

The European Flood Awareness System

From science to operations



www.jrc.ec.europa.eu

Jutta Thielen-del Pozo

& EFAS team and supporters

Serving society

Stimulating innovation

Supporting legislation

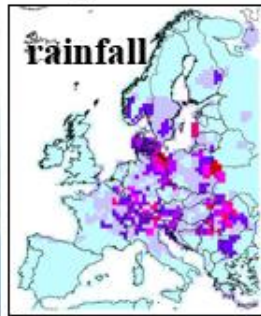
Looking back in time – promoting the idea of EFAS back in 2002



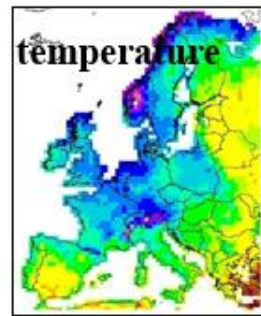
TOWARDS A EUROPEAN FLOOD ALERT SYSTEM



10 day weather forecasts:

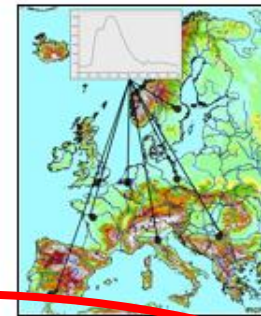


+



LISFLOOD
MODEL

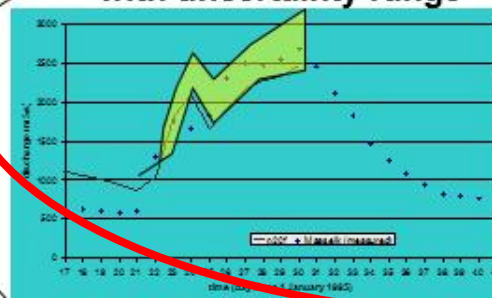
Flood forecasts for all major rivers:



discharge forecast



10-day forecast Meuse:
20-30 January 1995
with uncertainty range

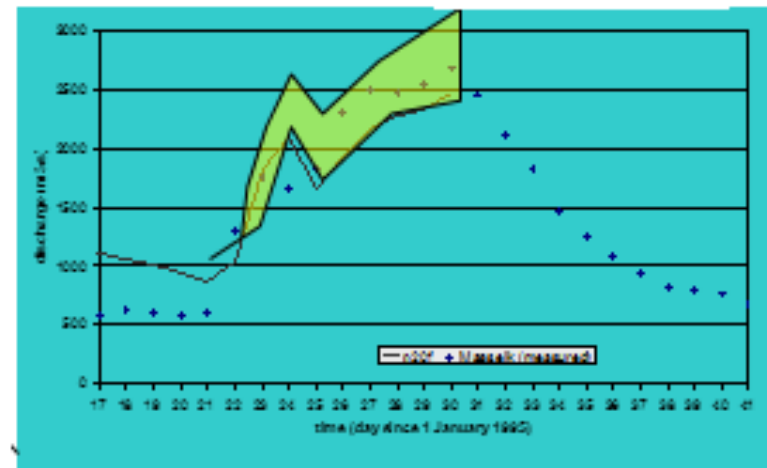


Example of a warning report

Flood Warning Report	
Date of forecast report	12-Jul-97
Date of expected peak	19-Jul-97
River	Oder
Countries Involved	Poland
Location	Wroclaw
Expected Peak Discharge (m³/s)	2800
Expected Water Level (m)	123.4

EPS in theory, Deterministic in reality

We discussed the building of a probabilistic system ...

