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Application of LIDAR Terrain Mapping to Flood-Hazard Mapping

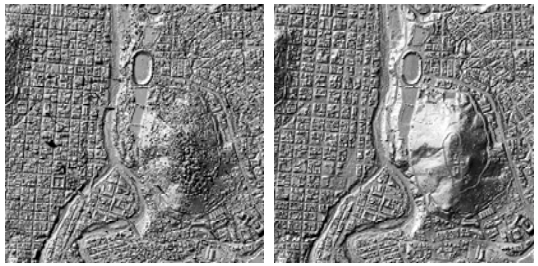
Methods described here were applied to 15 municipalities in Honduras in 2000 and 2001 as part of a U.S. Agency for International Development sponsored project for rebuilding in Central America after Hurricane Mitch, a category 5 hurricane that struck the country in October-November 1998.

1. Acquire LIDAR (Light Detection and Ranging) digital elevation data

From Optech website http://www.optech.on.ca

LIDAR was acquired under contract with the Bureau of Economic Geology, Coastal Studies at the University of Texas with an Optech ALTM 1225 module mounted in a fixed-wing airplane that was flown over selected municipalities in Honduras during February and March 2000.

2. Create "bare-earth" DEM by removing vegetation

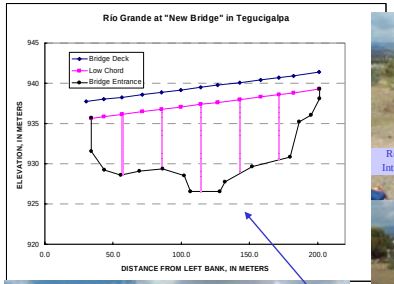


Hillshade of unfiltered LIDAR Digital Elevation Model (DEM)

Hillshade of filtered LIDAR of downtown Tegucigalpa

The vegetation-removal algorithm was applied to the left hillshade image to produce the right hillshade image. Note bare appearance of Juan A. Lainez hill, the large hill near the center of the image.

3. Survey bridge openings

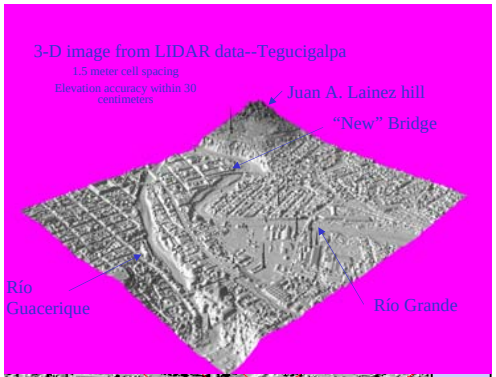


"New Bridge"

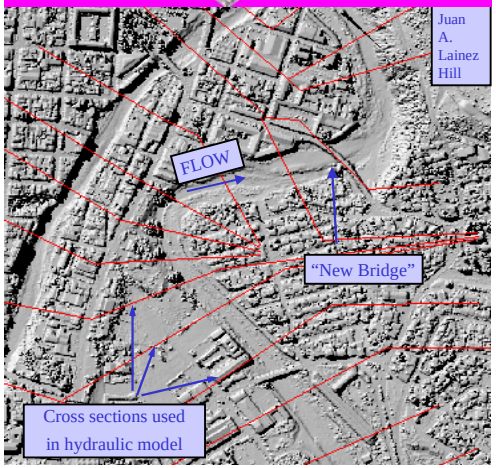
LIDAR cannot "see" critical bridge-opening geometry, therefore field surveys are needed.

4. Establish river cross sections

A



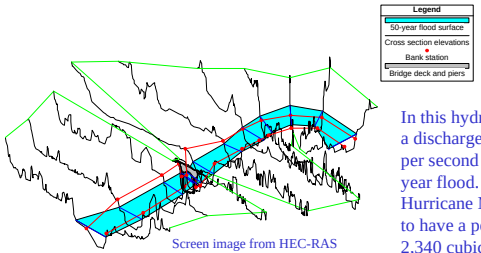
B



A. 3-D LIDAR hillshade image of downtown Tegucigalpa, Honduras

B. Cross sections superimposed on a 2-D LIDAR hillshade image of the same area.

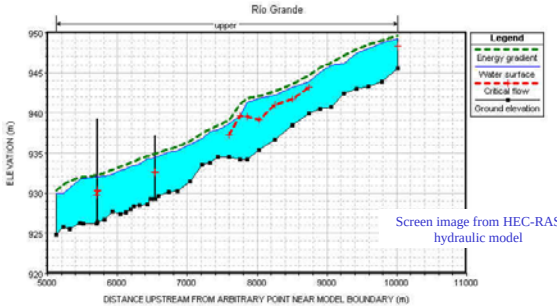
5. Enter cross-section data and discharge into step-backwater model



Screen image from HEC-RAS hydraulic model

In this hydraulic model we used a discharge of 663 cubic meters per second to represent the 50-year flood. The flood during Hurricane Mitch was estimated to have a peak discharge of 2,340 cubic meters per second near this location.

