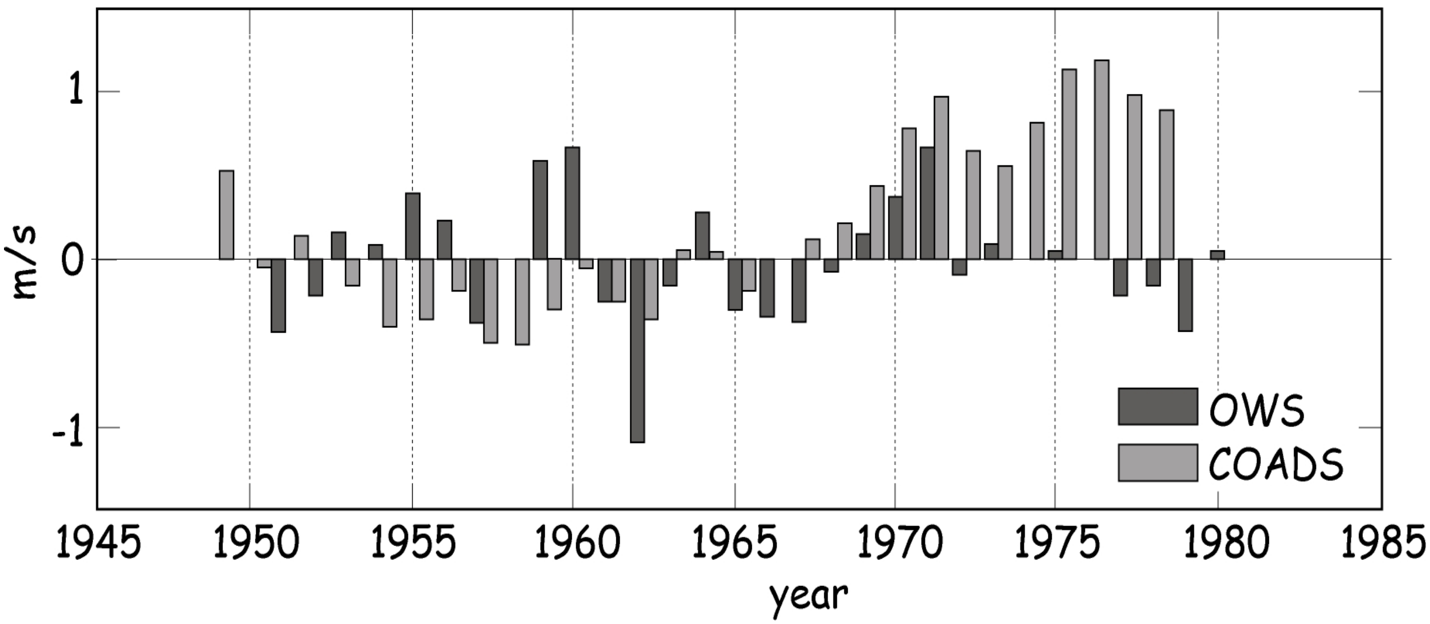
Wind, Waves & Storm Surges - Recent and Potential Future Changes -

Ralf Weisse, Hans von Storch Andreas Pluess, Katja Woth,
Frauke Feser, Heinz Guenther, and Iris Grabemann

- What are the extremes to be expected? (storms, waves, storm surges)
- How did extremes change in the recent past?
- What are the potential future developments?

- Needed: comprehensive observational data (long time series, high spatial and temporal detail, homogeneous data).
- Usually not available for coastal and marine areas



Estimated changes in mean wind speed in the North Pacific in the area of ocean weather station OWS P. Data from the ocean weather station are marked as “OWS” (ocean weather ship), and those from the ships of opportunity in the vicinity of OWS as “COADS”. **(After Isemer, pers. communication)**

- Needed: comprehensive observational data (long time series, high spatial and temporal detail, homogeneous data).

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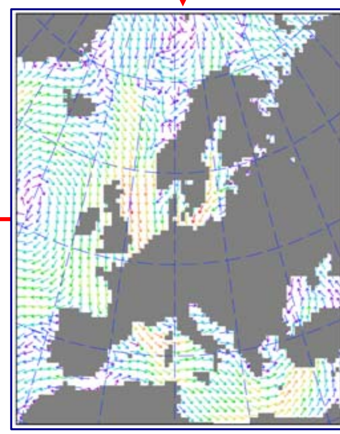
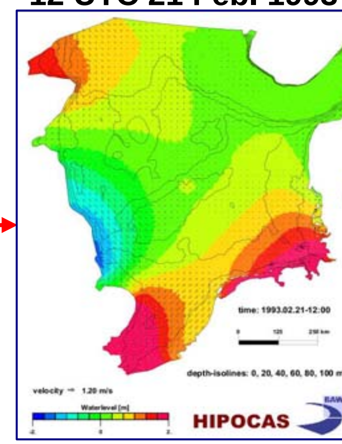
- ⇨ Use proxies
  ⇨ and of models in combination with existing measurements to reconstruct (hindcast) recent changes and to derive scenarios for the future

