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National Enhanced Elevation Program Concept and Applications

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U.S. Geological Survey

Outline

- Some Context
- Lidar Capabilities, Applications and Challenges
- Goals of a National Enhanced Elevation Program
- Development a National Business Plan
- Next Steps

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Geotechnology Evolution

- 1970's Introduction of the digital map
- 1980's Linking digital maps to descriptive records
- 1990's Map analysis and modeling
- Current decade – Multimedia internet mapping and visualization

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From John Berry "Beyond Mapping" GEOWORLD Jan 2010

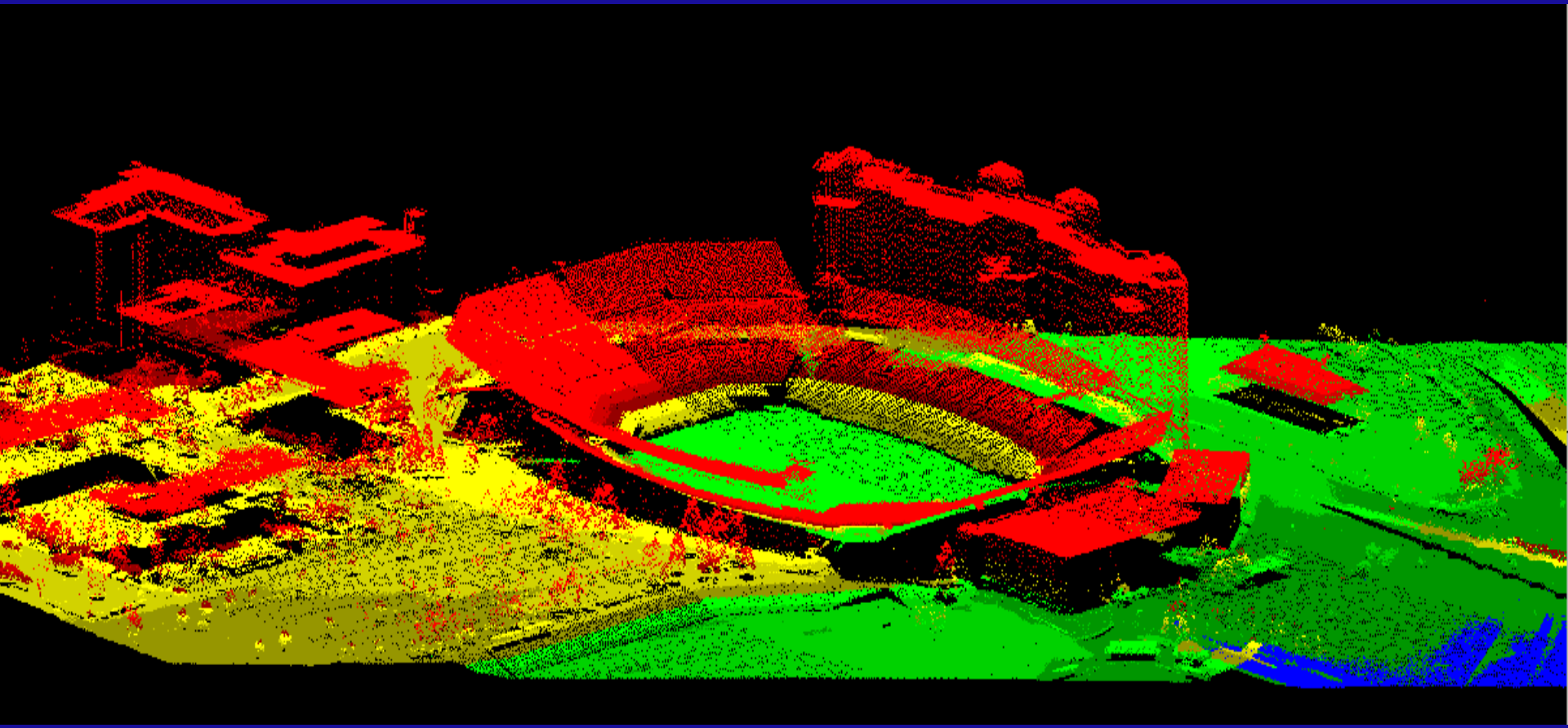
Perfect (Geotechnology) Storm

- Convergence of:
  - Computing power
  - Maturation of GPS and remote sensing
  - Ubiquitous internet
  - Availability of mapped data

