High latitude lightning atmospherics belonging to transient luminous phenomena

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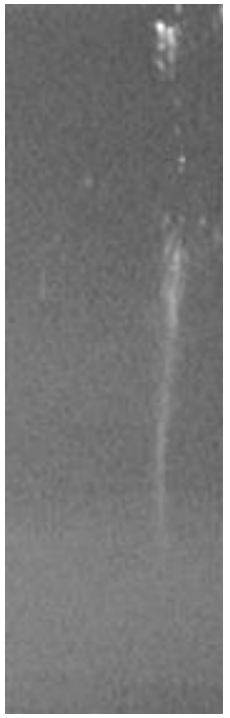
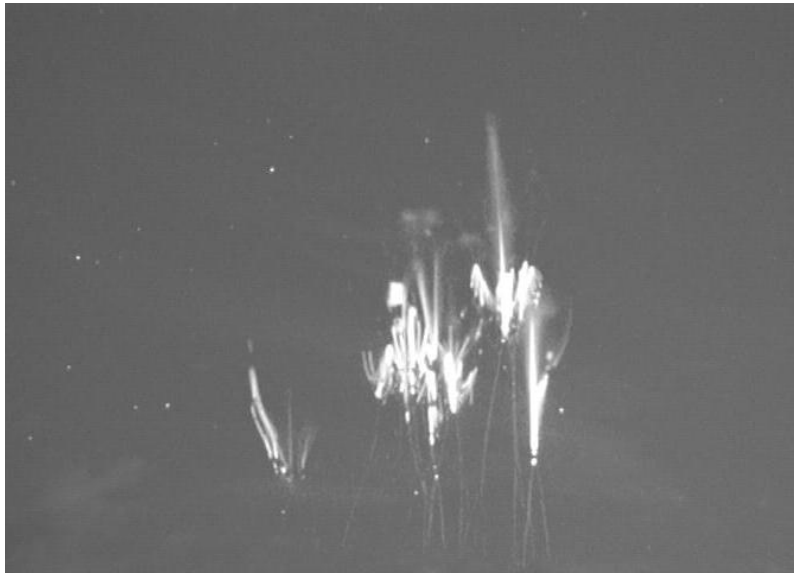
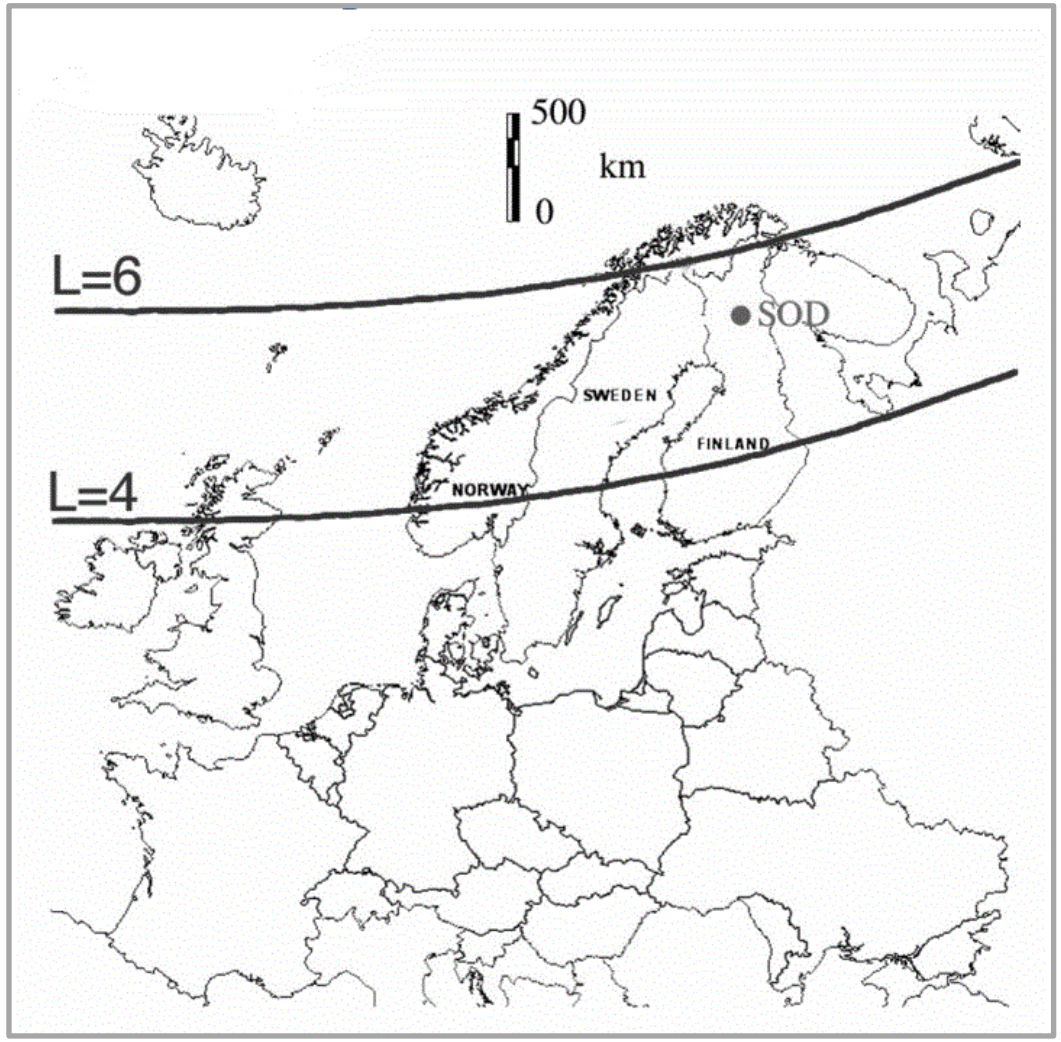
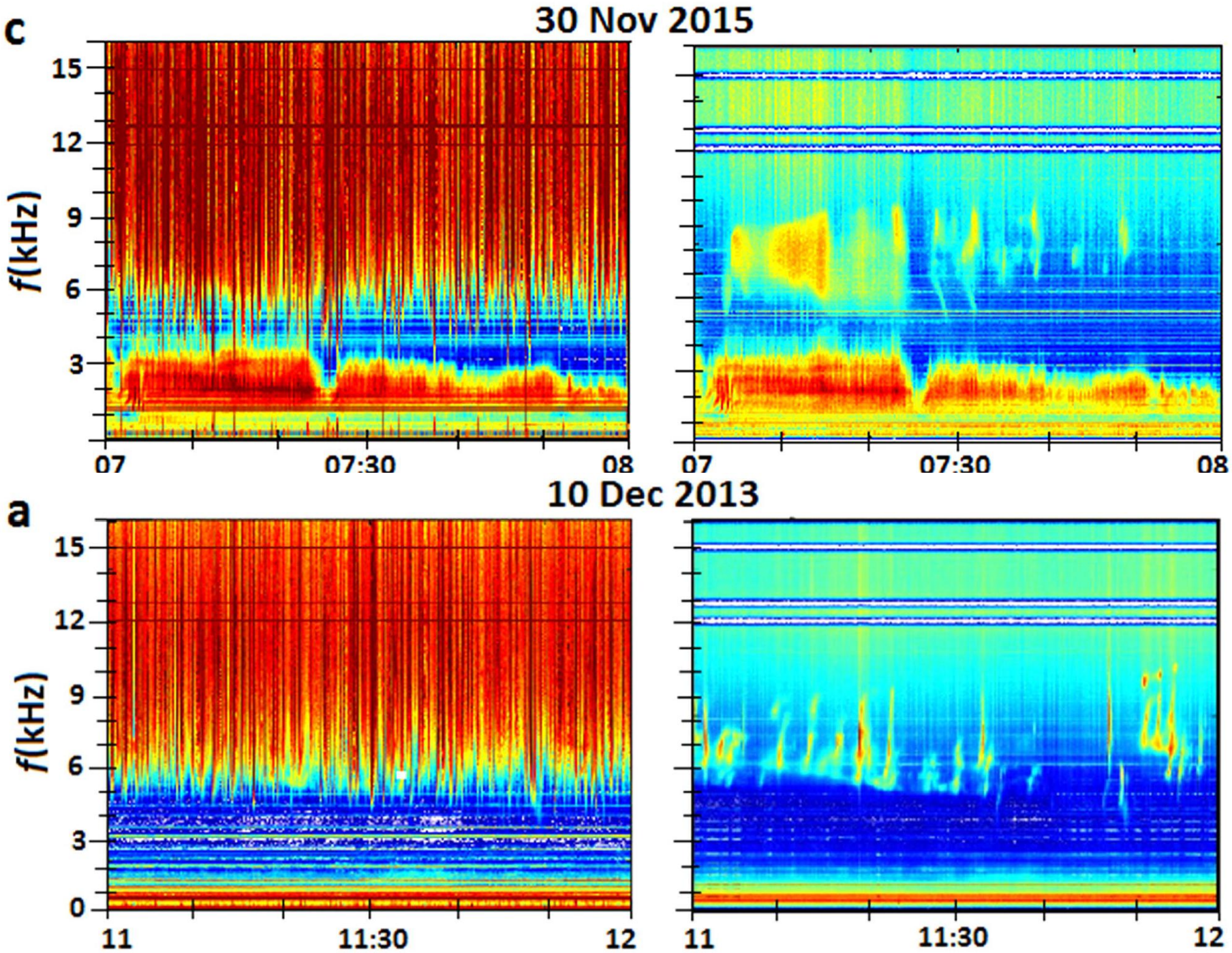




