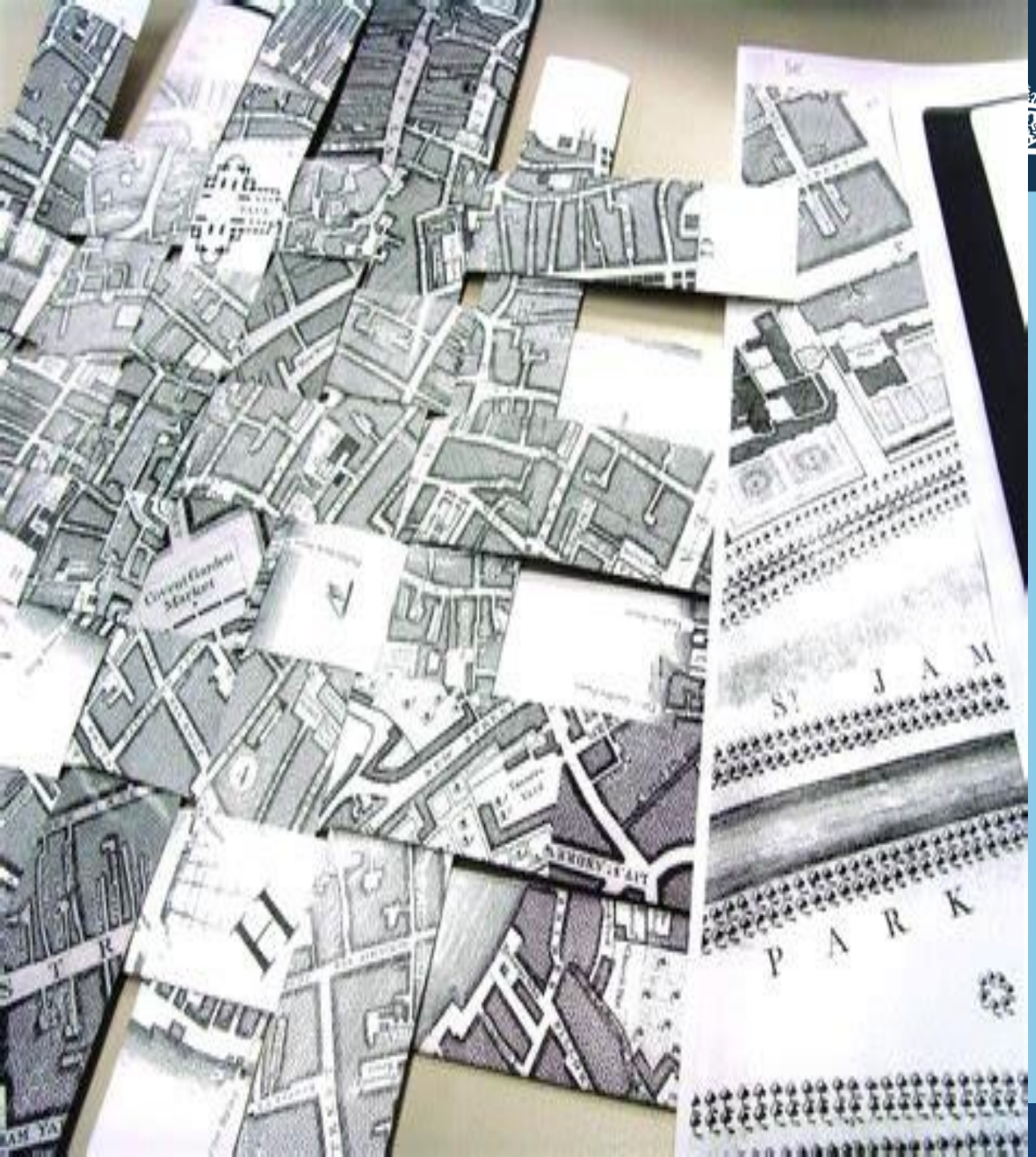
Lecture 3



Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu

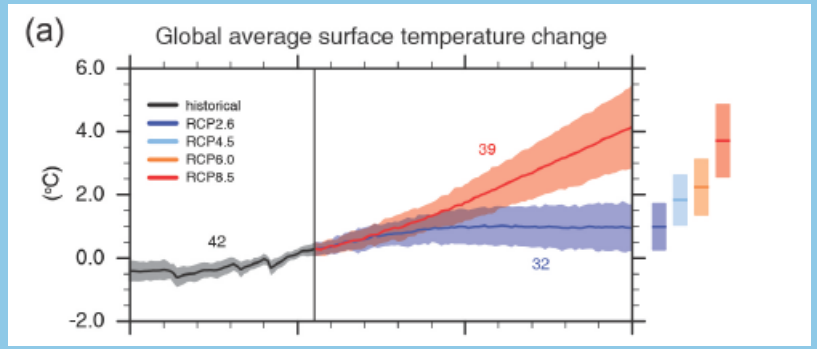
Exploiting the climate archives for meaningful events

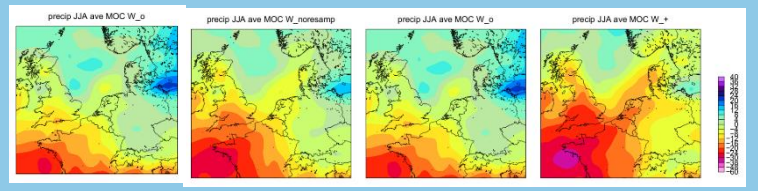
Bart van den Hurk

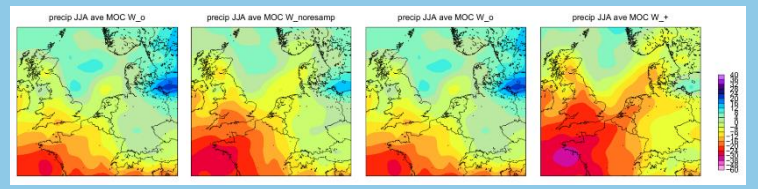
(mainly KNMI material)

The “IPCC” approach

- Future conditions are mapped using a scenario framework
  - complex GCMs as major mapping tool
  - Regional downscaling to generate “locally relevant” information
  - Detailled impact modelling to generate sector/region specific information







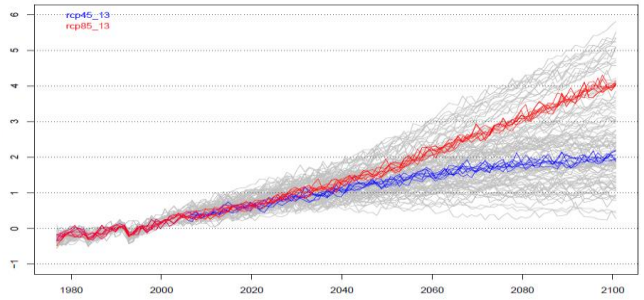
From data and models to decisions

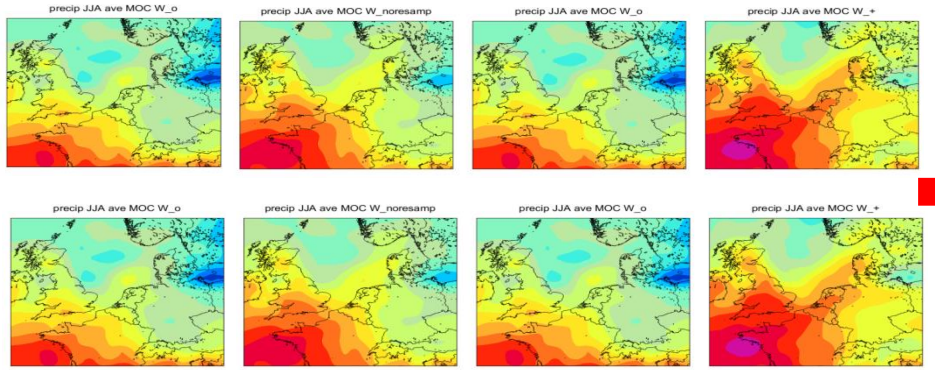
- The classical model:
  - Decisions need input information about likely circumstances
  - Scientists give evidence of cause and direction of change
  - Co-development of decision support tools needed to bridge “knowledge gap”

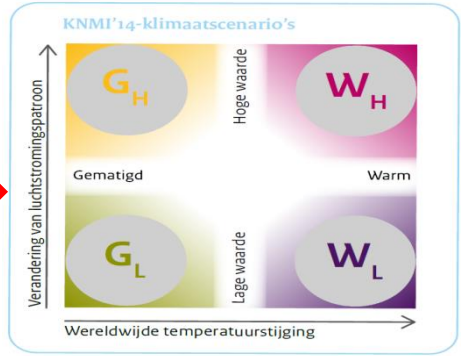
- The fundamental problems:
  - (Climate) information plays minor role in many (most) decisions
  - Scientific interest covers more than decision support
  - Fundamental difference in perception of the arena of interest by the “co-developpers”
    - science is built on “general concepts”
    - decisions are based on “special conditions”

What are (KNMI'14) climate scenarios?

- (1) A comprehensive summary of large ensemble of climate projections



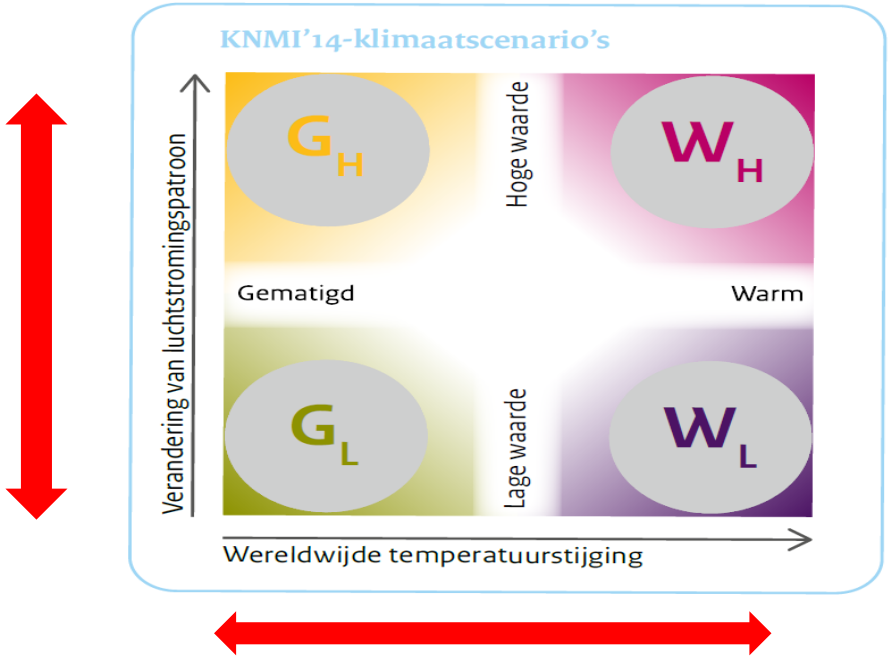




What are (KNMI'14) climate scenarios?

- (1) A comprehensive summary of large ensemble of climate projections

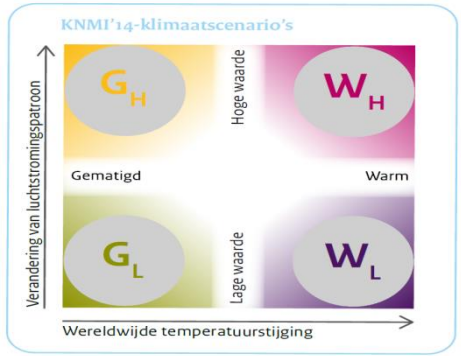
- Separating two important drivers:
  - Global temperature change
  - Anomalies related to variations in
    - regional atm. circulation (precipitation, extremes)
    - ice cap dynamics (sea level rise)

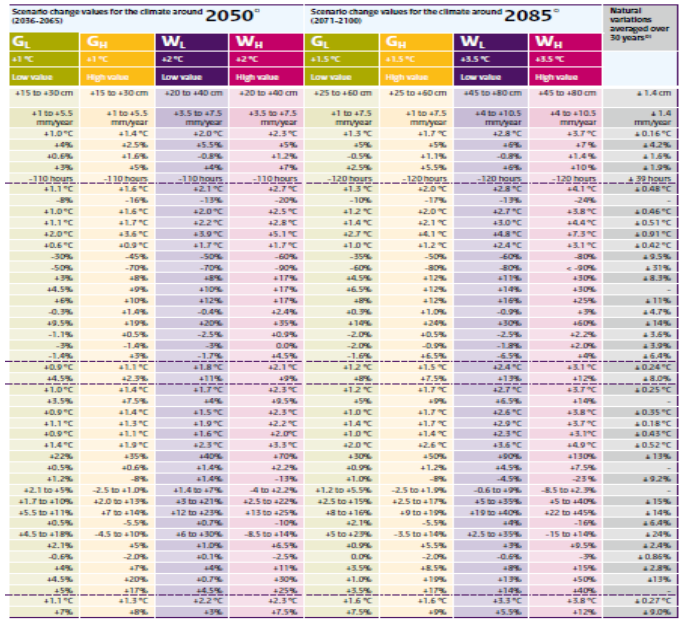


- Condensation of 245 GCM projections into 4 locally relevant scenarios

What are (KNMI'14) climate scenarios?

