Insight into Maritime Surveillance Through Integrated Multi-Source Satellite Imagery: Monitoring Oil Spills, Detecting Vessels, and Observing Extreme Weather

The recent expansion of the global economy has led to a substantial increase in maritime traffic, resulting in numerous adverse impacts on the environment and human life, particularly in coastal regions and vulnerable areas. Oil spills stemming from offshore exploration and transportation, such as oil leaks and shipwrecks, are frequently observed in various regions like the Gulf of Guinea, the Persian Gulf, and the Gulf of Mexico. These incidents have caused significant harm to ecosystems and local economic activities such as fishing, tourism, and aquaculture. Moreover, there has been a notable rise in vessel collision incidents in recent years, particularly in densely trafficked maritime zones. These collisions can lead to oil spills and disrupt maritime traffic for extended periods, which may result from human errors or extreme weather events over the sea, including strong surface winds and heavy rainfall associated with deep convection, cyclones, and storms. In recent years, satellite imagery provided by synthetic aperture radar (SAR) and optical sensors has been widely employed to enhance maritime surveillance and reduce incidents at sea. Particularly in isolated areas or open seas, satellite images have become the primary and effective data source for applications such as oil spill monitoring, ship detection, and extreme weather observation. This is owing to their high spatial resolution, wide swath, and availability. This study aims to explore the advantages of satellite data for maritime surveillance by integrating diverse image types, including SAR and optical images, for the following purposes: i. Oil spill detection and monitoring using a two-step method that combines the Hierarchical Split-Based Approach (HSBA) algorithm with oil contour determination. ii. Ship detection at various scales employing Deep Learning Object Detection approaches. iii. Estimation of strong surface winds associated with deep convection using the CMOD5.N Geophysical Model Function.

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