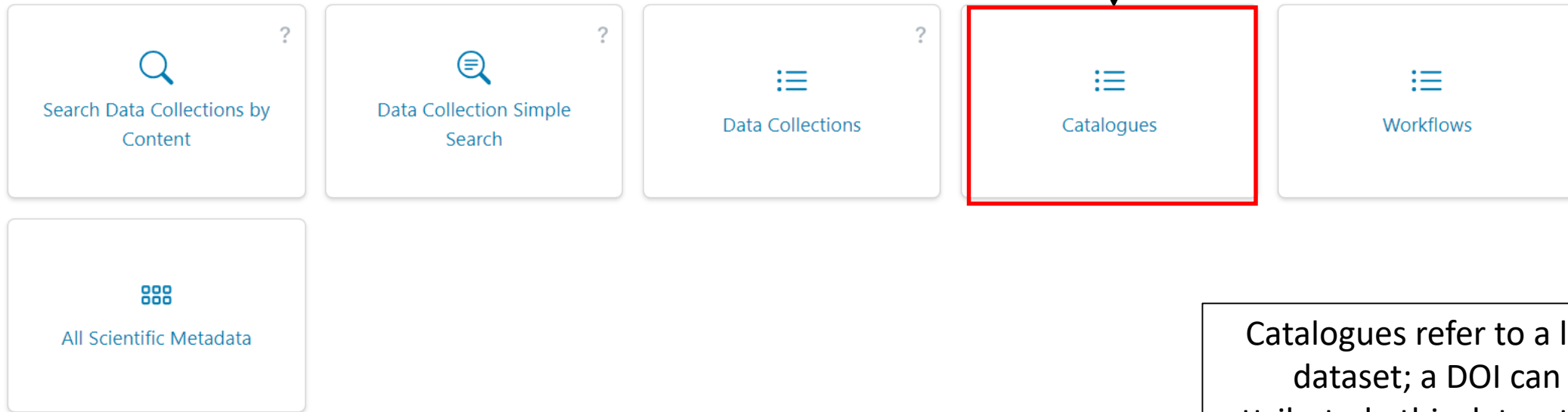
Computations from models

Data collections refer to data hosted at the data provider preferred location. Data corresponding to metadata registered in the eSC can be updated (ex. In real-time)



PITHIA e-Science Centre

Scientific Metadata



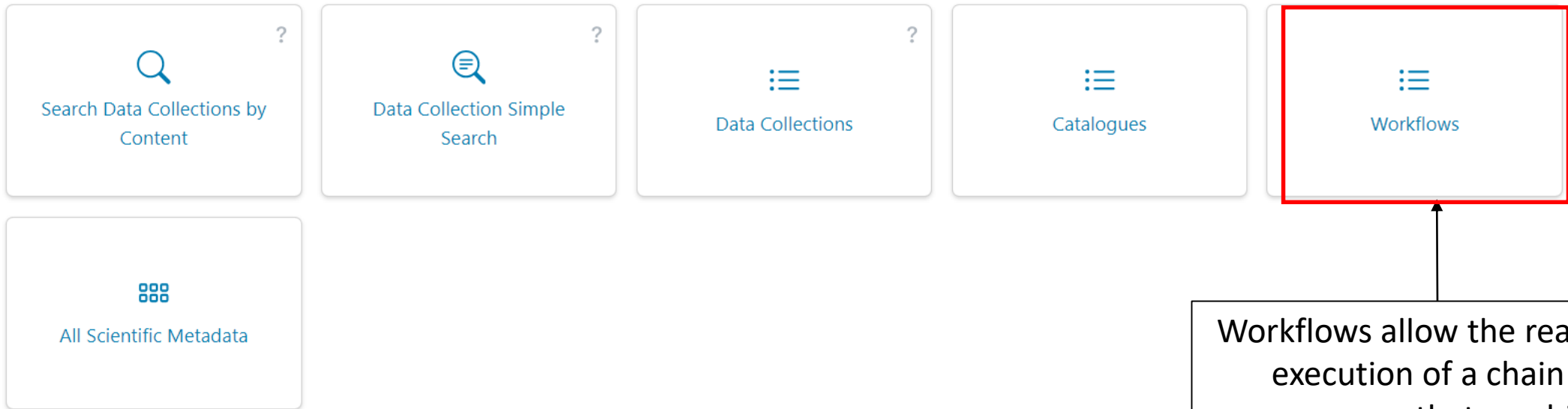
Data that refer to a specific event or are the result of a specific software process

