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# Polarimetric radars for detection and identification of marine oil pollution

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The roughness of the sea surface that is responsible for the backscatter is due to the small gravitational waves generated by winds. Oil slicks suppress the waves and backscatter and manifest itself on radar images as dark spots. However, the other processes could be shown on the radar images similarly: upwelling, atmospheric convection, internal waves, calm area, etc. All of them may be falsely interpreted as oil pollution.

Polarization SAR data carry additional information directly related to the vector nature of the reflected electromagnetic wave and can assist in the identification of different types of slicks. When polarized wave falls on a surface and reflects from it the reflected wave is also polarized. Sea surface is rough, i.e. consists essentially of a large number of differently oriented elementary areas. Consequently the signals reflected from different elementary areas are characterized by different polarization parameters and total signal carries information about all rough surface scanned [1]. When scanning sea surface, quad-polarization SAR generates scattering matrix for each pixel of radar data, which contains all the information regarding the polarimetric backscattering properties of the study area and that can be used for the classification of SAR images according to different scattering mechanisms.

As mentioned above, various surface manifestations (calm area, biogenic film, etc.) may be falsely interpreted as oil slicks. In [2] was proposed a method to distinguish them, for which the following parameters were chosen: the polarization ratio (HH channel to VV) and the difference (VV minus HH channel). Normalized radar cross-section (NRCS) $\sigma_0^{pp}$ can be represented as follows:

$$\sigma_0^{pp} = \sigma_{0B}^{pp} + \sigma_{wb},$$

where $\sigma_{0B}^{pp}$ - Bragg scattering, $\sigma_{wb}$ - non-polarized scattering. Thus the polarization ratio (PR) and the polarization difference (PD) can be expressed respectively as:

$$PR = \frac{\sigma_0^{HH}}{\sigma_0^{VV}} = \frac{\sigma_{0B}^{HH} + \sigma_{wb}}{\sigma_{0B}^{VV} + \sigma_{wb}}$$

$$PD = \sigma_0^{VV} - \sigma_0^{HH} = \sigma_{0B}^{VV} + \sigma_{wb} - \sigma_{0b}^{HH} - \sigma_{wb} = \sigma_{0B}^{VV} - \sigma_{0b}^{HH}$$

A number of radar images of German satellite TerraSAR-X were processed to verify the proposed method. Images of different surface slicks were used: biogenic films, oil spills, grifon films, ship discharges. As expected according to [2] for the polarization difference surface spills are clearly visible. However only thick films are visually distinguishable from the background on the images of polarization ratio. Estimated thin films (biogenic and grifon) become virtually invisible, that may indicate the presence of scattering mechanism different from the mechanisms in the area of other spills. These results suggest that use of polarization SAR and methods of combining different polarization characteristics can improve the detection and recognition of surface oil pollution.

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