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THE AURORAL ELECTROJET, MAGNETIC ACTIVITY, AND SOURCE EFFECTS IN MID-TO-HIGH LATITUDE INDUCTION ARROWS: RESULTS FROM LONG-TERM OBSERVATIONS

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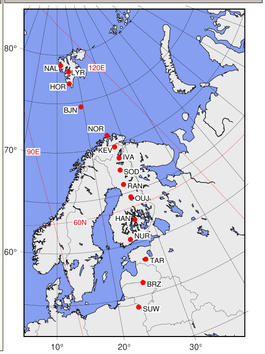
MOTIVATION

Magnetotellurics in the high latitudes is impeded by source effects [1]. A large part of the natural geomagnetic variations do not meet the plane-wave assumption since they origin in the auroral electrojet, a complex ionospheric current system roughly centered around 67° N or S. The most evident problems occur in induction arrows from this region (but also from mid-latitudes, [2],[3],[4],[5]) which show, e.g. unreasonable large lengths, patterns (scattering but not only) not typical for induction processes, and temporal variability that cannot be explained by a subsurface response. Whereas the issue has been known in the community for decades, proposed solutions are either somewhat general or rather ad-hoc. We attempt a systematic investigation of the topic based on variometer monitoring data from the Scandinavian and surrounding regions.

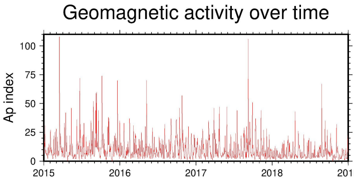
METHOD

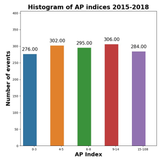
We used four years of publicly available 10-second magnetic variation data from 15 stations of the IMAGE network (https://space.fmi.fi/image/www/index.php?page=home, [6]) arranged in a N-S chain (see map). Previous work revealed that geomagnetic activity is a dominating factor for the success of passive induction methods ([7],[8]), therefore we reached out for the daily AP index (https://www-app3.gfz- potsdam.de/kp_index/Kp_ap_Ap_SN_F107_since_1932.txt, [9]). Geomagnetic activity over the considered four years and the distribution of days with no, neglectable, weak, moderate, and strong activity are shown in the Figures. Data (X, Y, and Z component) of all stations have been devided into fragments of one day length and have been assigned to subsets according to the activity level of that day. These subsets have been processed seperately. The resulting induction arrows are shown below.

MAP



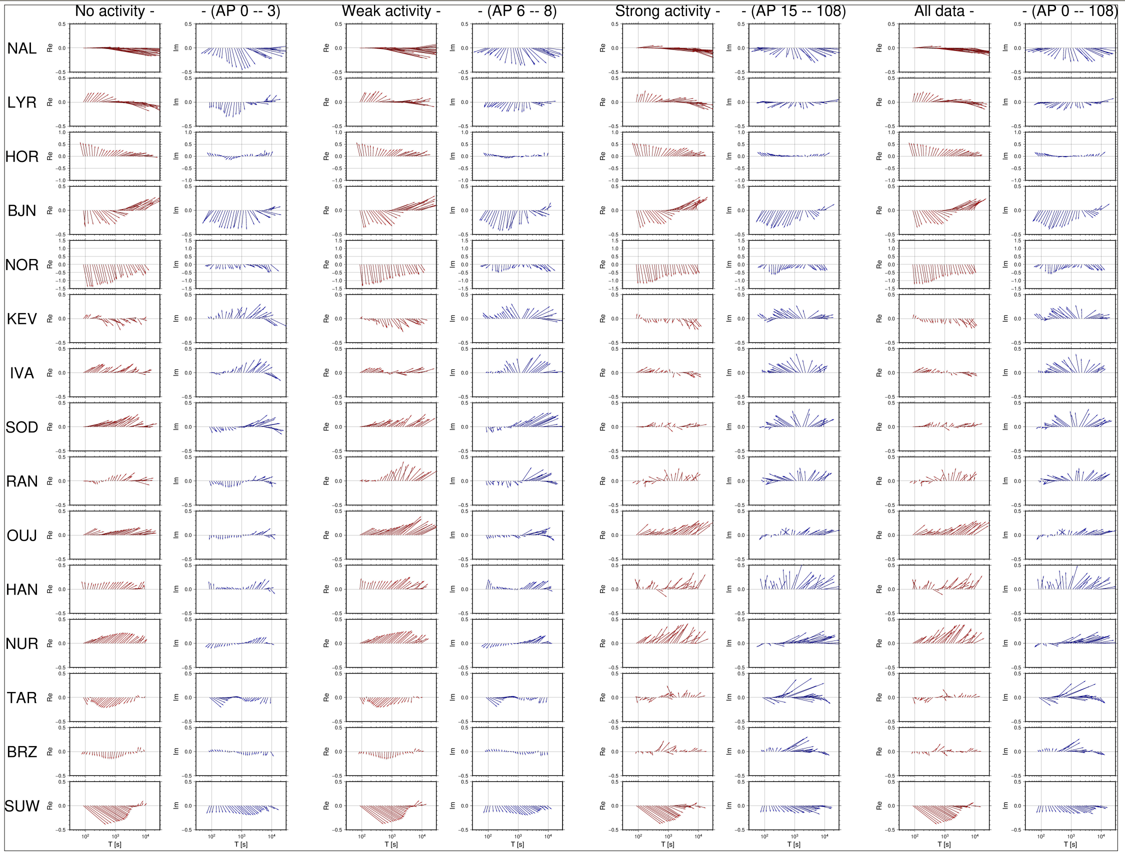
Geomagnetic activity over time





RESULTS

Rows represent stations from N to S, columns represent activity levels rising from left to right, where the basis for the rightmost column is the whole four-years period without distinction by activity. This column is most similar to the "Strong activity" third column indicating that strong activity events, even if their percentage in the overall dataset is low, dominate the outcome of the whole dataset. With the exception of the "beyond-electrojet" stations NAL-NOR and the "ordinary mid-latitude" station SUW the activity level has a clear impact on the induction arrow pattern. For the southern stations RAN-BRZ the patterns are more induction-like for the lowest (left columns) activity level(s) than for strong activity or for the undifferentiated dataset. For stations KEV-SOD that are situated immediately beneath the electrojet the induction-arrow pattern does not remind induction processes at all.



CONCLUSIONS

Unlike in low and mid latitudes where enhanced geomagnetic activity produces signals desired in magnetotellurics, even moderate activity data is something that should be rejected for stations in the low-latitude side of the auroral regions. This is because the near-source ionospheric currents do not only intensify, but also shift their position towards low latitudes during such events, and will distort transfer functions. However, there is a good chance to obtain reasonable induction arrows for regions up to ~62°geomagnetic N if the processing is restricted to low activity data. Whereas we do not see a chance for passive induction surveys immediately beneath the electrojet, there is a region beyond (like Svalbard ~75°) where such studies become possible again and strong activity does not seem to be of disadvantage.

OUTLOOK

- Our findings will be confirmed by a processing based on the Principal Component Analysis [10], where clear information on presence or absence of problematic sources can be obtained.
- In addition to activity, the dependency of induction arrow patterns on season and on time of day will be investigated.

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-Figures were created using the Generic Mapping Tools (GMT) software ([11]).

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