Numerical models for the monitoring and forecasting of hydrological disasters triggered by extreme meteorological events

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Outline

- CMCC activities for meteo-hydrological risk management
- CMCC and the hydro-meteo chain
- Numerical models and forecasting

Looking back to the past…

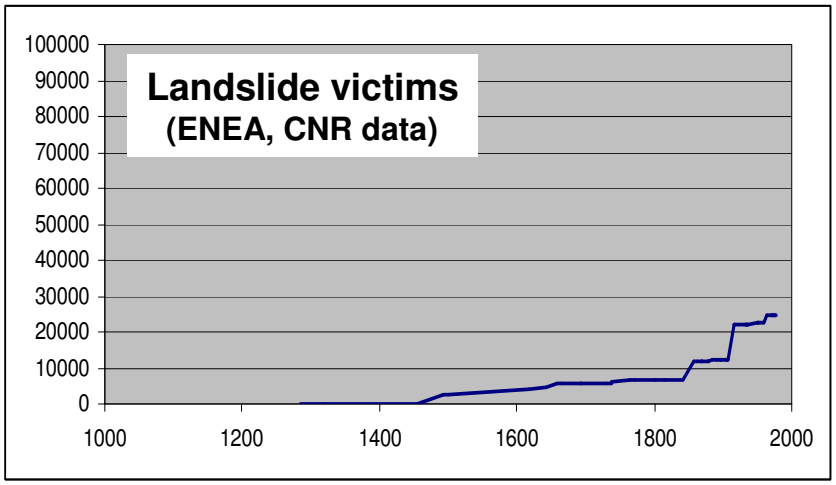
Hydrological phenomena triggered by heavy rains are becoming more and more frequent

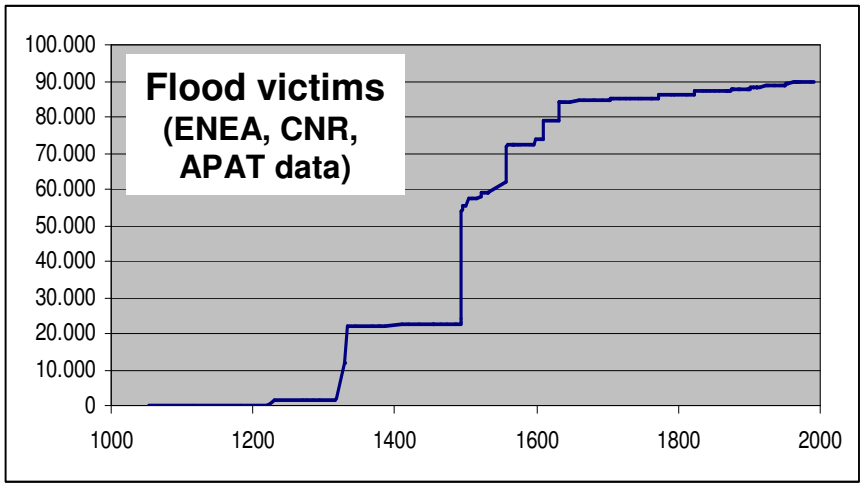
Heavy rainfall and flood,
30th of april 2006 Ischia (Southern Italy)

Heavy rainfall and flash flood,
16th of june 1996 Versila (Northern Italy)

Looking back to the past…

Hydrological phenomena triggered by heavy rains are becoming more and more frequent





