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Temporal stability of induction vectors from Antarctic Peninsula, AIA INTERMAGNET observatory

Abstract. Induction vectors represent geomagnetic transfer functions used in magnetotellurics and related passive electromagnetic sounding methods in geophysics. They are obtained from the measurements of geomagnetic variation and carry information on the distribution of local and regional electric resistivity in the subsurface, which can be interpreted in terms of geology and tectonics. The underlying concept of their interpretation works properly if the so-called far-field condition is fulfilled, i.e., if certain assumptions on the geometry of utilized natural electromagnetic source fields are met. The magnetotelluric practitioner expects problems in the regions where the electromagnetic variations originate to a high extent from ionospheric currents as sources. Due to the polar (or auroral) electrojets, this skepticism towards the electromagnetic far-field methods clearly applies to the high latitudes, polar regions, and auroral zones. In the present study, the investigation focuses on the extent to which problems typical for the auroral electrojet sources occur in the geomagnetic variation data from the Argentine Islands INTERMAGNET observatory (AIA) located at the Ukrainian Antarctic Akademik Vernadsky station. Induction vectors from one month of AIA variation data measured in the normal framework of the INTERMAGNET observatory are analysed for their stability over both period and time, where a time resolution of one day allows for the detection of changes originating from the source signals instead of from subsurface resistivity distribution. The outcomes from AIA are compared to the corresponding ones of two northern hemisphere stations which belong to the International Monitor for Auroral Geomagnetic Effects (IMAGE) network, located in Finland and Poland. Results show that AIA induction vectors do not exhibit the problems expected in the high latitudes; their time stability is very similar to that of stations at a comparable but opposite geomagnetic latitude of 50 degrees, which corresponds geographically to mid-latitudes in Europe. A further outcome of this study is that some slight, occasional changes in induction vectors can be attributed to increased geomagnetic activity because they are correlated to the planetary diurnal Ap index.

Keywords: auroral zone, geomagnetic activity, ionospheric currents, magnetotellurics

1 Introduction

Induction vectors (Parkinson, 1962) are the most illustrative way to depict the complex frequency-dependent transfer function between variations of the vertical and the two perpendicular horizontal components (in the North and East directions) of the geomagnetic field. The field components are connected through the phenomenon of electromagnetic induction. Therefore, the transfer function contains information about the distribution of electrical resistivity in the solid Earth beneath the point of measurement. In the convention used here (Wiese, 1962), the induction vector is constructed so that its real part points away from the conductive zones in the subsurface. Induction vector data of a profile or array of stations can (alone or along with transfer functions between other electromagnetic field components) be inverted for electric resistivity distribution in the Earth. The resulting models can be interpreted in terms of geology and tectonics. This approach belongs to magnetotellurics, a passive geophysical sounding method based on electromagnetic induction. For its fundamentals, see, e.g., Chave and Jones (2012), Simpson and Bahr (2005).

Using natural electromagnetic field variations as source signals and the relatively simple analysis make the magnetotelluric method economical and attractive. However, it also has a certain weakness as it relies on a specific geometry of the source fields referred to as the far-field or plane-wave assumption (Simpson & Bahr, 2005; Chave & Jones, 2012). Although usually natural signals in most regions of the world meet this condition, it is crucial for the magnetotelluric practitioner to know where to expect problems due to its violation. Such problems are commonly encountered in the case of anthropogenic electromagnetic signals (cultural noise is a major issue in magnetotellurics) and signals originating from ionospheric currents, i.e., the Sq variations in mid-latitudes, the equatorial electrojet above the geomagnetic equator, and the polar electrojet in the auroral zones. The problems manifest in differences between induction vectors obtained for different (disjoint) time fragments. Since these vectors should be determined by the subsurface resistivity, which is not expected to change in tectonically inactive regions, the most convincing explanation for such effects are problems with the source signals.

The data from Argentine Islands INTERMAGNET observatory (IAGA code AIA) located at the Ukrainian Antarctic Akademik Vernadsky station, provide a unique opportunity to assess whether the region of the Antarctic Peninsula is as difficult a terrain for magnetotellurics as it is feared sometimes (Gonzales-Castillo et al., 2022). These data are valuable due to their noise-freeness in this region far from human settlements and due to their long-term availability and monitoring character according to INTERMAGNET standards (St-Louis, 2020); usually, a magnetotelluric field campaign lasts no longer than a few weeks. This limits the chance to investigate time-dependent effects. In contrast, a previous study of AIA magnetic data analysing temporal changes in induction vectors (Maksymchuk et al., 2018) is based on a nearly 20-year-long dataset.

Data from this remote region of the world are rather rare due to logistic challenges; hence it is all the more interesting that there happens to be an INTERMAGNET observatory at the conjugate point (the other footpoint of the Earth's main magnetic field line) to the AIA Station. This is Fredericksburg in the United States (Neska, 2016).

