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Probability forecast use: selected experiences

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Probability forecast use: selected experiences

Contributors:

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Financing:

- FloodControl 2015 programme
- STOWA (Noorderzijlvest case)

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Presentation outline

- Introduction to probability forecasts
- Probability forecast use – overview
- Findings to date
- Summary and conclusions

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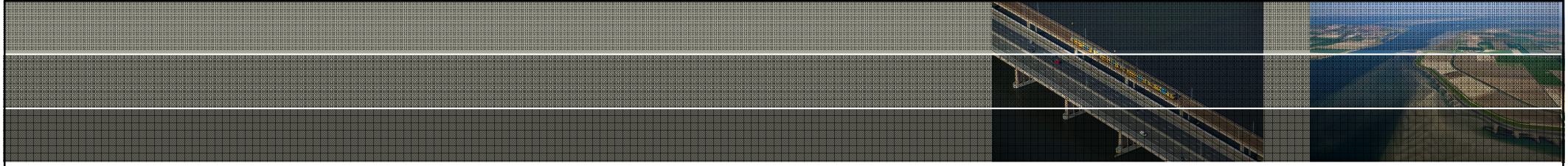
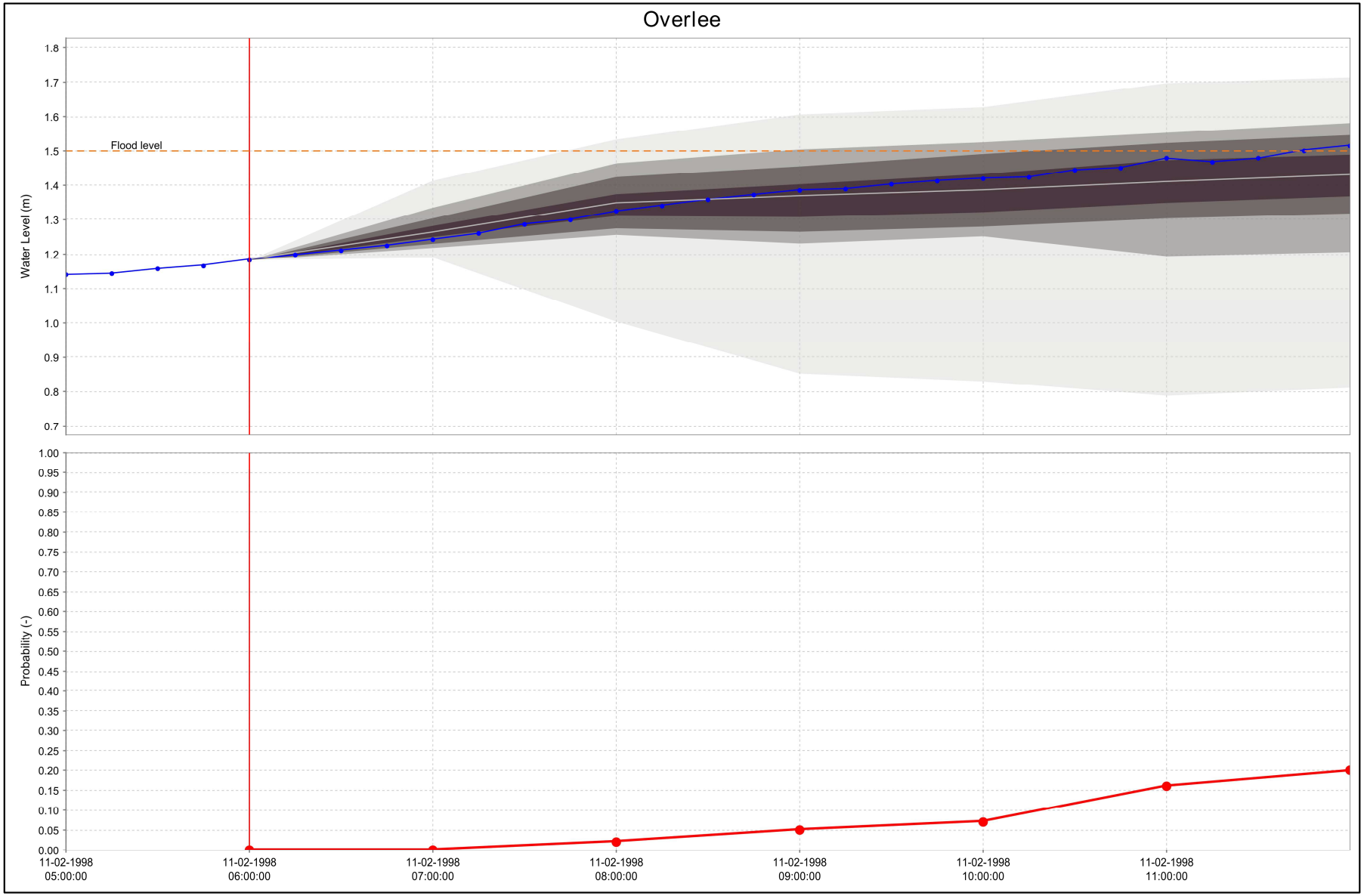
Probability forecasts and rationale




