RECONSTRUCTIONS OF NORTHEAST ATLANTIC AND GERMAN BIGHT STORM ACTIVITY FROM THE LATE 19TH CENTURY ONWARDS



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Birmingham, October 2019

- Motivation
- Reconstructed Geostrophic Storminess
- Uncertainty
- Conclusions

Why do we need information about past storminess?

- **Climate change**: How have storms changed and what to expect in the future?
- **Risk assessment**: Windstorms are one of the major natural hazards in terms of frequency and loss. They are associated with potentially high impacts. Coastal and inland cities and infrastructure supporting cities are heavily affected.
- **Renewable energy sector**

… but

... BUT

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- Systematic wind measurements available for a short amount of time
- Wind measurements are inhomogeneous due to
  - changes in measurement routines
  - instruments used
  - changes in station surroundings
  - relocation of stations

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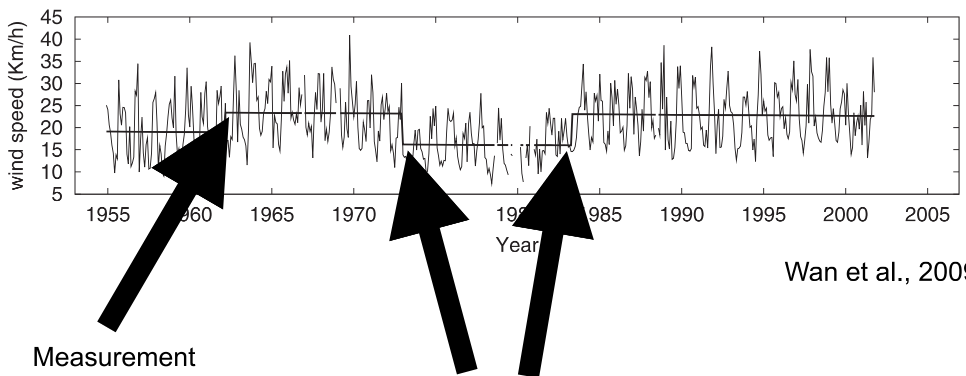
numerous examples

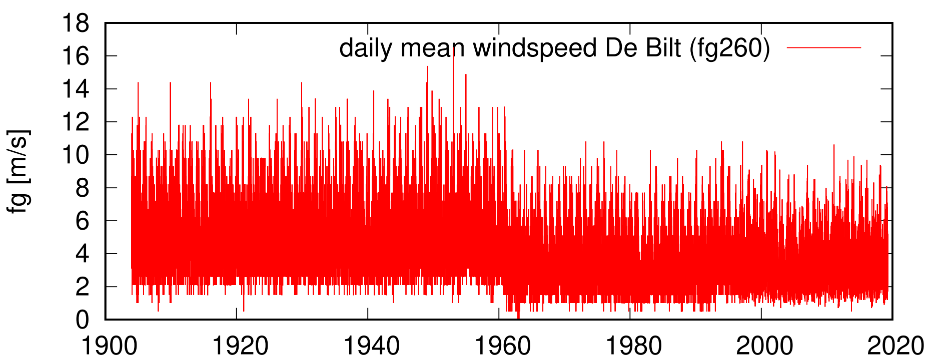
Monthly mean wind speed at McInnes Island, BC.



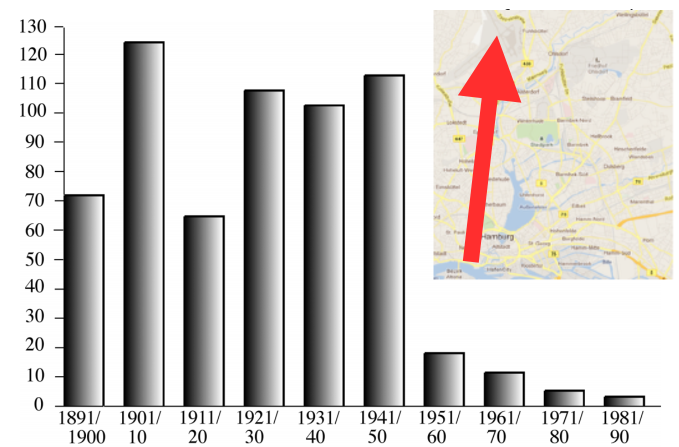
Wan et al., 2009

Measurement instruments were changed (1963)

