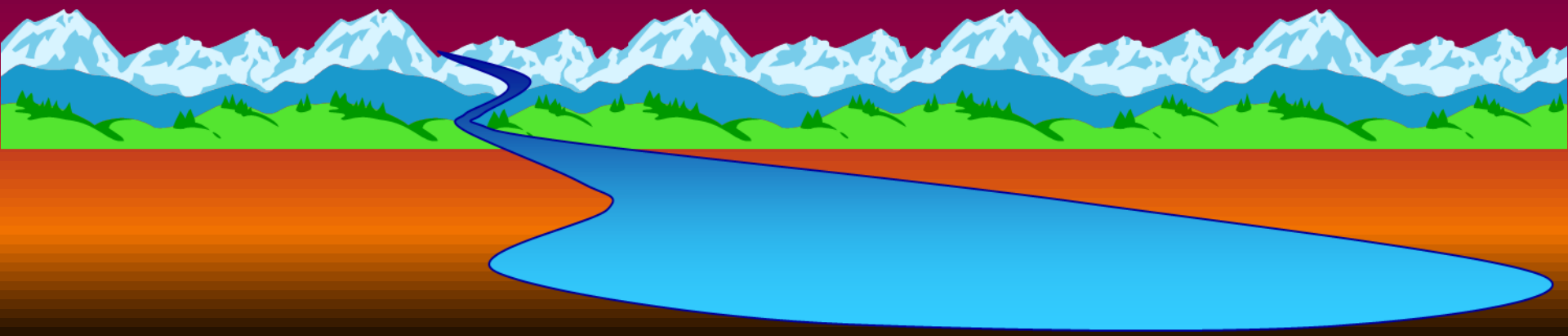
DAMAGING HYDROGEOLOGICAL EVENTS (DHEs) IN CALABRIA (ITALY)

Olga Petrucci

CNR-IRPI Cosenza



CNR - NATIONAL RESEARCH COUNCIL

CNR, National Research Council, the largest public research organization of Italy, was founded in 1923.

It is organised in 11 Departments

The staff is made of more than 8,000 people, 4,000 of which are researchers.

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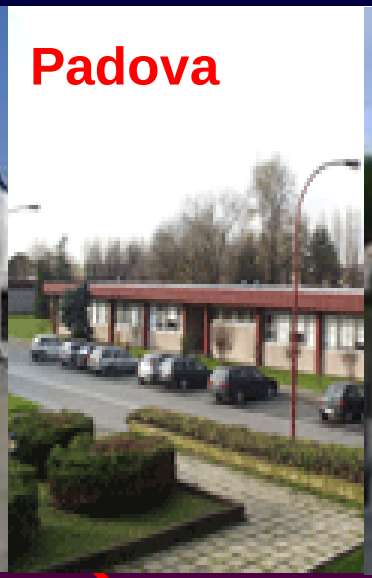
- Cultural Heritage
- Cultural Identity
- Energy and Transport
- Life sciences
- Materials and Devices
- Medicine
- Information and Communication Technologies
- Molecular Design
- Production Systems
- **Earth and Environment**

CNR-IRPI

RESEARCH INSTITUTE FOR HYDRO-GEOLOGICAL PROTECTION



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DAMAGING HYDROGEOLOGICAL EVENTS (DHE)

(EVENTS)

Predisposing factors

Geological and geomorphological framework

Triggering factors

Severe weather conditions (heavy/ prolonged rainfall and strong winds)

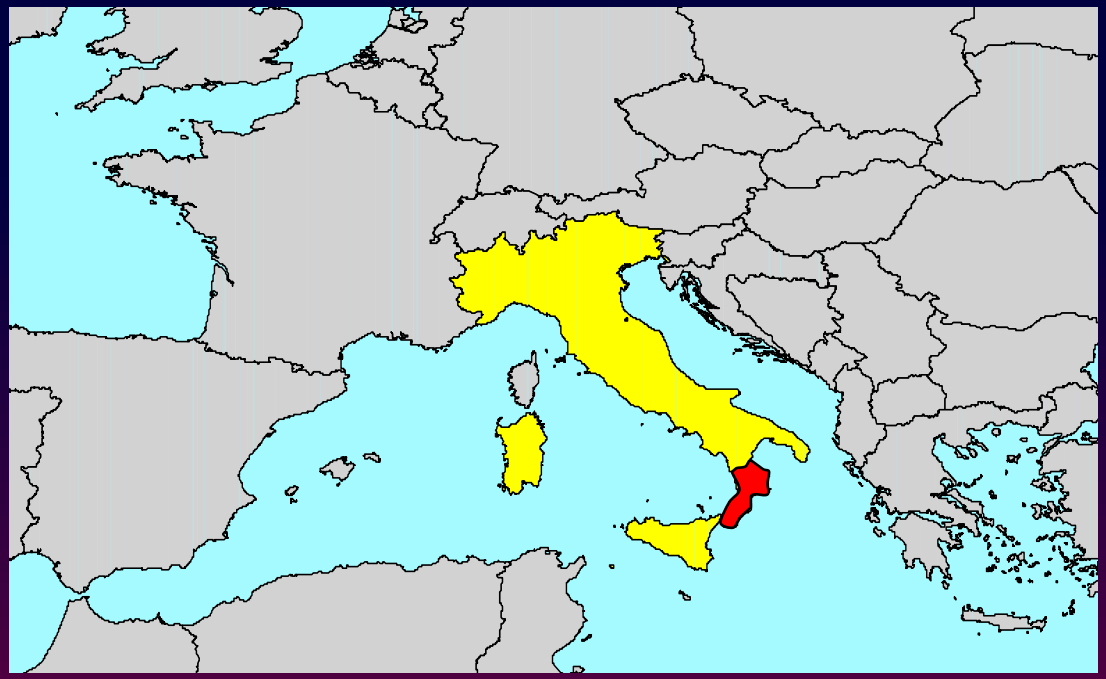
DAMAGING HYDROGEOLOGICAL EVENTS

Occurrence of damaging phenomena as landslides, flooding, and storm surges

Direct damage: *victims, injured, structures and goods destruction*

Indirect damage: *economic loss due to destruction of roads and services*

THE STUDY AREA: CALABRIA REGION (Italy)



