Hydrological applications of probabilistic ensemble forecasts for flash flood early detection

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Prague, 21/09/2010

Introduction

IMPRINTS EC-FP7 Project

IMproving Preparedness and RIsk maNagemenT for flash floods and debriS flow events

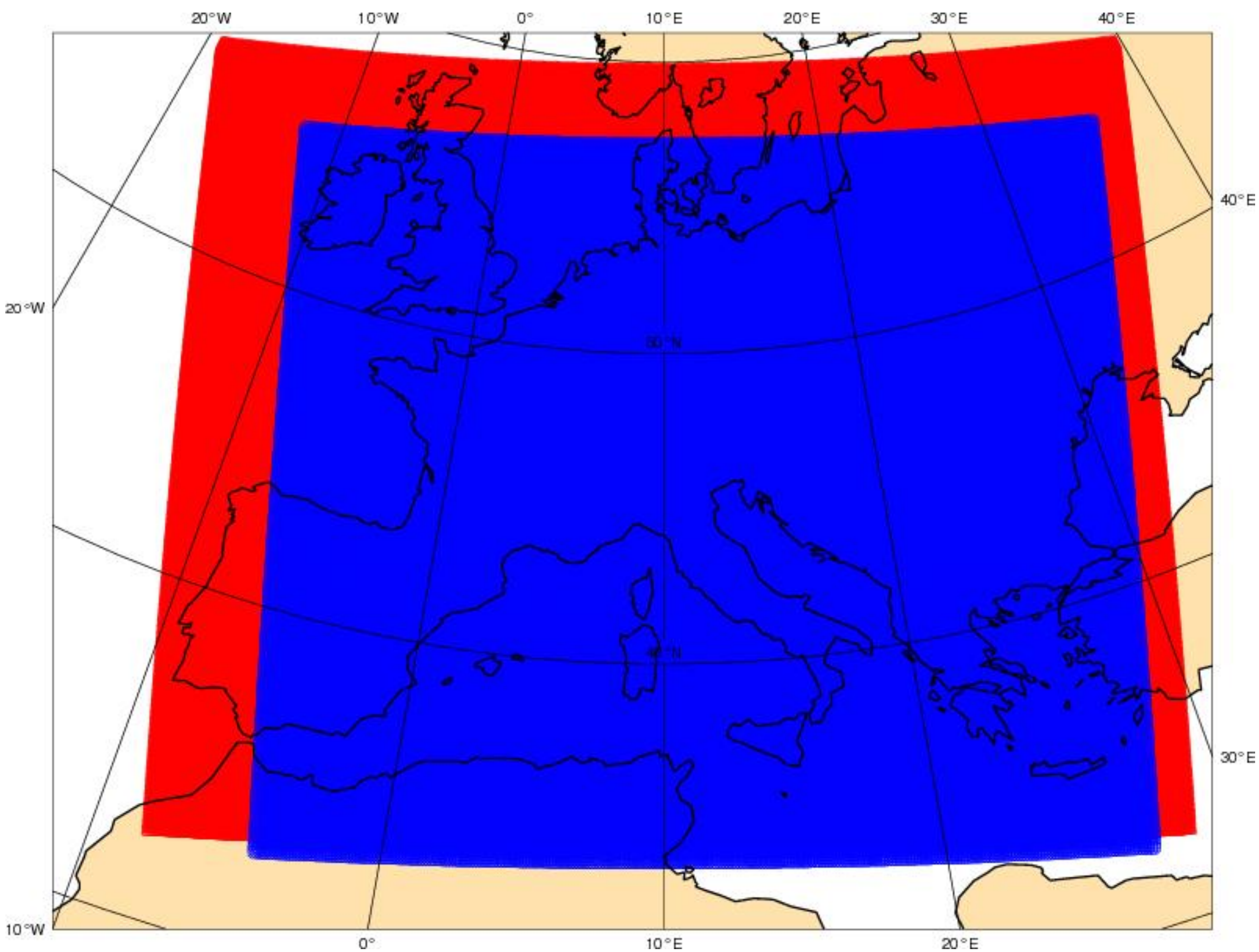
WHAT: Improve flash flood early detection

HOW: Hydrological simulation of probabilistic ensemble forecasts (EPS)

- Performance analysis from 3 predictors derived from the EPS
  - Quantitative estimation
  - Threshold exceedance analysis (Important for Early Warning)
  - Influence of forecast persistence

What is the best predictor to use in (flash) flood Early Warning?

