Identifying factors leading to hurricane induced landslide dam flood risk in Dominica

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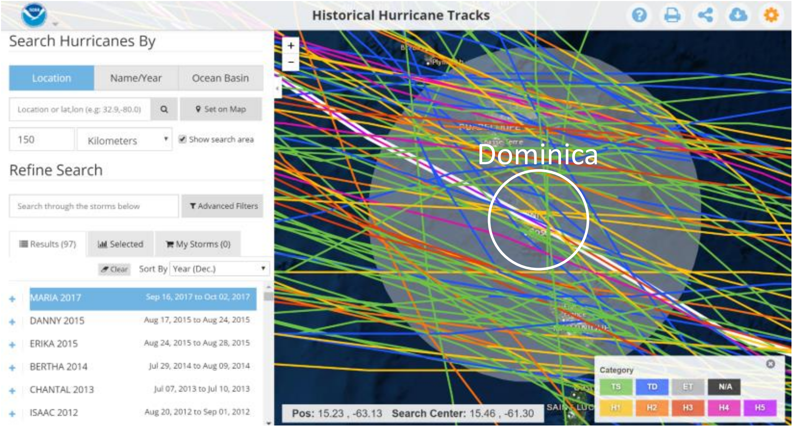
Dominica extreme events context

- **TS Erika** (2015) most deadly and destructive natural disaster in Dominica since **Hurricane David** (1979)
- Rainfall 850 mm (33 in) - catastrophic floods
- Accompanying landslides dammed rivers
- Recovery in Dominica halted in September 2017 by Cat 5 **Hurricane Maria**, even worse than TS Erika
- PDNA* for Dominica concluded that **Maria** resulted in total damages of US$931m and losses of US$380m, = **226 % of the GDP**

