Flood Risk Mapping using LIDAR, SE NB Climate Change Action Fund

Tim Webster & Edward MacKinnon
Applied Geomatics Research Group

Centre of Geographic Sciences
Applied Geomatics Research Group
Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of southeastern New Brunswick

Project Manager, Réal Daigle

Sub-Projects

- Project Team
- Université de Moncton
- University of New Brunswick
- Mount Allison University
- Centre of Geographic Sciences (AGRG)
- Dalhousie University
- La Dune de Bouctouche
- Province of New Brunswick
- Environment Canada
- Natural Resources Canada
- Parks Canada
- Department of Fisheries and Oceans
- Public Safety and Emergency Preparedness Canada
- Government of Canada's Climate Change Impacts and Adaptation Program
- Beaubassin Planning Commission
- Kent Planning Commission

http://atlantic-web1.ns.ec.gc.ca/slr/
Storm Surge + Sea Level Rise

- Jan. 2000, largest storm surge on record
- Pressure and wind raise water level above normal
- Impact if surge occurs on high tide
- Increased SLR will increase the problem
- Jan 17, 2004 another significant event
LIDAR coverage in the Maritimes since ‘98

Study Areas

Partners in CCAF projects
GSC, DFO/CHS, EC, universities

Radarsat data © Canadian Space Agency 1996
LIDAR Unit

LIDAR uses laser pulses, fired from an airborne platform, to determine and record the elevation of the ground integrated through the Time Interval Meter (TIM)

- GPS P-code is used to position the aircraft

- Inertial Reference System (IRS or IMU) is used to measure the attitude of the aircraft (pitch, yaw, roll).

- TIM used to record pulse 2 way time and scan angle (point spacing controlled by pulse rate, scan rate and forward speed).

- Target position latitude, longitude, ellipsoidal height (WGS84)
LIDAR Post Processing

- Differential processing of carrier phase GPS data from the ground and airborne units. Aircraft track plot can be generated at this time.
- Laser point coordinate determination from the eight data elements (aircraft XYZ and attitude from the IMU output, scanner angle and range from the TIM). The points are transformed into WGS-84 latitude and longitude or UTM.
- Point analysis is performed, classifying them into terrain or other objects.
- Accuracy analysis. Determination of systematic positioning errors in the points. Use overlap areas and GCPs as reference.
LIDAR – practical consideration

- Narrow non-divergent beam (18-25 cm footprint)
- NIR wavelength – less sensitive to aerosols
- Reflectors: good-vegetation, poor-water/wet snow
- Measure different returns: first, last, both, intensity
- Active sensor so less requirement for fair weather
- Higher probability of reaching ground in leaf-off conditions (especially first return sensors)
- Dense vegetation or smooth surface (mudflats) increase overlap between flight lines for good coverage (shadow and specular reflection)
Changes 2000 to 2003
Improved Applanix IMU
Collimator (laser beam 1.8m to 0.18m)
Project Chronology: LIDAR Acquisition

- Nov. 2002 mission cancelled due to poor weather, snow
- May 2003 LIDAR coverage prior to leaf emergence
- Fall 2003 mission with new LIDAR system cancelled due to technical problems
- Spring 2004 remaining areas acquired prior to leaf emergence with new multi-return system
Validation

“Z must be within an average 30 cm of measured points”

- Guaranteed only on flat hard open surface = road
- GPS points (ellipsoid and orthometric heights)
- Overlay GPS with LIDAR ground points (radius)
- Overlay GPS with LIDAR ground surface
- Compare Z value from GPS and LIDAR
Ground Validation Equipment

• Base and rover RTK system, 10 km range; Total station for under the canopy surveying
• Setup Base over HPN monument, RTK on Pole & vehicle mount
Cap Pele Block Validation Results