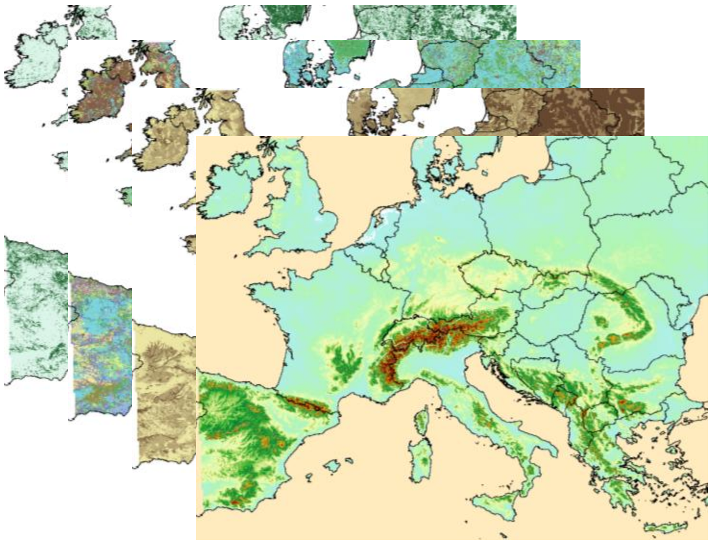
Meteorological data



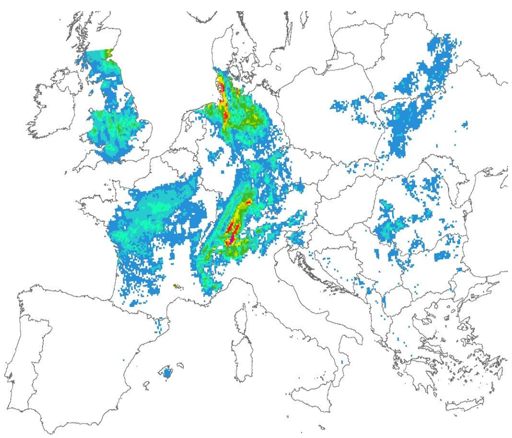
(Source: COSMO Consortium)

- **COSMO-LEPS 10 km**: 7/2008 - 11/2009, 3-hourly, 10 km grid, 16 members , lead time = 5.5 days.
- **COSMO-LEPS 7 km**: From 12/2009, 3-hourly, 7 km grid, 16 members, lead time = 5.5 days.
- **30-year Climatology**: (1971-2000), 3-hourly, 10 km grid resolution,1 member from ECMWF EPS control run

Hydrological simulation

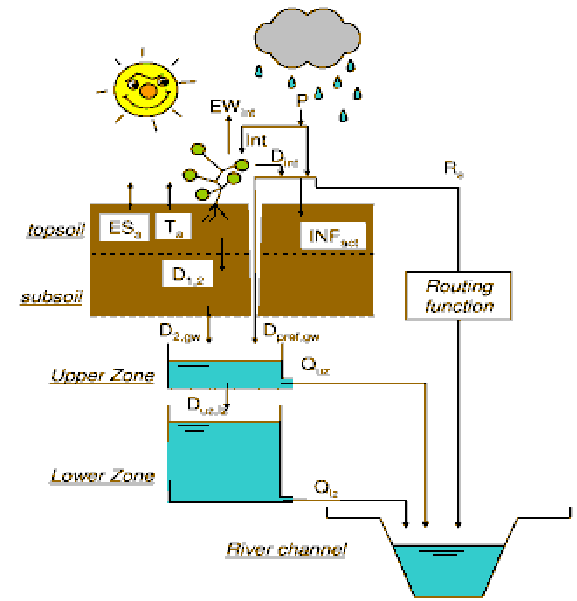


Static maps, 1 km resolution (whole Europe)



Meteo data (COSMO-LEPS)

Initial conditions



LISFLOOD model
(Van der Knijff et al., 2010)