Area: **15,230** km^2

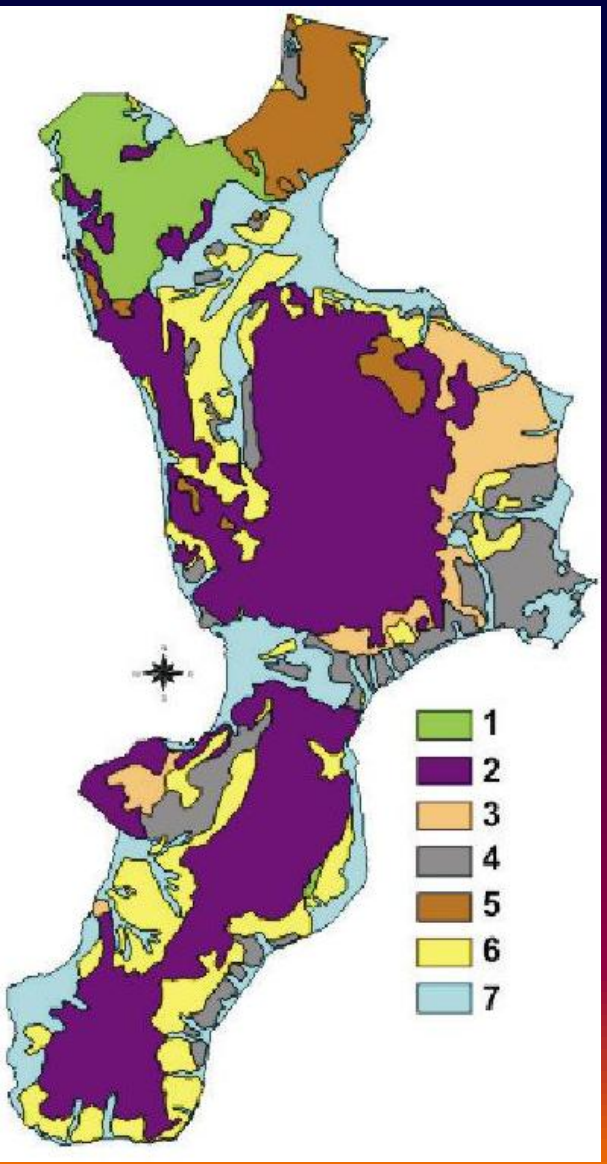
Mean altitude: **418** m a.s.l.

Maximum altitude: **2266** m a.s.l.

Population density: **133** inh/km^2

Mean annual rainfall: **1151** mm

GEOLOGICAL FEATURES OF CALABRIA



1. limestone and dolostone
2. metamorphic and igneous rocks
3. clays, marls and evaporitic rocks
4. sandstones, marly clays and limestone marls
5. flysch and clayey formations
6. conglomerates, sands and sandstones
7. alluvial deposits

Almost 90% of territory is in relief, and 10% is represented by coastal and fluvial plains. The river network is mainly made of ephemeral streams which are frequently affected by flash floods.

Tectonic stress and climatic conditions deteriorated the characteristics of rocks, predisposing slopes to landsliding

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ADMINISTRATIVE BOUNDARIES OF CALABRIA

Calabria is divided in **5 provinces** and in **409 municipalities**

The region is frequently affected by Damaging Hydrogeological Events

Some recent cases are shown in the next slides

MARCH 2011: REGGIO CALABRIA PROVINCE

66 municipalities hit

4 victims

NOVEMBER 2010: REGGIO AND CROTONE PROVINCES

62 municipalities hit

1 victim

JANUARY 2009

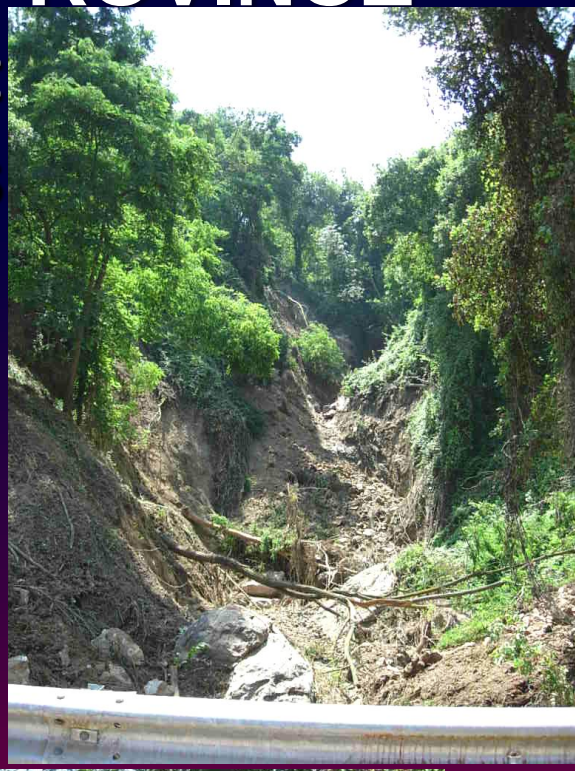
234 municipalities hit (57%)

