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

PITHIA-NRF

Innovation Platform

Hanna Rothkaehl, Barbara Matyjasiak
on behalf of **PITHIA-NRF Consortium**

Objectives of the PITHIA-NRF project

Objective 5

The overarching aim of the PITHIA-NRF project is to create a European distributed research infrastructure that will provide a range of research support services to the upper atmosphere research community. To meet this goal, the PITHIA-NRF builds the **innovation platform to promote cooperation between stakeholders and sets the standards for future collaboration** (i.e. the IPR policies for the exploitation of the services). It also provides the tools for continuous interaction with users, promotion of the PITHIA-NRF activities and services to the public and to the stakeholders, and promotes joint public-private collaboration for high-risk innovation and close-to-market activities.

also provides the tools for continuous interaction with users, promotion of the PITHIA-NRF activities and services to the public and to the stakeholders, and promotes joint public-private collaboration for high-risk innovation and close-to-market activities.

Objective

to **enhance and promote cooperation** with the space agencies, the aerospace industry, SMEs, and non-governmental organizations.

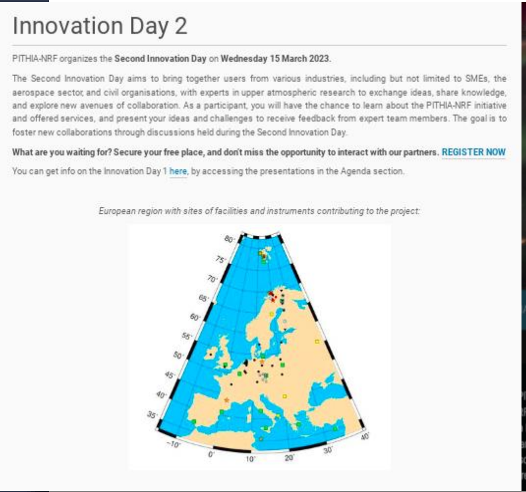
Specifically:

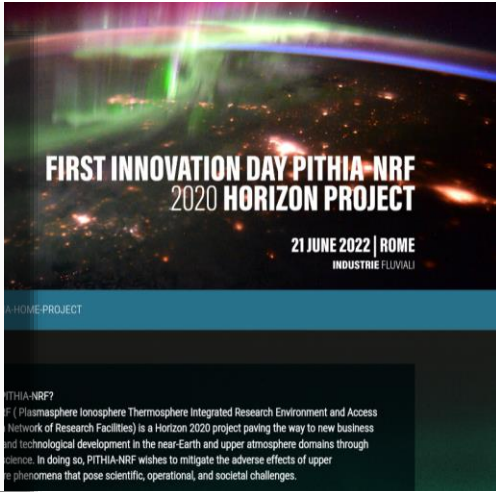
- To maintain and further develop standard-making processes for data-products validation and related software.
- To promote systematic use of the PITHIA-NRF nodes for the calibration and validation of novel instrumentation.
- To establish a platform for exchange of expertise and information with stakeholders for the promotion of joint public-private collaboration for high-risk innovation and close-to-market activities applied to PITHIA-NRF services.

How it will work?

definition of a joint campaigns in collaboration with the users

- **TNA input and E-science centre (data, models and learning services)**
- **Target definitions and request ID1, ID2 ID3**
- Finally – Review of innovation proposals for the **demonstration campaign** using the developed **protocol for the exchange of expertise and information with the private sector**.

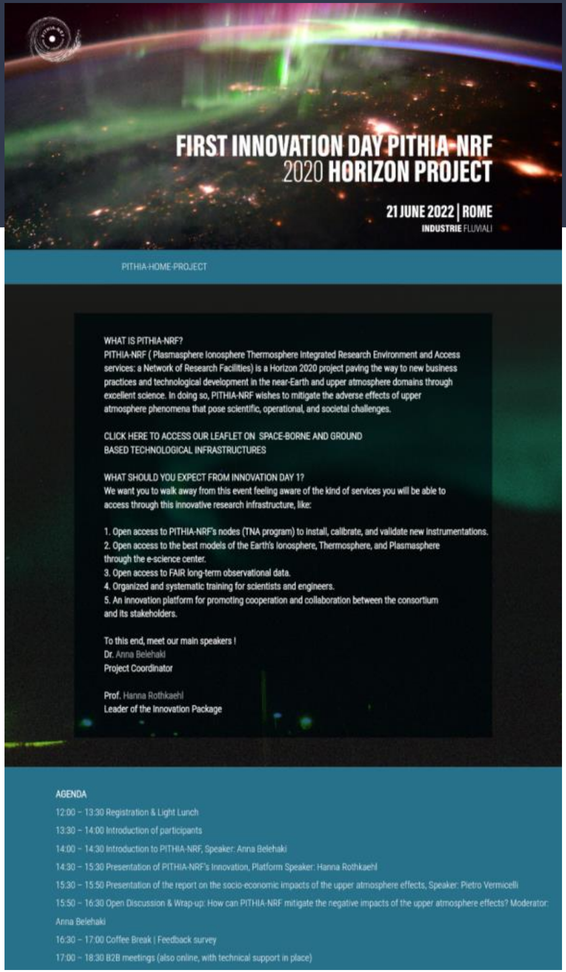




Innovation Days

- establishment of an **active dialogue among the PITHIA-NRF partners and the stakeholders**,
- discussions on proposed solutions and use cases in order to meet mutual agreement and **better understand stakeholders needs**
- serve as a efficient **promotion of expertise and knowledge transfer**,
- ensuring, through a specific Non-Disclosure Agreement, the proper management of the IPRs.

Innovation Day 1
21.06.2022, Rome, Italy
Innovation Day 2
15.03.2023 Brussels
Innovation Day 3
It is planned to take place in Warsaw spring 2024.



