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Application of EPS – Weather driven natural hazards

J.Thielen

EC Joint Research Centre
IES/LMU/WDNH

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Weather driven natural hazards

An unexpected or uncontrollable natural event of unusual magnitude that is driven or triggered by meteorological forcing. The event may be life and health threatening and/or negatively impact environment and socio-economic life.

Meteorological processes can be

- severe, unusual weather
- combination of weather and particular initial conditions
- duration of the order of hours to months

Examples : Weather driven natural hazards

FLOODS:

Riverine floods, flashfloods, snowmelt, coastal, ice jams, …

Most costly natural hazard around the world

STORMS:

Thunderstorms (extreme rainfalls, high winds, hail, lightning), tornados, wind storms, …

Most common natural hazard around the world

Mid-latitude and tropical cyclones

Globally ~85 tropical storms and 45 hurricanes/typhoons per year. 2 intense hurricane develop on average per year in the Atlantic

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Examples : Weather driven natural hazards

DROUGHTS

Particularly severe during growing season

LANDSLIDES

Mostly associated with rainfalls (trigger)

AVALANCHES

FIRES: wildland fires

In Europe ~ 95% are human caused, in other regions, e.g. boreal countries, Canada most fires are caused by lightning

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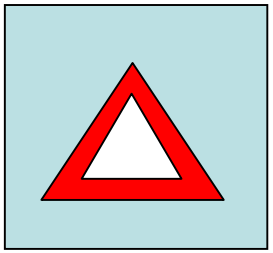
Examples : Weather driven natural hazards

And finally, there is obviously …



SEVERE WEATHER

Snowfall, dense fog, coldwaves, heatwaves, gales, freezing rain, …

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Weather driven natural hazards

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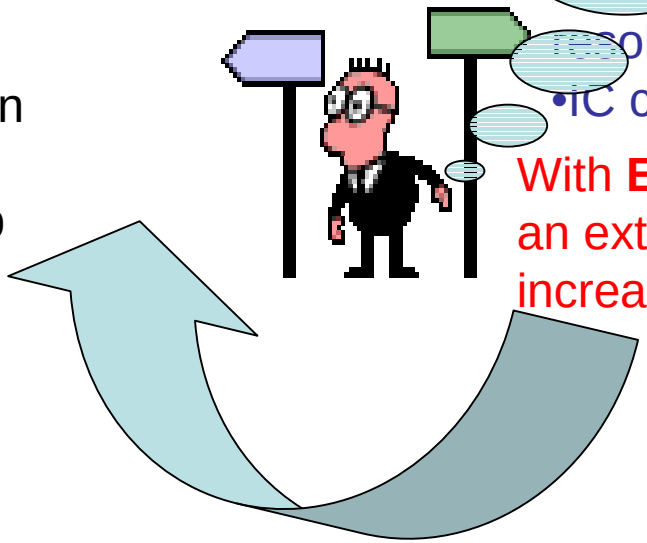
Severe weather events are a civil protection issue

- warning ahead in time to act
- warning should be precise enough to act
- too high false alarm rates problematic
- responsibilities

Raised expectations on the forecasting system's ability to help in the decision making process



Numerical prediction of severe events with **deterministic** forecasts are still not very skillful despite improvement over the last few years

… pfh … weather forecasts … is there nothing else?

Rare events

Ensemble models may not match in spatial-temporal resolutions

- IC crucial

With **EPS** the likelihood to capture an extreme event with NWP has increased

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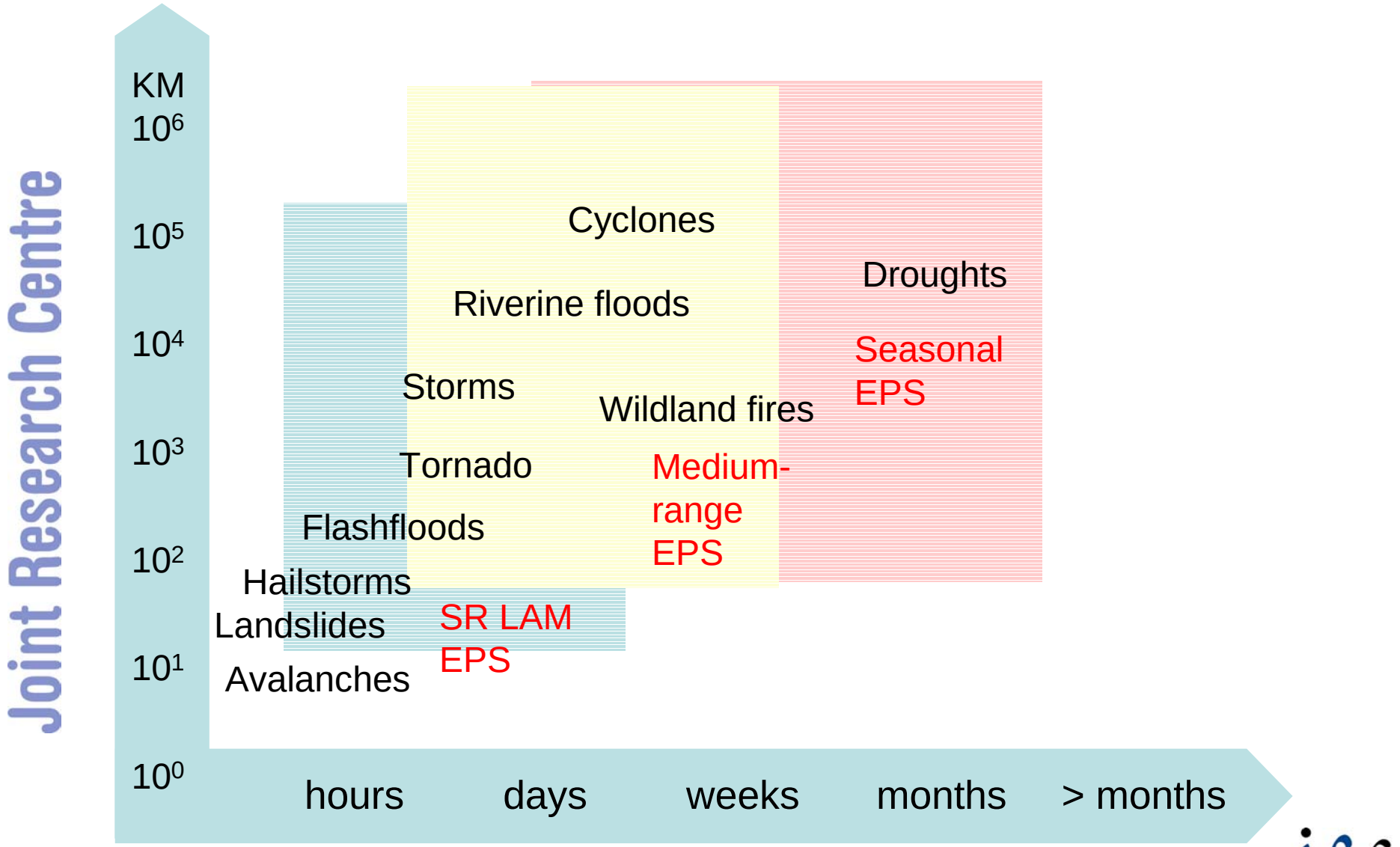
Future Challenges: *Ensemble prediction*

The non deterministic aspect of weather prediction at all time and space scales needs to be quantified with ensembles. This will lead to increased usefulness of forecasts.

Furthermore, such tools are necessary to meet the growing demand of probabilistic forecasts for operational decision making systems for economical, agricultural and industrial management.