2 victims

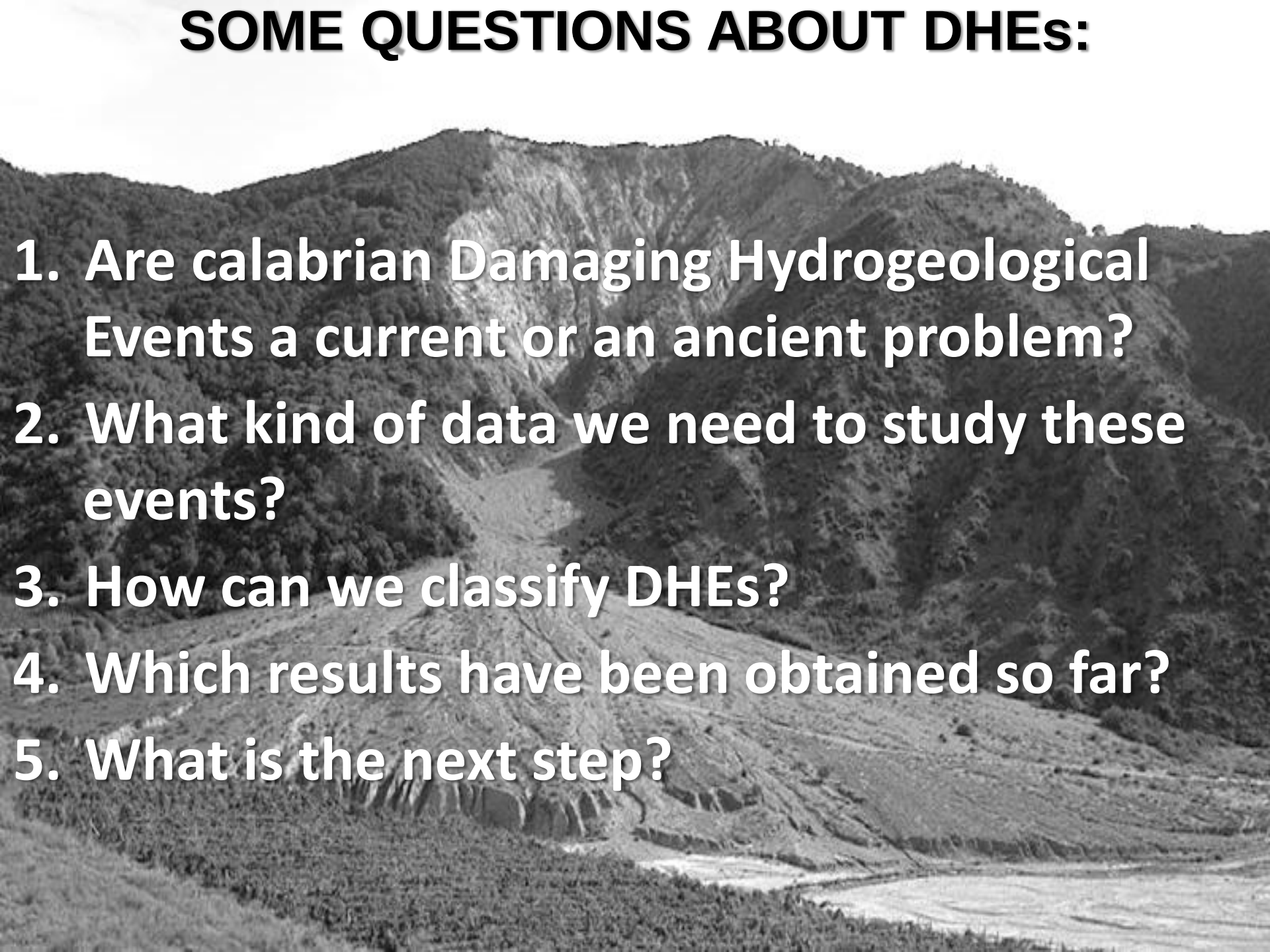
JULY 2006: VIBO VALENTIA PROVINCE

18 municipalities hit

4 victims

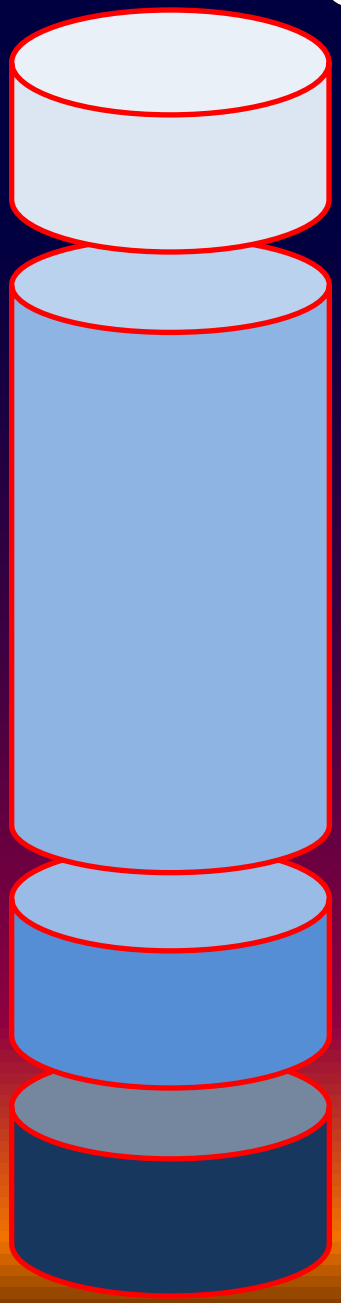


SOME QUESTIONS ABOUT DHEs:



1. Are calabrian Damaging Hydrogeological Events a current or an ancient problem?
2. What kind of data we need to study these events?
3. How can we classify DHEs?
4. Which results have been obtained so far?
5. What is the next step?

OUR KNOWLEDGE ABOUT PAST EVENTS



Currently: updating of database introducing both present and historical events

2005 Creation of the Historical archive, using data coming from several Agencies

-Genio Civile (Cosenza)
-Provveditorato alle OO.PP. Calabria Settore 32
-State Archive (Cosenza)
-Civil Protection of Calabria
-Emeroteca de "La Gazzetta del Sud"

2000 Implementation of ASICal database

www.camilab.unical.it

(Dep. of *Soil Defense, University of Calabria*)

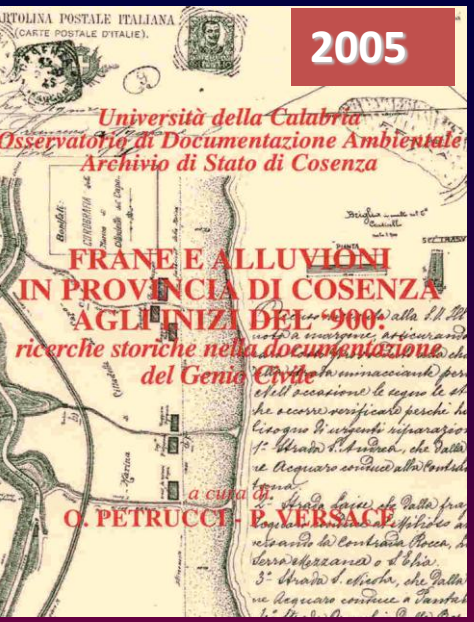
1999 Collection of published data

THE HISTORICAL ARCHIVE OF CNR-IRPI OF COSENZA

DATA DIFFUSION: QUADERNI DELL'ODA

CAMILAB
Laboratorio di Cartografia Ambient
Università della Calabria - Dipartim
Direttore: Prof.Ing.Pasquale Versac

Centro di Competenza del Dipartimento di Protez
(Decreto del 26/01/2005 emanato ai sensi della Direttiva d



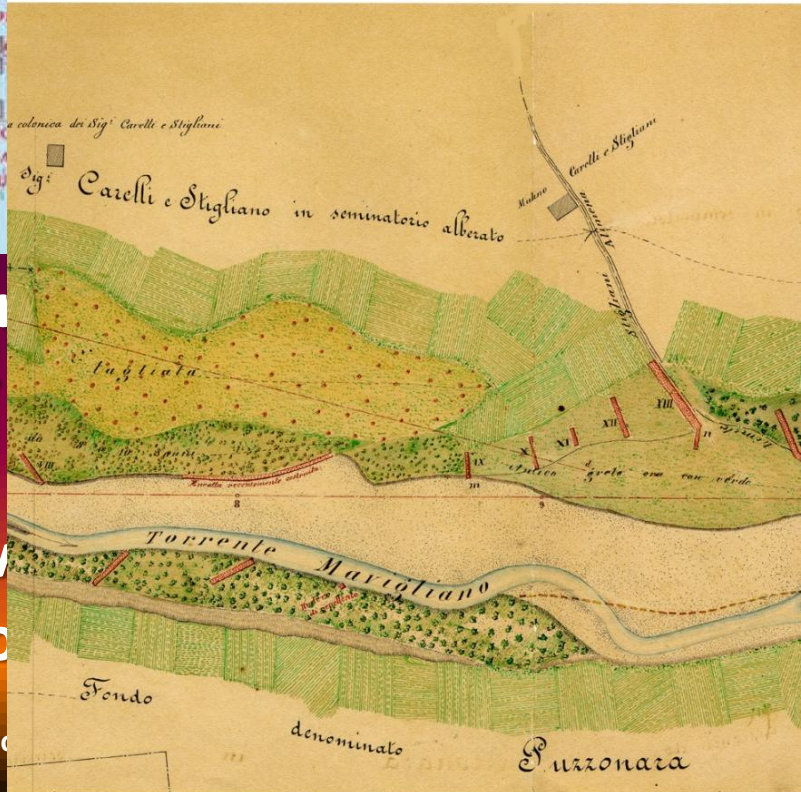
Dipartimento di Difesa del Suolo, UNICAL
CNR-IRPI (Cosenza)
CNR-ISSM (Napoli)

