GNSS probing of local ionospheric disturbances in high latitude

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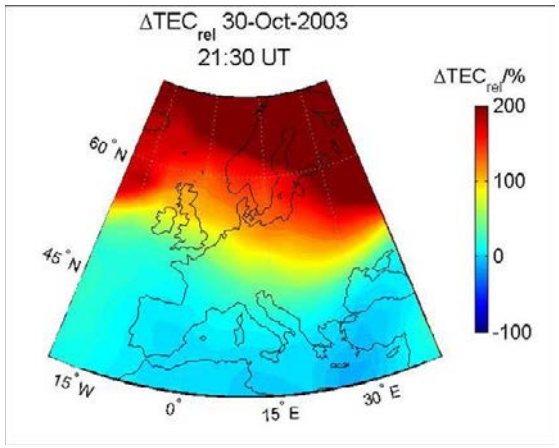
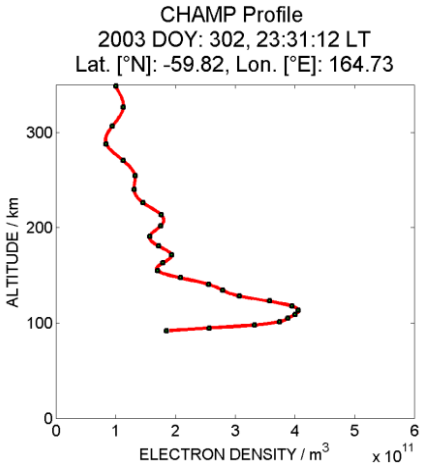
Ionospheric perturbations impacting GNSS





Large scale

≈1000 km

hours

Propagating Ionisation front

Horizontal gradients

Mid-scale

≈100 km

minutes

Wavelike phenomena

Ionisation patches

Plasma bubbles

Small scale

≈ ≤ 10 km

seconds

Plasma turbulences

Plasma instabilities

Particle precipitation

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Motivation

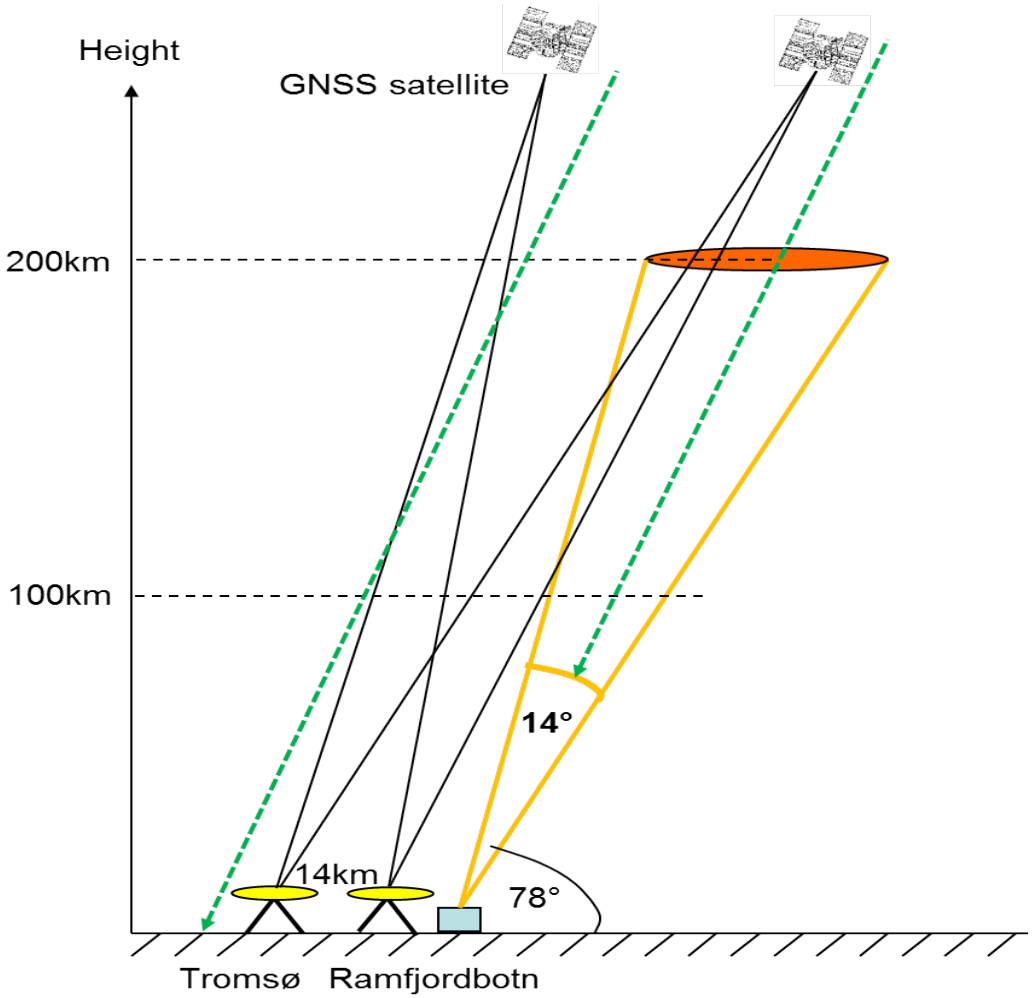
GNSS relative carrier phase slant TEC (**T**otal **E**lectron **C**ontent) to probe ionospheric plasma irregularities caused by powerful HF radio waves

$$sTEC_{rel} = \left(\frac{1}{40.3}\right) \cdot \frac{f_1^2 f_2^2}{f_2^2 - f_1^2} \cdot (\phi_1 - \phi_2)$$