Innovation Day 1

June 21, 2022, Rome, Italy. Organiser SET

Aim: to make users from SMEs and the aerospace sectors aware of the PITHIA-NRF concept, the expected results, and the possibility to use the nodes for developing projects on validation and calibration of new instrumentation.

Program included:

- **PITHIA-NRF concept introduction**
- **Presentation of the report on socio-economic impacts**
- **How can PITHIA-NRF mitigate impacts? - User perspective with discussion**
- **B2B meetings**

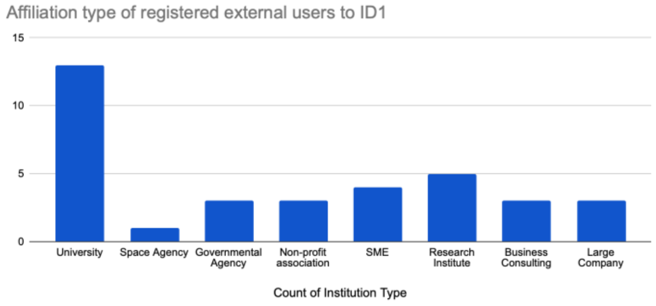
Some conclusions from the evaluation of the user questionnaires

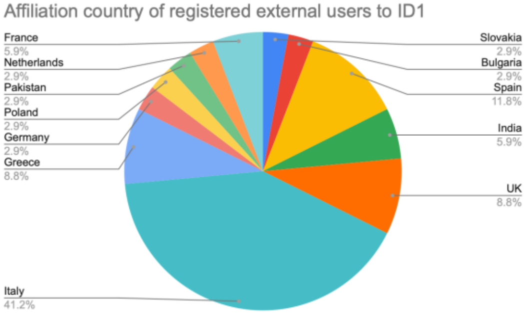
- Innovation day 1 was positively received - all users would participate again
- Participants find PITHIA-NRF as a interesting concept which was demonstrated in:
  - a general feeling that the e-Science Center will be useful to them
  - a willingness to contribute data collections or models to the e-Science Center
  - an interest in participating in the TNA

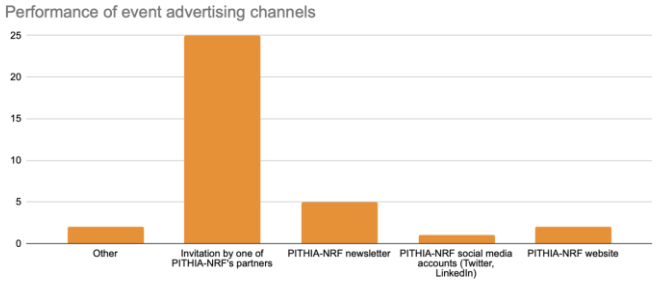
Innovation Day 1

Attendees statistics

	IN-PERSON	ONLINE	TOTAL
EXTERNAL	10	12	22
CONSORTIUM	28	10	38
TOTAL	38	22	60







Source P. Vermicelli, S. Mainella

Actions

Lessons learned & user feedback from ID 1,2,3

Specific experiments will be organized on demand with private sector entities, based on a standard-making process relevant to PITHIA

Selection and development of PITHIA’s most desirable products portfolio

Guidelines for PITHIA - users collaboration

Innovation Platform

How you can became involved in the development of PITHIA Innovation Platform?

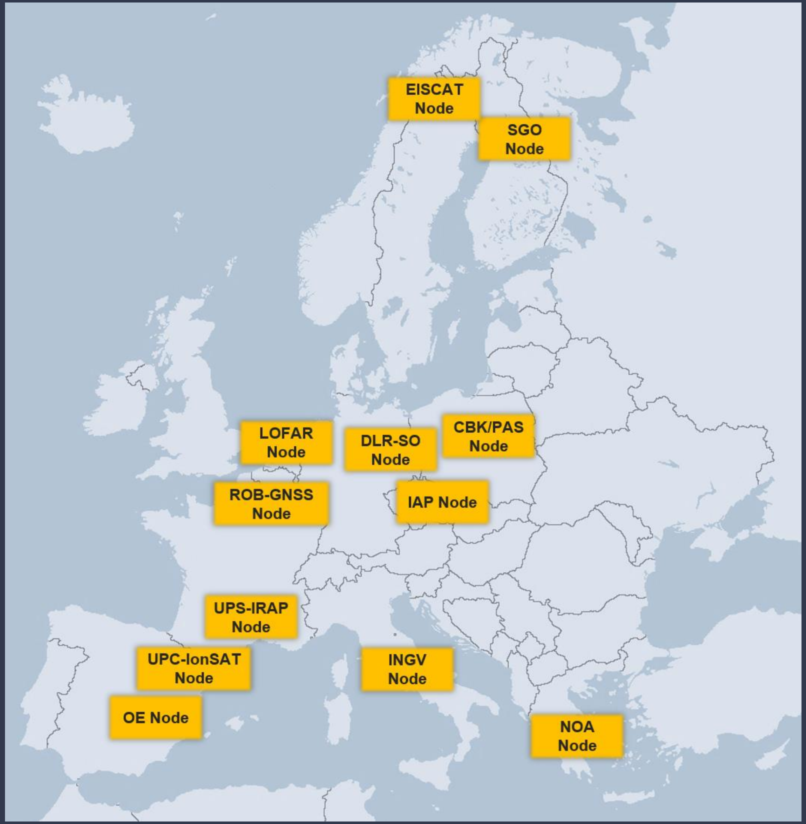
- **Attend the PITHIA Innovation days (B2B meetings)**
- **Tell us your problem slot, and** foster new collaborations by learning about users' operational challenges.
- **Submit your proposal for PITHIA TNA Call**
- Reach one of the PITHIA-NRF Partners directly
- Contact us with your ideas via the website https://www.pithia-nrf.eu

Also, fill in the ID2 Feedback Survey

Innovation examples

Internal co-operations: Node-Node, Node-Partner

External co-operations: Node - SME/Gov/Non-gov/Other



PITHIA-NRF services mitigating the socio-economic impacts of the upper atmosphere effects.

