Continental Shelf Research 125 (2016) 44–53

Contents lists available at ScienceDirect

Continental Shelf Research

journal homepage: www.elsevier.com/locate/csr

Landsat-8 imagery to estimate clarity in near-shore coastal waters: Feasibility study - Chabahar Bay, Iran

Keivan Kabiri *, Masoud Moradi

Department of Marine remote Sensing, Iranian National Institute for Oceanography and Atmospheric Science, Tehran, Iran

ARTICLE INFO

Article history:
Received 5 December 2015
Received in revised form
11 June 2016
Accepted 29 June 2016
Available online 30 June 2016

Keywords:
Remote sensing
Turbidity
Satellite imagery
Secchi disk depth

ABSTRACT

This study examined the advantages of incorporating the new band of Landsat-8 OLI imagery (band 1: Coastal/Aerosol, 435–451 nm) to a model for estimation of Secchi disk depth (SDD) values (as an indicator for transparency) in near-shore coastal waters using multispectral bands. In doing so, Chabahar Bay in the southern part of Iran (north of Gulf of Oman) was selected as the study area. Two approximately four-hour in-situ observations (including 48 and 56 field measured SDD values for each date respectively) were performed in the study area using Secchi disk; this was designed to start about two hours before and end about two hours after the time of satellite overpasses. Thereafter, a model was formed for estimation of SDD values based on the terms including all possible linear and mutual ratio values of Coastal/Aerosol (B1), Blue (B2), Green (B3), and Red bands (B4). In the first step, the correlation between reflectance/ratio reflectance values of these bands and $Ln(SDD)$ values were calculated to indicate higher correlated bands/band ratios with the first field measured SDD values. Consequently, 17 combinations of highest correlated bands/band ratios were selected to estimate SDD values. In this regard, 32 points among the 48 field observations were selected to determine unknown coefficients of models using a multiple linear regression, and the rest 16 points were designated for accuracy assessment the results. Eventually, the measured SDD values in second field observations were utilized for validating the results. Final results demonstrated that combination of linear terms including B1, B2 and B3 bands and band ratio terms including ratio reflectance values of B4/B3, B3/B1, and B2/B1 has led to obtain the highest accuracy ($R^2=0.866$ and $RMSE=0.919$, SVM feature weight=4.294). This was in agreement with the results obtained from the second observations. Finally, by applying the entire 104 field observed SDD values, the model in form of $SDD=0.077\exp(1.209R_{B1}-1.739R_{B2}+0.412R_{B3}-5.198R_{B3}/R_{B1}+10.408R_{B2}/R_{B1})$ can be used to determine SDD values in near-shore coastal waters of Chabahar Bay using atmospherically corrected reflectance values of Landsat-8 OLI bands.

1. Introduction

The livelihood of a large number of people living in coastal areas is affected by variations in the physical/chemical parameters of near-shore waters. For instance, the amount of turbidity of coastal waters is correlated with physical, chemical, and biochemical suspended materials, and any variation in this parameter may affect the health of habitats such as coral reefs and fishes (Fabricius et al., 2005; De'ath and Fabricius, 2010). Therefore, regular monitoring of water quality in near-shore areas is vital for coastal managers and decision makers. In doing so, conventional field observations are still the most reliable and accurate method to measure the required parameters, despite being the most expensive and time-consuming approach. In addition, these methods cannot cover a vast area in a short period of time. As an alternative tool, satellite remotely sensed data have shown their capabilities for measuring the incorporated water quality parameters. Although in comparison with direct field observations this technique is less accurate, it lowers the cost and may enable us to cover a large area of interest. Furthermore, remote sensing methods are applicable for inaccessible and remote areas.

Typically, high temporal resolution satellite imageries (usually they have low spatial resolution) such as NOAA-AVHRR series (Stumpf and Pennock, 1991; Framiñan and Brown, 1996), MODIS-Aqua and -Terra (Dall'Olmo et al., 2005; Chen et al., 2007; Petus et al., 2010), and SeaWiFS (Dall'Olmo et al., 2005; Bignami et al., 2007) have been designated to measure physical/chemical parameters of coastal waters such as Sea Surface Temperature (SST), Chlorophyll-*a*, and turbidity. Using the wavelengths which correspond to the wavebands of the major sensors applied in coastal

* Corresponding author.
E-mail address: kabiri@inio.ac.ir (K. Kabiri).

http://dx.doi.org/10.1016/j.csr.2016.06.016
0278-4343/

oceanography such as MODIS, MERIS, and ETM+, Ouillon et al. (2008) proposed a global algorithm for estimating turbidity values in coastal waters from remotely sensed reflectance values. However, lower temporal resolution images (with medium spatial resolution) such as Landsat sensors have also been widely used to measure water turbidity/clarity (Aranuvachapun and LeBlond, 1981; Lindell et al., 1985; Olmanson et al., 2008; Bustamante et al., 2009; Zhao et al., 2011; McCullough et al., 2012), suspended sediments (Ritchie et al., 1987; Harrington et al., 1992; Nellis et al., 1998; Min et al., 2012; Cai et al., In press), turbid plumes (Fernandez et al., 2014), and turbid wakes (Vanhellemont and Ruddick, 2014) in near-shore areas and reservoirs. In addition, multi-temporal Landsat imagery was used for assessing water quality parameters in reservoirs (Bonansea et al., 2015). Using a neural network methodology, Zhang et al. (2003) developed a method for retrieving water quality parameters such as Secchi disk depth from combined Landsat-TM and ERS-2 SAR data in the Gulf of Finland. Papoutsa et al. (2014) found a high correlation between reflectance values of Landsat TM/ETM+ band 3 (Red band) and turbidity values in inland water bodies such as reservoirs. However, it seems that combination of Landsat TM1 and TM3 bands (Blue and Red bands) may provide the best results to model water turbidity/

