



**MetOcean Consult**  
*MetOcean and Hydraulic Consultancy*



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# Data and information services

Reliable hydraulic design conditions are crucial in every offshore, port and coastal development project. This begins with the acquisition, interpretation and validation of accurate offshore data, knowledge of the local climatology and the technology of the sources that produced these data. MetOcean Consult has extensive experience in applying a vast range of metocean datasets and knows their limitations and how to account for them.

Where available, all data are validated with data from buoys or satellites. We deliver the following data:

- Global offshore hindcast wind and wave data
- Satellite altimeter and scatterometer data
- Tidal predictions of water levels and currents
- Ocean current data
- Global sea water and air temperature data

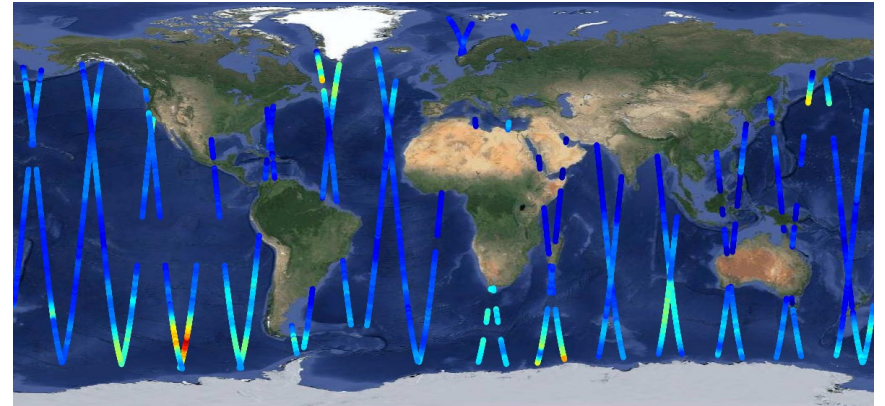
MetOcean Consult provides detailed and high quality meteorological and oceanic data for use in offshore and coastal projects both archived data and forecasts.



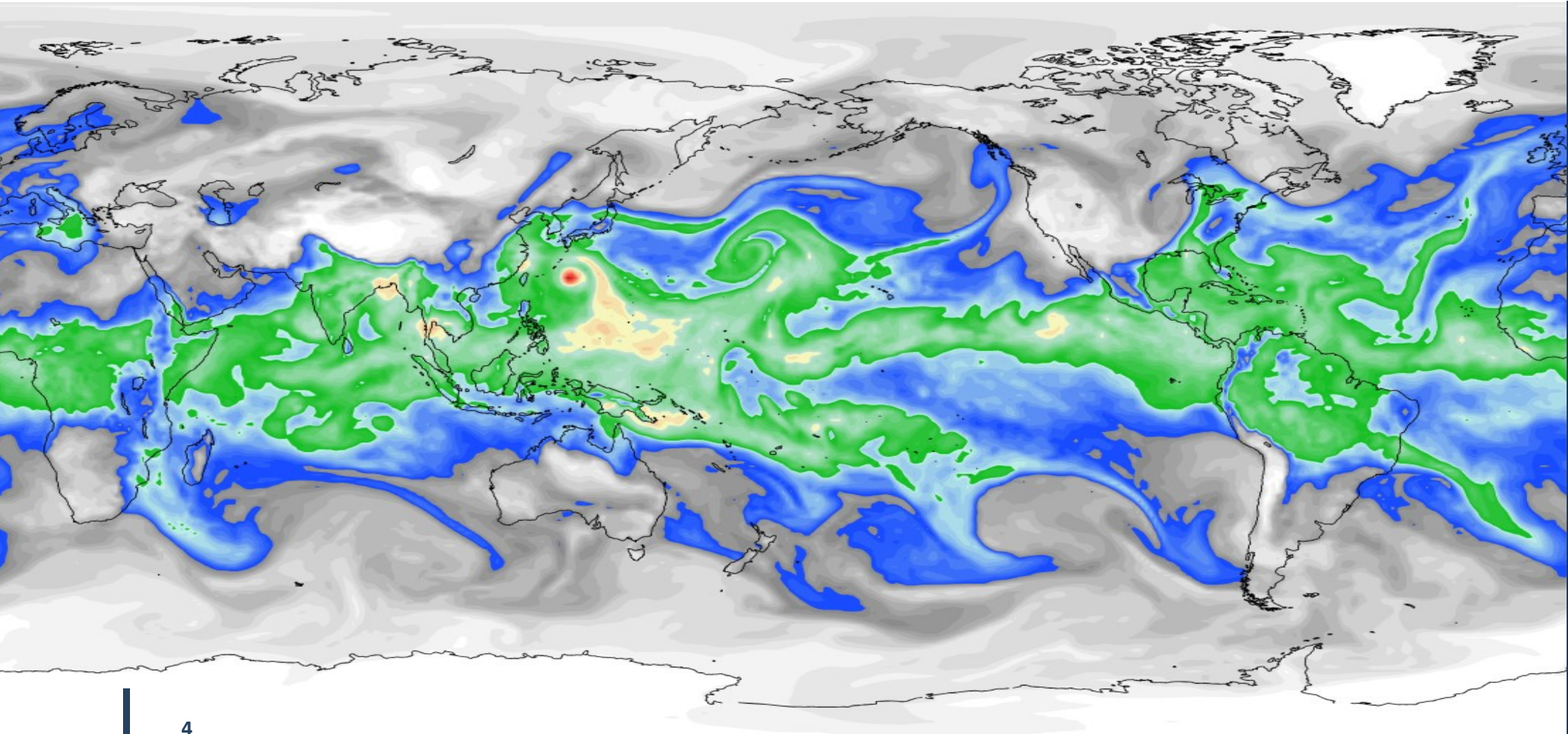
**MetOcean Consult provides daily updates on global wind forecasts based on global weather predictions by third parties.**

Forecasts are provided four times a day for a period of 192 hours ahead on a global grid. MetOcean Consult can deliver forecasts of waves, water levels and currents for project and site specific purposes.

The image below shows the global forecast of precipitable water in the atmosphere allowing engineers and scientists to track large scale weather patterns such as tropical cyclones and middle-latitude cyclones.



*MetOcean Consult has access to longterm satellite data from 1991 onwards using this data for validation of archived hindcast data*



# Global wind and wave data

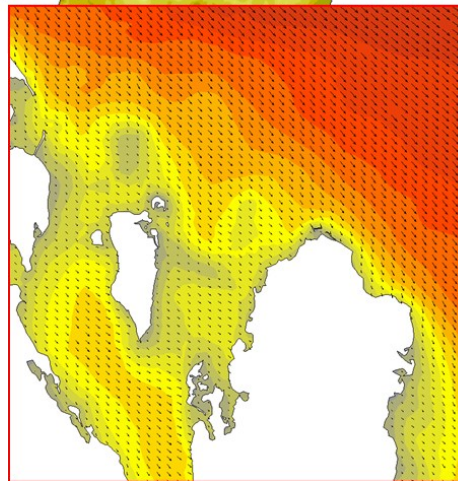
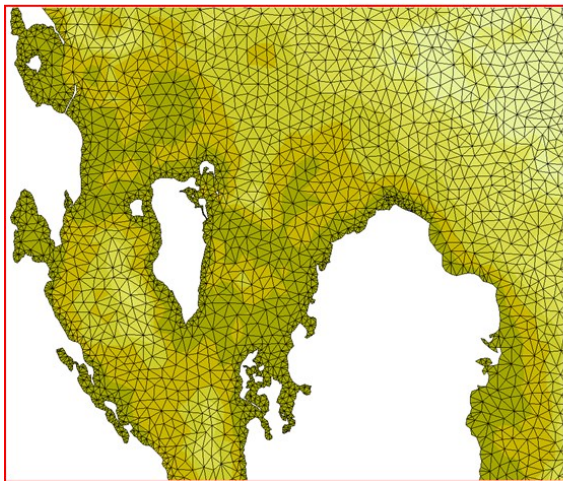
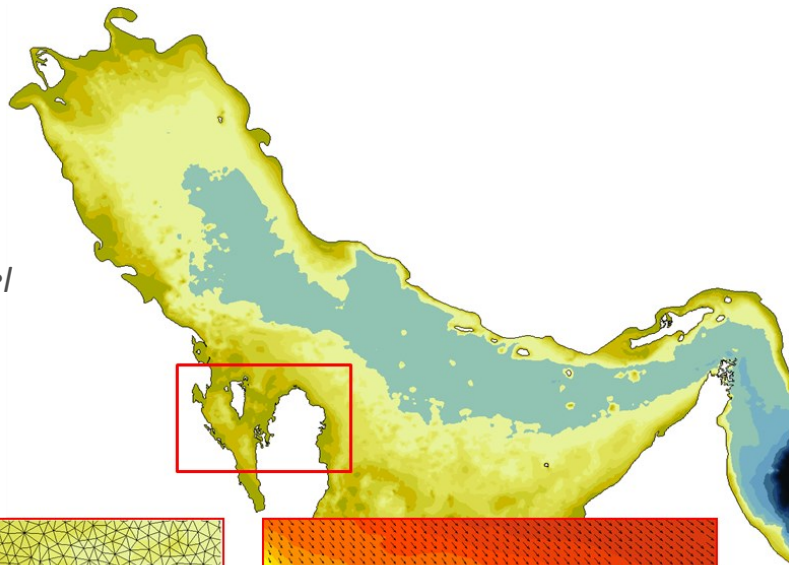
**MetOcean Consult maintains various global and regional hindcast wind and wave databases both in-house developed and produced by third parties by running large scale third generation wave models. The global wave model data, computed with WAVEWATCH III™ is available from January 1979 to date at a resolution of 0.5° x 0.5°.**

Recent developments in remote sensing techniques, high performance computing, atmospheric and environmental sciences, insights into ocean wave mechanics and wave modeling nowadays enable scientists and engineers to make highly accurate and detailed wave hindcasts validated with satellite measurements or in-situ data.

