Exploring the new Open Topography Points 2 Grid with null filling

Ramon Arrowsmith, January 7, 2010

Introduction

Chris Crosby and Sriram Krishnan at SDSC have been enhancing the original Points2Grid (P2G) code (aka interp) written by Han Kim (http://lidar.asu.edu/KnowledgeBase/Notes_on_Lidar_interpolation.pdf, http://lidar.asu.edu/KnowledgeBase/GLW_Search_Radius/, http://lidar.asu.edu/KnowledgeBase/LocalBinning_one-pager.pdf). One of the problems with the original implementation is the tradeoff between small search radii (more representative of the data near the grid node at which the elevation is being estimated) and large numbers of nulls (if there are no points within the search radius, the grid node is given a null elevation). I have written about this a bit in the past (http://lidar.asu.edu/KnowledgeBase/WCptcount/, and Arrowsmith and Zielke, 2009). The null problem is large in the computation of bare earth DEMs in which there are some large gaps between ground returns below canopy.

Chris writes: "The filling implementation is using a focal IDW mean - similar to ESRI's FOCALMEAN (http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=focalmean)

con(isnull([DEM]),focalmean([DEM], rectangle, 3, 3, DATA),[DEM])

but in this case we are using an inverse distance weight if the window is greater than 3x3. Fill window size options are 3, 5 and 7. Filling nulls in this manner is not necessarily ideal, but it does a relatively good job in most cases and allows us to take advantage of the fact that the grid is already in memory."

The current version is implemented in an alpha version web service within an Opal Framework (http://www.nbcr.net/software/opal/).

I embarked on a bit of exploration of the new version, comparing its results against the base OpenTopography production P2G results for a data set from the B4 data near Wallace Creek and GeoEarthScope data from the Teton Fault zone.

Testing on B4 data near Wallace Creek

Base OT results are here
http://opentopo.sdsc.edu/lidar/data/tmp/output12628273094671661317467.html and Figure 1.

All runs with search radius 0.8 and grid resolution 0.5.

1) OT base case versus Opal with no nulls: difference is 0.
2) Opal with 3x3 nulls gives error for IDW (see http://geon01.sdsc.edu:8080/app1262881329722/) and figure 2. Other bin estimates (min, max, mean are fine).
3) Opal with 5x5 and 7x7 null filling looks good and has zero difference from OT base case. Nulls with no null fill = 106, 5x5 nulls = 0, 7x7 nulls = 0.
4) Comparison with Arc Focal Mean calculation (which ran fast):
   con(isnull([idwpt5pt8]),focalmean([idwpt5pt8], rectangle, 5, 5, DATA), [idwpt5pt8])
   I subtracted them using Arc's Raster Calculator: [arcfm5x5] - [idwpt5pt8n5]
   gives some small differences (see Figure 3)

In summary (and aside from the 3x3 error), I am impressed by the null filling because it looks great and does not otherwise alter the resulting local binning DEMs.

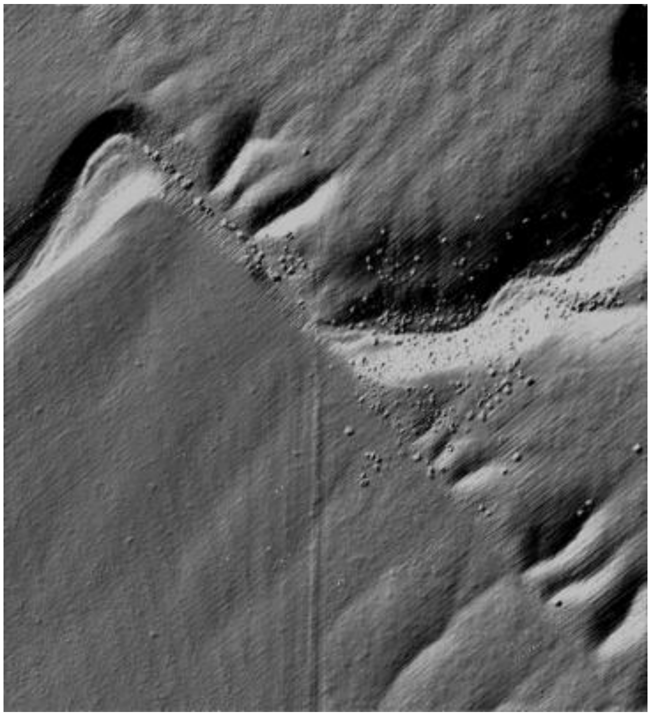

Figure 1: Test site along the San Andreas fault in the Carrizo Plain at Wallace Creek (B4 data). This DEM is a 0.5 m resolution with a 0.8 m search radius computed from 374,738 points and has 106 nulls in a 661x601 grid—397,261 nodes).

