This poster participates in OSP

Outstanding Student Poster Contest

Mechanisms of long-term mean sea level variability in the North Sea

Sönke Dangendorf[1] (soenke.dangendorf@uni-siegen.de), Francisco Calafat[2], Jan Even Øie Nilsen[3], Kristin Richter[4] and Jürgen Jensen[1]

[1]University of Siegen | Germany [2]National Oceanography Centre | UK [3]Nansen Environmental and Remote Sensing Centre | Norway [4]University of Innsbruck | Austria

No. B135

Motivation

With the release of the fifths assessment report (AR5) of the IPCC regional projections of mean sea level (MSL) rise have become available for the first time. However, these projections are based on the outputs of global climate models with a rather low spatial resolution of more than 100km questioning their reliability for shallow coastal areas. To assess possible future states of coastal MSL rise and variability knowledge about the underlying processes is required. Here, we investigate the temporal and spatial variability of MSL in the North Sea region since the late 19th century using a combination of tide gauge observations, altimetry, hydrographic profiles, and atmospheric reanalyis data as well as a baroclinic ocean model.

What are the causes of North Sea MSL variability and are there implications for the derivation of possible future projections?

Datasets

- 22 tide gauges from the PSMSL data set and *Wahl et al.* [2011]
- Atmospheric fields (SLP & u,v-wind) from the 20th century reanalysis
- Steric sea level (for the upper 200m) derived from updated temperature and salinity profiles [*Ishii and Kimoto*, 2009]
- Wind forced 3D non-Boussinesq ocean Model (MICOM, 10*10km)