Here we investigate whether induction vectors calculated from the AIA geomagnetic data show the same problematic features that one would expect in the northern hemisphere.

2 Data and methods

We used one month (June 2012) of geomagnetic variation data (North, East, and vertical component) from the AIA observatory (Melnyk & Bakhmutov, 2007/2008; Sumaruk et al., 2022). Although they were provided as one-second data, we resampled them to a 10s interval for better comparability with data from the other stations. Since we attempted to study effects attributed to latitude, we used the northern-hemisphere stations for comparison. These stations are part of the International Monitor for Auroral Geomagnetic Effects (IMAGE) variometer network in and around Scandinavia (https://space.fmi.fi/image/www/index.php?page=home; Tanskanen, 2009).

IMAGE provides 10s data. We selected the Finnish RAN station due to its geographic latitude being similar (but opposite) to that of AIA and the Polish SUW station for the same reason in terms of geomagnetic latitude. For these stations, we used one month of data (December 2015) to analyse winter data for the given hemisphere as we did for AIA. Recent research suggests that winter induction vector data are less distorted by source effects than summer ones (Bury, 2020). For verification, data of the following months were also analyzed (January 2013 for AIA and June 2016 for RAN and SUW). It is worth mentioning here that the study of Maksymchuk et al. (2018) uses many years of AIA data, but the resolution of induction vectors over time and period is coarser. All stations are listed in Table 1 and shown on a map in Figure 1.

A very suggestive explanation for many phenomena in the context of geomagnetic variations, which can be simply verified, is a connection with geomagnetic activity. For this, we used planetary daily Ap

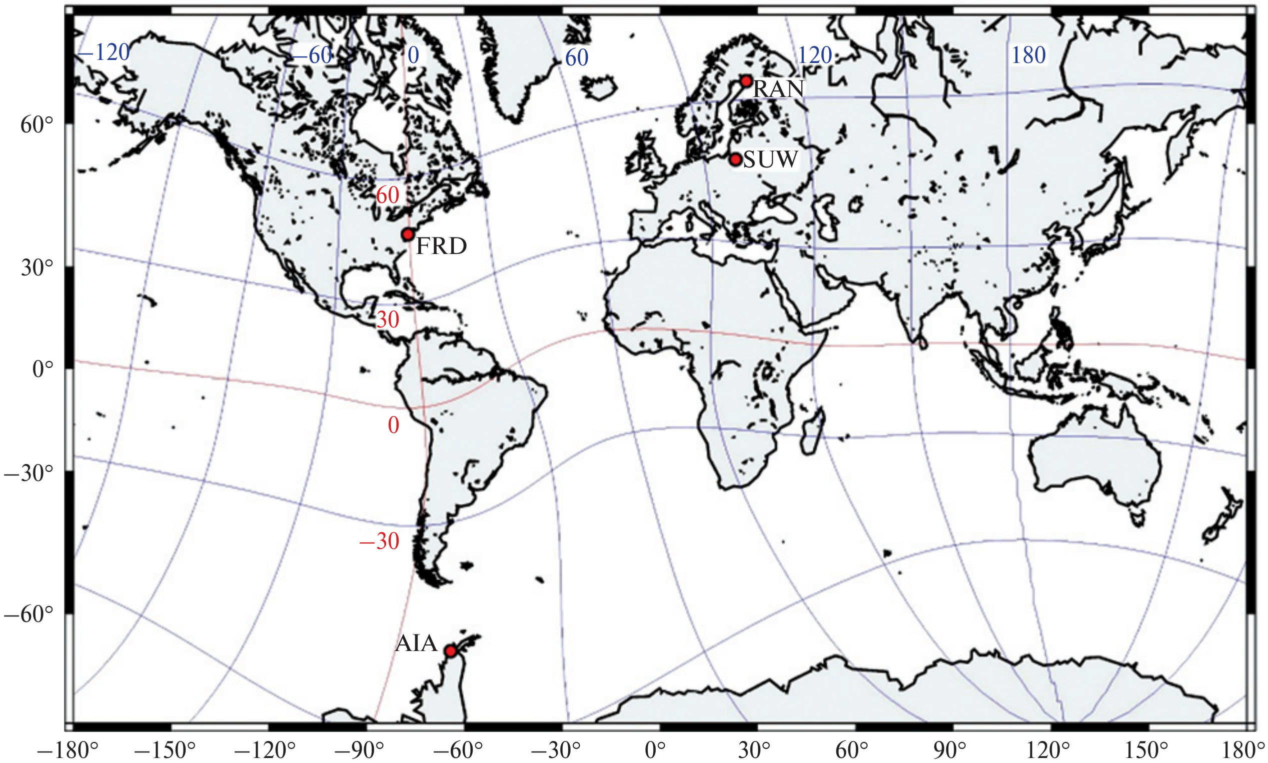

Figure 1. Map of considered stations with the geomagnetic grid, where the red numbers denote latitude and blue ones, the longitude of corrected geomagnetic coordinates after (Emmert et al., 2010)

indices taken from the archive provided by the German Research Centre for Geosciences Potsdam (https://www-app3.gfz-potsdam.de/kp_index/Kp_ap_Ap_SN_F107_since_1932.txt; Matzka et al., 2021).

