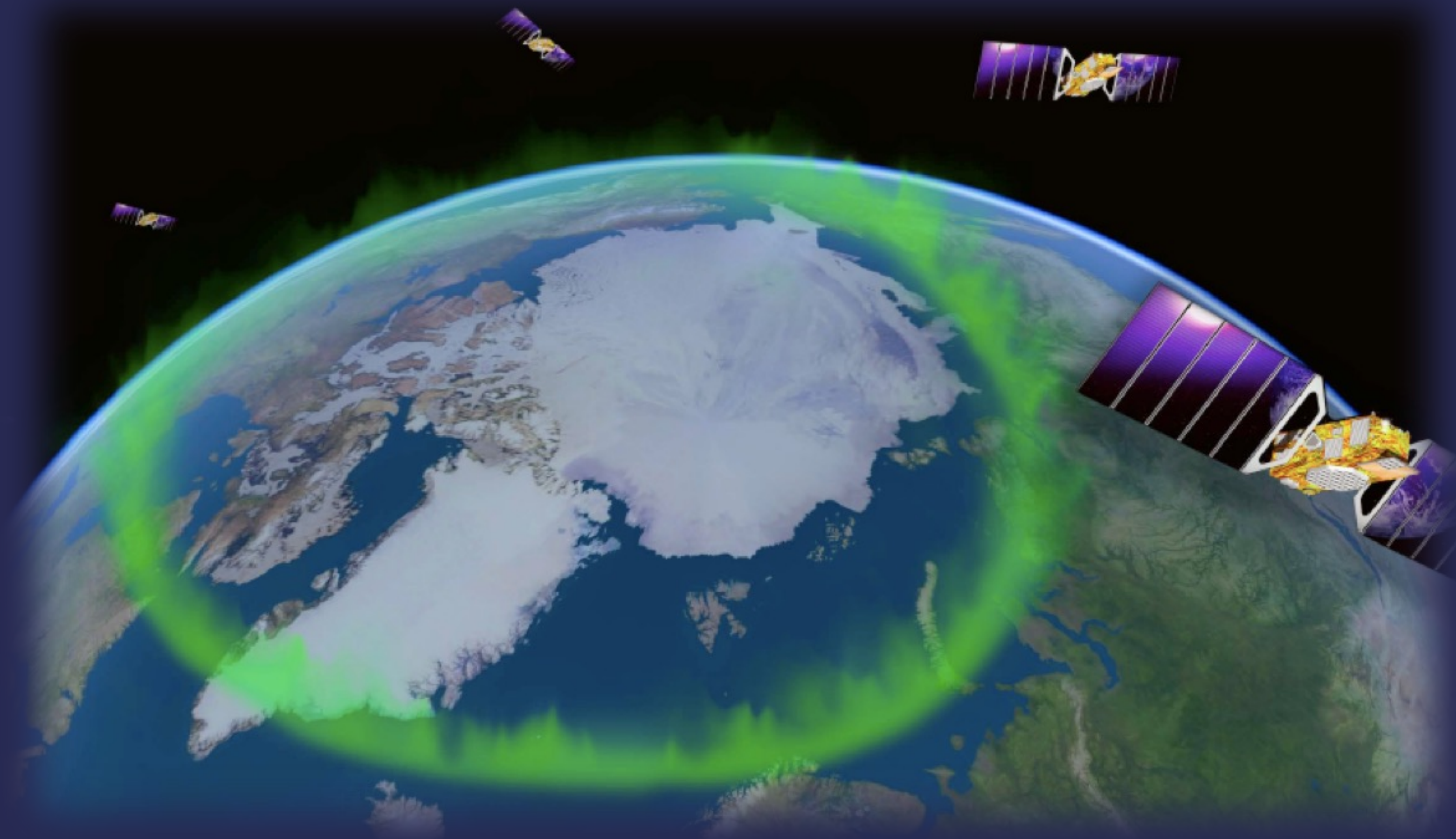
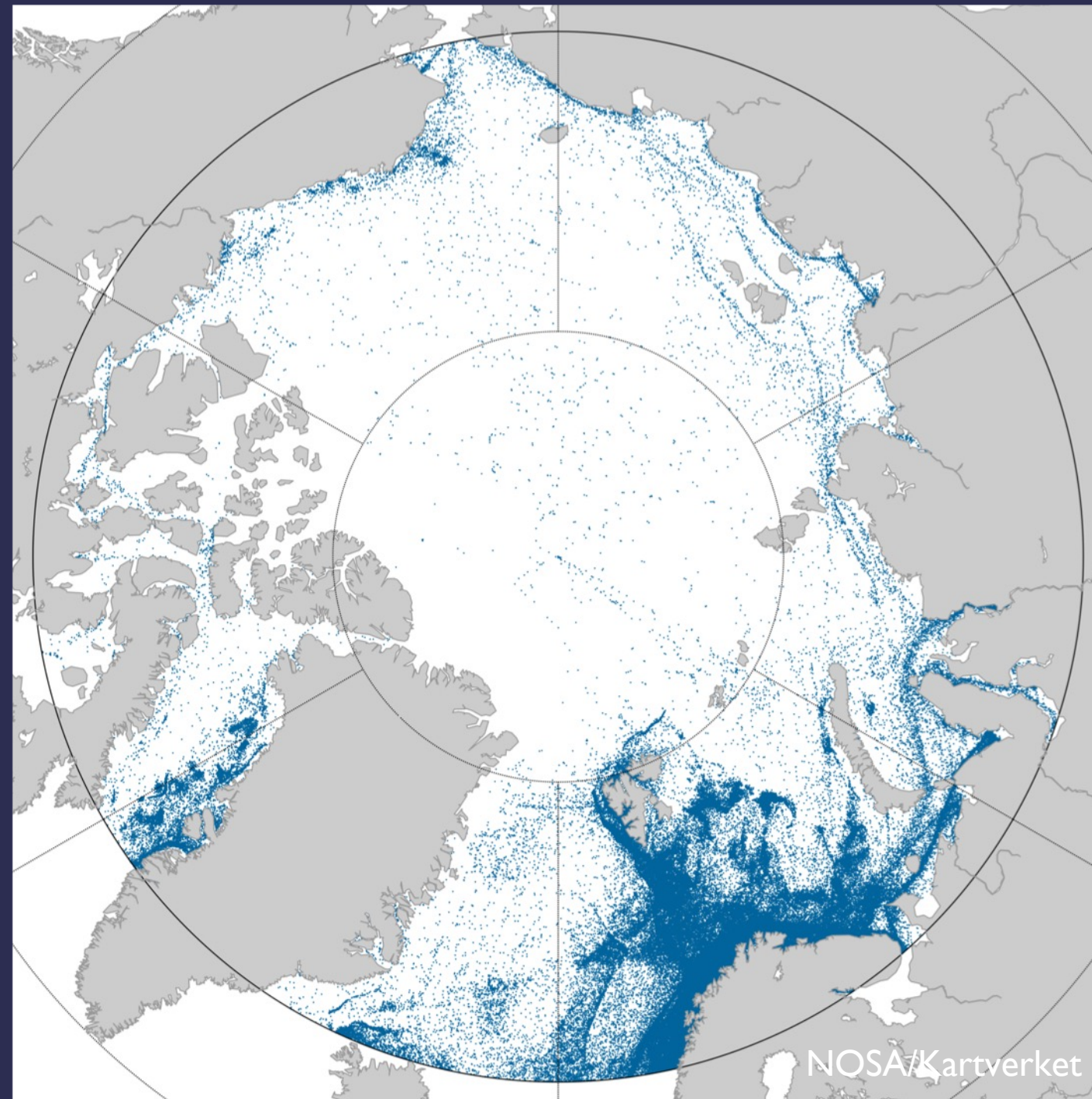


Norwegian Space Weather Activities in the Arctic

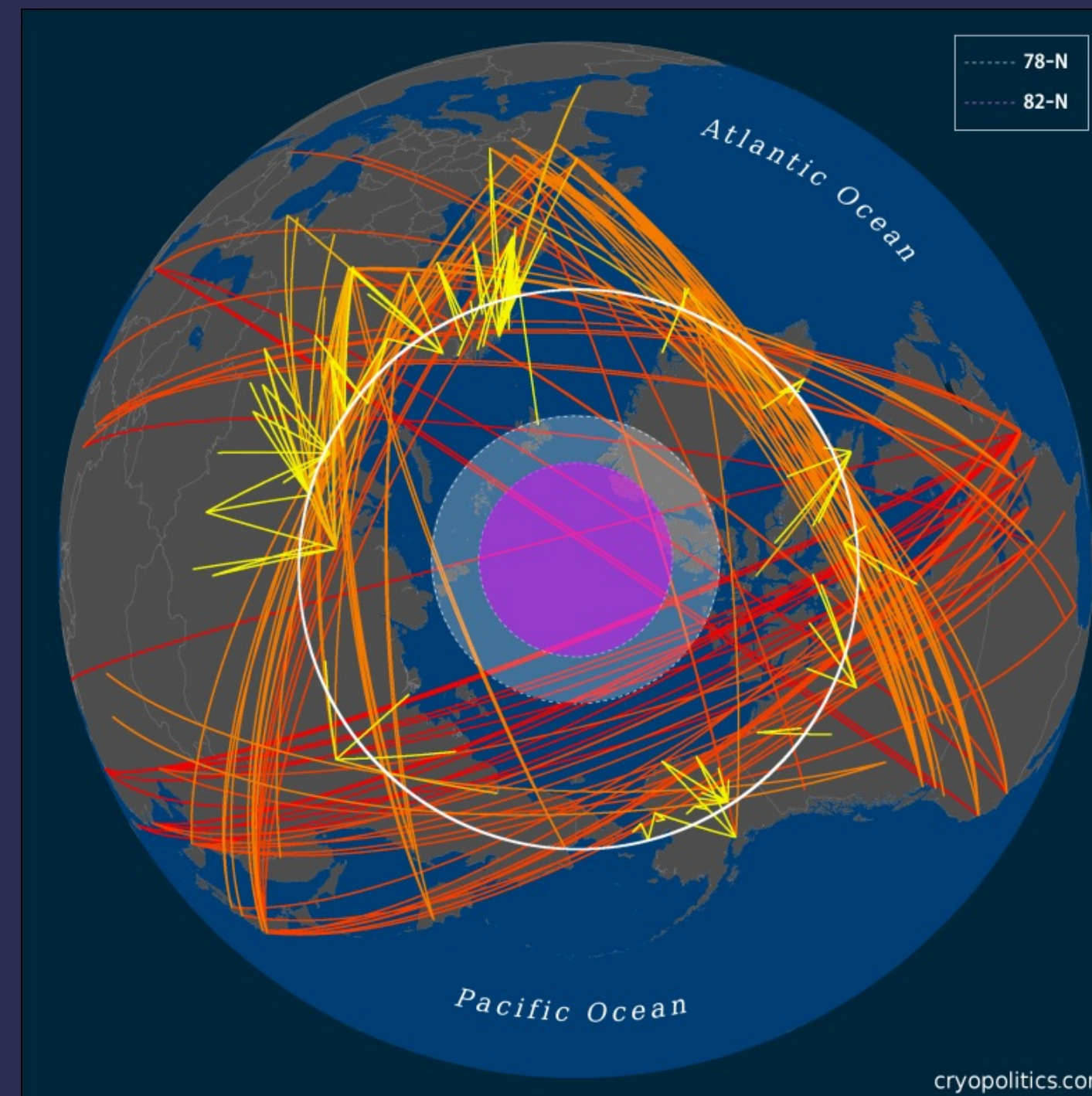


Space Weather in the Arctic

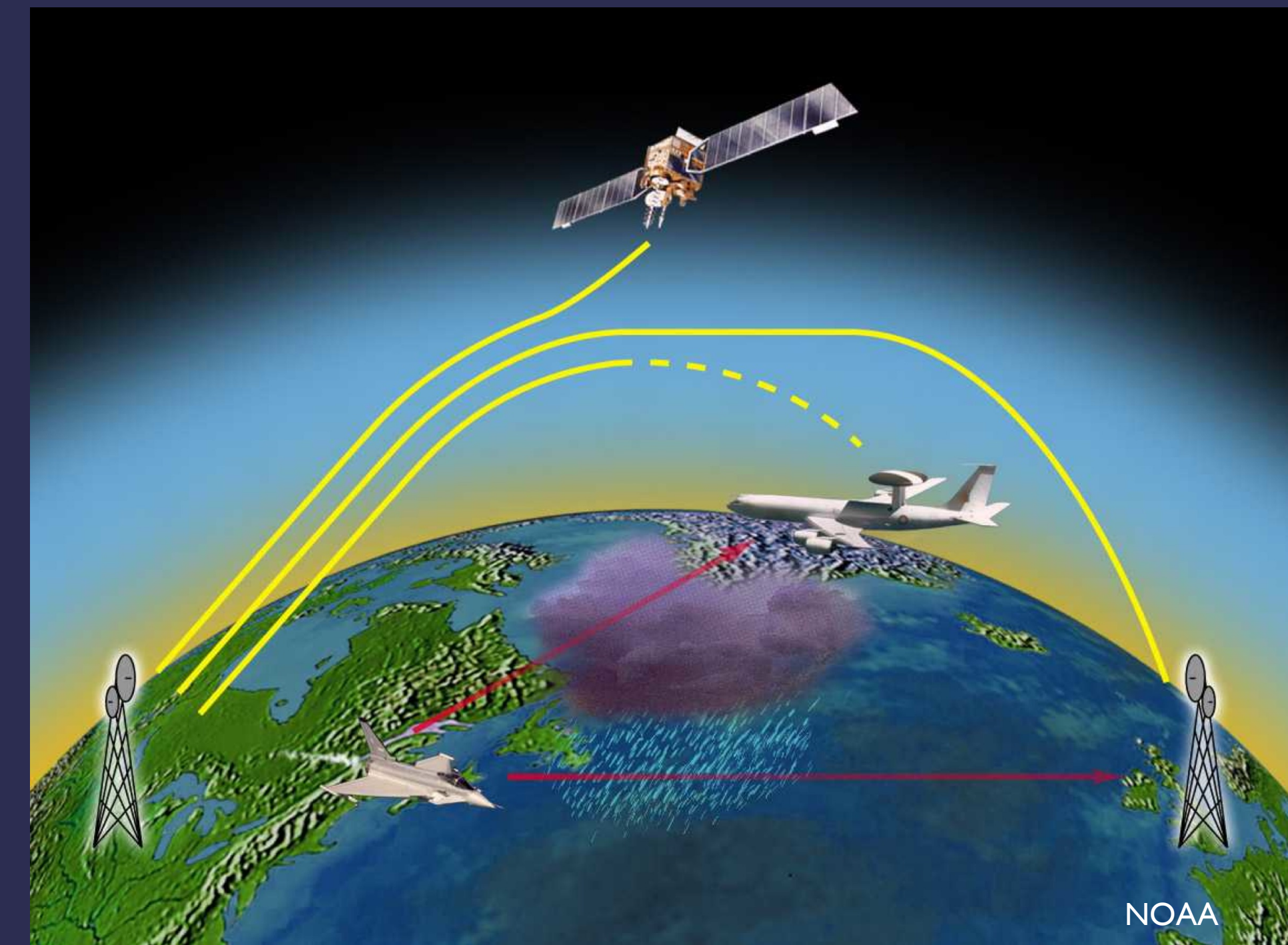
Space weather see no national boundaries - but in the Arctic there are some additional challenges



