Selected Geometric and Radiometric Considerations in Quantitative Exploitation of RADARSAT Data for Land Applications

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***Abstract* - RADARSAT images produced by the Canadian Data Processing Facility assume that the Earth is elliptical and locally spherical. This can have significant impact on the determination of location from the images and on the correction for antenna pattern that is performed in the processing. Selected examples show that these can be significant leading to radiometric errors of many dB and location errors of several km.**

I. INTRODUCTION

The launch of RADARSAT in November, 1995 was expected to lead to increased quantitative use of Synthetic Aperture Radar (SAR) data from space in applications where qualitative exploitation has been carried out. The step from qualitative assessment of SAR data for an application to quantitative exploitation of the data often can depend on calibration in terms of spatial and radiometric detail. As is well known, there are a number of limitations in such a process. The effects of assuming that the terrain is at sea level when, in fact, it is at a significantly different height can result in significant errors in radiometry and geometry for users of georeferenced and geocoded products. In this paper, we explore the impact of modest terrain heights for radiometry and geometry of SAR products.

II. RADIOMETRY

The RADARSAT Canadian Data Processing Facility was developed by MacDonald Dettwiller and Associates to produce calibrated data products on an operational basis [1]. An important aspect of the processing is the correction of the imagery for the illumination by the SAR implicit in the elevation gain pattern. These patterns have been determined from imagery of tropical rainforests [2]. By determining the geometry of the imagery acquisition (see Fig. 1) the inverse of the illumination pattern is applied and the imagery corrected. These calculations assume that the imaged terrain is at sea level. However, when images are acquired over a region of the Earth that is, in fact, at a significant height above this, the geometry will be slightly different. Consequently, the determination of the elevation angle, Θ_{elev}, corresponding to a slant range will, in fact, differ. There is a difference between the nominally "true" angles of elevation, Θ_{elev_true}, and incidence, Θ_{inc_true}, and those assumed in the processing for elevation, Θ_{elev_app}, and incidence, Θ_{inc_app}. (As well, there is a resulting location error ΔR_g discussed in the next section.)

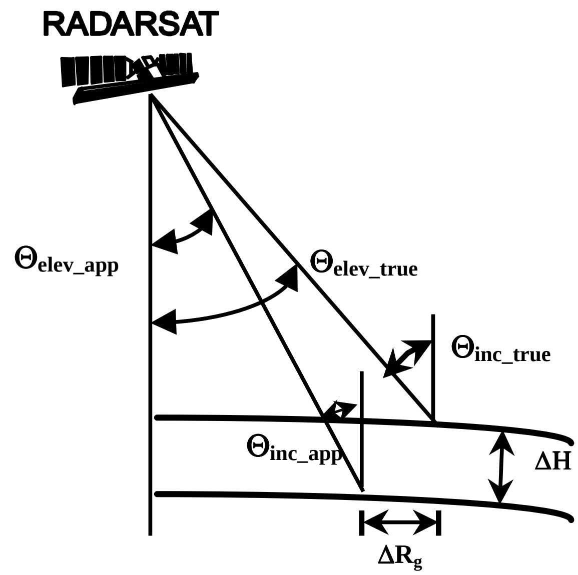

Fig. 1 Geometry as assumed by the processor and for reasonably flat terrain with a height ΔH above sea level.

As has been previously shown for other spaceborne SAR systems [3], these terrain height differences could result in significant elevation angle differences. Since the antenna gain pattern correction in elevation is applied as a function of the elevation angle, this will result in significant differences between the antenna gain that was used in imagery acquisition and that which was applied in the correction. To examine such differences for RADARSAT, the geometry calculations in the RADARSAT Image Data Calibration Workstations [4] (which include allowance for terrain height variations) were used to obtain the antenna gain as a function of elevation angle for both Θ_{elev_app} and Θ_{elev_true}. Differences between the gains at these two angles result directly in differences in the measured backscatter (σ_o or β_o [5]). Results of these calculations for a terrain height of 4000 m are plotted in Fig. 2 for beams S1, S3, and S7 respectively.