Overlee
Water Level (m)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Flood level
Probability (-)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
11-02-1998 05:00:00
11-02-1998 06:00:00
11-02-1998 07:00:00
11-02-1998 08:00:00
11-02-1998 09:00:00
11-02-1998 10:00:00
11-02-1998 11:00:00

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Why probability forecasts?

1. Explicitly show that future hydrological states are uncertain

2. Enable risk-based decision making

3. Enable separation of responsibilities between forecaster and decision-maker

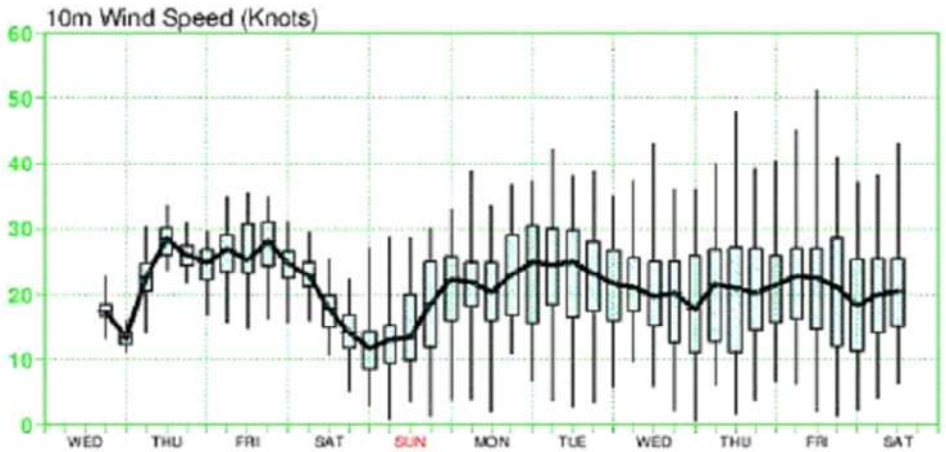
“How to <u>realise</u> the benefits of probability forecasting?”

- Probability forecasting brings benefits to forecasters and end users → move towards probabilistic forecasting, varying reasons
- Simply *having* a forecasting system that estimates predictive uncertainty is probably not sufficient to realise these benefits

→ What needs to be done in addition to having a probability forecast?

→ Present project aims to contribute to answer to this question

→ By eliciting expertise/judgement from forecasters and end-users



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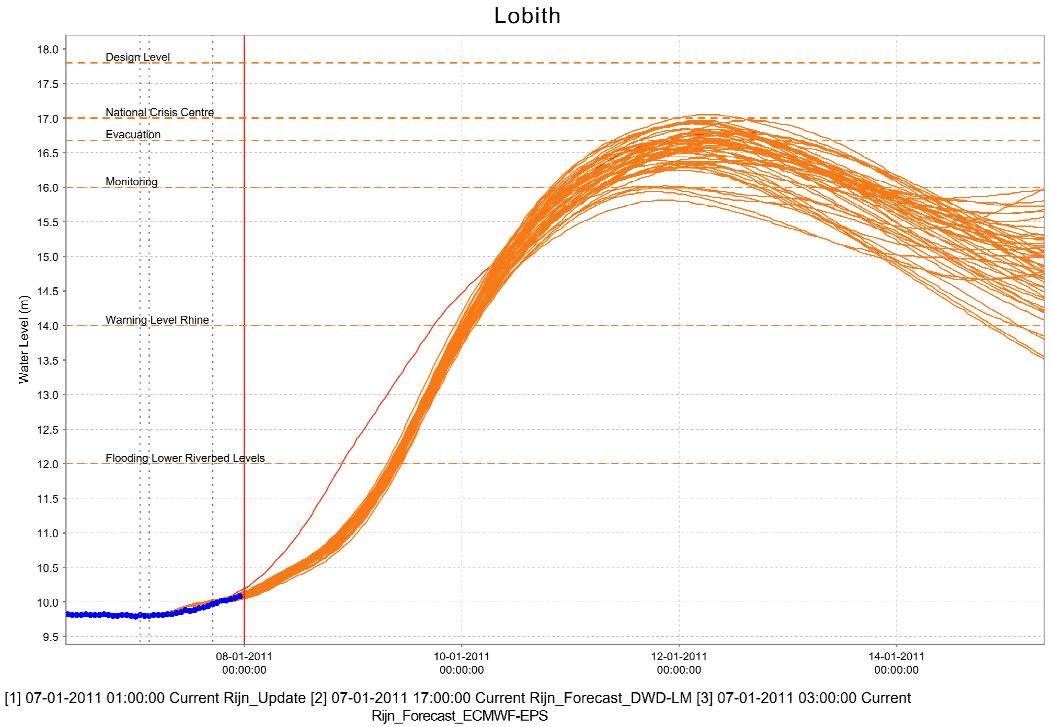
“*Use* of probability forecasts” project

