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

PITHIA-NRF

Innovation Platform

Barbara Matyjasiak, H. Rothkaehl on behalf of PITHIA-NRF Consortium

Objectives of the PITHIA-NRF project

➢ **Objective 1**

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.

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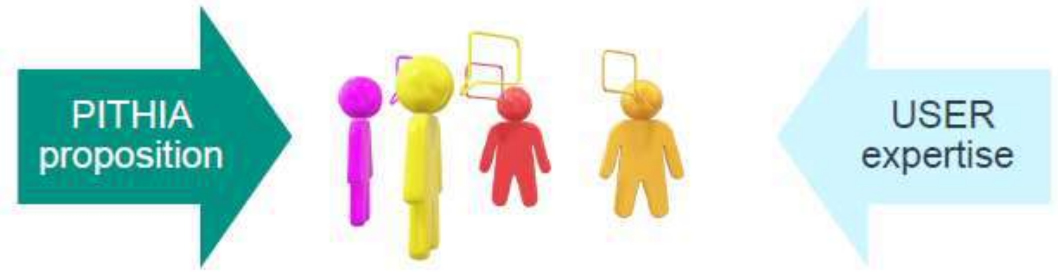
PITHIA - NRF for joint developments and testing of innovative instrumentation

- **Currently**, the operation of the participating Research Infrastructures is **not coordinated and its networking is very limited**.
- For the first time, **PITHIA-NRF can integrates on a European scale**, key national and regional research infrastructures tools to future development plans of the business /industrial sector
- the innovation platform will provide **support for the installation, calibration and validation of new instruments**, especially for SMEs



- platform to **exchange of the expertise** with the PITHIA and the private sector

How it will work?

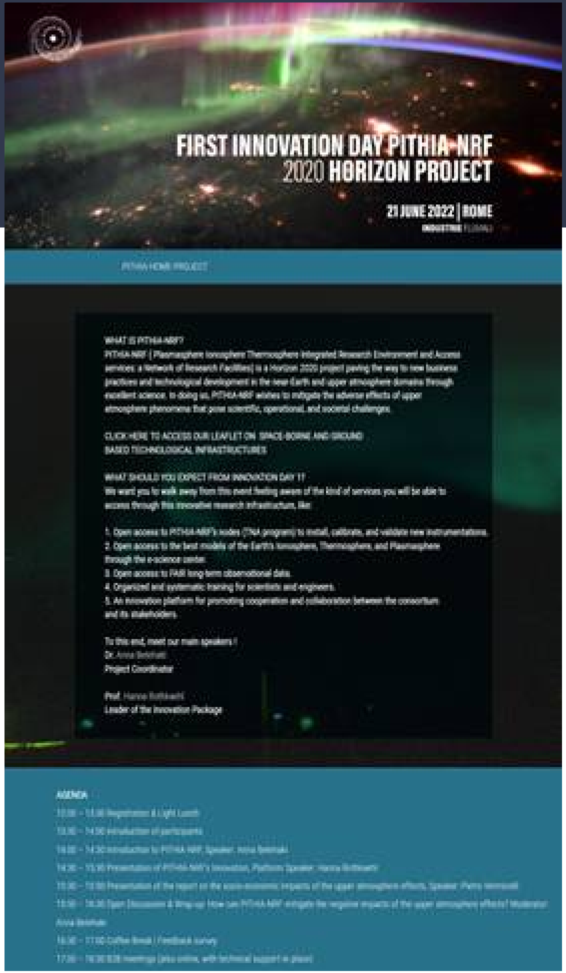
definition of a joint campaigns in collaboration with the users

- **TNA input** **(https://pithia-nrf.eu/pithia-nrf-users/tna/nodes)**
- **Target definition and request → ID1**
- Finally - Review of innovation proposals for **demonstration campaign** using the developed **protocol for exchange of expertise and information with the private sector**.

