Wind, wave and storm surge hindcasts and scenarios and related coastal and offshore applications

- The coastDat data set at the GKSS Institute for Coastal Research -

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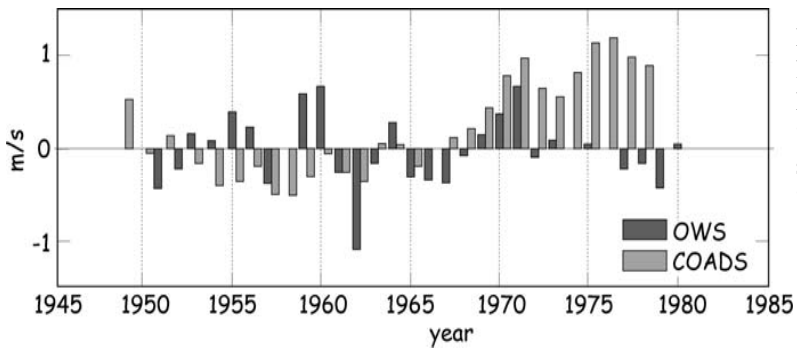
Brief Description of Motivation

What is coastDat?

- a set of model data (*hindcasts, scenarios*) based on experiences and activities in a number of national and international projects (*e.g. WASA, HIPOCAS, STOWASUS, PRUDENCE*)
- presently contains atmospheric and oceanographic parameter (*e.g. winds, sea states, water levels*)
- covers different geographical regions (*presently mainly North Sea*)

Why coastDat?

- Questions: What are the extremes to be expected? How have they changed and what may happen in the future?
- Needed: Comprehensive data base (long-time series, homogeneous data), usually not available for coastal & marine areas

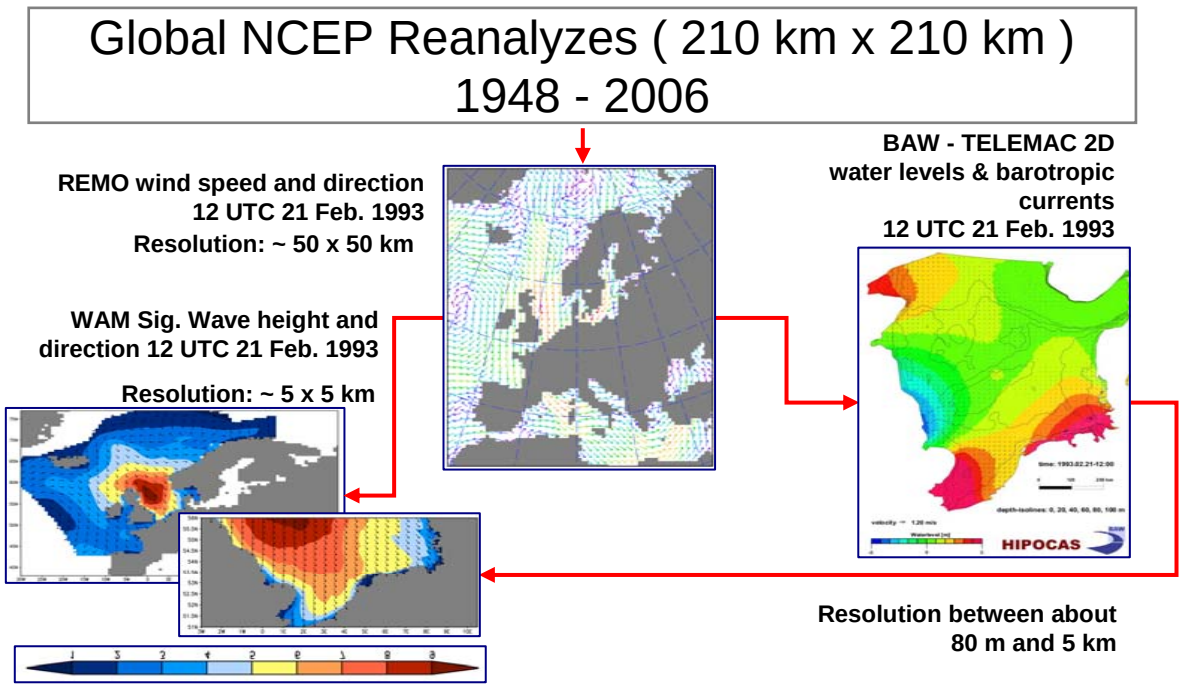


Estimated changes in mean wind speed in the North Pacific in the area of ocean weather station OWS P. Data from the ocean weather station are marked as "OWS" (ocean weather ship), and those from the ships of opportunity in the vicinity of OWS as "COADS". **(After Isemer, pers. communication)**

Brief Description of Methodology

Approach:

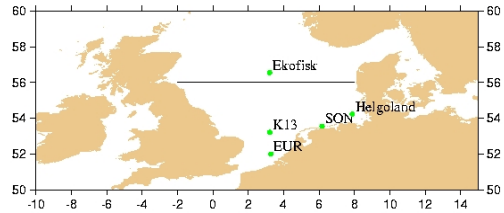
- Use proxies that are more homogeneous and
- Models in combination with existing measurements to reconstruct (hindcast) recent changes and to derive scenarios for the future

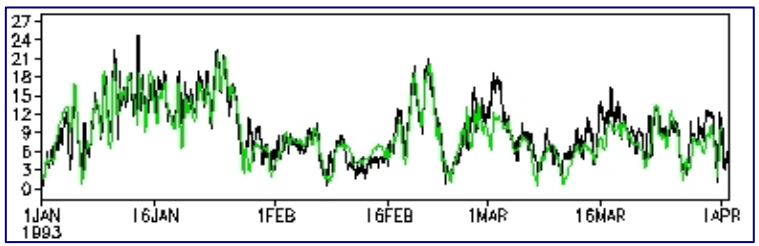


Summary of Conclusions

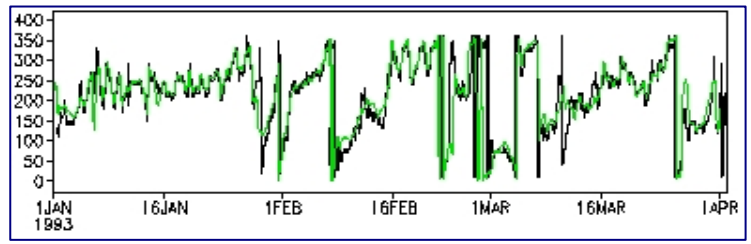
- Comprehensive meteo-marine data set
- Data set suitable to study long-term changes & variability
- Applicable to a large variety of coastal & offshore applications

