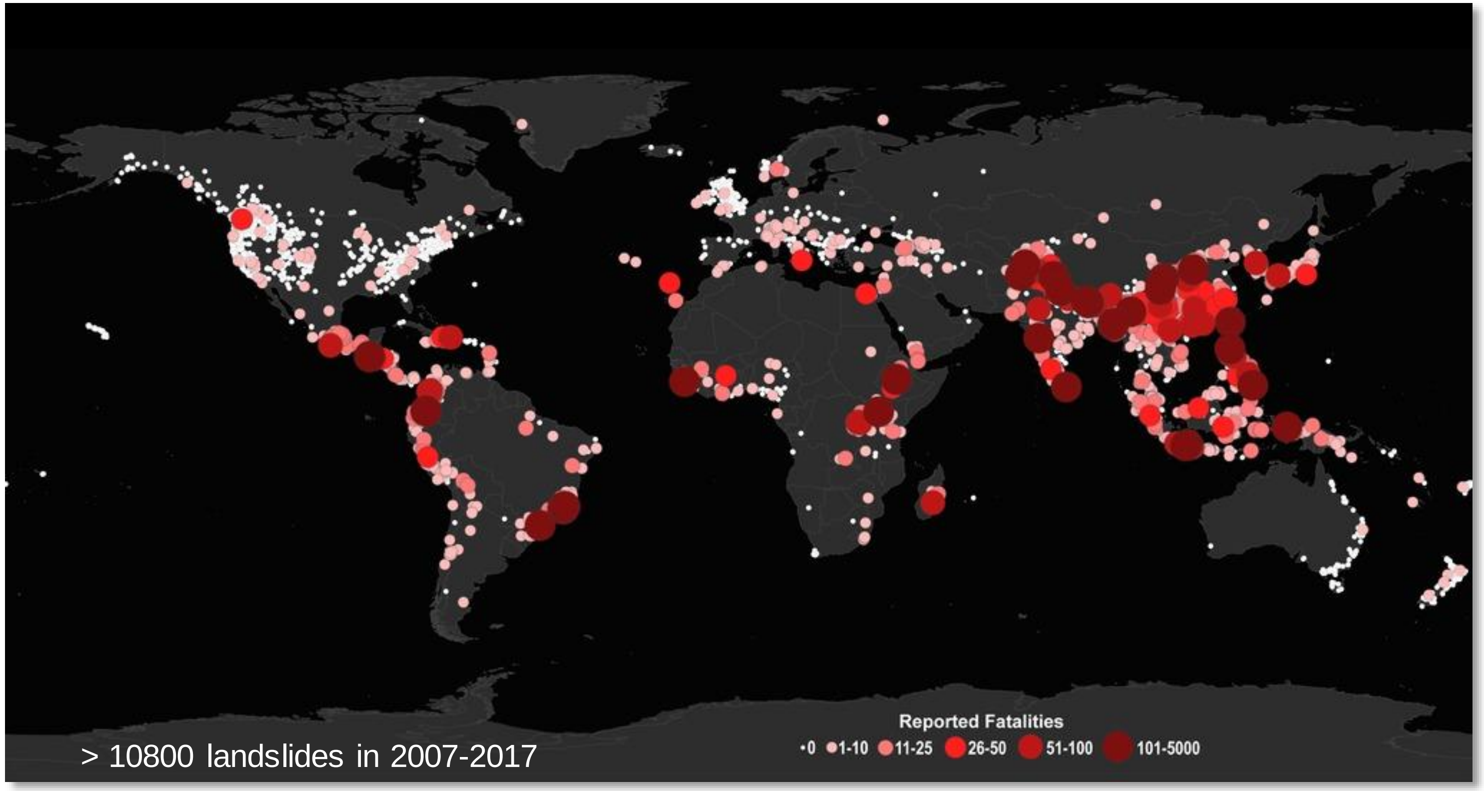
Landslide hazard assessment throught satellite precipitation products

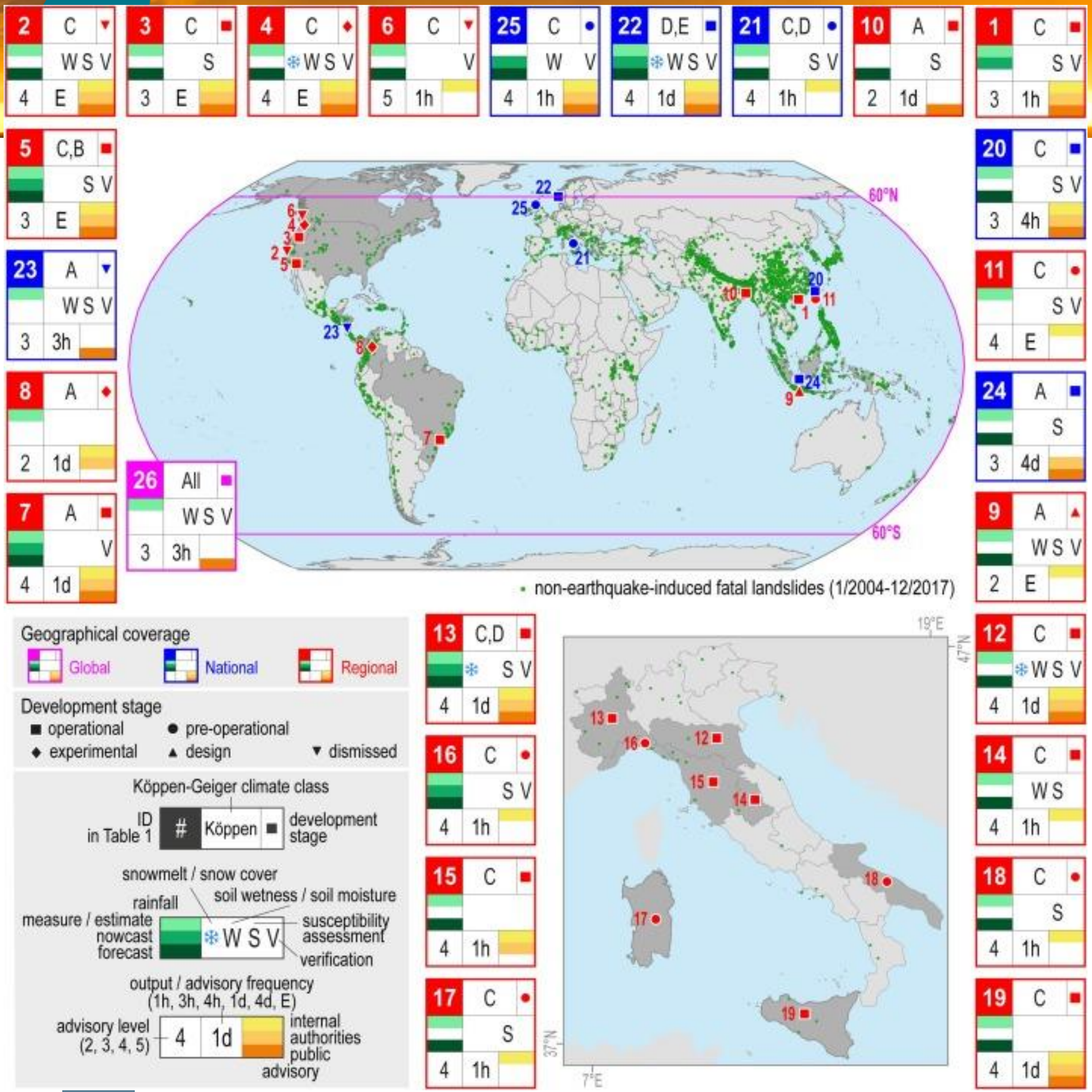
Luca Ciabatta and the Hydrology Group of IRPI-CNR (Italy)

Worldwide, **rainfall-induced landslides** are among the most common and dramatic natural hazards.



NASA's Goddard Space Flight Center

Introduction



To mitigate the landslide risk, **early warning systems** based on rainfall thresholds were developed in several countries

Only 26 past and present LEWS

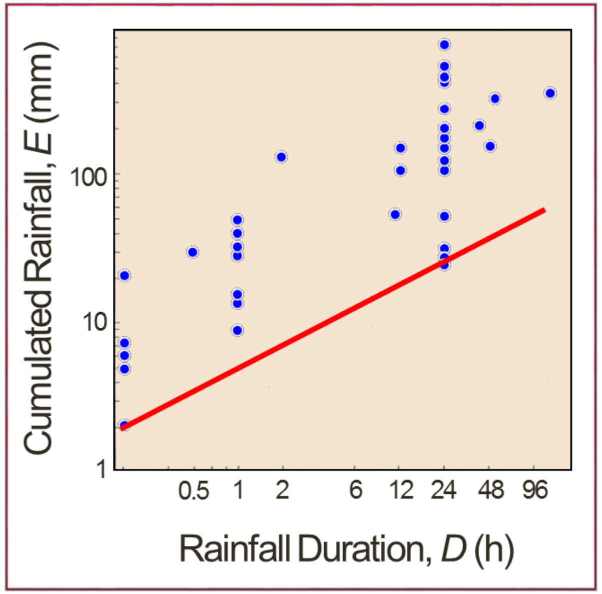
Not evenly distributed over the World

Many of them are still in development

LEWS are based mainly on **rain gauge** measurements.

Guzzetti et al. (2020) – Earth-Science Reviews

Rainfall thresholds



Innes (1983)

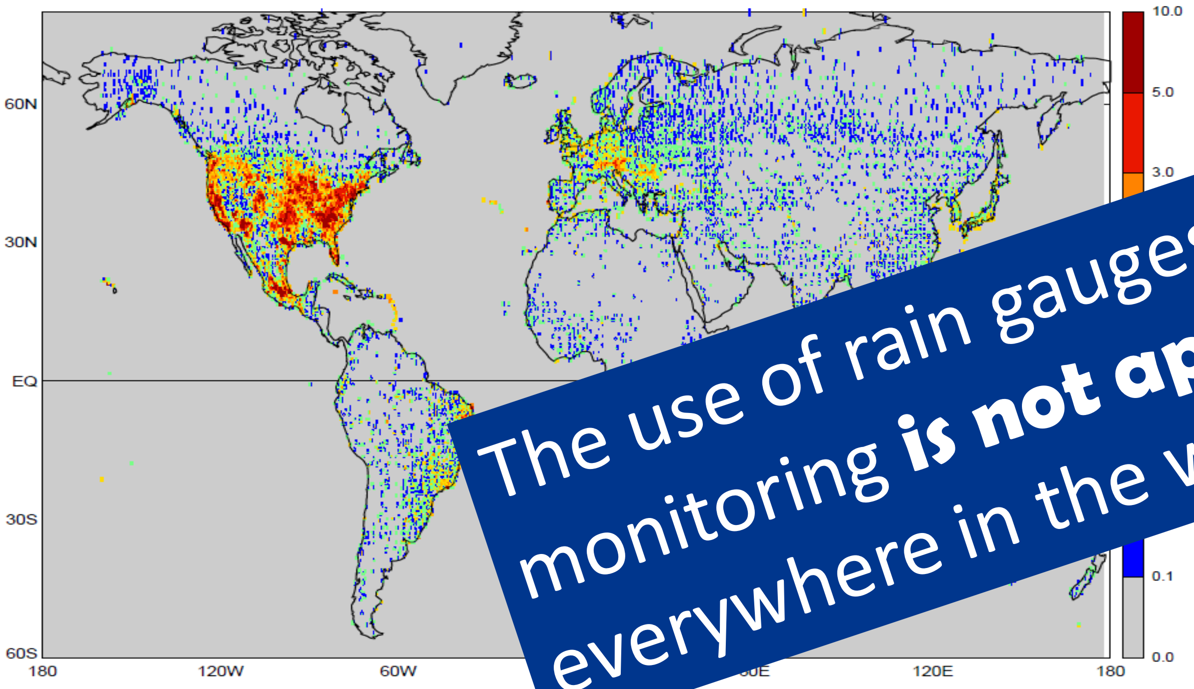
Empirical relationship that are defined as the best separators of rainfall conditions that resulted and did not result in slope instability. They take into account rainfall characteristics as for the ED thresholds:

