

## FACT SHEET

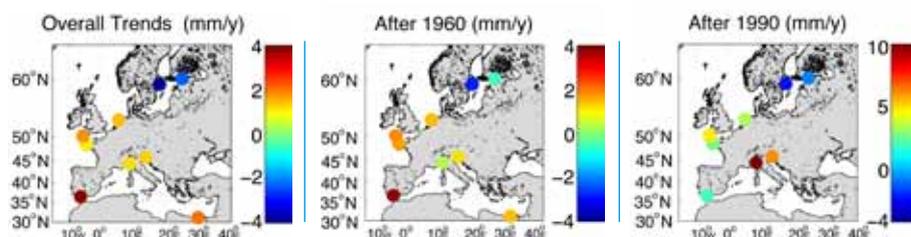
### DRIVERS OF SEA LEVEL CHANGE

**Global mean sea level** change is primarily driven by the addition of heat and mass to the oceans. The first is due to rising atmospheric temperatures which lead to a thermal expansion of the water. The second is caused by the melting of ice-sheets and glaciers. Changes in salinity are of lesser importance on a global scale.

**Local sea levels** are influenced by further factors, including changes in atmospheric pressure and wind distribution, oceanic circulation, local temperature and salinity, sediment supply and sediment compaction at estuaries, land movements caused by removal of mass from the earth's crust and tectonic movements.



The Maeslantkering storm surge barrier in the Netherlands automatically closes when needed for protection. It is part of the Delta Works and it is one of largest moving structures on Earth.



Long-term trends of sea-level rise in major European cities: yearly values of sea level in various European coastal locations and Alexandria (Developed by Andrew Shaw and Mikis Tsimplis based on data from the Permanent Service for Mean Sea Level website, <http://www.psmsl.org/>)

Sea level changes pose significant risks to European coastlines, thus changes in local mean sea level and sea level extremes are presently the primary concern for policy makers.

The rate of global sea level rise has been  $1.8 \pm 0.3$  millimeter per year over the last century, but has increased drastically up to  $3.3 \pm 0.4$  millimeter per year for the period from 1993 onwards.

However, sea level trends in Europe are not uniformly distributed and regional differences are evident from observations. These observations highlight the importance of obtaining regional and local estimates of sea level rise, as a global mean value cannot be used for coastal protection purposes.

### POSSIBLE IMPACTS

Sea level rise poses significant threats to human, plant and animal populations of low lying areas as a result of:

- Increased flooding and associated impacts;
- Loss of coastal ecosystems and associated services:
  - Increase of coastal erosion,
  - Salt contamination of ground water,
  - Loss of arable land,
  - Loss of salt marshes and mangroves.

Protection against rising sea levels is possible (e.g. in the Netherlands) but not always financially and/or ecologically feasible. In most cases human development will need to adjust and populations to be relocated.

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### WHAT ARE THE FUTURE PROJECTIONS?

Future projections of global sea level change are currently based on empirical estimates or on recent climate models which take into account two key components:

- The thermal expansion of water (the steric component). The steric component is considered to be quite reliable for the upper part of the water column and is already integrated in most climate models. Current projections estimate the global sea water level increase due to thermal expansion, to be less than 60 cm by the end of the 21st century (for the climate change scenarios determined by the Intergovernmental Panel on Climate Change, IPCC).
- The melting of ice-sheets (the mass addition component). There is a high level of uncertainty in these projections due to the fact that the non-linear process of ice-sheet breaking is not yet fully understood and that ground truth measurements to test models of these processes are lacking. The mass addition component has not yet been integrated in current climate models and must be calculated separately. Current projections estimate an increase in global sea water levels of 0-2 m due to mass additions, by the end of the 21st century.

None of the methods widely used has the resolution or skill to provide estimates for regional or local sea level. High resolution regional models with downscaled atmospheric forcing have been developed over the past five years. However, sea level parameterization has only recently come under scrutiny.



### RESEARCH GAPS AND PRIORITIES

- Develop a robust and efficient monitoring system for mass changes in Greenland and Antarctica;
- Understand the relative importance of ice-sheet breaking processes;
- Integrate modeling of ice-sheet changes into global climate models;
- Resolve whether sea level accelerated at the beginning of the 20th century;
- Understand the contribution of waters deeper than 1000 m to sea level changes due to the thermal expansion component;
- Improve the understanding of coastal sea level forcing mechanisms and coupling them with the regional variability in climate model;
- Develop reliable techniques to estimate regional / local sea level rise;
- Improve and expand the sea level monitoring network.

### FURTHER READING

- Alley RB, Clark PU, Huybrechts P, Joughin I (2005). Ice-Sheet and Sea-Level Changes. *Science* 310(5747):456-460.
- Merrifield MA, MerrifieldST, MitchumGT (2009). An anomalous recent acceleration of global sea level rise. *J. Climate* 22:5772-5781.
- Rahmstorf S (2010). A new view on sea level rise. *Nature Reports* 4:44-45.

This Fact Sheet is based on a chapter of the CLAMER / Marine Board Special Report *Synthesis of European Research on the Effects of Climate Change on Marine Environments* (Deliverable. 1.2) written by **Michael Tsimplis** of the National Oceanographic Centre, United Kingdom.