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Telluric currents play a big role in interpreting geomagnetic variations

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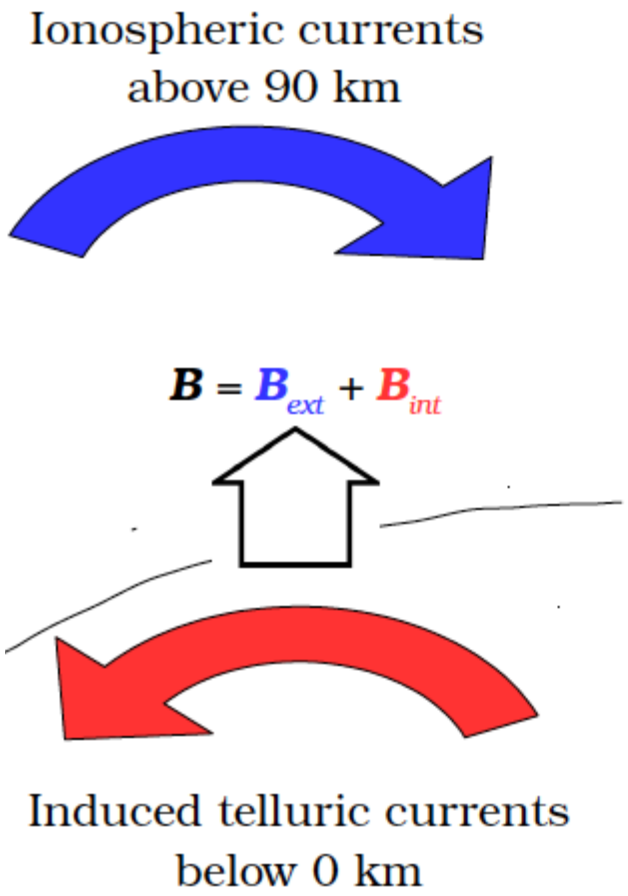
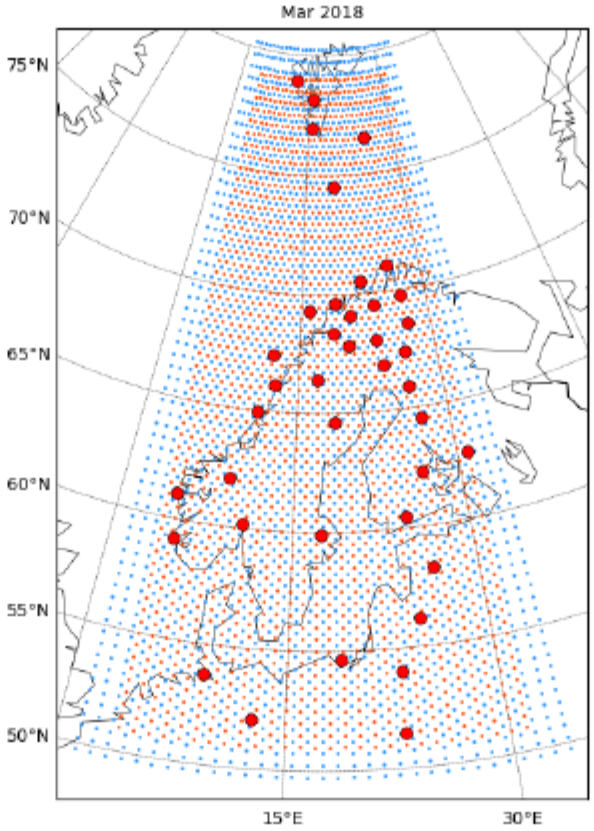
Introduction

- Ground geomagnetic variations are primarily produced by external currents in the ionosphere and magnetosphere, and secondarily by induced (internal, telluric) currents in the conducting Earth.
- Previous studies show that the internal contribution to the horizontal field ($\mathbf{H}$) at high latitudes is up to some tens of %.
- No corresponding investigations of the time derivative ($d\mathbf{H}/dt$) seem to exist.
- Analysis of $d\mathbf{H}/dt$ presented here based on the IMAGE magnetometer network.

