PO.ID 023

DONG Energy regional metocean atlas - fast-track wind, ocean and wave data for offshore wind farms

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Abstract

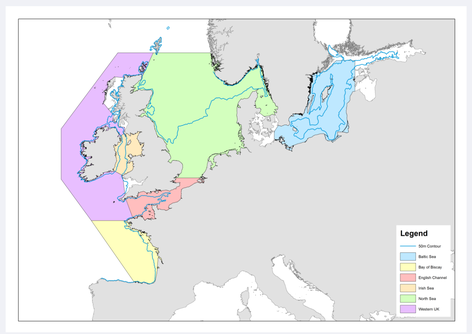
Northern Europe is a region where substantial development in offshore wind power is expected over the next 5-10 years towards fulfilling the EU renewable energy target. The client's ultimate goal was to be able to establish local certified metocean criteria within less than 4 months. The purpose of the project was to support this goal by establishing metocean conditions for structural design and operations of offshore wind turbines, substations and related infrastructures.

The solution was to deliver an extensive, validated and documented database covering meteorological, hydrodynamic and wave data for a period of 35 years with hourly values covering North European seas, supplemented by pre-conducted analyses relevant for planning, operating and design of offshore wind farms, and making it easily accessible through an in-house all-in-one database solution.

Objectives

A validated and quality flagged long-term (35 years) data set of meteorology, hydrodynamics and waves covering the areas of interest:

- Bay of Biscay
- Baltic Sea
- English Channel
- Irish Sea
- North Sea
- Western UK



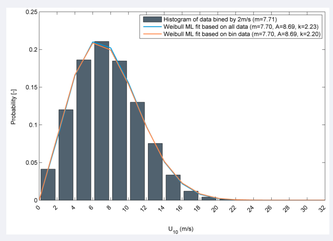
supplemented by pre-conducted analyses of normal and extreme metocean conditions, easily accessible through an all-in-one efficient database solution.

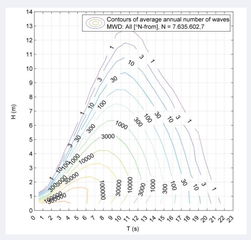
Methods cont.

NORMAL AND EXTREME CONDITIONS

A significant number of analyses detailing normal and extreme metocean conditions were made available at every mesh element (200.000+) for direct access in combinations with extraction of time series.

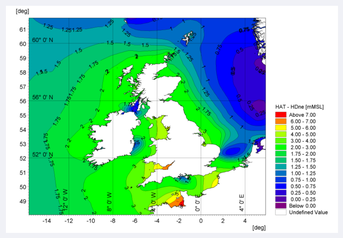
Analyses of normal conditions included time series, rose plots, scatter diagrams, persistence (weather windows), astronomical tide, Weibull parameters of wind speed, HT-scatter (individual waves) and surface maps of e.g. LAT and HAT etc.

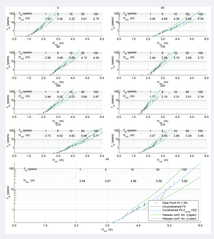




Weibull parameters of wind speed (left) and contours of annual average number of individual waves (right)

Analyses of extreme conditions included marginal distributions of wind speed, wave height, crest height, water level and current speed, (both total and residual), as well as associated parameters, directional distributions, confidence intervals and surface maps.





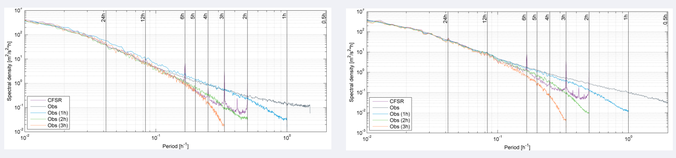
Surface map of HAT with zoom on UK (left) and directional extreme value analyses of significant wave height (right)

