

*IDA møde Nyborg 4. Februar 2016*

# **Ny realtids varslingsmodel til forudsigelse af oversvømmelser ved højt grundvandsniveau eller vandindhold i rodzonen**

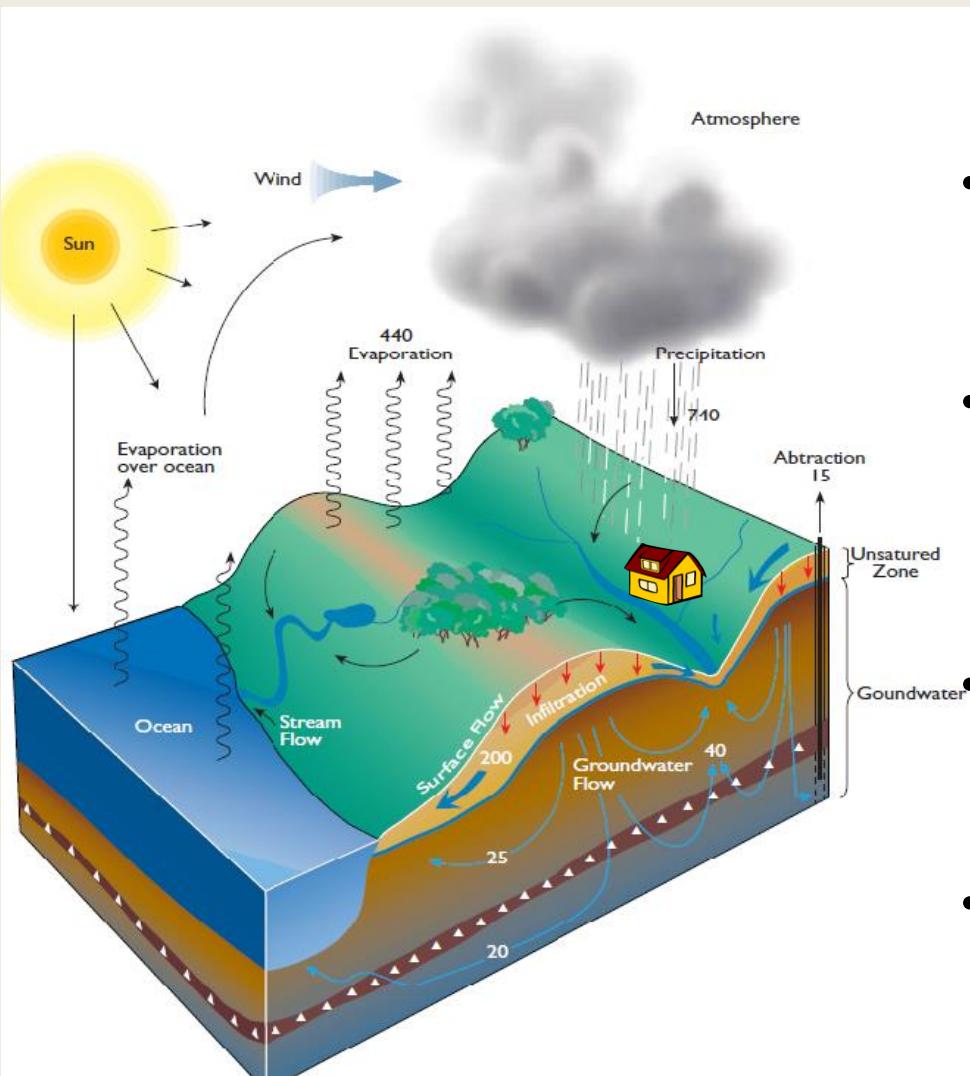
Hans Jørgen Henriksen og He, Xin GEUS

De Nationale Geologiske Undersøgelser for Danmark og Grønland

# Indhold

- Hvorfor realtidsmodellering i det urbane rum?
- Den nationale hydrologiske model (DK model)
- Fire scenerier (national-lokal model)
- Undersøgelsesmetodik
- Resultater og feedback
- Konklusion

# Hvorfor realtidsmodellering i det urbane rum?



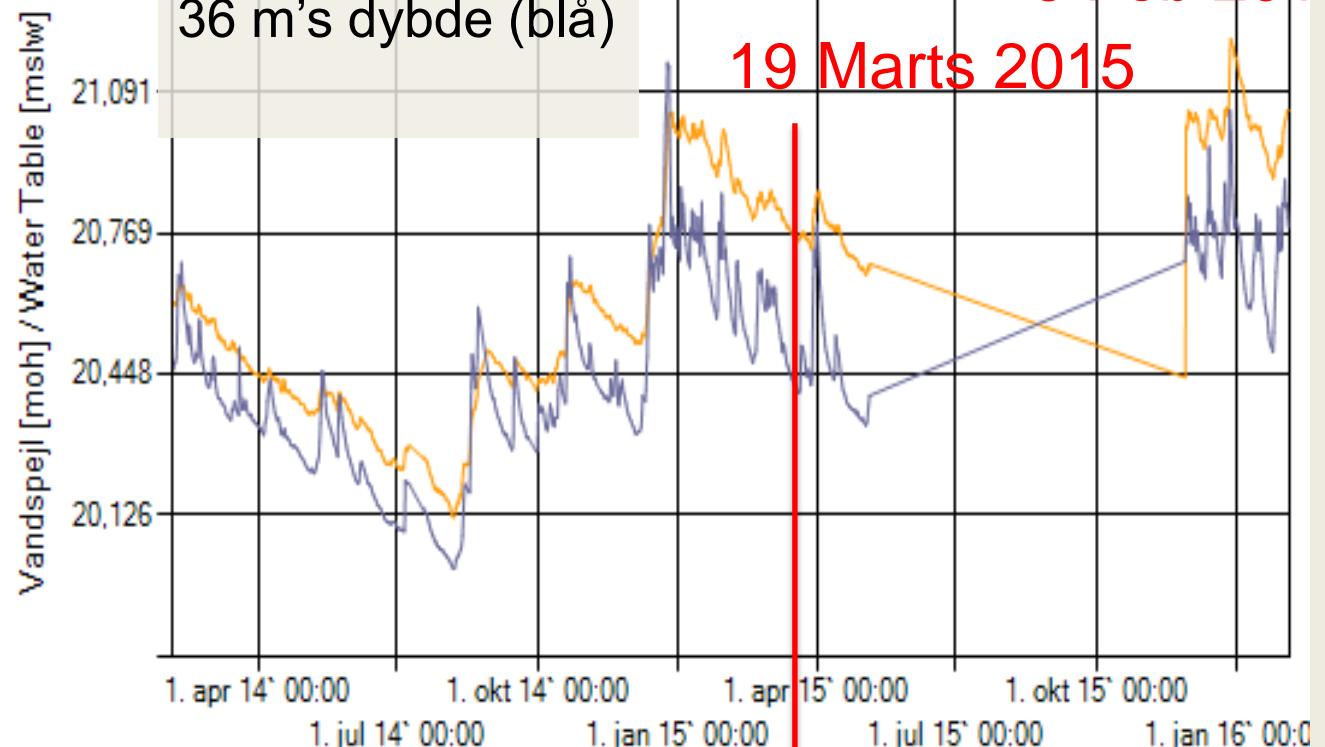
- Samfundets behov for hydrologisk realtids-information er voksende
- WFD og oversvømmelsesdirektivet efterlyser en integreret, oplands- og helhedsorienteret tilgang
- DK-modellen som platform for realtids modellering i urbane rum og vandløbsoplande
- Stationariteten er *død* men vandbalancen, hydrogeologien og grundvands-overfladevands interaktionen er *breaking news*

