European Flood Awareness System

Increasing preparedness for riverine floods across Europe

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The objective of this course

- General background and basic set up of EFAS
- Use of ensemble predictions in flood forecasting
- Employing model climatology to derive return period statistics
- Communication and visualization of uncertain results for decision making
- Flash flood predictions at a pan European scale

Background - Why did we start with EFAS?

Elbe and Danube floods in 2002 were a wake-up call for the European Commission to start different activities on floods and disasters.

JRC expanded the research project EFFS (1999-2003) to an operational stage to increase preparedness for floods and to improve international aid management

EFAS development is done in collaboration with national hydr-met services and research organizations

EFAS main objectives

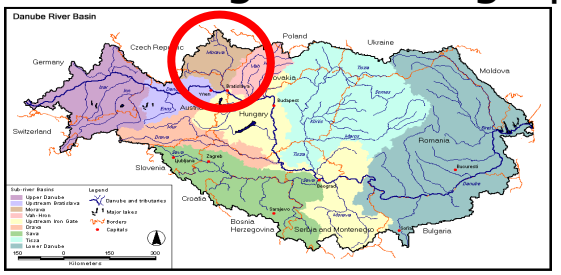
Added value

-Catchment based information

-Lead times up to 10 days

-Probabilistic information

- knowledge exchange platform

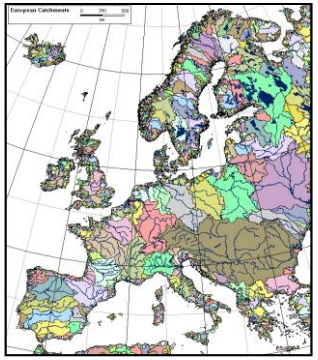


National hydro-met services

Novel information

- Comparable information across Europe

- Tool for international aid assistance during crisis



EC Emergency Response and Coordination Center

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Structure of operational EFAS

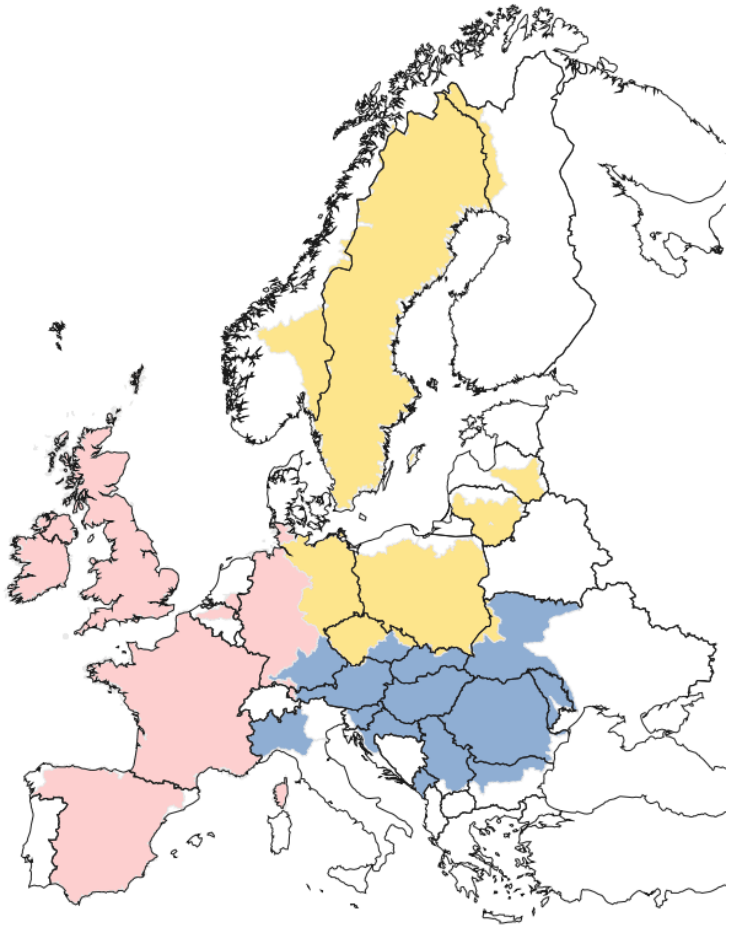
In 2011 EFAS was adopted as part of Copernicus (ex-GMES) emergency management service.

Since 2012 three operational EFAS Centers are in place:

- EFAS computational center (ECMWF)
- EFAS dissemination center (SE, *SK,* NL)
- EFAS hydrological data collection center (ES)

