S1 IWS data handling and basic functionality

Currently the GAMMA Software supports the use of S1 IWS Single (Look Complex) and GRD (Ground Range Dated) products. The GRD products may be used to analyse the backscattering coefficient and for offset tracking, e.g. to map glacier motion.

The S1 IWS SLC product is a set of three “burst SLC”, each one including a number of SLCs obtained by processing a single orbit of IWS SAR data through the full stripmap process. An example of a burst SLC of sub-swath I-WH is shown in Figure 1. The area covered by the individual bursts in both sub-swath and sub-subsequent bursts (and range between neighbouring sub-swaths) as sketched in Figure 2. In the GAMMA Software the S1 IWS SLC product is imported and stored as burst “SLC” consisting of the image data of the 3 sub-swaths and related parameter files containing the relevant metadata. In the importing, the radiometric calibration is applied. Functionally to process the “burst SLC” is to pass the individual mosaic SLC and a mosaic IWI (multi-look detected image). Figure 3. In both cases, this is a single data file with a single header file. The data file is cut in the overlap region path that all of the pixel only looks at the same burst with sub-swath combination into a single IWI. Geometrically and radiometrically the S1 IWS SLC are on a very high standard, so that the generated mosaics are typically seamless in both range and azimuth. The Oppler Center of the data varies strongly along track, which is very relevant for the SLC registration and interferometry. IWI mosaics can be generated using the normal procedures used in the GAMMA Software. Typically, the S1 IWS bursts include the data of which are very accurate results in geocoding accuracies better than one meter; even without applying a refinement. Besides packages to extract SLC data of a single burst into an individual data file with a corresponding parameter file and programs to remove the atmospheric variation phase related phase jumps from burst SLCs or SLCs of individual bursts are available.

Interferometric time series analysis

In the GAMMA IFTA Software a broad range of tools supporting different interferometric time series analysis approaches are supported, using either single or multilook interferometric mosaics and using either reference or multi reference stacks to define the deformation time series. In the following the SBAS and PSI procedures used and the results achieved are discussed.

S1 IWS offset tracking

To apply offset tracking for S1 IWS mode SLC data the basic strategy is to first-co-register the two burst SLC. In order to apply oversampling in the offset tracking procedure it is recommended to first denoise the SLC data for the azimuth phase jump. Further processing (quality control, geocoding, conversion to dems in meters, visualization) is then done as for normal stripmap mode data. An example of a glacer map velocity map over a part of Greenland in Figure 6. For S1 IWS mode GRD data offset tracking can be applied using the procedure described for stripmap mode data. The main interest in offset tracking is to map displacements. But azimuth offsets may also be of interest to identify ionospheric effects.[7,8] or radermorphology.

S1 IWS Example over Mexico City

We used an S1 IWS SLC stack over Mexico City, consisting of 12 repeat observations. Because of the very significant ground motion in the Mexico City area we used multi-reference stacks for both the SBAS and PSI processing.

As input to the time series analysis we co-registered all the S1 IWS SLC to one phase cycle of reference S1 IWS SLC, which was the main purpose of the procedure including the refinement with the spectral diversity method. The described interferogram generation process included the lowpass filtering of burst interfaces and between sub-swaths and with generally very high coherence sub-swaths. In this way we built a main reference SLC stack, which we then co-registered to the co-registered SLC mosaics for the azimuth phase jumps and cut out a common 16890 x 5000 pixel section over Mexico City.

PSI time series analysis with S1 IWS data

The co-registered deramped SLC mosaics over Mexico City can be input as input to a PSI procedure. As input to the conventional stripmap mode data. In the identification of persistent scatterer candidates, we applied the described stripmap processing to the bursts and used as reference data on the backscatter variability and level.[4] Thanks to the good registration of the S1 IWS SLC a high number of suitable persistent scatterers were identified. In urban areas the point density is typically larger than 1 point/100 m². To lower the number of point density points we initially reduced the candidate list size using the methodology described in [5]. This is done adaptively, such that the point density is strongly reduced in areas with a very high point density while not reduced at all in areas with a low point density (Figure 9). The fact that only the vector data stacks are used in the IFTA programs means that the relevant parameter for the speed of a processing step is not the size of the area or of the full SLC but only the number of points in the point candidate list. This makes the IFTA approach very efficient for S1 IWS PSI. We used the same multi-reference approach as used in the SBAS processing. Using this multi-reference stack we estimate point height corrections, (near) deformation rates and much more. This means that for areas with a lot of very high quality because they are based on the short time pairs. The PSI processing of the S1 IWS is then done using the same methodology as the multi reference stack for the multi-reference stack. Further processing may be done on this result considering the single reference stack. In this example we this was not done because of the small stack size.

The average deformation rate derived in the PSI processing is Figure 8 corresponds closely to the deformation rates of the SBAS procedure. Considering stable areas shows that minorp precision is clearly not reached with this C-band stack of 12 scenes between February 2014 and March 2015. In these results (SBAS and PSI) no anomalies were observed at the interface between subsequent bursts.

Conclusions

The procedures used in the GAMMA Software for interferometry, offset tracking and interferometric time series analysis (SBAS and PSI) using S1 IWS data were described. The main differences to “normal” stripmap mode interferometry are the organization of the IWS SLC data in 3 sub-swaths and by burst, the extremely accurate co-registration accuracy required for interferometry to avoid phase jumps between consecutive bursts (caused by the strong along-track Doppler Centroid variation). As a consequence much care is taken in the coordinate registration of the product processing also including new elements as the use of a spectral diversity method applied to the burst stack. The results achieved confirm that the S1 IWS data are well suited for interferometry, offset tracking and interferometric time series analysis.