Example Wind and Waves at K13

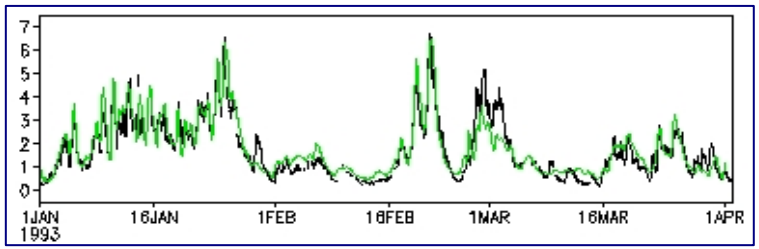




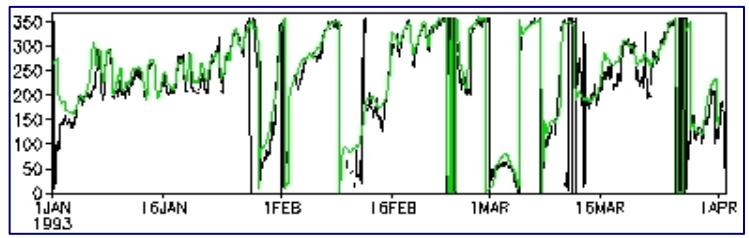
Wind speed [m/s]



Wind direction [degrees]



Sig. wave height [m]

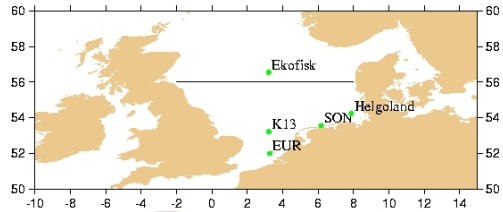


Mean wave direction [degrees]

Observations – black; Hindcast - green

(Weisse and Günther. 2006)

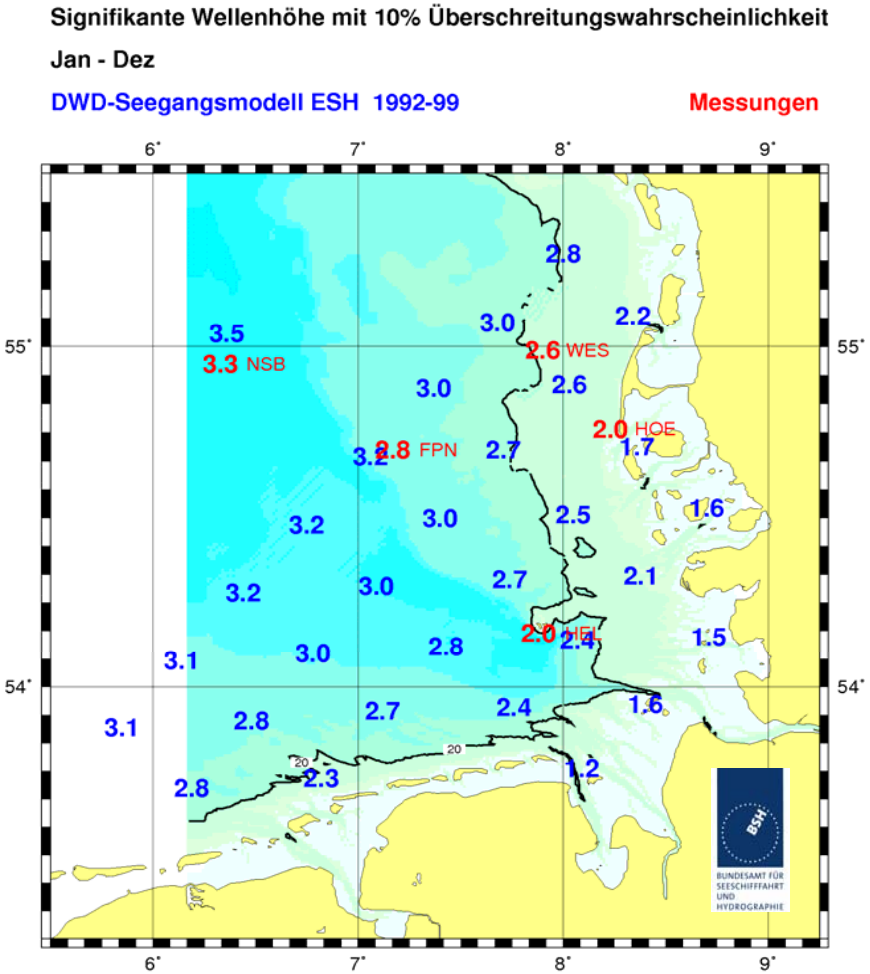
Example Extreme Events (Wind & Waves)

