43-years of regional Tide, Storm Surge and Wave Hindcasts : HYWAT (1979-2022)

A 43-years (1979-2022) storm surge and wave hindcast was performed (forced by hourly, 30km resolution ERA5 atmospheric reanalysis) with the French Atlantic configurations of HYCOM and WW3 models developed for the HOMONIM project (French operational forecasting of storm surge and waves). The 43-years hindcast is freely available to the public. It provides the scientific community an important source of data for the study of storm surge and waves phenomena and their resulting impacts on the French Atlantic coast. This hindcast represents the first step towards climate modelling of coastal flood risk on the scale of the French Atlantic coast.

Validation against tidal gauge, wave buoys data and satellite altimetry are presented in the following paper: *Seyfried L., Michaud H. , Pasquet A., Leckler F., Leballeur L., Lopez L., Krien Y., Brosse F., 40-years of regional Tide, Storm Surge and Wave Hindcasts : Application to coastal flood risks along the Atlantic French coast, to be submitted to ESSD in 2023*
Please cite this paper when using the data.

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1. Description of the hindcast

The sea state hindcast is based on the Wavewatch III® model (WW3 v5.16, Tolman et al., 2019). This is a third-generation phase-averaged sea state model developed and maintained by NOAA/NCEP/NWS. In recent years, the model has benefited from major developments, notably by the French teams of Shom and Ifremer, which make it a model of choice for studying sea states at different scales. Indeed, the model integrates both the latest parameterizations in terms of offshore processes of wave growth but also takes into account coastal processes of interaction with currents and bathymetry. The physical parameterization corresponding to TEST 471 (Ardhuin et al, 2010, Leckler et al., 2013) was used. It was then adapted to the study area, calibrated and validated through comparisons to in-situ or altimetric measurements. The grid used is an unstructured mesh created by Michaud et al. (2015) as part of the HOMONIM project, aimed at improving the Surge and Wave Flood Forecasting System (VVS) system (Figure 1). This grid has been put into operational production for the VVS at Météo France. The unstructured grid is made of 92 757 computational nodes (i.e. 175634 triangular elements), with a resolution ranging from 10 km at the open borders of the domain and refining to about 200 m resolution at the coast. The bathymetry of this mesh is based on the 100 m resolution digital terrain model (DTM) produced by Shom as part of the HOMONIM project (Biscara, 2015). This configuration benefits from level and current forcing (offline coupling) from the HYCOM model, every 12 min and is forced offshore by a global replay of the same wave model, at a spatial resolution of 0.5°. At the surface, the model is forced by the ECMWF atmospheric reanalysis, ERA5.

As the Atlantic coast is strongly tidal, the effect of tide-induced current and water level variations and meteorological effects must be taken into account for the wave calculation (Michaud and Pasquet, 2016). The currents and levels are derived from a tidal and surge simulation of the HYCOM model (Bleck, 2002), a finite difference model with discretization on an Arakawa C-grid, in the Shom version (Baraille and Filatoff, 1995), in barotropic formalism. The HYCOM kernel specific to this simulation has been the subject of numerous numerical developments, both algorithmic and computational, in the framework of the Homonim project. The dynamics is modeled on a domain covering from 43°N to 62°N in latitude and from 9°W to 10°E in longitude. The grid used is curvilinear and allows a resolution of less than a kilometer on the French coast. The model uses the 500m and 100m resolution DTMs from the Shom carried out in the framework of the HOMONIM project (Biscara et al., 2014; Biscara, 2015) and manages the wetting and dying zones. The model is forced at the boundaries in surface elevation by the LEGOS 2011 NEA tidal atlas comprising the 15 components. The chosen bottom friction is spatially adapted to the configuration by a stochastic optimization process (Boutet, 2015). This configuration was developed in the framework of the HOMONIM project, by the Shom (Pasquet, 2016) in collaboration with Météo France, and is currently used operationally in the Météo France VVS system. Like the wave model, it is forced at the surface by the ERA5 atmospheric reanalysis.

