



Forecasting exceedance probabilities of extreme sea level events based on ensemble forecasts

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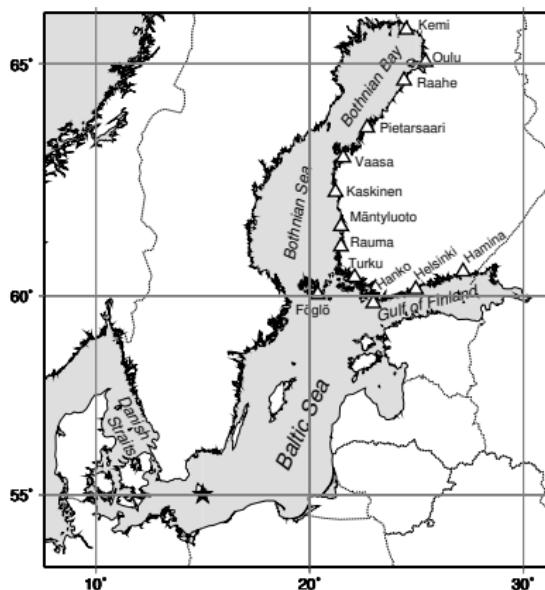


Introduction

- Sea level forecasts are made for the Baltic Sea
- Sea level forecasts needed from 2 to 10-day length
- Planning of ship cargo loading and ship route
- Preparing for sea level extremes at the coast
- Deterministic forecast too uncertain if forecast length is longer than 4-5 days
- Probability forecasts more useful for longer time periods



Baltic Sea





Combined model of Baltic Sea level

- Sea level components are modeled separately
- Internal fluctuations of the Baltic Sea level are calculated using 2-D Hansen sea level model and assuming Baltic Sea a closed basin
- Water balance of the Baltic Sea is estimated from the daily means of zonal surface winds v_B on Bornholm (55 N, 15 E)

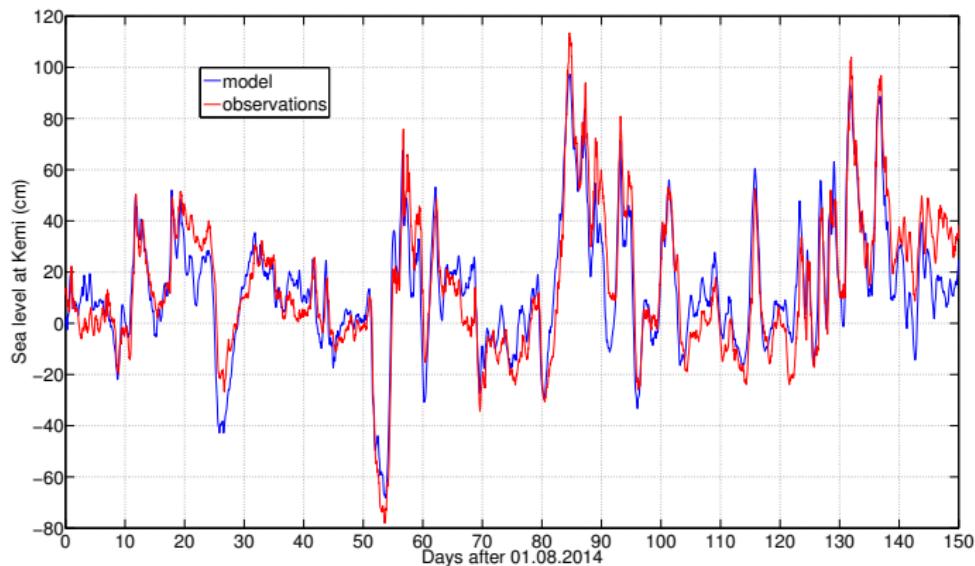
$$z(t) = \sum_{T=1}^{60} a(T) v_B(t - T)$$

