Tuesday, August 2nd

8:30-9:00	**Opening Plenary and Welcome**	**Ballroom C&D**
9:00-9:45	**Keynote: Christopher Fisher, Colorado State University: The Application of Lidar Scanning for the Documentation of Ancient Cities and Regions** The application of airborne lidar for the detection and documentation of archaeological sites in arid and semi-arid regions of the Americas has initiated a 'paradigm shift' for Mesoamerican archaeology. Here I discuss results from two archaeological projects in disparate areas of Mesoamerica that have utilized lidar to both examine intra-site and extra-site patterning. The first, centered at the site of Angamuco in the Lake Pátzcuaro Basin, Michoacán, used lidar as a tool to examine the spatial patterning of individual units of architecture. The second used lidar to document the complete settlement pattern of an unexplored valley within the Mosquitia tropical wilderness of Honduras. Both of these studies confirm that value and promise of lidar technology.	**Ballroom C&D**
9:45-10:00	**Workshop overview and Logistics**	**Ballroom C&D**
10:00-10:30	**Networking Break**	
10:30-12:00	**Panel Discussion 1: Contracting for Lidar Data- Quality Data for Quality Science-** Kim Mantey, Timothy Saultz, Karl Heidemann, Greg Stensaas, Aparajithan Sampath This session examines the contract process used by the US Geological Survey to acquire nationally standard lidar data. This process, which is available to USGS scientists, includes acquisition through an Architecture and Engineering contract, standards and specifications development, and quality control inspections to enforce compliance with those specifications.	**Ballroom C&D**
	Workshop 1: Lidar Point Cloud Geocalibration- Minsu Kim The theory of lidar point geocalibration will be presented. A lidar point cloud simulation software will be used to demonstrate boresighting error.	**Meeting Rooms 304-306**

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10:30-11:15	**[PP1a] Developing Height Above Ground Processes for 3DEP Lidar-** Karl Heidemann Over FY14 and FY15, with funding the Land Remote Sensing (LRS) Program, EROS lidar scientists began investigating the feasibility of generating consistent Height Above Ground (HAG) products from disparate projects from the ARRA lidar collections. In addition to the creation and refinement of products actually usable by the science community, another goal was to identify standard criteria for and conditions of lidar data, for it to be usable in automated or semi-automated production process. This presentation will review the successes and lessons learned from those investigations.	**Meeting Room 308**
	[PP2a] Using Airborne and Terrestrial Lidar to Identify, Visualize and Characterize Active Faults near Lake Tahoe, California- Jim Howle Overview of two published projects that utilized bare-earth lidar data to identify a previously unknown strike-slip fault and confirm the existence of a disputed normal fault zone near Lake Tahoe, CA. The presentation will demonstrate innovative techniques that use the lidar data to mathematically and objectively model the strike-slip displacement of a fluvial terrace riser, normal displacement of linear glacial moraine crests, normal displacement of range-front colluvial deposits, and estimate the strike and dip of fault planes.	**Meeting Room 310**
	[PP3a] Use of a Global Selective Drainage Toolbox for Hydro-enforcement of Culverts in Southeastern South Dakota- Ryan Thompson This presentation discusses an ArcGIS Toolbox that is useful for hydro-enforcing culverts through roadways or other man-made flow obstructions, so that lidar-based DEMs can be made to more accurately reflect actual flow directions and stream networks. The toolbox includes steps for hydro-enforcing known culverts, and also a tool which identifies likely locations of un-inventoried culverts based on user-specified criteria. The resulting hydro-enforced lidar-based DEM can be used for refining watershed boundaries, updating NHD, and a wide variety of land-use or resource management applications.	**Meeting Room 300**

10:30-11:15	**[PP4a] Summarizing and using Lidar to model and map wildlife-habitat relationships –** Wesley Newton Summarizing lidar point-cloud data into useful explanatory variables for modeling wildlife-habitat relationships can be challenging. This oral presentation briefly reviews wildlife-habitat relationships from an ecological and evolutionary perspective, describes various ways that lidar point-cloud can be summarized, and various modeling methods used to relate lidar-derived metrics with wildlife occurrence and abundance.	**Meeting Room 324**
11:15-12:00	**[PP1b] Forest canopy change assessments from lidar data: Potential, challenges, and example applications** – John Young We demonstrate land cover change assessment using lidar data for studies of Hurricane Sandy's impact on coastal forests, and for impacts from oil and gas development in the heavily forested northeast U.S. We discuss challenges and potential for lidar based change analysis.	**Meeting Room 308**
	[PP2b] Don't throw the bowls out with the pits! Identifying natural closed depression features in karst areas from lidar-derived bare-earth digital elevation models – Daniel Doctor An approach for targeted hydrologic conditioning of 1m lidar-derived DEMs will be presented. This approach targets 'digital dams' at road/ stream intersections, and enables the retention of true closed depressions which are common in karst areas.	**Meeting Room 310**
	[PP3b] Lidar processing tools to locate potential sediment sources in stream-channel networks – David Ladd Researchers at the Lower Mississippi-Gulf Water Science Center recently produced automated GIS tools for analysis of lidar-derived DEMs that can aid identification of potential sediment sources in stream-channel networks. The tools can be used to modify DEMs using known locations of storm-water infrastructure, derive flow networks at user-specified resolutions, and identify topographic features including steep banks, abrupt changes in channel slope, or areas of rough terrain. These topographic features may indicate sites of geomorphic instability that contribute sediment, such as eroding stream banks, head cuts, and gullies. Locations producing consistent results from multiple tools can be used to prioritize field efforts to assess and restore eroding stream reaches.	**Meeting Room 300**

11:15-12:00	**[PP4b] Airborne Lidar Applications in Small Mammal Research –** Aaron Johnston This presentation will overview recent studies on tree squirrels, red tree voles, and American pikas that relied on airborne lidar to describe habitat features at high resolution. New predictors for obscure habitat features within forests or taluses important to each species were developed to support habitat modeling and tests of ecological hypotheses. In each case, airborne lidar advanced our research by describing features undetected by other remote sensing technologies.	**Meeting Room 324**
12:00-1:30	**LUNCH – ON YOUR OWN**	
1:30-2:15	**[PP5a] The Most Challenging Lidar Acquisition in the Lower 48: Glacier Peak, Washington** – Dave Ramsey This presentation will cover the challenges of acquiring QL1 lidar on a steep, 10,541-foot stratovolcano located in a wilderness area covered with dense, old-growth forest. It will also show how the lidar data are being used to unravel the volcano's geologic history and to better understand the volcano's hazards. Future mapping directions and numerical modeling of hazardous volcanic processes will be presented as well.	**Ballroom C&D**
1:30-3:00	**Workshop 2: Know your lidar- Discovering and Understanding USGS Elevation Data-** Karen Adkins, Richard Brown, Kimberly Mantey The USGS, National Geospatial Technical Operations Center (NGTOC) is responsible for producing and distributing nationwide high-quality elevation data through The National Map (TNM). This 90-minute workshop will cover three topics: 1) how to access elevation products through The National Map, 2) how to access and use spatial metadata associated with the lidar point cloud and derived seamless DEMs (previously referred to as the National Elevation Dataset (NED), and 3) current and future web services for lidar point cloud visualization and distribution.	**Meeting Rooms 304-306**

1:30-2:15	**[PP6a] Change detection or Sensor change detection** – Silvia Terziotti We explore whether two different lidar collections, 12 years apart, with different point densities and vertical accuracies, can be used to identify areas of subsidence in the Coastal Plain of North Carolina.	**Meeting Room 308**
	[PP7a] Resolving the remaining 5% of lidar calibration errors – Scott Garrett There are typically unresolved errors in the post processing of discreet point linear mode lidar which prevent surfaces from being as accurate as they can be. Removing these, or preventing their inclusion through changes in collection, will help lidar achieve QL0 (quality level 0) accuracies. These errors are unofficially described as 'venetian blinds,' 'heading variability,' 'IMU latency,' and 'IMU float.'	**Meeting Room 310**
	[PP8a] South Carolina Lidar: Lessons Learned and Ongoing Efforts to Improve State Lidar Dataset(s)- Gary Merrill The acquisition, processing, and distribution Lidar data for South Carolina began in 2008 for a broad range of Federal, State, and local users. As a result of lessons learned and difficulties expressed while working with our Lidar products, statewide efforts started in 2014 to improve the quality of all Lidar deliverables and derivative products. The purpose of this presentation will be to demonstrate the user benefits and improvements to South Carolina's Lidar dataset for future consideration by USGS. Samples of user benefits are shown as follows, by order of product and process importance.	**Meeting Room 300**
2:15-3:00	**[PP5b] Landward migration of tidal saline wetlands under future sea-level rise and urban growth** – Nicholas Enwright In the coming century, accelerated sea-level rise and urbanization will greatly modify coastal landscapes across the globe. In this study, we quantified the potential for landward migration of tidal saline wetlands (i.e., mangrove forests, salt marshes, and salt flats, collectively) along the U.S. Gulf of Mexico coast under alternative future sea-level rise and urban growth scenarios. Coastal elevation is one of the primary abiotic factors influencing how current and future tidal saline wetlands will respond to accelerated sea-level rise. Our analyses incorporate bare-earth lidar elevation, tidal	**Ballroom C&D**