- (2) A local interpretation of this summary





- Long table of relevant climatological indicators and their change
- Well embedded in Dutch water management design

Main product

4 seasons

Many variables

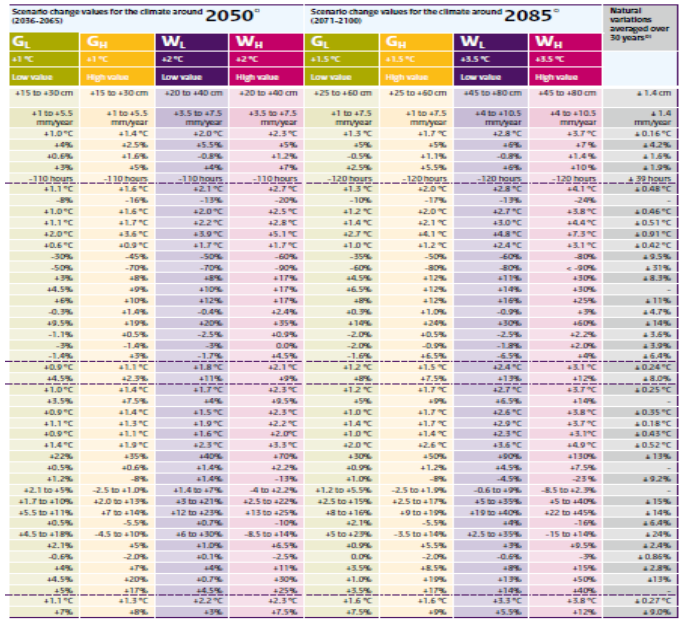
Normals and trends

Natural variability:
- 30 yr avg
- yr-2-yr

Season	Variable	Indicator	Climate 1951-1980	Climate 1981-2010 – reference period	Scenario change values for the climate around 2050 (2035-2065)				Scenario change values for the climate around 2085 (2071-2100)				Natural variations averaged over 30 years
					G_L	G_H	W_L	W_H	G_L	G_H	W_L	W_H	
	Global temperature rise:				+1 °C	+1 °C	+2 °C	+2 °C	+1.5 °C	+1.5 °C	+3.5 °C	+3.5 °C	
	Change in air circulation pattern:				Low value	High value	Low value	High value	Low value	High value	Low value	High value	
Year	Sea level at North Sea coast	absolute level	4 cm below NAP	3 cm above NAP	+15 to +30 cm	+15 to +30 cm	+20 to +40 cm	+20 to +40 cm	+25 to +60 cm	+25 to +60 cm	+45 to +80 cm	+45 to +80 cm	± 1.4 cm
		rate of change	1.2 mm/year	2.0 mm/year	+1 to +5.5 mm/year	+1 to +5.5 mm/year	+3.5 to +7.5 mm/year	+3.5 to +7.5 mm/year	+1 to +7.5 mm/year	+1 to +7.5 mm/year	+4 to +10.5 mm/year	+4 to +10.5 mm/year	± 1.4 mm/year
	Temperature	mean	9.2 °C	10.1 °C	+1.0 °C	+1.4 °C	+2.0 °C	+2.3 °C	+1.3 °C	+1.7 °C	+2.8 °C	+3.7 °C	± 0.16 °C
	Precipitation	mean amount	774 mm	851 mm	+4%	+2.5%	+5.5%	+5%	+5%	+5%	+6%	+7 %	± 4.2%
	Solar radiation	solar radiation	346 kJ/cm²	354 kJ/cm²	+0.6%	+1.6%	-0.8%	+1.2%	-0.5%	+1.1%	-0.8%	+1.4 %	± 1.6%
	Evaporation	potential evaporation (Makkink)	534 mm	559 mm	+3%	+5%	+4%	+7%	+2.5%	+5.5%	+6%	+10 %	± 1.9%
	Fog	number of hours with visibility < 1 km	412 hours	300 hours	-110 hours	-110 hours	-110 hours	-110 hours	-120 hours	-120 hours	-120 hours	-120 hours	± 39 hours
Winter	Temperature	mean	2.4 °C	3.4 °C	+1.1 °C	+1.6 °C	+2.1 °C	+2.7 °C	+1.3 °C	+2.0 °C	+2.8 °C	+4.1 °C	± 0.48 °C
		year-to-year variation	-	± 2.6 °C	-8%	-16%	-13%	-20%	-10%	-17%	-13%	-24%	-
		daily maximum	5.1 °C	6.1 °C	+1.0 °C	+1.6 °C	+2.0 °C	+2.5 °C	+1.2 °C	+2.0 °C	+2.7 °C	+3.8 °C	± 0.46 °C
		daily minimum	-0.3 °C	0.5 °C	+1.1 °C	+1.7 °C	+2.2 °C	+2.8 °C	+1.4 °C	+2.1 °C	+3.0 °C	+4.4 °C	± 0.51 °C
		coldest winter day per year	-7.5 °C	-5.9 °C	+2.0 °C	+3.6 °C	+3.9 °C	+5.1 °C	+2.7 °C	+4.1 °C	+4.8 °C	+7.3 °C	± 0.91 °C
		mildest winter day per year	10.3 °C	11.1 °C	+0.6 °C	+0.9 °C	+1.7 °C	+1.7 °C	+1.0 °C	+1.2 °C	+2.4 °C	+3.1 °C	± 0.42 °C
		number of frost days (min temp < 0°C)	42 days	38 days	-30%	-45%	-50%	-60%	-35%	-50%	-60%	-80%	± 9.5%
		number of ice days (max temp < 0°C)	11 days	7.2 days	-50%	-70%	-70%	-90%	-60%	-80%	-80%	< -90%	± 31%
	Precipitation	mean amount	188 mm	211 mm	+3%	+8%	+8%	+17%	+4.5%	+12%	+11%	+30%	± 8.3%
		year-to-year variation	-	± 96 mm	+4.5%	+9%	+10%	+17%	+6.5%	+12%	+14%	+30%	-
		10-day amount exceeded once in 10 years	80 mm	89 mm	+6%	+10%	+12%	+17%	+8%	+12%	+16%	+25%	± 11%
		number of wet days (≥ 0.1 mm)	56 days	55 days	-0.3%	+1.4%	-0.4%	+2.4%	+0.3%	+1.0%	-0.9%	+3%	± 4.7%
		number of days ≥ 10 mm	4.1 days	5.3 days	+9.5%	+19%	+20%	+35%	+14%	+24%	+30%	+60%	± 14%
	Wind	mean wind speed	-	6.9 m/s	-1.1%	+0.5%	-2.5%	+0.9%	-2.0%	+0.5%	-2.5%	+2.2%	± 3.6%
		highest daily mean wind speed per year	-	15 m/s	-3%	-1.4%	-3%	0.0%	-2.0%	-0.9%	-1.8%	+2.0%	± 3.9%
		number of days between south and west	44 days	49 days	-1.4%	+3%	-1.7%	+4.5%	-1.6%	+6.5%	-6.5%	+4%	± 6.4%
Spring	Temperature	mean	8.3 °C	9.5 °C	+0.9 °C	+1.1 °C	+1.8 °C	+2.1 °C	+1.2 °C	+1.5 °C	+2.4 °C	+3.1 °C	± 0.24 °C
	Precipitation	mean amount	148 mm	173 mm	+4.5%	+2.3%	+11%	+9%	+8%	+7.5%	+13%	+12%	± 8.0%
Summer	Temperature	mean	16.1 °C	17.0 °C	+1.0 °C	+1.4 °C	+1.7 °C	+2.3 °C	+1.2 °C	+1.7 °C	+2.7 °C	+3.7 °C	± 0.25 °C
		year-to-year variation	-	± 1.4 °C	+3.5%	+7.5%	+4%	+9.5%	+5%	+9%	+6.5%	+14%	-
		daily maximum	20.7 °C	21.9 °C	+0.9 °C	+1.4 °C	+1.5 °C	+2.3 °C	+1.0 °C	+1.7 °C	+2.6 °C	+3.8 °C	± 0.35 °C
		daily minimum	11.2 °C	11.9 °C	+1.1 °C	+1.3 °C	+1.9 °C	+2.2 °C	+1.4 °C	+1.7 °C	+2.9 °C	+3.7 °C	± 0.18 °C
		coolest summer day per year	10.3 °C	11.1 °C	+0.9 °C	+1.1 °C	+1.6 °C	+2.0 °C	+1.0 °C	+1.4 °C	+2.3 °C	+3.1 °C	± 0.43 °C
		warmest summer day per year	23.2 °C	24.7 °C	+1.4 °C	+1.9 °C	+2.3 °C	+3.3 °C	+2.0 °C	+2.6 °C	+3.6 °C	+4.9 °C	± 0.52 °C
		number of summer days (max temp ≥ 25°C)	13 days	21 days	+22%	+35%	+40%	+70%	+30%	+50%	+90%	+130%	± 13%
		number of tropical nights (min temp ≥ 20°C)	< 0.1 days	0.1 days	+0.5%	+0.6%	+1.4%	+2.2%	+0.9%	+1.2%	+4.5%	+7.5%	-
	Precipitation	mean amount	224 mm	224 mm	+1.2%	-8%	+1.4%	-13%	+1.0%	-8%	-4.5%	-23 %	± 9.2%
		year-to-year variation	-	± 113 mm	+2.1 to +5%	-2.5 to +1.0%	+1.4 to +7%	-4 to +2.2%	+1.2 to +5.5%	-2.5 to +1.9%	-0.6 to +9%	-8.5 to +2.3%	-
		daily amount exceeded once in 10 years	44 mm	44 mm	+1.7 to +10%	+2.0 to +13%	+3 to +21%	+2.5 to +22%	+2.5 to +15%	+2.5 to +17%	+5 to +35%	+5 to +40%	± 15%
		maximum hourly intensity per year	14.9 mm/hour	15.1 mm/hour	+5.5 to +11%	+7 to +14%	+12 to +23%	+13 to +25%	+8 to +16%	+9 to +19%	+19 to +40%	+22 to +45%	± 14%
		number of wet days (≥ 0.1mm)	45 days	43 days	+0.5%	-5.5%	+0.7%	-10%	+2.1%	-5.5%	+4%	-16%	± 6.4%
		number of days ≥ 20 mm	1.6 days	1.7 days	+4.5 to +18%	-4.5 to +10%	+6 to +30%	-8.5 to +14%	+5 to +23%	-3.5 to +14%	+2.5 to +35%	-15 to +14%	± 24%
	Solar radiation	solar radiation	149 kJ/cm²	153 kJ/cm²	+2.1%	+5%	+1.0%	+6.5%	+0.9%	+5.5%	+3%	+9.5%	± 2.4%
	Humidity	relative humidity	78%	77%	-0.6%	-2.0%	+0.1%	-2.5%	0.0%	-2.0%	-0.6%	-3%	± 0.86%
	Evaporation	potential evaporation (Makkink)	253 mm	266 mm	+4%	+7%	+4%	+11%	+3.5%	+8.5%	+8%	+15%	± 2.8%
	Drought	mean highest precipitation deficit during growing season	140 mm	144 mm	+4.5%	+20%	+0.7%	+30%	+1.0%	+19%	+13%	+50%	±13%
		highest precipitation deficit exceeded once in 10 years	-	230 mm	+5%	+17%	+4.5%	+25%	+3.5%	+17%	+14%	+40%	-
Autumn	Temperature	mean	10.0 °C	10.6 °C	+1.1 °C	+1.3 °C	+2.2 °C	+2.3 °C	+1.6 °C	+1.6 °C	+3.3 °C	+3.8 °C	± 0.27 °C
	Precipitation	mean amount	214 mm	245 mm	+7%	+8%	+3%	+7.5%	+7.5%	+9%	+5.5%	+12%	± 9.0%

What are (KNMI'14) climate scenarios?

