



Operational Space Weather in Norway

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**UNIVERSITY
OF OSLO**

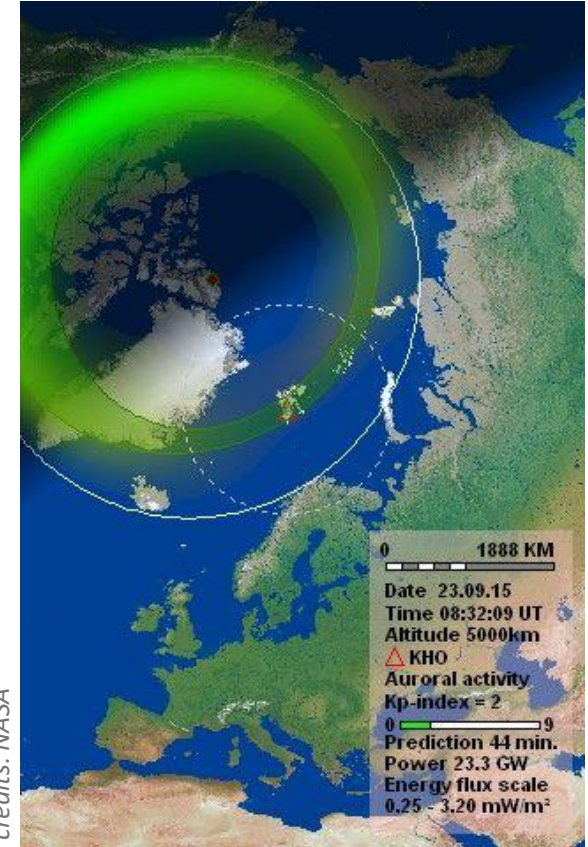
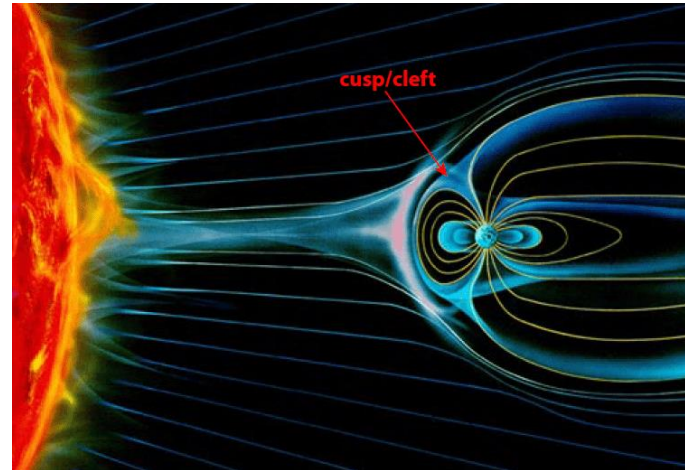
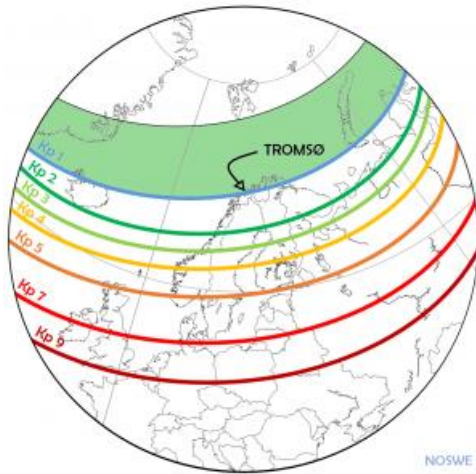
UN/Germany workshop on ISWI, Neustrelitz, Germany, June 10-14, 2024

- Geographical advantage
- Infrastructure
- Space weather studies
- User needs
- Operational space weather



Geographical advantage

- Northern Norway – auroral zone
- Svalbard Archipelago – cusp region / dayside aurora



credits: <http://kho.unis.no/Forecast>

Geographical advantage

Kristian Birkeland (13.12.1867-15.06.1917)

- Pioneer in space physics and space weather research.
- Auroral expeditions / aurora in the lab.
- Birkeland/field aligned currents.
- Also solved the problem of fertilizers in agriculture - nitrogen fixing.

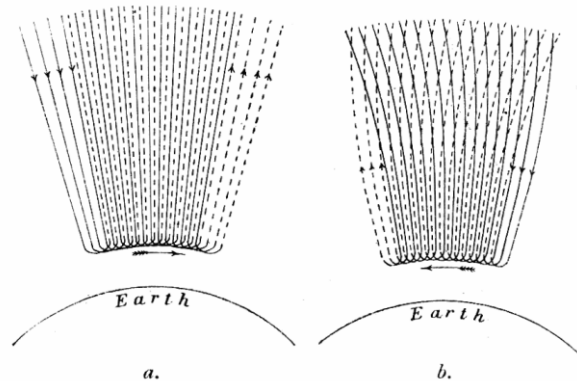
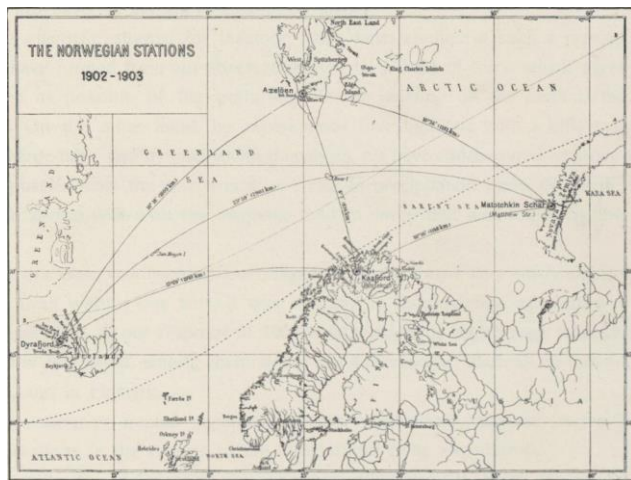
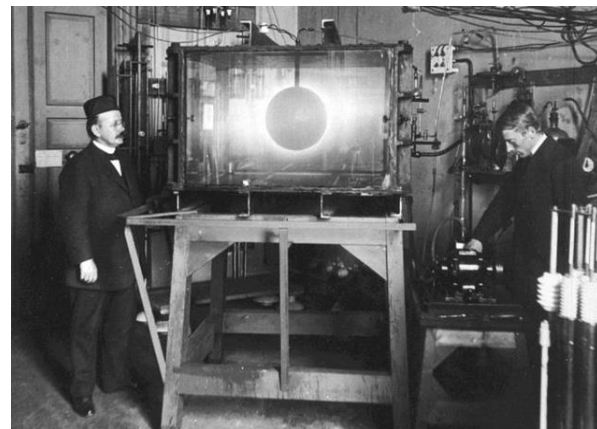