EARTH OBSERVATION (EO) SYSTEMS (E.G., LOW-FREQUENCY SAR), WHICH ARE AFFECTED BY:

- Faraday rotation.
- Ionospheric Scintillation.

UHF COMMUNICATIONS USED IN SATCOM THAT ARE ATTENUATED BY:

- Ionospheric plasma bubbles.

POSITIONING, NAVIGATION, AND TIMING (PNT) WITH GNSS SATELLITES AND GROUND-BASED AUGMENTATION SYSTEMS THAT IS MADE INACCURATE BY:

- Large total electron content (TEC) gradients.
- Ionospheric plasma bubbles (leading to scintillations and ionospheric delay).
- Travelling Ionospheric Disturbances.

ASTRONOMICAL OBSERVATION (AO) SYSTEMS (E.G., LOFAR), WHICH ARE RENDERED UNAVAILABLE BY:

- Geomagnetic storms & auroral jets intensifications
- Ionospheric plasma bubbles.

TERRESTRIAL RADIO SYSTEMS USING HF AND VHF COMMUNICATIONS, WHICH ARE DISRUPTED BY:

- Polar Cap Absorption.
- Sporadic E-layer.
- Travelling Ionospheric Disturbances.
- Ionization depletions.

SATELLITES IN LOW EARTH ORBIT (LEO), WHOSE ORBITS CAN BE AFFECTED BY THERMOSPHERIC DRAG.

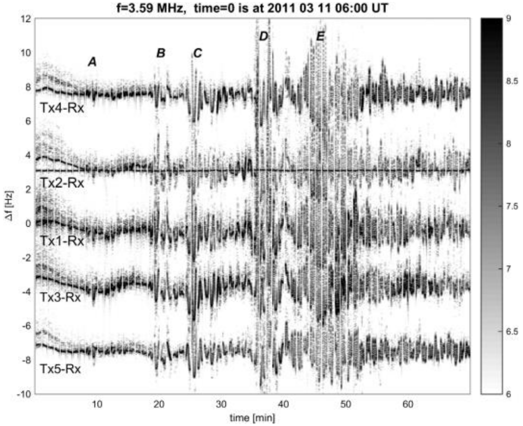
Multipoint Continuous Doppler sounding system
- Improvement of the coverage of CDSS data over Europe

collaboration within the consortium

- TNA node IAP install a continuous Doppler sounding system in Belgium, operated by the consortium partner RMI
- A data sharing agreement to be signed
- The Belgian instrument will be available for use in the TNA program via the IAP node

- more comprehensive studies not possible with a single instrument
- It can be used for an investigation of infrasound, acoustic gravity waves (AGWs), geomagnetic fluctuations.

Right: Doppler shift spectrogram recorded on 11 March 2011 (Tohoku earthquake) in 06:00 UT to 07:10 UT. The individual transmitters are offset by 4 Hz. The scale is the common logarithm of power spectral intensity. Letters A to E mark ionospheric response to individual seismic wave packets. After Chum et al. (2012b).



Validation of TEC products

collaboration within the consortium

Outcome of the TNA project with KNMI!

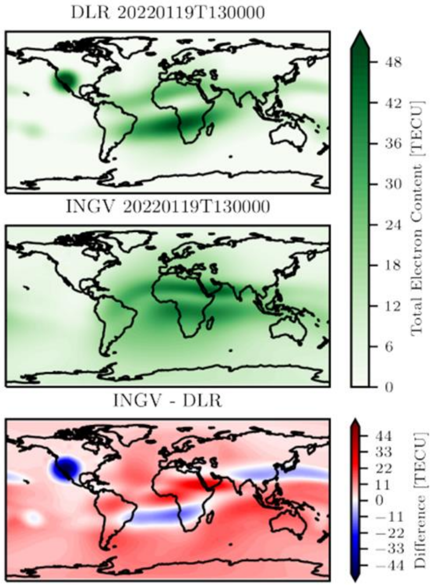


Figure 4 Comparison between nowcasted global TEC maps by DLR and INGV on 19 January 2022 13:00 UTC as obtained from the PECASUS data repository and eSWua. The upper and middle graphs show TEC heat maps by DLR and INGV resp. sharing the same colorbar (right). The bottom graph shows the difference between the INGV and DLR maps. In the blue regions (negative difference) the DLR TEC is larger whereas in the red regions the INGV TEC dominates. The localized peak in TEC in North-America is suspected to be non physical (e.g. detector noise) as the peak keeps reappearing at later times. The figure is part of a video showing the change of TEC over a period of time.

