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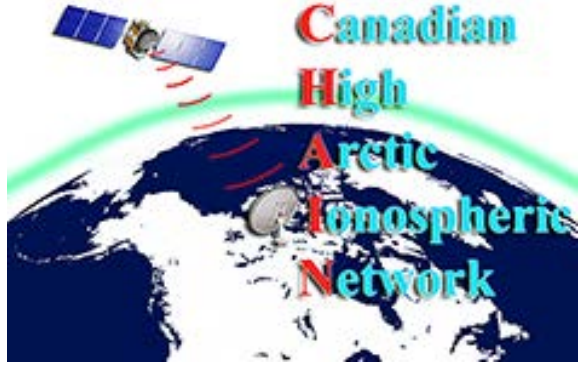

A new CHAIN site in New Brunswick: low-cost HF and GNSS instruments for Solar Eclipse 2024

A. Kashcheyev, A. Farnham, R. Chadwick, T. Kelly, P.T. Jayachandran

Physics Department, University of New Brunswick, Fredericton, Canada

INNOVATION.CA
CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION

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FI NB IF INNOVATION

NSERC CRSNG

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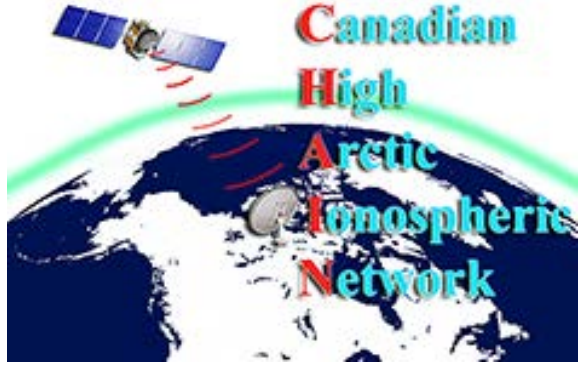
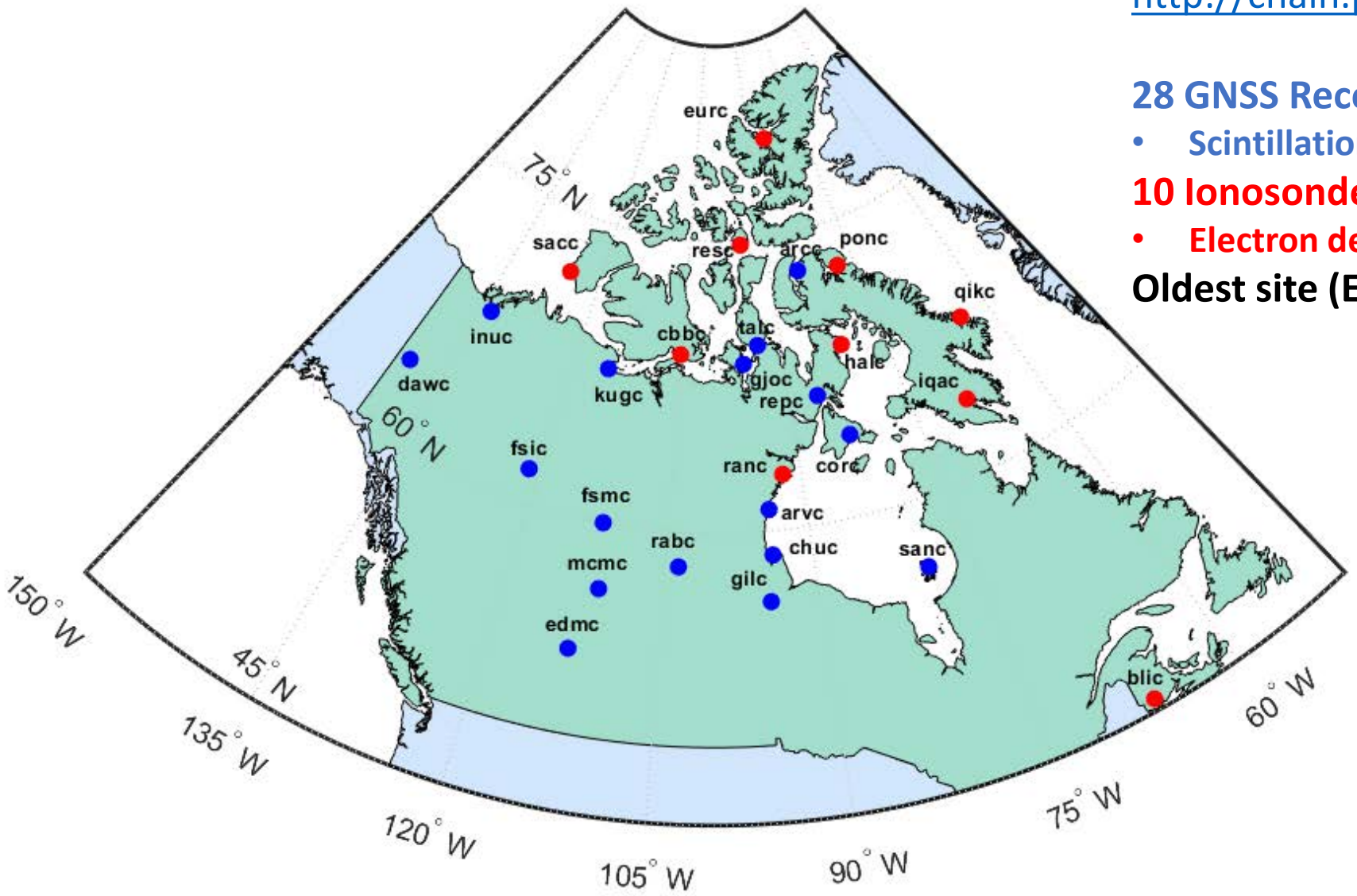


What is CHAIN?
What are we doing?
Why should you care?
Eclipse 2024

CHAIN (Canadian High Arctic Ionospheric Network)



http://chain.physics.unb.ca/chain/

28 GNSS Receivers

- **Scintillation, TEC measurements**

10 Ionosondes

- **Electron density height, drift measurements**

Oldest site (Eureka) has data from 1994

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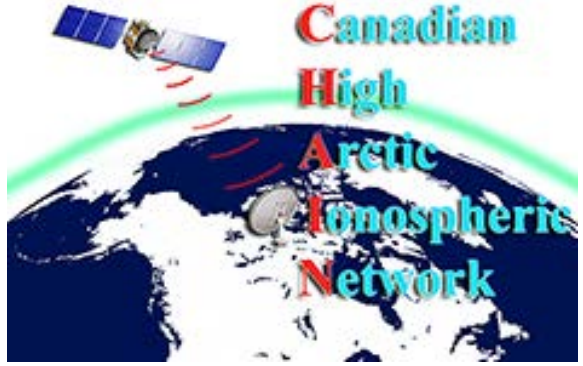

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Eclipse 2024

CHAIN is expanding

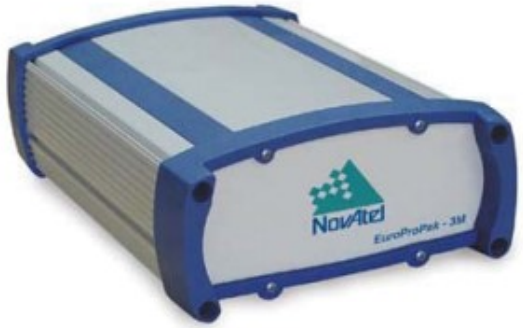
We want to densify ionospheric measurements in the Arctic

- **Using low cost GNSS receivers and SDRs to scale the network**
- **Use low cost passive receivers to densify the HF sounding network**

CHAIN is expanding

GNSS and Scintillation Monitors

Novatel GSV4004B



Septentrio PolaRxS

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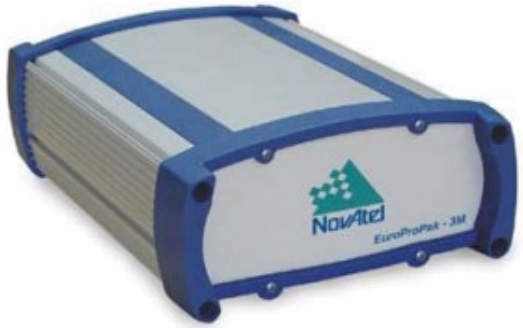
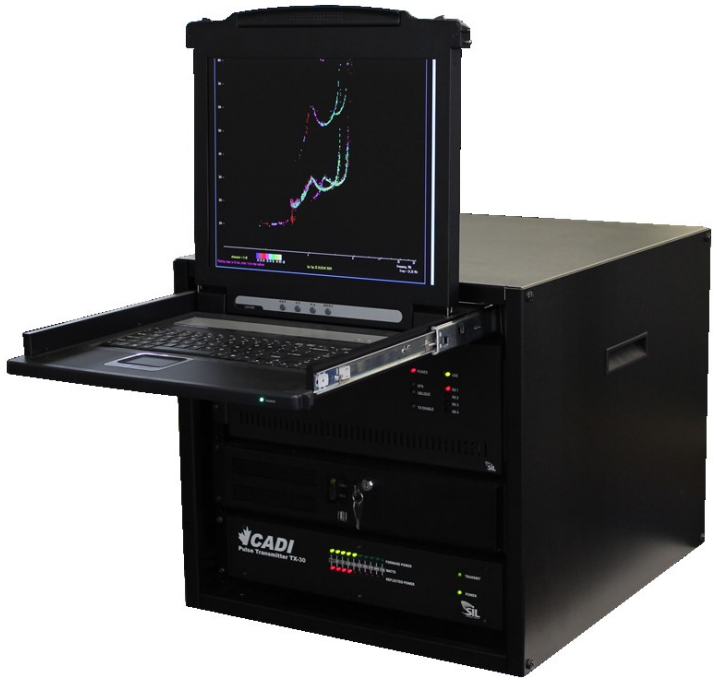


Septentrio PolaRxS

Ionosondes

SIL Canadian Advanced Ionosonde (CADI)



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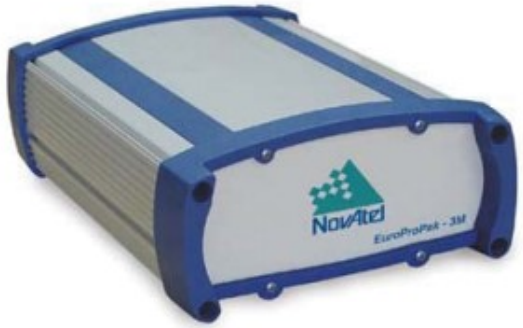

