Climate:
rainy winters and dry summers?

Ameland study weekend

2 April 2016

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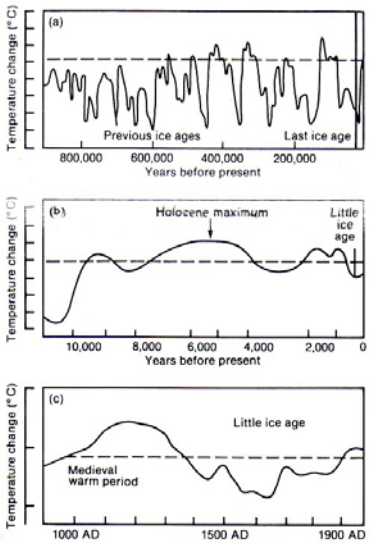
KNMI

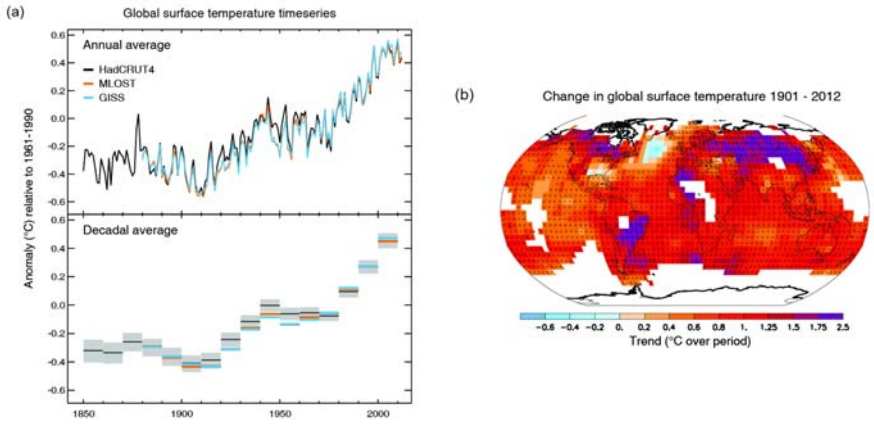
Overview

- Climate in the 20th century
- The greenhouse effect, climate models
- Causes of climate change in 20th century
- Climate change in 21th century
- Climate scenario's for the Netherlands

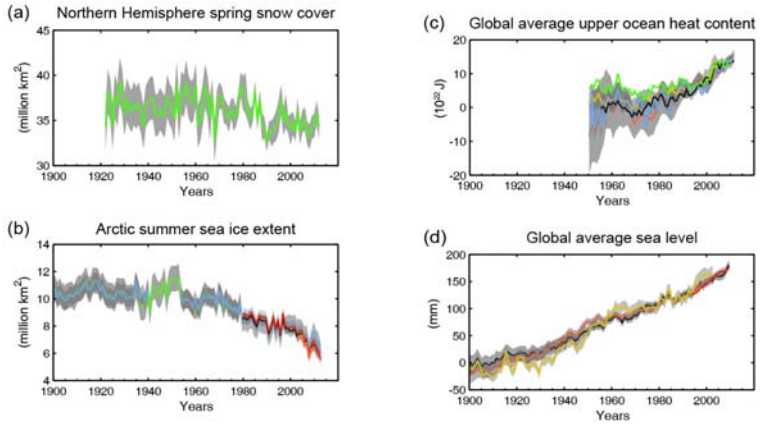
Temperature change in distant past



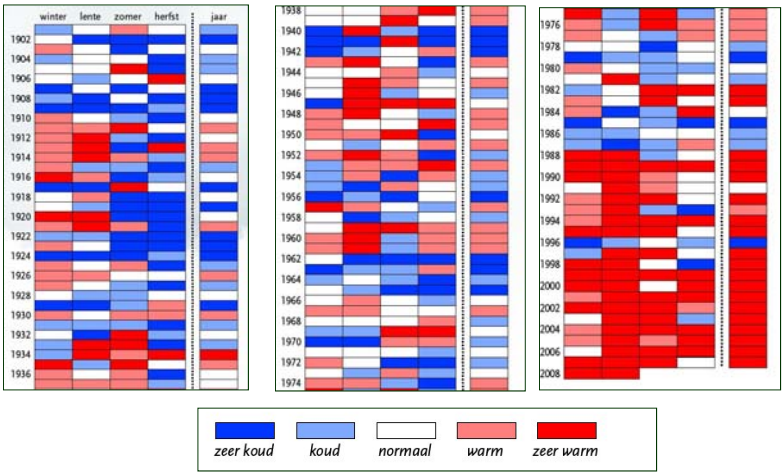
Temperature change in 20th century



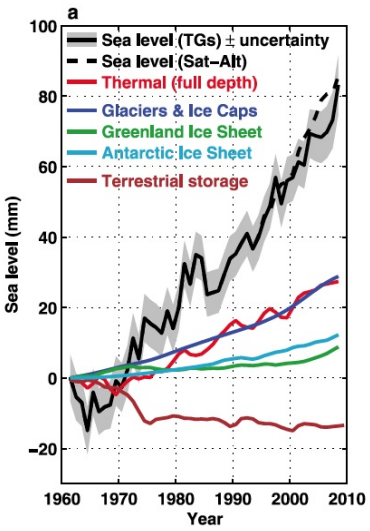
20th century change in: snow, ice, heat in oceans, sea level