Fig. 50.

Source: *The Norwegian Aurora Polaris Expedition 1902-1903*

Geographical advantage

Kristian Birkeland (13.12.1867-15.06.1917)



EISCAT: ESR– 500 MHz / Svalbard



EISCAT3D – Skibotn: Northern Norway + Sweden + Finland



EISCAT 3D Skibotn, Norway:

119 antenna units, 109 in the main site and 10 outriggers for calibrations. 9 919 + 910 dipole antenna elements.

EISCAT 3D Kaiseniemi,

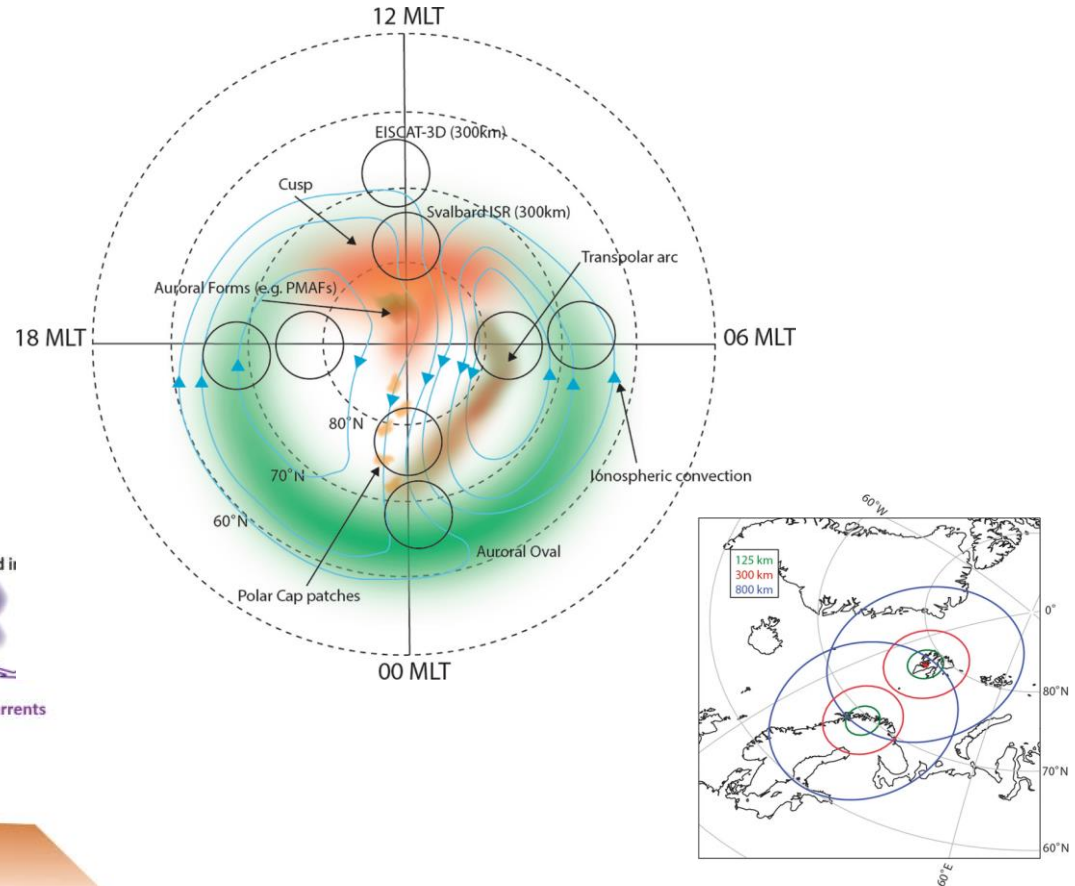
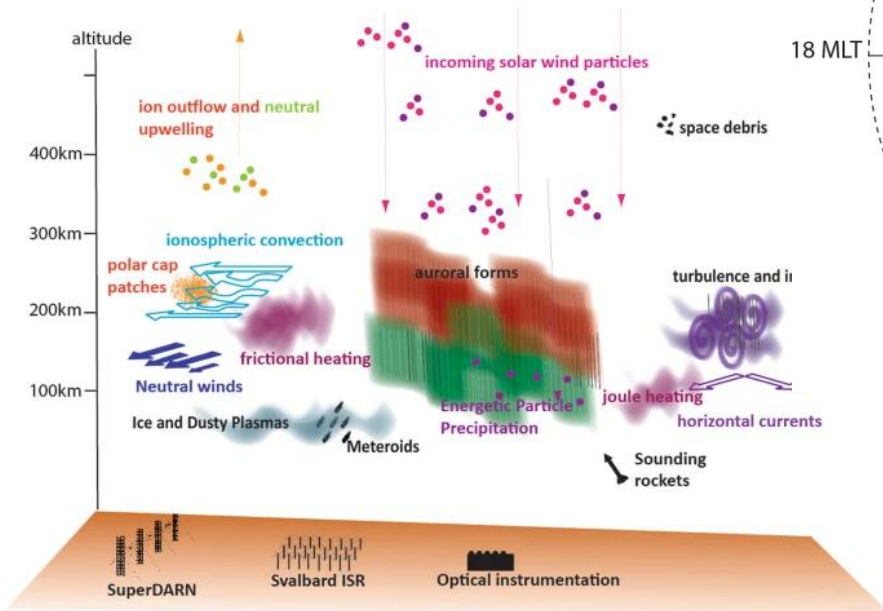
Sweden: 55 antenna units with 5 005 dipole antenna elements.