and also victims' number consequent such events is fearfully increasing

Numerical models for monitoring and forecasting

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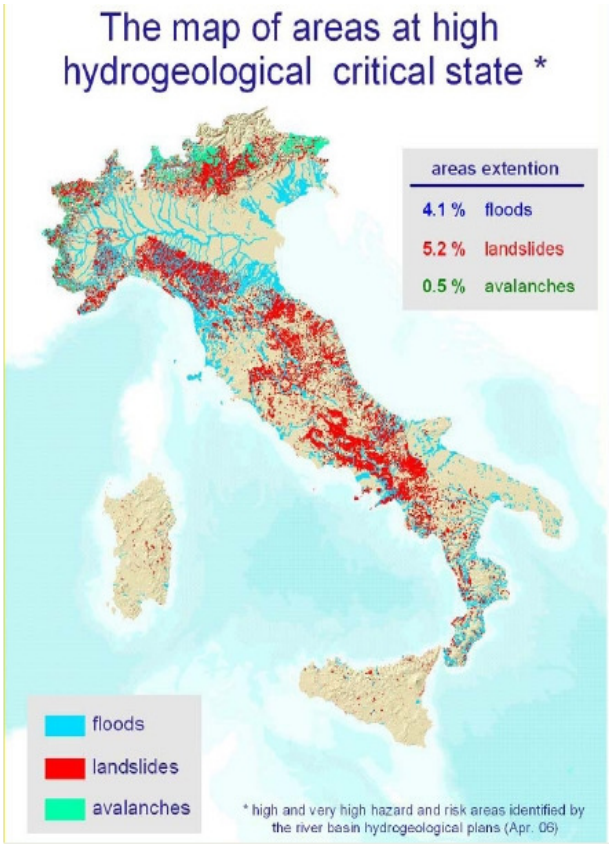
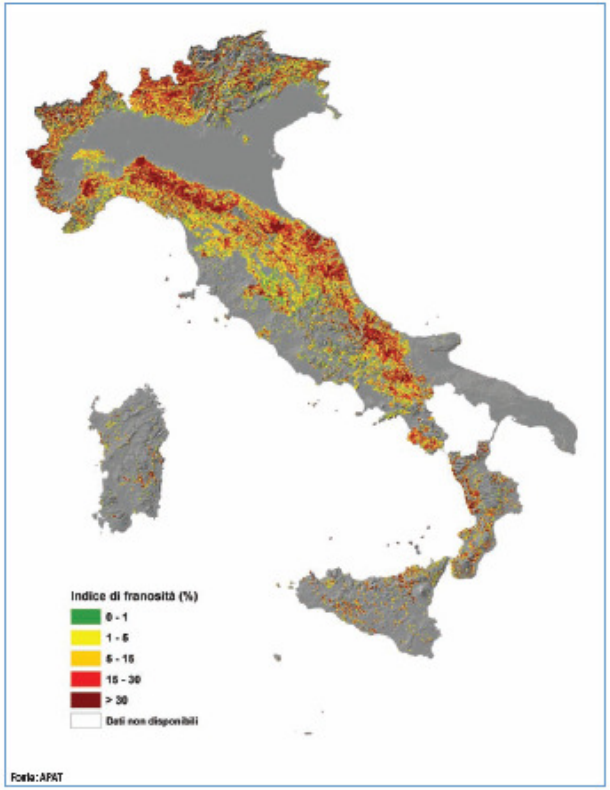
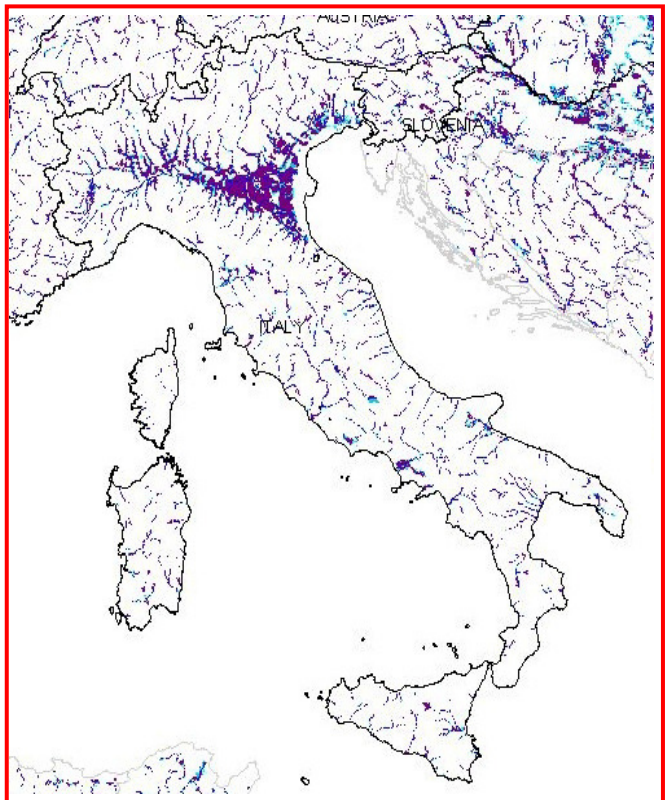
Italian areas at high critical state

