“Landsliding and the Evolution of Mountainous Landscapes.”

Joshua Roering, Ph.D.
Assistant Professor
Dept. of Geological Sciences
University of Oregon
325 Cascade Hall
Eugene, OR 97403-1272 USA
email: jroering@uoregon.edu
phone: (541) 346-5574 fax: (541) 346-4692

Figure 1 – GPS reference Stations at the Garberville Airport.

Survey Parameters

This LiDAR survey was conducted in three days over the Eel River at the southwestern corner of Trinity County, the southeastern corner of Humboldt County extending slightly into the northern portion of Mendocino County, California from September 24 - 26, 2006 (GPS days 267-269). The Cooksie Creek polygon in western Humboldt County was NOT surveyed due to foggy weather combined with a short deadline for the ALTM that was rented from Optech, Inc.

Data on the Eel River were collected with a (rented) Optech 1233 ALTM (serial# 99B112) mounted in a turbocharged twin engine Cessna 337 (tail number N86539). The survey required a total of three flights, with one flight occurring on each day. Figures 2 and 3 (below) show the location and sizes of the two project polygons – one surveyed (Eel River), one yet to be surveyed (Cooksie Creek).

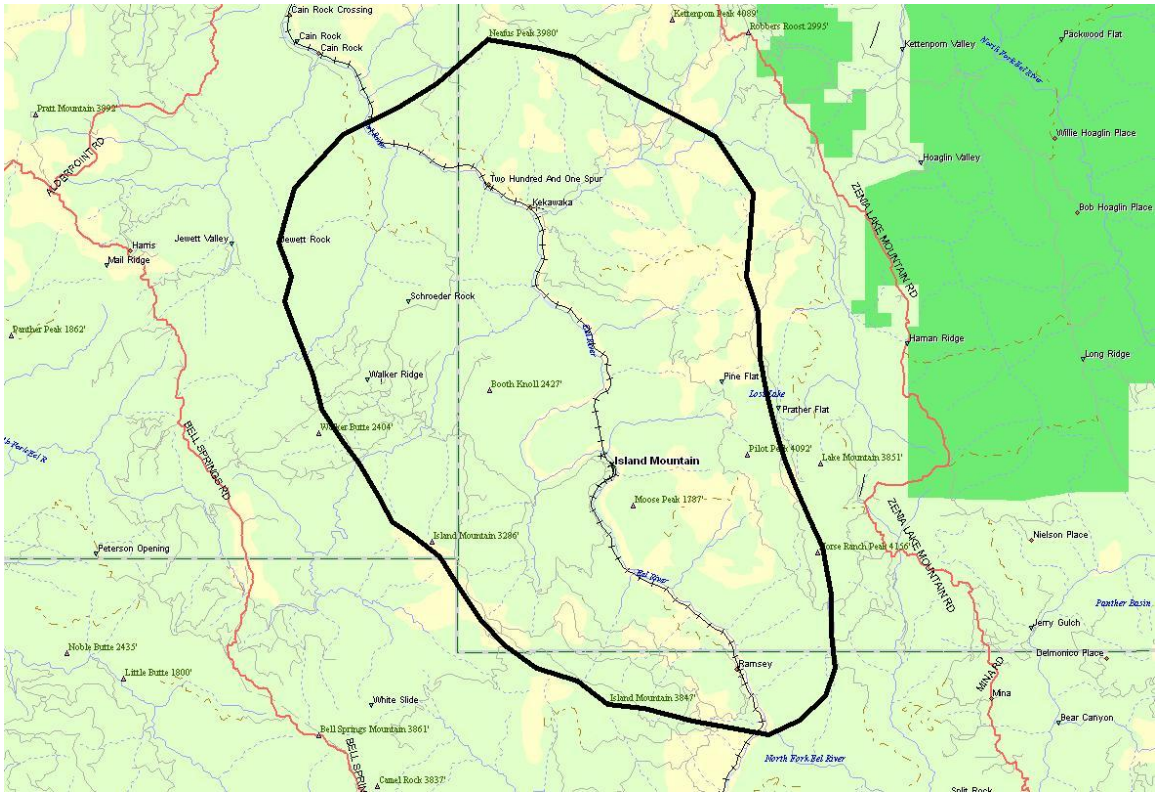


Figure 2 – Eel River polygon (225 square kilometers).