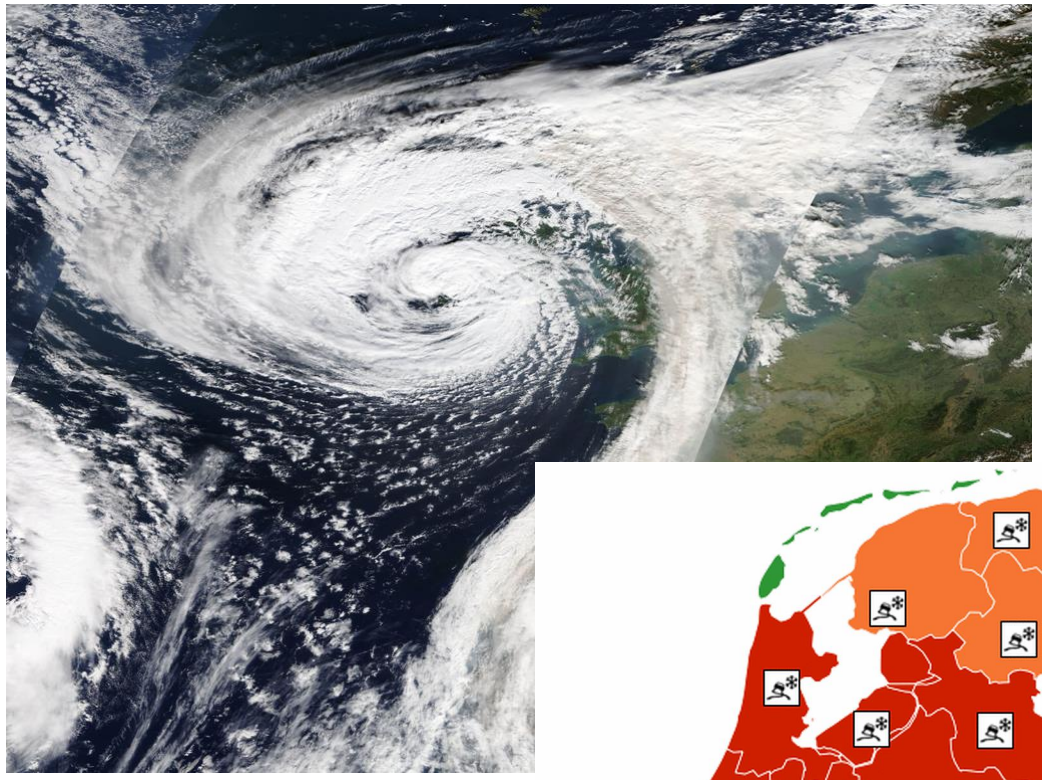
- (2) A local interpretation of this summary

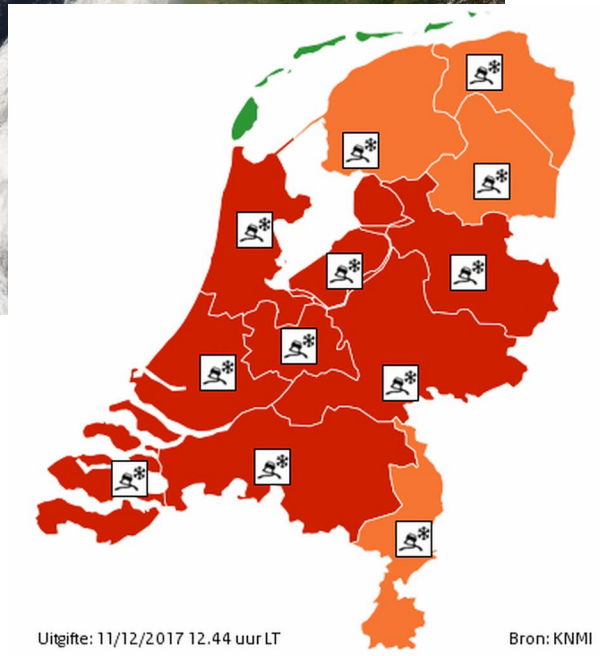


But a lot of **essential information** on weather, disasters, remote impacts, compounding effects etc. is hidden

- Long table tors and their change
- Well embec nt design
- But still a long distance from decision support

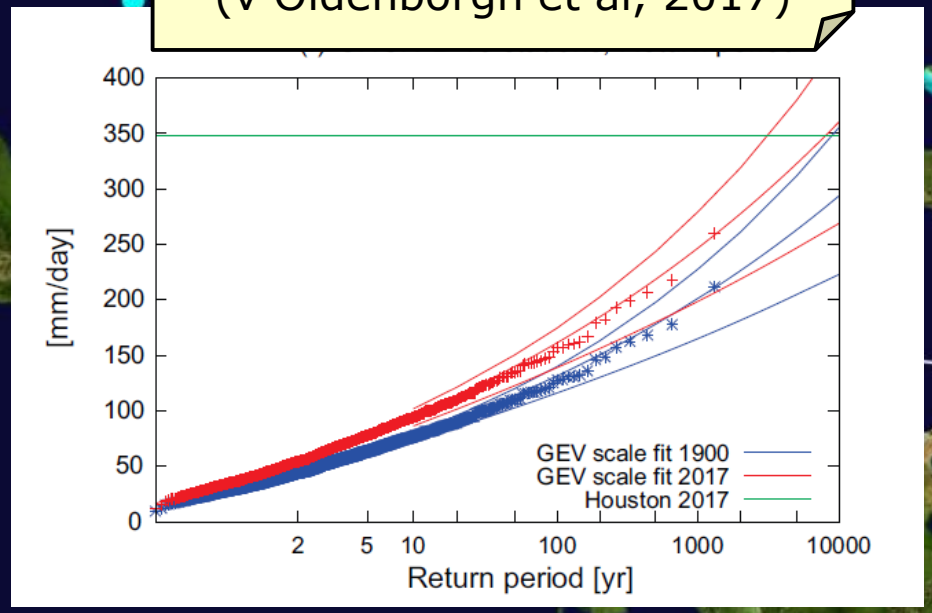
A few "incidents"

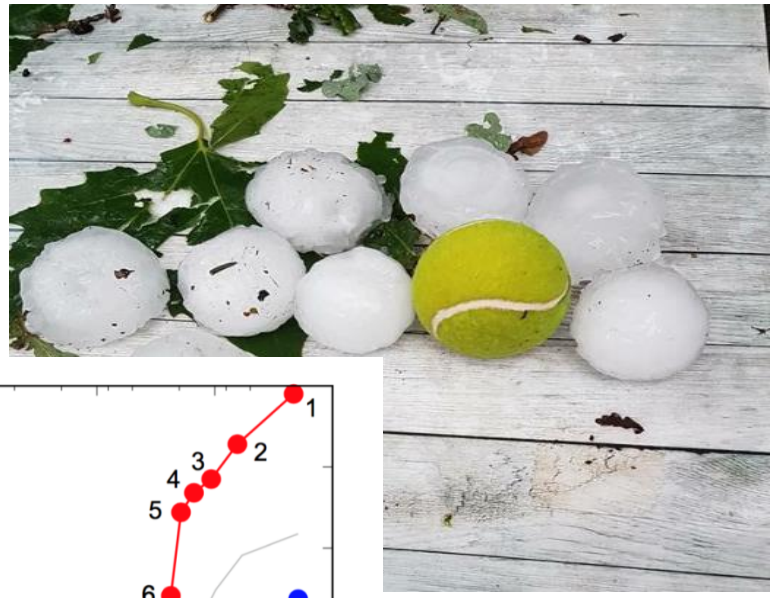


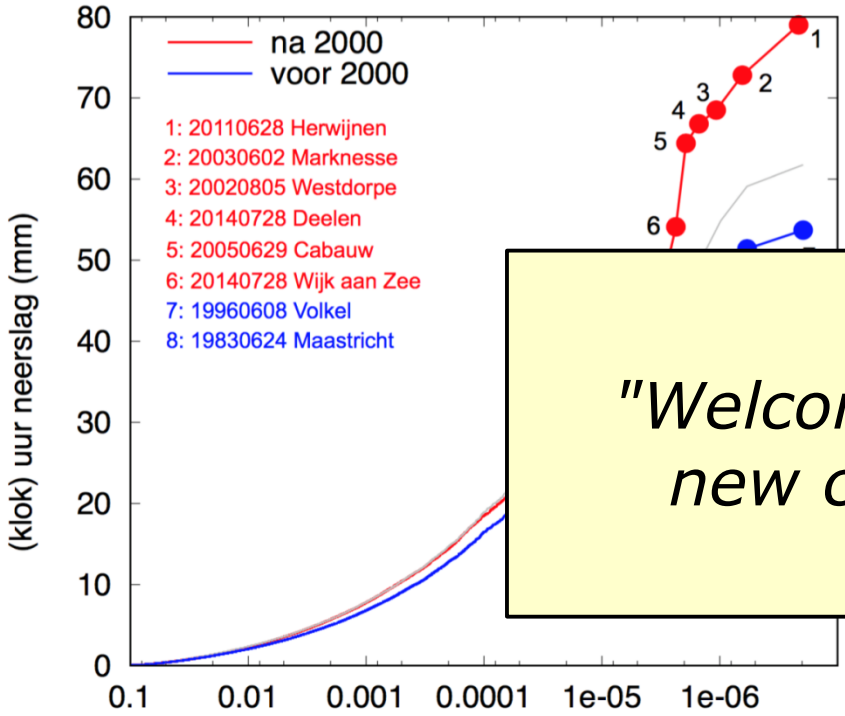


Events triggering discussions...

a 1/9000 yrs event
(v Oldenborgh et al, 2017)

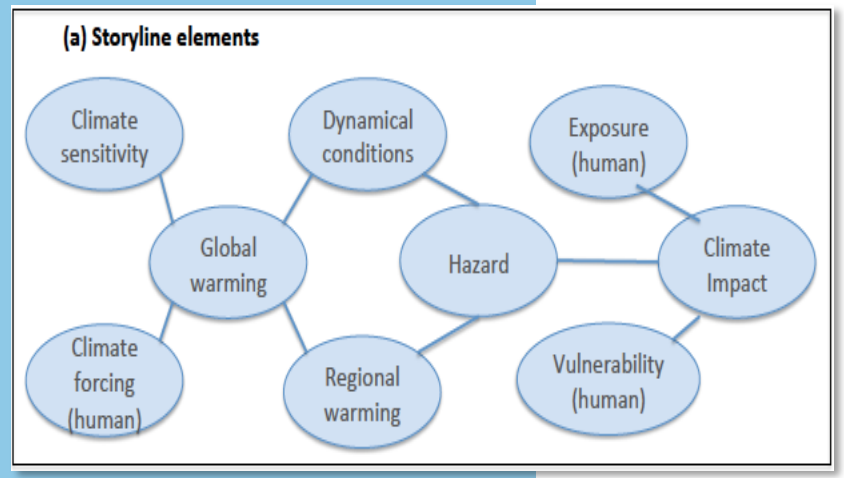


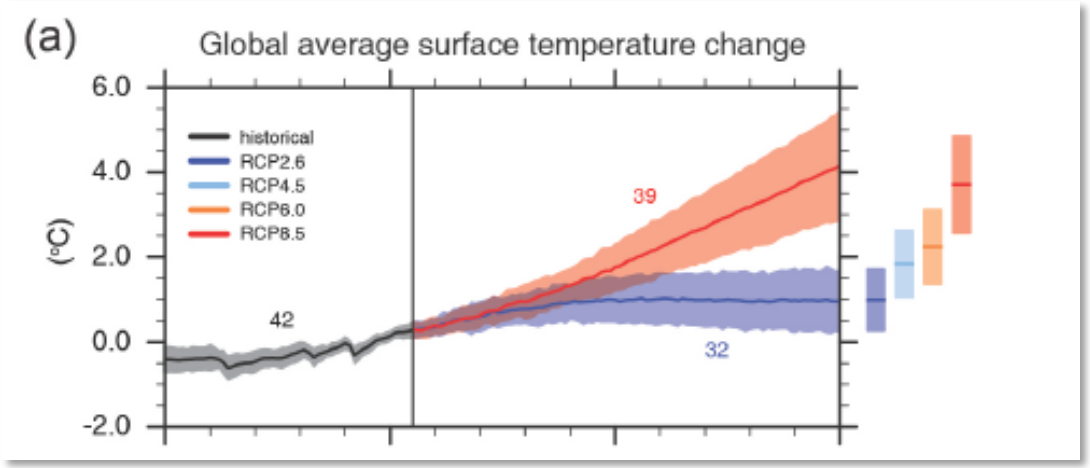


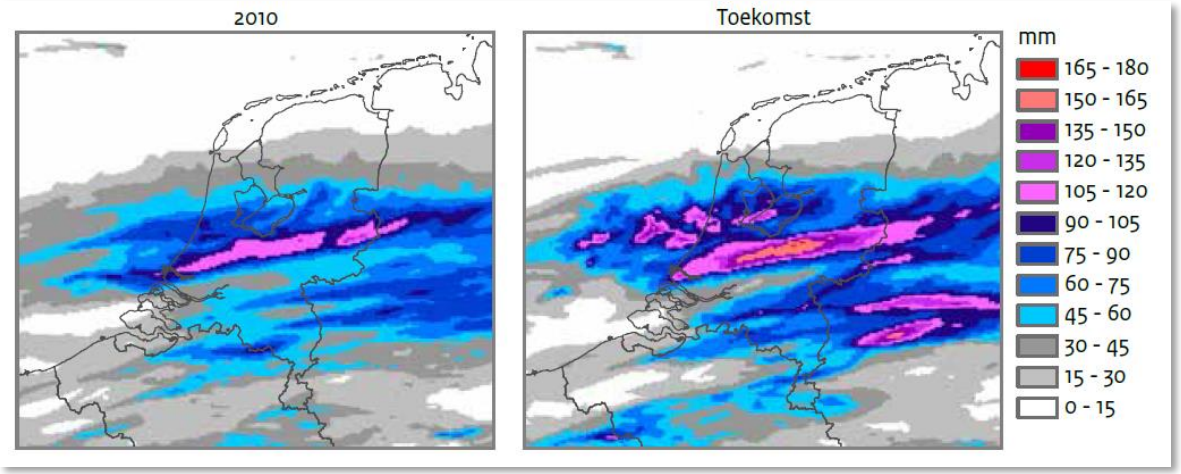


"Welcome in the new climate"