Experiment

EISCAT heating
Magnetic Zenith
EISCAT UFH radar

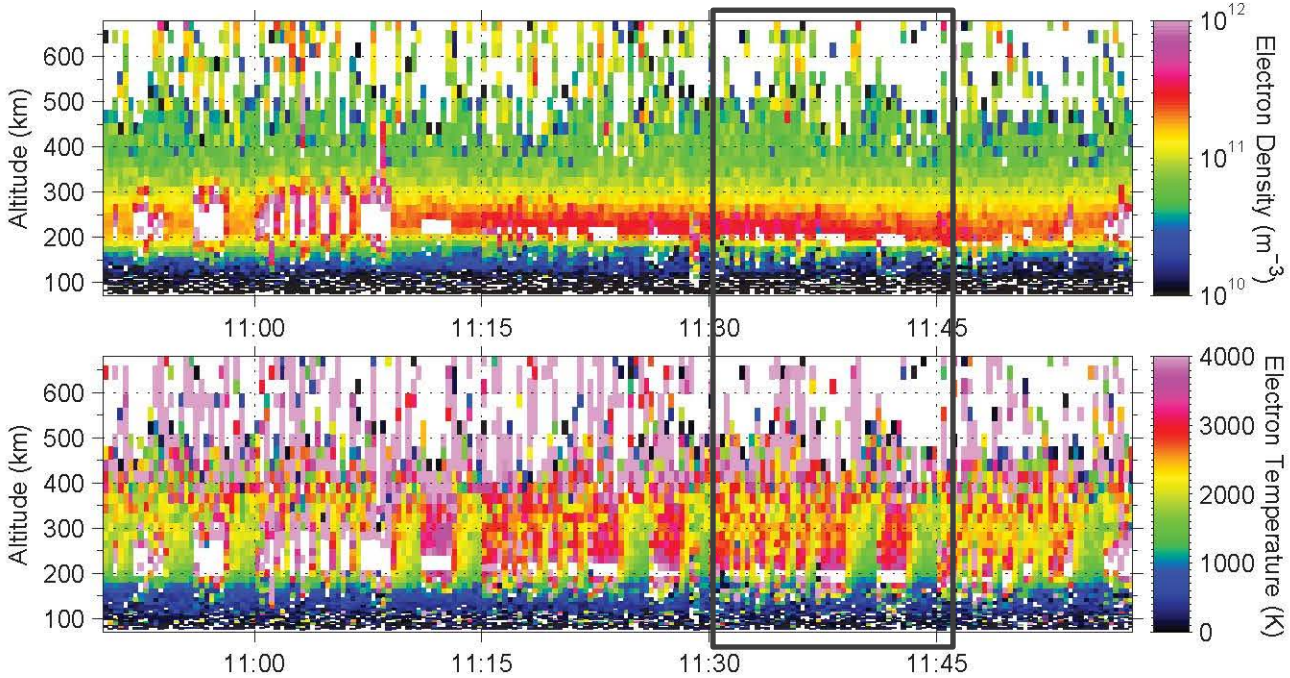
2 GNSS measurements
20Hz sampling rate
14 km separation
Tromsø and
Ramfjordmoen (EISCAT)



EISCAT UHF

04 December 2010

START (UT)	END (UT)	Frequency (MHz)	Description of Modulation
09:45	12:00	4.544	10s on /10s off for 60s, 20s on/20s off for 120s 40s on/40s off for 240s, 120s on/120s off for 480s



Heating Frequency 4.544MHz
Plasma instability near reflection height 192 km
UHF radar integration 20s

