



**MML**  
MAAN-  
MITTAUS-  
LAITOS

# Experiences from solar maximum 25 (so far)

NKG Science Week, WG GNSS Positioning

Simo Marila,  
& FINPOS team/NLS

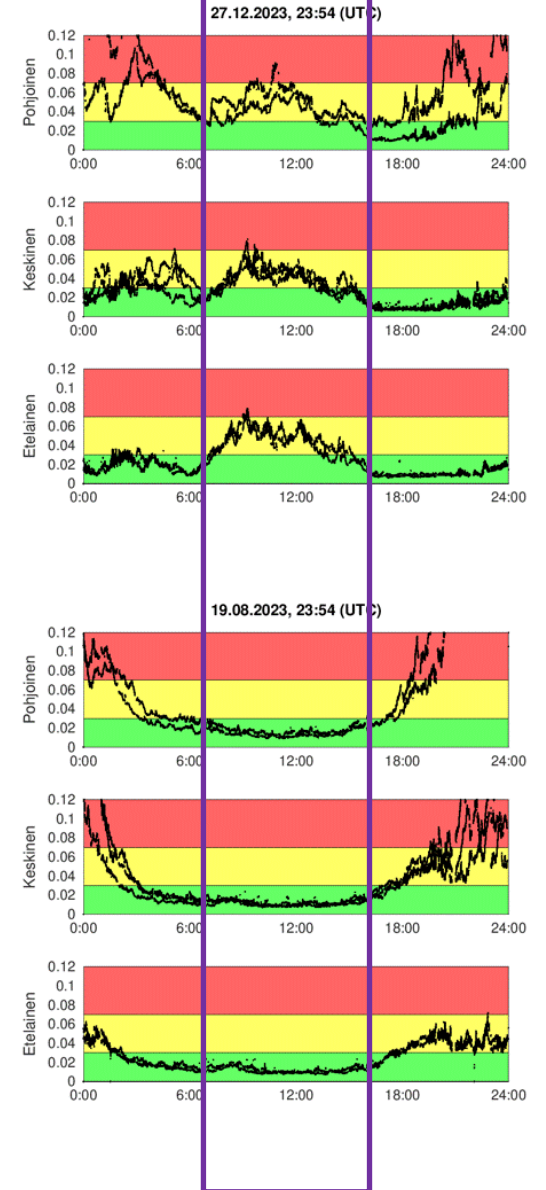
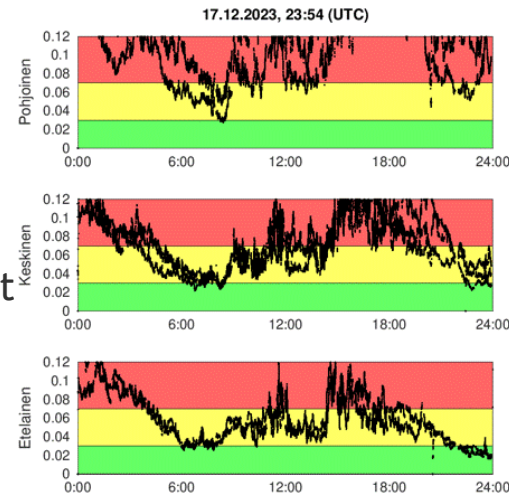
# Content

- Different situations
- How big effect to NRTK user
- Preparations



# Two kinds of moments with active spaceweather

- Active sun situations “nighttime activity”; Sun bursts/flares mass ejections etc. geomagnetic storms
  - Problems to use RTK when these “hit” the Earth
  - Shows up more often during solar maximums
- “Daytime” ionosphere activity
  - Annual strength variation, strongest in winter, weakest summer
  - Stronger during solar maximums
  - Winter anomaly



# Winter anomaly

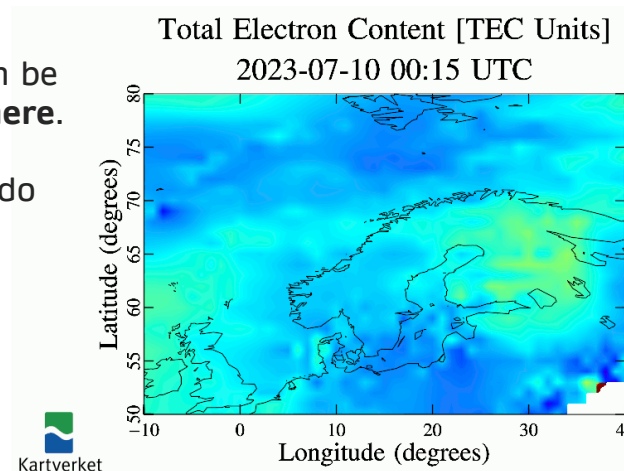
Reason behind "daytime activity" is so called winter anomaly (Explanation by FMI)

- The electron density of the F layer of the ionosphere increases so much during the winter months that it overcomes the variation of the density of the F layer depending on the sun's zenith angle. The reason for this phenomenon can be found from neutral atmosphere. The critical parameter is the O/N<sub>2</sub> ratio (oxygen atom/nitrogen molecule), which has a seasonal variation such that it is larger in winter than in summer. The difference between winter and summer becomes stronger during the peaks of solar periods and it may even almost disappear during the minimum periods. Around the time of the sunspot maximum, stronger temperature gradients are created in the upper atmosphere in the height direction, which makes the winter-summer differences stronger.
- The sun's EUV and UV effectively ionizes oxygen atoms, so positive ions are created. The ionosphere always seeks a balance in terms of electric charges, so an increase in positive ions always means an increase in electrons. On the other hand, N<sub>2</sub> is involved in chemical reactions that eliminate oxygen ions. Thus, when the O/N<sub>2</sub> ratio increases, it means an increase in the number of oxygen ions (and the number of electrons)

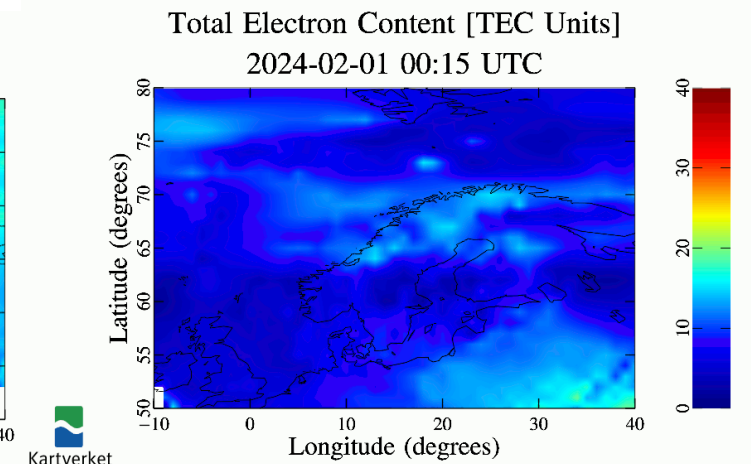
Winter anomaly is an ionospheric phenomenon, the cause of which can be found in the **interaction between the ionosphere and the thermosphere**. So it is **not related to geomagnetic storms**