Observed data shown that in Italy there are a lot of critical areas for hydrological disasters





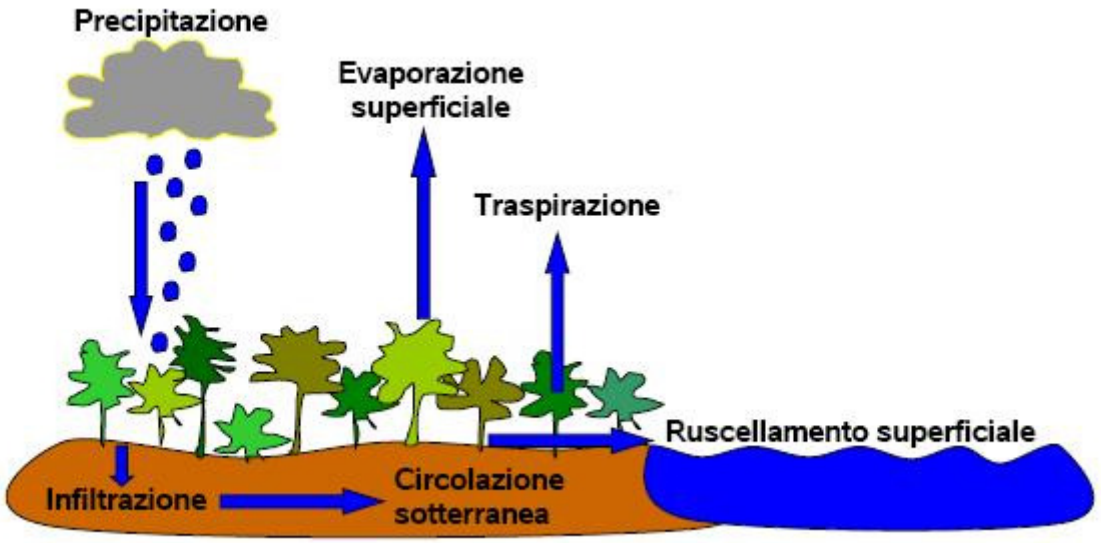
Landslide area/ total area (%)
(on a grid 1x1 km)
(www.mais.sinanet.apat.it)



Floods in Italy
(De Roo et al., 2006)

Is it possible to warn and forecast such phenomena?

NWP (Numerical Weather Prediction) **models** are an efficient method **to forecast** hydrological phenomena triggered by extreme meteorological events and **to qualitatively/quantitatively evaluate** the hazard and how it can impact on the ground in the short-middle time.



Numerical models

The ideal instrument is "something" able to find out possible time evolution of atmospheric and soil phenomena by:

- **simulating real physical processes**
- **analyzing impacts** of heavy meteorological events on the ground and soil
- taking into account **interactions atmosphere-ground-soil**

Such instruments are **numerical models**: the output information are as much detailed as higher is their horizontal/temporal resolution.

AIM

- To develop an efficient **high resolution atmospheric model**
- To develop an efficient **high resolution hydrogeological model**
- To couple high resolution atmospheric model with high resolution hydrological ones in order to **simulate phenomena of interest on small areas and basins**.

In which way are we developing such instrument?

