WAVE CLIMATE IN DEEP AND COASTAL WATERS: NUMERICAL MODELS

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1.0 GENERAL ASPECTS

The oceanic climate and the winds in particular are a dynamic phenomenon that exhibits cyclic variations of short periods (days, weeks), seasonal variations and long period variations (e.g., ENSO). Considering that the wind is the principal wave generating agent, the wave climate will vary according to wind patterns. The influence of the wave climate on the construction and operating costs of maritime constructed works underscores the importance of designing these constructed works with all due consideration given to the variations over time of the wind climate on both an oceanic and local scale.

Within this context, the conventional method for compiling historic data on waves consists of preparing predictions of waves based on historic wind information (from synoptic charts of surface wind patterns and meteorological stations) over a period of not less than 20 years (Hydrographic and Oceanographic Service of the Chilean Navy (SHOA), Pub. Nº 3201, 2005). Using this information as the basis, the worst case extreme wind values of each year are selected for use to extrapolate the results to different return periods.

This procedure, known as hindcasting (e.g., the SMB, Sverdrup, Munk and Brestchneider methods), corresponds to a long-range statistical prediction of waves. The intensity of the wind during each event and the areal extent affected by the wind are part of the variables to be considered in preparing predictions as they have associated with them wave heights and periods related with each condition in particular. Thereafter, refraction and diffraction techniques are used to evaluate the wave conditions at each point of interest.

Notwithstanding the above, the results of this prediction method need to be calibrated, i.e., the values predicted by hindcasting must be compared with simultaneous measurements of waves made in situ. Consequently, the values predicted can be corrected in accordance with the degree of correlation that results from the calibration study.

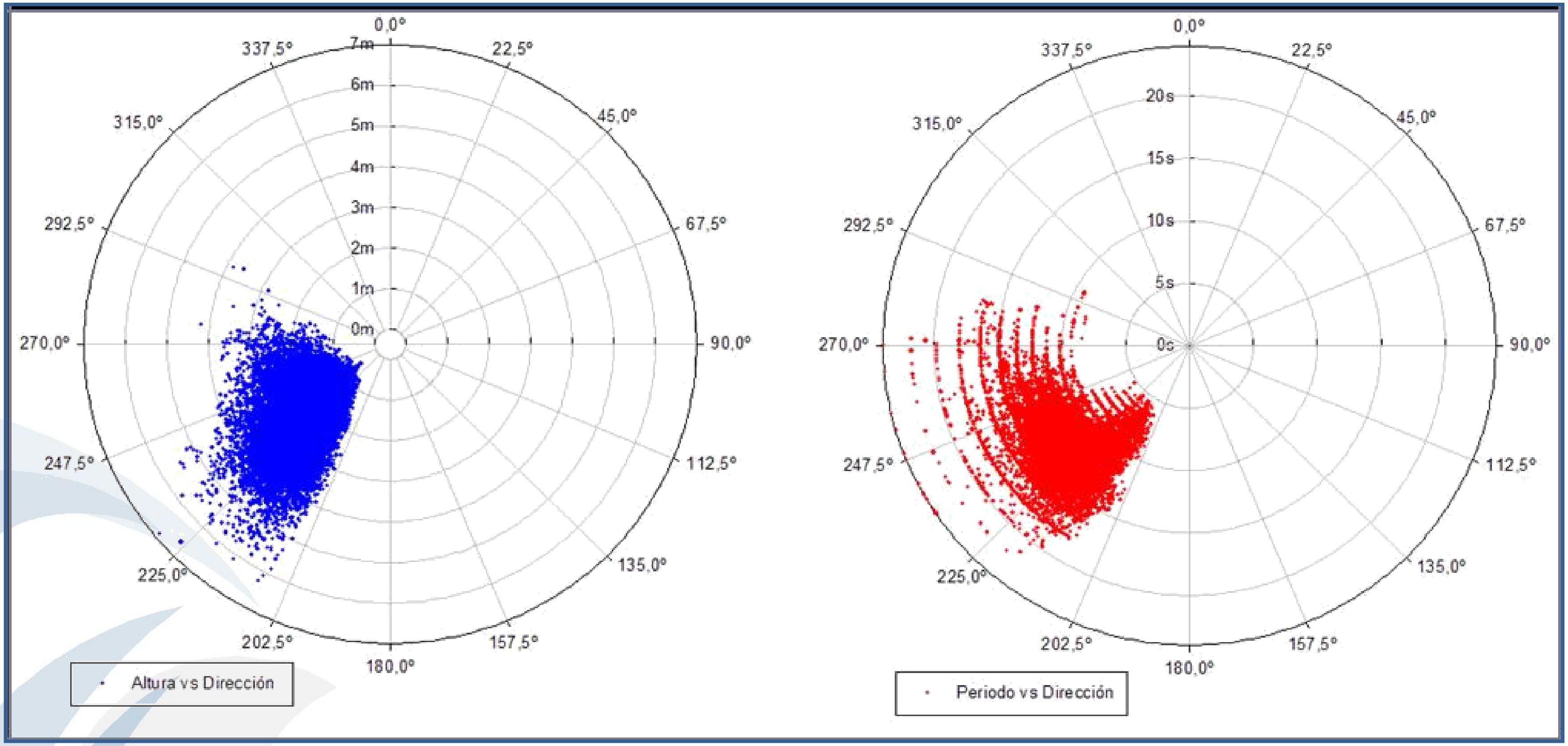
At present, and in keeping pace with technological development, a number of numerical models have been implemented for use in the estimation of waves in deep and coastal waters. This new methodology is comparatively more adequate than hindcasting, above all when considering the limitations of a technical nature that impinge upon the data input for hindcasting predictions. In this connection, it needs to be born in mind that synoptic charts of surface wind conditions reflect conditions at a general level and that meteorological stations, whether governmental or private, are not always located in areas and sectors that are representative for the particular study that is to be performed. In addition, these meteorological stations were of semi-automatic operation in the past and were not always accompanied by a sufficiently extensive and continuous database. Hence, it is appropriate to consider the use of this new predictive tool in the performance of the oceanographic studies that are to be performed along the Chilean coastline.