$$E = \alpha \cdot D^{\gamma}, \gamma > 0$$

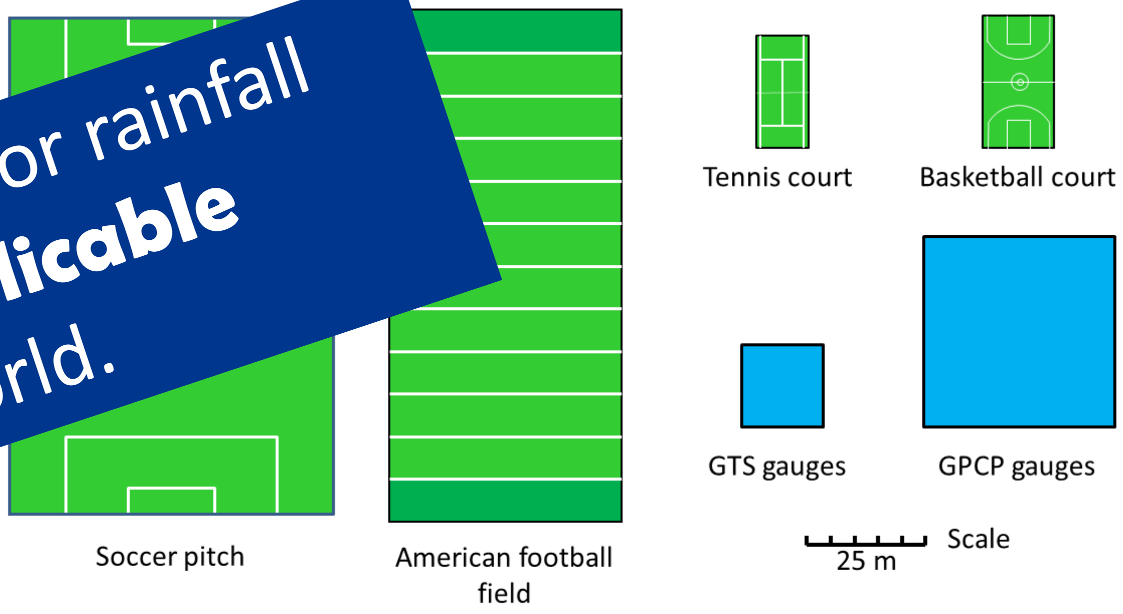
where *E* is in mm and *D* in h.

Introduction

Global precipitation climatology project rain gauge stations

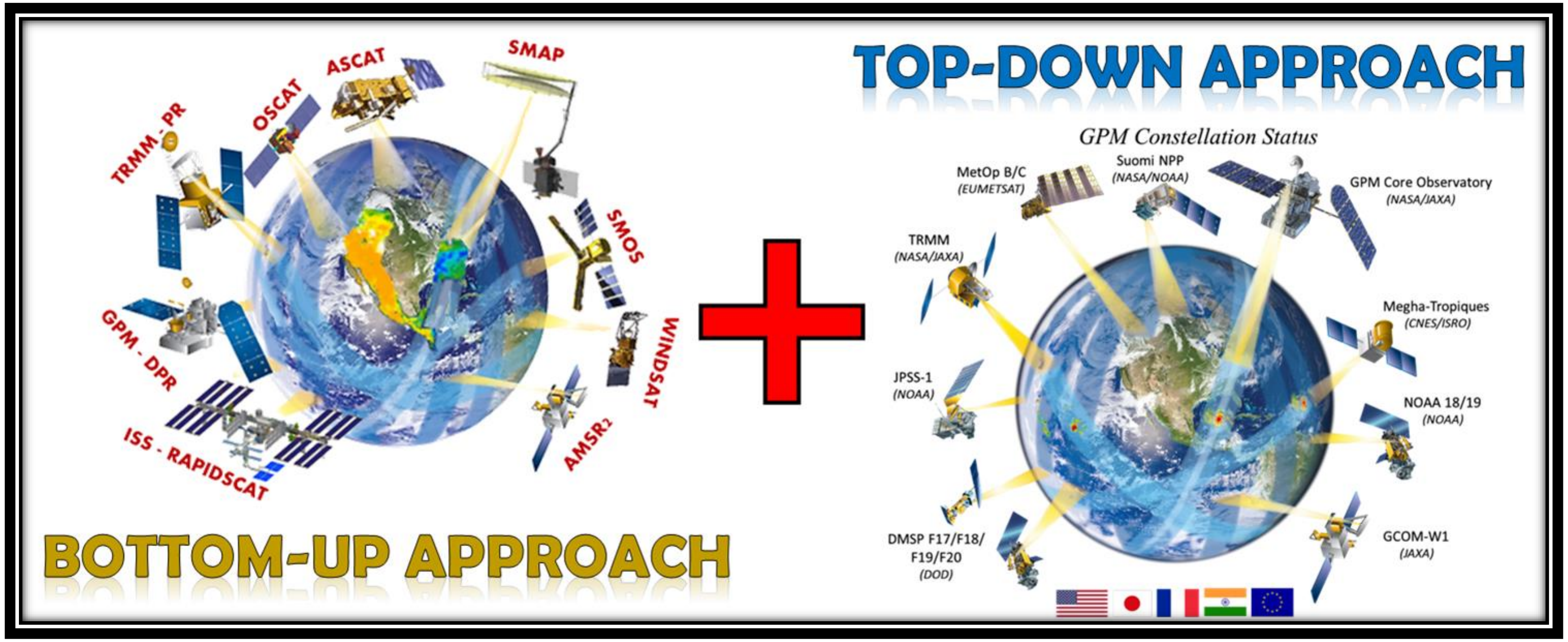


Equivalent areas of common sports pitches and courts compared with the total areas of orifices of all GTS and GPCC gauges (Kidd et al. 2015)



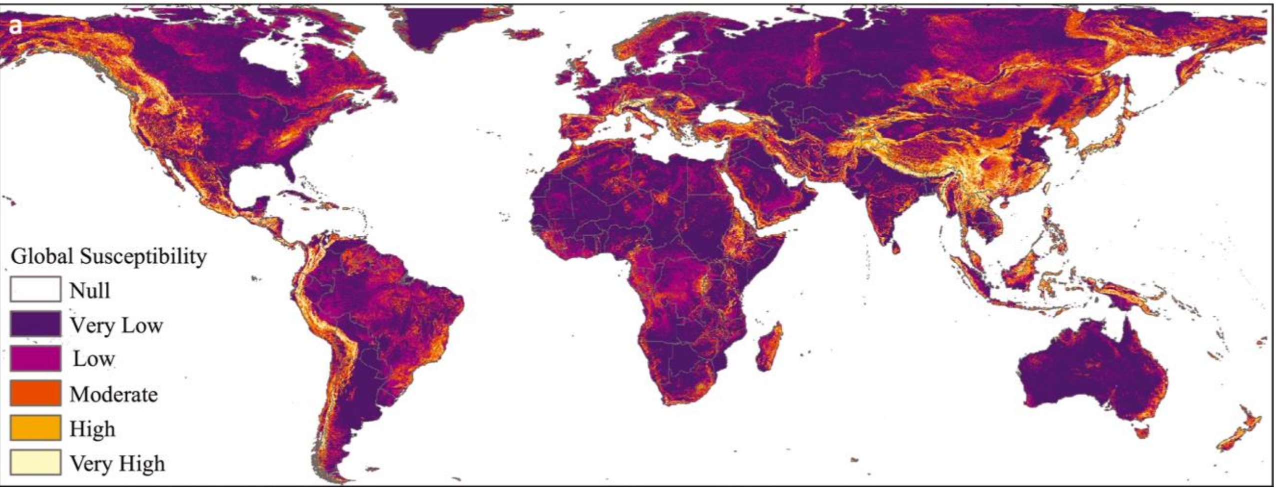
The use of rain gauges for rainfall monitoring **is not applicable** everywhere in the world.

Satellite-based rainfall products with global coverage and with adequate spatial-temporal resolution for landslide studies are now available.

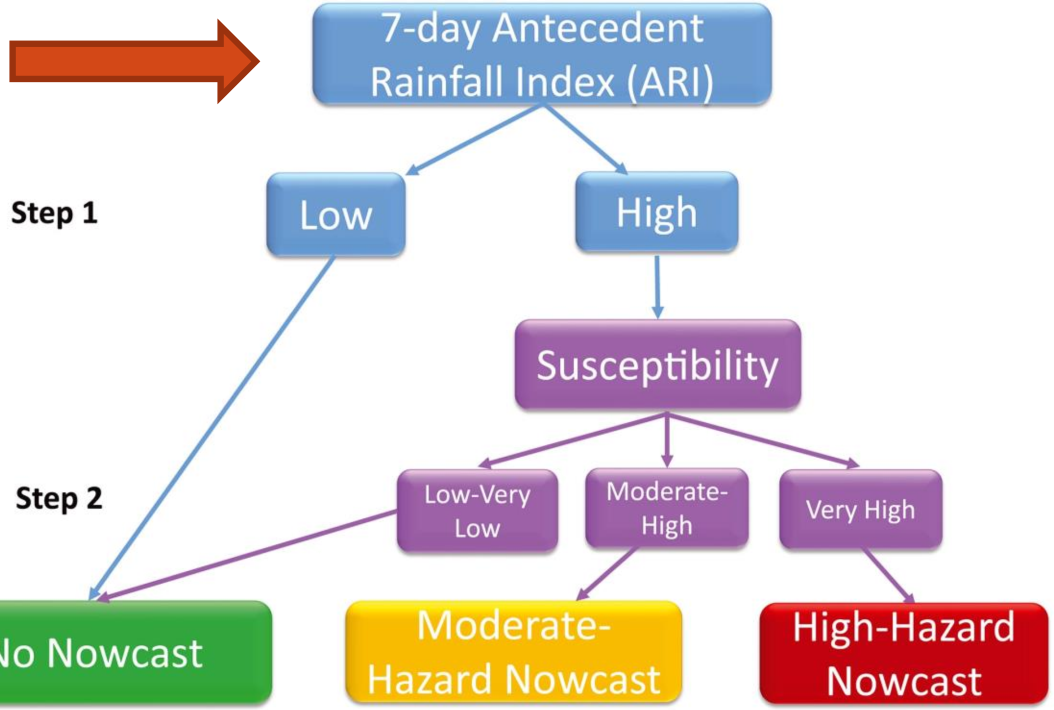


Global Landslide Hazard Assessment for Situational Awareness (Global LHASA)

Based on GPM Rainfall product



Stanley & Kirschbaum, 2017



Kirschbaum & Stanley, 2018

The question

Are there any other ways in which we can **use satellite rainfall products** in landslide forecasting?