VLF observations, Northern Finland, Kannuslehto (67.74°N, 26.27°E), 35 km North of the Sodankylä Geophysical Observatory, frequency band of 0.2–39 kHz, two orthogonal magnetic loop antennas oriented in the N-S and E-W directions. The receiver sensitivity is about 0.1 fT.



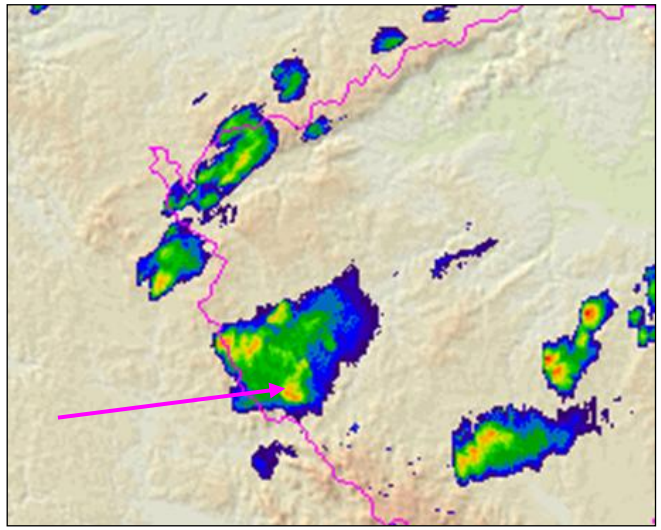


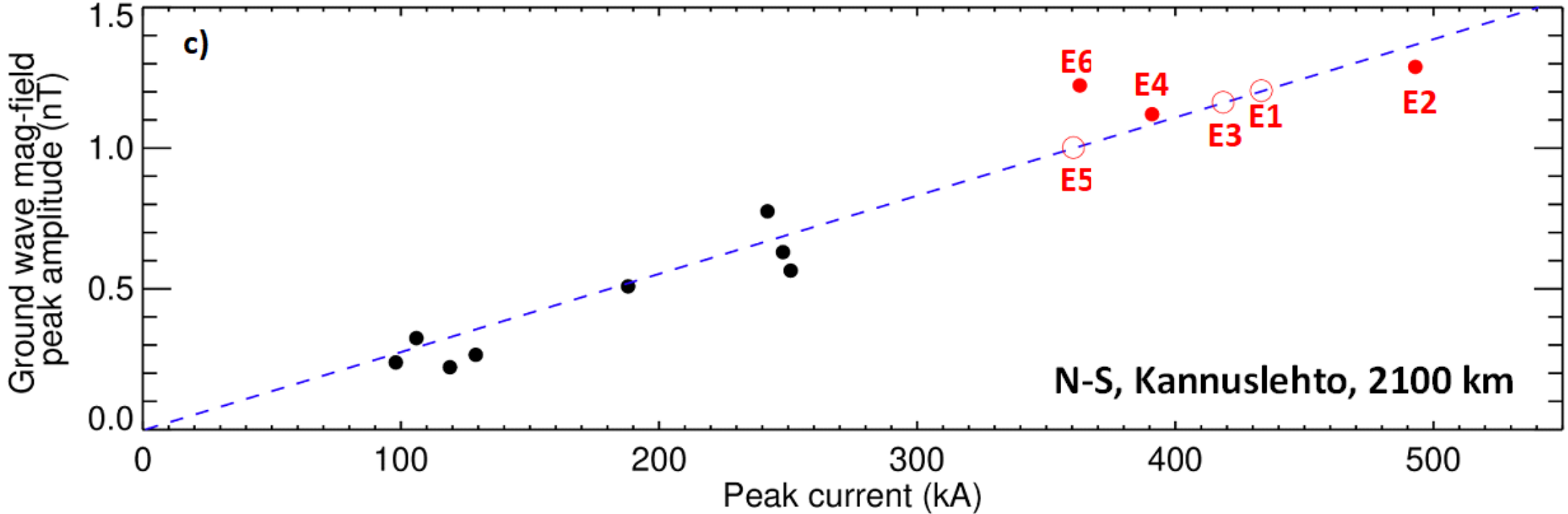
Sferics filtering

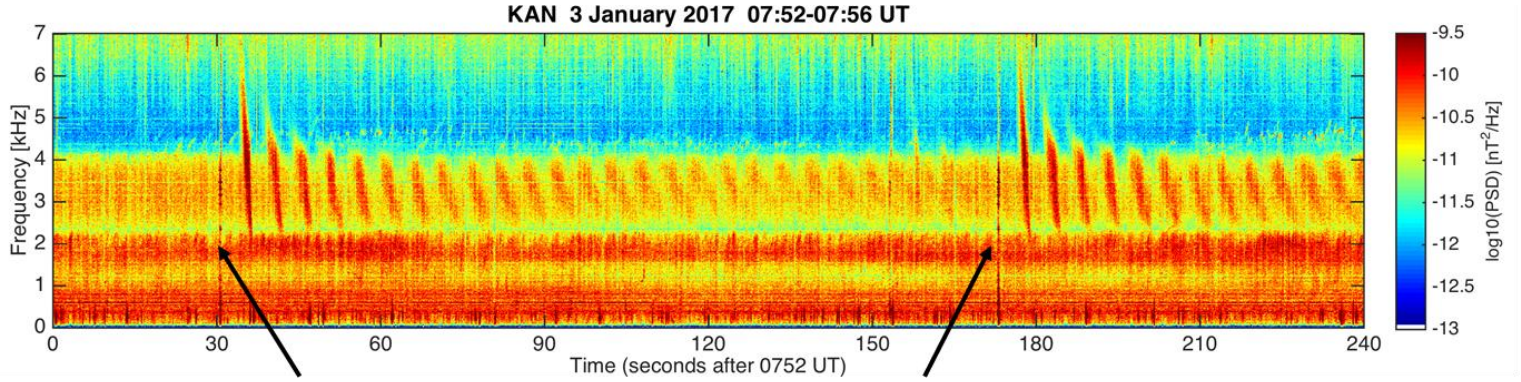
Manninen *et al.* 2016
***Environ. Res. Lett.* 11**

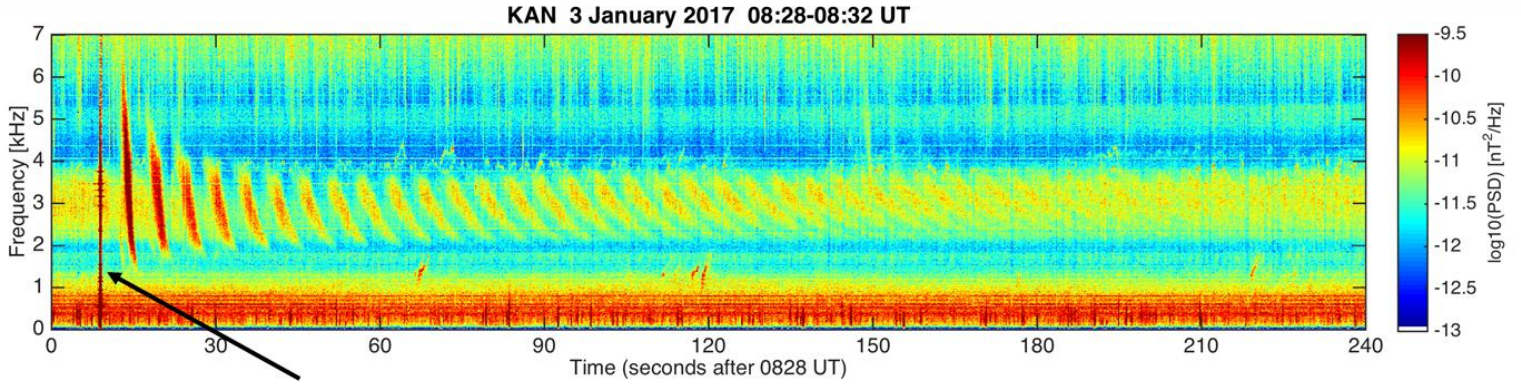
Unusually high frequency natural VLF radio emissions observed during daytime in Northern Finland