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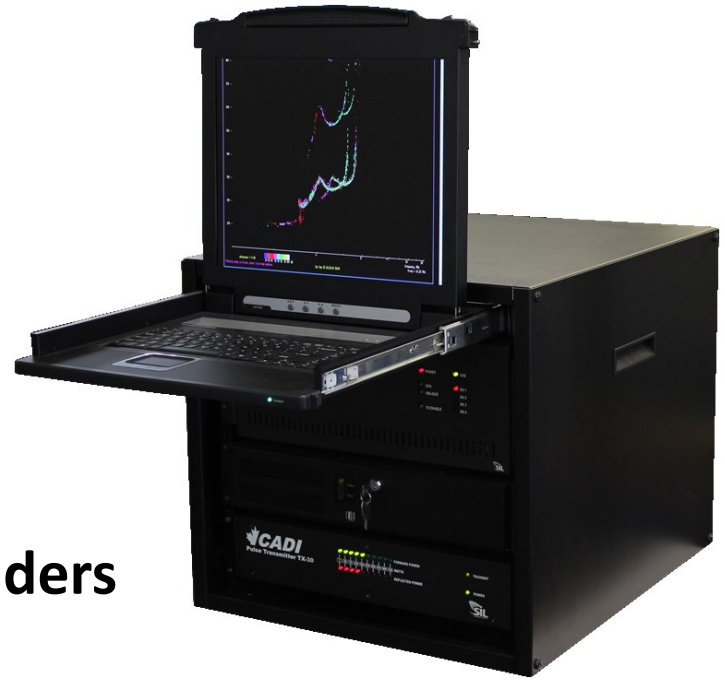

Instruments in test:

- **Ettus USRP Sounders**
- **Piksi GNSS**
- **Ublox GNSS**

We want to densify ionospheric measurements in the Arctic

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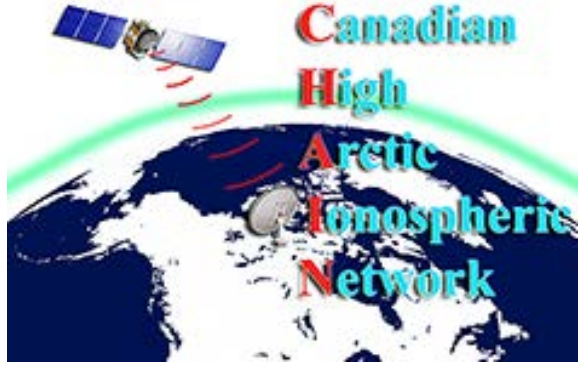

What is CHAIN?
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CHAIN data is freely available

Data products

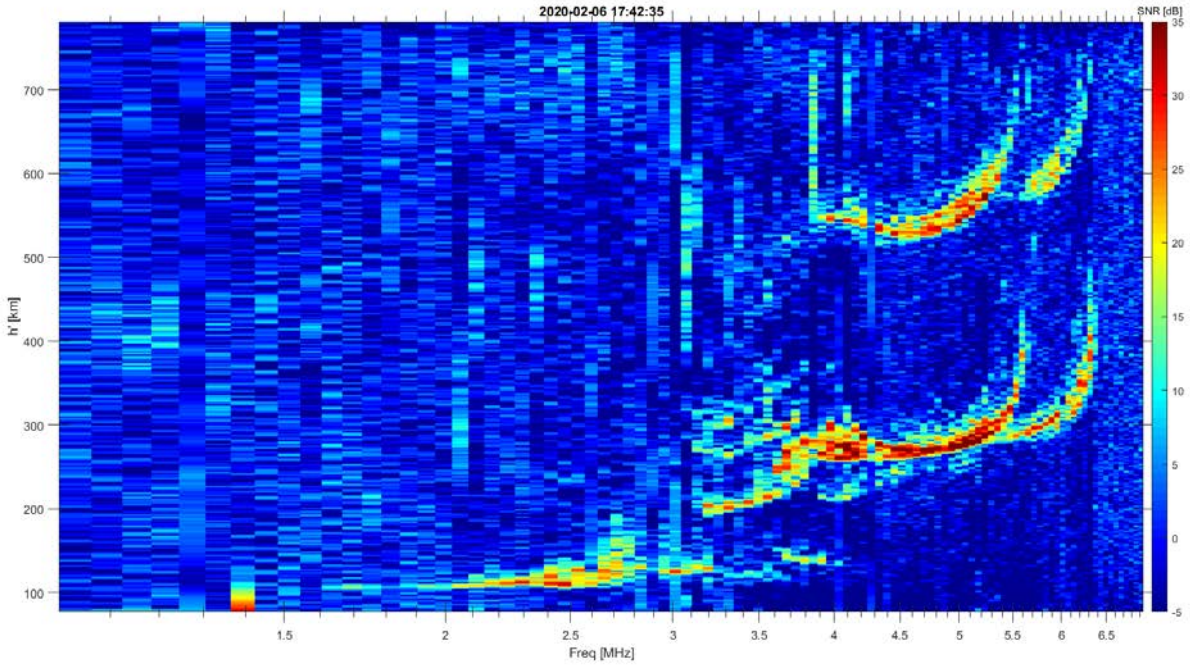
- Drift, Ionograms, S4, Phase data since 2007
- Some ionosonde sites have data from 1994

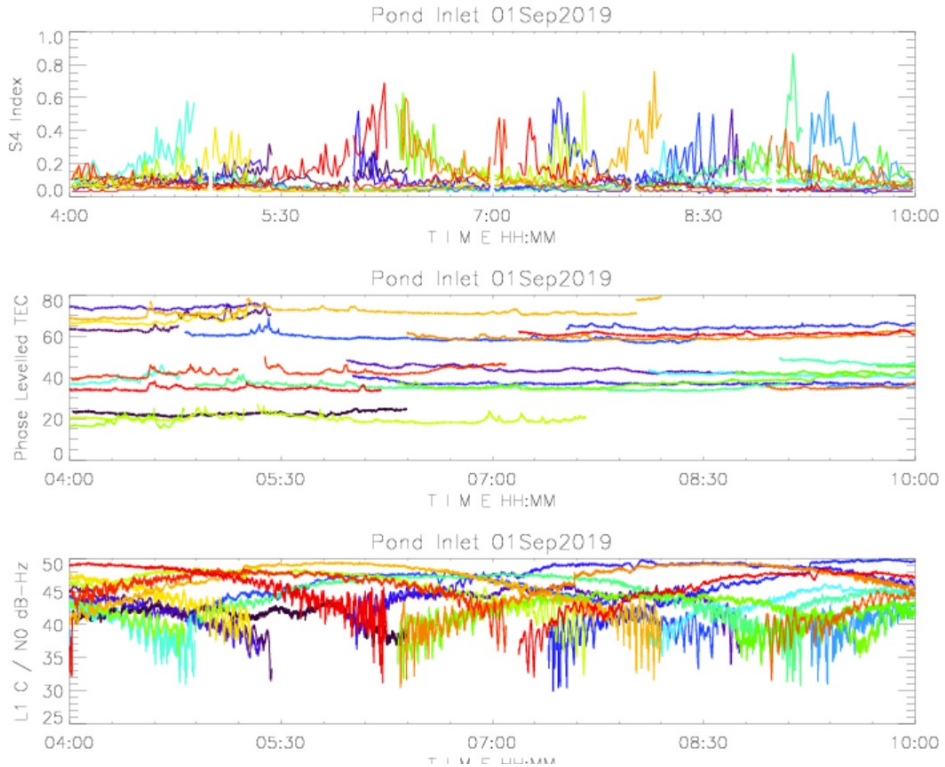
Empirical model (E-CHAIM)

- IRI substitute for High Latitude modelling

Assimilation model (A-CHAIM)

- In progress





open data policy

CHAIN is open for collaboration

We have a footprint in the Arctic

- 28 locations with internet access
- Multiple HF antennas, dual or tri-band GNSS antennas

Were are looking for ways to add value

- Augmenting data with second sources
- Coordinating schedules for oblique sounding

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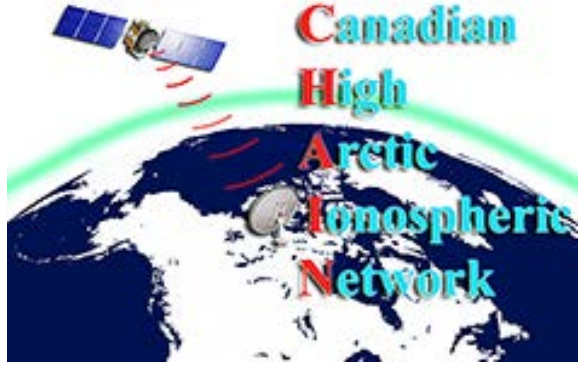