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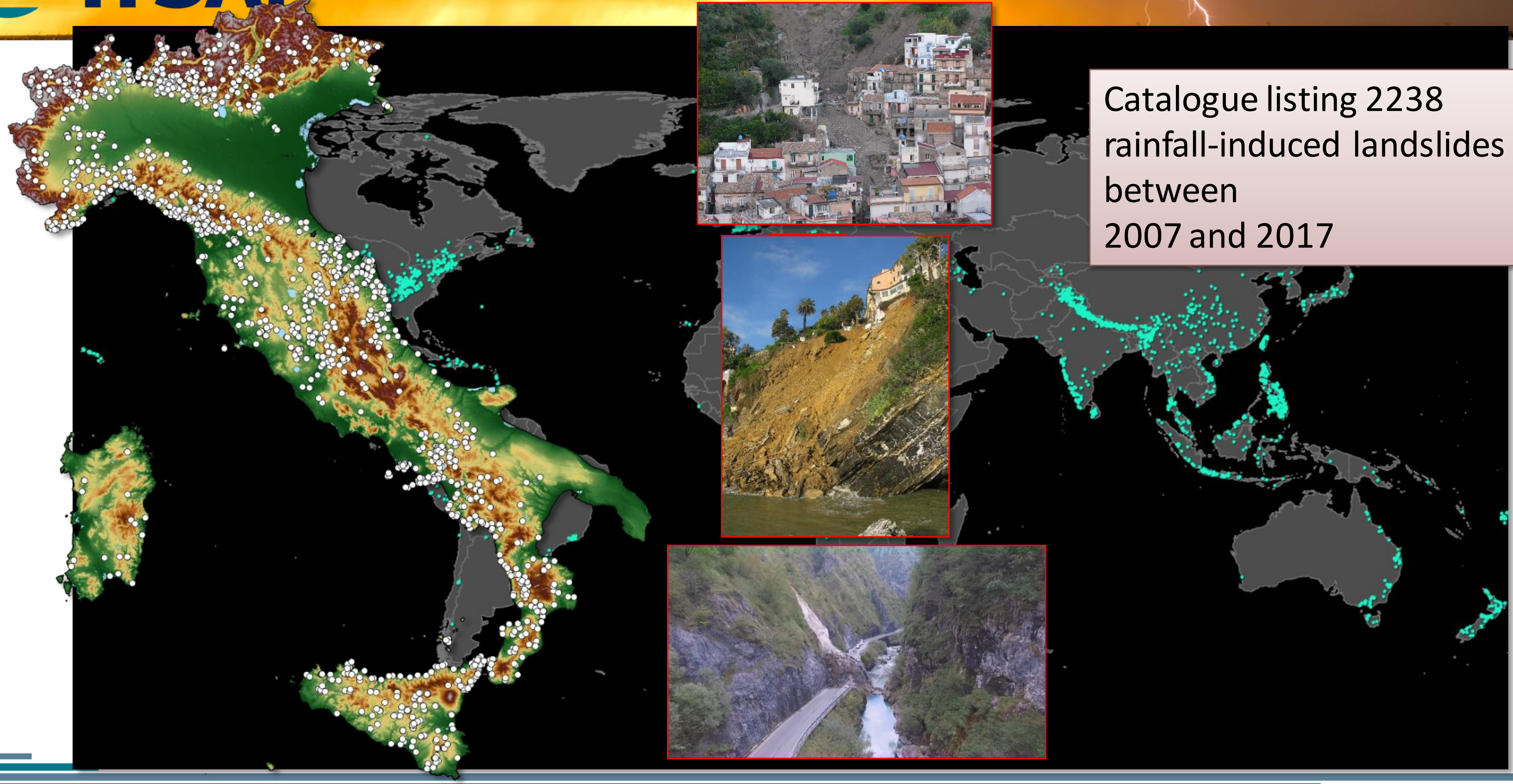
Case study: Italy

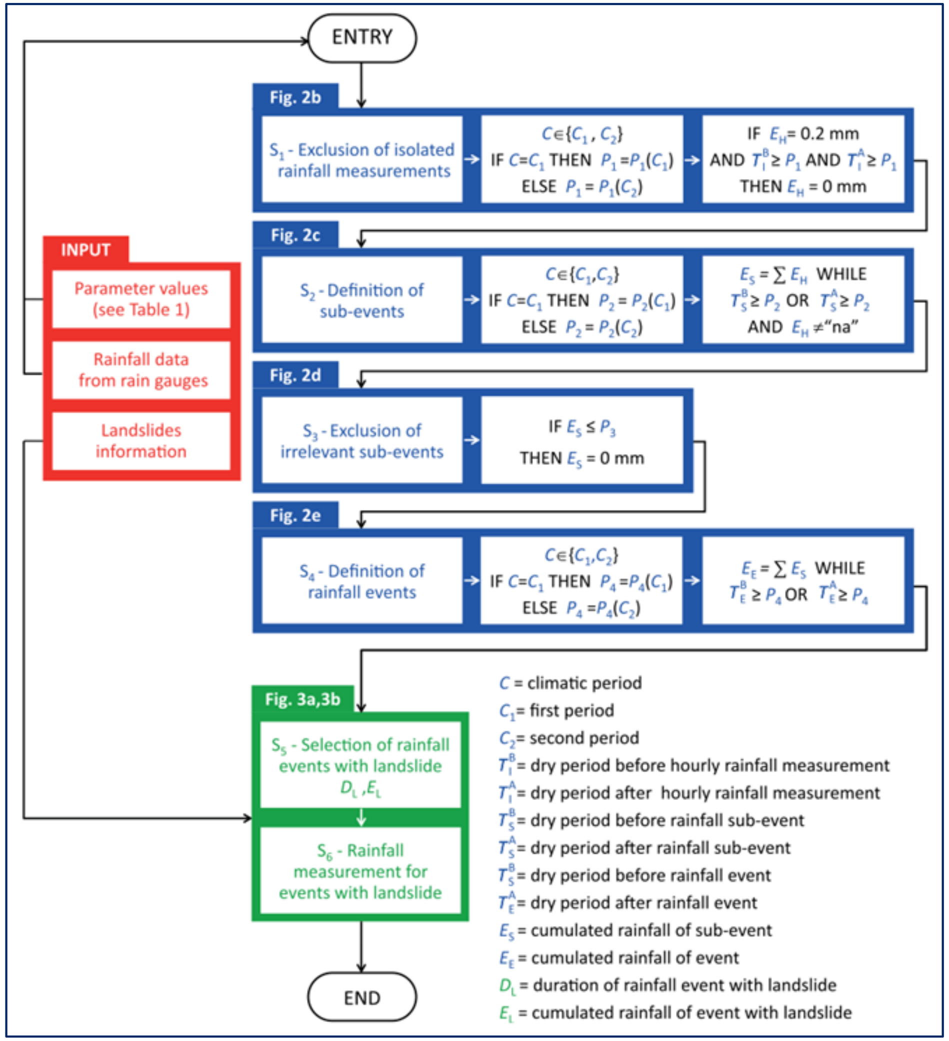


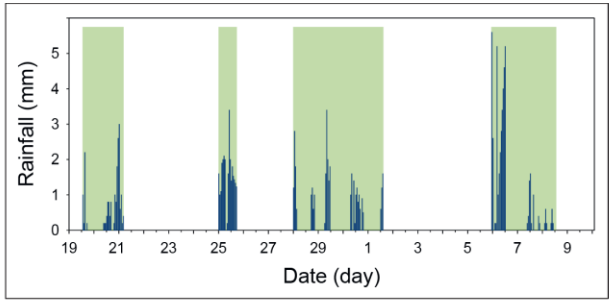
Catalogue listing 2238 rainfall-induced landslides between 2007 and 2017

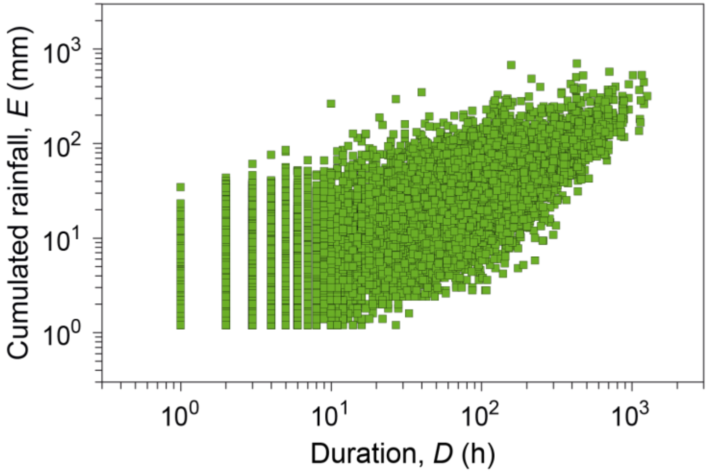
Data set	Approach	Grid (km)	Period (h)	Coverage	Time interval
SM2RASC	Bottom-Up	10	24	Global	2007-
3B42-RT	Top-Down	10	3	± 50°	1997-
GPM	Top-Down	10	1	Global	2014-
MERGED	Mixed	10	1	Global	2007-

Rainfall events

Methodology







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Melillo et al. (2015)

Methodology

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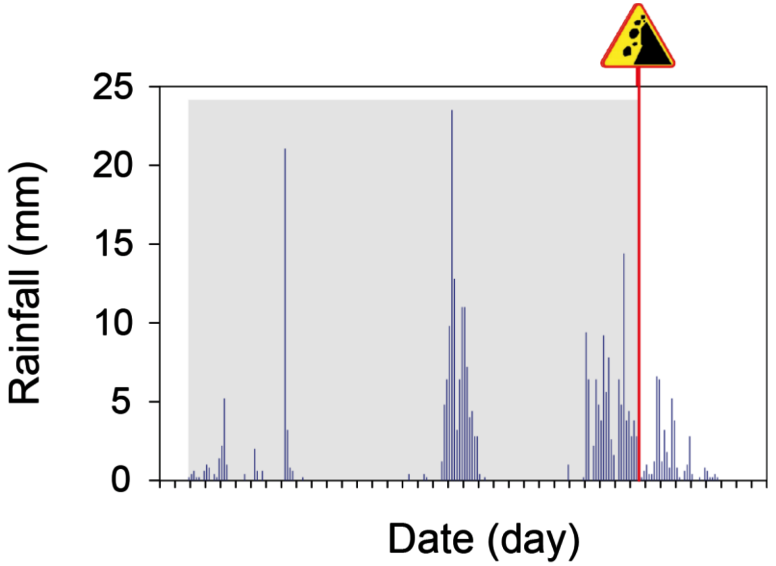
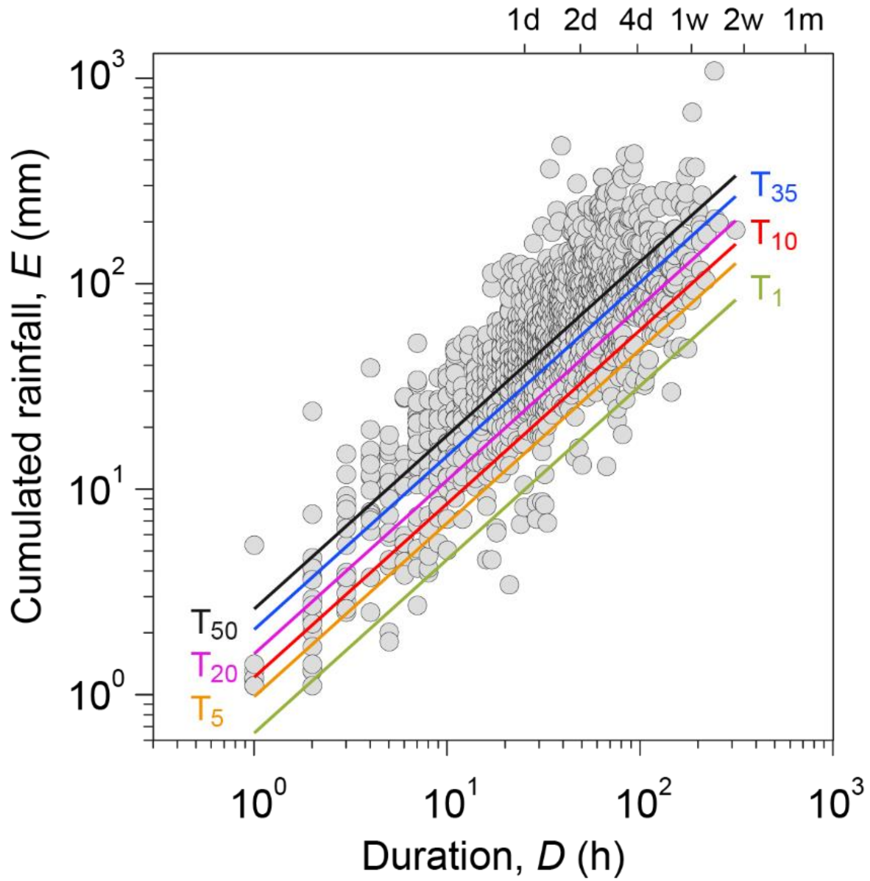
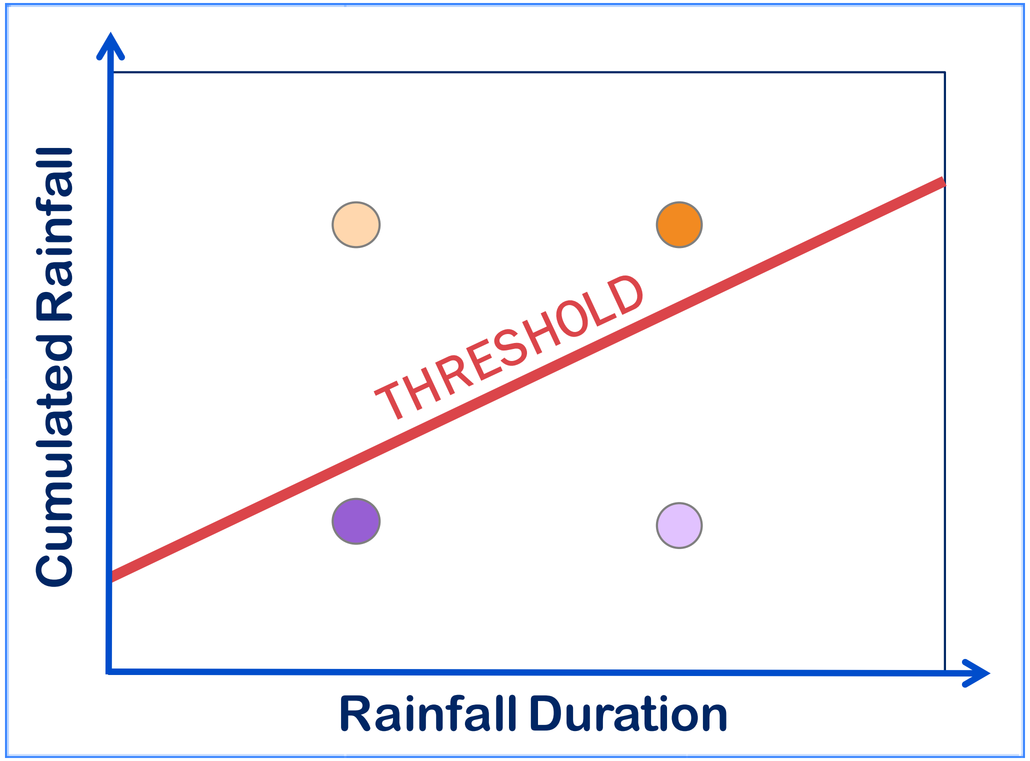