CMCC project

CMCC (euro**M**editerranean **C**entre for **C**limate **C**hanges) is a project **financed by MIUR Directorial Decree** (2004/03/30, prot. 411/Ric.) approved on 2005/08/04 (time scale of 3 years).

It is a **no profit centre** whose aims are to realize and manage the Centre, research coordination and different scientific/applied activities **in the field of climate changes.**

The Centre is organized in the following Divisions:

Div. Num.	Division Name	Manager – Center
1	Informatic Technology and Operations	Prof. G. Aloisio – UNIV. of LECCE
2	Agriculture, Forest and Ecosystems nat. & terr.	Prof. R. Valentini – INGV
3	Direct and Indirect Economical Impacts	Prof. C. Carraro - FEEM
4	Impacts on the ground and coastal zones	Dott. P. Schiano – CIRA
5	Numerical Applications and Scenario	Dott. A. Navarra - INGV
6	Training, Documentation and Divulgation	Prof. A. Blanco – UNIV. of LECCE
7	Administration	Dott. A. Navarra - INGV

CMCC ASSOCIATED PARTNERS

INGV - National Institute of Geophysics and Volcanology

CIRA – Italian Aerospace Research Centre

University of Sannio

University of Lecce

CVR - Venezia Research Consortium

FEEM - Enrico Mattei Eni Foundation

AFFILIATE CENTERS

- **CNR** – National Research Council, Dept. Of Environment
- **National Meteorological Service**
- **ENEA** - Italian National Agency for New Technologies, Energy and the Environment
- **SPACI** - Southern Partnership for Advanced Computational Infrastructures
- **Abdus Salam International Centre for Theoretical Physics**
- **OGS** - National Institute of Oceanography and Experimental Geophysics
- **APAT** - Agency for Environmental Protection and Technical Services
- **CRMPA** - Research Centre in Pure and Applied Mathematics
- **University of Sassari**

CMCC: project description

The goal is the investigation in the climatic variability field, its causes and its consequences, by:

- development/implementation/optimization of efficient numerical models and high resolution simulations
- development of software and middleware
- High Performance Computing
- staff training in climatic field and computer science technologies
- scattering of results

CIRA

Italian Aerospace Research Centre

CIRA is a **governmental organisation** that was assigned by the Italian Government to define and implement the National Aerospace Research Program

CIRA's institutional aim is:

To **integrate Research Capabilities** with the Large Fluid dynamic Facilities and Technological Laboratories in several main technologies areas;

To identify Scientific Objectives and **develop Basic Research in synergy with the National and International Scientific Community**;

To **provide technical assistance to public Authorities** for qualification and regulations.

CIRA

Italian Aerospace Research Centre

Areas of Competence

- ✓ Computer Science
- ✓ Aerodynamics, Icing and Aeroacustics
- ✓ Structures and Materials
- ✓ Flight Systems
- ✓ Aerothermodynamics and Space Propulsion

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CIRA ROLE IN CMCC: Impacts on territory monitoring and hydrological risk prevention