WAVEWATCH III™ is a third generation spectral wave model developed at NOAA/NCEP for prediction of ocean waves. With the latest version some source term options for extremely shallow water (surf zone) have been included, as well as wetting and drying of grid points. Whereas the surf-zone physics implemented so far are still fairly rudimentary, it does imply that the wave model can now be applied to arbitrary shallow water.



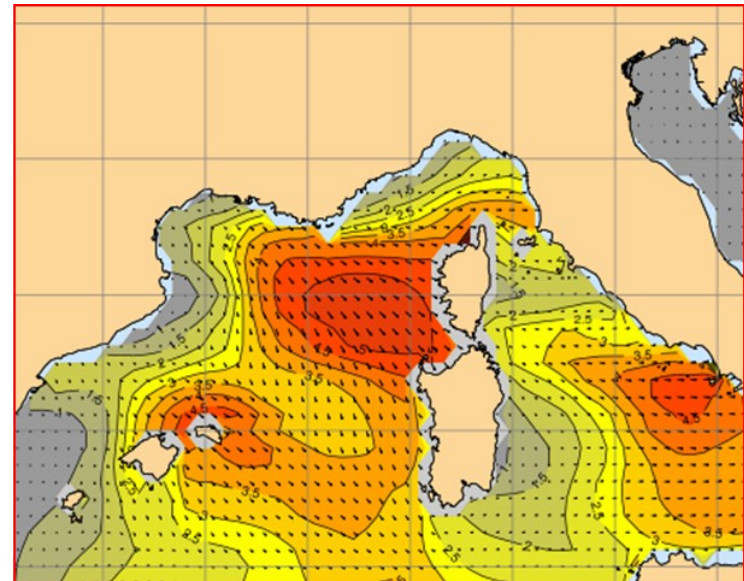
*Arabian Gulf model*



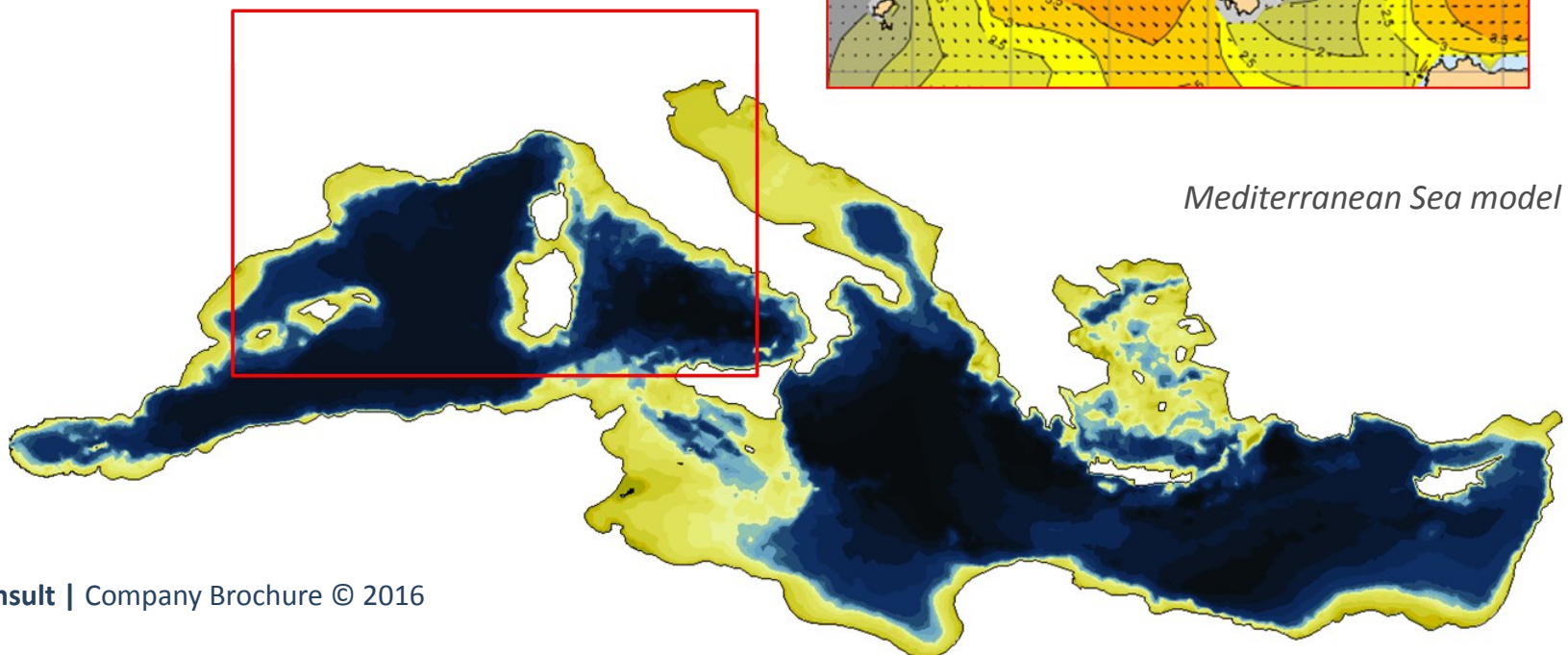
Regional models provide high resolution and accurate water level and wave information to support offshore and coastal projects at all phases of the development

The products of the regional models can be used in nearshore wave transformation studies to establish nearshore design criteria. We make use of state-of-the-art models taking into account all nearshore wave transformation processes such as refraction, shoaling, bottom friction, wave breaking and non-linear interactions.

Producing offshore and nearshore metocean information, we make use of the state of the art wave and flow modeling tools MIKE21, WAVEWATCH-III and SWAN

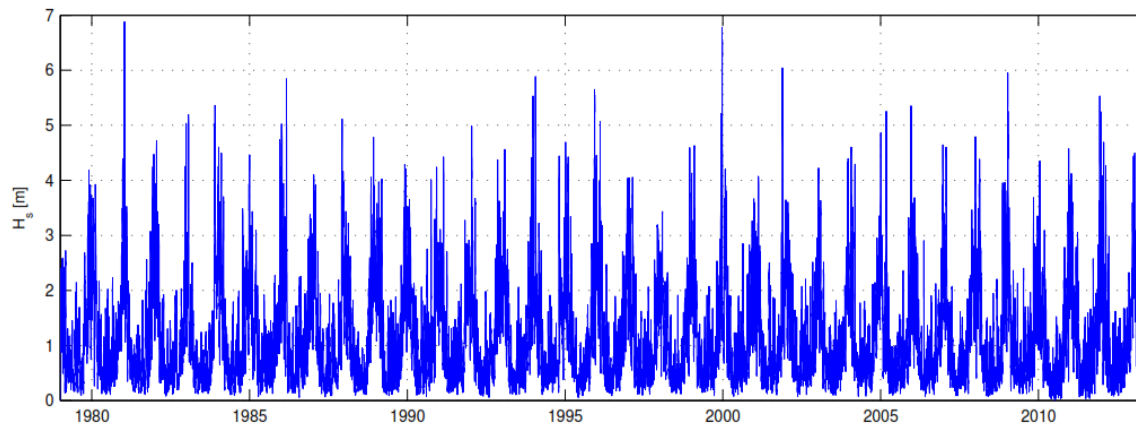


*Mediterranean Sea model*



# Regional hindcast models

Making use of products from reanalysis projects by third parties, MetOcean Consult develops in-house regional high resolution hindcast wave and flow models and archives its products into databases. The hindcast wind and wave data is validated with satellite scatterometer data and altimeter data or in-situ measurements.



The global database is supplemented with data produced by implementations of regional wave hindcast models. These models are forced by the reanalysis wind fields available at a resolution of  $\sim 0.3^\circ \times 0.3^\circ$  and  $\sim 0.2^\circ \times 0.2^\circ$  for the period 1979 to date.

Regional wave hindcast models have been developed for the following basins:

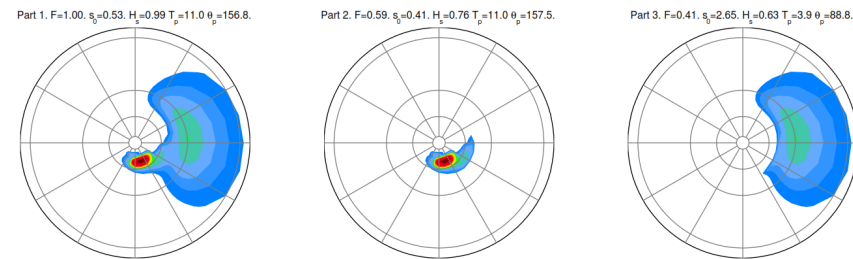
- Mediterranean Sea
- Black Sea
- Arabian Gulf
- South China Sea
- Baltic Sea

New models are developed on a regular basis. Please contact us to discuss the possibilities.



