

Interactive comment on “Implementation and validation of a new operational wave forecasting system of the Mediterranean Monitoring and Forecasting Centre in the framework of the Copernicus Marine Environment Monitoring Service” by Michalis Ravdas et al.

Dr Bidlot (Referee)

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Not much to say, the paper explains well what was done to validate this new operational wave forecasting system, now part of CMEMS. So it will be a good reference. But there is not much to get excited about as the paper confirms what is already known about the different components of the system.

The authors would like to thank Dr. Bidlot for the constructive review that has helped improve the quality of the manuscript. We do agree that the content of this paper is not very innovative in a research perspective. However, the description of the model and its validation is comprehensive including interesting aspects of regional validation against satellite data that have not been as thoroughly presented before. As a result, we do believe that this paper is giving a further insight regarding model performance in the Mediterranean Sea and its sub-regions and can be indeed a good reference of a CMEMS product that is totally open, free and widely used by various users ranging from research groups and port authorities to the general public. In addition, it constitutes a base reference for future upgrades of the system.

Specific comments: p5, line 14: 24 directions is a bit low for 1/24 degree

The authors take into consideration the suggestion of the reviewer that the choice of 24 directions to discretize the wave spectrum is a bit low for a wave model with a 1/24 degree spatial resolution. However the present selection of the number of frequency and directional bins was dictated by the need of setting up an operational system (and its backup) able to produce wave simulations, 5-10 days forecasts and multiyear re-analysis at 1/24 horizontal resolution given the computational resources available. In any case, in many other recent applications of spectral wave models in areas with complex wave conditions, even in higher spatial resolution, (Emmanouil G. et al. 2016, Inghilesi R. et al. 2016, Galanis G. et al. 2017, Staneva J. et al. 2017) the wave spectrum was also discretized using 24 directional bins providing sufficient reliability. However, despite the results of Piche S. et al. (2015) that show that the increase of directional bins have significant effect on computational resources for only moderate improvement in model accuracy, we plan in the future to investigate the impact of increasing the number of directional bins on the forecasting skill and if notable to upgrade our system accordingly.

p5, line 18: as mentioned in the ECMWF documentation: <https://www.ecmwf.int/en/elibrary/17739-part-vii-ecmwf-wave-model> The value now used by ECWAM are $C_{dis}=1.33$ and $\delta=0.5$, changes that were made as part of CY38R1, but it is also combined with a change in wind input source term, where ZALP was reduced from 0.011 to 0.008 (see (3.5 and the following discussion). This change had the desired impact of reducing low frequency energy. In the paper, it is mentioned that the North Atlantic model has too much swell. So I wonder if the change to C_{dis} and δ was or not accompanied with the related change to ZALP. Incidentally, as far as I can see, these CY38R1 changes were also made in WAM 4.6.2

We have performed a comprehensive tuning of the free parameters of the dissipation function of WAM model (C_{dis} and δ) in order to alleviate the problem of underestimation of wave heights originating to a great extent by the underestimated surface winds, especially in enclosed areas of the Mediterranean basin. Hence, for the Mediterranean wave model the modification of these parameters (for C_{dis} from 2.1 to 1.33

and for delta from $\delta=0.6$ to 0.5) seems to improve the underestimation of wave height and yields to a better agreement with the observations (fig 1). For the coarse model, we agree with the reviewer that this combination of values for the dissipation parameters led to a slight overestimation of wave heights but we think that our system validation results are in agreement with similar studies carried out in the North-West Atlantic (Aouf et. al . 2017, Lorente et. al. 2018). Within the framework of planned forecasting system upgrades we currently test the latest available version of WAM (WAM 4.6.2) which incorporates, as the reviewer pointed out, besides these adjustments of the tuning parameters of the dissipation source term, the change of wave age tuning parameter ZALP from 0.011 to 0.008. The relevant sensitivity results will be presented in future work.

