Research Note

3D Ambient Noise Mapping using Wittekind Model in Indian Ocean.

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INTRODUCTION:

The dumping of dangerous chemical, physical, or biological pollutants into the water is only one aspect of pollution in the ocean. Both natural and man-made noise sources contribute to ocean ambient noise. The latter being strongly tied to the maritime shipping sector, acoustic sources. How acoustic waves behave is a prospective area for in-depth research and mapping in the Indian littoral waters. Waters along the Tropical Littoral of the Indian Ocean Region (IOR) result in worse than ideal SONARS results, with performance drops of up to 70% due to adverse circumstances in the medium. Ambient Noise causes disturbance to marine mammals. It is also recognized as an obstacle for maritime security and strategic missions. It also affects the Health of Divers.

For improved Underwater Domain Awareness, the Indian Ocean Region (IOR) needs to have better acoustic capability (UDA). A 3D sound map can show the variation of sound at different depths in addition to the variation of sound on the surface. This mapping and characterisation of ambient noise in shallow water that is caused by distant ships can help set up inland canals, communication channels, and sensor deployment for effective AIS data collecting. The study makes use of information from earlier physical measurements to verify the simulations for the area.

NOISE:

Shipping Noise:

Commercial shipping is a major source of noise in the sea, and it is associated with adverse effects on the marine environment. Ship source spectrum contains line components and a continuous, broad-band contribution. Generally, for commercial ships at service speed, cavitation at the propeller is the dominating noise source, throughout the spectrum. At low-speed operating condition, other noise sources are the main contributions to the radiated noise i.e., Machinery noise Vibrations, Flow-noise, etc,

Models for Shipping Noise [1]:

Ross model:

It doesn’t take ship specifications into account. It doesn’t work well for frequencies under 100Hz.

RANDI model:

It extends ross model by incorporating correction term for low frequencies. But it again doesn’t take ship specifications into account.

Wales-Heitmeyer model:

Wales-Heitmeyer models works on just frequency of sound. It proposes that spectrum level doesn’t change below 30hz. It again doesn’t take ship specifications into account.

SONIC model:

First model to incorporate to the classes of ships. Advantage of this model are that it is based on the most comprehensive recent data set. It doesn’t go well so low shipping speeds as Machinery Noise become dominant in that regime in place of propeller noise.

Wittekind Model [2]:

It explicitly models engine noise. Wittekind model consideration of line contributions (at harmonics of blade-rate tonal, hull vibrational frequencies and frequencies associated with the machinery). During validation of models, Wittekind model perform better than SONIC model in low frequency range. But as frequency increases, difference decreases.

Wind Noise:

When the winds blow above the sea, underwater noise may be created by a variety of mechanisms including wind generated surface waves, the impact of water droplets, and the entrainment of air bubbles into the surface layer. Wind Noise dominates in the frequency of 400 Hz to 50kHz.

Empirical Model [3]:

Extensive underwater sound recordings allow an empirical model of wind generated noise. This model encompasses about hundred years of cumulative data and capture high wind events.

The model shows that the noise is highly dependent on frequency at higher frequencies but change a little at lower frequencies. Also, noise increases linearly in lower wind speeds but gets to higher power with increasing speed. At very high-speed noise start decreasing due to the decay caused by highly dense cloud of bubble.

To check the goodness-of-fit for the model the calculated average of devices at every 200m. When all the deployments are averaged together, the misfit is less than 0.25dB. The 0–200 m depth interval shows systematic deviations of 1-1.5 dB with frequency, presumed to be due to shallow water propagation effects.

This model gives rms difference of 1.6dB with old Knudsen model for shallow water and also in agreement with new models. Deep water noise data created by Ross shows a 1.1dB rms difference.

TRANSMISSION LOSSES [4]:

Transmission losses decreases the acoustic intensity due to geometrical spreading, attenuation and scattering as an underwater sound wave propagates outwards from a source. The prediction of underwater acoustic transmission loss in the sea plays a key role in generating situational awareness in complex naval battles and assisting underwater operations.

The ray model (RM), normal model (NM), fast field program (FFP) model, parabolic equation (PE) model. Each hydroacoustic model algorithm has limitations in the applicable situations. For example, the NM and FFP models are suitable for distance-independent sound field calculations; the RM and PE model are suitable for distance-dependent sound field calculation. In addition, the RM is suitable for high-frequency calculations, and it is more difficult to handle low-frequency and caustic calculations; the PE model is suitable for low-frequency and narrow-angle calculations, and the calculation efficiency is not very high for high-frequency and deep-sea environments.

Comparisons of Models [5]:

Empirical Model: Its's time of operation is quite low in microseconds. But it shows very poor accuracy (error >10dB).

Ray Theory: Its time of operation is in few seconds. It works well in ideal sea conditions. Its accuracy is less than 10dB.

Normal Node: Its time of operation is in thousands of seconds. It works quite good in frequency range 500Hz. Its error is less than 2dB.

PE Model: Its time of operation is in thousands of seconds. It works quite good in frequency range 500Hz. Its error is less than 2dB.

NOISE MAPPING:

A noise map, also known as a heatmap, is a map of an area that shows the various noise levels in a region in the form of a color-coded map. The borders between various noise levels in a region can often be depicted on a contour map, which is another way to display noise levels.

Calculating of the heatmap of ambient noise of the ocean provides a new perspective on the study of sound's spatial variation. Underwater noise levels can be measured using an instrument Hydrophone. The location of interest must be the location of this instrument, which directionally detects the local soundscape. However, taking measurements in this manner is a time-consuming operation, and it is not physically possible for the entire oceans to be subjected to such measurements. Instead, models that make use of AIS or any other source of shipping noise data can efficiently and precisely measure the total noise at a specific location in the waters using tabulated noise emissions.

3D MAPPING [6]:

3D mapping means to quantify something in three coordinates. Visualization become easier when a 3D map is available for the object under study. A GIS (Geographic information System) captures, stores, maps the object of interest in the coordinates of earth. ArcGIS and QGIS are two visualization software. QGIS is open-source software that uses linear interpolation to make noise map from data points.

CHALLENGES:

- Calculation of Transmission losses takes huge amount of time.
- As acoustic wave propagates in a shallow ocean, it gets attenuated due to multiple interactions with the boundaries above and below.
- Bottom make-up, such as clay and sand affect the reflective intensity and hence will affect the noise at observed point.
- Salinity and temperatures variances also cause effect on noise.

RESEARCH DIRECTIONS:

- Ships are divided into classes which does include the individual identity. Like individual age, structure can affect noise. So, ship data can be more comprehensive.
- Boundary scattering is not dealt in PERAM model which can be dealt with.
- Inclusion of wind and may be precipitation if possible as precipitation noise also falls in our interest of frequency.
- Use of DBN in calculation of Transmission loss.

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