Storm surge climate in the western Baltic Sea 1948-2012

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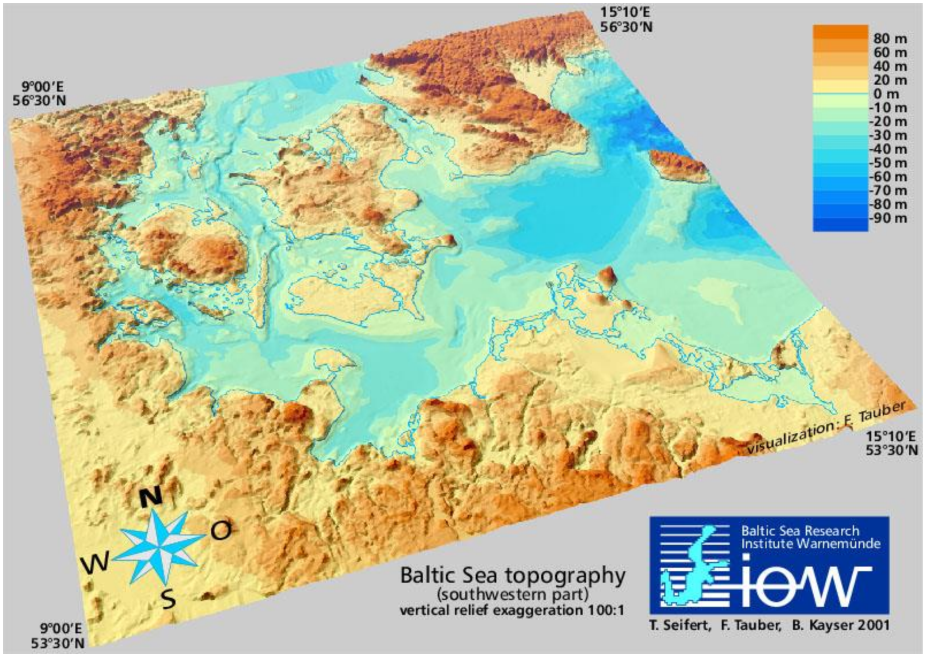
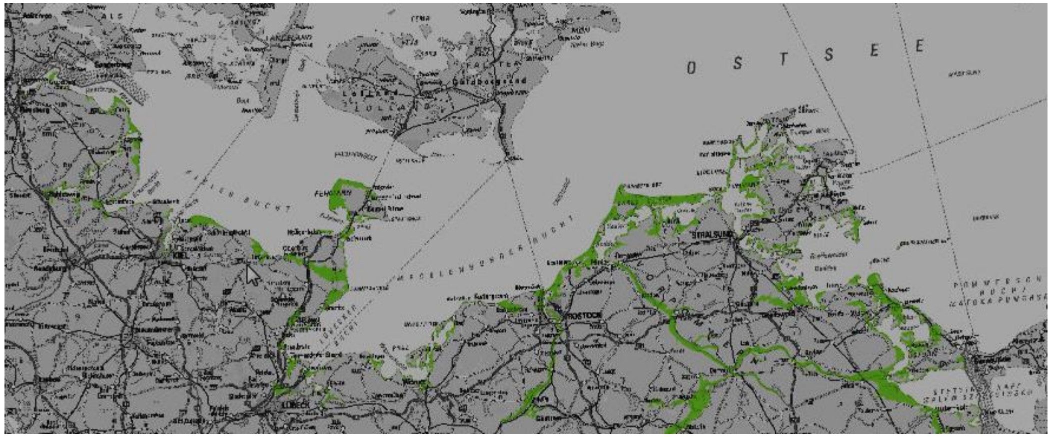
Zentrum für Material- und Küstenforschung

Introduction





Green: Land with elevation below height of the 1872 storm surge
Source: www.kuestenschutzbedarf.de

- → Germany coastline ~ 3.700 km; 50% Baltic Sea coast (BSH)
- → Western part
  - → relatively shallow (around 20m)
  - → low lying coast
  - → fragmented coastline
- → At risk for storm surges, rising mean sea levels and erosion

- → Can we describe the storm surge climate of the western Baltic Sea from numerical modelling?
- → Can we analyze long-term changes in a consistent and homogeneous way?
- → Can we enhance the understanding of potential contributions from processes such as prefilling and seiches?
- → Can we provide a first step towards a climatology of such processes including their long-term changes?

(PhD Thesis, Hendrik Weidemann,
To be submitted by the end of February 2014)

