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ARTICLE

Comparative Study of The ALADIN and AROME Wind Effect on Waves Characteristics: Application On The International Port Of Algiers

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ABSTRACT

Numerical modeling of sea states has been developed for years, and used for varied fields such as coastal work sizing, navigation safety, beaches and water leisure stability study. The third-generation ocean wind-wave spectral model WAVEWATCH III (WW3) software was adopted and developed to simulate wave propagation in the Mediterranean basin. In this work, a more detailed study was carried out on the port of Algiers. Two different atmospheric models have been used to get the wind forcing: ALADIN (Area Limited Dynamic Adaptation Inter National Development) with an 8 km resolution. And AROME (Application to Operational Research at Meso-scale) with a 3 km resolution. The results obtained using both of the atmospheric models have been compared and analyzed.

1. Introduction

The sea states Forecasts is historically linked to the military and commercial navigation security. For these applications, we first look at the wave's significant height and the mean period. Any marine activity is utilizing sea state forecasts in various forms. Thus the towing of large installations (barges, drilling platforms) and their use may require detailed information on the height of ridges, the energy of long waves that can arouse resonances in anchors. Sea states play an important role in the ocean surface mixing and coastal circulation, with effects that are beginning to be well understood [1,2,8], but the subject is far from exhausted. Thus the amplitude of long waves forced by waves, responsible for the generation of cuttlefish in small ports [7], and coastal circulation can be linked empirically to sea state parameters, but their detailed and quantitative explanation is not yet resolved. The vertical structure of the coastal currents and their role in the exchanges between the coast and the offshore are still very poorly known: it is nevertheless the vehicle of the mineral salts,

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nutrients, plankton and pollutants, which makes coastal zone management very sensitive.

Several works dealt with wind waves in numerical modeling. Bouws et al. [4] presented a self-similar spectral form (the TMA spectrum) to describe the finite deep wind waves. In order to show the general validity of the form, this self-similar spectral selected about 2800 spectra from three data sets (TEXEL storm, MARSEN, ARSLOE). Chen et al. [5] used an unstable curvilinear spectral wave model, which offers the flexibility to solve the large bathymetric and geometric gradients and enable to take into account the unstable forcing and currents allowing to predict the wind waves in Mobile Bay, Alabama. To test the wave's curvilinear model, Chen et al. [5] have chosen a set of laboratory data on wave transformation for a high circular background. Where they founded an excellent agreement between numerical results and laboratory measurements; and this for a directional wavelength input and a fine spatial resolution. In order to predict the variation of water levels and the current field that serve as the basis for the wave model, he used a three-dimensional circulation model and compared the results to existing field measurements of wind waves in Mobile Bay. Numerical simulations are conducted to examine the effects of grid resolution and estuarine circulation on model results. The study shows that the technique of linking a spectral wave model with a hydrodynamic model on curvilinear grids is an effective tool for predicting waves in estuaries. Adapting the Third Generation of Spectrum Sea Wind Model, WAVEWATCH III (WW3), operational since January 2005 at the Department of Applied Sciences of the University of Parthenope (Italy). Benassai & Ascione [3] simulated the spread of the waves in the Naples Gulf. The model has been coupled to the PSU/NCAR meso-scale model (MM5), which gives the forcing of the wind at one-hour intervals. The model is implemented using a configuration of four nested networks covering the Mediterranean Sea to the Naples Gulf. The internal mesh is having a higher resolution of 1 km*1 km. Simulated directional spectral waves were compared to storm surge data recorded in the winter of 2000 off the Naples Gulf and to wind-wave data collected by Idrografico and Mareografico off the mouth of the Sele in the Salerno Gulf. It showed that by the implementation of the wave model with reference to December 2004 storm on the Naples Gulf coast the need for a regional model of wind waves for this complex area from the orographic point of view. Ardhuin, et al. [1,2] used four different meteorological models and three different wave models to compare the characteristics of wind and waves measured in the Mediterranean basin, with satellite observations. Or he found that near high-resolution coasts, nested wave patterns are needed for sufficient reliability. An analysis of the wave threshold suggests sufficient reliability only off the coast, with a substantial decrease for low-level waves. Zijlema et al. [9] proposed to use a low value of quadratic friction law empirical coefficient for both cases: waves in a storm and swell. Examining a large number of more recent observations gives a new configuration of the wind drag with lower values he deduced from the same storm the lower value of the coefficient of friction lower. Zijlema also proved that using this lower value also improves estimates of wave growth in shallow waters and the decay of low-frequency waves in a tidal entrance, regardless of the wind drag. Zodiatis et al. [10] presented the main characteristics of the wave's energy potential in the Levant basin, eastern Mediterranean. This zone plays a significant role in exploration/exploitation of energy resources. The numerical results are analyzed using various statistical measures. He found that the regions where the wave's energy potential is increasing are mainly the western and southern coasts of the island Cyprus, the maritime areas of Lebanon, as well as the Egyptian coastline, especially around Alexandria. In these areas, the wave potential energy is relatively low but also stable and therefore exploitable. However, the non-negligible impact of infrequent values is also recorded. Mentaschi et al. [6] analyzed the Wavewatch III wave model performance forced by a limited-surface atmospheric model for the Mediterranean Sea and compared the simulation results to buoy measurements using single-point statistical indicators, such as standardized bias and symmetrically standardized mean square error. It has realized a performance evaluation of the terms source growth-dissipation and their reference characterizations on 17 cases studies corresponding to storms in the off the Spanish Mediterranean coast and northern Tyrrhenian Sea. Comparing these simulations with measures using single-point statistical indicators, he showed that high-resolution results are affected by the so-called double sanction effect, although in some cases they offer a better qualitative description of the event. Using a performance analysis of the configuration calibrated on the post-prediction dataset, he showed that it is more efficient than the reference configuration over a wide range of wave heights, for calm to moderate seas, while it increases the tendency to underestimate the significant wave's height under severe weather conditions.

