Extended abstract

Brilliant Marine Research Idea 2024

This extended abstract is part of the full report which should be submitted no later than 28 February 2025 via filantropie@vliz.be. Data of this specific final report are under embargo and are therefore not yet published online.

1. General information

Title of the idea	Proof of concept for a submersible autonomous turbulence sensor
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2. Brilliant Marine Research Idea

Extended abstract

Micro-scale turbulence in the ocean refers to chaotic, small-scale fluid motions occurring at scales ranging from millimeters to a few meters. This is typically caused by shear instabilities, breaking waves, and interactions with larger-scale currents. Micro-scale turbulence is crucial in enhancing the diffusion of dissolved gases and particles, impacting marine ecosystems and climate dynamics.

Most existing techniques for micro-scale turbulence measurement rely on mechanical, thermal, or acoustic methodologies, each with inherent limitations, including flow disturbances and the indirect inference of optical effects. In contrast, optical sensing offers a non-intrusive approach that directly quantifies the impact of turbulence on light propagation. This capability is also relevant for underwater imaging, optical communication, and Lidar-based remote sensing applications, where understanding turbulence-induced light scattering and depolarization is critical for performance optimization and data interpretation.

During the development of the optical sensor for particulate inorganic carbon, it was observed that water turbulence, introduced to maintain particle suspension, also induces depolarization, thereby interfering with the particle signal. This BMRI grant seeks to evaluate the feasibility of quantifying microscale turbulence using the small-angle depolarization signal, which is currently obstructed in the sensor design.

We established an optical setup in the laboratory to examine the characteristics of depolarized scattering induced by turbulence, including its intensity and angular distribution. The micro-scale turbulence parameters employed in this study were selected to represent typical oceanic conditions. We then compared these characteristics with the depolarization effects caused by birefringent and non-birefringent particles to distinguish their respective contributions in seawater. The results show that depolarized scattering induced by birefringent particles is angle-independent at small angles (up to at least 5 degrees), whereas non-birefringent particles produce a negligible signal. On the other hand, turbulence contributes within this angle range, especially at ultra-small angles, and its density is highly correlated with turbulence strength. This correlation implies the potential for quantifying micro-scale turbulence with minimal disturbance from particle signals.