2011

La difesa del suolo nell'Ottocento nel mezzogiorno d'Italia

a cura di

Walter Palmieri, Olga Petrucci e Pasquale Versace

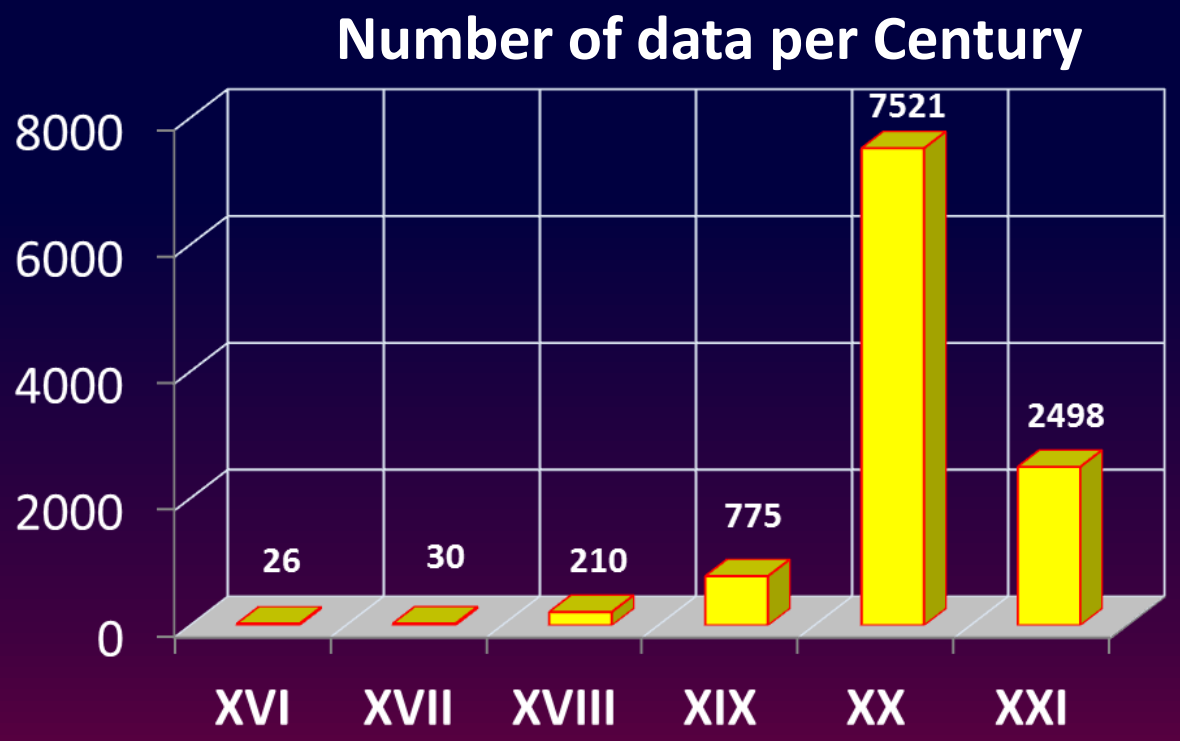


Data diffusion is realized by ODA (Osser Documentazione Ambientale), a sector Soil Defence – University of Calabria). Currently, three data-collections are av Google Books), and a new published bo the next weeks

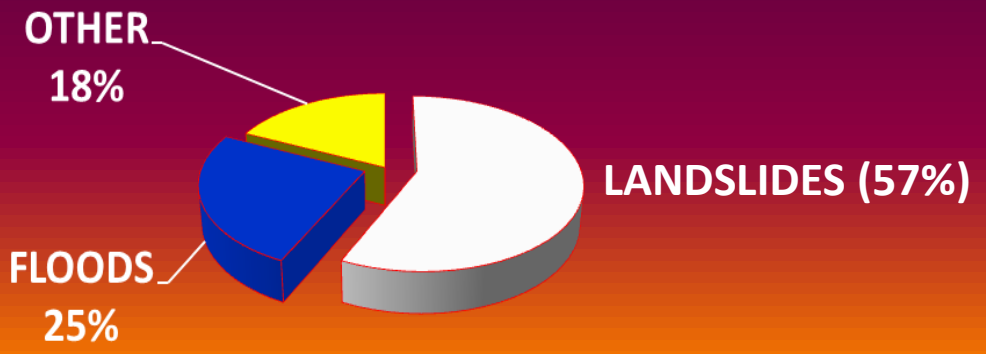
DATA AVAILABILITY ON DAMAGING PHENOMENA

According to both the increases of information sources and attention to these phenomena, data concerning the oldest epochs are less plentiful.

For these reasons, the highest number of data pertain to 1900, and to the last 10 years



