National Environmental Research Institute
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Runoff , Nutrient Loads and Freshwater Ecology in a changing Climate in Denmark: What can we learn from historical data and model scenarios?

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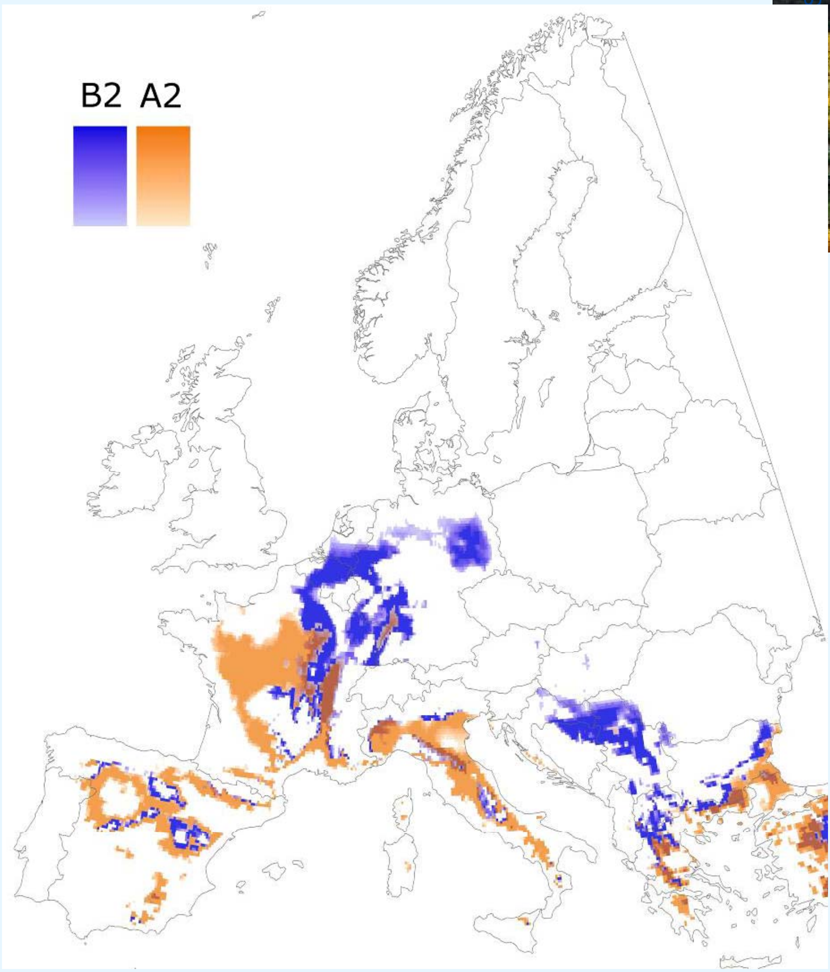
Can the future be found looking in a mirror?

Danish climate 2100 - spatial analogs?



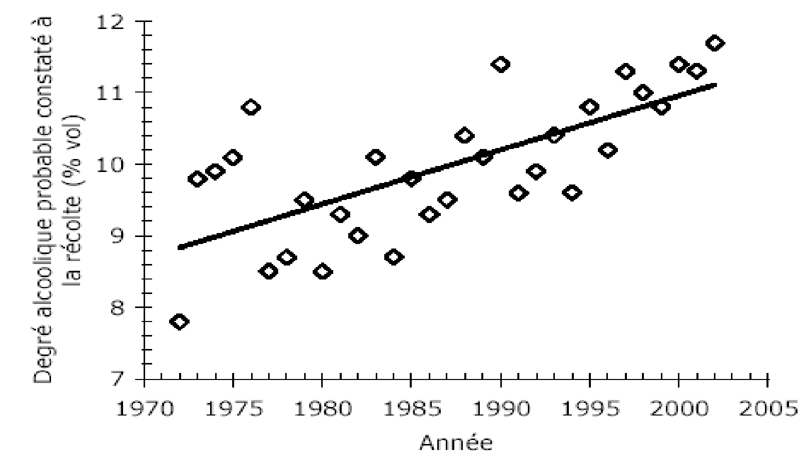
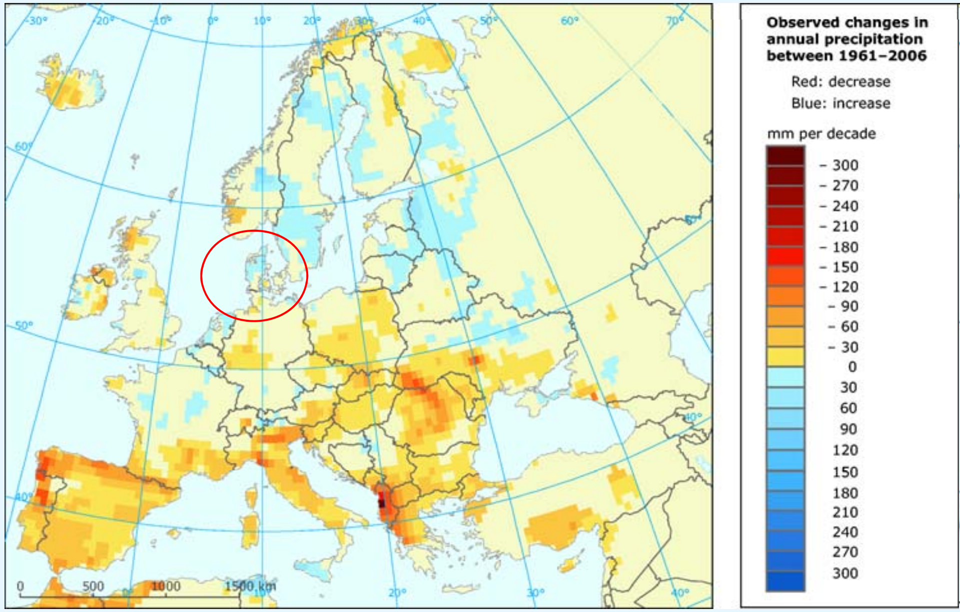
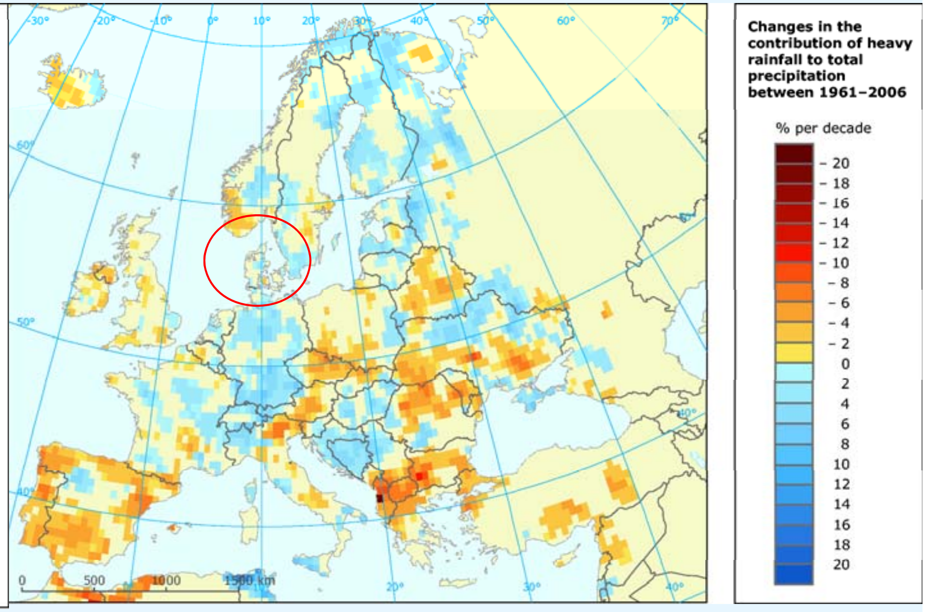


Figure 8 : Evolution des degrés moyens constatés à la récolte en Alsace pour le riesling. Source CIVA. Le gain moyen est de 0,08 % vol. par an.

Duchéne and Schneider 2004

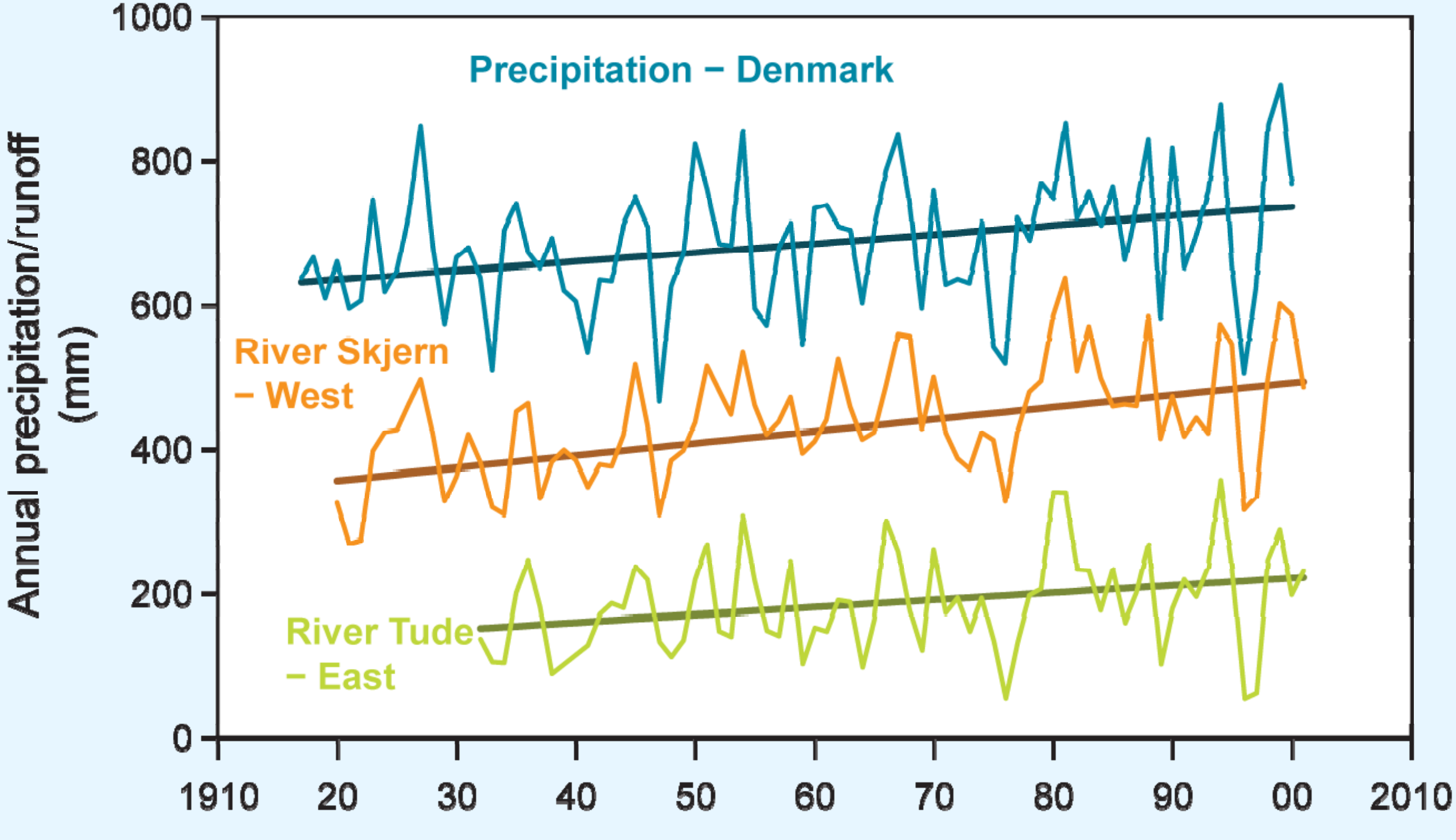
Observed changes in annual precipitation and the contribution of heavy rainfall to total precipitation 1961–2006



