

TRENT2D WG: A SMART WEB INFRASTRUCTURE FOR DEBRIS-FLOW MODELLING AND HAZARD ASSESSMENT

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Research & Development Lab



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OUTLINE



- Debris flows
- The Directive 2007/60/EC as a mission
- The model TREN2D
- SaaS approach and WebGIS technology
- TREN2D WG: a web integrated solution



MAIN REFERENCES:

- Armanini, A., Fraccarollo, L. & Rosatti, G. 2009. Two-dimensional simulation of debris flows in erodible channels. *Comput. Geosci.* 35(5): 993-1006.
- De Amicis, R., Conti, G., Piffer, S. & Simões, B. 2009. Open challenges and protection of the environment, *GeoSpatial Visual Analytics*: 265-286.
- Heinimann, H.R., Hollenstein, K., Kienholz, H., Krummenacher, B. & Mani, P. 1998. Methoden zur Analyse und Bewertung von Naturgefahren. In Bundesamt für Umwelt, Wald und Landschaft (eds.), *Umwelt-Materialien* 85: 248. Bern: BUWAL.
- Plewe, B. 1997. *GIS-Online: information retrieval, mapping and the Internet*, OnWord Press.
- Rosatti, G. & Begnudelli, L. 2013. Two-dimensional simulation of debris flows over mobile bed: Enhancing the TREN2D model by using a well-balanced Generalized Roe-type solver. *Comput. Fluids.* 71: 179-195.
- Rosatti, G. & Fraccarollo, L. 2006. A well-balanced approach for flows over mobile-bed with high sediment-transport. *J. Compu. Phys.* 220: 312-338

DEBRIS FLOWS



Rio Monzoni TN, Italy, 1 Aug 2012 - by Adriano De Silvestro



Video: Adriano Desilvestro (www.youtube.com/watch?v=aKm6zUaTr_s)

- ✓ Two-phase granular flows
- ✓ High concentration
- ✓ Significant morphological modifications



Photo: Autonomous Province of Trento

**COMPLEX AND
HAZARDOUS PHENOMENA**

THE DIRECTIVE 2007/60/EC AS A MISSION



The Flood Directive 2007/60/EC provides:

GOAL

*It is feasible and **desirable**
to **reduce** the risk of
adverse consequences.*

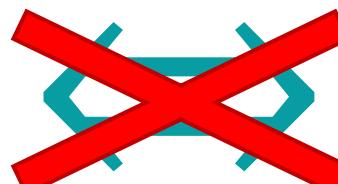
**SAFETY =
SOCIAL NEED**

METHOD

*[Hazard and risk]
assessment, maps and plans
should be based on
**appropriate best practice and
best available technologies**
not entailing excessive costs*

**COMPLEX
PHENOMENA**

**STATE-OF-THE-ART
MODELS**



THE DIRECTIVE 2007/60/EC AS A MISSION



Obstacles



High complexity + large computational burdens



High investment of resources (hardware, time)



Research tool



Not user-friendly



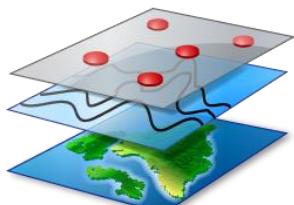
Stand-alone software logic



Hard maintenance



Weak connection researchers-users



Stand-alone GISs for geodata management



Fragmentation



Low interoperability



TRENT2D

Transport in Rapidly Evolutive, Natural Torrent – 2D

[Armanini et al., 2009]
 [Rosatti e Begnudelli, 2013]

