

# Wave Forecast Description (AEMET/OPPE)

---

The Organismo Público Puertos del Estado (OPPE) together with the Agencia Estatal de Meteorología (AEMET) run and distribute a twice-a-day wave and wind fields forecast for the Northern Atlantic and the Western Mediterranean area. Wind forecasts, used to force the wave models, come from the HARMONIE-AROME model, running operationally at AEMET.

Wave forecast system starts a new execution twice a day, at 5 and 17 hours. Model output are available on Puertos del Estado web site one hour later (maps, plots and tables). The system is based on a set of model applications forced with HARMONIE-AROME forecasted wind fields provided by AEMET. The forecast horizon is 72 hours for all the domains. 1-hour-outputs are generated.

## Wind Fields

AEMET HARMONIE-AROME wind fields are used to force the wave applications since October 2018, when they replaced the former HIRLAM model fields as the official product provided by AEMET. Table 1 shows the evolution of the atmospheric forcings as well as the improvements in spacial and temoral resolution.

HARMONIE-AROME is a non-hydrostatic convection-permitting model. Fields represent 10-meter-height winds. Fields have a resolution of 2.5km and the forecast length is 48 hours. To ensure good initial conditions, before the forecast starts, the model is forced using wind analyzed fields of the 12 hours prior to forecast initialization.

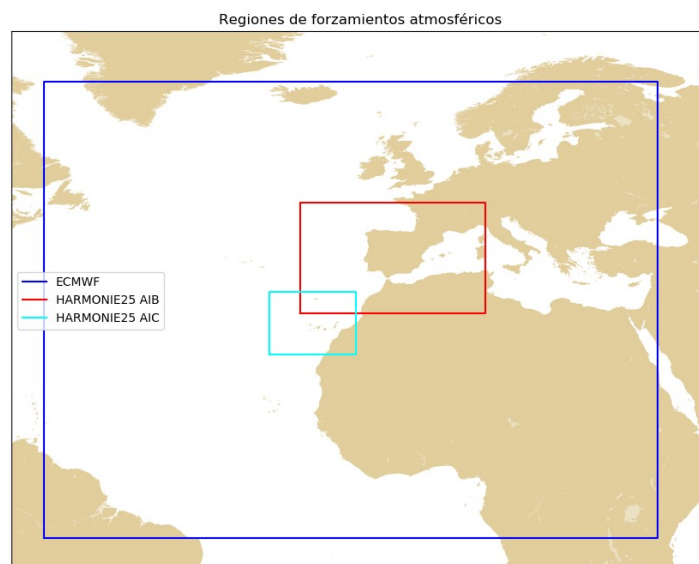


Figure 1. Atmospheric forcing domains since 2018

There are two HARMONIE-AROME applications, one centered on the Iberian Peninsula and the other on the Canary Islands. Figure 1 show the area covered by the AEMET model domains.

WIND						
Model	2006-2012		2012-2018		2018-present	
	temporal	spatial	temporal	spatial	temporal	spatial
<b>HIRLAM</b>	6h	16km	1h	5km	-	-
<b>HRES</b>	-	-	-	-	3h	10km
<b>HARMONIE</b>	-	-	-	-	1h	2.5km

Table 1. Evolution of atmospheric forcings and their spacial and temporal resolution.

To broaden geographic and temporal coverage, fields from the HRES model of the ECMWF (European Centre for Medium-Range Weather Forecasts) are used. It is an hydrostatic atmosphere global model with a resolution of 10km and a forecast length of 10 days. This model provides atmospheric fields every 3 hours.

## WAM wave model

WAM wave generation model (WAMDI, 1988), version 4 (Günther et al., 1991), integrates the basic transport equation. This equation describes the evolution of a two-dimensional ocean wave spectrum without additional ad hoc assumptions regarding the spectral shape.

The model was developed by a broad number of researchers from different institutions (WAMDI group), following 'Sea Wave Modeling Project' (SWAMP group, 1985) recommendations. One of the aims of the group was to develop an operational version of the model at the European Centre for Medium-Range Weather Forecasts (ECMWF). This was achieved in 1992 (Günther et al., 1992). In 1996 Puertos del Estado joined the group and has collaborated in differents aspects of the work done (Carretero and Günther, 1992). The group final report was released in 1994 (Komen et al, 1994).

