EGU General Assembly 2020

Spatio-temporal cluster analyses of landslides in Italy at national and regional scale

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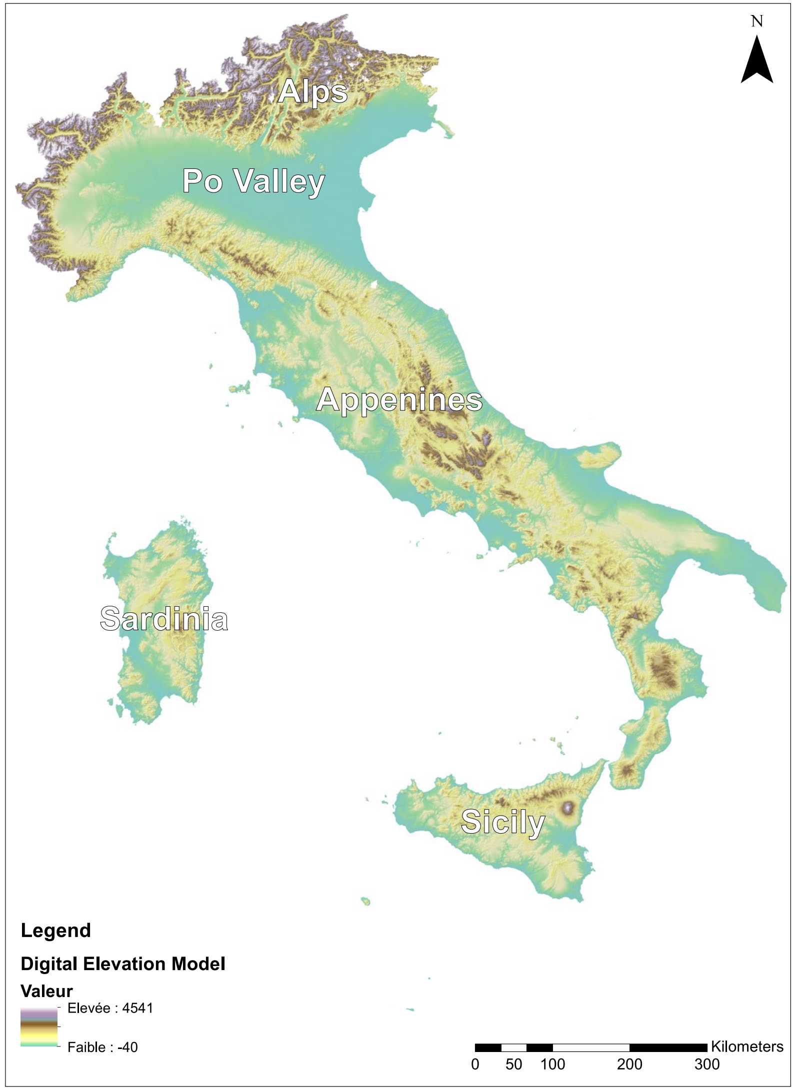
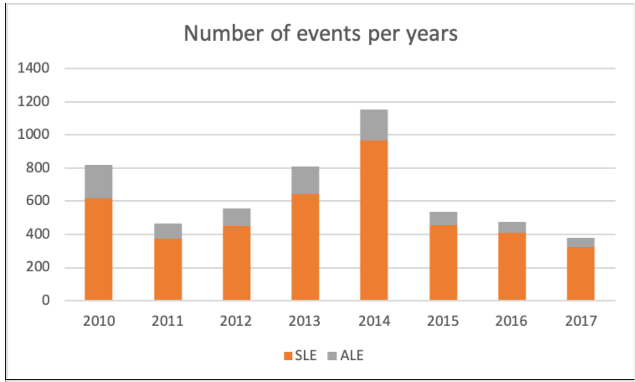
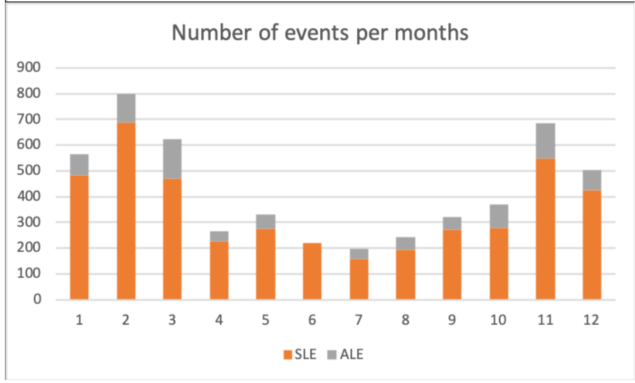
Main objective