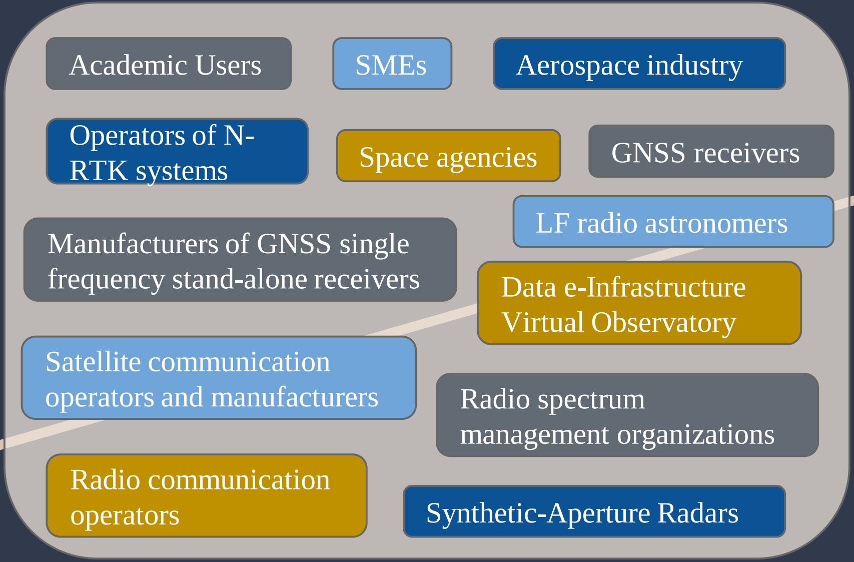
Innovation Days

- 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
It is planned to take place in month 24 of the project.
Innovation Day 3
It is planned to take place in month 40 of the project.



Standardisation of PITHIA-NRF software, data-products and policies



- **Review of past collaborations**
- **Standardisation of PITHIA-NRF software and data-products -** definition of a common product in collaboration with the users
- **Fair data policies**

The improvement of standard operating procedures and the development of standardization protocols (CEN and ISO) will be based on;

- NESDIS and SWPC recommendations of NOAA,
- World Meteorological Organization Observing Systems Capability Analysis OSCAR,
- European Cooperation for Space Standardization ECSS and the ITU-R recommendations.
- Result from previously performed EC project for example ESPAS
- The liaison with ESA is expected

Innovation Management Team

close cooperation with WP4

experts in standard-making procedures, in procedures for the development, validation and calibration of new instrumentation and software and partners with close-to-market activities applies to space observation technologies.

- will guide developments in WP7 (PITHIA-NRF Trans-national access activities) to allow scientists, service providers and potential users to cooperate with a common understanding of processes and goals targeting to the transfer of knowledge and results.

- The innovation management team **IMT** will also work with SMEs, space agencies and organizations with R&D departments, to develop standard making process for software and high-level data products

IMT members

- CBK PAN Hanna Rothkaehl
- INGV Dr. Vincenzo Romano
- EISCAT Dr Anders Tjulin
- UOW Gabriele Pierantoni
- NOA Anna Belehaki
- SGO Marzieh Khansari

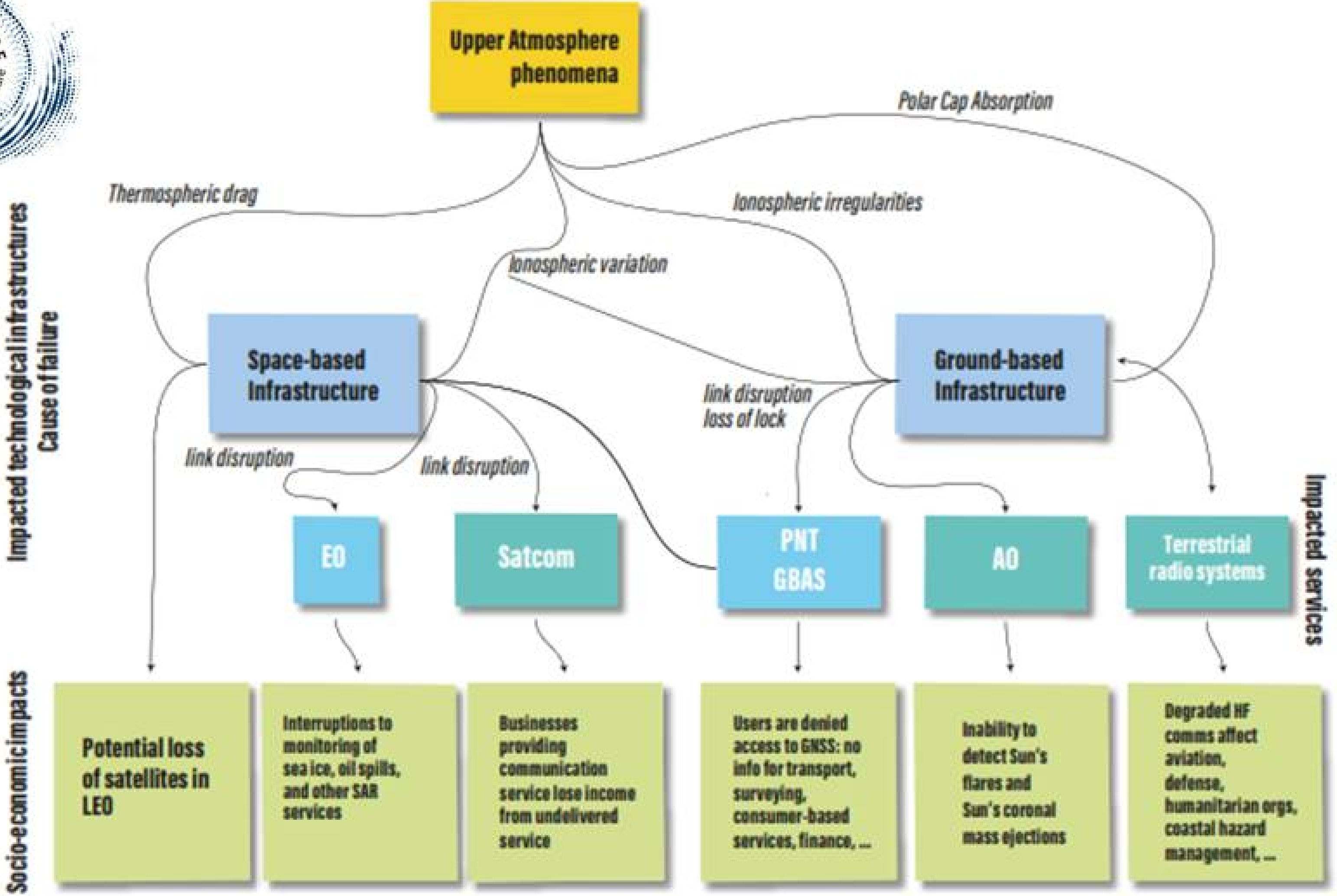
How you can become involved in the development of PITHIA Innovation Platform?

