Validation of the increased image resolution obtained using TOPSAR Sentinel-1 data in a bistatic setup

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Topic: Active and passive remote sensing systems, oral presentation

Abstract *Spaceborne Synthetic Aperture Radar (SAR) systems usually operate over land in complex scanning modes such as ScanSAR or TOPSAR that can achieve wide swath coverage in a single pass of the satellite at the cost of degraded cross-range resolution. This work demonstrates the feasibility to produce bistatic radar images using a SAR satellite as emitter of opportunity and a stationary ground-based receiver with a 5-fold increase in cross-range resolution. A Maximum A Posteriori-based method is validated using real measurements from the European Space Agency's satellite Sentinel-1A.*

Introduction

In monostatic SAR, the elevation antenna pattern is shaped to substantially attenuate echoes at angles that correspond to ambiguous ranges when the main beam is directed towards the scene of interest. This two-way attenuation of signals originating from sidelobe illumination yields a non-continuous illumination of the ground in the case of a burst-mode illumination such as ScanSAR or TOPSAR [1].
However, in a bistatic configuration with a receiver constantly pointing to the scene of interest, the returns originating from the elevation sidelobes of the transmit antenna may enter the mainlobe of the receiver with a sufficient SNR. This continuous illumination of the scene of interest may be used to increase the integration time and thus improve the cross-range resolution compared to the traditional monostatic SAR image. The considered bistatic space-ground geometry of the experiments is shown in Fig. 1.

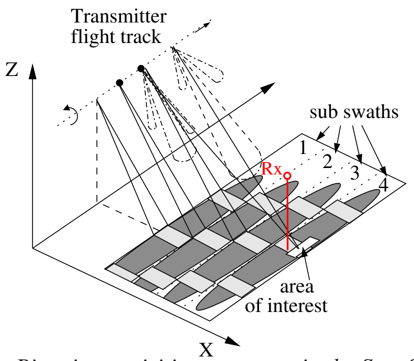
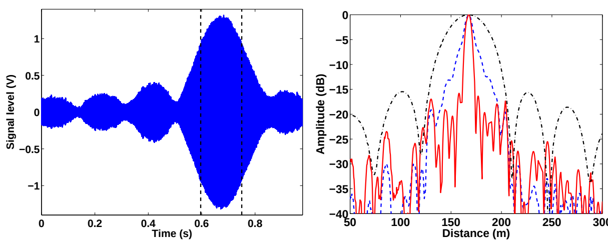


Figure 1: Bistatic acquisition geometry in the ScanSAR mode.



(a) (b)

Figure 2: (a) Direct signal acquired during an overpass of Sentinel-1A and (b) cuts of the Impulse Response Function (IRF) along the transponder's isorange.

Figure 2 (a) represents the direct signal acquired during an overpass of Sentinel-1A operating in TOPSAR mode over the ground-based receiving system. An active bistatic transponder was also deployed. It consisted of two antennas connected by an amplification stage: one antenna pointing towards the receiver and another antenna towards the transmitter.

Results and conclusion

To illustrate the performance in terms of cross-range resolution, a SAR image has been computed with the traditional integration time of classical monostatic processing, i.e. 3 dB mainlobe width of the transmit antenna. This integration time corresponds to the time between the two vertical dashed lines in Fig. 2 (a). The corresponding cross-range cut in the Impulse Response Function (IRF) of the transponder is shown in black dashed line in Fig. 2 (b). The measured cross-range resolution is equal to 22 m and corresponds to the theoretical monostatic value. This poor cross-range resolution can be enhanced by integrating the pulses transmitted in the azimuth sidelobes of the considered beam, i.e. the entire signal in Fig. 2 (a). An image can then be obtained using the conventional Matched Filter (MF). The corresponding cross-range cut in the IRF of the transponder is represented in blue dashed line in Fig. 2 (b) and exhibits high energy in the sidelobes. When the proposed method [2], based on the Maximum a Posteriori estimation, is used, the sidelobes are strongly reduced as illustrated in Fig. 2 (b) (solid line). The achieved cross-range resolution is five times better than that of the monostatic SAR image produced by the satellite.
In the final paper, we will show a comparison of a bistatic image obtained by our novel method with the monostatic radar image obtained by the radar satellite at the same time, including an analysis of the signal to noise ratio.
The exploitation of wide-swath SAR illuminations considerably increases the number of opportunities to produce high cross-range resolution images over the area of interest as there are many more passes in the wide-swath mode than in the conventional Stripmap mode.

References

[1] F. De Zan and A. Monti Guarnieri, "TOPSAR: Terrain Observation by Progressive Scans," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 44, no. 9, pp. 2352–2360, 2006.

[2] V. Kubica, X. Neyt, and H. D. Griffiths, "Along-track resolution enhancement for bistatic SAR imaging in burst-mode operation," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 52, no. 4, pp. 1568 – 1575, Aug. 2016.