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# Bridging between SeaWiFS and MODIS for continuity of chlorophyll-*a* concentration assessments off Southeastern China

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**Abstract**

Chlorophyll-*a* (Chl) concentration in the Taiwan Strait (TWS) and in the South China Sea (SCS) was estimated using time series of satellite data collected with the MODIS/Aqua and SeaWiFS instruments, and validated with in situ measurements from three cruises conducted in winter and summer 2004. For Chl between 0.1 and 10 mg $m^{-3}$, both SeaWiFS and MODIS agreed well with in situ data. Errors for turbid coastal waters were larger than for offshore waters but the overall RMS (root mean square) error in log scale was within 0.35. The percentage RMS error was much larger, varying between 60% and 170% for open ocean and most of the shallow (<30 m), coastal regions. However, there was no large systematic error or significant bias in either satellite data set, and these numbers were comparable to those for other global oceans and not significantly larger than the algorithm "noise" (0.22 in RMS error in log scale). Further, SeaWiFS and MODIS showed similar spatial and temporal patterns between July 2002 and October 2004, as well as nearly identical concentrations for Chl between 0.1 and 4 mg $m^{-3}$. RMS difference between the two data sets of monthly mean Chl for several sub-regions was generally <11% and <0.05 (after logarithmic transformation). For each individual month, the statistics (mean, mode, median) of the two data sets for the entire study region ($6–9\times10^5$ satellite pixels at ~1 km resolution) were very similar, with RMS differences typically between 30% and 40% and between 0.10 and 0.15 (after logarithmic transformation), where no significant bias was found. Therefore, it would be possible to continue the time series using only one sensor such as MODIS, in the eventual absence of SeaWiFS. Further research is needed to improve the remote sensing algorithms for application in turbid coastal waters.


*Keywords:* Remote sensing; Ocean color; Continuity; Chlorophyll a; SeaWiFS; MODIS; Taiwan Strait; South China Sea

## 1. Introduction

Assessment of environmental change over long periods of time requires a time-series of consistent observations. Phytoplankton pigment concentrations such as chlorophyll-*a* (Chl) provide a measure of the biological state of the surface ocean. Satellite sensors designed to observe the Visible Sea Spectral Reflectance (VSSR, traditionally called ocean color) provide estimates of short-term (seasonal and inter-annual) to long-term (decadal) changes in the global ocean Chl (e.g., Behrenfeld et al., 2001; Gregg & Conkright, 2002; Gregg et al., 2003). However, for a particular region, especially a coastal region, the accuracy of the long-term trend is often unknown due to uncertainties associated with satellite data products.

Of particular interest are observations from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) that has operated since 1997 (McClain et al., 1998) and from the two Moderate Resolution Imaging Spectroradiometers (MODIS), including Terra MODIS (since 1999) and Aqua MODIS (since 2002) (Esaias et al., 1998). These satellite sensors provide near-daily coverage of the global ocean. Continuity in coverage is

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expected with the future National Polar-Orbiting Operational Environmental Satellite System (NPOESS) and the NPOESS Preparatory Mission (NPP; expected launch in 2008), which will carry the Visible/Infrared Imager/Radiometer Suite (VIIRS) instruments, which are similar in capability to SeaWiFS and MODIS.

Some efforts have been made to merge global time series from different VSSR (i.e., ocean color) sensors, primarily the Coastal Zone Color Scanner and SeaWiFS (Gregg & Conkright, 2001; Siegel & Maritorena, 2000; Yoder et al., 2001). But little has been done on merging global-scale SeaWiFS and MODIS series. SeaWiFS is a well-calibrated and stable sensor (McClain et al., 2004). In comparison, there is a general perception that MODIS data are of lower quality due to the publicity that several artifacts in sensor design have received (for example stray light, polarization, and data striping). The future availability of SeaWiFS data is not clear, since the mission has exceeded its 5-year life design. However, MODIS is expected to continue into the future and provide a bridge to VIIRS. To enable a smooth transition from SeaWiFS to MODIS, it is necessary to assess differences between these sensors. Such comparison is particularly useful to regional investigators, given that some limited regional comparisons have shown large variations (Blondeau-Patissier et al., 2004; Darecki & Stramski, 2004). Here we present the first validation and comparison results for observations of Chl in the Taiwan Strait (TWS) and the northern South China Sea (SCS) to assess the utility of MODIS in case that SeaWiFS data may not be available in the future.