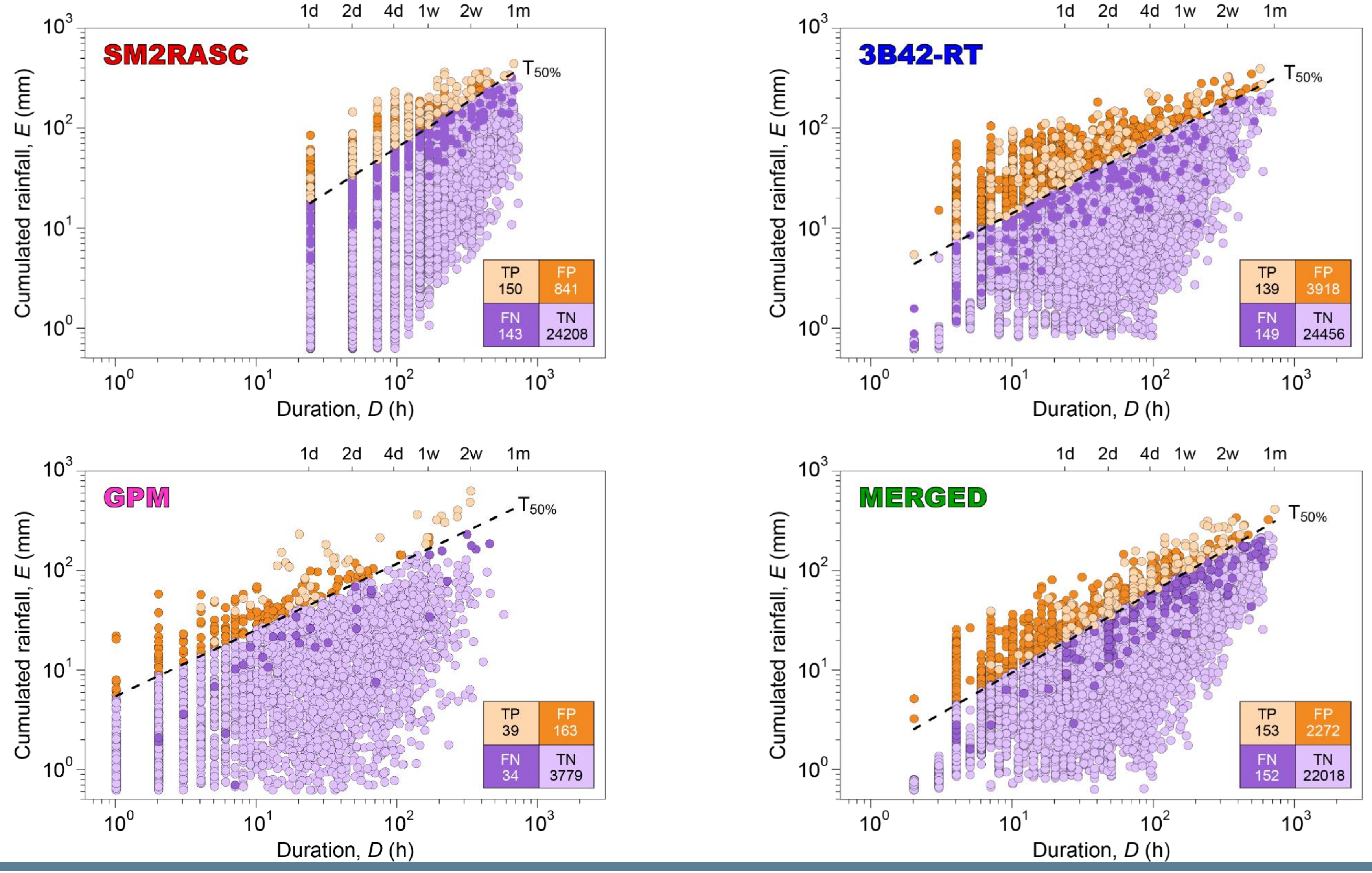
Brunetti et al. (2010)

Methodology

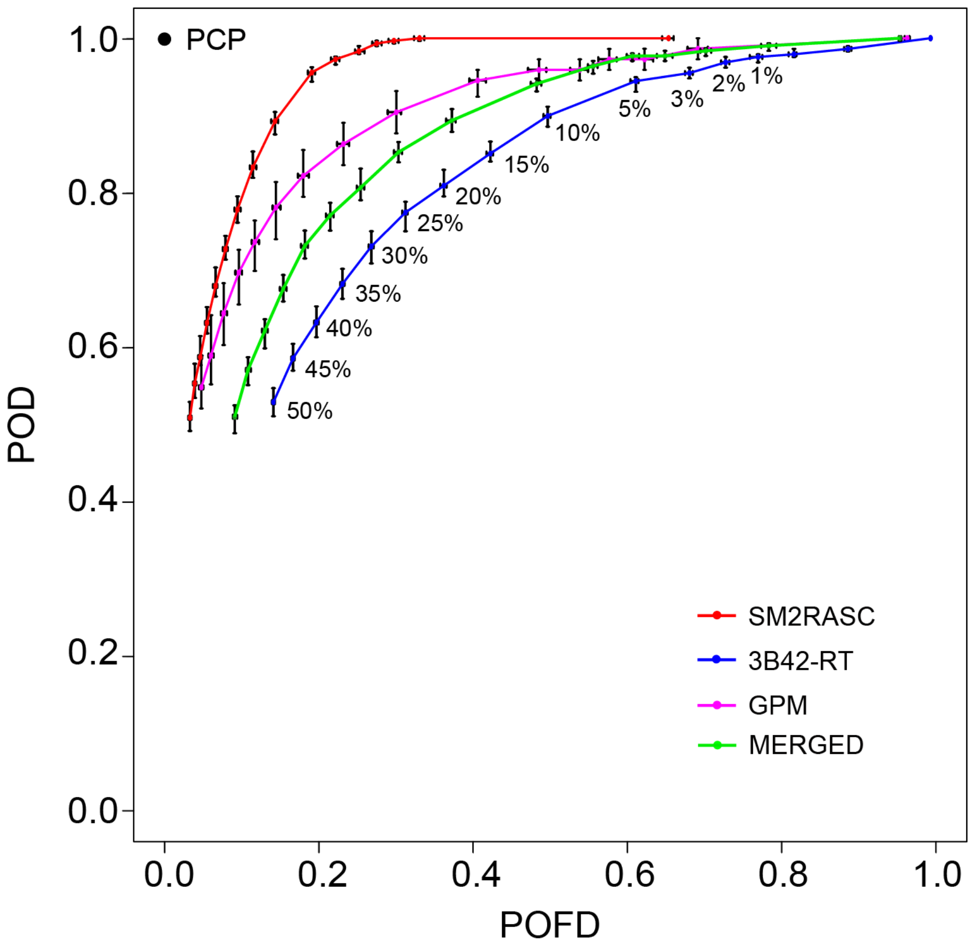


PREDICTED AND REPORTED (TP)	PREDICTED BUT NOT REPORTED (FP)
NOT PREDICTED BUT REPORTED (FN)	NOT PREDICTED AND NOT REPORTED (TN)

Results


SM2RASC
TP 150
FP 841
FN 143
TN 24208
3B42-RT
TP 139
FP 3918
FN 149
TN 24456
GPM
TP 39
FP 163
FN 34
TN 3779
MERGED
TP 153
FP 2272
FN 152
TN 22018
T50%
1d 2d 4d 1w 2w 1m
Cumulated rainfall, E (mm)
Duration, D (h)

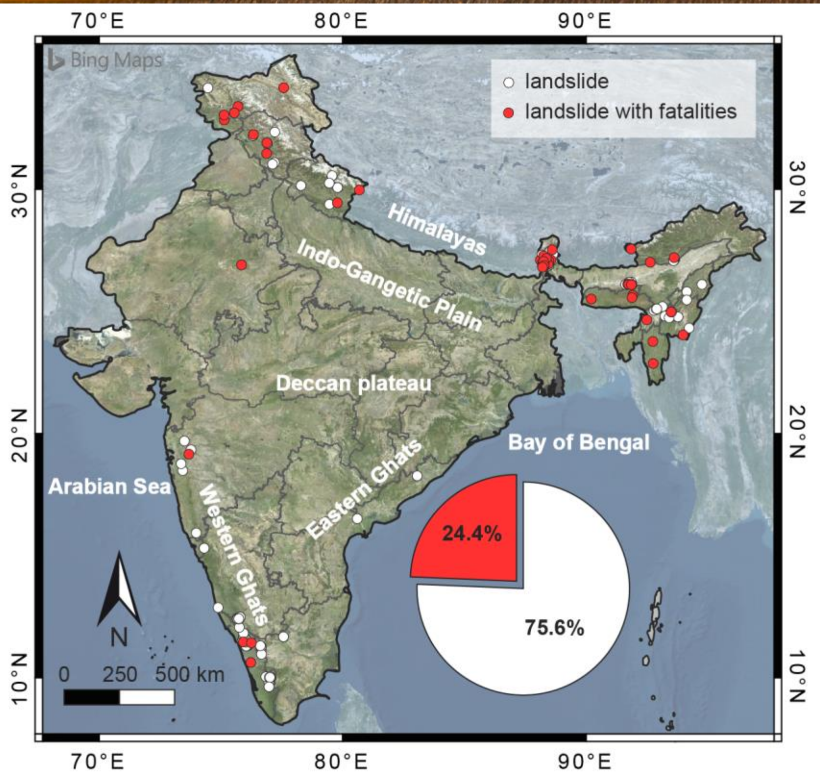
Results



SM2RASC gives the best performance.

GPM is performing better than **MERGED**, while **3B42-RT** is the worst.