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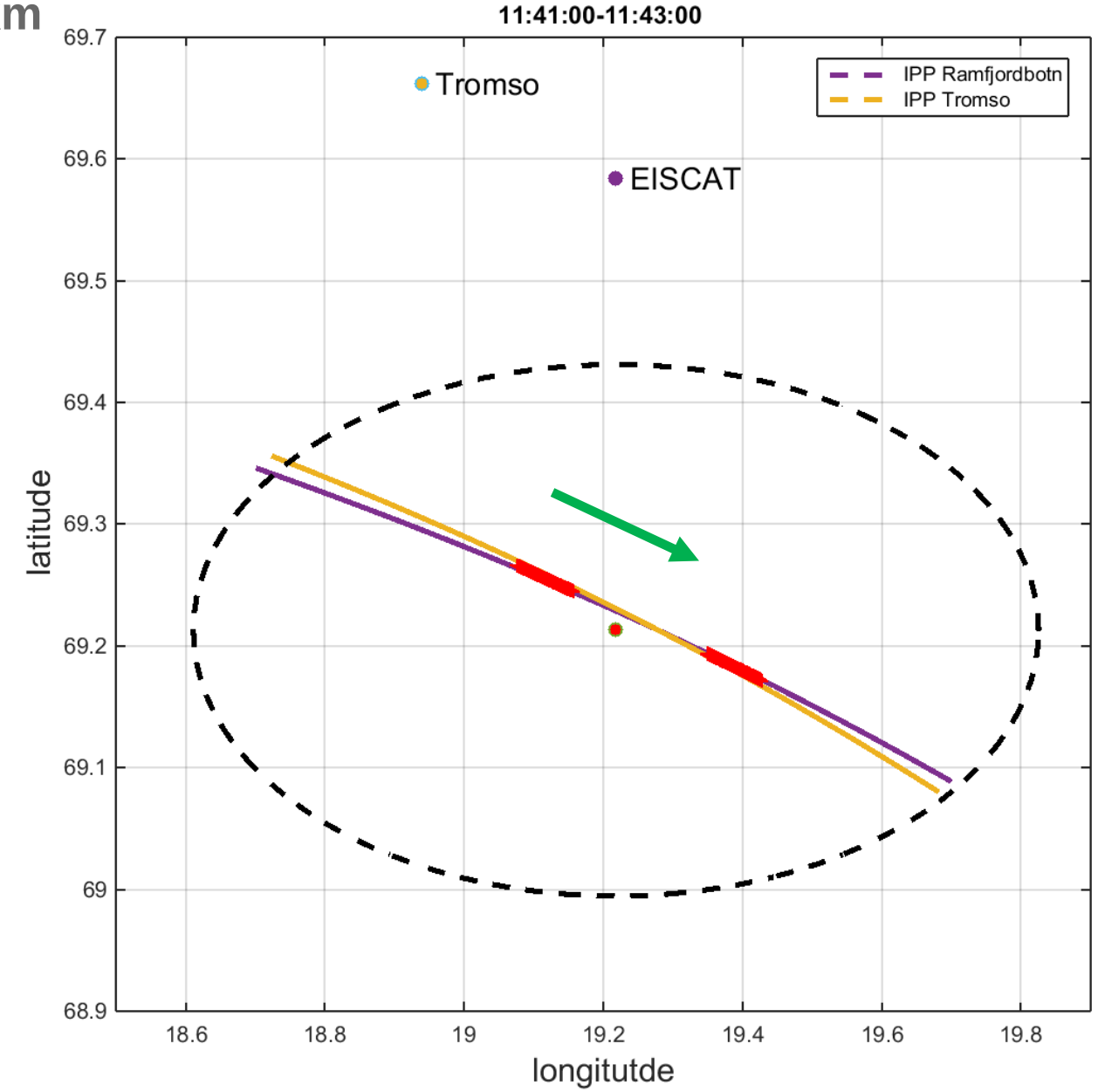