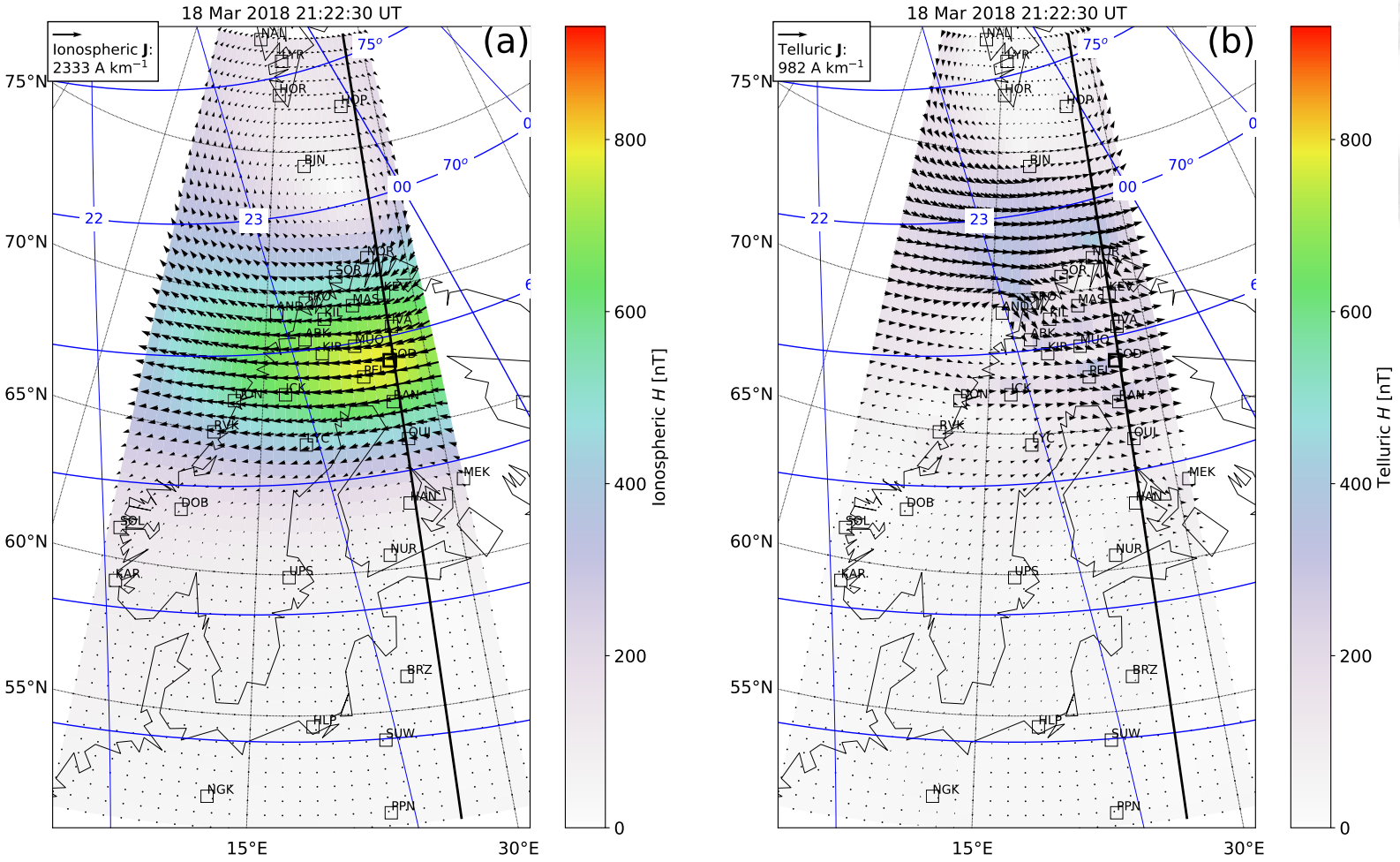
Separation of the ground magnetic field into internal and external parts