Hurricanes are common in the Caribbean

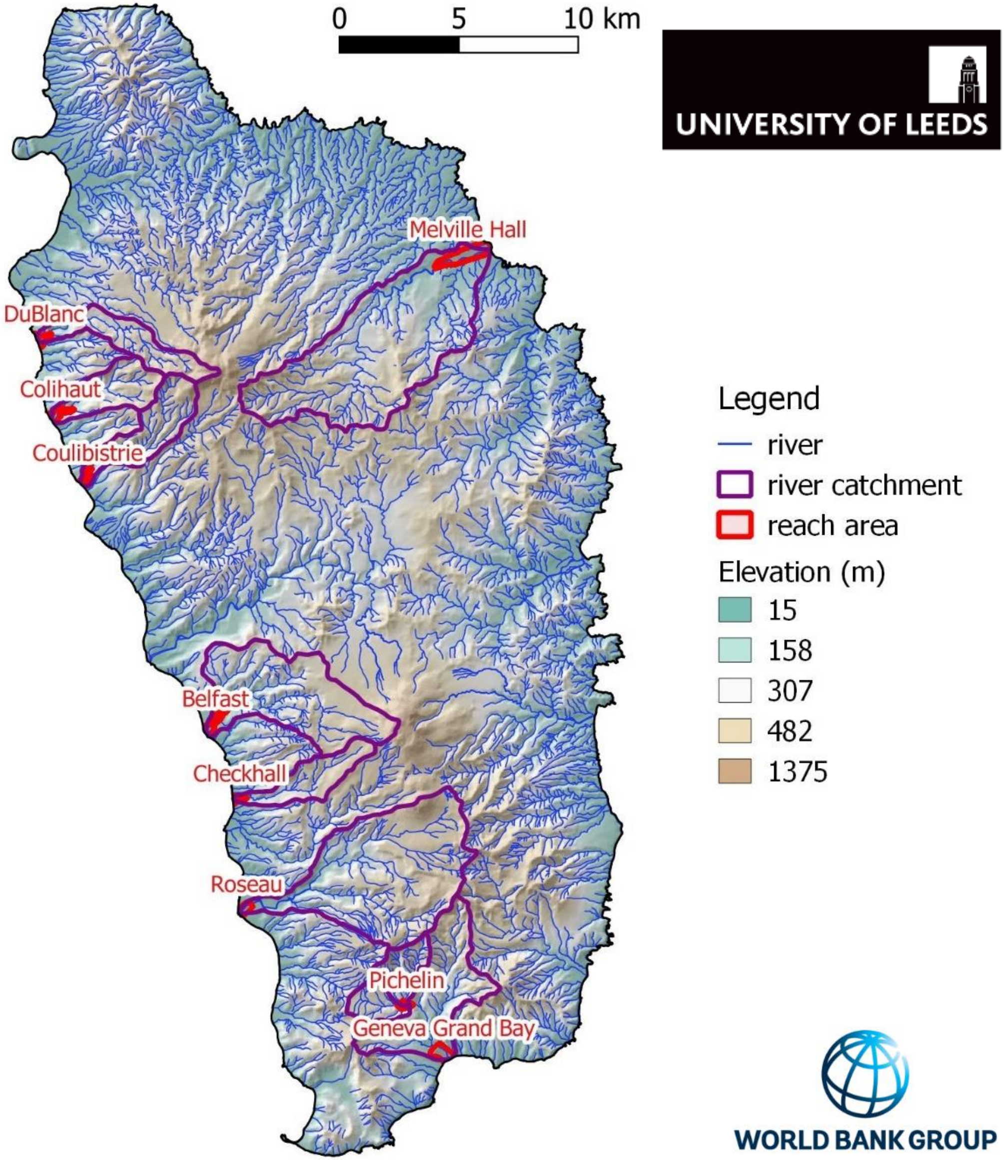


https://coast.noaa.gov/hurricanes/

*(*Post-Disaster Needs Assessment, Commonwealth of Dominica, 2017)*

Dominica Context

- Research is part of “Reducing flood debris and flow risk for infrastructure resilience” in Dominica (World Bank)
- We undertook 9 river reaches studies with 19 bridges included in the assessment
- Reaches prioritised by Government (MoPW)
- Engineering level assessment of key bridges (Hydraulic capacity, forces and scour)
- Included a study of bridge resiliance using post event forensics
- Used drones to file data gaps.
- Driving questions – “What makes a bridge resilient to multiple hazards and which risk is more important and where”



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Examples of bridges - post Maria

Topography of the island very steep > 60% of the slopes steeper than 30% gradient. Therefore, most of the populated areas are located on coastal alluvial fans.

River flows are very high and not monitored routinely. Rivers are steep and have a lot of energy, and also bringing sediment and debris as additional risks to infrastructure on the island.

Data needed from multiple sources

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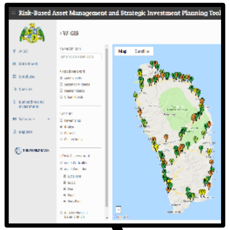
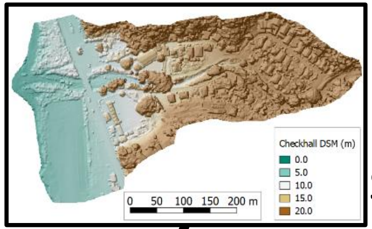
INES Asset Database

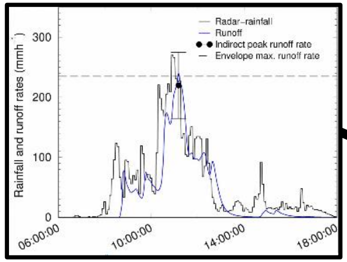




UoM Drone Surveys

Structure Details

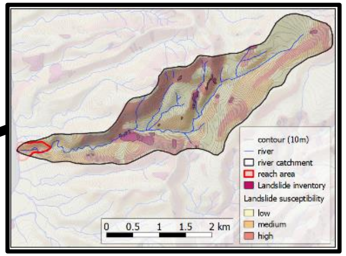
Terrain & channel



River Flows

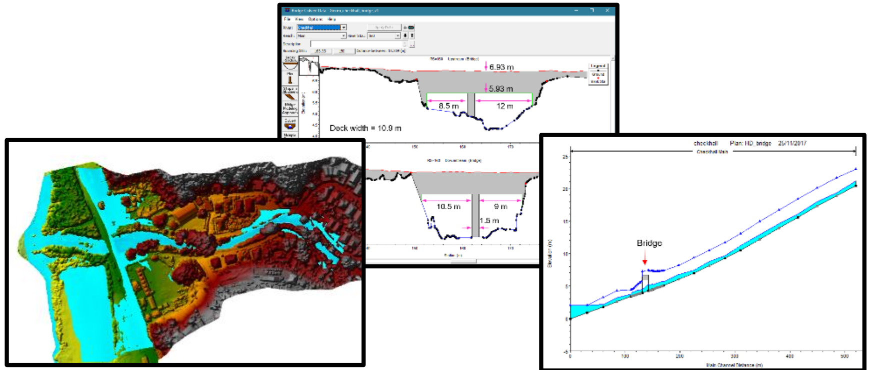
Bridge assessment

Upstream landslide



Ogden Hydrology assessment

ITC - CHARIM Landslide risk



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Bridge Assessment Conclusions