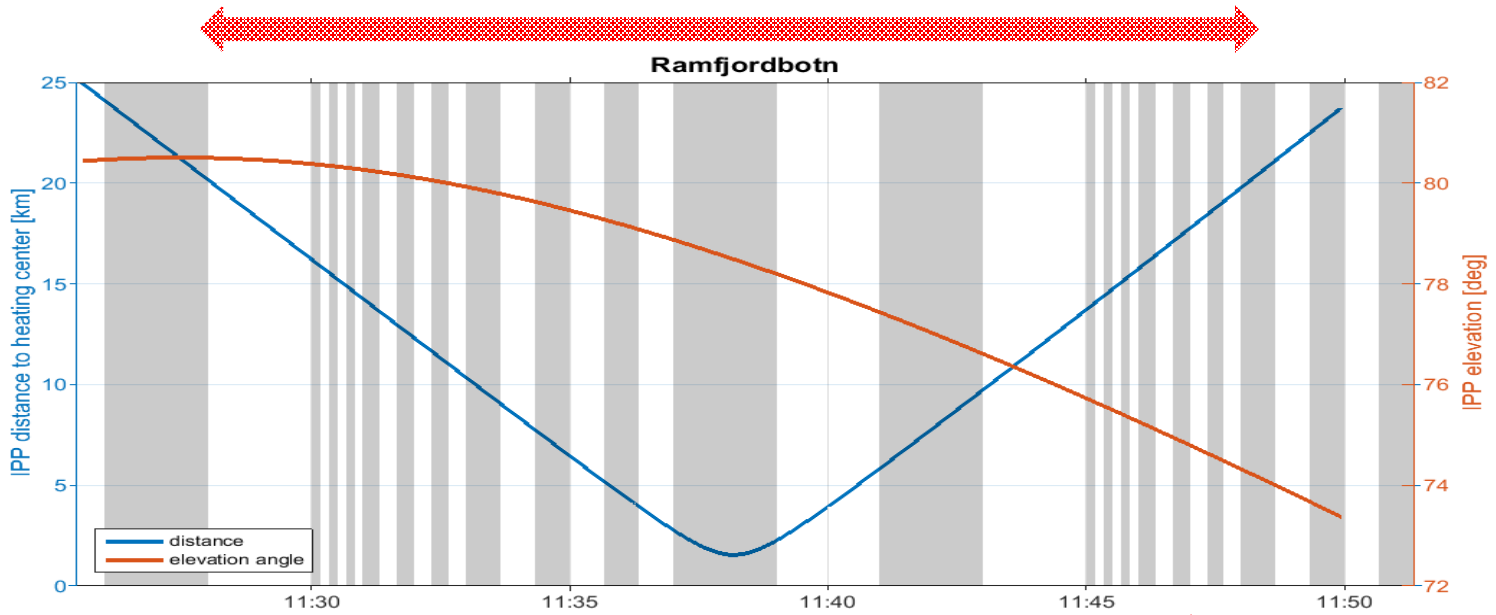
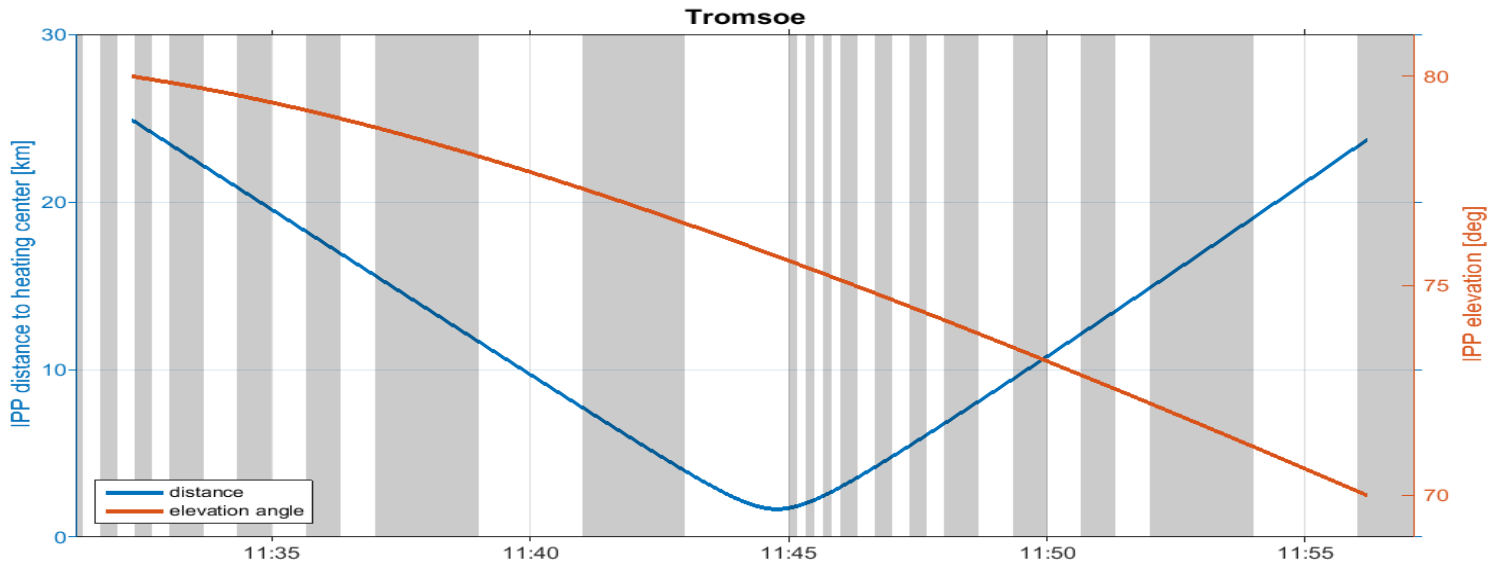
GLONASS R 23 satellite

