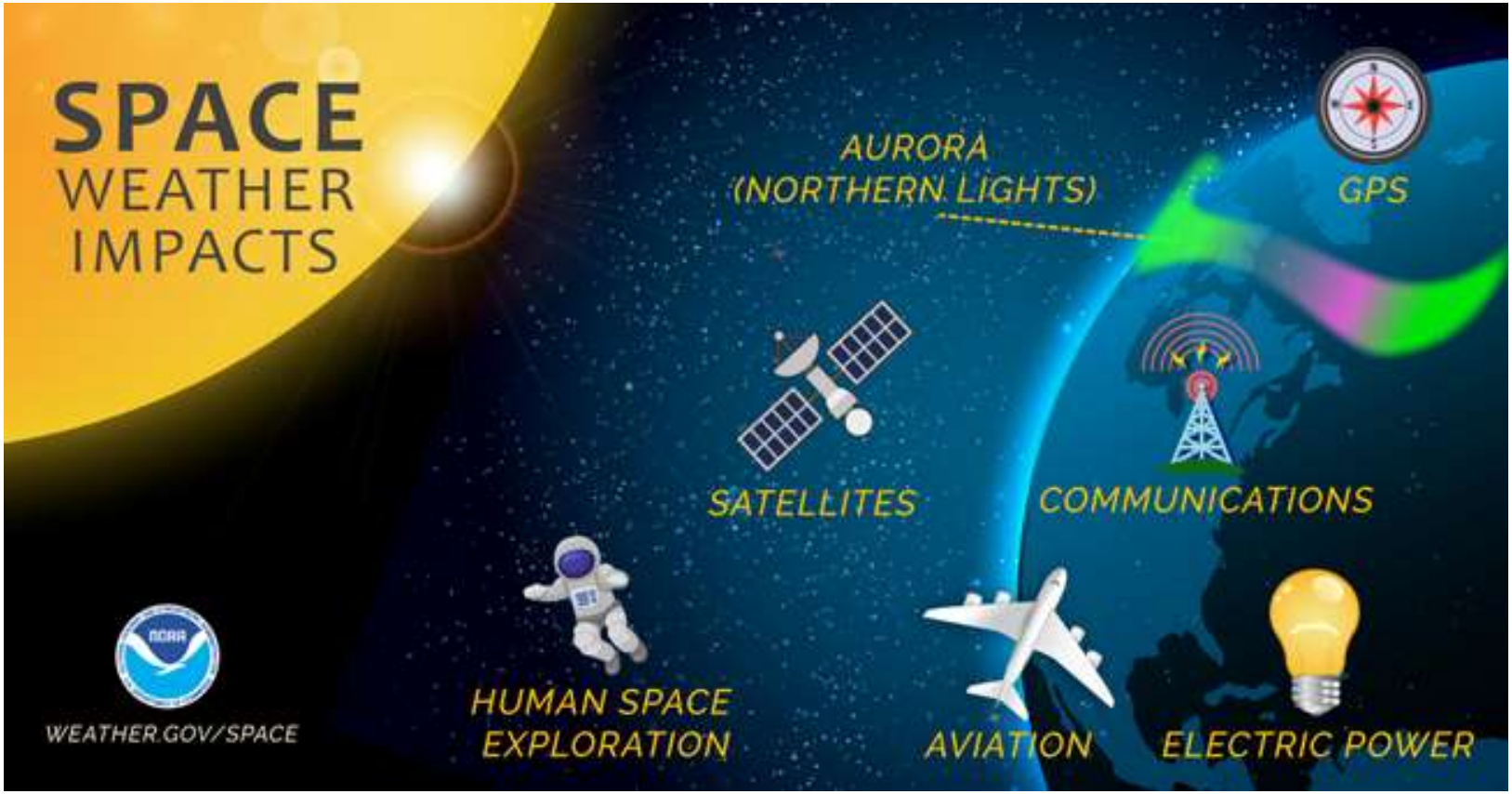
NKG Presentation by Sarah Beeck

SWADO - Towards real-time GNSS alerts for the Arctic

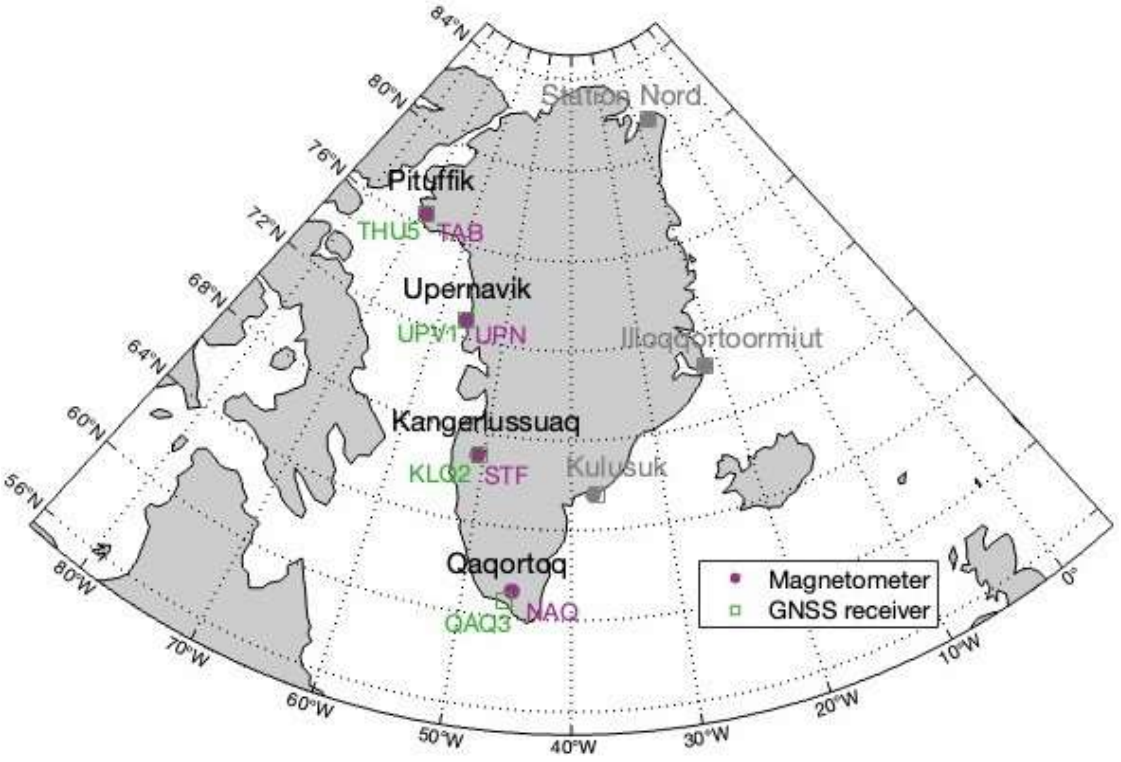
Space Weather



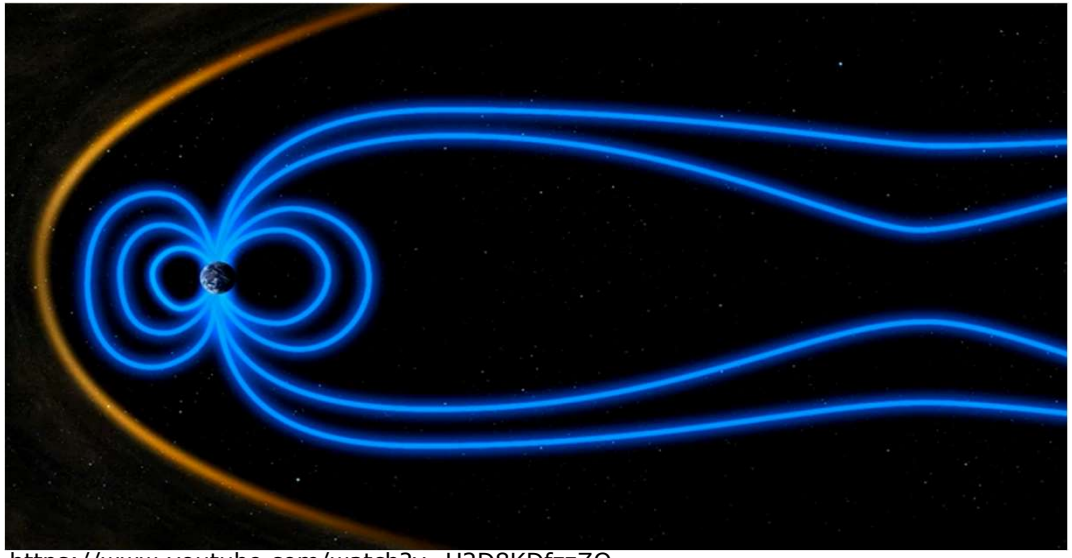