- **Attend the PITHIA Innovation days (B2B meetings)**
- **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 ID1 Feedback Survey:

It aims at understanding the institution's:

- interest in PITHIA's Innovation Program
- feedback on the Innovation Days, especially, the **b2b meetings.**
- legal requirements in previous collaborations with, e.g., Research Institutions to set up the **protocol for the bilateral exchange of information** (**Task 4.3**).


Upper Atmosphere phenomena
Polar Cap Absorption
Thermospheric drag
Ionospheric irregularities
Ionospheric variation
Impacted technological infrastructures
Cause of failure
Space-based Infrastructure
Ground-based Infrastructure
link disruption
loss of lock
link disruption
link disruption
Impacted services
EO
Satcom
PNT
GBAS
AO
Terrestrial radio systems
Socio-economic impacts
Potential loss of satellites in LEO
Interruptions to monitoring of sea ice, oil spills, and other SAR services
Businesses providing communication service lose income from undelivered service
Users are denied access to GNSS: no info for transport, surveying, consumer-based services, finance, ...
Inability to detect Sun's flares and Sun's coronal mass ejections
Degraded HF comms affect aviation, defense, humanitarian orgs, coastal hazard management, ...

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 (GBAS) 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.

Innovation examples

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

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

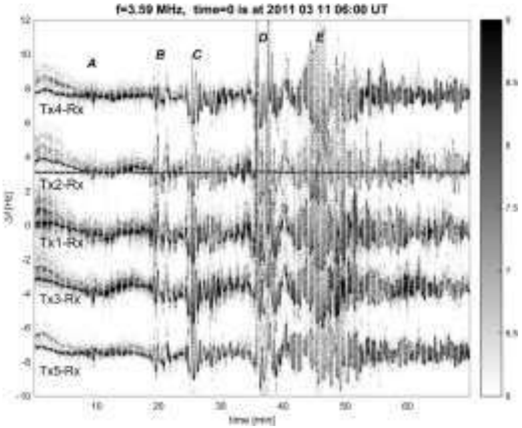
Multipoint Continuous Doppler sounding system
- Improvement of the coverage of CDSS data over Europe

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).



