Analysis of speckle manifestation on rotating near-nadir radar measurements. The SWIM case

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Résumé

Speckle is a well know phenomenon in wave theory, that is ubiquitous in experiments involving electromagnetic remote sensing and more specifically in the micro-wave regime. In spatial micro-wave remote sensing applications the most striking visual demonstration of speckle can be observed on all Synthetic Aperture Radar (SAR) images of backscattering cross-section. This random aspect of the back-scattered signal magnitude takes its origins in the phase randomness of the scatterers that contribute to each pixel. Speckle is usually called "noise" since it is a geophysical signal that superimposes on the signal of interest. In order to mitigate this effect, several techniques are usually applied during the On Board Processing or on ground during the post-processing steps. In order to reduce the impact of speckle, the SWIM instrument aboard CFOSAT sends series of about 200 pulses that are averaged onboard. The efficiency of the speckle reduction by this averaging procedure depends on the temporal decorrelation of the pulses. If the Pulse Repetition Interval is chosen too small, the echos do not decorrelate enough to reduce the speckle. On the contrary, if the PRI is too large, the echos decorrelate but the illuminated surface can not be considered to remain the same during the cycle. A compromise has to be found to choose the PRI. In this work, we present the origin of the speckle manifestation on the SWIM signal and exemplify its strong sensibility to the observing geometry and more specifically to the antenna azimuth direction. A theoretical analysis is performed in order to explain the azimuthal variability of the speckle. This analysis is coupled to numerical instrument simulation which represent the whole observation chain. These end-to-end simulations provide access to modelized RAW I and Q signals, obtained from a simulated electromagnetic field scattered from a synthetic numerical ocean surface. The simulations are used to exemplify SWIM speckle manifestation on the recorded signal at all steps of the processing chain. In this work, simulations are used to decouple some geophysical and instrumental parameters in order to independently evaluate their contributions to the final speckle level. Finally, both theoretical and numerical approaches are compared to a dedicated statistical SWIM data analysis. The SWIM speckle spectrum is carefully analysed against various representative geophysical and instrumental parameters such as incidence (beam), azimuth, latitude, significant wave height and wind speed.

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