- Detection and mapping of spatio-temporal **clusters of landslides** for warning purposes.
- Analyses are performed both at national scale, considering the **Italian peninsula** and the surrounding islands, and at regional scale, focusing on the **Campania region**.
- At national scale, a subdivision of the territory into 158 **warning zones** (WZ), as identified by the civil protection regional centers to deal with weather-induced hydrogeological hazards, was adopted.
- The landslides inventory supporting the results is available on an open data repository, **FraneItalia**, a geo-referenced catalog developed consulting online news sources and reporting landslide events in Italy from 2010 to 2017 (https://data.mendeley.com/datasets/zygb8jygrw/1)

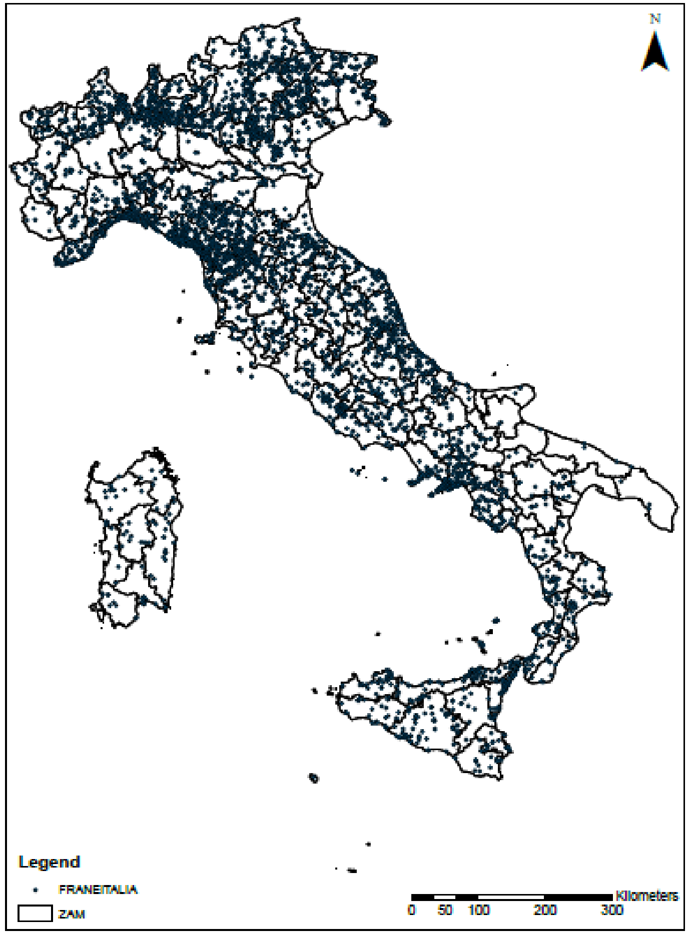


Dataset: landslide events at national scale

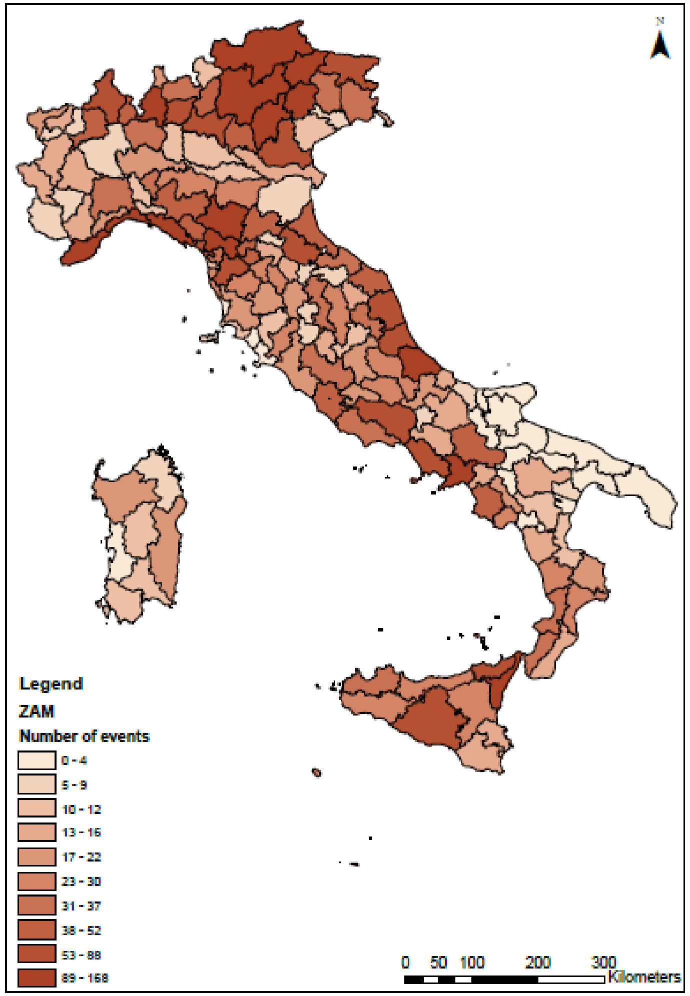




SLE = single landslide events .
ALE = areal landslide events, referring to multiple landslides occurring in the same area and triggered by the same cause.