Global NCEP Reanalyzes (210 km x 210 km) 1948 - 2006

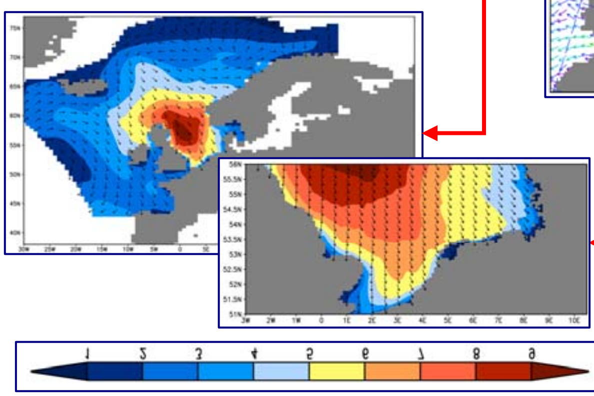
REMO wind speed and direction
12 UTC 21 Feb. 1993
Resolution: ~ 50 x 50 km



BAW - TELEMAC 2D
water levels & barotropic currents
12 UTC 21 Feb. 1993

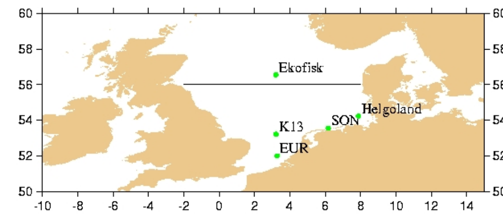


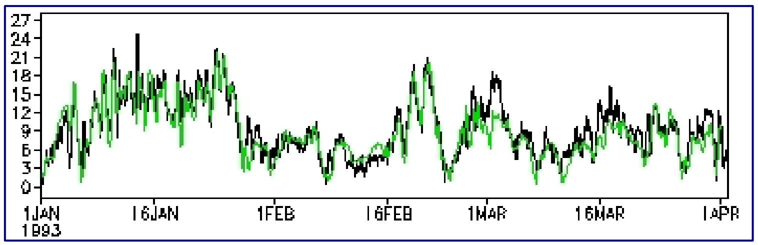
WAM Sig. Wave height and direction 12 UTC 21 Feb. 1993
Resolution: ~ 5 x 5 km



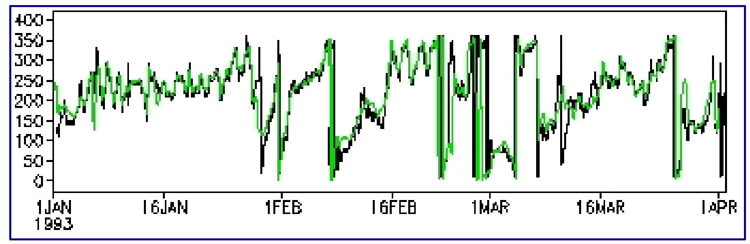
Resolution between about 80 m and 5 km

Example: Wind and waves at K13

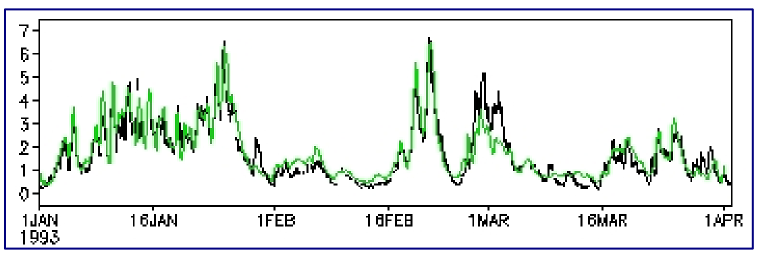




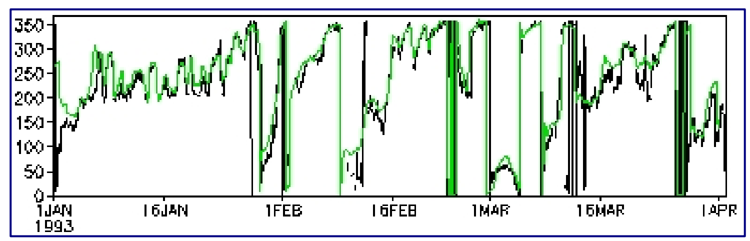
Wind speed [m/s]



Wind direction [degrees]



Sig. wave height [m]