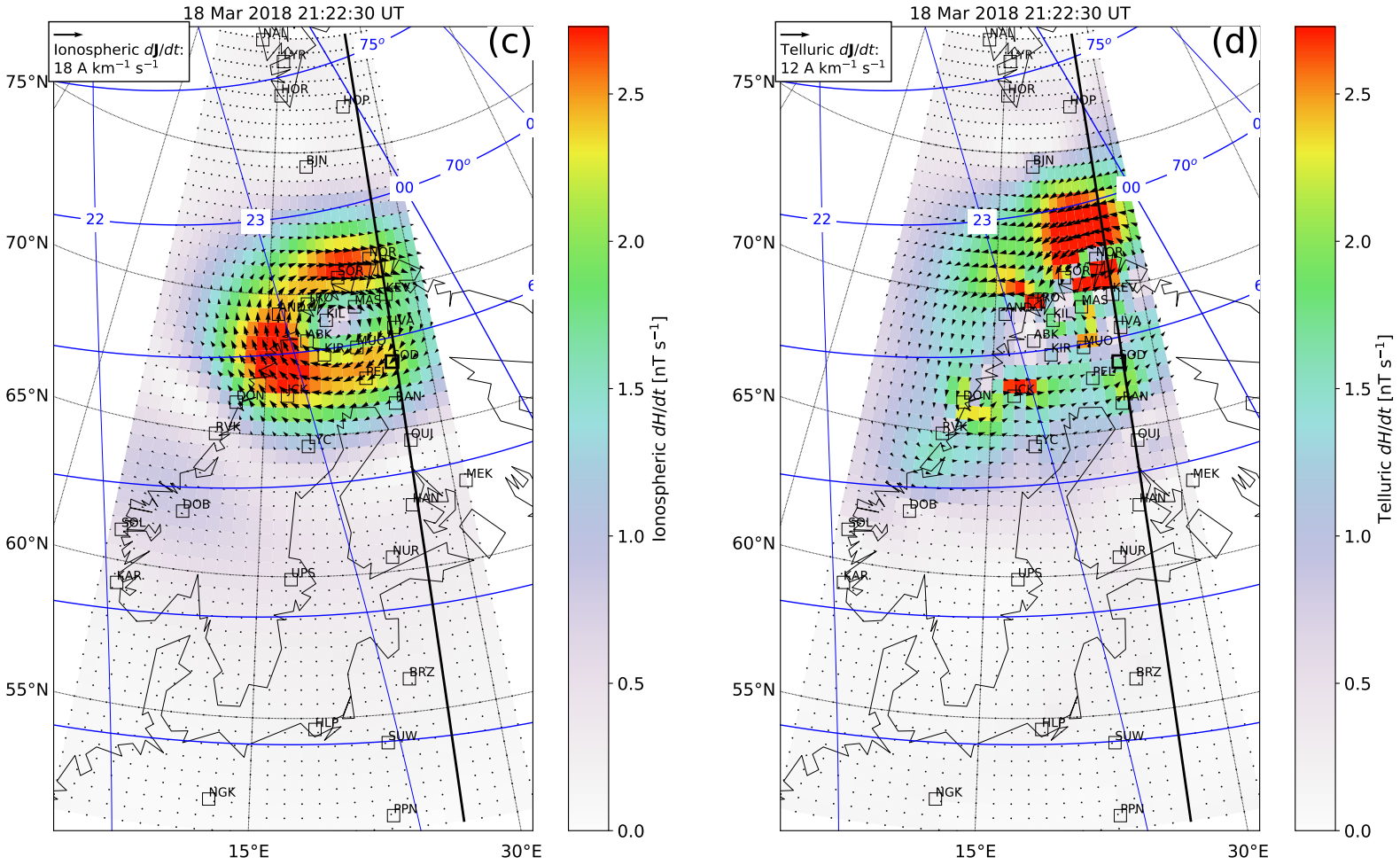


2-D SECS method:
Amm, 1997
Amm and Viljanen, 1999
Pulkkinen et al., 2003
Juusola et al., 2016