IPP at 200 km

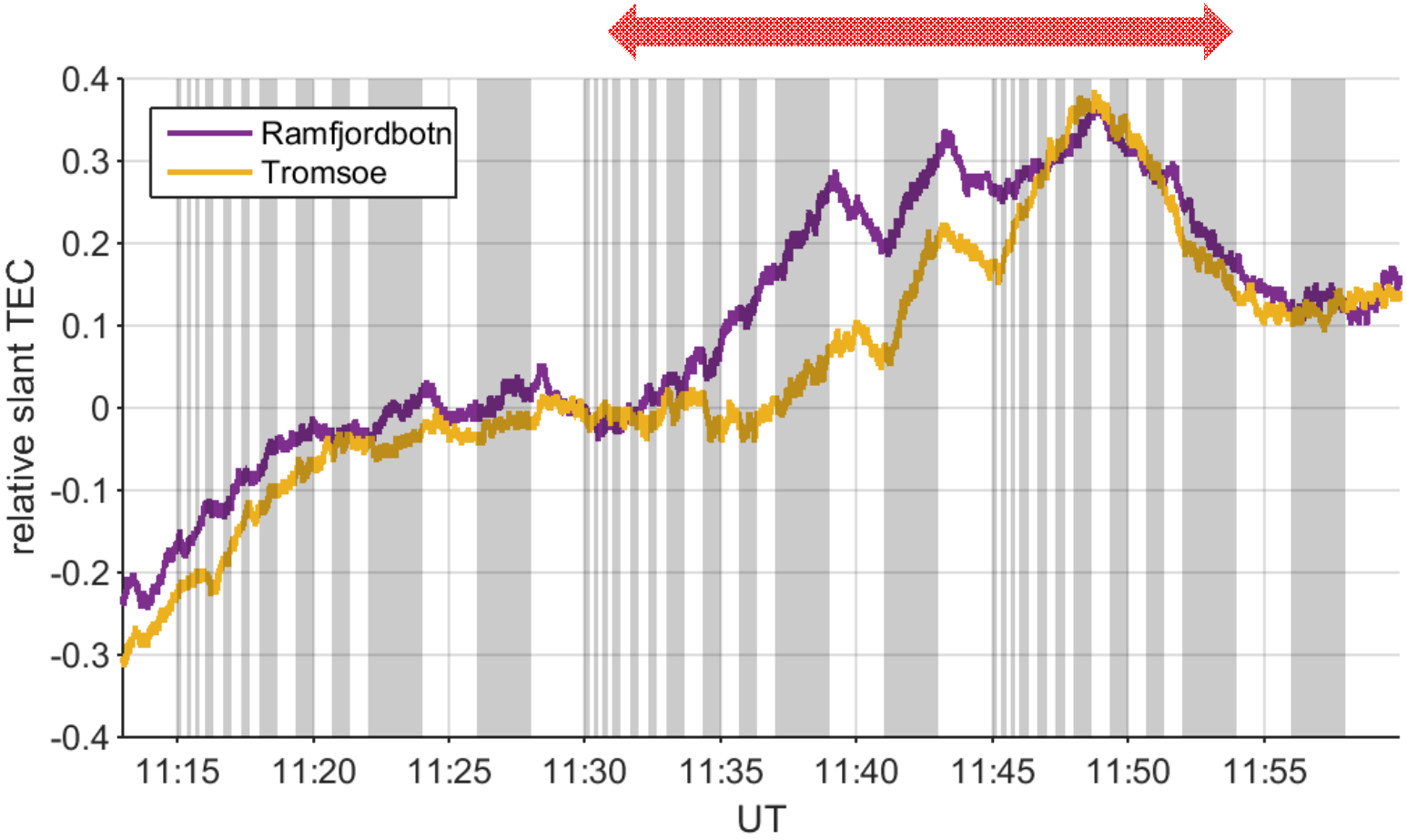


elevation angles





Result:
Relative slant TEC Ramfjordbotn vs Tromso



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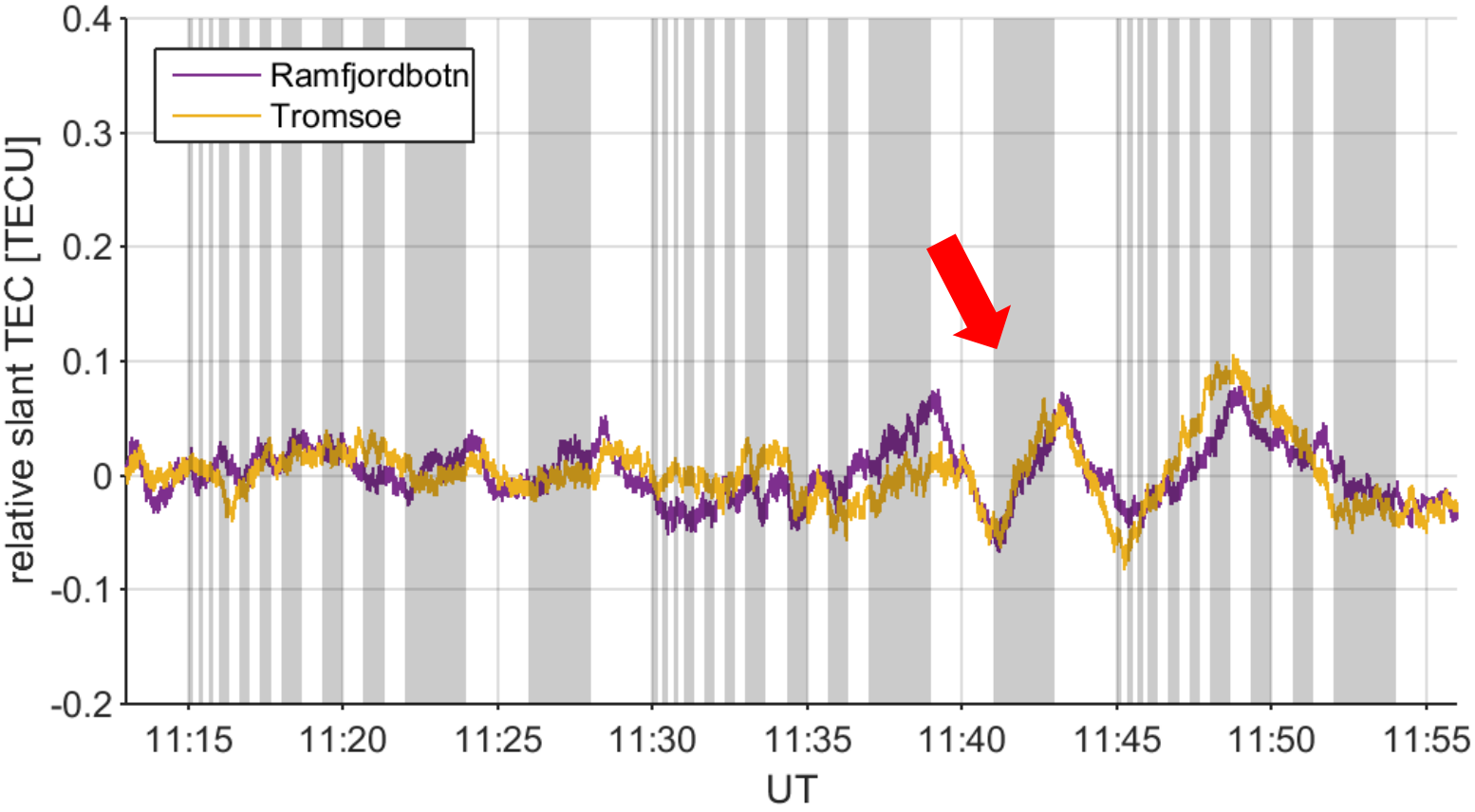
Detrended sTEC Ramfjordbotn vs Tromso