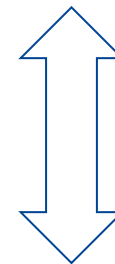


... but were still thinking deterministic

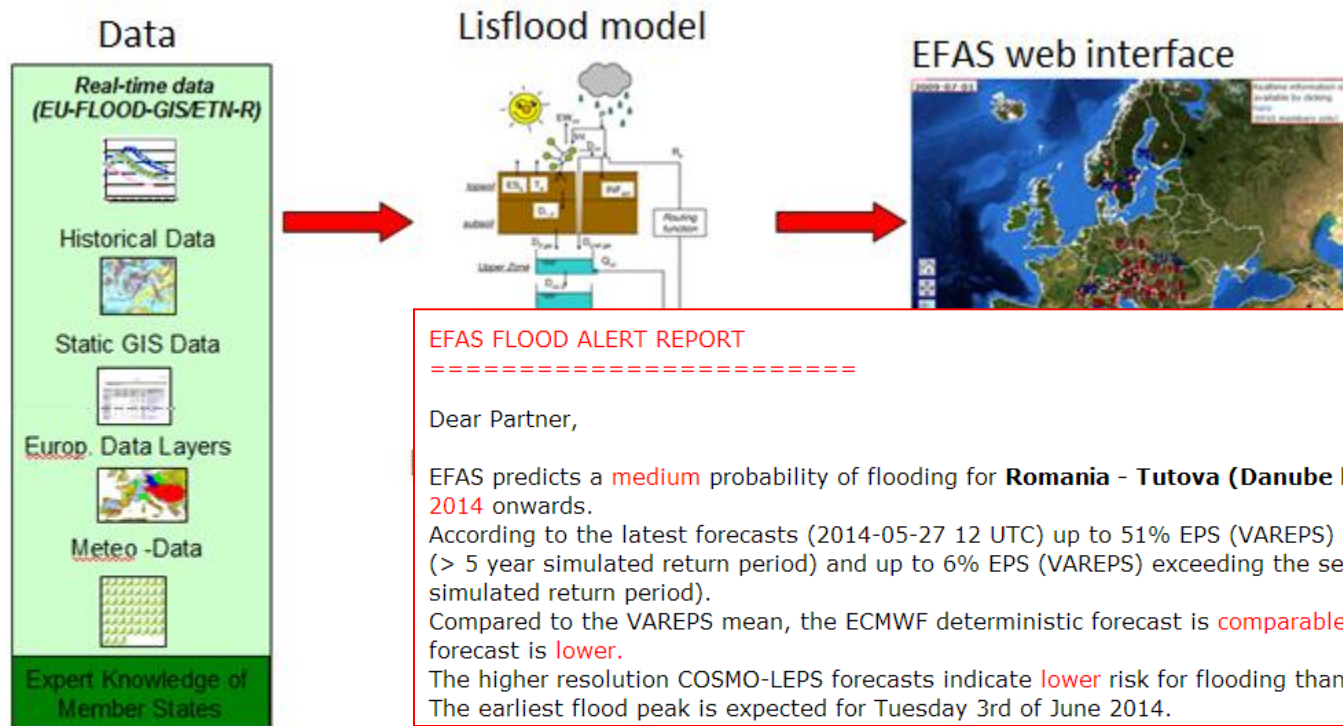
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HEPEX guidance for EFAS and vice versa

- *Demonstrate the reliability of hydrological ensemble predictions (HEPS) that can be used with confidence by emergency management and water resources sectors to make decisions that have important consequences for economy, public health and safety.*
- EFAS, a useful testbed for HEPEX