Temperature Netherlands, since 1901



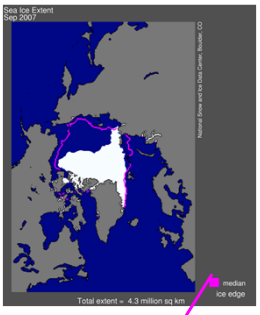
Contributions to seal level rise



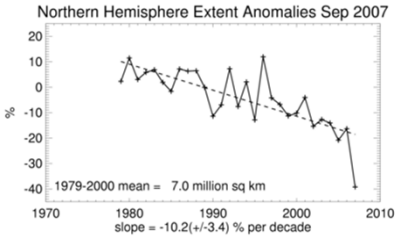
Arctic ice

1980, sept.

2007, sept.

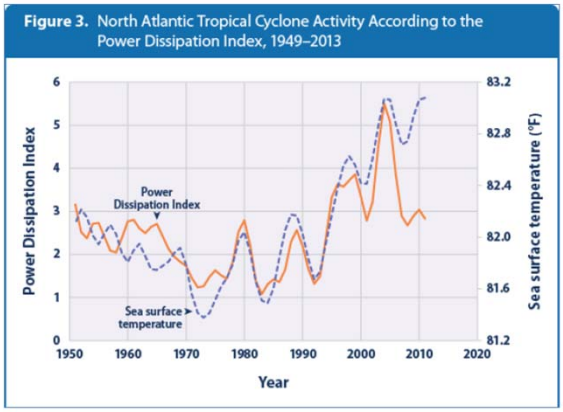


1979-2000



Tropical cyclones

Sea water temperature
Potential Destructive Index



Emanuel, 2014

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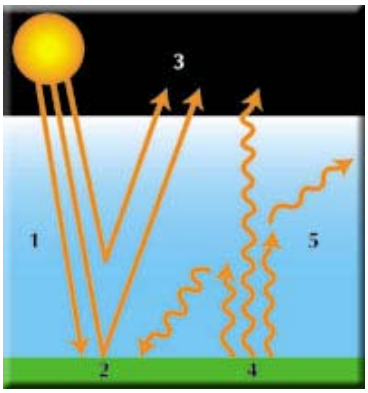
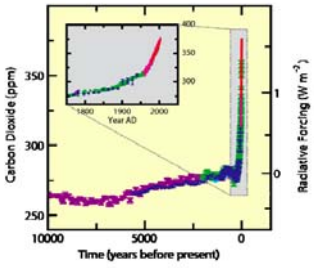
Greenhouse effect