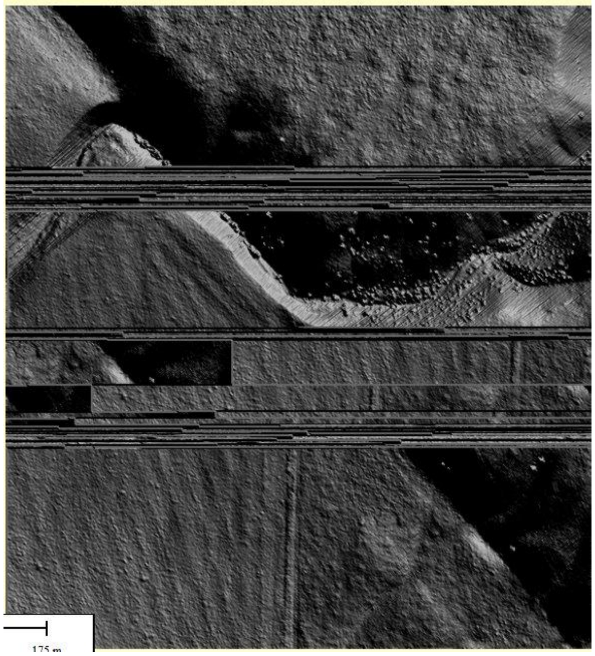

Figure 2: Wallace Creek test site problem DEM computed with a 3x3 null fill in an IDW P2G result (find results here: http://geon01.sdsc.edu:8080/app1262881329722/).

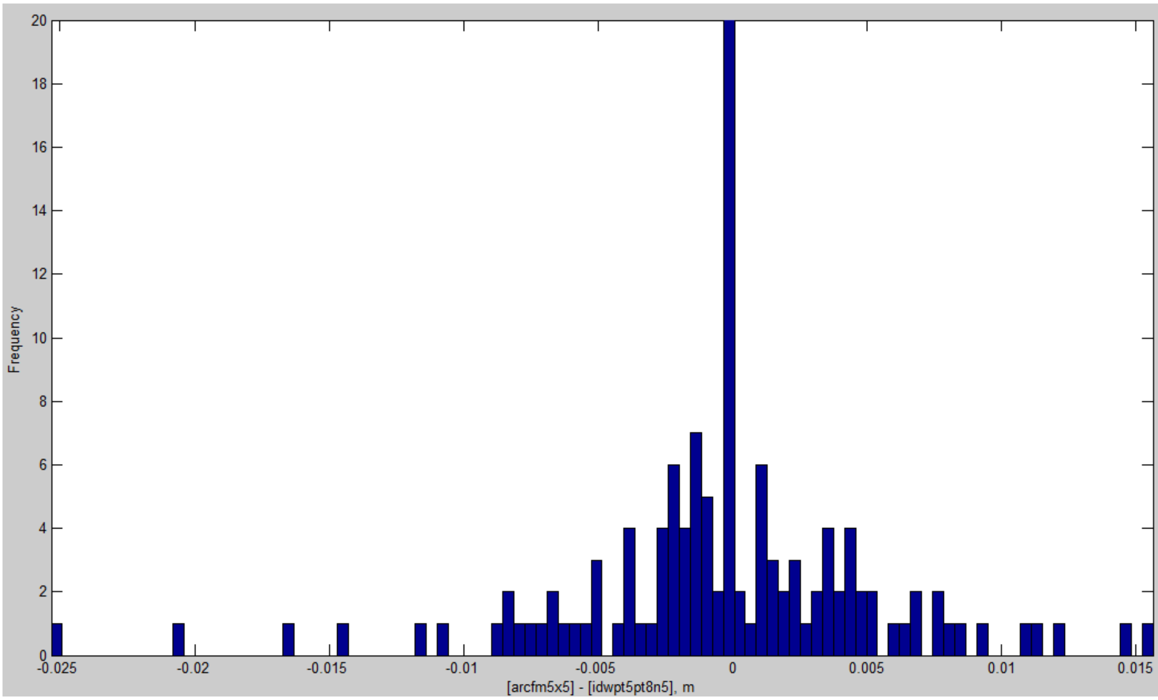

Figure 3: Difference between the ArcGIS focal mean 5x5calculation and the Opal P2G implementation at the Wallace Creek test site. The difference is not significant, but worth knowing about. Note that in the comparisons below with the 3x3 focal mean on the Teton GeoEarthScope data, the errors are significantly smaller (+/-0.0002 m).

