Dissesto idrogeologico nell’arco alpino e prealpino: previsione, prevenzione e gestione dell’emergenza

Flash floods, colate detritiche e scivolamenti superficiali nell’arco alpino: un segnale del cambiamento climatico?

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Summary

- Climate change and trends/changes in the flood and debris flows regime

- Changes with respect to what? Uncertainties in the definition of a (local) current flash flood / debris flow regime

- Flash flood/debris flows: need of an observation strategy

- Incorporation of new observations in the risk management structure

▪Increasing river floods: fiction or reality?

• surprisingly large number of major floods in the last years around the world,

•this suggests that floods may have increased and will continue to increase in the next decades

• not fully clear whether this perception of universally increasing floods is borne out by observational data

■ Have floods changed in the past?
(data from the FLOODChange ERC Project) [1]

•a review of the most recent studies provided below suggests some broader patterns, which are summarized here according to three climate regions relevant to flooding:

(i) Atlantic western Europe and northern Europe,

(ii) Continental central Europe and eastern Europe, and

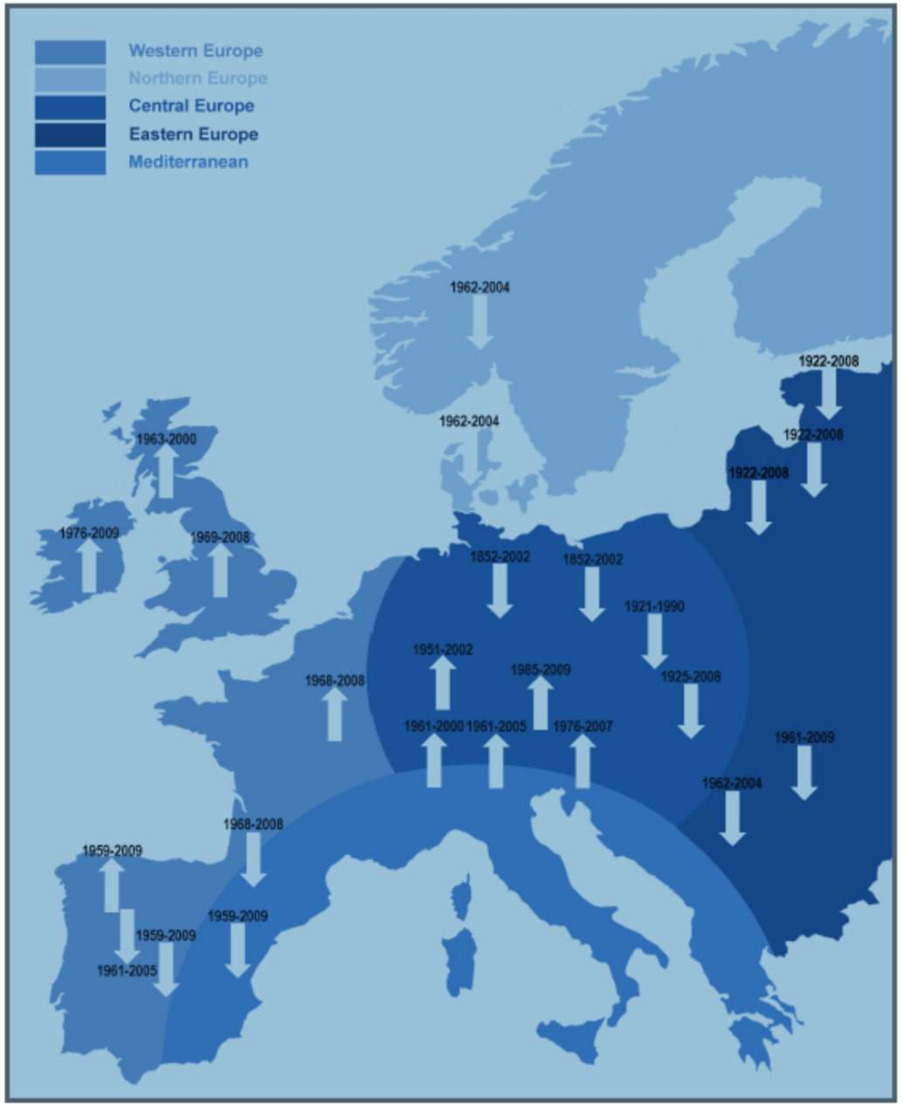
(iii) the European Mediterranean (southern non-Atlantic Europe)

1 Hall, J., et al., 2014: Understanding flood regime changes in Europe: A state-of-the-art assessment. Hydrology and Earth System Sciences, 18 (7), 2735-2772.

■ Have floods changed in the past?

•The outcomes of the literature review have been adapted into a schematic indicating some broad pattern of flood regime changes across Europe.

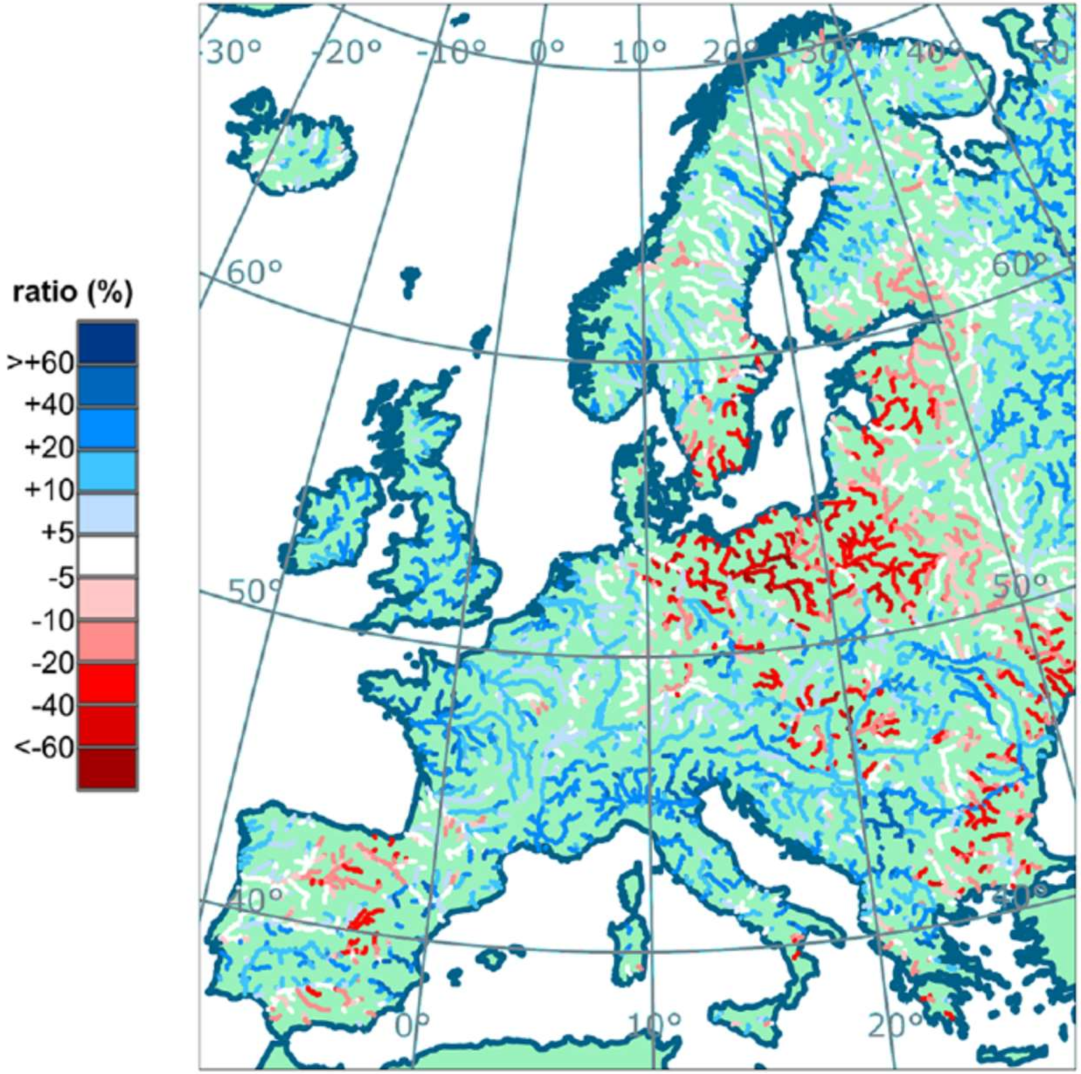
•The arrows in the schematic indicate the dominant pattern of change, encompassing both significant and non-significant changes of various magnitudes and periods.