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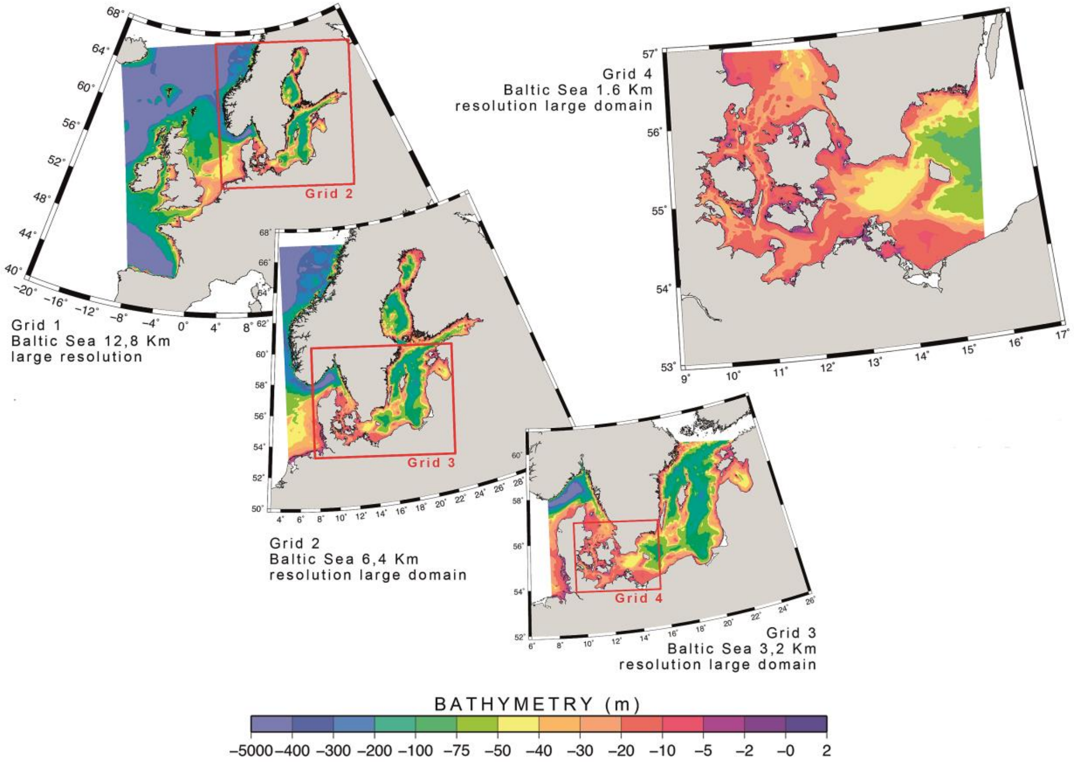


- → Ocean model TRIM-NP (Kapitza 2008)
- → 4 nests from 12.8 km to 1.6 km
- → Tides from FES2004 (grid 1)

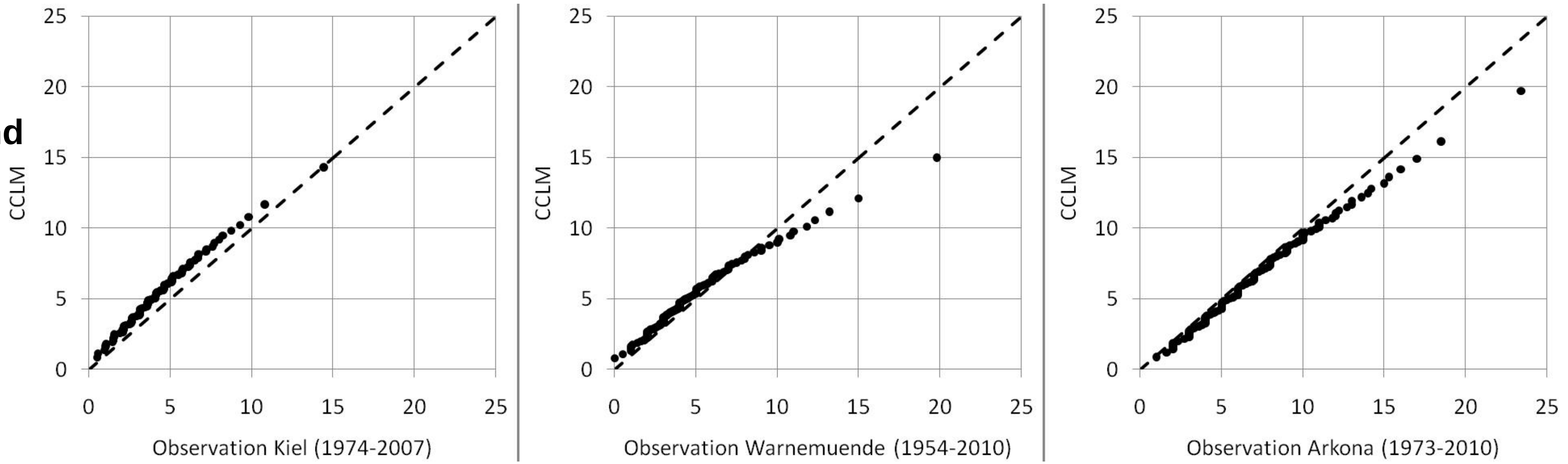
- → Atmospheric Forcing:
  - → Dynamically downscaled NECP Reanalysis 1948-2012 (Geyer 2013)
  - → Hourly near-surface marine wind fields and sea level pressure
  - → Approx. 18x18km grid bilinearly interpolated to model grids

- → Barotropic simulation (no temperature and salinity effects)
- → No sea-ice model included

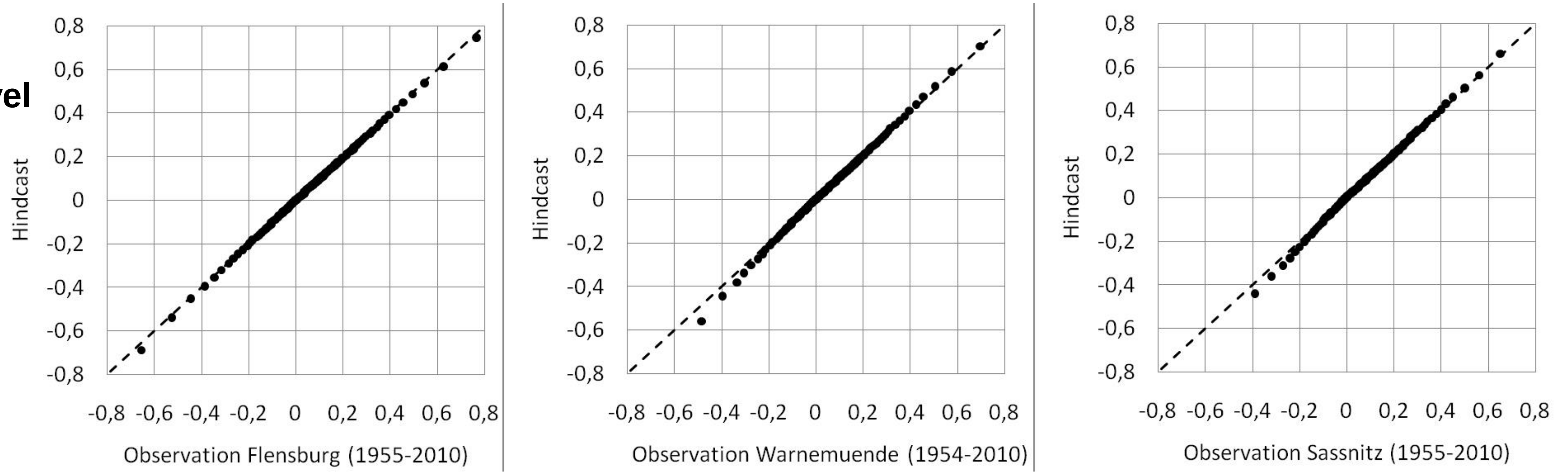
→ Can we describe the storm surge climate of the western Baltic Sea from numerical modelling?