From John Berry “Beyond Mapping” GEOWORLD Jan 2010

In Comes Lidar

- **Revolutionary 3D mapping technology**



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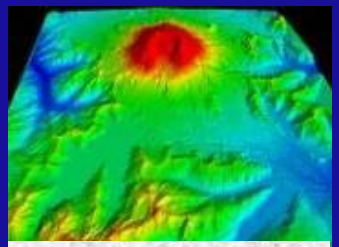
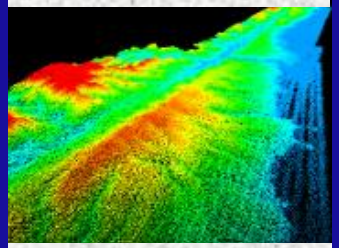
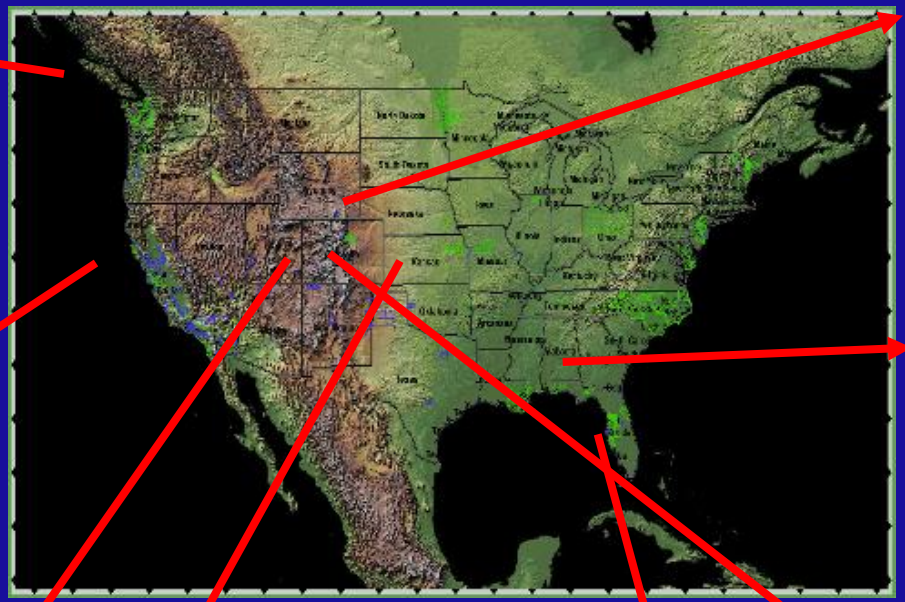
Lidar Supports Many National Applications

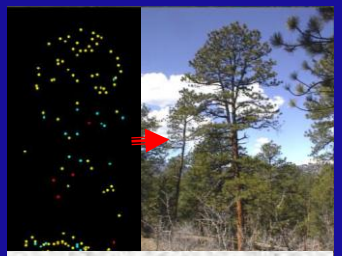


Volcano monitoring



Earthquake faults



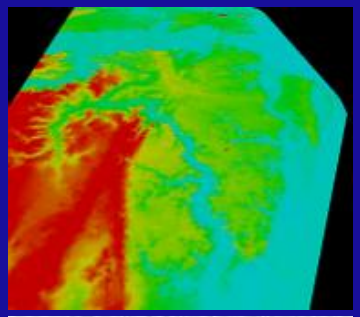


Vegetation / Biomass

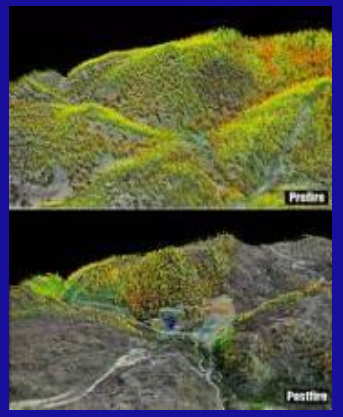
Land Cover

Hydrologic Studies

Urban / Suburban Response



Coastal Studies



Carbon / Disturbance studies

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Lidar Applies Across USGS Science Strategy Directions

