

# Marine Forecasting Systems in Caspian Sea, Persian Gulf and Oman Sea

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## ABSTRACT

There are several global marine forecast systems based on large scale regional data covering Iranian seas which are freely available on their websites. They are also several local marine forecast systems in Iranian waters. This paper performs an inter-comparison among different marine forecasting systems in Iranian seas in order to evaluate the accuracy and difference between them and give a proper ground for further investigation and research in this crucial issue. For this purpose, the results of two forecasting system in several points in the Persian are compared and the reason of differences are investigated.

## 1. Introduction

The marine forecasting is of great importance for several reasons including planning marine operations, scheduling shipping movements, dredging, survey, berth maintenance or construction. There are several global marine forecast systems based on large scale regional data which do not consider the localized effects of seabed and land topography on local wave and wind climate. They are also several local marine forecast systems in Iranian waters. This study aims to perform an inter-comparison among different marine forecasting systems in Iranian seas in order to evaluate the accuracy and difference between them and give a proper ground for further investigation and research in this subject.

### Global Marine Forecast Project Covering Iranian Seas

MetOcean Solutions Ltd (MSL) operates a GIS tool for a 3-hourly 10-days wave forecasting namely WXTiles which does not include closed seas such as the Caspian Sea [1].

NOAA Environmental Modeling Center operates a 3-hourly 7-days wave forecast project using WWIII wave model and 0.5 degree GFS wind boundary conditions in Indian Ocean including Oman Sea and half of the Persian Gulf [2]. This project provides wind sea, primary and secondary swell parameters separately as output as well as spectrum, sources and bulletin in several point in Indian Ocean. Figure 1

shows NOAA Indian Ocean forecast in one time step for instance.

ECMWF Company provides three global wave forecast projects namely HRES-WAM (10 days, 0.25 degree), HRES-SAW (10 days, 0.125 degree) and ENS-WAM (15 days, 0.5 degree) by running WAM Cy41r1 model which are not freely available [3]. They do forecast every 3 hrs for the first 6 days and every 6 hrs afterwards.

### Iranian Authorities Forecasts in Iranian Seas

Currently, there are three different authorities which are performing wave forecasts in Iranian Seas.

Iranian Meteorological Organization (IRIMO) runs a 6-hourly 4-days wind and wave forecast system in Iranian seas. They first run a WRF local wind model with resolution of 10 km using GFS boundary condition and the output is the input to a SWAN wave model with resolution of 2.5km to generate wave field [4]. There is two open boundaries in Oman Sea wave model (18N, 66E) without applying any boundary conditions.

Iranian National Center for Ocean Hazards (INCOH) at Iranian National Institute for Oceanography (INIO) runs a 6-hourly 4-days wave forecast system in Iranian seas using WWIII wave model (spatial resolution 0.05 degree) forced by GFS wind boundary condition [5]. There is an open boundary at 15N without applying any boundary condition.

Isfahan Technical University (ITU) performs a 6-hourly 4-days wave forecast system for Ports and

Maritime Organization (PMO) in Iranian seas using WWIII wave model forced by GFS wind boundary condition which uses the same method that INCOH uses for wave forecasting [6]. They have validated their forecast model by comparison with those of DHI forecast in Persian Gulf [7].

K.N. Toosi University (KNTU) with cooperation of Institute of Geophysics (IG) is currently working on a wave and 3D current forecast system in the Persian Gulf for PMO. They plan to run a WRF local atmospheric model with resolution of 0.1 degree and the wind and pressure output will be forced to PMO-Dynamics in-house wave and 3D current models [8].

### Foreign Companies Forecasts in Iranian Seas

MSL operates a local 3-hourly 7-days wave forecasting namely SwellMap for Persian Gulf which provides swell wave parameters for recreational activities [9].