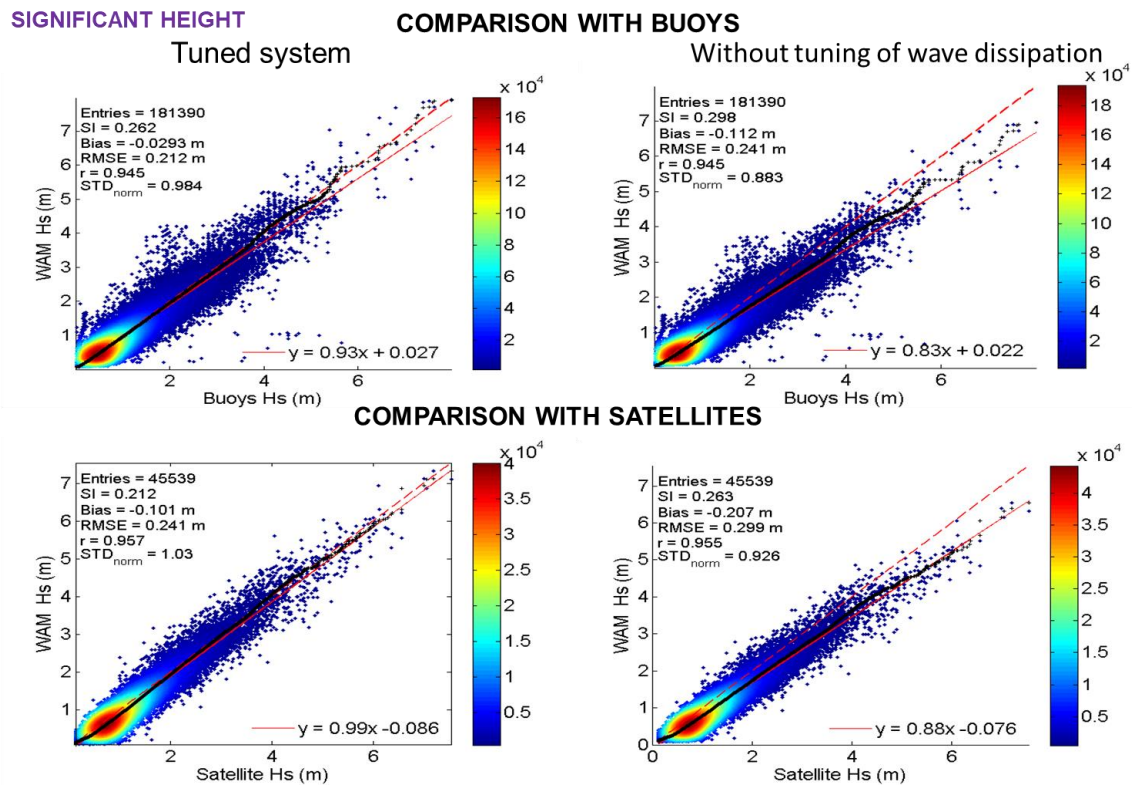


Fig1.

p6, line 3: is 6-hourly forecast still the case after day 3. ECMWF outputs forecast every 3 hours up to day 6 (Actually hourly up to t+90 hours, but the data are not available to CMEMS. ECMWF should be convinced hourly forcing data would be extremely beneficial, in particular for areas such as the Mediterranean Sea. The present study highlights the difficulty of getting good wind fields for the area, and mentions a need for higher spatial resolution but it should be mentioned that temporal resolution is also essential. Note that as far as the spatial resolution, ECMWF high resolution forecasts have now since spring 2016, a ~9 km resolution (from ~16km used in this study

