ASSIMILATION AND STATISTICAL MODELLING OF ALTIMETRY IN A COASTAL STORM SURGE FORECAST SYSTEM

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Introduction

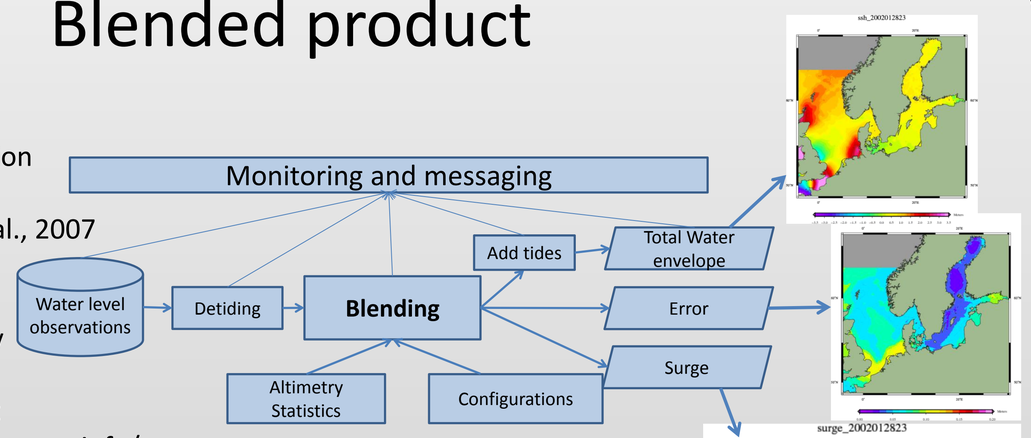
It is challenging to capture storm surges with satellite altimetry, since the time scale is on the order of hours, the spatial scale a few hundred kilometres, and the largest impact is in coastal regions. The combination of satellite and tide gauge observations in a statistical model has been shown to be useful for assessing storm surges in the North Sea and Baltic Sea. However, the standard along-track altimetry products have limited quality in coastal areas and are not available within approximately 20 km of the coast.

A revised statistical model has been developed and made operational in the ESA eSurge project to provide 2-D fields of near-real time sea surface height. The statistical model has been derived using coastal altimetry products from eSurge and Pistach to provide a high quality blended product for the North Sea and Baltic Sea. The new product using coastal altimetry products will be presented and validated and the benefits of using coastal altimetry data will be assessed.

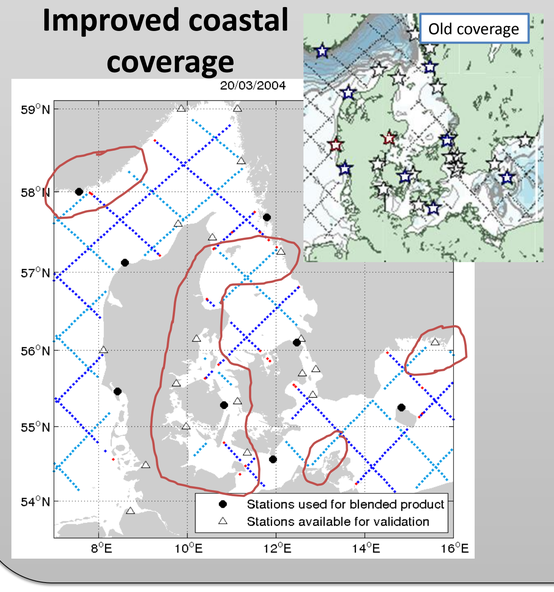
Within eSurge, the statistical model has been assimilated into a hydrodynamic model, to assess the impact of using coastal altimetry observations for sea level modelling and storm surge predictions. Validation against independent tide gauges show improvements in the mean sea level after assimilation for all stations in the North Sea and Baltic Sea and suggest new ideas for future experiments.

