CASE STUDY 7

ENERGY LOGISTICS: WIND AND WAVE CONDITIONS

Focus: Wind and wave conditions during seasonal ‘shoulder’ months in the North Sea and energy logistics

Industrial and research partners

The SECLI-FIRM project aims to demonstrate how improving and using long-term seasonal climate forecasts can add practical and economic value to decision-making processes and outcomes, in the energy and water sectors. To maximise success, each of the nine SECLI-FIRM case studies is co-designed by industrial and research partners.

For this case study, the industrial partner is Shell – an international energy company with expertise in the exploration, production, refining and marketing of oil and natural gas, and the manufacturing and marketing of chemicals. Their strategy is to strengthen their position as a leading energy company by providing oil and gas and low-carbon energy as the world’s energy system changes. Safety and social responsibility are fundamental to their business approach. As Shell’s purpose is to power progress together with more and cleaner energy solutions, Shell is investing in more lower-carbon technology including offshore wind developments as a renewable energy source.

Boosting decision making

The main objective of this case study is to illustrate the application of long-range forecast data (longer than that typically used by the offshore oil and gas industry) to identify calm weather windows in autumn and spring months, facilitating earlier decision-making and reduced operational costs for the marine energy sector. Whilst the case study focusses on oil and gas projects, the results are equally applicable to offshore wind developments.

The seasonal forecasting context

- Seasonal forecast evaluation will consider the skill of predicting calm weather windows in autumn (September to November) and spring (March to May) months in the North Sea within the years 2016 to 2018.
- This will be illustrated in the context of an Asset Manager or Metocean Engineer planning operations such as those involving drilling, large infrastructure installation or decommissioning activities.

Sectoral challenges and opportunities

- The expense of working in the offshore environment places special emphasis on the requirement to reduce supply chain costs, such as those related to vessel charter and personnel management, through efficient operational planning.
- At present, the application of the latest weather science developments by the offshore oil and gas industry is traditionally very conservative, with limited use of fortnightly, monthly and sub-seasonal outputs, or even climate projections and teleconnections.

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Wind and wave conditions

Logistics for the marine energy sector are governed by strict environmental limits under which work may safely be conducted, with the significant wave height (SWH), mean wave period and 10m wind speed representing the most important parameters.

Ocean currents also affect the station-keeping capabilities of vessels; however, since in the North Sea these are dominated by the tides (and therefore inherently predictable) they do not generally represent a significant issue or source of uncertainty within the decision making.

Offshore operational planning

The case study will be or is presented in the context of an Asset Manager or Metocean Engineer planning operations dependent on a sustained period of low wind speed and SWH in the North Sea.

Since these activities utilise vessels with estimated daily rates up to £500,000 (in addition to associated mobilisation and demobilisation costs), the benefit of avoiding costly downtime can be determined in industry-relevant economic terms – with a particular focus on optimising the use of vessels on long-term charter, and facilitating the earlier booking of auxiliary capability.

In the North Sea, these are typically booked from June until August, when wind and wave conditions are, statistically, the mildest – increasing the likelihood that weather-sensitive operations will be successful due to reduced odds of key thresholds (e.g. 10 m/s wind speed or 2m SWH) being breached (Figure 1).

However, the result of this is to constrain complex activities to a 3-4 month period, with the use of the existing 3-day forecast (primarily employed in safety-critical decision-making at short-range) providing limited opportunity for effective planning.

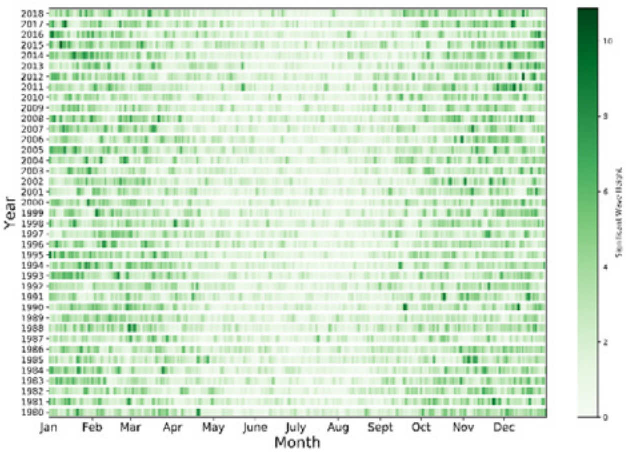

Figure 1: Hindcast values for daily maximum significant wave height (m) 1980-2018

Climate event

Workable weather windows in the North Sea for logistics operations

Sector impact

Reducing costs by improving operational efficiency

Industry context

Asset Manager or Metocean Engineer planning operations

Demonstrating value

In the planning of any new operation, it is typical for the Asset Manager to enlist the services of a Metocean Engineer or Engineering Team for outlining the scope of work, resourcing and scheduling the various operations for example pipe laying, crane lifting and vessel supply while considering their associated weather-sensitive thresholds. It is the role of the Metocean Engineering Team to establish when each component activity, necessary for the overall completion of the project can be performed based on metocean data.