$$a(T) = 2.9 \text{mm/ms}^{-1}, 1 \leq T \leq 4$$

$$a(T) = 4.0 \text{mm/ms}^{-1} \times \exp(-0.072T), 4 < T \leq 60.$$



Sea level at Kemi 2014



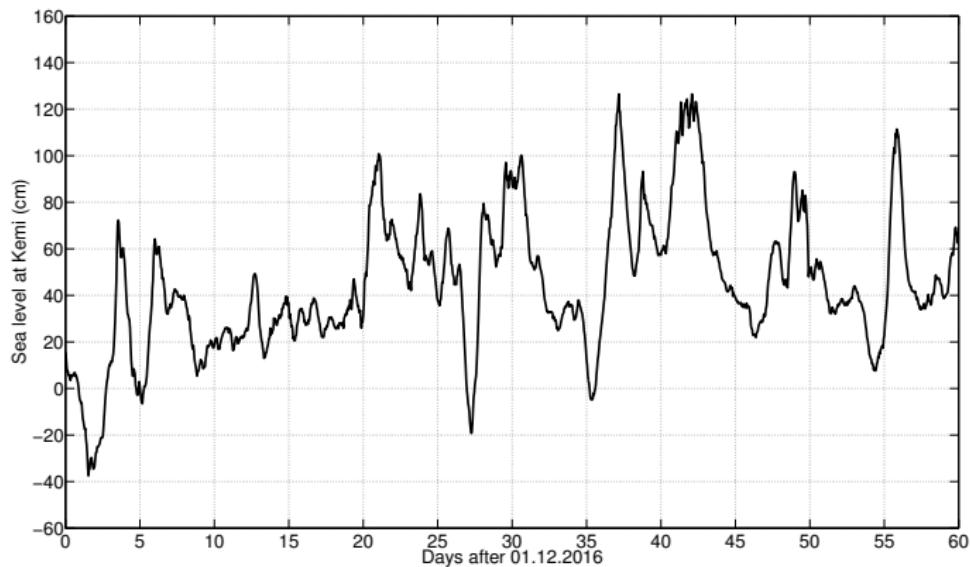


Sea level probability forecast

- 1 control and 50 perturbed forecasts from the ECMWF Ensemble Prediction System
- 15-day forecasts made daily at 00 and 12 UTC
- 10-day forecasts containing surface wind and air pressure data in the sea level model grid delivered to FMI
- Grid size 15 nmi, atmospheric input data time step 6 h
- 51 10-day sea level simulations take 3 minutes with a laptop
- Results saved for tide gauge locations (in the future the entire grid)
- Different sea level probability fractiles calculated from simulation ensemble

