Deriving Forest/Non-Forest Maps from TanDEM-X Interferometric SAR Data

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Abstract

The TanDEM-X mission (TerraSAR-X add-on for Digital Elevation Measurements), developed in public-private partnership between the German Aerospace Center (DLR) and Airbus Defence and Space, comprises two twin SAR satellites TerraSAR-X and TanDEM-X. They have been flying in a close orbit formation since 2010, with the main objective of generating a global and consistent digital elevation model (DEM) with unprecedented accuracy. In six years of operation, more than 500,000 bistatic SAR images have been acquired, having one satellite transmitting and both simultaneously receiving the backscattered signal from the Earth's surface. The result are highly accurate interferograms, which do not suffer from temporal and atmospheric decorrelation, which serve as basis for the generation of the DEM.

Moreover, the mission represents a highly valuable source for many scientific applications, among them land classification. In particular, the identification and monitoring of vegetated areas plays a key role in a large variety of different fields, such as agriculture, cartography, geology, forestry, global change research, and regional planning.

In this paper we present our activities for generating a global forest/non-forest map starting from TanDEM-X interferometric SAR data, operationally acquired by the TerraSAR-X and TanDEM-X satellites. The principle is to exploit the decorrelation contribution due to volume scattering, which results from the penetration of the radar wave within the foliage. This effect is highly related to the presence of vegetation and depends on several parameters, such as the forest vertical profile and its density, the sensor frequency, and the viewing geometry. It is named volume decorrelation and can be estimated from the total interferometric coherence. A weighted clustering approach based on fuzzy logic is utilized for partitioning each pixel into two classes: forest or non-forest, by associating a membership value to it, which expresses the weighted probability of an observation to belong to each single class. The global input data set consists of quicklooks images of the total interferometric coherence, characterized by a ground resolution of 50 m x 50 m and generated as by-pass products from the full resolution ones, acquired for the generation of the global DEM. Furthermore, several subsequent overlapping coverages are globally available and have to be properly combined together to generate consistent large scale maps. The method for the mosaicking of overlapping scenes will also be presented. It is based on a weighted average of multiple membership values which takes into account indicators of their reliability, such as the dependency of volume decorrelation on the height of ambiguity, on the signal-to-noise ratio (SNR), and on the acquisition geometry. The delivered product will be characterized by a resolution of 50 m $\times$ 50 m and global coverage. Full-resolution products (12 m x 12 m) will be initially used on a local scale only, in order to investigate the potentials of an increased resolution of classification purposes. The validation and performance measurement approach using ground truth maps and independent sources will be described and preliminary results will be discussed as well.

Finally, if input data covering a certain time span are available, the developed method can be used to detect temporal changes in the vegetation coverage. To conclude, we will present some examples for detecting on-going deforestation in the Amazon rain forest.