https://www.weather.gov/safety/space, 27-06-2023

Space Weather forecasting for Arctic Defence Operations

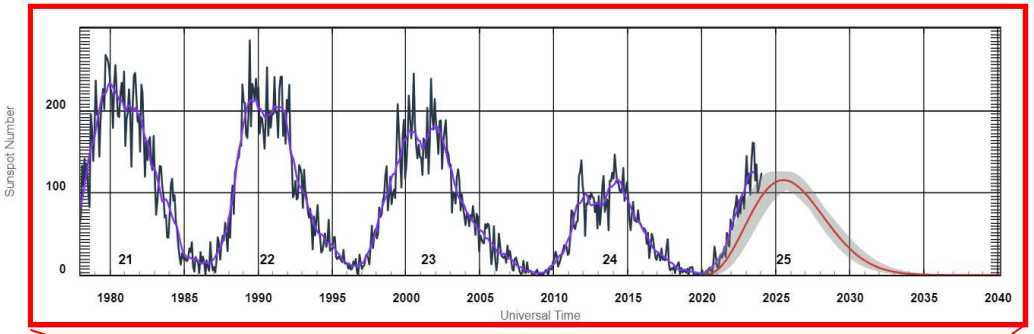
What	Investigate possibilities
How	Explore the advantages
Why	Pave the way