The TWS and the northern SCS are located along the southeast coast of China (Fig. 1). The region is characterized by marked seasonal changes in physical (Jan et al., 2002; Su, 2004) and biological properties (Liu et al., 2002; Ning et al., 2004). The near-shore, shallow (<200 m) waters of the northern SCS receive significant inputs of coastal runoff with high loads of nutrients and other terrestrial substances, including contributions from the Pearl River. Further, coastal upwelling occurs regularly in this region (Hong et al., 1991), affecting primary production and fisheries. Over half of the area of the TWS is <50 m deep. These shallow regions are optically complex compared to the adjacent deep SCS.

Preliminary studies used SeaWiFS data to examine the variability of surface chlorophyll-*a* (Chl) and driving factors in the SCS and TWS regions (e.g., Lin et al., 2003; Shang et al., 2004a; Tang et al., 2002). However, validation of the SeaWiFS products has been sparse because extensive and reliable in situ measurements have not been available. Further, no comparison has been made between SeaWiFS and MODIS for this region.

This study addresses two major questions:

1) How accurate are Chl estimates derived from SeaWiFS and MODIS?
2) How do MODIS data products compare with those from SeaWiFS?

Answering these questions will help develop a consistent, long-term Chl time-series off southeastern China, which is the

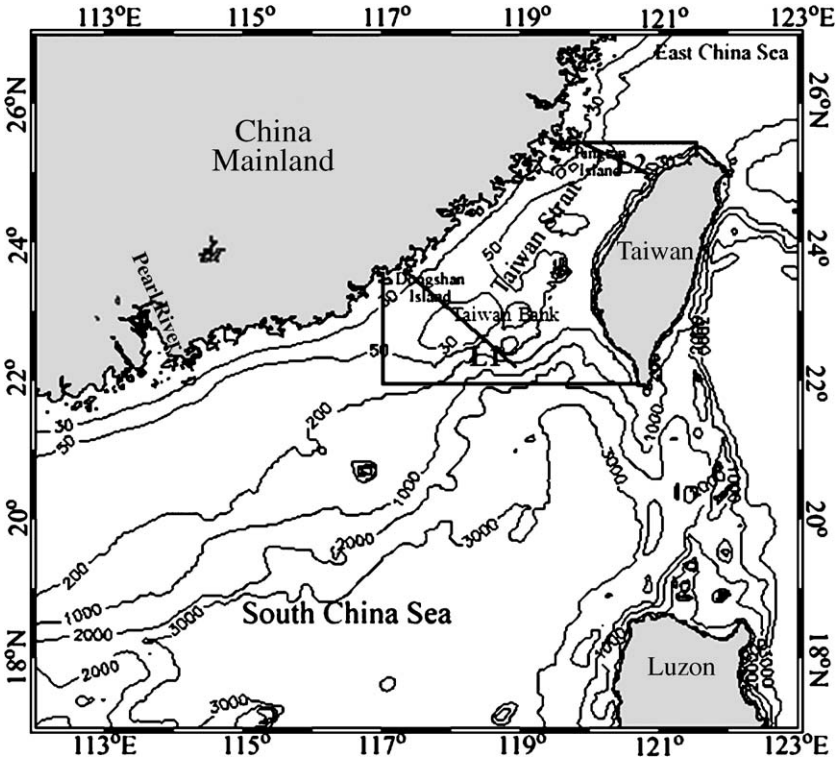


Fig. 1. Map showing the study area, with the Taiwan Strait as used here defined by solid lines. Overlaid on the map are the bathymetry contours (unit: meter) and two cross-shelf transect lines where chlorophyll from MODIS and SeaWiFS were extracted and analyzed.