2:15-3:00	datum, habitat, levee, land use, and conservation status data. Collectively, our approach and findings provide useful information for developing future-focused adaptation strategies for conserving coastal landscapes and wetland ecosystem goods and services.	
	[PP6b] DEMs from SfM photogrammetry and historical aerial photography as a complement to lidar data for change analysis – Pete Chrico This research presents an evaluation and comparison of high-resolution DEMs produced from historical USGS aerial photography and structure-from-motion (SfM) photogrammetry to lidar derived DEM data. The research quantifies the scale and resolution parameters for direct and indirect comparisons of historic DEMs to lidar as a method of analyzing geomorphic change over longer time scales than is currently possible with lidar data alone.	**Meeting Room 308**
	[PP7b] Geometric Accuracy Assessment Methodologies for Lidar and 3D data- Aparajithan Sampath This research presents assessment methods for geometric quality of lidar and other 3D data. The methods are purely point cloud based, and assess the data on all three dimensions, and not just on the vertical dimension	**Meeting Room 310**
	[PP8b] Lidar Base Specification (LBS), 2016 Update – Karl Heidemann In the ever changing world of lidar, standards and specifications for data must also evolve almost continuously. In this presentation, the changes in the upcoming revision LBS will be explained, along with a forward look to the topics expected in future revisions.	**Meeting Room 300**
3:00-3:30	**Networking Break**	
3:30-5:00	**Innovation Panel, led by Director Kimball**	**Ballroom C&D**
5:00-7:00	**Poster Session**	**Ballroom A&B**

Wednesday, August 3rd

8:30-10:00	**3DEP Plenary-** Kevin Gallagher, Michael Tischler An overview of the 3D Elevation Program, status of data and funding, and overview of data acquisition process and successful projects	**Ballroom C&D**
10:00-10:15	**Break**	
10:15-11:15	**Regional Breakout session: Northwest/ Alaska Regions**	**Meeting Room 304**
	Regional Breakout session: Pacific Region	**Meeting Room 306**
	Regional Breakout session: Northeast Region	**Meeting Room 308**
	Regional Breakout session: Southeast Region	**Meeting Room 310**
	Regional Breakout session: Southwest Region	**Meeting Room 300**
	Regional Breakout session: Midwest Region	**Meeting Room 324**
11:15-11:30	**Break**	
11:30-12:30	**Mission Area Breakout Session: CSS**	**Meeting Rooms 304-306**
	Mission Area Breakout Session: Water	**Meeting Room 308**
	Mission Area Breakout Session: Hazards & Energy and Minerals	**Meeting Room 310**
	Mission Area Breakout Session: Climate and Land Use	**Meeting Room 300**

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	Mission Area Breakout Session: Ecosystems & Environmental Health	**Meeting Room 324**
12:30-1:30	**LUNCH- ON YOUR OWN**	
1:30-2:15	**[PP9a] Lidar in Surface Water Case Studies –** Marie Peppler The Office of Surface Water supports many projects and programs that use lidar. This presentation will present case studies from five science areas: flood inundation mapping with hydraulic modeling, flood documentation mapping, T-lidar high-water marking, topobathymetric surveys for streamflow computations, and generating watershed characteristics for a StreamStats implementation.	**Ballroom C&D**
	[PP10a] Properties of Geiger mode lidar- Minsu Kim New lidar systems capable of detecting single photon level signal will be discussed. Main focus is on the physical principle of the system, such as photodetector array, solar background, radiometric limitation etc.	**Meeting Room 304**
	[PP11a] Quantifying the Eroded Volume of Mercury-Contaminated Sediment Using Time-Series Terrestrial Laser Scanning South Yuba River, Northern Sierra Nevada, California- Jim Howle This presentation will provide an overview of two studies (one published and another in review) that used time-series TLS to quantify the eroded volume of mercury contaminated sediment. The presentation will focus on the precise co-registration or alignment of sequential TLS surveys, which is critical to the success of differential lidar analyses. The presentation will also detail the methods used to quantitatively assess the time-series alignments and translate the alignment uncertainty into the calculated volume estimates. In addition, examples of visualization techniques (2D and 3D) that enhance the understanding of complex data sets and interpretation of physical process will be shown.	**Meeting Room 306**

1:30-2:15	**[PP12a] Using discrete-return Lidar for mapping habitat for sagebrush obligate wildlife-** Steve Germaine We report on the accuracy of lidar while mapping key components of sagebrush vegetative structure when compared with ground-truth vegetation data. We then use lidar vegetative descriptors to model sagebrush songbird distribution among variation in habitat structure during the songbird breeding season. Success of lidar at performing these two tasks will be reviewed in the context of lidar's unique utility to provide detailed habitat information over broad spatial scales.	**Meeting Room 308**
	[PP13a] California Sea cliff Metrics using Lidar-Derived High-Resolution DEMs: Mapping and Validation – Monica Palaseanu-Lovejoy Automated methods to extract cliff top and toe positions using bare-earth aerial lidar derived DEMs, and terrestrial lidar point clouds. The validation of the results is in progress and uses data collected by real-time kinematic GPS and terrestrial lidar. Custom code was written in open source statistical software R and Python using ArcPY routines.	**Meeting Room 310**
2:15-3:00	**[FS1] Featured Session: GPSC Contractor Forum**	**Ballroom C&D**
	[PP10b] Evaluating the Suitability of Single Photon Counting and Geiger Mode Lidar Technology for the 3D Elevation Program (3DEP)- Jayna Winehouse, Jason Stoker Presenting the results of two task orders, concerning the suitability of emergent Geiger and Single Photon datasets and how they compare to linear-mode sensors and the 3DEP program.	**Meeting Room 304**
	[PP11b] Utilizing new technologies for mapping river bathymetry for use in hydrodynamic modeling of aquatic habitat – Jeffrey Cole	**Meeting Room 306**

2:15-3:00	Evaluating lidar for use in 2D hydrodynamic modeling of aquatic habitat. Comparing derived river bathymetry map to bathymetry from other technologies.	
	[PP12b] Lidar remote sensing for wildland fire research- Jason Kreitler An overview of several research projects using lidar remote sensing to assess wildland fire as both a natural process and a hazard, using examples of recent fires from Colorado and Oregon.	**Meeting Room 308**
	[PP13b] Tracking development-induced geomorphic changes through time using a time series of lidar data- Daniel Jones A time-series of Lidar-derived digital elevation models (DEM) was used to track and quantify geomorphic changes in three small Maryland watersheds through time, and throughout watershed urbanization. Substantial modification to hillslope and channelized flowpaths was observed, favoring rapid convergence of overland flow and conveyance to stormwater management infrastructure. This talk will present methods and results from this work, and highlight ongoing research in Lidar-based watershed studies.	**Meeting Room 310**
1:30-3:00	**Strategic Discussions (New Products and Services)**	**Meeting Room 300**
	Doctor's Office: Bring your lidar data and/or questions and work toward answers	**Meeting Room 324**
3:00-3:15	**BREAK**	
3:15-5:00	**Panel 2: Lidar for the Nation: Four Trillion Points of Light and Growing-** Amanda Lowe, Drew Lane, John Kosovich Providing consistent lidar coverage for the nation is no simple task. Robust production processes ensure the integrity of lidar and other elevation products, and thoughtful planning for new technology strives to enhance data utility, visualization and exploitation. Attend this panel to learn how the USGS makes lidar and other national elevation products available to the Nation.	**Ballroom C&D**

3:15-3:30	**[LR1a] Lidar Applications for floodplain mapping-** Luther Schalk, Luke Sturtevant The New England Water Science Center is using lidar datasets to map floodplains for multiple flood frequencies. The input water-surface elevations can be taken from approximate models that are derived almost entirely from lidar data. To produce these models, lidar covering a river's entire watershed is processed to create stream networks, calculate peakflows, and determine channel and overbank geometry.	**Meeting Room 304-306**
	[LR2a] But what does it mean? Geomorphic process attribution in DEMs-of-Difference derived from repeat lidar – Joshua Caster, Alan Kasprak, Joel B. Sankey We propose a two part method for attributing geomorphic processes to apparent surface changes in repeat lidar surveys. Using detailed survey records, we assessed the accuracy of the method for determining the mechanism of change. The approach performs well across the sites analyzed and, with further automation, may prove useful for rapid geomorphic process attribution at large spatial scales	**Meeting Room 308-310**
3:30-3:45	**[LR1b] Three-dimensional surface modeling using terrestrial lidar and multibeam sonar-** Kathryn Lee This presentation will briefly highlight three-dimensional data collection from a marine vessel and the many applications in water resource management.	**Meeting Room 304-306**
	[LR2b] Application of Lidar for satellite based surface water extent detection and monitoring- John Jones The USGS is developing a Dynamic Surface Water Extent (DSWE) Landsat science product to meet broad scientific and resource management needs. Rigorous measurement and reporting of product uncertainty as well as the evaluation and refinement of product utility are primary objectives for DSWE research. When collected close to the timing of a Landsat overpass, imagery collected with or derived from Lidar can be used to assess DSWE accuracy. We are also evaluating the potential to combine publicly available Lidar and USGS project collected in situ data on water level to produce (valuable) time series inundation and DSWE verification datasets for various wetland and riverine environments.	**Meeting Room 308-310**