- ✓ 2D
- ✓ Shallow flow
- ✓ Mobile bed
- ✓ Two-phase mixture
- ✓ Isokinetic description
- ✓ Immediate adaptation

$$\left\{ \begin{array}{l} \frac{\partial}{\partial t}(z_b + h) + \frac{\partial}{\partial x}(hu_x) + \frac{\partial}{\partial y}(hu_y) = 0 \\ \frac{\partial}{\partial t}(c_b z_b + ch) + \frac{\partial}{\partial x}(chu_x) + \frac{\partial}{\partial y}(chu_y) = 0 \\ \frac{\partial}{\partial t}((1 + c\Delta)hu_x) + \frac{\partial}{\partial x}(1 + c\Delta)\left(u_x^2 h + \frac{1}{2}gh^2\right) + \frac{\partial}{\partial y}((1 + c\Delta)hu_x u_y) + (1 + c\Delta)gh \frac{\partial z_b}{\partial x} = -\frac{\tau_{bx}}{\rho_w} \\ \frac{\partial}{\partial t}((1 + c\Delta)hu_y) + \frac{\partial}{\partial x}((1 + c\Delta)hu_x u_y) + \frac{\partial}{\partial y}(1 + c\Delta)\left(u_y^2 h + \frac{1}{2}gh^2\right) + (1 + c\Delta)gh \frac{\partial z_b}{\partial y} = -\frac{\tau_{by}}{\rho_w} \end{array} \right.$$

Closure relations

- ✓ $c \propto Fr^2$
 [Rosatti and Fraccarollo, 2006]
- ✓ τ_b : grain-inertial regime
 [Takahashi, 1978]

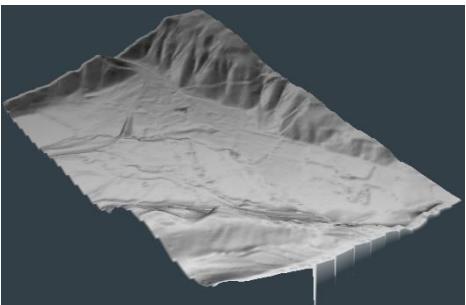
Numerical model

- ✓ Cartesian mesh
- ✓ Finite-volume method
- ✓ Godunov-type fluxes
- ✓ Second-order accuracy in space and time

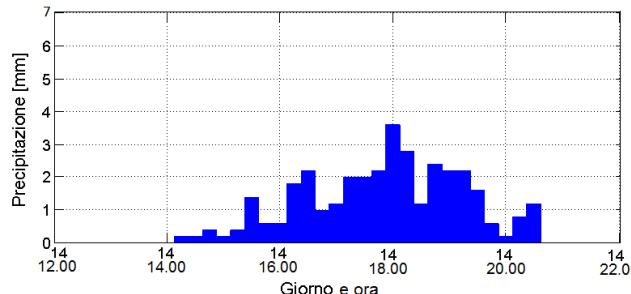
THE TRENT2D MODEL



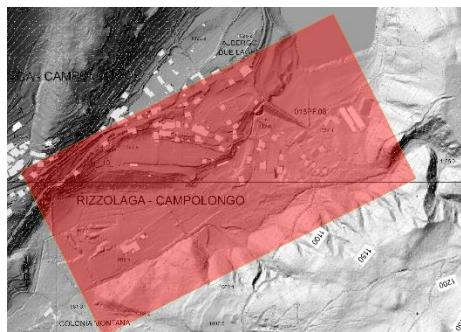
Geographic data



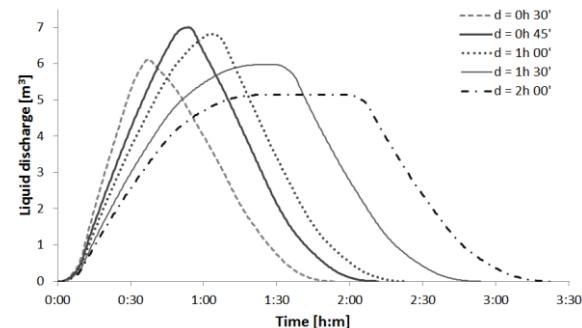
Hydrological data



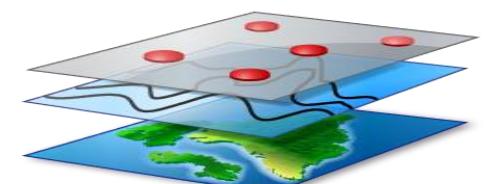
Computational domain



Boundary conditions



Maps (governing variables)



