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Statistical analysis of the polar electrojet influence on geomagnetic transfer functions estimates over wide time and space scales.

Daniele Rizzello (1), Egidio Armadillo (1), and Adele Manzella (2)
(1) DISTAV - University of Genoa, Genoa, Italy, (2) IGG - CNR, Pisa, Italy.

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D.Rizzello(1),E.Armadillo(1),A.Manzella(2)

1)DISTAV - University of Genoa,Italy.
2)Institute of Geosciences and Earth Resources - CNR, Pisa, Italy.

Magnetotelluric (MT) and magnetovariational (MV) investigations can provide original information and constraints on the electrical conductivity, thermal state and structure of the crust and mantle at the base of the polar ice sheets. These methods provide depth resolution, lacking in potential field methods, and can reach high investigation depth, an invaluable advantage where very difficult logistic conditions prevent or limit the use of active methods such as seismic surveys.
However, MT/MV surveys have not been applied extensively in polar areas mainly because electromagnetic data could be biased by the polar electrojet current systems (PEJ) occurring at high geomagnetic latitude. In fact, close to the auroral oval, the electromagnetic fields at ground may violate the uniform plane wave assumption at the base of standard MT/MV data processing, resulting in possible erroneous interpretations of the Earth's deep conductivity structure.
It has been shown that a careful selection of events to be analyzed may decrease bias, and different robust techniques have been developed and applied. Even if the source currents flow in complex 3D systems that change from event to event in an unpredictable way, some general rules have been observed. Violations of uniform plane wave source assumption are enhanced during higher geomagnetic activity induced by high solar activity, because PEJ equivalent geometry becomes more complicated, affecting also EM field at lower latitudes. Differences in the degree of source distortions have also been reported between day/night and seasonal observations.
The ISEE (Ice Sheet Electromagnetic Experiment) project, founded by the Italian National Antarctic Research Programme, aims to better understand the effects of non-uniform source fields on MT/MV data processing in polar areas, to quantify and possibly overcome the source effects and get more reliable impedance and magnetic transfer function (TF) estimates. Here we introduce the first step of the project, that is a statistical analysis of the geomagnetic data from polar and auroral zones, mainly based on the correlation between the geomagnetic single site Transfer Function (TF) residuals and the geomagnetic activity in time and space.
We have analyzed available data sampled every minute at about thirty magnetic observatories from the World Data Center for Geomagnetism (WDC)and Intermagnet databases, which provide data for wide time windows and a world spatial distribution. We have focused on two years of magnetic records corresponding to a high and low of solar activity, 2003 and 2009, respectively.
For the geomagnetic transfer functions estimation, we adopted different well consolidated methods and schemes and applied them on different data time windows. As expected, from this comparison robust schemes provided the more reliable results.
Then we have focused on time variations of the TF residuals with respect to day/night time windows, seasonal time windows and the geomagnetic activity. Thus, for each station and data time window, in order to produce a clearer and more effective screening of the phenomenon, plots of TF noise versus time and geomagnetic indices have been drawn, as well as plots of residuals against the signal power and field polarization at different frequencies.
At the same time, variations of the TF estimations with respect to their long-time average have been also investigated, in order to evaluate the relative importance of the TF noise and to pinpoint biases due to polar electroject effect; thus, also relevant plots of such variations with time and geomagnetic indices, have been produced.

As final step, to investigate the spatial influence of the auroral electrojet on TF estimates and residuals, we compared the results from stations at different geomagnetic latitudes at given time windows. This analysis has included, as a reference, geomagnetic mid-latitude stations, in order to evaluate the TF behaviour at low-activity and, presumably, low–noise areas.