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.

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Objective

Following the expertise coming from prevoius Innovation Days, it aims to bring together users to **enhance and promote cooperation** with the space agencies, the aerospace industry, SMEs, and non-governmental organizations.

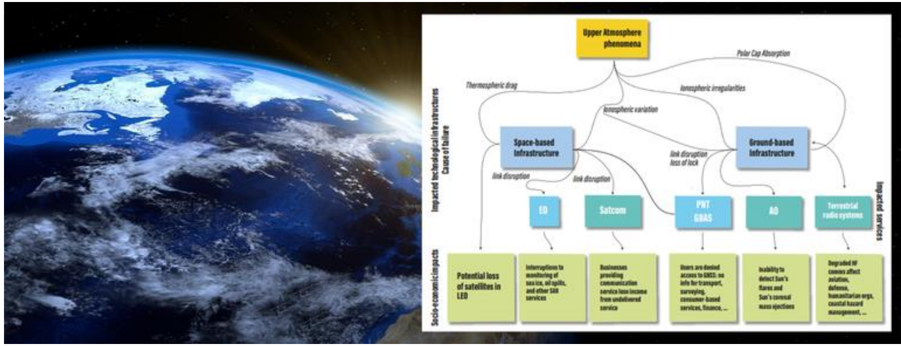
Specifically:

- 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 and protect each other's copyrights.

3 rd Innovation day WARSAW

The main goal of the this event is to promote the final PITHIA-NRF products, whose tasks were to develop solutions tailored to the needs of users, collect their opinions and support new cooperation.

- **To introduce you to the achievements of the PITHIA project.**
- **We would like to learn and listen to stakeholders' success stories.**
- **Meet our experts in B2B meetings**



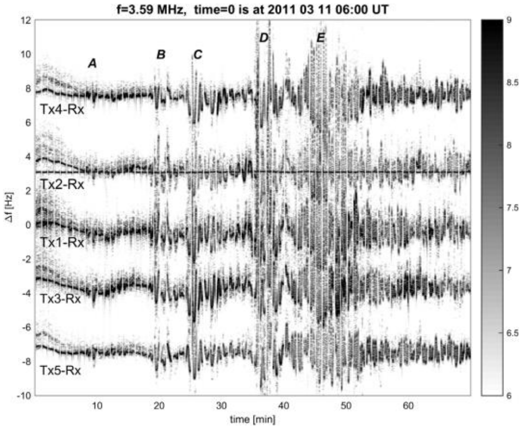
Multipoint Continuous Doppler sounding system
- Improvement of the coverage of CDSS data over Europe

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!

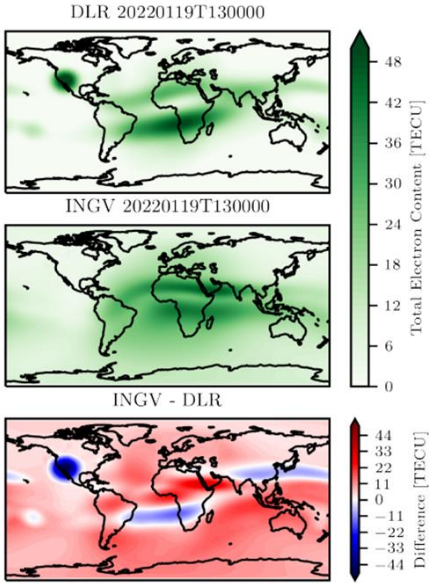


Figure 4 Comparison between nowcasted global TEC maps by DLR and INGV on 19 January 2022 13:00 UTC as obtained from the PECASUS data repository and eSWua. The upper and middle graphs show TEC heat maps by DLR and INGV resp. sharing the same colorbar (right). The bottom graph shows the difference between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

