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A framework for assessing sediment volumes mobilized by debris flows: test in the Liera catchment (Dolomites)

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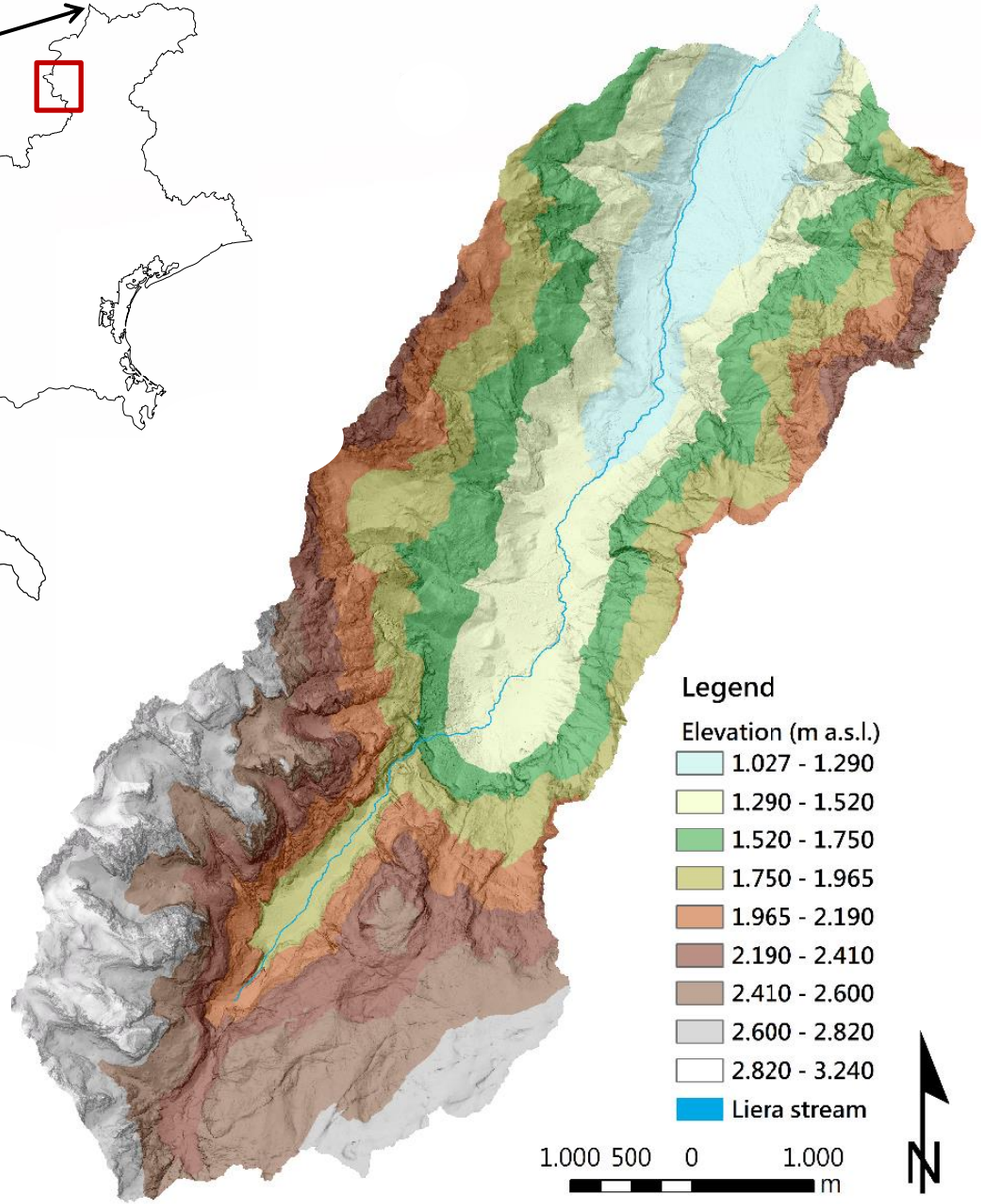
Liera basin & Vaia storm



The Liera creek is a stream of the Dolomites (northeastern Italy).
The Liera basin drains an area of **37.7** km^2 and its elevation ranges between 1027 and 3192 m a.s.l.

