HEIGHT ERROR CORRECTION FOR THE NEW SRTM ELEVATION PRODUCT

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ABSTRACT

The Shuttle Radar Topography Mission (SRTM), carrying a single-pass interferometric synthetic aperture radar (SAR) instrument, collected a global elevation data set, which has been widely used in scientific, military and commercial communities. In the new proposed NASA SRTM reprocessing task, the SRTM elevation data is going to be processed at higher spatial resolution and with improved height accuracy. Upon completion, the improved SRTM product will be freely available. This paper describes the calibration approaches for reduction of elevation ripple effects and height accuracy improvements.

1. INTRODUCTION

The Shuttle Radar Topography Mission (SRTM) provides a nearly global topographic map of the world, consistent in data acquisition and processing, which is widely used by scientific community. SRTM was a collaboration project between the National Aeronautics and Space Agency (NASA) and the National Geospatial-Intelligence Agency (NGA). Its objective was to use Synthetic Aperture Radar Interferometry (InSAR) [1] at C-band frequency to generate digital elevation maps of 80% of the landmass that lies between $\pm 60°$ latitude (Fig. 1). To accomplish this, the project used the Space-borne Imaging Radar-C (SIR-C) hardware that had flown twice before on the shuttle, modified with a 60 meter long mast with additional radar antennas at its tip to form a fixed-baseline interferometer. The data acquisition part of the mission took part in February 2000, when the SRTM InSAR instrument flew for eleven days on the space shuttle orbiter Endeavour. The data processing and DEM generation task took place at the Jet Propulsion Laboratory (JPL) in the subsequent months.

The original accuracy requirements (ITHD-2) consisted at 30m spatial resolution of: 16m absolute vertical error, 6m relative height error, 20m absolute lateral geolocation error, and 15m relative geolocation error (at 90% confidence level). These requirements were exceeded, in dependence of land cover type[2]. The absolute and relative height errors were about 8m and 7m, respectively, and the absolute geolocation error was about 9m.

The objective is to improve the accuracy of the SRTM-derived Digital Elevation Model (DEM). This will be achieved by reprocessing the entire SRTM dataset from raw measurements with new state-of-the-art techniques and ancillary datasets. The new free global DEM will have improved resolution ($\approx$ 30m), height error accuracy and less void areas, next to additional product layers.

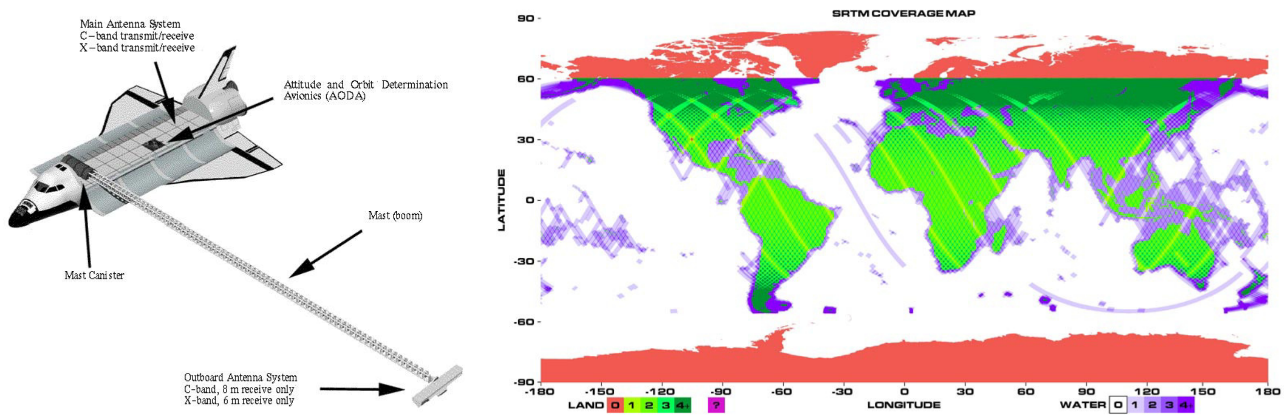

Fig. 1. Conceptual SRTM image with the coverage density map.