Multiple ionosondes observation possibilities

collaboration within the consortium

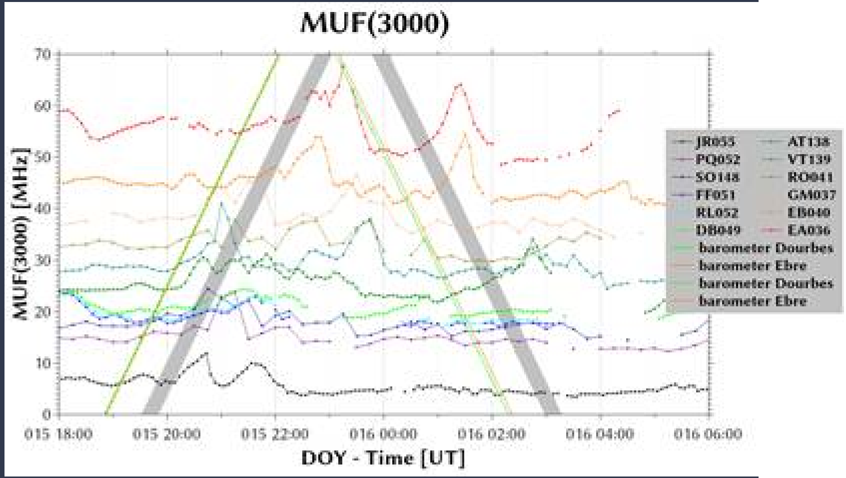
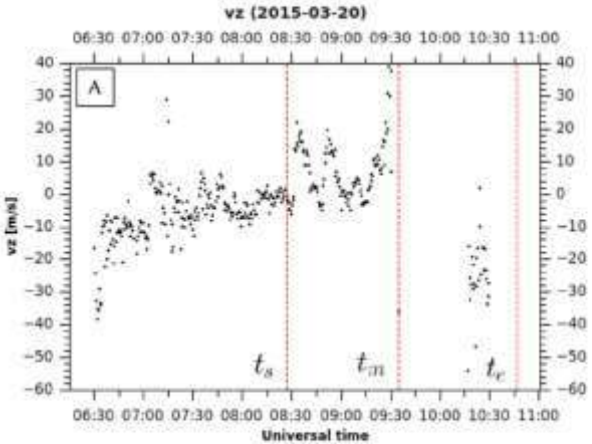
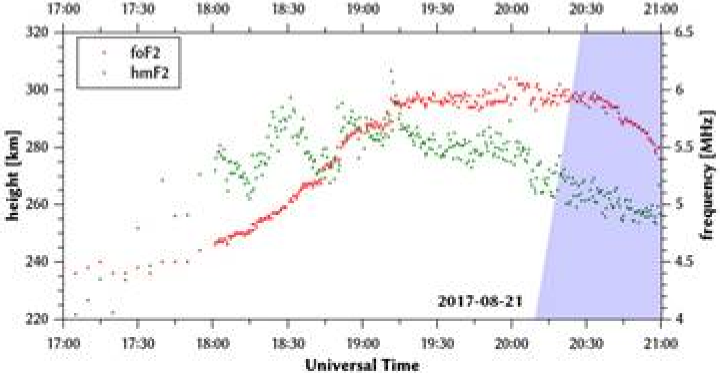


Fig. The maximum usable frequency (MUF) calculated from different sounders indicating ionospheric disturbances caused by the 15 January 2022 eruption of the Hunga volcano.



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

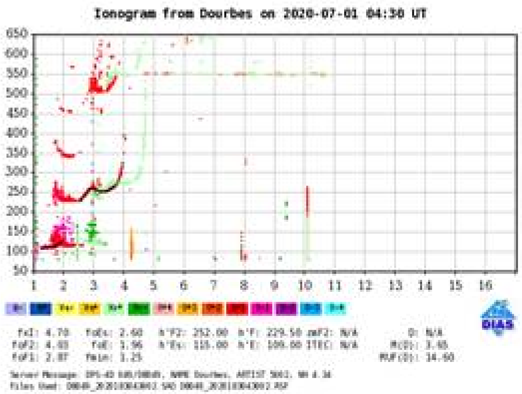
Anna Belehaki, NOA, Greece

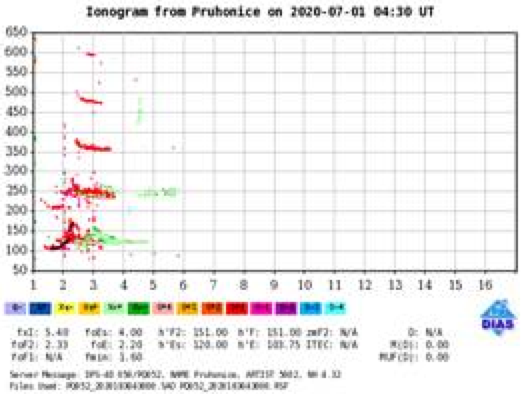
The network of PITHIA-NRF Digisonde stations

