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Detection of Oil Spill Hotspots Using Time-Series MODIS Data (Case Study: Persian Gulf)

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INTRODUCTION

Oil pollution at sea is mainly caused by the illegal discharge of hydrocarbons by ships into the marine environment. When oil contamination occurs, the location and extent of the oil spill should be specified. With timely knowledge of the location of the oil spill and its direction, planned actions can be taken to reduce its impact on the environment. In this regard, remotely sensed data play an important role in providing information on, the amount and direction of oil spill motion using multi-temporal images in predicting the motion as well as supporting oil spill control and clearance operations [1]. Moreover, viscosity, fluctuation, and toxicity are the main differences between the types of oil. In addition, viscosity is known as oil resistance to currents. The fluctuations indicate the rate of evaporation of oil. Toxicity also refers to the effects of oil on nature and living things. Moreover, the leakage of different types of oil affects the environment differently. In addition, operations and methods for cleaning oil spills may be different [2].

Oil leakage monitoring is an important component of oil crisis management. Remote sensing sensors can help identify minor leaks before they cause extensive damage. In the case of larger events, remote sensing satellites are a good aid in assessing leakage and tracking it.

Using a combination of electromagnetic energy in active or passive zones, it is possible to monitor a wide range of different climatic conditions, including cloud cover overnight.

Medium-resolution images with a resolution between 30 and 500 meters are suitable for monitoring large areas, while higher-resolution images can provide more detail on larger events [3]. Nowadays, the advantages and capabilities of new remote sensing knowledge and sensors have made good progress in identifying oil spills before causing much damage. In addition, modern remote sensing tools can monitor oil pollution for up to 2 hours [4]. Satellite data provide temporal, spatial, spectral and radiometric resolutions, adequate coverage and reproducibility, information layers required for studies; moreover, the satellite data enable one-piece (spatial and temporal) observations to be established. In addition, determination of the contamination layers is possible and manageable using various indices and related analyzes [4].

STUDY AREA

The Persian Gulf region is a platform along the Oman Sea between the Persian and Arabian plateau. This Gulf is connected to the Oman Sea by the Strait of Hormuz and through it to the free seas. Among the neighboring Persian Gulf countries, Iran has the largest water boundaries in common with the Persian Gulf [5].

Studies show that pollution from oil shipments in the Persian Gulf is estimated to account for about 86% of total oil pollution in the Gulf, which in comparison is about twice the share of pollution caused by sea shipping worldwide. Large numbers of marine accidents have also played a significant role in increasing oil pollution in the Persian Gulf

DATA AND METHODS

SATELLITE DATA REQUIRED

The MODIS sensor comprises a field of view of 2330 km. The MODIS sensor has 36 bands. 20 bands of them are reflective bands and 16 are thermal bands. Its spectral range is between 0.4 and 14.38 µm. MODIS bands have different spatial resolutions including 250 m (bands 1 and 2), 500 m (bands 3 to 7) and 1 km (bands 8 to 36). In this study, the MYD09 (250 m) product as Level 2 product from 2005 to 2015 was obtained through NASA's site to detect oil spills in the study area over a long period. In the case of MODIS first level data, some corrections such as atmospheric correction and radiometric correction are necessary, but the MYD09 data used in this study are a second level product, and atmospheric and geometric correction has been performed on it. Also, this product with a resolution of 250 m in bands 1 and 2 shows the difference between water and oil [7,8].

In this study, after selecting the Modis sensor, the relevant hdf format was obtained from NASA, which included spatial, spectral and metadata information. From the obtained data (about 2 satellite images), band 2 and 2 were extracted. In this study, due to the use of the MODIS Sensor Level 2 product, radiometric correction and geometric correction were not performed [8]. Here, this preprocessing [9] was omitted.

RESULTS AND DISCUSSION

RESULTS OF OIL STAIN HIGHLIGHTING

Figure 1 shows the specific range and timing of the oil contamination (red frame on the margin of the oil stain). Furthermore, in Figure 1, dark or very dark areas of poor data quality are shown. In this study, it has been attempted to have a good quality and data analysis in the area of oil pollution, and there is no cloud or haze in it. Bands 1 and 2 required extractions and analyses of these two bands. As illustrated in Figure 1, the raw image of band 2 can somewhat show the oil stain, but by applying the proposed method as seen in Figure 2, the oil contamination is fully characterized. In addition, after the enhancement, due to the ability of the remote sensing system to discriminate the oil stain from the water, all reports of oil contamination were considered for extraction (Figure 3).