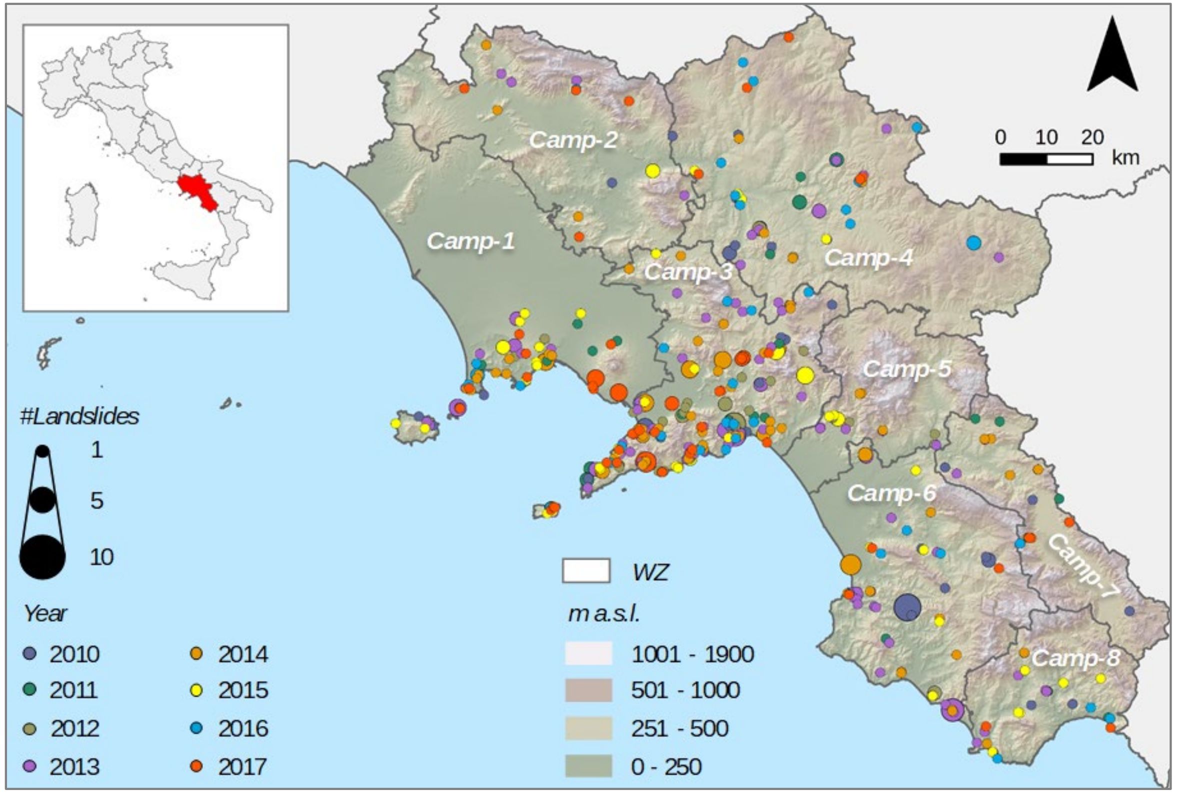
FraneItalia events

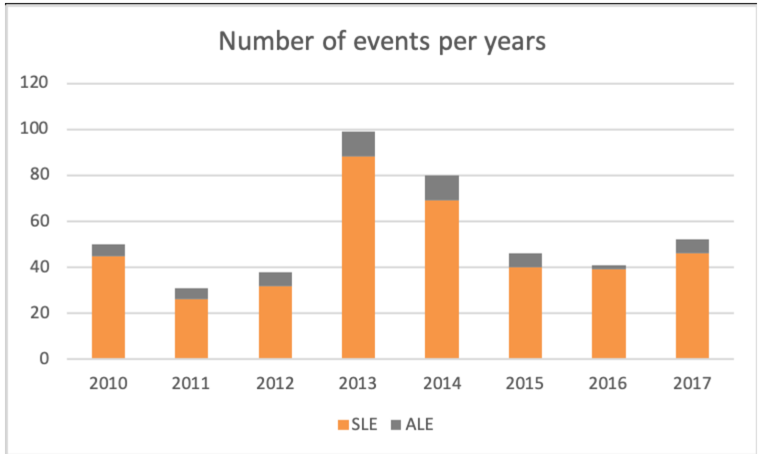


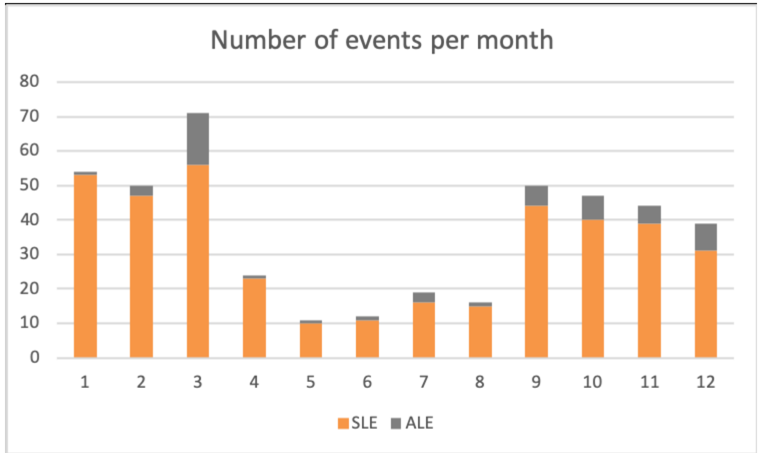
Density of events (by WZ)

Dataset: landslide events at regional scale

Campania region



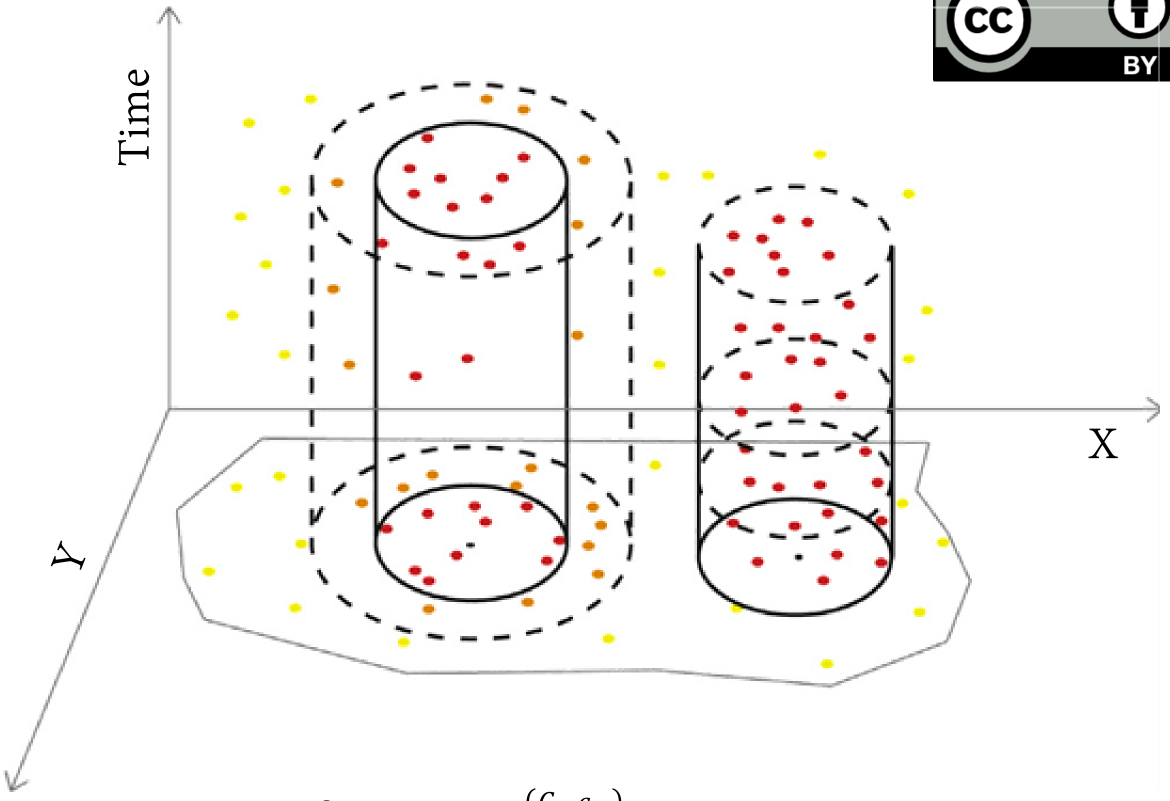




Statistical analysis

- The statistical analyses are conducted using the **space-time permutation scan statistics** model, accounting for the geographical spatial dimension as well as for the temporal dimension of events.

- Two types of analyses were performed, both at national and at regional scale:
  - **global analysis** encompassing the entire 8-year study period ;
  - **annual analysis** considering each single year.