Such an analysis includes interrogating weather information for weekly, monthly or annual milestones and refining or revisiting this information during the course of the work as these events draw nearer in time. Within this process, for project stages involving marine data, long-range strategic planning typically uses statistical analysis of past conditions (Figure 2), with the final approval as to whether to initiate a planned operation typically based on deterministic forecasts with a lead time of up to three days ahead. Ensemble prediction systems extend the forecast outlook beyond a week or so ahead.

The offshore oil and gas industry is traditionally very conservative and it is unrealistic (at least within the timescales of this project) to expect to convince operators to replace their business processes for long-range decision-making (based on analysis of historical data). There is however significant potential to extend the planning horizons considered in-year up to at least monthly lead-times, using seasonal forecasts. On this basis, the developments pursued here therefore focus only on the sub-seasonal period of between 10 to 46 days ahead, with a particular focus on SWH.

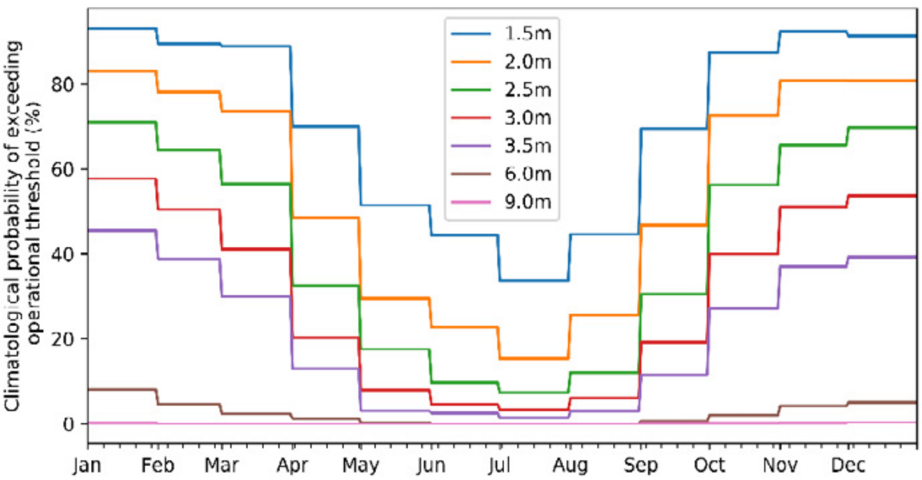

Figure 2: Monthly probabilities of exceeding specific significant wave height thresholds (1.5 to 9 m) based on climatology.

Demonstrating value

Extend planning horizons considered in-year up to at least monthly lead times using seasonal data

Case Study Highlights

Case Study 7 exploits weather pattern typology as a means of characterising the large-scale atmospheric circulation, which is more predictable than the actual weather itself at long lead-times. For effective decision-making, the occurrence of a particular weather pattern 'definition' can be linked to the viability of offshore operations at a local scale, via the so-called process of statistical downscaling. The probability of exceeding SWH thresholds out to 46 days ahead is estimated from the weather patterns.

A trial forecast was developed based on the requirements of the industry partner, Shell. The forecast (Figure 3) shows the probability of exceeding a 2.5m SWH threshold relative to the climatology. Additionally, the weather pattern trend (pressure, meridional, zonal) indicators can be included in to provide additional context/linkage to synoptic meteorology and associated variables (note this is not shown in Figure 3). This is important for building trust and understanding in the forecast itself, and further enhances its utility in relation to compound events.

- Annual comparisons of weather pattern derived wave forecasts against direct wave model output demonstrate similar performance at extended range lead times (beyond 15 days ahead), with both able to successfully discriminate between exceedance and non-exceedance of SWH threshold(s), albeit with results averaged over many events tending towards and remaining around the climatology.

- Seasonal verification results reveal improved performance at particular times of year and indicate forecasts which focus on several days to several weeks ahead are most beneficial for planning an early start to the operations in spring, as opposed to looking to extend activities at the end of the traditional summer work season into autumn.

