The effects of climate change: An increase in coastal flood damage in Northern Europe

Climate change is affecting storm surges in Europe. Based on the findings of scientific research, Swiss Re forecasts a significant increase in coastal damage in the long term. By the end of this century, once-in-a-millennium storm surge events could well be striking Northern Europe every 30 years. Governments and insurers will have additional risk to manage as a result.

Focus report

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Climate change will lead to more frequent and intense winter storms in Europe. Coupled with rising sea levels, intensifying storms increase coastal flood damage in the long term. This is the conclusion Swiss Re draws based on research it conducted in collaboration with the University of Berne in Switzerland.

Scientists have combined Swiss Re's loss model with climate and storm surge models to quantify the impact of climate change on Northern European coastal flood damage. Assuming the IPCC scenario A2 with a predicted sea level rise of 0.37 m, losses are forecast to increase in all countries towards the end of this century. The study confirms what many have suspected, namely:

- **an increase in peak surge height of between 36% and 55% compared to today's levels**
- **a disproportionate increase in annual expected losses of between 100% and 900%, depending on the country (at today's values)**
- **a water level seen once in a 1000 years occurring – on average – more often than every 30 years**

For the affected countries, these scenarios mean ensuring that the impacts of climate change are integrated systematically into risk assessment and risk management processes. Adaptation through adequate sea defences and the management of the residual risk is essential.

While the insurance industry is an important contributor to the absorption of volatile risk, it cannot address the challenges of climate change alone: To tackle this, a public-private partnership will be indispensable. Beyond traditional insurance, Swiss Re can contribute through alternative forms of risk transfer to absorb highly volatile losses.

Storm surge scenarios at the North Sea coast

Mid-latitude storms and the often related storm surges are a major source of loss potential for the insurance industry in the North Sea area. Under global warming, the evidence suggests that the sea level will rise and that mid-latitude storms will increase in severity. The resulting surge enhancement is therefore likely to increase the risk of coastal flood losses. The study compares recent climate data (1961 – 1990) with data from future climate model scenarios (2071 – 2100). The aim is to investigate coastal impact, in particular changes in storm surge characteristics, and combine these with related losses in five European countries bordering the North Sea (United Kingdom, Belgium, Netherlands, Germany and Denmark).

To reflect potential changes in climate storm surge scenarios, a cascade of numerical models was applied to transform the global emission scenarios into regional coastal flood damage, expressed as loss:

1) The experts used a global climate model to determine the potential future climate in the North Sea area on the basis of IPCC scenario A2.
2) A hydro-dynamic model transformed the climate input into storm surge events.
3) Local tidal cycles were implemented.
4) Three different sea level rise parameterisations were added to the surge and tide elevation: 37 cm based on IPCC scenario A2, 0 cm to model wind-only effects and 50 cm as a hypothetical scenario.
5) Taking account of current protection works, inland water depth was modelled based on surge heights.
6) And finally, the Swiss Re loss model transformed local water depths into financial losses.

The model runs show that winter storms in Europe will become more severe and more frequent, in turn triggering more intense surge events. Apart from intensifying storm activities, the sea level will rise in the same time period. The unfavourable impact of the tides, more intense surges and higher sea levels lead to an increase in peak surge heights of between 36% and 55% compared to today's levels, and consequently to a pronounced rise in coastal damage potential.

The results are best illustrated by means of a numerical example based on the mean values of the models used. Currently, the annual expected loss burden from surge events in the study area is about EUR 0.6 billion. This figure could rise to EUR 2.6 billion annual loss toward the end of the 21st century (see chart: Increase in annual expected loss). Overall, this means that losses can increase fourfold over today's level (on average over the study area).

The rarer and stronger the storm, the greater the increase in expected claims will be. The impact will depend on the country affected. That is to say, wind-driven surge intensity will not change uniformly in all countries. Because shifting storm tracks will mean that certain regions may see an increase, others will experience a decrease in storm activities. But when it comes to the sum of climate change impacted surge and sea level rise, the aggregated hazard potential exceeds all potentially positive regional storm impacts.