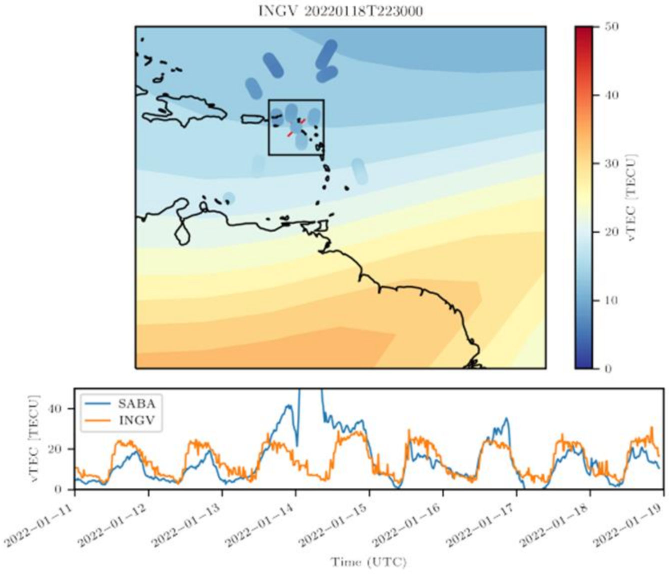


Figure 5 TEC measurements made KNMI's GNSS receiver on Saba compared to INGV TEC map on 18 January 2022 22:30 UTC. The upper graph shows the INGV TEC map in the Caribbean compared to individual vTEC measurements (GPS and GLONASS satellites only, blue dots) made within a 15 minute time window. The receiver location is indicated with a red cross. The average TEC is calculated within a 2°×2° box around the receiver location and is compared to the INGV TEC map evaluated at that position. The bottom plot shows the comparison of these values over time. On 13 and 14 January an increase in vTEC was measured which is not present in the INGV TEC maps.

Taken from the Report on the PITHIA-NRF TNA visit of KNMI to INGV

Acknowledgments:
Eelco Doornbos and Kasper Van Dam (KNMI)

Multiple ionosondes observation possibilities

collaboration within the consortium

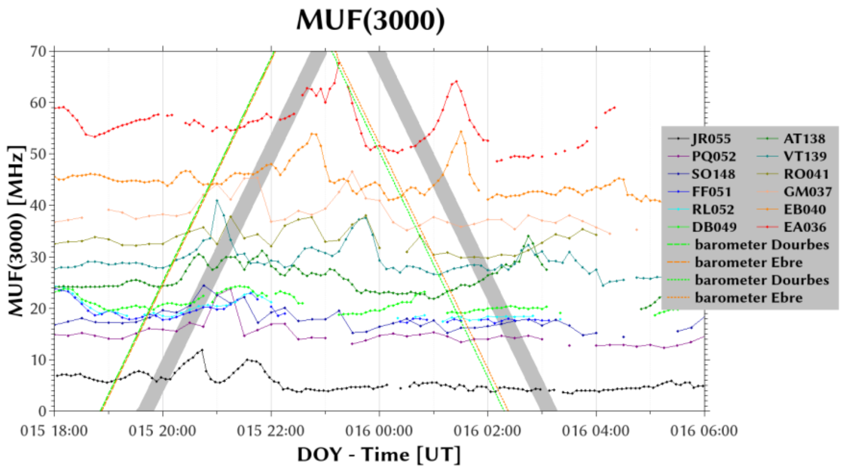
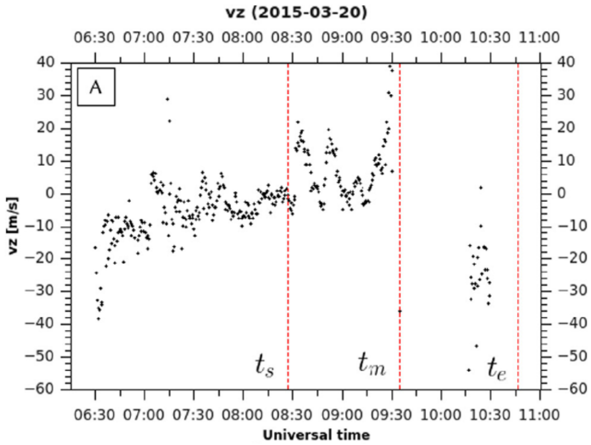
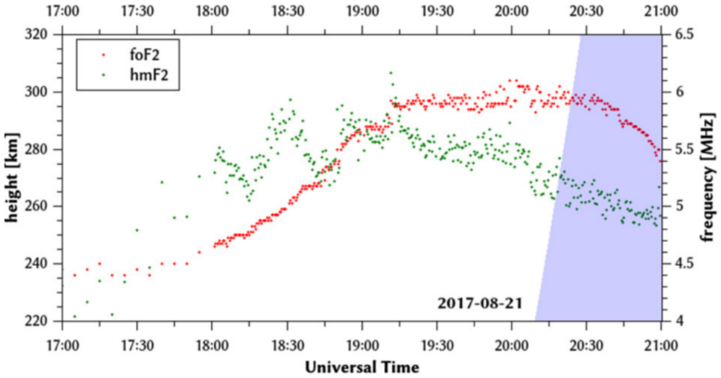


Fig. The maximum usable frequency (MUF) calculated from different sounders indicating ionospheric disturbances caused by the 15 January 2022 eruption of the Hunga volcano.



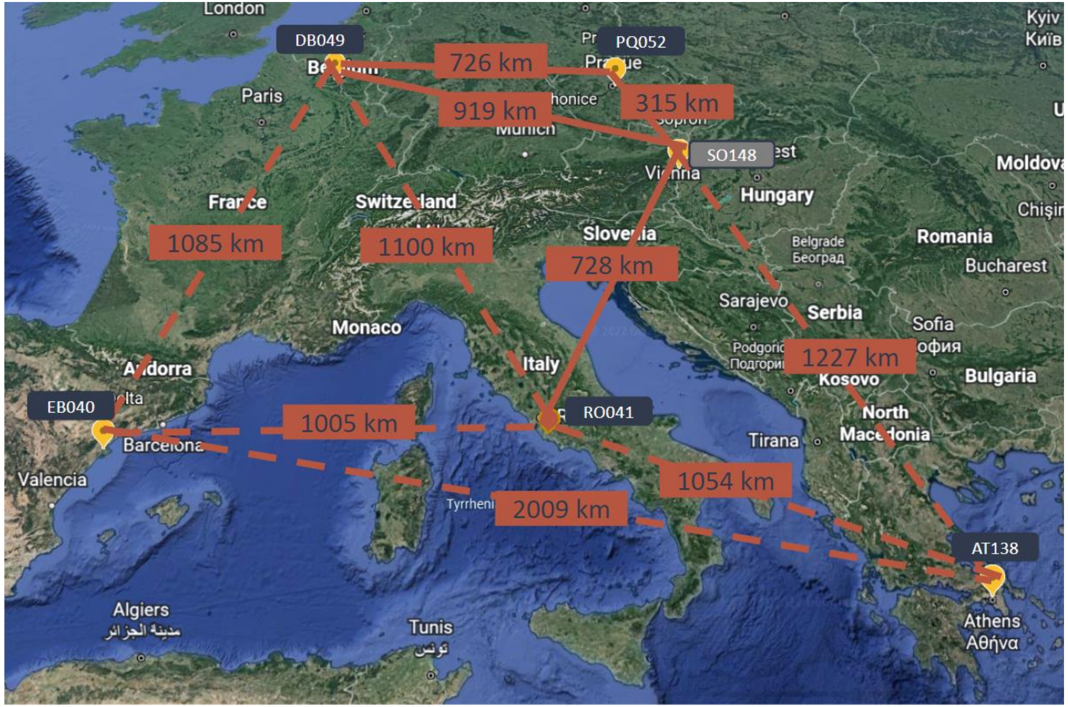
Predictable geophysical events (solar eclipses, meteor showers, other) can provide opportunities for special campaigns of high-cadence soundings at multiple observatories.



