Sediment Deposition Volume Assessment in Tropical Regions

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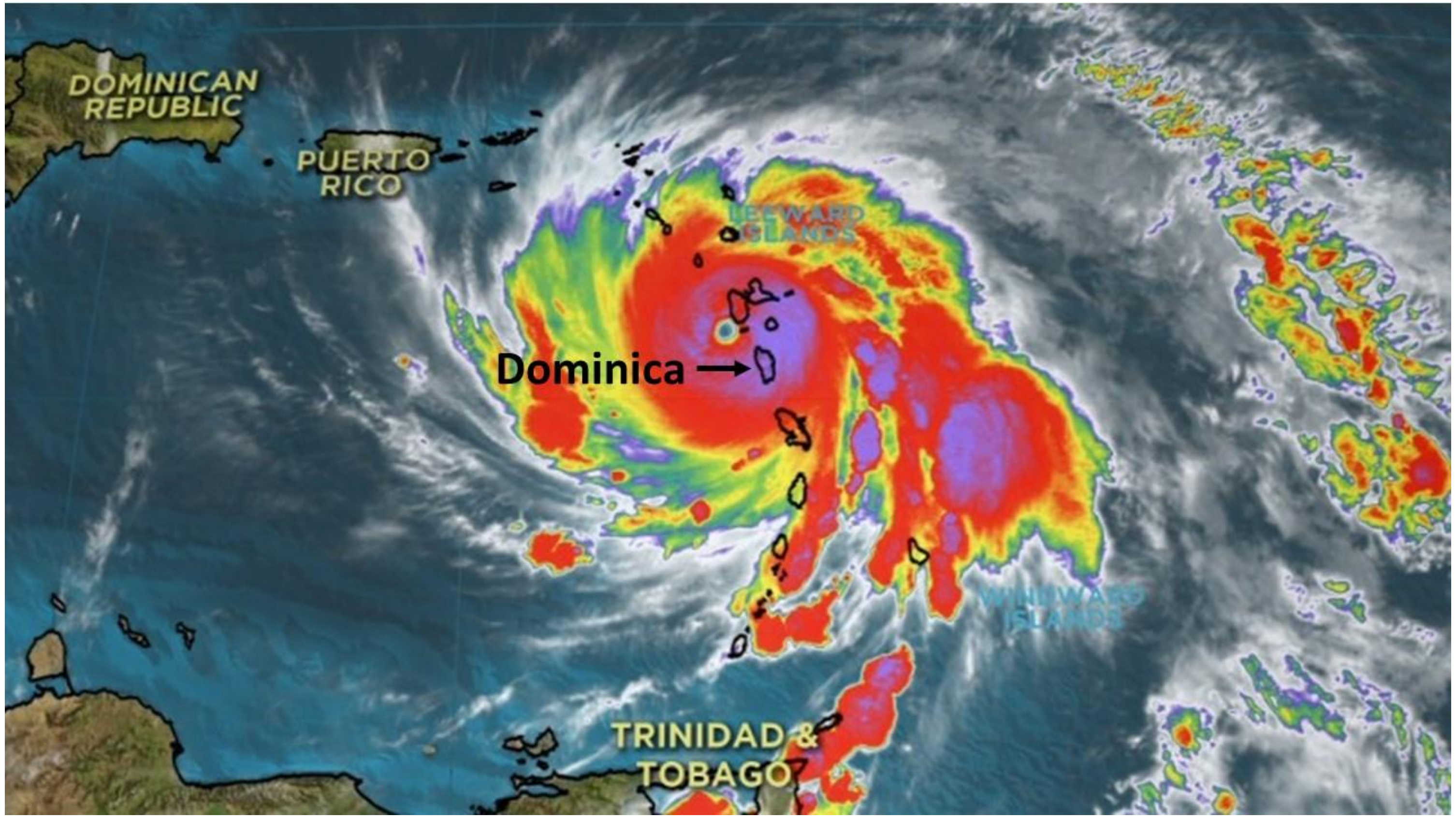

Source: CNN.com

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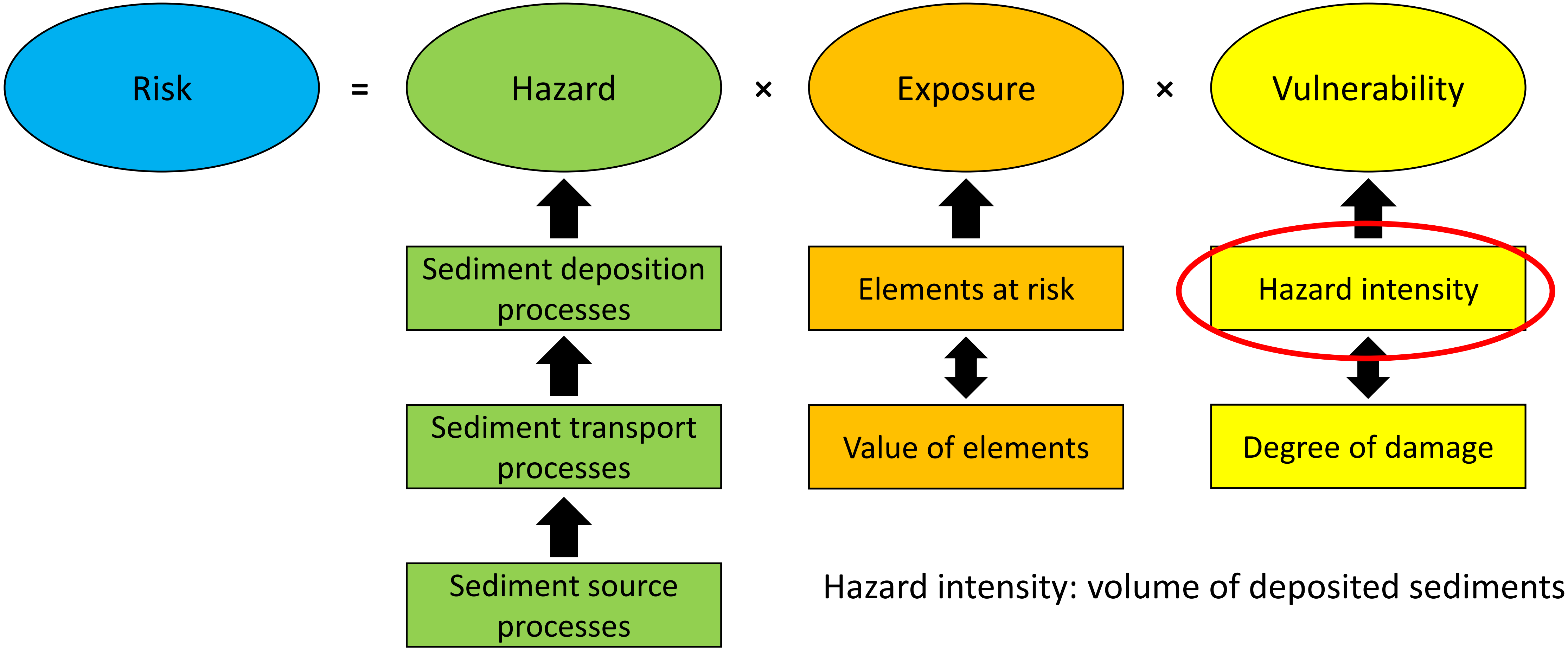
Risk assessment of sediment deposition



Hazard intensity: volume of deposited sediments

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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.