→ cf. magnetometers do not vibrate during the day, but other meters do and there may be measurement difficulties

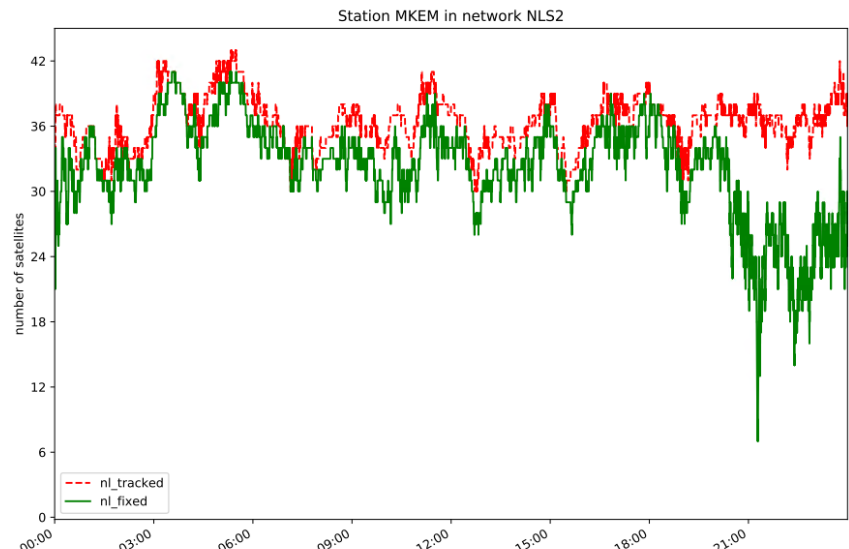
10.7.2023



1.2.2023

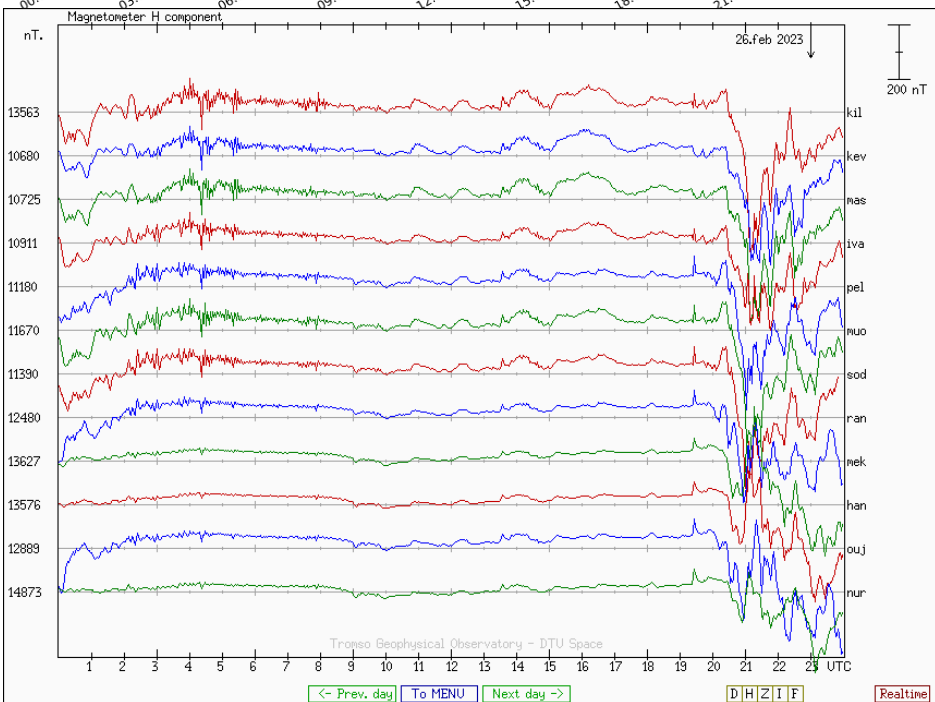
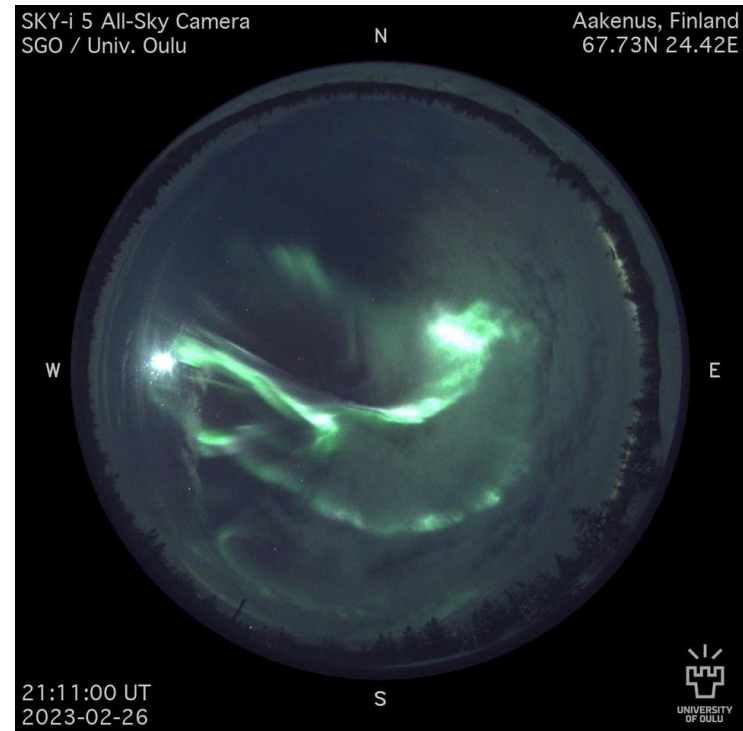


# “nighttime activity”



Kemijärvi (Lapland) reference station, total number of tracked and fixed satellites in network solution

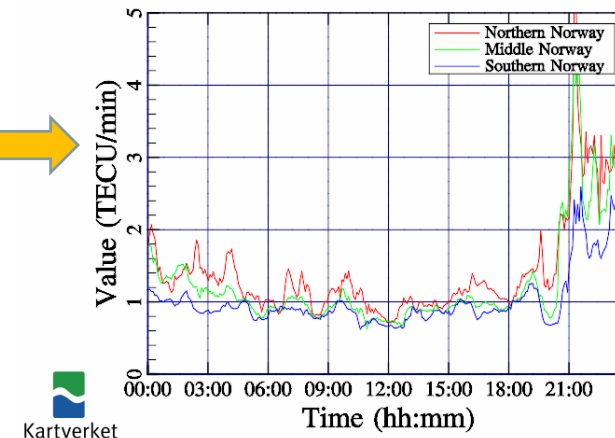
Aakenus (Kittilä, Lapland) Sky camera



Magnetometer data from Finland (north to south)