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3:45-4:00	**[LR1c] Potential applications of bathymetric lidar data for aquatic research in the Columbia River-** Tim Counihan The Columbia River contains anadromous fish species such as Chinook (Oncorhynchus tshawytscha), Coho (O. kisutch), chum (O. keta), and sockeye salmon (O. nerka), of which several populations are listed as threatened or endangered under the Endangered Species Act. Consequently, expensive mitigation actions to help recover these species are underway. Mitigation actions include altering flow to improve survival of migrating salmon, habitat restoration to improve habitat conditions for migrants, and managing flows and habitats to reduce the effects of non-native predators on juvenile salmon. To facilitate reliable simulations, high-quality elevation data of river channel beds, floodplains, and tributaries would be beneficial. I will briefly present some research applications of bathymetric LIDAR and the potential management implications of the research in the Columbia River.	**Meeting Room 304-306**
	[LR2c] Lidar-based studies in the central Virginia seismic zone following the 2011 Mineral, Va. M5.8 earthquake- William C. Burton, Richard W. Harrison, Anne C. Witt, Mark W. Carter, and Frank J. Pazzaglia The August 23, 2011 M5.8 Mineral, Virginia earthquake was felt by more people than any other quake in U.S. history, and prompted a renewed focus by the USGS on the extent and cause of neotectonism in the central Virginia seismic zone. New 1-meter resolution, bare-earth lidar-derived elevation models have been acquired for a 1300 km^2 area surrounding the epicenter of the Mineral earthquake, and these elevation models are being used to look for landforms of possible neotectonic origin. Such analysis is not possible with the existing 1:24,000-scale USGS topographic datasets, with their 10- or 20-ft contour intervals. Although no fault scarps have been recognized in the lidar-derived hillshade raster or other derivative imagery, a lineament has been identified along the surface projection of the N30E-trending, subsurface causative fault of the Mineral earthquake; trenching across this feature shows Cenozoic brittle reactivation of an older (Paleozoic and Mesozoic) fault zone. Regional lineament analysis shows other features that may indicate previously unrecognized bedrock faults and fractures of neotectonic origin; these will be investigated as part of future field work. Lidar is also being used to delineate Quaternary terrace deposits along the South Anna River and other regional drainage systems in the epicentral area. Downstream correlation of these terraces through mapping and age dating suggests neotectonic warping of terrace levels that could be used to estimate rates of Quaternary uplift.	**Meeting Room 308-310**

4:00-4:15	**[LR1d] Bathymetric lidar processing: Importance of customizing parameter sets and algorithms**- Xan Fredricks, Christine J. Kraneburg, David B. Nagle, David G. Zawada In order to yield the most valid results when processing bathymetric lidar data, it is important to customize parameter sets and use appropriate algorithms based on spatially varying conditions. Data from Fire Island, New York, were processed with a single parameter set, as well as with multiple parameter sets, thus providing examples of the limitations and capabilities of each approach.	**Meeting Room 304-306**
	[LR2d] USGS Lidar applications and user needs- Zhouting Wu, Greg Snyder, Greg Stensaas, Bruce Quirk, Carolyn Vadnais, Peter Doucette US Geological Survey (USGS) initiated the Requirements, Capabilities and Analysis for Earth Observations (RCA-EO) project in the Land Remote Sensing (LRS) program, to evaluate Earth observing systems impacts on USGS products and services, we engaged over 500 subject matter experts and evaluated more than 1000 different Earth observing data sources and products. Here, we summarized impacts of lidar data sources on USGS products and services, and incorporated user satisfactions to identify needs and gaps of lidar data and products.	**Meeting Room 308-310**
4:15-4:30	**BREAK**	
4:30-4:45	**[LR1e] Comparison of hydrographic features from the National Hydrography Dataset to features derived from inland bathymetric lidar surveys –** Cynthia Miller-Corbett Hydrographic features derived from lidar bathymetry data are assessed to determine their suitability for updating streamlines, flow networks, and catchments of the National Hydrographic Dataset (NHD). Using recently acquired lidar bathymetry data for a section of the Delaware River, a comparison of the lidar-derived hydrography with high-resolution National Hydrography Dataset (NHD) feature classes provides the basis for analysis. The results of this study provide an example of how well lidar based water feature extractions align with NHD feature classes and an indication of how lidar data might be used to support hydrographic mapping.	**Meeting Room 304-306**

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4:30-4:45	**[LR2e] Radiation Modeling Using Terrestrial Laser Scanning and Airborne Lidar –** J. Toby Minear, David Barnard For this talk, plot-scale radiation modeling in several types of Colorado forests is performed using high-resolution 3D vegetation maps collected by Terrestrial Laser Scanning and tested against measured radiation. The plot-scale radiation model is then upscaled using aerial lidar data to larger watersheds.	**Meeting Room 308-310**
4:45-5:00	**[LR1f] Applying Morphologic Filters to Multi-Resolution Lidar Data to Derive Hydrography in Three Physiographic Provinces of the Raritan River Basin, New Jersey -** Stephen Cauller, Kara Watson, Roger Barlow This presentation will highlight work undertaken in the Raritan River Basin in New Jersey to delineate hydrography from lidar-derived DEMs. Methods used to condition DEMs and derive stream networks will be discussed. Comparison statistics between derived streams and local-resolution NHD will be presented.	**Meeting Room 304-306**
	[LR2f] Lidar remote sensing of vegetation structure and biomass for ecology and geomorphology research and monitoring- Joel Sankey, Temuulen T. Sankey This presentation will describe methods we have developed for lidar data from manned and unmanned aerial systems as well as ground-based sensors to map vegetation structure, biomass, and canopy characteristics. I will describe how we use multitemporal data acquisitions and fusion of lidar with multispectral remote sensing data for change detection analysis of vegetation structure, biomass, and canopy characteristics. I will provide specific examples of environmental science applications for these methods that include (i) estimating impacts of tamarisk beetle herbivory along the riparian corridor of the Colorado River in Grand Canyon, (ii) monitoring Sonoran desert vegetation structure and phenology at long-term experimental study plots, (iii) characterizing effects of thinning and burning forest management practices on Ponderosa pine forest structure, and (iv) integrating vegetation structure measurements into soil erosion monitoring and modelling in desert shrublands.	**Meeting Room 308-310**

5:00-5:15	**[LR1g] Extracting Fluvial Geomorphic Measures from Lidar to Estimate Sediment Deposition and Erosion-** Peter Claggett, Samuel Lamont, Marina Metes, Greg Noe USGS developed a new GIS toolkit for extracting fluvial geomorphic features from lidar. The tool has been applied through the Chesapeake Bay watershed. Results have been correlated favorably with field measurements of bank erosion and floodplain sediment deposition rates enabling the estimation of erosion and deposition rates across broad regions.	**Meeting Room 304-306**
3:15-5:00	**Doctor's Office: Bring your lidar data and/or questions and work toward answers**	**Meeting Room 324**
	Hydro Network Connectivity Meeting	**Meeting Room 300**

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Thursday, August 4th

8:30-10:00	**Panel 3: Integrating lidar data with high precision hydrography data to deliver the next generation of topographic information for science –** Steve Aichele, Roland Viger, Al Rea New lidar data from the 3D Elevation Program has demonstrated issues with the existing National Hydrography Dataset, much of which originated with 1:24,000 scale cartographic products. The National Geospatial Program is beginning the process of integrating planning, acquisition, and production processes to deliver coherent topographic data for scientists, land managers, and other stakeholders.	**Ballroom C&D**
8:30-9:15	**[PP14a] The USGS Coastal National Elevation Database (CoNED): Integrated Topobathymetric Models for the US Coastal Zone-** Jeffrey Danielson CoNED topobathymetric models have been constructed for the San Francisco Bay Region, the Northern Gulf of Mexico, and the Hurricane-Sandy Region. Improved geospatial techniques to mask, interpolate, store multi-temporal terrain data, and to fuse elevation data from multiple point cloud sources will be presented along with an overview of the CoNED topobathymetric model development work flow.	**Meeting Rooms 304-306**
	[PP15a] Forecasting tidal marsh elevation and habitat change through fusion of Earth observations and a process model- Kristin Byrd I will summarize a paper in review on the use of remote sensing data with tidal marsh elevation process models to improve regional projections of tidal marsh habitat and carbon stock change with sea level rise. The presentation will include a sensitivity analysis of remote sensing error, and its effect on elevation forecasts across time and space. The presentation will also include a discussion on the need for accurate lidar DEMs of tidal marsh to support planning for coastal ecosystem services, including habitat, carbon and flood protection.	**Meeting Rooms 308-310**

8:30-9:15	**[PP16a] Radiometric theory of lidar radiative transfer**- Minsu Kim The radiometric theory of lidar return pulse detection is discussed. Using fundamental optics theories, a lidar return is modeled as an integration of the multiplication of two irradiance distribution; laser source irradiance and fictitious viewing field irradiance. The lidar radiometric theory will be demonstrated on topo lidar situation and more complicated bathy lidar situation.	**Meeting Room 324**
9:15-10:00	**[PP14b] US Interagency Elevation Inventory: Catalog of Nationwide High Accuracy Topographic Data-** Diana Thunen The US Interagency Elevation Inventory (USIEI) is a collaborative effort between five federal agencies (USGS, NOAA, USDA-NRCS, USACE, and FEMA) to create a nationwide listing of known high accuracy topographic and bathymetric elevation data. This effort includes gathering information about existing, planned, and in-progress elevation collections including lidar, IfSAR, and multibeam bathymetric data. The inventory provides details about these datasets including vertical accuracy, point spacing, and data access.	**Meeting Rooms 304-306**
	[PP15b] Overview and User Perspective of 3DEP Lidar- John Kosovich What exactly is lidar, and how is it collected? What types of lidar exist? What is the typical lidar terminology? What derivative products can be made from lidar, and why would a potential lidar user want them? How might a user utilize lidar acquired through the 3D Elevation Program (3DEP) and distributed through The National Map? This talk consists of a general lidar overview from a user's perspective: what a user would typically see in 3DEP-quality lidar; the LAS 1.4 specification; the USGS Lidar Base Specification; how these specifications affect scientist-users of the 3DEP data; types of lidar; lidar terminology; and a brief overview of some latest lidar technologies including multispectral, Geiger-mode, and single-photon.	**Meeting Rooms 308-310**
10:00-10:15	**BREAK**	
10:15-11:00	**[PP17a] Adequacy of current and planned coastal elevation data for high confidence assessments of sea-level rise impacts-** Dean Gesch	**Ballroom C&D**

