Baltic storm tide “Axel” from a climate perspective

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Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

Storm surge

→ *Large scale increase in sea level due to a storm*

→ *Primarily caused wind stress and horizontal atmospheric pressure gradients*

→ *In environments with large tides or other processes contributing to the extremes this is not automatically associated with high water levels*

Storm tide

→ *Extreme sea levels caused by combination of storm surge, high tides and other processes*

In this presentation

→ *Storm tide refers to the total water sea surface height*

→ *Storm surge to locally generated surge (wind surge)*

Storm flood

→ *Refers to the impact of a storm tide*

Storm tide Axel 04-05 January 2017

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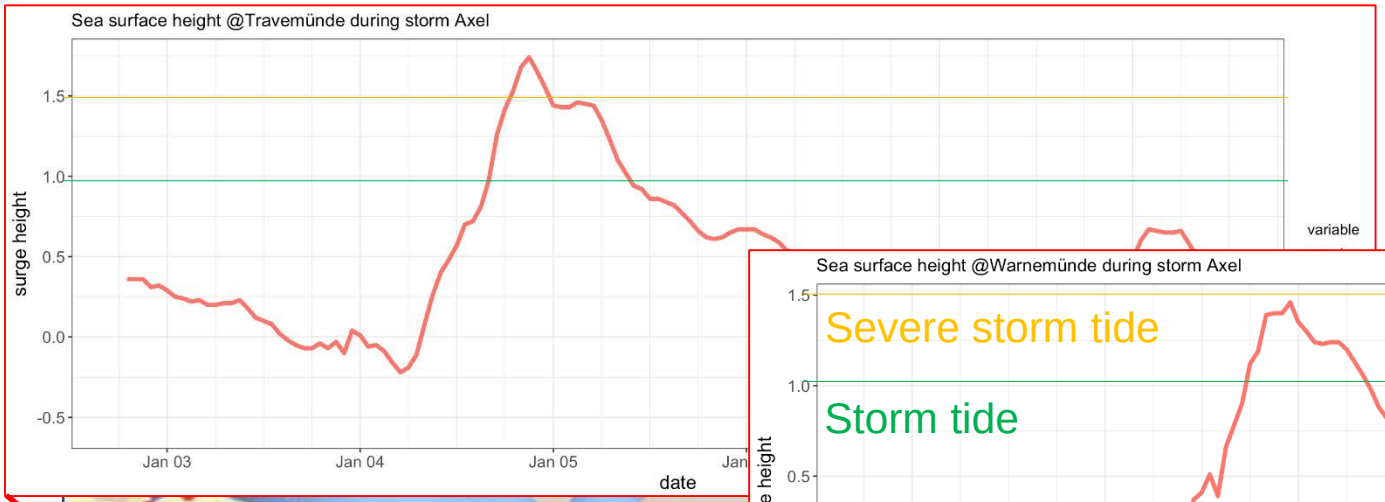
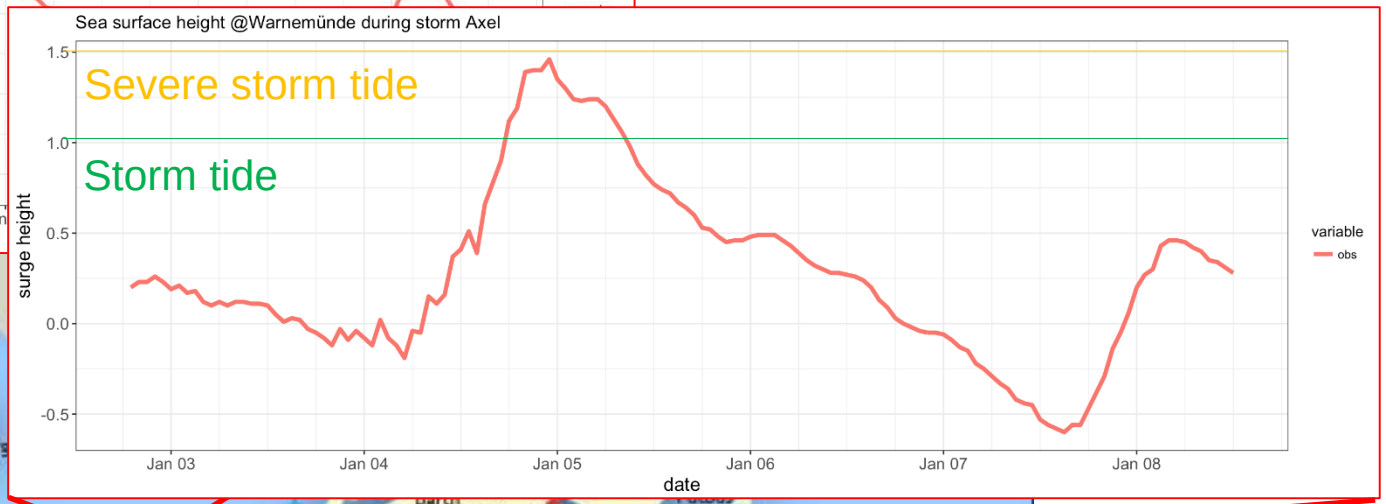
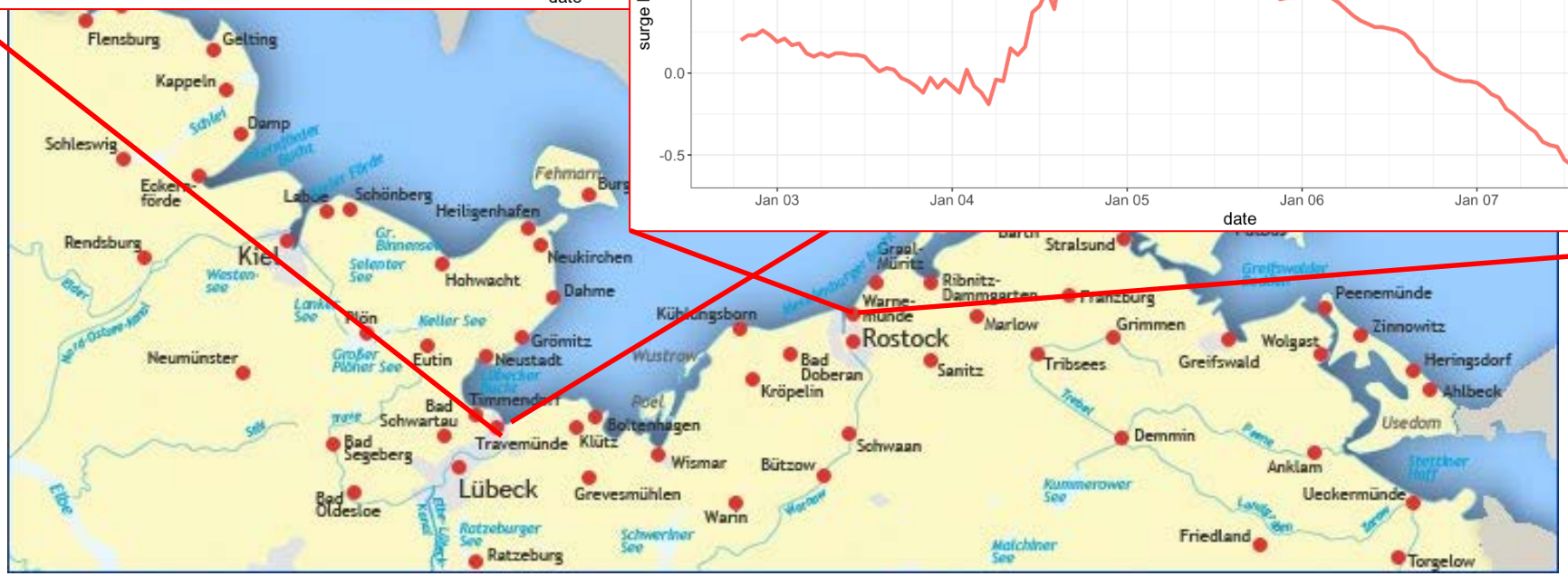