■ Scenario of changes for the future

•Example of estimated ensemble average change in the 100-year flood discharge between 2071–2100 and 1961–1990 (Rojas et al., 2011) [1]

1 Rojas, R., Feyen, L., Dosio, A., and Bavera, D, 2011.: Improving pan-European hydrological simulation of extreme events through statistical bias correction of RCM-driven climate simulations, Hydrol. Earth Syst. Sci., 15, 2599–2620, doi:10.5194/hess-15-2599-2011, 2011



■ Scenario of changes for the future Debris Flows in the Alps [1]

Expected events are likely to occur less frequently during summer,
•anticipated increase of rainfall in spring and fall could likely alter debris-flow activity during the shoulder seasons (March, April, November, and December).

The magnitude of debris flows could become larger due to larger amounts of sediment delivered to the channels and as a result of the predicted increase in heavy precipitation events.

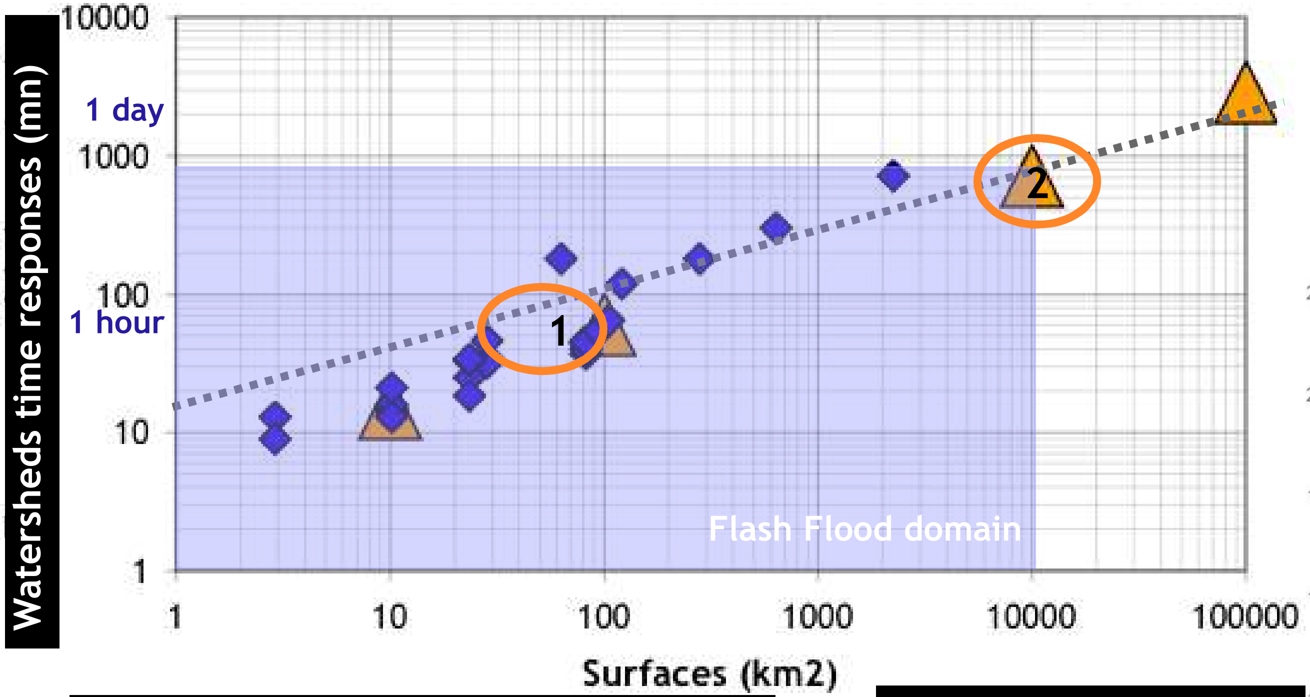
At the same time, however, debris-flow volumes in high-mountain areas will depend chiefly on the stability and/or movement rates of permafrost bodies, and destabilized rock glaciers could lead to debris flows without historic precedents in the future.

1 Stoffel, M., Tiranti, D., Huggel, C., 2014: Climate change impacts on mass movements - Case studies from the European Alps. Science of the Total Environment, 493, pp. 1255-1266.
Schneuwly-Bollschweiler, M., Stoffel, M., 2912: Hydrometeorological triggers of periglacial debris flows in the Zermatt valley (Switzerland) since 1864. Journal of Geophysical Research: Earth Surface, 117 (2), art. no. F02033, .

Flash floods: Observation challenges and Observation Strategy

- Flash floods: a working definition
- Observation challenges
- Establishment of an observation strategy

FF Space-time scales

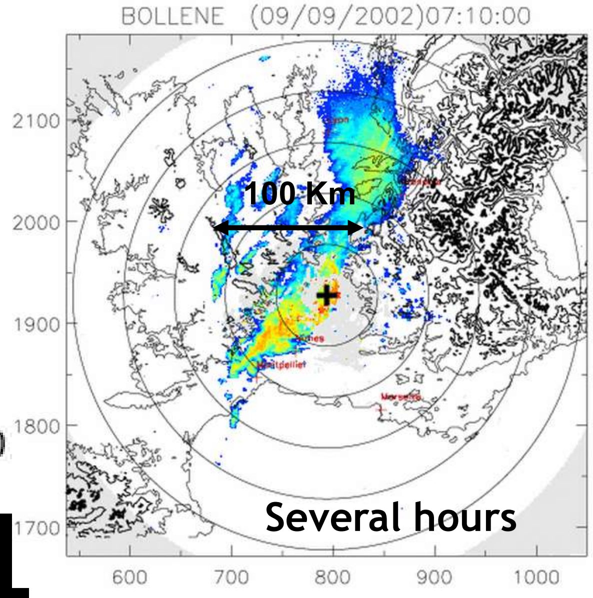


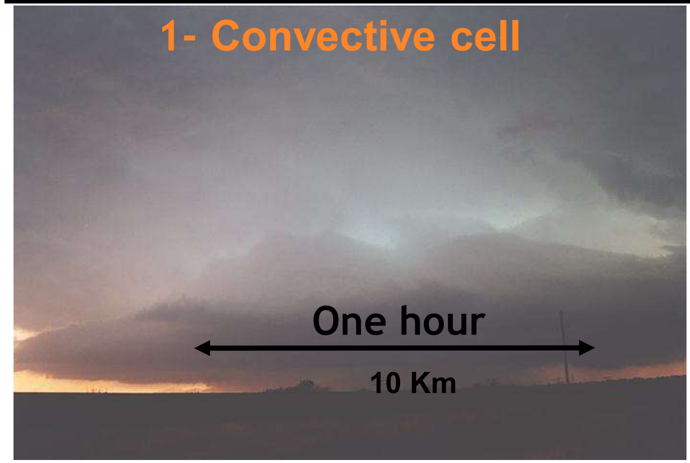
Scale of atmospheric objects (Orlanski, 1975)

