X-BAND BACKSCATTER MAP GENERATION USING TERRASAR-X DATA

Paola Rizzoli, Benjamin Bräutigam, Steffen Wollstadt, Josef Mittermayer

German Aerospace Center (DLR), Germany

ABSTRACT

The goal of this work is the generation of an X-Band backscatter map by assembling images acquired by the TerraSAR-X satellite. Global backscatter data is required for accurate performance estimation and instrument commanding inside the TerraSAR-X and TanDEM-X missions. The complete data ground coverage will be achievable with TanDEM-X mission data. An interpolator, that allows the estimation of the on ground backscatter for any required polarization and incidence angle from the available data, has been implemented. In this paper, the backscatter map generation algorithm will be presented, together with the first obtained results, generated using TerraSAR-X data. Moreover, the validity of the interpolation models will also be discussed, presenting a statistical analysis of backscatter behavior from TerraSAR-X data.

1. INTRODUCTION

TerraSAR-X (TSX) and the upcoming twin satellite TanDEM-X (TDX) are two new German SAR satellites, developed in a public/private partnership between DLR and EADS Astrium [1]. The primary target of the TanDEM-X mission is the generation of a worldwide, high precision Digital Elevation Model (DEM), according to the HRTI-3 specification [2]. Both satellites will fly in close orbit configuration, enabling the acquisition of highly accurate cross- and along-track interferograms. For realistic performance prediction of the SAR and DEM products, the backscatter information is a highly valuable input (e.g. for SNR estimation and height error calculation). Moreover, the availability of a new backscatter map, generated using TSX and, later on, also TDX data, leads to many future scientific applications, such as the monitoring of backscatter evolution in time and the study of reflectivity behavior depending on the atmospheric conditions. Section 2 shows the map generation algorithm and a preliminary validation using a statistical approach. Section 3 presents the interpolator of missing values, while the first results obtained for the generation of a global X-Band backscatter map are finally displayed in section 4.

2. BACKSCATTER MAP GENERATION

The generation of a backscatter mosaic requires two different steps: a dedicated processing for each input image, in order to retrieve a matrix of absolutely calibrated radar brightness values β^0, and the assembling of the suitable data inside the desired ground region.

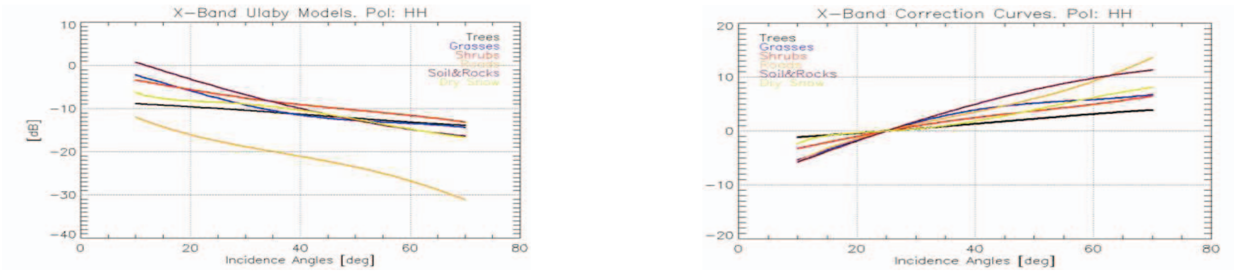
Since the total high amount of data to deal with requires the optimization of the processing time and, moreover, high resolution is not needed, TSX quicklook images have been considered as input data [3]. Such images provide less resolution regarding the standard SAR image, by a factor that depends on the acquisition mode. Each input image is then geocoded and, for every pixel, the correspondent incidence angle is evaluated. Each image has to be absolutely calibrated, in order to convert a single pixel digital number DN into the correspondent radar brightness β^0 in the following way: $\beta^0 = DN^2/K$, where K represents the calibration parameter, obtained from the combination of the processing gain and the TSX calibration constant. Notice that it is possible to retrieve the backscatter coefficient σ^0 directly from β^0, by compensating the dependence from the local incidence angle α: $\sigma^0 = \beta^0 \sin(\alpha)$. At this point, every single processed product is stored inside a long term data base, together with some additional parameters connected to it, such as the incidence angles matrix, the geocoded coordinates matrix, the acquisition times and the polarization channel. All these additional parameters are available later on to generate on-demand backscatter maps, for example, using data acquired only inside a certain temporal interval or seasonal period.

It is well known that, for a given pixel, the amplitude of the radar backscatter depends on several parameters, such as the incidence angle, the surface type, the polarization and the radar frequency. All this factors must be taken into account during the generation process.

Once the desired region of interest and other input parameters, such as polarization, reference incidence angle (explained below) and acquisition interval, have been properly set by the user, the β^0 database is accessed, to retrieve a list of all the available calibrated data for the required output map. Since the backscatter amplitude changes depending on the ground characteristics (e.g. type of vegetation, ice-covered regions) and on the incidence angle, it has been decided to refer the output backscatter map to a precise reference incidence angle α_{ref}, instead of simply applying the angular compensation previously described. For this reason, a dedicated interpolator has been implemented, able to convert β^0 values, acquired with different incidence angles, to the reference α_{ref}.

