



COMPARISON OF INDIAN OCEAN DATA WITH ATLANTIC OCEAN DATA AND DO THE TREND ANALYSIS ON VARIOUS PARAMETERS USING DEEP LEARNING TECHNIQUES

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Abstract: The global oceans play an important role in climate regulation, supporting the impact of marine biodiversity and global weather patterns. Understanding long-term trends in marine parameters is of great importance in monitoring climate change and impacts on marine ecosystems. This study presents a comparative analysis of the Indian and Atlantic Oceans by examining important ocean parameters such as sea level, sea surface temperature, salinity, pollution index, chlorophyll concentration, ocean pH, dissolved oxygen, nitric acid concentration, and phosphate concentration from 1990 to 2024. We adopted an analysis of historical trends and forecasts of future changes through 2030. The purpose of the study is to highlight differences in marine behavior, recognize potential anomalies, and contribute to a better understanding of oceanographic variation associated with climate. The results of this study can provide valuable insight into environmental surveillance, degree of climate change reduction, and marine resource management.

Index Terms - Oceanographic parameters, deep learning, trend analysis, anomaly detection, time series forecasting, GRU, sea level rise, sea surface temperature, salinity, pollution index, chlorophyll concentration, ocean pH, dissolved oxygen, climate change, environmental monitoring.

INDRODUCTION

The ocean covers more than 70% of the Earth's surface, plays an important role in regulating the global climate, supporting marine biodiversity and the maintenance of human life. However, climate change, pollution and increased anthropogenic activity have led to major changes in marine conditions. Understanding and analyzing these changes is extremely important for predicting long-term environmental impacts and developing effective reduction strategies. The purpose of this study is to compare comparative analysis of the Indian and Atlantic Oceans by examining the most important oceanographic parameters such as sea level, sea surface temperature, salinity, pollution index, chlorophyll concentration, ocean pH value, dissolved oxygen, nitrogen concentration, and phosphate concentration. These parameters provide insight into marine health, climate script trends, and ecosystem stability.

The Indian Ocean is known for its high standards of coastal pollution due to rapid global warming, its important monsoons, and industrial and agricultural wastewater. Meanwhile, the Atlantic Ocean plays an important role in the global ocean cycle and is affected by variations in the formation of gulf streams, saline and deep water. Comparisons of these two oceans can help identify regional differences, recognize anomalies, and predict future trends with the help of advanced analytical methods. To achieve this, deep-learning techniques from research, such as GRU models (Gated Recurrent Units), are used for trend prediction and anomaly recognition methods such as separating forests and Z-scores. By using these approaches, research seeks to uncover long-term trends, identify unusual variations, provide a data-driven perspective on ocean changes from 1990 to 2024, and forecasts will expand by 2030.

NEED OF THE STUDY.

The study of oceanic trends and anomalies is crucial due to the growing impact of climate change on global marine ecosystems. The Indian and Atlantic Oceans play a significant role in regulating Earth's climate, influencing weather patterns, biodiversity, and

human livelihoods. Rising sea levels, increasing ocean temperatures, and changing salinity levels pose threats such as coastal flooding, marine habitat loss, and disruptions to fisheries. Additionally, ocean acidification and pollution are escalating concerns, affecting marine biodiversity and water quality. A comparative analysis of the Indian Ocean with international ocean data using deep learning techniques allows for accurate trend prediction and anomaly detection. Traditional statistical methods often fail to capture complex, non-linear oceanic variations, making AI-driven approaches essential for future climate resilience planning. This research will aid policymakers, environmentalists, and marine scientists in understanding long-term oceanic changes, developing early warning systems, and formulating sustainable ocean management strategies.

RESEARCH METHODOLOGY

Deep learning methodologies were used to identify relative oceanographic features and their variability in the Indian and Atlantic Oceans. The procedures consist of data acquisition, data preprocessing, analysis, prediction, and anomaly identification. The details are as follows;

3.1 Population and Sample

The population for this study comprises oceanographic data from the Indian Ocean and Atlantic Ocean covering the period from 1990 to 2024. The study focuses on key oceanic parameters, including sea level, sea surface temperature, salinity, pollution index, chlorophyll concentration, ocean pH, dissolved oxygen, nitrate concentration, and phosphate concentration. A representative sample of this data has been extracted, ensuring inclusion of diverse temporal and spatial variations. The sampling strategy incorporates data points from different seasons and years, providing a robust foundation for analyzing trends and performing comparative assessments between the two oceans.