Investigation area and tide gauge locations

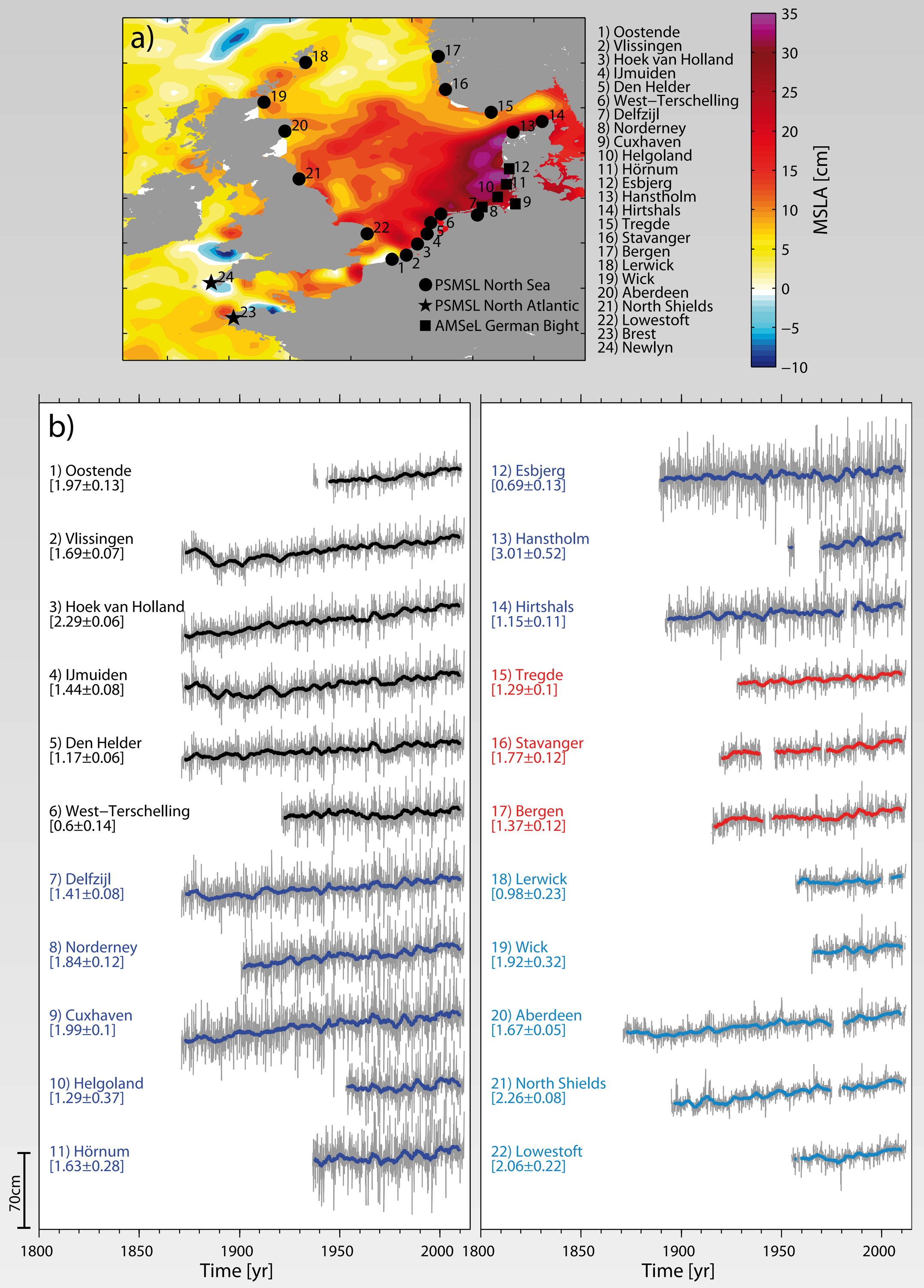


Fig. 1: *a) Investigation area with tide gauge locations and sea surface height (SSH) anomalies from Altimetry. b) Monthly de-seasonalized time series (grey) of local MSL (GIA corrected). The thick lines represent the 12 months low pass filtered component. The different colors mark sub-regions used for the calculation of regional indices.*

Results: Observations

Mean composites for monthly MSL and their atmospheric imprints

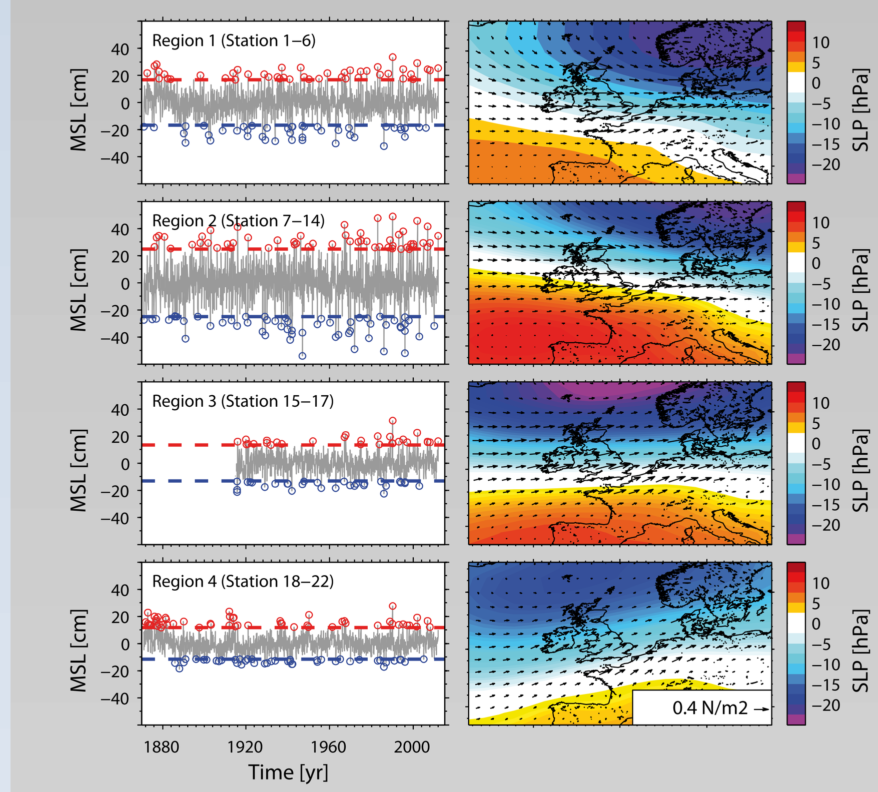


Fig. 2: *Composite plot showing wind and pressure conditions (right) during times of particularly high (>2*stdv) minus particularly low (<2*stdv) monthly MSL events (left). The plots are given for four regional indices (averages).*