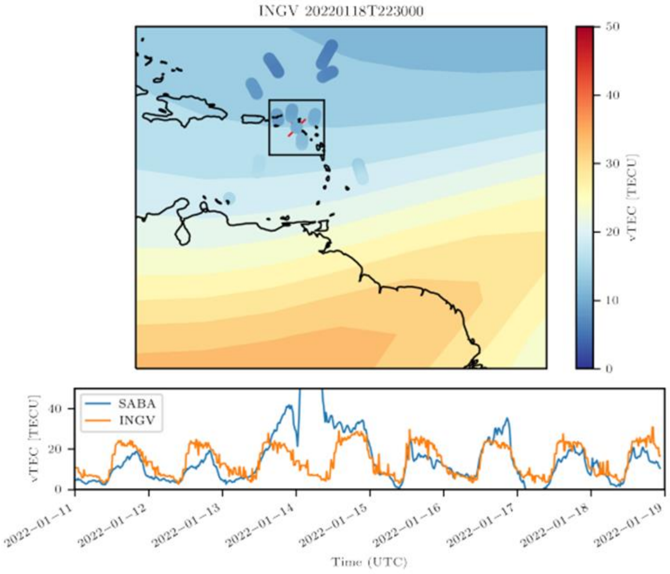


Figure 5 TEC measurements made KNMI's GNSS receiver on Saba compared to INGV TEC map on 18 January 2022 22:30 UTC. The upper graph shows the INGV TEC map in the Caribbean compared to individual vTEC measurements (GPS and GLONASS satellites only, blue dots) made within a 15 minute time window. The receiver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

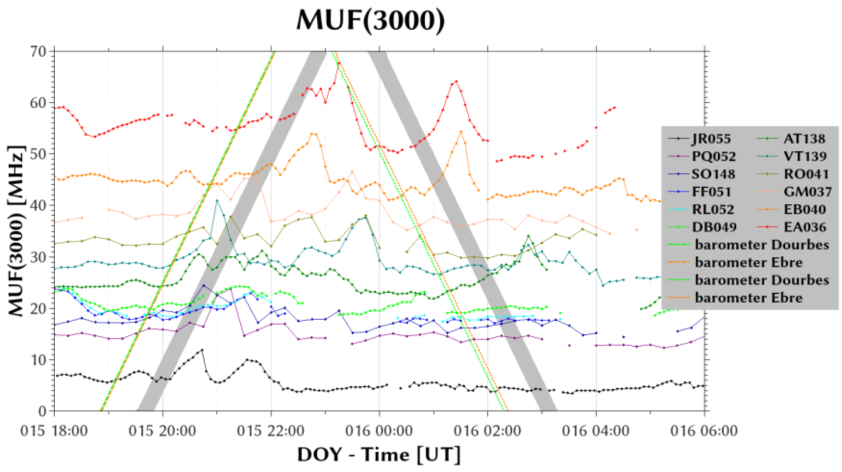
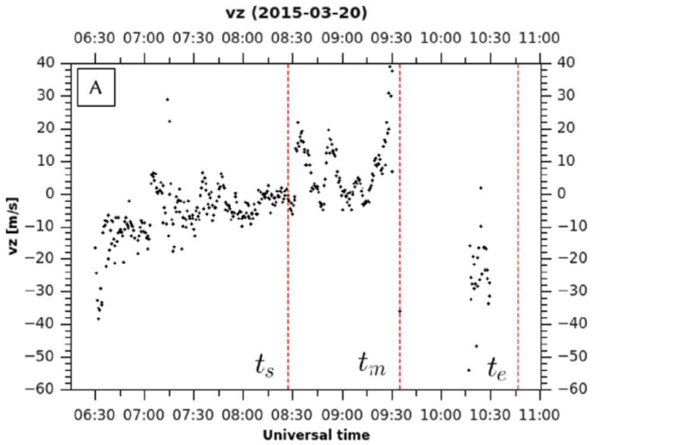
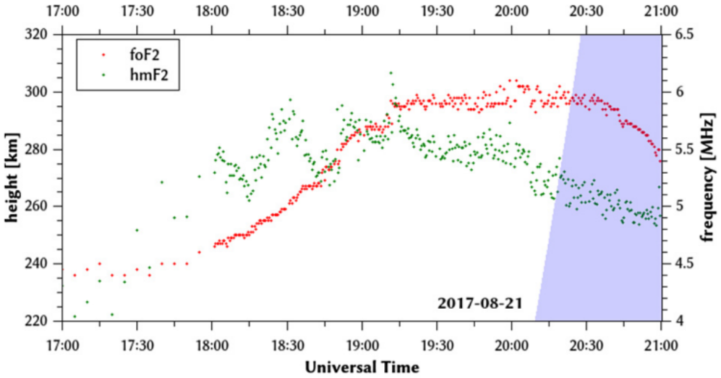


Fig. The maximum usable frequency (MUF) calculated from different sounders indicating ionospheric disturbances caused by the 15 January 2022 eruption of the Hunga volcano.