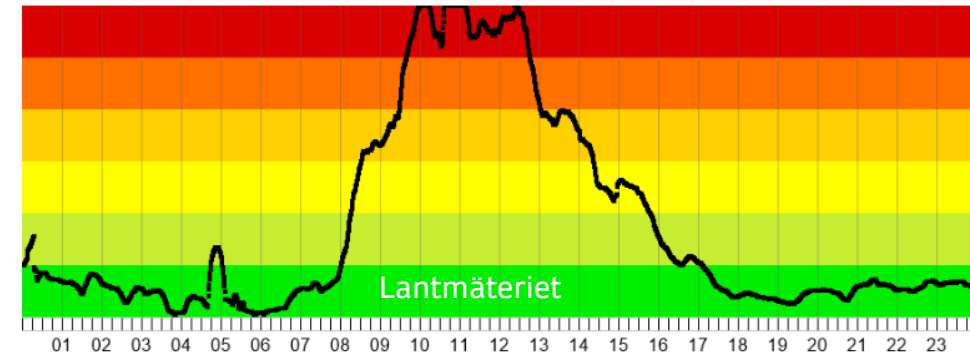
Norway, TEC values's change rate (ROTI)

2023-02-26 00:00 to 2023-02-26 23:59 UTC  
Rate of TEC Index at ground



# “daytime activity”

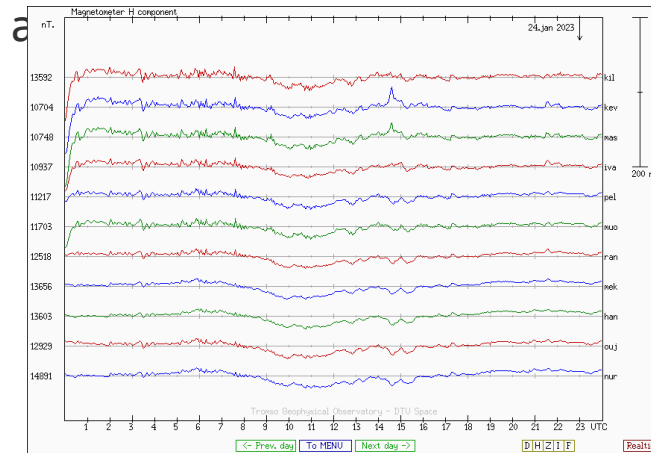
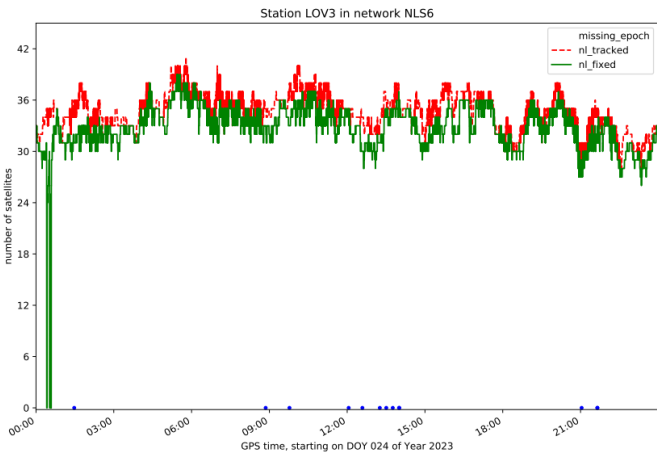
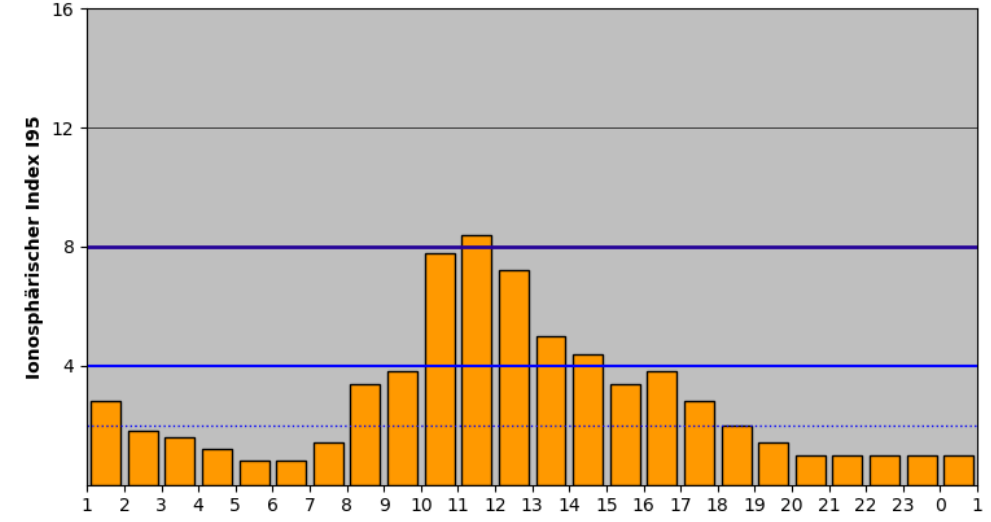
- Large number of electrons causes problems also during daytime
  - strengthens when Sun is active (11 year cycle) due to winter anomaly
- Visible bit differently in ionospheric indicators → Various indicators needed!



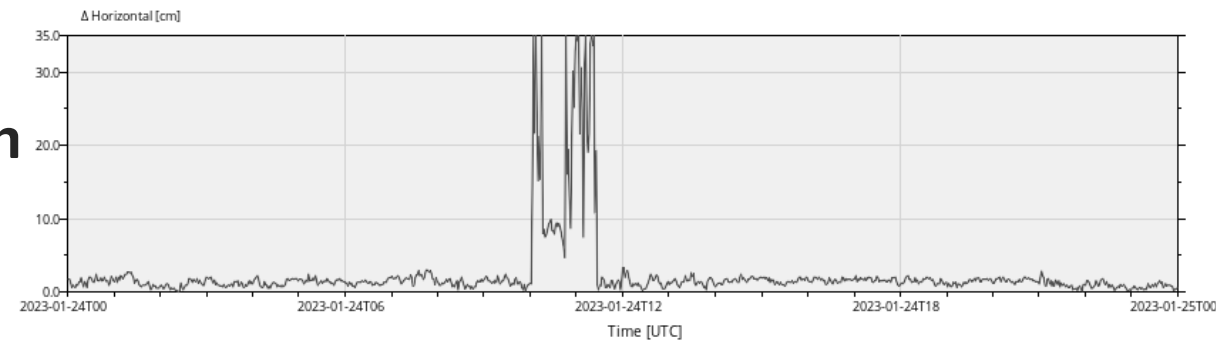
**Ionosphärischer Index I95 vom 24.01.2023 (024)**