Looking at aspects such as:

- visualisation
- communication
- decision-making
- verification
- training
- “downstream” decision support systems
- business procedures



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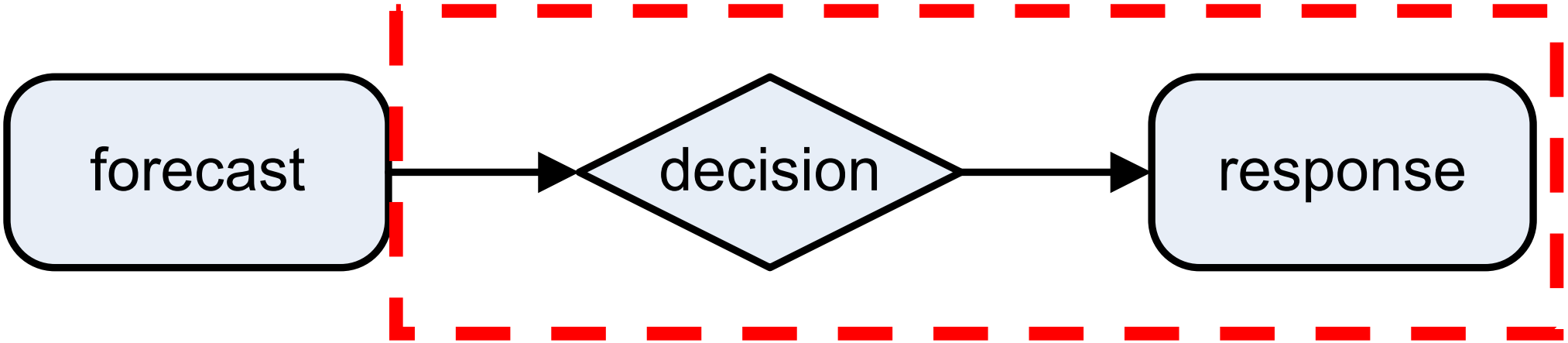
Probability forecast use study – purpose



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Case studies

1. Noorderzijlvest water board
2. US NWS, North Central River Forecast Centre
3. Meuse flood warning and response
4. Rhine river – Inland water shipping

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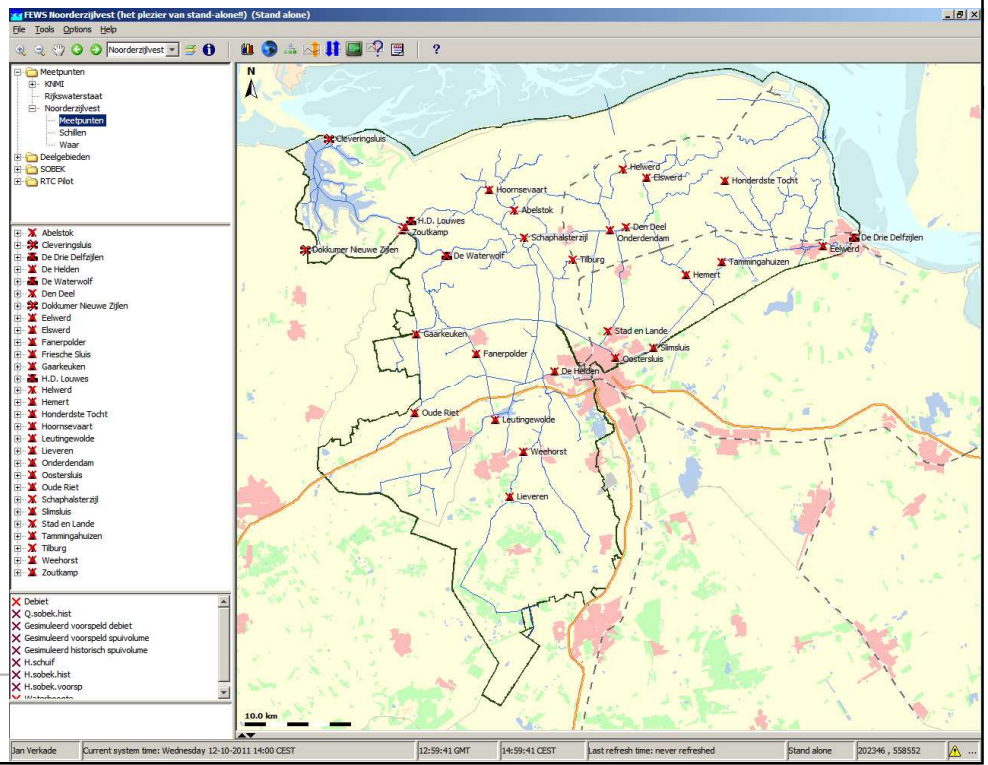
“Noorderzijlvest” Water Board

