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JIP regional dialogue\ Floods, 2nd Capacity Building Event (CBE2):
Flood Warnings & Decision Support to Civil Authorities and the Public
Phase I: Flood Forecasting Systems & Tools (On-line)

Guidelines on implementing a threshold-based flood early warning system

Angela Corina
WMO RAVI Regional Hydrological Adviser

webinar, *7 March 2022*

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OUTLINE

- Introduction and Background
- Risk forecasting and monitoring
- Flood forecasting principles
- Rainfall threshold (PRT,ART)
- River threshold

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Multi-hazard early warning systems: A checklist, WMO 2017)

Disaster risk knowledge

- Are key hazards and related threats identified?
- Are exposure, vulnerabilities, capacities and risks assessed?
- Are roles and responsibilities of stakeholders identified?
- Is risk information consolidated?

Detection, monitoring, analysis and forecasting of the hazards and possible consequences

- Are there monitoring systems in place?
- Are there forecasting and warning services in place?
- Are there institutional mechanisms in place?

Warning dissemination and communication

- Are organizational and decision-making processes in place and operational?
- Are communication systems and equipment in place and operational?
- Are impact-based early warnings communicated effectively to prompt action by target groups?

Preparedness and response capabilities

- Are disaster preparedness measures, including response plans, developed and operational?
- Are public awareness and education campaigns conducted?
- Are public awareness and response tested and evaluated?

Four elements of end-to-end, people-centric early warning systems following the Sendai Framework

WMO Assessment guidelines for flood forecasting

WMO guidelines intend to provide a guide for carrying out assessments of national End to End Flood forecasting Early warning system (E2E FFEWS) and the subsequent documentation of the relevant results. These guidelines cover all the processes of an E2E FFEWS chain, starting from data acquisition to forecast dissemination and communication to end users.

Hydrological value chain in flood forecasting and early warning - Source: WMO flood assessment guidelines, in review process

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WMO unified data policy
Key changes from Resolution 40

Resolution 40 (1995)

1. Covers weather data only;
2. Two main categories of data:
- *Essential* (*shall* be exchanged);
- *Additional* (*should* be exchanged);
3. Specific "*essential*" datasets listed directly in Annex I to the resolution (with some reference also to RBSN);
4. "*Free and unrestricted*" exchange (term not defined in the Resolution);
5. Covers exchange of data between NMHSs

New data policy (2021)

1. Covers all WMO Earth system data: weather, climate, hydrology, ...
2. Two main categories of data:
- *Core* (*shall* be exchanged);
- *Recommended;* (*should* be exchanged);
3. Specifics on *core* and *recommended* data referred to Technical Regulations, primarily Manuals on WIGOS, GDPFS;
4. "*Free and unrestricted*" exchange (term defined directly in the Resolution, literal interpretation);
5. Addressed to Members, but covers exchange of data between all partners, inclucing private sector, academia, etc.

EWS tailored on country's specifities

Early warning mechanisms can correspond to very different institutional arrangements, operational procedures, technical and scientific activities and communication mechanisms depending on each country's **specificities**

level of decentralization

authorities

legislation

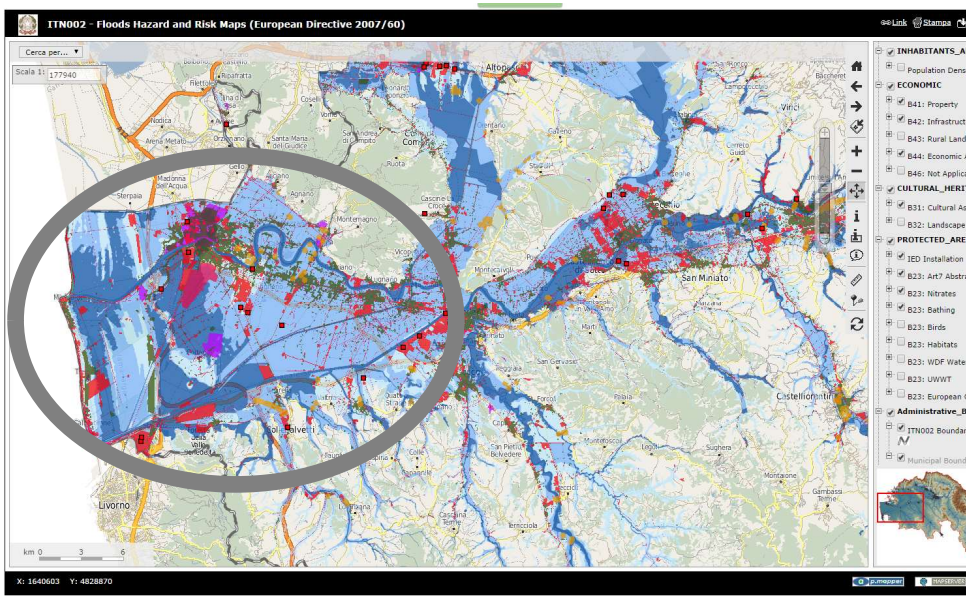
types of risks

population's degree of vulnerability

resources

Feasability of EWS

The goal of a national flood forecasting service is to provide a full level of operations throughout the country. This may not always be possible and so a compromise is often sought, which may include a lesser sophistication of service or equipment over low-risk areas, or a decision to use a phased approach that concentrates on high-risk areas first.



it is necessary to understand the type of service that is required or can be achieved technically and economically.

depending on the types of flood and on capability of an NHS, **different levels of E2E FFEWS can be used, from very basic to systems with advanced capabilities.**

Possible constraints to the EWS

The limitations on the level of service are largely dictated by cost and the complexity of modelling, but the following **reasons can also influence the choice of the relevant level of the service:**

(a) There are **too few locations vulnerable to flooding** or of economic importance in the basin to warrant the setting up of extensive and costly instrumentation;
(b) The nature of the hydro-meteorological conditions in the basin **does not generate sufficiently severe or frequent events to justify investment**, for example in arid and semi-arid areas;
(c) Despite the knowledge of the hydrological response of the basin, the state of the **art in hydrological monitoring and modelling is not advanced enough** to produce sufficiently accurate forecasts, for example in urban areas;
(d) **The level of development and economic conditions** of a country or region are **insufficient to provide and maintain technical services**.

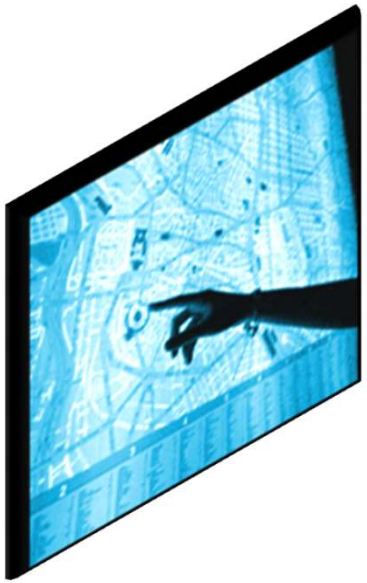
The type and level of service that can be provided is thus a **balance between the technical feasibility to forecast the flood hazards and the economic justification for protecting vulnerable populations, areas of importance and infrastructure**.

SYSTEM STRUCTURE: FORECASTING AND MONITORING PHASE

SYSTEM STRUCTURE: Forecasting And Monitoring Phase

The activity of EWS should be articulated in 2 phases:

1.to provide **forecasts of meteorological, hydrogeological, hydraulic** and marine weather phenomena that enable an assessment of their subsequent **impact on the territory and populations**, and to issue **preventive warnings** to contain their effects;



2.to ensure a **continuous monitoring and surveillance** service to monitor the real-time evolution in time and space of risk situations that are occurring, so to eventually, and **promptly update the warnings issued**.

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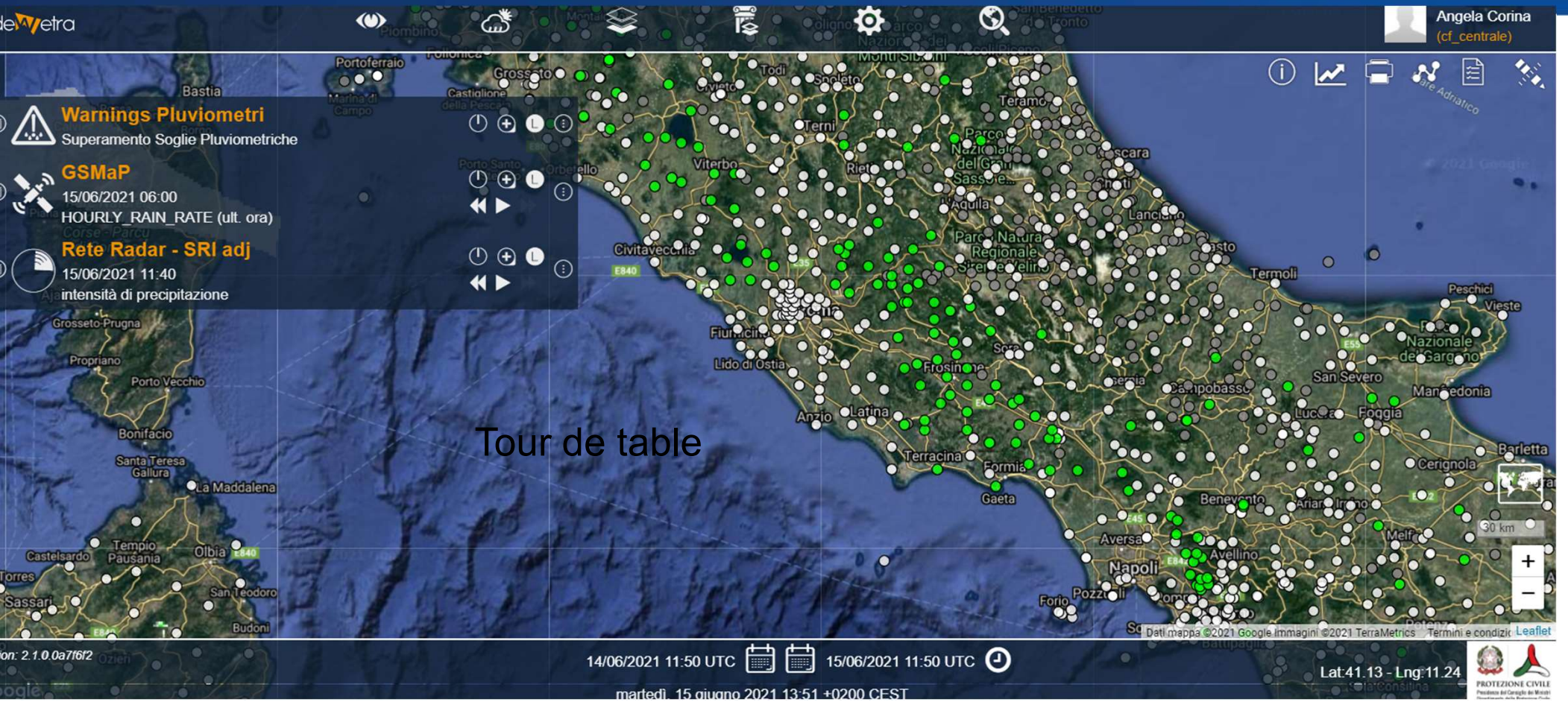
Monitoring and surveillance phase



The purpose of the monitoring and surveillance phase is to use information available to confirm or update the foreseen event scenario. This process is implemented through the transmission, collection and concentration of data retrieved by the available sensors, and by any non-instrumental source.

Urban flood:
Rome 8 June 2021

Urban flood: Roma 8 June 2021
Forecast of 07 June 2021

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PRESIDENZA DEL CONSIGLIO DEI MINISTRI
DIPARTIMENTO PROTEZIONE CIVILE
UFFICIO III
ATTIVITA TECNICO-SCIENTIFICHE PER LA PREVISIONE E LA PREVENZIONE DEI RISCHI
Centro Funzionale Centrale - Settore meteo

RIFERIMENTO: *DIRETTIVA PRESIDENTE DEL CONSIGLIO DEI MINISTRI 27-2-2004 "INDIRIZZI OPERATIVI PER LA GESTIONE ORGANIZZATIVA E FUNZIONALE DEL SISTEMA DI ALLERTAMENTO NAZIONALE E REGIONALE PER IL RISCHIO IDROGEOLOGICO E IDRAULICO AI FINI DI PROTEZIONE CIVILE".*

DATA E ORA	EMESSA DA	PARTECIPANTI AL TAVOLO TECNICO	
07/06/2021 ore 11:32	CFC - SETTORE METEO	CNMCA	X
		CFR-METEO EM. ROMA	X
		CFR-METEO PIEMONTE	X

SULLA BASE DI QUANTO EMERSO NELLA CONFERENZA ODIERNA, TENUTO CONTO DELLE INDICAZIONI DEI MODELLI NUMERICI **DEL ECMWF**, (CORSA DELLE 00.00 UTC DEL 07/06/2021), **DEL LM-17** (CORSA DELLE 00.00 UTC DEL 07/06/2021), DELLA **CONFERENZA SINOTTICA** TRA I PARTECIPANTI AL TAVOLO TECNICO GIORNALIERO, SI EMETTE LA SEGUENTE:

PREVISIONE SINOTTICA SULL'ITALIA
VALIDA FINO ALLE 24.00 DEL 09 GIUGNO 2021

SITUAZIONE: un flusso mediamente occidentale influenza l'area mediterranea: al suo interno si muovono piccole onde che causano infiltrazioni di aria più fresca creando condizioni di spiccata variabilità sul Paese, con fenomeni temporaleschi che, localmente, potranno risultare anche di forte intensità. Oggi l'instabilità atmosferica interesserà gran parte della Penisola. Domani ancora fenomeni ad evoluzione diurna sul Paese, con precipitazioni che interesseranno maggiormente i settori tirrenici. Mercoledì l'instabilità sarà presente soprattutto sui settori montuosi settentrionali, isole maggiori e zone tirreniche meridionali.

FENOMENI SIGNIFICATIVI O AVVERSI PER IL GIORNO 08 GIUGNO 2021
Precipitazioni:
- sparse, anche a carattere di rovescio o temporale, su Lazio, settori occidentali di Abruzzo e Molise, Campania, Puglia centro-settentrionale, Basilicata, Calabria settentrionale e fino al mattino sul Piemonte sud-occidentale, con quantitativi cumulati localmente moderati, specie nelle ore centrali della giornata;
- da isolate a sparse, anche a carattere di rovescio o temporale, sul resto del Piemonte, Valle d'Aosta, Liguria, Lombardia settentrionale ed occidentale, Trentino, Alto Adige, settori alpini di Veneto e Friuli Venezia Giulia, Emilia-Romagna occidentale e Appennino romagnolo, restanti zone delle regioni centro-meridionali peninsulari e su Sicilia centrale tirrenica e nord-orientale e zone interne della Sardegna orientale, con quantitativi cumulati generalmente deboli.

Visibilità: nessun fenomeno significativo.
Temperature: in locale sensibile diminuzione sulla Puglia centro-meridionale, Basilicata e Calabria.
Venti: localmente forti occidentali sulla Sicilia meridionale.
Mari: localmente molto mosso lo Stretto di Sicilia.

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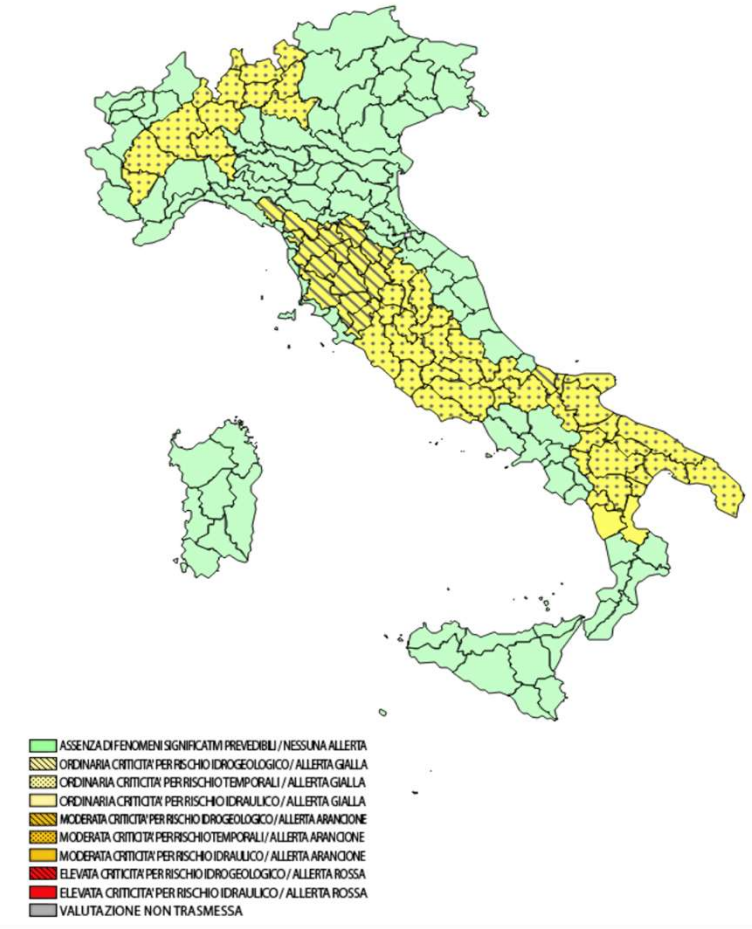
Centro Funzionale Centrale – Settore Idro

EFFETTI AL SUOLO PREVISTI PER Martedì 8 giugno 2021



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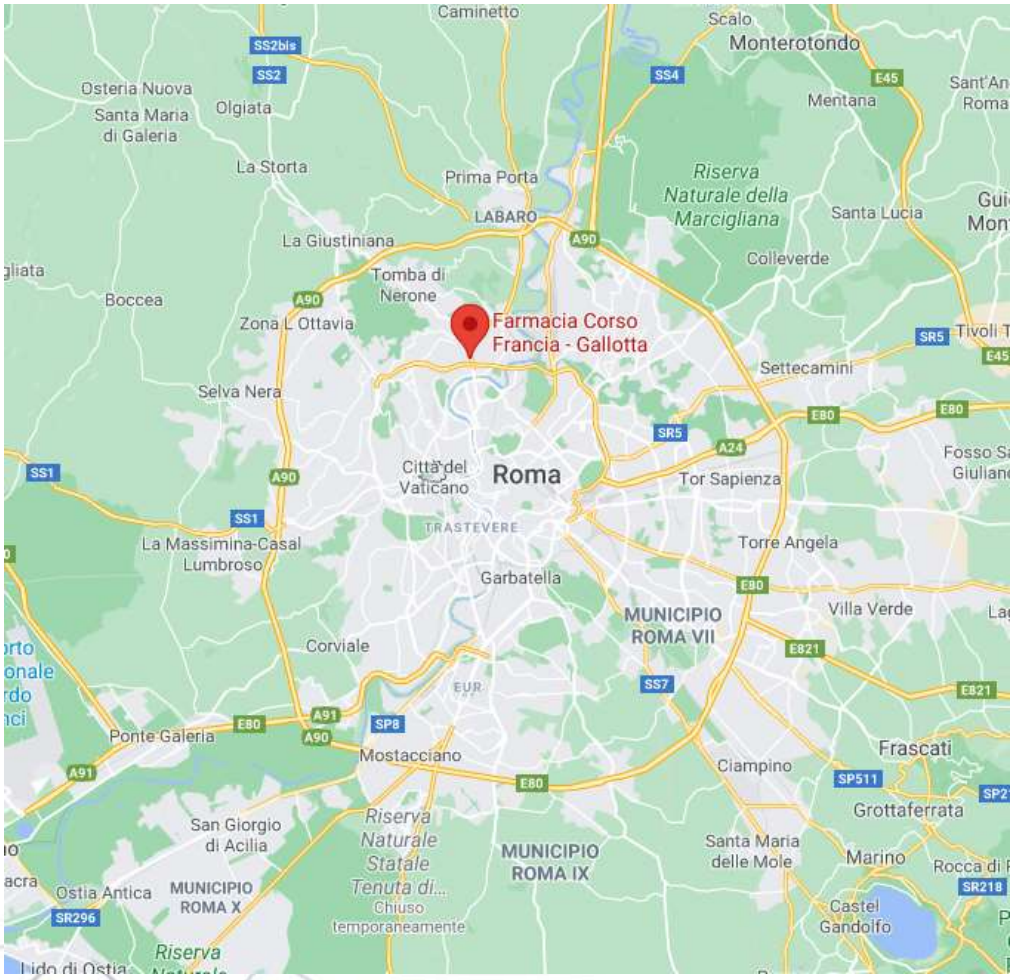
Urban flood: a recent episode in Rome
8 June 2021