Credits: Tobias G.W. Verhulst (IRM/KMI)

Extensive capabilities of the Digisonde observational network for identification of TIDs

Anna Belehaki, NOA, Greece

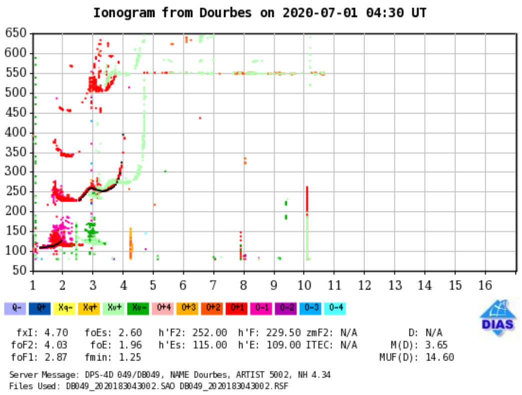


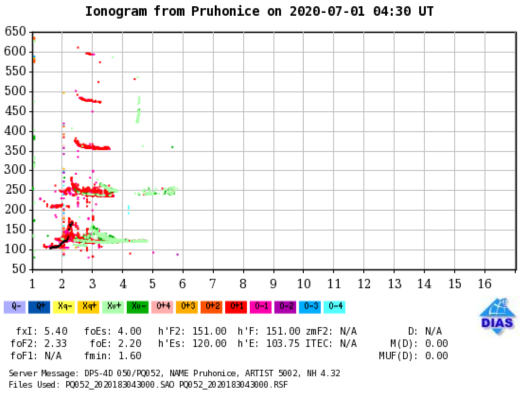
The network of PITHIA-NRF Digisonde stations

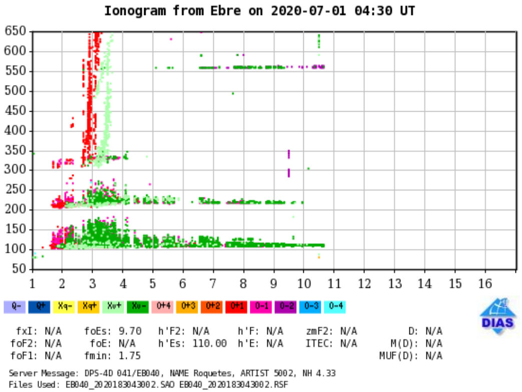
Synchronized soundings at short and long distances

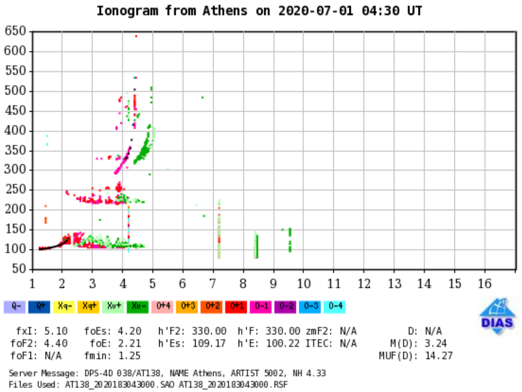
What this network can offer?

- Warnings for Spread F and Sporadic Es





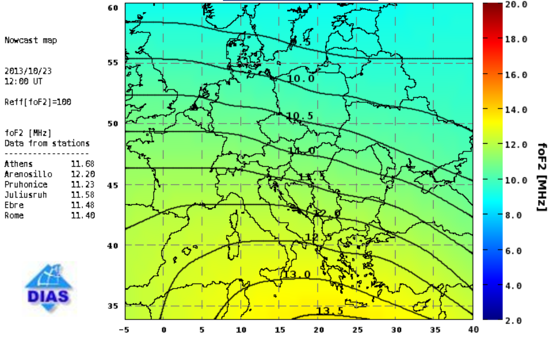




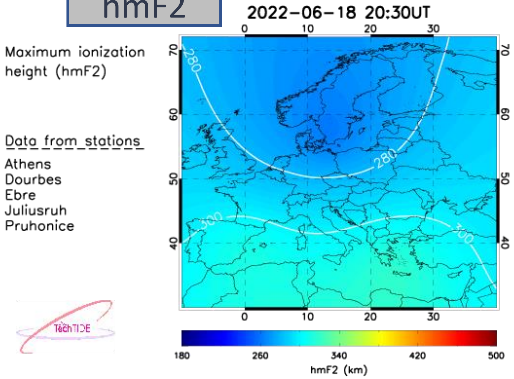
What this network can offer?

