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FOR SPACE SCIENCE

GPS scintillation and irregularities at the front of a tongue of ionization in the nightside polar ionosphere over Svalbard

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UNIS
The University Centre in Svalbard

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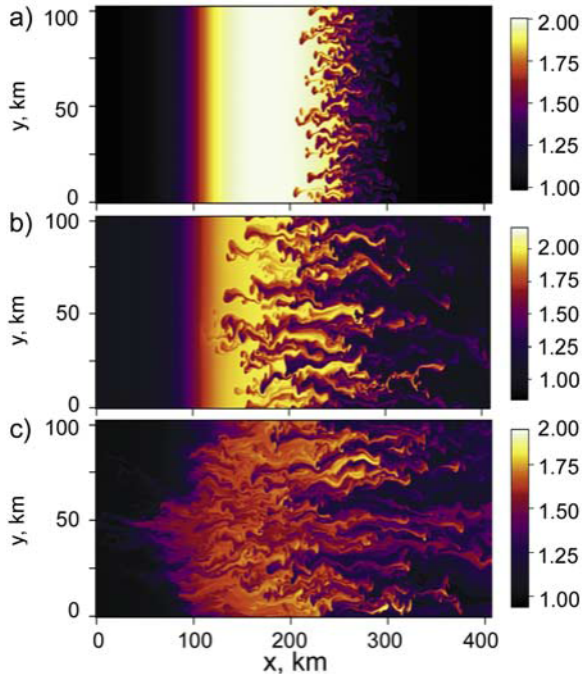
Det skapende universitet

Motivation

- Scintillations in polar cap well correlated with patch activity
- **What about continuous TOIs?**



[Gondarenko and Guzdar, 2004]

Background

- Plasma irregularities of scale sizes 10m–1km cause scintillations on GPS signals

- Amplitude scintillations: 10–100m-scale irregularities, S_4 index

$$S_4^2 = \frac{\langle I^2 \rangle - \langle I \rangle^2}{\langle I \rangle^2}, \qquad I = \text{power}$$

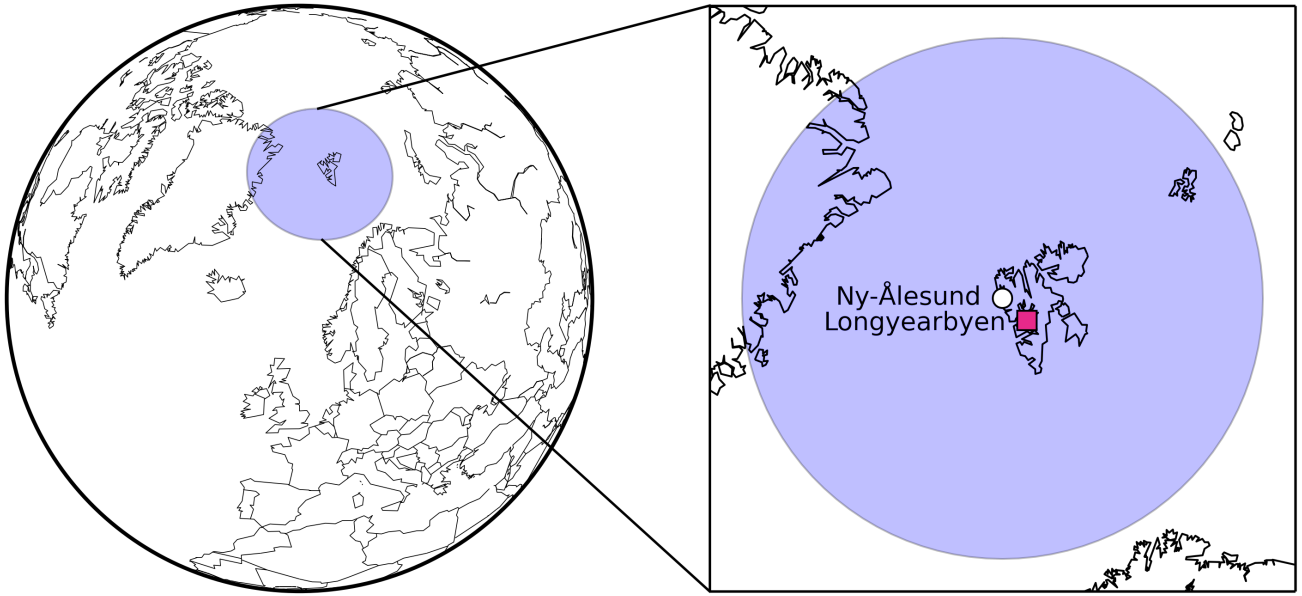
- Phase scintillations: 100m–1km-scale irregularities, usually σ_ϕ index

$$\sigma_\phi^2 = \langle \phi^2 \rangle - \langle \phi \rangle^2, \qquad \phi = \text{detrended phase}$$