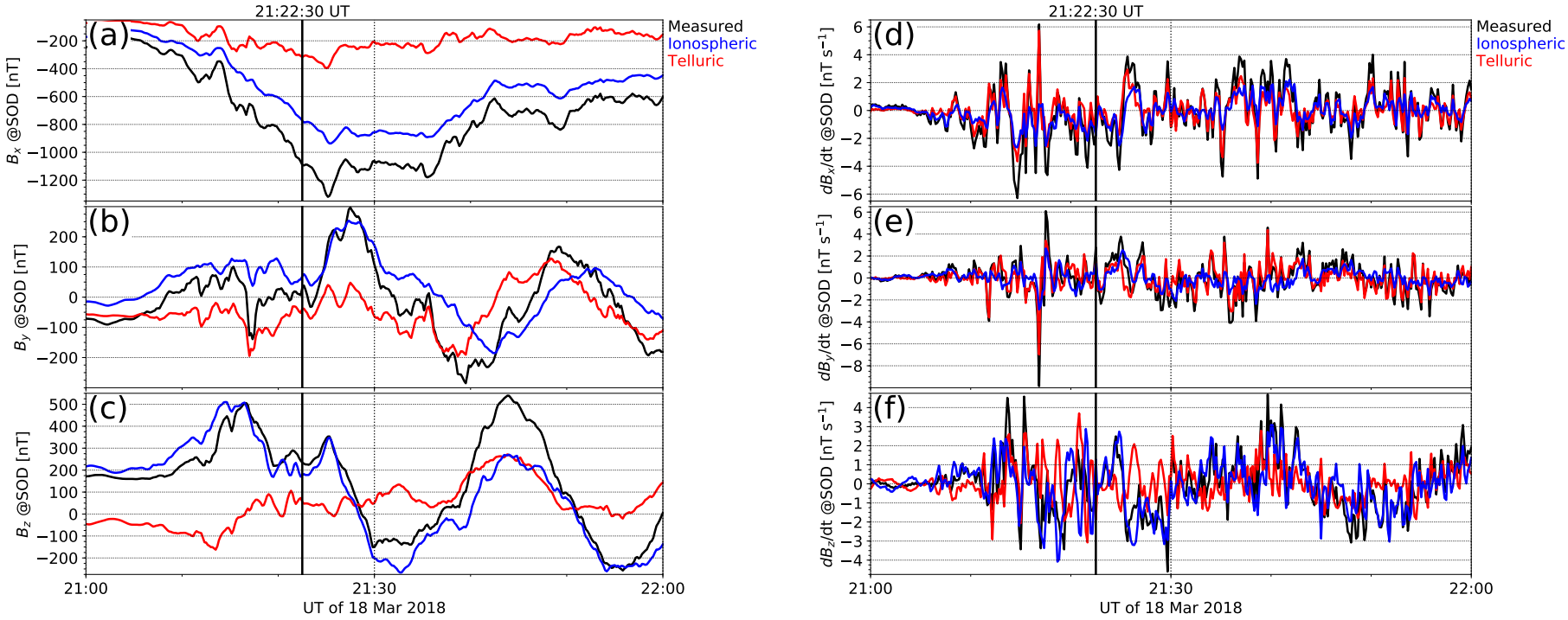
Equivalent ionospheric and telluric currents (J)