- Mapping of critical characteristics

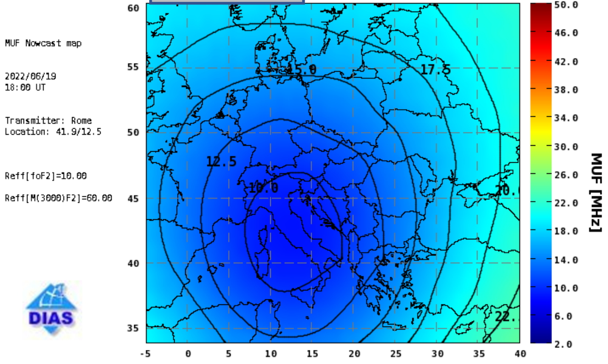
foF2



hmF2

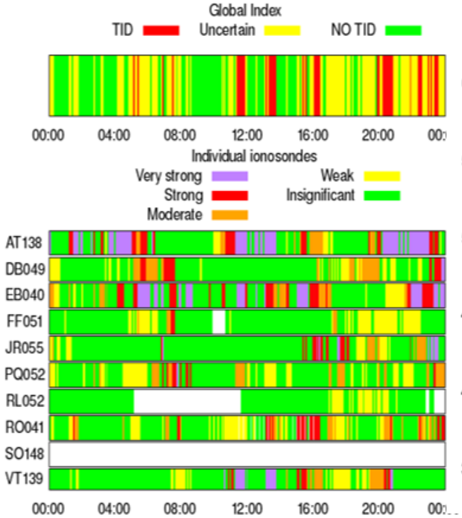


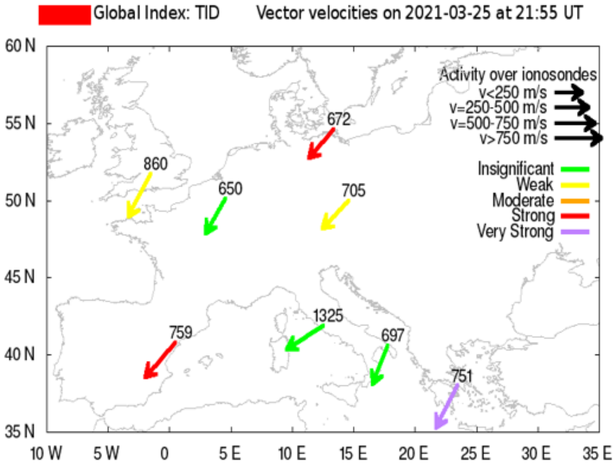
MUF

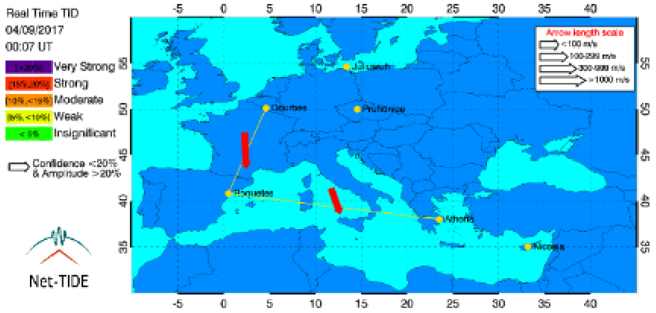


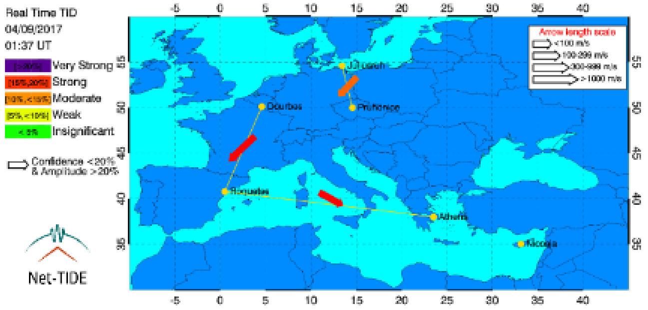
What this network can offer?

- Early detection of TIDs
- Estimation of TID propagation direction and velocity









LOFAR

- LOw Frequency ARray for radio astronomy (LOFAR),
- Designed and constructed by ASTRON,
- International array of radio telescopes consisting of 52 separate stations distributed across Europe,
- Each station can be used in single mode or in International LOFAR Telescope (ILT),
- Operates at the lowest radio frequencies that can be observed from Earth.
- Frequency range: 10 – 270 MHz

