Terrain Flattening Test

Data Set:

- S1A_IW_GRDH_1SDV_20150320T165052_20150320T165117_005118_00670A_80FC

Region:

- Prague, Czech Republic

S1TBX Processing Chain:

1. *Calibrate*:
   a. Output Beta0 Band

2. *Multilooking*:
   a. Number of Range Looks: 10
   b. Number of Azimuth Looks: 10

3. *Terrain Flattening*:
   a. Digital Elevation Model: SRTM 1Sec HGT
   b. DEM Resampling Method: Bi-cubic interpolation
   c. Re-grid method: selected

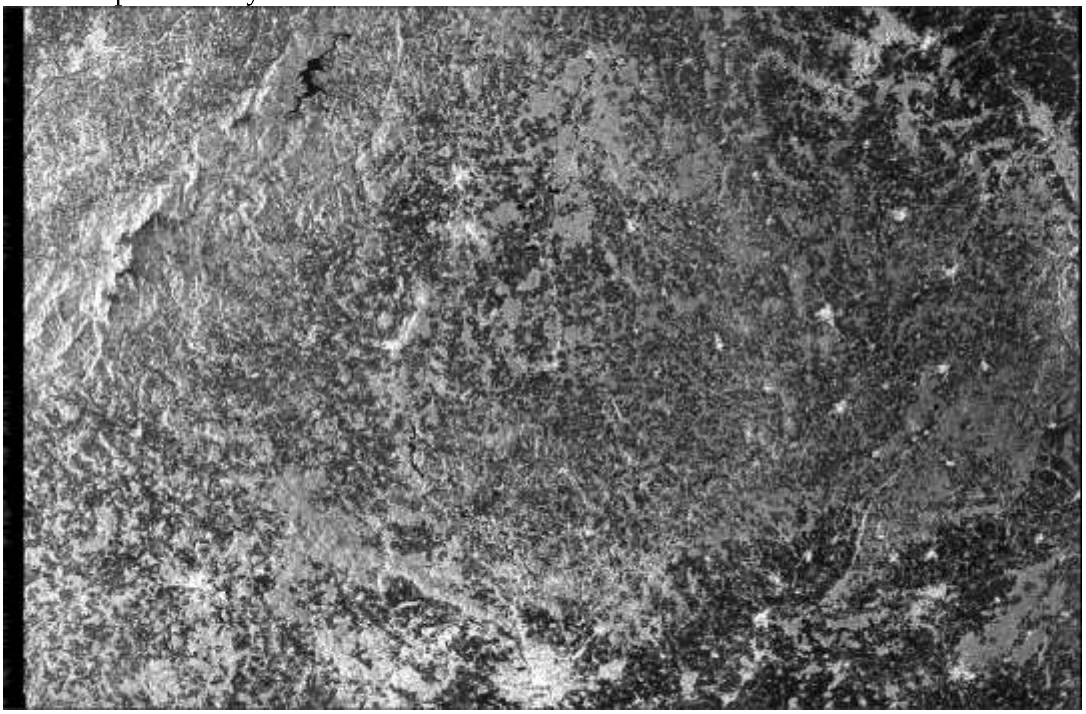
4. *Range-Doppler Terrain Correction*:
   a. Digital Elevation Model: SRTM 1Sec HGT
   b. DEM Resampling Method: Bi-cubic interpolation
   c. Image Resampling Method: Bi-cubic interpolation

Intermediate Result for Comparison:

