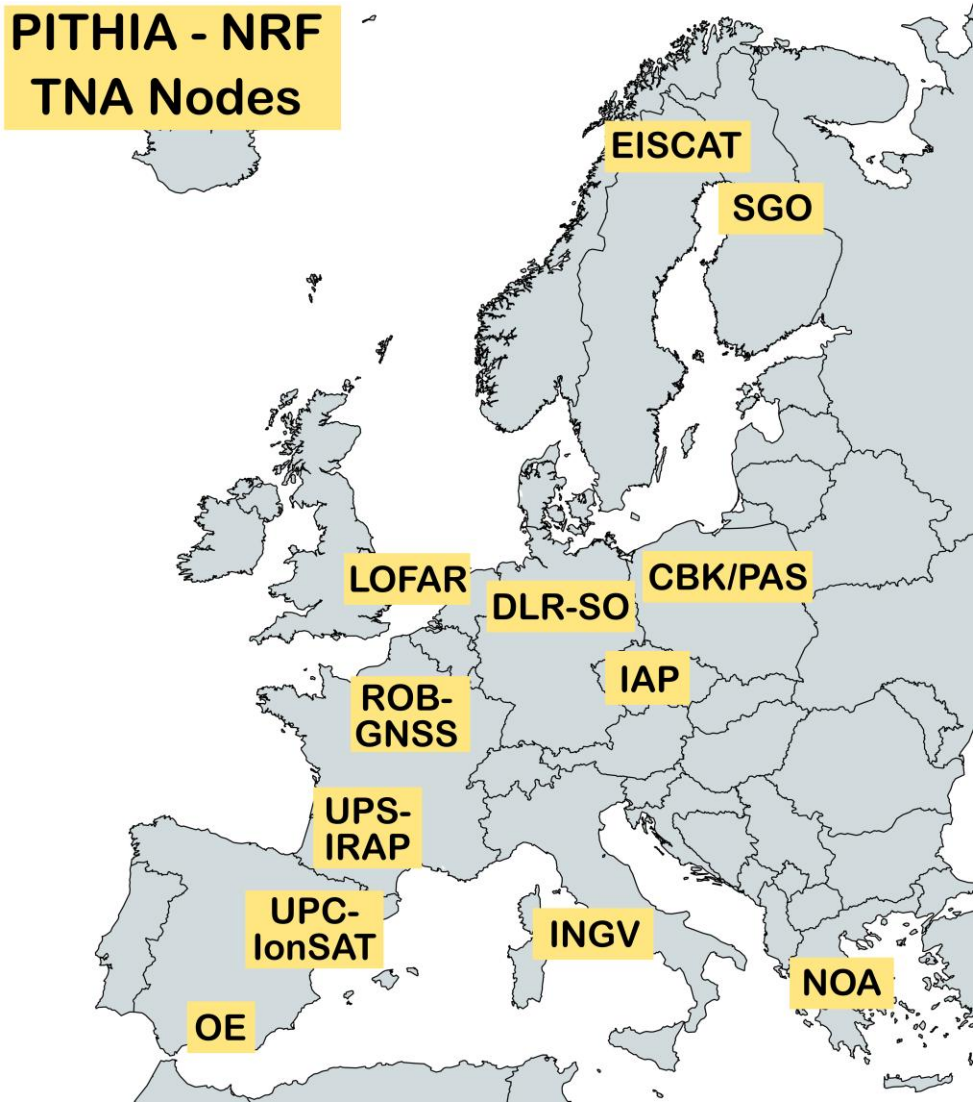
PITHIA-NRF research advancements through the TNA Programme

