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

Caroline Katsman, Wilco Hazeleger, Sybren Drijfhout, Geert Jan van Oldenborgh and Gerrit Burgers

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).

2. Global temperature rise \( \Delta T_{\text{gcm}} \)
   All major contributions in Fig. A depend on the global atmospheric temperature rise \( \Delta T_{\text{gcm}} \) achieved in GCM simulations [1] in the target periods considered. The scenarios are defined as:
   - 2050, moderate: \( \Delta T_{\text{gcm}} = -1 \)°C
   - 2050, warm: \( \Delta T_{\text{gcm}} = 2 \)°C
   - 2100, moderate: \( \Delta T_{\text{gcm}} = -2 \)°C
   - 2100, warm: \( \Delta T_{\text{gcm}} = 4 \)°C

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

4. Thermal expansion
   The thermosteric sea level rise (TSLR) in the eastern North Atlantic basin is estimated from GCM simulations [1].

4.1 Global mean
   For 2100, GCMs project a global mean TSR of 1.5 ± 0.5 cm (Fig. C) for \( \Delta T_{\text{gcm}} \) of 1.5 ± 4.5 °C. Linear fits describe the dependency of global mean TSR on \( \Delta T_{\text{gcm}} \) (solid lines). Uncertainty bands are defined on \( \Delta T_{\text{gcm}} \) and are based on the 10% and 90% quantiles (dashed).

4.2 Eastern North Atlantic Ocean
   In many simulations, TSR in the North Atlantic basin is larger than the global mean (Fig. D). The mean difference hardly depends on \( \Delta T_{\text{gcm}} \) but the scatter increases with \( \Delta T_{\text{gcm}} \). So uncertainty bands are defined to be proportional to \( \Delta T_{\text{gcm}} \) (Fig. E).

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: \( B = 0.6 \pm 0.2 \) mm/yr/K [1]
   - a current deviation of +1°C over the equilibrium temperature (Fig. F)

6. Greenland + Antarctic ice sheet
   The combined contribution of the Greenland and Antarctic ice sheet is calculated using the following expressions:
   - present-day melt rate
   - sensitivity B of the rate of SLR to a rise in \( \Delta T_{\text{gcm}} \) estimated from model results and observations
   - an upper bound for B representing increased mass loss for large \( \Delta T_{\text{gcm}} \) estimated from model simulations

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 ± 2 cm in 2100 (1 ± 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).

References
[2] Program for Climate Model Diagnosis and Intercomparison (PCMDI) - IPCC Data Archive

More Information