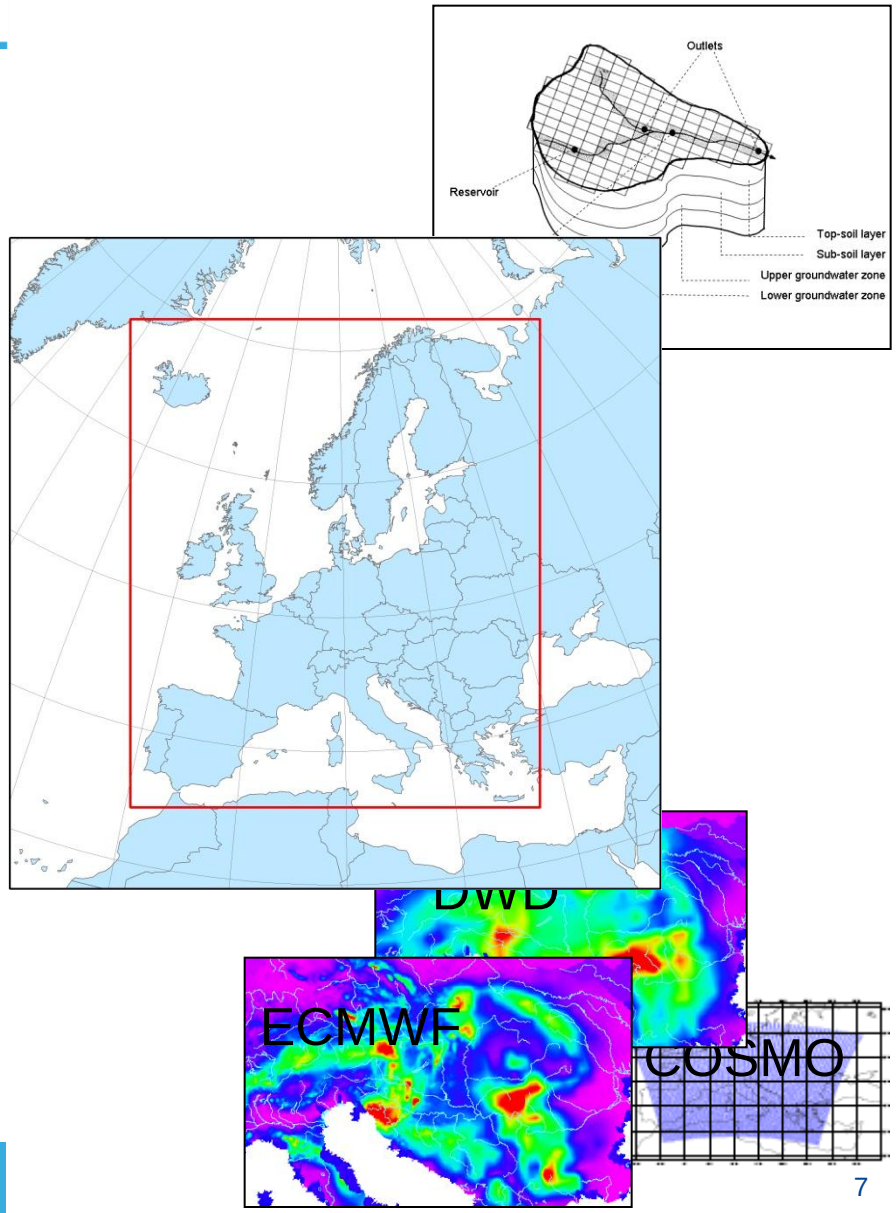
EFAS partner network

- EFAS is free and accessible for EU & non EU countries
- EFAS is made for the national/regional flood forecasting services
- EFAS respects the one voice principle!
- Currently 38 national/regional authorities as EFAS partners plus ERCC
- Most of the partners are hydro/meteorological services, only some include also civil protection
- First European operational flood forecastingg network
- Annual partner meetings



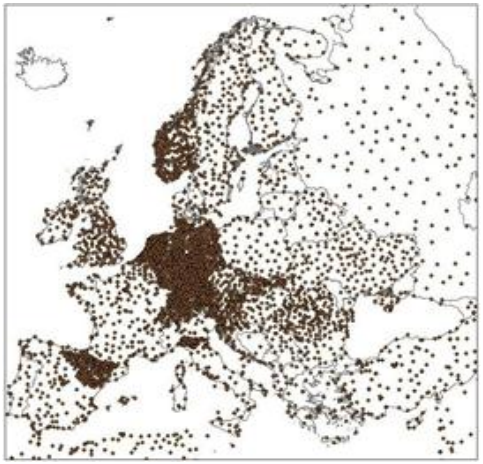
EFAS technical set up:

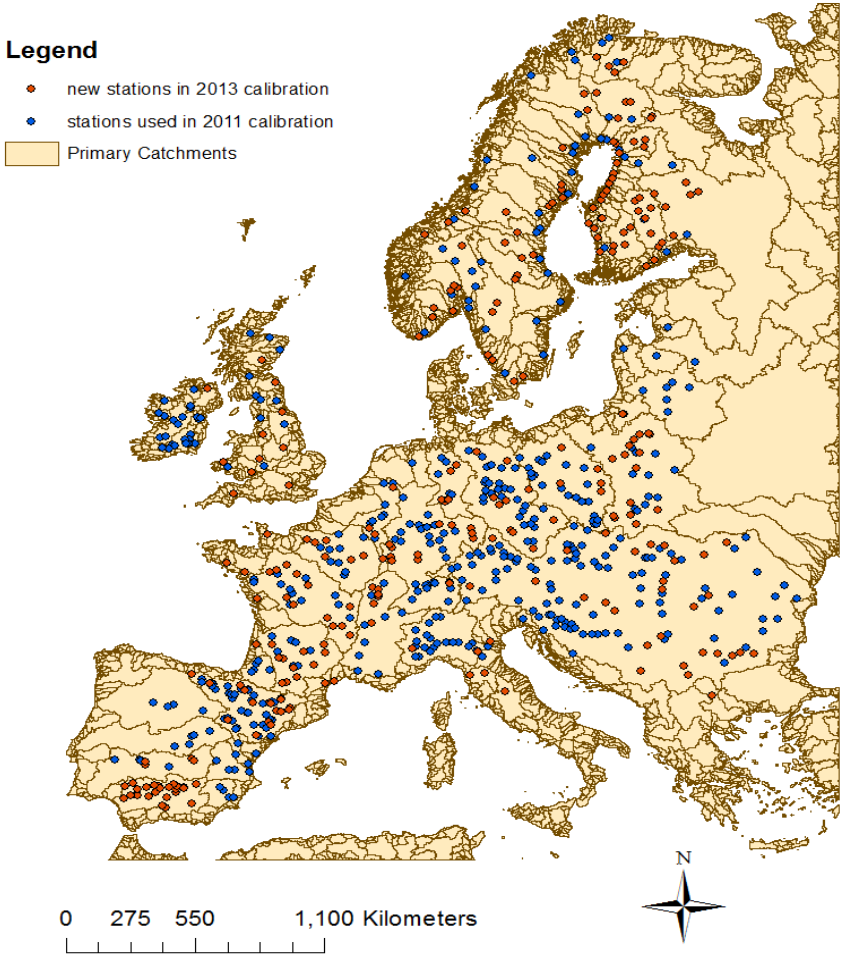
- Distributed hydrological model (LISFLOOD)
- Spatial extent: Europe
- Grid Resolution 5 km x 5 km
- Sources for meteorological forecasts: German Weather Service, European Center for Medium Range Weather Forecasts, COSMO Consortium



EFAS technical set up:

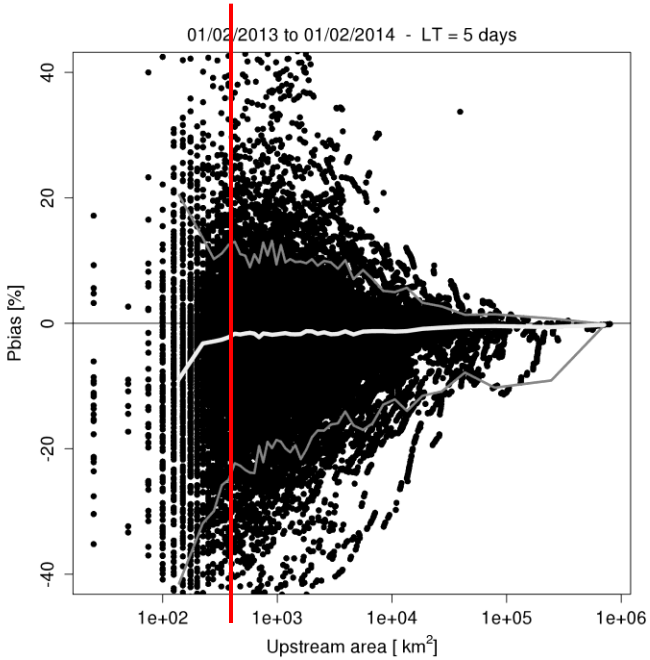
- 693 sub-catchments calibrated
- More than 6000 near real time meteorological observations



