

EARLY WARNING SYSTEMS FOR RAINFALL-INDUCED LANDSLIDES. NEED FOR AN INTERNATIONAL FORUM? | NVE | OSLO | 26-28 OCTOBER 2016

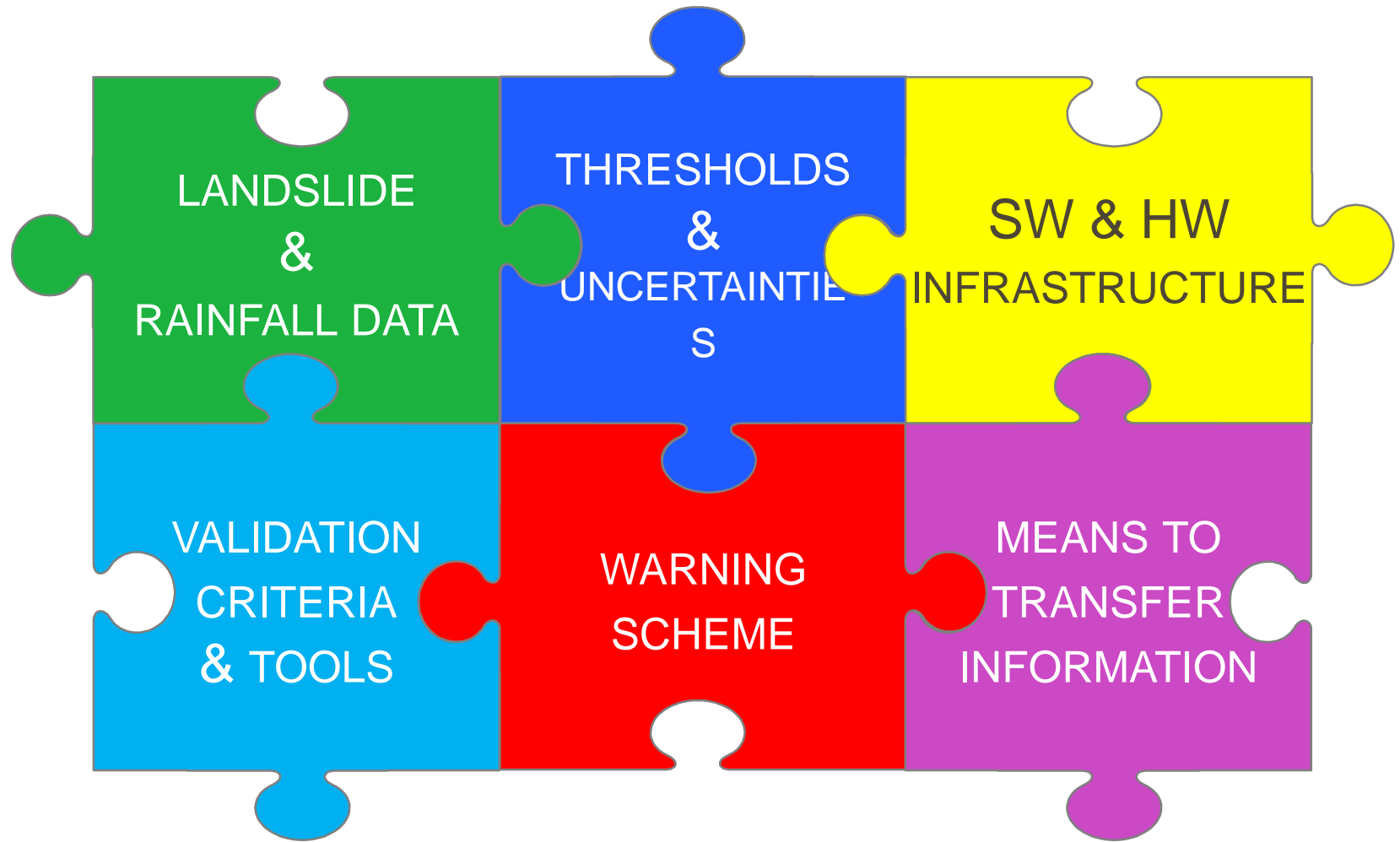
TOWARDS AN OPERATIONAL EARLY WARNING SYSTEM FOR RAINFALL-INDUCED LANDSLIDES IN ITALY

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OPERATIONAL LANDSLIDE FORECASTING

- **Predicting where** and **when** landslides will occur
- **Delivering** the forecast **in time** to relevant end **users**