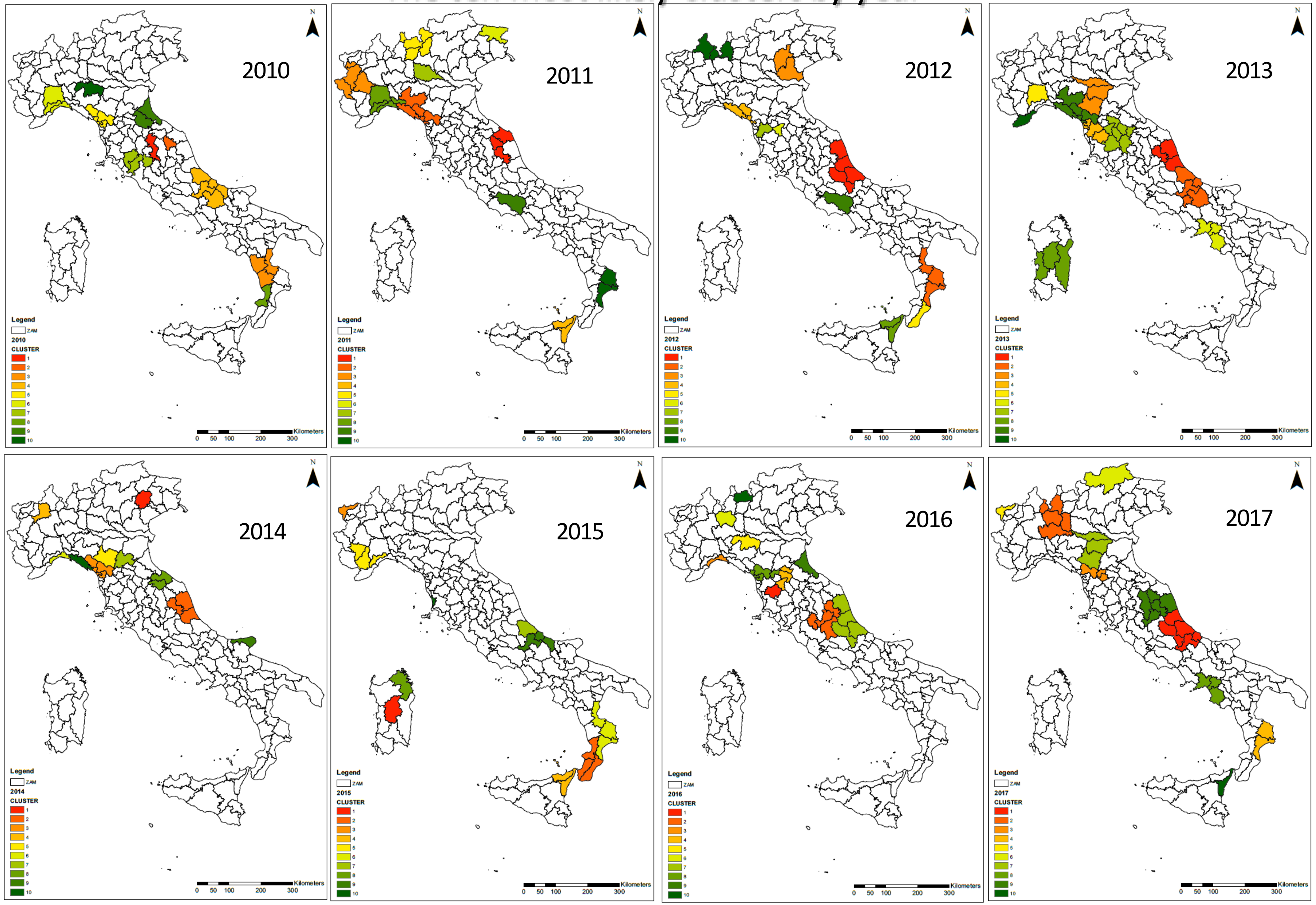
$$GLR = \left(\frac{c_{st}}{\mu_{st}}\right)^{c_{st}} \left(\frac{C - c_{st}}{C - \mu_{st}}\right)^{(C - c_{st})}$$