Source: Areal Dominica

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Objectives

- Assessment of:
  - Sediment deposition volume
  - Sediment deposition spatial variability
- Study area:

  Dominica affected by hurricane Maria

Source: Areal Dominica

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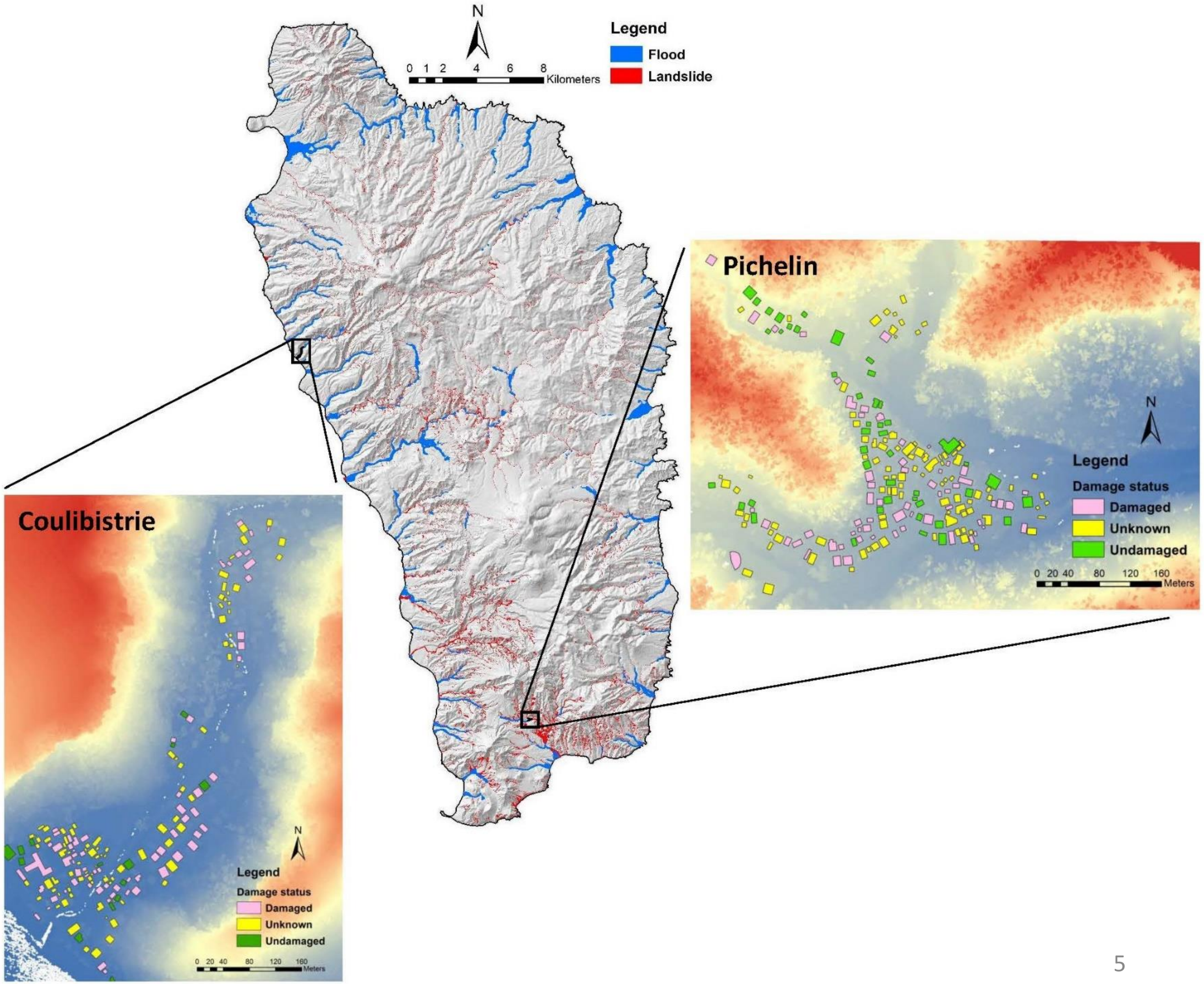
Study area:

Two villages in Dominica



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Methods

1. In-situ investigations

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

3. Creating deposition surface with trend interpolations

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In-situ investigations

- Deposition marks on the walls
- Remaining sediments in place
- Interviewing locals

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Pre- and post-event UAV and LiDAR Data

"UAV_DSM_Diff"

Hurricane Maria: Sep 18th, 2017

"LiDAR_DSM_Diff"

Data	Time of acquisition	Resolution (m)	Vertical accuracy (m)
UAV pre-event DSM	August 22nd to September 3rd, 2017	0.02	0.10
UAV post-event DSM	January 25th to February 2nd, 2018	0.04	0.10
LiDAR post-event DSM	February 19th to May 5th, 2018	0.50	0.05
LiDAR post-event DEM	February 19th to May 5th, 2018	0.50	0.05