Ship traffic from AisSat-1



Polar flights

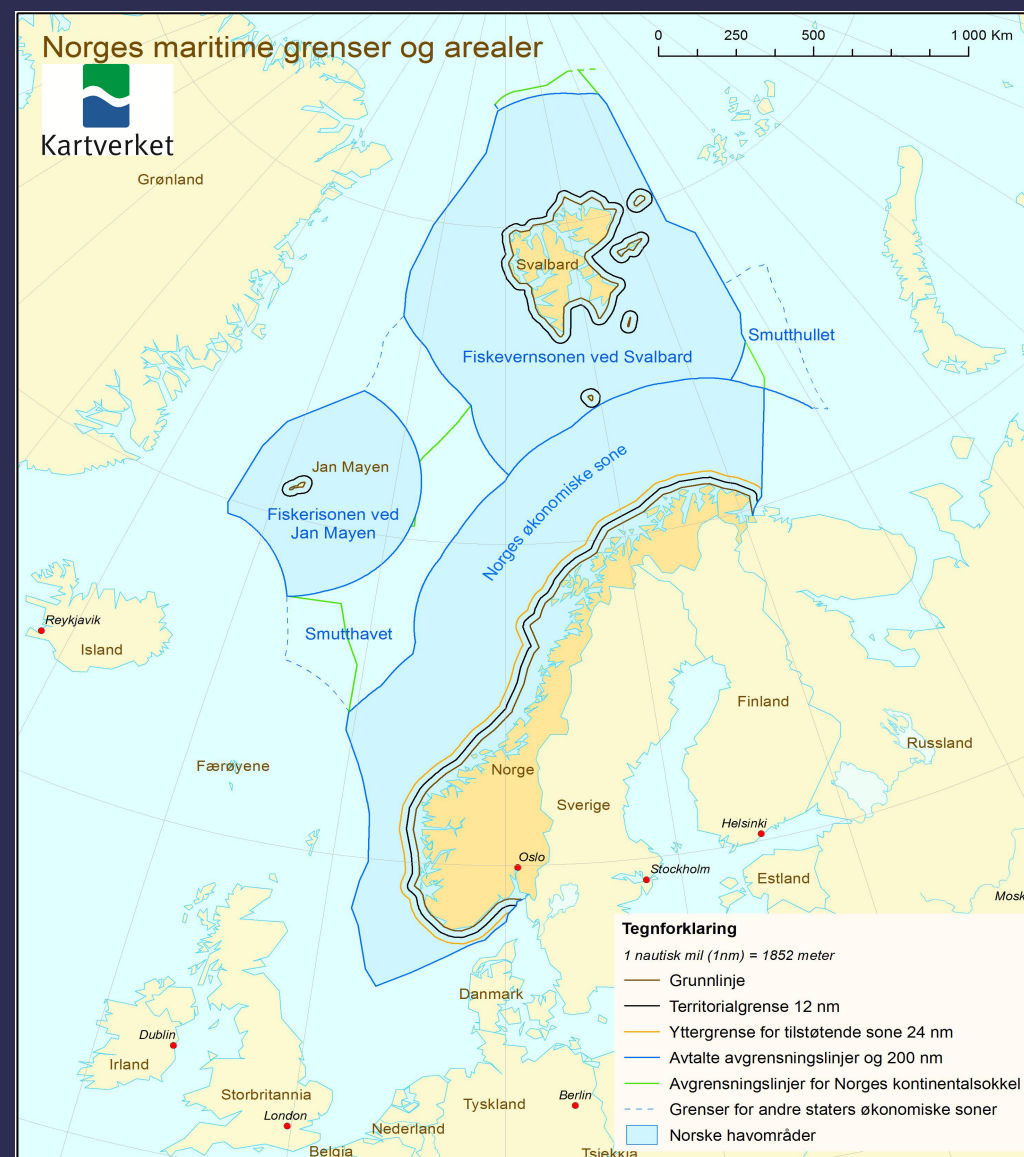


Radiocommunication

With increases activity in the Arctic region space weather will be an important part of Norway's role to ensure both safe navigation and good communication in these vast areas.

The need for reliable space weather forecast of high quality is necessary and highly wanted among Norwegian users.

Space Weather in the Arctic



Norway has

- operative demands and responsible for Search & Rescue in a sector up to the North Pole.
- interesting space weather infrastructure.
- several research groups on space weather (UiO, UiB, UiT, UNIS etc.)

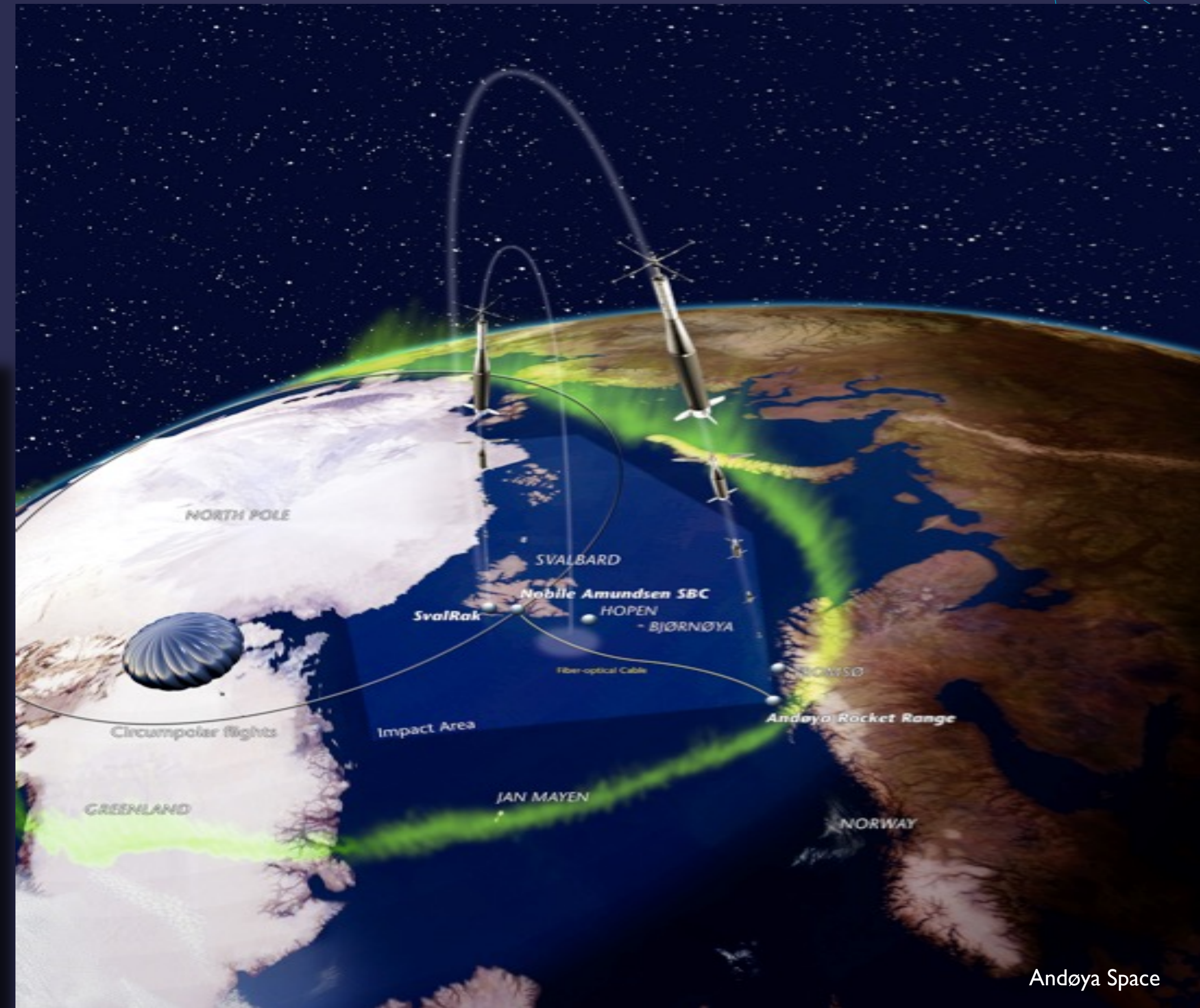
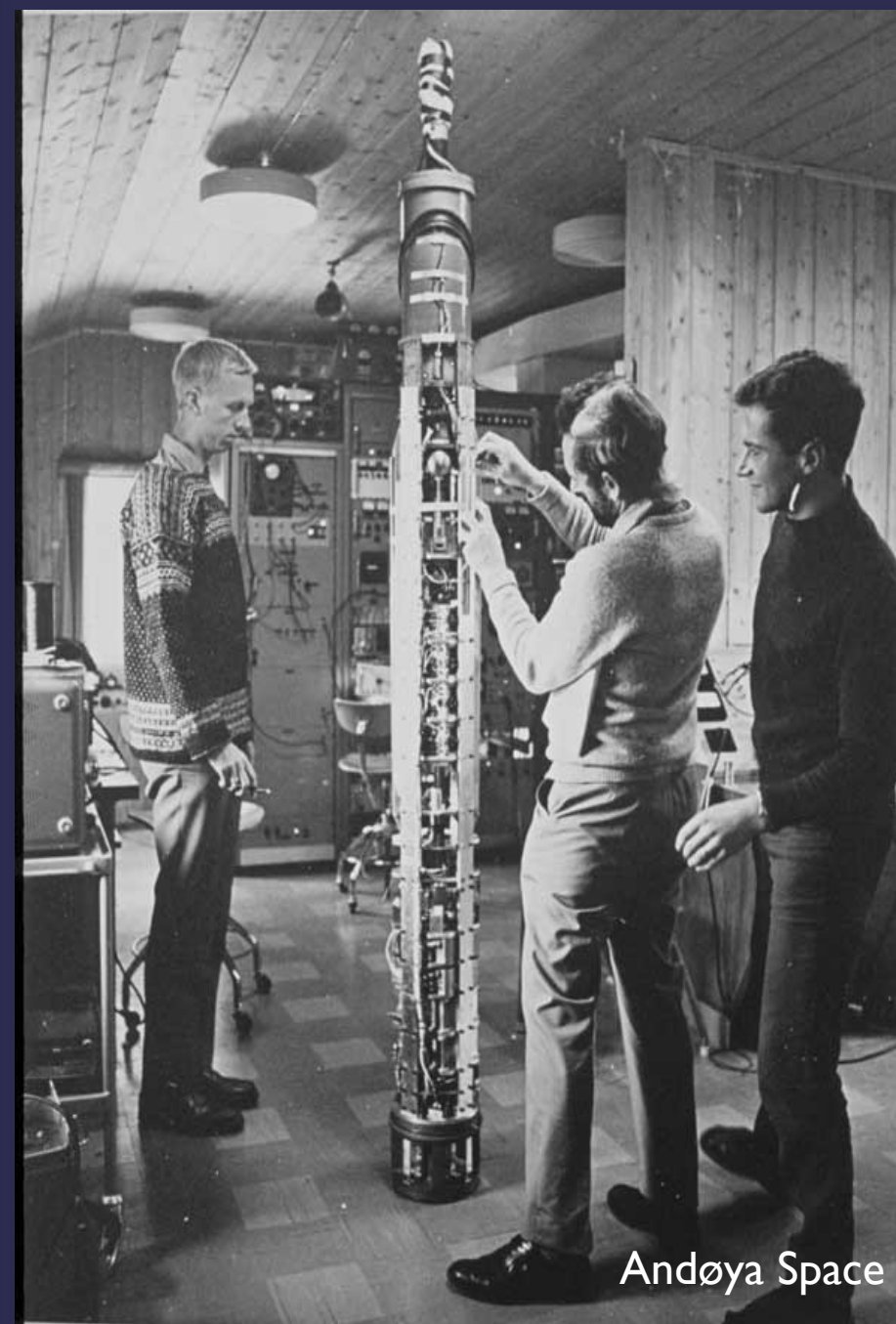
Long Traditions in Sun-Earth Connection

- Due to its northern location
 - Observations of the Aurora before 1900
 - Birkelands innovating aurora experiment (1886)
 - National solar observatory in 1950.
 - Early concerns about effects on military radio communication