For estimation of the induction vectors and other transfer functions a so-called magnetotelluric data processing has to be carried out. A variety of standard methods exists to perform this task, e.g. (Egbert & Booker, 1986; Chave & Thomson, 2004). All of them transform time-series data to the frequency domain, usually by the Fast Fourier Transform (FFT), provide many spectral values for each field component and frequency value, and estimate transfer functions between the appropriate field components through certain statis-

Table 1. Codes, coordinates, and network membership of considered stations. Geomagnetic coordinates are quasi-dipole ones after (Emmert et al., 2010) obtained by means of the calculator provided by the British Geological Survey (http://www.geomag.bgs.ac.uk/data_service/models_compass/coord_calc.html) or taken from the IMAGE website (https://space.fmi.fi/image/www/index.php?page=stations), respectively

Station	Code	Geographic latitude	Geographic longitude	Geomagnetic latitude	Geomagnetic longitude	Network
Akademik Vernadsky station, Antarctica, Ukraine	AIA	–65.246	295.743	–50.85	9.41	INTERMAGNET
Fredericksburg, Virginia, US	FRD	38.205	282.627	48.09	359.22	INTERMAGNET
Ranua, Finland	RAN	65.90	26.41	62.09	105.91	IMAGE
Suwałki, Poland	SUW	54.01	23.18	49.97	98.70	IMAGE

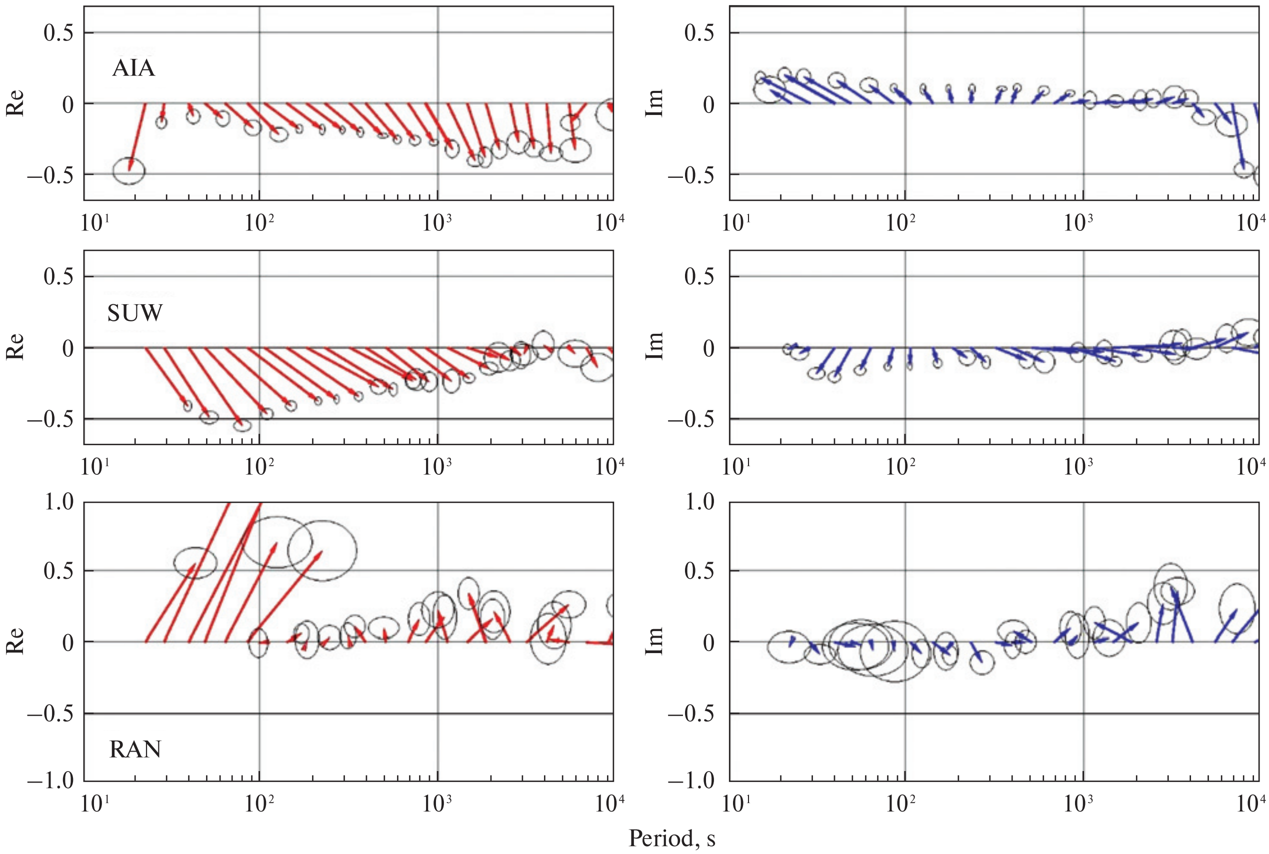

Figure 2. Real (left-hand side) and imaginary (right-hand side) induction vectors for AIA, SUW, and RAN stations (from top to down) calculated for one month of winter data each. Ellipses represent error "bars" in North and East directions. AIA and SUW vectors are smooth over period and characterized by small errors. RAN vectors are clearly more scattered and affected by larger errors

