Seminar om klimatilpasning Oslo, 31. august 2005

Meteorologisk institutt
met.no

Institutt for geofag
Universitetet i Oslo

Bjerknes Centre
for Climate Research

NERSC
Nansen Senter for
Miljø og Fjernmåling

Geofysisk institutt
Universitetet i Bergen

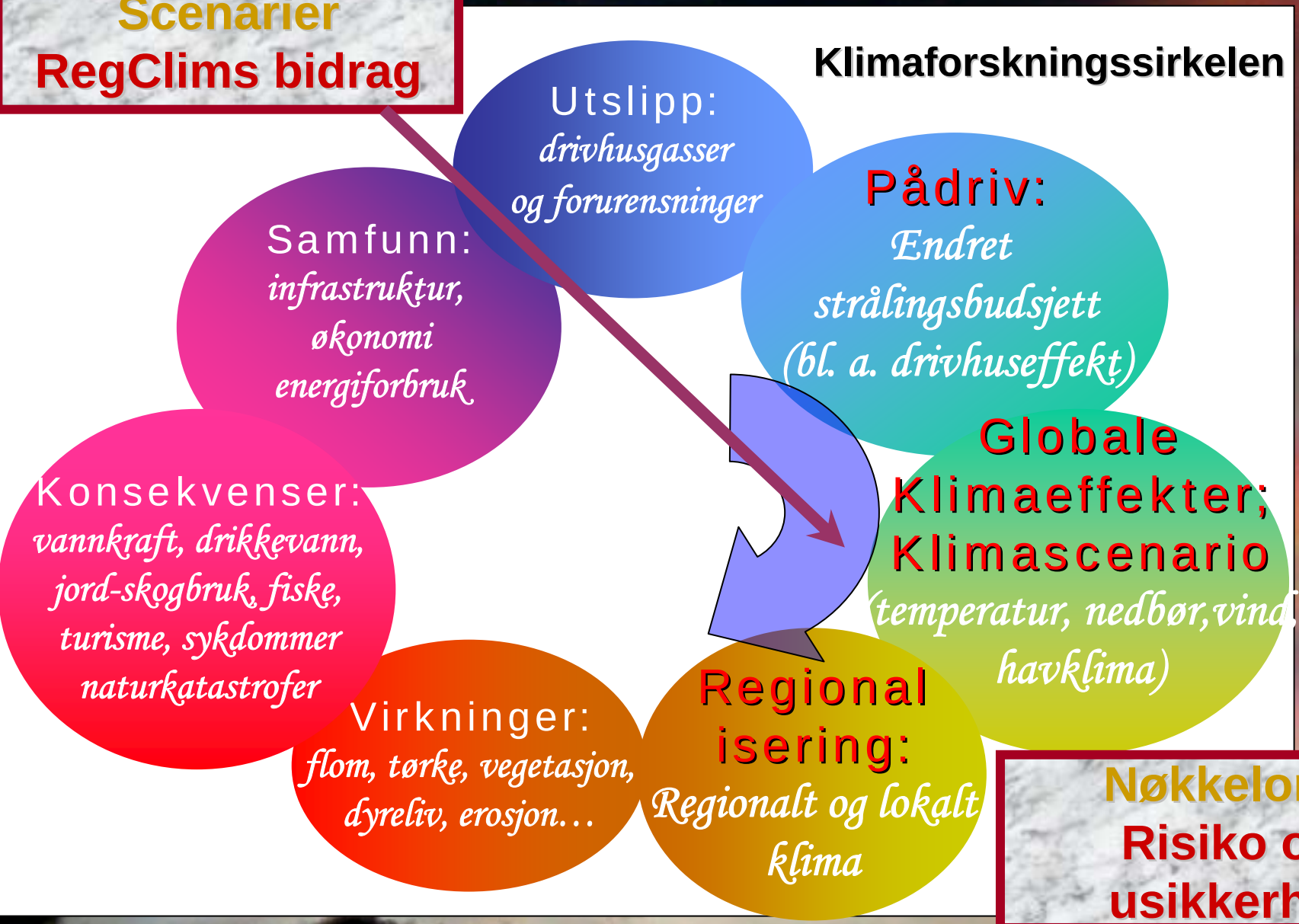
Havforskningsinstituttet

RegClim

Norges klima om 100 år
Usikkerheter og risiko

Trond Iversen
MetOs-UiO og met.no

Scenarier
RegClims bidrag



Nøkkelord:
Risiko og usikkerhet

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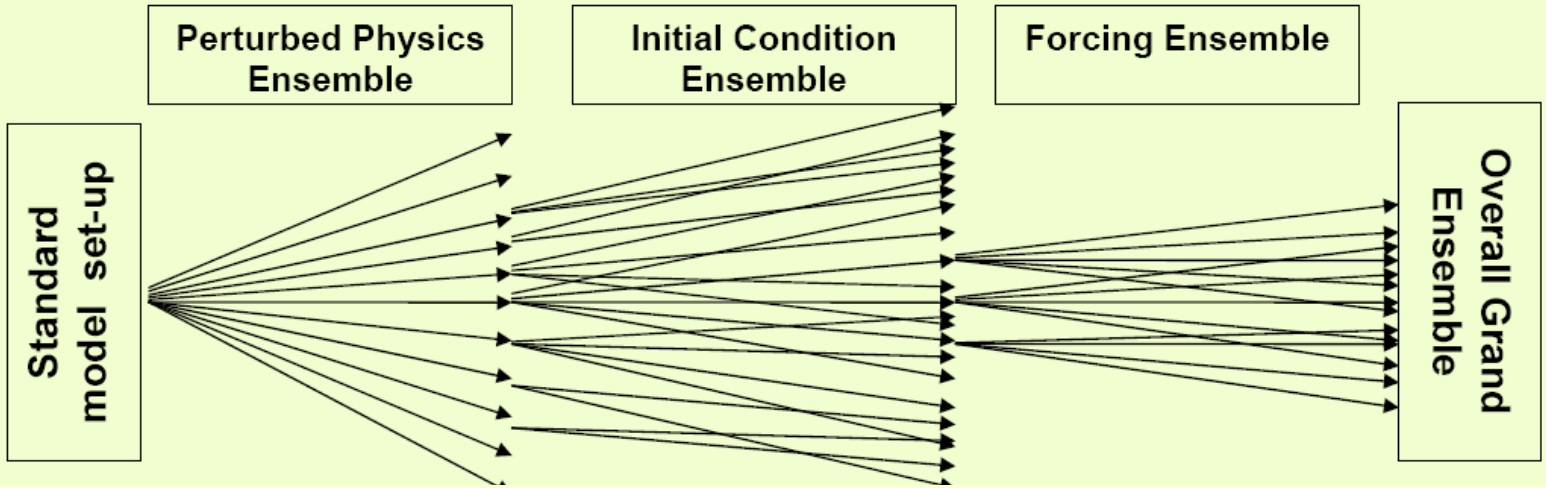
- Grand (nested) ensemble explores inter-dependence of the three main sources of uncertainty. Ref.: Myles Allen



Dekker modellusikkerhet tilfeldige variasjoner alternative utslippsscenarier

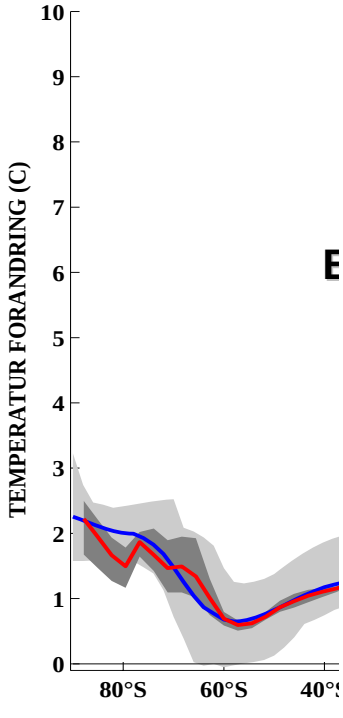
Risiko knyttes til usikkerhet

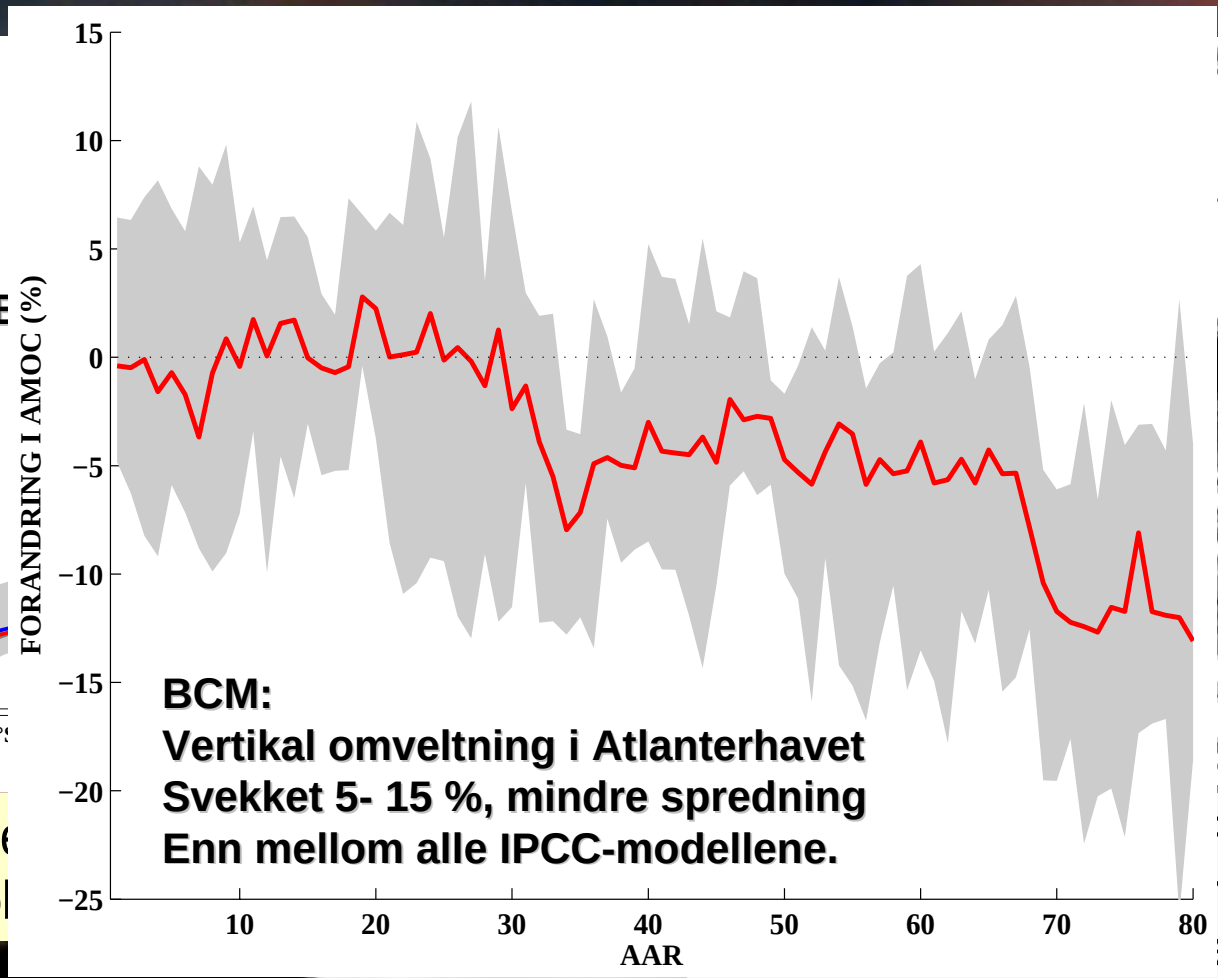
Usikkerhet gir mange mulige parameterverdier, og vi KAN ende opp med for store klimavariasjoner.

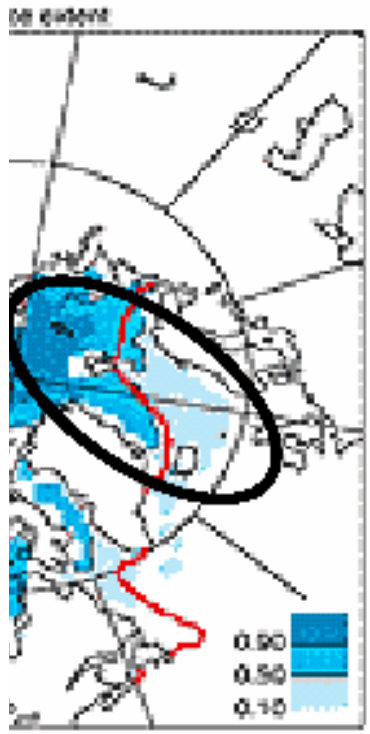
Dvs.: risiko for ekstremvær KAN bli overdrevet.

Særlig for å beregne risiko for ekstremvær må vår viten om nøkkelprosessene bli sikrere – og modellene nøyaktigere.

Store klimaendringer men også spesielt stor usikkerhet i klimamodellene nord for 60 grader N.







CMIP2: Tempe
forhold til glo

F) i dagens klima:
rd-Atlanteren;
egging helt ned til
60 grader N.

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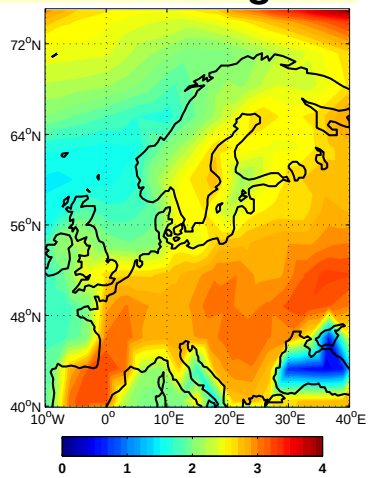
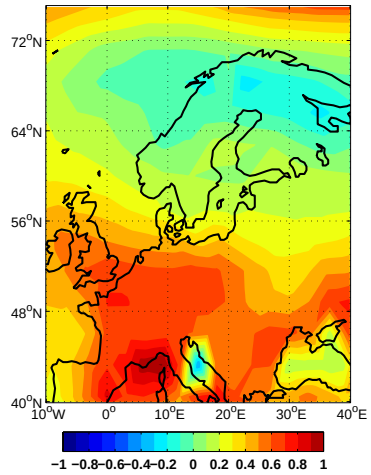
BCM: Regionale klimaendringer v. 2xCO_2 og vertikal omveltning i N.-Atl.

Tilfelle med Max ΔT_{reg}

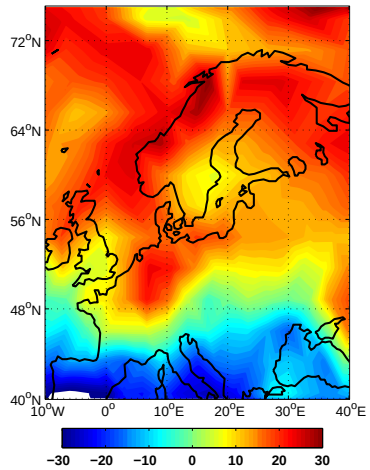
Spredning relatert til AMOC

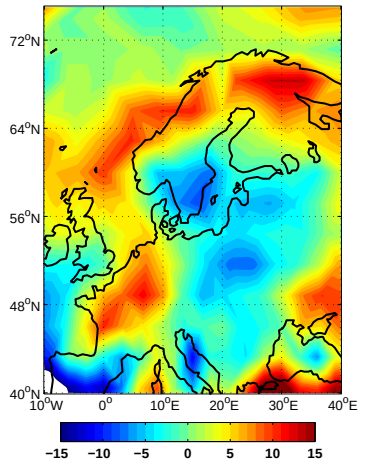
ΔT °C





ΔP %





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Science, 1. juli 2005: Aerosoler og skyer er listet blant de 25 viktigste vitenskapelige utfordringene for de neste 20.

