Cross-range resolution enhancement in burst-mode SAR in bistatic operation

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Abstract *This paper describes a cross-range resolution enhancement method for bistatic SAR systems operating in ScanSAR mode. The performance and the feasibility of the method are evaluated based on real data.*

Introduction

To increase the observed swath, modern SAR systems, such as RADARSAT-2, use a scanning technique, named ScanSAR, to illuminate several sub-swaths by steering the antenna in elevation at the expense of cross-range resolution. The 'burst' nature of the ScanSAR signal creates gaps in the azimuth phase history, leading to along-track grating lobes, which if not taken into account [1] create ghosts in the SAR image.

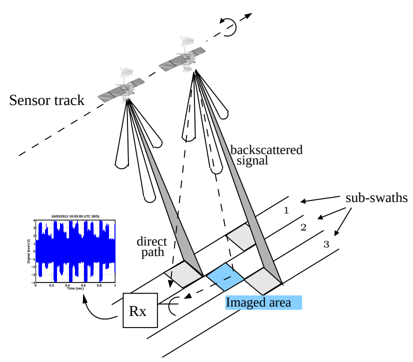

Figure 1: Geometry of the bistatic ScanSAR operating SAR.

In bistatic SAR, this degraded cross-range resolution can be enhanced by exploiting the sidelobe emissions of the beams illuminating the adjacent sub-swaths additionally to the mainlobe emissions of the beam illuminating the considered sub-swath. This is, however, only feasible on the twofold condition that the amplitude of the signal transmitted in the elevation sidelobes is sufficient (which depends on the elevation antenna diagram of the transmitter), and that the attenuation of the reflected signals is minimized which occurs for a receiver close to the imaged area.
This 'gap-filling' process will occur for favourable geometries, i.e. for a sufficient sidelobe illumination of the receiver and the imaged area.

Passive ScanSAR imaging

The passive SAR system considered in this paper consists in an opportunistic spaceborne transmitter operating in ScanSAR mode and a stationary ground-based receiver (Fig. 1).
In addition to the gap-filling process, the azimuth grating lobes can further be reduced by compensating the beam-to-beam amplitude differences. This compensation method performs very well if the SNR is sufficient in each beam. However, when one or several beams are barely presents (low SNR areas), a balance between the amplification of the weak signal and the noise inherently present in the received signal is required.

Results and conclusion

Figure 2 illustrates a point-like target in the georeferenced SAR image obtained during an ENVISAT overpass operating in ScanSAR mode (the receiver was in the centre of the swath of the ASAR instrument).

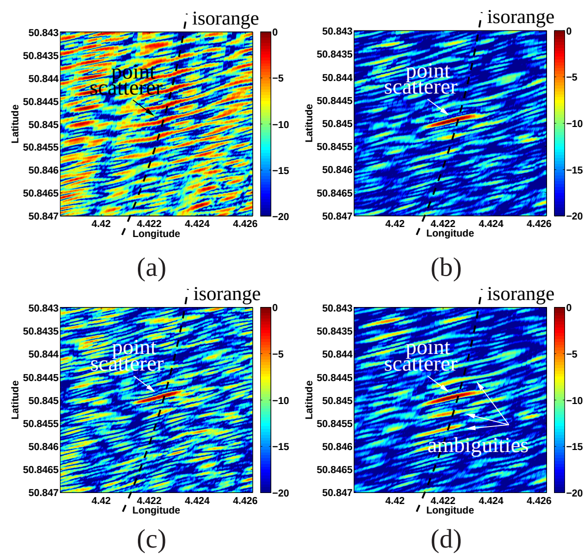

Figure 2: Zoom on a point scatterer in the SAR image.

If only one elevation beam is considered, the expected grating lobes along the azimuth direction appear on Fig. 2 (a). After the gap-filling process, a reduction of the grating lobes below the noise level occurs as shown on Fig. 2 (b). Figures 2 (c) and (d) respectively illustrate the performance of the amplitude compensation method for an underestimation of the noise (the noise level increases) and for an overestimation of the noise (the amplification of the noise is low while the grating lobes are less reduced and reappear).
In this paper, we demonstrate that, using a bistatic configuration, the cross-range resolution can be enhanced in favourable geometries, i.e. if the SNR is sufficient in each beam. This considerably increases the opportunity to produce high cross-range resolution images over the area of interest as there are many more passes in the ScanSAR mode than in the Stripmap mode.

References

[1] J. Holzner and R. Bamler, "Burst-mode and ScanSAR interferometry," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 40, no. 9, pp. 1917–1934, 2002.