Understanding Ecosystems and Predicting Ecosystem Change

Energy and Minerals for America's Future

A National Hazards, Risk, and Resilience Assessment Program

The Role of Environment and Wildlife in Human Health

A Water Census of the United States

Climate Variability and Change

Data Integration and Beyond

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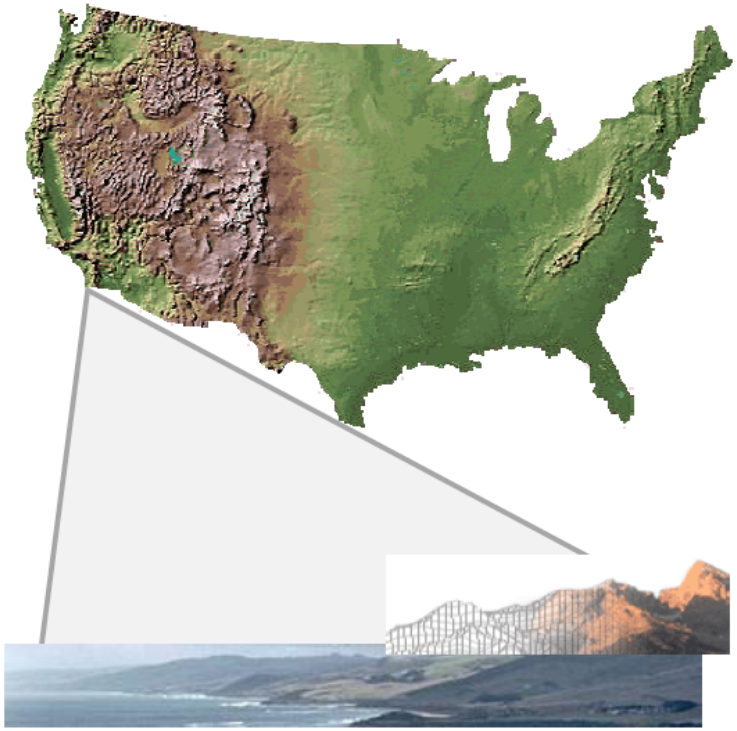
Lidar for Upgrading the NED

Pine warbler (*Dendroica pinus*)

Breeding habitats are open pine forests with little undergrowth in eastern United States. Forages on tree trunks and branches for pine cone nuts and the ground for insects. One of the few warblers that eats large quantities of nuts, particularly pine nuts. Nests are open cups towards end of tree branches.

Elevation Data Acquisition

Elevation data acquisition will establish FEMA's elevation data foundation and will enable credible Risk MAP products. Partnership contribution will increase data, reduce costs, and reduce duplication of effort amongst mapping partners.

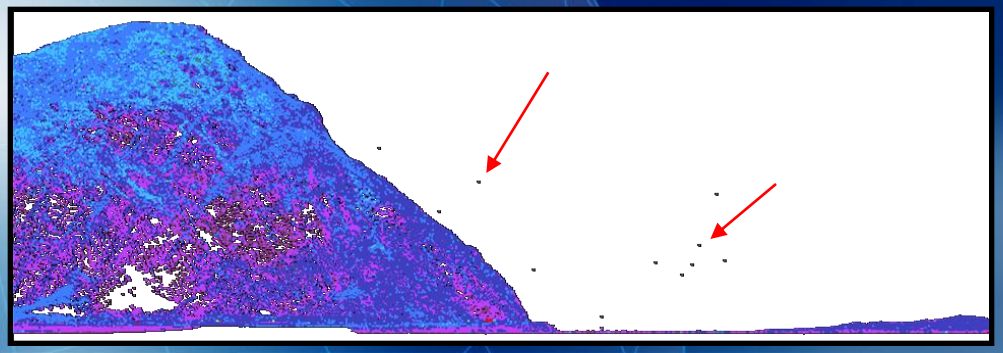


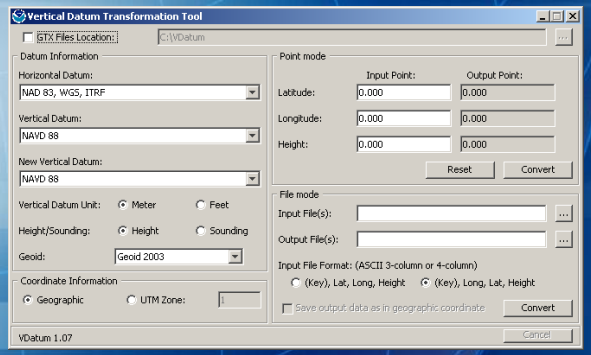
- Leverage available data and acquire limited new data
- Identify existing value-added sources of data and announce that FEMA seeks to cost share for high-quality data
- Permit data acquisition as separate element of work
- Acquire on watershed basis taking into account economies of scale

