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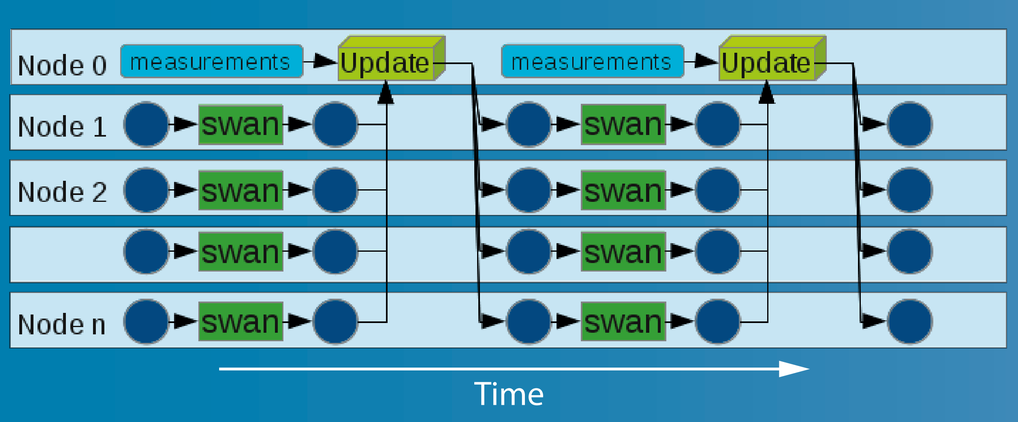
**OpenDA is an open-source generic data-assimilation toolbox that has been applied to a wide variety of cases. Here we show preliminary results for application of the EnKF to the SWAN wave model for the North Sea.
The connection between SWAN and OpenDA is implemented using the input and output files of SWAN. Using asynchronous filtering and parallel computing it is possible to achieve a much improved computational performance. A first experiment with real observations for December 2011 shows promising results.**

The OpenDA data assimilation toolbox applied to wave forecasting

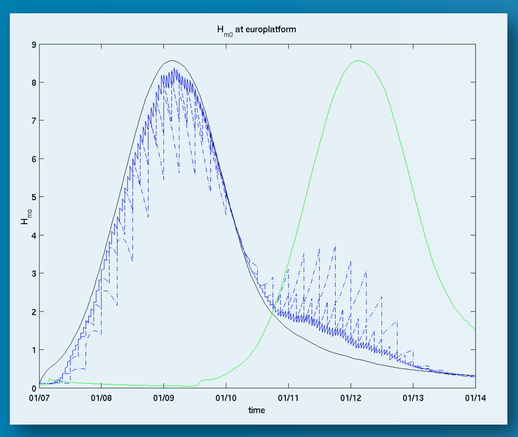
Implementation

Several methods have been developed for coupling models to OpenDA [2,3]. The easiest method for coupling uses the input and output files of the model [1]. A small number of additional subroutines to read and write the model specific formats is all that is needed. The model is started as an external program and so no source code of the model is needed, which is convenient for maintenance of the system; no modifications are made to the SWAN source code here.



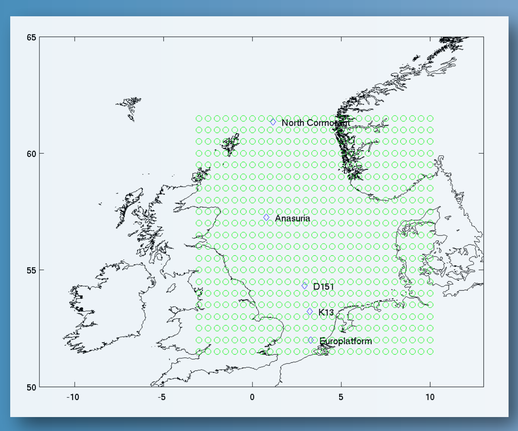
Parallel performance

To improve the computational performance we used parallel computing and asynchronous filtering. In our experiments OpenDA runs on a separate node and gathers the restart files before each analysis. Performing a smaller number of analyses by asynchronous filtering reduces the overhead. Some twin experiments were carried out to determine the time increment between analyses and the number of nodes used.



#Nodes	#Cores	Timing 1hr (min)	Timing 3hr (min)	Timing 6hr (min)
1+1	16	586	254	201
2+1	24	298	178	106
4+1	40	187	89	59
8+1	72	133	61	38
16+1	136	101	46	27
32+1	264	106	37	21
64+1	520	117	42	25

Wall clock times for a 7 day simulation and example time-series for time intervals of 1, 3 and 6 hours between analysis for a low resolution model (0.5º)

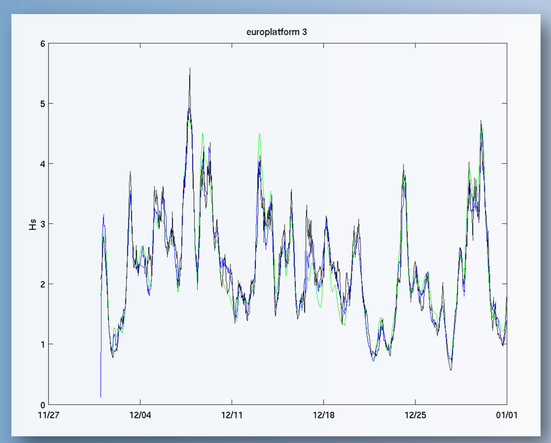


Model grid at 0.5º resolution with 27x21 grid-cells. We repeated the experiments at 0.25º and 0.125º resolution with similar results. The spectral wave model contains 32 frequencies and 36 directions. This leads to a state dimension of 653184 at the lowest resolution.

Experiments for December 2011

Hourly observations of significant wave-height at 5 locations were assimilated for December 2011. The EnKF analysis run clearly reduces the RMS of the residuals. The poor performance near the Northern boundary is due to the lack of forcing boundary data there.

Locatiom	RMSE Hs free run	RMSE Hs enkf async 3hr
North Cormorant	2.34	1.04
Anasuria	0.94	0.85
Platform D151	0.49	0.37
Platform K13a	0.34	0.25
Europlatform	0.29	0.24



Conclusions

Communication through files with the model is easy to implement. Using parallel computing and asynchronous filtering can improve the computational performance.

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The computations were carried out on the national super computer at SARA under project MP-241-13.

References
[1] M. Verlaan "*Wave data-assimilation for SWAN using OpenDA*" MyOcean science days 2012, 19-21 November, Geesthacht Germany.
[2] A.W. Heemink, R.G. Hanea, J.Sumihar, M. Roest, N. Velzen, M. Verlaan, "*Data Assimilation Algorithms for Numerical Models*", in Advanced Computational Methods in Science and Engineering, Springer, p.107-142
[3] http://www.openda.org

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