OPERATIONAL LANDSLIDE FORECASTING



OPERATIONAL LANDSLIDE FORECASTING



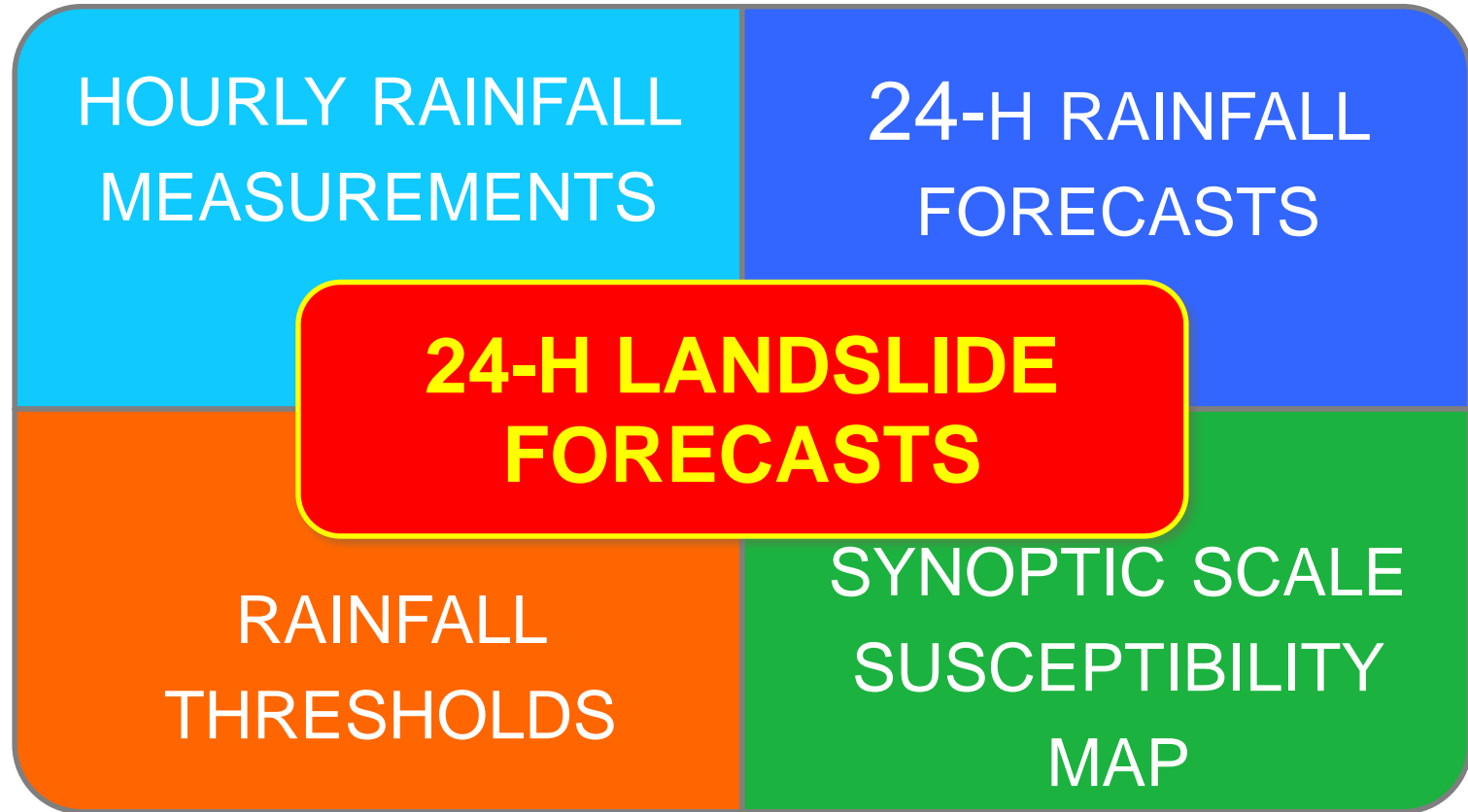
BE ROBUST

a chain has the strength of its weakest element

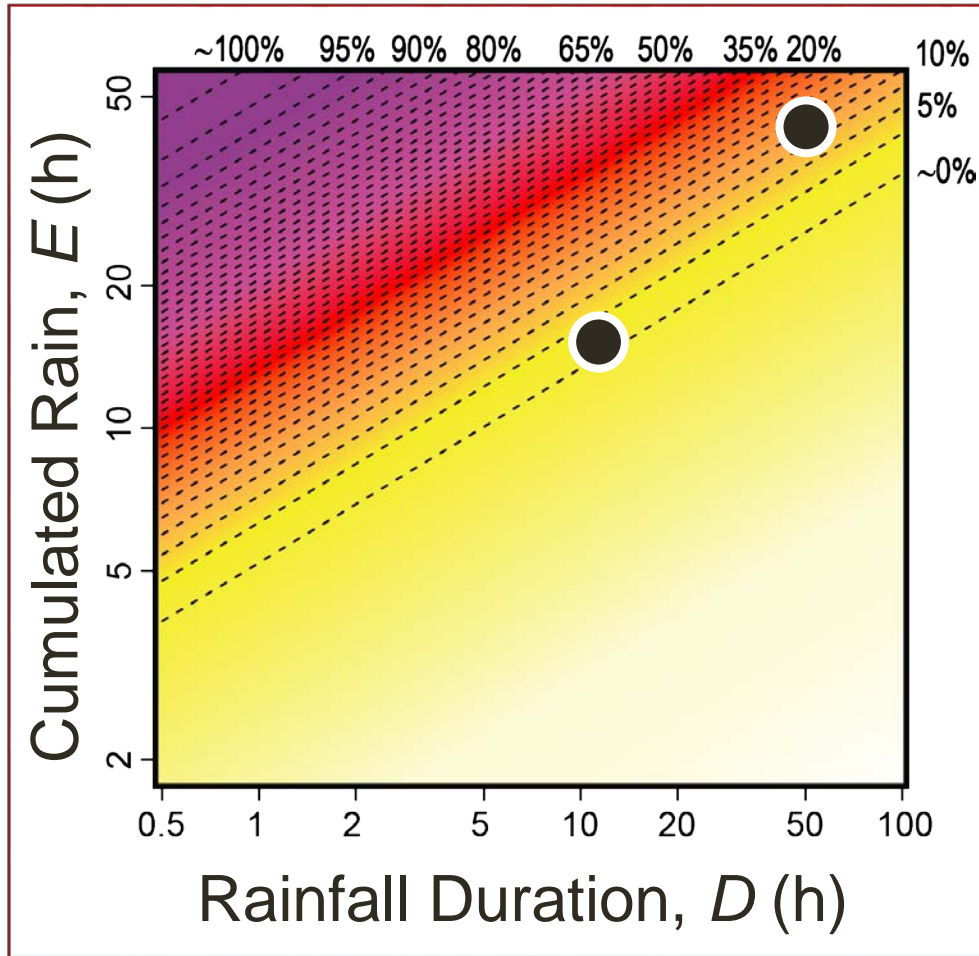
RELY ON SOUND SCIENCE

to be credible to the users

NATIONAL LANDSLIDE WARNING SYSTEM

