

Report1

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Contents

1	Introduction	1
2	Goal	1
3	Data	2
4	ASTER DEM production	2
5	Orthoprojection	2
6	Results	2
7	Analysis	3
8	Conclusion	4

1 Introduction

Digital elevation models (DEM), or digital terrain models (DTM) are widely used in research by scientists in governmental, university and private organizations. It is particularly useful for geoscientific applications such as glaciers and rock-glaciers, geomorphology and georisk, hydrology, and land cover/ land use (Toutin, 2008). By analyzing DEMs you can, among other things, estimate where a landslide might originate, estimate precipitation zones or estimate the volume changes of a glacier. All researches based on DEMs will be dependent on the quality of the DEM. The quality of a DEM depends on the method of how it was collected and generated. DEM can be generated with inSAR, LiDAR, and with stereoscopy. The last method will be used to generate a DEM of Jotunheimen from ASTER in this study. The DEM will then be compared with DEMs generated from kartverket and silcAst over the same area. The same stereo image that was used to generate a DEM will be orthorectified by the new DEM, and compared to the image orthorectified by kartverkets DEM.

2 Goal

The goal of this study is to generate a DTM from ASTER stereo images, orthorectify it, and assess accuracy of the DTM. The DTM and the orthophoto will

be compared to DTM from Statens kartverk and DTM generated from silcAst.

3 Data

Stereo images have been taken over Jotunheimen by ASTER on 12. Juli 2004. Additional DEM was provided by SilcAst and from Staten Kartverk. Theres DEM will be used to check the accuracy of the DEM that are to be generated from ASTER stereo images. The DEM from kartverket was also used to gather elevation for the GCPs. A map was optaint from statens kartverk in order to gather the coordinates for the GCPs.

4 ASTER DEM production

The DEM was generated with ASTER stereo image data Level 1B in Geomatica of PCI. The first object, after loading the image into the software, was to collect Global Control Points (GCPs). On the NADIR image, recognizable places in the map was found. The GCPs consisted mostly of lakes and rivers, since they was easy to find in both pictures. The elevation and coordinates for the points was gathered from a DEM and maps from kartverket. Kartverket had a tile map consisting of 9 tiles over the area of interest. Each tile was used to ensure GCPs over the entire area. The points was then transfered to the back-looking image. Most GCPs had to be adjusted to represent the same point. 30 points was found altogether, however, the position of two of the points was outside the bordars of the backlooking image. Therese points was therefore put to "check" in the this image, so not to affect the DEM. The residual of the remaining points then ranged from 0.20 to 5.69 in the two images. Tie-points was then collected. PCI geomatica did this automatically for me.

Next i created an epipolar image with 3N and 3B, now i can extract DEM. In the interface of 'Extract DEM automatically', I changed the terrain to mountainous from hilly, and gave the DEM a spacial resolution of 60x60m.

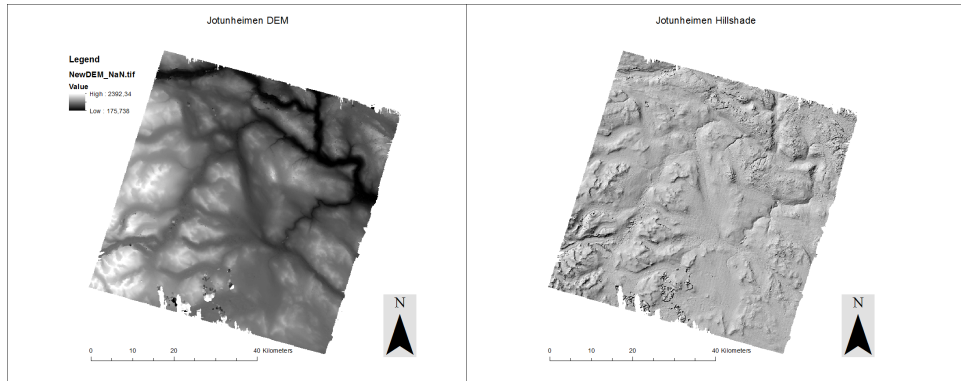
5 Orthoprojection

The 'Ortho Generation' step in PCI was done with both 3N and 3B and with my own DEM and Statens Kartverk DEM.

6 Results

When the DEM and othophoto was generated, the files was uploaded to ArcMap for visualization and further operations. When the DEM was first visualized, only a gray image was shown. In areas where no data was found, the value -150 had been given. This made the range of the minimum and maximum values so big, that it become impossible to differentiate between any other values. To get around this, all values of -150 was set to NaN (Not a Number), and was thereby ignored. In figure 1, the DEM (1a) and hillshade (1b) are displayed.