3.2 Data and Sources of Data

Data covering years 1990 to 2024 was sourced from both NOAA and NASA, including information such as sea level, temperature, salinity, chlorophyll concentration, ocean's pH, pollution, oxygen, and overlying nitrates and phosphates. Data gaps were imputed, and the data was standardized for deep learning framework.

3.3 Theoretical framework

The study is grounded in the integration of oceanographic sciences, statistical analysis, and machine learning techniques to assess long-term oceanic trends and environmental changes. The framework is based on climate science principles, data-driven modeling, and anomaly detection to systematically examine variations in key oceanographic parameters such as sea level, temperature, salinity, pollution index, and chlorophyll concentration across the Indian Ocean and Atlantic Ocean. Oceans play a crucial role in regulating global climate patterns, influencing temperature distribution, carbon cycles, and marine ecosystems. Changes in oceanic parameters are often linked to anthropogenic activities, greenhouse gas emissions, and natural climatic fluctuations such as El Niño and La Niña. By analyzing oceanographic datasets, this study aims to provide insights into the effects of climate variability and human-induced changes on ocean health.

The research employs a quantitative approach using historical oceanographic datasets to detect long-term patterns and emerging trends. By leveraging statistical comparisons and deep learning techniques, the study provides a data-centric perspective on oceanic variations. The incorporation of time-series forecasting models enables the prediction of future oceanic trends, helping to assess potential environmental risks.

The study integrates machine learning models such as GRU (Gated Recurrent Unit) networks for trend prediction, ensuring an efficient and adaptive approach to analyzing oceanic data. GRUs, known for their ability to process sequential data, facilitate the forecasting of sea level rise, temperature fluctuations, and salinity changes. Additionally, anomaly detection algorithms such as Isolation Forest and Z-Score methods are applied to identify irregular oceanic patterns, which may indicate climate-driven disruptions or extreme environmental changes.

By comparing the Indian Ocean and Atlantic Ocean, the study identifies regional differences in climate-driven oceanic transformations. This comparative framework highlights how ocean circulation, geographical factors, and climate influences contribute to distinct environmental patterns. Such an analysis helps in understanding localized vulnerabilities and formulating region-specific strategies for climate adaptation and marine conservation. By combining oceanographic theories with advanced computational methods, this theoretical framework establishes a foundation for the study's comparative analysis, predictive modeling, and anomaly detection, ensuring a robust approach to understanding oceanic trends and their implications for global climate change and marine ecosystems.

3.4 Statistical tools and Deep Learning Techniques

This section elaborates the proper statistical/econometric/financial models which are being used to forward the study from data towards inferences. The detail of methodology is given as follows:

3.4.1 Comparative Analysis

Long-term differences between the Indian Ocean and Atlantic Ocean were analyzed through statistical comparisons of key oceanographic parameters such as sea level, temperature, salinity, and pollution levels. The data was visualized using graphical representations to observe trends and variations across different time periods, providing insights into how these parameters evolve over time due to climate change and human-induced factors.

3.4.2 Trend Prediction using GRU

A Gated Recurrent Unit (GRU) model, a deep learning approach suitable for time-series forecasting, was trained on oceanic data from 2020 to 2024 to predict trends for 2025-2030. The model was trained and validated using performance metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) to ensure the accuracy and reliability of the predictions. This approach enabled an efficient and data-driven prediction of future oceanic conditions.

3.4.3 Trend Prediction using GRU

An anomaly detection framework was implemented using three techniques: Autoencoder-Based Anomaly Detection, which identifies complex anomalies in ocean data, Isolation Forest, which isolates outliers in pollution index, temperature, and chlorophyll concentration, and Z-Score Method, which statistically detects deviations from normal patterns. The integration of these methods provided a robust mechanism for detecting climate-induced abnormalities and ecological disruptions.