# Pejletids- serier

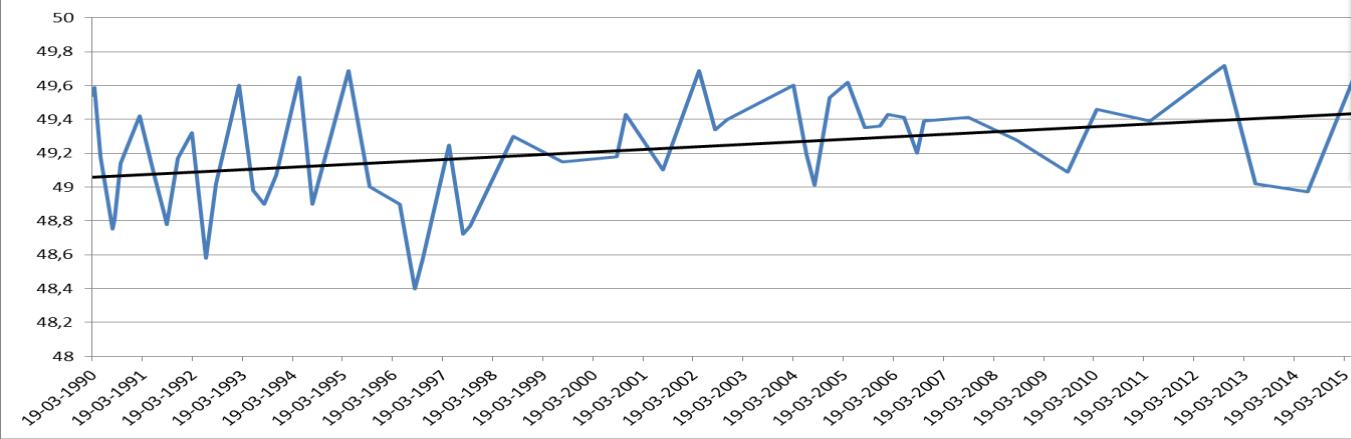
**Tinglevboringen:**  
[www.tinglevboringen.dk](http://www.tinglevboringen.dk)

Filtre:

4 m's dybde (gul)  
 36 m's dybde (blå)



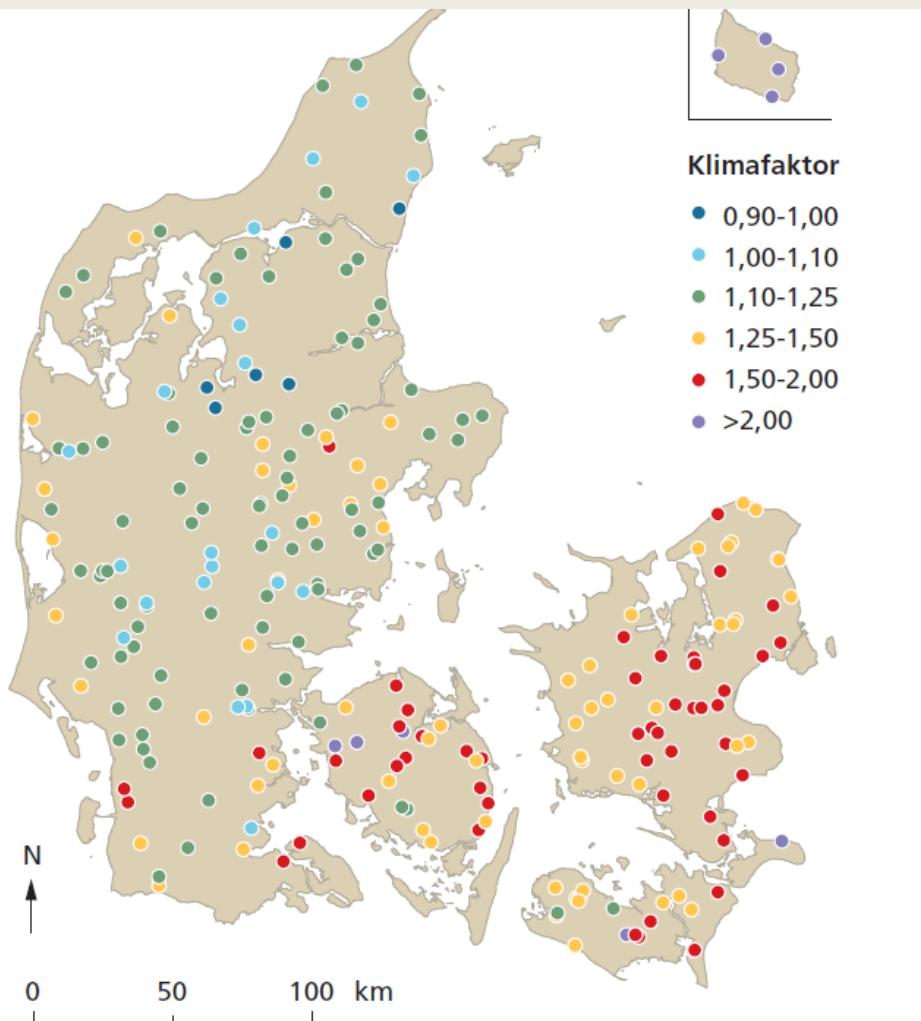
**Brande 4 DGU 104.1995.2-1 Vandstandskote (m)**



