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研究成果報告書

研究課題名
次世代の高速海底地殻変動観測を実現するための UAV 海底観測システムの実証

Demonstration of a UAV seafloor observation system for realizing next-generation high-speed seafloor crustal deformation observation

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Abstract

GNSS-A, a seafloor geodetic observation technology, combines GNSS and acoustic ranging on an underwater platform. It was practically used in the 2000s and has produced important seismological observation results, such as the 2011 Tohoku-oki earthquake and understanding the strain distribution in the Nankai Trough. GNSS-A is an essential technology for considering future earthquake disasters. Until the 2010s, GNSS-A observations were conducted using ships. However, given the construction and operation costs of ships, the lack of real-time response, and the difficulty of multi-point deployment, technological development of ship-based GNSS-A has reached its limits. To overcome this bottleneck, moored buoys and self-propelled buoys have been explored and developed since the 2010s. In particular, the US-made Wave Glider self-propelled buoy has been deployed for marine observations other than seafloor geodetic observations. However, the fast ocean currents in the waters near Japan and the insufficient solar power generation capacity due to the high latitudes remain bottlenecks. These technical challenges for surface platforms used in ocean observations have been raised as the "sea surface platform problem."

This research project aimed to develop and demonstrate GNSS-A observations using a sea-landing Unmanned Aerial Vehicle (UAV) to provide additional options for sea surface platforms for GNSS-A observations. We developed GNSS-A equipment that can be mounted on a UAV, verified its accuracy, established a software environment for real-time observations, established technology for safe UAV takeoff and landing, and conducted actual GNSS-A observation demonstrations.

In FY2021, we began construction of a battery-powered UAV and its equipment, and conducted an initial demonstration experiment in FY2022, the first year of full-scale research. Although the observations were only accurate to within a meter, this was an important initial result demonstrating the feasibility of GNSS-A observations using UAV.

Battery-powered UAVs have the drawback of a limited flight range of two to three hours, so we began construction of a gasoline-engine UAV between FY2022 and FY2023. In addition, GNSS wing installation, internal equipment updates, and updates to the bottom dome and containment lid were also carried out. This fiscal year, multiple water tank tests were conducted to verify the accuracy of individual components and the overall system. New insights into acoustic signal reading methods were also gained, making a significant contribution to marine GNSS-A technology.

From fiscal year 2023 to fiscal year 2024, actual sea trials using gasoline-engine equipment were conducted, and detailed analysis of the results demonstrated that UAV-based GNSS-A technology achieved observation accuracy comparable to that of marine GNSS-A. Furthermore, the establishment of communications equipment for real-time observation and internal software technology demonstrated on-site, unassisted GNSS-A observation. Progress was also made in the development of monitoring technology for UAV takeoff and landing on water, which is essential for automated observation. Empirical technology using radio, GNSS-R, and visible light sensors were developed for monitoring water landing. Technical verification of takeoff is currently also underway.