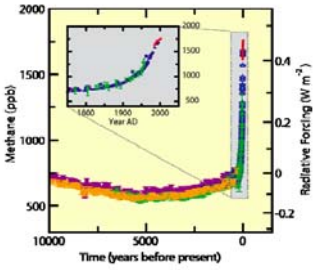


Increase of greenhouse gas concentrations

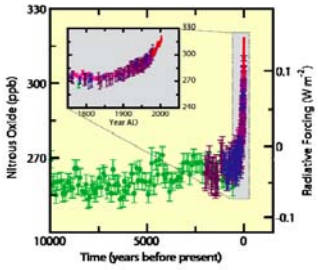
CO2



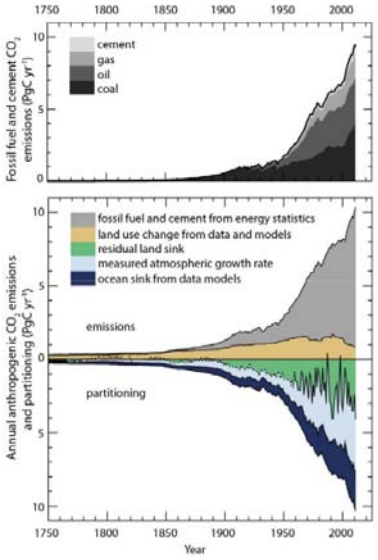
CH4

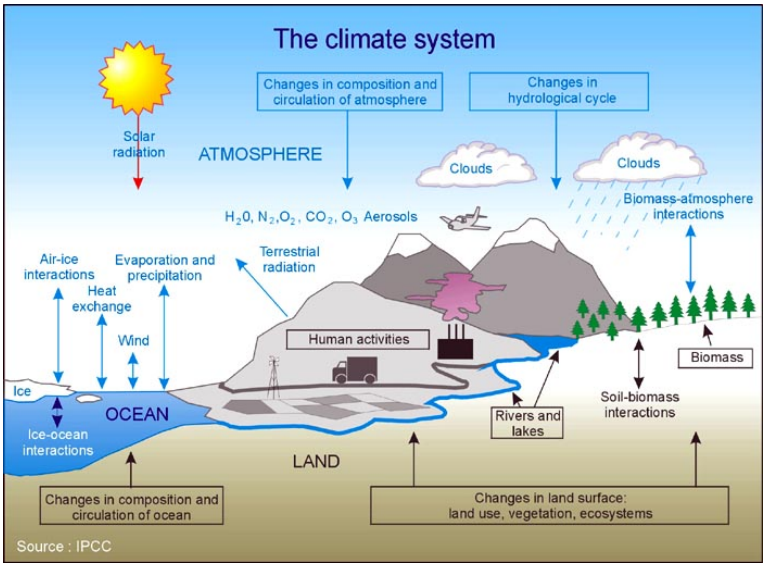


N2O

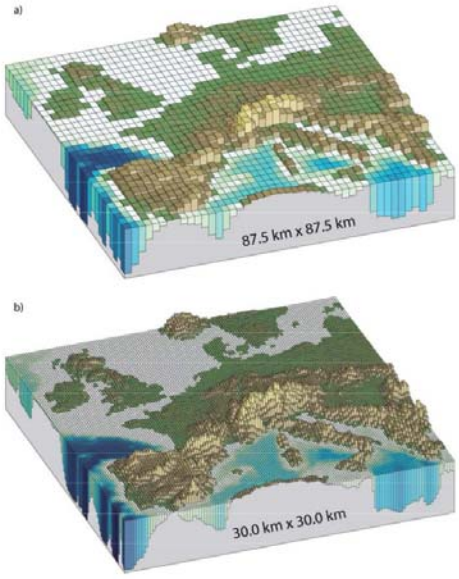


CO2: sources and sinks

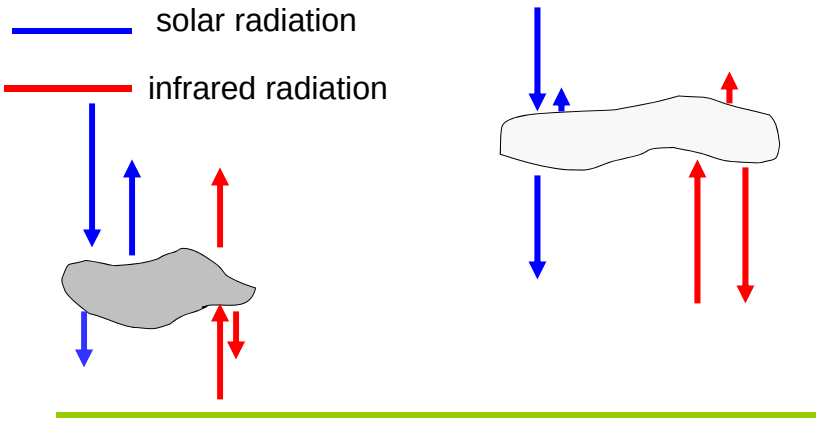




Climate models

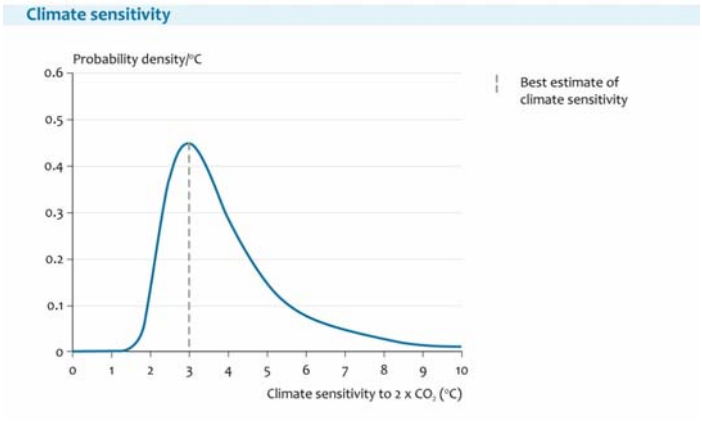


Clouds: why difficult to model?