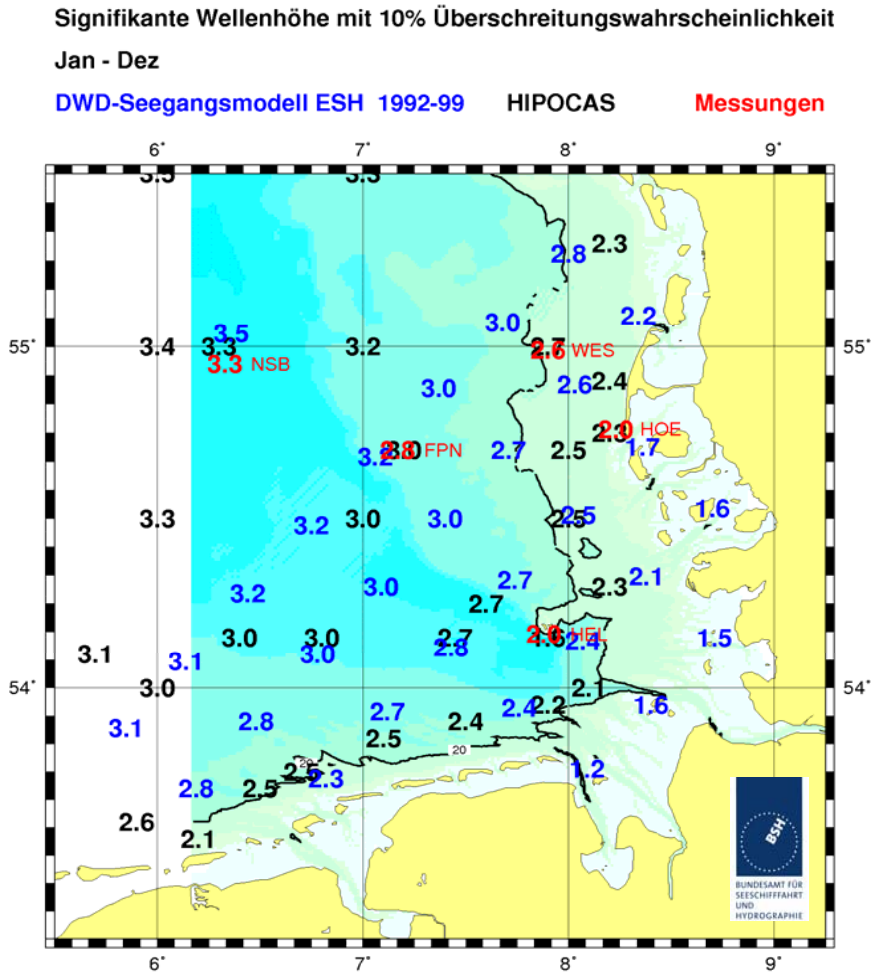


	Years	Wind [m/s]						Waves [m]					
		Hipocas			Observed			Hipocas			Observed		
		x_r^{90}	X_r	x_r^{90}	x_r^{90}	X_r	x_r^{90}	x_r^{90}	X_r	x_r^{90}	x_r^{90}	X_r	x_r^{90}
K13	2	24.38	25.17	25.96	24.05	25.21	26.37	7.12	7.49	7.86	6.41	6.77	7.13
	5	25.86	27.28	28.70	25.75	27.64	29.53	7.84	8.44	9.04	6.93	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.

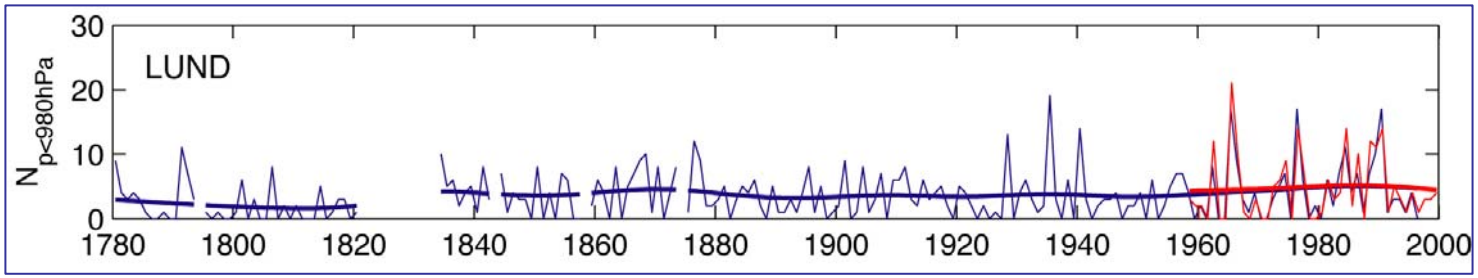
(Weisse and Günther. 2006)





(From D. Schrader (BSH) 2006)

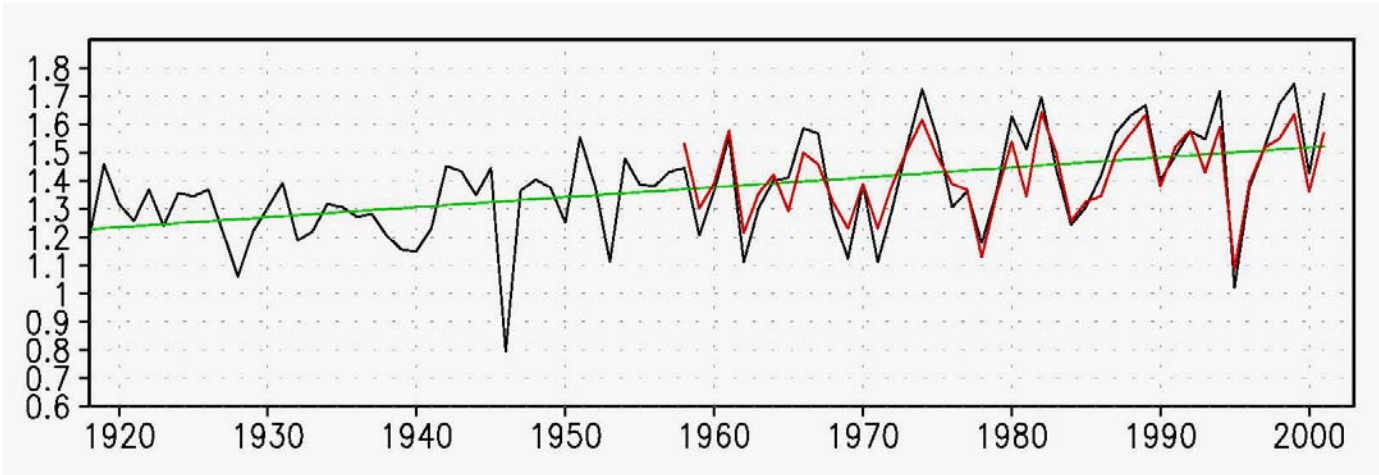
Example Interannual Variability Storm Indices



Storm index Lund: red - reconstruction, blue - observations

(after Bärring and von Storch 2005)

Example Interannual Variability Water Levels



Annual mean winter high waters Cuxhaven
red – reconstruction, black – observations