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CHAIN has a new R&D site

Capabilities

- CADI Ionosonde
- USRP Ionosonde
- Septentrio GNSS
- **Room for more!**

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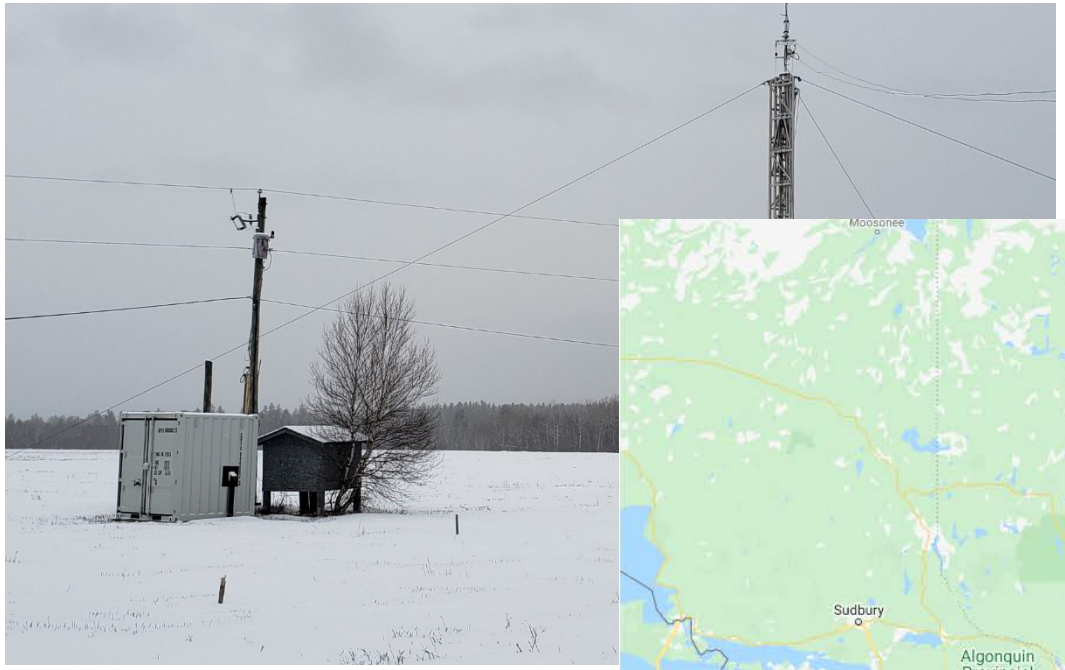
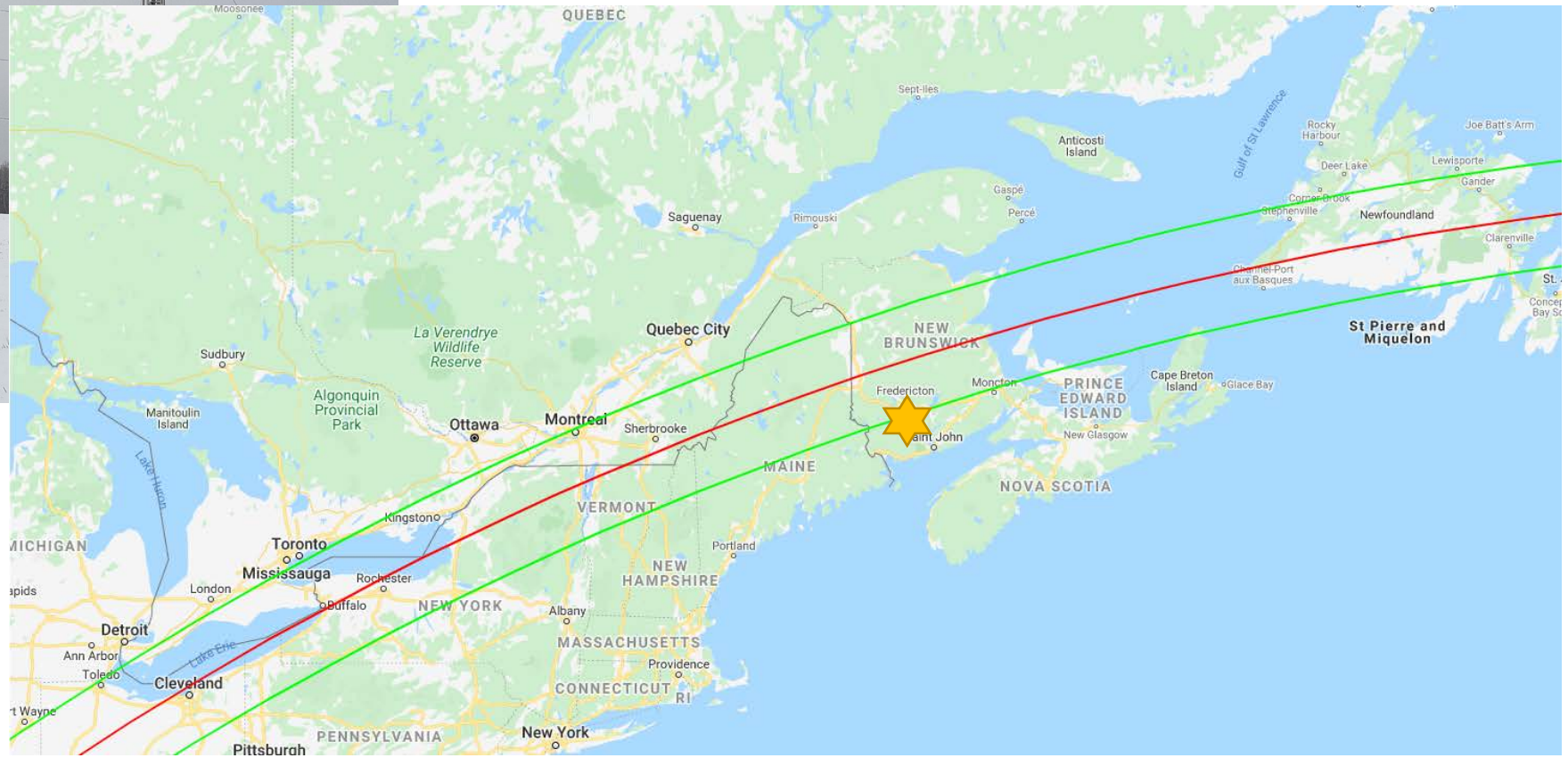


Located in Blissville, New Brunswick

- Under the totality of the 2024 Eclipse



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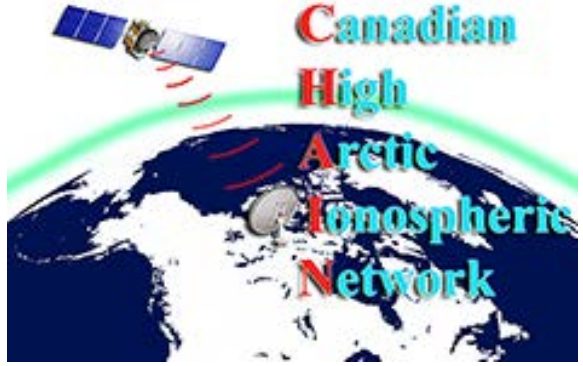


Other GNSS networks

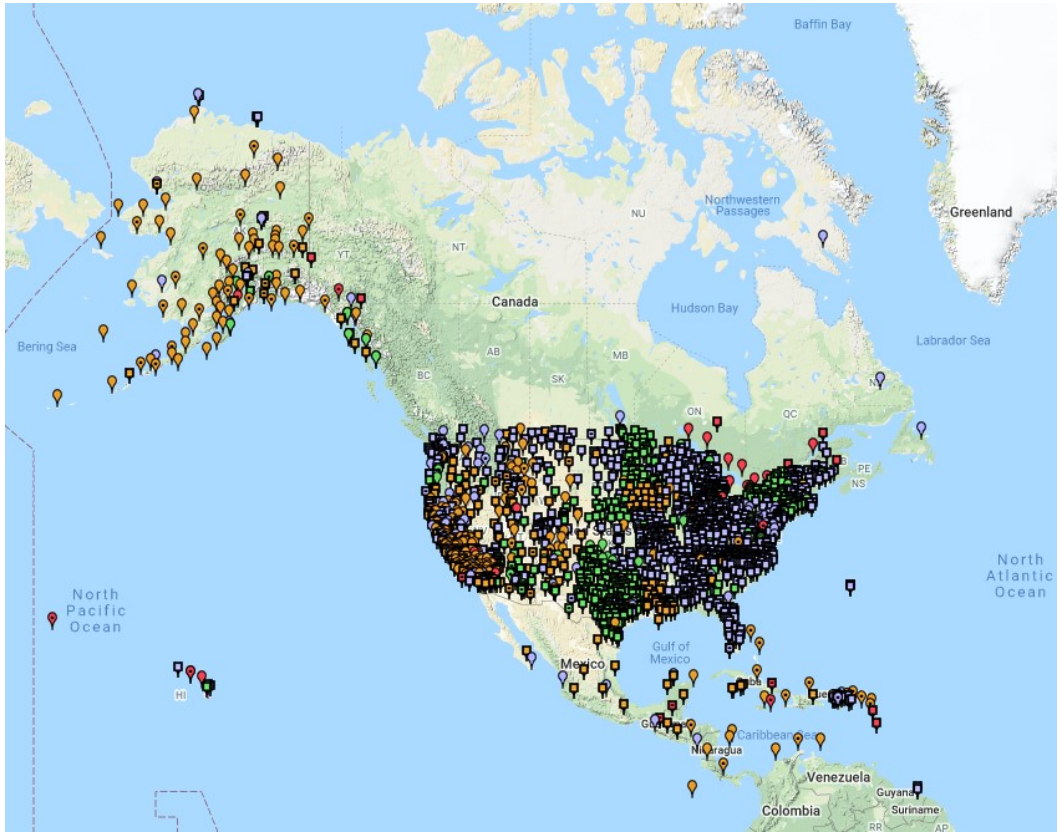
Ionospheric studies using GNSS

Low-cost GNSS receivers

Low-cost HF sounder

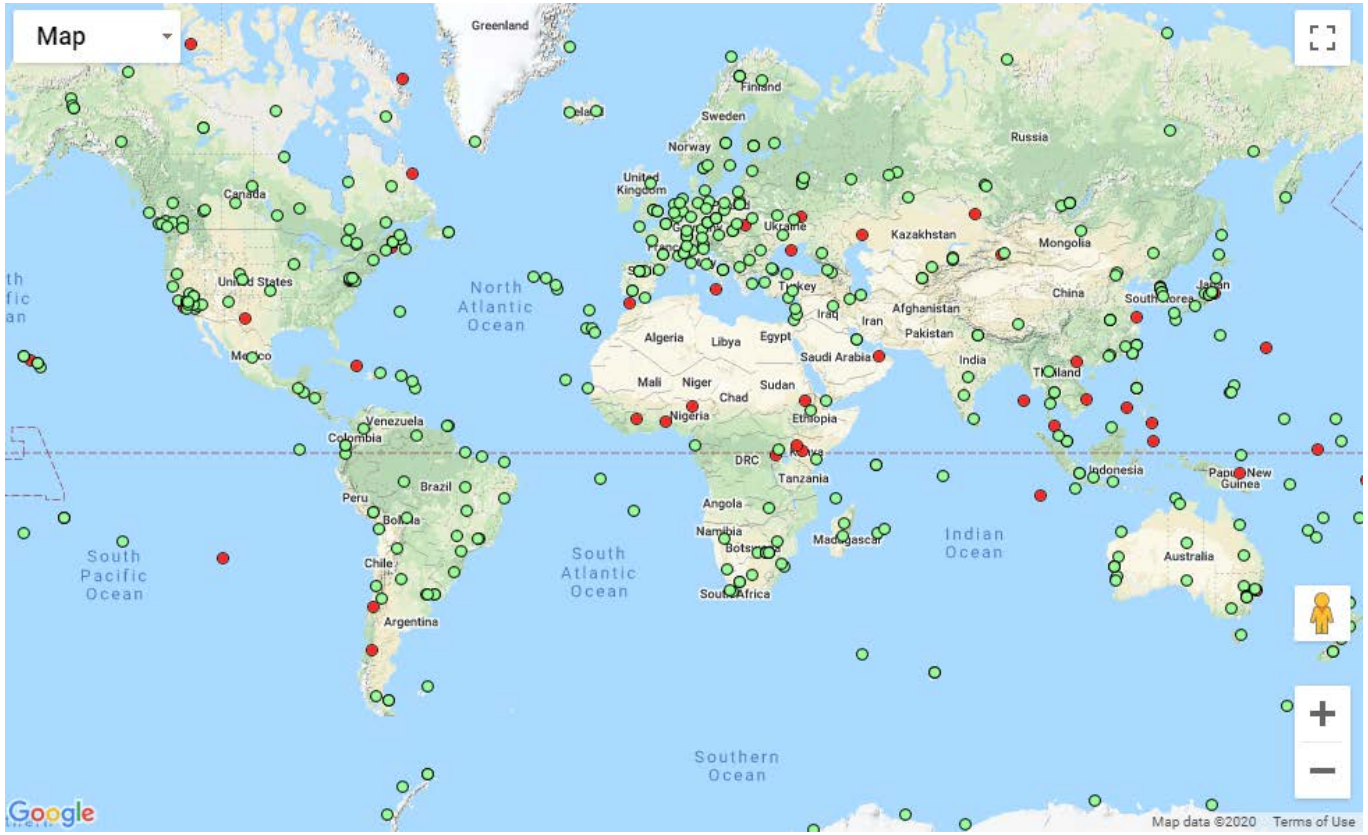
Other GNSS networks

CORS (Continuously Operating Reference Station)



https://www.ngs.noaa.gov/CORS/

IGS (International GNSS Service)



http://www.igs.org/network

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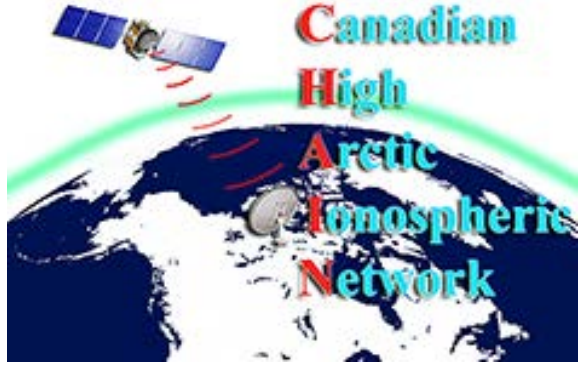

