Geodesy

G11A MCC: Level 1 Monday 0830h

Airborne Laser Swath Mapping (ALSM): Technology, Applications, and Results I Posters *(joint with H, GC)*

Presiding: **B E Schutz,** Center for Space Research, University of Texas at Austin**; B Dietrich,** University of California, Berkeley

G11A-0236 0830h POSTER

Simulation of Lidar System Performance in Terrestrial Mapping Applications

Robert T Pack[1] (435-797-7049; rtpack@cc.usu.edu)

R Rees Fullmer[1] (435-797-3894; rrfullmer@mae.usu.edu)

[1]Utah State University, Center for Advanced Imaging Ladar 4110 Old Main Hill, Logan, UT 84322-4110, United States

Anyone who has used terrestrial lidar data in physical science applications has likely observed both systematic and random errors in datasets. An understanding of the potential sources of error is important when applying post-mission filters that remove errors, artifacts and unwanted features - such as vegetation - from lidar "point-cloud" data sets. System error sources typically include, (1) range error associated with transceiver optoelectronics design and atmospheric transmission characteristics, (2) pointing error associated with scanner dynamics, platform instability and GPS/INS readouts. To better understand and anticipate lidar data phenomenology and quality when designing lidar systems and surveys, simulation software has been developed at Utah State University Center for Advanced Imaging Ladar. The simulation focuses on energy-detection lidars common in commercial airborne mapping applications. It accepts as inputs: laser power, pulse width, wavelength, beam divergence and pulse repetition frequency; optics including aperture, field-of-view, and transmission loss; detector characteristics including focal plane array geometry, quantum efficiency, noise-equivalent power, optical efficiency, optical pass band, noise bandwidth, and readout error; scanner dynamics including bandwidth and damping ratio; GPS/INS errors associated with various instrument grades; environmental parameters including aerosol type, visibility, and solar spectral irradiance; scene parameters including backscatter distribution and reflectivity; and trajectories including position, velocity, and attitude. The simulation is designed to be adaptable to a wide variety of lidar system types, environmental settings, and aircraft trajectories over specific terrain models. It was built in MATLAB/Simulink, a convenient environment for computation and data generation, and has many graphical interfaces. Principally funded by the U.S. Naval Air Warfare Center at China Lake, California, it has been proven capable of modeling lidar systems and missions within the U.S. Department of Defense. Examples will be given of simulated range images and point clouds with associated systematic and random errors. The ability of the simulation to predict the density and distribution of laser shots across a terrain model will also be shown. The modeling of lidar swath geometry is of particular use to mission planners and prospective clients who would like to predict the quality and distribution of lidar shots in irregular terrain.

G11A-0237 0830h POSTER

Extracting High Resolution Information From Laser Altimetry Data by Analysing the Instrumental Error Budget

Ian J Davenport[1] (+44-118-3788741; ijd@mail.nerc-essc.ac.uk)

Nick Holden[2] (nick.holden@environment-agency.gov.uk)

Robert J Gurney[1] (+44-118-3788741; rjg@mail.nerc-essc.ac.uk)

[1]NERC Environmental Systems Science Centre, University of Reading Harry Pitt Bldg, Reading, Ber RG6 6AL, United Kingdom

[2]UK Environment Agency National Centre for Environmental Data and Surveillance, Lower Bristol Road, Bath BA2 9ES, United Kingdom

The errors in airborne laser altimetry data are poorly understood, and inadequately quantified. While numbers such as 20cm elevation, 40cm planimetric error are generally cited, and this may well be adequate for large scale measurements, the error budget contributions for the different elements making up the laser altimetry system mean that the relative error between locally measured points is considerably lower. As an indication of the increase in information that can be extracted from such data with knowledge of the error budget, we recently demonstrated a processing algorithm which, with a standard altimetry acquisition of a farm field, was able to distinguish between a soil surface ploughed to 5cm in elevation roughness and a rolled soil surface, with a 92.5% success rate. Local relative measurements are better correlated because they are not subject to the instrumental disturbance that occurs between swathes, and the drifts due to the differential GPS and inertial navigation systems used to locate the aerial platform. To use such measurements effectively requires an understanding of the error sources affecting laser altimetry measurements. We present here a study of the error budget of an airborne laser altimetry system and describe the improvements in interpreting measurements that can be made by understanding the error budget. These enable us to extend the utility of airborne laser altimetry systems to the measurement of land surface properties, such as soil surface roughness and vertical vegetation density profiles, with a higher vertical resolution and better spatial coverage than is otherwise possible.