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

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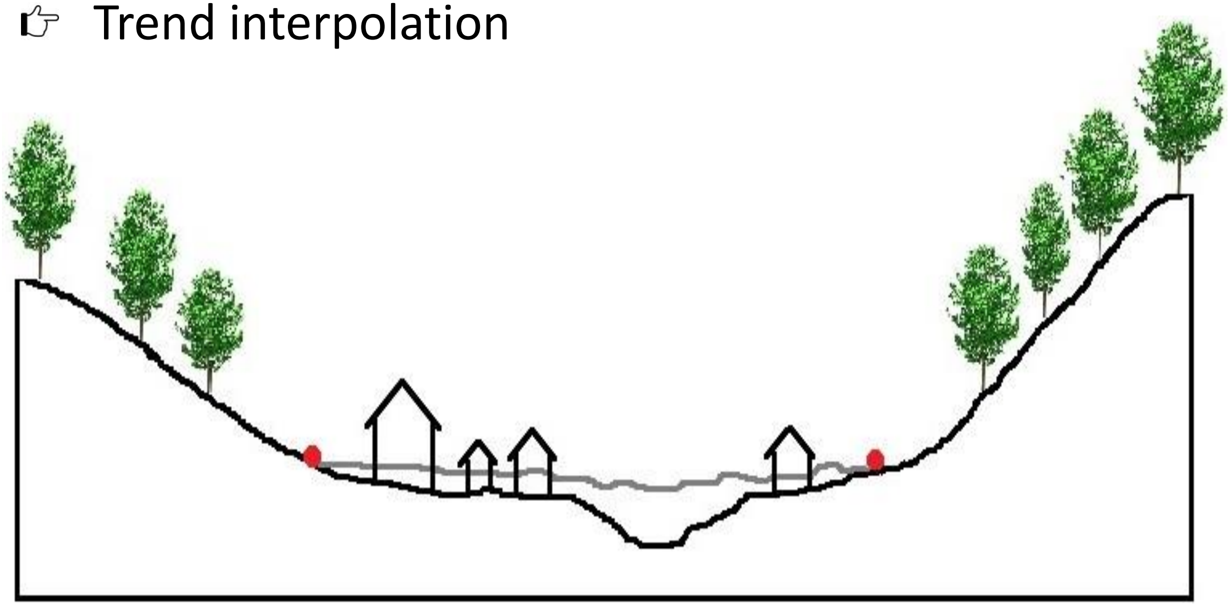
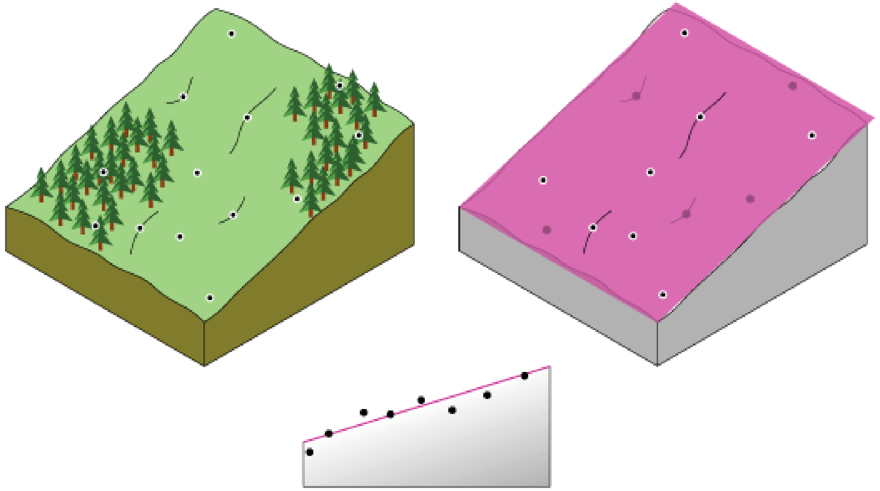
Trend surfaces

- Elevation values extracted from DEM
- Trend interpolation





Trend interpolation
Source: esri (2016)

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

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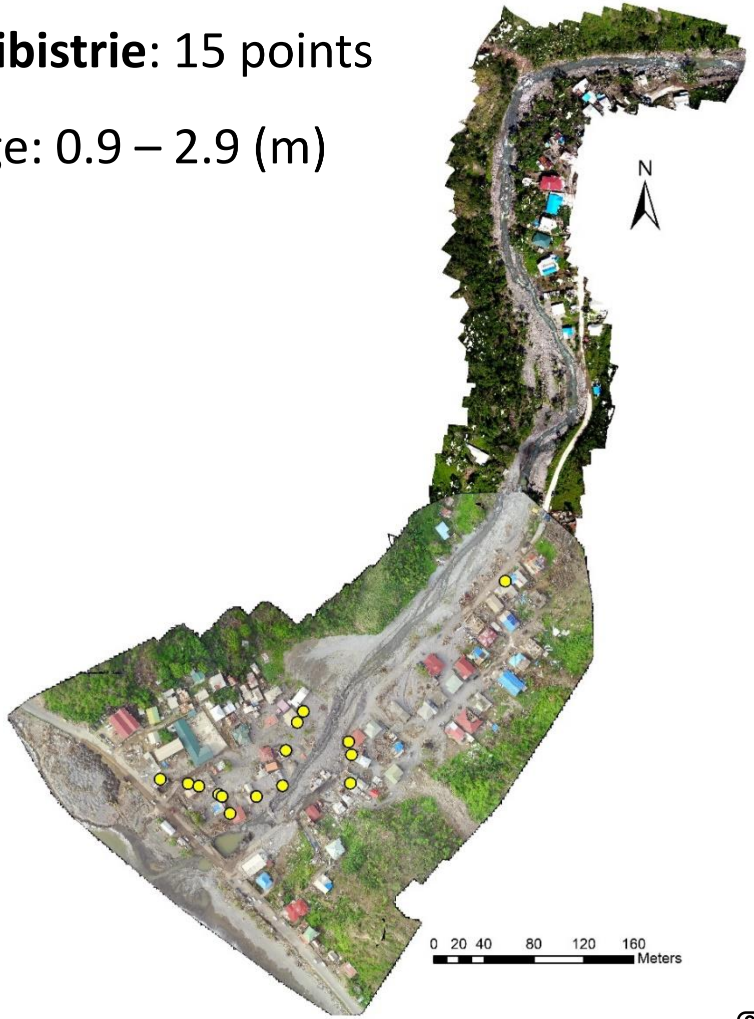
In-situ investigations