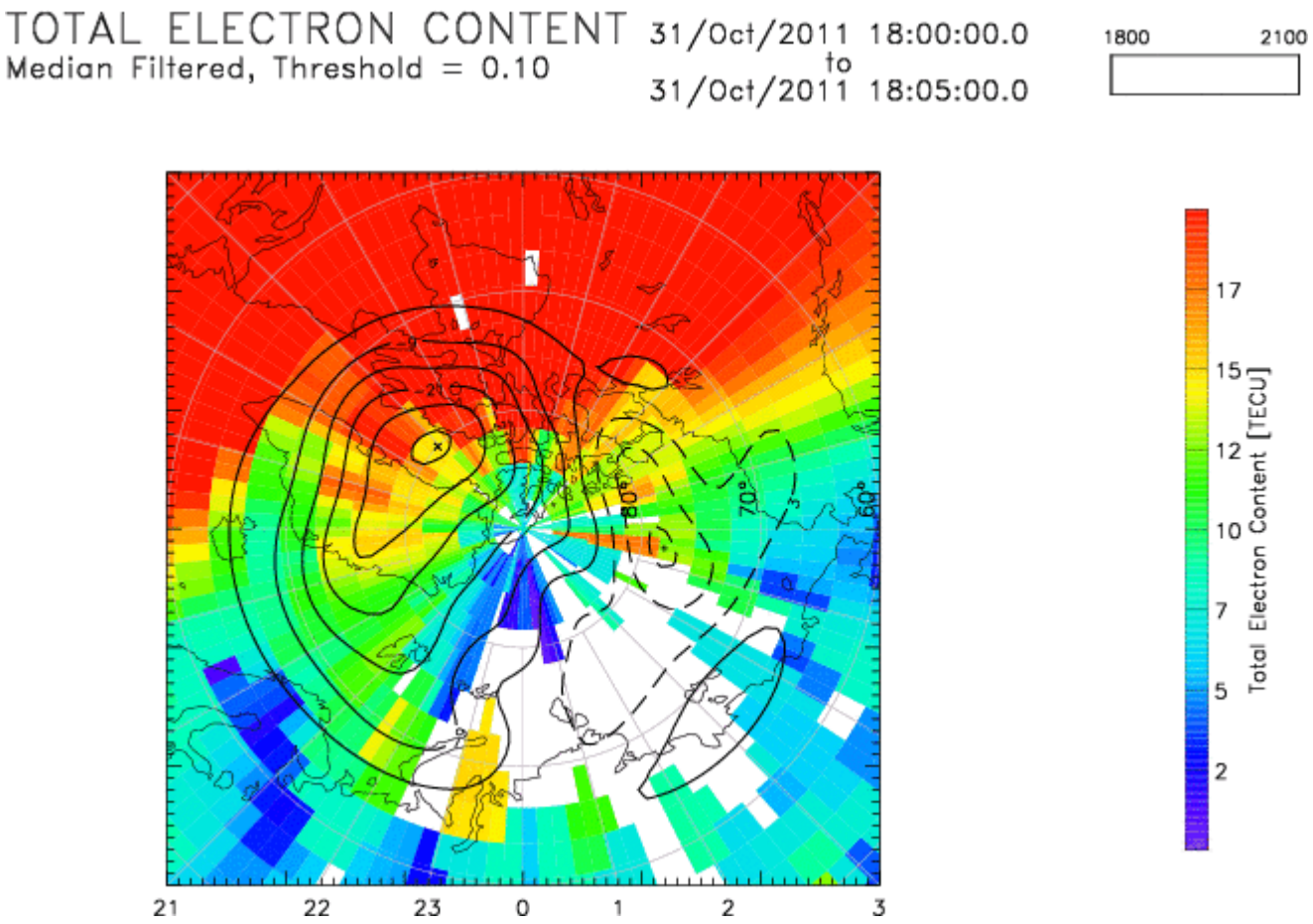
Methodology

- Case study of scintillation on the leading edge of a TOI over Svalbard on 31 Oct 2011