About storylines and event storylines

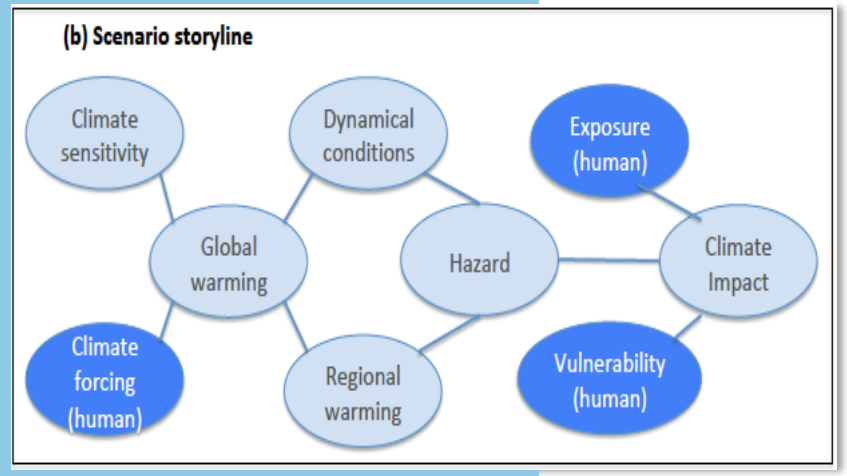


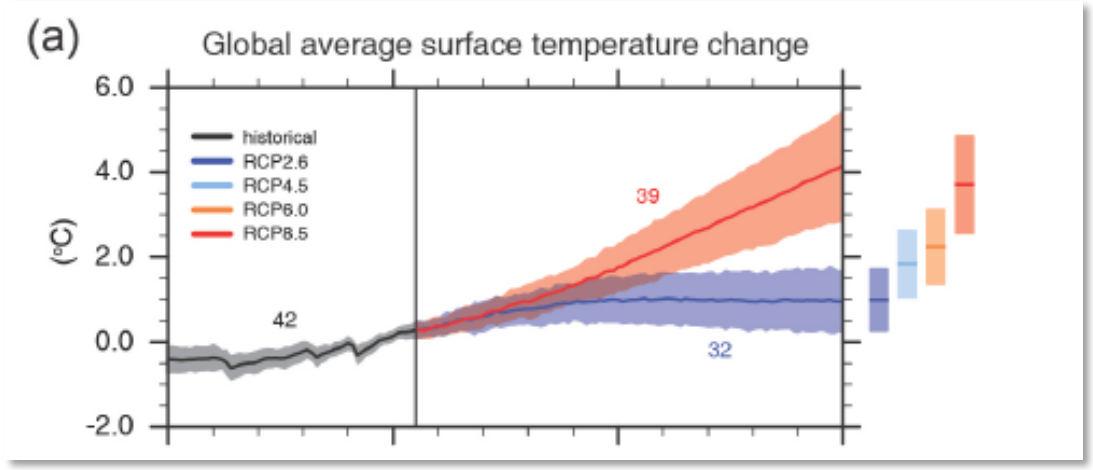


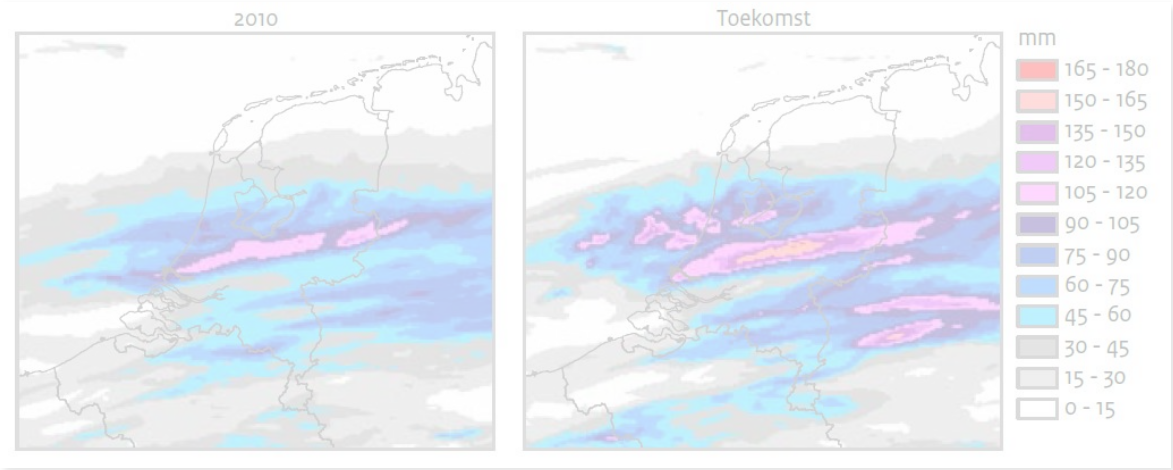


REGEIPT 2

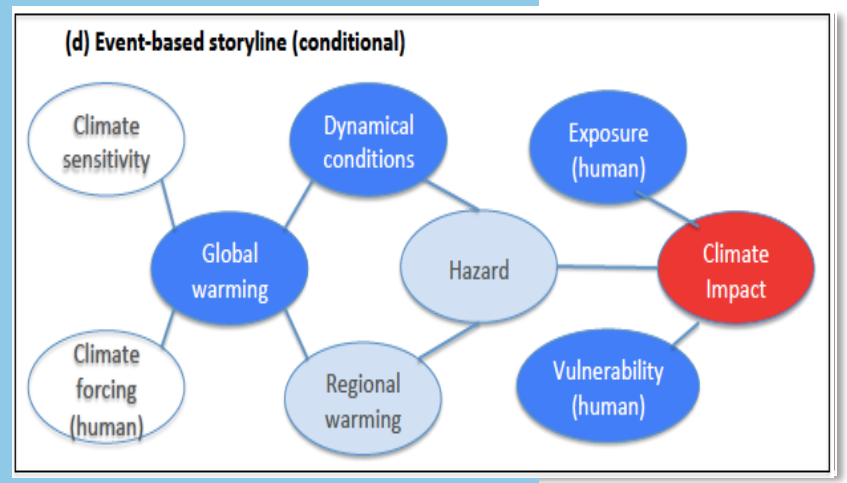
About storylines and event storylines

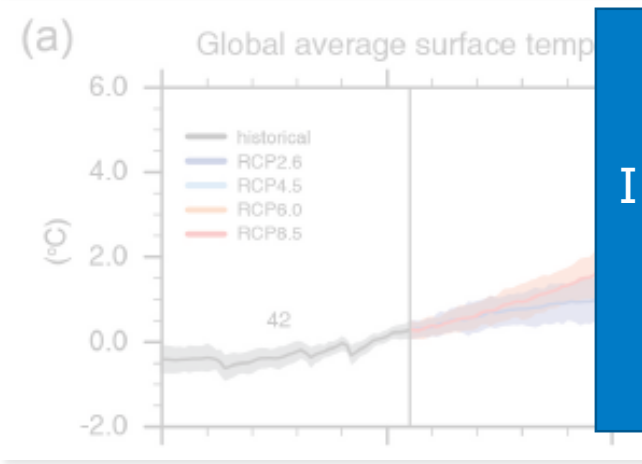




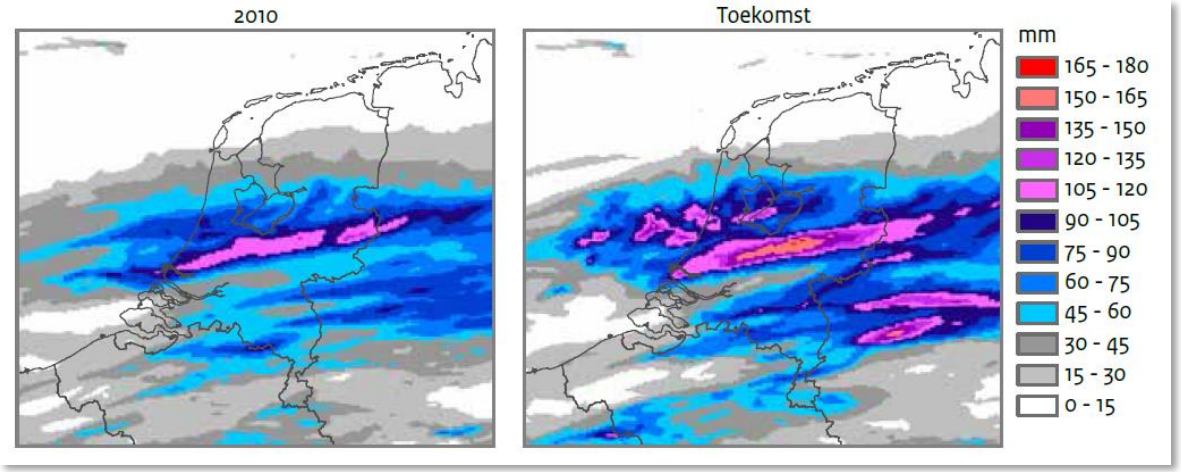


About storylines and event storylines



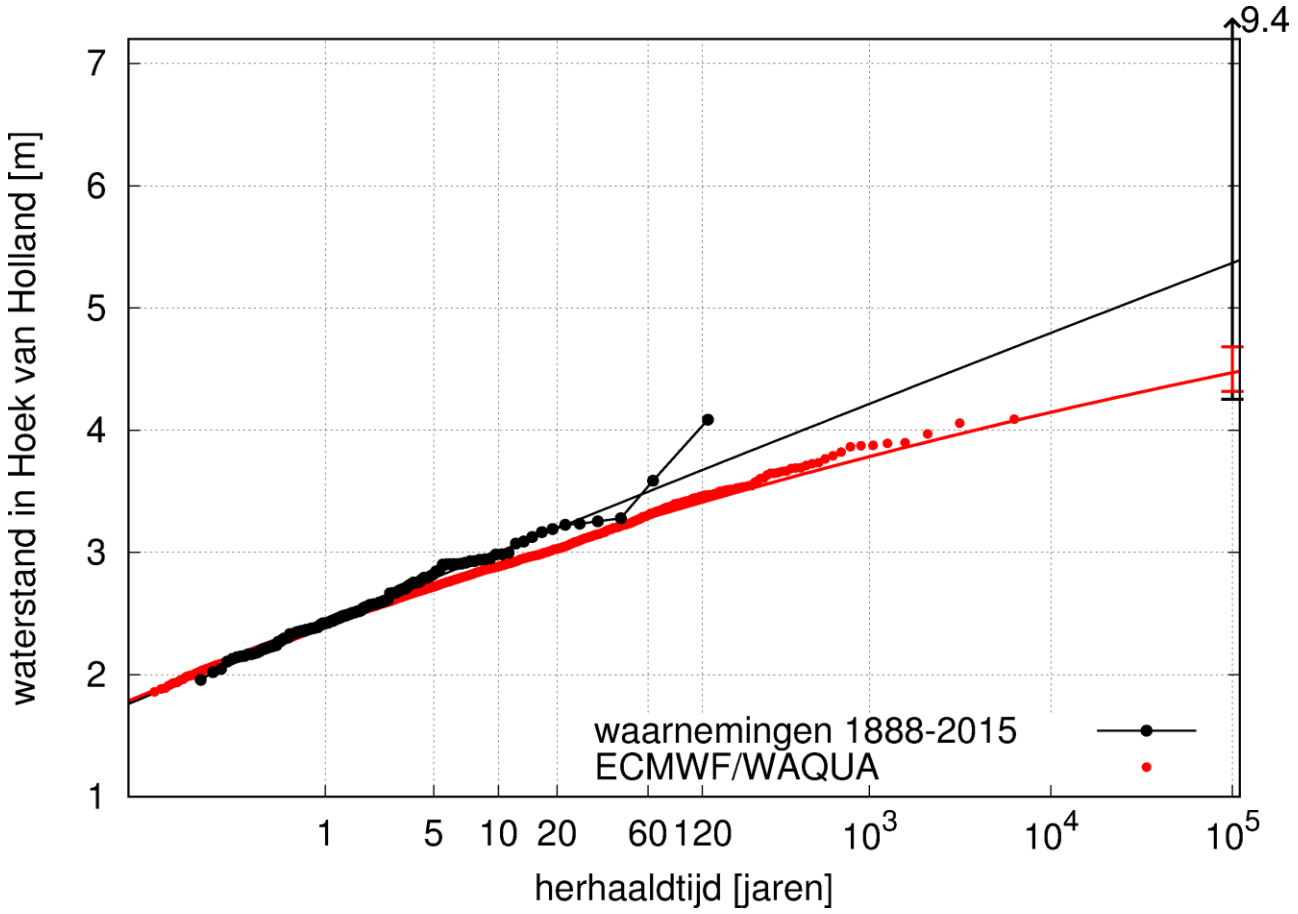


Confucius:
"I hear and I forget,
I see and I remember,
I do and I understand"