tic approaches. For the calculation using data from the whole month (see the next section), we used the approach by Neska (2006), which applies simpler statistics but delivers reliable results in the absence of serious noise. This provides a general impression of the induction vector for the given station.

Source effects in induction vectors are spotted by calculating them for different times and assessing differences between results that cannot be explained by obvious noise problems or changes in the solid Earth (Araya Vargas & Ritter, 2016; Ernst et al., 2020; Sanaka & Neska, 2021). To do this with our data, the spectral values were calculated utilizing a wavelet transform which enables attributing a time index to them (Neska et al., 2018) instead of by the FFT that cannot do so. In this way, it was possible in the next step to select spectral values for a single day to estimate the transfer function for the induction vector. Induction vectors for every day were obtained. To assess their stability, a single real vector at one specific frequency was picked from the function and depicted over time. The selected frequency, or rather period, is 1377 s but the results and conclusions would be the same for other periods of the same order of magnitude. We emphasize that estimating transfer functions in the long-period range (10—10.000 s) from data of just one day cannot be recommended for obtaining smooth, stable, and good-quality results. We use such an approach for identifying source problems in the data.

3 Results and discussion

Induction vectors obtained for the whole month's data are presented in Figure 2.

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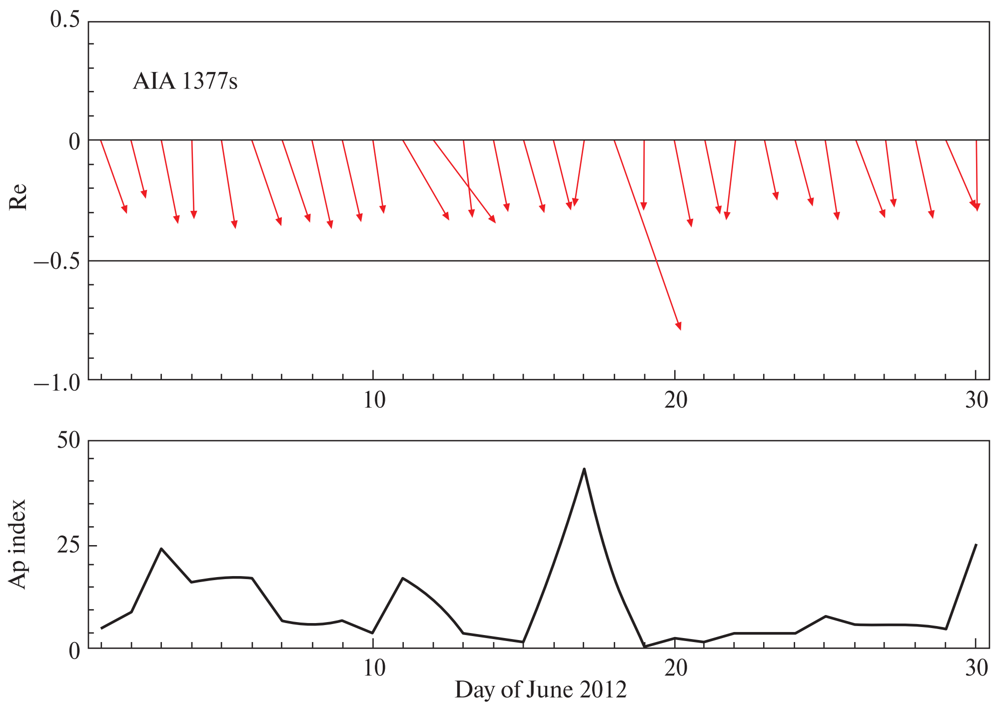

Figure 3. Real induction vectors from AIA station at a selected period (1377 s) estimated for data of single days (upper panel) and the corresponding Ap index of geomagnetic activity (lower panel). The largest deviations from the generally stable vector parameters occur during the increased activity on June 17—18, 2012

The AIA induction vectors change smoothly with period and have small errors. This is as it should be. An exception is the first real value at 20 s which is worse, possibly due to a technical issue. It is normal that values become slightly more scattered and errors larger towards the long periods for reasons of statistics. Real vectors from <100 s to >1000 s point in the SE direction and have lengths smoothly changing from 0.2 to 0.4. Imaginary vectors at short periods <100 s point to NW with lengths about 0.3, which smoothly become very short at several hundred seconds. This is a typical pattern hinting at a not-too-complicated (a so-called two-dimensional) resistivity structure of the subsurface with a well-conducting, SW-NE striking zone to the NW of the station. This may be simply due to the coastline and the resistivity contrast between the ocean water and continental rocks, where the south-pointing real induction arrow at several thousand seconds may reflect the same contrast concerning the larger region. However, it is neither possible to provide a detailed interpretation of the resistivity structure on the basis of a single station nor is such an interpretation within the scope of this work. The interested reader is referred to the literature (Hill, 2020 and citations therein).

