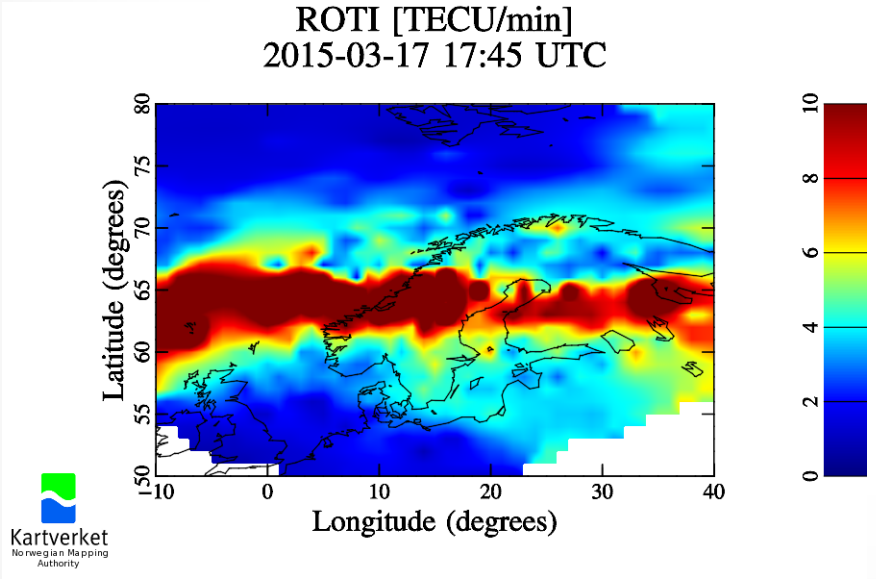
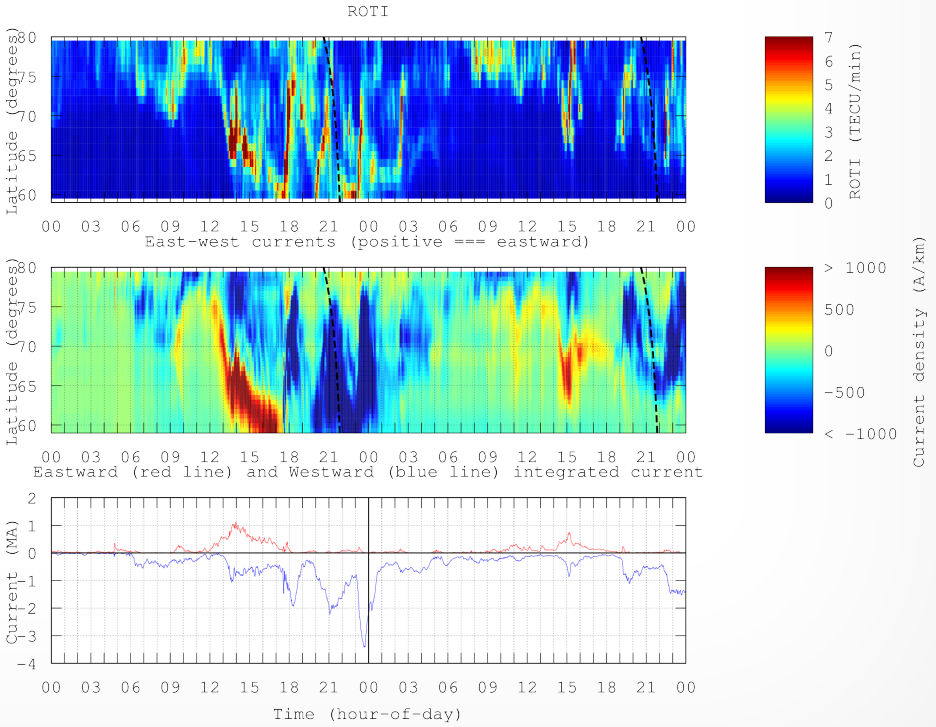
Overview of the 2015 St. Patrick's day storm and its consequences for RTK and PPP positioning in Norway

