Oil spill detection and monitoring in the Cyprus region

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ABSTRACT

Cyprus can be found in a critical location, a geostrategic location among Asia, North Africa, and Europe. This is particularly important, thus, can affect the marine environment with the vessels that pass through the sea. A severe form of pollution can be an oil spill. An oil spill is a liquid, usually petroleum hydrocarbon, released to the sea and can affect the marine ecosystem and humans. Oil spills can be recorded as marine incidents or accidents. In August 2022, one of the essential accidental oil spills came from the northeast coast of Syria. In the present study, we will try to implement a spatial analysis of oil spill detection by combing remote sensing techniques and monitoring, using the Sentinel Application Platform (SNAP) and the consequences that follow this procedure. The implementation was made using two different polarization; vertical polarization (VV) and horizontal comparison (VH). The preliminary results show that the Sentinel-1 SAR data would give effective results and spatial information on oil spill detection to decision-makers.

Keywords: Sentinel 1 SAR, Maritime ecosystem, Sentinel Application Platform (SNAP), Oil spill detection, Cyprus

1. INTRODUCTION

One of the challenges the oil and gas industries face is the management of oil spills at sea. Oil spill poses a severe threat and damage to the marine ecosystem. Oil spills are generally characterized as releasing liquid petroleum hydrocarbons into the environment due to human activities [1]. Oil pollution might devastate the marine environment and the communities along the coastline. From an environmental point of view, an oil spill affects not only the ecosystem right after the occurrence but also has long-term marine ecological effects that might take a long time for the environment to recover [2].

Moreover, Oil spills might have catastrophic impacts on the ecology and the local economy along Cyprus' lengthy coastline. Using satellite data can produce helpful information for locating and keeping track of local oil spills. Because it can see through clouds and produce sharp photos, Sentinel-1 SAR data, in particular, has been shown to help find oil spills.

Remote sensing is considered an increasingly important technology for the Maritime ecosystem. The SAR monitoring of the oil spills over the oceans has proved its efficacy during the daytime, nighttime, and weather [3]. In the last decade, a lot of research on automatic and semiautomatic methods of oil spill detection has been documented [4, 5], and they provided a lot of knowledge for creating a methodology using Sentinel-1 satellite images [3].

Oil spill detection using satellite-based imagery provides opportunities to map oil pollution on a large scale effectively. Satellite-based imageries of both active and passive sensors are frequently used to detect, map and monitor oil spills [6]

This paper aims to show how to detect and map oil spills in the Cyprus Region using freely available Sentinel 1 SAR imagery data [7]. An oil spill is automatically detected using the Oil Spill detection tool of the Sentinel Application Platform (SNAP). The methodology is applied to one satellite image to identify the effects of oil spills compared to the clean sea conditions. The comparison was made using two different polarization; vertical polarization (VV) and horizontal comparison (VH). The preliminary results show that the Sentinel-1 SAR data would give effective results and spatial information on oil spill detection to decision-makers.

2. METHODOLOGY

2.1 Study Area

The study's area of interest (AoI) is the Cyprus Coastal area. Figure 1 shows the study area. The data used includes SAR Sentinel-1A level 1 ground range detected high-resolution (GRDH) data acquired on 20 August 2022 with interferometric wide swath (IW) mode and vertical-horizontal (VH) polarization. Level 1 GRD data denotes that the data have been projected using an ellipsoid earth-modelling approach (ESA, 2014). Table 1 gives a detailed overview of the SAR Sentinel-1 image used in this study.