In addition to the standard products, MetOcean Consult also performs more in-depth analysis such as:

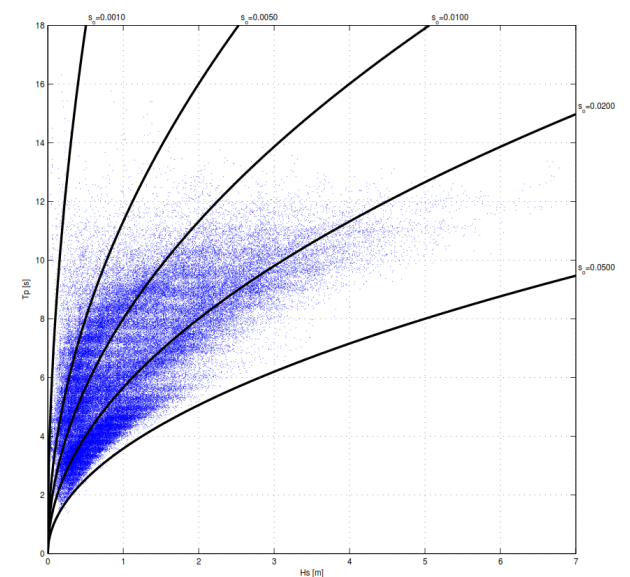
- Joint probability analysis
- Spectral analysis and filtering
- Spectral partitioning
- Short term extreme wave statistics
- Persistence analysis
- Wind-wave misalignment analysis



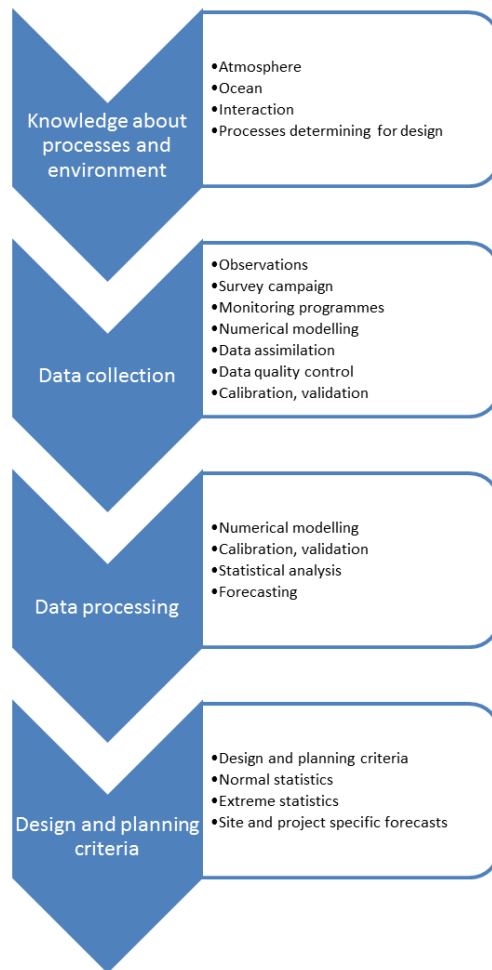
Spectral partitioning may be required for design of floating bodies. MetOcean Consult has developed tools to separate sea from swell and to analyze higher order swell systems.

Hs (m)	Tp (s)																			All Classes
	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	11.00	13.00	15.00	17.00	19.00	21.00	>			
0.00	0.25																			0.01
0.25	0.75		0.00	0.01	0.00		0.01		0.02	0.02	0.03	0.03	0.01		0.00	0.00				0.13
0.75	1.25			0.00	0.07	0.06	0.11	0.08	0.43	2.56	5.64	4.47	1.59	0.32	0.08	0.02				15.41
1.25	1.75				0.08	0.52	0.65	0.50	0.41	3.32	8.62	10.87	4.49	1.09	0.24	0.04				30.03
1.75	2.25					0.00	0.35	0.77	0.55	0.24	1.89	4.51	7.13	3.97	1.00	0.24	0.02			20.67
2.25	2.75						0.05	0.89	0.62	0.27	1.67	4.24	6.50	4.14	1.36	0.34	0.05			20.12
2.75	3.25							0.00	0.23	0.86	0.26	0.33	1.26	3.26	2.80	1.02	0.20	0.03		10.25
3.25	3.75								0.01	0.29	0.24	0.09	0.12	0.48	1.00	0.40	0.08	0.01		2.70
3.75	4.25								0.00	0.02	0.15	0.07	0.00	0.04	0.15	0.10	0.03	0.00		0.58
4.25	4.75										0.02	0.05		0.01	0.01	0.01	0.00			0.09
4.75	5.25											0.01	0.01							0.01
5.25	5.75												0.00							0.00
5.75	6.25												0.00							0.00
6.25	>																			0.00
Total			0.00	0.02	0.15	0.97	2.67	2.92	2.03	10.01	24.43	31.98	18.15	5.29	1.21	0.17				100.00

Season : All year  
 Period : 1979 - 2013  
 Location : 05.30N 081.00E  
 Record : Combined  
 Source : Hindcast data  
 Type of data : Hs and Tp  
 Number of records : 99933







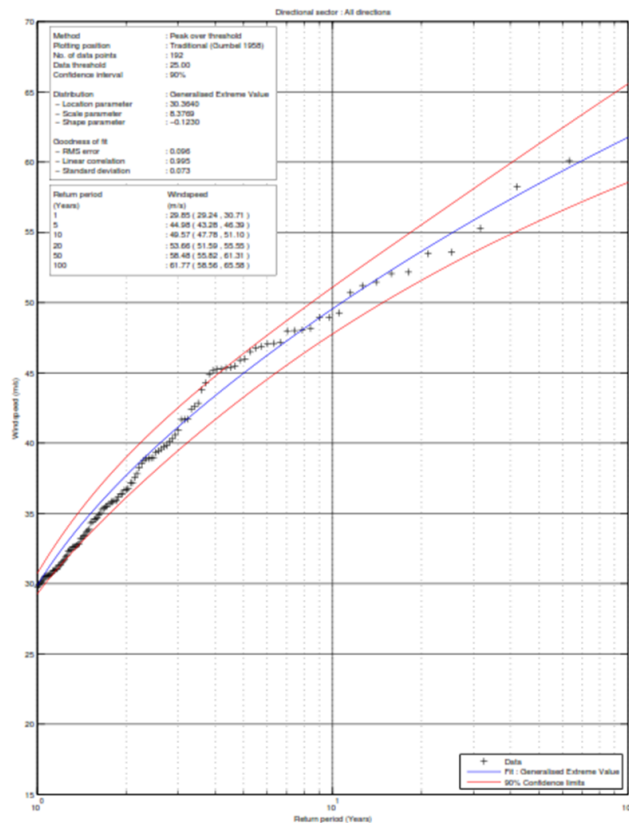
## Metocean studies

**We deliver high quality metocean information for use at all stages of offshore and coastal projects based on our vast experience and in-house and third party produced wind, wave and ocean current databases.**

MetOcean Consult has in-depth knowledge of the entire process of producing metocean information for a wide variety of customers and projects in all parts of the world; from data acquisition, data processing, validation, extreme value analysis to numerical modelling. MetOcean Consult has developed professional software packages for data analysis, visualization, spectral partitioning and extreme value analysis producing key metocean information related to ambient and extreme conditions.

We routinely produce a.o. the following metocean information for the ambient climate:

- Annual and seasonal (monthly and user defined) wind and wave roses
- Climatic tables showing (directional) joint probability and exceedance percentages or occurrences of wind and waves (e.g. wave height vs. wave direction, wave height vs. wave period, wind speed vs. wave height, etc.)
- Tables showing the mean value of e.g. wind speed in given classes of wave height and direction
- Monthly and annual statistics (e.g. average, 90% non-exceedance, maxima, etc.)
- Wind and wave persistency tables for an arbitrary number of (user defined) seasons, thresholds and duration intervals



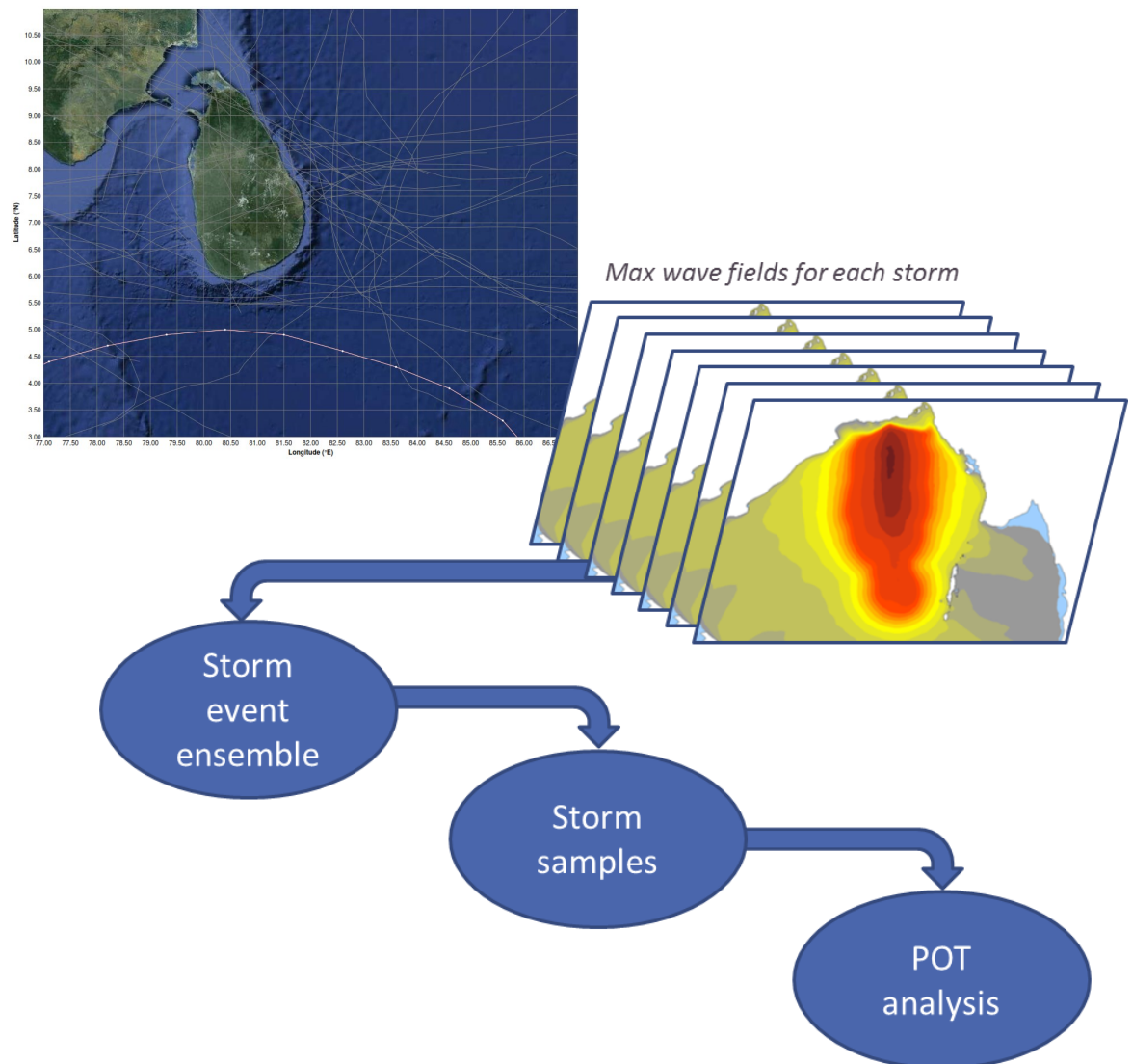
MetOcean Consult has developed software for performing extreme value analysis by implementing a wide range of statistical models and methods.