TRENT2D

SaaS = *Software as a Service*



- ✓ Cloud server
- ✓ Accessible via Web
- ✓    
- ✓ Suitable GUI

WebGIS

= *Web application able to manage, display and process geographic and economic data* [Plewe, 1997]



- ✓ GIS functionalities
- ✓ High flexibility
- ✓ Wide potential [De Amicis et al., 2009]

SAAS APPROACH AND WEBGIS TECHNOLOGY



**High investment of resources
(hardware, time)**



High-performing cloud server



Non user-friendly



Intuitive



Hard maintenance

Weak connection researchers-users



No installation
Centralised maintenance
Stronger connection researchers-users



Fragmentation

Low interoperability



GIS functionalities



TRENT2D (as a Service)



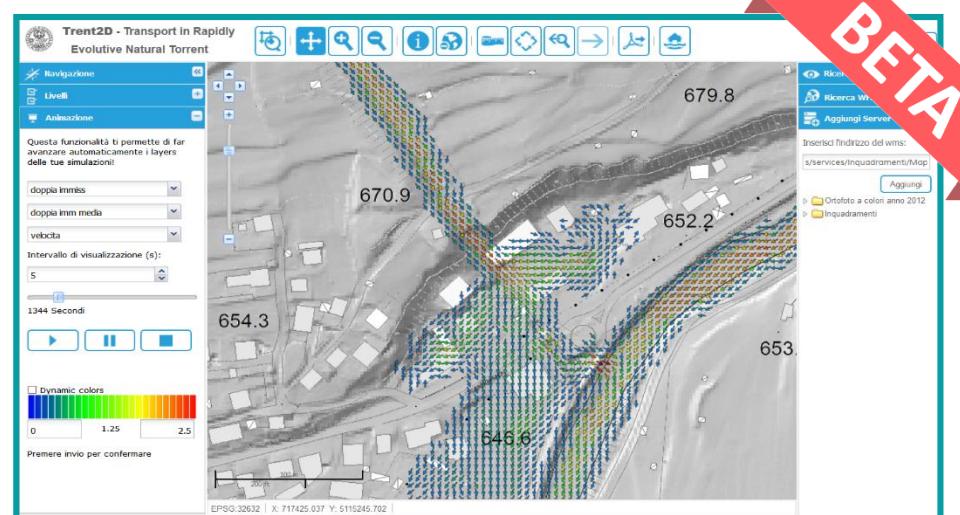
WEBGIS



**TRENT2D
WG**

Available on
trent2d.trilogis.it

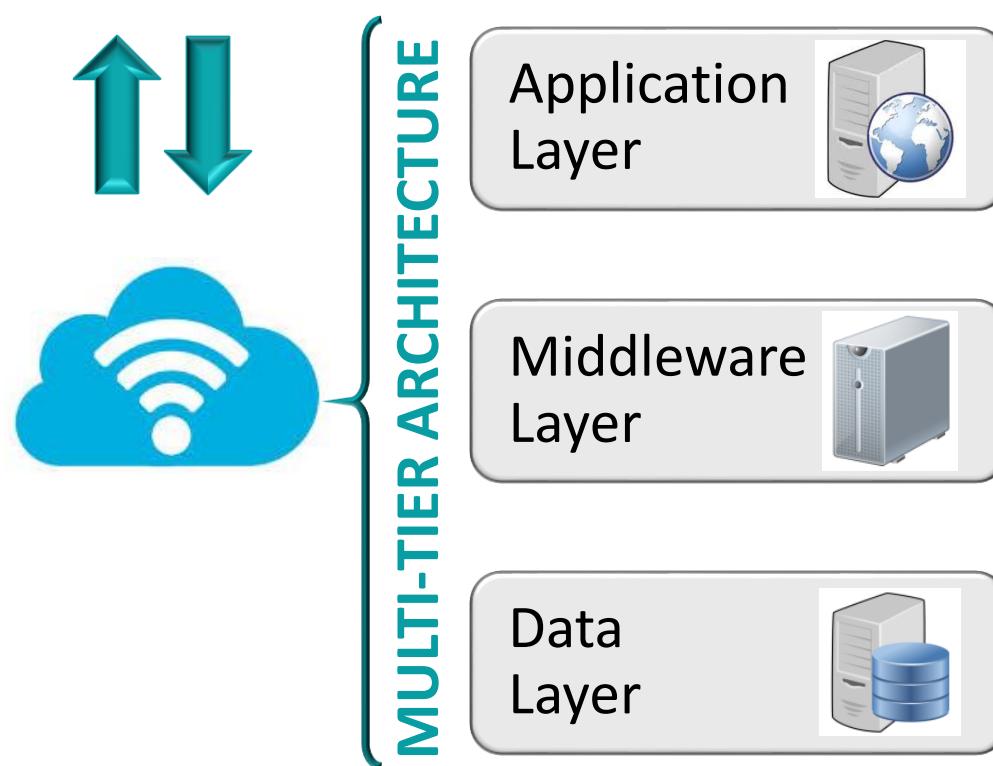
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System architecture



In keeping with
OGC® standards



Information display

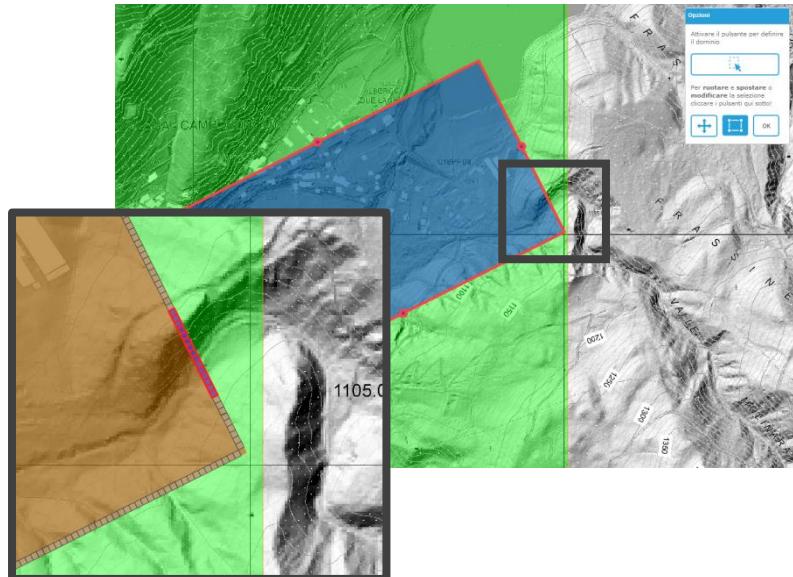
Complex processing
**(Trent2D, Geo Server,
Hazard Mapper...)**