In these figures, it is noted that in regions near the middle of the swath where there are small changes in the beam with

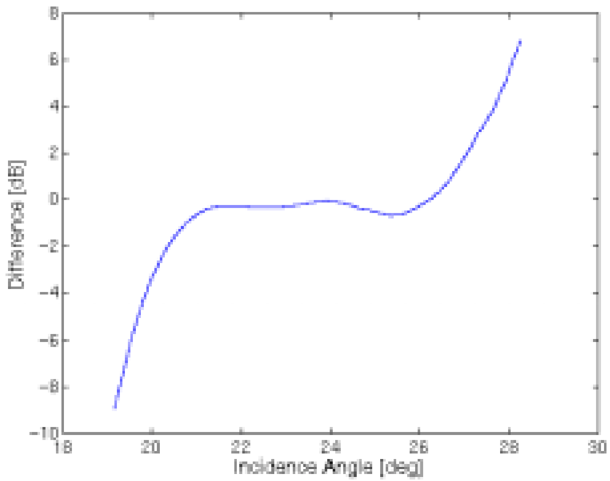

Fig. 2(a). Error in Backscatter Coefficient for a terrain height of 4000 m for beam S1.

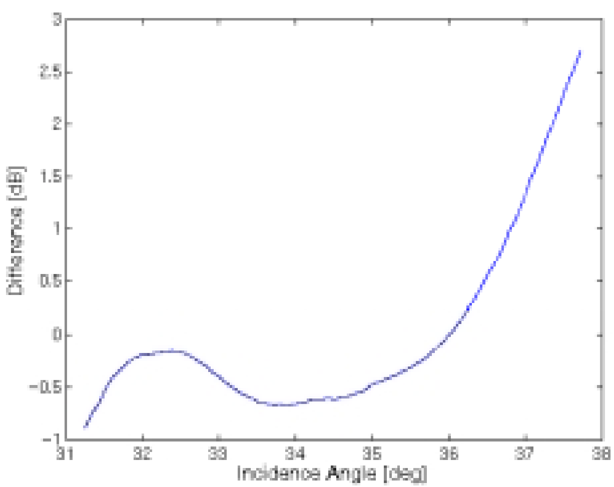

Fig. 2(b). Error in Backscatter Coefficient for a terrain height of 4000 m for beam S3.

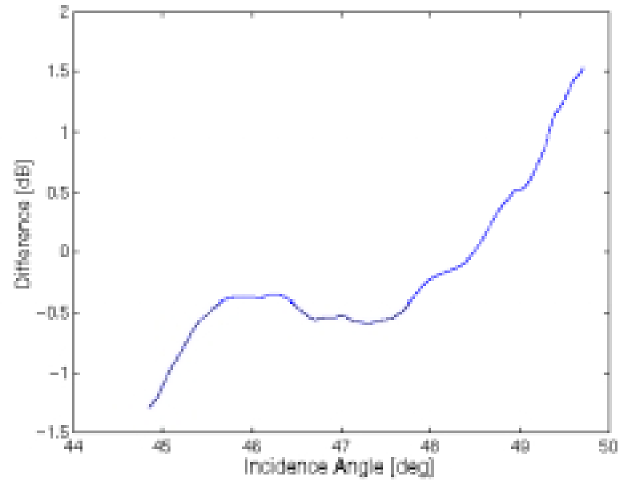

Fig. 2(c). Error in Backscatter Coefficient for a terrain height of 4000 m for beam S7.

elevation angle, the variation will tend to be small. On the other hand, major differences are noted at the edges of the image and can be several dB swamping the radiometric error budget [6].

Since these errors will not be corrected in the production of geocoded products from the georeferenced ones, such errors will be included in both geocoded and georeferenced products received from the CDPF.

