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# Airborne Laser Remote Sensing Technology: Providing Essential Hydrologic Information in the 21st Century

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Presented by:
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## *Points of Discussion*

- Brief overview of hydrology and why it is important.
- Geospatial data requirements
- Remote sensing tools
- Elevation data requirements
- Airborne laser mapping and its hydrologic applications
- Conclusions

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## *Background*

- Need for understanding of hydrology has exploded with the growing interest in climate change, water related disease, scarcity of water and water related disasters.
- Availability for consumption, hydro electric, irrigation, industry, transport.
- Conflict and disputes over valuable resource, trans boundary issues.
- Disaster management; floods, land stability, disease

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## *Hydrographic Models*

- Need better management tools
- Hundreds of hydrologic models have been developed
- Models include a multitude of parameters
- Measurements and data currently constrain hydrologic understanding
- Complicated surface was traditionally ignored
- Elevation models proved to be efficient way of representing the surface

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## Geospatial Information Needs in the Hydrology Context

| Flooding | Modeling | Management and General Needs |
|---|---|---|
| • Before: identification of risk (Flood Insurance Risk Zones see FEMA web site).<br>• After: What, Where, when and impact?<br>• Accurate information available in the field during event<br>• Same info throughout area | • DEM (10-15cm or better)<br>• Land use/cover<br>• Soil type and properties<br>• Weather details (precipitation amounts/type, snow)<br>• Stream dynamics, flow rates | • Detailed and holistic data sets of catchment/drainage basin<br>• Data fusion<br>• Water volumes<br>• Location of animal concentrations<br>• Location of construction<br>• Water harvesting details<br>• Faster data capture |

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## *Remote Sensing*

- Remote sensing makes study of messy surface possible by giving a more complete picture.
- Been used by hydrologists since its inception
- Many hydrologic models use remotely sensed data as input
- Only practical method to gain information on complex terrains and land utilization
- Can provide both the temporal and spatial requirements

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## *Elevation Data*

- A DEM is an efficient way of representing the surface
- Can provide a large number of Hydrologic features
- Detailed DEM's required for more complete and sophisticated models
- Example: flood mapping requires 1-3 m resolution, better than 15cm accuracy . Repeated between 1-3 years.
- Airborne laser mapping is the most practical method of collecting detailed elevation data

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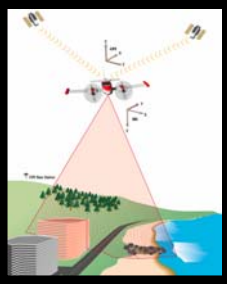
**Airborne LIDAR systems employ enabling technologies that include..**

- **GPS Constellation fully deployed**
- **IMU Inertial Measurement Unit**
- **Laser Diode-pumped solid state**
- **TIM Time Interval Meter- single-shot timing electronics**
- **OOS Oscillating Optical Scanner**
- **Powerful, low-cost PCs for data processing**



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**Optech's ALTM 3100 EA offers accuracy - second to none in the industry**

**Elevation accuracy ±1-sigma**

| Laser Rep Rate (kHz) | 500 m altitude | 1000 m altitude | 2000 m altitude | 3000 m altitude |
|---|---|---|---|---|
| 33 | <5 cm | <10 cm | <15 cm | <20 cm |
| 50 | <5 cm | <10 cm | <15 cm | N/A |
| 70 | <10 cm | <10 cm | <15 cm | N/A |
| 100 | <10 cm | <10 cm | N/A | N/A |

*Note: Quoted accuracies do not include GPS errors.*

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## *Airborne Laser Scanning*

- Provides improved data required for detailed modeling
- Greater resolution and accuracy ideal for hydrology
- Versatility and efficiency
- Provides ground model under vegetation
- Other important information: vegetation height, snow pack, surface roughness, change detection, volumes.
- Can produce both traditional cross sections as well as detailed catchment area models

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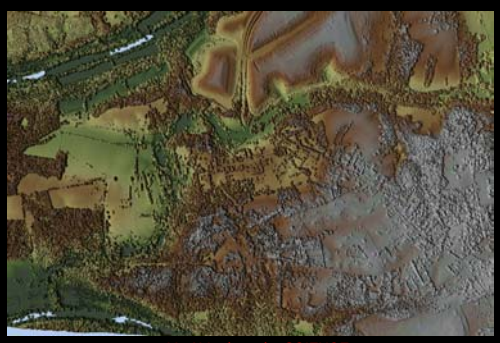
## *Airborne Laser Terrain Mapper (ALTM) DSM 1m*



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*Airborne Laser Terrain Mapper (ALTM) Intensity*