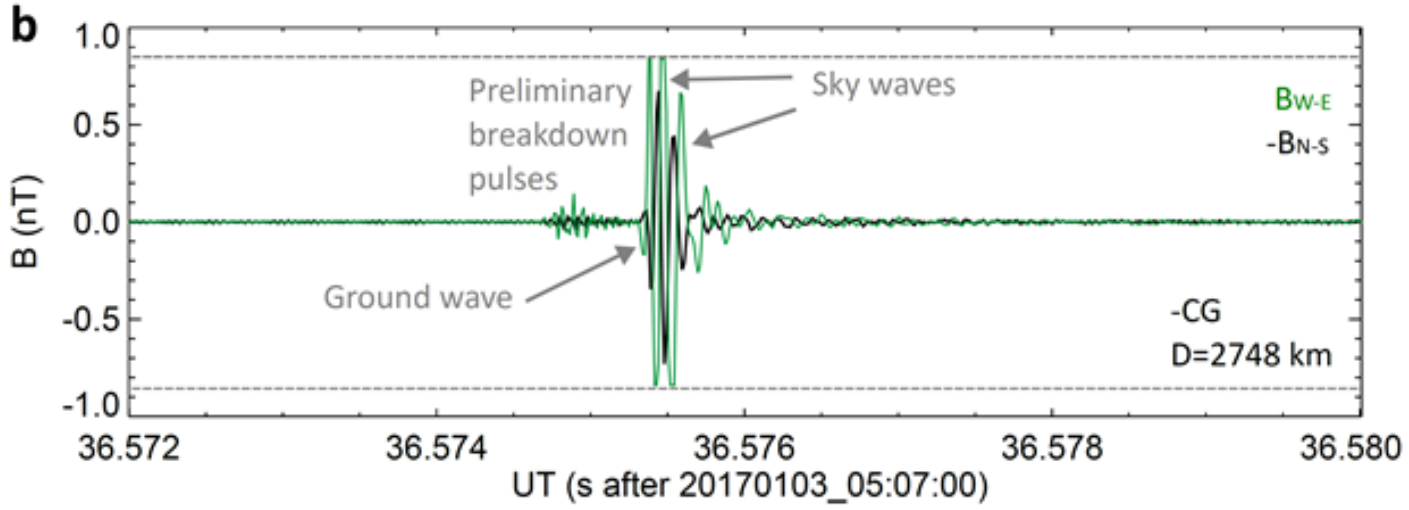
Kolmašová, et al. (2020). First observations of elves and their causative very strong lightning discharges in an unusual small-scale continental spring-time thunderstorm. *JGR: Atmospheres*.