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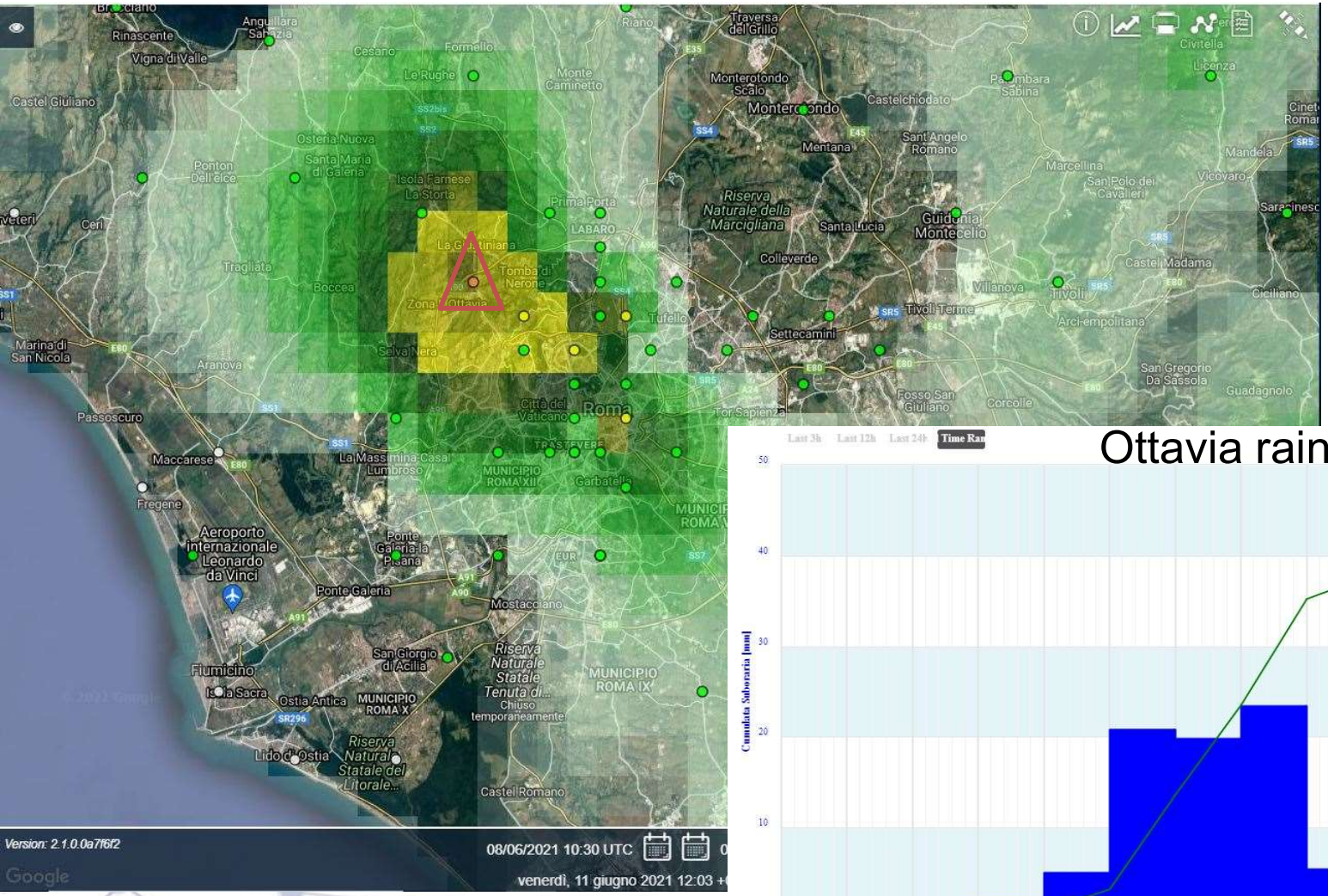
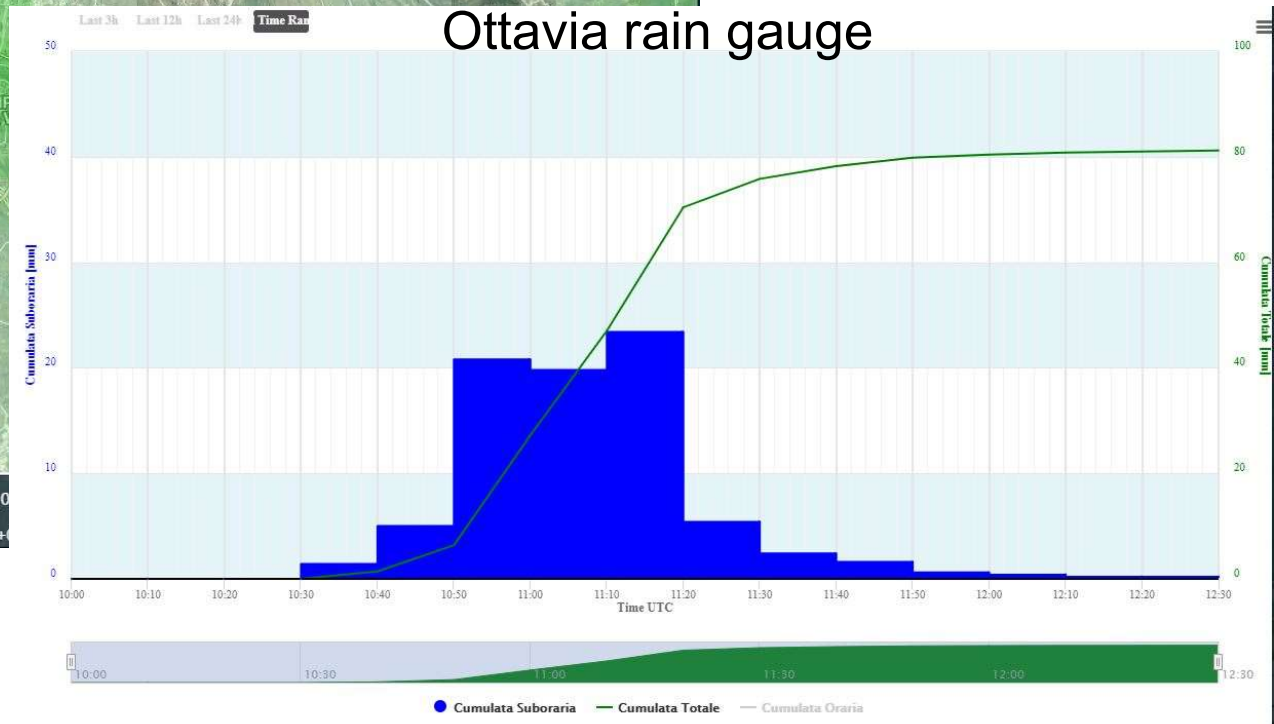
8 June 2021



Localized precip. almost 80 mm in about 1 h in one station (Ottavia)

Ottavia rain gauge



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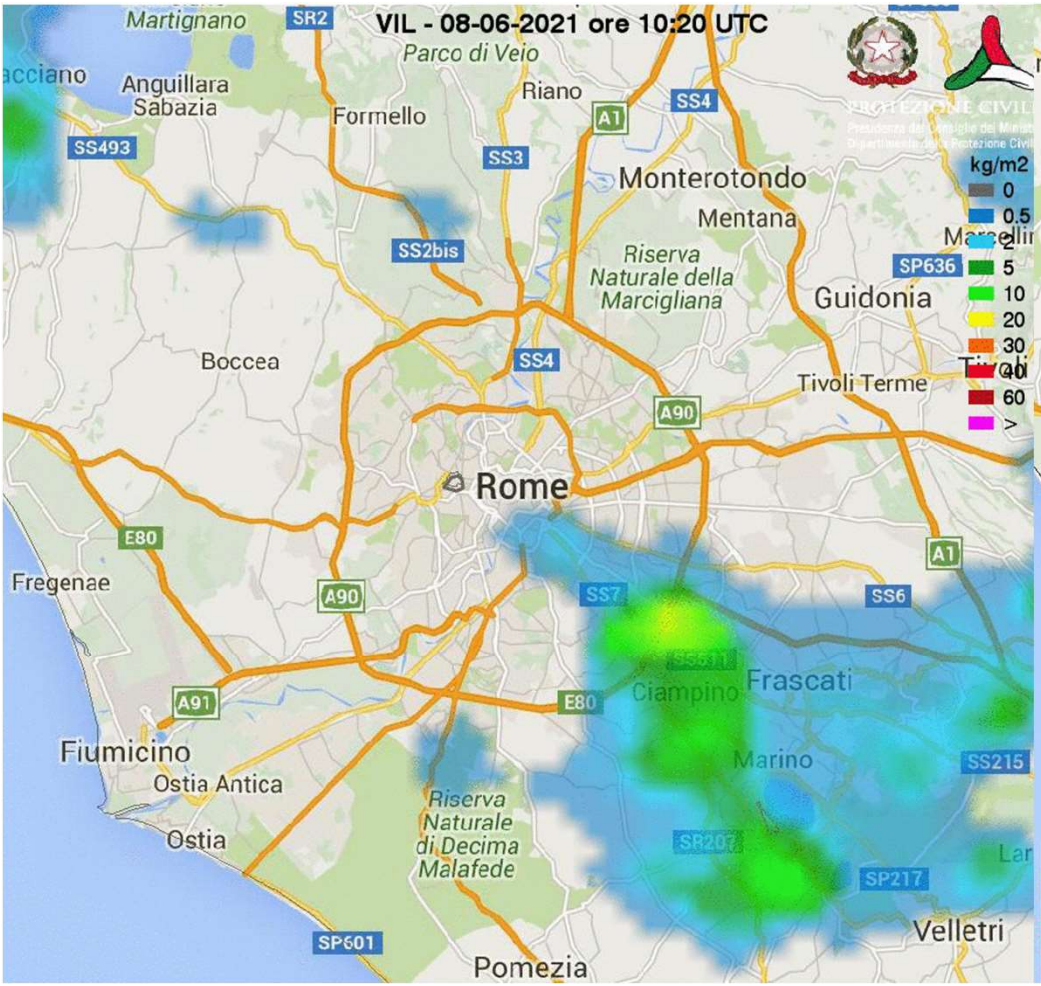
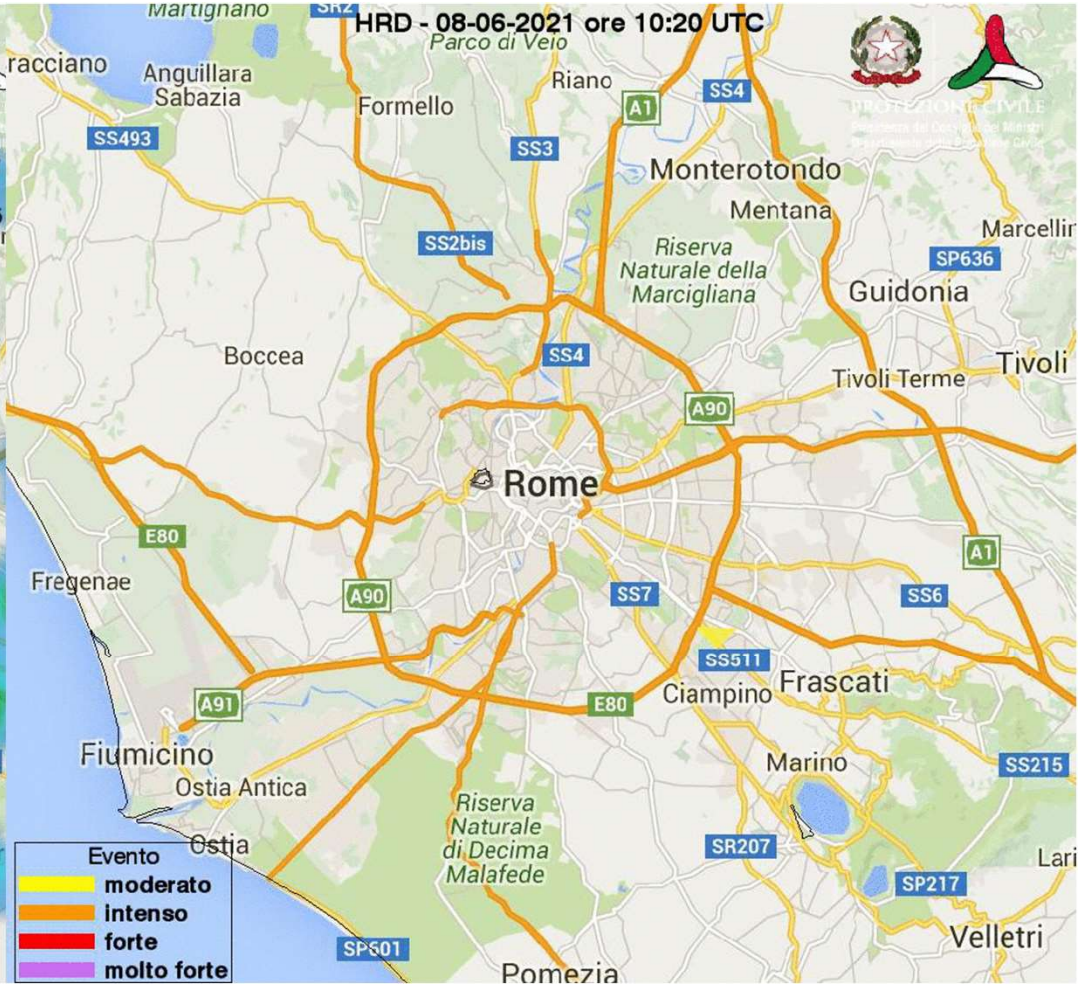




FLOOD FORECASTING AND RISK ASSESSMENT

flood warning process – hydro forecasts products

WMO Technical Regulations Vol. III – Hydrology

3.4.1.1 ***Based on the users' needs, hydrological forecasts products of different nature and lead time should be delivered****. These should reflect various forecast ranges:*
(a) - Flash flood forecasts and warnings for periods of up to several hours;
(b) Short-term hydrological forecasts and warning that are generally understood to cover periods up to three days;
(c) Medium range hydrological forecasts and warnings providing lead times of up to 10 days;
(d) Sub-seasonal to seasonal forecasts and outlooks beyond 10 days, providing descriptions of hydrological conditions for given periods.
NOTE: The defined temporal extents of hydrological forecast and warning ranges are indicative ***and differ for individual basins based on their response time*** *and the persistence of the effect of initial hydrological conditions.*

However, it has to be noted that **focus is put on users needs**, as stated in section 3.3

Members should identify users and understand their needs and requirements for hydrological forecasts and warnings in their decision-making practices. Users' needs and requirements should be reflected in the hydrological forecast products, their lead time, associated uncertainty, issuance frequency, form of communication, etc

WMO OMM

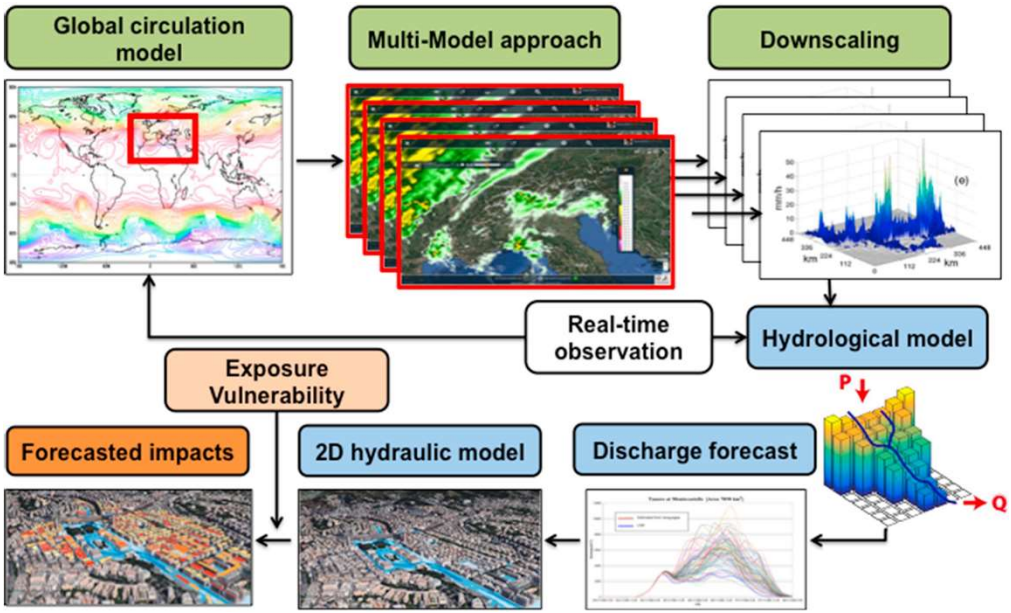
Flood forecasting technique selection

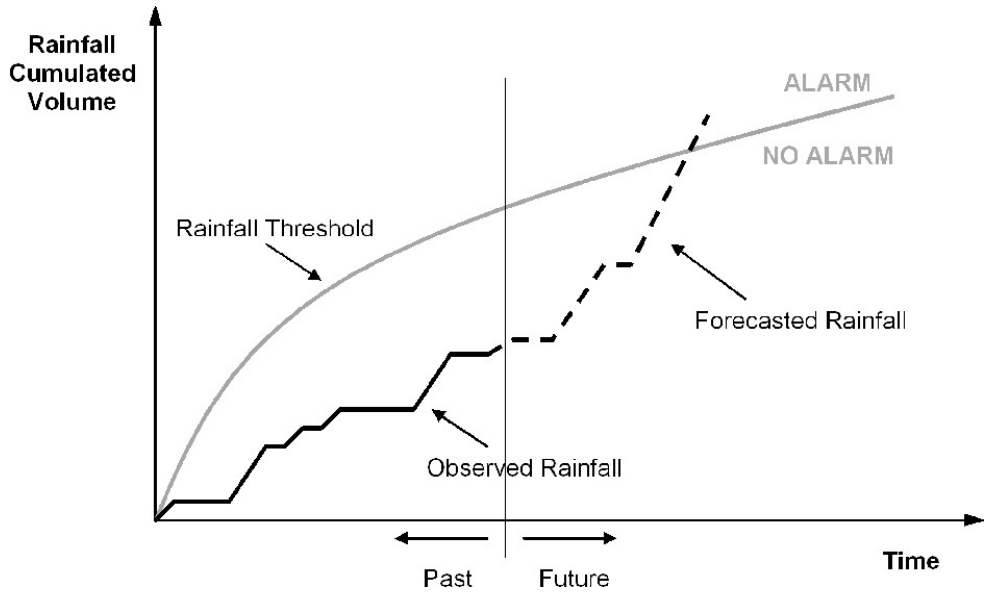
Furthermore, concerning the selection of forecasting techniques:

"*In selecting a forecasting technique, the hydrological forecasting service should take into account the forecast needs (hydrological variable, forecast lead time), the characteristics of the system, the data available (and their availability in real time or at adequate latencies), the resources available and, amongst others, the experience obtained through investigations and intercomparison of techniques.* ***A parsimonious approach should be preferred, especially in hydrological forecasting services at their initial stages of development, giving priority to simple low data-demanding models/techniques of low computational burden***".