Knut Stanley Jacobsen and Yngvild Linnea Andalsvik
Norwegian Mapping Authority

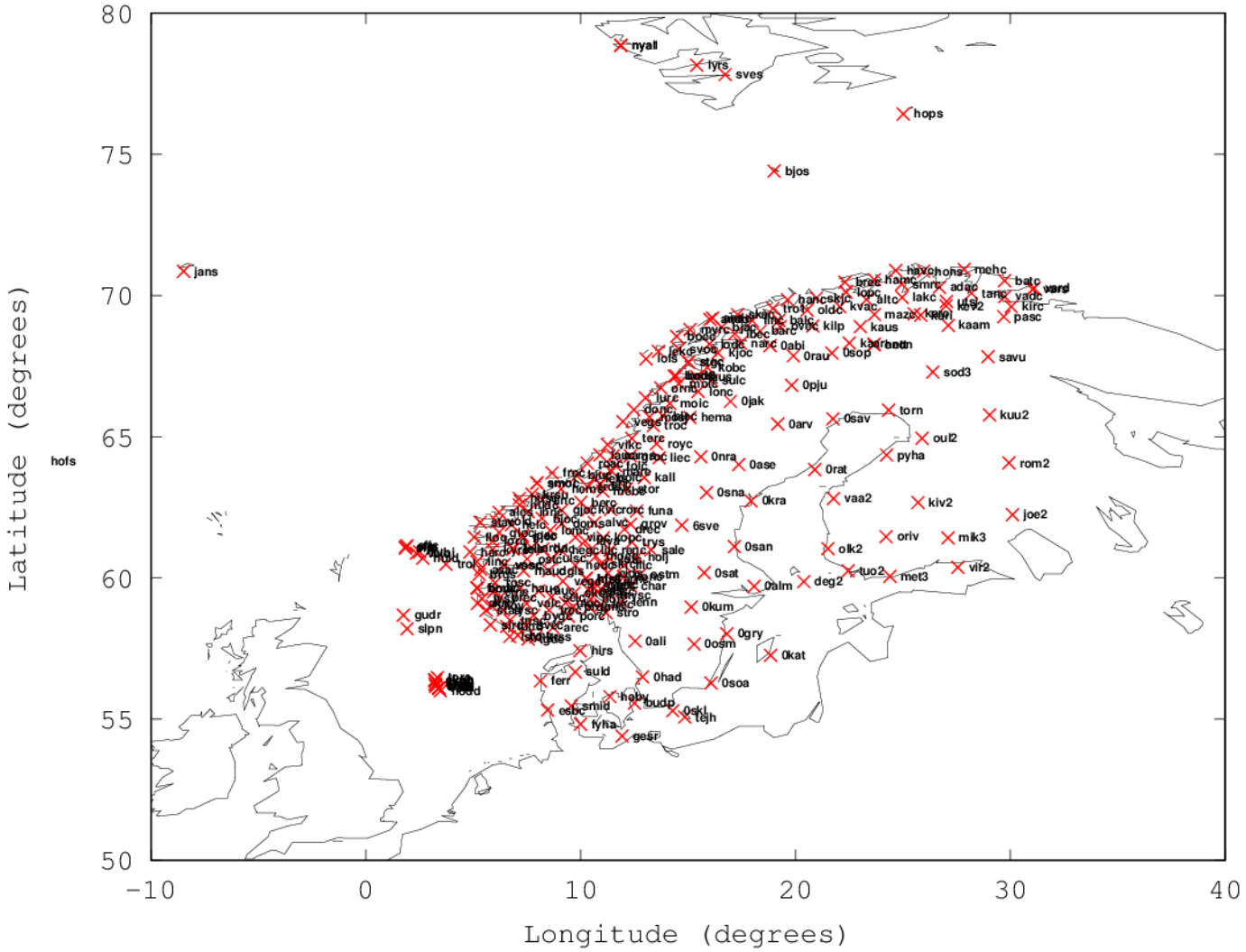
Published in Journal of Space Weather and Space Climate, Vol. 6
http://dx.doi.org/10.1051/swsc/2016004





Data sources – GNSS 1

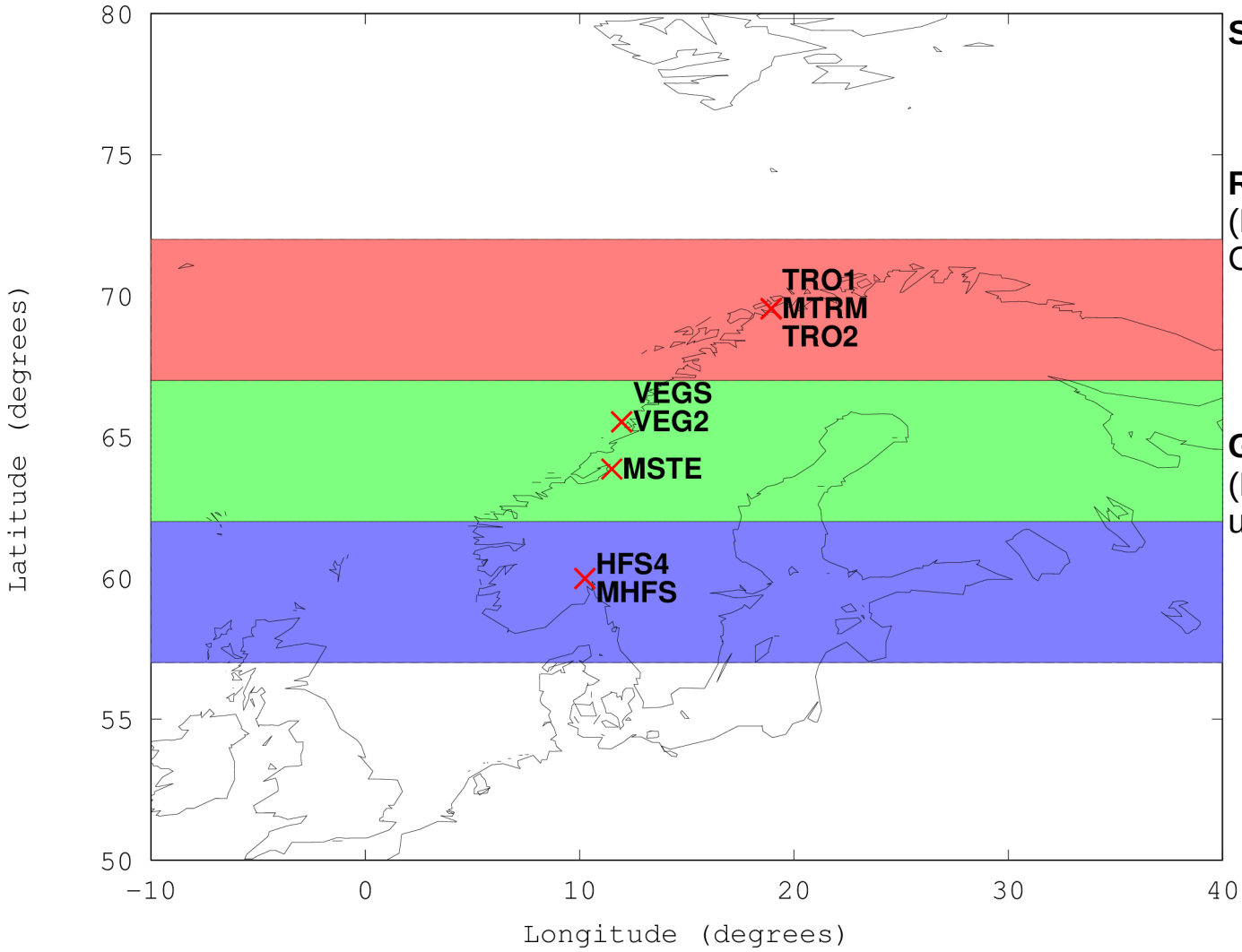
Network used for ionospheric maps



Kartverket

Data sources – GNSS 2

Specific receivers used in analysis



Scintillation receivers

- TRO2
- VEG2

RTK monitors
(Mimics users of NMAs CPOS service)