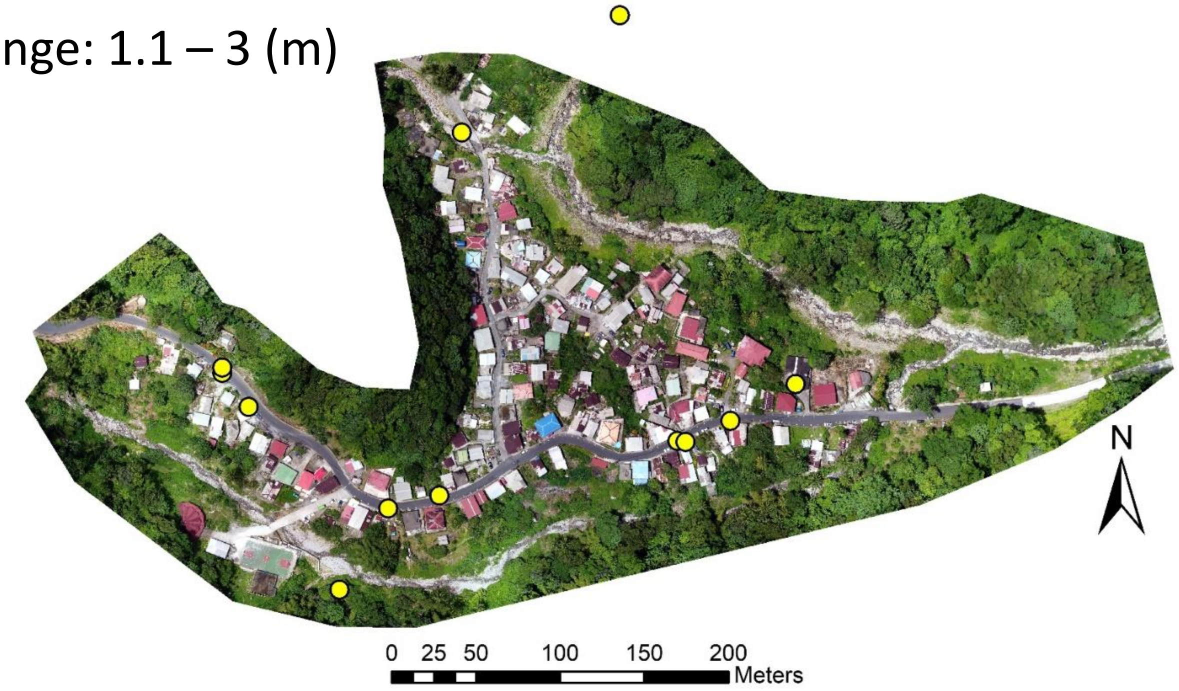
Coulibistrie: 15 points

Range: 0.9 – 2.9 (m)



Pichelin: 12 points

Range: 1.1 – 3 (m)



○ ➔ Location of data collection

1st method results

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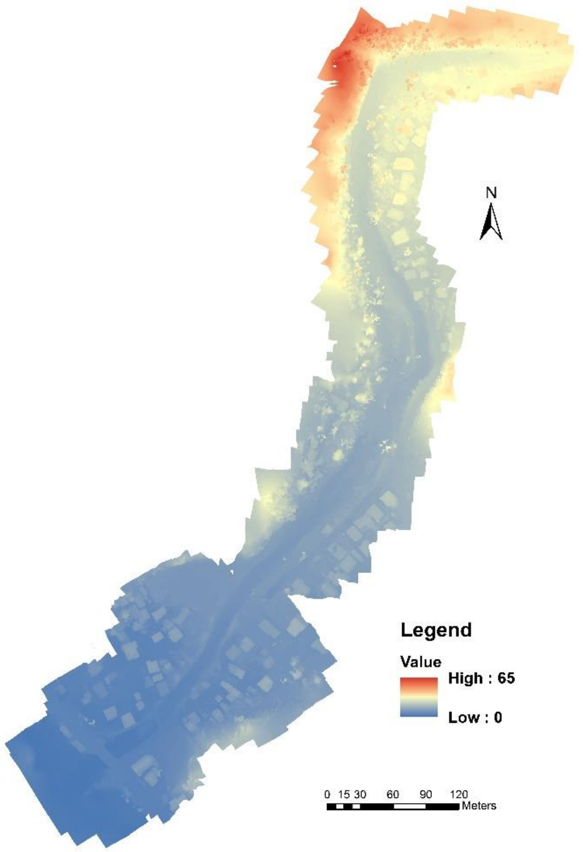
Pre- and post-event DSMs and DEM

UAV Post-event DSM



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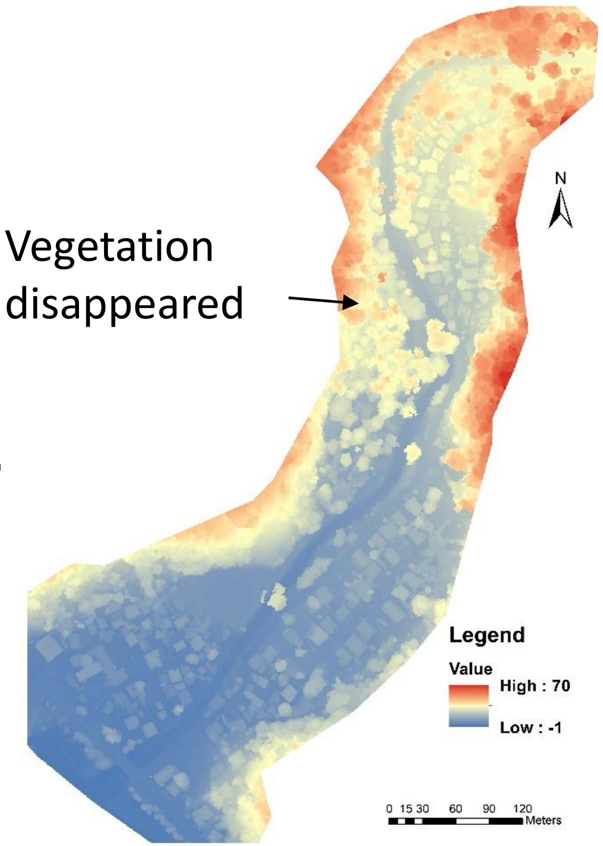
UAV Pre-event DSM

Vegetation disappeared



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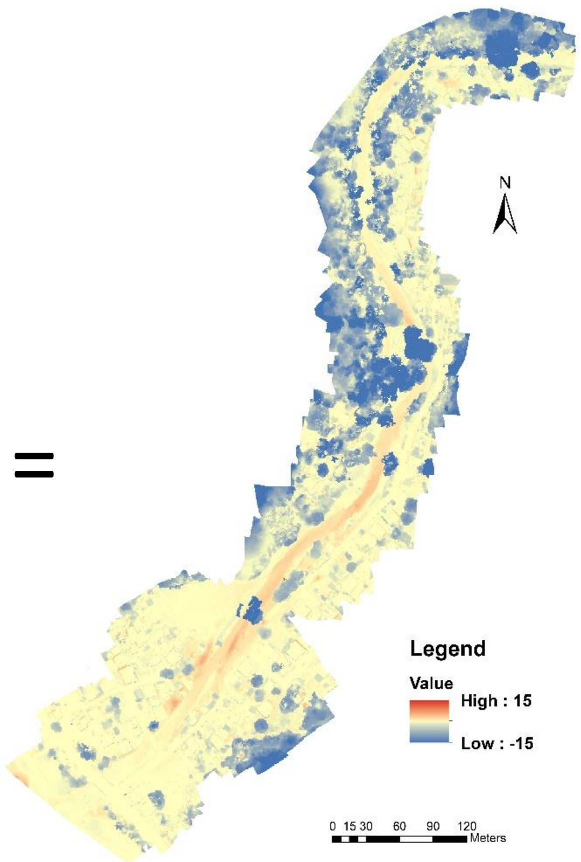
UAV_DSM_Diff



