Article

Oil Spill Detection in Trinidad and Tobago with SAR Data.

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Abstract: This article investigates the February of 2024 oil spill in the coasts of the island of Tobago using SAR. The objective of this study is to determine how SAR data can help to detect, quantify, and monitor the progression of spills in a marine environment. Two sets of images were used corresponding to the 14th of February 2024 during the morning and night. The spill extended northwest due to the marine currents and wind in the area. The morning observation showed a total area of 76.84 km2, in the subsequent night observation the total area was 50.49 km2. The findings ensure the role of radar data as a powerful tool to address environmental disasters, their dynamics and how can it be useful to respond rapidly to them.

Keywords: Oil Spill; SAR Imagery; Sentinel - 1

1. Introduction

Oil is a fundamental resource in our society to get products and services, from fuel, to asphalt, electricity, or health products, etc. This need for petroleum has led us to build a big network of supply and transport, however, is vulnerable to accidents in vessels, tanks, or pipelines that can lead into ocean leaks. These spills are dangerous to our environment due to the high pollution that it causes and the difficulties to clean them. It is important to know the exact coverage and evolution of an oil spill, to monitor this kind of disasters radar data is key (Shaban et al., 2021).

Synthetic Aperture Radar (SAR) is a microwave sensor that differs from traditional optical sensors in the sense that is non-dependent on the weather conditions and daylight, meaning that it can capture data in cloudy conditions or/and during the night (Shaban et al., 2021). For oil spill detection is useful to use this sensor due to the characteristics of it while interacting with the water, in which, the oil would be seen as a black surface caused by the calm surface and small backscatter, against the constant waves from the ocean that would appear more grey or white due to the high backscatter (Johansson, 2022).

The objective of the study is to detect oil spills by using SAR data to determine the presence, extent, and progression of them in marine environments.

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2. Study Area

Trinidad and Tobago are a set of islands located between the Caribbean Sea and the Atlantic Ocean. It lies in the north of Venezuela and Guyana, and south of Granada, Barbados, and Saint Vincent and the Grenadines. The location of the islands makes it great for petroleum and petrochemical production, industries that play an important role in the local economy. The proximity to major oil reserves, both within their own territory and their neighbor Venezuela, places Trinidad and Tobago at a crucial point for energy production in the Caribbean (Ministry of Finance, 2023)

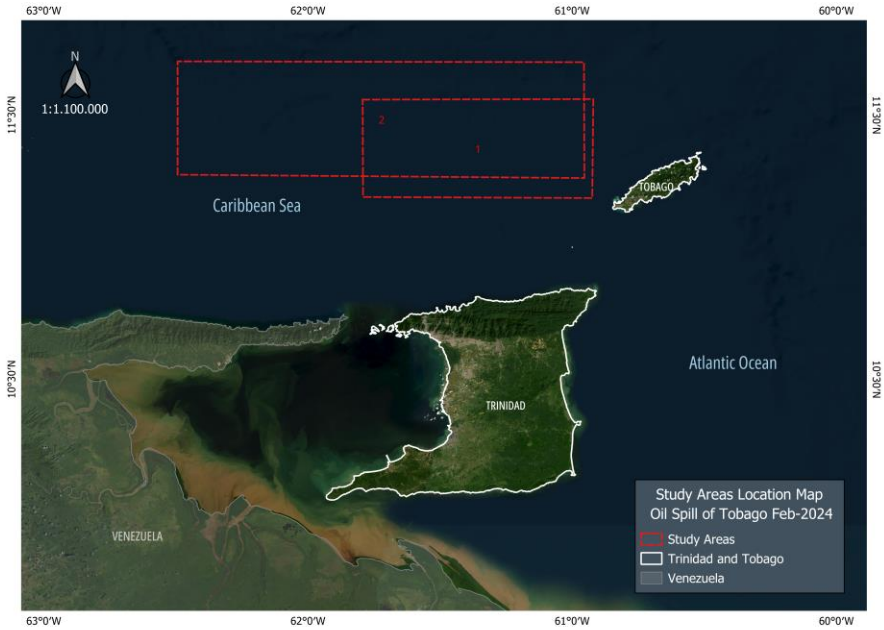

Figure 1. Study Area.

Marine Currents

Trinidad and Tobago are located in the convergence zone of the Caribbean and the Guyana Current. The Guyana Current originates in South America carrying warm waters to the northwest, into the Caribbean. Here the Caribbean Current receives parts of these waters, directing them to the west, until they reach the coasts of Nicaragua, where they begin migrating north (Hardeo and Chakrabarti, 2014).