Testing on GeoEarthScope data along the Teton Fault

Base OT results are here

Full Feature: http://opentopo.sdsc.edu/lidar/data/tmp/output12628274736501563716672.html

zoom: http://opentopo.sdsc.edu/lidar/data/tmp/output12628291513541770948855.html

Bare Earth: http://opentopo.sdsc.edu/lidar/data/tmp/output12628274995761446950642.html

zoom: http://opentopo.sdsc.edu/lidar/data/tmp/output12628291744602055344267.html

I ran the analysis on the zoomed results.

Before getting going on the null filling, I also took advantage of the availability of the Standard DEM tiles for the site, downloading and mosaicking the relevant 4. The standard DEMs are computed using kriging in Surfer (http://www.rockware.com/product/overview.php?id=129) (as far as we know by NCALM--http://www.ncalm.org/).

Figure 4 shows the various datasets, including the zoomed area where there are a lot of trees and thus a lot of nulls in the bare earth result with no null filling. Figure 5 shows the zoomed views analogously as Figure 4.

Figure 6 shows the elevation differences from subtracting the base OT (P2G) IDW DEMs from the kriging-derived standard DEMs. Most of the differences are small (within +/- 5 m). The variations probably derive from how the gridding algorithms handle outliers (P2G will be more sensitive to them), and how the local averaging of the cloud is handled.

All runs with search radius 0.8 and grid resolution 0.5.

Full feature assessment (Figure 7):

1) OT base case versus Opal with no nulls: difference is 0.
2) Opal with 3x3, 5x5 and 7x7 null filling looks good and has zero difference from OT base case. Nulls with no null fill = 715, 3x3 nulls = 4, 5x5 nulls = 0, 7x7 nulls = 0.
3) Comparison with Arc Focal Mean calculation (which ran fast):
   con(isnull([idwpt5pt8nn]),focalmean([idwpt5pt8nn], rectangle, 3, 3, DATA), [idwpt5pt8nn])
   I subtracted them using Arc's Raster Calculator: [arcfm3x3] - [idwpt5pt8n3]
   gives very small differences (+/-0.0002 m)

Bare earth assessment (Figure 8):

1) OT base case versus Opal with no nulls: difference is 0.
2) Opal with 3x3, 5x5 and 7x7 null filling looks good and has zero difference from OT base case. Nulls with no null fill = 432,739, 3x3 nulls = 122,556, 5x5 nulls = 44,544, 7x7 nulls = 17758. That is out of a 2,612,015 cells total.
3) Comparison with Arc Focal Mean calculation (which ran fast):
   con(isnull([beidwpt5pt8nn]),focalmean([beidwpt5pt8nn], rectangle, 3, 3, DATA), [beidwpt5pt8nn])
   I subtracted them using Arc's Raster Calculator: [arcfm3x3] - [beidwpt5pt8n3]
   gives very small differences (+/-0.0002 m)
4) Finally, I subtracted the bare earth IDW from OPAL with the 7x7 null filling (Figure 8D) from the standard bare earth DEM (Figure 4B) and got an error range of -13.2 to 14.7 m (Figure 9).

Very impressive and with this small test, seems ready for prime time!