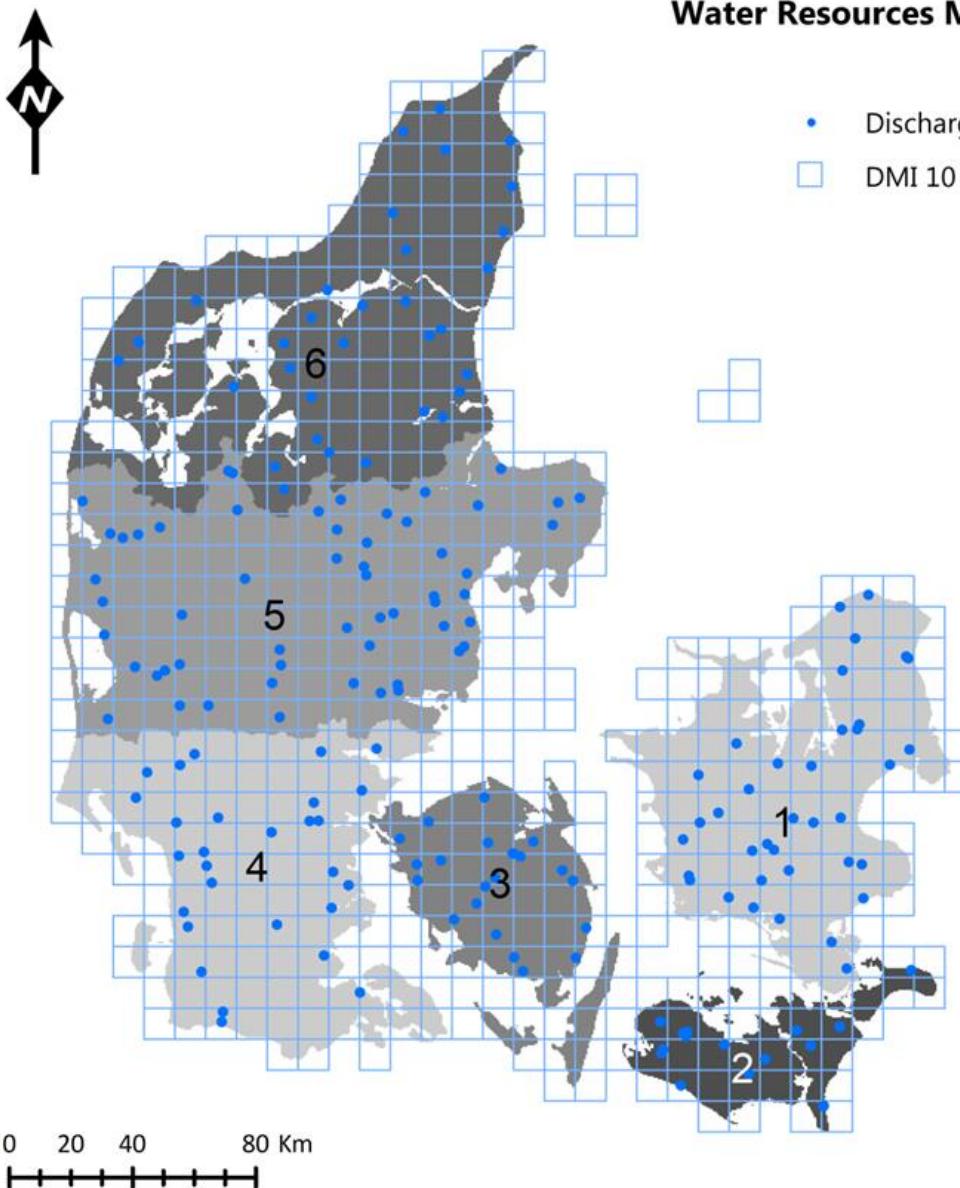
**Brande:**  
 kilde  
 JUPITER

AND

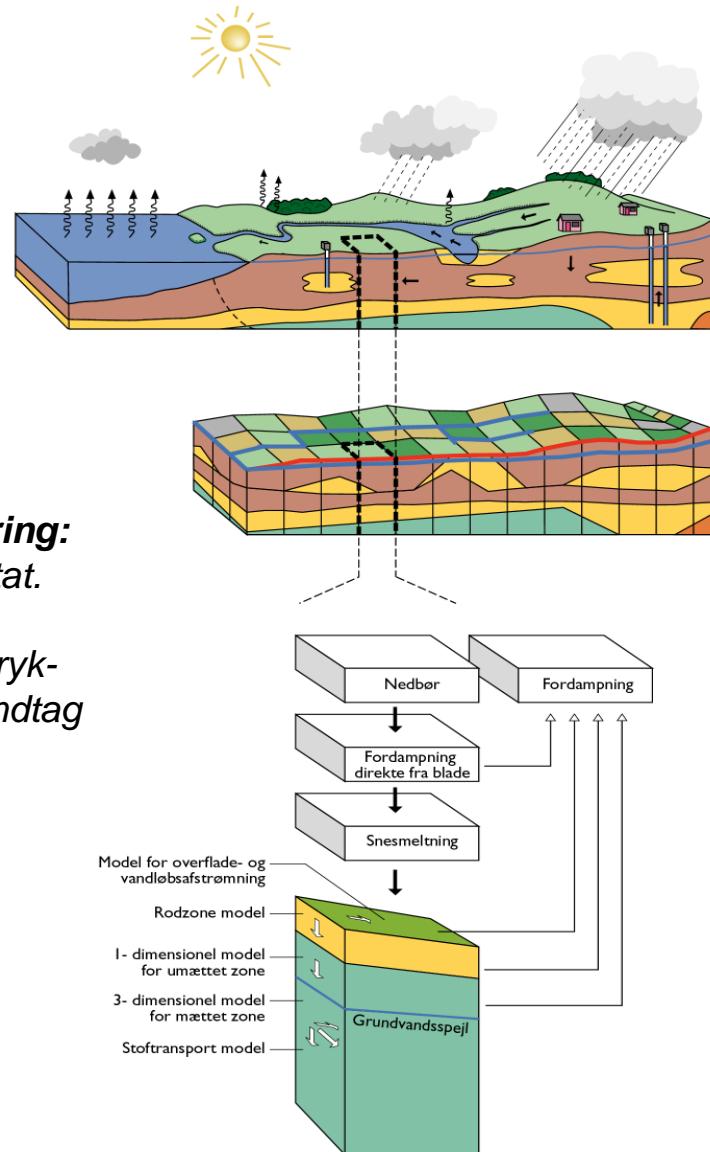
# Klimafaktor oversvøm. fra vandløb



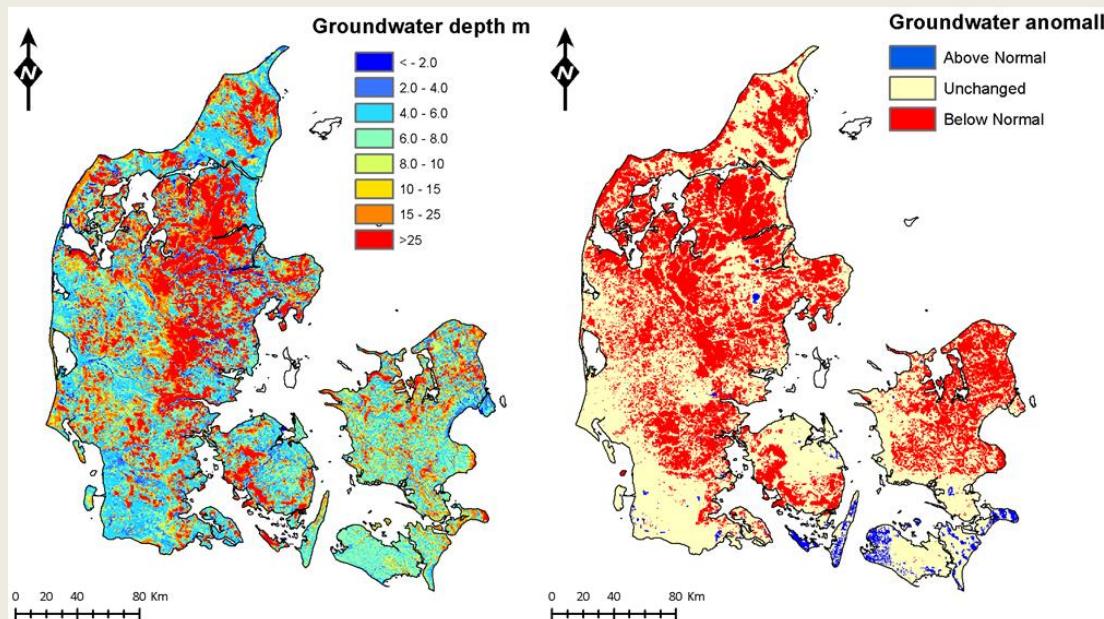
## Model domains of the National Water Resources Model