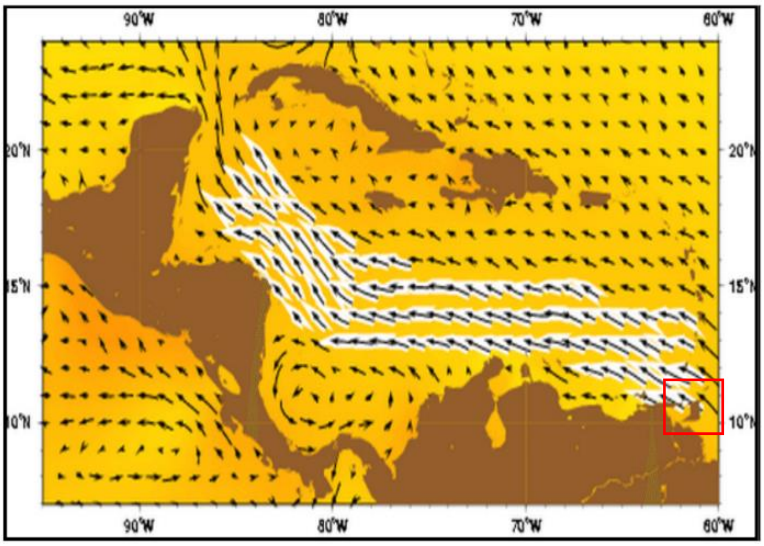

Figure 2. Caribbean Current (Hardeo and Chakrabarti, 2014).

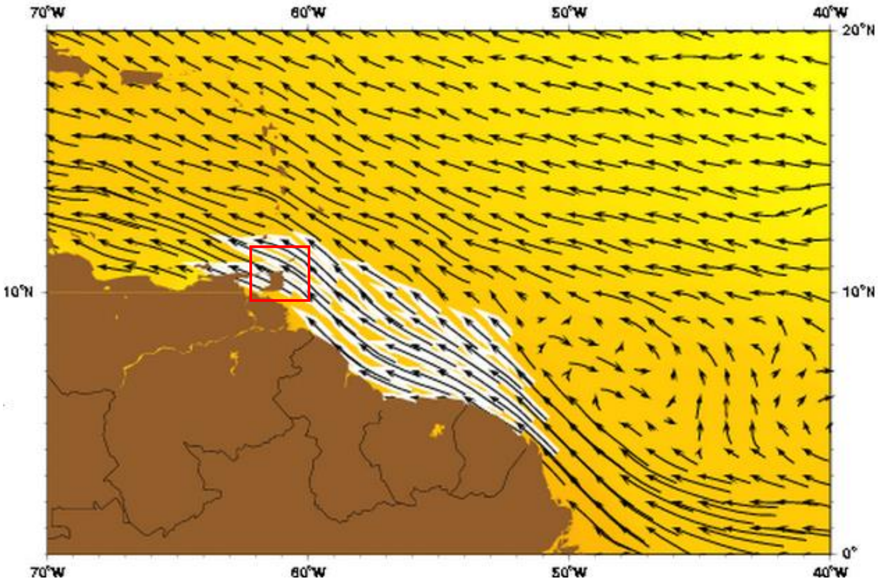

Figure 3. Guyana Current (Hardeo and Chakrabarti, 2014).

Background of the Oil Spill in the Study Area

On February 7th the spill was registered in Tobago´s coastlines, caused by an overturned vessel. On February 14th it was declared as a National Emergency by the government of Trinidad and Tobago, in addition to that with ongoing efforts to mitigate the spill. (Alvarado & Rios, 2024)

Authorities in Grenada, Venezuela and the Dutch municipality of Bonaire have recorded the extensive spill that has traveled from Tobago´s waters till their territory. This shows the environmental and ecological disaster that could cause in the Caribbean coral reefs and mangroves. (Buschschlüter, 2024)

3. Data and Methodology

The data was obtained in through the Alaska Satellite Facility and processed through the SNAP software (version 9.0) and QGIS (version 3.30.3).

Table 1. Downloaded Files and corresponding dates.

Data File	Date	Satellite	Orbit
S1A_IW_GRDH_1SDV_20240214T095216_20240214T095241_052553_065B51_9268	February 14, 9:52	Sentinel 1	Descending
S1A_IW_GRDH_1SDV_20240214T221831_20240214T221856_052561_065B99_FB82	February 14, 22:18	Sentinel 1	Ascending

The files were loaded into SNAP unzipped due to a constant bug in the oil spill detection tool that could only be solved by unzipping the file. The Ellipsoid Correction was applied to correct the positional distortions of the dataset (ESA, 2022). A Speckle filter was used to reduce the noise and have a clearer image (ESA, 2022). A Subset was applied to narrow the data to the designated study area. Calibration was performed for converting digital pixel values to radiometrically calibrated backscatter (ESA, 2022). For the final step in SNAP, the Oil Spill Detection tool was applied to detect dark spot areas that could potentially be oil spills following the characteristics of oil in water detected by the radar (ESA, 2022). The source band for this last step was the Sigma0_VV where the background Window Dimension was 1400 and the Threshold Shift in 3.5 dB. The VV polarization was selected for the ability to provide a clearer contrast of the oil spill against the VH.