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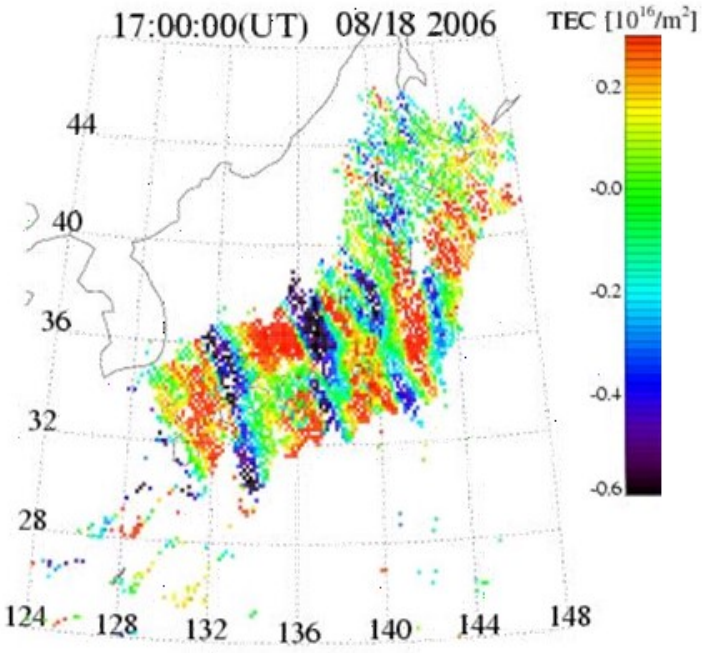
Low-cost GNSS receivers

