New processing approach and results for bistatic TerraSAR-X/F-SAR spaceborne-airborne SAR experiments

Marc Rodriguez-Cassola, Stefan V. Baumgartner, Pau Prats, Gerhard Krieger, Anton Nottensteiner, Ralf Horn, Irena Hajnsek, Alberto Moreira

German Aerospace Center (DLR)
Microwaves and Radar Institute, 82234, Oberpfaffenhofen, Germany
Email: marc.rodriguez@dlr.de

In November 2007, the first bistatic SAR spaceborne-airborne X-band campaign was carried out , using TerraSAR-X as transmitter and DLR's new airborne SAR system F-SAR as receiver [1]. The importance of the experiment was not only due to its pioneering character, but also to its potential to serve as a test-bed for the validation of non-stationary bistatic acquisition procedures, novel calibration and syncrhonisation algorithms, and advanced imaging techniques, as the ones required for future non-synchronised bistatic SAR systems. First results of this successful experiment were presented in [1], including the simultaneous bistatic and monostatic images acquired during the experiment. Compared to the very first experiment of this nature [2], the novelty of our approach was to include full clock synchronisation (achieved in processing steps and with no prior information of the relative clock behaviour) and high resolution imaging. The complete results of this first experiment, including performance, processing and image analysis were presented in [3].

The availability of both monostatic and bistatic images, both acquired with so different and varying geometries, highlighted one of the main applications of bistatic SAR systems: the obtainment of a whole new observation space due to the new possibilities offered by bistatic SAR configurations. The enlargement of this observation space was a main motivation for a second bistatic spaceborne-airborne campaign, performed successfully early July 2008. This second bistatic experiment, involving once again TerraSAR-X as transmitter and F-SAR as receiver, consists of an along-track side-looking acquisition with a notably smaller (around 30 deg) TerraSAR-X incidence angle. TerraSAR was operated in high-resolution spotlight mode with an additional polarisation toggling of consecutive transmitted pulses VH. F-SAR received data quasi-continuously using a single receiver channel and horizontal polarisation. The effective PRF for each polarisation was around 3 kHz, which limits the azimuth size of the scene but is still high enough to avoid ambiguities through the first lobes.

The paper also presents a revision of the processing approach presented in [3], with stress on the two fundamental issues of this non-synchronised bistatic azimuth-variant acquisition: synchronisation and focussing. The clock offset between both radars is now estimated, at least in a first stage, without using absolute positioning information of neither platforms nor reference targets, something which cannot be guaranteed in such opportunity acquisitions. The precision of this new synchronisation procedure is described in the paper. Regarding the focussing part, the existing fast algorithms dealing with the peculiarities of this kind of acquisition only achieve fast focussing at a cost of image quality; the room for high-precision fast bistatic azimuth-variant SAR processing algorithms is still open and a new high-precision approach is presented in this paper. The described results are tested and validated using the data obtained in the two DLR TerraSAR-X/F-SAR spaceborne-airborne bistatic SAR campaigns performed so far, including a comparison in terms of efficiency/precision with the existing approach and image results.

References:

[1] S. Baumgartner et al., "Bistatic experiment using TerraSAR-X and DLR's new F-SAR system, Proc EUSAR 2008, Friedrichshafen, Germany.

[2] D. Martinsek et al., "Bistatic radar experiment", Proc. EUSAR 1998, Berlin, Germany.

[3] M Rodriguez-Cassola et al., "Bistatic spaceboprne-airborne experiment TerraSAR-X/F-SAR: data processing and results", Proc. IGARSS 2008, Boston USA.