Validation

Wind



Waterlevel



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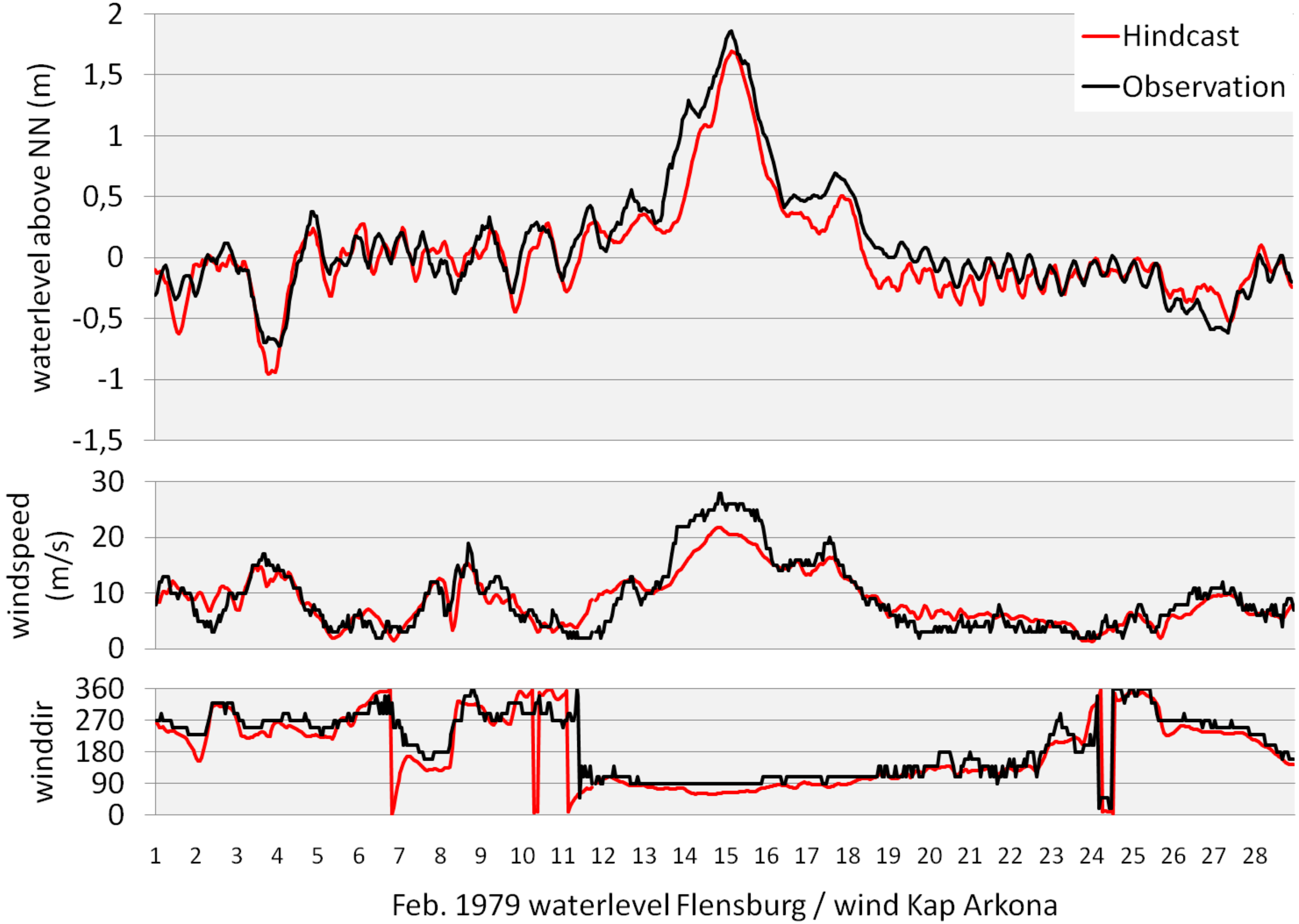
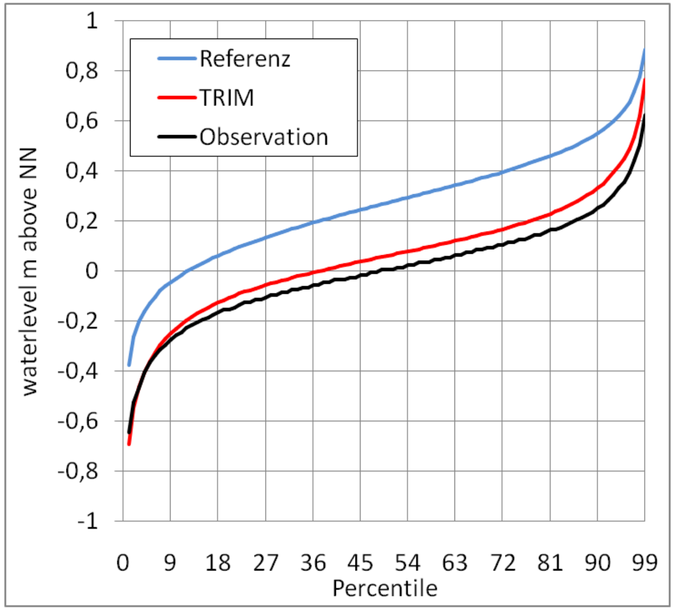
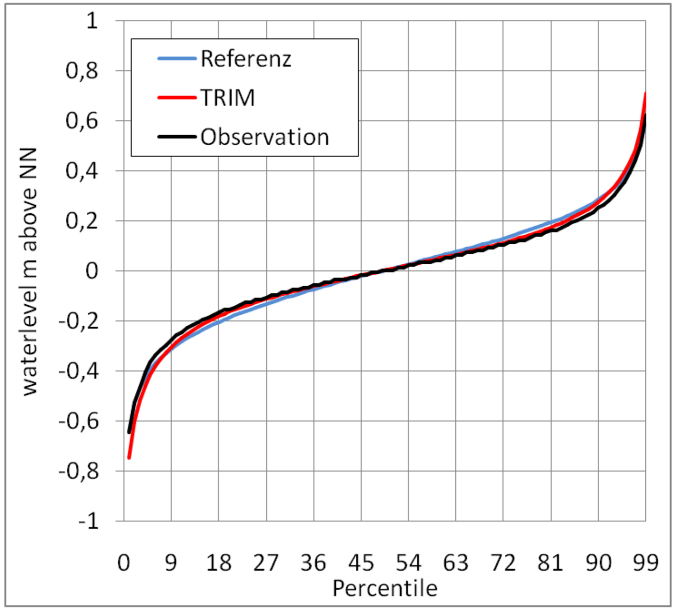
Validation







