On the Role Played by Magnetic Expansion Factor in the Prediction of Solar Wind Speed - Response to Reviewer

We would like to thank the reviewer for their positive, which have been thoroughly addressed in the revised version. Below are the comments from the reviewer (*italics*) and and our response to them (**bold**).

Reviewer #2 Evaluations:

Recommendation: Return to author for minor revisions

Grammar improvements needed: No

Annotated: No

Highlight: No

Willing to review a revision: Yes

The manuscript On the Role Played by Magnetic Expansion Factor in the Prediction of Solar Wind Speed is a well written, clear manuscript discussing how the empirical relationships between the solar wind speed and the coronal magnetic configuration have evolved. Specifically the authors look at the role of the coronal expansion factor–which historically has been thought to correlate best with solar wind speed variationsand show that the coronal hole boundary distance has supplanted the expansion factor in importance for predicting solar wind speeds. This is highly suggestive for boundary-layer theories of the slow solar wind and is an important step towards understanding the source of the slow solar wind.

This reviewer believes this is an important comparative work that should be published after some minor revisions, most of which are clarifications. Many of these clarifications are to be more precise in what model is being used, what combination of models, as well as making sure to define acronyms.

Major Comment:

The PCC is used heavily in this text to define the performance of the models, but was never adequately explained. It is unclear how the PCC is measured and what parameters are used to define it? Is it based on comparisons with observations? If so, how? Which ones? Are propagation models required to do in situ observations? Additional verbiage is needed to explain this concept as it is central to the conclusions of the manuscript.

Thanks for pointing this out. To address this, we have given a definition of the PCC, as well as the RMSE, when they are both first mentioned. Specifically:

"The PCC is a measure of the linear correlation between two variables, where total positive/negative correlation is given by +1/-1 and no correlation is given by zero. The RMSE, on the other hand, is a measure of the standard deviation of the

differences between predicted and observed values."

Line 39: The authors state that a PFSS model can be used as a coronal model, which spans from 1 Rs to 2.5 Rs. Then state that the heliospheric domain begins around 20-30 Rs when the models are coupled together. Some clarification is required here to explain the gap.

Agreed, this should be clarified. We have added the following statement to the end of this paragraph:

"Heliospheric boundary conditions derived from PFSS solutions at $2.5R_S$ are mapped outward without change to the inner boundary of the heliospheric model at $30R_S$. "

Line 41: Remove the word say

Line 73: Define HCS

Line 102: Does EF stand for Expansion factor? This should be stated.

We have removed the word 'say.'

HCS was in fact defined earlier in the same paragraph.

The abbreviation 'EF' has been removed and replaced with 'expansion factor' throughout for consistency.

Line 193: SCS method or you are merely using the numerical/empirical description of solar wind speed with a pure PFSS solution? This is a bit unclear and could use some clarification. If it is the latter, the SCS method changes the coronal configuration, which would require a change in the exponents/values within the numerical description. Is it valid to keep any of the coefficients constant?

Our point here was simply to highlight that we were exploring different techniques and not specifically attempting to reproduce any specifically-implemented ones elsewhere. The SCS current sheet model is an addition to the PFSS model that Nick Arge has implemented, but that we do not consider. To clarify this, we have modified the the following sentence:

"For example, the "official" WSA model incorporates a Schatten current sheet model (?). "

to:

"For example, the "official" WSA model incorporates a Schatten current sheet model (?), which is omitted in our analysis."

Line 302:

Could the authors define hypercubes in the context of their parameter study and explain more how this was used to arrive at your optimal parameters.

What parameters were decided on by your parameter study?

Were data comparisons used to arrive at your optimal parameters? If so, what type of mapping was employed? Was it ballistic or MHD? The type of solar wind propagation will define the parameters/coefficients obtained.

The hypercubes simply refer to the parameter space that was explored for each model. We have fixed a few typos concerning the definition of each one (number of dimensions in the DCHB and WSA models), which may have caused the reviewer some confusion. The parameters were not 'decided' by us, but were defined by the model prescriptions. They are the ones defined and discussed in Section 2. The 'optimal' parameters were derived by the analysis described in Section 3 (and, e.g., Figure 8).

Line 315: Define PCC, and how is it optimized.

PCC is defined earlier, when it is first introduced. We also provide a definition of how it is calculated.

Line 315: When calculating RMSE with observations, is the 1D MHD model used? Ballistic propagation? At 30Rs or 1AU?

Sorry for the confusion. Since we're comparing with observations, by inference, the comparisons are made at 1 AU, and thus, the 1D propagation model is used. This can be simply clarified by appending 'at 1 AU' to the end of this sentence.

Line 322:

Why do you believe these solutions are representative of the global minimum? Are the authors saying the Carrington rotations are representative of the global minimum, or that the solution to their parameter study is. If the later, it should be noted that optimal solutions for one Carrington Rotation can be severly less then optimal for another.

It is still unclear how the authors found the best fit parameters for each model.

Sorry for the confusion. The 'global minimum' we are referring to is that of the parameter space that the hypercube is sampling, and not the minimum of the solar cycle. To clarify, we have modified the sentence to read: 'representative of the hypercube's global minimum.'

Figure 5, or near line 336: Either in the caption or the text, the figure needs to be explained a bit more. There are several 'lines' on the graph (particularly the dotted ones), which are not referenced. There also appear to be 2 green lines in figure 5c. What is the distinction between these two?

Agreed. We have added the following sentences to the caption of Figure 5, which describes the meaning of these extra lines:

"The dotted red and blue lines show profiles at $\pm 2^{\circ}$ of the location of the spacecraft. The smooth green line is a 1-day running mean of the 1-hour in-situ measurements."

Line 376: Remove, 'It should be evident'

Text removed as suggested.

Line398: What do the authors mean by WS and WSA models were validated using PFSS models. PFSS is an inherent part of these models and so cant be used to validate it. Validation studies tended to be comparisons with streamer location, CH or in situ observations.

Sorry for the confusion. Our intention was not to suggest that the models were validated with model results. To clarify this, we have replaced:

"In particular, the WS and WSA models were validated using PFSS models...'

with:

"In particular, the WS and WSA models were validated against in-situ measurements using PFSS models...'

Line 399: What do you mean by computed solutions using both models? Do you mean that speeds were calculated based on fields derived in PFSS and MHD models?

Exactly. To clarify the meaning, we have modified the sentence:

"To address this, we computed solutions using both models."

to read:

"To address this, we computed solutions using results from both the PFSS and MHD models."

We have made several minor changes to improve the manuscript and also addressed the comments made by referee 1. These are all shown in the *diff* PDF file uploaded with this revision, which explicitly identifies all changes made to the document between original submission and resubmission.

Again, we thank the referee for taking their time to provide these constructive suggestions, which have improved the quality of the manuscript.