low clouds: net cooling; high clouds: net warming
all clouds: small net cooling

Climate sensitivity



'Best estimate': 3 ºC for a CO_2 doubling

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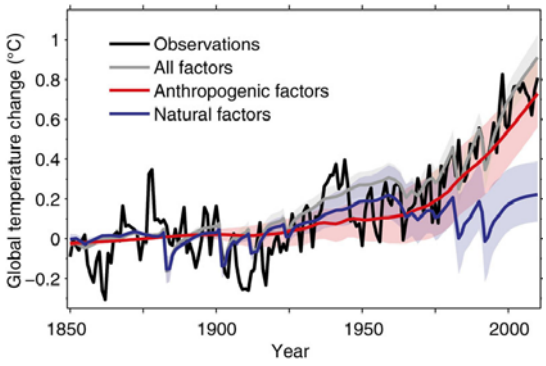
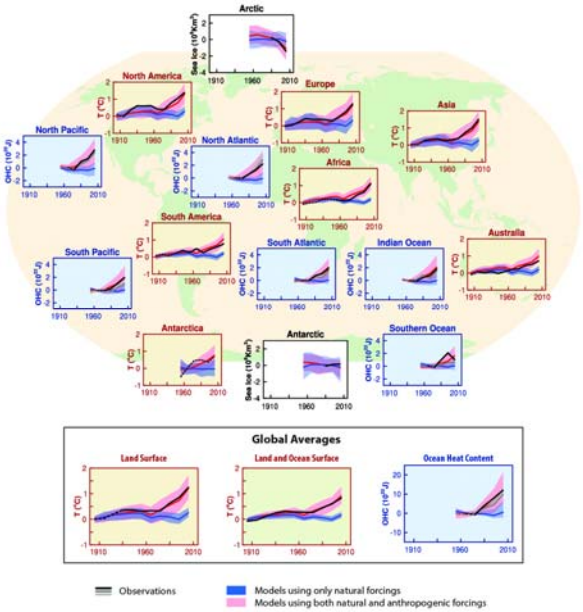
Temperature at earth's surface, global mean,observed and modeled (with and without human factors)



Temperatuur change: attribution



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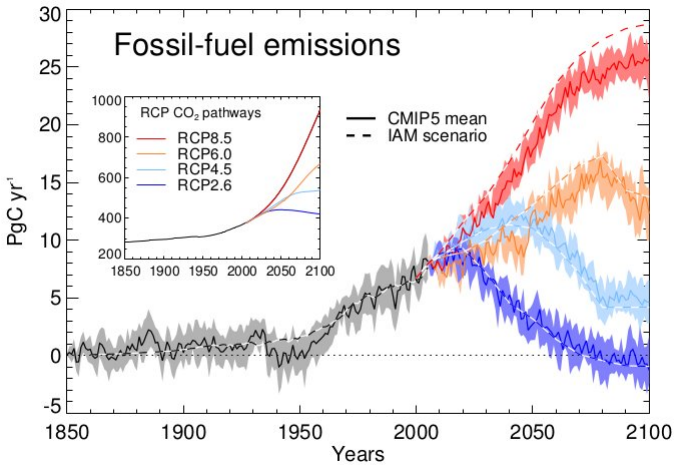
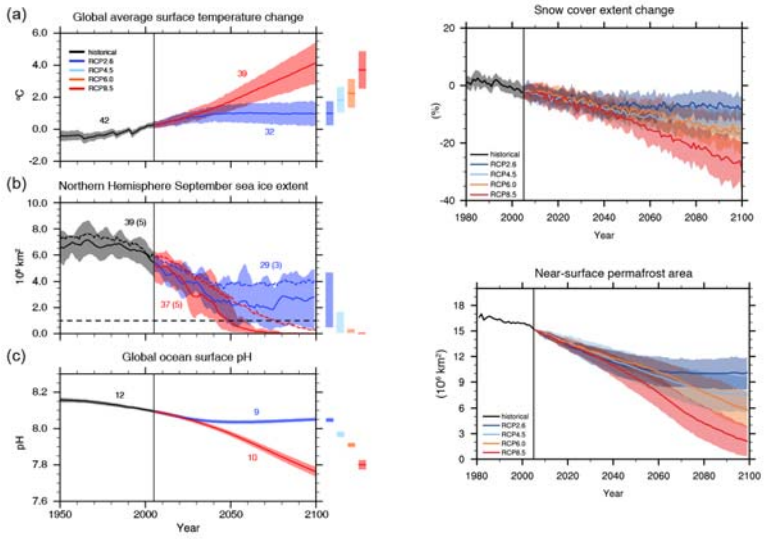
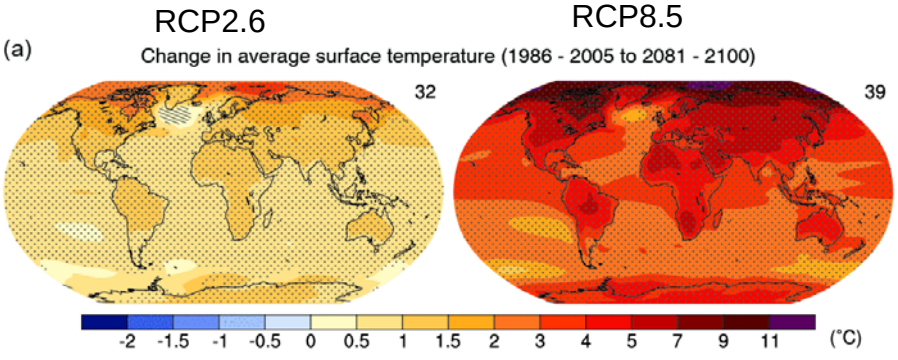
CO_2 emission scenarios