Based on PERGOS hindcast project, Danish Hydraulic Institute (DHI) with cooperation of OceanWeather Inc (OWI) runs a 3-hourly 7-days wave and current forecast in the Persian Gulf and Strait of Hormuz [10]. They use a modified NCEP wind field with spatial resolution of 0.75 degree as boundary condition which is adjusted using ship observations, QuikSCAT wind data and synoptic wind stations. Mike21 SW is run for wave forecasting and Mike21 HD 3D model for current and water level forecasting. The spatial resolution varies from 8 km offshore to 1 km near-shore. The output includes wave parameters, current speed and direction in different depth layers, and water surface level. Their results with coarse resolution is available on its website in time series, animation and tabular formats. Turkish State Metrological Service (TSMS) runs a 3-hourly 5-days wind and wave forecast project in Caspian Sea [11]. They first run a MM5 local wind model with resolution of 4.5km (inner domain), 13.5 km (outer domain) using 0.15 degree ECMWF IFS boundary condition and the output is the input to METU3 in-house wave model with resolution of 3 km.

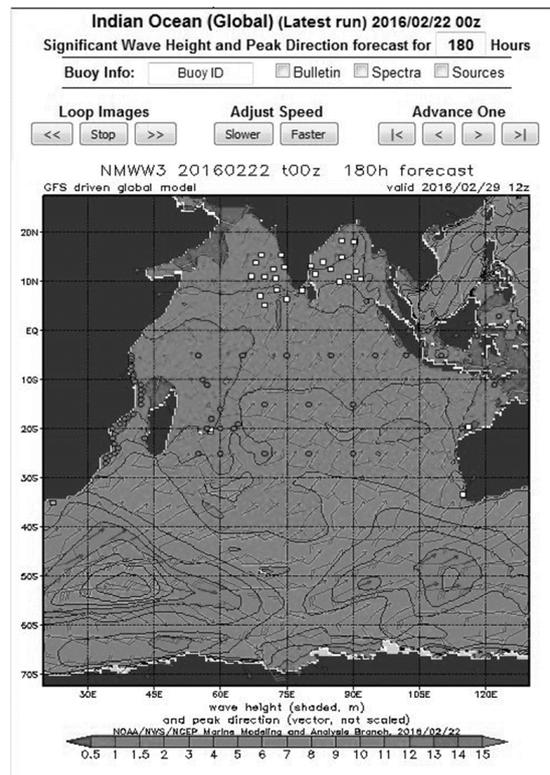


Figure 1: NOAA forecast in Indian Ocean

### Results and Discussion

We can categorize all above-mentioned forecasting systems in four main groups as below:

The first group is global forecast systems which use coarse wind fields as input and run wave models with relatively coarse resolution (MSL, NOAA, and ECWMF). Their results are not accurate in closed seas like Caspian Sea and Persian Gulf especially when they are surrounded by high mountain ranges like south of Caspian sea, however they work well in the open oceans.

The second group is local systems which use coarse global wind fields as input to local wave models with fine resolution (INCOH, PMO-ITU). Wind field as the main driving input for wave model is not improved in these systems therefore, the wave results are still not accurate despite the implementation of finer mesh resolution and better bathymetry resolving in the wave model.

The third group is the local systems which use modified global wind fields as input to local wave models (DHI-OWI).

The fourth group is the local systems which run both wind model and wave model with fine resolution (IRIMO, TSMS, KNTU-IG). They use global wind forecasts (GFS, IFS) as boundary condition for the local wind models.

The 3rd and 4th groups are the most accurate systems in our area and it is recommended to use them for forecasting purpose (IRIMO for all Iranian seas, DHI-OWI for Persian Gulf, TSMS for Caspian Sea).

The time series of the forecast data are only presented by DHI (covering only Persian Gulf) and INCOH (covering all Iranian seas) websites, therefore it is only possible to compare the time series from these two forecast projects in the Persian Gulf. For instance, Fig.1-3 illustrate the comparison between DHI (belongs to G3) and INCOH (belongs to G2) forecasts in south of Qeshm Island, vicinity of Bushehr port and Asaluyeh areas, respectively. DHI forecast is higher in Qeshm, as DHI's wind in Strait of Hormuz is higher and more accurate ( $CC=0.85, bias=0.3m$ ). INCOH's coarse GFS wind field is underestimated as this island is not well resolved in the wind model due to coarse land-sea mask and as a result high and unreal surface roughnesses in both sides of the strait. As for Bushehr Port, although two comparison points are 15 km away but results look very different and the reason for such a difference needs to be investigated. At Asaluyeh, despite their similar wave time series pattern, DHI point is located onshore while INCOH point is located offshore and they are 22 km away. This implies the necessity of application of a well-calibrated fine resolution model in Iranian waters via improvement of available forecasting systems for operational purposes.