Blended product

- Developed for operational applications and for data assimilation
- Use existing methodology from Høyer et al., 2002 and Madsen et al., 2007
- Combine tide gauge observations using satellite altimetry
- Updated using coastal altimetry observations
- Along-track and gridded output
- Available at: http://www.storm-surge.info/



Improved coastal coverage

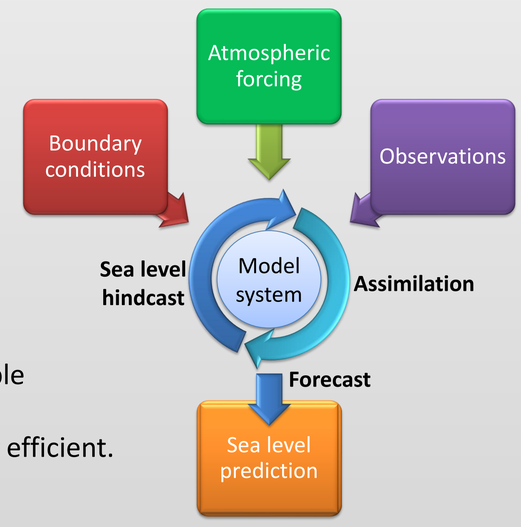


Station	RMSE [cm]		Correlation	
	New	Old	New	Old
Forsmark	6	6	0,95	0,97
Kungsholmsfort	4	4	0,98	0,98
Skanör	8	7	0,94	0,95
Rødbyhavn	8	8	0,96	0,95
Fynshav	10	11	0,91	0,89
Korsør	7	11	0,91	0,83
Fredericia	9	11	0,88	0,80
Aarhus	8	12	0,91	0,82
Viken	6	5	0,97	0,97
Ringhals	5	5	0,98	0,96
Smögen	6	6	0,95	0,95
Kungsvik	7	7	0,93	0,95
Frederikshavn	6	8	0,94	0,92
Hirtshals	8	10	0,94	0,93
Hvide Sande kyst	13	14	0,95	0,96
Cromer	15	20	0,80	0,60
Whitby	12	7	0,92	0,94
Aberdeen	9	8	0,87	0,92

Improved error statistics

- RMS error reduced by 1-5 cm and correlation improved by up to 8 percentage points at most Danish stations
- For stations close to more open waters changes are small (except Cromer)

Assimilation



Model setup

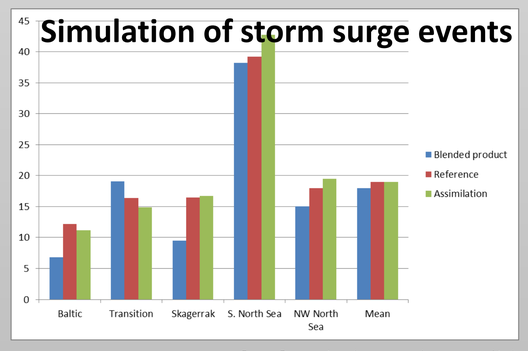
- Domain: North Sea and Baltic Sea
- Spatial resolution: Two-way nested, 6/1 nm for assimilation, 3/0.5 nm operational
- Operational with 4 forecasts a day, 5 days ahead
- SSH values extracted every 10 minutes for 133 stations

Assimilation method

- Ensemble Optimum Interpolation
- A simplified form of Ensemble Kalman Filter, only integrating one forecast state forward (Evensen, 2004; Oke et al., 2003).
- Background error covariance matrix calculated from 80 ensemble members derived from a 20 year reanalysis simulation.
- It is suboptimal to Ensemble Kalman Filter, but computationally efficient.