Relocation (1973, 1982)



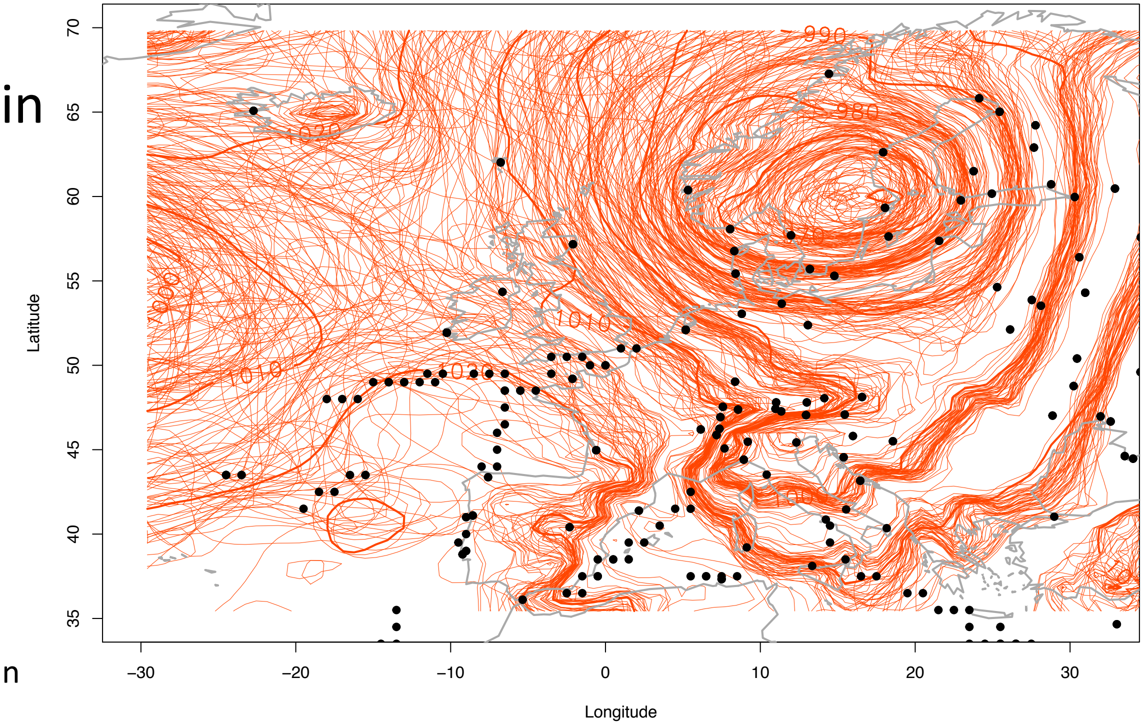
De Bilt, NL: station relocations, creeping vegetation
(reason for 1960 unclear, source: climate explorer, KNMI, 2019)



Time series of the 10-year sums of events with winds stronger than 7 Bft in Hamburg (about at least 14 m/s).

What about reanalysis data?