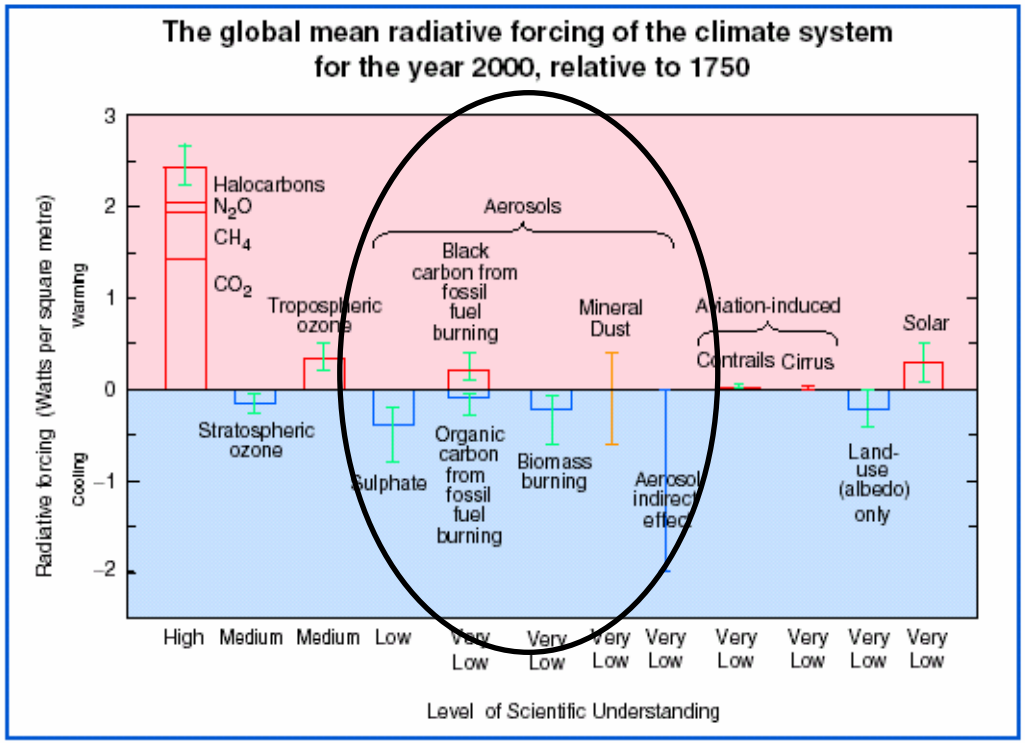
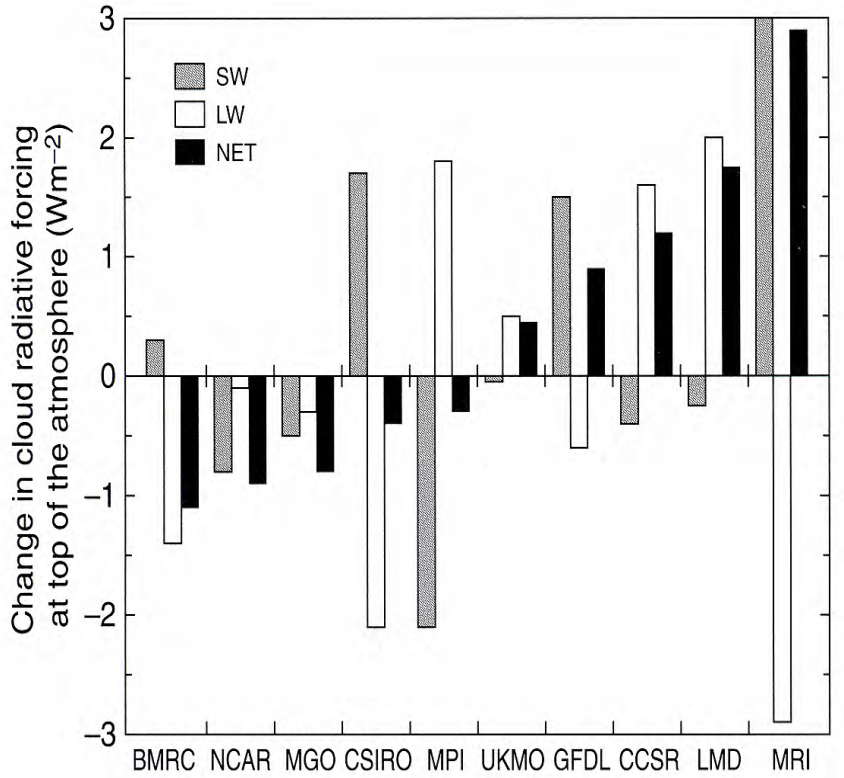


Figure 3: Many external factors force climate change.



Det knyttes store usikkerheter til aerosoler, og særlig til deres indirekte effekt via skyer.

Stor usikkerhet I hvordan skyer vekselvirker med stråling.

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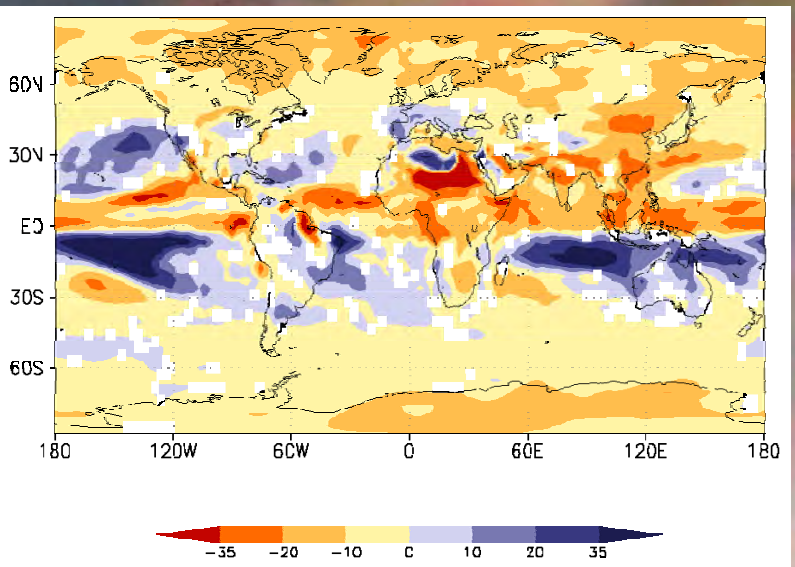
CCM-Oslo:

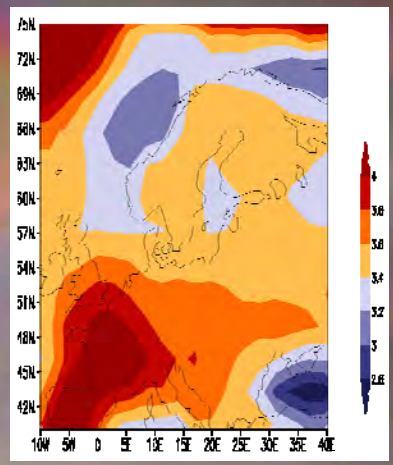
Effekter av antropogene aerosoler på klima

Kombinert respons pga. 2xCO2 og antrop. aerosoler

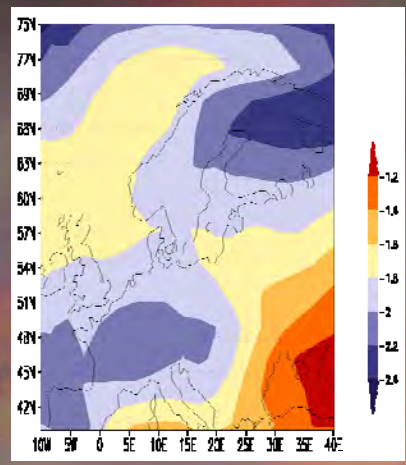
Bidrag fra antrop. aerosoler

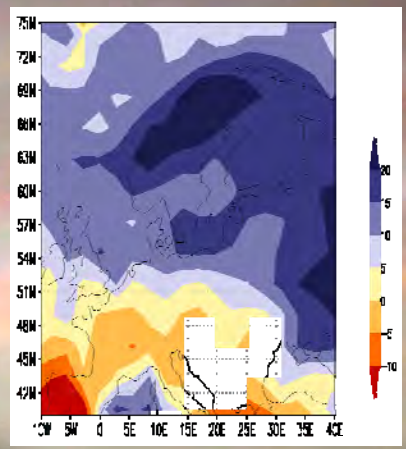


Nedbørrespons i %
pga. antropogene aerosoler

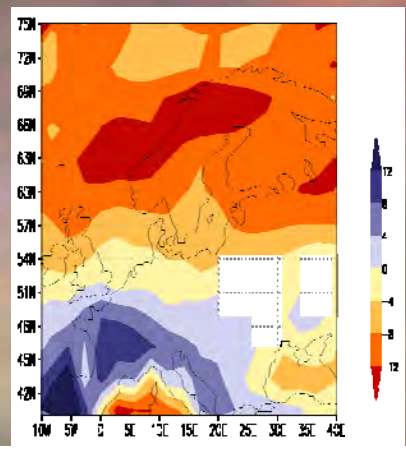


ΔT
°C





ΔP
%



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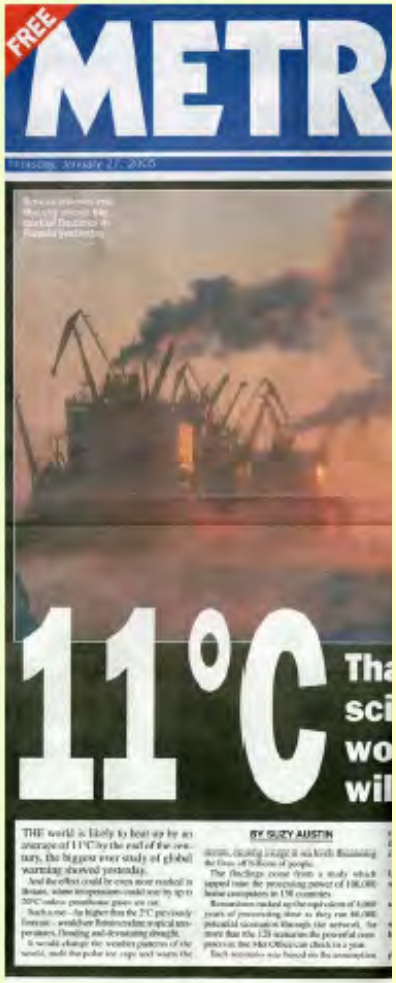
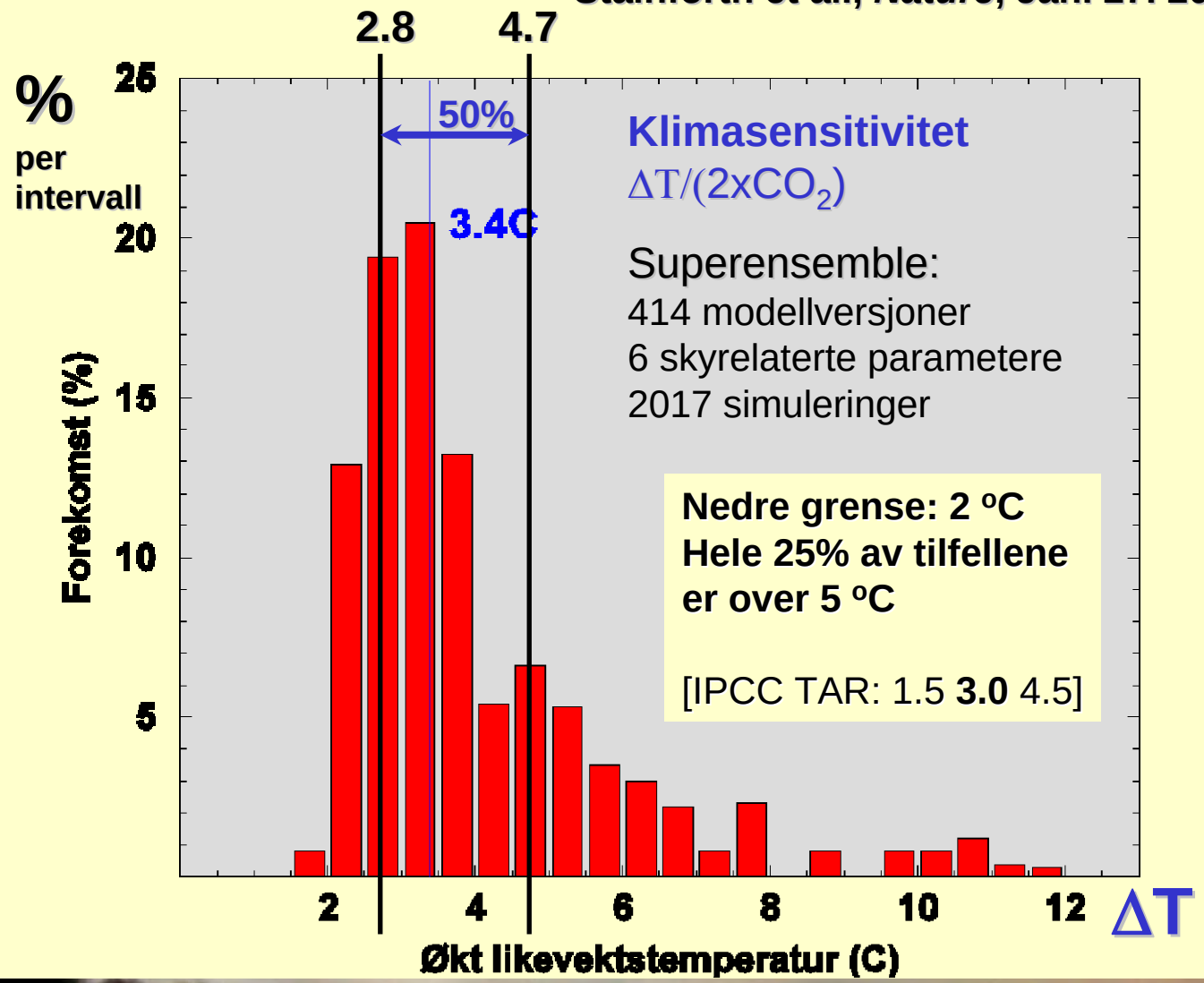
Still some v



climate*prediction*.net

Stainforth et al., *Nature*, Jan. 27. 2005



Klimasensitivitet

$\Delta T/(2xCO_2)$

Superensemble:
414 modellversjoner
6 skyrelaterte parametere
2017 simuleringer

Nedre grense: 2 ºC
Hele 25% av tilfellene er over 5 ºC

[IPCC TAR: 1.5 **3.0** 4.5]

