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Interactive comment on "Asymmetries in the Earth's dayside magnetosheath: results from global hybrid-Vlasov simulations" *by* Lucile Turc et al.

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We thank the referee for their positive feedback on our manuscript and for their insightful remarks. Please find below our point-by-point response in bold font.

This manuscript describes 2D simulations of the dayside magnetosheath using the hybrid Vlasiator code, for three different upstream conditions (one in the noon-midnight plane, and two in the GSE equatorial plane). The authors appropriately describe the capabilities as well as the issues and shortcomings pertaining to this hybrid model. The detailed description of the challenges of magnetosheath studies using spacecraft observations is also highly appropriate. The explanations provided regarding the nu-

merical results of magnetosheath asymmetries of parameters (B, density, and velocity) downstream of the Qpara and Qperp bow shock regions as a function of angle from the Sun-Earth line are plausible, though perhaps not the only possible explanations. Comparing the numerical simulation results with magnetosheath observations by the THEMIS spacecraft is also highly appropriate.

There are two significant concerns with the manner in which the study results are presented. These ought to be fairly easily addressed, but are important because they directly affect most of the figures and results presented in this study:

1) Magnetosheath parameters determined from the numerical simulations within each spatial bin and for the time interval used are presented as averages; whereas the magnetosheath parameters determined from spacecraft observations are presented as medians. In order to ensure that the comparisons between simulations and observations are meaningful, the same statistical measure should be used for both (ideally medians, to avoid outlier kinetic effects due to processes at the bow shock convected into specific magnetosheath bins from unduly influencing the overall average value). An alternative is to demonstrate that within the magnetosheath bins, the distribution of values used to determine the spatial and temporal average is Gaussian, so that the average and median values are the same.

Thank you for pointing this out, we should indeed have used the same statistical measure to quantify the "global" value of the asymmetry in each run.

First, we would like to clarify that the magnetosheath parameters were computed using the same methodology both in the numerical simulations and the spacecraft observations, as averages inside each spatial bin. We chose to use averages so that our results are comparable to the statistical results presented in Dimmock et al. [2017]. We note however that Walsh et al. [2012] used median values inside the spatial bins rather than mean values. In order to check that our results are not sensitive to using median or mean values, we calculated the

asymmetries based on the median value in each bin. We found that both the mean and the median yield very similar asymmetry levels.

Once we had obtained the asymmetry values for each azimuthal and radial bins, we looked for a means to quantify the "global" value of the asymmetry in each run. After carefully trying out both median and mean values as indicators of the "global" asymmetry level, we came to the conclusion that the large variation of the asymmetry level from bin to bin in each simulation makes both of these problematic. To give a better description of our results, in the revised manuscript, we will give instead the range of values for each asymmetry. For example the magnetic field asymmetry in the central magnetosheath in Run 1 ranges between 0 and 15%, and compare it with the 5-10% values in Dimmock et al. [2017].

2) It is difficult to judge the robustness of the results, because there are no estimates of the statistical spread (uncertainties) associated with the averages (or medians). From the simulations, sampling in appropriately sized sub-spatial and sub-temporal bins to provide e.g., standard deviations (or quartiles) used in the estimate of the asymmetry would instill considerable confidence that the percentage of asymmetry results are robust. Similarly for the THEMIS observations, it would be more appropriate if statistical estimates representing the range of values within each bin are determined and then used to estimate the range of values (measure of uncertainty) for the percentages of asymmetry for the various plasma parameters.

Thank you for this suggestion. In the revised manuscript, we will add error bars to the asymmetry plots (line plots in Figures 1, 3, 6 and 7). As done in Dimmock et al. [2017], we estimate the error on the magnetosheath parameters as the standard error of the mean (standard deviation divided by the square root of the size of the bin sample). We then use this error to calculate the minimum and maximum values of the asymmetry in each bin, which determines the extent of the error bars in the asymmetry plots.

The two figures below show two examples of the updated figures which will be included in the revised manuscript. The error bars in our numerical results are much smaller than for the observational spacecraft data set, most likely because of the steady upstream conditions in our simulations.

Minor issues:

Line 268: considerable -> considerably

Figure 4: Should label which side of the plot corresponds to Qpara, and which side corresponds to Qperp.

Line 341: magnetosheah -> magnetosheath

Thank you for picking up these typos, we will correct them in the revised manuscript. We will add the labels on Figure 4.