Severe storm tide

Storm tide





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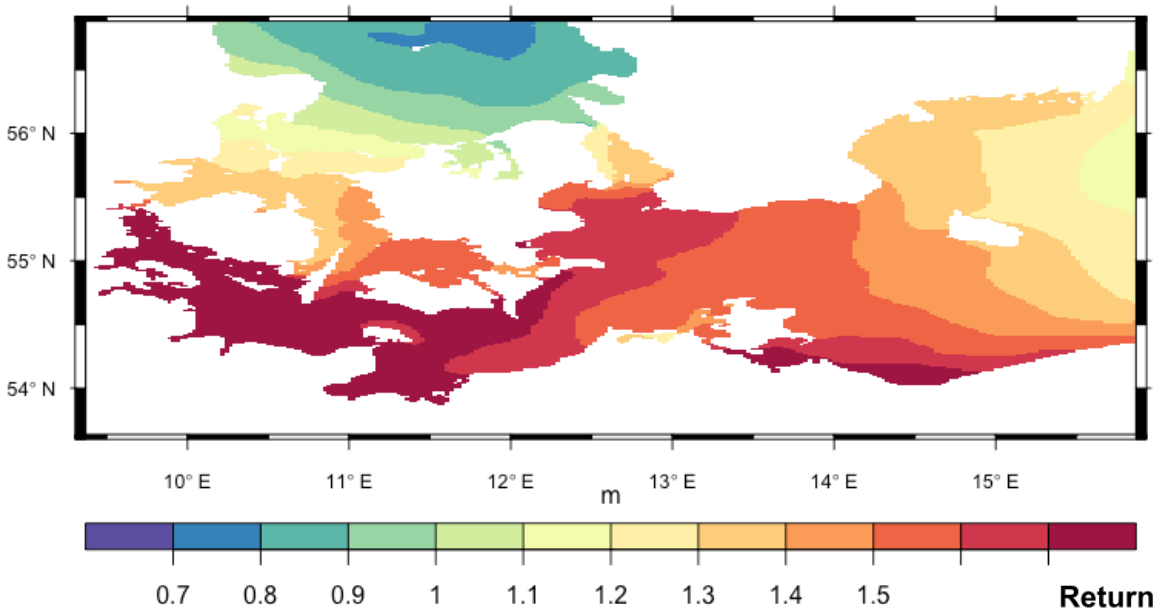
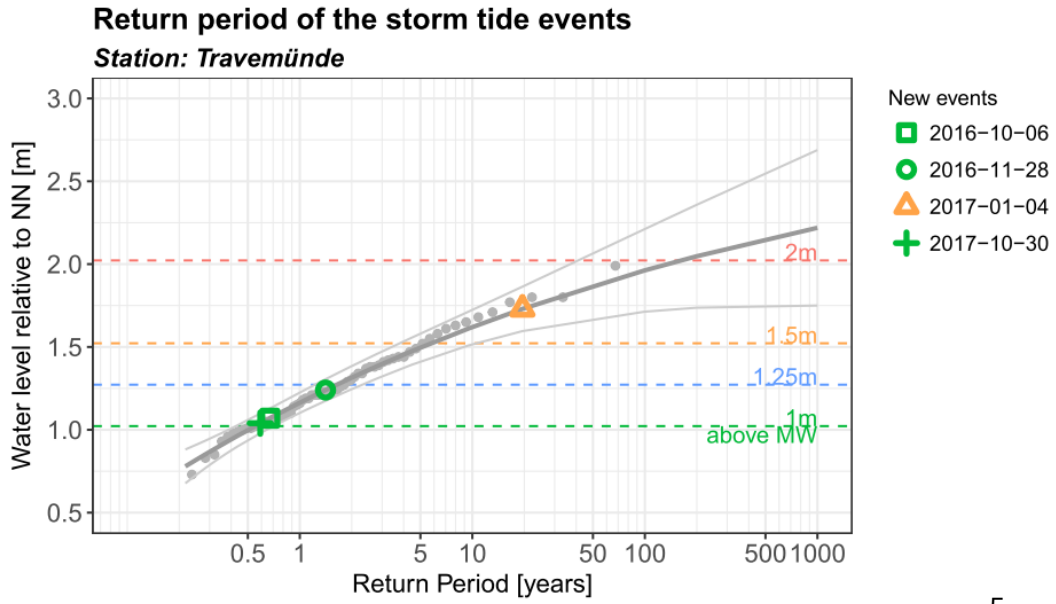


→ *Axel was a severe storm tide along most of the German Baltic Sea coastline.*

→ *It represents roughly a one in a 20 years event.*



How unusual was Axel?