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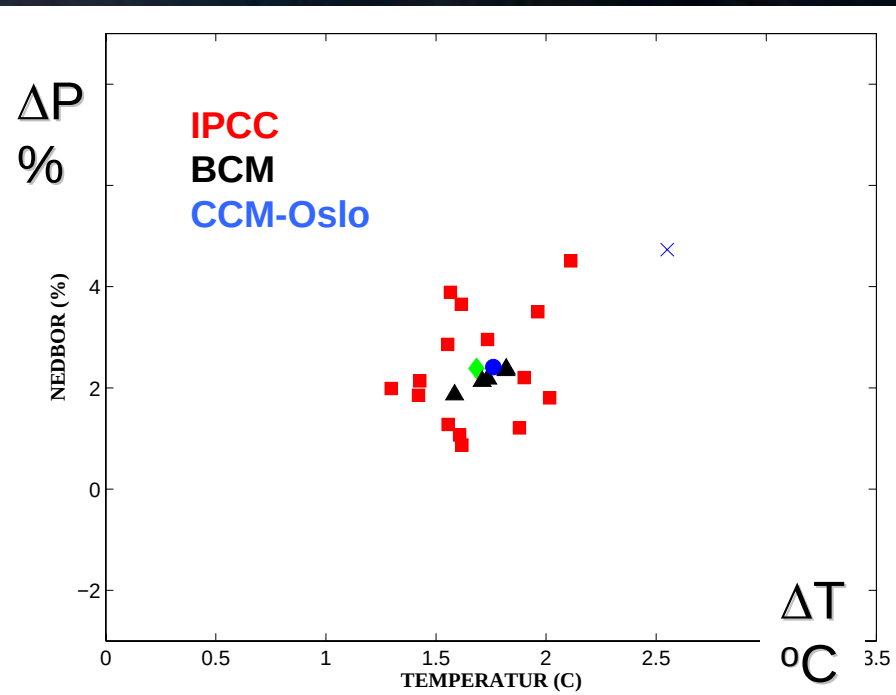
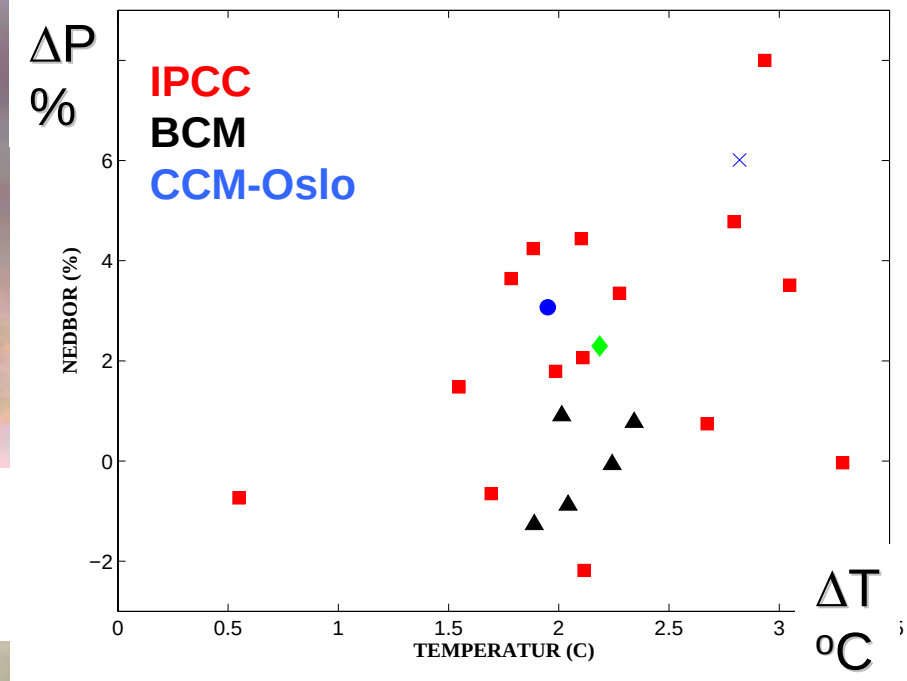


Global transient klimarespons



Regional transient klimarespons

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Regional betydning?

Mulige klimaendringer i Norge basert på 25 nedskaleringer fra EU-prosjektet PRUDENCE og klimasensitivitet mellom 2.8 og 4.7ºC.

Temperaturstigning (ºC) fra perioden 1961-90 til perioden 2071-2100

	Hele året	vinter	vår	Sommer	Høst
Sør- Norge	1.2 - 4.5	1.2 - 4.2	1.0 - 4.8	1.0 - 4.2	1.4 - 5.0
Nord- Norge	1.2 - 5.0	1.4 - 5.3	1.2 - 5.6	0.7 - 3.9	1.4 - 5.9

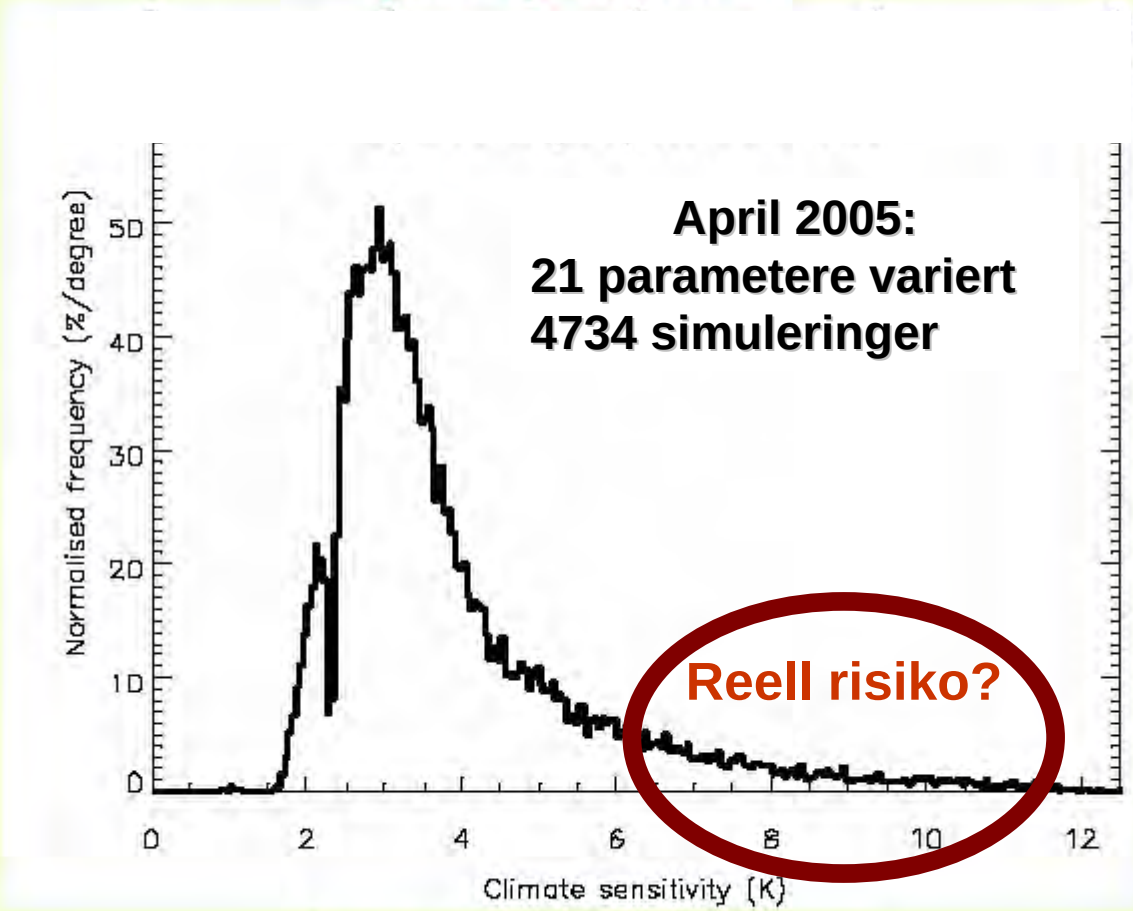
Nedbørøkning (%) fra perioden 1961-90 til perioden 2071-2100

	Hele året	vinter	vår	Sommer	høst
Sør-Norge	0.2 - 19.6	2.0 - 35.6	1.4 - 33.0	-13.4 - 9.0	-1.2 - 23.2
Nord- Norge	-7.0 - 35.0	-19.9 - 32.2	-9.0 - 54.0	3.9 - 24.9	-4.1 - 41.7

Svært stor spredning:

- RegClims scenarier dekker **ikke** hele denne bredden?
- Hva er reelle klimavariasjoner og hva er modellfeil?
- Er enda større klimasensitivitet en realistisk mulighet?