Puertos del Estado developed and implemented a two-way nesting procedure in the model (Gómez Lahoz, Carretero Albiach, 1997) for the Spanish Coast. Using this system the equation is integrated in the same time step for all points. Since it is possible to define the spacing depending on the grid point location, it works as a variable spacing schema. The resolution is enhanced using intermediate grids, which are placed between the coarse and the fine grids. The version of the WAM model, the distribution of grids have changed

over time to introduce improvements. Table 2 shows the evolution of the existing applications and their resolution.

WAVES						
Domain	2006-2012		2012-2018		2018-present	
	temporal	spatial	temporal	spatial	temporal	spatial
<b>Mediterranean</b>	3h	8.3km	1h	8.3km	-	-
<b>Cantabric Sea</b>	3h	4.2km	1h	4.2km	-	-
<b>Cadiz Gulf</b>	3h	8.3km	1h	8.3km	-	-
<b>Canary Islands</b>	3h	8.3km	1h	8.3km	1h	2.1km
<b>Gibraltar Strait</b>	3h	1.6km	1h	1.6km	1h	700m
<b>Peninsula</b>	-	-	-	-	1h	2.8km
<b>Balearic Islands</b>	-	-	-	-	1h	1.4km

Table 2. Evolution of spatial and temporal resolution of wave model applications

The deep water WAM model is run for the Atlantic-Mediterranean domains, therefore the shallow water effects are not performed. Nested to this domains, specific applications have been developed for the Peninsula, Canary and Balearic Islands domains. All these latter applications use the shallow water version of the WAM model, therefore, refraction and attenuation effects are considered for those (few) grid points located in shallow waters. Figure 2 shows the present domains of the wave forecast system.

The regional scale grid (Atlantic-Mediterranean) use ECMWF HRES model wind forcings, whereas the rest of the applications, given that they are within the AEMET HARMONIE spatial coverage, are forced with this model. Since HARMONIE model forecast length is 48 hours, HRES model is used for the last hours to extend this length until 72 h.

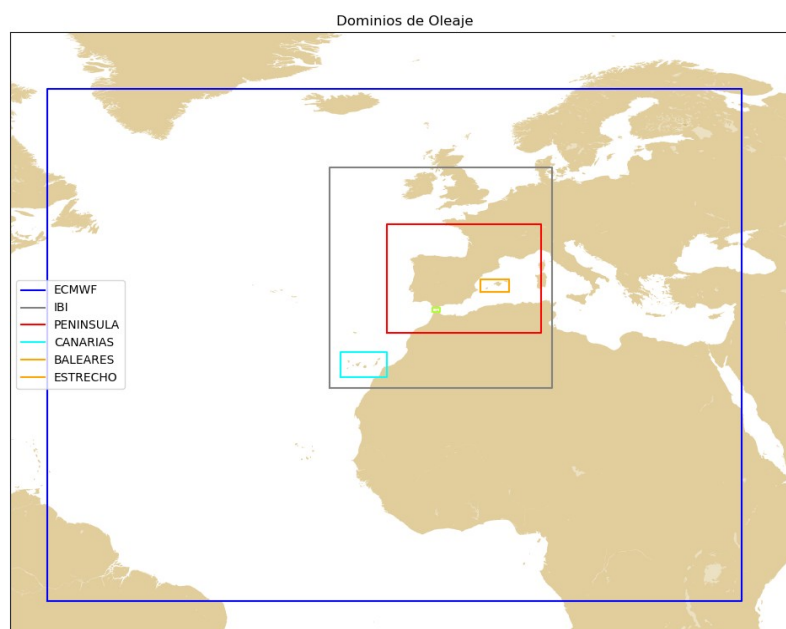


Figure 2. Wave forecast system domains since 2018

The model produces the wave directional spectra for each grid point. Then, it is used to obtain further information, i.e.:  $H_s$ ,  $T_p$ ,  $T_m$ , mean direction, wind sea and swell components, etc.

## **Local Wave Forecasting System at the Harbour Authorities (SAPO)**

The local wave forecast system at the Harbour Authorities (**SAPO** System) is formed by 72-hour local-scale forecast systems developed specifically for the harbour and its nearest surroundings. The system is based on the SWAN model considering waves transformations when they get near to the coast. SAPO applications spacial resolutions range from 350m to 150m, depending on the size of the coastal area to study and the geographical complexities of the region. In some cases an agitation forecast module inside the harbour is included in the system.