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Editorial: Remote sensing applications in oceanography with deep learning

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Editorial on the Research Topic

[Remote sensing applications in oceanography with deep learning](#)

Deep learning and remote sensing for the ocean: from concept to operational impact

Deep learning (DL) and remote sensing (RS) are transforming how we observe and manage the ocean. Modern algorithms, platforms, and multi-sensor data integration now deliver insights at scales and speeds that were impossible just a few years ago. This Research Topic gathers 17 contributions across seafloor geomorphology, Ship and hazard monitoring, water quality assessment, mesoscale dynamics, under-ice processes, sonar perception, and enabling methods—demonstrating a field that is both technically innovative and mission-driven.

Seafloor to shoreline

Ocean science relies on accurate mapping of the seabed. Automation can quickly analyse broad regions while collecting characteristics that satellite altimetry misses, as demonstrated by a CNN + U-Net pipeline for recognising tiny seamounts in multibeam data. RipFinder, a mobile machine learning system for real-time rip current identification that also functions as a citizen-science tool in places with restricted connection, exemplifies “AI to edge” at the land–sea interface.

Ships, safety, and hazards

For marine awareness, synthetic aperture radar (SAR), is still essential. While previous research use AIS data, sea fog, and remote sensing to evaluate collision risk, a super-

resolution Mask R-CNN architecture uses scale-aware fusion to improve ship detection in noisy SAR settings, providing evidence-based navigation management tools.

Ecosystems and water quality

Chlorophyll-a (Chl-a) variations and harmful blooms are important ecological markers. Green tide identification from MODIS images is enhanced by WaveNet (VGG16 + BiFPN + CBAM). The importance of physics-aware features is demonstrated by ResUNet models that relate ocean-atmosphere dynamics to Chl-a in the South China Sea. Long-term variability in the Persian Gulf and Arabian Sea is revealed by rebuilt MODIS datasets, and new techniques also yield transferable Chl-a products for estuaries. MarGEN, a GAN-based augmentation technique that enhances marine mammal call categorisation in situations where labelled audio is limited, is one example of an advancement in acoustic ecology.

Mesoscale and cryosphere dynamics

OIEDNet generates the first large-scale MIZ eddy catalogues by detecting under-ice eddies from Sentinel-1 dual-pol data, whereas Conv-LSTM GAN hybrids predict mesoscale eddy properties with high fidelity.

Perception underwater

Sonar and visual sensing are crucial for autonomous systems. Forward-looking sonar object detection is improved by MLFANet, side-scan sonar small-object recognition is improved by SOCA-YOLO, and underwater optical imaging is improved by CUG-UIEF using edge- and attention-based fusion.

Data, platforms, and decision support

New contributions also address scalable data management (LSH-based retrieval for ocean archives) and decision-making (multi-criteria approaches for underwater IoT and AUV deployments), underscoring the need to co-design sensing, connectivity, and computation.

Cross-cutting lessons

Five themes emerge: (1) multi-scale architectures consistently boost detectability; (2) embedding physics-aware features enhances generalization; (3) translating models to edge-deployable tools enables real-world impact; (4) data efficiency strategies such as augmentation and self-supervision are critical in data-sparse

regimes; and (5) benchmarking and openness will accelerate progress.

Outlook

This Research Topic highlights a decisive shift from proof-of-concept to operational potential in ocean AI. Future priorities include embedding physical priors, advancing generative/self-supervised methods for sparse data, and ensuring scalability, efficiency, and usability for real-world applications. Together, these works show how DL and RS can protect mariners, monitor ecosystems, and reveal ocean dynamics—bringing us closer to truly actionable ocean intelligence.

We thank all authors and reviewers for their contributions and the editors for their support. We hope that this Research Topic will serve as both a reference and a springboard for progress in observing and managing the blue planet.

Author contributions

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