G11A-0238 0830h POSTER

Correcting for GPS Multipath Error in LIDAR Surveys Using Crossover Analysis

Adrian A Borsa[1] (858-534-8202; aborsa@ucsd.edu)

Bruce G Bills[2] (bbills@ucsd.edu)

Helen A Fricker[1] (hafricker@ucsd.edu)

Jean Bernard Minster[1] (jbminster@ucsd.edu)

[1]Institute of Geophysics and Planetary Physics, University of California, San Diego, La Jolla, CA 92093-0115, United States

[2]NASA, Goddard Space Flight Center, Geodynamics Branch, Greenbelt, MD 20771, United States

The quality of the range measurement from an airborne Light Detection and Ranging (LIDAR) survey is largely dependent on the accuracy of the GPS trajectory for the aircraft. GPS elevation error - which today is largely due to multipath effects at the aircraft and the GPS base station - contributes a major portion of the LIDAR vertical error budget. The usual practice of quoting an RMS value for the GPS component of the error budget implies that GPS noise is Gaussian, yet the true nature of the noise signal is time-varying with significant power at long periods. GPS noise with a 3-cm RMS can easily have more than 10 cm of total variability on a time scale of tens of minutes to several hours. We show examples from an airborne LIDAR survey over the open-pit Hector Mine where repeated flyovers of an area used for ground truth revealed large elevation biases between passes that could not be resolved by adjusting the (non-GPS) parameters of the LIDAR system. As part of the post-processing of a large kinematic GPS survey of the salar de Uyuni, Bolivia, we have developed an algorithm to correct time-varying GPS error using elevation mismatches at crossovers between vehicle paths. The survey was originally designed to incorporate a large number of crossovers for the purpose of determining survey repeatability, and we were later able to exploit the crossover difference observations to solve for a model of the actual error signal generating those differences. We give results from tests with synthetic noise and topography data indicating that this method removes more than two-thirds of the added noise from the topographic signal, and we show the excellent results obtained for the salar de Uyuni survey data. We believe that airborne LIDAR surveys incorporating crossovers at regular intervals can also benefit from the application of this algorithm.

G11A-0239 0830h POSTER

Operational Accuracy of LIDAR in Mountainous Terrain

Jim McKean[1] (jmckean@fs.fed.us)

Josh Roering[2] (jroering@oregon.uoregon.edu)

[1]USDA Forest Service Rocky Mountain Research Station, 316 E. Myrtle St., Boise, ID 83702, United States

[2]University of Oregon Department of Geological Sciences, 1272 Univ. of Oregon, Eugene, OR 97403-1272, United States

Conventional airborne LIDAR accuracy assessments are done by surveys of very flat surfaces: commonly tarmac areas or the roofs of hangar buildings at airports. These tests characterize the errors of the LIDAR hardware/software system including the laser ranging unit, opto-mechanical scanner, data recording devices, and aircraft GPS/INS. However, surveys over horizontal surfaces are not sensitive to data positional errors. Also, tests of the LIDAR detection of the positions of edges of horizontal surfaces are often unrealistic if the test flight pattern is designed to enhance discrimination of those edges. Furthermore, little information is available about the operational accuracy of LIDAR surveys in mountainous terrain where all the system errors combine with uncertainty related to general topography and local surface roughness to produce the total three-dimensional survey error. We have evaluated the operational LIDAR accuracy at a large landslide complex that has an extreme variety of topographic roughness. LIDAR data were compared with total station and RTK GPS ground points and profiles. Over gently sloping, smooth terrain adjacent to the landslide, single point elevation absolute errors were generally <15 cm, similar in magnitude to the system errors normally reported by LIDAR contractors. There were local vertical discrepancies of up to 45 cm, presumably due to temporary GPS errors. Within portions of the landslide that are rough over a spatial scale of meters to tens of meters, the point elevation median absolute accuracy remained better than 15 cm, but the range of errors increased to plus-or-minus several meters. Relative elevation accuracy was evaluated by comparing gridded surfaces of small identical areas measured twice by the LIDAR in the overlap zones between adjacent flight lines. Relative differences in sample area average elevation were less than 60 cm over smooth unfailed terrain, increased to 1 m over an active fine-grained earthflow, and 3 m in a portion of the landslide complex that included large angular limestone blocks in the slide matrix. The relative differences in standard deviation of elevations within the sample areas also increased from about 30 cm in the smooth area outside the slide to up to 2.2 m in the blocky portion of the slide complex. We were not able to distinguish LIDAR data elevation errors from positional errors. Work is continuing to quantify the absolute and relative accuracy of local slope and topographic curvature predicted by the LIDAR data.