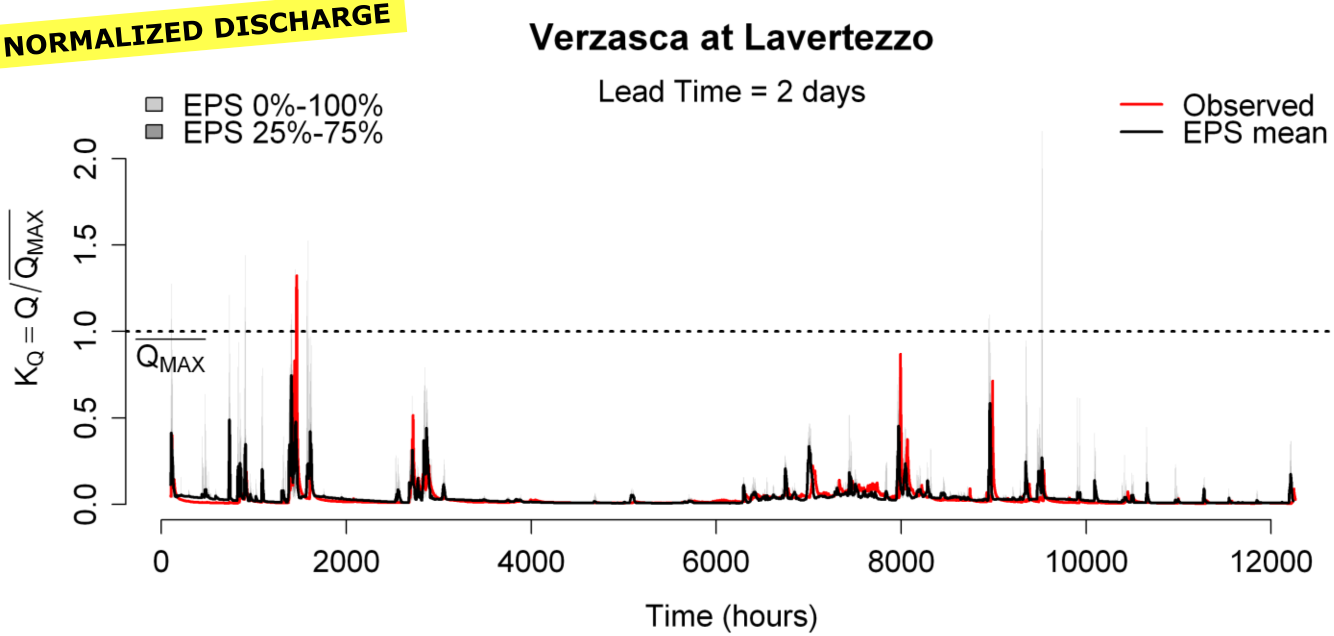
Output discharge

Case study

17-month simulation (Jul 2008 - Nov 2009) with COSMO-LEPS 10 km

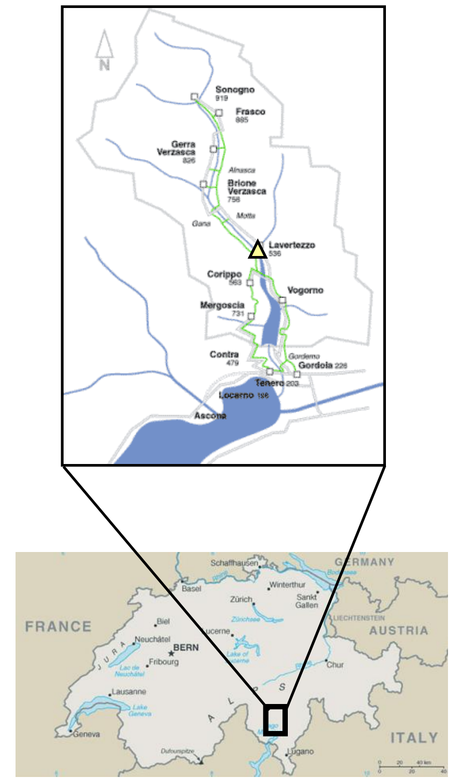
Comparison of simulated ensemble hydrographs with hourly discharge observations, for different forecast lead times (1 to 5 days).

NORMALIZED DISCHARGE



Verzasca (CH)