[Research and Development at Recherche en Prévision Numérique; (Environment Canada, 2003)]

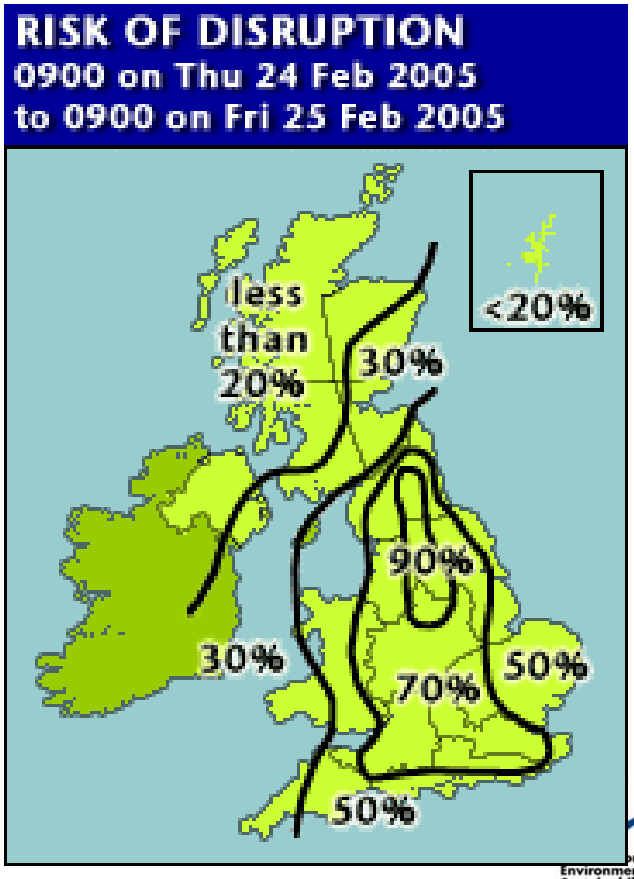


SEVERE WEATHER

Extreme Forecast Index (EFI)

Ranks the departure between the EPS forecast and the model climate.
Sensitive issue is definition of model climate.

(ECMWF, F. Laurette, G. van der Grijn, A. Ghelli)



Example: UK MetOffice products for severe weather

Gales, heavy snow, heavy rain, dense fog, freezing rain

Products that do not require coupling between meteorological information and other specific models

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Flood Forecasting

JRC Questionnaire (2003) on the state of the art of Flood Forecasting practices in Elbe and Danube countries

- 35 questionnaires were send out to Water Authorities in Elbe and Danube countries
- 10 (35) returned from 7 countries

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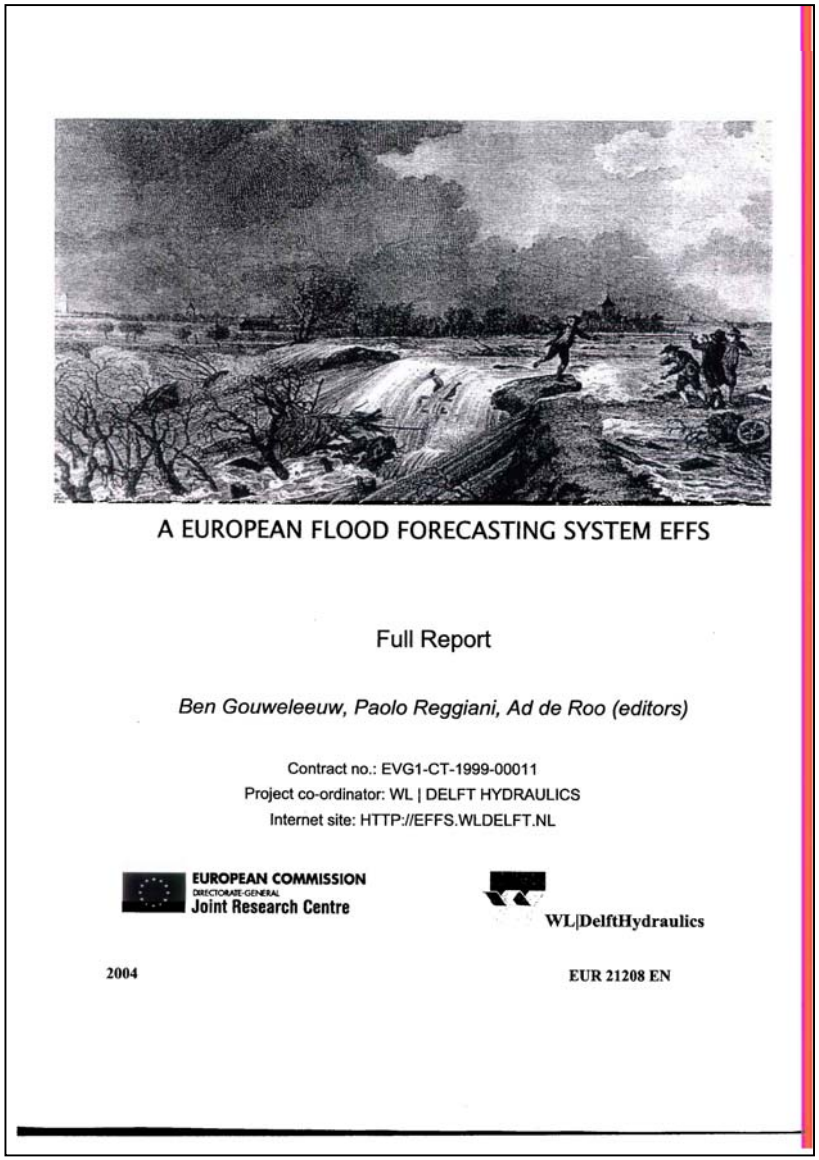
• Q/A: Use of weather prediction data

	Elbe (3)		Danube (7)	
Weather prediction	**Yes**	**No**	**Yes**	**No**
Used quantitatively	**3**	**-**	**6**	**1**
Used qualitatively	**1**	**2**	**2**	**5**
Downscaled	**1**	**1**	**4**	**3**
Receive EPS	**1**	**1**	**6**	**1**
• Qualitatively	NA	NA	3	NA
• quantitative input all	NA	NA	NA	NA
• quantitative input partially	NA	NA	2	NA
• Uncertainty analysis	NA	NA	2	NA

!

Flood forecasting : 7 out of 10 Authorities receive EPS but do not, or only qualitatively analyse the data and use as input



Example Research :

European Flood Alert System-

EFFS (2000-2003)

- trans-national flood forecasting
- medium range flood forecasting using different meteorological forecasts (ECMWF, DWD, DMI)
- EPS based flood forecasting (EPS, mini ensembles from DMI)
- comparison different flood models

Partners :
WL-Delft Hydraulics
JRC-IES
ECMWF-Reading, DMI, DWD
SMHI, RIZA
Univ. Bologna, Univ. Lancaster, Univ. Bristol
GRDC

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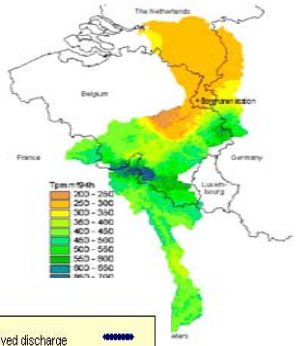
Example of EFFS project: Rainfall in Meuse river basin Jan 1995