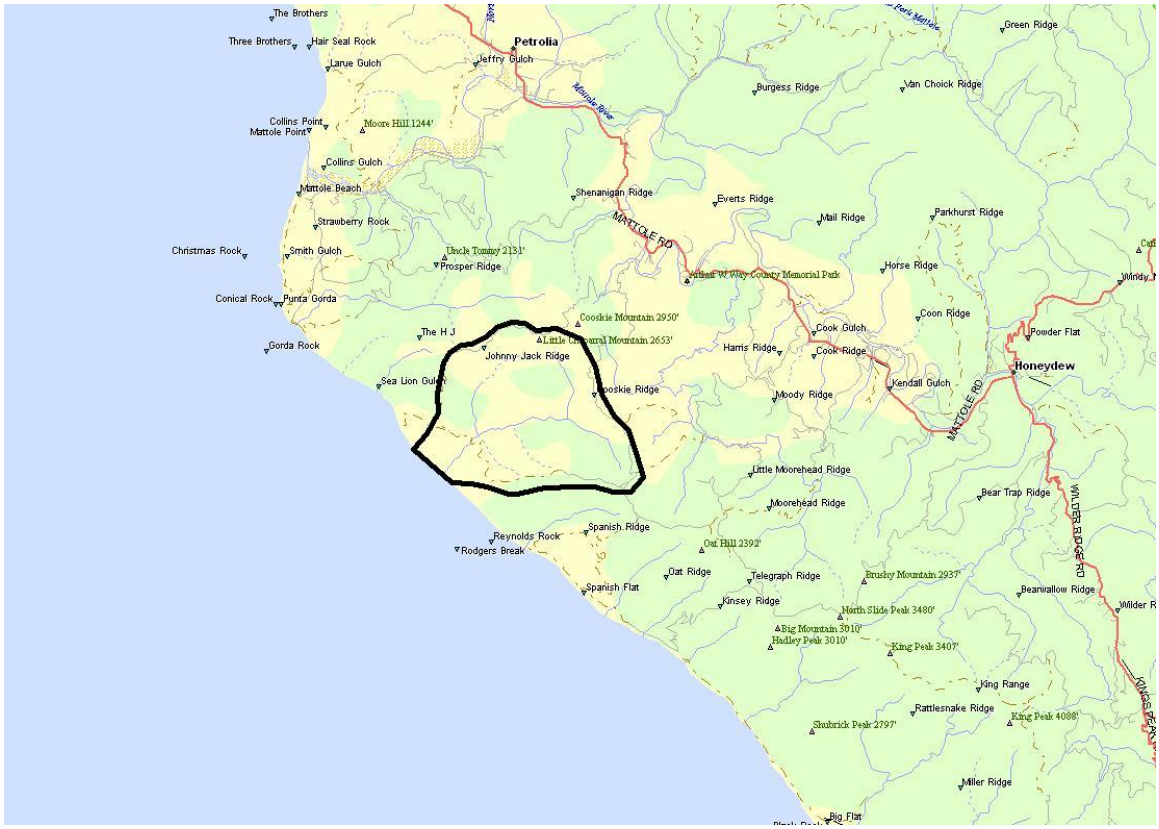


Figure 3 – Cooksie Creek polygon (21 square kilometers).

Accurate estimates of flying heights and point spacing at any particular instant are difficult due to the mountainous terrain surrounding the Eel River. LiDAR settings were held constant as follows: the flight line spacing was fixed at 230 meters. This fixed line spacing resulted in widely varying percentages of overlap depending on the height of the aircraft over the terrain at any particular instant. The scan angle was held constant at +/- 20 degrees, and scan frequency (mirror oscillation frequency) was fixed at 28 Hz for all flights.

Figure 4 (below) in a map showing the 63 planned flight lines for The Eel River polygon.

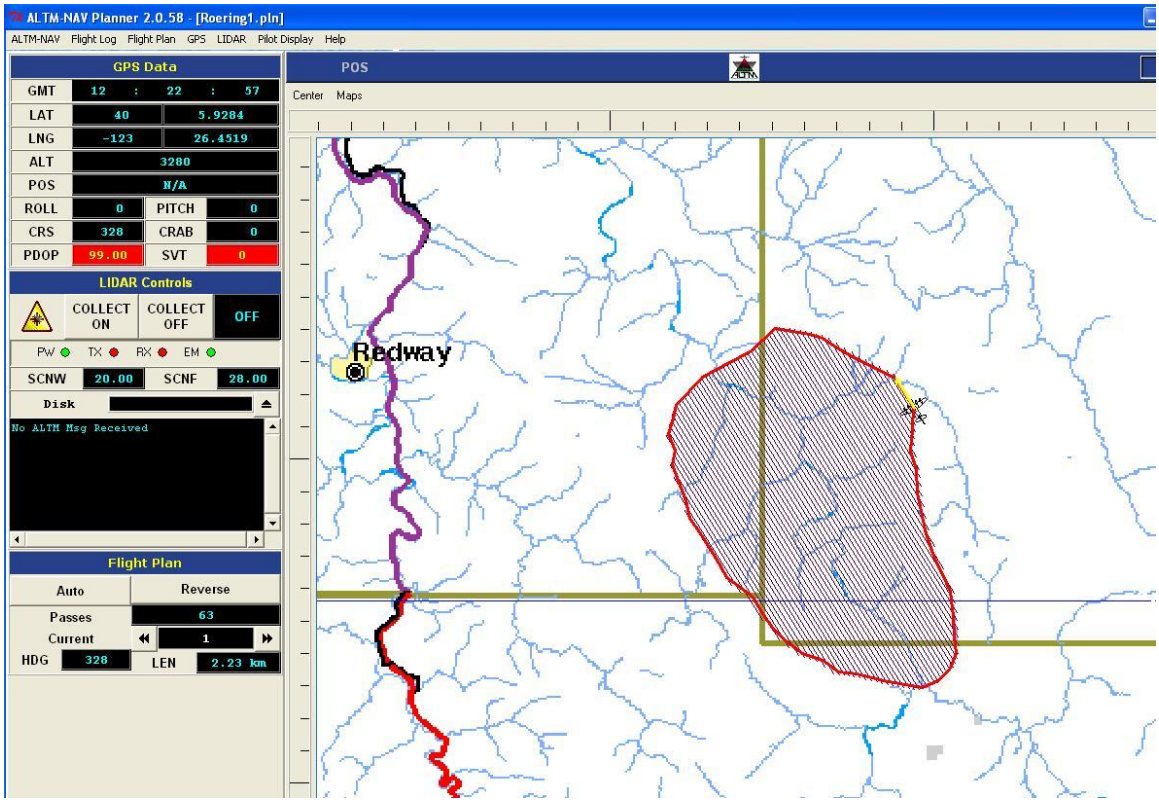


Figure 4 - Map showing planned flight lines on Eel River polygon.

Below are some point space numbers that approximate the survey parameters for different flying heights.

1. At flying height 600 meters Above Ground Level (AGL) the cross-track point spacing is 0.73 meters. At 125 knots (64.3 m/s) along track point spacing varies from 1.1 meters at nadir to 2.2 meters at the edge of the swath. The swath is 425 meters wide. Swath overlap is 195 meters. Laser spot size is 0.18 meters.
2. At flying height 800 meters AGL the cross-track point spacing is 0.98 meters. At 125 knots (64.3 m/s) along track point spacing varies from 1.1 meters at nadir to 2.2 meters at the edge of the swath. The swath is 567 meters wide. Swath overlap is 337 meters. Laser spot size is 0.24 meters
3. At flying height 1000 meters AGL the cross-track point spacing is 1.2 meters. At 125 knots (64.3 m/s) along track point spacing varies from 1.1 meters at nadir to 2.2 meters at the edge of the swath. The swath is 708 meters wide. Swath overlap is 478 meters. Laser spot size is 0.30 meters

Figure 5 (below) shows the planned flight lines and LiDAR settings for Cooksie Creek.