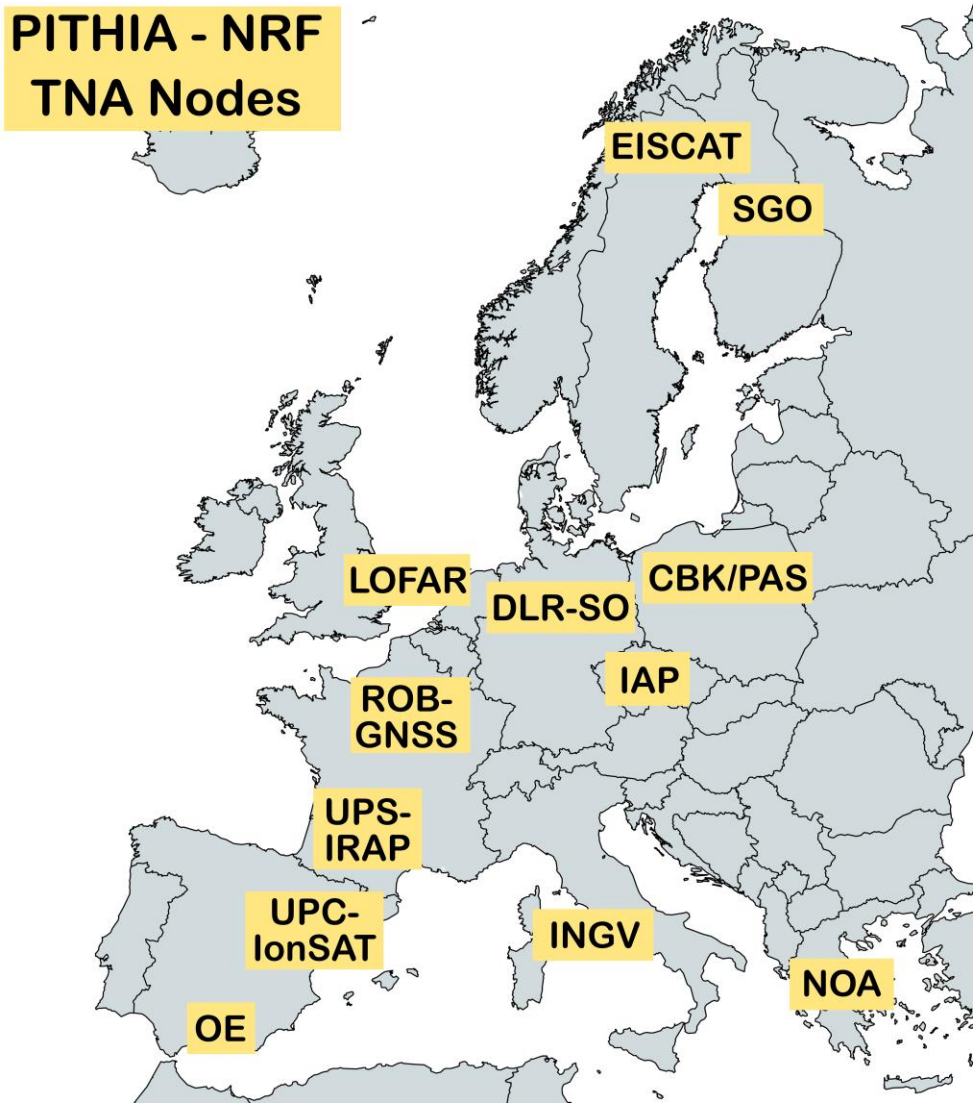
Anders Tjulin, EISCAT AB

The TNA programme



- Open for researchers, students and others to execute and carry out their own projects at a research facility connected to PITHIA-NRF
- Hands-on access to key experimental and data processing facilities for studies and modelling of physical processes acting in the Earth's plasmasphere, ionosphere and thermosphere
- Training and support from experts in the field
- Physical access or Remote access sessions for one work week
- Travel support and one week of accommodation
- Scientific support of the project