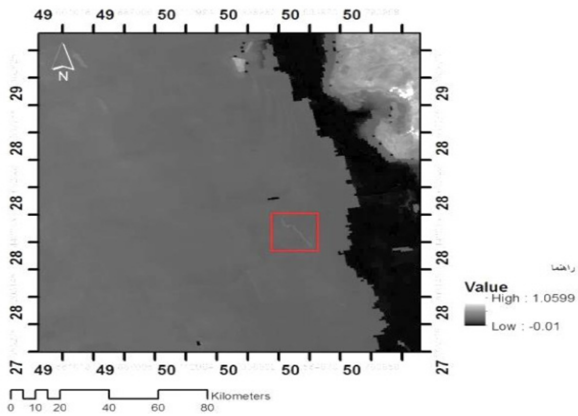

Figure 1: Image of oil pollution range with MODIS data.

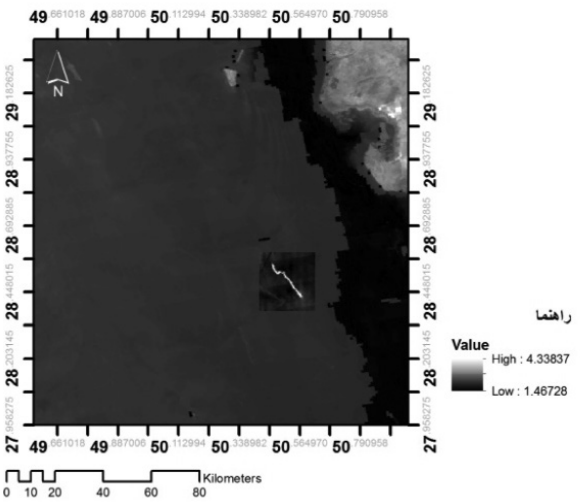

Figure 2: Enhanced image of oil pollution ranges with MODIS data.

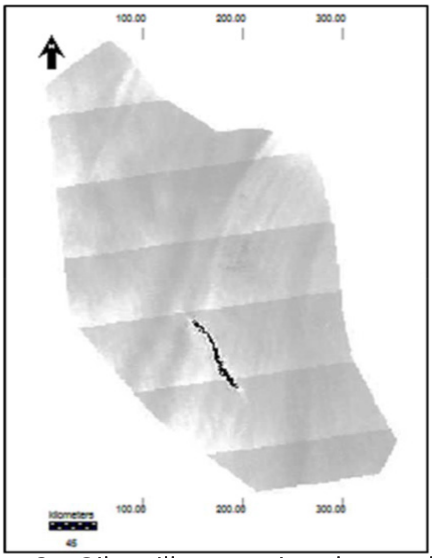

Figure 3: Oil spill extraction by applying a threshold dated 15/8/2007.

CONCLUSIONS

Using satellite imagery to monitor oil pollution will be very effective in terms of dramatically reducing costs and saving time. In addition, monitoring oil pollution continuously requires sensors that have a short-term return period. Due to the importance of oil pollution monitoring, this study attempted to detect oil pollution using MODIS satellite images, which the study provides the researchers with a good overview of the extent of oil pollution. Also, in this study, oil spots were performed using long-run statistical parameters and standard deviation of time series data. In this study, it was determined that remote sensing time series data could be used to identify oil pollution, but each data could provide unique information not found in any other data. Moreover, cloud coverage is an important factor in determining the efficiency of MODIS images. Since it is practically impossible to detect oil spills covered by clouds, it is not possible to monitor oil spills in cloudy weather and cold seasons. As a result, other technologies such as active sensors should be used to fill the gap time. Finally, since the MODIS sensor is capable of providing day and night images of the Earth's surface, it is possible to design an automated system for the detection of oil spills using the method used in this study; in addition, operations will be carried out to manage and prevent further oil spillage.

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