SRTM HEIGHT MODELS

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INTRODUCTION

Digital elevation models (DEMs) are a basic component of any geo information system (GIS). The terrain cannot only be described by the horizontal components; the height belongs to complete information. In addition height models are required for the generation of orthoimages – one of the most often used photogrammetric product. DEMs can be generated by laser scanning, photogrammetric methods or interferometric synthetic aperture radar (InSAR). In any case it is time consuming and expensive. The worldwide lack of qualified and accessible DEMs has been improved with the Shuttle Radar Topography Mission (SRTM) in February 2000. Based on InSAR height models have been generated covering the world from 56° southern up to 60.25° northern latitude. The DEMs based on the US C-band are available free of charge in the internet via http://www2.jpl.nasa.gov/srtm/ with a spacing of 3 arcsec, corresponding to approximately 92m at the equator. Only for the USA data with a spacing of 1 arcsec (~ 30m) are also in the WEB. The DEMs based on the German / Italian X-band can be ordered from the DLR, Germany with a spacing of 1 arcsec. But without scanSAR-mode the X-band DEM has large gaps between the swaths of 45km width.

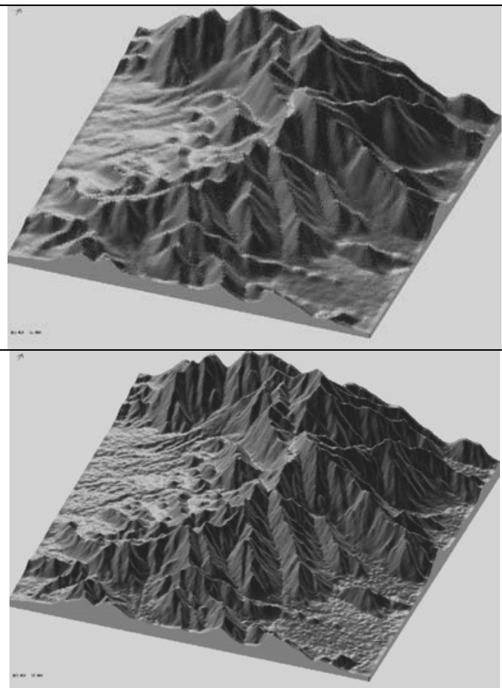
CHARACTERISTICS OF SRTM DEMs

The short wavelength C- and X-band radar cannot penetrate the vegetation, that means, not digital elevation models showing the height values of the bare ground, but digital surface models (DSMs) showing the height of the visible surface – top of buildings and vegetation – have been generated. By this reason different accuracy has to be expected for open area and forest or cities. All SRTM height model investigations are leading to a clear linear dependency of the accuracy from the tangent of the terrain inclination by this reason the geometric quality cannot be expressed just by one figure.

	RMSZ [m]	bias [m]	RMSZ F(slope) [m]
Arizona	3.9	1.3	$2.9 + 22.5 * \tan\alpha$
Williamsburg NJ	4.7	-3.2	$4.7 + 2.4 * \tan\alpha$
Atlantic City NJ	4.7	-3.6	$4.9 + 7.6 * \tan\alpha$
Bavaria, rolling	4.6	-1.1	$2.7 + 8.8 * \tan\alpha$
Bavaria, mountainous	8.0	-2.4	$4.4 + 33.4 * \tan\alpha$
Zonguldak	7.0	-4.4	$5.9 + 5.6 * \tan\alpha$

Table 1: accuracy of SRTM C-band DEMs for open areas
α = terrain inclination

The accuracies of the SRTM height models listed in table 1 are computed by comparison with precise reference DEMs. A comparison with check points always leads to too optimistic results because check points are located in flat und undisturbed areas. The mountainous areas Zonguldak and Bavaria "mountainous" have quite larger values for the root mean square differences without respecting the terrain inclination because of the large average slope. The clear bias (systematic height difference) mainly is caused by absolute orientation of SRTM height models. Of course this can be determined by means of control points and will lead to improved results of 3 – 4m for flat and open areas. The SRTM X-band results are quite similar.



SRTM C-band DEM Arizona: above 3 arcsec spacing (85m), below 1 arcsec spacing (28m)

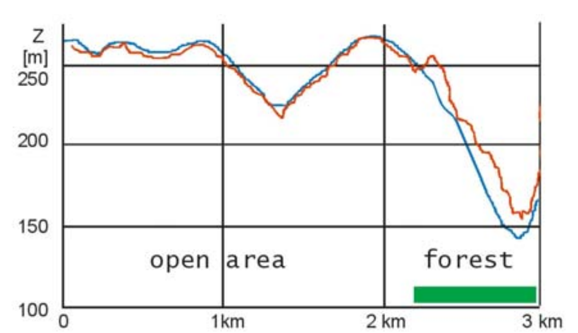
	average change of terrain inclination	SZ for whole DEM
Zonguldak	0.32	8.5m
Arizona	0.09	3.4m
Bavaria	0.12	2.1m
New Jersey	0.015	0.5m

table 2: loss of accuracy by interpolation over 80m

The standard deviation of the height points is not identical to the DEM accuracy because it is not including the influence of the point interpolation over the spacing of 3 arcsec. The accuracy loss by interpolation is a function of the change of the terrain inclination. For flat areas it is close to negligible but it is dominating in rough mountainous areas as it can be seen in table 2. In the area of Zonguldak the tangent of terrain inclination is changing from 40m spacing to 40m spacing by 0.32 causing a loss of 8.5m accuracy. This has to be root mean square added to the accuracy of the SRTM height points. That means in the extremely rough area of Zonguldak the influence of interpolation is exceeding the SRTM accuracy, but in the flat and rolling areas the interpolation effect is limited.

With the 1 arcsec spacing of the C-band height model available in the USA or the X-band data from the German DLR the influence of the interpolation is reduced to 11% of the values listed in table 2. The X-band data are not available free of charge and do have large gaps between the flight strips. The C-band data do have only gaps in water bodies, at very steep mountains and dry sand desserts, but 60% of the 1° x 1° sheets do have voids below 0.1%.

In addition to the loss of accuracy by the interpolation, the point spacing of the DEM is causing a loss of details as it can be seen at the shown DEM of Arizona based on the 1 arcsec spacing available for the USA and the international available 3 arcsec spacing.



influence of the forest to the SRTM height model
blue line = reference DEM, red line = SRTM DSM

The influence of the vegetation to the SRTM height model can be seen at preceding profile. In the open area the root mean square differences between the SRTM heights and the reference DEM is in the range of 3m while in the forest systematic height differences up to 25m are available. The influence of not too dense vegetation and buildings can be eliminated by special DEM filters if the height differences, caused by buildings and single trees or groups of trees are clearly exceeding the roughness of the terrain. It is successful in flat and rolling areas outside dense forest. Here by filtering the main influence of the elements on top of the bare ground can be eliminated.

CONCLUSION

The nearly worldwide and free of charge available SRTM C-band height models are an important component of the knowledge about our spatial environment. The homogenous accuracy is sufficient for several applications and for wide areas of the world it is more detailed information about the surface than known before. The standard deviation of approximately 4m for flat and open areas is sufficient also for the generation of orthoimages from space data.