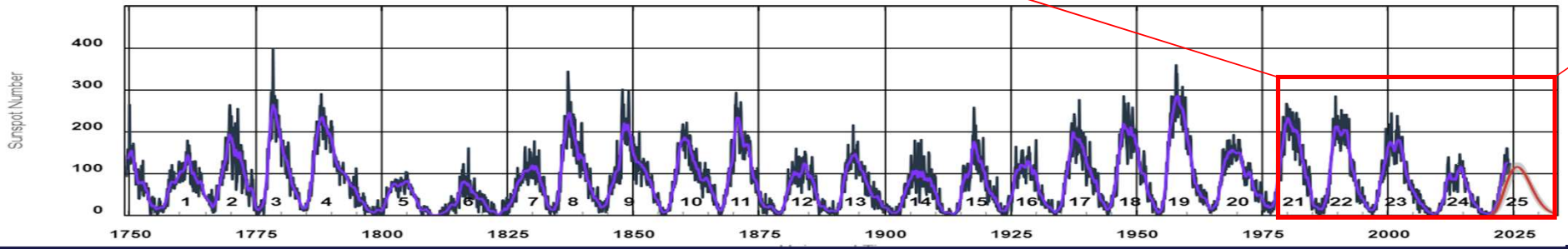


Space Weather – The environment we navigate in



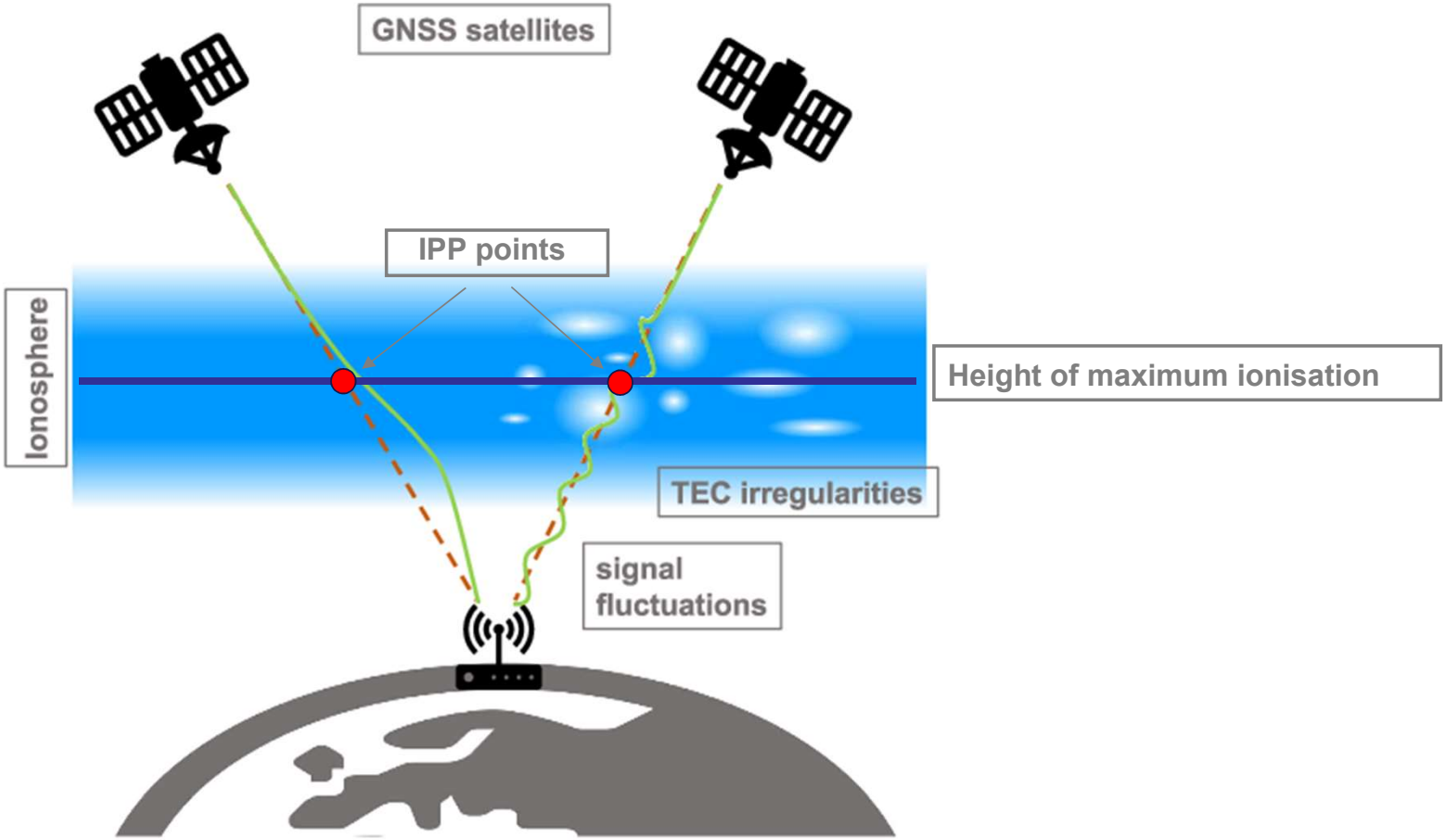
https://www.youtube.com/watch?v=U2D8KDfzzZQ





https://www.swpc.noaa.gov/products/solar-cycle-progression

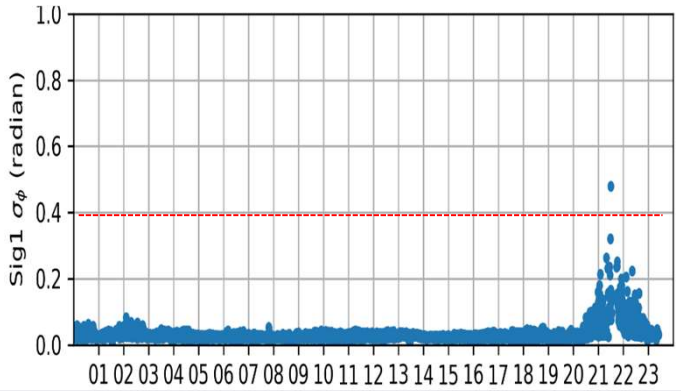
Space Weather – The environment we navigate in



Modified from Linty, N., Farasin, A., Favenza, A., & Dovis, F. (2019). Detection of GNSS Ionospheric Scintillations Based on Machine Learning Decision Tree. *IEEE Transactions on Aerospace and Electronic Systems, 55*, 303-317.

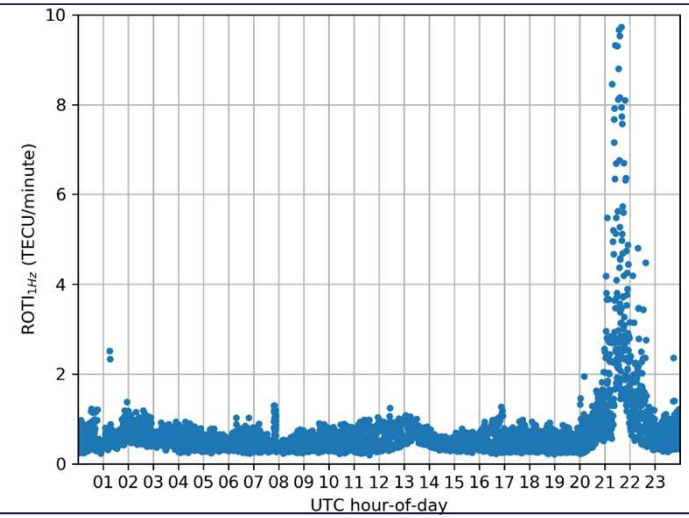
Scintillation indices

$$\sigma_{\Phi} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(\phi_i - \langle\phi\rangle)^2}$$