$d\mathbf{J}/dt$ emphasizes ionospheric dynamics and telluric effects

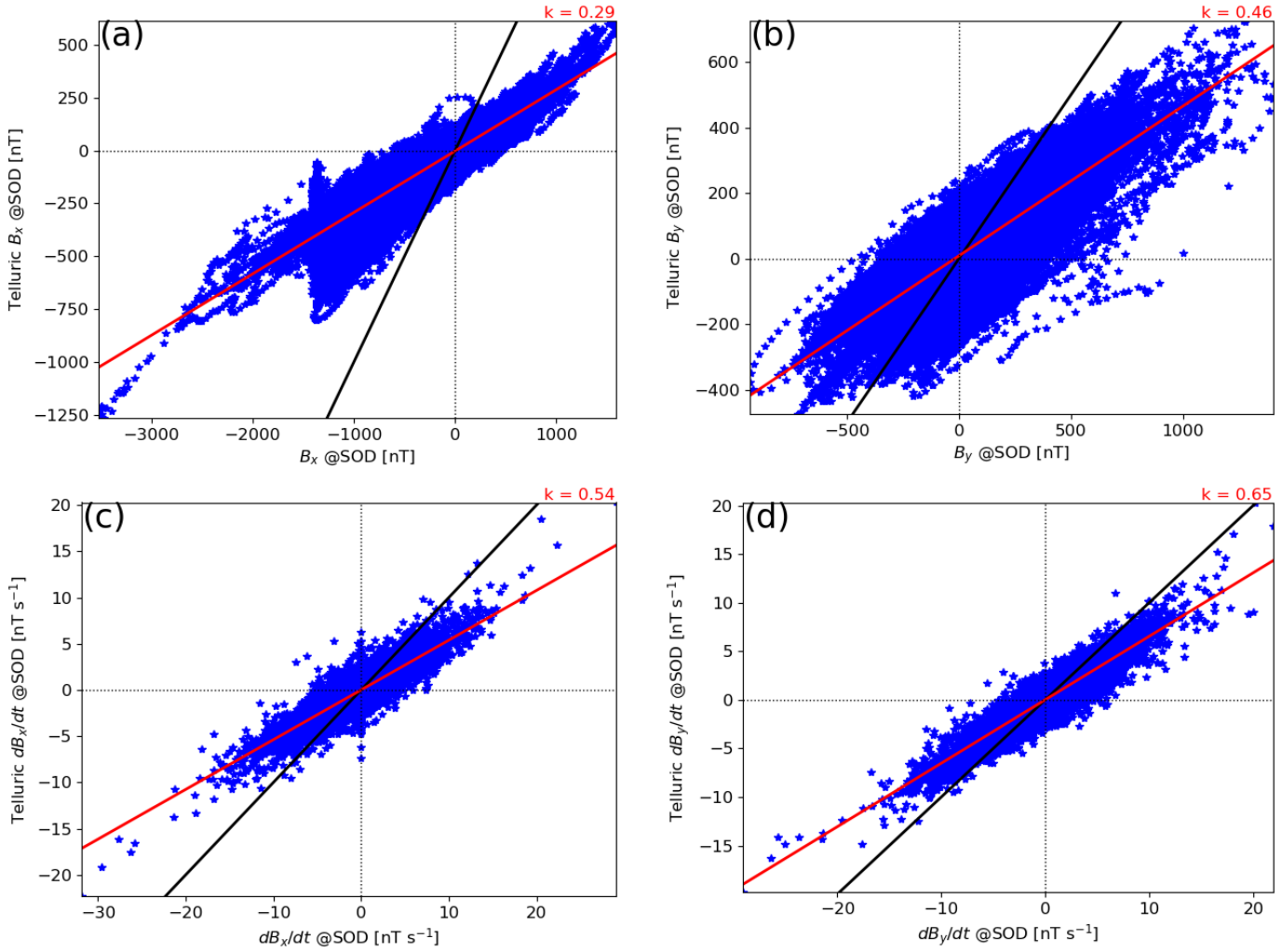


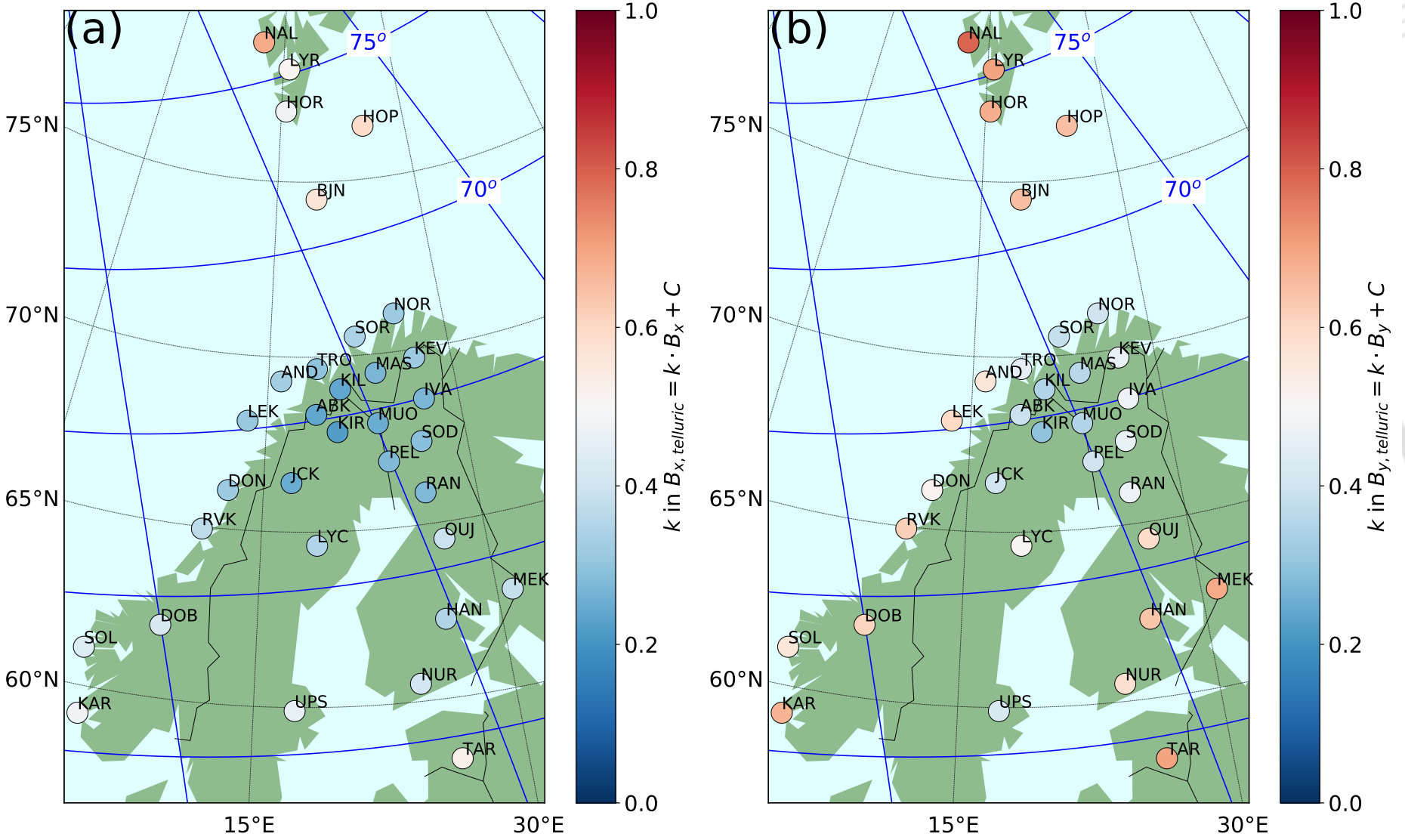
External and internal fields at Sodankylä (SOD)



The magnetic field behaves quite smoothly, whereas its time derivative varies rapidly both in time and space.