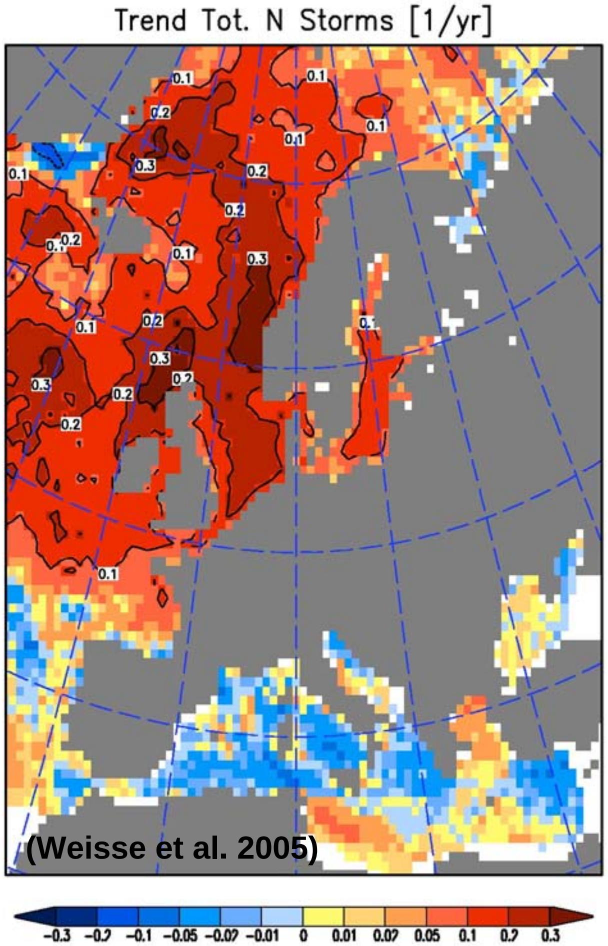


Mean wave direction [degrees]

Observations – black;   Hindcast - green

(Weisse and Günther. 2006)

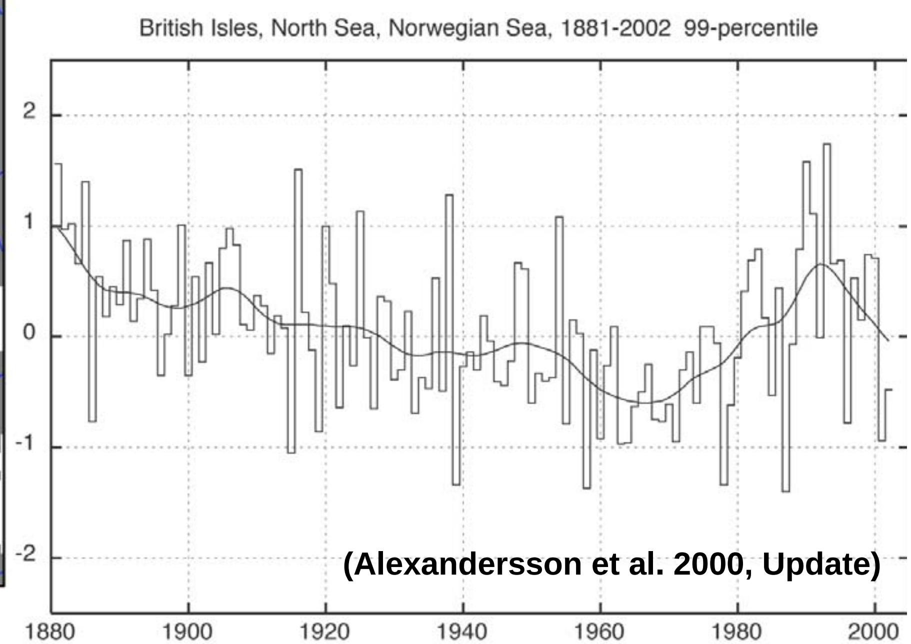
Long-term changes in storminess



(Weisse et al. 2005)