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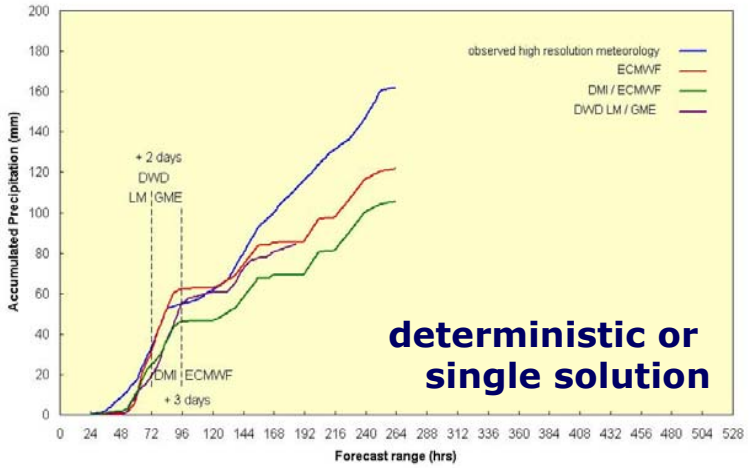
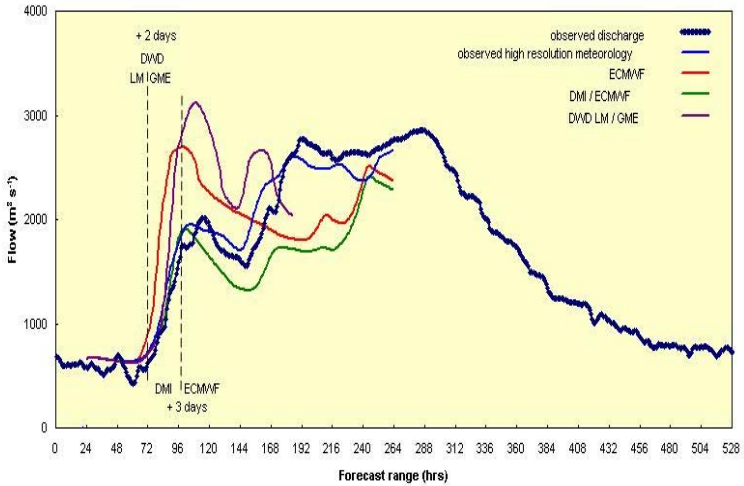
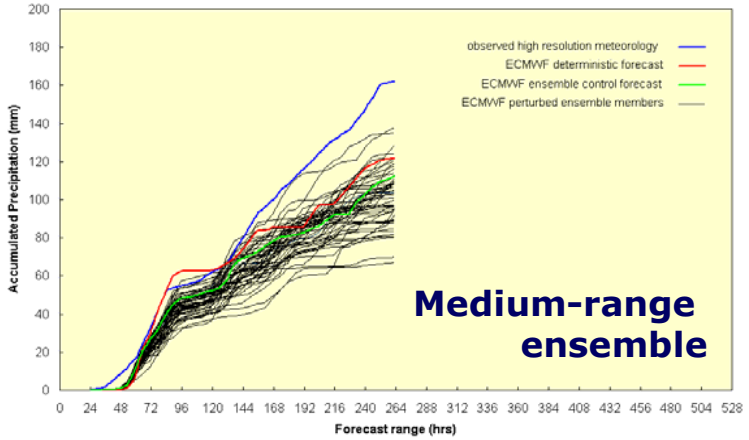
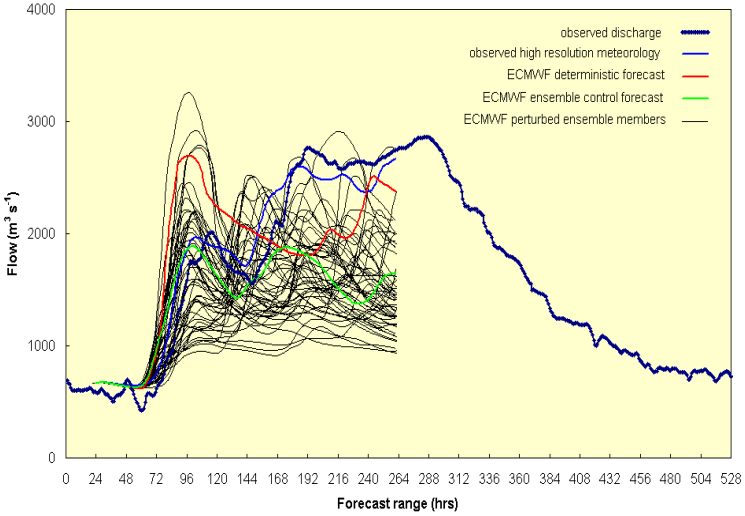


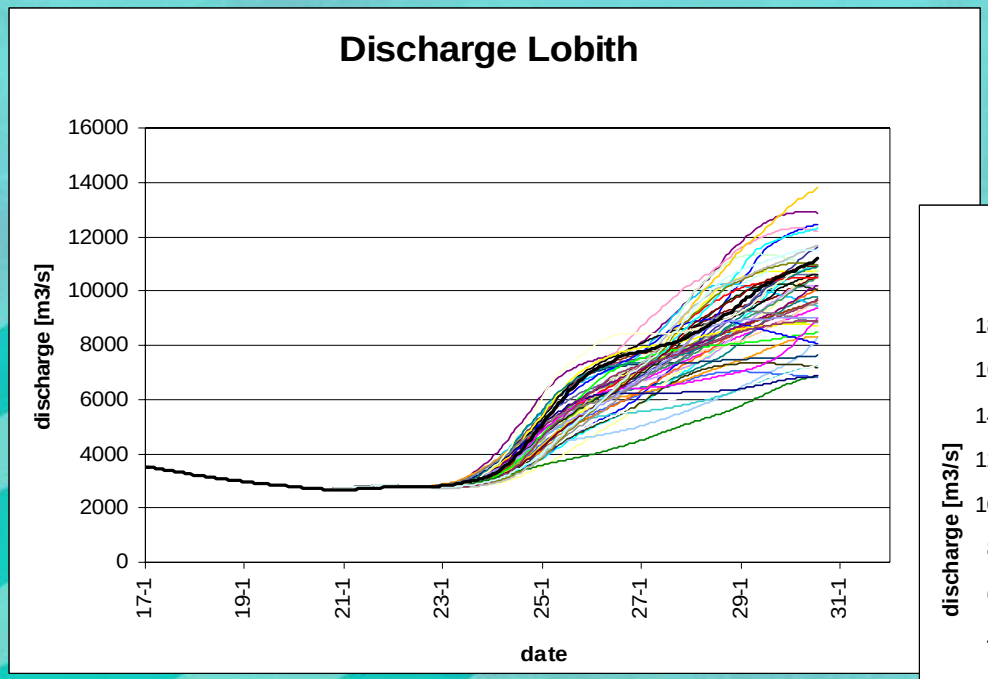


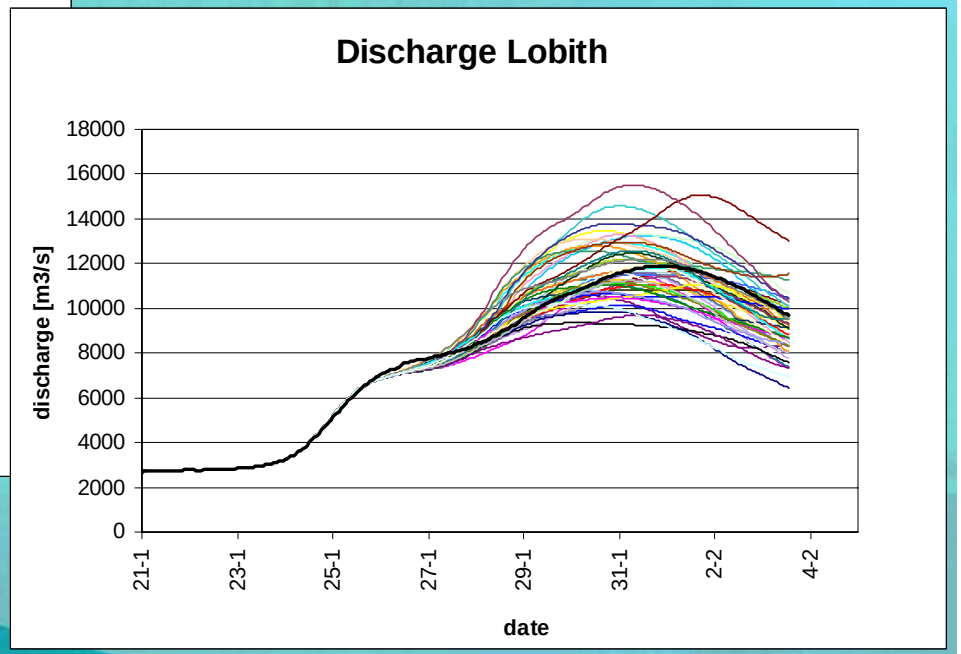




Ministerie van Verkeer en Waterstaat

EPS hindcast flood 1995 model simulation for the Rhine, 20&24 January (E. Sprokkereef, RIZA, 2004)





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Hydrological Ensemble Prediction Experiment

(HEPEX, start 2004)

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Main objectives:

- to bring together the international hydrological and meteorological community
- To produce reliable hydrological ensemble forecasts that can be used for decision making

1st workshop beginning 2004 at ECMWF to define the goals and scope of HEPEX

2nd workshop July 2005 at NCAR, Boulder

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Ensemble prediction flood forecasting

- translating a range of different forecasts into concise and useful information for local forecasters