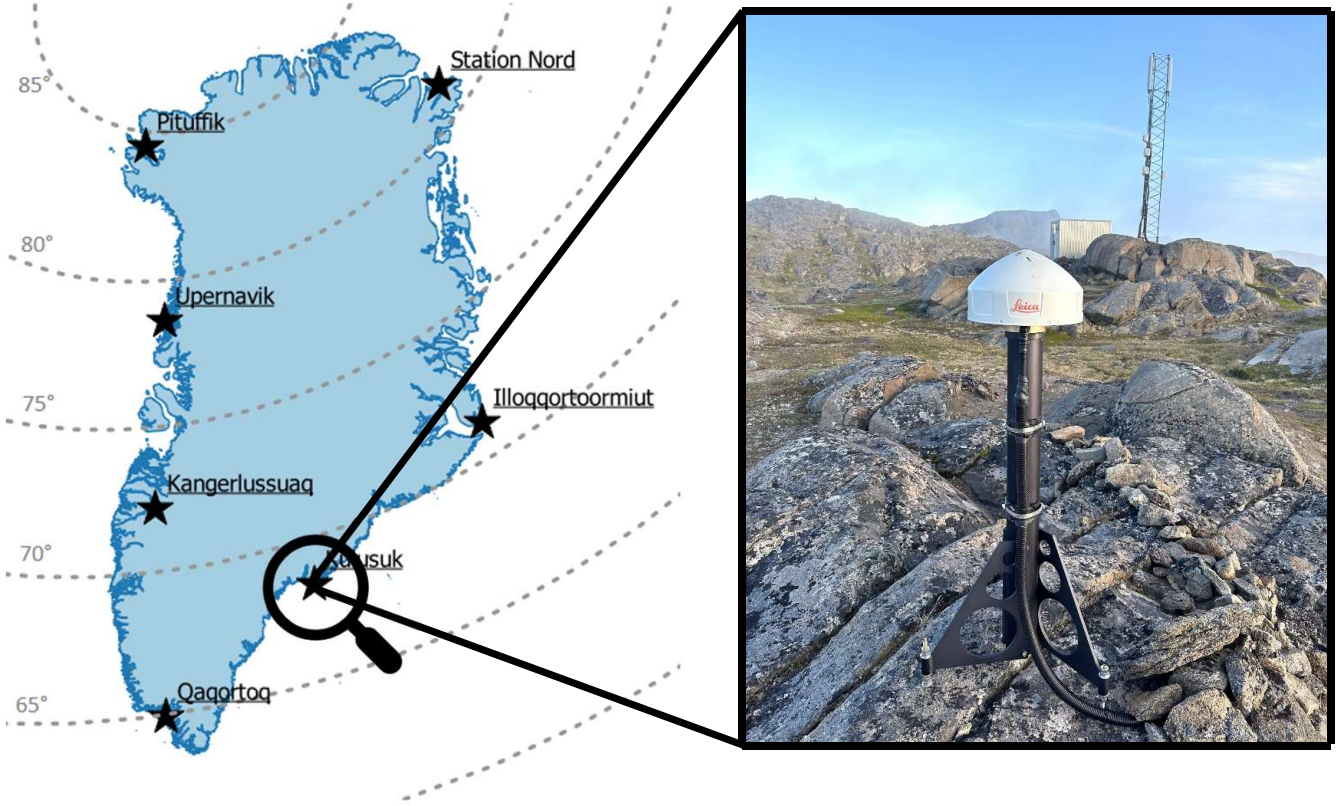


$$ROTI = \sqrt{\frac{1}{N-1}\sum_{m=n}^{m+N-1}(ROT_m - \langle ROT\rangle)^2}$$

$$ROT_m = \frac{TEC_m^i - TEC_{m-1}^i}{t_m - t_{m-1}}$$



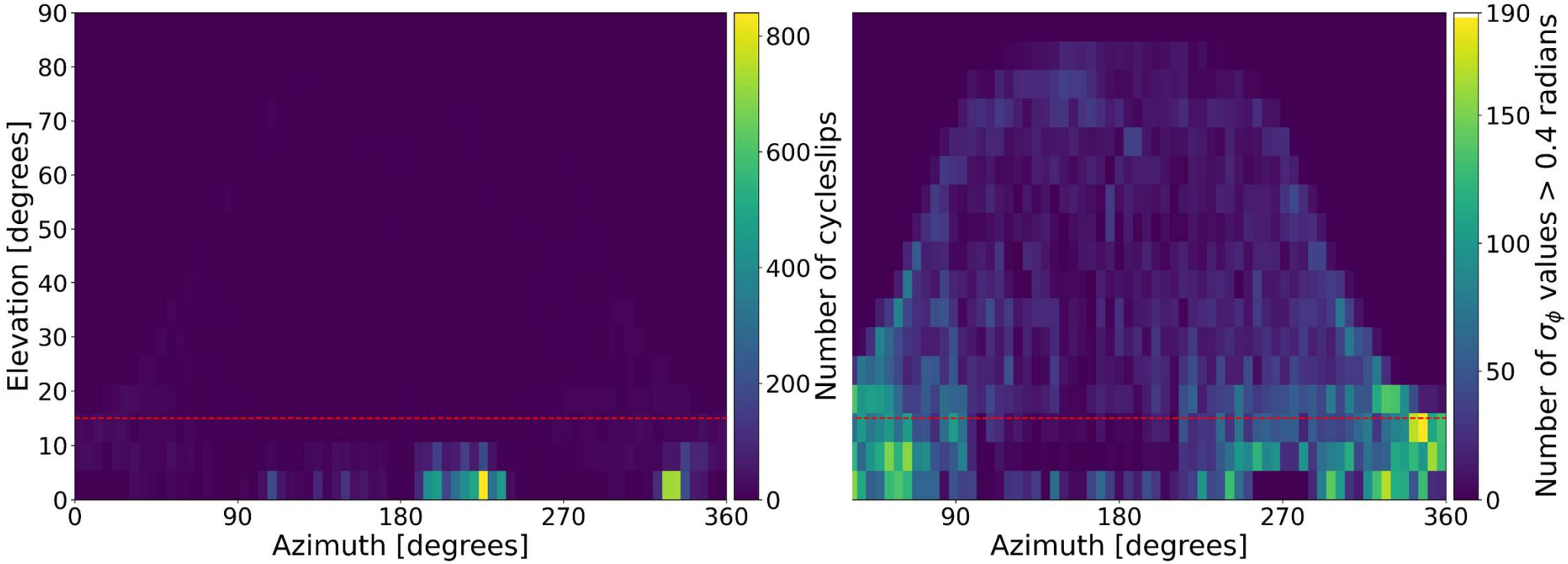
The SWADO network



- Multi frequency & multi constellation receiver
- GISTM – GNSS ionospheric scintillation and TEC monitor
- Samples at 100 Hz
- Computes ISMR files with 1-min resolution at the station