	Lidar-derived elevation data are widely used for sea-level rise (SLR) assessments. The vertical accuracy of the elevation data largely control the critical parameters (SLR increments and planning horizons) of an assessment. Current and planned (3DEP) lidar elevation data are evaluated for adequacy considering various projected SLR rates and local land conditions. National level statistics are reported for U.S. coastal counties.	
10:15-10:30	**[LR3a] Evaluating Lidar Point Densities for Effective Estimation of Aboveground Biomass**- Zhouting Wu, Dennis Dye, Jason Stoker, John Vogel, Miguel Velasco, Barry Middleton We evaluated the performance of airborne lidar data at various pulse densities against Landsat 8 satellite imagery in estimating above ground biomass for forests and woodlands in a study area in east-central Arizona. We found that a national aboveground biomass product with optimal accuracy could potentially be achieved with 3DEP data at 8 points/m2, and our results also indicated that even lower density lidar data could be sufficient to provide a national biomass product with accuracies significantly higher than those from Landsat observations alone.	**Meeting Rooms 304-306**
	[LR4a] Extraction of lidar-based features to assess barrier-island marsh vulnerability to storms- Kathryn Smith Elevation plays an important role in sediment deposition and coastal marsh vulnerability to future storms. Lidar provides a critical means for acquisition of spatially-comprehensive elevation data. We will provide an example where full-width barrier island elevation data can be used to evaluate the vulnerability of coastal wetlands to storm-induced coastal change.	**Meeting Rooms 308-310**
10:30-10:45	**[LR3b] The use of terrestrial lidar and field data to evaluate forest vegetation structure metrics derived from airborne lidar-** Cindy Thatcher, John Young, Kathryn Lee, Jeff Danielson, Dean Gesch This presentation focuses on an assessment of airborne lidar-based forest structure metrics such as percent canopy cover, canopy height, and the vertical distribution of forest vegetation. More information is needed about how well these vegetation metrics characterize the actual forest structure, given that airborne lidar laser penetration under the tree canopy is reduced by branches and foliage. Field measurements and very high resolution terrestrial lidar are used to quantify how well the airborne lidar-based metrics describe forest structure, and we present graphics comparing the two types of lidar point clouds in a forested environment.	**Meeting Rooms 304-306**

10:30-10:45		
	[LR4b] Statistical correction of lidar-derived digital elevation models with multispectral airborne imagery in tidal marshes- Kevin Buffington Description of a statistical method for adjusting high resolution (1m) lidar-derived DEMs in areas of dense vegetation, specifically for creating bare earth models in tidal marshes. The method relies NDVI from NAIP imagery and ground surveys to calibrate a simple correction model that is applied to the original DEM. The number of ground points needed for a robust correction depends on the spatial variation of vegetation height and density.	**Meeting Rooms 308-310**
10:45-11:00	**[LR3c] LANDFIRE Remap: Integrating lidar for Improving Vegetation Structure Mapping-** Jordan Long, Birgit Peterson, Kurtis Nelson The presentation focus is on integrating lidar data with satellite imagery and ancillary geospatial data for improving mapping accuracies of existing vegetation characteristics (e.g., type, cover, and height). Results from a prototype study area in western Idaho are discussed in detail as are proposed strategies for extrapolating the information gleaned from lidar data to vegetation mapping beyond the area of the lidar survey. The results of this study will help LANDFIRE leverage available lidar datasets collected throughout the U.S. to improve vegetation mapping.	**Meeting Rooms 304-306**
	[LR4c] Comparing 10m DEM- and Lidar-derived landform predictors of groundwater influence in forested headwater streams- Zachary Johnson, Nathaniel P. Hitt, Craig D. Snyder We evaluated spatial landform features derived from relatively coarse- (10 m cell size, 1.6 m vertical resolution) and fine-scale (76 cm cell size, 9.2 cm vertical resolution) elevation data sources characterizing stream geomorphology and stream network topology in order to identify landscape attributes that predict groundwater influence on temperatures of headwater streams of the greater Chesapeake Bay Watershed, USA. Results indicated that groundwater thermal influence was spatially structured within watersheds and that spatial variation in groundwater contribution is influenced by complex interactions among landscape attributes. Because of these complex interactions, high resolution spatial data (i.e., lidar) is hypothesized to aid in the	**Meeting Rooms 308-310**

10:45-11:00	description of factors controlling groundwater influence on stream temperature such as channel cross-section geometry and stream confluence configuration. We discuss the benefits, challenges, and limitations of using the fine-scale lidar data to describe groundwater influence on stream temperature in forested headwater streams.	
11:00-11:45	**[FS2] Featured Session: Mapping ecosystem structure with lidar and photogrammetry –** Michael Lefsky, CSU, S. Leisz, S. Filippelli Lidar remote sensing has earned a reputation for its unparalleled ability to characterize the height, biomass, and three-dimensional structure of ecosystems. However, recent advances in photogrammetry have made it possible to retrieve 3d positions from photography taken in a variety of contexts. While this technique cannot measure the elevation of terrain under canopy (as lidar can) it can be used with existing elevation models to create data products that are similar to lidar but without the constraints of lidar's relatively high cost and limited historic availability. We will review some of our applications of this technique in the area of ecosystem monitoring using both modern digital and historic film photography.	**Ballroom C&D**
11:00-11:15	**[LR3d] Using Terrestrial Laser Scanning to Estimate Hydraulic Resistance for Floodplain Mapping and Hydraulic Studies-** J. Toby Minear, Jon Nelson Floodplain mapping and hydraulic studies are one of the main economic benefits of aerial lidar data collection, such as the USGS 3DEP program. One of the largest unknown parameters for floodplain studies is hydraulic resistance. In this talk, we show how Terrestrial Laser Scanning can be used to estimate hydraulic resistance.	**Meeting Rooms 304-306**
	[LR4d] Quantifying Regional-Scale Elevation Changes Of Modern Coral Reef Ecosystems- David Zawada, Kimberly K. Yates Recent predictions, however, assert that anthropogenic impacts and climate change will cause the global degradation of coral reefs, leading to a net-erosional state by mid-century. Using bathymetric lidar data and historical depth soundings, we show that 5 reef systems have already transitioned to a net-erosional state. This talk highlights the methods we developed and the benefit of repeat lidar surveys for quantifying spatial changes in seafloor elevation.	**Meeting Rooms 308-310**

11:15-11:30	**[LR3e] Correspondence of Coastal LIDAR and Leveling Surveys for Documenting Causal Relations of Damaged Forests from Hurricane Sandy-** Thomas Doyle, Bogdan Chivoiu Evaluation and Use of Lidar products for Coastal Forest Damage Assessment following Hurricane Sandy. Accuracy and rectification issues may exist to limit Lidar application for dense vegetation canopies and soft/wet surfaces common to wetlands. Pre and Post-Sandy Lidar products for sampled sites were compared with ground leveling surveys to produce some understanding of sources of variation in accuracy and rectification.	**Meeting Rooms 304-306**
	[LR4e] Application of lidar in coastal environments: an overview of the National Assessment of Coastal Change Hazards lidar requirements and uses- Kara Doran, Hilary F. Stockdon, Nathaniel G. Plant, Joseph W. Long, Soupy Dalyander The National Assessment of Coastal Change Hazards (NACCH) provides robust scientific findings that help to identify areas that are most vulnerable to diverse coastal change hazards including beach and dune erosion, long-term shoreline change, and sea-level rise. Accurate, timely lidar observations of beach morphology and nearshore bathymetry are essential to the research and operational tasks of the NACCH project. This presentation will give an overview of the many applications and requirements of lidar in coastal environments.	**Meeting Rooms 308-310**
11:30-11:45	**[LR4f] 3D Elevation Program Data Product Specifications-** Christy-Ann Archuleta The U.S. Geological Survey (USGS) publishes national standards and specifications defining quality and completeness requirements for lidar point clouds and derived digital elevation models. The USGS National Geospatial Program updates, publishes, and inspects elevation data using these standards and specifications to ensure the elevation data consistently meet the quality requirements of the 3D Elevation Program (3DEP) and The National Map. Current publications include: Lidar Base Specification version 1.2 and the 1-Meter Digital Elevation Model Specification. A Seamless DEM Specification will be published in 2016. This lightning talk will introduce the 1-Meter Digital Elevation Model Specification and the Seamless DEM Specification and share what types of requirement information can be found within the documents.	**Meeting Rooms 308-310**
11:45-12:30	**CLOSING PLENARY**	**Ballroom C&D**

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1:30-5:00	**Geologic Mapping Applications Meeting (Moderator: John Brock)**	**Meeting Rooms 304-306**
	Topo-Bathymetric Lidar Program Development Community Discussion (Moderator: Robert Swanson)	**Meeting Room 308**
	Birds of a Feather meeting	**Meeting Room 310**
	Hydro Network Connectivity Meeting	**Meeting Room 324**

Session Color Key

Yellow	**Plenary Sessions**
White	**Paper Sessions**
Light gray	**Panel Sessions**
Light blue	**Featured Sessions**
Orange	**Lightning Round Sessions**
Gray	**Breaks**
Blue	**Non-contributing Area Meeting (hydro)**
Green	**Doctor’s Office**
Pink / Purple	**Facilitated Discussions**

POSTERS

The use of lidar data to improve geologic mapping in Virginia

Heller, Matthew J., Coiner, Lorrie V., Witt, Anne C., and Cross, Aaron, and Occhi, Marcie E.