Scale of hydrological responses

Source : Creutin, 2001

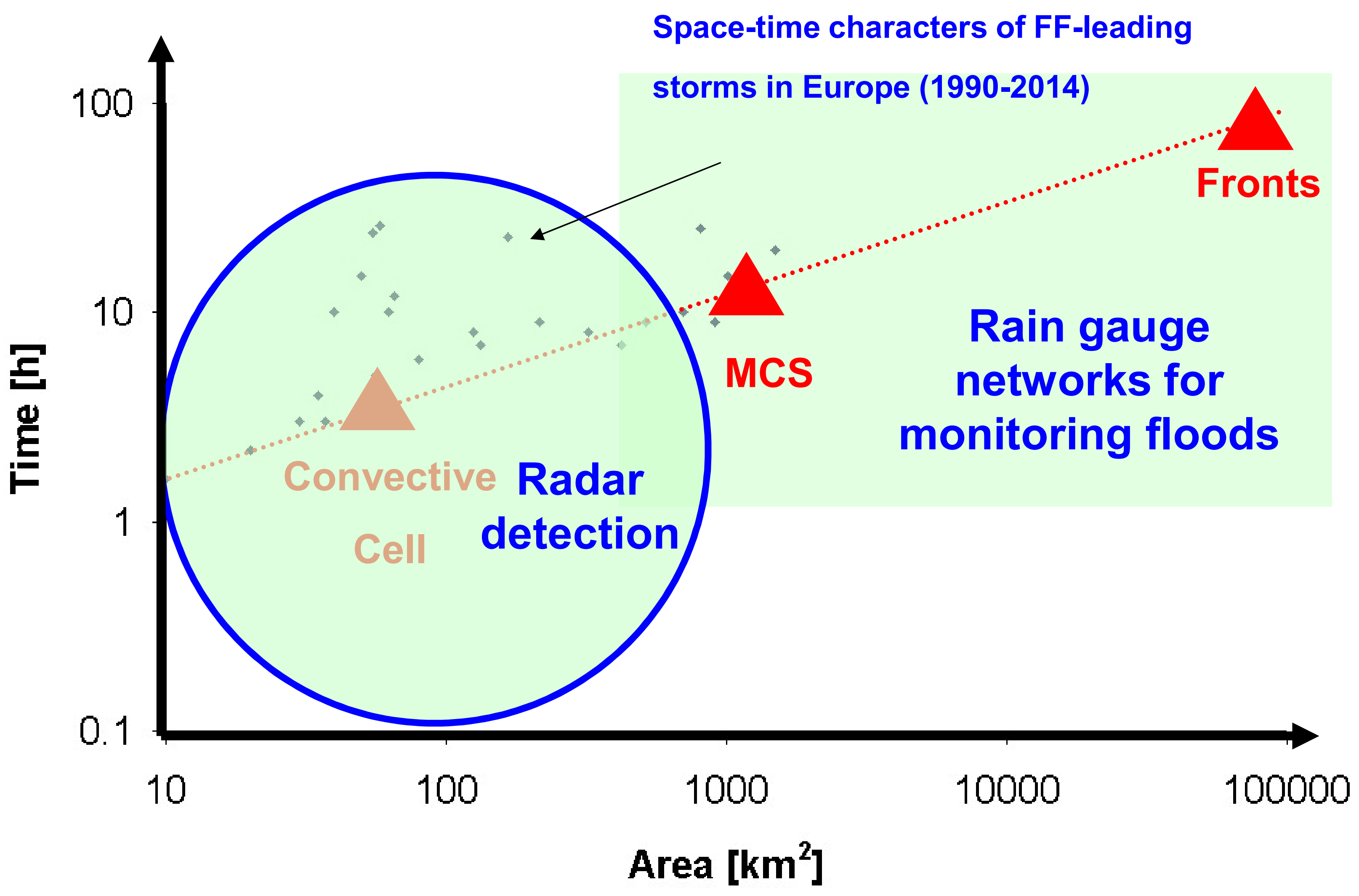
2- Meso-scale convective system





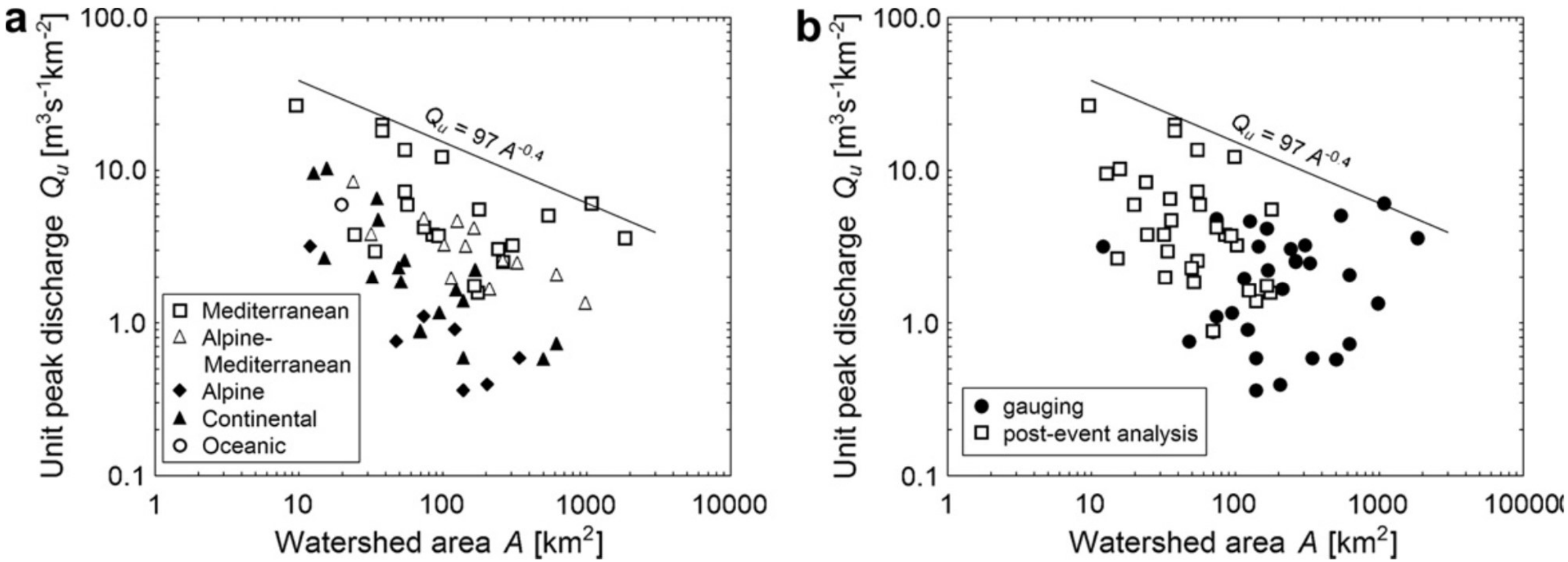
Observation challenges

Space-time scales of flash floods



Observation challenges [1]

Space-time scales of flash floods: hydrometric data challenge



Marchi, L., Borga, M., Preciso, E., Gaume, E. Characterisation of selected extreme flash floods in Europe and implications for flood risk management (2010) Journal of Hydrology, 394 (1-2), pp. 118-133.
Zanon, F., Borga, M., Zoccatelli, D., Marchi, L., Gaume, E., Bonnifait, L., Delrieu, G., 2010: Hydrological analysis of a flash flood across a climatic and geologic gradient: The September 18, 2007 event in Western Slovenia. Journal of Hydrology, 394 (1-2), pp. 182-197.
Borga, M., Stoffel, M., Marchi, L., Marra, F., Jakob, M., 2014: Hydrogeomorphic response to extreme rainfall in headwater systems: Flash floods and debris flows. Journal of Hydrology, 518 (PB), pp. 194-205.
Borga, M., Anagnostou, E.N., Blöschl, G., Creutin, J.-D., 2011: Flash flood forecasting, warning and risk management: The HYDRATE project. Environmental Science and Policy, 14 (7), pp. 834-844.