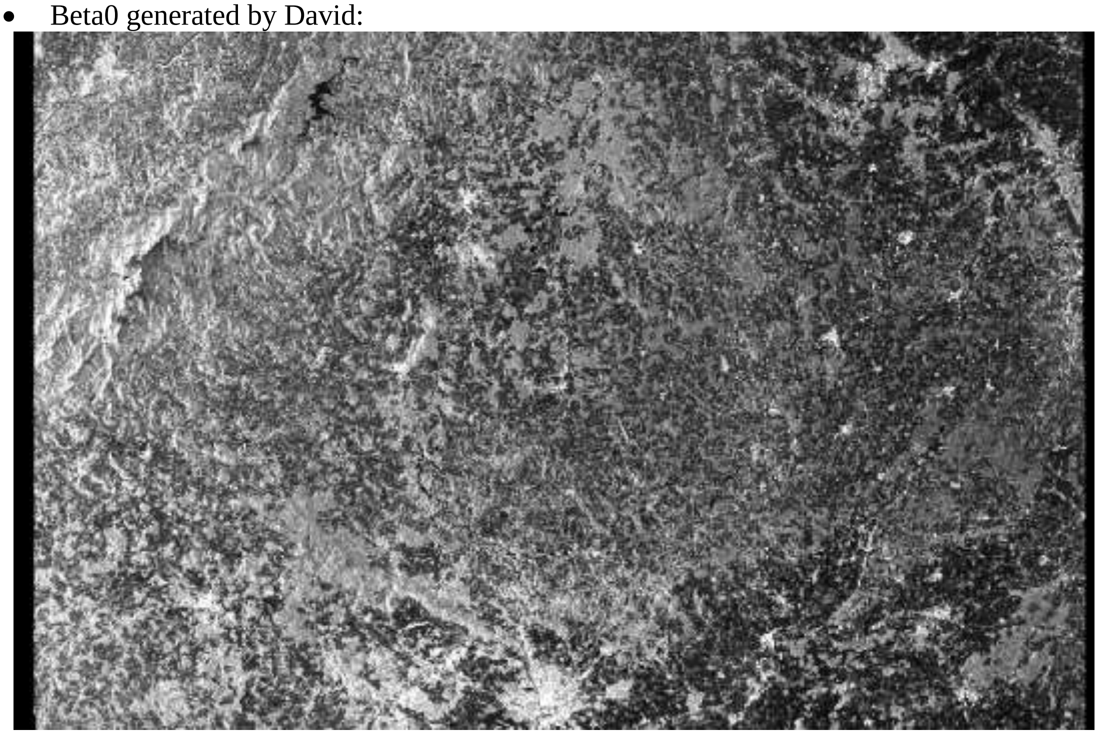
1. multilooked beta0
2. simulated image in SAR geometry
3. flattened image in SAR geometry

Comparison on Multilooked Beta0:

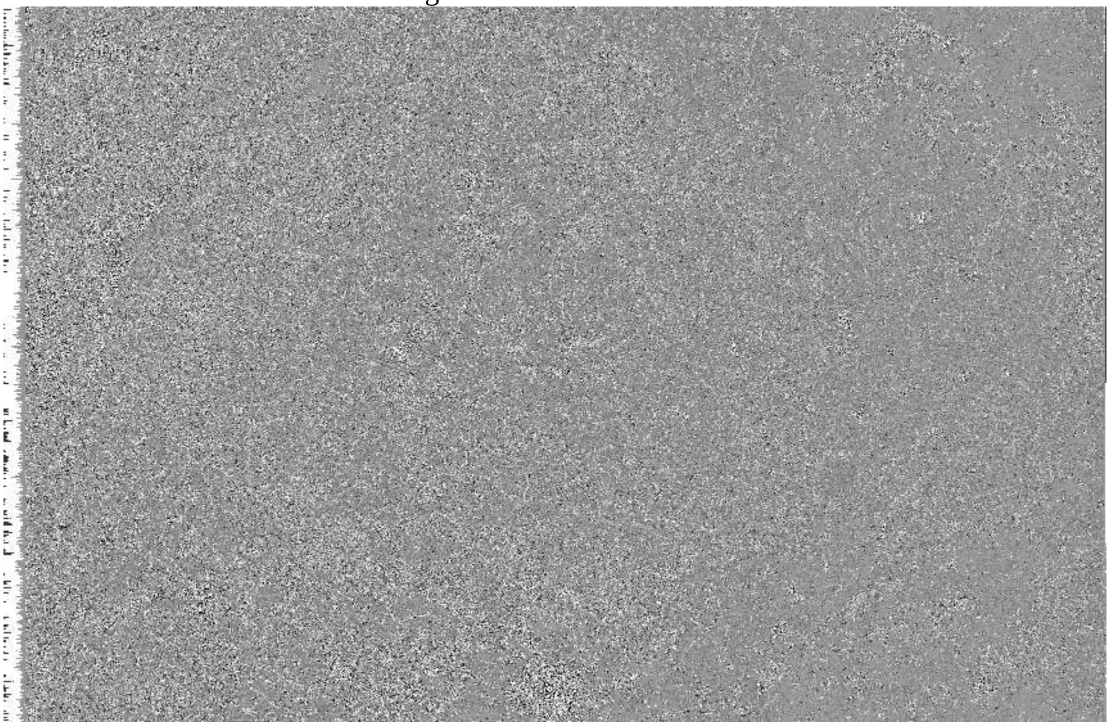
- Beta0 produced by S1TBX:



- Beta0 generated by David:



- Difference of the two beta0 images:



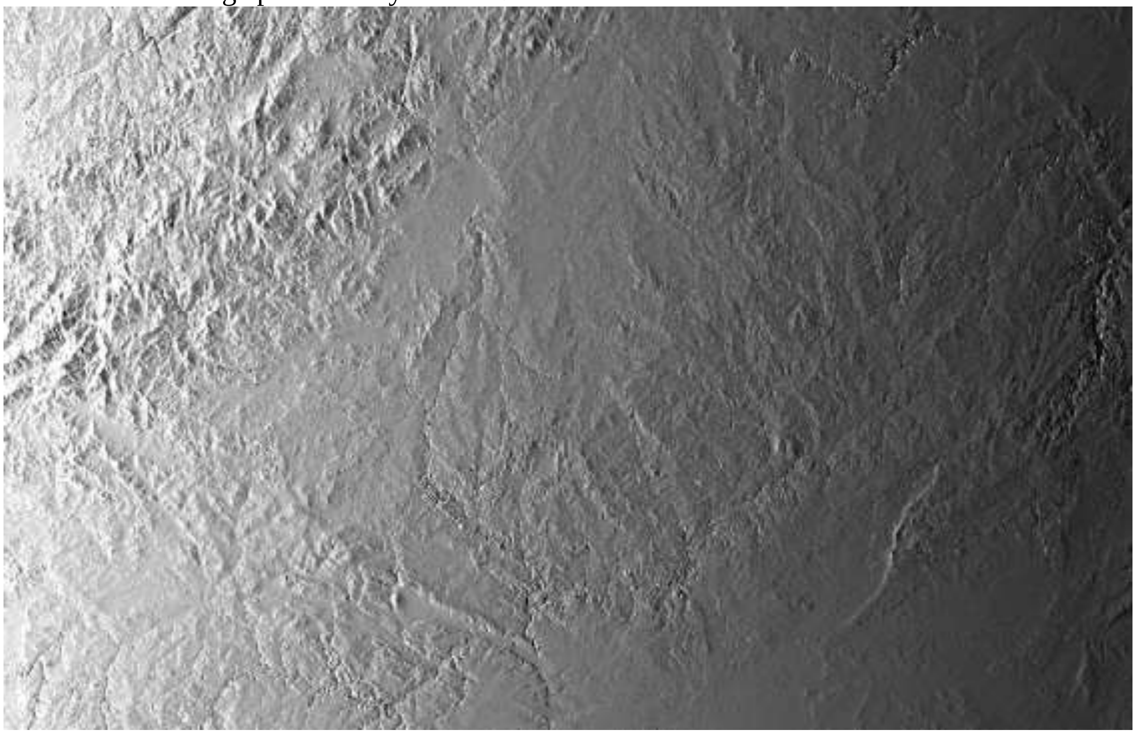
- The following are some statistics of the difference of the two images:

Min	Max	Mean	Median	Sigma
-7.6294e-6	1.7265e-4	2.3215e-8	3.3606e-8	2.843e-7

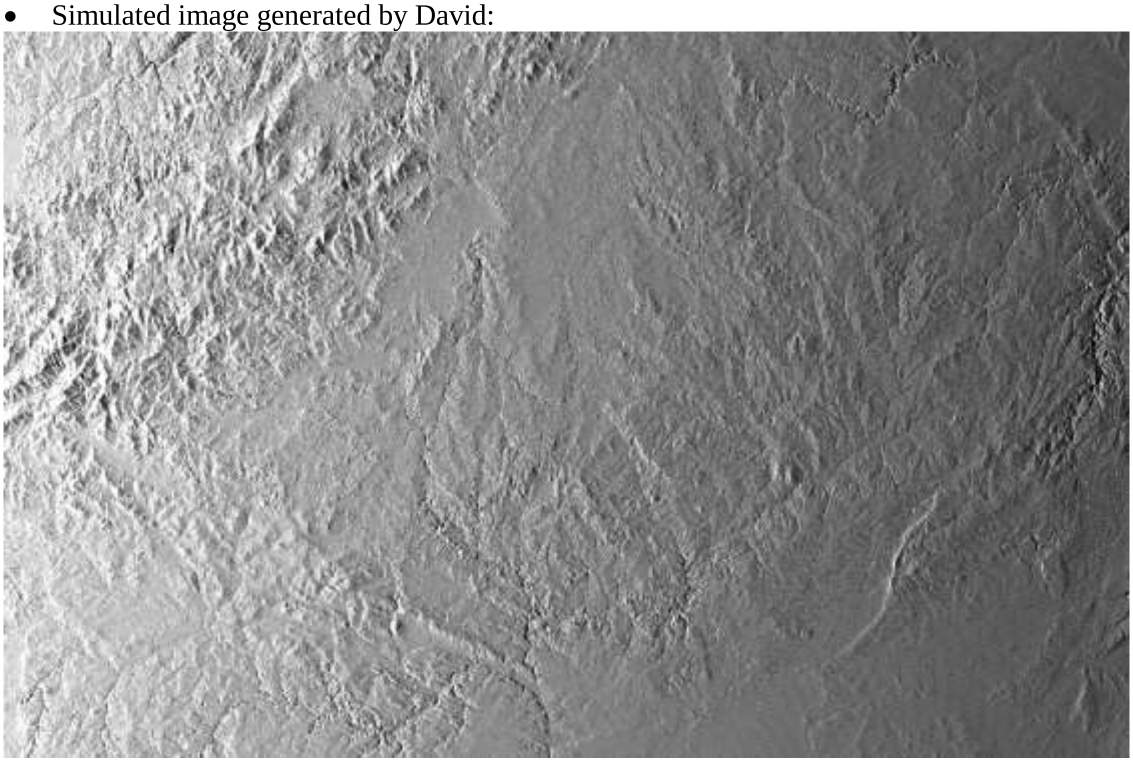
- We can see that the difference between the two Beta0 images is small.