The SUW result is similar to AIA in terms of smoothness over period, small errors, and the main direction of real induction vectors. Unlike in AIA, the main effect with the longest vectors occurs at the shortest periods indicating a well-conducting zone NE of the station in very close proximity. The overall structure seems more complicated since the real and imaginary vectors are not (anti)parallel. The station is situated on the East European craton on rocks known to contain iron ore deposits (Nieć, 2003) which are good conductors and could explain the behavior of the induction vectors.

The induction vectors for RAN have large errors and are not smooth over period; the jump in the length of real vectors at 100 s is especially suspicious.

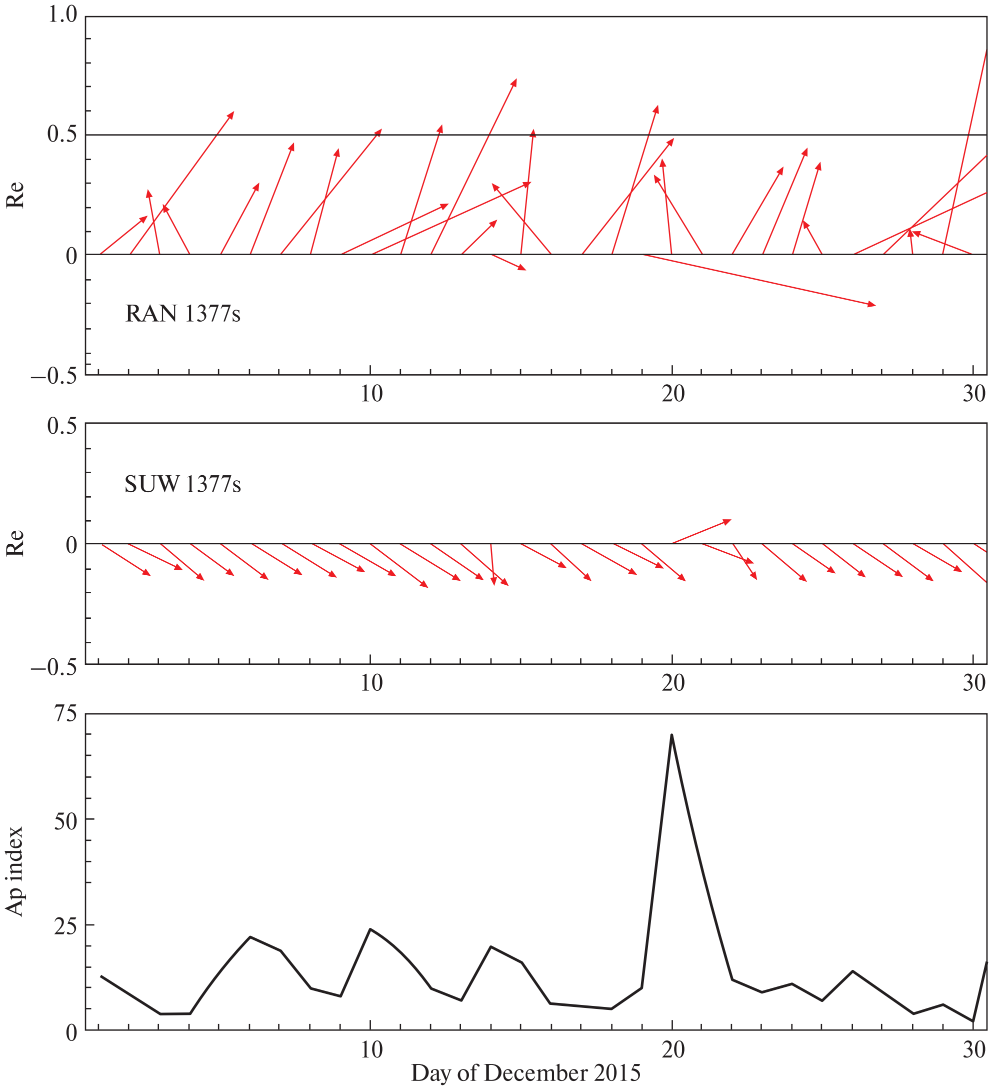

Figure 4. Real induction vectors at one selected period (1377 s) estimated for data of single days from RAN station (upper panel) and SUW station (middle panel) along with the corresponding Ap index of the geomagnetic activity of that day (lower panel). The RAN vectors are heavily scattered and prevalently much too long compared to the one-month vector in Figure 2, whereas the SUW vectors are very stable. Largest deviations correspond to increased geomagnetic activity on December 19–20, 2015

In general, the induction vector estimation for the data of this station failed. The long real values at short periods probably have nothing to do with induction and the rest is not clear enough to allow for interpretation. Unfortunately, this is how induction vectors in the high latitudes beneath the auroral oval tend to look (Neska, 2019).

