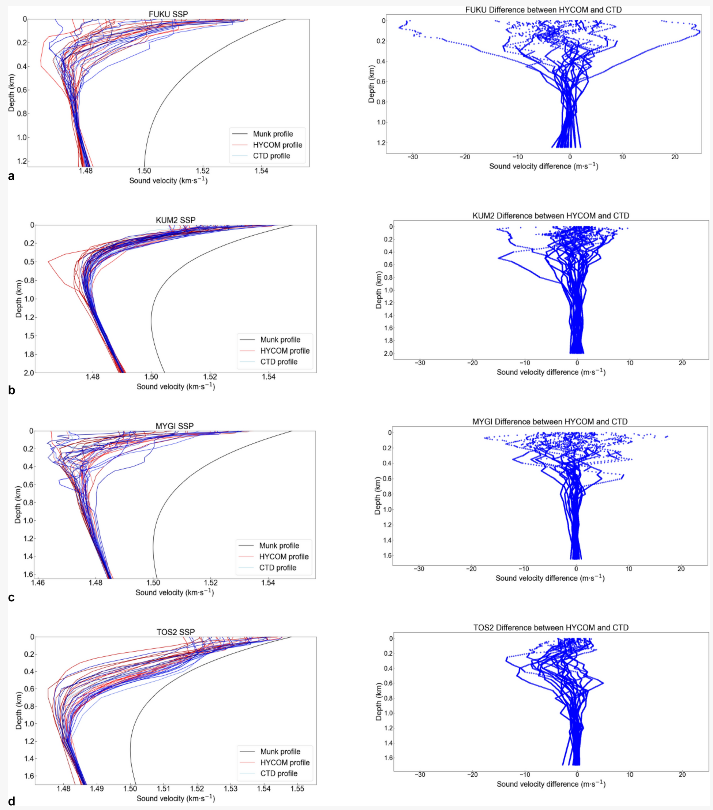
Global ocean analysis could replace costly in-situ sound speed profiles in seafloor positioning, study finds

GA, UNITED STATES, July 10, 2025 /EINPresswire.com/ -- A new study reveals that global ocean analysis products can effectively replace expensive in-situ sound speed measurements for precise seafloor positioning. The research demonstrates that using sound speed profiles (SSPs) from the HYbrid Coordinate Ocean Model (HYCOM) global ocean analysis achieves centimeter-level accuracy in seafloor positioning, comparable to traditional methods. This innovation could significantly reduce costs and logistical challenges in marine geodetic surveys, particularly for unmanned vehicles or long-term monitoring.



Comparison of the in situ profile, HYCOM profile, and Munk profile sound speed at the four sites FUKU a, KUM2 b, MYGI c, and TOS2 d.

Accurate seafloor positioning is critical for studying tectonic movements, earthquakes, and marine resource exploration. The Global Navigation Satellite System-Acoustic (GNSS-A) technique combines satellite and acoustic measurements to achieve centimeter-level accuracy. However, GNSS-A traditionally relies on costly measurements of in-situ SSPs, which require extensive time and resources to collect. Variations in ocean temperature, salinity, and pressure further complicate in-situ measurement sampling, which cannot adequately represent the spatial-temporal changes of sound speed, limiting the efficiency of seafloor geodesy. Based on these challenges, there is a pressing need to explore cost-effective alternatives to in-situ SSPs.

Published on June 30, 2025, in Satellite Navigation, researchers from the First Institute of Oceanography, Ministry of Natural Resources and Shandong University of Science and Technology evaluated the feasibility of using HYCOM global ocean analysis products for GNSS-A positioning. By comparing global ocean analysis derived SSPs with traditional in-situ and Munk empirical profiles, the study found that global ocean analysis delivers comparable accuracy while slashing operational costs.

The study revealed that global ocean analysis derived SSPs delivered horizontal positioning accuracy of 0.2 cm (RMS) and vertical accuracy of 2.9 cm (RMS), closely matching traditional in-situ measurements while eliminating the need for costly sound speed field surveys. In contrast, the Munk empirical profile introduced significant vertical errors (10.3 cm RMS) due to its oversimplified assumptions, making it unsuitable for high-precision applications. HYCOM global ocean analysis excelled in energetic and eddying marine regions like the Kuroshio Current, with the seafloor displacement linear fitting residual of 2.3 cm horizontally, though slightly higher discrepancies (~3 cm horizontally) occurred in complex dynamic zones like the Kuroshio-Oyashio confluence region. Long-term data (8 years) confirmed HYCOM global ocean analysis's reliability, with displacement trends aligning at sub-mm/year levels horizontally, proving its viability for tectonic monitoring. Notably, the method's cost-efficiency and compatibility with unmanned vehicles could facilitate access to seafloor geodesy, offering a practical alternative for scientific and industrial use.

Dr. Yanxiong Liu, corresponding author of the study, noted: "Our results confirm that global ocean analysis sound speed profiles are a practical alternative to in-situ measurements. This advancement not only cuts costs but also expands access to seafloor geodetic technology for broader scientific and industrial applications."

The study's findings could expand seafloor geodetic monitoring by making GNSS-A positioning more affordable and accessible. Using global ocean analysis sound speed profiles instead of costly in-situ measurements facilitates frequent, high-precision surveys - particularly valuable for earthquake-prone regions like the Japan Trench. Offshore industries could benefit from cheaper seafloor positioning for infrastructure projects, while seismology scientists gain better tools to study seafloor plate tectonics. The approach also holds promise for unmanned vehicle navigation and deep-sea exploration. By eliminating the need for expensive SSPs measurements, this innovation could expand marine geodesy and advance our understanding of seafloor science.

References
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