This work aims to compare the sea characteristics forced by the wind obtained by the atmospheric model ALADIN (Area Limited Dynamic Adaptation Inter National Development) 8 km resolution, with those obtained using AROME wind (Application to Operational Research at Mesoéchelle) 3km resolution, which propagate in the

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Algiers port region of using the Wave Watch III numerical model.

2. Simulation

The wave model solves the random spectral phase action density equilibrium equation for the wavelength direction spectrum. Indeed, thanks to this spectrum it is possible to carry out a sea state modeling since this spectrum contains implicitly or explicitly wave data, sea current, wind, etc. The implicit assumption of this equilibrium equation is that the characteristics and the properties of the medium such as water depth and current, as well as the field of wave, vary with scales of time and space that are much larger than the single wave variation scales. The governing equations modeling the spatial and temporal variations in the growth and decay of waves produced by surface wind, dissipation, and the bottom friction effects.

$$\frac{\partial N}{\partial t} + \nabla_{xy} \cdot [(C_g + \mathbf{U})N] + \frac{\partial}{\partial k}\frac{\partial k}{\partial t}N + \frac{\partial}{\partial \theta}\frac{\partial \theta}{\partial t}N = \frac{S}{\sigma} \quad (1)$$

∇_{xy} represents the limited spatial divergence operator on the ocean surface, $C_g = \partial\sigma/\partial k$ is the group speed, U is the advection speed (current function), the intrinsic frequency and S represents the source term for wave formation and dissipation. The net source term is frequently given by summing up the nonlinear term of wave-wave interactions (S_{nl}), the term of wind-wave interaction (S_{in}), and the term of dissipation (S_{ds}). In shallow water, additional processes have to be taken account, most notably wave-bottom interactions $S_{bot.}$

$$S = S_{in} + S_{nl} + S_{ds} + S_{bot} \quad (2)$$

As force, we used the zonal and meridian wind ALADIN atmospheric model output (Area Limited Dynamic Adaptation Inter National Development) with an 8 km resolution (Figure 2), and AROME (Application to Operational Research at Mesoéchelle) with a 3km resolution (Figure 3), for the 01/01/2019 on international port of Algiers (Figure 1). While the other simulation hypothesis is shown in Table 1.