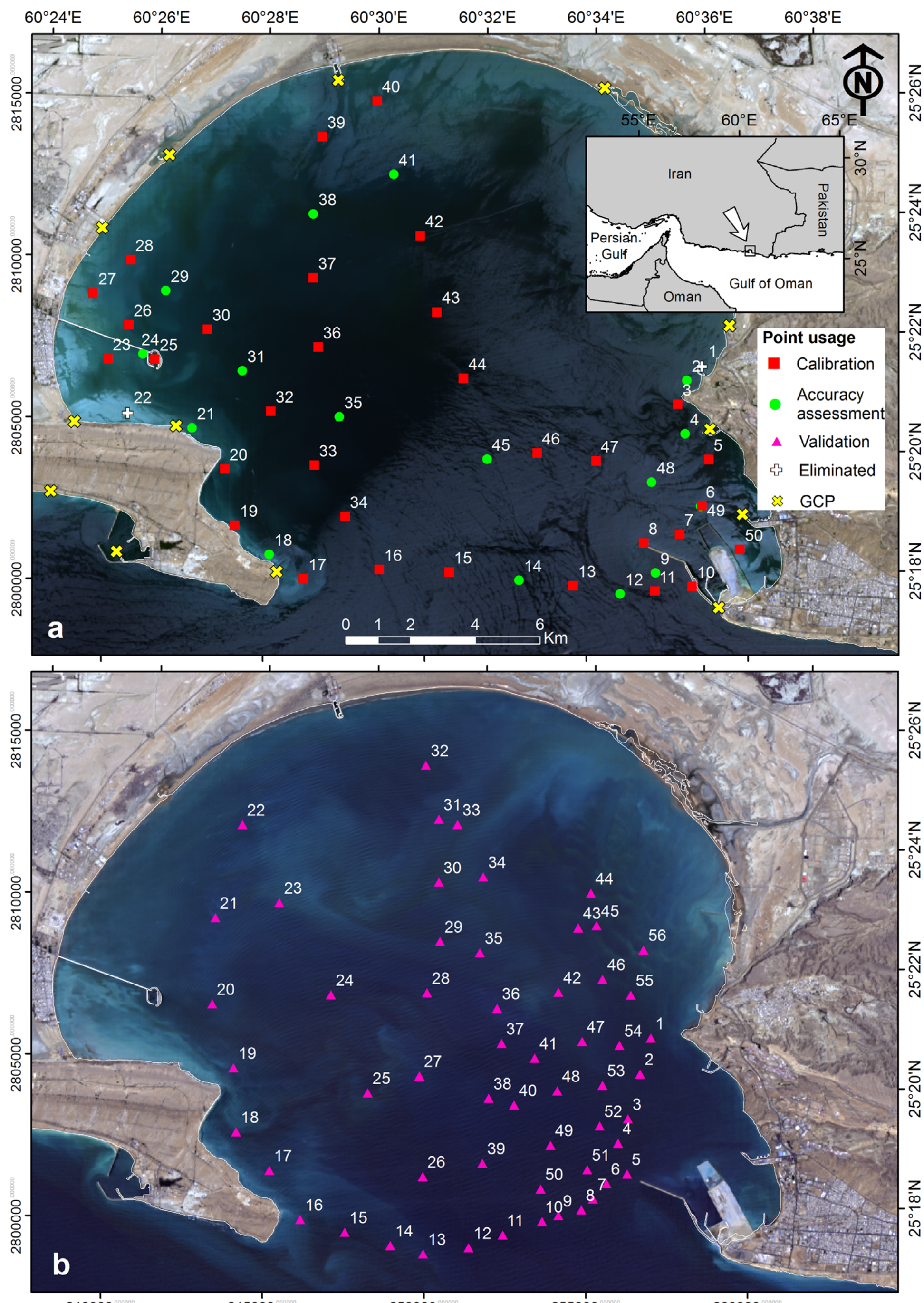

Fig. 1. Chabahar Bay located in the southeast of Iran selected as the study area: 32 points out of the 50 observed points for first date were designated for calibrating the models (red squares in (a)) and 16 points were selected for accuracy assessment of the results (green circles in (a)). Besides, 2 points were eliminated because of shallowness (point No. 1 in a) and extra high turbidity (point No. 22 in (a)). 56 points were selected for validation of the obtained results from first image (b). Background maps are true color composite of applied Landsat-8 images (XY referred to UTM-Zone 41 (WGS-84) projection system). Ground Control Points (GCPs) for geometric correction of raw image are shown as yellow crosses in (a). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)