Low-cost HF sounder

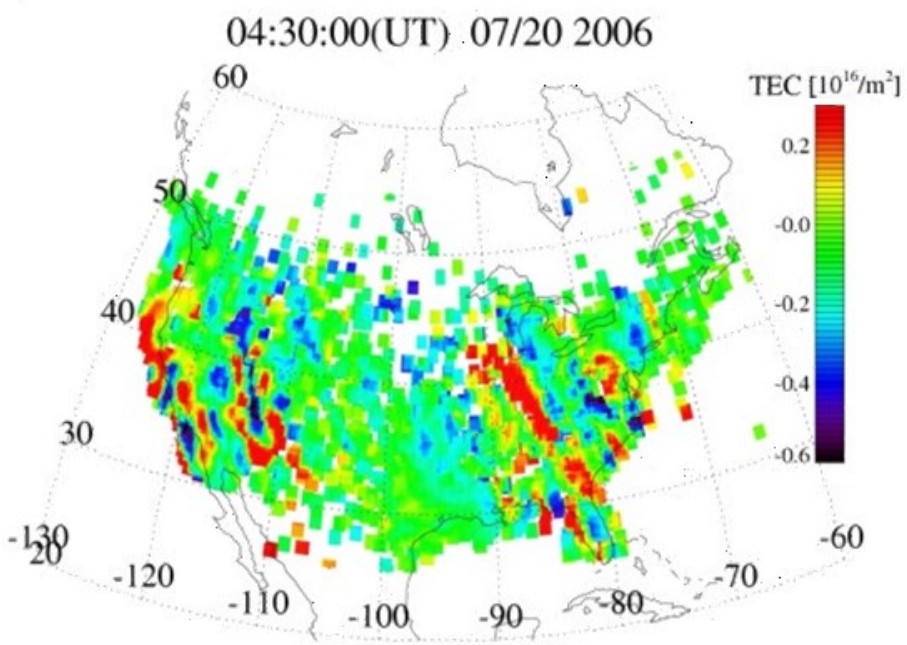
Case studies: MSTIDs

Japan



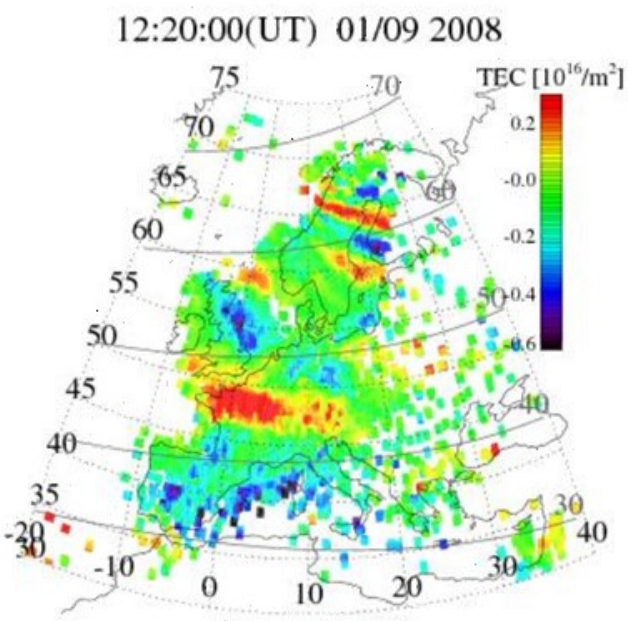
Tsugawa et al., 2007a

USA



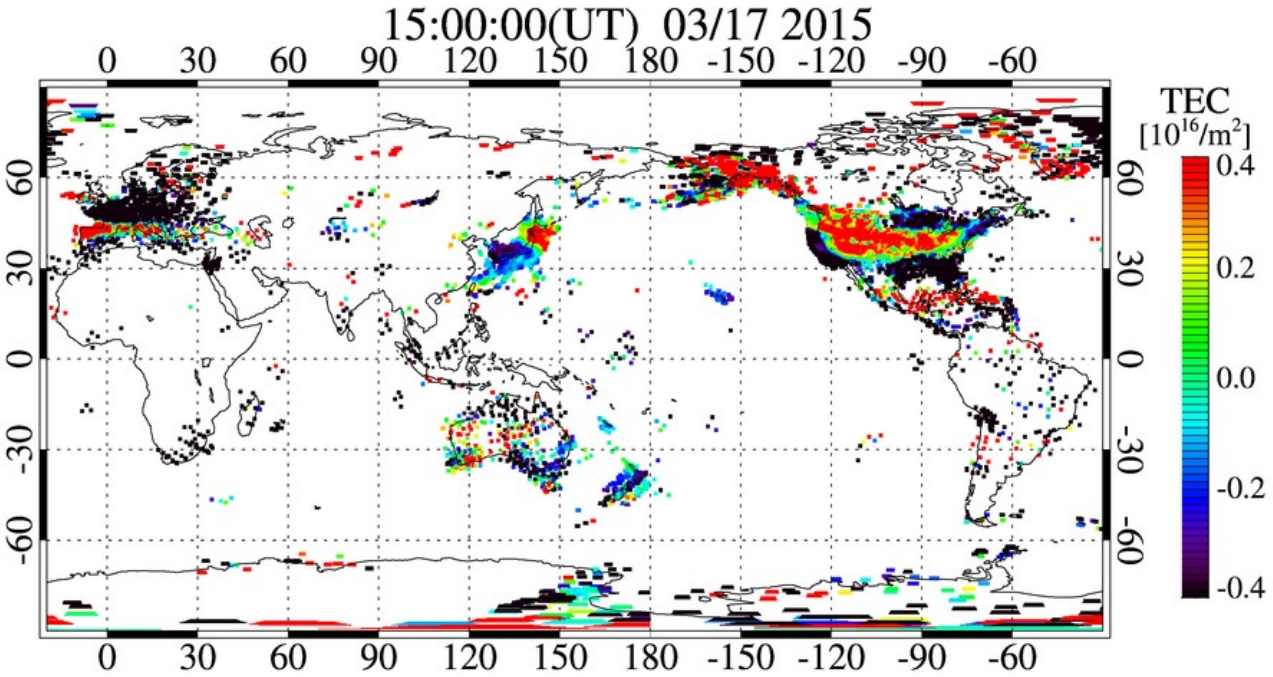
Tsugawa et al., 2007b

Europe

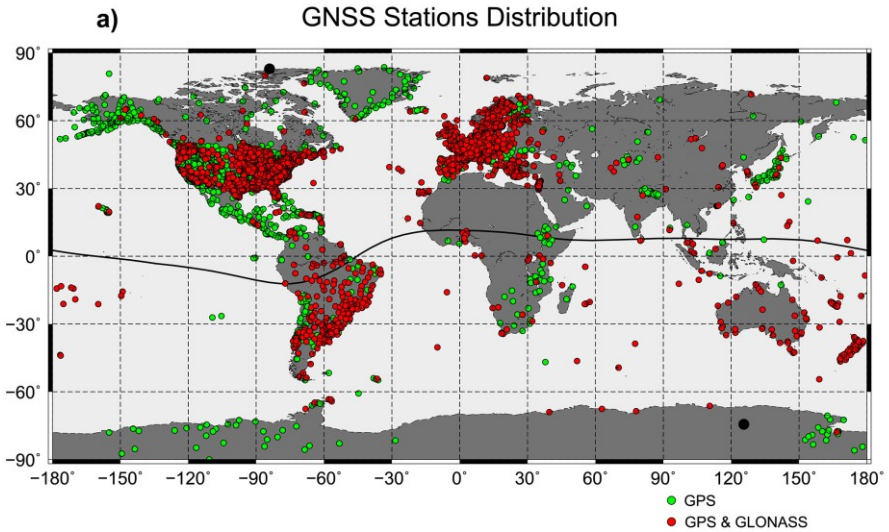


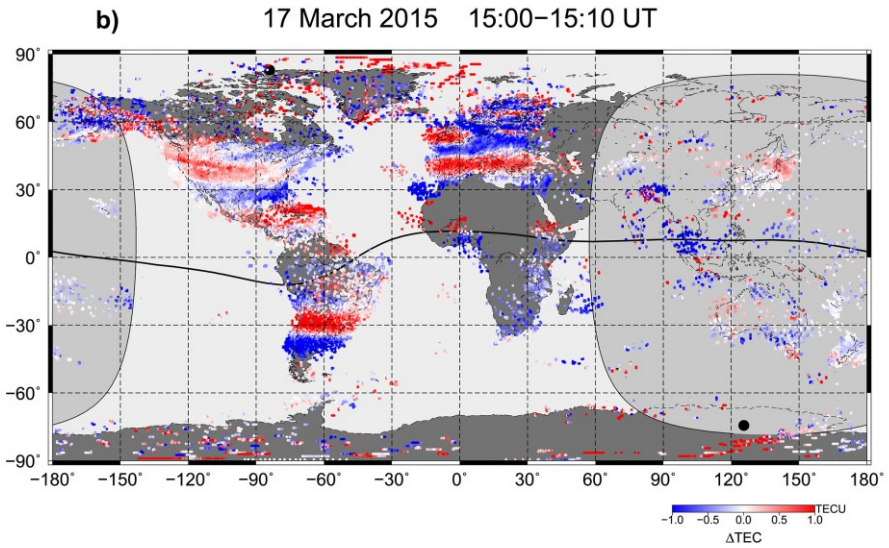
Otsuka et al., 2013

Case studies: LSTIDs



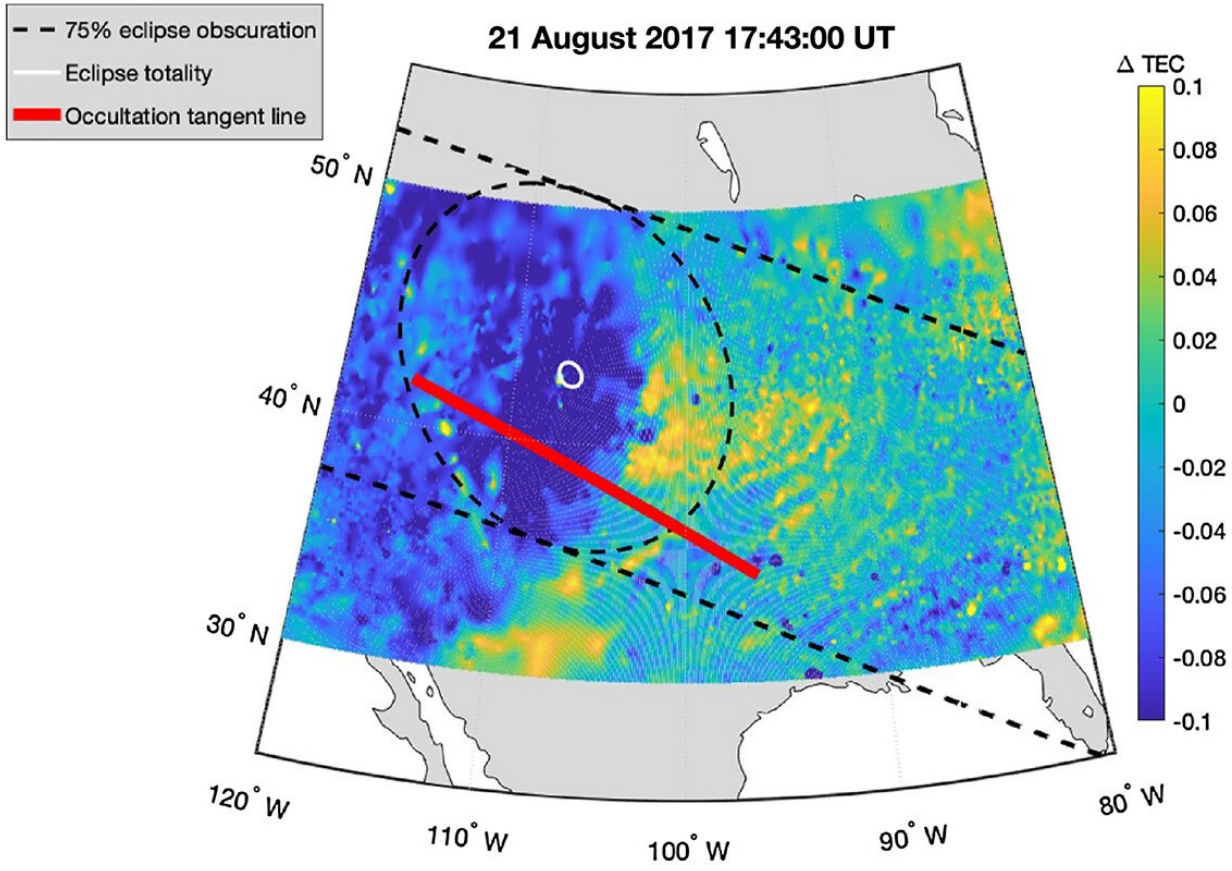
http://seg-web.nict.go.jp/



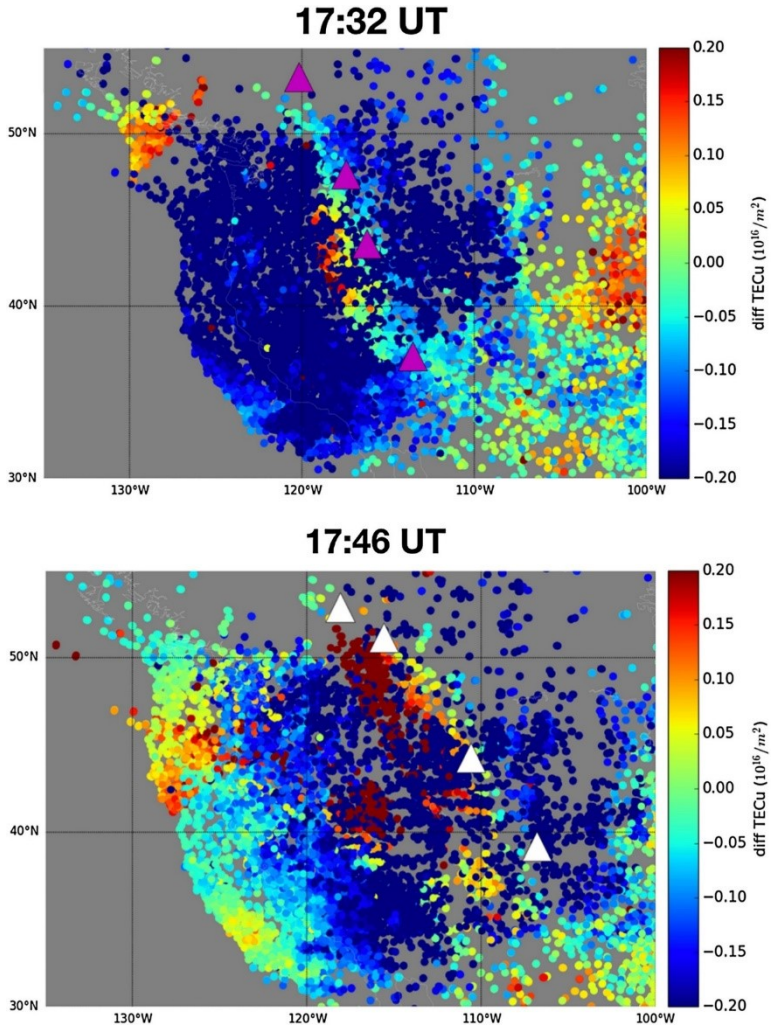


Zakharenkova et al., 2016

Case studies: LSTIDs



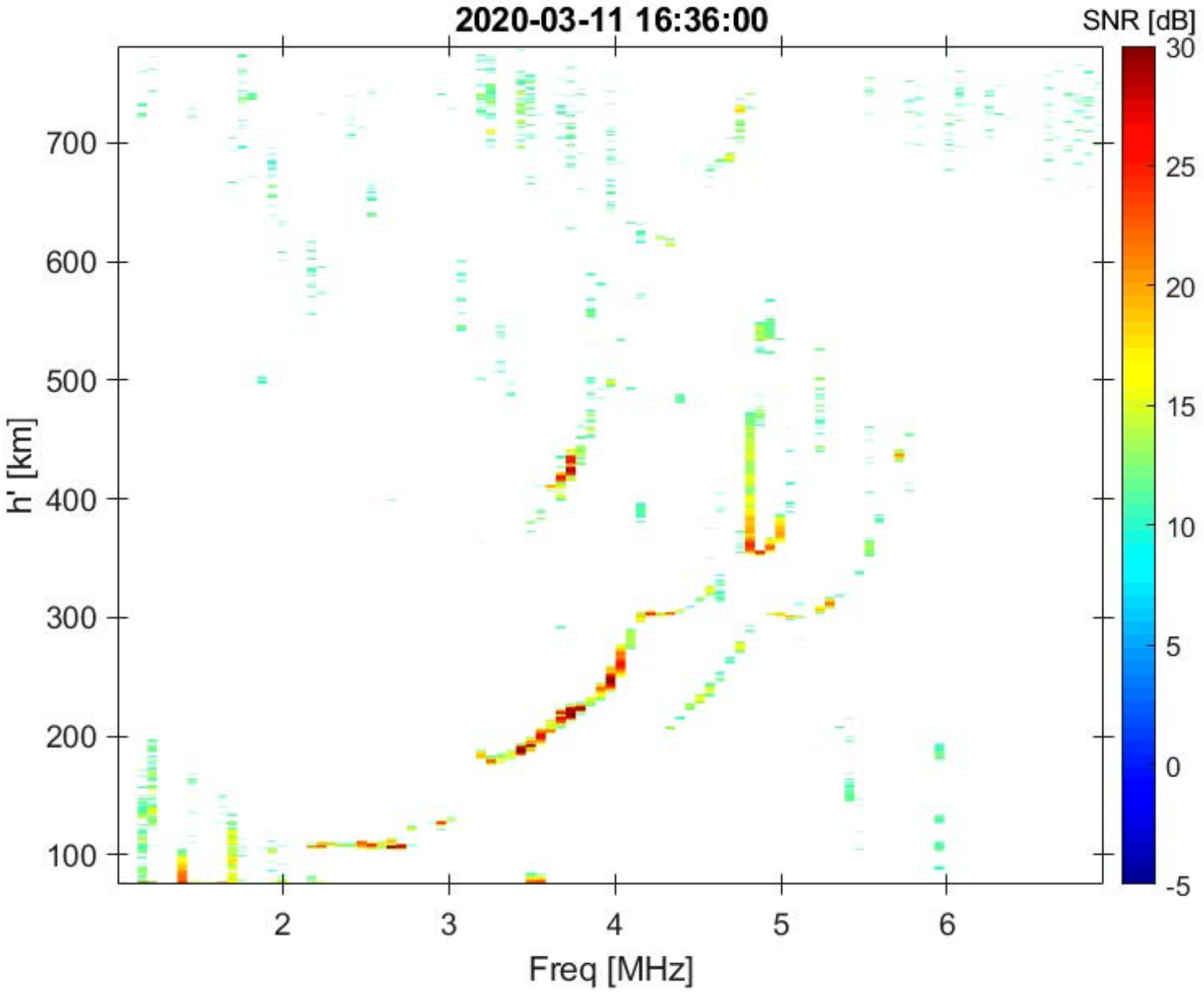