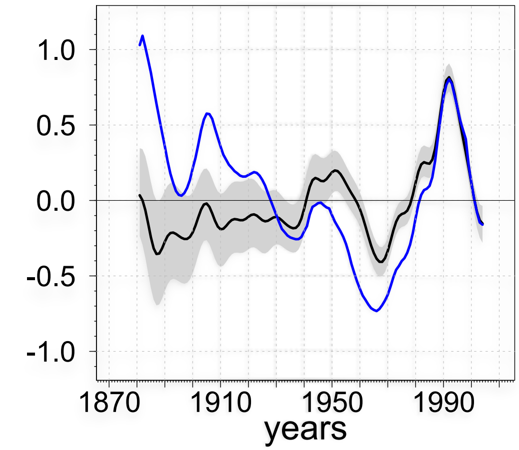
- Reanalyses, especially on longer time scales, are **uncertain** and inconsistent
- Long-term trends of storminess from reanalyses often do not agree with those derived from observations
- few observations to constrain the models



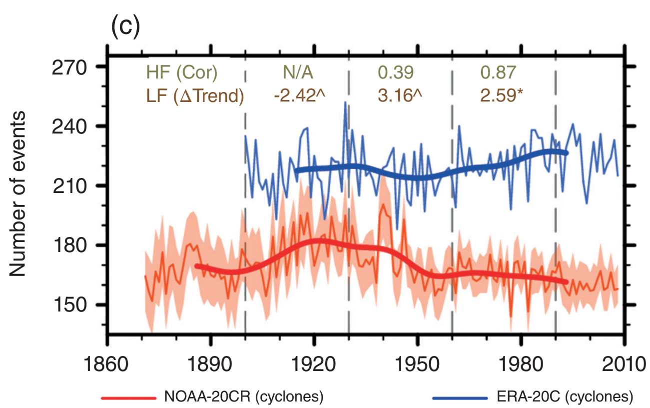
Example: SLP and assimilated observations from 20CRv3 (ensemble) at 12 March 1906 21:00 UTC. (Isobars have a distance of 10 hPa) (Meyer et al., in preparation)

What about reanalysis data?

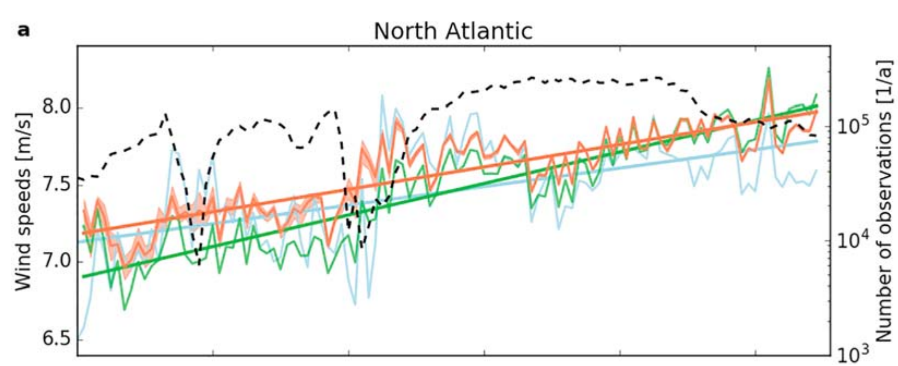
- Reanalyses, especially on longer time scales, are uncertain and **inconsistent**
- Long-term trends of storminess from reanalyses often do not agree with those derived from observations
- changing station density



Example: Long-term NE Atlantic storm activity in the Twentieth Century Reanalysis dataset 20CR (black) and that derived from station-based geostrophic wind speeds. (Krueger et al., 2013)



Example: Time series of cyclone events for the North Atlantic in 20CR and ERA-20C (Befort et al., 2016)



Example: Time series of annual mean windspeed for the North Atlantic in 20CR (green) and ERA-20C (red) (Wohland et al., 2019)