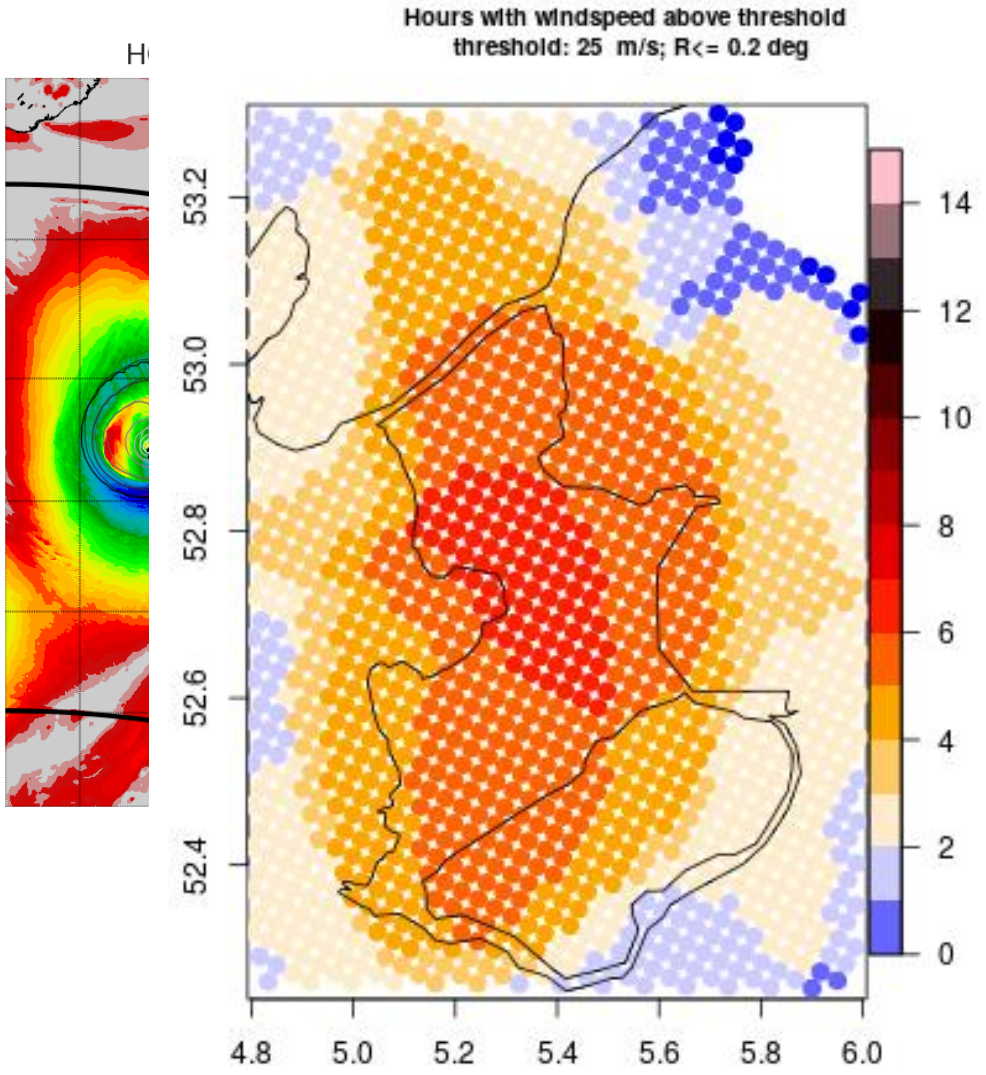


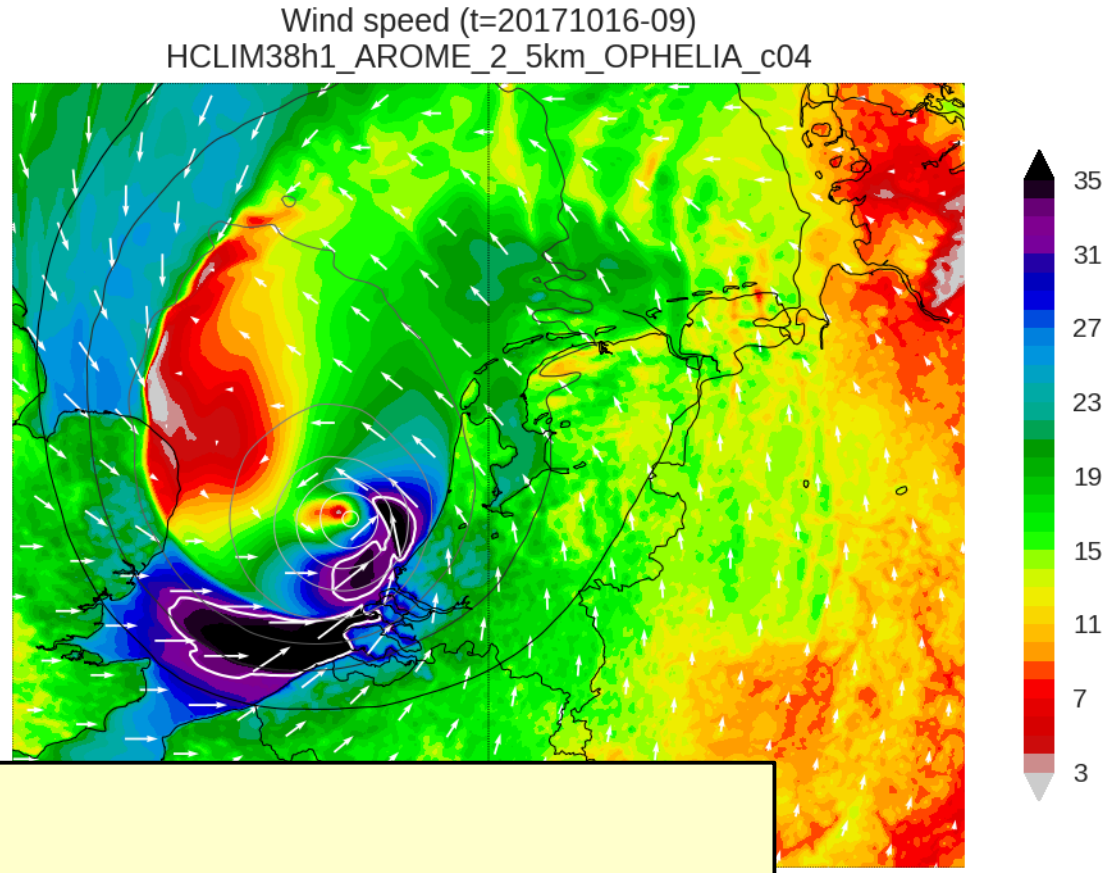
Wind research in context of national infrastructure

- Use of (ECMWF) EPS to improve on the statistics
  - Strong reduction of uncertainty in extreme values



How does Ophelia fit in this distribution?

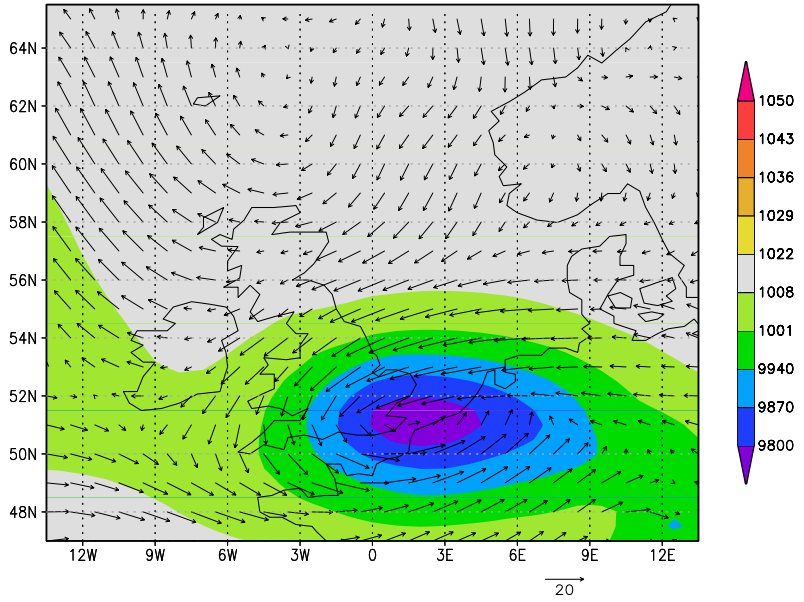




Interesting extreme wind-case

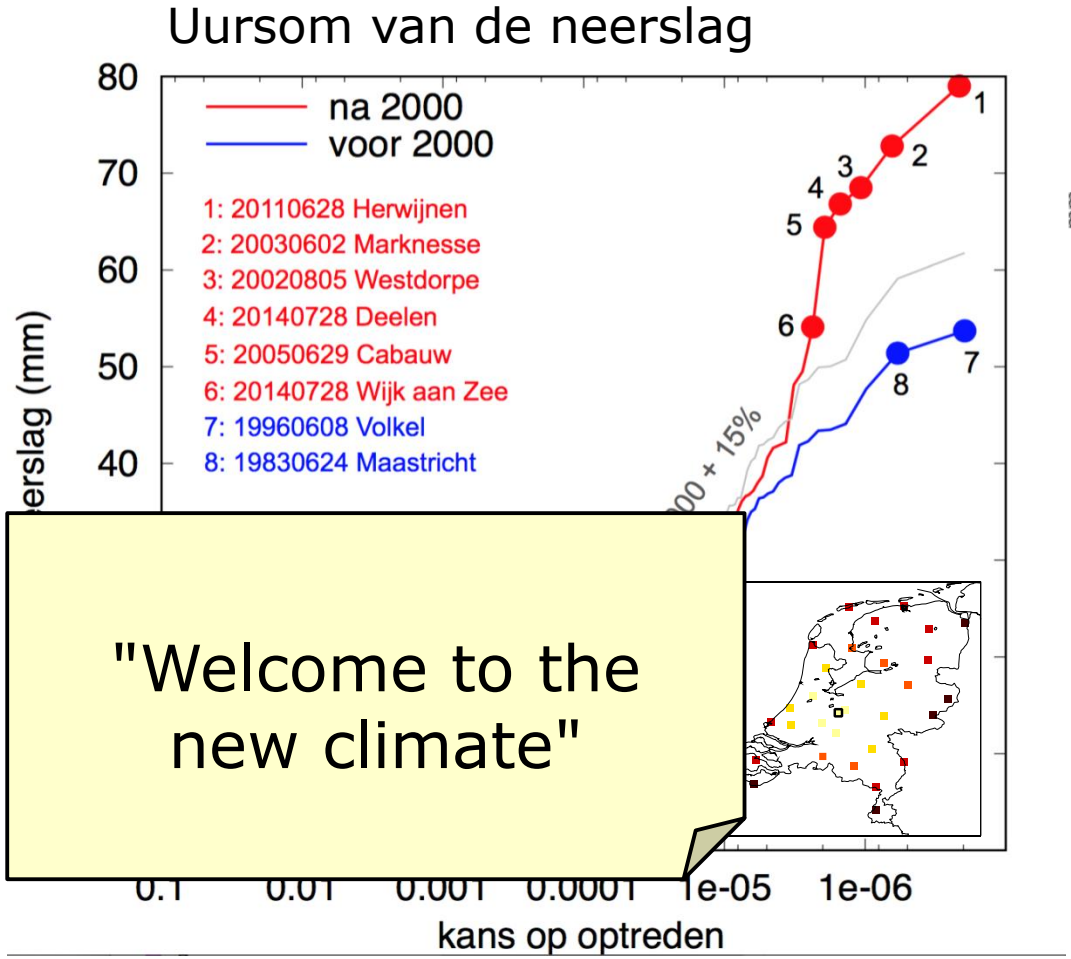
Dike reinforcement plan north of Amsterdam

- Citizen's concern
  - Design criteria inspired by extreme water levels induced by multiday strong Eastern Wind over Ijsselmeer
- Future Weather question:
  - Are the meteorological conditions representative for the (statistically obtained) wind conditions realistic?
- Solution:
  - Browse >3500 yrs of seasonal forecast EPS data for multiday easterly winds in target area. Reconstruct the meteorological pressure and wind field.
- Conclusion:
  - the meteorological conditions are realistic, even though they have no precedent.