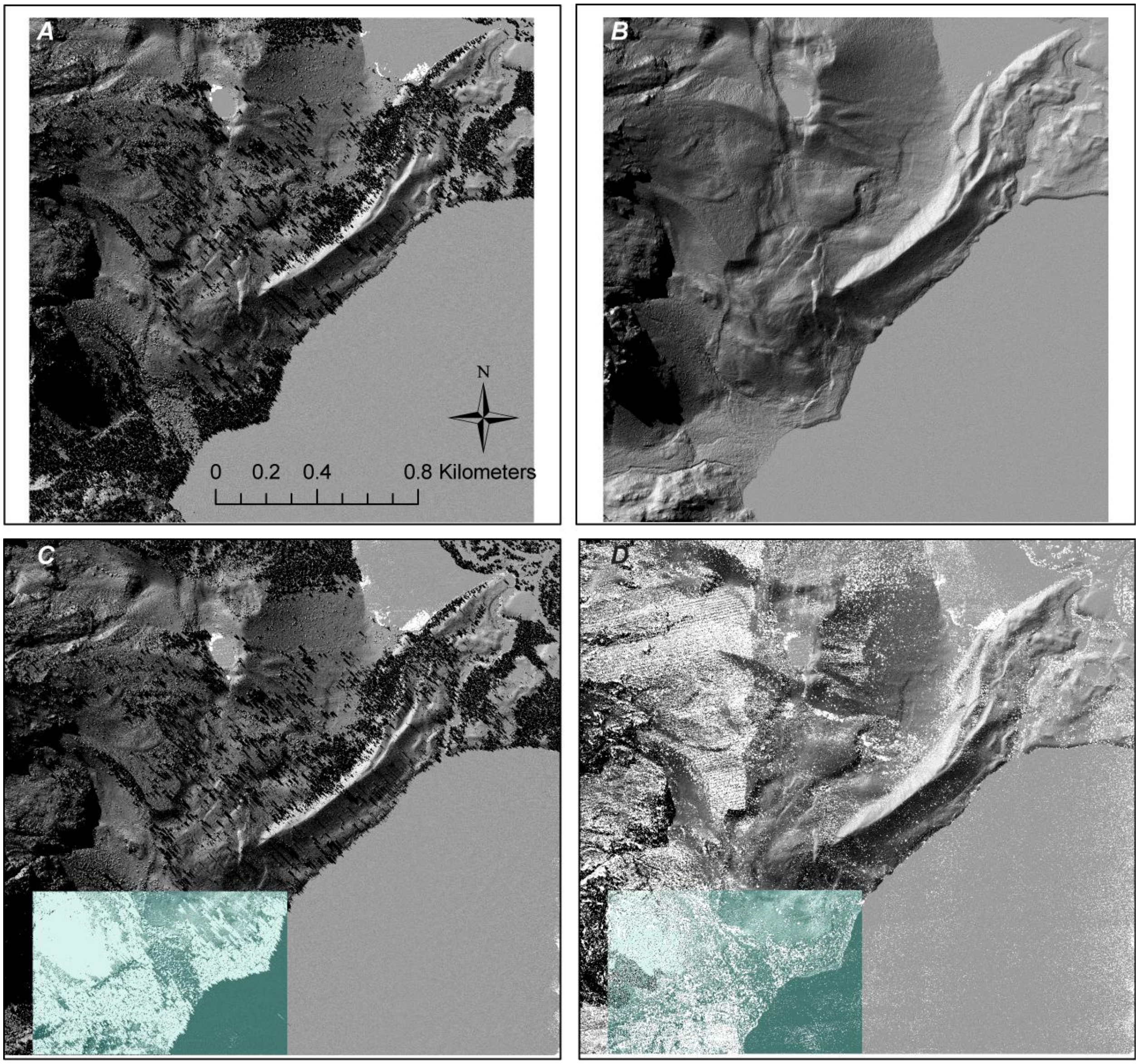

Figure 4: Teton Fault zone. A) Standard full feature DEM (4x 1 km wide 0.5 m grid resolution). B) Standard bare earth DEM. C) OpenTopography P2G full feature with no null filling at 0.5 m resolution. Inset area shown in green is the test site where there are 3,212,621 total returns). D) OpenTopography P2G bare earth (ground only returns) with no null filling at 0.5 m resolution. Inset area in green is the test site with 849,550 ground returns. See Figure 5 for a view of the test area.