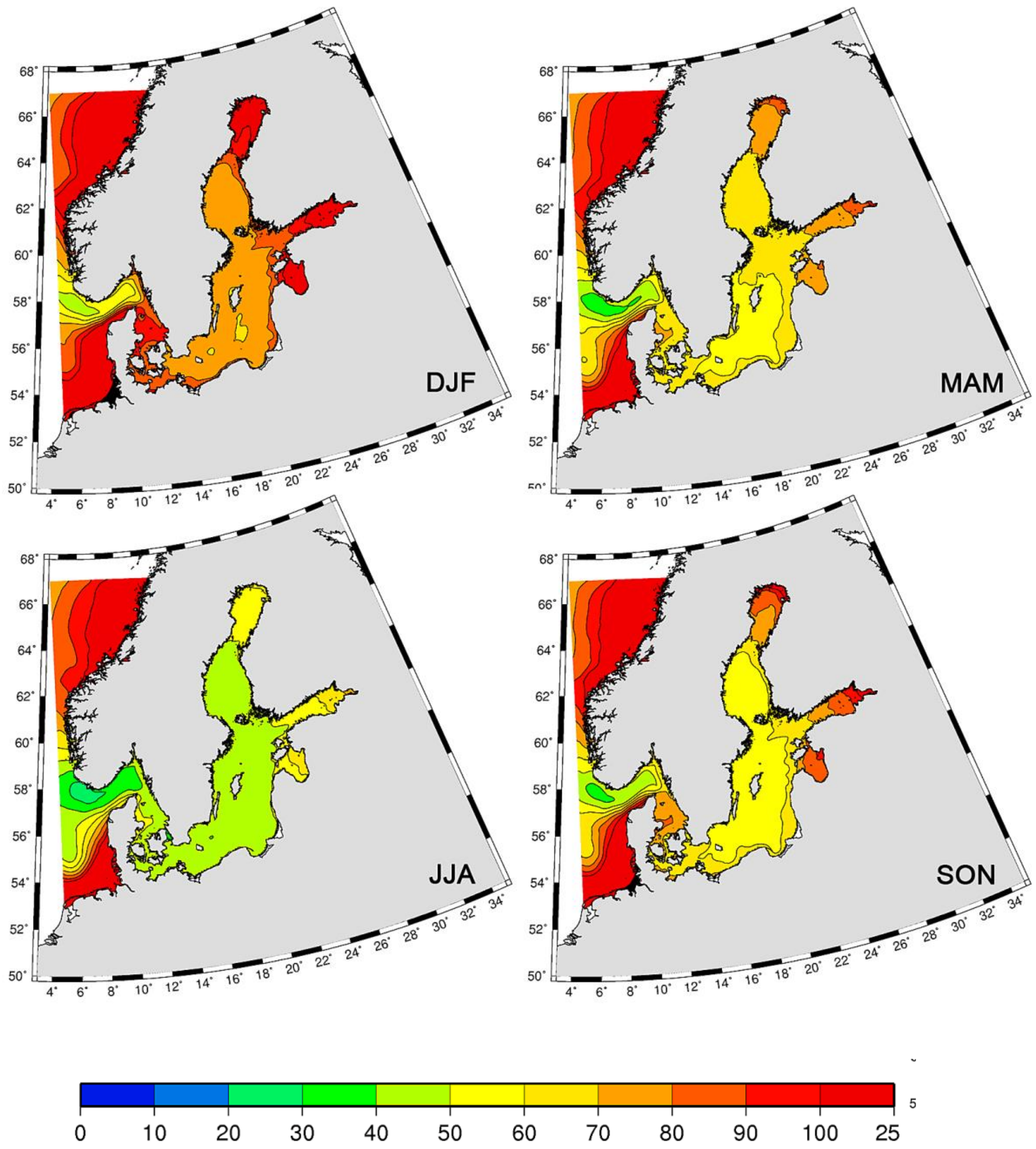
- → Barotropic simulation
  No sea-ice model included
- → Does it matter?