Methods

LONG-TERM VALIDATED METOCEAN DATA

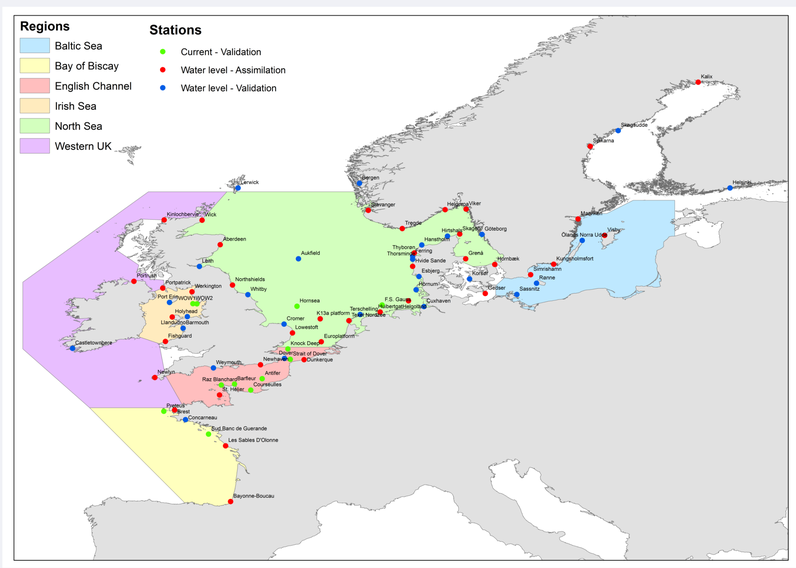
The success of the project was very much dependent on establishing a robust, accurate, consistent and validated long-term data basis. This was achieved through a combination of available meteorological data, in-situ measurements and satellite data combined with extensive modelling of flow and wave conditions.

Meteorological data was adopted from the recognized global Climate Forecast System Reanalysis (CFSR) and validated for accuracy and consistency over North European seas. Comparisons with in-situ frequency power spectra of wind speed indicated that the data was representative of 2h average conditions.



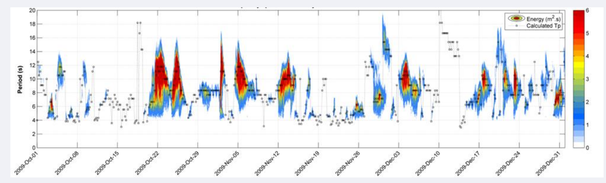
Modelled and measured frequency power spectra of wind speed

Simulations of water level and current conditions were conducted using boundaries conditions from DHI's global tide model and meteorological forcing from CFSR. The flow model was further optimized using data assimilation from numerous stations across the entire domain, improving overall accuracy by a factor of ~2.

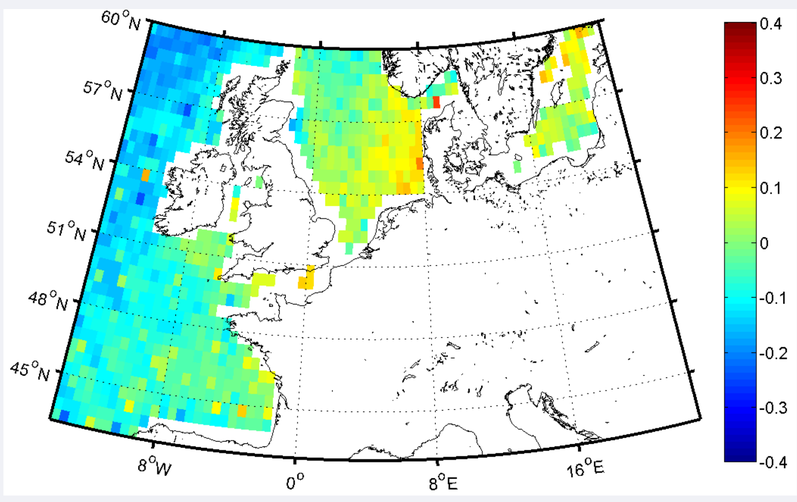


Locations of water level and current measurements used for assimilation and validation of the MIKE 21 flow model, hydrodynamic module

The 3rd generation wind-wave model applied full spectral boundaries conditions from DHI's global spectral wave model and wind forcing from CFSR. Comprehensive calibration and validation was conducted (and documented) at more than 80 in-situ stations (including spectra) and against satellite altimeter data.