Area = 186 km^2

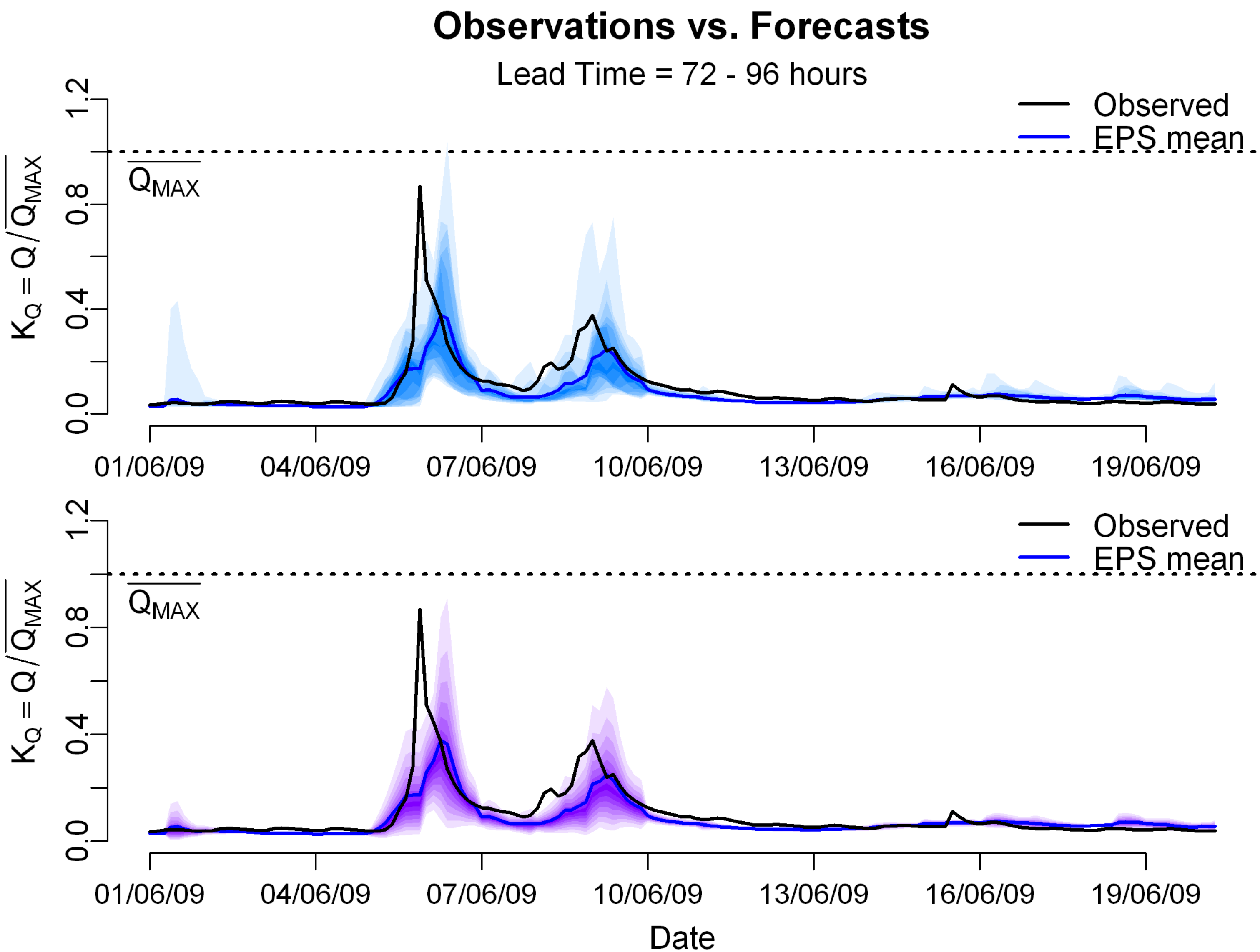


Search of the optimal predictor

1. Sample quantiles of the ensemble (EPS)
2. Ensemble mean (EPS mean)
3. Fitting of a probability distribution to the EPS (Gamma)
   Gamma distribution with L-moments fit (Hosking and Wallis, 1997)

	Advantages	Drawbacks
EPS	Use of the original EPS sample quantiles	Little robust, especially in the lowest/highest quantiles
EPS mean	Very robust, it considers all the members	Deterministic prediction, no info on uncertainty/spread of EPS
Gamma	Probabilistic forecast. Robust	Additional uncertainty due to fitting a probability distribution

