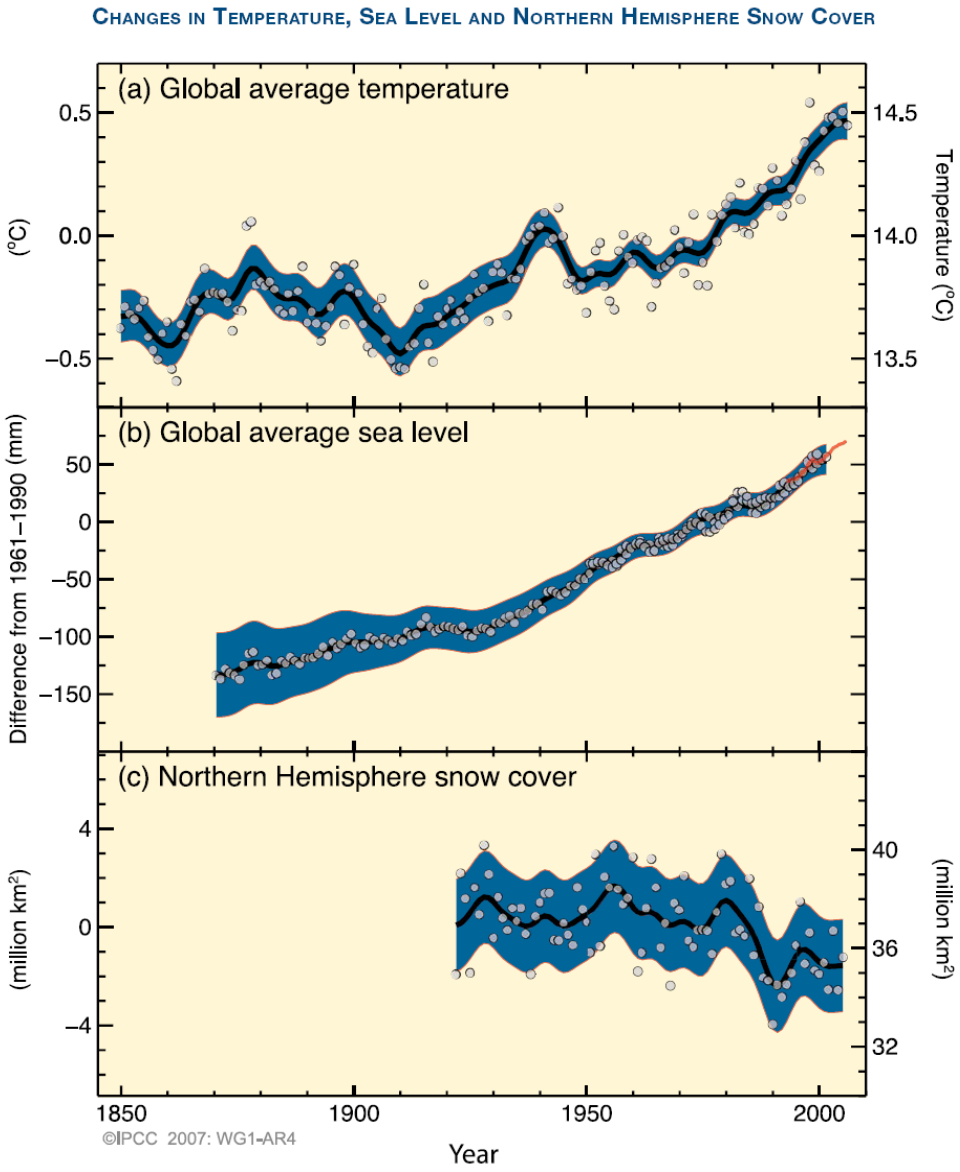
The Netherlands approach for generating climate change scenarios

Bart van den Hurk, KNMI

and many others

Climate change in observations



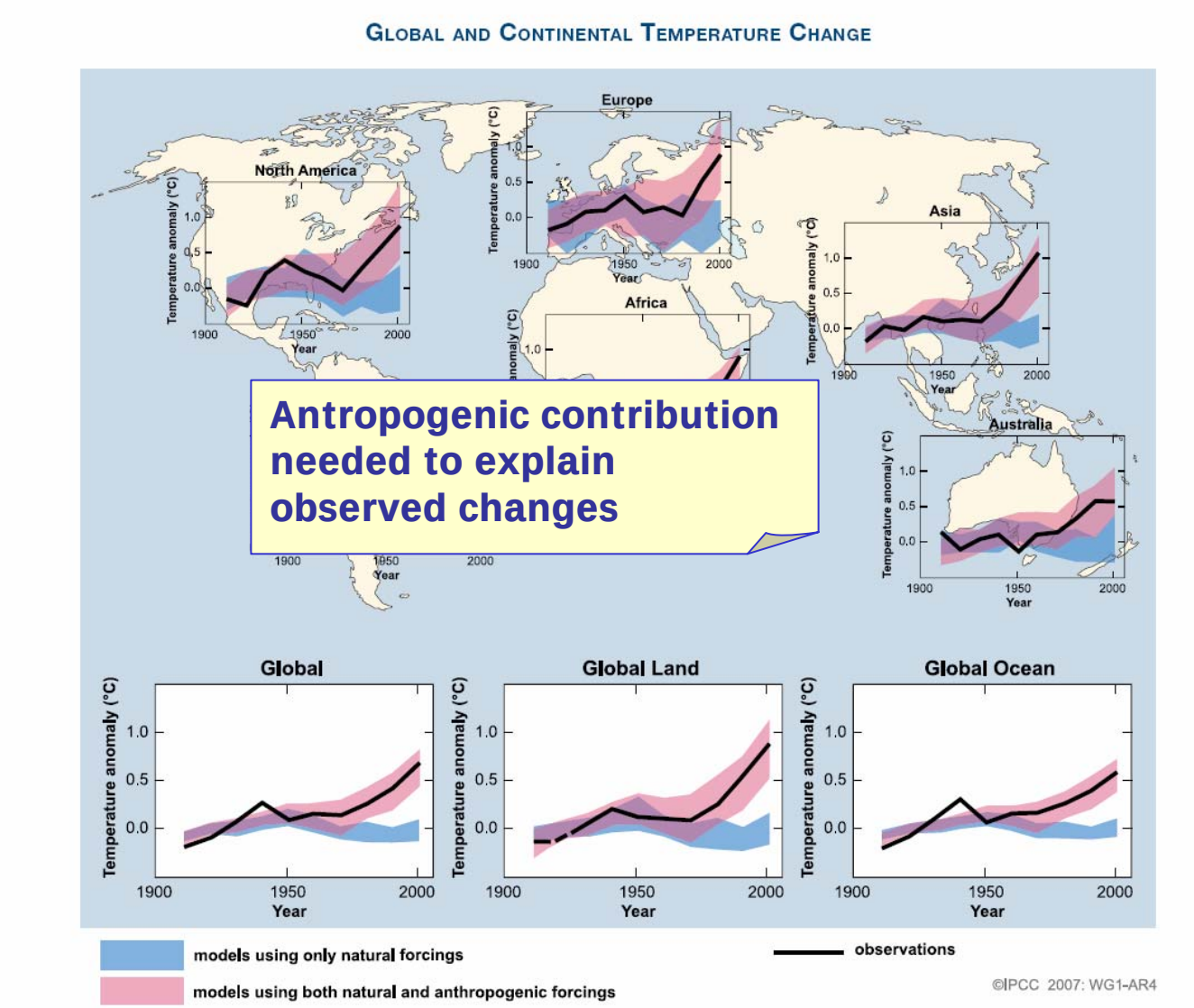
IPCC, 2007

Temperature rise since 1956 accelerating to 0.13 ± 0.03 K/10yrs

Sea level rise since 1993 accelerating to 3.1 ± 0.7 mm/yr

Snow cover/glacier length decreasing

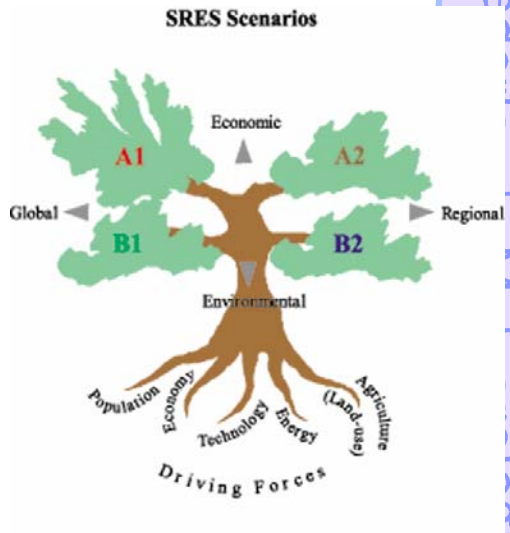
Model reconstructions



IPCC, 2007

Model projections of future global climate

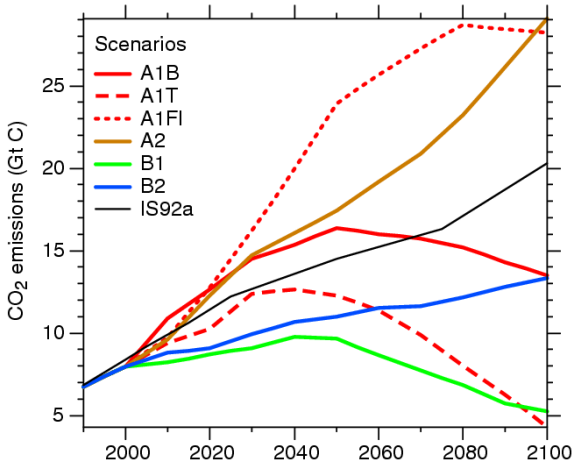
- Models are imperfect
- Future greenhouse gas concentrations are unknown
- Coordinated effort:
  - define set of emission scenarios



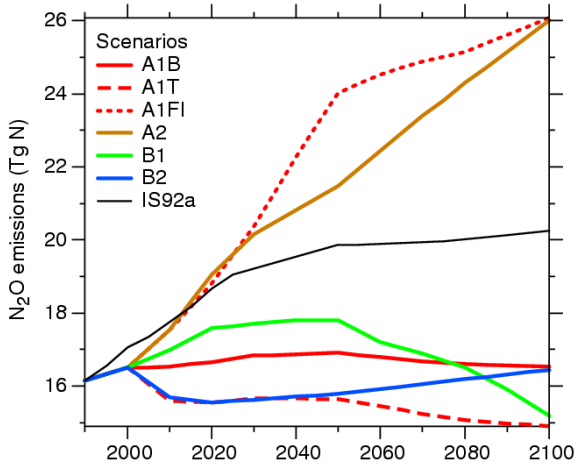
  - calculate concentration evolution
  - use this to make projections with range of GCMs
- AR4: Large (~25) nr of GCMs available for 1900 – 2200 (http://www-pcmdi.llnl.gov/)

Emission scenario's (SRES)