Figure 1. Study Zone: international port of Algiers

Table 1. Simulation characteristics

Simulation Model	WaveWatch III
Study period	24h for 01/01/2019
Temporal resolution	Criterion CFL (Courant-Friedrichs-Levy)
Initial Conditions	Fetch-lim.JONSWAP
bathymetry	ETOPO1
Parameterization	shallow water
Time step	900s

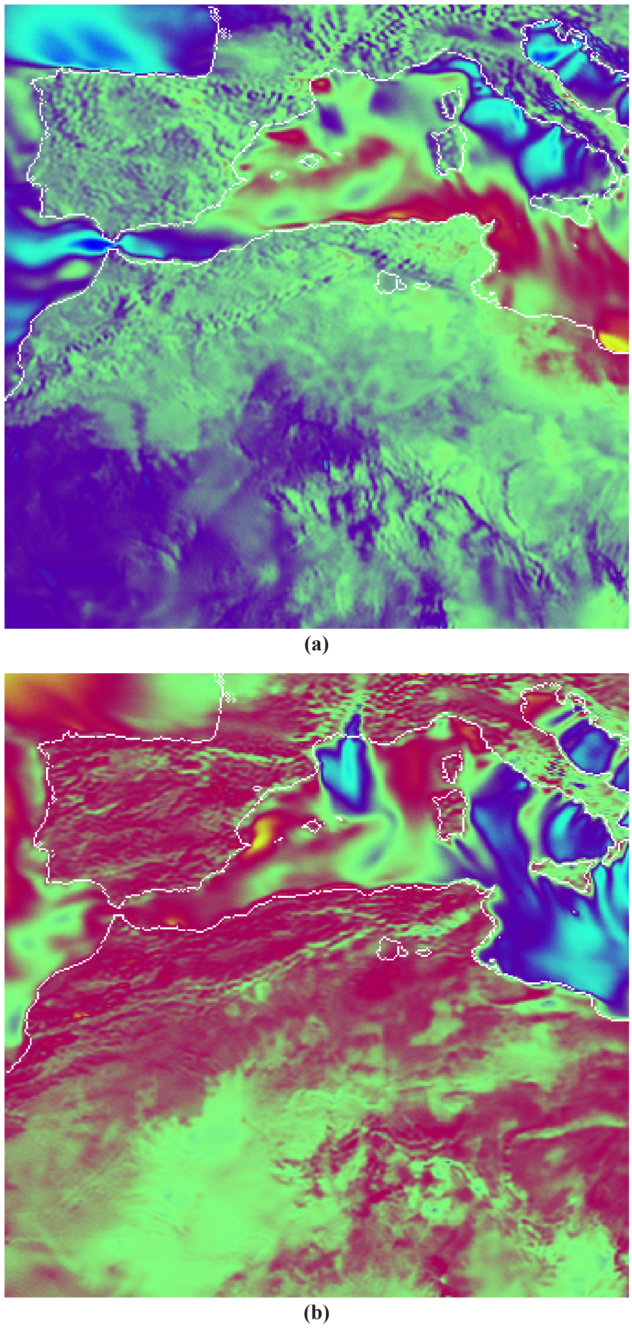

Figure 2. Zonal (a) and meridian (b) wind predicted by ALADIN model

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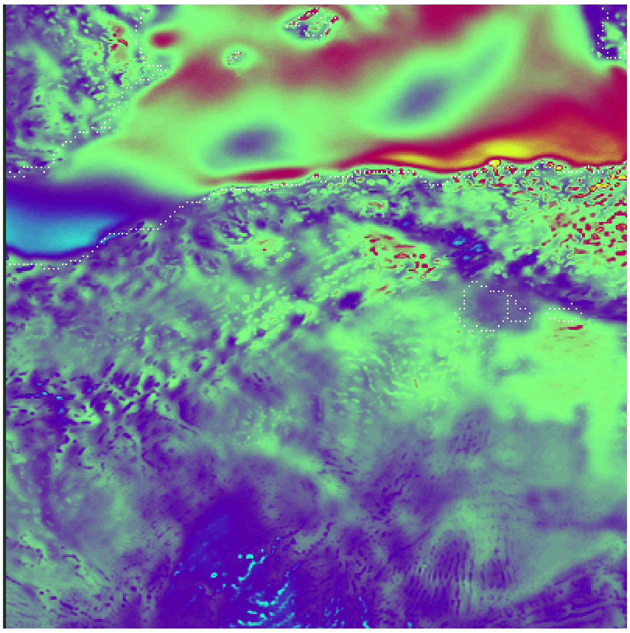
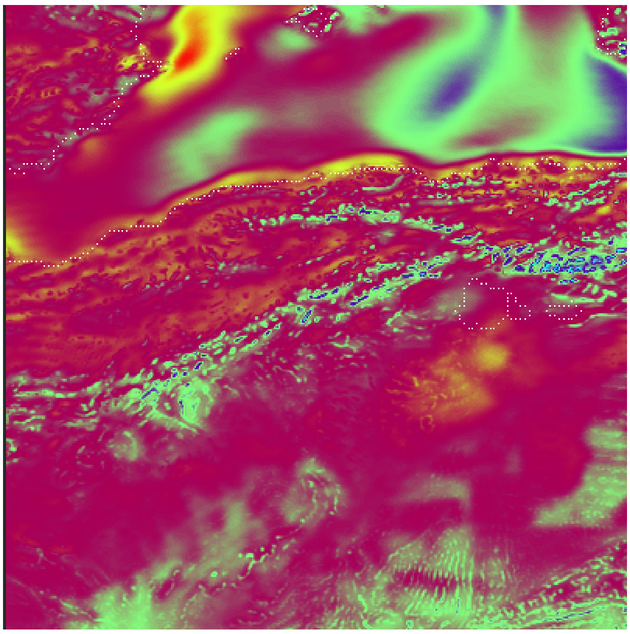