The software accounts for:

- Both global models (using all data e.g. cumulative distribution approach) as well as event based models (e.g. Peak Over Threshold , Annual Maxima)
- Choice between various statistical distributions, such as: Weibull, Exponential, Generalized Extreme Value, Pareto
- Computation of confidence intervals based on bootstrapping
- Seasonal and directional analysis
- Threshold analysis

We develop specific methods to deal with tropical cyclones when establishing extreme criteria.

- Robust and reliable method of estimating extreme deep water wind and wave criteria
- The method makes optimum use of all available data based on storm characteristics that are representative for the area under consideration
- Allows refinement of extreme wind and wave criteria, reducing uncertainties leading to cost savings
- Successfully applied in various offshore, port and coastal development projects

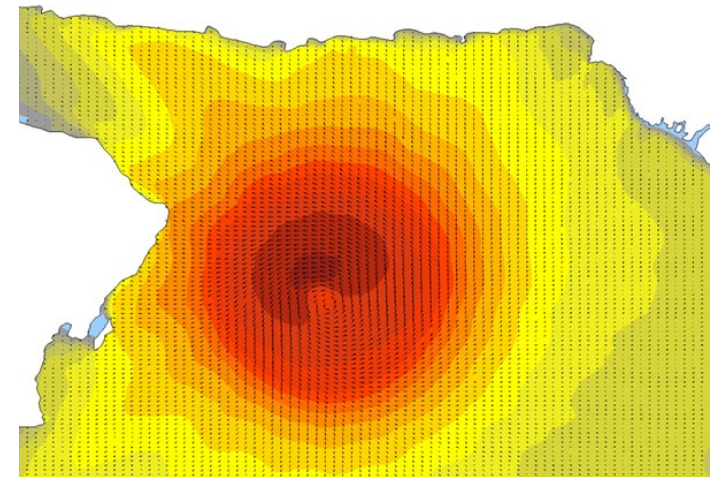




# Extreme design criteria

MetOcean Consult provides extreme wind, wave and current criteria for application in offshore and nearshore areas. Extreme criteria in nearshore areas are derived using numerical wave and flow modelling tools such as SWAN, MIKE21, Delft3D and DFLOW-FM.

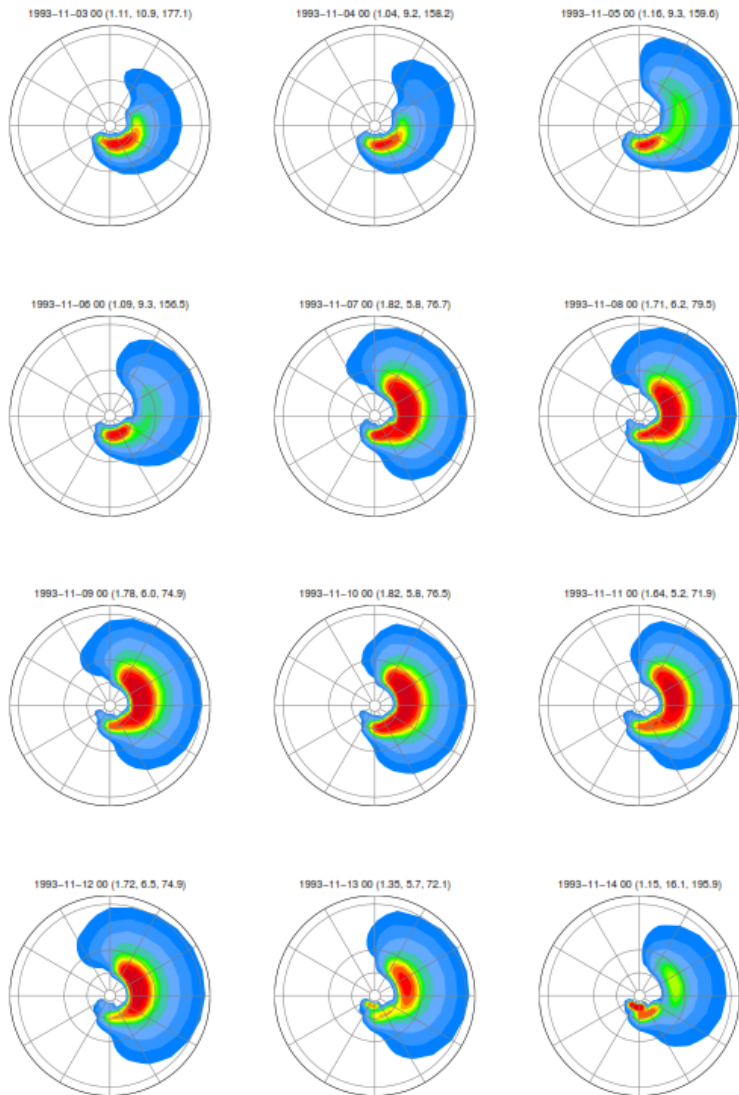
If required, wave and hydrodynamic models will be operated in coupled mode enabling real time exchange of information of the wave, current and water level field. Establishing extreme design criteria (e.g. for the 10, 50 and 100 year return period events), every project requires a site specific analysis of the key metocean processes.



*Computed wave field during cyclone GONU 2007*

## Tropical storm analysis

- In areas of mid to high latitudes, extreme criteria can often be based on archived satellite and hindcast data. However, to resolve the effects of tropical cyclones, the large scale (global) wave hindcast models and windfields produced by the atmospheric models often lack sufficient spatial resolution. Also, the amount of information about historical storms is often limited.
- Therefore, MetOcean Consult has developed a method to account for this by supplementing the hindcast data with information produced by high resolution wind and wave modelling of tropical cyclones based on historical storm track data.



2D wave energy density spectra computed with SWAN

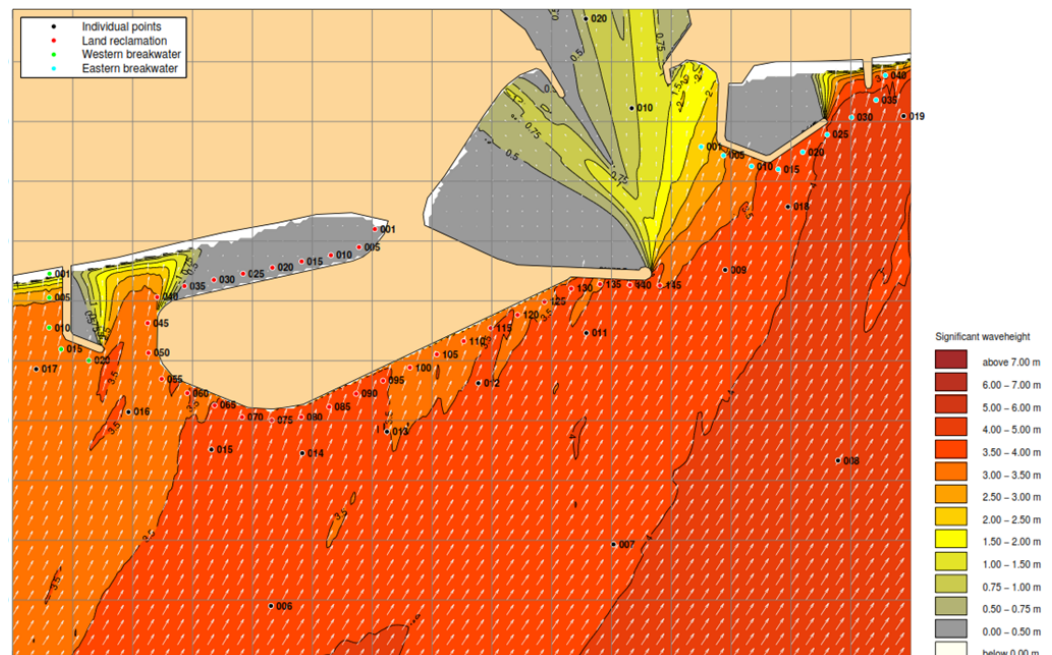
MetOcean Consult applies a wide range of wave models at all scales, from basin scale (for the development of hindcast wave databases) to port areas to perform wave disturbance studies.

We apply wave models in non-stationary mode and stationary mode, regular grid as well as flexible grid. If required, we also run wave models dynamically coupled with flow models.

MetOcean Consult routinely applies the state of the art third generation SWAN (Simulating WAVes Nearshore) model developed by Delft University of Technology. SWAN accounts for the following processes:

- Wave growth by wind
- Dissipation by white-capping
- Quadruplet and triad non linear interactions
- Bottom friction
- Depth induced wave breaking
- Refraction, shoaling and diffraction
- (Partial) transmission and reflection

SWAN is continuously actively developed and one of the most widely applied wave models in the world. New versions are published on a regular basis making it one of the most sophisticated wave models available. MetOcean Consult maintains close relationships with its developers which ensures that we always are up to date with the latest developments.