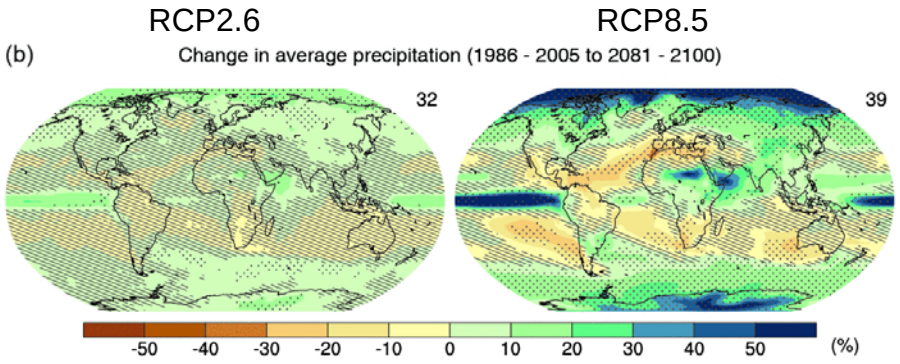
Global climate change: observations + projections



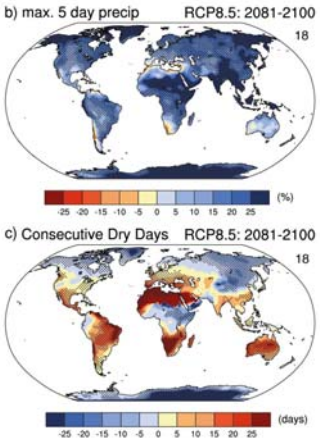
Temperature projections

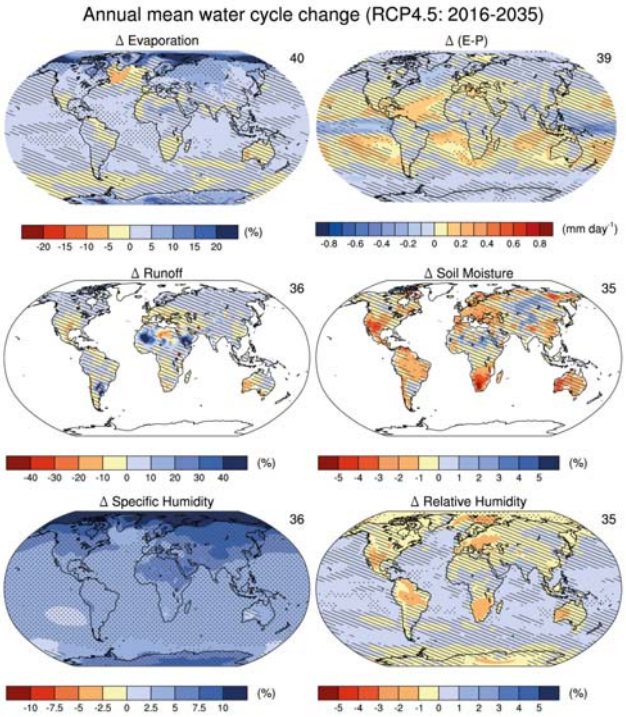


Precipitation projections

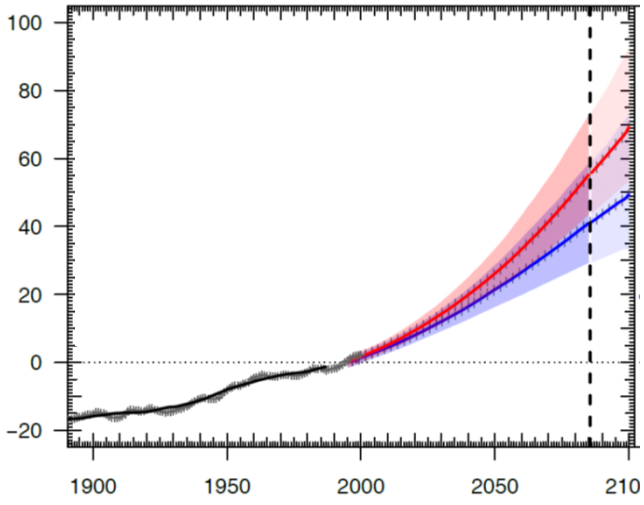


Precipitation: changes in extremes

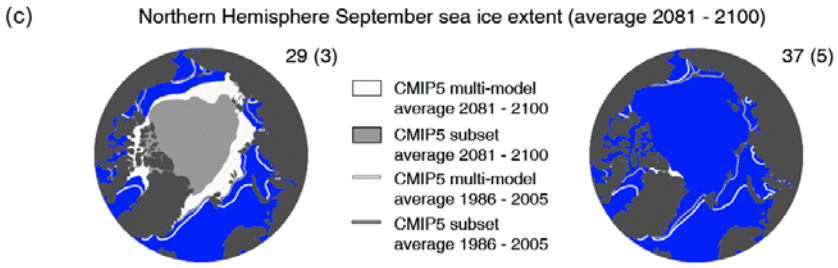




Global mean sea level change



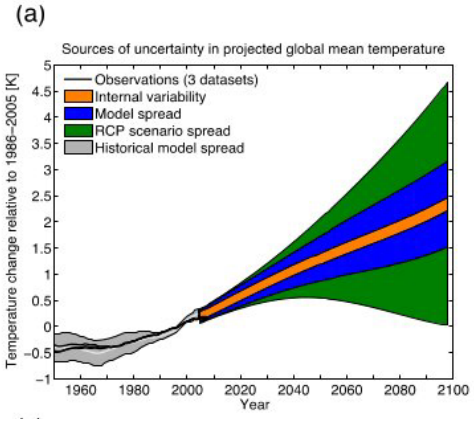
Arctic September sea ice projections



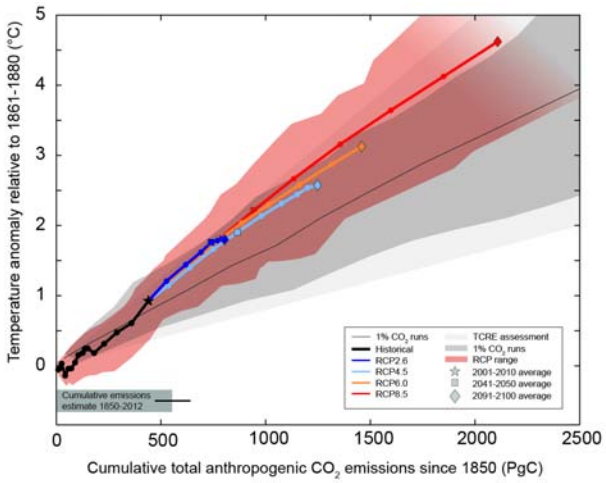
RCP2.6

RCP8.5