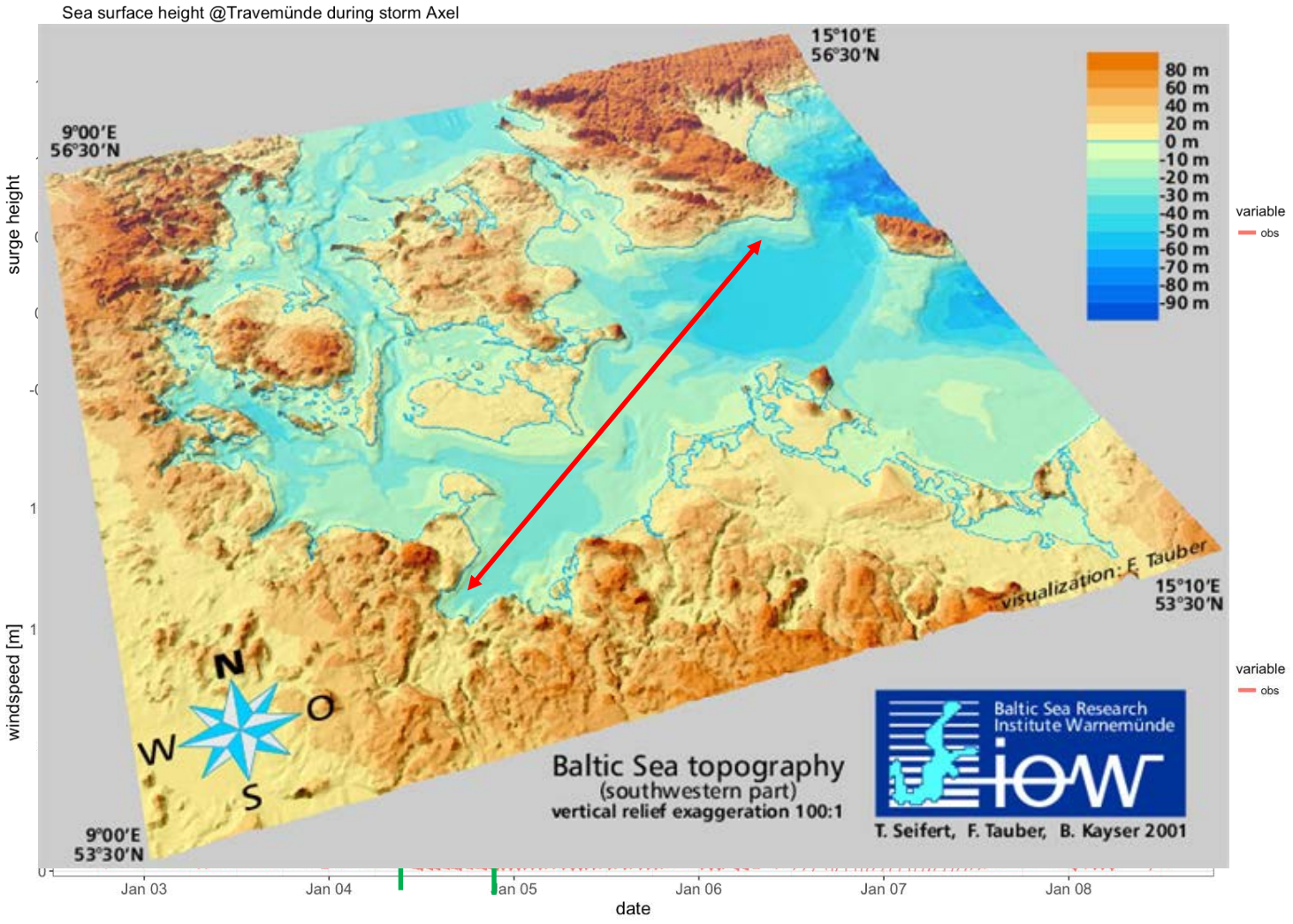
→ *Contributions of the various processes contributing to storm tides*

How have this factors changed over the past?

→ *Trend and/or long-term variability*

How unusual was Axel?

How much can the direct wind forcing contribute to the observed peak water levels?



$$\Delta surge = \frac{\rho_a}{\rho} \frac{c_d u^2}{Dg} \times fetch$$

$\rho_a = 1.2\ \mathrm{kgm^{-3}}$

$\rho = 1025\ \mathrm{kgm^{-3}}$

$c_d = 5 \times 10^{-3}$

$u = 13\ \mathrm{ms^{-1}}$

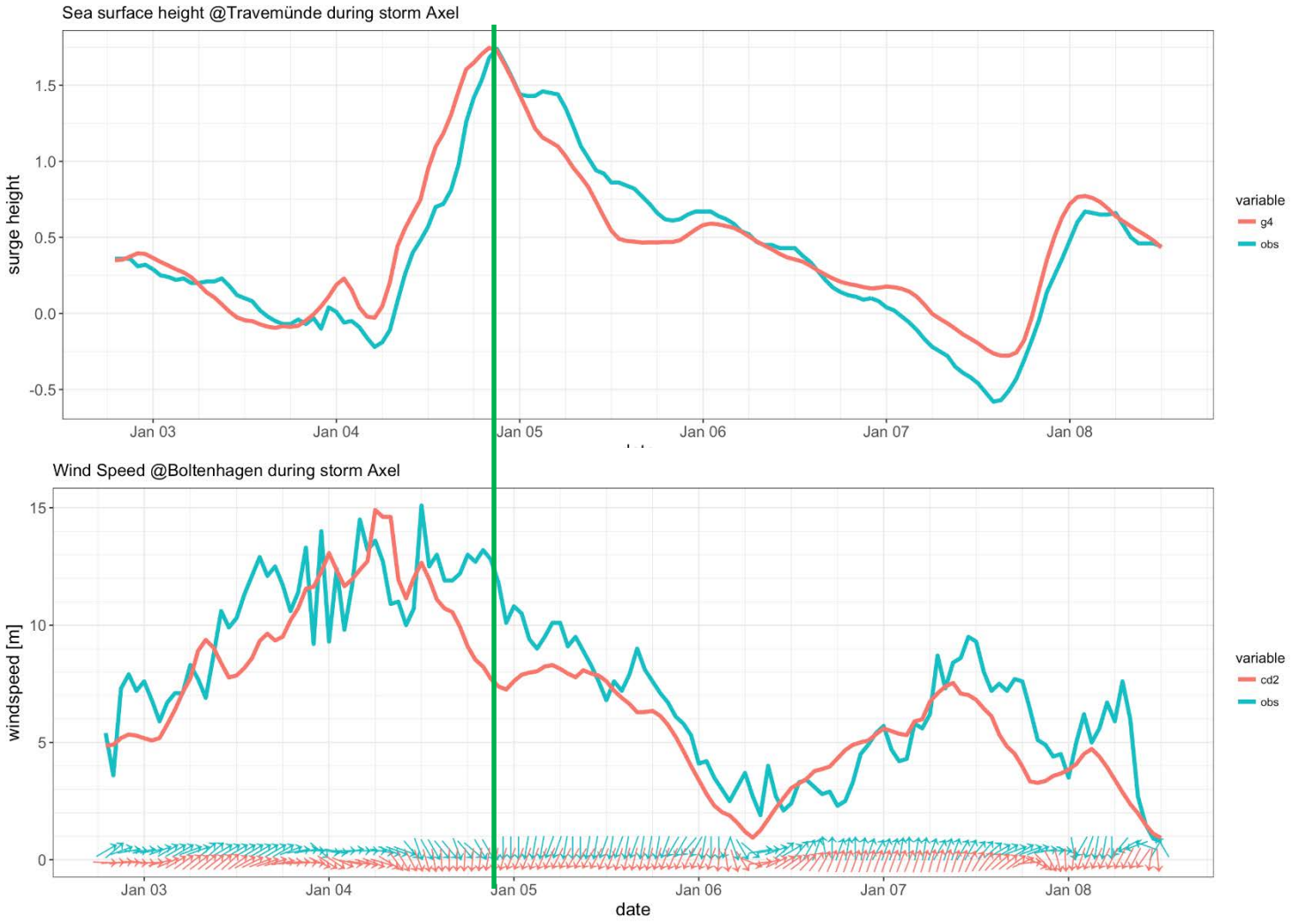
$g = 9.81\ \mathrm{ms^{-2}}$

$D = 30\ \mathrm{m}$

$fetch = 230\ \mathrm{km}$

$\Delta surge_{max} \approx 0.7\text{-}0.8\ \mathrm{m}$

How unusual was Axel?