The Flash Flood Observation strategy

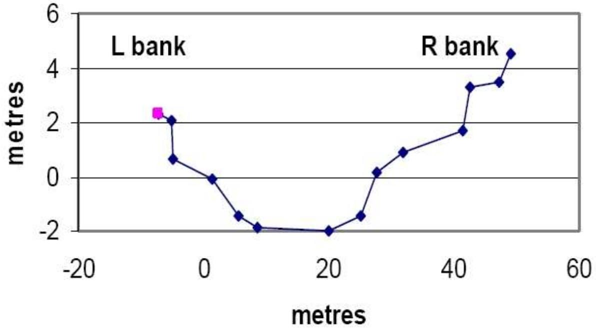
- **The principles**:
  - **Flash floods are locally rare phenomena. Need to observe flash floods where they happens in a wide region, by using opportunistic observations**
  - **To benefit from the density and the quality of the radar coverage as well as from dense rain and river gauging networks in order to collect physical variables.**
  - **To collect complementary information from field investigations carried out during the days following the event (*hazard* and *vulnerability*).**

Post-event analysis

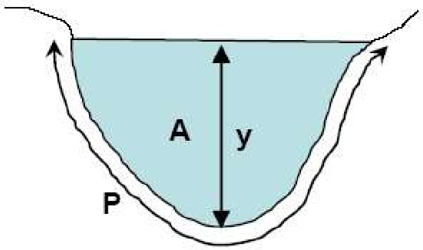
- Data
  - Flood traces
  - Witnesses accounts

Post-event analysis - 2

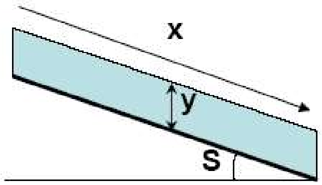
- River sections survey



- Use of hydraulic models for peak Q estimation



Longitudinal view



Cross-sectional view

Post-event analysis 1 - Sardinia Nov 2013

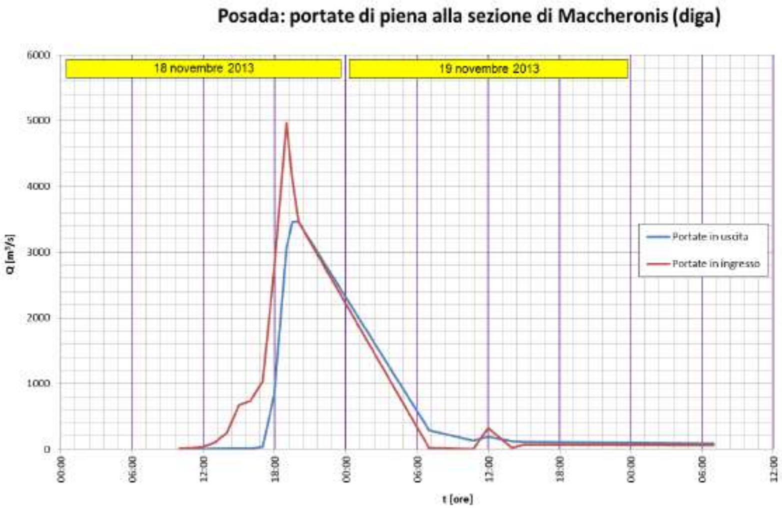
- Available data
  - Flood traces
  - Witnesses accounts

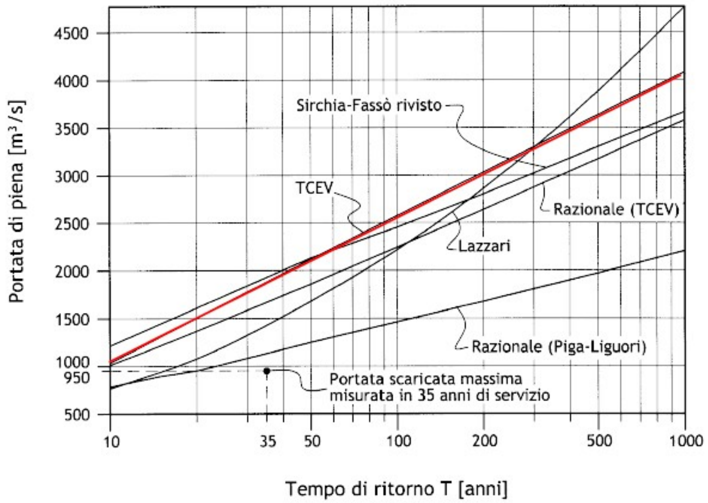
- **Surveys**

Post-event analysis 2 - Slovenia Sept 2007

- Available data
  - Flood traces
  - Witnesses

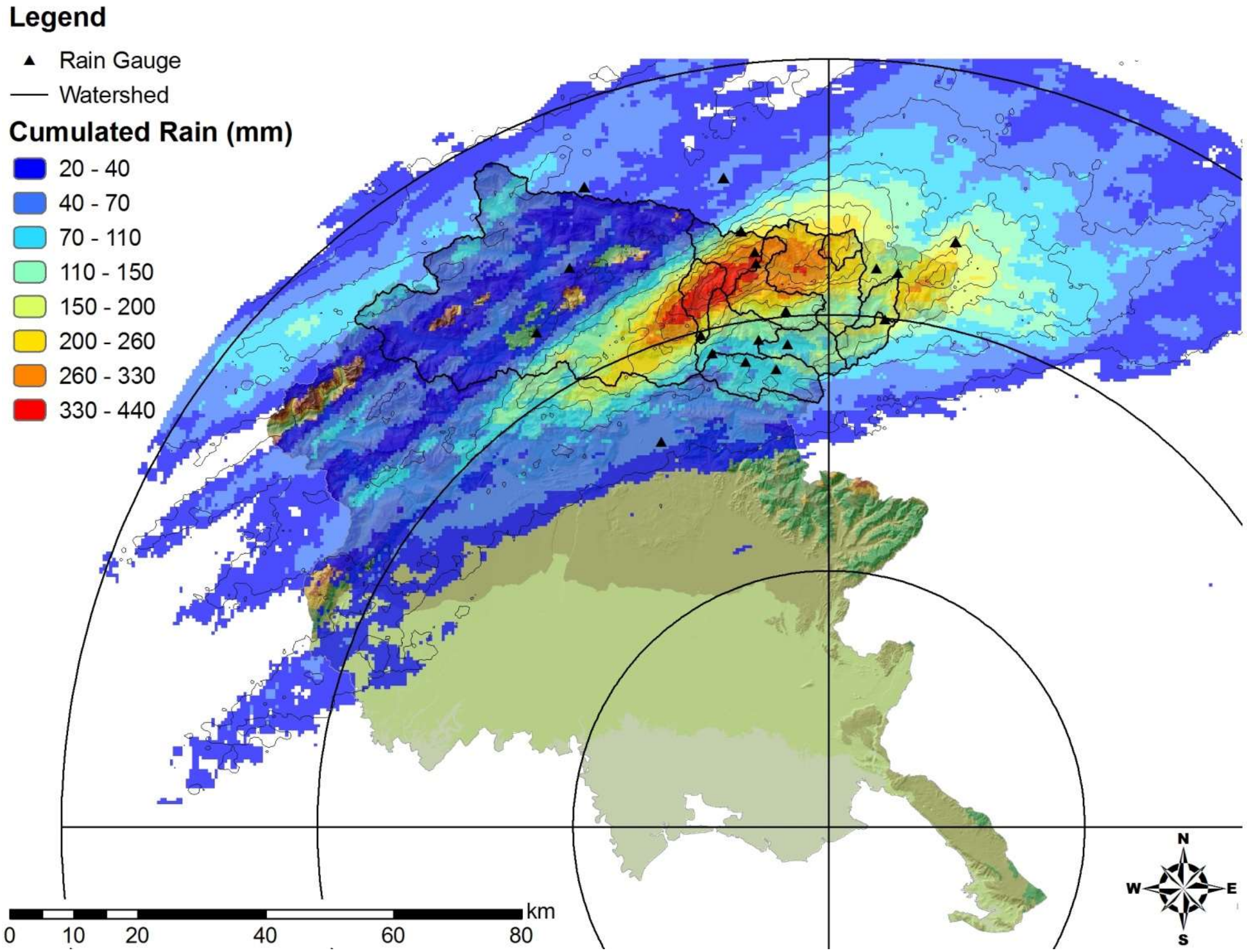
Post-event analysis - 3 Supplementary data Reservoir data