**Recommendation**

For forecasting in Oman Sea, it is recommended to apply spectral or parametric wave boundary condition in open boundary or alternatively extending the Oman Sea mesh to cover the whole Indian Ocean to be able to capture properly the swells coming from the South Pole. Neither of the local forecasts have considered

the open boundary conditions. NOAA Indian Ocean forecast model is extended to South Pole and has no open boundary.

It is also suggested to plot the buoys data in a graph together with forecast data and put them in the forecasting website for comparison between “the forecast results and what is happening in reality in the seas” purpose. It is worthy to mention that IRIMO and PMO has 10 and 7 operating buoys in Iranian Seas, respectively [12, 13] which can be used in this regards. Figure 5 shows the location of these buoys in Iranian waters.

**References**

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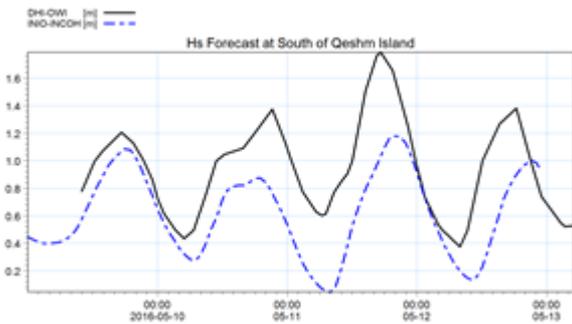


Figure 2 Comparison between DHI and INCOH forecasts at Qeshm

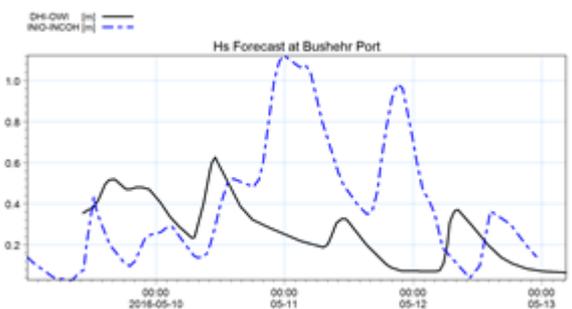


Figure 3 Comparison between DHI and INCOH forecasts at Bushehr



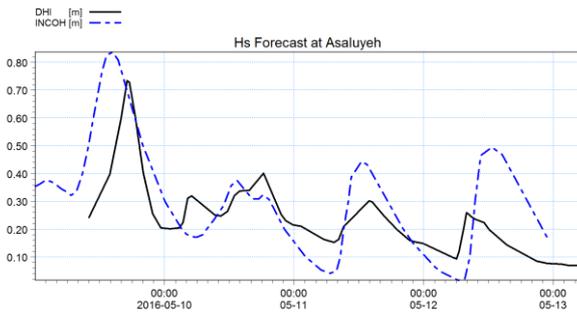


Figure 4 Comparison between DHI and INCOH forecasts at Asaluyeh

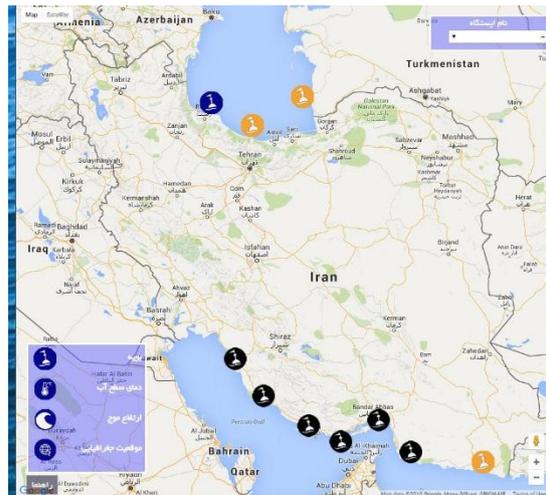


Figure 5 Location of operating buoys in Iranian Seas (left belongs to: PMO, right belongs to: IRIMO)