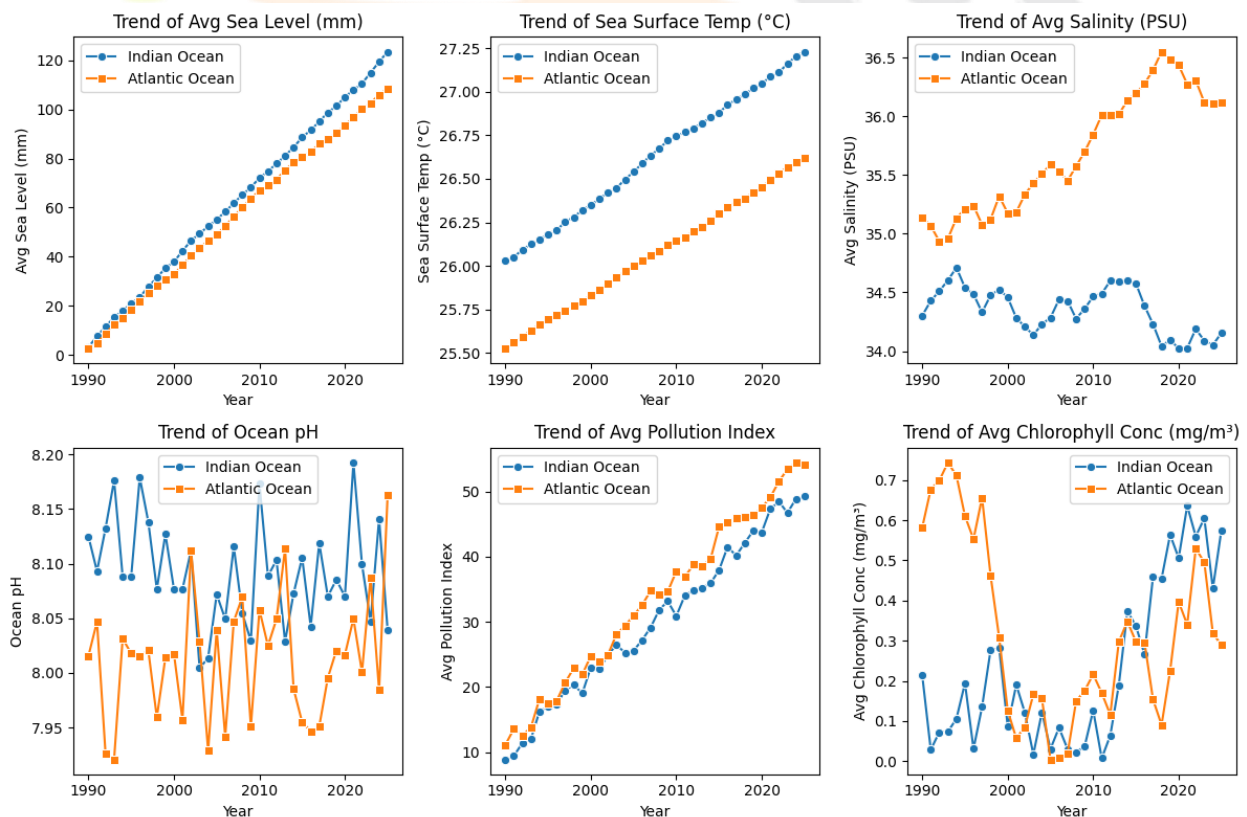
3.4.4 Comparative Trend Analysis

A comparative trend analysis of predicted data for both oceans was conducted to highlight climate-driven differences, emerging environmental risks, and potential future changes. This holistic approach contributes to understanding oceanic trends, aiding climate scientists and environmental policymakers in making informed decisions.