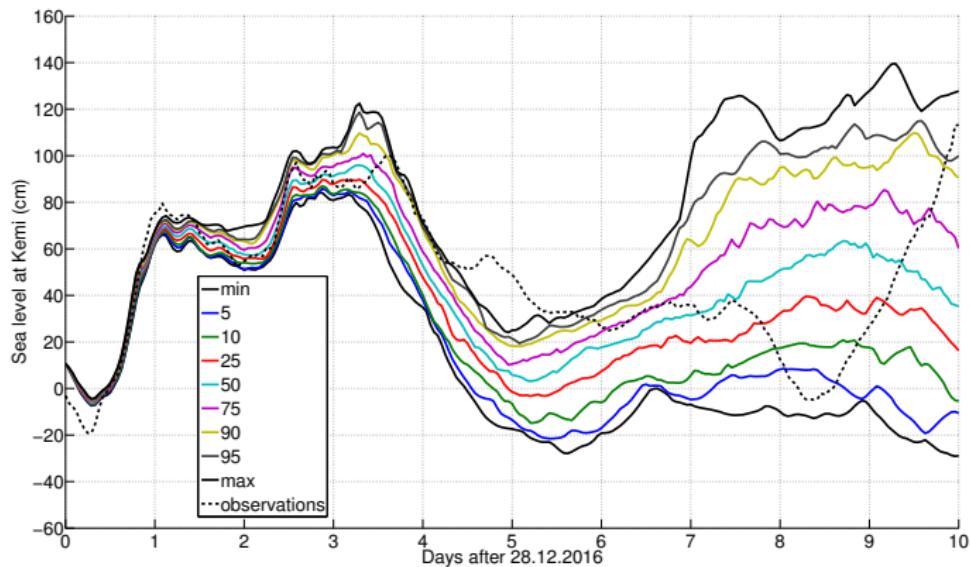


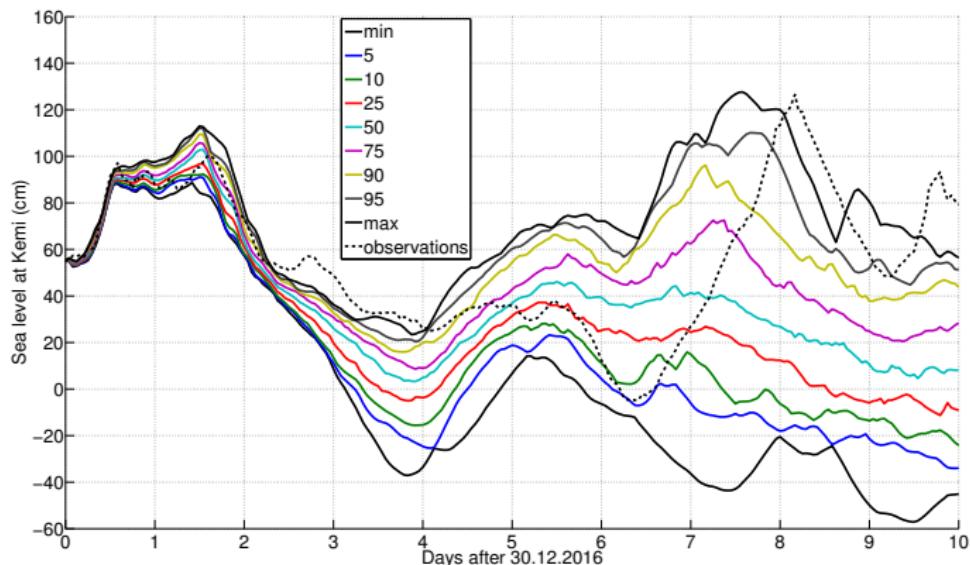
Sea level at Kemi December 2016-January 2017