Data storage and
retrieving

Pre-processing

Wizard

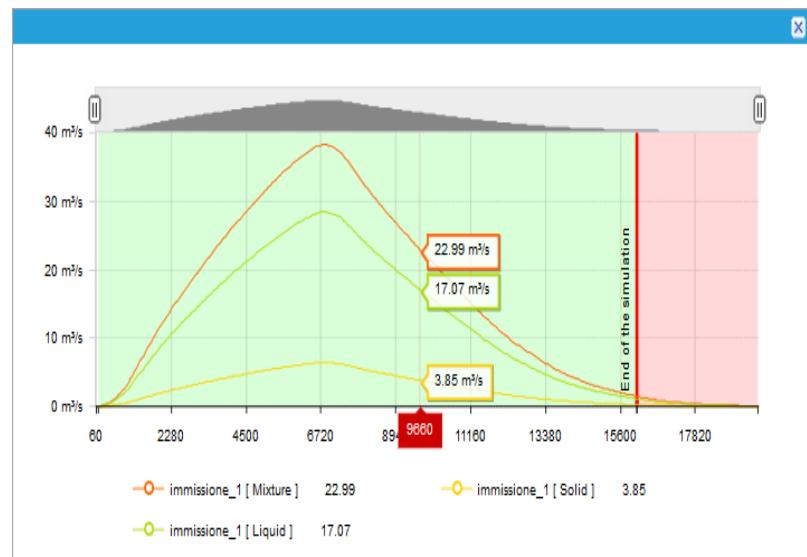
- ✓ Create/manage computational domains
- ✓ Define inflow sections
- ✓ Define boundary conditions
- ✓ Prepare new simulations
- ✓ ...