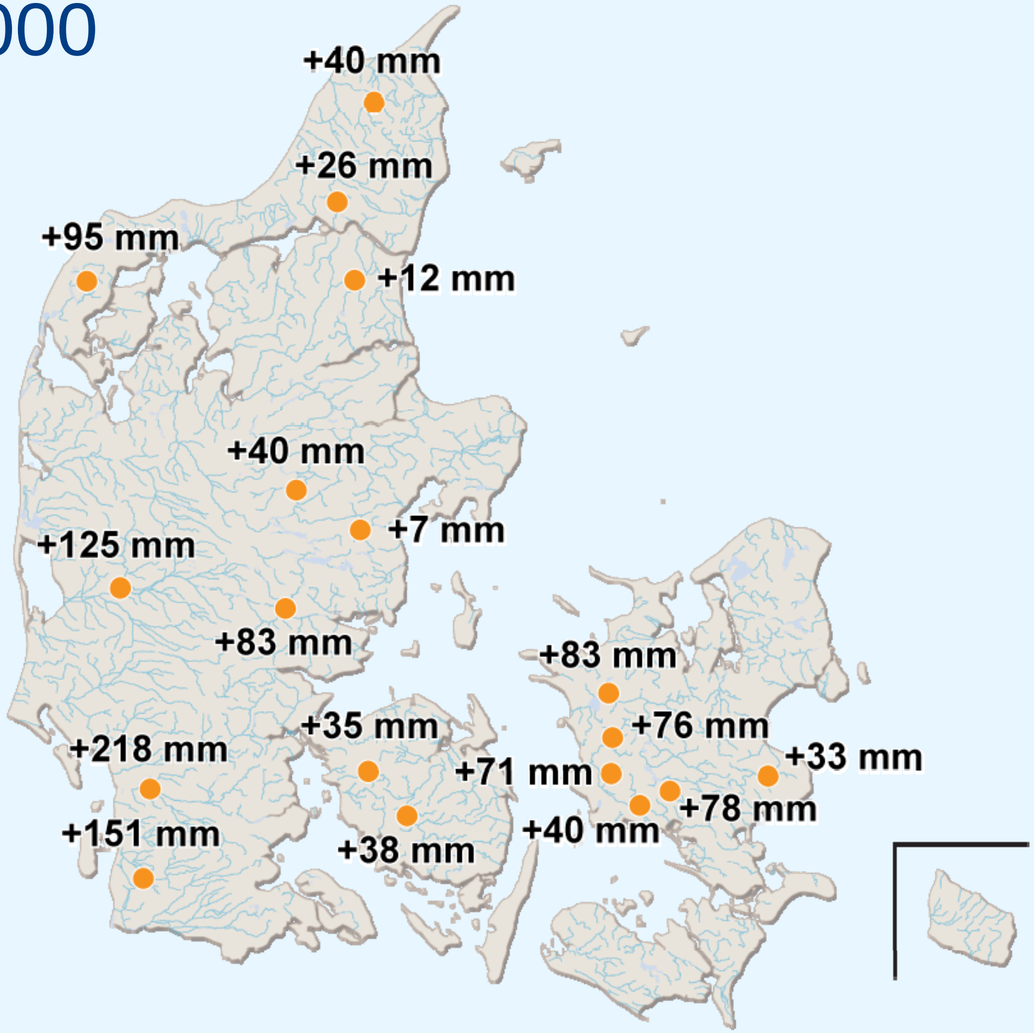


Source: EEA, 2008. The climate dataset is from the EU-FP6 project ENSEMBLES (http://www.ensembles-eu.org) and the data providers in the ECA&D project (http://eca.knmi.nl).

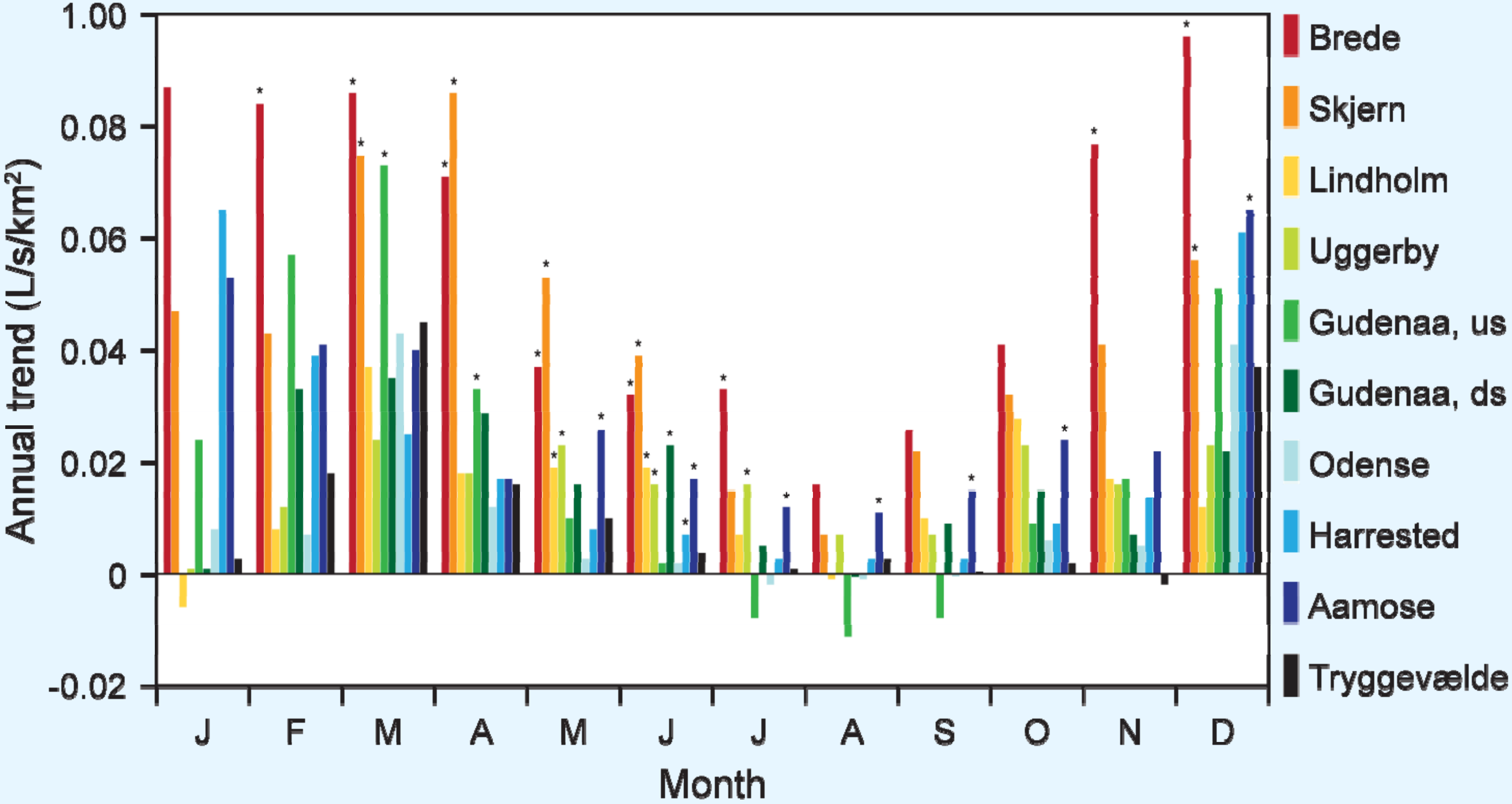
Trend in average precipitation and runoff in two Danish rivers