**Kalibrering:**  
200 Q stat.  
og  
20.000 trykniveau indtag

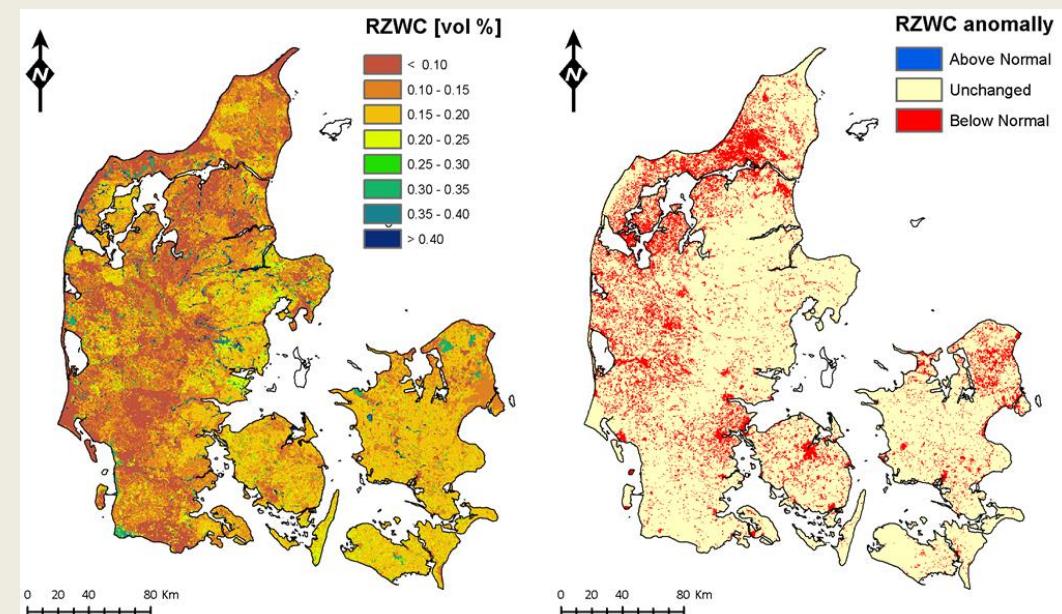


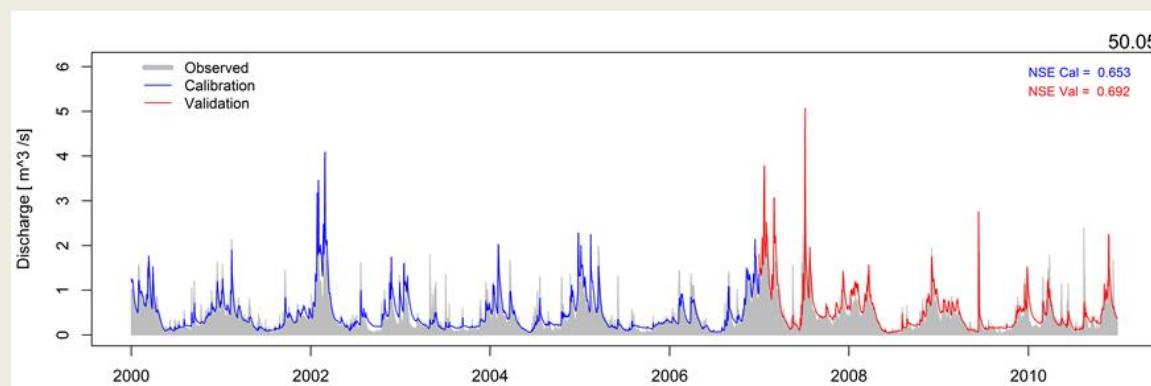
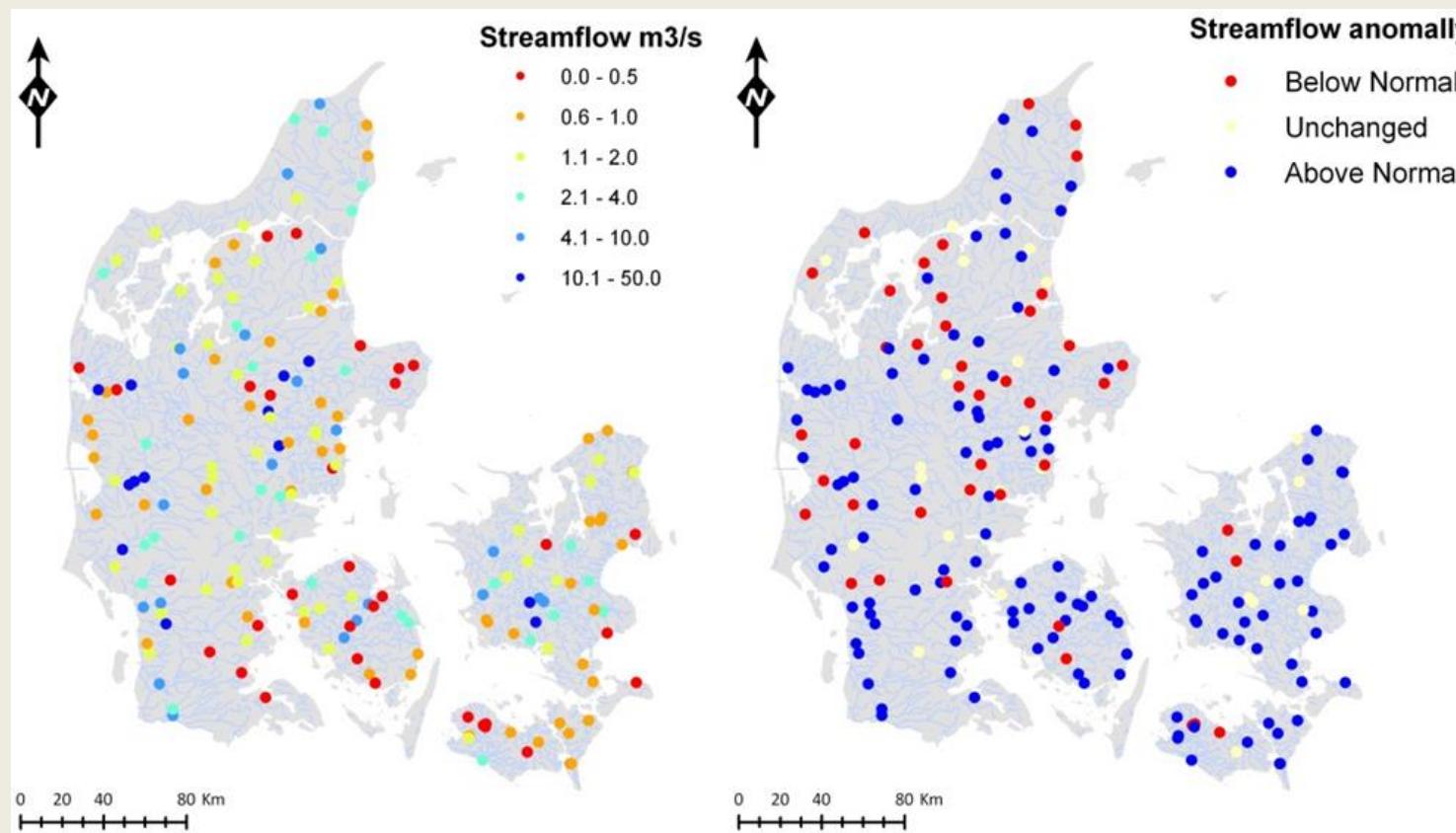
Diskretisering 500 m og 8-12 lag



Simulering af  
trykniveau i  
grundvand

Simulering af  
jordfugtighed





Simulering af  
vandføring i vandløb  
(kalibreret og valideret for  
2000-2011 ud fra historiske  
klimadata; har aldrig været  
anvendt til realtid/prognose  
modellering)

# Fire scenerier er undersøgt i projektet Realtidsvarsling

Nationalt  
niveau

**Opdateret DK-model**  
Real tids simulering  
seneste DMI klima data  
Ren model  
Ingen monitering  
Ingen data assimilering  
Simpel usikkerheds vurdering

**DK-model prognose**  
Baseret på DMI vejr prognose  
2-5 dages prognose  
3-6 mdr. prognose  
Ren model  
Usikkerheds analyse/skill score  
Ingen monitering / DA

Lokalt  
niveau

**Beslutningsværktøj**  
Simpelt styrings system  
Kombination af  
DK-model output  
Moniterings data  
Lokalt kendskab  
Baysiansk net  
Decision tree

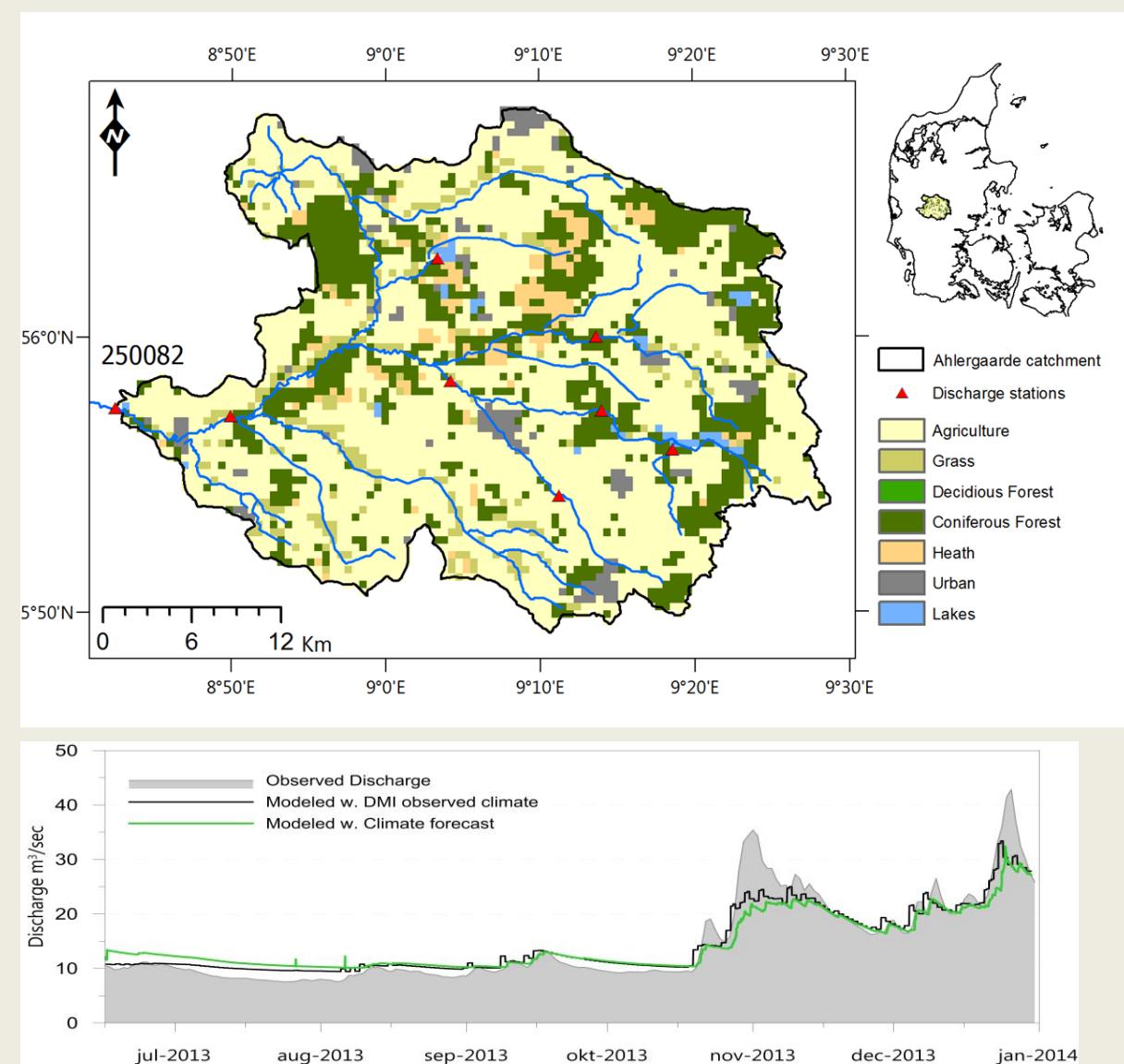
**Kompleks  
lokal model**  
Kombination af  
Detaljeret model  
MIKE 11 / MIKE URBAN  
DK-model output  
Moniterings data  
Data assimilering

# Skjern å case study area / prototype

Henriksen, HJ, Stisen, S,  
He, X and Wiese, MB 2015.  
A hydrological early warning  
system for Denmark based  
on the national model.