Flood forecasting technique selection

As explained in the Manual on Flood Forecasting and Warnings (WMO No. 1072) It can **vary from advanced application** (real time forecast of flooded area and impacts) to **basic application** (parsimonious approach: precursors threshold system on predefinied alert areas, especially for short response time basins)





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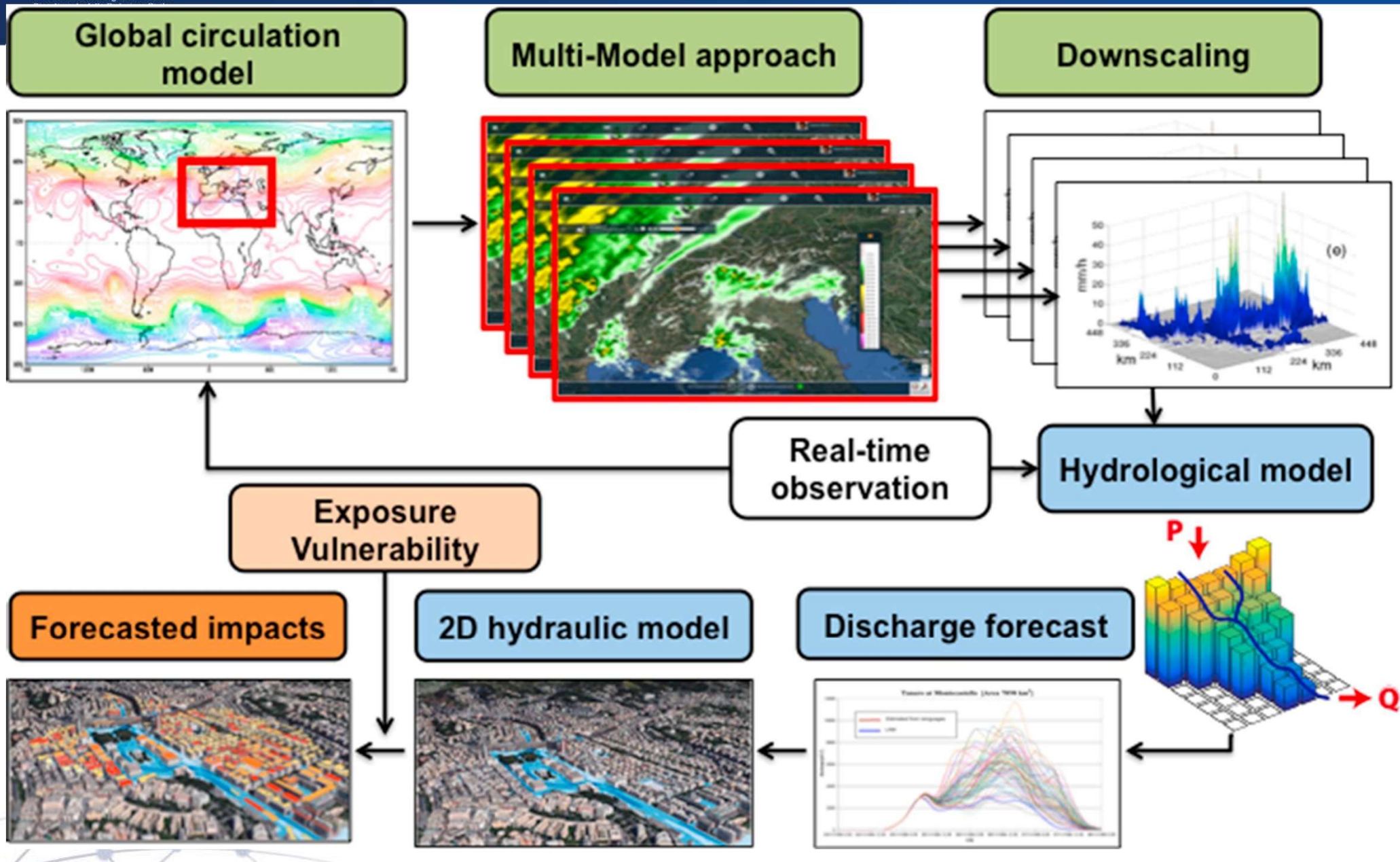
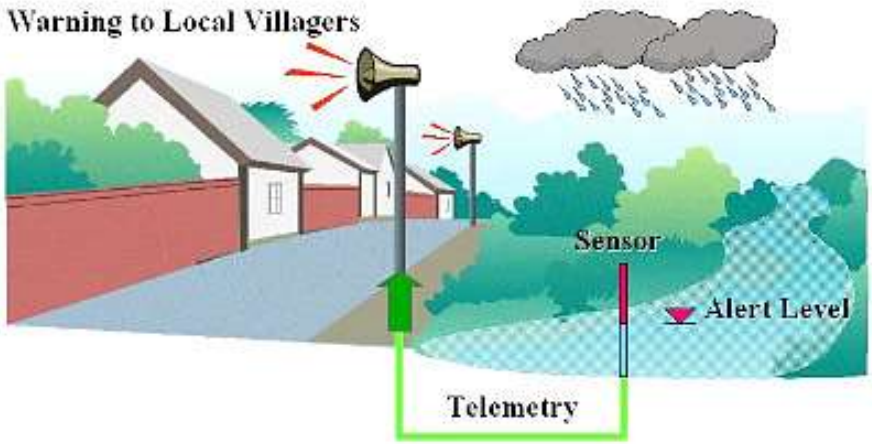
Flood forecasting: advanced model



Flood forecasting: basic model

A **parsimonious approach can be based on a precursors thresholds system**. The **flood precursors** (intended as the value of a parameter significant for the triggering of a hazardous event) **can be the hydrometric levels or the rainfall amounts (observed or predicted) depending on the requested forecasting lead time that is a crucial point for civil protection**. Thus, the concept of lead time needs to be flexible, and the minimum time may be entirely dependent on the catchment structure and the forecasting and warning system facilities.



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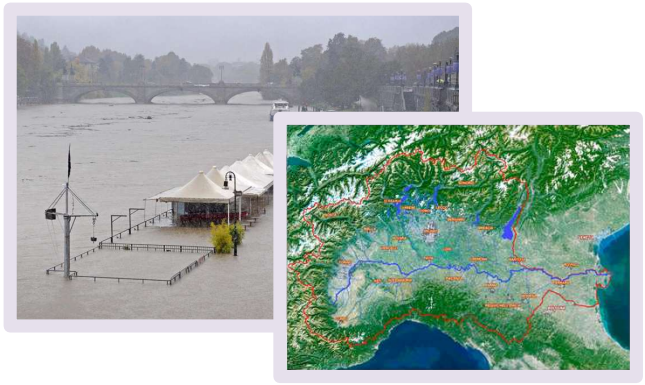
Lead time:
predictability and response capacity

Quiliano creek, 22 sept 1992

Basin's response time and predictability

The bigger the basin, the bigger the predictability capacity

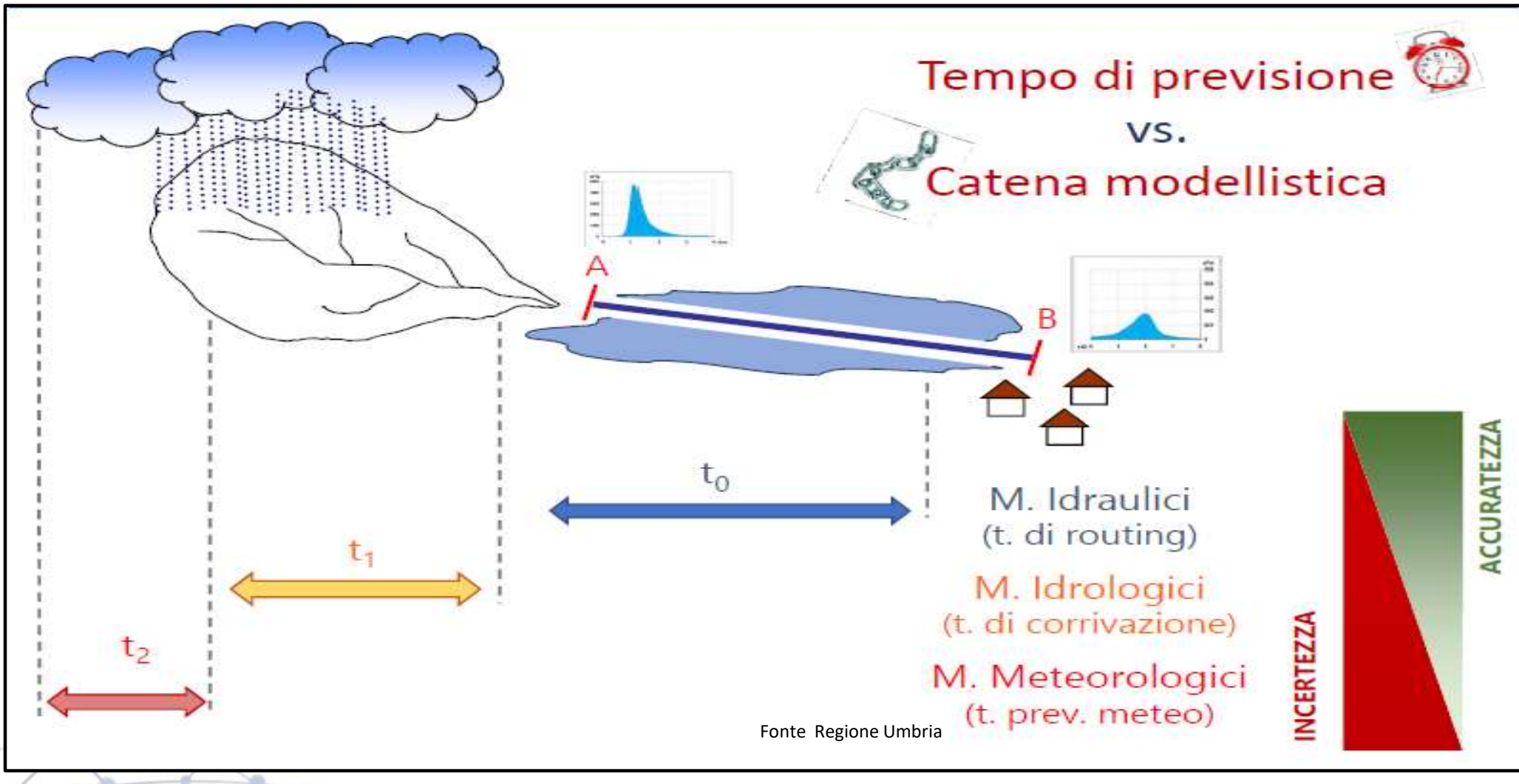
time of concentration Period of time required for storm runoff to flow to the outlet from the point of a drainage basin having the longest travel time.



Large catchments: water level raises slowly
(t_c several hours-days)

Small catchments: watel level raises rapidly
(t_c minutes-few hours)

Predictability and lead time



Fonte Regione Umbria

Precursors and basin characteristics Vs uncertainty

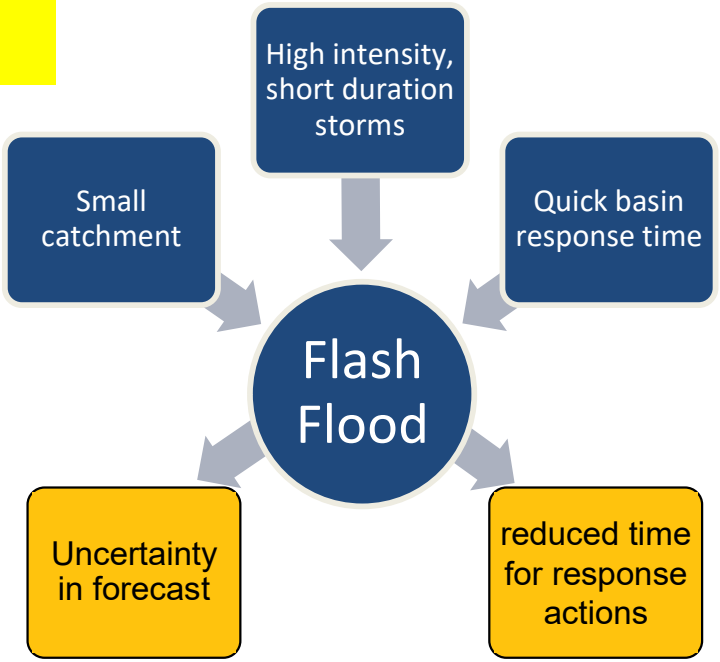
Critical flow for catchments :

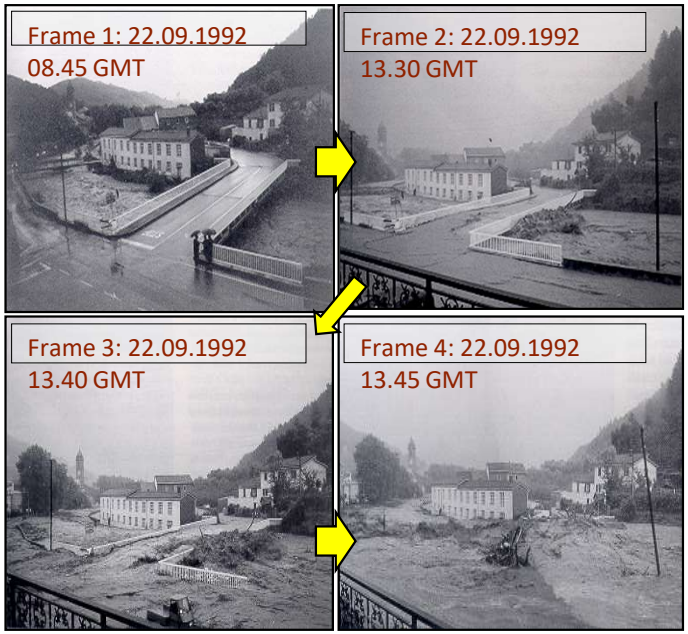
Small size	Medium size	Large size
Area<10 Km2	10<A<1000 Km2	A>1000 Km2

Event precursors :	Meteorological (NWP/Satellites/Radar)	Rain gauges	River gauges

Rapid onset phenomena

- Short time of concentration
- High content of transported sediment
- High velocity flow

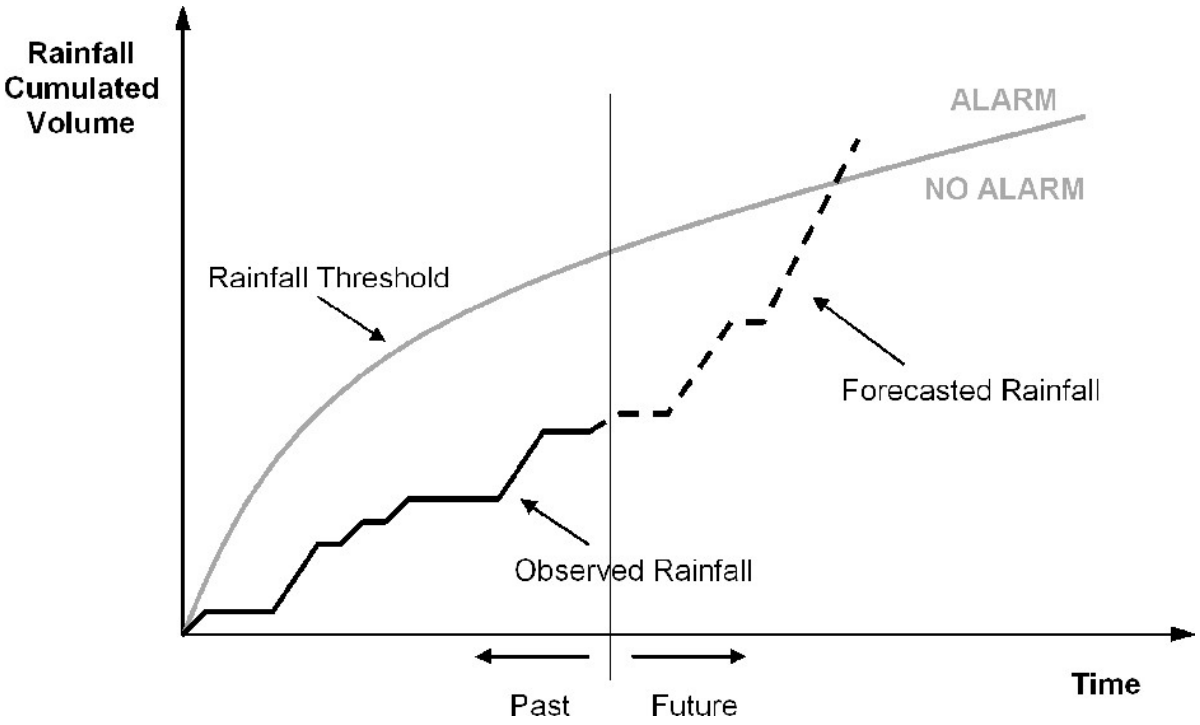




Damage due to combination of water level and flow velocity

Rainfall-threshold early warning system

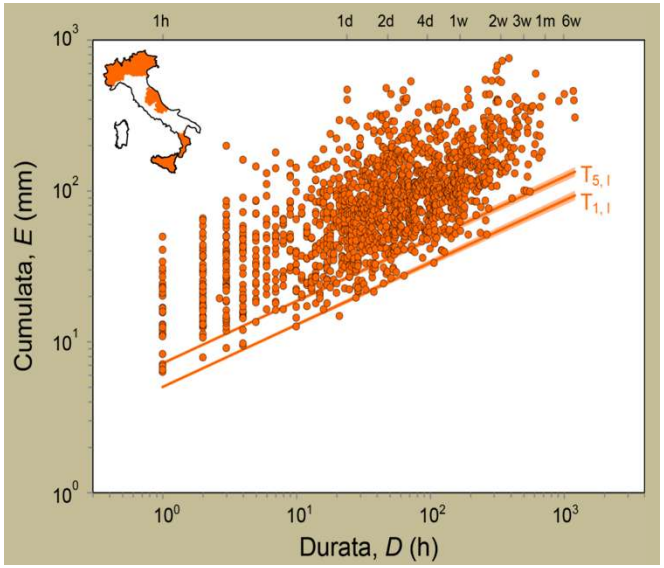
A simple warning system, applicable to the whole national territory, in the Mediterranean area, characte rized by intense meteorological phenomena, and short response time basins (area <400 skm), **can be based on the comparison of Quantitative Precipitation Forecast with a set of rainfall thresholds** that identifies precipitation critical values concerning landslides and/or flood occurrence, to support emission of warnings with sufficient lead time.

