GERMAN SEAPORTS AND CLIMATE CHANGE – RECOMMENDATIONS FOR CLIMATE CHANGE ADAPTATION MEASURES

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INTRODUCTION

In 2022, the working group 'Climate Change Adaptation of Sea and Inland Ports in Germany' (in short: KlimaHafen) was founded at the German Port Technology Association HTG with the aim of developing national recommendations on the topic. To address the relevant aspects, the HTG working group is composed of experts from the disciplines of meteorology, oceanography and hydrology as well as planning, construction and operation of sea and inland ports. The recommendations of the KlimaHafen working group are scheduled to be completed in the last quarter of 2024.

The following topics are dealt with in detail with special reference to German seaports:

1. Climate change basics including discussion of the inherent uncertainties
2. State of research on the consequences of climate change in Germany
3. Relevance of climatic changes for the port economy
4. Climate change-related vulnerability of German seaports and adaptation options
5. Development of port-friendly adaptation strategies
6. Case studies on climate change adaptation of seaports

RELEVANT CLIMATE PARAMETERS AND CLIMATE PROCESSES

The German seaports, with their location at the interface between sea and land, will be particularly affected by the effects of climate change (Figure 1). In addition to sea level rise and its impact on tidal and morpho-dynamics, these include the increase in extreme temperature and precipitation events as well as possible changes in storm intensity or storm activity and water chemistry.

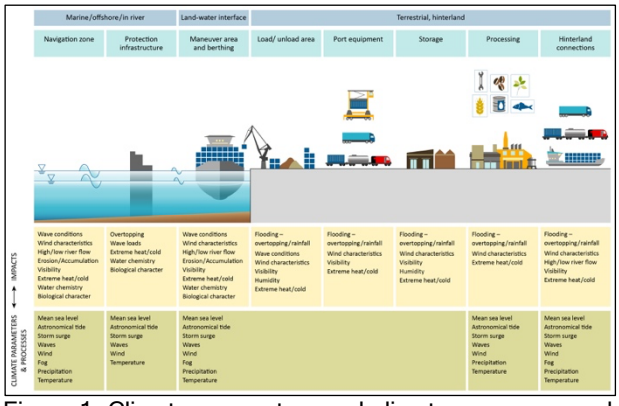

Figure 1: Climate parameters and climate processes and their effects relevant to German seaports

CLIMATE CHANGE IN GERMANY

Climate is defined as a summary of the weather phenomena that characterize the average state of the atmosphere over a sufficiently long period of time at a specific location or in a more or less large area. There are diverse interactions between the atmosphere and the hydrosphere (oceans, rivers, lakes), the biosphere (fauna, flora), the lithosphere (solid, inanimate earth) and the cryosphere (ice, glaciers, permafrost). The entirety of these components is called the climate system.

Germany lies in the temperate climate zone, with the north of the country having a strong maritime influence, while the east and south are subject to a more continental influence. The temperature shows a pronounced annual cycle, the precipitation is present all year round. The weather is determined by the alternation of high- and low-pressure areas.

Figure 2 shows the temperature development in Germany since 1881. From around the mid-1980s there was a clear upward trend. Fourteen of the twenty warmest years occurred in the 21st century. The warmest years since records began in 1881 were 2018 and 2022 with 10.5°C. Comparing the current reference period 1991-2020 with the previous reference period 1961-1990, the mean annual temperature in Germany has increased by 1.1 K from 8.2°C to 9.3°C. At the mean extreme values of temperature, the maxima show a stronger upward trend than the minima.

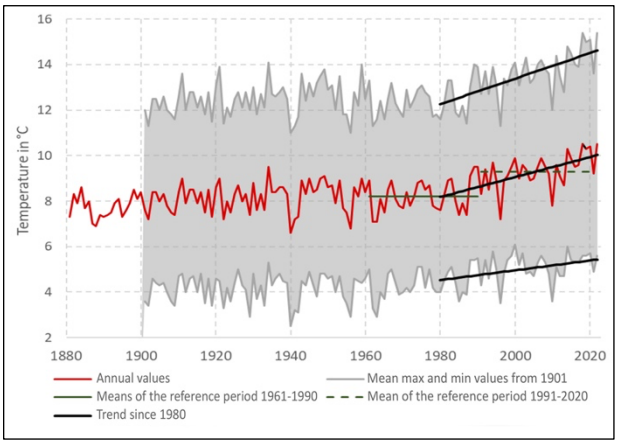

Figure 2: Time series of annual average temperatures (area averages from station measurements at a height of 2 m) from 1881 to 2022 (data basis: DWD, 2023)