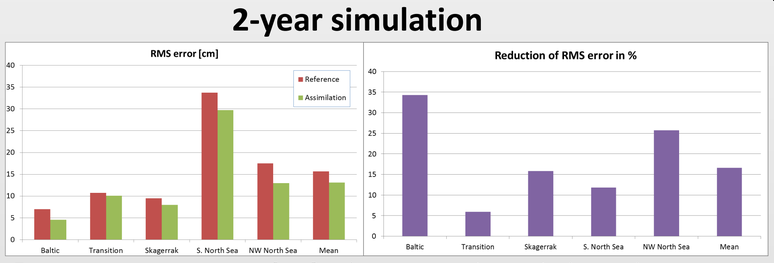
Experiments

- Two year simulations 2002-2003
- Five specific storm surge events
- Reference and data assimilation run
- Same surges on the outer boundary
- Same tides
- Validation against independent tide gauge observations

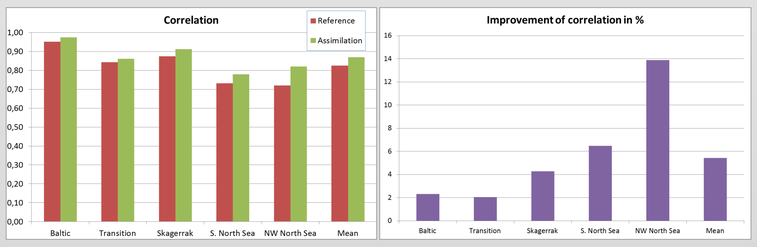


Root mean square error [cm] at independent validation stations, 1 hour after assimilation averaged by area and over 5 days for all 5 cases (25 days in total).

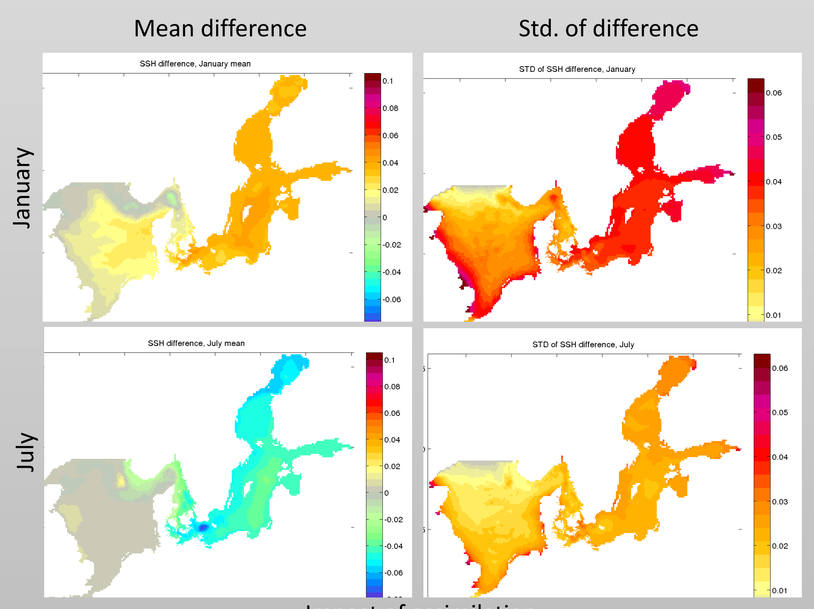
2-year simulation



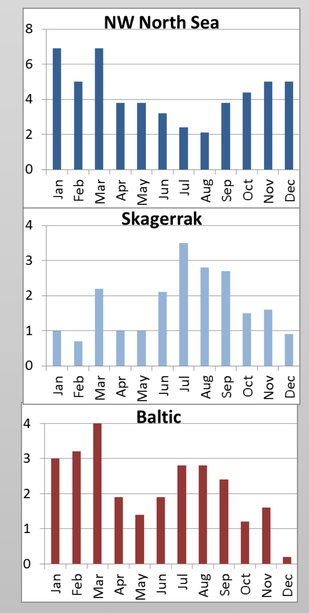
Root mean square error [cm] when comparing to independent validation stations, averaged by area.



Correlation with independent validation stations, averaged by area.



Impact of assimilation.



Seasonal variation of RMS error for selected areas.

Conclusions

- Statistical product improved using coastal altimetry and gridded fields
- Data assimilation improves the performance of the model, up to 30 % in RMS error
- Improvements consistent for all regions
- Assimilating storm surge situations is challenging

Acknowledgements

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