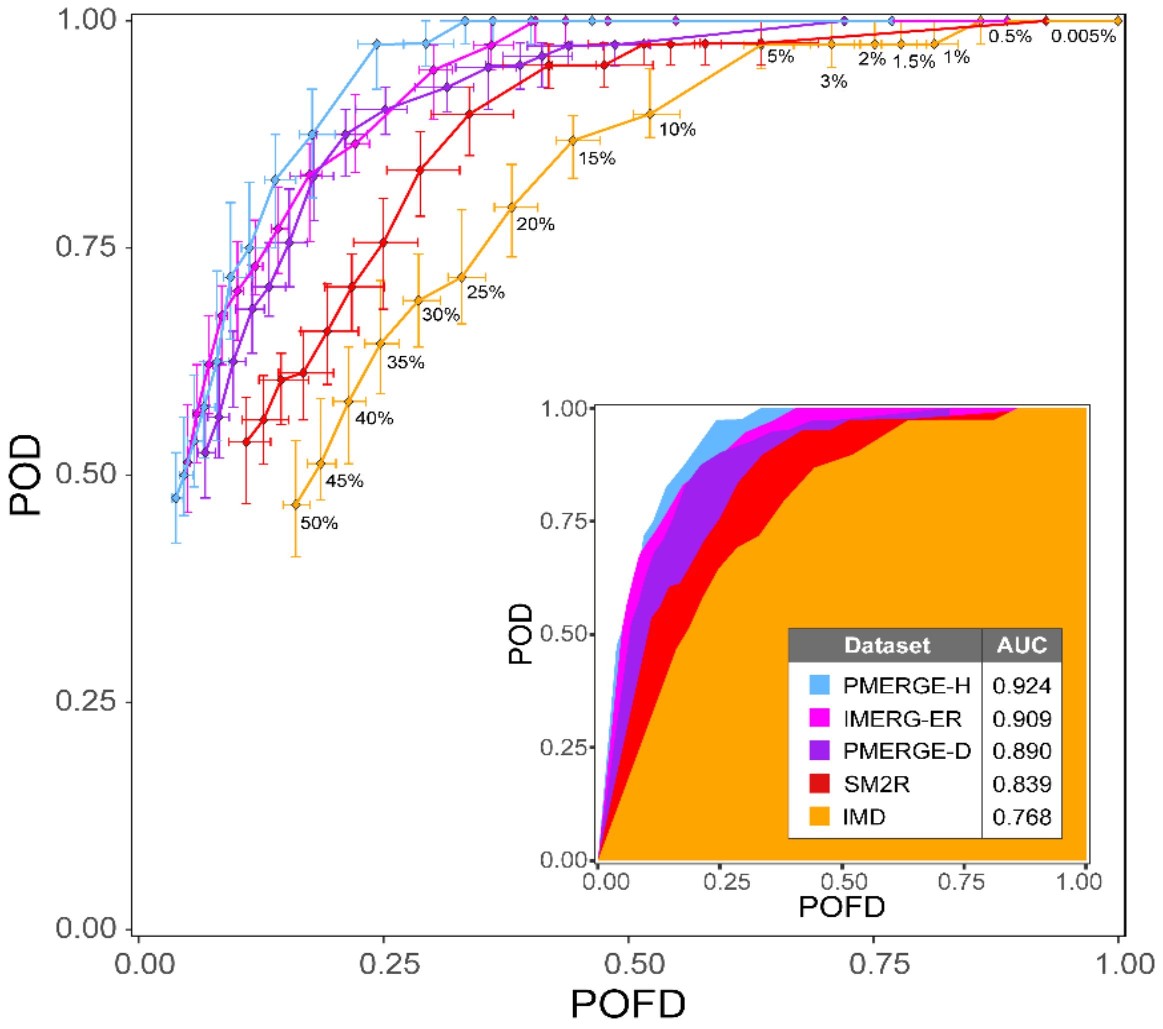
Case study: India



We compiled a catalogue of **197** rainfall-induced landslides occurred in India in the 13-year period between **April 2007 and October 2019**

Dataset	Approach	Spatial Resolution	Temporal Resolution	Coverage	Time interval
IMD	Ground	0.25°	Daily	India	2007-2019
GPM-ER	Top-Down	0.10°	30 min	Global	2000-
SM2RASC	Bottom-Up	12.5 km	Daily	Global	2007-
Merged	Mixed	0.10°	1-hour	Global	2007-

Results



The satellite products provided **better performance wrt ground data**, confirming the added value of using satellite rainfall products for landslide forecasting.

High resolution application in Italy

Soil Moisture from Fusion of Scatterometer and SAR: Closing the Scale Gap with Temporal Filtering

Bernhard Bauer-Marschallinger*,1, Christoph Paulik1, Simon Hochstöger1, Thomas Mistelbauer2, Sara Modanesi3, Luca Ciabatta3, Christian Massari3, Luca Brocca3, Wolfgang Wagner1

1 TU Wien, Department of Geodesy and Geoinformation Research Group Remote Sensing; remote.sensing@geo.tuwien.ac.at
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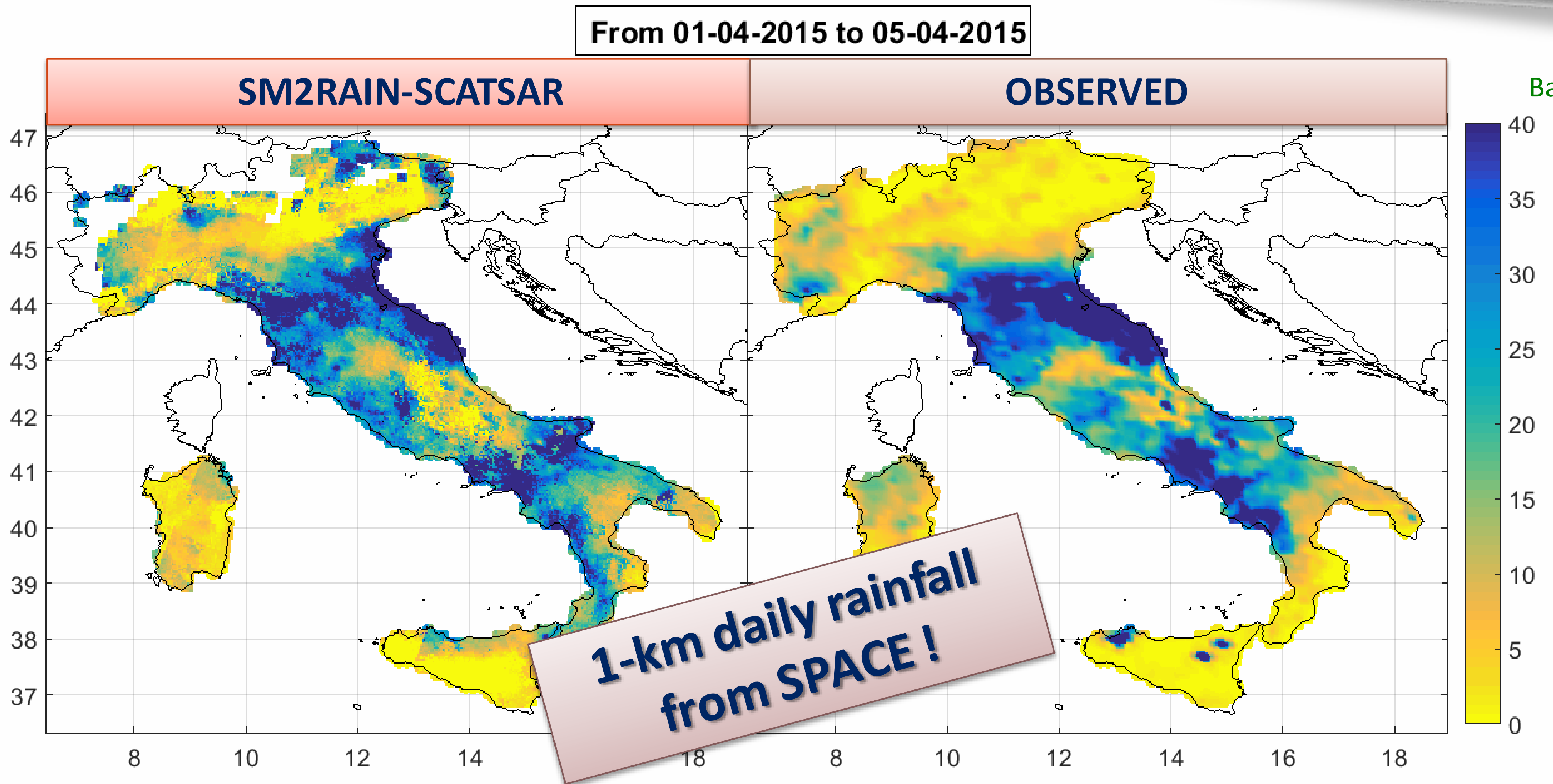
3 National Research Council (NRC), Research Institute for Geo-Hydrological Protection (IRPI); direzione@irpi.cnr.it

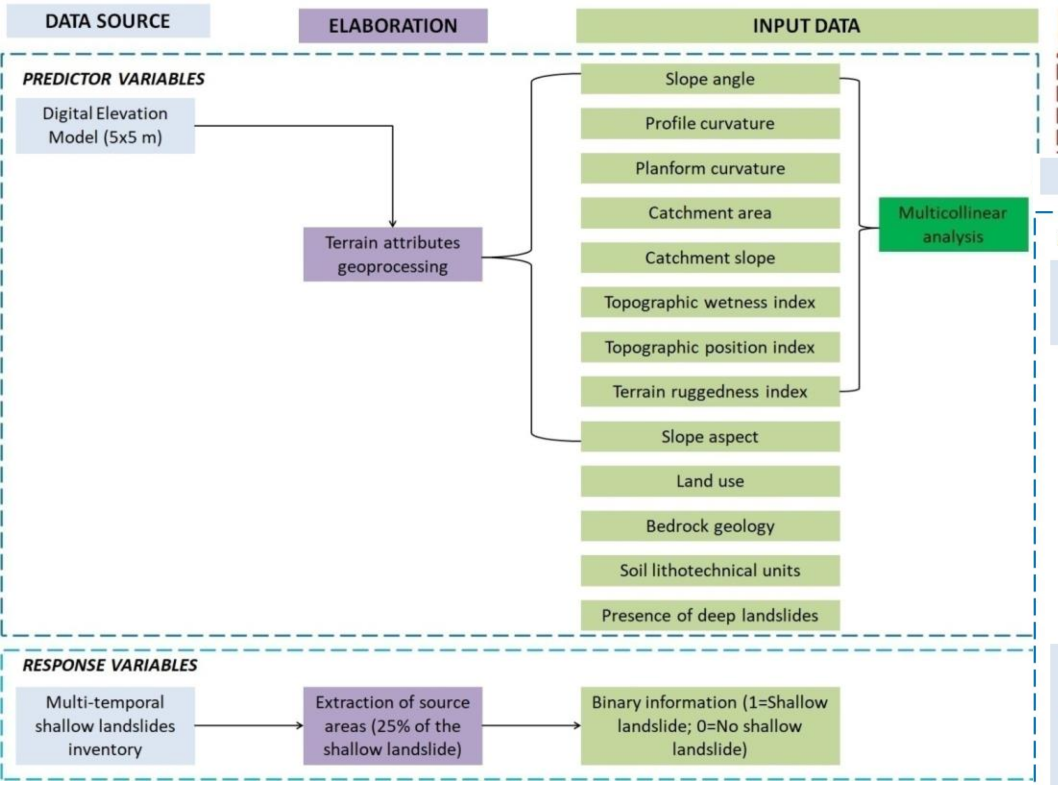
Integration of Sentinel-1 and ASCAT: SCATSAR