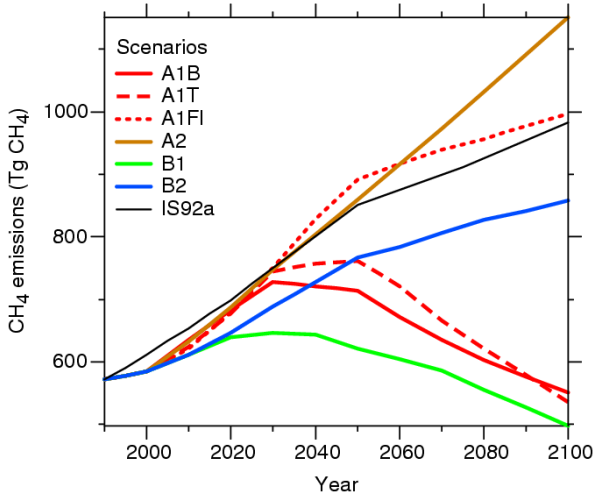
CO_2



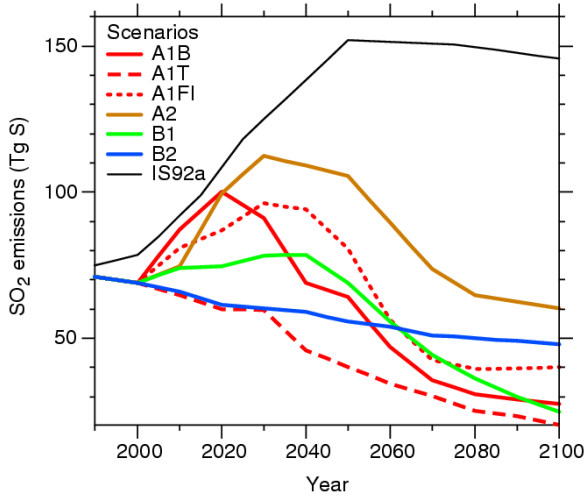
N_2O



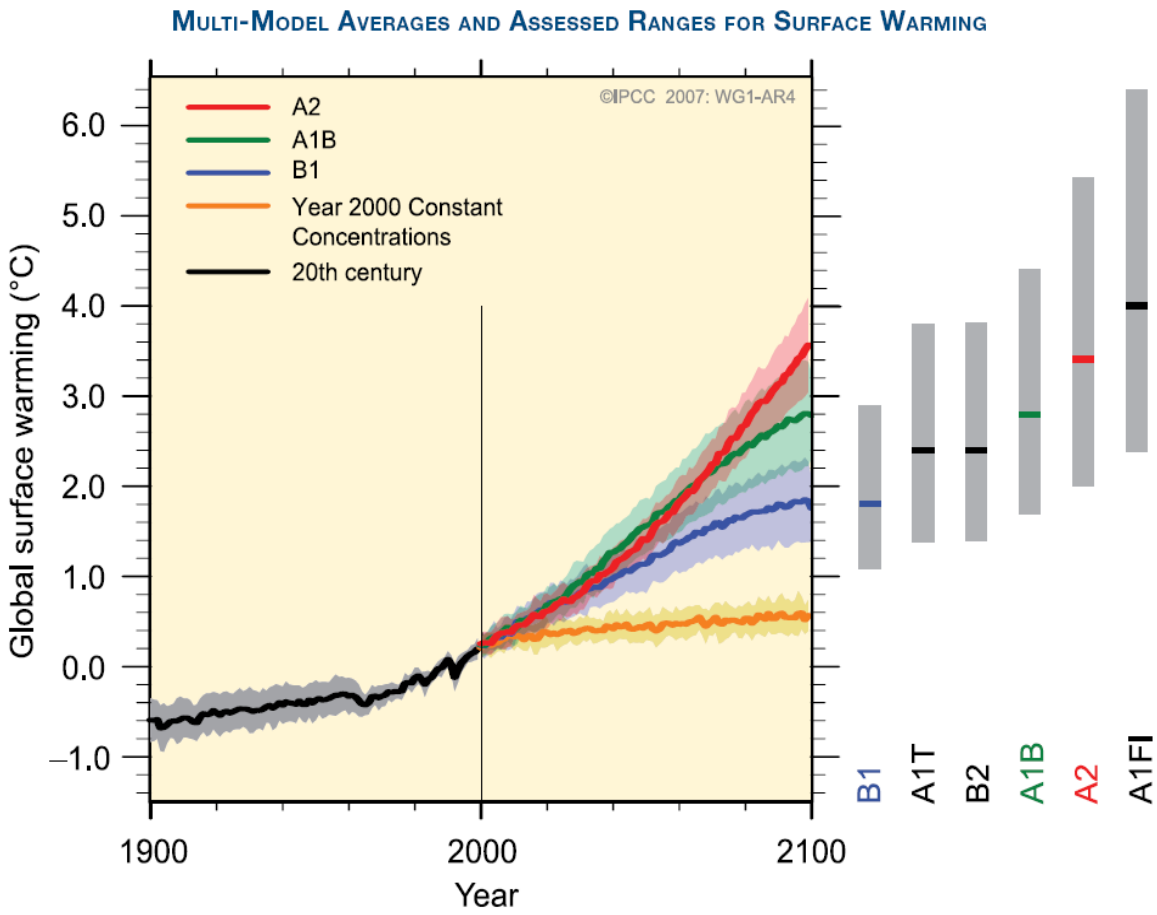
CH_4



SO_2



Model projections (global mean temperature)

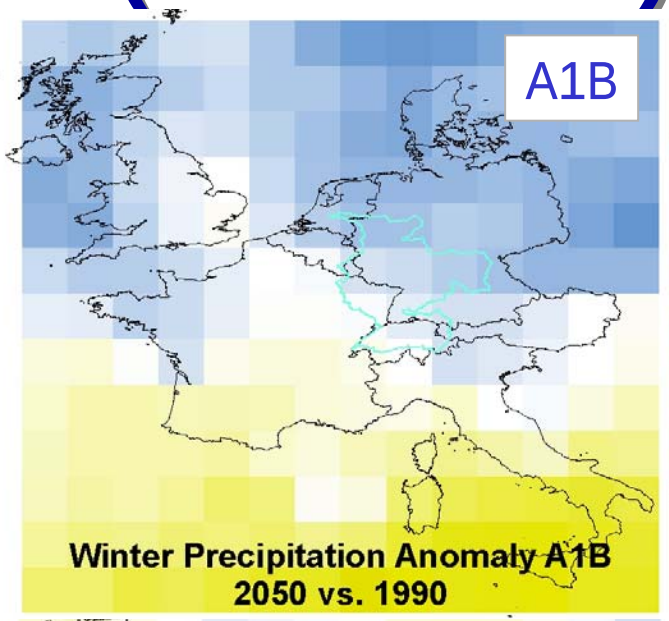


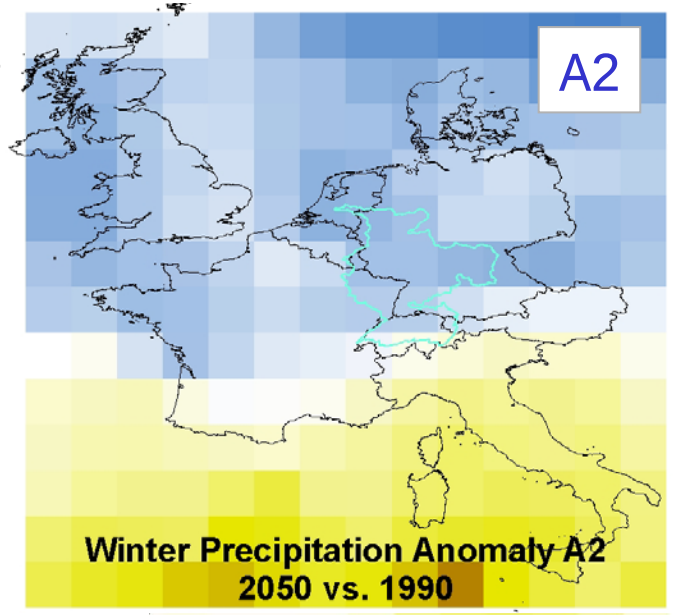
IPCC, 2007

Projections mean precipitation (2050/1990) with the MPI model

Winter

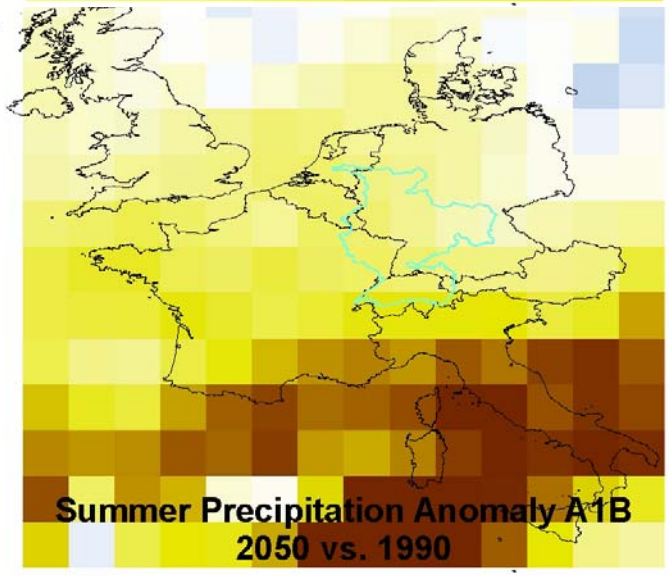
Summer

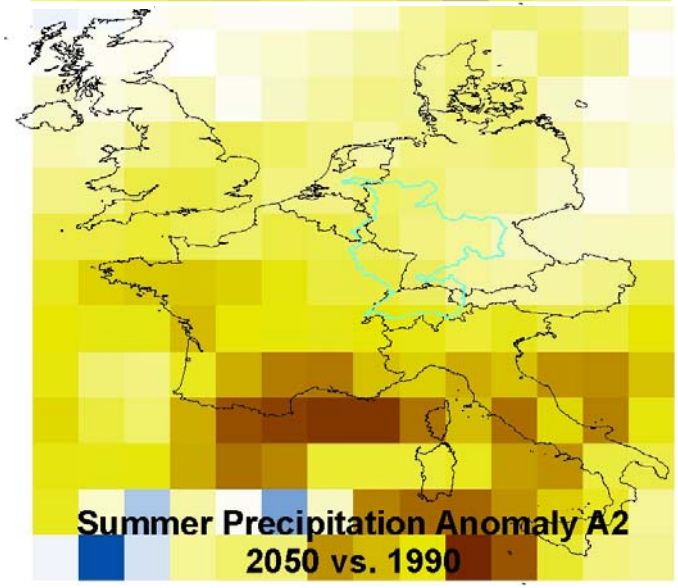




+25%

- 50 %





+ 25 %

-50%

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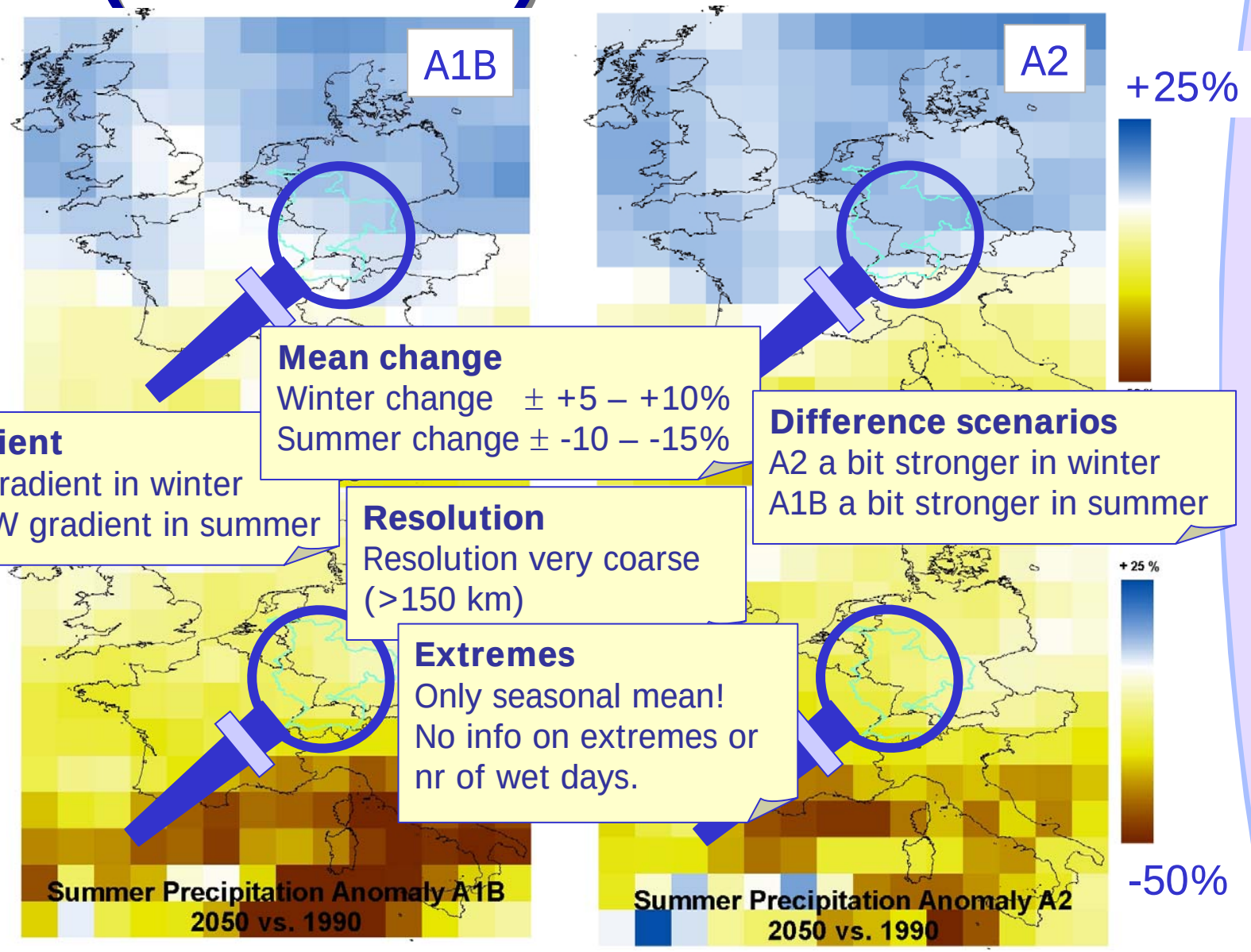
Projections mean precipitation (2050/1990) with the MPI model



Mean change
Winter change ± +5 – +10%
Summer change ± -10 – -15%

Gradient
N-S gradient in winter
SE-NW gradient in summer

Difference scenarios
A2 a bit stronger in winter
A1B a bit stronger in summer

Resolution
Resolution very coarse (>150 km)

Extremes
Only seasonal mean!
No info on extremes or nr of wet days.

