MemoD14 The Netherlands

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0.1 Introduction

This study describes an analysis of change in coastal storm occurrence for the Netherlands. Both observed trends in storminess as well as expected climate change impacts on future storm occurrence are examined.

In different studies different measures are used to quantify "storminess". A storm can be characterised by intensity, frequency and duration of characteristic storm properties like wind speeds. In some studies proxies are used, for example pressure tendencies, surface air pressure and storm surge. Other studies examine wind speeds directly. An overview of different proxies and research methods for determining storminess changess can be found in ???. ? concludes that different methods can lead to a different interpretation of the data, and the predicted changes.

In the current work coastal storminess change is assumed to be an underlying variable representing both frequency and intensity of storms directed at the coast. Change in storminess is operationalised [see ?, chap. 1] as the relative changes in the annual number of storm events. We will compare the storminess changes with storminess changes measured by changes in storm surges.

The availability of data determines the frequency of storms that can be investigated. Low frequency storms require a long period of measurements. For the Netherlands, sets of continuous measurements are available since the 60's. This is just enough to notice big changes in storminess for infrequent (twice per year) events. In case the trend changes in storminess are small, they can only be observed over longer timespans or for higher frequent events. From a short term, tactical perspective, which fits in the operational focus of the MICORE project, the return period of interest for the Netherlands is about once every 2 years. The power of a 40 years dataset is still not enough to examine trends with the order of magnitude as found so far. Examing changes over longer periods using historical records could provide more insight in the changes in the occurence of storms with a 2 year return period.

We will first examine wind observations at coastal stations over the last decades. These results will be compared with previous analysis of surge levels. Storminess in the context of climate change will be examined using results from scenario studies and reanalysis studies.

0.2 Method

0.2.1 Observations over the last decades

The relative changes in the annual number of storm events can be examined using decadal length time series of wind speeds collected by weather stations or by proxies of these like pressure measurements. The most important dataset for examining storminess changes in the Netherlands resides at the Koninklijk Nederlands Meteorologisch Instituut (KNMI). The KNMI measures wind speeds at different stations in the Netherlands. Because direct station measurements of storm occurrence and intensity are available, studies doing reanalysis of proxy data [for example ?] will not be considered as the measure for describing observed changes in storminess. Comparisons between these studies can be found in for example ?.

The wind data of the KNMI have been analysed by ?. They analysed wind data for 13 stations, both coastal as well as inland stations over the period 1962 through 2002 . For the current work, only the analysis of the coastal stations is used. ? look at the annual numbers of independent wind events that last for several hours. The intensity is determined by the observed hourly peak wind speeds. Frequency is determined by the number of occurrences per year. The study makes an ordinal categorisation of storms where weak events occur on average 30 times per year, moderate wind events are defined as winds which occur on average 10 times (windspeed 6-7Bft), and strong events have an occurrence rate of 2 times per year (windspeed 7-8Bft).

Longer timeseries (100 years), using storm surges as a proxy, were analysed by ?. We only look at the high water setup of the Hoek van Holland and Vlissingen stations. The authors define a storminess factor for each station, using four different storm frequencies , by splitting the timeseries in groups of 10 years. For each decade an expected $1/10000$ year storm surge is computed. The expected $1/10000$ year storm surge over the whole 100 years is substracted from the decadal storm surge. This is what the authors call the "storminess factor". Note that extrapolation using a weibull distribution was used to obtain an estimate of the $1/10000$ year event. This is done for comparison purposes and does not imply changes in the $1/10000$ year storm trend.

0.2.2 Modelled climate change effects

The expected climate change impacts on storm occurrence has been examined using numerical weather prediction models with hypothetical scenario's. An overview will be given of the analysis of climate change scenario's and their expected impact on storm occurrence.

The wind data of the KNMI combined with historic records is also used as a source for the climate change scenarios described in ?. This study extrapolates expected wind occurrence using numerical weather prediction models and 4 different climate scenario's.