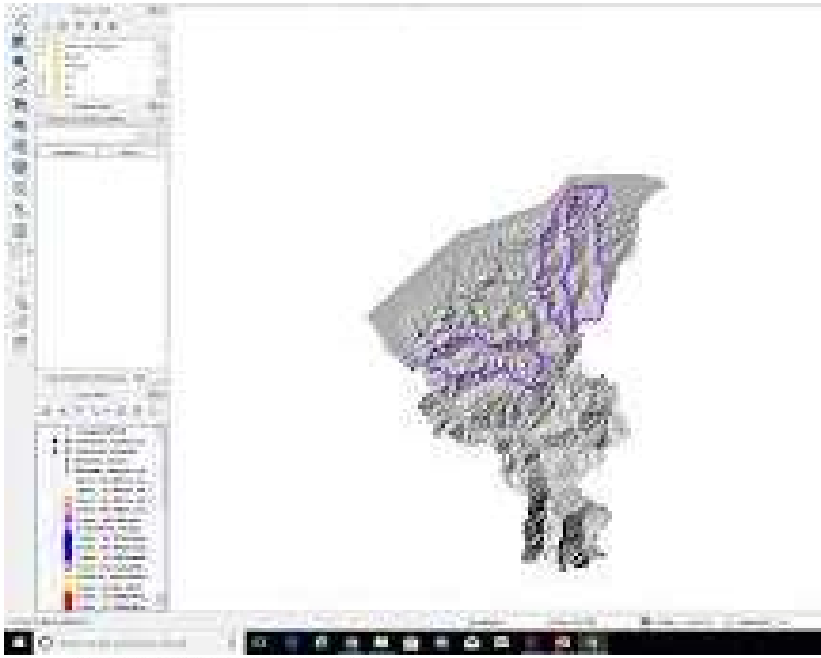


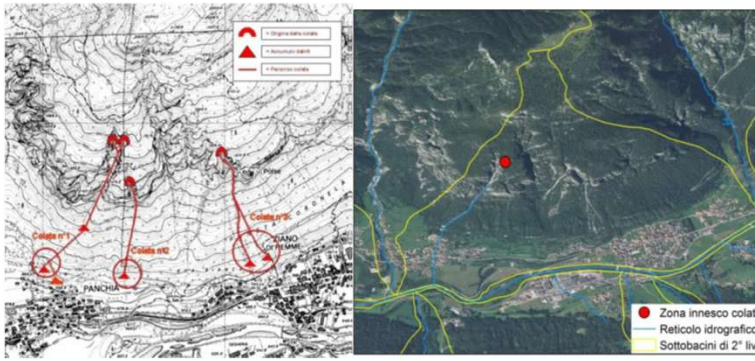
Rainfall-threshold definition

The definition of a rainfall threshold can be based

- on a "**physical" basis** (conceptual or physically based models)
- on an **empirical (statistical) basis**.

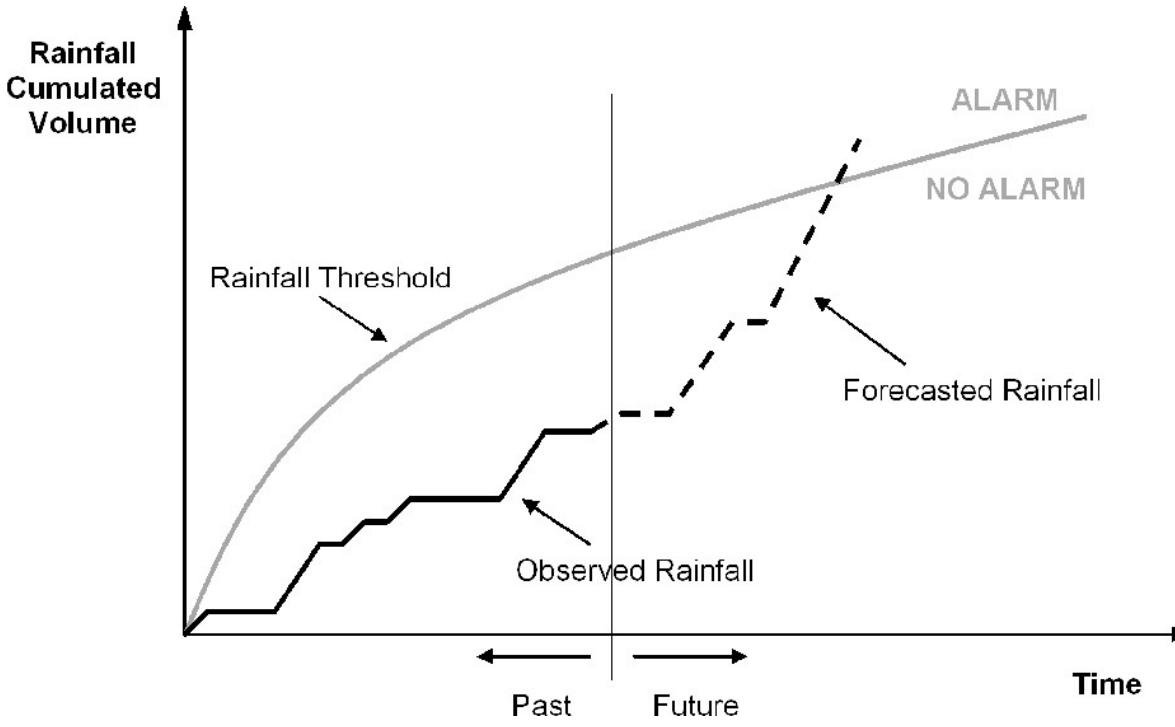






Rainfall-threshold correlation with risk scenarios

A very important phase consists in defining the **levels of attention and the alarm thresholds that these indicators can assume**, which they are strictly linked to the vulnerable conditions of the territory and **must take into account the risk scenarios that the system intends to monitor and predict.**



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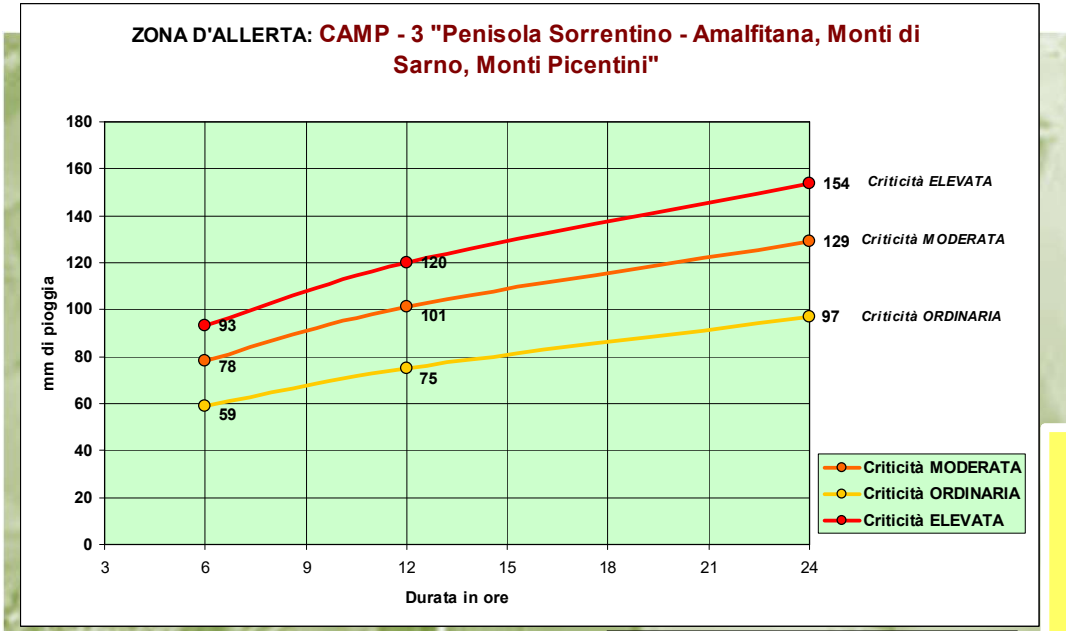
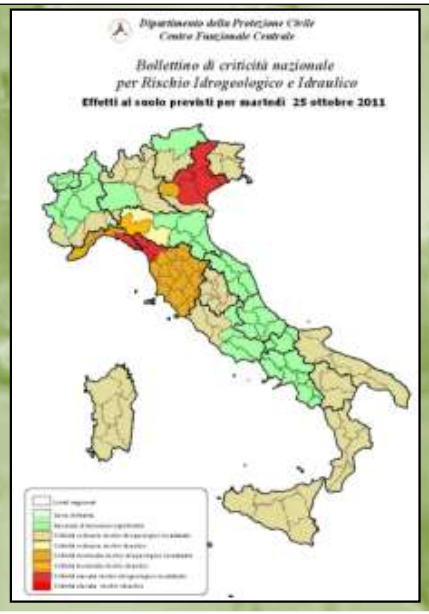
Predefinied risk scenario approach





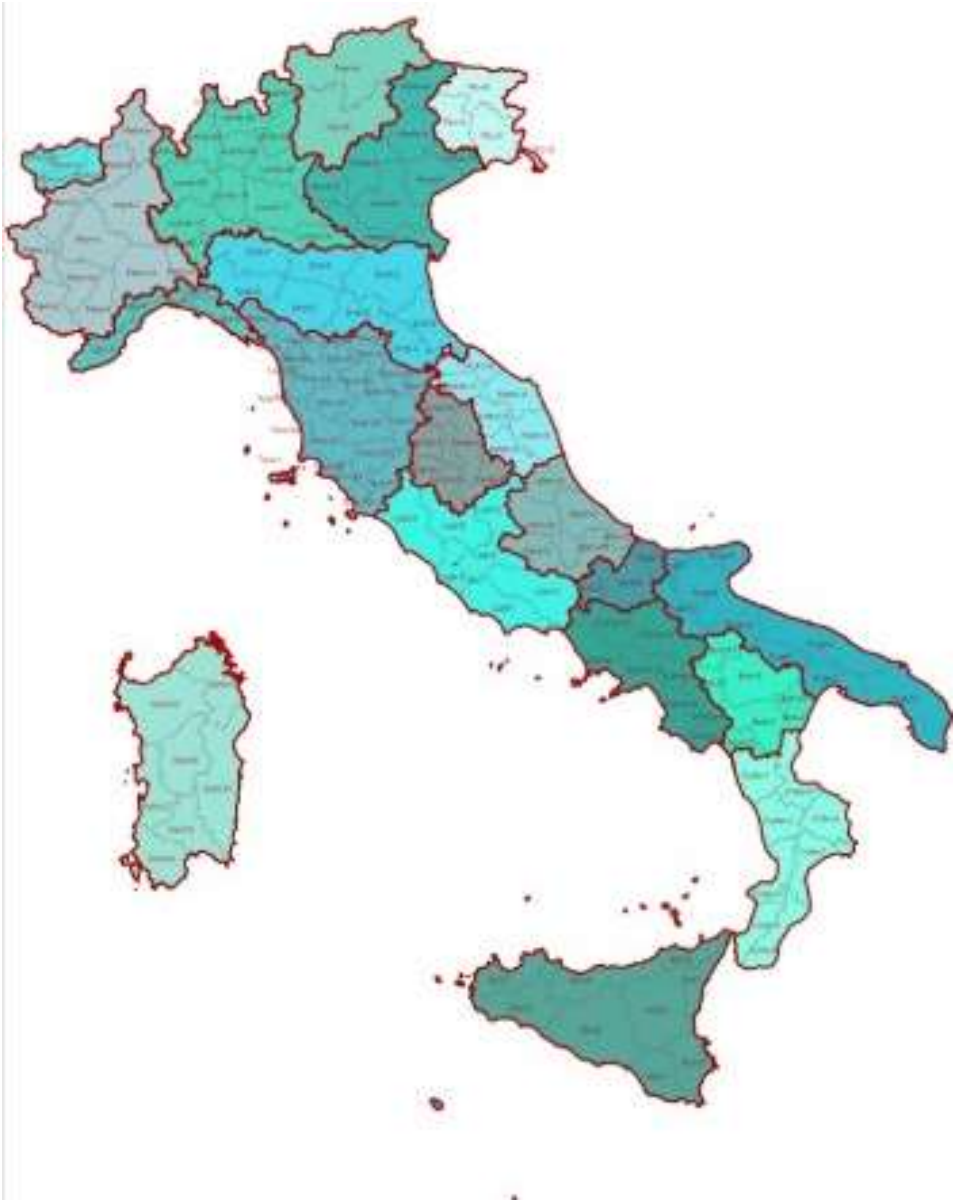
Yellow code(flooding of basements, temporary and punctual traffic problems near small watershed due to surface runoff phenomena, accidental loss of life)

Orange code(temporary and punctual traffic problems, damages to individual buildings or to small towns affected by slopes instability, damages to agricultural activities, industrial and residential areas situated in floodplains, accidental loss of life and possible widespread damage to people)

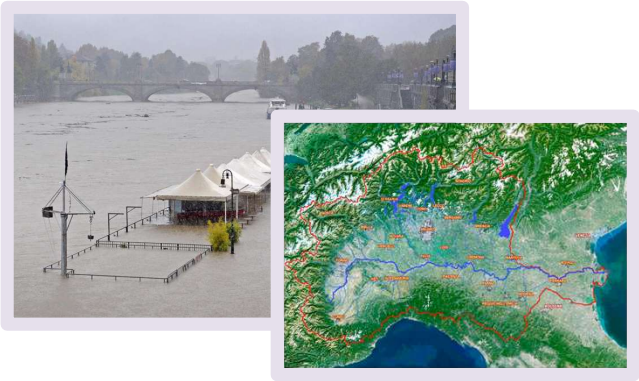
Red code(damages to agricultural activities, industrial and residential areas situated near rivers and streams, damage or destruction of towns, possible loss of life or serious injury to people)

Alert zones identification

Identification of distinct areas, within a large region, which have **similar hydrological characteristics.**



Relationship of precipitation with durations



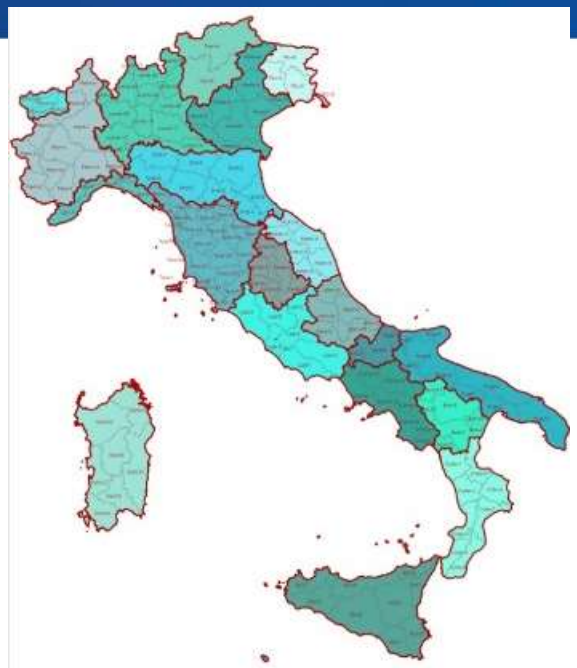
hydrographic basins of different extension produce a maximum peak hydrogram - called critical, in correspondence of different precipitation durations: more extensive basins are critically stressed by prolonged precipitation over time, while smaller basins have a shorter critical duration.

To have a general tool it is therefore necessary to have one locally (alert zones) general relationship between extreme rainfall and their duration

Rainfall-threshold definition on empirical basys

At each alert zone can be associated a system (several duration) of rainfall threshold

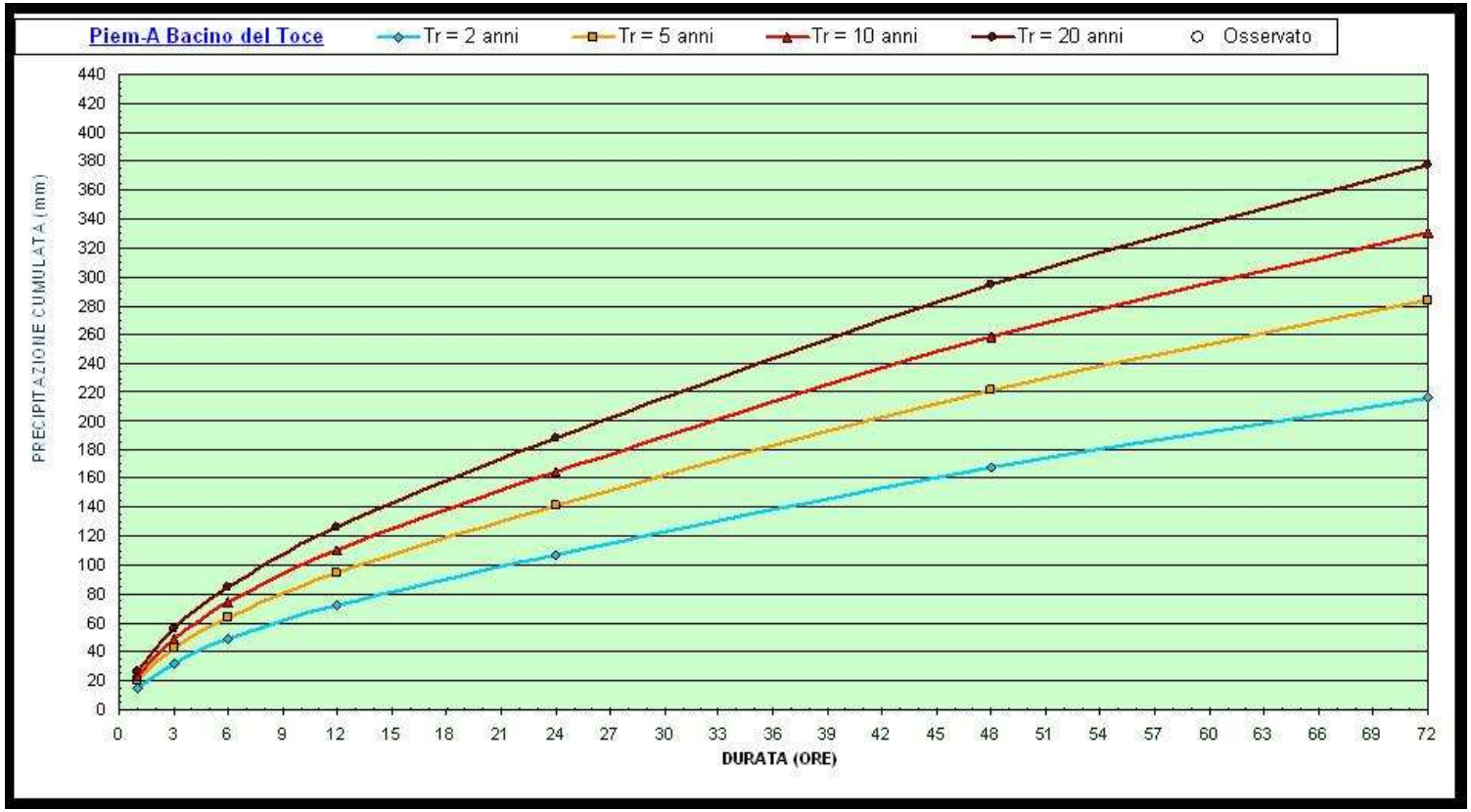
1) Use of probability distribution models that provide rainfall values of assigned return time, used as reference thresholds
2) Cause-effect analysis of past events (contingency matrix).
3) Areal threshold can be derived by puctual by using a areal reduction factor



Criticità		Stato del suolo UMIDO					Stato del suolo SECCO				
		H01	H03	H06	H12	H24	H01	H03	H06	H12	H24
GEO-A1 GEO-A2 GEO-A3	Ordinaria	16,8	27,2	37,6	53,6	75,2	22,4	36,0	49,6	70,4	97,6
	Moderata	21,0	34,0	47,0	67,0	94,0	28,0	45,0	62,0	88,0	122,0
	Elevata	28,0	45,0	62,0	88,0	122,0	38,0	62,0	84,0	118,0	162,0
GEO-H1 GEO-H2 GEO-H3	Ordinaria	23,2	30,4	37,6	53,6	75,2	30,4	40,8	49,6	70,4	97,6
	Moderata	29	38	47	67	94	38	51	62	88	122
	Elevata	38	51	62	88	122	52	69	84	118	162
GEO-B1 GEO-B2	Ordinaria	20,0	28,8	39,2	54,4	74,4	26,4	39,2	51,2	71,2	96,8
	Moderata	25,0	36,0	49,0	68,0	93,0	33,0	49,0	64,0	89,0	121,0
	Elevata	33,0	49,0	64,0	89,0	121,0	45,0	66,0	87,0	120,0	161,0
GEO-C	Ordinaria	20,8	28,8	36,8	48,8	64,0	27,2	38,4	48,0	63,2	82,4
	Moderata	26,0	36,0	46,0	61,0	80,0	34,0	48,0	60,0	79,0	103,0
	Elevata	34,0	48,0	60,0	79,0	103,0	46,0	64,0	81,0	105,0	137,0
Vene-D	Ordinaria	18,4	24,8	29,6	36,0	43,2	25,6	33,6	39,2	47,2	56,8
	Moderata	23,0	31,0	37,0	45,0	54,0	32,0	42,0	49,0	59,0	71,0
	Elevata	32,0	42,0	49,0	59,0	71,0	43,0	58,0	67,0	80,0	96,0
Vene-E	Ordinaria	21,6	28,8	34,4	43,2	53,6	28,8	38,4	45,6	56,0	69,6
	Moderata	27,0	36,0	43,0	54,0	67,0	36,0	48,0	57,0	70,0	87,0
	Elevata	36,0	48,0	57,0	70,0	87,0	49,0	65,0	77,0	94,0	117,0
Vene-F	Ordinaria	23,2	30,4	36,8	46,4	58,4	30,4	40,8	48,0	60,8	76,0
	Moderata	29,0	38,0	46,0	58,0	73,0	38,0	51,0	60,0	76,0	95,0
	Elevata	38,0	51,0	60,0	76,0	95,0	52,0	69,0	82,0	101,0	127,0
Vene-G	Ordinaria	24,8	36,0	47,2	63,2	84,0	33,6	48,0	61,6	83,2	108,8
	Moderata	31,0	45,0	59,0	79,0	105,0	42,0	60,0	77,0	104,0	136,0
	Elevata	42,0	60,0	77,0	104,0	136,0	57,0	82,0	105,0	139,0	182,0

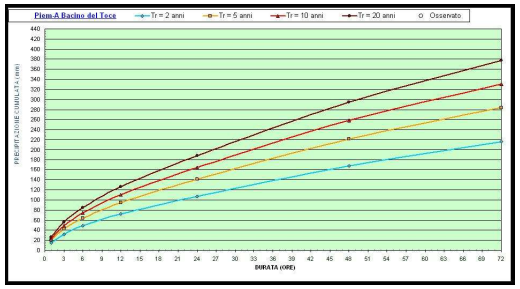
Punctual Rainfall-threshold definition on empirical basys

(1) curve that gives the relationship between duration t and height of precipitation h with assigned return time T



Punctual Rainfall-threshold definition on empirical basys

2)Cause-effect analysis of past events (contingency matrix).

