Pembrokeshire Demonstration Zone – Wave Resource Assessment

Introduction

PDZ site

Figure 1: Pembrokeshire Demonstration Zone

Data

ERA5 (*Hersbach et. al., 2018*) datasets are provided by the European space agency for free. It provides a plethora of spectral data for ocean waves. The horizontal resolution for ocean waves is 0.5° x 0.5°.

Quality-assured monthly updates of ERA5 (1940 to present) are published within 3 months of real time. Preliminary daily updates of the dataset are available to users within 5 days of real time. Due to the latency of the Quality assured ERA5 dataset, currently there is no concurrent period with the FLS data and hence in this report we will only provide concurrency results with the ERA5T (preliminary dataset).

ERA5 combines vast amounts of historical observations into global estimates using advanced modelling and data assimilation systems.

The Wave parameters considered for this report are –

Table 1: ERA5 Wave Parameters

MAIN VARIABLES		
Name	**Units**	**Description**
Mean wave period	s	This parameter is the average time it takes for two consecutive wave crests, on the surface of the ocean/sea, to pass through a fixed point. The ocean/sea surface wave field consists of a combination of waves with different heights, lengths, and directions (known as the two-dimensional wave spectrum). This parameter is a mean over all frequencies and directions of the two-dimensional wave spectrum. The wave spectrum can be decomposed into wind-sea waves, which are directly affected by local winds, and swell, the waves that were generated by the wind at a different location and time. This parameter takes account of both. This parameter can be used to assess sea state and swell. For example, engineers use such wave information when designing structures in the open ocean, such as oil platforms, or in coastal applications.
Significant height of combined wind waves and swell	m	This parameter represents the average height of the highest third of surface ocean/sea waves generated by wind and swell. It represents the vertical distance between the wave crest and the wave trough. The ocean/sea surface wave field consists of a combination of waves with different heights, lengths, and directions (known as the two-dimensional wave spectrum). The wave spectrum can be decomposed into wind-sea waves, which are directly affected by local winds, and swell, the waves that were generated by the wind at a different location and time. This parameter takes account of both. More strictly, this parameter is four times the square root of the integral over all directions and all frequencies of the two-dimensional wave spectrum. This parameter can be used to assess sea state and swell. For example, engineers use significant wave height to calculate the load on structures in the open ocean, such as oil platforms, or in coastal applications.

Mean wave direction	degree true	This parameter is the mean direction of ocean/sea surface waves. The ocean/sea surface wave field consists of a combination of waves with different heights, lengths, and directions (known as the two-dimensional wave spectrum). This parameter is a mean over all frequencies and directions of the two-dimensional wave spectrum. The wave spectrum can be decomposed into wind-sea waves, which are directly affected by local winds, and swell, the waves that were generated by the wind at a different location and time. This parameter takes account of both. This parameter can be used to assess sea state and swell. For example, engineers use this type of wave information when designing structures in the open ocean, such as oil platforms, or in coastal applications. The units are degrees true, which means the direction relative to the geographic location of the north pole. It is the direction that waves are coming from, so 0 degrees means "coming from the north" and 90 degrees means "coming from the east".
Peak wave period	s	This parameter represents the period of the most energetic ocean waves generated by local winds and associated with swell. The wave period is the average time it takes for two consecutive wave crests, on the surface of the ocean/sea, to pass through a fixed point. The ocean/sea surface wave field consists of a combination of waves with different heights, lengths, and directions (known as the two-dimensional wave spectrum). This parameter is calculated from the reciprocal of the frequency corresponding to the largest value (peak) of the frequency wave spectrum. The frequency wave spectrum is obtained by integrating the two-dimensional wave spectrum over all directions. The wave spectrum can be decomposed into wind-sea waves, which are directly affected by local winds, and swell, the waves that were generated by the wind at a different location and time. This parameter takes account of both.