Trent2D

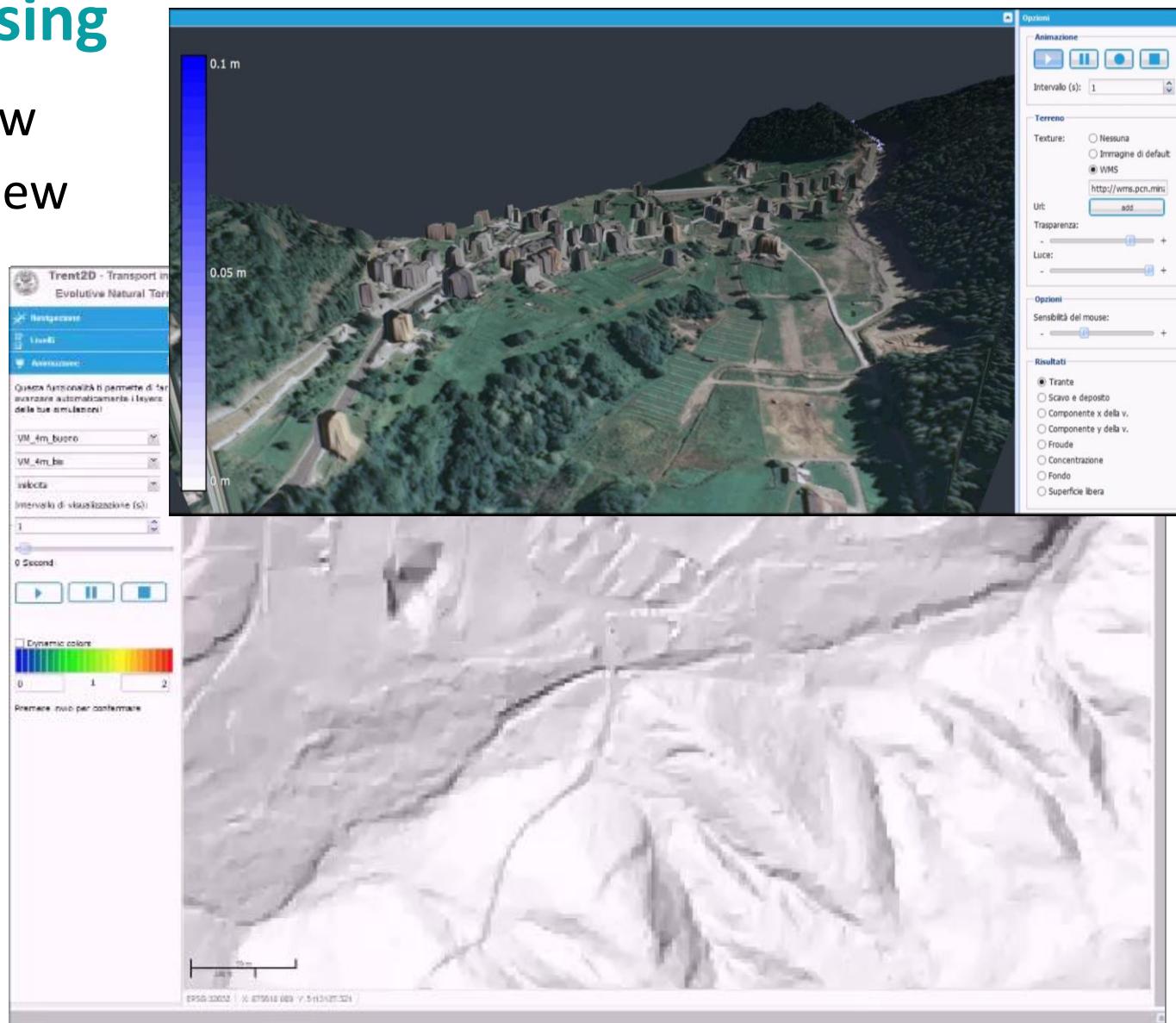
New simulation

Name:	test
Description:	notes about the simulation "test"
Dominio:	Dom_GrandValey
Return period:	Low
Type:	<input checked="" type="radio"/> Debris flow <input type="radio"/> Sediment transport
Use parameters that:	<input type="button" value="***"/> <input type="button" value="***"/> <input type="button" value="30_Grand_Valey"/> <input type="button" value="100_GrandValey"/> <input type="button" value="200_GrandValey"/>
Ks (*.asc):	<input type="button" value="Browse..."/> <input type="button" value="Continue"/>



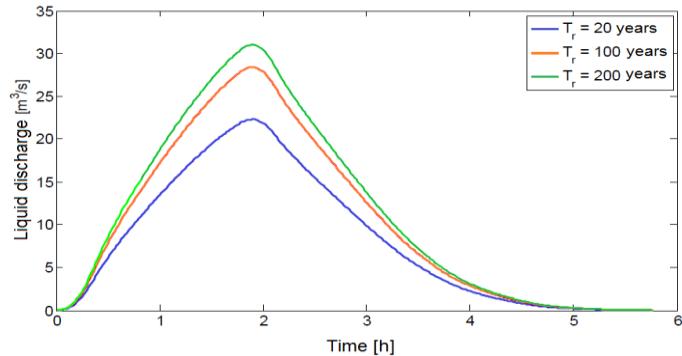
Post-processing

- ✓ 2D local view
- ✓ 2D global view
- ✓ 3D view
- ✓ ...