February 2012

Executed in co-operation with
Marjolein de Jong @ HKV consultants (www.hkv.nl)

Water Board “Noorderzijlvest”

- Water Board: responsible for maintaining water levels in polder districts within acceptable levels (Fully controlled systems, well below MSL)
- 2010 event: flood warning called, but nothing happened
- Hydrologist was blamed
- Way forward: probability forecasts allowing for separation of responsibilities between forecaster and decision-maker



Water Board “Noorderzijlvest”

- November 2011: forecasting – warning – response exercise
- Lessons:
  - interpretation of probability forecasts not an issue
  - however: information overload is
  - decision makers: “with these forecasts, I don’t have to make my own estimates of the inherent uncertainties”
  - probability forecasts used to devise scenarios (worst case)

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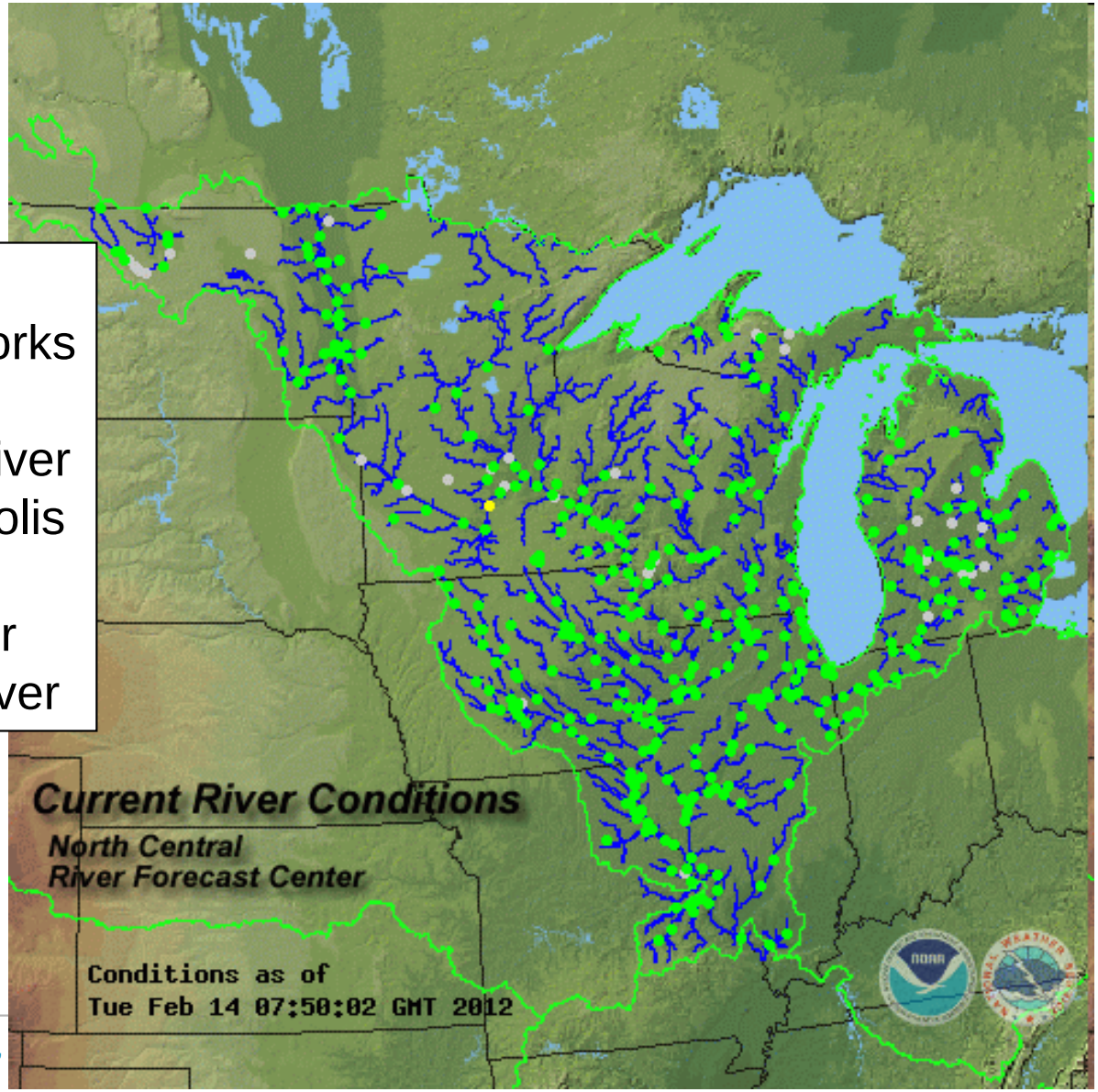
US National Weather Service North Central region