berechnet mit WaSoft/WaV2

LGLN - Landesamt für Geoinformation und Landesvermessung Niedersachsen

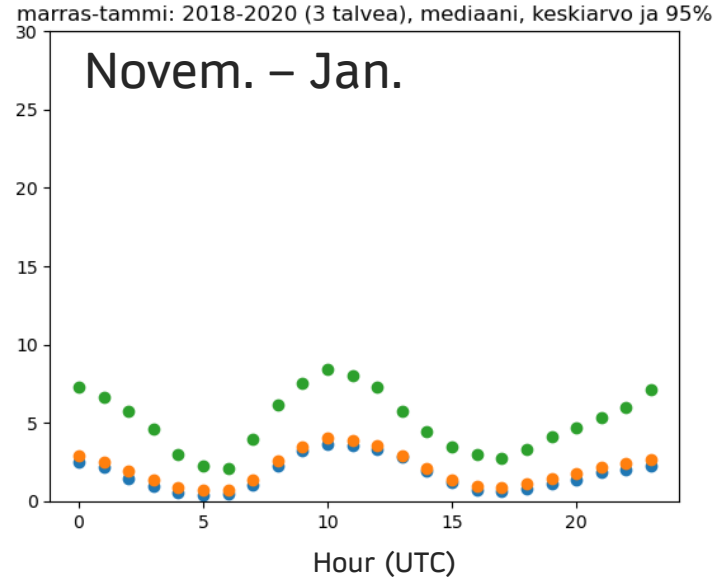
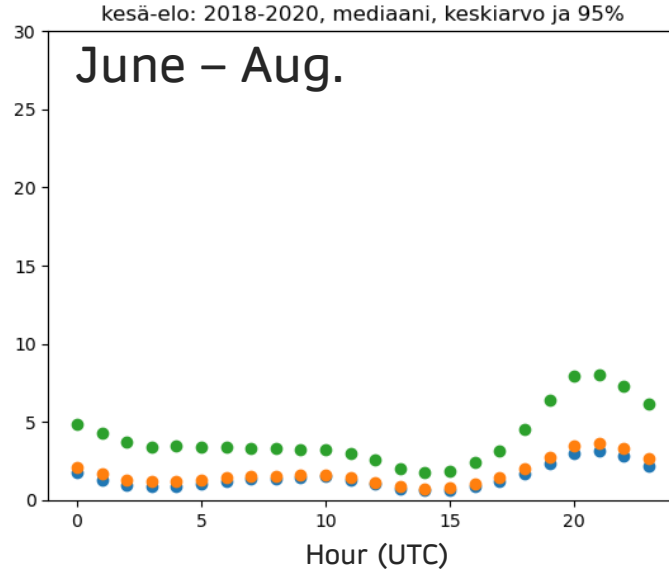


**Helsinki monitoring station**  
→ No fix solution!



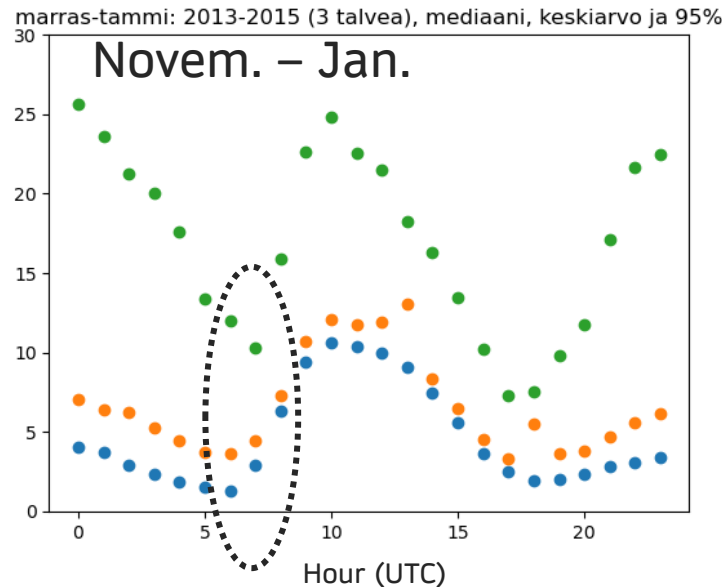
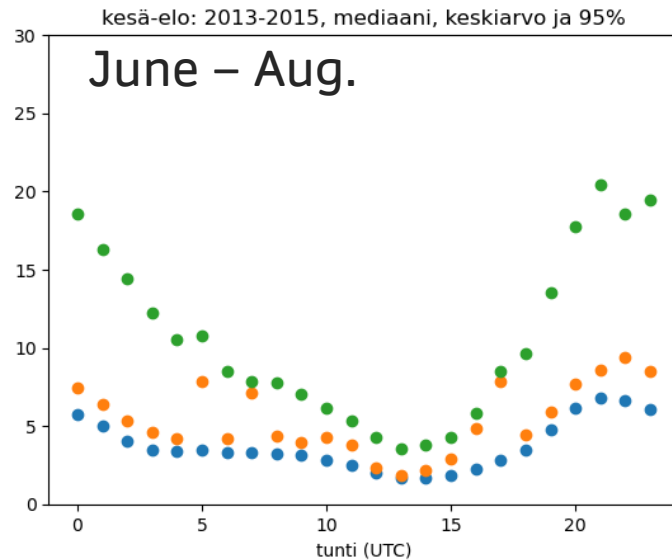
# “daytime activity”

- Variations during a day change during sunspot cycle



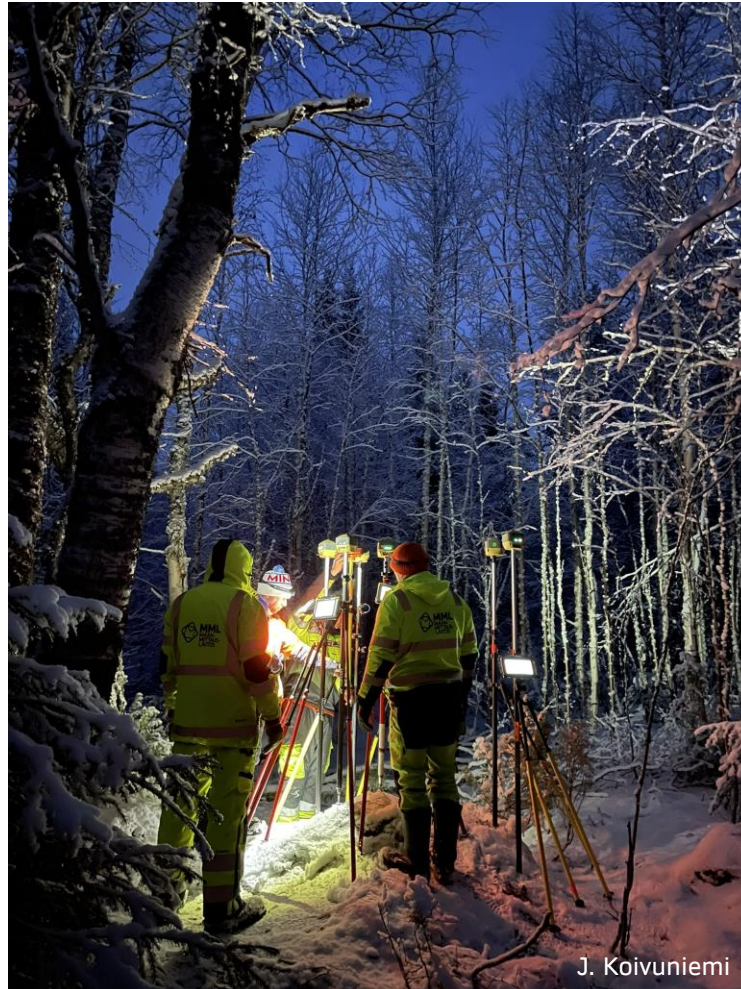
During the active period

- In summer more issues during nights
- In winter much more issues both during day and night  
→ Middle of day average over x2 bigger, maximums even bigger!!!



