Highly Accurate Satellite Topographic Mapping Accuracy Study

A PhotoSat 50 cm Elevation Grid, produced from the new 30 cm resolution DigitalGlobe WorldView-3 Stereo Satellite Photos, is accurate to better than 15 cm RMSE, as determined by direct comparison to a highly accurate LiDAR Elevation Grid.

A 50 cm square grid of elevations was produced by geophysical processing of WorldView-3 stereo satellite photos over an area of 144 square kilometers.

The stereo WorldView-3 elevation accuracy, using a single ground reference point, is better than 15 cm RMSE, as determined by comparison to an 88 square kilometer 50 cm LiDAR elevation grid, accurate to about 5 cm RMSE.

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In February 2015, PhotoSat conducted a study to measure the elevation mapping accuracy of PhotoSat's WorldView-3 (WV3) stereo satellite elevation grid, produced from the newly released 30 cm resolution WV3 photos, relative to a highly accurate LiDAR elevation grid. For this accuracy study PhotoSat used a WV3 stereo satellite photo pair acquired November 28, 2014 over a 144 km² area of Southeast California, approximately midway between Los Angeles and Las Vegas. This area has 88 km² of overlap with the LiDAR data.

This area was mapped with a LiDAR survey in April 2008 by Open Topography. This dataset was also used for a previously published WorldView-2 elevation accuracy study completed by PhotoSat. The LiDAR elevation grid is available on the OpenTopography website at www.opentopography.org. The area used for the accuracy study is shown outlined on the WV3 satellite imagery in Figure 1. The comparison of the LiDAR elevation grid and Stereo WV3 elevation grid is shown in Figures 2-9.

Figure 1: WV3 30 cm resolution satellite ortho photo, created from WV3 stereo photos, for the area of the LiDAR survey used in this study. The 7.5 mile oval track is the Honda Proving Center of California. The area of the LiDAR dataset is outlined. The dimensions of the WV3 area are 12 km by 12 km.
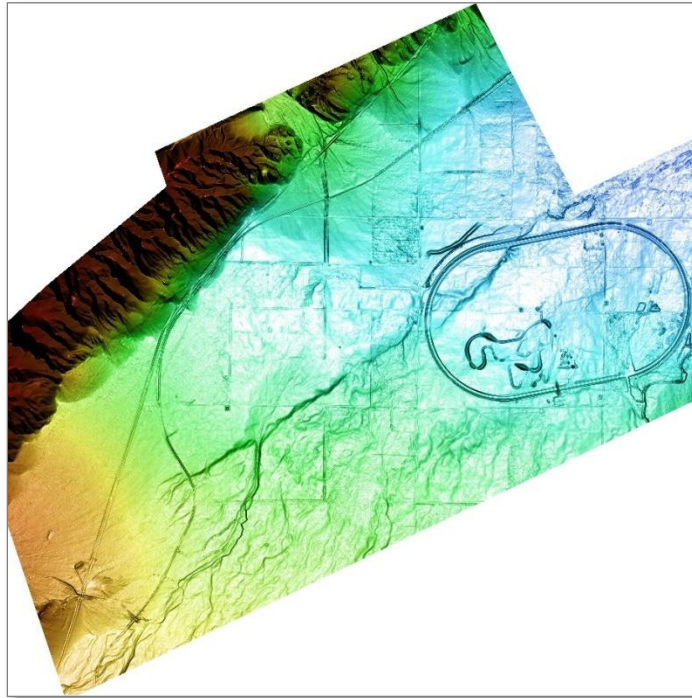
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Figure 2: An image showing a portion of the OpenTopography LiDAR elevation grid. Lower elevations are blue, and higher elevations are red. The area of the LiDAR dataset used was 88 km². The accuracy of the LiDAR elevation grid is expected to be in the range of 5 cm RMSE.
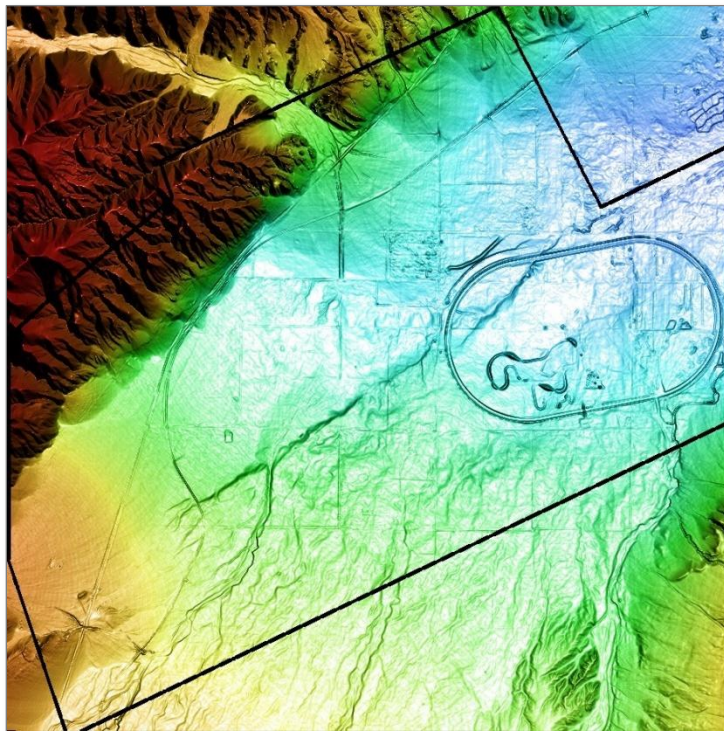