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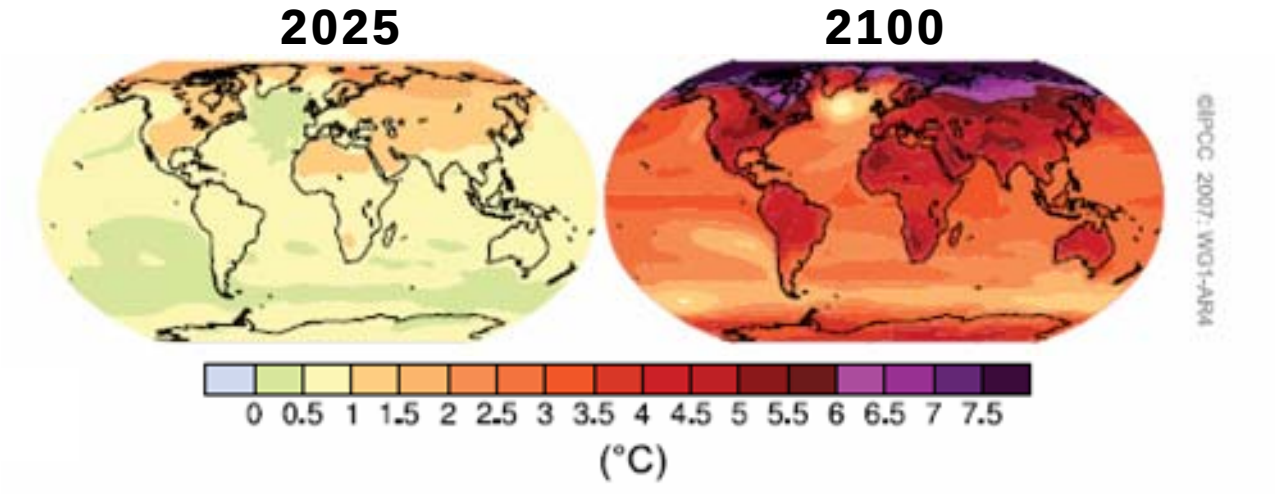
Climate change involves many aspects

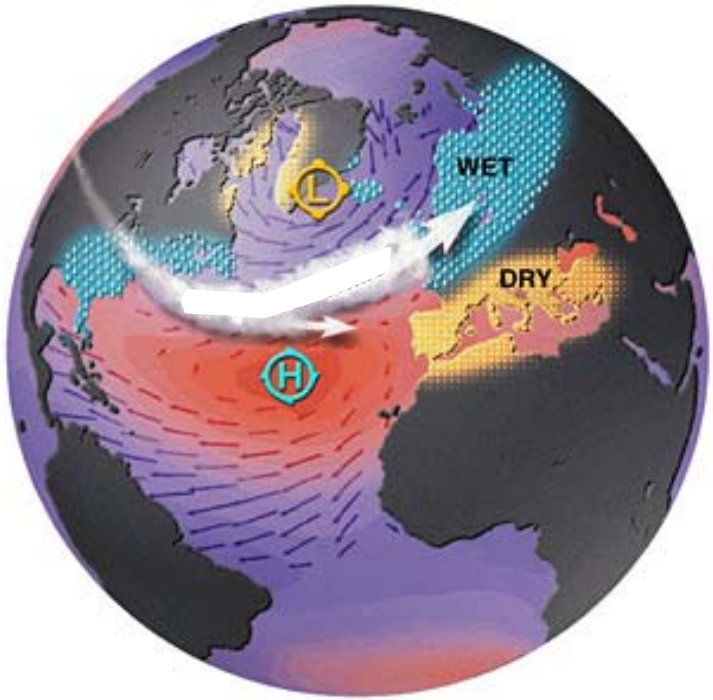
- Future temperature change varies between regions
- Mean wind patterns may also change!