Data from Lantmäteriet  
<https://swepos.lantmateriet.se/services/iono.aspx>

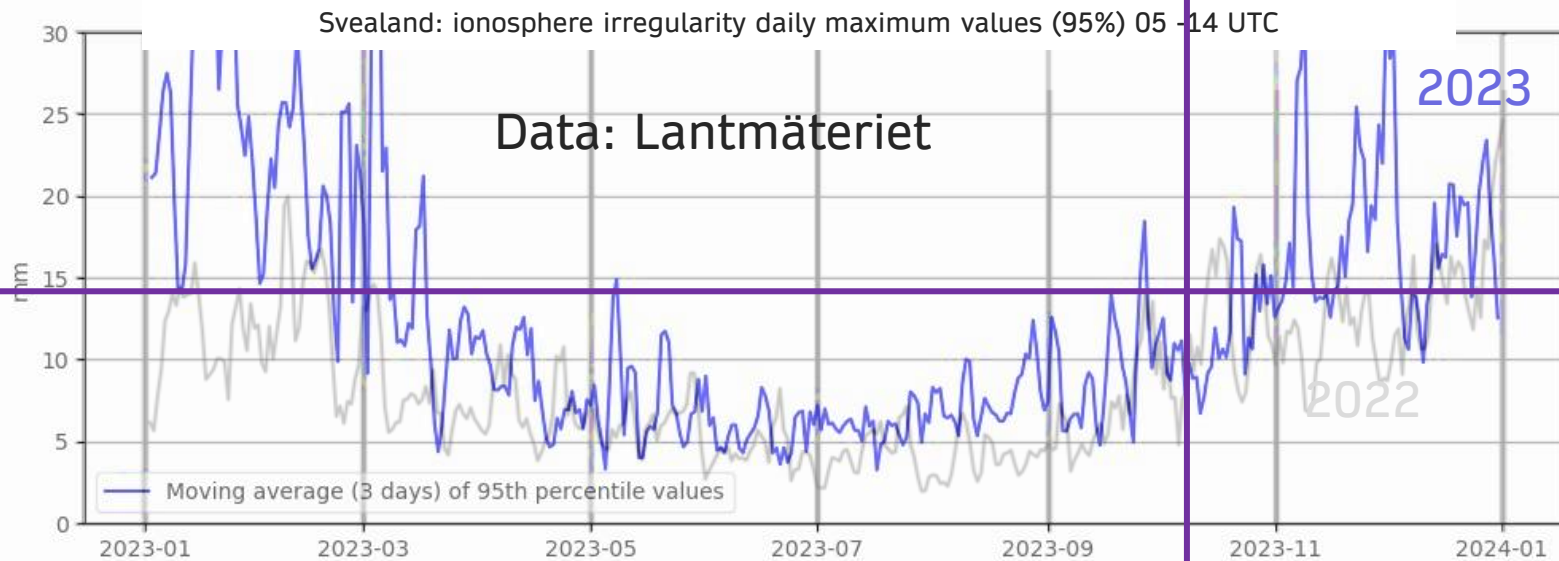
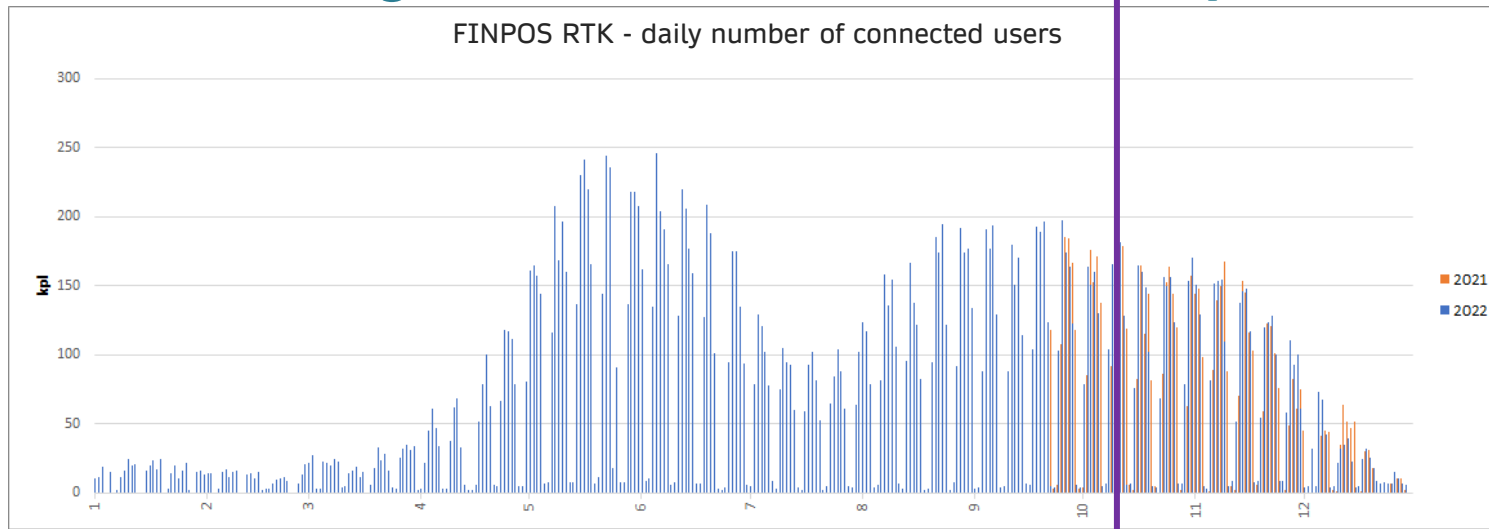
# How much iono things have effect to user?