Trends in annual runoff in 18 Danish rivers during the period 1925-2000



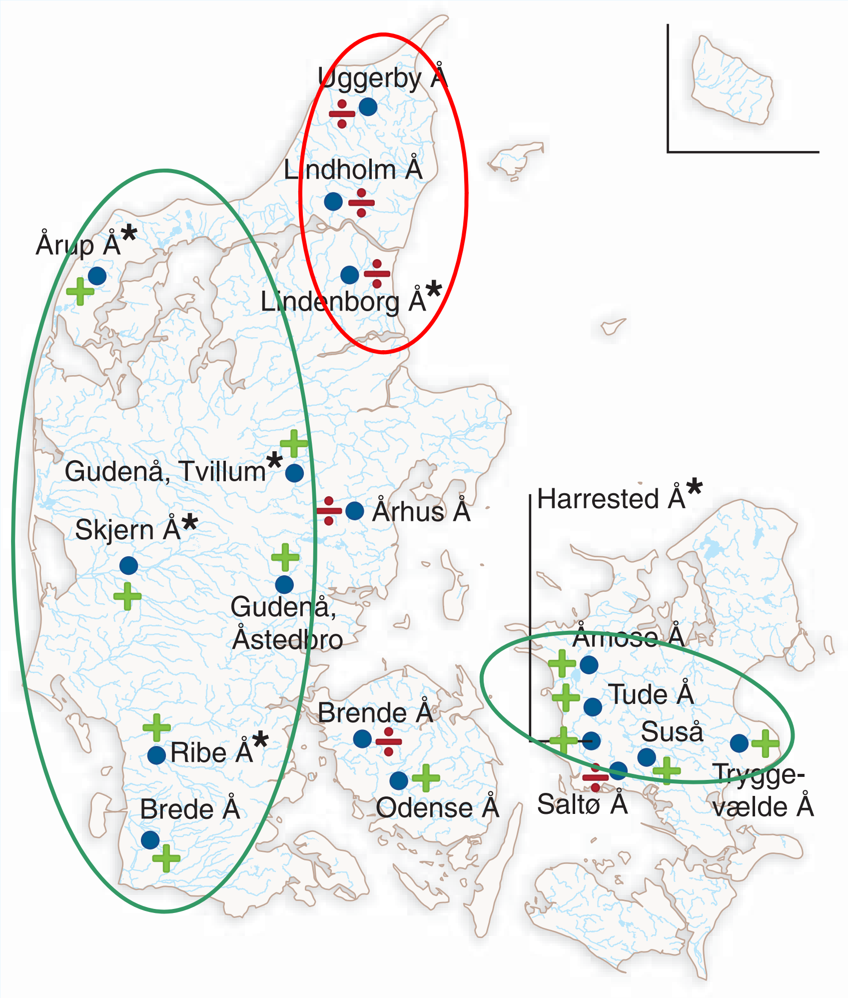
Monthly trends in runoff in 10 Danish streams – 1920-2000



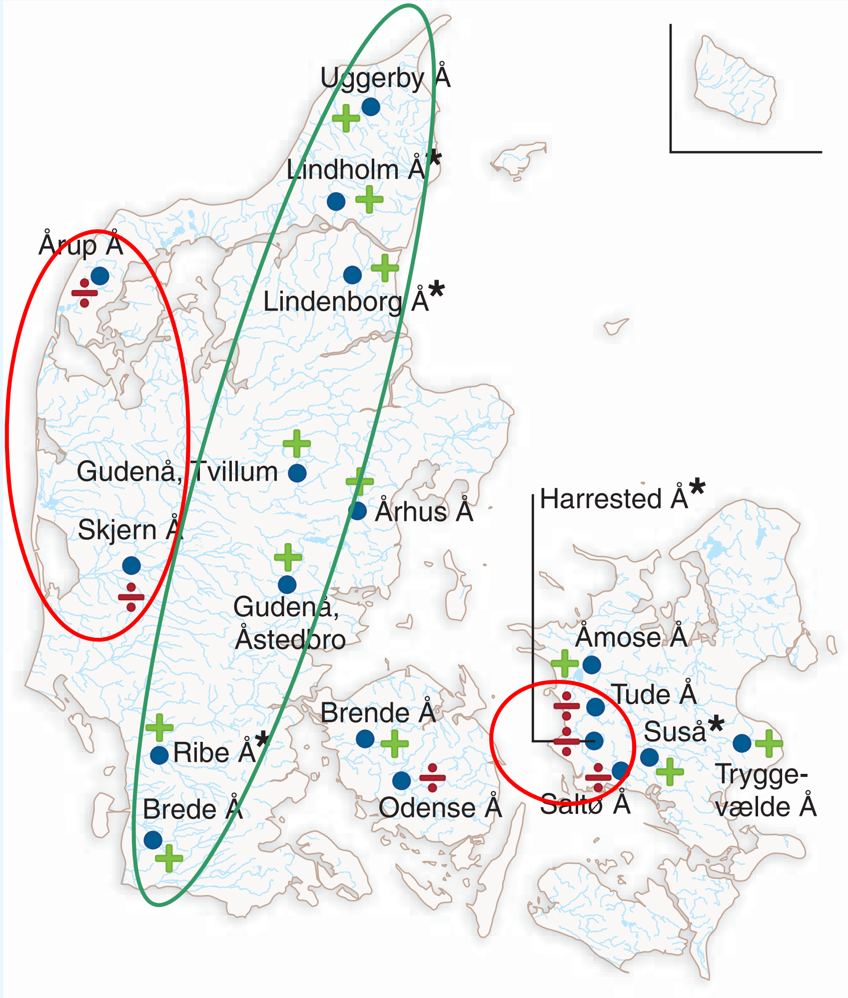
IGLOO project results changes 1950-2007:

Hansen et al., 2009

Max. discharge



Min. discharge



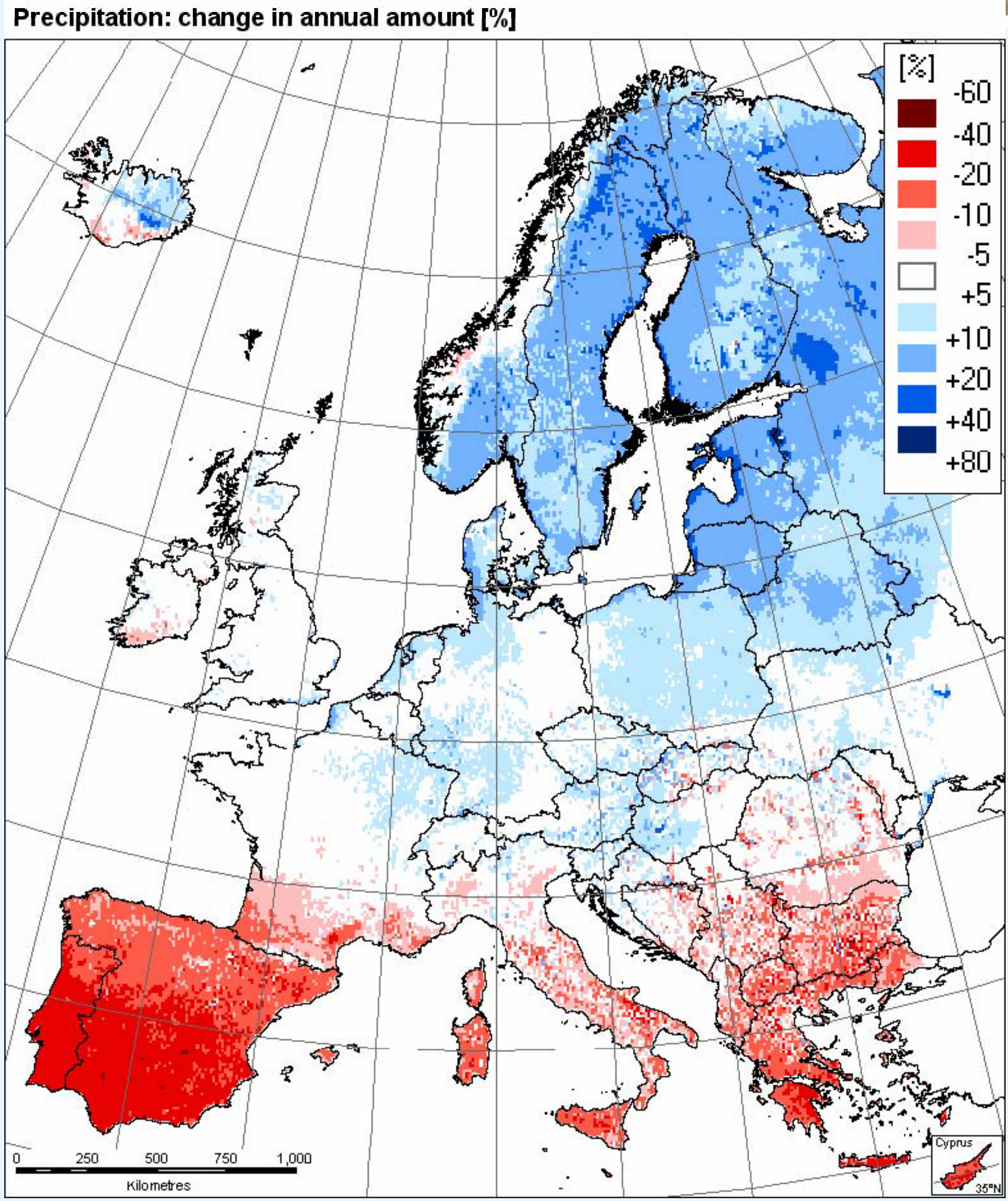
We are already adapting to extreme weather conditions !

Where are we going ?