The Virginia Department of Mines, Minerals, and Energy makes use of available Lidar data to assist with geologic mapping in several ways. First, hillshade maps derived from Lidar data are used to identify discontinuities that are sometimes associated with faults, and rock layers of different resistance to weathering in vegetated areas. Locating these features allows for the more precise location of fault and stratigraphic contacts. Second, hillshade maps are used to precisely locate the boundaries of alluvial and colluvial deposits. Our surficial mapping methodology has adapted to the availability of Lidar data and we are now commonly drawing preliminary contacts first and performing QA/QC on these contacts during subsequent field work. Third, hillshade maps are used to identify areas of modified land, including former mine sites and archeological features, which improves both the accuracy and usefulness of map products for applied purposes. Fourth, we are using Lidar data to assist in characterizing fractures and other fault-related features within the Central Virginia Seismic Zone. Fifth, Lidar data are used to detect sinkholes and better understand the association of sinkholes and geologic conditions in western Virginia. As lidar data become more widely available in Virginia, it is anticipated that the use of these data for geologic mapping purposes will continue and increase in volume and breadth of application.

Geologic Mapping and other Lidar Applications: Examples from Illinois.

Steven E. Brown, Illinois State Geological Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign

Use of enhanced elevation data and derivative elevation products are a requirement for geologic mapping and other resource evaluation and planning applications. Four examples highlight outcomes in Illinois: 1.) surficial geologic mapping and Quaternary chronologic control in northern Illinois, 2.) ancient and modern fluvial processes, 3.) identification of karst features, aided by climate driven events and substantiated by mining patterns, and 4.) documentation of underground coal mine extent and land surface subsidence.

The Midwest glacial landscape includes thousands of small, local lake plains that reveal a number of depositional settings and hold archives of deglacial histories. Many are subtle features and are difficult to identify on-the-ground and on topographic maps. Lidar elevation data reveal morphologic details never before observed that subsequently have been a catalyst for hypothesis driven research. Ice-walled lake plains are features formed on the surface of stagnant ice. They occur as a single landform, but also in large numbers within groups covering many square miles. They represent former tracts of stagnant glacial ice. Associated lake sediment commonly hosts tundra vegetation, creating a geochronology archive. Importantly, these time records provide refined constraints on ice-margin fluctuations during the last glacial events because they document the time of last remnant ice on the landscape. This information then leads to analyses of the rate of late glacial climate change, and rates of ice-margin fluctuation and sediment accumulation. Similarly, in ongoing STATEMAP supported surficial mapping in Will County,

Illinois, lidar data reveal a number of surficial lakes in high landscape positions, never before mapped or identified. Associated features include shorelines and evidence for former ice-margin positions and tracts of stagnant ice that blocked meltwater drainage.

The Wabash River includes the longest section of free-flowing river east of the Mississippi River. Its lower reaches are characterized by large tracts of meander scars. In 2008, in a rare event, a cutoff and formation of a new channel was observed over an eight-day period near the confluence of the Wabash and Ohio rivers. Use of lidar data in the lower Wabash Valley has been essential, if not required, for mapping the geologic framework of the valley landforms and sediment—relating evidence of glacial meltwater floods, slackwater lake plains, complex meander patterns, intricacies of channel fill, and terrace evolution. Importantly, lidar elevation data underpinned the re-evaluation of a distinct landform, the Meadowbank Lineament, formerly thought to be neotectonic in origin, and now interpreted to be erosional.

About 10% of Illinois is underlain by karst that is parsed into 5 distinct regions. One of those regions is within the Driftless area of northwestern Illinois where the bedrock surface is fractured and creviced Silurian dolomite. A severe 2012 Midwest drought revealed features, primarily in alfalfa hay fields, described as “crop lines”—linear tracks of alfalfa that appeared taller, greener, and healthier than adjacent alfalfa plants in the fields. The crop lines occurred over bedrock crevices, consistent with the regional fracture pattern identified with lidar bare earth data. This discovery was instrumental for demonstrating the potential negative impact on water quality under certain land-use practices. Lidar data also revealed aligned cover-collapse sinkholes and lead-zinc mining disturbances or diggings, some of which follow the regional fracture and crevice trend exhibited by the crop lines. The enhanced elevation data both confirmed understanding of geologic regional structure and karst, but also related mining patterns to geologic trends at a level of detail never before revealed.

Lidar data have also been used in Illinois to document the location and extent of underground coal mines in northern Illinois where a manual longwall mining method was used to remove coal in thin seams. Subsidence is a known outcome associated with longwall mining, and the degree of subsidence is somewhat proportional to the thickness of the removed material. Historical documents that show or describe mined areas can be incomplete, inaccurate, or of poor quality. Lidar data provide remarkable detail of longwall mined areas, some with expected subsidence of as little as 2 feet, and the data enabled remapping the extent of underground mines.

Shaping the mapping future: How Lidar is transforming geologic mapping and geologic hazard assessment in Colorado

Matthew L. Morgan, Colorado Geological Survey Colorado School of Mines

Lidar has revolutionized geologic mapping by providing a snapshot of a bare-earth landscape at resolutions typically less than 1 m, making it ideal for delineation of many geologic and geomorphic features. In particular, lidar has played a key role in our ability to map potentially hazardous features such as landslides, debris flows, alluvial fans and fault scarps as well as stream terraces, eolian dune forms, and bedrock contacts. Using a combination of sub-meter contours generated from lidar together with enhanced hillshades, stereo aerial photography and field control points, Colorado Geological Survey (CGS) geologists are able to precisely map geologic contacts and create hazard-assessment maps. The lidar DEMs are also used to model debris flow run-out zones and delineate areas susceptible to slope failures. These types of datasets could not be generated accurately using traditional (NED-scale) DEMs. Lidar has become so important that the CGS STATEMAP and Geologic Hazard Mapping Programs are now prioritizing project areas to coincide with current lidar data or where lidar will be collected in the near future.
The CGS has been on the forefront of LIDAR collection in Colorado by acquiring needed data in hazard-prone areas and coordinating collection and cost-sharing efforts with other county, state, and federal agencies. These data benefit multiple agencies and have become cost-effective in the last few years. Almost half of Colorado will be covered by QL2 or better data by mid-2017 with the majority of this data collected in the last three years.

Using Lidar data to model forest structure for canopy-associated wildlife species in old-growth forest

Joan Hagar, Bianca N.I. Eskelson, Patricia Haggerty, S. Kim Nelson, David G. Vesely

Recovery plans for threatened species associated with old-growth forest identify the need for refined measures of habitat structure to more accurately estimate the availability of suitable habitat. Yet accurately modeling habitat for these species can be challenging because of the difficulties of discerning and measuring the relevant features at an appropriate spatial scale in complexly structured, 3-dimensional space. Lidar can provide fine-scale data describing vertical complexity of vegetation, offering a promising application for improving characterization of habitat for species that are responsive to forest structure. We used lidar data to address needs identified in recovery plans for more accurate estimate of the availability of nesting habitat to model habitat for the federally threatened marbled murrelet in the Oregon Coast Range. We used murrelet occupancy data collected by the Bureau of Land Management Coos Bay District, and canopy metrics calculated from discrete return airborne lidar data, to model probability of occupancy. Lidar provided a means of quantifying 3-dimensional canopy structure with variables that are ecologically relevant to canopy-associated species, but have not been as accurately quantified by other mensuration methods. By providing new ways to quantify forest structure, Lidar expands the lexicon that can be used to describe and understand the physical features that influence habitat selection and use, thereby increasing our capacity to understand habitat relationships.

ENHANCEMENTS TO MAPPING OF GLACIAL DEPOSITS IN THE NORTHEASTERN U.S. USING LIDAR

Mary DiGiacomo-Cohen, Janet R. Stone, Byron D. Stone

Mapping of complex surficial geology in the glaciated Northeast U.S. has traditionally relied on detailed 1:24,000-scale, 10-ft contour interval topographic maps. Predictive geologic models developed using topographic maps and detailed field investigations during the past 50 years have made it possible to produce 1:24,000-scale surficial geologic maps with minimal time spent doing fieldwork. Comparison of current maps in Massachusetts with recently acquired lidar digital elevation models now confirms the basic paradigm of the distribution of sediment types within a bounding landform, but also shows that high resolution, lidar-derived hillshaded imagery depicts highly precise and accurate details not seen before. Remarkable images require revised identification of earth-surface materials in some areas, and invite more detailed, accurate mapping (vector contacts) of various map units and cross-cutting relationships. Enhanced lidar resolution adds convincing proof of bounding contacts and slopes that resolve questions and withstand critical review.