G11A-0240 0830h POSTER

Using Artifacts to Detect Systematic Errors in ALSM Observations

Brian J. Luzum[1] (352-392-9776; luzum@ufl.edu)

William E. Carter[1] (352-392-5003; bcarter@ce.ufl.edu)

Michael Sartori[1] (352-392-1571; michaels@ufl.edu)

Ramesh L. Shrestha[1] (352-392-4999; rshre@ce.ufl.edu)

[1]University of Florida, 365 Weil Hall Department of Civil and Coastal Engineering, Gainesville, FL 32611, United States

Even well calibrated Airborne Laser Swath Mapping (ALSM) data contains systematic errors. Evidence of these errors can be seen in distinctive artifacts found in the digital models created from the ALSM data. For instance, errors in the automatic gain control or the range walk lookup table could cause intensity-related artifacts that become especially obvious on smooth surfaces as spurious elevations. Also, errors in the trajectory of the sensor, reading the scanner mirror angle, the scale, and the range walk lookup table can cause the elevations in adjacent ALSM strips to not match in the overlap areas. Careful calibration and reduction needs to be performed to reduce these effects to an acceptable level. The remaining errors can be further reduced by new post-processing algorithms. As an example, since some errors increase as the scan angle increases, the inter-strip inconsistencies (sometimes called seams) can be decreased by using schemes which decrease the weight of data as it gets further from nadir. With the effects of the errors minimized, the resulting ALSM elevation and intensity data show a wealth of features. ALSM data users need to be aware of the possible sources of contamination and need to ensure that their data will suit their needs. The flight specifications need to be made not just considering the obvious data spacing and accuracy, but also accounting for secondary concerns such as the desire to have the laser shots penetrate the vegetation canopy and to get returns from dark surfaces. Although increasing the overlap and low flying heights can be seen by some as counterproductive to the efficiency of data collection, the resulting quality of the product often outweighs the cost' of additional data collection and processing time.

G11A-0241 0830h POSTER

Using Airborne LIDAR Data to Determine Old vs. Young Cottonwood Trees in the Riparian Corridor of the San Pedro River

Ali Farid[1] ((520)626-1205; farid@hwr.arizona.edu)

david goodrich[2] (520-670-6381 (ext. 144); dgoodrich@tucson.ars.ag.gov)

michael Sartori[3] ((352) 392-9776; michaels@ufl.edu)

Soroosh Sorooshian[4] (soroosh@hwr.arizona.edu)

[1]Department of hydrology and water resources, university of arizona, 1133 E. North Campus Drive, tucson, az 85721, United States

[2]USDA-ARS-SWRC, SW Watershed Research Center, 2000 E. Allen Road, tucson, az 85719, United States

[3]department of civil and coastal engineering, university of florida, 345 Weil Hall, P.O. Box 116580, Gainesville, fl 32611, United States

[4]department of civil and environmental engineering, university of California - Irvine, 305 Rockwell Engineering Center, Irvine, ca 92697, United States