Uncertainties in future climate



Cumulative CO2 emissions versus temperature change



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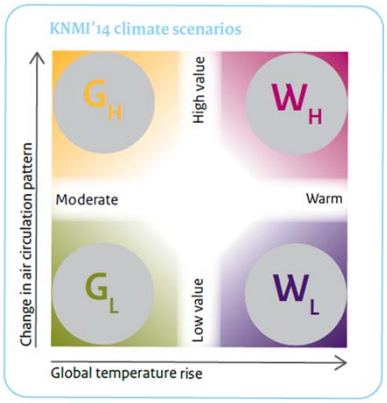
www.climatescenarios.nl/



Temperature

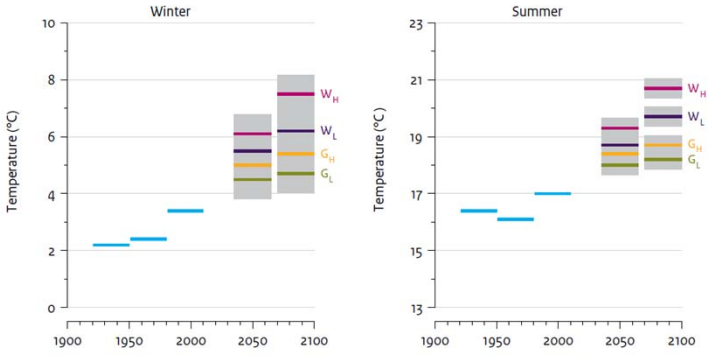


FIGURE 4 Winter and summer temperature in De Bilt (Netherlands): observations (three 30-year averages, in blue), KNMI'14 scenarios (2050 and 2085, in four colours) and natural variations (in grey). These are natural variations for 30-year averages.