Currently, the highest number of data available concern landslides

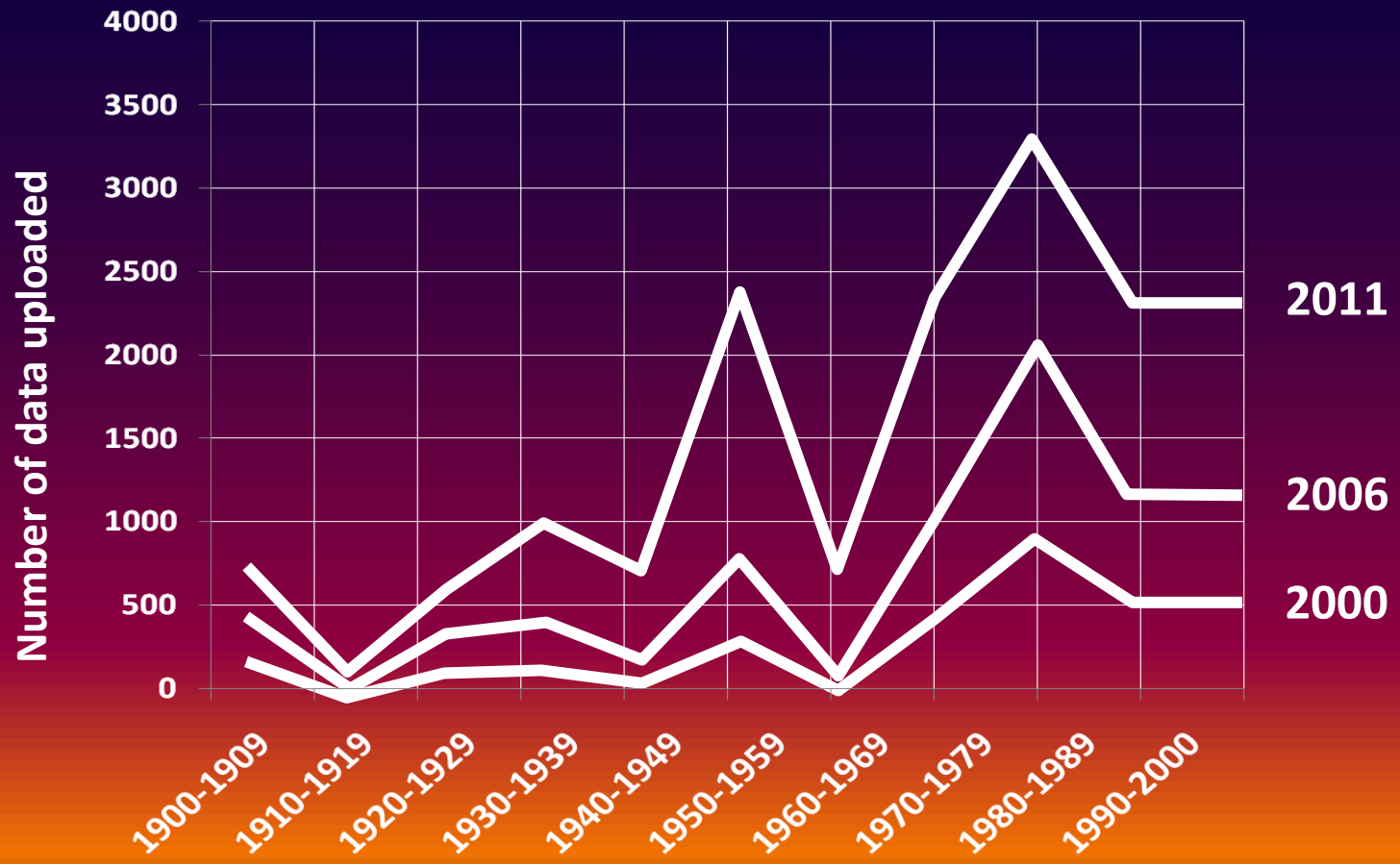


DATA AVAILABLE FOR XX CENTURY

As the work goes on, the number of data available increases constantly and allows us to:

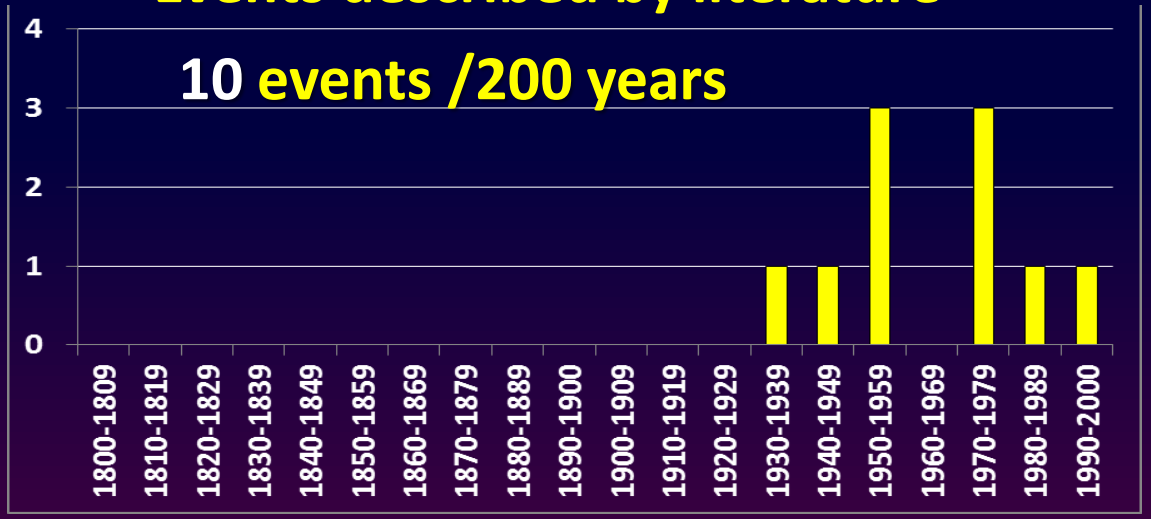
A) Improve the historical series of landslides and floods

B) Increase the knowledge about DHE throughout the Centuries



CURRENT KNOWLEDGE ABOUT THE EVENTS

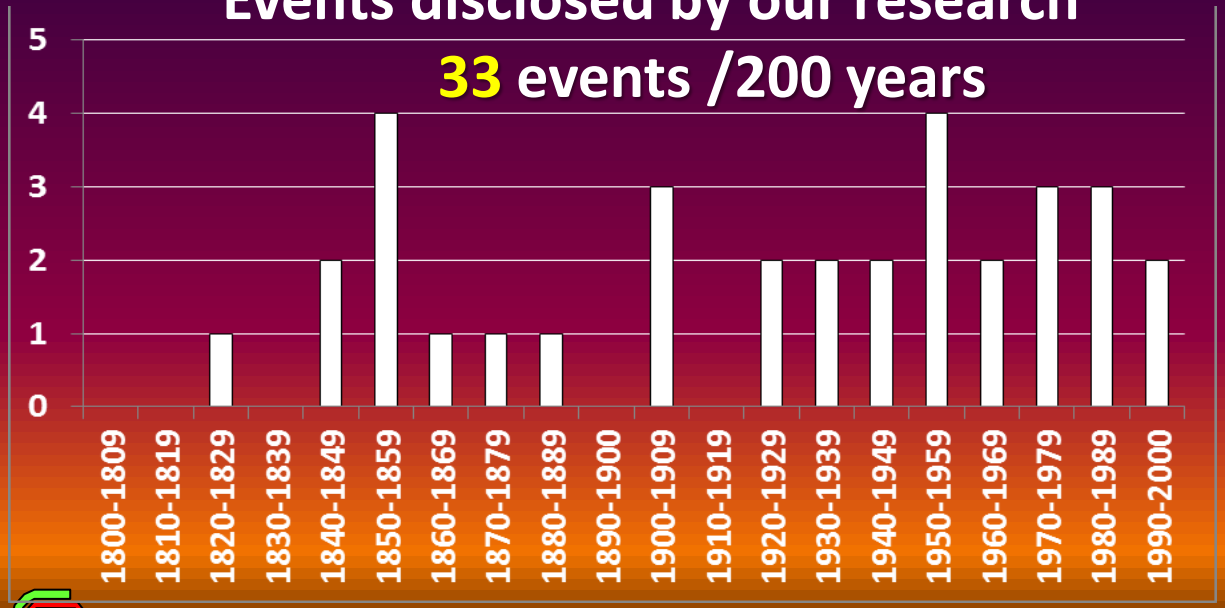
Events described by literature



If we analyze the period 1801-2000, the events described by literature are 10 in 200 years.