Mean temperature change SRES A2 scenario



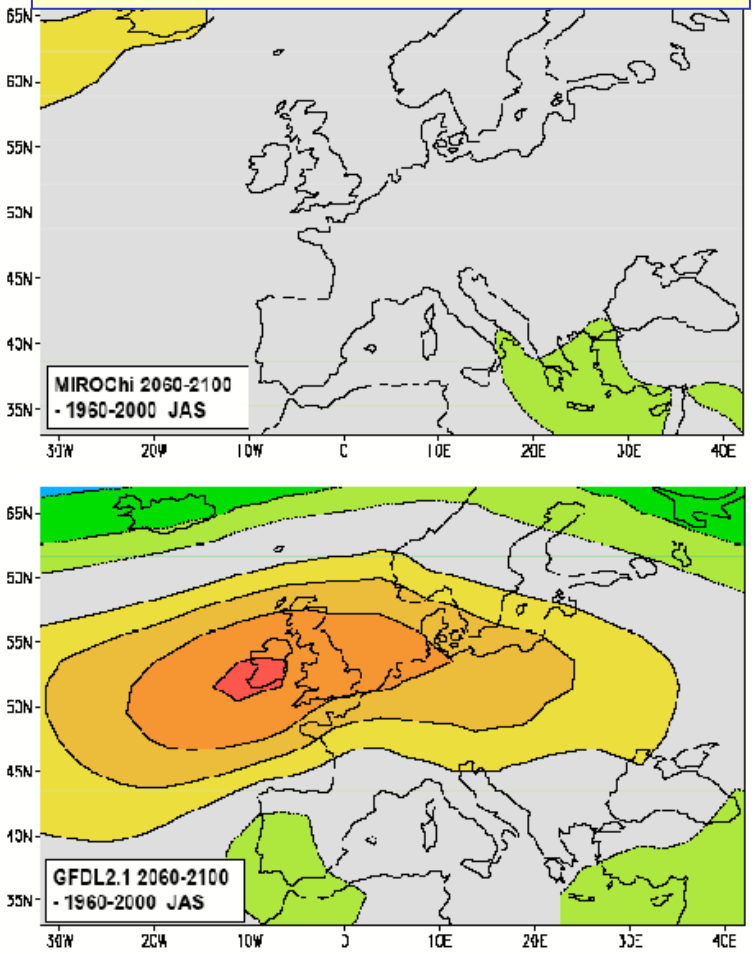
IPCC, 2007

Atmospheric circulation change



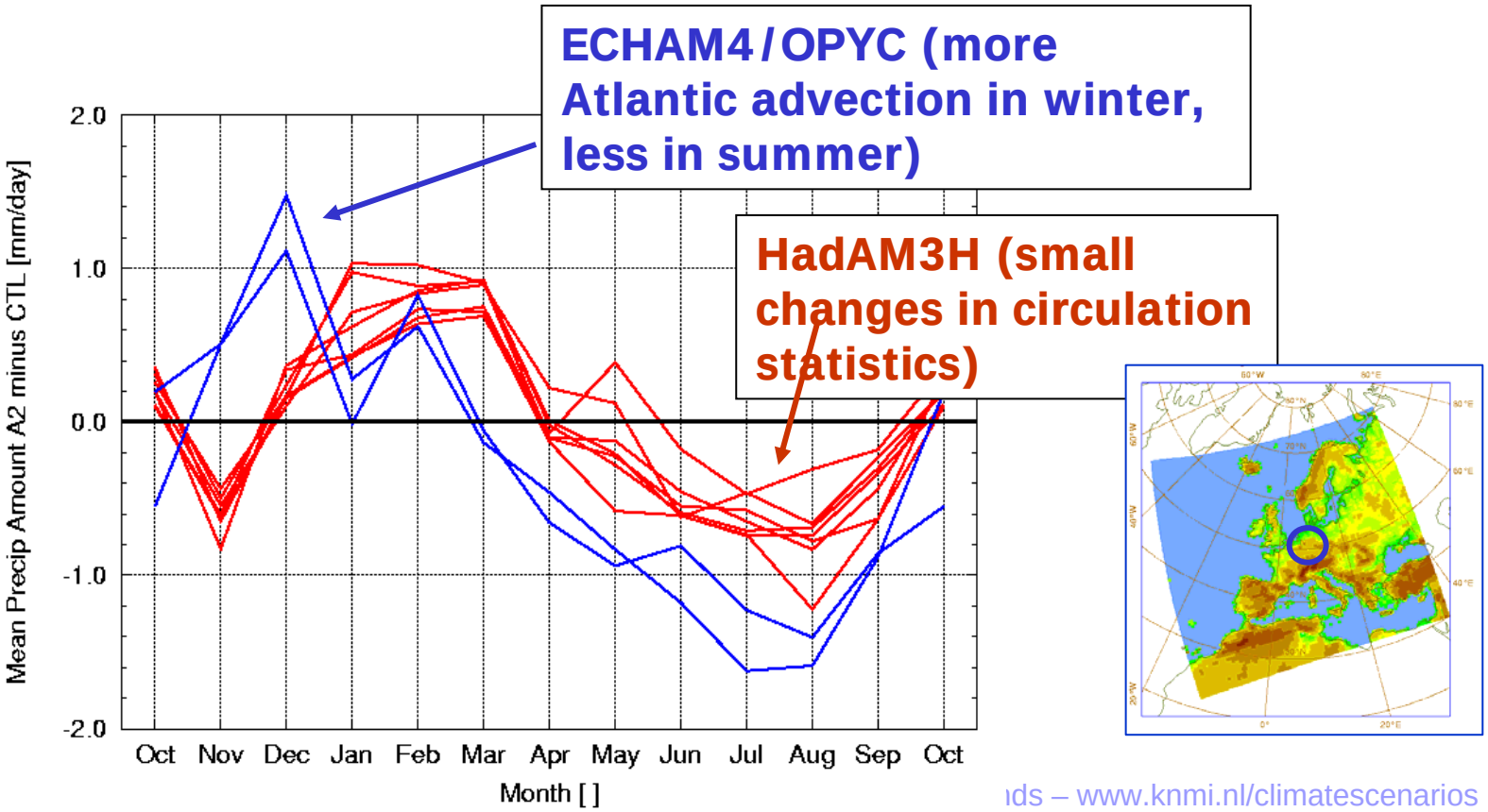
Van Ulden and Van Oldenborgh, 2006

Sea level pressure difference from 2 different GCMs

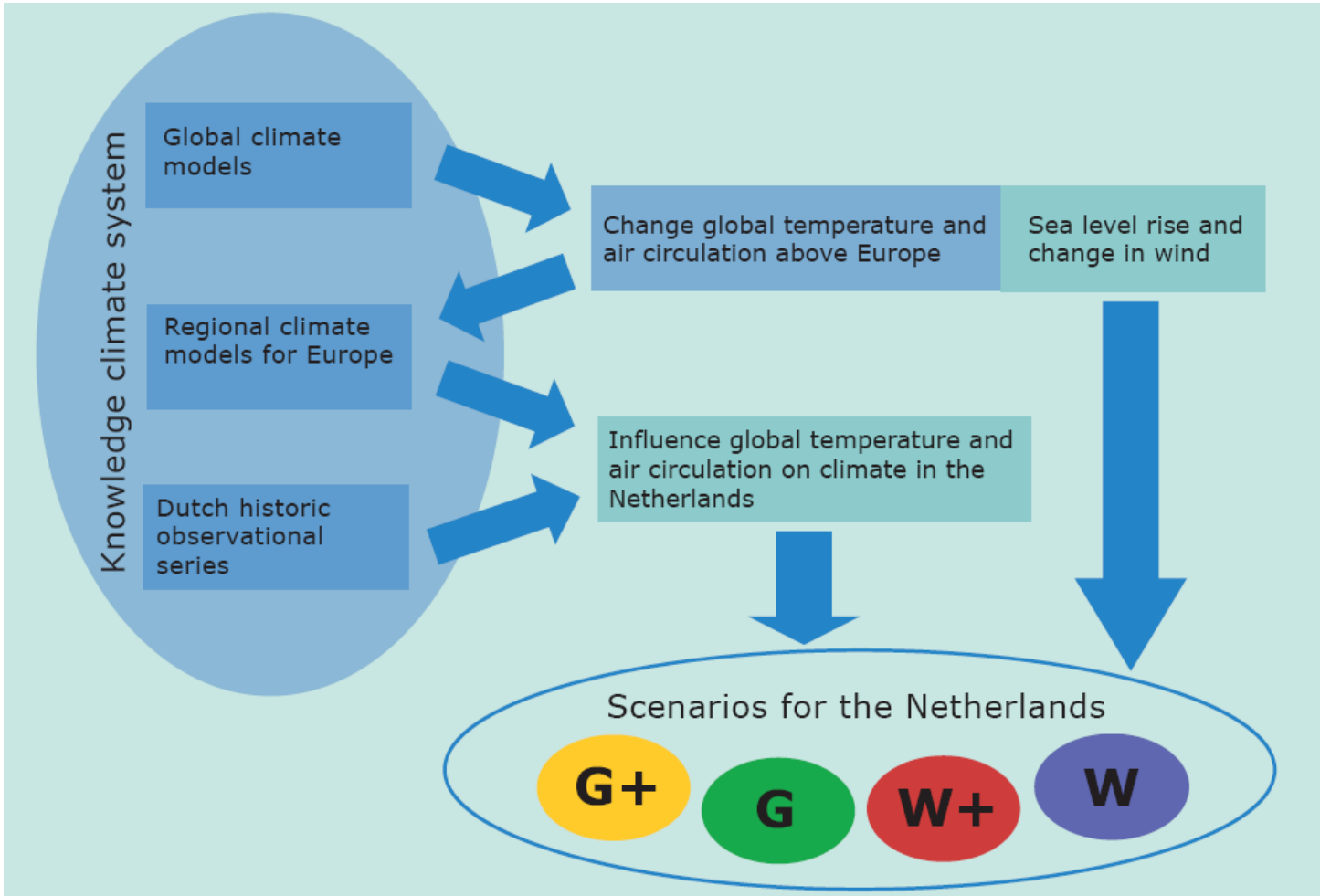


The influence from circulation change

- Change of precipitation annual cycle in Rhine area from multiple regional climate model simulations
- Two different GCM's

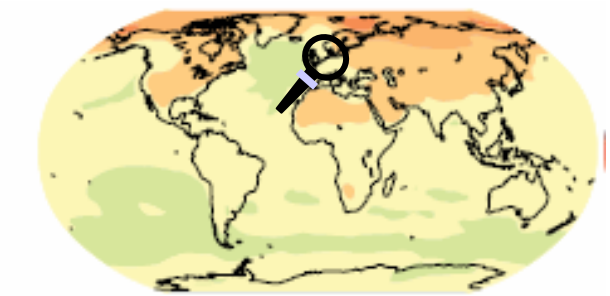


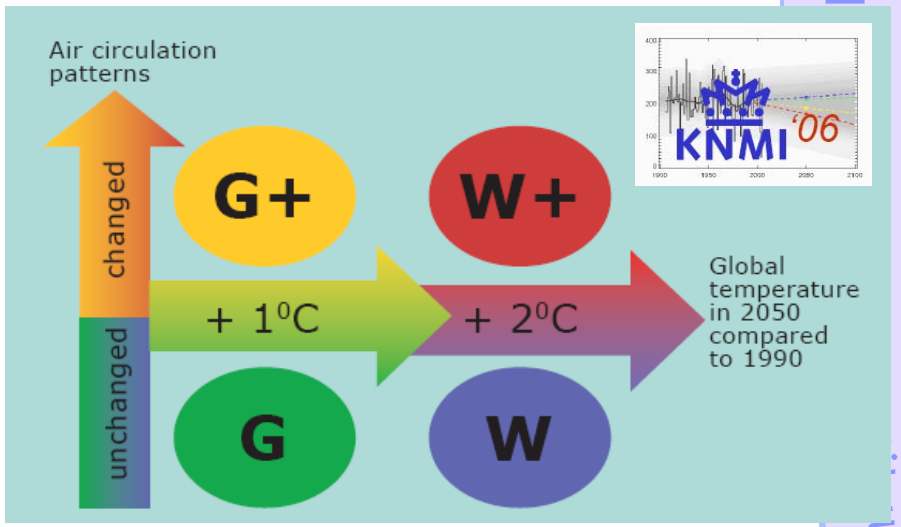
The production of the KNMI'06 scenarios



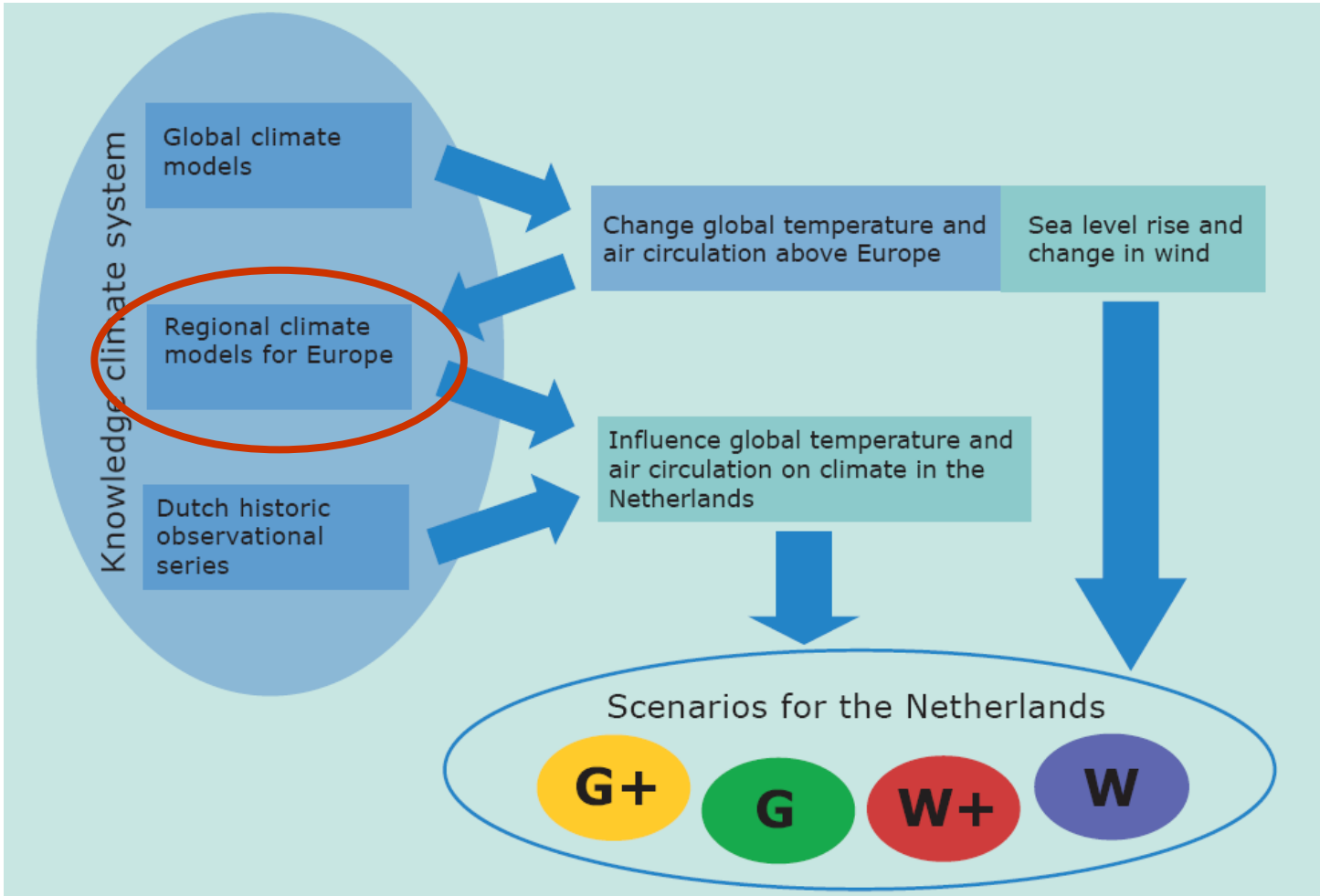
Climate change in the Netherlands

- Climate change in the Netherlands depends on
  - global temperature rise
  - change in local wind regime