- Solution: proxies based on air pressure observations

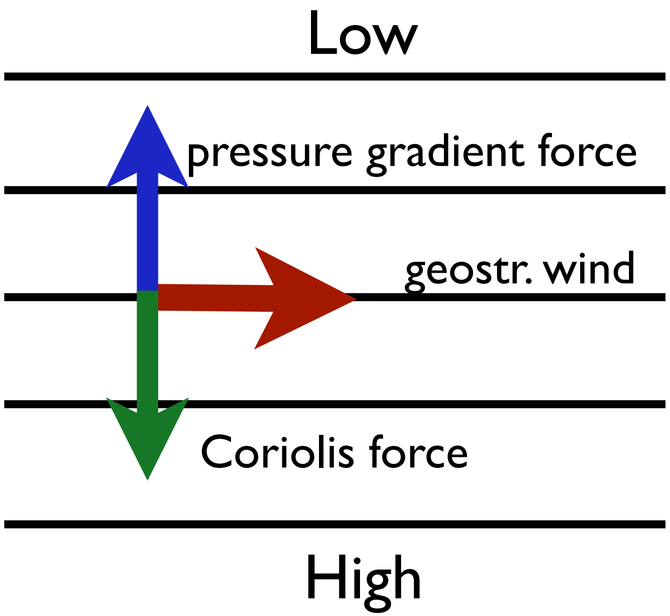
➡ air pressure less disturbed by surroundings
➡ air pressure does not change much on small scales
➡ long time series of measurements available at some sites

- triplets (triangles) used to derive geostrophic wind speed

- atmospheric circulation in midlatitudes is mostly geostrophic

- balance between pressure gradient force and Coriolis force

- pressure gradient determines strength of wind speed



STORM ACTIVITY

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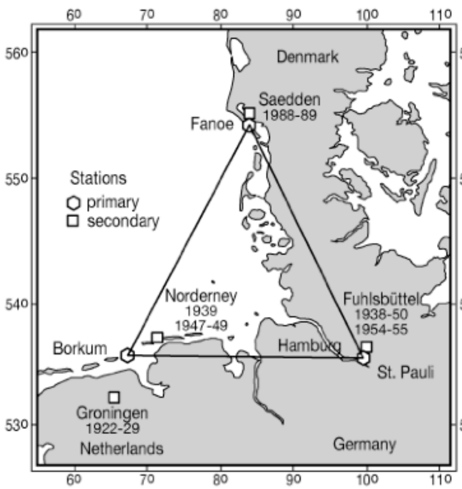
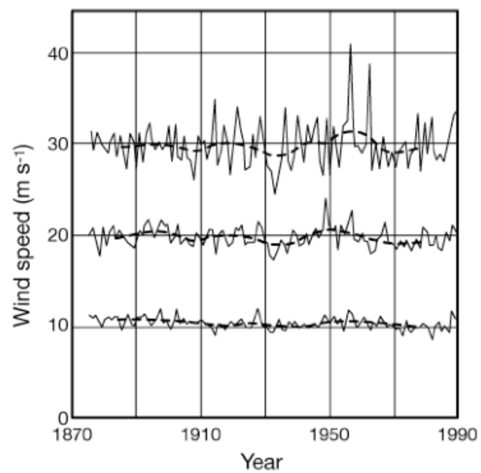
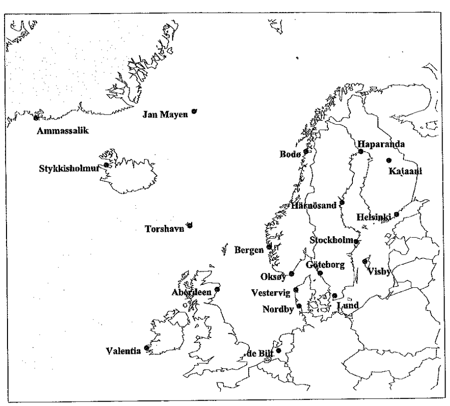
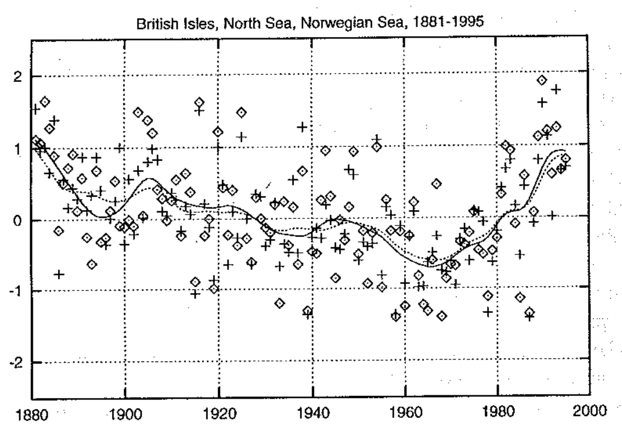




Schmidt and von Storch, 1993 used daily geostrophic wind speeds to derive annual frequency distributions to infer about German Bight storminess.