(a)



(b)

Figure 3. Zonal (a) and meridian (b) wind predicted by AROME model

3. Results and Discussions

The different waves characteristics propagating on Algiers port evolution has been traced, for both fcases; that forced by the atmospheric model ALADIN, and the other with AROME:

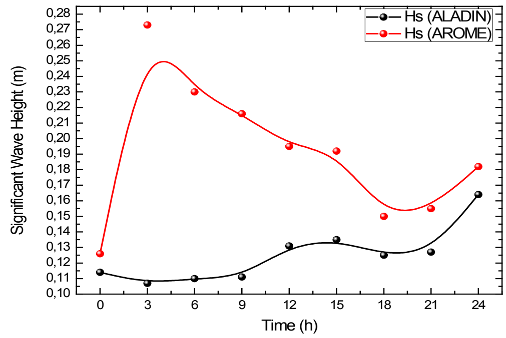


Figure 4. Significant wave height at the Algiers port for the 01/01/2019

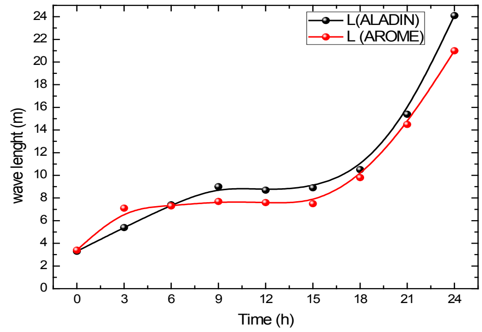


Figure 5. Wavelengths at the Algiers port for the 01/01/2019

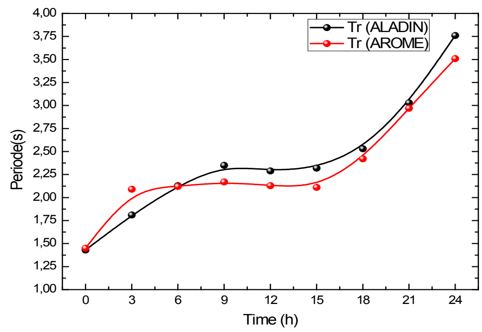


Figure 6. wave periods at the Algiers port for the 01/01/2019

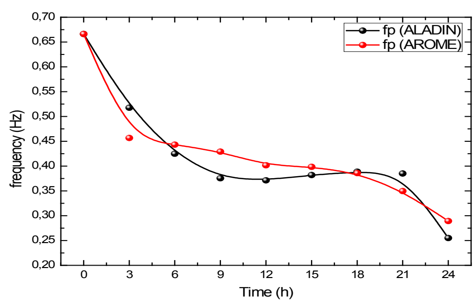


Figure 7. Wave frequencies at the Algiers port for the 01/01/2019

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The significant height (Figure 4), is a very important statistical parameter used to characterize the sea state, it represents the average of the heights (measured between peak and trough) of the one-third of the highest waves.To calculate it from a surface elevation record, the waves are classified in order of height, and the average of the heights of the upper third gives the short of time, their evolution is random due to its direct discordance to the wind. The comparison between the two significant height obtained by ALADIN and AROME forcing wind shows a wide range of variability. The amplitude degrades from 0.14 m around the 3h AM to 0.02m at 24h PM (Figure 5) Also present a difference between the two results obtained for wavelengths. It noted L and defined by the distance between two successive ridges. This difference varies from 1m to 3m around 24h PM. The periods corresponding to the maximum spectral density was influenced to (Figure 6), and a difference of 0.25 s has been registered. The peak periods of the spectrum are empirically related to the periods significant by the relation: Tp=1.05 Ts. Peak frequencies (Figure 7) representing the number of wave trains passing at a fixed point in one second (in Hertz), marks a gap from 0.25Hz to 0.5Hz. These differences are mainly due to the high resolution (3km) of the AROME model, compared to that of ALADIN (8km).

4. Conclusion

The numerical modeling of sea states is a fundamental field in the coastal work sizing, the navigation safety, and the beaches stability study . A sea state numerical simulation in the Algiers port for 01/01/2019 using the WaveWatch III software was carried out. We used as forcing the zonal and meridian wind of the two atmospheric models; ALADIN (Area Limited Dynamic Adaptation Inter National Development) with an 8 km resolution and AROME (Application to Operational Research at Meso-scale) with