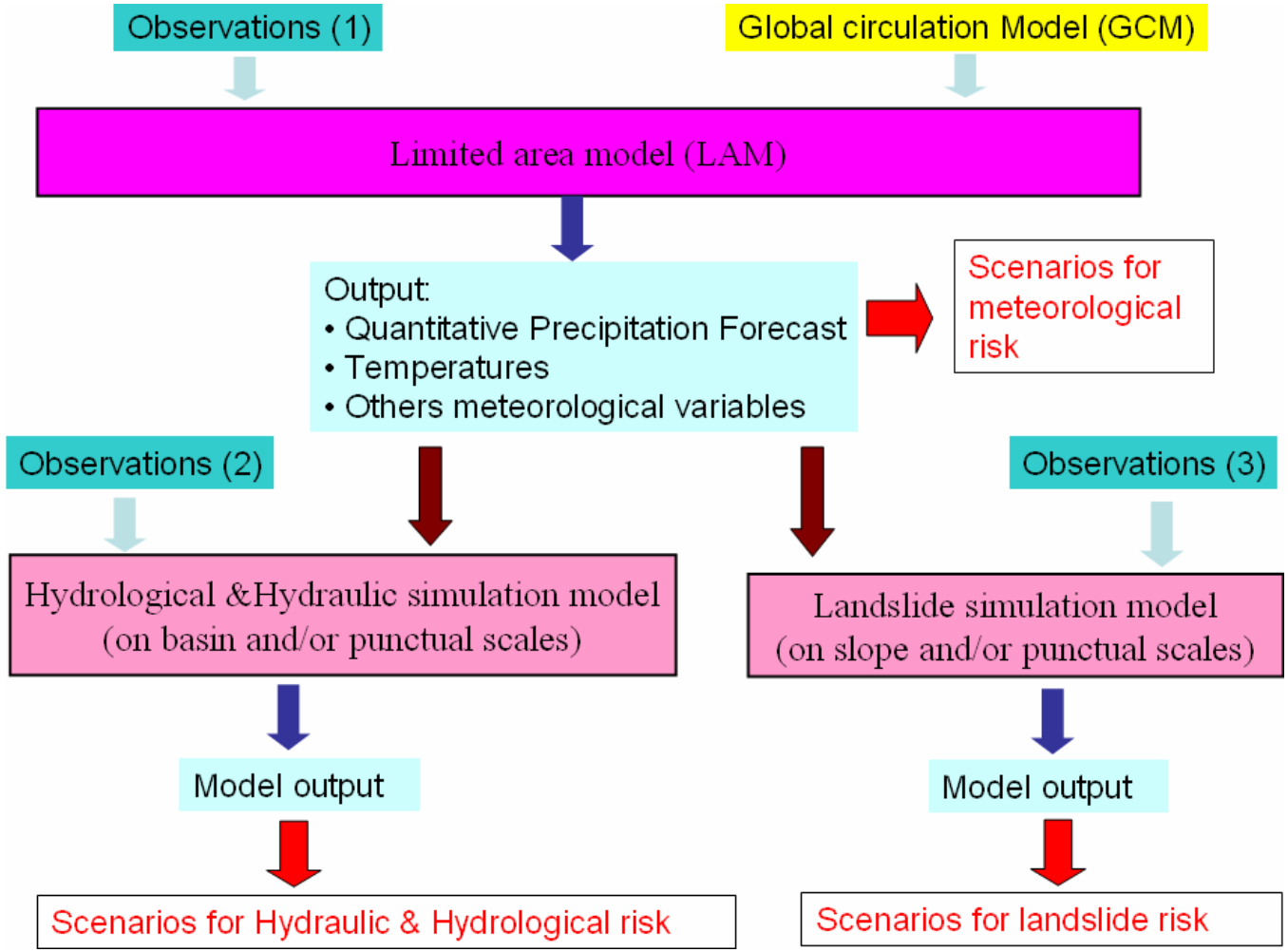
Goal

High resolution numerical simulations to forecast extreme meteorological events and their effects on ground and coastal zones (floods and landslides)

Activity

- Codes development/implementation (numerical optimization and physical modelling)
- Optimization of pre-existing numerical codes
- Coupling meteorological – hydrological models

Hydro-meteo chain



Tasks & Partners

METEO	**CIRA** - Italian Aerospace Research Centre
HYDRO	**LAMPIT** - Laboratory of Numerical modeling for the Hydraulic Protection of the Territory - Dept. of Defense of the Ground, University of Calabria
LANDSLIDE	**AMRA** - Regional Center for Analysis and Monitoring of environmental risk