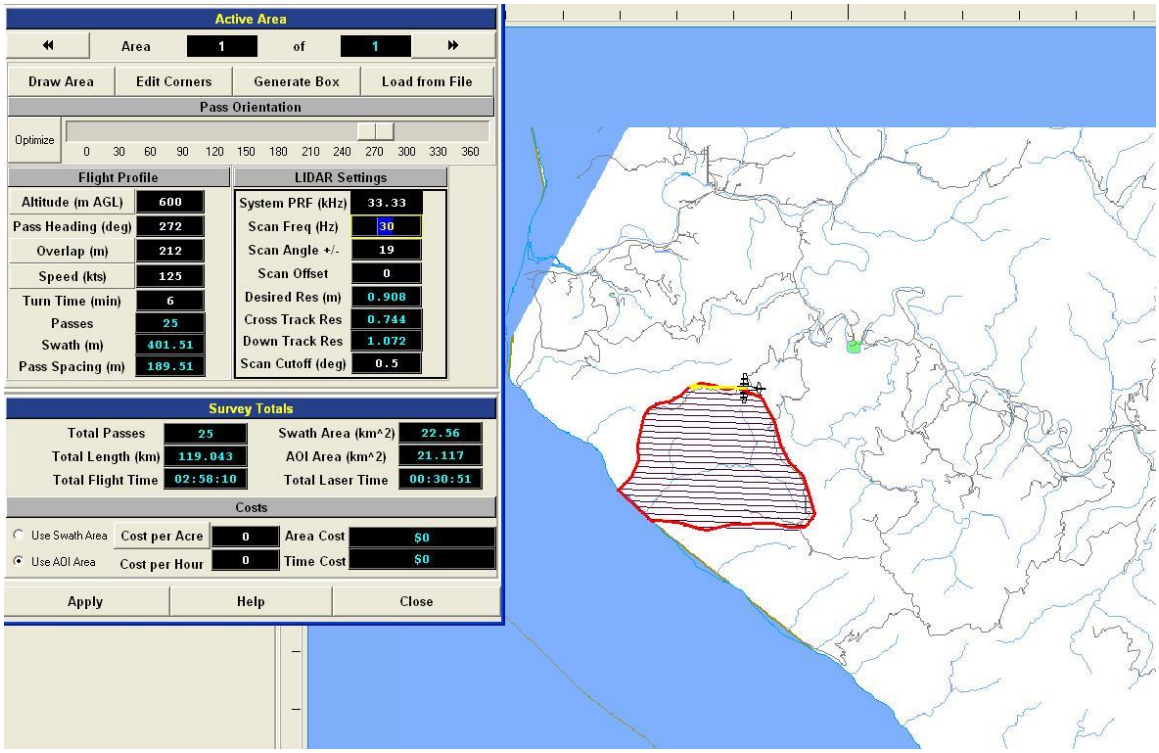


Figure 5 - Planned Survey on Cooksie Creek Polygon - Not yet completed.

GPS Reference Stations

Two locations were selected and occupied as GPS reference stations for the three flights; both stations collected data for every survey. These stations are pictured above in Figure 1 (page 1). A nine inch nail was set near the parking area at the Garberville Airport for each station. Both stations were occupied for four sessions averaging six hours each. Equipment included Ashtech dual-frequency Z-Extreme receivers with choke-ring antennas (ASH700936.D) on 1.500 meter fixed height tripods. Baseline lengths from these stations to the Eel River project area varied from 20 to 40 kilometers.

All observations were submitted to the NGS on-line processor OPUS with solution files included as Appendix A. Final control coordinate values (NAD83) were obtained from the OPUS solutions and referenced to the CORS network. For further information on OPUS see http://www.ngs.noaa.gov/OPUS/ and for more information on the CORS network see http://www.ngs.noaa.gov/CORS/ .

Navigation Processing

Airplane trajectories were processed using KARS (Kinematic and Rapid Static) software written by Dr. Gerry Mader of the NGS Research Laboratory. KARS software yields ionosphere-free differential GPS solutions that are based on carrier phase double-differences with fixed integer ambiguities. These are the preferred solutions and have been shown to be accurate over long baselines – 60 to 100 kilometers. Below (Figure 6) is a plot showing the positional differences in the aircraft trajectory as processed from the two different base stations at the Garberville Airport for the survey flight of September 26 (day 269).