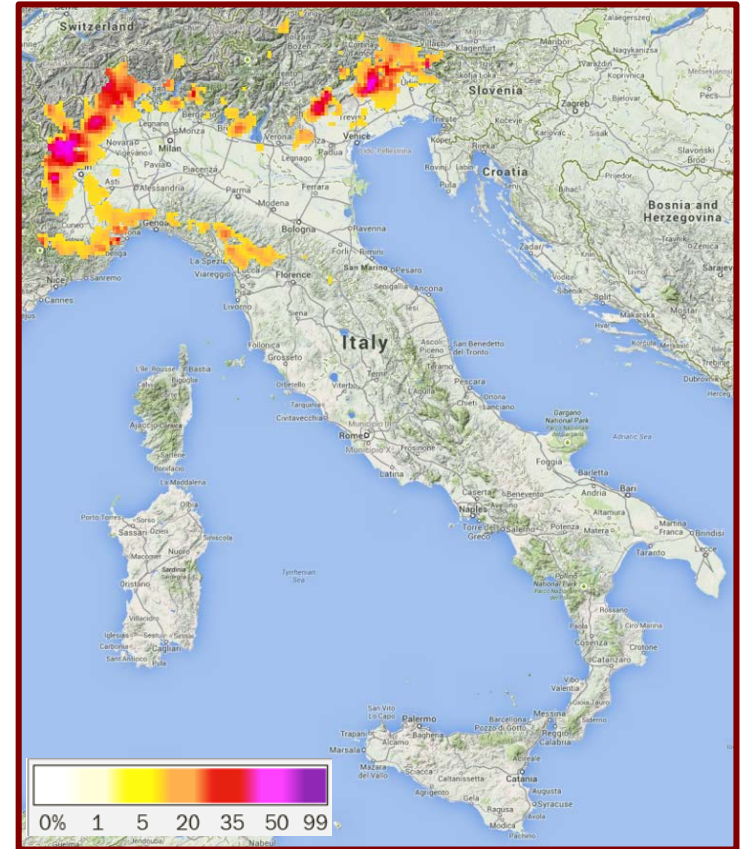
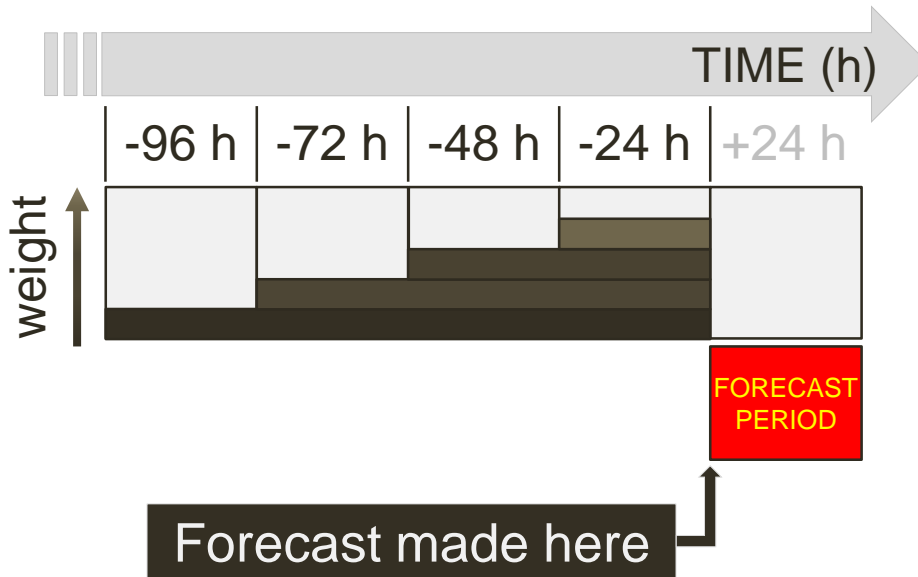


FORECASTING SCHEME



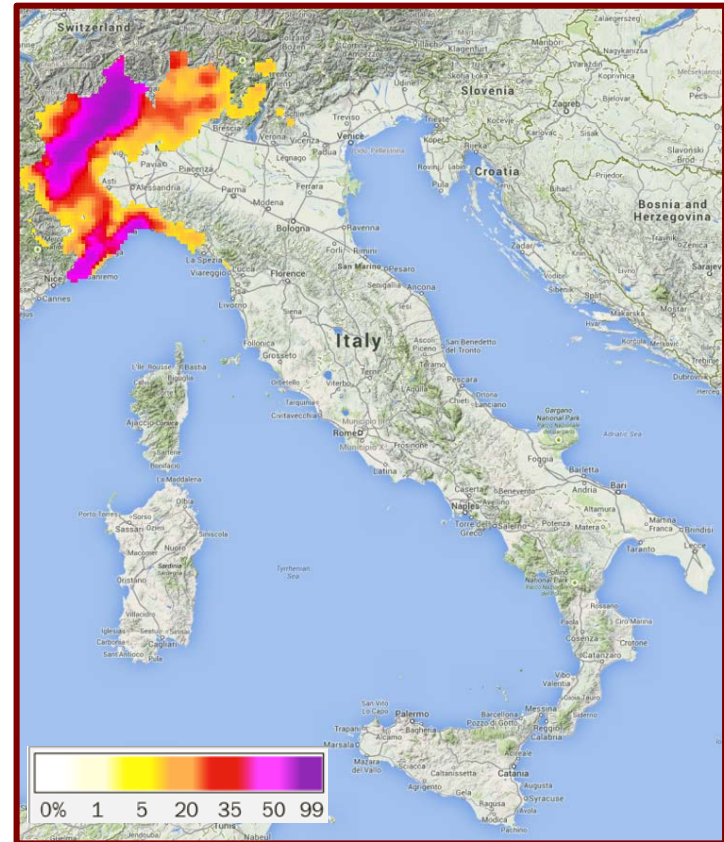
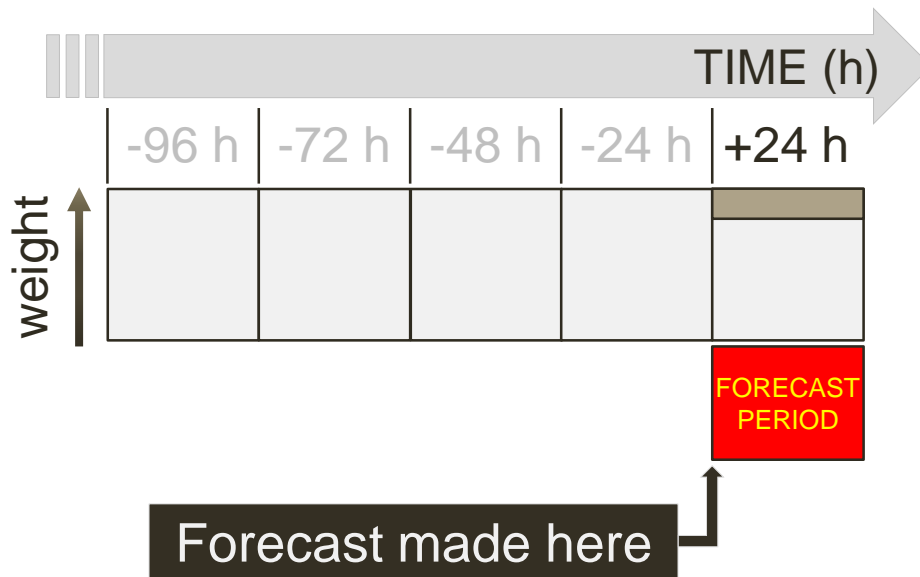
Non-
exceedance
probability of
landslide
occurrence
given ED
rainfall
conditions