J. Koivuniemi

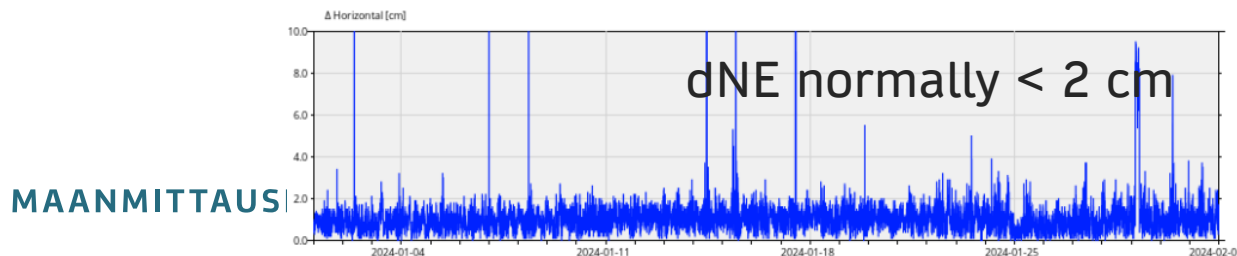
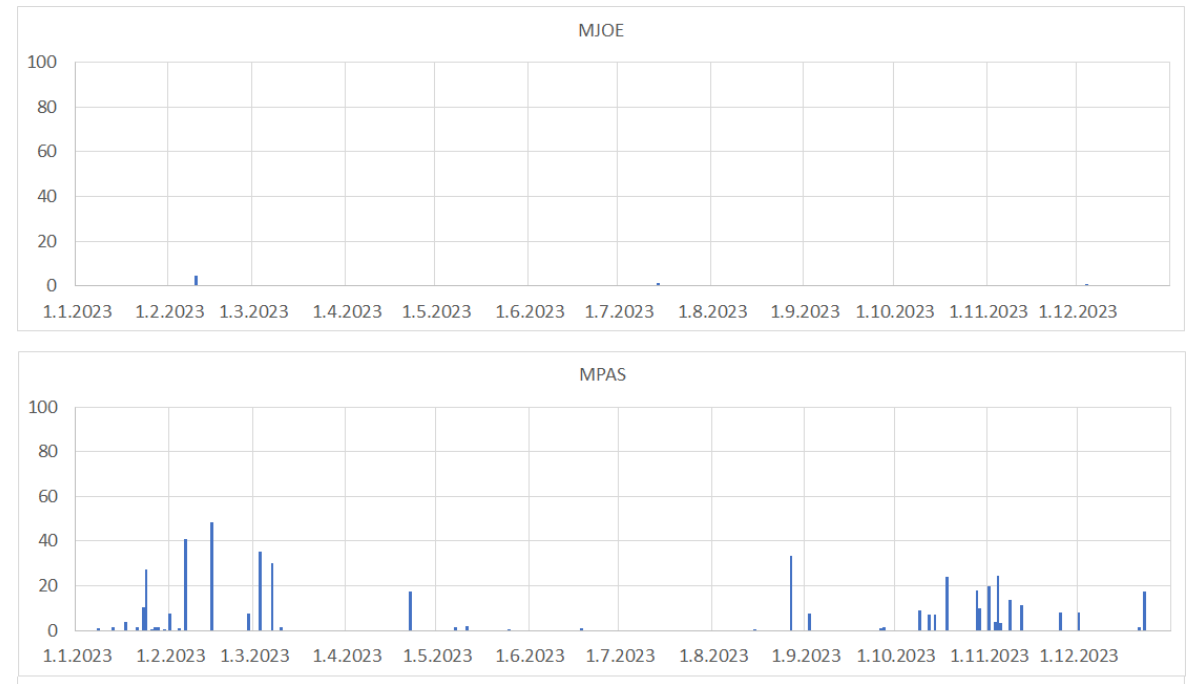
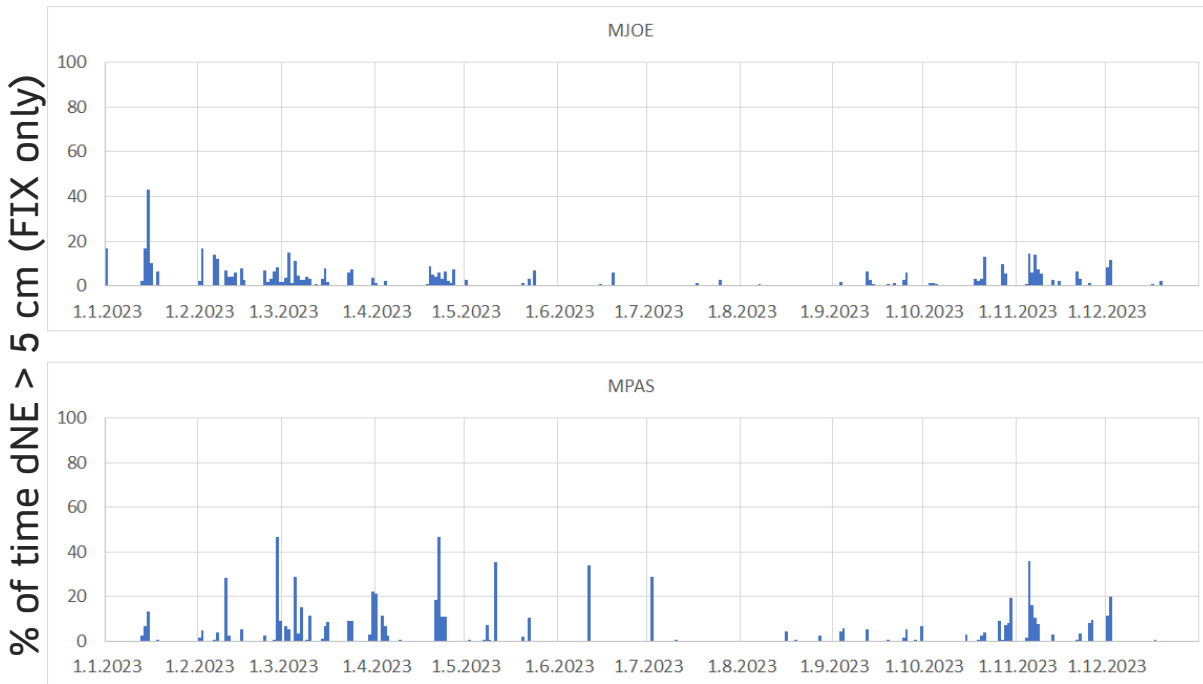