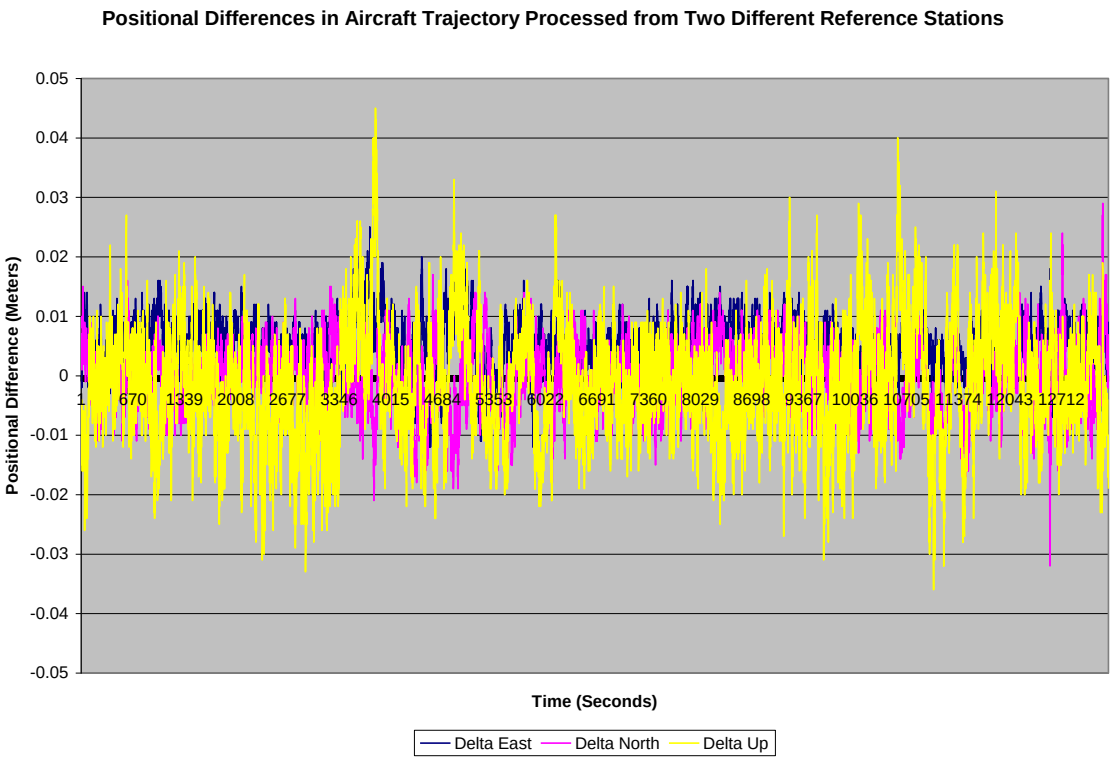


Figure 6 - Trajectory comparison – KARS processing.

Figure6 represents typical difference plots for all project flights.

After GPS processing was completed for all flights, the GPS and the raw IMU (Inertial Measurement Unit) data collected during each flight were input into APPLANIX software POSPROC. This software employs a sophisticated Kalman Filter algorithm to combine the 1-Hz final differential GPS solutions with the raw 50-Hz IMU data and their respective error models. The final result is a smoothed and blended solution of both aircraft position and orientation at 50 Hz, in SBET format (Smoothed Best Estimated Trajectory).

Calibration and Laser Point Processing

The SBET, raw laser range, and mirror-angle data were combined using Optech's REALM processing suite to generate the laser point dataset. System calibration was then performed as a 2-step process: step one (relative calibration) is to adjust the bore sight values of heading, roll, pitch, and scanner mirror scale such that systematic positional errors are minimized; and step two is an absolute calibration such that the laser DEM will match the height values of ground truth collected by vehicle-mounted GPS.

Step 1: Relative calibration was performed in TerraMatch software please see (**http://terrasolid.fi/ENG/Products.htm**) for detailed information.

A general description of the relative calibration procedure follows.

1. Cross-lines are flown for every flight with a heading perpendicular to the project flight line heading.
2. Small polygons containing these cross lines along with project flight lines are processed using approximate calibration values for heading, roll, pitch, and scanner mirror scale. Each line is processed separately.
3. Continuing to process each line separately, all lines are filtered to remove vegetation; then individual flight line surfaces are created.
4. TerraMatch uses an iterative algorithm to compute the best-fit between the individual flight line surfaces: simultaneously solving for the optimal changes to bore sight values of heading, roll, pitch, and scanner mirror scale.
5. These changes to the calibration values are updated in REALM; then output is checked for all flights using each flight's cross lines.
6. Complete and final output is run using the optimized calibration values for each flight.

This procedure yielded very tight results – once optimal values were computed from the first flight on September 24 all subsequent flights showed no significant change in any bore sight calibration value.

Step 2: Absolute calibration is done by comparing the height of the nearest neighbor laser point to the height of a set of check points that are collected by vehicle-mounted GPS.

Using a set of 225 check points spread over the Garberville Airport, a height bias was found to average +168 mm (Ground - Laser). This bias is viewed as statistically significant and was applied to the final output heights computed by REALM – all output was lowered by 0.168 meters. The standard deviation of the laser – check point differences was 0.054 meters, which is fairly typical.

All coordinates were processed with respect to NAD83 and referenced to the national CORS network. The 9-column output provides ellipsoid heights in UTM Zone 10, with units in meters.

The last return data was extracted from the 9-column format and ellipsoid heights were converted to orthometric heights in NAVD88 using NGS GEOID03 model with Corpscon v6.0 (Corps of Engineers Coordinate Conversion).

The complete output format is a 9-column ASCII file (space delimited), one file per flight strip. The nine columns are:

1. GPS time (seconds of week)
2. Easting last return
3. Northing last return
4. Height last return
5. Intensity last return
6. Easting first return
7. Northing first return
8. Height first return
9. Intensity first return

Note that in these 9-column files height values are ellipsoid heights which do NOT match orthometric heights (elevations) found in the 3-column files or 1-meter DEM grid nodes.

Filtering and DEM Production

Terrasolid's TerraScan (http://terrasolid.fi) software was used to classify the last return LIDAR points and generate the "bare-earth" dataset.

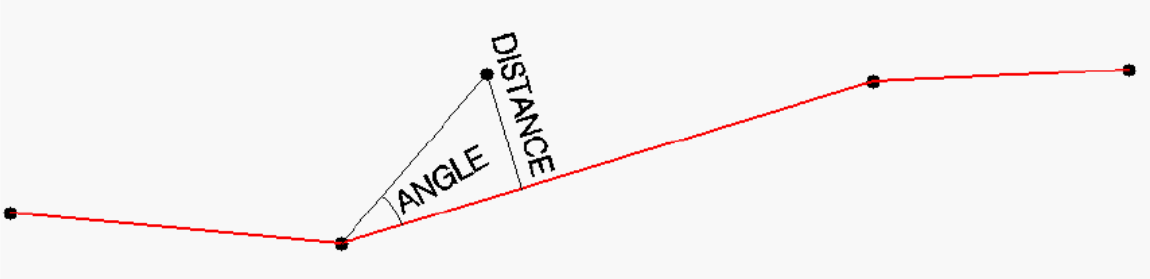
The classification routine consists of three algorithms:

1) Removal of "Low Points". This routine was used to search for possible error points which are clearly below the ground surface. The elevation of each point (=center) is compared with every other point within a given neighborhood and if the center point is clearly lower then any other point it will be classified as a "low point". This routine can also search for groups of low points where the whole group is lower than other points in the vicinity. The parameters used on this dataset were:

```
Search for: Groups of Points
Max Count (maximum size of a group of low points): 6
More than (minimum height difference): 0.5 m
Within (xy search range):  10.0 m
```

2) Ground Classification. This routine classifies ground points by iteratively building a triangulated surface model. The algorithm starts by selecting some local low points assumed as sure hits on the ground, within a specified windows size. This makes the algorithm particularly sensitive to low outliers in the initial dataset, hence the requirement of removing as many erroneous low points as possible in the first step.