COSMO-LM Model

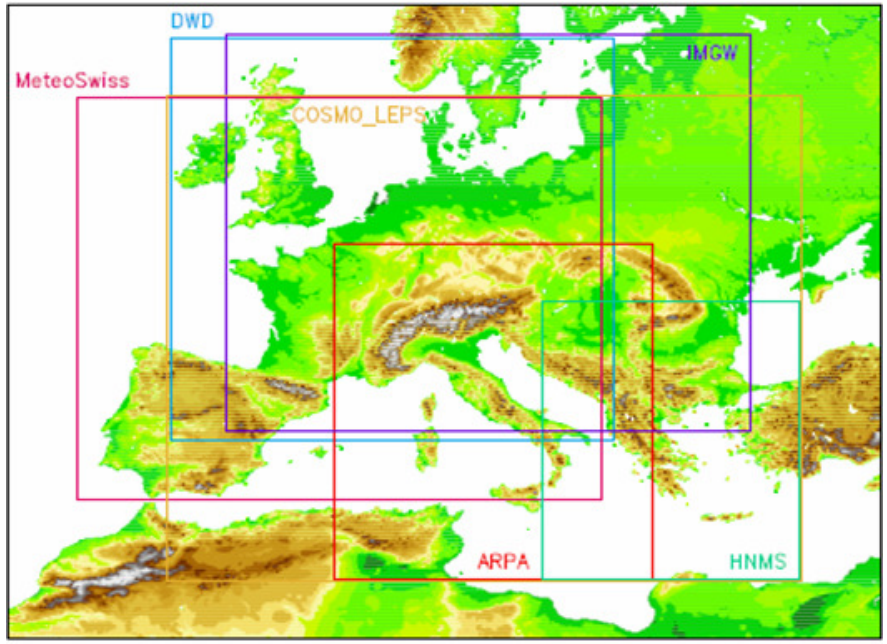
Collaboration with COSMO European consortium to **develop** and **update** the limited area non-hydrostatic model COSMO-LM

COSMO members are national meteorological services and research centers of:

- Germany (DWD)
- Switzerland (MeteoSchweiz)
- Italy

(USAM, ARPA-SMR, ARPA Piemonte, CIRA)

- Greece (HNMS)
- Poland (IMGW)
- Romania (NMA)



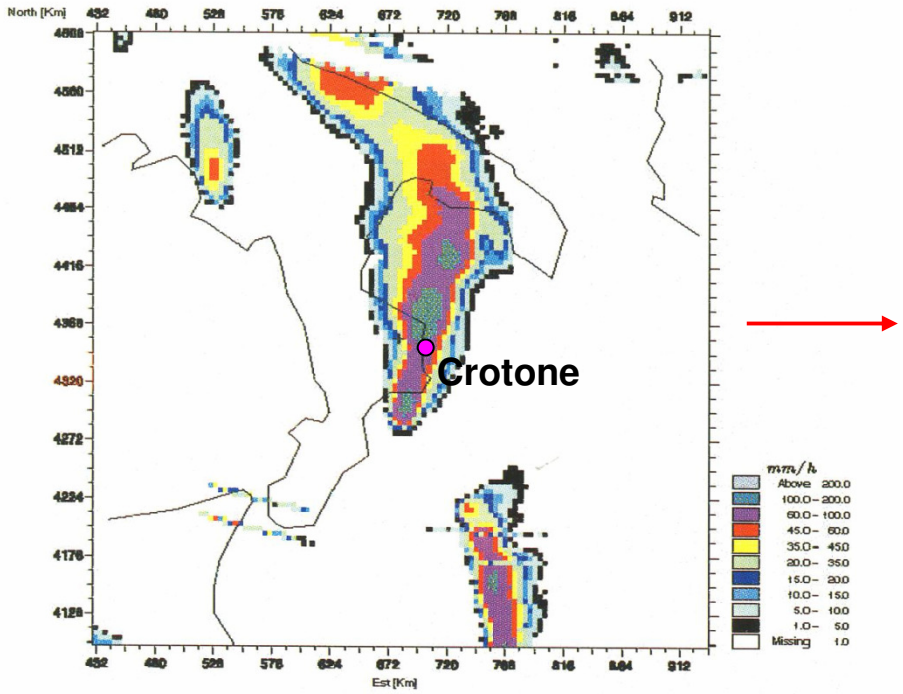
Horizontal resolution	Vertical levels	Time step	Forecast range
7 km	*40*	*40 s*	*≤72h*
2.8 km	*50*	*30 s*	*≤18h*