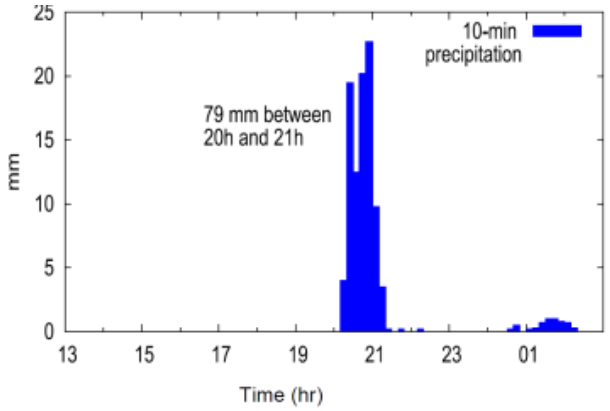


Update of precipitation statistics

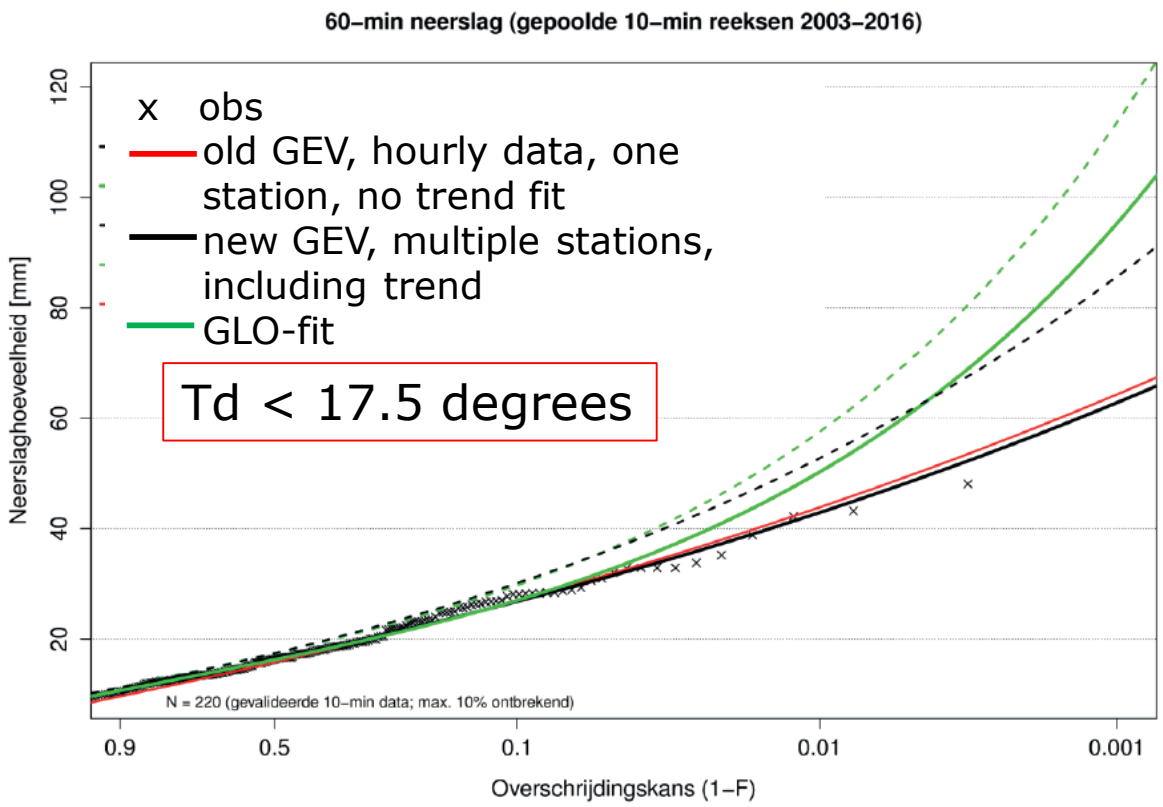
- Relatively many extreme events after 2000

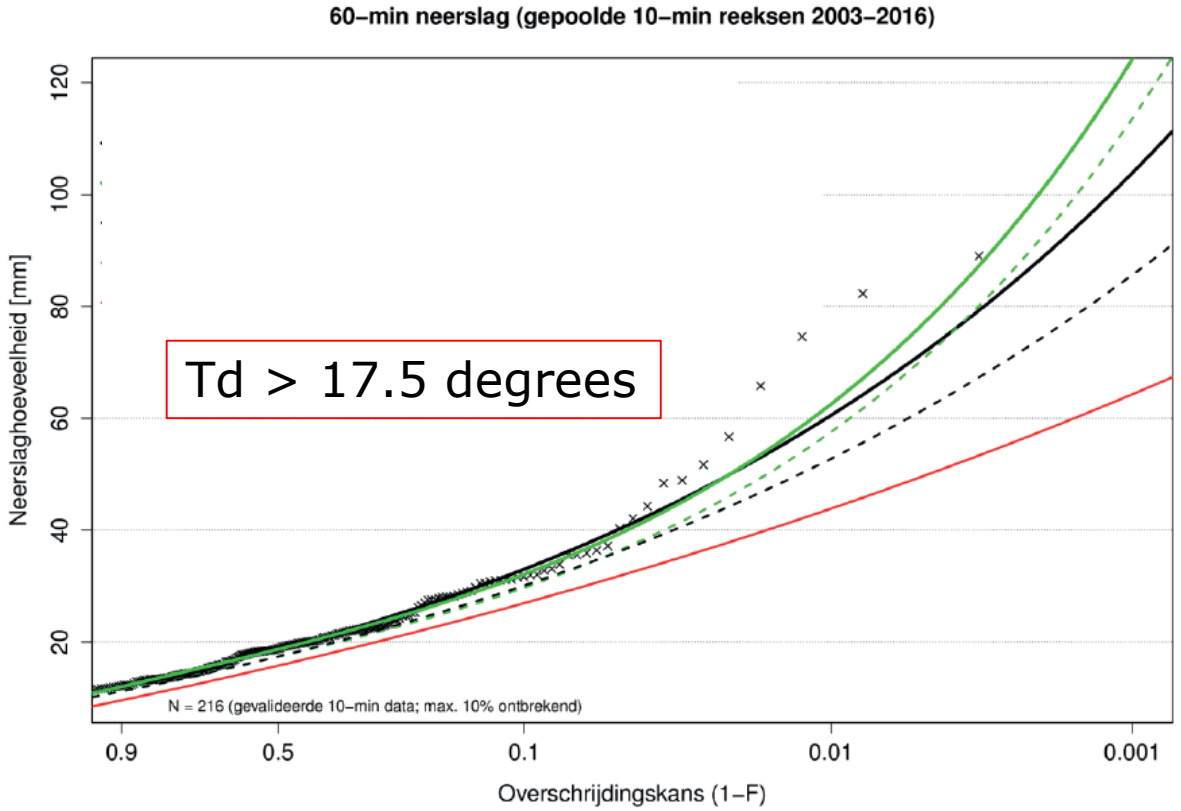


"Welcome to the new climate"



The role of dewpoint

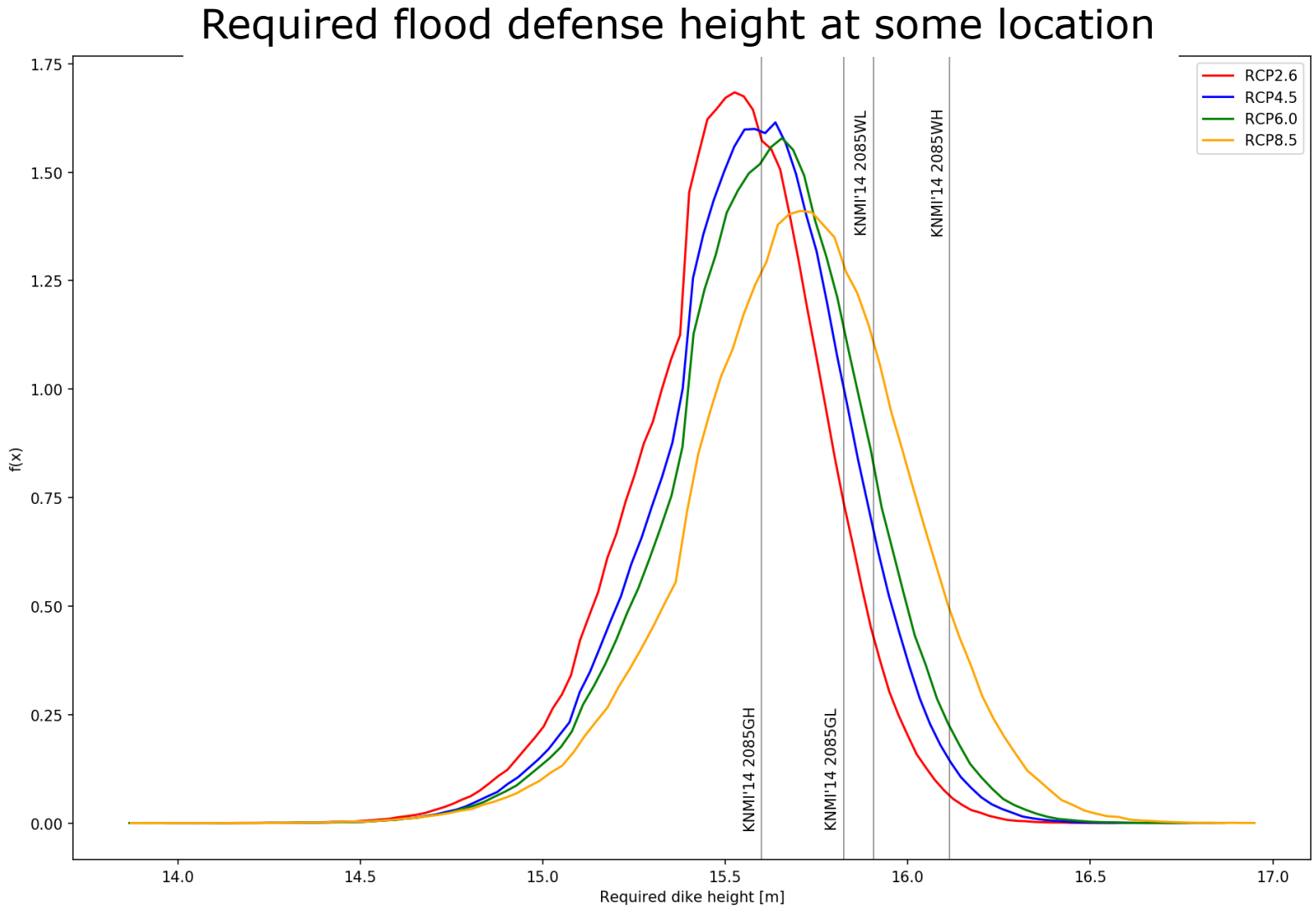




Probabilistic river-discharge scenarios?