Kristian Birkeland (1867 - 1917) - the first space scientist

The very start of space research - Andøya Space



Ferdinand from Oksebåsen, Andøya 18 august 1962

Andøya Space

A cost effective entrance to space



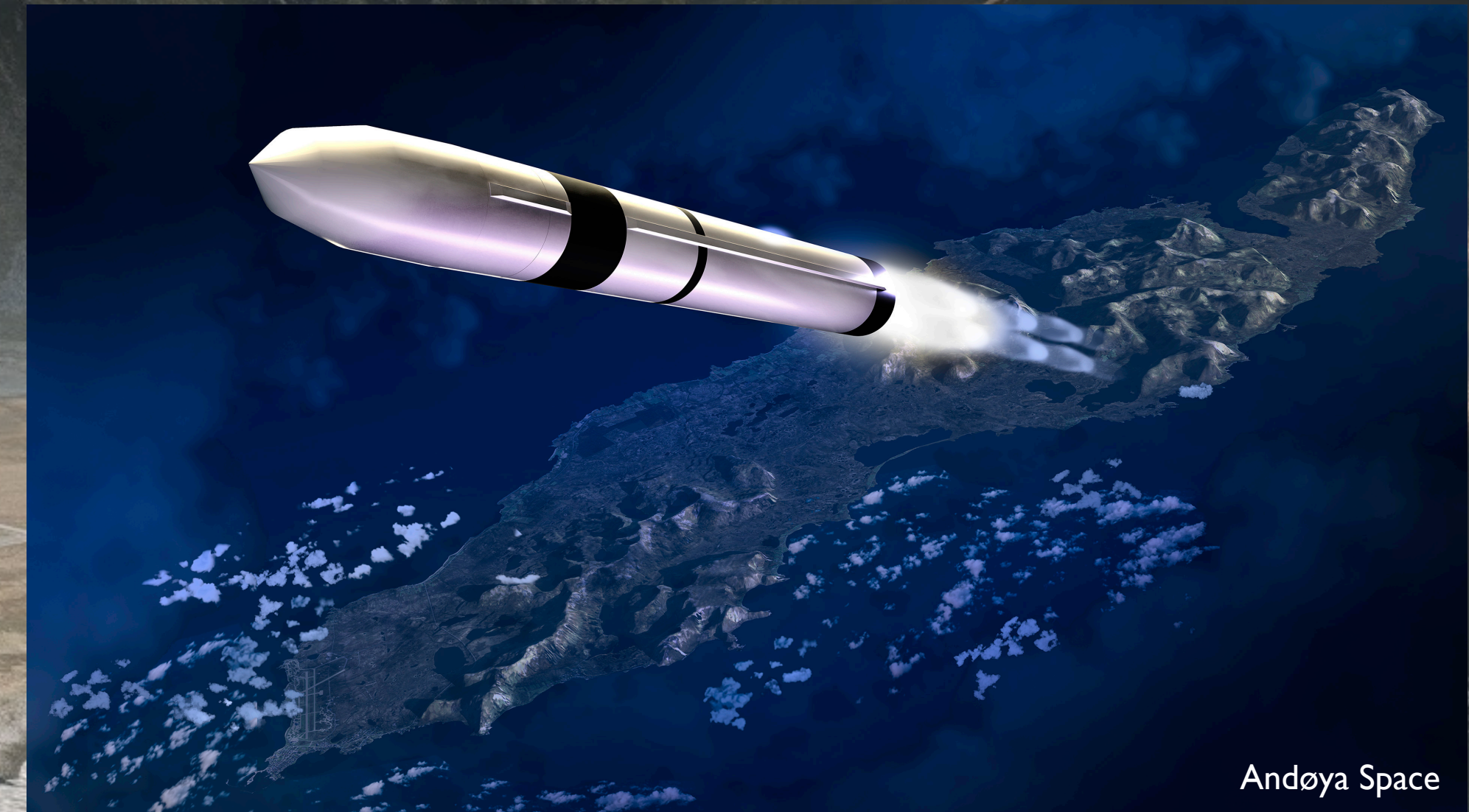
NASA successfully launched the Auroral Zone Upwelling Rocket Experiment or AURE mission on April 5 from the Andøya Space Center in Norway.

Andøya Space

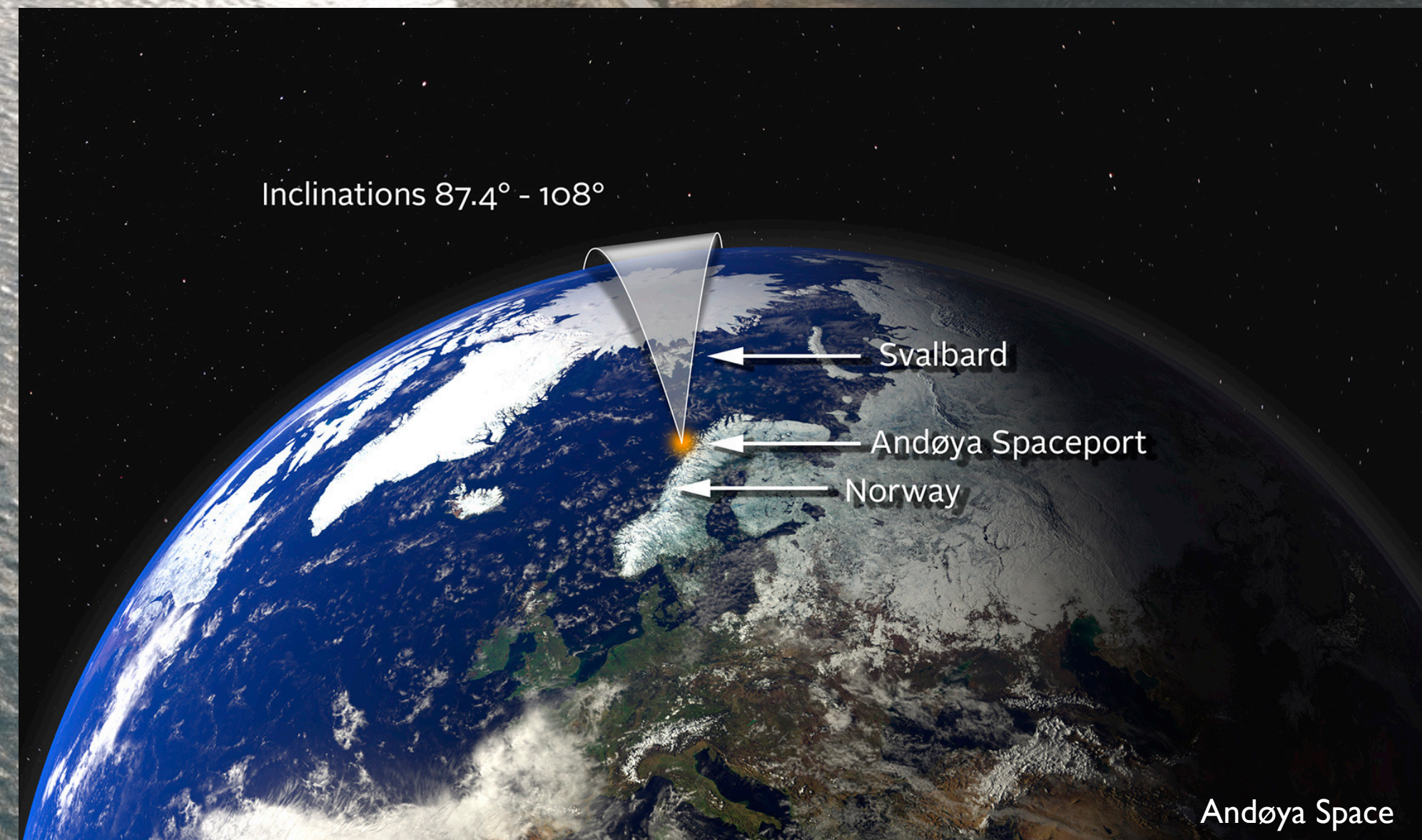
© Yang Suite

Andøya Space

Main users: NASA, JAXA, DLR, Australia, and Norway



Andøya Space



Andøya Space

Svalbard - 79 degree North



Kjell Henriksen Observatory

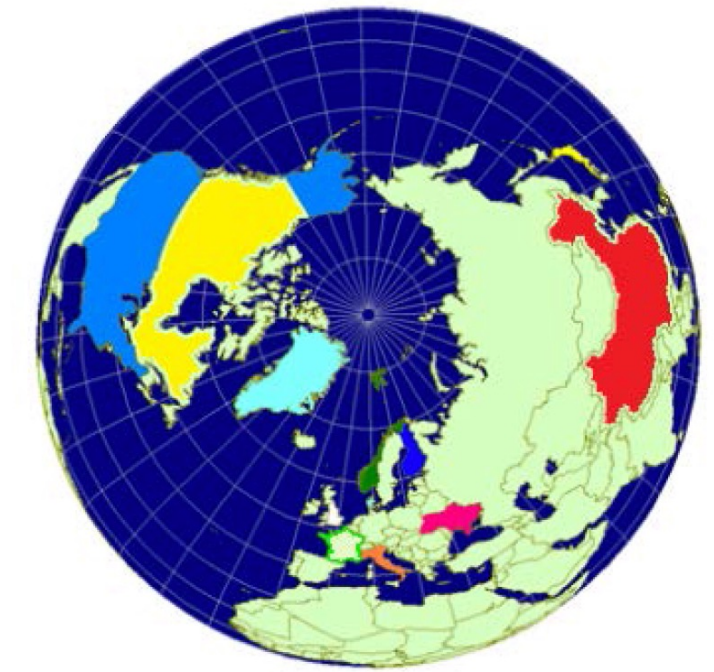
The world largest optical aurora observatory



KHO

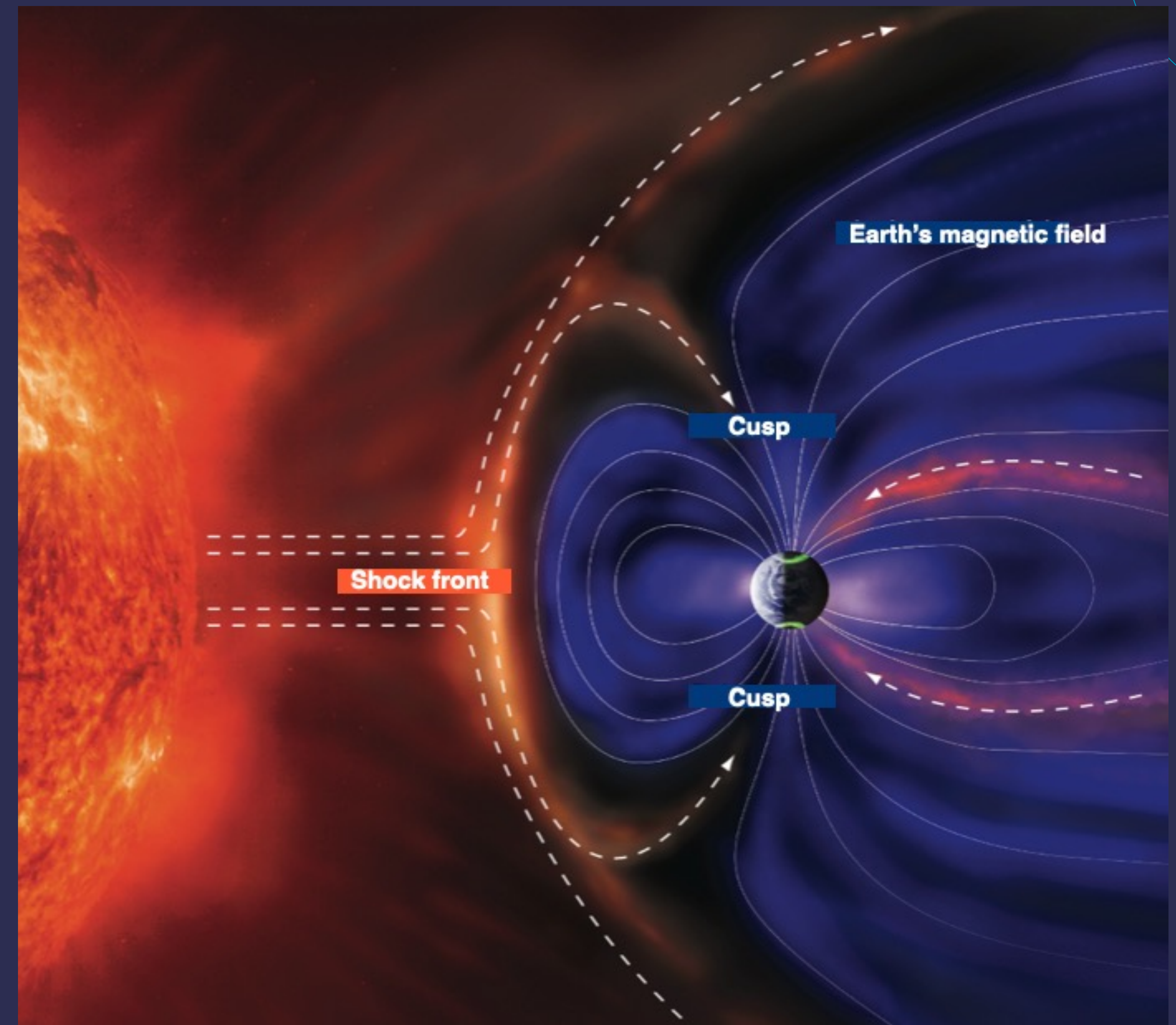
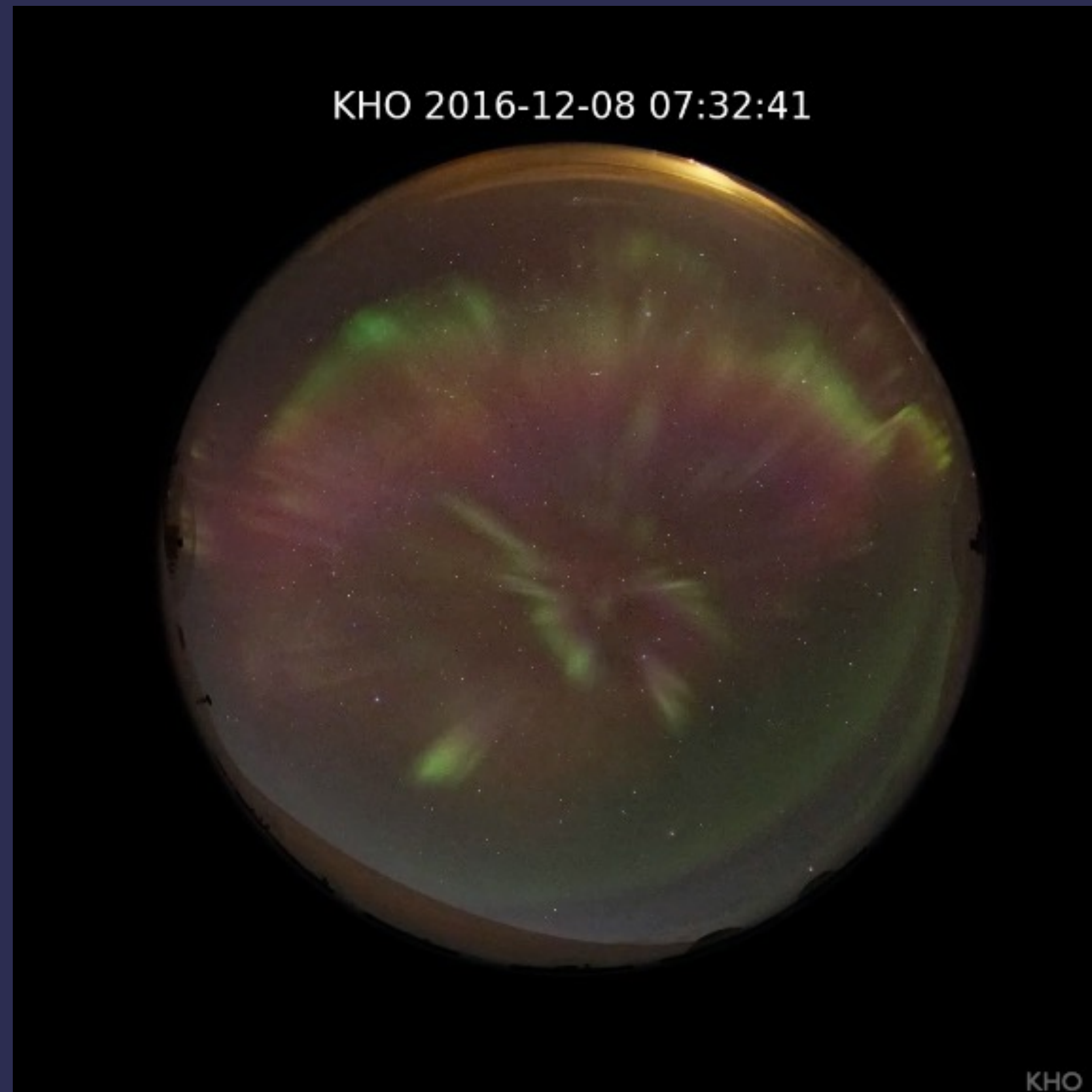


