



## **Storm surges and human reactions at the North-Sea area from Medieval time until 1825**

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Since the high Medieval age the entire area of the North-Sea area were intensively cultivated and more densely populated than ever before. The salt marshes were protected by dikes and the former peat land was drained and cultivated. First dikes along rivers are known since the Roman time in the southern Netherlands and Flanders, since the 12th century AD also along the northwest German coast. As a consequence of dike building the water level increase during storm surges due to the reduction of flood plains. Initially, the medieval dikes were not high enough to protect low-lying land against higher storm surges. Storm surges are natural events that have always threatened the life at the North-Sea coast, and which may cause heavy damage due to increasing use of the coastal regions nowadays. Both, natural disaster and coastal protection defence measures are based on analyses of extreme flood levels. Frequency and occurrence of historical storm surge events have to be considered in the context of former climatic and weather conditions. Extreme storm surge events causing major losses of land have shaped the coastlines over centuries. Especially, storms from the North-West forced water into the German Bight and the estuaries, and breaches of the dikes were common. It should be considered that the not very detailed medieval chronicles, which describe such catastrophic events, focused primarily on the effects and damage caused by catastrophic consequences after the breaking of dikes. The disasters were a common analogy to the coming final judgement of God. To be able to classify historical storm surges before the 19th century, it is necessary to know the former tidal levels.

Due to the expensive draining and subsequent compaction of the soil the surface in some coastal areas had sunk in late Medieval time, which has catastrophic consequences. Large bays – such as the Dollart in the Ems Estuary as well as the Jadebusen between Wilhelmshaven and Butjadingen – developed instead of the former cultivated peat land. Some of the largest land losses in the 14th century along the North-Sea coast were recorded in the North-Frisian Uthlande, Schleswig-Holstein. A massive southwesterly Atlantic gale, which swept across England, Northwest Germany and Schleswig-Holstein around January 16, 1362, causing at minimum around 25,000 deaths. Cultural remnants of the drowned cultural land, such as sluices, field strips and Warften, in the south North-Frisian Wadden-Sea around the Hallig Südfall dating back to the 12th to 14th century. Also northward of the old island of Strand large cultivated areas changed into tidal flats, as cultural remnants around the today Halligen of Langeness, Habel and Gröde indicate.

The magnitude of the land losses in the southern North-Frisian Uthlande was mostly the effect of the geology, landscape development and landuse. As a result of drainage and salt peat cutting, the MHW was mostly higher than the surface of the embankened areas. Thus, in particular, the exploitation of the coastal area by its inhabitants has to be blamed for the disaster. However, the coastal population could not know that the geological subsidence of the land, which depended on the relief of the glacial surface and the type and thickness of the overlying marine deposits, had not yet come to an end. Large tidal channels and gullies such as the Norderhever cut into the embanked salt marsh area in 1362. These tidal channels followed old, deep glacial melt water valleys of the Pre-Holocene landscape which had been filled up with sediments after the North-Sea reached this area 6,000 years ago. Also after the disasters of the 14th century another storm surges hit the North-Sea coast, f. e. in 1404 and 1532. After this disasters the dikes became higher and larger, but were still not high enough as the so-called Buchardi Flood struck the North-Sea coast of Denmark and North-Frisia in the night between the 11th and 12th October 1634. This disastrous storm surge turned extended

areas of coastal marshland into tidal flats. The 22,000 ha large island of Strand was divided into the islands of Pellworm and Nordstrand as well as a group of smaller islands (Halligen). 6,123 inhabitants of the former island were killed and 1,336 houses as well as 28 windmills were destroyed. The dramatic dimensions of landscape change are exemplified by the deepening and widening of the tidal channel Norderhever, which evolved from the Fallstief channel, itself the result of previous storm surges. At least, 4,000 ha of land had been lost in this area during earlier storm surges (Fig. 1). By 1660 the storm surges had thus sculpted the characteristic shape of the island out of the former shoreline with a lot of small islands. An impressive evidence of this disaster are the cultural remnants in the today tidal flats near around the islands.

Since 1634 the dikes became higher and larger and the coastal protection more and more professional. But again the natural powers were stronger than the human reactions. As a result of the following heavy disasters of 1717/18 and 1720 a lot of dikes broke and the North-West German salt marshes were inundated again by salt water. Thousands of Humans lost their live. Also in 1825 a lot of dikes broke but heavy land losses stayed away. Since the 17th/18th century – as a result of new embankments – the coastline has gradually shifted the seaward margin of the Wadden-Sea eastward. Anyway, the losses in the material substance of the Wadden-Sea which began in the 17th century have continued until today. Today, the tidal volume has increased, partly as a result of the ongoing sea level rise. Therefore, more water flows in and out of the tidal basins through the channels with each tide, increasing erosion. The analyses of the changes in landscape leads to insight that greater attention must be paid to the history of morphological and landscape changes of the Wadden-Sea area.