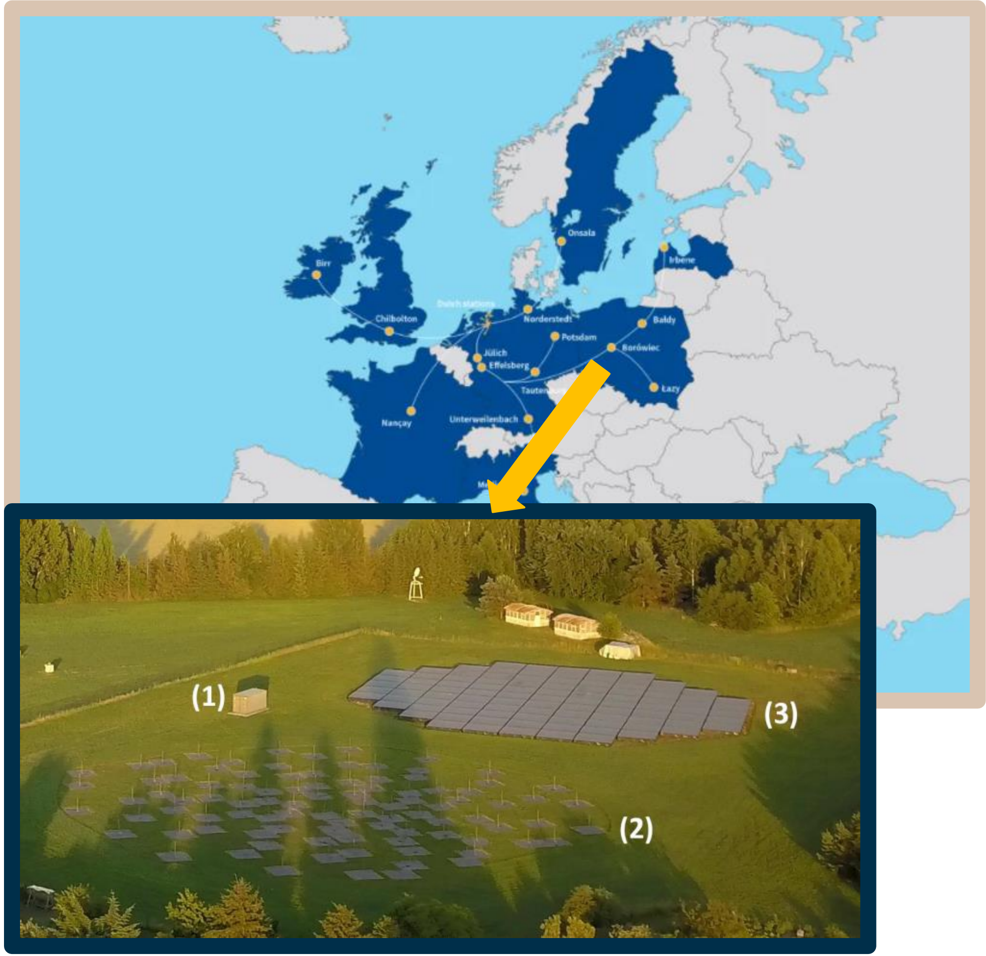
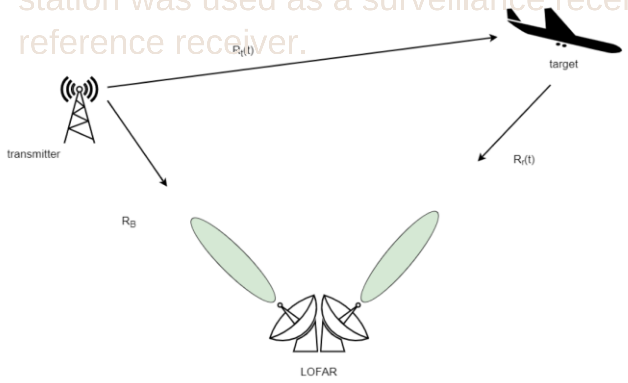


Fig. LOFAR PL610 station, Borówiec, Poland

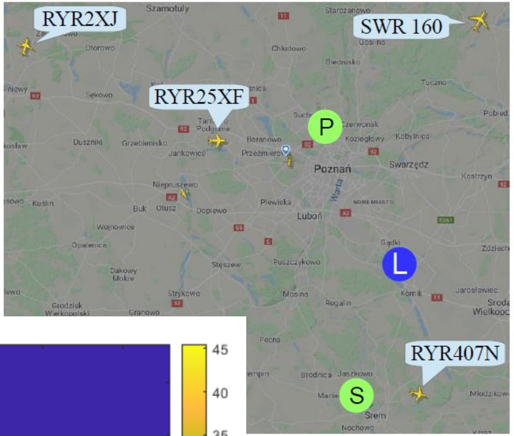
LOFAR as a passive radar

Node - external (academic) example

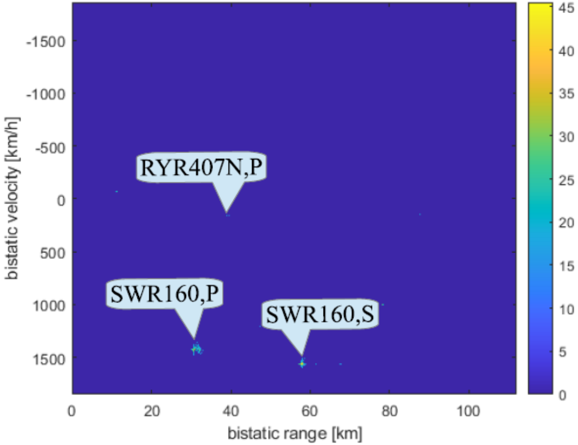
- Project led in collaboration with Warsaw University of Technology (Politechnika Warszawska),
- Receivers, such as LOFAR, can be used in passive radiolocation systems (aircraft detection, space targets detection),
- DAB+ commercial transmitters are being used as illuminators of opportunity, while LOFAR station was used as a surveillance receiver and reference receiver.



Passive radiolocation setup.



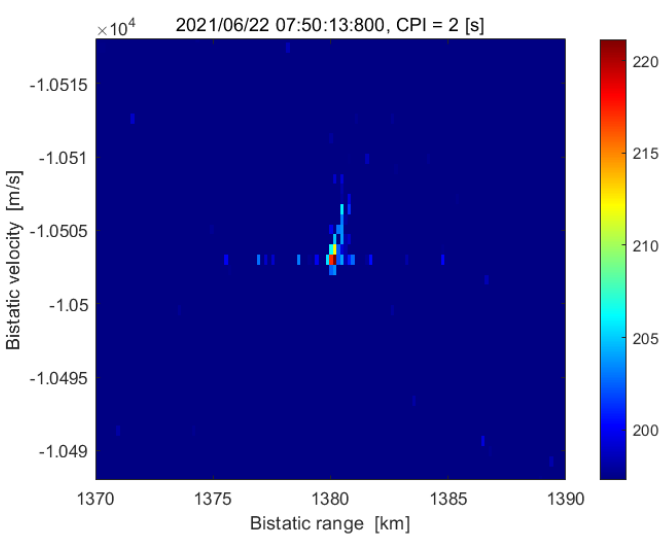
Top: Map with planes around the LOFAR station in Borowiec in the moment of the registration, L – the LOFAR station in Borowiec, S – the broadcasting station in Srem, P – the broadcasting station in Piatkowo (A. Droszcz et al., 2020)