Results

The most commonly used parameters used to describe the spectral shape of ocean waves are significant wave height, mean period, and dominant (peak) period. Significant wave height is proportional to the square-root of total wave energy, and it tells us how much bulk wave energy is there at any given location. Mean period tells us how long the waves are, on average, and peak-period indicates how long are the waves with maximum energy. These are just statistical parameters describing the shape of the spectrum. The basic statistics like mean, standard deviation, min, max, and the 25th, 50th, and 75th percentiles of these parameters are presented in Table X.

Table 2: Wave Statistics

Statistics	Significant Wave Height H_{m0}	Mean Wave Period T_{m02}	Mean Wave Dir	Peak Period T_p
count	175320	175320	175320	175320
mean	1.615942	6.950706	238.140686	8.212909
std	1.00236	1.743074	57.310513	1.872609
min	0.132385	3.256947	0.011002	3.725577
25%	0.8847	5.628326	230.236359	6.790663
50%	1.362607	6.701629	248.070686	7.974737
75%	2.091584	8.061805	260.944763	9.41058
max	9.165155	15.97348	360.002808	18.727846

Figure 2 shows the distribution and the scatterplots for these parameters as a pair plot.

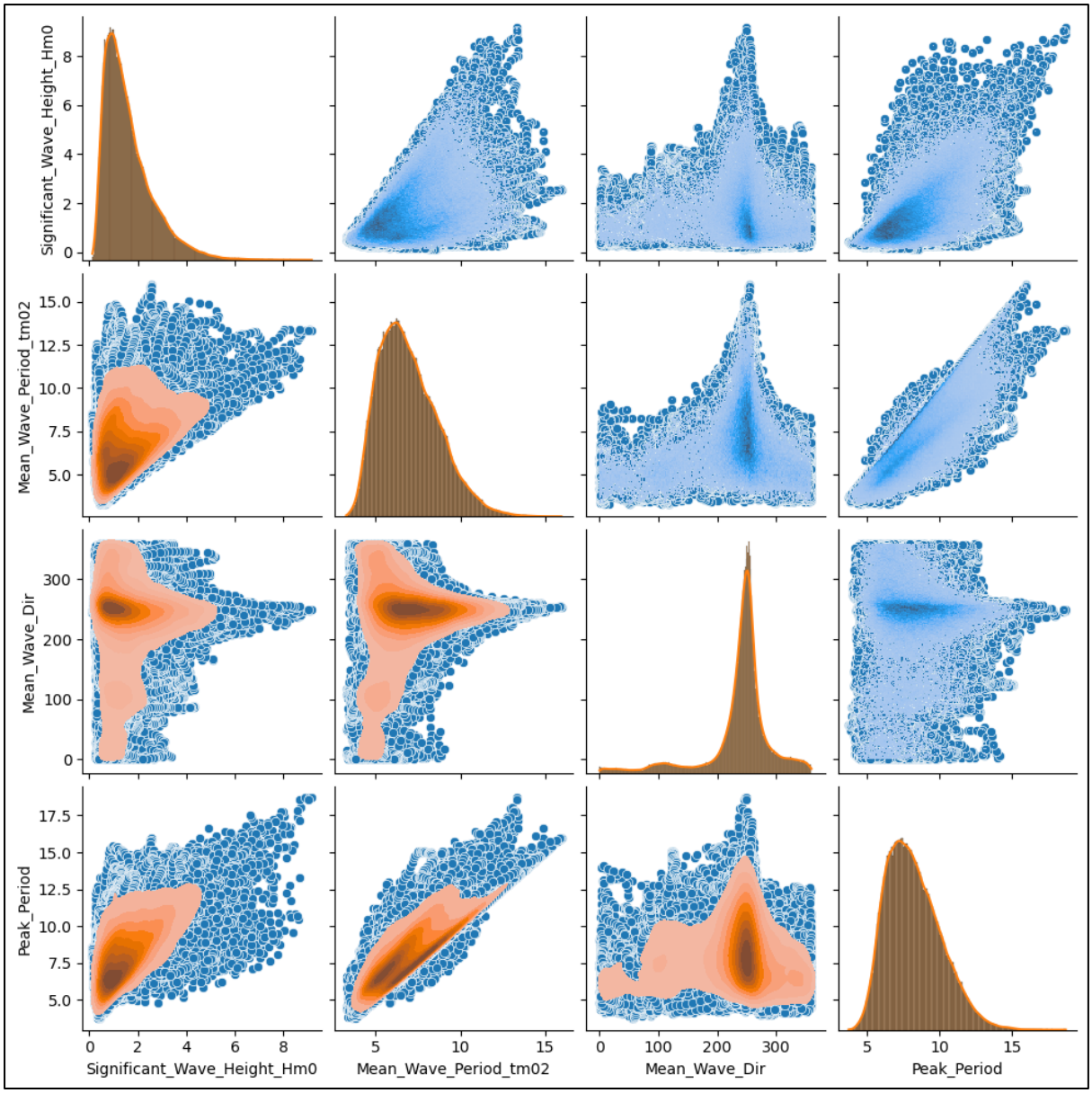

Figure 2: PDZ site: ERA Wave Parameters; Significant Wave Height, Mean Wave Period, Peak Wave Period, Mean Wave Direction.

Wave climate is very well described with the help of a matrix, the mean distribution of wave events for a range of significant wave heights Hm0, mean wave period Tm02, and mean wave period Tp at the ERA5 grid point nearest to the centroid of the PDZ site, during the period of 20 years from 2002 to 2021 is presented in Figure 3. The colour bar shows the occurrence of wave events in percentages.