- MTRM
- MSTE
- MHFS

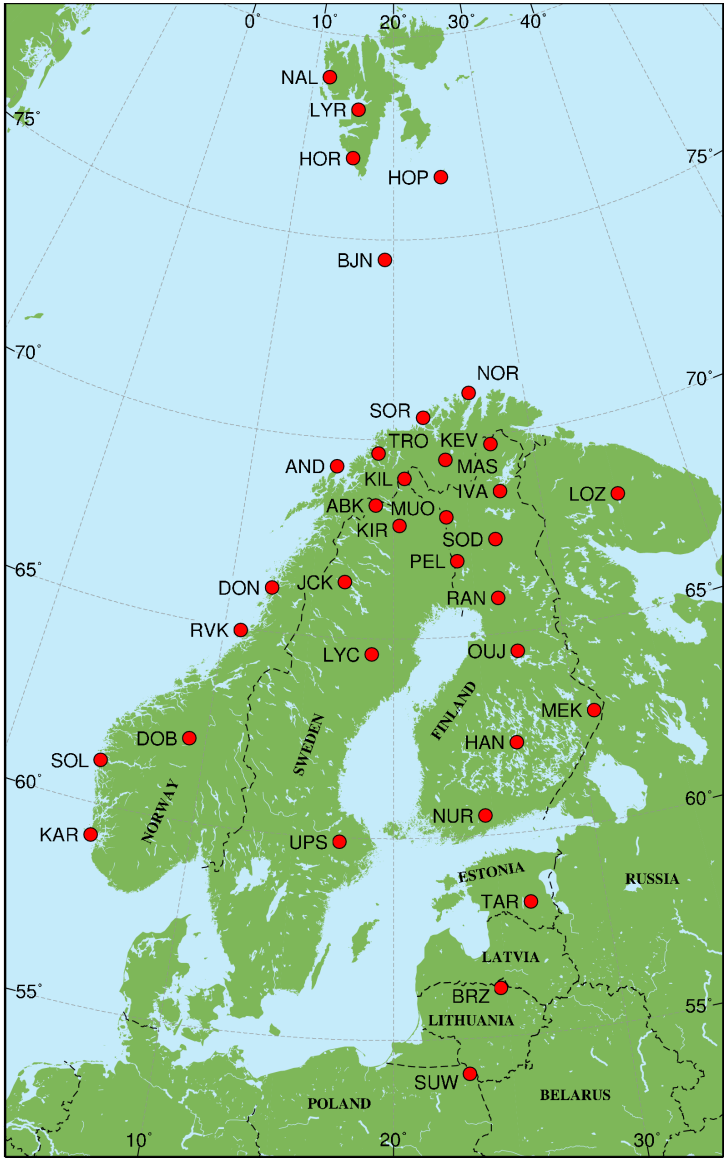
Geodetic GNSS receivers
(PPP coordinates processed using the GIPSY software)