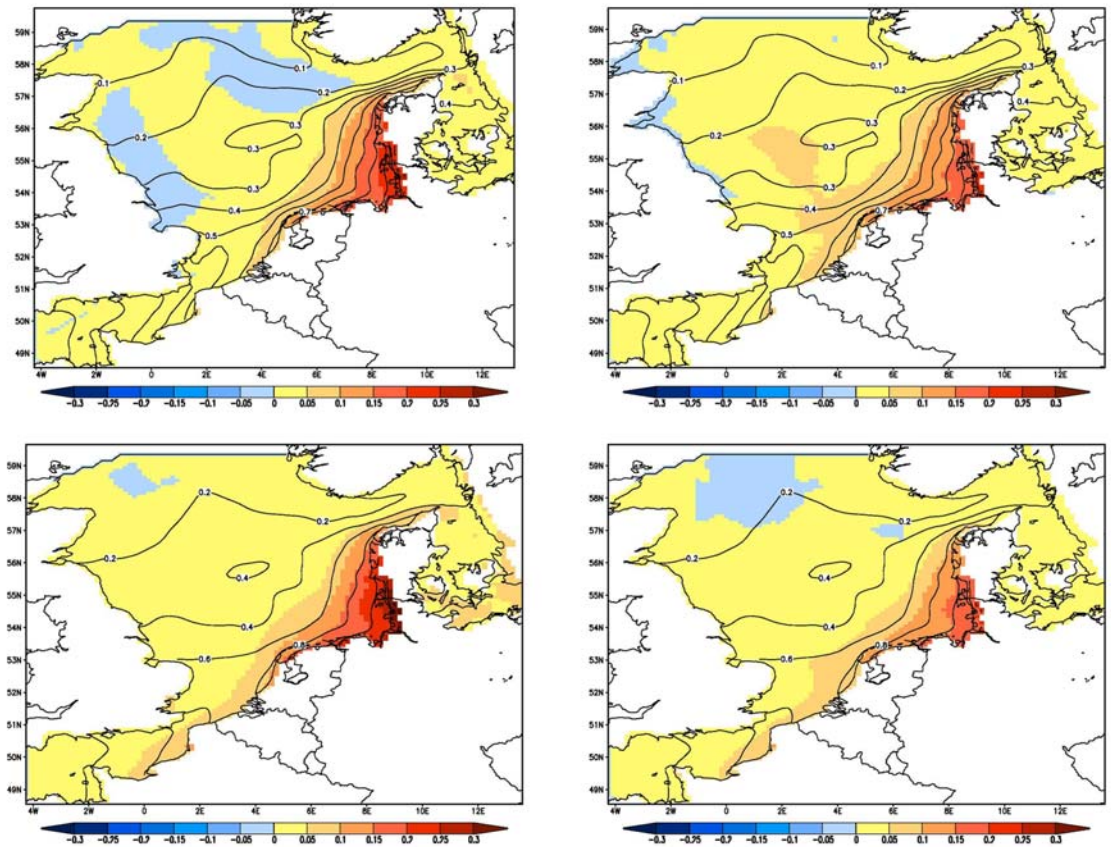
(Weisse and Plüß 2006)

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

Example Storm Surges

Change of annual max. storm surge 2085-present

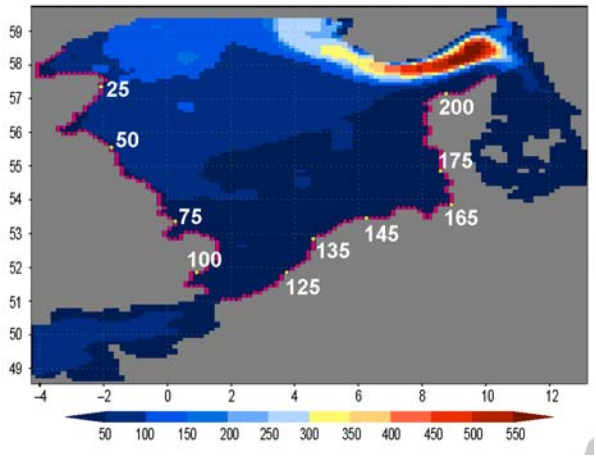
A2 B2



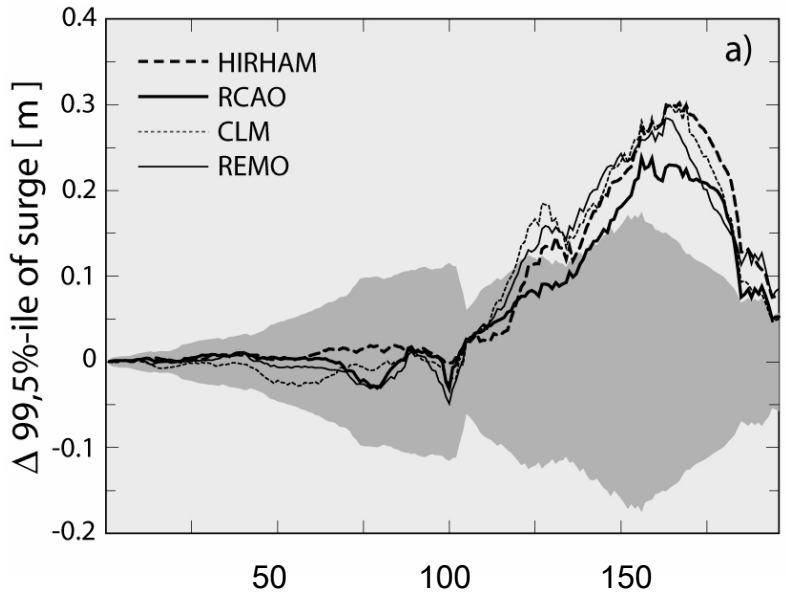
RCAO/ ECHAM

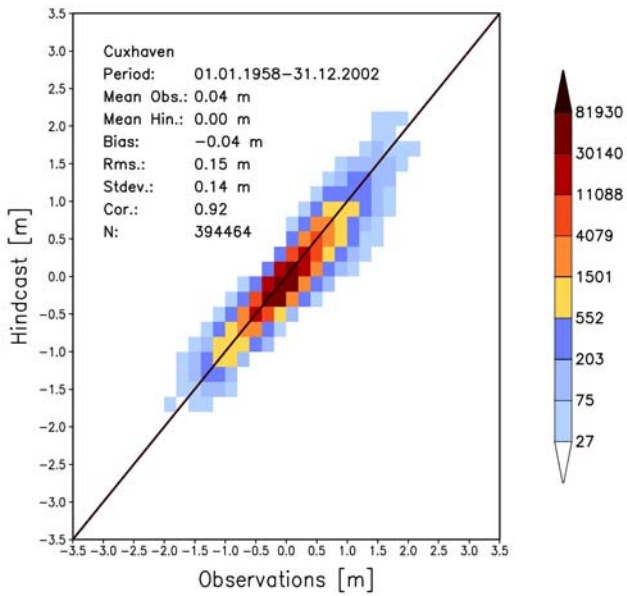
RCAO/ HadAM3H

(Woth 2005, Woth et al. 2005)



