Country	Denmark
Institution	**Danish Meteorological Institute**
Observations	*Status:*

Observations — *Status:*

- *Tide gauges.* DMI acts as data centre for a national network of some 90 coastal sites, one third owned by DMI, two thirds by other national or local agencies. About half the sites are doubly equipped, with two recording techniques. A handful of off-shore stations are being closed down due to maintenance cost. New stations are added, mostly by municipalities increasingly concerned with flooding.
- *Current meter moorings.* 3 Belt Sea moorings are being transferred back to FCOO (today: GeoMetoc) for economical and practical reasons.
- *Water temperature.* Recorded at some metres' depth by DMI pressure tide gauges, and strictly speaking representative for harbours only.
- *Sea surface temperature*: Daily SST and SST anomaly maps based on midnight infra-red remote sensing.

New initiatives:
- None

Under development:
- Expanded sea level quality control, both real-time and in delayed mode, as a prerequisite for the DMI Free Data project. Sea level is to be released no later than medio 2020.

Modelling — *Status:*

The modelling exercises described below encompass the North Sea – Basltic Sea region. The DMI Arctic involvement is left out.

The effort in general is mainly on implementation, less so on code development.

- *Circulation*: HBM model code in a two-way nested implementation
  - Storm set-up with 4 nested grids (3 to 1/6 n.m. resolution) plus an off-line fjord module. Oil Drift stand-by module.
  - Copernicus set-up with 4 nested grids (3 to ½ n.m resolution), and increased vertical resolution in the Baltic to properly resolve benthic processes and salt intrusions. Tidal potential added, but the formulation using ephemerides expires ult. 2020. Coupled with ERGOM model for marine ecology. The ERGOM model is developed further by BSH.
- *Circulation*: NEMO 4.0
  - Copernicus re-analysis run using the NEMO Nordic 1 n.m. set-up.

- *Waves*: WAM cy4.5
  - A three-level nested set-up, with a coarse grid North Atlantic model run mainly as a swell generator, a regional 3 n.m model, and a ½ n.m. model for Dansh Domestic Waters.
- *Tracer model:*
  - An Eulerian tracer model has been developed in HBM framework to modelling the fate of microplastics in the sea, by adding sinking and biofouling processes.
  - A BSH developed Lagrangian drift model simulates drift of objects, drift and spreading of substances, drifrt, spreading and weathering of oil, in off-line mode.
- *Weather forcing:*
  - 2.2 km DMI-Harmonie (non-hydrostatic) 0-2½ days
  - 9 km ECMWF 0-6 days.

Operational
- *Storm surge*: A 5 day forecast is updated every 6 hours.
- *Tides*: A one-year tidal run (no atm. forcing) carried out for use in NOOS surge forecast exchange.
- *Drift*: An off-line Lagrangian drift/dispersion model (BSHdmod) for substances and objects interfaced. To be run on demand.
- *Copernicus*: A 5 day forecast is updated every 12 hours..
- *Hydrology*: SMHI E-hype3 hydrological model for daily run-off and (optionally) bioloads interfaced to HBM. Of the 8-day forecast, only the analysis is used so far.
- *Waves*: A 5½ day forecast is updated every 6 hours.

New initiatives
- Local geography optimization combining recent surveys and sea chart information. Five to ten focus areas, identified by systematic sea level phase, extreme high, and/or extreme low error.
- Flooding pilot project. The DMI storm surge forecast of coastal sea level is combined with a high-resolution (0.4m) height model to give a real-time estimate of flooding potential.
- Storm surge prediction using 9km ECMWF forcing. Validation study to quantify the (possible) benefit of using DMI-Harmonie in high resolution.
- Storm surge ensemble prediction. Validation study to inter-compare the quality of deterministic vs. ensemble mean or median predictions.
- Ensemble forecasts based on DMI-Harmonie NWP (COMEPS) forcing. 18 ensemble members. Only weather forcing is perturbated, ocean models run as deterministic threads. Ensemble mean and ensemble spread, and risk assessment results.

