R&D item

2. Development of Atmosphere-Ocean Sensors for Stormy Environments

Progress until FY2023

1. Outline of the project

We develop atmosphere-ocean sensors outfitted on virtual mooring drones (VMDs) which provide sufficient accuracy even in stormy environment with large hull motion caused by strong wind and high waves around the center of typhoons and waterproofness enough to withstand temporary submergence and heavy rainfall.

In the first year (2002), atmospheric sensors were waterproofed and then tested in laboratory, water tank, and coastal waters by using VMD prototype #0 and #1. In the current year (2023), we conducted the first short-term open ocean test off the east coast of Philippines during R/V *Mirai* tropical ocean cruise to confirm waterproofing and accuracy of atmospheric sensor installed on #2 as well as oceanographic sensor.

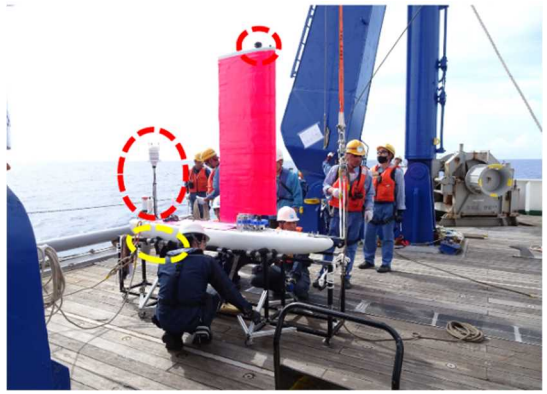

Fig. 1 Refurbished atmospheric and oceanographic sensor (red and yellow dashed circles, respectively) installed with VMD prototype #2 during R/V Mirai tropical ocean cruise. Tose sensors and satellite communication are carefully inspected before deploying the prototype into the ocean.

2. Outcome so far

1. Continuing from previous year, we improved waterproof performance of atmospheric sensor and correction method for hull motion by repeated tests in coastal waters as well as oceanographic sensor (no winch, so far) installed on prototype #2.
2. We made short-term open ocean test off the east coast of Philippines, where is main location of typhoon generation season, during R/V *Mirai* tropical ocean cruise in summer (June-July).
3. Atmospheric and oceanographic data from sensors installed on prototype #2 were obtained successfully, and validated with true values of *Mirai's* observation data. We confirmed that those data were sufficiently accurate though it is limited in relatively calm condition of weak winds (< 10 m/s) and low significant wave heights (about 1 m).

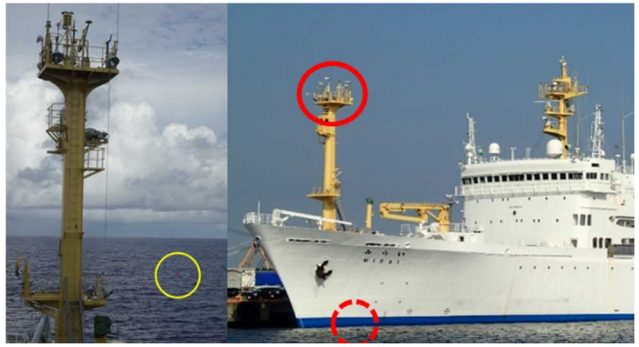

Fig. 2 Locations of meteorological sensors named SOAR (sea surface altitude: 23 m, red solid circle) and surface seawater analyzer (water depth: 5 m) (dashed red circle) equipped with R/V *Mirai* (right). Overall view of the foremast (left) and a distant view of VMD prototype #2 (solid yellow circle) undergoing open ocean test.

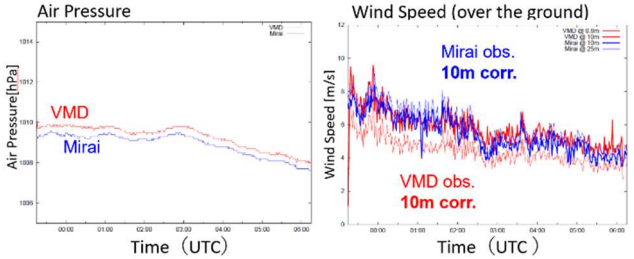

Fig. 3 Comparison of atmospheric observation data obtained by VMD prototype #2 (VMD, red line) and *Mirai* (blue line) (left: air pressure, right: wind speed, July 15, 2023). Air pressure and wind speed are corrected to the sea level and 10 m height, respectively. Both air pressures show almost identical variation and have bias of approx. 0.5hPa. Wind speeds are in agreement with each other within 1 m/s accuracy, but the error trend differs greatly depending on period by period, and its cause is under investigation.

3. Future plans

Based on test results in 2023, we will further improve atmospheric sensor and equip ocean sensor with a winch, and test them at open ocean again during R/V *Mirai* cruise in 2024. The test was originally planned to be conducted at the tropical ocean in the summer season as same as that in 2023, but we will change the test schedule to *Mirai* Bering Sea cruise in autumn (October-November) because stormy conditions such as strong winds and high waves are expected, which is much suitable for the final test focusing on the weather resistance performance of the observation sensors.