RESULTS AND DISCUSSION

4.1 Results of Comparative Analysis

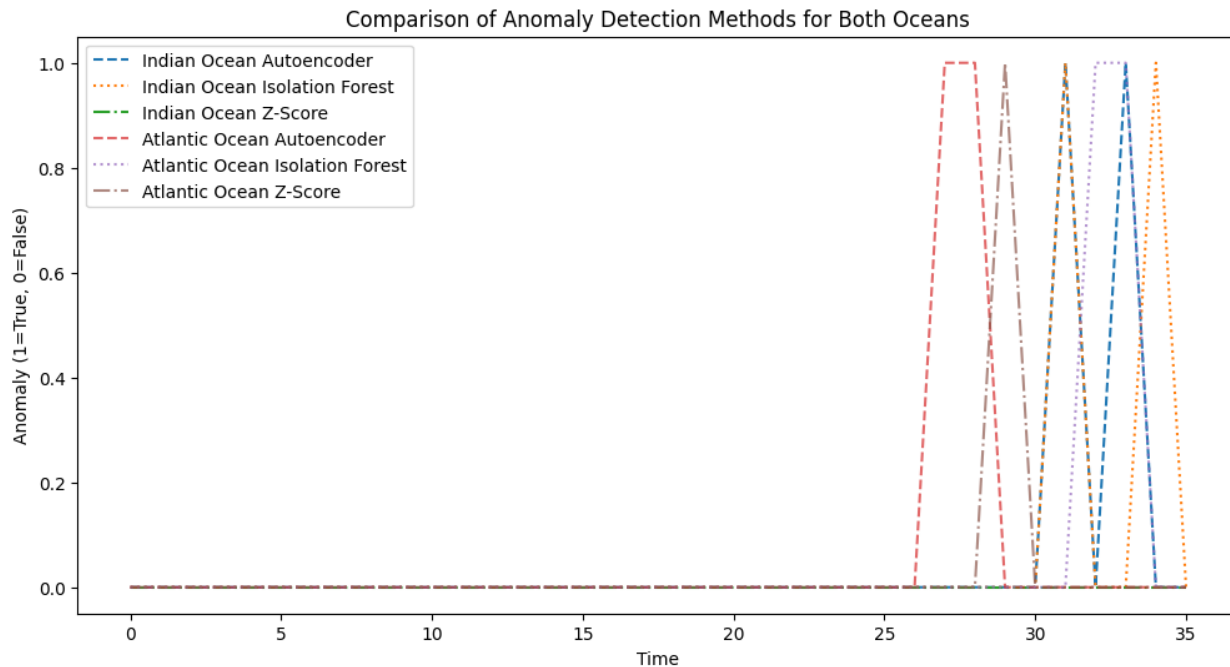
Comparative analysis of the Indian and Atlantic Oceans showed different trends in the most important ocean parameters. Both oceans have been constantly increasing in sea levels between 1990 and 2024, and the Indian Ocean is rapidly increasing, perhaps due to local climate change and melted glaciers. Sea surface temperatures are rising in both oceans, and a significant increase in the Indian Ocean is observed, leading to ecological changes and obstacles in marine bidding. The salinity of the Atlantic Ocean fluctuates significantly, but the Indian Ocean is relatively stable. Ocean pH values drop in both oceans, indicating an increase in acidification that can affect ocean duration. Polluting levels are rising in both oceans, and the Indian Ocean has recorded a sharp increase due to industrial and coastal activity. Chlorophyll concentrations, which are likely influenced by seasonal and climatic factors, fluctuate.



4.2 Results of Anomaly Detection

Anomaly detection analysis showed that the Indian Ocean has more frequent anomalies than the Atlantic Ocean. The Autoencoder recognized significant anomalies, particularly in relation to temperature tips, contamination and salt pay fluctuations, especially in

the Indian Ocean. The insulation identified approximately 5% anomalies in both oceans, resulting in the Indian Ocean being slightly higher due to increased variability. The Z-score method marked extreme variations in which the parameter values exceed three standard deviations. These results highlight the potential environmental risks and the need for further monitoring and reduction strategies. Variations in Atlantic salt pay are expected to be more pronounced, but ocean pH is expected to reduce both, indicating continuous acidification. Levels of contamination are increasing, particularly in the Indian Ocean, correlate with industrial activity, but we expect regular deviations in chlorophyll concentrations. Although dissolved oxygen levels can affect marine organisms, it is predicted that changes in nitrate and phosphate concentrations may indicate a continuous shift in the marine nutrient cycle. These trends underscore the importance of positive climate and environmental measures.