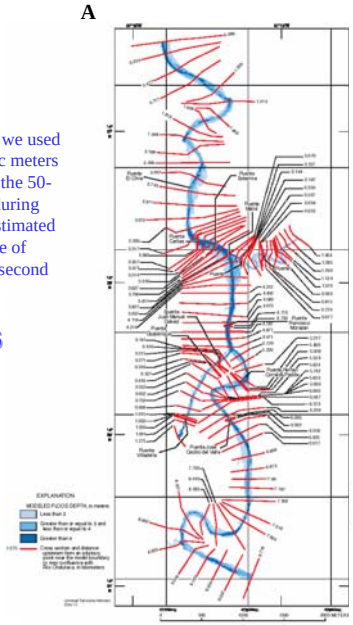
6. Estimate water-surface elevations at cross section locations



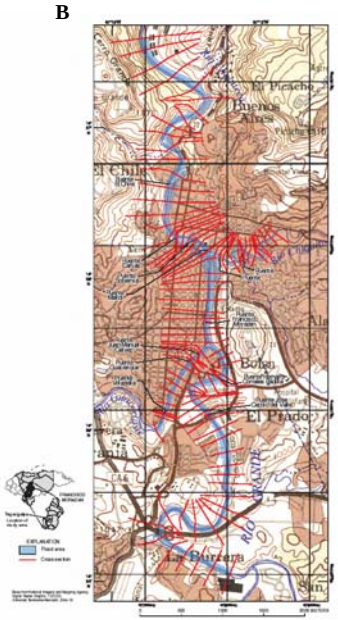
Screen image from HEC-RAS hydraulic model

7. Map depth and area of inundation

A



B



Depth of inundation (A) and flood area (B) for the 50-year flood on Río Grande, Río Guacerío, Río Chiquito at Tegucigalpa, Honduras

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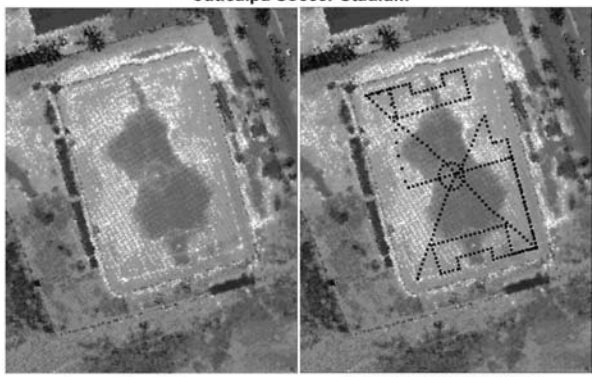
How accurate is LIDAR?

Analysis from the Honduras Flood-Hazard Mapping Application

Comparison of coordinates of LIDAR-determined ground points with those determined by GPS ground surveys

Juticalpa Soccer Stadium



Laser Intensity Image

Laser Intensity Image with Ground GPS superimposed

Plot of precise Global Positioning System (GPS) ground-surveyed points along field lines on a soccer field shows close horizontal agreement with LIDAR image at Juticalpa Honduras.

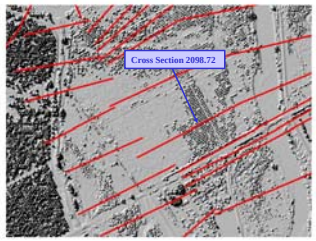
Field survey of Cross Section 2098.72 just downstream of highway bridge, Tocoa, Honduras