In this paper, we present an approach to remove elevation ripples caused by AODA and other effects. The approach relies on availability of elevation estimates from the Ice, Cloud, and Land Elevation Satellite (ICESat) Geoscience and Next to the used methodology, the improvements over the original SRTM DEM are going to be presented.

2. INITIAL RESULTS

2.1. Bare Ground Results

For ripple removal evaluation, a 3 x 3 degrees region was chosen in Australia. All SRTM orbit pieces which covered this area were processed and corrected using the proposed methodology. These data were used for further mosaic generation and correction assessment.

In total, 52 strip beams were processed for the construction of the Australia mosaic for the final evaluation. The processed area (accumulating repetitive processing of same area, during different orbits) covered 2.3 million km^2, the total range and azimuth were 3,721 and 38,122 km. The ICEsat lidar waveform density of only bare surfaces was 1.38 per km^2. The average absolute height error bias was found to be 3.37m with an average standard deviation of 2.66m, the original average RMSE was 4.37m. After correction of the error based on second order moving polynomial averaging with a 6km window along azimuth (range dependency of the error was found minimal inside of individual beams), the bias was removed and the RMSE was reduced to 3.02m. The result statistics are presented below in Table 1. The final mosaic and the corresponding correction are shown in Fig. 2. Individual SRTM vs. ICESat GLAS height estimation errors before and after correction are shown in Fig. 3 for two sample beams in slant range geometry.

2.2. Vegetated Areas Results

For the evaluation of ripple removal over heavily vegetated area, a tropical forest region in the Amazon, close to Manaus, was selected and several orbits were processed and the error removal was applied. It was found that only few ICEsat lidar shots could be characterized as bare surface only. Initial analysis of using the lidar waveforms over forested areas for ripple removal were conducted.

Table 1. Updated SRTM beam, ICESat, and correction statistics for the Australia Mosaic. Presented are average results per individual beams (in total 52 beams).

	Mean	SDev	Min	Max
Swath width [km]	71.6	12.4	55.8	94.2
Along track length per strip [km]	733.1	85.4	438.5	772.0
Valid area [km^2]	44,414	9,896	21,201	61,528
ICESat GLAS shots number	61,091	13,745	28,565	99,966
ICESat GLAS shot density [1/km^2]	1.38	0.15	1.06	1.78
Mean Absolute Error [m]	3.37	1.38	1.68	8.76
SDev Absolute Error [m]	2.66	0.85	1.38	4.82
RMSE [m]	4.37	1.41	2.17	9.28
Bias after correction [m]	0	0.03	-0.12	0.05
Abs. Error after correction [m]	2.05	0.34	1.52	2.95
RMSE after correction [m]	3.02	0.82	1.95	5.26

32 strip beams were processed over the Amazon tropical forest near Manaus. It was found that the density of ICEsat lidar shots without the vegetation bias is very low (0.04 shots per km^2, or 1 shot per 51 km^2), making the ripple correction task more difficult. When analysing the full lidar wavelength data, extracting several height metrics, it was experimentally found that the SRTM height falls mostly between rh50 and rh75 lidar height metric (50% and 70% energy level from the bottom). The density of valid ICEsat lidar shots including forested areas was 0.48 shots per km2, or 1 shot per 2.1 km2. Figure 4 shows an example profile of the SRTM derived height, together with ICEsat lidar waveform derived height metrics (ground=rh0, rh25, rh50, rh75, rh100).