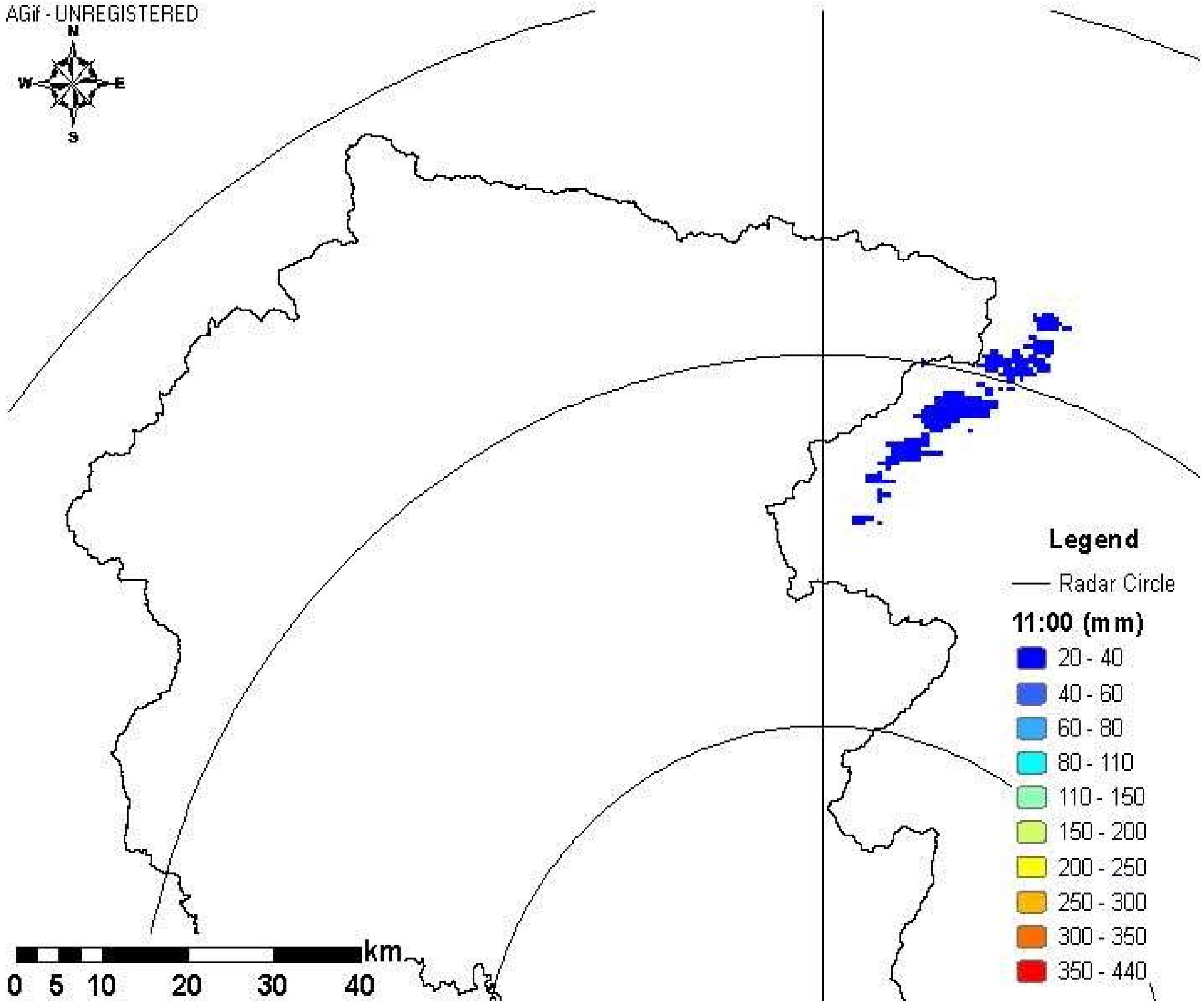
Rio Posada, 604 km^2 Sardinia 2013

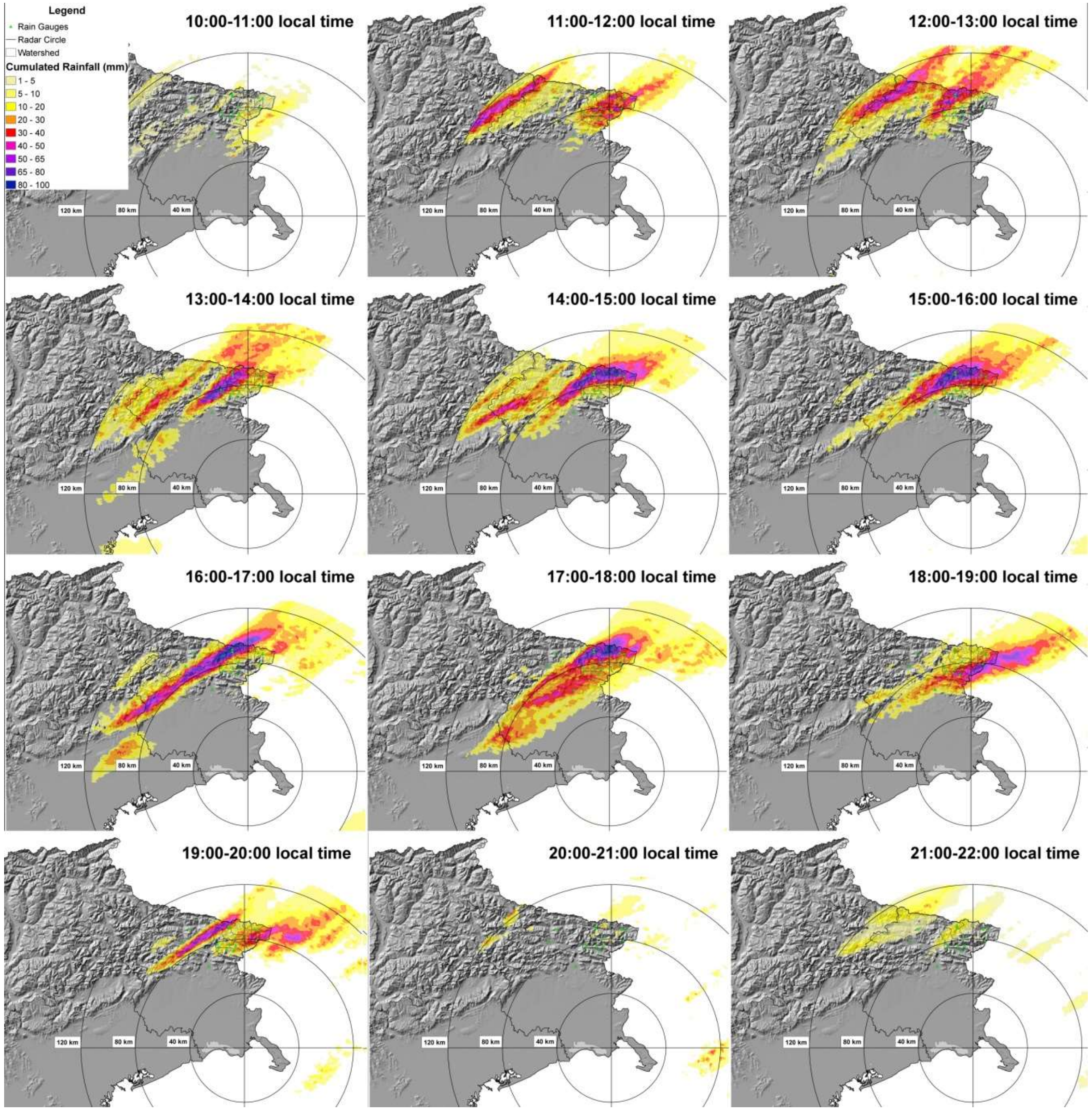
Case Study - Val Canale (Friuli) August 2003



