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The concept of delay/Doppler radar altimeter has been under study since the mid 90’s, aiming at reducing the measurement noise and increasing the along-track resolution in comparison with the conventional pulse limited altimeters. This paper introduces a generalized semi-analytical model for the delay/Doppler echo that accounts for antenna mispointing, as well as an associated least squares estimation algorithms. The mean power of a delay/Doppler echo can be expressed by a convolution of three terms that are the probability density function (PDF) of the heights of the specular scatterers, the time/frequency point target response (PTR) of the radar and the flat surface impulse response (FSIR). The first contribution of this paper is the derivation of a generalized analytical model for the FSIR that accounts for antenna mispointing. The proposed analytical expression for the FSIR also considers Earth curvature, a circular antenna pattern and a Gaussian approximation for the antenna gain. The two dimensional delay/Doppler map (DDM) is then obtained by a numerical computation of the convolution between the proposed analytical FSIR expression, the PDF of the sea wave height and the time/frequency PTR. The resulting DDM depends on five altimetric parameters that are the epoch, the significant wave height, the amplitude, the along-track and the across-track mispointing angles. Appropriate processing, including range migration and multi-looking, is applied to the resulting DDM yielding the Doppler echo (also known as the multi-look echo). The second contribution of this paper is the derivation of estimators for the five parameters associated with the multi-look echo. A least squares approach is investigated by means of the Levenberg-Marquardt algorithm. Moreover, the study of the effect of antenna mispointing shows high correlation between the along-track mispointing and the echo's amplitude. Thus, a four parameter estimation strategy has been proposed rather than the mere estimation of the five parameters of interest. In order to evaluate these strategies, we compare their estimation performance to that obtained using the three parameter model derived in a previous paper [1]. Validation of the proposed model and the corresponding algorithms is achieved on simulated and real Cryosat-2 data. The obtained results are very promising and confirm the accuracy of the proposed model.

[1] A. Halimi, C. Mailhes, J.-Y. Tourneret, P. Thibaut and F. Boy, "A semi-analytical model for delay/Doppler altimetry and its estimation algorithm," IEEE Trans. Geosci. and Remote Sensing, 2013, to appear
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