a 3km resolution. We also used ETOPO1 bathymetry, a 900s time steps, a Time Resolution and an initial Criterion CFL (Courant-Friedrichs-Levy), and Fetch-Lim. JONSWAP respectively. The results represented by wave characteristics such as significant height, wavelength, the peak frequency and period show a gap between those obtained using the wind of the ALADIN model and AROME. These gaps are mainly due to the high resolution (3km) of the AROME model, compared to that of ALADIN (8km).

References

[1] Ardhuin, F., Jenkins, A. D., & Belibassakis, K. A.. Comments on "The Three-Dimensional Current and Surface Wave Equations." Journal of Physical Oceanography, 2008a, 38(6): 1340–1350. https://doi.org/10.1175/2007jpo3670.1

[2] Ardhuin, F., Marié, L., Rascle, N., Forget, P., & Roland, A.. Observation and estimation of Lagrangian, Stokes and Eulerian currents induced by wind and waves at the sea surface, 2008b: 2820–2838. https://doi.org/10.1175/2009JPO4169.1

[3] Benassai, G., & Ascione, I.. Implementation and Validation of Wave Watch III Model Offshore the Coastlines of Southern Italy, 2008: 553–560. https://doi.org/10.1115/omae2006-92555

[4] Bouws, E., Günther, H., Rosenthal, W., & Vincent, C. L.. Similarity of the wind-wave spectrum in finite depth water. Spectral Form. J. Geophys. Res, 1985, 90(C1): 975–986.

[5] Chen, Q., Zhao, H., Hu, K., & Douglass, S. L.. Prediction of Wind Waves in a Shallow Estuary. Journal of Waterway, Port, Coastal, and Ocean Engineering, 2005, 131(4): 137–148. https://doi.org/10.1061/(asce)0733-950x(2005)131:4(137)

[6] Mentaschi, L., Besio, G., Cassola, F., & Mazzino, A.. Performance evaluation of Wavewatch III in the Mediterranean Sea. Ocean Modelling, 2015, 90: 82–94. https://doi.org/10.1016/j.ocemod.2015.04.003

[7] Okihiro, M., Guza, R. T., & Seymour, R. J.. Excitation of Seiche Observed in a Small Harbor which are sheltered frequency The oscillatory outside the harbor at swell frequencies -2 Hz). 1993, 98.

[8] Rascle, N., & Ardhuin, F.. Drift and mixing under the ocean surface revisited: Stratified conditions and model-data comparisons. Journal of Geophysical Research: Oceans, 2009, 114(2): 1–17. https://doi.org/10.1029/2007JC004466

[9] Zijlema, M., Van Vledder, G. P., & Holthuijsen, L. H.. Bottom friction and wind drag for wave models. Coastal Engineering, 2012, 65: 19–26. https://doi.org/10.1016/j.coastaleng.2012.03.002

[10] Zodiatis, G., Galanis, G., Nikolaidis, A., Kalogeri, C., Hayes, D., Georgiou, G. C., … Kallos, G.. Wave energy potential in the Eastern Mediterranean Levantine Basin. An integrated 10-year study. Renewable Energy, 2014, 69: 311–323. https://doi.org/10.1016/j.renene.2014.03.051