Comparison on Simulated Image:

- Simulated image produced by S1TBX:



- Simulated image generated by David:



- Difference of the two simulated images:

- Statistics of the difference image:

Min	Max	Mean	Median	Sigma
-2.7162	4.6125	-0.0028	-0.0050	0.1320

- Here we can see that the difference between the two simulated images is large.

- In the simulated image produced by S1TBX, we can see the gradual change of brightness from left to right. This is caused by the incident angle used in the modulation of ground range image radiometry. While in David's simulated image, we did not see this change.

- According to [1] (Section II.G), if the source image is ground range image, then the simulated area should be adjusted with the following equation

$$A_\gamma(g,a) \leftarrow A_\gamma(g,a) \cdot \delta_g(g) / \delta_r$$

  where δ_r is the slant range sample interval and $\delta_g(g)$ is the equivalent ground range interval.

- In the implementation, we have used the following equation for the area adjustment

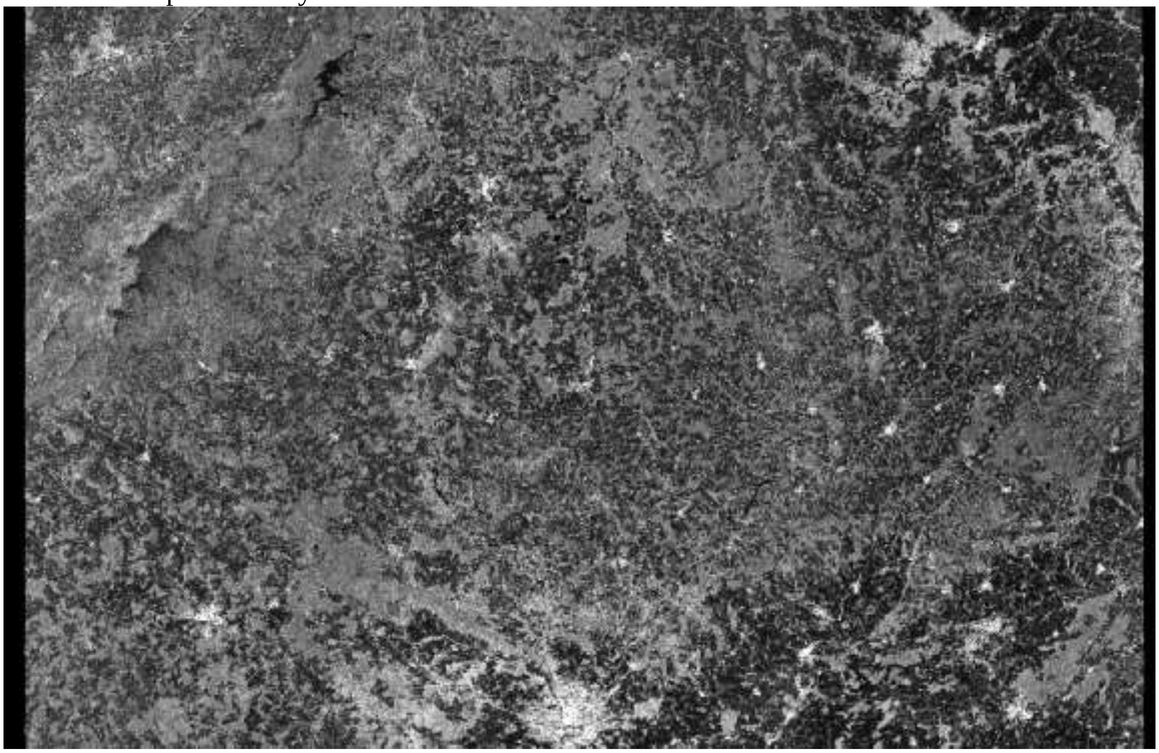
$$A_\gamma(g,a) \leftarrow A_\gamma(g,a) / \sin(\theta)$$

  where θ is ellipsoidal incident angle, because according to Figure 2 in [1], $\sin(\theta) = \delta_r / \delta_g$. Our understanding here could be wrong.

