02 / 12 / 2015

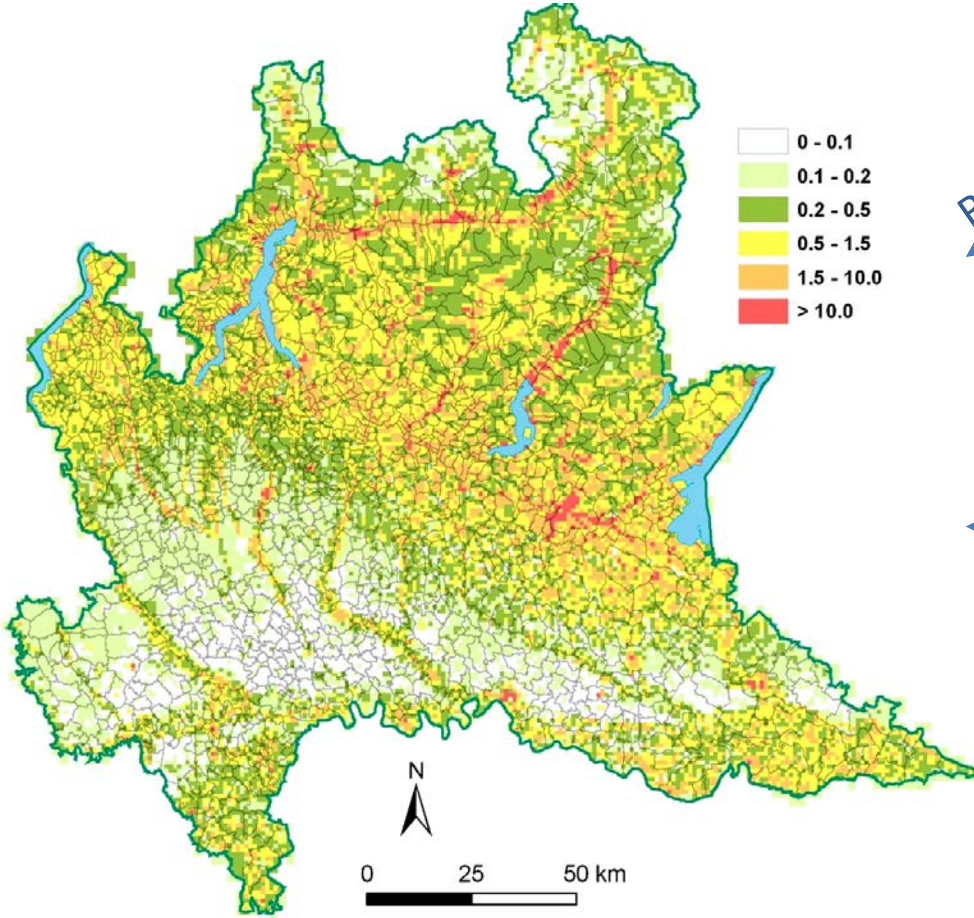
Relatore | **Paolo Frattini**

Rischi naturali

L'AGGIORNAMENTO DEL PROGRAMMA REGIONALE INTEGRATO DI MITIGAZIONE DEI RISCHI P.R.I.M. 2015

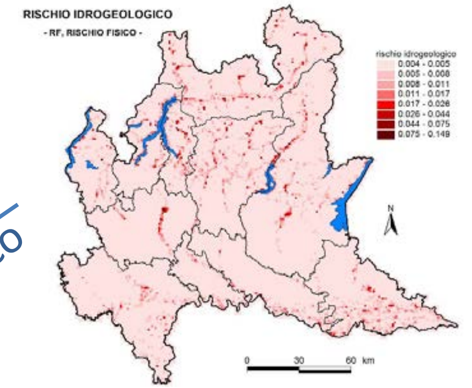
Regione Lombardia

Rischi naturali nel PRIM

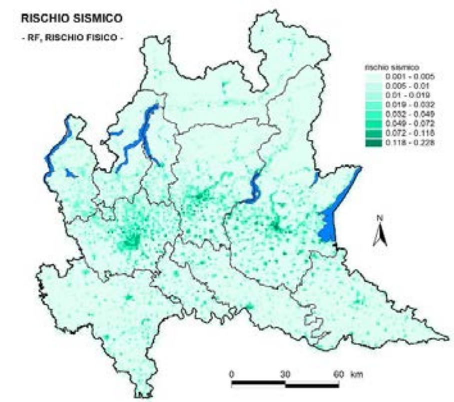


Rischio naturale

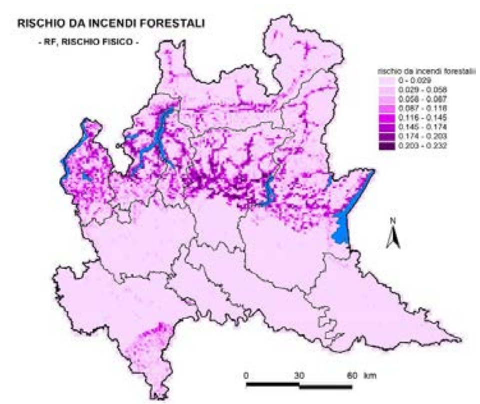
Rischio idrogeologico



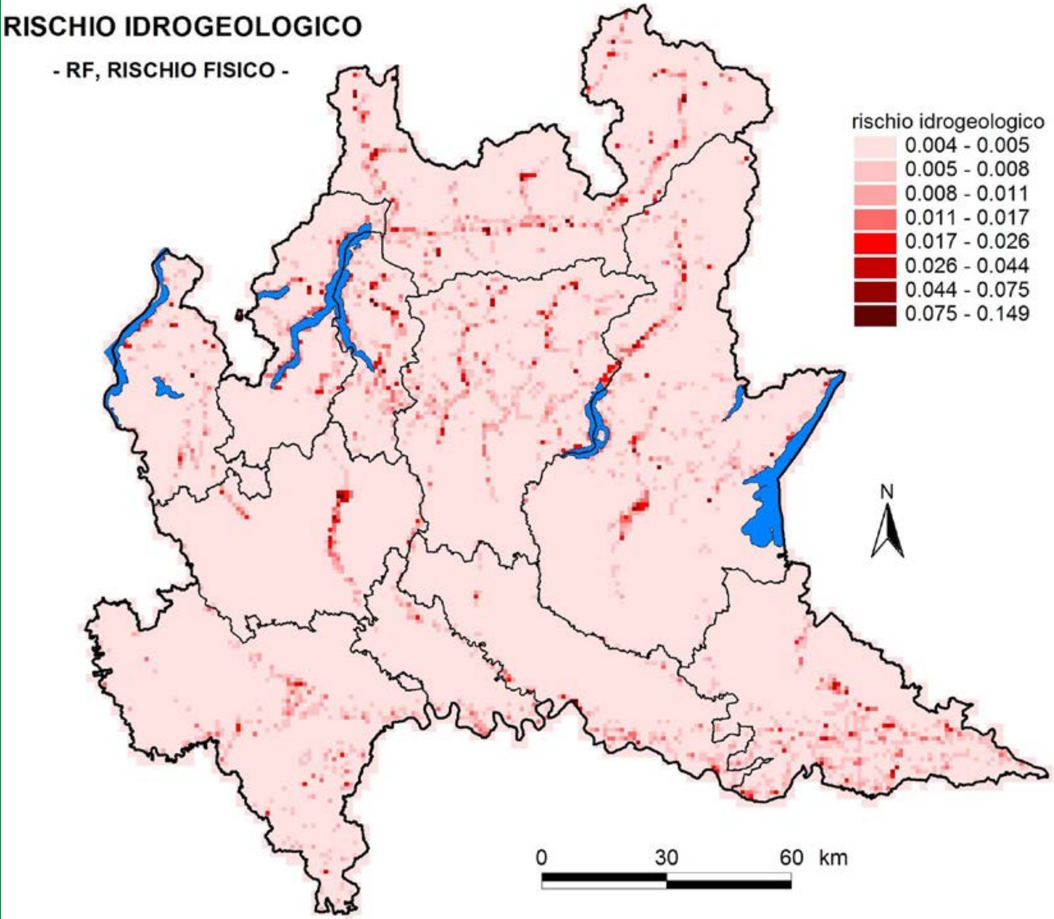
Rischio sismico



incendi forestali

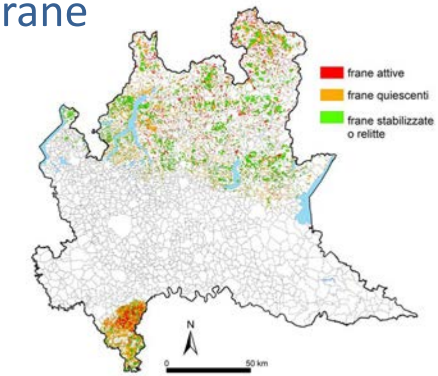


Rischi naturali nel PRIM

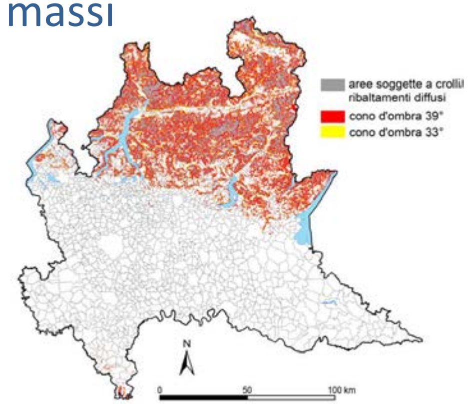


Rischio idrogeologico

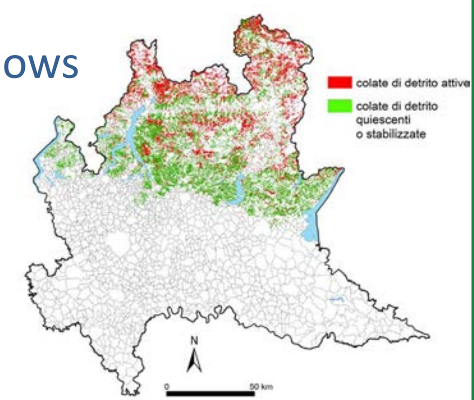
Grandi frane



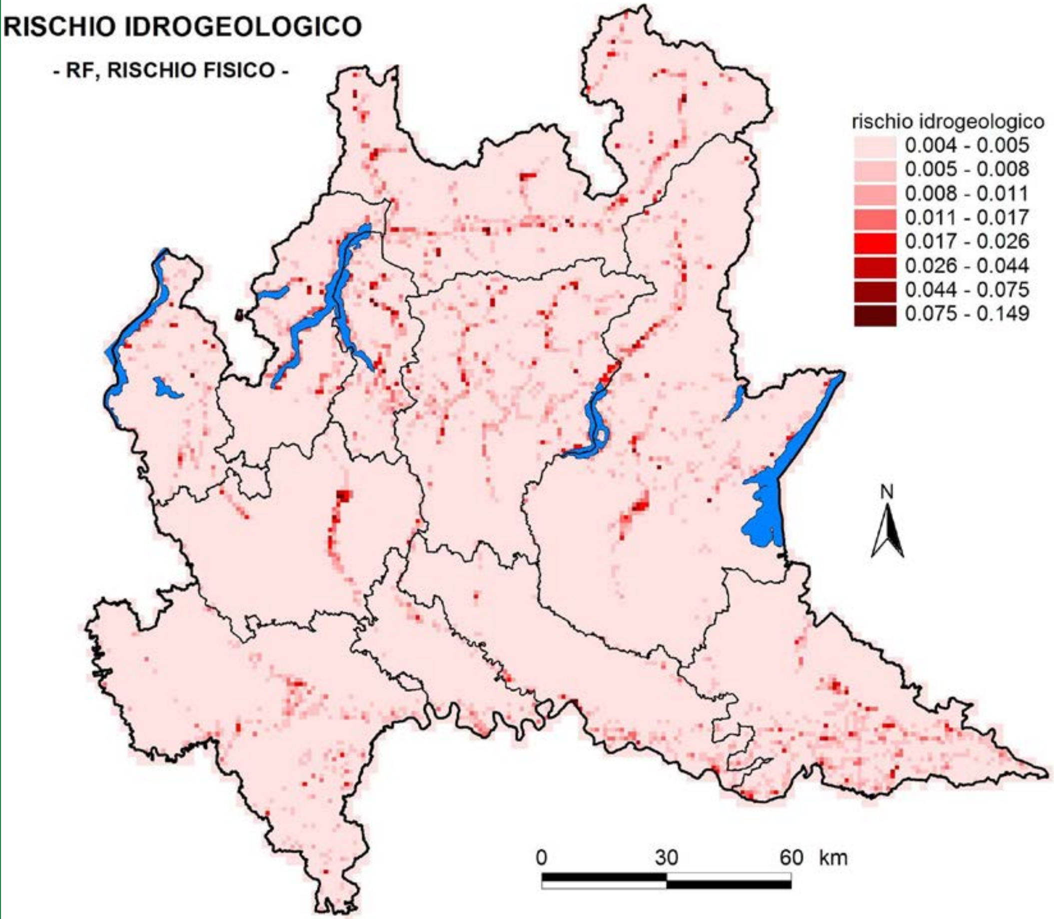
Caduta massi



Debris flows

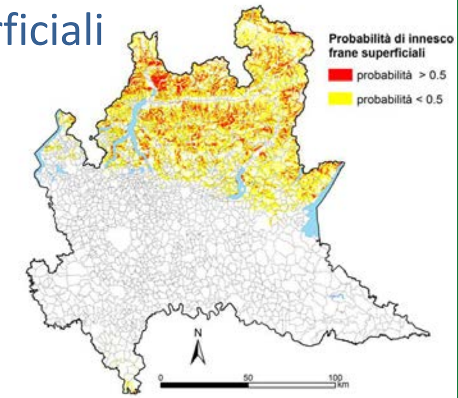


Rischi naturali nel PRIM

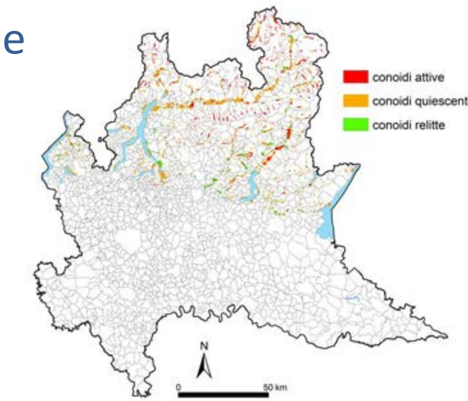


Rischio idrogeologico

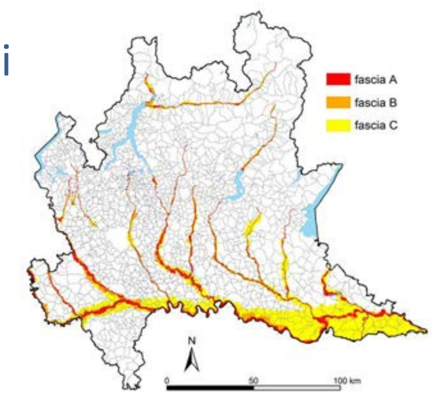
Frane superficiali



Alluvioni in conoide

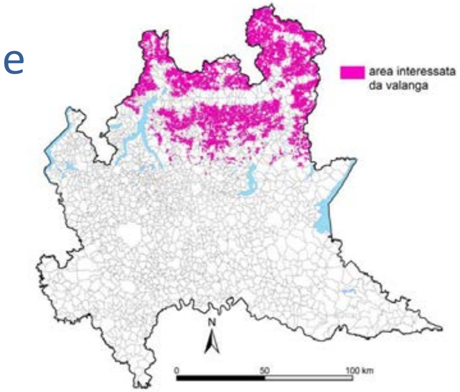


Alluvioni

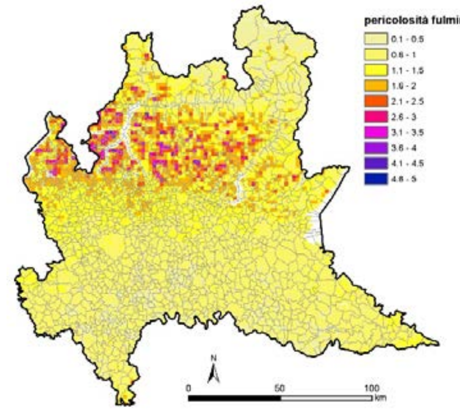


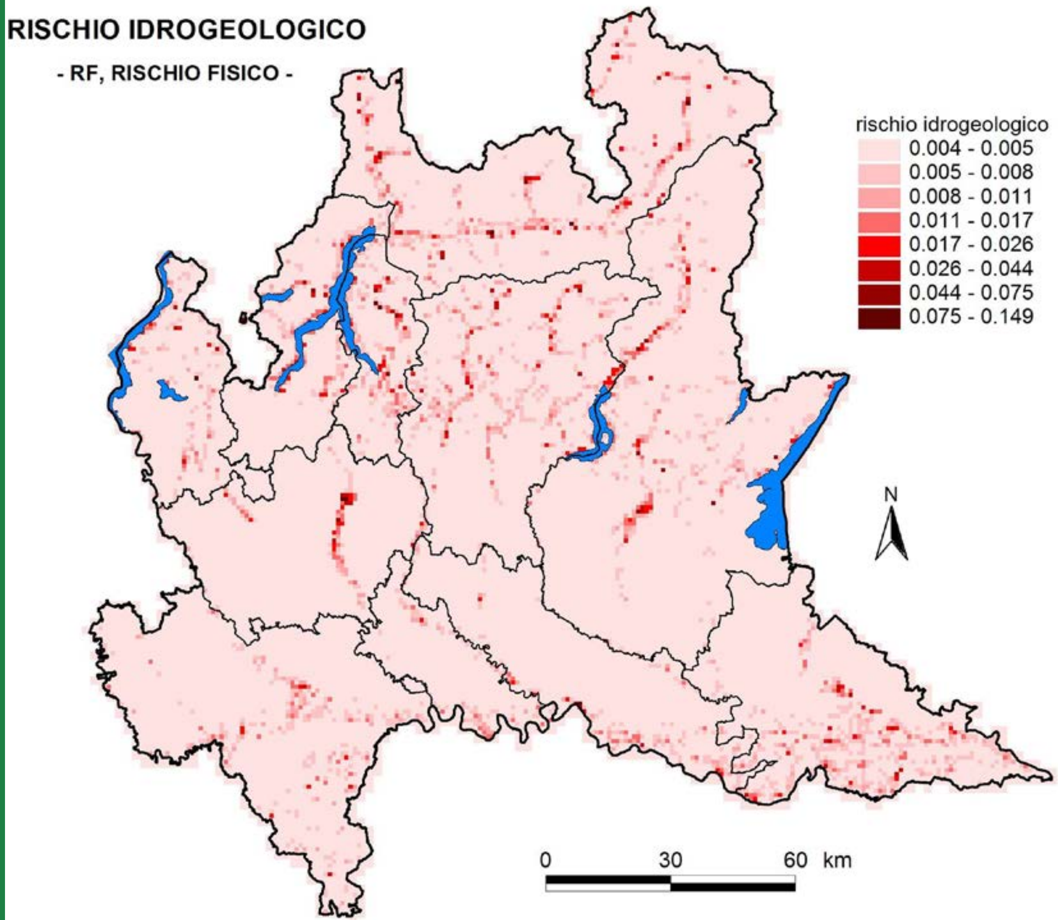
Rischi naturali nel PRIM

Valanghe



Fulmini





Rischio idrogeologico

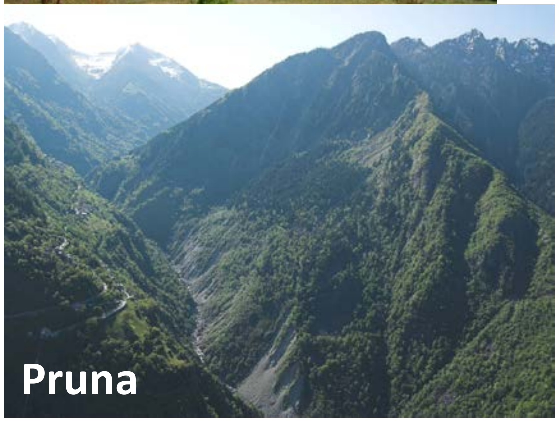
Aggiornamento del PRIM

- Aggiornamento tematismi → processamento automatico

- **Nuovi tematismi**
  - Espandimento grandi frane
  - Grandine
  - Permafrost

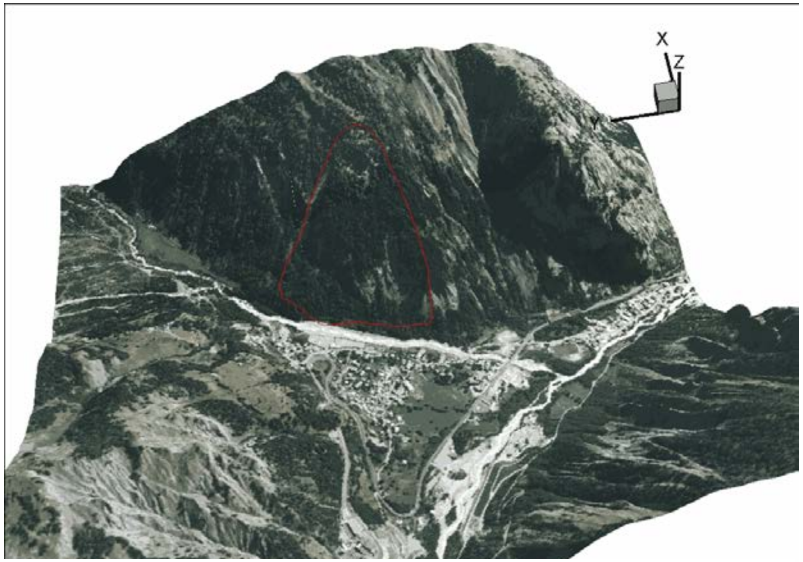
- **Rischi «emergenti»**
  - Rischio meteo
  - Innalzamento falda

Espandimento grandi frane: perché?