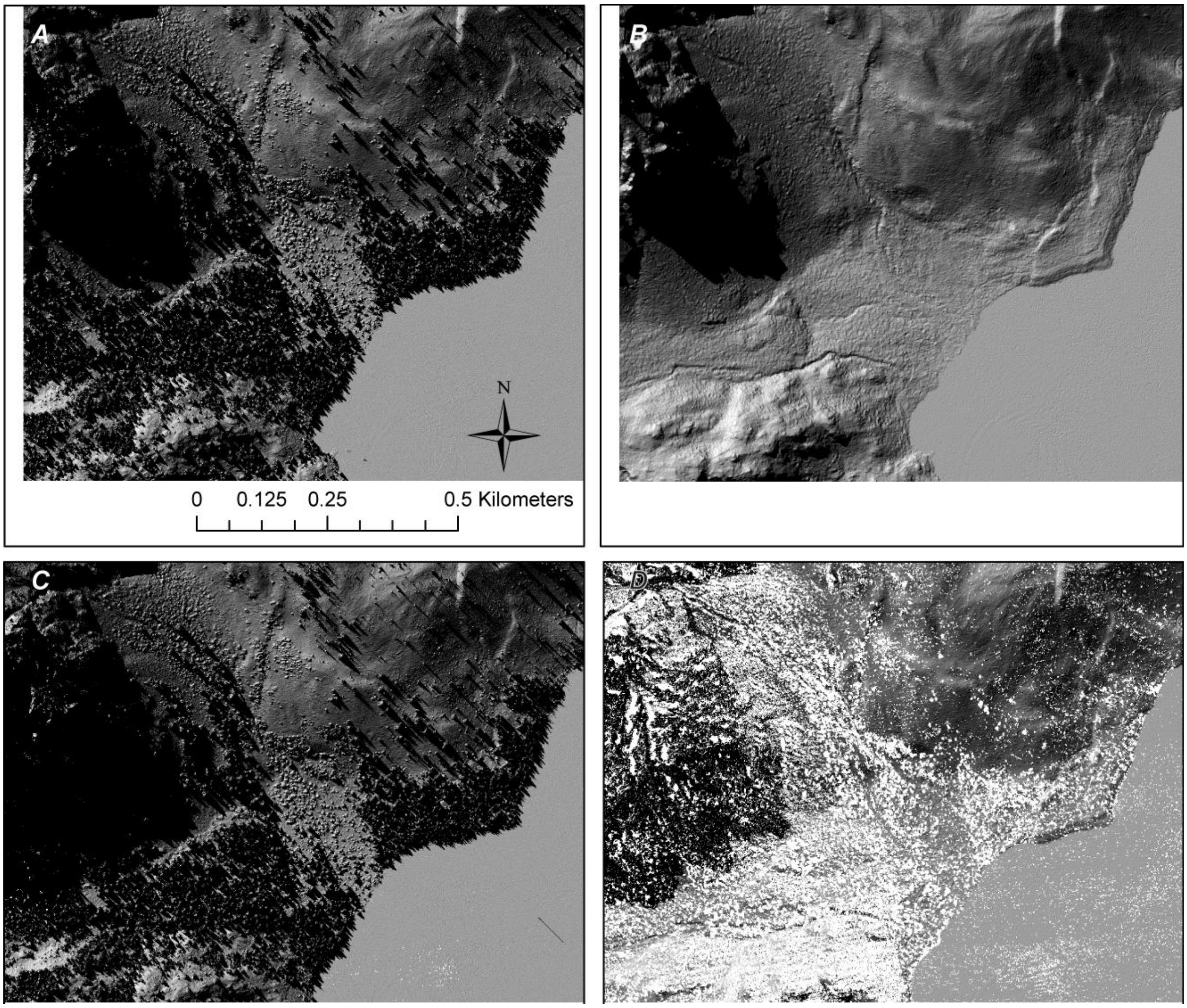

Figure 5: Teton Fault zone test area. A) Standard full feature DEM (4x 1 km wide 0.5 m grid resolution). B) Standard bare earth DEM. C) OpenTopography P2G full feature with no null filling at 0.5 m resolution. D) OpenTopography P2G bare earth (ground only returns) with no null filling at 0.5 m resolution.