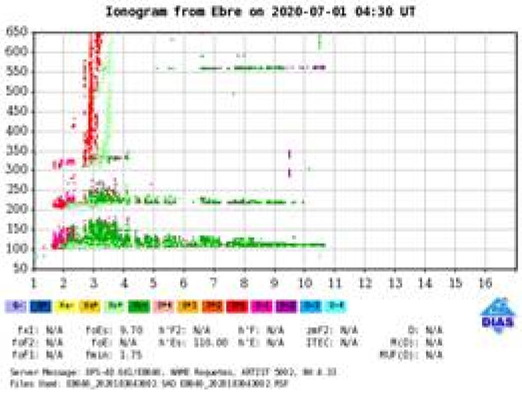
Synchronized soundings at short and long distances

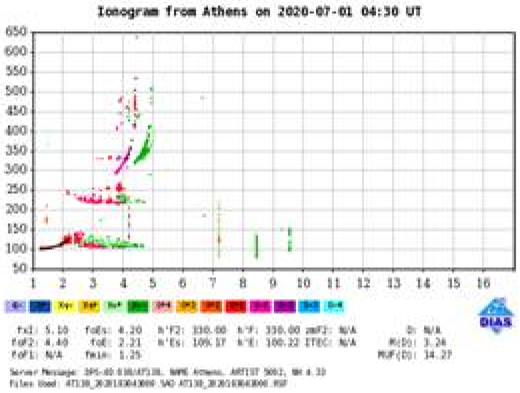
What this network can offer?

- Warnings for Spread F and Sporadic Es



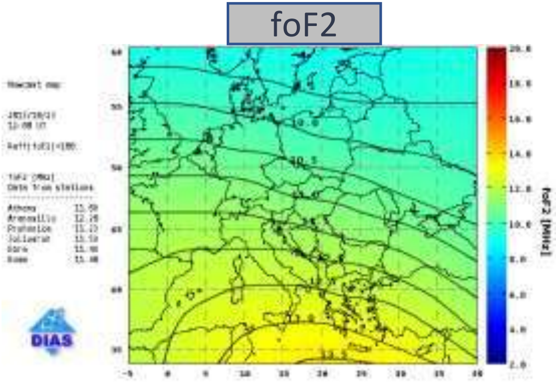


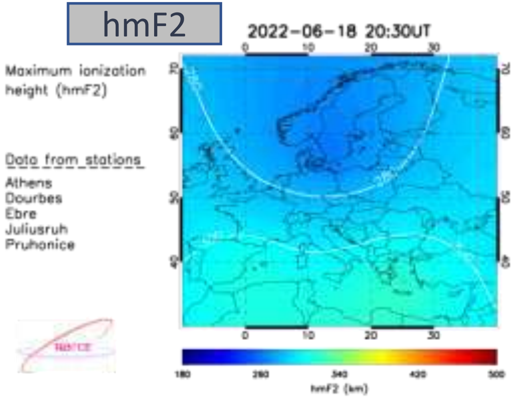


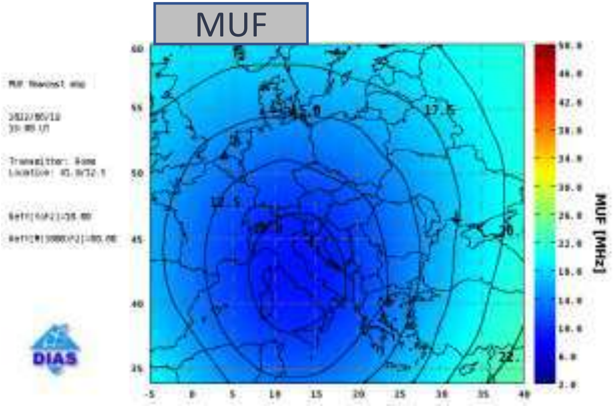


What this network can offer?