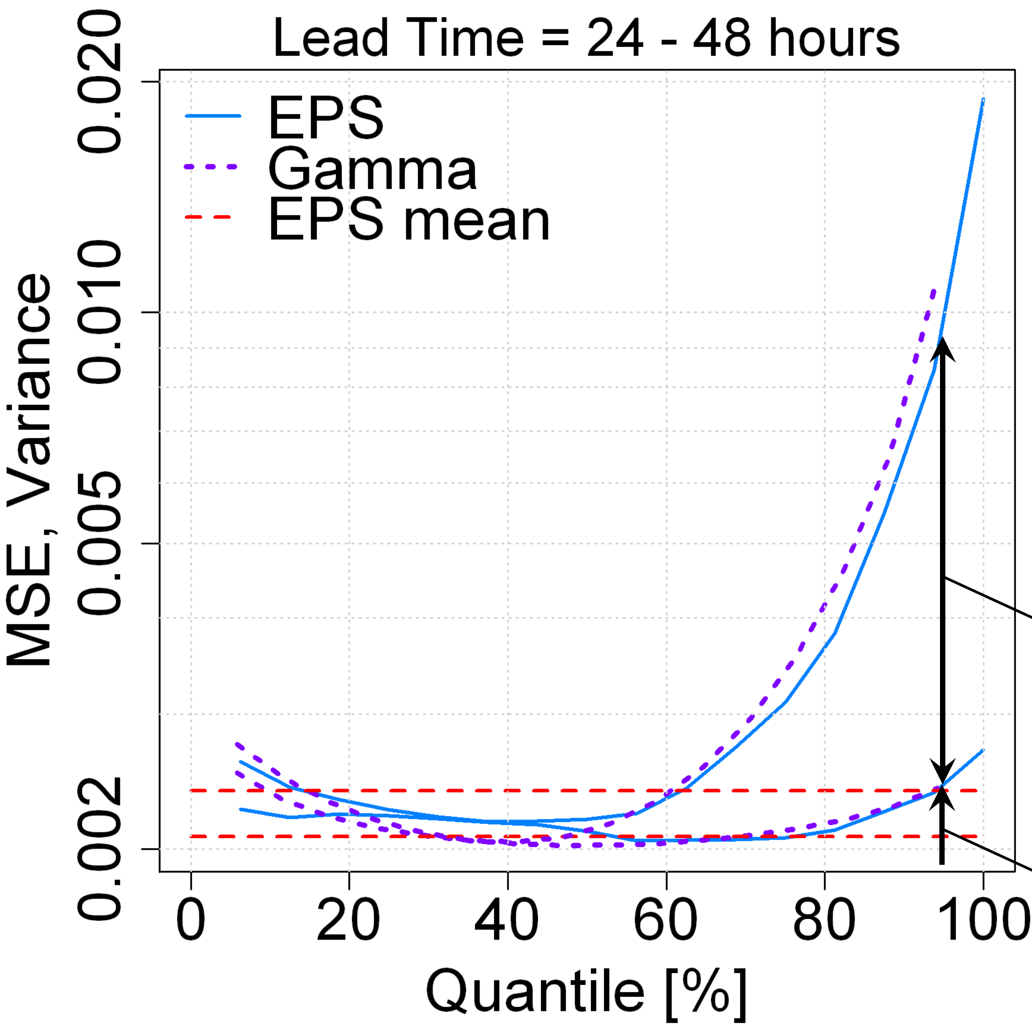
Comparison of the predictors



EPS

fitted distribution

Quantitative discharge estimation



$MSE(x) = Var(x) + bias^2(x)$

Resolution **Reliability**

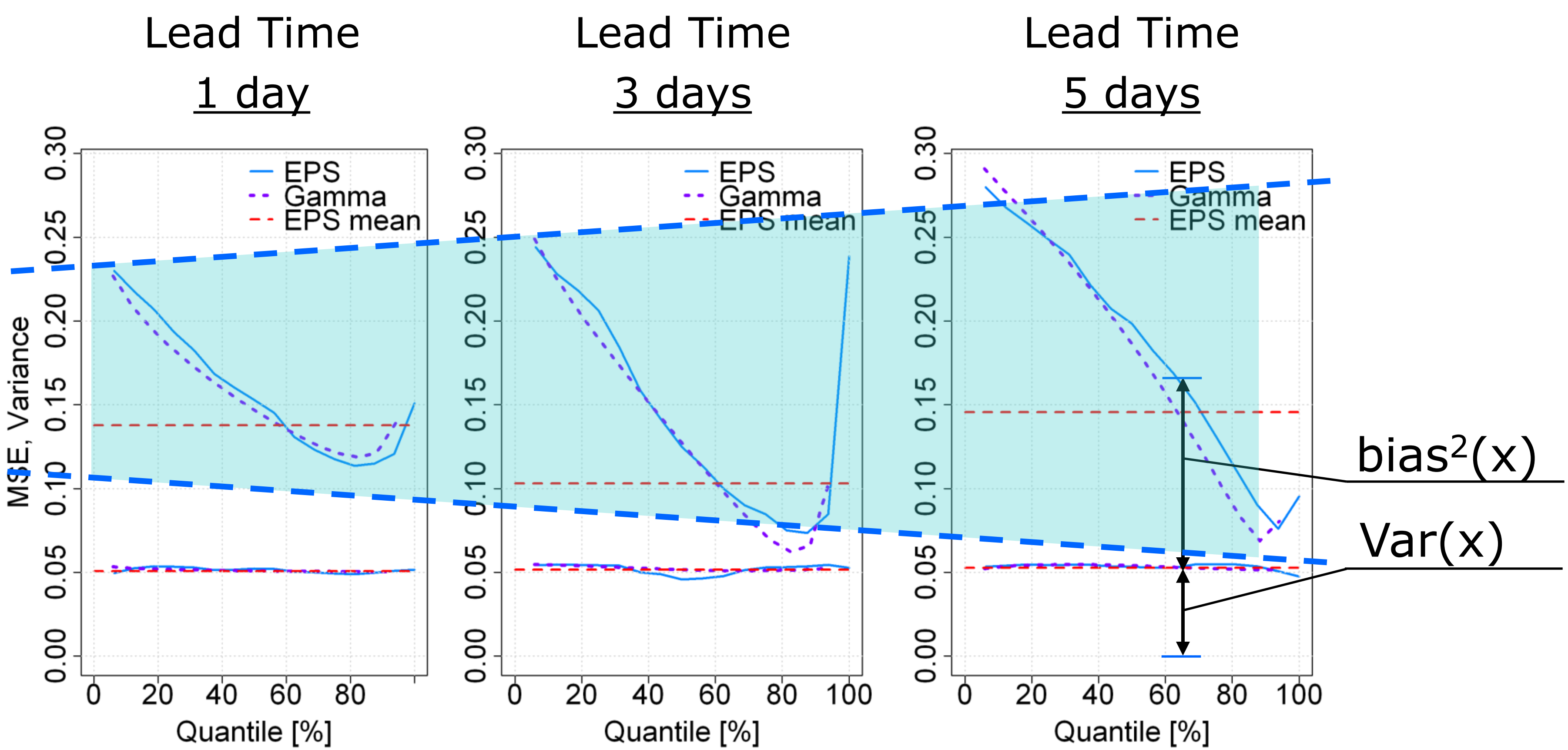
$x = (Q_{FCST} - Q_{SIM})$

$bias^2(x)$

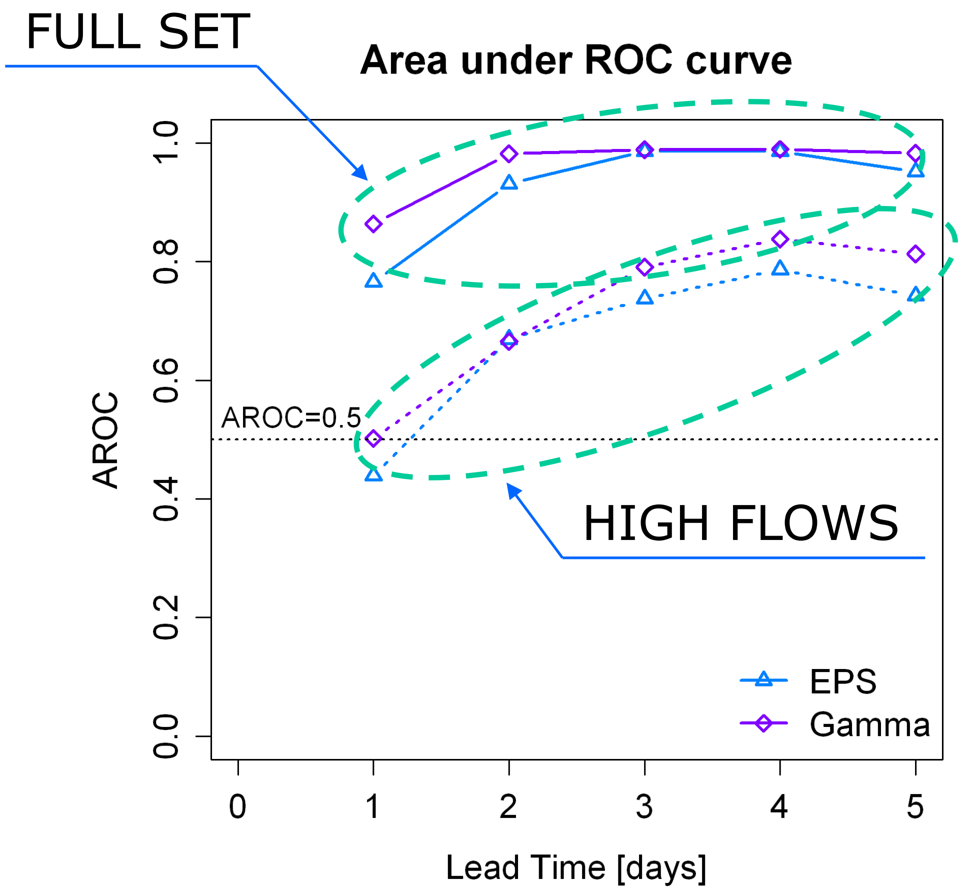
$Var(x)$

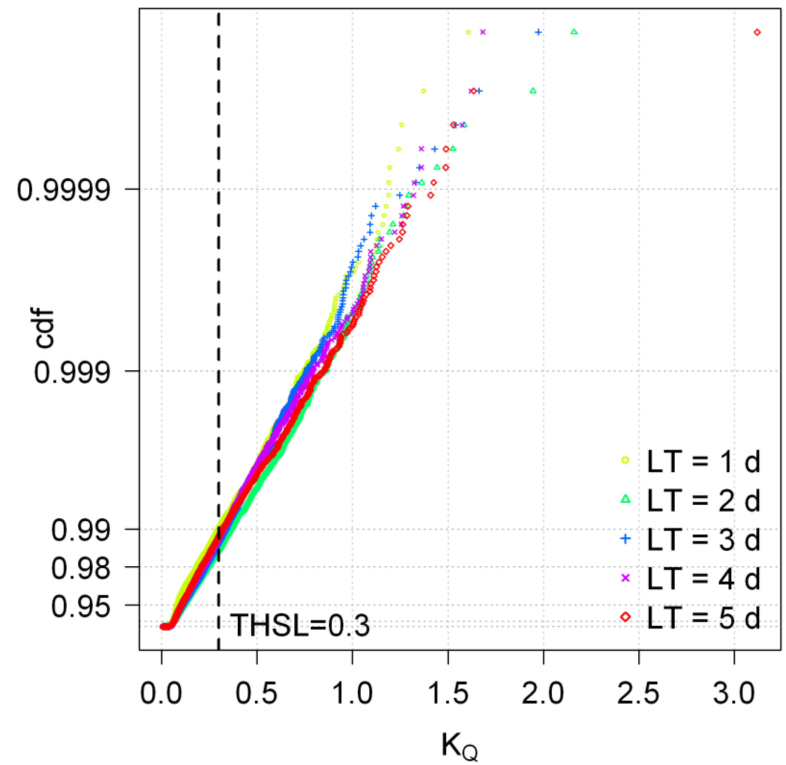
Discharge estimation - High flow