*Geological Survey of  
Denmark and Greenland  
Bulletin 33, 29-32*

He, X, Stisen, S, Wiese, MB  
and Henriksen, HJ  
(accepted WARM)  
Designing a hydrological  
real-time system for surface  
water and groundwater in  
Denmark with engagement  
of stakeholders.



# Undersøgelses-Metode:

- Prototype test
- Web baseret spørgeskema
- Model workshop  
([vandmodel.dk/realtidsvarsling](http://vandmodel.dk/realtidsvarsling))



**National Vandressource Model**  
Realtidsprojekt

[Spørgeskema Reeltidsvarsling](#) | [Indledning](#)

Hvem er det der svarer?

Dit Navn\*  \* Navnet er det eneste som skal udfyldes

Din organisation / virksomhed

Din rolle i organisationen

**Spørgsmål til det nationale niveau om en opdateret hydrologisk DK - model**

**Spørgsmål til det nationale niveau om en hydrologisk prognose**

**Spørgsmål til det lokale niveau**

**Hvordan skal realtidssimuleringsresultater geres tilgængelige?**

**Hvordan kan vi bedst inddrage din viden i undersøgelsen af reeltidsvarsling ved hjælp af DK model?**

**Send besvarelse!**

**Spørgsmål til det nationale niveau om en hydrologisk prognose**

I hvor høj grad ser du muligheder og relevans af en "DK-model Forecast" som giver et estimat af hydrologiske variable i nær fremtid baseret på vejrprognoser?

Ved ikke  
 Ringe  
 Nogen  
 Høj  
 Møget høj

I hvor høj grad ville en "DK-model Forecast" kunne indgå direkte som et led i lokal vandforvaltning?

Ved ikke  
 Ringe  
 Nogen  
 Høj  
 Møget høj

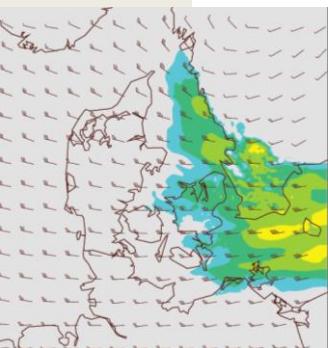
**Har du et bud på krav til en DK model Forecast?**

Hvilke typer af hændelser kunne umiddelbart være relevant for dig at kunne varse i real tid på nationalt niveau?

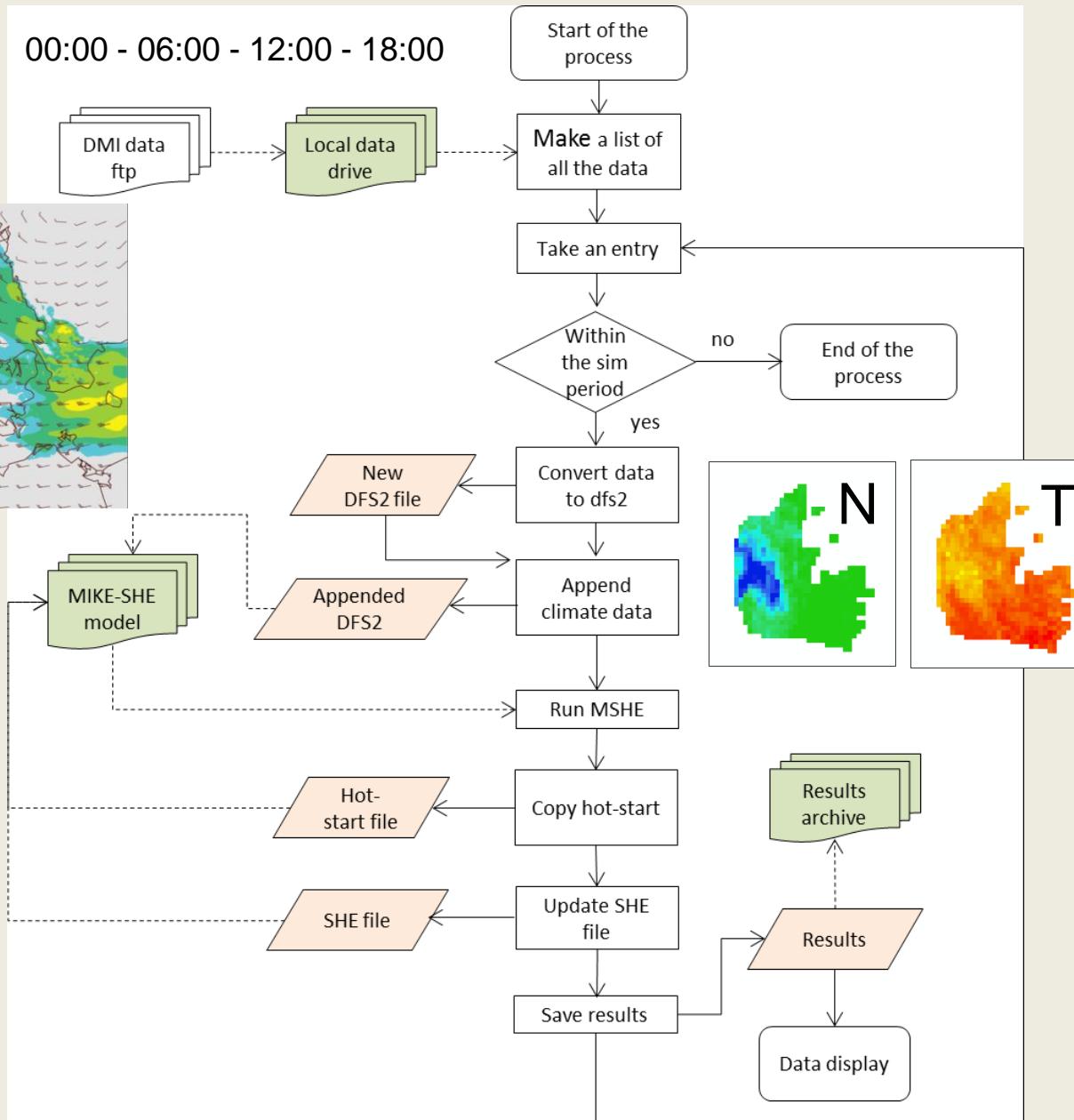
Marker gerne flere muligheder

Reeltidsvarseling af oversvømmelser i det åbne land med mulighed for at iværksætte målrettede beredskabsplaner  
 Tørke og vandringsheds i det åbne land, hvor målrettning giver mulighed for effektivisering af kulturlandbrug, bl.a. ved sæsonprædikoner for mærensemværdier  
 I byområder hvor målrettning af oversvømmelser giver mulighed for tilbageholdelse og forsinkelse af regnvandstrømme fra opstand og bedre styring af vandkredsløb  
 Varsling af evt. oversvømmelser af bygninger fx afledning af smeltevand med henblik på minimering af skader fra oversvømmelse  
 Varsling af trafikanter og transportsектор i forhold til ekstremregn og oversvømmede veje og jernbaner  
 Bedre information af borgere og offentlighed om der og nu grundvandsudslag (fx tørke- og oversvømmelsesindex jf. meget lav eller meget høj ekstremgrundvandsudslag)  
 Beredskab i forhold til risiko for jordskred og stabilitet af dæmninger mv.