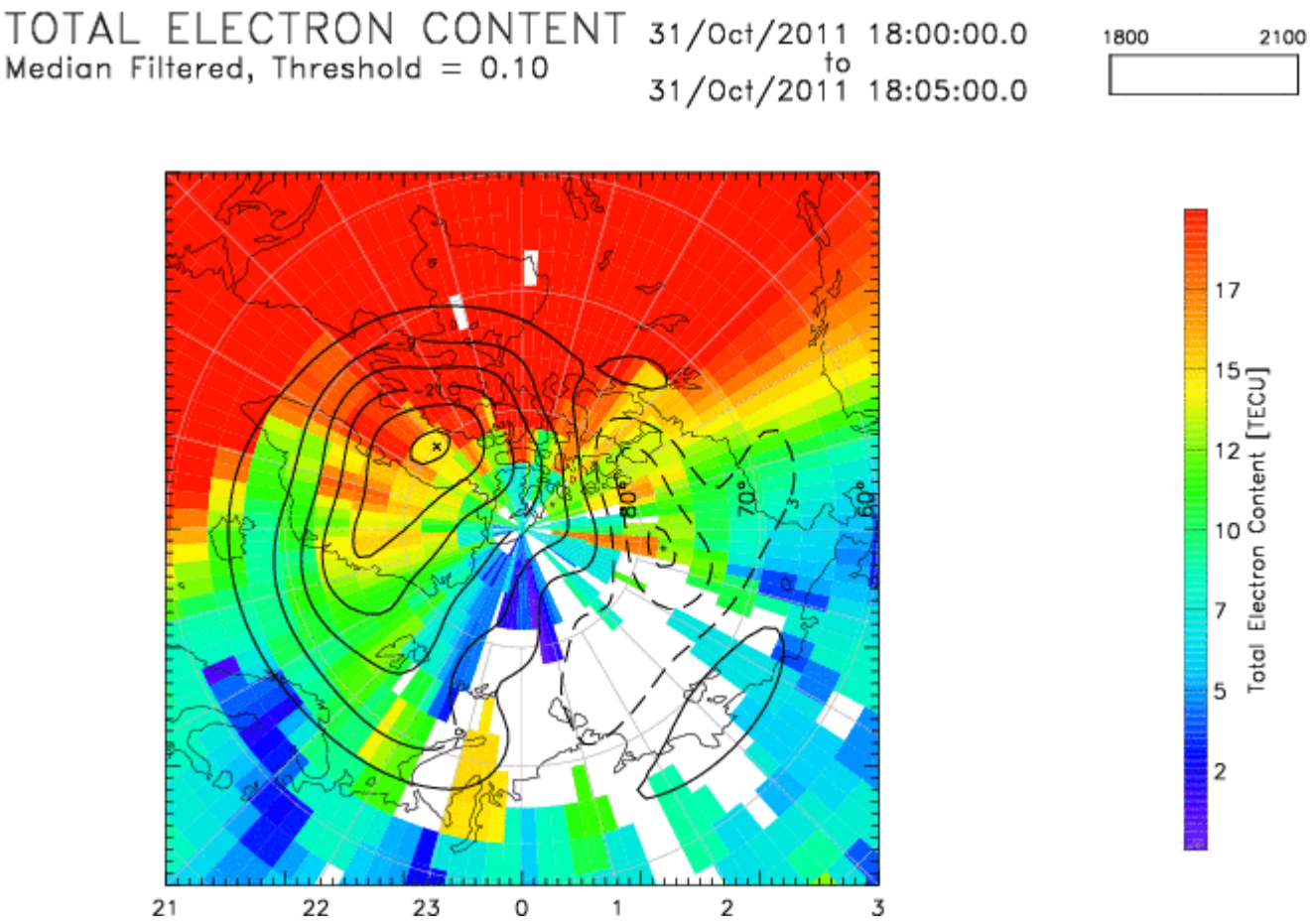
- 3 GPS receivers (NovAtel GSV4004B GISTM) (2 in NYA, 1 in LYR)
- EISCAT Svalbard Radar
- 630.0nm ASI at NYA
- SuperDARN Hankasalmi radar