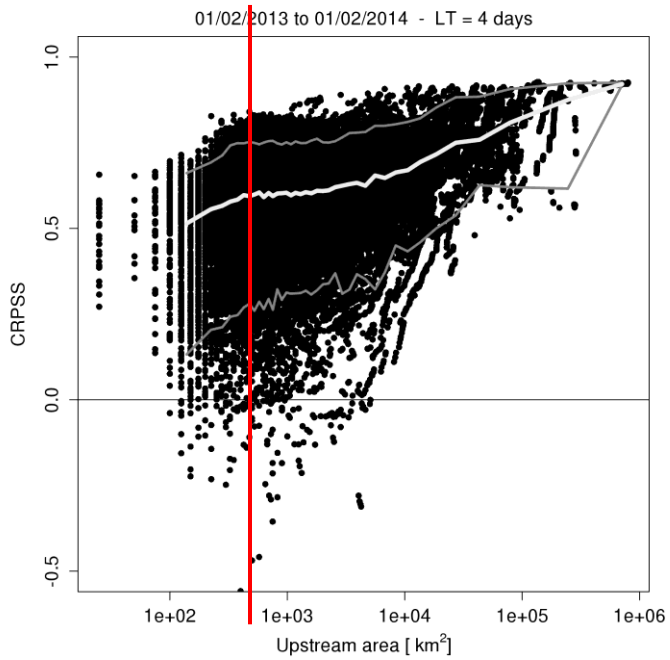


EFAS limits

- Remember: EFAS is a **continental scale** system providing **complementary** information!



Significant drop in bias for upstream areas below approx. 600km2



Significant drop in CRPSS for upstream areas below approx. 700km2

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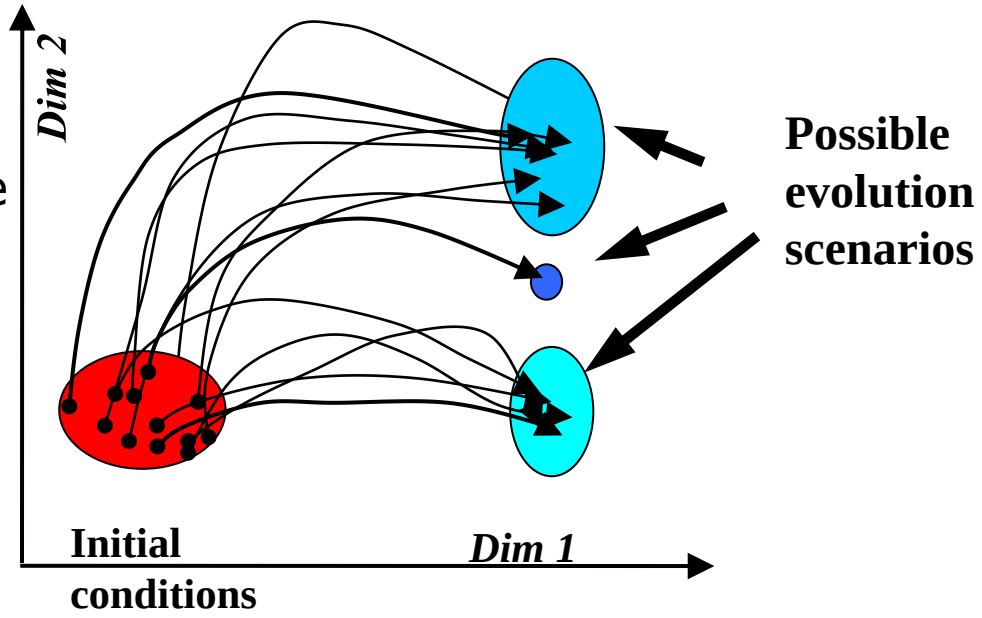
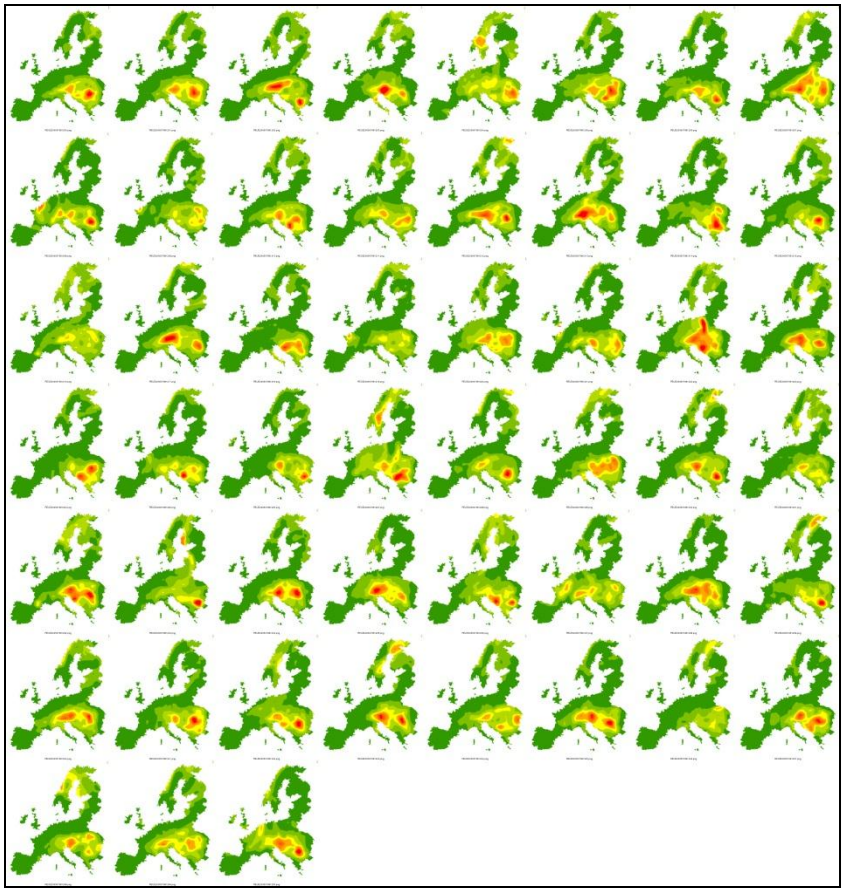
Why probabilistic forecasting?