Our historical research pointed out a greater number of events even occurred in oldest epochs.

Events disclosed by our research



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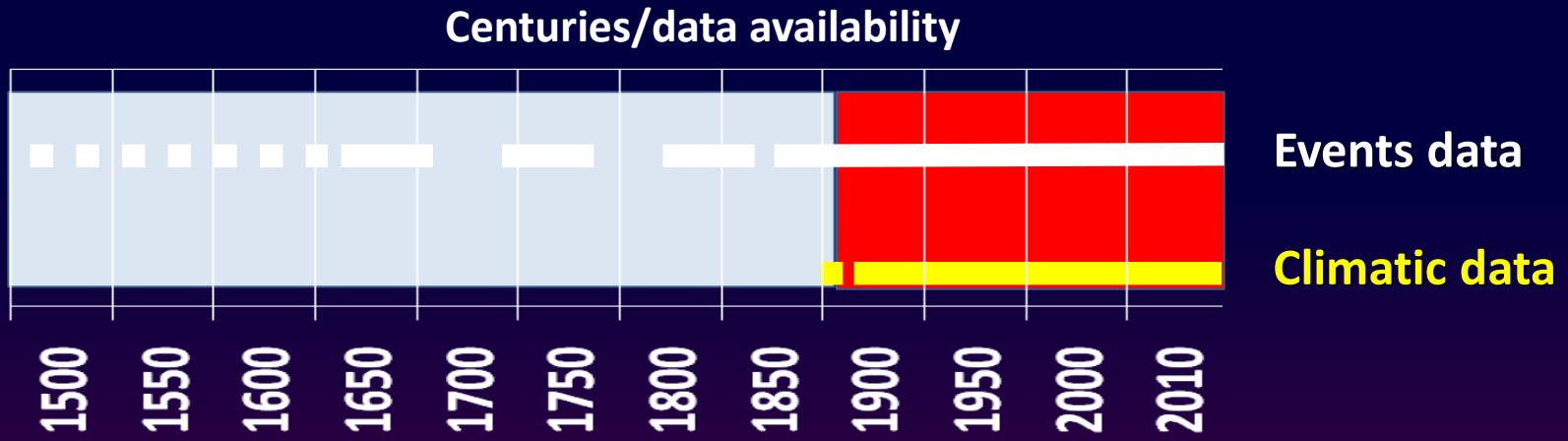
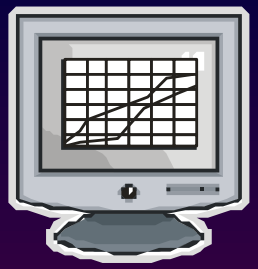
COMPARISON BETWEEN EVENTS AND CLIMATIC DATA



According to data availability, the past can be divided in two periods

- **<u>Pre-measurements period</u> (before 1900): measured climatic data are not available and data on the events (floods, drought…) can be used to infer climatic conditions**
- **<u>Measurements period</u> (after 1900): climatic data are available and can be compared to historical data about the events**

METODOLOGICAL APPROACH: Measurement period

	DAMAGE DATA	RAINFALL DATA
DATA COLLECTION		
DATA ELABORATION	INDIVIDUATION OF DHEs	ANALYSIS OF TRIGGERING RAINFALL
RESULTS	CHARACTERISATION OF DHEs (rainfall/damage) FOR DAMAGE-PREVENTION PURPOSES	

CLASSIFICATION OF THE EVENTS : REGIONAL SCALE

We classified regional events basing on:

- **N_{gg}: duration (days)**
- **F: Number of landslides (as % of the total of phenomena)**
- **P: Floods (as %...)**
- **A: Urban flooding (as %...)**
- **IAD: index expressing % of regional area affected**
- **ID: Damage Index**
  (*Vi x Li* V: relative value of damaged elements; L: damage level)
- **V: number of victims**
- **Tr: return period of max daily rainfall**

Petrucci, O. and Polemio, M., 2009. *The role of meteorological and climatic conditions in the occurrence of damaging hydro-geologic events in Southern Italy*. NHESS, 9(1): 105-118.

CLASSIFICATION OF THE EVENTS: REGIONAL SCALE

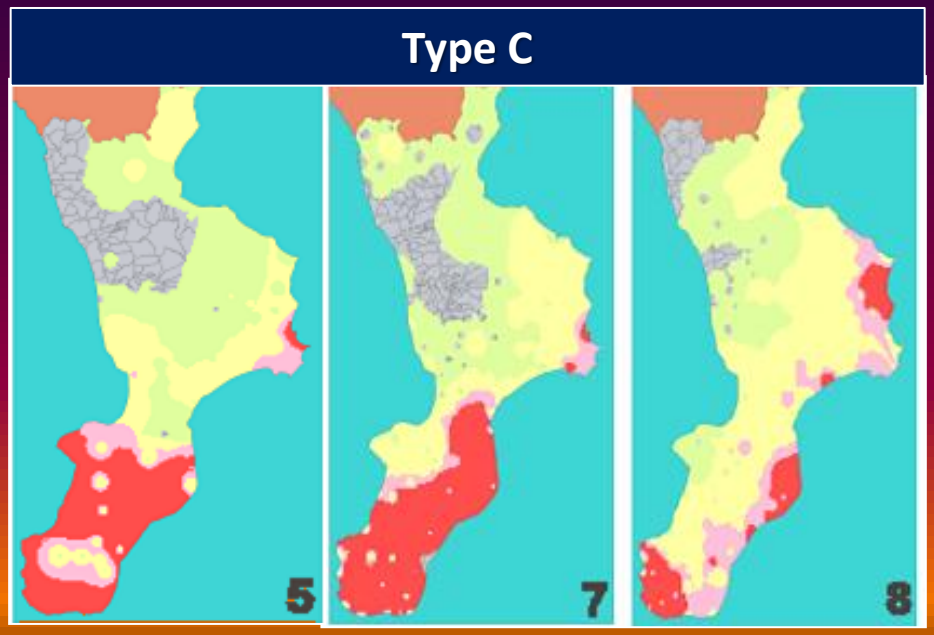
- At a regional scale, three types of events were individuated (A, B, C)
- The events of Type C show the severest effects,
  - They occurred between October and November
  - Affected the south-south east sector of Calabria
  - Floods are the most frequent type of damaging phenomena, and caused 77% of victims
  - They occurred in the first half of XX Century (1932, 1951, 1953)
  - Return period of daily rainfall were greater than 20 years

PARAMETERS OF THE EVENTS OF TYPE C

	Year	Month	Ngg	F(%)	P(%)	A(%)	IAD	ID	V
C	1932	nov	8	37	58	5	6	142	65
	1951	oct	18	36	64	0	12.9	158	110
	1953	oct-nov	24	28	64	8	27.8	189	85

Ngg: duration (d)
F: landslides (%)
P: floods (%)
A: urban flooding (%)
IAD: % of regional area affected
ID: damage index $(V_i \times L_i)$;
V: number of victims

Regional distribution of return period of maximum daily rainfall (T)



CLASSIFICATION OF THE EVENTS: LOCAL SCALE

According to the local geomorphological and climatic framework, in each regional sector the events can develop in a different way.