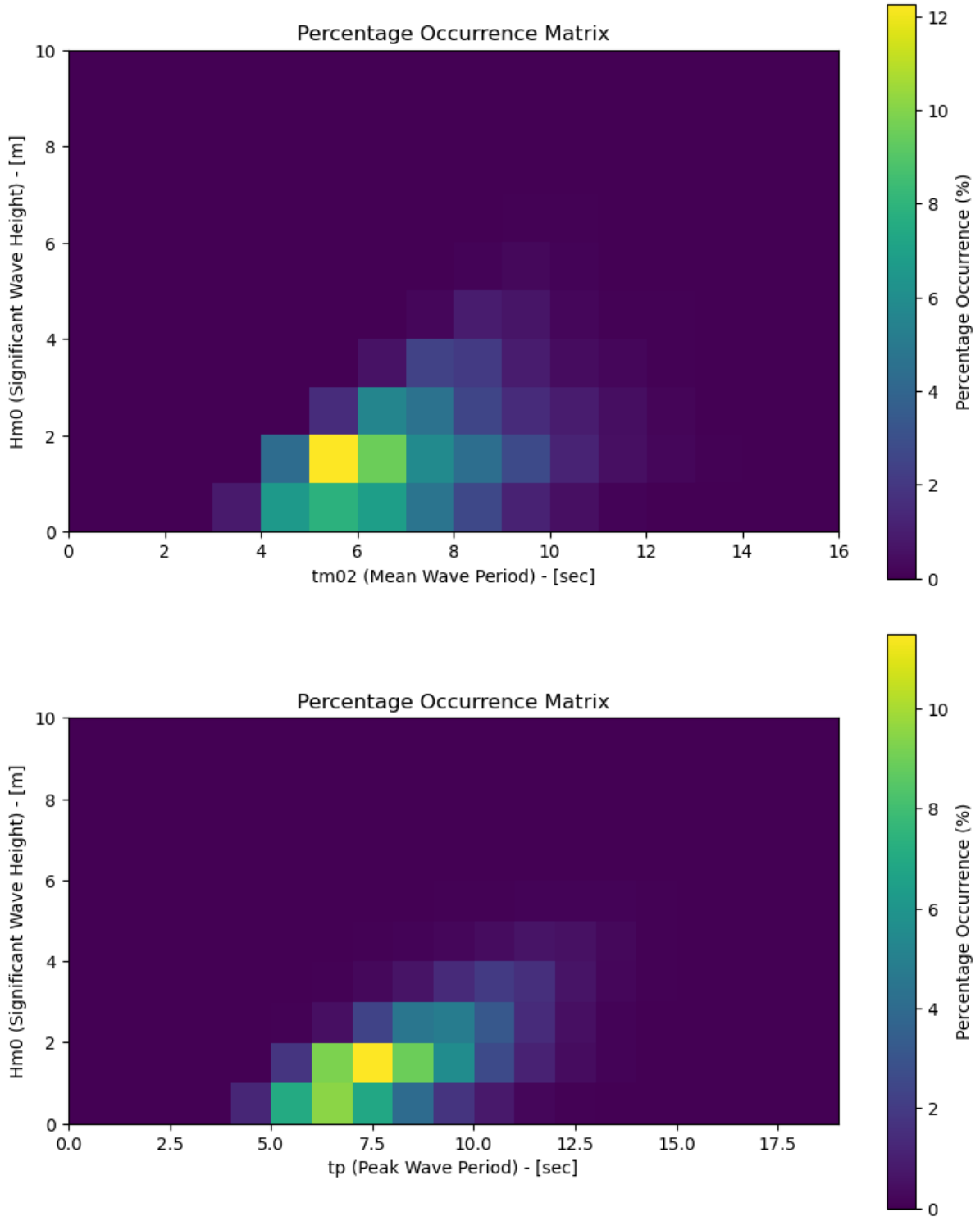

Figure 3: Mean Distribution of wave events for a range of significant wave heights H_{m0}, mean wave period and peak period T_p.

The timeseries plots are presented in the Figure 4.