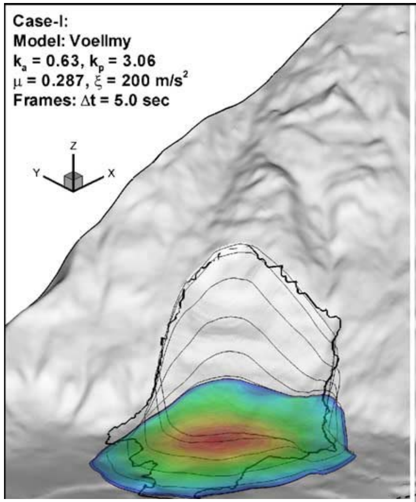


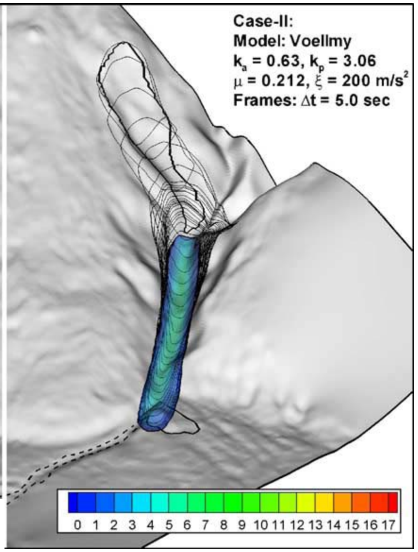
prima → dopo

Espandimento grandi frane: come?



Modello numerico 3D FEM
(rock avalanche, 8Mm³)



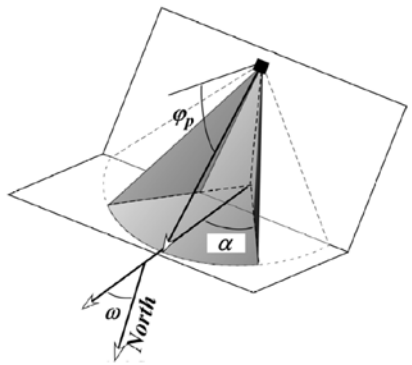


Modello numerico 3D FEM
(debris avalanche, 1.5 Mm³)

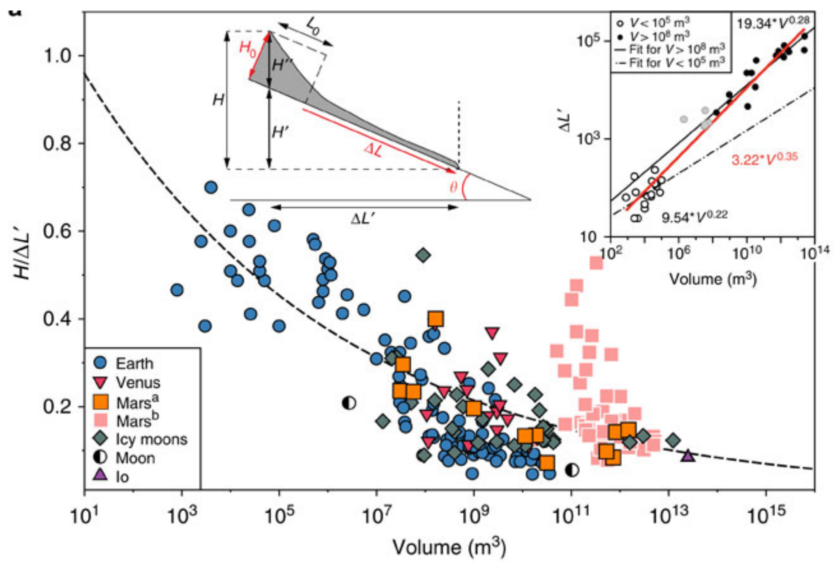
Crosta G.B., Chen H., Frattini P. (2006) Engineering Geology, 83:236-253

	Scala locale	Scala regionale
Crolli	Modelli matematici 2D e 3D	Empirico (es: cono d'ombra), modelli matematici 2D e 3D
Scorrimenti profondi	Modelli sforzi-deformazioni	Approccio empirico (cono d'ombra)
Scorrimenti Superficiali	n.a.	
Debris flows	Modelli numerici 2D e 3D	Approccio empirico (cono d'ombra) + modello empirico per la direzione di flusso
Valanghe roccia/detrito	**Modelli numerici 2D e 3D**	Approccio empirico (cono d'ombra)
DGPV	n.a.	

Espandimento grandi frane: come?



- Espandimento = inviluppo del cono d'ombra
- H/L → angolo d'attrito equivalente
- H/L varia con volume



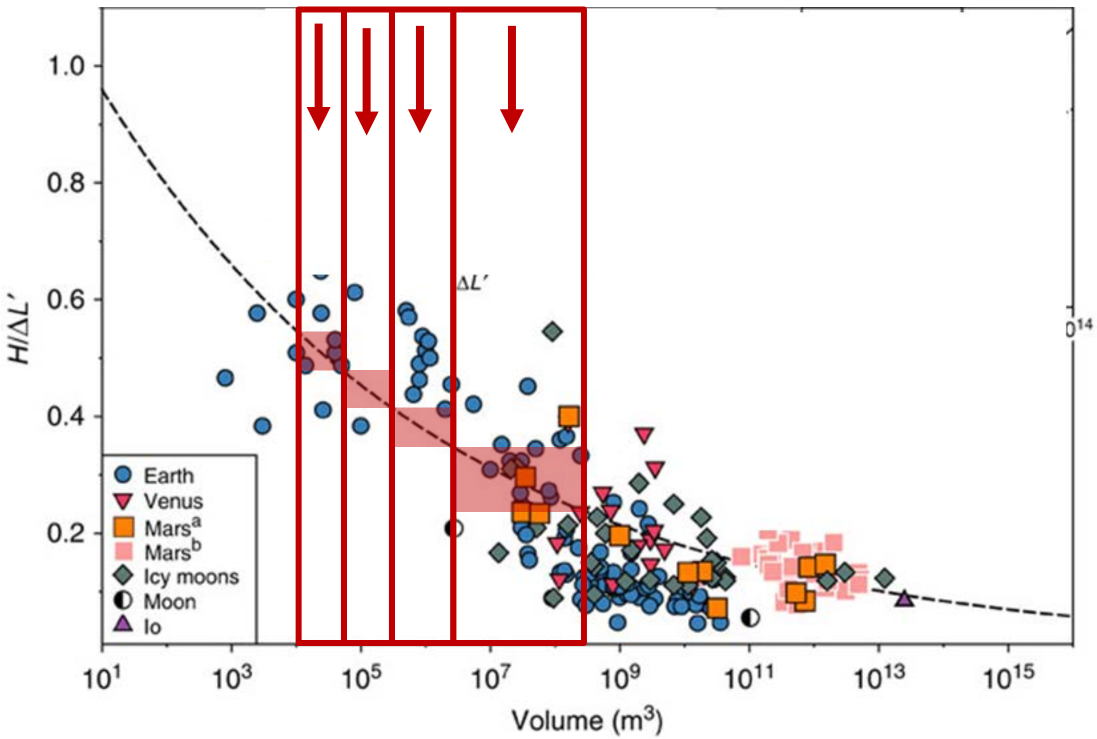
	Scala locale	Scala regionale
Crolli	Modelli matematici 2D e 3D	Empirico (es: cono d'ombra), modelli matematici 2D e 3D
Scorrimenti profondi	Modelli sforzi-deformazioni	Approccio empirico (cono d'ombra)
Scorrimenti Superficiali	n.a.	
Debris flows	Modelli numerici 2D e 3D	Approccio empirico (cono d'ombra) + modello empirico per la direzione di flusso
Valanghe roccia/detrito	Modelli numerici 2D e 3D	**Approccio empirico (cono d'ombra)**
DGPV	n.a.	

Espandimento grandi frane: come?