Animation (3 months) of 5-day accumulated precipitation



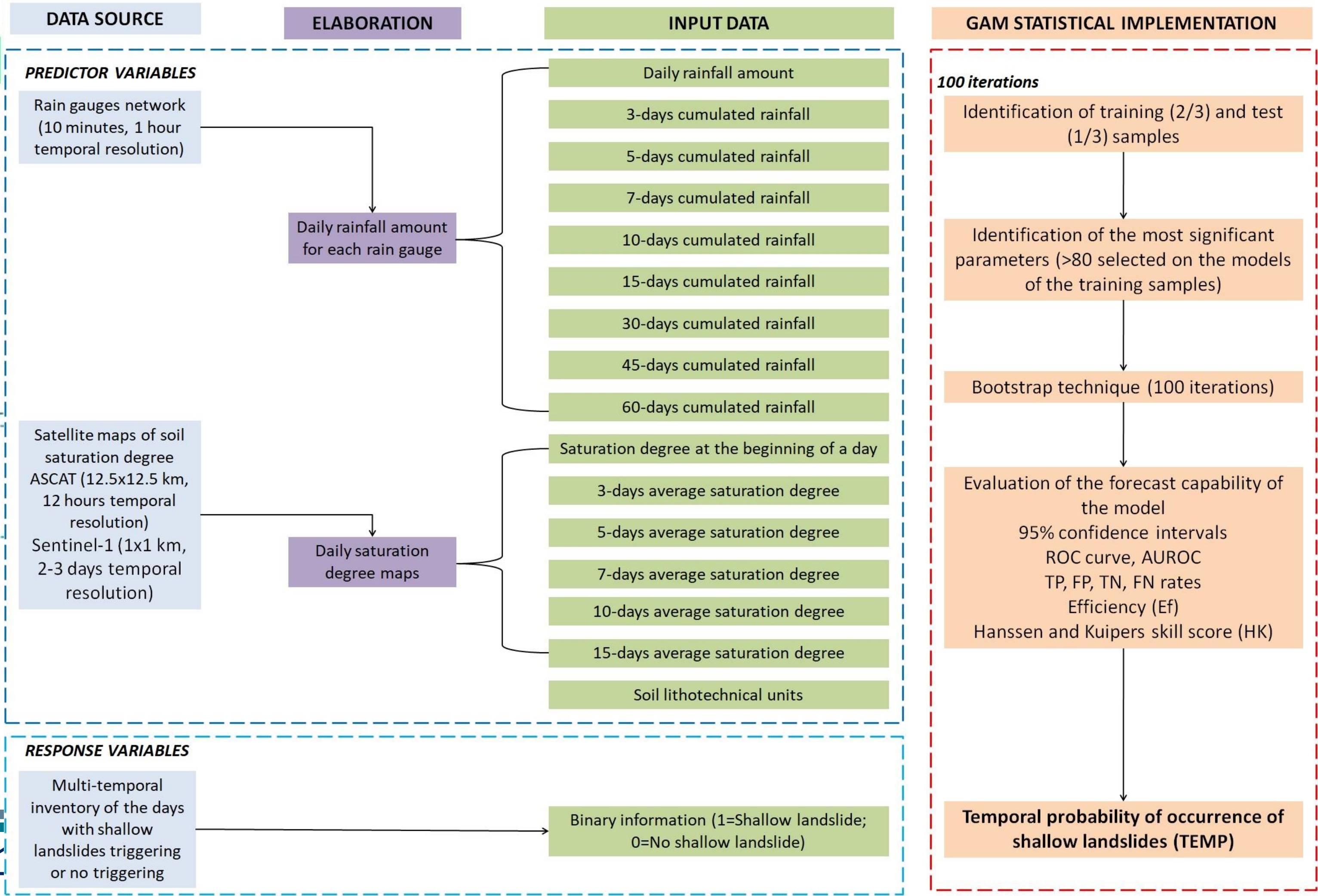
Bauer-Marschallinger, B. et al (2018) Remote Sensing 10(7), 1030

High resolution application in Italy



Static parameters

Dynamic parameters



ANDROMEDA Project - Funded by Cariplo Fondation

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High resolution application in Italy

ANDROMEDA

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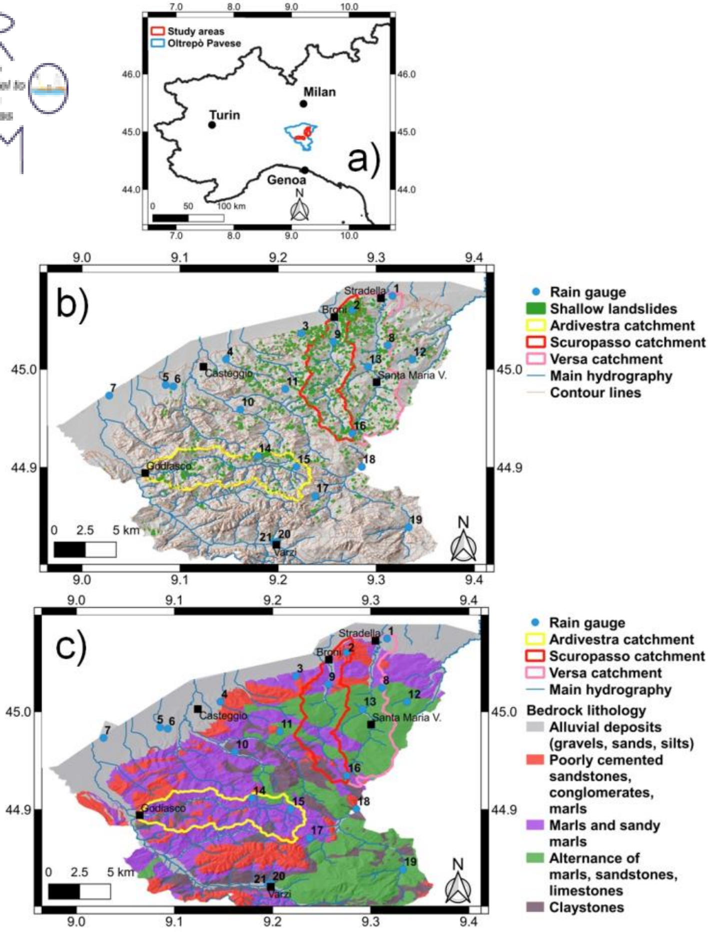
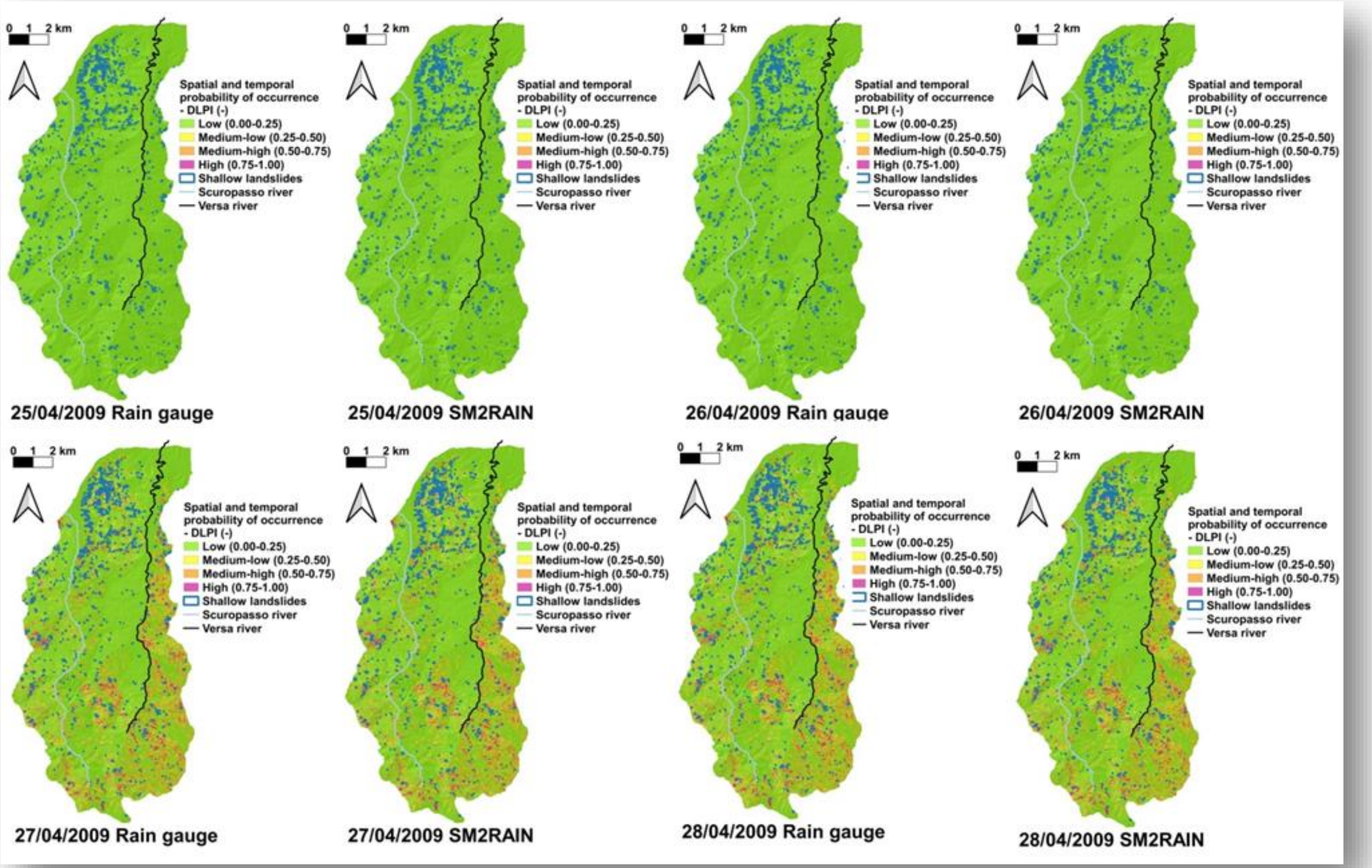
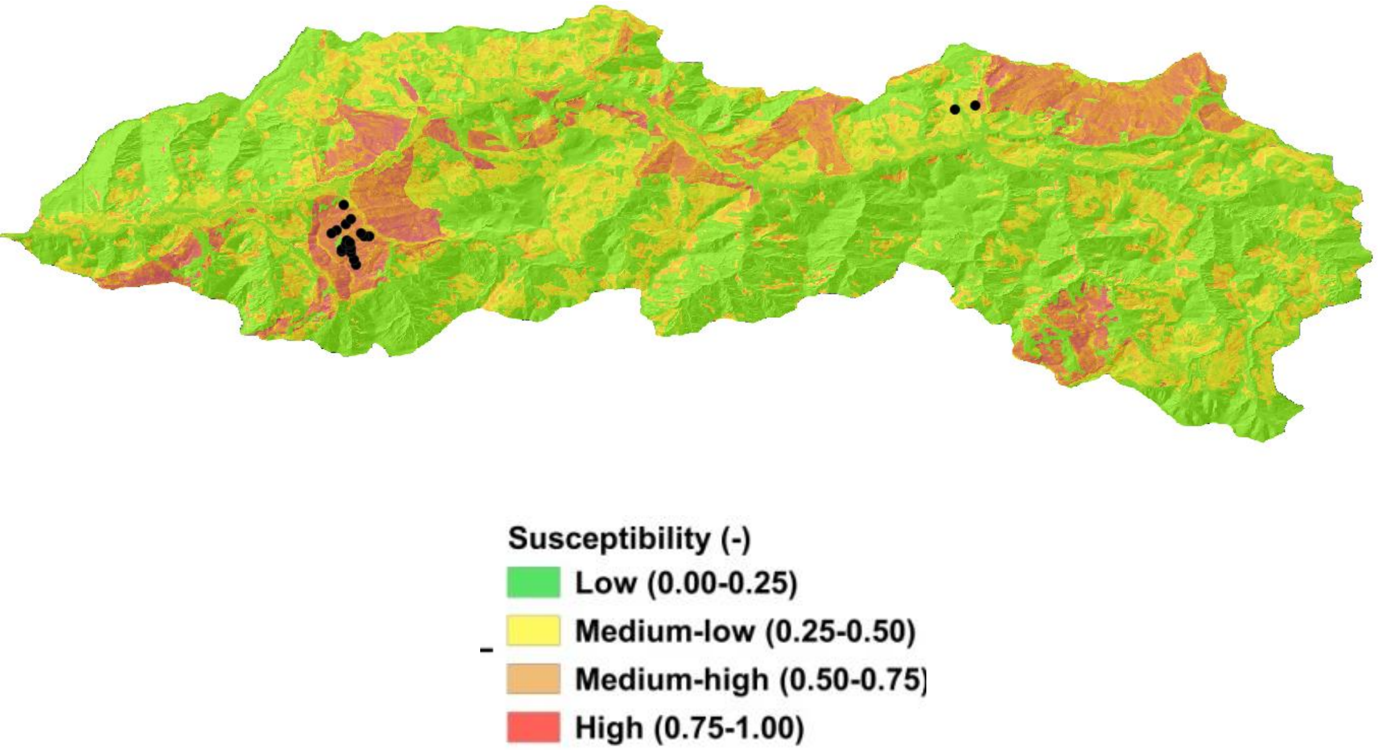