- TRO1
- VEGS
- HFS4

Kartverket

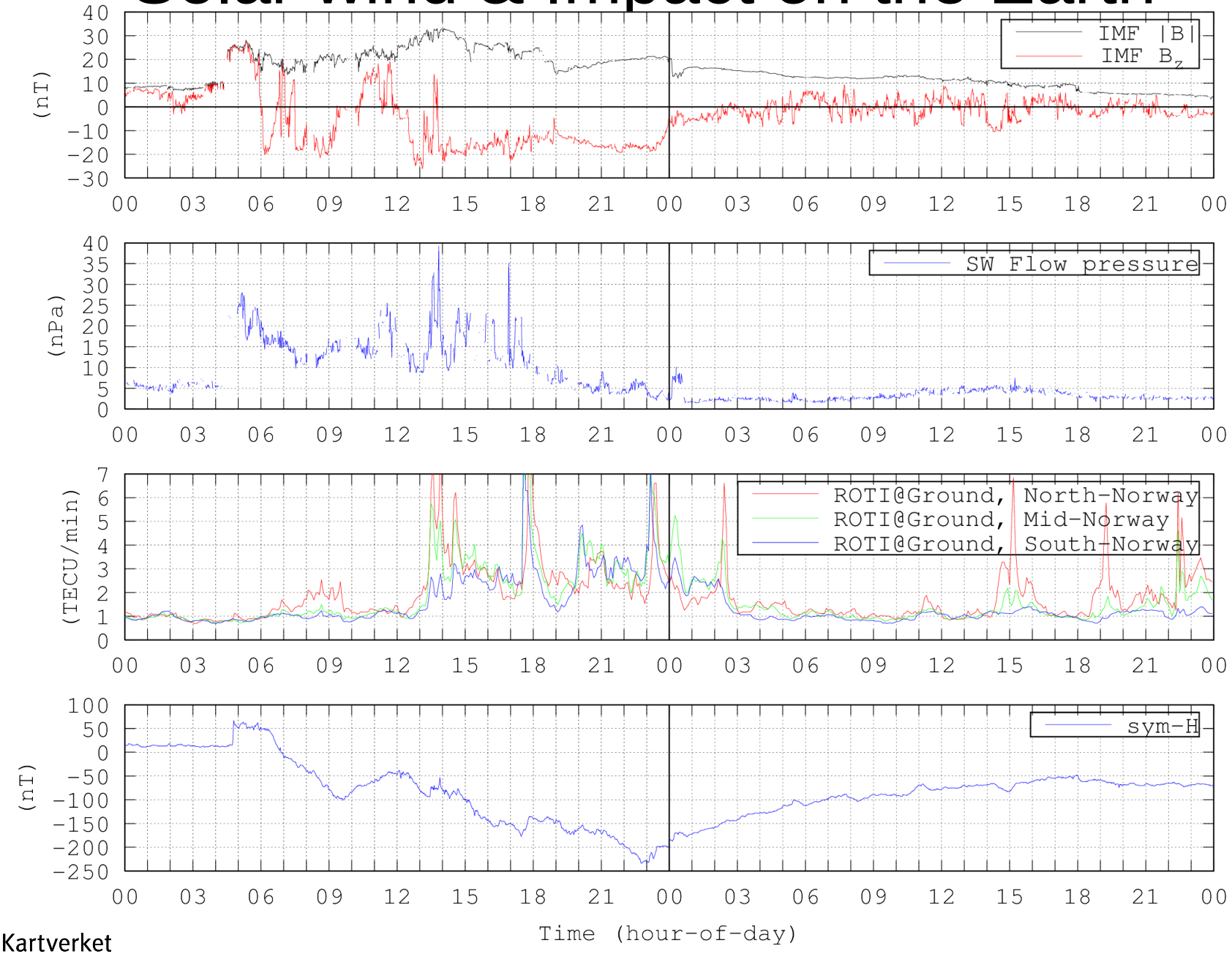
Data sources – Magnetometers

The IMAGE network



Kartverket

Solar wind & Impact on the Earth

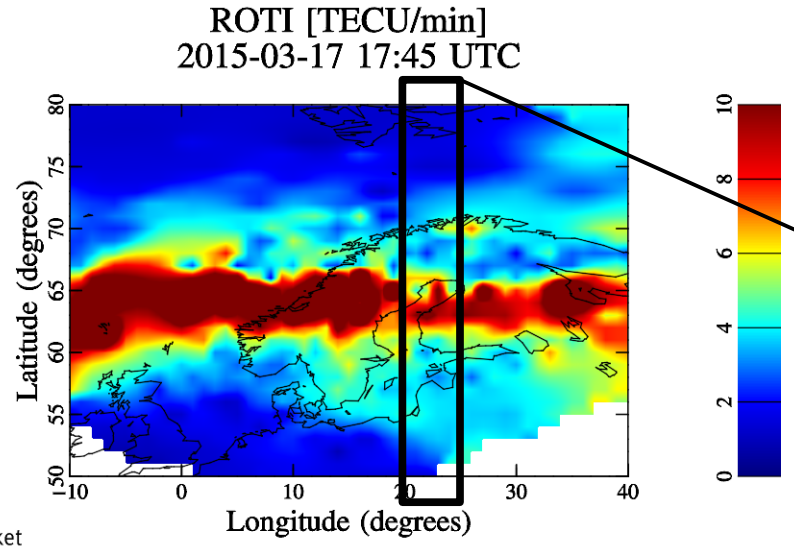


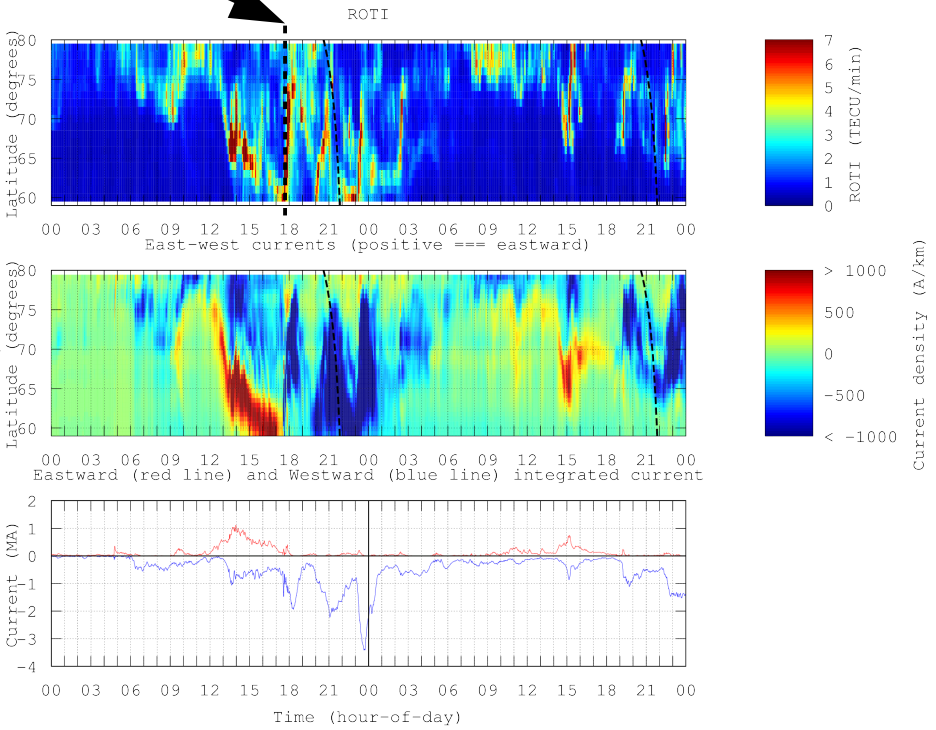
Kartverket

ROTI VS Auroral electrojet current

Rate-Of-TEC Index (ROTI) is the standard deviation of the geometry-free phase combination.

To compare ROTI to auroral currents, a latitudinal slice is taken every 5 minutes to form the upper panel of the plot below.