EISCAT 3D Karesuvanto,

Finland: 54 antenna units with 4 914 dipole antenna elements.

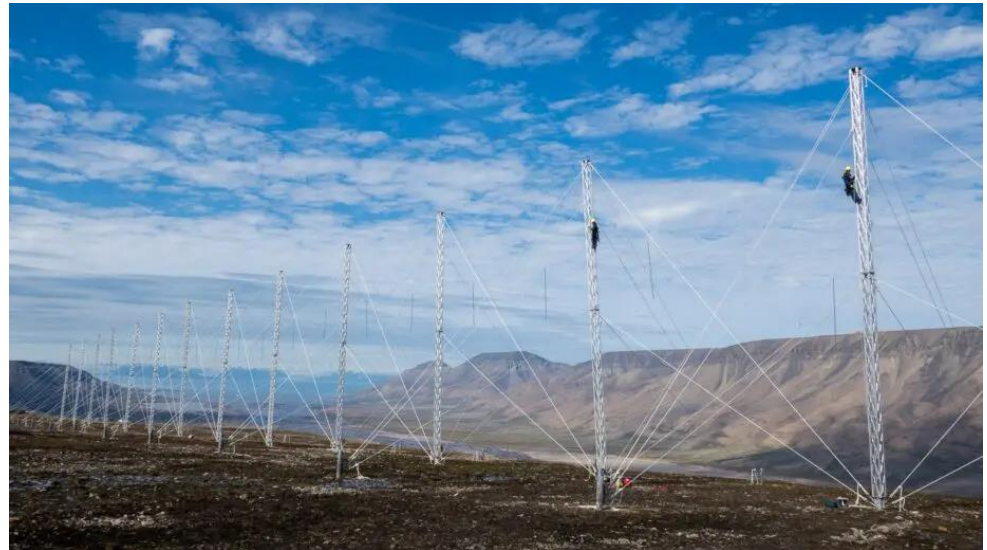
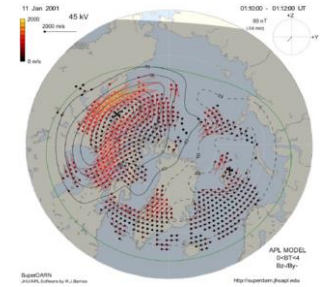
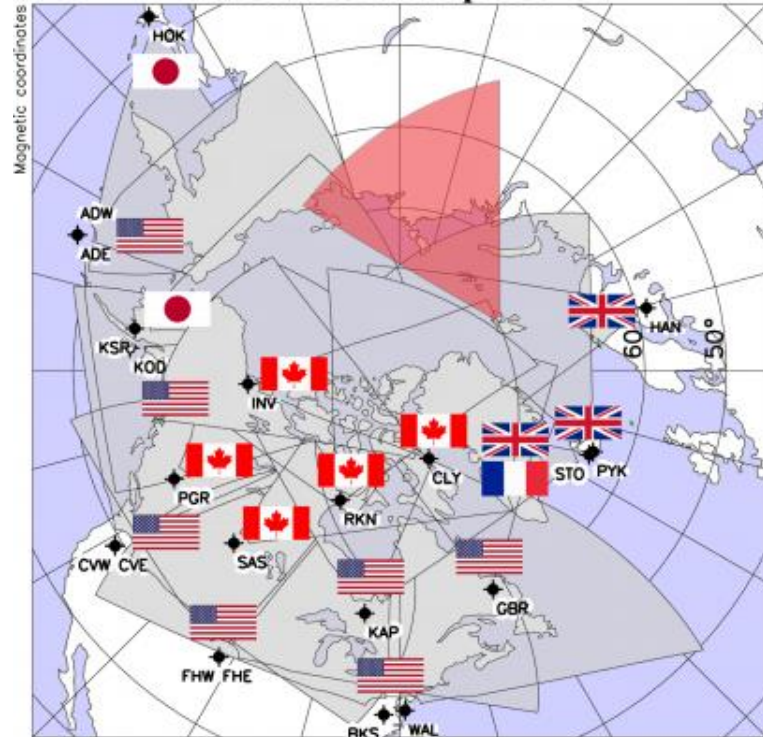
The first stage consist of three sites with around 20 000 crossed dipole antenna elements arranged in 228 hexagons in a honeycomb-structure.

EISCAT: what can we use it for?