Still they come: 47334 simulations passing initial quality control

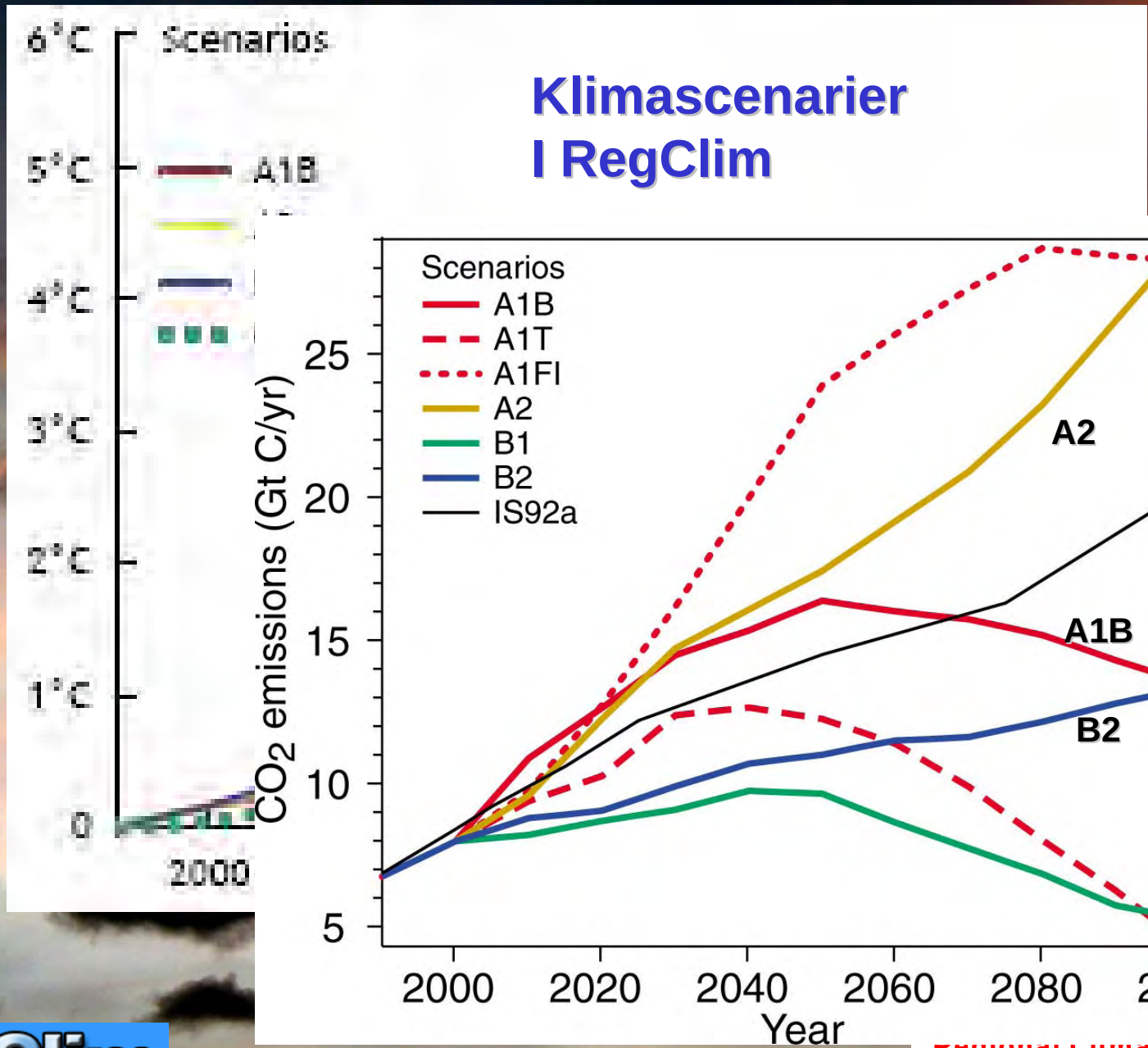


Courtesy of Ben Sanderson

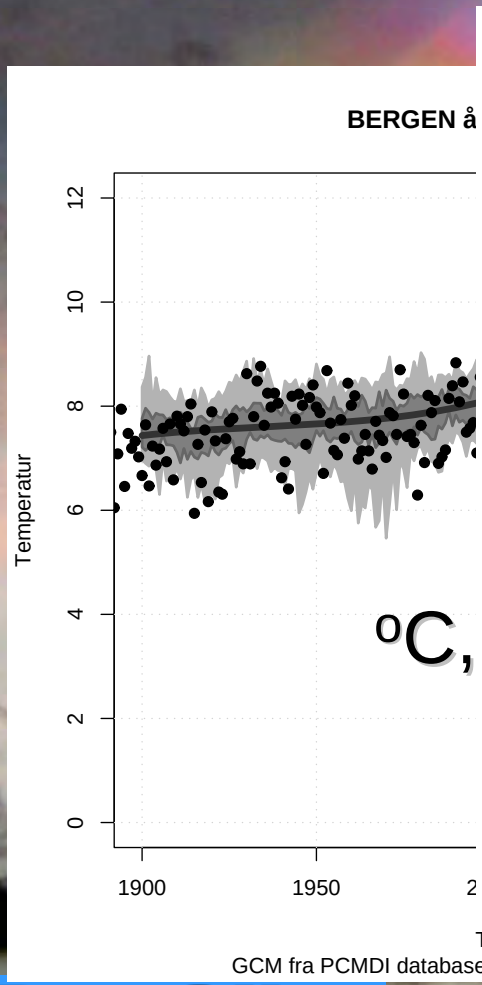
climateprediction.net

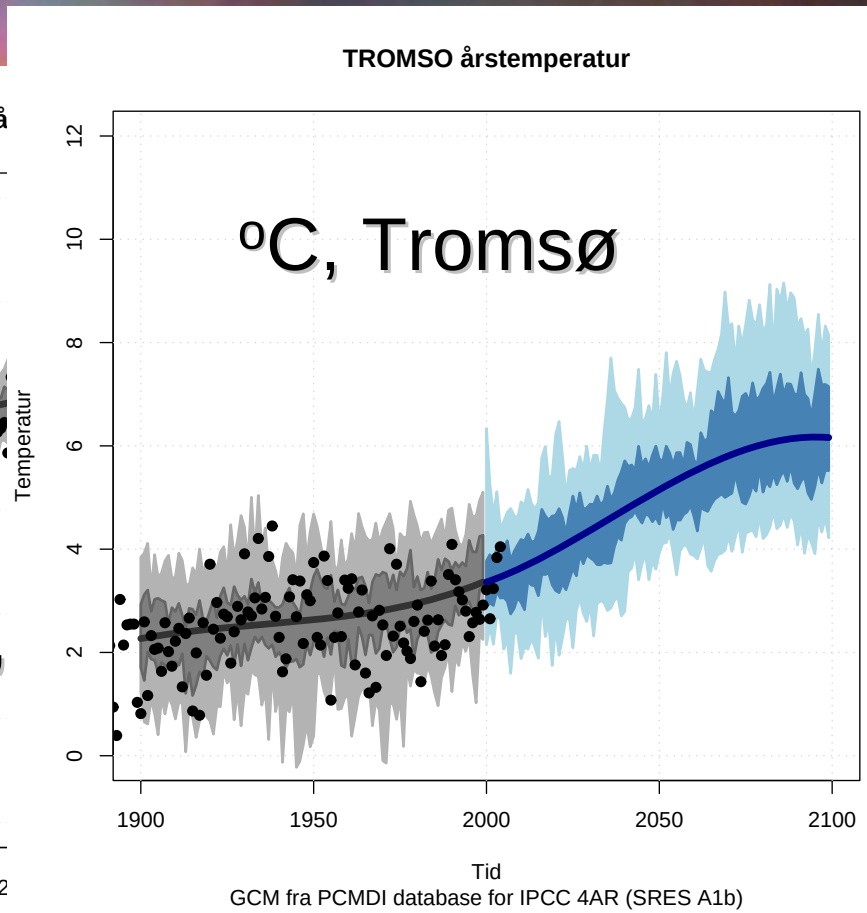
Oxford University

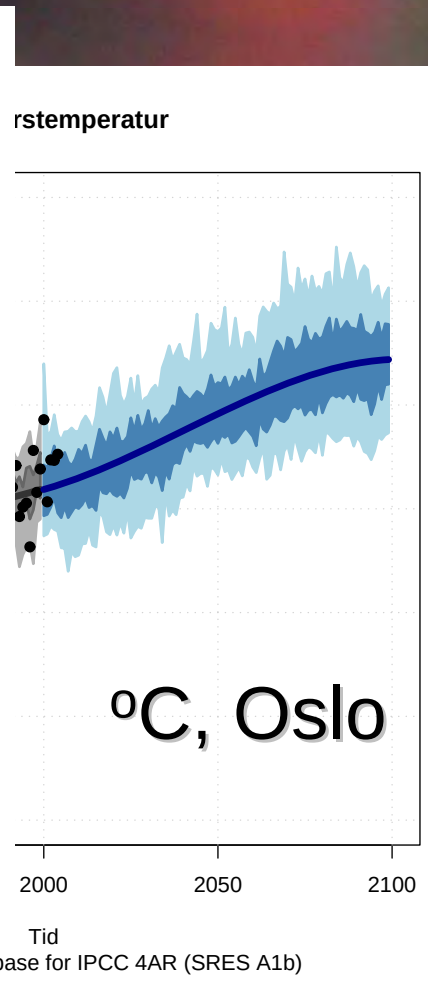
Klimascenarier I RegClim



Empirisk nedskalerte beregninger med SRES A1B for IPCC AR4: 11 modeller, 23 beregninger.







Globale scenario-data for dynamisk nedskalering med HIRHAM-modellen (0.5 grader 19 lag)

- **Simulering HAD**:

  Hadley Centre HadAM3H
  1.875x1.125 grader

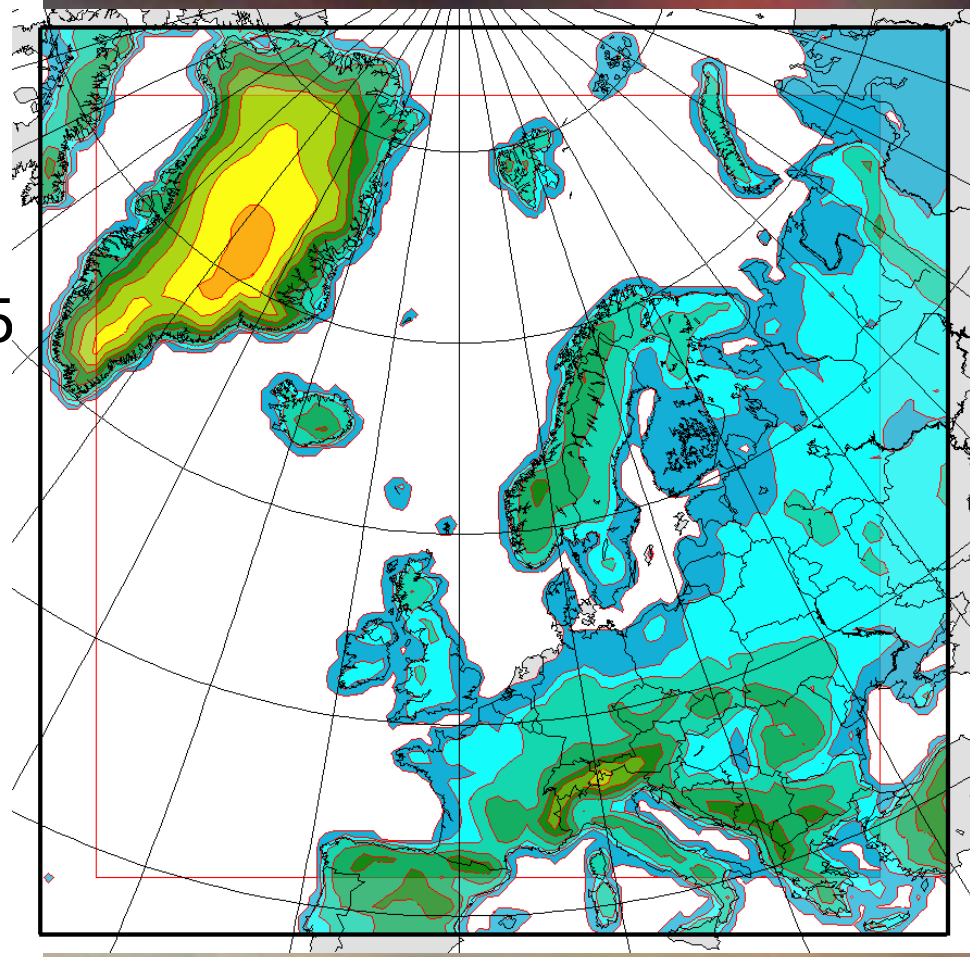
- **Simulering MPI**:

  Max Planck Instituttet ECHAM5
  T106 (1.125 grader)