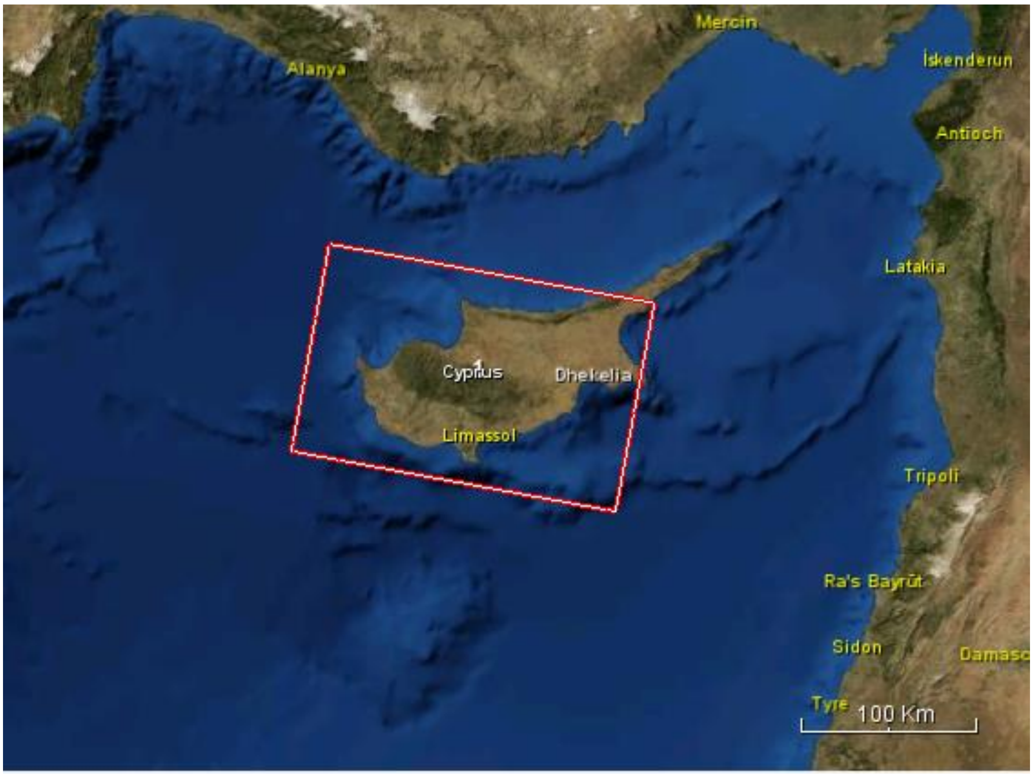

Figure 1: The area of interest (AoI) (on 20 Febrouary 2020) used in this study.

Table 1: The detailed overview of the SAR Sentinel-1 imagery on 20 August 2022

No	Characteristic	Data 1
1	Mission	Sentinel-1A
2	Acquisition Date	20 August 2022 06:24:36
3	Acquisition Mode	IW
4	Pass Direction	Descending
5	Polarization	VH, VV
6	Product Type	GRD
7	Instrument Name	Synthetic Aperture Radar (C-band)

2.2 Methods

The main idea of this study is to detect oil spills in Cyprus' Exclusive Economic Zone (EEZ). Data from Sentinel-1 from the Copernicus Open Access Hub was used through the online interface. The preprocessed SAR imagery was run via SNAP's oil spill identification program to find regions with oil slicks. The tool recognizes the variation in reflectance between water and oil, enabling it to pinpoint locations where oil is present. The overall methods adopted in this study consist of eleven (11) processing steps briefly described below (see Figure 2):

Step 1: Select Areas of Interest from Copernicus Open Access Hub.

Step 2: Download data from Sentinel-1 via the Copernicus Open Access Hub using the online interface by specifying the following parameters:

> **Sensing period:** From 20/08/2022 to 20/08/2022
> **Check Mission:** Sentinel-1
> **Satellite Platform:** S1A*
> **Product Type:** GRD (Ground-range-detected product)

Step 3: Using SNAP (Sentinel Application Platform) software. Opening Amplitude_VH to visualize the band.

Step 4: Input preprocessed image to SNAP – oil spill detection tool

Step 5: Subset: Since our Area of Interest (AoI) is relatively small and there is no need to process the whole image, we start with sub-setting the scene to a more manageable size. This will reduce the processing time in further steps and is recommended when the analysis is focused only on a specific area and not the complete scene [8].

Step 6: Speckle filter: To reduce the usual salt and pepper-like texturing of SAR images, a speckle filter is needed [9].

Step 7: Run Oil Spill Detection. SNAP provides a fully automatic oil spill mapping called Oil Spill Detection. This is one of the tools provided under the SAR Ocean Application of SNAP. The process is performed automatically by the algorithm. The basic principle of Oil Spill Detection by SNAP is to identify dark pixels over the sea. The algorithm includes dark pixels identification using adaptive thresholding, clustering and discriminating dark pixels based on cluster dimension with user preference of cluster size input [10]. It consists of four (4) stages briefly described below:

Land-Sea Mask: The first stage is masking the land areas to avoid false target detections on land [7].

Calibration: Calibration is the procedure that converts digital pixel values to radiometrically calibrated SAR backscatter [7].

Oil Spill Detection: This tool identifies dark pixels over the sea.

Oil-Spill-Clustering: The parameter remains as default.

Step 8: Terrain correction: Terrain corrections are intended to compensate for the distortions arising from the sensor's side-looking geometry so that the geometric representation of the image will be as close as possible to the real world [11].

