remote sensing

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Letter

Landsat 8 Virtual Orange Band for Mapping Cyanobacterial Blooms

Abhishek Kumar *, Deepak R. Mishra and Nirav Ilango

Center for Geospatial Research, Department of Geography, University of Georgia, Athens, GA 30602, USA; dmishra@uga.edu (D.R.M.); niravilango@uga.edu (N.I.)

* Correspondence: ak68883@uga.edu; Tel.: +1-706-542-2721

Received: 10 February 2020; Accepted: 5 March 2020; Published: 8 March 2020

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Abstract: The Landsat 8 Operational Land Imager (OLI) has a panchromatic band (503–676 nm) that can be used to derive a novel virtual orange band (590–635 nm) by using the multispectral green band and red band components. The orange band is useful for the accurate detection and quantification of phycocyanin (PC), an accessory pigment in toxin-producing cyanobacterial blooms, because of the specific light absorption characteristics of PC around 600–625 nm. In this study, we compared the Landsat 8 OLI's and Sentinel-3 Ocean and Land Color Instrument's (OLCI) derived orange band reflectance and PC products corresponding to a same-date overpass during a severe cyanobacterial bloom in Lake Erie, USA. The goal was to determine if the OLI's virtual orange band can produce results equivalent to the OLCI's actual orange band. Band-by-band match-ups used the OLI's top-of-atmosphere (TOA) reflectance versus TOA reflectance from the OLCI, and surface reflectance (SR) from the OLI versus SR from the OLCI. A significant correlation was observed between the OLI's and OLCI's derived orange band TOA reflectance (R^2 = 0.86; p < 0.001; NRMSE = 9.01%) and orange band SR (R^2 = 0.93; p < 0.001; NRMSE = 20.23%). The PC map produced using the best-fit empirical models from both sensors showed similar PC spatial patterns and concentration levels in the western basin of Lake Erie. The results from this research are particularly important for the study of smaller inland waterbodies with the 30 m resolution of the OLI, which cannot be studied with the 300 m resolution of OLCI data, and for analyzing historical bloom events before the launch of the OLCI. Although more analysis and validation need to be conducted, this study opens up Landsat 8's applicability in research on cyanobacterial harmful algal blooms (cyanoHABs).

Keywords: cyanobacteria; phycocyanin; cyanoHABs; Lake Erie; Landsat 8 OLI; orange band; Sentinel 3-OLCI

1. Introduction

Cyanobacterial harmful algal blooms (cyanoHABs) have become a major concern for water resource managers, environmental agencies, and public health organizations across the globe because they pose serious health problems to humans and livestock via cyanotoxin production and result in significant negative economic impacts ($2.2 billion annually in the U.S. alone) [1,2]. CyanoHABs are comprised of photosynthesizing prokaryotic cyanobacteria that multiply rapidly in favorable environmental conditions to form harmful mats or blooms. Early detection and monitoring of cyanoHABs is critical for developing management strategies in advance, limiting their environmental exposure, and reducing the associated economic and health impacts. Many past studies have used phycocyanin (PC), an accessory pigment in cyanobacteria, as a proxy for the detection and monitoring of cyanoHABs, using their specific absorption feature around 600–625 nm in remotely sensed reflectance data [3–5]. Various remote sensing platforms, sensors, and techniques such as optical buoys, hyperspectral drones, and airborne and spaceborne sensors can use the 620 nm band to detect and quantify PC concentrations. However,