February 2012

Executed in co-operation with Deltares USA, Inc.

National Weather Service: North Central RFC

- Red River
  - Grand Forks
  - Fargo
- Mississippi River
  - Minneapolis
  - St Paul
- Missouri River
- Minnesota River



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National Weather Service: North Central RFC

- Region characterised by frequent flooding (e.g. 2009, 2010, 2011)
- 1997 “missed flood” prompted implementation of probability fcsts
- Currently, medium term probability forecasts (~90d) only
- Shortly: short term probability forecasts (~10d) also

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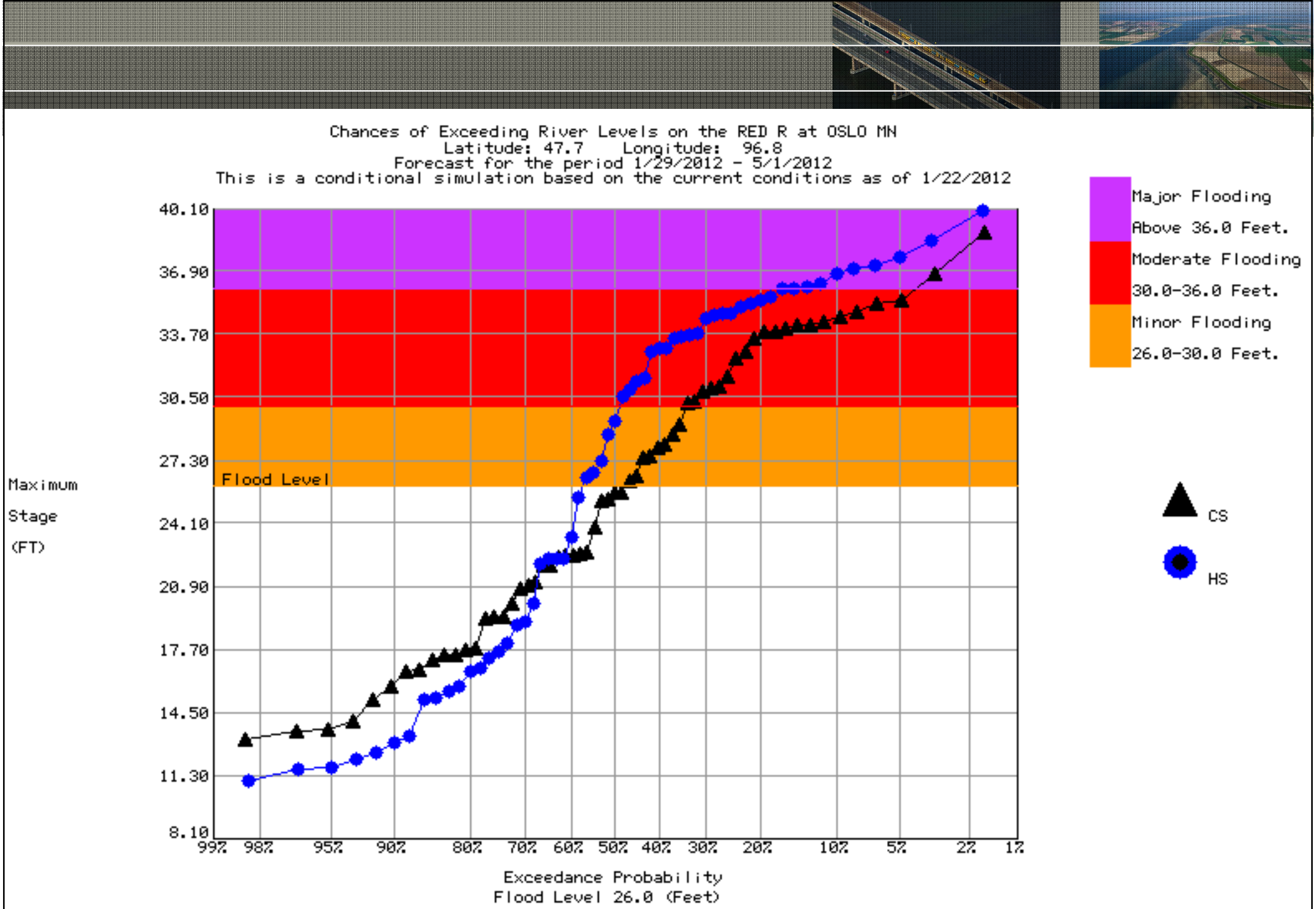
Chances of Exceeding River Levels on the RED R at OSLO MN
Latitude: 47.7 Longitude: 96.8
Forecast for the period 1/29/2012 - 5/1/2012
This is a conditional simulation based on the current conditions as of 1/22/2012
Major Flooding
Above 36.0 Feet.
Moderate Flooding
30.0-36.0 Feet.
Minor Flooding
26.0-30.0 Feet.
Maximum
Stage
(FT)
40.10
36.90
33.70
30.50
27.30
24.10
20.90
17.70
14.50
11.30
8.10
Flood Level
CS
HS
99% 98% 95% 90% 80% 70% 60% 50% 40% 30% 20% 10% 5% 2% 1%
Exceedance Probability
Flood Level 26.0 (Feet)

