"Does high-latitude ionospheric electrodynamics exhibit hemispheric mirror symmetry?" by Spencer Mark Hatch, H. Vanhamäki, K.M. Laundal et al., 2023
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1. General Comments

The paper presents comprehensive data sets of electrodynamic parameters obtained by in-situ observations onboard nearly circular, polar-orbiting LEO satellites in the upper ionosphere. The focus of this challenging study is on the interhemispheric differences between mirror-symmetric patterns of electrodynamic parameters obtained at high geomagnetic latitudes. The mirror symmetry between hemispheres is defined here with respect to opposite signs in both dipole tilt and IMF By component in GSM coordinates.

Novel empirical models of both ionospheric drift and currents are presented, which are based on consistent building principles and measurements from similar satellites: CHAMP and Swarm data for the empirical current's models AMPS, and newly TII observations of the Swarm satellites for the high-latitude ionospheric drift model called Hi-C.

Based on these empirical models, which are independently developed for both hemispheres, a series of further patterns of various electrodynamic parameters are revealed with their variations with respect to season (tilt angle) and IMF clock angle in the By/Bz plane of GSM coordinates. These parameters comprise the electromagnetic work as well as Hall and Petersen conductances, deduced provided that the neutral wind at high latitudes can be considered as corotating with the Earth.

The manuscript is of good quality, well written and organized and has a plenty of Figures, which illustrate the physics of ionospheric electrodynamics and its degree of interhemispheric symmetry optimally. The compilation of formulas is also notably (37) and gives the manuscript partly the character of a good review paper on empirical modeling.

2. Specific Comments

The comparison between the cross-polar cap potential (CPCP) values of various data sets with the empirical model Hi-C of the Swarm satellites in Fig. 5 is quite illuminating. The interhemispheric ratio of the Hi-C model is contrary to both PRO2 and FH15, while the CS10 model corresponds partly to the present study, though with a different clock angle dependence. For purely southward Bz, the CS10 is in favour of the PR02 and FH15 models, while the NH/SH ratio for the other IMF orientations is similar to the Hi-C findings.

The IMF dependence of the CS10 model is hence quite variable with respect to the other data sets. I think that this is due to the finite latitudinal extent of the CS10 SuperDARN network at that time. It would be of interest to know, how the pattern of interhemispheric ratio looks like with the present-day, more extented SuperDARN network. I'm not aware of any study in this regard.

The results of this Hi-C study suggest, that the PR02 and FH15 models might feature some seasonal biases toward a preference of local winter patterns. The highly elliptical orbit of the Cluster satellites might indeed have generated some seasonal imbalance of the mapped high-latitude drift patterns. This should be investigated independently. The short data set of PR02 was taken near equinox and disagrees therefore somehow with the present findings.

In relation to Hall conductances (section 5.2, page 25), just at one place in line 469, the standard deviation of Hall conductances are mentioned. I wonder, where this pattern is shown in the manuscript or in some supplement materials? Unless I'm very much mistaken, standard deviations of any parameters are not shown nor discussed elsewere in the manuscipt.

The notion regarding the role of neutral winds on line 532ff. is remarkable in my mind. However, the criteria given in Equation 37 alone is not sufficient to determine the locations, where the assumption that the neutral gas simply corotates with the Earth breakes down. I'm missing here a somehow better identification of those circumstances (IMF orientation, season), where "... namely negative or unphysically large conductances and sharp conductance gradients..." (line 538) occur.

3. Technical Corrections

The manuscript is very well written with almost no misprints (the very few exceptions that I found are listed at the bottom). The Figures, however, could still be somehow improved in my mind (see remarks below).

In Section 5.2 (Hall conductance) and 5.3 (Petersen conductance), reference is made to Supporting Information of Figs. (S1)-(S6), which I couldn't find in the Preprint community platform.

I like the idea of direct interhemispheric comparisons in one and the same plot by using isolines and colored contours simultaneously for the opposite hemispheres. A problem might arise from the fact that the Figure's legends in Figs. 2-4 and 6-8 show a continuous color bar, while the contours are discrete. This is made differently for Figs. 10-15.

Yes, the potential range for the various panels in the Figs. 2-4 is quite dynamic and therefore also the potential steps are quite variable.
I agree that it is reasonable to keep the number of contours and contour lines small. However, it might be useful to indicate the common constant step sizes then for each panel individually within the inscription blocks.

The inlets (or inscription blocks) of Figs. 2-4 and 6-8 provide parameter values of the Northern and Southern hemisphere with 1-2 digits, while the ratio of the value is given with three digits. This allows some space for speculations about the correct numbers as, e.g., for the upper left panel of Fig.7 with values for W_N and W_S between 6.4 and 7.6 GW. I think it would be better to provide about the same number of digits for the parameter values as for their ratio.

Line 197: just below eq. (15) after "with d1 and d2" I miss a verb or "as"
Line 438: parenthesis for the reference not needed here
Line 461: "Bz" is probably meant here instead of "By"
Line 585: one "in" should be deleted
Line 618: "HH" is probably "HT"(?)