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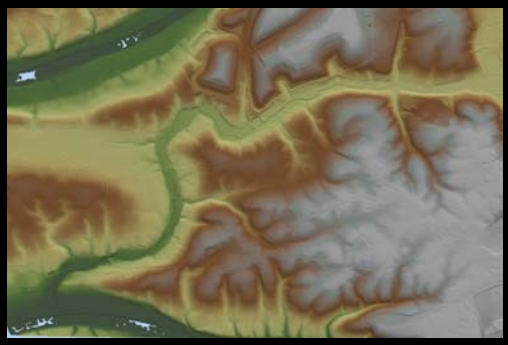
*Bare Earth model 1m*



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*Bare Earth model 10 m*

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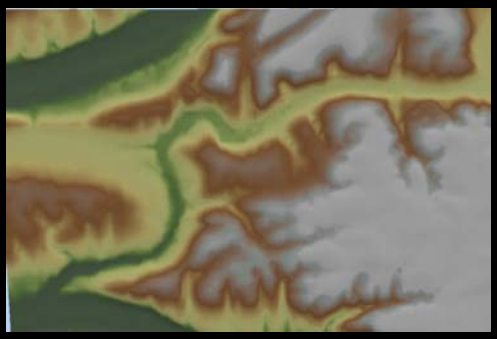
*Bare Earth model 30 m*



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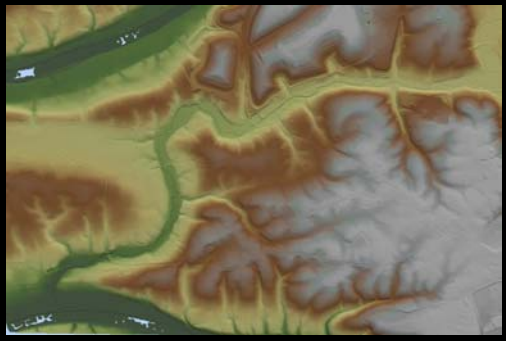
*Bare Earth model 1m*



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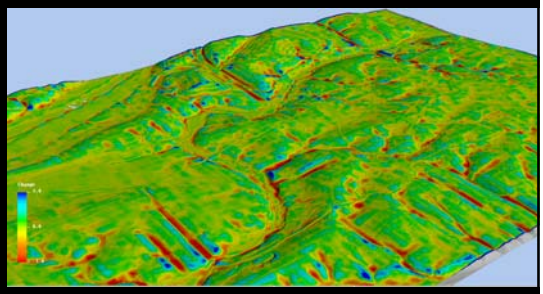
*Difference between a 1m and 30 m DEM*



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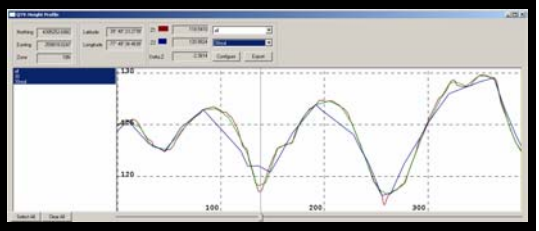
*Profile comparing three resolution DEM's*



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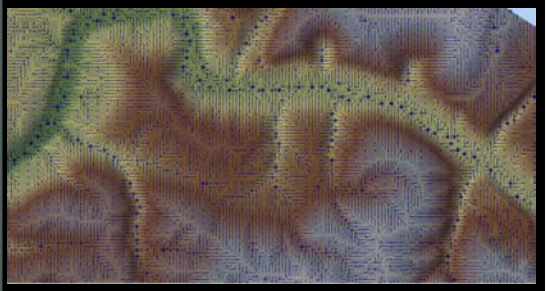
*Surface drainage network 10 m*



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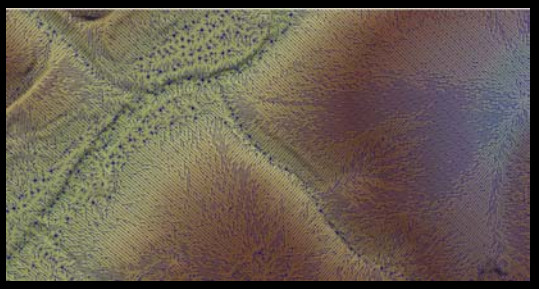
*1m Surface drainage network*



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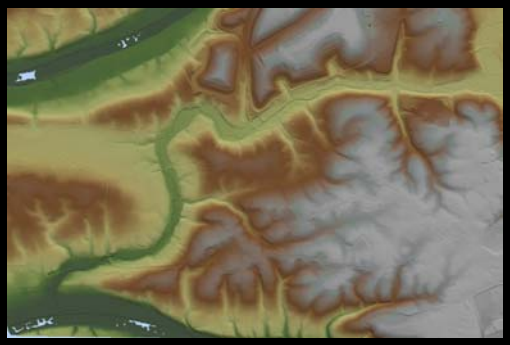
*Small problem areas*



