The measurement of ocean currents is extremely important to several applications spanning from human activities (e.g. fishery) to ocean monitoring and modeling. Synthetic Aperture Radar (SAR) sensors, which allow ATI mode, provide image pairs of the ocean surface. Since the ATI phase is proportional to the along range velocity component of the imaged object, i.e. target or scene, it permits the estimation of its line-of-sight velocity.

The paper presents a method to retrieve the speed of the sea surface from Along Track Interferometry (ATI) data beside the typical use for target speed retrieval. The described technique provides for a data prefiltering in order to obtain the necessary accuracy because of the low speed range of the currents. Furthermore, an example of target velocity estimation is provided. The results are validated by TerraSAR-X Dual Receive Antenna (DRA) ATI campaign that it was carried out on April and May 2010. The sea surface estimation is accurate and consistent with the real speed range.

1 INTRODUCTION

The paper presents a method to retrieve the speed of the sea surface from Along Track Interferometry (ATI) data beside the typical use for target speed retrieval. The described technique provides for a data prefiltering in order to obtain the necessary accuracy because of the low speed range of the currents. However, in case of targets, the prefiltering is not necessary because the phase is less noisy and the speed range is at least one order of magnitude higher.

A short overview of the ATI SAR is presented in Section 2 together with the processing chain. The case study and the results are presented in Section 3. TerraSAR-X stripmap Dual Receive Antenna (DRA) ATI image pairs are used to validate the results. The conclusion ends the paper in Section 4. The data have been acquired in April and May 2010 during the DRA ATI campaign.

2 ATI OVERVIEW AND PROCESSING

A space ATI SAR is a system of two antennas mounted on the same platform or two different satellite [6]. The TerraSAR-X has a 4.8 m phased array antenna on board which, in the DRA mode, is split into two halves exploiting the receiving redundant electronics. The whole antenna is transmitting and the two halves are contemporaneously receiving [4]. The mode is similar to the Aperture Switching [3] but it is better in terms of Signal-to-Noise Ratio (SNR) and Pulse Repetition Frequency (PRF).

The ATI phase is given by

$$\phi_{ATI} = \frac{4\pi B}{\lambda} v_s \sin(\theta)$$

where $B$ is the baseline, i.e. half of the actual distance between the phase center of the two antennas, $\lambda$ is the wavelength, $v_s$ the sensor velocity, and $\theta$ is the local incidence angle. The across track target component of the line-of-sight velocity $v_{gr}$ is obtained by inverting equation 1. The ATI geometry configuration is shown in Fig. 1.

The data are processed according to the flow chart shown in Fig. 2. The interferogram is given as input to the chain, thus a spatial averaging with a window of $49 \times 49$ pixels is done in order to reduce the noise. Therefore, the intensity threshold and the intensity median filter allow to discard the bright points and the outliers which affect the estimation. The median filter on the phase is done for the same reason. Therefore, the irregular grid is interpolated and a boxcar filter is applied to the phase image. Finally 1 is inverted in order to obtain the sea surface speed.
3 RESULTS

Three ATI images acquired over Gibraltar on 23rd of April and over the Bay of Fundy on 21st of April and 2nd of May 2010 are used to validate the presented method. Differently from [1, 2], where it is applied on Aperture Switching mode, here the validation is made on DRA data.

The location have been chosen because of the strong currents which may occur. Moreover the direction of the current is consistent to the SAR line-of-sight. Thus, they represent good test areas to validate the techniques. All the cases present low wind conditions according to visual inspection, i.e. low intensity and not visible wind strikes. Unfortunately azimuth ambiguities, which are well visible in the interferogram, affect the correctness of the speed surface in an area of 5 km from the coast. They are caused by the acquisition mode and the chosen PRF.

The currents, corresponding to Figs. 3a and 4a, are moving from East to West direction with an average speed of 2 m/s and 3 m/s, Figs. 3b and 4b respectively. An evident feature, caused by the current, is visible in Fig. 4a which is also confirmed by the estimation of the surface speed. The third image, Fig. 5a, shows current from Atlantic Ocean to Mediterranean see with an average speed of 1.5 m/s, Fig. 5b.

Although ground truth measurement are missing, the estimated speeds are consistent to the current velocity in the selected areas.

The ATI acquisitions allow also to estimate the across track velocity component of moving targets [5]. It has a strong impact for the monitoring of moving vessels. An example is shown in Fig. 6 where a ship is moving from West to East with a speed of 14.3 knots.

4 CONCLUSIONS

The results on TSX DRA ATI data are promising for ocean currents measurements. The accuracy of the estimation is about 0.2 m/s and the spatial resolution about 2 Km. The problem of the ambiguities which introduces a phase error might be approached by a spectral windowing. The estimation of the meteo-marine parameters (i.e. wind and waves) would allow the correction of their contributions to the sea surface motion estimation in order to retrieve the actual current stream.
On the other hand, the chosen images are not affected by rough or high sea state, but moderate. Thus, the estimation is not altered by wind or wave motions.
Figure 5: Original image (a) and sea surface speed results (b).

Figure 6: Ship from the red box in Fig. 5a.

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REFERENCES