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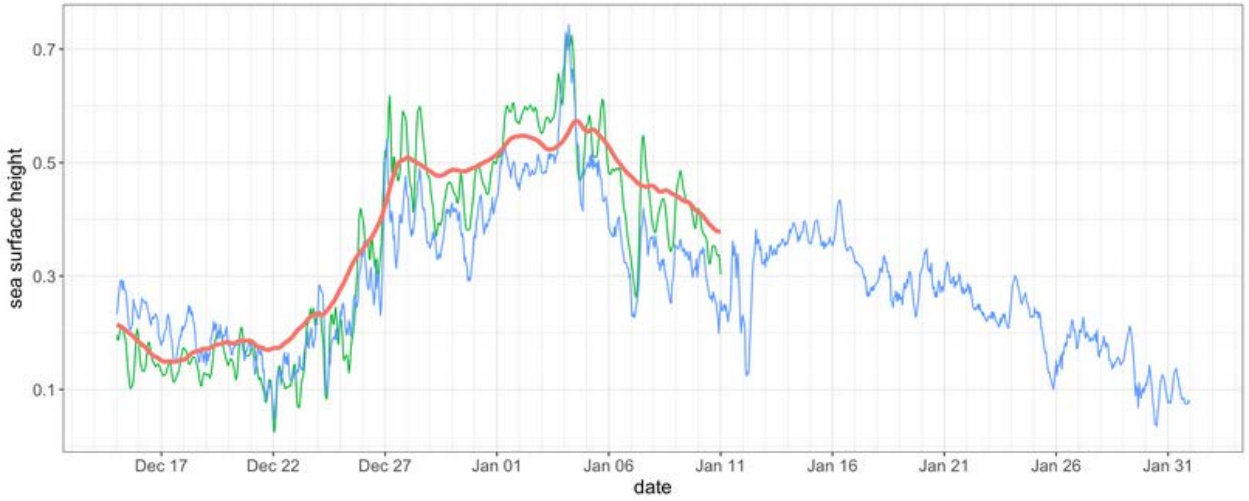
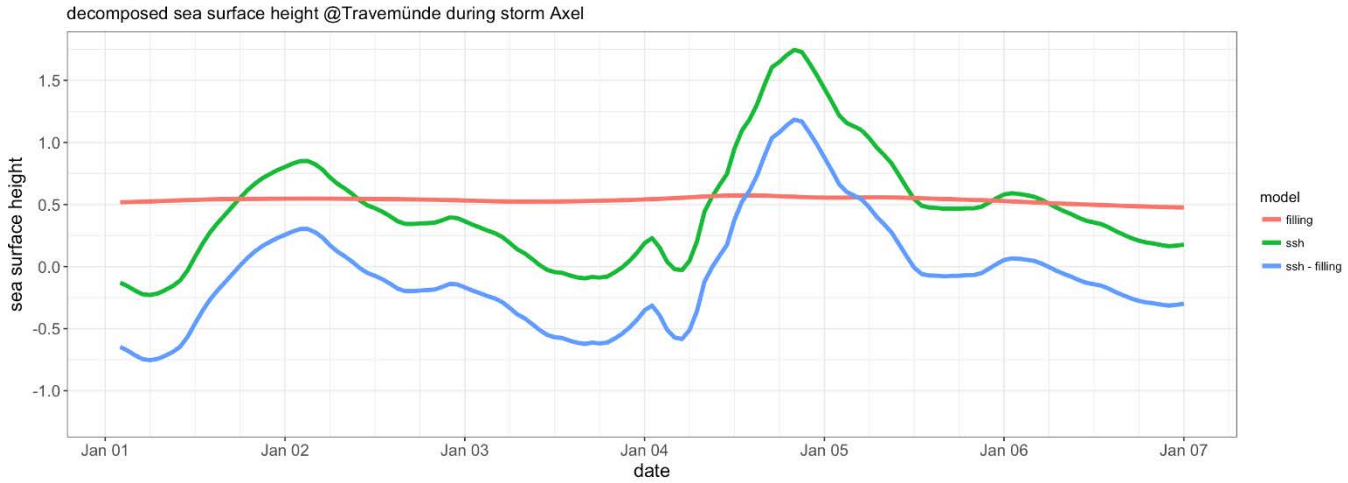
Factors that may have contributed

→ *High Baltic Sea volume (BSV)*





→ *BSV@Travemünde*
Max. contribution 56 cm

→ *Local surge 70-80 cm*

→ *Max. SSH 176 cm*

→ *Unexplained ~50cm*

→ *Other Factors*

→ *Tides (20-30 cm)*

→ *Seiches*

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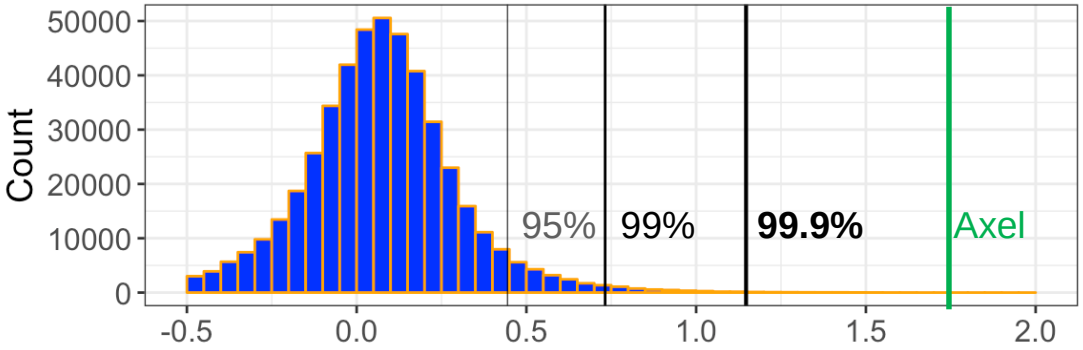
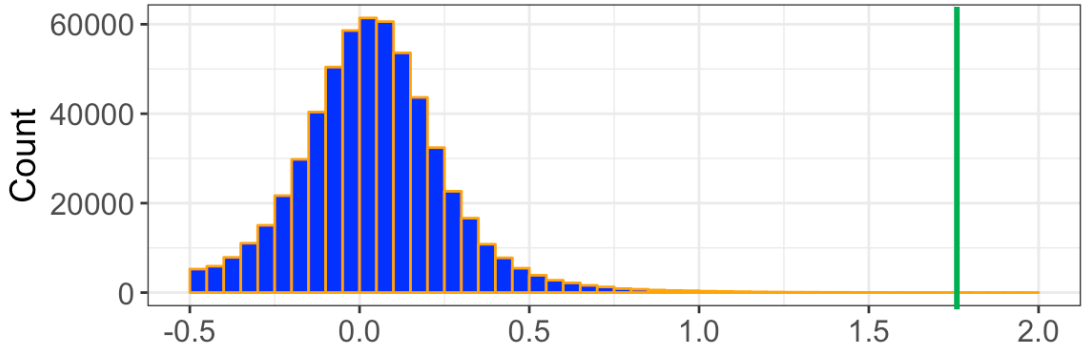
Frequency of sea surface heights at Travemünde [m]