The TNA programme in numbers

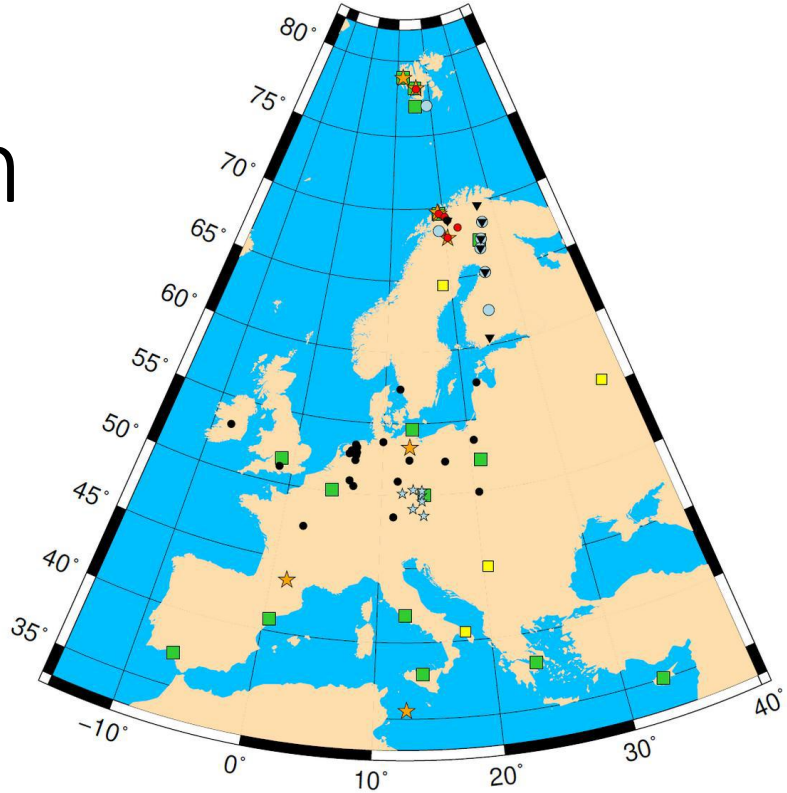


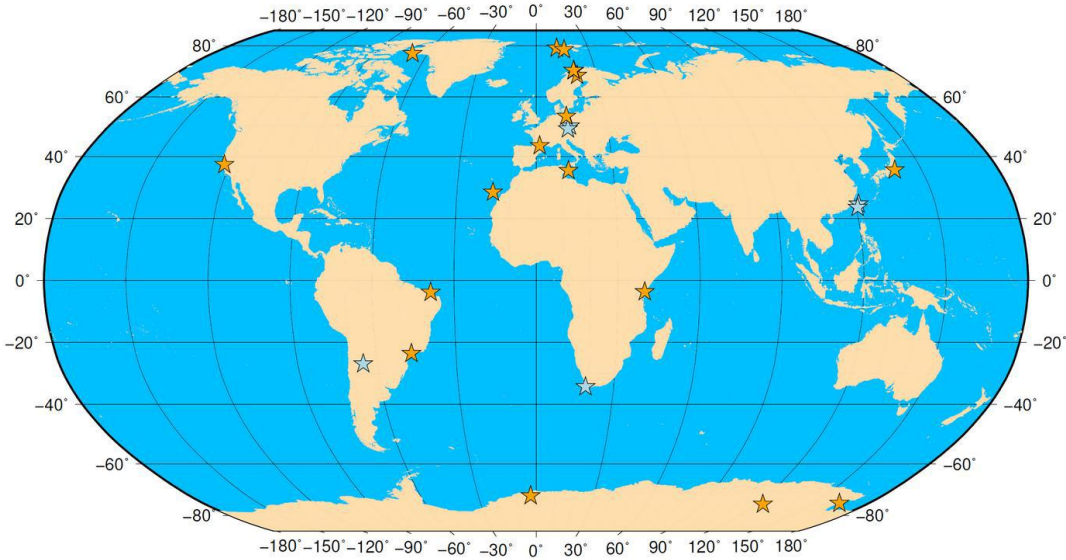
- 12 Nodes
- 8 TNA calls (2021–2025)
- 63 applications received
- 54 projects accepted
- 34 projects finished
- 14 projects ongoing

- TNA user meeting in Brussels 3 June, 2025

Instrumentation

- Ionosondes (■ ■)
- Doppler sounders, CDSS (★)
- GNSS scintillation receivers (★)
- Incoherent scatter radars (●)
- Riometers (●)
- Pulsation magnetometers (▼)
- LOFAR sites (●)
- GNSS sites of standard networks
  - EUREF and IGS
- Space models
  - local/regional/global