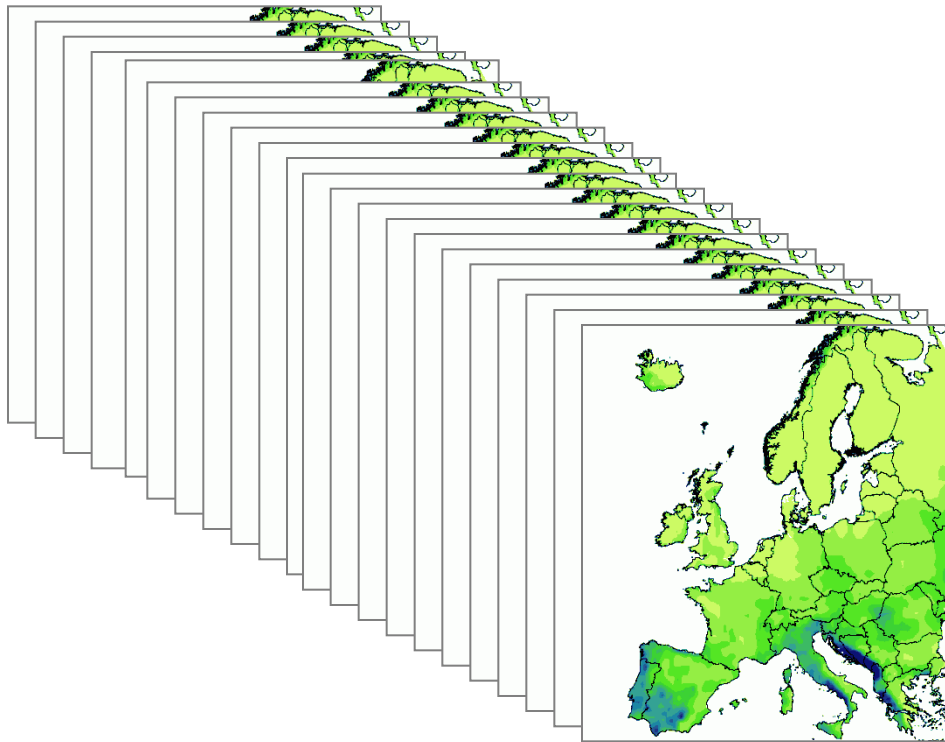


European Flood Awareness System (EFAS)



- European Response and Coordination Centre (ERCC) – EU civil protection
- > 40 national hydro-met partner services ⁵
- Research networks (HEPEX, Horizon2020)

NWP inputs for EFAS



Deterministic (single) forecasts:

ECMWF (15 days, 15 km resolution)

DWD (7 days, 40 km resolution)

Probabilistic (multiple) forecasts:

ECMWF-VAREPS (15 days, 51 members, 32 km resolution)

COSMO-LEPS (5 days, 16 members, 7 km resolution)

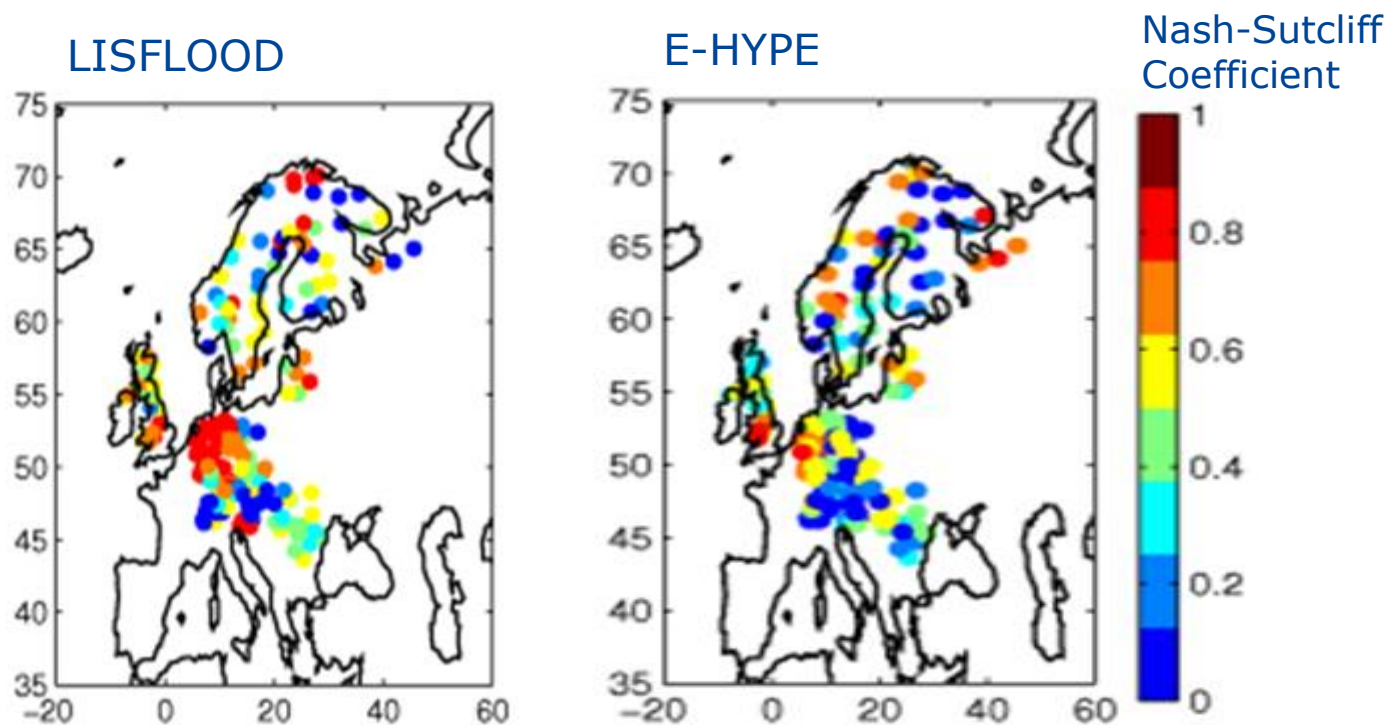
EFAS with multiple hydrological models?