III. GEOMETRY

The data accompanying each line of a SAR image include the latitudes and longitudes [7] that were calculated during the processing. Determination of the latitude and longitude at any other pixel in the line is performed by interpolation of these values. Since they are obtained assuming acquisition at sea level, the location error includes the contributions of orbit predictions and other effects of the processing (which have been measured and found to be well within the limits specified [6]) along with the contributions due to terrain height effects.

To quantify these last effects, calculations have been performed as a function of the incidence angle. These contributions can be well approximated by:

$$\Delta R_g \approx \frac{\Delta H}{\tan \Theta_{inc}}$$

where:

ΔR_g location error [m]

ΔH terrain height above sea level [m]

Θ_{inc} incidence angle [deg].

Results are shown in Fig. 3. These indicate that at the incidence angles (assuming flat terrain) that are available for RADARSAT imagery even for terrain heights on the order of 1000 m location errors over 2 km can easily result. Since these errors are for georeferenced products, they will not necessarily be representative of the location errors in RADARSAT geocoded products obtained from these georeferenced ones.

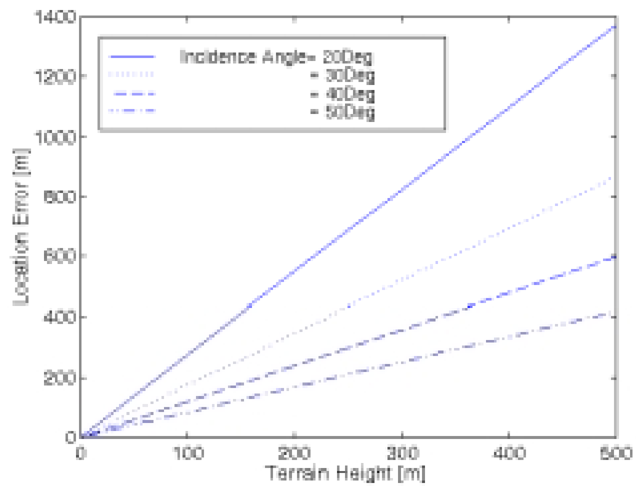

Fig. 3(a). Error in location at various incidence angles due to assumption of sea level for varying terrain heights (from 0 to 500 m).

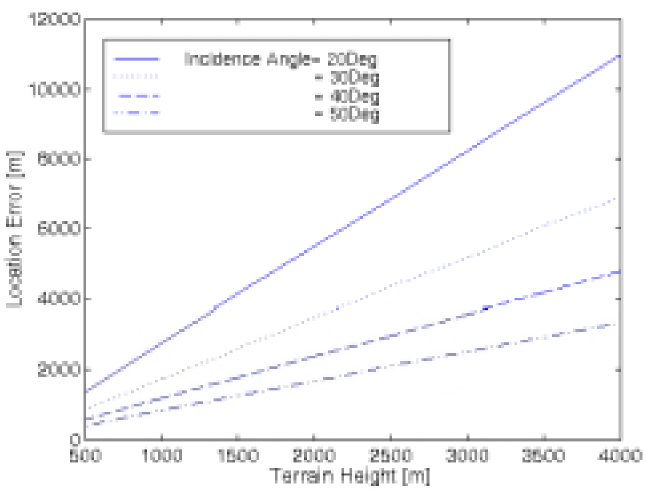

Fig. 3(b). Error in location at various incidence angles due to assumption of sea level for varying terrain heights (from 500 to 4000 m).

IV. CONCLUSIONS

It has been found that when imaging terrain above sea level, significant effects on the radiometry and geometry of the imagery can result. These differences become more severe with increasing terrain height and can be neglected for terrain close to sea level. When high accuracies in location and backscatter are required such variations must be considered.

It is recommended that in future processor developments such effects of terrain height be included in the processing algorithms. Users, however, need to be aware of the limitations that the elevation can impose on the fidelity of their data.

V. REFERENCES

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