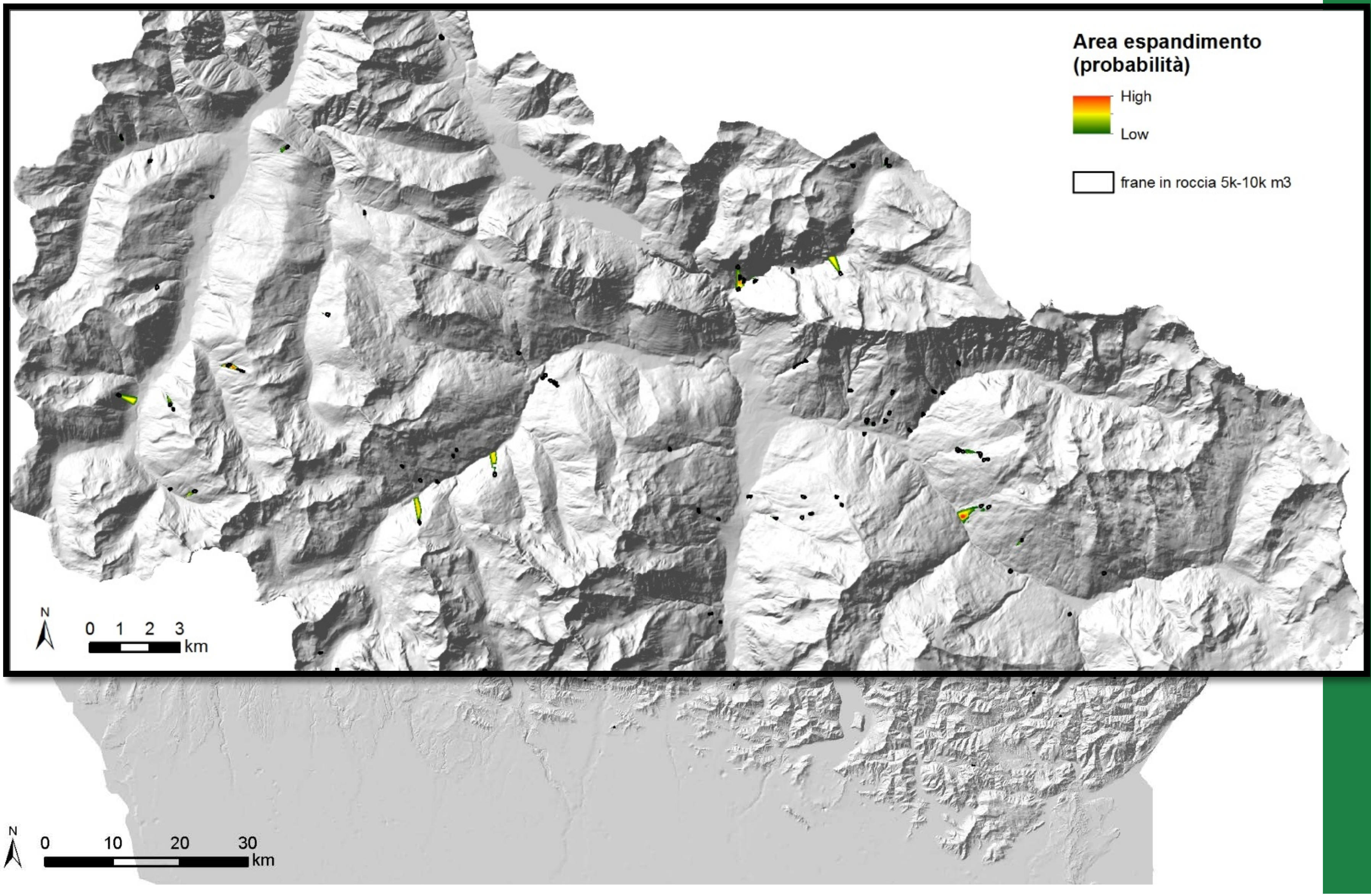
Area (m^2)	Volume (m3)	Angolo del cono d’ombra	Numero di frane
5000 - 10.000	18.000 – 47.000	31°	373
10.000 – 50.000	47.000 – 410.000	26°	897
50.000 – 250.000	410.000 – 3.600.000	24°	532
>250.000	> 3.600.000	20°	214

- 4 classi volumetriche
- Curva di H/L in funzione di volume da Lucas et al, 2014

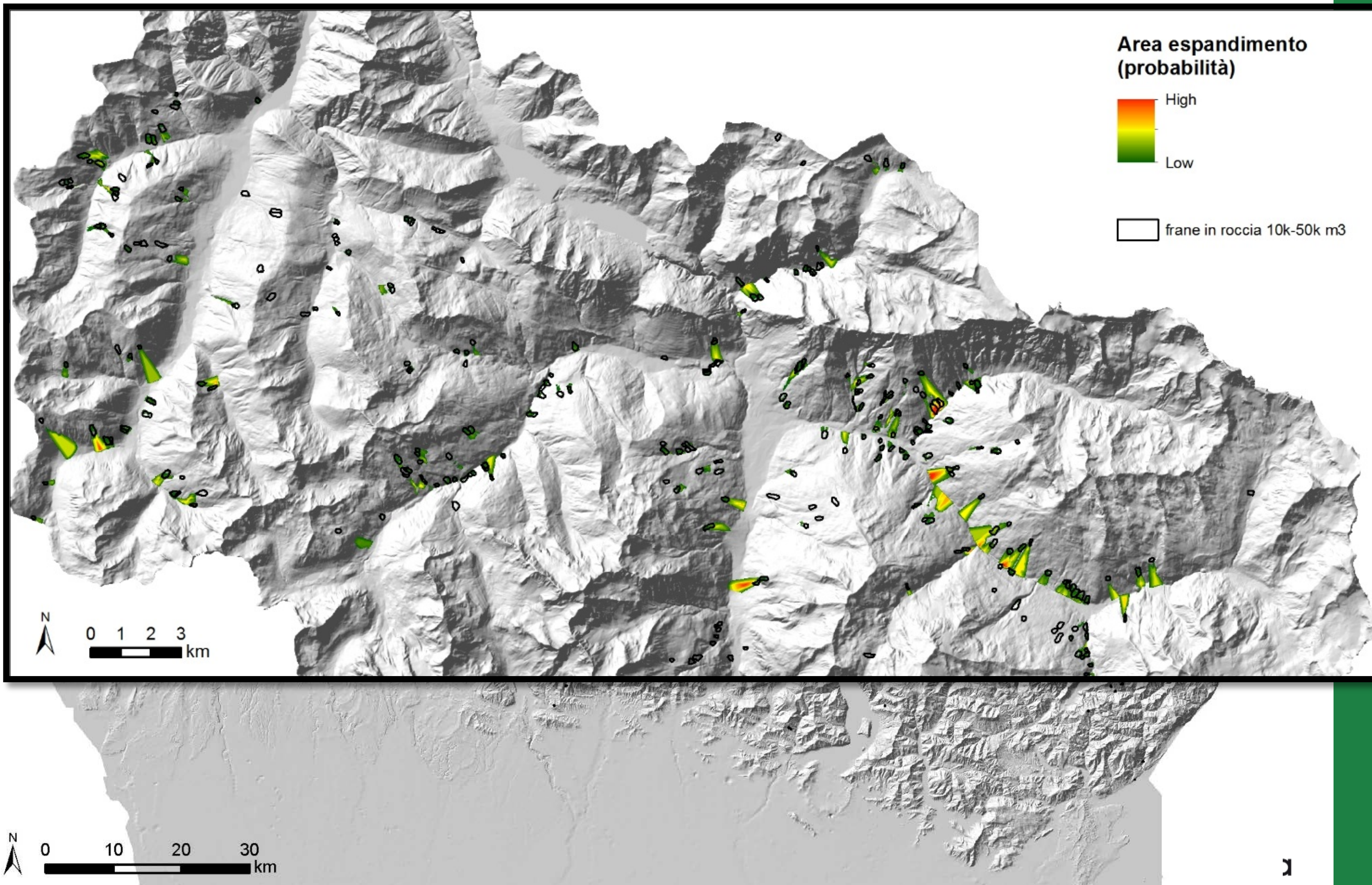
$$\frac{H}{L} = 1.2 \cdot V^{-0.089}$$



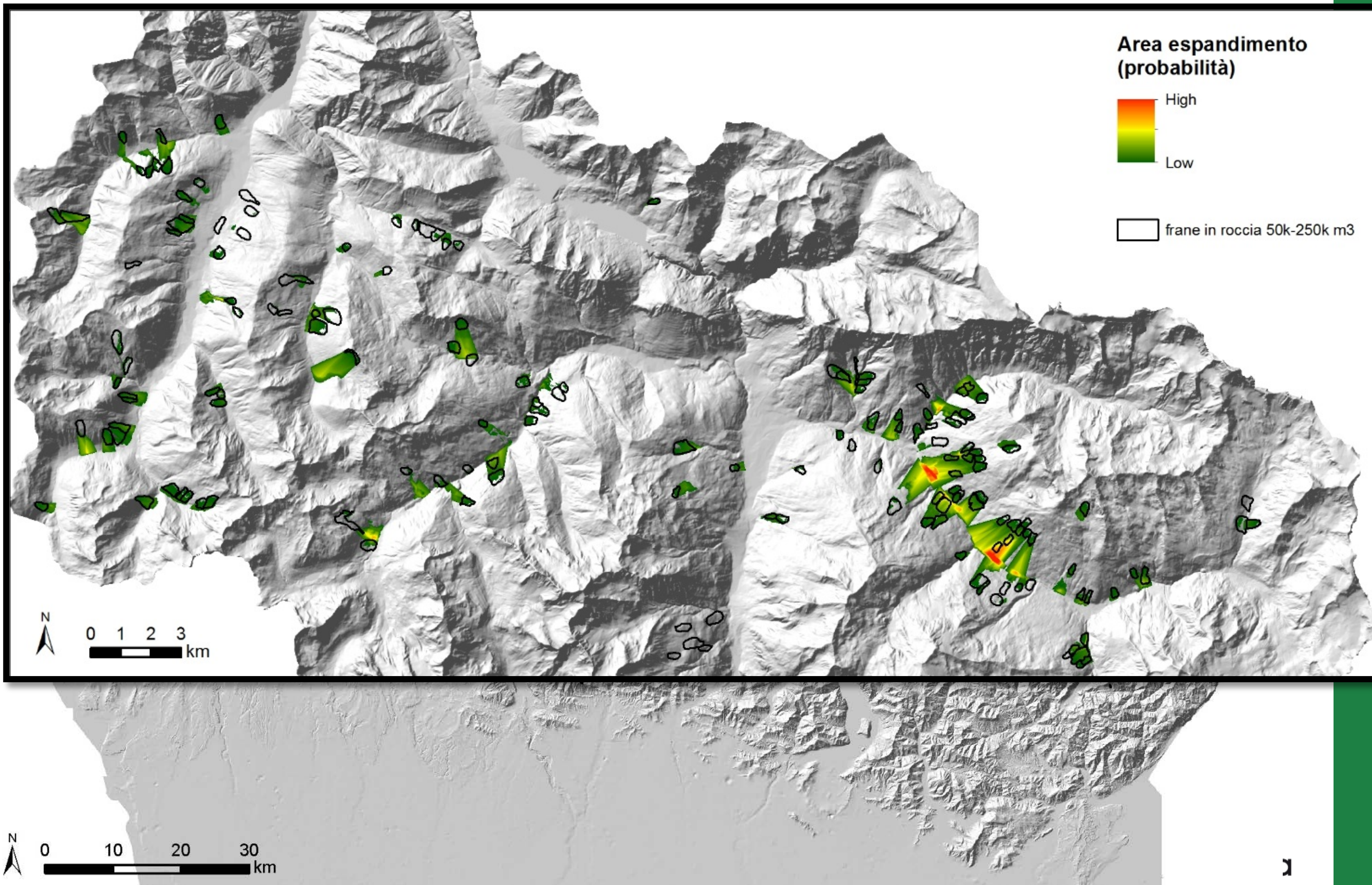
Espandimento grandi frane



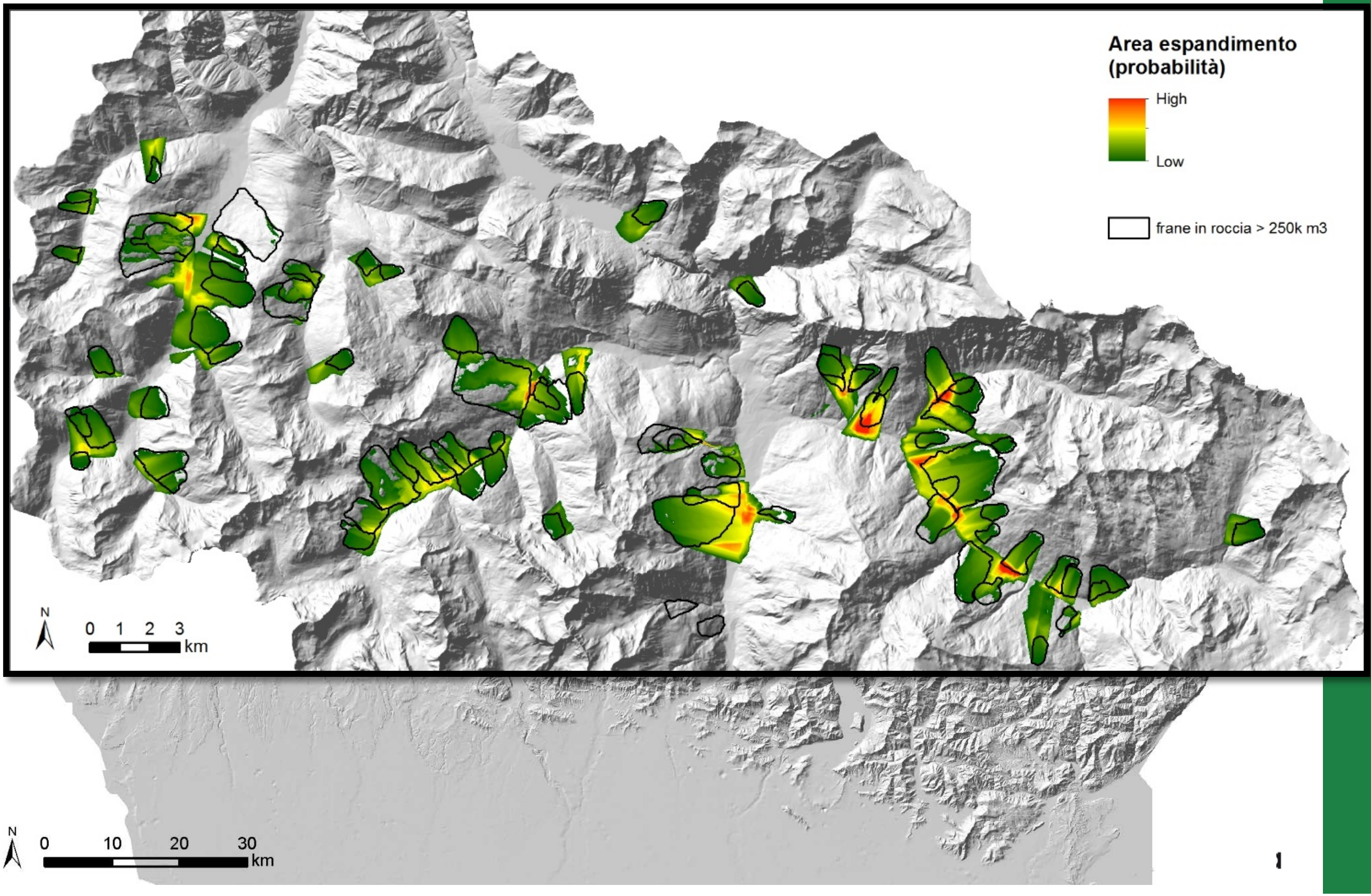
Espandimento grandi frane: come?



Espandimento grandi frane: come?



Espandimento grandi frane: come?



Grandine: perchè?