Acknowlegement

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3. REFERENCES

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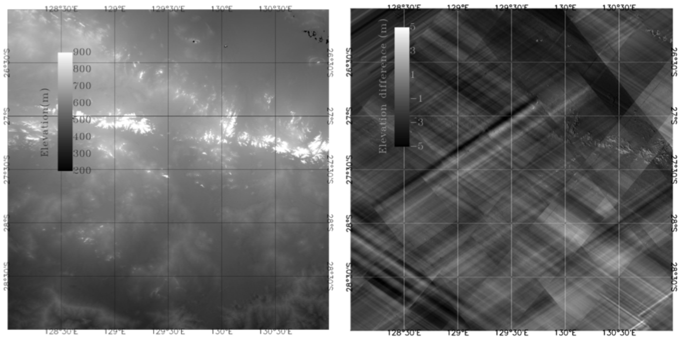

Fig. 2. SRTM elevation correction resulting from proposed methodology, after mosaic generation. Left: New SRTM DEM over central Australia. Right: Correction (difference) between the new and original SRTM DEM. The observed ripples are due to unmeasured SRTM boom motion. The crisscross pattern results from merging several SRTM ascending and descending passes containing artifacts. The ripples along each radar strip are removed with the approach incorporating ICESat/GLAS data.

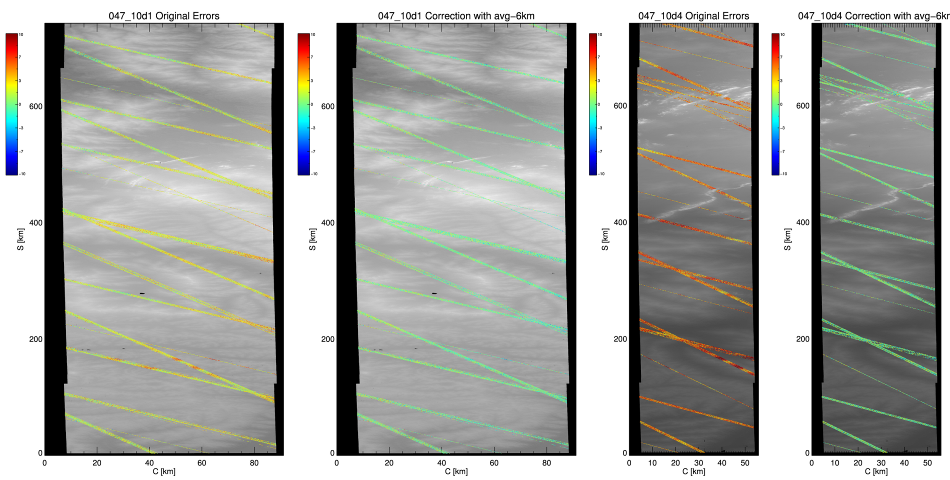

Fig. 3. Orbit 47, peg 10, beams 1 and 4: Overploting estimated errors (beam 1: (a), beam 4: (c)) and residual errors after correction (beam 1: (b), beam 4: (d)) on the strip height map in slant range geometry [image is not x-y isotropic].

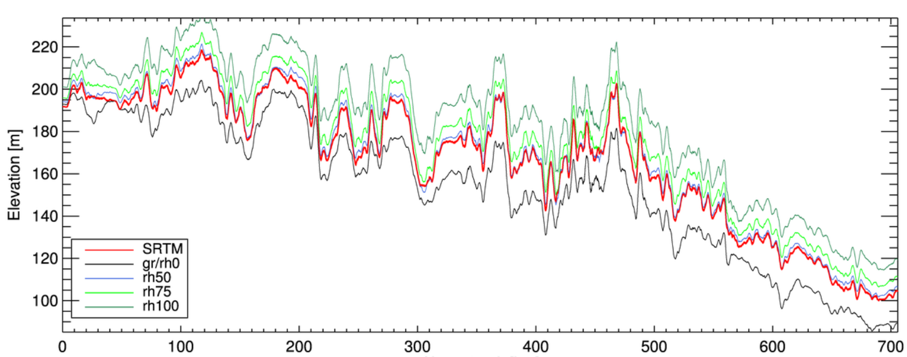

Fig. 4. Processed SRTM and ICESat/GLAS waveform data over the Amazon. An example profile, showing how the SRTM estimated height closely overlaps in this particular case with the rh50 lidar metric.