

# Topical Discussion Meeting report – TDM6



**Name of the TDM:** Impacts of climate change on ground-based measurements: testimonies

**Conveners:**

Maxime Grandin (Finnish Meteorological Institute, Helsinki, Finland)

Aurélie Marchaudon (IRAP, University of Toulouse, France)

Véronique Delouille (STCE/Royal Observatory of Belgium, Belgium)-

Secretary: Sophie Chabanski (BIRA, Belgium)

**Date:** 17:00-18:00 Tue 28<sup>th</sup> Oct 2025

**Number of attendees (approximate):** ~25 people (~20 in the room, 5 online)

**Panellists:** Thomas Ulich (EISCAT) , Urban Brändström (Kiruna Observatory, Sweden)

**Form of TDM:** Panel Forum

**Description:** see Annex 1.

## Objective of the TDM

To share examples and collect testimonies from the audience on evidence that climate change has a significant impact on ground-based observations of space weather and space climate, especially at (but not limited to) high latitude regions.

Panelists were invited to provide their opinions on the following:

- What might be the challenges posed by a changing climate on the deployment, maintenance and operations of instruments in space weather/space climate research?
- Do you have in mind specific instruments or geophysical parameters which might be affected by climate change?
- Can you think of specific geophysical parameters that could be worth analysing in search for possible signatures of climate change?
- What are the possible avenues to reduce the carbon footprint of geophysical observations without jeopardising their continuity?

## Discussion Highlights

The TDM opened with introductory remarks from the lead convener, Maxime Grandin, who recalled that climate change impacts our research in several ways:

- long-term atmospheric changes are affecting radio wave propagation,
- more extreme weather events may disrupt observations,
- thawing of the permafrost affects the stability of observatories,
- changes in cloud cover hinders optical observations

The two panelists were invited to provide their testimonies.

Dr Thomas Ulich operates radar in the Arctic and has lived there for 15 years.

- He has noticed changes in weather patterns, e.g. the once-regular -40°C cold nights in January no longer occur.
- He observes fewer northern lights due to increased cloud cover.
- To date, Thomas has not observed any effects of climate change on the measurements he routinely works with.

- He raised the question whether the vast historical data collected over these last centuries is sufficiently protected from extreme weather events to make sure it stays available for future generations.
- We are facing different types of risks: extreme weather events, geopolitics risks to network infrastructure and marine cables, NASA de-funding research on climate, climate deniers.

Dr Ulich concluded that we need more redundancy to be more resilient to these threats.

Dr Urban Brändström (head of IRF Kiruna) has experienced *direct effect* of climate changes such as:

- damage to magnetometers due to thunderstorm
- permafrost melting in Svalbard affecting the stability of magnetometer baselines,
- more cloudy nights preventing the optical measurements that require clear skies at multiple locations simultaneously.

But there are also some *indirect effects* of climate change, such as the increased mineral exploitation which is leading to industrialization in previously untouched regions, which in turn affects the quality of scientific measurements taken there. With politics becoming more polarised to extremes, there is the risk of funding cuts for basic research. Dr Brändström also mentions the importance of preserving data archives for future generations.

The first part of the discussion with the audience was about **data archive preservation**.

There are different types of archives: short, mid, and long-term. For long-term archive preservation (>100 years), redundancy should be put in place amongst different countries, to share data and prevent political risk.

Problem: different countries have different policies, some do not want to share data, e.g. for military reasons. But at least the metadata could be provided.

Data standardisation is necessary, with a proper description of data and experiment used to obtain the data. This is to make sure that knowledge on how the data must be used is preserved.

The support for such an archive is also subject to debate: Tape archives are used a lot for long-term archiving, but in the long-term, they are affected by the Earth's magnetic field. There is also continuous evolution in informatics: to follow the evolution, it is necessary to recover existing archive data and keep data in readable format.

In conclusion, for sensitive datasets preserved at high latitudes (such as collections of seeds), long term storage should not be taken for granted, when climate change is suddenly affecting regions that were chosen for their particular environment.

The second part of the discussion concerned testimonies of **climate change impact and effect of human activities on measurements**. Several testimonies were collected:

Effect of extreme weather on measurements:

For instruments placed at high altitude, an increased amount of lightning impacts particle detectors.

It happened that ionosonde and magnetometers were lost for several days due to thunderstorm

The Super Dual Auroral Radar Network (SuperDARN), placed near the Antarctic, suffers when there is strong wind, and time for which they can operate becomes more and more limited (basically between 3:00 and 6:00am)

### Effect of human activities on measurements:

Mining activities are now taking place in once remote locations. This human activity causes disturbances in measurements of the Earth's magnetic field.

There is a pollution of radio-frequencies, finding a clean radio environment is more and more challenging. For example, the site at Nancay, which was a quiet zone, becomes increasingly difficult to preserve, both from ground and from space activities (starlink).

About the multiplication of space debris: for EISCAT, satellites echoes are not a problem at this stage (but could become when more, huge, constellations of satellites will be in space)., echoes from satellite could cause saturations in the measurements, for which a higher dynamic range would be needed.

Unknown potential impacts were also discussed: When we bring down what was launched in space, more chemicals are deposited in the mesosphere and mesopause, and we do not know how this affects the atmosphere (and hence the measurements we are making there).