   The routine builds an initial model from selected low points. Triangles in this initial model are mostly below the ground with only the vertices touching ground. The routine then starts molding the model upwards by iteratively adding new laser points to it. Each added point makes the model follow ground surface more closely. Iteration parameters determine how close a point must be to a triangle plane so that the point can be accepted to the model. **Iteration angle** is the maximum angle between point, its projection on triangle plane and closest triangle vertex. The smaller the Iteration angle, the less eager the routine is to follow changes in the point cloud. **Iteration distance** parameter makes sure that the iteration does not make big jumps upwards when triangles are large. This helps to keep low buildings out of the model. The routine can also help avoiding adding unnecessary point density into the ground model by reducing the eagerness to add new points to ground inside a triangle with all edges shorter than a specified length.



   Ground classification parameters used:

```
Max Building Size (window size): 40.0 m
Max Terrain Angle: 89.50
Iteration Angle: 6.10
Iteration Distance: 2.0 m
Reduce iteration angle when edge length < : 5.0 m
```

3) Below Surface removal. This routine classifies points which are lower than other neighboring points and it is run after ground classification to locate points which are below the true ground surface. For each point in the source class, the algorithm finds up to 25 closest neighboring source points and fits a plane equation through them. If the initially selected point is above the plane or less than "Z tolerance", it will not be

classified. Then it computes the standard deviation of the elevation differences from the neighboring points to the fitted plane and if the central point is more than "Limit" times standard deviation below the plane, the algorithm it will classify it into the target class.

```
Parameters used:
Source Class: Ground
Target Class: Low Point
Limit: 8.00 * standard deviation
Z tolerance: 0.10 m
```

While analyzing the filter's performances and behavior with this particular kind of terrain, we observed several instances where large boulders were mistakenly removed by the ground classification routine, mainly due to their morphological similarities with urban development, which the filter is design to remove. To some extent this side-effect is unavoidable with all block-minimum-based filters designed to remove buildings and vegetation. In our experience we couldn't find a good compromise in the filtering parameters that will leave these features in without significantly reducing the quality of the ground model.
Using TerraScan's manual classification tools we improved the ground model in several areas by adding key points to the ground class and re-running the filter routine over a surrounding area of 100m.

After classification the ground points were outputted in 2km x 2km overlapping tiles (60m overlap), ASCII format (XYZ), and gridded at 1m cell size using Golden Software's SURFER ver. 8.01. The tiles need to overlap in order to obtain consistent transitions from one tile to the adjacent ones.

Gridding parameters:

```
Gridding Algorithm: Kriging
Variogram: Linear
Nugget Variance: 0.07 m
MicroVariance: 0.00 m
SearchDataPerSector: 10
SearchMinData: 5
SearchMaxEmpty: 1
SearchRadius: 40m
```

The resulted Surfer grid tile set was exported to ESRI ArcInfo floting point binary format and using an in-house C++ application the overlap was trimmed from each tile. The trimmed tiles were exported to ESRI ArcInfo GRID format and merged into one seamless raster dataset.

A similar process was used to generate the unfiltered seamless grids. The unfiltered points were krigged using a 5m Search Radius because of the higher data density.

Appendix A – OPUS Solutions

NGS OPUS SOLUTION REPORT
==========

USER: michaels@ufl.edu
RINEX FILE: gb0_270p.06o

DATE: October 11, 2006
TIME: 15:30:47 UTC

SOFTWARE: page5 0601.10 master22.pl
EPHEMERIS: igr13943.eph [rapid]
NAV FILE: brdc2700.06n
ANT NAME: ASH700936D_M NONE
ARP HEIGHT: 1.500

START: 2006/09/27 15:22:00
STOP: 2006/09/27 22:57:00
OBS USED: 16372 / 16554 : 99%
FIXED AMB: 67 / 68 : 99%
OVERALL RMS: 0.013(m)

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2006.7392)	
X:	-2719224.118(m)	0.019(m)	-2719224.892(m)	0.019(m)
Y:	-4060096.263(m)	0.015(m)	-4060094.947(m)	0.015(m)
Z:	4085493.212(m)	0.012(m)	4085493.303(m)	0.012(m)
LAT:	40 5 14.38013	0.004(m)	40 5 14.39622	0.004(m)
E LON:	236 11 16.97643	0.014(m)	236 11 16.91837	0.014(m)
W LON:	123 48 43.02357	0.014(m)	123 48 43.08163	0.014(m)
EL HGT:	131.149(m)	0.021(m)	130.701(m)	0.021(m)
ORTHO HGT:	161.513(m)	0.033(m) [Geoid03 NAVD88]		

	UTM COORDINATES UTM (Zone 10)	STATE PLANE COORDINATES SPC (0401 CA 1)
Northing (Y) [meters]	4437765.674	585320.737
Easting (X) [meters]	430780.078	1845482.038
Convergence [degrees]	-0.52288017	-1.18480632
Point Scale	0.99965898	0.99997915
Combined Factor	0.99963842	0.99995858

US NATIONAL GRID DESIGNATOR: 10TDK3078037766(NAD 83)