Figures 3 and 4 show real induction vectors of the three stations for single days at a period of 1377 s, along with the corresponding Ap index of geomagnetic activity. For AIA and SUW, it is obvious that, except for very few days, the vector is stable over time. Its length and direction are the same as for the one estimated for the whole month, cf. corresponding value in Figure 2. It is interesting to consider the exceptions. The largest deviations from the overall value occur during or immediately before days with much increased Ap indices, that is, during a geomagnetic storm. In these cases, the deviation at AIA increases the vector component to the south and, in SUW, to the north direction, i.e., towards the higher latitudes and the auroral oval.

For RAN, the one-day induction vector oscillates widely over time. For most days, it is several times longer than the corresponding one-month vector at this period (Fig. 2, even if one may have the impression that a NE direction as in the month vector is prevalent in the daily ones).

Interestingly, for this difficult case, the largest outlier in direction and length also occurs during the magnetic storm.

The general features in terms of induction vector length, direction, and stability over period and time re-appear in the results of all three stations for the second month.

4 Conclusions

The properties of the induction vector at the AIA station situated on the Antarctic Peninsula with regard to smoothness over period and stability over time are very similar to the same properties of the SUW station in Poland, which is a rather ordinary mid-latitude region. AIA data do not show the issues encountered when estimating induction vectors at higher latitudes, as in the example of the Finnish RAN station. The determining factor for these properties is not the geographic latitude but the geomagnetic latitude. Thus, in terms of issues with the ionospheric sources, magnetotelluric surveys for the region of the Antarctic Peninsula are not different from measurements in mid-latitudes. It has to be noted that the discrepancy between geographic and geomagnetic latitudes is very large for the western Antarctic region.

Moreover, it can be concluded that the problems in induction arrow estimation in mid-latitudes based on single days arise from the geomagnetic activity increased to storm level. This does not apply to all outliers in single-day induction vectors but to the largest ones. It reminds of the soundness of a magnetotelluric processing approach that aims at limiting the influence of spectral values containing the most energy (Chave & Thomson, 2004) and it fits the fact that the ionospheric currents known as auroral electrojets increase with magnetic activity.

With some caution, it can be presumed that the distortion affecting an induction vector under such an influence concerns its North component, increasing it in the case of the northern hemisphere and decreasing it for the southern one. This would mean that the distorted vector is forced to point towards the ionospheric current system known to cause its source issues. The same observation has been made for a much longer, seasonal time scale (Bury, 2020) for mid-latitude induction vectors based on data from summer months. The same effect (a decreased North component of the induction vector during the austral summer) is described in a long-term study of AIA data (Fig. 2 in Maksymchuk et al., 2018). Also, in the case of the anthropogenic distortion caused by direct-current railways, the distortion part of the real induction vector points towards the source (Neska, 2006; Schäfer et al., 2011).

However, if increased activity added distortion in one preferred direction to the “true” induction vector (i.e., the one caused by electromagnetic induction in the subsurface alone and exclusively fed by unproblematic, far-field sources) even in mid-latitudes, this would mean that most induction vectors ever estimated contain systematic errors. It would be a possible explanation for the peculiarities (“long tail”) recently reported for the statistical distribution of magnetotelluric transfer functions (Chave, 2014), which are, although less sensitive to source effects than induction arrows, also affected by them. Further research on the dependency of source effects in transfer functions on both time (with regard to geomagnetic activity) and latitude (with regard to the position of the ionospheric current system) will contribute to clarifying this interesting question in magnetotellurics.

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Conflicts of Interest. The authors declare no conflict of interest.

References

Araya Vargas, J., & Ritter, O. (2016). Source effects in mid-latitude geomagnetic transfer functions. *Geophysical Journal International, 204*(1), 606—630. https://doi.org/10.1093/gji/ggv474

Bury, A. (2020). Temporal variations visible in induction arrows and their spatial distribution — preliminary results. In J. Börner, P. B. M. Yogeshwar, & M. Becken (Eds.), *Protokoll über das 28. Schmucker-Weidelt-Kolloquium für Elektromagnetische Tiefenforschung: Haltern am See, 23—27 September 2019* (pp. 38—44). https://gfzpublic.gfz-potsdam.de/rest/items/item_5002002/component/file_5002003/content

Chave, A. D. (2014). Magnetotelluric data, stable distributions and impropriety: an existential combination. *Geophysical Journal International, 198*(1), 622—636. https://doi.org/10.1093/gji/ggu121