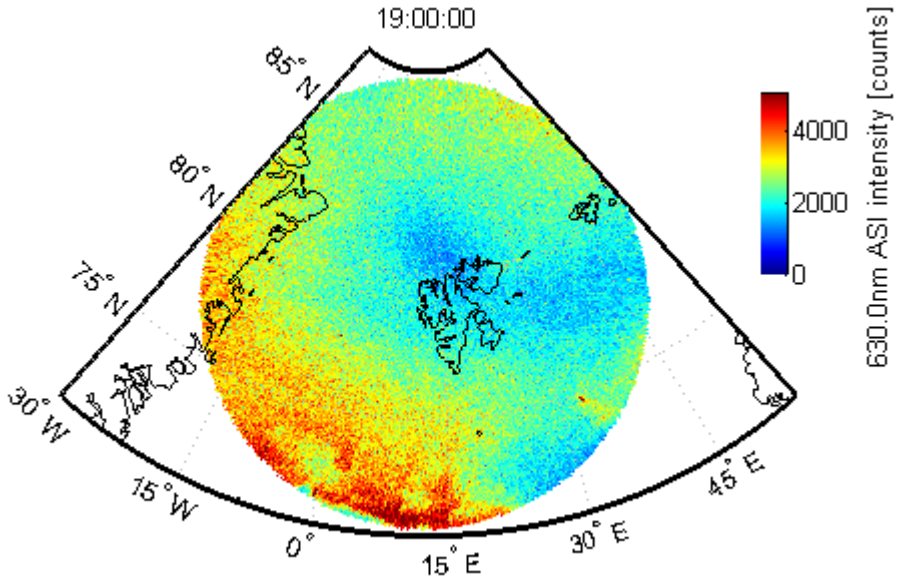
TOI across polar cap



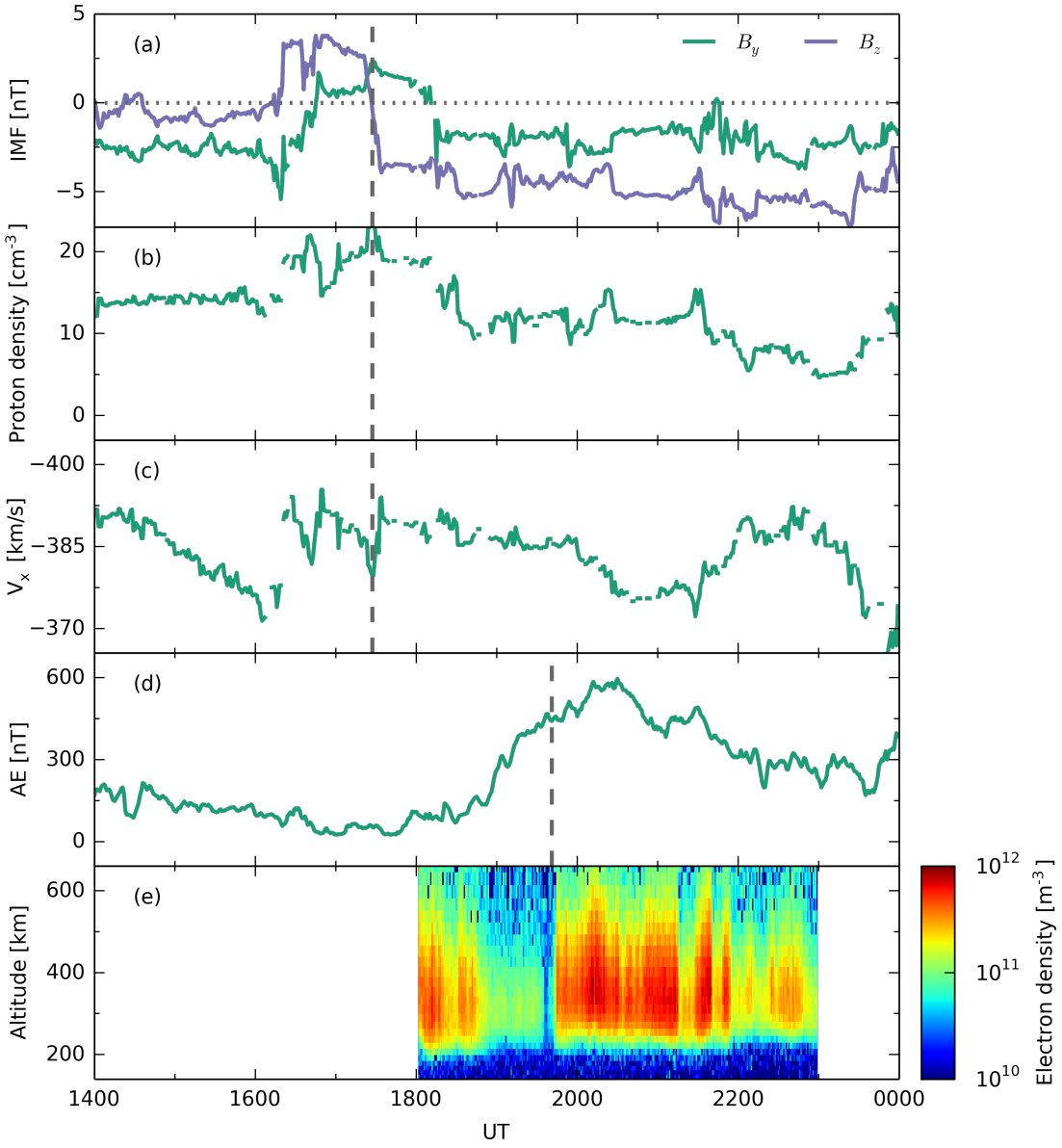
TOI across polar cap



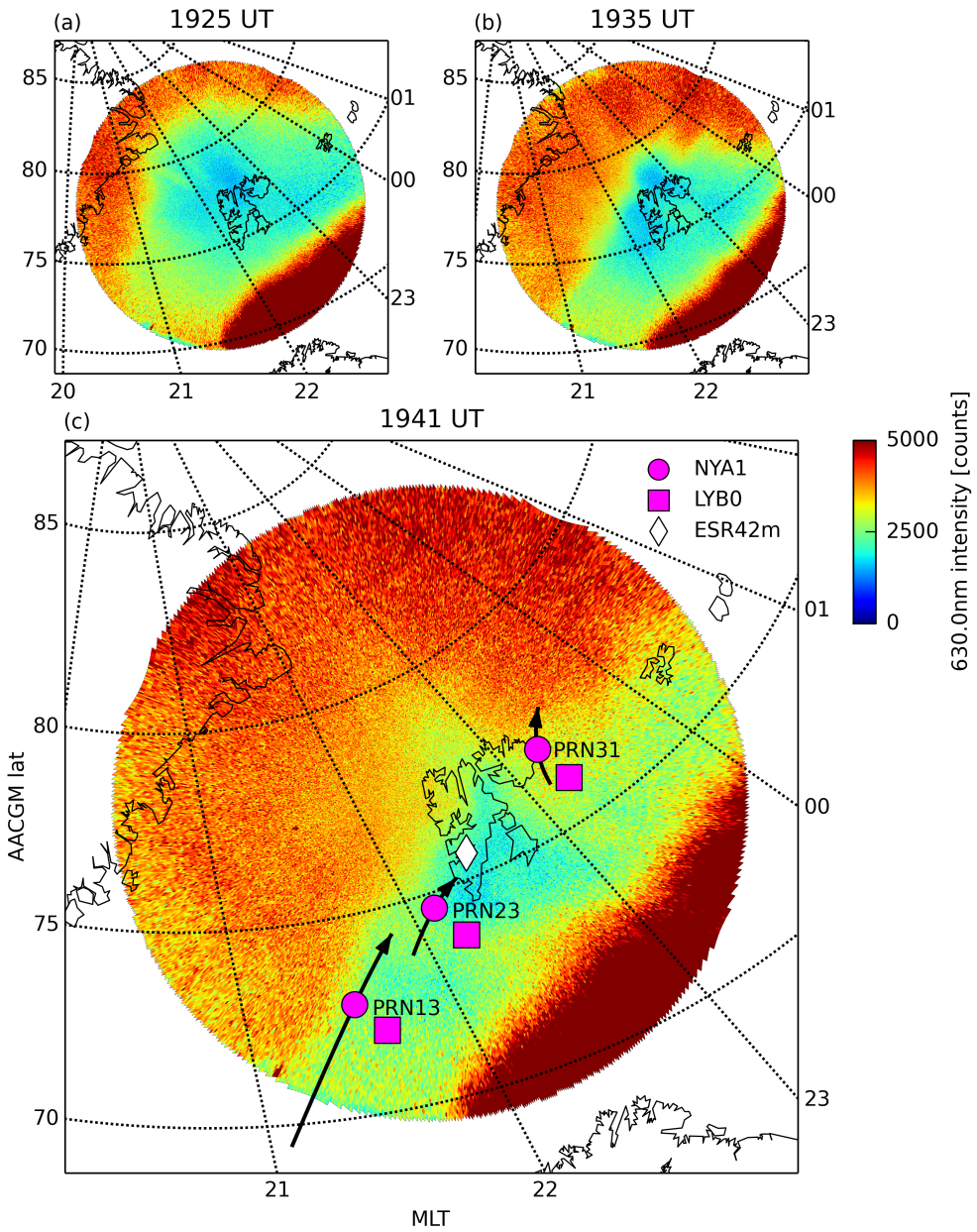