The role of atmospheric forcing on intra- and inter-annual timescales

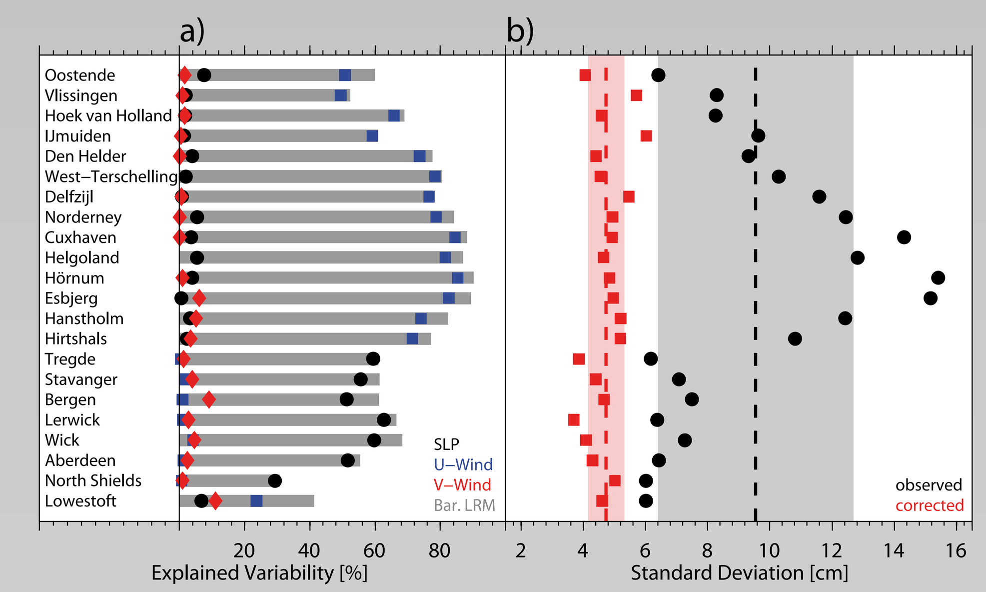


Fig. 3: *a) Explained variability of barotropic atmospheric forcing estimated with a stepwise multiple linear regression model (LRM; grey bars). The colored dots mark the contribution given by each predictor alone. Only predictors explaining a significant fraction of variability are shown (95% confidence level). b) Stdv. of the observed (black) and atmospherically corrected (red) monthly MSL time series. The dashed lines with the shaded areas mark the mean and stdv. over all stations.*

Decadal variability and steric sea level

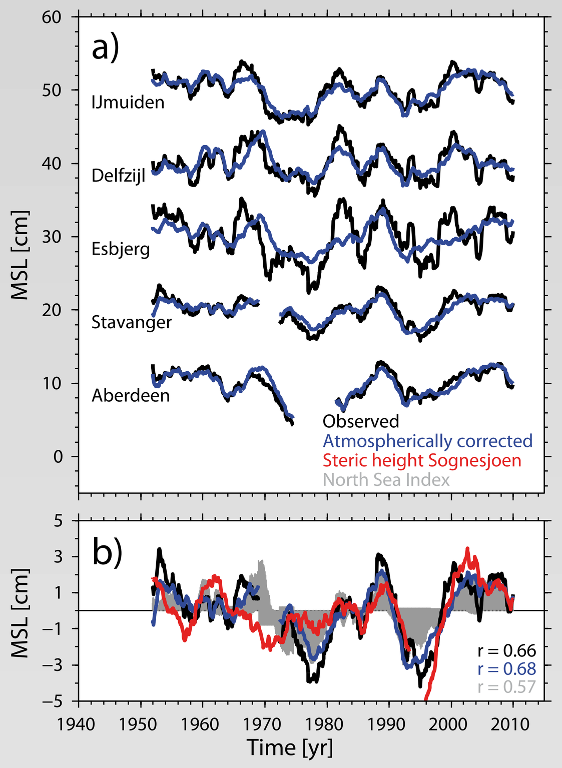


Fig. 4: *Coherence of decadal (48 months low pass filtered) sea level (black: observed, blue: atmospherically corrected) in the North Sea (a). Also shown (b) is the steric height obtained from hydrographic observations near Sognesjoen in the Norwegian Trench (referenced down to 700m).*