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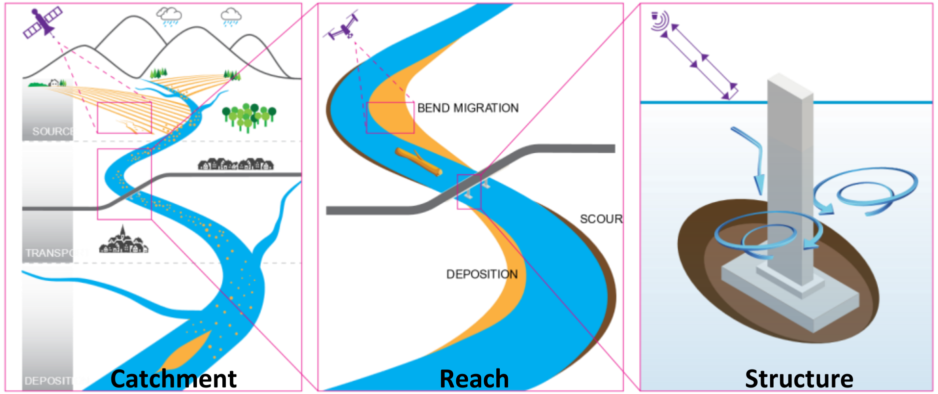
1. No bridge has sufficient hydraulic capacity. Newest only 50%
   - *Building a bridge “big enough” is expensive & max design flow very uncertain*
2. Bypass flows always evident and cause damage in settlements
   - *Future designs should assume bypass flow WILL occur and manage it*
3. Hydraulics supercritical & high energy, so forces & scour high
   - *Design details important to minimise forces and the impacts of scour*
4. Debris quantity large and flow/sediment modifies channel
   - *Most difficult aspects for design. Quantities and distribution are very uncertain.*

Outcomes are already being fed into recent infrastructure replacement projects on the island.



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Phase 2 – Bridge Risk Index

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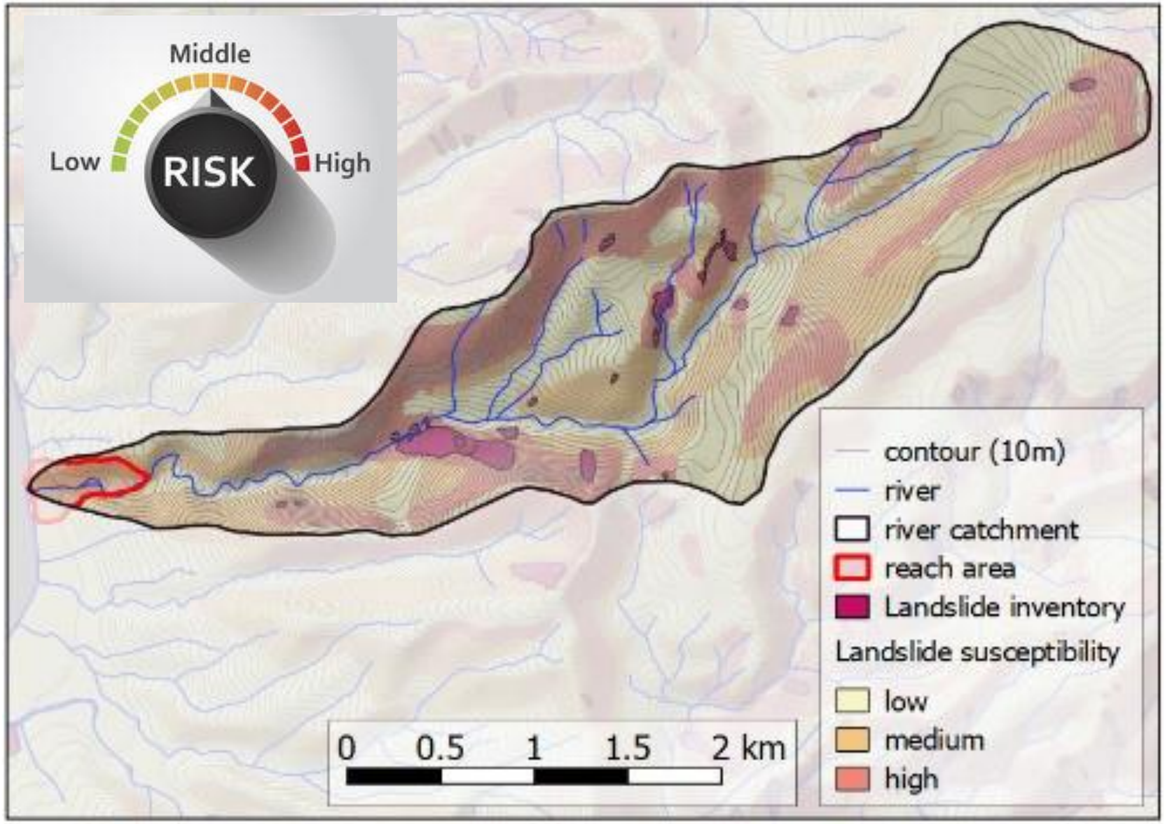
- We now have a good understanding of structure and reach scale risks
- But need a better understanding of upstream risk from landslide dams as well as debris and flow dynamics
- Landslide dam failures can cause flows 3-4 times what is normally possible from a catchment* – exceeding bridge design standards
- Driving question – "Can we identify bridges most at risk from these multiple hazards to target limited resources for mitigation?"