Temperature extremes

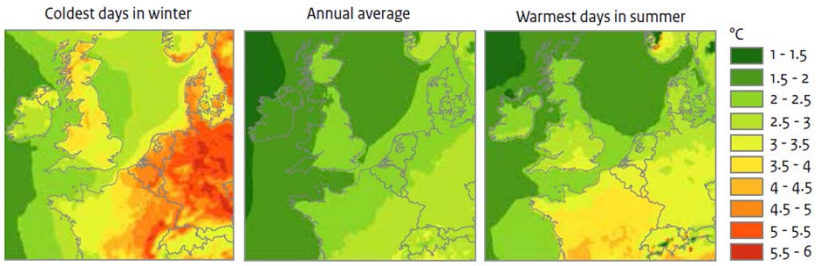


FIGURE 5 Temperature change on the coldest days in winter (left) and the warmest days in summer (right) compared to the annual average warming (middle) in the W_H scenario for 2050 relative to 1981-2010.

Precipitation

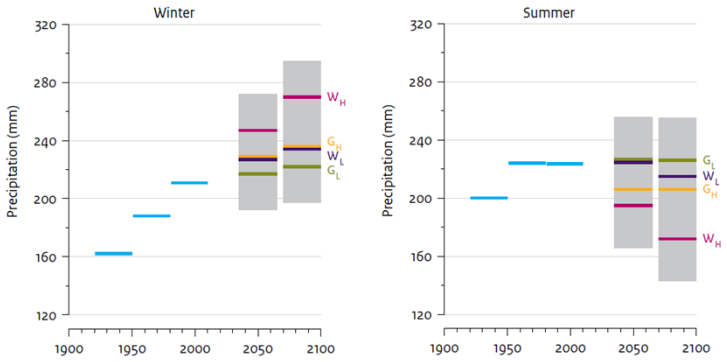
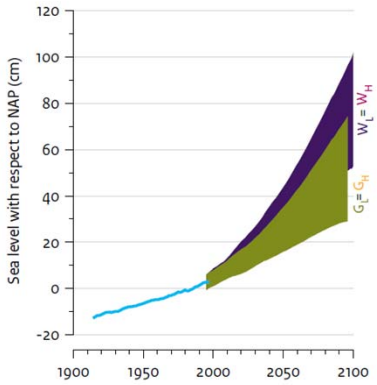
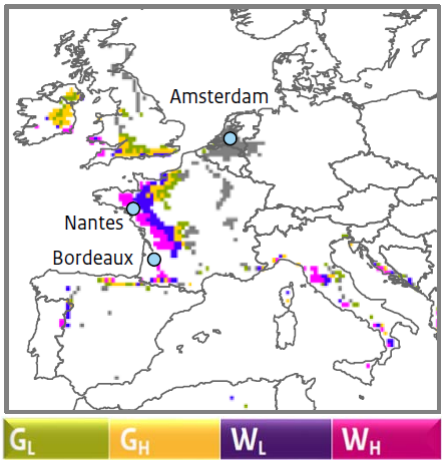


FIGURE 8 Precipitation climate in the Netherlands: observations and KNMI'14 scenarios for 2050 and 2085.

Sea level rise



Winter in Amsterdam in 2050 resembles that of Bordeaux now



Future weather

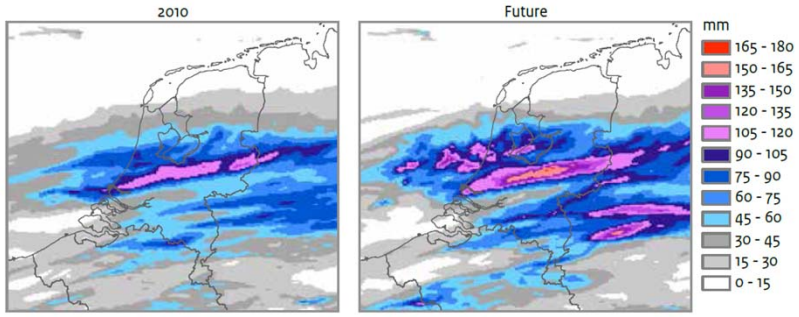


FIGURE 18 An event with more than 100 mm precipitation in two days in August 2010 (left), and its transformation into a 2 °C warmer climate (right).