Regional coherence of decadal sea level

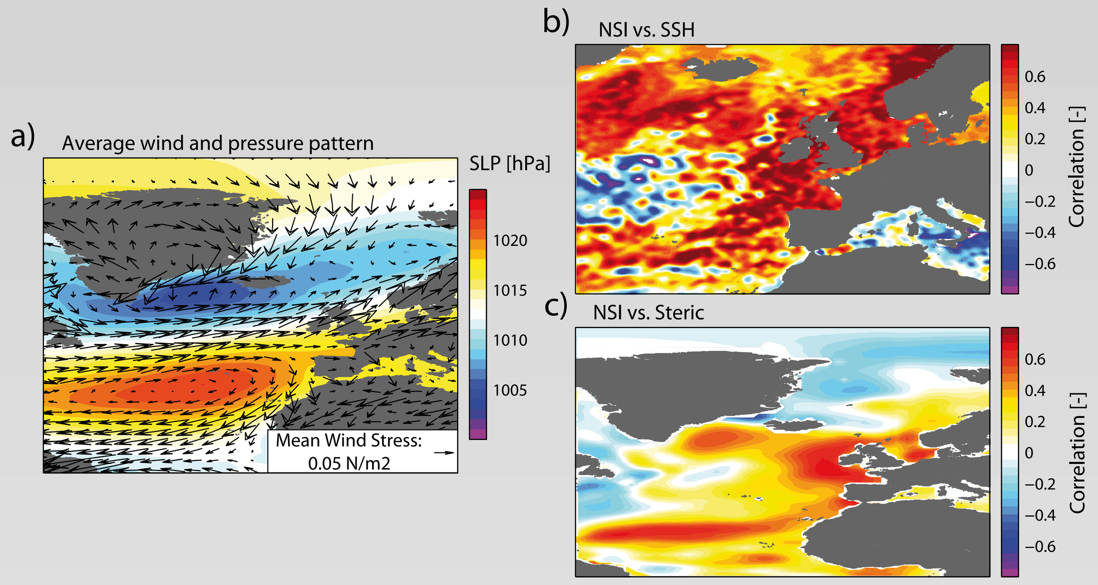


Fig. 5: *a) Average wind and pressure conditions over the period 1945-2011. b) Correlation between the low pass filtered (48 months) and atmospherically corrected North Sea index (NSI) and SSH from Altimetry, and c) the steric height for the upper 200m.*

Forcing of decadal sea level

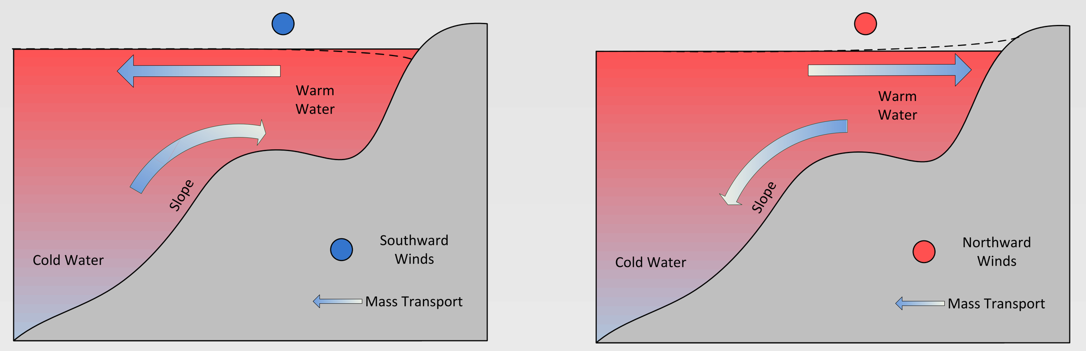


Fig. 6: *Schematic of eastern boundary wind forcing and the respective changes in coastal sea level.*

