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Nearshore Wave Prediction for Renewable Energy: Initial Results with Remote Sensing and Buoy Data

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Background

Accurate prediction of nearshore waves is essential for optimizing renewable energy resources and ensuring safe maritime operations [2][1]. This study investigates the potential of remote sensing data from Copernicus, specifically Synthetic Aperture Radar (SAR) from Sentinel-1 and Normalized Difference Water Index (NDWI) from Sentinel-2, in predicting nearshore wave characteristics. We aim to enhance current predictive models by integrating advanced remote sensing technologies with traditional buoy data measurements from Irish Marine Institute.

Our study combines satellite images with actual ocean measurements to predict wave behavior near shorelines. We used images from Sentinel-1 and Sentinel-2 satellites that help us see the ocean’s surface from space. These images were paired with data from ocean buoys that measure wave conditions directly. Our goal was to align these two types of data, by matching them in date and location, to see how well changes seen from space correspond with what’s happening in the ocean. By comparing these two data sets, we were able to analyze patterns and predict wave behavior.

Key words - Nearshore wave prediction, remote sensing, oceanography, buoy, Copernicus, SAR, Sentinel-1, NDWI, Sentinel-2

Applications - Wave energy optimization, coastal management and planning, environmental monitoring, maritime navigation safety

Results

Mean Wave Height and Mean SAR Values
- The regression line shows a positive slope, indicating that as SAR values increase, indicating rougher sea surfaces, the wave height also tends to increase.
- This positive correlation supports the question that SAR backscatter intensities can be effective predictors of wave height.

Mean Wind Speed and Mean SAR Values
- There is a clear positive correlation, as seen by the upward slope of the regression line.
- This strong correlation confirms that higher wind speeds, which contribute to greater surface roughness, are effectively captured by SAR, making it a valuable tool for predicting wind conditions at sea.
- NDWI values had no correlation with buoy data.

Methodology

SAR Images for Surface Roughness
- Capture radar backscatter intensities from the ocean surface.
- Analyze pixel intensity values to gauge sea surface roughness.
- Correlate these intensities with buoy measurements to predict wave conditions.

NDWI Images for Water Content
- Utilize green and near-infrared bands to distinguish water from land and assess water saturation.
- Applied to study saturation levels and surface moisture near coastlines.
- Compare NDWI values with buoy data to explore correlations with wave activity and oceanographic conditions.

Conclusion and Future Work

This study demonstrates the potential of Synthetic Aperture Radar (SAR) from Sentinel-1 for predicting nearshore wave characteristics, with SAR data showing strong correlations with wave height and wind speed. Conversely, NDWI data showed limited relevance in predicting wave conditions, highlighting the importance of choosing the right remote sensing technologies based on specific needs.

Future Work
- Implementing deep neural networks to capture complexities, exploring models such as Regression Convolutional Neural Networks (RCNN), Long Short-Term Memory (LSTM) and Conv-LSTM, to improve the predictive accuracy of SAR data.
- Expanding data sources by integrating additional remote sensing data types to enhance environmental monitoring capabilities such as significant wave height (SWH) from altimetry data.
- Exploring different pre-processing techniques on SAR data and evaluating which techniques are most suitable.
- Focusing on a specific target variable such as wave height.

References

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