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



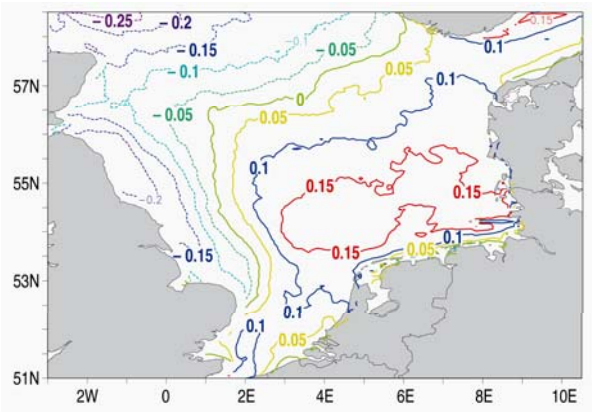


Change in Extreme Storm Surge Height along the 10-m Depth Contour Line as from Wind Fields from Different Climate Models and Natural Variability Estimated From the HIPOCAS Hindcast (Grey)

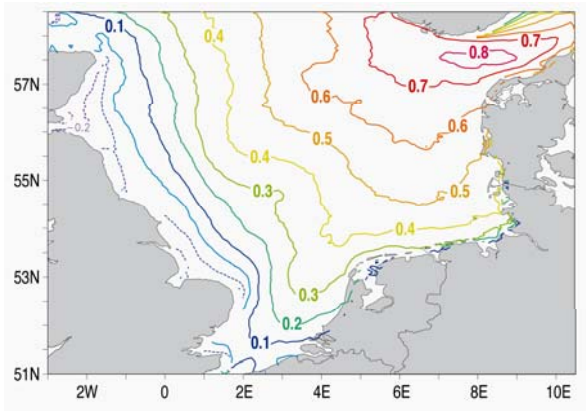
(Woth 2005,
Woth et al. 2005)

Example Sea State Scenarios North Sea

RCAO/HADAM3



RCAO/ECHAM



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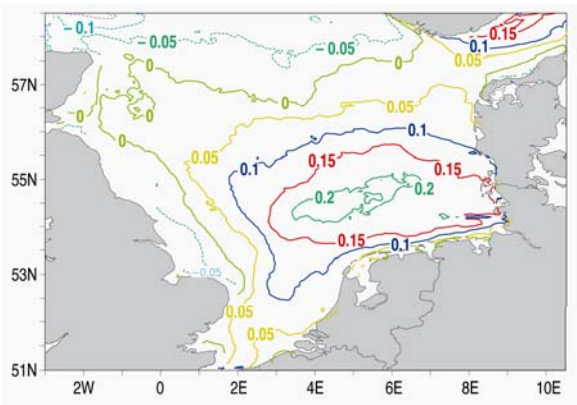
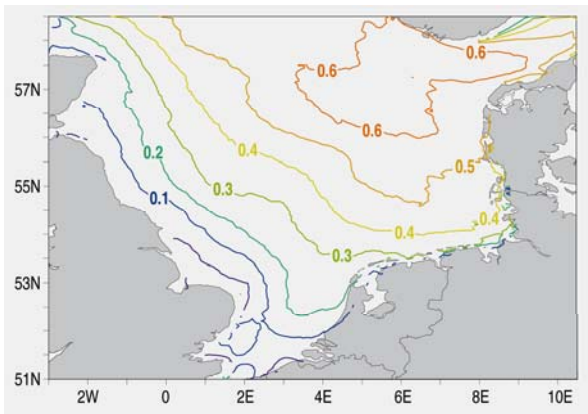




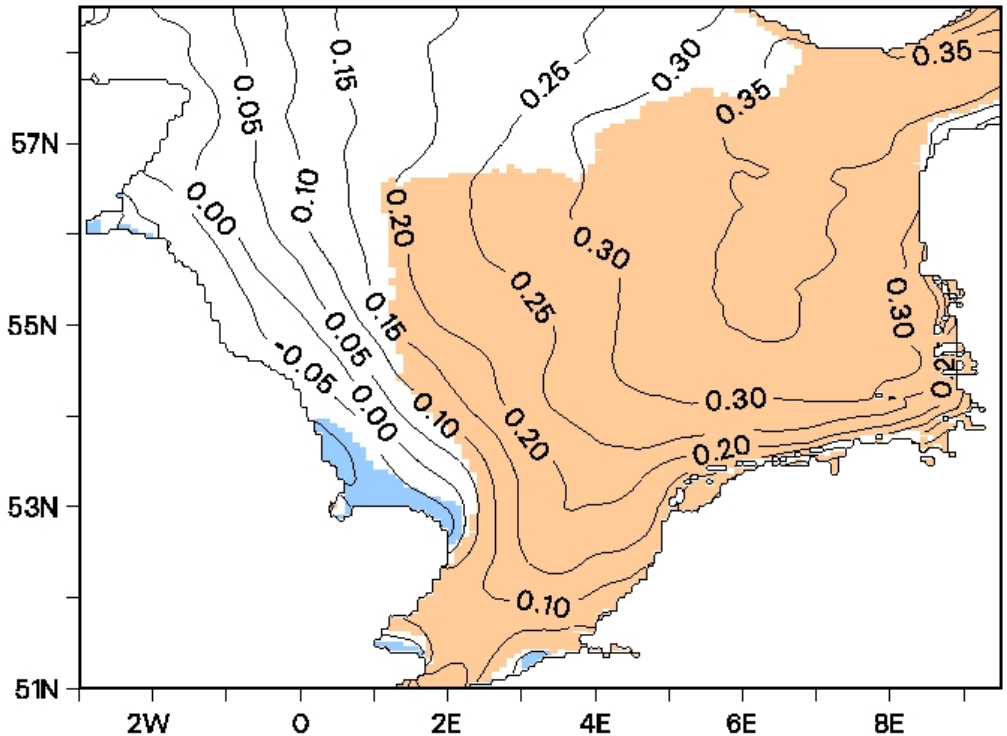
B2

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

(Weisse and Grabemann 2007)