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

2^{nd} method results

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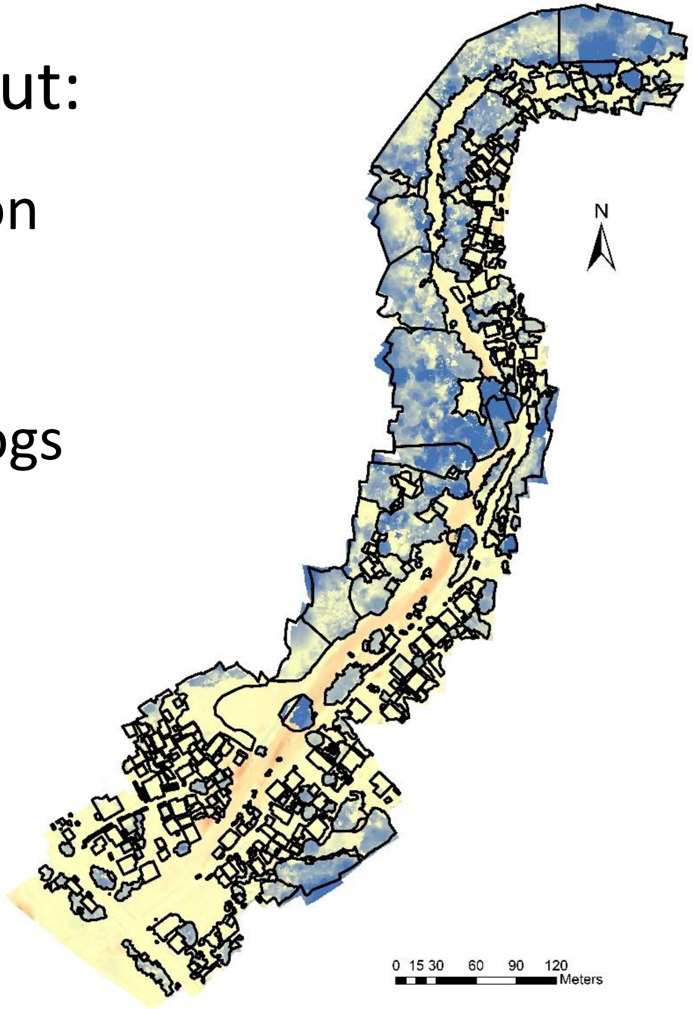
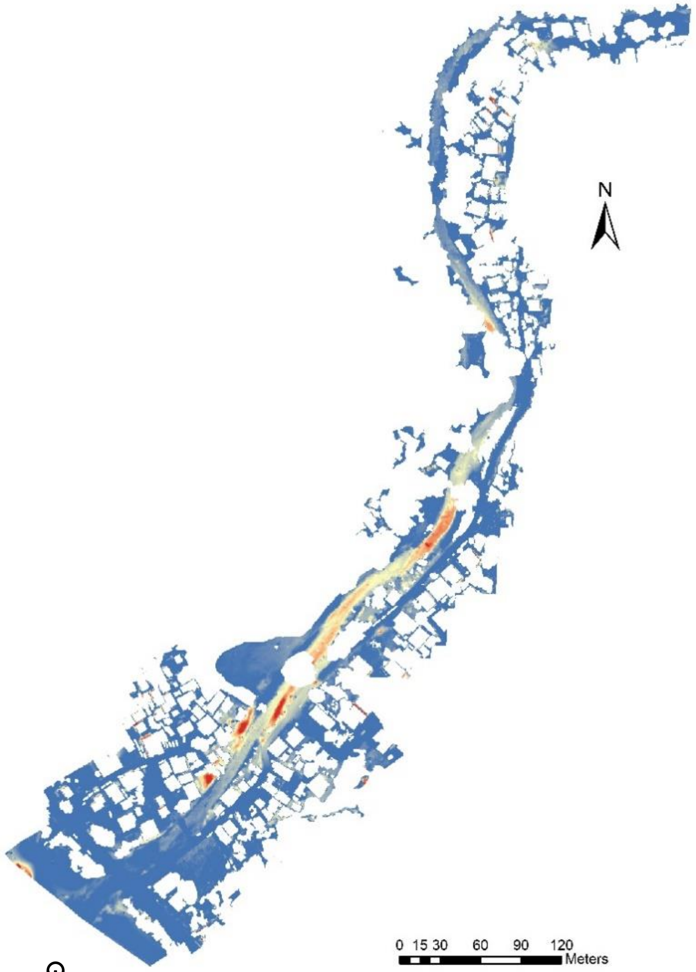
Pre- and post-event DSMs and DEM

Masking out:

- Vegetation
- Buildings
- Piles of logs
- Cars





2[nd] method results

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Pre- and post-event DSMs and DEM