FORECAST WITH MEASURED RAIN



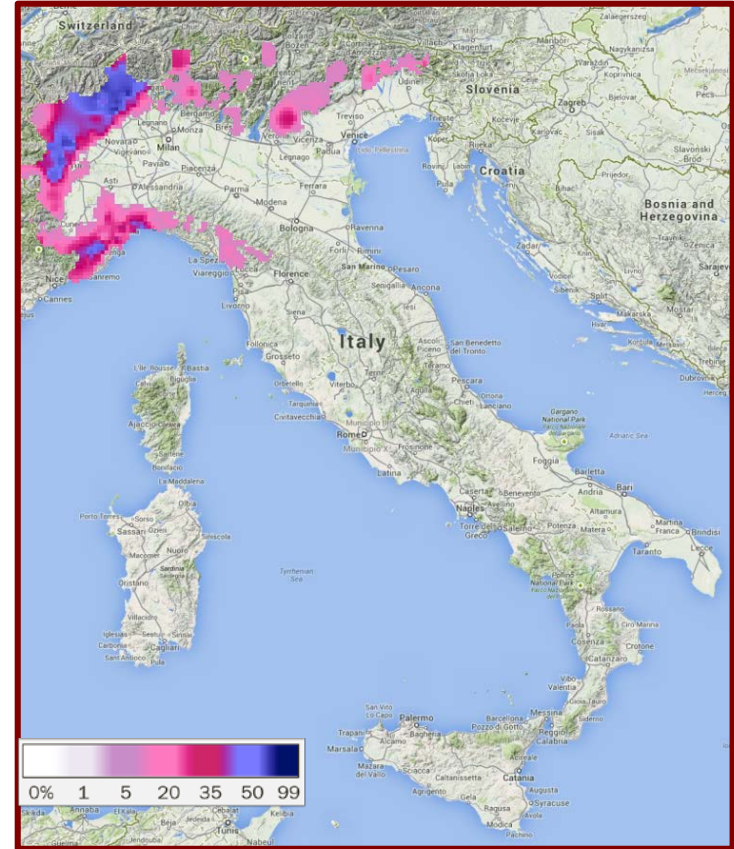
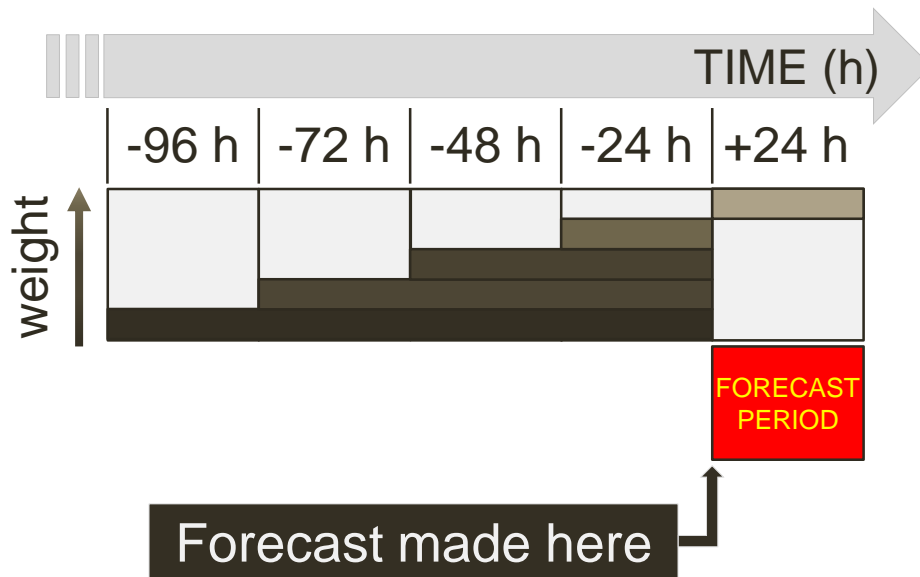
$$P_w = \frac{96 P_{-24} + 72 P_{-48} + 48 P_{-72} + 24 P_{-96}}{96 + 72 + 48 + 24}$$