- Mapping of critical characteristics

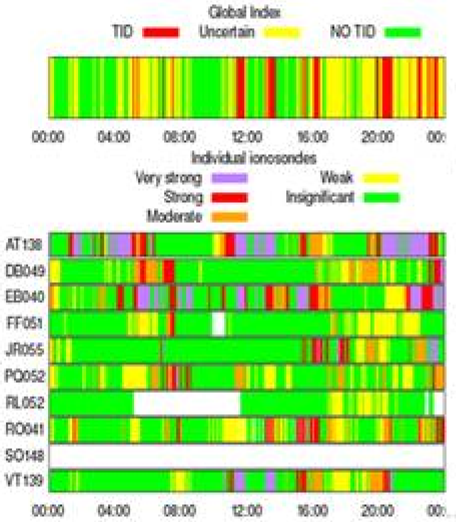


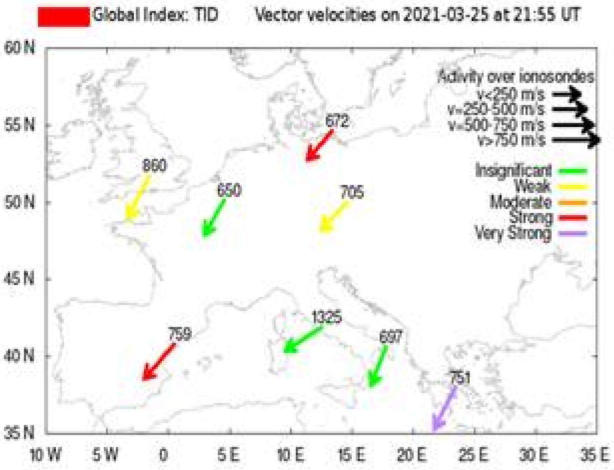


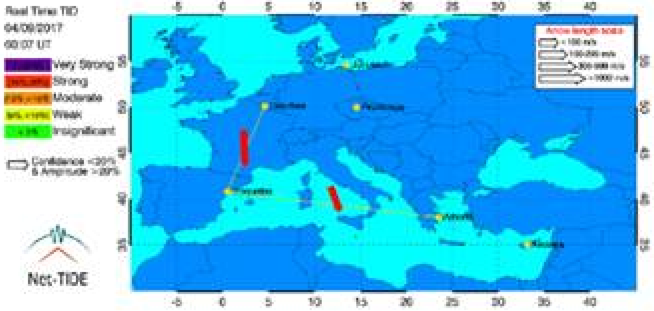


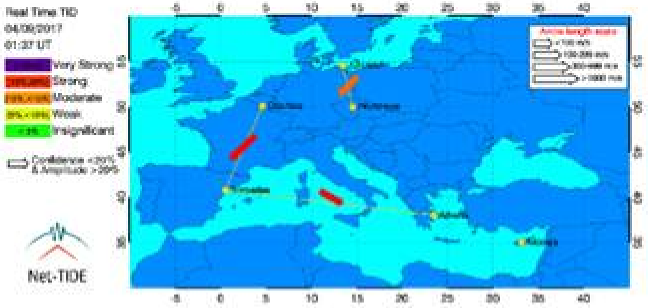
What this network can offer?

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









Validation of TEC products

collaboration within the consortium

Outcome of the TNA project with KNMI!

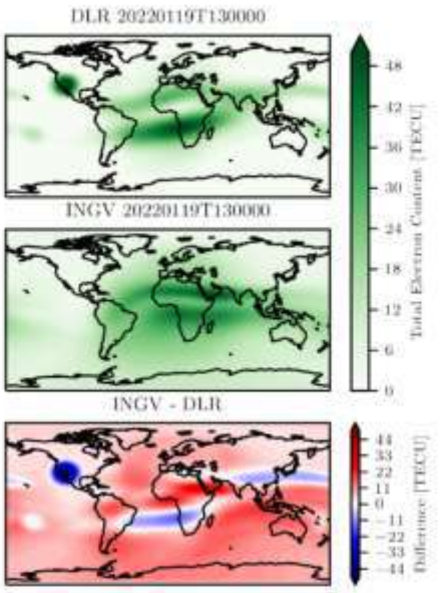


Figure 4 Comparison between nowcasted global TEC maps by DLR and INGV on 19 January 2022 13:00 UTC as obtained from the PECASUS data repository and eSWua. The upper and middle graphs show TEC heat maps by DLR and INGV resp. sharing the same colorbar (right). The bottom graph shows the difference between 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.

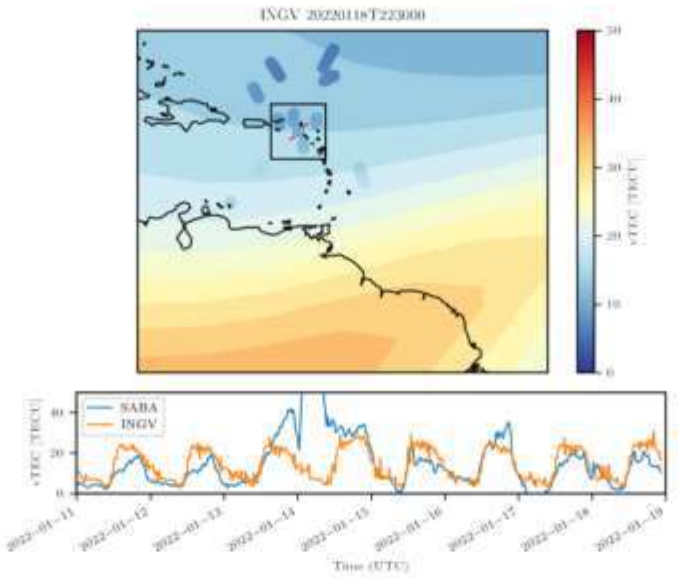


Figure 5 TEC measurements made KNMI's GNSS receiver on Saba compared to INGV TEC map on 18 January 2022 22:30 UTC. The upper graph shows the INGV TEC map in the Caribbean compared to individual vTEC measurements (GPS and GLONASS satellites only, blue dots) made within a 15 minute time window. The receiver 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.