Threshold = 0.3



Threshold exceedance analysis



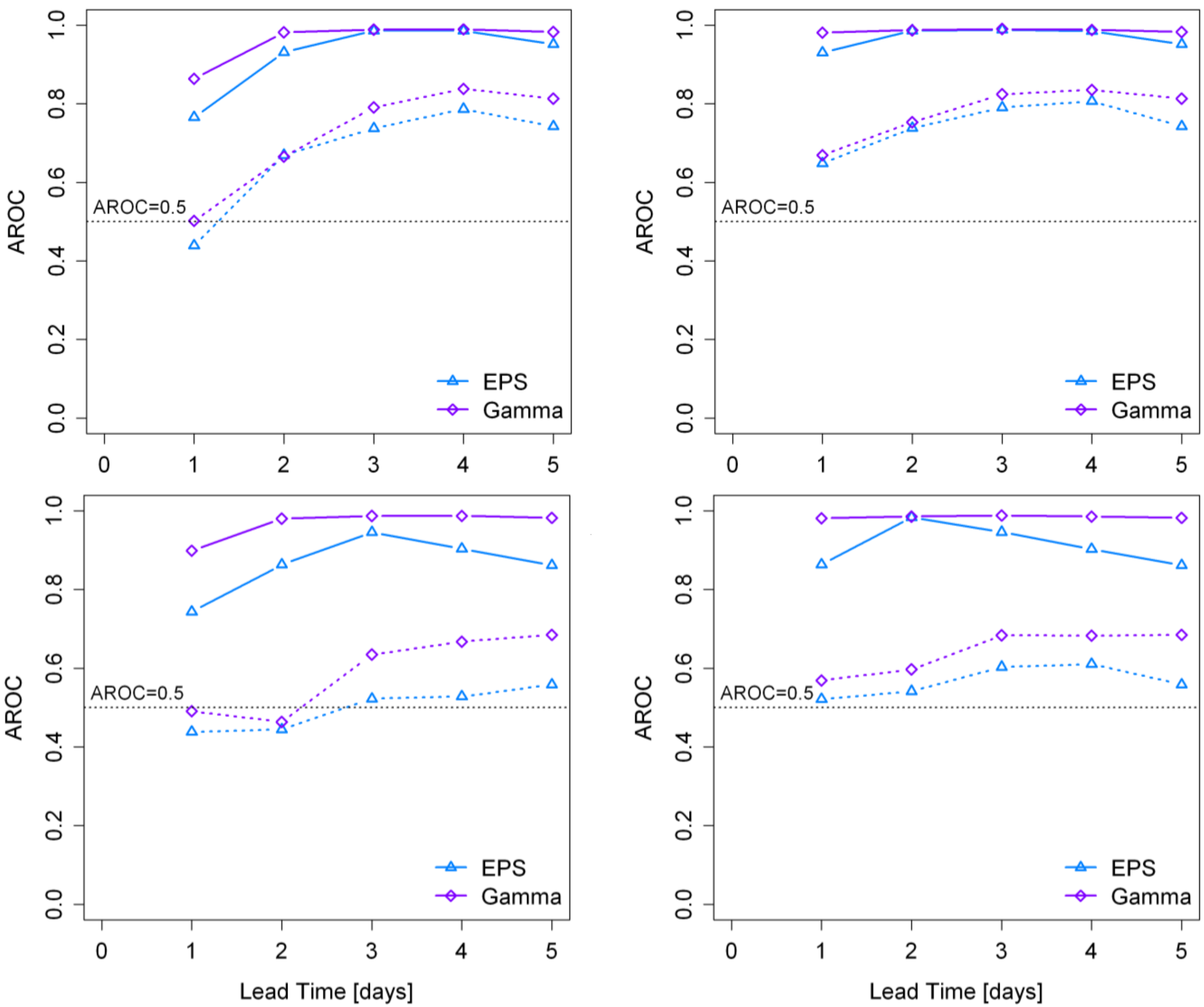


Threshold = 0.3

Persistence of forecasts

Single forecast

Two consecutive forecast



Threshold = 0.3

Threshold = 0.5

Conclusions

- A framework aimed to operational probabilistic flash flood early warning is being tested. The adopted methodology is derived from that of the European Flood Alert System (EFAS)