FORECAST WITH FORECASTED RAIN



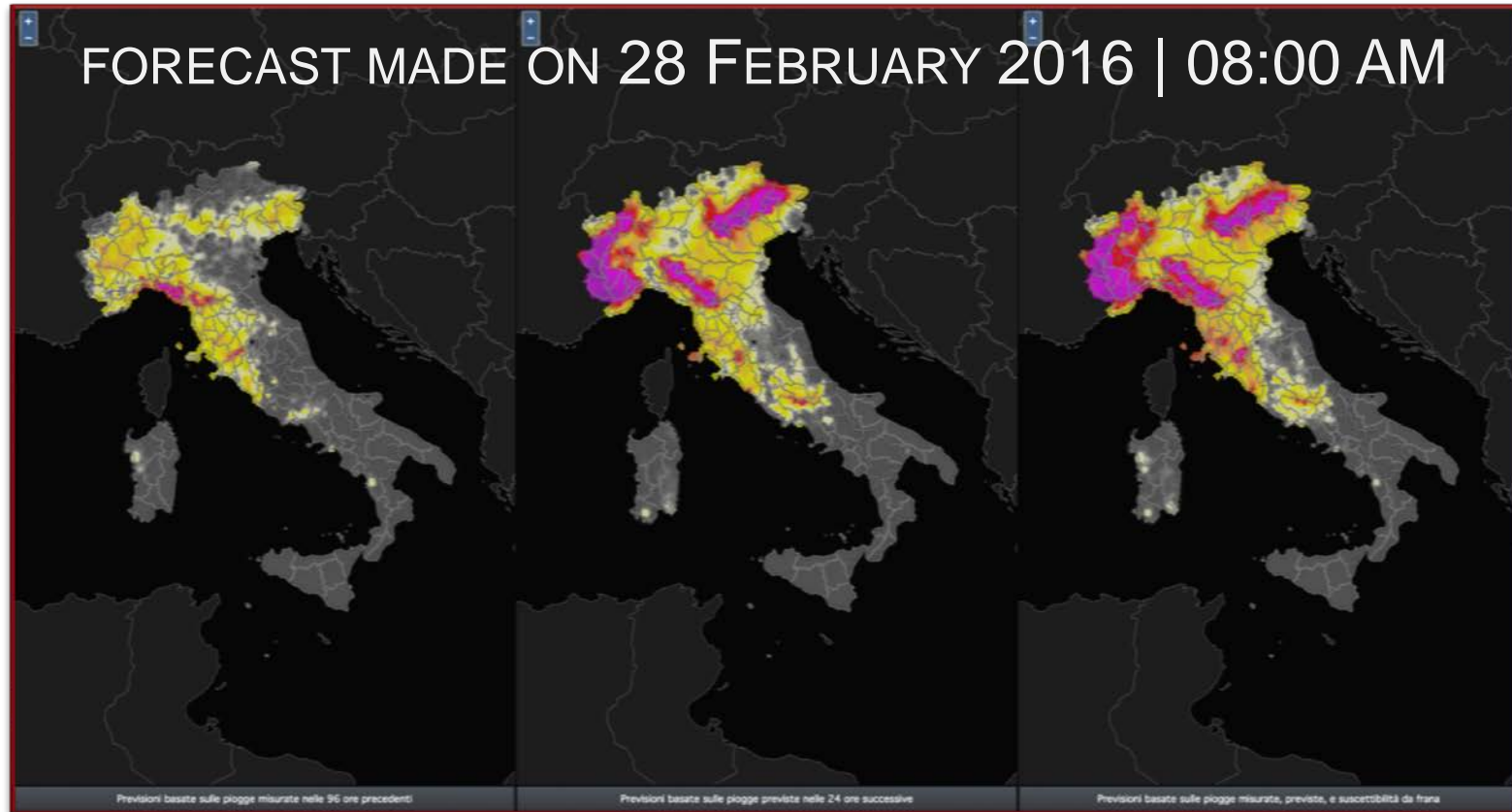
$$P_w = \frac{24 P_{+24}}{24}$$

COMBINED (“OPTIMAL”) FORECAST



$$P_w = \frac{120P_{+24} + 96P_{-24} + 72P_{-48} + 48P_{-72} + 24P_{-96}}{120 + 96 + 72 + 48 + 24} \times S$$