Quantification of vegetation patterns and properties is needed to determine their role in the landscape and to develop management plans to conserve natural resources. Vegetation patterns can be mapped from the ground, or by using aerial photography or satellite imagery. However, quantifying the physical properties of vegetation patterns with ground-based or remote sensing technology is difficult, time consuming, and often costly. Digital data from an airborne lidar (light detecting and ranging) instrument offers an alternative method for quantifying vegetation properties and patterns. Using lidar, a study was conducted in the San Pedro National Riparian Conservation Area in an attempt to differentiate young and old Cottonwood trees in southeastern Arizona as young and old cottonwoods have significantly different water use per unit area of canopy. The lidar data was acquired in June 2003, using Optech's ALTM (Airborne Laser Terrain Mapper), during flyovers conducted at an altitude of 750 m. It has been demonstrated that the height of old and young cottonwood canopies can be measured by using lidar. Canopy heights measured with the lidar show a good degree of correlation with ground-based measurements. Methodologically, the first step required is to differentiate old from young cottonwood canopies by the differences in canopy height obtained from lidar data. In addition to vegetation heights, spatial patterns of crown area, canopy cover, and intensity of return laser pulse are measured for both old and young cottonwood trees with the lidar data. The second stage of this study demonstrates that these other parameters of old and young cottonwood trees, when extrapolated from lidar, are significantly different. This study indicates the potential of airborne lidar data to distinguish between different ages of cottonwood forest canopy for large areas quickly and quantitatively.

G11A-0242 0830h POSTER

Application of Local Surface Matching to Multi-Date ALSM Data for Improved Calculation of Flood-Driven Sediment Deposition and Erosion

Kelly J Crowell[1] (505-667-5996; crowell@lanl.gov)

Cathy J Wilson[1] (505-667-0202; cjw@lanl.gov)

H Evan Canfield[2] (520-670-6380; ecanfield@tucson.ars.ag.gov)

[1]Earth and Environmental Sciences, Los Alamos National Laboratory, PO Box 1663 MS J495, Los Alamos, NM 87545, United States

[2]USDA-ARS Southwest Watershed Research Station, 2000 E Allen Rd, Tucson, AZ 85719, United States

The headwaters of Pueblo Canyon, Los Alamos County, New Mexico, were severely burned during the May, 2000 *Cerro Grande* Fire, after which occurred a series of floods of significantly increased magnitude compared to pre-fire records. Data from two ALSM missions offered the opportunity to quantify the flood-driven sediment deposition and erosion through the canyon, as well as to aid efforts to model sediment and contaminant transport in the post-fire hydrology. The datasets exhibited an array of processing artifacts and errors but were deemed to be of higher quality than existing photogrammetry-derived elevation data. However, the difference raster exhibited unrealistic patterns of erosion and deposition on hillslopes which were found to be caused by variable horizontal position errors. These combined with background vertical offsets greatly distorted the patterns of sediment deposition and erosion along the stream channel, with a large bias toward deposition throughout. Surface matching over local windows was used to correct the data for sediment volume change calculation. Cross correlation maximization followed by a vertical correction was sufficient to remove the majority of the relative error so that calculated sediment deposition and erosion were consistent with field observations. While the vertical offsets accounted for much of the depositional bias, the horizontal error component of the calculated sediment change volume was not trivial. The effects of this image-based surface matching technique and of an application of iterative point matching as a refinement are presented.

G11A-0243 0830h POSTER

Detection and Characterization of Rangeland Vegetation Using Airborne Laser Swath Mapping

David R. Streutker[1] (208-685-6770; stredavi@isu.edu)

Nancy F. Glenn[1] (glennanc@isu.edu)

[1]Idaho State University - Boise Center, 12301 W. Explorer Dr. Suite 102, Boise, ID 83713, United States

Airborne Laser Swath Mapping (ALSM, also referred to as LiDAR) is used to determine the presence and height of various vegetation types in rangeland areas of southeastern Idaho. Vegetation heights are difficult to determine using established multispectral and hyperspectral methods and are of interest in differentiating between spectrally similar subspecies (i.e. big sagebrush and low sagebrush) and in determining vegetation maturity (and thus history, such as evidence of past burns or other catastrophic events). While ALSM has been shown to be of great use in studying the high-relief canopies of forests, the low canopy heights of grasses and brush encountered in rangeland areas make such vegetation difficult to discern from the bald ground surface. An added obstacle is that the elevation uncertainties of ALSM are often comparable to the rangeland vegetation heights. Techniques used in this investigation to determine vegetation heights include localized point cloud analysis and detrending. Vegetation types are then classified using surface roughness and fractal analysis.