SuperDARN - Svalbard

Northern Hemisphere



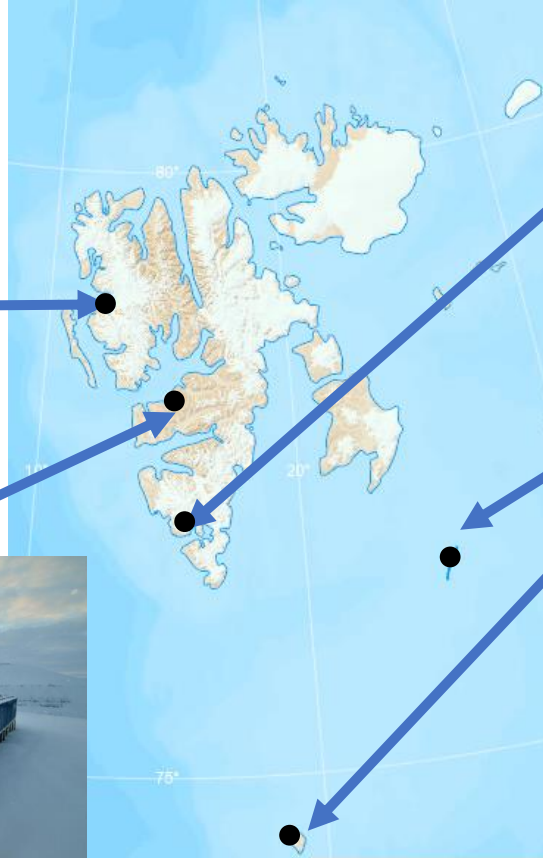
credits: M. Syrjäso / UNIS

All sky imager
GNSS / GISTM
Rockets
Ionosonde
Magnetometer

All sky imagers
GNSS / GISTM
Radars
and many more...



photo: KHO



All sky camera
GNSS / GISTM
Magnetometer

GNSS / GISTM
Magnetometer



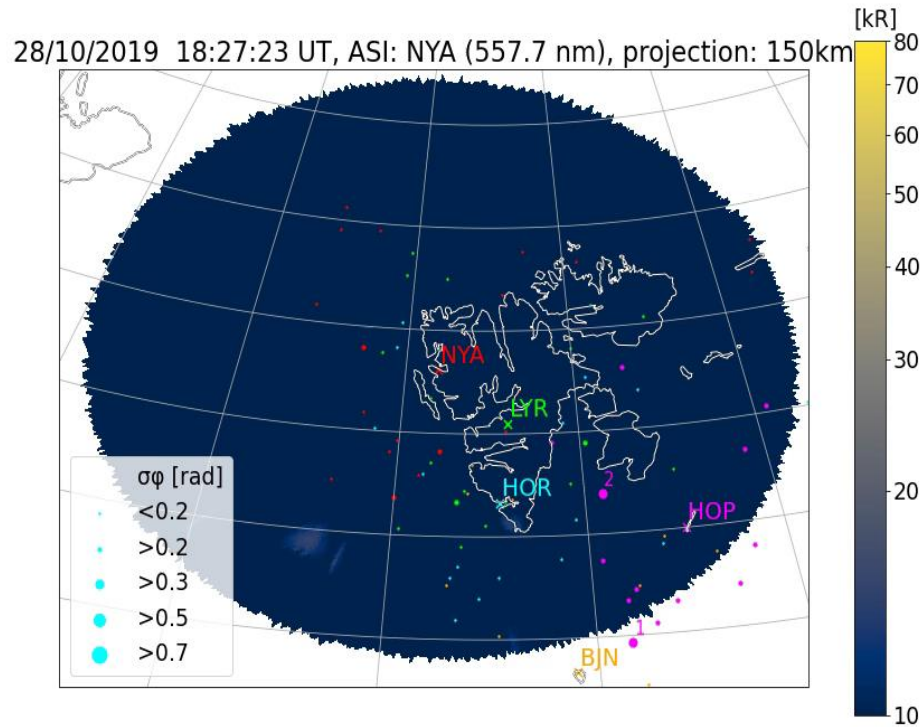
+ mainland

Radars
Sounding rockets
Optical instruments
GNSS/GISTM
Magnetometers
Digisonde

+ Antarctica

GNSS/GISTM
Digisonde
All sky imagers
(Troll Ionospheric
Observatory)

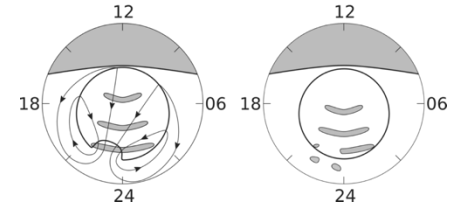
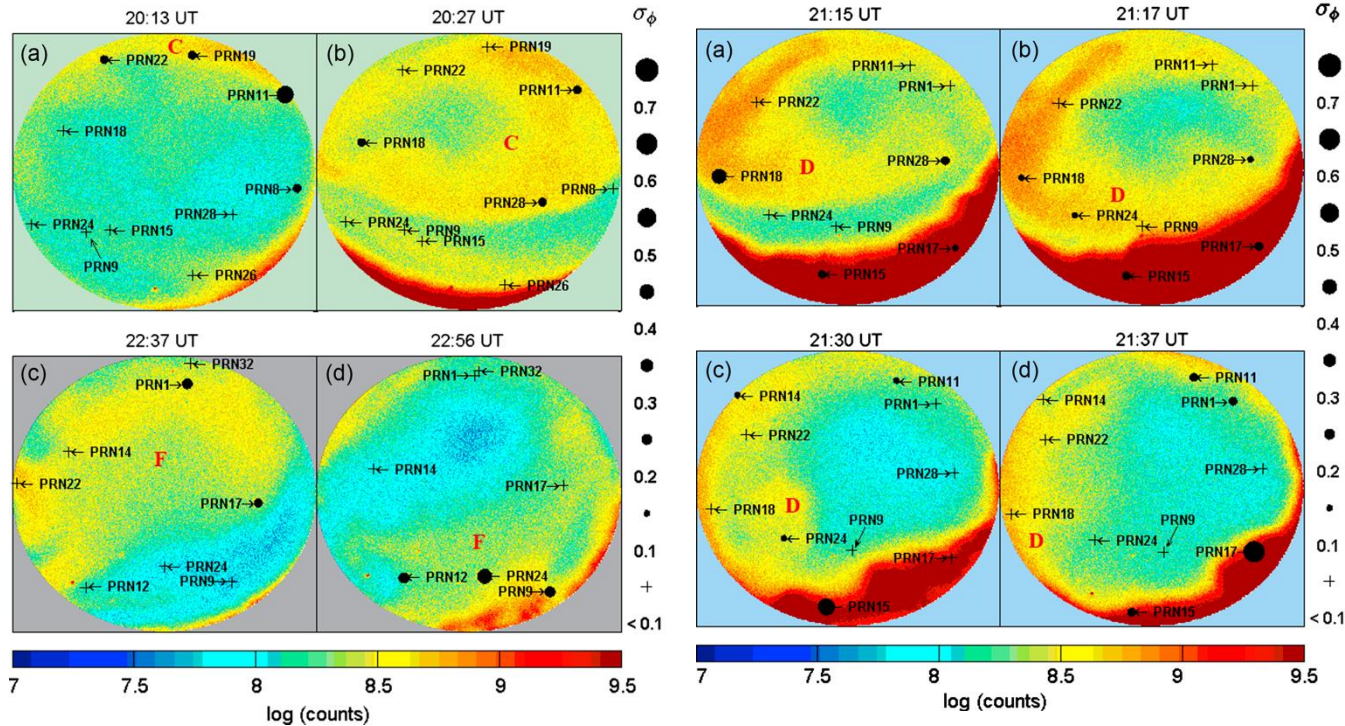
Examples of studies: irregularities and scintillations