Nearshore wave field computed with SWAN



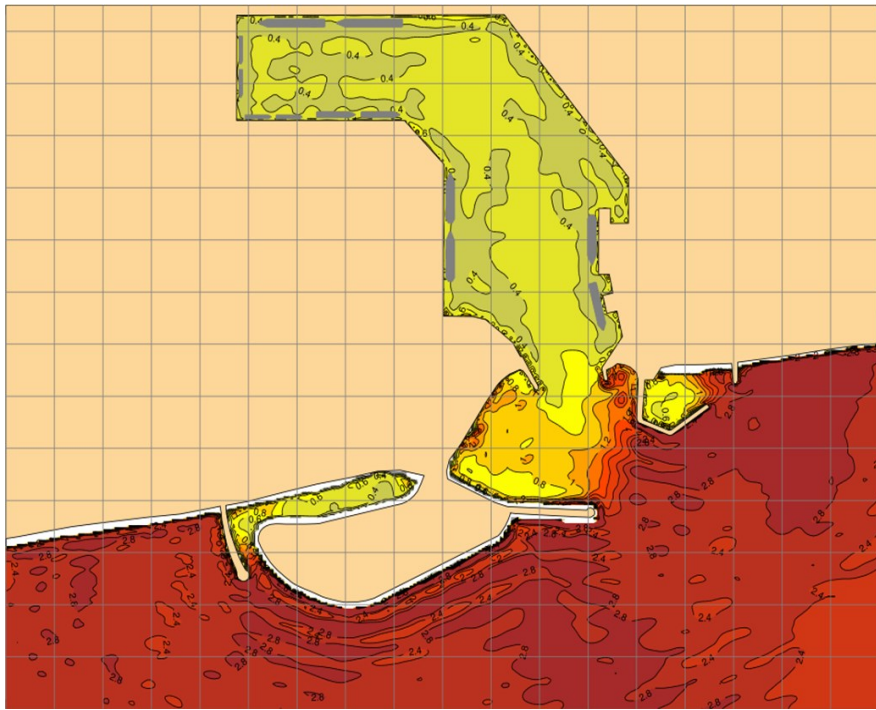
# Wave transformation studies

Ocean waves transform due to complex processes when approaching the coast and shallow waters. Therefore, computation of nearshore wave conditions is of utmost importance for port, coastal and oil and gas projects that are located in areas where the waves are affected by the coastline and bathymetry.

MetOcean Consult has an extensive track record in performing wave transformation studies and application of state of the art third generation spectral wave models such as SWAN and MIKE21-SW in all parts of the world. We provide wave climate studies, extreme offshore and nearshore wave conditions, dedicated wave hindcasts and wave forecasts for offshore and coastal areas.

## Spectral and time domain models

- Spectral wave models such as SWAN and MIKE21-SW are phase averaged, which means that they cannot be applied in situations where phase information is of importance. Such situations occur typically in ports and harbors where diffraction and reflection patterns may cause resonance conditions that could potentially affect moored vessels and berth operations.
- In such circumstances, it is often recommended to apply time domain models such as Boussinesq models like MIKE21-BW or non-hydrostatic models such as SWASH.
- The area that can be effectively modelled with time domain wave transformation models in general is limited. It requires extensive computational resources to run such models which are available at MetOcean Consult.

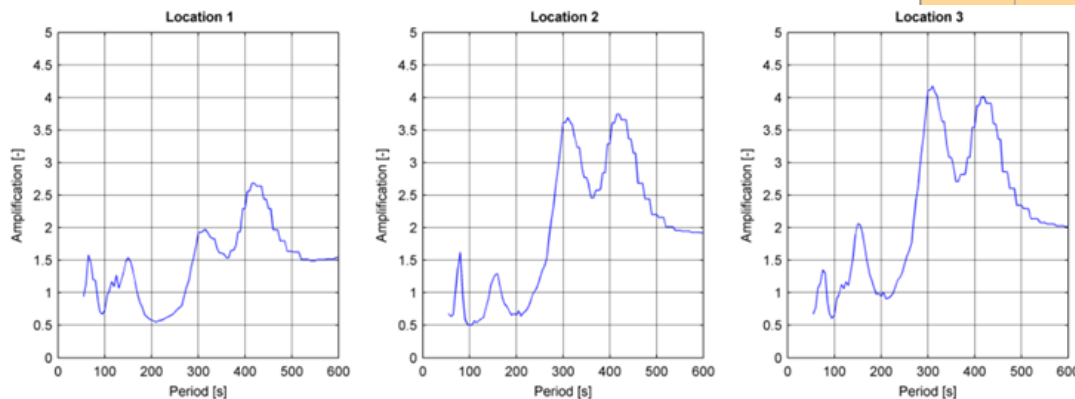


Wave height in harbor computed with SWASH

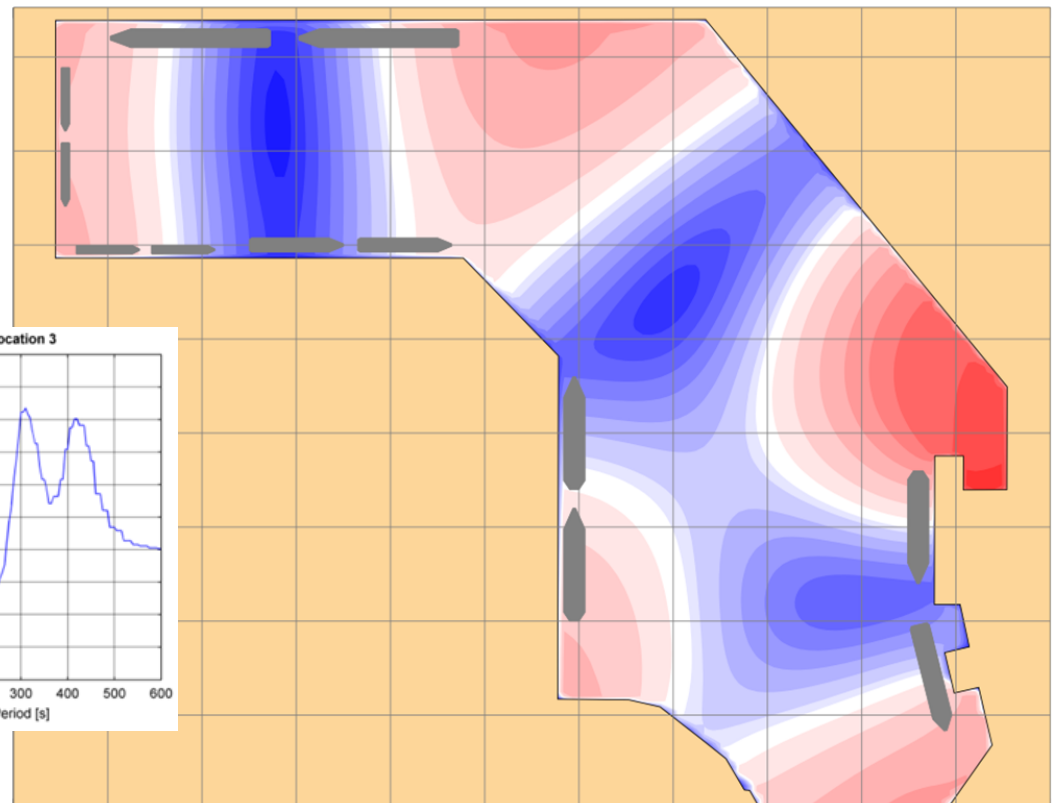
**SWASH accounts for the following physical phenomena:**

- Propagation, frequency dispersion, shoaling, refraction and diffraction
- Nonlinear wave-wave interactions (including surfbeat and triads)
- Wave breaking
- Wave run-up and rundown
- Moving shoreline
- Bottom friction
- Partial reflection and transmission
- Wave induced currents and wave-current interaction
- Vertical turbulent mixing
- Subgrid turbulence
- Mass and momentum conservation and
- Rapidly varied flows

MetOcean Consult recently performed a wave disturbance assessment in which the wave amplification for a wide range of incoming long infragravity wave conditions was computed as well as the wave action due to incoming long swells from the ocean.



Amplification graphs for three locations computed with SWASH

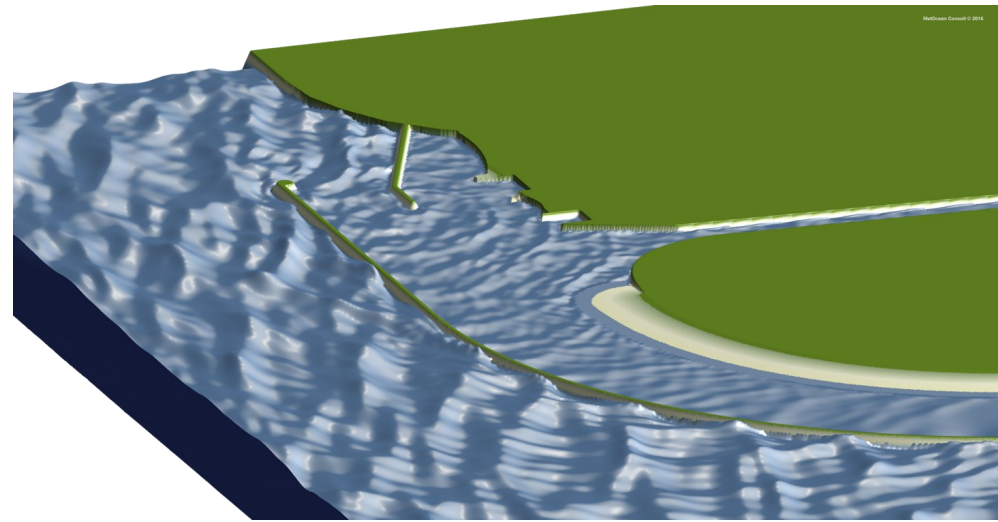


Amplification of surface elevation in harbor computed with SWASH. Red areas indicate an increase in surface elevation, the blue areas a reduction.