G11A-0244 0830h POSTER

Airborne Laser Swath Mapping of the Erebus Volcanic Province, Antarctica: New Means to Map Structure of Volcanic Cinder Cones and Volcanic Alignments

Timothy Paulsen[2] (paulsen@uwosh.edu)

Terry J Wilson[1] (wilson.43@osu.edu)

Beata Csatho[1] (csatho.1@osu.edu)

Tony Schenk[1] (schenk.1@osu.edu)

William Krabill[3] (william.b.krabill@nasa.gov)

[1]Byrd Polar Research Center Ohio State University, 108 Scott Hall 1090 Carmack Road, Columbus, OH 43210, United States

[2]University of Wisconsin-Oshkosh, Dept of Geology, Oshkosh, WI 54901, United States

[3]NASA Laboratory for Hydrospheric Processes, Wallops Flight Facility, Wallops Island, VA 23337

The intraplate stress field within Antarctica is largely unknown because of a lack of commercial drilling and the scarcity of recorded earthquakes with reliable focal mechanism solutions. Volcanic cone alignments are geologic indicators of the crustal stress regime, because eruptions occur above stress-controlled magmatic hydrofractures. Neogene-Quaternary volcanism occurs over large sectors of the Antarctic interior, providing an opportunity to obtain regional stress information. We are investigating the volcanic structure of the McMurdo Volcanic Group, a suite of alkaline volcanic rocks that extends from the Transantarctic Mountains to offshore localities within the West Antarctic rift system. In December, 2001, high-resolution surface elevation data were obtained by NASA's Airborne Topographic Mapper (ATM) laser altimetry system over portions of Mt Morning and Mt Discovery volcanoes in the Erebus Volcanic Province. The ATM surveys were conducted as part of a joint project of NASA and NSF to evaluate the potential of laser altimetry for topographic mapping in Antarctica. Data from the ATM system was interpolated into a regular grid with 2-4 meter resolution. The elongation of elliptical cone rims can be directly related to the trend of the subsurface fissure that controlled cone emplacement. Volcanic cone alignments are defined based on elliptical cone trends together with circular cones that are proximal and along the same trend. We initially mapped the distribution and shape of the volcanic cones using a combination of SPOT 3 panchromatic satellite imagery (10 m ground resolution), RADARSAT and JERS radar imagery and LANDSAT imagery (30 m ground resolution), aerial photography, and field work. For smaller cones, it was difficult to map the shapes of the cone rims due to the resolution limit of available imagery. The new DEM data from the laser mapping provides detailed information on the shapes of volcanic cones, including ellipticity, the symmetry of maximum/minimum elevation points, and the position of breaches on cone rims. These morphometric data yield information on the geometry of underlying magmatic fissures and/or of faults that controlled ascent and emplacement of volcanic materials. The detailed elevation information from the laser data makes it possible to quantify morphologic parameters of volcanic cones around Mt Discovery and Mt Morning and thus to obtain information on the structural kinematics and dynamics of the region in the late Cenozoic.

G11A-0245 0830h POSTER

Integrating an RGB - CIR Digital Camera With an Airborne Laser Swath Mapping System

Mark Lee[1] (352-392-1571; markage@ufl.edu)

William Carter[1] (352-392-5003; bcarter@ce.ufl.edu)

Ramesh Shrestha[1] (352-392-4999; rshre@ce.ufl.edu)

[1]University of Florida, Department of Civil and Coastal Engineering 365 Weil Hall, Gainesville, FL 32611, United States

The National Science Foundation supported Center for Airborne Laser Mapping (NCALM) utilizes the airborne laser swath mapping (ALSM) system jointly owned by the University of Florida (UF) and Florida International University (FIU). The UF/FIU ALSM system is comprised of an Optech Inc. Model 1233 ALTM unit, with supporting GPS receiver and real-time navigation display, mounted in a twin-inline-engine Cessna 337 aircraft. Shortly after taking delivery of the ALSM system, UF researchers, in collaboration with a commercial partner, added a small format digital camera (Kodak 420) to the system, rigidly mounting it to the ALSM sensor head. Software was developed to use the GPS position and orientation parameters from the IMU unit in the ALSM sensor to rectify and mosaic the digital images. The ALSM height and intensity values were combined pixel by pixel with the RGB digital images, to classify surface materials. Based on our experience with the initial camera, and recommendations received at the NCALM workshop, UF researchers decided to upgrade the system to a Redlake MASD Inc. model MS4100 RGB/CIR camera. The MS4100 contains three CCD arrays, which simultaneously capture full spatial resolution images in red and near IR band bands, and a factor of two lower spatial resolution images in the blue and green bands (the blue and green bands share a single CCD array and the color bands are separated with a Bayer filter). The CCD arrays are rectangular with 1920 x 1080 elements, each element being 7.4 x 7.4 micrometers. With a 28 mm focal length lens, and at a flying height of 550 meters, the effective groundel is approximately 15 x 15 cm. The new digital camera should be particularly useful for studies of vegetation, including agricultural and forestry applications, and for computer automated classification of surface materials. Examples of early results using the improved ALSM-digital imaging capabilities will be presented.