Municipality in Honduras	Mean elevation difference GPS – LIDAR (meters)	Standard deviation of elevation differences (meters)	Range of elevation differences (meters)	Ground feature surveyed	Number of elevation points compared
Tegucigalpa	-0.134	0.097	0.10 to -0.45	Building roof	89
Tegucigalpa	-0.152	0.071	0.03 to -0.30	Soccer field	142
Choluteca	-0.195	0.097	0.07 to -0.48	Bridge	862
Choluteca	-0.222	0.090	0.12 to -0.47	Bridge	742
Nacaome	-0.573	0.068	-0.39 to -0.78	Unpaved bridge	312
El Progreso	0.100	0.112	0.42 to -0.26	Highway	539
La Lima	-0.125	0.092	0.24 to -0.35	Airport road	1,185
Catacamas	-0.356	0.110	-0.16 to -0.53	Low-water crossing	21
Choloma	-0.103	0.076	0.19 to -0.35	Highway	647
Juticalpa	-0.169	0.088	0.03 to -0.51	Soccer field	417
La Ceiba	-0.302	0.077	-0.06 to -0.51	Wooden pier	245
Olanchito	-0.318	0.098	-0.03 to -0.67	Unpaved road	1,708
Olanchito	-0.304	0.066	-0.14 to -0.50	Soccer field	903
Comayagua	0.143	0.089	0.50 to -0.10	Unpaved road	1,091
Siguatepeque	-0.154	0.098	0.13 to -0.45	Soccer field	1,252
Sonaguera	0.029	0.110	0.35 to -0.32	Unpaved road	1,285
Tocoa	-0.182	0.093	0.09 to -0.47	Unpaved road	341
Santa Rosa de Aguán	0.092	0.068	-0.07 to -0.26	House foundations	25

Comparison of GPS-surveyed ground point elevations compared with LIDAR-derived elevations at 15 municipalities in Honduras. Data was acquired and compiled by Roberto Gutierrez, Bureau of Economic Geology, Coastal Studies at the University of Texas during February and March 2000.

Cross-section data from LIDAR may need corrections.

A.



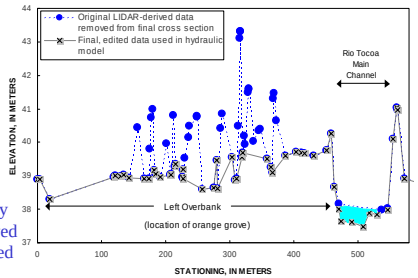
B.

A. Shaded relief image of original LIDAR-derived digital elevation model (DEM) of Tocoa, Honduras, showing cross-section locations.

Filtering removed the randomly distributed natural vegetation (left side of figures A and B), however, many of the regularly spaced trees in the orange groves (top center of figures A and B) remain.

B. Shaded relief image of DEM after LIDAR data were filtered to remove vegetation.

C.



C. Cross section 2098.72 derived from filtered LIDAR data. The high points representing tree tops, which were not removed by the filter, were removed manually to approximate actual ground elevations. Field-surveyed channel bottom points in the main channel were inserted between the LIDAR-derived edge-of-water points.

Location of Study Areas

Location of flood-hazard areas that were mapped by LIDAR and extents of drainage basins that contribute streamflow discharge to the flood-hazard areas.

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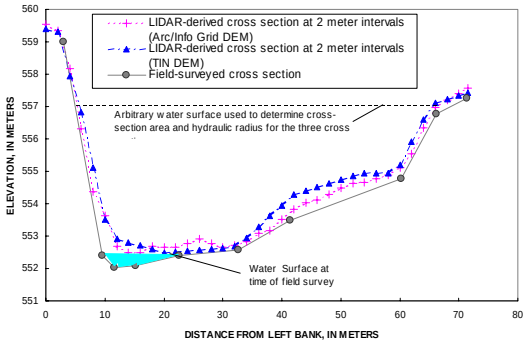
For more information about this project, contact the authors listed above or visit the following web sites:
http://wa.water.usgs.gov/wadmin/Projects/summary.812.htm
http://mitchnts1.cr.usgs.gov/projects/floodhazard.html

LIDAR data compared with field survey and error due to format conversion.



Comparison of river cross sections on Río Humuya in Comayagua, Honduras using elevations from a ground survey and an airborne LIDAR survey. LIDAR survey results are shown in Arc/Info GRID and TIN formats.

Source of elevation data used to derive the cross section	Area (square meters)	Hydraulic radius (meters)
Field Survey	209.5	3.16
Arc/Info Grid DEM	192.8	2.99
TIN DEM	183.0	2.95

Comparison of cross-sectional area and hydraulic radius for the three cross sections shown above assuming a water-surface elevation of 557 meters. The cross sections from the TIN DEM were used in the hydraulic models.