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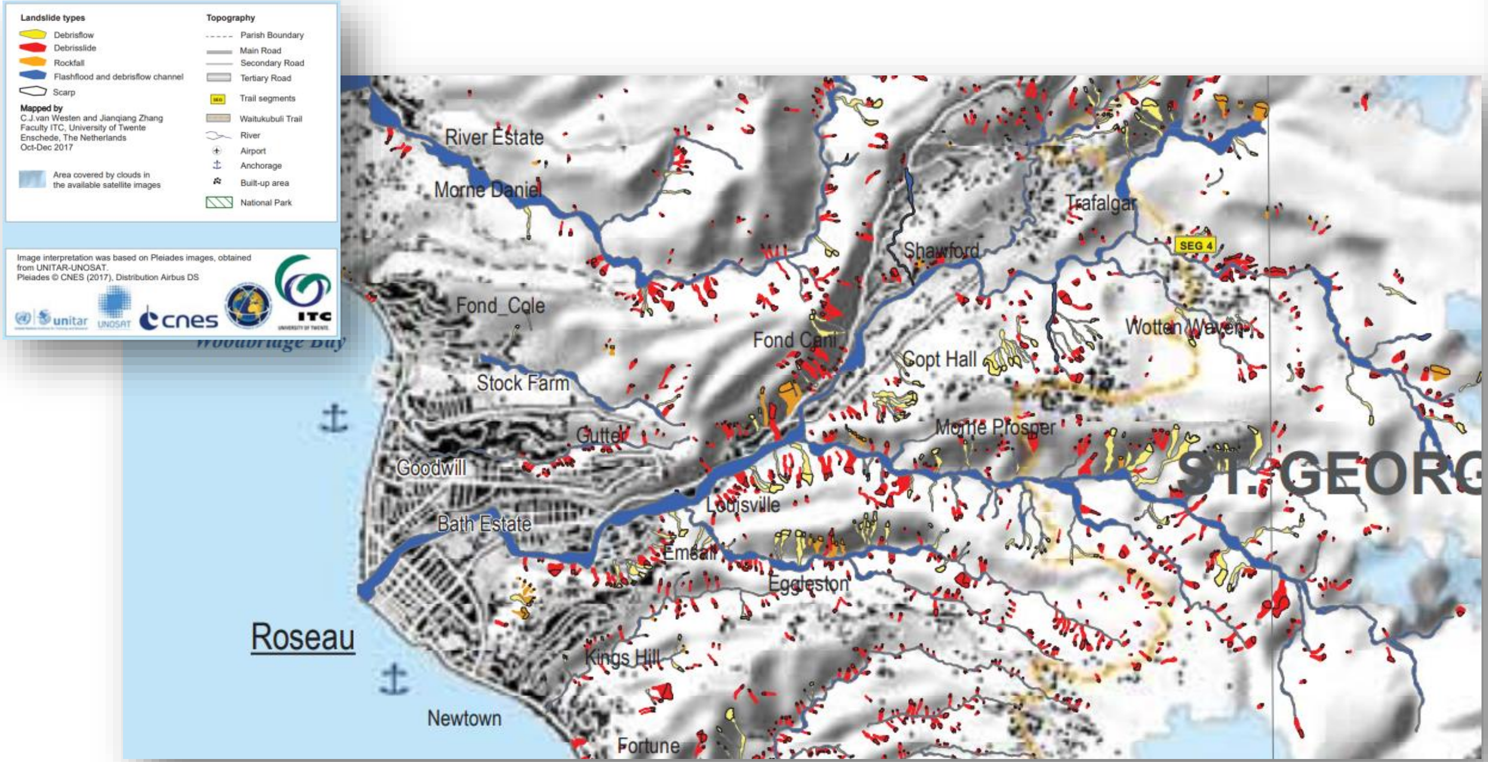
*Ogden, F.L., 2016. Journal of hydrology, 542