G11A-0246 0830h POSTER

Multiscale Data Fusion Regulated by a Mixture-of-Experts Network

K. Clint Slatton (352.392.0634; slatton@ece.ufl.edu)

University of Florida, Engineering Building, Rm 459 PO Box 116130, Gainesville, FL 32611, United States

Laser altimetry (LIDAR) and interferometric synthetic aperture radar (InSAR) have emerged as important tools for remotely sensing topography at fine and medium scales, respectively. Strip-map InSAR provides large coverage areas, but at spatial resolutions that are often insufficient for many applications. Conversely, LIDAR provides higher resolution, but covering large areas can be impractical. Slatton, et al. (2001) demonstrated that digital elevation models (DEMs) derived from LIDAR and InSAR data could be fused to provide large coverage areas, while maintaining high resolution locally. A multiscale Kalman smoother (MKS) employing a fractional Brownian motion stochastic model allowed the estimation of fused elevations with uncertainty measures at every pixel. However, the standard MKS algorithm with a single stochastic model does not incorporate spatial variations in the elevation statistics. For example, rough undulating terrain yields an elevation surface with a shorter correlation length than flat smooth terrain. In this work, multiscale Kalman filters are defined in a multiple-model configuration that accommodates local variations in elevation statistics. Stochastic model realizations for long and short correlation length surfaces are blended together with a simple Mixture-of-Experts (ME) network. Implementing classical multiple-model approaches, such as a Magill filter bank, on multiscale data structures would require that a particular model be selected for every node

in the quadtree. The selection of the best model at a parent node becomes potentially problematic if different models were selected as best at the children nodes. The need to explicitly map different stochastic models to the quadtree nodes of a multiscale estimator is obviated in the ME approach because the relative weighting of the individual Kalman estimates is automatically determined based on the innovation sequences to provide an adaptive estimate of the elevations.

G11A-0247 0830h POSTER

Acquiring Research-grade ALSM Data in the Commercial Marketplace

Ralph A Haugerud[1] (rhaugerud@usgs.gov); David J Harding[2] (David.J.Harding@nasa.gov); Damir Latypov[3] (damir.latypov@terrapoint.com); Diana Martinez[4] (dmartinez@psrc.org); Stephanie Routh[3] (stephanie.routh@terrapoint.com); John Ziegler[3] (john.ziegler@terrapoint.com)

[1]USGS at University of Washington, Earth and Space Sciences, Box 351310, Seattle, WA 98195, United States

[2]NASA Goddard Space Flight Center, Geodynamics Branch, Mail Code 921, Greenbelt, MD 20771, United States

[3]TerraPoint, LLC, 25216 Grogans Park Drive, Woodlands, TX 77380, United States

[4]Puget Sound Regional Council, 1011 Western Ave, Suite 500, Seattle, WA 98104, United States