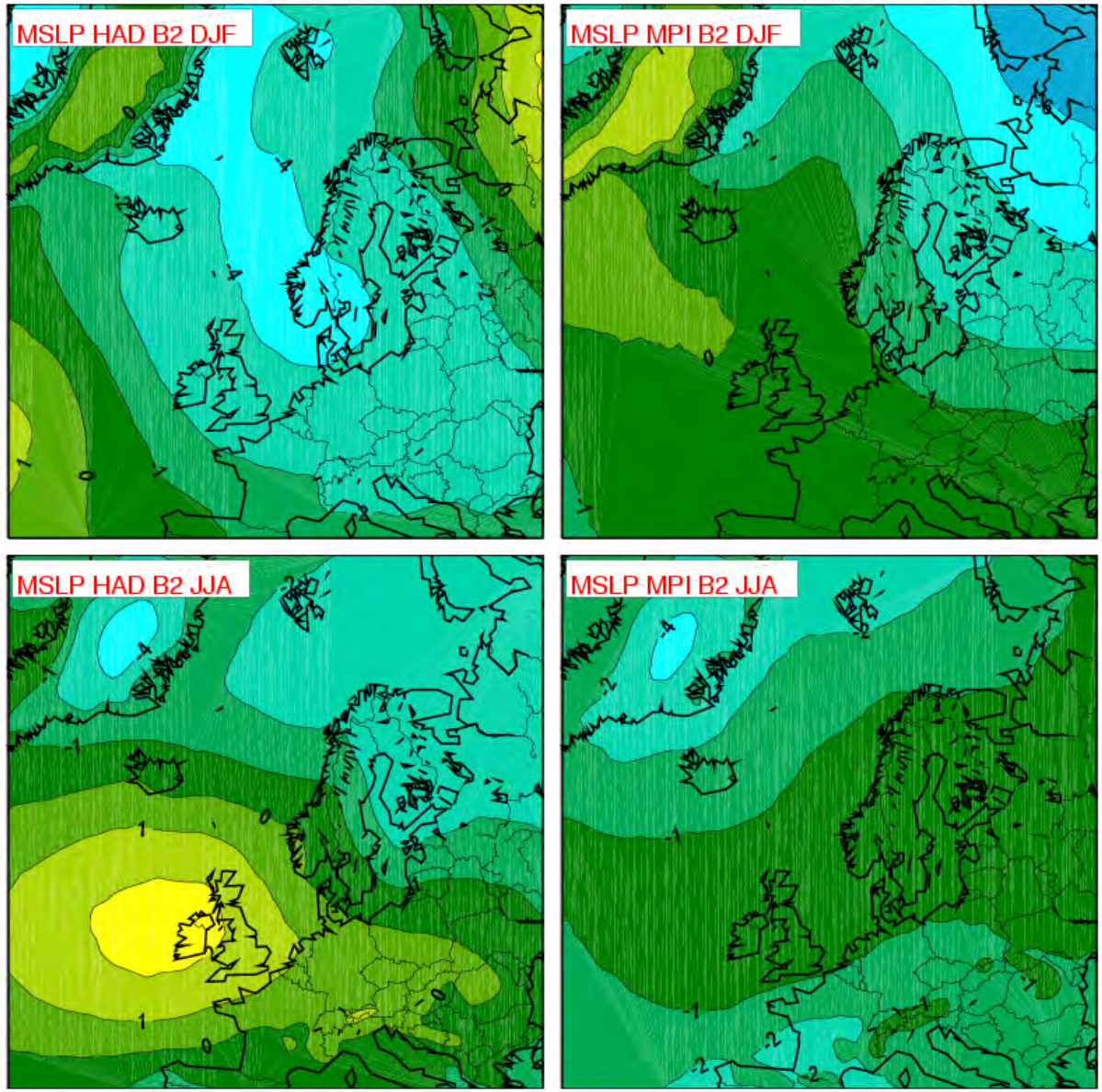
IPCC scenario SRES B2

1961-1990 og

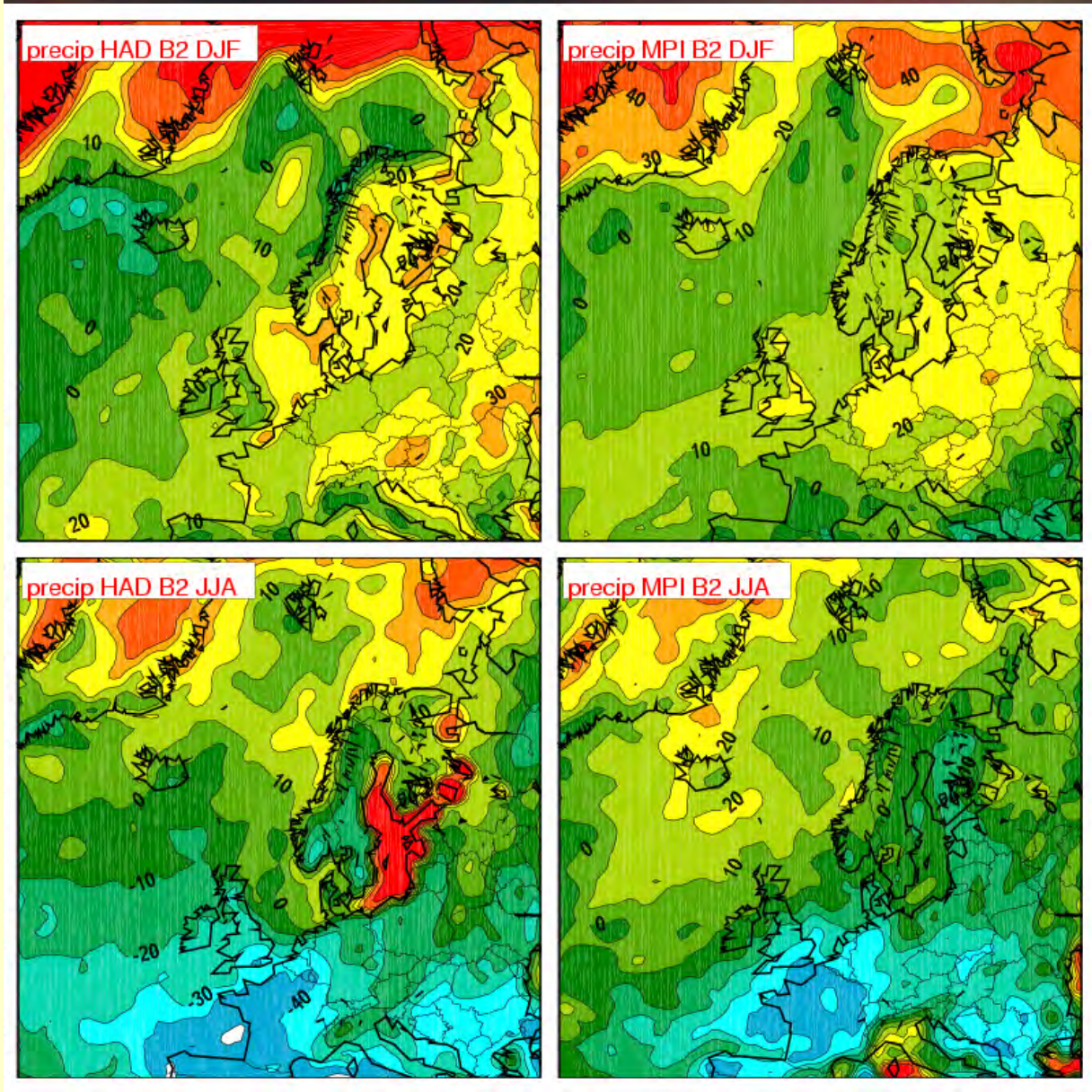
2071-2100



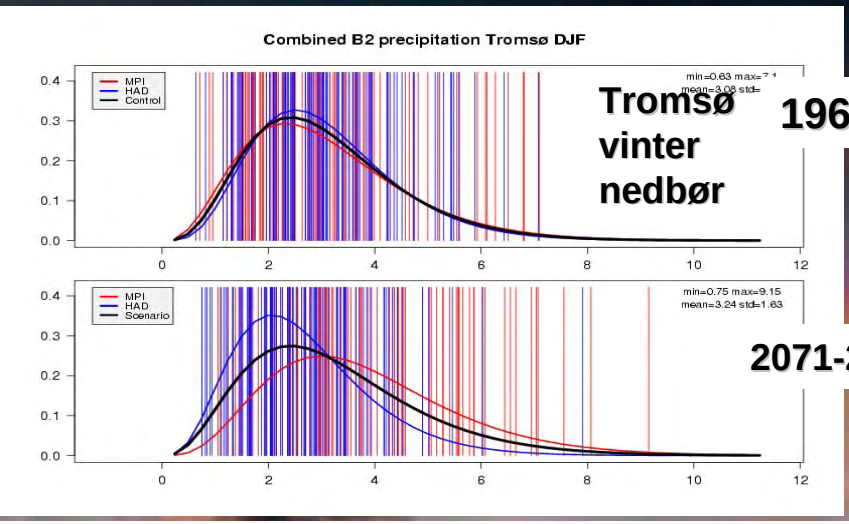
HIRHAM respons i bakketrykk B2

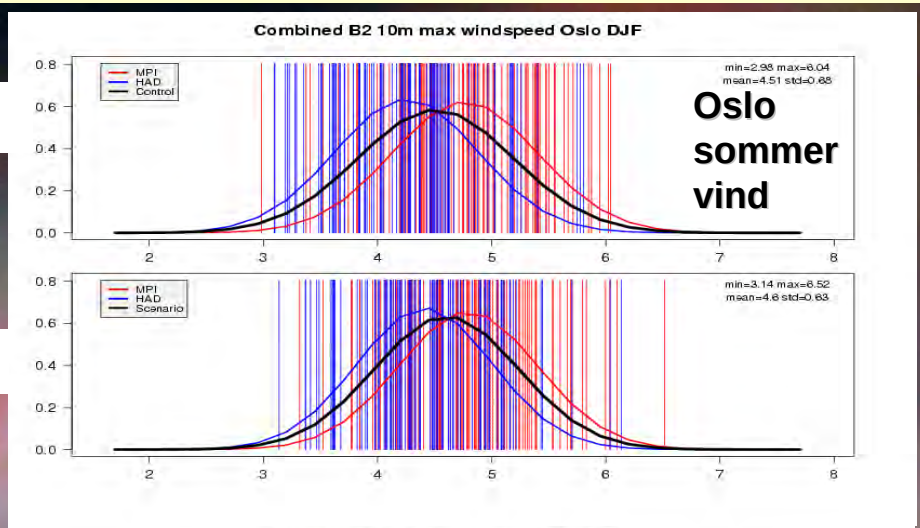


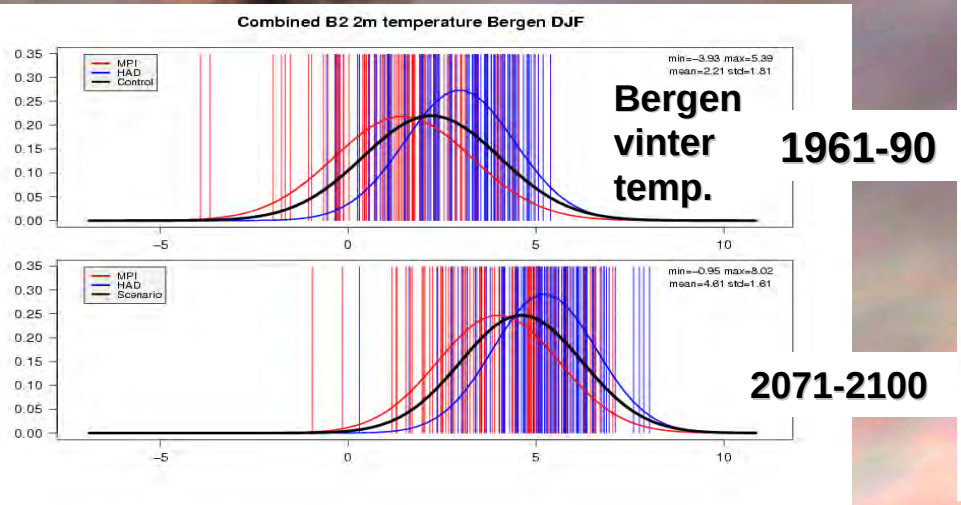
HIRHAM nedbørrespons B2

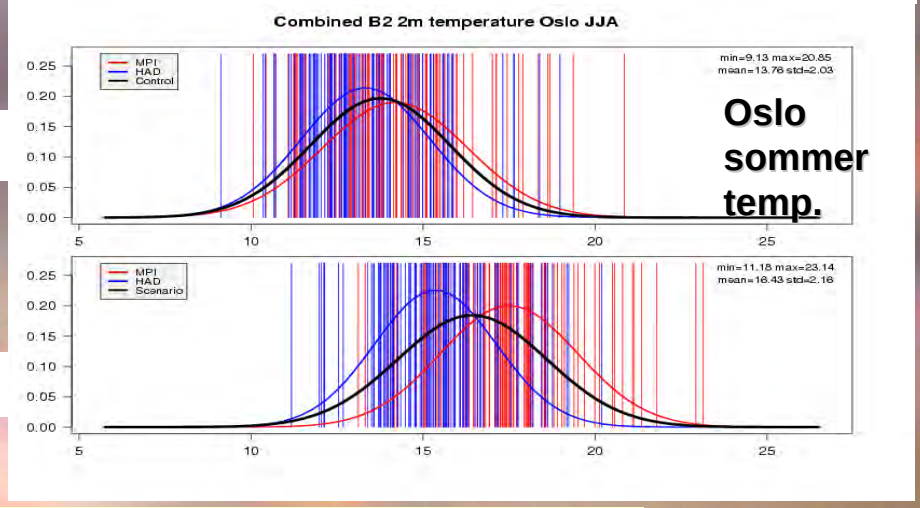


Eksempel på kombinert nedskallert statistikk: MPI and Hadley









Hvor mye av spriket er ukorrelerte modellfeil; hvor mye er reelle tilfeldige klimavariasjoner?

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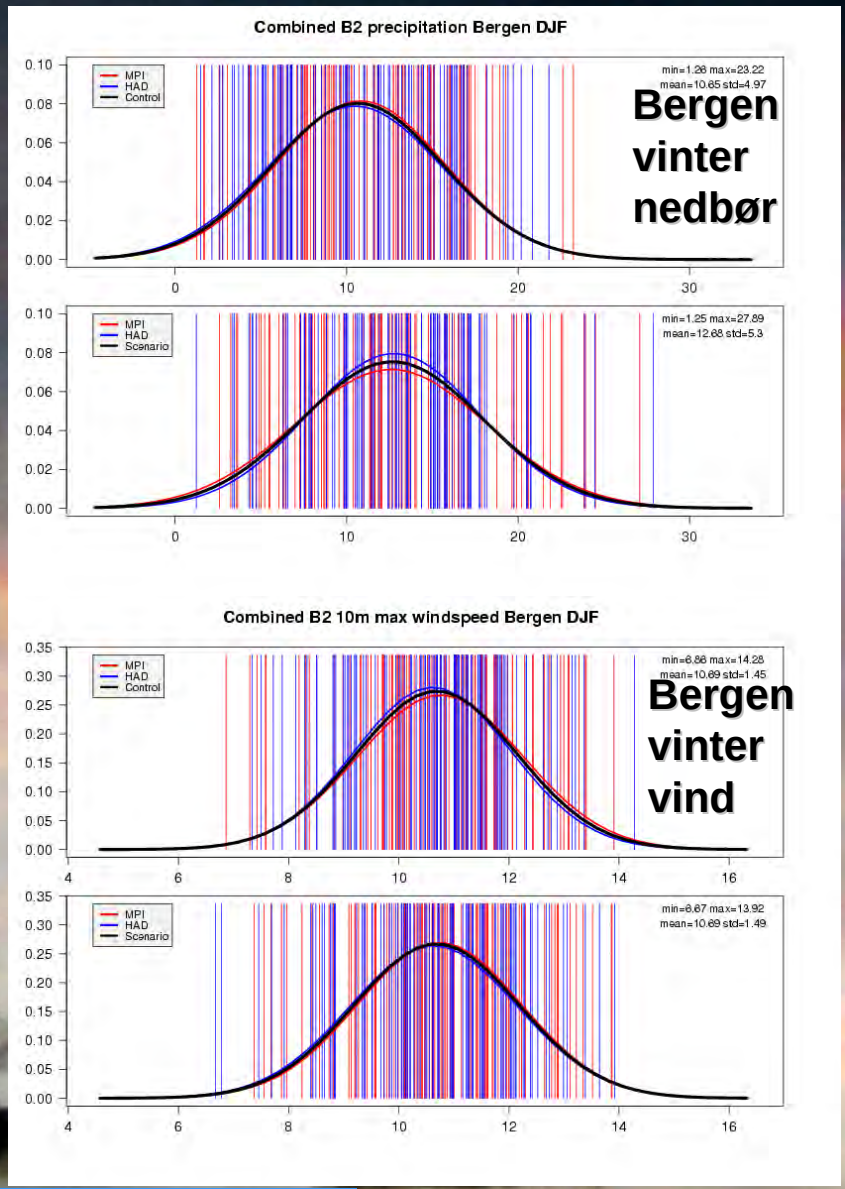
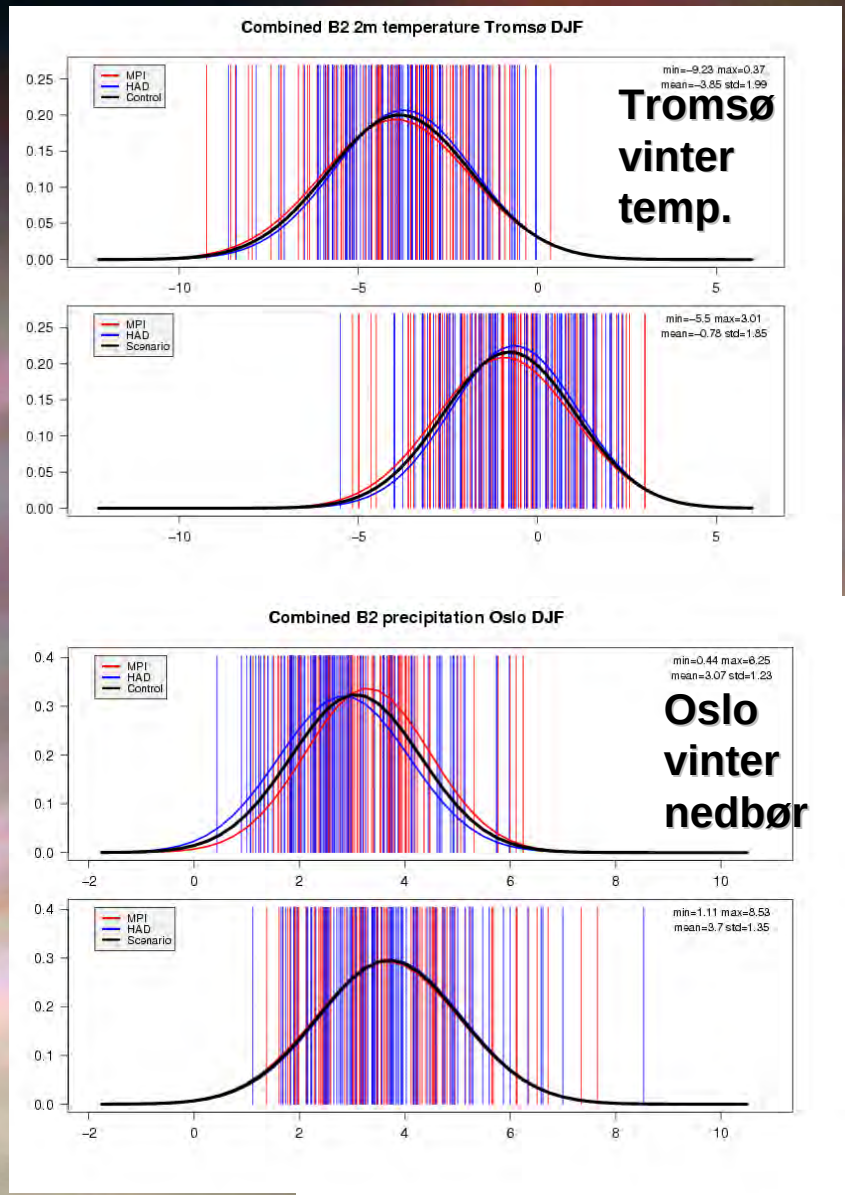
MPI and Hadley: NB: det er også overensstemmelser





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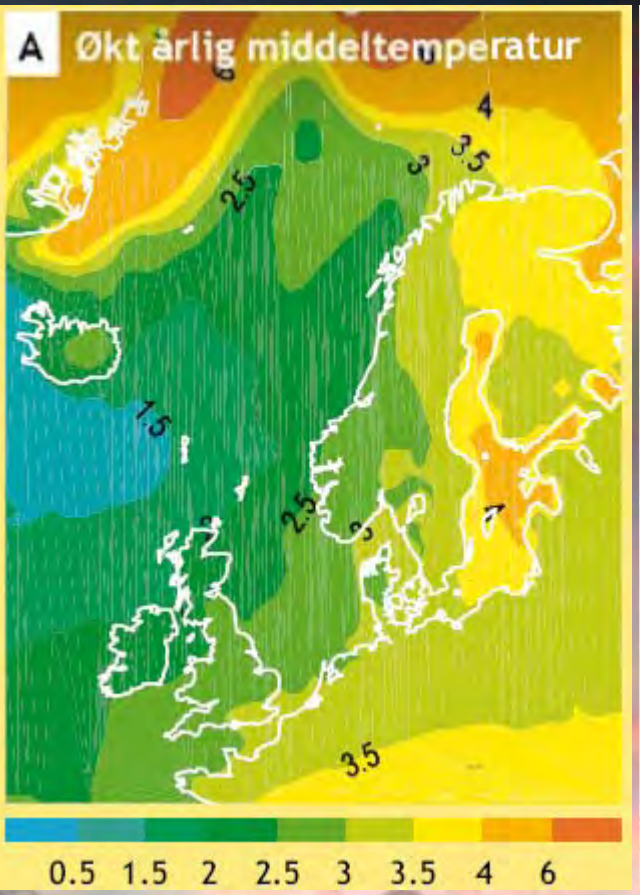
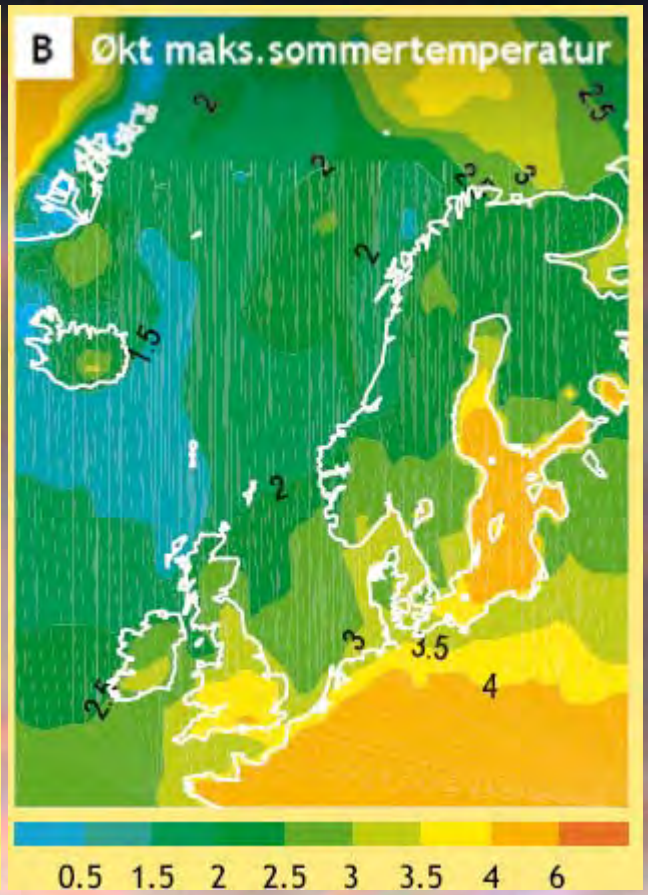
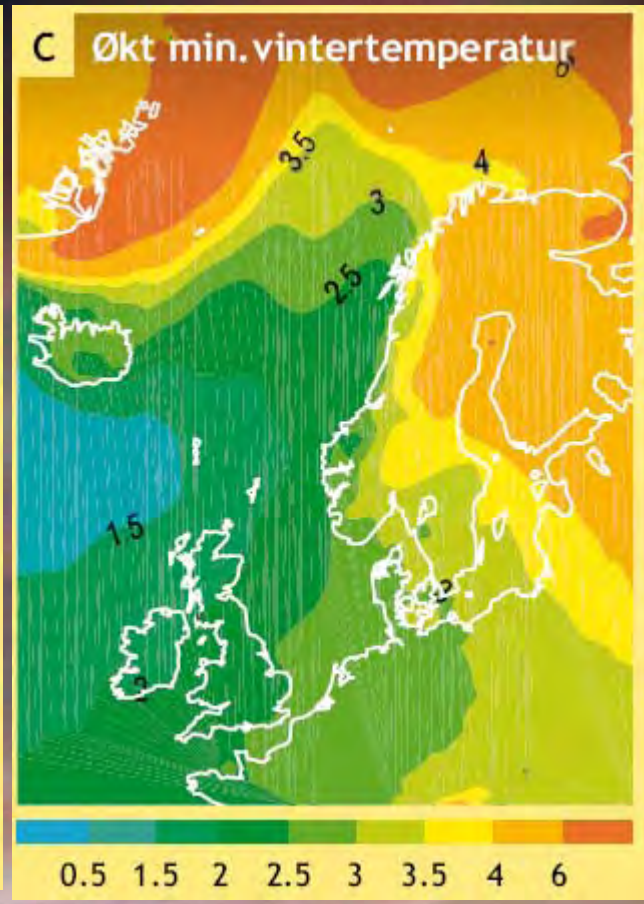
Temperaturstigning (ºC) | MPI og HAD kombinert – B2