1. University Centre in Svalbard
2. University of Oslo
3. University of Tromsø
4. University of Bergen
5. University of Alaska, Fairbanks
6. University College London
7. University of Wales Aberystwyth
8. University of Southampton
9. University of New Hampshire
10. University of Rome
11. University of Calgary
12. Augsburg College
13. Tohoku University
14. National Institute of Polar Research Japan (NIPR)
15. Finnish Meteorological Institute (FMI)
16. Danish Meteorological Institute * (DMI)
17. Institute of Radio Astronomy (Ukraine)
18. The Polar Institute of China (PRIC)
19. NORSAR
20. National Institute for Aeronautics (LAPAN)
21. Technische Universität Berlin (TU)
22. Korea Polar Institute (KOPRI)
23. Kongsberg Satellite Service (KSAT)
24. University of Madrid (UCM)



KHO

Kjell Henriksen Observatory



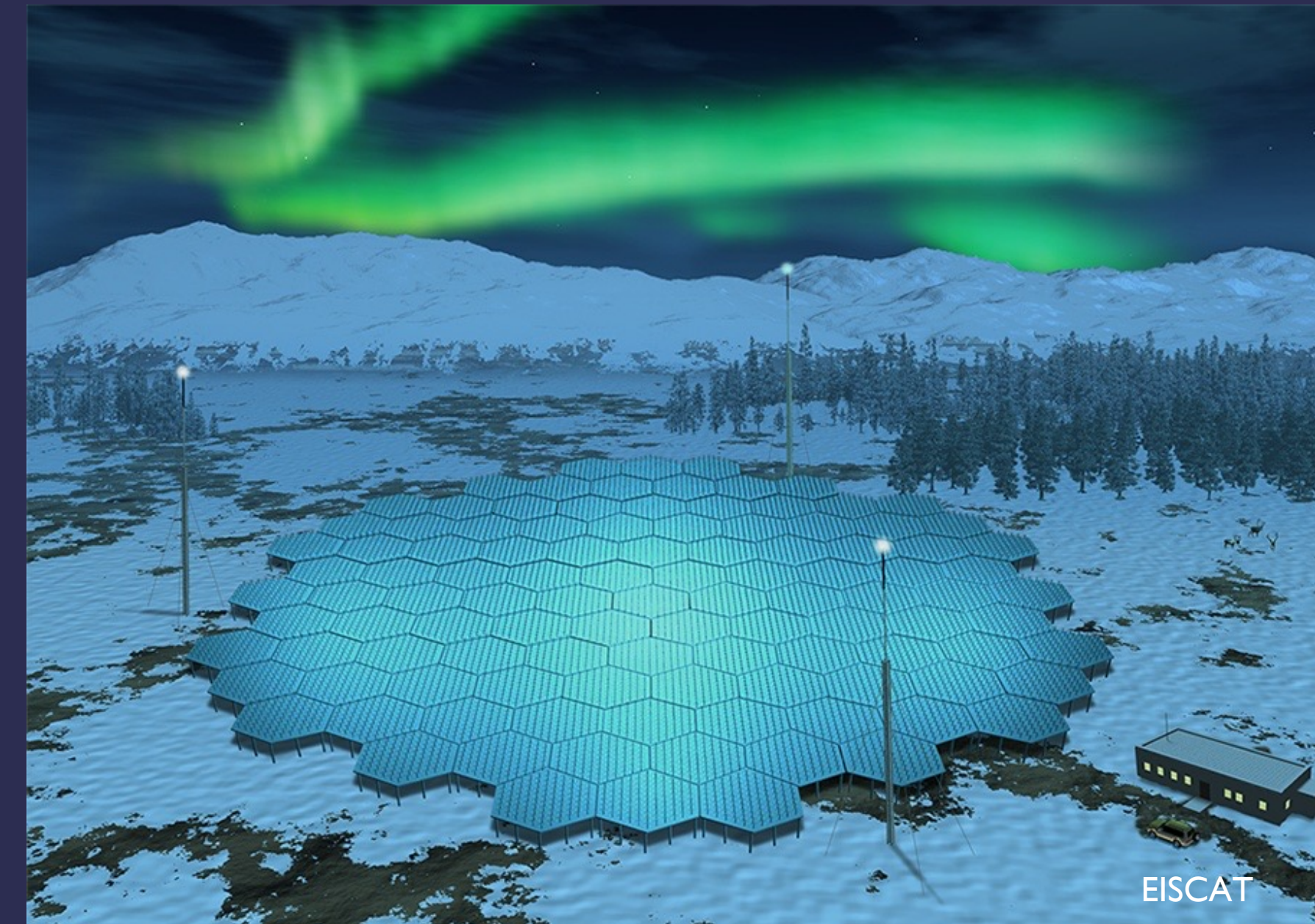
EISCAT Svalbard Radars

EISCAT (European Incoherent Scatter) antennas in Norway, Sweden and Finland. Studies the interaction between the Sun and the Earth (ionosphere, plasma clouds etc.) Also useful for tracking space debris.



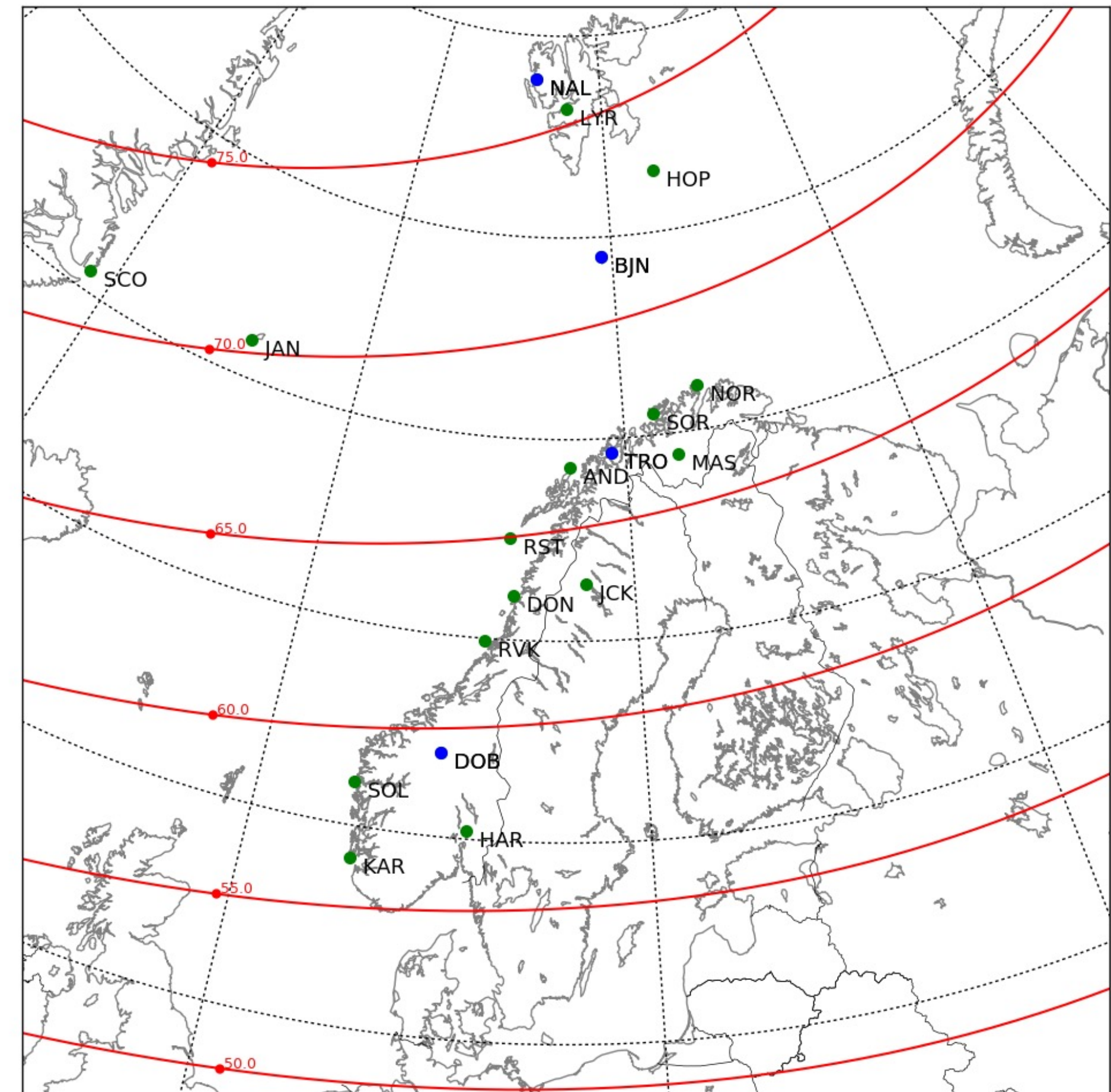
EISCAT 3D

- Will be the largest and most advanced radar system ever built
- Phased array with 3 sites - over 50,000 antenna in total!
- Started to build in 2017, operational in 2023
- Looks at large parts of the sky simultaneously and can scan extremely fast (ms)
- **Will measure an entire 3D volume of the ionosphere in unprecedented detail!**



Tromsø Geophysical Observatory (TGO)

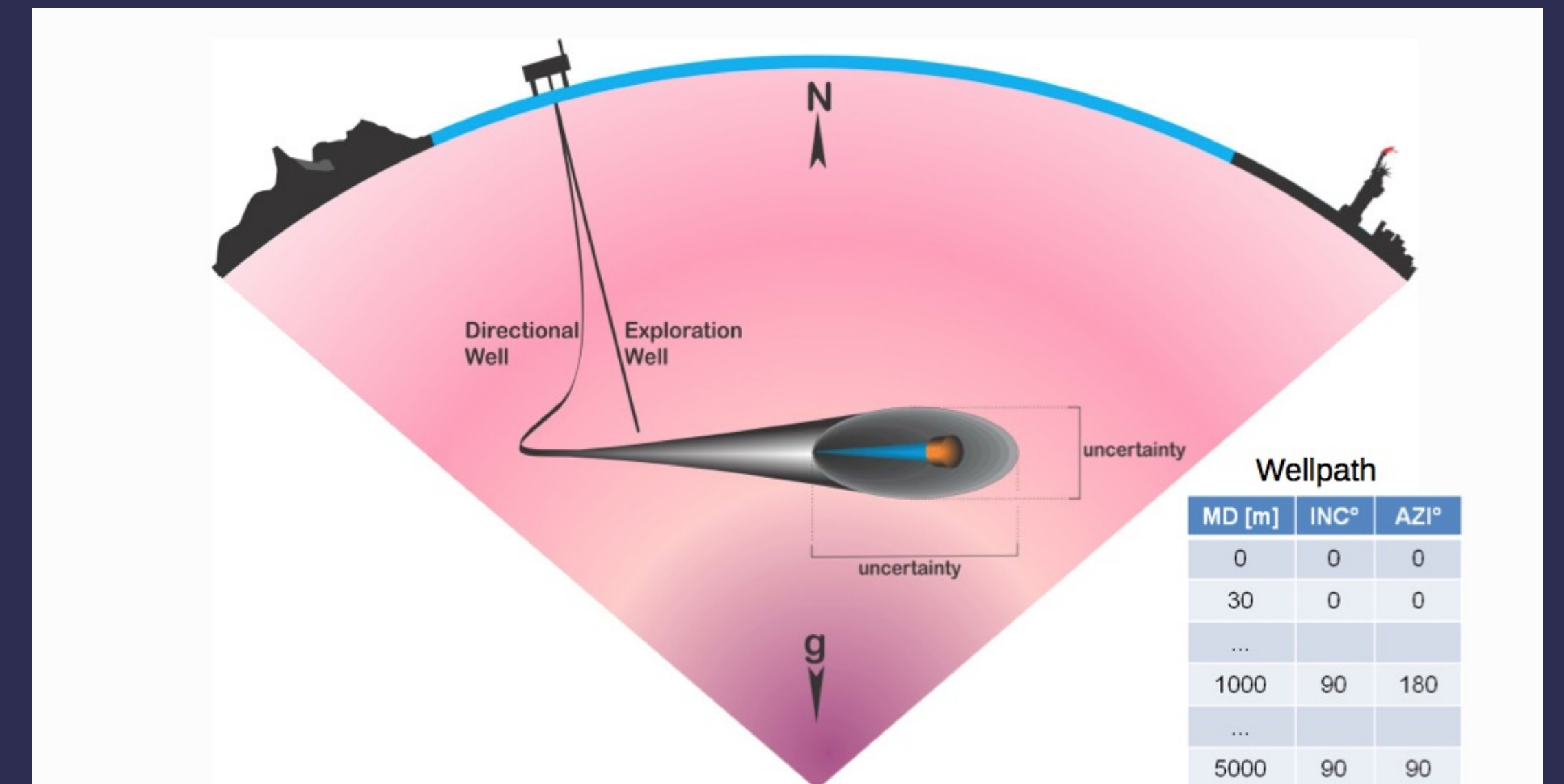
Part of the University of Tromsø. Their main responsibility is to maintain observational time series (1928/32 – future) of the geomagnetic field in Norway (magnetometers).