Viewing the newly generated DEM, some clear outliers are spottet. Some of these can easily be seen in a 3D representation of the DEM (figure 2). On



(a) DEM generated from aster stere images (b) Hillshade generated from the new DEM

Figure 1: Hillshade of the generated DEM and the generated orthophoto

the left of figure 2, there are some really high, steep "mountains" (a). This is clouds from the satellite image. The clouds are blocking the satellites view of the ground terrain, and we will therefore not get ground data in these areas. A little left of the center in figure 2 (b), and to the right in the figure (c), tall black "mountains" can be spotted. These are located in lakes, and therefore there can not be any mountain or elevation difference here. This is an error that was obtained when generating the DEM. When adding contour lines over the orthophoto, some more errors are spotted. The small hills in the lakes are spotted, as well as massive gathering of contour lines around the clouds.

The difference between the newly generated DEM, Kartverkets DEM and SilcAst DEM are calculated in ArcMap using the raster calculator. The results are then transferred to MATLAB to extract statistical information. The differences consist of rather large outliers, due to errors in the DEM. Outliers bigger than 3 standard deviations (3σ) are removed. After the outliers have been removed, and the statistical operations are done, the differences between the DEMs are transferred back to ArcMap.

7 Analysis

When visualizing the difference between the newly generated ASTER DEM, a DEM generated of SilcAst and Kartverkets DEM, it is revealed that the new DEM has larger errors in the south east and north west border and in the center parallel to these borders (figure 3). In the borders figure 3 shows a lot of green, which means the difference is negative. In the center, parallel to these borders, the figure shows a lot of red, symbolizing positive difference. This systematic error is not present when we look at the difference between SilcAst and Kartverket, indicating that this error is in the newly generated DEM only. It appears that the new DEMs south east and north west borders have been raised, while the center parallel to these borders have been lowered, making the new DEM convex.

Parallel to the convection, some stripes are visible in the images of the new DEM differences. These stripes are not visible in the difference image of



Figure 2: 3D representation of new DEM over ortopotho

kartverkets DEM and silcast DEM. These lines might have something to do with the fact that the level 1B image was used, as this image is the raw image. Level 1B has been corrected for the systematic distortions due to the sensor, the platform and the Earth rotating and curvature (Toutin, 2001). However, further investigation is required to know whether or not the stripes are a result of the corrections made on 1B.

In figure 4, a histogram is presented for all the difference DEM. The histogram for the difference between the statkart and silcast DEM shows a histogram that resembles a normal distribution (figure 4c), while the histogram of the differences between the new DEM and the two others resembles a normal distribution with a left skew (figure 4a and 4b). In figure 3a and 3b, the green at the borders is quite clear, the center however is more orange than red. This shows that the new DEM has been more lifted at the borders, than it has sunken in the center. Which could explain the left skew in the histogram.

8 Conclusion

There are definitely biases in the DEM generated from ASTER stereo image in PCI geomatica. The convex bias is likely to occur during the extraction of parallax. The reason the parallax isn't extracted properly might have something to do with the GCPs.

References

- Toutin, T. (2001). Elevation modelling from satellite visible and infrared (visir). *REMOTE SENSING*, 22(6):1097–1125.
- Toutin, T. (2008). ASTER DEMs for geomatic and geoscientific applications: a review. *International Journal of Remote Sensing*, 29(7):1855–1875.