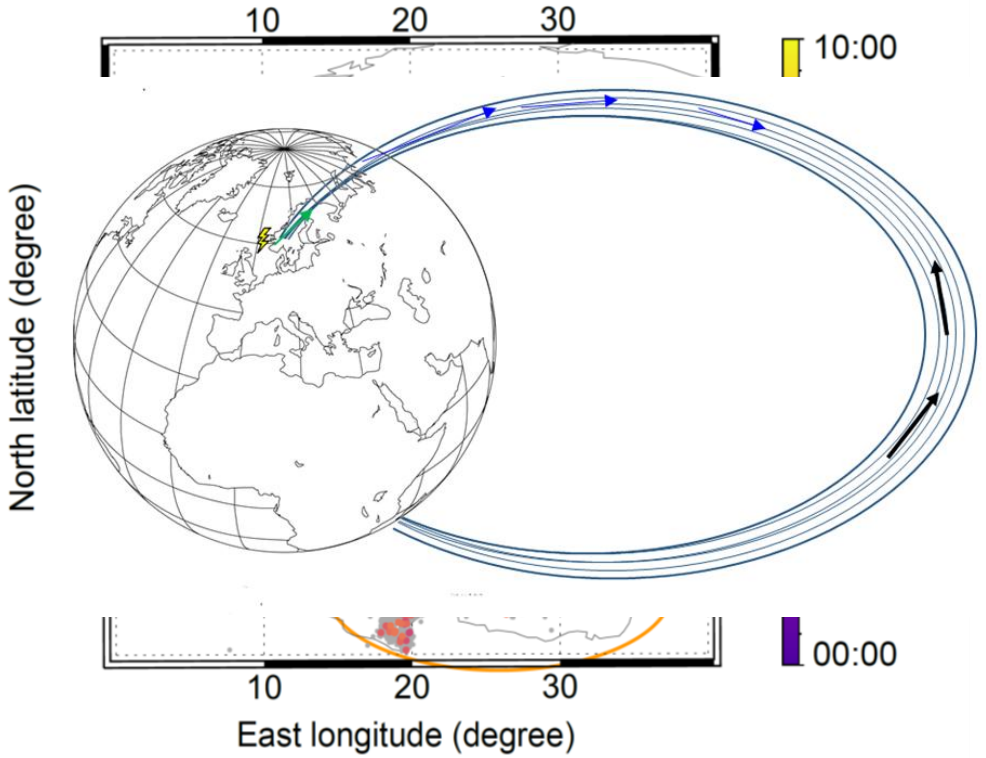


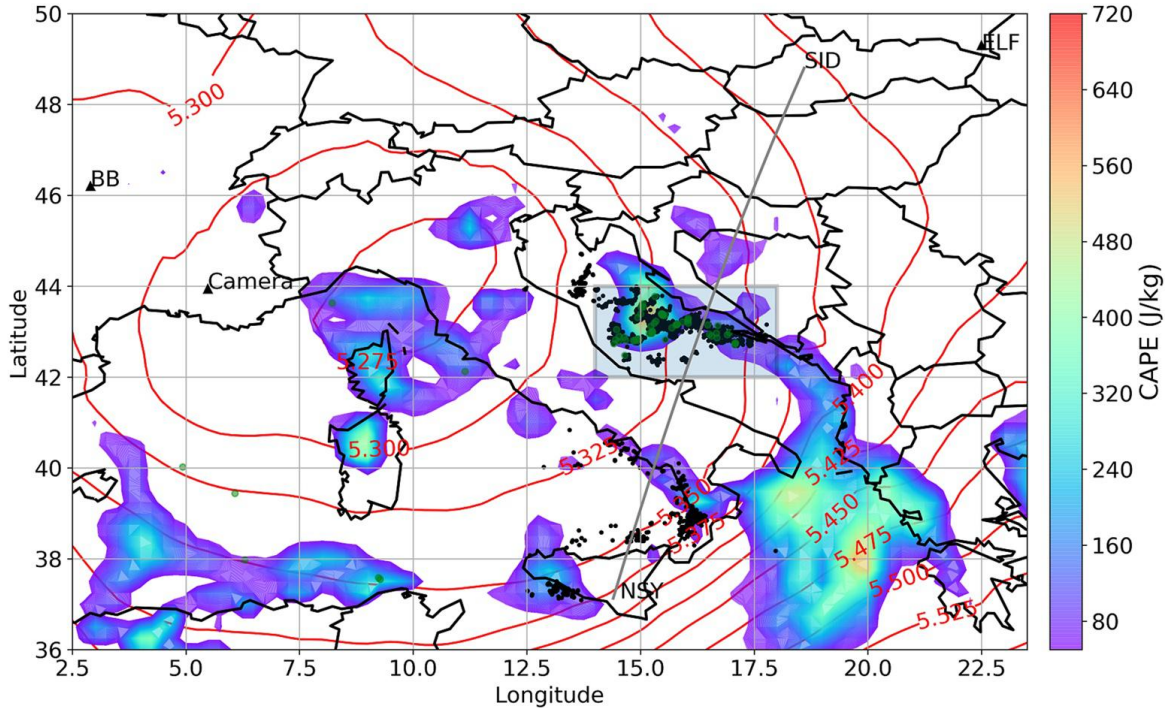




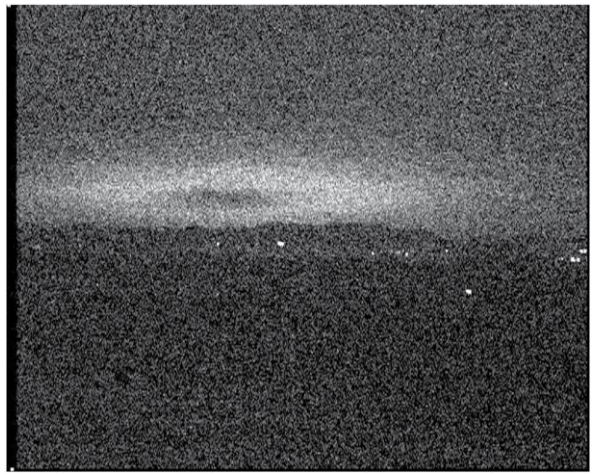


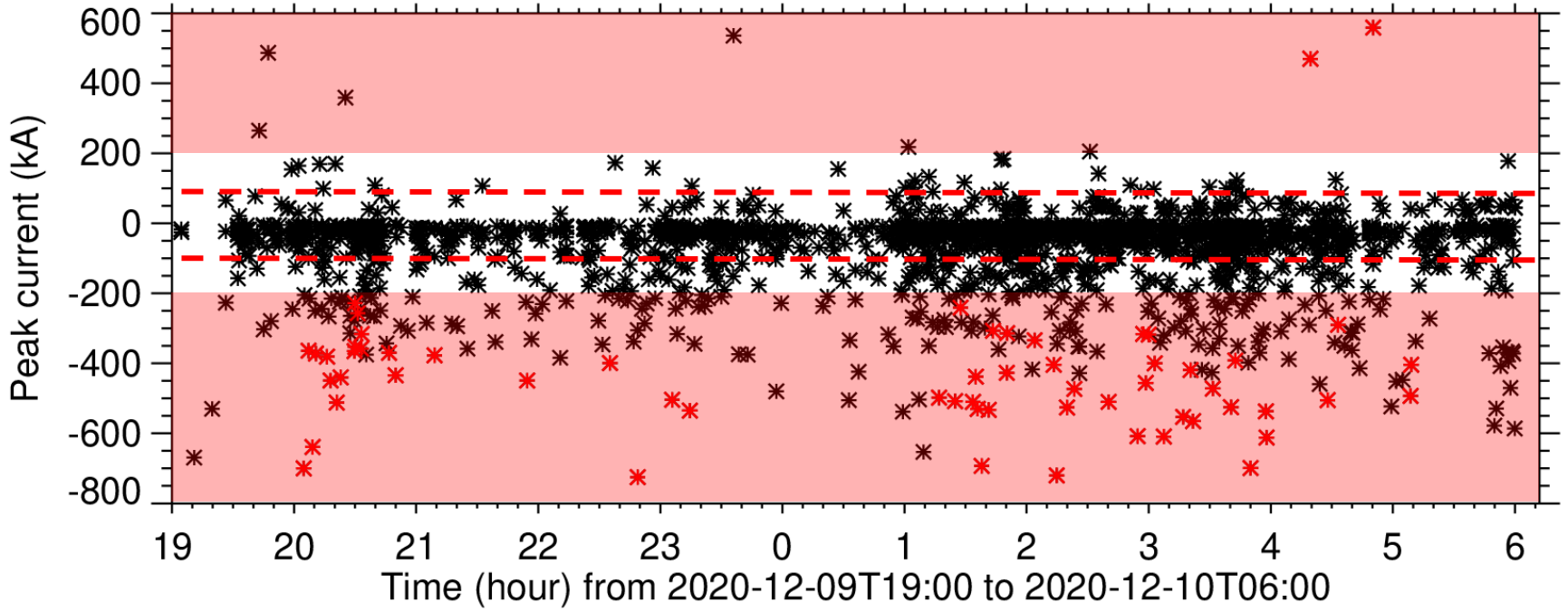
Kolmašová, I., Santolík, O. & Manninen, J. (2024), Whistler echo trains triggered by energetic winter lightning. *Nature Communications,* 15, 7166.





Tomičič et al. (2023). Observations of elves and radio wave perturbations by intense lightning. *JGR: Atmospheres.*