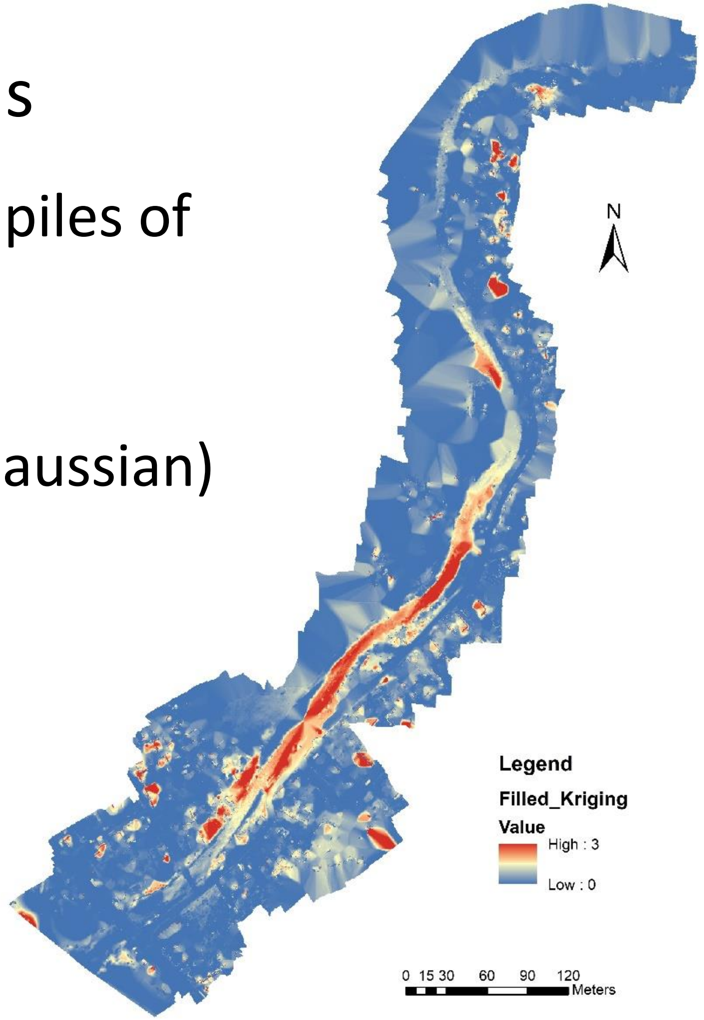
Filling of obscured areas

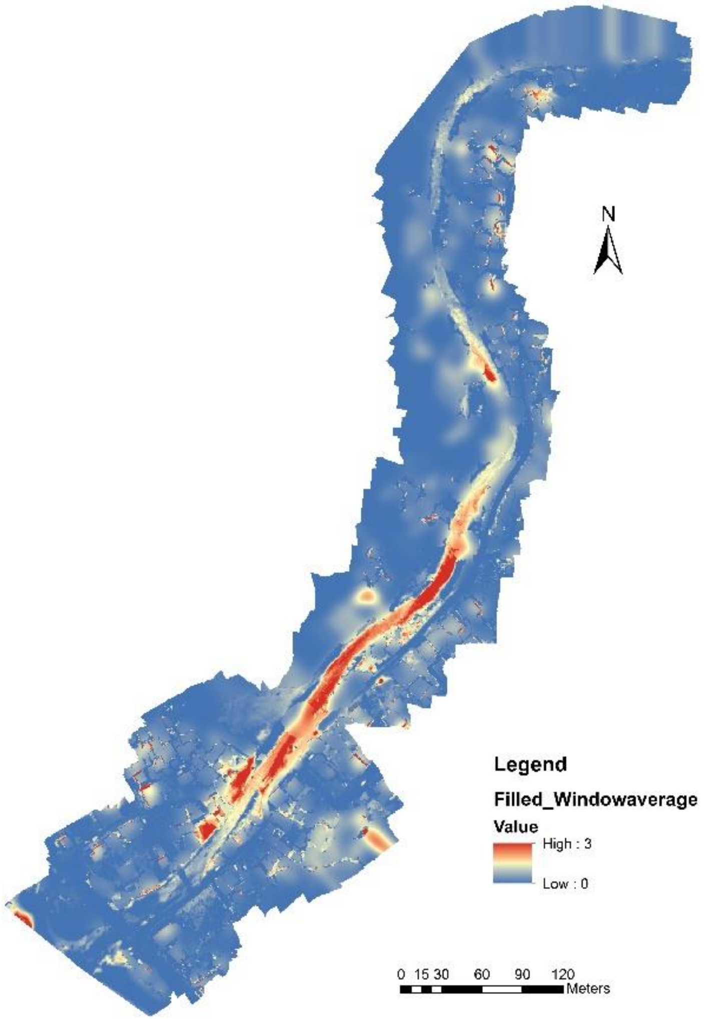
(vegetation, buildings, and piles of

logs):

- Kriging interpolation (Gaussian)
- Window average

using edge pixel elevation





2nd method results

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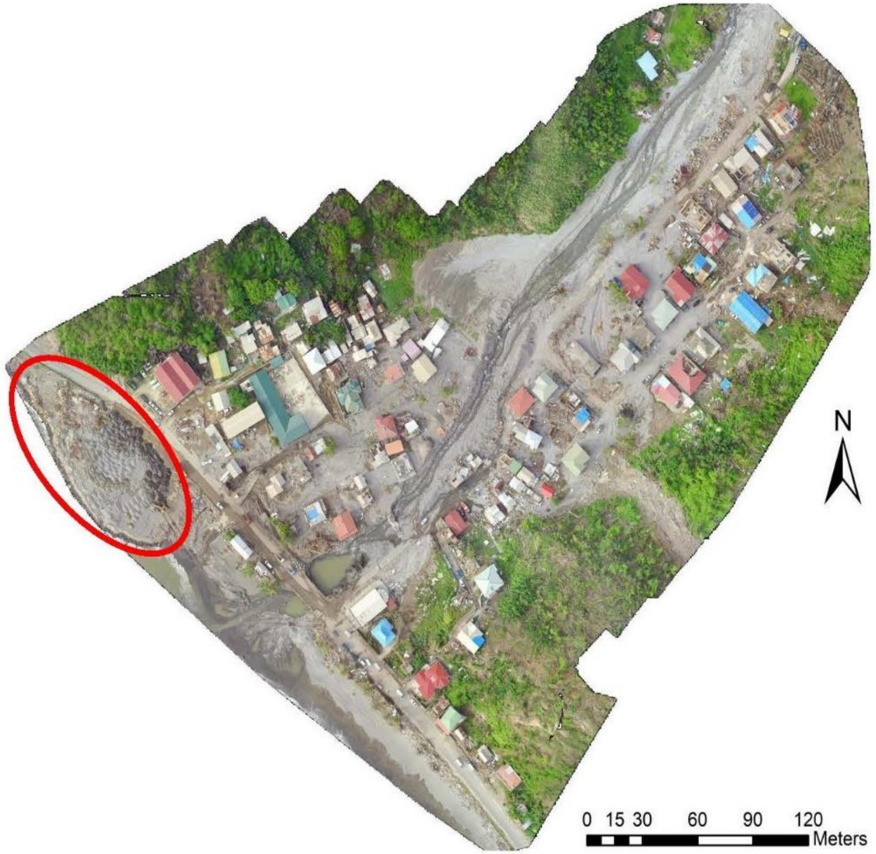
Reference volume: sediment dump at Coulibistrie shoreline