The Puget Sound Lidar Consortium, working with TerraPoint, LLC, has procured a large volume of ALSM (topographic lidar) data for scientific research. Research-grade ALSM data can be characterized by their completeness, density, and accuracy. Complete data includeat a minimumX, Y, Z, time, and classification (ground, vegetation, structure, blunder) for each laser reflection. Off-nadir angle and return number for multiple returns are also useful. We began with a pulse density of 1/sq m, and after limited experiments still find this density satisfactory in the dense second-growth forests of western Washington. Lower pulse densities would have produced unacceptably limited sampling in forested areas and aliased some topographic features. Higher pulse densities do not produce markedly better topographic models, in part because of limitations of reproducibility between the overlapping survey swaths used to achieve higher density. Our experience in a variety of forest types demonstrates that the fraction of pulses that produce ground returns varies with vegetation cover, laser beam divergence, laser power, and detector sensitivity, but have not quantified this relationship. The most significant operational limits on vertical accuracy of ALSM appear to be instrument calibration and the accuracy with which returns are classified as ground or vegetation. TerraPoint has recently implemented in-situ calibration using overlapping swaths (Latypov and Zosse, 2002, see http://www.terrapoint.com/News_damirACSM_ASPRS 2002.html). On the consumer side, we routinely perform a similar overlap analysis to produce maps of relative Z error between swaths; we find that in bare, low-slope regions the in-situ calibration has reduced this internal Z error to 6-10 cm RMSE. Comparison with independent ground control points commonly illuminates inconsistencies in how GPS heights have been reduced to orthometric heights. Once these inconsistencies are resolved, it appears that the internal errors are the bulk of the error of the survey. The error maps suggest that with in-situ calibration, minor time-varying errors with a period of circa 1 sec are the largest remaining source of survey error. For forested terrain, limited ground penetration and errors in return classification can severely limit the accuracy of resulting topographic models. Initial work by Haugerud and Harding demonstrated the feasibility of fully-automatic return classification; however, TerraPoint has found that better results can be obtained more effectively with 3rd-party classification software that allows a mix of automated routines and human intervention. Our relationship has been evolving since early 2000. Important aspects of this relationship include close communication between data producer and consumer, a willingness to learn from each other, significant technical expertise and resources on the consumer side, and continued refinement of achievable, quantitative performance and accuracy specifications. Most recently we have instituted a slope-dependent Z accuracy specification that TerraPoint first developed as a heuristic for surveying mountainous terrain in Switzerland. We are now working on quantifying the internal consistency of topographic models in forested areas, using a variant of overlap analysis, and standards for the spatial distribution of internal errors.

G11A-0248 0830h POSTER

Field Test Results of the CHARTS Airborne Coastal Mapping and Charting System

W Jeff Lillycrop[1] (jeff.lillycrop@usace.army.mil)

Robert W Pope[2] (poper@navo.navy.mil)

[1]US Army Corps of Engineers, 109 St. Joseph Street, Mobile, AL 36602, United States

[2]US Naval Oceanographic Office, 1005 Balch Blvd, Stennis Space Center, MS 39522, United States

The Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system is the next generation airborne lidar system for coastal mapping and charting. CHARTS, owned by the US Naval Oceanographic Office, incorporates the knowledge and experience gained through over 7,000 hours of operating the US Army Corps of Engineer's SHOALS system. CHARTS is actually the fusion of three sensors; a 1,000 Hz hydrographic lidar, a 10,000 Hz topographic lidar, and a high resolutions digital camera. During August 2003 CHARTS was field tested in Ft. Lauderdale, FL, where it collected over 40 million hydrographic soundings and 90 million topographic elevations to assess a matrix of contractual specifications and requirements. This presentation will present the CHARTS system and results of the field tests.

G12A MCC: 3002 Monday 1600h

Airborne Laser Swath Mapping (ALSM): Technology, Applications, and Results II *(joint with H, GC)*

Presiding: **M Bevis,** University of Hawaii**; W E Carter,** University of Florida

G12A-01 1600h

NCALM: NSF Supported Center for Airborne Laser Mapping

Ramesh L Shrestha[1] ((352) 392-4999; rshre@ce.ufl.edu)

William E Carter[1] ((352) 392-5003; bcarter@ce.ufl.edu)

William E Dietrich[2] ((510) 642-2633; bill@eps.berkeley.edu)

[1]University of Florida, 365 Weil Hall, PO Box 116580, Gainesville, FL 32611, United States

[2]University of California-Berkeley, Department of Earth & Planetary Science, Berkeley, CA 94720, United States

