A novel approach to the external calibration of multi-channel SAR sensors based on range compressed data

* Marc JÄGER, Rolf SCHEIBER

1. German Aerospace Center (DLR), Microwaves and Radar Institute, P.O. Box 1116, 82230 Wessling, Germany
marc.jaeger@dlr.de

* Corresponding Author

ABSTRACT

The presented approach concerns a method for the accurate calibration of multi-channel SAR instruments, such as those required to support SAR polarimetry, single-pass interferometry and digital beam-forming, on the basis of dedicated SAR acquisitions containing reference targets with known properties. Unlike conventional approaches, the method is based entirely on the analysis of range-compressed raw data. It leverages the pulse-by-pulse analysis of amplitude, phase and delay variations observed within the range histories of reference targets to fully characterise and correct propagation direction dependent calibration issues. In addition, the approach does not require SAR image focussing in azimuth, which is essential in cases where azimuth focussing requires beam-forming techniques and thus pre-supposes an accurate calibration of the antenna array.

The approach is complementary to the internal calibration implemented in modern SAR sensors and focuses on providing an accurate and consistent characterisation of the antenna array, which is, by definition, outside the scope of internal calibration techniques. The approach introduces an explicit model of possible calibration error sources and uses the radar measurements to derive corresponding corrections. The error sources considered, for each individual antenna element in an array, are as follows:

1. **Element mount angles**: these describe a mispointing of the antenna element in terms of the attitude angles pitch, yaw and roll. Accurate determination of mount angles enables accurate radiometric calibration of SAR imagery in arbitrary imaging geometries.

2. **Element baselines**: The relative separation between element phase centres. Accurate baselines are essential for multi-channel SAR sensors, as even small baseline errors translate to phase errors that distort interferometric and polarimetric SAR measurements as well as the effective antenna illumination pattern when beam-forming is employed.

3. **Absolute array position**: A reference point that, in conjunction with the element baselines, determines the absolute position of element phase centres in 3D space. Errors in the absolute array position translate into geo-location errors in the focussed SAR image.

4. **Residual impulse response errors**: These are frequency dependent, incremental corrections to the characterisation of the radar instrument’s transfer function provided by internal calibration measurements.

5. **Residual errors**: Frequency and propagation direction dependent amplitude and phase errors that remain after all corrections have been taken into account serve to validate the error model used and point to remaining calibration issues, e.g. residual errors in the on-ground antenna diagram characterisation.

6. **Calibration constants**: Constant corrections in terms of intensity, delay and phase can be derived once other corrections have been taken into account. These constants are introduced to ensure the absolute calibration of the SAR instrument and ensure that SAR imagery can be related to physical properties of the imaged scene in terms of backscatter intensity, geo-location and inter-channel phase differences.

The approach is illustrated and validated using real polarimetric/interferometric multi-channel SAR data acquired by DLR’s airborne SAR sensor F-SAR.