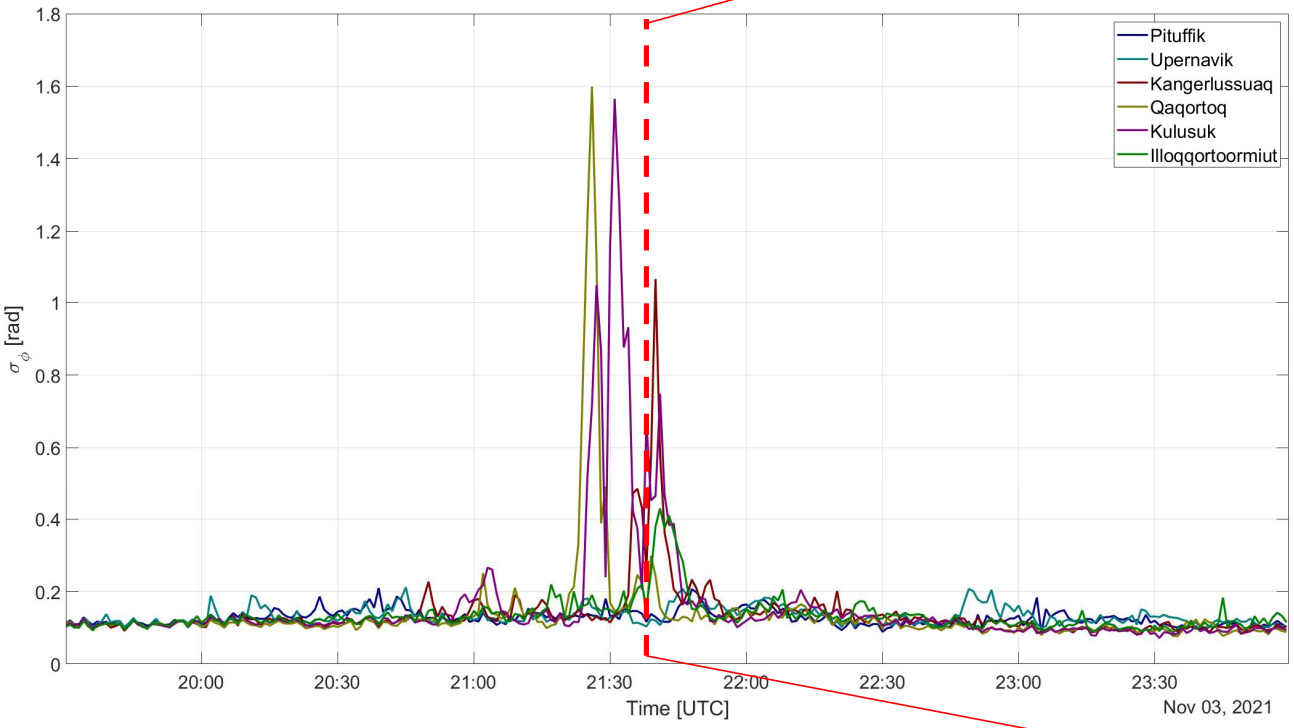
PolaRx5S user manual, version 2.3, 2021, Septentrio

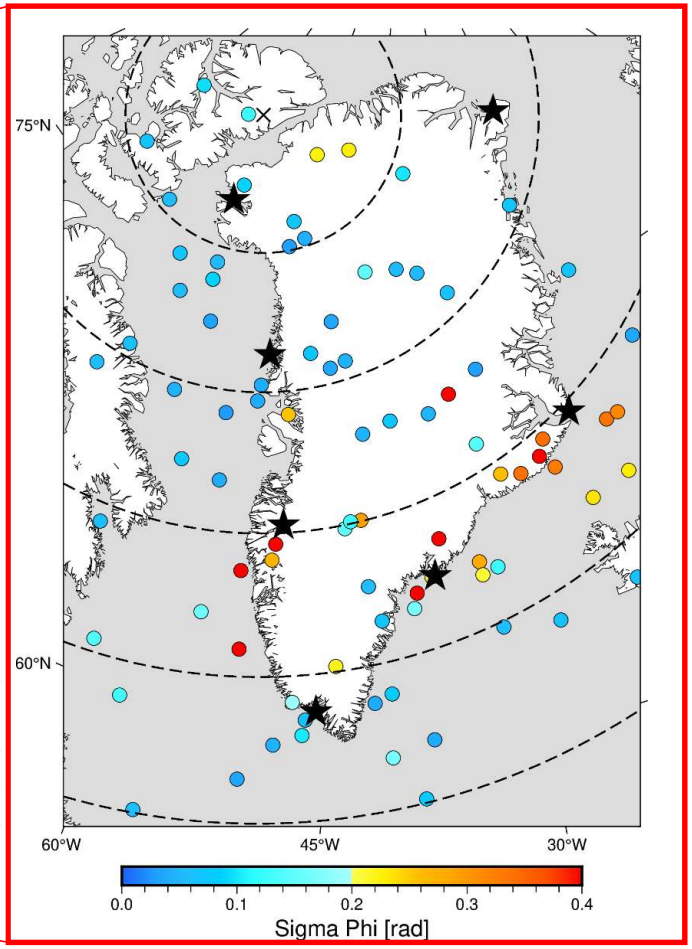
SWADO - data


Elevation [degrees]
Azimuth [degrees]
Number of cycleslips
Azimuth [degrees]
Number of σ_ϕ values > 0.4 radians

SWADO - data

- 15 degree elevation mask
- Utilise GPS and Galileo





Paper II

(2) Examine user impact to determine alert levels.