Internal contribution to $d\mathrm{H}/dt$ is larger than to H

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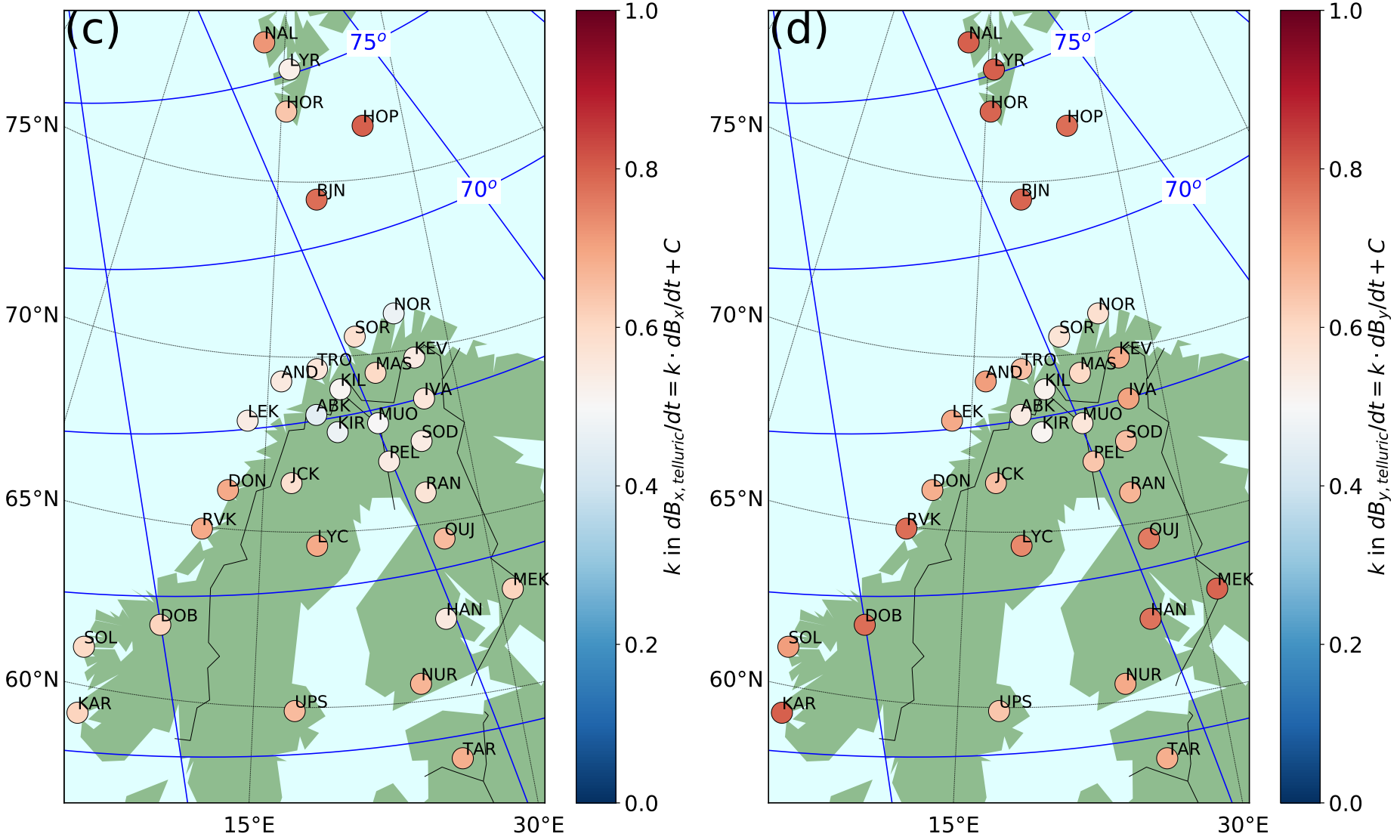
k in $B_{y,\,telluric} = k \cdot B_y + C$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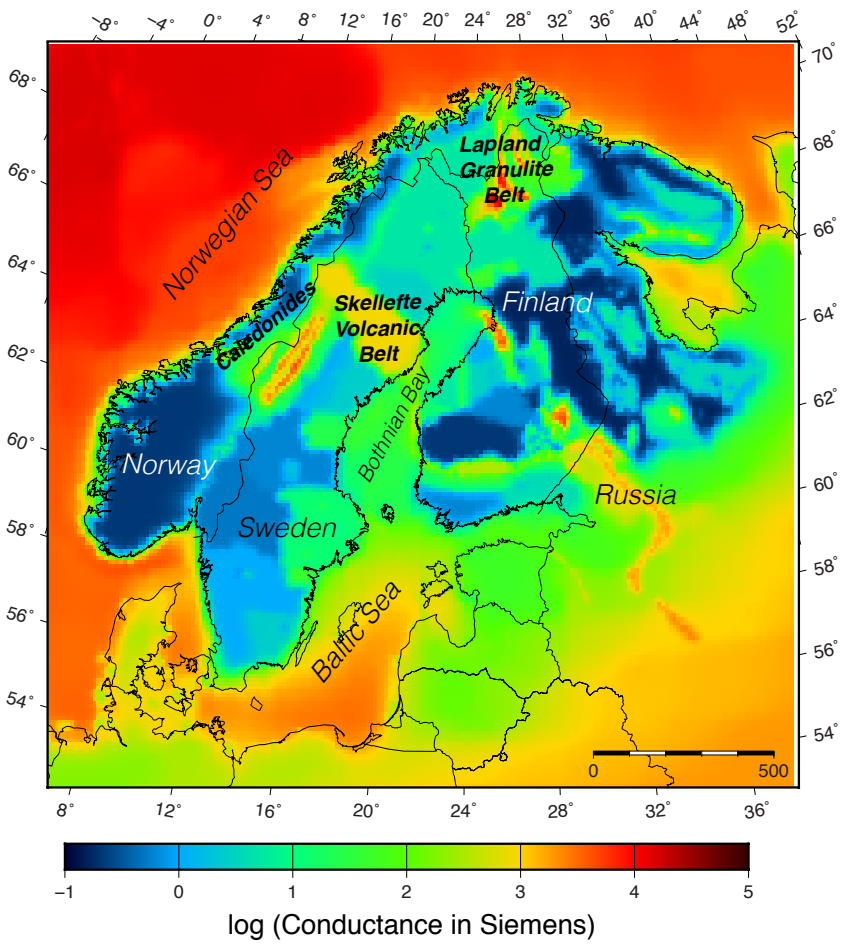
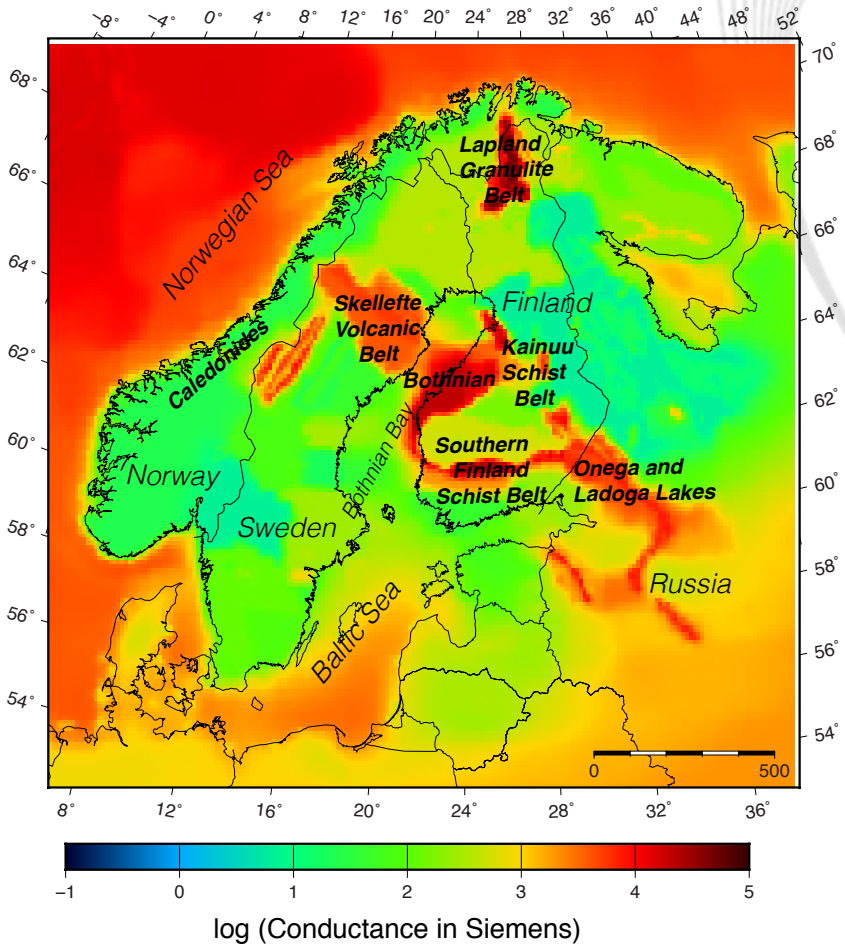
k in dB_x, telluric/dt = k · dB_x/dt + C
k in dB_y, telluric/dt = k · dB_y/dt + C

