Reply to Comment by Troshichev et al. on “The Use of Invalid Polar Cap South (PCS) Indices in Publications”

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Abstract The publication by Stauning (2022b, 10.1029/2022JA030355): “The use of invalid Polar Cap South (PCS) indices in publications.” Journal of Geophysical Research: Space Physics, 127, e2022JA030355 is based on values of the PCS indices derived at the Arctic and Antarctic Research Institute (AARI) by the authors of the Comment and made available at the web portal maintained by the International Service of Geomagnetic Indices (ISGI) supported by the International Association for Geomagnetism and Aeronomy and also at the web portal maintained by AARI. One PCS version (“pre-2021PCS”) comprises a series of indices spanning 1997–2021 published by AARI up to December 2021 and by ISGI up to April 2022. Since no other PCS version has been in play at AARI prior to 2021, this version, labeled “provisional” by ISGI, was beyond doubt used in the 9 publications listed in the commented publication by Stauning (2022b, 10.1029/2022JA030355). A modified PCS version (“post-2021PCS”) was published by AARI in December 2021 and recently by ISGI (May 2022). The pre-2021PCS version has been proven invalid by many examples of unfounded excessive index excursions and also by comparisons with indices of the post-2021PCS index version. Its devaluating imprints on the publications issued by AARI between 2014 and 2021 are indisputable regardless of later modifications of the PCS index series.

1. Detection of Invalid PCS Index Values

The initial detection of invalid PCS index values was made in 2017 with the examination of PCS indices derived from different sources in Stauning (2018). These results are displayed in Figure 1a here (from Figure 8 of Stauning, 2018).

Panel b (“IAGA” version) of Figure 1A displays the failure in the PCS indices by the systematic excursions between appr. −1.5 and +2.5 mV/m superimposed on expected PCS index values. Note the agreement between Vostok-based and Dome-C based “DMI2016” PCS values and their agreement with the £EM (£KL) values in the top field. This agreement indicates that the Vostok data are of usual quality, while the failure resides in the processing of PCS indices at AARI.

The existence of two different published PCS index version was brought up to IAGA EC in mail from 30 December 2021 with ample documentation (Stauning: “NotePCIndexExamination-27-12-2021.pdf,” Mendeley Data, V1, https://doi.org/10.17632/mphb8d7cv5.1). Thus, further demonstration of the invalid PCS index values is obtained by simply comparing the new (post-2021) PCS indices with the former (pre-2021) PCS indices. Examples are displayed in Figures 1B and 1C.

2. Precise and Reliable PC Indices From Multiple Sources

In order to ensure precise PC index values the derivation procedures reported in Stauning (2016) are used to derive PCN values from Qaanaaq data and PCS values from Vostok data. Compared to the high stability and low fluctuation level of the data from Qaanaaq, which facilitates PCN index calculations, the handling of Vostok data for PCS calculations requires particular precautions. An illustration of the difficulties for Vostok data is provided in Figure 2.

The availability of magnetic observations and the derivation of calibration parameters for Dome Concordia data described in Stauning (2022a) provide back-up for Vostok-based PCS index values and may prevent issuing of faulty index data.
Throughout all years of Dome-C observations and all seasons, the correlation between Dome-C-based PCS values and $E_{KL}$ is higher than the corresponding correlations between Qaanaaq-based PCN or Vostok-based PCS index values. Corresponding to using Dome-C as back-up for Vostok, the supply of data for PCN index values might be consolidated by using alternative sources of magnetic data such as Resolute Bay in Canada or Thule Air Base in Greenland (Stauning, 2018). An example of PCN and PCS values compiled from different sources is displayed in Figure 3a for the strong magnetic storm (Dst (min) = −222 nT) on 16–19 March 2015 (Hapgood, 2022; Stauning, 2022a).

The future supply of regular magnetic observations from Alert (ALE) close to the northern geomagnetic pole would make the derived PCN indices still more relevant with these data being void of auroral substorm and NBZ effects.

3. Conclusions

1. The new comment from Troshichev et al. (2022) does not contest the validity of the documentation provided in Stauning (2018, 2020, 2021, and 2022a) of the faulty PCS indices issued from AARI between 2014 and 2021 and used in publications by Troshichev (2017), Troshichev and Sormakov (2015, 2018, 2019a, 2019b), and Troshichev et al. (2014, 2018, 2021).

2. On the contrary, it is admitted by Troshichev and colleagues at AARI that the pre-2021 PCS indices were faulty (which is the main point of Stauning, 2022b) with the statement: “According to the IAGA rules, all indices obtained by data of current magnetic observations are considered as “preliminary” indices. They should be recalculated afterward making allowance for all possible faults of
observational, technical and computer-assisted origin, to produce “definitive” indices, which will be valid for ever. This work was fulfilled in 2021 in AARI.”

3. Recalculation of Vostok-based PCS indices by using a different procedure (Stauning, 2016) gave valid index values which were confirmed by and agreed well with PCS values derived from Dome-C data (Stauning, 2018). Thus, the data from Vostok were of reasonably good quality and are not to be held responsible for the excessive systematic excursions in the PCS index values derived at AARI.

4. Consequently, the failure must reside in the data processing implemented in 2013. Until otherwise documented, it would be prudent to assume that the failure is present also in the duplicate software installed at DTU Space (Matzka & Troshichev, 2014; Nielsen & Willer, 2019) and in the present software installed at AARI in 2021.

5. As suggested in Stauning (2022b) it is recommended that the authors of the 9 publications in question are asked to specify, for instance in corrigenda that the PCS indices used in their work are provisional values which may suffer from undetected failures.
An extended analysis of the polar cap south (PCS) index series could be found in “Note on examination of PCS index versions” from 27 December 2021 and Stauning, Peter: “NotePCSindexExamination-27-12-2021.pdf,” Mendeley Data, V1. The “pre-2021” PCS index series is provided in the file “hour_data_pc_pos_60_ekl.csv” of http://geophys.aari.ru/PCspaceweather at extension “MEAN” (Troshichev et al. 2021). Geomagnetic data from Qaanaaq, Vostok, and Dome-C observatories were downloaded from the INTERMAGNET data service web portal at http://intermagnet.org. Spacecraft data needed to generate
merging electric field values were downloaded from the OMNIweb service portal http://omniweb.gsfc.nasa.gov. QD data were downloaded from the international service of geomagnetic indices data service portal http://isgi.unistra.fr. The magnetic observatory in Qaanaaq is managed by the Danish Meteorological Institute, while the magnetometer instruments are operated by DTU Space, Denmark. The Vostok observatory is operated by the Arctic and Antarctic Research Institute in St. Petersburg, Russia. The Dome-C observatory is managed by École et Observatoire des Sciences de la Terre (France) and Istituto Nazionale di Geofisica e Vulcanologia (Italy). The “DMI2016” PC index version is documented in the report SR-16-22 (Stauning, 2016) available at the web site: http://www.dmi.dk/fileadmin/user_upload/Rapporter/TR/2016/SR-16-22-PCIndex.pdf.

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