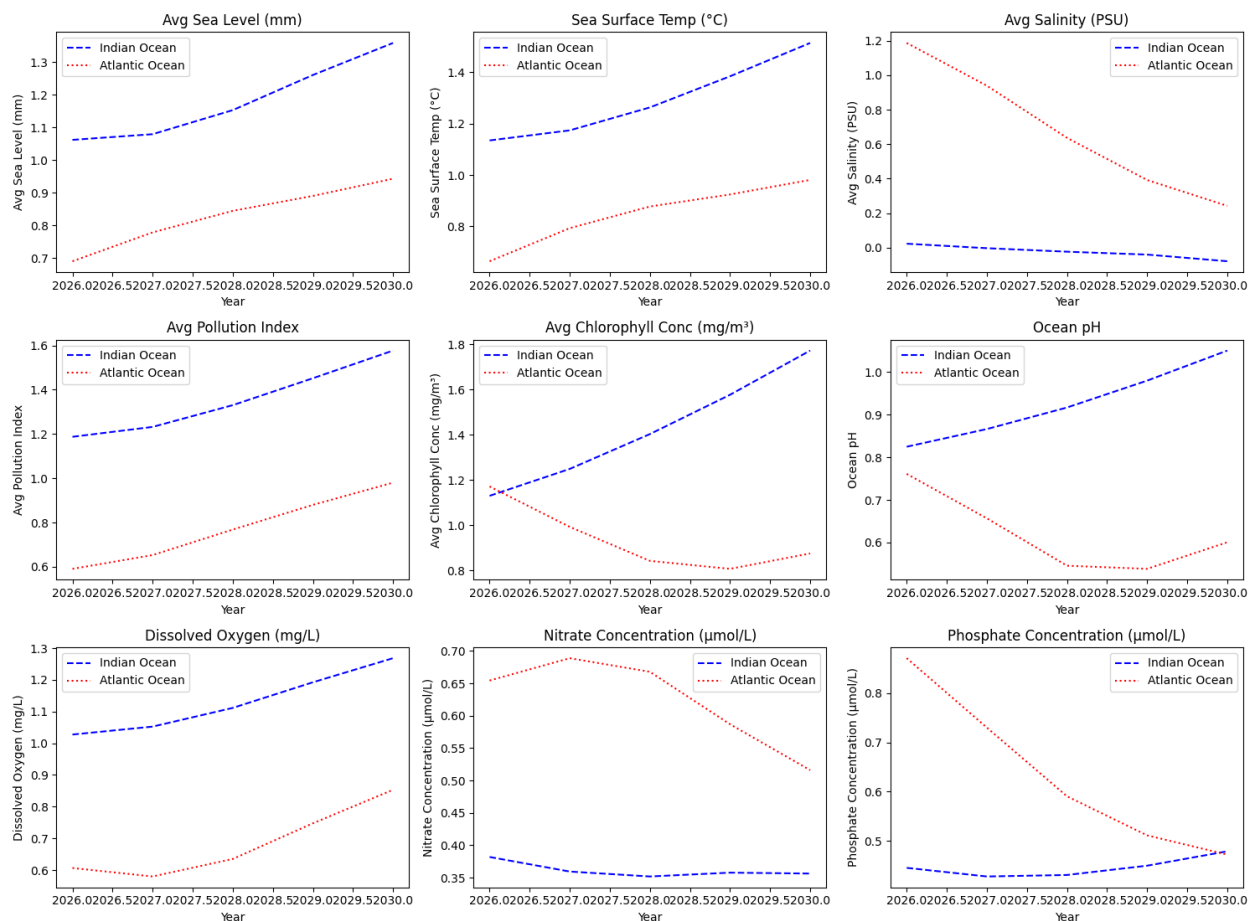


4.2 Results of Predictions

The GRU model predicts a continued rise in sea level and sea surface temperature for both oceans, with the Indian Ocean experiencing a sharper increase. Salinity fluctuations are expected to be more prominent in the Atlantic Ocean, while ocean pH is predicted to decline across both, indicating continued acidification. Pollution levels are set to increase, especially in the Indian Ocean, correlating with industrial activities, whereas chlorophyll concentration is expected to show periodic variations. Dissolved oxygen levels are forecasted to decrease, potentially affecting marine life, while changes in nitrate and phosphate concentrations indicate ongoing shifts in oceanic nutrient cycles. These trends emphasize the importance of proactive climate and environmental measures.



Predicted Trends (2026-2030) for Indian and Atlantic Oceans



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