



# Climate scenarios of sea level rise for the Netherlands: combining model results, observations and expert judgment

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The Royal Dutch Meteorological Institute (KNMI) constructed climate scenarios of sea level rise (SLR) along the Dutch coast, by combining model results, observations and expert judgment. The resulting set of scenarios meets the requirements of stakeholders and at the same time does justice to scientific uncertainties.

## 1. Structure of the scenarios

Climate scenarios of SLR are constructed for the target years 2050 and 2100, relative to 1990. Contributions from various sources are combined (Fig. A).

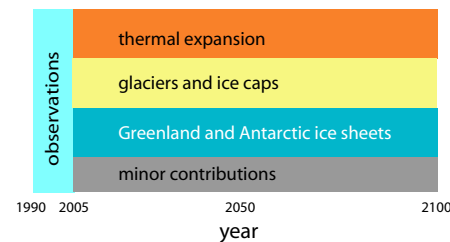


Figure A. Contributions considered in scenarios for SLR

## 2. Global temperature rise $\Delta T_{atm}$

All major contributions in Fig. A depend on the global atmospheric temperature rise  $\Delta T_{atm}$  achieved in GCM simulations [2] in the target periods considered. The scenarios are defined as

- 2050, moderate:  $\Delta T_{atm} = 1^\circ\text{C}$
- 2050, warm:  $\Delta T_{atm} = 2^\circ\text{C}$
- 2100, moderate:  $\Delta T_{atm} = 2^\circ\text{C}$
- 2100, warm:  $\Delta T_{atm} = 4^\circ\text{C}$

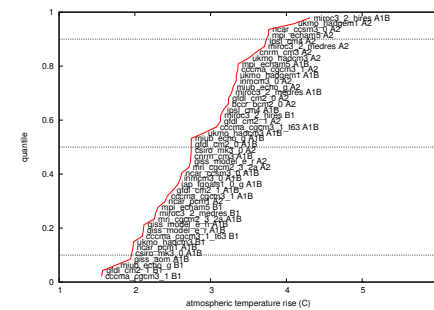


Figure B.  $\Delta T_{atm}$  projected for 2100 by AR4 GCMs [2]

The chosen values for  $\Delta T_{atm}$  correspond to the 10% and 90% points of the probability distribution function of  $\Delta T_{atm}$  (Fig. B).

## 3. Observed SLR 1990-2005

Along the Dutch coast, sea level rises at a rate of about  $2.5 \pm 0.6$  mm/yr ( $4 \pm 1$  cm for 1990-2005), in line with the rate of global SLR over the last 25 years (Fig. E).

## 4. Thermal expansion

The thermosteric sea level rise (TSLR) in the eastern North Atlantic basin is estimated from GCM simulations [2].

### 4.1 Global mean

For 2100, GCMs project a global mean TSLR of  $\pm 15$ - $35$  cm (Fig. C) for  $\Delta T_{atm}$  of  $1.5$  -  $4.5$   $^\circ\text{C}$ . Linear fits describe the dependency of global mean TSLR on  $\Delta T_{atm}$  (solid lines). Uncertainty bands are independent of  $\Delta T_{atm}$  and are based on the 10% and 90% quantiles (dashed).

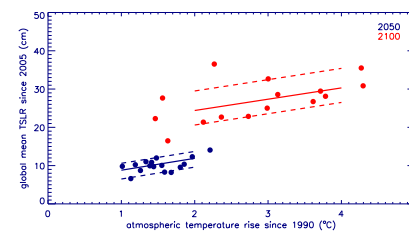


Figure C. Projected global mean TSLR as a function of  $\Delta T_{atm}$  for 2050 (blue) and 2100 (red). Solid (dashed) lines denote mean values (uncertainty bands)

### 4.2 Eastern North Atlantic Ocean

In many simulations, TSLR in the North Atlantic basin is larger than the global mean (Fig. D). The mean difference hardly

depends on  $\Delta T_{atm}$ , but the scatter increases with  $\Delta T_{atm}$ . So uncertainty bands are defined to be proportional to  $\Delta T_{atm}$  (Fig. E).

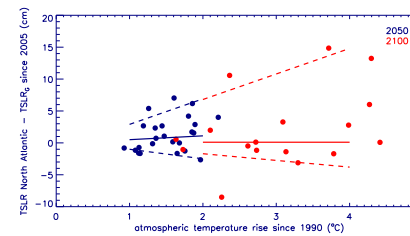


Figure D. As Fig. C, but for the difference between the global mean value and the value in the eastern North Atlantic Basin [25W, 10E] x [40N, 65N]

## 5. Glaciers and ice caps outside Greenland and Antarctica

The response of glaciers and ice caps to atmospheric warming is characterized by the sensitivity B. The contribution of glacier melt is crudely assessed [1] by assuming

- at present:  $B = 0.5 \pm 0.25$  mm/yr/K [1]
- a current deviation of  $\pm 1$   $^\circ\text{C}$  over the equilibrium temperature (Fig. E)

## 6. Greenland + Antarctic ice sheet

The combined contribution of the Greenland and Antarctic ice sheet is constructed using (Fig. F)

- present-day melt rate
- sensitivity B of the rate of SLR to a rise in  $\Delta T_{atm}$  estimated from model results and observations
- an upper bound for B representing increased mass loss for large  $\Delta T_{atm}$  estimated from model simulations

moderate, 2100 (+2 $^\circ\text{C}$ )			
	central	lower	upper bound
observed	+4	+3	+5
thermal expansion	+24	+20	+33
glaciers	+8	+4	+11
Greenland and Antarctica	+9	-0.5	+19
minor contributions	+2	0	+4
<b>total</b>	<b>+47</b>	<b>+35</b>	<b>+60</b>

Figure E. Example of contributions to the moderate scenario for 2100 ( $\Delta T_{atm} = 2^\circ\text{C}$ , in cm).

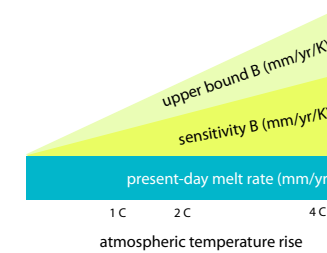


Figure F. Components determining the contribution of the Greenland and Antarctic ice sheets

## 7. Minor contributions

Contributions from melting permafrost, the response of ice sheets since the last glacial maximum and changes in land water storage are estimated at  $2 \pm 2$  cm in 2100 ( $\pm 1 \pm 1$  cm in 2050).

## 8. Dutch scenarios for SLR

In combining the various contributions (Fig. E), the median values are added linearly while the 10% or 90% quantiles are added in quadrature. The lower and upper bounds are treated separately. The final scenarios are rounded off to 5 cm (Fig. G).

2050, moderate	(+1 $^\circ\text{C}$ )	+15	+25 cm
2050, warm	(+2 $^\circ\text{C}$ )	+20	+35 cm
2100, moderate	(+2 $^\circ\text{C}$ )	+35	+60 cm
2100, warm	(+4 $^\circ\text{C}$ )	+40	+85 cm

Figure G. Scenarios for SLR along the Dutch coast

### References

- [1] van den Hurk et al (2006), KNMI Scientific Report
- [2] Program for Climate Model Diagnosis and Intercomparison (PCMDI) - IPCC Data Archive

### More information

The brochure "Climate in the 21st century: Four scenarios for the Netherlands" (KNMI, 2006) and the accompanying Scientific report "KNMI Climate Change Scenarios 2006 for the Netherlands" are available from <http://www.knmi.nl/climatescenarios> or KNMI, PO Box 201, 3730 AE De Bilt, the Netherlands

