Reply to the Referees

We thank the Referees for their valuable comments. Here are our replies:

Referee 1

R: The first task is to properly reference past research. Both Howe and Binsack (JGR, 77, 3334, 1972) and Crooker et al. (JGR, 89, 9711, 1984) have compared flow directions within the magnetosheath with theoretical and model predictions. They are not referenced in the present paper.

A: We added citation of these papers in Introduction (l. 26).

R: The present paper finds discrepancies between observed flows and model predictions, particularly in the vicinity of the magnetopause, but makes no attempt to explain why this might be the case. The authors should consider the various predictions described by Crooker et al. and see if these help explain their results.

A: We added our explanation in Sec. 5, ll. 182-184.

R: The authors scale magnetopause and bow shock positions by the solar wind dynamic pressure, but they must surely be aware that magnetic reconnection and erosion cause the magnetopause (and therefore the bow shock) to move inward during periods of southward IMF orientation. They should note

that they are ignoring this effect near line 73.

A: We comment on it in Sec. 5, ll. 179-181.

R: The authors tell where the bow shock and magnetopause shapes come from for Magnetic field model 2 and 3, but there is no statement about this for Magnetic field model 1 in the vicinity of line 80.

A: Model 1 is solely by Kobel and Flueckiger, which are cited.

R: In Section 3, the authors report that they require bow shock and magnetopause crossings to be clearly identifiable, but they do not tell what they do when there are multiple magnetopause and bow shock crossings. Which one do they choose?

A: Multiple crossings are not considered. It is now clearly stated in Sec. 3, ll. 112-113.

R: The authors shift solar wind observations to the bow shock nose, but how do they shift them to match spacecraft observations further downstream? Some of the intervals in Table 1 occur near the terminators.

A: The matter with the upstream solar wind observation is discussed in Sec. 5, ll. 185-187. We do not shift data ourselves, but use the product from OMNIWeb. Downstream values are determined from the models.

R: Could the authors please comment on what the typical cause of high delta? Is it a poor prediction for the flow direction in the Y-Z plane or a poor predictions of VX?

A: We comment it in Sec. 5, ll. 192-195. But the answer is that we do not know.

R: Successful prediction of magnetosheath parameters may depend on the location of the solar wind monitor. Monitors far off the sun-Earth line may not see the features that reach Earth. Can the authors please present the dependence of delta on the distance of the solar wind monitor from the Sun-Earth line?

A: It is a new figure Fig. 6j and we comment on it in Sec. 5, ll. 187-191.

R: Reconnection at the magnetopause may affect plasma flow patterns in the magnetosheath. Could the authors please present the dependence of delta on the north/south component of the IMF orientation?

A: It is a new figure Fig. 6h and we comment on it in Sec. 5, ll. 180-181.

R: Magnetic fiield directions and strengths may be more important in the magnetosheath when the solar wind Mach number is low. Could the authors please present the dependence of delta on the solar wind Mach number?

A: It is a new figure Fig. 6i.

R: The dashed line "fits" to the point in each panel of Figure 6 are not very compelling. The authors should provide the correlation coefficients for each fit.

A: We agree that they are not compelling. Therefore, we do not consider them as fits, but only identify trends. We write about it in Sec. 5, ll. 196-198.

R: It would be good if the authors make an effort to explain why the discrepancies between observed and predicted flow direction are greatest in the subsolar magnetosheath for large cone angle.

A: Our suggested explanation is given in Sec. 4, ll. 173-175.

Referee 2

R: 1. In general, there are several qualitative and subjective judgmental comments such as "performances are comparable", "comparisons are satisfactory", and "reported a fairly good agreement". It would be helpful to the reader if such comments had more quantitative support.

A: We revised these sentences, which concerns our analysis, particularly in Abstract.

R: 2. The description of the selection criteria in Lines 100-102 appears

to be incomplete. For example, what quantitative criterion was used for the selected cases to be close to radial IMF (or aligned with the solar wind flow)? What criterion was used for the steadiness of the IMF during the magnetosheath pass? Are there any other criteria applied?

A: We described the criteria in more detail in Sec. 3, ll. 109-116.
We do not limit cases to radial IMF. Changes in upstream values (IMF and plasma) are considered. See also our answer of the next point.

R: 3. Related to the previous point? if these cases occurred during times of nearly radial IMF, it was expected that the magnetosheath magnetic field and velocity components would be similar to each other. Instead, the sample intervals in Figs. 1,2 show several changes in the sign (polarity) of By, Bz that are not seen in the velocity components. Please explain in the manuscript why the magnetic field and velocity components are so different.

A: Upstream IMF can be arbitrary. Probably we do not explain our approach satisfactorily, so we do it now in more detail in ll. 45-57.

R: 4. For the comparisons between models and observations, how do the authors match model boundary crossings with the actual crossings? In general, model and observed boundary crossings are co-located in a statistical sense. Not so much during individual traversals.

A: The models are calibrated by the actual crossings and then scaled according to the dynamic pressure.

R: 5. Related to the previous point, how did the authors treat multiple crossings of boundary during a given pass? Is this part of the selection criteria for the data set? Additional details regarding the selection criteria would be helpful for the reader.

A: Multiple crossings are not considered. The selection criteria are now described in more detail in Sec. 3, ll. 110-116.

A: Spreiter and Rizzi (Acta Astro., 1974) describe how a field aligned flow in the solar wind is field-aligned everywhere.

A: We added this reference in Introduction, l. 35.

R: Other suggested references …

A: We thank you for your suggestions. The papers deal with radial IMF. Our paper deal with general IMF.

R: Minor suggested edits (technical corrections) …

A: We incorporated them into the revised version.

R: Figures: Please consider using different colors. Individuals with red-green color-blindness may not be able to discriminate between the different traces.

A: We changed from green to blue.