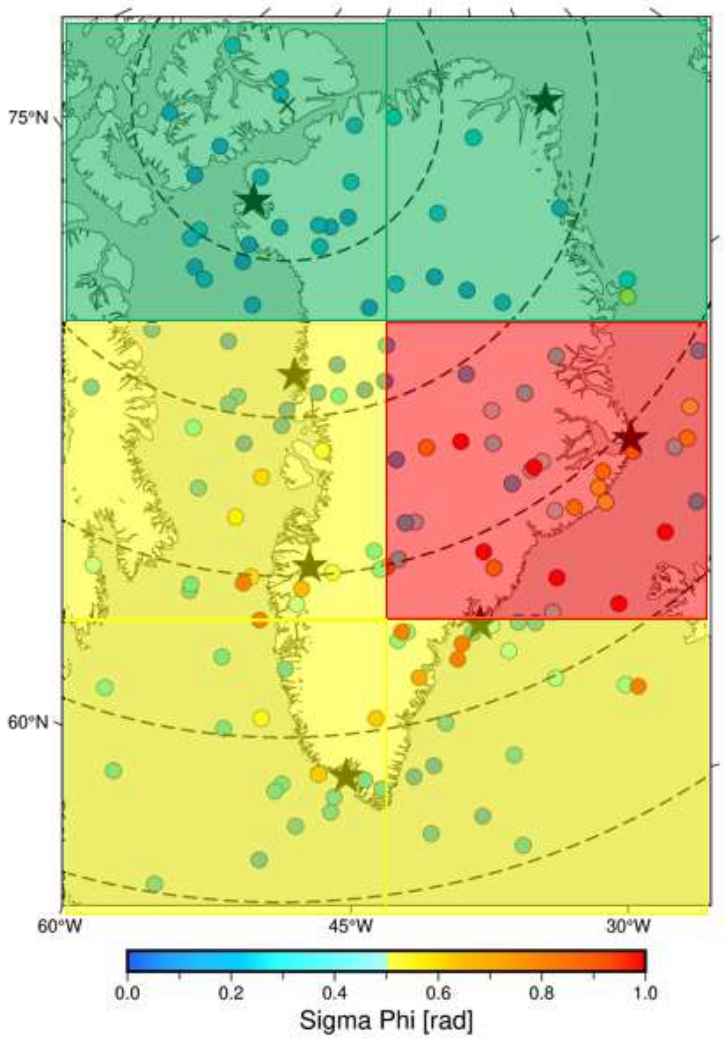
(3) Evaluate the capabilities of simulations for estimating realistic scenarios.

Experimental determination of ionospheric effects and cycle slip phenomena for Galileo and GPS in the Arctic

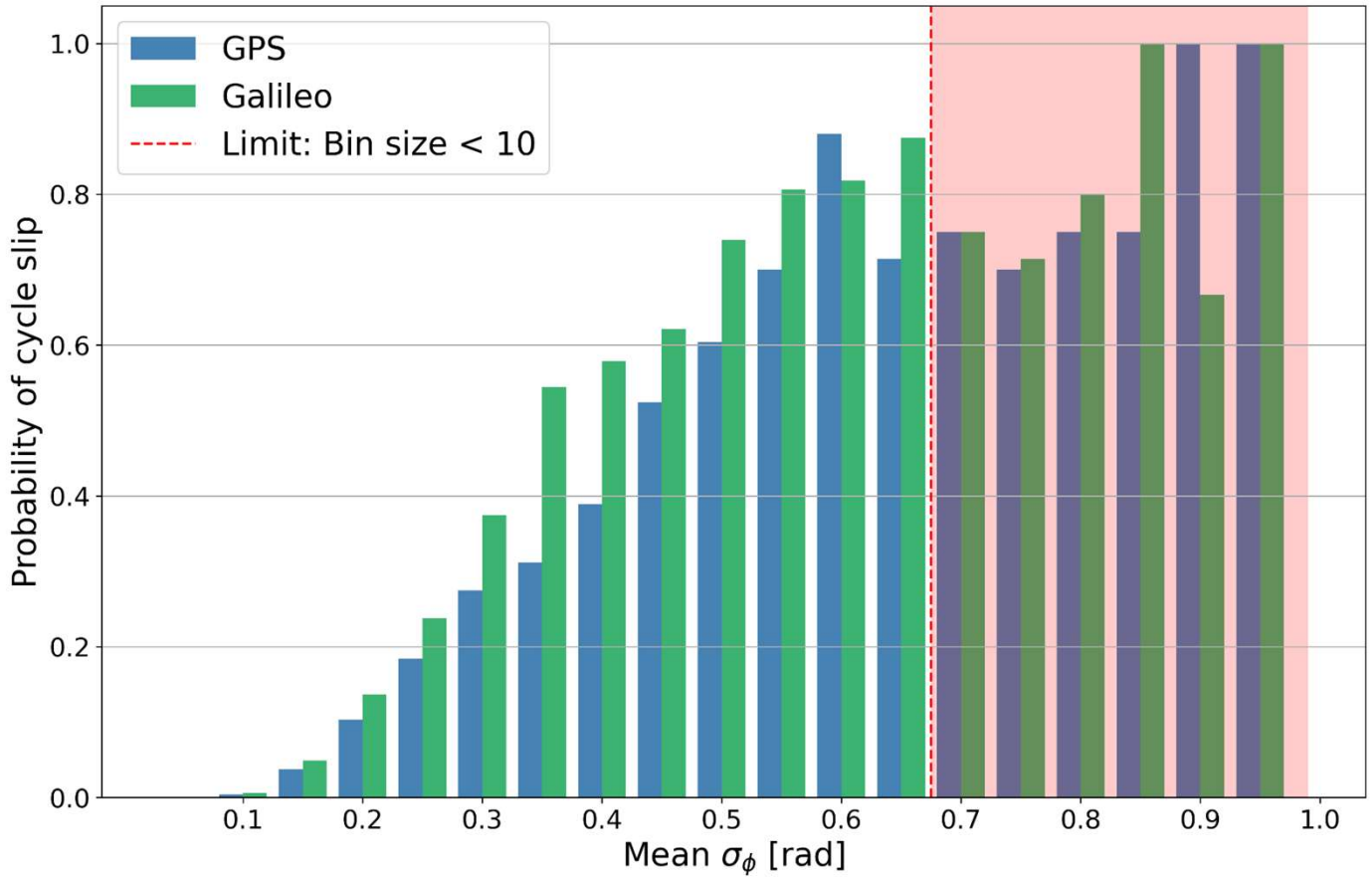
S.S. Beeck, C. N. Mitchell, A. B. O. Jensen, L. Stenseng, T. Pinto Jayawardena, and D. H. Olesen *Remote Sens.*, **December 2023**, 15, 5685.