The utilization of “bare-earth” Lidar data has significantly enhanced the surficial mapping process and outcome as demonstrated in newly identified areas of closely spaced outcrop and shallow bedrock (bedrock structure such as strike ridges and fracture patterns), thick till (drumlins), and stratified glacial meltwater deposits. For example: detailed classification of altitudes modeled with glacio-isostatic depression has led to the delineation of new Lake Hitchcock shoreline features (deltas, spits, wave-cut benchs). The high resolution lidar data shows features that are too subtle to appear on topographic maps such as the small closed depressions that are pingo-remnants indicative of former permafrost. Additional examples include newly mapped eskers and landslides (both in thick-till areas and in ice-contact meltwater deposits).

Fault Mapping in an Urban Setting Using Lidar: the Rodgers Creek fault through central Santa Rosa, California

Suzanne Hecker

Most studies that make use of airborne Lidar to map active faults have been located in dense forest canopy, notably in the Pacific Northwest, where traditional mapping methods using aerial photography are hampered by ground cover. In this study, we use high-resolution Lidar topography to map faulting through an urban area, the city of Santa Rosa, CA, where infrastructure obscures the location of the Rodgers Creek fault, a major strand of the San Andreas fault system. We examined the fault crossing through Santa Rosa using a 0.5-m resolution bare-earth DEM from a targeted airborne Lidar survey of the fault. High-density (5 pts/m2) Lidar data were acquired by The National Center for Airborne Laser Mapping (NCALM) in 2007 for NSF-EarthScope along the principal active faults in northern California.

Santa Rosa is situated on the low-gradient (~1°) Holocene alluvial fan of Santa Rosa Creek, and, prior to this study, the trace of the Rodgers Creek fault was thought to be concealed by young alluvium over a distance of 2 km through central Santa Rosa. The bare-earth imagery largely removes the obscuring effects of the urban environment and reveals that the alluvial fan is a high-quality strain marker, preserving in some detail the recent pattern of vertical deformation. A color DEM overlaid on a derivative hillshade with illumination from the northeast effectively highlights small scarps (< 1-m-high) on the floodplain. The scarps define a structurally complex zone of principally transtensional faulting (a pull-apart basin) up to 0.4-km in width that spans much of the floodplain and is part of a broader 1-km-wide right-releasing bend in the fault. We also integrated the surface-trace mapping with geophysical subsurface datasets for the Santa Rosa area to infer three-dimensional fault geometry and rupture behavior. The results of this study demonstrate the value of high-resolution Lidar for mapping faults in an urban setting.

Use of 3DEP lidar for estimating base roughness for hydraulic modeling applications in forested floodplains

Emitt Witt, David Goodrich

Estimating roughness coefficients can be a time consuming and inefficient process during the calibration of hydraulic models. The effort oftentimes requires extensive field labor that can drive modeling costs to unsustainable levels. Furthermore the results of field investigation only represent the area observed during a field visit, therefore, requiring hydraulic engineers to make assumptions regarding the remaining modeling domain that cannot be observed. This is problematic because as the computational domain for such models increases, the amount of unobserved estimation and error increase. This results in a model outcome that cannot withstand critical review because the roughness coefficient estimation method is subjectively derived from individuals of variable field and modeling experience. Therefore an objective methodology for calculating base roughness in a forested floodplain to characterize the land surface component of total hydraulic roughness is needed. Fortunately the USGS 3D Elevation program through its many partners is acquiring lidar source point data at quality levels that support representation of the land surface beneath canopies of forested floodplains. These data should be able to provide an objective process for determining base roughness for further calculating a final floodplain roughness coefficient for hydraulic modeling purposes. This study is designed to validate lidar ground point penetration and accuracy in forested floodplains thereby supporting the development of a method for computing base roughness directly from publicly available lidar source point data.

3DEP - Availability of Quality Level (QL) 2 or Better Lidar Point Cloud Data

Hannah Boggs

The 3D Elevation Program's (3DEP) primary goal is to systematically collect enhanced elevation data in the form of high-quality light detection and ranging (lidar) data, with data acquired over an eight year period. Interferometric synthetic aperture radar (IfSAR) data is acquired for Alaska, where cloud cover and remote locations preclude the use of lidar in much of the State. The data are made available to the public via The National Map, USGS Science Base, Geospatial Platform, and Data.gov. This poster presentation will focus on current high resolution lidar point cloud data availability that meets 3DEP requirements of QL2 or better in the conterminous United States (CONUS), Hawaii, and the U.S. territories.

Editing Contributed Data in Order to Comply with 3DEP Standards

Jeremiah Greif

3DEP receives much of its data from contributed sources that do not necessarily follow the standardized GPSC or Partnership contracting procedures. This poster will highlight how simple in house editing procedures can speed up the process from the time of collection to when it is served out to the public. In many situations the organization that contributed the lidar data free of charge may not have additional resources to make costly and time consuming edits. Having a knowledgeable in house editing team with the correct software to make simple fixes can make the usage of much of this data compliant with 3DEP standards and available for public use.

The unique capabilities of time-series analyses of structural and bare earth terrestrial Lidar data

Sandra Bond, Jim Howle, Gerald Bawden

The USGS California Water Science Center (CAWSC) has successfully utilized time-series terrestrial laser scanning (TLS) to visualize and track motion of structural targets such as levees, bridges, breakwaters, and dams, and of bare-earth targets such as land-surface elevation changes, erosion, tectonic slip, landslides, and glacial creep throughout the western United States. The main purpose has been to create high-resolution lidar (light detection and ranging) datasets for detailed time-series TLS analyses of complex 3D motion over time.

The task of quantifying 3D motion in structural and bare earth applications has typically been attempted by using traditional ground-based total station and GPS or remotely-sensed geodetic techniques such as photogrammetry and airborne lidar. However, these techniques have proven ineffective at capturing complex and small-scale 3D motion. While these techniques can typically cover larger areas, they are limited to a single perspective and a lower spatial resolution and therefore cannot resolve complex movements such as rotation or track centimeter-scale movements over time. TLS offers the unique capability of capturing smaller target areas from multiple perspectives at a substantially higher spatial resolution, thereby minimizing data gaps and shadowing effects and producing an accurate and dense 3D point cloud. Each survey creates a stand-alone dataset which preserves the target area in its entirety as a complete 3D snapshot in time. In addition, the initial survey of a target area produces a comprehensive baseline dataset to which future surveys can be compared. Even small, but potentially significant changes can be detected by differencing sequential TLS surveys that are carefully aligned or co-registered using existing reference features or constructed bench marks.

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During post-processing, the datasets can then be manipulated to create bare earth digital elevation models (DEM), track positional changes of objects, create colored change detection maps, and conduct volume calculations, thus allowing for a multitude of analytical possibilities. Time-series TLS has proven to have a unique ability to quantify, measure, and visualize even small, multi-directional movements that can occur in complex environments, where traditional methods fall short.

U.S. Geological Survey Elevation-Hydrography Breakline Specifications

Christy-Ann Archuleta, H. Karl Heidemann, Silvia Terziotti, Kristina Yamamoto

The U.S. Geological Survey (USGS) is developing hydrographic breakline specifications to improve spatial alignment and integration of the National Hydrography Dataset (NHD), Watershed Boundary Dataset (WBD), and digital elevation models (DEMs). Breaklines are vector features that are used to enforce or maintain linear features on an elevation surface, and can also be used, with proper attribution, as standalone water features in a hydrographic dataset. This poster explains the concept of breaklines and shows how they can be used by the scientific community with digital elevation models and NHD features.

Applications of Airborne Lidar to Landslide Hazard Assessments and Modeling

Rex Baum, Jeff Coe, Bill Schulz, Mark Reid, Dennis Staley, Jason Kean, Dianne Brien, Jonathan Godt, Robert Schmitt, and Eric Jones

Airborne lidar has several important applications to landslide research and hazard assessments. These include (1) mapping landslide deposits and features to constrain their extent and relative age, (2) detailed mapping of rock avalanche deposits to understand their dynamics, (3) ground-surface change detection, (4) statistical or process-based modeling to estimate the landslide susceptibility, (5) process based modeling to predict the timing and locations of landsides, and (6) modeling travel distance and inundation of debris flows for hazard assessment. We present several examples to illustrate the utility of bare-earth lidar in greatly improving the quality of data interpretation and analysis, when compared to results using conventional digital elevation models derived from USGS topographic maps. Mapping landslides using lidar enhances the mapper's ability to recognize landslides and define their boundaries, particularly in areas that are heavily forested. When combined with high-resolution optical imagery, lidar has contributed to mapping and analyzing a recent large, rock avalanche deposit in unprecedented detail. In addition, detailed lidar topography of the valley where the avalanche was deposited facilitated an emergency post-disaster assessment of potential runout in case of future rock avalanches. Pre and post event lidar makes it possible to determine the thickness of slide deposits or quantify erosion and deposition along the paths of debris flows. Computer models of landslide susceptibility and processes benefit from the increased elevation accuracy and high resolution of lidar. Slope is one of the more important parameters in these models and more accurate lidar-derived slopes enhance the predictive power of these models. Another benefit is more detailed and accurate representation of the ground surface, because surface form influences landslide location, movement, and area of inundation both in nature and in models. For these and related reasons, we consider availability of high-quality lidar data essential to further progress in landslide research and hazard assessment.