Figure 3: Stereo WV3 elevation grid image covering the area of the LiDAR image in Figure 2. This elevation grid has an elevation point every 50 cm. At this scale the LiDAR and WV3 images are identical. Low elevations are blue and high elevations are red.
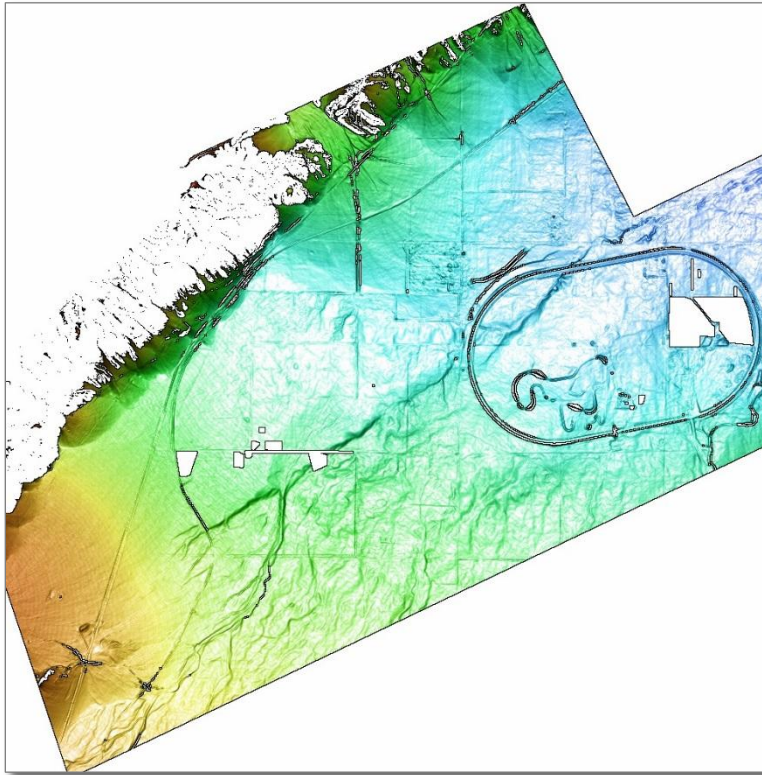
Figure 4: Stereo WV3 elevation image covering the area of the LiDAR elevation image in areas with slopes less than 20% grade. Areas where development had occurred since the LiDAR survey was acquired in 2008 were removed for the accuracy analysis.
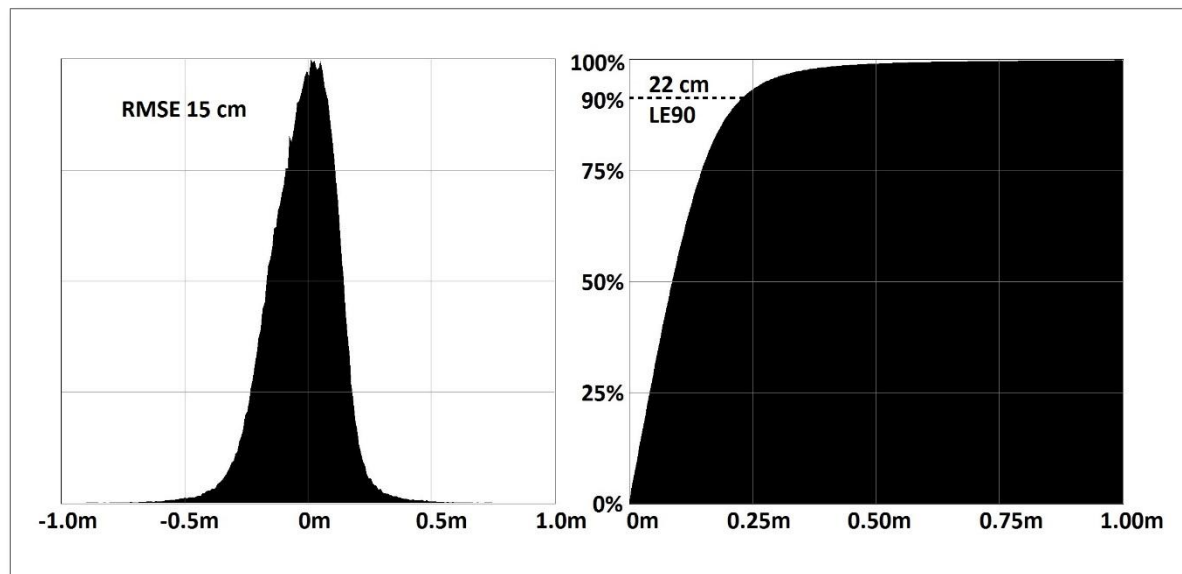