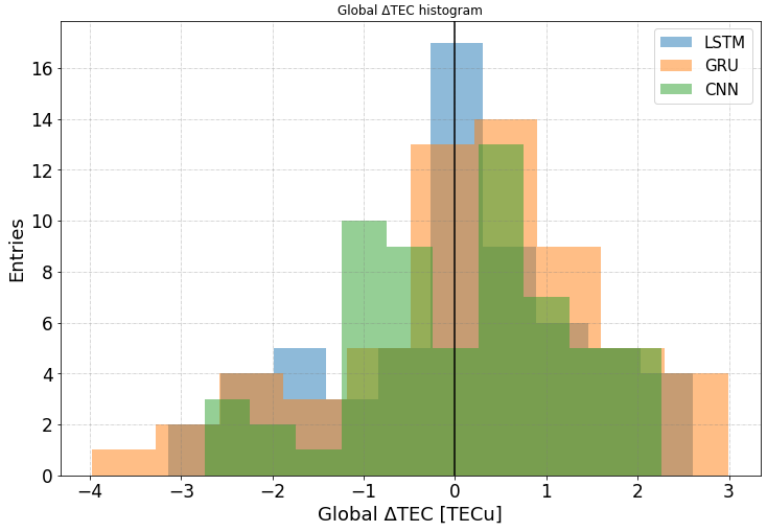


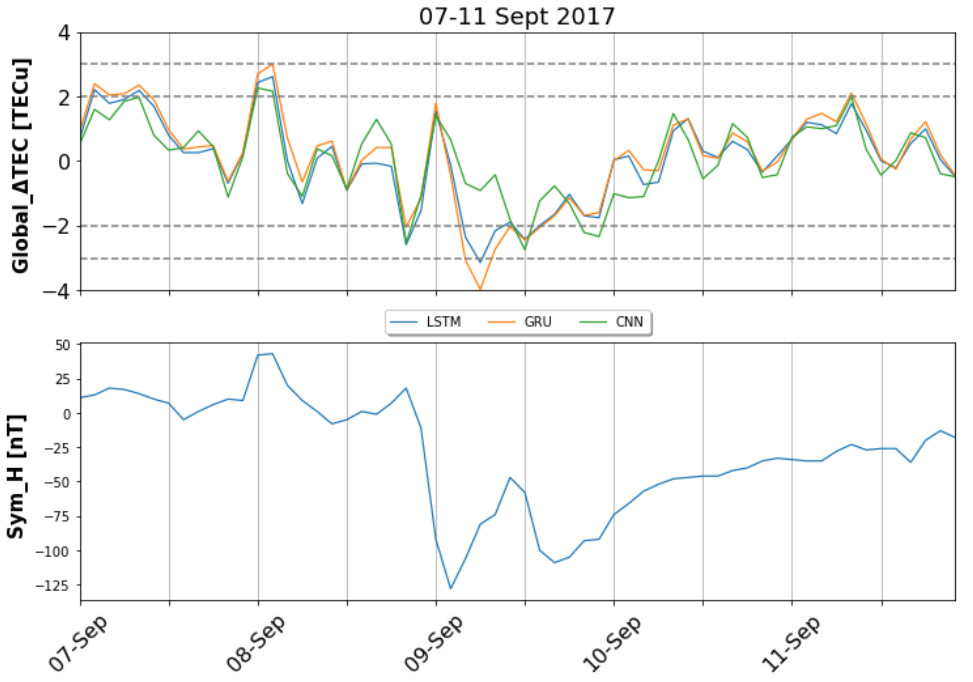
AI4TEC – Machine learning techniques applied to ionospheric and space weather research

- Jorge Habib Namour (Universidad Nacional de Tucumán, Tucumán, Argentina)
  - María Graciela Molina, Noelia Agüelles, Eric Asamoah
- PITHIA node: INGV
- Investigating ionospheric forecasting using machine learning algorithms.
  - Is it possible to enhance the existing INGV model for global forecasting of total electron content 24 hours in advance?

AI4TEC – Machine learning techniques applied to ionospheric and space weather research

- Insight in challenges related to data constraints
- Identification of optimal datasets and suitable parameters
- Implementation of machine learning models in real-time scenarios
- Development of improved models for total electron content on global scale, and forecasting 24 hours in advance
  - To be made available at space weather portals:
    - spaceweather.facet.unt.edu.ar
    - eswua.ingv.it
  - Molina, María Graciela et al,, “Boosting total electron content forecasting based on deep learning toward an operational service”, JATP 268, 2025 (https://doi.org/10.1016/j.jastp.2025.106427)