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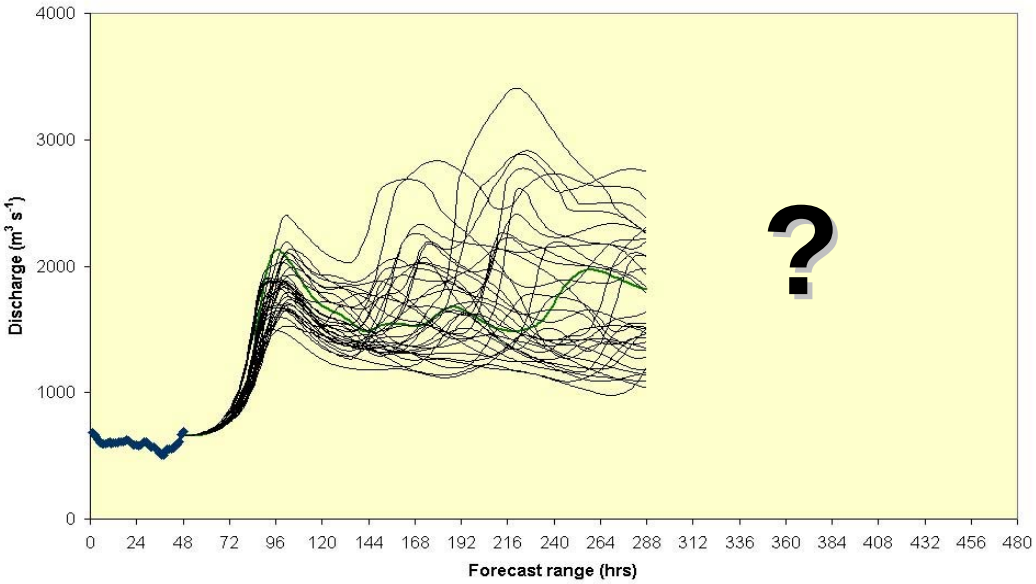

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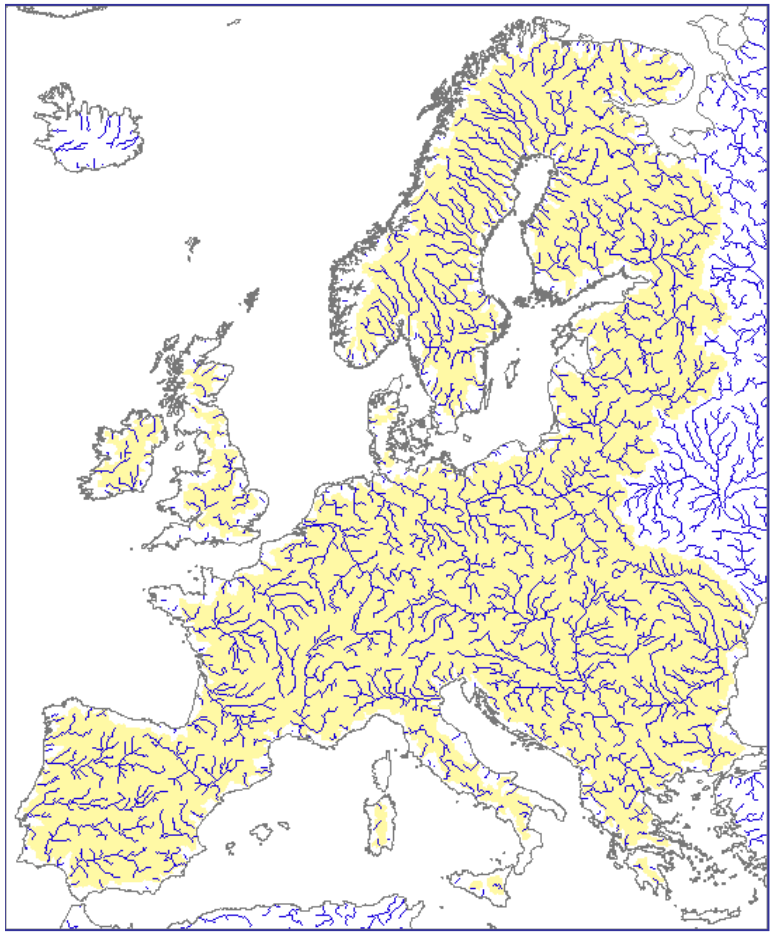
Development of a pre-operational European Flood Alert System (EFAS)



- European catchments > 2000 km^2 on a 5 km grid
- Selected transnational catchments on a 1 km grid (Danube, Elbe, Meuse, Oder)
- hourly time step
- forecast run on arrival of meteo forecasts (00&12)

Input data

- 2xDWD, 7 days
- 2xECMWF – Deterministic, 10 days
- 51x2 ECMWF EPS, 10 days
- observed meteo data

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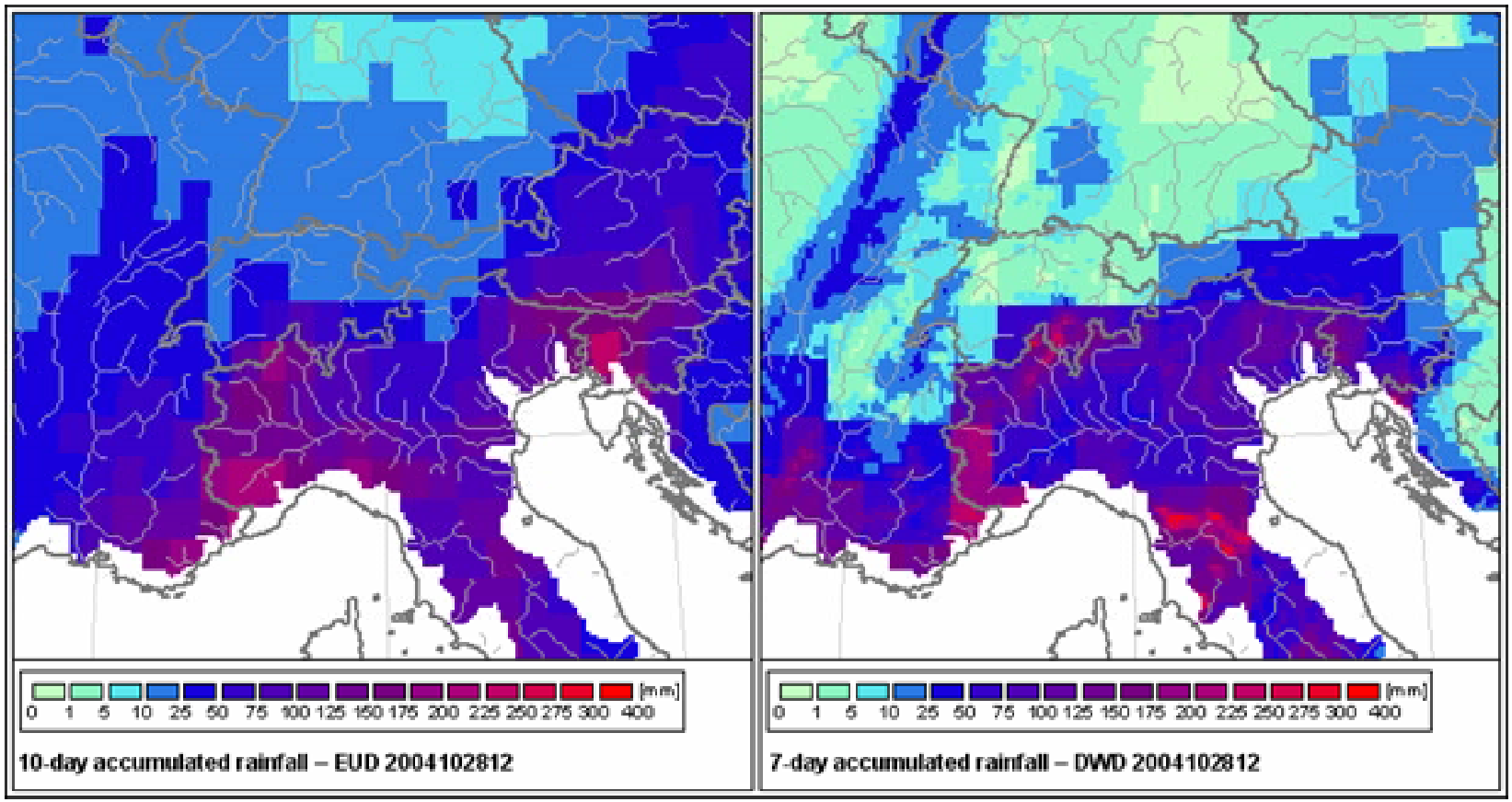
EFAS case study

Example: 2004 10 28, 12:00 Forecasts EUD (L) & DWD (R)

Accumulated rainfalls over forecasting period



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ECMWF Ensemble Prediction System and EFAS

Example: 2004 10 28, 12:00 Forecasts EUD (L) & DWD (R)