An intense storm, named Vaia, occurred from **27th to 30th October 2018** over Northeastern Italy, triggering mass wasting processes, generating new slope instabilities, causing widespread windthrows, and damaging anthropic structures. The Liera catchment was severely affected by the Vaia storm and **34** sub-basins featured debris flows.

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STUDY AIMS

1. SEDIMENT SOURCE AREAS INVENTORIES
2. UNDERSTAND SEDIMENT DYNAMIC AND RAINFALL PATTERNS
3. QUANTIFY THE MOBILIZED SEDIMENT FROM EACH SEDIMENT SOURCE AREAS
4. ESTIMATE THE MAGNITUDE OF THE DEBRIS FLOWS TRIGGERED BY THE EVENT

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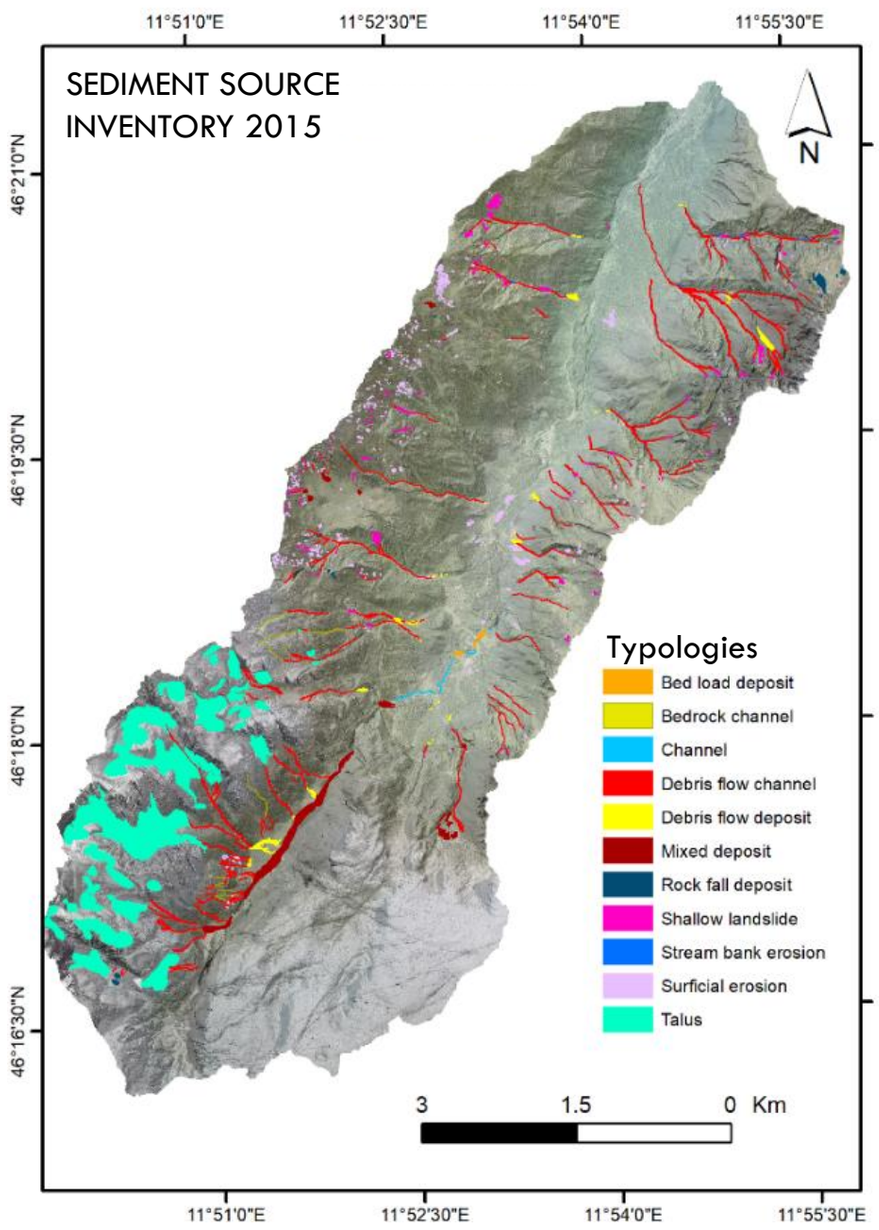
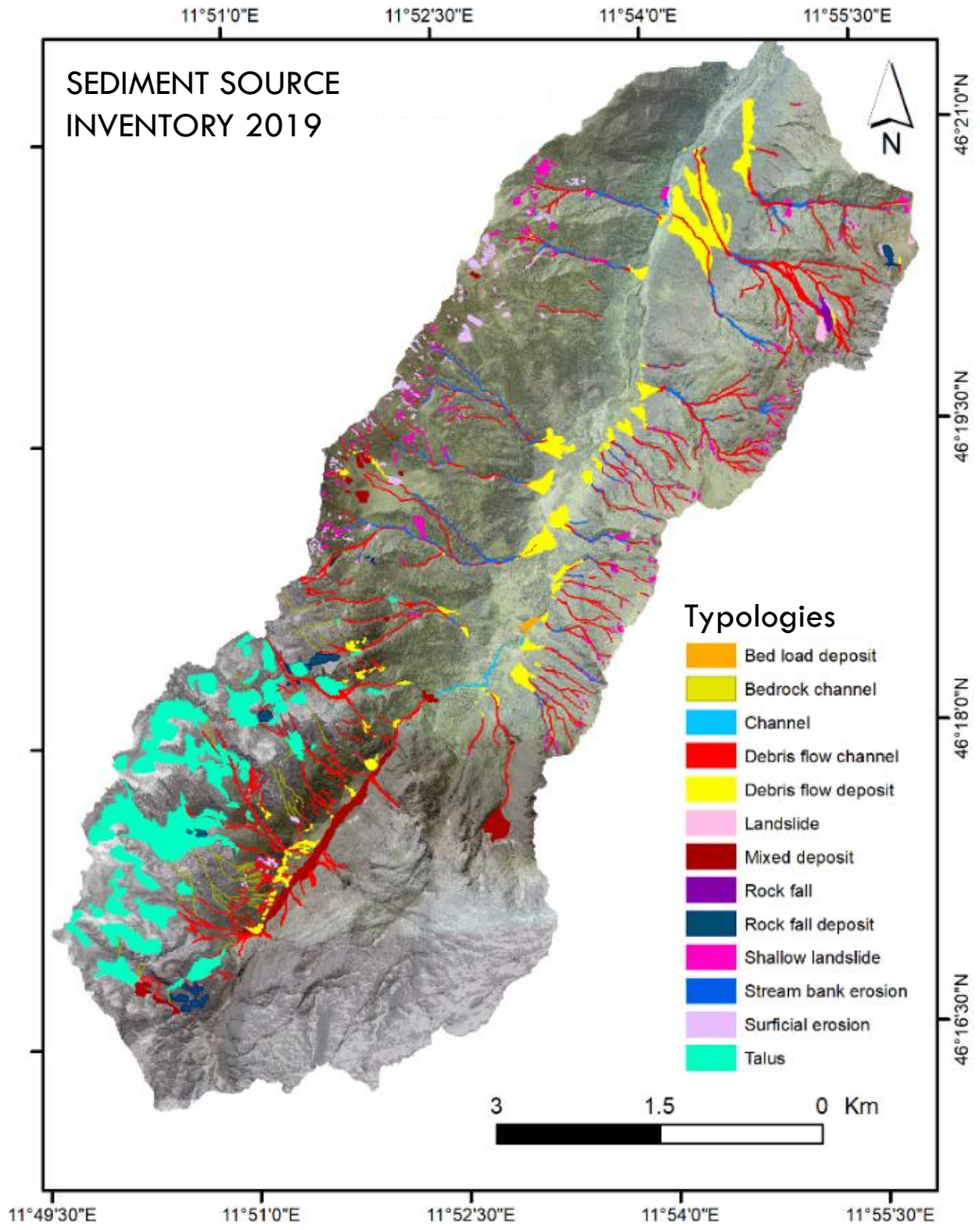
Sediment Source Inventories





Sediment sources identified and mapped in 2015 in the Liera catchment cover a total area of about 1.88 km^2.
The 2015 inventory was compared with the 2019 one in order to evaluate changes that occurred during the time interval between the two orthophotos.
The 2019 inventory consist of nearly 2150 mapped areas that covers an area of 2.40 km^2, pointing out an increase of 22%.