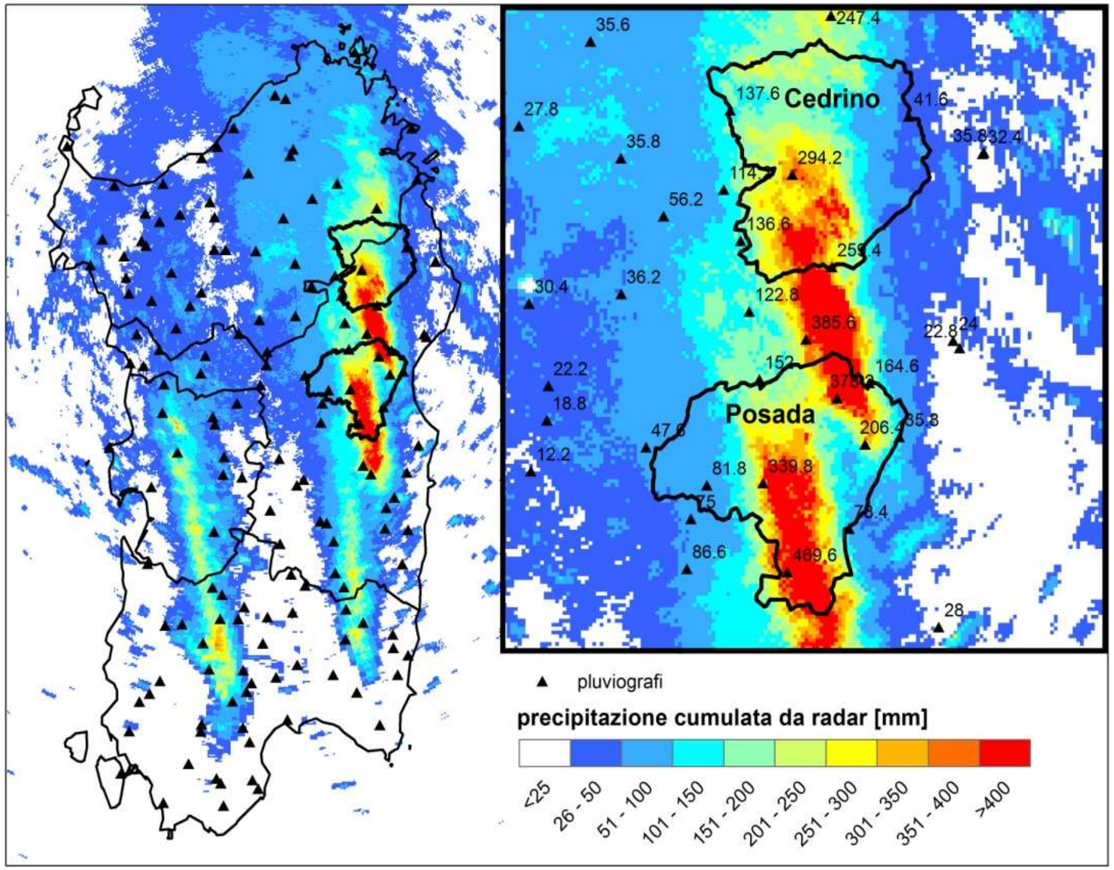
Val Canale FF 29.08.2003

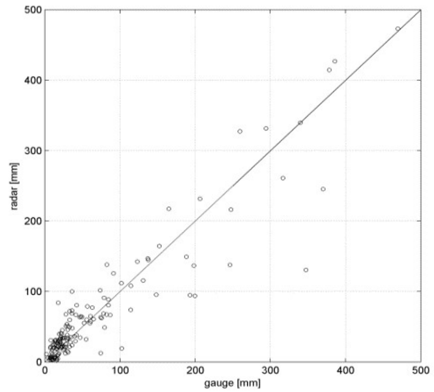
cumulata > 400 mm (in 6 ore) (RT> 500 anni)



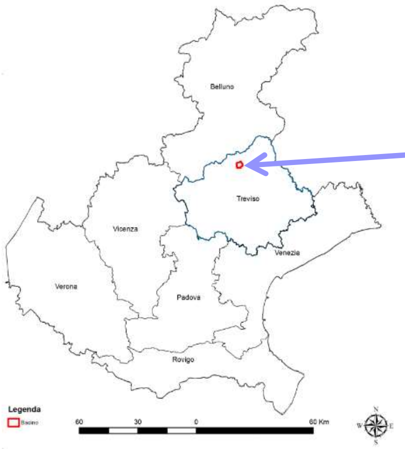

Legend
Rain Gauges
Radar Circle
Watershed
Cumulated Rainfall (mm)
1 - 5
5 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 65
65 - 80
80 - 100
10:00-11:00 local time
11:00-12:00 local time
12:00-13:00 local time
13:00-14:00 local time
14:00-15:00 local time
15:00-16:00 local time
16:00-17:00 local time
17:00-18:00 local time
18:00-19:00 local time
19:00-20:00 local time
20:00-21:00 local time
21:00-22:00 local time
120 km
80 km
40 km