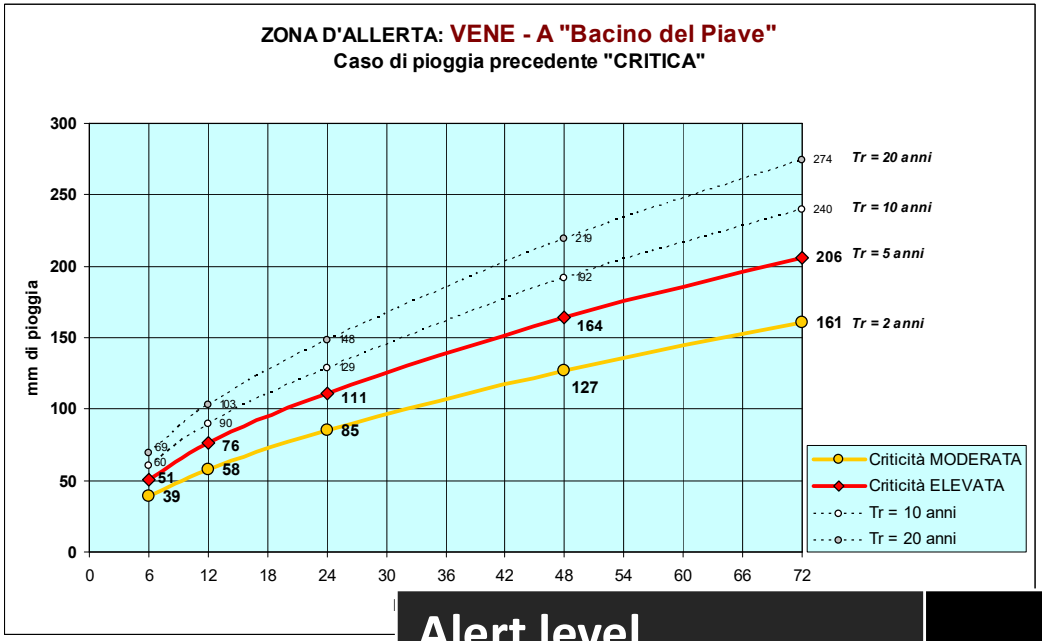


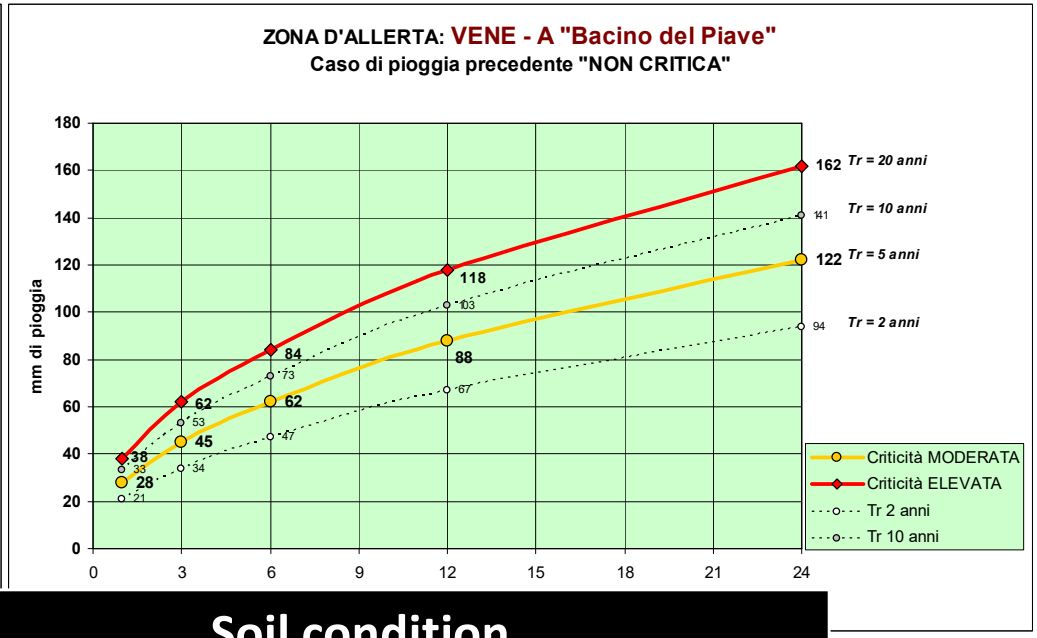
	Threshold overpassed	Damage (low,high)
Missed alarm	no	yes
False alarm	yes	no
hit	Yes (no)	Yes (no)

→TR : min $\Phi = p_1 * MA_{(TR)} + p_2 * FA_{(TR)}$

Punctual Rainfall-threshold definition on empirical basys

The results obtained for the pilot **regions are very similar**. For this reason it was decided as a first instance to extend the data obtained to all the other Regions.





Alert level	Soil condition	
	Not saturated	saturated
Orange (low damage)	5	2
Red (high damage)	20	5

Punctual Rainfall-threshold definition on empirical basys

Criticità		Stato del suolo UMIDO					Stato del suolo SECCO				
		H01	H03	H06	H12	H24	H01	H03	H06	H12	H24
GEO-A1 GEO-A2 GEO-A3	Ordinaria	16,8	27,2	37,6	53,6	75,2	22,4	36,0	49,6	70,4	97,6
	Moderata	21,0	34,0	47,0	67,0	94,0	28,0	45,0	62,0	88,0	122,0
	Elevata	28,0	45,0	62,0	88,0	122,0	38,0	62,0	84,0	118,0	162,0
GEO-H1 GEO-H2 GEO-H3	Ordinaria	23,2	30,4	37,6	53,6	75,2	30,4	40,8	49,6	70,4	97,6
	Moderata	29	38	47	67	94	38	51	62	88	122
	Elevata	38	51	62	88	122	52	69	84	118	162
	Ordinaria	20,0	28,8	39,2	54,4	74,4	26,4	39,2	51,2	71,2	96,8
	Moderata				68,0	93,0	33,0	49,0	64,0	89,0	121,0
	Elevata				89,0	121,0	45,0	66,0	87,0	120,0	161,0
GEO-C	Ordinaria	20,8	28,8	36,8	48,8	64,0	27,2	38,4	48,0	63,2	82,4
	Moderata	26,0	36,0	46,0	61,0	80,0	34,0	48,0	60,0	79,0	103,0
	Elevata	34,0	48,0	60,0	79,0	103,0	46,0	64,0	81,0	105,0	137,0
Vene-D	Ordinaria	18,4	24,8	29,6	36,0	43,2	25,6	33,6	39,2	47,2	56,8
	Moderata	23,0	31,0	37,0	45,0	54,0	32,0	42,0	49,0	59,0	71,0
	Elevata	32,0	42,0	49,0	59,0	71,0	43,0	58,0	67,0	80,0	96,0
Vene-E	Ordinaria	21,6	28,8	34,4	43,2	53,6	28,8	38,4	45,6	56,0	69,6
	Moderata	27,0	36,0	43,0	54,0	67,0	36,0	48,0	57,0	70,0	87,0
	Elevata	36,0	48,0	57,0	70,0	87,0	49,0	65,0	77,0	94,0	117,0
Vene-F	Ordinaria	23,2	30,4	36,8	46,4	58,4	30,4	40,8	48,0	60,8	76,0
	Moderata	29,0	38,0	46,0	58,0	73,0	38,0	51,0	60,0	76,0	95,0
	Elevata	38,0	51,0	60,0	76,0	95,0	52,0	69,0	82,0	101,0	127,0
Vene-G	Ordinaria	24,8	36,0	47,2	63,2	84,0	33,6	48,0	61,6	83,2	108,8
	Moderata	31,0	45,0	59,0	79,0	105,0	42,0	60,0	77,0	104,0	136,0
	Elevata	42,0	60,0	77,0	104,0	136,0	57,0	82,0	105,0	139,0	182,0

Alert level	Soil condition	
	Not saturated	saturated
Orange (low damage)	5	2
Red (high damage)	20	5

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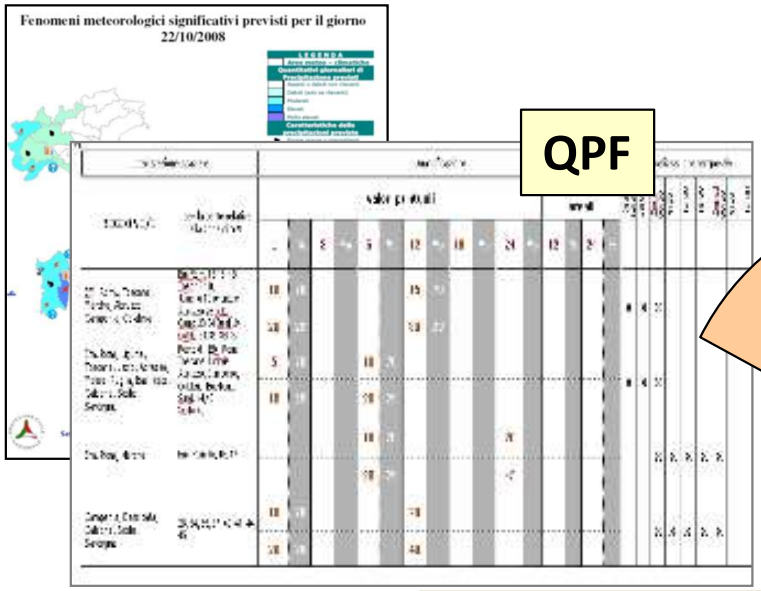
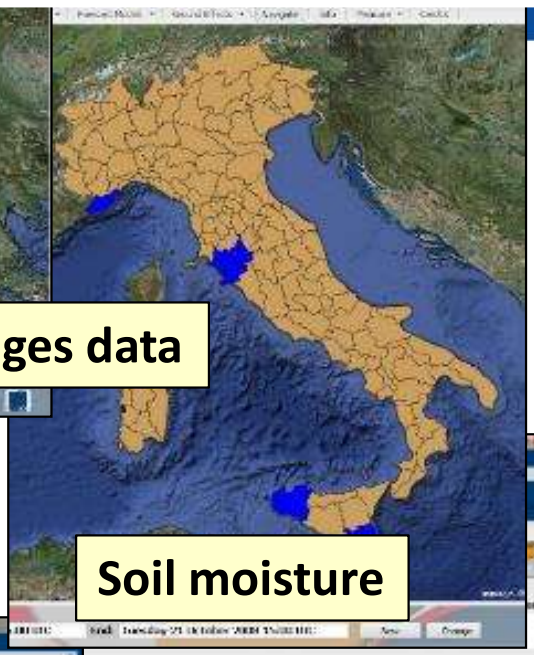
Use of Rainfall-threshold in subjective risk assessment



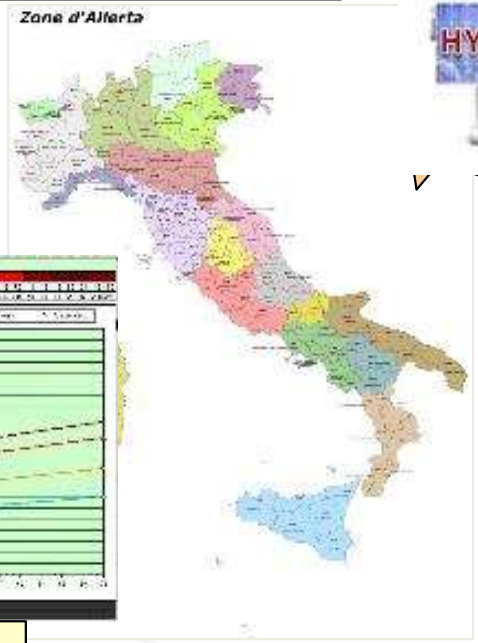
QPF

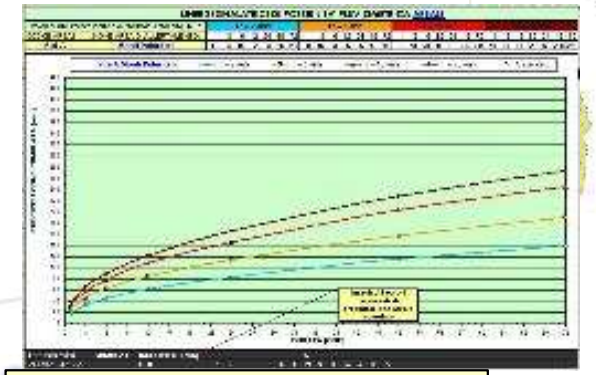
Hydro-Geo

Rain gauges data



Soil moisture





Complex thresholds

River gauges data

snowmelt

landslides

The basic rainfall-trigger approach for national scale assessment

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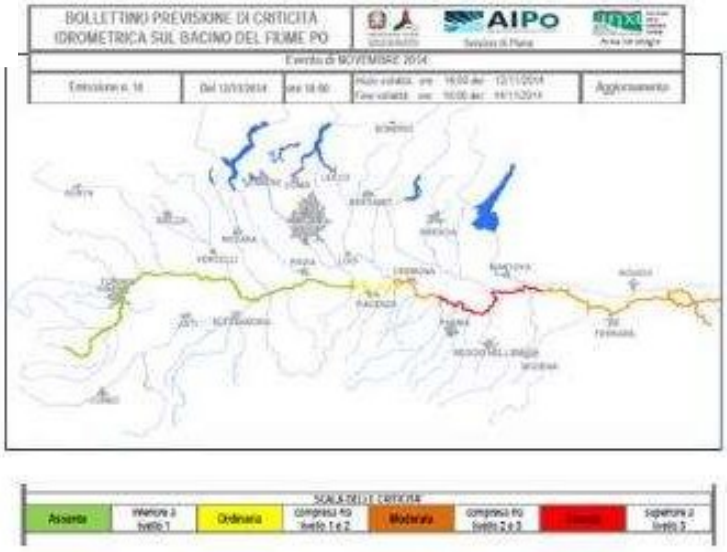
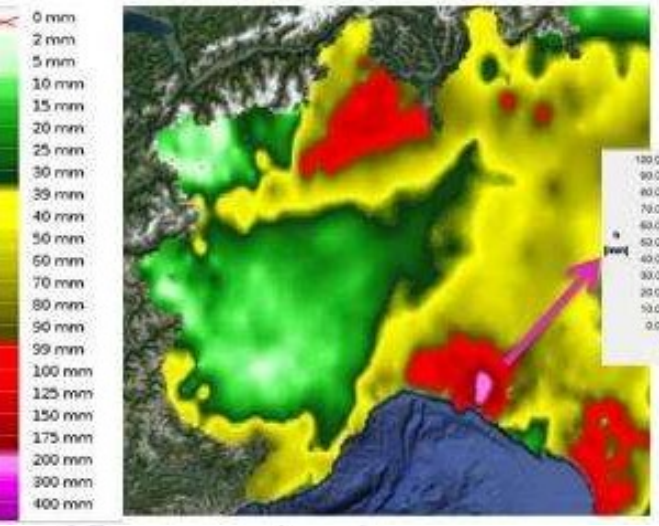
FORECAST PHASE

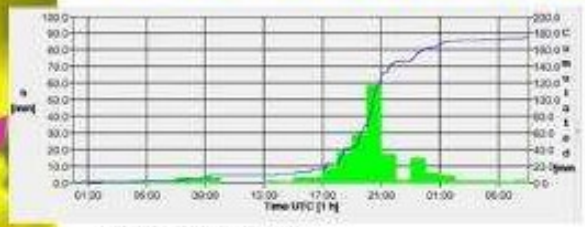
Forecast for the Centa river performed by CF of Liguria Region on 14° Nov for the day after (source CF-ARPA Liguria)

Bollettino di criticità
November 15th, 2014



MONITORING PHASE





- 58,4 mm in 1 h
- 104,6 mm in 3h
- 174,8 mm in 24 h

Correlation with contingency plans

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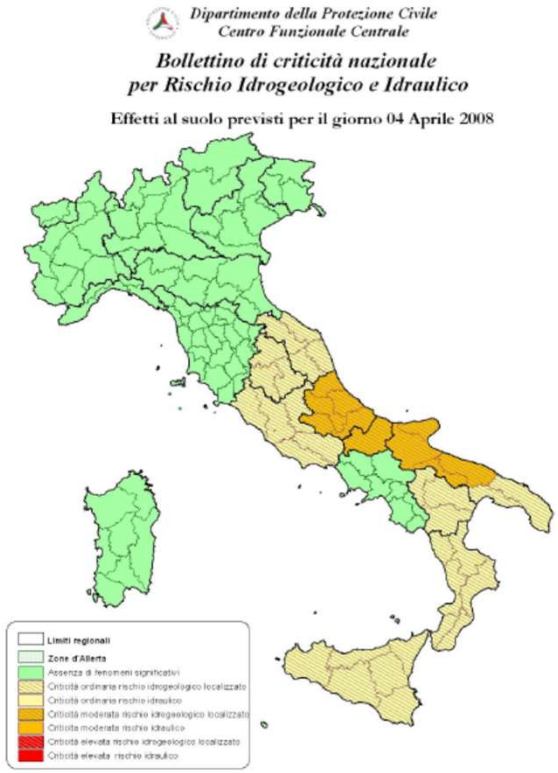


Warning → activation of operative response in real time at different territorial levels

REAL TIME risk assessment

NATIONAL EARLY WARNING SYSTEM– HYDRAULIC AND HYDROGEOLOGICAL RISK

Centres for forecasting and survaillance network

Central (National Civil Protection Department)

Regional (Autonomous Regions)

FORECAST
MONITORING and SURVAILLANCE

Zones in which the effects of meteorological phenomena are similar

FORECAST of SCENARIOS in ALERT ZONES
according to COMPLEX THRESHOLDS OVERCOMINGS

ORDINARY CRITICITY | MODERATE CRITICITY | HIGH CRITICITY

Criticity levels are communicated to Municipalities through warnings. They activate Emergency Plans phases