Lidar Shoreline Extraction

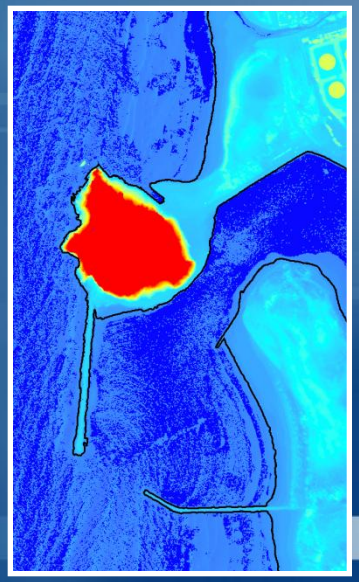
NATIONAL GEODETIC SURVEY

Edit Lidar Point Cloud

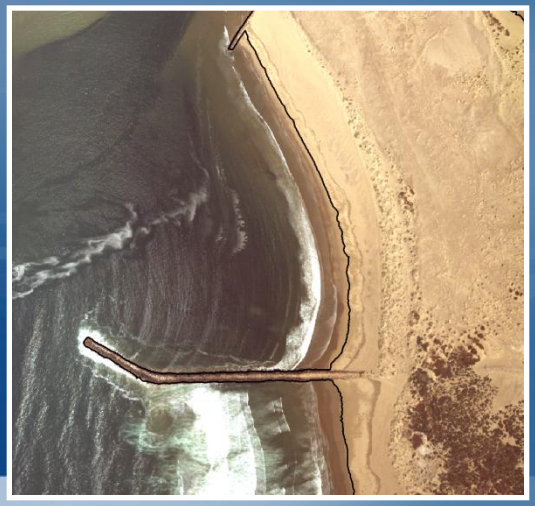




VDatum



Contour Shoreline from DEM



Quality Control &
Feature Attribution

National Oceanic and Atmospheric Administration

- **Conservation Planning**
  - Assists in practice alternative selection.
- **Conservation compliance**
  - Improved wetland boundary mapping with 2 foot contour maps.
- **Emergency Watershed Protection**
  - Debris and sediment removal LIDAR data provided a pre-storm contour map

Examples of Products Derived from Automated Feature Extraction (in the State of Ohio)

- Land Cover
- CAUV
- Property Appraisal
- Impervious Surface
- ROW
- Change Detection
- Building Footprints
- Insurance Assessment
- Flood Zones
- Green Space
- Parks

Bsse image courtesy Woolpert. For purposes of example – not as a company endorsement or preference

WOOLPERT

How Many Applications ?

- Mapping confined urban channels vs natural stream
- In the creation of seamless topo/bathy products
- Integration of elevation data into the National Elevation Dataset
- Derivation of stream channel characteristics
- Mapping and monitoring coastal hazards
- Identification of small hydrologic features (ditches, tile drain studies)
- Mapping fish habitat
- Characterizing wildlife habitat
- Identification of canopy gaps
- Flood inundation modeling
- Derivative hydrologic profiling
- Disaster response
- Fire science
- High-resolution floodplain mapping
- Characterization of canopy structure
- Defining drainage basins
- Jokulhaup monitoring
- Fault-rupture mapping
- Monitoring sea level rise
- Natural Hazards
- Identifying landslide-prone areas
- Creating topographic maps
- Glacier changes
- Carbon sequestration assessments
- Homeland security scenarios
- Delineation of canopy surface and forest metrics
- Determination of watershed characteristics
- Delineation of building structures
- Characterization of urban settings
- Monitoring long-term shoreline change
- Mapping land cover and land use
- Measuring earthquake deformation
- Delineation of volcanic structure
- Monitoring volcano hazards
- Urban mapping
- Powerline mapping
- Hydrologic Modeling
- Bare earth products
- Monitoring debris flows
- Wave height surveys
- Sedimentation into rivers
- Monitoring geomorphic processes
- Identification of ponding areas
- Mapping wetland drainage
- Creation of synthetic drainage networks
- Identifying culverts
- Transportation mapping
- 3-D visualization of buildings
- Volume visualization
- Identifying bird habitats
- ……..