We totally agree with the reviewer that in wind-wave dominated areas with complex orography such as the Mediterranean Sea, the accuracy of the wave model is strongly dependent on the quality and the resolution of the wind forcing used to drive model analyses and forecasts. Considering that our system is fully aligned to all the latest ECMWF outputs operationally available) higher temporal and spatial resolution wind fields offered by ECMWF would be a significant add on as it is expected to further reduce the bias in the wave model results. In the introduction and in the conclusions we point out this need for higher temporal and spatial resolution of wind forcing.

p6, line 33 and section 4.2: Tm: are you sure you use the same spectral definition for both the model and the buoy mean wave period. WAM usually add a high frequency tail for the calculation of the all integrated parameters and hence extend all calculation of infinity, whereas buoy parameters are usually only computed to the cut-off frequency (~ 0.5 Hz). For mean wave period, such as the T02, it can results in bias (model-buoy) ~ -0.5 s So what as done?

We have used the Tm02 mean wave period for both the model results and the buoy observations. The computation employed for the model estimation of Tm02 includes also the high frequency spectral tail as

this is standard for the WAM model. On the other hand, for the wave buoys, the frequency band (and the frequency cut off) where the mean wave period is calculated depends on the wave sensor and the software employed by each data provider and can vary for different buoys over the Mediterranean Sea (INSITU TAC, personal communication). Thus, a non-standard model estimation of Tm02 for each wave buoy over the basin, can be quite complicated. As a result, we believe that it is acceptable to proceed with the current approach and anticipate that there will be a bias in the mean wave period estimation.

In the revised version of the manuscript the first paragraph of page 7 has been extended in order to explain the difference in the computation of model and buoy Tm and that this difference is anticipated to introduce a bias in the model-buoy comparisons. In line with the previous, the first paragraph, p14, section 4.2, has also been extended.

p9, line 1: I notice that the positions for buoy 61218 and 61220 in Figure 1, do not seems to be what I have from the GTS data we have received: I have the following 61218: 43.83N, 13.72E 61220 45.33N, 12.52E

The GTS position for location 61218 seems to coincide with the location of the buoy in Figure 2 (GTS and CMEMS IN-SITU TAC locations also coincide in Google Earth). Regarding buoy 61220, the GTS coordinates place it more to the north than the CMEMS IN-SITU TAC coordinates which are: 44.97N, 12.66E. The latter have been used as provided by the CMEMS IN-SITU TAC; however, we have sent a request to the TAC for checking this out.

Noting the lack of agreement for 61218, even though it appears to be one of the most exposed buoys is still surprising, so I just wonder if there is simply and position error

From the previous, at least with respect to buoy 61218, we believe that this is not a position error. Firstly, the buoy is located within the North Adriatic Sea, which as shown in Figure 8, p31 (depicting regional model-satellite comparisons) is a region with poor overall statistics compared to the rest of the Mediterranean Sea. In addition, the QQ-Scatter and time-series plots below (fig. 2 & 3), which correspond to location 61218 for year 2014, show that the model has failed to reproduce a number of stormy wave events at the location. These 'outliers' (also in Figure 4, p28) could have introduced some extra bias to the computed statistics. These events happened between the 10th and 15th of January 2014 and mostly belong to a single storm.