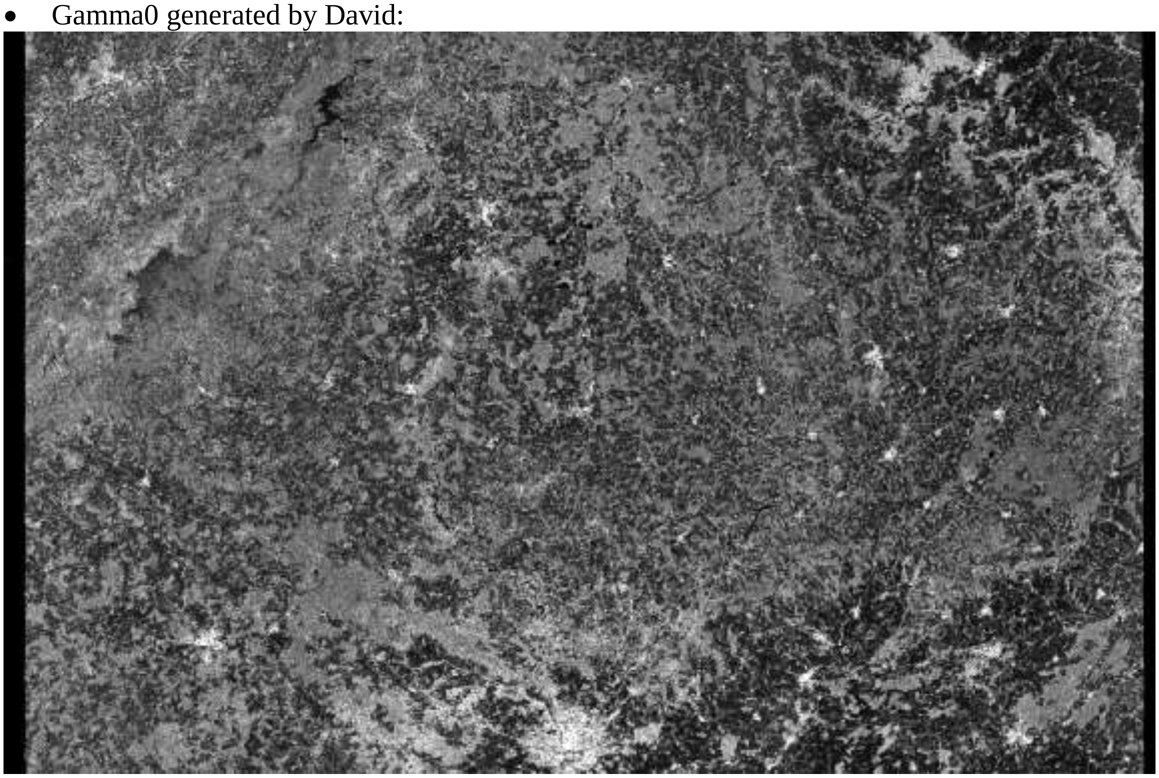
- Another factor that could contribute to the difference of the simulated images is that we could have used different DEM and interpolation method.

Comparison on Terrain Flattened Gamma0:

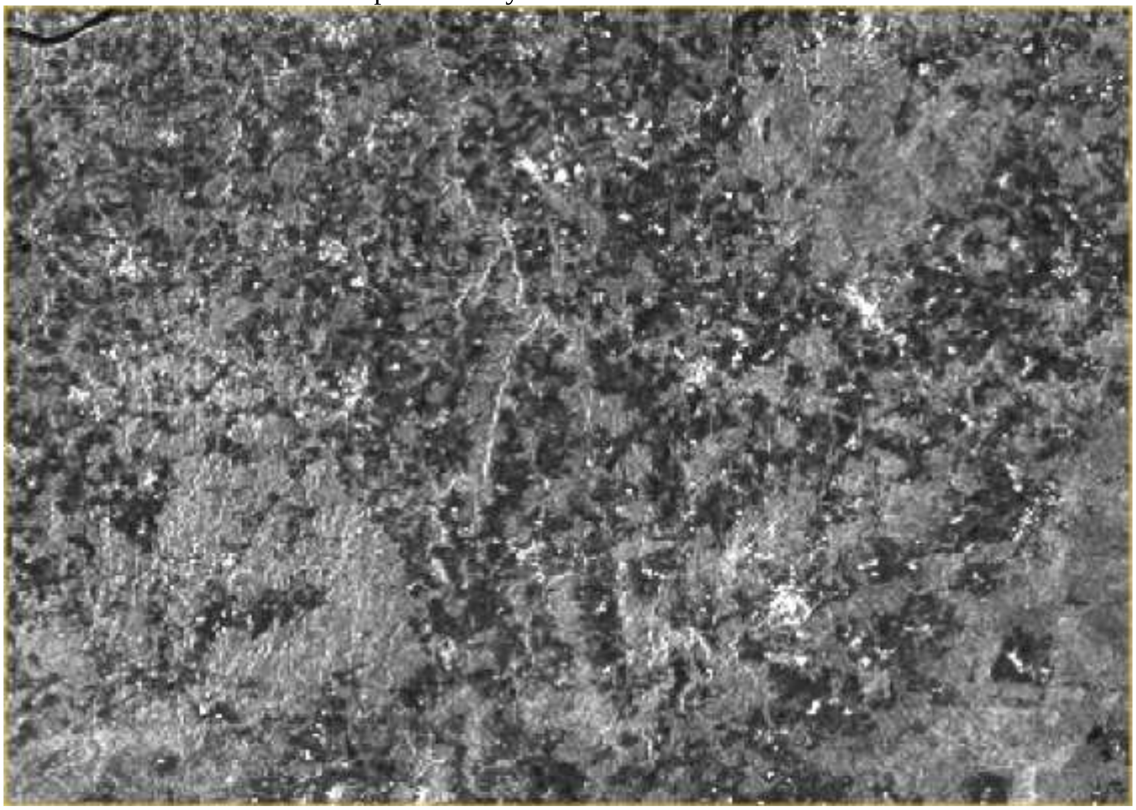
- Gamma0 produced by S1TBX:



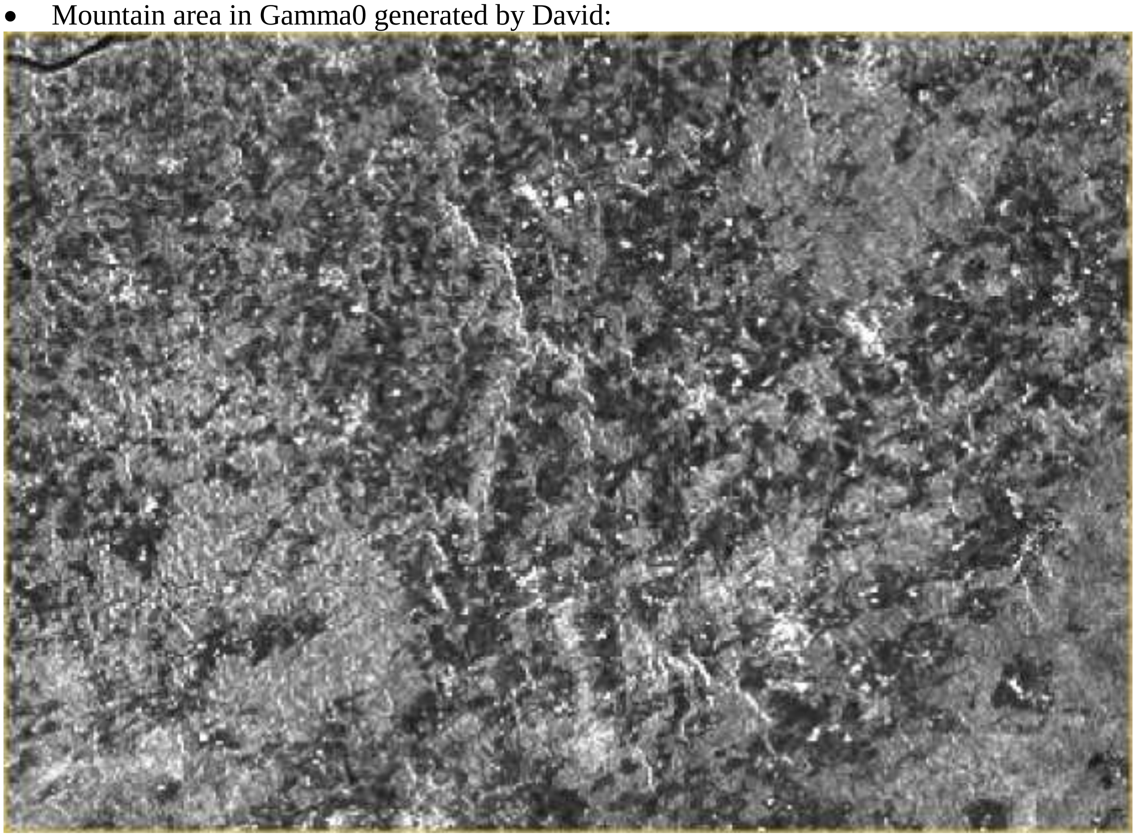
- Gamma0 generated by David:



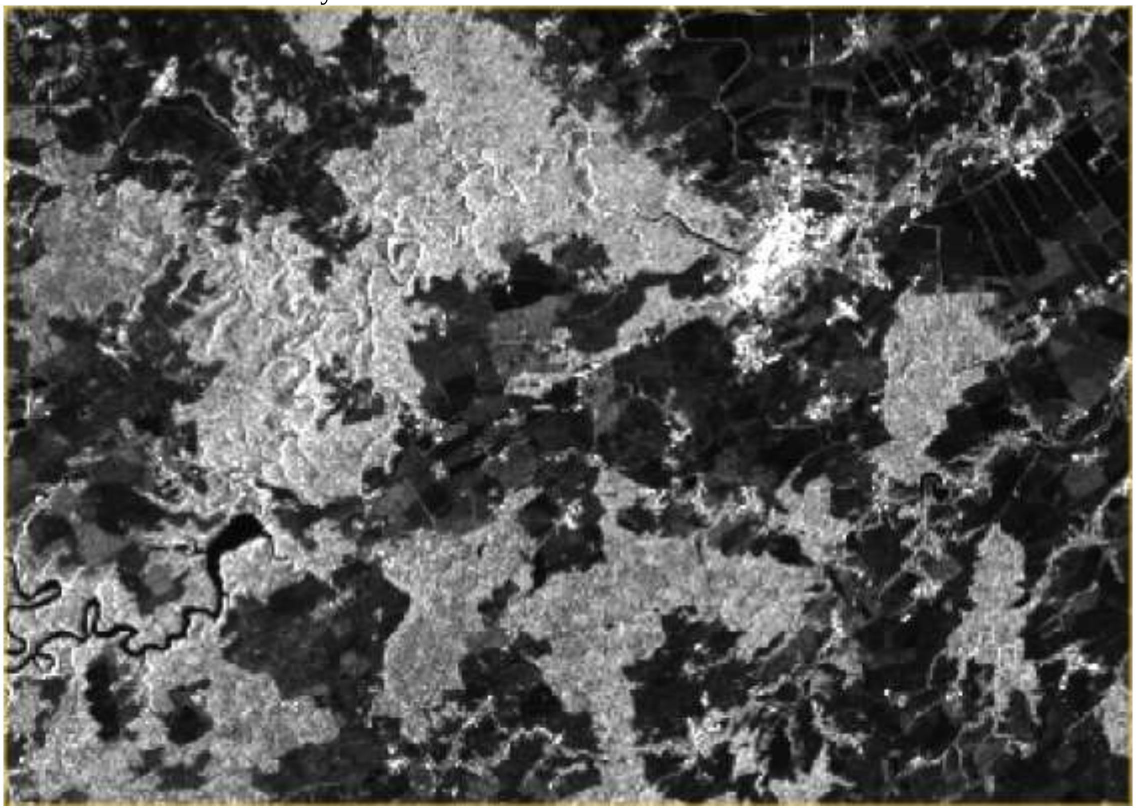
- Mountain area in Gamma0 produced by S1TBX:



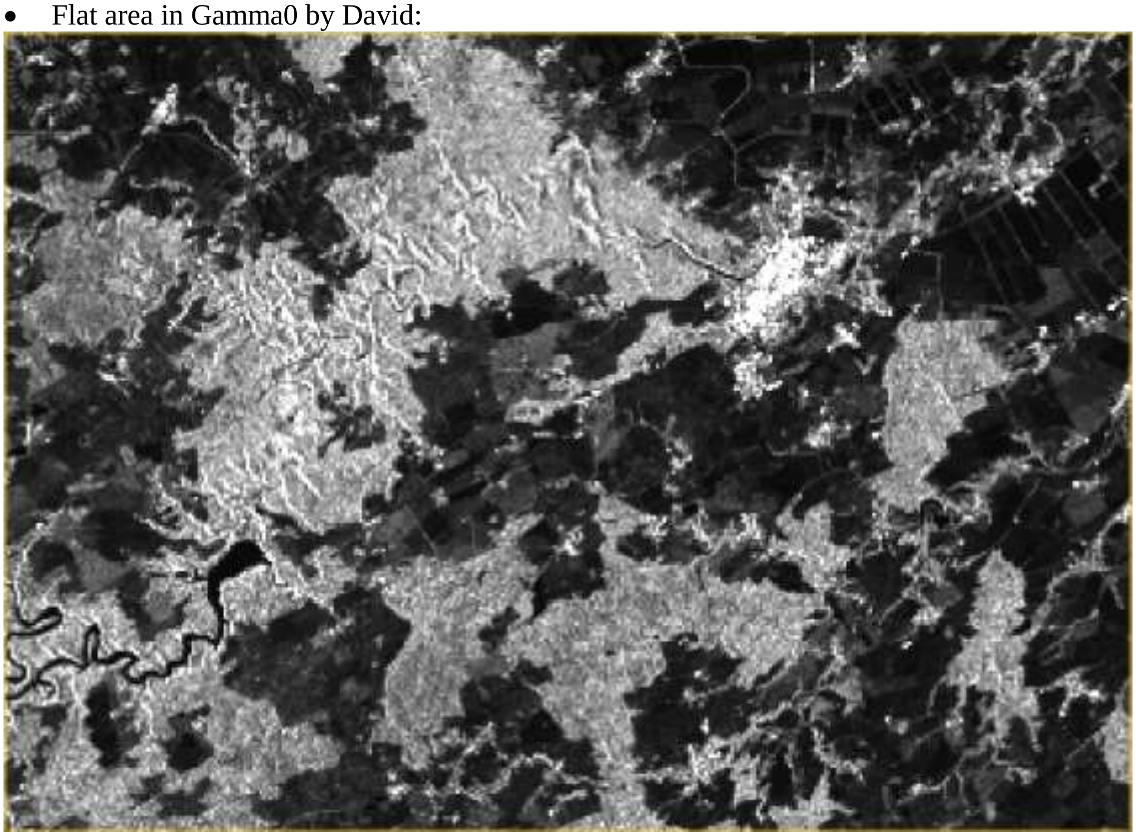
- Mountain area in Gamma0 generated by David:



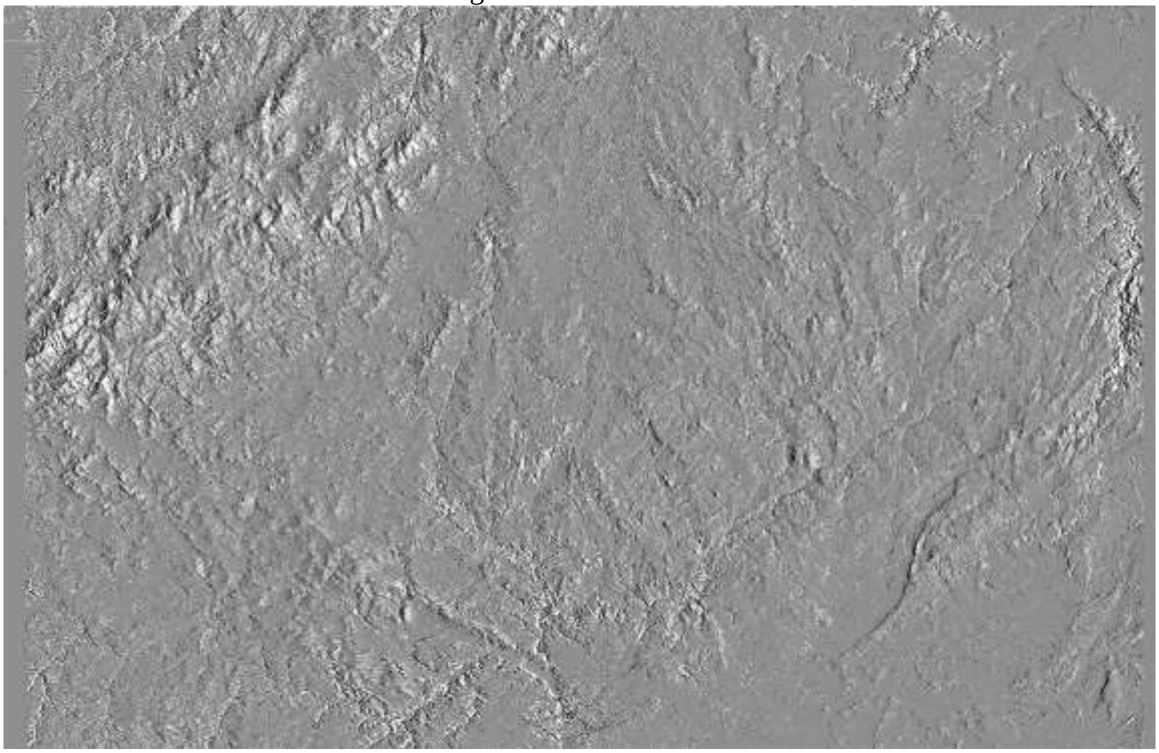
- Flat area in Gamma0 by S1TBX:



- Flat area in Gamma0 by David:



- Difference of the two Gamma0 images:



- The difference here should be mostly caused by the difference in the simulated images.

Questions:

- Regarding the adjustment of the simulated area when the source image is ground range image, i.e. equation (24) in Section II.G in [1], how is the equivalent ground range interval computed?

- Is it correct to use ellipsoidal incident angle in the area adjustment as indicated above?

Reference:

[1] David Small, "Flattening Gamma: Radiometric Terrain Correction for SAR imagery", IEEE Transaction on Geoscience and Remote Sensing, Vol. 48, No. 8, August 2011