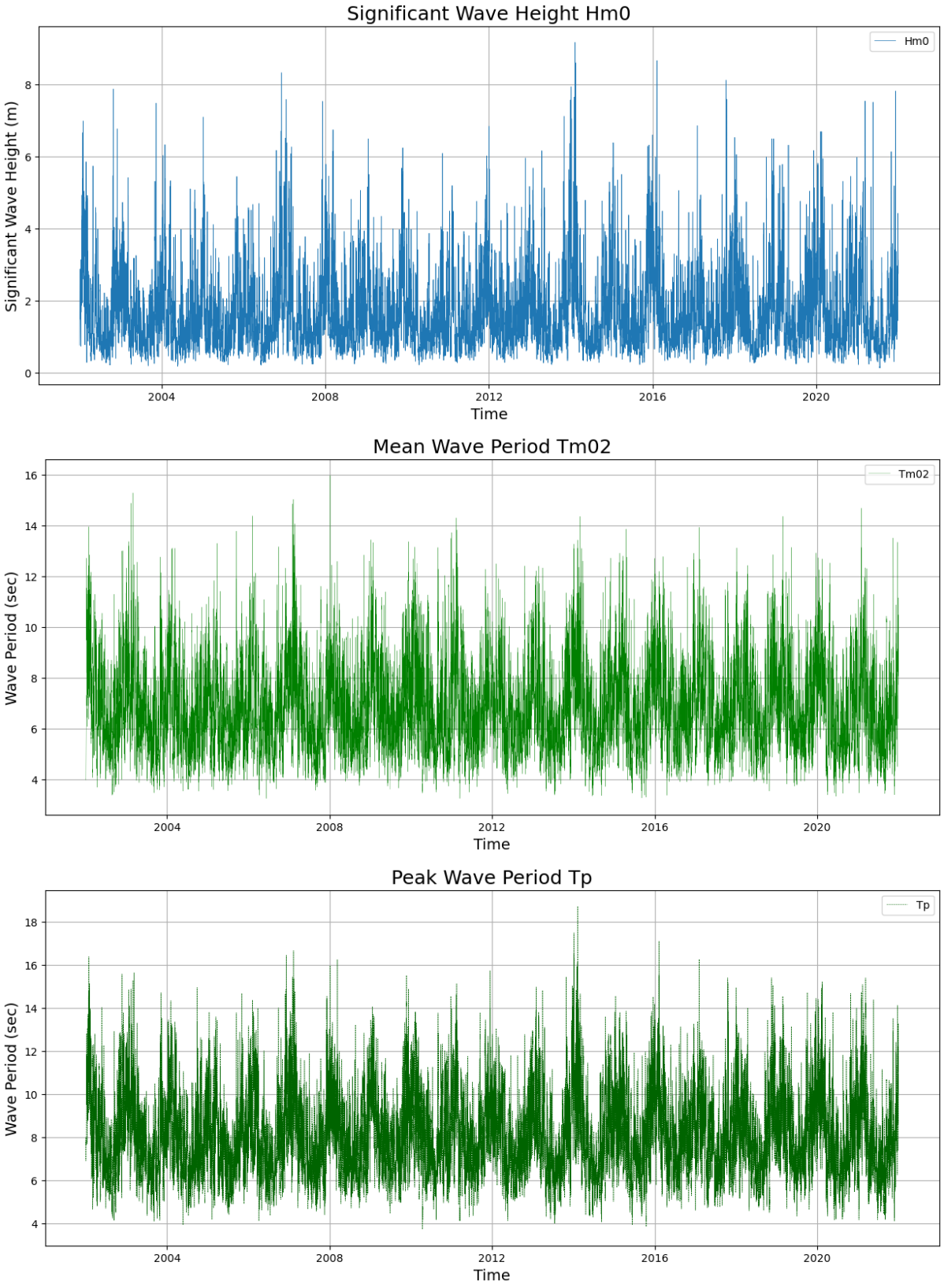

Figure 4: Timeseries plot: Significant Wave Height, Mean Wave Period, and Peak Wave Period.

The direction of the wave is predominantly from West-South-West, the time series plot for the mean wave period and the Wave Rose are presented in Figure 5 and Figure 6.