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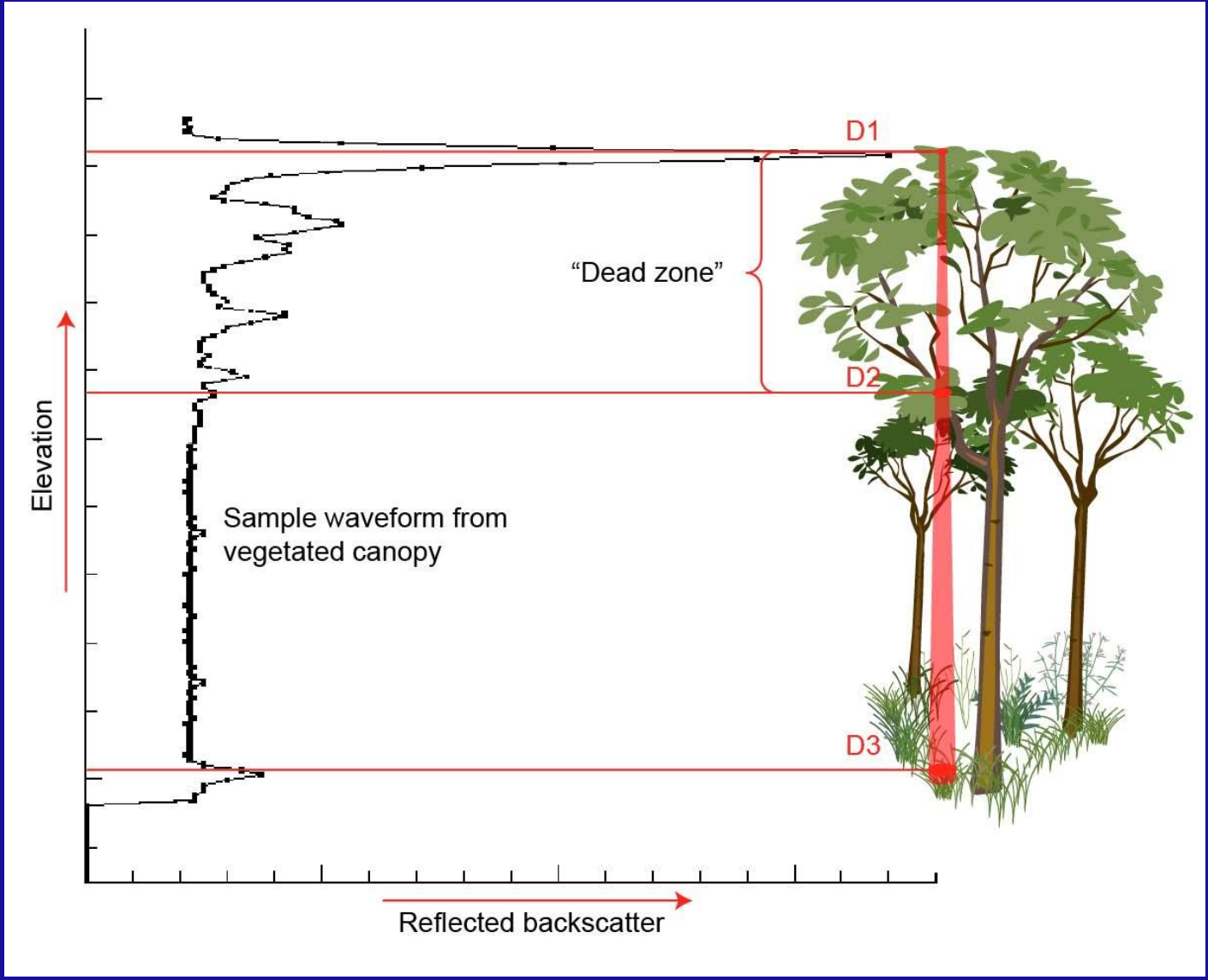
Waveform-digitizing vs. Discrete-return



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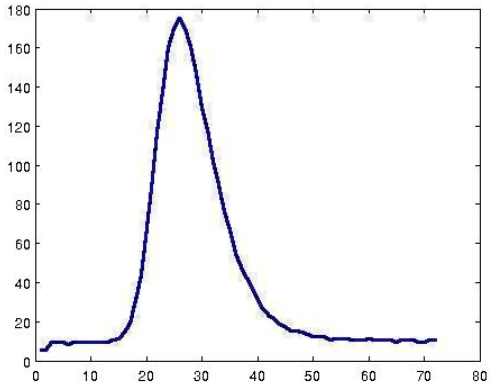
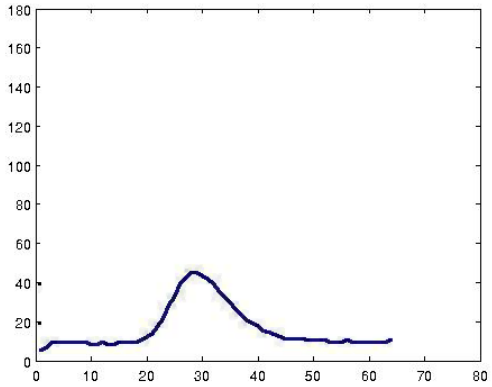
Examples of typical waveforms