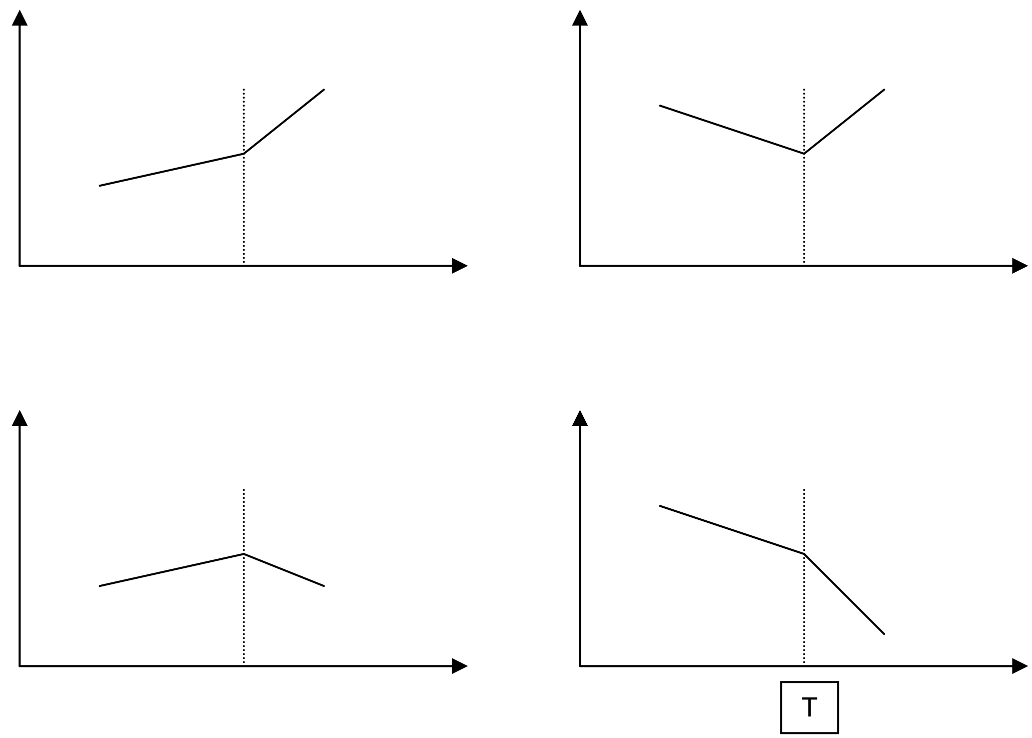
Reconstructed trends 1958-2002 of annual storm counts

Storm index based on geostrophic wind speed percentiles derived from station pressure triangles



(Alexandersson et al. 2000, Update)