Information from territorial guards

Overcomings of thresholds related to local early warning systems

Phase of PRE-ALERT | Phase of ATTENTION | Phase of PRE-ALARM | Phase of ALARM

Attivation phases: they lead to the implementation of prevention and emergency management actions scheduled in the Plan

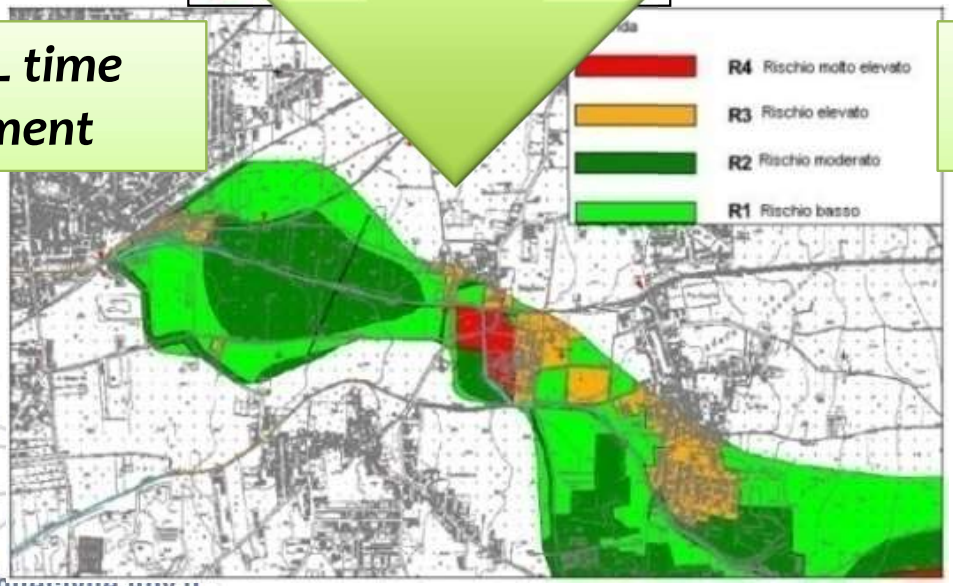
Criticity levels correspond to defined scenarios which are expected to verify on the municipality territory and which must activate the gradual answare of the Civil Protection System

Specific impact based warning at local level

REAL time assessment

Warning messages
predefined general impact scenario

NO-REAL time assessment

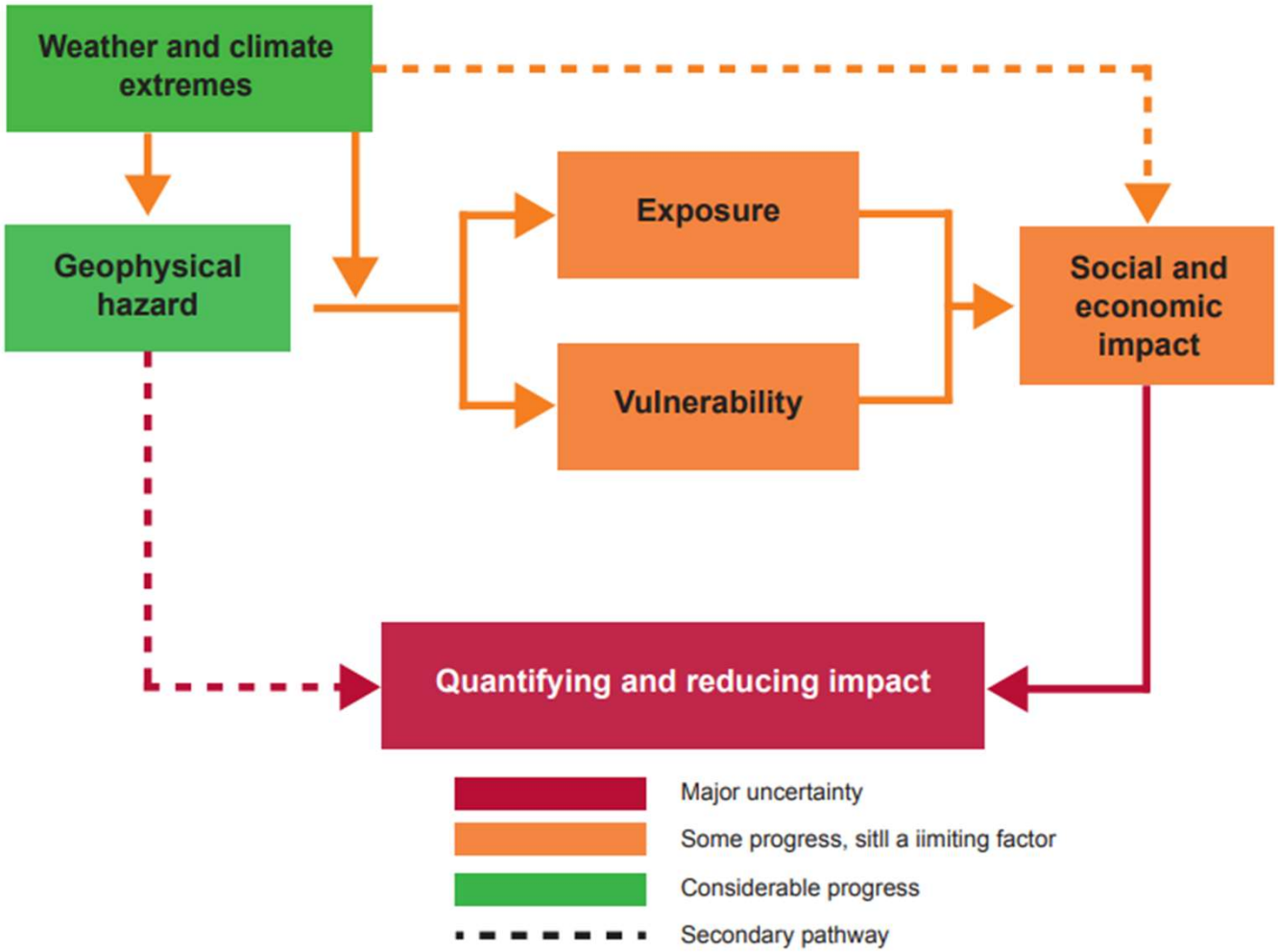


CIVIL PROTECTION PLANS

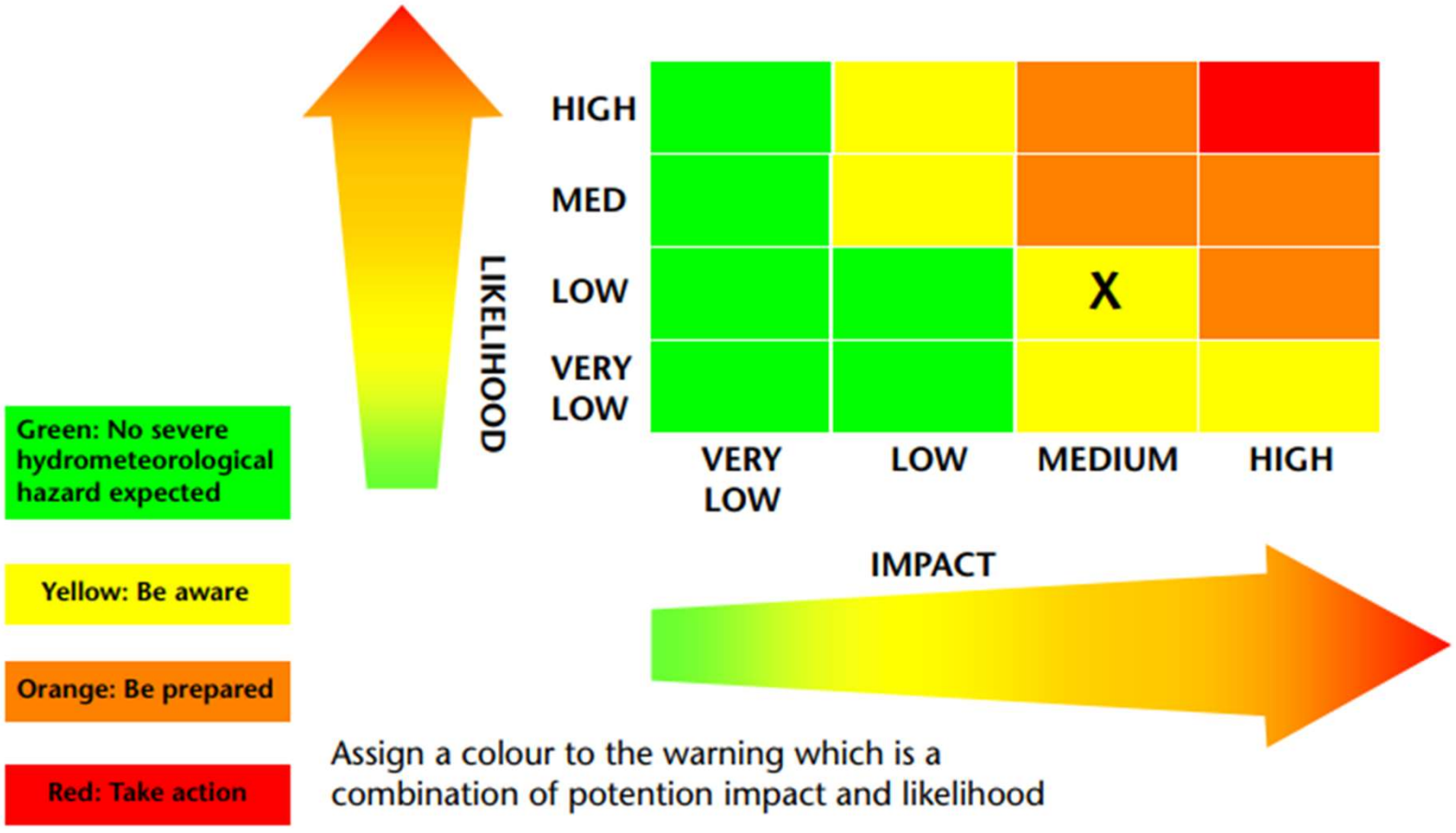
Communication to the public:

- Specific **impact** scenario (exposure, vulnerability)
- actions to mitigate risk
- safety instructions

Impact based forecasting conceptual paradigm



Operational application of impact warning concept combining impact with likelihood

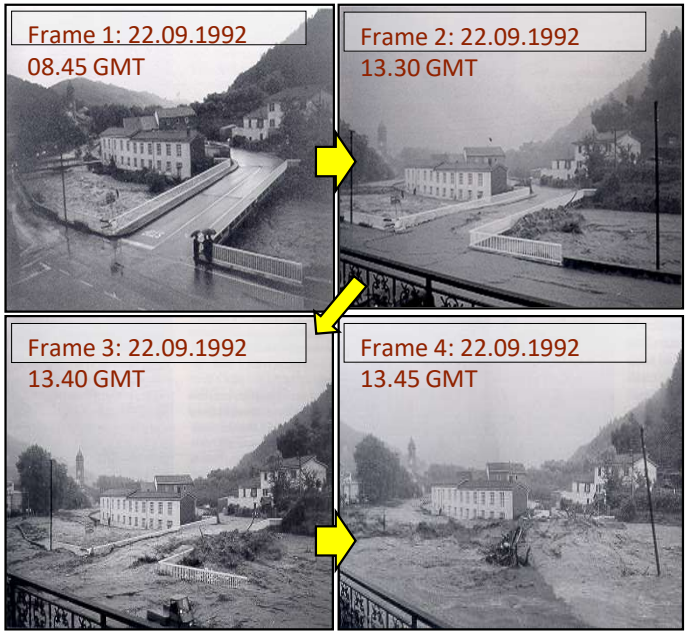


Assign a colour to the warning which is a combination of potention impact and likelihood

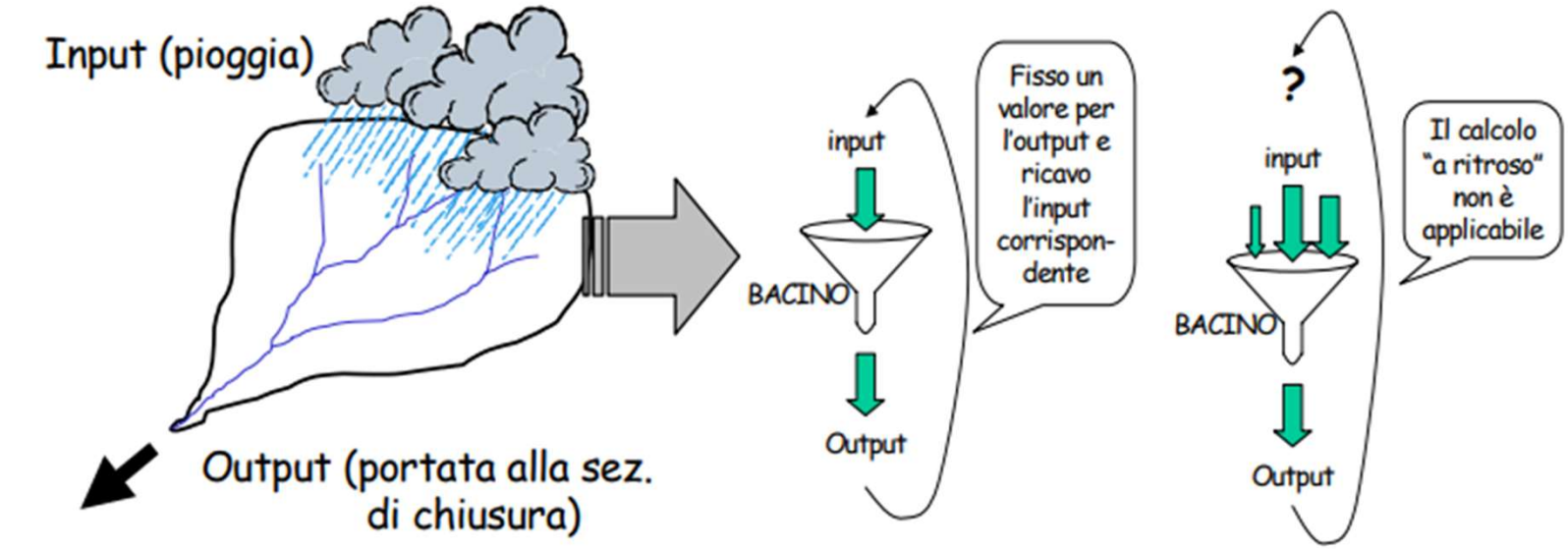
(Source: Met Office, United Kingdom)

To sum up part (1)

- Precursors, lead time, basin time of concentration, uncertainty
- Use of rainfall trigger
- Punctual precipitation threshold definition based on empirical approach
- Example of Italian system for a basic approach at national level
- Impact based forecasting : national /local level

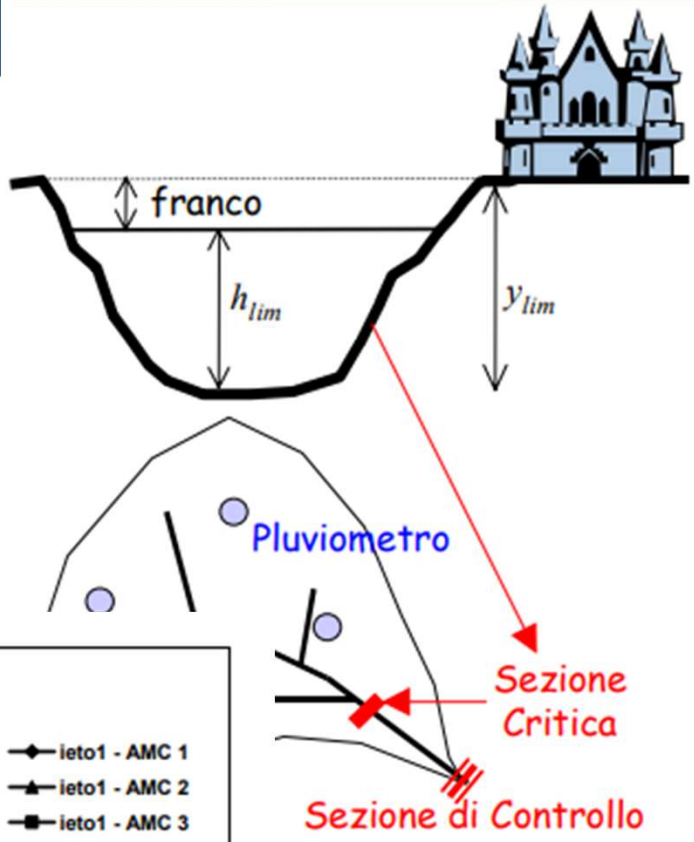


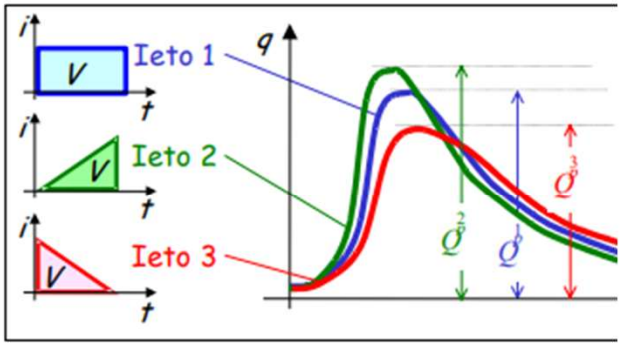
Areal rainfall thresholds based on numerical simulations

