Comments for "Foreshock cavitons and spontaneous hot flow anomalies: A statistical study with a global hybrid-Vlasov simulation" by Tarvus et al. (Paper # angeo-2020-87)

This manuscript presents results of a statistical study of foreshock cavitons and spontaneous hot flow anomalies using a global hybrid-Vlasov simulation. Their properties and evolution have been investigated with interesting results. The manuscript is well written in general and I enjoyed reading it. However, some conclusions are not convincing and the event selection criteria could be improved. My specific comments for improving the manuscript are listed below.

Major:

1. Lines 131-134: About the event selection criteria, I have the following questions:

1a. Since cavitions are embedded in ULF waves in the foreshock, it is crucial to distinguish cavitions from ULF waves. Cavitons should have lower B and N than ambient waves. Is 20% depletion a good enough criterion to distinguish cavitions from ULF waves? What if the background ULF wave amplitude is greater than 20% of Bsw and Nsw? In line 147, it was mentioned that "several transients exhibit elongated shapes and are found together in "chains" that are aligned with the direction of the IMF." Could they be an ULF wave train with amplitude greater than 20% of Bsw and Nsw?

1b. Plasma beta > 10 is used as a criterion to identify SHFAs. Would it be better to use the ion temperature and bulk flow instead of plasma beta to identify SHFAs? First, it is possible that some events with beta > 10 do not show ion heating at all and the high beta is simply due to very low Bt. Using solar wind beta =0.7, for an event with beta = 10 and without heating, B = sqrt(0.07) Bsw =0.26 Bsw. Figure 2b shows that some SHFAs have B below this value. Second, some SHFAs with weak B depletion and moderate heating can also be misidentified as foreshock cavitions. Figure 2c shows that a few SHFAs have low foreshock ion density ratio and some foreshock cavitons have large ratio. Is it possible that these special events were misidentified due to the two reasons mentioned above? Third, the average value of the bulk flow speed inside SHFAs is 19.4% decrease from the solar wind bulk flow speed (lines 210-211). Does this mean that about half of the SHFAs have less than 20% flow decrease and should not be called SHFAs since there is no significant "flow anomaly"?

2. The authors did not compare the plasma properties inside cavitons and SHFAs with the ambient foreshock. Without this comparison, the following conclusions are either not convincing or lack of a physical explanation.

2a. Lines 295-296: "The low amount of suprathermals beyond 1 RE suggests that the accumulation of suprathermals occurs principally very close to the bow shock."
Line 427: "Our results indicate that the accumulation of suprathermals inside cavitons/SHFAs is closely tied to the transients' distance from the bow shock."
Background foreshock ion density, temperature, and velocity need to be used to compare with transient values (increase/decrease ratio). Those background values are also very sensitive to thetaBn and distance from the bow shock. Is there really foreshock ion density increase compared to the background foreshock? The high density ratio could also be due to a decrease in Nsw. Therefore, this may not be due to more accumulation close to the bow shock.

2b. Line 316: "we observe a clear nose angle dependence in the proton temperature"
Line 441: "the temperature inside SHFAs increases towards the bow shock nose."

Is it because near the nose, as foreshock ions are more radially sunward, there are larger relative motion between foreshock ions and solar wind ions causing larger measured ion temperature? I suggest to check the background foreshock ion temperature.

2c. Lines 373-374: “True to their name, the SHFAs in our simulation run are associated with high temperatures and high levels of bulk flow deflection due to the large quantities of suprathermals inside them”
It would be more convincing to say “high temperatures” if they were compared with those in the background foreshock. “high levels of bulk flow deflection” may not be accurate since the average value of the bulk flow speed inside SHFAs is 19.4% decrease from the solar wind bulk flow speed (lines 210-211). See comment 1b above.

Minor:
3. Line 70: “Cavitons were found preferentially during stronger IMF, lower solar wind density and larger solar wind and Alfvén speeds.” Is this conclusion based on Figure 16 in Kajdic et al. (2017)? If so, this conclusion may not be correct since the distributions in this figure are not normalized by the background solar wind distributions. If not, please provide the reference.

4. Line 74: This conclusion is based on observations of “19 SHFAs found in the Cluster data between the years 2003 and 2011” by Kajdic et al. (2017). It is very likely that very strict criteria were used and only very significant SHFAs were included in this study because the following studies based on 300 SHFAs from Cluster data and 66 SHFAs from 3 years of THEMIS data showed less than 90% depletion in many SHFAs. Please see Figure 3 in Wang et al. (2013) and Figure 5a in Chu et al. (2017).

Wang, S., Q.-G. Zong, and H. Zhang (2013), Hot flow anomaly formation and evolution: Cluster observations, J. Geophys. Res. Space Physics, 118, 4360–4380, doi:10.1002/jgra.50424.

Chu, C. S., H. Zhang, D. G. Sibeck, Otto, A., Zong, Q., Omidi, N., McFadden, J. P., Fruehauff, D., and Angelopoulos, V. (2017), THEMIS satellite observations of hot flow anomalies at Earth's bow shock, Ann. Geophys., 35, 443-451, doi:10.5194/angeo-35-443-2017.

5. Lines 156, 218-219: Is there any reason to set the lower limit of the event size to 5 cells (0.011 RE)? Why are the transients in the simulation smaller than those observed?

6. Lines 182 and 187: SHFAs tend to be more depleted (up to 94%) than cavitons. This is partially due to the SHFA selection criterion of beta > 10. See comment 1.2 above.

7. Lines 192-193: “Figure 2c shows that nst rarely exceeds 15% of the solar wind density inside cavitons,” This is true, but many of them can still have density ratio larger than that in the background foreshock causing higher ion temperature. The ion temperature inside foreshock cavitons should be similar to that that in the ambient foreshock.

8. Lines 203-205: Figure 2d shows that the proton temperature separating cavitons and SHFAs is 14 times the solar wind ion temperature. What is the ion temperature in the background foreshock? Are the ion temperature inside foreshock cavitons similar to that that in the ambient foreshock?

9. Line 213: Could the few examples of cavitions with less than 600 km/s flow speed be SHFAs?

10. Lines 219-220: “Cavitons have a slightly larger average maximum area than SHFAs which could be due to SHFAs forming only near the bow shock, where they do not have time to grow large.” This might be true for SHFAs that form independently. How about SHFAs that evolve from cavitons? Shouldn't they be larger than cavitions？

11. Line 271: Should “along the bow shock” be “along the bow shock surface”?

12. Lines 270, 299, 316, 438: The parameters are organized as a function of the nose angle. “There is no single trend controlling the properties of cavitons and SHFAs as the nose angle varies.” How about organizing them as a function of thetaBn? “The amount of SHFAs decreases towards the flank of the bow shock.” The physics behind this is likely the occurrence rate of SHFAs depends on the thetaBn and the local shock Mach number which decreases towards the flank.

13. Line 371: “we observe a clear difference in the amount of suprathermal protons inside cavitons and SHFAs” There is “a clear difference”, but there is also some overlap. What about the ratio of suprathermal protons to Nsw in the ambient foreshock?

14. Line 392: “pick up even the smallest transients that may not be resolvable from spacecraft data amidst ULF waves.” Are they really transients or waves? Why are they not resolvable from spacecraft data?

15. Line 446: “larger reductions in the bulk flow speed inside SHFAs near the bow shock nose”
As backstreaming foreshock ions are more sunward, which can reduce more bulk speed (same reason as the high ion temperature near the nose).