GNSS-Acoustic Observation Using the Wave Glider to Detect the Seafloor Crustal Deformation (4)

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The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and Tohoku University have been developing a system to conduct the GNSS-acoustic observations to detect the seafloor crustal deformation (hereafter GNSS-A observations) using an unmanned surface vehicle, the Wave Glider (hereafter WG) since 2018. Based on the results of the test observation during the KS-19-12 cruise in July 2019 (Iinuma et al., 2021, Front. Earth Sci.), the system has been continuously operated twice a year since 2020, visiting many (around 15) observation sites. Since the autumn of 2021, we have added a function to collect meteorological and oceanographic observation data.

The WG is an unmanned ocean observation vehicle developed by Liquid Robotics, Inc. (USA), and its third-generation model, the SV3, consists of a 3 m-long float and a 2 m-long glider. The float part is connected to the underwater glider part by an 8 m-long umbilical cable. The vertical motion of the float due to sea surface waves is converted to forward force by the wings of the glider, and propulsion is obtained without consuming fuel or electricity. The WG is controlled autonomously by adjusting the angle of the rudder based on the direction of the ocean currents so that it can follow a set course and avoid collisions with vessels that is equipped with the Automatic Identification System for ships. The solar panels on the float and the rechargeable battery supply power for navigation control, communication with land, operation of observation equipment, and data recording.

Equipment to perform GNSS-A observations and a Thuraya satellite communication system was also installed to control the instruments and transmit data. By transmitting a part of the collected data and the history information of the observation equipment control in quasi-real time to the land, it is possible to confirm the activation status of the seafloor stations, and to acquire the acoustic traveltime data and GNSS positioning results. If highly accurate GNSS positioning using correction information is available, we can detect the changes in seafloor station array positions, that is, crustal deformation of the seafloor, in quasi-real time. In addition, since 2021, we have installed thermo-hygrometers on the pillars of the GNSS antennas at the head and tail of the float and on the central mast, and a CTD sensor on the stern of the float to record data on sea surface humidity, temperature, and salinity. The data acquired during the 5-th long-term operation from May to July 2022 have been reported in Nagano et al. (2022, Sensors). In 2022, the sea surface altitude was measured by the reflected acoustic wave from the sea bottom directly above the tsunami gauge (ocean bottom pressure gauge, PG1) off Tokachi, and the seafloor water pressure, sea surface altitude, water temperature, salinity, humidity, air temperature, pressure, and water vapor in the sky by GNSS observation were successfully measured at the same time.

Since June 2020, we have conducted one- to two-month observations covering observation sites off the Nemuro Peninsula to off Fukushima Prefecture in spring and summer, and less than one-month observations focusing on observation sites off Aomori Prefecture to off Iwate Prefecture in summer and autumn. Although the mast in the center of the float collapsed during the 4-th cruise and the recovery could not be completed as planned due to bad sea conditions during the 6th cruise, the observation has been carried out without any major trouble related to data acquisition, such as contact with other vessels or serious malfunction of the internal equipment. By the time of the meeting, the 7-th long-term cruise is expected to have been conducted. In the presentation, we will introduce the results of the 7-th and other long-term cruises, and report on the limitations of GNSS-A observations using the WG and our plans for technological development.

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