IfSAR: facilitating high resolution, cost effective mapping of Alaska

Robert Haselwander

Interferometric synthetic aperture radar (IfSAR) is an airborne mapping technology being used to systematically collect new elevation data for the State of Alaska. This collection effort is being coordinated under the 3D Elevation Program (3DEP), an initiative for covering the US with high resolution, high accuracy elevation data over an eight year period. IfSAR usually provides lower resolution elevation products than Lidar; however, it has advantages for mapping in more remote areas and in the presence of cloud cover. The USGS, state, and federal partners have been using IfSAR to map Alaska more quickly and cost effectively than would be possible with lidar technologies. Although lower resolution than lidar, IfSAR products provide much higher resolution, detail, and accuracy than previous statewide mapping efforts. Data generated from IfSAR missions over Alaska are used to create a standard 5 meter DEM product for 3DEP, and to update the Seamless DEM layers of The National Map (1/3rd, 1, and 2 arc seconds). Orthorectified imagery (ORI) and digital surface models (DSM) are additional IfSAR products that are available for some areas through The National Map as "source" data.

Quaternary geologic mapping using Lidar data for a dynamic sandy riverscape in the northern Great Plains: the Norden area of the Niobrara National Scenic River valley corridor, Nebraska

Scott Lundstrom, Jamie McBeth, Jason Alexander

As part of a CSS-NCGMP project on landscape response to climate change in the Greater Platte region, geologic mapping along the Niobrara National Scenic River in northern Nebraska is done in partnership with NPS, USFWS, and the Nature Conservancy, as conservators of this area known for its unique ecological crossroads.

Airborne Lidar data (RMSE horizontal <0.6m; RMSE vertical <0.185m; to produce 1m bare earth grid) was acquired in November 2012 for an area of 68 square miles along the central part of the river valley corridor. The data acquisition was piggybacked on an adjoining, larger area of Lidar acquisition for NRCS. The new Lidar data enables more accurate and precise delineation of many landforms that record extensive postglacial geomorphic response to climate change in this dynamic and ecologically significant area of the Great Plains.
Mapping of several types of geomorphic features in this area are especially facilitated by analysis of Lidar data. Fluvial scarps that bound terraces are basic elements of fluvial landscapes and provide constraints on the history of erosion, incision and changing riparian environments during recent geologic and historic time. Scarps thus provide relatively sharp bounds to deposits of differing ages and potentially to polygonal map units, depending on how classifications are defined. Other geomorphic elements in which mapping is improved by Lidar data include valley/slope margins, distinction of alluvial types (tributary vs. riverine) and characterization of high terraces and eolian dune forms mantling uplands that adjoin the modern river valley.

Combined with analysis of historical airphotos, the above types of mapping can be further classified relative to airphoto dates. Geologic mapping typically involves toggling between various views and combinations of Lidar data within an ArcGIS platform: hillshades (with aspect bias), slope classification (for which aspect is NOT a factor); altitude by color spectra and contours; as well as other georeferenced data, including NAIP orthoimagery and field observations/ sampling sites, partly located with GPS.

Our geologic mapping thus documents historic narrowing of the modern river system and riparian environments and tests for increased incision rates during historic time, among other aspects of environmental change.

Applying topographic openness to measure channel incision in urbanizing watersheds

Marina Metes, Andrew J. Miller, Matthew E. Baker, Dianna M. Hogan

Two small (1.2 and 0.9 km2) predominantly rural headwater watersheds in Clarksburg, Maryland were urbanized beginning in 2003. To mitigate the impacts of urbanization on the surrounding headwater streams, infiltration-focused stormwater best management practice (BMP) facilities were distributed throughout the watersheds to intercept and infiltrate runoff from impervious surfaces. Airborne lidar data were collected before, during, and following urban development at six time steps: 2002, 2004, 2006, 2007, 2008, and 2013. Lidar coverage of a forested control watershed and an urban control watershed were also collected for each time step. This dataset comprised a unique opportunity to examine changes in watershed geomorphology occurring both as a direct and indirect result of urban development.
Grids of tangential curvature (or topographic openness) were extracted from lidar-derived bare earth digital elevation models (DEMs) and used to examine temporal changes in the degree of dominance or enclosure of each pixel in each DEM. Pixels with a value of 90° indicate a flat surface while pixels > 90° indicate enclosure in the landscape. For pixels representing stream segments, the degree of enclosure was used to infer channel incision, and document the rate and magnitude of channel incision through time in both urbanizing and control watersheds. Channel cross-sections measured in the field at multiple sites within each watershed from 2002 to 2010 were used to help ground-truth incised stream reaches delineated from the tangential curvature grids. This information was then used to determine where the highest rates of incision occurred. Channel width, bank height, and longitudinal profile were also extracted from the lidar to further document where significant geomorphic changes occurred along the channels. Observed geomorphic changes were then assessed relative to spatial patterns of BMP placement, forest loss, and local changes in the hydrologic regime in an attempt to understand where and why geomorphic changes occurred.

Identifying Errors within Lidar Datasets

Brent Marz

The 3D Elevation Program (3DEP) was developed to provide high-accuracy lidar for the conterminous United States. This process includes: acquisition, quality control (QC), development of standard lidar based products, and the delivery of these products. The purpose of lidar QC is to find errors and anomalies in the point cloud data and point cloud derived Digital Elevation Models (DEMs). In order to ensure datasets are acceptable they are checked against the USGS Lidar Base Specifications and against the ASPRS LAS specifications to verify the data are compliant. There are a wide variety of errors that may occur in the various datasets such as: spikes/pits, misclassifications, data holidays, tile mismatches, etc. The process of quality control is essential in assuring that errors in lidar data are corrected before being published through The National Map.

Point Clouds from Photogrammetry to Map Coastal Changes

Chris Sherwood, Brian D. Andrews

Point clouds are the fundamental data produced by lidar data collection. There has been a huge effort invested to develop the algorithms and tools needed for processing point clouds to produce a wide array of scientific products. Point clouds are also the fundamental data produced by structure-from-motion (SfM) photogrammetric methods that make use of inexpensive cameras and increasingly powerful software. Several unmanned aerial systems (UAS) were used to collected sample datasets at two locations in Cape Cod, Massachusetts to assess their use in mapping coastal changes. We discuss some of the differences between point clouds from lidar and SfM and our experiences acquiring processing, and using SfM point cloud data for high-resolution coastal modeling applications.

Enhanced Canopy Fuel Mapping through Integration of Lidar Data

Kurtis Nelson, Birgit Peterson

LANDFIRE provides a set of geospatial data layers for modeling fire behavior, among other applications, for all lands within the United States. For current and past mapping and updating efforts, LANDFIRE has relied heavily on field observations and Landsat data for developing a number of products. This has presented challenges in areas where field data are sparse. Such is the case in Alaska, where significant portions of the state are difficult to access and field data collection is expensive and time-consuming. Consequently, data holdings are typically localized and sparse. This led to a reduction in the thematic resolution of LANDIFRE forest canopy height and cover legends for Alaska compared to those in the conterminous United States. In subsequent updates to LANDFIRE products, improving these mapping legends for Alaska was a priority. Lidar data acquired by the satellite-based Geoscience Laser Altimeter System (GLAS) were used in the mapping process in lieu of field observations. GLAS provided hundreds of thousands of observations in Alaska between 2003 and 2009, which were vetted for quality and then used as a substitute for ground-based structural data in the mapping process. The updated forest canopy height and cover products were released as part of the updated LANDFIRE 2010 and 2012 product suites, respectively.

Lidar, an Essential Tool for Geologic Mapping in Subtle Terrain of the South Platte River Corridor, Eastern Colorado

Margaret Berry

Quality-level 2 lidar data acquired for the South Platte River corridor following severe flooding on the Colorado Front Range in September of 2013 have greatly facilitated surficial geologic mapping funded by the Core Science Systems (CSS) National Cooperative Geologic Mapping Program (NCGMP). The South Platte River task of the CSS-NCGMP project strives to better understand the river's history and its relation to eolian activity in the area. The mapping area is mostly of low relief, and has been extensively farmed and cultivated for more than a century. As a result, many geomorphological features of the surficial deposits are either naturally subtle or subdued by land use, making them difficult to distinguish in orthoimagery or aerial photographs. The lidar data are from the 2013 South Platte River Flood Area 1 Lidar data set collected between October 2013 and May 2014, which is publicly accessible from The National Map. The lidar data became available to the project in the summer of 2015 and have since provided a unique view of the landscape. Extent of flood-water inundation of floodplain and low terraces along the river during September 2013 is clearly visible, which facilitates interpretation of the young river-terrace map units. The lidar data also reveal the extent of artificial levees on floodplains of the river and its tributaries. Eolian sand deposits are clearly visible, with dune form evident even within areas traversed by central pivot irrigation. Thin eolian sand deposits, which are particularly difficult to map because underlying river-terrace deposits are also sandy, tend to be distinguishable, as are breaks in slope that mark contacts between other geologic mapping units. Having lidar data available as a tool for geologic mapping at a 1:24,000-scale not only allows for more accurate placement of contacts, but also helps speed the mapping process because subtle geomorphic features are accentuated and therefore more readily mapped. This important benefit results in more time for interpreting the geology of the map area, which leads to a better understanding of geomorphic system response in the region.