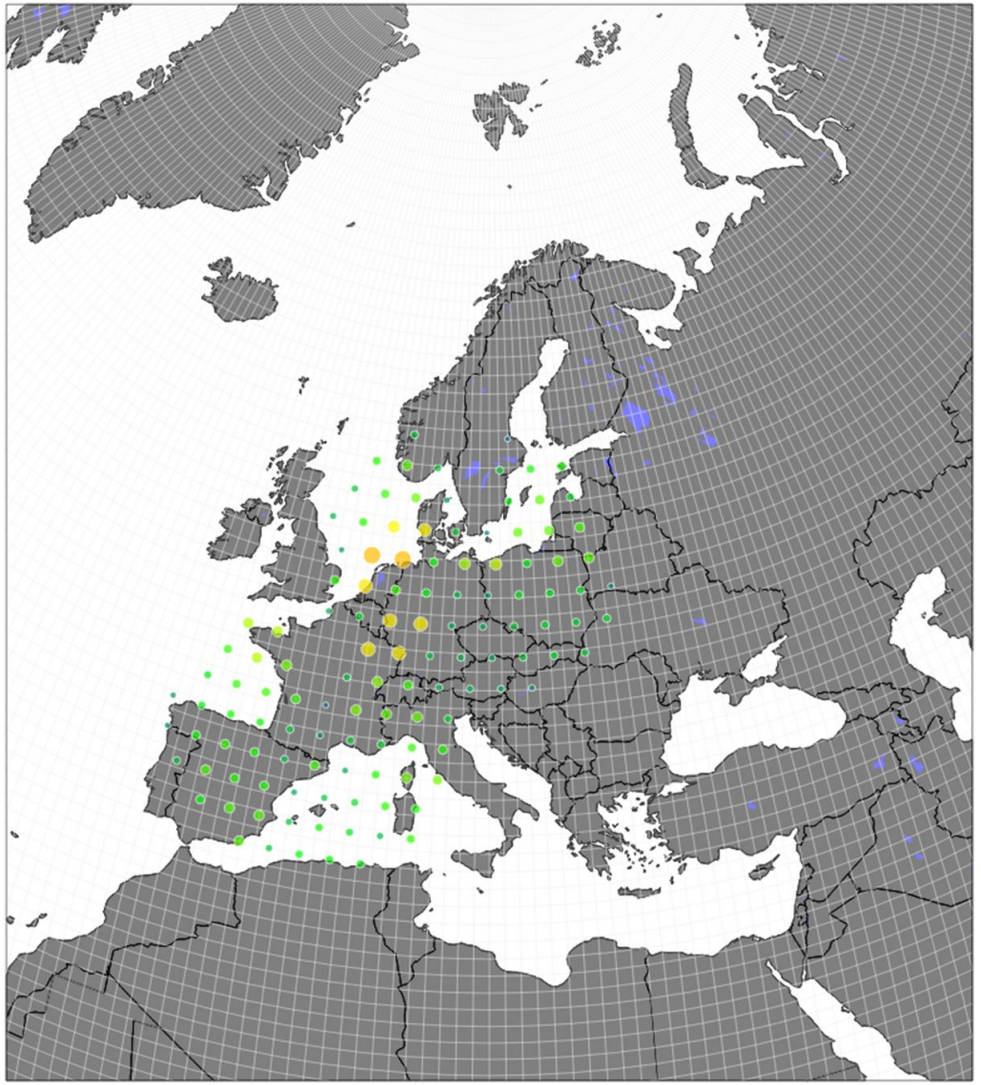




ASPIS – Feasibility study of data-driven autonomous service for prediction of ionospheric scintillations

- Šimon Mackovjak (Slovak Academy of Sciences, Košice, Slovakia)
  - Matej Varga, Samuel Amrich, Peter Butka, Viera Maslej-Krešňáková
- PITHIA node: DLR-SO
- Developing a data-driven service to provide assessment of ionospheric scintillation in a specific time ahead
  - Is such a service feasible?

ASPIS – Feasibility study of data-driven autonomous service for prediction of ionospheric scintillations



- Familiarisation with ionospheric parameters provided by DLR-SO, and incorporation of the parameters into a data-driven service
  - Removing systematic and gross errors and outliers
  - Project measured data to geographical coordinates
  - Prepare time series for input to the model
- Investigation of its performance in comparison with other models
- Nowcast and forecast available:
  - https://aspis.services/