As a result of global warming, major changes in extreme weather events are occurring. This leads to regional shifts or an increase or decrease in extreme weather events such as heat waves or severe frosts. It can be assumed that global warming with the effects described will continue and thus become more severe in the coming decades. This causes an increasing tendency towards days with high temperatures while at the same time decreasing the tendency towards days with low temperatures. New

temperature records are becoming more likely. It should be taken into account that, due to natural variability, there will continue to be cold winters, cool summers and the risk of late frosts. However, the probability of these three events occurring is decreasing as a result of global warming.
The wind conditions at a location are essentially determined by the general air pressure distribution. Depending on the general weather conditions, winds can blow from all directions. The predominant wind direction in Germany is west. However, the terrain relief as well as vegetation, buildings and subsoil have a significant influence on wind direction and wind speed. In weather conditions with only small differences in horizontal air pressure, local wind systems such as the land-sea wind can develop. Currently, no trend statements can be derived from model calculations in the context of climate change, as the results vary greatly from model to model.
The observed global mean sea level increases are 1.4 mm/year in the period 1901-1990 and 3.6 mm/year in the period 2006-2015 (IPCC, 2019). In the German Bight the increases are 1.7 mm/year in the period 1901-2008 (Wahl et al., 2011) and in the German Baltic Sea they are 1.0 mm/year for the 20th century (Weisse & Meinke, 2017) and in the southwestern Baltic Sea in the period 1900 to 2015 at 1.2 mm/a (Kelln, 2019). For the German coasts, there are minor regional and local trend differences due to the local effects, but the trends are still in the range of the trend estimates for global mean sea level (Kelln, 2019).
Because of the increased water levels in the North Sea and Baltic Sea due to sea level rise, the tidal high and low water levels influenced by the tides are also higher along the German coasts and in the estuaries under medium conditions and during a storm surge.
Under identical meteorological conditions, a rise in sea level causes the highest water level during a storm surge to increase to approximately the same extent as the sea level rise and the peak of the flood occurs a few minutes earlier. High water levels also last up to several hours longer due to a significant rise in sea level.
Since, according to current knowledge, no climate change-related increase in wind speeds can be assumed during storms, it can be assumed that storm surges will not occur more frequently when referring to the mean water level on the coasts of the German North and Baltic Seas, but caused by the rise in mean sea level will take place at a different altitude. Storm surges will be higher in the future compared to today and the duration of high-water levels will be longer.

VULNERABILITY OF GERMAN SEAPORTS AND ADAPTATION TO CLIMATE CHANGE

Based on the identification of relevant climate parameters and processes and their changes, the climate change-related vulnerability of German ports is derived in order to then show possible adaptation options. The following areas will be considered in the recommendations:

- Port infrastructure: port access and roadstead, harbor entrance (facilities, navigation), internal port access channels/turning circles/port basins (facilities, navigation), quays/piers, dolphin berths, pontoons and jetties, internal port flood protection, internal port traffic areas, hinterland connections, electrical engineering and information technology and renewable energies
- Port superstructure: surfaces/coverings, drainage systems, warehouses, handling equipment, office and service buildings as well as manufacturing industries
- Port operations: port handling, traffic and passenger safety, control of the inflow and outflow of goods, security and sediment management

OUTLOOK

The HTG KlimaHafen Working Group, founded in 2022, aims to develop recommendations on the subject of vulnerability and adaptation of German ports in the context of climate change. The interdisciplinary working group made up of climate scientists and port industry actors offers the opportunity to combine expertise on the expected climate changes and the resulting vulnerability of German ports in order to then identify options for adapting to climate change. With the defined framework of consideration of climate changes, consequences and adaptation options for port infrastructure and superstructure as well as port operations and, in addition, the development of a port-friendly adaptation strategy and case studies on climate change adaptation, the working group has set itself an ambitious goal, the achievement of which will be supported by the members of the working group is being pursued ambitiously and is scheduled to be achieved in the fourth quarter of 2024.

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