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An Integrated Observation System from the Ocean Bottom to the Atmosphere to Study Air-Sea Interaction in the Kuroshio Region South of Shionomisaki

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1. Introduction

The Kuroshio, the western boundary current in the North Pacific, transports huge amounts of water volume and heat from the subtropical region to the downstream south of Japan, where active interaction occurs perpetually between the atmosphere and the ocean. Massive water vapor is supplied from the ocean to the atmosphere, which drives energetic disturbances to cause disasters such as typhoons and explosive cyclones. Meandering of the Kuroshio is also well known to bring heavy snowfalls to the Kanto region in winter. On the other hand, the atmospheric disturbances promote development of wind waves and storm surges at the sea surface and intensify vertical mixing due to enhanced turbulence inside the ocean.

In the Kuroshio region, conventional ship-based measurements can hardly approach the actual condition of the air-sea interaction mainly because of ordinarily strong currents and frequent attacks of severe storms. However, recent studies present probability of detecting the oceanic and atmospheric events by using bottom pressure gauges distributed at the sea floor originally for monitoring the hydraulic pressure fluctuations due to submarine earthquakes (e.g., Tono et al., 2014).

This study aims to construct an integrated observation system from the ocean bottom to the atmosphere in order to elucidate processes of the air-sea interaction in the Kuroshio region, which generate frequently several disturbances in the atmosphere and ocean. This observation system is expected to contribute to realization of more accurate monitoring or forecasting of severe natural disasters.

2. Integrated observation system

We constructed a new observation system integrated from the ocean bottom to the atmosphere in the region south of Shionomisaki, the southern tip of Kii Peninsula, where the Kuroshio flows and it has been well known that several atmospheric and oceanic events frequently occur. And importantly, the Dense Ocean floor Network system for Earthquakes and Tsunamis (DONET) has been arranged widely by JAMSTEC at the sea floor off Kii P. since 2006 for monitoring precisely the hypocentral region of Tonankai earthquake that are very likely to occur around Nankai trough. DONET/DONET2 (the second phase of DONET) consists of a 300/450 km length of a backbone cable system with 20/29 observatories, each of which is equipped with a high-precision quartz pressure gauge and seismometer. The pressure gauge can measure fine fluctuations of water pressure at the bottom with an accuracy of 0.01 db, hence in some cases it has a potential to detect signals attributed to disturbances generated in the ocean interior, at the sea surface, and even in the atmosphere, in addition to its intended purpose.

Our new observation system is mainly composed of three platforms: (1) a network of water pressure gauges at the ocean bottom by DONET and DONET2, (2) an atmospheric observatory located at Shionomisaki wind effect laboratory of DPRI, Kyoto University, which carries out vertical profiling by radiosondes, a Doppler lidar, a microwave radiometer, a UAV, etc., and (3) a cooperated ship-observatory among the R/V Shinsei-maru, JAMSTEC, the T/S Seisui-maru, Mie University and the D/V Chikyu, JAMSTEC, which conducts conventional oceanic profiling by CTD, atmospheric profiling by radiosonde and continuous measurement of current velocity, surface waves, air-sea fluxes and principal meteorological elements by the old and new types of shipboard observation devices.

3. Detection of oceanic events from the bottom

The first trial of our new observation system was conducted in autumn 2018. Profiles of water mass and horizontal current-velocity from the sea surface down to the bottom were observed by a CTD attached with a lowered-ADCP on the 13 points of DONET/ DONET2 in the cruise of the R/V Shinsei-maru (KS-18-13) conducted in October 10-21, 2018 (Fig. 1). The cruise also conducted one-day continuous profiling on the two DONET2 points. The main purpose of this cruise was to validate the accuracy of detecting sub-mesoscale oceanic frontal disturbances linked with fluctuation of the Kuroshio current-path by the bottom pressure gauges of DONET/DONET2, as part of the observational campaigns.

In the cruise period, the Kuroshio has taken a large meander path for the first time in twelve years; therefore, the Kuroshio flowed far away from Kii Peninsula and all the DONET/DONET2 points were covered with the slope waters (Fig. 1). Timeseries of the bottom pressure at 0.1 s intervals presented temporal variation identical within the range of 0.16 db to the fluctuation of the external tide estimated from an astronomical tide model (Matsumoto et al., 2000). It was suggested that oceanic disturbances with the period of approximately an hour to propagate northeastward from the Kuroshio front to Kii P. (Fig. 2), by analyzing the cross-spectrum of the temporal variation of the bottom-pressure excluded from the external tide component.

4. Conclusion

We constructed an integrated observation system from the ocean bottom to the atmosphere focusing on the air-sea interaction in the Kuroshio region south of Shionomisaki. First trial of this new system presented a capability of the sea floor observatory to detect oceanic disturbances originated from the Kuroshio front even under the calm conditions in autumn 2018.

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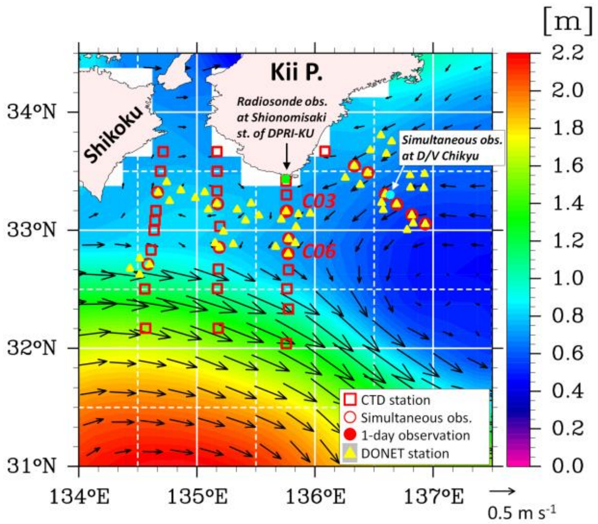

Fig. 1 Station map of the cruise in October 2018. Background hatch and arrow indicate the absolute dynamic height (ADT from AVISO) and the surface geostrophic current velocity, respectively.

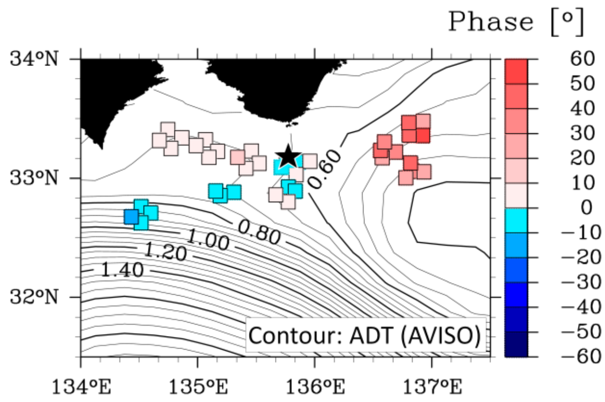

Fig. 2 Horizontal map of the cross-spectral phase of the 1-hour period component of the bottom pressure fluctuation that is excluded from the external tide in October 2018. Reference position is marked by ★.