		BASE STATIONS USED		
PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DH5841	P158 MONUMNTRDGCN2004 CORS ARP	N402520.946	W1240625.890	44908.4
DH5844	P164 PRATTMTN__CN2004 CORS ARP	N400709.305	W1234135.965	10767.2
DH5855	P314 CAHTOPEAK_CN2004 CORS ARP	N394108.372	W1233454.593	48766.7

NEAREST NGS PUBLISHED CONTROL POINT

LU2297	H 1463	N400515.	W1234838.	120.4

NGS OPUS SOLUTION REPORT
==========

```
      USER: michaels@ufl.edu                       DATE: October 11, 2006
RINEX FILE: gb0_269q.06o                           TIME: 15:33:28 UTC


  SOFTWARE: page5  0601.10 master30.pl            START: 2006/09/26  16:53:00
 EPHEMERIS: igr13942.eph [rapid]                   STOP: 2006/09/26  23:34:00
  NAV FILE: brdc2690.06n                      OBS USED: 14460 / 14621   :  99%
  ANT NAME: ASH700936D_M    NONE            # FIXED AMB:    54 /    54   : 100%
ARP HEIGHT: 1.500                           OVERALL RMS: 0.012(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.7366)

         X:     -2719224.119(m)   0.012(m)          -2719224.893(m)   0.012(m)
         Y:     -4060096.273(m)   0.013(m)          -4060094.957(m)   0.013(m)
         Z:      4085493.215(m)   0.009(m)           4085493.306(m)   0.009(m)

       LAT:   40  5 14.38002      0.000(m)        40  5 14.39611      0.000(m)
     E LON:  236 11 16.97663      0.014(m)       236 11 16.91857      0.014(m)
     W LON:  123 48 43.02337      0.014(m)       123 48 43.08143      0.014(m)
    EL HGT:          131.158(m)   0.014(m)              130.710(m)   0.014(m)
 ORTHO HGT:          161.522(m)   0.028(m) [Geoid03 NAVD88]

                       UTM COORDINATES    STATE PLANE COORDINATES
                        UTM (Zone 10)         SPC (0401 CA 1)
Northing (Y) [meters]     4437765.670          585320.733
Easting (X)  [meters]      430780.082         1845482.043
Convergence  [degrees]    -0.52288014         -1.18480628
Point Scale                0.99965898          0.99997915
Combined Factor            0.99963841          0.99995858

US NATIONAL GRID DESIGNATOR: 10TDK3078037766(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                       LATITUDE    LONGITUDE DISTANCE(m)
DH5841 P158 MONUMNTRDGCN2004 CORS ARP      N402520.946 W1240625.890   44908.4
DH5844 P164 PRATTMTN__CN2004 CORS ARP      N400709.305 W1234135.965   10767.2
DH5855 P314 CAHTOPEAK_CN2004 CORS ARP      N394108.372 W1233454.593   48766.7

                 NEAREST NGS PUBLISHED CONTROL POINT
LU2297      H 1463                         N400515.    W1234838.        120.4
```

NGS OPUS SOLUTION REPORT
==========

```
      USER: michaels@ufl.edu                       DATE: October 11, 2006
RINEX FILE: gb0_268r.06o                           TIME: 15:25:53 UTC


  SOFTWARE: page5  0601.10 master.pl               START: 2006/09/25  17:18:00
 EPHEMERIS: igr13941.eph [rapid]                    STOP: 2006/09/25  22:19:00
  NAV FILE: brdc2680.06n                      OBS USED: 10963 / 11101   :  99%
  ANT NAME: ASH700936D_M    NONE            # FIXED AMB:    43 /    43   : 100%
ARP HEIGHT: 1.500                           OVERALL RMS: 0.011(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.7338)

         X:     -2719224.122(m)   0.010(m)          -2719224.896(m)   0.010(m)
         Y:     -4060096.268(m)   0.004(m)          -4060094.952(m)   0.004(m)
         Z:      4085493.217(m)   0.006(m)           4085493.308(m)   0.006(m)

       LAT:   40  5 14.38012      0.003(m)        40  5 14.39621      0.003(m)
     E LON:  236 11 16.97641      0.009(m)       236 11 16.91835      0.009(m)
     W LON:  123 48 43.02359      0.009(m)       123 48 43.08165      0.009(m)
    EL HGT:          131.157(m)   0.010(m)               130.709(m)   0.010(m)
 ORTHO HGT:          161.521(m)   0.027(m) [Geoid03 NAVD88]

                       UTM COORDINATES    STATE PLANE COORDINATES
                        UTM (Zone 10)         SPC (0401 CA 1)
Northing (Y) [meters]     4437765.674          585320.737
Easting (X)  [meters]      430780.077         1845482.038
Convergence  [degrees]    -0.52288018          -1.18480632
Point Scale                0.99965898           0.99997915
Combined Factor            0.99963841           0.99995858

US NATIONAL GRID DESIGNATOR: 10TDK3078037766(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                       LATITUDE    LONGITUDE DISTANCE(m)
DH5841 P158 MONUMNTRDGCN2004 CORS ARP      N402520.946 W1240625.890   44908.4
DH5844 P164 PRATTMTN__CN2004 CORS ARP      N400709.305 W1234135.965   10767.2
DH5855 P314 CAHTOPEAK_CN2004 CORS ARP      N394108.372 W1233454.593   48766.7

                NEAREST NGS PUBLISHED CONTROL POINT
LU2297      H 1463                         N400515.    W1234838.        120.4
```