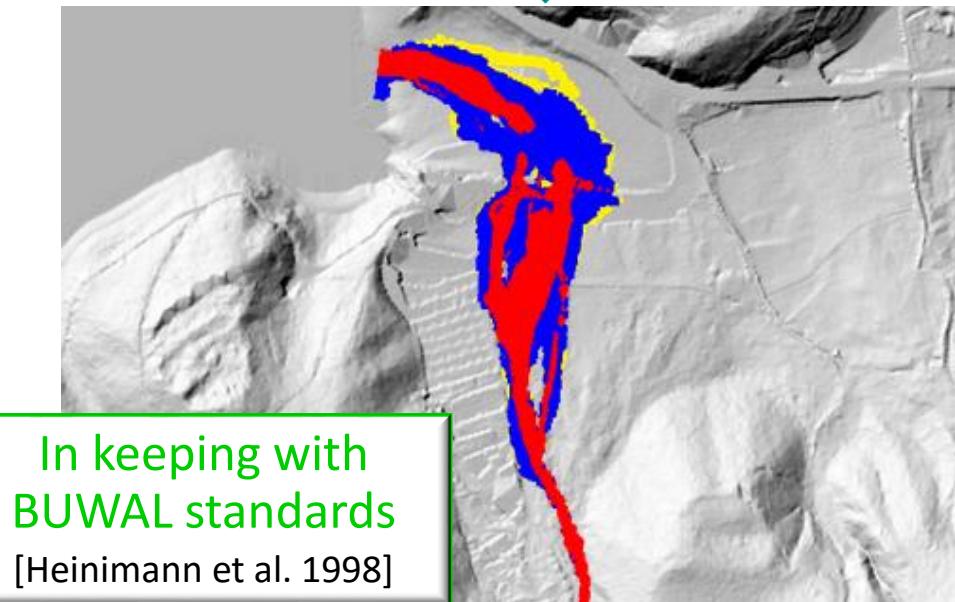
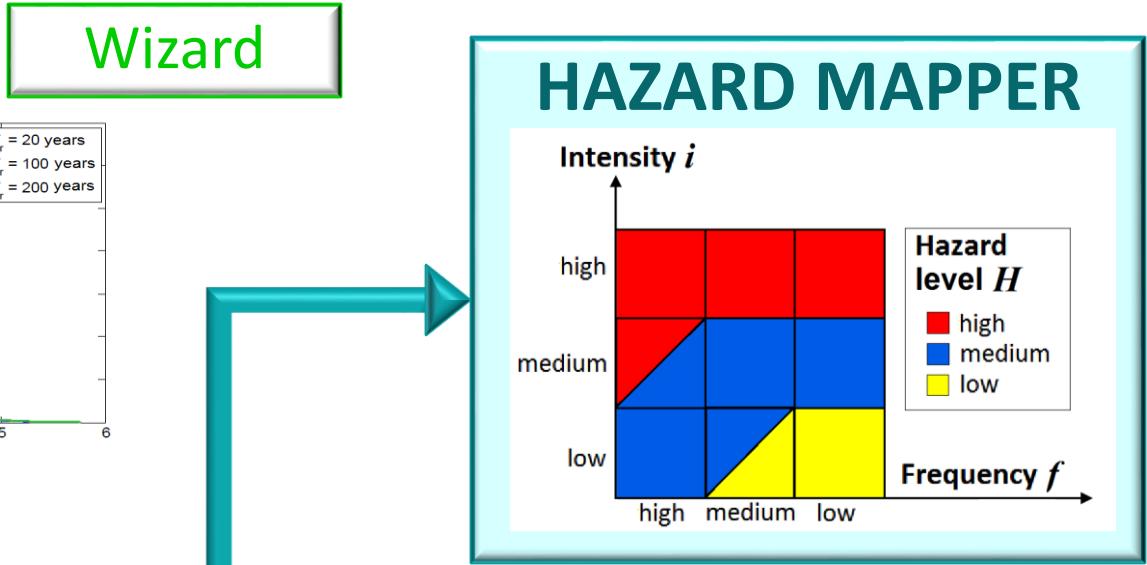
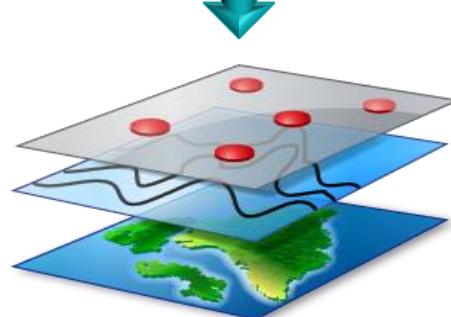


Hazard Mapper

Wizard



TRENT2D



In keeping with
BUWAL standards
[Heinimann et al. 1998]

TRENT2D WG

= a smart web infrastructure for debris-flow modelling and hazard assessment



- ✓ Hazard assessment
- ✓ Design of protection measures
- ✓ Back-analyses

Future developments

The TRENT2D model

- Fixed-mobile bed
- Closure relation for concentration

The TRENT2D WG system

- New functionalities
- A rainfall-runoff model
- Other models as services



THANK YOU FOR YOUR ATTENTION

ARE YOU INTERESTED? Register on
trent2d.trilogis.it

This modelling solution was partially realized within two research projects:

*the CLIMAWARE project,
funded by the University of Trento (Italy),
and the MHYMESIS project,
funded by the CARITRO Foundation (Italy)*