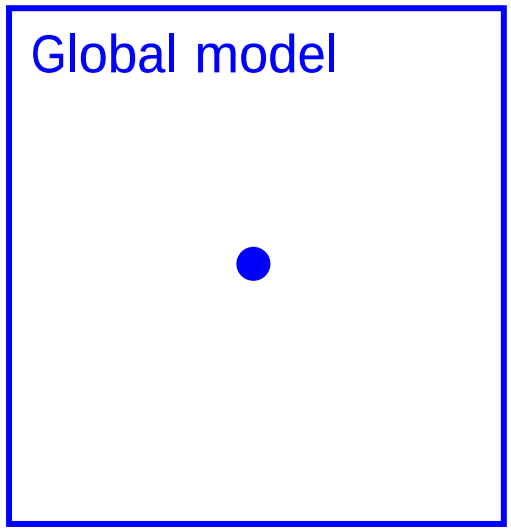


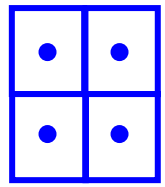
The production of the KNMI'06 scenarios

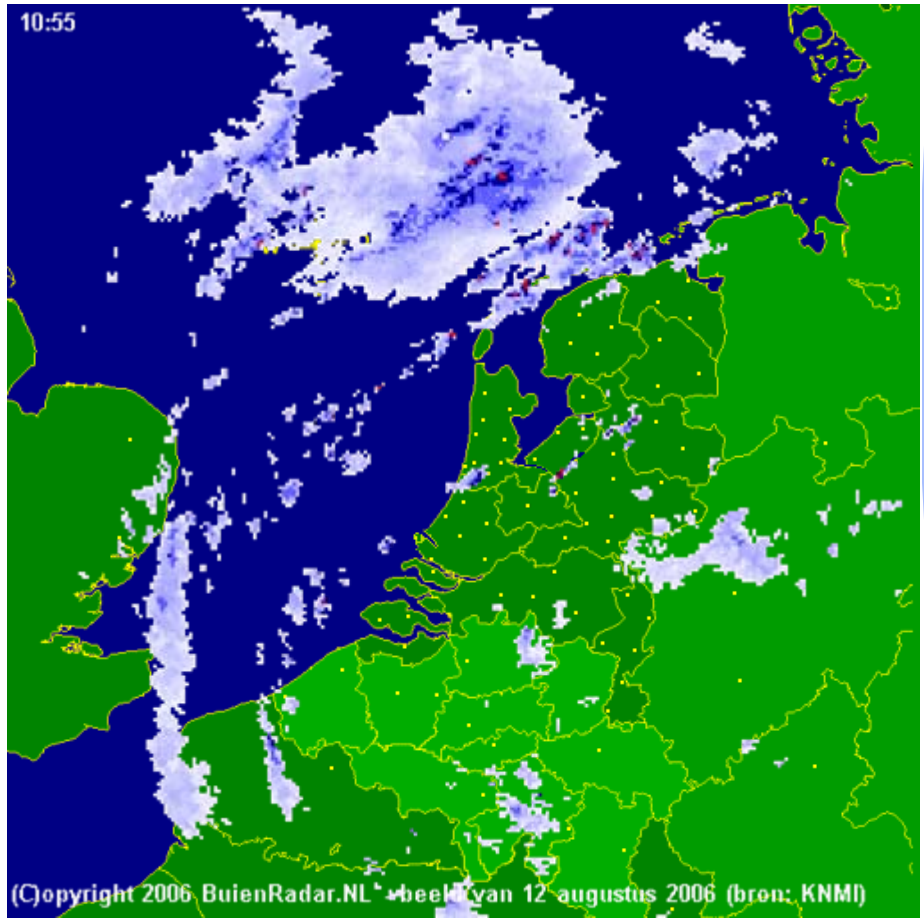


Regional climate change: downscaling

- GCM-grid box too coarse

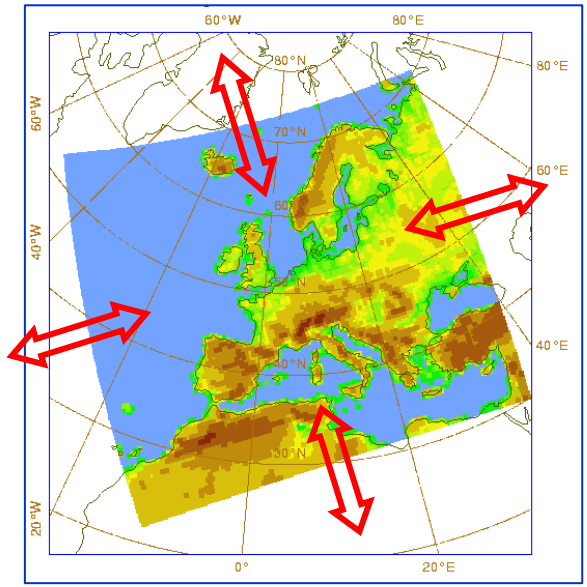






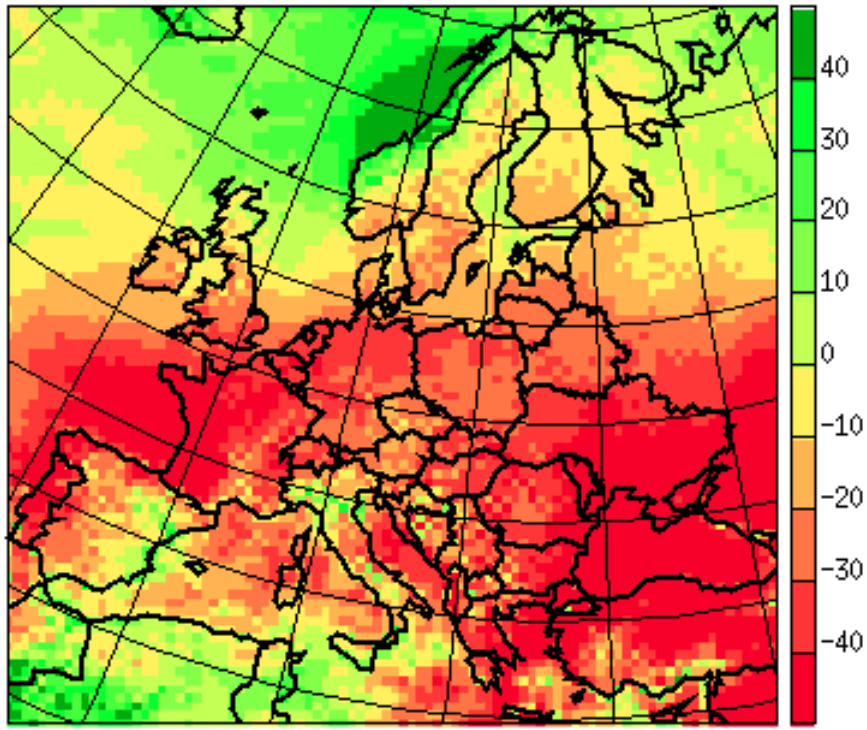
Regional Climate Modelling (RCM)

- High resolution GCM (50 – 20 km)
- Lateral boundary conditions from reanalysis (present-day climate conditions) or GCM runs (scenario runs)
  - multi-level
  - temporal frequency dependent on domain
- Inner domain free evolving



Precipitation extremes in summer (difference A2 – CTL)

Purpose of downscaling:
extra spatial and temporal detail



more

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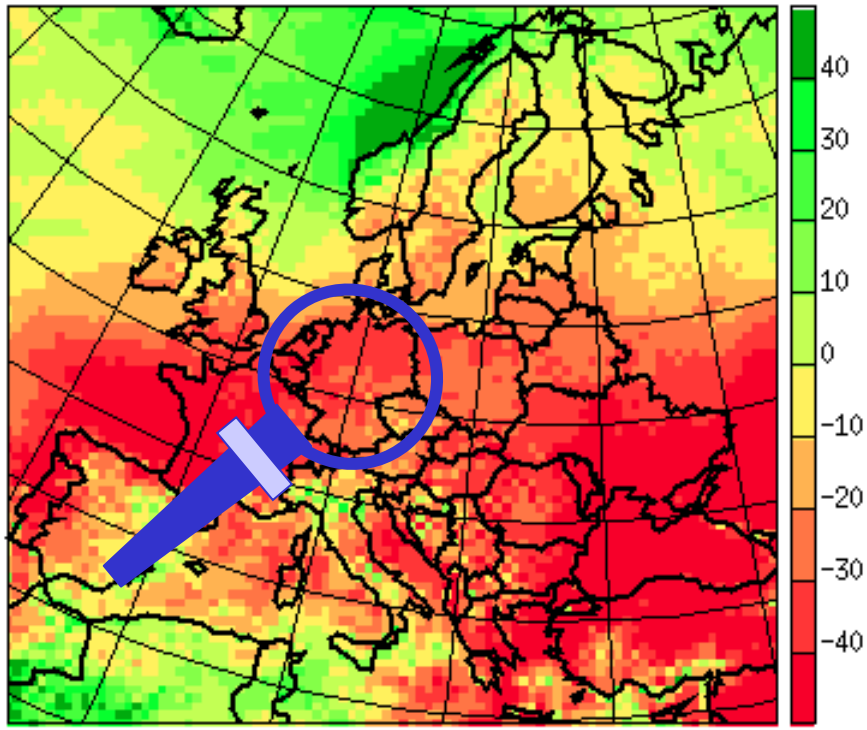
Danish Met. Institute

Precipitation extremes in summer (difference A2 – CTL)

Mean; 90%; 95%; 99%; 99.5%; 99.9%



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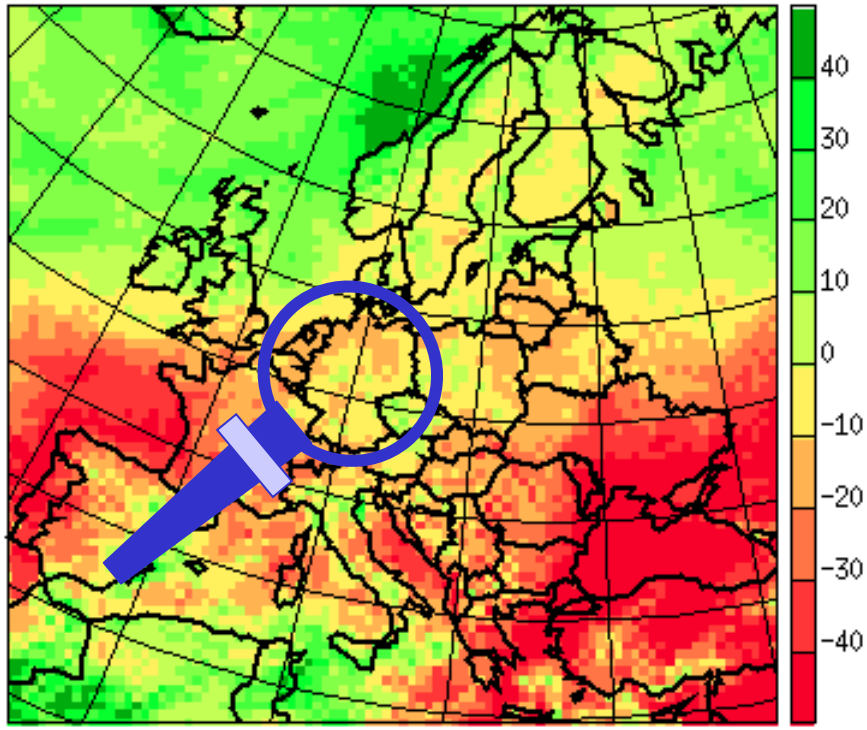
Danish Met. Institute

Precipitation extremes in summer (difference A2 – CTL)

Mean; **90%**; 95%; 99%; 99.5%; 99.9%

~10 times per summer



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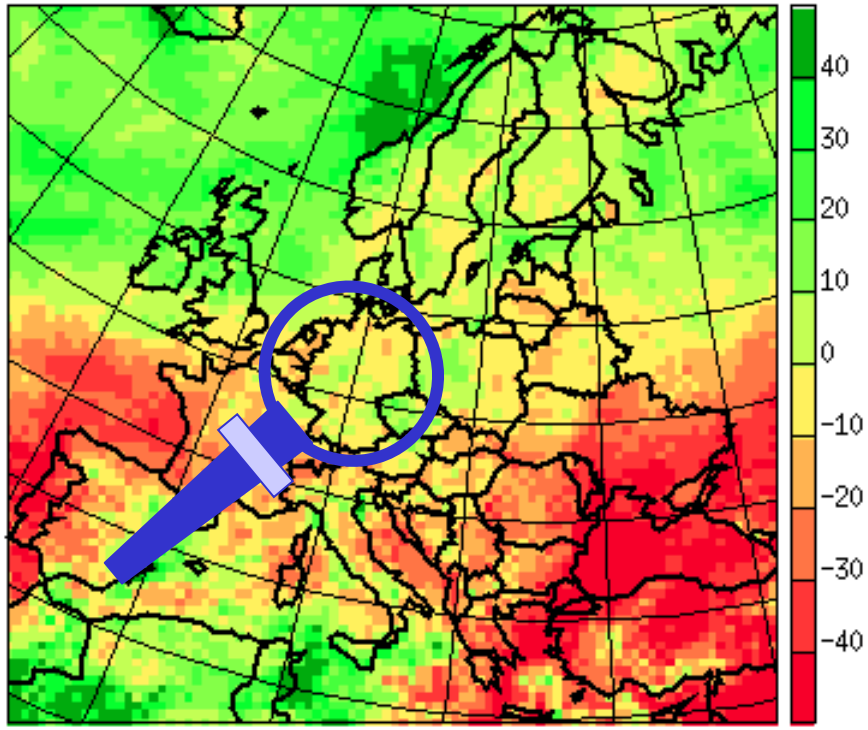
Danish Met. Institute

Precipitation extremes in summer (difference A2 – CTL)

Mean; 90%; **95%;** 99%; 99.5%; 99.9%

~5 times per summer



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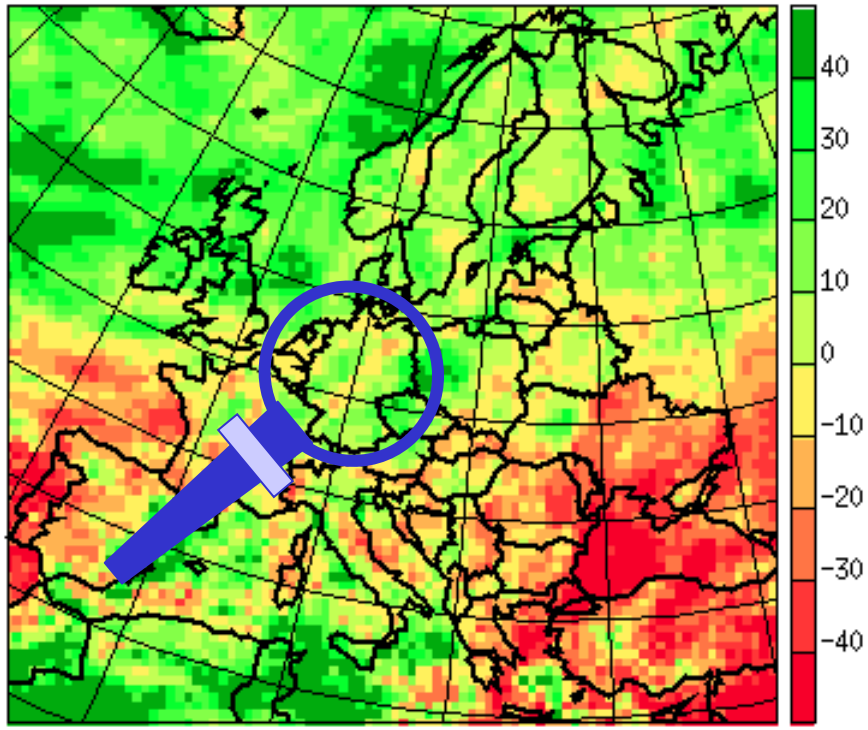
Danish Met. Institute

Precipitation extremes in summer (difference A2 – CTL)