0.3 Results

0.3.1 Observations over the last decades

The analysis of wind data as observed at different stations in the Netherlands over the period 1962 through 2002 was analysed by ? (FIGURE 1). For each storm frequency (number of storms per year), the trend over 40 years was analysed. If for example the moderate storms (10 times per year) occur more often over this period, the trend (% of increase over 10 years) will be positive (e.g. for IJmuiden). If the number of moderate storms decrease over the years, the trend will be negative (e.g. for Hoek van Holland). For identical storm occurrences, the trends are different for the different stations. Note that the 0 axis intersects with the confidence interval meaning that moderate to strong events do not statistically significant decrease. Figure 2 presents this spatial variability in trends in storm occurrence for the strong storm events (twice per year). The figure presents increasing trends along the Southern part of the Dutch coast and mainly decreasing trends along most of the Holland coast (Western part of The Netherlands). It should be noted that strong winds in The Netherlands generally come from the North Sea (FIGURE 3). The presented analysis on wind speeds can therefore be used to understand the trends in storminess of events that may pose a hazard to the Dutch coastal area.

The analysis of 100 year storm surge variations showed no significant trend for both stations. The results of their analysis, for different storm return periods, show no overall significant trend (FIGURE 4).

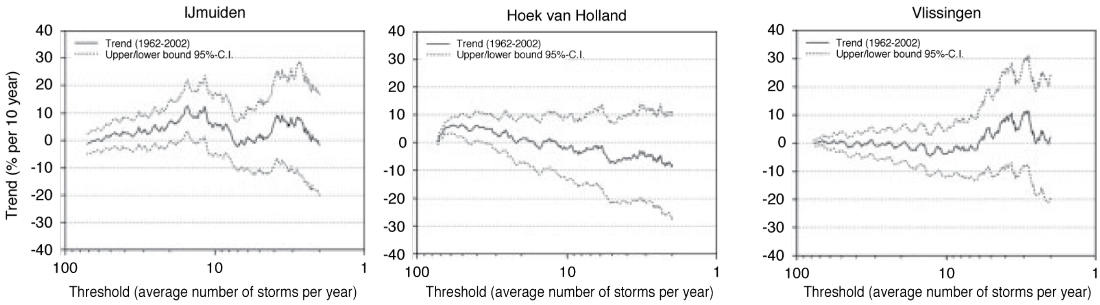

Figure 1: Trends(%/decade) in the annual number of storm events as a function of severity level for three coastal stations (from North to South with geographical locations indicated in Figure 2. Left: IJmuiden, middle: Hoek van Holland, right: Vlissingen). From: ?

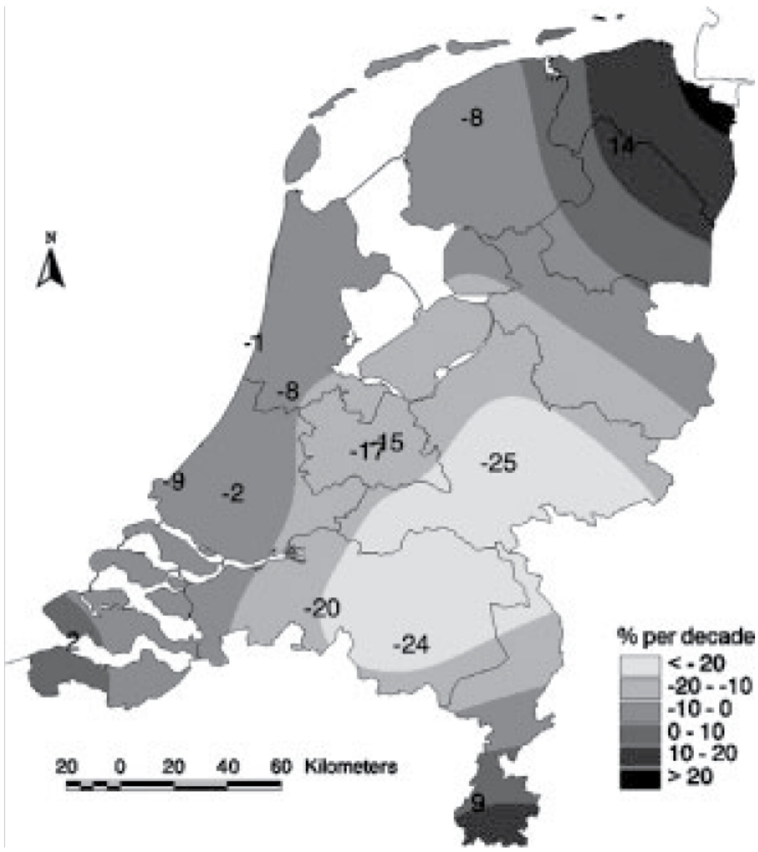

Figure 2: Trends($\%/decade$) in the annual number of storm events for strong events. From: ?