Example Sea State

Change of annual 99%ile of significant wave height in m 2085-present



Average over several models and scenarios

colour: areas in which all changes from all models and scenarios have at least the same sign

(Grabemann and Weisse 2007)

Coastal & Offshore Applications

www.coastdat.de

User

(as of October 2007)

- Amt für Ländliche Räume (ALR), Husum
- Bundesamt für Seeschifffahrt und Hydrographie (BSH)
- Bundesanstalt für Gewässerkunde
- Bundesanstalt für Wasserbau (BAW) Hamburg
- Centro de Estudios y Experimentacion de Obras Publicas (CEDEX) / Cento de Estudios de Puertos y Costas (CEPyC)
- Deutscher Wetterdienst
- Duke University
- Flensburger Schiffbau Gesellschaft
- GEO Gesellschaft für Energie und Ökologie mbH
- Hochtief Construction AG
- IMS Ingenieurgesellschaft mbH
- Louc Rouille (Versicherungsberater)
- Lund University, Sweden
- Max-Planck-Institut für Biogeochemie, Jena
- Niedersächsicher Landesbetrieb für Wasserwirtschaft und Küstenschutz (NLWK)
- Noble Denton Consultants Ltd.
- Offshore Windpark Butendiek
- Overspeed GmbH & Co KG
- surfersmag.de
- Universidad de Cantabria Ocean & Coastal Research Group
- Universität Hamburg, Institut für Geophysik
- Windland Energieerzeugungs GmbH
- WL Delft
- Intern (Ölausbreitung; Atmosphärische und ozeanische Transporte; Interpretation von Beobachtungsdaten; Wasserqualität; Randwerte für hochaufgelöste Seegangssimulationen)

Applications

(as of October 2007)

- Wind and sea state statistics (for e.g., offshore wind, coastal protection, Jade-Weser Port)
- Boundary conditions for high resolution near-shore wave modeling (e.g., Butendiek, Norderney, Helgoland)
- Ship design (simulation of ship behavior)
- Simulation of oils spills and risk assessment
- Analysis of storm surge and storm flood risk (Ostfriesland, Langeoog)
- Comparison with observed storm indices
- Atmospheric und ocean transports
- Probabilities for the detection of oil spills
- Water quality studies
- Interpretation of measurement data (FerryBox)
- Micro seismic
- Analysis o trends in heavy precipitation events
- Carbon balance of terrestrial ecosystems

Some applications of coastDat

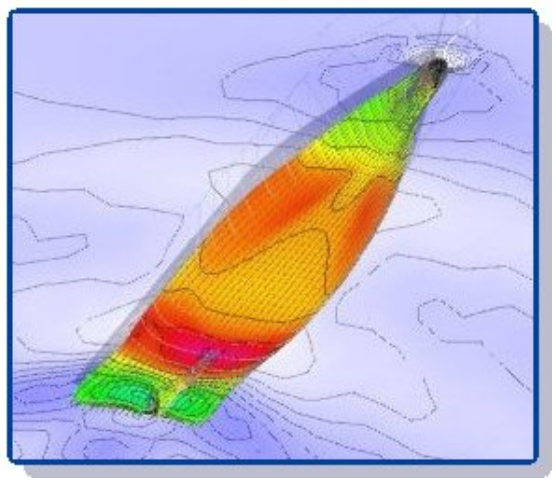
(as of October 2007)

- Ship design

- Problem:
  . RoRo liners operating on fixed routes
  . Operation time critical

- Idea:
  . Optimization of velocity profile taking environmental conditions into account (e.g. water depth, wave height, wave angle)

- Example:
  . 200 m RoRo liner Zeebrügge-Immingham
  . Compared to conventional approach delayed in 7% of time; only in 0.5% more than 30 min
  . Reduced operation costs (200 TEUR/year due to reduced fuel consumption)



Source: Flensburger Schiffbau Gesellschaft

Some applications of coastDat

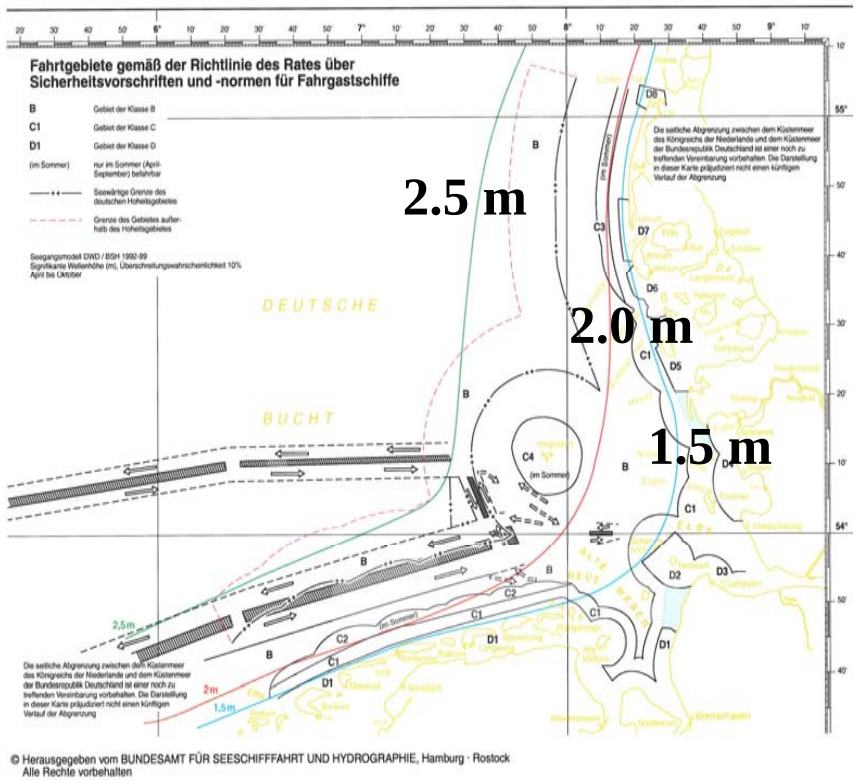
(as of October 2007)