## Wave disturbance studies

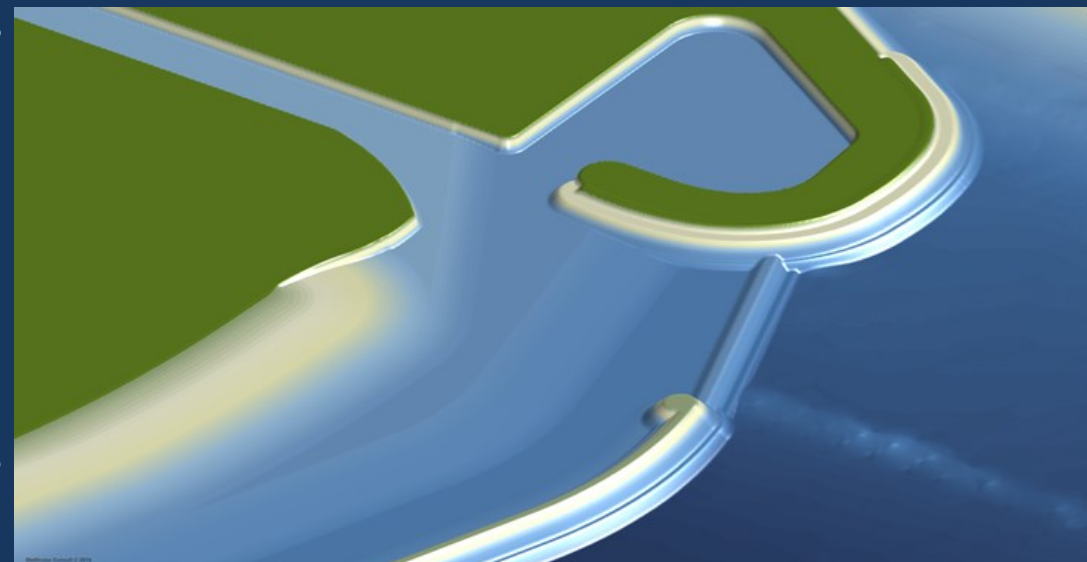
Studies for ports and harbors often require the application of phase resolving models to properly take into account processes such as wave transmission, reflection and diffraction which are typically dominant in those areas.



In certain circumstances, also long wave (infragravity wave) action and the port's response to long waves requires investigation when moored vessels are potentially responsive to long wave frequencies. MetOcean Consult has wide experience in studying wave phenomena typically dominant in port areas, making use of the MIKE21-BW model and, more recently, SWASH. We perform detailed wave amplification analysis and wave resonance studies, as well as wave penetration of primary (sea and swell) waves.

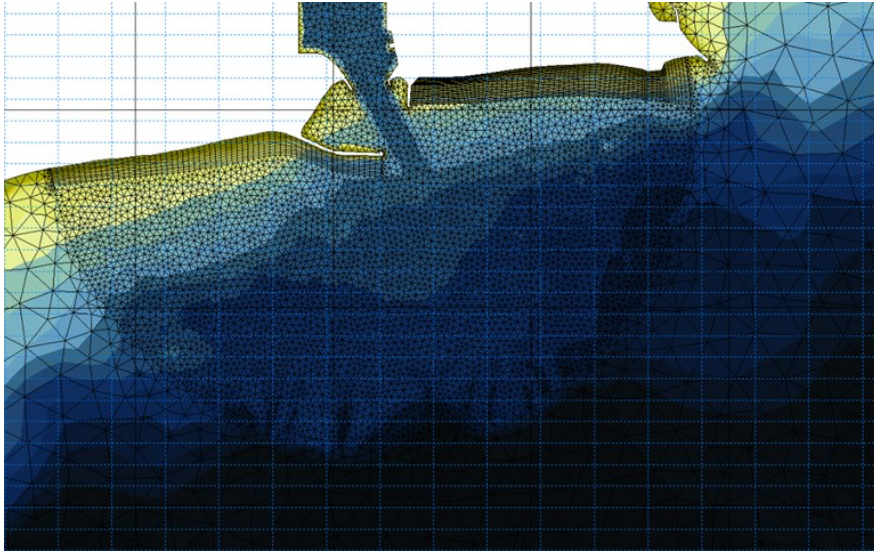
### Application of non-hydrostatic models in ports and harbors

- The open source non-hydrostatic model SWASH (Simulating WAVes till SHore), developed by Delft University of Technology has proven a successful alternative to the application of Boussinesq models for wave disturbance modeling
- MetOcean Consult has experience with the application of both Boussinesq and Non-hydrostatic SWASH and maintains close connections with its developers





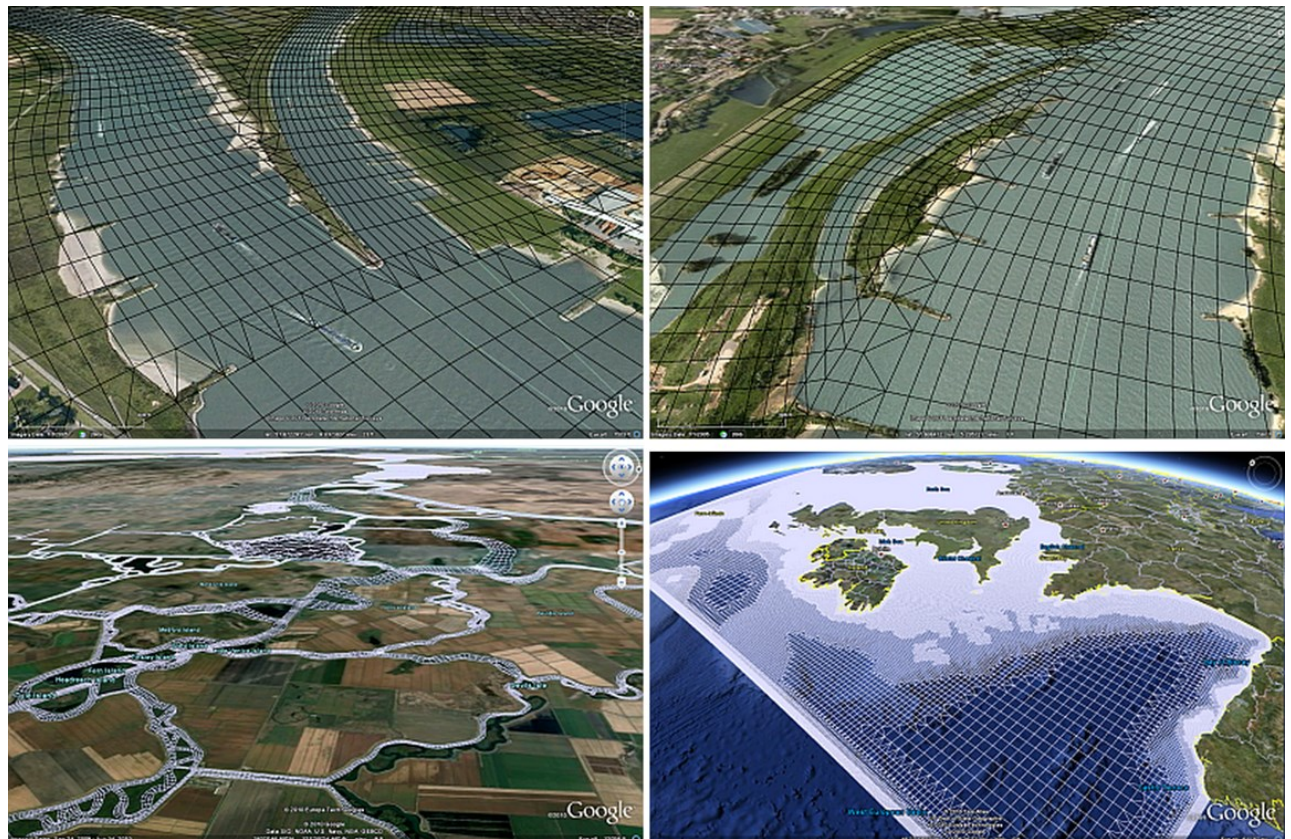
MetOcean Consult has wide experience in application of the MIKE21-FM modelling software in all parts of the world for a wide variety of clients.