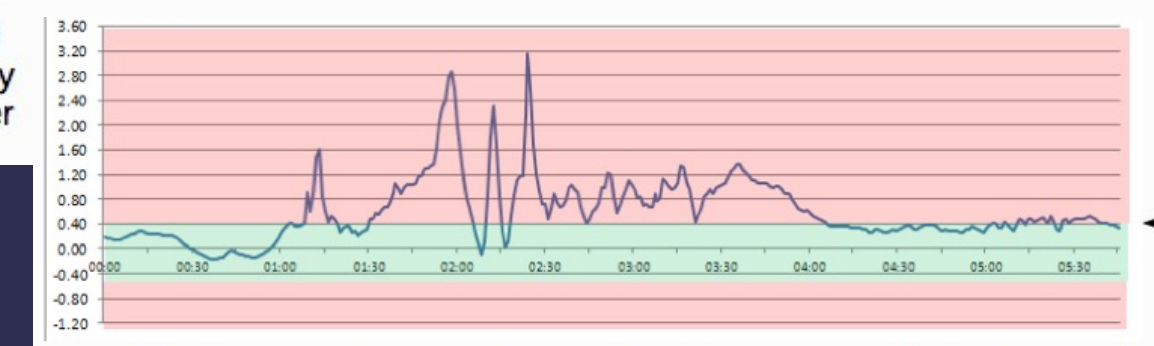
Directional drilling

Oil industry relies on geomagnetic maps to guide the drill and monitor the well direction.

UiT/TGO delivers “real-time” magnetometer data to the drilling companies to either correct or extend the time they can operate.

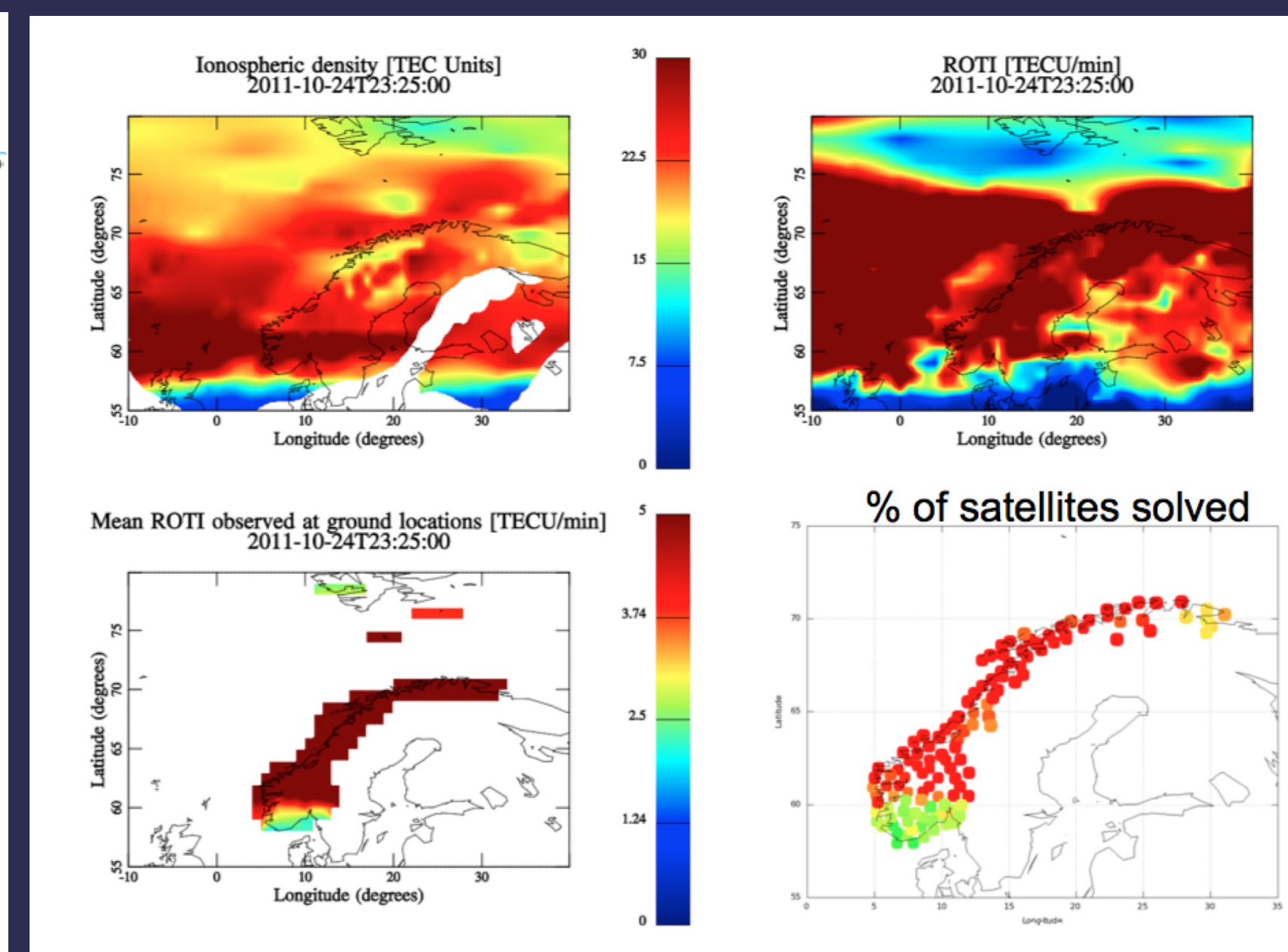
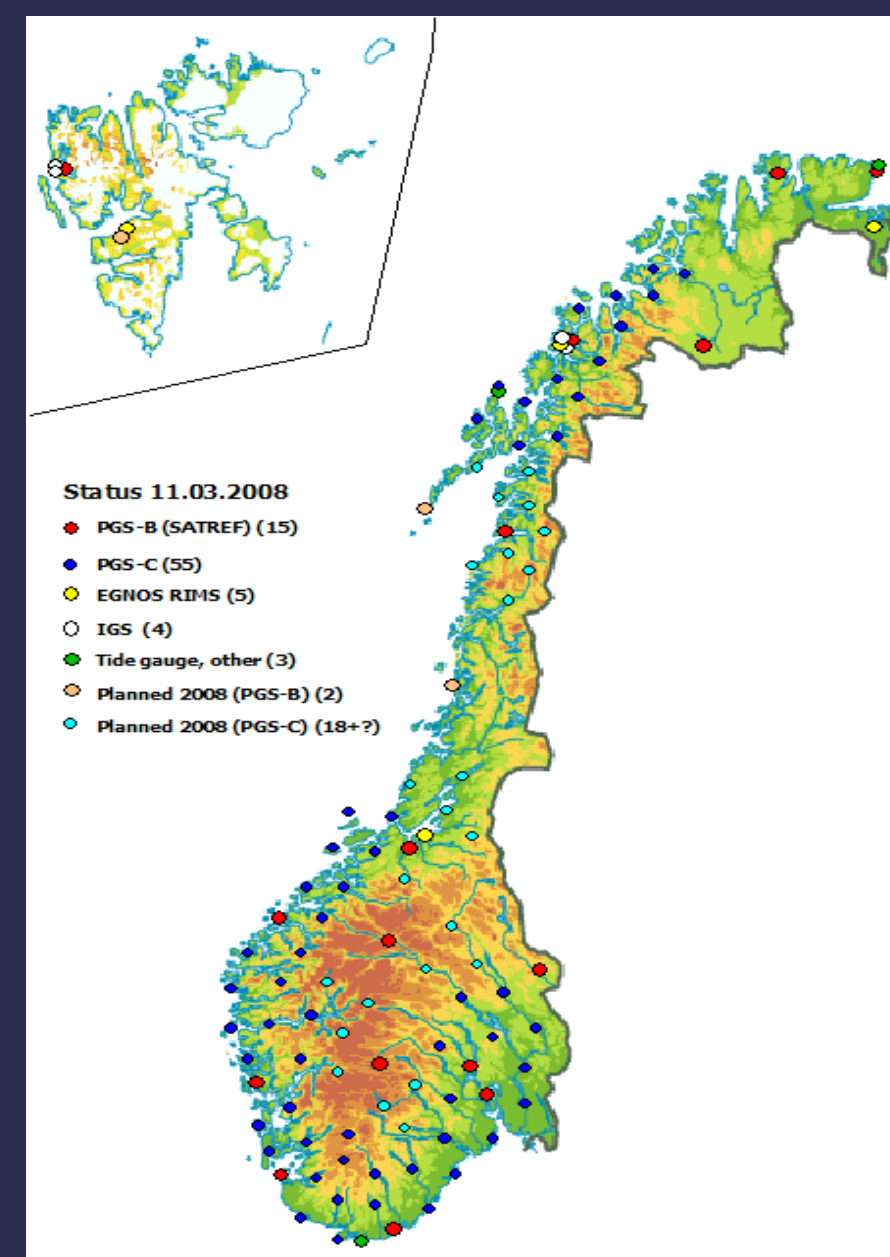


Inge Edvardsen
PhD Candidate/Survey
Management Engineer



The Norwegian Mapping Authority

- In Norway the Norwegian Mapping Authority has the national responsibility for providing corrections to GPS users.
- They monitor the Sun and have developed an ionospheric model that improve these corrections and warn their customers.



<http://sesolstorm.kartverket.no>



The Scandinavian Power Grid

Statnett, the Norwegian Power Grid Company, supervises and co-ordinates the operation of the entire Norwegian power system.

The have monitored GIC for about 15 years.

A few damages due to space weather has been reported.

New sea cables to electrify the oil/gas platforms can be a challenge.



Induced currents in power grids.

Introduction - The geomagnetic storm August 26th 2018 (2)



- At 05:26 AM, a 200 MVA transformer in Mid-Norway was tripped by differential protection (87T)
- From the fault records it was obvious that this was no normal internal transformer fault.
- We have seen such measurements a few times before and it was reason to suspect geomagnetic activity.
- A magnetometer located 50 km away confirmed the suspicion.