Probability forecasts: User base

- Emergency managers at State of Minnesota, municipalities
- US Army Corps of Engineers: “flood fighters”
- Reservoir managers
- Power plants (coal, nuclear)
- Media

→ Many users make their own decisions (!)

→ Ample interaction between forecasters and forecast users

→ Sometimes forecast interpretation by intermediaries

US NWS case: conclusions

- RFC supplies forecasts of a flood hazard; however, flood consequences are primary interest for emergency mgt
- Often, uncertainties are managed by intuition rather than by “rational” decision criteria (i.e. “risk”)
- Mutual understanding (RFC ←→ users) increased by webinars
- No best practice exists for visualising and communicating probability forecasts

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Meuse Emergency management

Executed in co-operation with

Hanneke Vreugdenhil @ HKV consultants (www.hkv.nl)

Project outline

- Meuse: relatively frequent flooding of floodplains
- ~5 years experience with “interval forecasting”
- Probability forecasts are imminent (2013)
  - New to both forecasters and forecast users
  - But welcomed by both groups
  - Raises lots of questions
  - Forces organisations to re-consider their procedures

→ Project aimed at developing “pilot” procedures

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Risk-based decision-making: disclaimers apply!

- Attractive because it allows optimisation over many decisions

→ However: frequency of decisions may be too low for that

- Risk estimates, cost-loss analyses can only be made if:
  - Consequences of flooding can be estimated in €€€
  - Damage reduction can be estimated in €€€
  - Cost of flood mitigation measures can be estimated in €€€

→ Very often, it is hard to put numbers to these elements!

→ Not in the least if you want these numbers to be available real-time

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Rhine inland shipping case

Rhine inland shipping case

- Slightly different problem: how deep to load a barge?
- Water level forecast is one of the main inputs to that problem
- Here, risk approach may be easier to implement
- Shipping companies…
  - … make many, many decisions.
  - … are very aware of costs and benefits of measures.