- → Comparison with baroclinic simulation including sea-ice

- → Example here: Kiel
  - → Baroclinic simulation reveals systematic bias not present in the 2D simulation
  - → Problem might be associated with model and/or tide gauges
  - → When bias removed skill of simulations comparable

- → Barotropic simulation adequate for the purpose of this study

Storm surge climate 1948-2012



→ Seasonal 99-Percentiles from hourly values

→ Generally extremes are highest in winter and lowest in summer

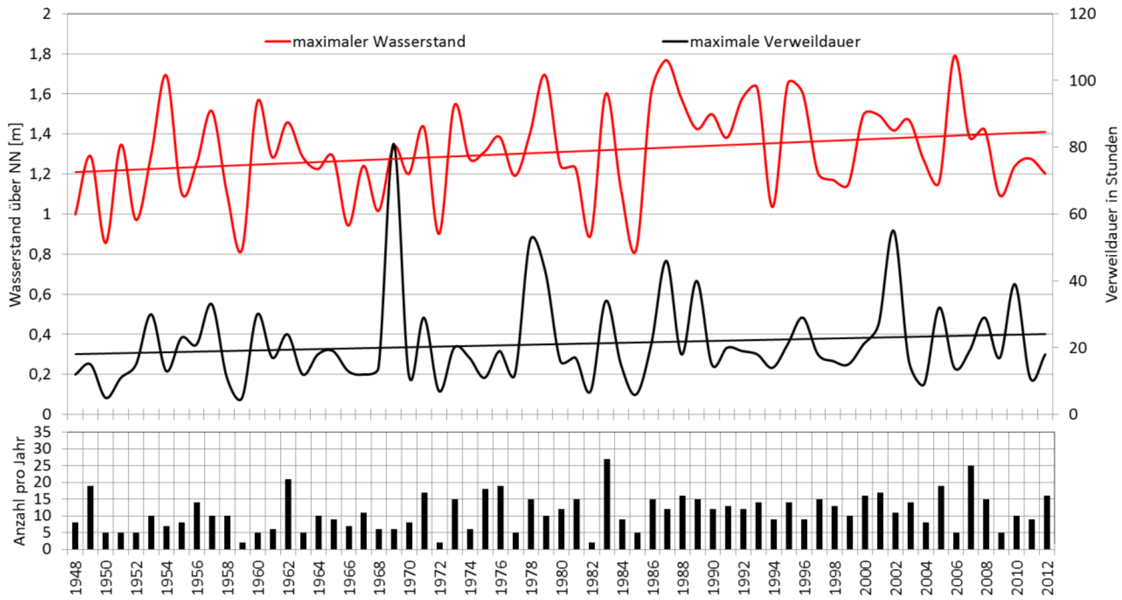
→ Intermediate values in the intermediate seasons

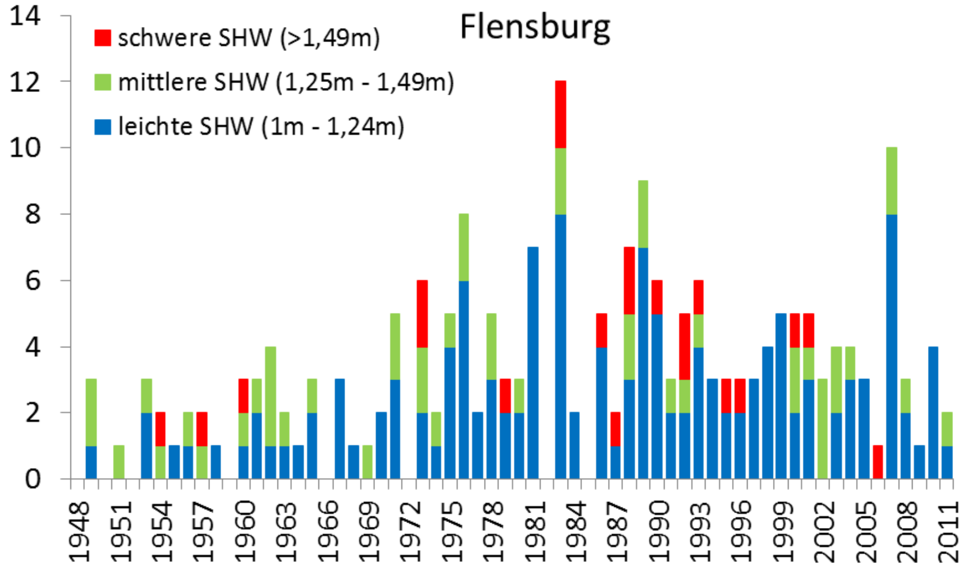
→ Values generally smaller in open sea; increasing towards the coast

→ More comprehensive analysis in Hendrik's PhD

→ Can we analyze long-term changes in a consistent and homogeneous way?

