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Review article

Satellite data and real time stations to improve water quality of Lake Manzalah

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Abstract

The objective of this study is to choose suitable approach for generating quantitative water quality products from Medium-Spectral Resolution Imaging Spectrometer (MERIS) imagery in near real-time. Four MERIS Case-II water processors included in the BEAM software package were studied for estimating the lake water quality. Chlorophyll-a (CHL), Turbidity (TUR) products of the BEAM processors were compared to in situ data. No statistically significant correlations were observed between in situ data and individual top-of-atmosphere (TOA) reflectances. By contrast, significant correlations were observed for the Band9/Band 7 ratio. Using uncorrected band ratios of TOA reflectances as input, coefficients of determination of 0.83 and 0.76 were obtained for TUR and CHL, respectively. The regression models for TUR and CHL were subsequently validated. The formulating regression models based on TOA reflectances is a valid approach to generate Earth Observation (EO) based water quality information in an operational setting. The results revealed that the empirical models estimated for TUR and CHL are more appropriate to generate water quality products from MERIS imagery.

Keywords: Satellite data; Real time monitoring; Water quality

Contents

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1. Introduction

Egypt's large water bodies are the cornerstone of the country's water resources management strategy. In addition to the Nile River, Egypt's northern lakes are major sources of water for fisheries and aquaculture activities. Water quality concerns arise from the inflow of agricultural drainage water as well as the direct discharge of industrial and domestic wastewaters into the lakes system. Key to the design of adequate water management scenarios is the access to accurate and reliable information on the occurrence and distribution of water quality parameters.

The lake water quality monitoring procedures currently in place rely on the monthly of in situ measurements of drainage channels leading to the lake. These traditional monitoring programs provide essential and accurate results on water monitoring however, they are expensive and insufficient. Furthermore, it does not adequately capture the spatial and temporal variability of water quality parameters in the highly dynamic lake ecosystems.

Remote sensing techniques have been used to assess several water quality parameters such as TUR and CHL. The strength of remote sensing techniques lies in their ability to capture the spatial and temporal variability of water quality parameters in the highly dynamic lake ecosystem that is typically not possible from in situ measurements. The extraction of water constituents from EO data is frequently based on empirical algorithms where water quality variables are estimated from the reflectance at one wavelength or from ratios between reflectance measured at two wavelengths. The empirical approach is simple to apply and has been shown to produce accurate results even in cases of lakes with more than one dominant optically active ingredient (Kallio et al., 2005). However, extracting quantitative TUR and CHL information relies on the availability of in situ measurements collected concurrently with the acquisition of satellite imagery.

Several algorithms that use reflectance in the red and near infrared (NIR) regions have been developed and shown to yield accurate estimates of Chlorophyll-a concentration in turbid productive estuarine and coastal waters (Le et al., 2009; Yang et al., 2010; Gitelson et al., 2011; Gurlin et al., 2011). It has also been estimated with the blue/green reflectance ratio in the case of oceans (O'Reilly et al., 1998) and with NIR/red ratio (Gitelson et al., 2000) in lakes. Bostater et al. (2009) found low relative errors in turbidity retrieval at 681 nm (less than 35%) provided no significant fluorescence affects this range. Rim et al. (2013) mapped total suspended matter (TSM) data from the Moderate Resolution Imaging Spectroradiometer (MODIS) images using a semi-empirical algorithm at band 667 nm and obtained a correlation coefficient of 68.9%. MERIS is an instrument aboard the Environmental Satellite (Envisat), its objective is, among others, remote sensing of water quality. Moses et al. (2009, 2012) demonstrated that MERIS band 2 and 3 algorithms can yield accurate estimates of Chl-a concentration in the Azov Sea. Härmä et al. (2001) revealed that MERIS band 9 centered at 705 nm is proven to be of vital importance for the detection of chlorophyll a in the surface waters of Finland. The objective of this study is to choose the most suitable approach to generate quantitative water quality products from MERIS imagery in near real-time.

2. Materials and methods

2.1. Description of Lake Manzalah

Lake Manzalah is located in the northeastern edge of the Nile Delta, separated from the Mediterranean Sea by a sandy beach ridge. It is bordered by the Mediterranean Sea in the north, the Suez Canal in the east and Damietta Branch in the West. It extends between Latitude 31.03°N and 31.53°N, Longitude 31.84°E and 32.31°E (Fig. 1).

The lake is rectangular in shape, about 60 km in length and 40 km in width with an average depth of 1.3 m. At the beginning of the 20th century the lake covered an area of 1698 km^2 and contained approximately 1000 islands of