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Oil Spill Index (OSI) to Sentinel-2 satellite data of European Space Agency to map oil spills: QU in International Contribution

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Abstract

An Oil Spill Index (OSI = (B3+B4)/B2) was developed and applied to Sentinel-2 optical satellite data of European Space Agency (ESA) to map of marine oil spills using the spectral absorption characters of spectral bands of the Sentinel-2. The potential application of OSI and derived indices [i. (5+6)/7, (3+4)/2, (11+12)/8 and ii. 3/2, (3+4)/2, (6+7)/5] were demonstrated to the oil spills that occurred off Mauritius, Indian Ocean, on August 06, 2020, and Norilsk region, Russia on May 29, 2020, and the results were published in the peer-reviewed research journals. Recently (August 19, 2021), our mehodology was recognized by the Sentinel-Hub (a repository of custom scripts) https://custom-scripts.sentinel-hub.com/sentinel-2/oil-spill-index/ for OSI calculation. We validated the remote sensing results with the drone images taken during the incident. Our OSI index is the first to Sentinel-2 optical data to map oil spills. We proved the potential of indices and the capability of Sentinel sensors to detect, map, monitor, and assess the oil spill, which can be used for emergency preparedness of oil spills.

Introduction

Oil spill incidents occur due to various reasons and contaminate the water body, forming oil sludge in the sea and along the coast. The spill affects severely the seagrasses, coral reefs, aquaculture, desalination plants, etc. in the marine environment and distresses the economy, including tourism activities. Environmental Science Center (ESC) of Qatar University researched the oil spill from the Wakashio tanker, which occurred off Mauritius in the Indian Ocean on August 06, 2020, and Norilsk region, Russia on May 29, 2020, using Sentinel data of European Space Agency (ESA) joining with an international multidisciplinary research team from University of Mauritius (Mauritius), Sultan Qaboos University (Oman), State Hydrological Institute (Russia), and National Institute of Technology (India) and showed the occurrence and distribution of oil spills. We studied the VV (vertical-vertical) polarization images of the Synthetic Aperture Radar C-band (5.404 GHz) of Sentinel-1 and characterized the spectral absorptions of the bands of MSI (MultiSpectral instrument) of Sentinel-2. We constructed Sentinel-2 band ratios/ indices (5+6)/7, (3+4)/2, (11+12)/8 and 3/2, (3+4)/2, (6+7)/5 by summing the bands that representing the shoulders of absorption features as a numerator, and the band located nearest to the absorption feature as a denominator and distinguished well the oil spill on the images. We validated the remote sensing results through field studies and using the drone images taken during the incidents (Rajendran et al., 2021 a, b, c; Rajendran, 2021).

OSI index

The Oil Spill Index uses visible Sentinel-2 bands to display oil spills over water in the coastal/marine environment. The OSI is constructed by summing up the bands representing the shoulders of absorption features of oil as a numerator and the band located nearest to the absorption feature as a denominator to discriminate oil spill (Rajendran et al., 2021a,b).

$$OSI = (B3 + B4) / B2$$

The indices derived using OSI are

R:(5+6)/7; G:(3+4)/2; G: (11+12)/8
R: 3/2; G: (3+4)/2; B: (6+7)/5

Results

For example, mapping of the oil spill which occurred off Mauritius, Indian Ocean on August 06, 2020 was carried out using indices (5+6)/7, (3+4)/2, (11+12)/8 and the Sentinel-2 data acquired before, during and after the incident and the results are given below:

The images show the land, Ile aux Aigrettes and reef ridge in cyan blue and coarse texture, the offshore water in red to light magenta with medium to fine textures, and the lagoon in light brown to orange with fine texture. The clouds over the images appear light blue to light green and medium texture. The image acquired on July 17, 2020, before the oil spill, shows the absence of ship (Fig. 1a), whereas the images acquired during August 01, 06, 11, and 16, 2020 show the presence of ship and the oil spill around the incident site (Rajendran et al., 2021a, b). The image acquired on September 05, 2020 did not show the ship since it was under scuttling from August 20, 2020 (Fig. 1f; Hand, 2020). The images of August 01 and 16, 2020 show the presence of suspended sediments around the ship due to the grounding and breaking of the ship. The oil spills in and around the ship appear in light blue (very thick oil spill) to bright white (thick oil spill) to light orange (thin oil spill) with fine texture, and the spills are distinguishable from light tone (Fig. 1b and c). The distribution of spilled oil over the lagoon shows shades of orange, and the spread can be well interpreted on the image acquired on August 06, and 16, 2020 compared to the image of August 11, 2020 (Fig. 1c, d & e).
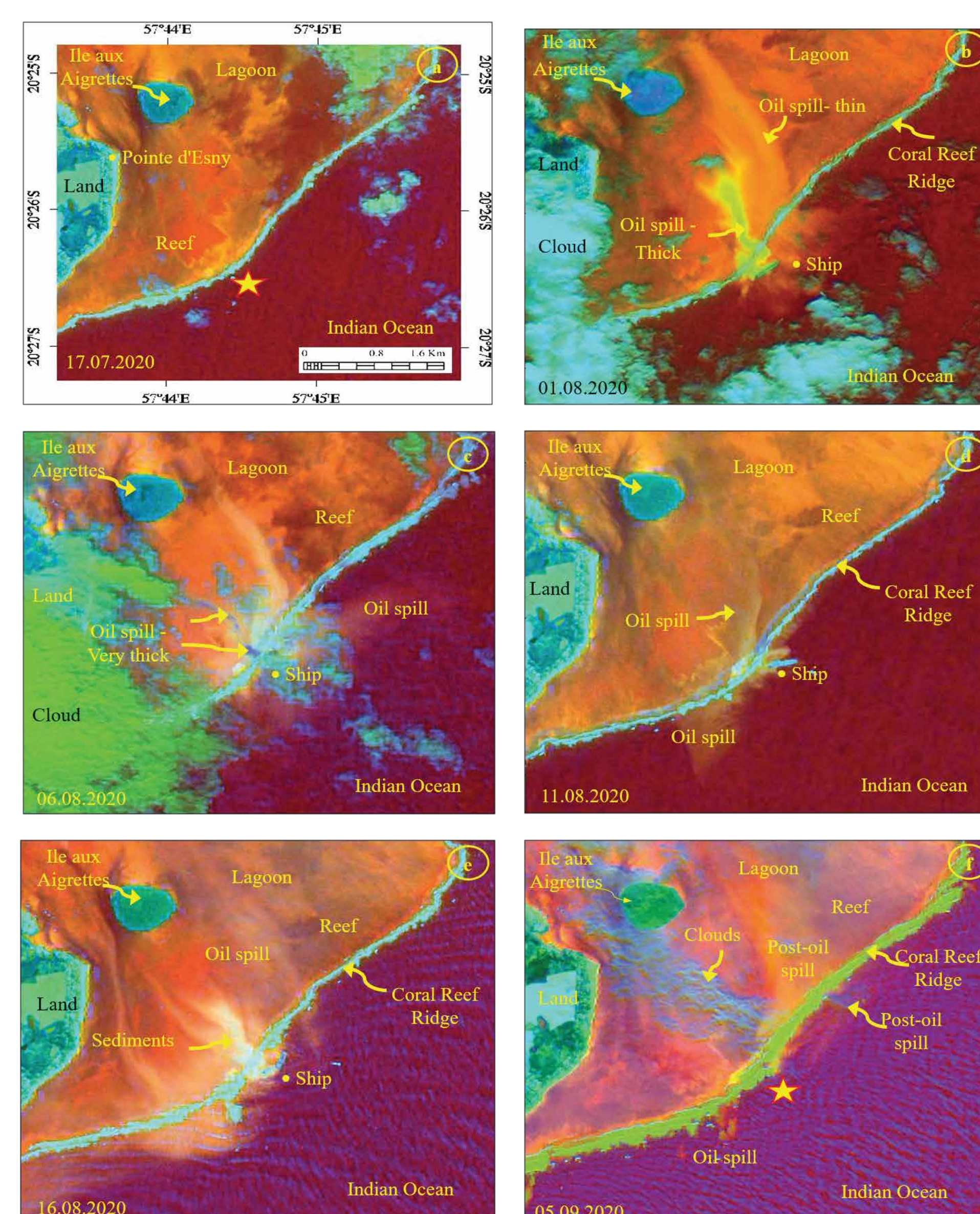