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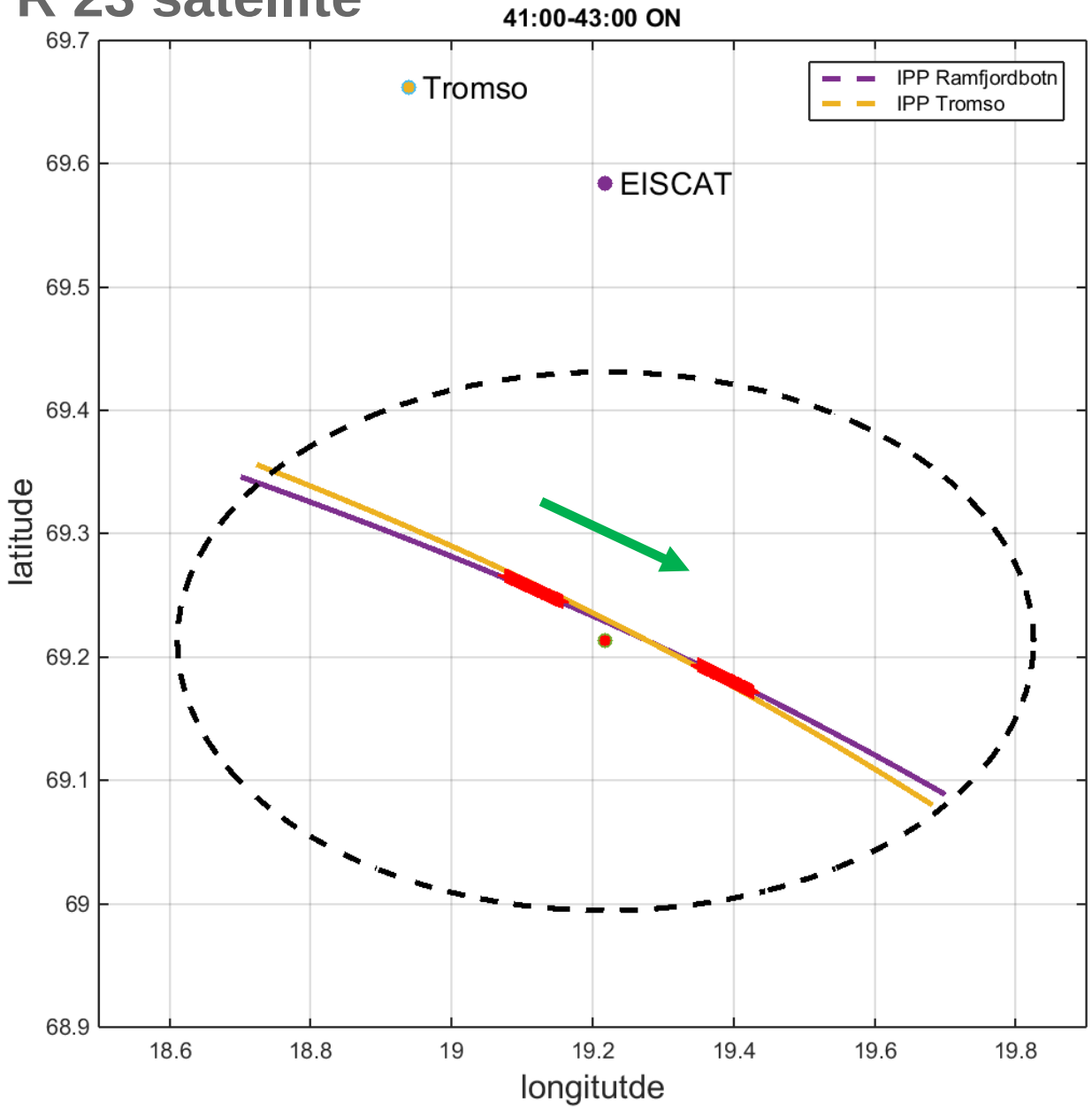