Criteria								
Model	Availability of code	User community	Input data requirements ¹	Flexibility to grid structure	Possibility of calibration	Flexibility in grid resolution	Facility to introduce Q observation stations	Pan-European model set up?
CLM (D. Lawrence, pers. comm., 21 Mar 2014)	<ul style="list-style-type: none"> Open source http://www.cesm.ucar.edu/models/clm/	Active working group > 100 members, user base broader	netCDF <6h, ~2/0.1° 18F, 20S Hydro1K?	<ul style="list-style-type: none"> Regular or irregular spectral grids 	<ul style="list-style-type: none"> In theory, but complex. No tools available 	<ul style="list-style-type: none"> 5-10km, but higher resolution possible. Routing 0.1-0.5 deg 	<ul style="list-style-type: none"> In place 	<ul style="list-style-type: none"> Set up for global applications, but can be run for any domain
E-HYPE (B. Arheimer, pers. comm., 25 Mar 2014)	<ul style="list-style-type: none"> Open source http://hype.sourceforge.net	Main collaborations outside SMHI: UFZ (Germany) and IRSTEA (France). Results used by a broader group.	Text files D, Median 215km ² 2F, 15S HydroSHEDS/Hydro1K	<ul style="list-style-type: none"> Sub-basin structure, but can be run on regular grid 	<ul style="list-style-type: none"> >35 000 gauging stations included 	<ul style="list-style-type: none"> Sub-basin structure of varying size. 	<ul style="list-style-type: none"> >35 000 gauging stations included 	<ul style="list-style-type: none"> Existing
G2G (R.J. Moore, pers. comm., 10 Apr 2014)	<ul style="list-style-type: none"> only executables 	The Flood Forecasting Centre (England & Wales), Scottish Flood Forecasting Service, Environment Agency, Natural Res. Wales, and more	BIL 15min, 1 km 2-3F, 4S Corrected Hydro1K	<ul style="list-style-type: none"> Runs with grid structure 	<ul style="list-style-type: none"> Variety of tools available, both manual and automatic 	<ul style="list-style-type: none"> Yes 	<ul style="list-style-type: none"> Observed discharge is used for data assimilation, comparisons and calibration 	<ul style="list-style-type: none"> Offline pan-European model set up. Can be set up for operational forecasts.
GWAVA (E. Dumont, pers. comm., 21 Mar 2014)	<ul style="list-style-type: none"> only executables and training courses available outside CEH 	Water resources team in CEH Wallingford	- 1D, 0.5°/5' ≥28 CCM2.1	<ul style="list-style-type: none"> Runs with grid structure 	<ul style="list-style-type: none"> Inbuilt calibration algorithm to obs. Q 	<ul style="list-style-type: none"> Lower limit currently approx. 10 km 	<ul style="list-style-type: none"> In place 	<ul style="list-style-type: none"> Existing
H08 (N. Hanasaki, pers. comm., 23 Mar 2014)	<ul style="list-style-type: none"> Open source http://h08.nies.go.jp/h08/	National Institute for Environmental Studies, Thai Meteorological Dept., Princeton University, ISI-MIP, EU-WATCH	Plain binary format 6h, 1°/0.5° 8 inputs TRIP	<ul style="list-style-type: none"> Runs with grid structure 	<ul style="list-style-type: none"> No tools provided 	<ul style="list-style-type: none"> Flexible 	<ul style="list-style-type: none"> No tools provided 	<ul style="list-style-type: none"> Set up for global application, high res. model set up for Thailand
HTESSEL	<ul style="list-style-type: none"> Open source/in house 	ECMWF	1h, N/A	<ul style="list-style-type: none"> Runs with grid structure 	<ul style="list-style-type: none"> Typically not calibrated 	<ul style="list-style-type: none"> Flexible 	<ul style="list-style-type: none"> No tools provided 	<ul style="list-style-type: none"> Existing

++ 17 more models (from Wetterhall et al., 2014)