8 giugno 2015 – Darfo Boario Terme
50.000 € di danni in 1 sola azienda

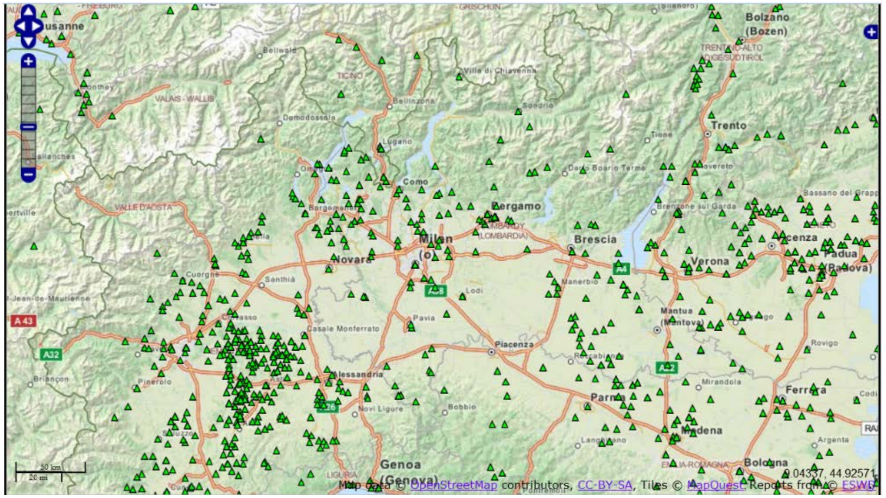
Calgary, MI, US

Taizhu, China

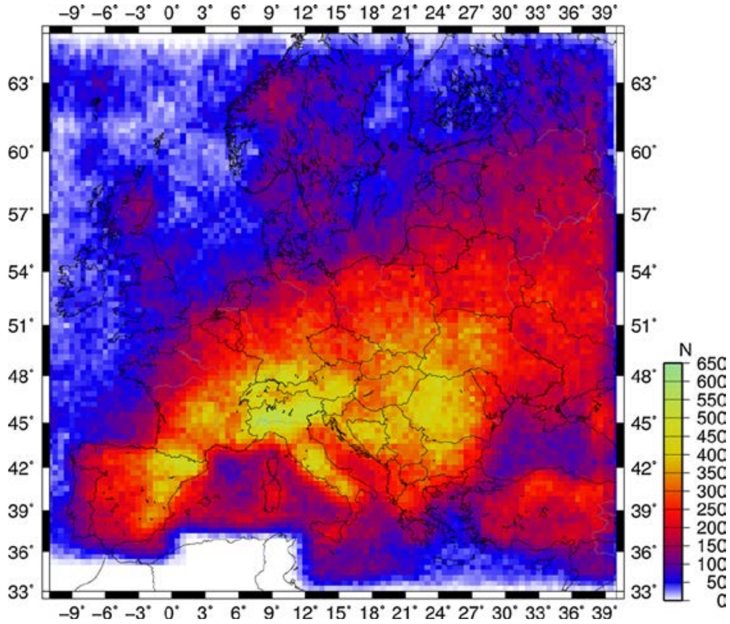
Table 4: Major Loss Events in the Alps, 1980-2006

Date	Region	Event	Deaths	Economic Losses (Mio €)*	Insured
12.7.1984	Southern Germany	Hailstorm		950	480
18.-28.7.1987	Northern Italy (Veltlin)	Landslides, flash floods	44	625	0
July- Aug. 1987	Switzerland (Brig)	Flash flood	8	800	175
25.2.-1.3.1990	Alpine region	Winter storms	7**	700**	460**
Sept.- Oct. 1993	Switzerland	Flood	2	620	320
4.-6.11.1994	Northern Italy (Veltlin)	Flood	64	9,300	65
Jan.-March 1999	Alpine region	Avalanches, winter damage	108	850	150
1.5.1999	Germany, Switzerland	Flood	8	670	290
3.-7.7.2000	Austria	Hailstorms	2	125	70
14.-21.10.2000	Northern Italy, Switzerland	Flood	38	8,500	ca. 420
6.-7.7.2001	Southern Germany	Severe storms	6	300	200
7.-8.7.2001	Northern Italy	Severe storms, tornado		175	30
3.8.2001	Southern Germany	Severe storms, Hailstorm		300	200
Aug.02	Southern Germany, Austria, Italy	Floods, severe storms, hailstorms	30	10.000	1.000
Aug.03	Austria, Switzerland, Italy, France	Severe storms, land slides, heat wave	5	500	5
20.-27.8.2005	Switzerland, Germany, Austria	Floods	11	2,500	1,400
Feb. 2006	Austria, Germany	Winter damage	3	650	290

Grandine: perchè?



grandinate forti nel database ESWD (European Severe Weather Database, Dotzek et al, 2009)

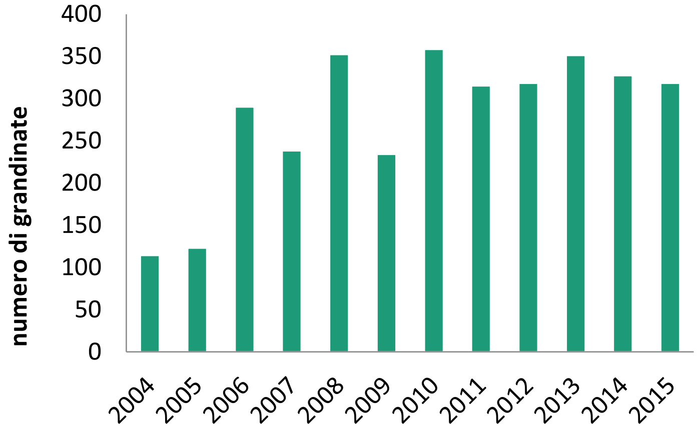


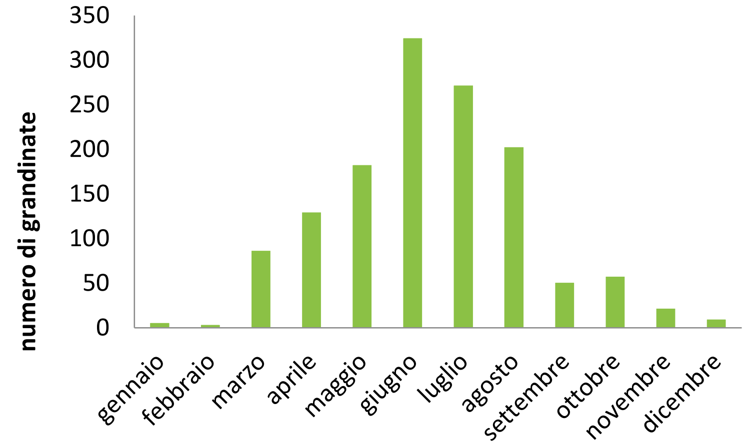
Frequenza simulata di eventi di un modello stocastico costruito sulla base degli eventi storici riportati in ESWD e degli overshooting top (OT) riconosciuti da satellite (Punge et al, 2014)

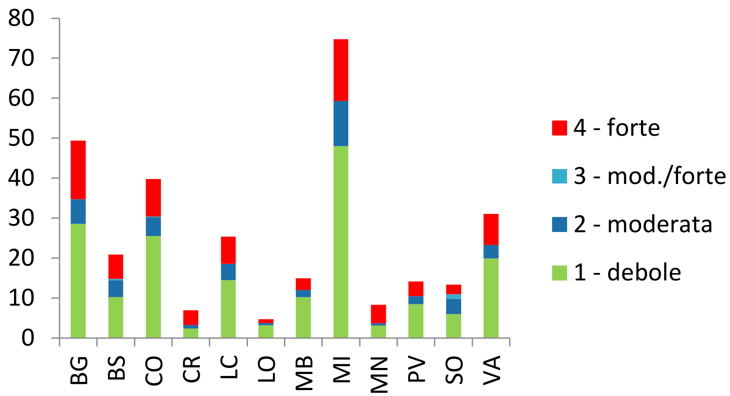
Grandine: come?

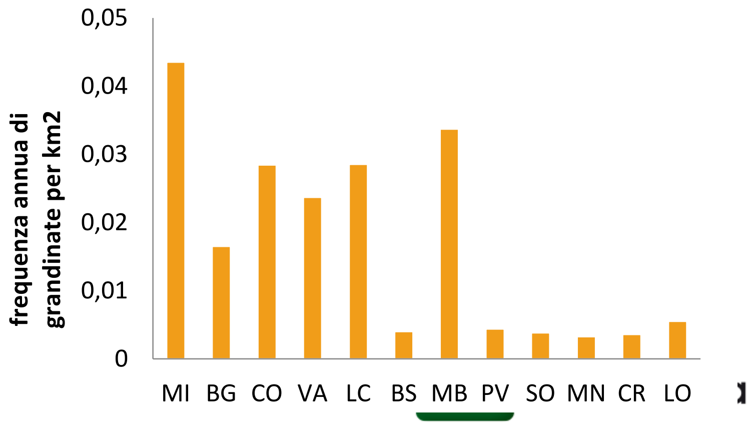
Database meteograndine.com

periodo: 1 gennaio 2004 – 30 ottobre 2015
3338 eventi aggregati per comune
fonte: news e assicurazioni