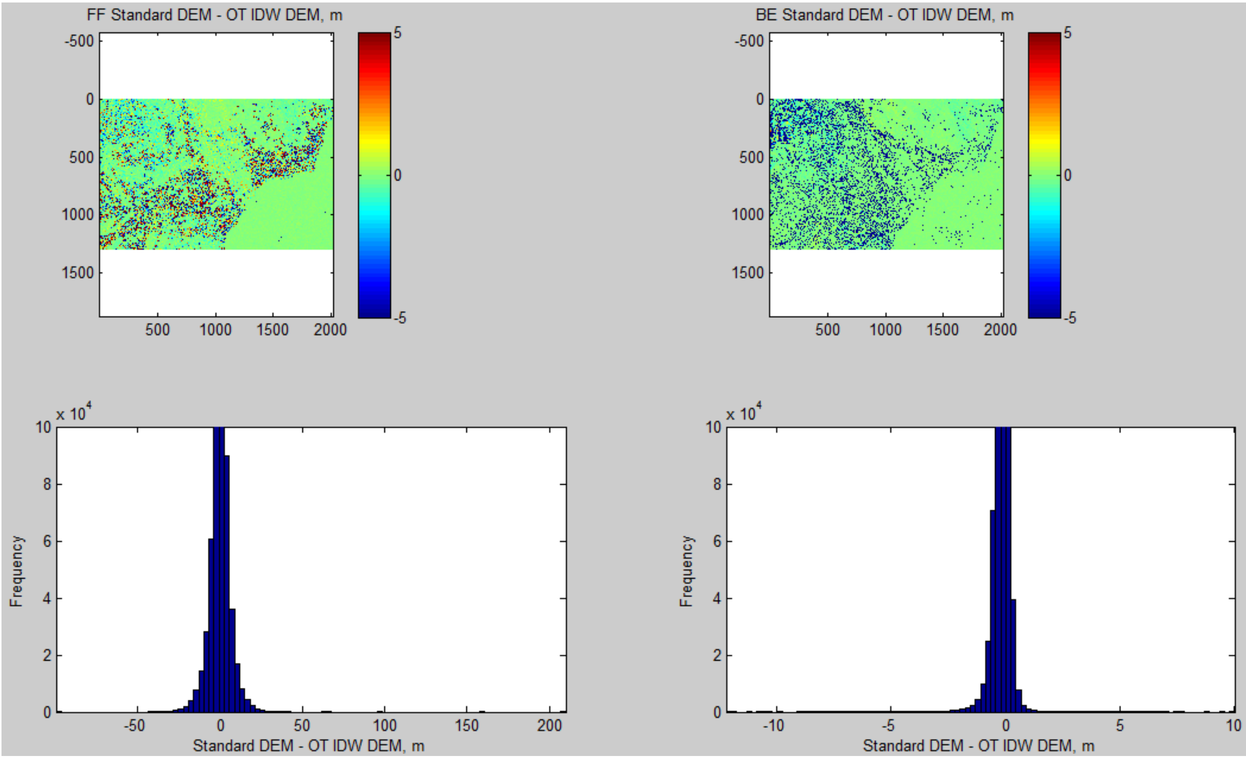

Figure 6: Teton Fault zone test area standard DEM and base OT differences. Left column: Full feature differences and right column: bare earth differences.