Currently, most coastal defences are designed to protect efficiently against today's exposure. Therefore today's annual expected losses are small. Assuming that the hazard will intensify substantially, today's coastal protection is exhausting its initial design capability. The consequence is disproportionate growth in loss potential.

The change in protection capability illustrates the impact of climate change best: the sea wall that is rarely overtopped in the current climate, will be overtopped

Summary of the findings

- Storm surge exposure will increase substantially with climate change
- Constant strengthening of sea defences is a prerequisite to keep the residual risk manageable
- To tackle the substantially increasing residual risk of surge losses, a well established public-private partnership is indispensable
- Swiss Re continues to develop alternative forms of risk transfer such as catastrophe bonds, weather derivatives or parametric solutions that enable the transfer of existing and emerging risks.

Change in surge height

Projected increase in surge height for peak events (IPCC scenario A2, including 37cm sea level rise).

much more frequently in the future. To exemplify the point: today's extreme water level seen once in a 1000 years will, on average, be seen every 11 years in UK, every 29 years in Belgium, every 15 years in Netherlands, every 13 years in Germany and every 5 years in Denmark.

At first glance, the rise may seem exaggerated, particularly since all model runs carry some element of uncertainty, and natural variability will confuse the signal of the underlying trend. However, the fact is that the IPCC scenario A2, with an estimated sea level rise of 37 cm, is viewed as an optimistic assessment. This is because the dynamic effects of ice sheets are not taken into account due to the fact that all models of these polar ice sheets are still in their infancy. An alternative approach would be to base projections on the observed temperature and sea level rise in the past. New estimates[1] based on this approach suggest a sea level rise of around a metre or more by 2100.

The experts used three different parameterisations of the loss model, generating a broad spread in expected losses. What is particularly meaningful, however, is that the underlying trend was consistent in all three models. The study did not consider the impact of changing precipitation, value concentration and inflation.

Tackling the residual risk
Since storm surge exposure will increase substantially with climate change, the results of the study underline the need for a systematic quantification of natural catastrophe risks and consequent adaptation through risk reduction and risk transfer measures. The findings from this and other studies need to be reviewed and integrated into country risk management.

Besides mitigation, local adaptation will be another key factor. The study demonstrates that the way sea walls are constructed, and consequently their failure probability, is crucial to the residual risk. Adequate sea defences and the management of the residual risk are therefore essential.

Since we are already more than one third of the way into the period between the two climatic reference periods in the study, one must assume that some of the change has already taken place.

Today's economy would not function without effective and efficient mechanisms to manage risks. Governments and the insurance industry play a pivotal and complementary role in preventing, mitigating and taking on risks. Thus to tackle the substantially increasing residual risk of surge losses, a well established public-private partnership is indispensable. In the absence of any major recent events, the first priority is to raise risk awareness by encouraging an open debate amongst all relevant stakeholders.

Adapting land use planning and continuous strengthening of sea defences are the prerequisites for keeping the residual risk constant and manageable. Governments will therefore need to set aside substantial funds to invest into necessary protection and other mitigation measures.

While insurance is usually a very useful way of managing the residual risk, the main focus still has to be on minimising this residual risk by other means. Storm surge is a challenging peril and clearly less

Methodology of the study[2]
As part of a study to quantify the impact of climate change on storm surge damage in Northern Europe, scientists from the University of Berne and Swiss Re's natural catastrophe professionals used state-of-the-art numerical simulations to evaluate the effects of the recent climate (reference period: 1961 – 1990) and in the future (scenario period: 2071 – 2100). The scenario used in the models (A2 in IPCC 2007, Intergovernmental Panel on Climate Change) is based on significant population and economic growth and a twofold increase in CO_2 concentrations by the end of the century. Two additional (virtual) model runs without sea level rise and with 0.5m sea level rise extend the study focus.

Experts combined global and regional climatic models to determine half-hourly water elevations (PRUDENCE data set). Natural perils professionals combined extracted surge scenarios out of this water elevation dataset with Swiss Re's probabilistic storm surge loss model. Uncertainty regarding the probability of sea wall failure was taken into account with three different parameterisations of the measures. The annual expected loss and the loss frequency curve were calculated for a wind insurance portfolio representative of today's market.