Figure 4. SNAP Methodology Graph

The resulting layer from the oil spill detection was exported into QGIS, where through the process of vectorization, to obtain a polygon of the spill. The vectorized polygon was divided into two categories, one of which was designated for the oil spill. Polygons that did not fall into the oil spill category were filtered out by leaving the relevant polygons. The process concluded with the area calculation for each period.

4. Results

The graph represents the backscatter profile along the white line in the sample image of the study area, where it shows the difference that the petroleum has compared to the water. Areas with a low backscatter suggest the presence of oil, attributed to the smoother consistence of it compared to the rough water surface, resulting in a reduced return to the radar.

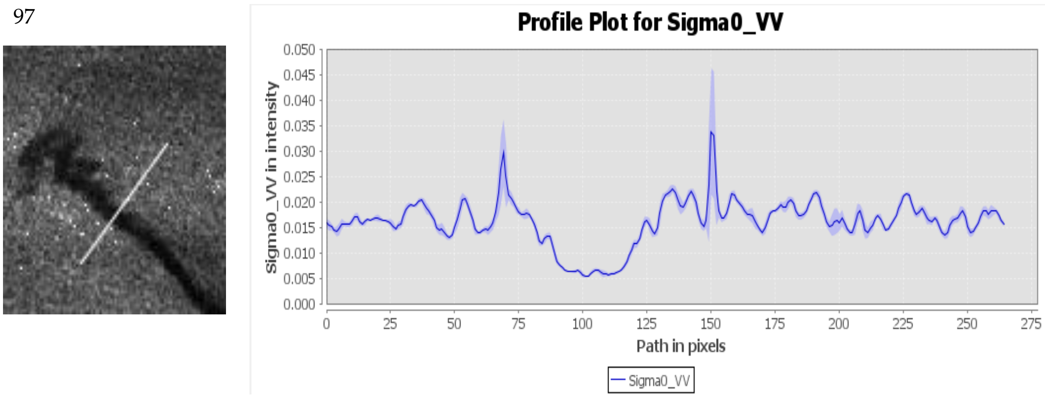

Figure 5. Extracted image from the study area (Left). Profile Plot from the extracted image (Right).

The identified oil spill at 9:52 a big oil spill path was located, originating from the coast in Tobago that is traveling further northwest, this trajectory suggests the interaction with the wind and marine currents. The initial estimated total area of this spill is 76.84 km2. At 22:18 the same spill has moved further away, elongating its trail, and braking into smaller parts compared to the morning stage. The estimated total area reduced to 50,49 km2.

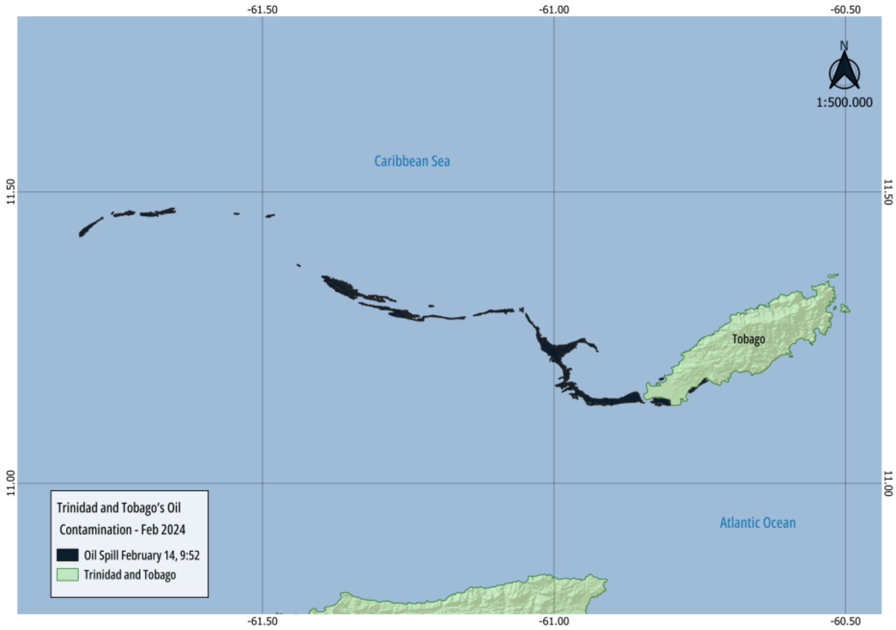

Figure 6. February 14 9:52.