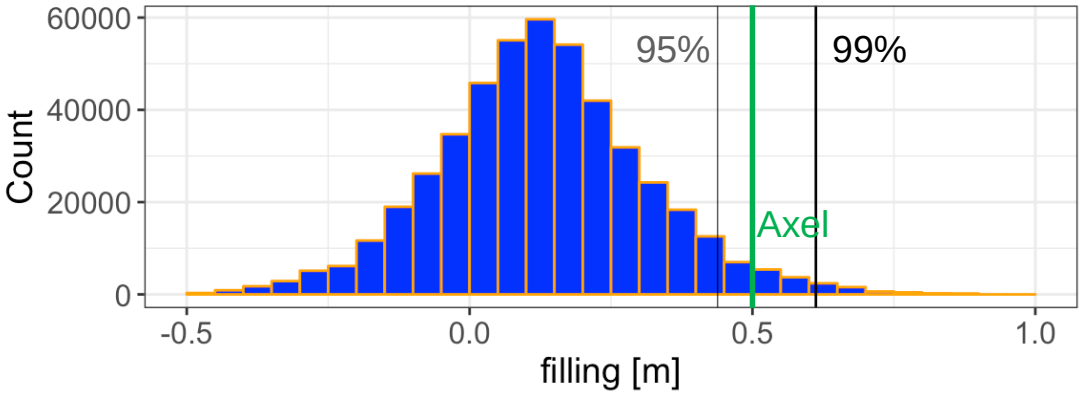
C Histogram for Travemünde from coastDat2 grid4



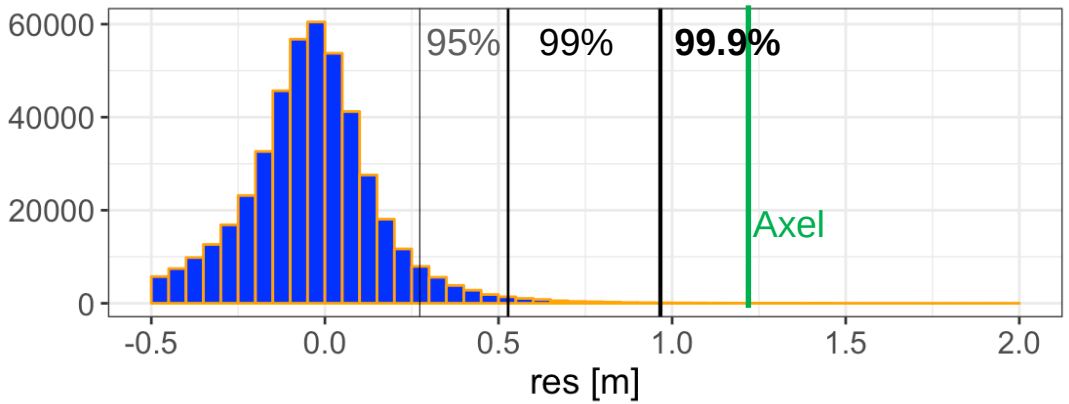
D Histogram for Travemünde from observations



A Histogram for Baltic Sea Volume from coastDat2 grid2



Histogram for Travemünde from coastDat2 residum (ssh-filling)



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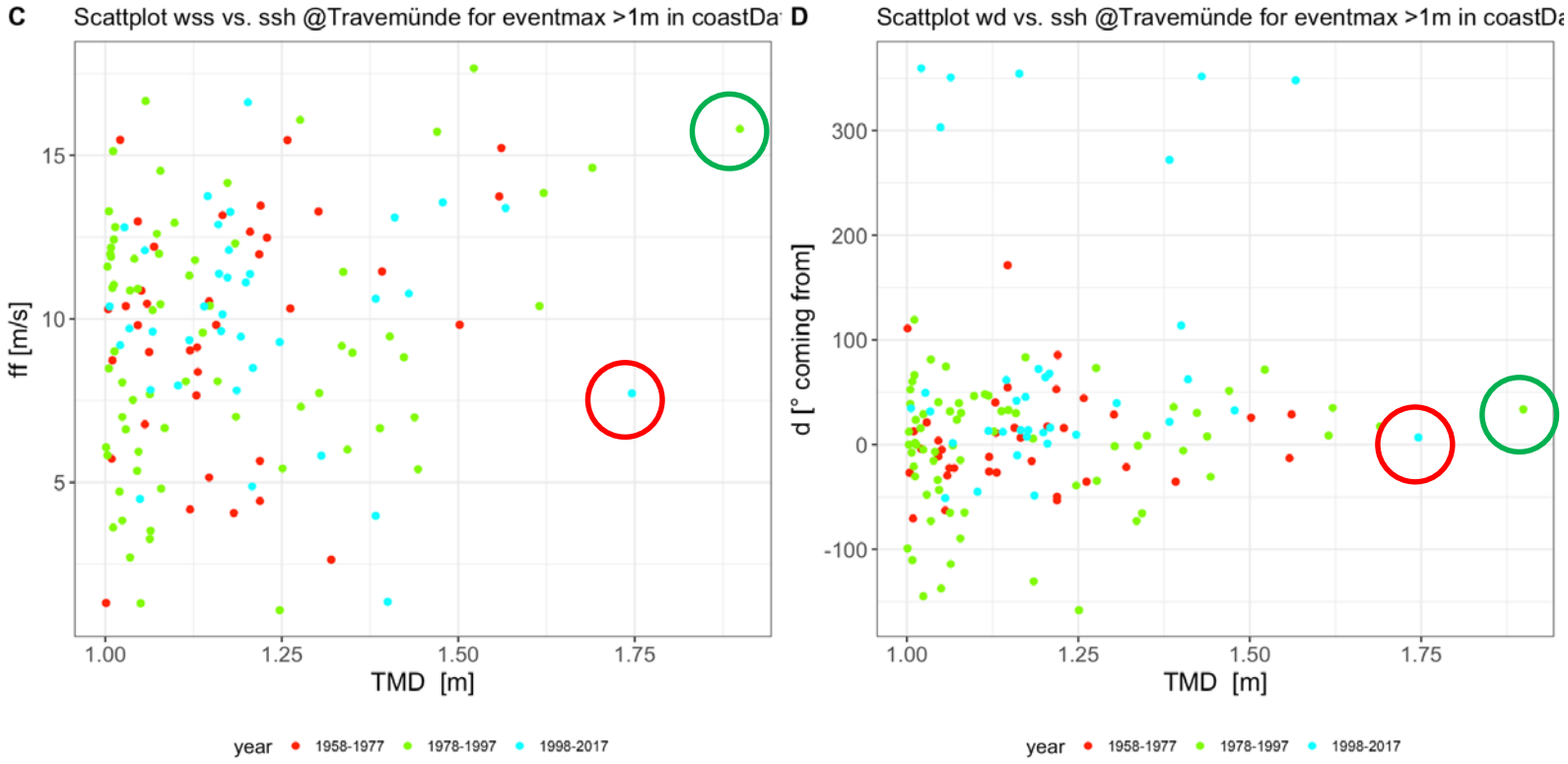
Scatterplots for ssh > 1.0 m @ Travemünde