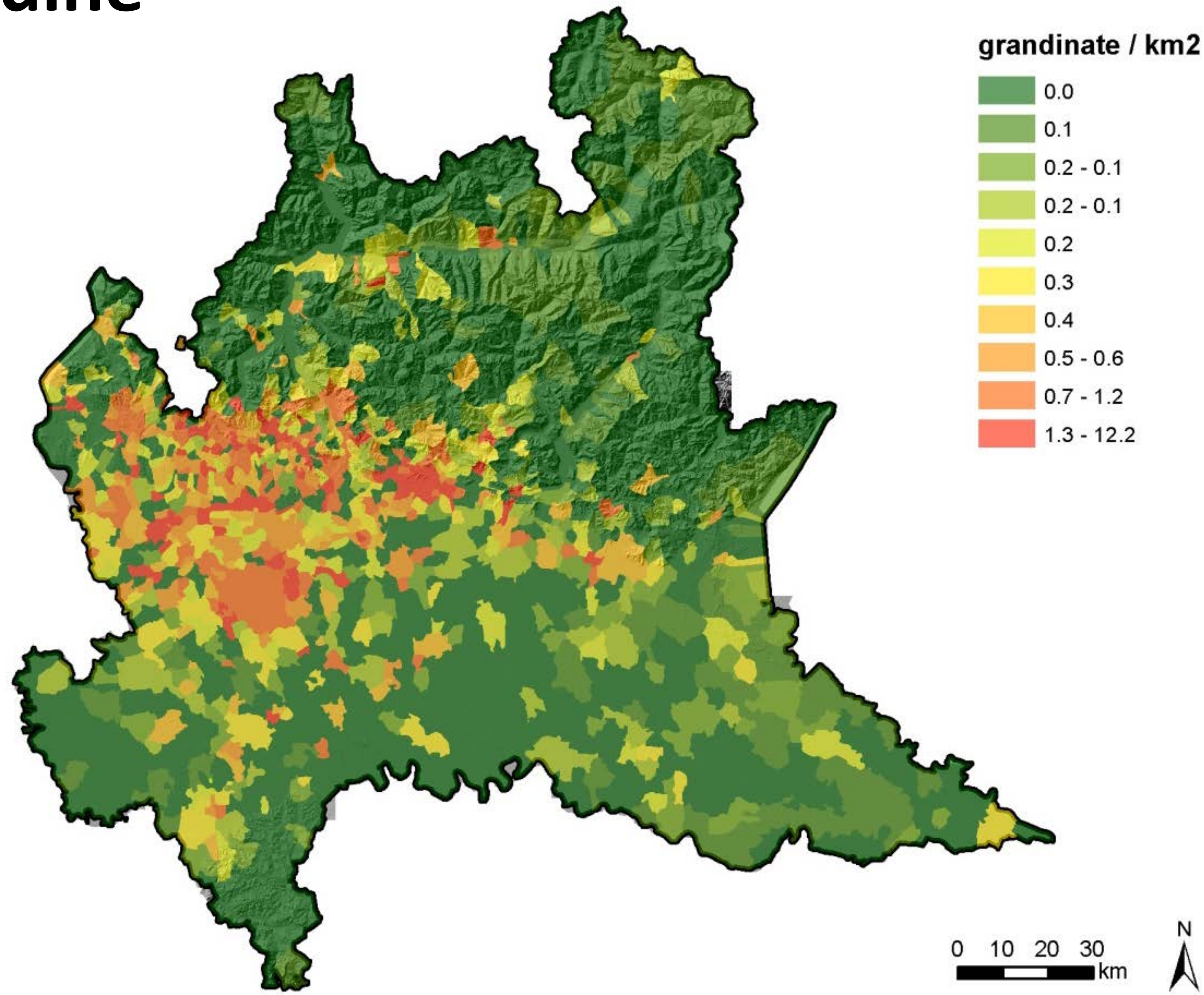






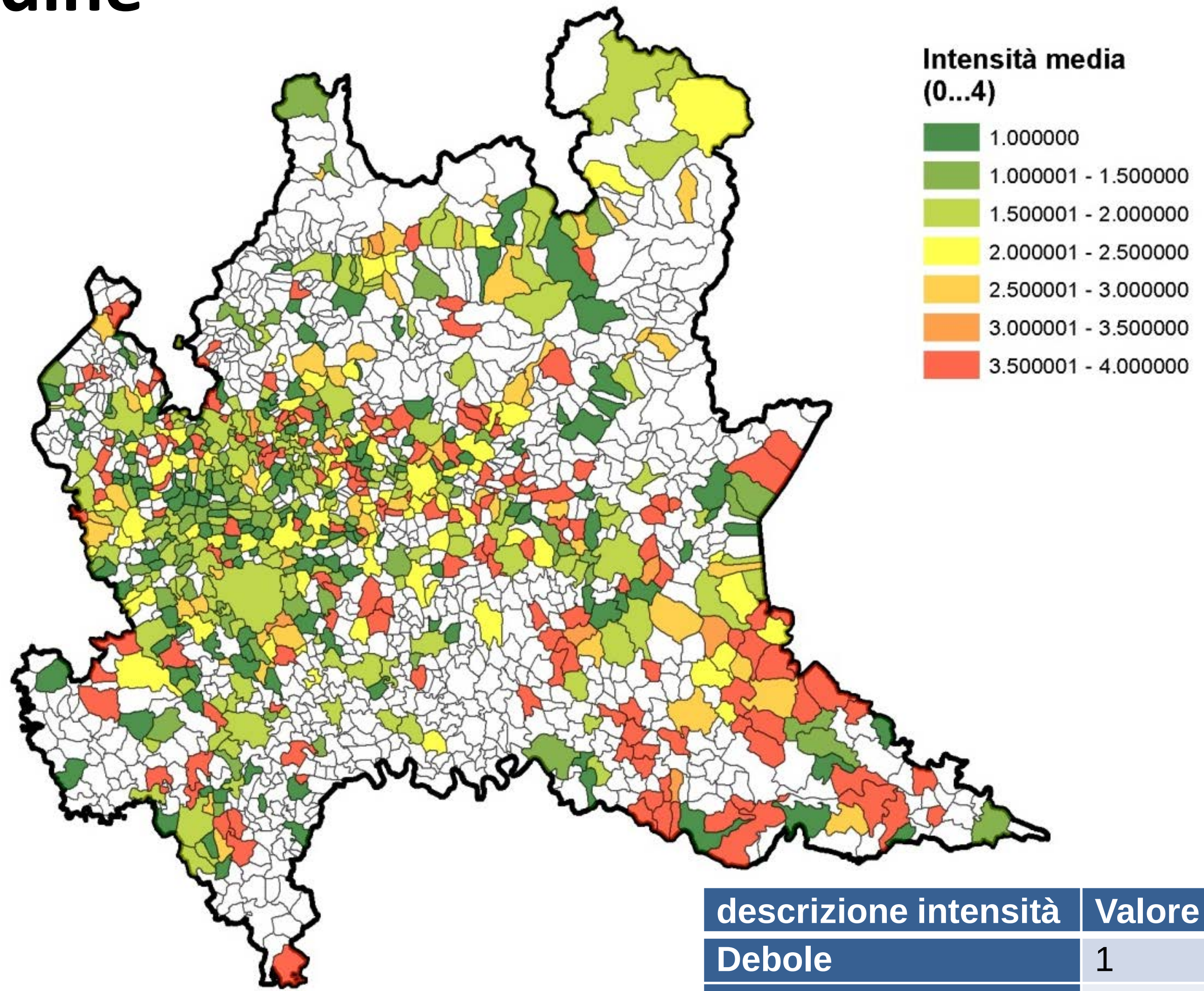


Grandine



Numero di grandinate per comune normalizzate per l'area
→ grandinate per km^2

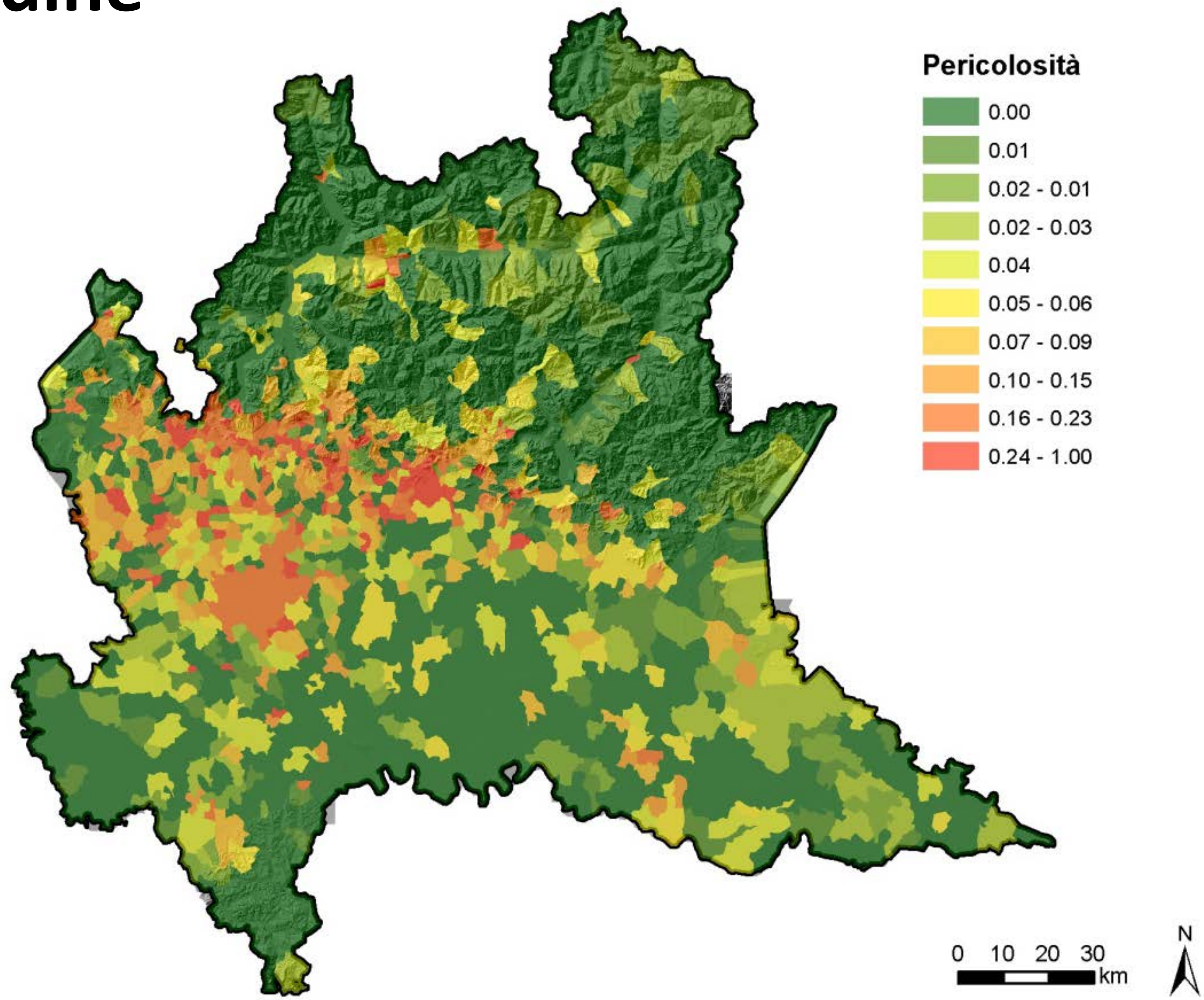
Grandine



Intensità della gradine: 4 classi

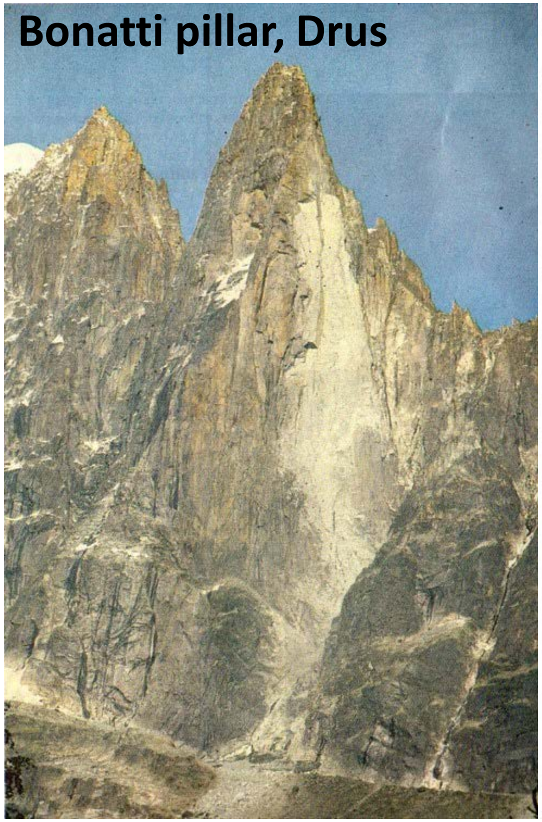
descrizione intensità	Valore quantitativo
Debole	1
Moderata	2
Moderata/forte	3
Forte	4

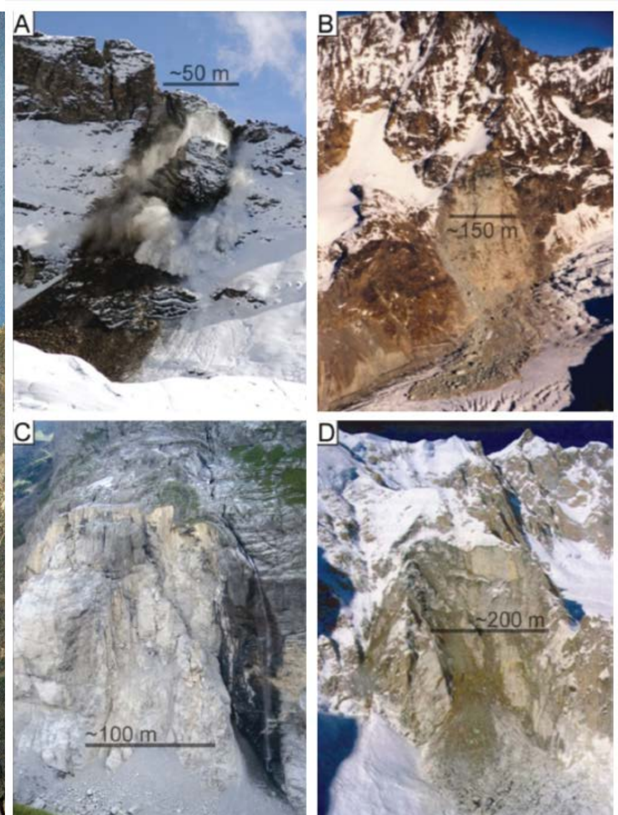
Grandine

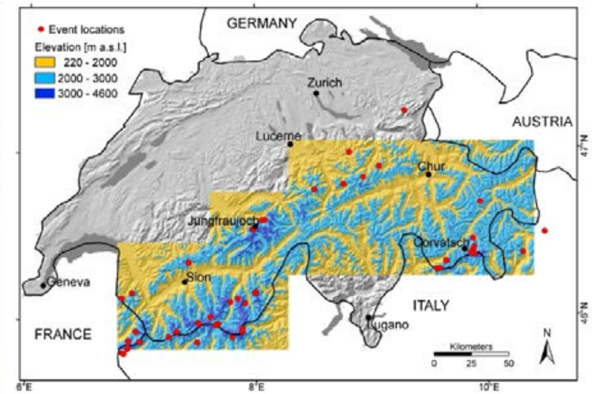


Pericolosità = frequenza * intensità (riscalata 0 - 1)

Permafrost: perché?







A: Kärpf (CH), 2007, 2×10^4 m^3
B: Tschierva (CH), 1988, 3×10^5 m^3
C: Eiger (CH), 2006, 1×10^6 m^3
D: Brenva (I), 1997, 2×10^6 m^3

Degradazione permafrost → perdita di coesione → instabilità

Fischer, L., Purves, R. S., Huggel, C., Noetzli, J., & Haeberli, W. (2012). *Natural Hazards and Earth System Sciences*, *12*(1), 241-254.

Permafrost: come?

- Mappa dei rock glacier
- **Modelli empirici**
- **Modelli semi-empirici e matematici**

Permafrost: come?

- Mappa dei rock glacier

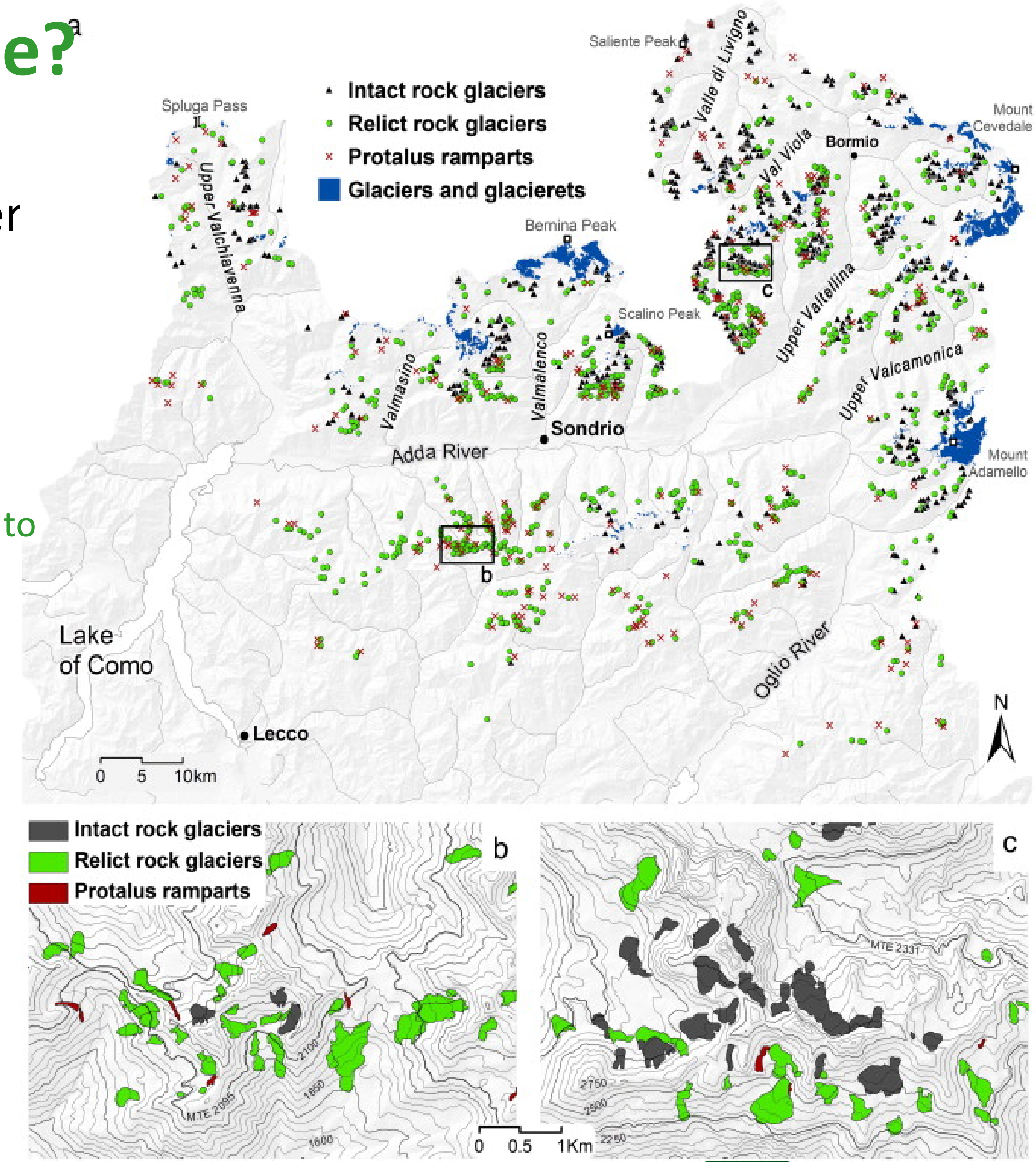
Mappa dei rock glacier della Regione Lombardia 2013

1514 rock glacier

639 intatti → permafrost attivo

875 relitti → permafrost degradato

Poligoni



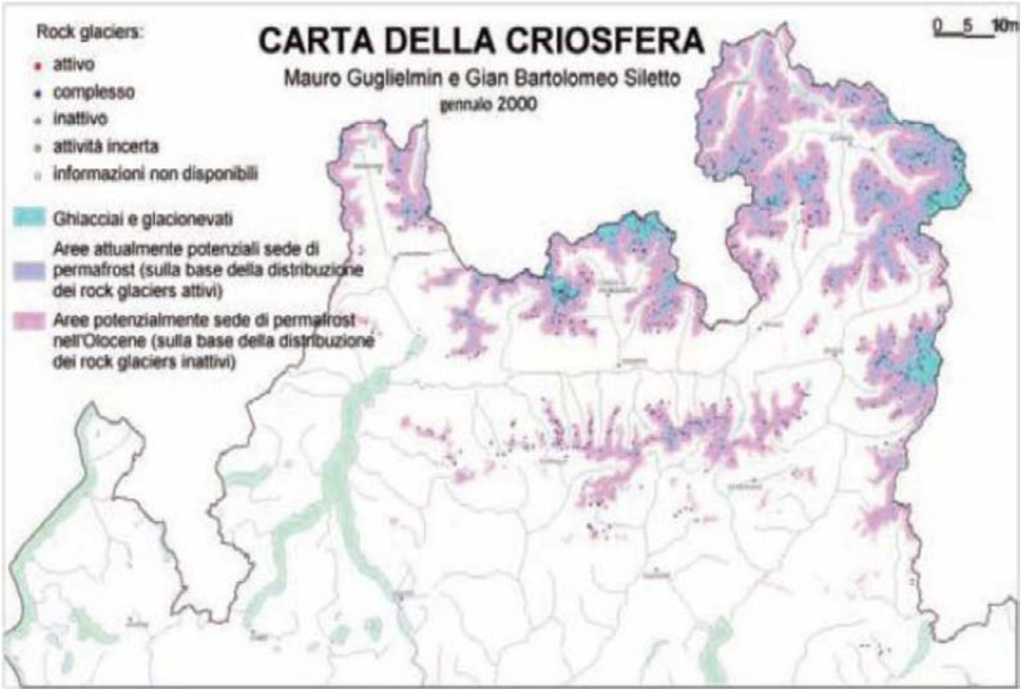
Scotti, R., Brardinoni, F., Alberti, S., Frattini, P., & Crosta, G. B. (2013). Geomorphology, 186, 136-149.

Permafrost: come?

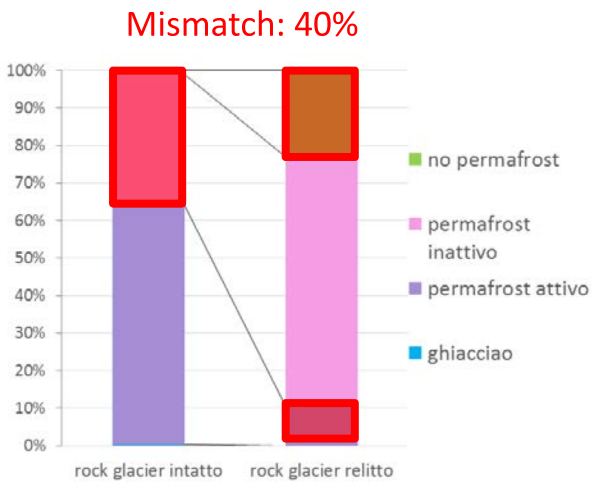
- Modelli empirici

Carta della criosfera della Regione Lombardia

- Localizzazione rock glaciers (punti)
- Quota
- Esposizione



Guglielmin, M., & Siletto, G. B. (2000). Carta della criosfera. Regione Lombardia. Edilizia Residenziale, Firenze.



