

Can machine learning integrate physical processes to accurately reconstruct satellite-derived sea surface temperature under cloud and cloud-free areas?

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ABSTRACT

Sea surface temperature (SST) plays a crucial role in weather patterns, climate systems, and marine ecosystems, as it reflects the energy exchange between the ocean and the atmosphere that regulates the climate. Hence, obtaining continuous, high-quality SST data with broad spatial coverage and long temporal duration is a fundamental requirement for various applications in atmospheric and oceanic sciences, marine resource management, and disaster prevention. With the rapid advancement of remote sensing technology, meteorological satellites have been launched over the past decades to monitor weather activities over the ocean. However, satellite remote sensing with infrared sensors can be affected by interference from atmospheric conditions, particularly cloud cover. Therefore, we proposed a physically-informed machine learning approach to reconstruct daily SSTs in both cloud-covered and cloud-free regions. Following this core concept, we developed the Temporal-Spatial Radial Basis Function Neural Network (TS-RBFNN) and suggested an appropriate model evaluation procedure to address the lack of data in cloudy areas. Overall, the TS-RBFNN showed significantly improved performance in full SST reconstruction; it achieved up to a 60% improvement compared to traditional statistical methods (Data Interpolation Empirical Orthogonal Function).

Keywords: Sea surface temperature, Reconstruction, Satellite observation, Physical process, Machine learning, TS-RBFNN.