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

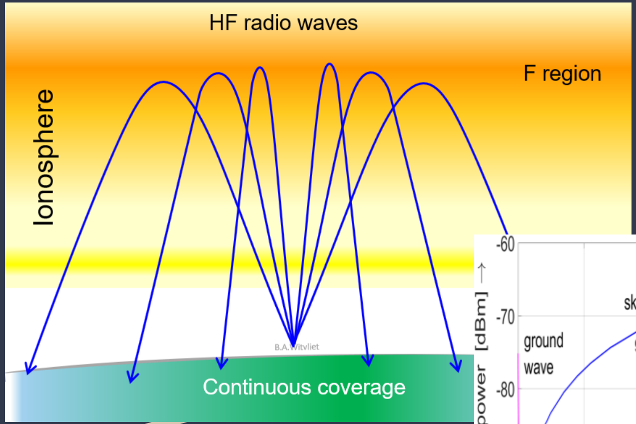
The network of PITHIA-NRF Digisonde stations

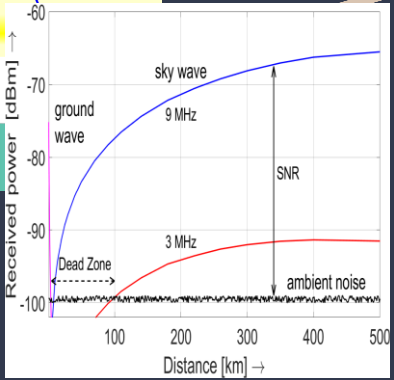
Synchronized soundings at short and long distances

Calibration and validation of HF radio equipment

Node - Non-gov organisation example

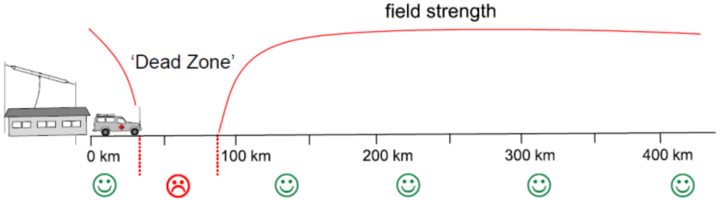
MEDECINS SANS FRONTIERES





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)

LOFAR ILT ⟶ LOFAR ERIC

- 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

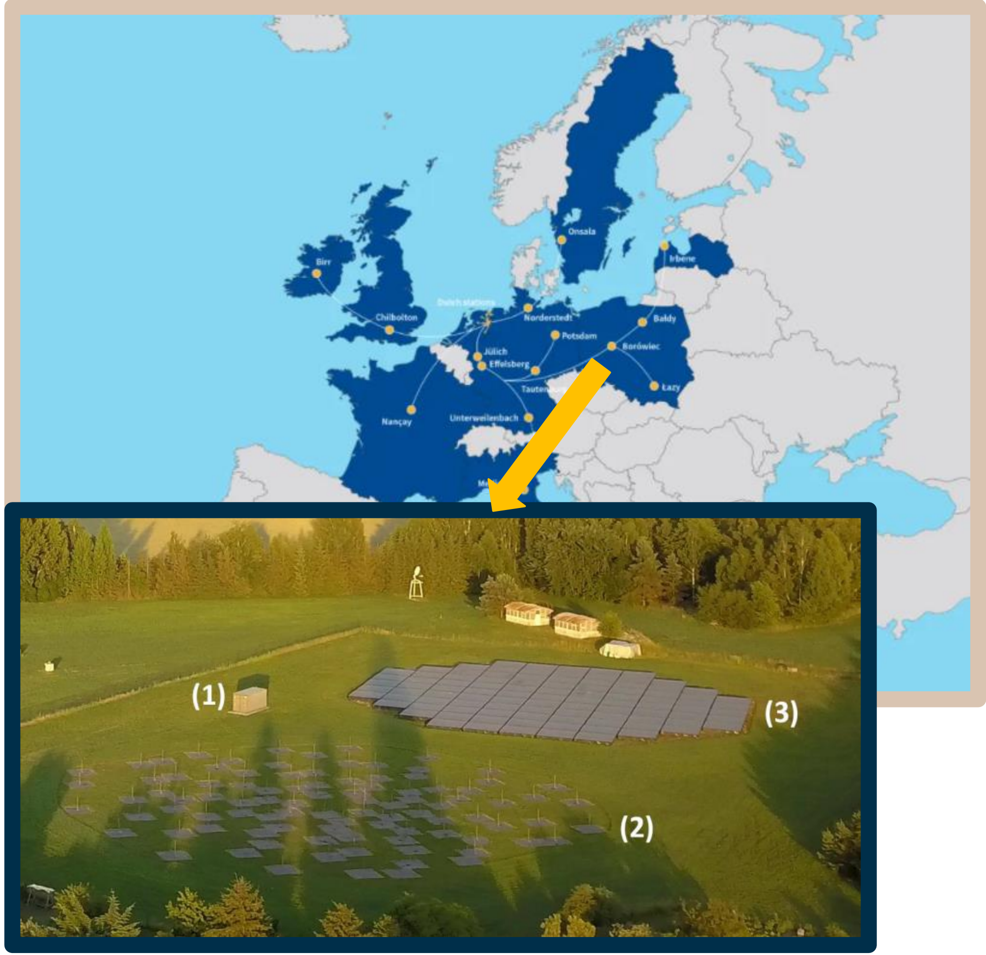
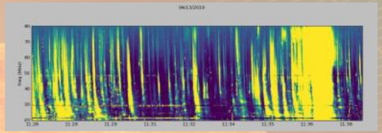