# “daytime activity”- Late season problem



# Monitoring station solutions

% of time (window 21-04 or 06-13UTC) dNE > 5 cm (FIX only)  
21-04UTC 06-13UTC

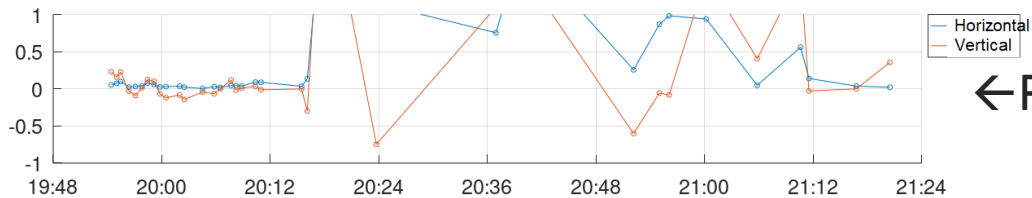


Helsinki (MPAS) **30 km** and  
Joensuu (MJOE) **10 km** to nearest ref. station

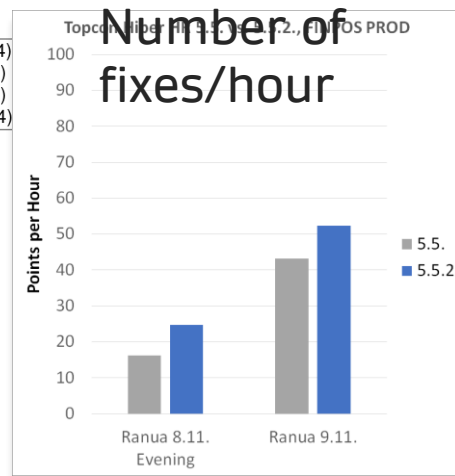
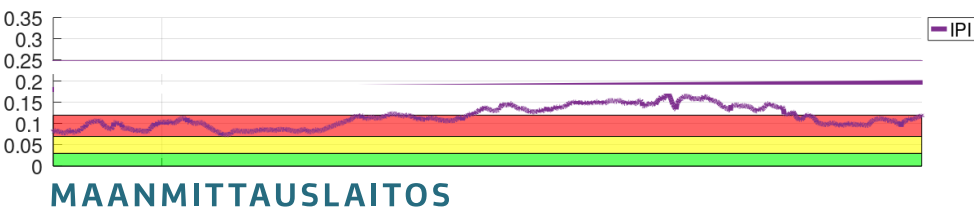
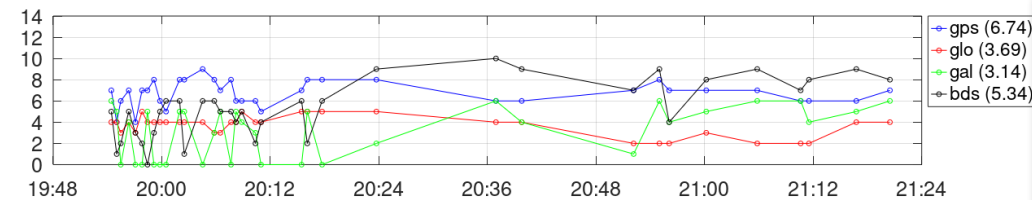
# Test measurements

- Field team tests
  - FINPOS (GNSMART) versions before production use
  - Rover receiver firmwares etc.
  - Comparisons of receivers and services
  - in various places/condition/iono etc

Spaceweather example:



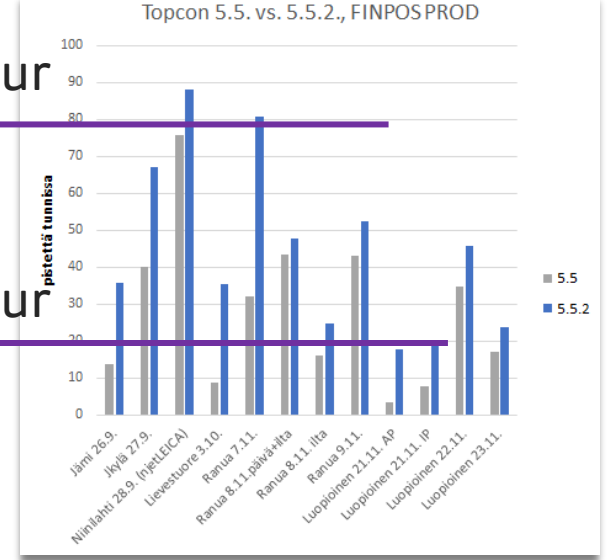
← Position error [m] →



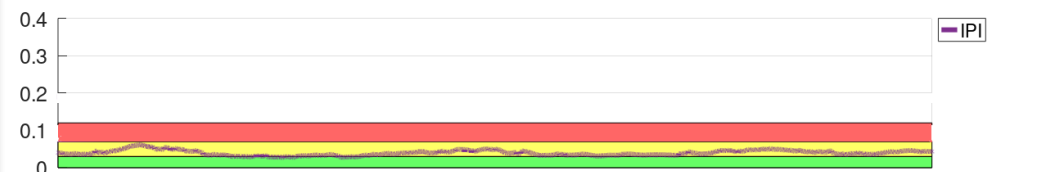
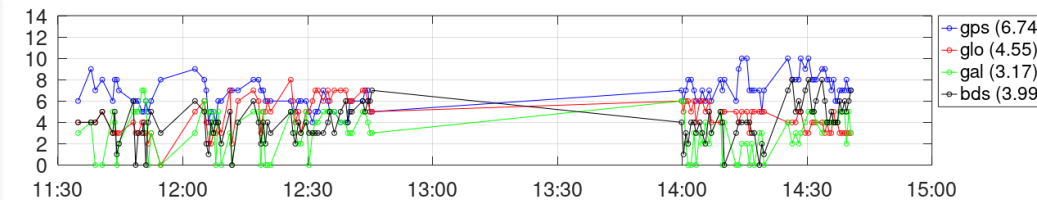
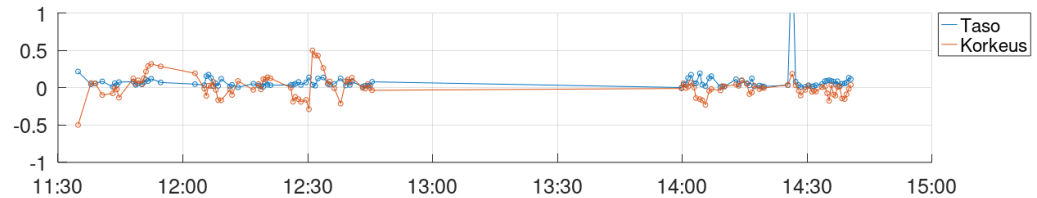
## Rover Firmware tests 2023 autumn

> 80 points/hour

< 20 points/hour

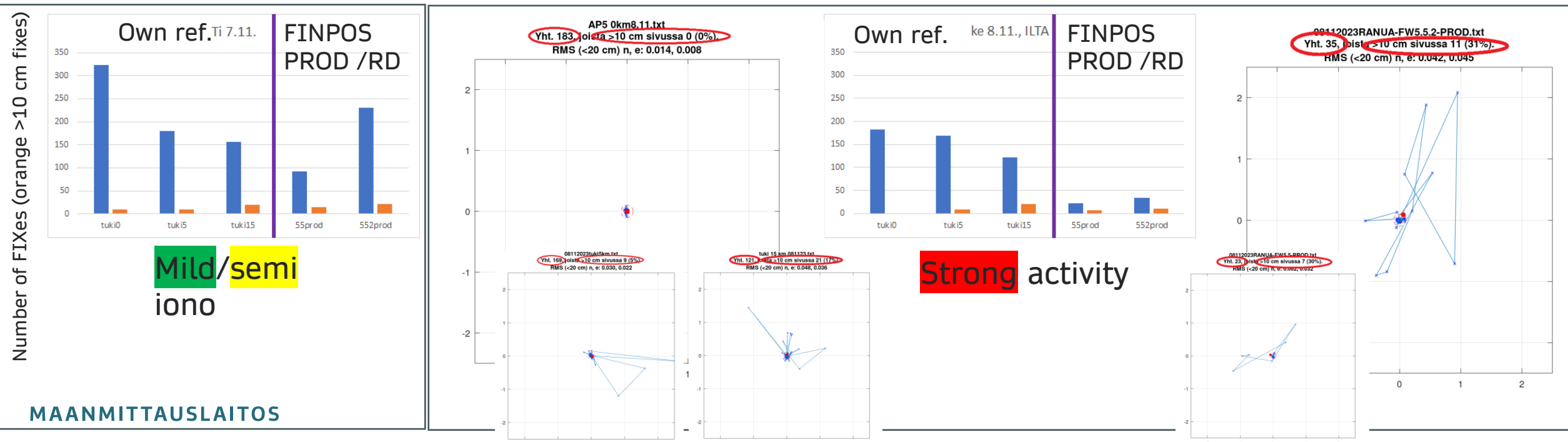


Not so bad spaceweather:



# Own reference station vs. FINPOS NRTK

- FINPOS
  - Nearest station 45 km
- Own reference station
  - 0 km, 5 km, 15 km distance to rover
  - Corrections delivered from reference rec. to rover via cloud
  - Reference & rover same model



# Comments from the field – Query

“End of autumn, every day when I measured, it was so difficult to get a fix. Places with much three canopy, the point measurement time could be up to 20 minutes. I hope it gets better next summer. ”

"It's been a couple of mornings without measuring at all, since then I've been monitoring the ionosphere more closely"

"A few times during the year. So many random times that I can't remember exactly when it happened. However, I often got measured on the same day or at the latest on the second visit."