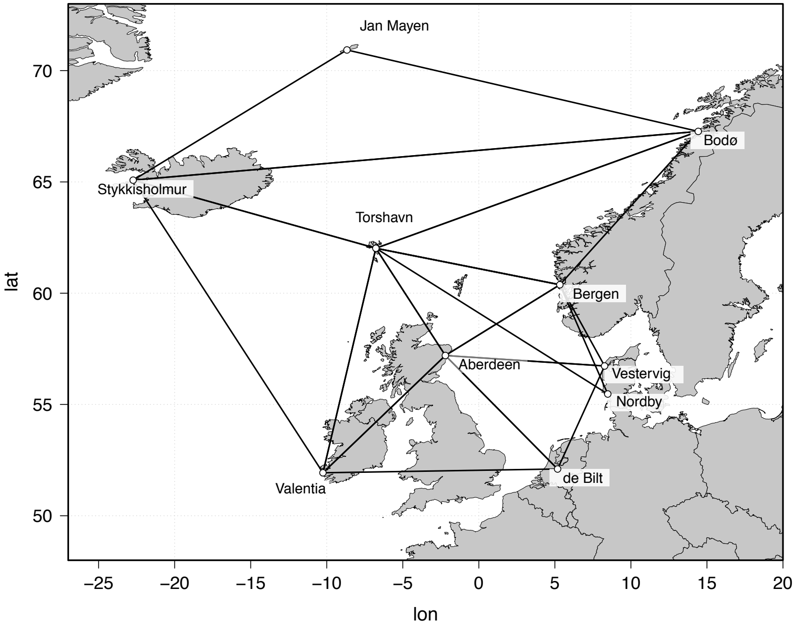
Long-term variations of the Storm Climate over NW Europe (Alexandersson et al., 1998)

- method established
- time series of NE Atl. storminess later extended to 2007 (Feser et al., 2015)

STORM ACTIVITY

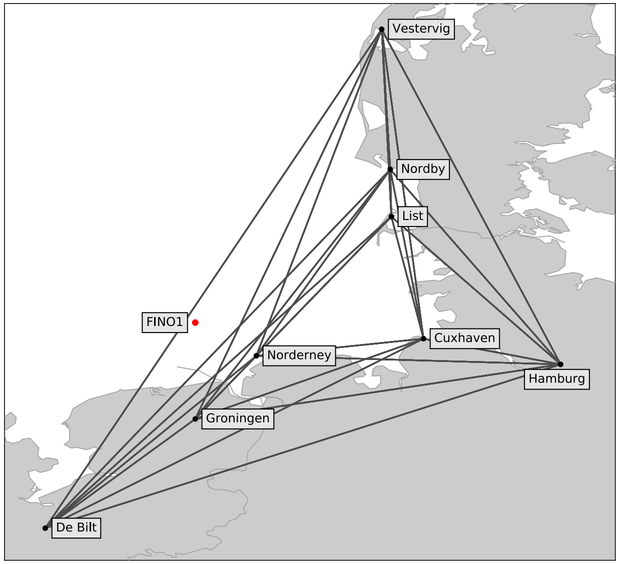
Northeast Atlantic

- mean sea level pressure from 10 stations (ISPD)
- 1875-2016



German Bight

- mean sea level pressure from 8 stations (ISPD, DWD, KNMI, DMI)
- 1897-2018



- 95th/99th percentiles of geostrophic wind speed
- standardized
- averaged and lowpass filtered