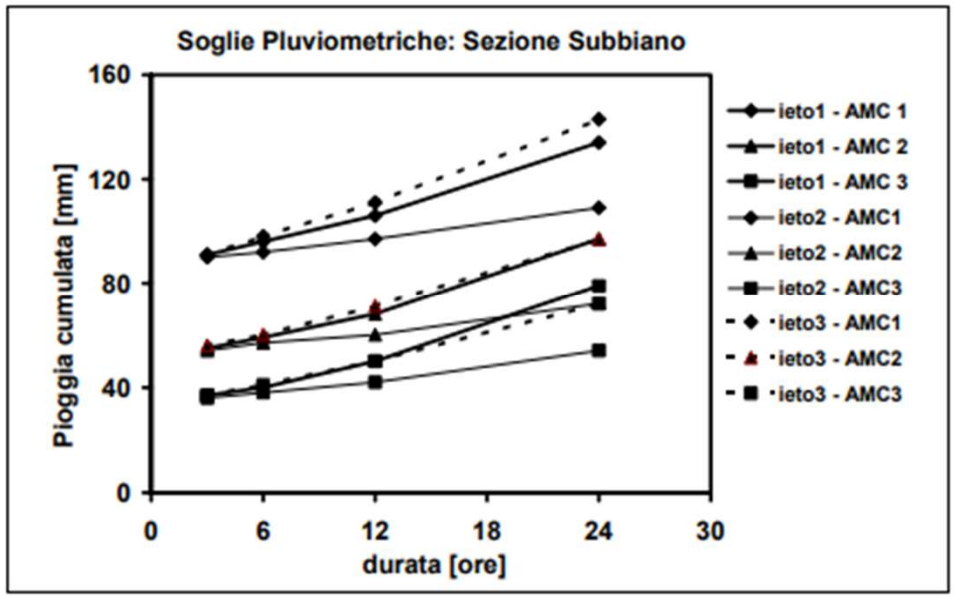


Areal rainfall thresholds based on numerical simulations

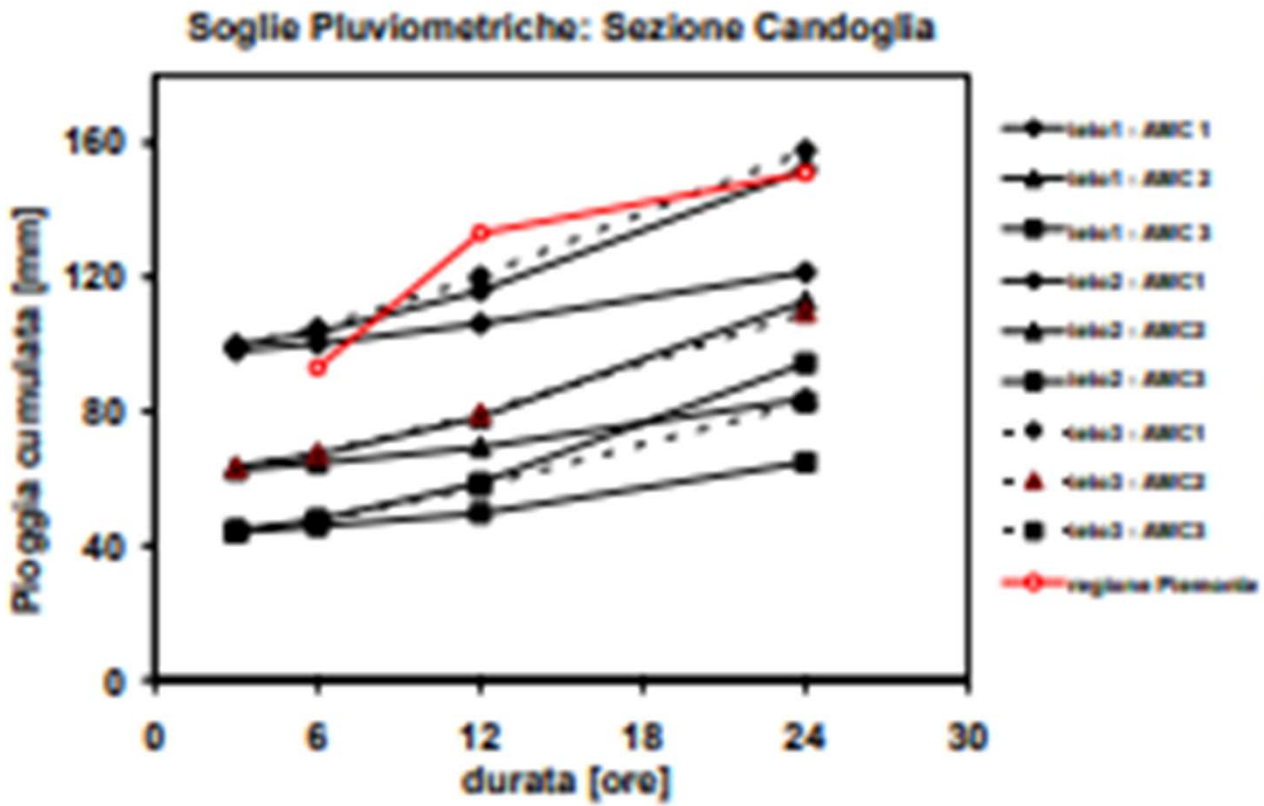
1. Identification of critical sections
2. Identification of corresponding alert discharge
3. For a given duration, ieto, AMC→numerical simulation (by using a Rainfall-runoff model) of Rainfall







Empirical vs numerical approach: comparable results



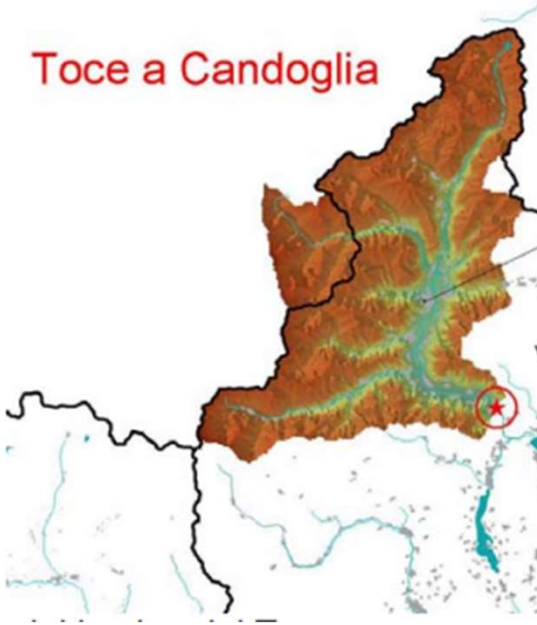
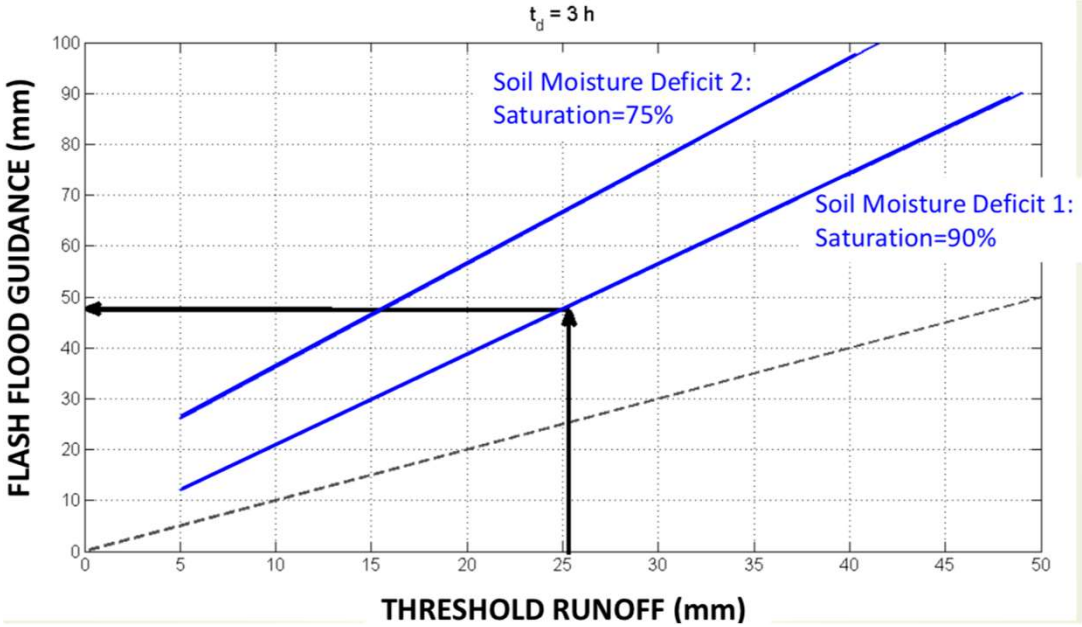


Figura 24 Confronto fra le soglie pluviometriche di preallerta idraulica (metodo numerico) per la sezione critica di Candoglia e le soglie per rischio idrogeologico moderato per l'area del Toce (metodo semiempirico).

International tools: Flash flood guidance

Flash Flood Guidance: for a given duration and the current soil moisture condition the Volume of rainfall that is just enough to cause bankfull discharge condition at the outlet of the draining stream of each basin. If this FFG amount is known, one may compare it to the forecast or nowcast rainfall of the same duration and for the same period (and other local information) to determine whether there is a risk of flash flooding in the sub-basins



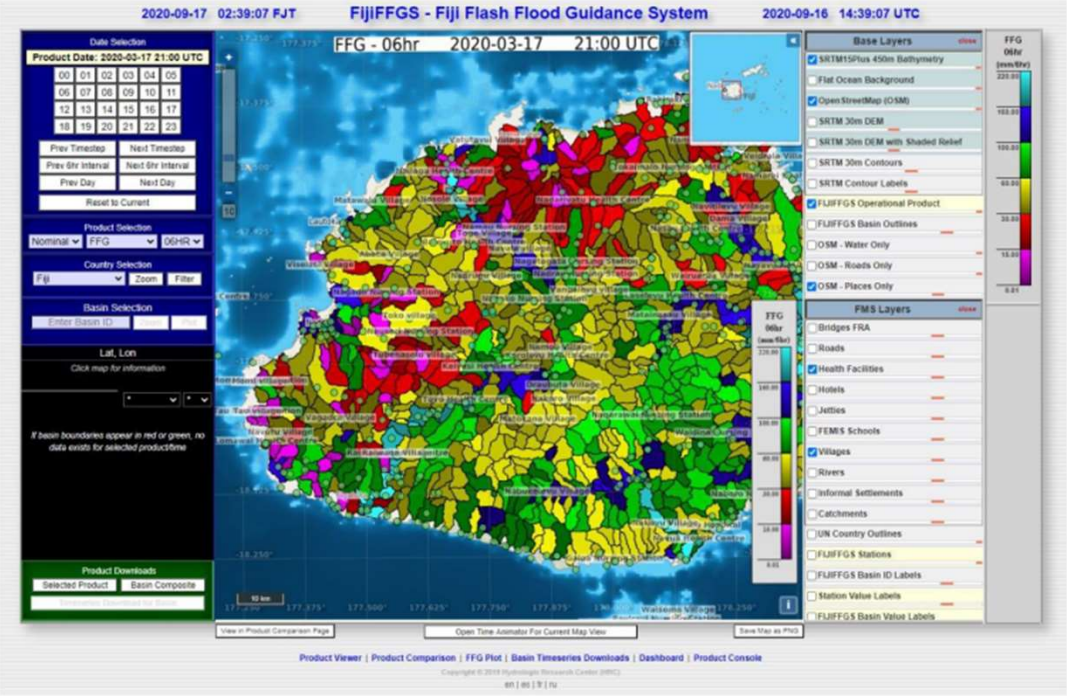
threshold runoff refers to the volume of rainfall of a given duration distributed uniformly over a small catchment that is just enough to cause bankfull discharge

International tools:Flash flood threat products

Merged MAP better areal mean rainfall estimation on a basin for several duration (1, 3, 6, 24 hours,including satellite,radar).

Flash Flood Threat FFT = MAP – FFG;

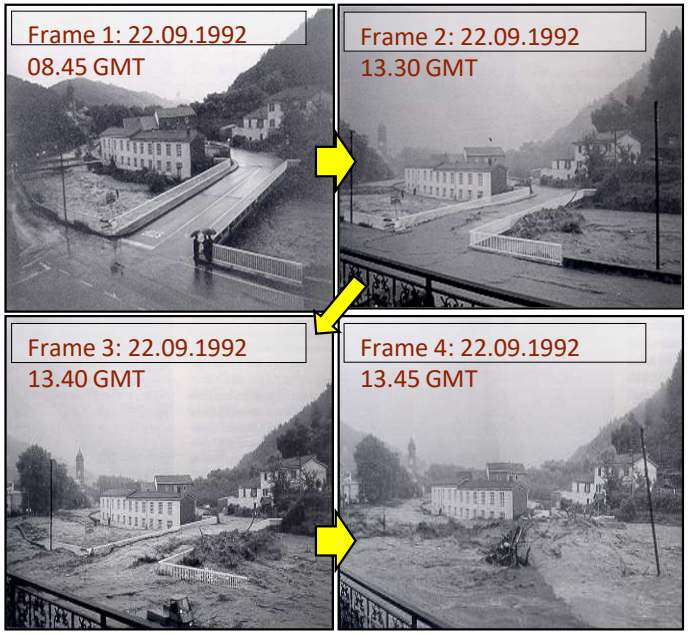
- **IFFT**: Imminent Flash Flood Threat indicates that a flash flood is happening now or is imminent,
- **PFFT**: persistent FFT is considered a forecast flash flood threat using persistence for the rainfall forecast
- **FFFT:** forecasted FFT, based on forecasted precipitation by NWP.



6-hr FFG on 17 March 2020 at *21 UTC, Viti Levu, Fiji*

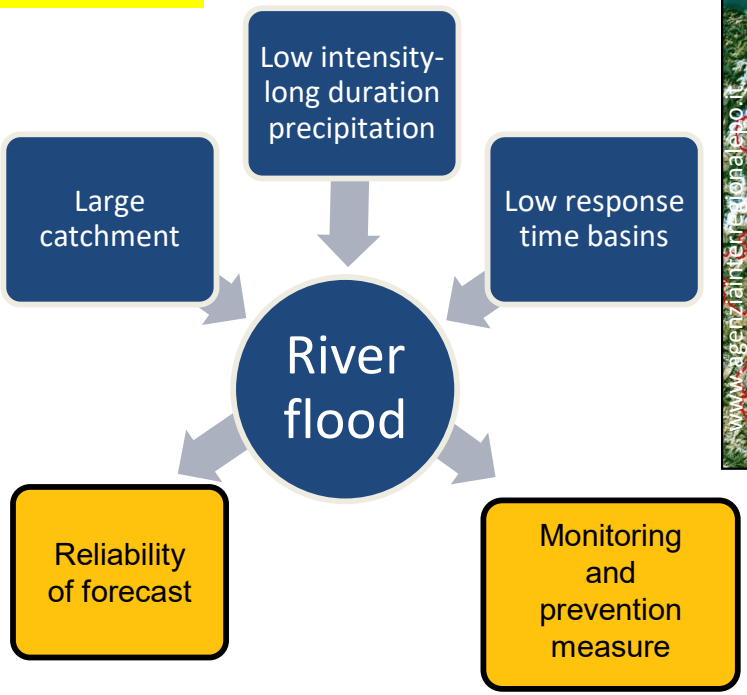
To sum up part (2)

- Areal precipitation threshold based on numerical analysis
- International tools: what is the Flash flood guidance system
- Flash flood threat products



slow onset flood phenomena

- Large catchment
- Long time of concentration



Damage mainly due to water level

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Further mechanisms of flooding (levee breaches and boils) –uncertainty factors

Rotta arginale sul Serchio, natale 2009.

Rotta arginale sul Secchia, marzo 2014.

Fontanazzo di Boara Pisani - Piena dell'Adige, Novembre 2014

Fontanazzo di Ro Ferrarese – Piena del Po, Novembre 2014

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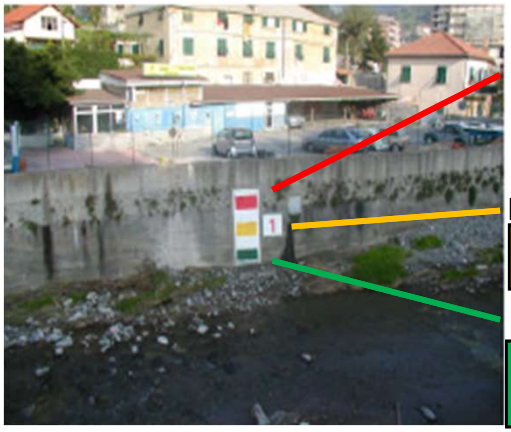
River-based threshold, local surveys and flood control

Flood risk preparedness

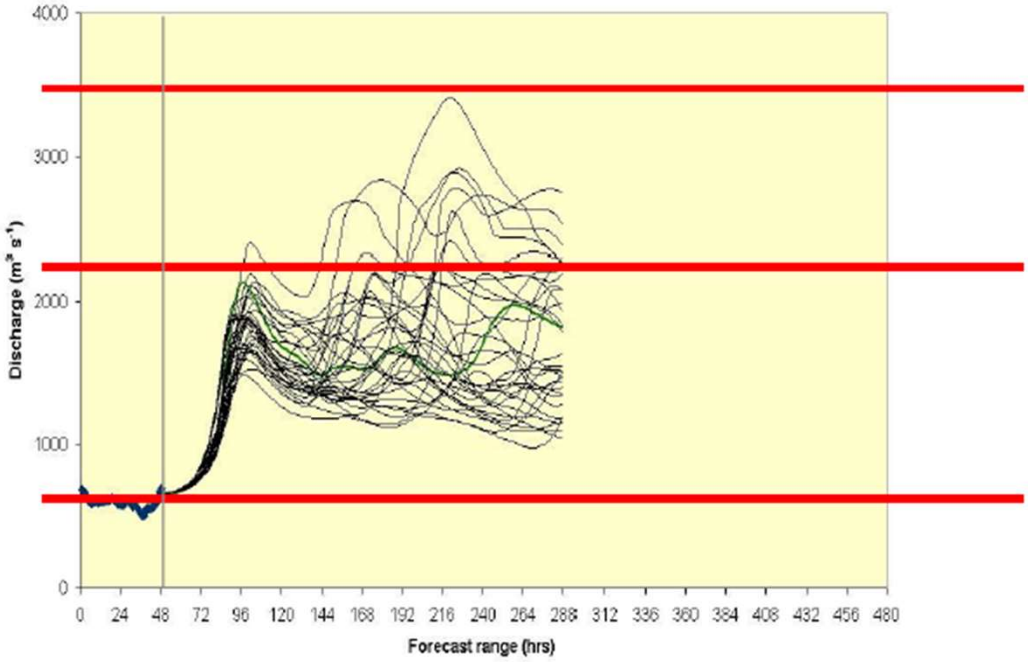


River threshold

Local surveys

Reservoir regulation for flood control

River thresholds



If the threshold for flooding is here, there is no problem

If the threshold for flooding is here, there might be a problem

If the threshold for flooding is here, there is almost certain a problem

River thresholds definition

In national institutions critical levels are often linked to "local" phenomena:

bridges overtopped

roads flooded

bankful conditions reached

Stage 1 - likely flooding to Longsfields Bridge and environs.
Stage 2 - likely flooding to the Park Rd, Mallow and Environs.
Stage 3 - the likelihood of serious flooding in Mallow.

River Blackwater

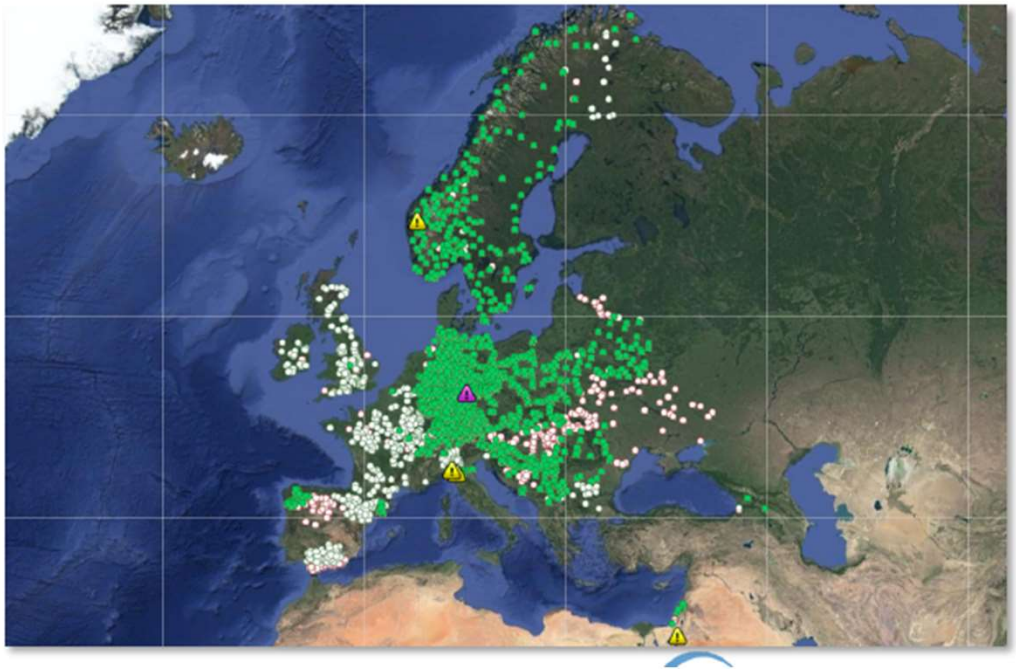
River-based threshold-generic guidelines, based on WMO manual on flood forecating and warning

(a) Early observation of the development of flooding – in this case at the borders where rivers cross from other countries;
(b) Successive monitoring points along main rivers and tributaries to identify the progress of flooding;
(c) Location of gauges at principal infrastructure points, rail bridges and ferry crossings;
(d) Detailed monitoring close to the capital city;
(e) Simple graphical forecast procedures using time-of-travel and level-to-level correlation.