Fig. LOFAR PL610 station, Borówiec, Poland

LOFAR A comprehensive Space Weather Observatory
Sun, Heliosphere and Ionosphere observations

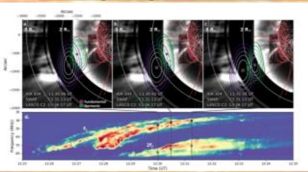
Sun

➔ **Monitoring Solar Radio Activity**



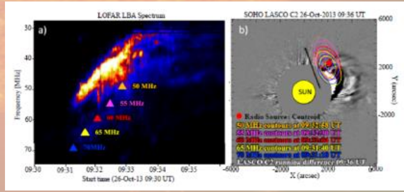
Zucca @ *Twitter*

➔ **Imaging of Radio Emissions**



Maguire et al., 2021

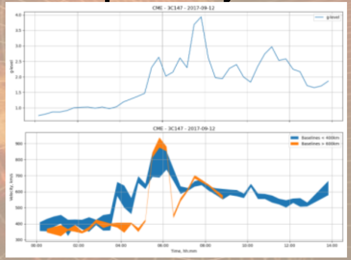
➔ **Solar radio bursts**



Zucca *et al.*, 2018

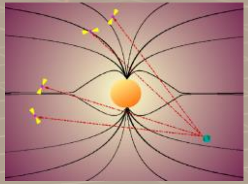
Heliosphere

➔ **Interplanetary Scintillation (IPS)**



Beamformed observations of point-like, distant, astronomical radio sources - determine the plasma outflow velocity(ies) across each line of sight and single-site techniques.

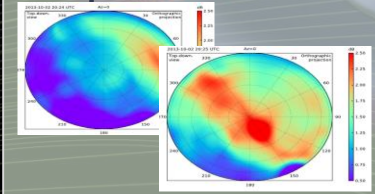
➔ **Faraday Rotation**



Determine the plasma density (and potentially the heliospheric magnetic field) using pulsars.

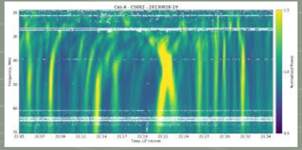
Ionosphere

➔ **Spectral riometer**



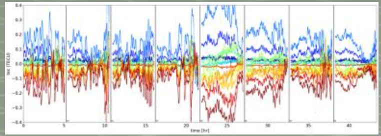
KAIRA data: McKay *et al.* (2015), Radio Science 50

➔ **Ionospheric scintillations**



Single station Scintillation spectrum CasA

➔ **TIDs**



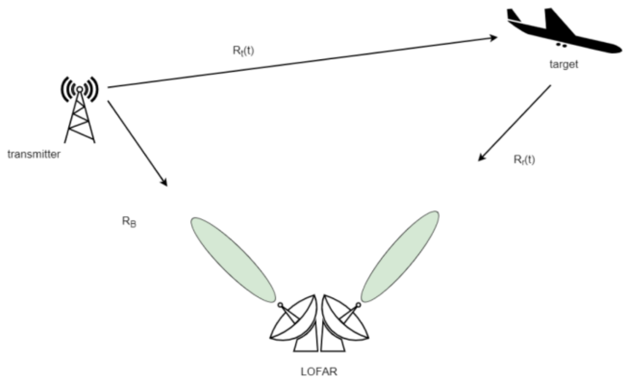
differential TEC vs time, all Dutch stations