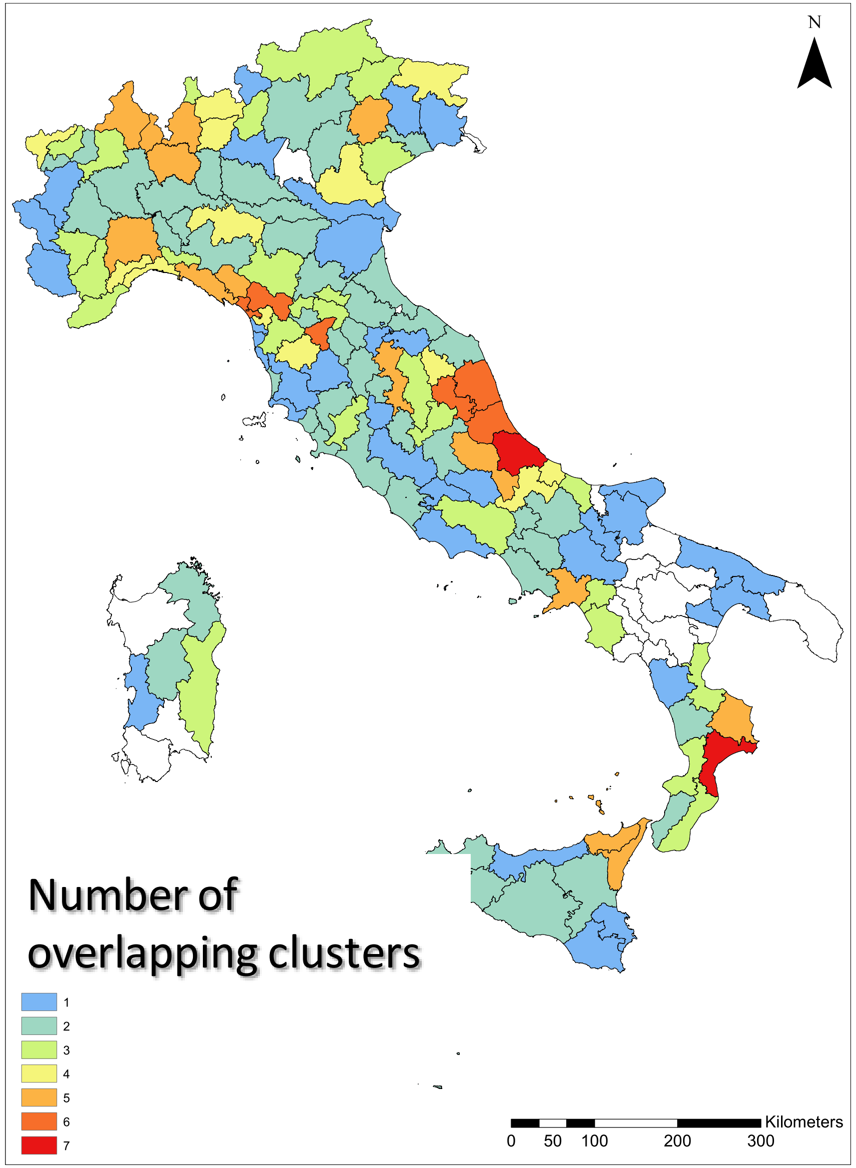
C_{st}: events falling inside and outside (C-c_{st}) the cylinder
μ_{st}: expected number of events

Scale	Spatial aggregation	Temporal aggregation		Max spatial size (radius)	Max temporal size	
		Annual	Global		Annual	Global
National	Warning zone	1 day	1 month	50 Km	1 month	6 months
Regional	(None)	1 day	1 month	10 km	1 week	6 months