- **Ship design**
- **Navigational safety**

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

- Background:
  . EU safety regulations for RoRo passenger vessels

-Criteria:
  . Sig. wave height of 1.5, 2.5, 4.0 m exceeded in less than 10% of time (according to ship specifications)
  . Distance to next harbour



(Source: BSH)

Some applications of coastDat

(as of October 2007)

- Ship design
- Navigational safety
- Offshore wind

IMS

- Wind and sea state statistics
  . Wind power availability
  . Design of structures
  . Design of entire system (ultimate and fatigue limit states)
  . Planning of installation
  . Planning of maintenance (weather windows)

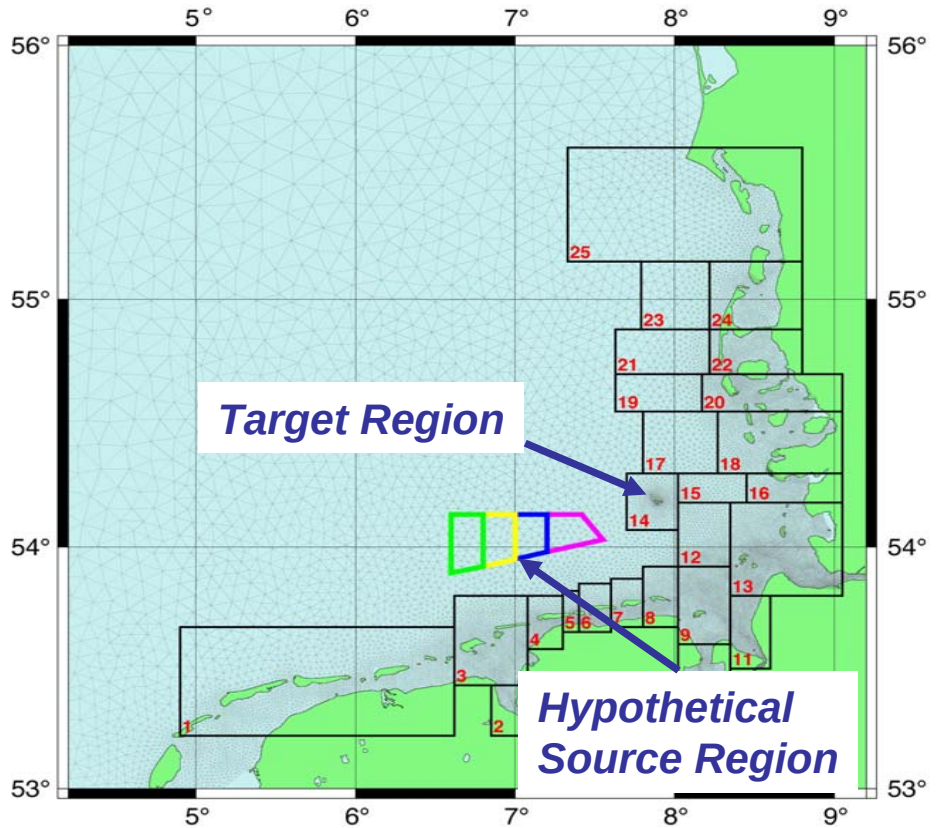
(Source: IMS)

Some applications of coastDat

(as of October 2007)

- **Ship design**
- **Navigational safety**
- **Offshore wind**
- **Oils spill risk**

- Hypothetical oil accidents
  . Any source region
  . Any target region of interest
  . Hypothetical accidents every hour over 50 years (sampling of large variety of different possible weather conditions)



(Source: U. Callies)

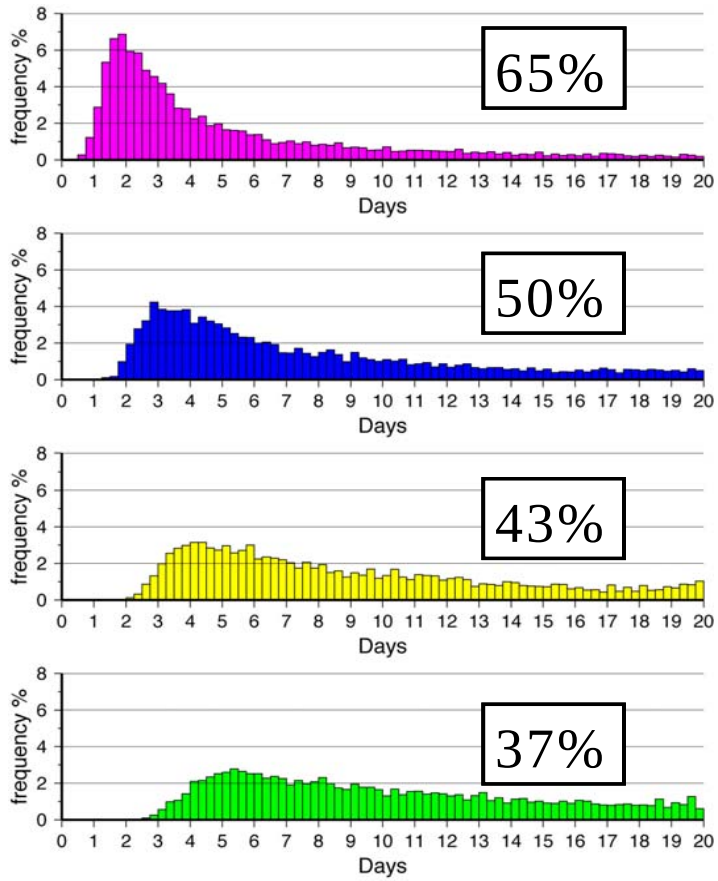
Some applications of coastDat

(as of October 2007)

- **Ship design**
- **Navigational safety**
- **Offshore wind**
- **Oils spill risk**

- Hypothetical oil accidents
  . Any source region
  . Any target region of interest
  . Hypothetical accidents every hour over 50 years (sampling of large variety of different possible weather conditions)

- Probability distributions
  . E.g. of travel times
  . May be combined with different accident probabilities, oil fighting strategies & sensitivities