STORM ACTIVITY

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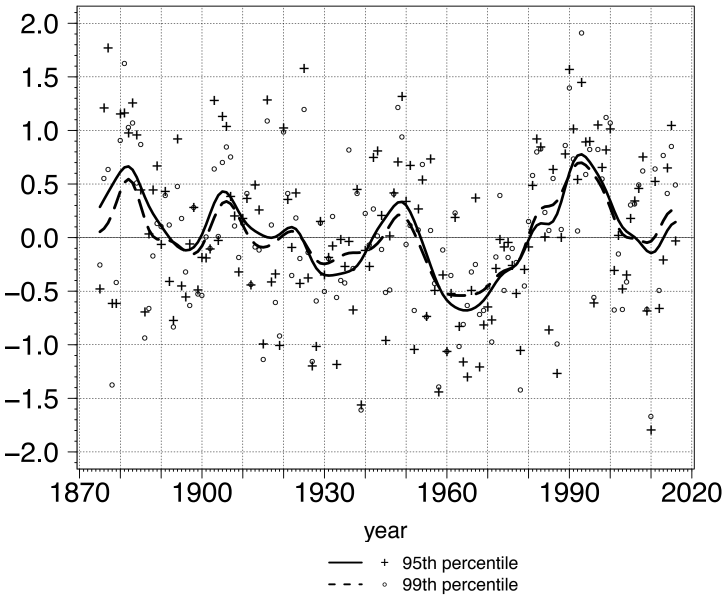
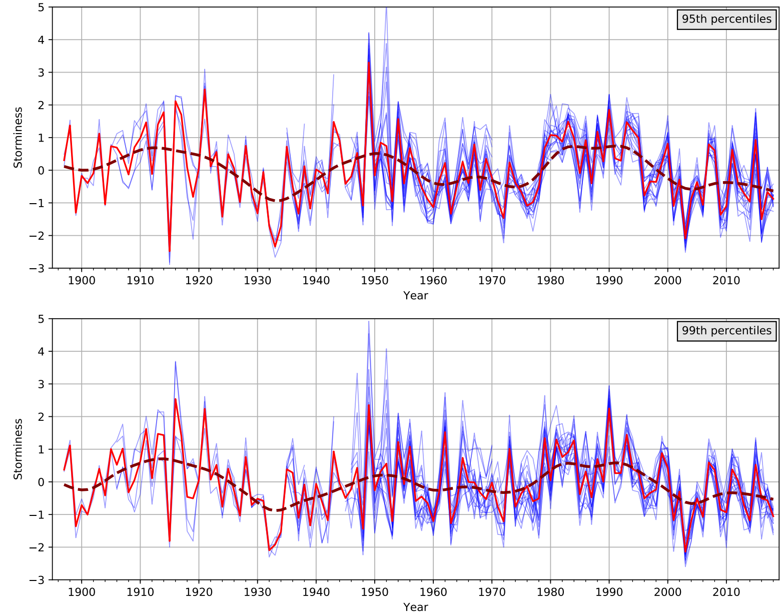
Northeast Atlantic



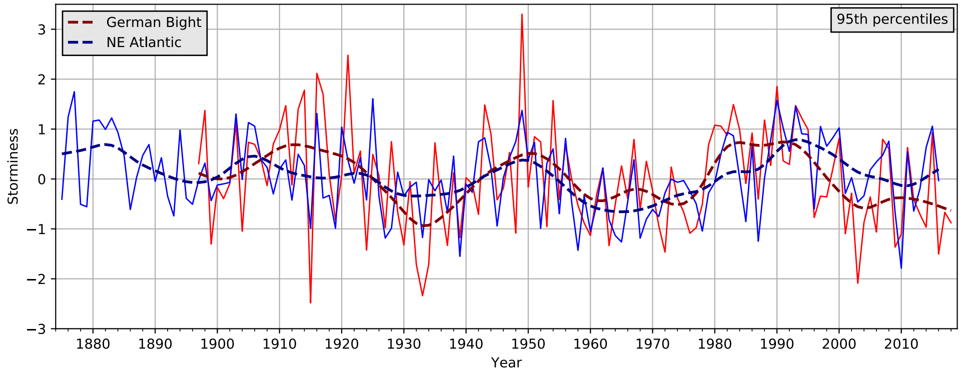
- rel. high values in the beginning
- low in the 1960s
- remarkable increase to the 1990s
- afterwards decrease to average levels
- annual and decadal variability