Fig. 1. R: (5+6)/7; G: (3+4)/2; B: (11+12)/8 images showing the occurrence and distribution of oil spill in the incident site and from the site to lagoon (stars locate the incident site).

Sentinel-Hub

Sentinel-Hub: Services to use OSI from a repository of custom scripts.
Indices used and scripts developed to OSI

```
// Oil Spill Index in grayscale
let OSI = (B03 + B04) / B02;
return [OSI/3]
// RGB visualization a)
/*
let R = (B05+B06)/B07
let G = (B03+B04)/B02
let B = (B11+B12)/B08
return [R/3, G/3, B/3]
*/
// RGB visualization b)
/*
let R = (B03/B02)
let G = (B03+B04)/B02
let B = (B06+B07)/B05
return [R/3, G/3, B/3]
*/
```

OSI for emergency preparedness

EO Browser: An interactive platform links the OSI scripts of Sentinel-hub and satellite data and shows oil spills of the area interested in the global data by selecting the date of oil spill incident for research scientists worldwide.
For example, the outcome of the oil spill off Mauritius on the grayscale image (Fig. 2a) and indices on RGB visualization (Fig. 2b; R:(B05+B06)/B07; G:(B03+B04)/B02; B:(B11+B12)/B08).
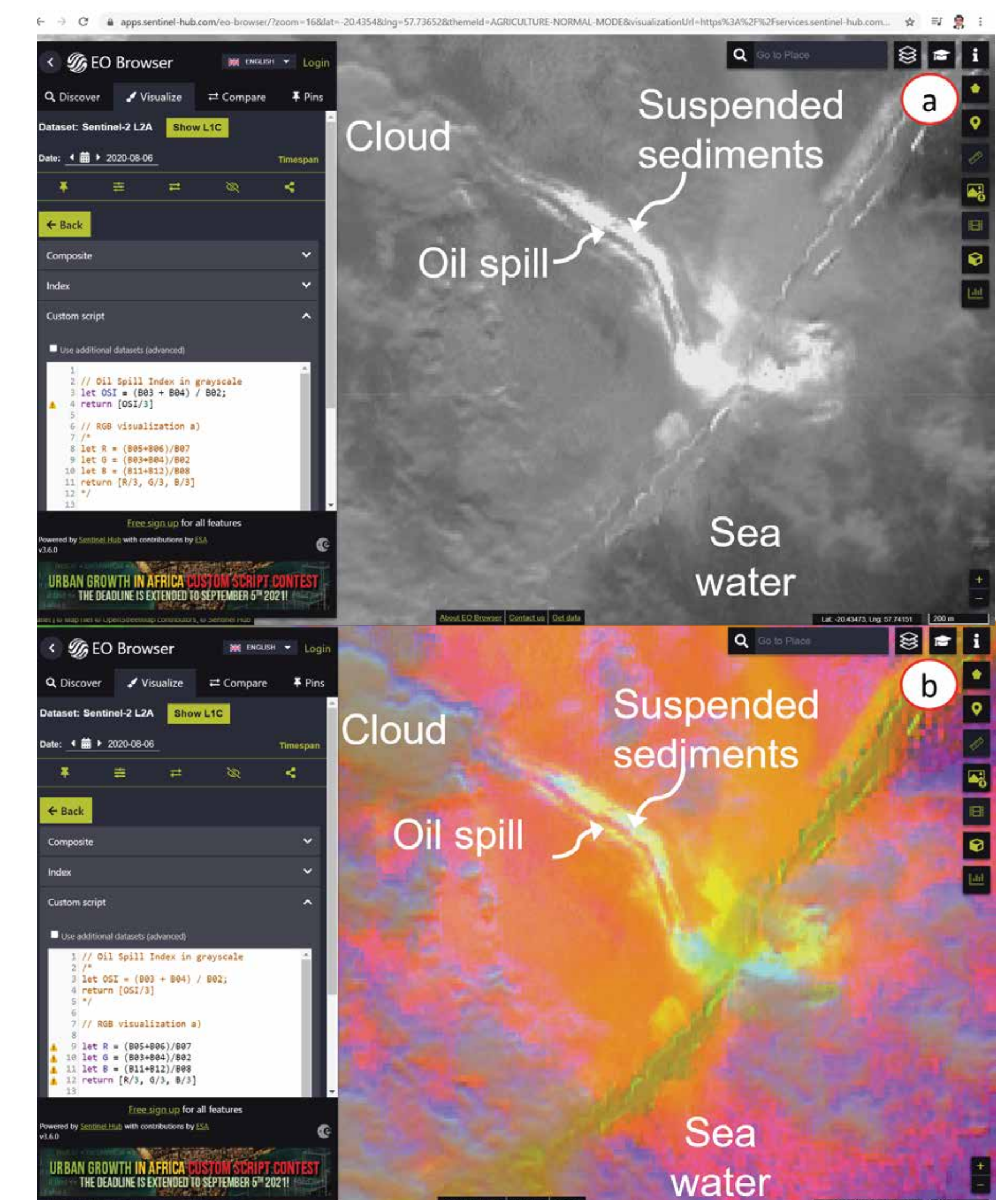