NGS OPUS SOLUTION REPORT
==========

```
      USER: michaels@ufl.edu                      DATE: October 11, 2006
RINEX FILE: gb0_267s.06o                          TIME: 15:33:05 UTC


  SOFTWARE: page5  0601.10 master30.pl            START: 2006/09/24  18:23:00
 EPHEMERIS: igr13940.eph [rapid]                   STOP: 2006/09/24  23:32:30
  NAV FILE: brdc2670.06n                      OBS USED: 11491 / 11715   :  98%
  ANT NAME: ASH700936D_M    NONE            # FIXED AMB:    45 /    46   :  98%
ARP HEIGHT: 1.500                           OVERALL RMS: 0.011(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.7312)

         X:     -2719224.118(m)   0.013(m)          -2719224.892(m)   0.013(m)
         Y:     -4060096.270(m)   0.006(m)          -4060094.954(m)   0.006(m)
         Z:      4085493.213(m)   0.007(m)           4085493.304(m)   0.007(m)

       LAT:   40  5 14.38003      0.006(m)        40  5 14.39613      0.006(m)
     E LON:  236 11 16.97660      0.013(m)       236 11 16.91854      0.013(m)
     W LON:  123 48 43.02340      0.013(m)       123 48 43.08146      0.013(m)
    EL HGT:          131.154(m)   0.008(m)              130.706(m)   0.008(m)
 ORTHO HGT:          161.518(m)   0.026(m) [Geoid03 NAVD88]

                       UTM COORDINATES    STATE PLANE COORDINATES
                        UTM (Zone 10)         SPC (0401 CA 1)
Northing (Y) [meters]     4437765.671          585320.734
Easting (X)  [meters]      430780.082         1845482.042
Convergence  [degrees]    -0.52288014         -1.18480629
Point Scale                0.99965898          0.99997915
Combined Factor            0.99963842          0.99995858

US NATIONAL GRID DESIGNATOR: 10TDK3078037766(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                       LATITUDE    LONGITUDE DISTANCE(m)
DH5841 P158 MONUMNTRDGCN2004 CORS ARP      N402520.946 W1240625.890   44908.4
DH5844 P164 PRATTMTN__CN2004 CORS ARP      N400709.305 W1234135.965   10767.2
DH5855 P314 CAHTOPEAK_CN2004 CORS ARP      N394108.372 W1233454.593   48766.7

                 NEAREST NGS PUBLISHED CONTROL POINT
LU2297      H 1463                         N400515.    W1234838.        120.4
```

NGS OPUS SOLUTION REPORT
========================

```
      USER: michaels@ufl.edu                       DATE: October 11, 2006
RINEX FILE: gr1_270p.06o                           TIME: 15:27:05 UTC


  SOFTWARE: page5  0601.10 master4.pl             START: 2006/09/27  15:18:00
 EPHEMERIS: igr13943.eph [rapid]                   STOP: 2006/09/27  23:02:00
  NAV FILE: brdc2700.06n                      OBS USED: 16992 / 17253   :  98%
  ANT NAME: ASH700936D_M    NONE            # FIXED AMB:    64 /    65   :  98%
ARP HEIGHT: 1.500                           OVERALL RMS: 0.013(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.7392)

         X:     -2719230.968(m)   0.018(m)          -2719231.742(m)   0.018(m)
         Y:     -4060096.626(m)   0.001(m)          -4060095.310(m)   0.001(m)
         Z:      4085488.497(m)   0.006(m)           4085488.589(m)   0.006(m)

       LAT:   40  5 14.17730      0.003(m)        40  5 14.19342      0.003(m)
     E LON:  236 11 16.74472      0.015(m)       236 11 16.68666      0.015(m)
     W LON:  123 48 43.25528      0.015(m)       123 48 43.31334      0.015(m)
    EL HGT:          131.260(m)   0.012(m)              130.812(m)   0.012(m)
 ORTHO HGT:          161.624(m)   0.028(m) [Geoid03 NAVD88]

                       UTM COORDINATES    STATE PLANE COORDINATES
                        UTM (Zone 10)         SPC (0401 CA 1)
Northing (Y) [meters]     4437759.470          585314.596
Easting (X)  [meters]      430774.533         1845476.421
Convergence  [degrees]    -0.52292101         -1.18484840
Point Scale                0.99965899          0.99997916
Combined Factor            0.99963841          0.99995857

US NATIONAL GRID DESIGNATOR: 10TDK3077537759(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                       LATITUDE    LONGITUDE DISTANCE(m)
DH5841 P158 MONUMNTRDGCN2004 CORS ARP      N402520.946 W1240625.890   44910.6
DH5844 P164 PRATTMTN__CN2004 CORS ARP      N400709.305 W1234135.965   10774.4
DH5855 P314 CAHTOPEAK_CN2004 CORS ARP      N394108.372 W1233454.593   48763.2

                 NEAREST NGS PUBLISHED CONTROL POINT
LU2297      H 1463                         N400515.    W1234838.        126.9
```

NGS OPUS SOLUTION REPORT
==========

```
      USER: michaels@ufl.edu                      DATE: October 11, 2006
RINEX FILE: gr1_269q.06o                          TIME: 15:31:21 UTC


  SOFTWARE: page5  0601.10 master25.pl            START: 2006/09/26  16:42:00
 EPHEMERIS: igr13942.eph [rapid]                   STOP: 2006/09/26  23:36:00
  NAV FILE: brdc2690.06n                      OBS USED: 14997 / 15133   :  99%
  ANT NAME: ASH700936D_M    NONE            # FIXED AMB:    57 /    57   : 100%
ARP HEIGHT: 1.500                           OVERALL RMS: 0.012(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.7366)

         X:     -2719230.969(m)   0.009(m)          -2719231.743(m)   0.009(m)
         Y:     -4060096.622(m)   0.014(m)          -4060095.306(m)   0.014(m)
         Z:      4085488.490(m)   0.007(m)           4085488.581(m)   0.007(m)

       LAT:   40  5 14.17718      0.003(m)        40  5 14.19328      0.003(m)
     E LON:  236 11 16.74459      0.014(m)       236 11 16.68653      0.014(m)
     W LON:  123 48 43.25541      0.014(m)       123 48 43.31347      0.014(m)
    EL HGT:          131.254(m)   0.009(m)               130.805(m)   0.009(m)
 ORTHO HGT:          161.618(m)   0.027(m) [Geoid03 NAVD88]

                       UTM COORDINATES    STATE PLANE COORDINATES
                        UTM (Zone 10)         SPC (0401 CA 1)
Northing (Y) [meters]     4437759.467          585314.592
Easting (X)  [meters]      430774.530         1845476.418
Convergence  [degrees]    -0.52292104          -1.18484843
Point Scale                0.99965899           0.99997916
Combined Factor            0.99963841           0.99995857

US NATIONAL GRID DESIGNATOR: 10TDK3077537759(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                       LATITUDE    LONGITUDE DISTANCE(m)
DH5841 P158 MONUMNTRDGCN2004 CORS ARP      N402520.946 W1240625.890   44910.6
DH5844 P164 PRATTMTN__CN2004 CORS ARP      N400709.305 W1234135.965   10774.4
DH5855 P314 CAHTOPEAK_CN2004 CORS ARP      N394108.372 W1233454.593   48763.2

                 NEAREST NGS PUBLISHED CONTROL POINT
LU2297      H 1463                         N400515.    W1234838.        126.9
```