Enengl et al., SWSC 2023



Examples of studies: irregularities and scintillations



- Edges of polar cap patches are associated with higher values of sigma_phi scintillation indices.
- When a PCP enters auroral oval the structuring is largest.

All-sky-imager and GISTM data from Svalbard / NYA – Jan 13, 2013

Jin et al, SWSC, 2014

Examples of studies: irregularities and scintillations

ICI-2 05. Dec 2008, 1037 UTC / cusp



UiO: multi Needle Langmuir Probes

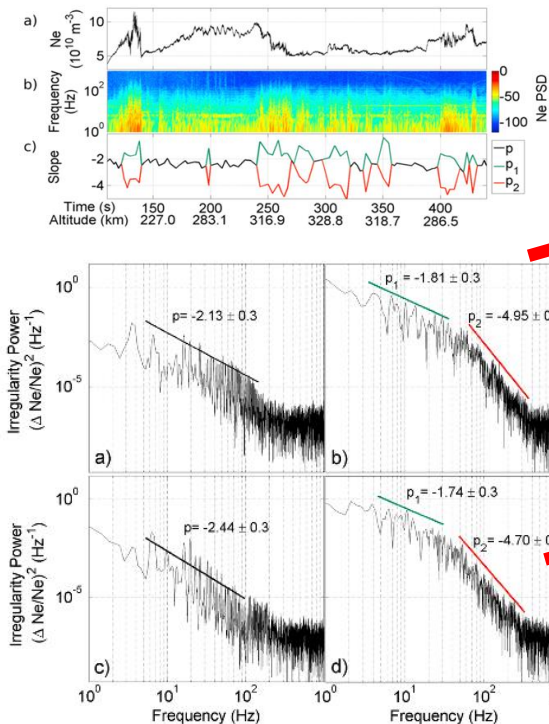
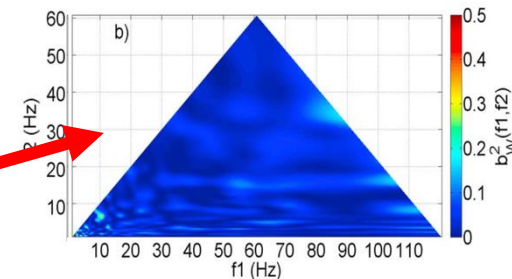
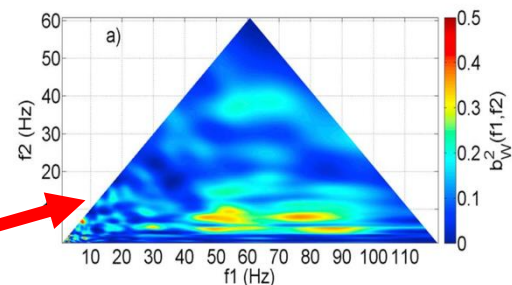
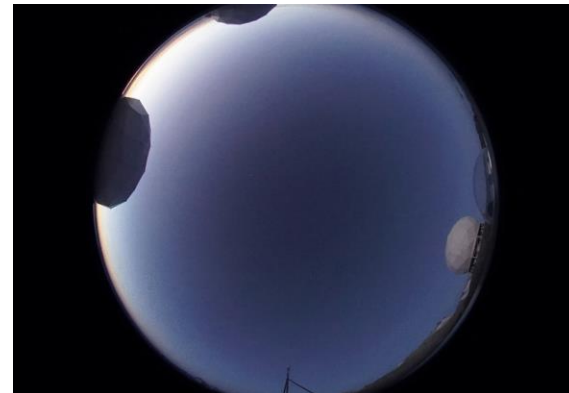


Figure 2. Power spectra and the fits of the slopes for (a) $t_{\text{of}} \in (271.5, 273.5)$ s just after strong fluctuations with no significant precipitation, (b) $t_{\text{of}} \in (265, 267)$ s for strong fluctuations with no significant precipitation, (c) $t_{\text{of}} \in (425, 427)$ s just before strong fluctuations with a significant electron precipitation, and (d) $t_{\text{of}} \in (428, 430)$ s for fluctuations with precipitating electrons. For visualization, the fits are shifted above the data.