Results: annual analyses at national scale

The ten most likely clusters by year

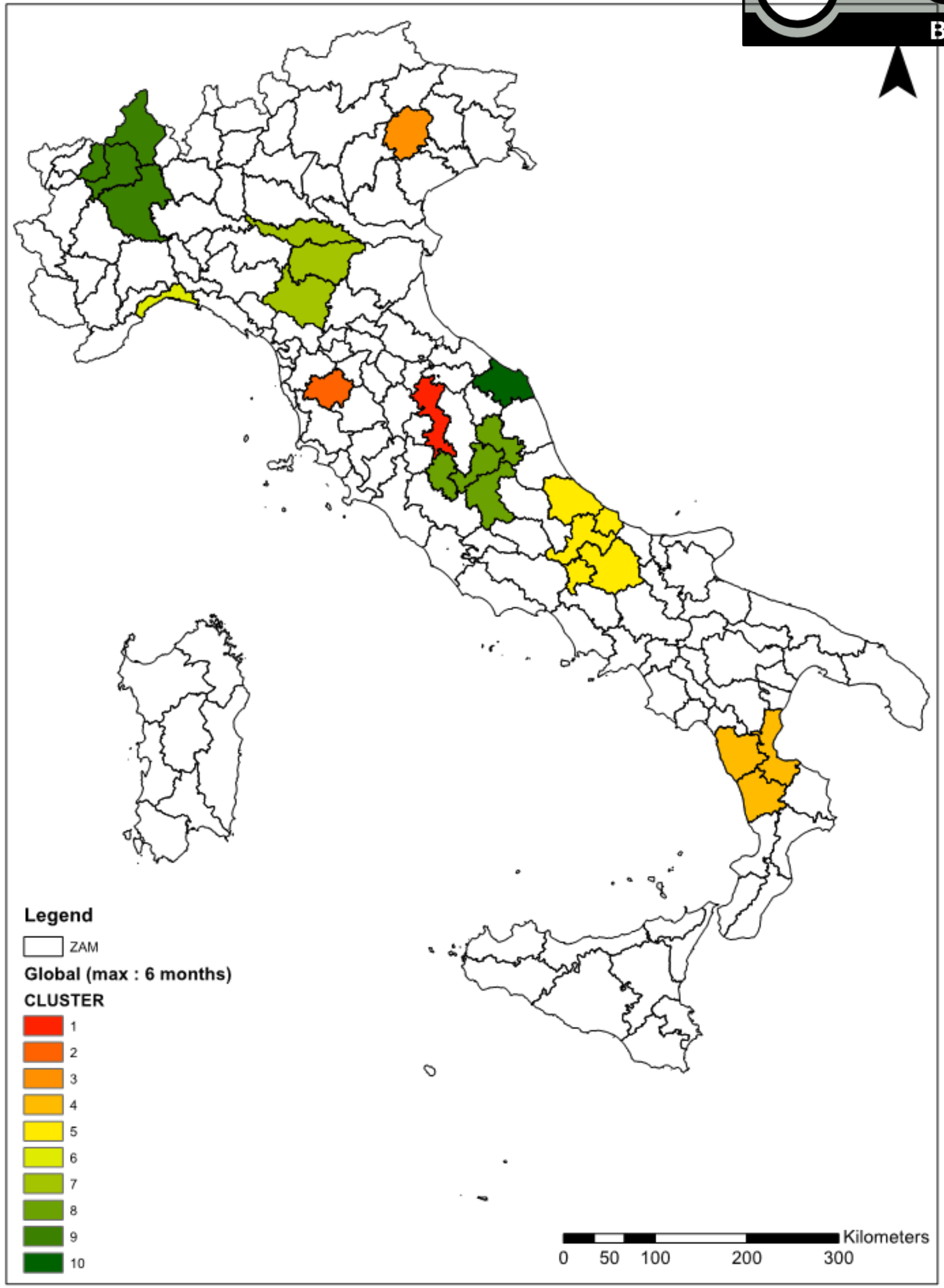




Results: global analyses at national scale

The ten most likely clusters over the entire study period (2010-2017)

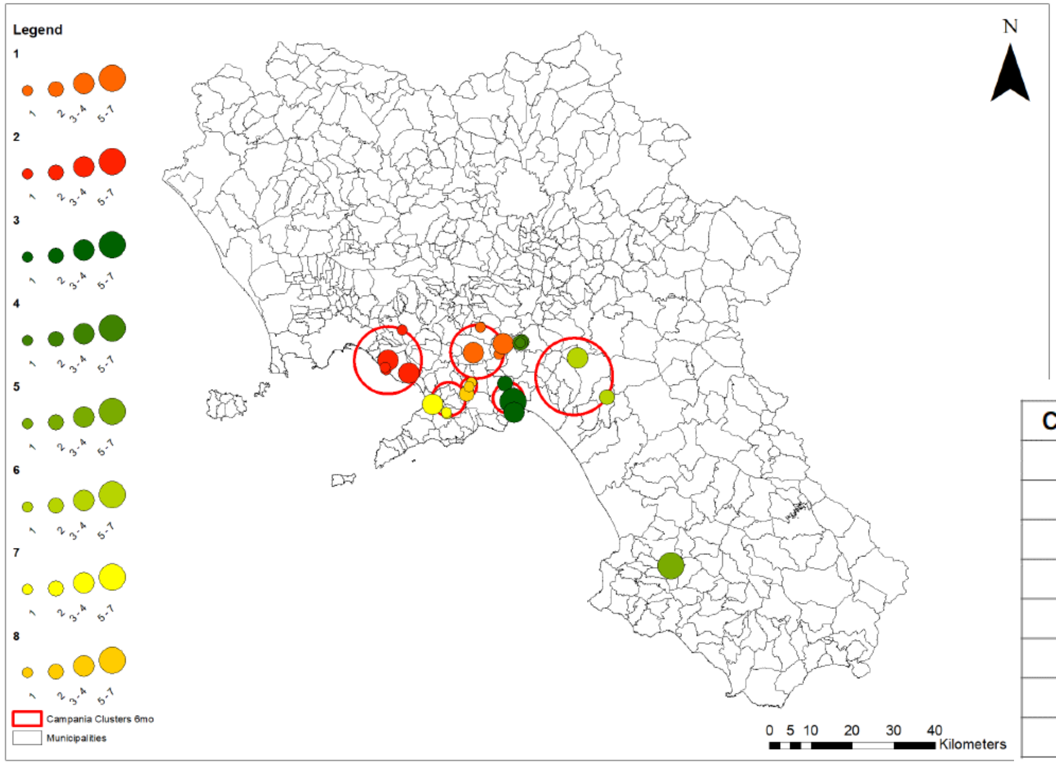
CLUSTER	START_DATE	END_DATE	P_VALUE	OBSERVED	EXPECTED
1	2010/12/1	2010/12/31	1.00E-17	61	4.52
2	2016/4/1	2016/4/30	1.00E-17	30	0.52
3	2014/8/1	2014/8/31	1.00E-17	43	2.03
4	2010/1/1	2010/2/28	1.00E-17	44	2.94
5	2015/1/1	2015/4/30	1.00E-17	78	12.63
6	2014/10/1	2014/11/30	1.00E-17	59	7.89
7	2013/3/1	2013/4/30	1.00E-17	79	15.46
8	2016/10/1	2016/10/31	1.00E-17	28	1.05
9	2014/11/1	2014/12/31	1.00E-17	50	6.00
10	2011/3/1	2011/5/31	1.00E-17	40	3.65