Fig. 2. OSI mapping of the oil spill off Mauritius a. OSI on grayscale and b. in RGB using indices R:(B05+B06)/B07; G:(B03+B04)/B02; B:(B11+B12)/B08.

Conclusion

In this research, we constructed the OSI to Sentinel-2 data and demonstrated the capability of OSI through case studies to map the oil spill elsewhere in the world.

Acknowledgment

References

1. Hand, M., 2020. Wakashio Forward Hull Section Scuttled off Mauritius. Seatrade Maritime News. Accessed on. https://www.seatrade-maritime.com/casualty/wakashio-forward-hull-section-scuttled-mauritius (Accessed 25 August 2020).

2. Rajendran. S., Vethamony. P., Sadooni, F.N., Hamad Al Saad., Jassim A. Al-Khayat., Vashist O. Seegobin., Govil. H., Nasir. S. 2021a. Detection of Wakashio oil spill off Mauritius using Sentinel-1 and 2 data: Capability of sensors, image transformation methods and mapping. Environmental Pollution 274, 116618 IF: 8.07. Indexed in ISI and Scopus. . https://www.sciencedirect.com/science/article/pii/S0269749121001962?via%3Dihub

3. Rajendran. S., Vethamony, P., Sadooni, F.N., Hamad Al Saad., Jassim A. Al-Khayat., Govil, H., Nasir, S. 2021b. Sentinel-2 image transformation methods for mapping oil spill - A case study with Wakashio oil spill in the Indian Ocean, off Mauritius. MethodsX 101327, Indexed in Scopus. https://www.sciencedirect.com/science/article/pii/S2215016121001205?via%3Dihub

4. Rajendran, S., Sadooni, F.N., Hamad Al Saad., Oleg, A., Govil, H., Nasir, S., Vethamony, P., 2021c. Monitoring Oil Spill in Norilsk, Russia using satellite data. Scientific Reports 11, 3817. IF: 4.37. Indexed in ISI and Scopus. https://www.nature.com/articles/s41598-021-83260-7

5. Rajendran, S. 2021. Oil spill Index (OSI). A repository of custom scripts that can be used with Sentinel-Hub services. https://custom-scripts.sentinel-hub.com/sentinel-2/oil-spill-index/.

Sentinel-hub   How to use OSI