- Small differences in initial conditions result in diverging outcomes
- long-term prediction are impossible in general – there is a limit to the predictability of the weather

But: we can stretch the limit of Predictability when we quantify the uncertainties



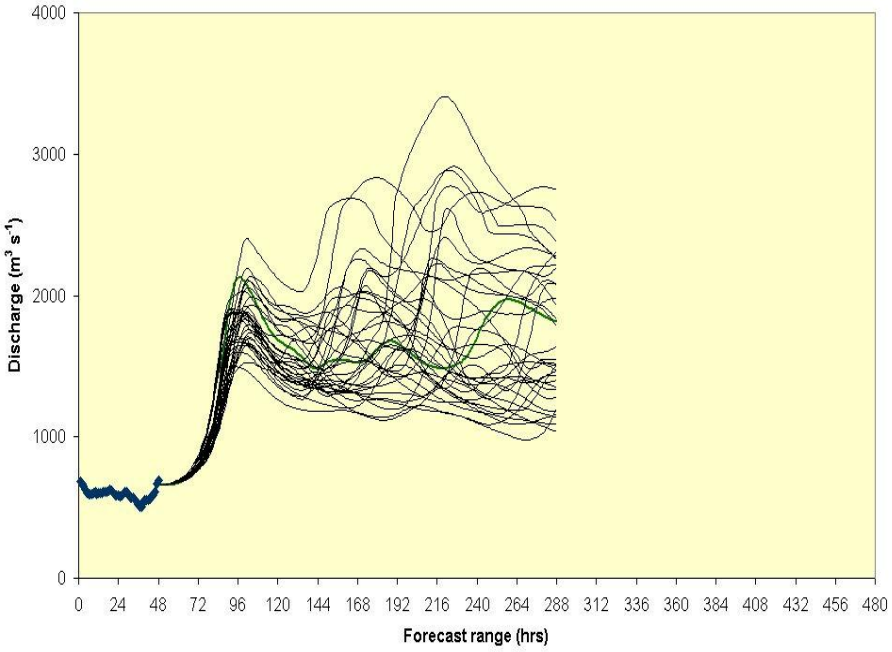
Ensemble Prediction System



- *n* weather forecasts are calculated
- A priori all *n* members of the ensemble are equally likely
- Ensembles are designed to capture a large variety of possibilities – the truth may not always be captured
- Extreme events may be captured by 1 or few members
- Errors grow with time

Ensemble Prediction System (EPS)

- At the beginning the differences are small between the ensembles (small spread)
- The longer the forecasting range, the bigger the differences (big spread)



EPS increase robustness of system through multiple inputs

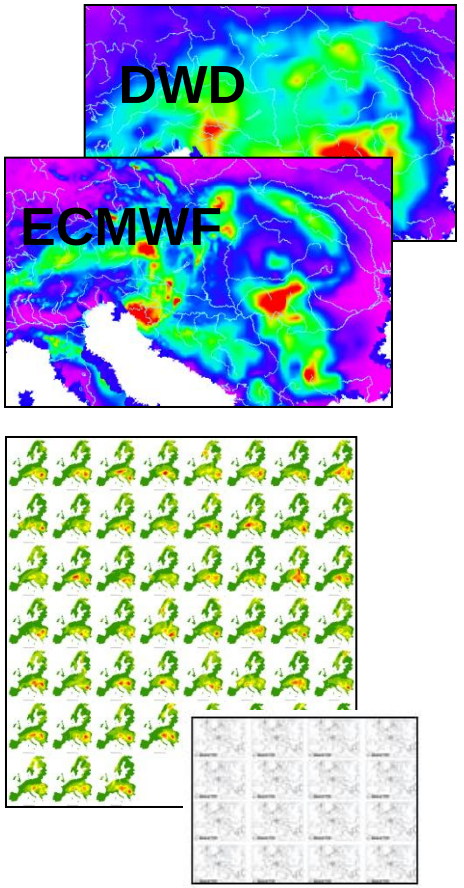
Ensemble Prediction System in EFAS

Deterministic

- DWD – 7 days, ~ 7 km (Day 1 – 3), ~ 30 km (day 4 - 7), twice daily
- ECMWF, 10 days, ~16 km, twice daily

Ensembles

- ECMWF VAREPS – 10 days , ~ 30 km, 51 members, twice daily
- COSMO-LEPS - 5 days, ~ 7 km, 16 members



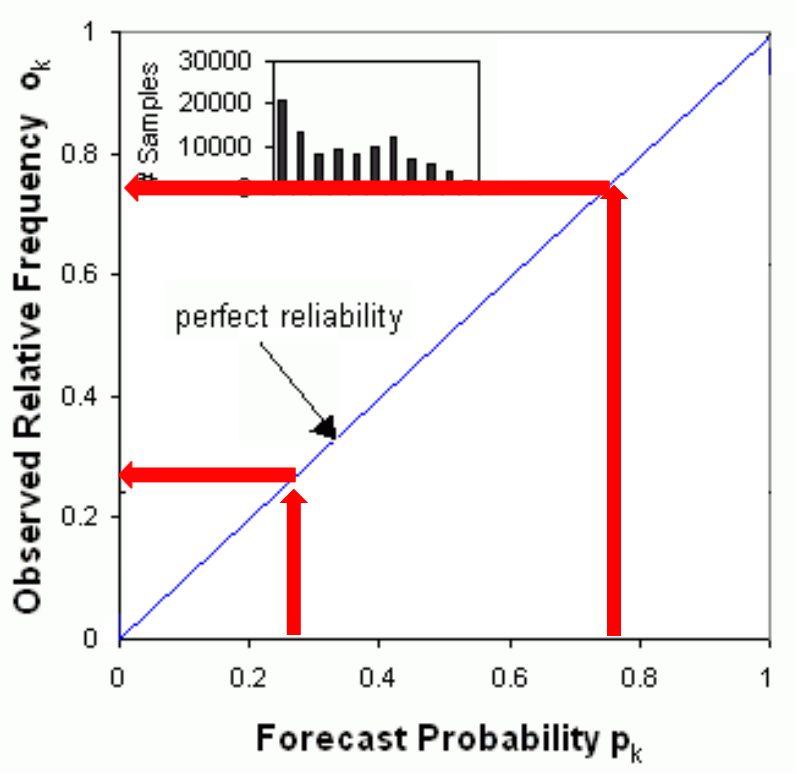
In total the EFAS EPS system contains 69 ensemble members.