Piecewise linear trends

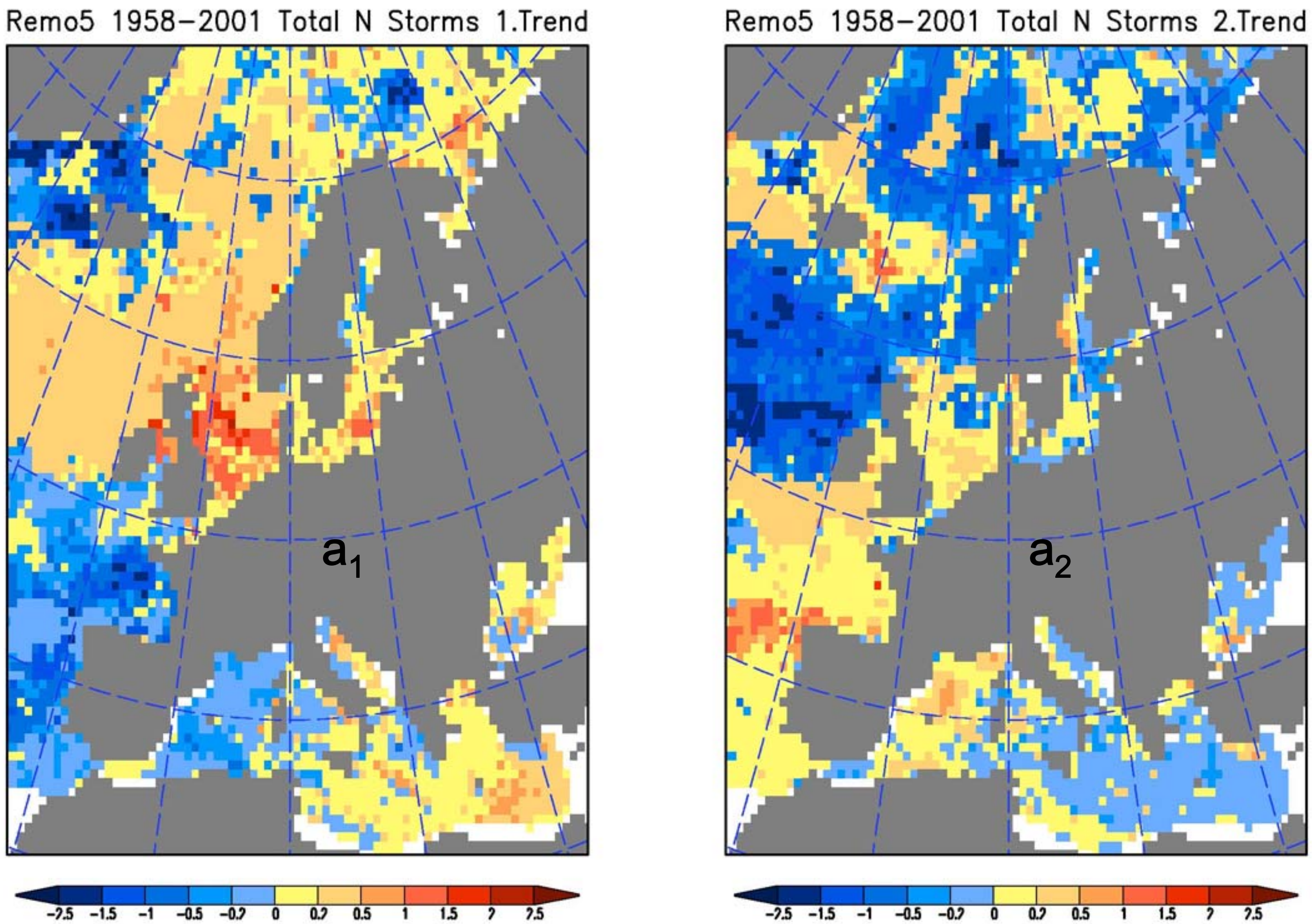


$$y_i = ax_i + b$$

$$a = \begin{cases} a_1; i \le T \\ a_2; i > T \end{cases}$$

$$b = \begin{cases} b_1; i \le T \\ b_2; i > T \end{cases}$$

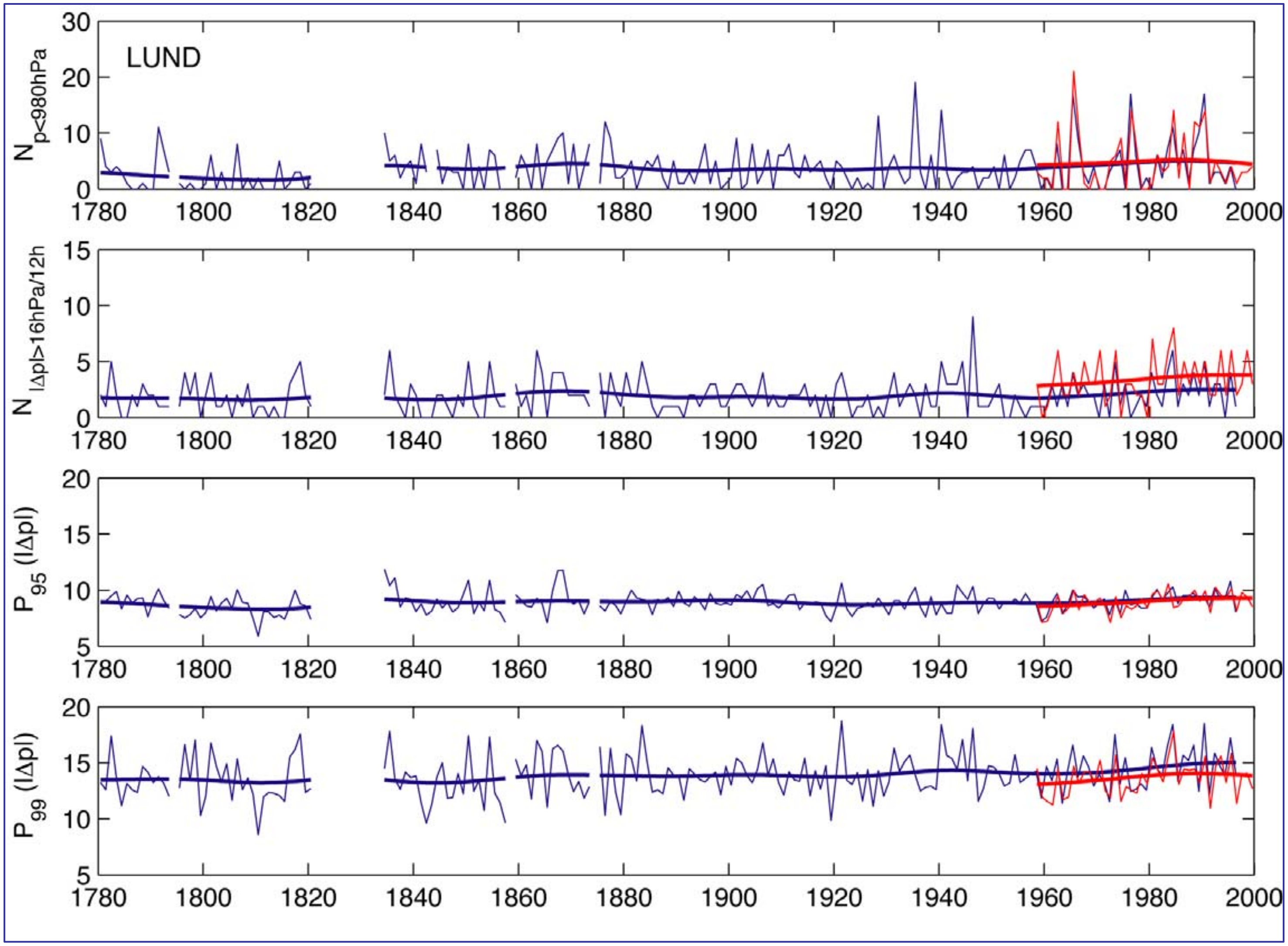
Piecewise linear trends



(Weisse et al. 2005)