International tools: national data needed for EFAS

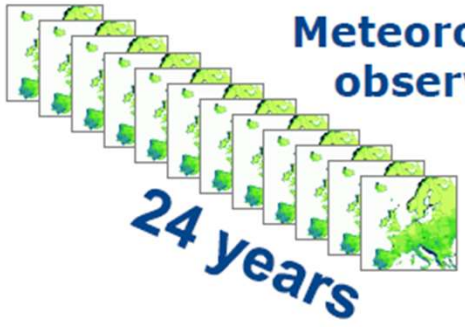
No	River basin	River	Station	ID	Lowest level	Second lowest level	Second highest level	Highest level
					(m)	(m)	(m)	(m)
1	XXX	XXX	XXX	XXX	-	-	-	-

	PURPOSE / BASIC DESCRIPTION	Return Period
Lowest level		
Second lowest level		
Second highest level		
Highest level		

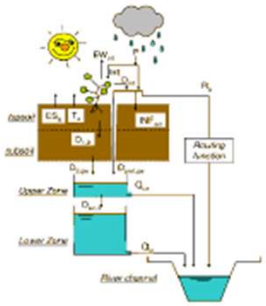


EFAS threshold based on model climatology

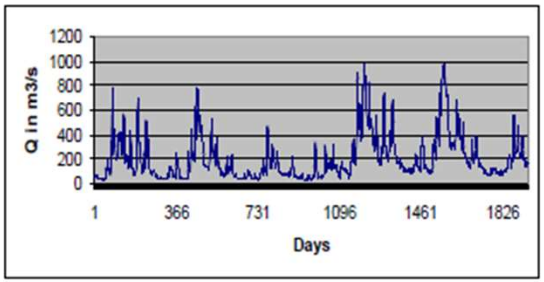
Thresholds



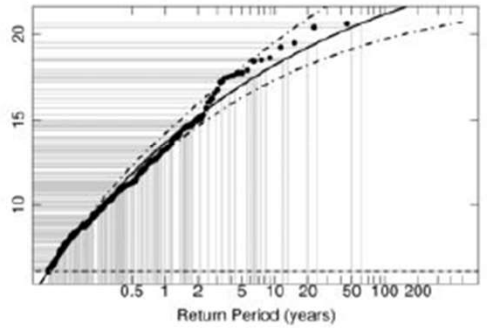
LISFLOOD



Discharge time series



Return period statistics



Thresholds (return period)

- 20
- 5
- 2
- 1.5

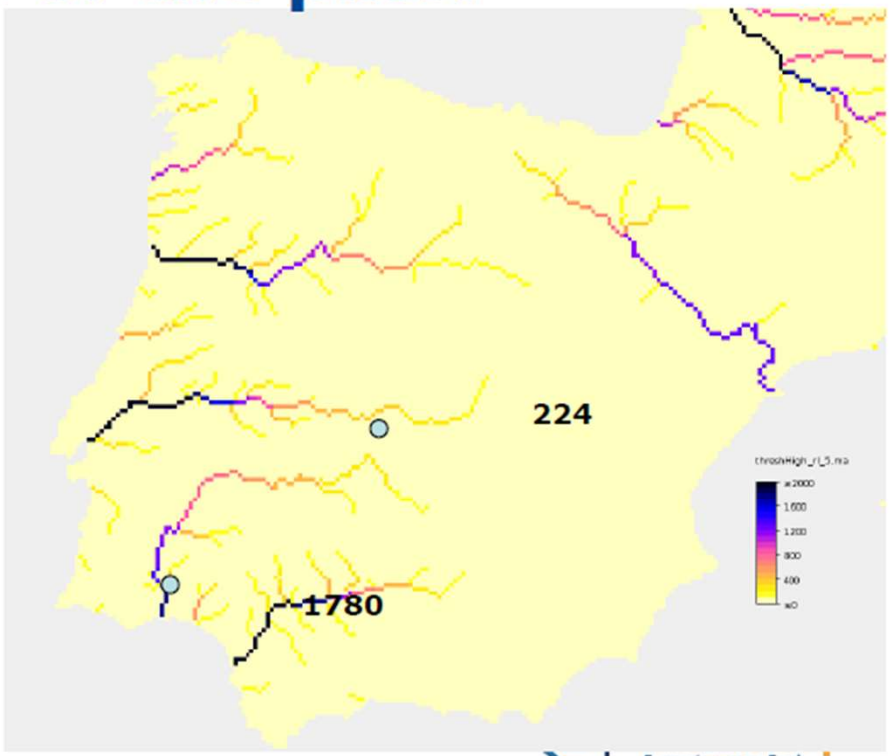
- Thresholds are derived from simulated time series.
- The same model setup and parametrisations are used in the forecasts to remain model consistency

Copernicus Europe's eyes on Earth

EFAS threshold based on model climatology

Thresholds are calculated with the same method for every pixel across Europe

SO every pixel has its own threshold derived from the local climatology of the pixel



Operator reporting: direct surveys

Early development of operator reporting of river levels and rainfall by radio, to provide rapid situation appraisal

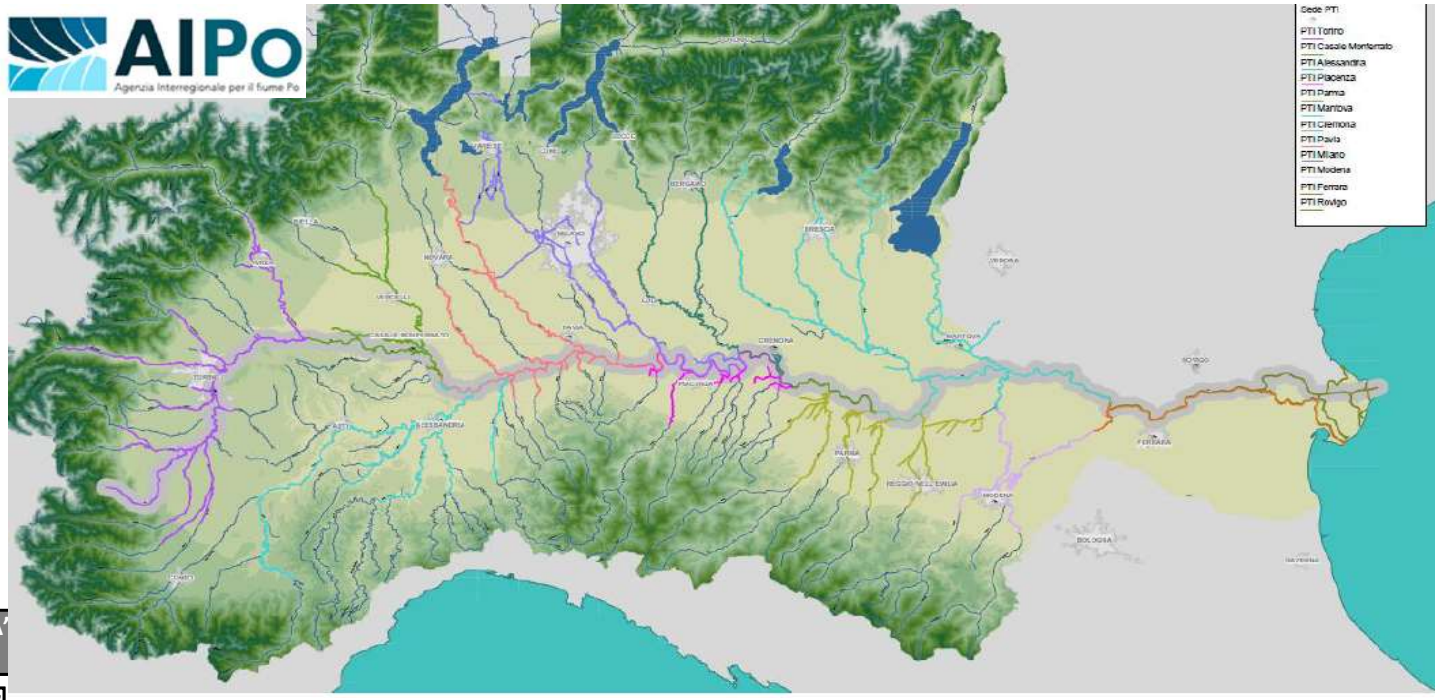
The instrumental data may be complemented with direct surveys for a better and comprehensive understanding of the hazard event manifestation and the consequent impact (i.e. the flooding event itself)

The surveillance activity should be implemented for critical points of the territory (singularity points of the watersheds sections, etc)In the monitoring phase,

. A rapid exchange of information is extremely important in order to update in real time the event and the risk scenarios.

River-based threshold and local surveys

pannello cromatico



	Presidi idraulici di primo livello	Regione	Provincia
1	Ufficio AIPo di Torino – Moncalieri	Piemonte	Torino
2	Ufficio AIPo di Casale Monferrato	Piemonte	Alessandria
3	Ufficio AIPo di Alessandria	Piemonte	Alessandria
4	Ufficio AIPo di Pavia	Lombardia	Pavia
5	Ufficio AIPo di Milano	Lombardia	Milano
6	Ufficio AIPo di Cremona	Lombardia	Cremona
7	Ufficio AIPo di Mantova	Lombardia	Mantova
8	Ufficio AIPo di Piacenza	Emilia–Romagna	Piacenza
9	Ufficio AIPo di Parma	Emilia–Romagna	Parma
10	Ufficio AIPo di Modena	Emilia–Romagna	Modena
11	Ufficio AIPo di Ferrara	Emilia–Romagna	Ferrara
12	Ufficio AIPo di Rovigo	Veneto	Rovigo

Flood monitoring and control

the possibility of implementing a **discharge regulation procedure** during floods should preliminarily be based on :

•List of **relevant reservoirs** in the territory , and identification of those that can be used to mitigate the impact of floods in case of adverse events,

•Stipulation of **agreements** between neighboring administrations (including private companies) **regarding specific procedures to be used to mitigate the impact of floods** in shared catchments. International agreements for transboundary basins are strongly recommended.

Regulating reservoir identification

Regulating Reservoir identification

a) **Specific studies on attenuation effect that the reservoir accumulated volume can have on dowstream flow**

b) **On the basys of the studies and dam regulating operational procedures, identification of REGULATING RESERVOIRS**

Preventive discharge regulation plan definition and implementation, in coordination among all stakeholders

Emergency procedure for safety of the infrastructure itself

Discharge regulation plans

- Civil defense authority
- National hydrological service
- …water authority
- Dam manager
- National authority with coordination role

Discharge attenuation plan

a) STATIC

- **Limitation of water level reservoir for critical period for flood events (cost/benefit analysis)**

b) DYNAMIC

- **Real time Prevention manouvres da to be activeted on the basys of input forecasted discharge , state of reservoir, and downstream sustainable flow , with a sufficient lead time.**

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

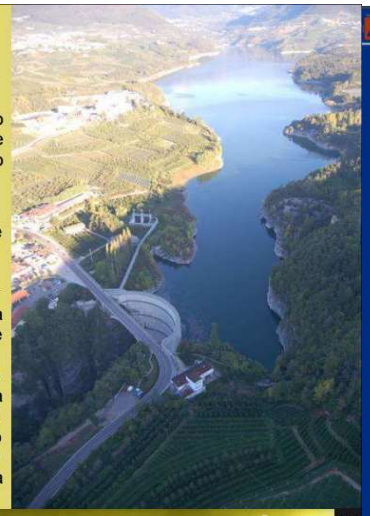
Example of discharge regulation plan operational in Itlay

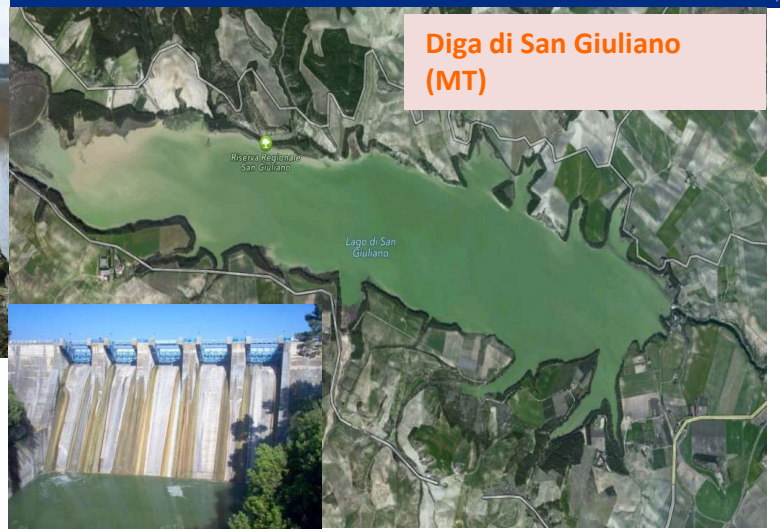
LE DISPOSIZIONI NORMATIVE DELLA PROVINCIA AUTONOMA DI TRENTO

La Provincia autonoma di Trento, in forza del proprio statuto di autonomia, con legge n. 2 del 1992 e successiva legge n. 9 del 2011, ha disciplinato l'utilizzo degli invasi artificiali per la laminazione delle piene.

Particolarità:

- la decisione spetta unicamente al Dirigente Generale Protezione civile. Può temporaneamente disporre l'invaso o lo svaso anche totale dei serbatoi di accumulo idrico e adottare ogni altra misura per regolare i livelli d'invaso dei serbatoi idrici e la portata dei corsi d'acqua, al fine di prevenire esondazioni o altri pericoli per l'incolumità pubblica;
- il concessionario viene indennizzato solo quando le misure di regolazione comportino vincoli di durata superiore a 20 giorni nel corso dell'anno solare; in tal caso viene corrisposto ai concessionari, su loro richiesta, un indennizzo pari, per ciascun giorno successivo al ventesimo, al doppio della misura giornaliera del canone annuo di concessione.





- Alluvioni Marzo 2005, Marzo 2009, Aprile 2009
- Notevoli danni al territorio ed alle infrastrutture
- Condizioni di RISCHIO IDRAULICO MOLTO ELEVATO
- Tavolo Tecnico Prefettura di Foggia marzo 2009

Data exchange procedure

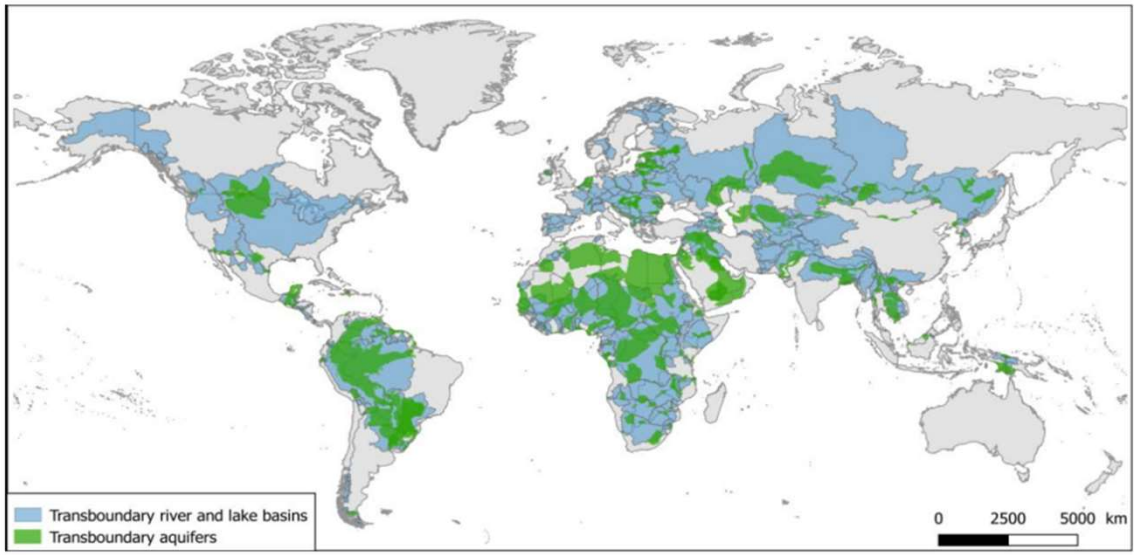
For a more rapid dissemination of information aimed at regulating the outflows downstream of the dams, the managers must adopt the necessary measures so that the **hydrological-hydraulic data** (monitoring data of the reservoir level and discharged flows**) are made available continuously and in real time**, through telematic contacts, to the civil defence and NHS.

Overview of flood warning process - how does the process flow differ among countries

WMO Technical Regulations Vol. III – Hydrology deals with the exchange of hydrological forecasts and warnings on international basins

3.18 International basins

***The exchange of hydrological forecasts and warnings on international basins should be organized on the basis of bilateral or multilateral agreements**. Provisions should be made in the agreements for the effective usability of prediction and forecasting products (e.g. by including requirements for common datum, common system of units, and addressing different language and time zone issues) (*

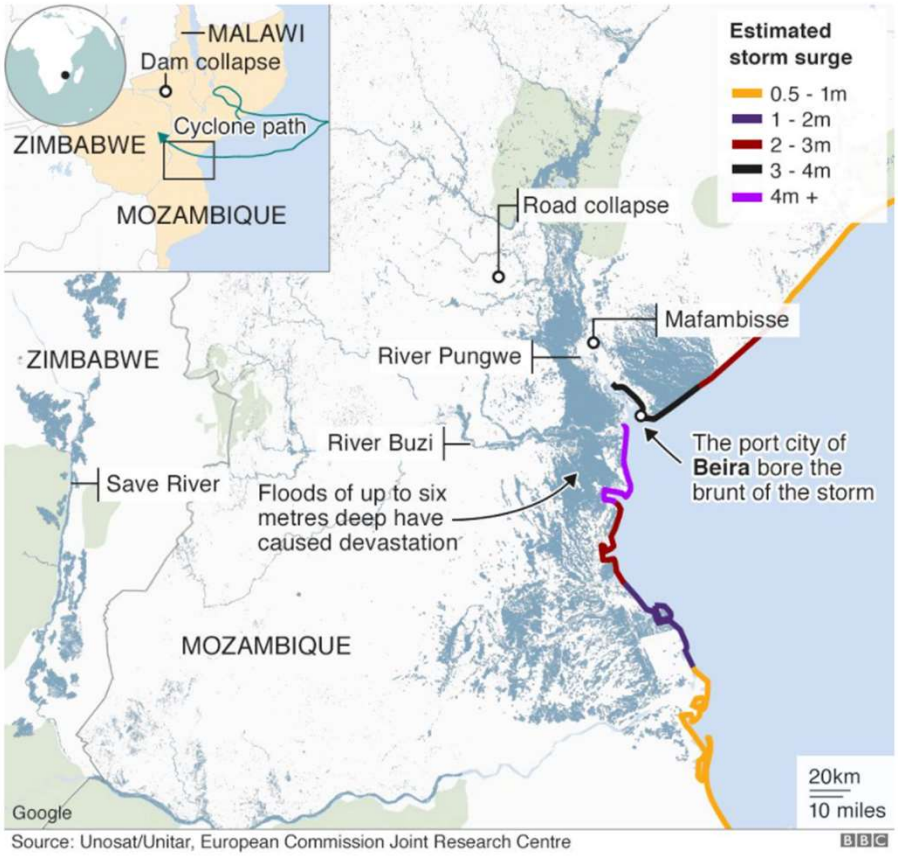


WMO OMM

flood warning process - how does the process flow differ among countries

It is consolidated the **river-based approach**, that embeds **collaborative risk assessment** at a catchment scale.
For transboundary basins, the flood management should be coordinated throughout the river basin if they are to be effective (data exchange, joint flood forecasting, flood warning, common procedure, and reservoir regulations and emergency plans) , since the merely warning exchange may be not sufficient.

It is recommended that countries work together to create a comparable knowledge base for their joint analysis and planning, for instance under the responsibility of a joint body such as an inter-Transboundary Flood Risk Management river commission.



WMO OMM

To sum up part (3)

- River thresholds definition
- International tools (EFAS thresholds)
- Direct surveys to provide rapid situation appraisal
- Reservoir regulations for flood control
- International data exchange

Thank you

angela.corina@protezionecivile.it