Pre-operational
- Wave model ensembles. See http://ocean.dmi.dk/validations/waves/ensemble.php Operationalisation is an open question.
- Storm surge ensembles. See

http://ocean.dmi.dk/validations/surges/ensemble.php
Probably to be operationalised.
- Wave model upgrade. WAM cycle 4.5.4 run on a Gaussian grid for Greenland/Arctic wave forecasting, using Osisaf as ice data source for wave modeling.
  To be operationalised.

Under development
- Storm surge model geography. Combining digital depth data with sea charts in order to optimize bathymetry in narrow passages. Make use of the model's ability to nest efficiently. Work on four fjords completed. Three to four more focus areas identified.
- Pdaf data assimilation for NEMO under BALMFC. Pdaf in HBM ocean model put on hold.

Planning:
- Nemo vs. HBM storm surge comparison
- Prolong tidal potential / ephemerides beyond 2020.

Dissemination

Status:
- Ocean forecast service (www.dmi.dk, ocean.dmi.dk), including
  - Sea level
  - Tide
  - Water temperature
  - Surface salinity
  - Sea ice
  - Waves
  - Sea state
- Ocean monitoring service, including
  - Sea level
  - Tide
  - Daily SST map
- Ftp box service (for NOOS):
  - Tide gauge data (DMI and other providers)
  - Wave buoy data (third party)
  - Sea level forecast at North Sea ports
  - Wave forecast at buoy/platform locations
  - Modelled transport for North Sea cross-sections
  - Modelled hydrodynamics for North Sea multi-model ensemble
- in-NOOS service
  - Responsible for North Sea – Baltic Sea region real-time synoptic sea level information system at noos.eurogoos.eu .Maintenance level is low due to lack of internal technical support and general re-building of DMI web services.

New initiatives:
- "Free Data" project funded and kicked off. A four-year project with six milestones, the first being synop data, the last forecast data.

	• Climate atlas for future climate adaption. Funded and underway. Includes hydrodynamic and wave modelling and statistics in 30-year time slots; historical and one or two future scenario(s).
National projects	Climate Atlas: Information system aimed at municipalities for climate adaptation. First release primo Oct 2019 included air temperature, precipitation, mean sea level and storm surges. MEMC: On-going national co-operation on marine ecological modelling (DTUaqua, DCE, DMI) Flooding: Pilot study, setting up a warning system for in-land flooding caused by storm surges. Combines a high-resolution height model with coastal surge prediction. COHERENT: Development of software tools, data, and recommendations for effective coastal hazard risk reduction and management, to be presented at a multidisciplinary digital platform.
International projects	Copernicus: EU Marine Core Service project, Baltic physics and ecosystem. ESA-CCI: long-term SST re-analysis from satellite Jcomm: Wave/wind forecast quality intercomparison exercise on a running three-monthly basis. Managed by ECMWF. LC-WFV: Expanding upon the Jcomm project (all partners in that project invited), with participants to operationally wave/wind forecasts. More parameters, better time resolution. Managed by ECMWF. CLAIM: Cleaning marine Litter by developing and Applying Innovative Methods – a H2020 project, coordinated by HCMR. DMI will use HBM-WAM-drift models to simulate the fates of the plastic litters in the Baltic Sea. Very high resolution modelling (a few hundred meter resolution), impact of eddies and waves on litter drift will be studied. EuroSea: European Contribution to the Future of the Seas and Oceans Flagship Initiative, H2020 project. DMI works on BOOS-HELCOM integration with Technical University of Tallinn (TTU) via near real time delivery of HELCOM ship observations and rapid assessment of environment by assimilating the ship data FORCOAST: Earth Observation services for Fishery, bivalves Mariculture and Oyster ground Restoration along European COASTs, H2020 project. DMI's role is to develop information service together with DCE/AU for Limfjord oyster restoration. JERICO-S3: Joint European Research Infrastructure for coastal observatories – S3, H2020 project. DMI's role is to assess added value by integrating monitoring and modelling for resolving challenging issues in regional connectivity and to on

	integrated monitoring strategy in Kattegat-Skagerrak- East North Sea region together with SMHI, NIVA, IMR and HZG.
Additional information	http://ocean.dmi.dk DMI ocean products, studies and services. http://research.dmi.dk/home/research-topics/ocean DMI ocean research projects