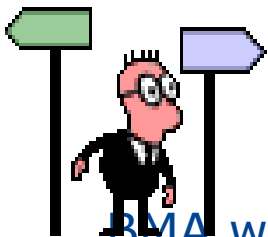
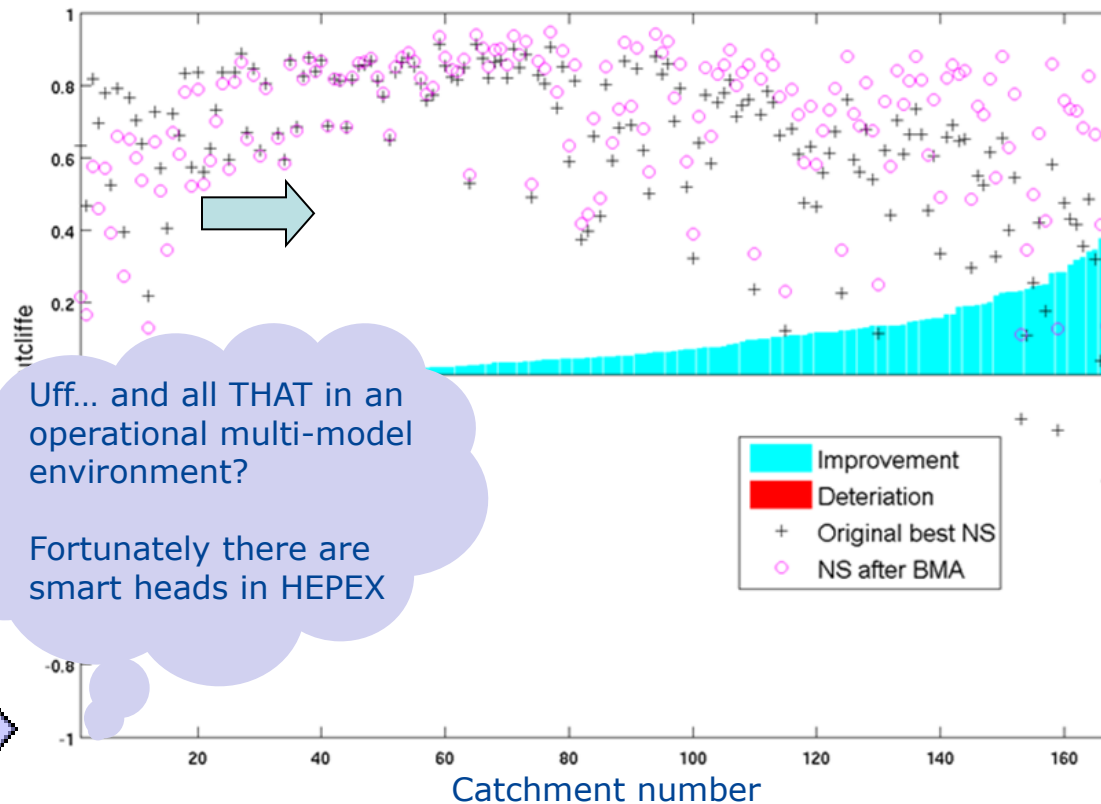
E-HYPE currently tested pre-operationally

Comparison Lisflood E-Hype



Initial study 1990-2010 (Wetterhall, 2014)

Bayesian model averaging of results

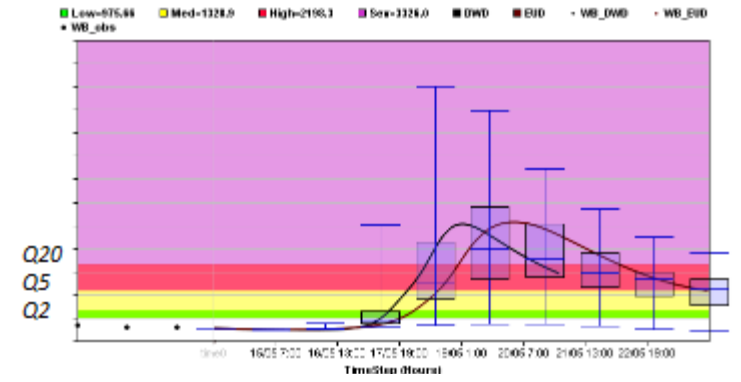
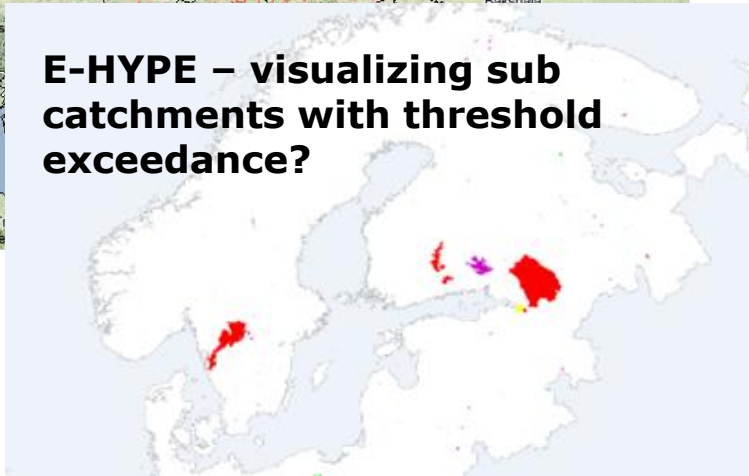