Combining the different information including EPS

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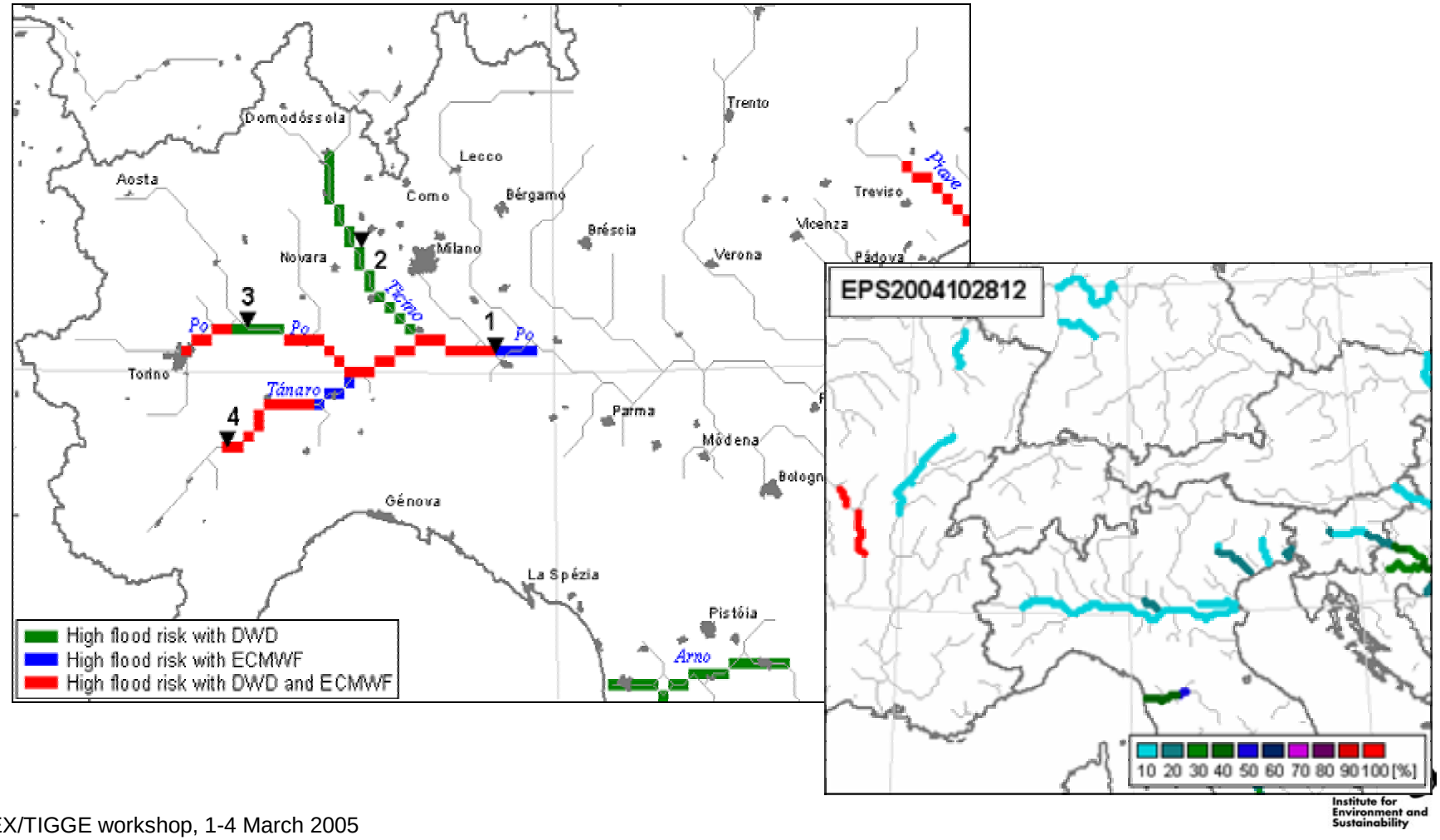
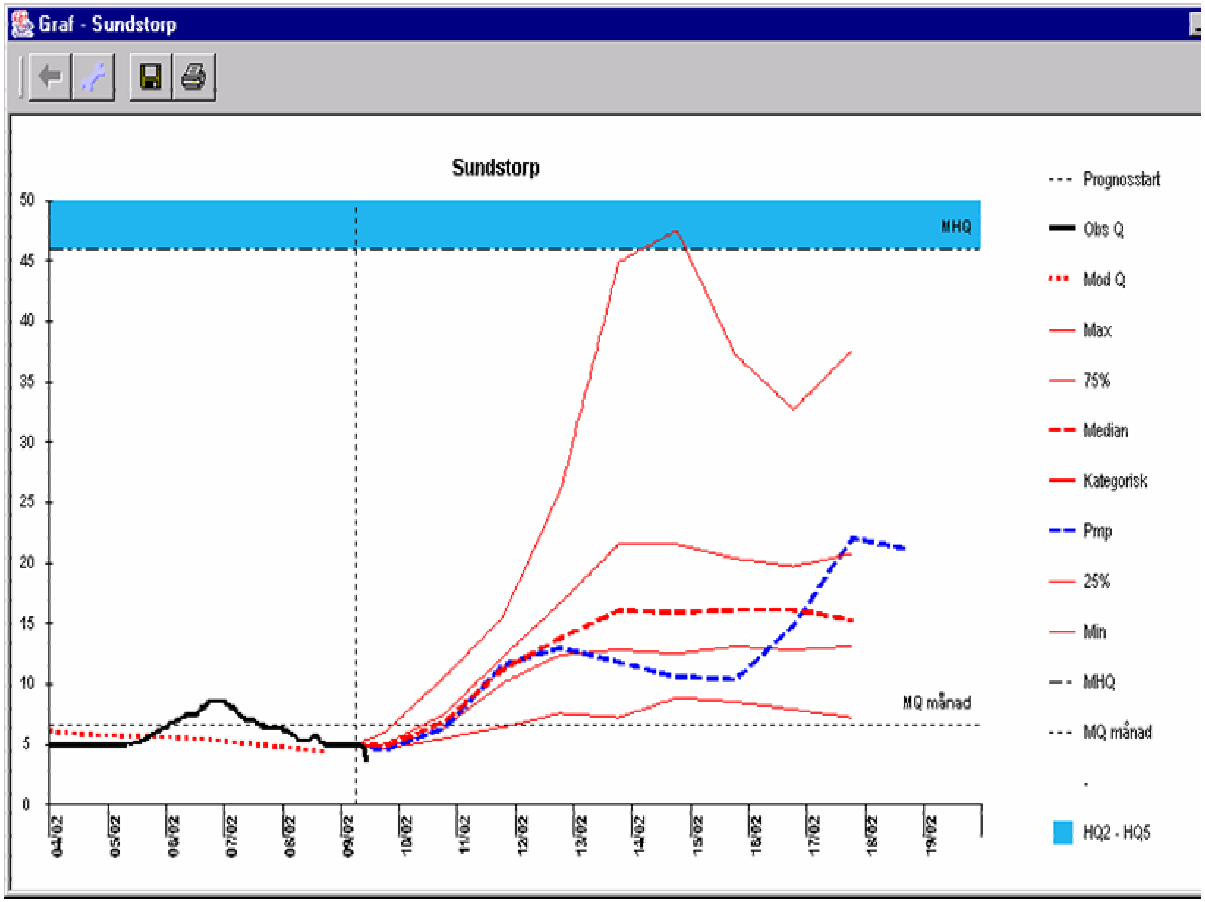


Operational application of flood forecasting with EPS

Example SMHI - 9 day flood forecast



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Application of high-resolution EPS to get the extremes….