Step 9: Output Imagery with Oil Spill Mask

Step 10: Colour Manipulation

Step 11: Results – Detection of Spill Patch: Open band using Sigma_VH and Sigma_VV. We can see the red circles representing targets.

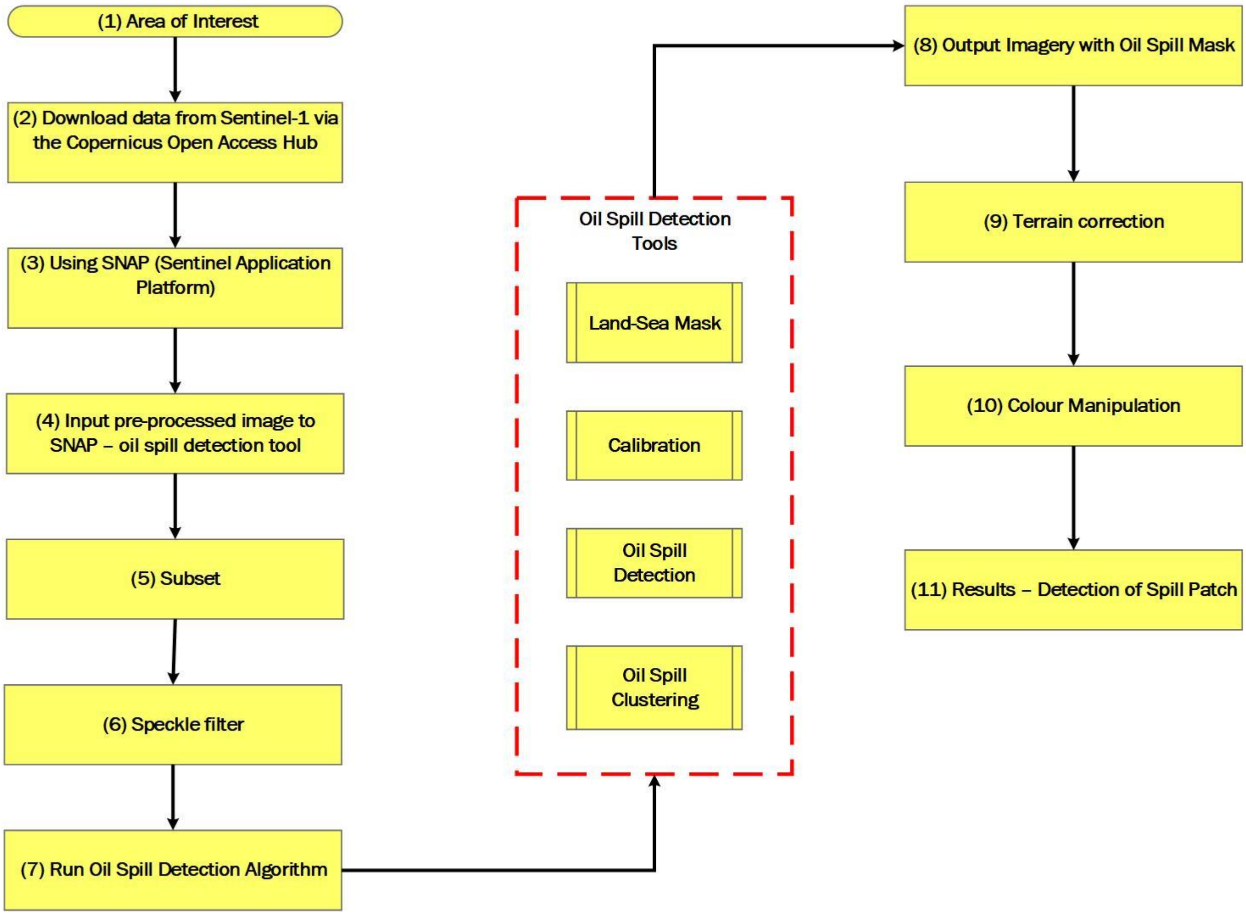

Figure 2: The overall methodology adopted in this study

3. RESULTS

SNAP oil spill detection tool is used to identify oil spills. In this case, the default parameters (Background Window Size—61; Threshold Shift (dB)—2.0, Minimum cluster size of 0.1 sq. km) for both case studies are retained to evaluate the efficiency of the tool for quick oil spill detection [10]. Sentinel-1A is a critical remote sensing tool for sea and ocean waters oil spill detection and monitoring. Still, also the VV polarization gives better results than the other polarizations for detection and monitoring oil spill scenarios in the marine environment [12]. In this study, VH and VV polarizations have been tested for detecting oil spills, and results showed using VV polarization leads to greater accuracy. The VV image is better for detecting oil spills. It can be used to differentiate between the VH and VV polarization for detecting oil spills in sea and ocean surface areas [12].