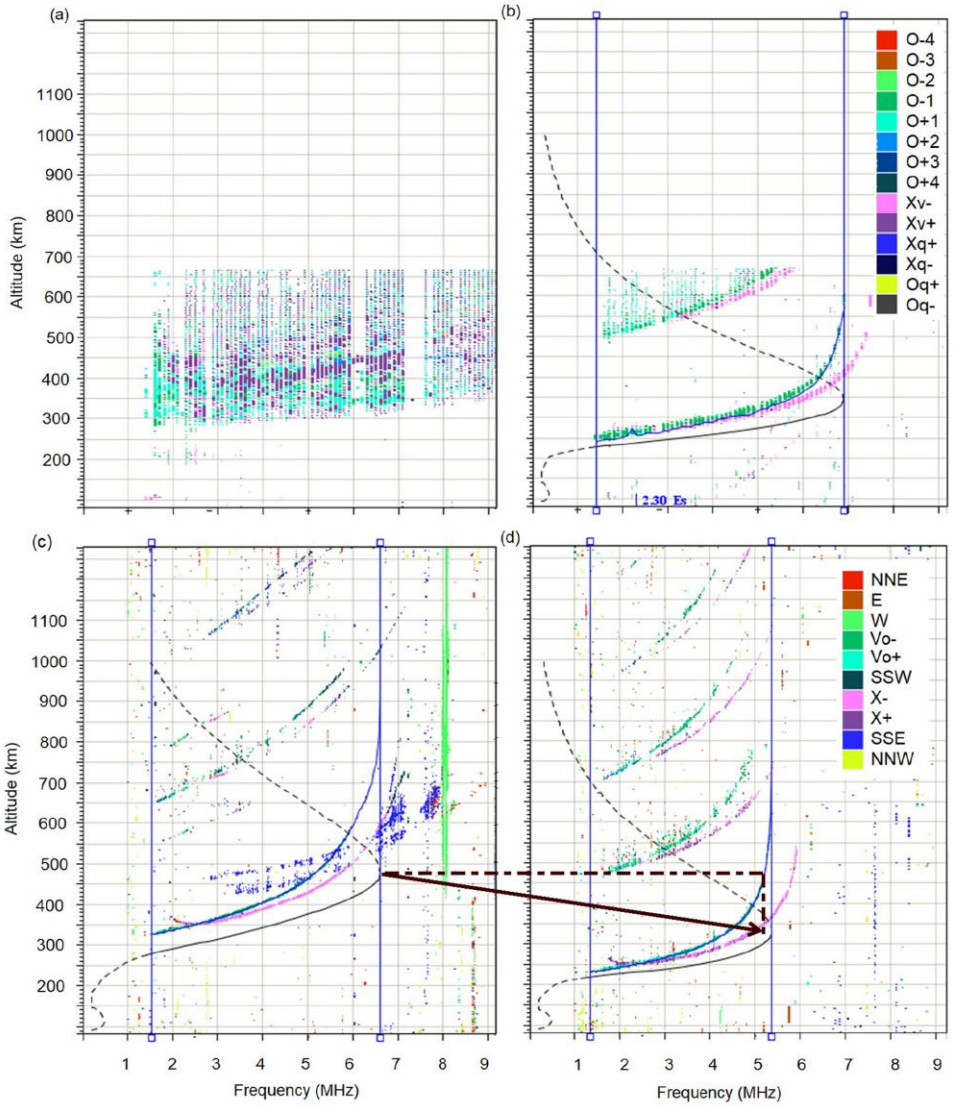
CPD&EGA – Characterization of plasma depletions and effects on geodetic applications

- Andrés Calabia Aibar (Universidad Politécnica de Madrid, Madrid, Spain; Nanjing University, Nanjing, China)
  - Nadia Imtiaz, Yury Yasyukevich, Iñigo Molina, Binod Adhikari, Anoruo Chukwuma

- PITHIA node: OE
- Equatorial plasma bubbles are regions of depleted ionisation within 25° from the equator, with dynamics not yet fully understood
  - What can be learned about these phenomena using multi-instrumental data and what are their effects for navigation?

CPD&EGA – Characterization of plasma depletions and effects on geodetic applications