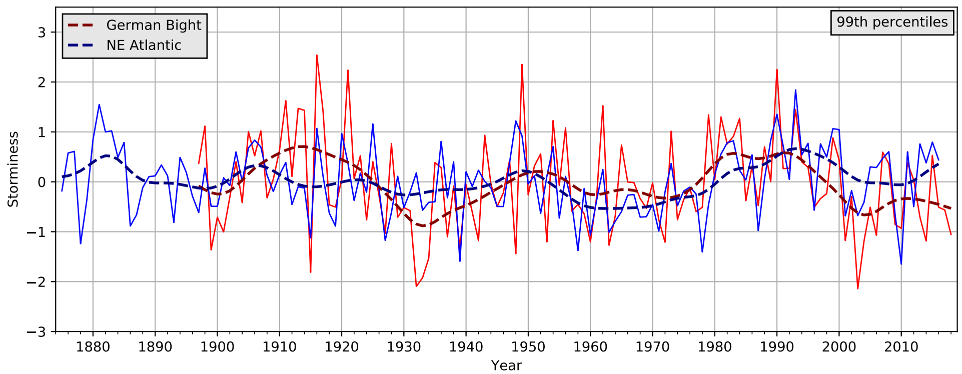
German Bight



- annual variability higher (artifact from different standardization periods) with absolute minimum and maximum in the 1910s and around 1950 (1949 highly active; notable events; 1962 also visible)
- annual and decadal variability

STORM ACTIVITY





- if standardized for the same periods:
- annual variability similar, but slightly higher for the German Bight
- both decadal variability
- both show increase from the 1960s to the 90s, but German Bight reaches plateau earlier
- German Bight afterwards decreases to sub-average values

- differences due smaller German Bight region
- detect more small-scale disturbances (higher variability)
- last years: German Bight anticyclonic circulation during storm seasons

sources of uncertainty

- digitization errors
- sampling errors
- conversion errors (height correction, time zones, pressure units)
- errors due to measurement routines

considered through:

- using quality control metadata of the ISPD, of weather services, and our own procedures
- mimic uncertainty through bootstrapping

UNCERTAINTY (RANGE)