TOI airglow over Svalbard



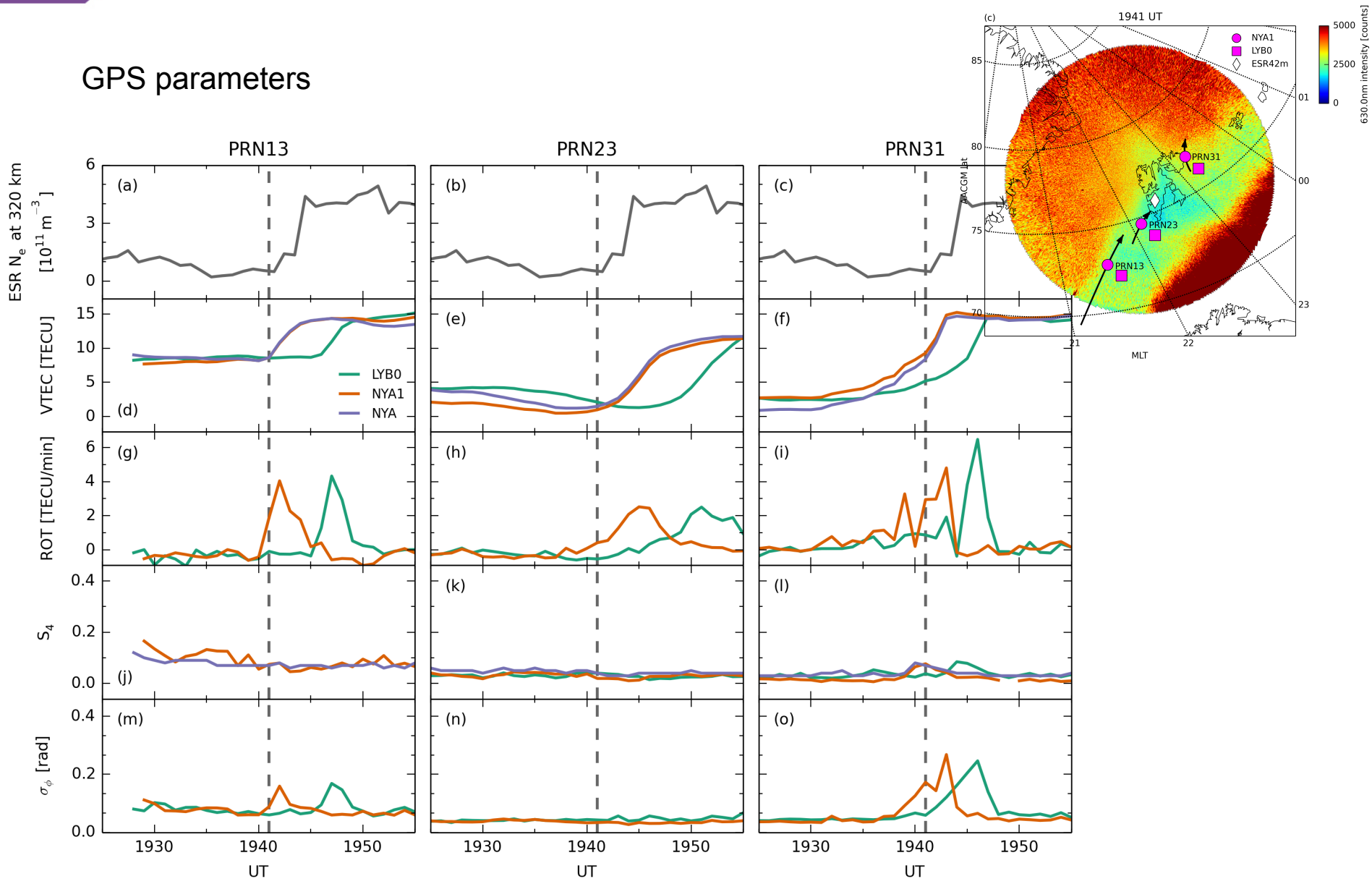
Geomagnetic overview



GPS IPP locations



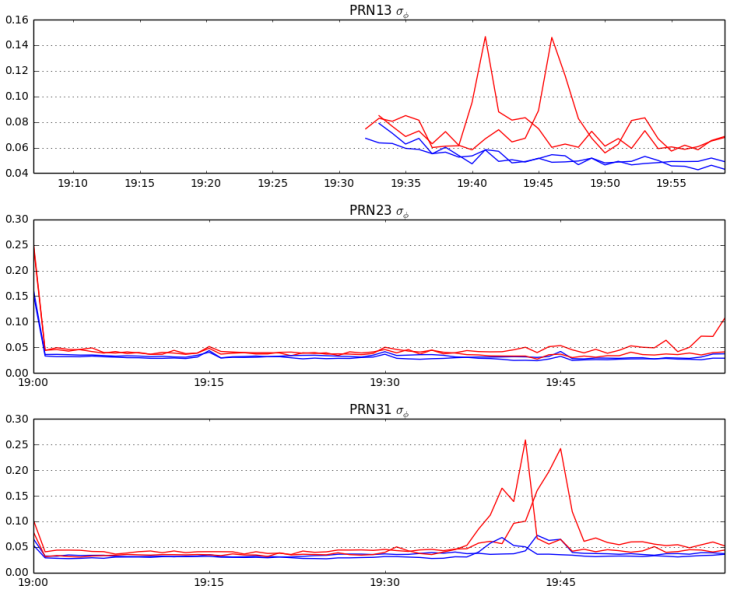
GPS parameters



Discussion – the problems of σ_ϕ

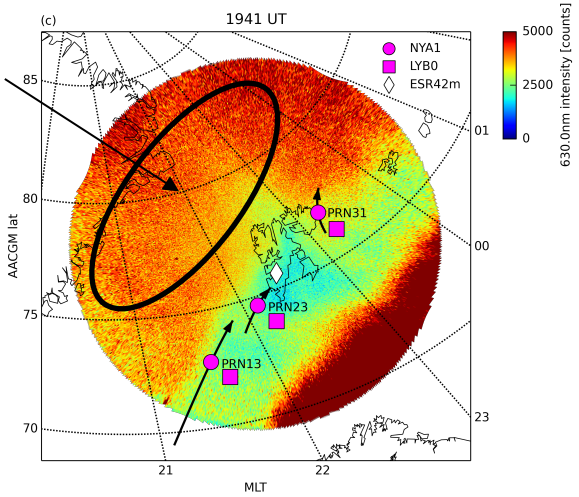
[Forte and Radicella, 2002; Béniguel et al., 2004; Forte, 2005; Beach, 2006; Mushini et al., 2012]

- Phase scintillation does not necessarily imply irregularities
- May instead be «false» scintillations from the gradient itself