Perry et al. 2019



Coster et al. 2017

Case studies: TID in HF

Blissville, New Brunswick



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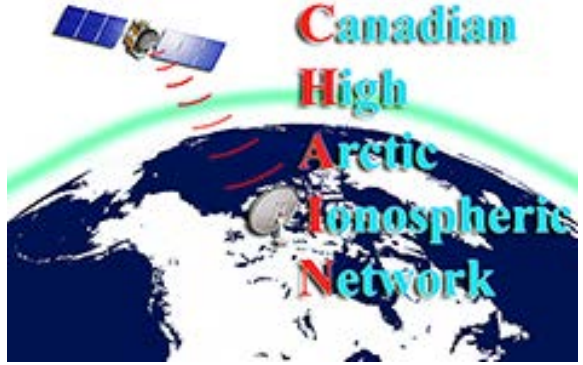
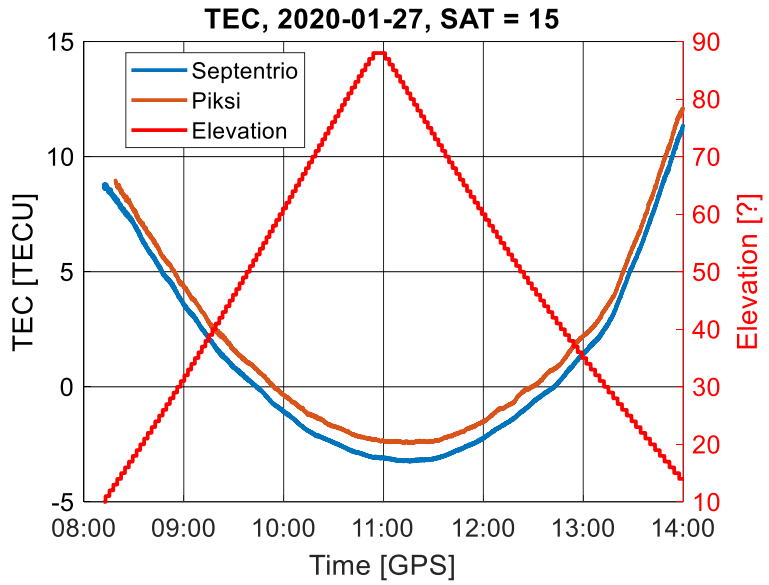


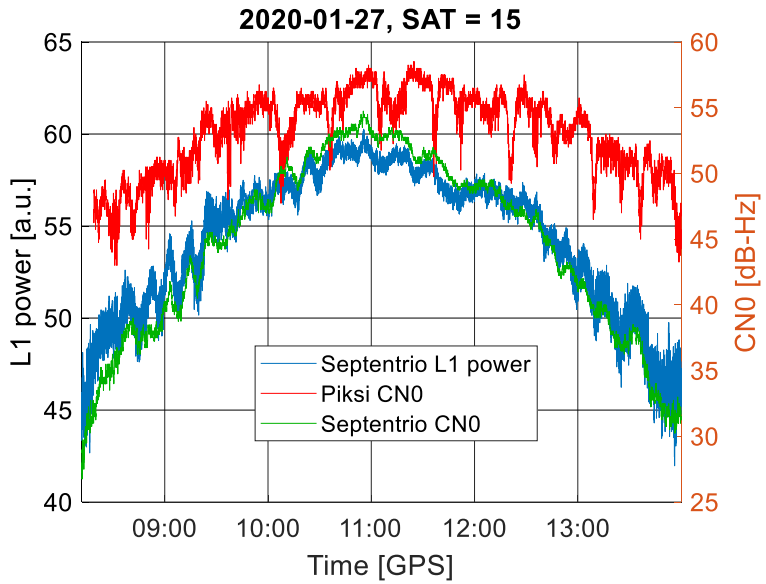
Other GNSS networks
Ionospheric studies using GNSS
Low-cost GNSS receivers
Low-cost HF sounder

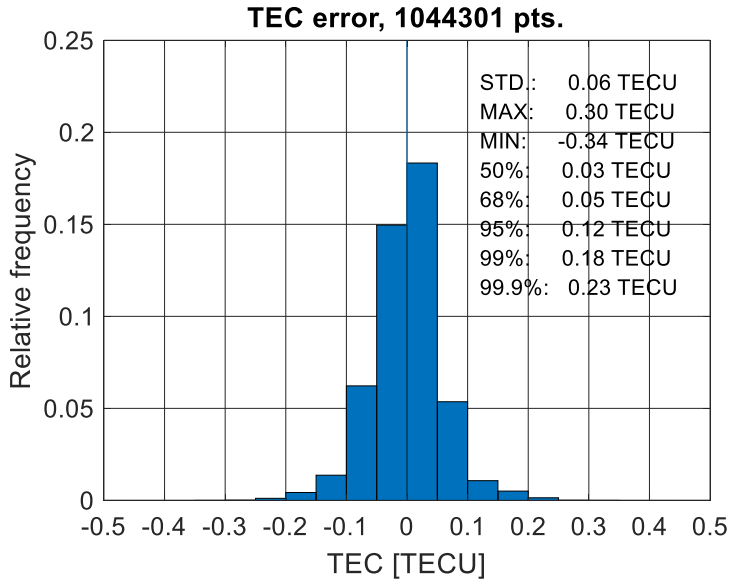
GNSS receivers under test

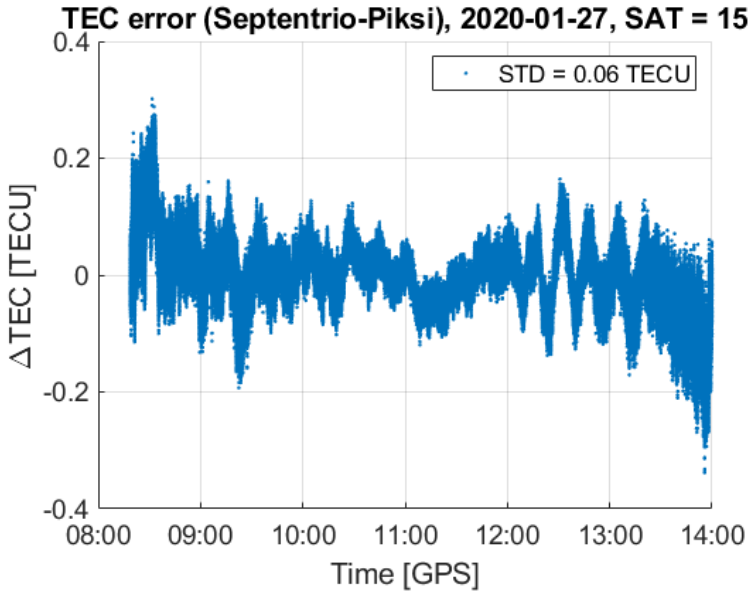
- Septentrio PolaRxS Pro, 50 Hz, >10k USD
- Swift Piksi Multi, 20 Hz, ~1k USD
- U-Blox ZED-F9P, 20 Hz , 250 USD