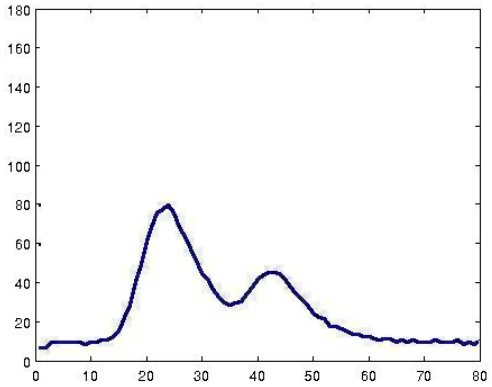
Grass



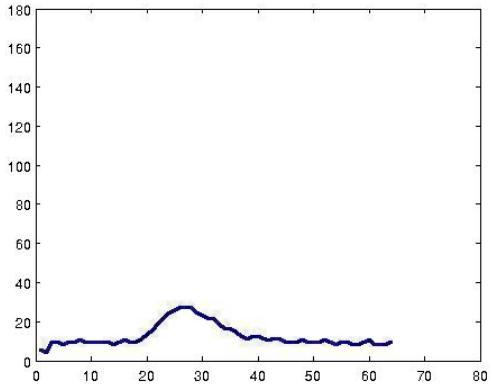
Roof



Tree

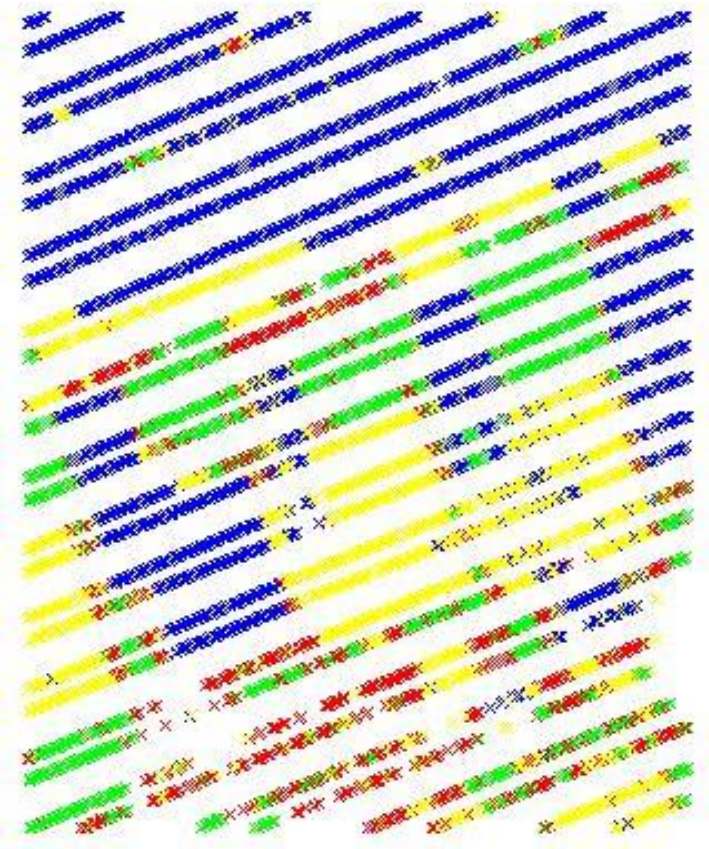


Road



Using the web based application different types of backscattered signals can be observed for trees, grass, pavement, roofs on the Scarborough dataset. Some typical waveforms are illustrated here.