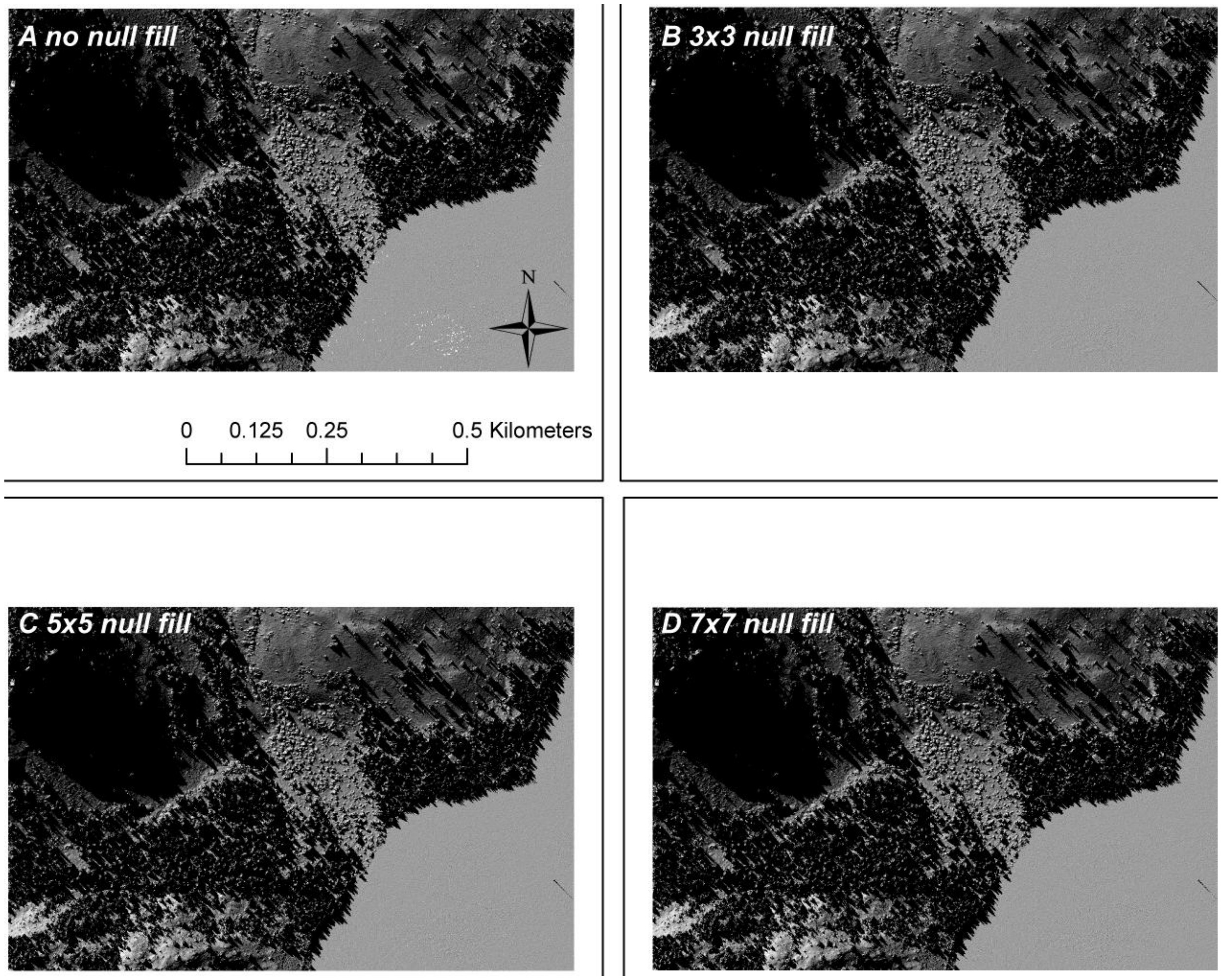

Figure 7: Teton Fault zone test area full feature 0.5 m DEMs with increasing number of cells in the null filling.