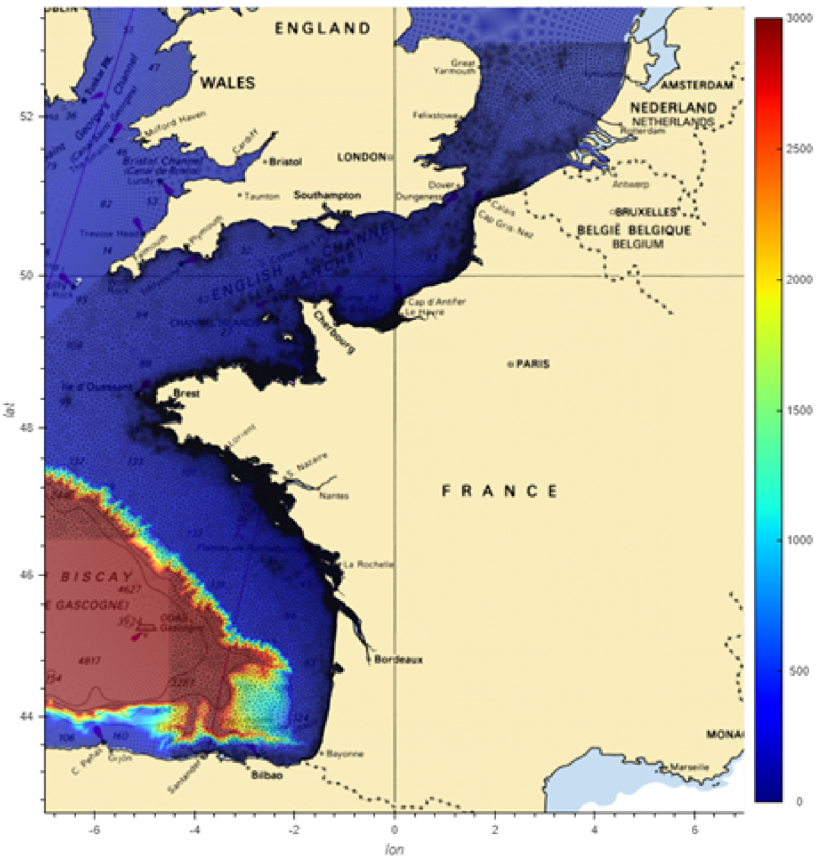

Figure 1: Marine map of the French Atlantic coast (Shom) with the overlay of the bathymetry of the HYCOM regional model (in color) and the unstructured grid of the WW3 regional model (black triangles).

