Marine Geology 351 (2014) 109–111

Contents lists available at ScienceDirect

Marine Geology

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

Discussion

Reply to Comment on "A technique for estimation of suspended sediment concentration in very high turbid coastal waters: An investigation from Gulf of Cambay, India" by D. Ramakrishnan, R. Bharti and M. Das [Marine Geology 346 (2013) 256–261]

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ARTICLE INFO

Article history:
Received 21 December 2013
Received in revised form 17 February 2014
Accepted 19 February 2014
Available online 11 March 2014

We welcome comments by Warrick (2013) on our paper "A technique for estimation of suspended sediment concentration in very high turbid coastal waters: An investigation from Gulf of Cambay, India (Ramakrishnan et al., 2013). We agree that Warrick et al. (2004) have used 765 and 865 nm bands in addition to 555 and 670 nm bands for estimating the suspended sediment load up to 700 ppm. But, our work emphasizes the significance of 743 and 835 nm wavelength regions (not entire 743–835 nm range as mentioned in Warrick, 2013 in his comments) for accurate retrieval of sediment load in very high turbid coastal waters with sediment load over 1000 ppm. As our paper was published as a letter, we had to cut short some of the figures that have given the reader a feeling of "no newness" in our paper. We believe that our paper contributes to contemporary understanding on this subject based on the following.

1. In the case of very high sediment laden waters (typically >1000 ppm), the reflectance–sediment load relationship in bands centered at 765 and 865 nm (as suggested by Warrick et al.(2004)) is not well correlated for coarse grain (silty-sand) and fine grain (silty-clay) dominated waters (Figs. 1, 2), whereas the reflectance at 743 and 835 nm wavelength regions reported by us (Fig. 2 a & b in Ramakrishnan et al., 2013) for high turbid waters have very high correlation ($R^2 = 0.98$-0.99 at 99% significance level) with sediment load. The sediment load retrieved using these wavelengths was field validated and found to be accurate (>90%).
2. Further, researchers working on coastal remote sensing (eg. Warrick et al., 2004; Binding et al., 2005; Bowers et al., 2007; Petus et al., 2010) usually relate reflectance to sediment load with the continuum envelope in the reflectance spectra. Since the continuum envelope is influenced by several other parameters (like the source-sensor geometry, size of the sediments, and presence of ripples/swirls) besides the sediment load, the non-linearity in reflectance–sediment load relationship cannot be attributed to sediment concentration alone, whereas by using continuum removed spectra (Fig. 3) we have reduced the effects of other influencing parameters and hence, the established relation between reflectance and sediment concentration at 743 and 835 nm absorption features is clear and robust.
3. The laboratory-generated spectral library of White et al. (1981) used by Warrick et al. (2004) is valid for sediment load up to 700 ppm. In this study, we collected in situ and laboratory spectral measurements under solar irradiance (where source light beam width related intensity changes are absent) up to 6000 ppm.
4. Since the amplitude of reflectance spectra is also affected by source-sensor geometry, we have suggested Average Weighted Spectral Similarity (AWSS) (Ramakrishnan et al. (2012)), which is insensitive to amplitude differences between the reference and image spectra, for image classification. In contrast, it is known that the Spectral Mixture Analysis (SMA) will have the detrimental effects related to amplitude changes which will result in over or under estimation of sediment concentrations.

In brief, our work (Ramakrishnan et al., 2013) certainly contributes some new insights to the existing understanding on sediment load retrieval in high turbidity coastal waters using remote sensing technique corroborated by field data. Further, this study also provides reference spectral data for coastal waters with very high turbidity.

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DOI of original article: http://dx.doi.org/10.1016/j.margeo.2013.11.015.
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http://dx.doi.org/10.1016/j.margeo.2014.02.010
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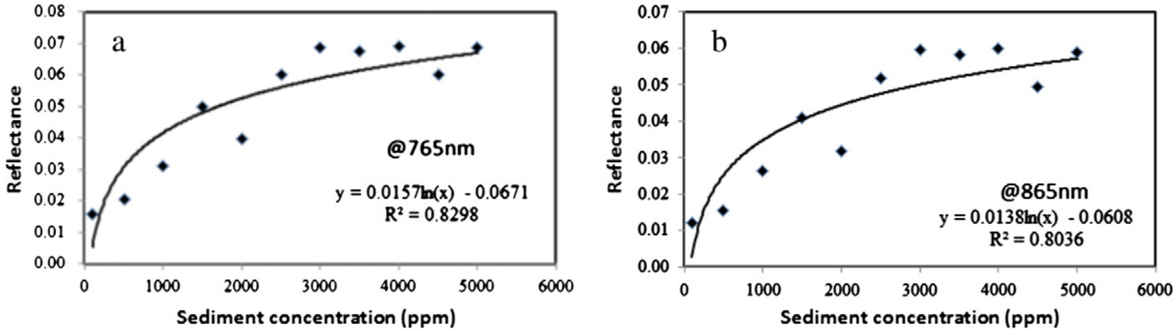

Fig. 1. Sediment load–reflectance relationship for coarse grain dominated waters at (a) 765 nm, and (b) 865 nm.