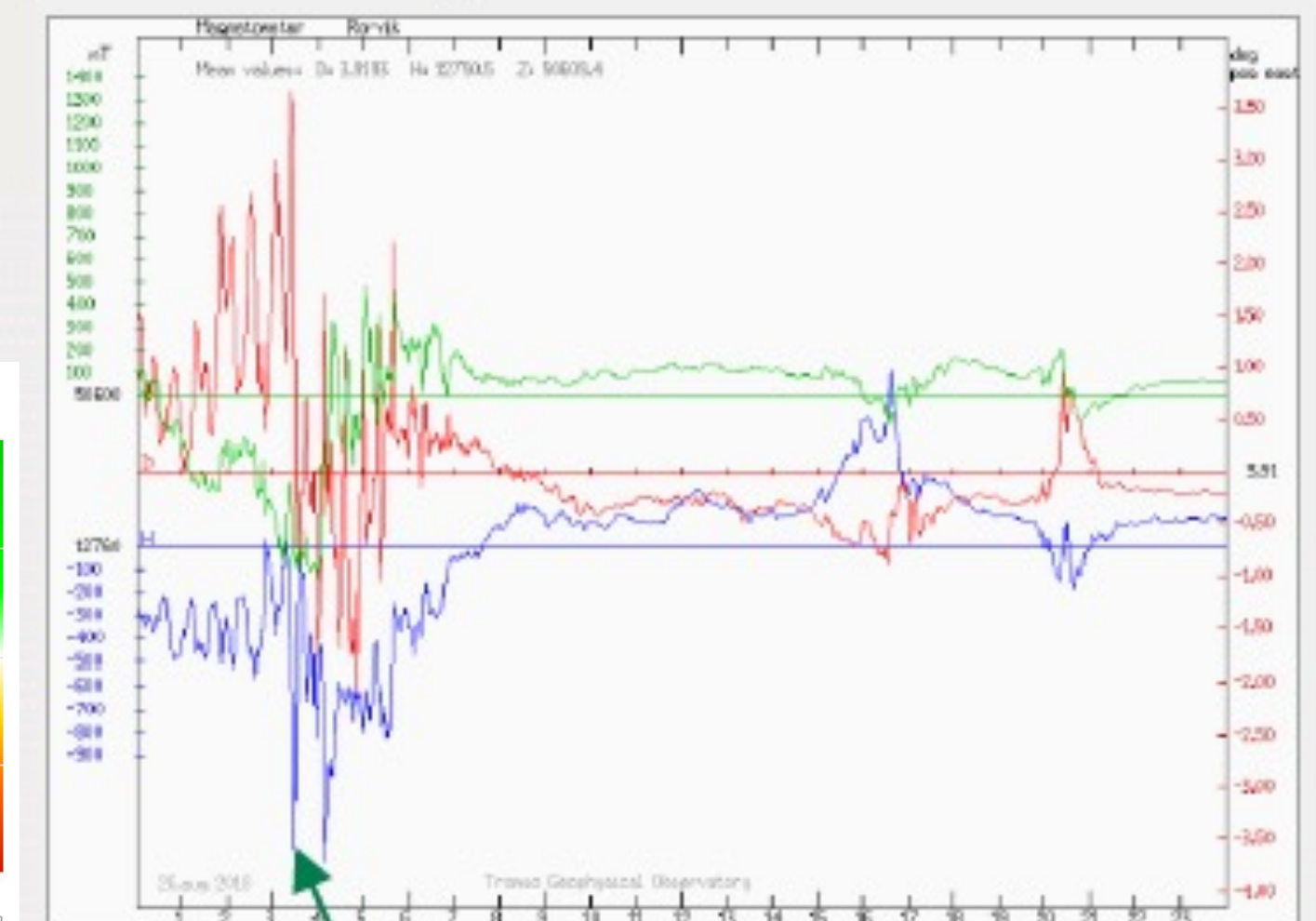
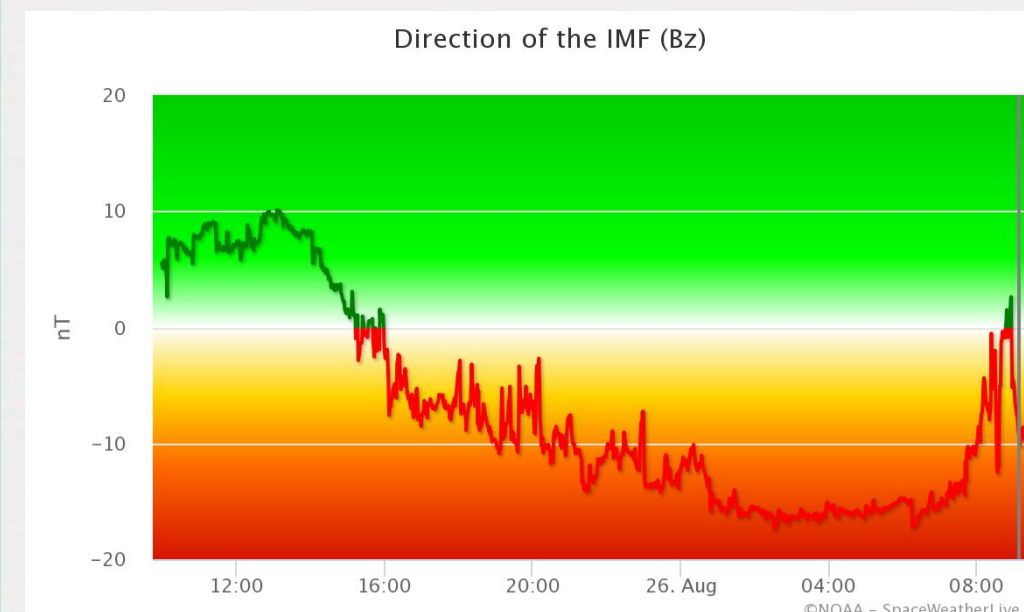
200MVA Transformer (420/66 kV)



Magnetometer recording August 26th 2018

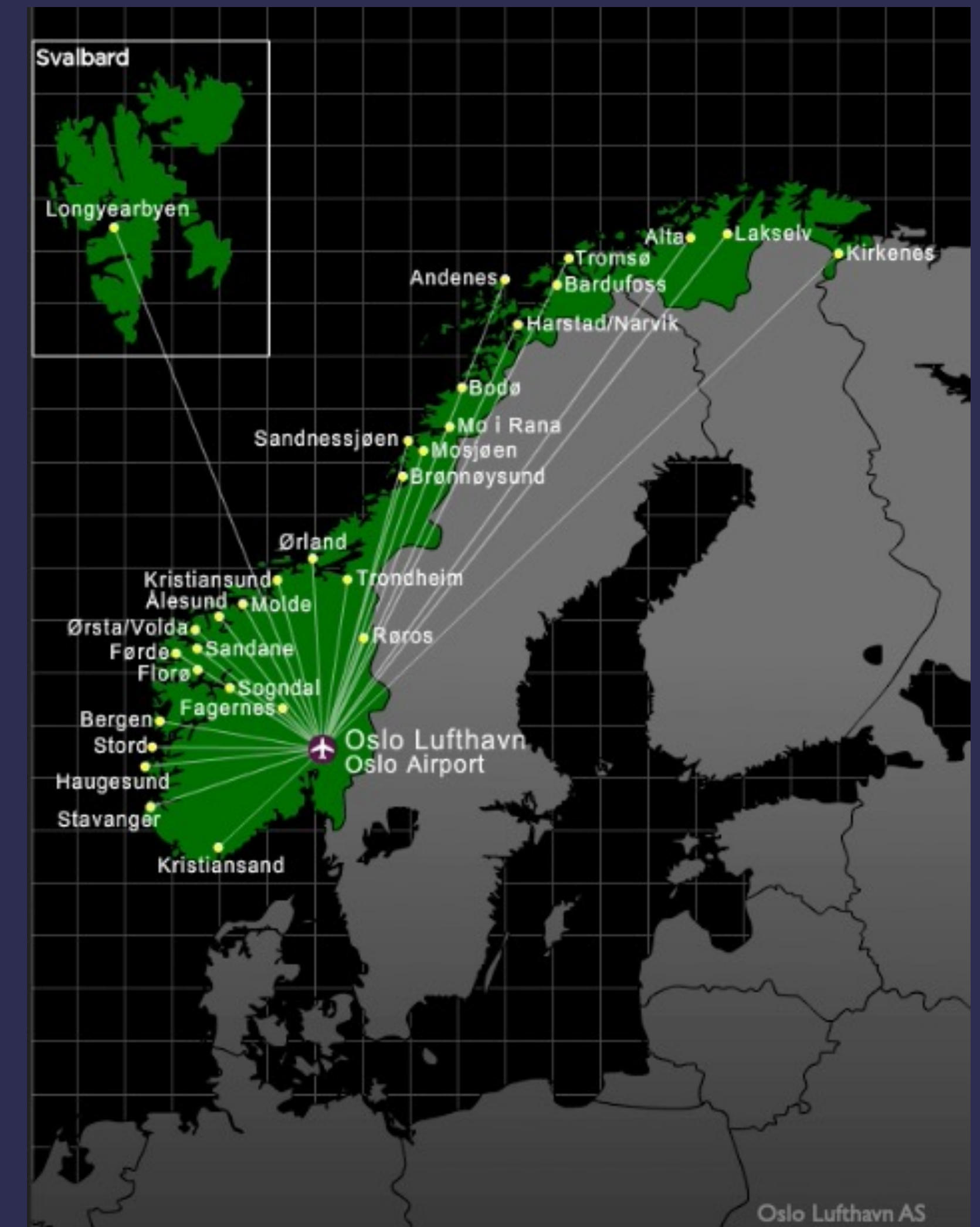


Tromsø Geophysical Observatory
Faculty of Science and Technology
University of Tromsø, Norway.



Aviation in the Arctic

- Many small airports far north
- Radio communication is a challenge



Solar radio burst affected flight radars

- 4th November 2015: Radio burst affected flight radars in Sweden and Norway.
- The event led to 5776 delay-minutes for SAS



Radio burst detection system



Radio Burst Radar

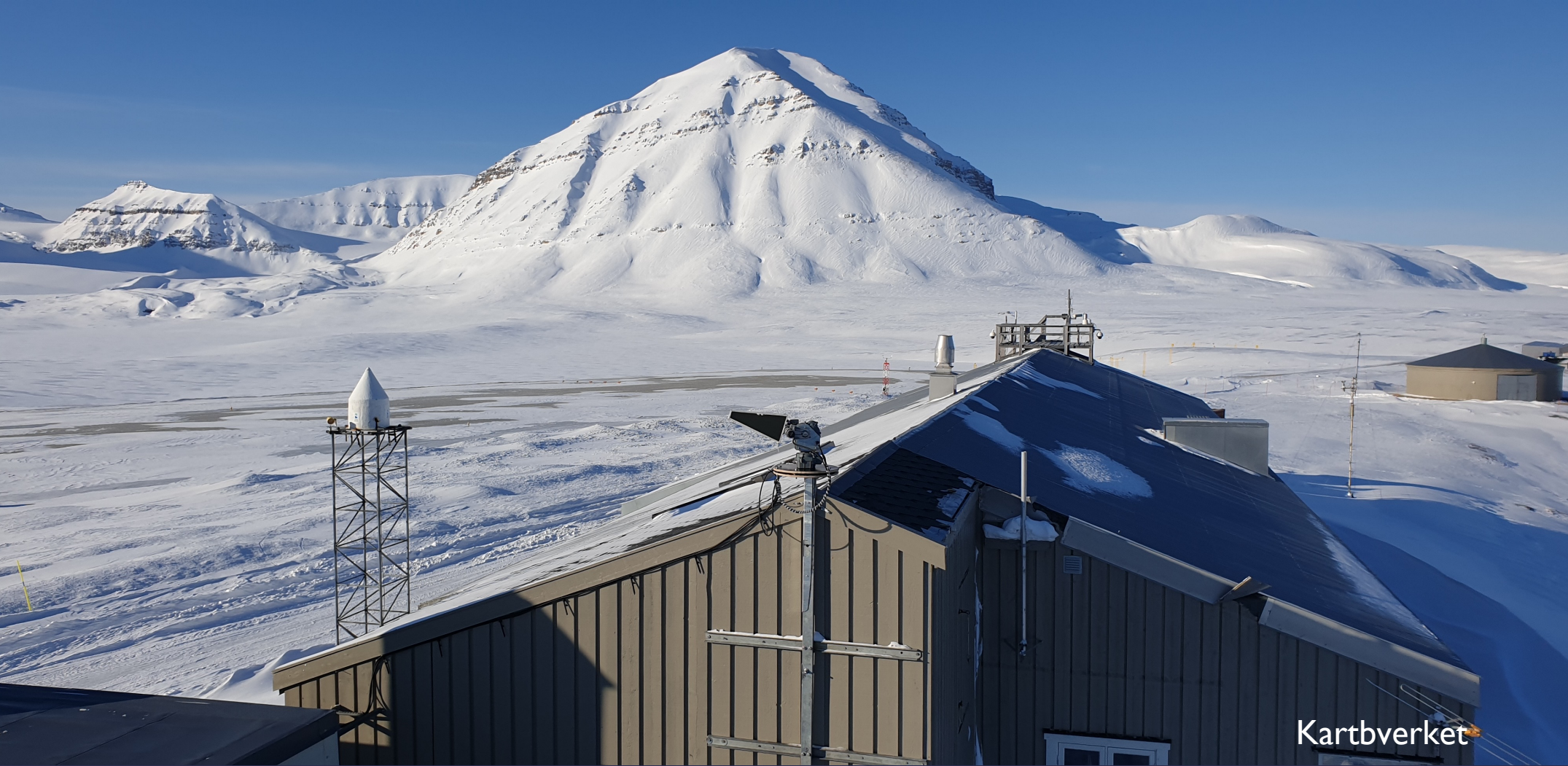
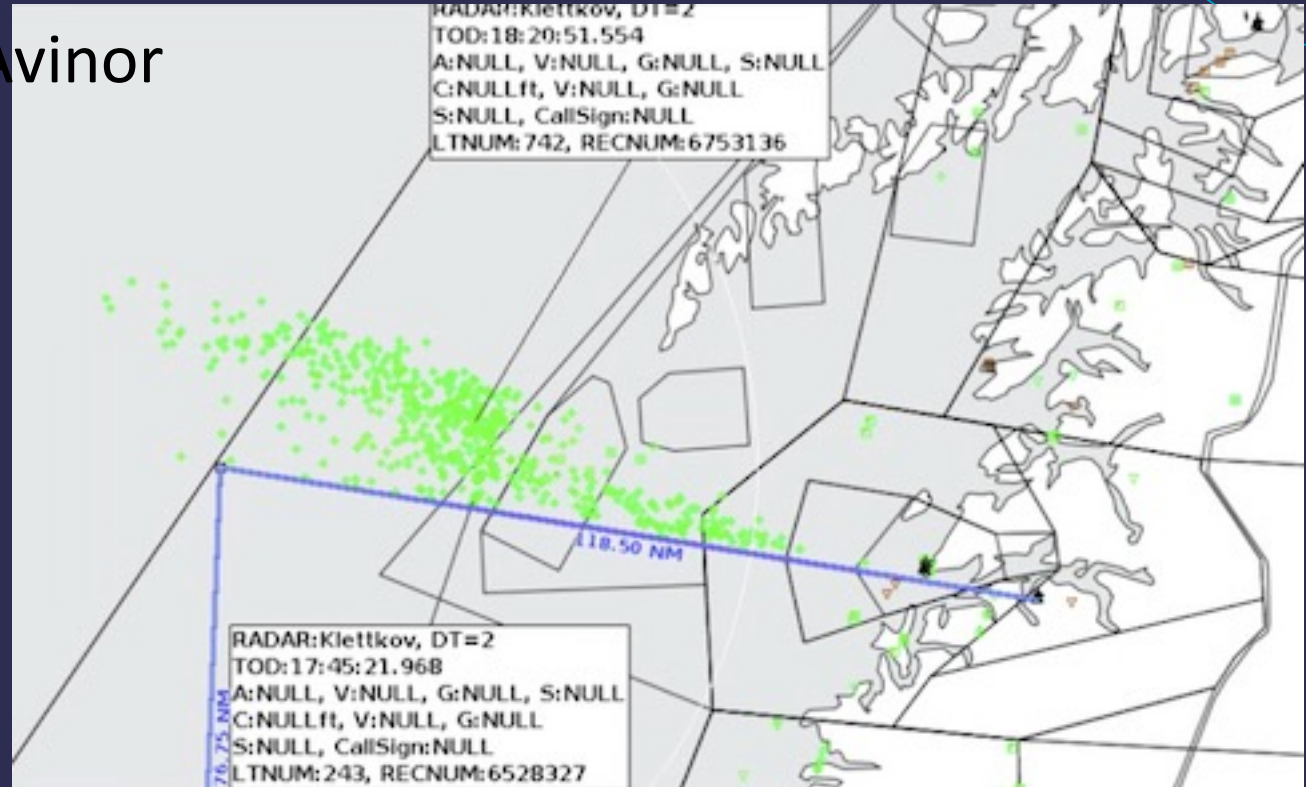
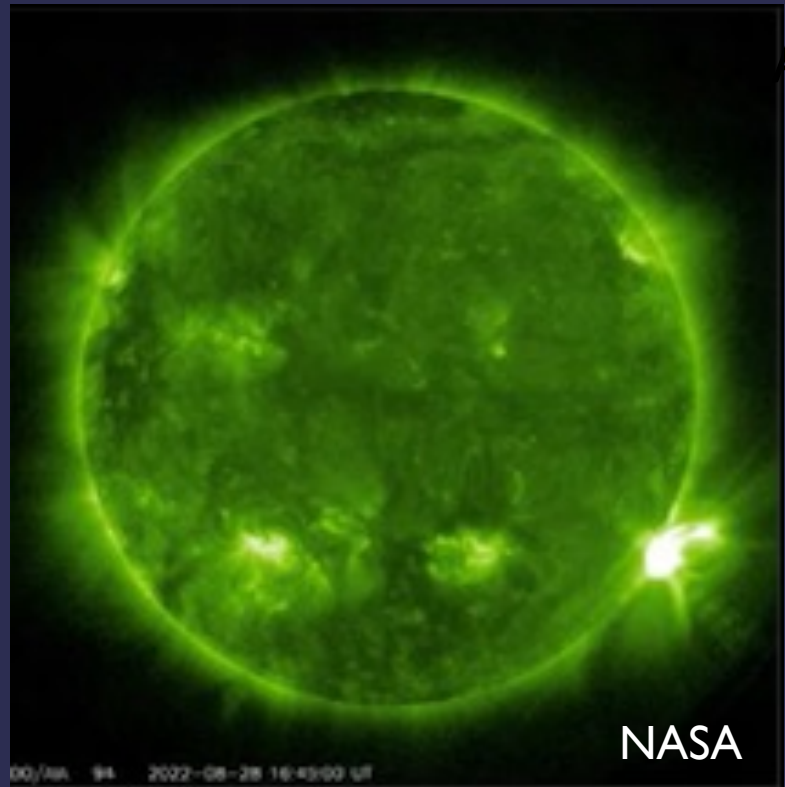
Kartverket System Setup and Documentation
version 0.9