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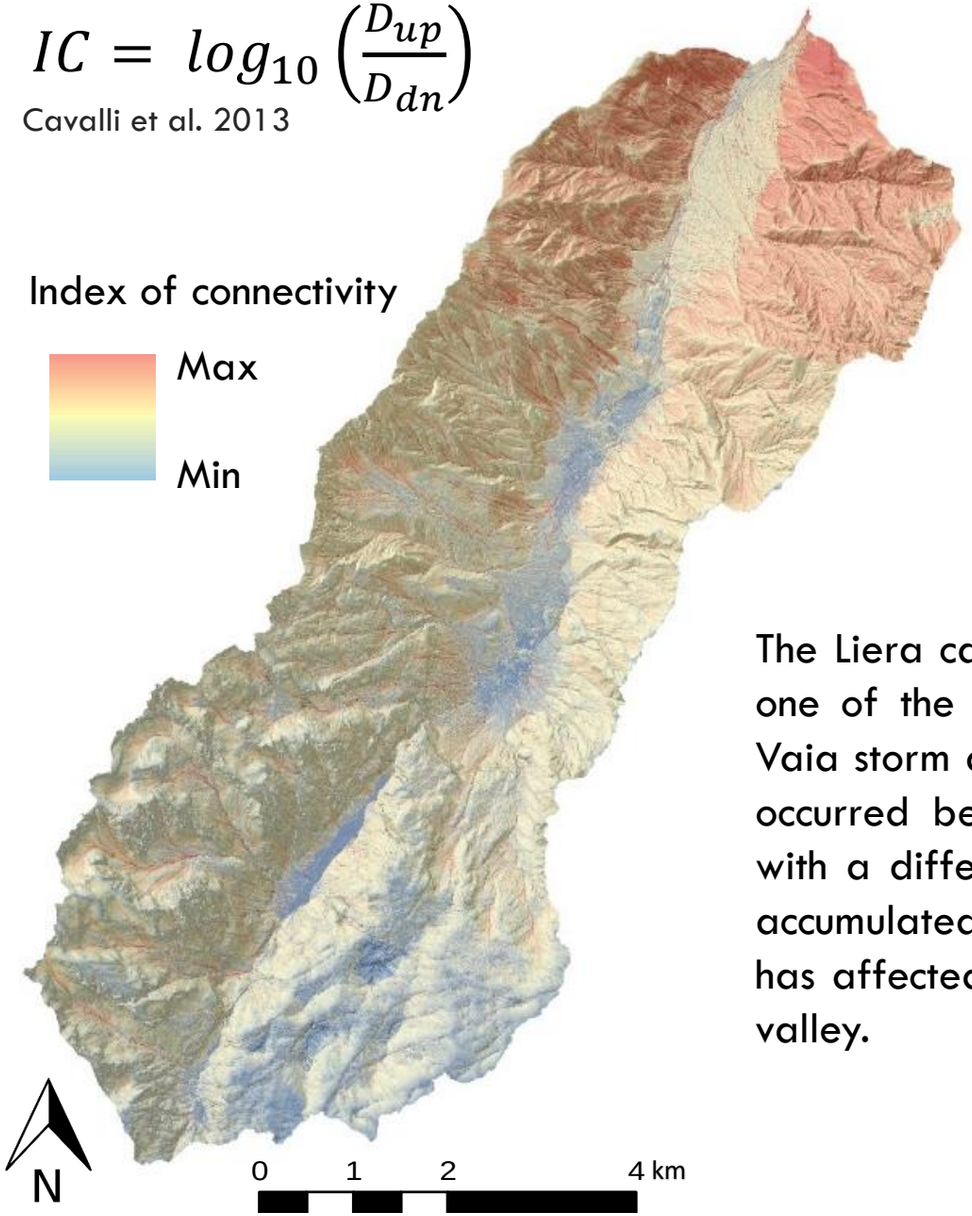
Index of connectivity