Confronto tra mappa dei rock glacier e carta della criosfera della Regione Lombardia

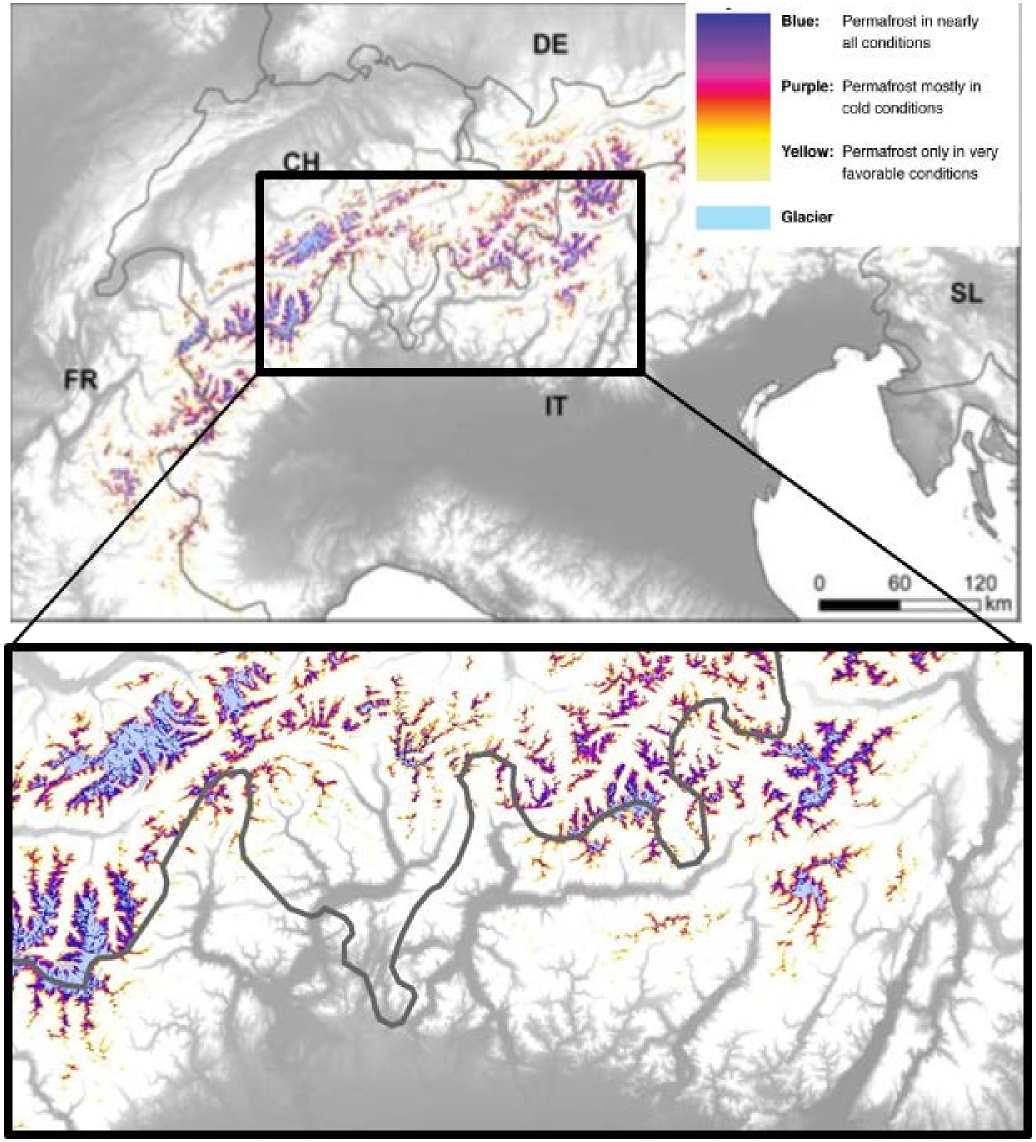
Permafrost: come?

- Modelli semi-empirici e matematici

Indice di Permafrost alpino

Localizzazione rock glaciers (punti)

- Quota
- Esposizione



Boeckli, L., Brenning, A., Gruber, S. & Noetzli J. (2012) The Cryosphere, 6, 807–820.

Rischi «emergenti»: rischio meteo

15/5/2015 Malpensa chiusa per 45 minuti
→ **nubifragio**

22/12/2009 Linate chiusa
→ **nevicata intense** → **gelata**

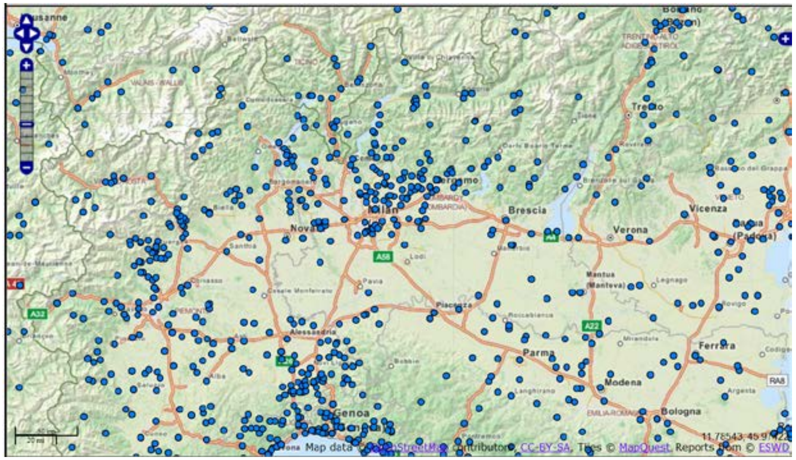
6/2/2015 disagi e incidenti sulla rete viaria
→ **nevicata intense** → **gelata**

Rischi «emergenti»: rischio meteo

Database ESWD (European Severe Weather Database, Dotzek et al, 2009)

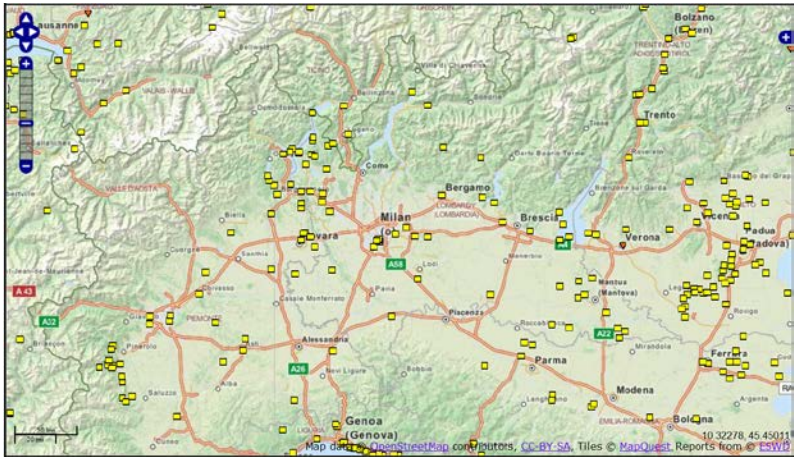
- quadro sinottico della frequenza dei diversi fenomeni meteorologici pericolosi
- consultabile gratuitamente da internet
- eventi estremi dal 2006 (con alcuni dati ricostruiti a posteriori dal 1995)

20238 eventi (alla data del 14 novembre 2015)
200 in Lombardia



nubifragi

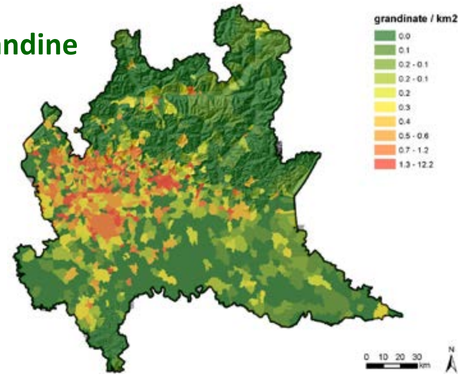
30904 eventi
50 in Lombardia



tempeste di vento

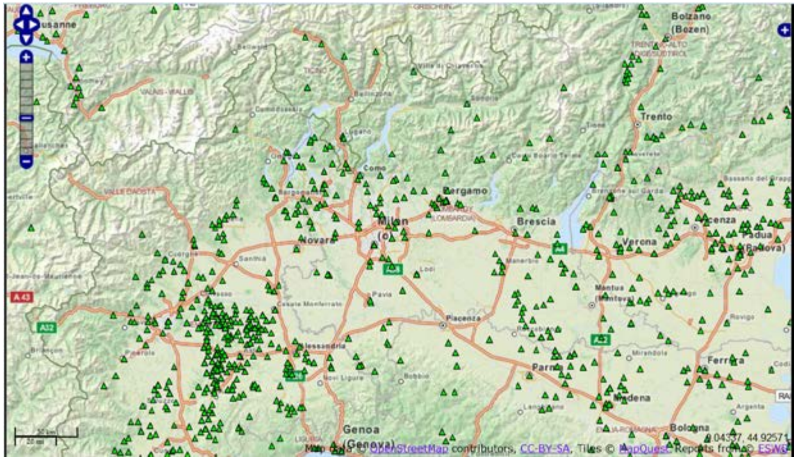
Rischi «emergenti»: rischio meteo

Database meteograndine
3338 eventi

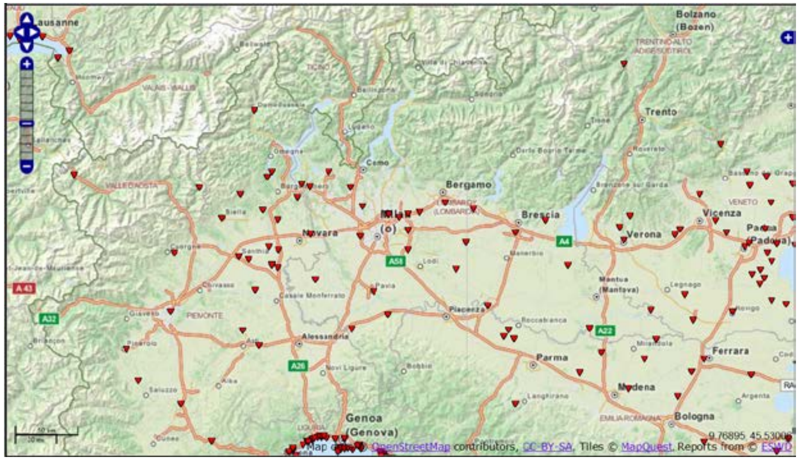


20793 eventi
150 in Lombardia

4930 eventi
25 in Lombardia



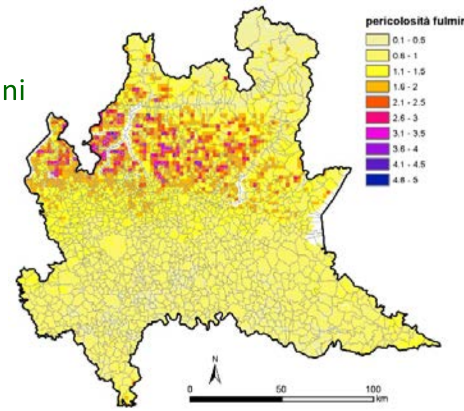
grandinate



tornado

Rischi «emergenti»: rischio meteo

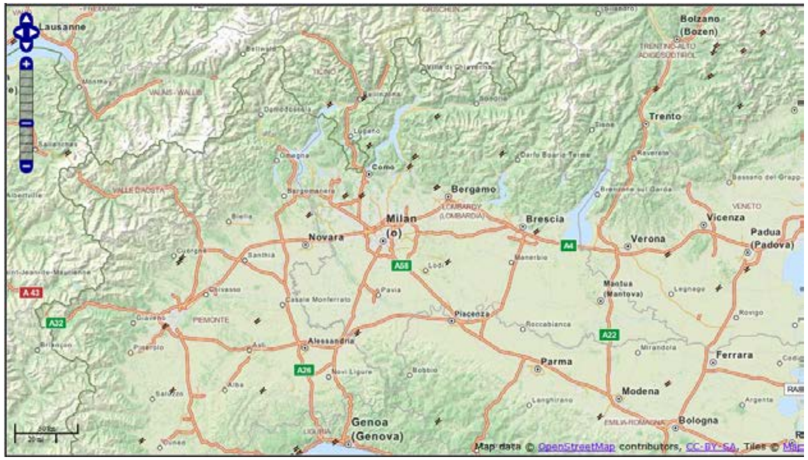
Sistema SIRF
3.5 milioni di fulmini in Italia nel solo 2014