Pressure-based storm indicators derived from pressure readings in Lund. From top to bottom: The number of deep pressure readings, number of absolute 12h pressure differences exceeding 16 hPa., Intra-annual 95-percentile and 99-percentile of the 12h pressure differences. In red statistics simulated by the regional model REMO for 1958-2000 are added.

(After Bärring and von Stoch 2004)



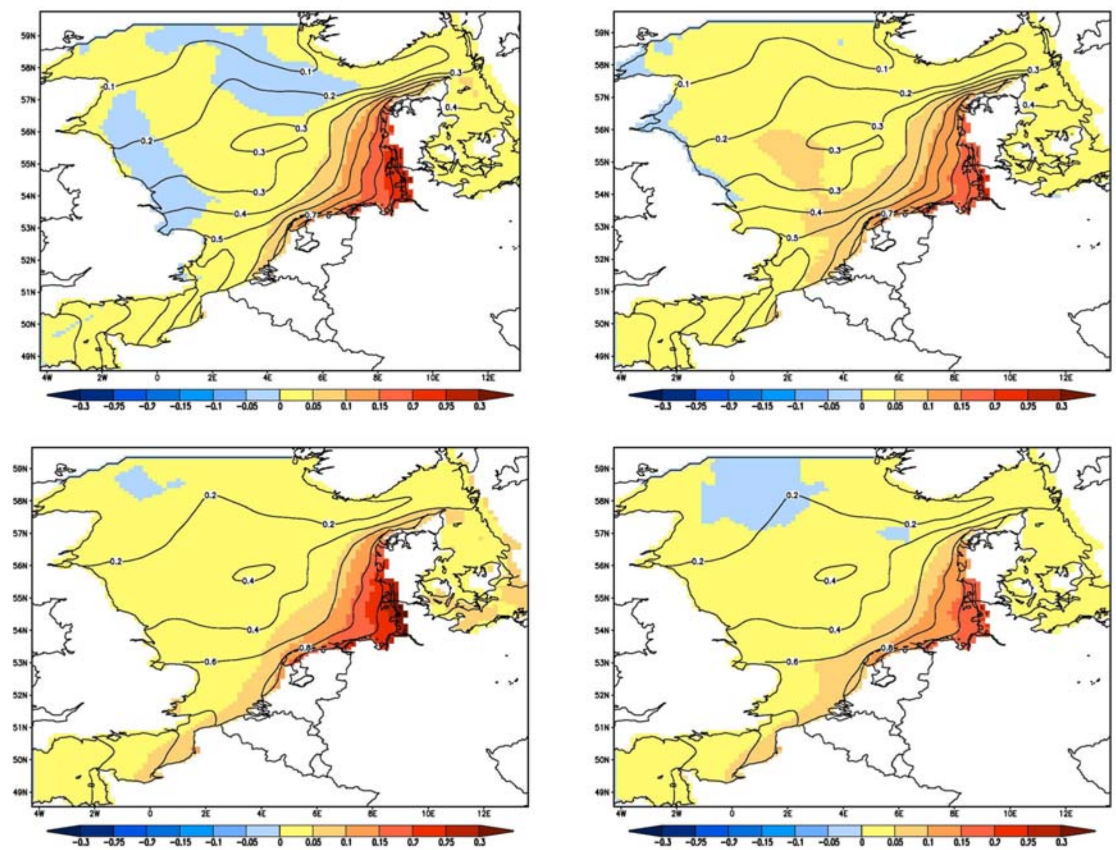
… and what may happen in the expected course of anthropogenic climate change?