BMA weighted discharge time series (including HTESSSEL) yields better performance in most catchments

Visualising hydrological EPS

Time series of flood probability

Flood probability exceeding critical threshold within the next 10 days



Forecast Day	12	13	14	15	16	17	18	19	20	21
DWD						Yellow	Red			
ECMWF						Yellow	Purple	Purple	Purple	Red
EUE > HAL						2	16	23	22	18
EUE > SAL							5	14	8	6

Thresholds

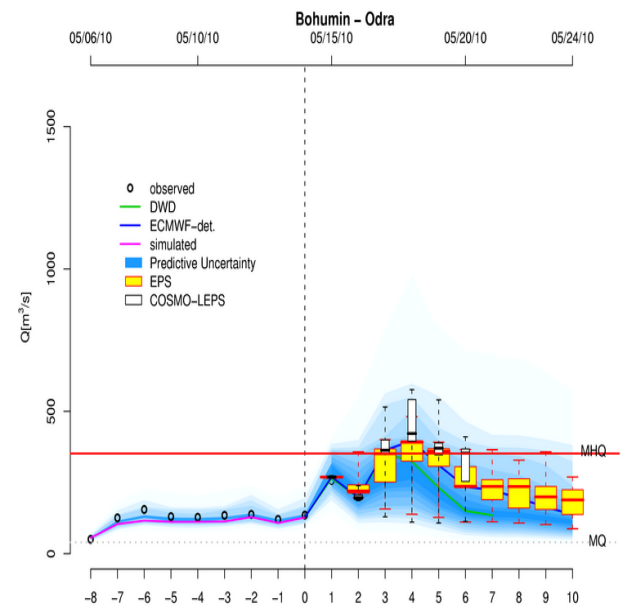
- Q20 (Purple)
- Q5 (Red)
- Q2 (Yellow)
- Q1.3 (Green)

Forecast Day	11	12	13	14	15	16	17	18	19	20	21	22	23
2010051100								8	13	19			
2010051112							3	12	18	17			
2010051200							2	16	23	22	18		
2010051212							7	22	26	23	18		
2010051300							2	23	32	29	25	15	
2010051312							7	29	37	35	26	14	
2010051400							4	29	45	42	40	31	26

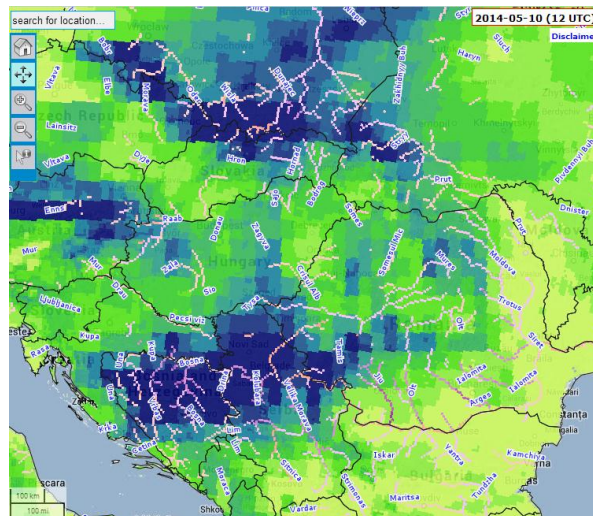
Towards predictive uncertainty

(Bogner and Pappenberger, WRR. 2010)