Upper Mississippi River System Elevation

Jayme Stone, Jenny L. Hanson, Stephanie R. Sattler, James Rogala, Jason Rohweder

Lidar and bathymetry data were obtained by the U.S. Army Corps of Engineers' Upper Mississippi River Restoration (UMRR) Program Long Term Resource Monitoring (LTRM) element for the Upper Mississippi River and Illinois River floodplains. Previously, the best publicly available elevation data for the entire Upper Mississippi River System (UMRS) was at a resolution of 30 meters per cell, though 10 meter per cell data was available for few areas. Through funding by the UMRR, the Upper Midwest Environmental Sciences Center (UMESC) processed the lidar which was completed in three phases: Tier 1, Tier 2, and Tier 3. Tier 1 derivatives consisted of quick "process and serve" of original LAS files into 1-meter Digital Elevation Models (DEMs), 1-meter Hillshades, and 0.5-meter contours, to make the data available to contributors and researchers. Tier 2 methodology further processed the lidar by classifying data errors, flattening the water surface, smoothing contours, followed by a thorough Quality Assurance/Quality Control (QA/QC) assessment. Tier 3 concluded with the 2-meter topobathy dataset that combined both lidar and bathymetry together. Lidar and bathymetry datasets are beneficial separately but can be powerful when combined into a seamless elevation dataset. Currently, hydrodynamic models used to predict flow and inundation have been limited to predictions in low water conditions. A topobathy product is an important tool in modeling connectivity across a range of flow conditions over time. Topobathy is also important for habitat restoration planning, landscape modeling, and ecological research of floodplain communities. A topobathy data layer is vital to improve the scientific understanding of the river ecosystem, the processes that drive habitat patterns, and the ecological responses to natural and anthropogenic forces. These datasets fill a much needed information gap in large river restoration efforts.

Application of lidar for understanding landscape position and connectivity of wetland ecosystems

Nicholas Enwright, Michael J. Osland, Richard H. Day

Elevation is a fundamental component required for most landscape-scale wetland ecosystem studies. Elevation plays a critical role in regulating coastal habitat found along the land-sea interface through direct influence on the exposure to tidal inundation, salinity, and wave energy. Drainage area and hydrologic connectivity, both of which are important for freshwater wetlands found at higher elevations, are controlled by elevation. Scientists at the U.S. Geological Survey Wetland and Aquatic Research Center utilize lidar data to quantify the landscape position of wetlands and other coastal habitats at high spatial resolutions. These data provide critical information for advancing landscape-level science related to mapping coastal and interior wetland habitats, assessing the vulnerability, and modeling future environments.

The objective of this poster is to provide a brief overview of three efforts that have included application of lidar data. The first project is a recently completed effort that used a bare-earth lidar digital elevation model (DEM), habitat data, and land use data for an assessment of the potential for landward migration of tidal saline wetlands (i.e., mangrove forests, salt marshes, and salt flats, collectively) along the U.S. Gulf of Mexico coast under alternative future sea-level rise and urban growth scenarios. The second project is an ongoing study that involves use of a bare-earth lidar DEM, wetland habitat information, and river stage data to assess connectivity and vulnerability to hydrologic changes of bottomland hardwood forested wetlands along the lower Trinity River in Texas. The final project is an ongoing effort that involves use of bare-earth lidar and bathymetry data for modeling future barrier island habitats for Dauphin Island, Alabama by using relationships between contemporary barrier island habitats and landscape position.

Turning space into time: an example from northwest Washington

Ralph Haugerud, Dori Kovanen, Don Easterbrook

Mapping landforms from large-area lidar surveys illuminates recent earth history. The frame of reference shifts from the vertical succession of strata in the outcrop to the planform view of evolving surficial processes. The simplification that mappable patches of ground were shaped by particular processes at particular times is remarkably successful—obvious overprinting relations are relatively rare. Interpretation of map relations grows from the principles of (1) original near-horizontality (for water-formed features); (2) a modified version of lateral continuity, which we might term continuity of flow (or conservation of mass)--flowing water has a source and a sink; and (3) superposition, though often in an upside-down form, as lower-elevation fluvial features are usually younger.
Interpretation of a 2006 lidar survey of western Whatcom County, Washington shows 9 stages in the retreat of the Cordilleran ice sheet. Marine shorelines which extend to ~450' above sea level demonstrate a large amount of isostatic rebound. Preserved shorelines are short, but stacking them allows fitting of a plane that shows modest (~1 m/km) up-to-the-NE tilting associated with rebound. Anomalously high late Holocene shoreline benches and a deformed fluvial terrace suggest local active faulting.
The earth history obtained from such geomorphic maps has obvious application to studies of earthquake hazards and groundwater resources. The maps include well-documented landslide inventories. Many of the landforms correlate strongly with substrate, thus geomorphic maps are excellent precursors to geologic maps.

Integrating lidar and multi-resolution imagery for vegetation mapping under the National Vegetation Classification System hierarchy

Miguel Villarreal, Natalie R. Wilson, Sarah Studd, Dan Stauning, Jeff Galvin

The National Vegetation Classification System (NVCS) is a hierarchical system designed to classify existing vegetation based on percent cover, structure, and floristics. The upper levels of the classification are defined by community characteristics that can be measured in 3-dimensions: plant growth form, spatial structure and percent cover, while the lower levels are defined by floristic characteristics that are better measured with spectral data. We hypothesized that aerial lidar combined with multispectral imagery collected before and during the growing season could be used to accurately map both upper and lower level characteristics of certain plant communities. We employed high- and mid-resolution imagery and airborne lidar to map vegetation at Saguaro National Park, which has a wide-range of vegetation types ranging from sparse, low-elevation desert communities to closed-canopy mixed conifer forests at upper elevations. Vegetation was classified using Random Forest models and a suite of spatial predictor variables. The most accurate models included the following predictor variables: lidar canopy height models, topography, vegetation phenological proxies from multi-temporal Landsat 5 Thematic Mapper (TM) imagery, and bare ground and vegetation spatial/structural information derived from high-resolution (1m) multispectral imagery. Incorporation of vertical and horizontal structural information improved class discrimination in transitional zones and areas where different dominant species had similar spectral profiles.

Comparisons of lidar- and SfM-based topographic mapping of California sea cliffs.

Alex Snyder, Jonathan Warrick, Patrick Limber, Andrew Hill, Joshua Logan

Remote sensing methods such as airborne and ground-based lidar are critical to monitoring coastal change and conducting detailed studies of the physical processes involved in shaping the coastline, especially in inaccessible areas such as sea cliffs. Structure-from-Motion (SfM) techniques, which use overlapping photos taken from consumer grade cameras to produce digital elevation models, have recently emerged as another remote sensing option. SfM methods have the advantage of producing low-cost, high-resolution measurements, making studies that require higher temporal frequencies more feasible. Additionally, SfM's photo-derived dataset can be analyzed visually as well as quantitatively. Here we evaluate the utility of ground-based and aerial SfM methods for measuring sea-cliff erosion and compare these techniques with aerial and ground-based lidar. The datasets used for this comparison are focused on the soft, quickly-eroding cliffs at Fort Funston National Park in California. Surveys were conducted over the course of the recent El Nino event during the winter of 2015-16, which produced large waves and significant beach and sea cliff erosion. Data from ground-based lidar and SfM are compared to assess spatial coverage afforded by each method, and evaluate the level of ground control required for SfM techniques to yield accuracy comparable to lidar.

Extracting Fluvial Geomorphic Measures from Lidar to Estimate Sediment Deposition and Erosion

Peter Claggett, Samuel Lamont, Marina Metes, Greg Noe

The USGS and West Virginia University have recently developed a Python toolbox for ArcGIS leveraging the capabilities in TauDEM to calculate key metrics describing channel and floodplain geometry based on published works such as GeoNet (Passalacqua, 2012), the Riparian Topography Toolbox (Dilts and Yang, 2010), and the River Bathymetry Toolkit (McKean, et al, 2009). No other tools were found that automatically calculate specific channel and floodplain geometry metrics on a watershed scale rather than a reach scale, with no required field data. The USGS Stream Channel and Floodplain Metric Toolbox enables the automated extraction of channel width, bank height, bank angle, floodplain width, and floodplain elevation range, allowing for regional analyses based solely on lidar-derived digital elevation models. These geomorphic measures have been field verified through comparison with stream cross-section data. The metrics are currently being related to field measurements of bank erosion and floodplain deposition rates in the Chesapeake Bay watershed to facilitate inferences about local-scale sediment budgets. The features and functionality of the tool will be presented along with its application for modeling sediment budgets. The limitations of available lidar data for assessing stream geomorphology will also be discussed.

Utilization of Small Unmanned Aircraft Systems for Acquiring High-Resolution Elevation Data

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Joseph Richard, U.S. Geological Survey – Missouri Water Science Center
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The U.S. Geological Survey (USGS) Unmanned Aircraft Systems (UAS) National Project Office in Denver, Colorado is working to implement the use of UAS technology into assisting with mapping data acquisition and derivation of datasets for point cloud creation, digital surface model and orthophotography generation. Contracted small UAS flights were used over the West Fork Lead and Zinc Mine near Bunker, Missouri in cooperation with the USGS Missouri Water Science Center in Rolla, MO. Use of small consumer UAS, inexpensive commercial off-the-shelf cameras and computer vision structure-from-motion software allows for creation of very accurate data using this technology. This project investigates comparisons with satellite elevation derivation, pros and cons of using these techniques and illustrates a new capability of supplementing other mapping capabilities.