Kraken Offshore Metrological Aid

Beaufort wind force scale

Specifications and equivalent speeds

Beaufort wind scale	Mean Wind Speed		Limits of wind speed		Wind descriptive terms	Probable wave height	Probable maximum wave height	Sea state	Sea descriptive terms
	Knots	ms^{-1}	Knots	ms^{-1}		in metres*	in metres*		
0	0	0	<1	<1	Calm	-	-	0	Calm (glassy)
1	2	1	1-3	1-2	Light air	0.1	0.1	1	Calm (rippled)
2	5	3	4-6	2-3	Light breeze	0.2	0.3	2	Smooth (wavelets)
3	9	5	7-10	4-5	Gentle breeze	0.6	1.0	3	Slight
4	13	7	11-16	6-8	Moderate breeze	1.0	1.5	3-4	Slight - Moderate
5	19	10	17-21	9-11	Fresh breeze	2.0	2.5	4	Moderate
6	24	12	22-27	11-14	Strong breeze	3.0	4.0	5	Rough
7	30	15	28-33	14-17	Near gale	4.0	5.5	5-6	Rough-Very rough
8	37	19	34-40	17-21	Gale	5.5	7.5	6-7	Very rough - High
9	44	23	41-47	21-24	Strong gale*	7.0	10.0	7	High
10	52	27	48-55	25-28	Storm	9.0	12.5	8	Very High
11	60	31	56-63	29-32	Violent storm	11.5	16.0	8	Very High
12	-		64+	33+	Hurricane	14+	-	9	Phenomenal

The Beaufort scale, which is used in Met Office marine forecasts, is an empirical measure for describing wind intensity based on observed sea conditions.

* Notes

1. These values refer to well-developed wind waves of the open sea.
2. The lag effect between the wind getting up and the sea increasing should be borne in mind.
3. The official term is Strong gale, however, the Met Office uses the descriptive term Severe gale

To convert knots to mph multiply by 1.15, for m/s multiply by 0.514.

Wave Forecast Parameters

Symbol	Definition	Description
Dir	Direction of sea	Mean (origin) direction of wind waves, usually equal to wind direction.
swell	Direction of swell	Mean (origin) direction of primary swell waves (= highest group of swell waves).
Hs	Significant wave height	Mean height (crest to trough) of highest third part of all waves. Equivalent to four times the square root of the area under the wave energy spectrum graph, which is usually referred to as the mean spectral wave height Hm0.
Hmax	Maximum wave height	Largest expected single wave height (equal to 1.667 times Hs). There is a 1% probability that this wave height is exceeded.
Hsea	Significant height of wind waves	Same definition as Hs but applied to wind waves only.
Hswell	Significant height of swell waves	Same definition as Hs but applied to swell waves only.
Psea	Mean period** of sea waves	The period corresponding to the weighted average of the wind wave energy.
Pswell	Mean period** of swell waves	The period corresponding to the weighted average of the swell wave energy.
Tp*	Peak wave period	The period with the maximum wave energy.
Tz*	Zero crossing wave period, also called mean spectral period	The average time interval between similar direction crossings of mean water level. The zero-crossing period can also be calculated from the moments*** of wave frequency spectra. Tz = square root of(m0/m2).

* Can be delivered on request, instead of the regular Psea and Pswell.
** Mean wave period, also referred to as Te, is derived from the zeroth and first negative moments*** of the wave frequency spectrum, i.e. Te = m(-1) / m(0).
*** Moments of wave frequency spectra are calculated from the surface elevation spectrum:
$mk = \sum \{(f)k * S(f)*df\}$ where: f is the band frequency, k is 0 to 4, and S(f) is band energy

Risk

Wind Speeds

A nautical forecast may contain the element "Risk 10m wind speed". It means there is 90% confidence that wind speed at 10 metres height will not exceed this value.

For example: suppose the average wind speed is 22 knots and the risk is 25 knots at a particular time. This means we expect the wind speed to be 22 knots at the forecast location, with 90% confidence that it will not exceed 25 knots.

For the computation of the risk wind speed, the following items are taken into consideration:
1) The usage of various models (in particular ECMWF, ECMWF-ENS, NCEP-GFS, UKMO)
2) Spatial wind variations of the different models within a range of 100km
3) Timing differences of these models
4) The occurrence of thunderstorms

Basically, this means that different solutions (tracking) of weather systems are taken into account. Different timings and associated winds generated by those systems are reflected within the wind risk.

How to interpret the risk wind speed:
1) The risk value applies to the 10m wind speed. Other wind speed parameters e.g. 50m wind speed and wind gusts will have a corresponding risk value, which can be calculated by applying the same ratio as between the risk wind and the 10m wind. Example: 10m wind speed is 24kts, risk wind speed is 30kts, 50m wind speed is 28kts. Then risk 50m wind speed is 28 x 30 / 24 kts = 35kts.
2) When there is a relatively large difference between 10m wind speed and risk wind speed, it means that there is a great uncertainty of the forecast thus a low forecast confidence for that particular place and time. The risk value should be treated merely as an indication of what could also happen.

Wave Heights

A nautical forecast may contain the element "Risk (significant) wave height". It means there is 90% confidence that the significant wave height will not exceed this value.