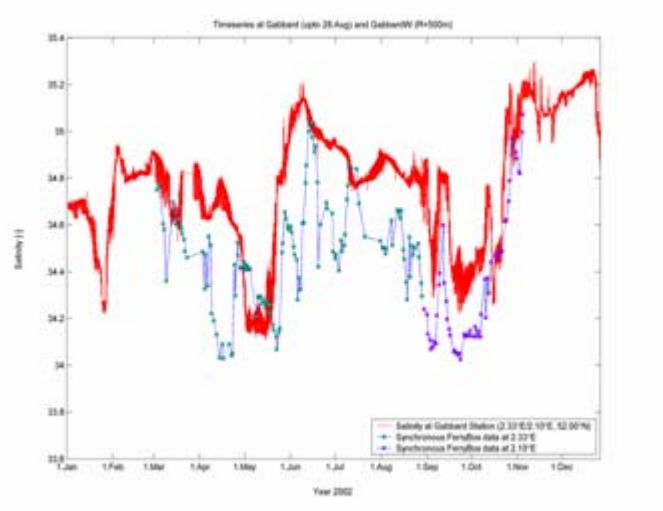
(Source: U. Callies)

Some applications of coastDat

(as of October 2007)

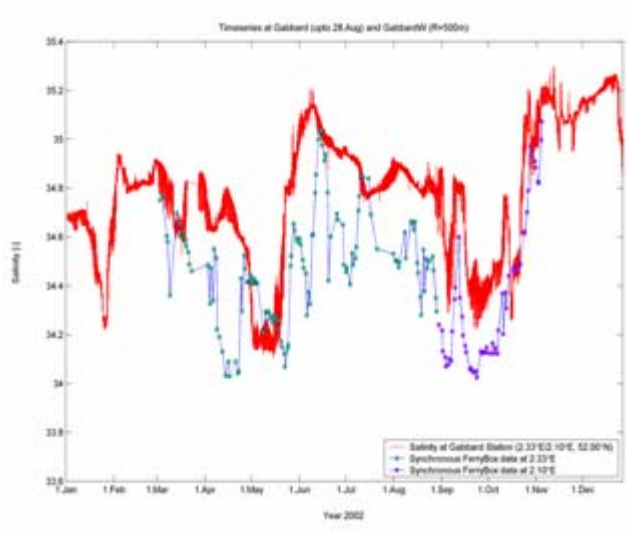
- **Ship design**
- **Navigational safety**
- **Offshore wind**
- **Oils spill risk**
- **Interpretation of measurements**

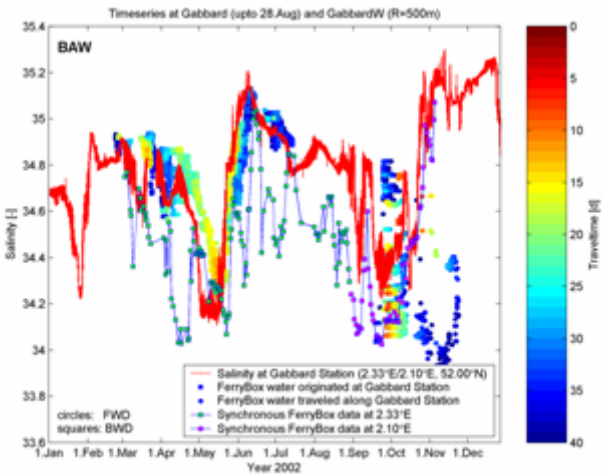
GKSS FORSCHUNGSZENTRUM in der HELMHOLTZ GEMEINSCHAFT



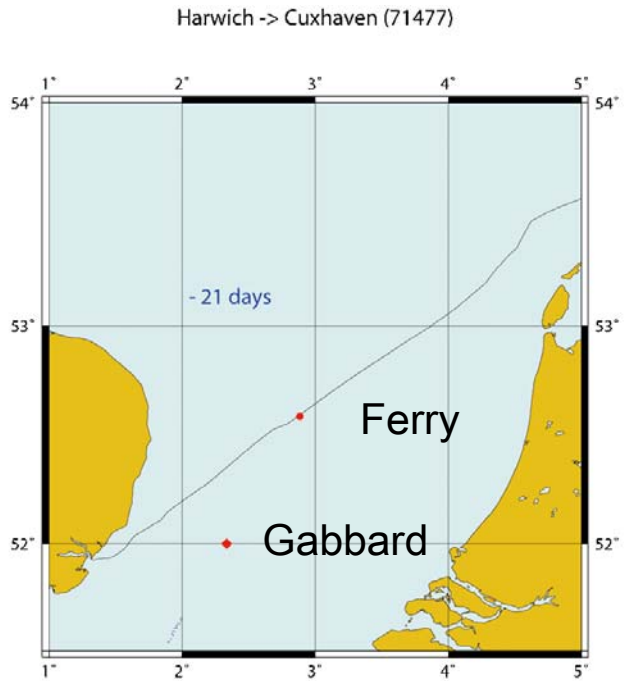
(Source: U. Callies)

Example Ferry box





Comparison between observed salinity at Gabbard and salinity obtained from the ferry box for times when the distance between Gabbard and the ferry was smallest



Using coastDat to compute, when and where water masses „coming from“ Gabbard intersect with ferry route and comparison with new time series

(Callies pers. Mitteilung)

Some applications of coastDat

(as of August 2007)

- **Ship design**
- **Navigational safety**
- **Offshore wind**
- **Oils spill risk**
- **Interpretation of measurements**
- **Coastal protection**

- Planning of levee reconstruction Helgoland (ALR)
- Boundary conditions for near-shore wave modelling (e.g. MOSES)
- Storm surge risk (e.g. NLWKN)

(Island of Helgoland)

Concluding Remarks

coastDat-II

- new regional atmosphere model with higher spatial resolution
  (CLM with 25 km / 8 km)
- updated wave and storm surge simulations
  (entire North Sea, some model improvements and higher resolution)
- new scenario runs
  (transient simulations)

New regions & phenomena

(e.g. SE Asia & typhoons; polar regions & polar lows, Baltic Sea)

New parameter

(e.g. ocean temperature and salinity, atmospheric transports, substances)

Thank you for your attention!