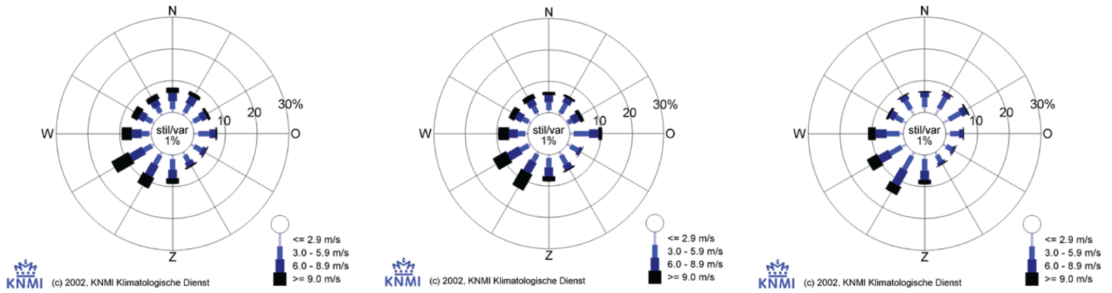

Figure 3: Average (1971-2000) yearly wind climate. Left: IJmuiden, middle: Hoek van Holland, right: Vlissingen. From: ?

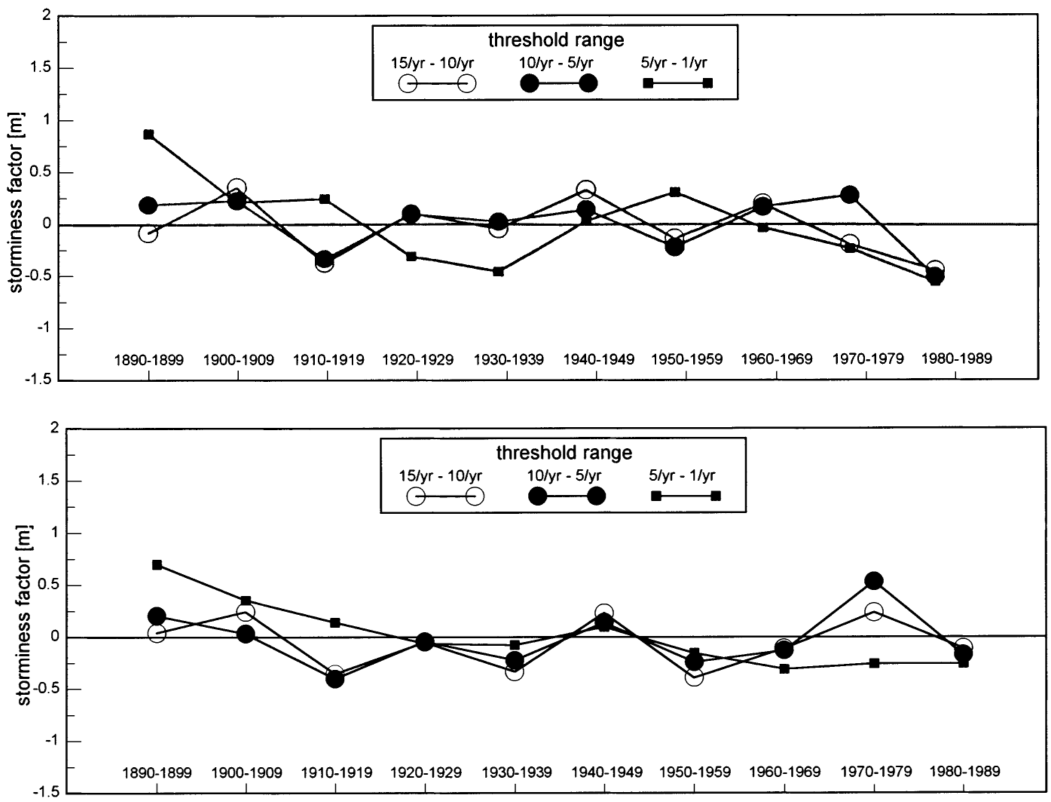

Figure 4: Decadal high water set-up storminess factors. Top: Hoek van Holland, bottom: Vlissingen. From ?

0.3.2 Modelled climate change effects

The only climate change model available so far that looks at wind and is specific for the Netherlands is described by ?. The four climate scenarios described in this research vary on two factors: air circulation patterns (constant, increased) and temperature increase (1°, 2°). FIGURE 5 shows the expected change in the yearly maximum daily mean wind speed until 2050 for the four scenarios. It shows an increase in two scenarios, a decrease in one scenario and one with a constant maximum wind speed.

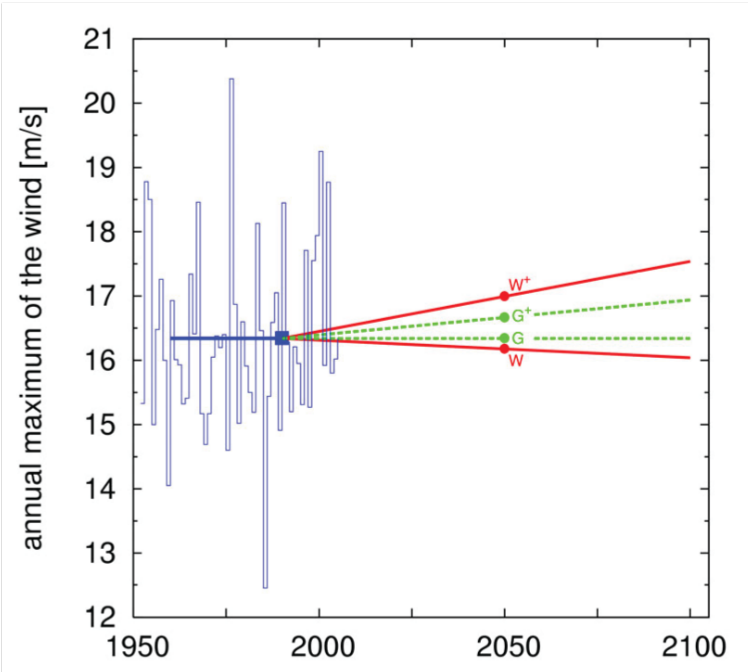

Figure 5: Time series of observed yearly maximum daily mean wind speed (m/s) in IJmuiden, plus the scenario values for 2050. From: ?

0.4 Conclusions

The trends in storminess shows a big variation across research methods, region, season and observed period. Observations in the Netherlands show a slight decrease in storminess while reanalysis models show an increase. There are different aspects which can explain these differences which have been discussed by the original authors [see ???] like homogeneity breaks and increase in surface roughness due to population increase.

The statistical power of the dataset is enough to show differences in storminess of storms up to 10 storms per year. Less frequent storms do not show a significant change. While one series of observations alone does not provide enough statistical power to test hypotheses on the decadal trends, doing a meta analysis over several European countries can give more insight into the harder to observe trends in storminess. However with the combination of different research the ambiguity of the definition of storminess will perhaps result in more variation than added explanation. For this meta analysis it is therefor important to aim for a consistent definition of the storminess and focussing on the storminess only in coastal regions.

From a long term, strategical perspective, the coastal defence in the Netherlands the coastal protection is designed to withstand storms with a 10000 year return period. The storminess itself can, with a limited reliability, be computed by fitting extreme value distributions to the observed data. But changes in storminess, for storms with such low frequency, can not be examined using a series of 40 years of data. To examine trends in return periods the length of the observed timeseries has to be an order of magnitude greater than the return period of the storm.