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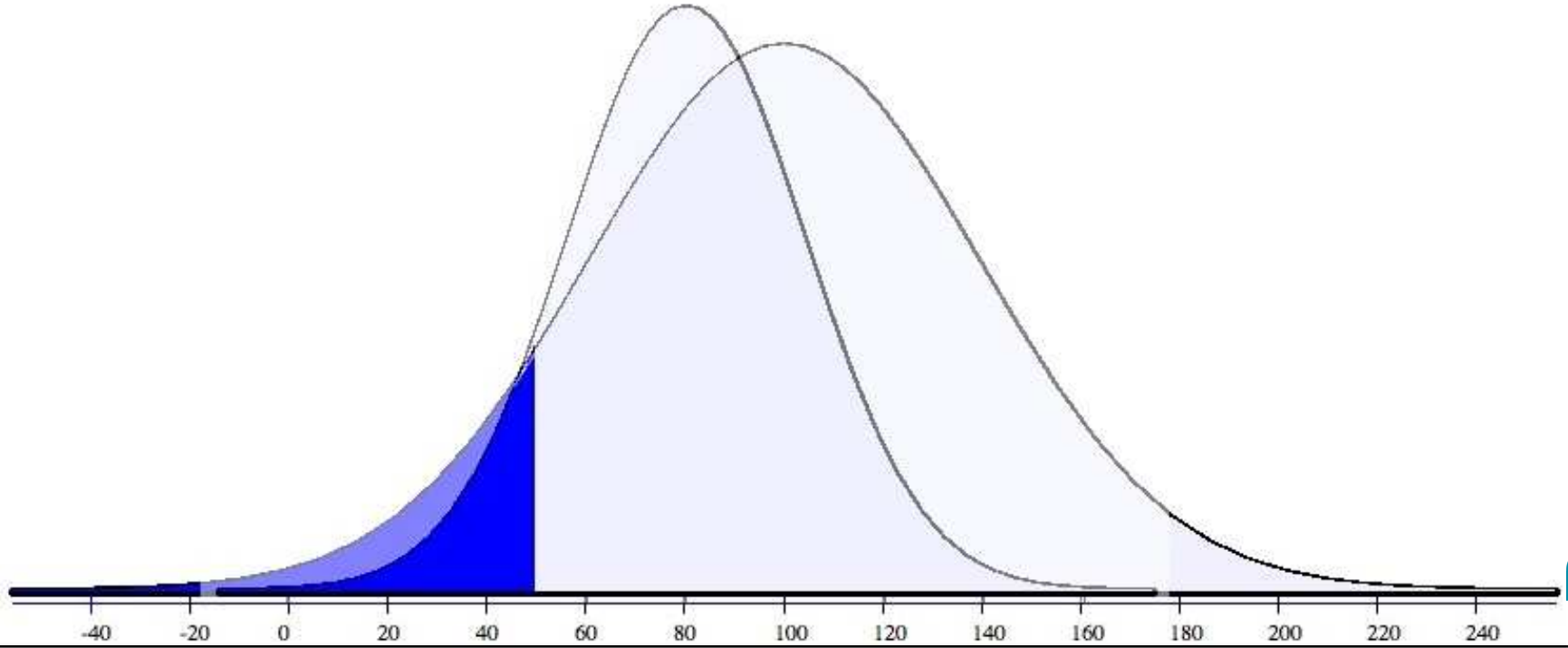
Summary findings and conclusions

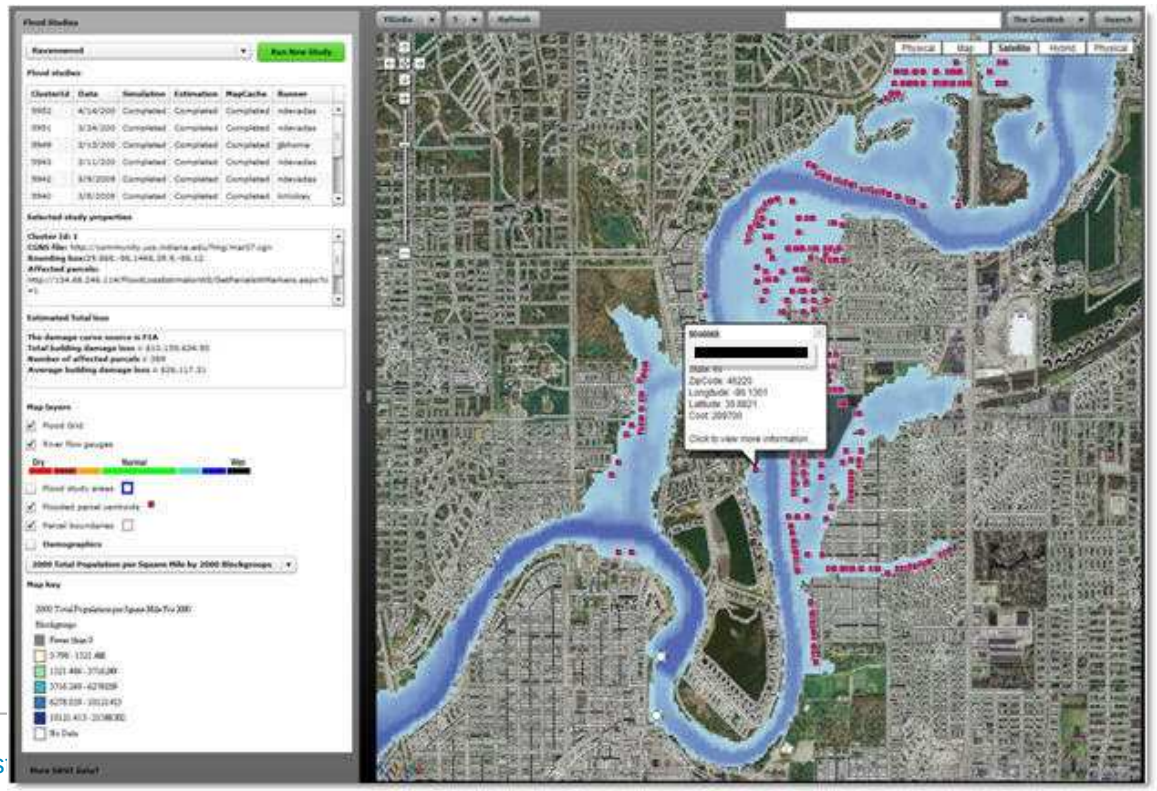
Main findings

1. Hydrological forecasting community supplies hazards whereas often, users are more interested in consequences
2. Manipulating – not *understanding* – probabilities is an issue; asking the right question of a forecast largely resolves this.
3. Disclaimers apply to the risk rationale



