Hydrological Models and their application in Hazard Warning Systems

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ANYWHERE

Motivation

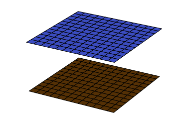
Rainfall-induced floods are one of the main extreme weather and climate events in terms of impact, causing serious damage especially in urban and highly populated areas. In Europe flooding is the major natural hazard. In the last years frequency and magnitude of flash floods have increased leading to greater damage and higher reconstruction costs. Forecasting these floods and their impacts on flood-prone regions is still one of the biggest challenges for hydro-meteorological forecasters. In order to develop reliable early warning products, improve risk management, and enhance prevention measures, it is crucial to identify the expected precipitation-induced impacts and localize upcoming floods in space and time before they occur.

Types of Rainfall-Runoff Models & Requirements

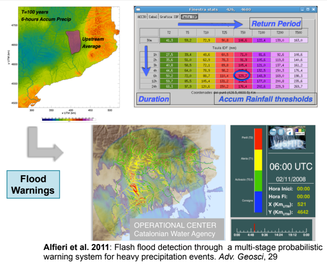
To forecast precipitation-induced floods, a rainfall-runoff model is needed to convert precipitation amounts into river runoff and warnings. Depending on the purpose, available instrumentation, observations and background information, models with different complexity and accuracy can be used.

1 *Flood guidance systems*

- rainfall forecast is directly transformed into warnings based on rainfall accumulation over the drainage system
- reference thresholds based on available rainfall statistics associated to probability of occurrence
- warnings are issued by basin-aggregated rainfall at each point of the drainage network against selected reference thresholds
- no calibration needed
- flood guidance for **large areas** (e.g. whole countries)



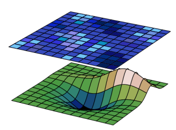
Rainfall



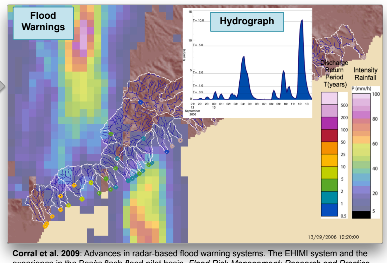
Alfieri et al. 2011: Flash flood detection through a multi-stage probabilistic warning system for heavy precipitation events. *Adv. Geosci*, 29

2 *Simple rainfall-runoff model*

- rainfall forecast is transformed into estimated runoff by a simplified lumped model in limited outputs of the catchment
- estimation of basin parameters using datasets of land-use, elevation (digital terrain model), etc.
- rainfall is spatially averaged in the sub-basins
- hydrograph is simulated at the output of each sub-basin
- no calibration with stream gauge measurements needed (regionalisation of parameters when ungauged)
- simulation only in **selected basins** (< 100 km^2)



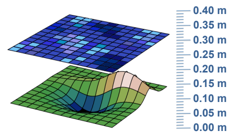
Rainfall, cartography & basin properties



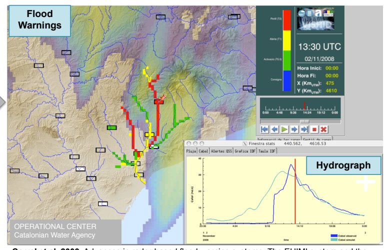
Corral et al. 2009: Advances in radar-based flood warning systems. The EHIMI system and the experience in the Besòs flash-flood pilot basin. *Flood Risk Management: Research and Practice*

3 *Fully distributed rainfall-runoff model*

- distributed rainfall inputs → loss function at cell scale
- estimation of basin parameters using datasets of land-use, elevation (digital terrain model), etc.
- adjustment to the basin characteristics through the analysis of past events (rainfall, runoff, evapotranspiration, snow water equivalent....)
- calibration using stream gauge measurements
- simulation only in **selected basins**



Rainfall, cartography, basin properties & stream measurements



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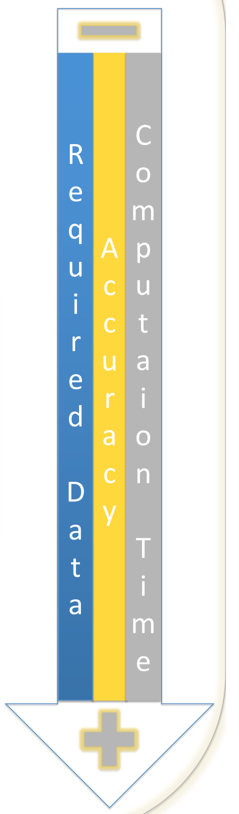
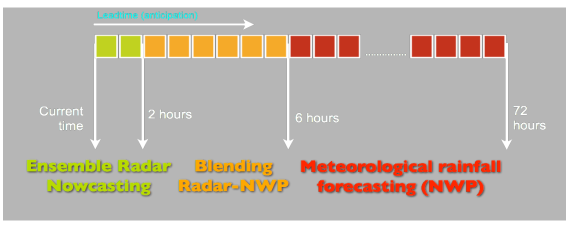


Rainfall anticipation

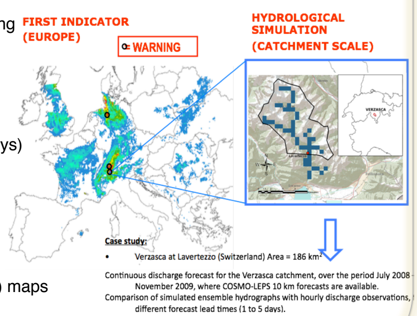


- High-resolution radar-based probabilistic nowcasting (ensembles) for flash flood and debris flow forecasting: up to 2h
- Combing (blending) radar rainfall nowcasting with probabilistic Numerical Weather Prediction (NWP) products: 2h – 6h
- Adapting high-resolution meteorological model forecasts to flash flood and debris flow early warnings: 6h – 72h

European Flood Awareness System

Distributed Hydrological Model (LISFLOOD)

- Physically based rainfall-runoff and routing model
- Cell resolution: 1 – 5 km^2
- Temporal resolution: 3 hours
- Input: → rainfall based on precipitation forecast ensembles (5 – 10 days)
  → digital elevation model
  → slope gradient
  → land use classes
  → fraction of urban area
  → soil depth and texture classes
  → channel geometry
  → averaged leaf area index (LAI) maps
- Output: → hydrograph
  → discharge thresholds



Source: Lorenzo Alfieri and Jutta Thielen Del Pozo European Commission - Joint Research Centre Institute for Environment and Sustainability

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