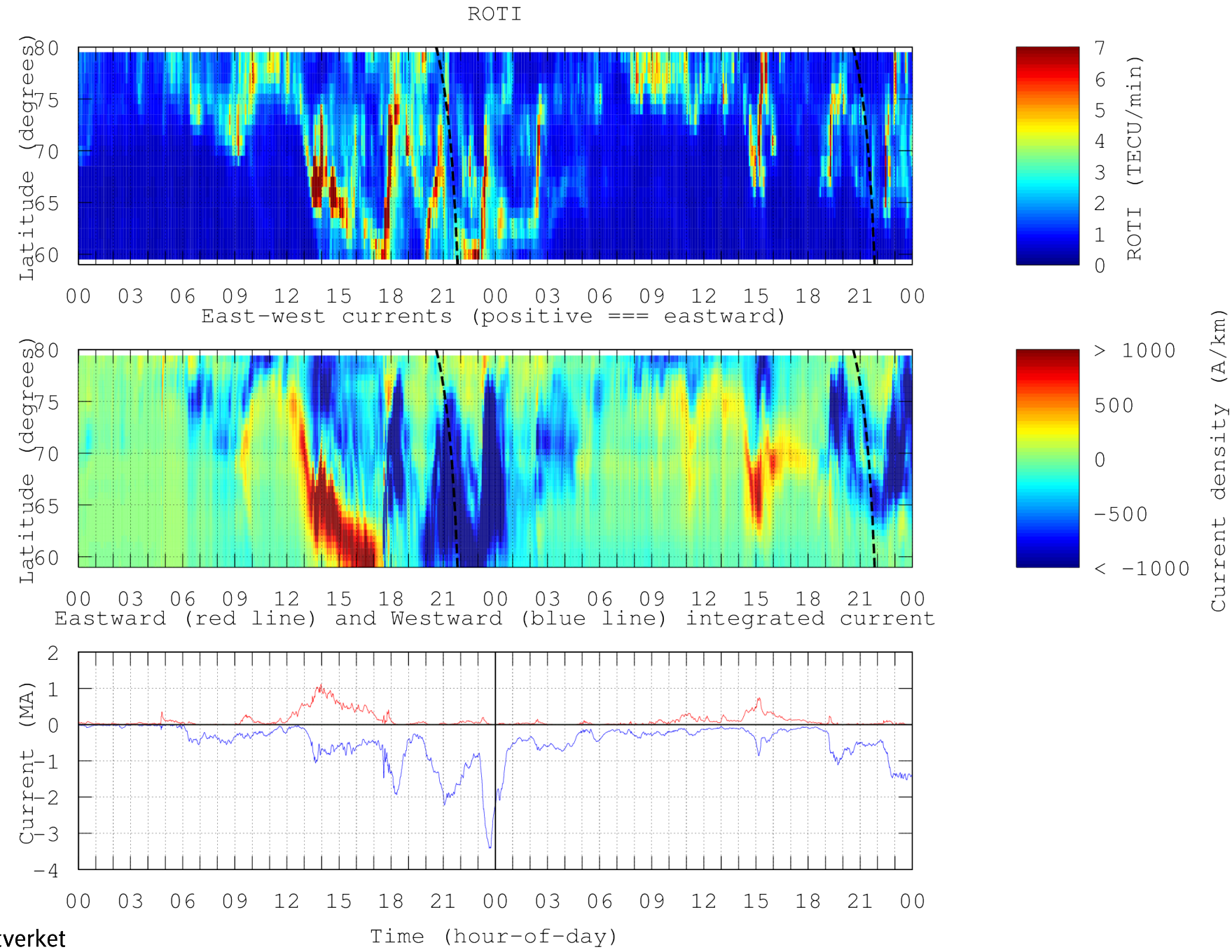


East-west current density →

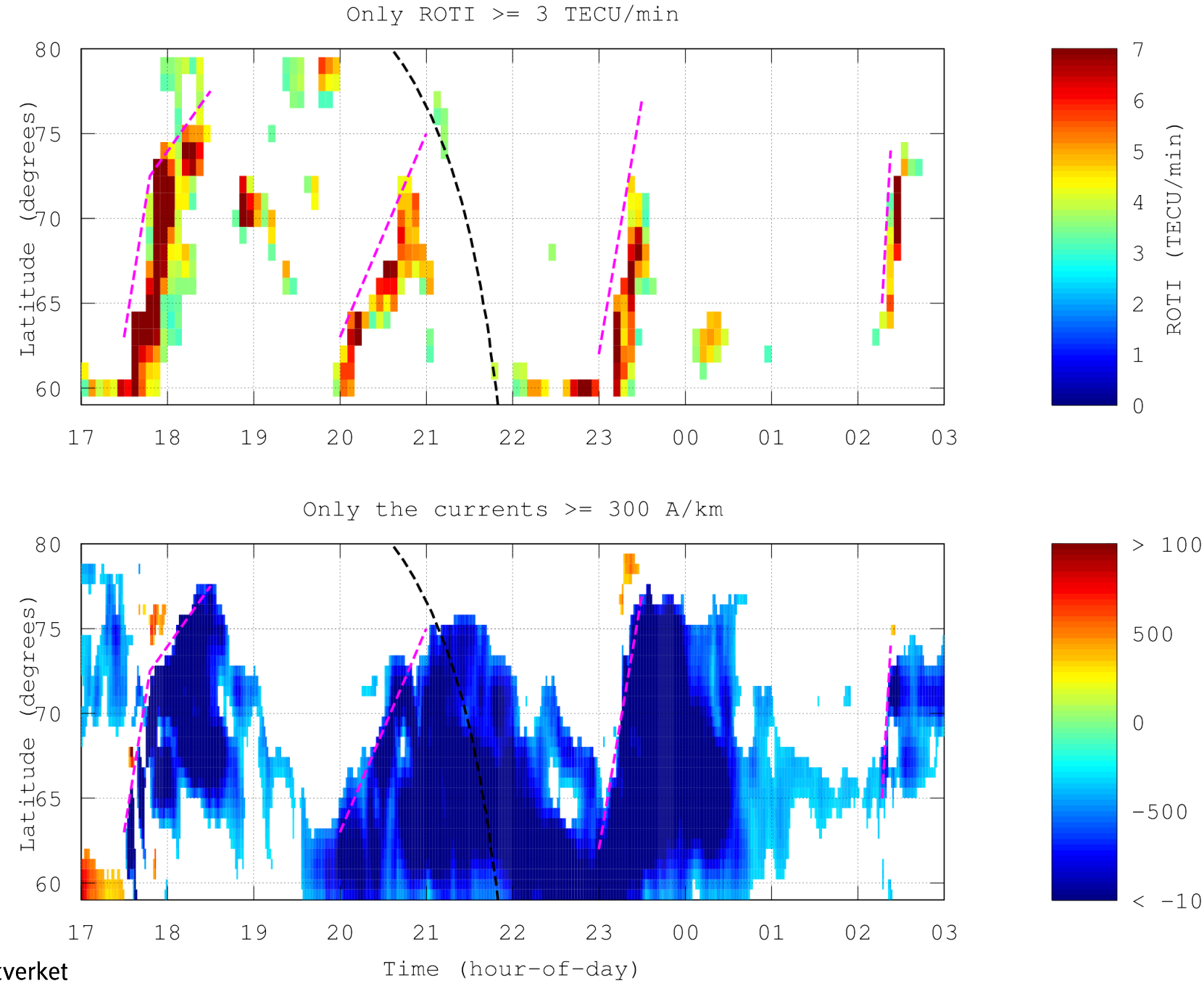
Total east/west current →

Kartverket
Norwegian Mapping Authority

Kartverket


ROTI
Latitude (degrees)
80
75
70
65
60
00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00
East-west currents (positive === eastward)
ROTI (TECU/min)
7
6
5
4
3
2
1
0
Eastward (red line) and Westward (blue line) integrated current
> 1000