Mean; 90%; 95%; **99%;** 99.5%; 99.9%

~annual wettest summer day



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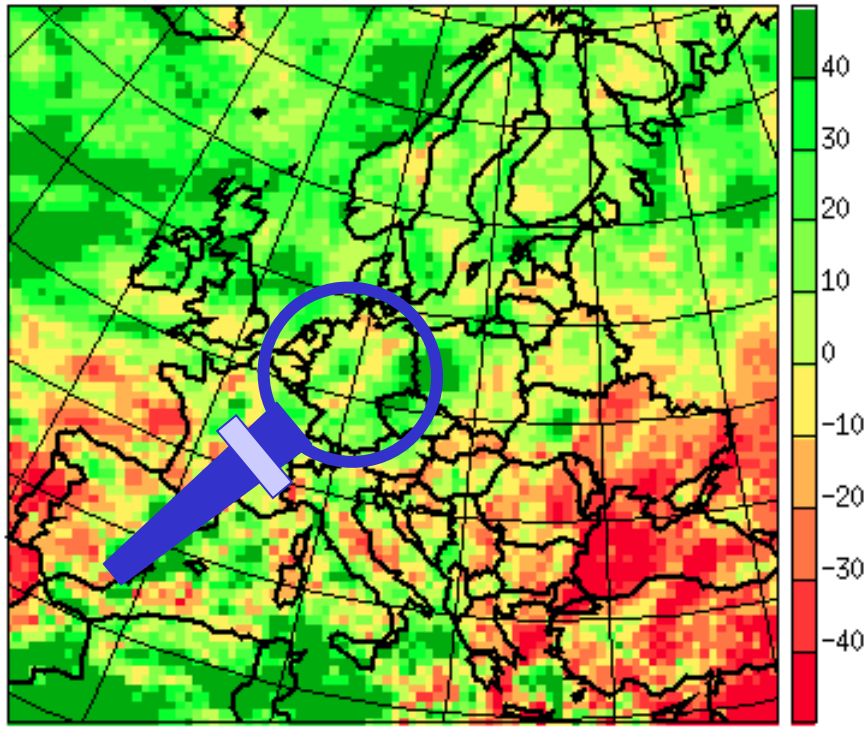
Danish Met. Institute

Precipitation extremes in summer (difference A2 – CTL)

Mean; 90%; 95%; 99%; **99.5%**; 99.9%

~shower exceeded once per 5 yrs



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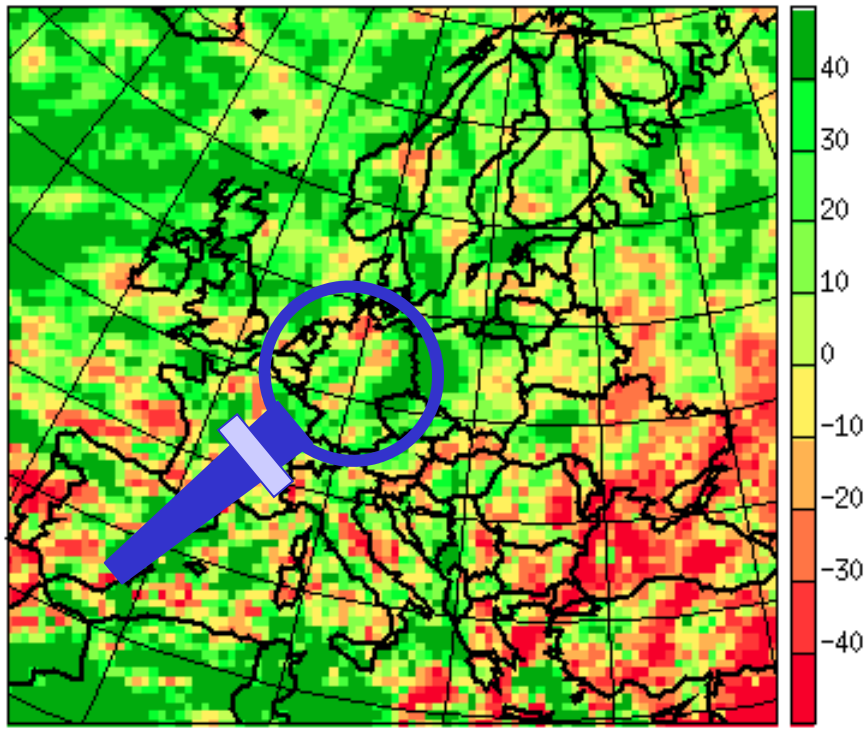
Danish Met. Institute

Precipitation extremes in summer (difference A2 – CTL)

Mean; 90%; 95%; 99%; 99.5%; **99.9%**

~shower exceeded once per 10 yrs



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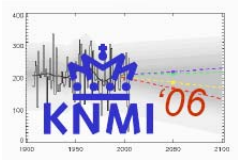
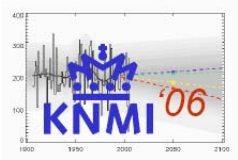
Danish Met. Institute

The KNMI'06 climate scenarios: change in 2050 relative to 1990



		G	G+	W	W+
Global temperature rise		+1°C	+1°C	+2°C	+2°C
Change in air circulation patterns		no	yes	no	yes
Winter [3]	average temperature	+0.9°C	+1.1°C	+1.8°C	+2.3°C
	coldest winter day per year	+1.0°C	+1.5°C	+2.1°C	+2.9°C
	average precipitation amount	+4%	+7%	+7%	+14%
	number of wet days (≥ 0.1 mm)	0%	+1%	0%	+2%
	10-day precipitation sum exceeded once in 10 years	+4%	+6%	+8%	+12%
	maximum average daily wind speed per year	0%	+2%	-1%	+4%
Summer [3]	average temperature	+0.9°C	+1.4°C	+1.7°C	+2.8°C
	warmest summer day per year	+1.0°C	+1.9°C	+2.1°C	+3.8°C
	average precipitation amount	+3%	-10%	+6%	-19%
	number of wet days (≥ 0.1 mm)	-2%	-10%	-3%	-19%
	daily precipitation sum exceeded once in 10 years	+13%	+5%	+27%	+10%
	potential evaporation	+3%	+8%	+7%	+15%
Sea level	absolute increase	15-25 cm	15-25 cm	20-35 cm	20-35 cm

Some examples



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	average precipitation amount	+4%	+7%	+7%	+14%
	maximum average daily wind speed per year	0%	+2%	-1%	+4%
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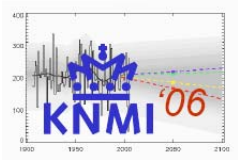
Sea level	absolute increase	15-25 cm	15-25 cm	20-35 cm	20-35 cm

With circulation change the coldest and warmest temperature change more than mean

Some examples



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					+2%
					+12%
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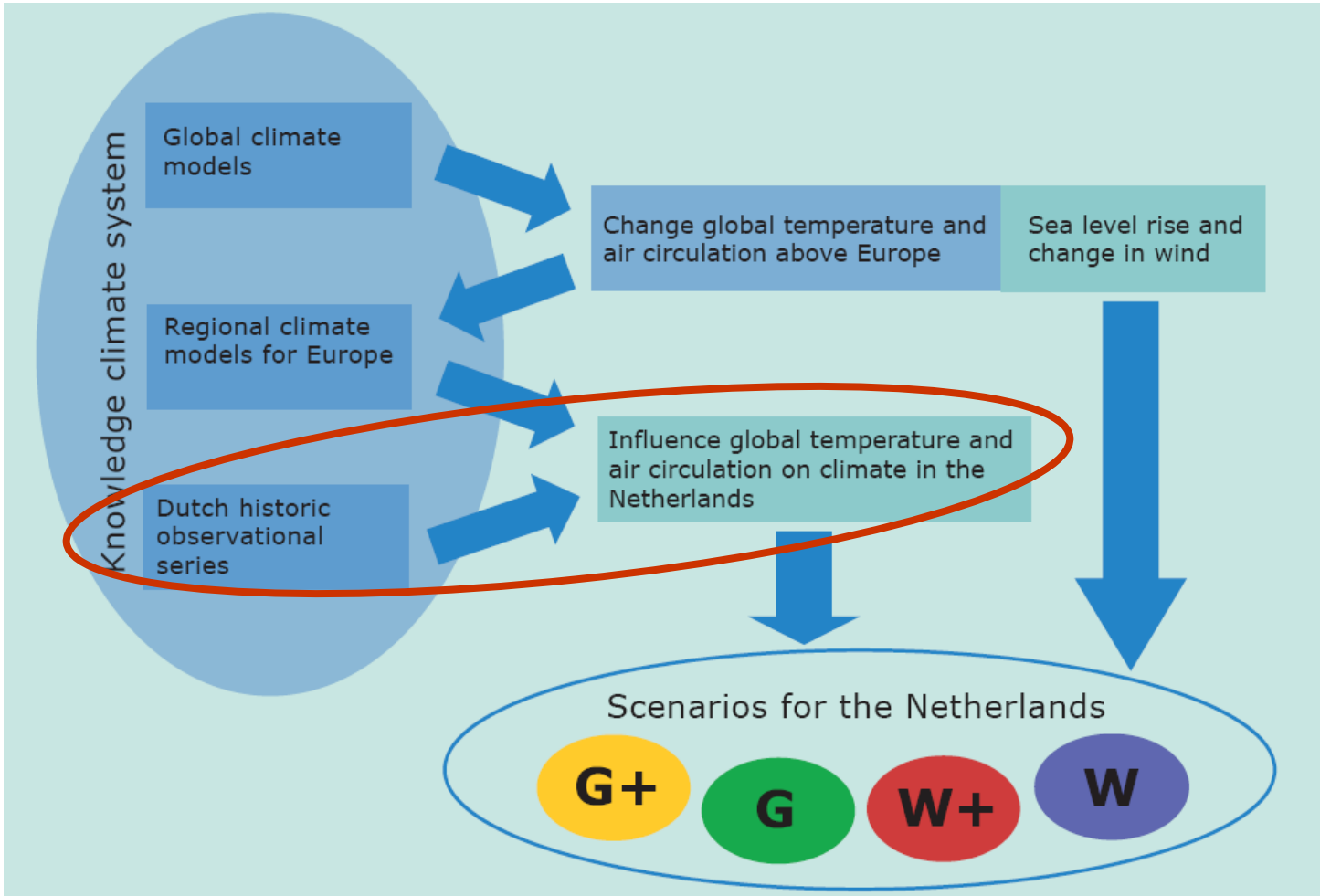
	number of wet days	-2%	-10%	-3%	-19%
	daily precipitation sum exceeded once in 10 years	+13%	+5%	+27%	+10%
	potential evaporation	+3%	+8%	+7%	+15%
Sea level	absolute increase	15-25 cm	15-25 cm	20-35 cm	20-35 cm

Nr of wet days strongly dependent on circulation change

General picture

- **Extreme temperature change is stronger than mean**, especially when circulation also changes
- When circulation changes **number of precipitation days** is strongly reduced in summer, causing a reduction of mean summertime precipitation
- In **winter mean precipitation increases** (dependent on circulation)
- **Extreme precipitation increases** both in summer and winter
- **Sea level rise** is slightly smaller than in TAR
- 1/yr Wind slightly increases (but **not significantly**)

The production of the KNMI'06 scenarios



Return time of 2003 drought

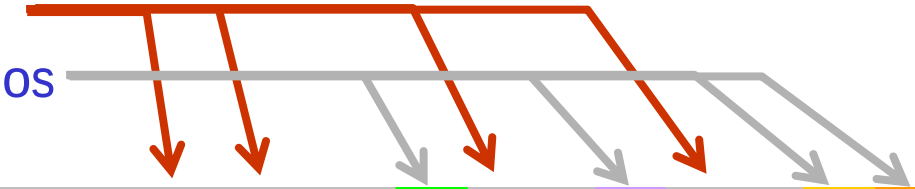
	1906-2000	G	G+	W	W+
Precipitation deficit (mm)	144	151	179	158	220
Return time of 2003-drought (yrs)	9,7	7,9	4,1	6,5	2,0

Tailored climate scenarios

- Specific use in water management requires “tailoring”
- Dutch Programme **Climate Changes Spatial Planning** co-funded a “tailoring project”
- Examples (not all from this project)
  - High resolution time series of precipitation
  - Ground water tables in the Netherlands
  - Rhine discharge
  - Closure of Maasland barrier