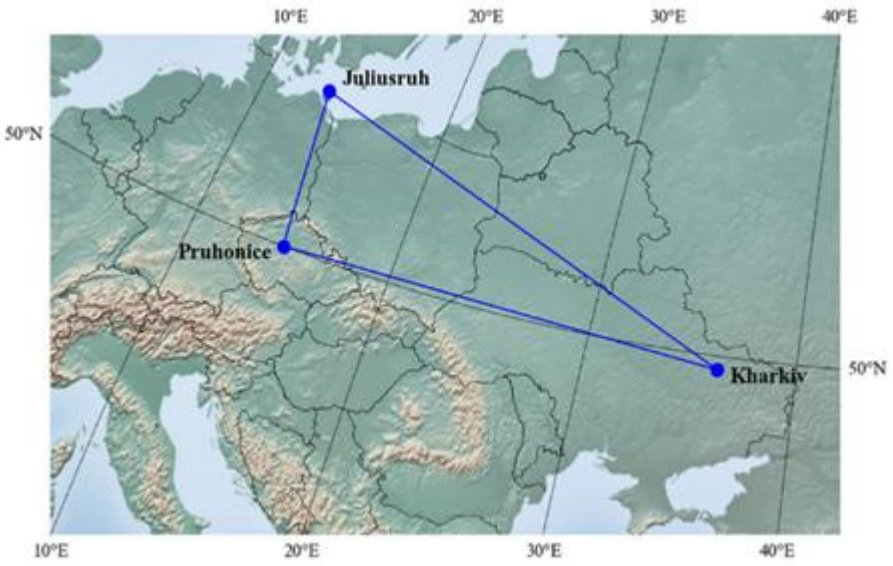
- Combination of airglow remote sensing, ionosonde, magnetometers and in-situ satellite data
- Detailed investigation of the Kp5+ geomagnetic storm of 27 February 2014, which caused large GNSS positioning errors
- Could describe the potential for using ionosonde data to characterise localised plasma depletions
  - Observed three large plasma depletions, reaching 40° north, travelling in northeast direction, lifting the ionosphere by 100 km
- Publication:
  - Calabia, A., et al. (2024), “Uncovering the drivers of responsive ionospheric dynamics to severe space weather conditions: A coordinated multi-instrumental approach”, JGR: SP 129, e2023JA031862 https://doi.org/10.1029/2023JA031862



LONG – Longitudinal differences in travelling ionospheric disturbance characteristics at mid-latitudes

- Kateryna Aksonova (Institute of Ionosphere, Kharkiv, Ukraine)
  - Dalia Buresova, Jaroslav Chum
- PITHIA node: IAP
- Detecting travelling ionospheric disturbances and calculating their parameters using ionosondes and Doppler radars.
  - What can be learned from the longitudinal differences about the physical processes responsible for their formation?

LONG – Longitudinal differences in travelling ionospheric disturbance characteristics at mid-latitudes



- Three ionosondes (Juliusruh, Pruhonice, Kharkiv) and the Kharkiv incoherent scatter radar were used to detect variations of the F2 peak in the ionosphere
  - Diurnal occurrence at each location, predominant period, vertical and horizontal phase velocity and wavelength, relative amplitude of electron density fluctuations, propagation direction
- Detailed analysis of the Kp6- geomagnetic storm 22-24 September 2020
  - Knowledge about regional behaviour of TID characteristics, improved prediction capabilities
- Publications:
  - Panasenko, Sergii V. et al, “Large-scale traveling ionospheric disturbances over central and eastern Europe during moderate magnetic storm period on 22–24 September 2020”, AdvSpaceRes 72(10), 2023 (https://doi.org/10.1016/j.asr.2023.09.035)

PRISMATIC – Can polarisation measurements of auroral emissions trace the ionospheric currents?

- Hervé Lamy (Royal Belgian Institute for Space Aeronomy, Brussels, Belgium)
  - Gaël Cessateur, Léo Bosse, Jean Lilensten, Urban Brändström
- PITHIA node: EISCAT
- The polarisation of upper atmospheric emissions is measured by the group's own instrument PLIP (Polar lIghts Imaging Polarimeter). The results are interpreted using measurements from EISCAT and ALIS_4D, and applying POMEROL polarised radiative transfer code.
  - Ìs it be possible to trace the ionospheric currents using the PLIP data?

PRISMATIC – Can polarisation measurements of auroral emissions trace the ionospheric currents?