Time series of measured wave frequency spectra used for model validation

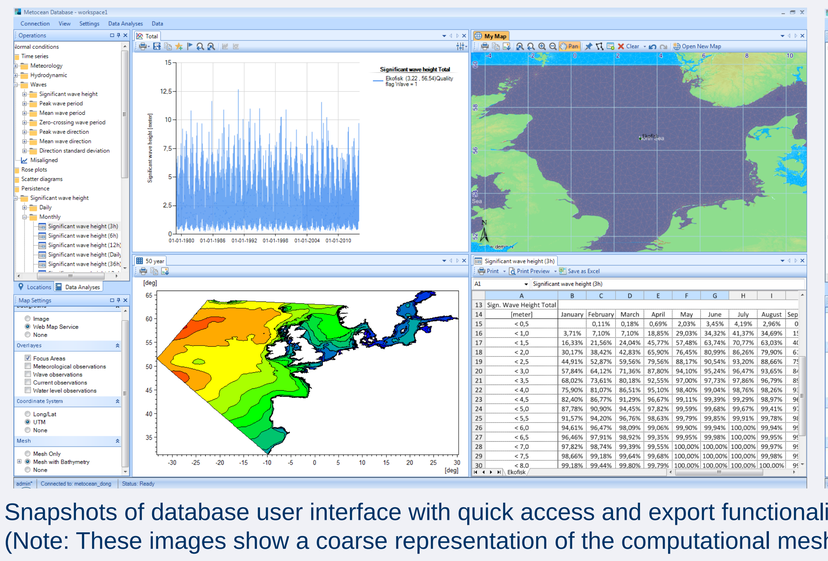


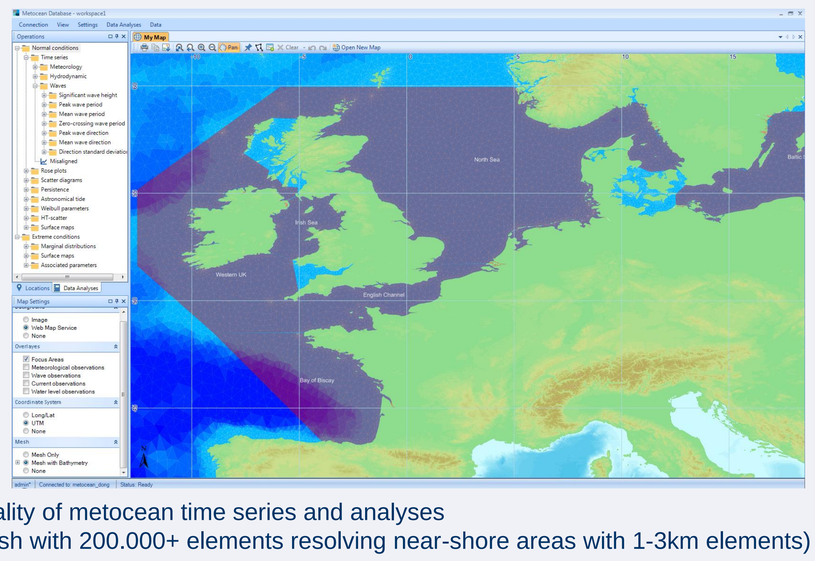
BIAS between modelled and altimeter significant wave height [m]

The accuracy and reliability of the data was assessed and visualized through designated quality flags covering the entire area and each parameter in the database.

- Bathymetry: GEBCO08 and sea chart data
- Resolution: Down to 1-3 km (near-shore)
- Meteorology: CFSR (by NCEP, NOAA)
- Water level & depth-averaged currents (tide & residual): MIKE 21 Flow model (assimilated)
- Waves: MIKE 21 spectral wave model (full spectra @ 0.1° grid) with global model boundary conditions

Results





Snapshots of database user interface with quick access and export functionality of metocean time series and analyses
(Note: These images show a coarse representation of the computational mesh with 200.000+ elements resolving near-shore areas with 1-3km elements)

ALL-IN-ONE DATABASE WITH USER INTERFACE

The metocean database solution was based on MIKE Powered by DHI customizable components and the huge amount of data (10+ TB) was handled by an efficient Mesh Database technology developed by DHI. The database server software was PostgreSQL and data was stored on a NAS drive. The database features are accessed through a GIS-based user interface. The user interface is flexible and allows direct access and customization of analyses as well as time series export functionality.

Conclusions (value)

- Quick access to regional long-term validated and documented metocean data and analyses
- Faster certification of local metocean design basis
- Consistent metocean data background and methods across sites in Northern Europe
- Good agreement with other sources of extreme values estimates of metocean conditions
- In-house all-in-one database solution with easy access to data and customizable analyses

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EWEA Offshore 2015 – Copenhagen – 10-12 March 2015