Catalogues refer to a locked dataset; a DOI can be attributed; this dataset can be hosted in EOSC



PITHIA e-Science Centre

Scientific Metadata



Workflows allow the real-time execution of a chain of processes that combine different data collections and software codes



PITHIA-NRF data quality and data management



Data quality

Scientific Quality : Data Quality Flag, Scientific Relevance

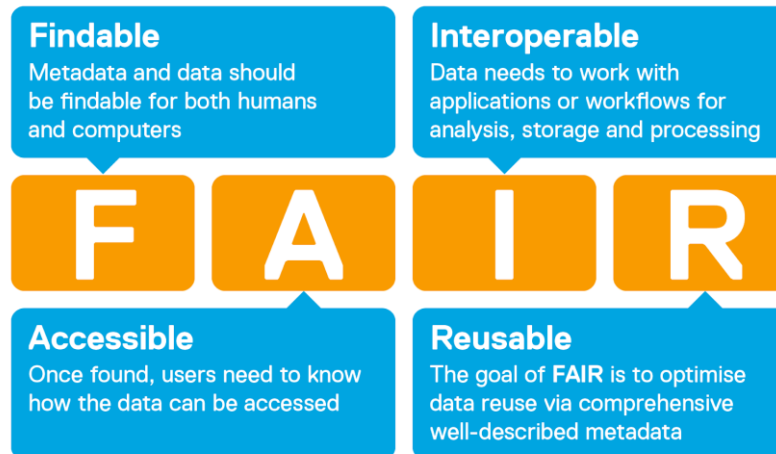
Quality of Metadata : Usage, Scope, Provenance, Persistence, Standardization, Interoperability, Quality, Earliness, Availability

Quality of Data Resources : Quality of data generation, Quality of data repository, Quality of data usage

Compliance to FAIR

Data management

The focus is on FAIRness.



The basic PITHIA-NRF data collections are assessed against a full list of FAIR data maturity model indicators.

Our ambition is to bring PITHIA-NRF facility nodes to achieve FAIRness, through the e-science center.



PITHIA-NRF Training



Training Schools

The First Training School was held in Rome, INGV headquarters, from 29 May to 1 June 2023.

- 30 students
- 14 lectures
- 6 working groups for students

The Second Training School is supported by T-FORS Machine Learning models will be held in KU Leuven, Belgium, from 5 to 9 February 2024.

- 15 students
- 22 lectures
- 5 working groups for students

Training for Partners Workshops

TPW#1, 8-9 November 2021

53 members from the PITHIA-NRF beneficiaries and third parties.

TPW#2, 28-29 March 2022

53 members from the PITHIA-NRF beneficiaries and third parties.