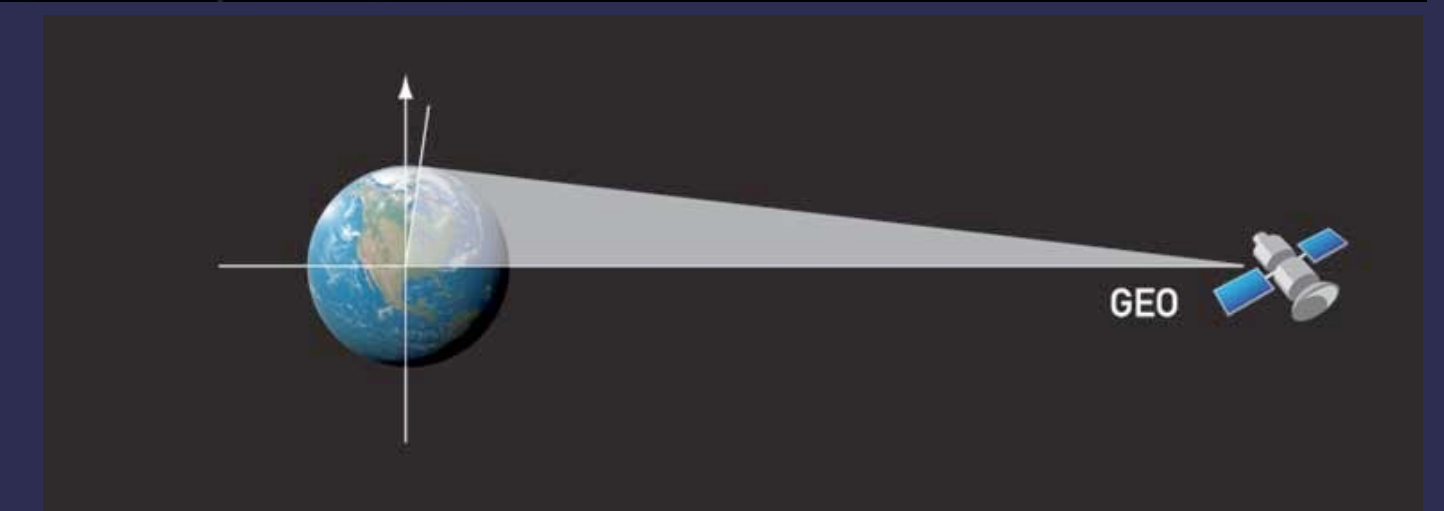
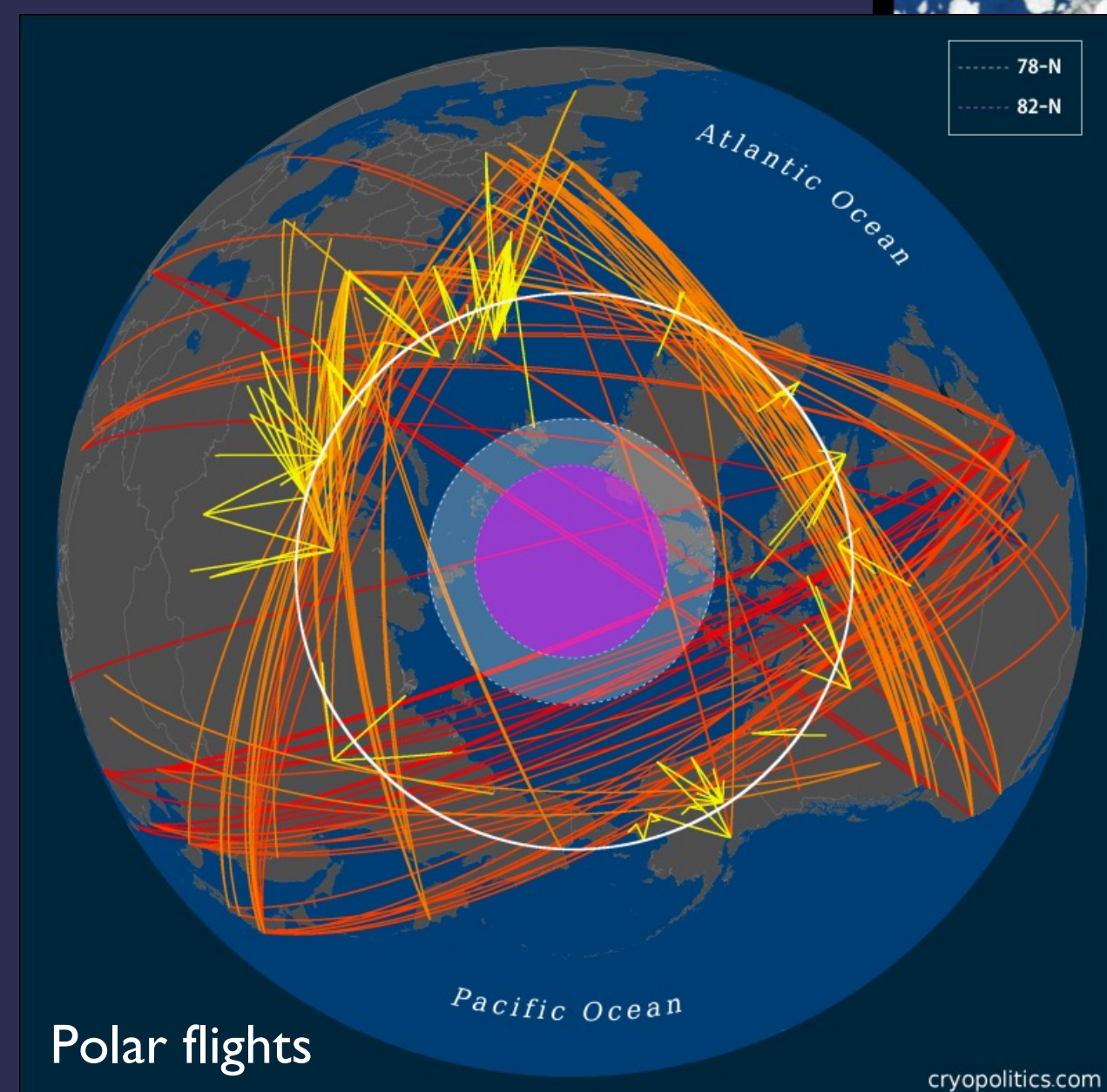
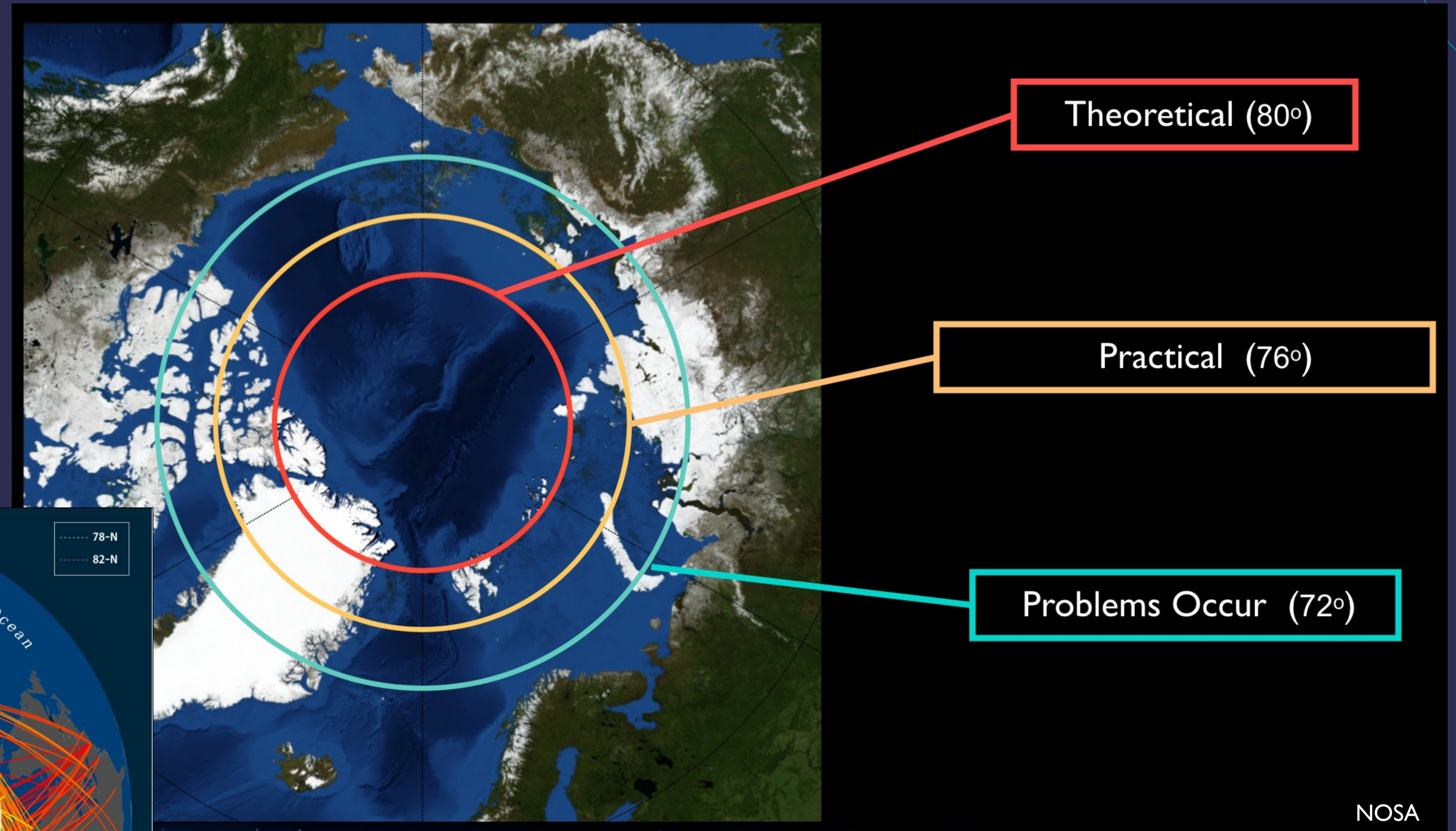


Solar flare /Radio burst 28 August 2022



Limited satellite communication in the Arctic

”Existing satellite communication systems have **little or no coverage north of 75 degree**. The HF radio communication is strongly affected by space weather



Geostationary satellites is located extremely low in the horizon as seen from the arctic

Arctic Satellite Broadband Mission (ASBM)

Space Norway is building 2 satellites in highly elliptical orbits (HEO) alternating to cover the high north