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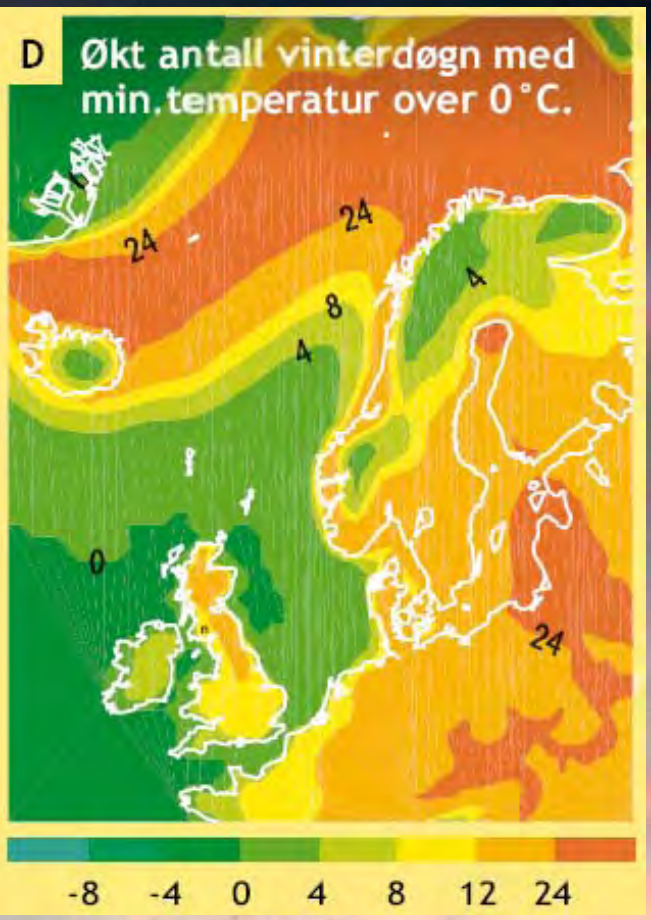
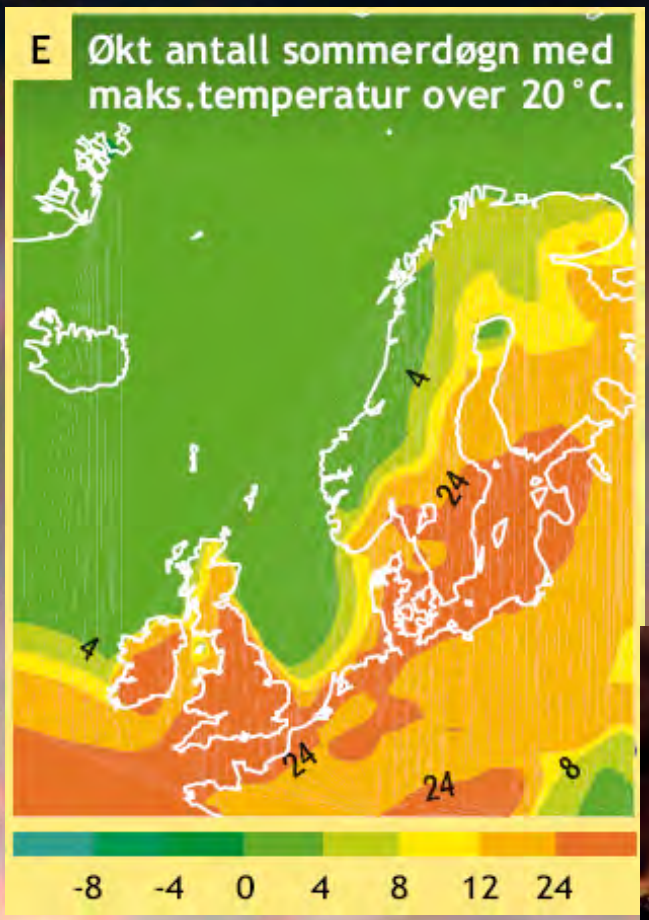
Milde vinterdager og varme sommerdager

MPI og HAD kombinert – B2





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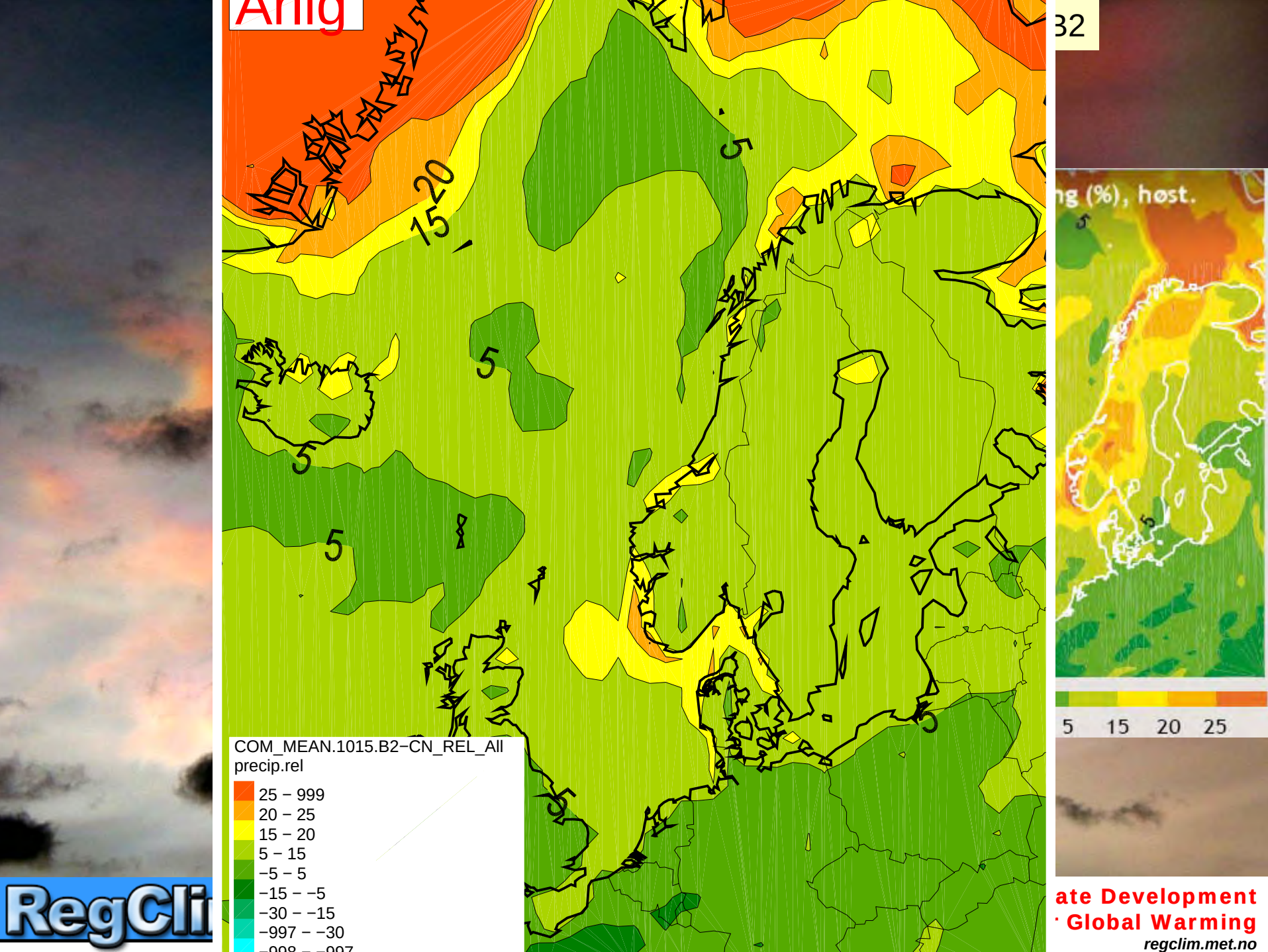
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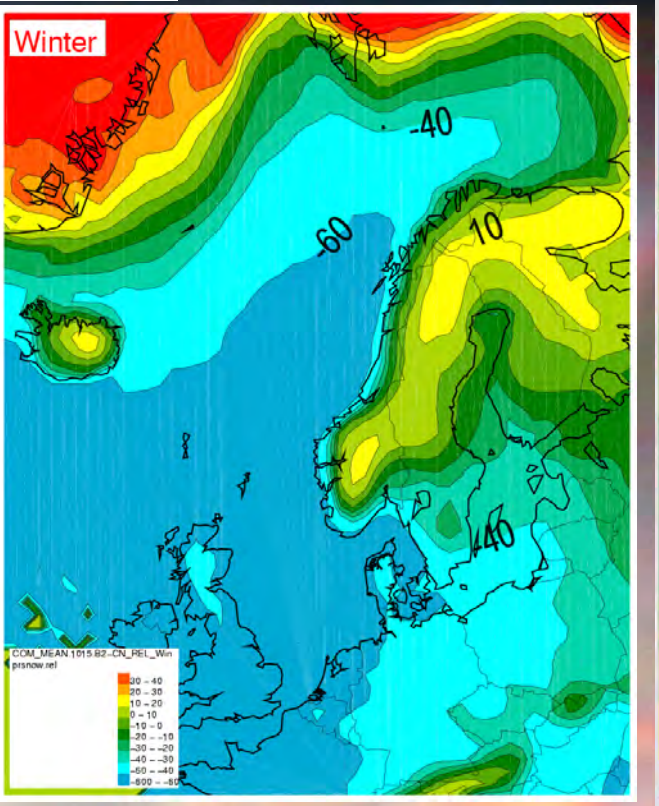
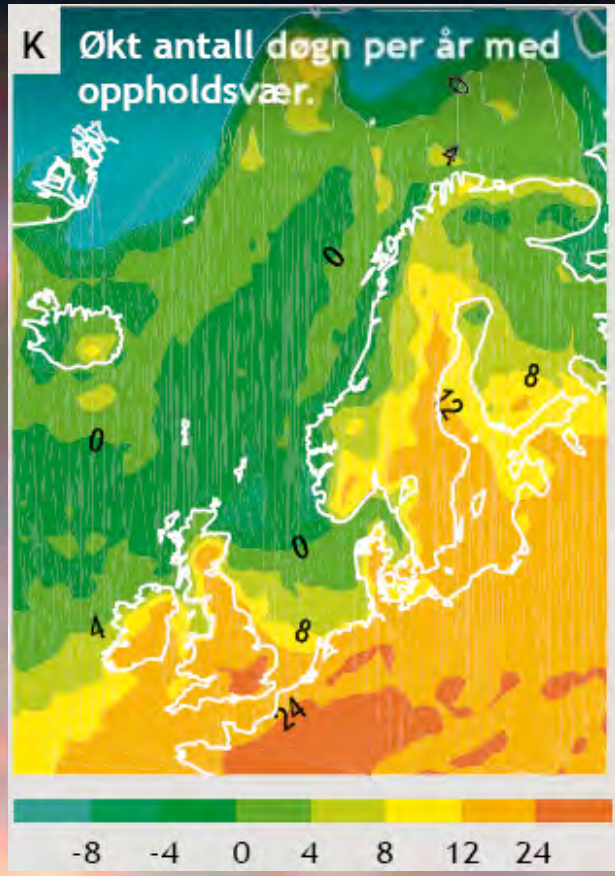
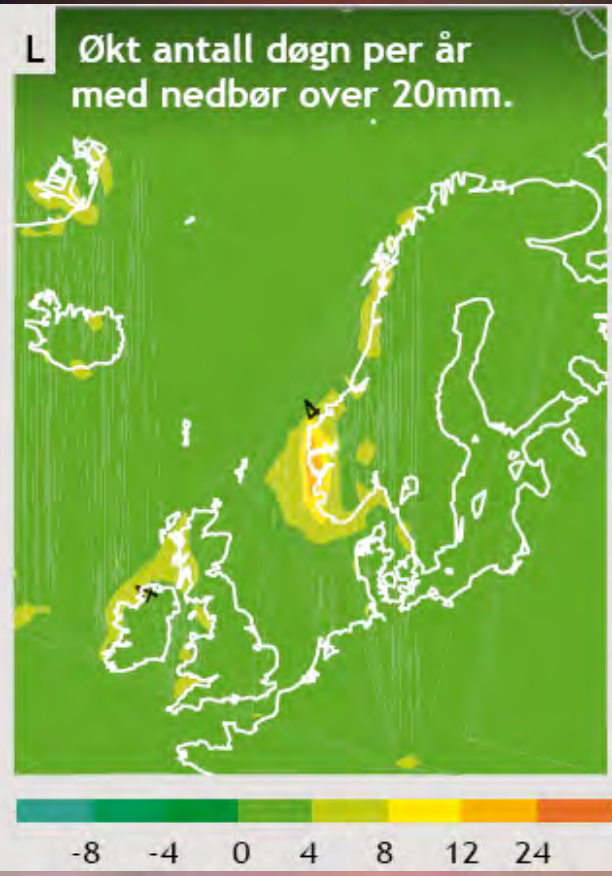
Snø, oppholdsvær, sterk nedbør

