Effect of Sound Speed Profiles on Wind-Generated Ocean Noise

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ABSTRACT

The power spectrum densities of underwater noise recorded on the seafloor at a site northwest of Australia were compared for the same wind speeds in summer and winter, when the predominant sound speed profiles were distinctly different for underwater sound propagation, with the primary difference being the presence/absence of the surface acoustic duct in the top mixed layer in the colder/warmer seasons respectively. For the same wind speeds in different seasons, little differences were found between the noise levels at frequencies where wind-generated noise dominates, indicating that the sound speed profiles had little effects on wind-generated underwater noise. Acoustic modelling showed that the surface acoustic duct trapped only an insignificant amount of noise energy propagated within a narrow range of shallow grazing angles from distant sources and most of the noise was contributed from a local surface area with relatively steep propagation angles to the receiver.

1 INTRODUCTION

Ocean noise has been used to estimate seabed properties such as reflection loss (Harrison and Simons, 2002; Donnelly 2006), seabed sub-bottom layering (Harrison and Siderius, 2008), sediment parameters (Gebbie and Siderius; 2021), and wind speeds (Vagle et al, 1990). In these studies, the effects of sound speed profile were not considered. On the other hand, there have been studies on the seasonal variation of the characteristics of wind noise in cold (Klusek and Lisimenka, 2016) and warm (Yang and Yang, 2021) deep oceans. In this paper, we study the variation in wind noise levels at a site near the shelf-break of northwest Australia at the same wind speeds in winter and summer with consequenty distinctly different sound speed profiles.

2 MEASUREMENTS

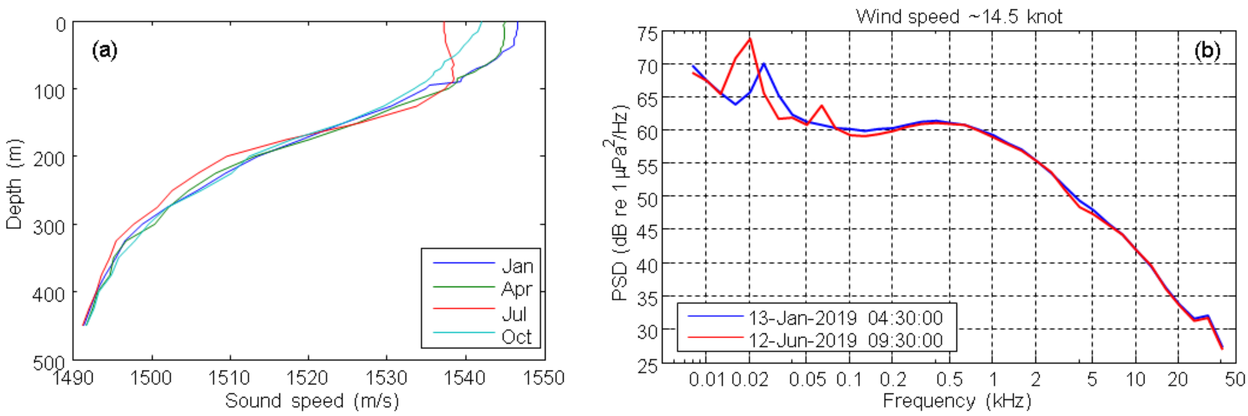

Figure 1: (a) Comparison of sound speed profiles in different months extracted from World Ocean Atlas 2018 (https://www.ncei.noaa.gov/products/world-ocean-atlas) near a site of northwest of Australia; (b) Noise levels recorded on the seafloor (420 m depth) when wind speeds extracted from the CCMP (Mears et al, 2019) database were about the same in January and June 2019.

Figure 1a shows that for near surface sources such as wind-generated noise, ducted propagation may occur at small grazing angles in winter up to about 80 m depth and downward-refracted propagation is typical in other seasons. Figure 1b shows that for acoustic frequencies greater than 100 Hz, where wind noise dominates, the difference in sound speed profiles has negligible effects on the wind noise levels. Below 100 Hz, we can distinguish the sounds of Omura's whale at about 25 Hz in January and pigmy blue whale calls at about 20 and 60 Hz in June.

3 MODELLING

Figure 2 shows the modelled ratio (in dB) of noise energy received from wind sources beyond a certain range to the total noise energy received from sources at all ranges. The receiver was at the seafloor and the wind noise sources were assumed to be uniformly distributed near the surface. We can see noise energy at all frequencies from sources beyond 2 to 5 km horizontal range from the receiver is 10 to 20 dB down, hence contributing little to the total noise energy. Furthermore, the presence/absence of the surface duct in the winter and summer sound speed profiles has negligible effects.

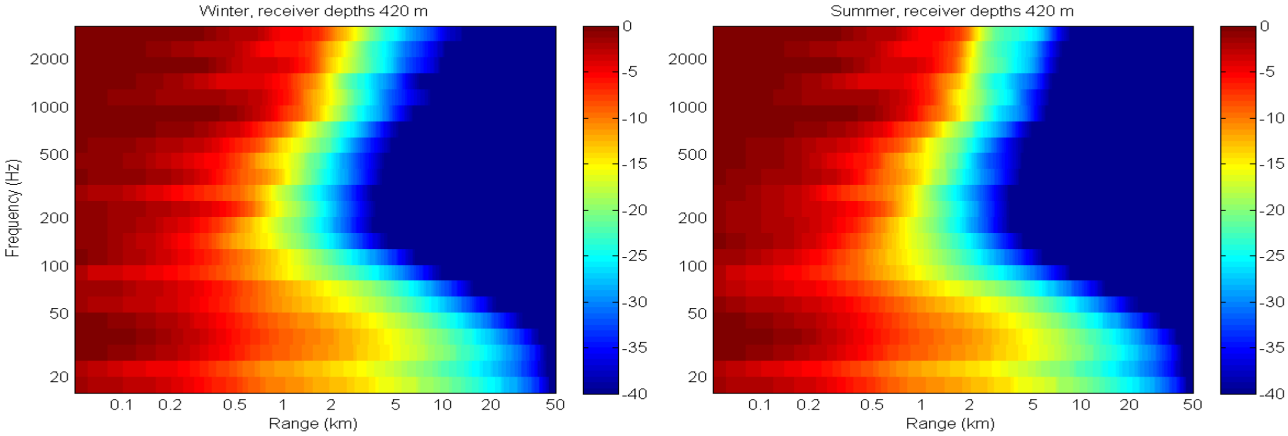

Figure 2: Modelled ratio (in dB) of noise energy received from far-field (greater than the range indicated on the horizontal axis) wind noise sources to the total noise energy received from sources at all ranges.

The explanation for the results in Fig.2 is that most of the noise energy was contributed from a local surface area above the receiver with relatively steep propagation angles to the receiver. The steep propagation paths were not trapped by the surface ducts and are insensitive to the variation in the sound speed profiles.

Future extension of this work may include examination of the “afternoon effect” (downward-refrating of acoustic energy near the surface in the afternoons and evenings of calm sunny days due to solar heating with low mixing) on wind noise levels; and comparison of measurements with modelling using wind noise source levels derived from other experiments in shallow (Harrison, 1997) and deep (Jiang et al, 2017) waters.

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