Thousands of landslides and floods triggered by Hurricane Maria (18 Sept 2017), Dominica



https://reliefweb.int/sites/reliefweb.int/files/resources/DOMINICA_Maria_2017_Landslides_UTwente.pdf

Identifying historic landslide dams and where they occur in the landscape

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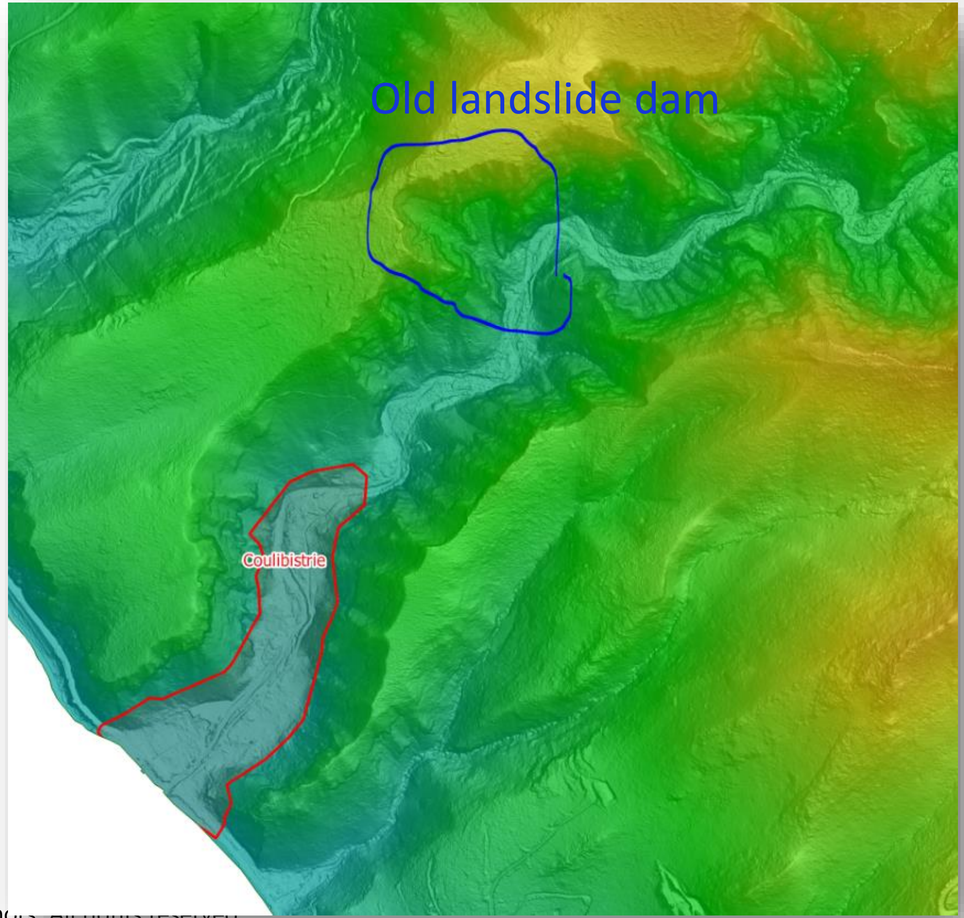

- New LiDAR data available to study the islands morphology.
- Currently exploring the use of morphometric analysis to understand factors that increase landslide dam risk – e.g. Melton Index
- Key locations appear to be in narrow mid-catchment transport reaches. Catchment is big enough for significant flow storage and topography is steep and close to the river to cause landslides that block the river. Closely tied to river geomorphology.