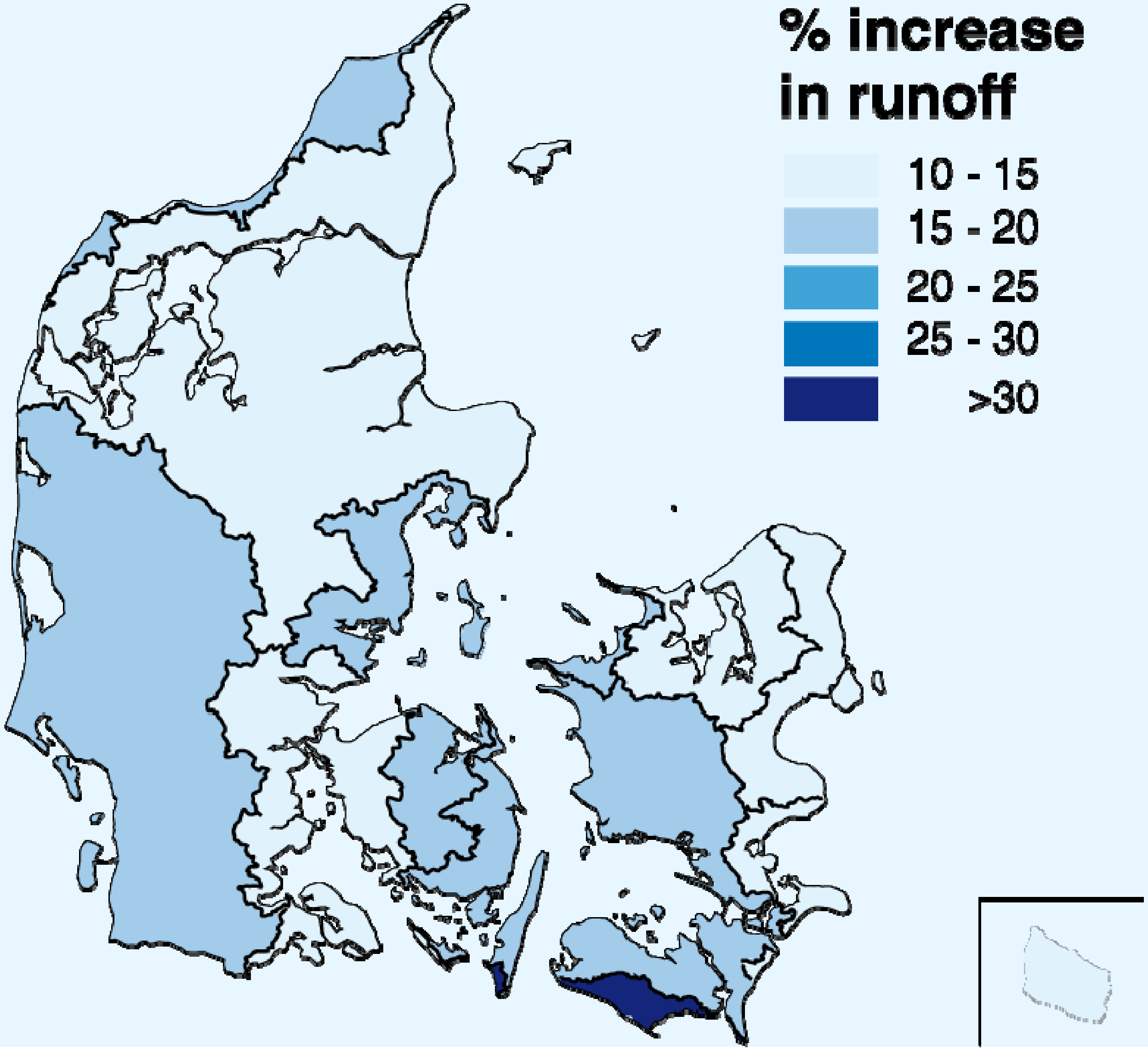
From IGLOO project report – Hansen et al., 2009

Predicted change in precipitation over Europe

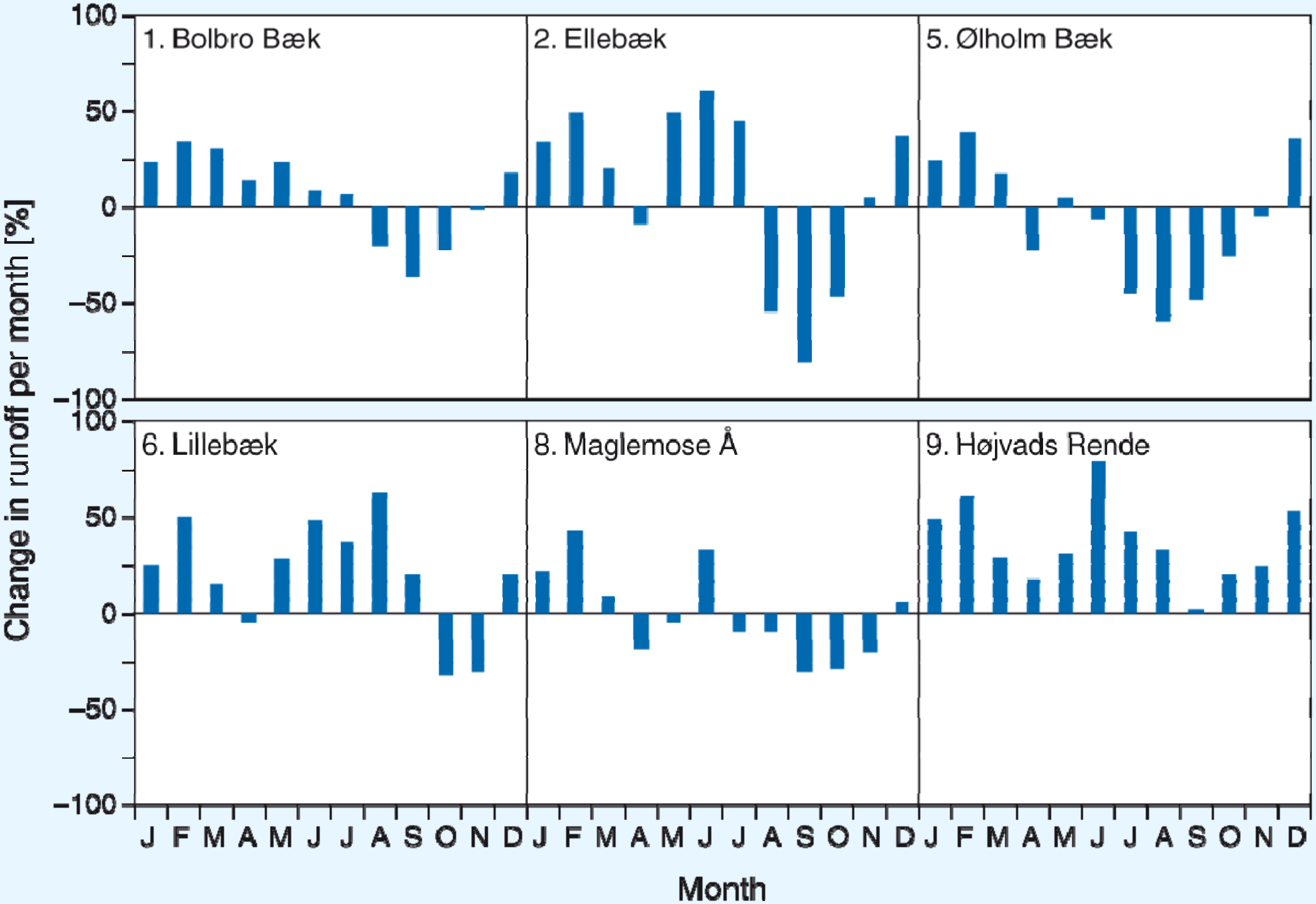
(1961-90 to 2071-2100)



Scenario A2– HIRHAM regional model



Projections for future runoff in Danish catchments – HIRHAM A2 scenario – control: 1961-90; Scenario: 2071-2100

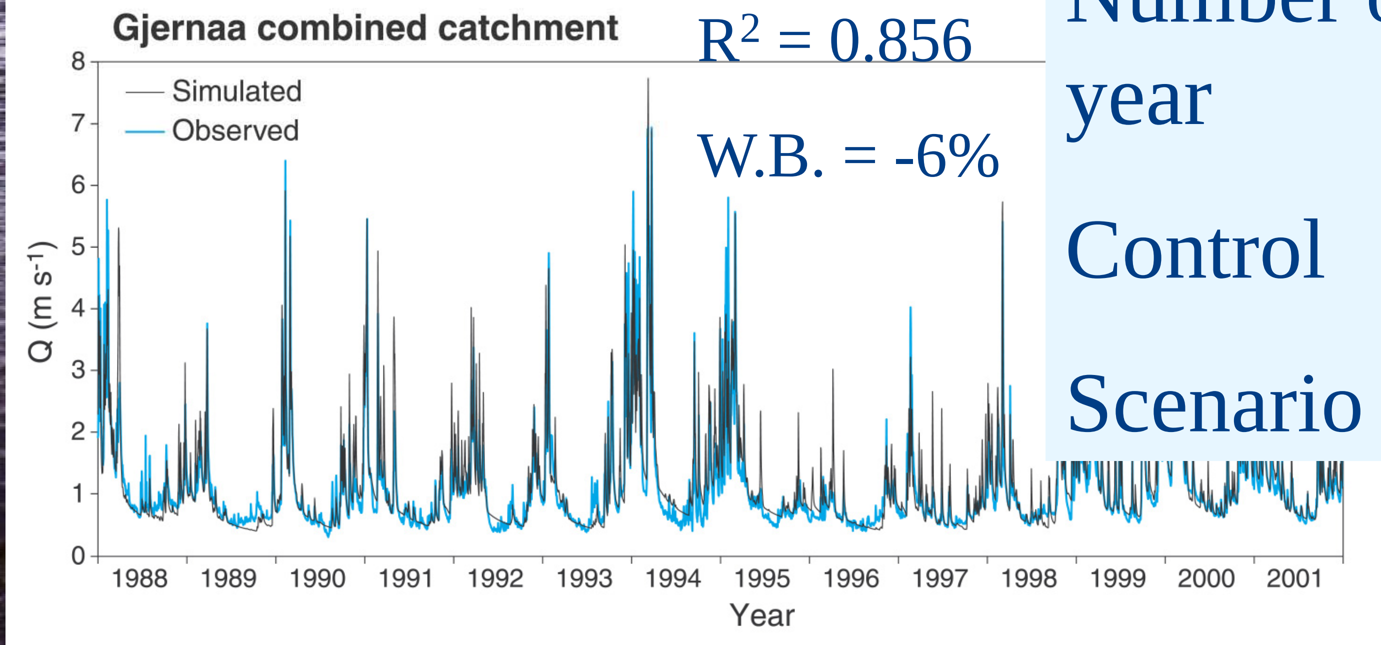


Comparison of recent trends and A2 scenario trends for Denmark

	Recent trends 1950-2010	HIRHAM A2 scenario 1961-90 to 2071-2100
Temperature	**0.9 ^{o}C**	**3.2 ^{o}C**
Precipitation	**100 mm**	**77 mm**
Runoff	**70 mm**	**58 mm**

Can we expect more extremes in floodings and drought periods in Danish streams?