Classification according to the waveform shape



Classification using amplitude, standard deviation, skewness and kurtosis

Challenges

- Software lags behind sensor development
- Consistent methodology for error/performance, validation/characterization
- Seamless integration of lidar from a variety of sensors
- Fusion of lidar and spectral imagery
- Rapid evolution challenges standards process
- Very large data volumes, a persistent challenge

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Expectations of a National Program

- Cohesive pre-planned national effort to map the terrain, built environment and vegetation structure at high spatial detail and accuracy
- Multi-use for environment, infrastructure, forestry, hazards, etc.
- Balances requirements, benefits and costs
- Standards-based to maximize interoperability and multi-use
- Includes partnerships among Federal, State and other organizations
- Offers on-demand derivative products for agency business uses
- Relies extensively on commercial sector capabilities
- Spawns new markets and user communities

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Why is Better Data Needed?

- Many applications require it!
  - For example, National Elevation Dataset has an RMSE of 2meters
  - FEMA guidelines for flood hazard mapping require a RMSE of .185meters
- 3D data for above-terrain features (vegetation and built-up) has never been fully utilized
- Recent high resolution lidar collections are inconsistent and difficult to integrate

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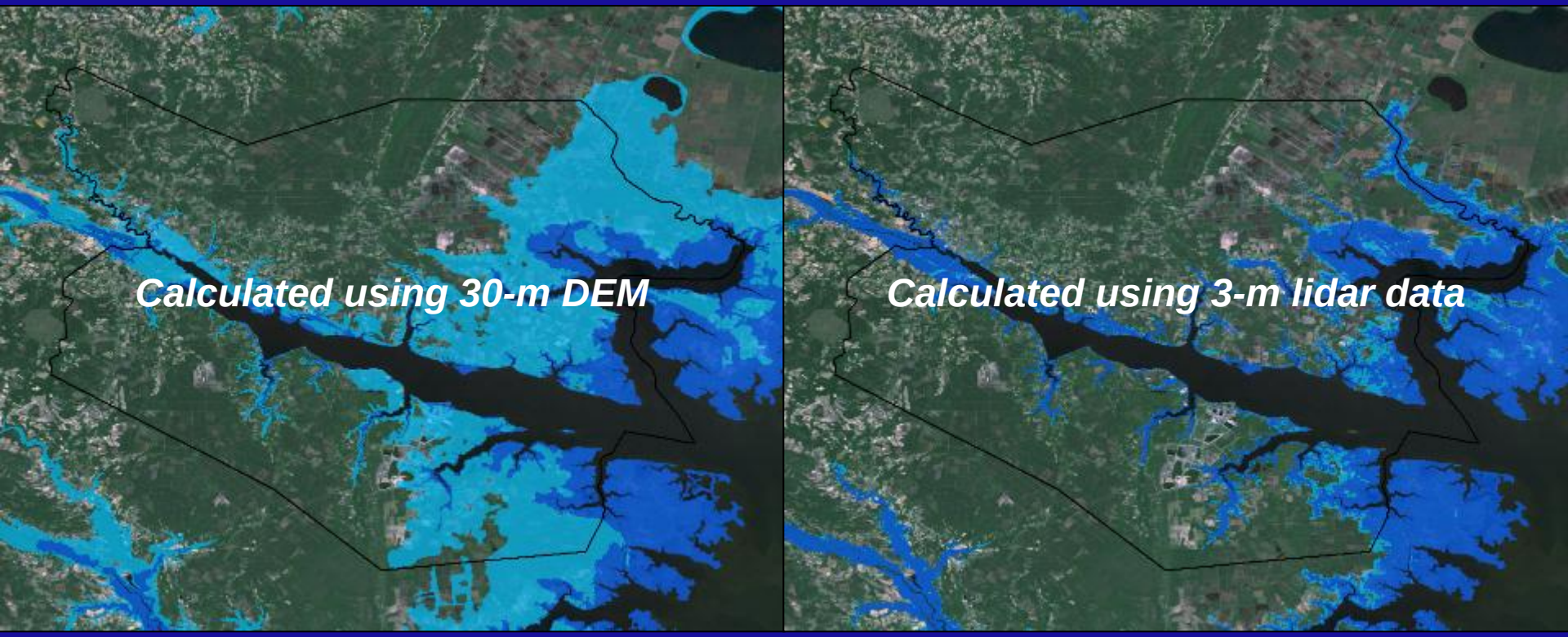
Beaufort County, North Carolina

Modeling Flood Inundation: if Sea-Level Rises 1-Meter

Lighter blue tint is the area of uncertainty



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NRC 2007 - Elevation Data for Floodplain Mapping

Recommendations:

- "*Elevation for the Nation* shall employ lidar as the primary technology for digital elevation data acquisition.