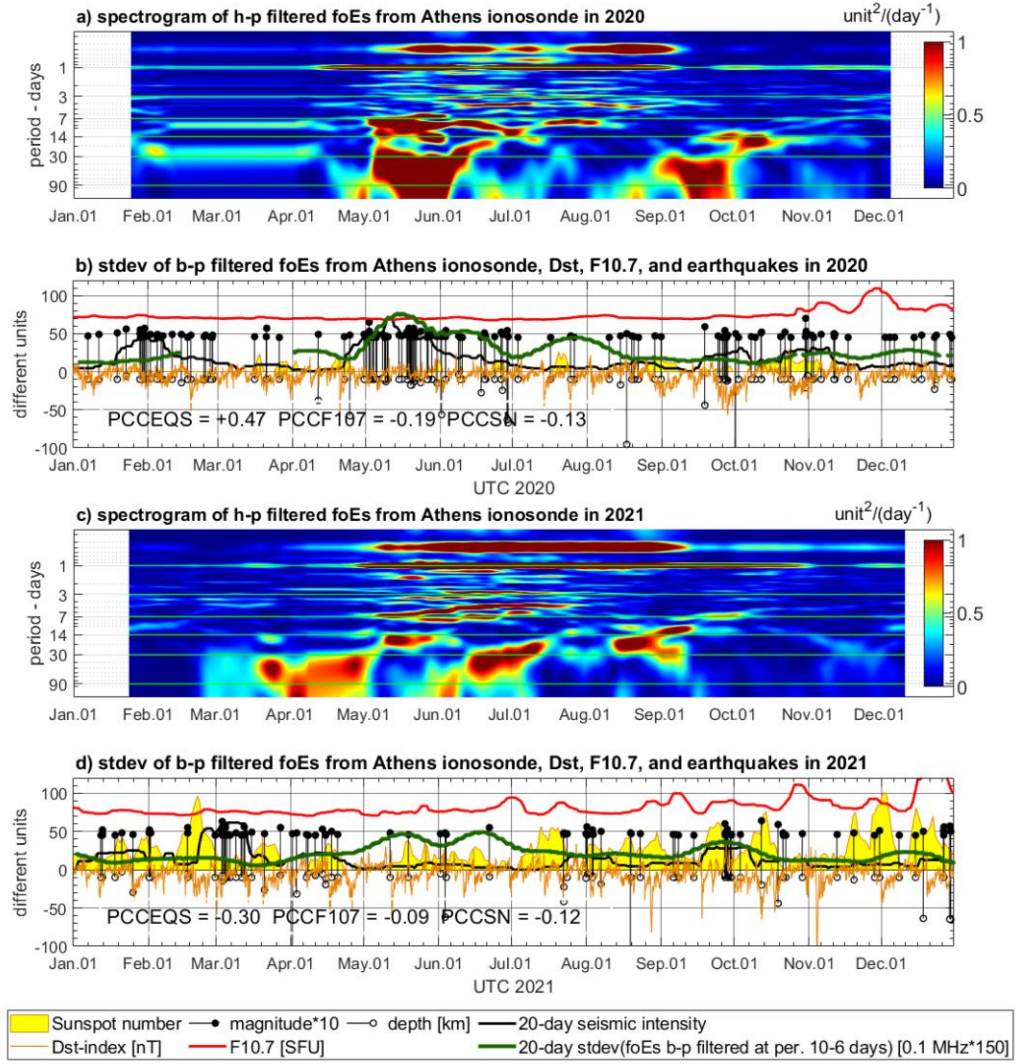
- Requiring simultaneous optical observations of the same light emitting volume from several places
  - Clear night with northern lights required
- An interesting case found: a strong decrease of the degree of linear polarisation with a clear rotation of its angle occured during the main phase of the geomagnetic storm.
  - Indicates a scattering by electrons as the source of polarisation

SIDSEA – Sensitivity of ionospheric disturbance detection by Swarm in time of strong earthquakes in Aegean region

- Wojciech Jarmołowski (University of Warmia and Mazury in Olsztyn, Olsztyn, Poland)
  - Paweł Wielgosz, Anna Krypiak-Gregorczyk, Beata Milanowska
- PITHIA node: NOA
- Earthquakes result from tectonic processes, which generate the Lithosphere-Atmosphere-Ionosphere Coupling (LAIC). These processes affect the ionosphere from below, but their imprints are mixed with those coming from different processes from above
  - How sensitive are measurements from the Swarm satellite to these disturbances?

SIDSEA – Sensitivity of ionospheric disturbance detection by Swarm in time of strong earthquakes in Aegean region

- Studied sensitivity to various frequencies in the ionosphere above Aegean Sea 2020-2021
- Data coming from Athens digisonde, TEC from GNSS receivers and electron density in-situ from Swarm.
- Band-passing of signals could be used to detect weak signals
- High-level data can efficiently support phenomenological studies and advanced ionospheric modelling
- Data quality is critical to the reliability of results
- Results led to DISPEC project (January 2024 to December 2026):
  - https://dispec.eu



Final words

- Large variations in the focus for the different TNA activities
  - From pure fundamental science to ionospheric service development
- Most projects were successful
- Access to data and equipment was of course important for the success
- Access to expertise and the possibility for new connections was maybe more important

Thank you for your attention!

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

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