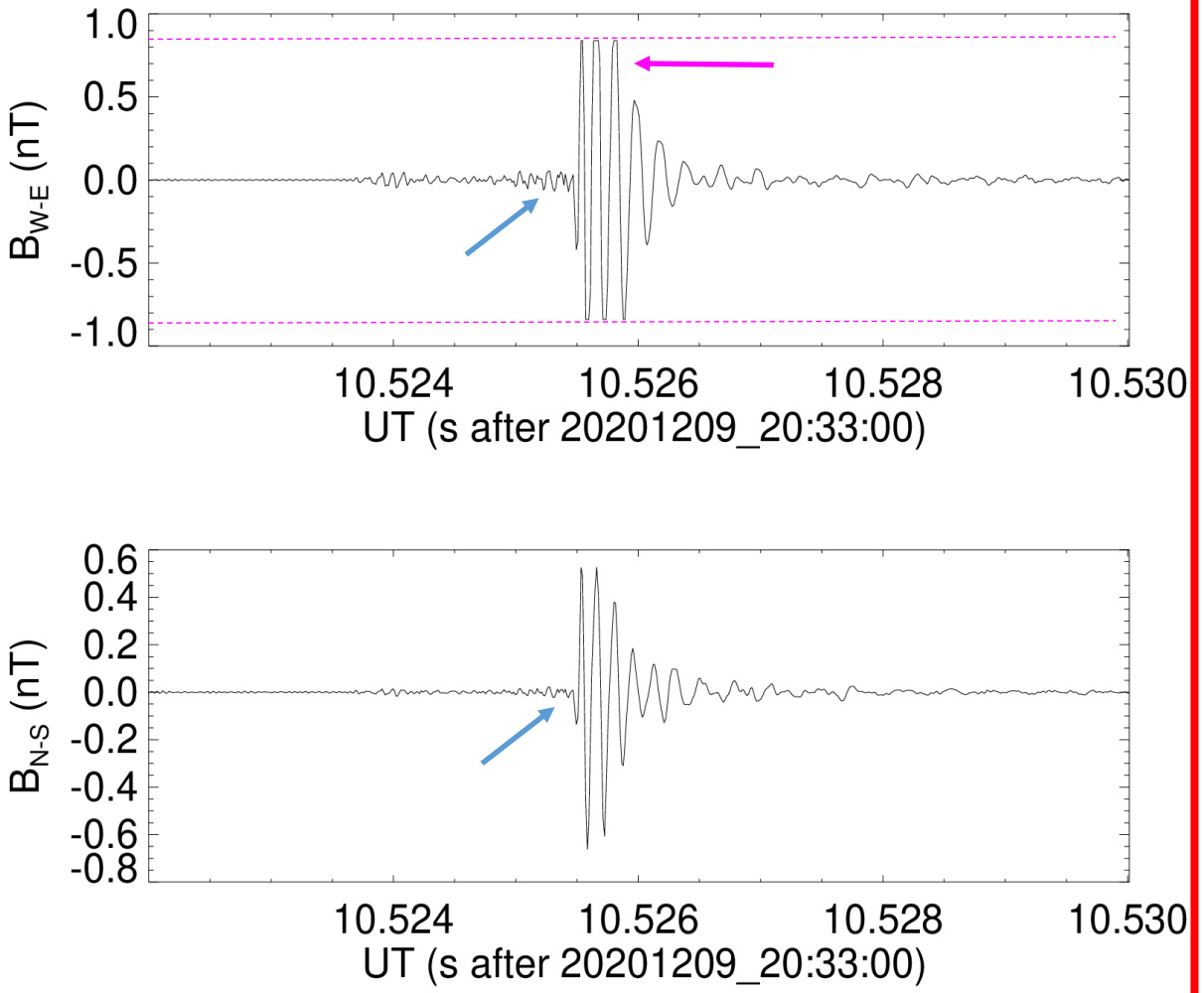




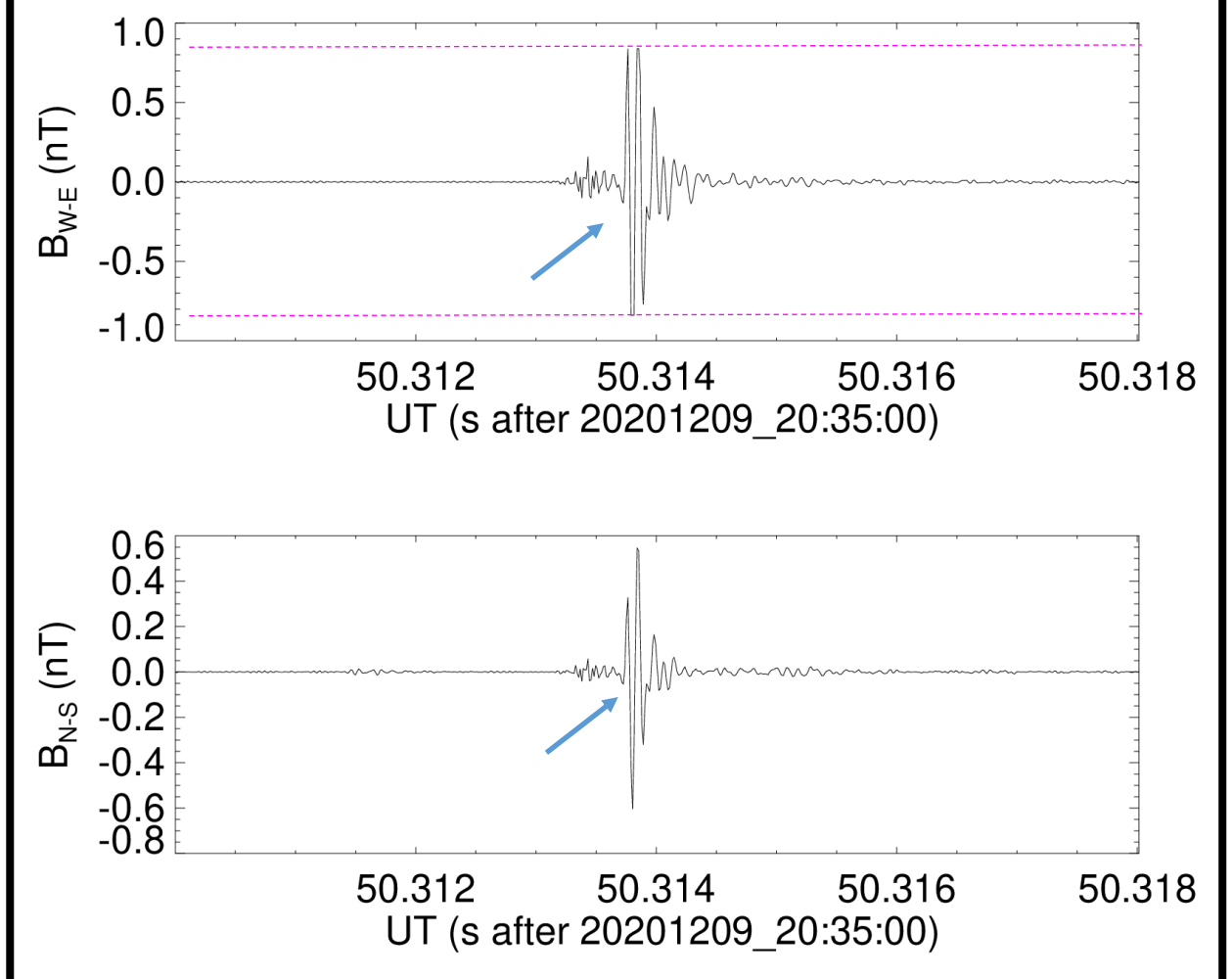
- 1801 CG strokes
- 288 strokes stronger than 200 kA
- only 60 elves