The main reason for successful VV polarization is to detect oil spills, sensitive to the roughness of the sea and ocean waters surface. Two essential factors in this case: are wind speed and wind direction. The imagery acquired at VV polarization by the SAR satellite is very sensitive to wind speed variability [12].

Figure 3 presents the results for Cyprus Coastline, 20 August.. 2022. The results show that the oil spill areas are near the coastline, mainly marine areas. Most of these spills, as shown in Figure 3, are minor. Results showed that Cypru's Coastline waters have limited spatial effects from oil spills. In the Area of Interest, we can see oil spill areas within the red circles (Figure 3).

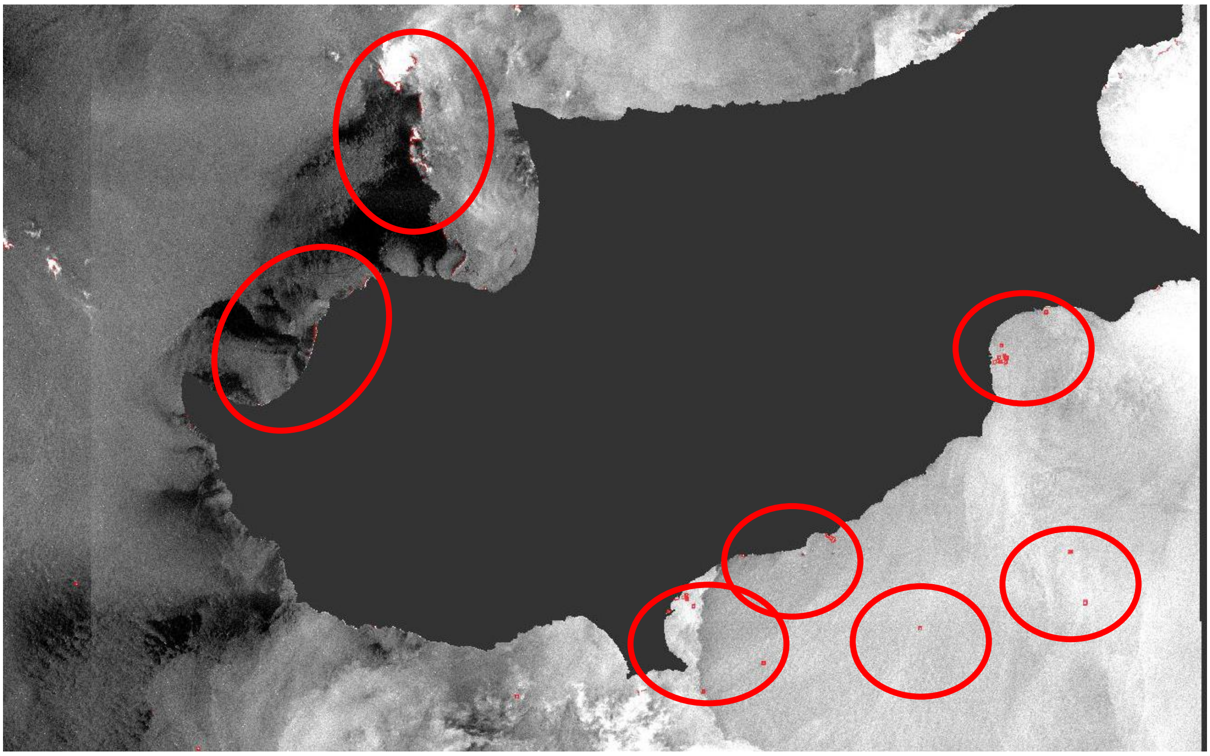

Figure 3: Sentinel 1 (SAR) images acquired on the 20.08.2020. Oil detection results in SNAP viewer for AoI. The oil spill areas are outlined with a red circle.

4. CONCLUSIONS

Monitoring the scattering characteristics of spilt oil, in the Mediterranean Sea, especially near the coast, is essential from the perspective of environmental impact and the associated threat to the ecosystem [10]. In this study, an attempt has been made to detect and map oil spills using satellite imagery. The free, complete, and open nature of the Sentinel-1 SAR images gives access to unprecedented volumes of data [7]. Sentinel-1A results show that using Oil Spill Detection by SNAP with the default parameters to detect oil spills near the Cyprus coastline provides more consistent results.

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