BOOS Annual Meeting 2015

Member report

Country	Denmark
Institution(s)	Danish Meteorological Institute (DMI)
Observations **Status and new initiatives**	**Current meter observations** *The Sound* - Current meter, temperature (ADCP) at Drogden Light house (real time) *Great Belt, East* - Current meter, temperature (point measurements in real time). *Great Belt, South* - Current meter (point measurements) and temperature at Vengence Ground Pro Ocean buoy (real time). Temperature and current every 30 min. **Water level observations** DMI operates 33 tide gauges in the Danish waters, and get additional real time tide gauge data from other Danish govermental and local harbour authorities. These are for example presented on dmi.dk and BOOS.org.
Modelling **Status and new initiatives**	**Wave modelling** *WAM cycle 4.5.4* (Helmholtz Zentrum Geesthacht, HZG) is installed and run in a pre-operational setup include Global (0.5 deg), North Atlantic, Greenland, North Sea/Baltic Sea and Inner Danish waters (2 km). This setup to take over as the operational WAM system at DMI in 2015. Setup now uses 1) Satellite-derived sea ice concentration maps. Critical issue with standard code has been identified and reported back to HZG. 2) In the standard code during wave breaking, the amount of energy removed depends critically on time step size, leading to errors at large time steps ice. Issues have been circumvented. A number of long-term wave simulations and climatologies have been produced 1) A 40-year hindcast run of wave climate in the North Sea and Baltic Sea (Baltadapt, 2013) 2) Climate scenario runs (RCP 4.5 and 8.5) till 2100 (Baltadapt, 2013) 3) New 15 year wave climatology for Innter Danish water finalised in 2014 using newest bottom bathymetry data from a number of sites. **Circulation modelling** At DMI, major activities concerning 3D ocean modelling are linked to major EU research projects and governmental funds to maintain a national storm surge warning capacity. DMI use the same model code but at different configurationd and set up for storm surge warning and for our involvement in major projects like, eg, CMS, MyOcean, OPEC, JERICO, eSurge, EfficienSea, EfficienSea 2, Mona Lisa, Mona Lisa 2. *DKSS, National storm surge model*: DKSS is DMI's storm surge model. It is based on HBM, but with a different setup as the one operationalised in e.g MyOcean and CMS. New release of DKSS is planned for autumn 2015 and will include: 1) High-resolution (500 m) Limfjord model online (previously it was off-line) coupled with rest of the model

2) Revision and extension of the Wadden Sea bathymetry and update of the high resolution bathymetry in the Danish straits. The Wadden Sea domain now covers a larger part of the North Sea (north to about Limfjorden) with a horizontal resolution of 1 nm and has a higher vertical resolution (4m,2m,…) near the surface.
3) Inclusion of open water between Copenhagen and the island of Amager (Copenhagen harbour). Previously the harbour was closed
4) Modifications to a number of fjords on Jutland's east coast.
5) Inclusion of e-Hype (SMHI) as the new model providing freshwater and nutrient runoff from land.
6) Inclusion of internally generated tides by implementation of the Moons and Suns tidal potential.
7) Development of new KPI's for national storm surge model.

New 15 year hydrodynamic and hydrographic climatology of the North Sea and Baltic Sea finalised in 2014 using newest available bottom bathymetry data from a number of coastal areas in Danish waters.

***MyOcean (EU FP7)*:**
DMI managed the Baltic modelling component within MyOcean and participated in the code development. DMI served as nominal operational product provider; MSI and BSH were cal/val units; BSH provided the back up operational product; SMHI acted as dissemination unit and local service desk; FMI lead the BAL part in the R&D WP19 related to DA; HZG lead the R&D in BAL and other regions.

Since start of MyOcean 2 (April 2012). Three version upgrades (V2.2, V3 and V4) plus one in MyOcean FO (V5).

Major Improvements to HBM and coupled sea ice model include, e.g.,:
1) Increased resolution, now: Vertically 122 layers; Horizontally 0.5/1 n.m.
2) Improved coastline, bottom topography & bottom friction
3) Improved air-sea thermodynamics
4) Improved exchange coefficients for latent and sensible heat
5) Improved description of near-zone mixing
6) Improved description of sea-ice thermodynamics, improved snow cover and albedo model
7) Improved parameterization of near-surface shear production
8) Improved parameterization of bottom mixing owing to tides
9) Inclusion of tidal potential in addition to the prescribed tidal signal on the open boundaries.
10) Tracer advection: Allowing automatic, temporarily reduction of tracer advection time step (e.g., during extreme storm surge events)
11) Other numerical and technical improvements