The National Science Foundation (NSF) recently awarded a grant to create a research center to support the use of airborne laser mapping technology in the scientific community. The NSF supported Center for Airborne Laser Mapping (NCALM) will be operated jointly by the Department of Civil & Coastal Engineering, College of Engineering, University of Florida (UF) and the Department of Earth and Planetary Science, University of California-Berkeley (UCB). NCALM will use the Airborne Laser Swath Mapping (ALSM) system jointly owned by UF and Florida International University (FIU), based at the UF Geosensing Engineering and Mapping (GEM) Research Center. The state-of-the-art laser surveying instrumentation, GPS systems, which are installed in a Cessna 337 Skymaster aircraft, will collect research grade data in areas selected through the competitive NSF grant review process. The ALSM observations will be analyzed both at UF and UCB, and made available to the PI through an archiving and distribution center at UCB-building upon the Berkeley Seismological Laboratory (BSL) Northern California Earthquake Data Center system. The purpose of NCALM is to provide research grade data from ALSM technology to NSF supported research studies in geosciences. The Center will also contribute to software development that will increase the processing speed and data accuracy. This presentation will discuss NCALM operation and the process of submitting proposals to NSF. In addition, it will outline the process to request available NCALM seed project funds to help jump-start small scientific research studies. Funds are also available for travel by academic researchers and students for hands-on knowledge and experience in ALSM technology at UF and UCB.

G12A-02 1615h INVITED

ALSM and GIS Analysis of Debris Flow Fan Variability, Death Valley, CA

Thad Wasklewicz[1] (9016784452; twsklwcz@memphis.edu)

Heather Volker[1] (9016782386; hvolker@memphis.edu)

[1]University of Memphis Department of Earth Sciences - Geography, Johnson Hall 113, Memphis, TN 38152, United States

Analysis of form in geomorphology has gone through numerous transitions that began with the qualitative assessments of form through field observations as well as an attempt to unravel the historical development of landscapes. The dissatisfaction with the historical approach led to an emphasis on quantitative measures and analyses of planimetric (2D) boundary conditions of surficial features. The advent of Airborne Laser Swath Mapping (ALSM) and other remotely sensed techniques provided access to high-resolution data and permitted geomorphologic research to move beyond 2D measures to more closely approximate the form in 2.5D space. The current study presents preliminary results from a GIS analysis of ALSM data of alluvial fan form in Death Valley, CA. Functional surficial units, identified from field observations and DEM data, from debris flow fans were extracted from the ALSM point cloud. The functional units consisted of channels, levees, snouts, and interfluves between levees of two separate debris flow channels. The morphometric characteristics of these features were compared using spatial statistical analyses. The spatial interpretation provides a 2.5D assessment of within- and between-fan variability. It explains similarities and differences between the geomorphometric signatures of debris flow fans in a hyper-arid setting. The findings have implications for process-response models and planning/management of these often inhabited features.

G

G12A-03 1630h INVITED

Measuring Landscape Scale and Testing Landscape Evolution Models With an Airborne Laser Swath Map of the Gabilan Mesa, California

J. Taylor Perron[1] (perron@eps.berkeley.edu)

James W. Kirchner[1]

William E. Dietrich[1]

[1]Department of Earth and Planetary Science, University of California at Berkeley, 307 McCone Hall, Berkeley, CA 94720, United States

High-resolution topographic data acquired through airborne laser swath mapping (ALSM) allows geomorphologists to observe and measure features that cannot be resolved in coarser topographic maps. One of the most promising applications of ALSM data in geomorphology is the measurement of landscape properties that can be used to calibrate and test landscape evolution models. We illustrate this process with examples from the analysis of an ALSM dataset covering 40 km^2 of the Gabilan Mesa, a soil-mantled landscape in central California's Salinas Valley. The fine-scale ridge-and-valley topography of the Gabilan Mesa is characterized by a regular spacing of 180m between adjacent ridgelines. This regular spacing, which is not apparent in coarser digital elevation models (DEMs), defines a dominant topographic "wavelength." The magnitude of this wavelength is hypothesized to reflect spatial and tectonic boundary conditions and the relative rates of hillslope and channel erosion. We apply signal processing techniques to the ALSM data to measure the magnitude and regularity of the topographic wavelength. We then extract topographic profiles and drainage areas from the ALSM data that, when combined with exposure ages obtained from cosmogenic radionuclides, allow us to calibrate hillslope and channel erosion laws. The output of a numerical model based on these erosion laws can be analyzed by the same signal processing techniques applied to the ALSM-derived DEM. In this way the DEM and the model can be compared statistically. We also consider several challenges posed by the acquisition, processing and analysis of ALSM datasets that are relevant to terrain analysis, including the potential distortion of small-scale topographic features by filtering algorithms and the computational load imposed by large data volumes and grid-based representations of topography.