Assessment of impact of KNMI'06 scenarios on Rhine discharge

Old WB21 scenarios
New KNMI'06 scenarios



Scenario's KNMI zie www.knmi.nl Variabele	laag WB21	midden WB21	G '06	hoog WB21	W '06	hoog droog WB21*	G+ '06	W+ '06
Temperatuur (°C)								
Gemiddeld winter (DJF)	0,5	1	0,9	2	1,8	2	1,1	2,3
Gemiddeld zomer (JJA)	0,5	1	0,9	2	1,7	3,1	1,4	2,8
Neerslag zomer (%)								
Gemiddeld (halfjaar)	0,5	1		2				
Gemiddeld (JJA)			3		6	-20	-10	-19
Intensiteit in buien	5	10		20				
dagsom, eens in 10 jaar overschreden			13		27		5	10
Neerslag winter (%)								
Gemiddeld (halfjaar)	3	6		12				
Gemiddeld (DJF)			4		7	13	7	14
10-daagse som (halfjaar)	5	10		20				
10-daagse som, eens in 10 jaar overschreden			4		8		6	12
Potentiële evaporatie (%)								
Jaarlijks	2	4		8		8		
Zomer (JJA)			3		7	24	8	15

klimaat voor ruimte

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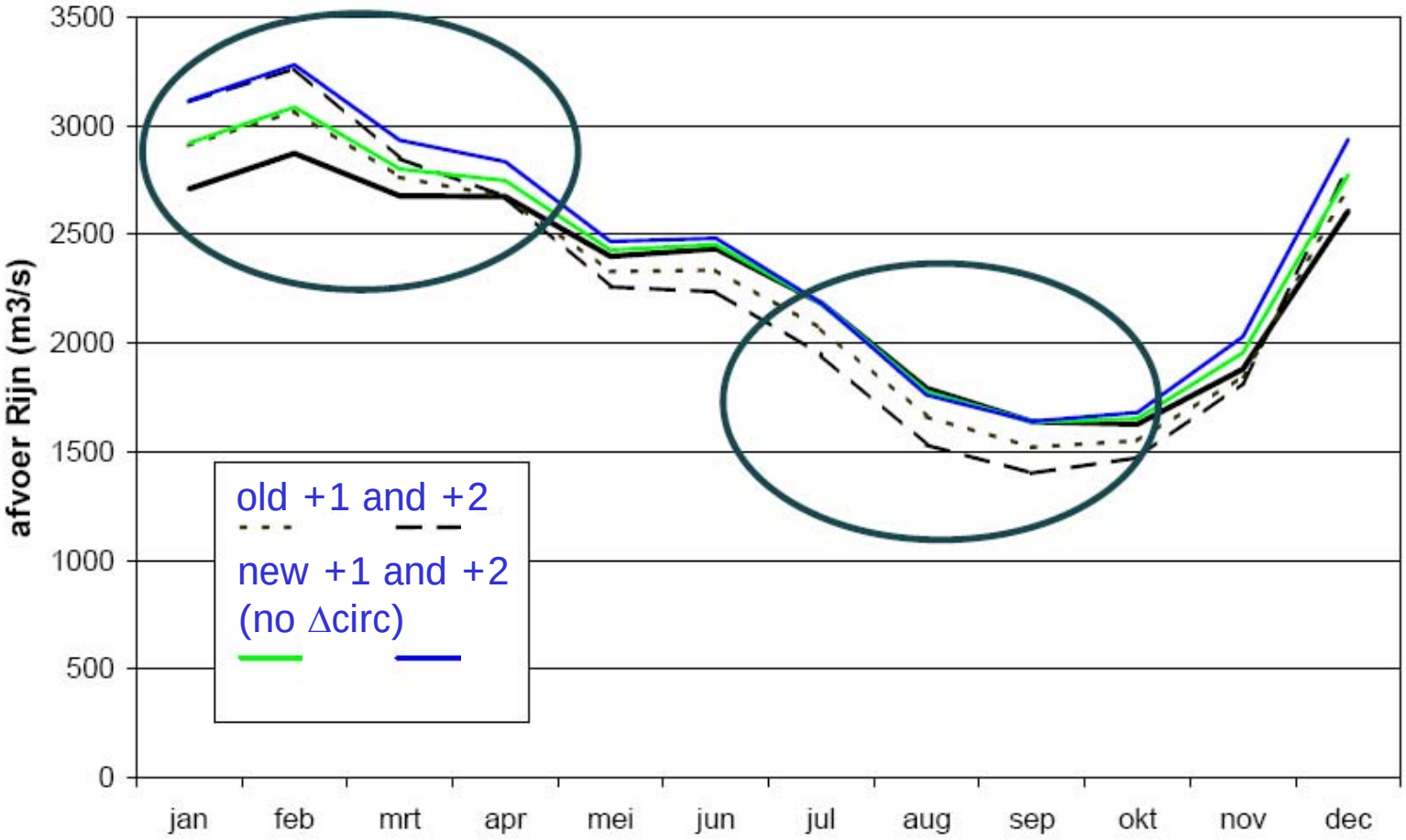
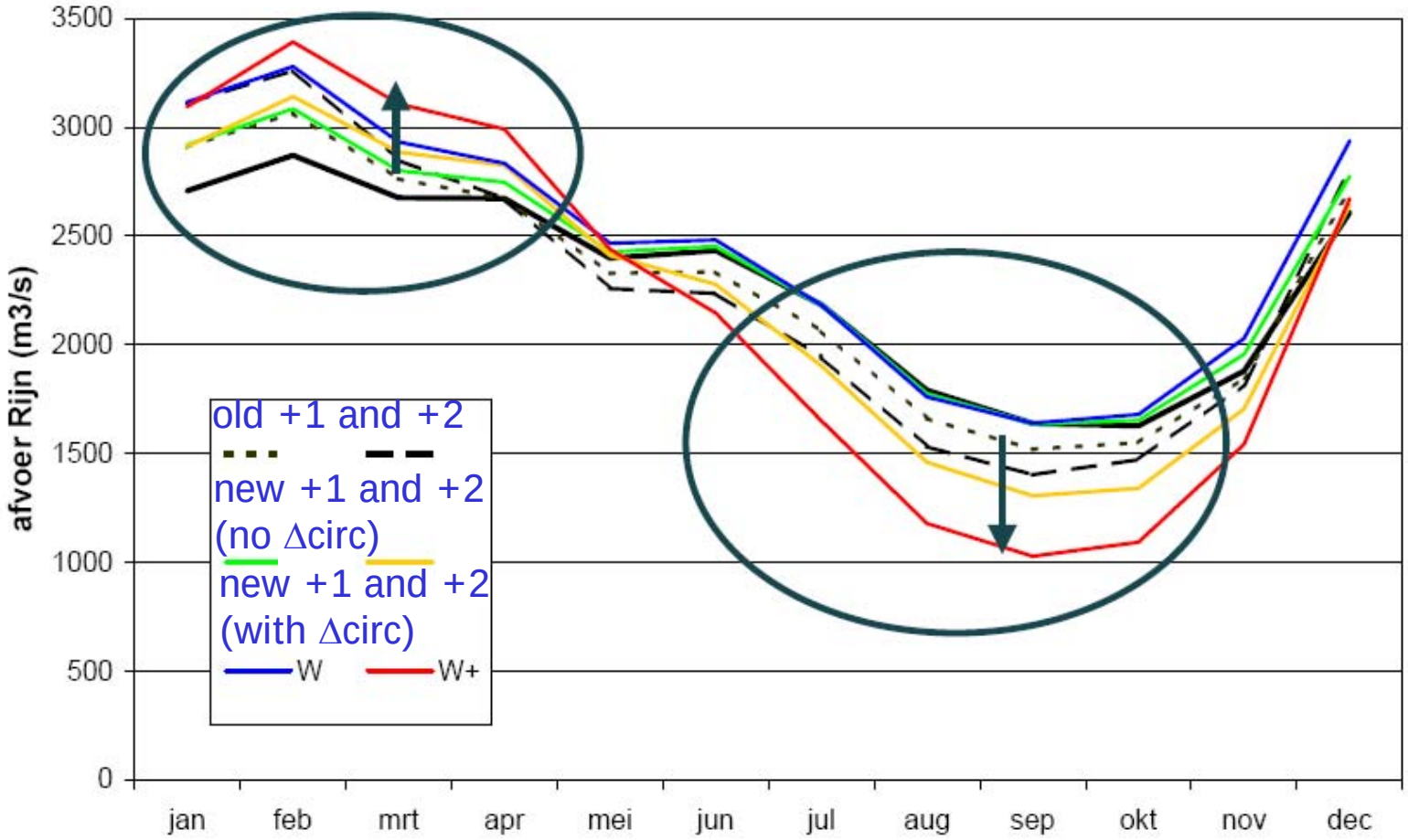
Assessment of impact of KNMI'06 scenarios on Rhine discharge

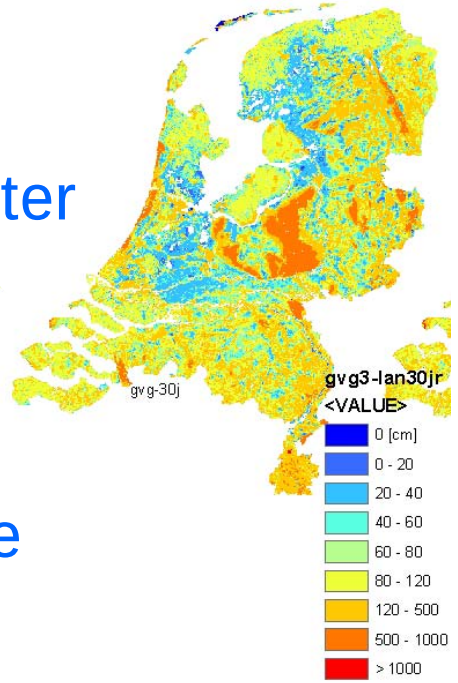


Assessment of impact of KNMI'06 scenarios on Rhine discharge



Groundwater tables in the Netherlands

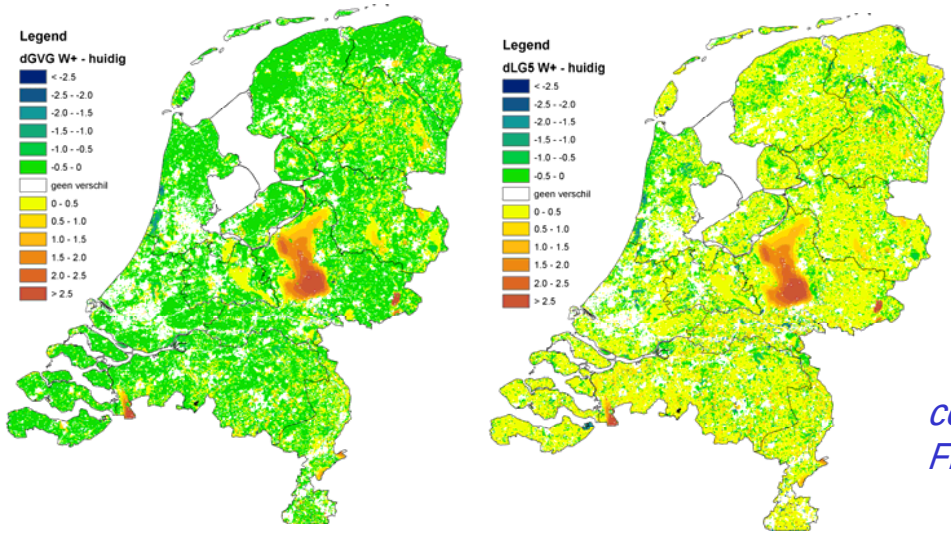
- Current practice: **detailed hydrological model** is used to calculate high resolution ground water balance
- Climate change assessment needs long records: **expensive**!
- To enable affordable climate change assessment: can one construct a **single reference year** that reproduces proper reference climatological ground water product?