"Usually random moments during the day when the work slowed down. One day was completely wasted when the solutions were unreliable"

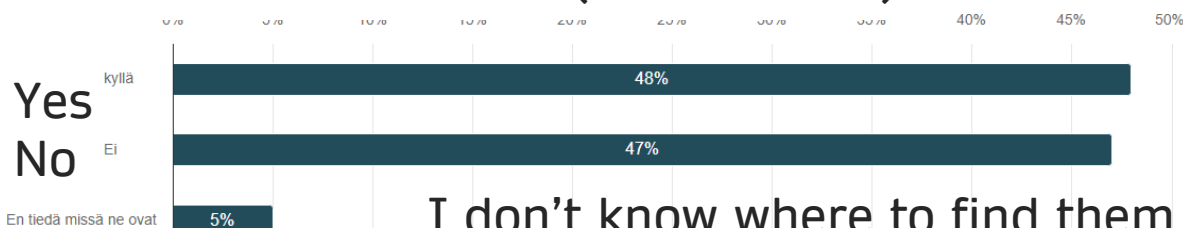
"There may be difficult days every few weeks, or repeatedly every day in some weeks"

"Once on 21.11. I went to home..."

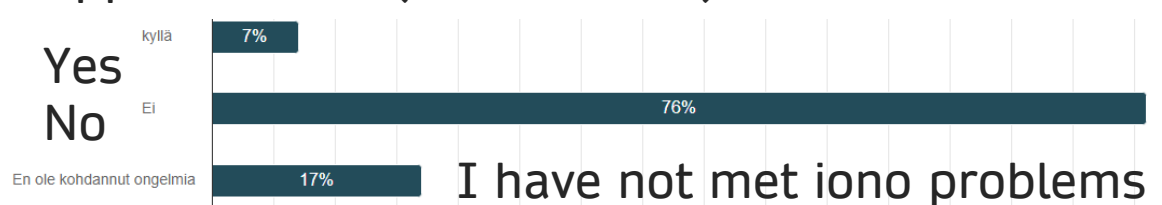


Seuraan ionosfäärin tilanteesta kertovia mittareita/sivuja:

I follow iono-indicators (238 answers):

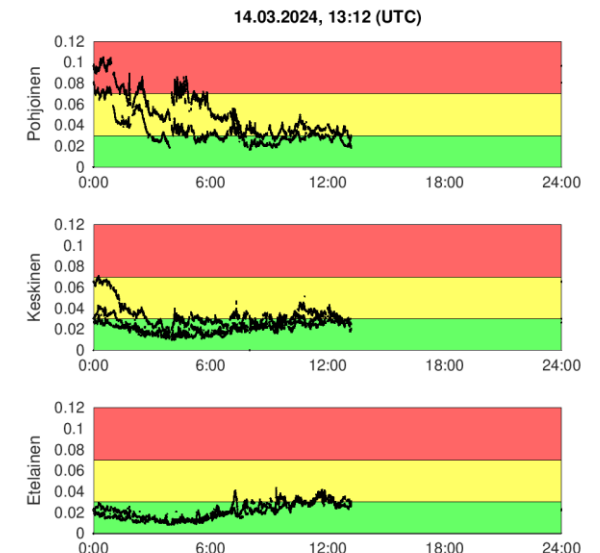


Have you reported about iono problems to NLS support service (237 answers)?



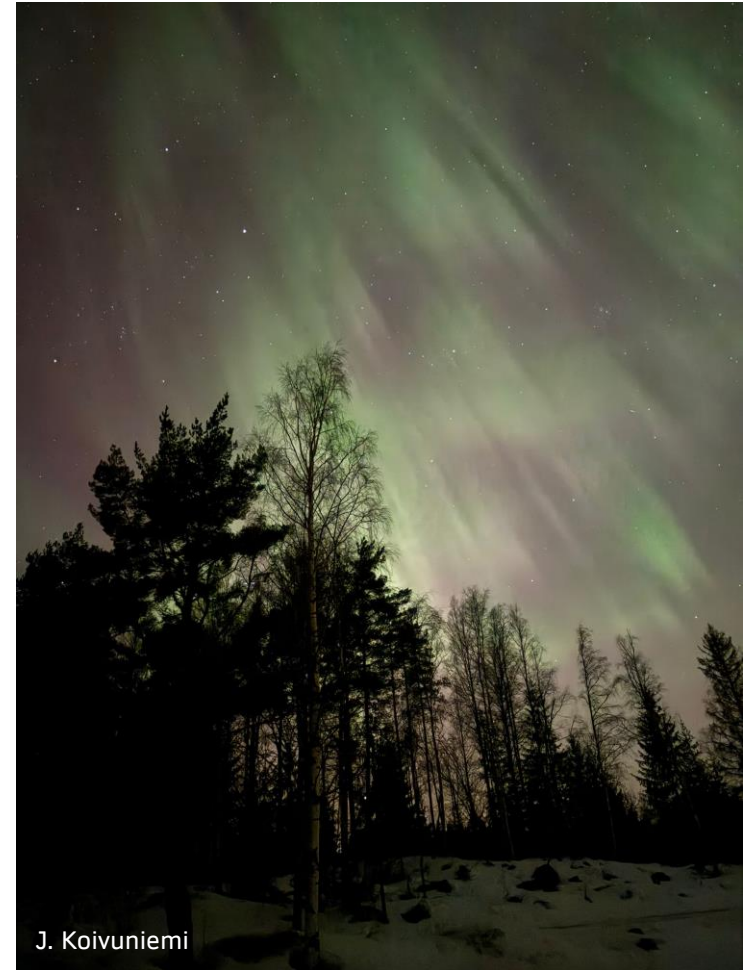
# Preparations to reduce effects of ionosphere to RTK positionings

- Information to field → growing knowledge about the theme
  - Intra news and NLS web pages
- Uptodate service and user equipment/software
  - Test campaigns + feedback to manufacturers
- Densified network
  - Collaboration with NMAs and companies
- Indicators → data from GNSMART (IPI, I95) / <https://finpos.nls.fi/iono/>
- Back up methods: "traditional RTK" (data delivery modern way via cloud)



# Experiences from solar maximum 25 (so far)

- Different situations → Sun bursts and 11y/annual/daily etc cycles of ionosphere, winter anomaly
- How big effect to user → RTK accuracy/availability can be "zero" at its worst, main field season went mainly OK
- Preparations to reduce effects of ionosphere to RTK positionings



# The End