Motivation for Paper II

The purpose of the SWADO project, is to investigate the possibility of near real time monitoring of the ionosphere above Greenland



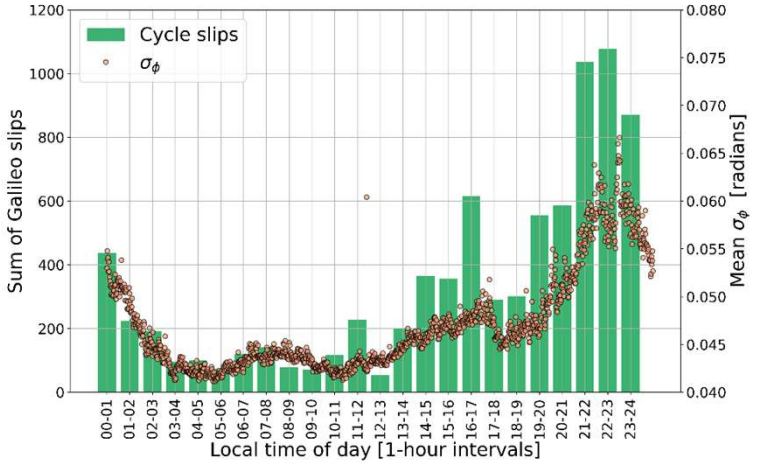
Cycle slips and σ_Φ - threshold

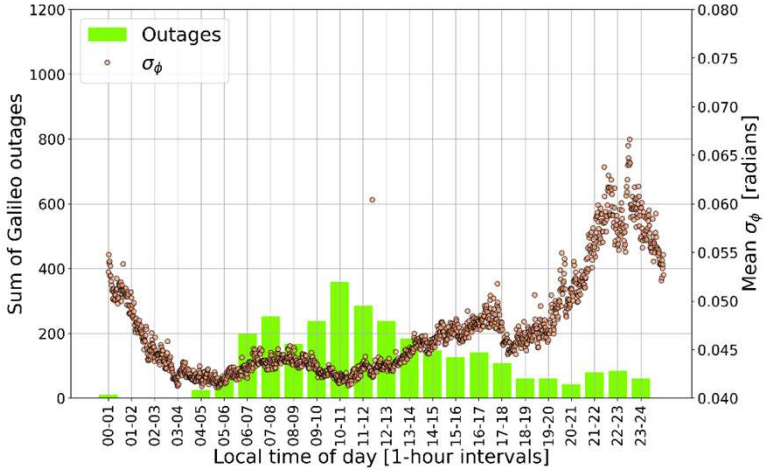


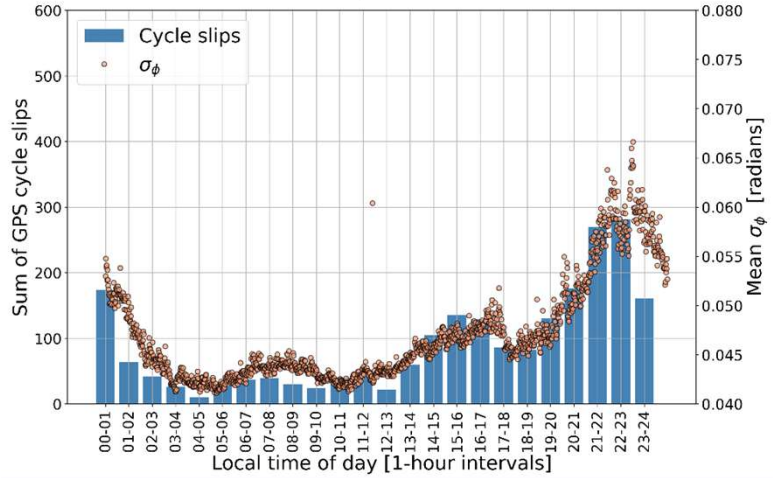
Cycle slips & outages in numbers

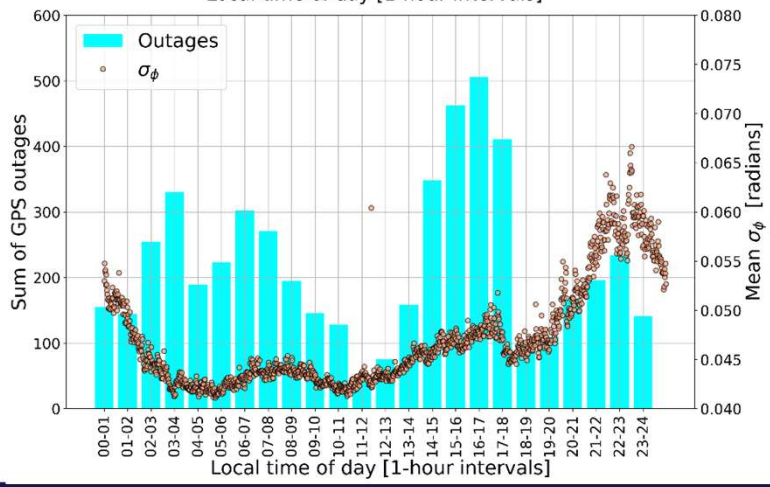
	GPS	Galileo
Number of cycle slip	2,197	8,183
Intervals with cycle slips	921	1,149
Number of outages	5,292	2,929