For example, in **Alto Jonio** sector, landslide damage prevails on flood damage, because flood prone areas are quite free of vulnerable elements while landslides affect both villages and roads

CLASSIFICATION OF Alto Jonio EVENTS

Tipo	Damage	Damage index		Duration days	Period	T (Return period rainfall YEARS)		Rainfall with max T	Affected areas
		MED	MAX			MED	MAX		
4	VERY HIGH	72	86	165	Nov-May	18	57	Mean duration	
3	HIGH	24	32	90	Oct Feb	52	>100	Short duration	
2	MEDIUM	6	14	95	Nov-Apr	2	17	Long duration	
1	LOW	3	6	88	Sep Mar	<5			

Petrucci O. and Pasqua A.A. (2009) - A methodological approach to characterise Landslide Periods based on historical series of rainfall and landslide damage. Nat. Hazards Earth Syst. Sci., 9, 1655–1670.

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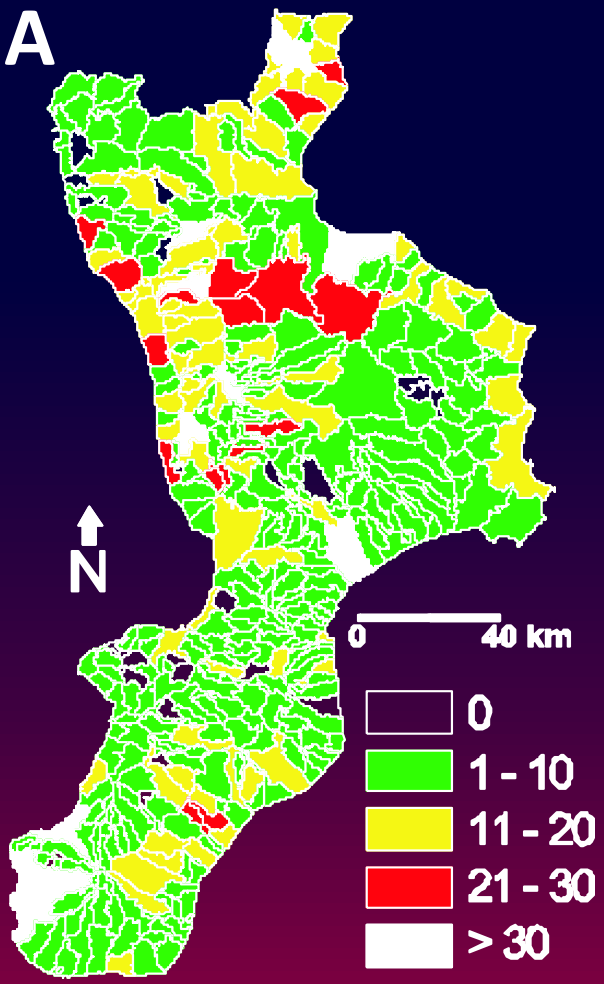
DAMAGING LANDSLIDES IN CALABRIA (1921-2006)

Besides to the study of damaging hydrogeological events as a whole, we even studied a single type of phenomena (landslide, flood…)

We compared the historical series of landslide and rainfall data by using monthly and annual indices



Municipal classification according to the number of landslides (1921-2006)

LANDSLIDES AND MONTHLY CLIMATIC VARIABILITY

We set some indices in order to easily compare the series of climatic data (rainfall, number of daily rainfall) and landslides data

Monthly precipitation index

$$IP_1(x,y) = \frac{\sum_{i=1}^{n} MP_i(x,y)}{\sum_{i=1}^{n} AMP_i(x)} 100 - 100$$

y : year

X : month (1<x<12)

Mpi* : monthly rainfall at the gauge *i* in the month *xy

***AMPi* : monthly average of rainfall of the month *x* in the gauge *i*.**

***i*: 1, 2, ….n**

n*: number of gauges available for the month *xy

Monthly landsliding index

$$IL_1(x,y) = \frac{\sum_{i=1}^{n} ML_i(x,y)}{\sum_{i=1}^{n} AML_i(x)} 100 - 100$$

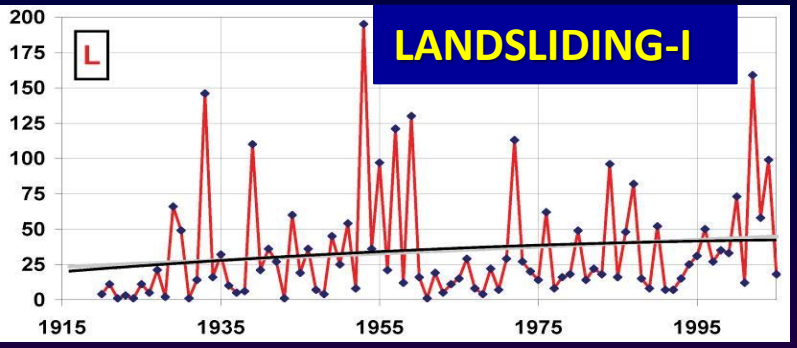
ML*: number of landslides occurred in the month *xy

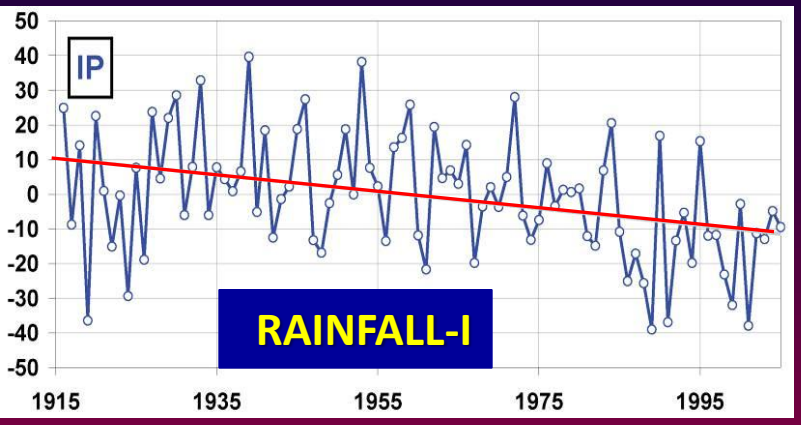
AMLi*: monthly average of landslides in the month *x* in the municipality *i

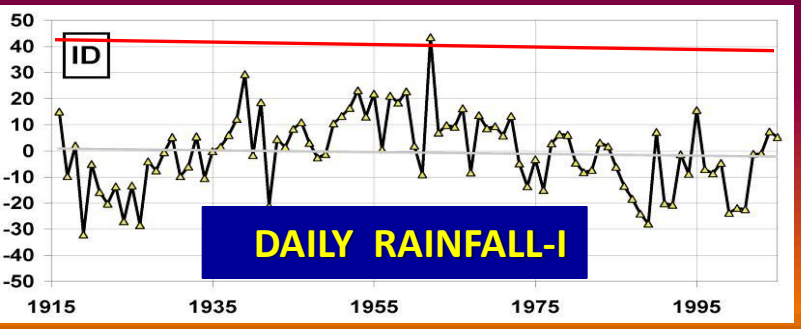
(i= 1, 2, ...n; n= number of municipalities)

Polemio, M., and Petrucci, O. (2010) - *Occurrence of landslide events and the role of climate in the twentieth century in Calabria, southern Italy.* Quarterly Journal of Engineering Geology and Hydrogeology, 43: 403-415.