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Example: Limited-Area Ensemble Prediction: the ARPA-SMR LEPS system

ARPA-SIM, Italy

Stefano Tibaldi, Tiziana Paccagnella,
Chiara Marsigli, Fabrizio Nerozzi, Andrea Montani

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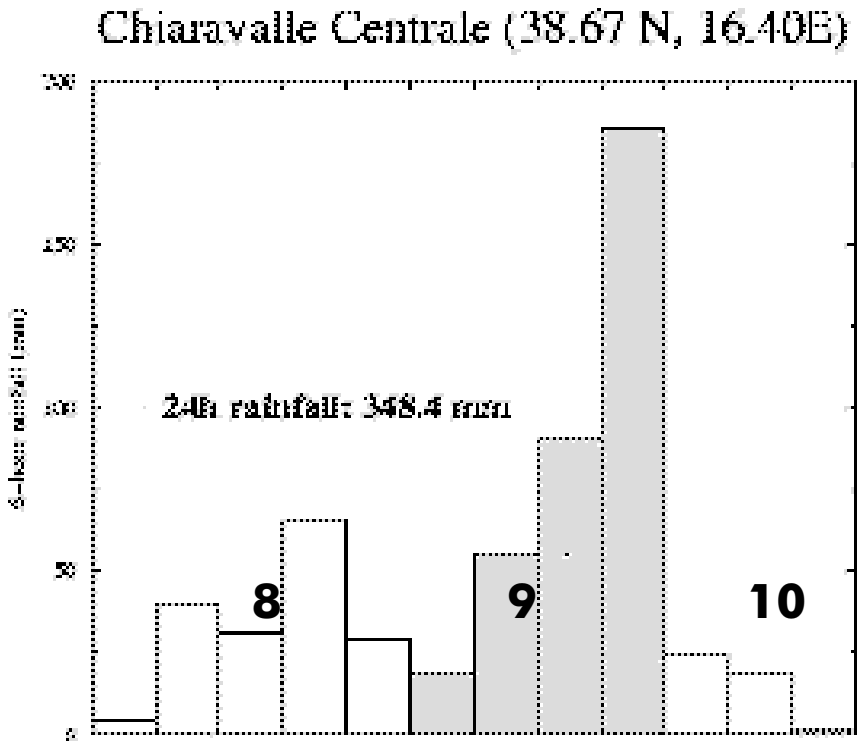
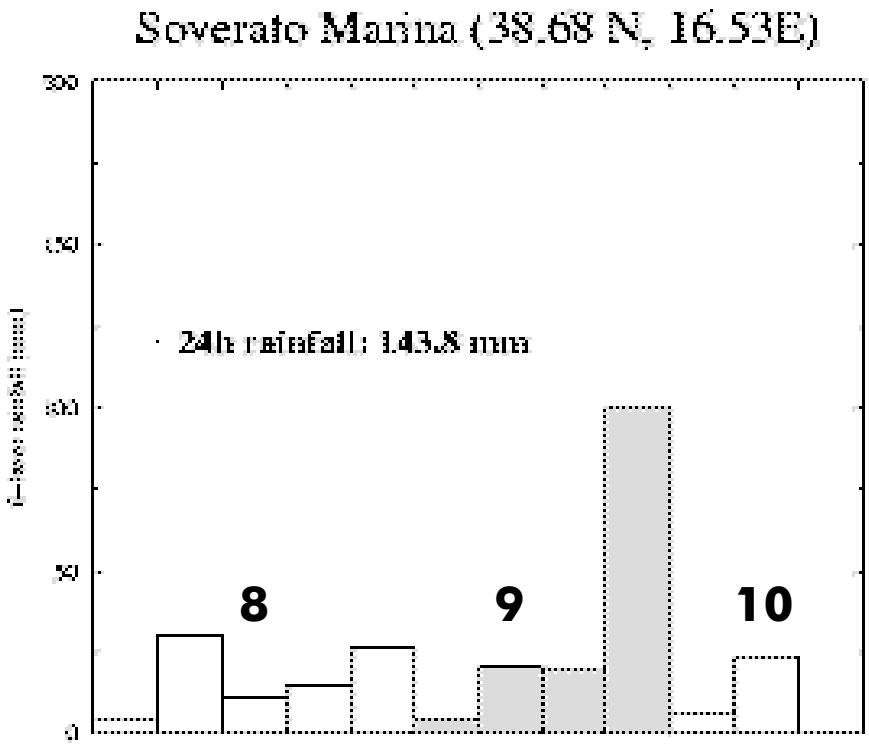
EXAMPLE: Soverato floods and landslides (Italy, Calabria, 8-10 Sep 2000)

Between 9 and 10 September, rainfall peaks above 300 mm in 24 hours were recorded close to the village of Soverato this causing landslides, great disruption and losses of life.





From Tibaldi (2002)

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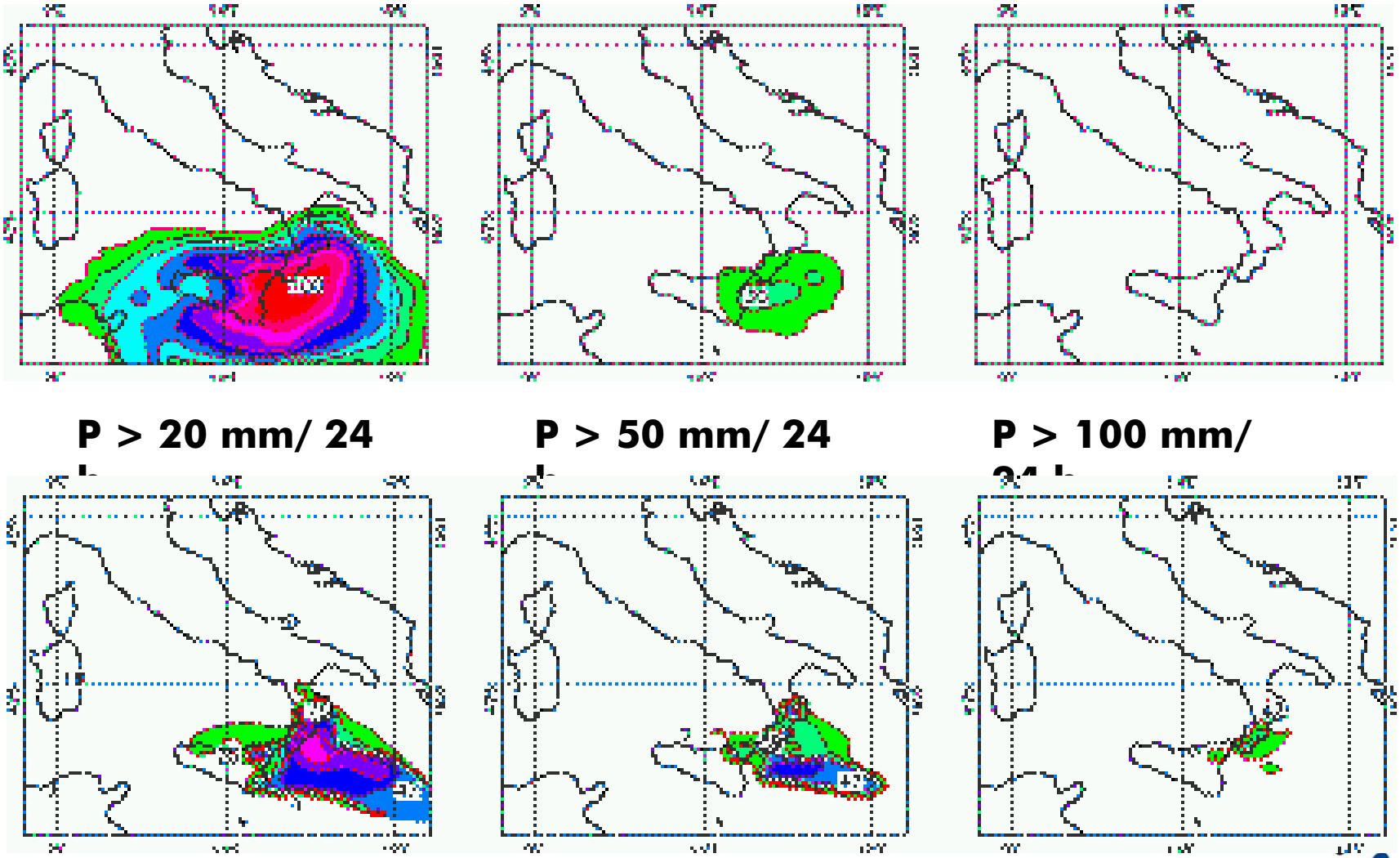
Precipitation analysis for the event with Ensemble T255 (top) and LEPS (bottom, 5 LAMBO members)



From Tibaldi, 2002

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Short-medium term hydrological applications :

drive hydrological TOPKAPI model with COSMO-LEPS for the RENO river, Italy (from Tibaldi)