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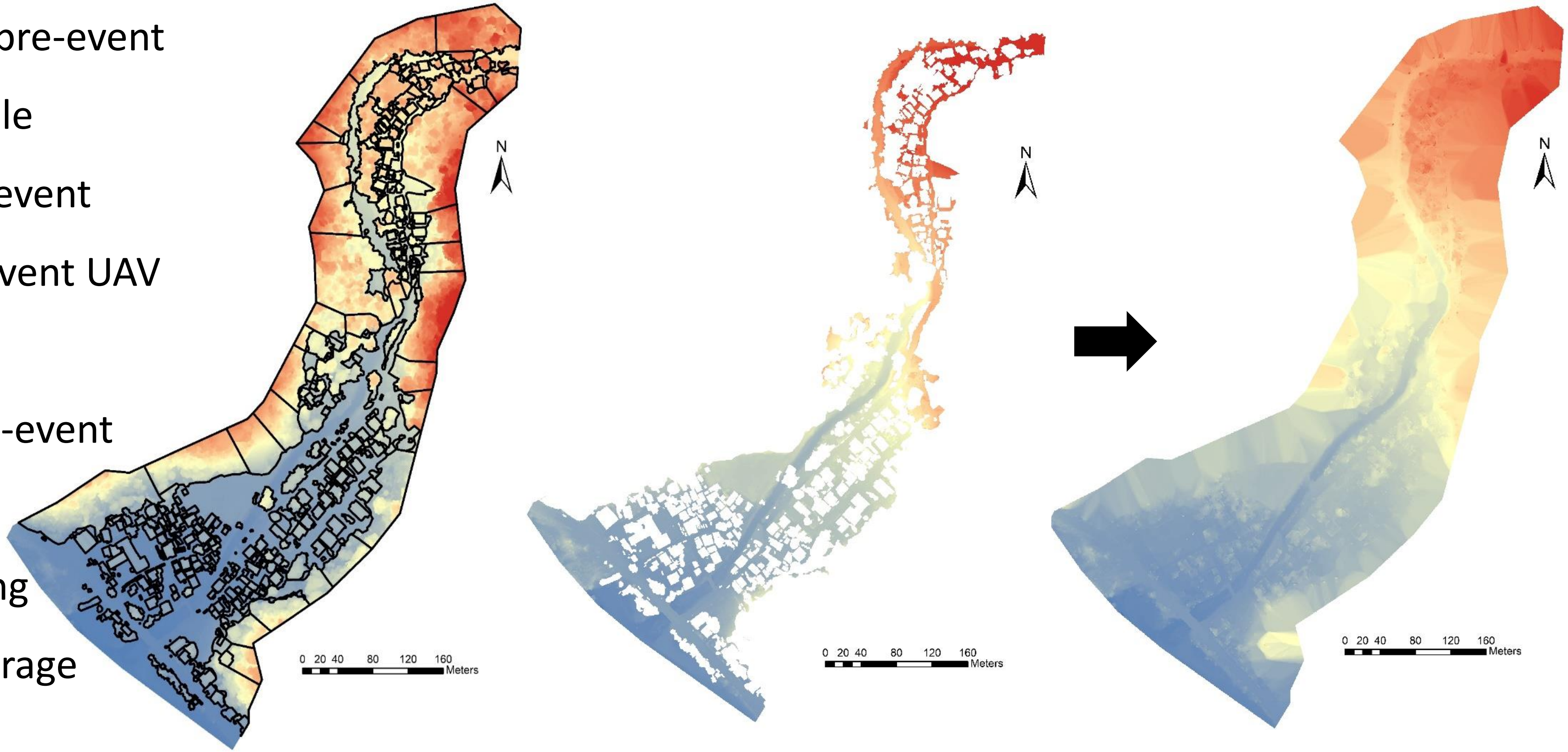
2nd method results

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

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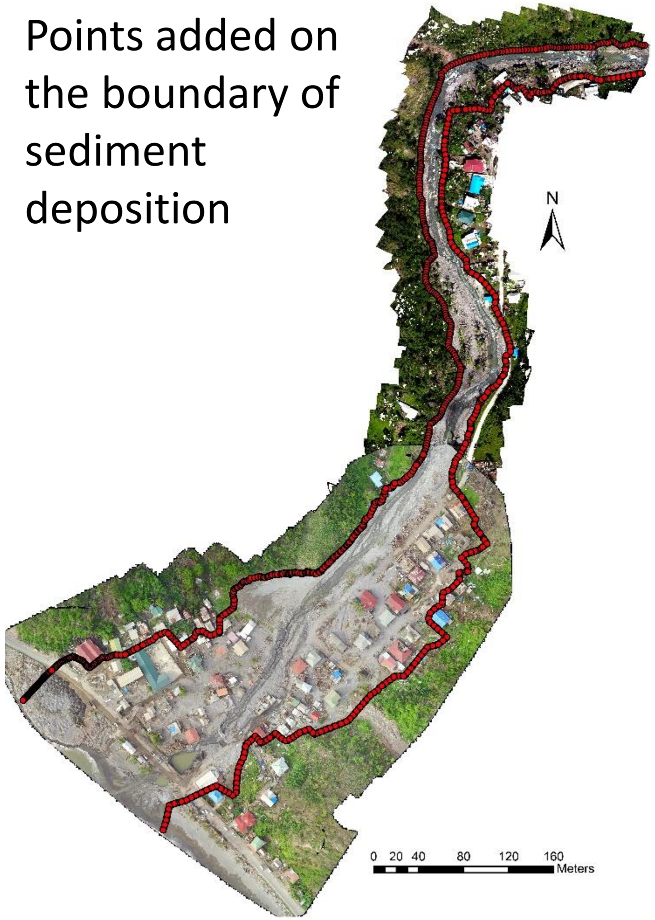
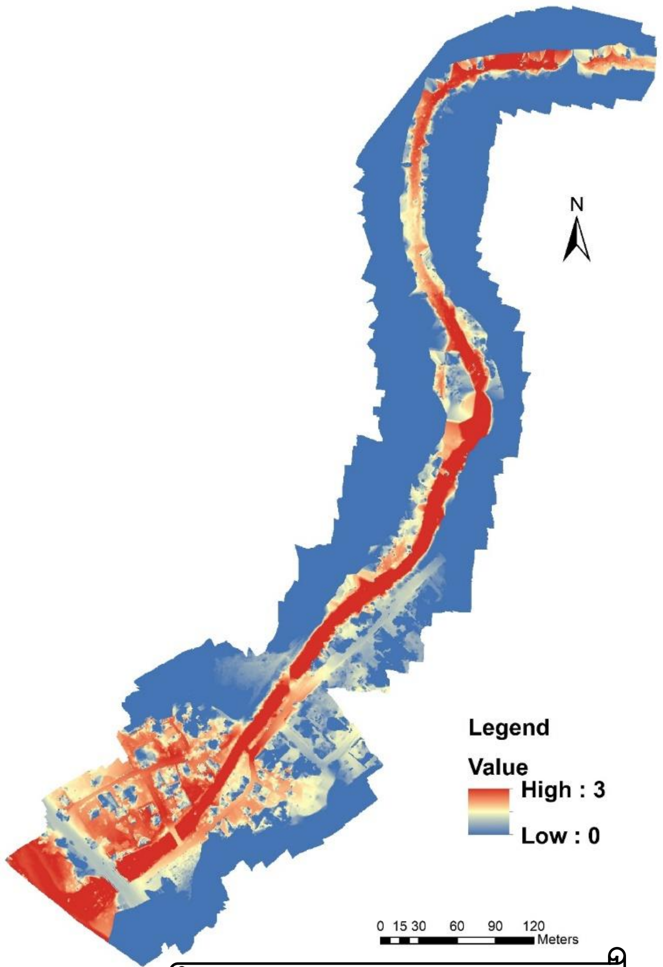
Trend surfaces