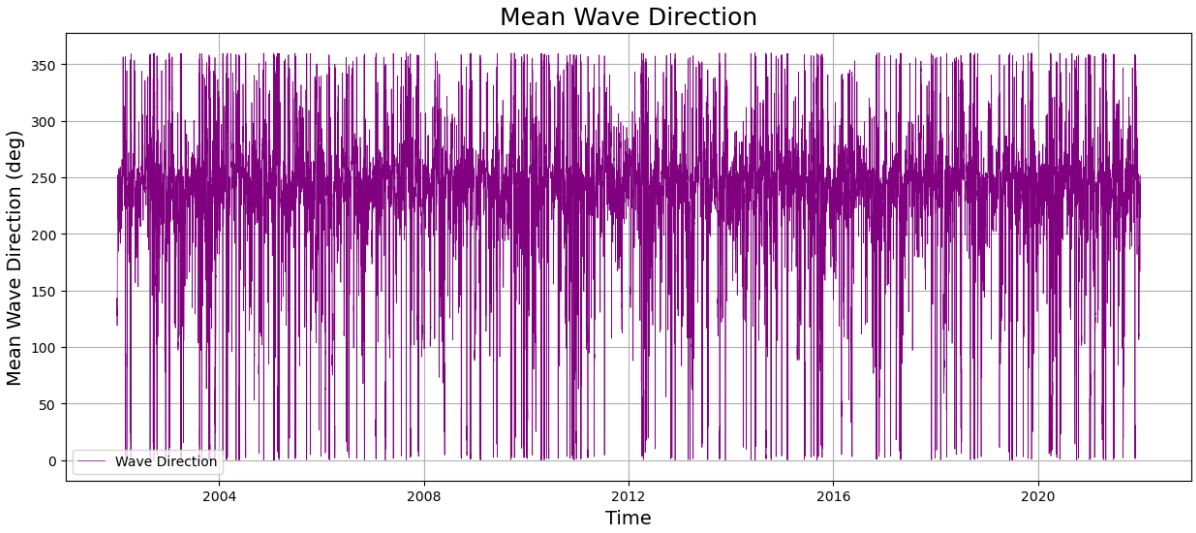

Figure 5: Mean Wave Period Time Series plot

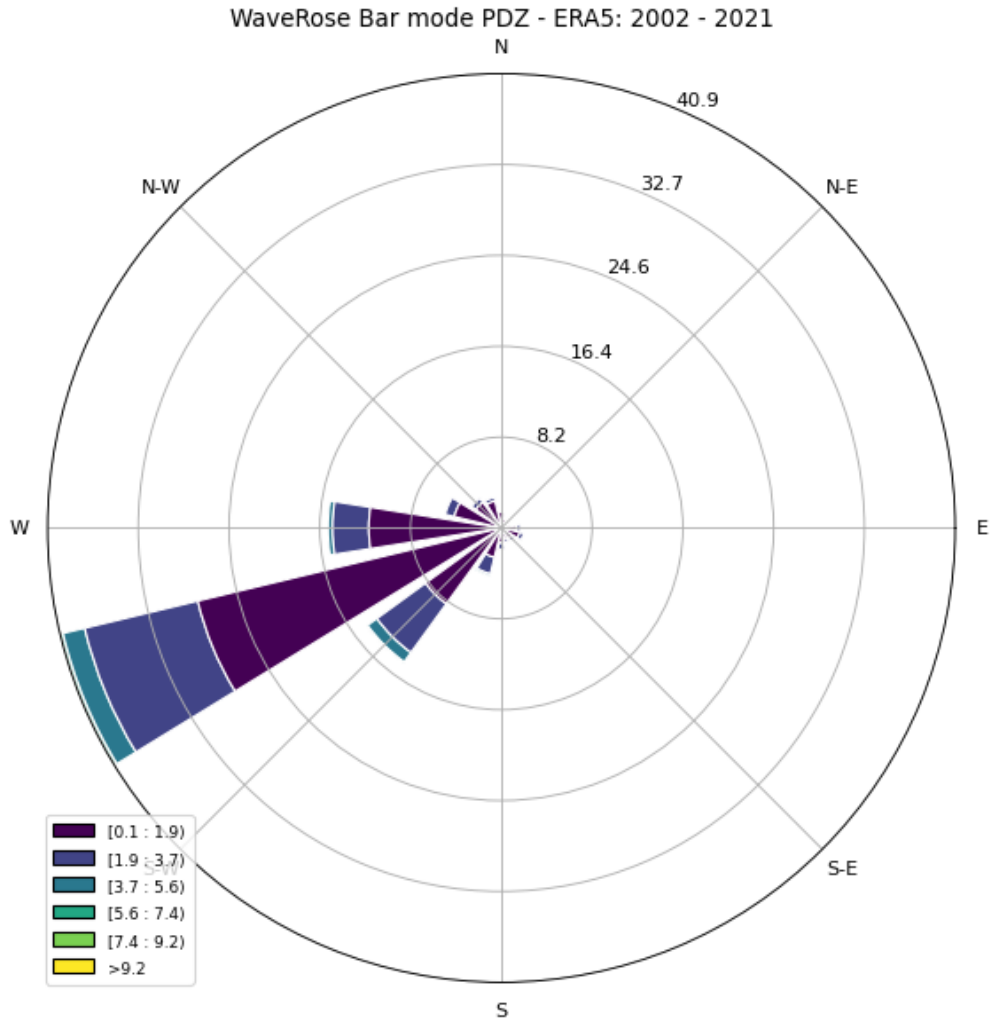

Figure 6: Wave Rose

The annual mean for Significant Wave Height for the 20-year period varies between 1.3m in 2010 and 1.8m in 2015. The annual, seasonal, diurnal variations of mean for the three parameters are presented in figure 7.