Finally, we discussed how we could **quantify the effects of climate change** on our observations, and on the reliability of space weather services. It is useful to proceed, as in meteorology, with scenarios ("what will happen if..." ?). A Working group with different expertise could work on mapping the scenarios with their foreseen consequences.

For example, some changes in the F2-layer heights have been studied, but more studies, with more instruments should be done, to understand the F2-layer heights change in the long term. This is complicated to model as there are a lot of interacting factors.

## **Main Conclusion of the Meeting**

- To be averse to climate risk, preservation of (really) long-term data archiving should include a redundancy between countries/institutions. More generally, a collaboration between European institutes on all aspects of data archive (also short and mid-term) would be welcome. E-SWAN WG on 'Operational activities, infrastructure, data, and models (OAIDM) could be the place to discuss such issues.
- It would be useful to set up a WG with different expertise to study different scenarios and show their potential impact on the reliability of space weather services.
- It is necessary to continue to talk to the public and schools about climate change
- We need to lobby for funding to preserve time series

## **Annex 1: TDM Description**

There is growing evidence for climate change to have a significant impact on ground-based observations of space weather and space climate, especially in high-latitude regions. The list of impacts includes long-term atmospheric changes affecting radio wave propagation, more extreme weather events that can disrupt observations, thawing of the permafrost affecting the stability of observatories, changes in cloud cover hindering optical observations, and more. While some of these impacts have been documented, most remain largely unknown or are rarely mentioned. This TDM, which is organised by the E-SWAN Sustainability Working Group, aims at sharing some examples but also, and foremost, collecting testimonies from the audience. Our objective is to raise awareness of these impacts and pave the way for a document that could provide a global view of the numerous

(and often unsuspected) consequences of climate change on scientific activities. The format will be that of a panel forum, targeting all users of infrastructure, especially in high-latitude regions.

## **Annex 2: Minutes of meeting**

Introduction by Maxime Grandin

Our long-running observatories may offer insights into climate change, either as unintended indicators or through its impact on data quality. Extreme weather and environmental shifts—like permafrost thawing—could threaten infrastructure and measurement stability. We're seeking testimonies to explore these effects.

Introduction by Panellist 1: Thomas Ulich

Thomas, who operates radar in the Arctic and has lived there for 15 years, has noticed changes in weather patterns. He observes fewer northern lights due to increased cloud cover, and notes that the once-regular -40°C cold snaps in January no longer occur.

To date, Thomas has not observed any effects of climate change on the measurements he routinely works with.

Thomas raises the question whether the vast historical data collected over these last centuries is sufficiently protected from extreme weather events to make sure it stays available for future generations.

Thomas lists the different risks we may face: extreme weather events, geopolitics, risks to network infrastructure and marine cables, NASA defunding, climate deniers. Thomas concludes that we need more redundancy to be more resilient to these threats.

Introduction by Panellist 2: Urban Brändström

Urban is head of IRF Kiruna.

Urban has experienced direct effects of climate changes such as damage to magnetometers due to thunderstorms, permafrost melting Svalbard affecting the stability of magnetometer baselines, more cloudy nights preventing the optical measurements that require clear skies at multiple locations simultaneously.

Urban then highlights indirect effects of climate change, such as for example the increased mineral exploitation which is leading to industrialization in previously untouched regions, which in turn affects the quality of scientific measurements taken there. Urban also mentions the politics which is getting polarised and extreme and the risks of funding cuts for basic research.

Finally Urban also mentions the importance of preserving data archives.

Discussion with audience

The first part of the discussion concerned data archiving:

- cost of digitization and archiving
- types of archive (short term, mid term and long term)
- international redundancy

- resilience to hacking, geo-politics and management issues
- maintenance of archives
- metadata preservation
- accessibility
- standardisation
- preserving data for future generations.

The second part of the discussion concerned testimonies of climate change impact on instruments. Several testimonies were collected:

- increased lightning impacting particle detectors, in high mountains
- ionosonde and magnetometers lost for several days due to thunderstorm
- Human activity because of mining is creating disturbances at nearby magnetic observatories, when there are lots of machines on the road, the data is disturbed.
- light pollution problem everywhere in the world
- urbanisation in Kiruna impacting measurement sites
- SuperDARN next to the Antarctic is exposed to more and more very strong winds. The only quiet time is between 3am and 6am.
- Snow mobiles preventing measurements
- Increasing number of satellite, loose access to space, optical interference with Starlink
- Maintaining protected frequency bands for radio astronomy
- Space debris is already making measurement difficult
- Dynamic range problem, when satellite passes the measurement saturates
- Chemical impact of rocket launches whose plumes impact the mesosphere and the stratosphere

Unknown potential impacts are discussed:

- The Mesosphere is full of satellite debris that will impact its conductivity, property of propagation?
- What will be the ionospheric height of f2 layers because of climate change, will the height go up or down

Take away message

Several suggestions were made:

- creation of a working group of different expertise to study different scenarios and their potential impact on the reliability of space weather services.
- creation of a new working group for long term preservation and for lobbying to the EU to open long term preservation projects.
- need to talk to the public and schools about climate change

- make a call in E-SWAN for establishing standardisation
- need to lobby for funding to preserve time series