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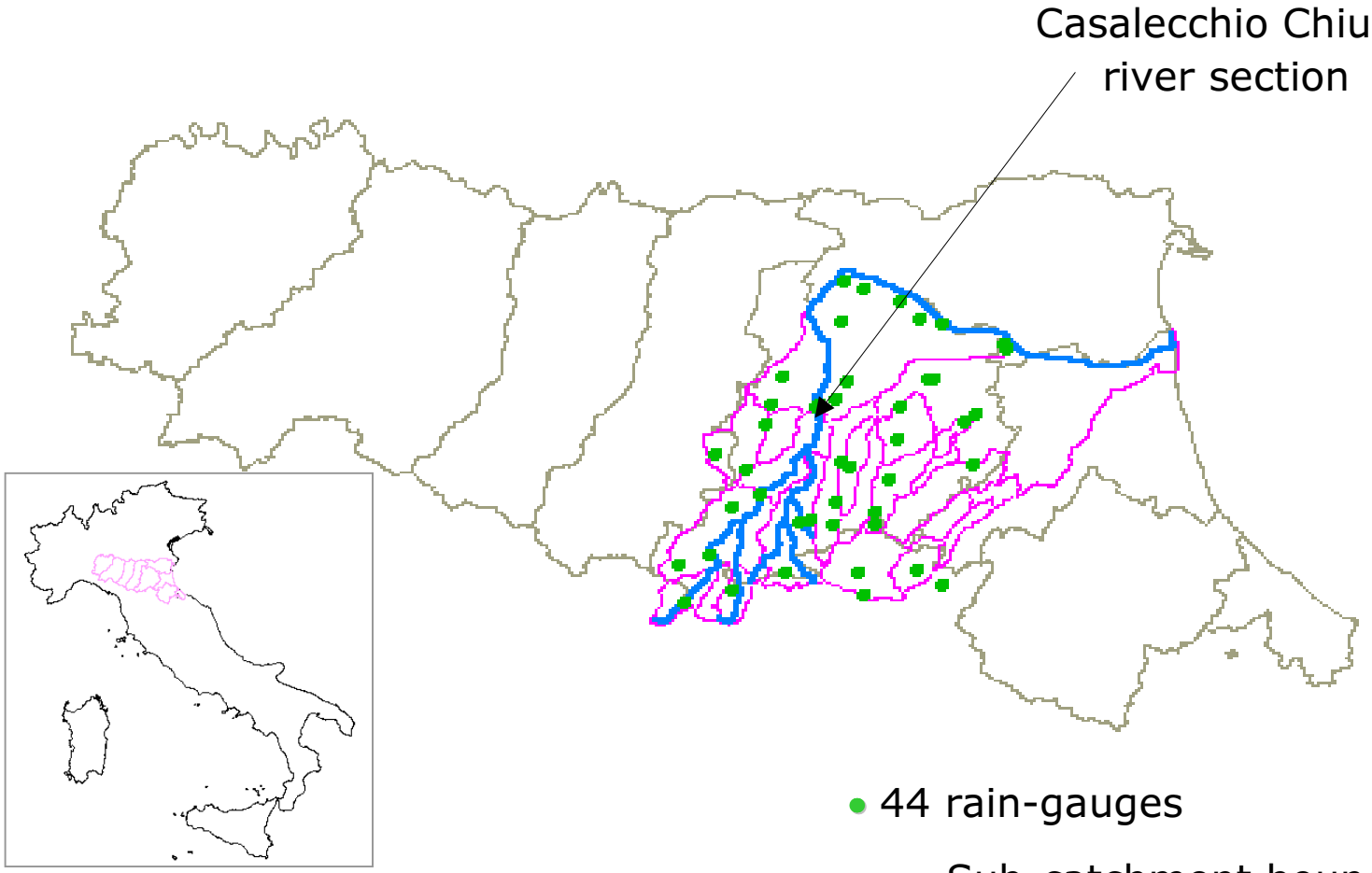

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Severe weather prediction has been a prime motivation for the development of an ensemble system based on the BoM's operational Limited Area Prediction System (LAPS)

[K. Puri et al., Bureau of Meteorology Research Centre, Melbourne, Australia]

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Tropical cyclones

Windstorm Slovakia,
20-21st Nov. 2004

© G. Stumpf

STORMS

Tracking Cyclogenesis:

Using Ensemble Prediction System to determine the confidence estimates for track guidance and predictability studies

Improve landfall predictions for hurricanes

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National Centre for Environmental Prediction (NCEP, NOAA)

NCEP delivers national and global weather, water, climate and space weather guidance, forecasts, warnings and analyses to its Partners and External User Communities

NCEP Global Ensemble

- Since 2000, the NCEP global ensemble forecasts are run operationally
- 17 members
- 0 – 372 hrs forecasting range
- 2.5^{o} grid spacing

NCEP short range ensemble

- multiIC and multiModel
- 15 members
- 09:00, 17:00

National Centre for Environmental Prediction (NCEP, NOAA):

Tracking of Cyclogenesis in Models

- NCEP GFS, NCEP Eta, UKMET and NOGAPS models, and ***NCEP global ensemble***, ***NCEP short range ensemble (SREF)***
- Tropical cyclones (7 parameters)
- Extratropical cyclones (only 1 parameter mslp)
- 2 constraints

  (1) the storm must live for at least 24 hours within a forecast,

  (2) the storm must maintain a closed mslp contour, using a 2 mb contour interval.

National Centre for Environmental Prediction (NCEP, NOAA)