TPW#3, 26-28 September 2022

38 Consortium members and external users. The workshop was held at ASTRON, Dwingeloo, the Netherlands.

TPW#4, 16 March 2023

47 Consortium members and external users. The workshop was held at the Brussels Planetarium, Belgium.

TPW#5, 12-13 September 2023

34 Consortium members and external users. The workshop took place at University of Westminster, London, UK.

Training material is available in the project web site in the form of webinars

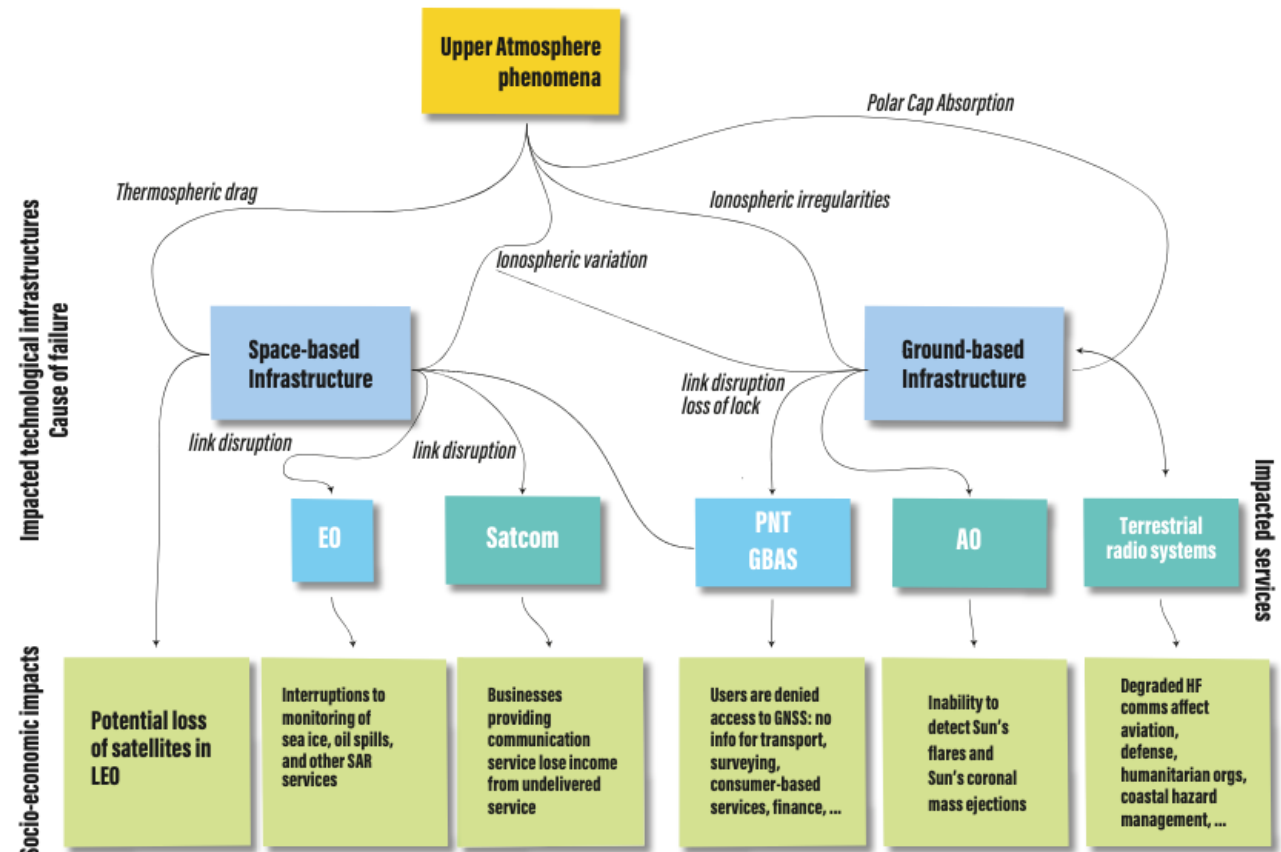


PITHIA-NRF Innovation



How PITHIA-NRF services can mitigate the socio-economic impacts of the upper atmosphere effects:

- Standardization of data registration, discovery and access
- Standardization of scientific models' registration, and delivery of high-level data products and workflow solutions
- Standardization of policies for the optimized operation of experimental facilities
- Trans-national access to research facilities for academics and SMEs
- E-science tools to support R&D projects, while ensuring compliance with FAIR criteria.
- Software solutions for new high-level data products
- Support for development and deployment of new experimental facilities.





PITHIA-NRF consortium

22 Beneficiaries

2 Third Parties

5 External Advisors



UNIVERSITY OF WESTMINSTER





Thank you for your attention!

WEB: <https://www.pithia-nrf.eu>



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