SYSTEM INTERFACE



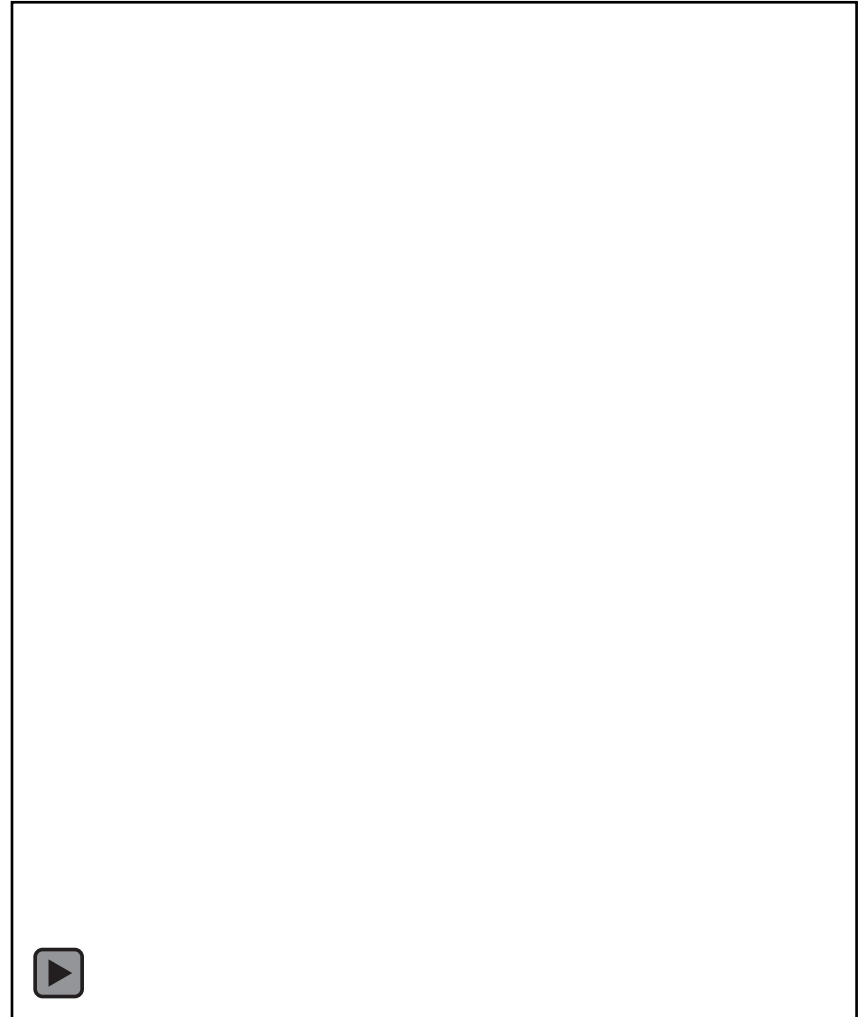
Measured Rainfall

Forecasted Rainfall

“Combined”
measured & forecasted
rainfall & susceptibility

HOURLY RAINFALL FORECASTS

Hourly
landslide
forecasts from
8 September to
16 October
2015

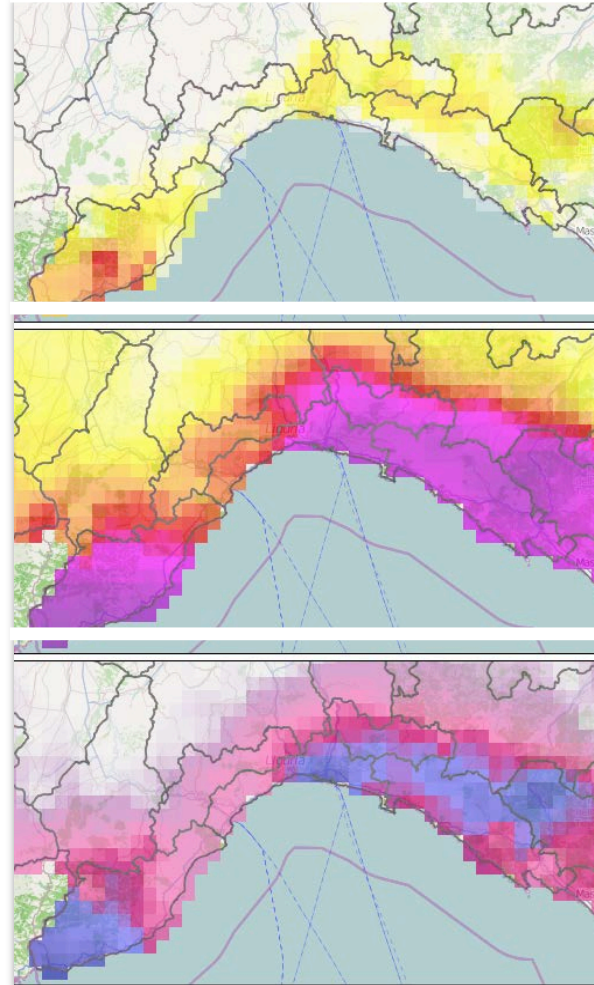


REGIONAL EARLY WARNING SYSTEM

- Uses **regional thresholds**
- Uses **regional rainfall** measurements
- Uses **regional weather forecasts**
- Uses **regional susceptibility** assessment
- Exploits national **data & forecasts**

REGIONAL EARLY WARNING SYSTEM

Regional
landslide
forecast
of
5 Jan. 2014
@ 24:00



Measured Rainfall
0% 5% 20% 50% 99%

Forecasted Rainfall
0% 5% 20% 50% 99%

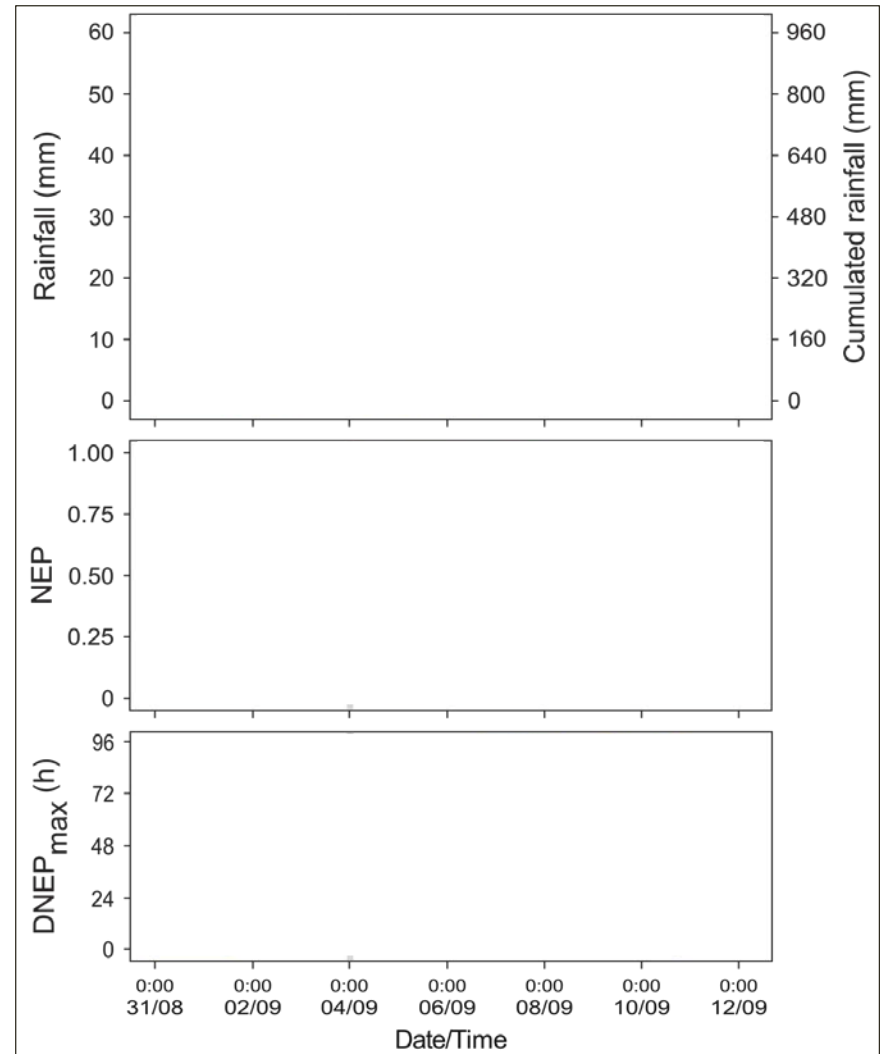
“Combined”
measured & forecasted
rainfall & susceptibility
0% 5% 20% 50% 99%

LOCAL EARLY WARNING SYSTEM

Rainfall **history**

Probability of
landslide occurrence
(quantiles)