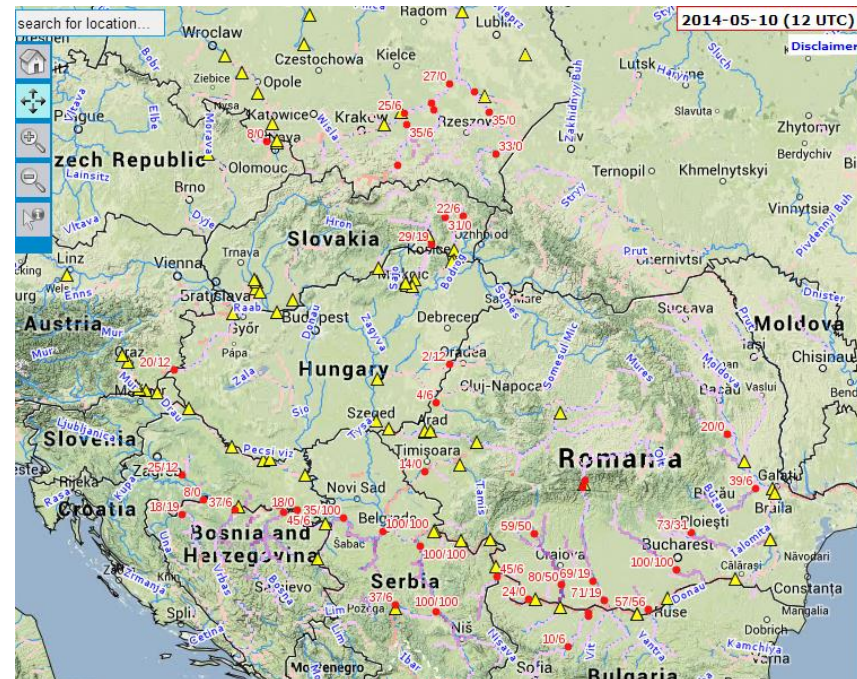
- Wavelet transformations
 - analyze scale dependences of the error time series
 - capture errors by nonlinear processes at different time scales (snowmelt, flash floods)
- Real-time correcting and updating through Vector AutoRegressive model with eXogenous Input (VARX) in the Wavelet domain
- Integrating the various sources of uncertainties: Bayesian Forecasting System (Krzysztofowicz, 1999)



Case study European floods May 2014



Forecasted accumulated precipitation from 10 – 20 May based on forecast from 10th May 2014



EFAS 12:00 forecast from 10th May indicating probability of exceeding 20 (5) year return period threshold in purple (red)

- Rainfall forecasts from 10th May : heavy rain in Balkan region from 14th May
- EFAS forecast shows high probabilities of severe flooding (>20 year, purple) for Bosnia, Serbia, Romania and Southern Poland

Decision making with EFAS on EU scale

Overview active EFAS warnings for 2014-05-15 12UTC forecast:



EFAS Flood/Watch/Flash Flood Watch issued



ERCC Activation



COPERNICUS rush model satellite requests

- 11– 16 May : 19 EFAS alerts to European Response Coordination Centre (ERCC), RS, BG, RO (*BA is not an EFAS partner*)
- 12-13 May: *pre-tasking of satellites for COPERNICUS rush mode* (rapid mapping of flooded areas) *based on EFAS*.
- 15th May (evening) : BA and RS requested international assistance through EU Civil Protection mechanism
- 16th May: BA and RS request satellite information on flooded areas

Decision making HAS improved !