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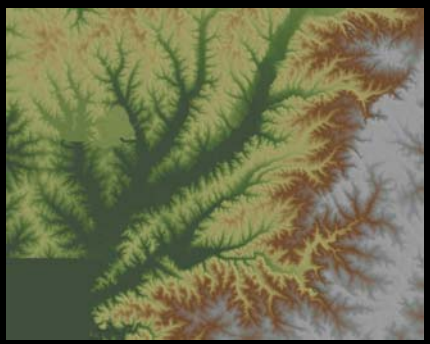
*Large area mapping*



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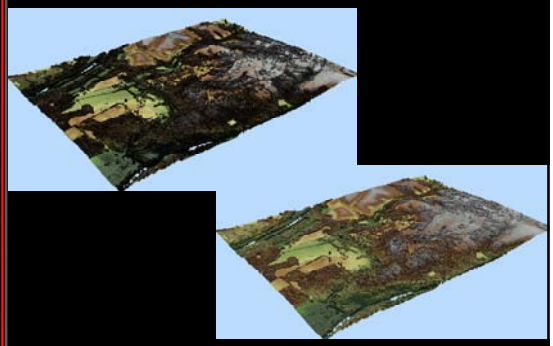
*Visualization of models*



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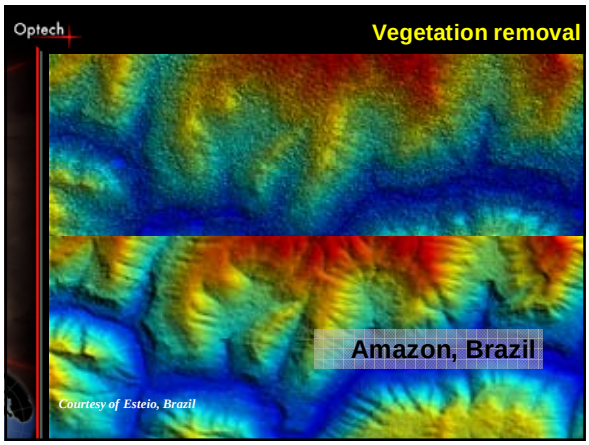
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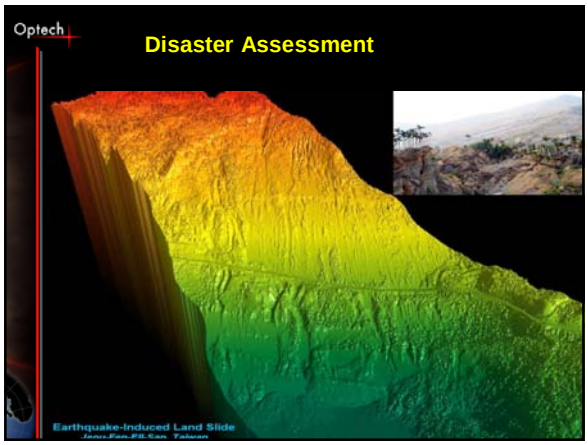
Vegetation removal
Amazon, Brazil
Courtesy of Esteio, Brazil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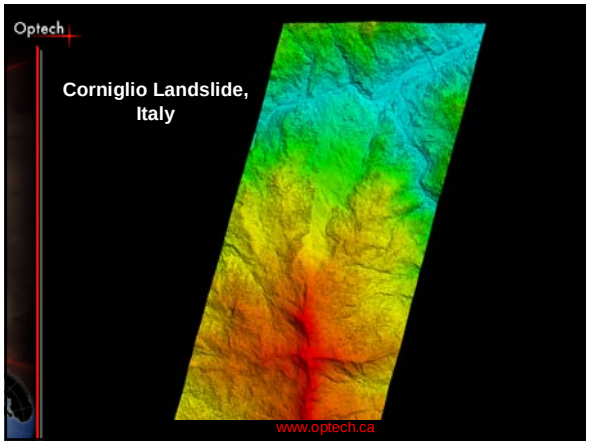
Disaster Assessment
Earthquake-Induced Land Slide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Corniglio Landslide, Italy
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Corniglio Landslide, Italy
Vegetation On
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Corniglio Landslide, Italy
Bare Earth Model
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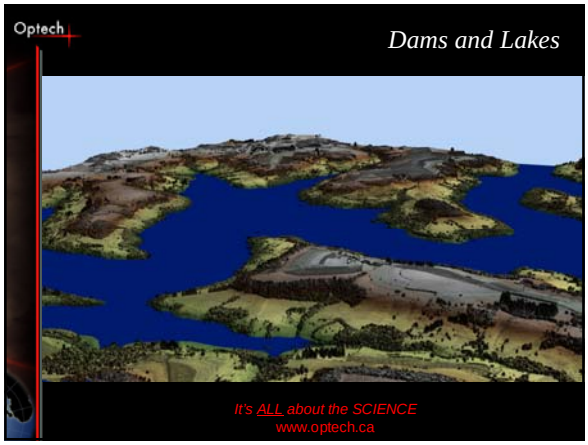
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Dams and Lakes
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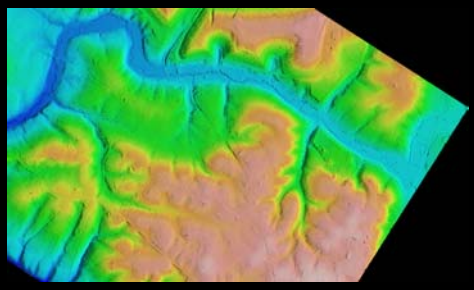
*Simulated Dam*