2. Files description and arborescence

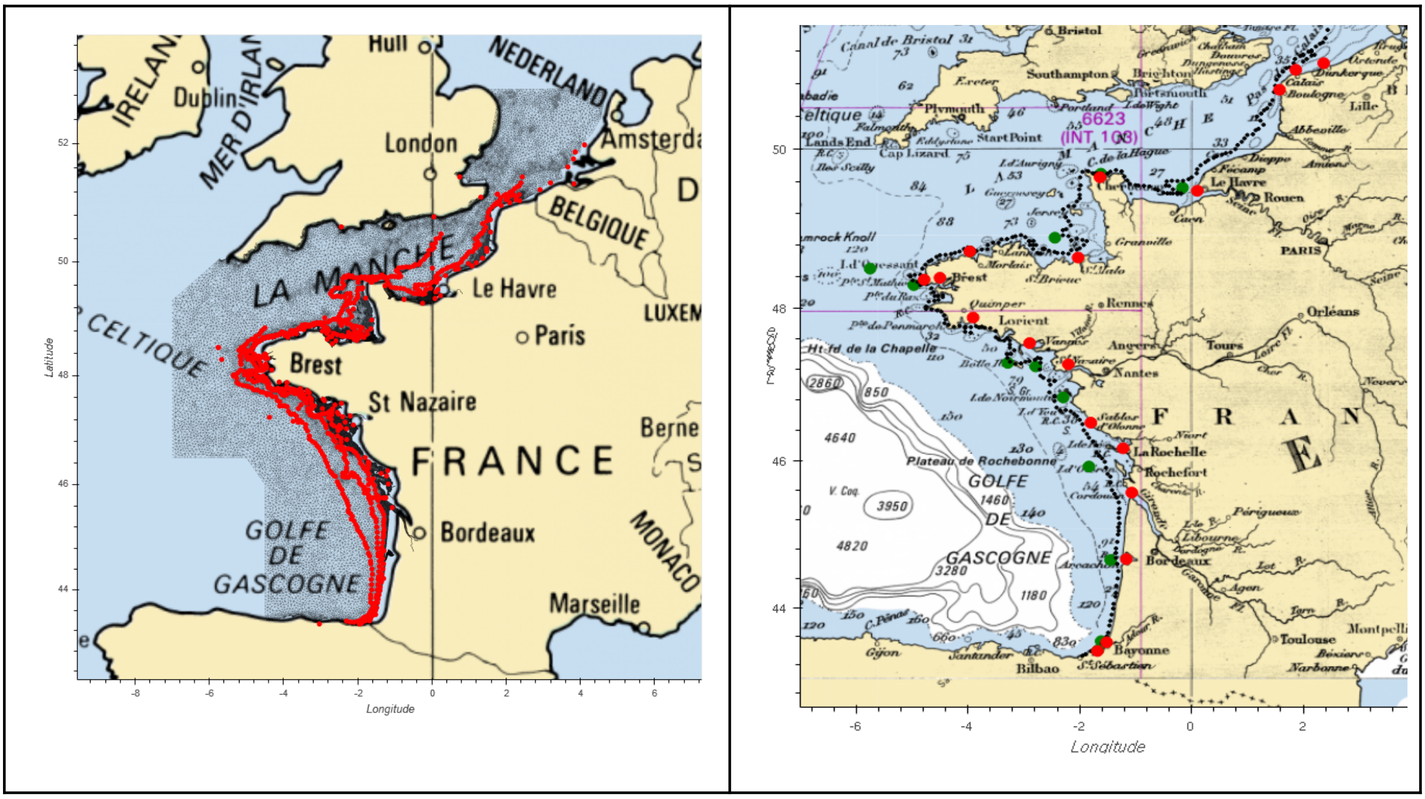

Figure 2: left: Output locations of the wave simulation (red dot) on the mesh (black points). Right: Nautical chart of the French Atlantic coast, locations of tide gauges stations (red dot) and wave buoys from the Candhis network (green dot). Wave hindcast output along the 30-m isobath (black dot).

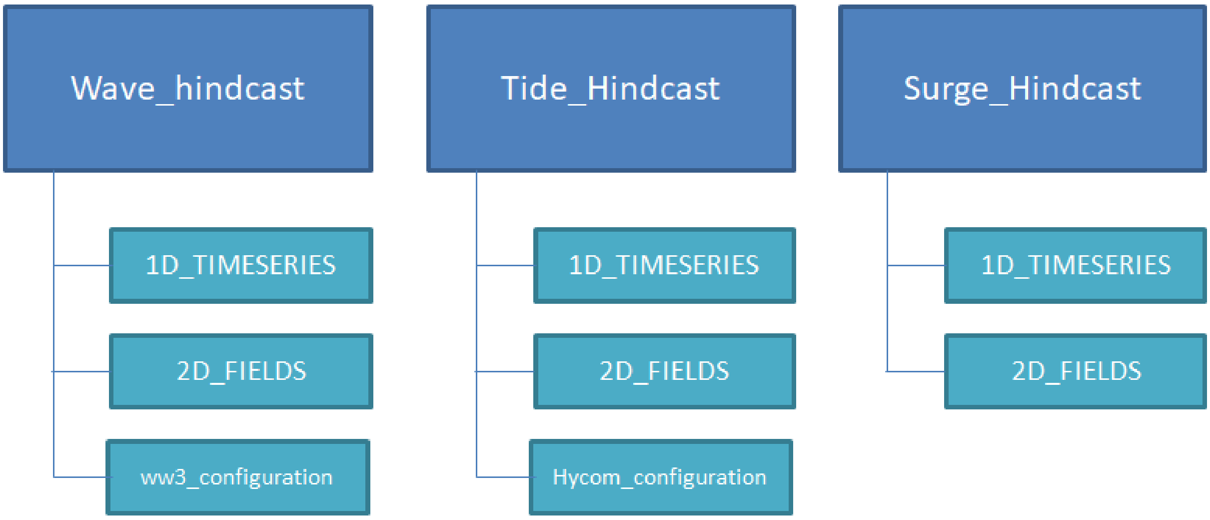

Figure 3: Arborescence of the hindcast

The different directories are:

- Wave_hindcast/
  - 1D_TIMESERIES/{year}/

  We furnish at an output frequency of 30min spectra and wave characteristics at XX output points located on the 30M, 50M and 100M isobath (files ww3.ISOXXM*nc), on the houlographic Candhis network (files ww3.0500*nc) on the tide gauges and on other points for diverse purposes (see figures 2 and 3 for the locations).