Interpreting Ensembles

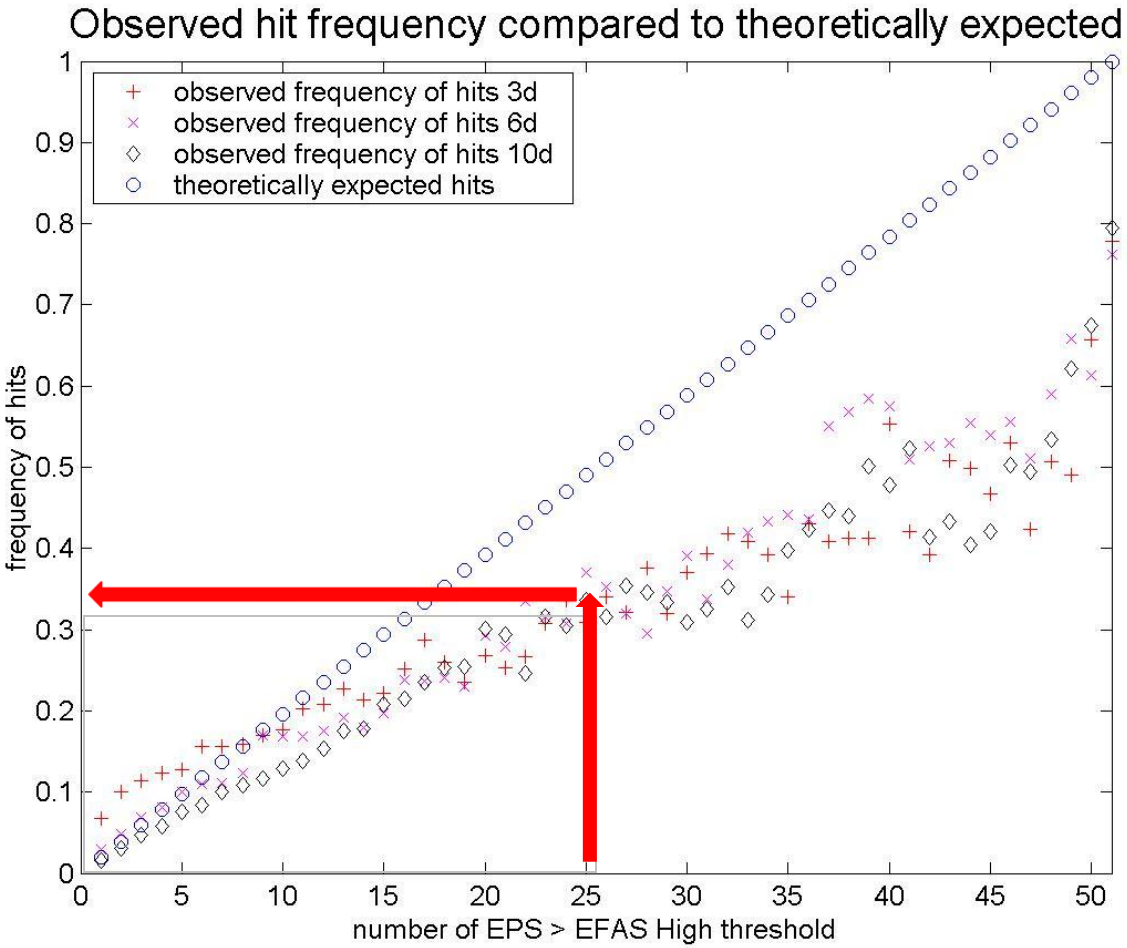
Ensembles are most useful for early warning to prepare for serious events – in the range when weather forecasts are most uncertain (3-15 days)

Let's assume for the moment that our EPS have been corrected from systematic biases and are well calibrated. In this case,

- ❑ if 25% of all EPS exceed the threshold, there is a 25% chance of the event to happen
- ❑ if 75% of all EPS exceed the threshold, there is a 75% of the event to happen



Reliability diagrams

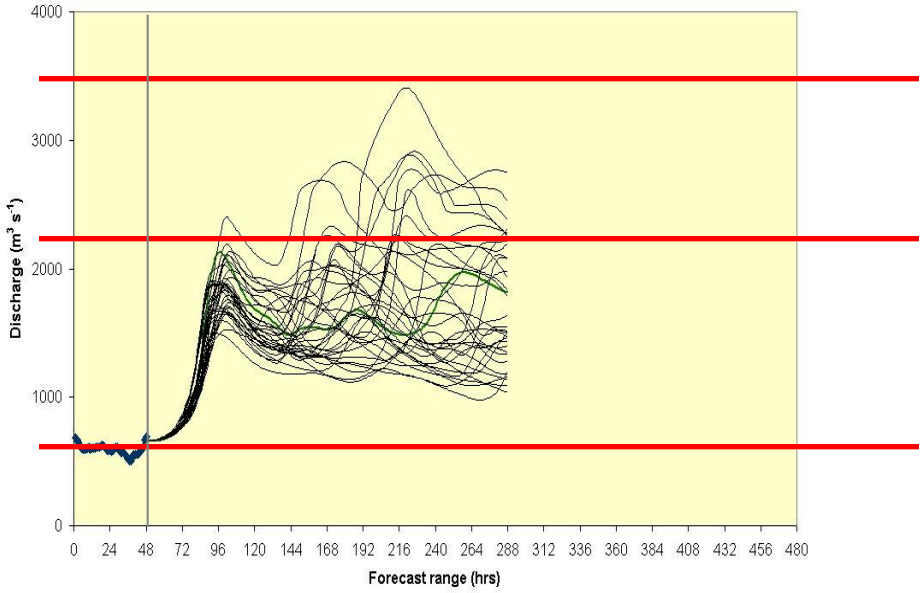


EFAS analysis 2005/2006

Indicates that the forecasts are not fully reliable and that there is a bias.

Flood Thresholds

For floods: not the discharge is important but if the discharges EXCEED critical values



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

Flood Thresholds

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

- Bridges overtopped
- Roads flooded
- Bankfull conditions reached

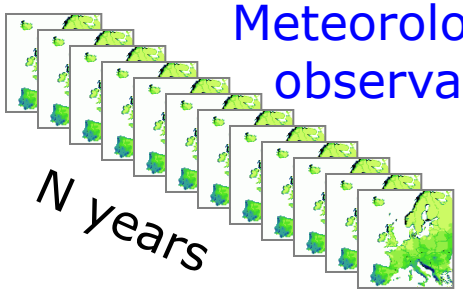
River Blackwater

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.