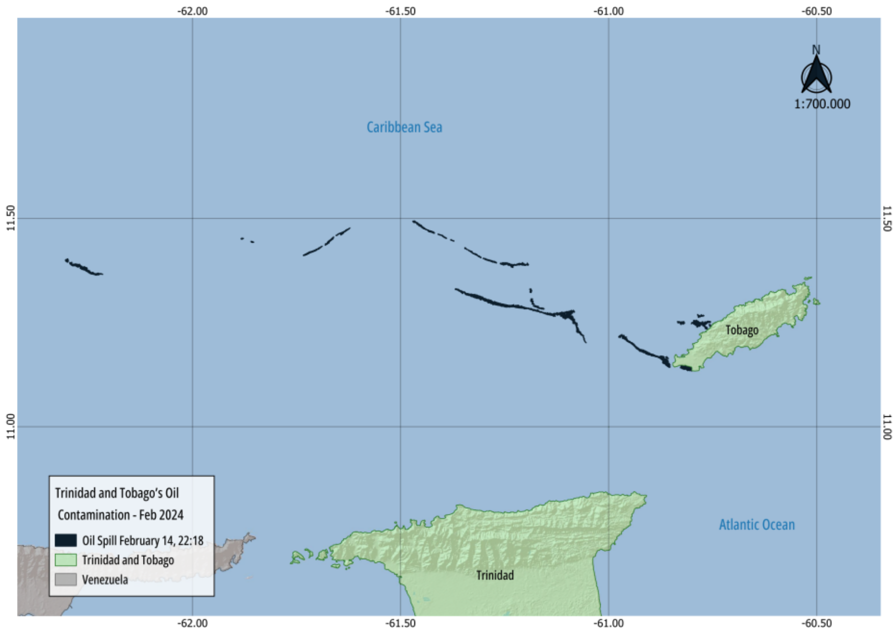

Figure 7. February 14, 22:18.

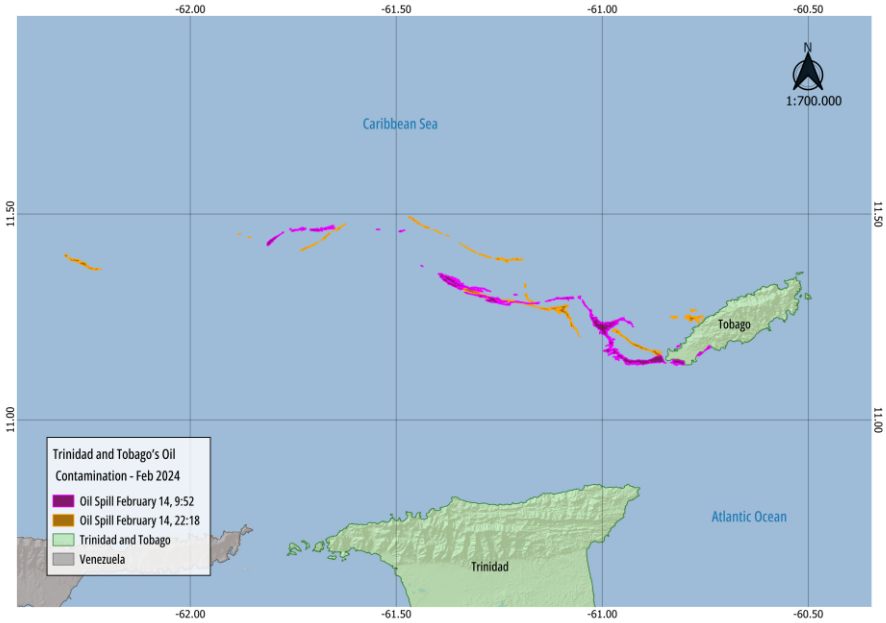

Figure 8. Transposed oil spills.

5. Discussion and Conclusions

The use of SAR data to detect and track environmental threats, such as oil spills, was explored, yielding positive results in areas of difficult access in terms of cloud conditions. The capability of SAR to provide high quality imagery by penetrating through cloudy areas is crucial in those scenarios. Furthermore, the ability to correlate current events with physical conditions could provide a better display and enhance accuracy for future predictions and models. This is important for developing strategies for environmental protection and disaster response, while helping to mitigate in an effective way the effects of this kind of ecological disasters and safeguarding the flora and fauna of these ecosystems.

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