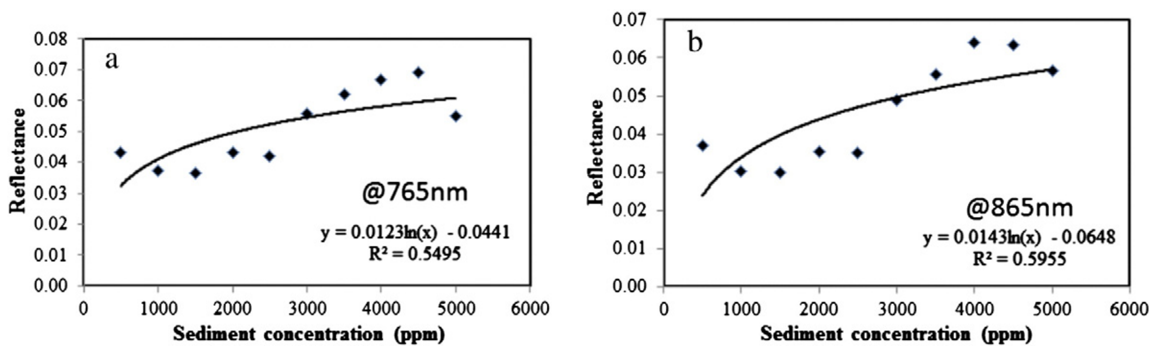

Fig. 2. Sediment load–reflectance relationship for fine grain dominated waters at (a) 765 nm, and (b) 865 nm.

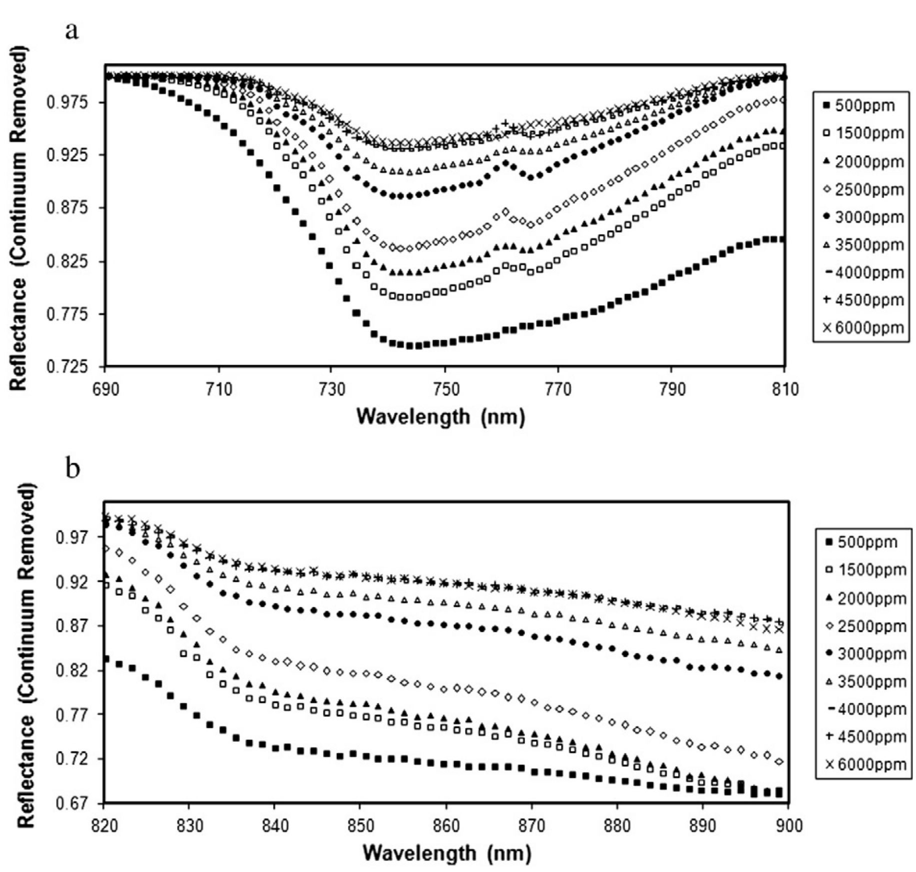

Fig. 3. Sediment concentration vis-à-vis continuum removed reflectance indicating a strong sensitivity at (a) 743 nm, and (b) 835 nm.

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