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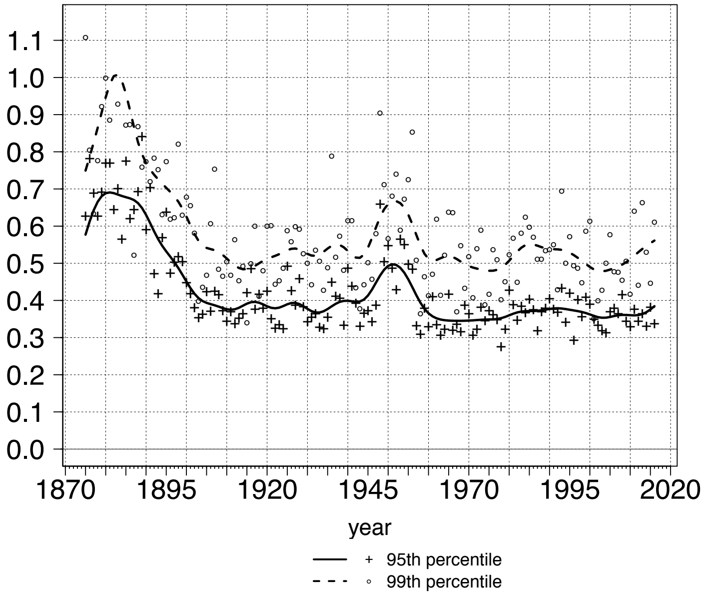
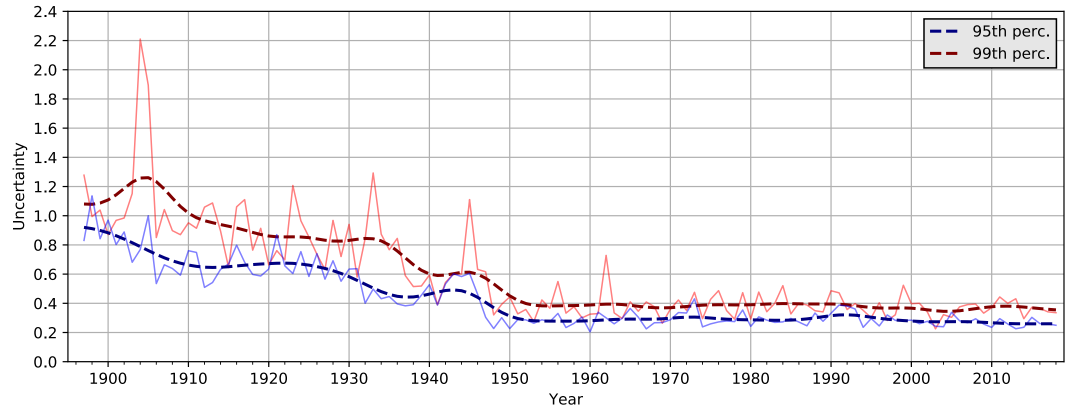
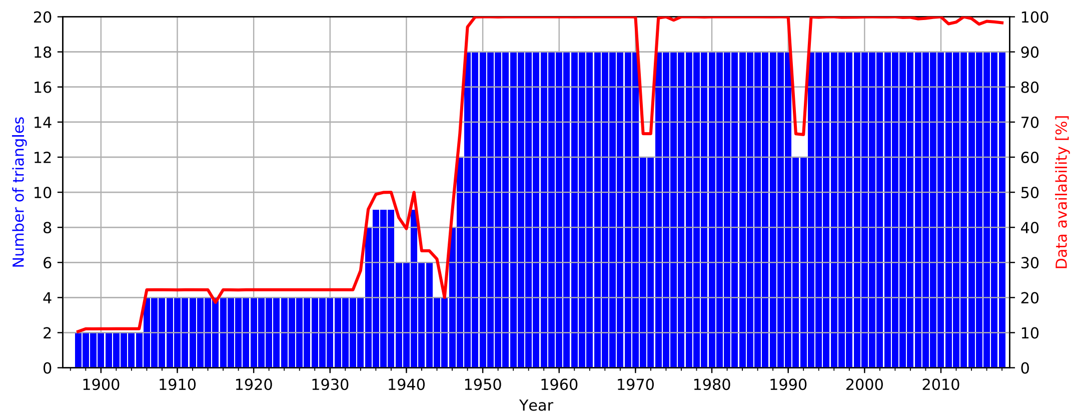
Northeast Atlantic



German Bight





- high values in the beginning
- higher values 1948-1956 (NE Atl)
- decrease in later years afterwards and rel. stable (higher data quality)
- German Bight less uncertainty due to higher data availability in general

CONCLUSIONS

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- why we need (long) reconstructions of past storm activity
- Northeast Atlantic storm activity from 1875-2016 and German Bight storm activity from 1897-2018
- no long-term trend, but multidecadal variability
- uncertainty inherent in the reconstruction of storminess

➡ Northeast Atlantic storm activity is published in Journal of Climate DOI: 10.1175/JCLI-D-18-0505.1

➡ German Bight storm activity submitted

➡ Ongoing: Implementing storm indices in an online monitoring tool that allows near-real time assessment of events

  ➡ How have storms changed and what to expect in the future?

  ➡ What is the contribution from climate change to ongoing events ("Is this still weather or already climate change?")

Thank you!