MPI og HAD kombinert – B2

SNØ %







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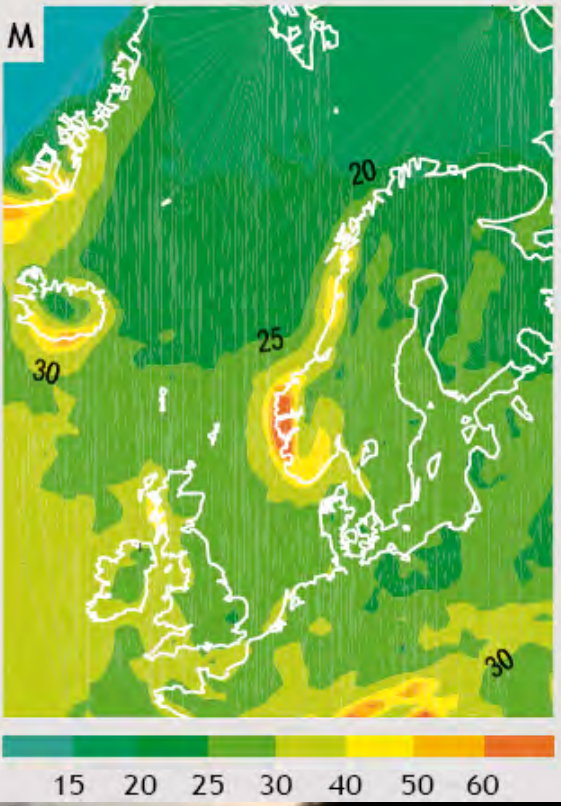
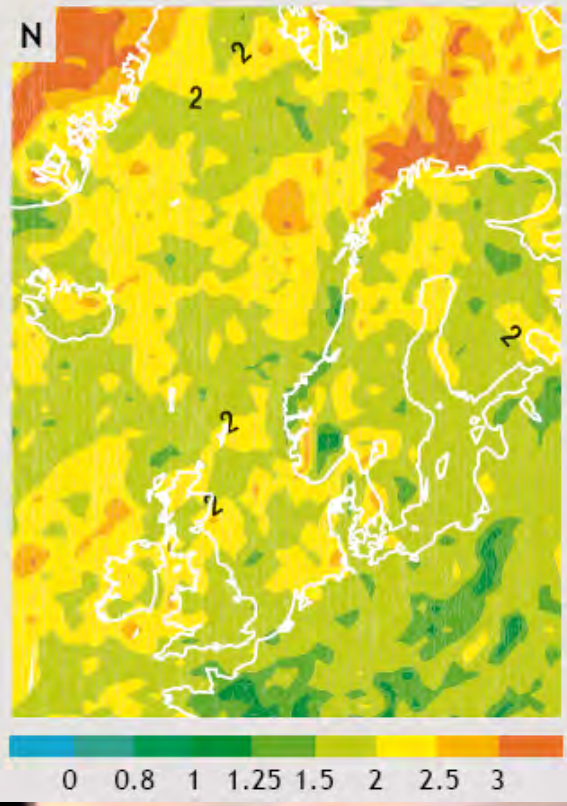
Økt retur av dagens årlige nedbørmaks. | MPI og HAD kombinert – B2

Årets maksimale
nedbørmengde
per døgn (mm) i 1961-90.



Antall ganger per år som nedbørmengdene
i figur 13M vil forekomme i 2071-2100.
Tall større enn 1 betyr at ekstremer blir mer vanlig.



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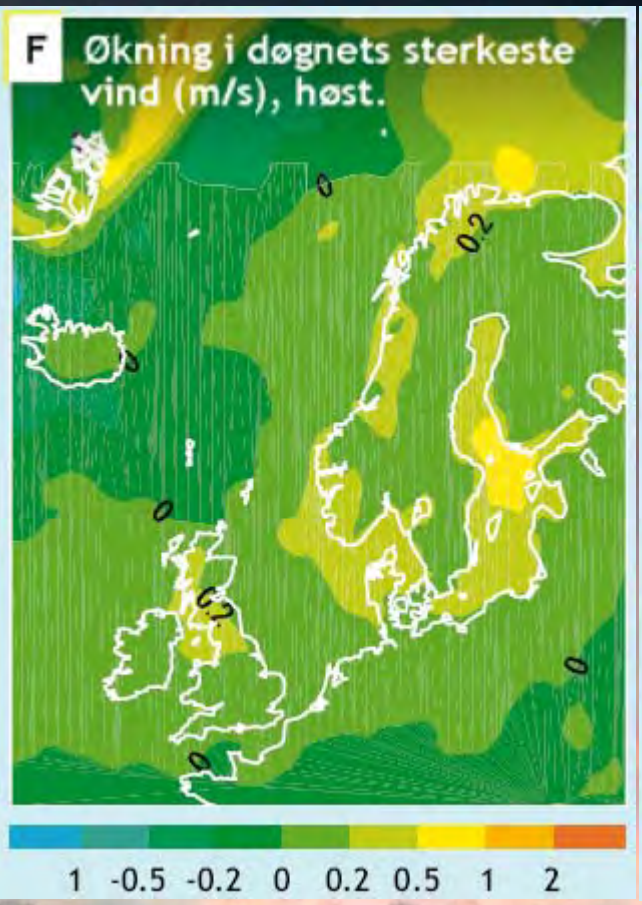
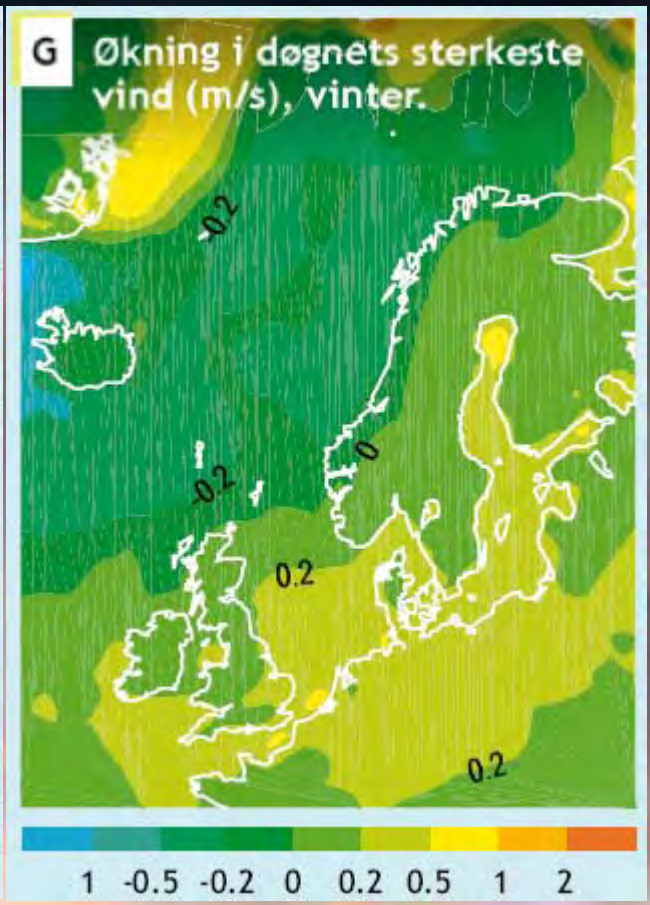
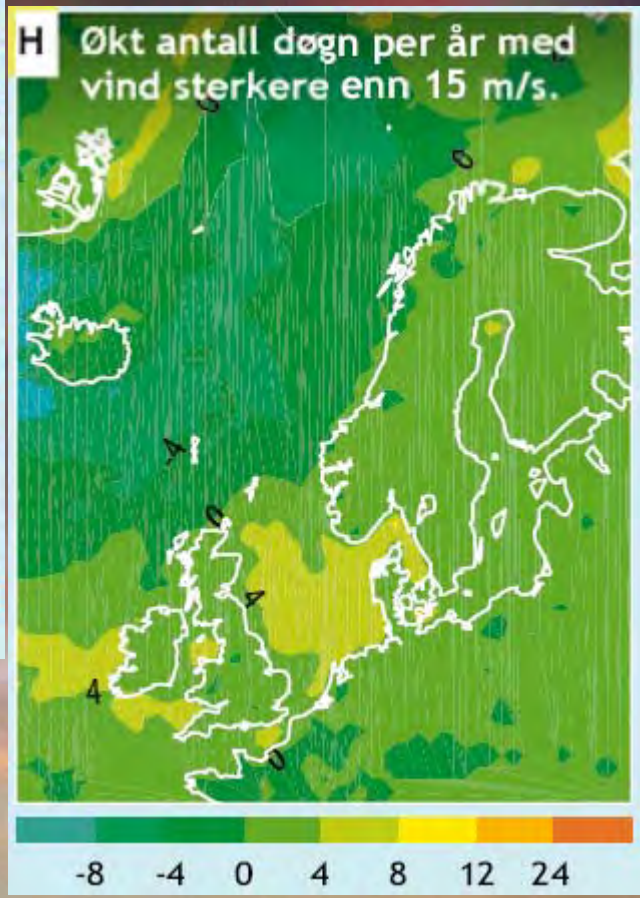
Økning av døgnets maks-vind (m/s) og Økt antall døgn per år over stiv til sterk kuling (15 m/s)

MPI og HAD kombinert – B2







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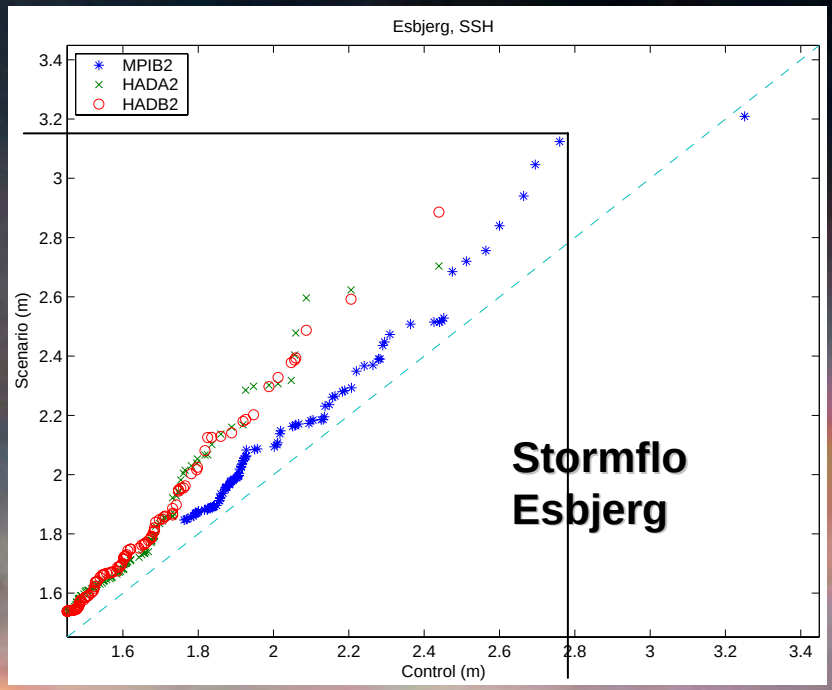

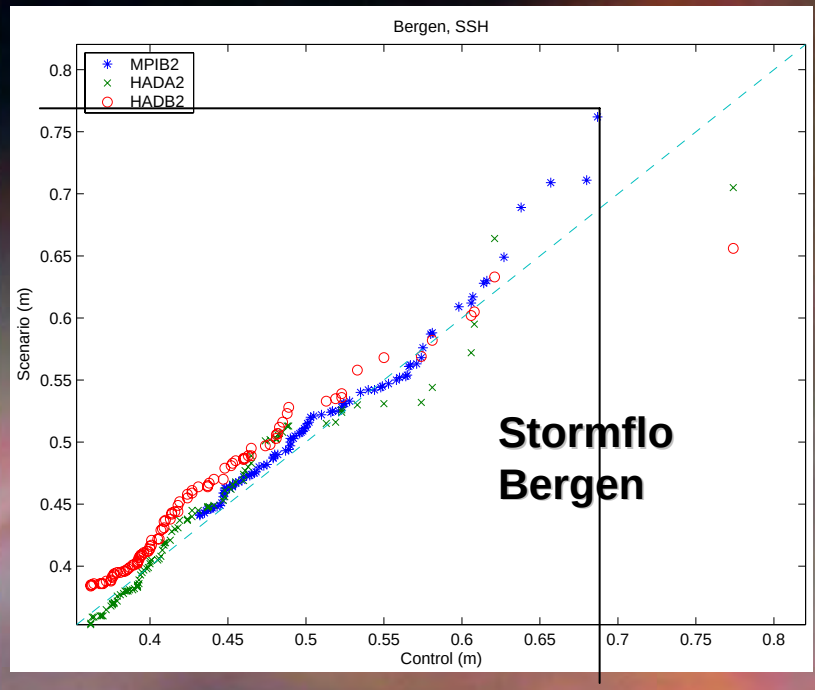

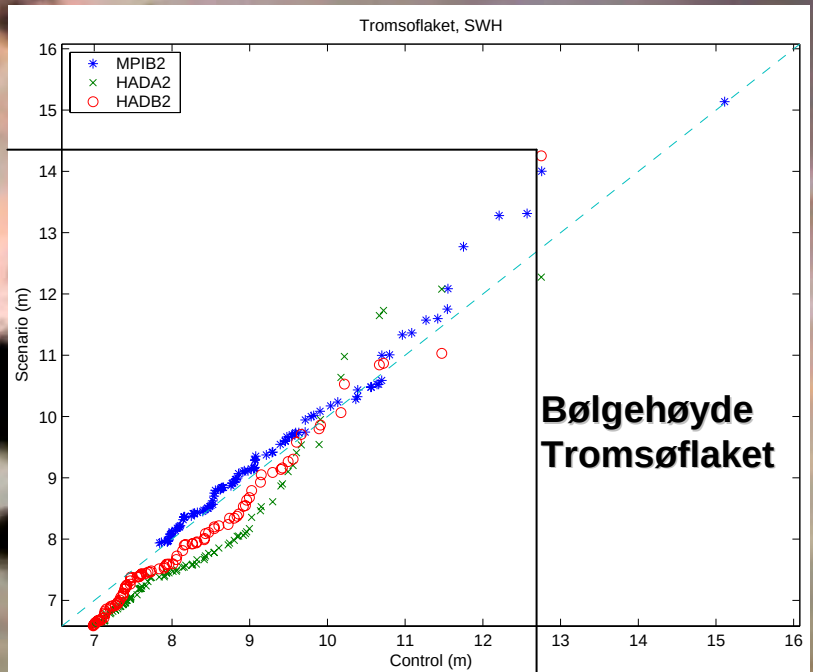

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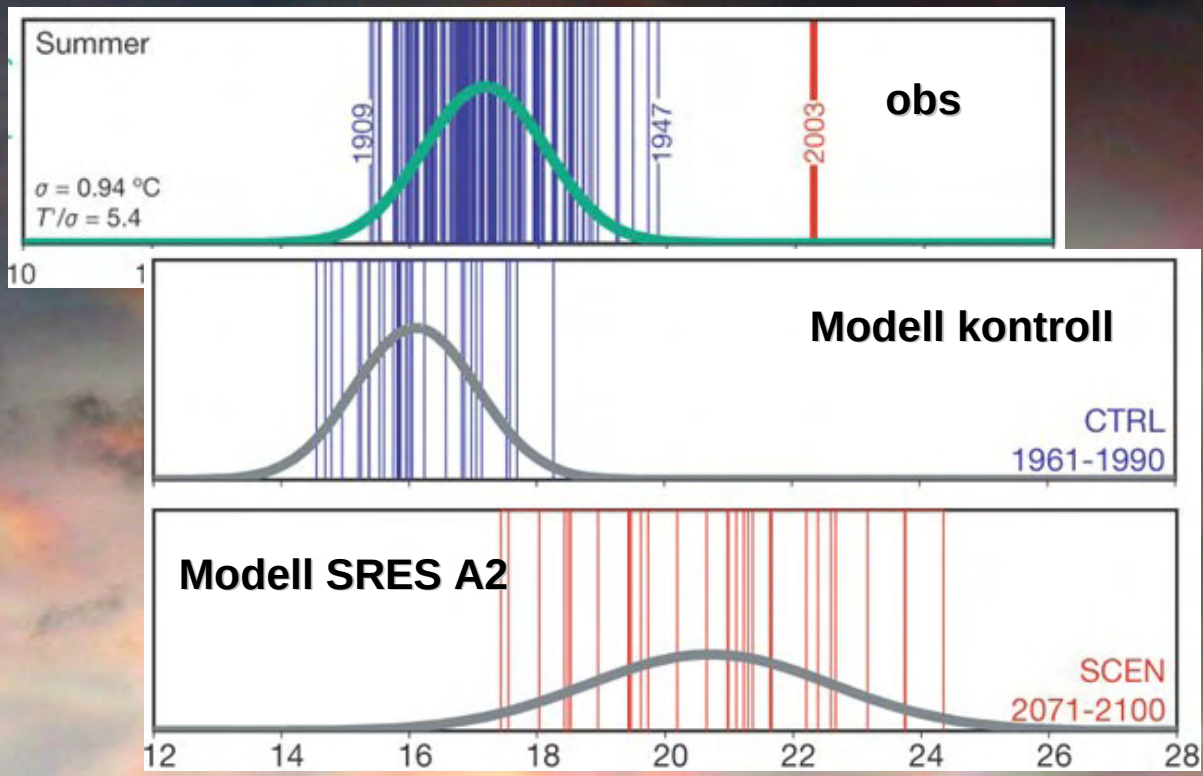
Har det vært noen ekstremer?