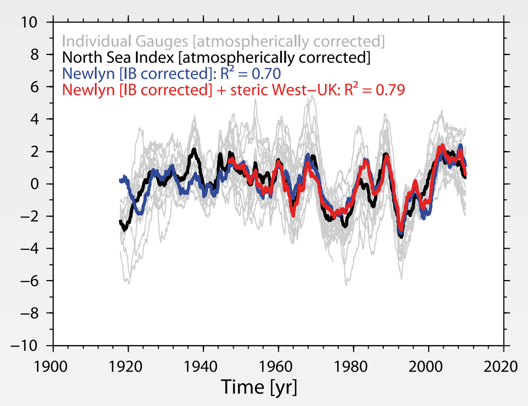


Fig.7: *Reconstruction of decadal MSL variability in the North Sea based on barotropically corrected Newlyin (NEW) and steric sea level west of the UK. NEW is used as a proxy for boundary wave forcing along the continental slope of the North Atlantic [Calafat et al., 2012].*

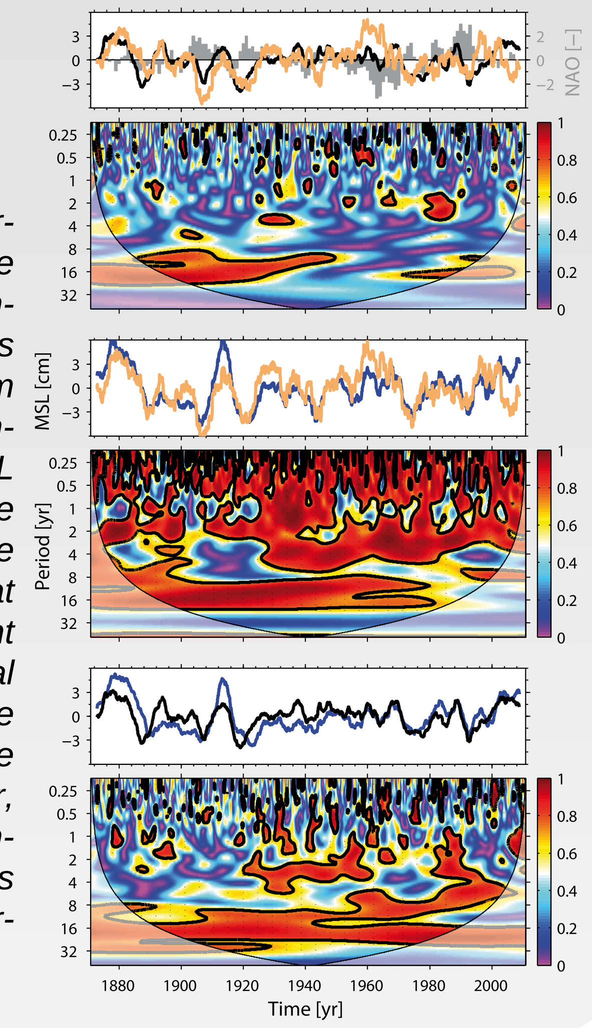
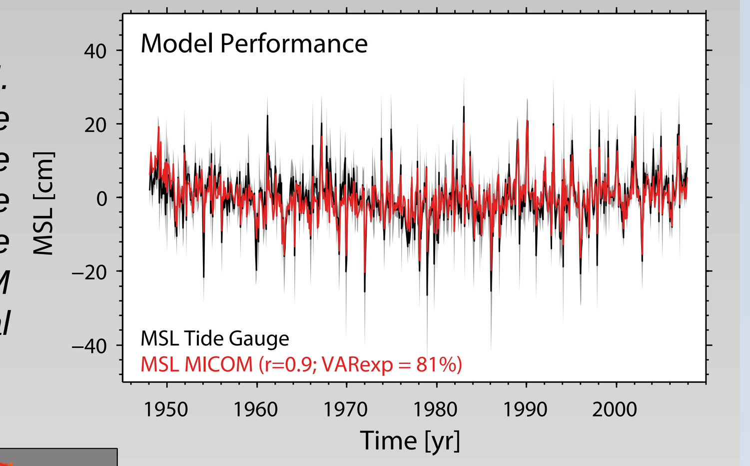


Fig. 8: *Wavelet coherence between (top) the NSI and eastern boundary longshore winds (LSW, integrated from the equator northwards), b) NEW MSL and LSW, and c) the NSI and NEW. The results suggest that winds play an important role in forcing decadal sea level along the eastern boundary of the North Atlantic. However, travelling further northwards, the signal seems to be increasingly disturbed by topography.*