Outage and cycle slip vs time of day

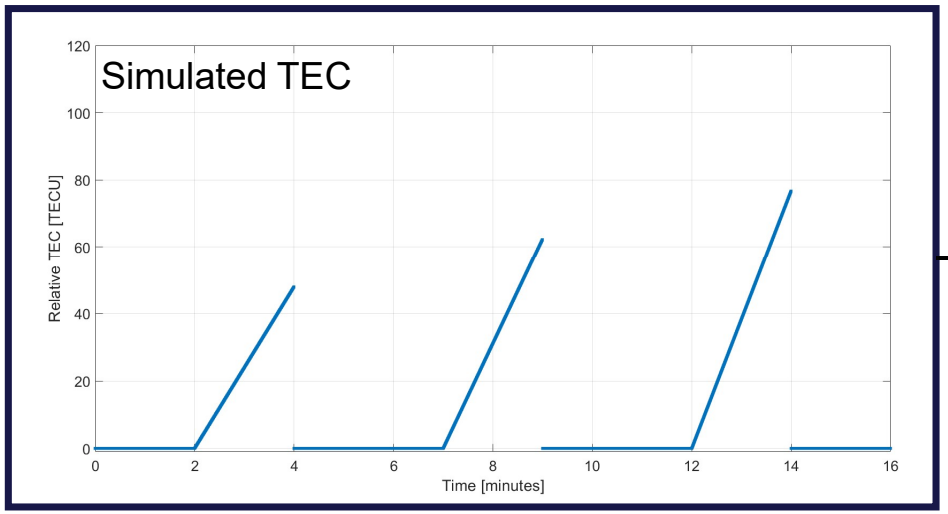


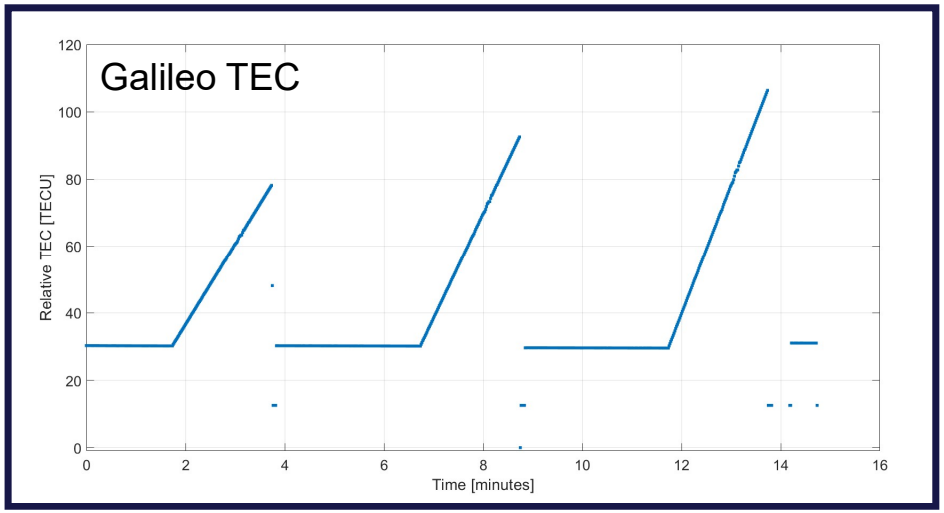


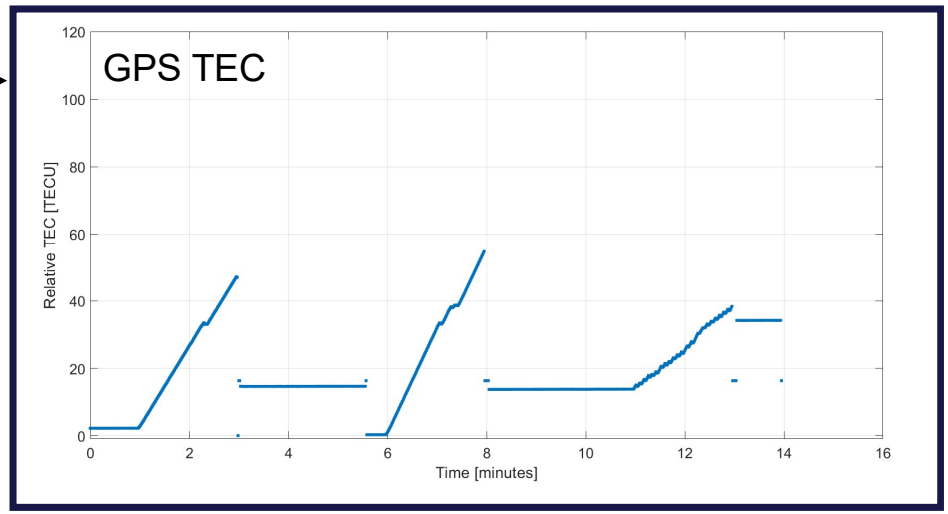




Simulation of scintillation effects on GPS and Galileo







Keypoints of Paper II

TEC can be underestimated during large gradients if only GPS L1 and L2 are used.

Galileo signals experience more cycle slips than GPS signals, which experience more outages than Galileo.

The chance of cycle slips increases faster for Galileo signals than GPS signals as a function of σ_{Φ}.

Thank you!