Hetebølgen 2003, Schär m.fl., Nature, 2003

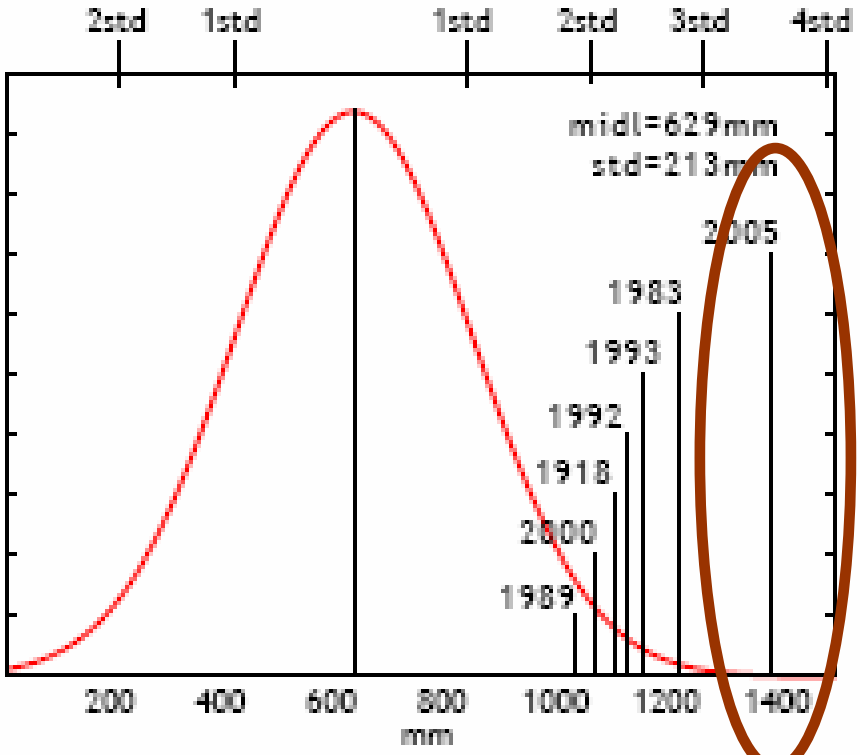


Bredere fordeling vel så viktig som økt i middelverdi

Sommer 2003:

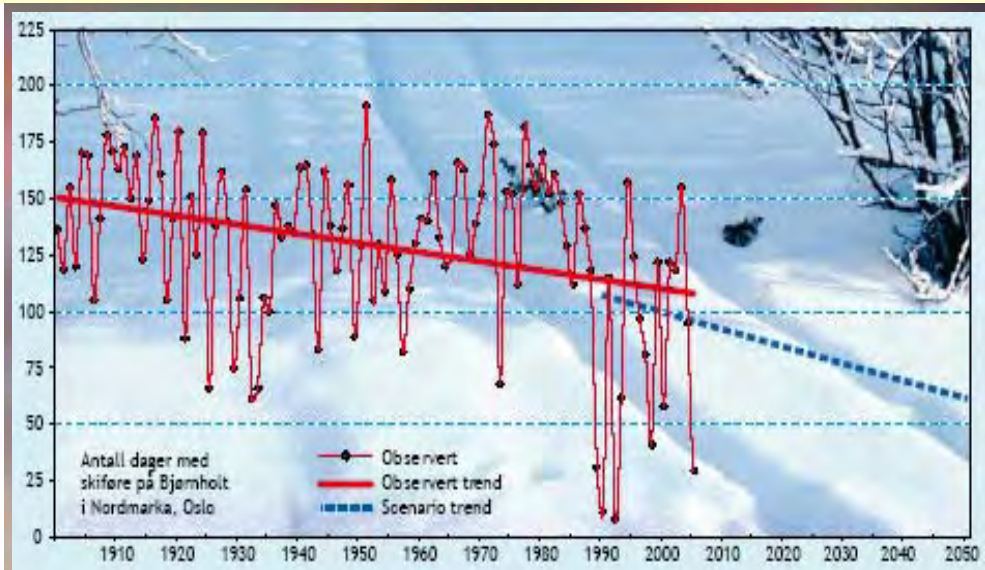
eksempel på hva modeller beregner kan bli ganske vanlig

Nedbør i Bergen: nov-des-jan 2004-05



Figur 3. Akkumulerte tremåneders nedbør-mengder for perioden november-januar er målt i Bergen sentrum fra 1861 til 2005. En normalfordeling (rød gausskurve) er tilpasset. De sju periodene med mest nedbør er merket med januar-årstallet. Avviket for 2005 var på over 3,5 standardavvik.

Skiføre i Nordmarka (Bjørnholt)



Figur 14. Utvikling av antall dager per år med skiføre ved Bjørnholt i Nordmarka, definert som dager med snødybde over 25 cm. Røde kurver er basert på observasjoner, stiplet blå kurve er en beregnet trend mot 2050 basert på nedskalerte klimascenarier fra RegClim.

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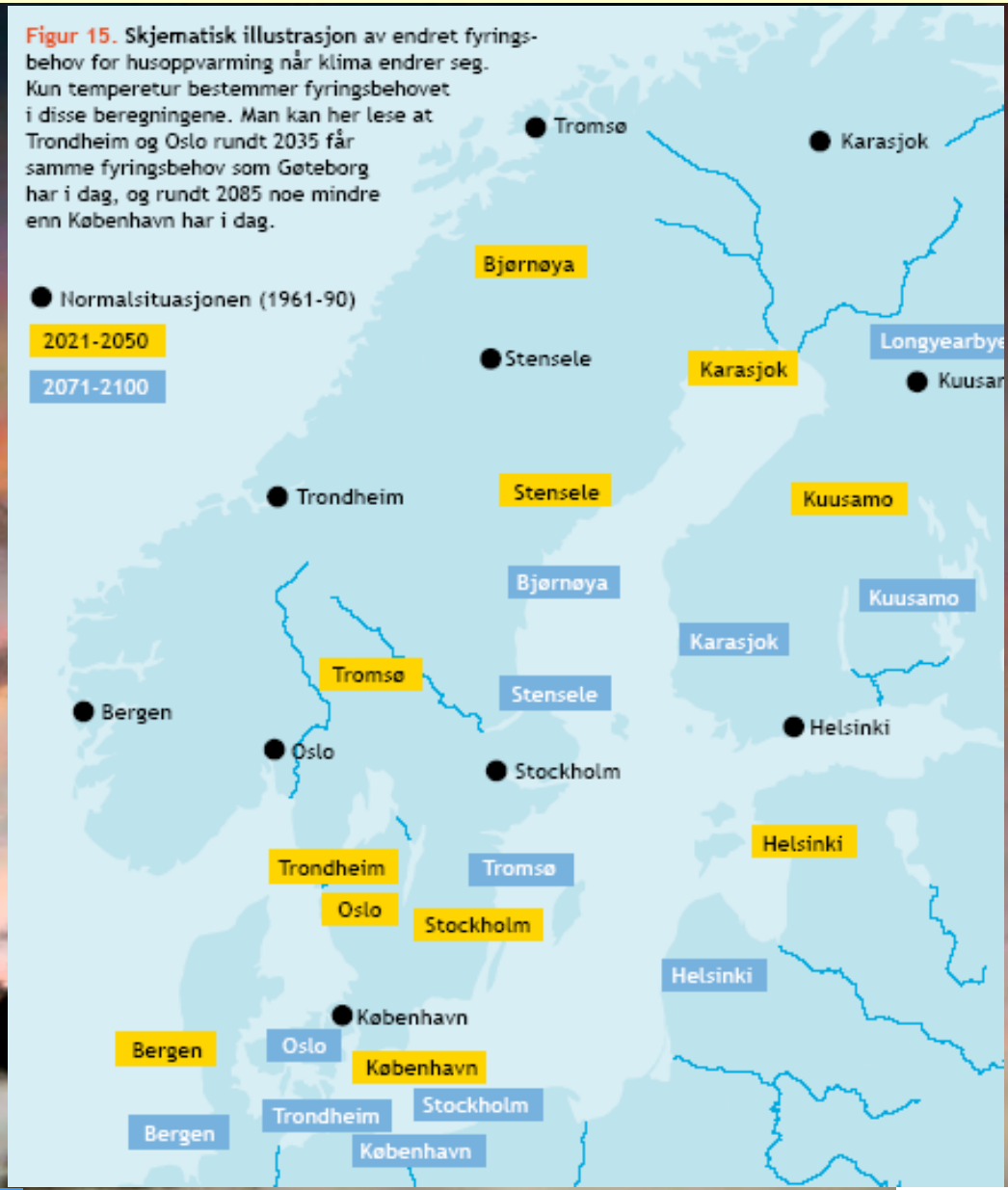
Fyringsgraddager (behov for husoppvarming)



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RegClim: Oversikt over dynamisk nedskalerte data

Simulation	Scenario	Domain	Method	Period	State
ERA-15 (1979-93)	-	D1,D2,D3	D:RCM	1979-1993	F
ERA-40 (1957-2002)	-	D2	D:RCM	1957-2002	P
ECHAM4/OPYC3	IS92a	D1	D:RCM	1980-1999, 2030-2049	F
ECHAM4/OPYC3	IS92a	D2	D:RCM	1980-2049	F
ECHAM4/OPYC3	IS92a	D3	D:RCM	1980-1999, 2030-2049	F
ECHAM4/OPYC3 T106	B2	D2	D:RCM	1961-1990, 2071-2100	R
HadAm3H	A2	D3	D:RCM	1961-1990, 2071-2100	F
HadAm3H	B2	D3	D:RCM	1961-1990, 2071-2100	F
ECHAM4/OPYC3	IS92a	D2	E:Analog	1980-2049	F
ECHAM4/OPYC3	IS92a	D2	E: Linear	1980-2000 2030-2049	F
HadAm3H	A2	D3	E:Analog	1961-1990, 2071-2100	P

Domains: **D1:** Large, **D2:** Medium, **D3:** Small

Method: **D**ynamical/RCM (Regional Climate Model), **E**mpirical: Linear regression & Analogs

State: **F:** Finalised, **R:** Downscaled, but not finally quality-checked, **P:** Planned downscaling

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Eksempler på virkningsstudier RegClim er involvert i:

- **NIVA (Øyvind Kaste, Richard Wright):** Linked models to assess the impacts of climate change on rivers and fjords (elements: temperature and precipitation).
- **NIBR (Terje Kleven):** Regional studies of vulnerability to climate related risks and climate change in Norway. (elements: temperature, precipitation, wind,...) Not yet started.
- **UMB (Lars Bakken):** Ecology and Economy of Agriculture in a Changing Climate (elements: precipitation, temperature, wind, ...)
- **EBL (Knut Ola Åmodt):** Climate development -consequences for runoff, environment and energy production. (elements: temperature and precipitation). (Collaboration with NVE (Norwegian Water Resources and Energy Directorate))
- **Skogforsk (Svein Solberg):** Impacts of climate change on Norwegian forests (elements: temperature, precipitation, wind)
- **Skogforsk (Bjørn Økland):** Cyclone analysis will be used as input to a research project on forest windfall, and 'Ips acuminatus' also known in the US as the 'six-toothed bark beetle'.
- **Byggforsk: KLIMA2000 (NRC-project, Kim Robert Lisø):** Climate effects (present & future) for buildings and constructions
- **Climate & Energy, CE (Nordic project, Snorri Arnason):** Climate impacts on energy production & consumption. Norwegian contribution to climate part of CE: Empirical and dynamical downscaled scenarios for the Nordic region (incl. Iceland & Greenland) (Rasmus Benestad & Jan Erik Haugen). Regional influence of aerosols (Alf Kirkevåg).

Målene for RegClim Fase III

By the end of 2006:

- ***to produce scenarios for regional climate change suitable for impact assessments***
  - in Northern Europe, bordering sea areas and major parts of the Arctic (our region), given a global climate change;

- ***and to quantify uncertainties and thus induced risks***
  due to
  - choice of downscaling method (e.g. empirical vs. dynamical),
  - choice of global scenarios (MPI, Hadley, BCM, CCSM-Oslo),
  - poorly understood processes influencing our region's climate
    - **processes maintaining warm Nordic and Barents Seas**
    - **the effects of anthropogenic aerosols**

Nøkkelord: Risiko og usikkerhet

Forskning for økt prosessforståelse trenger dedikerte klimamodeller som lokomotiv.

- Og de blir premissleverandør for god virkningsforskning.

Dedikerte studier
- Atmosfære
- Hav
- koordinerte
- frittstående

RegClim
- Forbedret global modellering
- Forskning i klimamodus
- Jordsystemet
- Forbedret Regional modellering

Grunnlag for bedre Virknings studier

Klimamodellenes beskrivelse av fysiske prosesser er en altoverskyggende utfordring.

Fysiske prosesser bestemmer modellenes beregning av:

- menneskeskapte og naturlige pådriv
- tilbakekoblingene i klimasystemet
- den romlige struktur til klimaresponsen på ytre pådriv

→ dvs. det regionale klima som omgivelsene tilpasser seg

Mangler og unøyaktigheter kan for klimascenariene medføre:

- **Biasfeil:** Simulert klima avviker systematisk fra virkelig klima, selv når mange klimamodeller brukes
- **Usikkerhet og spredning:** Klimamodellene framstiller fysikken ulikt → simulerte klimavariasjoner overdrives (det ropes "ulv i utide")

→ MEN: spredningen mellom modellene er trolig for liten!