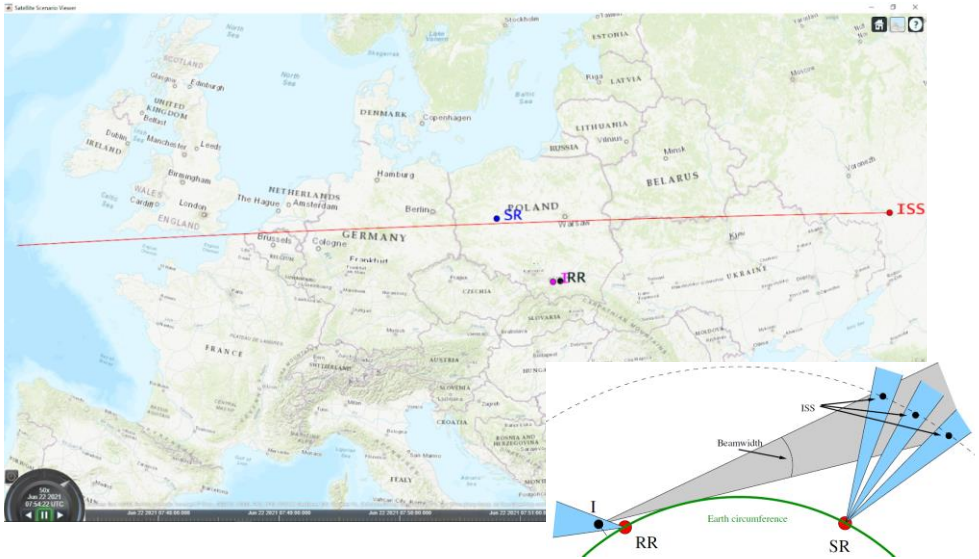
Cross-ambiguity function obtained for 64 tiles combined into a beam steered in the direction of SWR160 plane

LOFAR as a passive radar

Node - academic example



Above: Zoom on the ISS echo in the range-velocity maps obtained for subsequent time moments (Jędrzejewski et al, 2021).

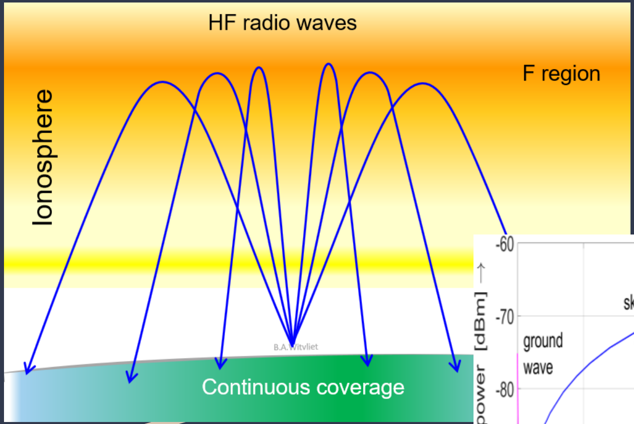


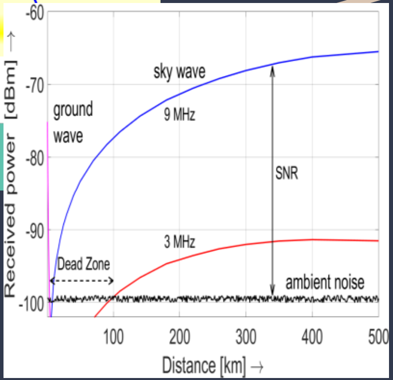
Map: ISS (red line), surveillance receiver (SR), reference receiver (RR) and illuminator of opportunity (I) positions during measurements. Sketch: the geometry of the experiment.(Jędrzejewski et al., 2021).

Jędrzejewski, K., Kulpa, M. Malanowski, K., Pożoga, M., Experimental Trials of Space Object Detection using LOFAR Radio Telescope as a Receiver in Passive Radar, 2021, DOI:10.1109/RADARCONF2248738.2022.9764165

Calibration and validation of HF radio equipment

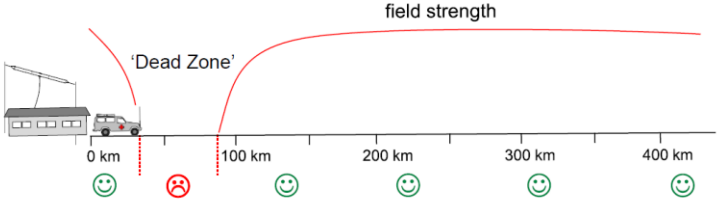
Node - Non-gov organisation example





Top: Illustration of ionospheric reflection of HF radio signal. Right: Ambulance antenna gain versus distance (Credits: B. Witvliet, GHTC 2021).

HF radio uses radio wave refraction in the ionosphere to cover large distances.
It is used by humanitarian organizations such as Médecines sans Frontières (MSF), who provide basic healthcare in poor and remote regions.



Reported so called consistent 'Dead Zones' - no signal reception in the short distance from the station

Possible causes were examined:

1. Ambient electromagnetic noise
2. Propagation above the critical frequency of the ionosphere
3. Antenna characteristics

Work by dr. ing. B. A. Witvliet (b.a.witvliet@utwente.nl)

Thank you for your attention!

and

How can PITHIA-NRF serve you?

WEB: **https://www.pithia-nrf.eu**

The PITHIA-NRF project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101007599