Rainfall duration for
largest probability



FORECAST EVALUATION ISSUES

Lack of
landslide
have not

PREDICTED
AND
REPORTED



PREDICTED
BUT
NOT REPORTED



of
des

NOT PREDICTED
BUT
REPORTED



NOT PREDICTED
AND
NOT REPORTED

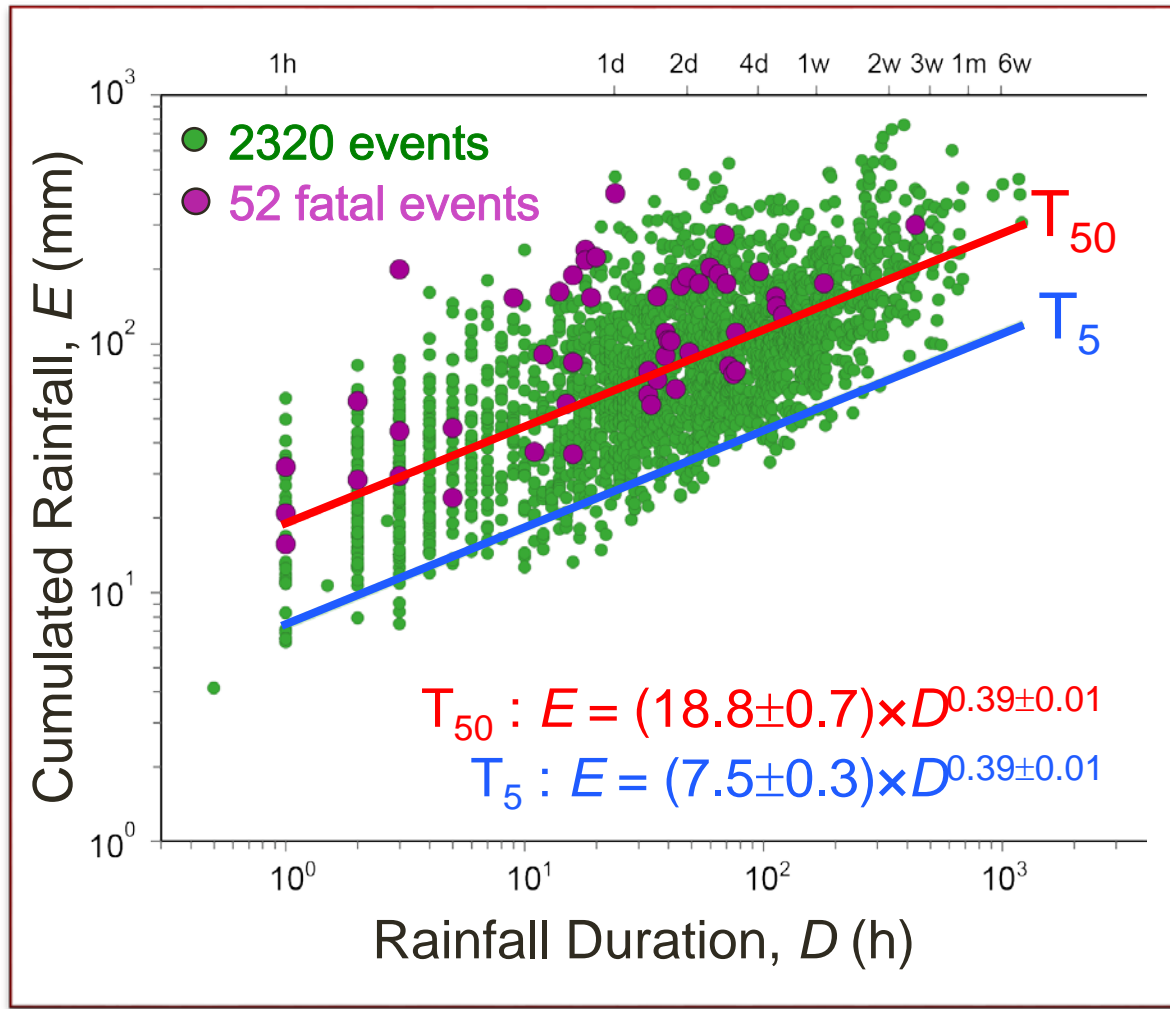


STATISTICAL METRICS ISSUES

Standard metrics used for forecast evaluation are **problematic** for the evaluation of **landslide forecasts**.