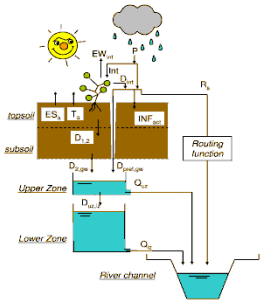
For EFAS this kind of information is not available: need to construct critical levels differently

Employing model climatology to derive return period statistics

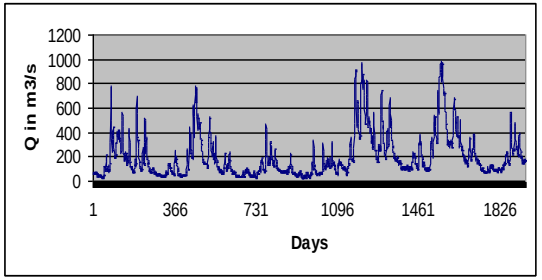
Meteorological observations



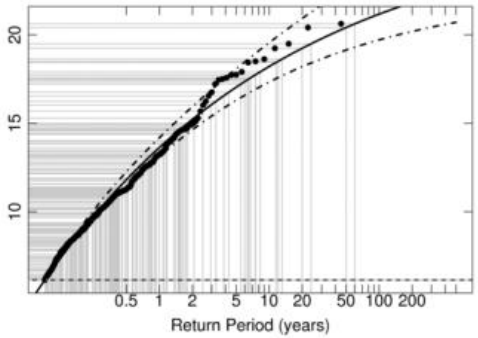
LISFLOOD



Discharge time series



Return period statistics

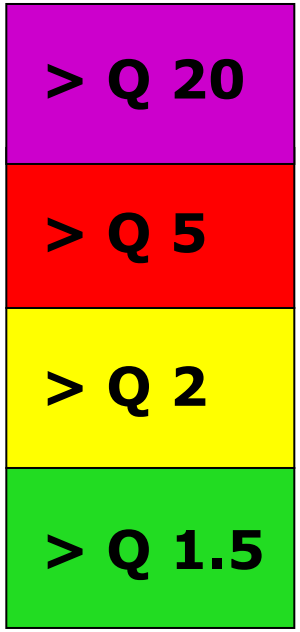


Thresholds

- Q20
- Q5
- Q2
- Q1.5

- Thresholds are derived from simulated time series.
- The same model set-up and parameterisations are used in the forecasts to remain model consistent

EFAS Thresholds - Meaning



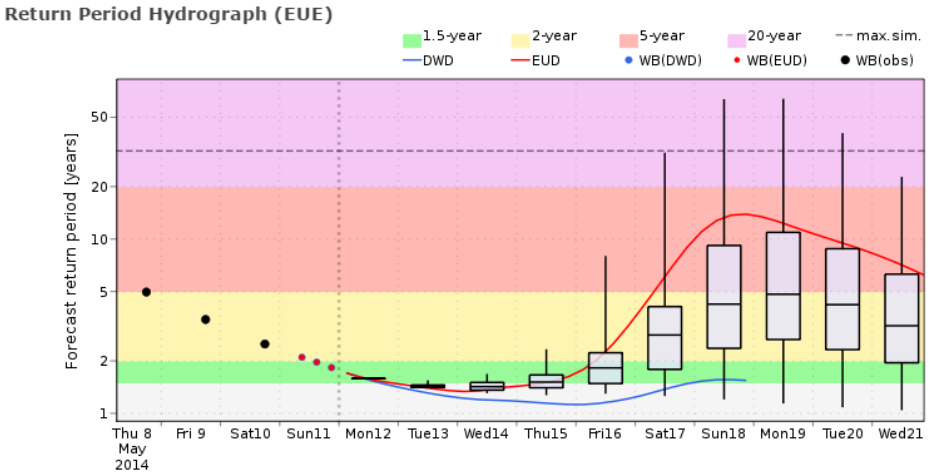
- Approach eliminates systematic bias (e.g., systematic influence of reservoirs not included
- Easily understandable
- Can be more easily linked to national levels

EFAS web interface – Communication

Easy and fast access to flood forecast for end users:

- Password protected Web Interface for partners only
- Updates twice a day
- Easy understandable hotspot maps, flood probability maps, flood threshold exceedances
- Hydrologically relevant meteorological information (upstream rainfall, snowmelt, rainfall probabilities, etc)

Visualization of uncertain results



Return period hydrograph using box-plot diagrams and thresholds

Overview of DWD, EUD, EUE > HAL, EUE > SAL

Forecast Type	13	14	15	16	17	18	19	20	21	22
DWD		↓	↓	↑	↑	*	↓			
EUD		↓	↑	↑	↑	*	↓	↓	↓	↓
EUE > HAL				14	61	90	90	88	82	69
EUE > SAL					22	47	47	37	31	14
COS > HAL				25	69					
COS > SAL				12	37					

EFAS threshold exceedance box diagrams

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Visualizing uncertain results

Forecast consistency

Overview of DWD, EUD, EUE > HAL, EUE > SAL

Forecast Type	14	15	16	17	18	19	20	21	22	23
DWD		↑	↑	↑	*	↓	↓			
EUD		↑	↑	↑	*	↓	↓	↓	↓	↓
EUE > HAL			4	98	100	100	100	100	96	94
EUE > SAL				35	92	92	86	55	31	8
COS > HAL			62	100	100					
COS > SAL			37	87	94					

Consistent between DWD, ECWMF determinstic and EPS

Overview of DWD, EUD, EUE > HAL, EUE > SAL

Forecast Type	28	29	30	1	2	3	4	5	6	7
DWD		↑	↑	*	↓	↓	↓			
EUD		↑	↑	*	↑	↓	↓	↓	↓	↓
EUE > HAL										
EUE > SAL										
COS > HAL			19	75	62					
COS > SAL			6	25						

No consistency

Visualization of uncertain results

Forecast persistence

EUE > HAL

Forecast Day	10	11	12	13	14	15	16	17	18	19	20	21	22
2014-05-10 00:00							16	33	35	35			
2014-05-10 12:00					2	6	14	27	37	33			
2014-05-11 00:00						4	27	43	53	53	39		
2014-05-11 12:00						10	35	49	55	43	39		
2014-05-12 00:00							6	22	41	49	41	31	
2014-05-12 12:00						2	18	47	59	57	51	41	
2014-05-13 00:00							14	61	90	90	88	82	69

Previous forecasts

Today's forecast

EUE > HAL

Forecast Day	18	19	20	21	22	23	24	25	26	27	28	29	30
2014-10-18 00:00						12	10	6					
2014-10-18 12:00													
2014-10-19 00:00						2							
2014-10-19 12:00					8	6							
2014-10-20 00:00						39	35	6	4	2			
2014-10-20 12:00					27	20	8	12	4	2			
2014-10-21 00:00						31	31	16	6				2

No forecast persistence

Visualization of uncertain results

Overview of DWD, EUD, EUE > HAL, EUE > SAL

Forecast Type	13	14	15	16	17	18	19	20	21	22
DWD		↓	↓	↑	↑	*	↓			
EUD		↓	↑	↑	↑	*	↓	↓	↓	↓
EUE > HAL				14	61	90	90	88	82	69
EUE > SAL					22	47	47	37	31	14
COS > HAL				25	69					
COS > SAL				12	37					