1293 eventi
3 in Lombardia

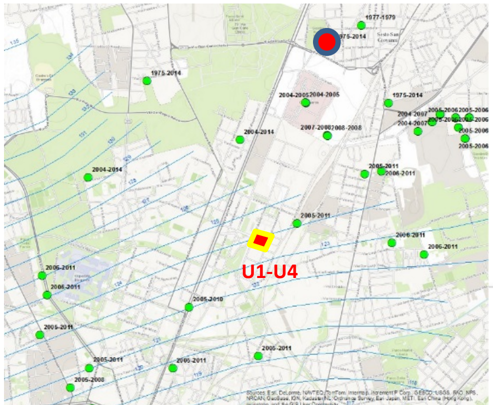
Tormente di neve

2586 eventi
11 in Lombardia

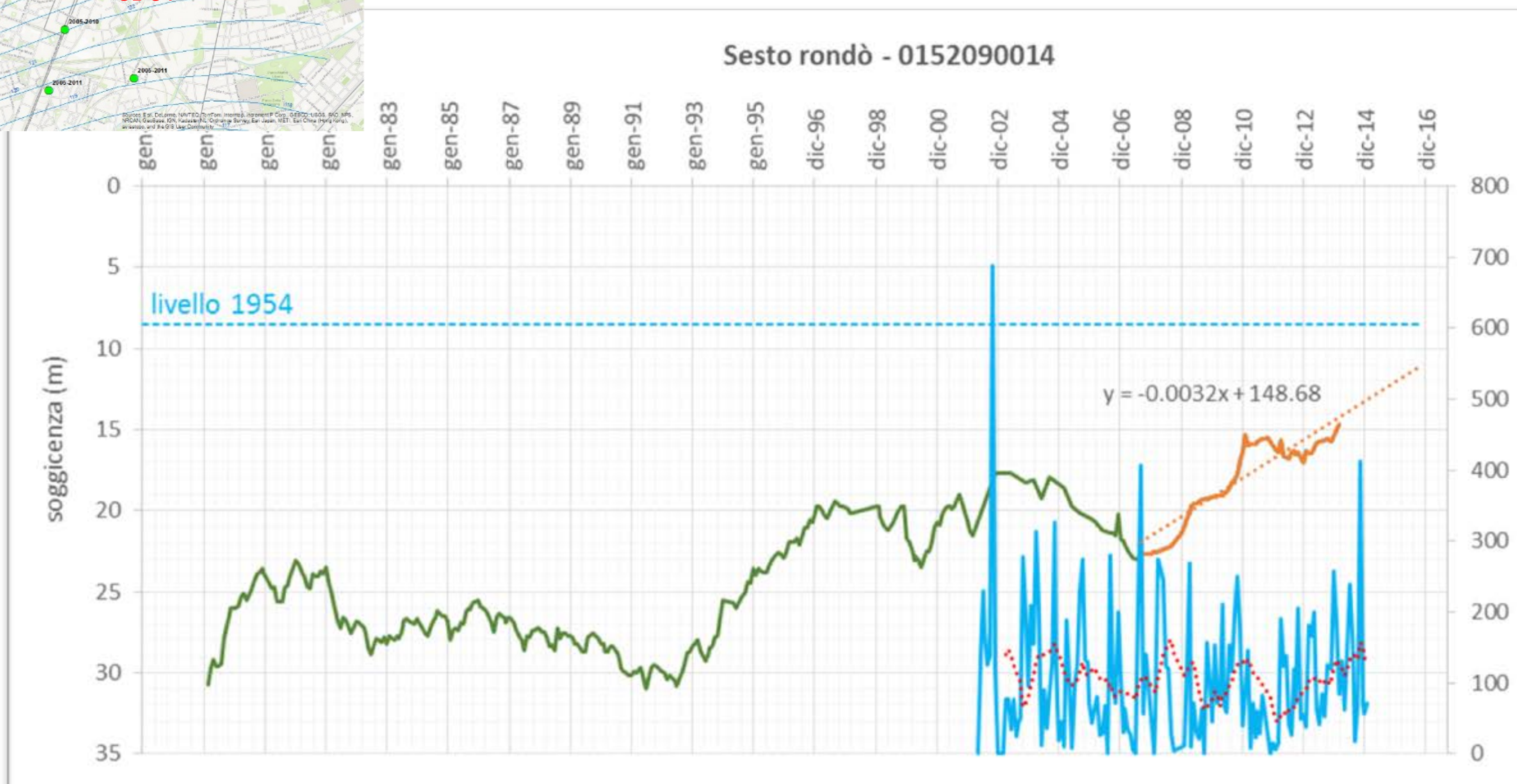


Fulmini

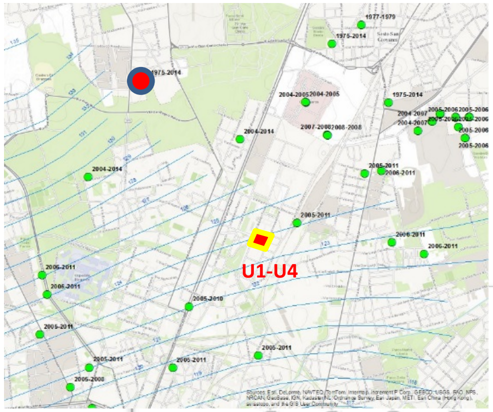
Rischi «emergenti»: innalzamento falda



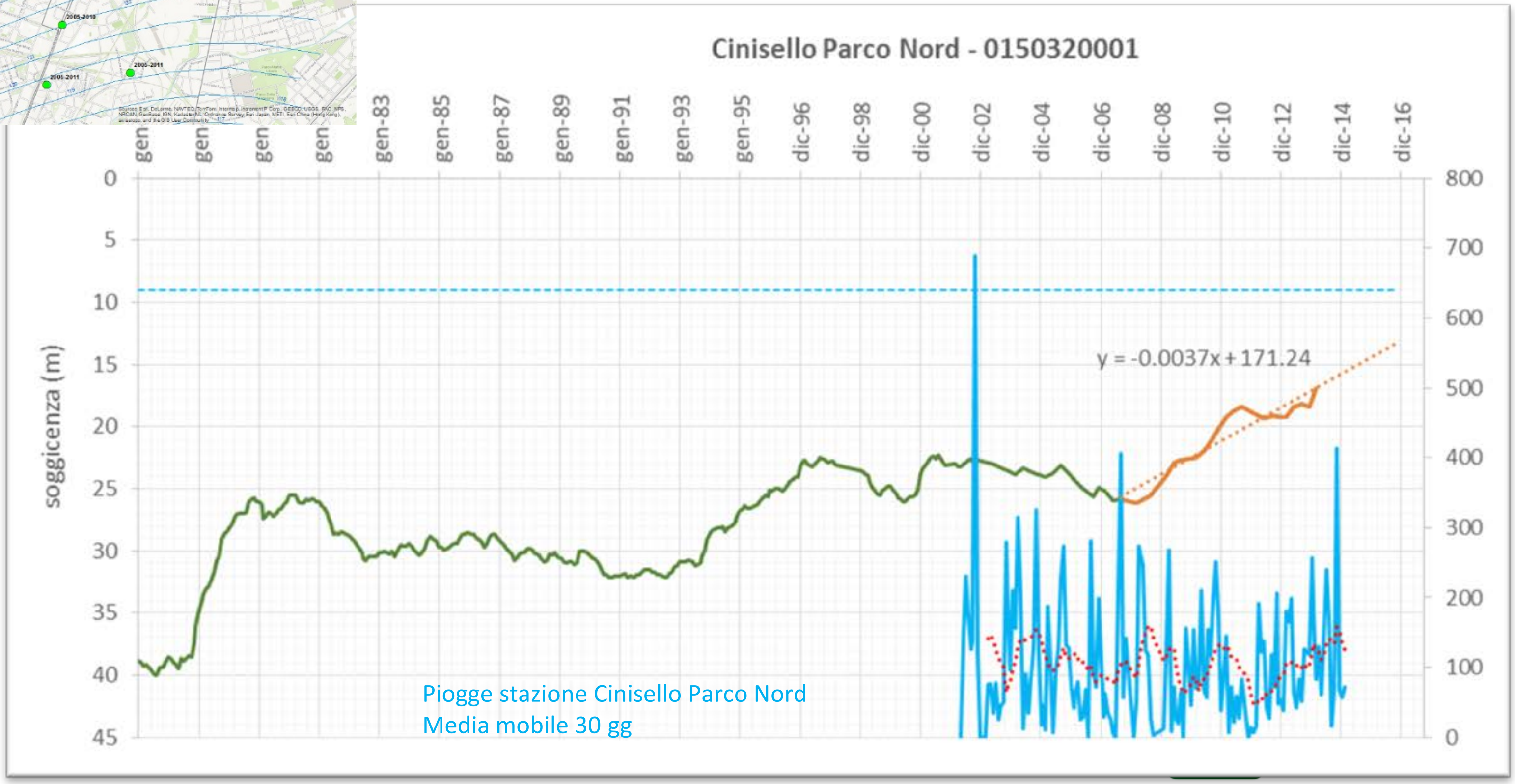
Dati di soggiacenza dal database SIF della Provincia di Milano nell'area dell'Università di Milano - Bicocca



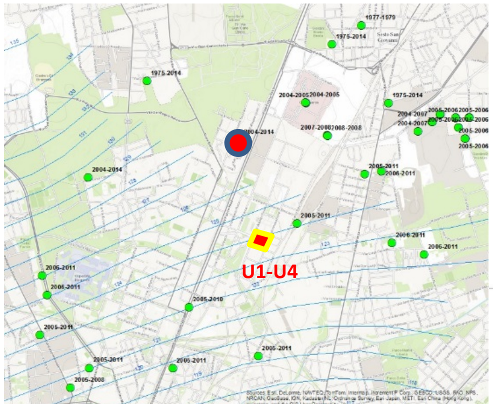
Rischi «emergenti»: innalzamento falda



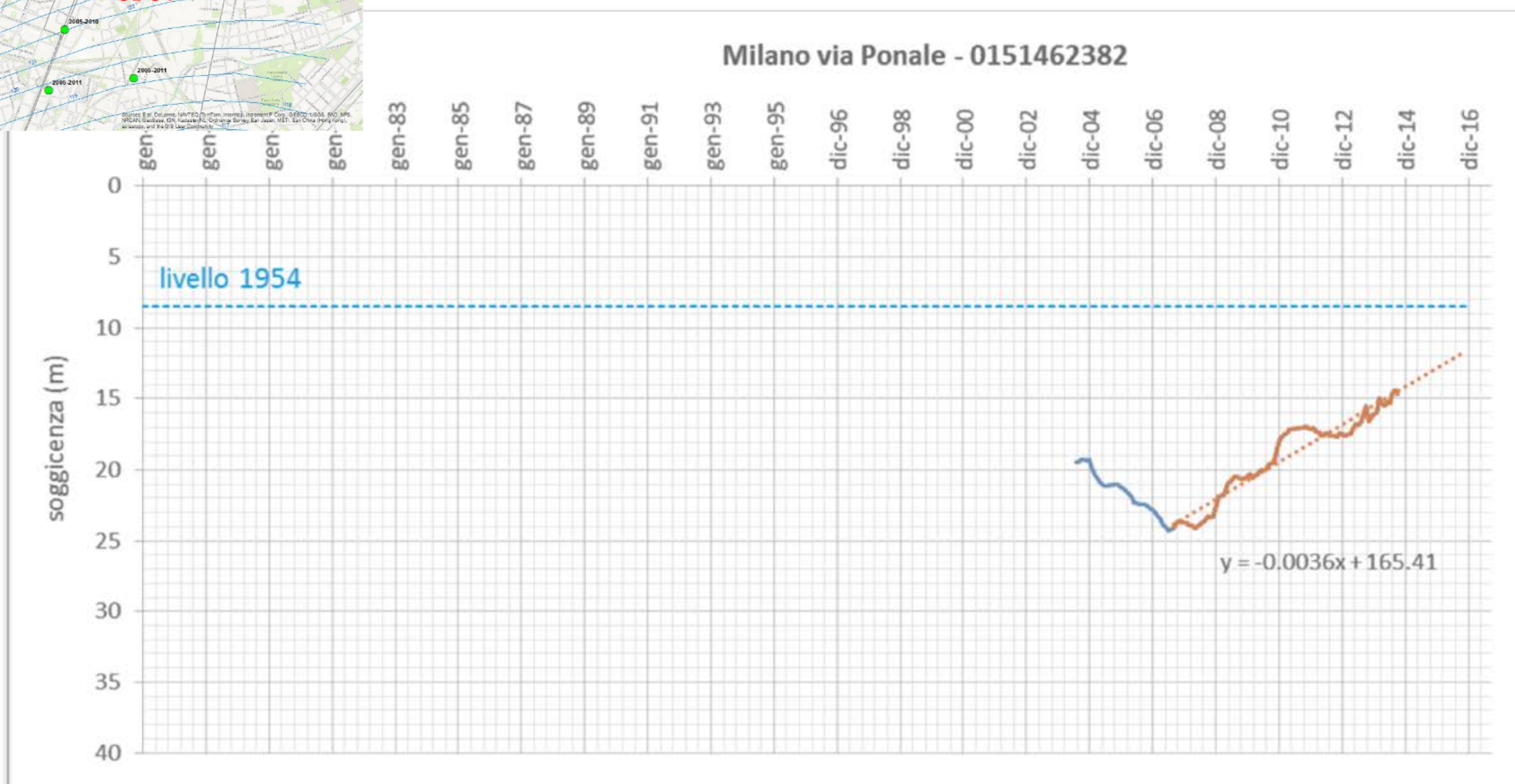
Dati di soggiacenza dal database SIF della Provincia di Milano nell'area dell'Università di Milano - Bicocca



Rischi «emergenti»: innalzamento falda



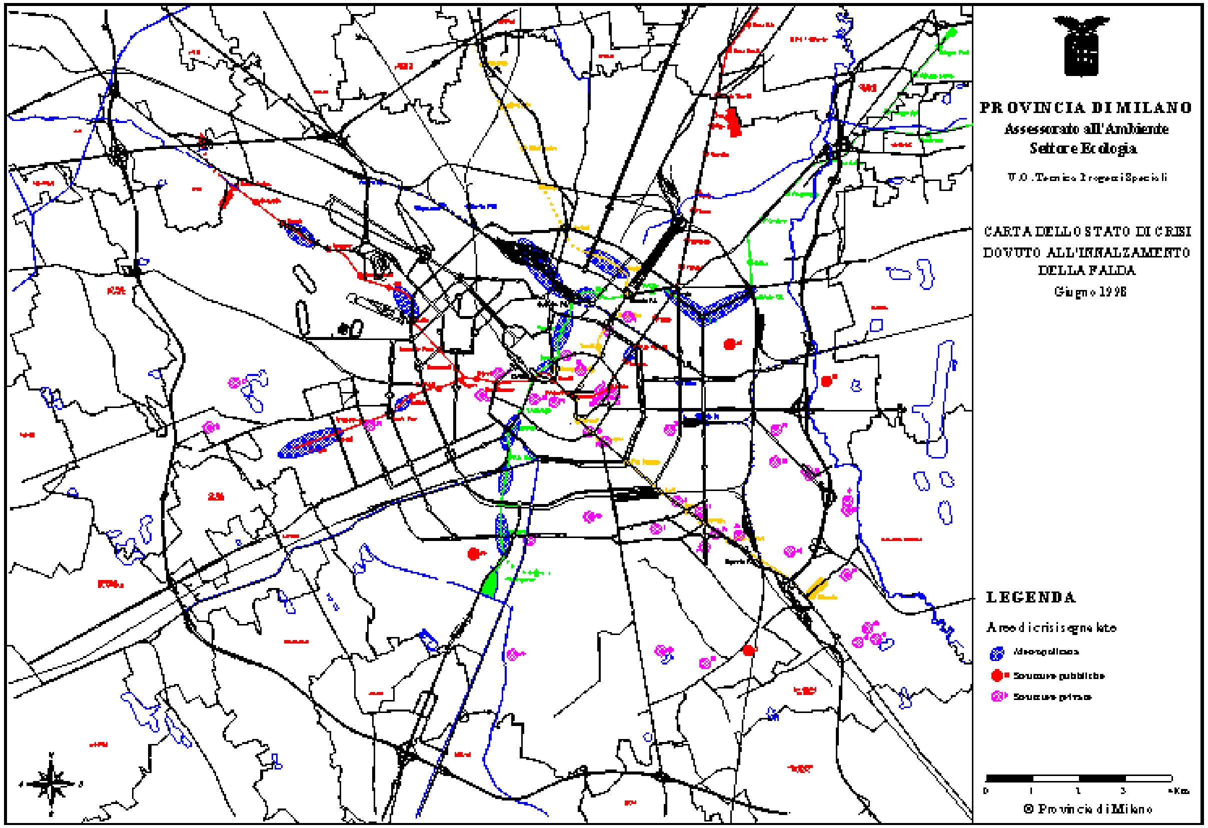
Dati di soggiacenza dal database SIF della Provincia di Milano nell'area dell'Università di Milano - Bicocca