Number of days with floodings per year increases with 50% from control period to scenario period (NAM-MIKE11 model predictions: Gjern river, Jutland)



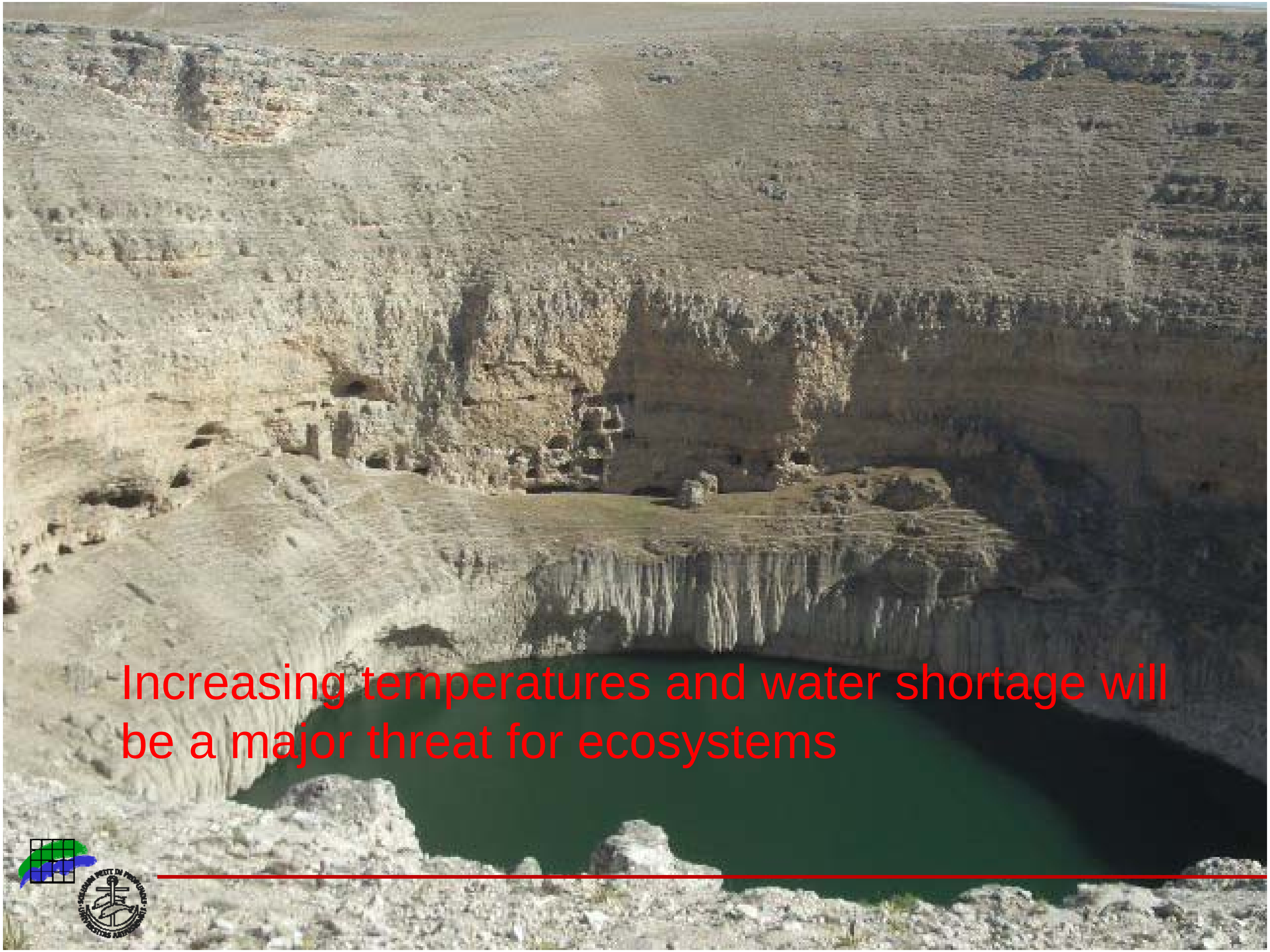
$R^2 = 0.856$

W.B. = -6%

Floodings

Number of days per year

Control	34
Scenario	51

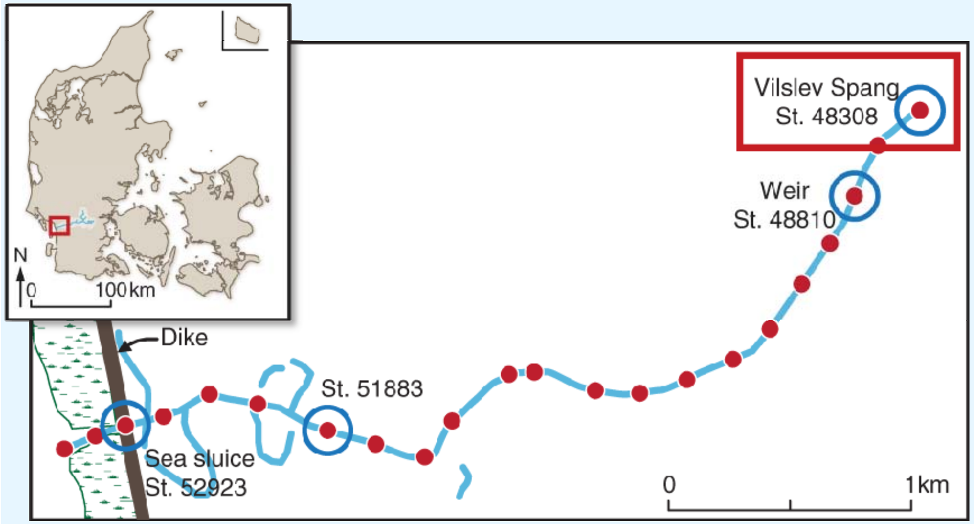

Increasing temperatures and water shortage will
be a major threat for ecosystems

We predicts a doubling of number of days with drying out in the small brook Ølholm Bæk from control (1961-1990) to scenario (2071-2100) in an A2 emission scenario

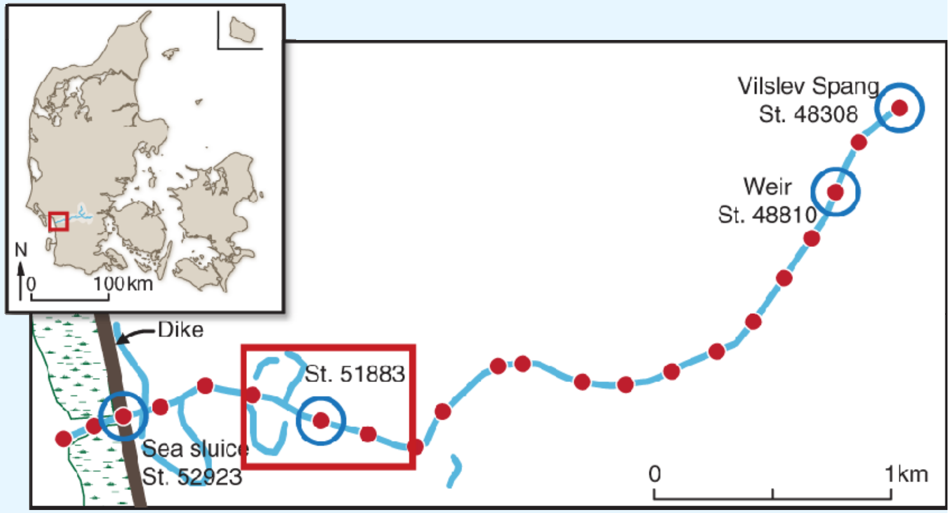
Ølholm brook	Number of years	
Number of days per year with drying out	Control periode (1961-1990)	Scenario period (2071-2100)
0-10	13	7
10-20	12	6
20-30	3	12
30-40	2	4
> 40	0	1

What happens with the sediment transport in Danish rivers?

Sediment transport is predcited to increase in streams but in lower parts of rivers highly dependent on Sea Level Rise (SLR)



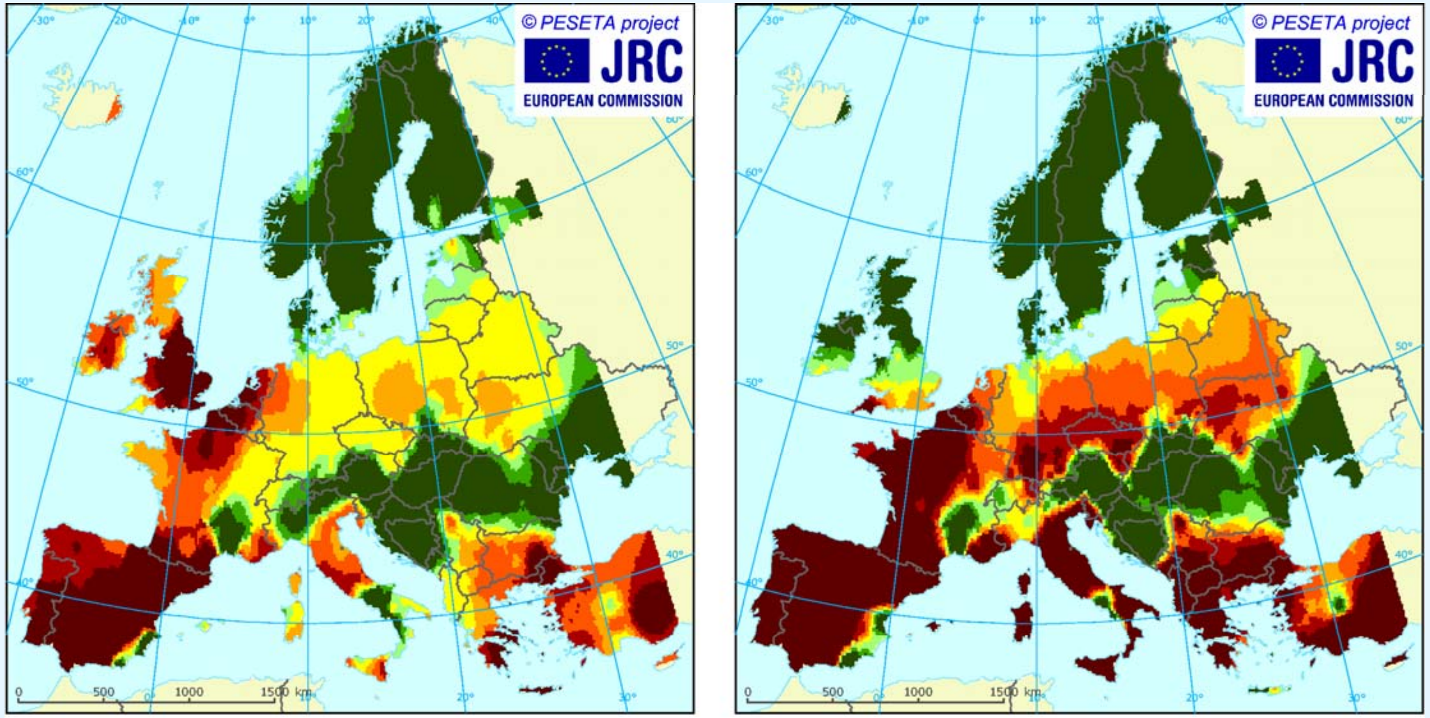
	Standard control	Standard scenario +SLR	Standard scenario ÷SLR
Bed sediment transport (m³/y)	5753	6999	7414
Percentage change (%)		22	29