Figure 5: The differences between the WV3 elevation grid and the LiDAR elevation grid for areas with slopes less than 20% grade are shown in a standard histogram on the left and a cumulative histogram on the right. If we assume that the LiDAR elevation grid is perfect, the WV3 elevations have a Root Mean Square Error (RMSE) of 15 cm. Ninety percent of the stereo WV3 elevations are within 22 cm of the LiDAR elevations giving a 90% Linear Error (LE90) of 22 cm. Since the LiDAR elevation grid has an accuracy of about 5 cm RMSE, the accuracy of the WV3 elevation grid must be significantly better than 15 cm RMSE. Areas where development had occurred since the 2008 LiDAR data was acquired were removed for the accuracy analysis.
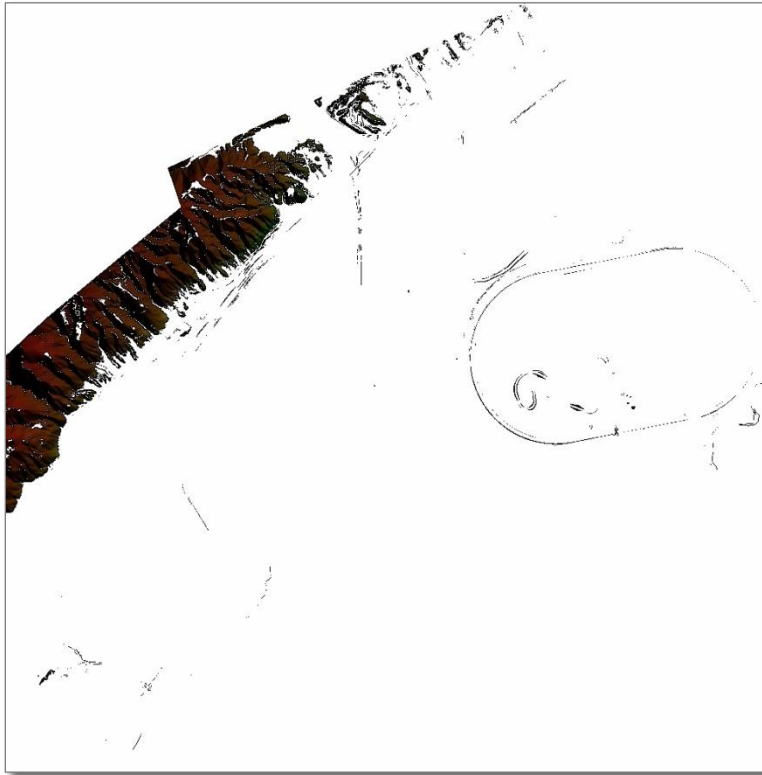
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Figure 6: *Stereo WV3 elevation grid image covering the area of the LiDAR image in areas with slopes greater than 20% grade. Areas where development had occurred since the LiDAR survey was acquired in 2008 were also removed for the accuracy analysis.*
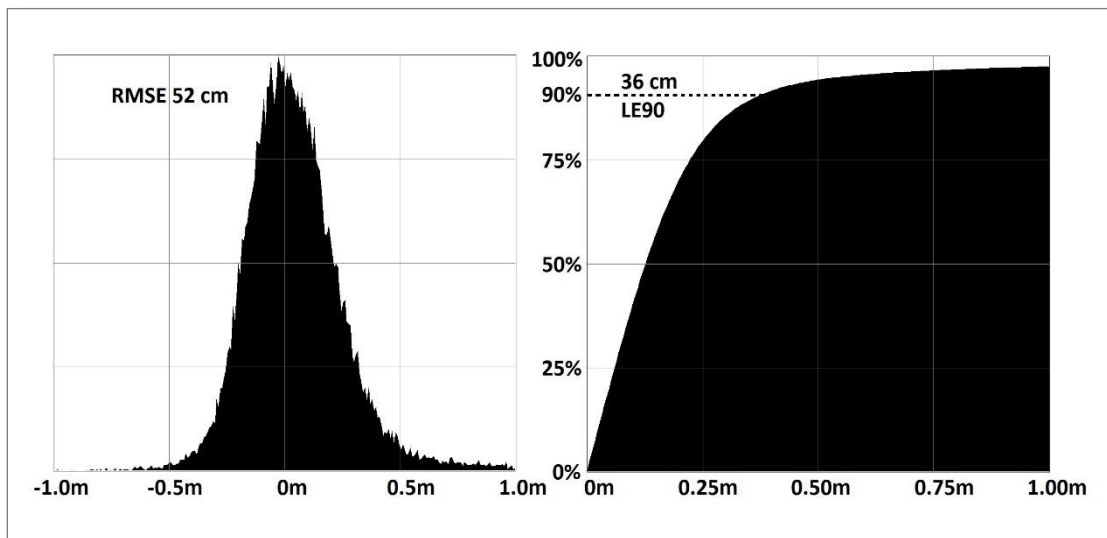