Cap Pele Validation

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of GPS Points</td>
<td>20748</td>
</tr>
<tr>
<td>Number of GPS Points &gt; 30 cm</td>
<td>113</td>
</tr>
<tr>
<td>Number of GPS Points &gt; 35 cm</td>
<td>28</td>
</tr>
<tr>
<td>Percent of Points Less then 30 cm</td>
<td>99.46</td>
</tr>
<tr>
<td>mean (GPS - DEM)</td>
<td>0.04</td>
</tr>
<tr>
<td>magnitude of deviation</td>
<td>0.09</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.11</td>
</tr>
<tr>
<td>Avg. Mag</td>
<td>0.09</td>
</tr>
<tr>
<td>RMS</td>
<td>0.11</td>
</tr>
</tbody>
</table>

GPS Record

DZ (GPS - DEM) (m)
Cormierville: addition of waterfront structures in the ground DEM
Bouctouche
Shediac – Pointe du Chene Wharf
Ground DEM – Flood Risk Maps

- Ground DEM used to generate flood risk maps
- Water levels based on historic storm surge events (Jan. 2000) and future sea level rise
- SLR Worse case: 70 cm/100 yr (50 global + 20 subsidence)
- SLR moderate: 50 cm/100 yr (30 global + 20 subsidence)
- Resolve vertical datum issues (chart vs geoid MSL)
- DEM flooded from the ocean
- Low lying Inland areas must have free connection with ocean
- 3 flood levels generated plus other products
This map depicts two possible flood levels overlaid on top of a color shaded relief ground elevation model of the Pointe du Chene area in New Brunswick. Areas with low topographic heights are represented with green colours and areas with higher topographic heights with yellow. The 2.65 m level represents the Jan. 21, 2000 storm surge event. The 3.05 m level represents the same event with 100 year of sea level rise.

The ground DEM was constructed from LIDAR data collected in the spring of 2003. DEM processed and flood risk mapping by the Applied Geomatics Research Group, COGS, NSCC as part of the CCAF project lead by Environment Canada.
Service NB digital ortho series
Jan. 2000 storm surge 2.55 m above MSL
Jan. 2000 storm surge + 100 years sea level rise (0.5m/100 yrs estimate)
Jan. 2000 storm surge + 100 years sea level rise (0.7m/100 yrs estimate)
Combined flood levels
Jan. 2000 event
Jan. 2000 event

Flood Extent layer with an All-hits LIDAR CSR

Legend
- 3.6 m Flood above chart datum
- Allhits LIDAR CSR
- RGB:
  - Red: Band_1
  - Green: Band_2
  - Blue: Band_3

Scale: 0 625 125 250 375 500 Meters
Jan. 2000 event

Flood Extent layer with a Ground LIDAR CSR

Legend
- 3.6 m Flood above chart datum
- Ground Only CSR

RGB
- Red: Band_1
- Green: Band_2
- Blue: Band_3

Scale: 0 - 625 meters
Impact to infrastructure, $$

Flood Extent layer with an All-hits LIDAR SR showing affected buildings and roads

Legend
- Flood Extent
- Roads

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Flood</td>
</tr>
<tr>
<td>25</td>
<td>Minor Flood</td>
</tr>
<tr>
<td>50</td>
<td>Moderate Flood</td>
</tr>
<tr>
<td>75</td>
<td>Major Flood</td>
</tr>
<tr>
<td>100</td>
<td>Critical Flood</td>
</tr>
</tbody>
</table>

Scale: 0-625 meters
Flood Depth Maps

Flood RiskLayer with an All-hits LIDAR SR showing depth of flood and affected buildings and roads.
Flood Animation 5 m ASL
Spring 2004 data

• New LIDAR system for Terra RS capable of measuring 1\textsuperscript{st} and last returns and Intensity on alternating returns
Conclusions

- LIDAR requires planning, ground validation, intensive GIS processing
- Need P-code GPS in order to validate accuracy
- LIDAR ideal for modeling storm surges of 1-2 m
- NB Orthophotos compliment LIDAR DSM/DEM
- Remainder of NB polygons acquired 2004
- Terra using a new multi-return system
- Intensity of return may be a useful product
- Flood modelling complete for 2003 data
- Economic and ecosystem impact analysis to follow
Acknowledgements

• Funding CCAF, AIF, and CFI
• Fieldwork support by AGRG students
• All CCAF partners