	Standard control	Standard scenario +SLR	Standard scenario ÷SLR
Bed sediment transport (m³/y)	4030	4149	5597
Percentage change (%)		3	39

Nutrients

Increases in crop yields are of course also important – but higher crop yields will demand more fertiliser/pesticide use and therefore use of more sustainable production methods

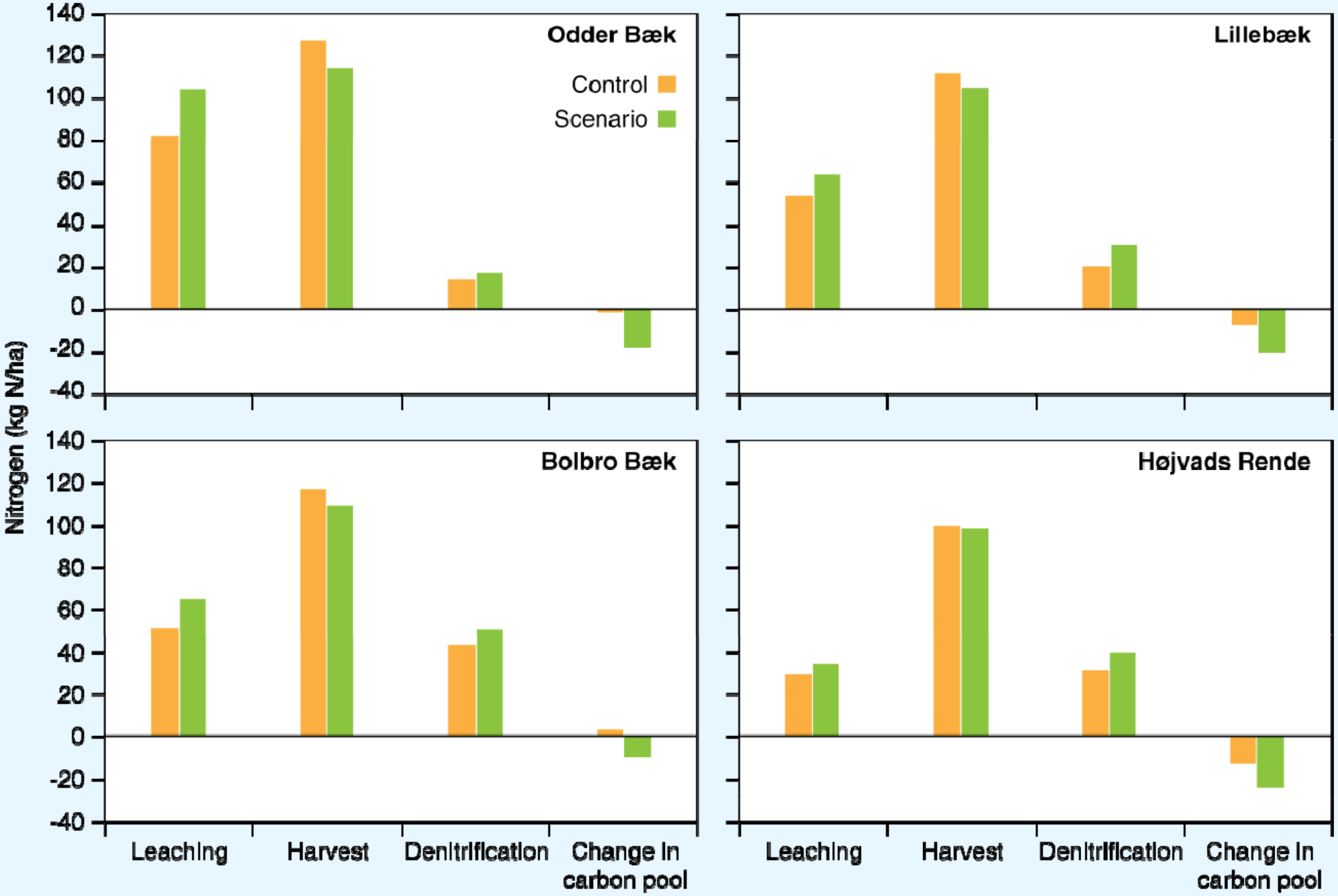


Simulated crop yield changes by 2080s relative to the period 1961–1990 under the HadCM3/HIRHAM (left) and ECHAM4/RCA3 (right) A2 scenario

Change in %

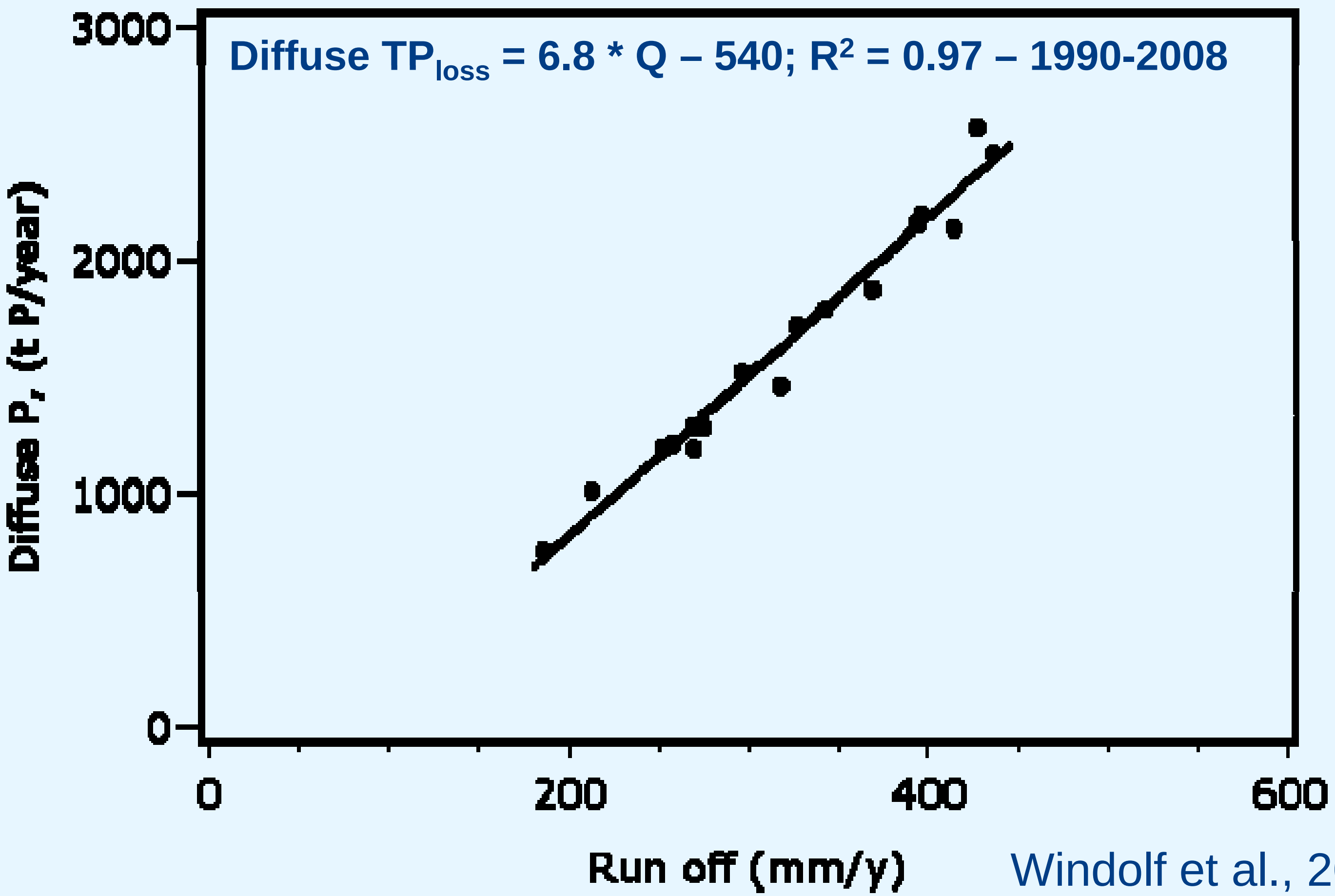
– 30 – 15 – 10 – 5 0 5 10 15 30

DAISY modelled changes in nitrogen cycling in 4 agricultural Danish catchments – rootzone (< 1 m) HIRHAM A2 scenario