2.0 OPERATIONAL AND DESIGN MODEL OF THE WAVE CLIMATE

2.1 Sources of Information

Particularly to be noted among the principal sources of wave climate information in deep and coastal waters is the global database (statistical/directional spectral parameters) generated by the wave model of the European Centre for Medium-Range Weather Forecasts (ECMWF), which is used in turn as input for the FUGRO OCEANOR World Waves coastal model and for measurements of waves made by the GEOSAT and TOPEX altimetric satellites. In this connection, the satellite data are used to validate and subsequently correct the results of the World Waves model. The summary parameters output by the World Waves model include both wave and wind parameters, viz.:

Abbreviation	Parameter
Hm0 - Hs	Significant wave height (m)
Tm-10	Mean period (s)
MDir	Mean wave direction
HmOw	Significant height of local waves (sea)
Tm-10w	Mean period of local waves (sea)
HmOs	Significant height for swell
Tm-10s	Mean period for swell
WindDir	Wind direction (also sea direction)
WindSp	Wind speed (m/s)



Incidence of wave heights and periods in Chilean coastal waters (Source: *World Waves* model, *FUGRO OCEANOR*).

2.2 Wave Propagation

The wave climate in the area of interest is derived by means of spectral transfer. Using a propagation methodology in which a numerical model (STWAVE 3.0) is employed to transfer wave spectra for the purpose of obtaining the coefficients of height and directional variation, and these are then applied to the actual sea states of the waves in deep waters to thereby obtain the wave statistics for the study site. For the correct propagation toward the area of interest it is of vital importance to have precise and up to date bathymetric information on the study area to rely on.

BENTOS has prepared a number of processing routines in Matlab language that are specially designed to propagate the waves from deep waters to shallow waters using the coefficients of height and the coefficients of direction obtained by the numerical model (STWAVE 3.0) and, additionally, to prepare the wave characterization statistics (tables of incidence) for the points selected.

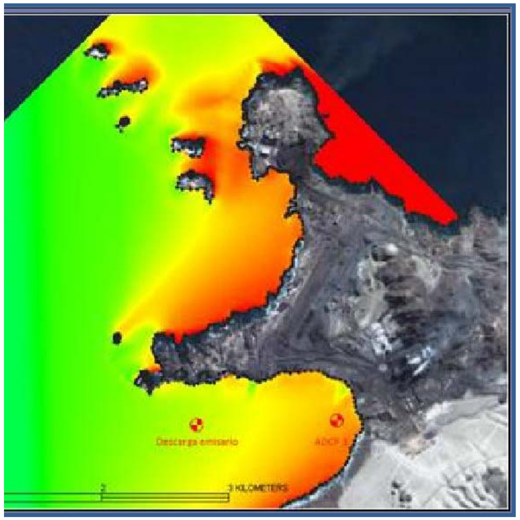


Image of spectra propagated by means of STWAVE software and location of the control points.

2.3 Results

a) Tables of Joint Distribution of Waves

The results of the model are presented in the form of tables by means of tables of joint distribution of directional waves:

- Significant height and mean period;
- Significant height and spectral peak period;
- Significant height and spectral peak direction;
- Height and direction of swell;
- Height and direction of sea,

b) Estimation of extreme values

For the estimation of extreme significant wave height values, Hm0, use is made of the Weibull or Gumbel distribution as applicable. In addition, extreme values are estimated by means of extrapolation of the distribution for return periods of 5, 10, 25, 50 and 100 years.

2.4 Validation

In regard with the validation of the wave model, the results of the transfer of the directional spectra to the site or interest are compared with measurements of waves made in situ during a minimum period of 30 effective days per campaign, in summer and winter, as indicated in Publication 3201 of the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA).

3.0 REFERENCES

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