- Current NWPs give useful support in flash flood forecasting, though some limitations are found in quantitative discharge estimation (extreme events).
- Fitting a (gamma) probability distribution to the hydrologic EPS leads to significant improvements, particularly in the threshold exceedance analysis
- Persistence of forecasts improves the early detection of (flash) floods, especially for short lead times.
- The EPS mean is however a robust and quite accurate (deterministic) predictor

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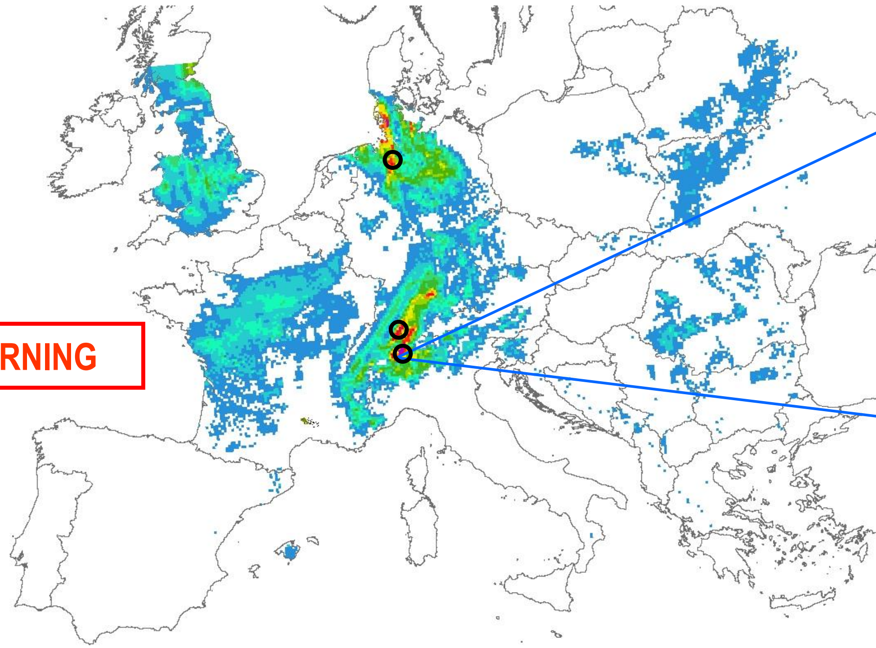
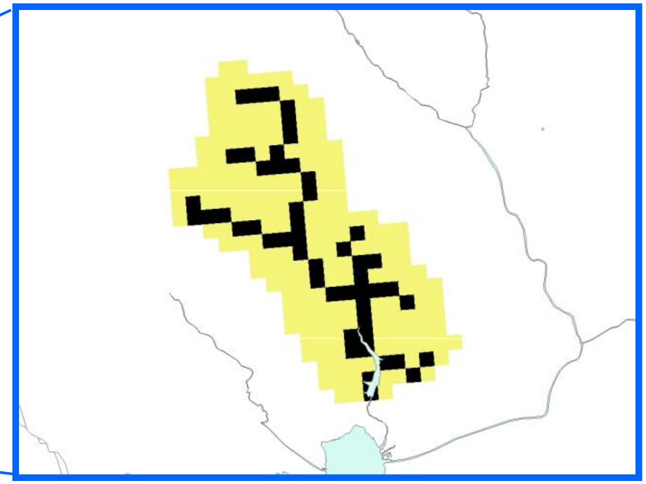
Flash Flood Warning

PRECIPITATION-BASED INDICATOR (COSMO-LEPS)



○ = WARNING

HYDROLOGICAL SIMULATION (CATCHMENT SCALE)



THRESHOLD EXCEEDANCE ANALYSIS + PERSISTENCE