500
0
-500
< -1000
Current density (A/km)
Current (MA)
2
1
0
-1
-2
-3
-4
Time (hour-of-day)

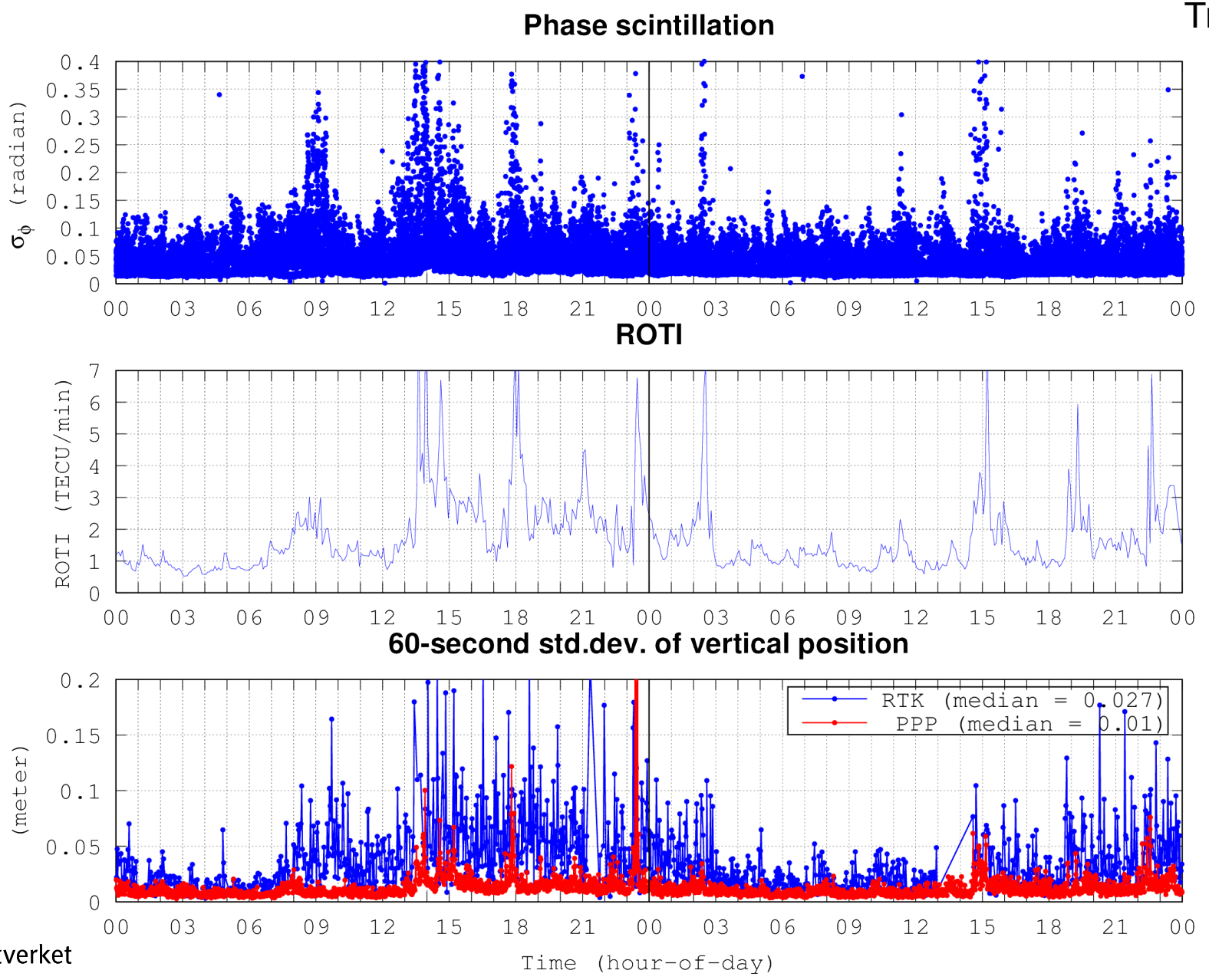
Kartverket


Only ROTI >= 3 TECU/min
Latitude (degrees)
80
75
70
65
60
17
18
19
20
21
22
23
00
01
02
03
ROTI (TECU/min)
7
6
5
4
3
2
1
0
Only the currents >= 300 A/km
Latitude (degrees)
80
75
70
65
60
17
18
19
20
21
22
23
00
01
02
03
Time (hour-of-day)
Current density (A/km)
> 1000
500
0
-500
< -1000

