Performance assessment for the high resolution and wide swath (HRWS) post-Sentinel-1 SAR system

The next generation, post-Sentinel-1, ESA's C-band synthetic aperture radar (SAR) system is conceived to provide simultaneously high azimuth resolution and wide swath width (HRWS).

There are different ways in which the imaging capabilities of the HRWS SAR system can be exploited, which translate to different operation modes. The more attractive are the wide swath modes, operating in ScanSAR, with 400 km swath width and a resolution of 5m x 5m for single/dual-polarization and, maybe even more noteworthy, the fully-polarimetric 280 km swath width at 5m x 5m single-look resolution. These modes represent a factor four improvement in terms of azimuth resolution with respect to Sentinel-1. Considering also the extended swath or the quad-pol capabilities, the information rate will increase by close to and order of magnitude.

Indeed, wide unambiguous swath coverage and high azimuth resolution pose contradicting requirements on the design of spaceborne SAR systems. Nevertheless, recent studies have shown that by applying Digital Beam Forming (DBF) techniques, such as Scan-on-Receive (SCORE), and Multiple Azimuth Phase centers (MAPS), it becomes possible to overcome these fundamental limitations of conventional SAR systems. The use of MAPS in azimuth enables the decoupling of the high azimuth resolution and wide-swath SAR coverage. It employs a multichannel receiver in combination with mutually displaced multiple aperture elements and the azimuth resolution results determined by the length of the individual sub-aperture elements. At the same time, employing multiple channels in elevation, according to the SCORE technique, allows to collect radar echoes from a wide image swath despite using a receiver aperture with large vertical extension. The trade-off between antenna gain and swath width can thus be relaxed.

In this framework, DLR has reviewed the capabilities of the HRWS SAR system in light of the associated requirements provided by ESA and of the science requirements associated to operational GMES applications. Indeed, many and potentially new applications can benefit from the HRWS SAR operational modes.

Moreover, a HRWS application performance toolkit has been designed and implemented to compare product-level performance for different operating modes and mission scenarios.

The established applications defined within the GMES services and selected for the HRWS performance study are:

- Deformation monitoring
- Regional land cover
- Ocean applications (wind and currents retrieval and oil spill monitoring)
- Land ice (wet snow mapping and ice drift)
- Sea ice (iceberg detection and ice motion)
- Iceberg detection
- Security (vessel detection)

Thus, th resulting HRWS toolkit includes for every application analytical expressions or numerical models and, if these are not available, real SAR images as well as numerical algorithms and some explicit simulations of the data and of the inversion process are employed. The tool uses as input the HRWS SAR instrument performance for the different applicable modes and produces as output results comparable with the existing C-band SAR missions.

Due to its wider swath, high resolution and multipolarimetric capabilities, the performance for the HRWS SAR system show a substantial improvement when compared to those of Sentinel-1A, for most of the applications and operational scenarios.

In the final paper a short description of the employed product-level performance models together with the main results will be provided. Furthermore, an analysis based on the different applications performance and on their relative relevance will give a single operational mode for the best compromise.