EFAS performance and skill – public information

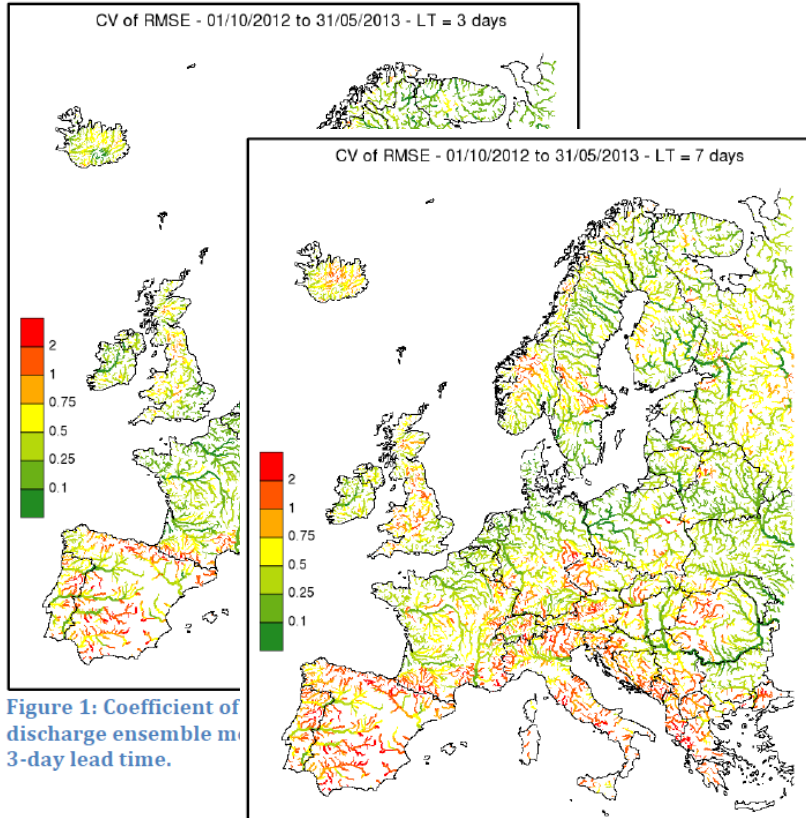
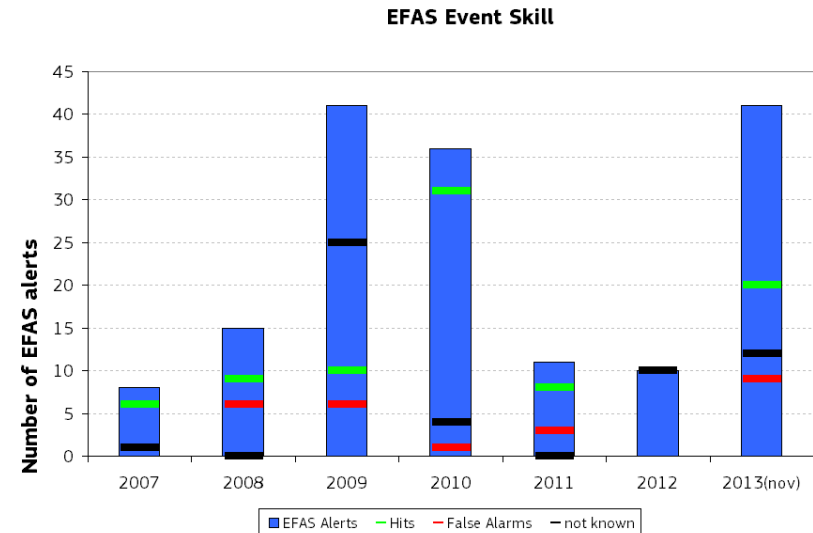


Figure 1: Coefficient of discharge ensemble mean 3-day lead time.

Figure 2: Coefficient of variation of the RMSE of ECMWF discharge ensemble mean from October 2012 onwards, 7-day lead time.

Type	Forecast date	Issue date	Lead time*	River	Country
Alert	12/05/2013 12 UTC	13/05/2013	0	Po, section Adda - Oglio	Italy
Alert	16/05/2013 12 UTC	17/05/2013	4	Vorma	Norway
Alert	16/05/2013 12 UTC	17/05/2013	5	Lainioalven	Sweden
Watch	20/05/2013 12 UTC	21/05/2013	0	Adda	Italy
Alert	27/05/2013 12 UTC	28/05/2013	0	Unstrut	Germany
Watch	28/05/2013 12 UTC	29/05/2013	2	Sebes Koros, Crisul Repede	Hungary
Alert	30/05/2013 00 UTC	30/05/2013	3	Saale, below Elster	Germany
Alert	30/05/2013 00 UTC	30/05/2013	1	Neckar	Germany
Alert	29/05/2013 12 UTC	30/05/2013	4	Rhine	Germany



European Flood Awareness System

Operational Consortium

*Meteo data
collection*

Computations

Dissemination

Hydro data
collection



Summary and conclusions

- EFAS has matured from a research project to a fully operational flood forecasting system on EU scale within 10 years
- Fostered use of hydrological ensemble prediction and medium-range flood forecasting in Europe (short-medium scale, visualization, implementation)
- Organisation of operational hydrological services into an active network with regular exchange of information and training
- Fostered communication between hydrologists, civil protection and the science community
- HEPEX played a major role in the research development for EFAS and vice versa