Kartverket

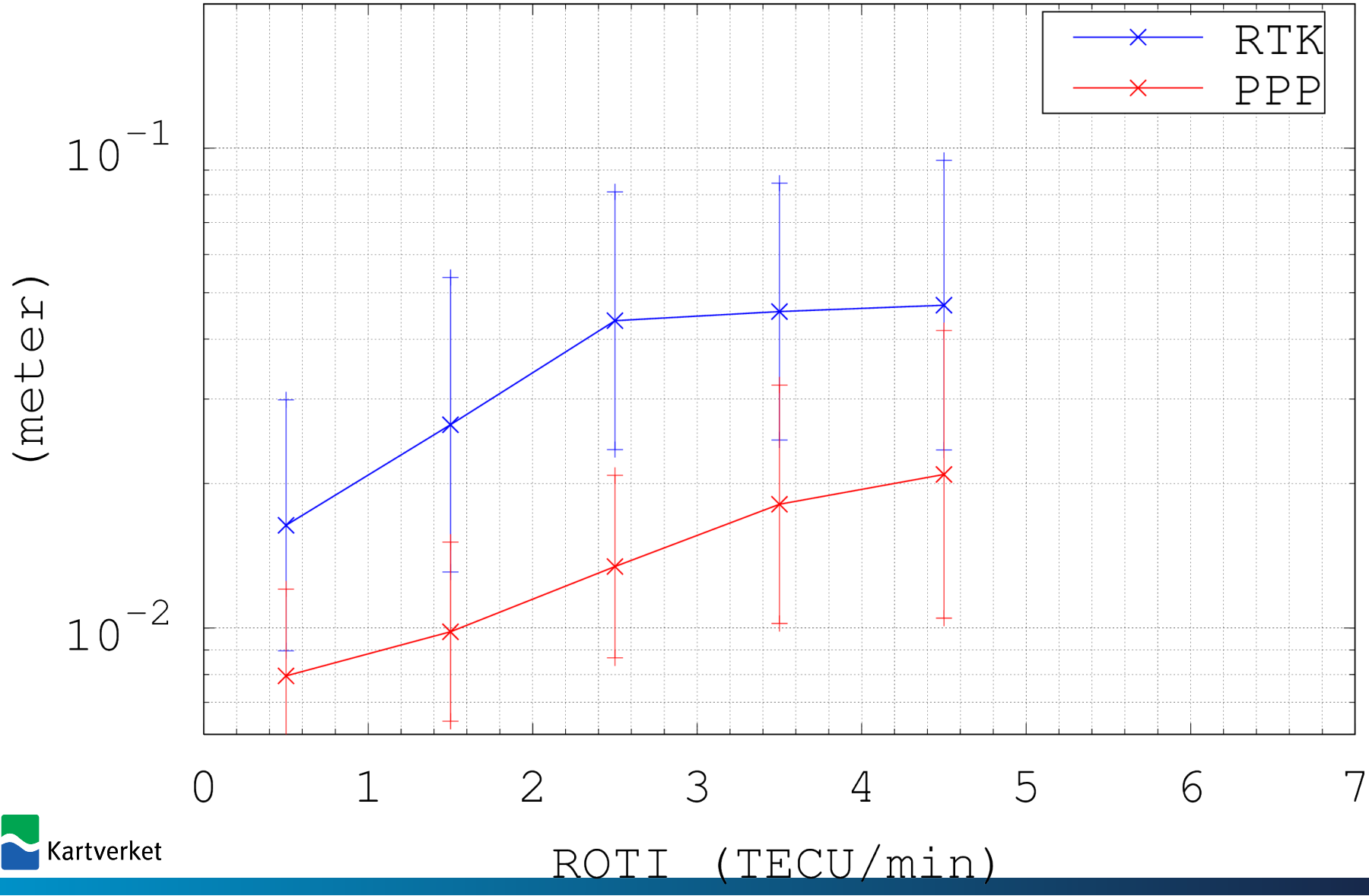
ROTI VS Position errors

Location:
Tromsø



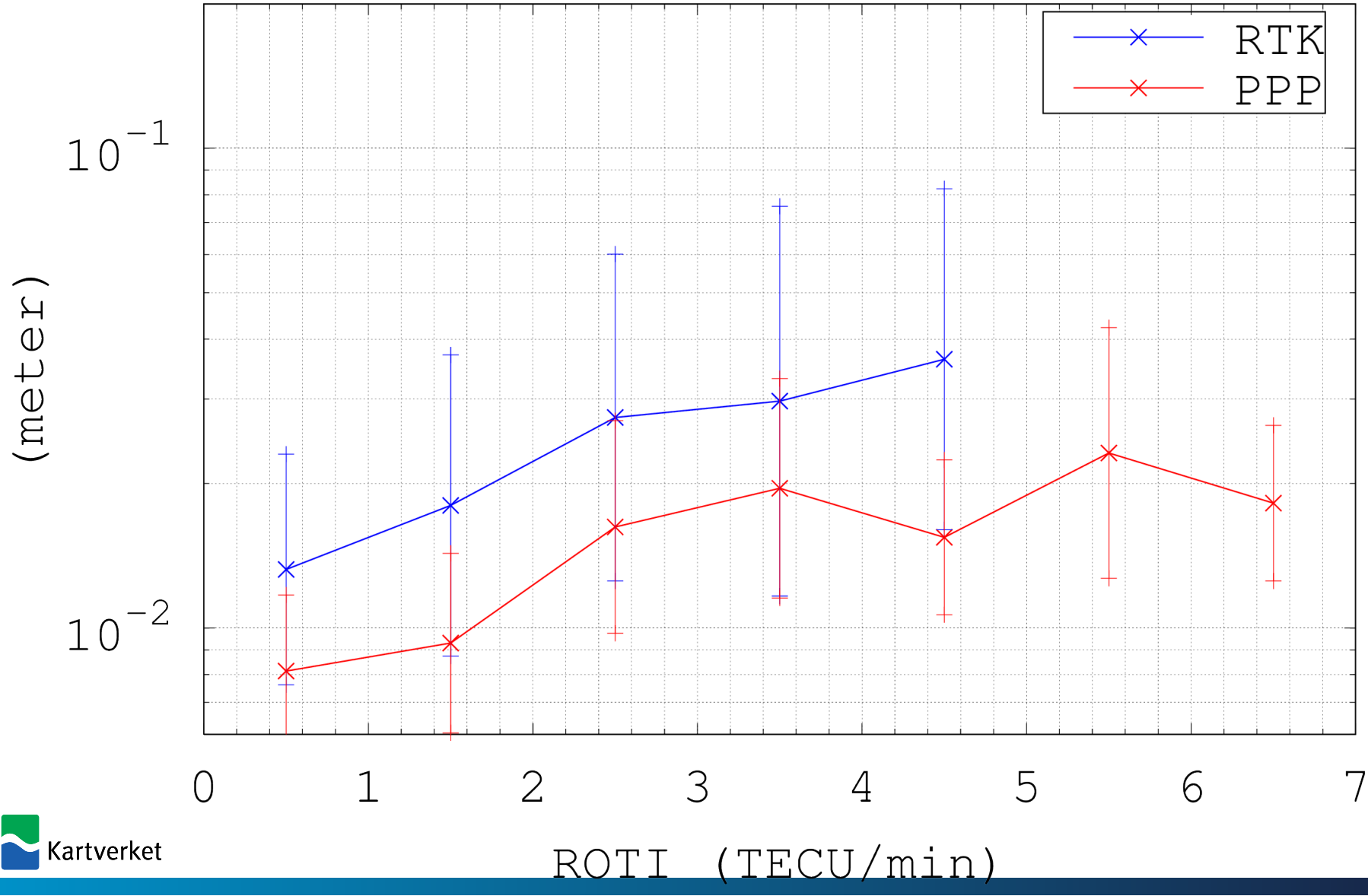
Kartverket

Position error binned by ROTI
Tromso



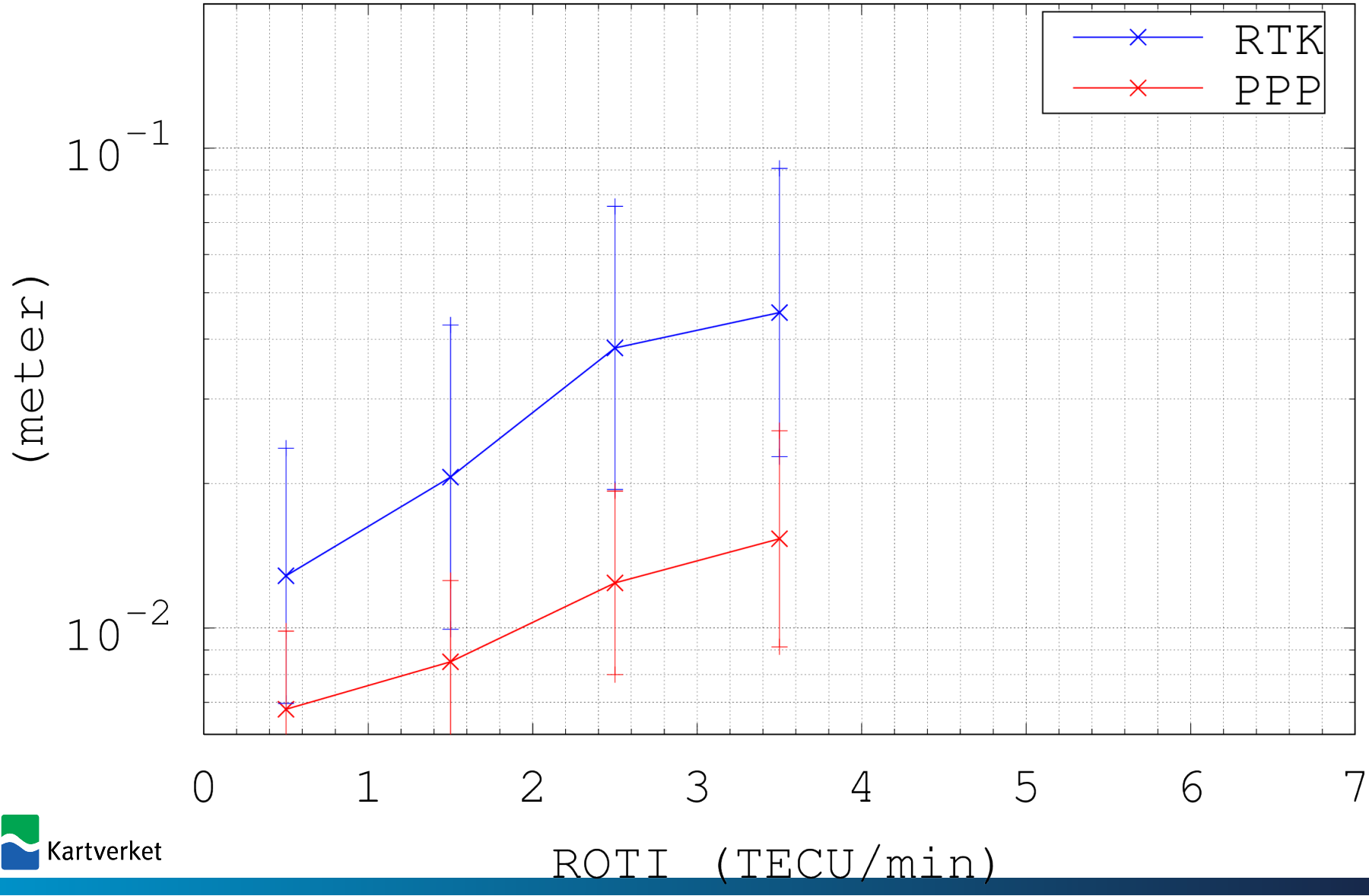
Kartverket

Position error binned by ROTI
Vega



Kartverket

Position error binned by ROTI
Honefoss



Kartverket

Conclusions

- Strong GNSS disturbances were observed at all latitudes in Norway on March 17th and early on the 18th. Late on the 18th, strong disturbances were only observed in the northern parts of Norway.
- GNSS disturbances, measured by ROTI, were most intense on the poleward edge of poleward-moving electrojet currents. This is possibly related to patches and/or particle precipitation activity caused by active tail reconnection. The relative importance of these phenomena, or the importance of having both simultaneously, cannot be determined from our data.
- Regions with less intense currents and/or equatorward motion of the current region were associated with less severe GNSS disturbances.
- Positioning errors increased rapidly with ROTI for both the RTK and PPP techniques. PPP was most precise regardless of disturbance level.