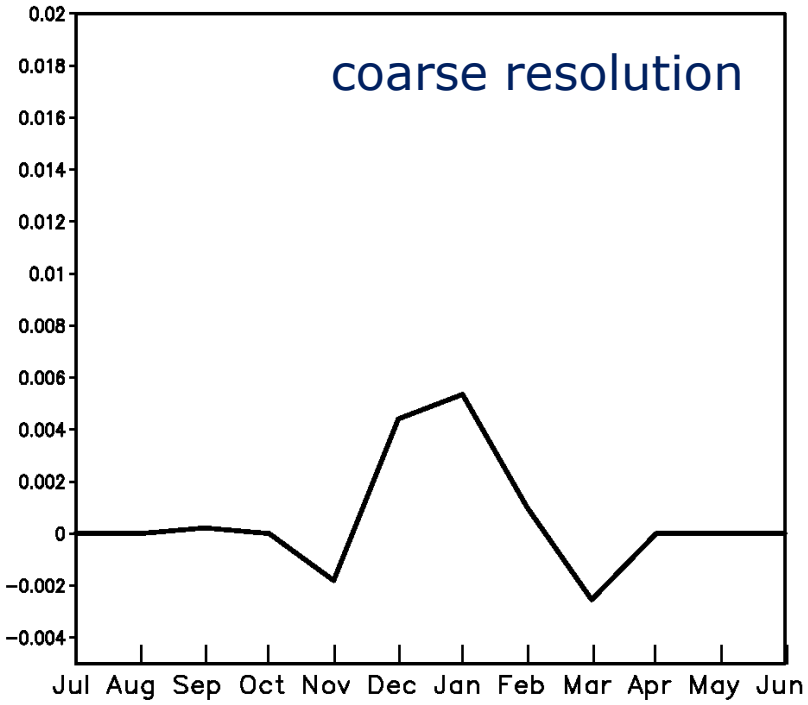
- Role of uncertainty of emission scenarios

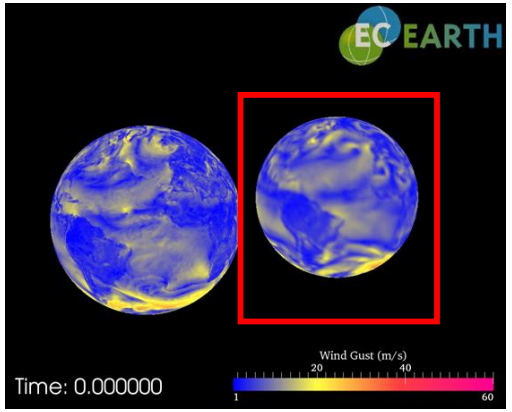
Strong overlap



Simulating unprecedented events

Beaufort 11 or higher

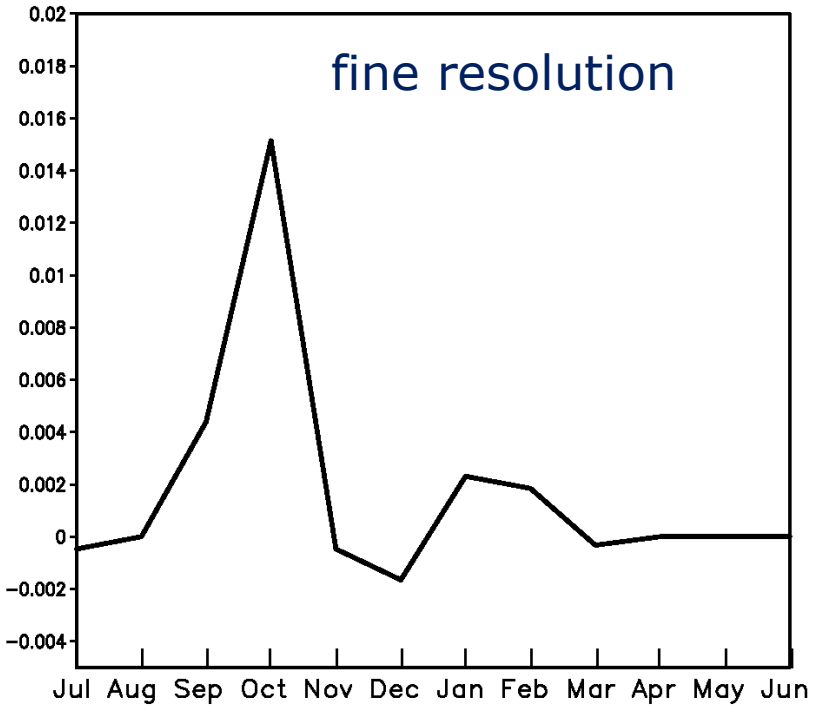


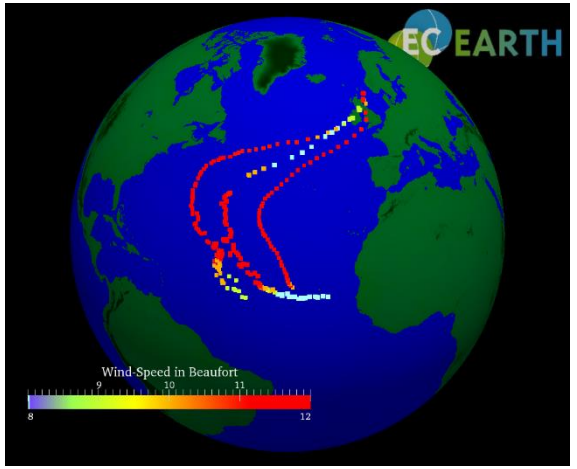


Difference 20th – 21st century

Simulating unprecedented events

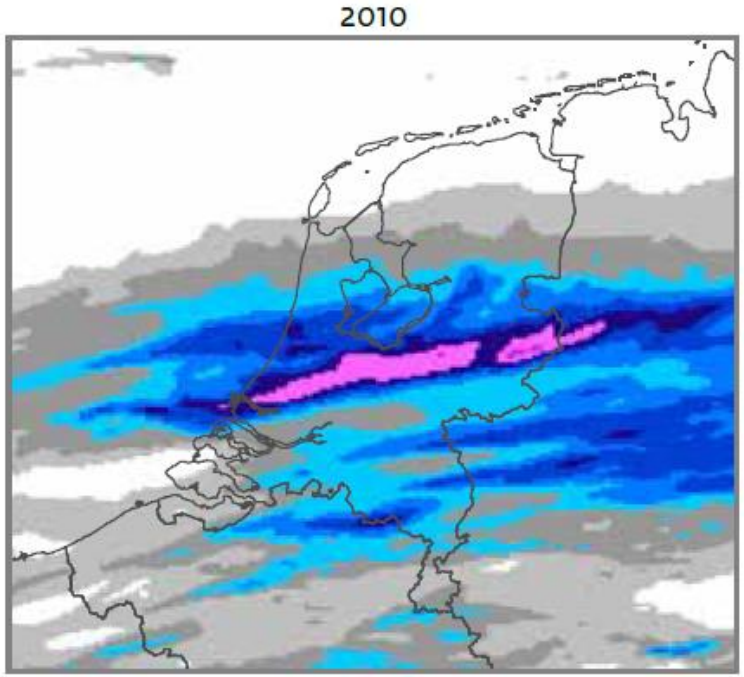
Beaufort 11 or higher



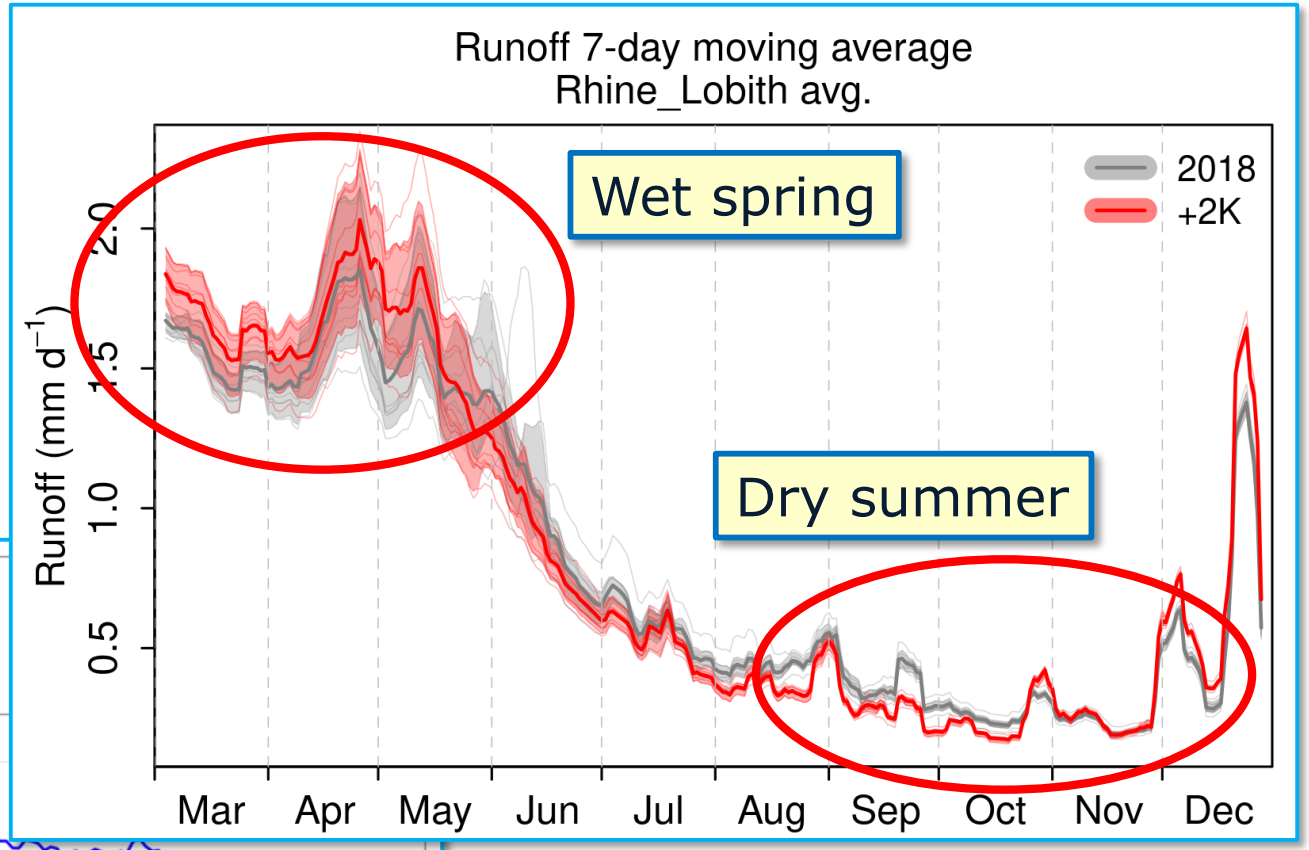


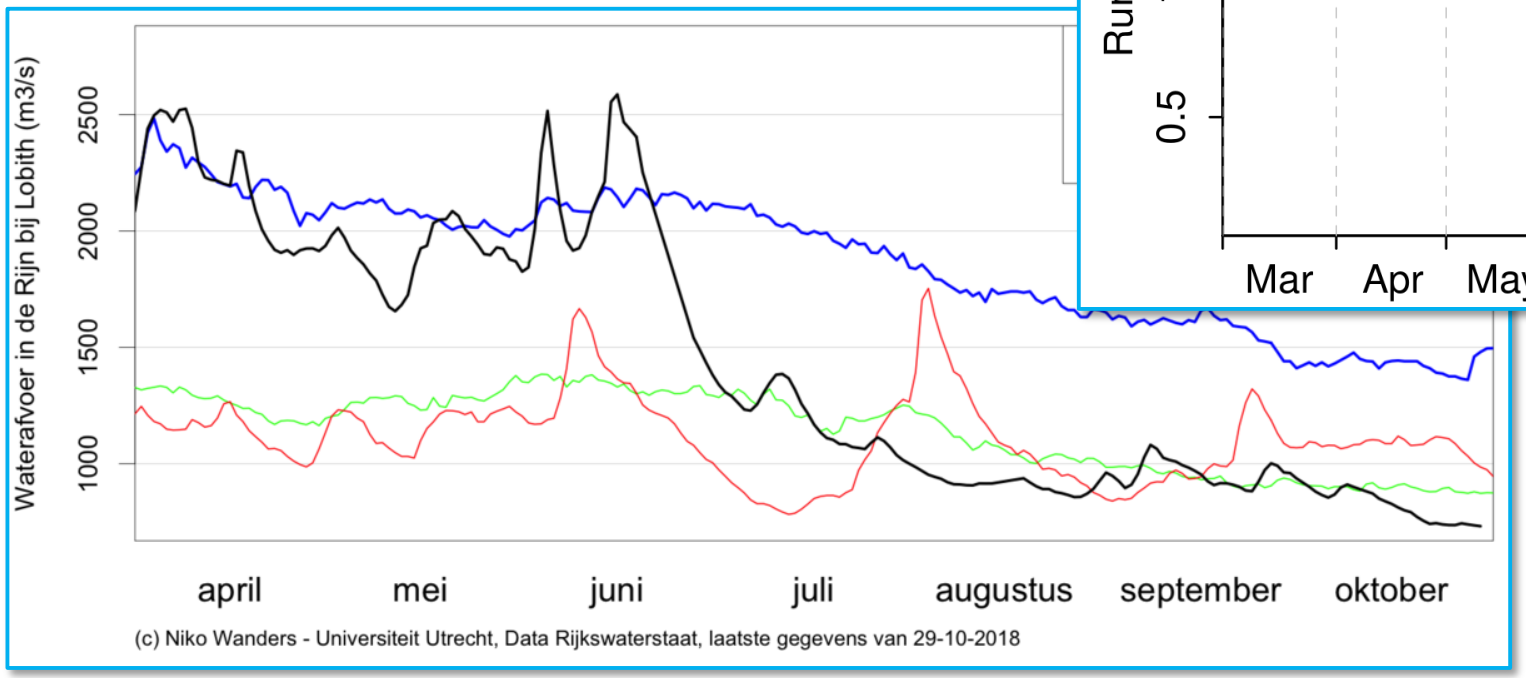
Difference 20th – 21st century

(4) Simulations of “Future Weather”