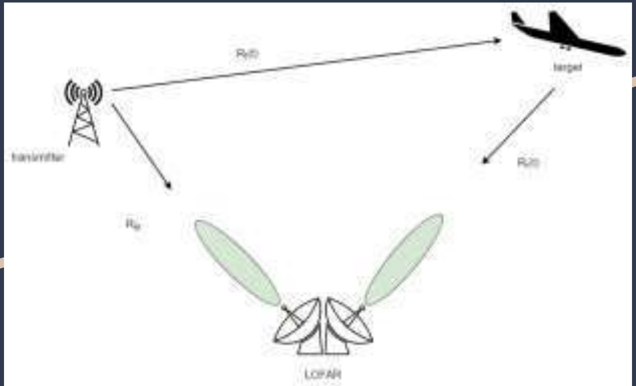
Taken from the Report on the PITHIA-NRF TNA visit of KNMI to INGV

Acknowledgments:
Eelco Doornbos and Kasper Van Dam (KNMI)

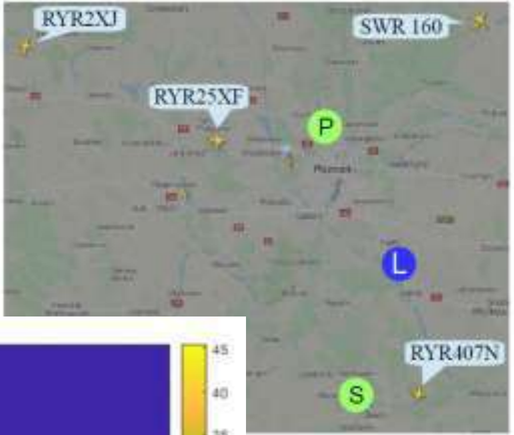
LOFAR as a passive radar

Node - external (academic) example

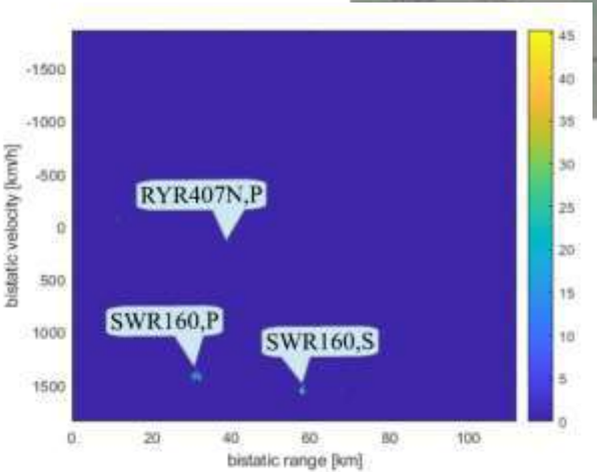
- Project led in collaboration with Warsaw University of Technology (Politechnika Warszawska),
- Receivers, such as LOFAR, can be used in passive radiolocation systems (aircraft detection, space targets detection),
- DAB+ commercial transmitters are being used as illuminators of opportunity, while LOFAR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



Passive radiolocation setup.



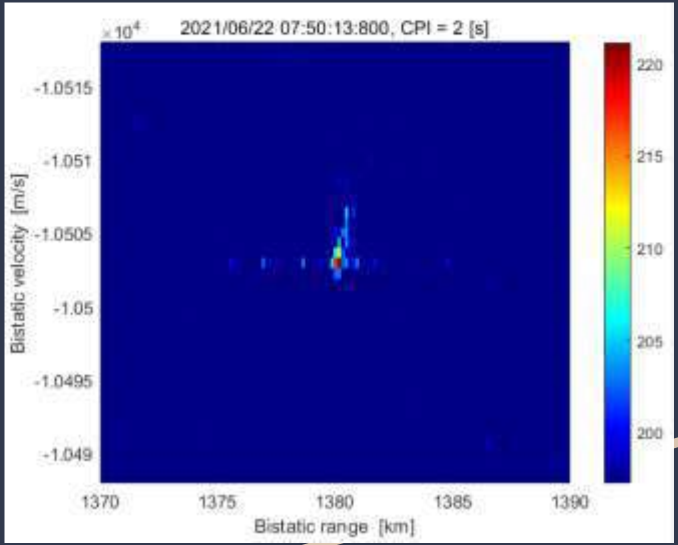
Top: Map with planes around the LOFAR station in Borowiec in the moment of the registration, L – the LOFAR station in Borowiec, S – the broadcasting station in Srem, P – the broadcasting station in Piatkowo (A. Droszcz et al., 2020)