Long-term changes

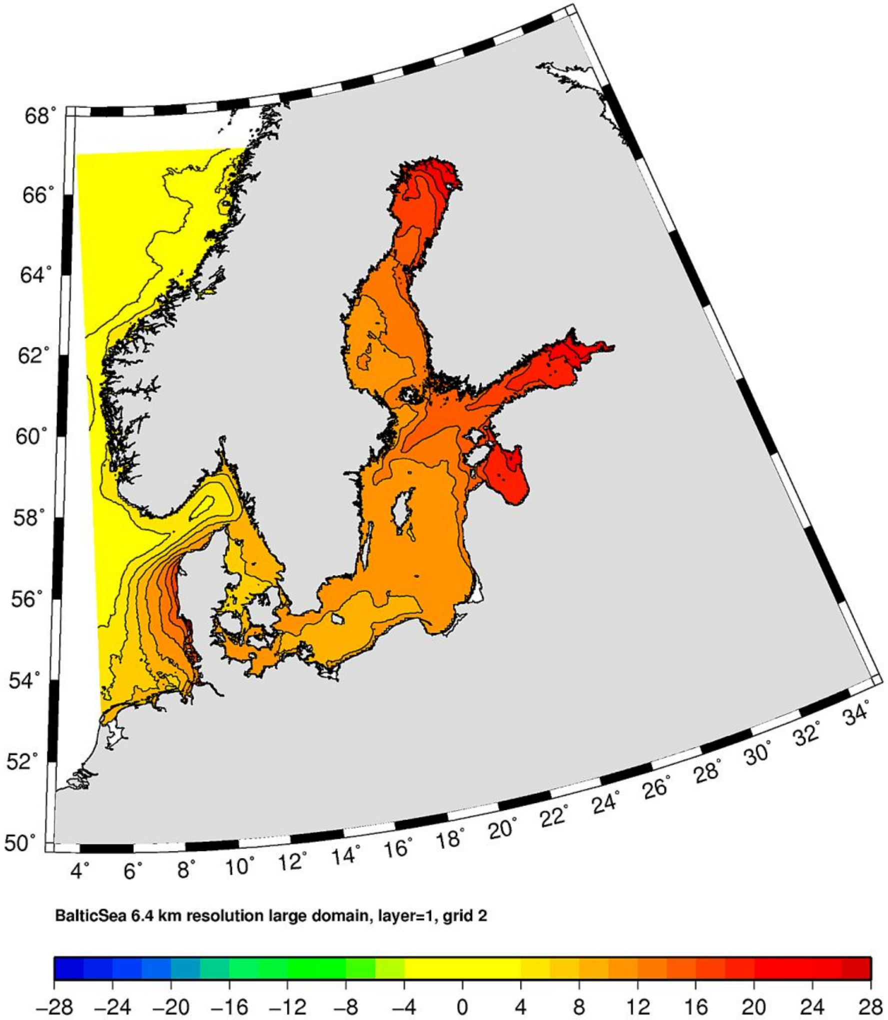


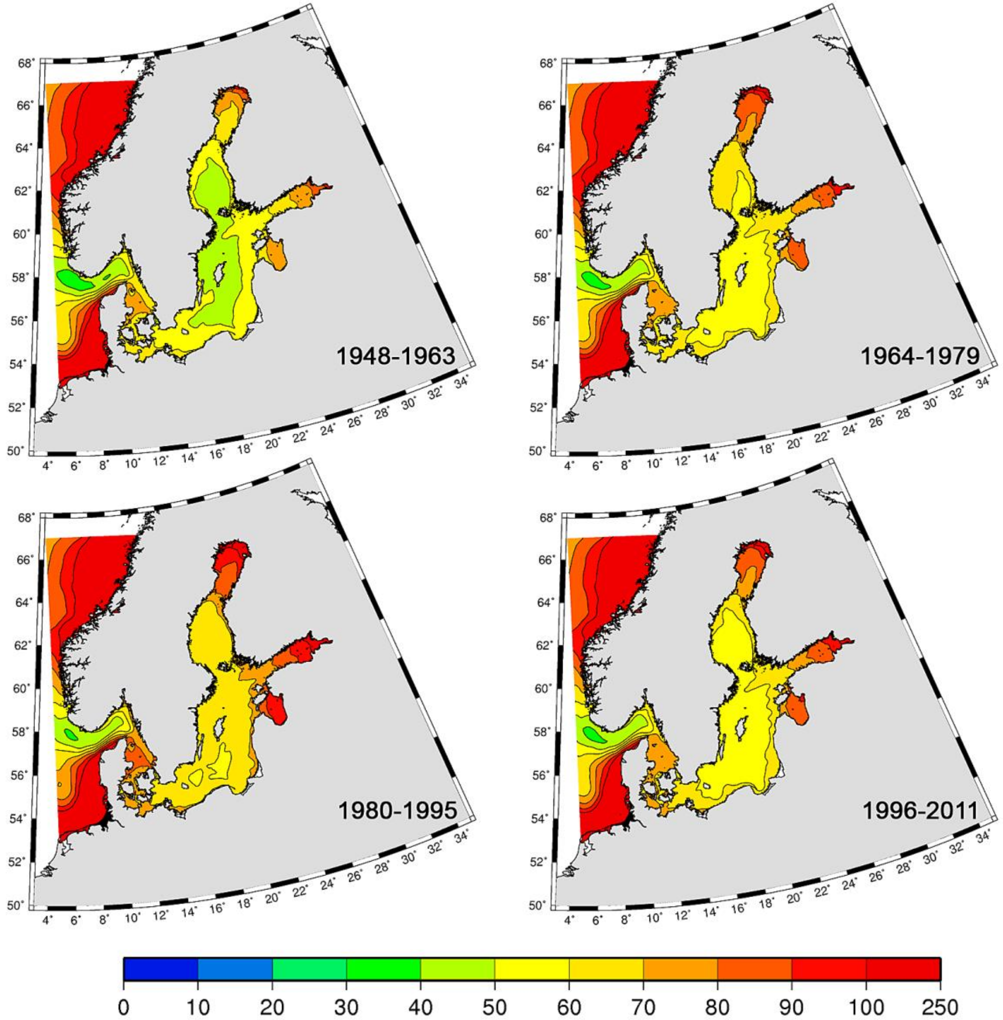


- → Example here Flensburg
- → Upper panel: Metric
  - → Number
  - → Duration and
  - → Intensity

    of events exceeding the long-term 99 Percentile
- → Lower panel: Different Metric
  - → BSH operational definition (light, average, severe storm surge)
- → Pronounced inter-annual and decadal variability in all metrics
- → Upward trends over the analysis period not significant