Spicher et al. *JGR* 120, 10959, 2015

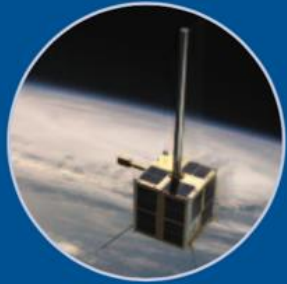
- University Center in Svalbard (UNIS); Kjell Henriksen Observatory (KHO)
- University of Bergen (UiB)
- UiT The Arctic University of Norway (UiT)
- University of Oslo (UiO, ionosphere, space, and solar); Troll Ionospheric Observatory
- Norwegian University of Science and Technology, NTNU
- Tromsø Geophysical Observatory (TGO)
- Norwegian Centre for Space Weather (NOSWE)
- Norwegian Mapping Authority (NMA, Kartverket)
- Meteorological Institute (MET)
- Norwegian Space Agency
- Andøya Space
- Industry
- Governmental Agencies
- ...



Aurora australis, Troll, UiO



Bifrost 3D simulation, RoCS, UiO



Source: NRS

- 1) Oil and gas companies : navigation, positioning, exploration
- 2) Aviation : HF communication and GNSS
- 3) Maritime sector: HF communication and GNSS
- 4) Power grid operators: preparedness and GNSS timing
- 5) Satellite operations
- 6) Constructions and field operations: GNSS and communication
- 7) Tourism industry – Aurora

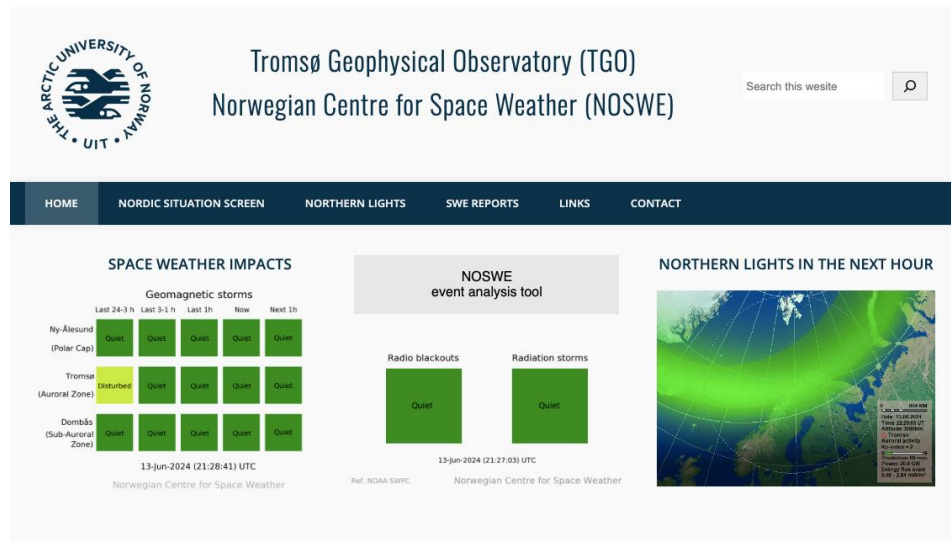
Established in collaboration with the Norwegian Space Agency in 2014.

RWC – ISES since 2019.

Provides picture of conditions in the Arctic (Nordic Situation Screen).

Real time data and forecasts:

- Aurorae & Geomagnetic Field
- Ionospheric Conditions
- Sun and Solar wind
- Event analysis



ISES – International Space Environment Service
Regional Warning Center in Norway

Tromsø Geophysical Observatory

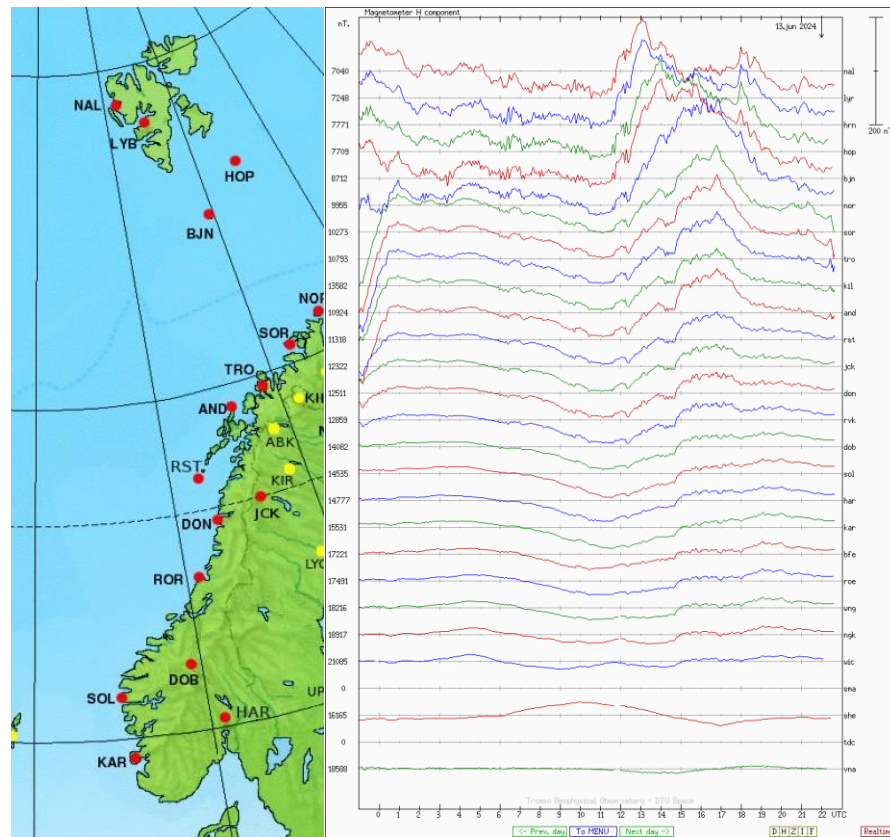


Provides monitoring of geomagnetic conditions. 20 magnetometers across Norway.