Piksi vs Septentrio

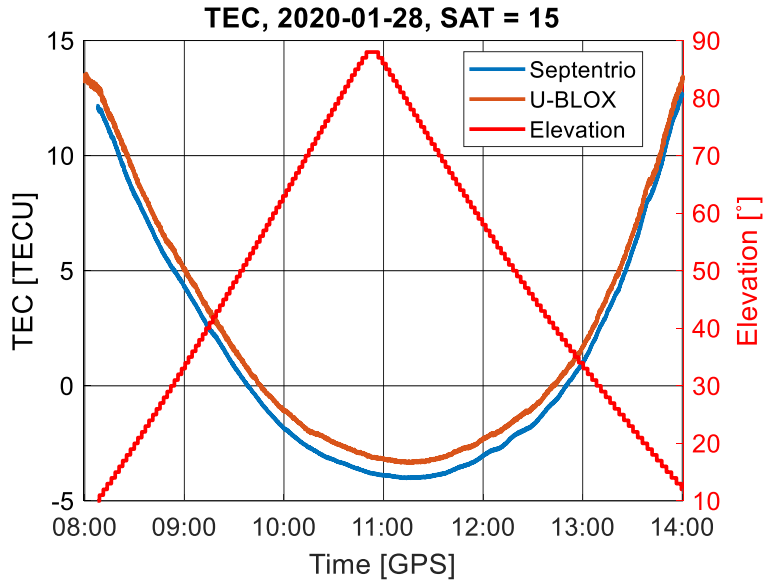


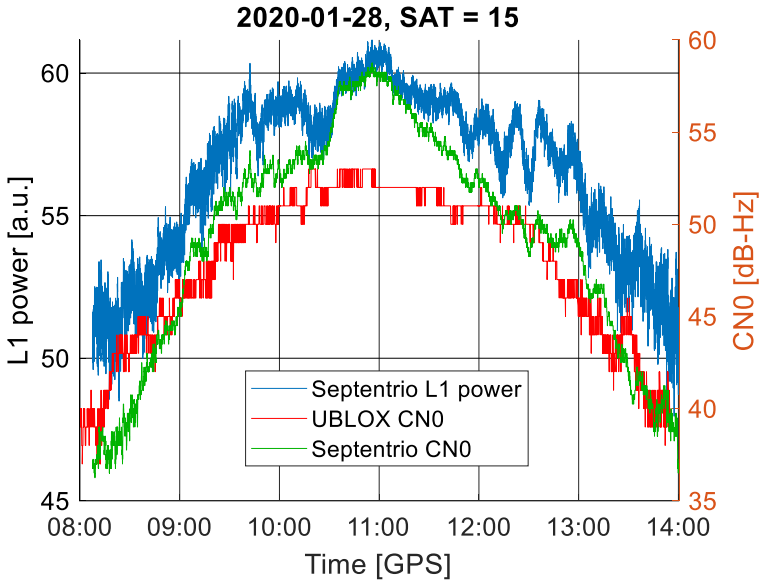


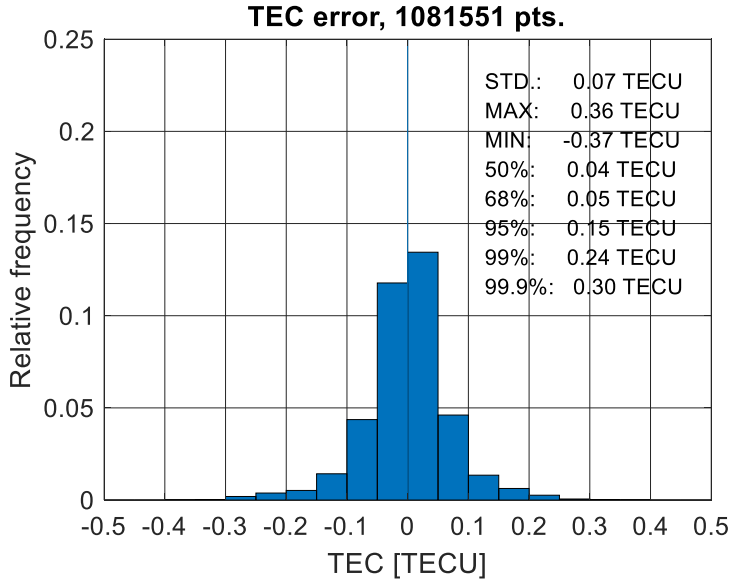


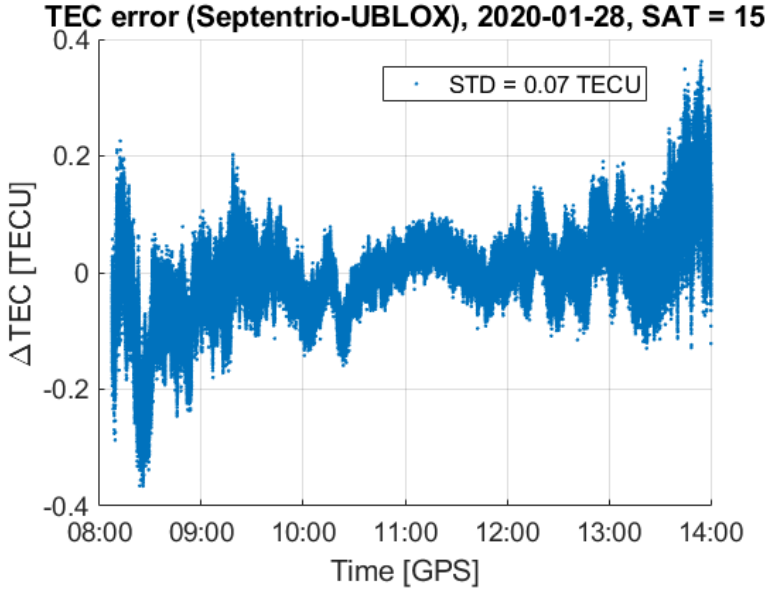


U-Blox vs Septentrio









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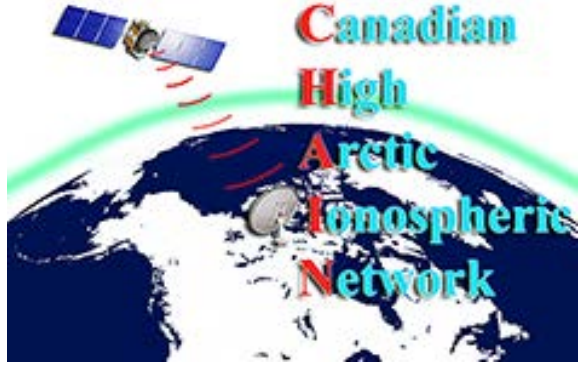

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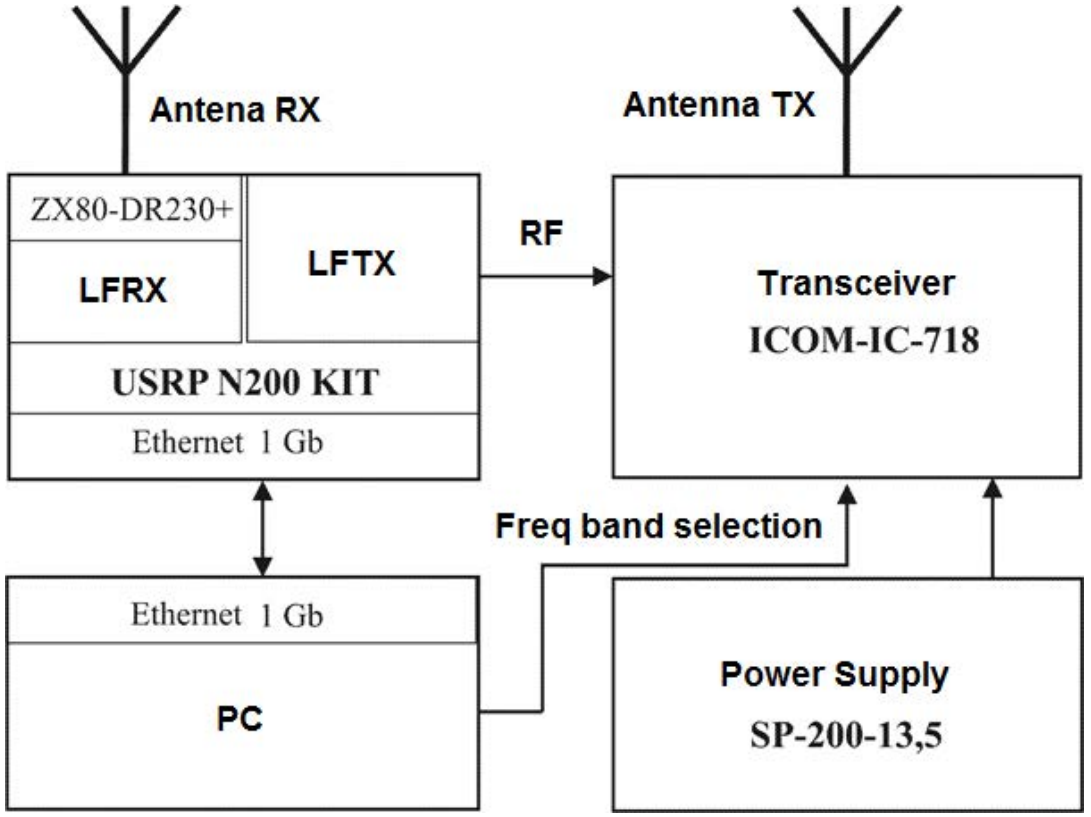
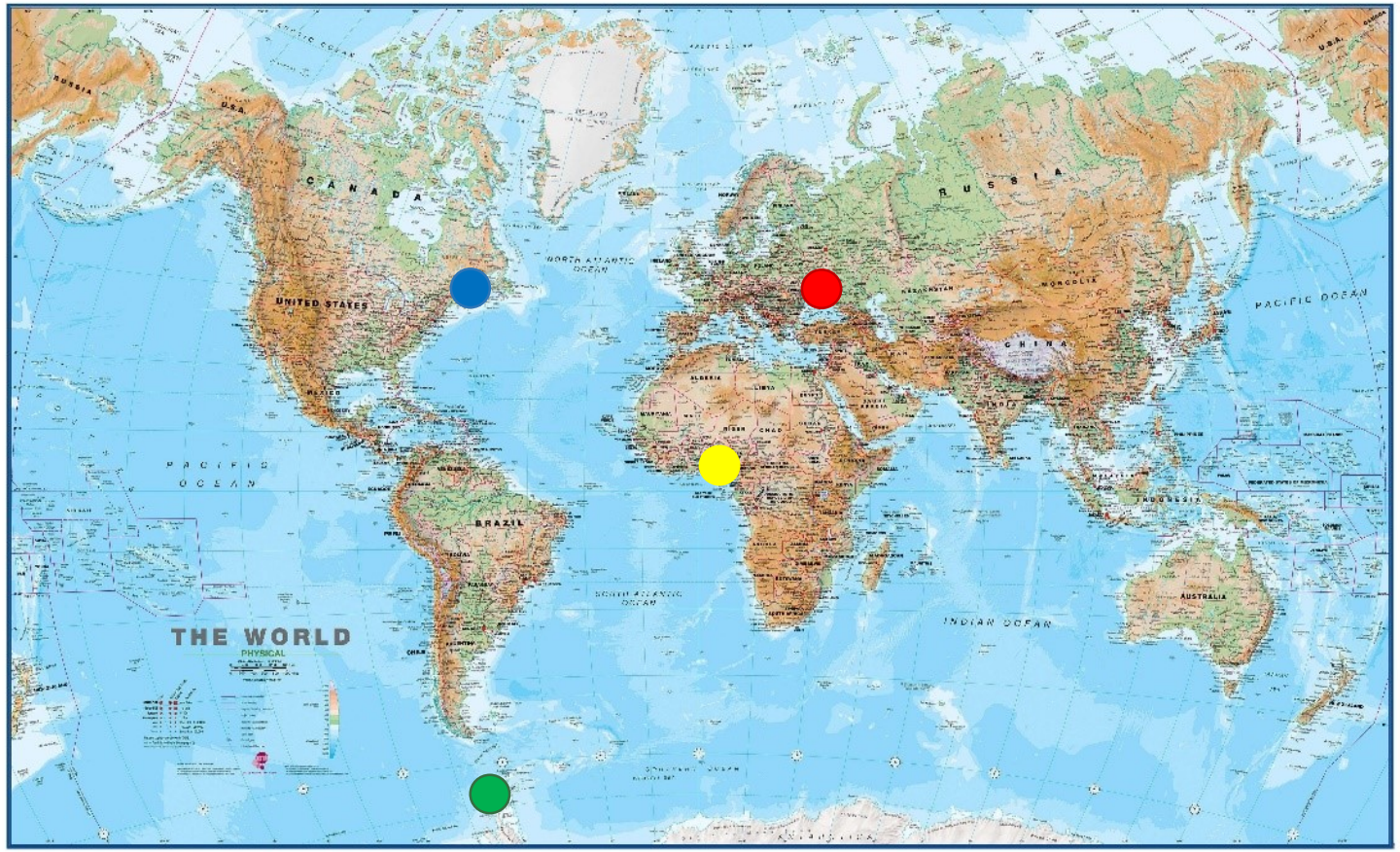
Low-cost ionosonde: block diagram