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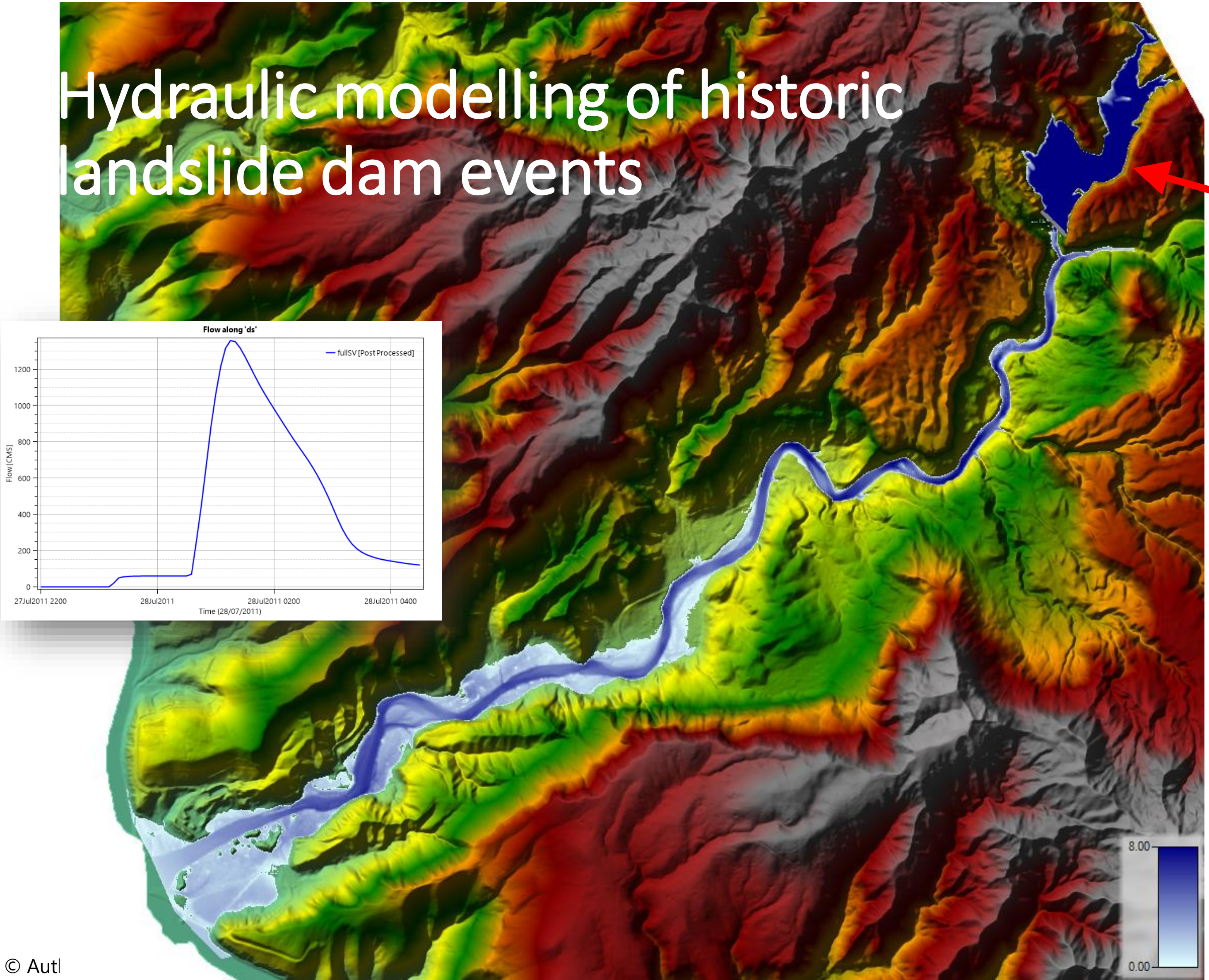
Hydraulic modelling of historic landslide dam events



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Using HecRas 2D modelling of historic landslide dam events to understand downstream implications for structures

James, and De Graff, 2012. The draining of Matthieu landslide-dam lake, Dominica, West Indies. *Landslides*

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Next steps – CV19 permitting!

- Develop integrated multi-hazard risk index for all bridges on the island to allow a ranking of bridges for prioritisation of repair and replacement funding
- We welcome suggestions on research directions to explore and collaborations
- Thank you for your interest!