Figure 7: *The elevation difference between the WV3 elevation grid and the LiDAR elevation grid for areas with slopes greater than 20% grade are shown in a standard histogram on the left and a cumulative histogram on the right. If we assume that the LiDAR elevation grid is perfect, the WV3 grid elevations have a Root Mean Square Error (RMSE) of 52 cm. Ninety percent of the stereo WV3 elevations are within 40 cm of the LiDAR elevations giving a 90% Linear Error (LE90) of 36 cm. Areas where development had occurred since the 2008 LiDAR data was acquired were also removed for the accuracy analysis.*
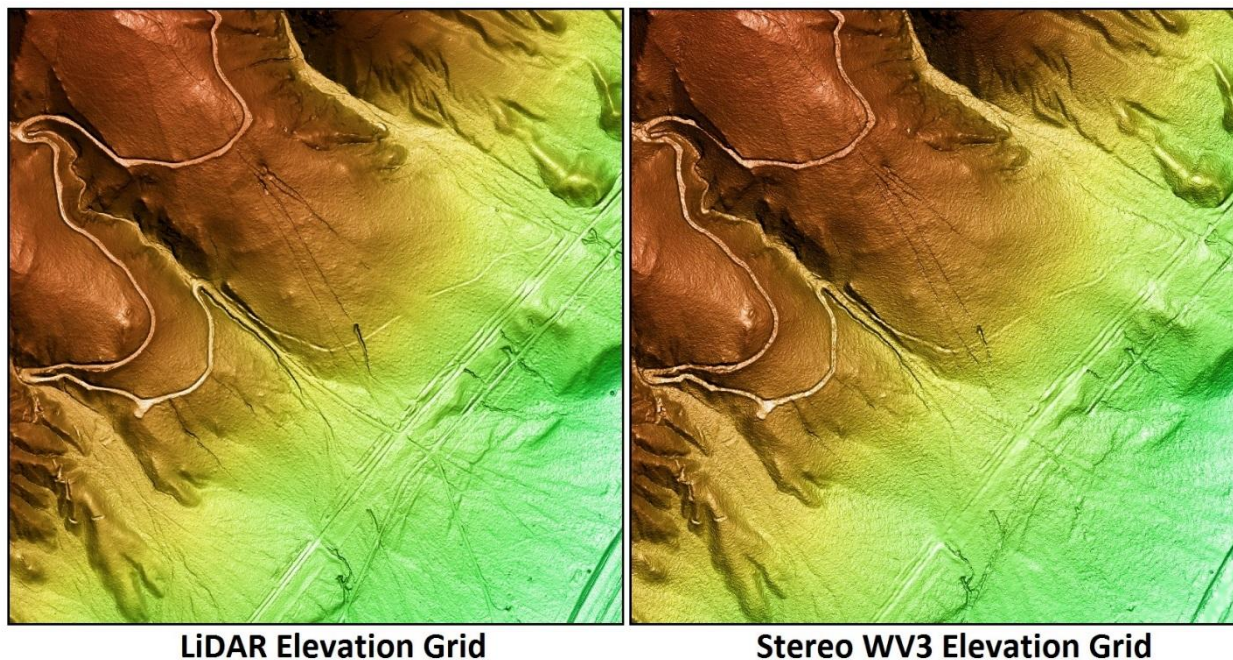
LiDAR Elevation Grid