Wind speed

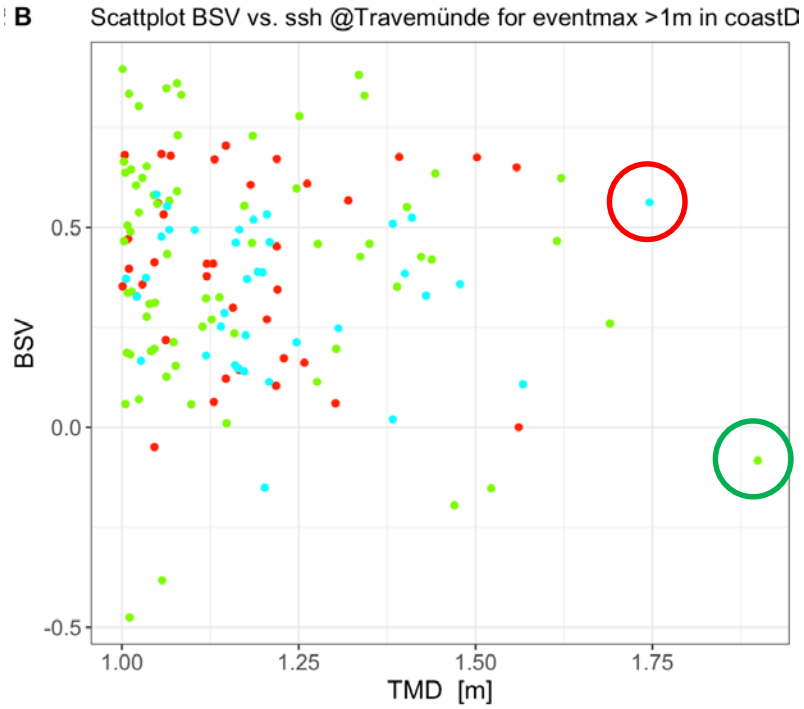


Wind direction

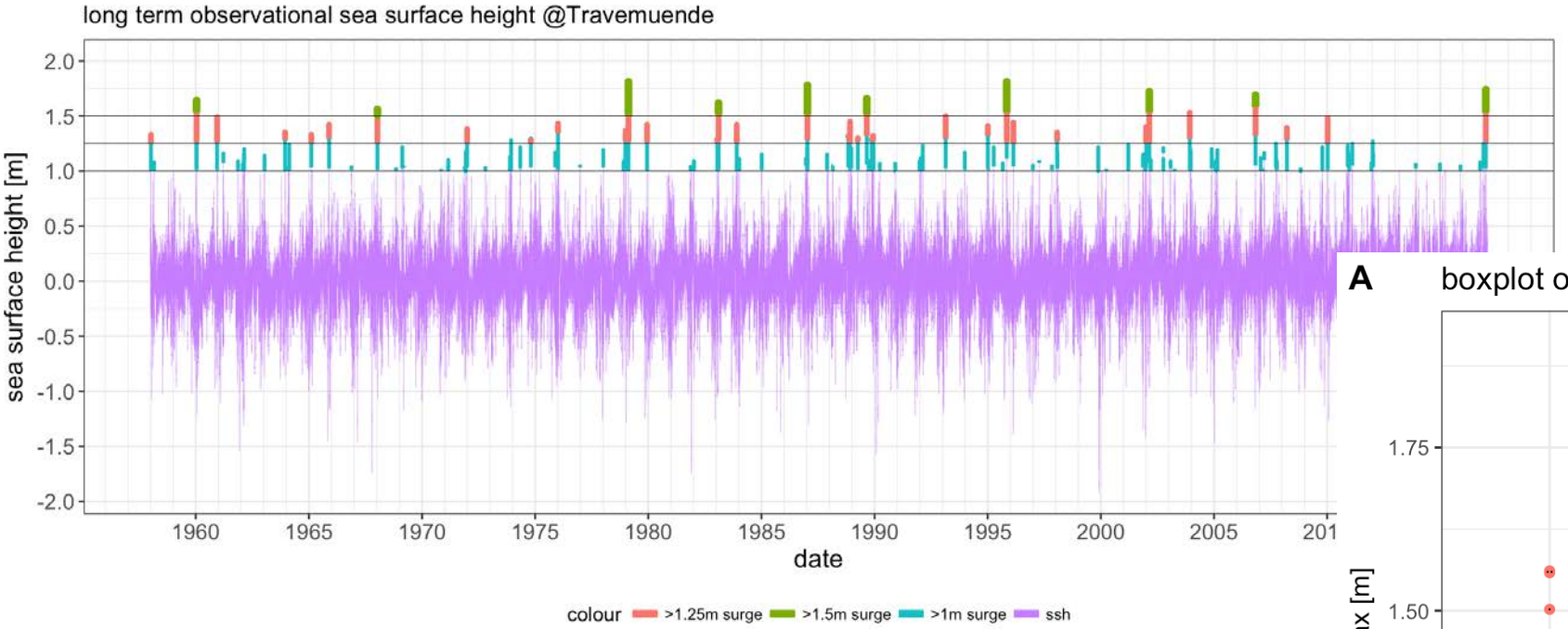
It could have been worse.