Applying the proper correction value to each image pixel, depending on the acquisition incidence angle, we are now able to generate a mosaic of σ^0 values which is completely referred to a single incidence angle value α_{ref} (Figure 1).

The backscatter map interpolator was implemented taking into account the reflectivity models proposed by F. T. Ulaby in [5]. In order to provide a validation of such models and of the interpolation process itself, a statistical analysis of backscatter reflectivity for TSX data is being performed.



(a) (b)

Fig. 1. (a) - X-Band backscatter dependency with the incidence angle. Ulaby Models (mean value). (b) - Correction curves referred to $\alpha_{ref} = 25\ [deg]$.

3. FILLING DATA GAPS

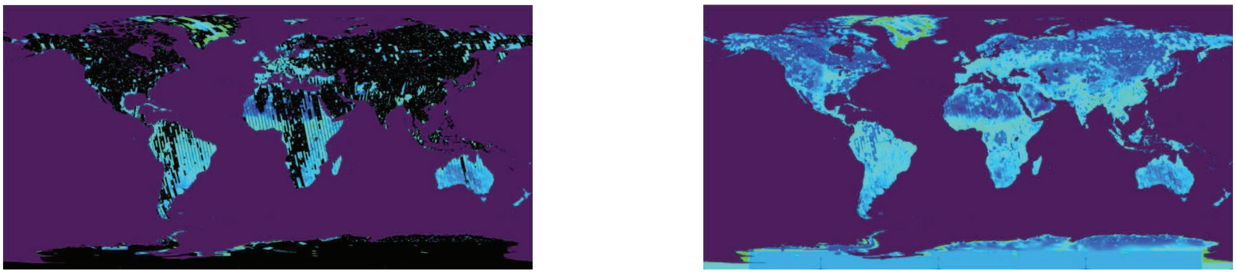
Since the global earth coverage of TSX data is not available yet, some ground regions can remain uncovered. In order to provide a complete map, required i.e. for commanding applications, such areas must be filled. The idea is to use TSX data acquired using different polarizations first and interpolate them for the right polarization and incidence angle in the same way as explained in section 2. Then, small gaps can be filled by averaging the nearest available samples. Finally, if empty areas are still present, they can be filled by a coarse C-Band backscatter map, referred to X-Band.

4. PRELIMINARY RESULTS OF GLOBAL X-BAND BACKSCATTER MOSAIC

In the current section the preliminary results obtained for the generation of a global X-Band backscatter map are presented. Figure 2 (a) shows the backscatter mean value, generated using all the available TSX data, acquired from October 2008 until August 2009, for HH polarization and a pixel spacing of 0.05 [deg] in lat/lon coordinates (which corresponds to an on-ground resolution of about 5x5 km^2 at the equator). Finally, Figure 2 (b) presents the global backscatter map after the application of the interpolation processing for missing values.

5. SUMMARY

In this paper, the actual work developed for the generation of X-Band backscatter maps using TerraSAR-X data has been discussed. The processing approach and the first results obtained for the generation of a global backscatter map have been presented. Moreover, on demand backscatter maps, characterized by higher resolution, can be generated as well. Not enough data have been acquired with TerraSAR-X satellite yet, to generate a complete global backscatter map, covering the whole earth. The full coverage will be achieved with the systematic acquisitions provided during the TanDEM-X mission. For this reason an interpolator has been implemented, filling gaps with corrected data from other polarizations, neighbor samples or even other sensors. The validation of the entire process is under testing and a statistical analysis of the X-Band backscatter behavior is being performed.



(a) (b)

Fig. 2. (a) X-Band global backscatter map (mean value) for HH polarization, generated using all the TSX available quicklook data, acquired from October 2008. Values are saturated inside the interval of [-30,+30] dB. (b) X-Band global backscatter map (mean value) for HH polarization, after filling gaps of missing data.

6. REFERENCES

[1] Buckreuss S.; Werninghaus R.; Pitz W.: *German Satellite Mission TerraSAR-X*, 2008 IEEE Conference, Rome, Italy, 2008

[2] Krieger G.; Moreira A.; Fiedler H.; Hajnsek I.; Werner M.; Younis M.; Zink M.: *TanDEM-X: A Satellite Formation for High-Resolution SAR Interferometry*, IEEE Transactions on Geos. and Remote Sens., vol. 45, no. 11, pp. 3317-3341, Nov. 2007

[3] Fritz T.; Eineder M.; Breit H.; Schättler B.; Boerner E.; Huber M.: *The TerraSAR-X Basic Products - Format and Expected Performance*, Eusar Proceedings, 2006

[4] http://edc2.usgs.gov/1km/1kmhomepage.php

[5] Ulaby F. T.; Dobson M. C.: *Handbook of Radar Scattering Statistics for Terrain*, Norwood, MA: Artech House, 1989