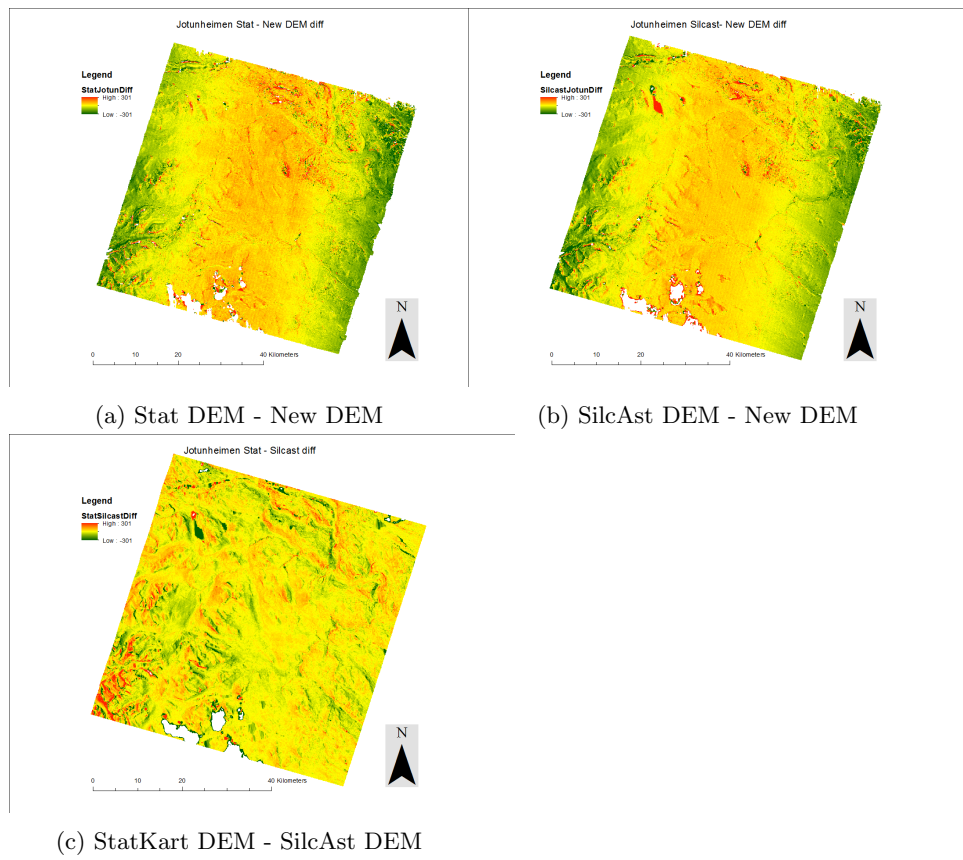


Figure 3: The differences of all DEMs

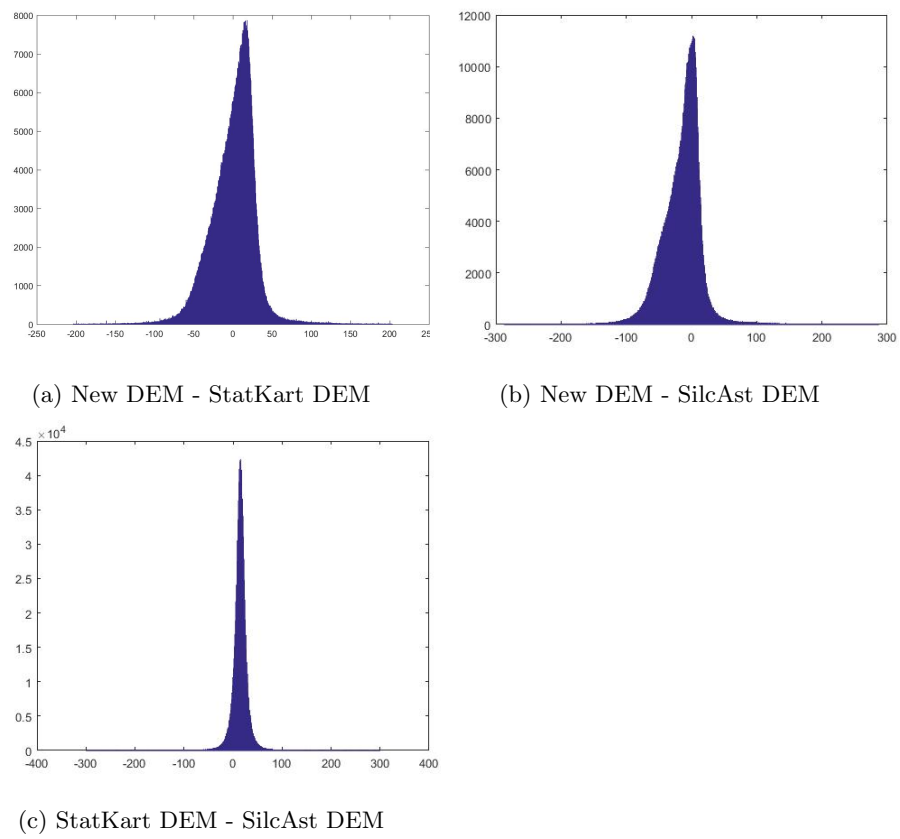


Figure 4: A histogram of the values in the all the DEM differances of Jotunheimen