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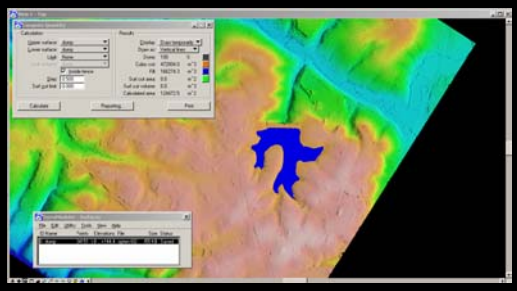
*Simulated Dam*



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*Flood Simulation*

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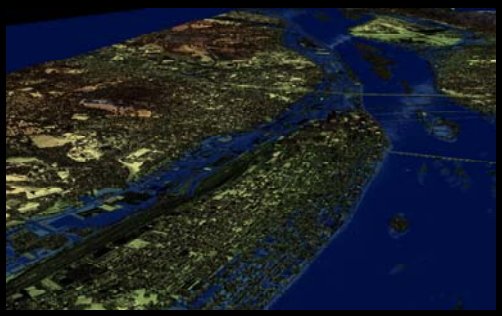
*Visualization of models*



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***Camden & Burlington Counties, NJ***

- July 12, 2004. Heavy rains New Jersey (USA). Over 13 inches in less than 24 hours.
- Significant localized flooding in Burlington and Camden Counties.
- Failure of 12 dams and the partial breach of 5 more in Burlington County.
- Perform a riverine hydrologic and hydraulics analysis.
- Spot spacing of no more than 1.4m. Met FEMA specs for mapping up to a 2ft contour interval

Airborne 1

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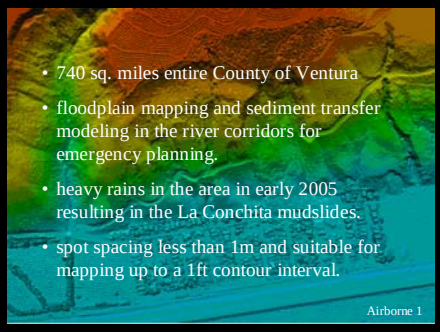
## *Ventura Country, CA*






## Hydrology Geospatial Requirements Met With Lidar Data

| Flooding | Modeling | Management and General Needs |
|---|---|---|
| • Provides 3.5 to 15 cm accuracy DEM suitable for flood prediction<br>• Provides What, Where, when and impact information<br>• Fast collection and data turn around during event | • Provides DEM (3.5-15cm) Land use/cover<br>• Lidar combined with digital cameras /multispectral sensors can provide most relevant data<br>• Wall to wall data improves stream dynamics data modeling | • Provides detailed and holistic data sets of catchment/drainage basin<br>• Data fusion easily obtained<br>• Accurate volumes quickly obtained<br>• Identification of physical factors influencing water courses.<br>• Fast data capture and processing<br>• Multiple data sets from one sensor |



## Toronto, Canada



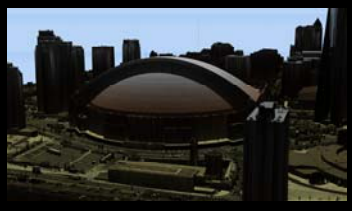
## *Conclusion*

- Hydrologists require high resolution DEM's to create accurate models
- Airborne laser mapping can provide this type of information in a fast and convenient manner.
- Airborne laser mapping technology has gained acceptance by hydrologists
- Airborne laser mapping is a tool that will truly change the way hydrologists do their work in the 21st century



## Thank You

**Questions?**



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