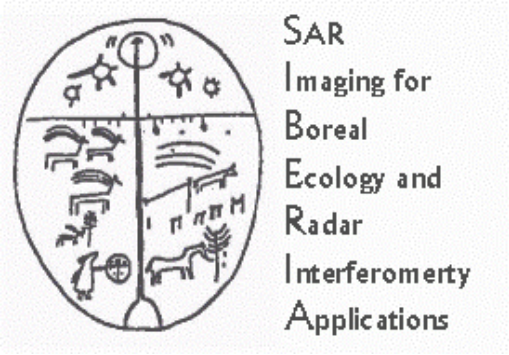

DLR

Working Note

Comments and Summary:

Ground offsets during coregistration of JERS-1 and ERS images

Jan Vietmeier and Wolfgang Wagner (DLR-DFD/AN[1])

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Introduction

The aim of this working note is to summarize the note "Ground offsets during coregistration of JERS-1 and ERS images", by Kevin Tansey and Heiko Balzter, and the comments on this working note from Torbjörn Westin. To have a better overview (we hope) and to be able to make the right decisions we also have something to add on this topic.

Summary of the contributions so far

In the mentioned working note the ground offset between ERS products which are geocoded using an InSAR DEM and JERS products which are geocoded using the GTOPO30 DEM is estimated. Following formula is used for the estimation of the offset between the two images dependent on the height differences of the DEMs and the look angle of the sensor (Schreier 1993, p. 120):

$$\Delta g = \frac{h}{\tan\theta}$$

[1] Our group moved to a other institute of the DLR.
DFD = Deutsches Fernerkundungsdatenzentrum
AN = Anwendung und Nutzerbetreuung

Only the look angle of JERS where used for the calculation of the offset. The elevation of the investigated area varies from about 250 m to about 650 m. That means the variation in height over the area is about 400 m.
The conclusions of the working note are: 95% of the calculated differences of the DEMs are varying between –20 m and 114 m, that means 25 m or 146 m ground offset (or 0 to 3 pixels offset). Torbjörn Westin disagreed with some conclusions of the working note, e.g. with the statement that if the ERS is geocoded using the GTOPO30 the registration should be better with the JERS which is also geocoded using the GTOPO30 DEM. Additionally he pointed out, that not only the JERS look angle has to be considered but also the ERS look angle.

Remarks on the contributions so far

The equation by Schreier (1993) is a very good approach to estimate the ground offset dependent on the height error of the used DEM. Additionally the use of both available look angles of the sensors is recommendable. But it's still not clear from what kind of dataset combination - either ERS-InSAR products registered to JERS-GTOPO30 products or ERS-GTOPO30 products registered to JERS-GTOPO30 products - we can expect larger ground offsets.
The use of a InSAR DEM with a relative topography of about 400 m is representative for almost all DEMs but not for all DEMs. For example the "Krasnoyarsk"-scene, the first GTC product of the project which was presented at the Toulouse meeting, has a relative topography of about 1000 m (but this mountainous regions will be masked out surely).

Approach based on the contributions so far

We are confronted with two different dataset combinations for co-registration:

1. InSAR/GTOPO:
   ERS is geocoded using InSAR DEM and JERS is geocoded using GTOPO30 DEM.
2. GTOPO30/GTOPO30:
   ERS is geocoded using GTOPO30 DEM and JERS is geocoded using GTOPO30 DEM.

InSAR/GTOPO30

The ground offsets of the ERS and JERS, Δg_{ERS} and Δg_{JERS}, are:

$$\Delta g_{ERS} = \frac{h_{InSAR} - h_{true}}{\tan\theta} \quad \text{and} \quad \Delta g_{JERS} = \frac{h_{GTOPO} - h_{true}}{\tan\theta}$$

where h_{InSAR} is the height of the InSAR DEM, h_{GTOPO} of the GTOPO30 DEM, and h_{true} the true height. For co-registration we need to consider the difference in the offsets:

$$\Delta g = \Delta g_{ERS} - \Delta g_{JERS}$$

For $\theta_{ERS} = 23°$ and $\theta_{JERS} = 35°$ the equation looks like:

$$\Delta g = 2.35 \cdot (h_{InSAR} - h_{true}) - 1.4 \cdot (h_{GTOPO} - h_{true})$$

As can be seen from the equation the offset between the both images is smaller if the direction of the error of both DEMs has the same sign. Due to the smaller look angle of ERS the image offset is much more sensitive on the error of the InSAR DEM.

GTOPO30/GTOPO30

If both image products are geocoded using the GTOPO30 DEM the equation looks like follows:

$$\Delta g = \left(h_{GTOPO} - h_{true}\right) \cdot \left(\frac{1}{\tan \theta_{ERS}} - \frac{1}{\tan \theta_{JERS}} \right)$$

or for our example

$$\boxed{\Delta g = 0.95 \cdot \left(h_{GTOPO} - h_{true}\right)}$$

or in words, the offset between the ERS GECs and the JERS images is more or less equal to the height error of the GTOPO30.

Let is ask the question what would be the error if we would not have decided to use the GTOPO30 for correcting the ERS and JERS Data. Then the offset between the images would be in the order of the true elevation, h_{true}. That means that in almost all cases the use of the GTOPO30 DEM for geocoding will reduce the offset between the images and will make the co-registration easier.

Estimation of the ground offset

The DFD partner stated, that the InSAR DEM has a maximum error of about 50 m and the GTOPO30 DEM has an maximum error of about 150 m. Therefore we assume that the standard deviation is 25 m for InSAR and 75 m for GTOPO30. The standard deviation of the image offset for the "InSAR/GTOPO30"-case therefore is estimated with:

$$sd_{Insar/GTOPO}(\Delta g) = \sqrt{2.35^2 \cdot 25^2 + 1.4^2 \cdot 75^2} = 120m$$

That means 95% of the values are lying in the interval ±240 m (or about ±5 pixels).
For the "GTOPO30/GTOPO30"-case we get:

$$sd_{GTOPO/GTOPO}(\Delta g) = \sqrt{0.95^2 \cdot 75^2} = 71m$$

about 75 m and 95% of the values are lying in the interval –142 m to 142 m (that means ±3 pixels).

Conclusion

Using the values of maximum errors proposed by the DFD we can expect ±5 pixels image offset for the InSAR/GTOPO30-case and about ±3 pixels for the GTOPO30/GTOPO30-case. Besides regarding the geolocation accuracy of InSAR products there are some information in the 2nd Progress Report of the Siberia project at page 43.
However we can state that it is almost always useful to use a DEM to reduce the ground offsets between ERS and JERS products. But apart from this theoretical point of view we have to carry out the co-registration of the given datasets and we can not alter the accuracy or the properties of them. Therefore we should have an eye on the development of the best possible method for co-registration (which is in progress by UWS) independent on the accuracy of the datasets.

References:

Schreier, G. (1993): Geometrical properties of SAR images. In: Schreier, G. (Editor): SAR Geocoding: Data and Systems, Wichmann, Karlsruhe, 103-134.