Rischi «emergenti»: innalzamento falda

Problemi di interazione con strutture sotterranee

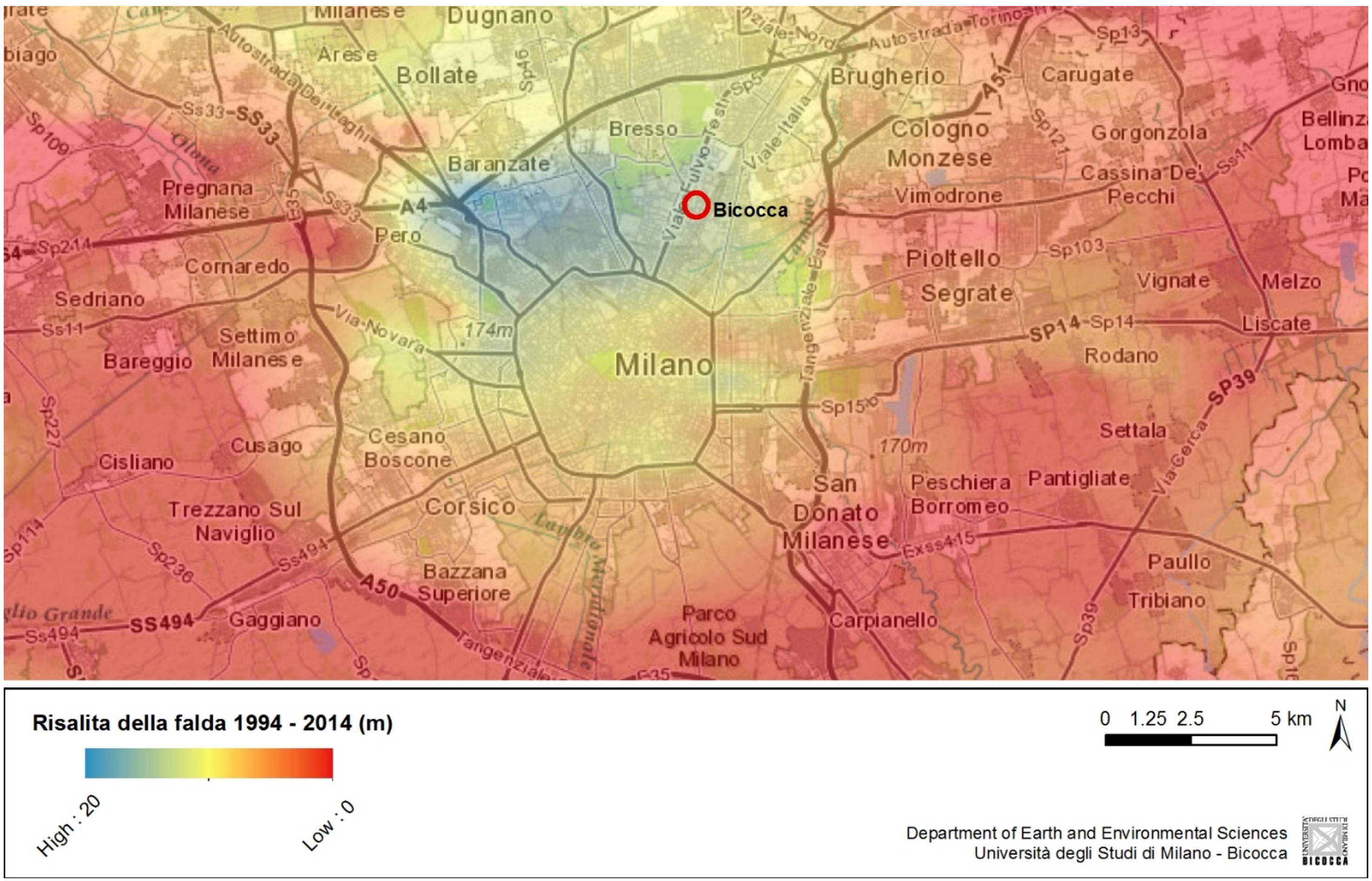
- noti a partire dagli anni ’90
- Carta dello stato di crisi del 1998 (sotto)



Rischi «emergenti»: innalzamento falda

Ampio areale di distribuzione del problema

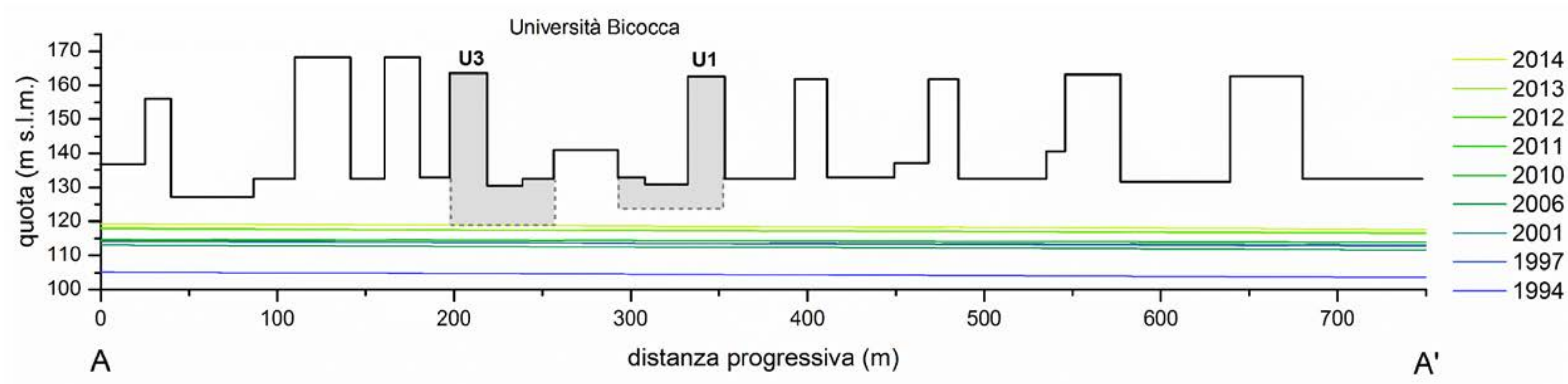
Innalzamento dal 1994 (m)

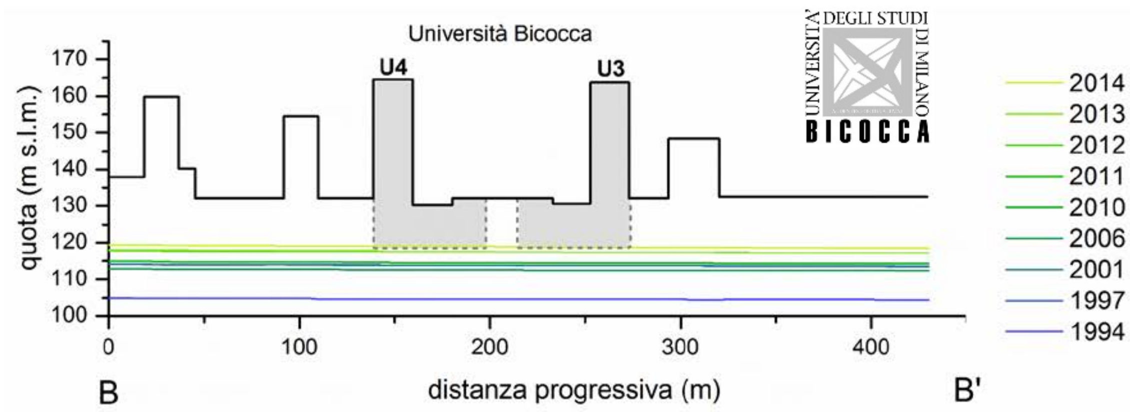


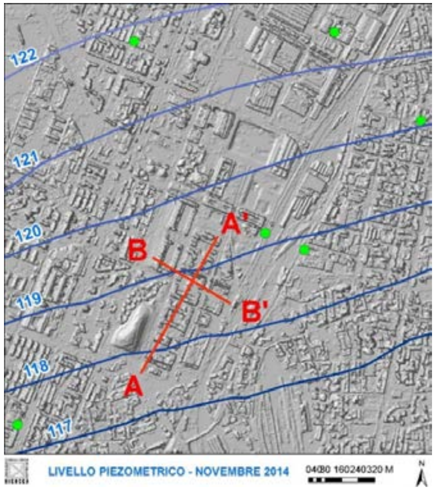
Rischi «emergenti»: innalzamento falda

Caso Bicocca

- Allagamento di locali sotterranei dell'Università (es: vano ascensori)
- Necessità interventi impermeabilizzazione/pompaggio → centinaia di migliaia di euro di danni



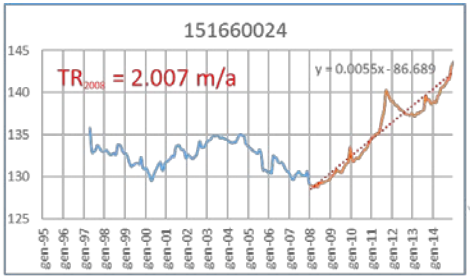


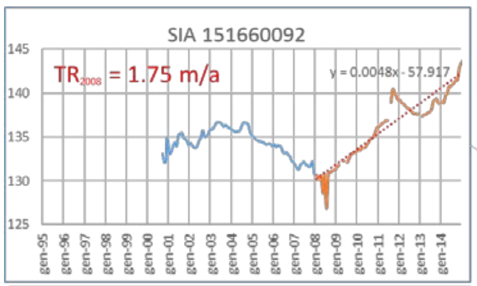


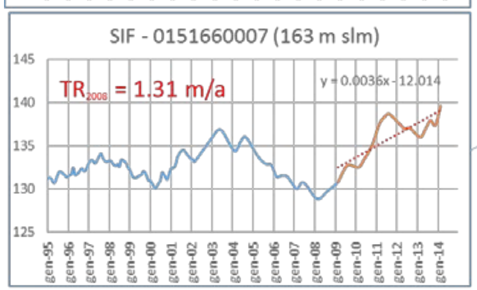
Rischi «emergenti»: innalzamento falda

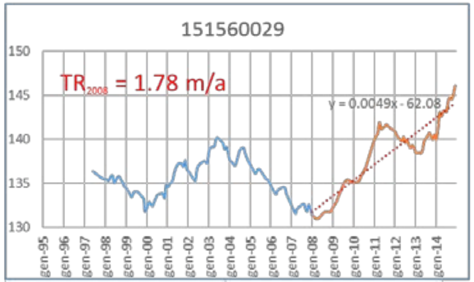
Caso Cava Nord srl

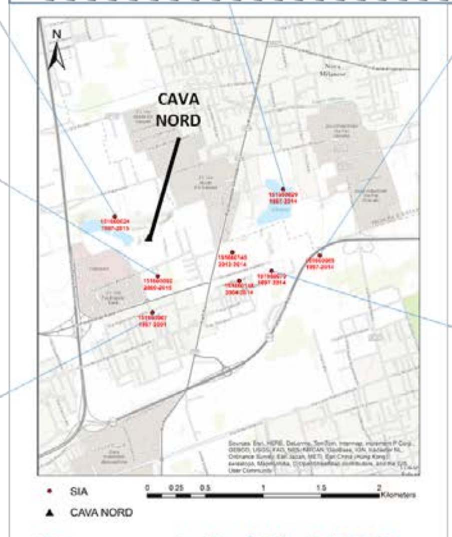
- Allagamento cava con concessione di coltivazione in asciutto
- Riduzione volumetria di cava → oltre 100.000 euro di danni







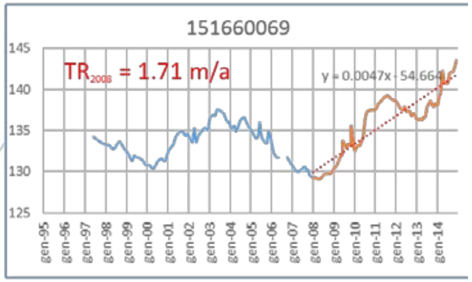


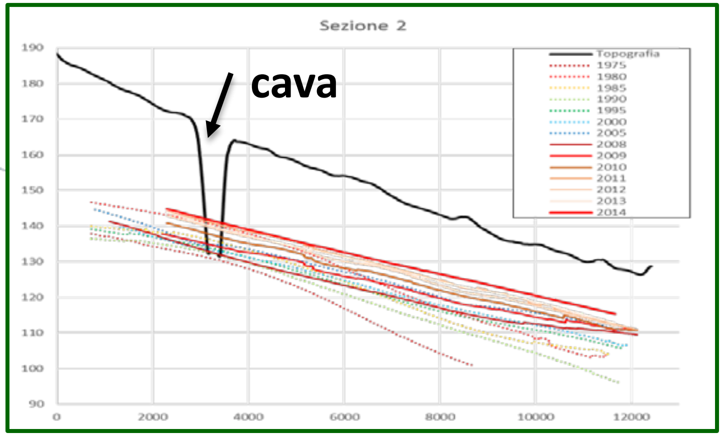


TR_{2008} = tasso risalita falda dal 2008

CAVA NORD S.R.L.

Inerti da costruzione dal 1962

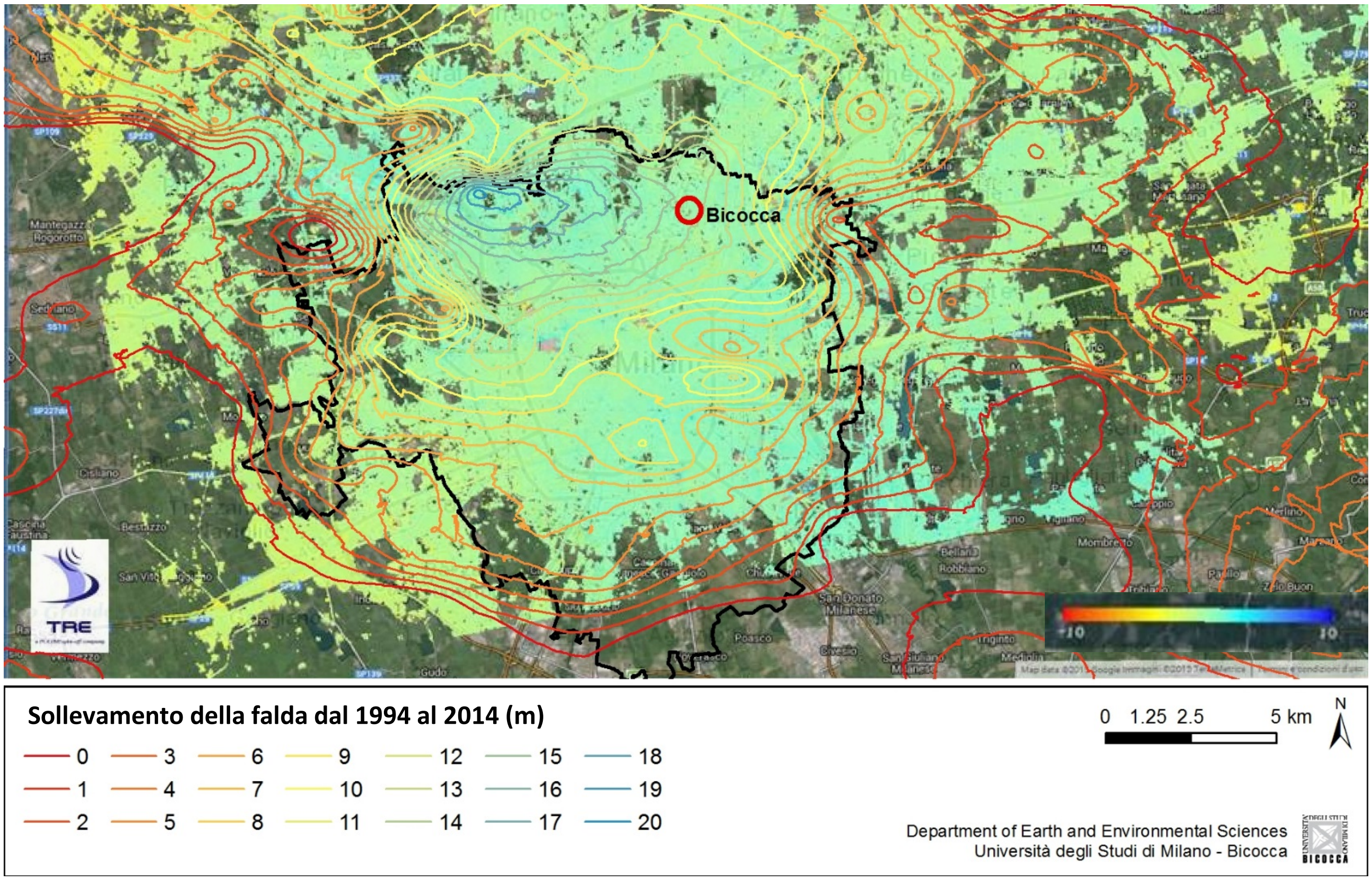




Rischi «emergenti»: innalzamento falda

Possibili effetti geotecnici

Spostamenti (componente verticale) da interferometria radar (mm)



(gentilmente da TRE Europa srl)

Grazie per l'attenzione!

Per ulteriori informazioni:

paolo.frattini@unimib.it