Preliminary Analysis of Wind-driven Ocean Ambient Noise in the North Area of Zhongsha during Typhoon

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Aim
The ocean ambient noise level has been shown to be correlated with the local wind speed over the measurement hydrophone. Strong air-sea interaction and disastrous weather would be caused by typhoon, and human lives and properties would be endangered in typhoon. Consequently, it is of great significance to carry out wind-driven ocean ambient noise research in typhoon in order for typhoon warning, disaster prevention and mitigation, as well as the global climate change research, etc.

Background of Experimental
Continuous 415 hours ocean ambient noise had been measured by the acoustic mooring in the north of Zhongsha and east of Xisha in the South China Sea. The time course in this paper is hour (h). The measurement began at 17:00 in August 6th is expressed as 1 h, the measurement ended at 24:00 in August 23th is expressed as 415 h. Only the shallow 23 hydrophones are working during the measurement. The depth of the first hydrophone is 155 m, the depth of the 25th hydrophone is 875 m. The typhoon “KAI-TAK” passed nearby during the noise measurement. The distance from the typhoon center to the receiving hydrophones is shown in Fig. 1. The wind speed at the receiving acoustic mooring is shown in Fig. 2. The sound speed profile at the hydrophone receiving location is shown in Fig. 3.

Results
In the continuous 415 hours ocean ambient noise data, the data which were measured in time 214-293 h were near typhoon data and the others were belonged to non-typhoon period data.
During the non-typhoon period, the correlation coefficient of ocean ambient noise with wind speeds had been calculated and it was shown in Fig. 4 and Fig. 5.
During typhoon period, the correlation coefficient of ocean ambient noise with wind speeds had been calculated and it was shown in Fig. 6 and Fig. 7.

Discussion and Conclusion
From Fig. 4 to Fig. 7, we can find the correlation coefficient of noise level with wind speeds has no significant trend with frequency and receiving depths when the frequency is < 200 Hz. The correlation of the 250 Hz - 1.6 kHz ocean ambient noise with wind speeds in typhoon period is significantly better than that in non-typhoon period. The lower frequency limit of wind-driven ocean ambient noise has been decreased during typhoon periods. The correlation coefficient of 250 Hz is an example, it is < 0.2 during non-typhoon period which means uncorrelated, but in typhoon period it is > 0.55 to achieve a moderate correlation.
In non-typhoon period, the correlation coefficient is decreased with the increase of receiving depth when the frequency is > 250 Hz. It is indicated that the ocean ambient noise of this frequency band has been mainly generated from the wind-driven noise sources near the receiving sea surface.
In typhoon period, the correlation coefficient is wanderingly increased with the increase of receiving depth. It is indicated that the wind-driven ocean ambient noise also had been originated from the long distance not only the local noise source. It may be deduced that the ocean ambient noise traveling along the slope of seabed was received by the hydrophones. It may be coming from the stormy waves beating against the islands of Zhongsha and Xisha in typhoons. This is called the “down-slope conversion effect”.
The acoustic propagation simulation research had been developed which was from the Zhongsha and Xisha sea area to the acoustic mooring sea area. They are shown in Fig. 8 and Fig. 9. It is shown that the sea-floor terrain from the Zhongsha and Xisha islands to the acoustic mooring sea area is conductive to the propagation of noise. The sound energy is convergent or enhanced at the depth from several hundred meters to thousands of meters.

Fig. 1. Distance from the typhoon center to the receiver.
Fig. 2. Variability of wind speed from hour to hour at the receiver.
Fig. 3. Sound speed profile at the receiving sea area.
Fig. 4. The correlation coefficient of ocean ambient noise level with wind speeds for various receiving hydrophone in non-typhoon period.
Fig. 5. Depth profiles of correlation coefficient in non-typhoon period.
Fig. 6. The correlation coefficient of ocean ambient noise level with wind speeds for various receiving hydrophone in typhoon period.
Fig. 7. Depth profiles of correlation coefficient in typhoon period.
Fig. 8. Acoustic propagation simulation from the Zhongsha island to the noise measuring submarine in the sea.
Fig. 9. Acoustic propagation simulation from the Xisha islands to the noise measuring submarine in the sea.