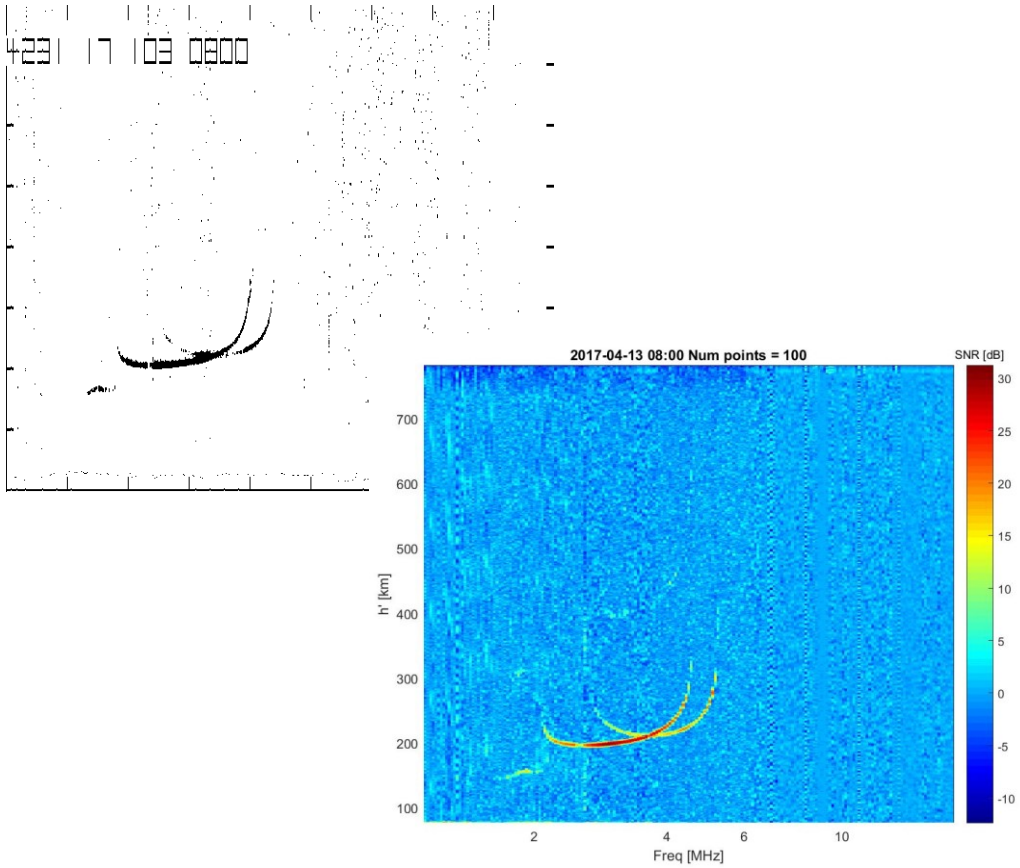
Low-cost ionosonde: network



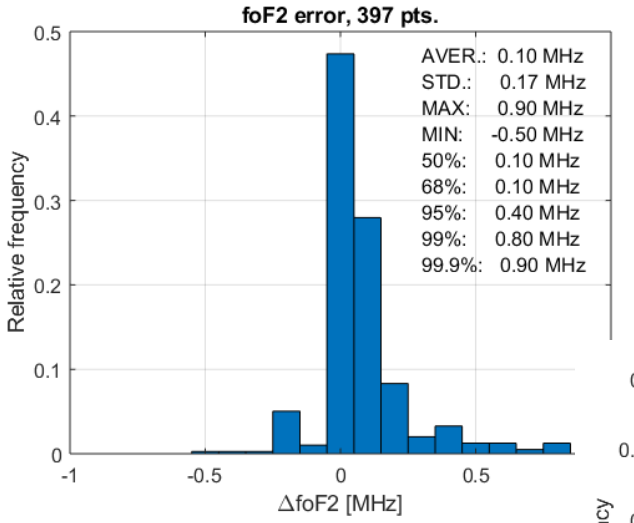
- Research Base “Ak Vernadksy”, Antarctica (Apr 2017)
- Kharkiv, Ukraine (Dec 2017)
- Blissville, Canada (Dec 2019)
- Abuja, Nigeria (~Sep 2020)

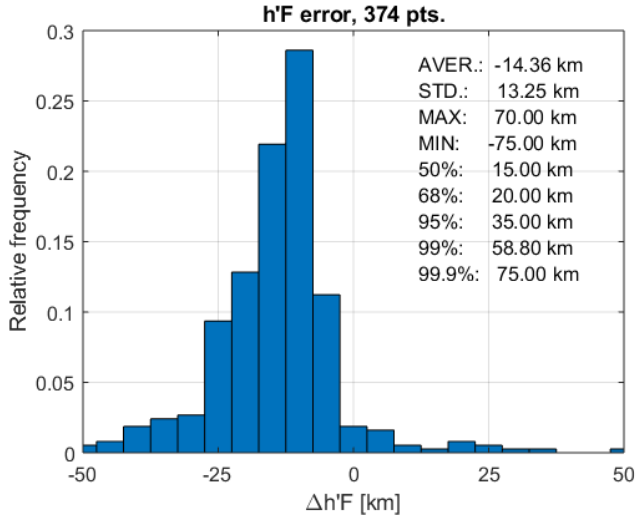
Low-cost ionosonde: IPS-42 vs SDR

3.5 kW vs 0.1 kW



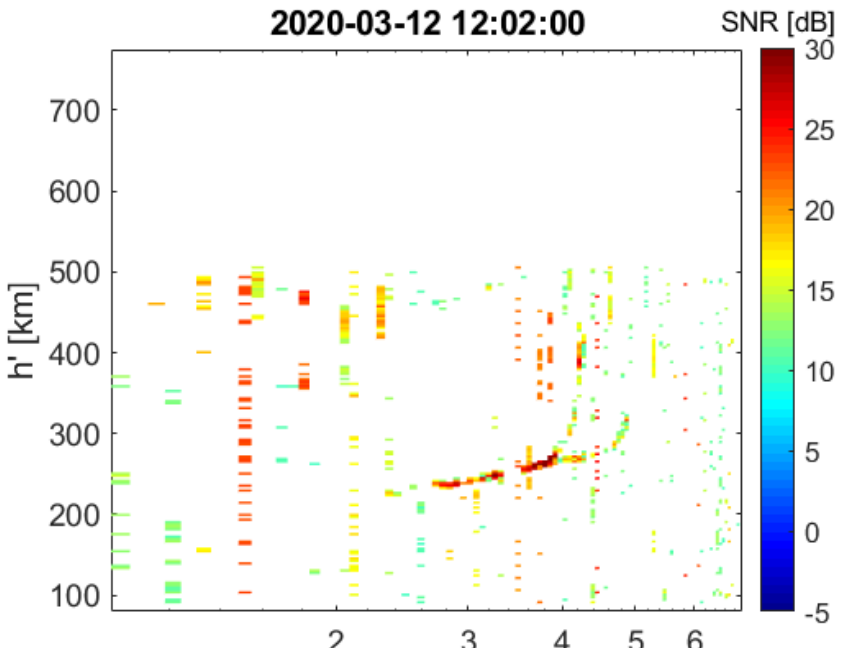
July 2017, manually scaled ionograms

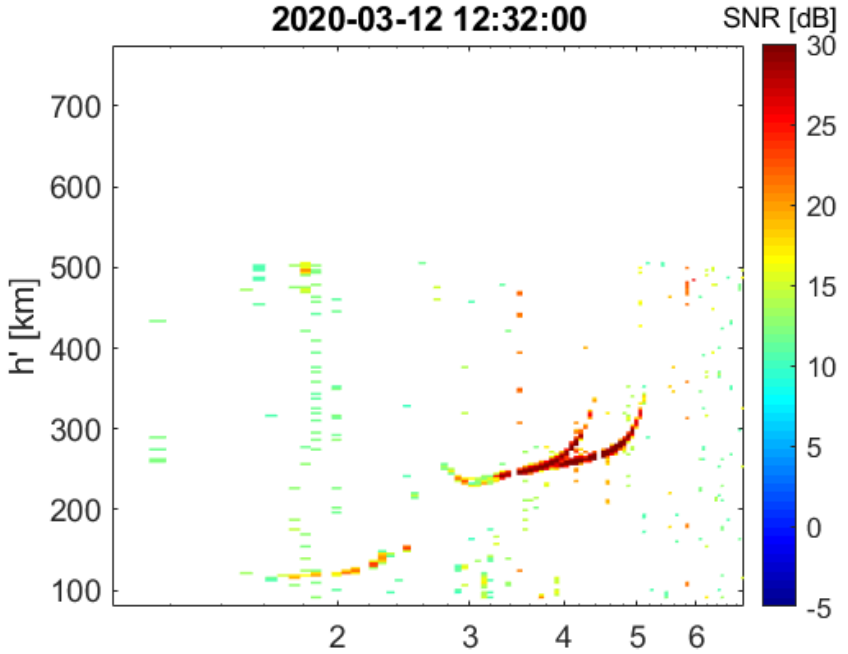




Low-cost ionosonde: CADI vs SDR

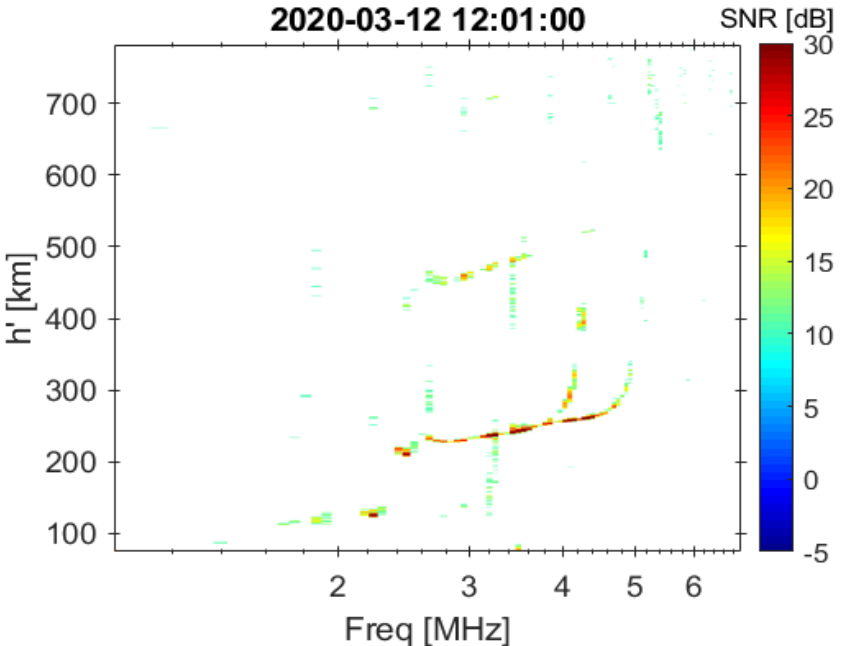
CADI

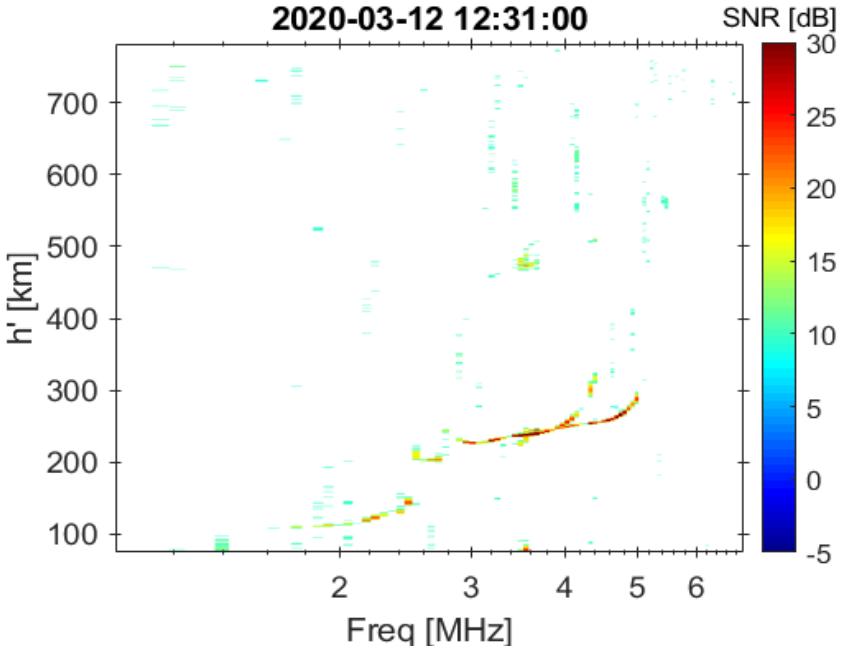




CADI

USRP





USRP

Conclusions

- CHAIN is open for collaboration and is interested in opportunities for value added expansion
- Low-cost dual frequency GNSS receivers are a good alternative to scientific-grade receivers to estimate TEC values
- Low-cost HF sounders can be used as an alternative to ionosondes