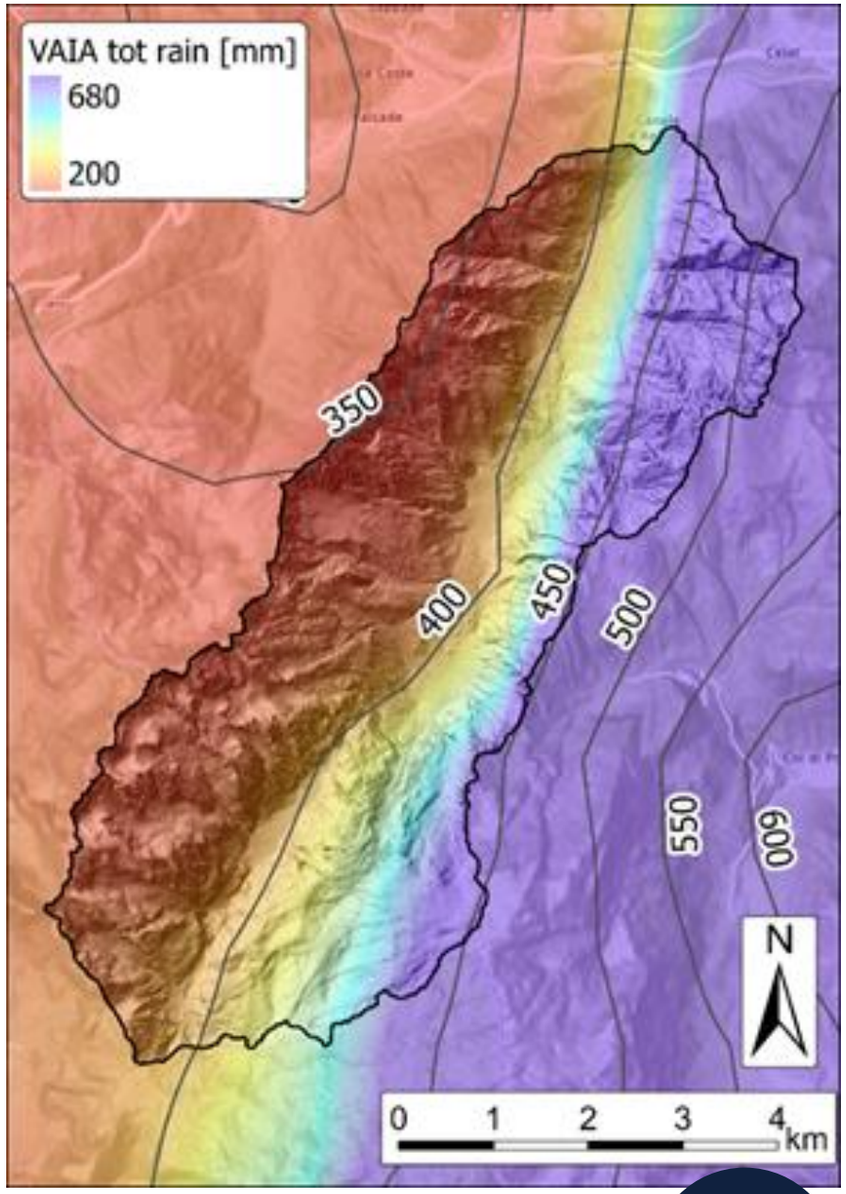
$$IC = log_{10}\left(\frac{D_{up}}{D_{dn}}\right)$$

Cavalli et al. 2013



The connectivity analysis showed that the upstream sector of the catchment (San Martino plateau) is not connected to the lower Liera valley and the debris originating in the highest portion of the relief are stored in the low-slope hanging valley upstream of the morphological step.

The Liera catchment is located near the edge of one of the convective precipitation belts of the Vaia storm and very important rainfall gradients occurred between the two flanks of the valley with a difference of approximately 200 mm of accumulated rainfall over the entire event, which has affected more severely the right side of the valley.