Results: cluster analyses at regional scale

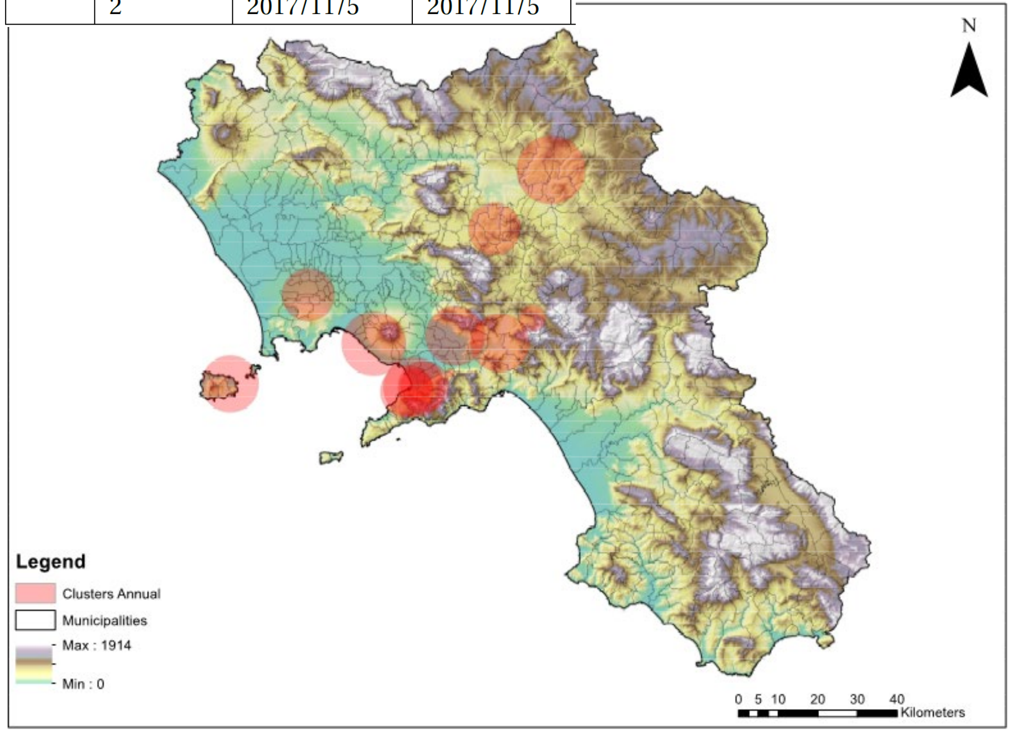
YEAR	CLUSTER	START_DATE	END_DATE
2010	1	2010/12/27	2010/12/27
	2	2010/9/9	2010/9/11
	3	2010/12/4	2010/12/5
2011	1	2011/3/8	2011/3/9
2012	1	2012/12/15	2012/12/15
	2	2012/9/13	2012/9/13
	3	2012/10/31	2012/10/31
2013	1	2013/1/15	2013/1/15
	2	2013/1/19	2013/1/25
	3	2013/10/6	2013/10/6
2014	1	2014/7/31	2014/7/31
	2	2014/2/27	2014/3/2
	3	2014/9/12	2014/9/12
	4	2014/9/1	2014/9/1
2015	1	2015/10/11	2015/10/11
	2	2015/10/7	2015/10/7
2017	1	2017/11/6	2017/11/6
	2	2017/11/5	2017/11/5

Significant cluster over the entire investigated period



Cluster ID	Start date	End date
01	2010/09/01	2010/09/30
02	2010/12/01	2010/12/31
03	2012/09/01	2012/10/31
04	2012/09/01	2013/01/31
05	2014/07/01	2014/07/31
06	2015/12/01	2015/12/31
07	2017/09/01	2017/10/31
08	2017/10/01	2017/11/30

Overlapping annual clusters



Conclusions

- The **spatio-temporal cluster analysis** allows discovering clusters of landslides caused, in a given period, by a single triggering event, usually an intense rainfall.
- This approach can be considered complementary to the **landslide index** (LI), for the visualization and the quantitative assessment of landslides events inventoried both at national and regional scale:
    - LI highlights areas where the density of landslides is higher during the entire study period;
    - the spatio-temporal cluster analysis allows detecting areas characterized by relevant and recurrent landslide activity in a specific time frame.

REFERENCE: Tonini M., Pecoraro G., Romailler K., Calvello M. *Spatio-temporal analysis of recent Italian landslides for warning purposes*. Submitted to Journal (April 2020).