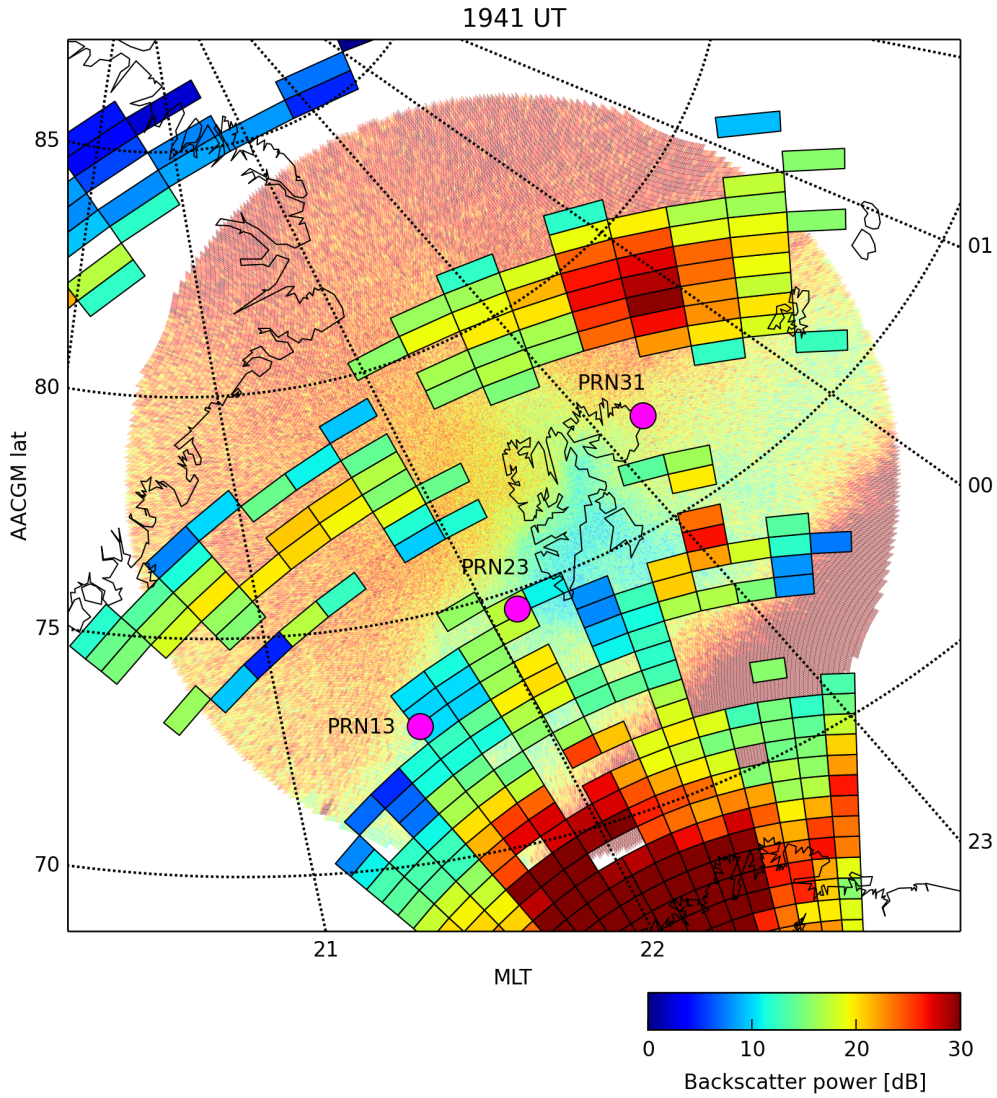
1. Poor data detrending
   - σ_ϕ index sensitive to low-frequency phase variations
   - Gradient = low-frequency phase variation
   - 0.1 Hz too low at high latitudes (gradients correspond to phase variations > 0.1 Hz)

No scintillation!



2. No scintillation after the gradient
   - Gradient drift instability (GDI) stable on leading edges
   - Irregularities would most likely develop from inside the structure toward the front
   - Uncertain – vorticities, rotations making the front unstable to the GDI

SD Hankasalmi backscatter



Conclusion

- Case study of GPS scintillation at TOI front on 31 October 2011
- Notable phase scintillation at the leading gradient, no significant amplitude scintillation
- Increases in the σ_ϕ index are most likely due to TEC gradient and poor data detrending
- No evidence in favour of structuring (significant enough to cause GPS scintillation) on the TOI front, or inside the high-density region immediately behind the gradient