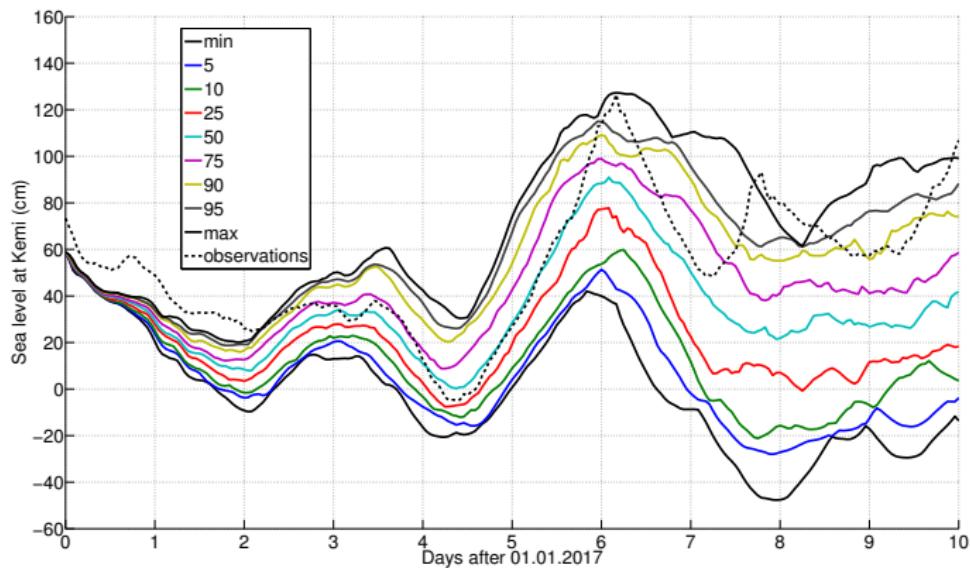


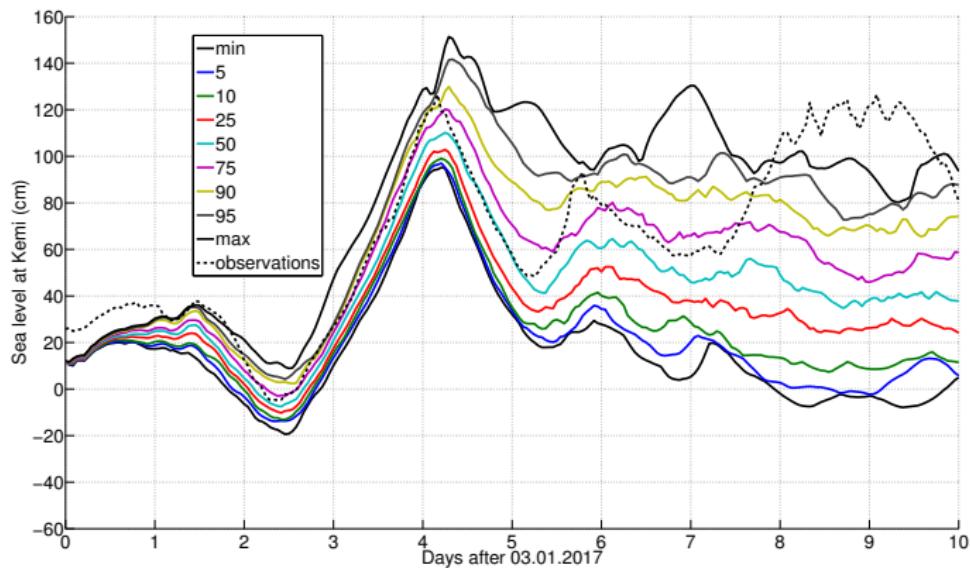


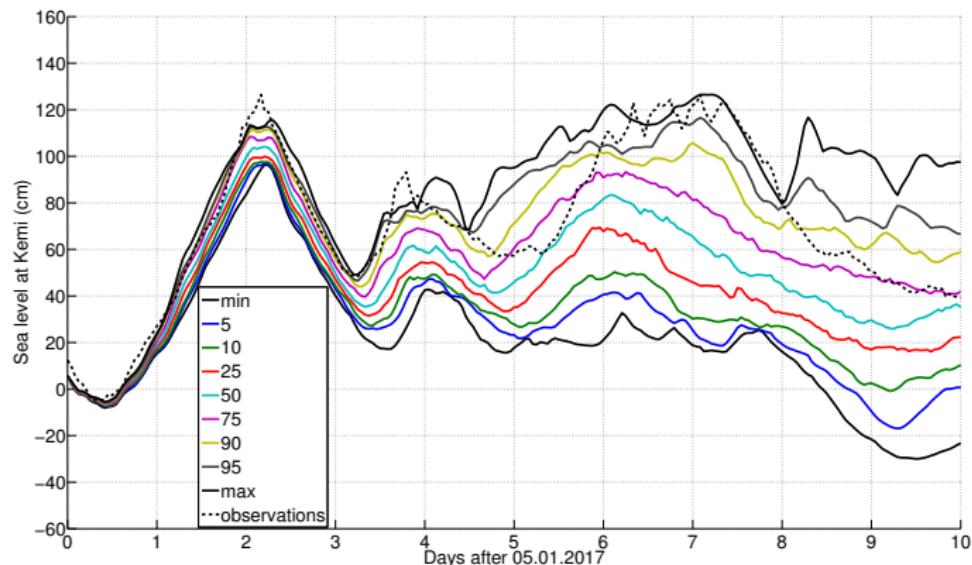
Sea level probability forecast at Kemi

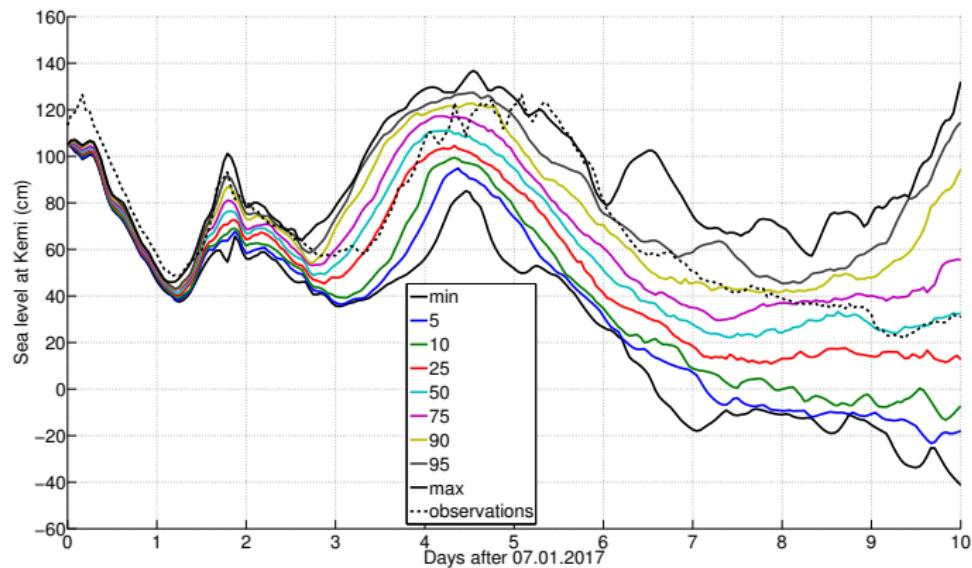


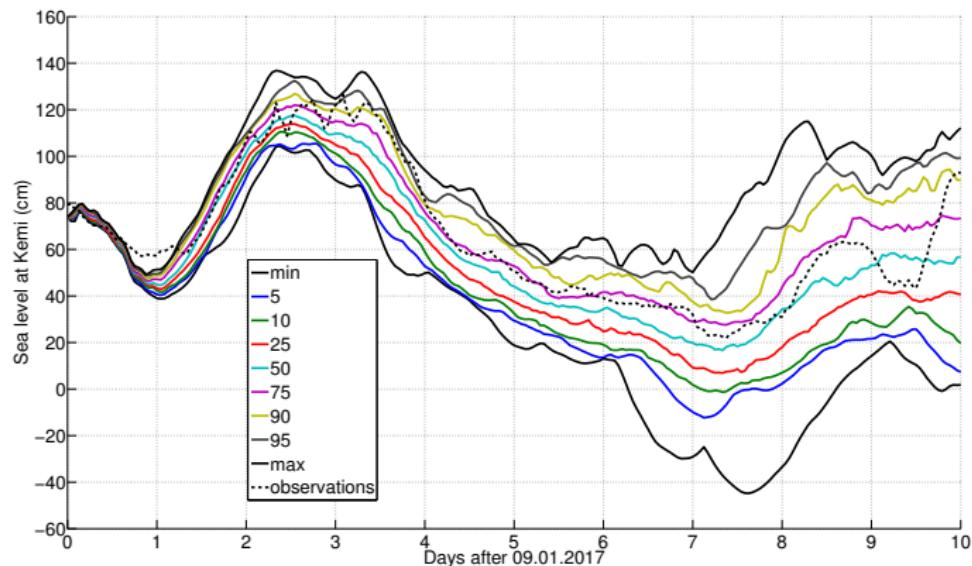


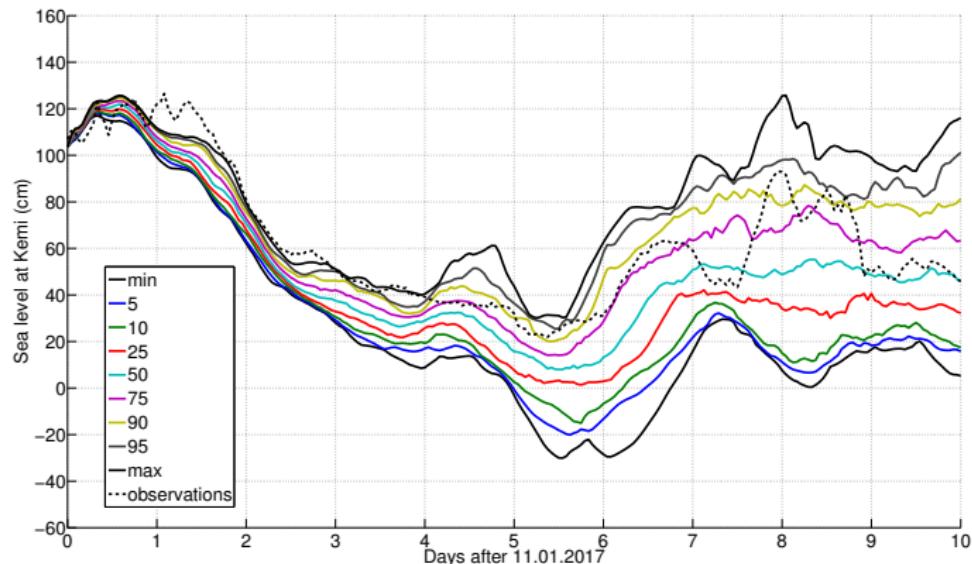