Vivaldi et al. (2020, doi:10.5194/egusphere-egu2020-22240)

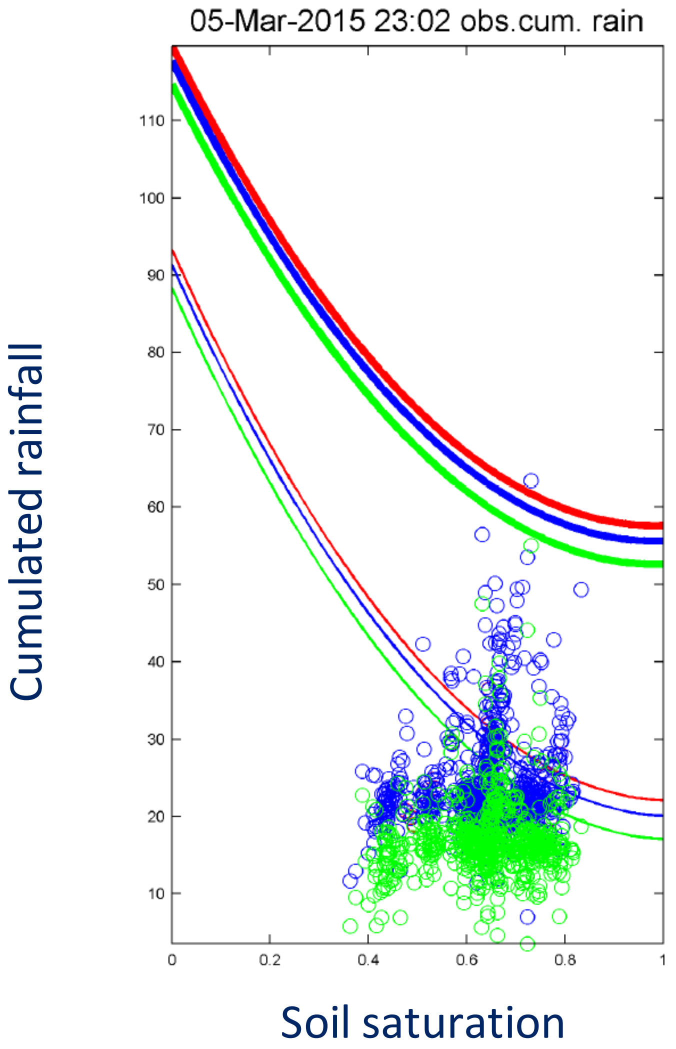
November 2019 rainfall events validation

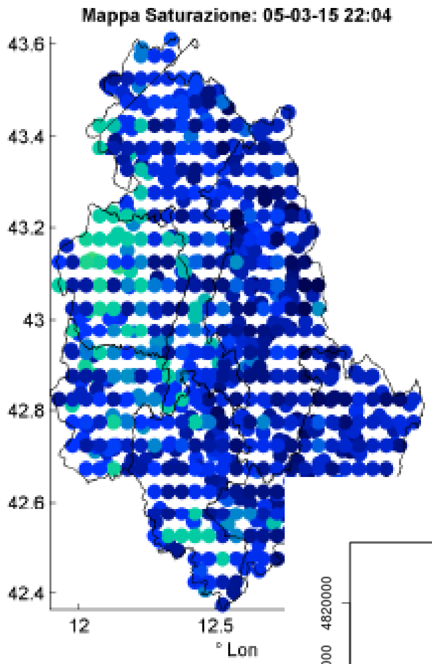


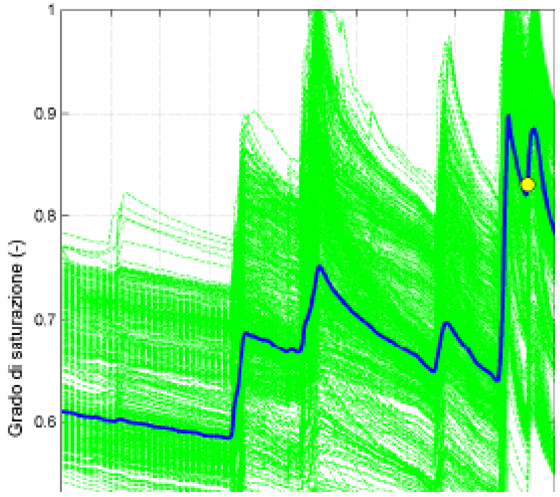
All the landslide events (black dots) in Ardivestra basin fall within **high and medium high susceptibility areas**, confirming the skill of the proposed methodology in landslide risk assessment at **high spatial resolution**

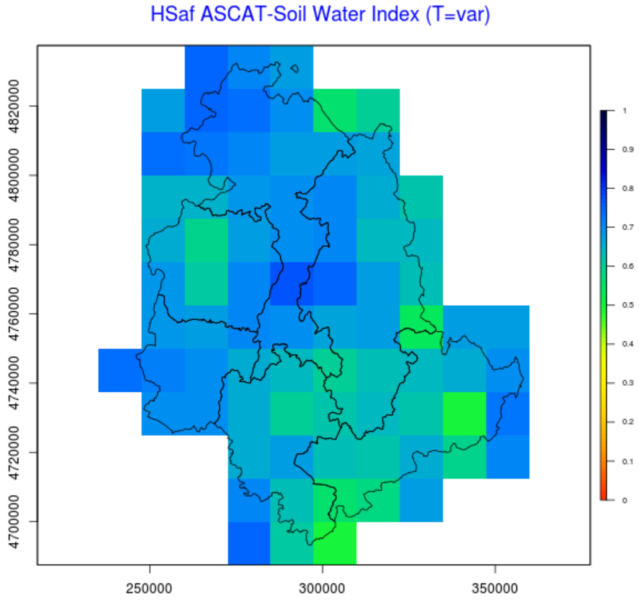
The experience in Umbria

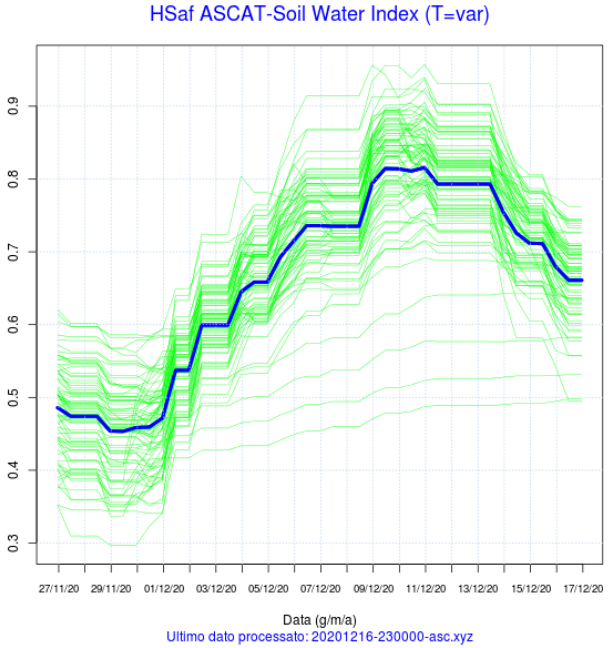
Ponziani et al. (2012)





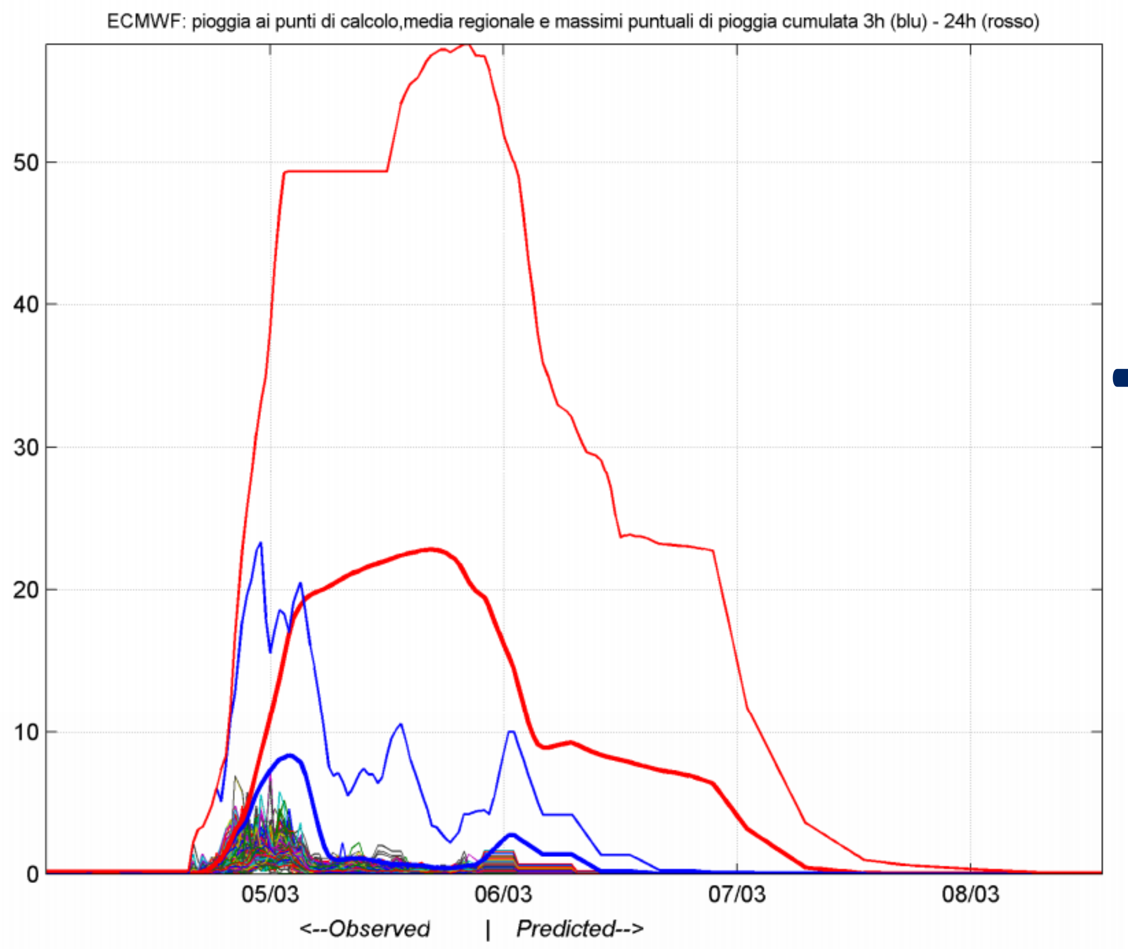






The experience in Umbria

Meteorological forecast



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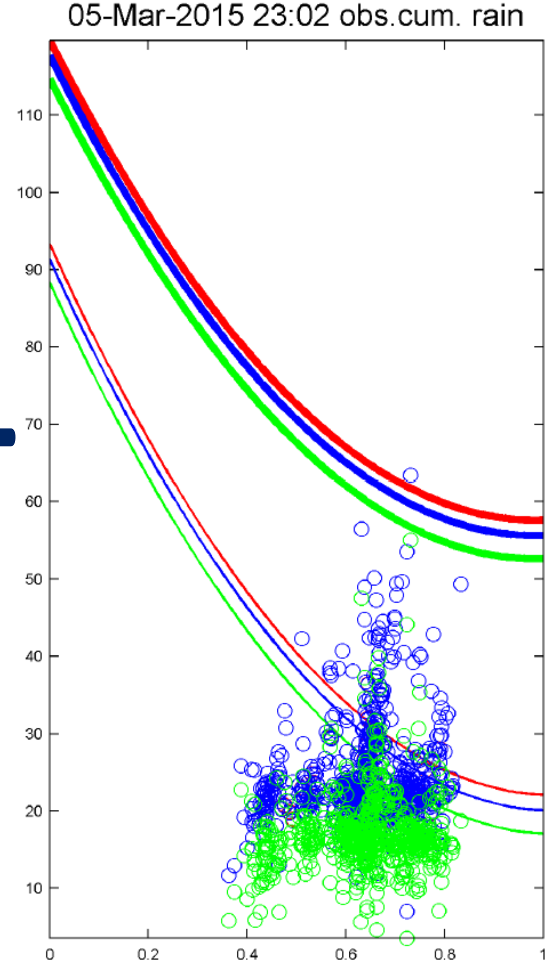