Long-term changes

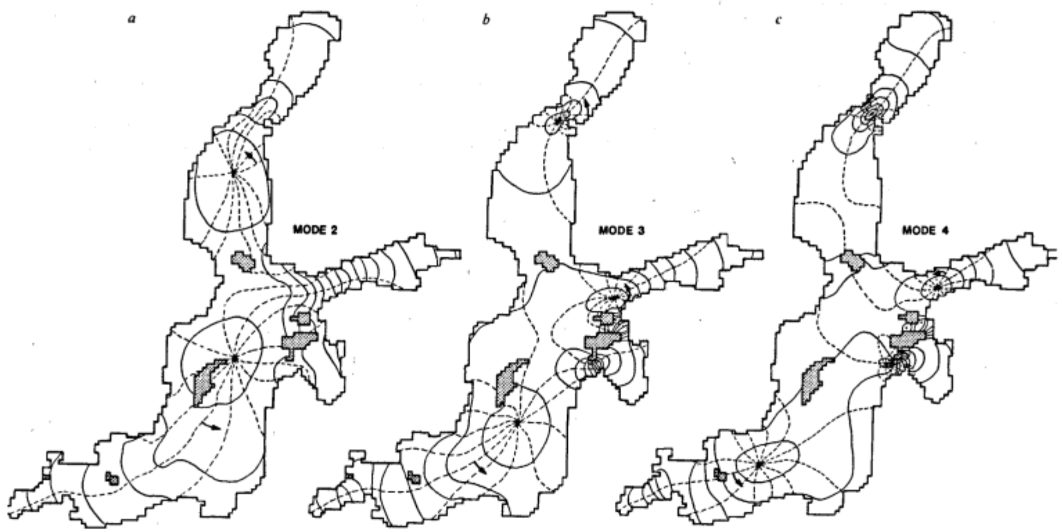




Change in annual 99 Percentiles in cm/65 years derived from linear trend

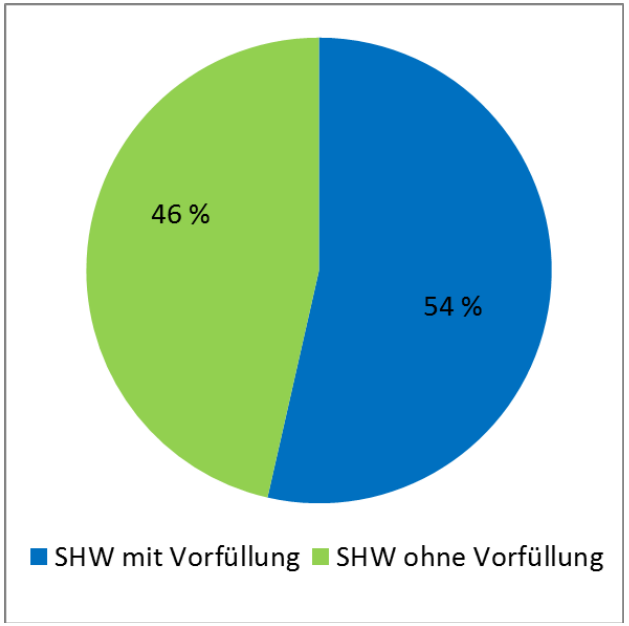
Decadal variability illustrated by 15-year means of annual 99 Percentiles

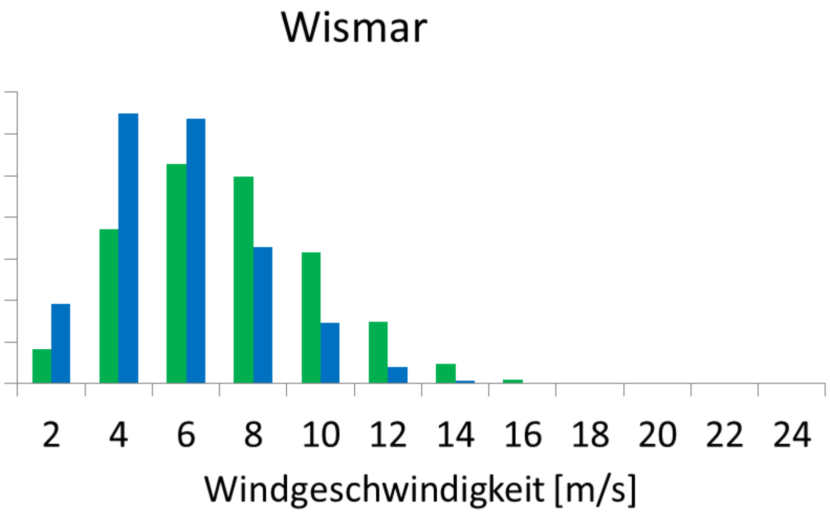
→ Can we enhance the understanding of potential contributions from processes such as prefilling and seiches?



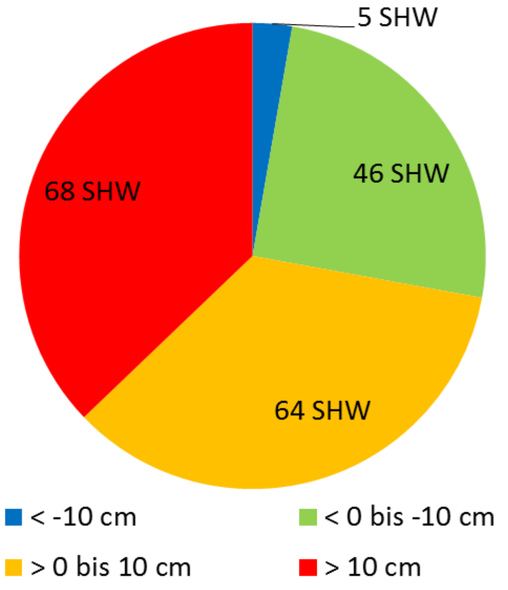
→ Prefilling
  → Mean sea level in Landsort exceeds long-term average by 15 cm or more for at least 15days

