

Response to Reviewer 2

We are grateful to the reviewer for the very careful and thorough examination of our manuscript. We think the revised manuscript is substantially improved as a result.

Specific Comments:

1. Line 54: In order to get the true acoustic speed in a particular antenna beam direction, the radial wind speed should be subtracted from the measured acoustic speed. Therefore, “vertical wind” should be replaced with “radial wind”.

Response: We have replaced “vertical wind” with “radial wind” in lines 50, 54 and 56.

2. Lines 138-144:

- 2-1. The sound pressure level (SPL) output of the PAA in the audible range is given in dB. It would be better to give the reference to weighting curve e.g. dBA or dBZ to make it more explicit.
- 2-2. In figure 2, the SPL is measured at a distance of 25 m from the PAA. As the general practice of measuring SPL for an acoustic source is at 1 m above the source, the reason for measurement having been done at 25 m should be explained.
- 2-3. Why is the SPL of PAA not available in the elevation angle range of $0^\circ - 40^\circ$. This measurement is of high relevance as the unique advantage of PAA is high directivity (meaning low transmission along the horizon when transmitting vertically). Effort should be made to provide these measurements.

Response:

2-1. We have added “dBA” (line182): “the SPL was less than 55 dB (**dBA**) at a zenith angle of 40° ”

2-2. We have added an explanation to respond to this comment (line 174): “The measurements were made ... at a distance of 25 m, because a range of 10 m would be necessary to complete producing audible sound from ultrasound with a PAA of this size (Prof. Kamakura, 2018, personal communication). Safety was also considered for the level-meter operators in determining the distance, as is discussed later.”

2-3. We have revised Fig. 11 to show the SPL of the PAA.

Section 3.1 :

3. Lines 175-177: It is stated that “the PAA radiates bifrequency primary waves that are around 37 kHz and 40 kHz”. However, Table 2 indicates Amplitude Modulation (DSB). It is not clear if these two frequencies were generated simultaneously by two halves of the PAA or the 40 kHz was modulated with the desired audio frequency. This should be clarified.

Response: The reviewer is right. The term DSB in the original Table 2 was wrong and removed. (We

don't think that the AM works well for RASS because ultrasound, the carrier, cannot propagate long distances.)

The two frequencies were generated simultaneously by all transducers of the PAA. To avoid confusion, we have revised our manuscript (lines 219–222): “The MRI PAA radiates bifrequency primary waves that are around 37 kHz and 40 kHz from all the transducers **simultaneously** to generate the parametric sound”.

4. Further, it is stated in line 122 that pseudorandom frequencies were chosen. What is the range of frequencies and how were they sequenced.

Response: We have added an explanation for this comment (lines 145–152): “Prior to every experiment, an acoustic wave with a wide frequency range (2715 to 3265 Hz corresponding to about $\pm 50^\circ\text{C}$) was generated to detect center Doppler frequency of the RASS echo. Then, during each experiment, the emitted acoustic frequency range was automatically narrowed down to a shorter frequency span (130 Hz, corresponding to about $\pm 12^\circ\text{C}$) around the detected center frequency to increase SNR and height coverage. The frequency sweeps were randomly shuffled within each frequency range to make acoustic spectrum almost uniform (Angevine et al., 1994).”

5. The ultrasonic SPL generated by the PAA is 200 dB which is extremely high. As per several studies (cf.[1] and [2]) physiological effects start manifesting in small animals at 120 dB and increase in severity with increasing SPL; exposure above 180 dB, death of a human could occur. Observations of insect, animal or bird mortality in the vicinity of the PAA should also be mentioned. Instances of hearing loss or any other discomfort faced by operators exposed to the PAA should be mentioned for the benefit of prospective users. In view of the high potential for biological hazard from this speaker, the paper should clearly mention the potential for harm from these high levels of ultrasound and give references to internationally accepted safety procedures to be adopted while using high power ultrasonic sources.

Response: We have added Section 4.4 for this comment. We have also added some considerations for safety in the revised manuscript (e.g., line 178 and Fig. 1d). We thank the reviewer for this comment and providing the references.

6. Section 4.3: The effect of horizontal wind on the height coverage can be estimated using acoustic ray tracing. Therefore, it is recommended that the discussion about height coverage should be given with reference to the ray tracing results.

Response: We have estimated the horizontal displacement of the sound from the radio wave by using acoustic ray tracing and revised Figs. 5 and 10 to discuss the effect of horizontal wind on height coverage in Section 4.3.

7. Line 408: How was the power decreased by 15 dB – by reducing the input drive or by using smaller aperture. This clarification should be added.

Response: The decrease in line 497 was not made manually but associated with the beam broadening as written in the same line. On the other hand, the peak power was reduced manually in measuring the SPL at multiple zenith angle (Fig. 11). We have added an explanation for this comment (line 503): “The peak power was decreased by about 7.5 dB by reducing the power supply to the PAA amplifier, which decreased not only the audible sound but also the ultrasound levels for practical reasons (noisy) and measurement safety.”

Minor corrections

8. Line 80: Replace “is expected” with “would be ideal”.

Response: Done (line 101).

9-1. Line 86: Replace “audible frequencies” with “frequencies in the audible range”.

9-2. Line 88 : Replace “Hence after” with “Thereafter”.

Response:

9-1. Done (line 106).

9-2. Done (line 109)

10. Line 107: Add “and” between Oceanic and Atmospheric

Response: Done (line 127).

11. Line 124: Replace “comprised” with “consists of”.

Response: Done (line 153).

12. Line 136: Replace “broaden” with “broadened”.

Response: Done (171).

13. Line 199: Replace “reached” with “were obtained from altitudes”

Response: Done (line 245).

14. Line 200: Replace “also reached” with “were obtained from”

Response: We have modified the text to response to a comment from another reviewer (line 246): “the PAA reached an altitude of 1.1 km AGL”.

15. Lines 396- 399: The sentence need to be rewritten. I suggest as follows,

“Since the four acoustic speakers were not adjusted in phase, this robustness could be explained by the higher aggregate sound power than that shown in Fig. 2 and possible location of sound waves above the antenna in spite of relatively high winds.”

Response: Done (lines 485–488). Thank you.

16. Line 429: Replace “availability” with “applicability”.

Response: Done (line 546).