Example storm surge

Change of annual max. storm surge 2085-present

A2

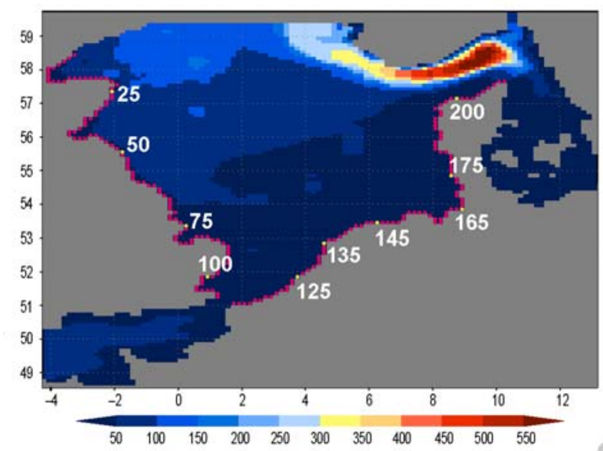
B2



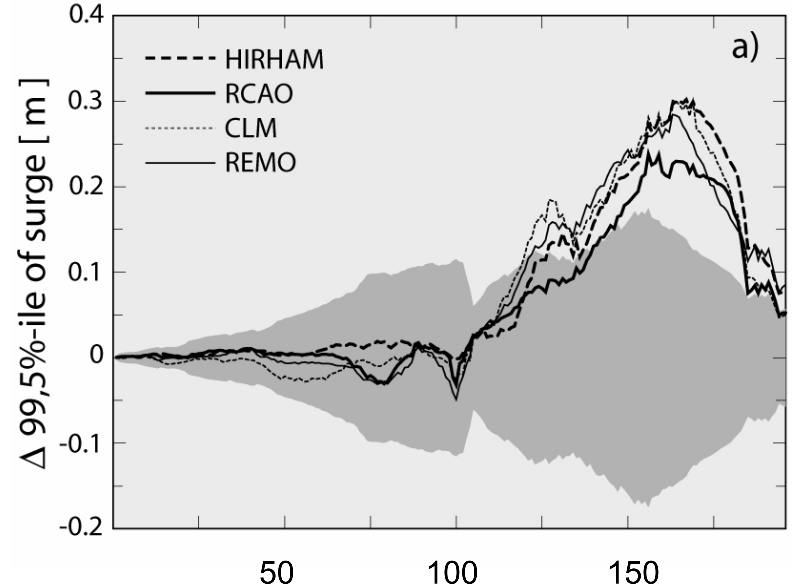
RCAO/ ECHAM

RCAO/ HadAM3H

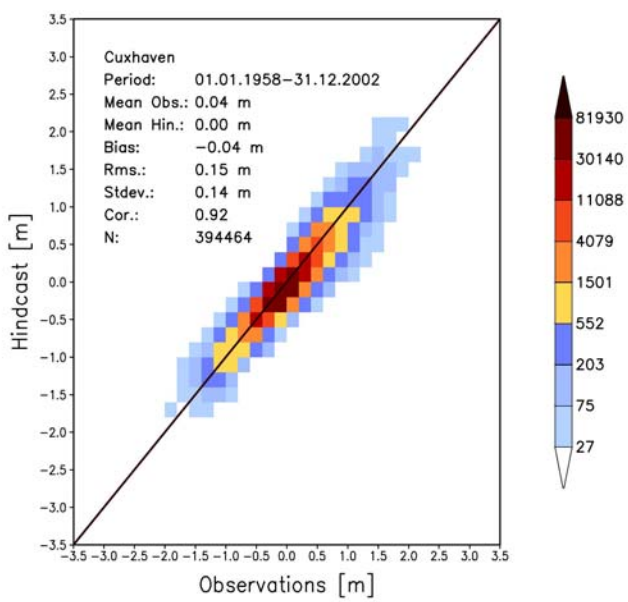
(Woth 2005, Woth et al. 2005)