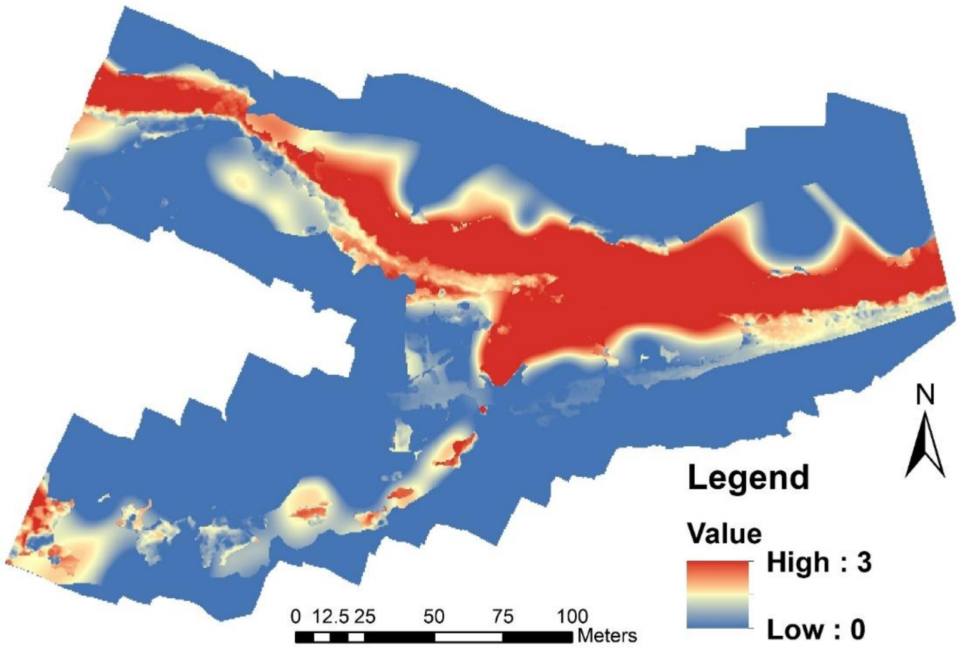
Points added on the boundary of sediment deposition



Trend surface minus DEM; Coulibistrie



Trend surface minus DEM; Pichelin



3rd method results

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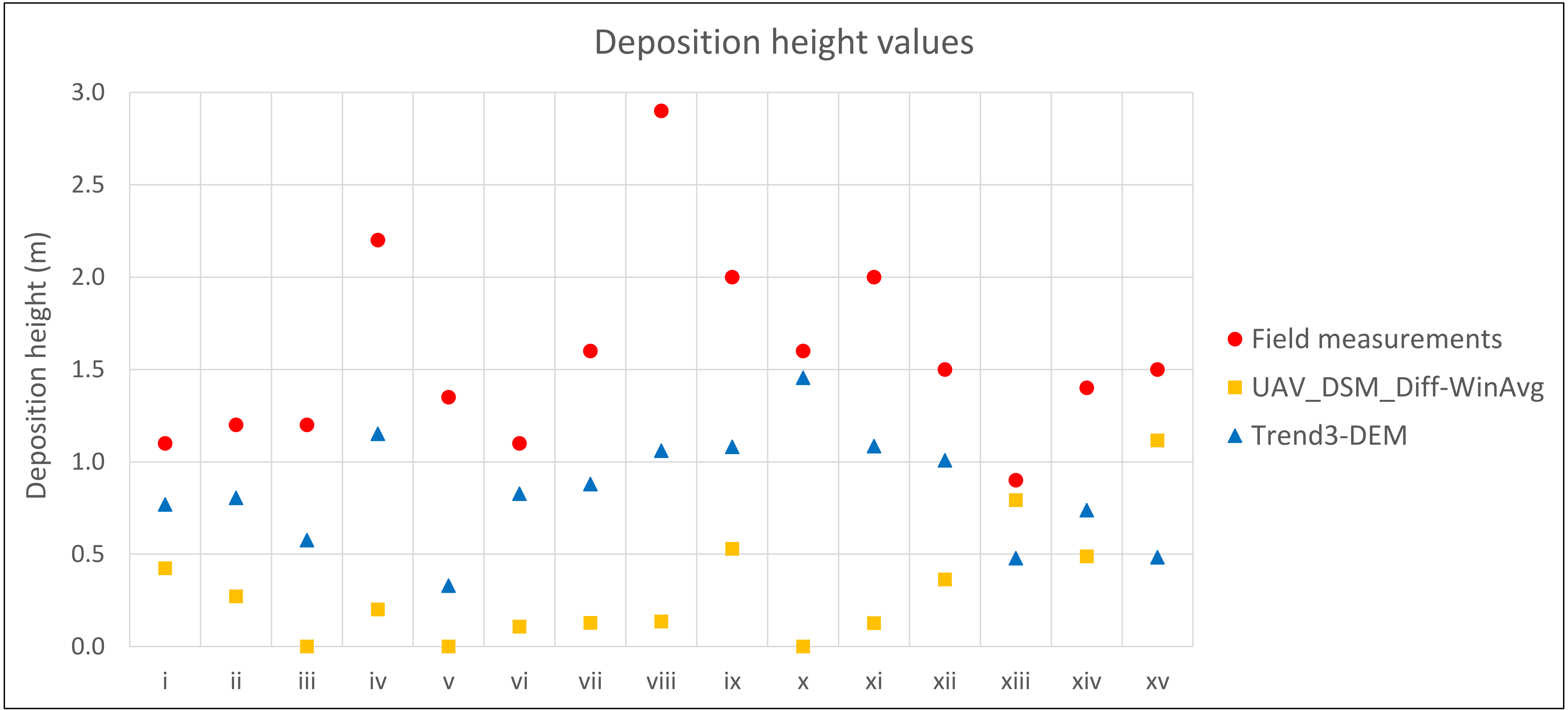
Deposition height value comparison



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Summary: sediment volume estimates (10^3 m^3)

Methods				Coulibistrie	Pichelin
1	In-situ investigations			-	-
2	Analysis of UAV and LiDAR data	UAV_DSM_Diff (UAV DSM Post – UAV DSM Pre) (Jan 2018 - Aug 2017)	Masked-out parts filled with Kriging interpolation	42.47	22.20
			Masked-out parts filled with windowaverage	40.05	18.84
		LiDAR_DSM_Diff (LiDAR DEM Post – UAV DSM Post) (Apr 2018 – Jan 2018)	Masked-out parts filled with Kriging interpolation	-18.97	-
			Masked-out parts filled with windowaverage	-20.60	-
		Volume of sediment dump at the shoreline	Masked-out parts filled with Kriging interpolation	28.29	-
			Masked-out parts filled with windowaverage	28.31	-
3	Analysis of trend surfaces and DEM	1st order trend surface minus DEM		77.70	42.64
		2nd order trend surface minus DEM		86.79	41.84
		3rd order trend surface minus DEM		86.79	41.84

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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.

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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

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