- Since version 2014 MIKE21 has the possibility to perform the computations on the GPU making this currently the fastest commercially available numerical hydrodynamic modeling tool
- MIKE21 is one of the most widely used and accepted modeling solutions for offshore and coastal applications
- MIKE21 has a very user friendly user interface which for example allows the user to make a smooth and easy coupling between the wave and flow models

Hydrodynamic model studies are performed for the following purposes:

- Design water levels (tide, wind setup)
- Cyclone hindcasting
- Operational conditions
- Input to navigation / mooring studies
- Water circulation
- Advection / dispersion
- 3D effects
- Tsunami propagation



*DFLOW-FM has the ability to combine different mesh types into one model grid.*



# Hydrodynamic model studies

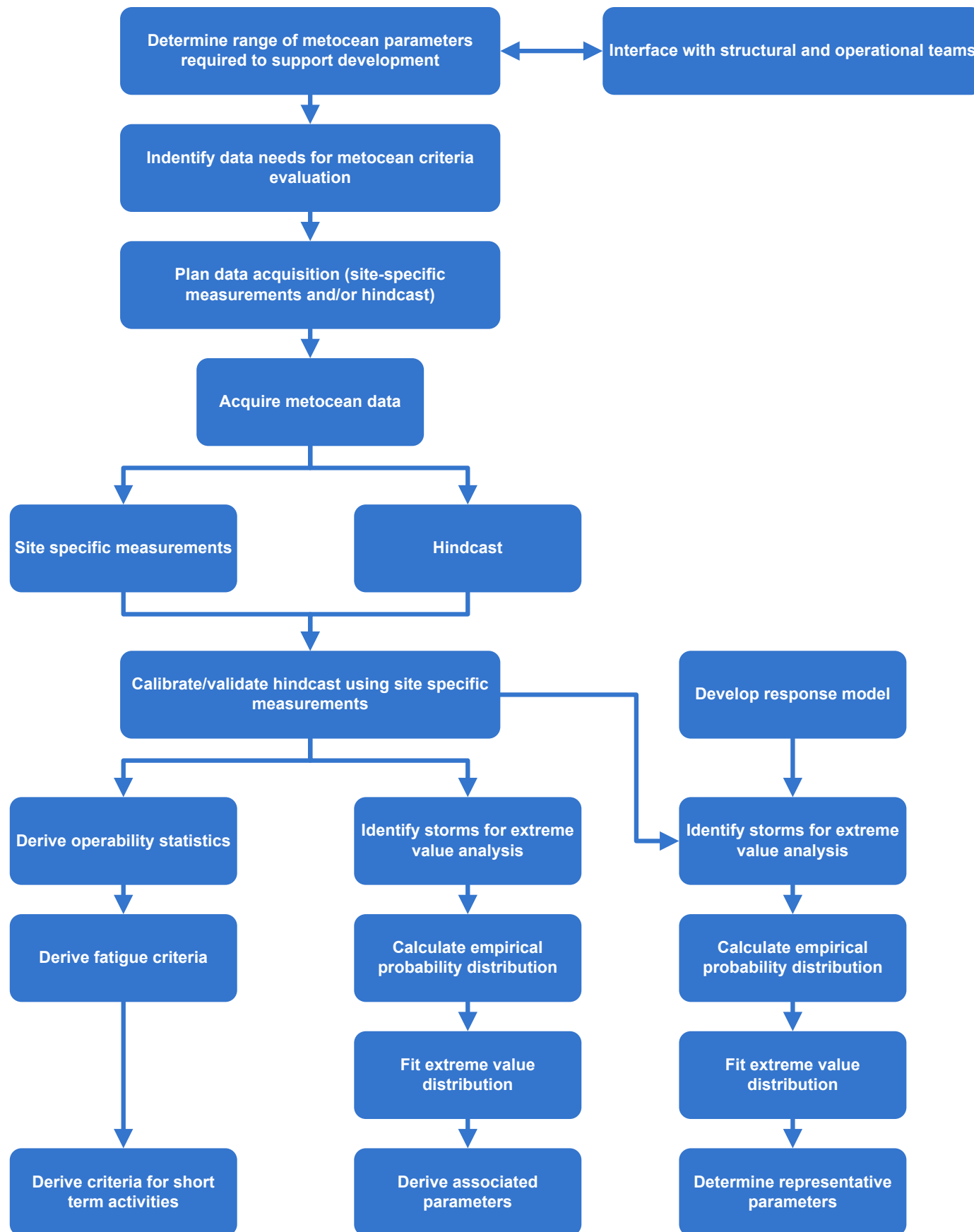
**Detailed current and water level information derived by hydrodynamic modeling is one of the key activities of MetOcean Consult. For this purpose we make use of professional commercial and open source modeling packages MIKE21-FM, Delft3D and DFLOW-FM.**

Hydrodynamic model studies are performed to derive tidal and wind driven currents and water levels required for example for design, morphological studies and navigation studies. MetOcean Consult has developed various regional and detailed flow models for many areas in the world such as for the Arabian Gulf, Mediterranean Sea, Gulf of Thailand, Bay of Bengal and the North Sea to establish design and operational current and water level criteria.

## **NGHS (Next Generation Hydro Software)**

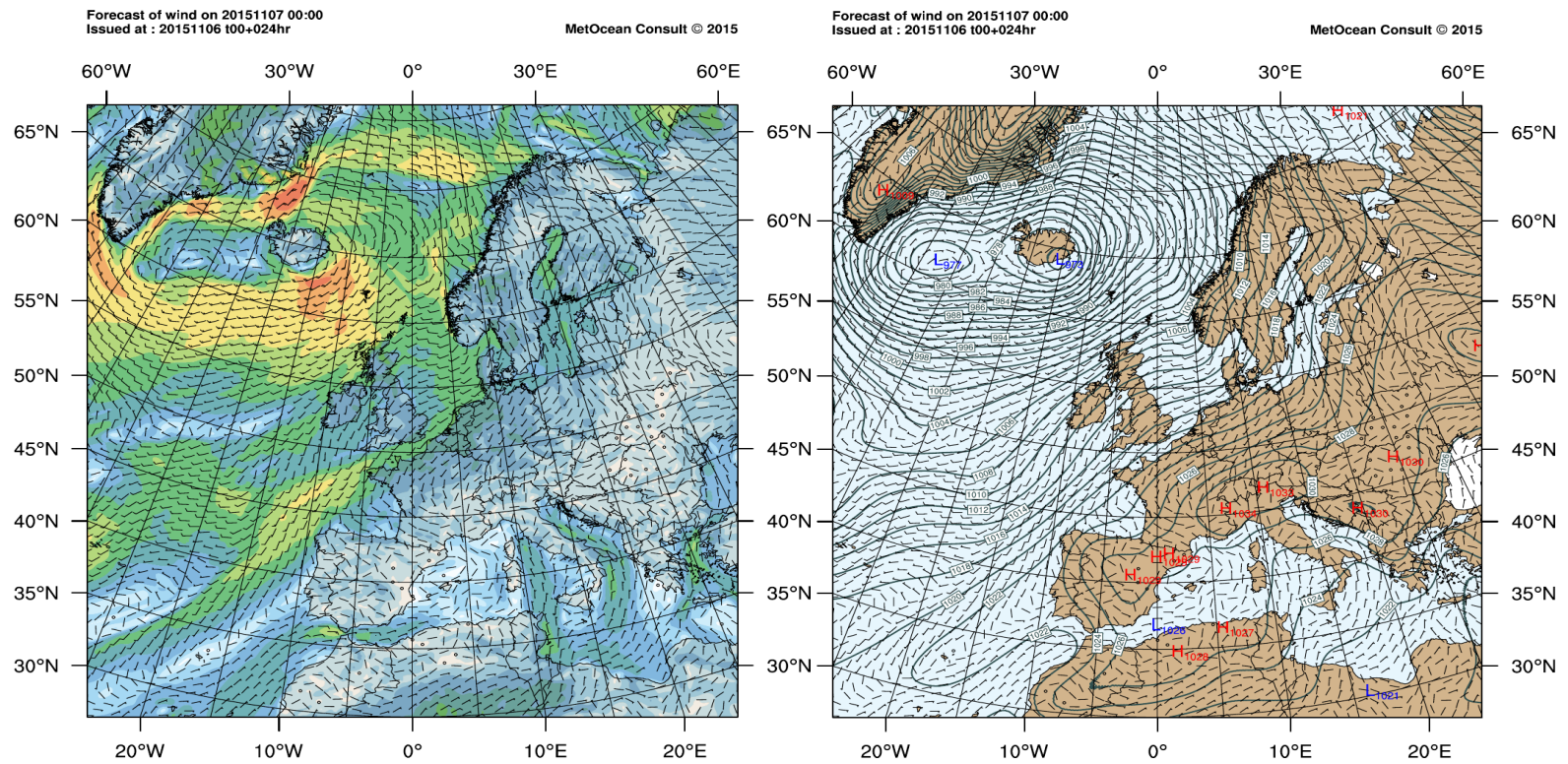
- Deltares is currently developing DFLOW-FM, expected to become open source in 2014 and the successor of the hydrodynamic modelling package Delft3D. As early adaptor and beta tester of DFLOW-FM, MetOcean Consult has access to the newest releases of this new advanced software package for simulation of 1D, 2D and 3D free surface flows.
- DFLOW-FM's computational core and user interface have been redesigned and allows the user to combine 1D, 2D and 3D computational grids into one model grid.
- The programme allows the user to design unstructured meshes that combine regular grids, triangles, curvilinear elements and other mesh types into one grid. This enables the user to optimise computational grids for speed and performance for the most complex situations.
- The numerical solver has been improved and shown to be very efficient compared to other models.

# Roadmap to metocean information



# Forecasting Services

As of 2016, MetOcean Consult provides forecasting information of key metocean parameters such as wind, waves, water levels and currents for any location in the world. As this is a service under development, we recommend to contacts us to discuss the possibilities for your situation.