Some thoughts on hazards and consequences

- From hazards to consequences
- → conceptually simple decision support
- → e.g. real-time probabilistic flood maps



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Some thoughts on Asking the Right Question (1)

- A forecast needs to support a decision
- Essential: what question should be answered by a forecast?
- Forecast visualisation should be “fit for purpose”

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Some thoughts on Asking the Right Question (2)

- Probability forecasts have many dimensions: location X and Y, variate/event, probability, time
  - → there are <u>many</u> possible combinations to display a forecast
  - → each offers the answer to a different question

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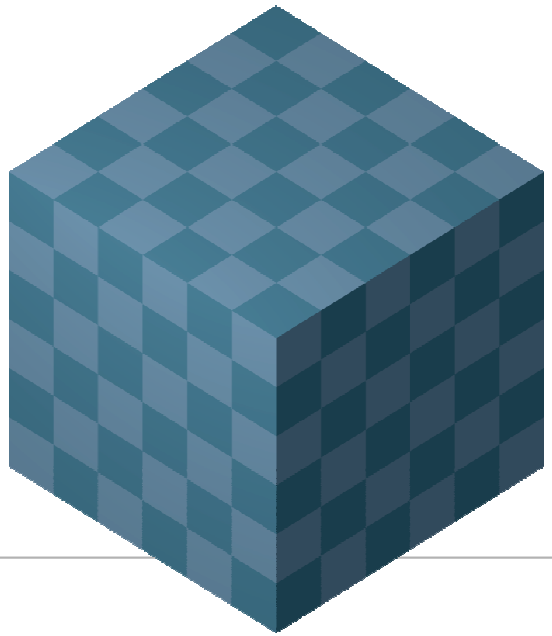
Some thoughts on Asking the Right Question (3)

- Asking the Right Question reduces the number of dimensions and points towards most suitable type of visualisation, e.g.:
  - Maps: variate or probability as function of space
  - Timeseries; often for a specified location
- This requires that some choices have to be made re the dimensions not shown → these should be communicated!



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Some thoughts on Risk Based Decision-Making

- Risk approach may be best suited for users that decide often
- Decision Support Systems that allow for probabilistic inputs need to be developed (similar to those used in hydropower production)
- In some cases, risk is qualitatively assessed only and That's Okay Too

Some thoughts on The Way Forward

- In addition to algorithmic development of probability forecasts, forecast use deserves at least equal attention
- Best practices will be developed over the next few years → these will benefit from close cooperation between scientists and forecast users
- Possibly, water management can benefit from expertise and experience developed elsewhere (e.g. industry, energy, military, medicine, atmospheric sciences)

Recommended reads…

- Krzysztofowicz, R.: The case for probabilistic forecasting in hydrology, Journal of Hydrology, 249(1-4), 2–9, 2001.
- Nadav-Greenberg, L. and Joslyn, S. L.: Uncertainty Forecasts Improve Decision Making Among Nonexperts, Journal of Cognitive Engineering and Decision Making, 3(3), 209–227, doi:10.1518/155534309X474460, 2009.
- Nobert, S., Demeritt, D. and Cloke, H.: Informing operational flood management with ensemble predictions: lessons from Sweden, Journal of Flood Risk Management, 2010.
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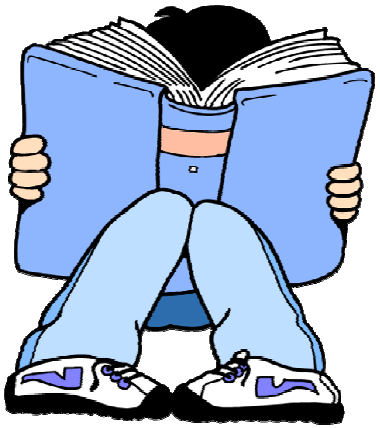
- Verkade, J. S. and Werner, M. G. F.: Estimating the benefits of single value and probability forecasting for flood warning, Hydrology and Earth System Sciences, 15(12), 3751–3765, doi:10.5194/hess-15-3751-2011, 2011.



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