Consistence between forecasts

EUE > HAL

Forecast Day	10	11	12	13	14	15	16	17	18	19	20	21	22
2014-05-10 00:00							16	33	35	35			
2014-05-10 12:00					2	6	14	27	37	33			
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2014-05-12 12:00						2	18	47	59	57	51	41	
2014-05-13 00:00							14	61	90	90	88	82	69

Persistence of results from forecast to forecast

Reduction of false alarms

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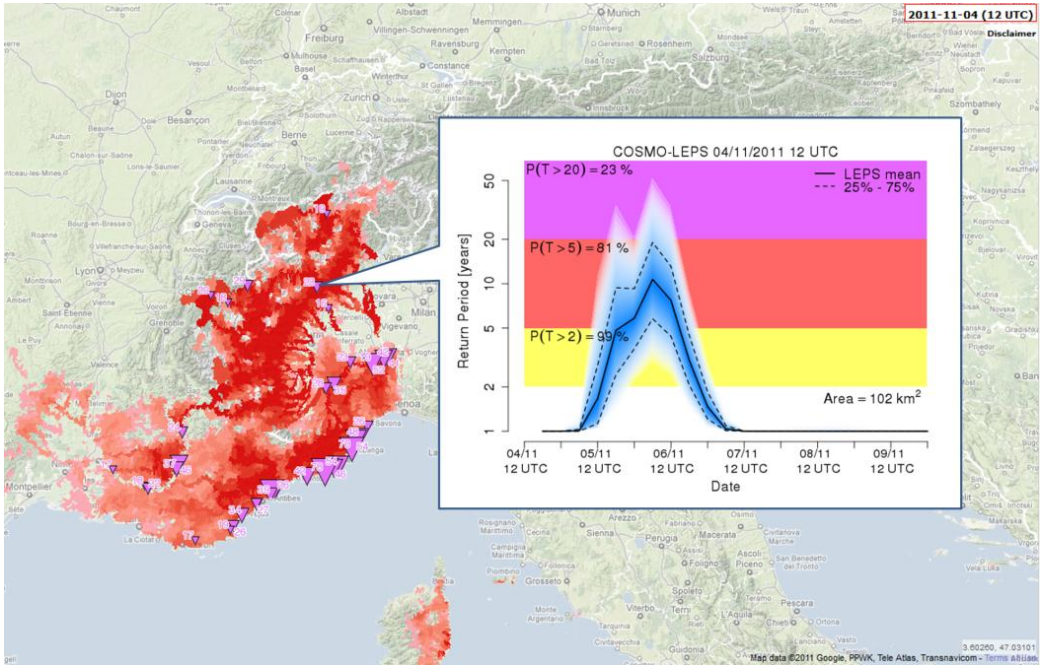
Predicting flash flood in EFAS



European **P**recipitation **I**ndex based on simulated **C**limatology (EPIC) is an indicator for upcoming extreme precipitation events and aid the early detection of flash floods at the scale of small catchments.

At each time step, EPIC compares accumulated upstream precipitation for durations 6/12/24 hours, with reference thresholds derived from a long-term reforecasts dataset

No hydrological simulation

Alfieri, L. and Thielen, J. (2012), A European precipitation index for extreme rain-storm and flash flood early warning. Met. Apps.

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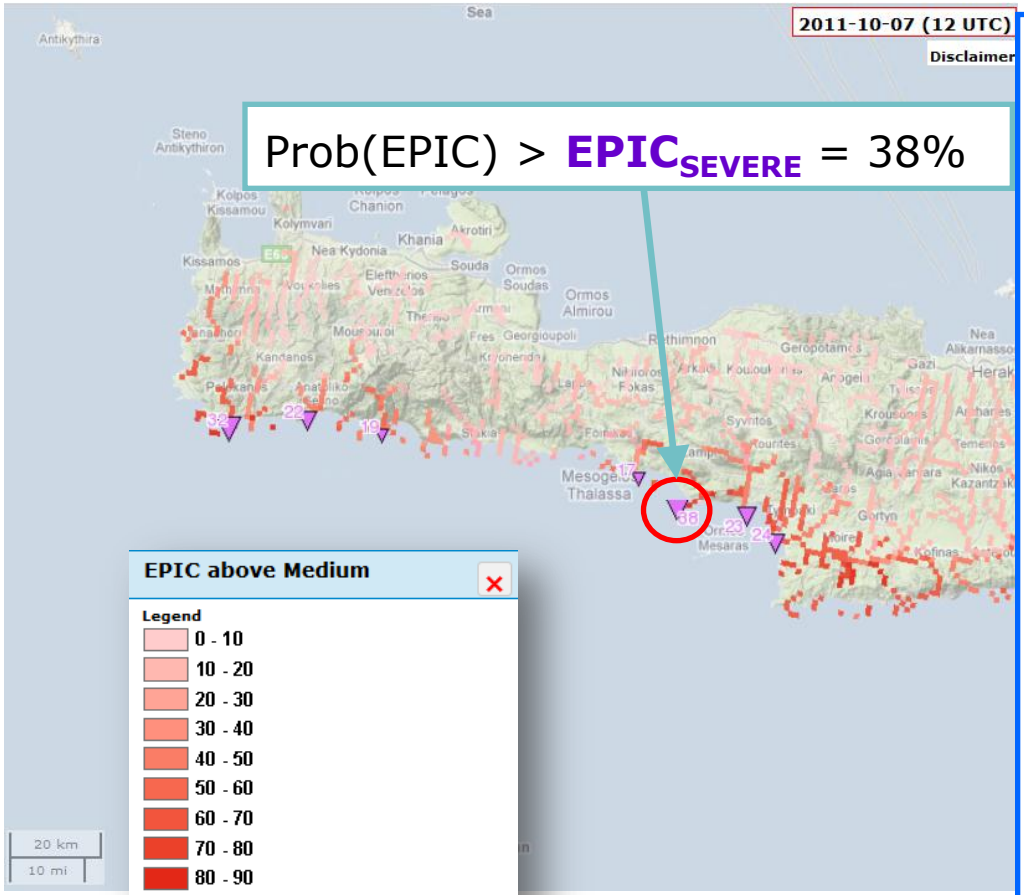
Predicting flash flood in EFAS