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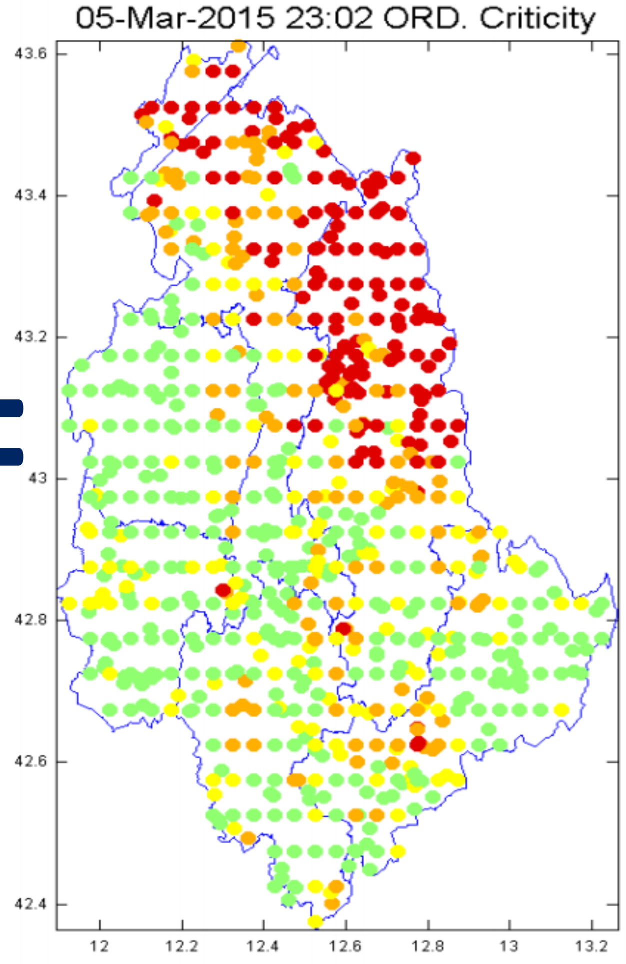
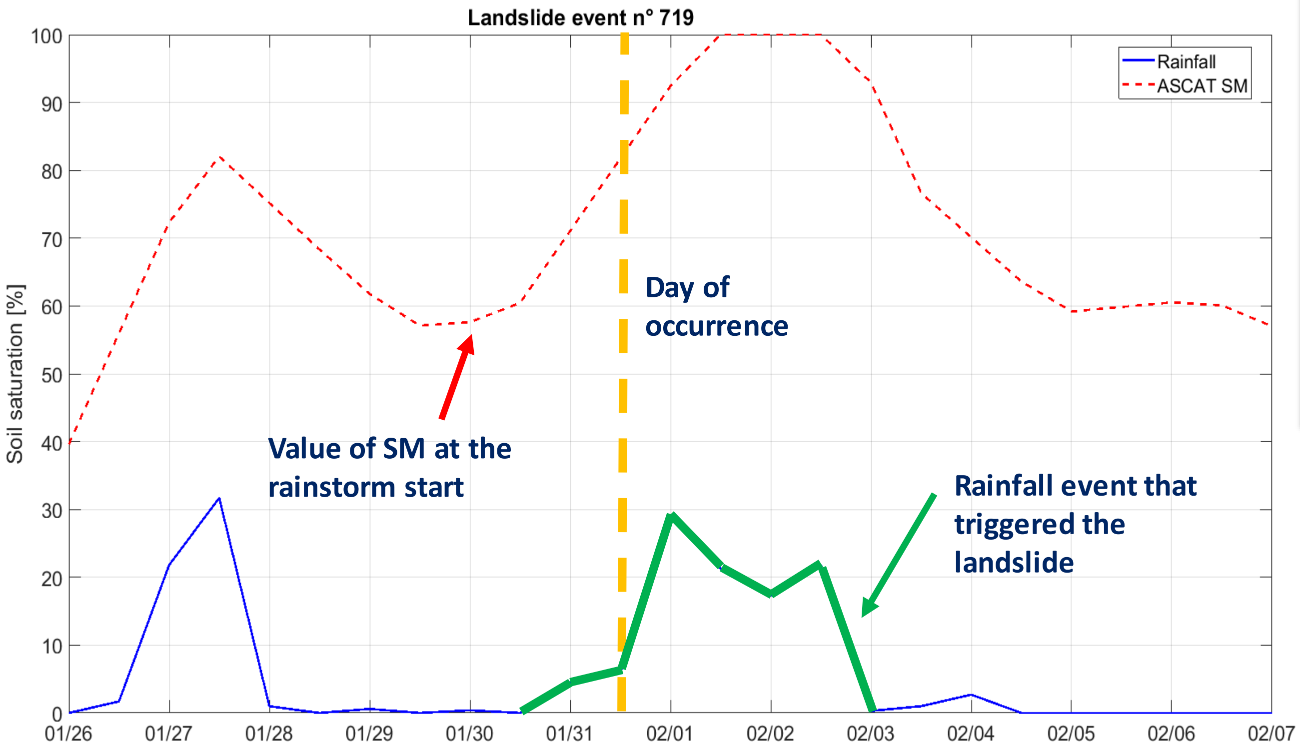
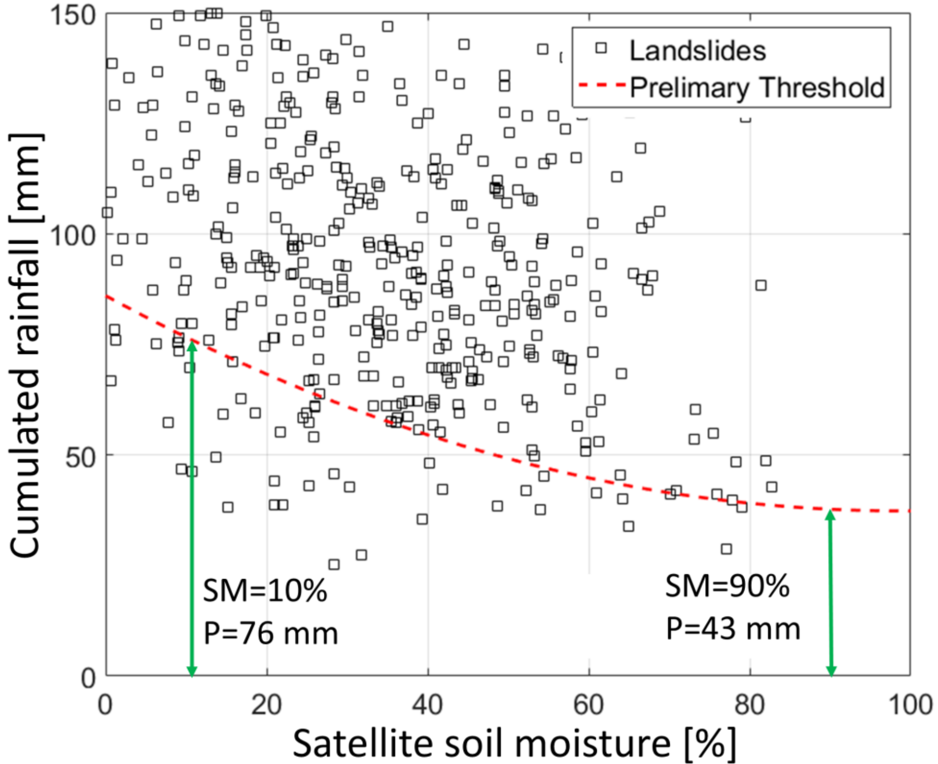


Landslides guidance

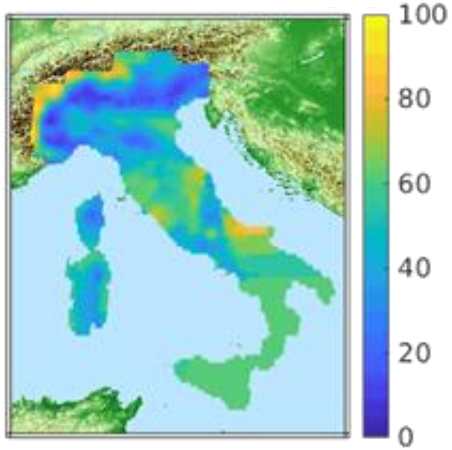
- 1184 landslide events between 2007 and 2014 over Italy
- ASCAT SM data 12.5 km/daily spatial/temporal resolution
- Observed rainfall from the Italian monitoring network





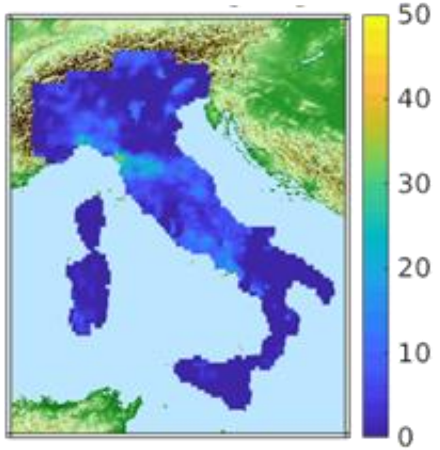
Landslide guidance

Relative soil moisture



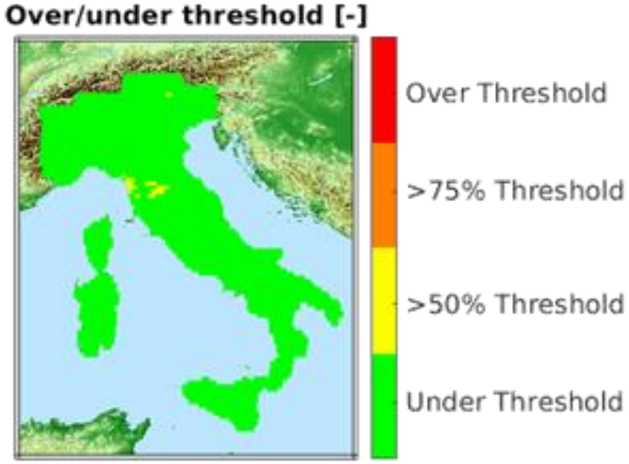
How much water is in the soil?

GPM+SM2RAIN daily rainfall

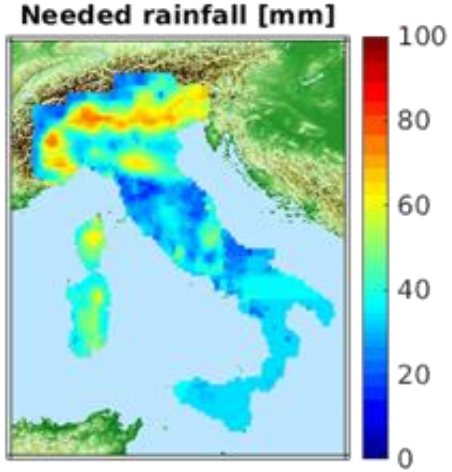


How much does it rain?

Landslide Alert map



1-day Landslide Guidance



How much rainfall is needed for the occurrence of landslide?

Conclusion

- Satellite rainfall products considered here are able to **satisfactorily predict landslide** occurrence in Italy and India through the use of different methodologies;
- Both the **top-down** and **bottom-up** approaches are found to provide good performance;
- The obtained results will have a more important use in scarcely gauged regions (e.g., developing countries);
- The combined use of satellite **soil moisture** and **rainfall** data for landslide guidance analysis show promising results

Thank you for your attention

For further information just contact us:
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References

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