Rainfall analysis from Zaramella (UniPD)

Rainfall patterns

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Quantify volumes by DoD

START HERE

DTM 2010+2015 (pre-Vaia)

DTM 2019 (post-Vaia)

Gross DOD

$Z = ZDT_M + \delta Z$

Create an uncertainty* mask

* Measurement errors, sampling bias, interpolation methods.

Assign spatially variable elevation uncertainty δZ at each DTM

Propagate elevation uncertainty from each DTM into DoD calculation

(on a cell-by-cell basis)

$\delta U_{DoD} = \sqrt{(\delta Z_{new})^2 + (\delta Z_{old})^2}$

Choose confidence interval to apply threshold to DoD

(probabilistic)

98%

$t = \frac{|Znew - Zold|}{\delta U_{DoD}}$

Apply minimum level of detection threshold to DoD

$minLoD = t\sqrt{(\delta Z_{new})^2 + (\delta Z_{old})^2}$

Thresholded DoD

Perform geomorphic segregation of DoD on 2019 sediment source areas

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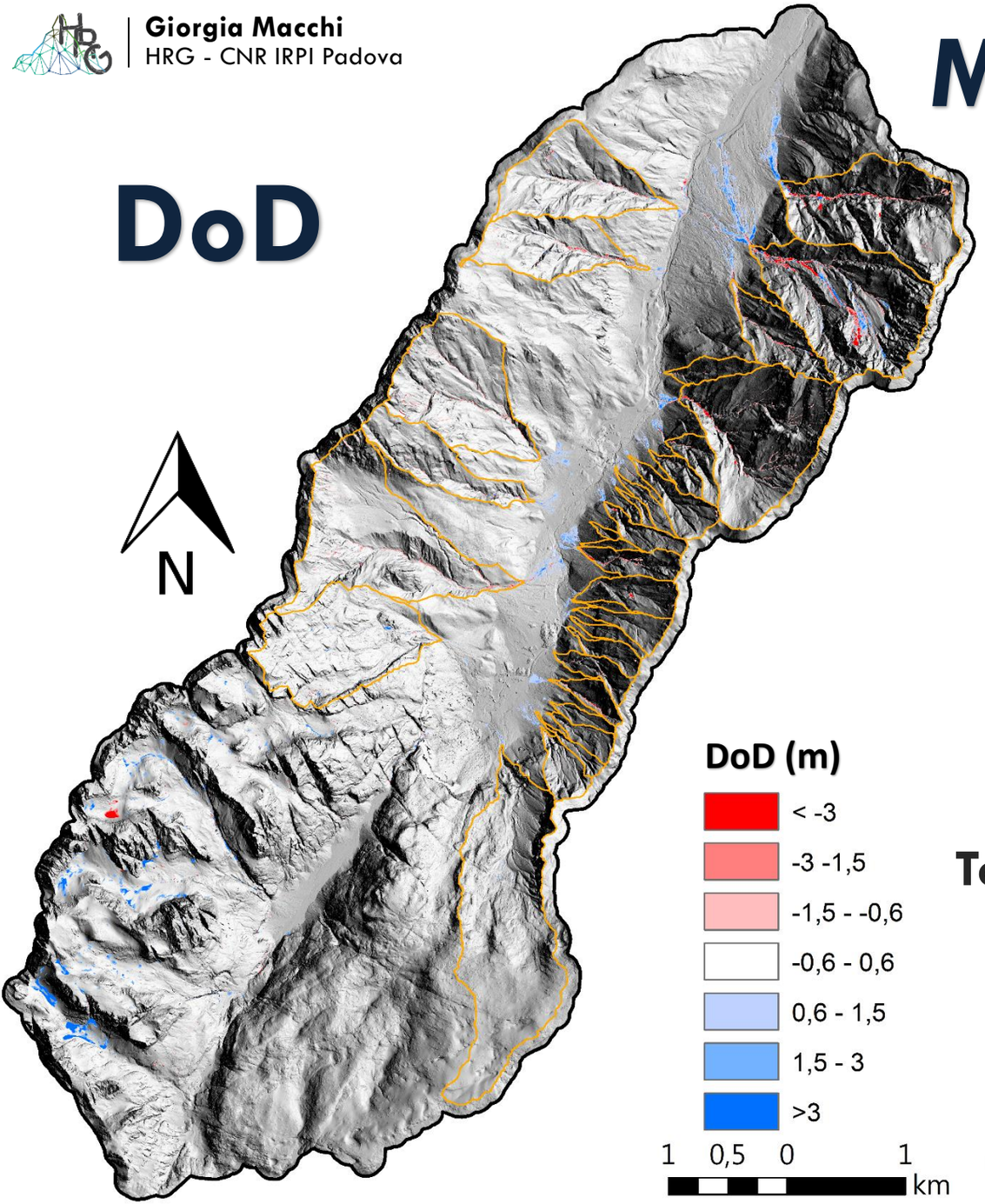
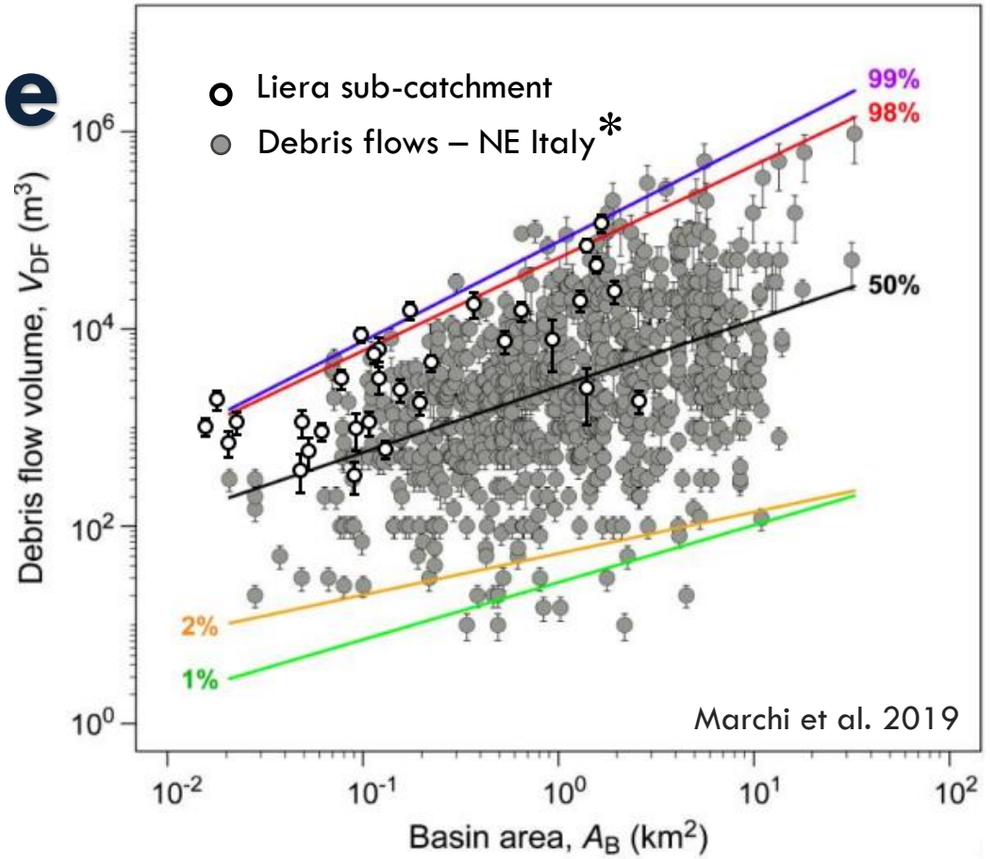
DoD



Magnitude

*dataset of 809 debris flows that occurred in mountainous areas of northeastern Italy between the mid-19th century to 2016



Volume quantification

Total amount of sediment mobilized from the sub-basins

307,000±63,500 m^3

Total sediment volumes exiting the sub-basin

64,000±14,500 m^3

The latter value encompasses the volume entered the Liera stream and the material that has been removed during and after the emergency operations.

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Thank you!

DO YOU HAVE

ANY QUESTIONS?

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