Sediment Deposition Volume Assessment in Tropical Regions

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Source: CNN.com
Risk assessment of sediment deposition

Risk = Hazard × Exposure × Vulnerability

Hazard intensity: volume of deposited sediments
Sediment hard to quantify compared to flood level

Total additional cost of cleaning sediment after hurricane Maria in Dominica: 92 million US$

Mixture of flash floods, debris flows, trees, etc.
Objectives

Assessment of:

- Sediment deposition volume
- Sediment deposition spatial variability

Study area:

Dominica affected by hurricane Maria

Source: Areal Dominica
Study area:

Two villages in Dominica
Methods

1. In-situ investigations

2. Analyzing pre- and post-event UAV and LiDAR data

3. Creating deposition surface with trend interpolations
In-situ investigations

- Deposition marks on the walls
- Remaining sediments in place
- Interviewing locals
Pre- and post-event UAV and LiDAR Data

<table>
<thead>
<tr>
<th>Data</th>
<th>Time of acquisition</th>
<th>Resolution (m)</th>
<th>Vertical accuracy (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAV pre-event DSM</td>
<td>August 22(^{nd}) to September 3(^{rd}), 2017</td>
<td>0.02</td>
<td>0.10</td>
</tr>
<tr>
<td>UAV post-event DSM</td>
<td>January 25(^{th}) to February 2(^{nd}), 2018</td>
<td>0.04</td>
<td>0.10</td>
</tr>
<tr>
<td>LiDAR post-event DSM</td>
<td>February 19(^{th}) to May 5(^{th}), 2018</td>
<td>0.50</td>
<td>0.05</td>
</tr>
<tr>
<td>LiDAR post-event DEM</td>
<td>February 19(^{th}) to May 5(^{th}), 2018</td>
<td>0.50</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Sediment deposition = UAV post-event DSM – UAV pre-event DSM
Sediment removal = LiDAR post-event DEM – UAV post-event DSM
Trend surfaces

- Elevation values extracted from DEM
- Trend interpolation

Deposition volume = (Trend surface – DEM) × Cell area

Trend interpolation
Source: esri (2016)
In-situ investigations

**Coulibistrie**: 15 points
Range: 0.9 – 2.9 (m)

**Pichelin**: 12 points
Range: 1.1 – 3 (m)
Pre- and post-event DSMs and DEM

UAV Post-event DSM

UAV Pre-event DSM

UAV_DSM_Diff

Problem: vegetation and some buildings disappeared during hurricane; causing negative values in UAV_DSM_Diff

Objectives

Methods

Conclusions
Pre- and post-event DSMs and DEM

Masking out:
- Vegetation
- Buildings
- Piles of logs
- Cars

2nd method results
Pre- and post-event DSMs and DEM

Filling of obscured areas
(vegetation, buildings, and piles of logs):

- Kriging interpolation (Gaussian)
- Window average

using edge pixel elevation

2nd method results
Reference volume: sediment dump at Coulibistrie shoreline
Trend surfaces

- High resolution pre-event DEM not available
- Generating pre-event DEM from pre-event UAV DSM
- Masking out pre-event UAV DSM and filling with Kriging and window average

3rd method results
Trend surfaces

Points added on the boundary of sediment deposition

Trend surface minus DEM; Coulibistrie

Trend surface minus DEM; Pichelin

3rd method results
Deposition height value comparison

![Deposition height values](image)
## Summary: sediment volume estimates \((10^3 \text{ m}^3)\)

<table>
<thead>
<tr>
<th>Methods</th>
<th>Coulibistrie</th>
<th>Pichelin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 In-situ investigations</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 Analysis of UAV and LiDAR data</td>
<td>Masked-out parts filled with Kriging interpolation</td>
<td>42.47</td>
</tr>
<tr>
<td>UAV DSM Diff</td>
<td>Masked-out parts filled with windowaverage</td>
<td>40.05</td>
</tr>
<tr>
<td>(UAV DSM Post – UAV DSM Pre) (Jan 2018 - Aug 2017)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LiDAR DSM Diff</td>
<td>Masked-out parts filled with Kriging interpolation</td>
<td>-18.97</td>
</tr>
<tr>
<td>(LiDAR DEM Post – UAV DSM Pre) (Apr 2018 – Jan 2018)</td>
<td>Masked-out parts filled with windowaverage</td>
<td>-20.60</td>
</tr>
<tr>
<td>Volume of sediment dump at the shoreline</td>
<td>Masked-out parts filled with Kriging interpolation</td>
<td>28.29</td>
</tr>
<tr>
<td></td>
<td>Masked-out parts filled with windowaverage</td>
<td>28.31</td>
</tr>
<tr>
<td>3 Analysis of trend surfaces and DEM</td>
<td>1st order trend surface minus DEM</td>
<td>77.70</td>
</tr>
<tr>
<td></td>
<td>2nd order trend surface minus DEM</td>
<td>86.79</td>
</tr>
<tr>
<td></td>
<td>3rd order trend surface minus DEM</td>
<td>86.79</td>
</tr>
</tbody>
</table>
Notes

- Due to presence of vegetation and buildings, analysis of UAV data is associated with high uncertainties.
- Marks on the wall might in fact belong to flooding level.
- Analysis of trend surfaces are in fact representing the flow surface.
Conclusions

A large number of field measurements with good distribution over the entire study area is required.

- But it is very hard to characterize sediment volumes in the field because of the high spatial variability.

It is wise to inspect the places where the sediment deposition is hard to recognize from remotely sensed products.

Pre- and post-event UAV and LiDAR products provide the most reliable results.

- Corrections for vegetation and buildings are necessary.
Thank you