TP	FP
FN	TN

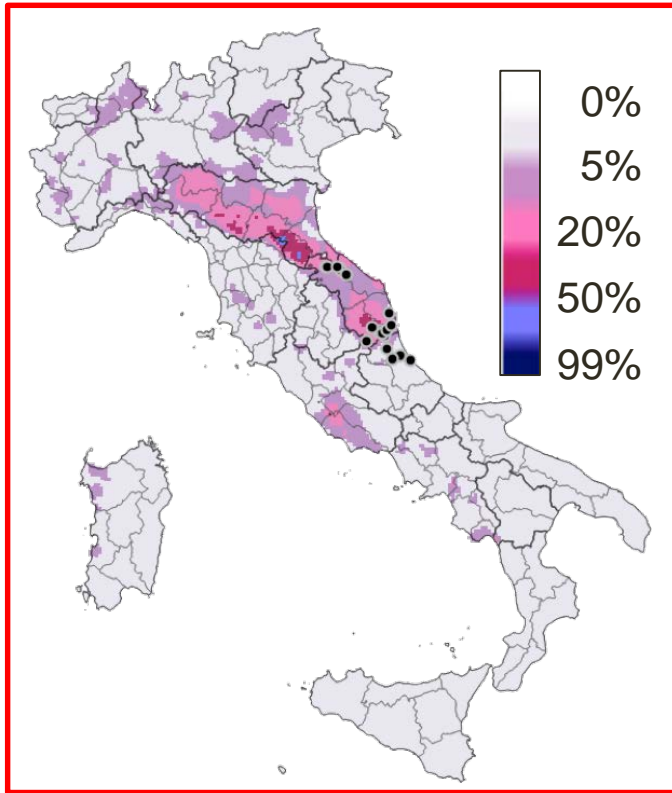
FORECAST EVALUATION IN ITALY



All 52 fatal landslide events between 2002 and 2012 in Italy were predicted

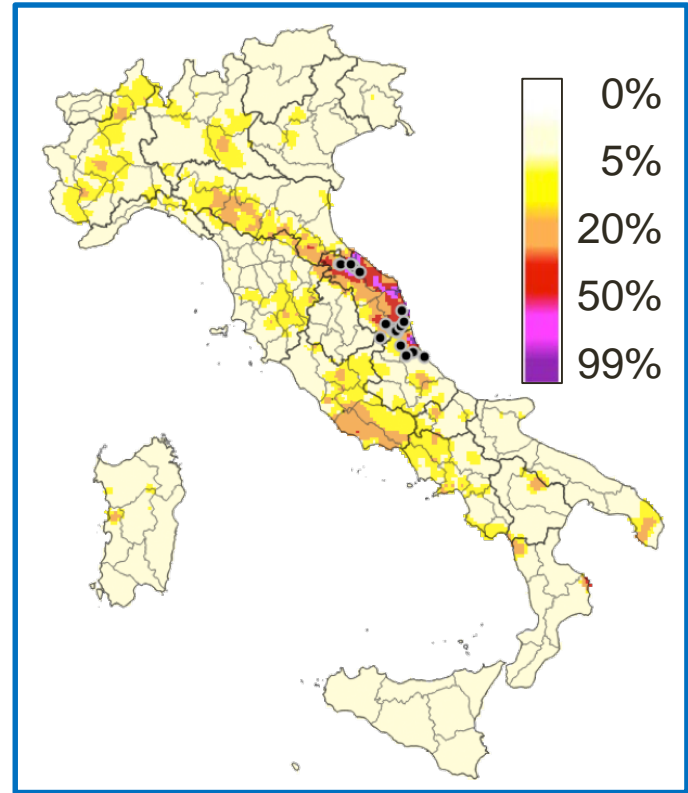
FORECAST EVALUATION IN ITALY

Forecast 2/5/14 | 23:30



2/5 3/5

Hindcast 3/5/14 | 23:30



3/5

LIMITATIONS

- Relies on **accurate** rainfall **measurements** and **forecasts**
- Does not consider all landslide **triggers** (**snowmelt**, **rain-on-snow**)
- May not work for **deep-seated** landslides

WHAT'S NEXT?

- Better **landslide susceptibility** models
- **New** quantitative **rainfall forecasts**
- Use of **radar rainfall** estimates
- Include “**physically-based**” forecasting **models**

WHAT'S NEXT?

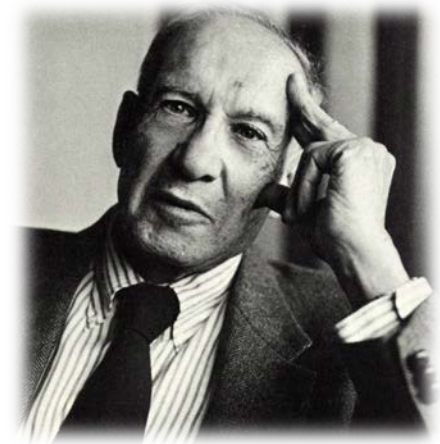
- **Scopes** of the evaluation
- **Feedback** from **users**
- Different **metrics**
- Optimal **warning levels**
- Collect information on **landslide occurrence**

LANDSLIDE FORECASTING IS POSSIBLE

Operational forecasting of populations of rainfall induced landslides **is possible**, and it can **contribute** to **mitigate landslide risk**.

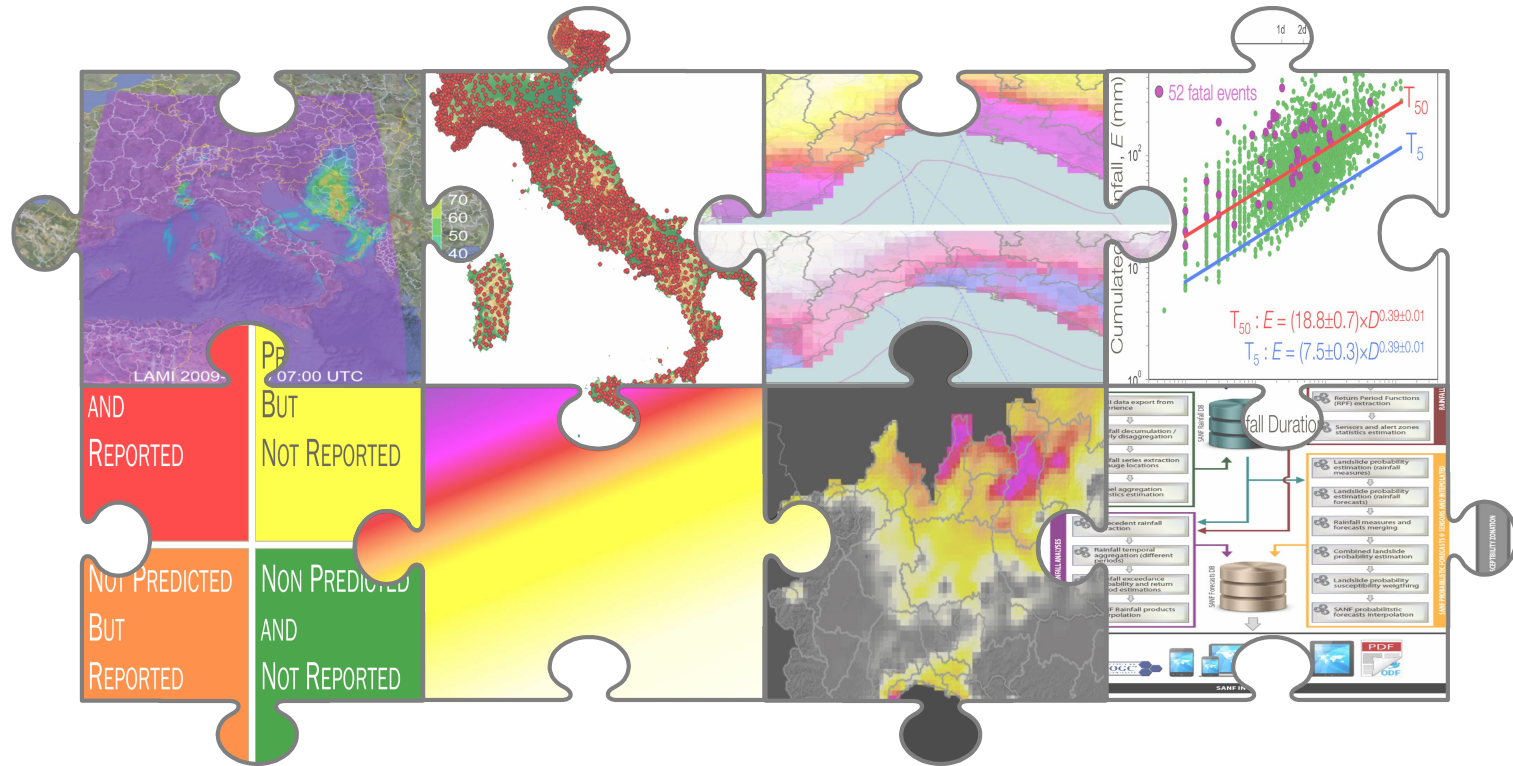
... WITH A FEW WORDS OF CAUTION

“Trying to predict the future is like trying to drive down a country road at night with no lights while looking out the back window.”



Peter F. Drucker
Economist and writer

... THANK YOU!



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