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Monitoring Shallow Water Depths: A Review of Satellite-Derived Bathymetry Methods

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Satellite-Derived Bathymetry (SDB) offers a cost-effective alternative to traditional shipborne surveys for mapping large coastal areas. This technique utilizes optical remote sensing data from multispectral sensors to estimate water depth. The fundamental principle relies on the behavior of light as it travels through the water column; as depth increases, light intensity decreases due to absorption and scattering. Different wavelengths penetrate to varying degrees, with blue light reaching the greatest depths while red light is absorbed quickly. By analyzing these spectral features, researchers can calculate underwater topography. Currently, SDB techniques are categorized into two primary groups: physically based (analytical) models, which simulate light propagation without needing local in-situ depth calibration, and statistical (empirical) models, which correlate satellite data with known depth measurements from nautical charts, ship-based acoustic surveys or airborne LiDAR.

While both approaches provide extensive spatial coverage at a lower cost, they are generally limited to clear, shallow waters, typically reaching depths of less than 20 meters. Analytical models are highly accurate but complex and data-intensive, whereas empirical models are more accessible but rely heavily on the quality of reference data. Recent advancements in machine learning have significantly improved the automation and performance of these empirical methods. This study evaluates the core concepts, advantages, and limitations of various SDB approaches, with a focus on Landsat-8 and Sentinel-2 data. Furthermore, the research details essential processes for empirical model calibration, validation, and detecting model bias. The findings emphasize that rigorous evaluation and bias correction are critical for ensuring the reliability of depth data in diverse coastal environments.

Keywords: Satellite-Derived Bathymetry, Remote Sensing, Empirical Models, Stumpf Algorithm, Coastal Waters, Model Bias Detection and Correction.