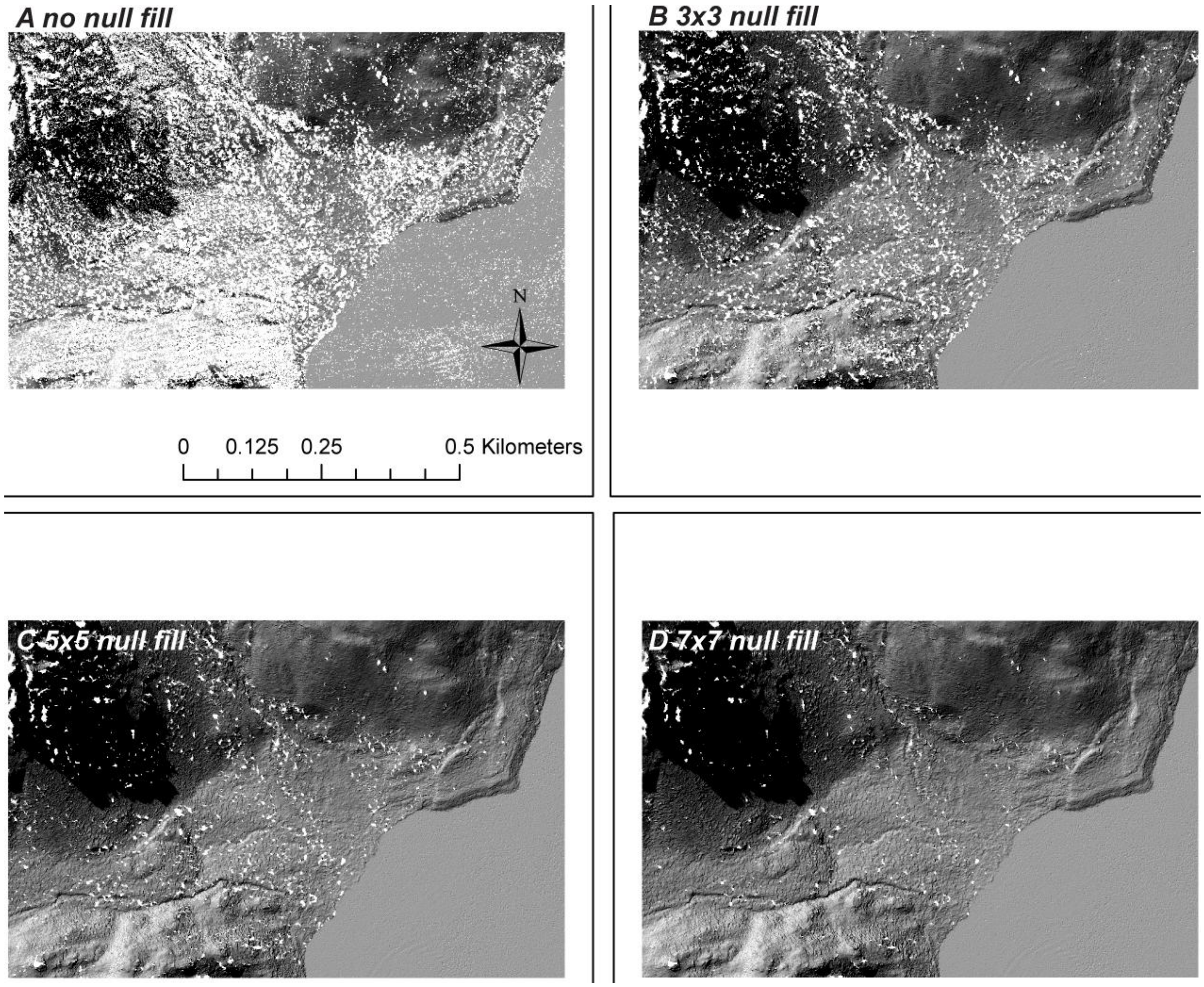

Figure 8: Teton Fault zone test area bare earth 0.5 m DEMs with increasing number of cells in the null filling.

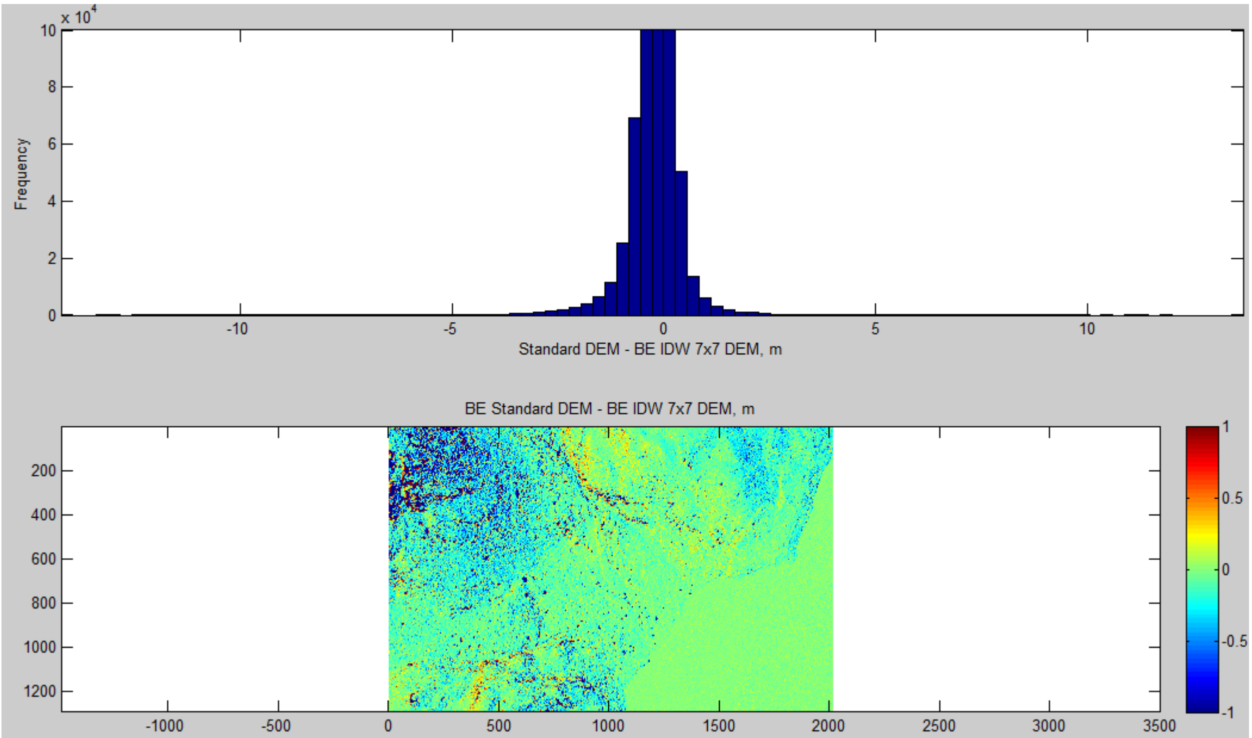

Figure 9. Difference between the bare earth IDW from OPAL with the 7x7 null filling (Figure 8D) from the standard bare earth DEM (Figure 4B). Most differences are less that +/- 2 m.