- Importantly, forecast skill is not equivalent to forecast value. While the skill verification statistics indicate a reduction in skill in both approaches beyond around 15 days, an assessment of the potential value of the forecast shows there is value to the user in the weather pattern forecast at lead times beyond 15 days.

- The forecast was applied to the 'Beast from the East' event (Spring 2018) to demonstrate its use and application. For the offshore industry, the Beast from the East was a concern as cold weather can cause damage to offshore assets. The forecast successfully identified the event and a window with a decreased probability of exceeding the 2.5m threshold before the onset of the event. Based on vessel hire data from Seabrokers, assuming preparatory action to protect offshore assets from the impacts of cold weather is taken upon the identification of the weather window, a theoretical economic saving of up to 28% can be achieved.

Tailoring Seasonal Forecasts

Case Study 7 exploits the skill in the forecasts of weather patterns to forecast the exceedance of SWH thresholds at longer lead-times.

Forecast Skill

Forecasts which focus on several days to several weeks ahead are most beneficial for planning an early start to the operating season.

Value Add

Using the Beast from the East case study, clear cost saving benefits can be achieved through earlier identification of calm weather windows.

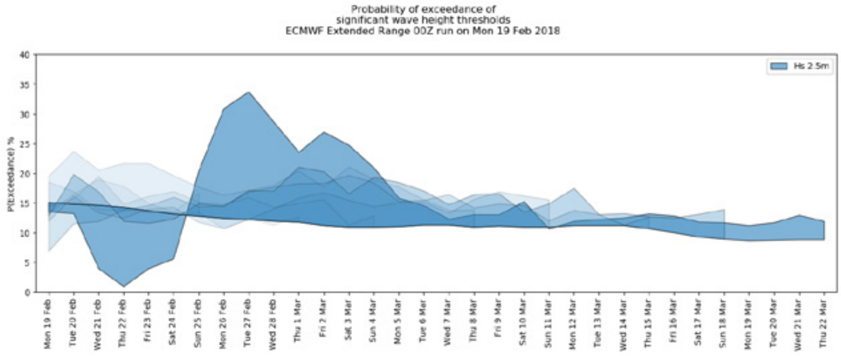

Figure 3: Example forecast visualisation generated for the 19th February 2018 in the lead up to the Beast from the East for a site in the southern North Sea. The panel shows the probability of exceedance in sequential blue shades with the darkest blue showing the most recent forecast and the lighter shades from previous forecasts. The black line is the average climatological probability of exceedance.

Decision tree

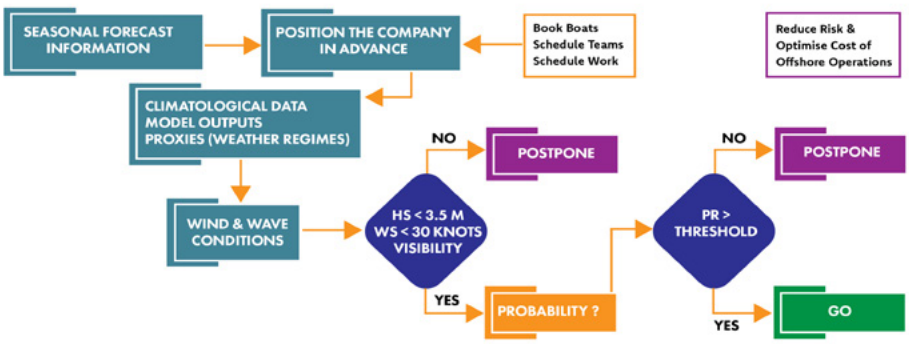

Figure 4: A decision tree which summarises the operational decision process for the marine energy sector (in the context of weather and climate information), which was established in collaboration with offshore industry stakeholders from Shell and TenneT.

The future

Following a trial of the service developed under Case Study 7 at a location in the central North Sea, there are further plans to work with the industry partner, Shell, to extend the trial of the application of this approach to a wider range of locations in the North Sea in late 2021.

The Added Value of Seasonal Climate Forecasting for Integrated Risk Management (SECLI-FIRM)

For more information visit:

www.secli-firm.eu or contact us at: **info@secli-firm.eu**

The Future

Work with the industry partner will extend the trial forecast application to a wider range of locations in the North Sea in the late summer season and into the autumn.

Related Materials

Watch the Case Study 7 video
https://www.youtube.com/watch?v=Oz7XrQrFIRs

Read the blog about how SECLI-FIRM Trial Forecasts added support to a North Sea Rig Move
http://www.secli-firm.eu/2021/05/04/rig-move/

For more about this and the eight other case studies, visit www.secli-firm.eu

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