Commercial and governmental communication capabilities

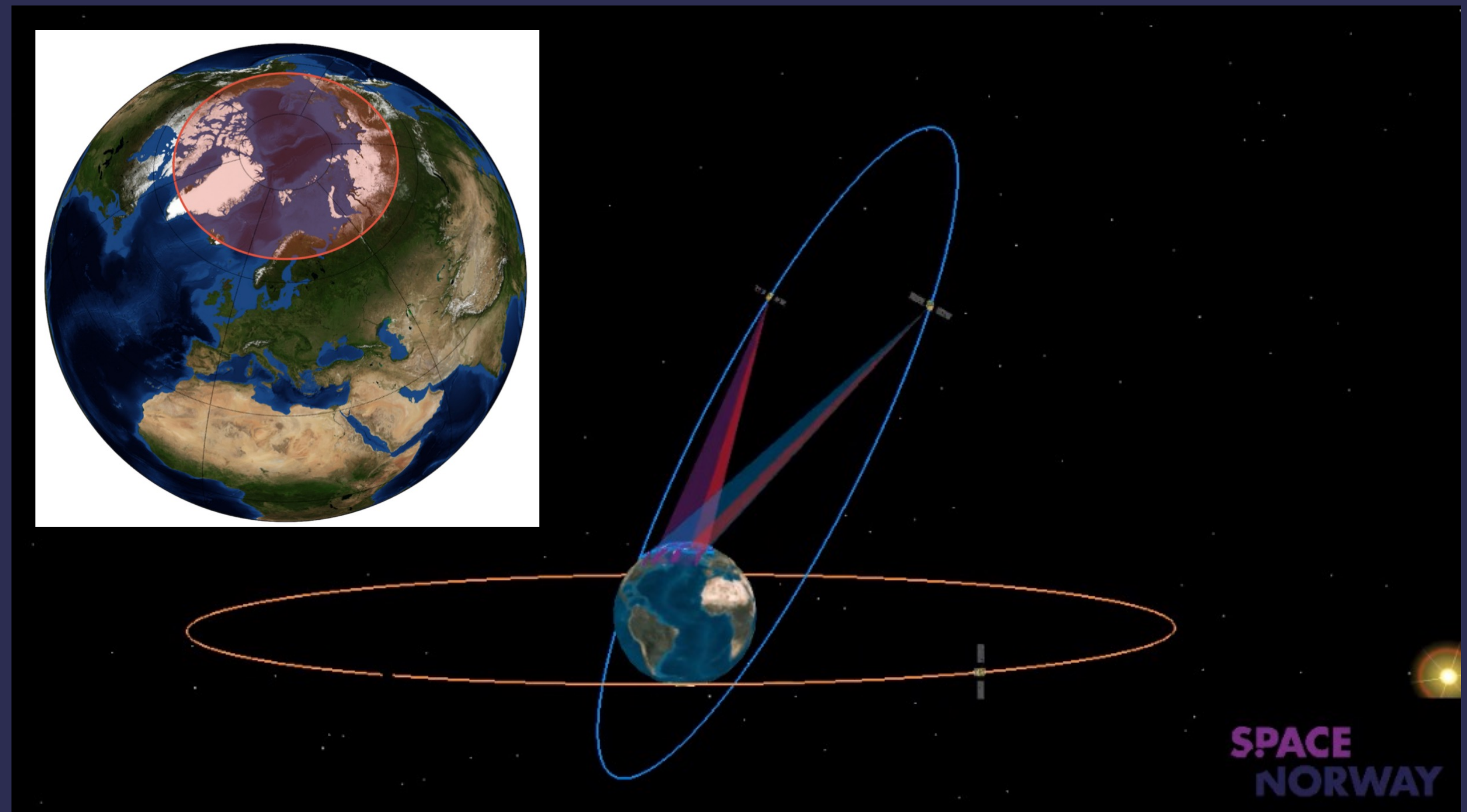
Communication capacities for the US Space Force, the Norwegian Armed Forces and Inmarsat

Funded by the Norwegian Government

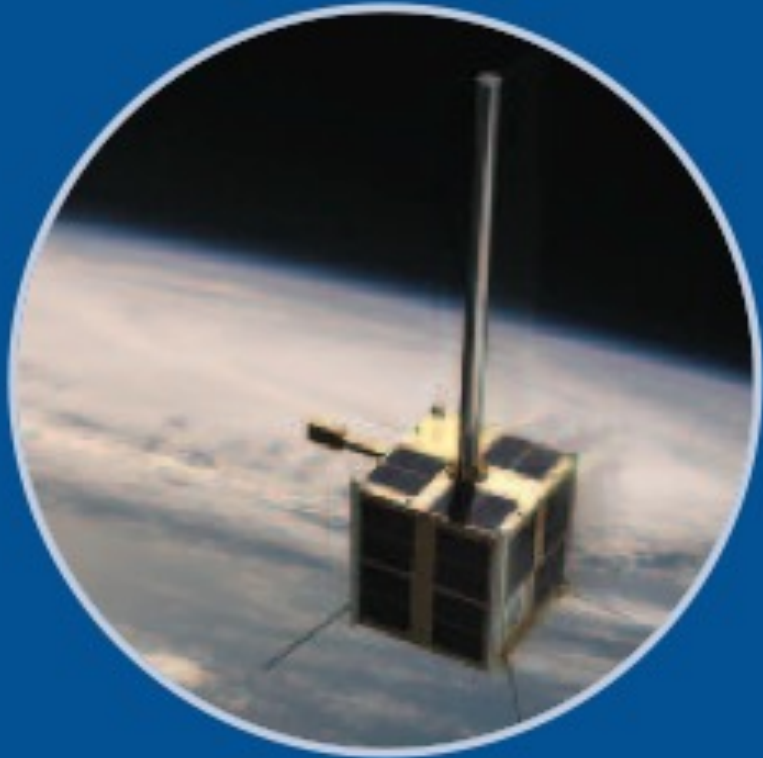
Planned launch Q4/23-Q1/24

Launcher: SpaceX Falcon 9

Poor coverage in the High North makes it harder for the authorities to carry out security and emergency services such as search and rescue at sea, oil spill protection and crisis management. Not least, the Armed Forces requires stable and secure communications for operations in Norwegian waters.



Users of Space Weather Services in Norway



Who:

- Oil&Gas companies
- Aviation
- Maritime Sector
- Power grid operators
- Satellite operators
- Survey, Construction, etc.
- Tourism sector

Why:

Navigation, positioning and exploration activities

GNSS navigation and HF communication

GNSS navigation and HF communication

Ground Induced Currents and GPS timing

Damages to systems

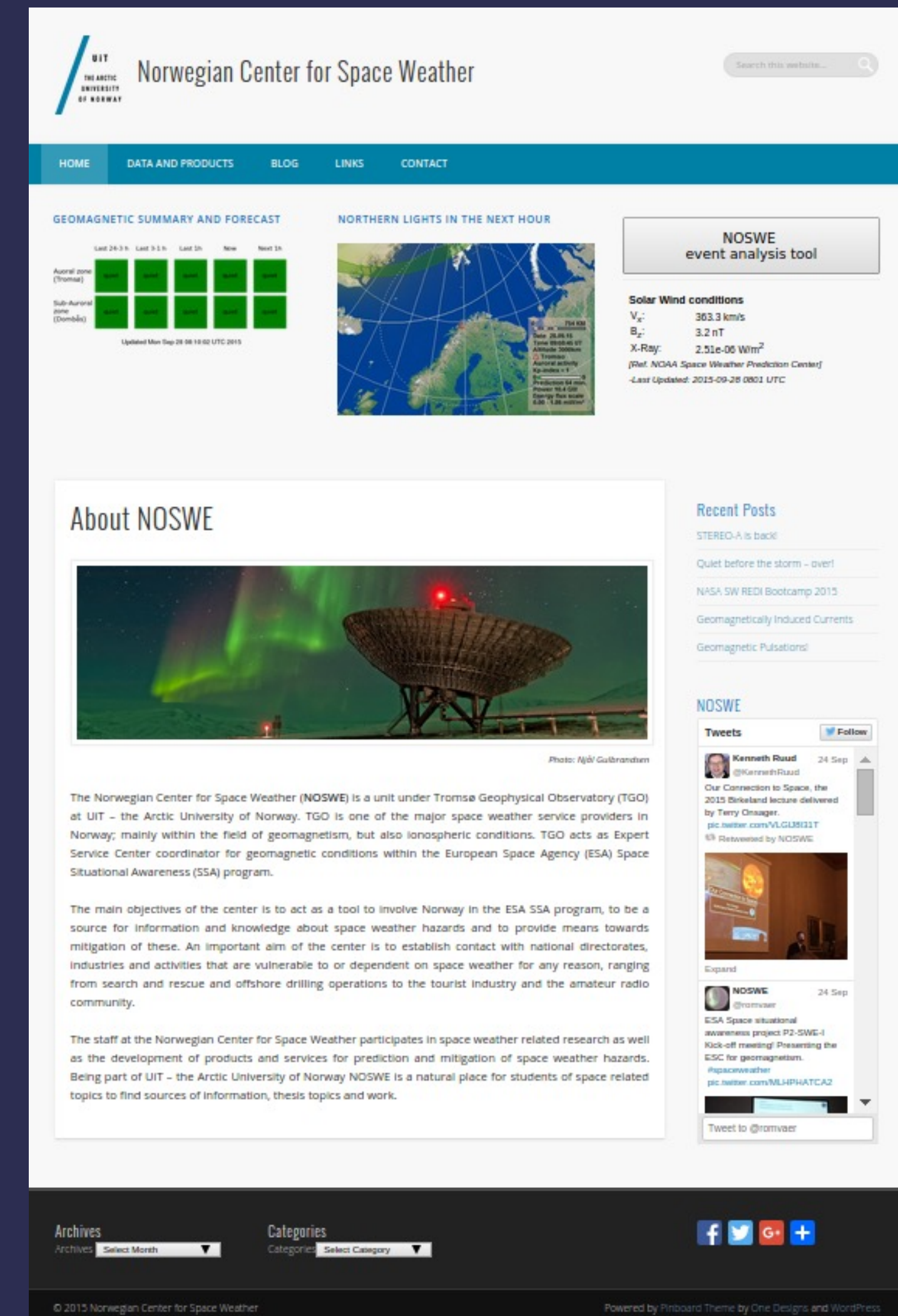
GNSS positioning

Aurora forecasts

Norwegian Space Weather Center

Aim to get national responsibility for operational space weather activities. Already planned emergency readiness with Norwegian Power Grid company (Statnett).

We have initiated a collaboration with our national Met Office (met.no) to distribute future space weather alerts/warnings 24/7.



Norther Lights

The Northern lights has become a multi-billion Euro tourist business

People from all over the world are coming to the arctic to experience nature's most spectacular light phenomena. The Norwegian tourist companies rely on good aurora forecasting to guide their guests. Forecasts that are based on good space weather observations.



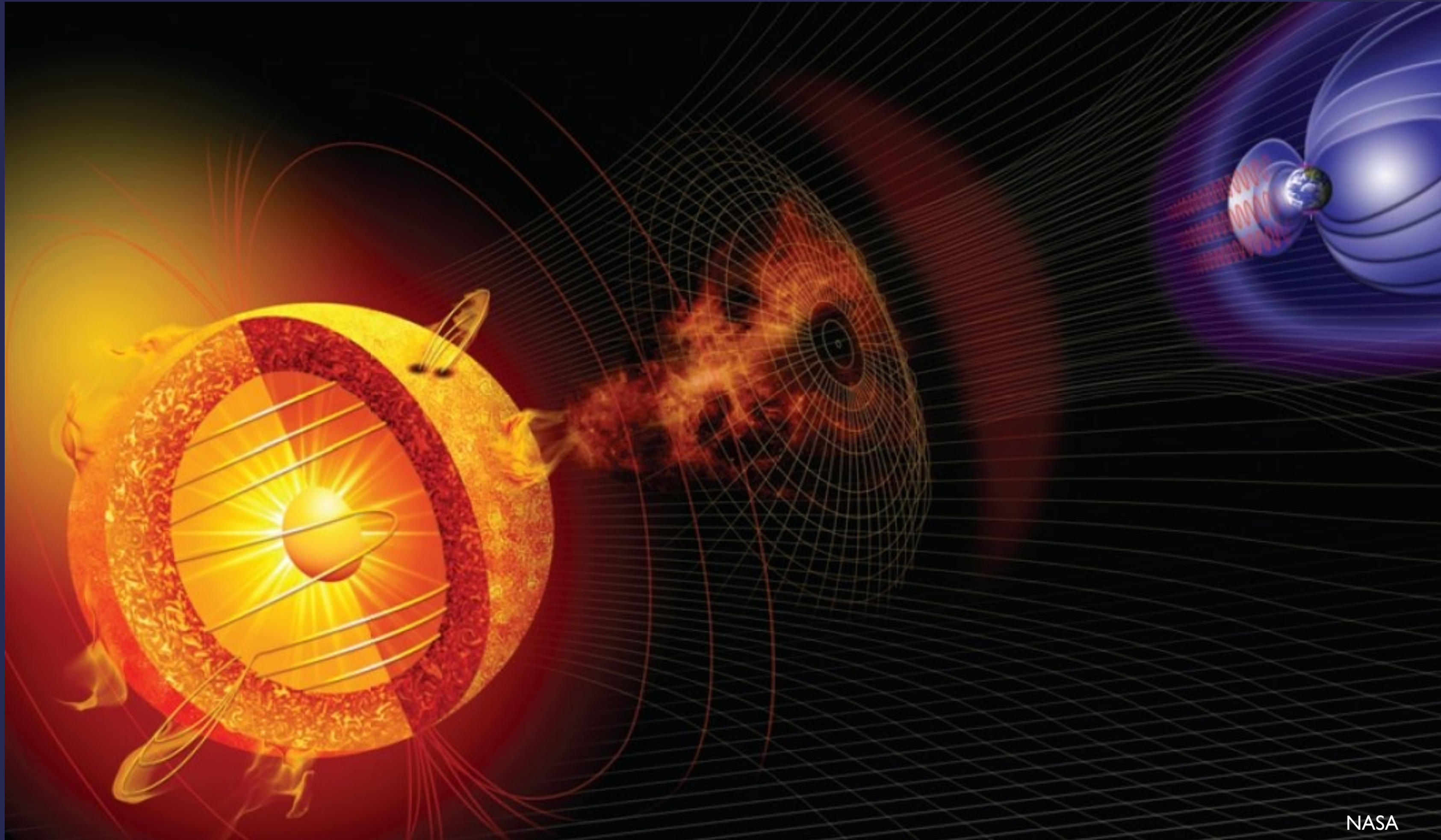
Summary

The economic significance of the Arctic region is increasing. Activity is increasing.

This means that space weather forecasting will become more important, because [space](#) weather impacts on many different kinds of infrastructure and business activities in the Arctic region, including electricity networks, oil and gas pipes, mining operations, aviation and shipping.



Thank you for your attention



NASA