

# ***Interactive comment on “Application of Parametric Speakers to Radio Acoustic Sounding System” by Ahoro Adachi and Hiroyuki Hashiguchi***

## **Anonymous Referee #2**

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General Comments This paper discusses operation of a Parametric Acoustic Array (PAA) speaker along with an L-band Wind profiler resulting in a Radio Acoustic Sounding System (RASS) to obtain height profiles of atmospheric virtual temperature. RASS consists of a wind profiling radar and collocated acoustic sources. Acoustic excitation is generated at a wavelength that is half of the radar transmission wavelength, so as to obtain echoes by means of Bragg scatter from the propagating acoustic wavefronts. As the sound speed generally decreases with altitude in the troposphere, the frequency of excitation required for obtaining radar backscatter at different altitudes is different in order to keep the wavelength relationship with the radar transmission. Therefore, an FM-chirped acoustic pulse is normally employed to expand the height coverage of RASS observations.

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The acoustic sources employed for RASS work in the audible frequency range and have wide beamwidths resulting in surroundings being exposed to high acoustic levels. The main impediment to operational use of RASS has been high noise pollution in the neighbourhood of the site of its operation. Therefore, RASS with acoustic sources having low sidelobe levels is highly desirable. The application of high directivity acoustic source achieved through the non-linear interaction of ultrasonic sound waves in air resulting in audio frequencies has been exploited towards this goal.

The PAA developed by the authors generates ultrasonic frequency at  $\sim 37$  kHz and 40 kHz. These two ultrasonic waves interact in the air and generate sum and difference frequencies. The difference frequency falls in the audible region of the acoustic spectrum. Intercomparison of measurements of virtual temperature made with PAA-RASS, conventional acoustic speaker-RASS and in situ measurements made with a GPS Radiosonde have been presented. Shortcomings of the RASS with PAA as compared to conventional acoustic source have also been outlined.

This paper presents an important step forward towards operational use of RASS.

### Specific Comments

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”.

Lines 138-144 : 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. 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.

Why is the SPL of PAA not available in the elevation angle range of  $0^\circ - 40^\circ$ . This

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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.

Section 3.1 : 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. Further, it is stated in line 122 that pseudorandom frequencies were chosen. What is the range of frequencies and how were they sequenced.

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.

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.

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.

Minor corrections Line 80: Replace “is expected” with “would be ideal”. Line 86 : Replace “audible frequencies” with “frequencies in the audible range”. Line 88 : Replace “Hence after” with “Thereafter”. Line 107 : Add “and” between Oceanic and

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Atmospheric Line 124 : Replace “comprised” with “consists of”. Lne 136 : Replace “broaden” with “broadened”. Line 199 : Replace “reached” with “were obtained from altitudes” Line 200 : Replace “also reached” with “were obtained from” 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.” Line 429 : Replace “availability” with “applicability”.

References [1]. Environmental Health Criteria 22 : Ultrasound, World Health Organisation Geneva 1982. [2]. Guidelines for the Safe Use of Ultrasound: Part II \_ Industrial and Commercial Applications Safety Code 24, Health Canada, 1991.

Please also note the supplement to this comment:

<https://www.atmos-meas-tech-discuss.net/amt-2019-92/amt-2019-92-RC2-supplement.pdf>

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