Telluric currents tend to concentrate on regions of high crustal conductivity

Conductance: upper crust 0–10 km



Conductance: crust 0–60 km



Conclusions

- $d\mathbf{H}/dt$ is typically dominated by the contribution from the telluric currents.
- Unlike $d\mathbf{H}/dt$, $\mathbf{H}$ is typically dominated by the primary ionospheric currents in the vicinity of the source currents.
- The coast as well as inland conductivity anomalies tend to rotate $d\mathbf{H}/dt$ and increase the internal contribution at nearby stations.
- $d\mathbf{H}/dt$ is typically dominated by telluric currents and $\mathbf{H}$ by ionospheric currents, because shorter periods are more pronounced in $d\mathbf{H}/dt$ than in $\mathbf{H}$, and their signature is strongly amplified by the Earth.
- Measured $d\mathbf{H}/dt$ depends strongly on location, and field separation should be carried out before interpreting it in terms of dynamics of the ionospheric currents.

More information

This study is presently under review for *Annales Geophysicae*:

L. Juusola, H. Vanhamäki, A. Viljanen and M. Smirnov: Induced telluric currents play a major role in the interpretation of geomagnetic variations.
URL: https://www.ann-geophys-discuss.net/angeo-2020-21/
Please provide online comments (deadline: 3 June 2020)!

Acknowledgements

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