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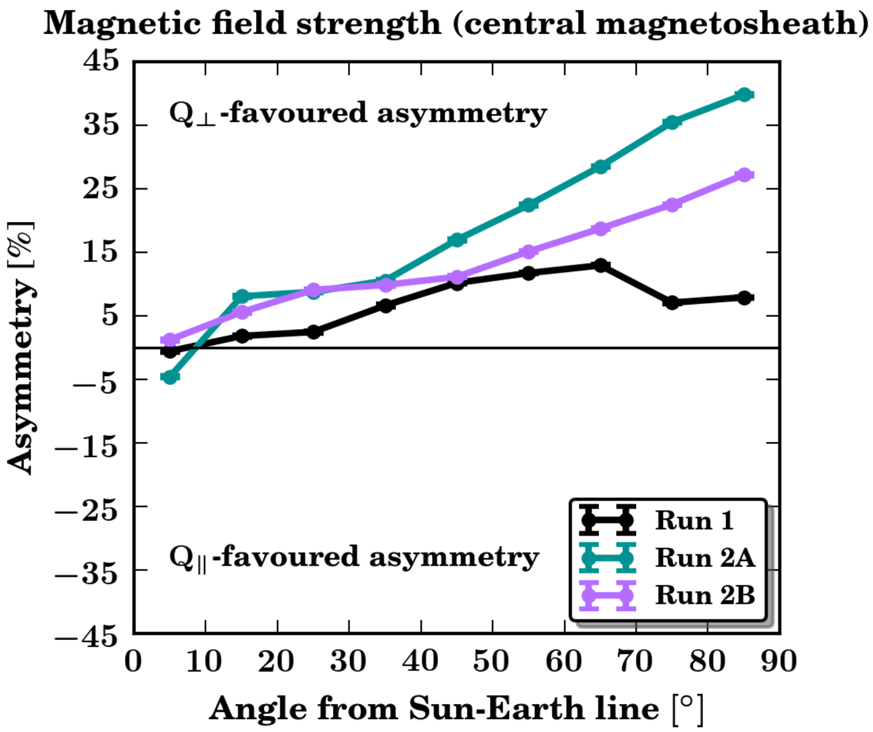

Fig. 1. Magnetic field asymmetry in the central magnetosheath (simulations) (Fig 1e – should be 1d in the manuscript)

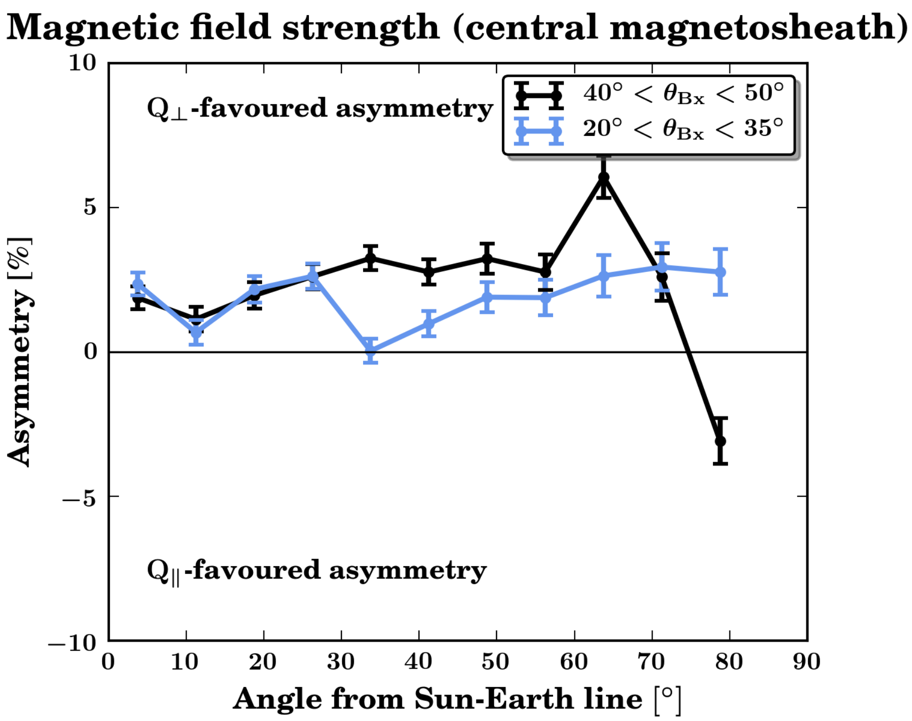

Fig. 2. Magnetic field asymmetry in the central magnetosheath (observations) (Fig. 7a in the manuscript)