Credit: NASA

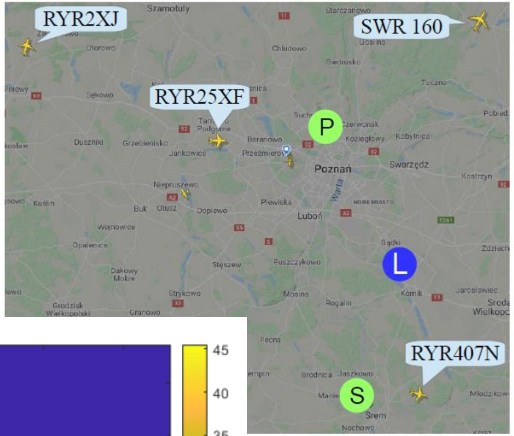
LOFAR as a passive radar

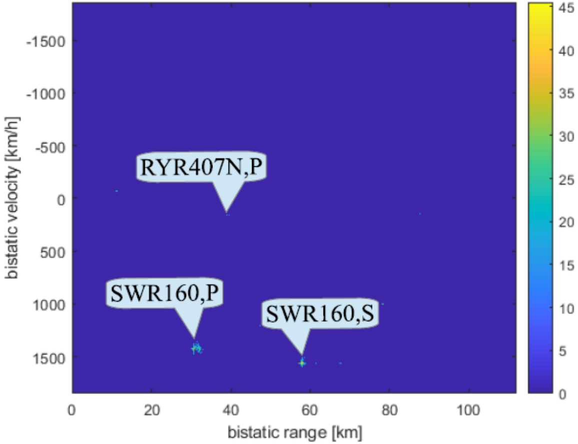
Node - external (academic) example

- 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.



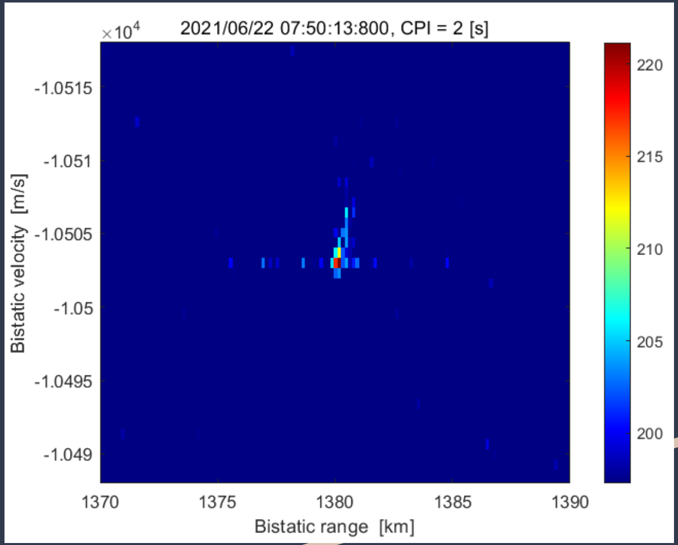


Top: Map with planes around the LOFAR station in Borowiec in the moment of the registration, L – the LOFAR station in Borowiec, S – the broadcasting station in Srem, P – the broadcasting station in Piatkowo (A. Droszcz et al., 2020)

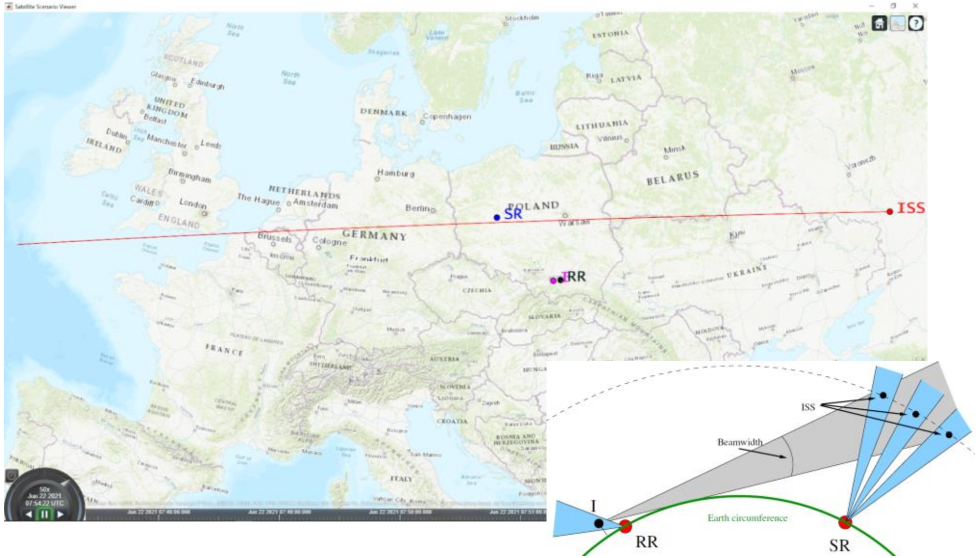
Cross-ambiguity function obtained for 64 tiles combined into a beam steered in the direction of SWR160 plane

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

Thank you for your attention!

and

How can PITHIA-NRF serve you?

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

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