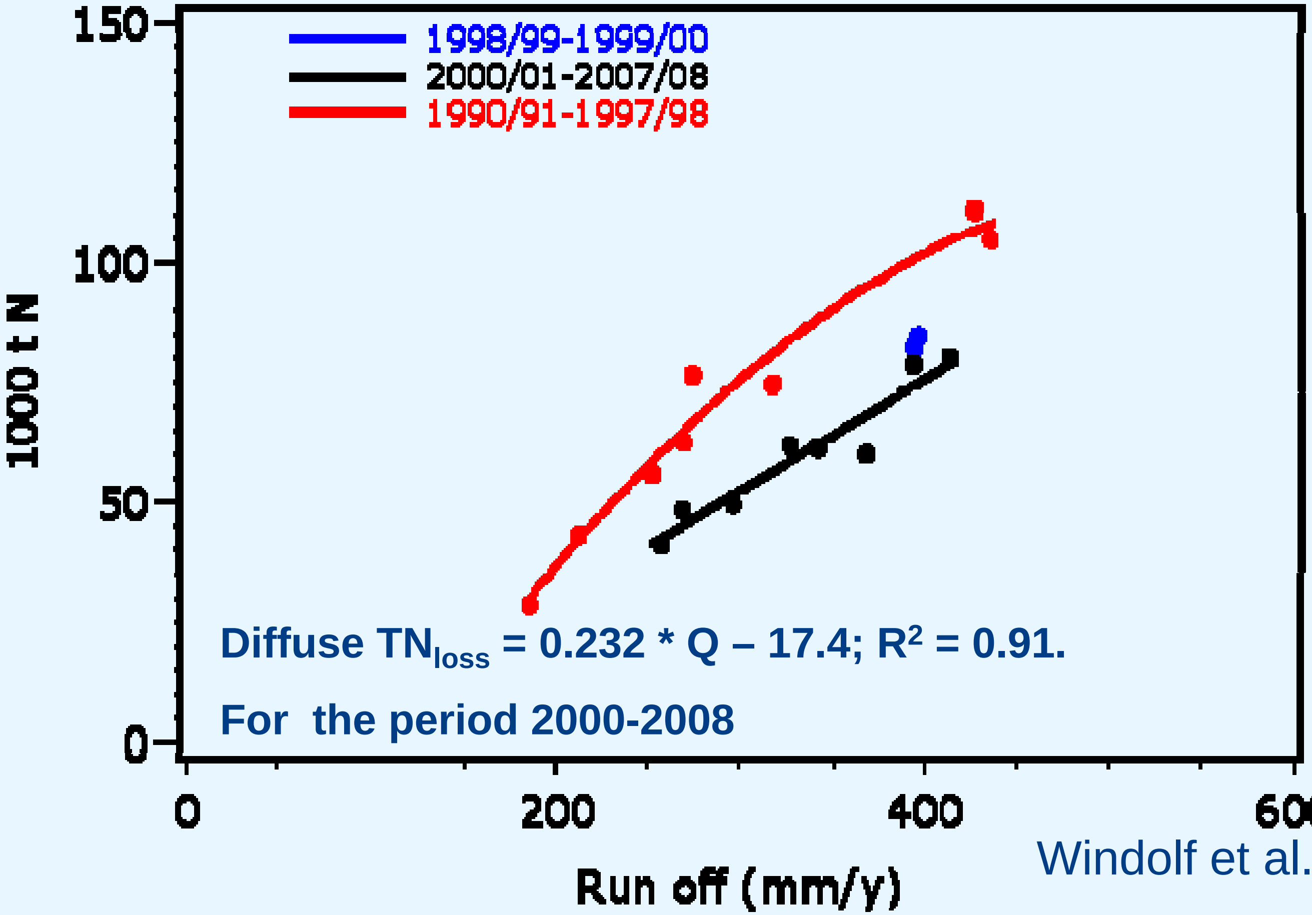
Grant et al., 2009

Phosphorus losses from diffuse sources to coastal waters in Denmark increases with increasing runoff



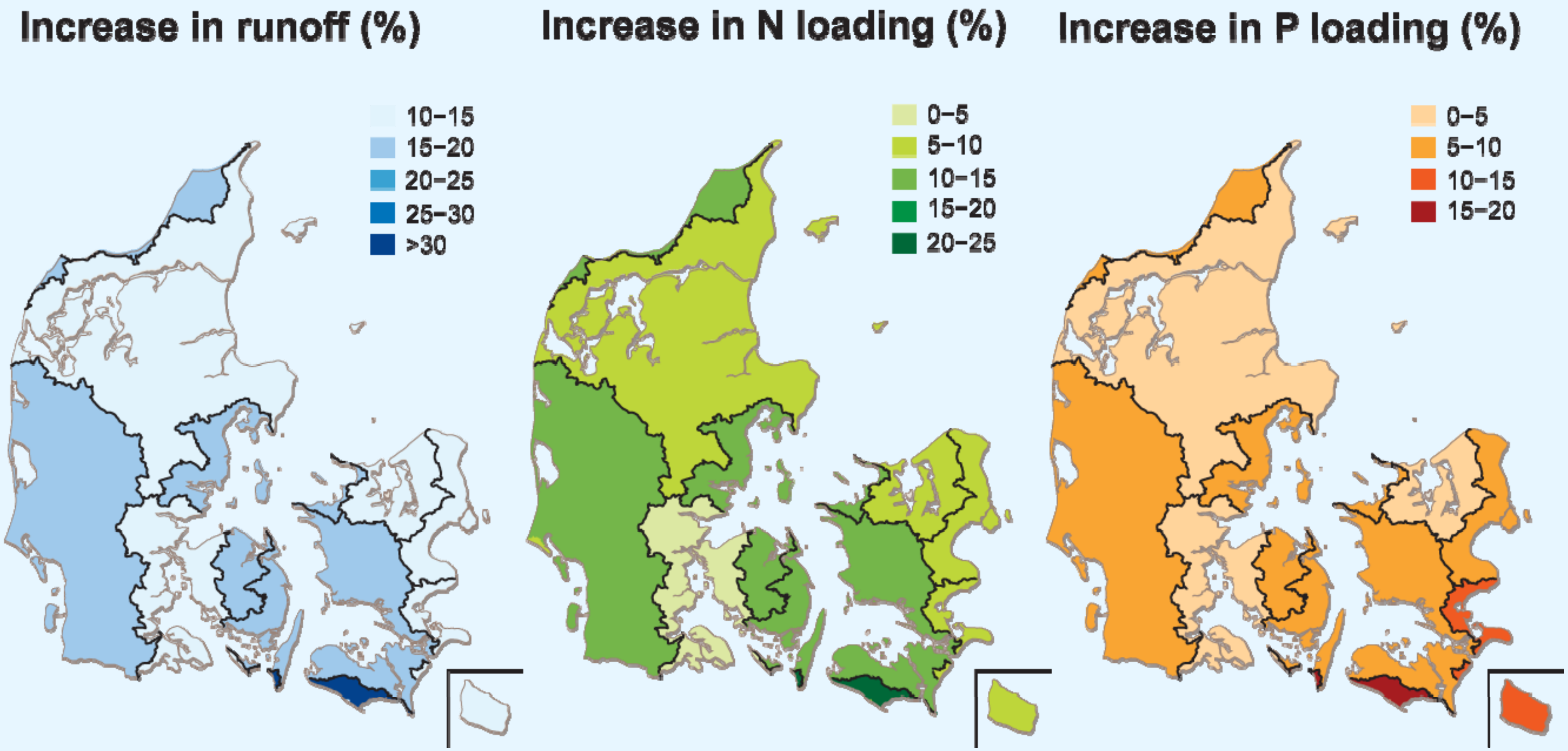
Windolf et al., 2010

Total nitrogen losses from diffuse sources to Danish coastal waters increases with increasing runoff – relationship has changed due to the effect of Action Plans



Windolf et al., 2010

Nitrogen and phosphorus losses is predicted to increase from baseline (1961-1990) to scenario period (2071-2100) – HIRHAM A2

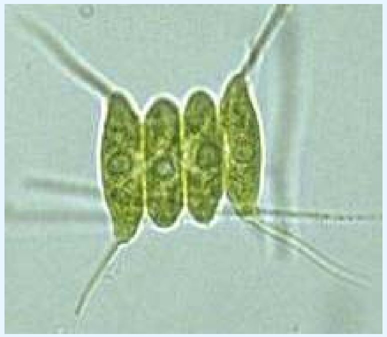


Søndergaard et al., 2006 Vand og Vejr om 100 år

Two ways of predicting changes in diffuse nutrient losses to marine waters in Denmark

	Total N Tonnes (%)	Total P Tonnes (%)
Predicted change with assumed runoff trends as modelled in HIRHAM A2 scenario	13,400 (23 %)	400 (25%)
Predicted change with runoff trends as last 60 years + A2 HIRHAM	29,700 (51 %)	870 (52 %)