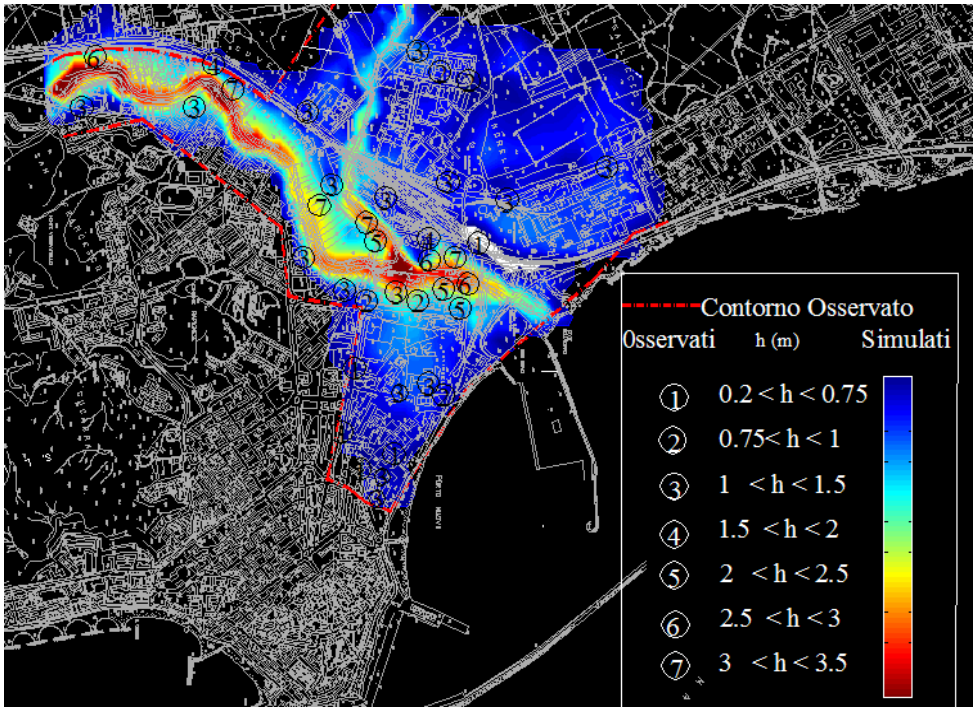
Examples: Forecast of Floods

Simulation of flood in Crotone (1996)

Rain forecast
from COSMO-LM
(2.8 km x 2.8 km)

Hydraulic model describing the
propagation of floods event
(50 m x 50 m)





Application of activities research

Development and validation of numerical model COSMO-LM is devoted to **warn and forecast hydrogeological events induced by heavy rains**: looking back to the past, it is possible to verify the reliability of the model by verifying its forecast capability on past real cases and, then, correct model bugs.

In this way, it is possible to "teach model" in order to detect future meteo-hydrogeological events (in the short-middle time) and develop opportune risk maps

Meteorological forecasts by numerical models → **Hydrogeological** forecasts by numerical models → **Risk maps**

The development of such "chain" requires **integration of knowledge and expertise** from multiple disciplines to understand what parameters have to be took into account in order to create feasible and representative risk scenarios.

Application of activities research

The early warning systems which make use of measurements of flow and rainfall rates can issue a warning only shortly before the disaster, which is often not sufficient to adopt appropriate protective measures.

The **flood events have to be predicted ahead of the rainfall**, and this with sufficient degree of reliability. It is possible to realize a complete forecasting chain that starts from precipitation forecast and translates it into run-off

Thanks for your attention!

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Contribution to COSMO-LM development

Improvements of SVAT module (Soil Vegetation Atmosphere Transfer) to better simulate heat and humidity fluxes at the soil-atmosphere interface