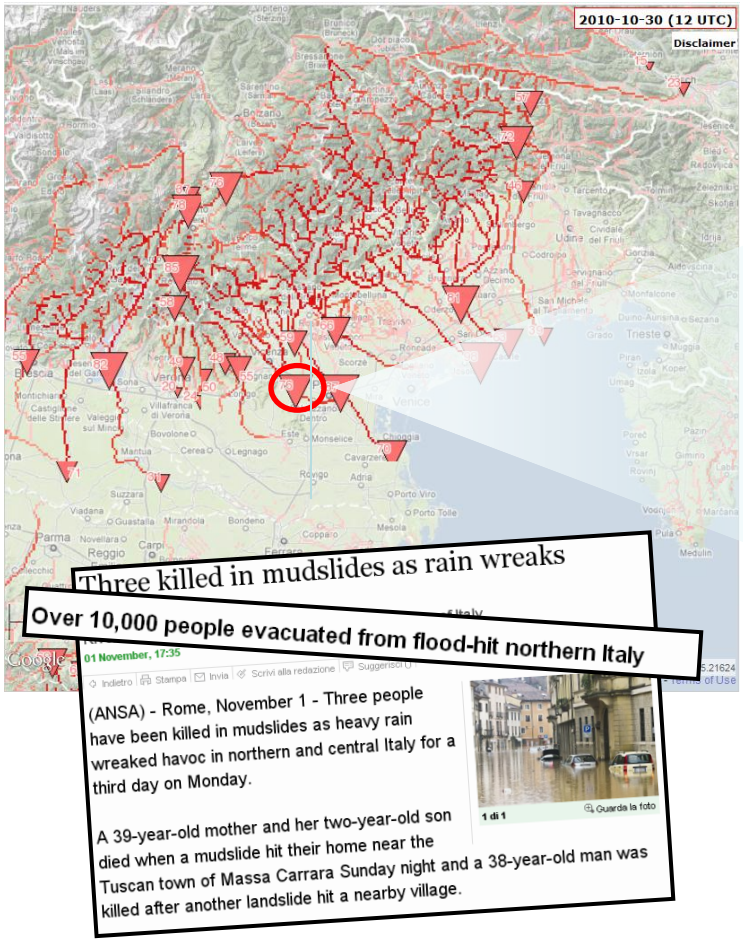


Technical details

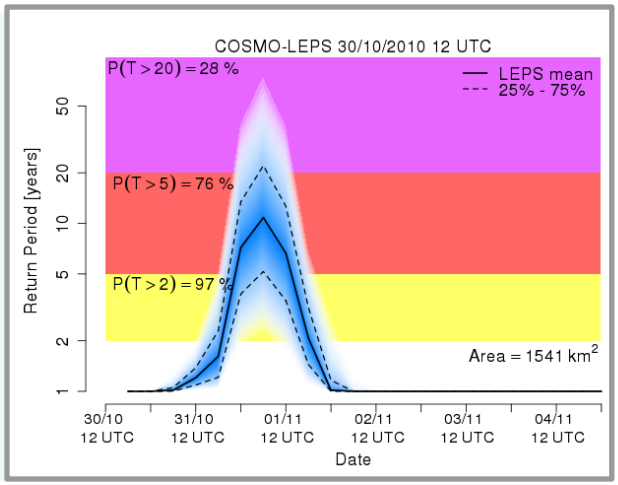
- Based on COSMO-LEPS forecasts (16 members)
- Alert thresholds derived from a consistent 20-year climatology
- River network at **1 km resolution** (EFAS stream flow simulations use 5 km resolution)
- Fit for catchments between 50 km^2 and 2000~4000 km^2
- EPIC probabilities are considered for the lead time range 12÷120 hours

Predicting flash flood in EFAS

EPIC time plot for COSMO-LEPS forecast on 30/10/2010 12 UTC, for the north-western Italy.



Bacchiglione River near Padova



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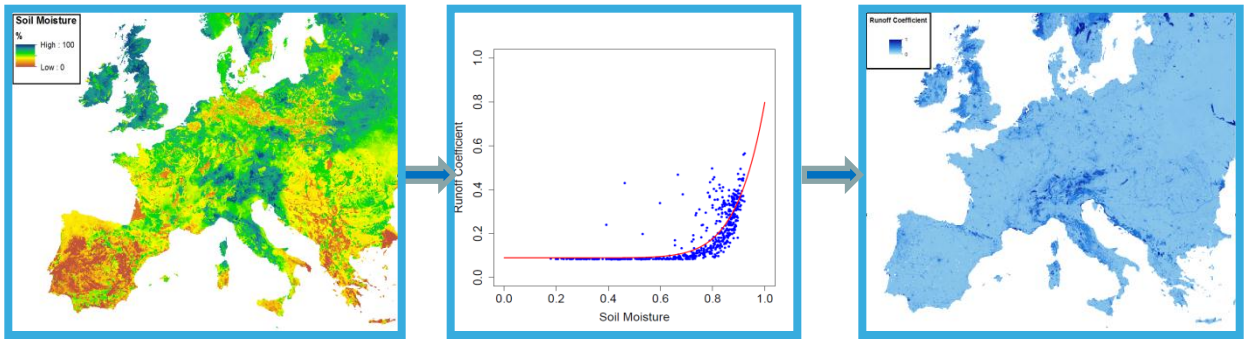
New developments for flash floods:

From EPIC to ERIC: from Precipitation to Runoff

EPIC indicator (European Precipitation Index based on Climatology) : Only based on precipitation

➔ Introduction of the Runoff Coefficient to weight the different contributions of rainfall



Daily initial soil moisture

Daily runoff map

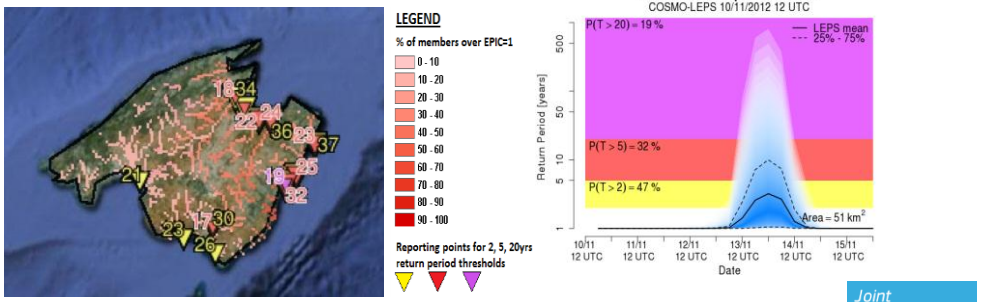
Functioning:

I. Separation rain and snow

II. Introduction of the runoff coefficient

III. Computing the upstream runoff

IV. Assessing the probability of exceedance of different return period events



Raynaud et al. (2014), A dynamic runoff co-efficient to improve flash flood early warning in Europe: evaluation on the 2013 central European floods in Germany. Met. Apps.

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Questions ?

For further info:

www.efas.eu

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