Ecological impacts - indicators



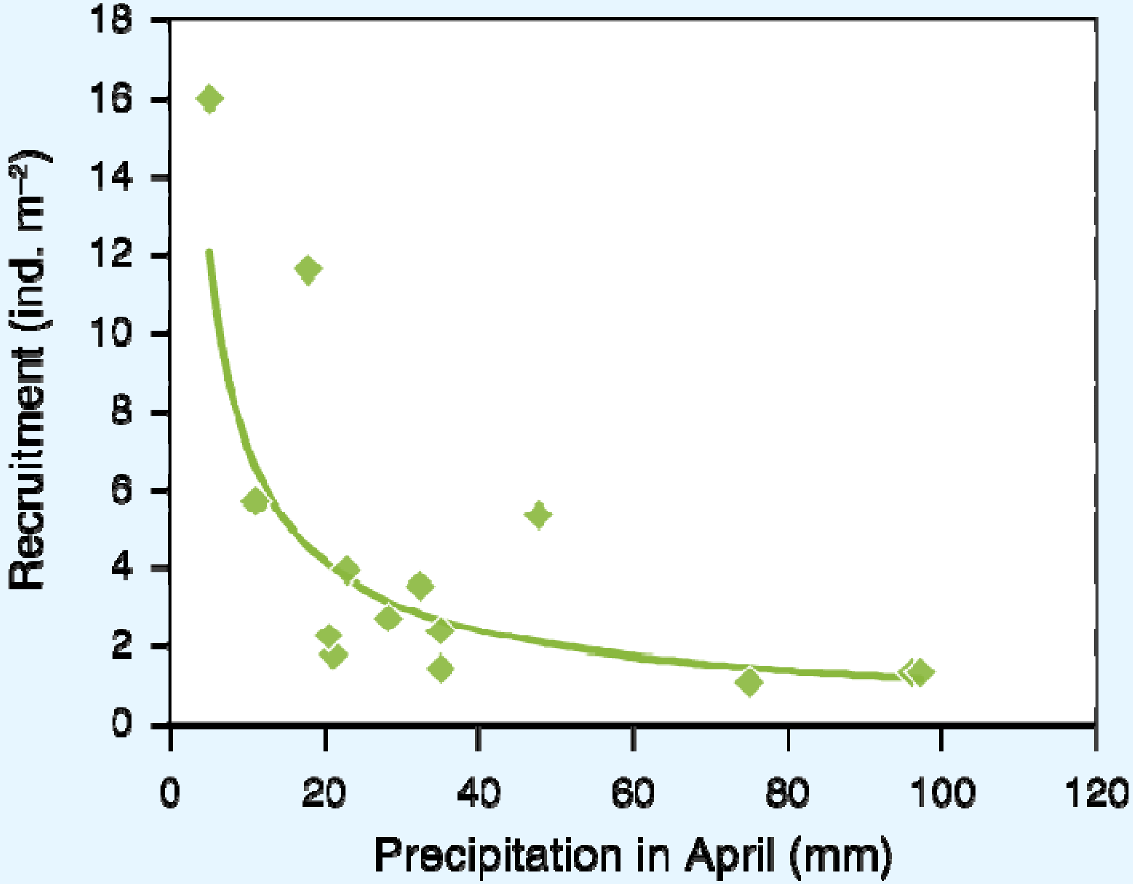
Phytoplancton

Macrophytes

Macroinvertebrates

Fish

Model for recruitment of juvenile trout against precipitation after emergence in a Danish brook based on 13 years of observations



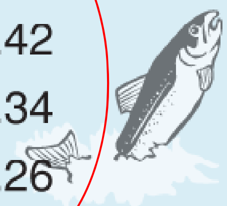
Combined increase in temperture and increased precipitation in egg period for trout reduces the recruitment of juvenile trouts with nearly 50%

Data from Bisballe Bæk (from Lobón-Cerviá & Mortensen, 2005)

	Emergence date	Mean monthly precipitation in April from 1974–1987 (mm)	Mean recruitment from 1974–1987 (ind m^{-2})
	1 April	39.1	4.33

Data from modelling

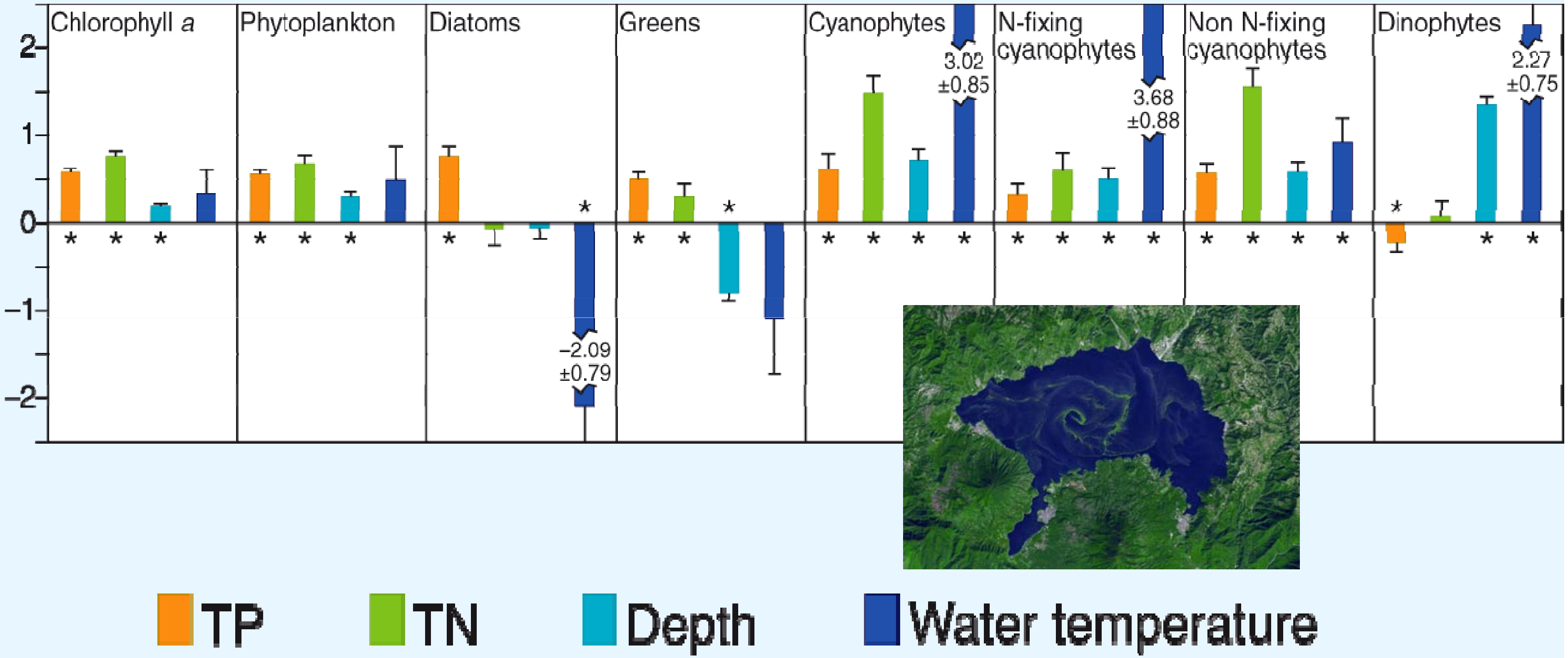
Temperature scenario	Emergence date	Mean monthly precipitation one month after emergence from the period 2071–2100 (mm)	Recruitment (ind m^{-2})
No increase	1 April	35.8	3.07
0.8	16 March	47.3	2.42
1	12 March	49.2	2.34
2	28 February	51.1	2.26



Multiple regression 250 lakes – 800 lake years

log(algae biomass) = log(TP)+ log(TN) + log (mean depth)+log(water temp) – data from August only (late summer)

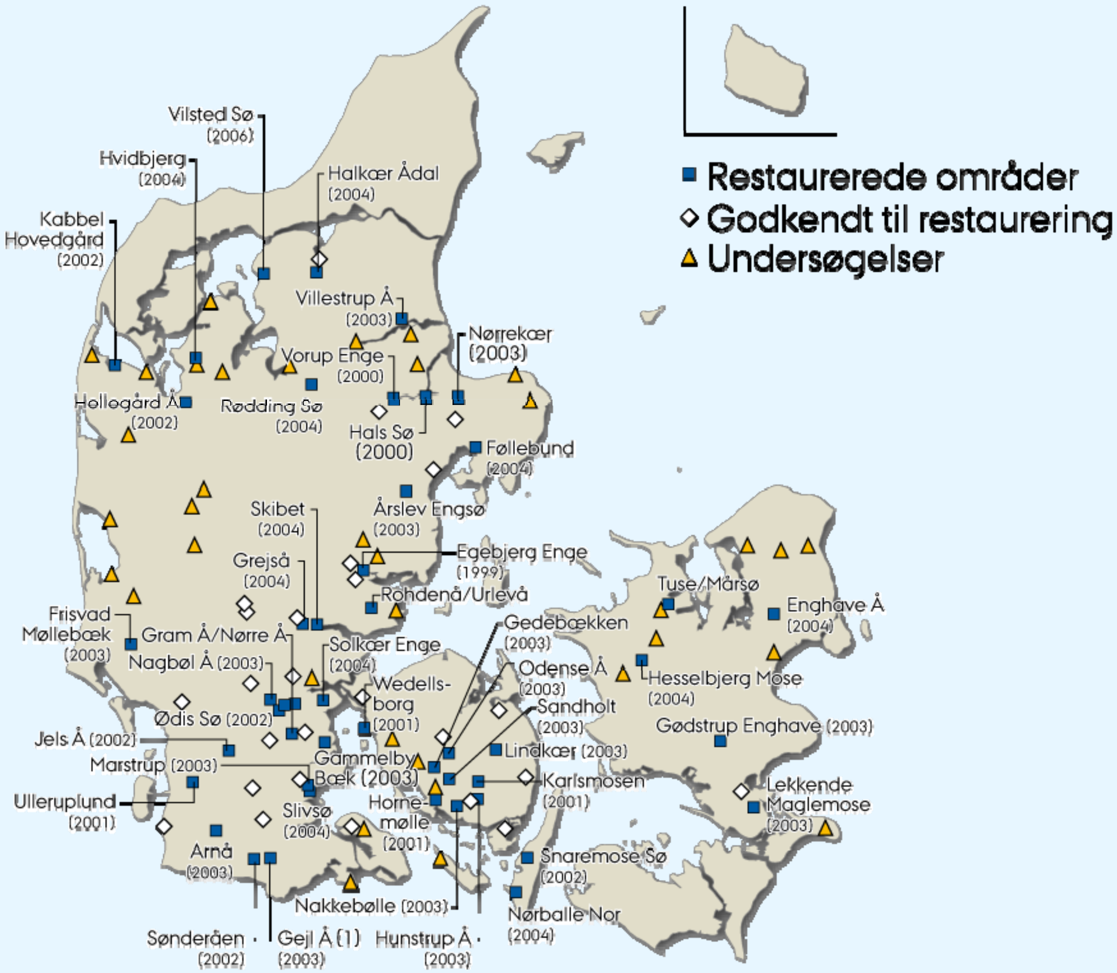
Slope



Adaptation tools – lake restoration

Adaptation tools – river restoration

Adaptation tools – wetland restoration



Thank you for your attention !