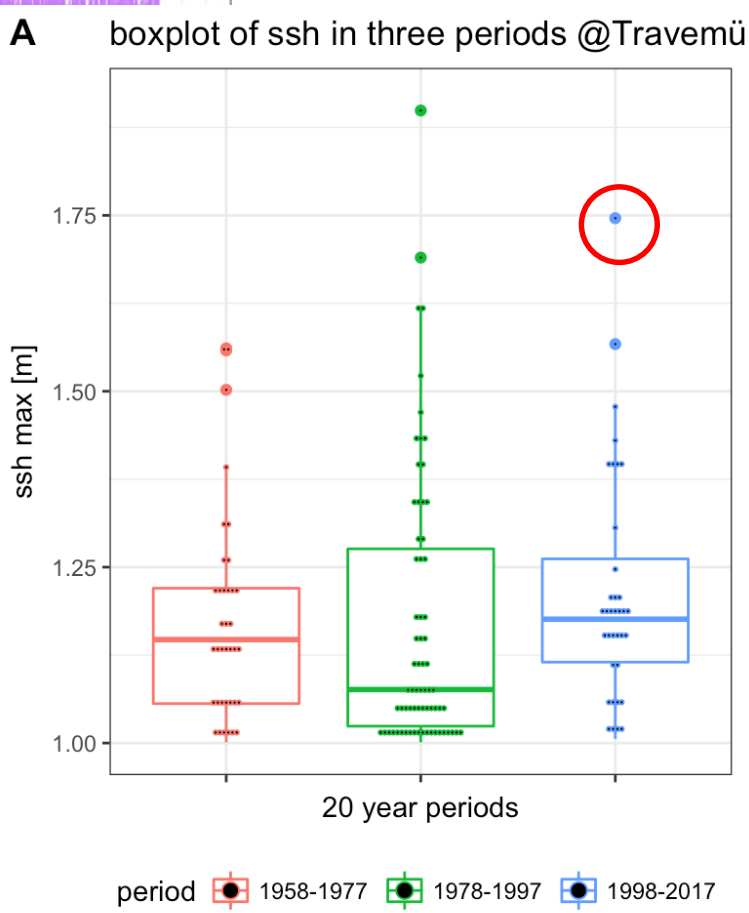
Scatterplots for ssh > 1.0 m @ Travemünde

Baltic Sea Volume



How have the factors changed over time?





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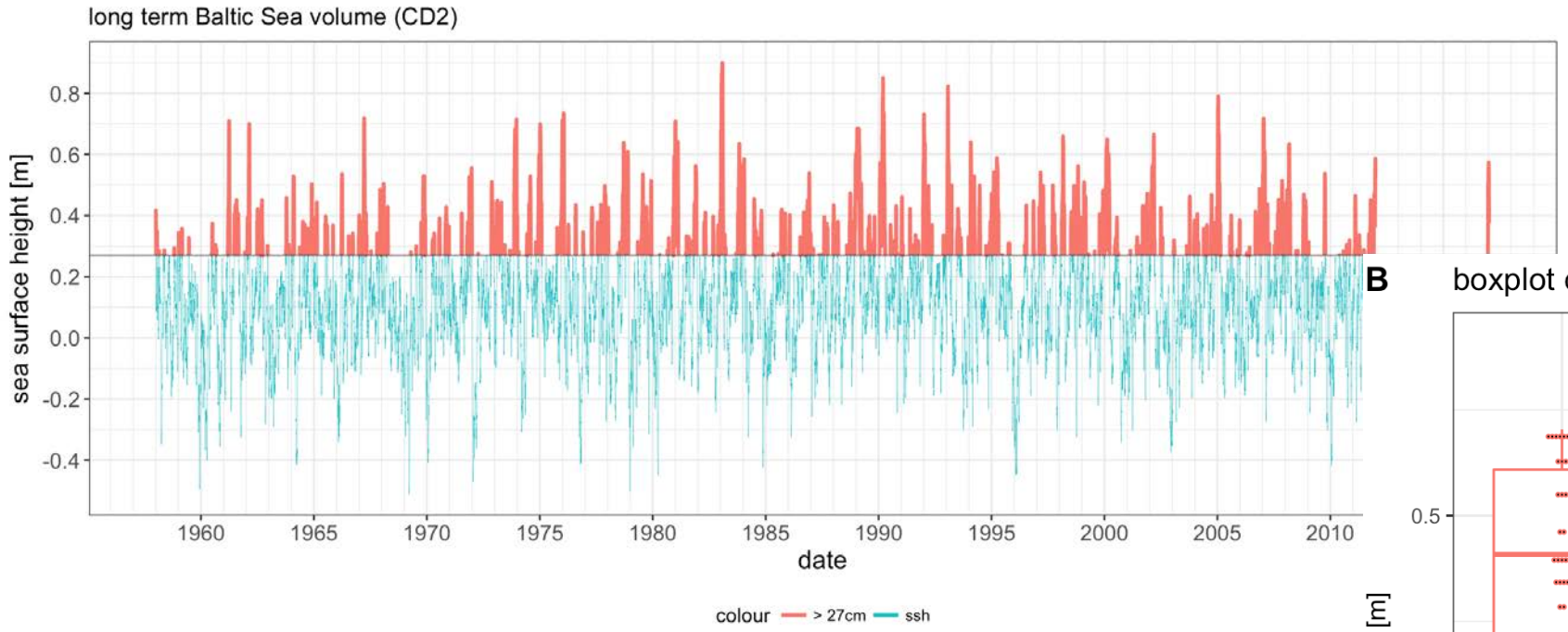