Ca. 12000 users and 600 000 magnetograms downloaded per week.

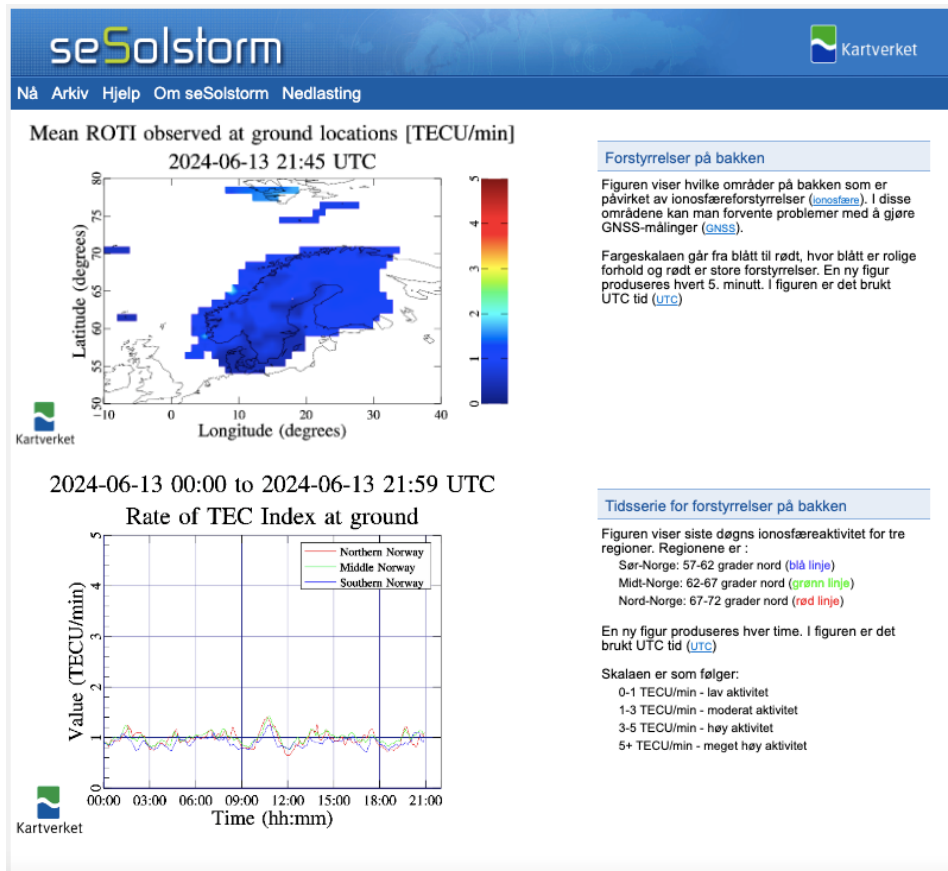
Data products for use for geological surveys and undersea drilling / offshore industry.

Digisonde in Tromsø – ionosonde data from 1980 on the portal. Historical data since 1932.



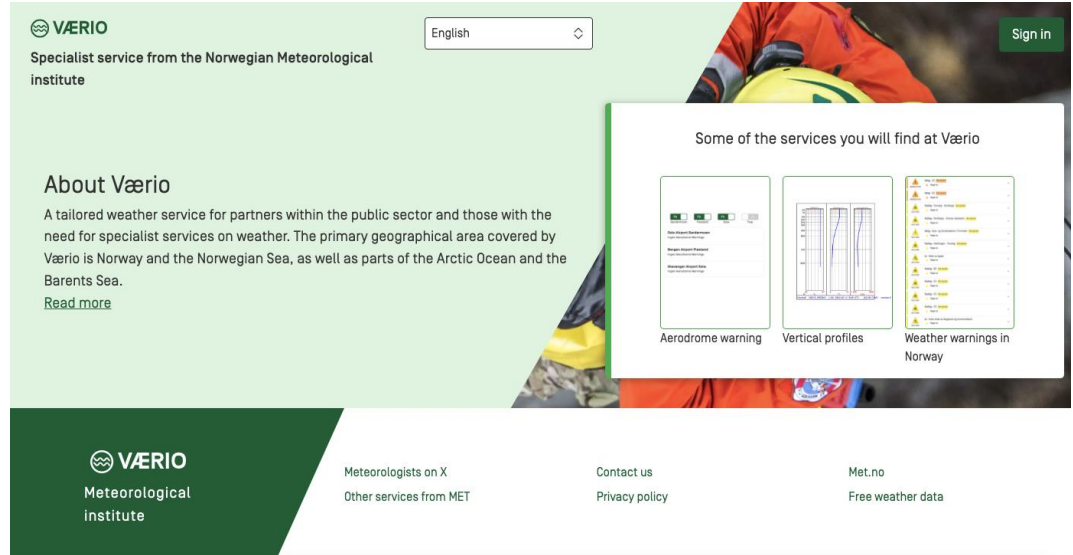
NMA is a supplier of the CPOS location service, used for mapping and surveying, in construction machinery, in the mining industry, in agriculture and forestry, nautical mapping (mm precision). 160 base stations in Norway.

The seSolstorm (“see the solar storm”) is an additional service that gives an overview of ionospheric conditions (ROTI and ROT) over Fenno-Scandia. Collaboration with Danmark, Finland, Sweden.



Værio.no portal has now a possibility of including space weather data from third parties in the specialised in the specialist service. e.g. GOES, magnetometer data, foF2 data, aurora forecast etc.

Description of consequences and level or risk.



The screenshot shows the Værio.no portal homepage. The header includes the Værio logo, the text "Specialist service from the Norwegian Meteorological institute", a language dropdown set to "English", and a "Sign in" button. The main content area features an "About Værio" section with a description of the service and a "Read more" link. A pop-up window titled "Some of the services you will find at Værio" displays three service categories: "Aerodrome warning", "Vertical profiles", and "Weather warnings in Norway". The footer contains the Værio logo, contact information, and links to "Met.no" and "Free weather data".

