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Change detection target by semivariogram textural classification added to practical application of wind speed retrieval using RADARSAT-1/SAR imagery

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Abstract. Coastal surveillance activities have increased in recent years, so accurate information as target detection and wind speed are required to oil spill contingency plans. The main goal is to test practical applications to SAR wind speed retrieval algorithms into a developed controlling method for oil rigs positions. A semivariogram textural classifier (STC) was applied in RADARSAT-1/SAR images of ScanSAR Narrow and Extended Low 1 beam modes. The comparison between the measured position of fixed and floating targets and the data provided by official organizations was done to validate the methodology. Limitations regarding wind vector field obtained by atmospheric modeling can be connected to poor resolution. Thus, SAR wind speed retrieval algorithms have been applied to the images in order to get a more appropriate resolution to coastal applications.

Keywords: target detection, SAR, wind speed, detecção de alvos, SAR, velocidade do vento.

1. Introduction

Coastal surveillance and environmental monitoring has motivated the development of automatized feature extraction tools using remote sensing data. Activities of intrinsic risk as oil exploitation and transportation demand appropriate contingency plans for emergency situations as well as illegal oil spills. Hence, there is a need of controlling the fixed, floating and moving targets position in exploitation areas, so that one can correctly connect them to eventual oil spills.

Target detection by Synthetic Aperture Radar (SAR) has been extensively studied in recent years, and several techniques can be found in literature (Li and Zenio, 1996; Perlovsky et al., 1997; Howard et al., 1999). Among these techniques, the use of contextual information added to radiometric values of each pixel provides a more complete scenario for digital classification algorithms. Considering this, a contextual classifier based on semivariogram function was applied to a set of ten multitemporal SAR images in order to detect fixed, floating and moving target on the sea (Soler and Landau, 2003).

Although efficient, the contextual targets classification method has presented limitations regarding to incident angles of radar systems and high wind speed occurrence. Some images classification resulted in a poor discrimination of targets which was connected to lack of accuracy in geometrical correction. However, this can be due to high wind speed occurrence which was not revealed by the wind field modeled data used considering its poor spatial resolution. Thus, SAR wind speed retrieval algorithms have been applied to the images in order to get a more appropriate resolution to coastal applications.

2. Study Area

Located along the coast of Rio de Janeiro and Espírito Santo States, Campos Basin region keeps 86.9% of the total Brazilian oil and gas reserves (ANP, 2002). Exploitation activities in Campos are very significant in deep waters (depths greater than 1000 m). The most important oceanographic feature present in the area is the predominantly southward flux of Brazil Current (BC). However, BC may take different flow directions along Campos Basin due to the submarine elevation of Abrolhos and the shelf break offshore of Capes São Tomé and Frio. These discontinuities can cause flow instability and origin meanders and eddies with

diameters between 50 and 200 km that may last for weeks. These features in SAR images can be misclassified as oil slicks, so ancillary data as wind at ocean surface and atmospheric conditions must be considered. Beyond this, the constant passage of cold fronts during wintertime causes a significant change in wind regime at ocean surface along the coast (Stech and Lorenzzetti, 1992). However, these changes can not be detect by wind scatterometer data and buoys sampling due to their coarse spatial resolution, so wind field retrieval by SAR may diminish these limitations (Korsbakken et al. 1998, Kim and Moon 2002).

3. Methodology

In the first phase of the methodology, a set of ten RADARSAT-1/SAR images was used in the oil rigs detection study. The images specifications, the classification results and the wind speed observed in modeled data are presented in **Table 1**. The ScanSAR Narrow A and B beam modes used (SNAR and SNB respectively) present image swaths of 300 km and 50 m of nominal resolution.

Table 1. Images specifications with the numbers of fixed, floating and moving targets identified in each image and the wind speed interval observed in the modeled data.

Date and beam mode	Orbit	Fixed targets	Floating targets	Moving targets	Wind speed interval (m/s)
25/03/2002 SNAR	Descending	40	10	58	3<|v|<8
13/04/2002 SNB	Ascending	41	10	62	3<|v|<8
18/04/2002 SNAR	Descending	40	10	30	2<|v|<6
12/05/2002 SNAR	Descending	32	10	37	5<|v|<7
19/05/2002 SNB	Descending	42	10	60	6<|v|<8
01/08/2002 SNAR	Ascending	34	07	54	6<|v|<9.5
12/10/2002 SNAR	Descending	28	07	29	8<|v|<13

After the pre-processing steps of geometrical corrections and speckle filtering, the Semivariogram Textural Classifier (STC) was applied to images. Detailed information about the classification procedure can be seen in Miranda and Carr, (1994) Soler and Landau (2003).

In the second phase of the methodology a comparative analysis will be done between wind speed obtained by atmospheric modeling (which values are show in **Table** 1) and the one estimated by the same SAR images used to oil rigs distinguishing. Wind speed retrieval algorithm CMOD4 (Stoffelen ans Anderson, 1997) has been applied to SAR images.

The CMOD4 algorithm was initially developed to ERS-1 Scaterometer wind retrieval, but significant results has been reached when used with the same end in SAR images (Wackerman et al. 1996, Korsbakken et al. 1998, Vachon et al. 2000). Radar scatterometer as SeaWinds/QuikSCAT-1 provides global wind vector field at spatial resolution of 50 km with an accuracy of 2.0 m/s in speed, 20° in direction and a directional ambiguity of 180°. On the other hand, by using SAR images to wind vector field estimation, one can reach a spatial resolution of 10 km, an accuracy of 1.5 m/s in speed and 33° in direction. Although SAR wind vector field estimation also results in a directional ambiguity of 180°, it can be solved by using external data as the data used in the first phase of the present study or scatterometer data.

In the third phase of the study, it is intended to apply the above detailed methodology in Mexican Gulf where SAR images and *in situ* measurements of wind intensity and direction will be used. Thus, not only will it be possible to estimate wind speed, but also wind direction. It is intended to compare CMOD4 algorithm to CMOD_IFR2 (Kim and Moon, 2002) and to used new computational techniques as neural networks to obtain the wind speed as an improvement of actual algorithms used.

4. Previous and Expected Results

The occurrence of wind speed higher than 8 m/s was a determinant aspect to images from August 1st and October 12th present a lower rate of detection in both: fixed and floating targets. It is expected to confirm this range limitation by using a great number of images in Mexican Gulf.

The classification result of image from May 12th showed a noticeable diminishing of fixed targets. When compared to the other ScanSAR Narrow images, the expressive RMS error in geometrical correction (about of 50%) may be associated to the poor discrimination of features. However, a detailed comparison between wind vector fields must be done in order to evaluate possible errors in atmospheric modeling. It is expected this comparison reveals the efficiency of wind vector field estimated by SAR images.

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