DMI  
HIRLAM



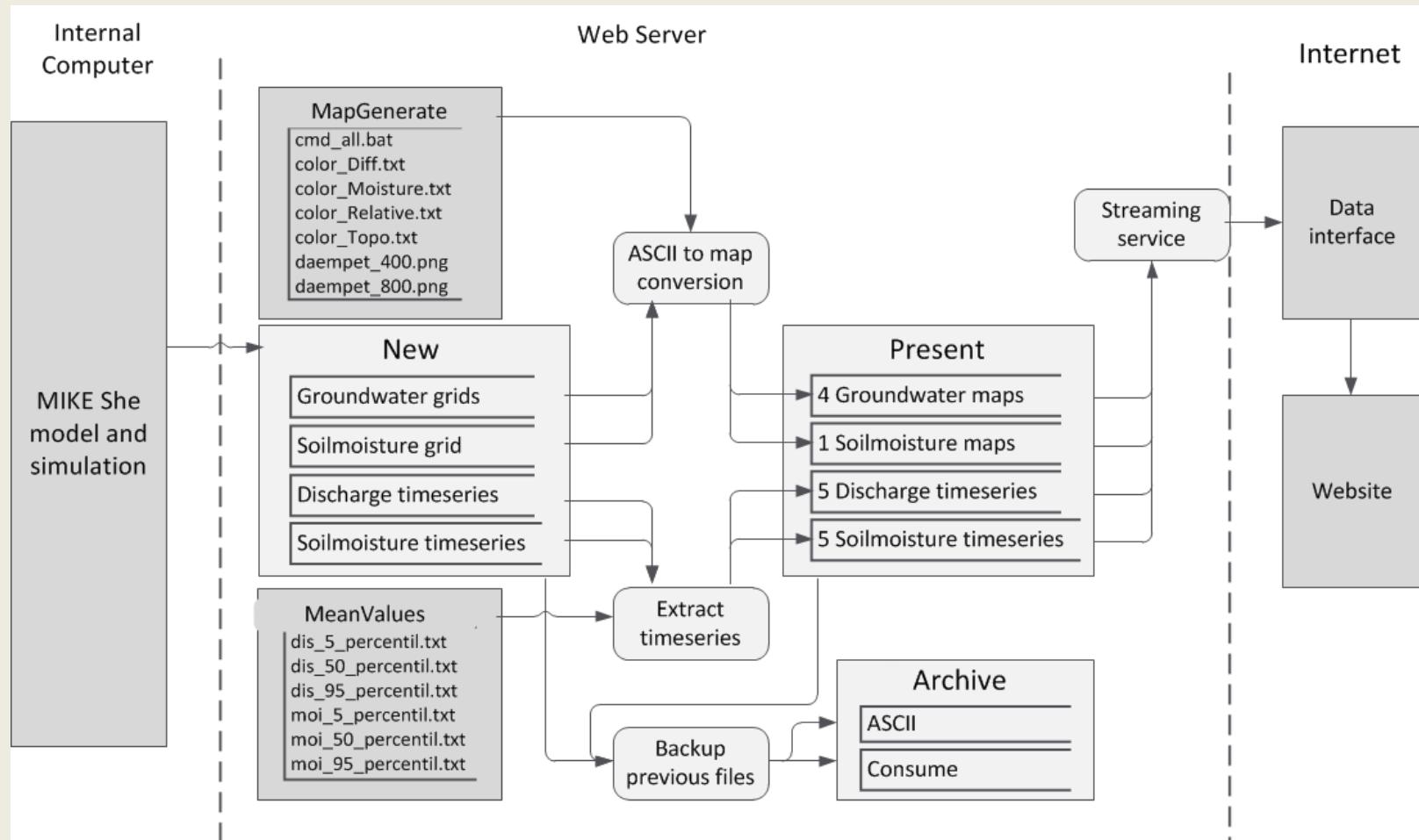
00:00 - 06:00 - 12:00 - 18:00

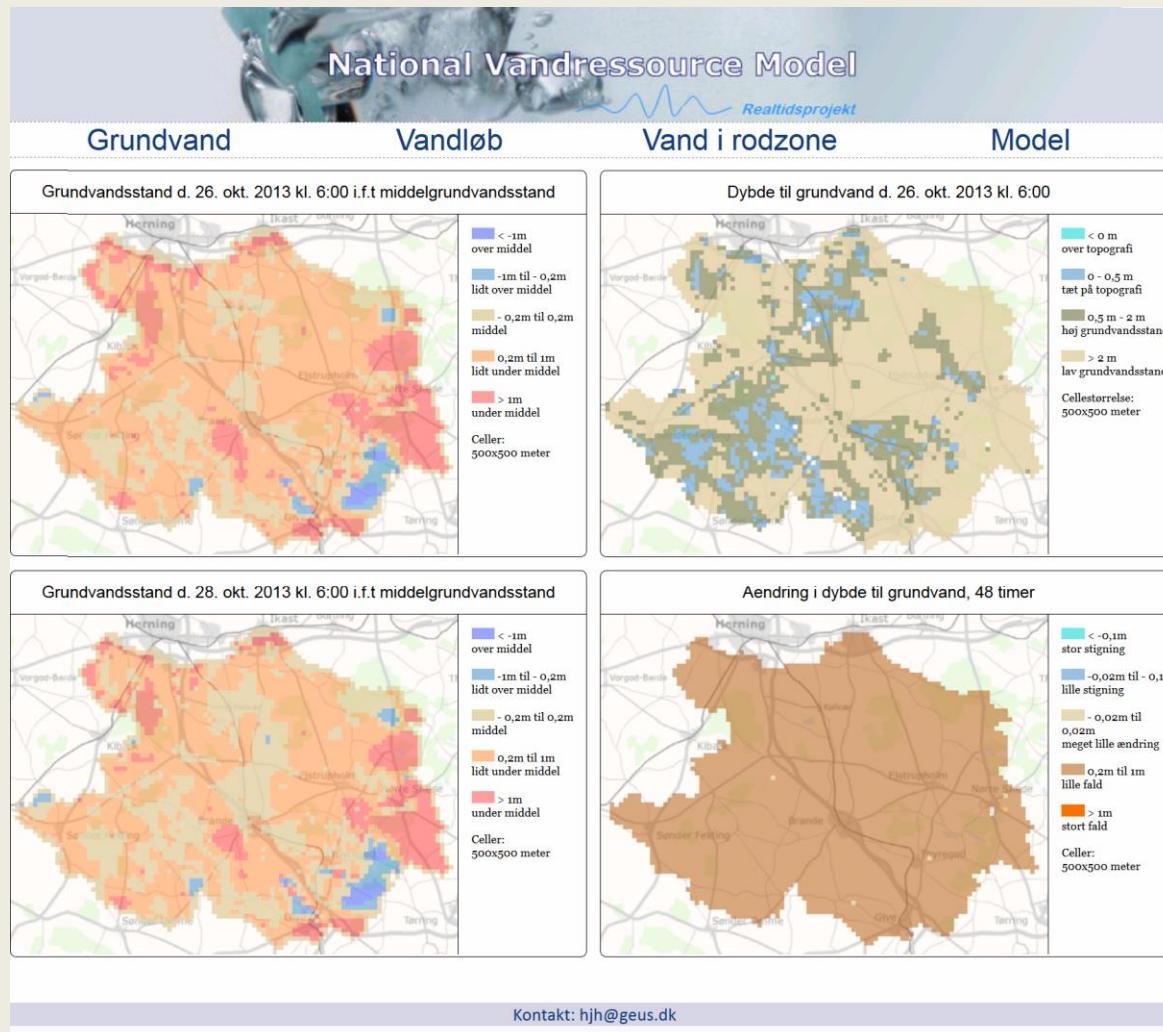


## Realtidsmodel workflow

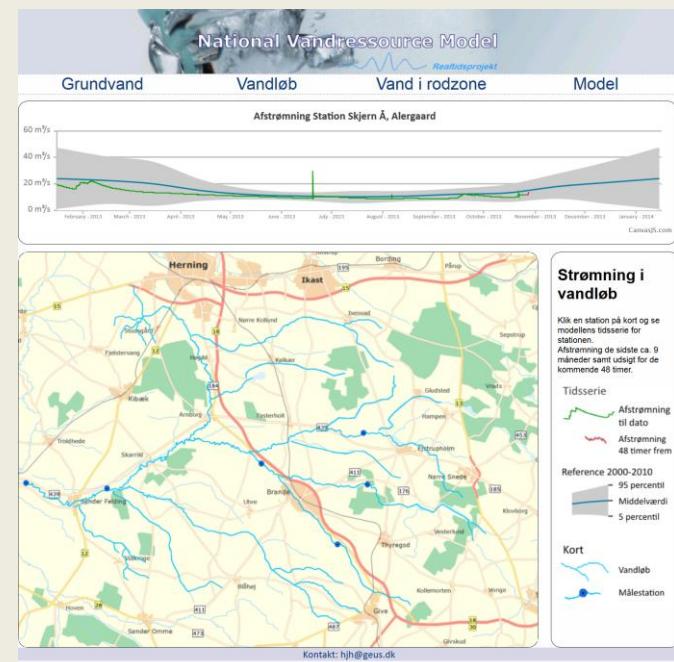
- Klimadata:  
**HIRLAM (DMI)**
- Software:  
**Mike Customized (DHI)**
- Model,  
prototype,  
workshop  
**(GEUS)**