KNMI'14, enkele getallen

			1951-1980	1981-2010	2050 G_L +1 °C Low value	G_H +1 °C High value	W_L +2 °C Low value	W_H +2 °C High value
Temperature	mean	winter	2.4 °C	3.4 °C	+1.1 °C	+1.6 °C	+2.1 °C	+2.7 °C
	year-to-year variation [e]		-	± 2.6 °C	-8%	-16%	-13%	-20%
	daily maximum		5.1 °C	6.1 °C	+1.0 °C	+1.6 °C	+2.0 °C	+2.5 °C
	daily minimum		-0.3 °C	0.5 °C	+1.1 °C	+1.7 °C	+2.2 °C	+2.8 °C
	coldest winter day per year		-7.5 °C	-5.9 °C	+2.0 °C	+3.6 °C	+3.9 °C	+5.1 °C
	mildest winter day per year		10.3 °C	11.1 °C	+0.6 °C	+0.9 °C	+1.7 °C	+1.7 °C
	number of frost days (min temp < 0°C)		42 days	38 days	-30%	-45%	-50%	-60%
	number of ice days (max temp < 0°C)		11 days	7.2 days	-50%	-70%	-70%	-90%
Precipitation	mean amount		188 mm	211 mm	+3%	+8%	+8%	+17%
	year-to-year variation [e]		-	± 96 mm	+4.5%	+9%	+10%	+17%
	10-day amount exceeded once in 10 years [i]		80 mm	89 mm	+6%	+10%	+12%	+17%
	number of wet days (≥ 0.1 mm)		56 days	55 days	-0.3%	+1.4%	-0.4%	+2.4%
	number of days ≥ 10 mm		4.1 days	5.3 days	+9.5%	+19%	+20%	+35%
Temperature	mean	summer	16.1 °C	17.0 °C	+1.0 °C	+1.4 °C	+1.7 °C	+2.3 °C
	year-to-year variation [e]		-	± 1.4 °C	+3.5%	+7.5%	+4%	+9.5%
	daily maximum		20.7 °C	21.9 °C	+0.9 °C	+1.4 °C	+1.5 °C	+2.3 °C
	daily minimum		11.2 °C	11.9 °C	+1.1 °C	+1.3 °C	+1.9 °C	+2.2 °C
	coolest summer day per year		10.3 °C	11.1 °C	+0.9 °C	+1.1 °C	+1.6 °C	+2.0°C
	warmest summer day per year		23.2 °C	24.7 °C	+1.4 °C	+1.9 °C	+2.3 °C	+3.3 °C
	number of summer days (max temp ≥ 25°C)		13 days	21 days	+22%	+35%	+40%	+70%
	number of tropical nights (min temp ≥ 20°C)		< 0.1 days	0.1 days	+0.5%	+0.6%	+1.4%	+2.2%
Precipitation	mean amount		224 mm	224 mm	+1.2%	-8%	+1.4%	-13%
	year-to-year variation [e]		-	± 113 mm	+2.1 to +5%	-2.5 to +1.0%	+1.4 to +7%	-4 to +2.2%
	daily amount exceeded once in 10 years [i]		44 mm	44 mm	+1.7 to +10%	+2.0 to +13%	+3 to +21%	+2.5 to +22%
	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%
	number of wet days (≥ 0.1mm)		45 days	43 days	+0.5%	-5.5%	+0.7%	-10%
	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%
Solar radiation	solar radiation		149 kJ/cm² [f]	153 kJ/cm²	+2.1%	+5%	+1.0%	+6.5%
Humidity	relative humidity		78%	77%	-0.6%	-2.0%	+0.1%	-2.5%
Evaporation	potential evaporation (Makkink)		253 mm [f]	266 mm	+4%	+7%	+4%	+11%
Drought	mean highest precipitation deficit during growing season [i]		140 mm	144 mm	+4.5%	+20%	+0.7%	+30%
	highest precipitation deficit exceeded once in 10 years [i]		-	230 mm	+5%	+17%	+4.5%	+25%

Impact example 1: Heating degree days

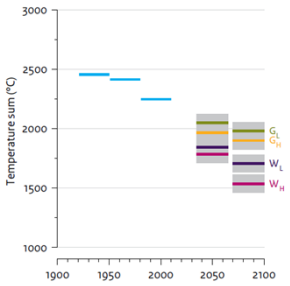


FIGURE 22 Number of heating degree-days as an indicator of gas and energy consumption in De Bilt, and KNMI'14 scenarios for 2050 and 2085. Heating degree-days: sum of the deviations from 17 °C for all days with an average temperature of less than 17 °C; e.g. a daytime temperature of 14 °C adds 3, and a daytime temperature of -2 °C adds 19 degree-days.

Impact example 2: Start of growing season

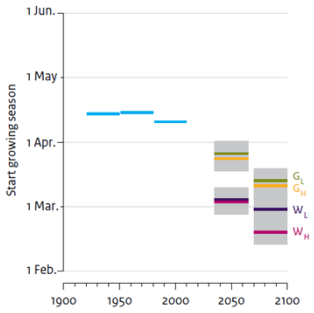
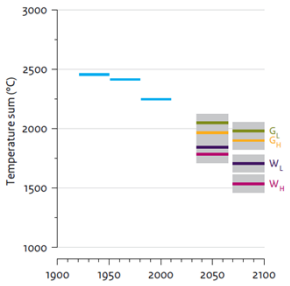


FIGURE 23 Start of the growing season in De Bilt, and KNMI'14 scenarios for 2050 and 2085. The growing season starts on the calendar day when the mean temperature exceeds 5 °C, and continues until at least 1 July.

Impact example 1: Heating degree days



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CO_2 concentrations, temperature and sea level continue to rise long after emissions are reduced