  Files are:
    - ww3.{point}_{yearmonth}*spec.nc : directional spectra, depth, wind speed and direction, current speed and direction
    - ww3.{point}_{yearmonth}*tab.nc: wave characteristics: hs(significant wave height), lm (mean wave length), th1p (dominant wave direction), sth1p(directional spread at spectral peak), fp (peak frequency), th1m (mean wave direction), sth1m (mean wave spreading)
  - 2D_FIELD
    - ww3.{yearmonth}.nc

We furnish at an output frequency of 60 min wave characteristics and forcings on the mesh. Files contain on each node these values:

Name of the variable	Description
dpt	depth
ucur	eastward current
vcur	nothward current
uwnd	eastward wind
vwnd	northware wind

wlv	sea surface height above sea level
hs	significant wave height
lm	mean wave length
t02	mean period T02
t0m1	mean period T0m1
t01	mean period T01
fp	dominant wave frequency
dir	wave mean (from) direction
spr	directional spread
dp	peak direction
tws	wind sea fraction
uust	eastward friction velocity
vust	northward friction velocity
cha	charnock coefficient
utaw	eastward wave supported wind stress
vtaw	northward wave supported wind stress
utwa	eastward wave to wind stress
vtwa	northward wave to wind stress
sxx	radiation stress component Sxx
syy	radiation stress component Syy
sxy	radiation stress Sxy
utwo	eastward wave to ocean stress
vtwo	northward wave to ocean stress
utus	eastward stokes transport
vtus	northward stokes transport
uuss	eastward surface stokes drift

vuss	northward surface stokes drift
uabr	rms of bottom displacement amplitude zonal
vabr	rms of bottom displacement amplitude meridional
uubr	rms of bottom velocity zonal
vubr	rms of bottom velocity meridional
bed	bottom roughness
ripplex	eastward ripple wavelength
rippley	northward ripple wavelength
fbb	wave dissipation in bottom boundary layer
utbb	eastward wave to bottom boundary layer stress
vtbb	northward wave to bottom boundary layer stress
mssx	eastward mean square slope
mssy	northward mean square slope

Table 1: List of the wave variables included in the 2D fields

- ww3_configuration : we furnish the list of the location and name of the output points (point.list).

- Tide_hindcast/
    - 1D_TIMESERIES/{year}/
      we furnish at a temporal frequency of 10 minutes, values of sea surface elevation (lssh_NAME.nc) at the RONIM tidal gauges (at the nearest grid point, Table 2).
    - 2D_FIELD:
        - lssh_global_ms_${period}.nc.gz
        - uv_${period}.tar (u_global_ms.nc.gz, v_global_ms.nc.gz)

      We furnish at a temporal frequency of 60 minutes, values of sea surface elevation (lssh) and currents (u,v) on the Hycom curvilinear grid.
    - Hycom _configuration : bathy_Hycom_ATLV4.nc that contains the bathymetry of the Hycom grid.

- Surge_hindcast/
  - 1D_TIMESERIES/{year}/
    we furnish at a temporal frequency of 10 minutes, values of sea surface elevation at the tidal gauges.
  - 2D_FIELD:
    - lssh_global_full_${period}.nc.gz
    - uv_${period}.tar (u_global_full.nc.gz, v_global_full.nc.gz)

    we furnish at a temporal frequency of 60 minutes, values of sea surface elevation (lssh) and currents (u,v) on the Hycom curvilinear grid.

Tidal gauge	Latitude	Longitude
ARCACHON_EYRAC	44.6754	-1.1685
BOUCAU-BAYONNE	43.5319	-1.5470
BOULOGNE-SUR-MER	50.7434	1.5726
BREST	48.3614	-4.5035
CALAIS	50.9872	1.8648
CHERBOURG	49.6666	-1.6205
CONCARNEAU	47.8611	-3.9316
DUNKERQUE	51.0675	2.3784
LA_ROCHELLE-PALLICE	46.1752	-1.2330
LE_CONQUET	48.3780	-4.7871
LE_CROUESTY	47.5274	-2.8988
LE_HAVRE	49.4797	0.0925
LES_SABLES-D_OLONNE	46.4910	-1.8216
PORT-BLOC	45.5653	-1.0495
ROSCOFF	48.7137	-3.9520
SAINT-MALO	48.6428	-2.0365
SAINT-NAZAIRE	47.2647	-2.1972
SOCOA	43.4187	-1.6827

Table 2: Position des marégraphes projetés sur la grille Hycom

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