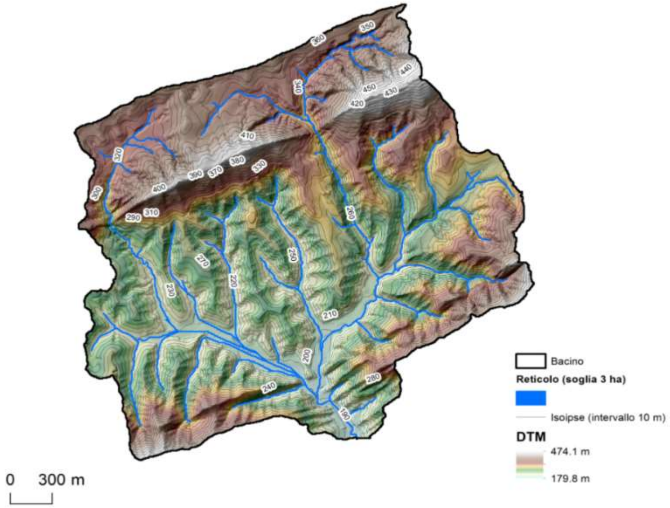
Case Study - Sardegna, Nov 8 2013

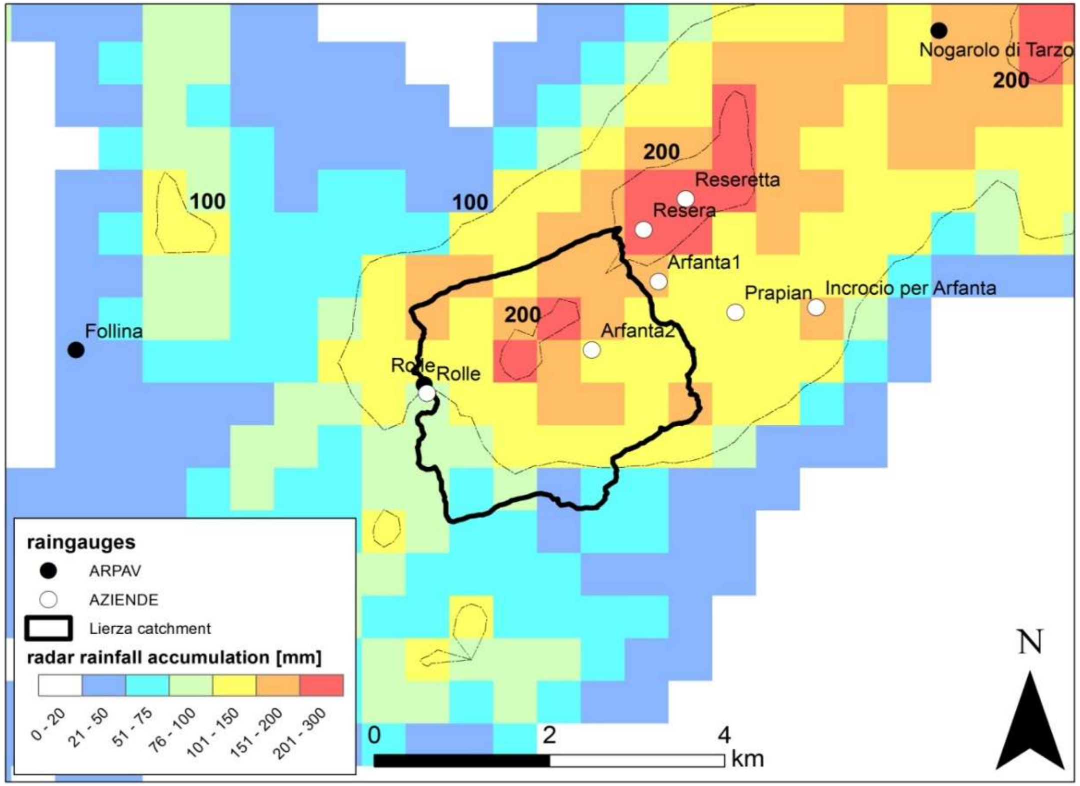




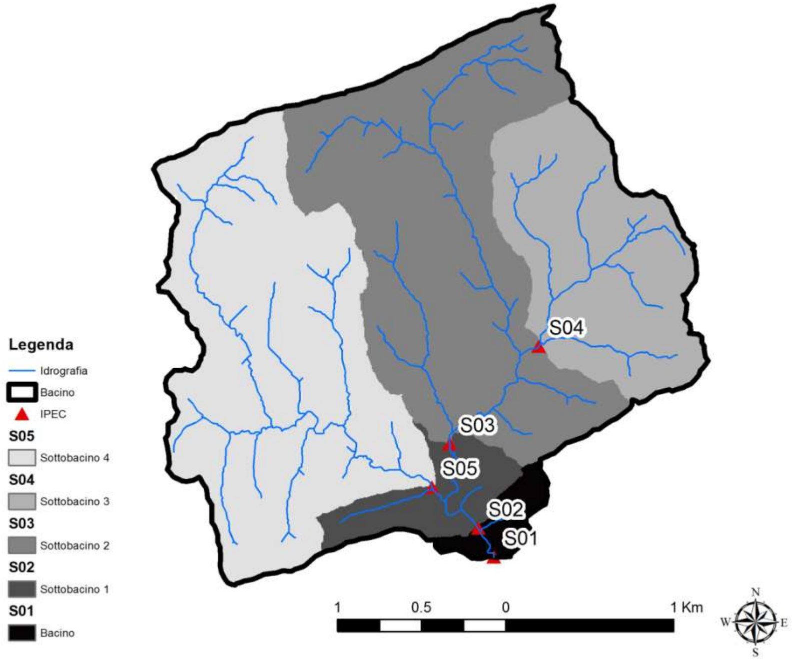
Case Study - Veneto, Aug 2 2014 (duration: 2.0 hr, 7 km2)







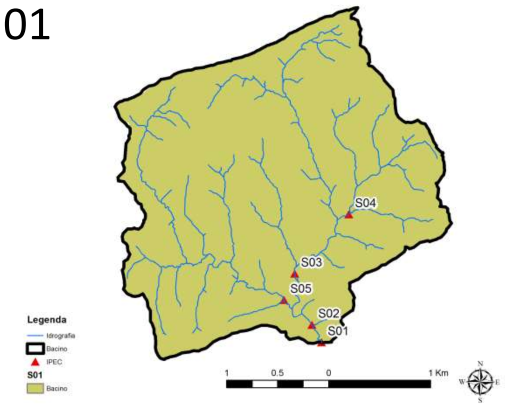
Post flood surveys

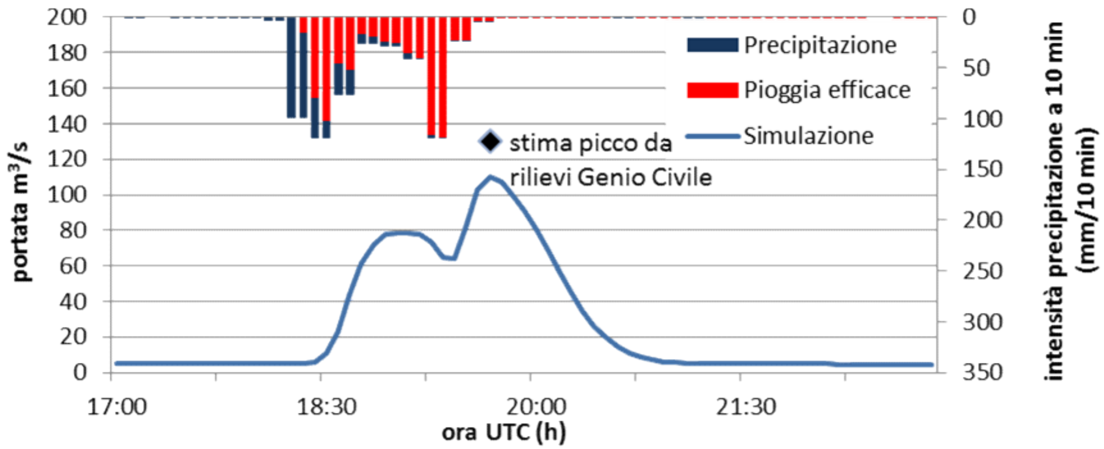


- 5 river sections;
- Extreme specific peaks for drainage areas up to 7 km2, with values up to 17 m3/(s km2);