Improvements to ERGOM includes, e.g.,:
1) Sediment re-suspension implemented. Benthos material will be converted to detritus if the bottom shear is larger than a certain threshold
2) Original ERGOM zooplankton group now divided into to groups (micro- and meso-zooplankton) for improved seasonality of the grazing pressure
3) Improved formulation of light attenuation
4) Silicate added to nutrients-list to support simulation of the silicate-limited ecosystem in the North Sea
5) Implementation of regional-variable N/P ration of nutrients
6) Option to switch off eco-dynamics in prescribed estuaries

Technical improvements include, e.g.,:
1) Tight cooperation: Daily commit into same Version Control System
2) Technical correctness has high priority (i.e., very high code standard: binary identical across compilers, platforms, decompositions etc.)
3) Speed & performance continuously being improved (V4: 2x faster than V3 on same resources)
4) HBM model runs efficiently, out-of-the-box on many-core architectures
5) Full support of openMP and MPI
6) Initial view on openACC for porting to GPUs
7) Code improved for better vectorization

OPEC project (EU FP7), efforts are put on:
1) Developing a coupled Hirham, HBM, Ergom modelsystem. Producing i) reanalysis and hindcasts (1990-2020), ii) rapid envirionmental assessment (rolling hindcast/reanaysis of recent past), iii) season forecasts

eSurge project (ESA), efforts are put on:
1) Assimilation of SSH (obtained from satellite and tidegauges) into the circulation model to explore its applicability in relation of storm surge modelling. 5 storm surges have been modelled and validated with and without data-assimilation

JERICO project (EU FP7), efforts are put on:
1) Observing System Experiment and Observing System Simulation Experiment. Explore the added value of given observations (S-, T-profiles and SST) wrt. data-assimilation compared to simulations without these stations.

MONA LISA 2 project (EU Ten-T), efforts are put on:
1) Provision on high quality forecasts to increase navigational safety in European and arctic waters. A Pan European setup for seemless forecasting of ocean circulation conditions is implement and an ensemble wave forecasting test system for North Sea/Baltic Sea.

2) About the Pan European setup:

Purpose: To provide seamless, high-resolution, two-way nested, high-quality forecasts for the European waters.

Setup: Based on HBM, covering Baltic Sea-North, Sea-Western Shelf-Mediterranian Sea-Black Sea (high-resolution: 01 nm - 3 nm).

2-way nested horizontally & vertically.
No. levels: 34-122

SST
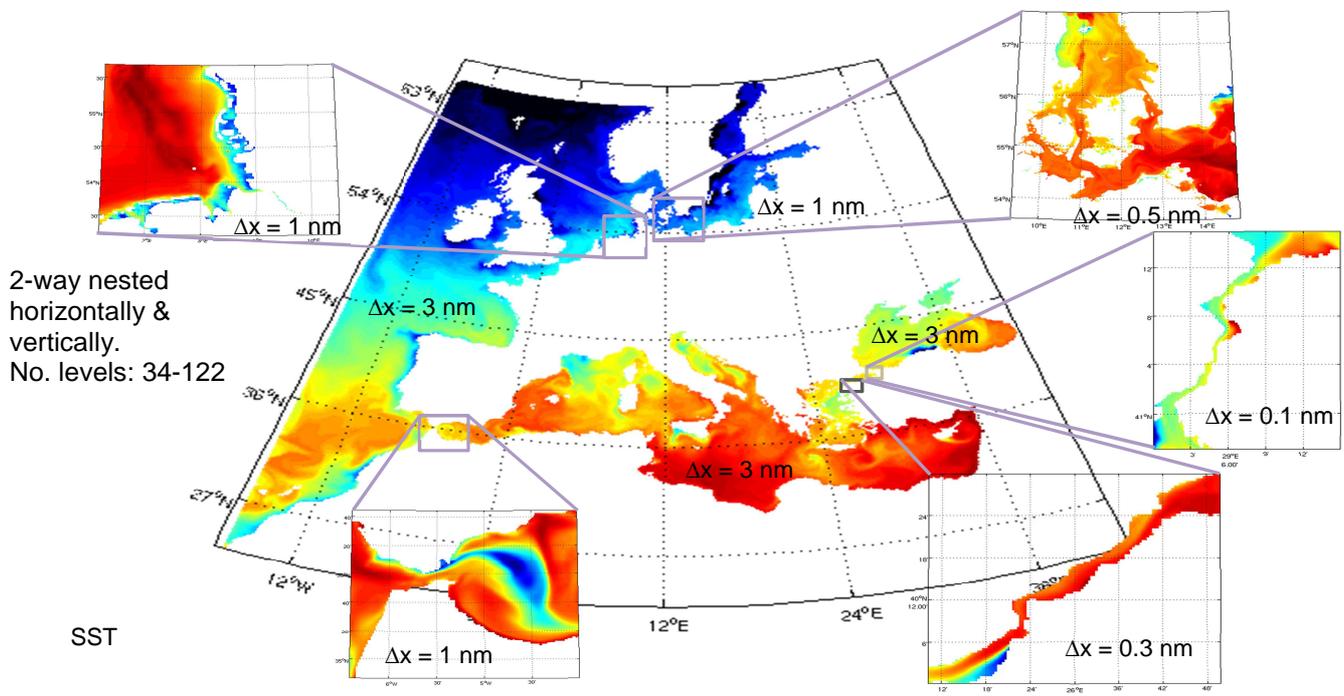
3) WAM-EPS. Wave ensemble forecasting using 11 Hirlam ensemble members. Wam setup covers the Noth Sea and the Baltic Sea with a present resolution of 10 km.