NGS OPUS SOLUTION REPORT
==========

```
      USER: michaels@ufl.edu                      DATE: October 11, 2006
RINEX FILE: gr1_268r.06o                          TIME: 15:34:03 UTC


  SOFTWARE: page5  0601.10 master30.pl            START: 2006/09/25  17:20:00
 EPHEMERIS: igr13941.eph [rapid]                   STOP: 2006/09/25  22:21:00
  NAV FILE: brdc2680.06n                      OBS USED: 11001 / 11104   :  99%
  ANT NAME: ASH700936D_M    NONE            # FIXED AMB:    44 /    44   : 100%
ARP HEIGHT: 1.500                           OVERALL RMS: 0.011(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.7338)

         X:     -2719230.968(m)   0.010(m)          -2719231.742(m)   0.010(m)
         Y:     -4060096.622(m)   0.002(m)          -4060095.306(m)   0.002(m)
         Z:      4085488.493(m)   0.006(m)           4085488.584(m)   0.006(m)

       LAT:   40  5 14.17727      0.003(m)        40  5 14.19336      0.003(m)
     E LON:  236 11 16.74463      0.009(m)       236 11 16.68657      0.009(m)
     W LON:  123 48 43.25537      0.009(m)       123 48 43.31343      0.009(m)
    EL HGT:          131.255(m)   0.008(m)               130.807(m)   0.008(m)
 ORTHO HGT:          161.619(m)   0.026(m) [Geoid03 NAVD88]

                       UTM COORDINATES    STATE PLANE COORDINATES
                        UTM (Zone 10)         SPC (0401 CA 1)
Northing (Y) [meters]     4437759.469          585314.595
Easting (X)  [meters]      430774.531         1845476.419
Convergence  [degrees]    -0.52292103          -1.18484842
Point Scale                0.99965899           0.99997916
Combined Factor            0.99963841           0.99995857

US NATIONAL GRID DESIGNATOR: 10TDK3077537759(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                       LATITUDE    LONGITUDE DISTANCE(m)
DH5841 P158 MONUMNTRDGCN2004 CORS ARP      N402520.946 W1240625.890   44910.6
DH5844 P164 PRATTMTN__CN2004 CORS ARP      N400709.305 W1234135.965   10774.4
DH5855 P314 CAHTOPEAK_CN2004 CORS ARP      N394108.372 W1233454.593   48763.2

                 NEAREST NGS PUBLISHED CONTROL POINT
LU2297      H 1463                         N400515.    W1234838.        126.9
```

NGS OPUS SOLUTION REPORT
==========

```
      USER: michaels@ufl.edu                       DATE: October 11, 2006
RINEX FILE: gr1_267s.06o                           TIME: 15:18:58 UTC


  SOFTWARE: page5  0601.10 master11.pl            START: 2006/09/24  18:29:00
 EPHEMERIS: igr13940.eph [rapid]                   STOP: 2006/09/24  23:35:00
  NAV FILE: brdc2670.06n                      OBS USED: 11407 / 11529   :  99%
  ANT NAME: ASH700936D_M    NONE            # FIXED AMB:    59 /    63   :  94%
ARP HEIGHT: 1.500                           OVERALL RMS: 0.014(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.7312)

         X:     -2719230.962(m)   0.016(m)          -2719231.736(m)   0.016(m)
         Y:     -4060096.621(m)   0.013(m)          -4060095.305(m)   0.013(m)
         Z:      4085488.483(m)   0.007(m)           4085488.574(m)   0.007(m)

       LAT:   40  5 14.17711      0.006(m)        40  5 14.19320      0.006(m)
     E LON:  236 11 16.74481      0.013(m)       236 11 16.68676      0.013(m)
     W LON:  123 48 43.25519      0.013(m)       123 48 43.31324      0.013(m)
    EL HGT:          131.245(m)   0.016(m)              130.797(m)   0.016(m)
 ORTHO HGT:          161.609(m)   0.030(m) [Geoid03 NAVD88]

                       UTM COORDINATES    STATE PLANE COORDINATES
                        UTM (Zone 10)         SPC (0401 CA 1)
Northing (Y) [meters]     4437759.464          585314.590
Easting (X)  [meters]      430774.536         1845476.423
Convergence  [degrees]    -0.52292100         -1.18484839
Point Scale                0.99965899          0.99997916
Combined Factor            0.99963841          0.99995858

US NATIONAL GRID DESIGNATOR: 10TDK3077537759(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                       LATITUDE    LONGITUDE DISTANCE(m)
DH5841 P158 MONUMNTRDGCN2004 CORS ARP      N402520.946 W1240625.890   44910.6
DH5844 P164 PRATTMTN__CN2004 CORS ARP      N400709.305 W1234135.965   10774.4
DH5855 P314 CAHTOPEAK_CN2004 CORS ARP      N394108.372 W1233454.593   48763.2

                  NEAREST NGS PUBLISHED CONTROL POINT
LU2297     H 1463                 N400515.  W1234838.       126.9
```