- ≈ 2800 km from the receiver

Sferics waveform examples

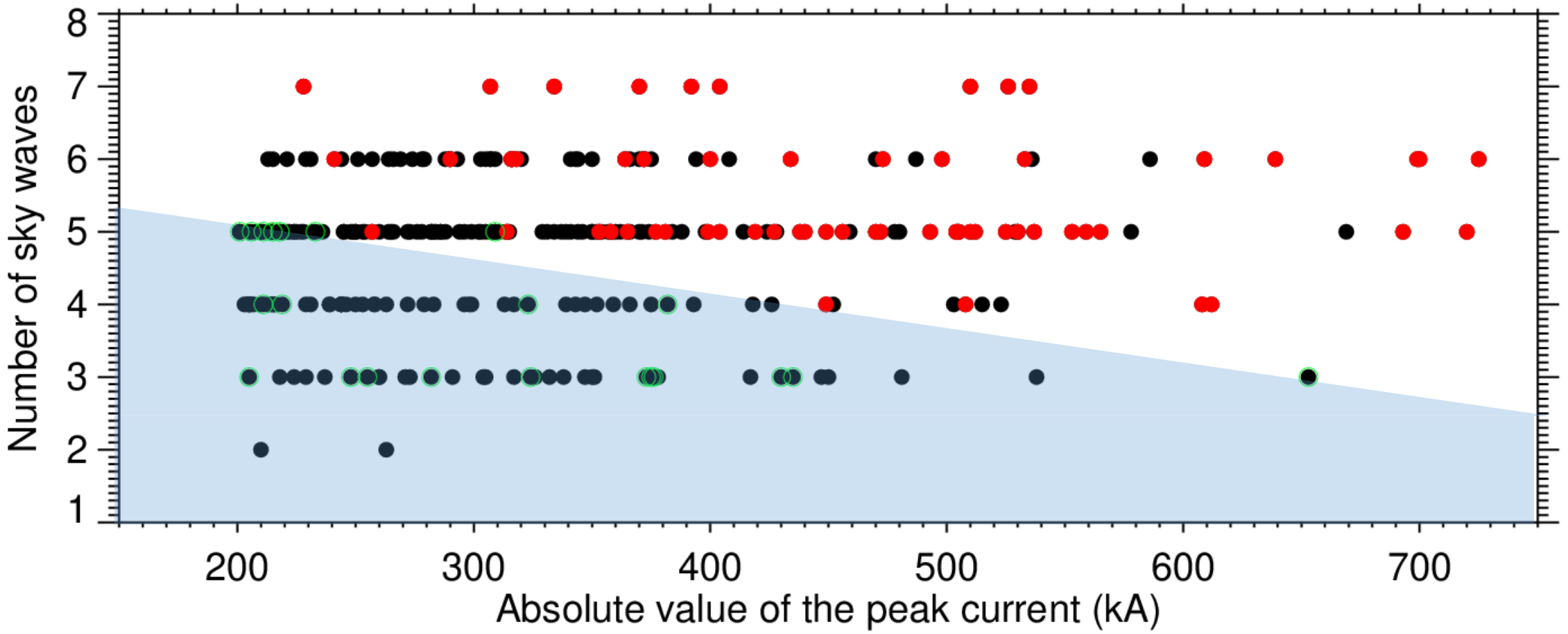


ELVES / - 316 kA



NO ELVES / -317 kA

Sferics waveform characteristics

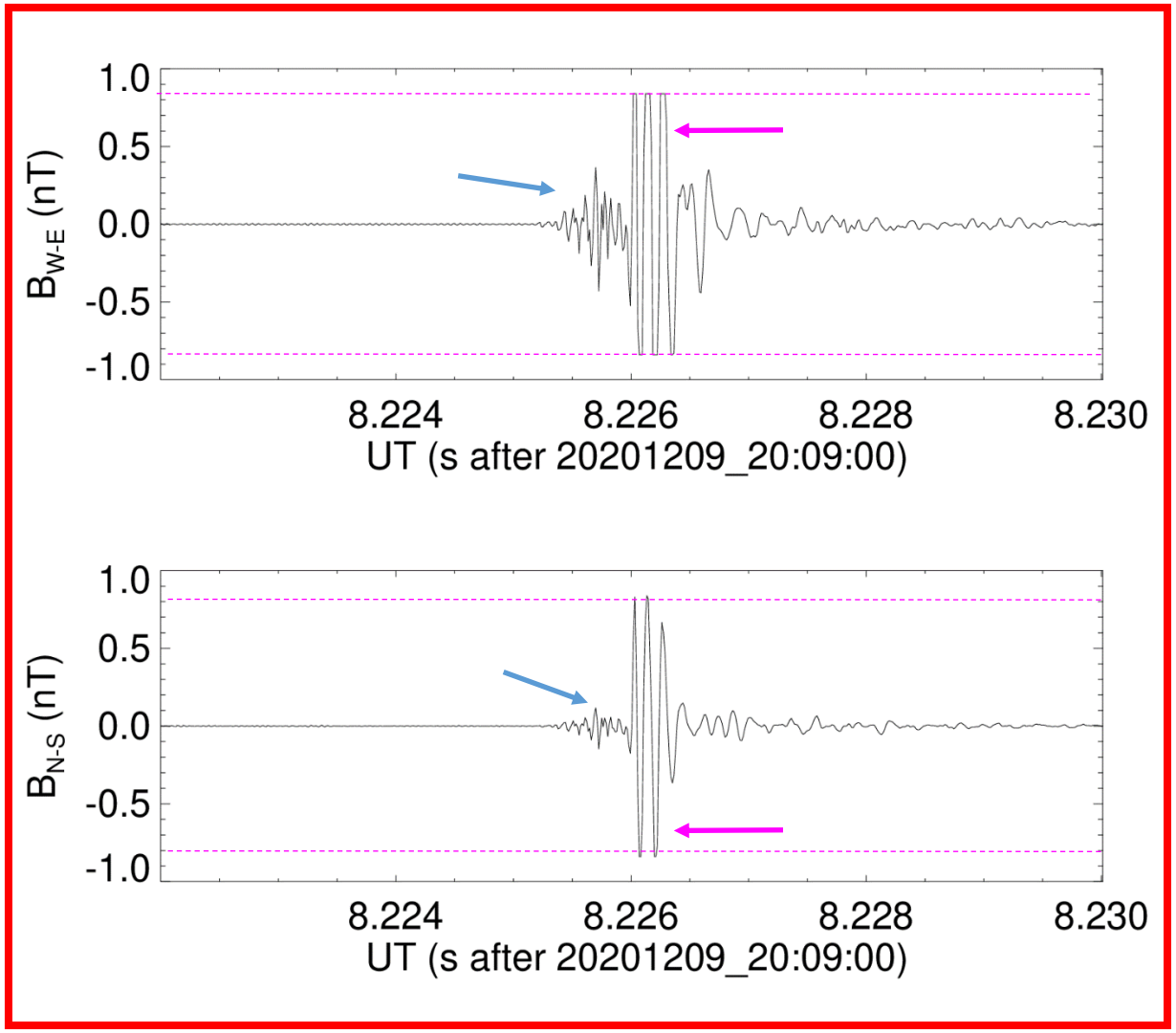


ELVES

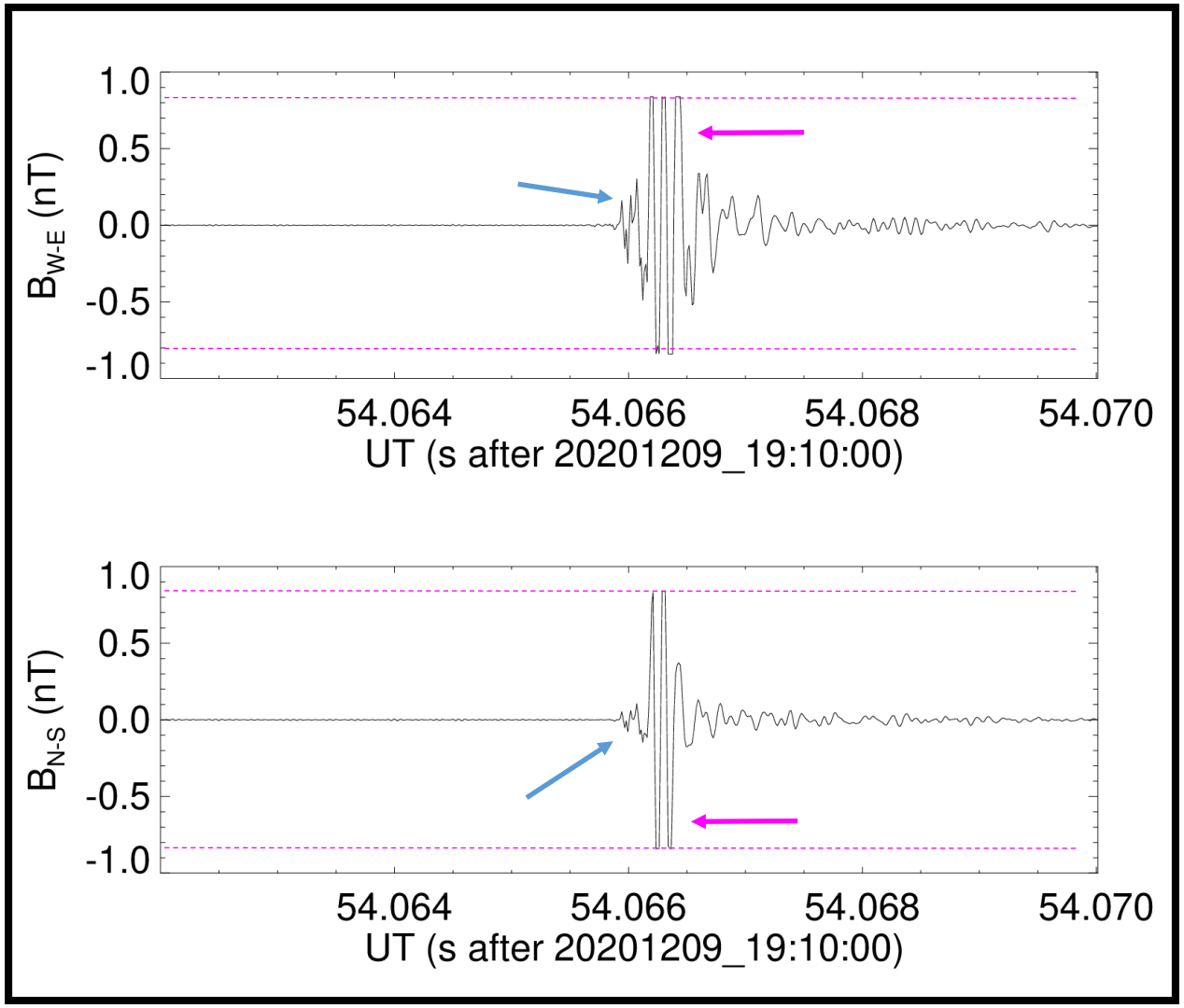
NO ELVES

initiation phase not identifiable

Sferics waveform examples (extremly strong lightning)



ELVES / -639 kA



NO ELVES / -669 kA

Summary

Lightning-generated atmospherics carry important information about the properties of the causative lightning strokes, potential TLEs (Transient Luminous Events), and the characteristics of the propagation paths.

Based on the analysis of nearly **300 lightning strokes stronger than 200 kA** — with only 60 identified as parent strokes to elves — we can conclude:

- **All parent strokes of elves were the first strokes in their respective flashes.**
- **Peak current is not the sole parameter governing the generation of elves.**
- **Sferics associated with elves' parent strokes surprisingly exhibited more sky waves**.

The Transnational Access (TNA) programme of PITHIA-NRF allowed me to extent my knowledge of the VLF data and to strengthen my collaboration with SGO.