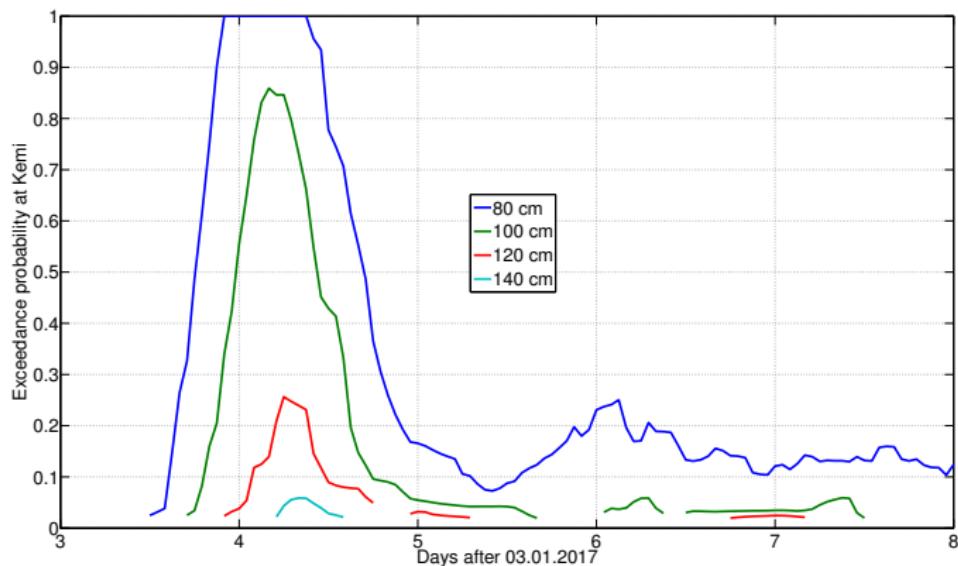








Exceedance probabilities of threshold levels





Summary

- Spread of forecast is small for length under 2 days
- Forecast is most useful for 2-5 days
- Spread increases after 5 days
- Sharp sea level peaks are underestimated due to 6-hour time step in input data
- Water balance variations are well described by statistical model
- For details of the sea level model, see Särkkä et al. (2017), Boreal Environment Research 22:299-315
- Sea level probability forecast is already operational at FMI



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