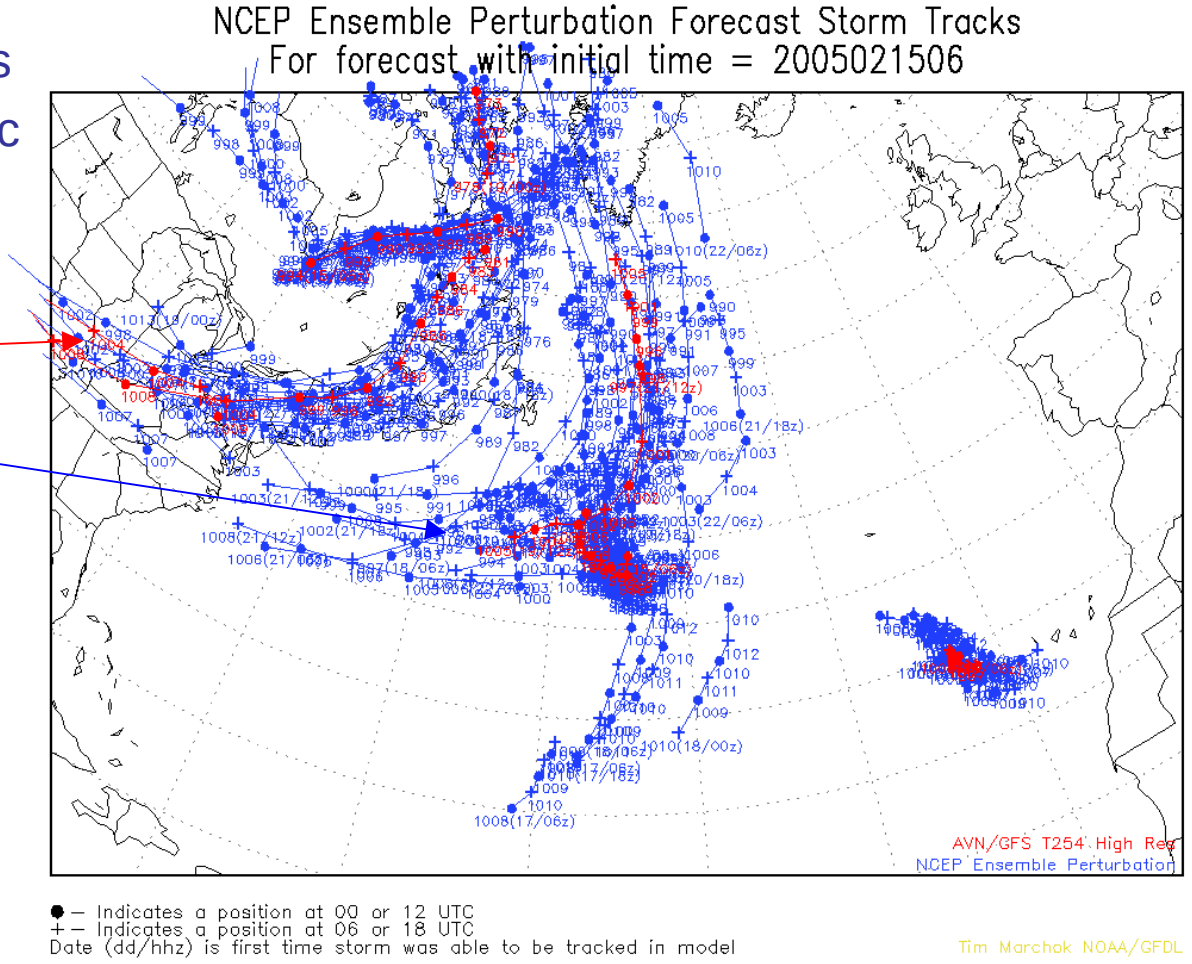
Example

Tracking of Cyclogenesis
2005021506, NW Atlantic

GFS model

NCEP ensemble

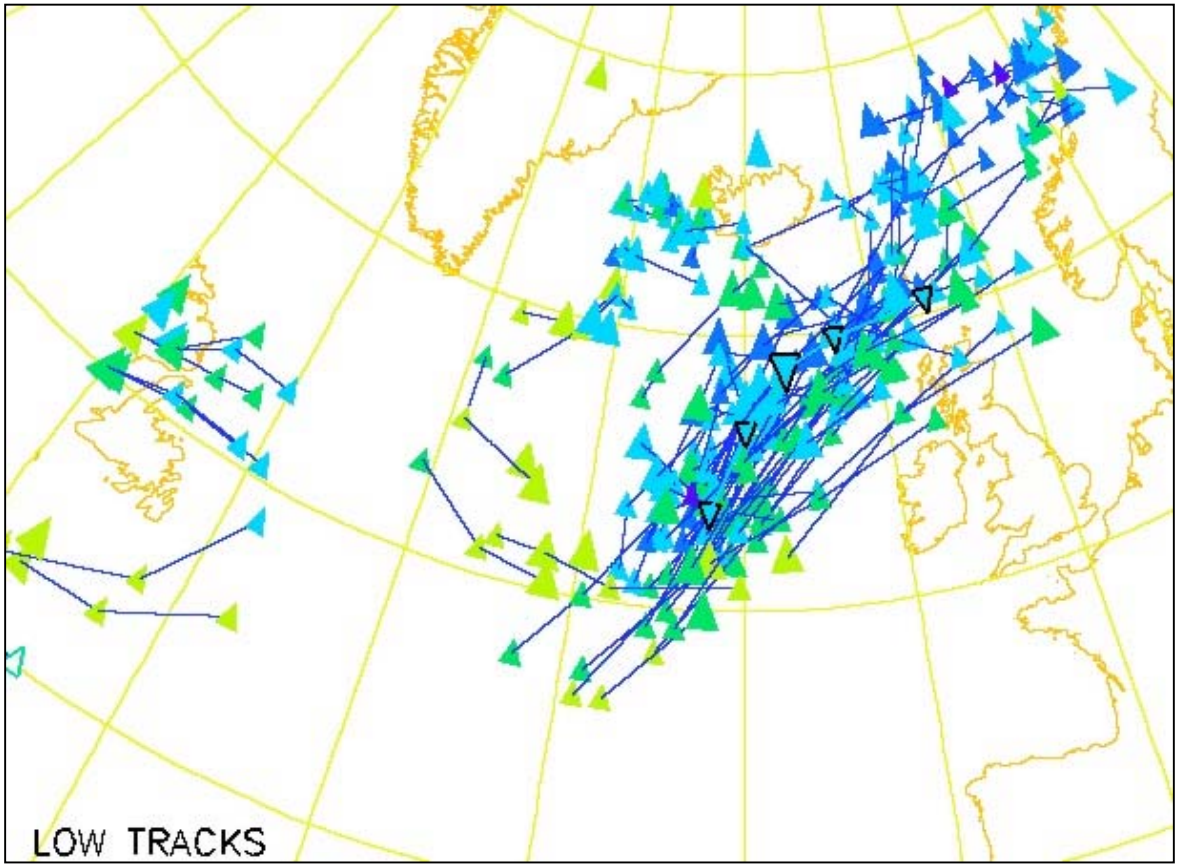
Confidence estimates for track guidance via ensemble prediction system and predictability studies -> under research



UK Meteorological Office

Another Example

Tracking of Cyclogenesis, 3-day forecast in February 2004



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A potential for using EPS in forecasting wildland fire risk?

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FIRE POTENTIAL INDEX

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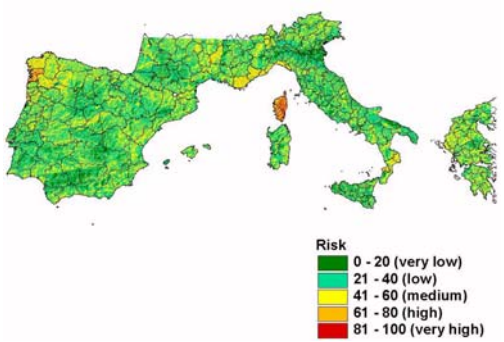
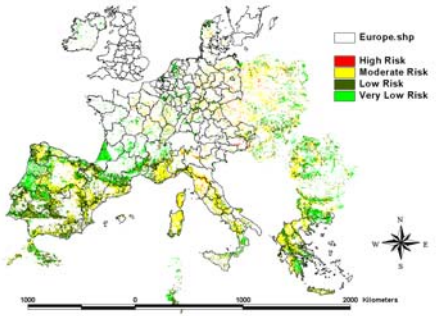
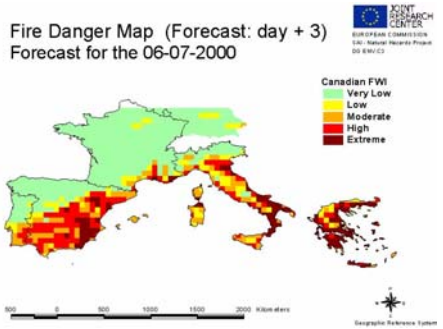
Structural Risk



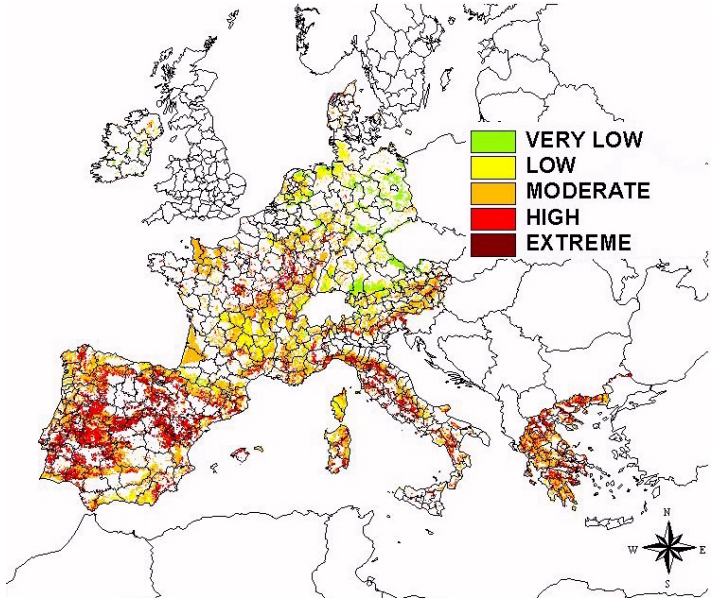
Vegetation Stress Risk



Meteorological Risk



Fire Potential Index



JRC is intending to make a case study on the use of EPS for calculating the fire potential risk

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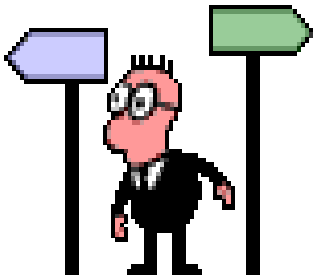
A potential of using EPS for droughts?

WMO webpage:

Products for extended and long-range:

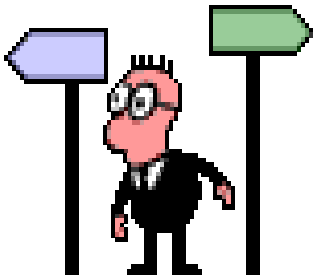
The following EPS products are recommended for routine distribution (Expert Team on EPS, Tokyo, 15-19 October 2001). *Not all products are currently available.*

Relevant post processed fields from sequence of daily output (e.g., indices of monsoon onset, droughts, tropical storm activity, extratropical storm track activity)



Conclusions (I)

- Experts and decision makers require reliable forecasts of extremes
- EPS enhances possibilities for predicting extremes
- Research in progress on EPS across the world
  - for different applications (mostly floods, storms, severe weather)
  - across the disciplines
  - on all scales (short-range, medium-range, long-range)
  - studying EPS on global scale increases the number of case studies



Conclusions (II)

- **Interpretation and presentation of EPS results for decision making need to be thoroughly investigated**
  - To what extent is EPS truly representative of all possible weather events?
  - Guidance in needed – who can give it?
- **Products from meteorological services, e.g. in the case of severe weather are possible. In other cases coupling between the EPS and other models need to be performed, e.g. in the case of flooding, fires, droughts.**
- **For some applications EPS is already being used operationally (floods, storm tracking, ???)**