Stereo WV3 Elevation Grid

Figure 8: *Comparison of the LiDAR and WV3 elevation grids for a 1000 m wide area. Minor differences between the elevation grids are visible at this scale.*

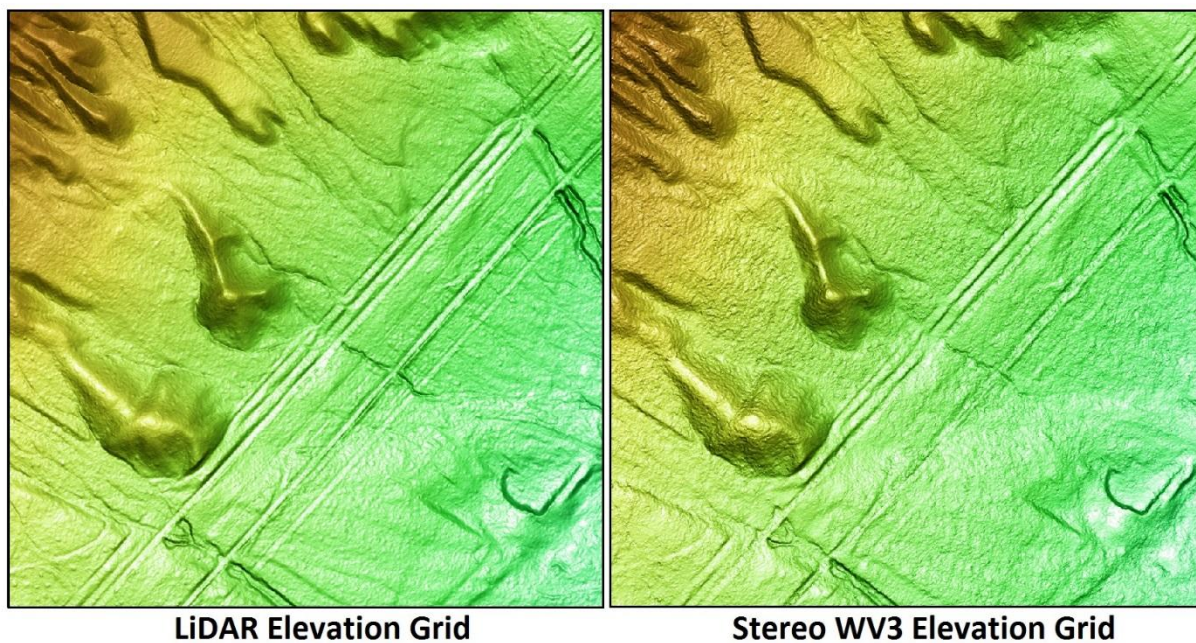**LiDAR Elevation Grid**

Stereo WV3 Elevation Grid

Figure 9: *Images of the LiDAR and WV3 elevation grids for a 500 m wide area. At this scale fine topographic features are clearer in the LiDAR elevation grid.*

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Discussion:

PhotoSat's elevation grid was matched to a single point on the LiDAR dataset. The PhotoSat WV3 elevation grid was compared to the LiDAR elevation grid in areas of slope less than 20% grade and areas with slopes greater than 20% grade. If we assume that the LiDAR elevation grid is perfect, which cannot be true, the WV3 elevations have a Root Mean Square Error (RMSE) of 15 cm. Ninety percent of the stereo WV3 elevations are within 22 cm of the LiDAR elevations giving a 90% Linear Error (LE90) of 22 cm. Since the LiDAR elevation grid has an elevation accuracy of about 5 cm RMSE, the accuracy of the WV3 elevation grid must be significantly better than 15 cm RMSE in areas with slopes less than 20% grade. By the same reasoning the WV3 elevation grid in areas of slopes greater than 20% grade has accuracy better than 52 cm RMSE and 36 cm LE90.

Cautionary Statement:

This is an accuracy assessment for elevation mapping from a specific stereo pair of WV3 satellite photos. These results will not apply to all stereo pairs of WV3 photos.

References:

NCALM LiDAR. Southern California and Washington (Yakima) Fault Systems LiDAR Survey (April 2 – April 26, 2008) Processing Report. http://opentopo.sdsc.edu/metadata/SOCAL_REPORT_final.pdf

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