Chave, A. D., & Jones, A. G. (2012). *The magnetotelluric method: Theory and practice*. Cambridge University Press. https://doi.org/10.1017/CBO9781139020138

Chave, A. D., & Thomson, D. J. (2004). Bounded influence magnetotelluric response function estimation. *Geophysical Journal International, 157*(3), 988—1006. https://doi.org/10.1111/j.1365-246X.2004.02203.x

Egbert, G. D., & Booker, J. R. (1986). Robust estimation of geomagnetic transfer functions. *Geophysical Journal International, 87*(1), 173—194. https://doi.org/10.1111/j.1365-246X.1986.tb04552.x

Emmert, J. T., Richmond, A. D., & Drob, D. P. (2010). A computationally compact representation of Magnetic-Apex and Quasi-Dipole coordinates with smooth base vectors. *Journal of Geophysical Research: Space Physics, 115*(A8). https://doi.org/10.1029/2010JA015326

Ernst, T., Nowozyński, K., & Jóźwiak, W. (2020). The reduction of source effect for reliable estimation of geomagnetic transfer functions. *Geophysical Journal International, 221*(1), 415—430. https://doi.org/10.1093/gji/ggaa017

González-Castillo, L., Madarieta-Txurruca, A., Hill, G., Castro, C., Galindo-Zaldívar, J., & Junge, A. (2022). Long period magnetotelluric at the Antarctica: The role of asthenospheric mantle anisotropy in Glacial Isostatic Adjustment. In A. Basokur (Ed.), *25th Electromagnetic Induction Workshop: Cesme, 11—17 September 2022* (p. 311). International Association of Geomagnetism and Aeronomy, Division VI Electromagnetic Induction in the Earth and Planetary Bodies. https://www.emiw.org/fileadmin/emiw2022/abstracts/Book/EMIW_2022_Book_of_Abstracts_11-17-Sept.pdf

Hill, G. J. (2020). On the Use of Electromagnetics for Earth Imaging of the Polar Regions. *Surveys in Geophysics, 41,* 5—45. https://doi.org/10.1007/s10712-019-09570-8

Maksymchuk, V. Yu., Chobotok, I. O., Klymkovych, T. A., Kuderavets, R. S., Nakalov, E. F., & Otruba, Y. S. (2018). Complex magnetovariational and tectonomagnetic monitoring of recent geodynamics in the Western Slope of the Antarctic Peninsula. *Ukrainian Antarctic Journal,* 1(17), 3—19. https://doi.org/10.33275/1727-7485.1(17).2018.27

Matzka, J., Stolle, C., Yamazaki, Y., Bronkalla, O., & Morschhauser, A. (2021). The geomagnetic *Kp* index and derived indices of geomagnetic activity. *Space Weather, 19*(5). https://doi.org/10.1029/2020SW002641

Melnyk, G. V., & Bakhmutov, V. G. (2007/2008). The «Academic Vernadskiy» station in the network of the Ukrainian magnetic observatories of INTERMAGNET. *Ukrainian An-*

tarctic Journal, 6–7, 66–73. https://doi.org/10.33275/1727-7485.6-7.2008.494

Neska, A. (2006). *Remote reference versus signal-noise separation: A least-square based comparison between magnetotelluric processing techniques*. PhD thesis. Fachrichtung Geophysik, Freie Universität Berlin. https://refubium.fu-berlin.de/handle/fub188/9007?show=full

Neska, A. (2016). Das magnetische Joch und andere Gründe zur Betrachtung von MT-Quellsignalen. In M. Miensopust, & M. Becken (Eds.), *Protokoll über das 26. Schmucker-Weidelt-Kolloquium für Elektromagnetische Tiefenforschung: Dassel 21. – 25. September 2015* (pp. 91–101). https://gfzpublic.gfz-potsdam.de/rest/items/item_1579917_2/component/file_1579918/content (In German)

Neska, A. (2019). Non-stationarity in induction arrows derived from IMAGE data [Conference contribution]. *15th IMAGE meeting: Uppsala, 5–6 September 2019.* https://space.fmi.fi/image/www/image2019a/presentations/IMAGE2019_Neska.pdf

Neska, A., Reda, J. T., Neska, M. L., & Sumaruk, Yu. P. (2018). On the relevance of source effects in geomagnetic pulsations for induction soundings. *Annales Geophysicae, 36,* 337–347. https://doi.org/10.5194/angeo-36-337-2018

Nieć, M. (2003). Geo-economic evaluation of vanadiferous titanomagnetite deposits in Suwałki massif in Poland. *Gospodarka Surowcami Mineralnymi – Mineral Resources Management*, *19*(2), 5–28. https://gsm.min-pan.krakow.pl/Geo-economic-evaluation-of-vanadiferous-titanomagnetite-deposits-in-Suwalki-massif,96372,0,2.html