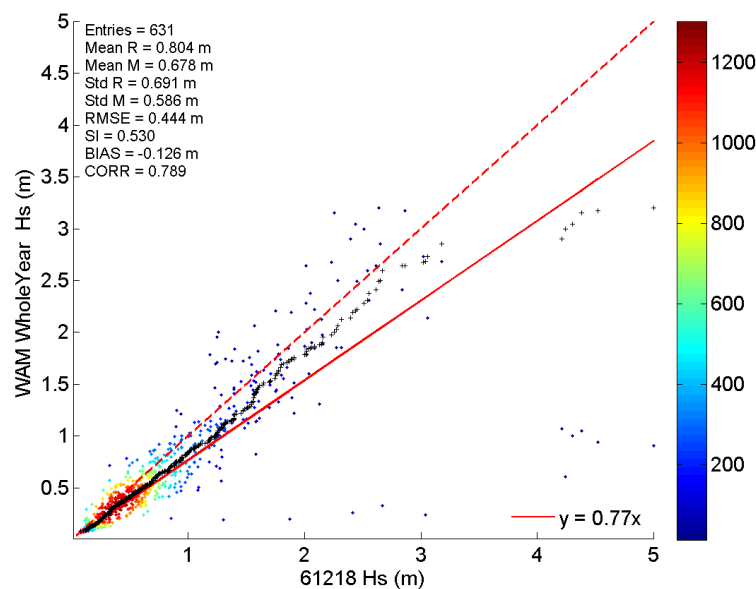


Fig2

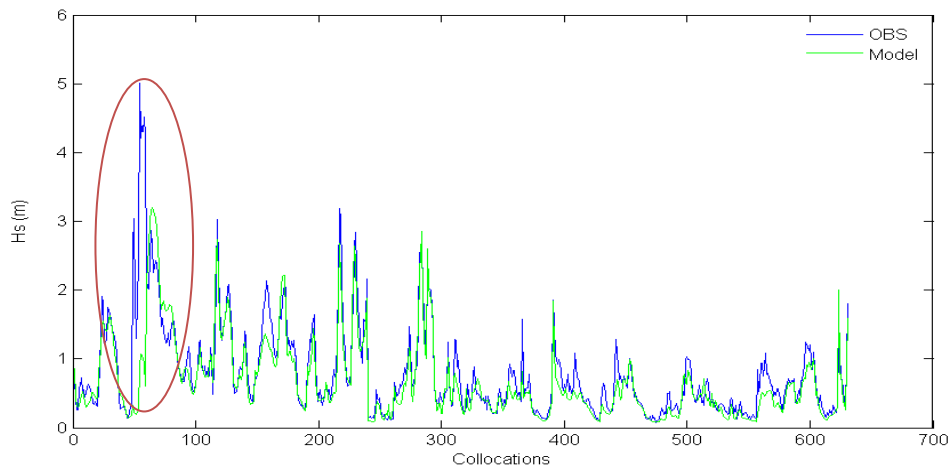


Fig. 3

p11, line 23: why are there not altimeter below ~ 2m/s?

This comes from an older analysis where altimeter U10 obs < 2 m/s have been removed considering that altimeter measurements below 2 m/s are not very reliable (e.g. Cavaleri and Sclavo, 2006). However, in later analysis and now in the paper (revised version) we have included all observations obtained from CERCAT-IFREMER considering that these are filtered and corrected and according to the provider they can all be considered as valid. The revised analysis has lead to marginal improvement in BIAS and CORR and a marginal deterioration in SI. In general, full MED and regional statistics have been so slightly affected by this revision. The revision includes:

- Fig. 7 (left)
- p11, lines 25-26: minor modifications
- Fig. 8 (left column)
- Fig. 10 (top row)
- p15, lines 21, 28: change of percentage numbers

Minor corrections:

p2, line 18: Forecast -> Forecasts mid-range -> medium-range

Corrected

p3, line 29: Holthuijsen

Corrected

p6, line 21: Stokes

Corrected

p8, line 21, Figure 7 -> 8 (?)

It was Fig. 8, corrected to Fig. 7.

p8, line 23: what is said in the text about Figure 4 is not very visible. Could you add a plot of just the QQ plot

The QQ plot alone has been added to Figure 4. In agreement, the figure description in the first paragraph of Section 4.1.1 has been modified.

p8, line 26: there are only a few outliers, out of ~67000 collocations, it will only have a very minor impact.

These outliers all correspond to location 61218 in the Adriatic Sea as seen in the Scatter plot inserted above. In the revised manuscript, this fact was mentioned while the comment on the impact of the outliers on the overall statistics has been removed.

p9, line 9: well reproducing -> reproducing well

Corrected

p11, line 17: well approximate -> approximate well

Corrected

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