LANDSLIDES AND YEARLY SERIES OF CLIMATIC INDICES







On a yearly scale, despite the rainfall and daily rainfall indices show a decreasing trend, the **trend of landslides tend to increase.** This can be due to:

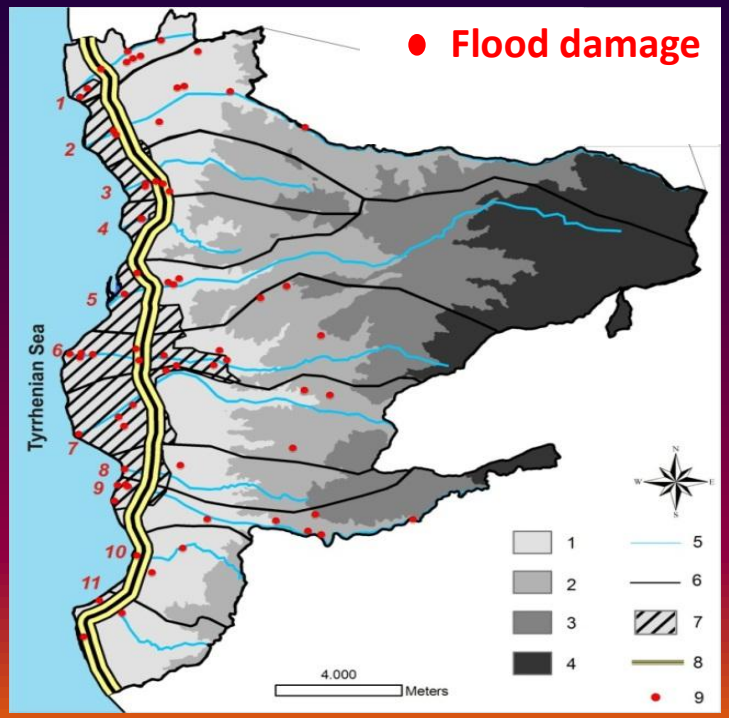
- Underestimation of the number of landslides in the oldest periods
- Amplification of landslide damage. The increasing urbanization caused the increasing of vulnerable elements and, then, of landslide damage

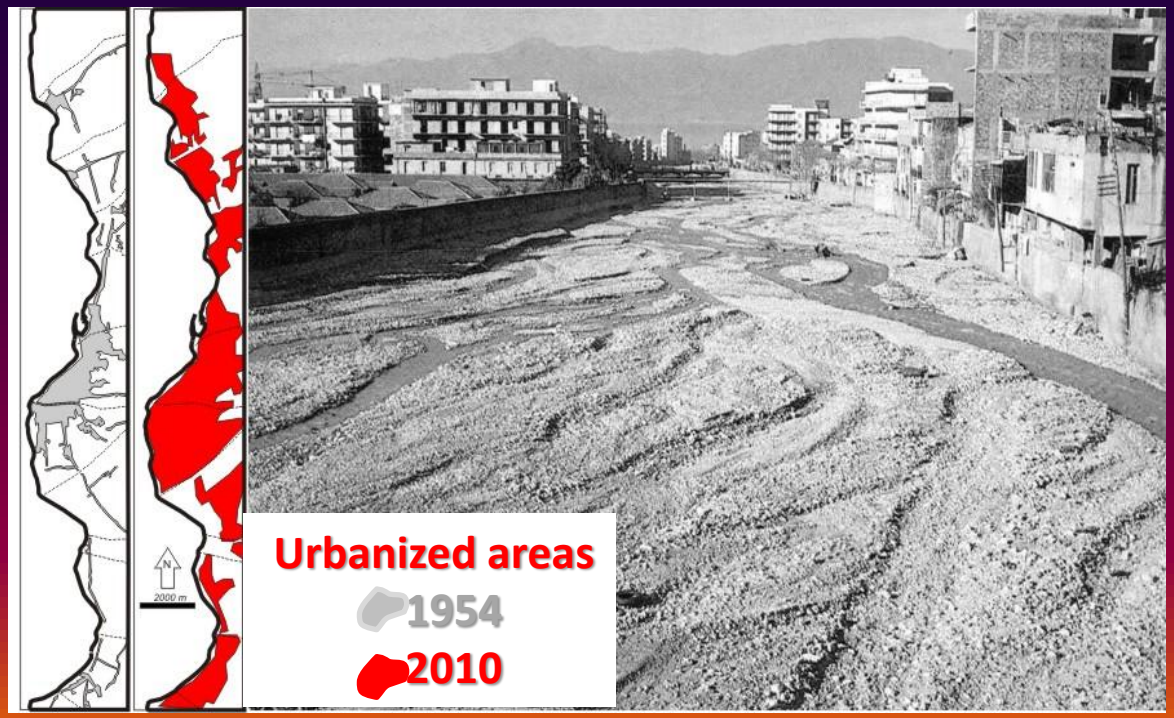
FLOOD TREND IN REGGIO CALABRIA (XVII-XXI CENTURIES)

Even for FLOODS, an increasing urbanization can cause the increasing of flood damage, as for example, in Reggio Calabria municipality. Here, floods which in the past didn't caused damage currently can affect residential areas, as emerged from the study of old and recent floods

166 floods/387 years

Victims: about 400





Petrucci, O., Polemio M., and Pasqua A.A. (2010) - *Flash floods risk variation of steep drainage basins in Calabria (Italy) and the role of rainfall and anthropogenic modifications since 1800* - IAHS Publ. 340, 2010: 103-110.

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SOME QUESTIONS/ANSWERS ABOUT DHEs:

1. Are calabrian Events a current or an ancient problem?
   DHEs are a persistent problem in Calabria
2. How can we classify these events? Basing on their effects (damage) and triggering factors (rainfall)
4. What kind of data we need to study DHEs? Data on damage, climate and anthropogenic landscape modifications
5. Which results have been obtained so far?
   We characterized both the severest type of regional events and local events for some regional sectors
5. What is the next step?
   The elaboration of further historical data in order to improve the characterization of the events both to the regional and local scale

DAMAGING HYDROGEOLOGICAL EVENTS IN CALABRIA

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Thank you for your attention