Near-Coastal Cross Section along the 10-m Depth Contour Line

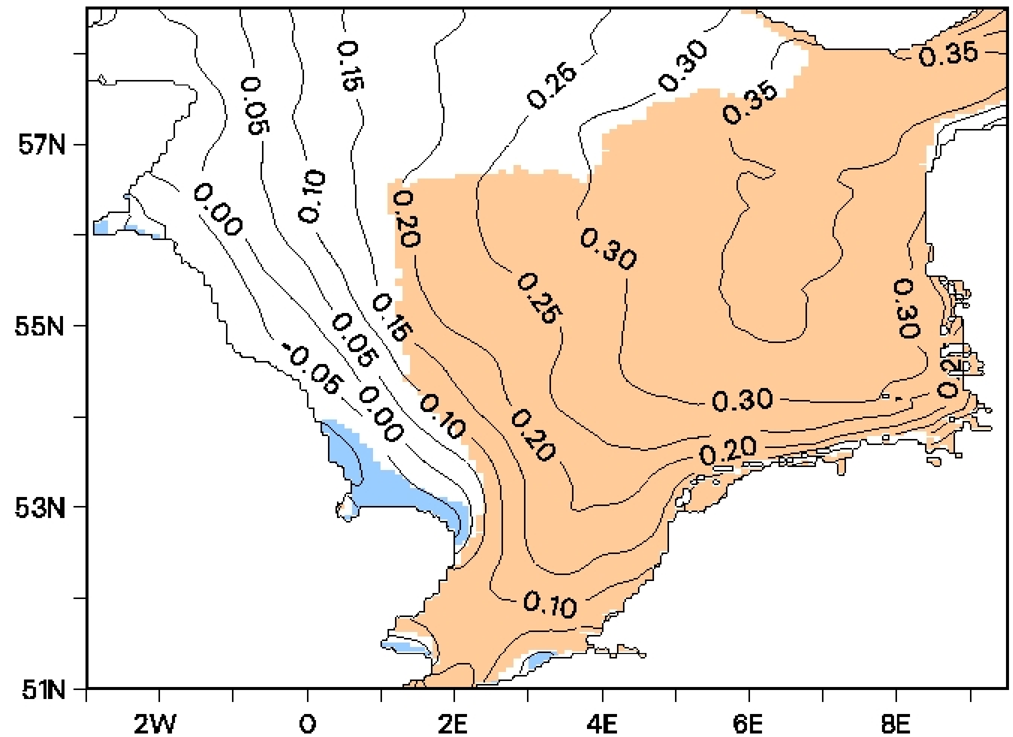


Change in Extreme Storm Surge Height along the 10-m Depth Contour Line as from Wind Fields from Different Climate Models and Natural Variability Estimated From the HIPOCAS Hindcast (Grey)



(Woth 2005,
Woth et al. 2005)

… and what may happen in the expected course of anthropogenic climate change?



Example sig. wave height

Change of annual 99%ile wave height 2085-present.

Average over several models and scenarios

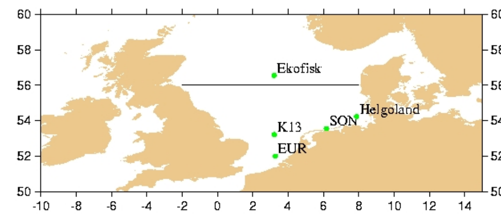
Shaded: All models and scenarios have the same sign.

(Weisse and Grabemann 2006)

Summary

- *How to determine decadal and longer variations in the storm climate?*
  - inhomogeneities
  - proxies and hindcasts in combination with available observations as useful indicators
- *How has the storm climate developed in the last few decades and last few centuries?*
  - increase in storm activity over the NE Atlantic, N Europe for a few decades since about 1960s
  - replaced a downward trend since about 1900
  - air pressure readings at two stations in Sweden since about 1800 no significant changes
- *How did wind storm impact on storm surges and ocean waves develop in the past decades, and what may happen in the expected course of anthropogenic climate change?*
  - changes consistent with the changes of storm activity
  - scenarios prepared by a chain of assumed emissions, global and regional climate models point to a slightly more violent future of storminess, storm surges and waves in the North Sea.
- Other areas (Baltic Sea, polar areas, Tropics) – other phenomena (tropical cyclones, polar lows)
- Application of coastDat (Ship movements, transports, storm surge risk, offshore wind …)

Thank you for your attention!



Example: Extreme events (wind & waves)

	Years	Wind [m/s]						Waves [m]					
		Hipocas			*Observed*			*Hipocas*			*Observed*		
		x_r^{90}	X_r	x_r^{90}	x_r^{90}	X_r	x_r^{90}	x_r^{90}	X_r	x_r^{90}	x_r^{90}	X_r	x_r^{90}
K13	2	24.38	25.17	25.96	24.05	25.21	26.37	7.12	7.49	7.86	6.41	6.77	7.13
	5	25.86	27.28	28.70	25.75	27.64	29.53	7.84	8.44	9.04	6.93	7.54	8.15
	25	28.44	31.33	34.22	28.09	32.77	37.45	8.99	10.35	11.71	7.52	9.21	10.90
EUR	2	22.50	23.16	23.82	23.16	24.03	24.90	5.89	6.15	6.41	5.52	5.84	6.16
	5	23.76	24.82	25.88	24.33	25.94	27.55	6.34	6.83	7.32	5.89	6.46	7.03
	25	25.67	28.00	30.33	26.43	29.75	33.07	6.90	8.20	9.50	5.99	7.88	9.77
SON	2	23.29	24.15	25.01	23.11	24.03	24.95	6.78	7.06	7.34	5.60	5.84	6.08
	5	24.89	26.32	27.75	24.15	25.94	27.73	7.37	7.79	8.21	5.97	6.46	6.95
	25	26.68	30.70	34.72	26.42	29.75	33.08	8.04	9.03	10.02	6.34	7.88	9.42

2, 5, and 25-year return values with 90% confidence limits based on 10.000 Monte Carlo simulations each.

(Weisse and Günther. 2006)