A similar explanation as above for risk wind speed applies to risk wave height, with the following remarks:
1) The models we particularly use for wave heights are ECMWF, ECWMF-ENS and NOAA-WW3.
2) Unlike risk wind speed, the risk wave height does not depend on the occurrence of thunderstorms. Enhanced winds near thunderstorms are usually short-lived, occurring only locally without a strong effect on wave heights.
3) Risk wave height applies to significant wave height. The value indicates what that could also be, with a 10% chance of exceedance. It is essentially different from maximum wave height, which is usually also provided in the forecast and denotes the upper limit for the height of a single wave. Nevertheless, the corresponding value for maximum wave height can be calculated by applying the same ratio as between the risk wave height and the significant wave height.
Example: Hsig = 2.4m, Hrisk= 3.0m, Hmax = 4.0m. Then the risk for Hmax is 4.0 x 3.0 / 2.4 m = 5.0m.

Forecast Glossary

Low pressure: An area of a relative pressure minimum that has converging winds and rotates in the same direction as the earth. This is counter clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Also known as a cyclone, it is the opposite of an area of high pressure, or an anticyclone. The typical N-Atlantic low-pressure forms outside the coast of Newfoundland and then moves eastwards towards the North Sea and the Norwegian Sea.

High pressure: An area of relative pressure maximum that has diverging winds and a rotation opposite to the earth's rotation. This is clockwise the in Northern Hemisphere and counter clockwise in the Southern Hemisphere. This is an anticyclone and is the opposite of an area of low pressure or a cyclone. In the North-West European Seas and the Atlantic Margin, high pressure usually means calm winds and stable atmospheric conditions. There is often an increasing risk of fog or misty conditions.

High pressure ridge: The extension of a high-pressure area. Forms a ridge-looking feature on a pressure map. Typically positioned in between two low pressures, causing a shorter period with calmer weather.

Storm centre: Strong low pressure where wind of force 10 (48-55 knots) or higher can be expected.

Pressure gradient: The rate of change of pressure with distance. Strong pressure gradients lead to strong winds, while weak pressure gradients lead to calm winds.

Cold Front: The leading edge of an advancing cold air mass that is under-running and displacing the warmer air in its path. Generally, with the passage of a cold front, the following occur:

- the temperature and humidity decrease
- the pressure rises
- the wind shifts (usually from the southwest to the northwest in the Northern Hemisphere)
- precipitation is generally at and/or behind the front. Shower lines (strong showers, perhaps with thunder) may develop behind the cold front.

Warm Front: Is the leading edge of an advancing warm air mass that is replacing a retreating relatively colder air mass. Generally, with the passage of a warm front, the following occur:

- the temperature and humidity increase
- the pressure rises slightly, but not necessarily
- the wind shifts (usually from the southwest to the northwest in the Northern Hemisphere), it is not as pronounced as with a cold frontal passage.

Precipitation, in the form of rain, snow, or drizzle, is generally found ahead of the surface front, as well as convective showers. Although clearing usually occurs after passage, some conditions produce fog, mist and drizzle in the warm air.

Occluded Front: Also known as an occlusion, it is a complex front formed when a cold front overtakes a warm front. It develops when three thermally different air masses conflict. The type of frontal boundary they create depends on the manner in which they meet.

Stationary front: A front, which is nearly stationary or moves very little since the last synoptic position. May be known as a quasi-stationary front.

Unstable atmosphere: Atmospheric condition dominated by high shower activity with strong showers and strong winds in connection with the showers and strong gusts.

Through Line/Squall Line: An organised line of Thundershowers. Often observed as a sudden onset of strong winds with speeds increasing to at least 16 knots (18 miles per hour) and sustained at 22 or more knots (25 miles per hour) for at least one minute. The intensity and duration is longer than that of a gust.

Polar Low: A small but intense cyclone that forms in cold polar air which then moves over warmer water. These vortices often form in the sub polar North Pacific and sub polar North Atlantic to the south of the sea ice margin. Horizontal scales range from several tens to several hundreds of kilometres. Because of strong winds and intense precipitation, these cyclones are sometimes referred to as arctic hurricanes.

Forecast Confidence (conf): Confidence in forecast. Given as High, Medium or Low. The forecast confidence is calculated based on ensemble spread and then adjusted by the duty forecaster.

High: Subjective evaluation carried out by duty forecaster. When confidence is high wind speeds can vary up to 6 knots from the forecast up to 48 hours and up to 10 knots over 48 hours ahead. Wave heights (Hs) can vary up to 0.5 metres from the forecast up to 48 hours and up to 1 metre over 48 hours ahead.

Med: Subjective evaluation carried out by duty forecaster. When confidence is medium wind speeds can vary up to 10 knots from the forecast up to 48 hours and up to 20 knots over 48 hours ahead. Wave heights (Hs) can vary up to 1.5 metres from the forecast up to 48 hours and up to 2 metres over 48 hours ahead.

Low: Subjective evaluation carried out by duty forecaster. When confidence is low wind speeds can vary more than 10 knots from the forecast up to 48 hours and more than 20 knots over 48 hours ahead. Wave heights (Hs) can vary more than 1.5 metres from the forecast up to 48 hours and more than 2 metres over 48 hours ahead.