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Case Report

Geochemical Analysis of Radar Backscatter (Sentinel-1) Over the Corsica Island Oil Spill

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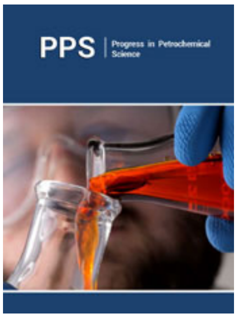

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Abstract

Offshore oil spills represent a major polluting potential in the marine environment [1,2]. Oil spill surveillance is a major part of contingency planning (Jha et al., 2008) and remote sensing techniques enable mapping these events in outlying areas. With essential information such as backscatter and polarimetry data that further the oil spill detection (Shinga et al., 2013). Therefore, the use of Synthetic Aperture Radar (SAR) data for mapping ocean oil spills has been widely applied, as well as the identification of oil on the ocean surface is independent of weather conditions and solar incidence [3]. As mineral oil has hydrophobic constituents, can persist on the ocean surface in the form of multiple layers [4].

Keywords: Backscatter; Polarimetry; Oil spill detection; Synthetic aperture radar; Geochemical oil; Petroleum

Abbreviations: SAR: Synthetic Aperture Radar; GRD: Ground Range Detected; NRCS: Normalized Radar Cross Section

Introduction

Currently, the main studies of oceanic oil detection by SAR imaging focused on analyzing the backscatter signal or polarization, in a purely analytical way. Manuscripts such as [5-8] are references that spatially and statistically correlate some geochemical oil signatures such as: density, viscosity, API degree and molecular composition; with radar signal backscatter values. The API degree is a parameter used to classify the oil type or derivative and established by the American Petroleum Institute and had a direct relationship with the oil specific gravity (density), being and quality indicator [9]. The density is an important information to represent the contribution of light and/or heavy compounds to petroleum fractions. The oil behavior when spilled depends on chemical composition, which impacts the distribution and intensity of weathering. After an oil spill at sea, there is a tendency to spread over the water surface [10], forming a slim stain on lighter products (gasoline, diesel, and light oils), or spots millimeters thick initially, such as heavier oils and Bunker C (Speight & El-Gendy, 2017). In this way, this case reports a Corsica Island oil spill (43°33'N/9°29'E), on October 8, 2018, in which we analyze the radar signal backscattering values and correlate it with the geochemical signature of each analyzed oil. The aim was to identify patterns in the physicochemical characteristics of different oil spills in backscattering fingerprints. Considering that the geochemical signatures of the oil and the degree of weathering should imply different backscattering responses of the radar signal.

Observation

For the study, we used two synthetic aperture radar images, operating in the C-band (between 8-4GHz or 3.8-7.5cm), from the satellite Sentinel-1, downloaded from the Copernicus Open Access Hub portal (https://scihub.copernicus.eu/), in Ground Range Detected (GRD) format, spatial resolution 10×10m. With satellite orbit and altitude provided in zero-Doppler tilted-range geometry. The Normalized Radar Cross Section (NRCS) describes the combined effects of Bragg scattering mechanism [11] and it is a measure of a target's backscattering. In order to obtain the radar signal backscatter values, cross-sections were made over the Sigma 0 data values in areas with mineral film samples on the ocean surface (Figure 1), like made [12-15]. The effect of weathering on the NRCS damping, in the SAR image, is evident for the oil spill near the Corsica Islands. In 24-hour interval, during the oil spill image acquisition, over the Corsica Islands, the mean backscatter values showed a reduction of 5,76dB, a relative discrepancy of 23%. As the oil spilled type near the Corsica Islands (Bunker-C) has lower levels of volatile elements (about 14%), than other oils analyzed, the oil evaporated quickly [16]. In this case, the weathering emulsification process changed the oil spill composition, due to the local wind speed, about 5,2m/s. Thus, water-in-oil emulsion and evaporation reduced the effective dielectric constant, leading to a decrease in backscattered energy. The weathering modified the spot characteristics, consequently reducing the specular backscatter in the SAR image (October 9) compared to the previous day (October 8) in 2018. When comparing the oil backscatter values, close to the Corsica Islands, the relative discrepancy was greater for edge (-27.78) in relation to the spill core (-28.36). We expect that the outer regions are more subject to the action of weathering. The evaporation, emulsification, and dispersion caused by wind-driven sea surface generated higher rates at the edges than at the spill core. This is due to the variation in thickness and composition of the oil spill. Therefore, this change generates a geochemical signature that occurs from the edge to the center, changing the damping intensity of the NRCS. This process presents a small variation of relative discrepancy (only 2%), between the external and internal values of the stain.

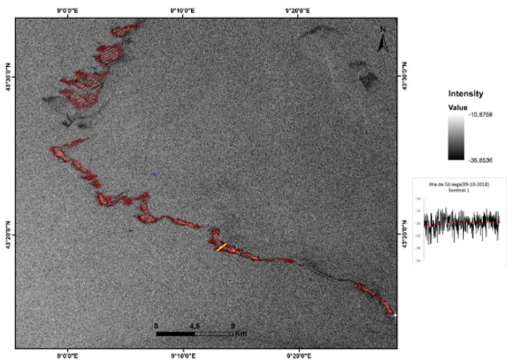

Figure 1: Cross-sections application in SAR image for oil spill Corsica Island study case.

Conclusion

Our analyzes show that the edges spots had lower backscattering values than core areas, due to the oil solubility in water and the increase of the dielectric constant, we have a reduction in damping and a higher back scattering. This pattern is associated with an oil greater concentration in the spill core and a greater performance of weathering at the edges. The events that occurred on Corsica Island and Mexican Gulf showed that oil weathering is strongly associated with a reduction in the backscattered signal damping. In addition to geochemical factors, we identified that low wind speeds are associated with a greater occurrence of specular backscatter, reducing signal backscatter in spills. The relationships identified between the reduction of backscatter and the API degree, density, viscosity, weathering, spill region, and factors related to wind and angle of incidence of radiation. The variables density and viscosity have positive correlation with wind and negative correlation with the oil API degree. The temperature co-varies with viscosity and is associated with API and larger incidence angles, with a tendency to present an attenuation of the Bragg waves and lower values of backscattering on the oil spot.

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