# Fra MIKE SHE simulering til website





# Web interface for Ahlergaarde oplandet

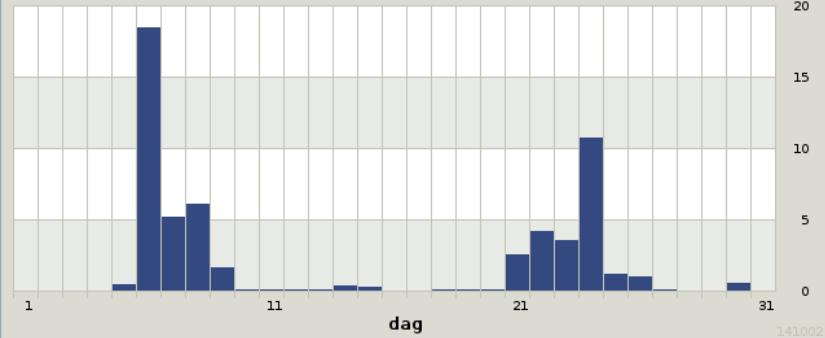




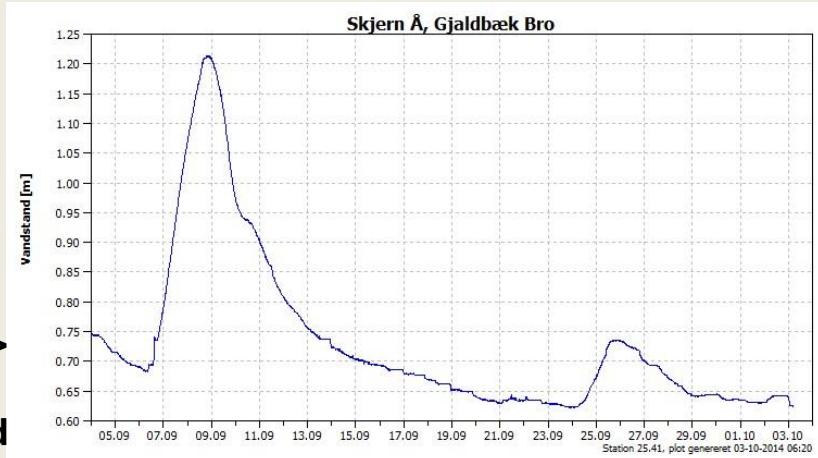
Nedbør i mm for september 2014  
Midt- og Vestjylland

Nedbør pr. døgn

Månedssum: 57 mm, normal (1961 - 1990): 86 mm



Cloudburst 6-7  
September  
2014 hit Midt-  
and Vestjylland  
with heavy rain  
locally more  
than 50 mm  
precipitation =>  
flooding hazard



# Workshop design

## Program:

9.30 – 10.00	Ankomst og kaffe/te/rundstykker
10.00 – 10.10	Velkomst og introduktion til dagen – <i>Hans Jørgen Henriksen, GEUS</i>
	Om realtidsvarslingsprojektet:
10.10 – 10.30	Introduktion til Realtidsprojektet – <i>Simon Stisen, GEUS</i>
10.30 – 10.50	Tekniske udfordringer i forbindelse med hydrologisk modellering i realtid – <i>Xin He, GEUS</i>
10.50 – 11.10	Web præsentation af hydrologiske realtids- og forecast data for case et område – <i>Marianne Wiese, GEUS</i>
11.10 – 11.30	Kort pause
	Eksempler på realtidsvarsling i Danmark og udland:
11.30 – 12.00	Bedre forudsigelse af kraftig nedbør – <i>Henrik Vedel, DMI</i>
12.00 – 12.30	Varslingssystemer i forhold til hydrologi og vandløbskredsløb – <i>Torsten Jacobsen, DHI</i>
12.30 – 13.30	Frokost
	Tre cases:
13.30 – 13.50	Oversvømmelse fra Storåen i Holstebro – <i>Projektkoordinator Leif Theilgaard, Holstebro Kommune</i>
13.50 – 14.10	Usserød Å projektet – <i>Projektleder Klaus Pallesen, Fredensborg Kommune</i>
14.10 – 14.30	Varslingsmodel for oversvømmelse langs Aarhus å – <i>Ingeniør Ole Helgren, Aarhus Kommune</i>
	Diskussion (og kaffe mv):
14.30 – 14.50	Oplæg til diskussion – resultater fra spørgeskemaundersøgelse af behovsafdækning af realtidsvarslingssystemer – <i>Hans Jørgen Henriksen, GEUS</i>
14.50 – 15.20	Diskussion i grupper eller plenum
15.20 – 15.50	Opsamling i plenum
15.50 – 16.00	Afslutning – <i>Hans Jørgen Henriksen, GEUS</i>

- Welcome and presentation of early warning system prototype and web interface for case study area (GEUS)
- Partner presentations by DHI and DMI of 20 years experiences with early warning systems
- Three community based early warning system examples (Holstebro, Fredensborg and Århus)
- Break out group session and plenum

(a) Relevance of hydrological real-time system at national scale.  
 (b) Desired hydrological model configuration

Grid size	%	Temporal discretization	%	Frequency for model refreshing	%
250 m	90	Minutes	12	Hours	27
500 m	10	Hours	23	Days	60
1000 m	0	Days	65	Months	13
Relevance of a national level real-time hydrological model describing the actual water state		Ability of the national model simulations to be directly used as a part of the local water management	Relevance of the DK-model forecast giving estimates of hydrological variables in the future based on weather forecasts	Ability of the DK-model forecast can be used directly as a part of the local water management	
Low	14	15	20	16	
Intermediate	29	46	40	42	
High	57	39	40	42	

(c) Model results to present in the hydrological real-time system and their uncertainty

(d) Preferences for the information and communication tools (ICT)

Relevant variables	%	Importance of uncertainty assessment	%
Groundwater level, groundwater recharge, river discharge and soil moisture	52	Not very important	5
Groundwater level, groundwater recharge and river discharge	28	Important	71
River discharge and soil moisture	10	Of critical importance	24
<u>River discharge</u>	<u>10</u>		
Communication methods	%	Stakeholders' involvement	%
SMS	41	Face-to-face meetings	78
Mobile phone APP	56	Information on DK-model homepage	59
Internet homepage	67	Focus groups	30
Newsletters	7	Think tank	30
Download data	30	Telephone interviews	7

## (e) Hydrological real-time system at the national level and at the local level.

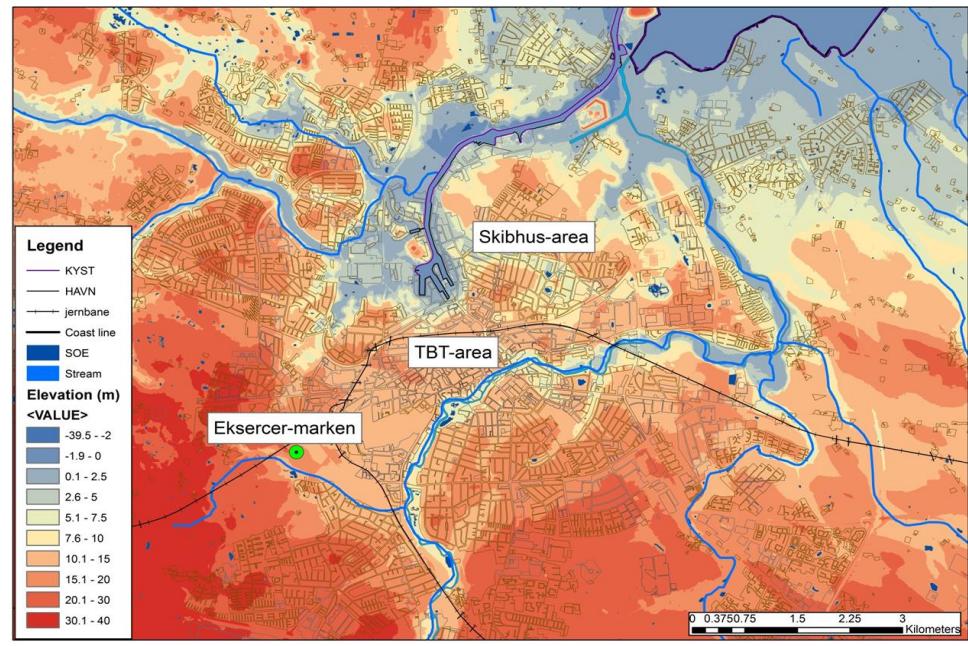
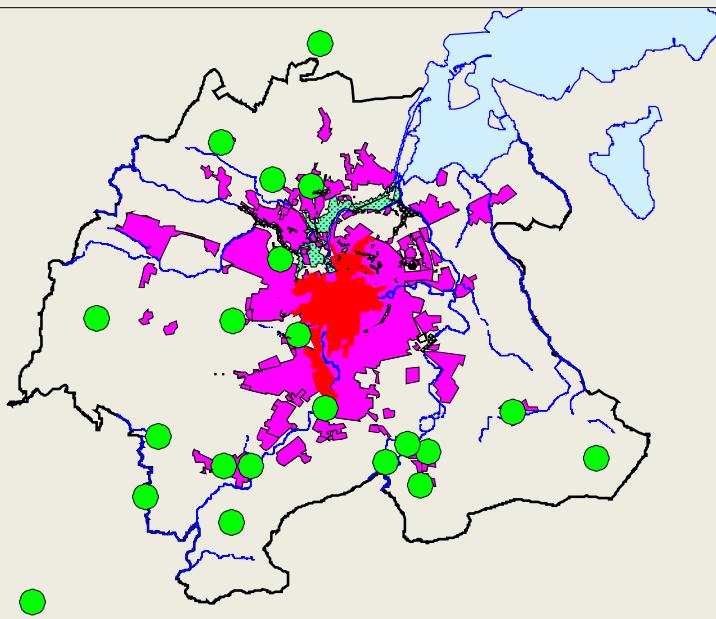
Questions	National level (%)	Local level (%)
Already use systems for monitoring and/or early warning in relation to water management?	N/A	30
Have plans of using real-time system as an element in water management and/or climate change adaptation?	N/A	44
Relevance for real-time forecasts of flood in rural areas with possible preventive emergency actions	59	N/A
Relevance for drought and water scarcity in rural areas, where real-time forecasts gives possibilities for more effective irrigation, based on seasonal forecasts	70	N/A
Relevance for urban areas where real-time forecast enables possible local retention and delay of storm water runoff from catchment and control of water flows	52	56
Relevance for early warning of flooding for buildings, management of melt water runoff and steering of water cycle	59	44
Relevance for early warning of traffic and transport sector in relation to extreme rain events, flooding of roads and railways	67	52
Relevance for information update to the general public including indexes for drought and flooding	74	41
Relevance for emergency management in relation to risk of landslides and stability of dams	78	22