Parkinson, W. D. (1962). The influence of continents and oceans on geomagnetic variations. *Geophysical Journal International, 6*(4), 441–449. https://doi.org/10.1111/j.1365-246X.1962.tb02992.x

Sanaka, S., & Neska, A. (2021). Source effects causing non-stationarity in long term mid latitude magnetotelluric data. In J. Börner, P. Yogeshwar, & M. Grinat (Eds.). *Protokoll über das 29. Schmucker- Weidelt-Kolloquium für Elektromagnetische Tiefenforschung virtuell, 29. September – 1. Oktober 2021* (pp. 43–47). https://gfzpublic.gfz-potsdam.de/rest/items/item_5010132_2/component/file_5010134/content

Schäfer, A., Houpt, L., Brasse, H., & Hoffmann, N. (2011). The North German Conductivity Anomaly revisited. *Geophysical Journal International, 187*(1), 85–98. https://doi.org/10.1111/j.1365-246X.2011.05145.x

Simpson, F., & Bahr, K. (2005). *Practical magnetotellurics*. Cambridge University Press. https://doi.org/10.1017/CBO9780511614095

St-Louis, B. (Ed.). (2020). *INTERMAGNET Technical Reference Manual*, Version 5.0.0. INTERMAGNET Operations Committee and Executive Council. https://intermagnet.github.io/docs/Technical-Manual/technical_manual.pdf

Sumaruk, Yu., Marusenkov, A., Neska, A., Korepanov, V., & Leonov, M. (2022). Increasing the accuracy of absolute measurements at the Argentine Islands geomagnetic observatory of the Ukrainian Antarctic Akademik Vernadsky station. *Ukrainian Antarctic Journal, 20*(2), 151–163. https://doi.org/10.33275/1727-7485.2.2022.697

Tanskanen, E. I. (2009). A comprehensive high-throughput analysis of substorms observed by IMAGE magnetometer network: Years 1993–2003 examined. *Journal of Geophysical Research: Space Physics, 114*(A5), A05204. https://doi.org/10.1029/2008JA013682

Wessel, P., Luis, J. F., Uieda, L., Scharroo, R., Wobbe, F., Smith, W. H. F., & Tian, D. (2019). The Generic Mapping Tools version 6. *Geochemistry, Geophysics, Geosystems*, *20*(11), 5556–5564. https://doi.org/10.1029/2019GC008515

Wiese, H. (1962). Geomagnetische Tiefentellurik Teil II: Die Streichrichtung der Untergrundstrukturen des elektrischen Widerstandes, erschlossen aus geomagnetischen Variationen. *Geofisica Pura e Applicata, 52,* 83–103. https://doi.org/10.1007/BF01996002 (In German)

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Часова стабільність векторів індукції з Антарктичного півострова, магнітна обсерваторія AIA

Вектори індукції — це графічні зображення геомагнітних передавальних функцій в геофізиці, які використовуються при магнітотелуричних дослідженнях і пов'язаних із ними методах пасивного електромагнітного зондування. Їх розраховують з даних вимірювань геомагнітних варіацій, і вони містять інформацію про локальний і регіональний розподіл питомого електричного опору в земних надрах, який можна інтерпретувати з точки зору геології та тектоніки. Концепція, що є основою при їх інтерпретації, справедлива, якщо виконується так звана умова далекого поля, тобто виконуються певні припущення щодо геометрії використовуваних природних джерел електромагнітних полів. У практиці магнітотелуричних досліджень виникають проблеми у регіонах, де джерелом електромагнітних коливань в значній мірі є іоносферні струми. Через такі полярні (або авроральні) електрострумені виникає певний скептицизм щодо можливостей застосування електромагнітних методів дальнього поля у високих широтах, зокрема у полярних регіонах і авроральних зонах. У нашій роботі досліджено, наскільки проблеми, типові для джерел авроральних електроджетів, стосуються даних щодо геомагнітних варіацій на обсерваторії Аргентинські острови (AIA) Української антарктичної станції. Вектори індукції, розраховані за даними варіацій AIA за один місяць, які виміряні у звичайному стандарті INTERMAGNET, проаналізовано за стабільністю як періоду, так і часу, де часова роздільність для одного дня дозволяє виявити зміни, які походять від зовнішніх джерел, а не від питомого опору порід. Результати AIA порівнюються з відповідними даними двох станцій мережі IMAGE (International Monitor for Auroral Geomagnetic Effects) у північній півкулі, розташованими у Фінляндії та Польщі. Результати показують, що вектори індукції AIA не мають проблем, які можуть очікуватися у високих широтах, а їхня стабільність у часі дуже схожа на станції на відповідній протилежній геомагнітній широті 50 градусів, що географічно відповідає середнім широтам Європи. Додатково отримано, що деякі незначні випадкові зміни у векторах індукції можна віднести до збільшення геомагнітної активності, оскільки вони корелюють з планетарним добовим Ар індексом.

Ключові слова: геомагнітна активність, іоносферні течії, магнітотелурика, полярна зона