Ocean Forecasting for Biogeochemical Parameters Using Copernicus Marine Data in the Global Ocean, Bay of Bengal, and Mediterranean Water

The sustainable management of marine ecosystems relies heavily on the accurate forecasting of biogeochemical parameters, including Sea Surface Temperature (SST), Nitrate Concentration, Oxygen Concentration, pH, Phosphate Concentration, Phytoplankton Concentration, Silicate Concentration, and Chlorophyll. These parameters are crucial for understanding ecosystem dynamics and are vital for stakeholders involved in fisheries management, environmental conservation, and climate adaptation. Despite their importance, accurate forecasting across diverse marine regions such as the Global Ocean, Bay of Bengal, and Mediterranean is challenging due to complex interactions and high variability in oceanic conditions. Current methods often lack the necessary spatial and temporal resolution, limiting their utility in comprehensive decision-making, particularly in under-observed ocean regions. To address these challenges, this study aimed to develop robust forecasting models using historical Copernicus Marine Data to analyze and predict biogeochemical parameters in the Global Ocean, Bay of Bengal, and Mediterranean waters. The specific objectives were to (1) analyze historical data to identify patterns and trends, (2) develop and validate machine learning models for forecasting, and (3) provide actionable insights for multiple stakeholders. The historical data were meticulously preprocessed to ensure consistency and quality, involving steps such as standardization, gap-filling, and rigorous quality checks. Machine learning techniques, particularly Convolutional Neural Networks (CNNs) and Long Short-Term Memory networks (LSTMs), were employed to model the spatiotemporal dynamics of biogeochemical parameters. CNNs were adept at identifying spatial patterns and regional variations, while LSTMs were effective in capturing temporal trends and dynamics. The models were trained on an extensive dataset and validated using a holdout dataset to ensure robustness and generalizability. Optimization techniques, including hyperparameter tuning and cross-validation, were used to enhance model performance. The findings revealed that the developed forecasting models demonstrated strong predictive capabilities across different temporal scales, from short-term variations to seasonal trends. Significant spatial variations in biogeochemical parameters were observed across the Global Ocean, Bay of Bengal, and Mediterranean, providing valuable insights into ecosystem health and dynamics.

Notably, SST values in the Bay of Bengal were consistently above 25°C, underscoring substantial regional differences compared to the Global Ocean and Mediterranean. These insights form a critical foundation for informed decision-making in fisheries management, environmental monitoring, and climate adaptation strategies, highlighting the study's contribution to sustainable marine ecosystem management.

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