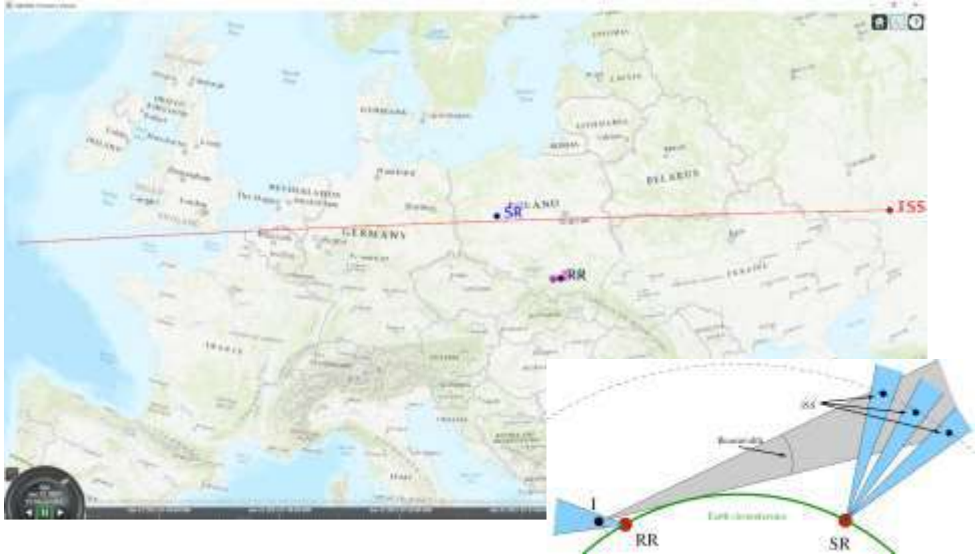
Cross-ambiguity function obtained for 64 tiles combined into a beam steered in the direction of SWR160 plane

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).

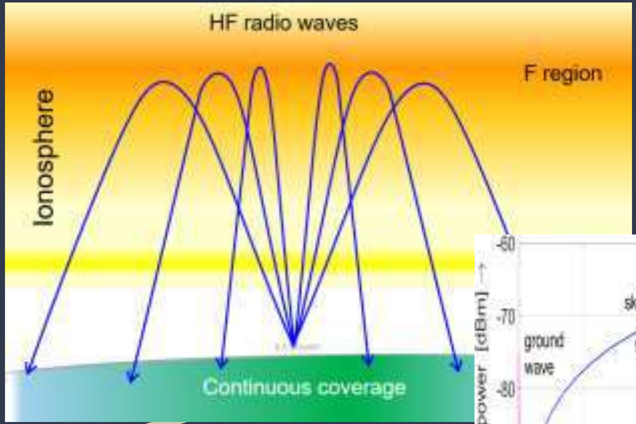


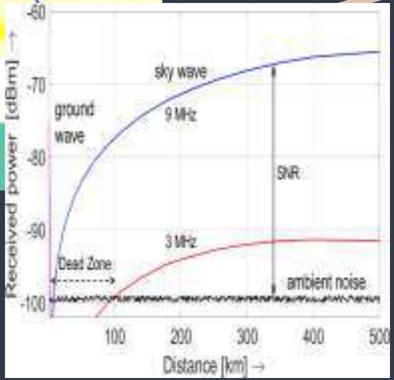
Map: ISS (red line), surveillance receiver (SR), reference receiver (RR) and illuminator of opportunity (I) positions during measurements. Sketch: the geometry of the experiment.(Jędrzejewski et al., 2021).

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

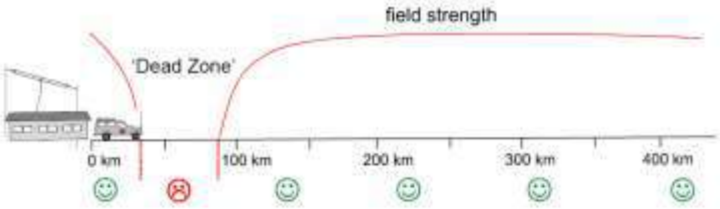
Node - Non-gov organisation example





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

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