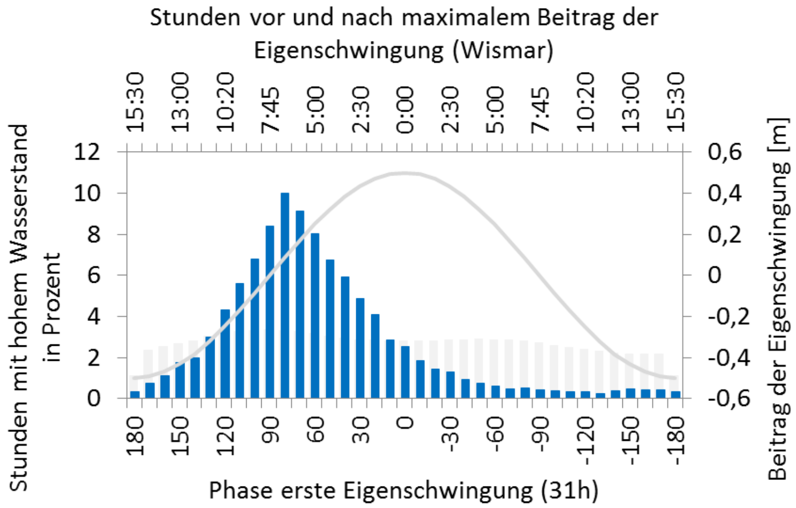
→ Seiches
  → detected by means of a moving harmonic analysis
  → using prescribed frequencies from Wuebber and Kraus (1979) (31.0, 26.4, 22.4 and 19.8 hrs)
  → analysis window 96 hrs shifted by 1hr to account for the pulse-like character of the seiches
  → time series of amplitude, phase and contribution to observed water level for each constituent





- → Example here: Wismar
- → Separation of storm surge cases according to prefilling
  - → Approx. half of the storm surge occurred when prefilling was observed
  - → Approx. half when prefilling conditions were absent
- → Wind speeds
  - → On average smaller when storm surge occurred and prefilling was observed
  - → For cases without prefilling distribution shifted towards higher values
- → When prefilling occurs, lower wind speeds are needed to exceed storm surge thresholds

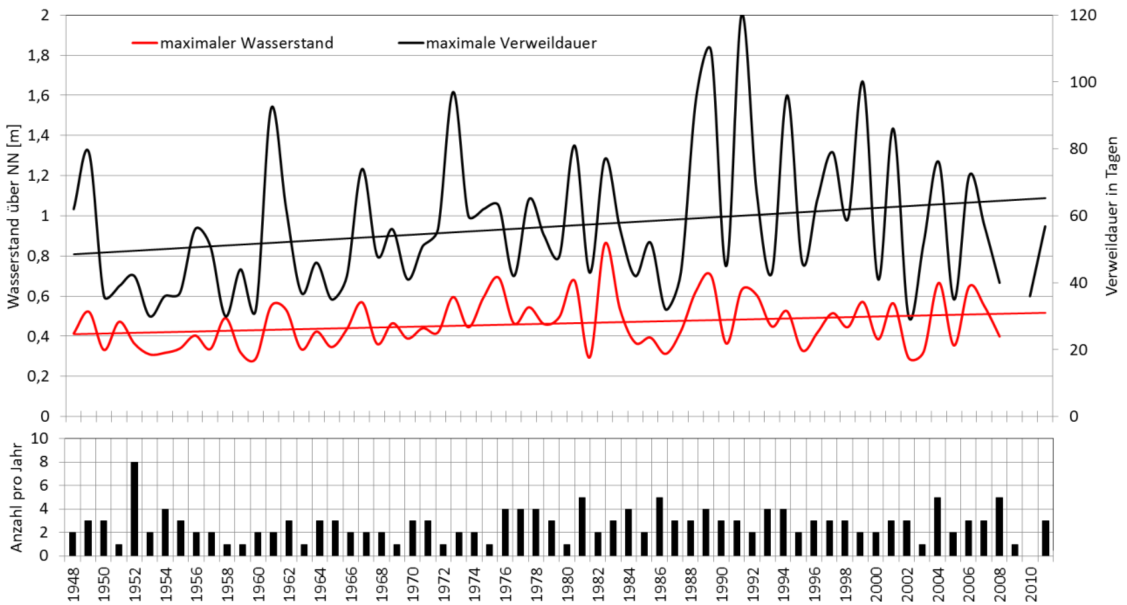




- → Example here: Wismar
- → Separation of storm surge cases according to contribution from seiches
  - → Approx. 60% of storm surges with contributions from seiches <10 cm
  - → About 37% with contributions >+10cm
  - → ~3% with contributions <-10cm
- → Preferred phase-shift between peak of surge and peak of seiche
  - → For Wismar and T=31 hrs ~90 degrees
  - → On average only small contributions
  - → However, considerable amount of cases with substantial contributions

→ Can we provide a first step towards a climatology of such processes (seiches and prefilling) including their long-term changes?

Example: Prefilling



- → Example here: Landsort
- → Number, duration and intensity of prefilling conditions
- → On average conditions lasted for 43 days
- → Longest event: 123 days (12/91-04/92)
- → Pronounced inter-annual and decadal variability with strongest events occuring in the early 1990s
- → No significant trends

- → Storm surge climate of the western Baltic Sea can reasonably be derived from numerical modelling.
- → Results suggest pronounced inter-annual and decadal variability of the storm surge climate but no substantial long-term trend.
- → Prefilling and seiches contributed substantially to some of the observed peak water levels at the German coast.
- → When prefilling occurs, generally lower wind speeds were needed to sustain comparable peak water levels.
- → In roughly 1/3 of the storm surge cases (in Wismar) contribution from seiches to peak water levels exceeded 10 cm.