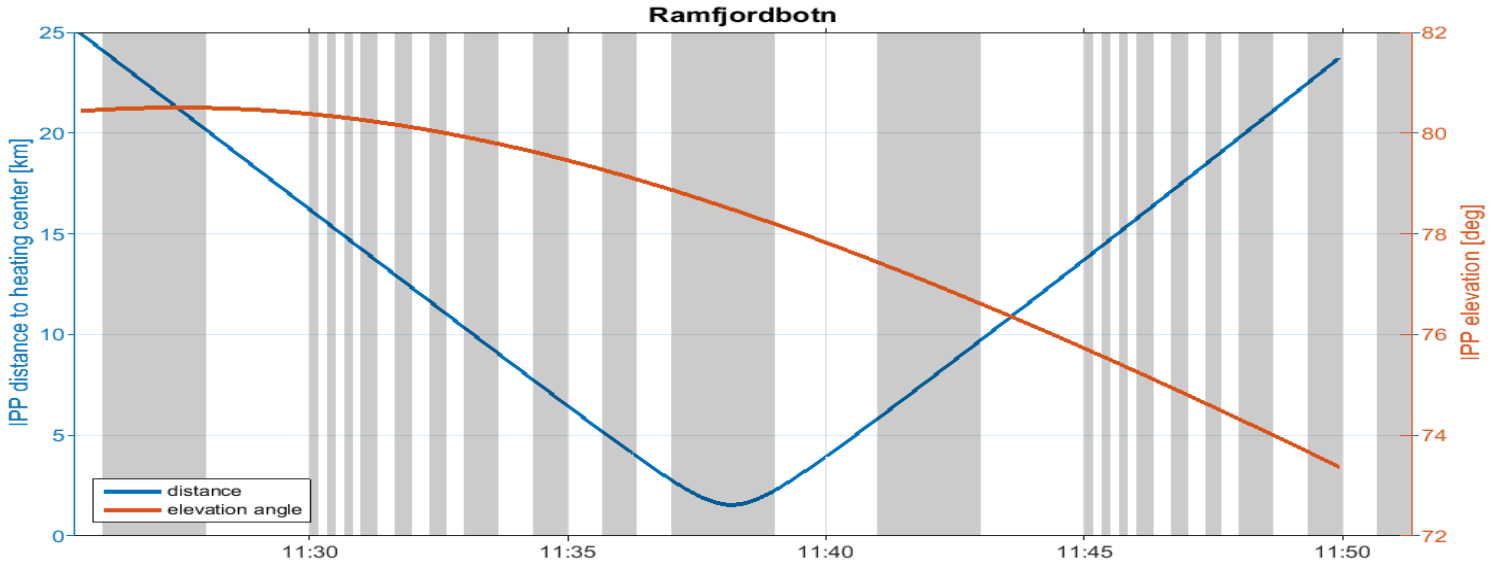
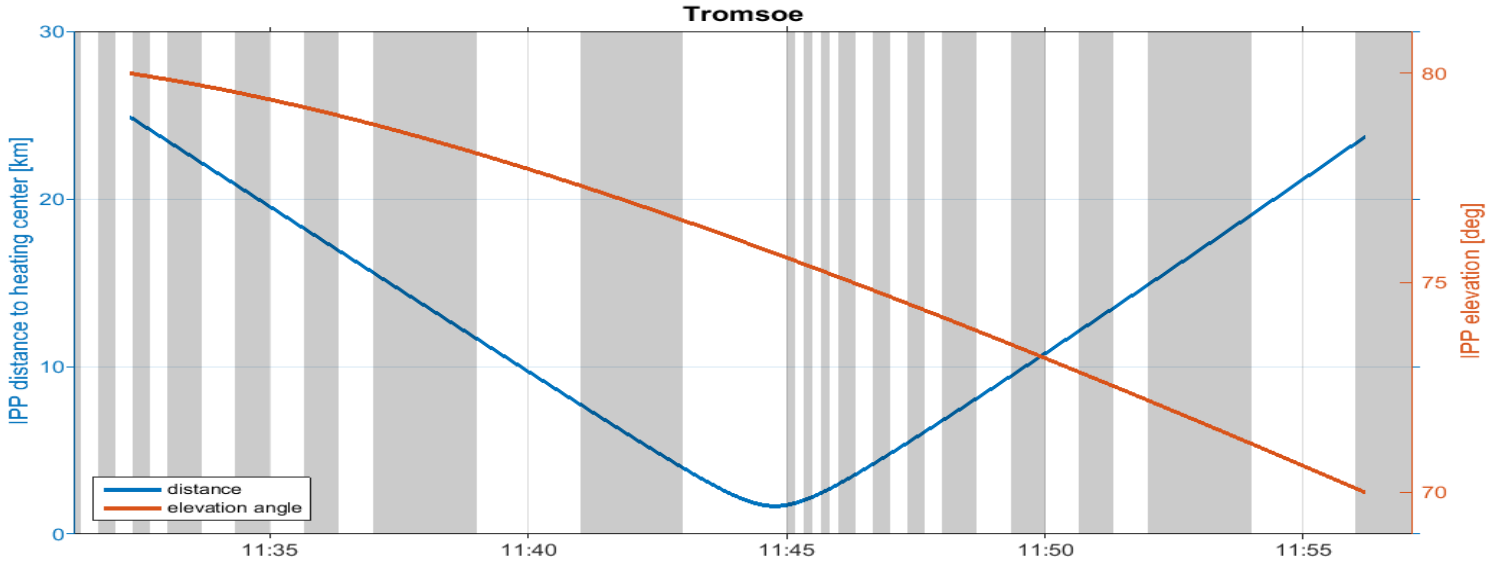
GLONASS R 23 satellite