- "A seamless nationwide elevation model has application beyond the FEMA Map Modernization program … As part of *Elevation for the Nation*, federal, state, and local mapping partners should have the option to request data that exceed minimum specifications if they pay the additional cost of data collection and processing required to achieve higher accuracies.

- "The new data collected in *Elevation for the Nation* should be disseminated to the public as part of an updated National Elevation Dataset."

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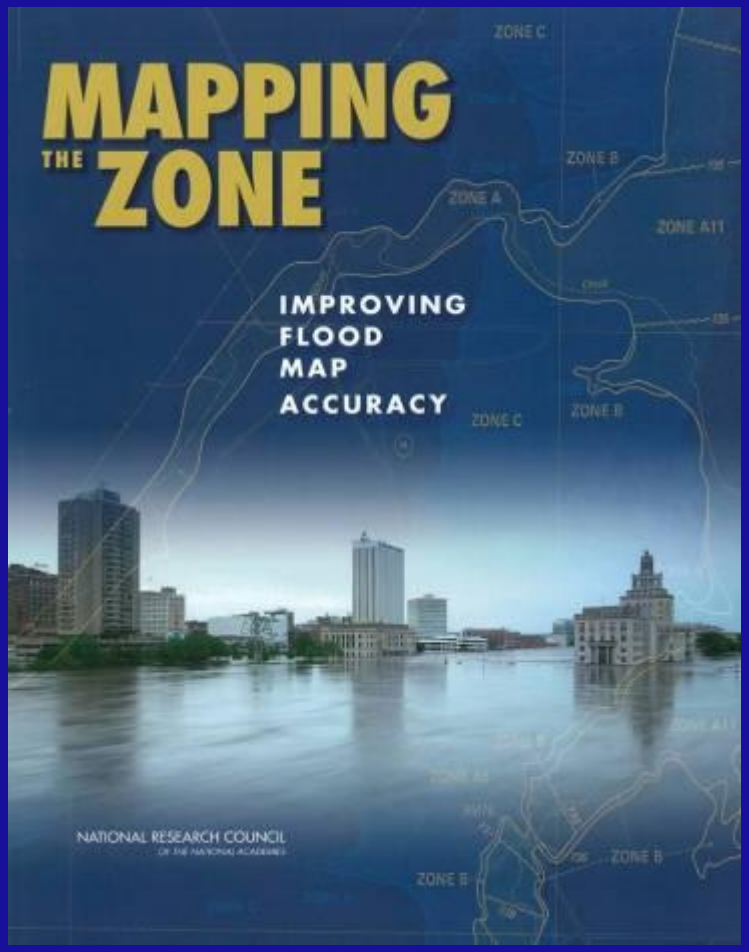
2009: 2nd NRC Report



Finding 1: "Topographic data are the most important factor in determining water surface elevations, base flood elevations, and the extent of flooding and, thus, the accuracy of flood maps in riverine areas."

Recommendation 1: "FEMA should increase collaboration with federal (e.g., USGS, NOAA, U.S. Army Corps of Engineers), state, and local government agencies to acquire high-resolution, high-accuracy topographic and bathymetric data throughout the nation."

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Business Plan Development: 2010 National Enhanced Elevation Study

- Being funded by National Digital Elevation Program agencies to:
  - Develop and refine requirements for a national program to meet priority Federal, State and other national business needs
  - Identify optimal program implementation alternatives and associated benefits and costs

- Quantify answers to key questions:
  - Is it more cost effective for the Government to manage these activities within the context of a national program?
  - Are there additional national or agency benefits derived from such a strategy, and what are they?
  - What are key technical limitations or innovations that may impact the appropriate timing or strategy for a national program?

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National Lidar Stakeholders

- DOI/USGS, FEMA, USDA, NOAA, USACE, NASA, DOT, NGA and others
- States, regional, local and tribal governments
- Private Sector
- Organizations:
  - Association of American State Geologists
  - National States Geographic Information Council
  - National Association of Counties
  - AmericaView
  - Coastal States Organization
  - ASPRS, AAG, URISA, etc.
  - MAPPS
  - Science consortiums
  - Academia
  - Others…

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Plans for FY 2010

- Advance coordinated lidar program planning through NDEP steering committee
- Enhance data consistency across agencies through best practices and standards
- Expand collection activities funded by ARRA and evaluate the benefits
- Complete the National Enhanced Elevation Program Study

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