



3D Radargrammetric Modeling of RADARSAT-2 Ultra-Fine Mode: Preliminary Results of the Geometric Evaluation

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The geometry and the accuracy of the three-dimensional (3-D) cartographic localisation of RADARSAT-2 Synthetic Aperture Radar (SAR) data are evaluated as part of Earth Science Sector's Topographic Mapping Initiative program (a project in collaboration with the Centre for Topographic Information in Sherbrooke). This project is supported by the Science and Operational Applications Research and Government related Initiatives programs of the Canadian Space Agency.

In order to appropriately use the new high-resolution and polarimetric modes of RADARSAT-2 SAR data, a precise, rigorous and robust 3-D radargrammetric model must be developed and evaluated.

In a first step, the Toutin's 3-D physical model, previously developed for RADARSAT-1, was adapted to the RADARSAT-2 sensor and applied to two ultra-fine mode images (U2 and U25) acquired over an area in Beauport, Quebec. Afterwards, the 3-D modeling and geometric localisation were evaluated using different error analysis (statistical results, relative comparisons of the two quasi-epipolar images and the two ortho-images) and using different checked data (check points, 1-m accurate ortho-photos, 1:20,000 scanned maps).

Toutin's 3-D physical model is a multi-sensor model and can geometrically process different VIR/SAR sensor geometry including:

- Oscillating scanning mirrors (e.g. Landsat series),
- Push-broom scanners (e.g. SPOT, IRS, ASTER),
- Agile scanners (e.g. Ikonos, EROS, QuickBird, Formosat), and
- SAR (e.g. Seasat, SIR-C, RADARSAT-1).

Preliminary adaptation was recently performed for RADARSAT-2.

Toutin's 3-D radargrammetric model, adapted to take into account the new characteristics of RADARSAT-2 SAR, was tested on two ultra-fine mode images, U2 (30.8-32° look angle) and U25 (47.5-48.3° look angle), acquired June 2008 over a hilly relief study site (600-m elevation variation) north of Quebec City.

The stereoscopic pair has a 17° stereo-intersection angle, twice that of RADARSAT-1 fine mode stereo-pair. Using different numbers and distribution of ground control points, the model was computed with an iterative least-squares adjustment for each image separately and for both images simultaneously. The different tests validated the potentiality, stability and robustness of Toutin's 3-D radargrammetric model to RADARSAT-2, without generating systematic or local error.

All these coherent results can be summarized: (1) an accuracy of 2 m for the 2-D positioning; and (2) an accuracy of 1 m in planimetry and 2 m in elevation for the 3-D positioning and restitution (which combined the image pointing error). Three other validations of the model were performed: (A) the quasi-epipolar images and 3-D anaglyph viewing show an error less than 0.2 m (see enlargement of the quasi-epipolar images with 0.5-m spacing); (B) the ortho-images registration and comparison give an error less than 1 m; and (C) the registration and comparison of the U25 ortho-image with an ortho-photo give an error less than 1 m. In conclusion, these four validations, and mainly the quasi-epipolar images viewing, give a high level of confidence that the precision of Toutin's 3-D radargrammetric model is 0.2 m and that the 2-D/3-D restitution accuracy is 1-2 m.



Figure 1: The study site, north of Québec City, Québec, Canada (47°N, 71°30'W), spans different environments: urban and residential, semi-rural and forested.

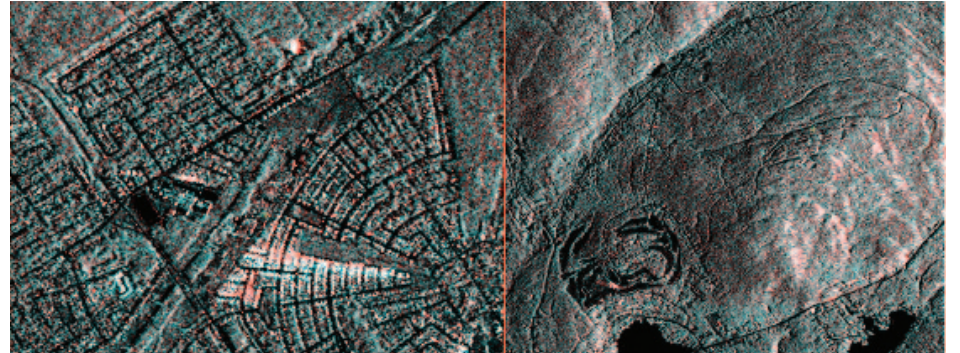


Figure 2: Ortho-image, colour composite R=U2, G=U25, B=U25. Maximum difference of 1-2 pixels (1-2 m) between the two ortho-images.

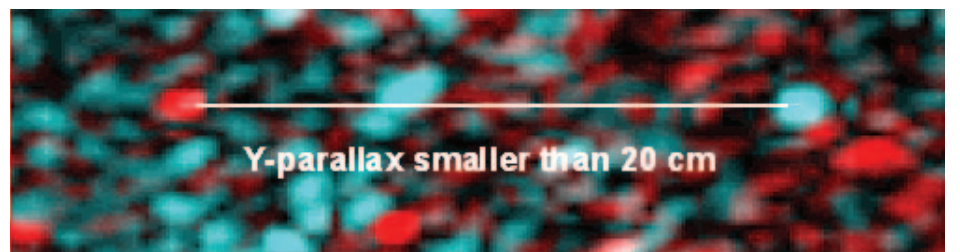


Figure 3: Enlargement of the 3-D anaglyph (0.5-m spacing) demonstrating a precision for Toutin's 3-D geometric model less than 0.2 m.

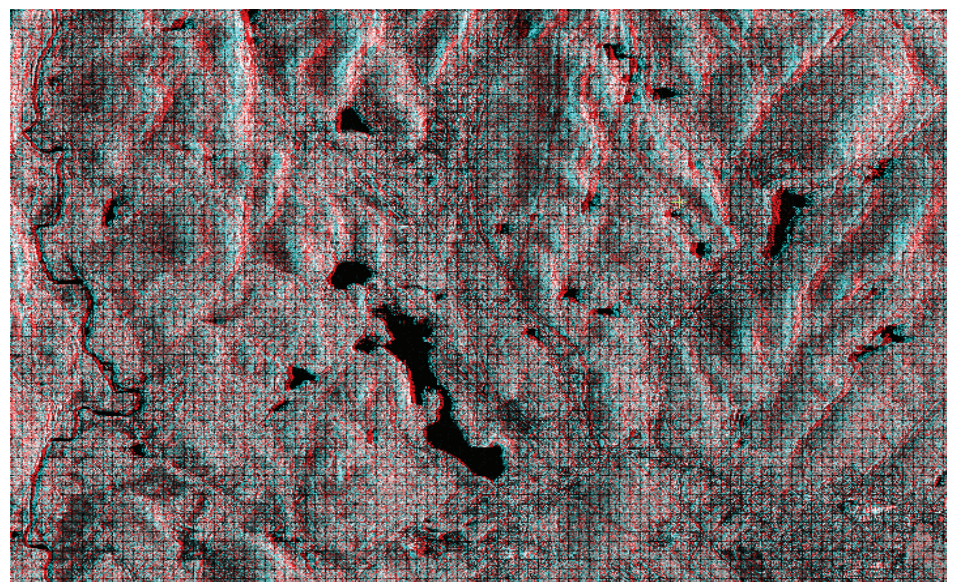


Figure 4: Anaglyph image (1-m spacing) using the U25 (red) and U2 (blue): A good stereo-vision implies no Y-parallax and confirms a good 3-D radargrammetric modelling.