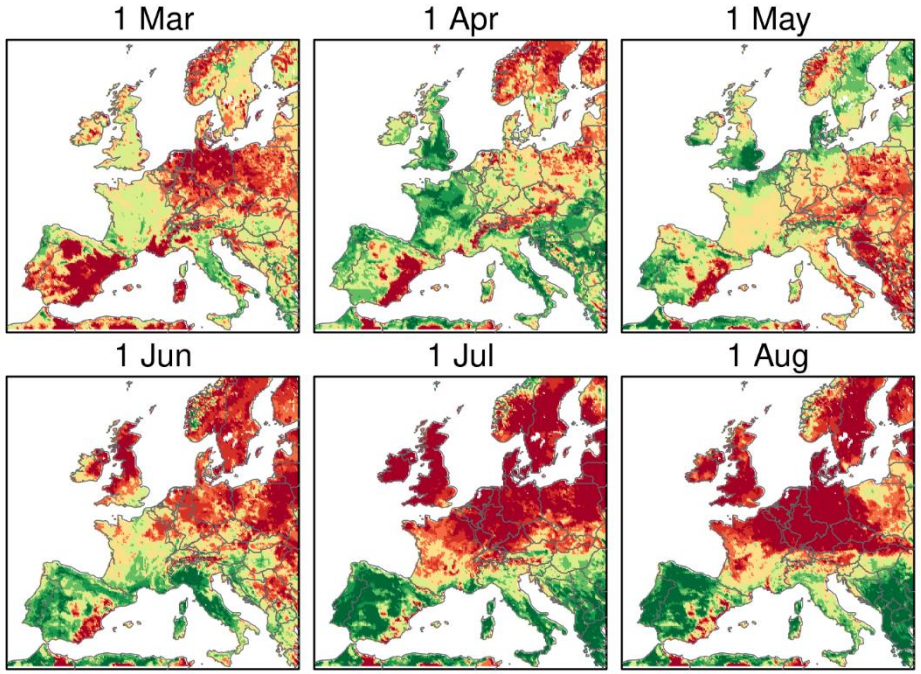
European drought 2018



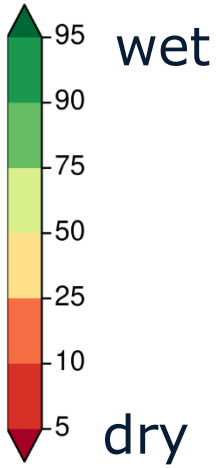


The 2018 drought in a warmer climate?

Course of 2018



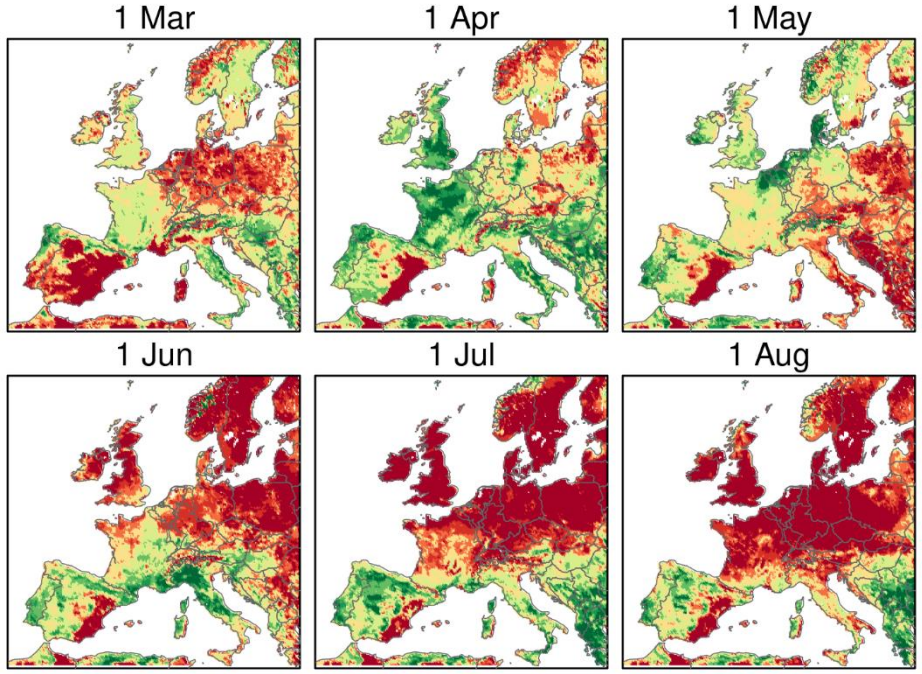
Drought indicator



wet

dry

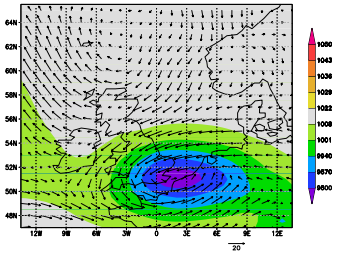
Course of 2018 in a world being 2 degrees warmer



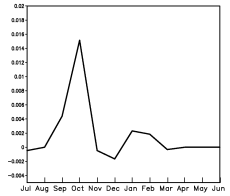
Experiment with KNMI climate model, using 2018 weather (KNMI, 2019)

Alternative information frameworks

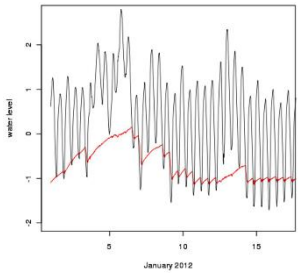
- Make explicit reference to **present day weather**
  - Attribution of events
  - Putting events in the context of a different (climate) setting



- Explore the **unresolved and unprecedented features** in a changing climate
  - e.g. by high resolution climate simulations



- Explicitly analyse statistics of **compounding events**
  - including features that are non-climatic



Thank you

Scenario change values for the climate around 2050[1] (2036–2065)				Scenario change values for the climate around 2085[1] (2071–2100)				Natural variations averaged over 30 years[2]
G_L	G_H	W_L	W_H	G_L	G_H	W_L	W_H	
+1 °C	+1 °C	+2 °C	+2 °C	+1.5 °C	+1.5 °C	+3.5 °C	+3.5 °C	
Low value	High value	Low value	High value	Low value	High value	Low value	High value	
+15 to +30 cm	+15 to +30 cm	+20 to +40 cm	+20 to +40 cm	+25 to +60 cm	+25 to +60 cm	+45 to +80 cm	+45 to +80 cm	± 1.4 cm
+1 to +5.5 mm/year	+1 to +5.5 mm/year	+3.5 to +7.5 mm/year	+3.5 to +7.5 mm/year	+1 to +7.5 mm/year	+1 to +7.5 mm/year	+4 to +10.5 mm/year	+4 to +10.5 mm/year	± 1.4 mm/year
+1.0 °C	+1.4 °C	+2.0 °C	+2.3 °C	+1.3 °C	+1.7 °C	+2.8 °C	+3.7 °C	± 0.16 °C
+4%	+2.5%	+5.5%	+5%	+5%	+5%	+6%	+7%	± 4.2%
+0.6%	+1.6%	-0.8%	+1.2%	-0.5%	+1.1%	-0.8%	+1.4%	± 1.6%
+3%	+5%	+4%	+7%	+2.5%	+5.5%	+6%	+10%	± 1.9%
-110 hours	-110 hours	-110 hours	-110 hours	-120 hours	-120 hours	-120 hours	-120 hours	± 39 hours
+1.1 °C	+1.6 °C	+2.1 °C	+2.7 °C	+1.3 °C	+2.0 °C	+2.8 °C	+4.1 °C	± 0.48 °C
-8%	-16%	-13%	-20%	-10%	-17%	-13%	-24%	-
+1.0 °C	+1.6 °C	+2.0 °C	+2.5 °C	+1.2 °C	+2.0 °C	+2.7 °C	+3.8 °C	± 0.46 °C
+1.1 °C	+1.7 °C	+2.2 °C	+2.8 °C	+1.4 °C	+2.1 °C	+3.0 °C	+4.4 °C	± 0.51 °C
+2.0 °C	+3.6 °C	+3.9 °C	+5.1 °C	+2.7 °C	+4.1 °C	+4.8 °C	+7.3 °C	± 0.91 °C
+0.6 °C	+0.9 °C	+1.7 °C	+1.7 °C	+1.0 °C	+1.2 °C	+2.4 °C	+3.1 °C	± 0.42 °C
-30%	-45%	-50%	-60%	-35%	-50%	-60%	-80%	± 9.5%
-50%	-70%	-70%	-90%	-60%	-80%	-80%	< -90%	± 31%
+3%	+8%	+8%	+17%	+4.5%	+12%	+11%	+30%	± 8.3%
+4.5%	+9%	+10%	+17%	+6.5%	+12%	+14%	+30%	-
+6%	+10%	+12%	+17%	+8%	+12%	+16%	+25%	± 11%
-0.3%	+1.4%	-0.4%	+2.4%	+0.3%	+1.0%	-0.9%	+3%	± 4.7%
+9.5%	+19%	+20%	+35%	+14%	+24%	+30%	+60%	± 14%
-1.1%	+0.5%	-2.5%	+0.9%	-2.0%	+0.5%	-2.5%	+2.2%	± 3.6%
-3%	-1.4%	-3%	0.0%	-2.0%	-0.9%	-1.8%	+2.0%	± 3.9%
-1.4%	+3%	-1.7%	+4.5%	-1.6%	+6.5%	-6.5%	+9%	± 6.4%
+0.9 °C	+1.1 °C	+1.8 °C	+2.1 °C	+1.2 °C	+1.5 °C	+2.4 °C	+3.1 °C	± 0.24 °C
+4.5%	+2.3%	+11%	+9%	+8%	+7.5%	+13%	+12%	± 8.0%
+1.0 °C	+1.4 °C	+1.7 °C	+2.3 °C	+1.2 °C	+1.7 °C	+2.7 °C	+3.7 °C	± 0.25 °C
+3.5%	+7.5%	+4%	+9.5%	+5%	+9%	+6.5%	+14%	-
+0.9 °C	+1.4 °C	+1.5 °C	+2.3 °C	+1.0 °C	+1.7 °C	+2.6 °C	+3.8 °C	± 0.35 °C
+1.1 °C	+1.3 °C	+1.9 °C	+2.2 °C	+1.4 °C	+1.7 °C	+2.9 °C	+3.7 °C	± 0.18 °C
+0.9 °C	+1.1 °C	+1.6 °C	+2.0°C	+1.0 °C	+1.4 °C	+2.3 °C	+3.1°C	± 0.43 °C
+1.4 °C	+1.9 °C	+2.3 °C	+3.3 °C	+2.0 °C	+2.6 °C	+3.6 °C	+4.9 °C	± 0.52 °C
+22%	+35%	+40%	+70%	+30%	+50%	+90%	+130%	± 13%
+0.5%	+0.6%	+1.4%	+2.2%	+0.9%	+1.2%	+4.5%	+7.5%	-
+1.2%	-8%	+1.4%	-13%	+1.0%	-8%	-4.5%	-23%	± 9.2%
+2.1 to +5%	-2.5 to +1.0%	+1.4 to +7%	-4 to +2.2%	+1.2 to +5.5%	-2.5 to +1.9%	-0.6 to +9%	-8.5 to +2.3%	-
+1.7 to +10%	+2.0 to +13%	+3 to +21%	+2.5 to +22%	+2.5 to +15%	+2.5 to +17%	+5 to +35%	+5 to +40%	± 15%
+5.5 to +11%	+7 to +14%	+12 to +23%	+13 to +25%	+8 to +16%	+9 to +19%	+19 to +40%	+22 to +45%	± 14%
+0.5%	-5.5%	+0.7%	-10%	+2.1%	-5.5%	+4%	-16%	± 6.4%
+4.5 to +18%	-4.5 to +10%	+6 to +30%	-8.5 to +14%	+5 to +23%	-3.5 to +14%	+2.5 to +35%	-15 to +14%	± 24%
+2.1%	+5%	+1.0%	+6.5%	+0.9%	+5.5%	+3%	+9.5%	± 2.4%
-0.6%	-2.0%	+0.1%	-2.5%	0.0%	-2.0%	-0.6%	-3%	± 0.86%
+4%	+7%	+4%	+11%	+3.5%	+8.5%	+8%	+15%	± 2.8%
+4.5%	+20%	+0.7%	+30%	+1.0%	+19%	+13%	+50%	±13%
+5%	+17%	+4.5%	+25%	+3.5%	+17%	+14%	+40%	-
+1.1 °C	+1.3 °C	+2.2 °C	+2.3 °C	+1.6 °C	+1.6 °C	+3.3 °C	+3.8 °C	± 0.27 °C
+7%	+8%	+3%	+7.5%	+7.5%	+9%	+5.5%	+12%	± 9.0%

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