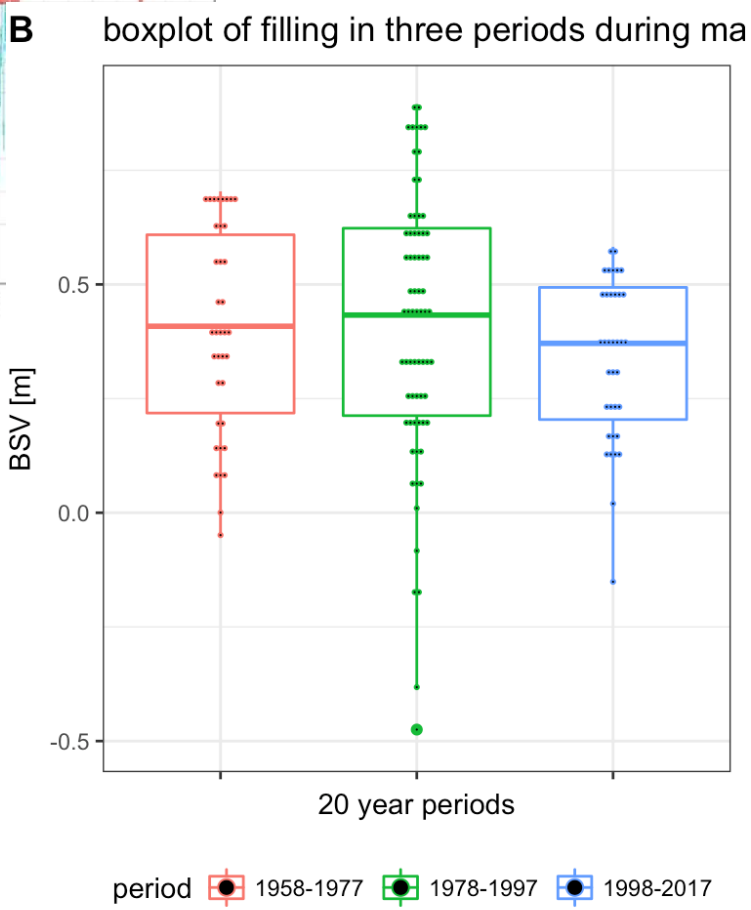

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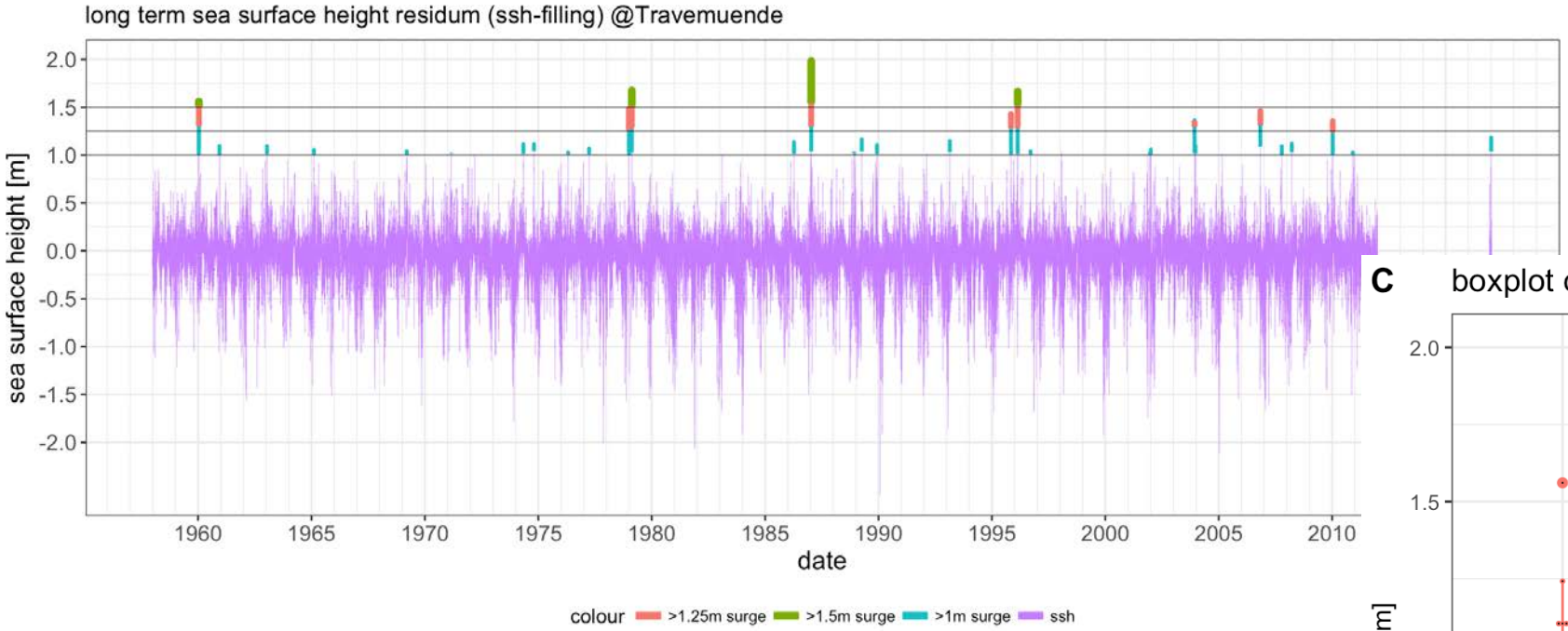

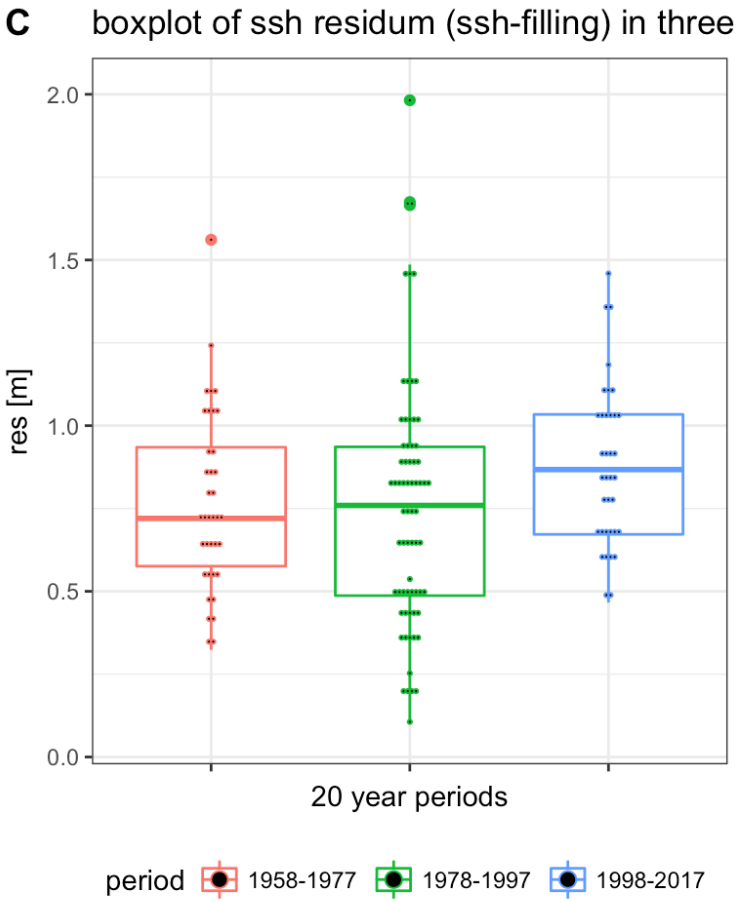

Summary

→ Storm tide Axel in January 2017 was a severe storm surge along most of the German Baltic Sea coast (roughly a one in a 20 years event)

→ It was exceptional because it occurred at relatively low wind speeds (“silent storm”) and had a high contribution from preceding Baltic Sea filling.

→ From a climate perspective, we could not detect any significant long-term change in the frequency of such events, the frequency of high Baltic Sea filling levels, or the residuum time series.

→ Contributions from tides and seiches need to be disentangled to fully assess the event.