Left:
Position of station Soda

Below:
WAM ensemble forecast
Station number: sodra
blue lines/yellow circles: ensemble forecasts
black line: deterministic forecast

sodra : Significant wave height (m)
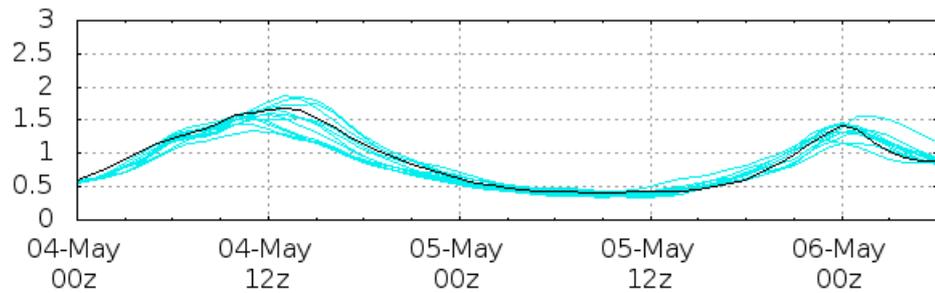
sodra : Mean wave period (s)
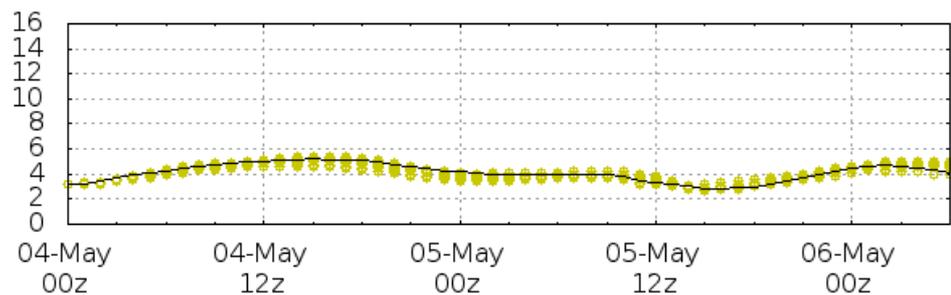
A number of peer review articles on the operational modelling system and of the coupled modelling system have been produced (see DMI.dk)

Technical HBM model reports (see DMI.dk)

Relevant national projects	**Horns Rev 3 offshore wind farm** (off Jutland west coast): Met Ocean study (10 yr analysis of wind, waves and current at construction site, including model validation for periods where observations are available). Finalise 2015 **Mejlflak offshore wind farm**: (off Jutland, Aarhus Bay): Met Ocean study (10 yr analysis of wind, waves, current, sea ice etc at construction sit). Finalise 2015. **Stor strømmen and Vejle Fjord bridge constructions**: Met Ocean study (10 yr analysis of wind, waves, current, sea ice etc. at construction sit). Finalise 2015. **Coast-near wind farms** (six sites: 2 off Jutland west coast, 3 in inner Danish waters; one by Bornholm). Comprehensive MetOcean study (11 yr analysis of wind, waves, current, sea ice etc at construction site, including model validation for periods where observations are available). Finalised 2015. **VARSKO Warning system for water on land** (inner Danish waters): Coupling of the storm surge model with inundation model. Finalise 2018 **GUDP-VIND** (North Sea/Baltic Sea). Using ecosystem model as input for modelling of higher trophic levels (fish), to optimise fishery in a sustainable way (reducing CO_2 emissions). Finalised 2018.
Relevant International projects	**CMS BAL MFC** (Baltic Sea). EU's operational capacity in the Baltic Sea. Finalised 2018 **eSurge** (North Sea). ESA, satellite data for the storm surge community. Finalised 2015 **Efficiency 2** (North Sea, Baltic Sea, North Atlantic). Facilitate efficient and safe ocean based operations and navigation in North Atlantic and Artic waters. Finalised 2018
Additional information	Operational HYCOM-CICE model system (forced with ECMWF and assimilation of sea ice observations). Covering the North Atlantic north of 20°N incl the Arctic Ocean.Hycom. Horizontal resolution 10 km. Operational oil spill modelling of the North Sea and sea around Greenland.