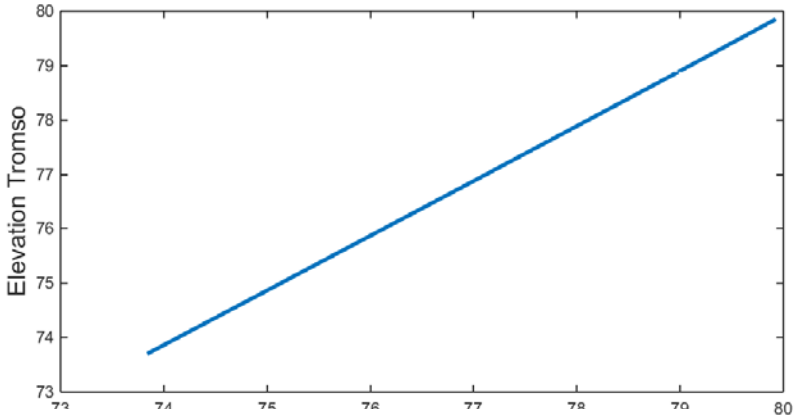


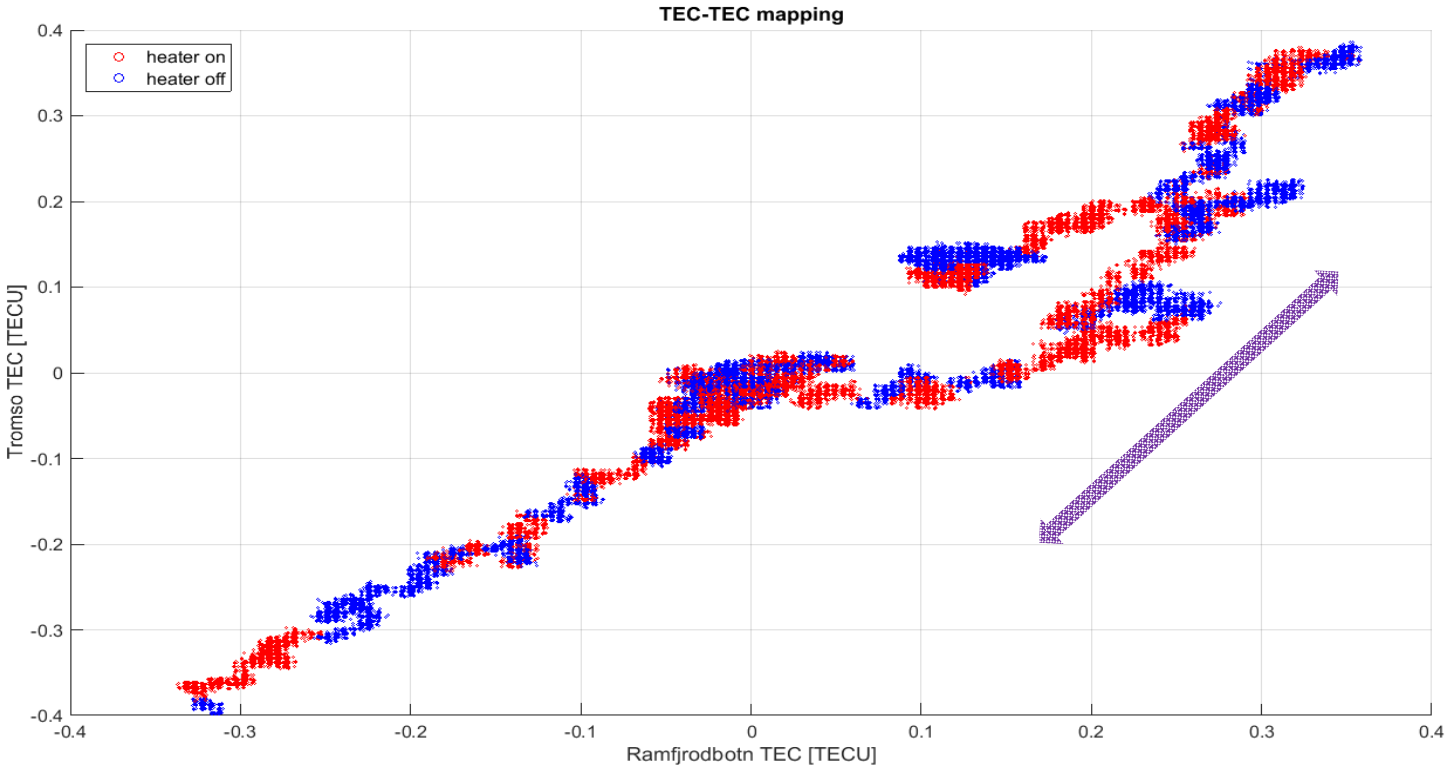
elevation angles





$TEC_{tromso} \propto TEC_{ramfjordbotn}$?





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Summary

- GNSS TEC responses to artificial ionospheric modifications by HF radio waves
- TEC responses to heating ON/OFF is most clearly seen in the vicinity of the heating center
- Background TEC may be also modified by heating
- Complimentary measurements for EISCAT experiments