1 International Scientific Congress Climate Change: Global Risks, Challenges & Decisions – Synthesis Report; Copenhagen 2009
2 A study entitled Future storm surge impacts on insurable losses for the North Sea region, is in preparation. Authors: L. Gaslikova (Uni Bern), A. Schwerzmann (Swiss Re), C. Raible (Uni Bern), T. Stocker (Uni Bern)

well suited for tackling through conventional insurance coverage. The enormous losses resulting from a major failure in a sea barrier illustrate the point. Another important aspect relates to the well known anti-selection phenomena. Unless coverage is mandated for everyone, demand for storm surge insurance will remain limited to a rather small number of highly exposed risks which will then put a strain on affordability.

These challenges can be addressed and hopefully overcome, if not by means of traditional insurance then by finding new solutions. This is why Swiss Re continues to develop alternative forms of risk transfer such as catastrophe bonds, weather derivatives or parametric solutions that enable the transfer of existing and emerging risks.

Of course, insurance and alternative risk transfers are only one part of the solution. The principles of sustainability are important, and significant effort should be devoted to working collaboratively to mitigate the impact of natural events.
The public-private partnership can play a significant role in this context.

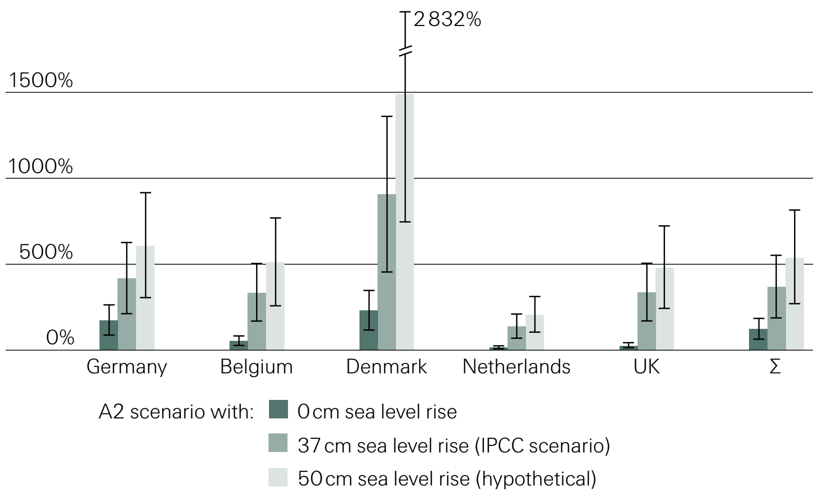
Climate protection efforts need to be accelerated. These include reducing greenhouse gas emissions and energy consumption, and developing new, green technologies.

Swiss Re's commitment
Climate change is one of the greatest challenges for our planet in the 21st century. To address global warming effectively and adapt to its inherent consequences, immediate action is called for. The financial services industry can play its part as an enabler of change to help guide society towards an effective response.

As a premier global reinsurer, Swiss Re is a major participant in the climate debate. Our actions are based on the premise that it is in the interest of all stakeholders to tackle this issue:

- We are committed to help reduce emissions and facilitate adaptation to the inevitable consequences of climate change.
- Swiss Re continues to develop alternative forms of financial risk transfer to manage large or new risks.
- At the prevention level, Swiss Re is actively engaged in activities to mitigate further global warming, investing in renewable energy sources and assessing the economics of climate adaptation.
- Additionally, Swiss Re has embraced sustainability as a fundamental tenet of its business activities. The group has been fully greenhouse gas neutral since October 2003.

Increase in annual expected loss.



Increase in annual expected loss for Germany, Belgium, Denmark, Netherlands, UK and over all countries from current to future climate (in %). The broad bars represent the mean value of the models, and the error bars show the spread of the results from all model runs. Currently, the annual expected loss burden from surge events in the study area is approximately EUR 0.6 billion.

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