Results: Model

Regional coherence in MICOM

Fig. 9: *Model performance of MICOM. Shown is a comparison between the NSI from coastal tide gauges and the sea surface height (SSH) from the closest grid points in MICOM. The comparison sug-gests that MICOM reproduces the majority of coastal MSL in the North Sea (81%).*



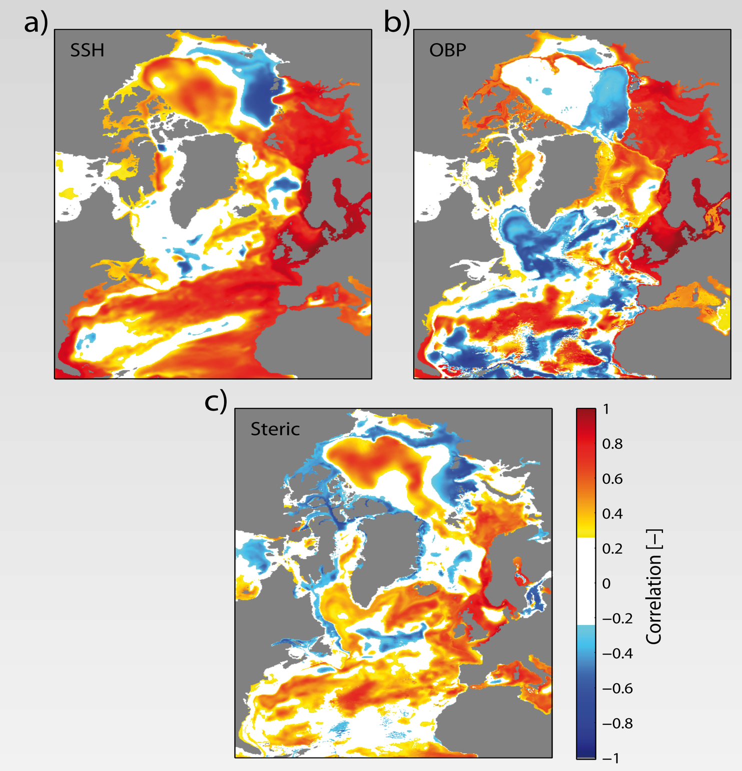


Fig. 10: *Correlations between the low pass filtered NSI (48 months) from MICOM and each grid point time series calculated for the a) SSH, b) ocean bottom pressure (OBP), c) steric height. The correlation analysis suggests a coherent OBP signal extending from the west coast of Africa along the continental slope into the Arctic ocean.*

Take Home Messages

North Sea MSL is marked by pronounced internal climate variability acting on timescales from months to several decades.

Barotropic atmospheric forcing dominates the variability on timescales up to a decade. This variability can be accurately modelled using statistical downscaling techniques (Dangendorf et al., 2014a).

The decadal MSL is dynamically (via boundary waves) connected to the Northeast Atlantic. An accurate description of the processes producing this variability requires high resolution (<10-20km) 3D models.

For the derivation of future coastal MSL projections in the North Sea statistical-dynamical downscaling techniques are required, which are able to reproduce the small scale processes along the continental slope.

References

Calafat F.M. et al. (2012), Mechanisms of decadal sea level variability in the eastern North Atlantic and the Mediterranean Sea, *J. Geophys. Res.*, 117, C09022.

Dangendorf, S. et al. (2014a), A new atmospheric proxy for sea level variability in the southeastern North Sea: observations and future ensemble projections, *Climate Dynamics*, 43, 447-467.

Dangendorf, S. et al. (2014b), Mean sea level variability in the North Sea: processes and implications, *J. Geophys. Res.*, 119, 6820-6841.

Ishii, M., & M. Kimoto (2009), Reevaluation of historical ocean heat content variations with time-varying XBT and MBT depth bias corrections, *J. Oceanogr.*, 65, 287–299.

Wahl, T. et al. (2011), Improved estimates of mean sea level changes in the German Bight over the last 166 years, *Ocean Dynamics*, 61(5), 701-715.

UNIVERSITÄT SIEGEN

National Oceanography Centre