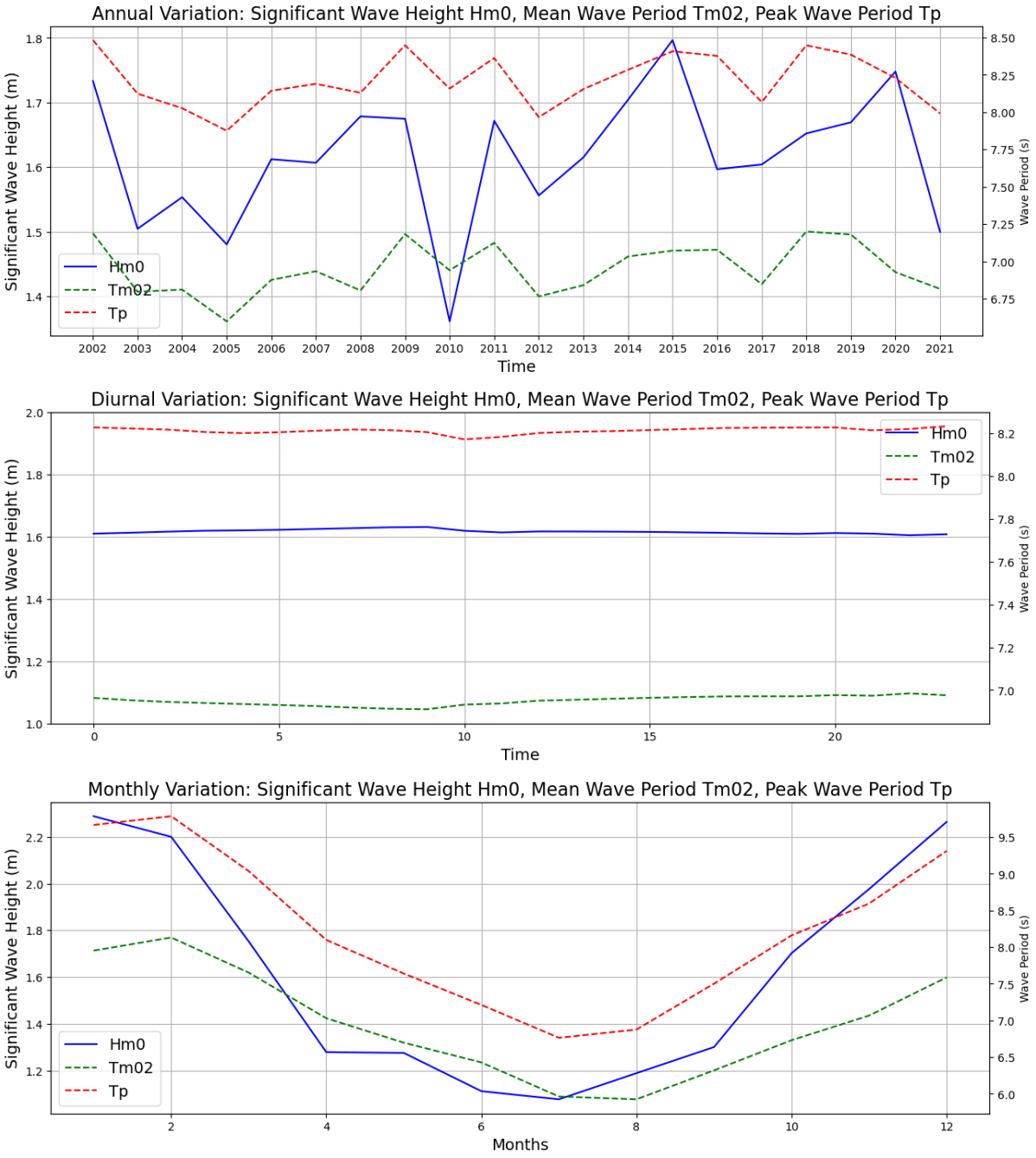

Figure 7: Annual. Seasonal, Diurnal variation of mean for Significant Wave Height, Mean Wave Period, Peak Wave Period.

References

Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2023): ERA5 hourly data on single levels from 1940 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), DOI: 10.24381/cds.adbb2d47 (Accessed on 07-Sep-2023)