Change in ground water table the Netherlands

- Aim: first assessment of effect of W+ scenario on ground water table in various stages of the growing season
- Tailoring:
  - production of location specific meteo (applied linearly in this example)
  - running high resolution ground water model

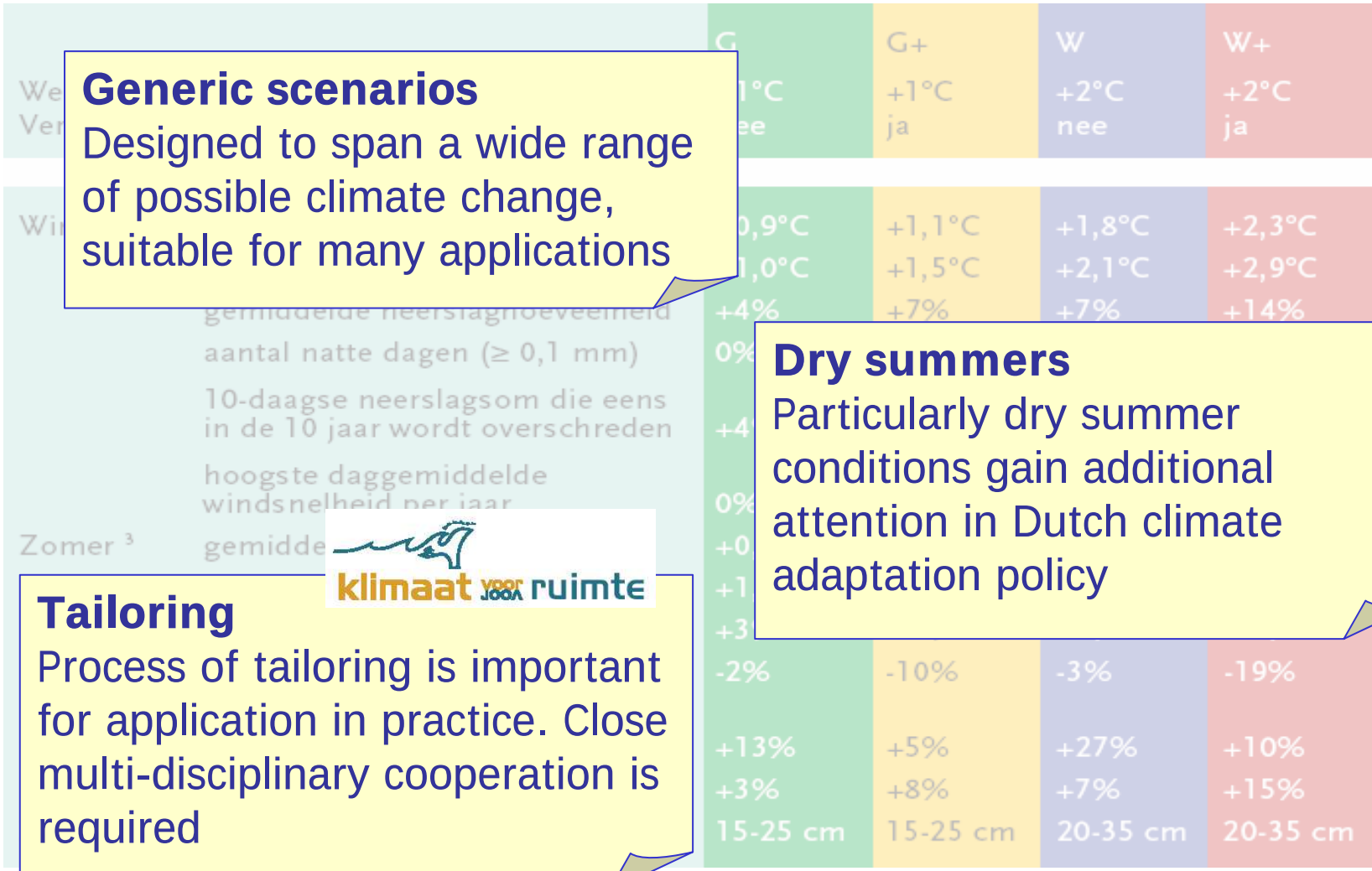
Start of growing season: **generally wetter**



Lowest water table during growing season: **generally drier**

courtesy Timo Kroon, Franziska Keller ea

Remarks on the scenarios



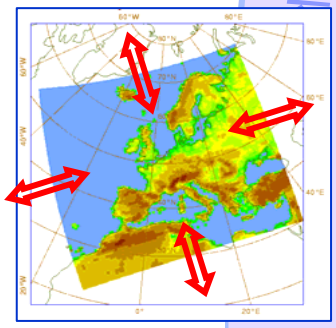
Generic scenarios
Designed to span a wide range of possible climate change, suitable for many applications

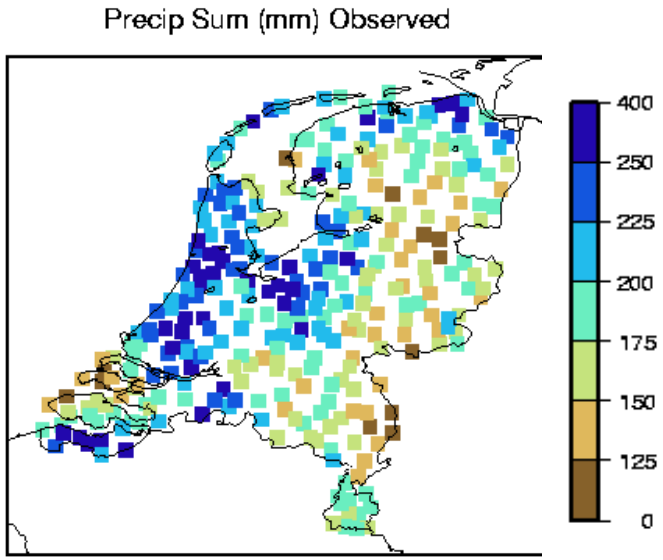
Dry summers
Particularly dry summer conditions gain additional attention in Dutch climate adaptation policy

Tailoring
Process of tailoring is important for application in practice. Close multi-disciplinary cooperation is required

And the real world: The summer of 2006

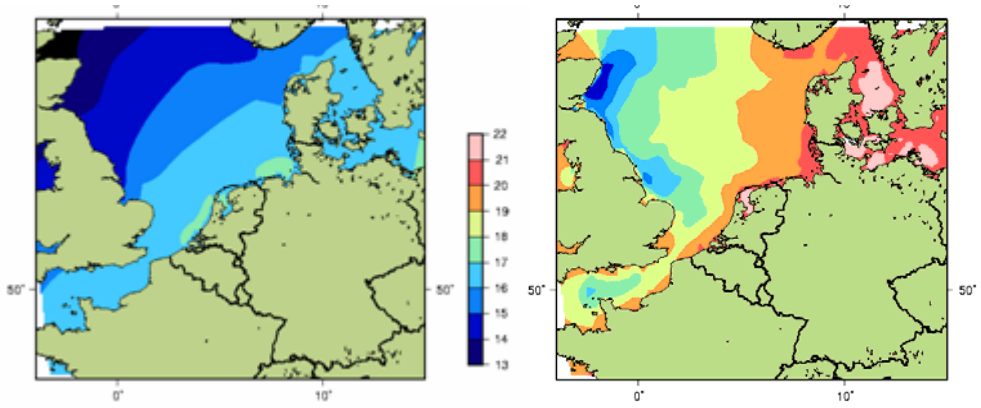
- July was anomalously warm and dry
- Precipitation August 2006





Sea surface temperature

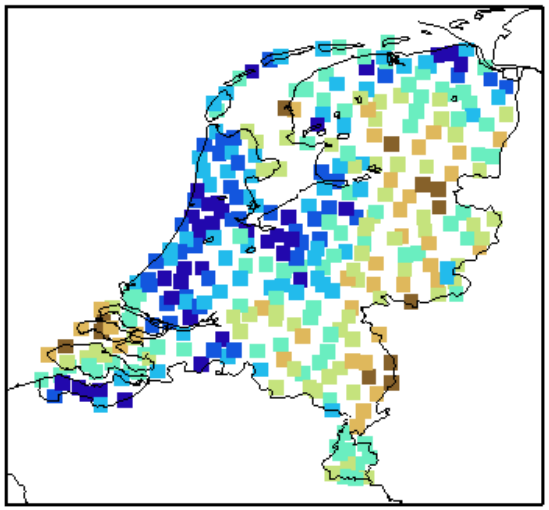
normal Aug 2006



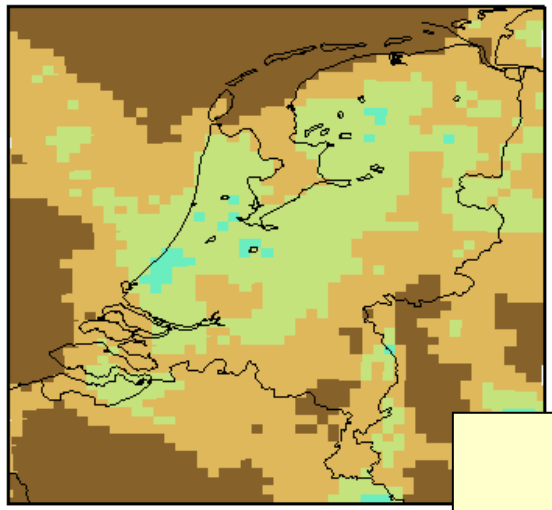
courtesy Geert Lenderink
Erik van Meijgaard

Precipitation gradient

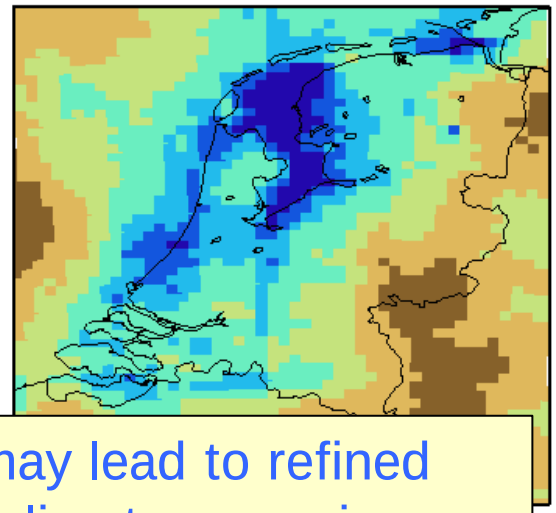
- Heavy precipitation limited to coastal zone



run with normal SST



run with true Aug'06 SST

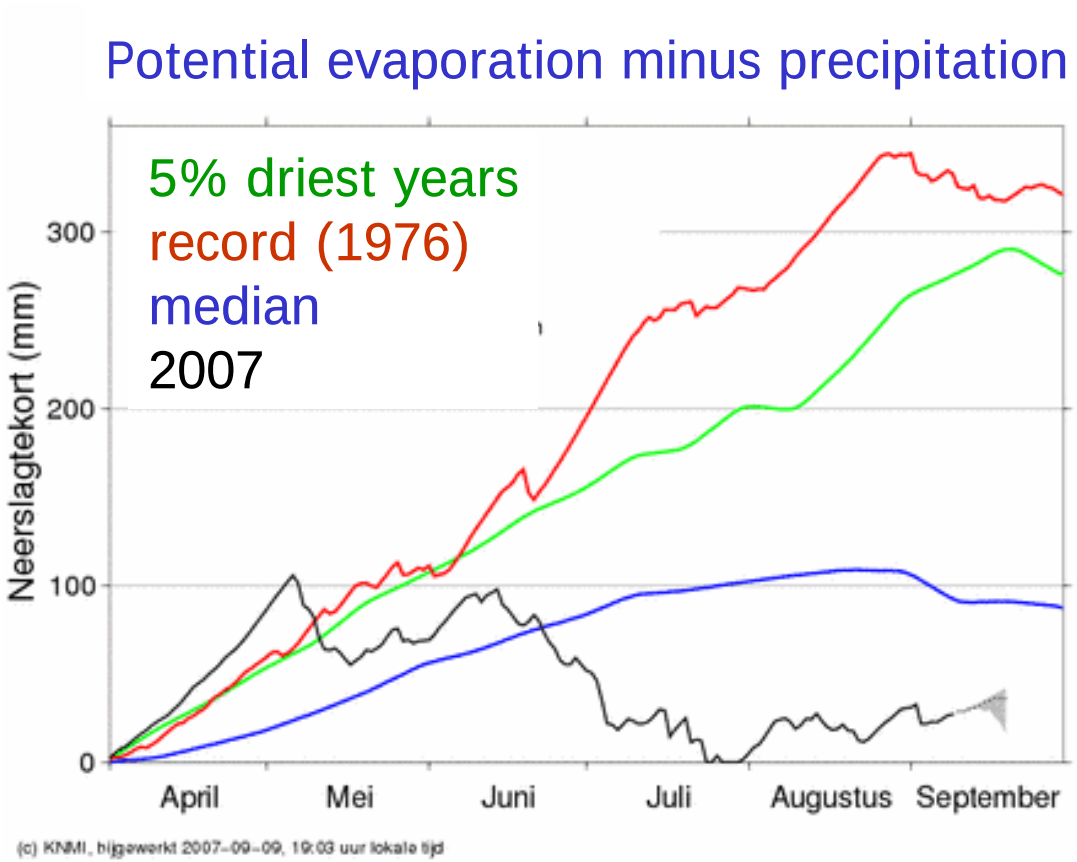


may lead to refined climate scenarios

courtesy Geert Lenderink
Erik van Meijgaard

Spring and summer 2007

- April was extremely dry and warm
- Summer (June-July-August) very wet and cool



Conclusions

- Regional variability increases
  - at daily time scale (changes of extremes are stronger than changes of means)
  - within a season (nr of wet days changes, evidence for rapid transition of persistent anomalous episodes)
  - between years (scenarios differ widely but none can be excluded)
- Climate change scenarios will continue to develop
  - present state of the art is different from yesterday's