Værio
Specialist service from the Norwegian Meteorological institute

English

Sign in

About Værio

A tailored weather service for partners within the public sector and those with the need for specialist services on weather. The primary geographical area covered by Værio is Norway and the Norwegian Sea, as well as parts of the Arctic Ocean and the Barents Sea.

[Read more](#)

Some of the services you will find at Værio

Aerodrome warning

Vertical profiles

Weather warnings in Norway

Værio
Meteorological institute

Meteorologists on X
Other services from MET

Contact us
Privacy policy

Met.no
Free weather data

<https://xn--vrio-voa.no/>

Contribution to ESA Space Weather Portal

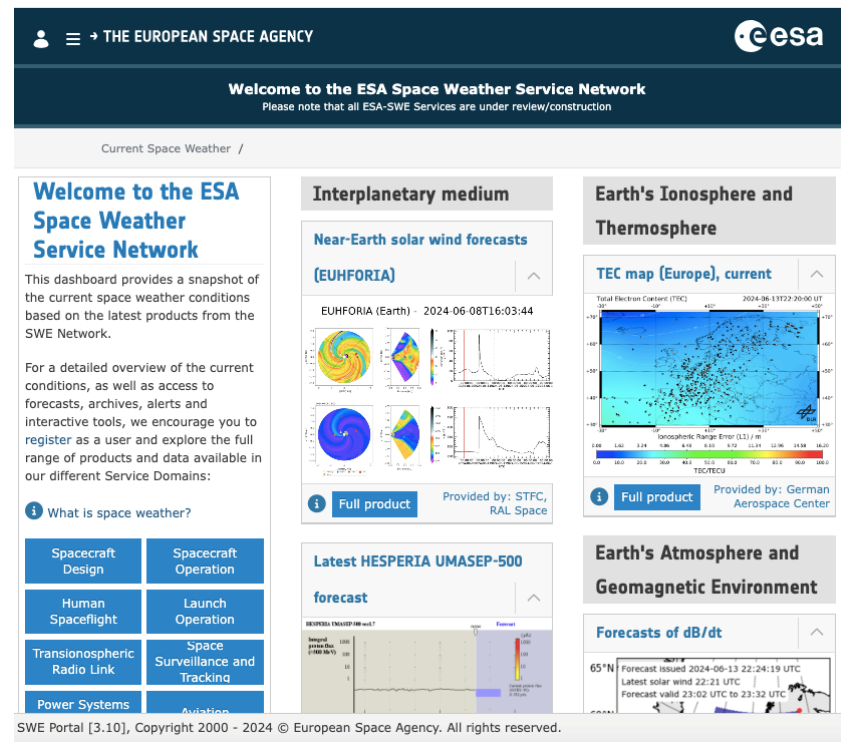


Norwegian Mapping Authority (NMA):
ionosphere monitoring.

Tromsø Geophysical Observatory:
magnetometer data to several products
related to Northern Europe.

University of Oslo, NMA, GMV: nowcasting
and forecasting ionospheric conditions
related to scintillations (to be deployed).

University of Bergen: contribution to
Geomagnetic Expert Service Centre.



Other developments and actions

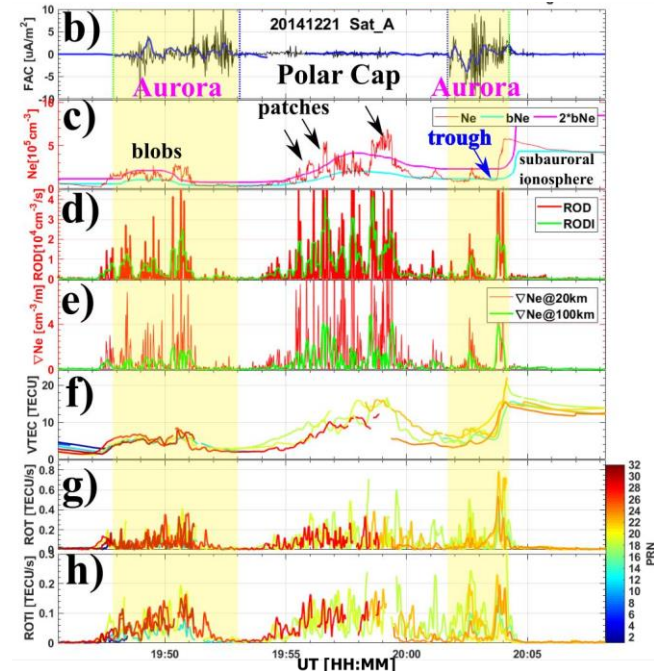


Development of data products and models.

Prototypes for forecasts of ionospheric irregularities: Swan, Forswar (ESA funded projects).

Local and global models for ionospheric variability based on satellite data and controlled by geophysical proxies (e.g., Swarm-VIP models), magnetic field, global models for ionospheric currents: Average Magnetic Field and Polar Current System (AMPS).

Maintenance of networks of instruments: University of Bergen (GISTM), University of Oslo (GISTM and All Sky Cameras) and others.



swarm Data, Innovation, and Science Cluster

Data product example:

IPIR: Ionospheric Plasma Irregularities by Swarm

Consolidating the community towards developing a national 24/7 capacity in space weather alerts, alerting lines, and response.

Main actors have now formed a committee to establish the integrated National Space Weather Forecasting service.



credits: T Abrahamsen, Andøya Space

Thank you!

Acknowledgments (R&D funding):



E.g., European Union's Horizon 2020 research and innovation programme: ERC Consolidator Grant agreement No. 866357, POLAR-4DSpace