Impacts of Radar Echoes on Internal Calibration Signals in the TerraSAR-X Instrument

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Abstract

In June 2007, the first German SAR satellite for commercial and scientific applications, TerraSAR-X, was launched. TerraSAR-X is a flexible X-Band SAR operating in Stripmap, Spotlight, ScanSAR, and additional experimental modes. Its active phased array antenna hosts 384 transmit/receive modules (TRMs) controlling the beam steering and shaping in azimuth and elevation.

For calibrating and monitoring the required radiometric stability, the radar instrument of TerraSAR-X features an internal calibration facility coupling into an additional port of the TRMs. Calibration pulses are routed through the front-end to characterise critical elements and parameters of the transmit (TX) and receive (RX) path. Changes in the signal path appear due to thermal effects, degradation, or extreme conditions in space. Especially the front-end TRMs controlling the phased array antenna are of crucial significance for the instrument reliability.

Since launch TerraSAR-X has been producing SAR images of outstanding quality which is due to an extensive and experienced preparation of the SAR processing chain. The processing inherently accounts for the internal calibration sequences within the data take to provide a high-quality product better than the required radiometric stability. The commissioning phase of TerraSAR-X showed that most calibration pulses work very well within the expected accuracy range, however some calibration pulses are heavily interfered from an additional signal.

Explicitly the RX-Calibration pulses for the receiving path are sporadically too noisy to be processed correctly. When no calibration signal can be retrieved, the Internal Calibration processing is deactivated and SAR products are not calibrated. Additionally, the reference chirp for range compression is directly calculated from the calibration pulses. If no reference chirp can be extracted due to interfered signals, range compression is performed with the ideal chirp from waveform parameters. The disadvantage of the ideal chirp is a less accurate correlation with the raw data. The ideal chirp amplitude is a virtual value that does not correspond to the real chirp energy, i.e. it is not absolutely calibrated.

There are many indications that the interference of the RX-Calibration signals is caused by an echo from a transmitted TerraSAR-X chirp pulse of the same data take. As consequently implemented in the TerraSAR-X system, different approaches solve these effects of signal interference. In orbit, the commanding sequence can be optimised for avoiding interference. At processing level, averaging techniques minimise the noise effects inside the calibration signals. This paper presents the effects of the radar echoes on the whole internal calibration process and how they can be detected and minimised.