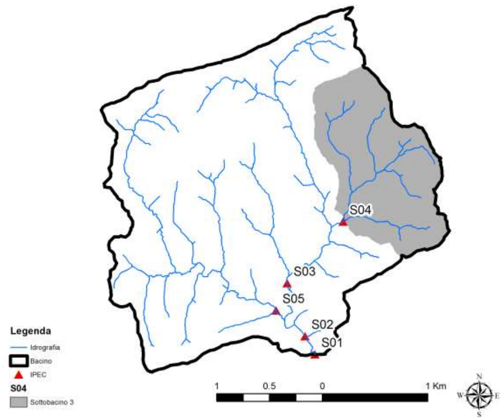
Model vs surveys

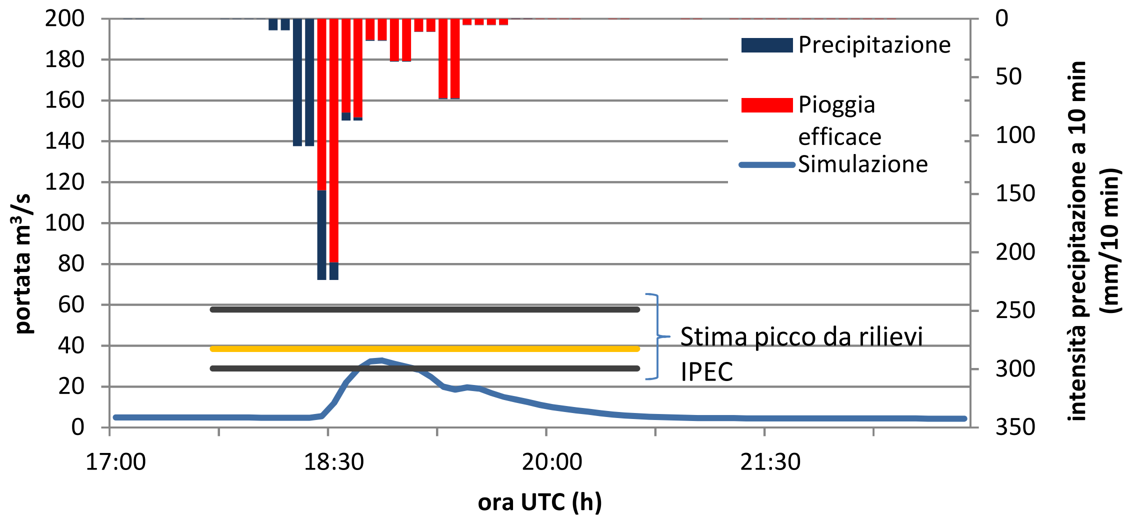
Sezione 01





Sezione 04





Regional frequency assessment using post-flood data - 1

A method for using major flash flood events occurred at ungauged catchments to reduce the uncertainties in estimating regional flood quantiles.

The approach is based on standard regionalization methods assuming that the flood peak distribution rescaled by a site-dependent index flood is uniform within a homogeneous region.

A likelihood formulation and a Bayesian Markov Chain Monte Carlo (MCMC) algorithm are used to infer the parameter values of the regional distributions.

This statistical inference technique is:
Flexible enough as for the type of data that can be treated,
able to compute accurate estimates of the confidence intervals for the adjusted parameters and for the corresponding flood quantiles

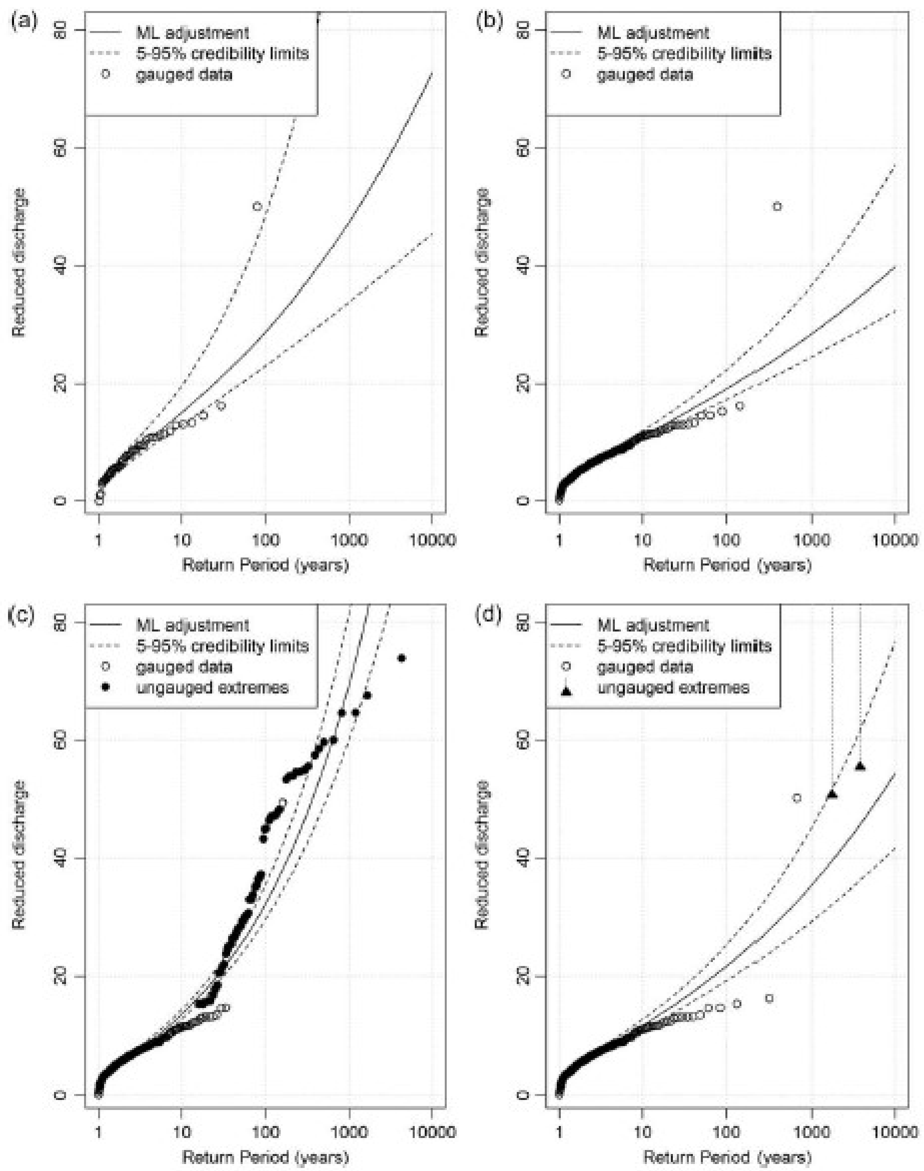
Regional frequency assessment using post-flood data – 2
Fitted GEV distributions in the Gard region

data of the Mialet gauging station

regional gauged data set,

including the whole set of ungauged extremes,

including the two highest ungauged extremes with uncertainty.



Risk management implications - 1

The Observation problem and the Observation strategy:
The uncertainties in quantifying the current flash flood regimes are significant and affect any change analysis of flash flood regime with CC.
Effective analysis of flash flooding requires a systematic effort aimed to carry out in a **routinary way the program of field visits and post-event analysis after each flash flood event.**

Prospects for incorporating opportunistic data into extreme events regional analyses:
Procedures have been established for using data from opportunistic campaigns to reduce the uncertainties in estimating regional flood quantiles**. It has been shown that the changes implied by the incorporation of these data overcome those determined by including CC impact.**

Risk management implications - 2

Added value of post event campaigns:
Radar Rainfall data + Atmospheric models + Hydrological models required to understand and forecast flash floods.
Post event campaigns force re-analysis of these data set with a task to **establish uncertainties thresholds** for extreme events. This may have invaluable impact on collaboration between different technical communities and on reducing uncertainties for real time forecasting and warning.

Flash flood vulnerability observations:
Preparedness is a key element to reduce the impact of these events on society. **The observation strategy (when extended to capture social vulnerability features) may reveal key social elements capable to improve preparedness programs.**

QUESTIONS?

THANK YOU FOR YOUR ATTENTION!