# Feedback from the stakeholders

- National v.s. local systems
- Interaction between shallow groundwater aquifer and surface water is a unique feature.
- Inconsistency in the understanding of time scale between the surface water and groundwater community.
- For future system development: (1) Model uncertainty in the input data and the forecast; (2) early warning schemes need to be developed on top of hydrological forecasts; (3) agriculture related issues need to be given more attention.

# NORDRESS Odense case study

[www.nordress.hi.is](http://www.nordress.hi.is)



## The evolution of Odense

(Kilde:  
Johan Linderberg  
Vandcenter Syd)

Oversvømmelses hotspots  
Eksercermarken  
TBT  
Skibhus området  
(*infrastructure+community resilience*)

# Local decision support

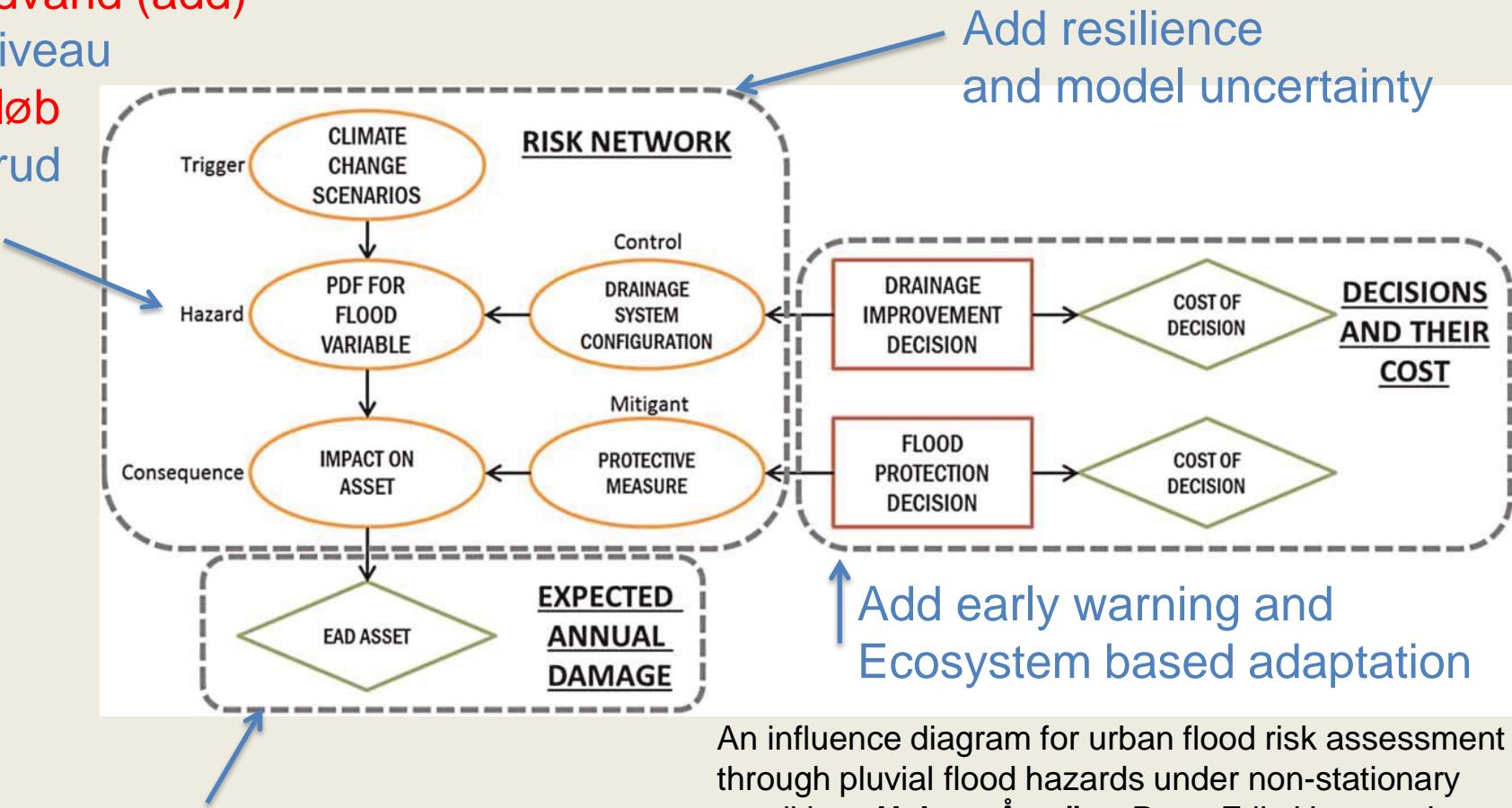
(time-sliced bayesian networks: PhD study DTU Helena Åström 2015)

Grundvand (add)

Havniveau

Vandløb

Skybrud



Add social and environmental  
benefits (ecosystem services)

An influence diagram for urban flood risk assessment through pluvial flood hazards under non-stationary conditions **Helena Åström**, Peter Friis Hansen, Luca Garré, Karsten Arnbjerg-Nielsen  
*Journal of Water and Climate*, 5(3), 276-286 (2014)

# Concluding remarks

- The prototype we developed has significant implications for water resources management (1) Accessible by stakeholder; (2) open dialogs on uncertainty; (3) inclusion of hydrological components outside surface water.
- The experience from the stakeholders can effectively bridge the knowledge gap.
- DK-model can be used as a information gathering system and awareness communication system.

# More information

- Videnskab.dk
- Sciencenordic.co
- The national hydrological model DK model:  
[www.vandmodel.dk](http://www.vandmodel.dk)
- NORDRESS (Nordic Centre of Excellence on Resilience and Societal Security):  
<http://nordress.hi.is>

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**New model can help predict flooding two days in advance**

January 5, 2016 - 06:25

A new model can monitor underground water in real-time and will help to improve early flood warnings.

Keywords: Climate, flood, hydrology

Send PDF Print

By: Catherine Jex

When it comes to predicting when and where the next devastating flood will strike, meteorologists and town planners need more information than simply the weather forecast for that week. They also need to know what is happening underground. How high is the water table? And how wet is the soil? But many flood-forecasting models do not include this information.

Now, a group of Danish scientists have developed a nationwide model that could help local flood forecasters predict imminent floods up to



A new computer model will monitor Denmark's water cycle—from the rain that falls on land to the groundwater stored under the earth. The new model will help local weather forecasters to predict where and when the next flood will strike. (Photo: Shutterstock)

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