## Key features:

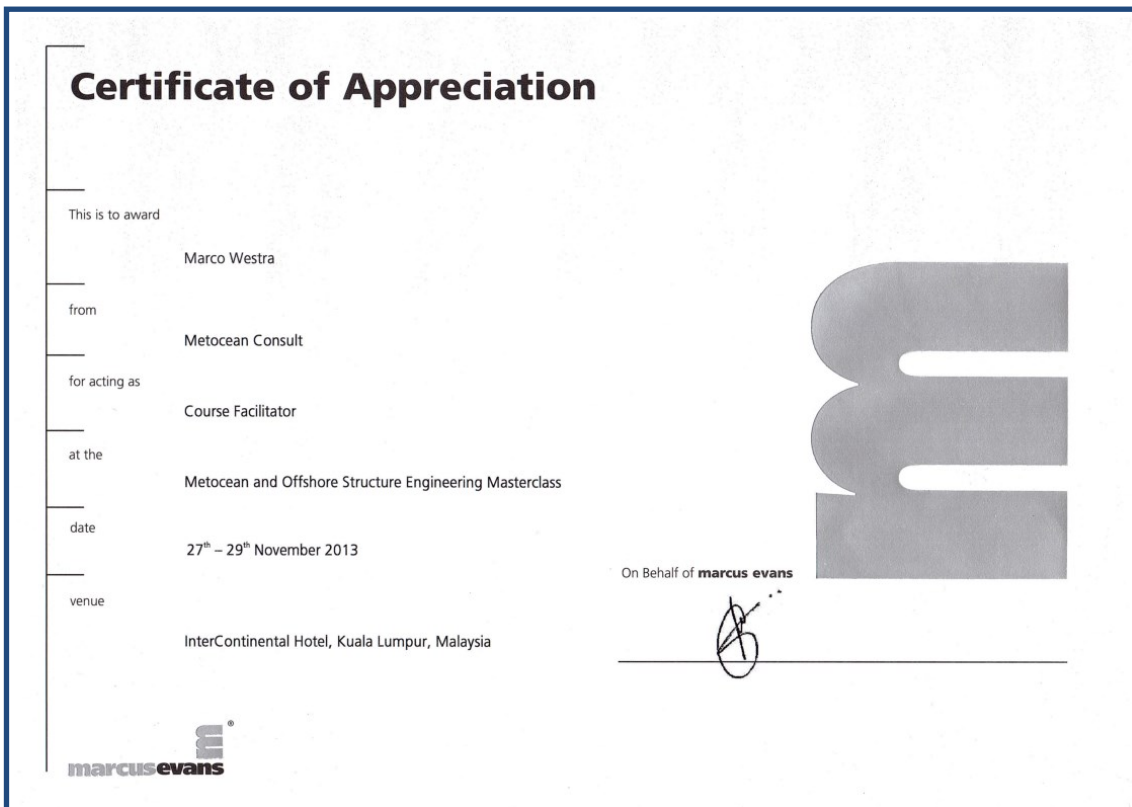
- Source data: NCEP / NOAA
- Global coverage of meteorological parameters at ~13km grid resolution or higher (locally)
- Global coverage of waves, currents and water levels
- Tools used: WaveWatch-III <sup>TM</sup>, SWAN, WRF
- Platform : Amazon AWS and High Performance Compute Centra in The Netherlands and the UK



# More than consultancy

**MetOcean Consult facilitates tailor made and interactive metocean engineering courses, workshops and master classes to the industry teaching best practices on applications to off-shore and coastal engineering.**

Please feel free to contact us if you think we can make a difference to your organization by bringing you our knowledge suited to your specific companies needs.



## Metocean and Offshore Structures Engineering Masterclass

Understanding your operational environment to achieve optimal performance and gain more from your CAPEX

27-29 Nov 2013  
InterContinental Kuala Lumpur, Malaysia

MetOcean Consult and associates have developed a metocean and offshore structures engineering masterclass which covers the following key topics:

- Evaluating and understanding metocean phenomena, processes and parameters
- Identifying with various metocean processes and it's effects on your design and operations
- Metocean data sources, data quality control, calibration, validation and archiving
- Deciphering the numerical modeling of ocean dynamics and implementations of ocean modeling techniques
- Taking into consideration the metocean load for design criteria

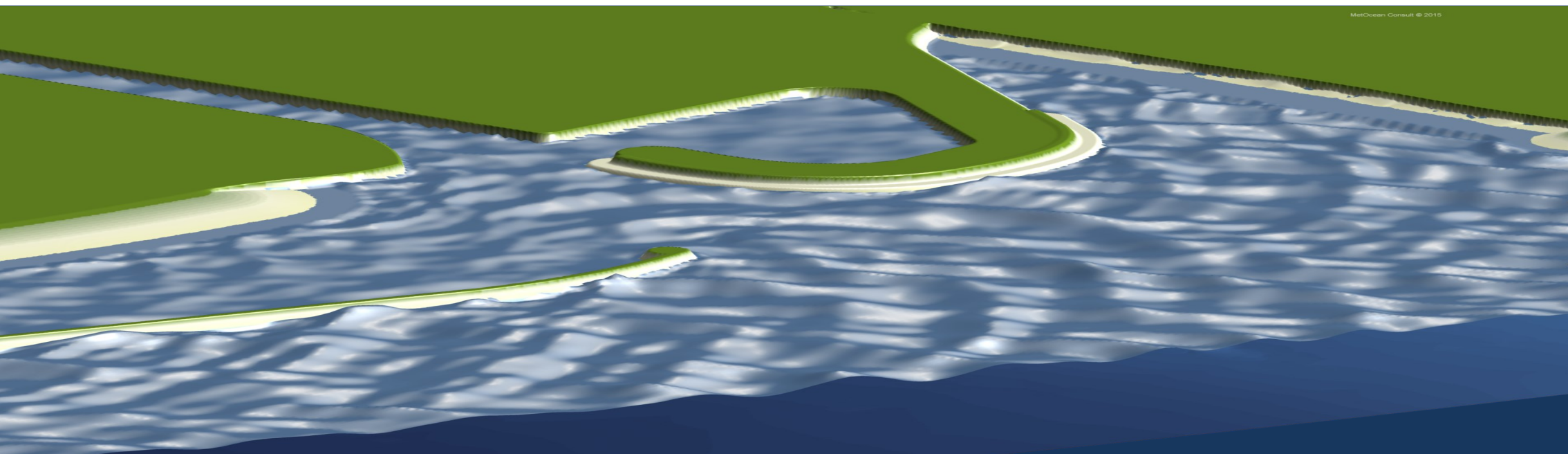
# Our idea of doing business

**A key factor for happy clients is that one has to understand the needs and wishes of the client at all stages of the project as well as the ability to provide top level consultancy services. This requires a continuous communication during the course of the project and a proactive and flexible attitude from our side as well as good connections with the academic and research institutes.**

Creating a mutual understanding of each others' expectations and ideas during an early stage of the project is of great importance for a successful completion of the study. Projects are carried rather 'with' than 'for' the client in close cooperative and strategic partnerships.

MetOcean Consult would like to invite you for an introductory discussion where we can get a good understanding of your wishes and way of working and where we can explain into more depth our capabilities.

MetOcean Consult, 2016

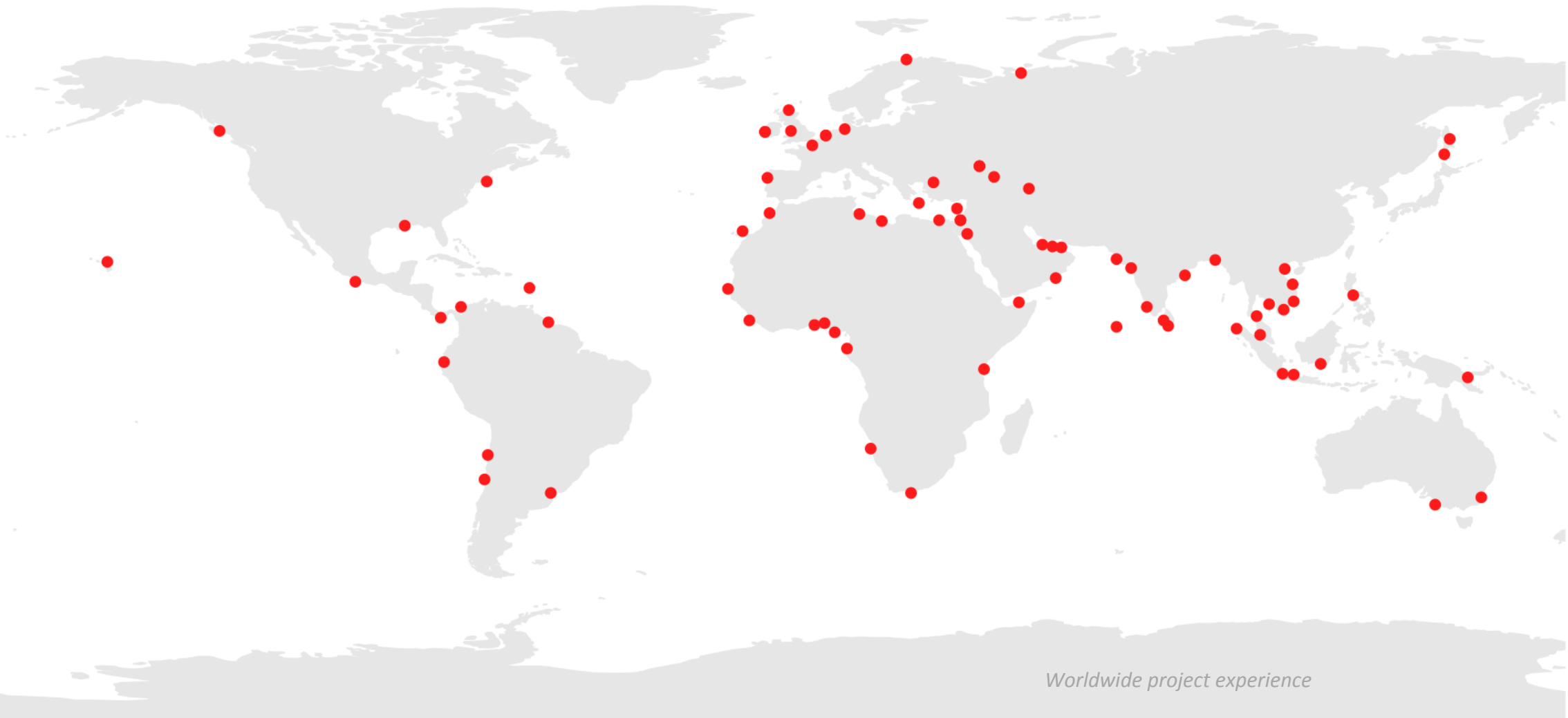


*Wave disturbance pattern for Port City Development, Colombo, Sri Lanka (2015)*



# MetOcean Consult

*Metocean and Hydraulic Consultancy*



*Worldwide project experience*

With its office located in Rotterdam, The Netherlands, **MetOcean Consult** is an independent international engineering and consultancy provider.

For further information about our services, please contact:

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