6 Conclusions

The results from this work illustrate the complex wave generation and propagation processes that occur across the NW Mediterranean and the complexity of the regional models, and lead the way to further improvements on regional wave modelling.

As described in Chapter 2, coastal wave storms in the region were confirmed to be highly affected by the spatial and temporal variability of the local wind fields. Isolated H_s peaks were registered at some of the instruments along the transect but not at all of them, and important differences in PWD were also identified, all related to the patterns of the wind field. Bimodal events were also frequent. Even though integrated parameters follow the theoretical growth in terms of H_s and T_p increasing with fetch, they might also be affected by the high spatial and temporal variability of the wind and wave fields, and be a source of error when modelling wind-waves in the area.

In Chapter 3, the local features and the high spatial and temporal variability of the wind fields were signalled to be responsible for the large inaccuracies of the operational wave predictions (e.g. up to -50% under-prediction of H_s at the storm peak). Wave modelling was consequently expected to improve by increasing the temporal and spatial resolution of atmospheric and wave models in the region. The study indicated that bimodal sea conditions could play an important role in this region, although its consequences were unfortunately not fully understood yet.

In Chapter 4, it is shown that during a particular storm event, under fetch-limited growth conditions, wind and wave models with higher spatial and temporal resolutions improved H_s predictions: the storm peaks were properly resolved and their magnitude more closely approximated. However, H_s was still under-predicted by up to 1m (30%), and the reason could not be attributed to the modelled wind fields, which were over-predicted (35%). T_p was also under-predicted by about 25%. The results pointed to an inaccurate parameterization of the transfer of energy from the wind to the waves.

Finally, in Chapter 5, the wind fields were further studied. The wind input was modified by (1) using wind observations, (2) forcing the wave model with the maximum WS along the fetch, (3) enhancing the WS by a factor of 1.1, and (3) using growth and sink expressions for which C_D increases with rougher seas (JAN formulation). The results were diverse: from the consistent under-prediction obtained when using in-situ observations (up to -78% for H_s and -38% for T_p), to the better results obtained when using higher WS (as good as +1% for H_s and -15% for T_p). But they all pointed out the need to better understand the energy input and growth processes in such fetch-limited wave growth and highly variable wind conditions. For modelling purposes, the mechanisms for energy input should be further studied in order to improve the air-sea coupling. Because of the seldom presence of swell and the high variability of the area, it was suggested that

wave growth could be deviated from the theoretical growth curves and new parameterizations might be needed.

The results from this work were presented in:

Alomar, M., Bolaños, R., Sairouni, A., Ocampo-Torres, F., and Sanchez-Arcilla, A.: High resolution wave modelling in fetch-limited conditions, in: WISE Meeting, Ensenada, Mexico, 27th-30th April 2009, 2009.

Alomar, M., Bolaños, R., Sairouni, A., Ocampo-Torres, F., and Sanchez-Arcilla, A.: Modelado de oleaje en alta resolución en condiciones de fetch limitado. in: Jornadas Españolas de Costas y Puertos, Santander, Spain, 27-28 May 2009, 2009.

Alomar, M., Bolaños, R., Sanchez-Arcilla, A., Sairouni, A., and Ocampo-Torres, F.: Uncertainties in wave modeling for fetch-limited growth conditions, in: 33rd IAHR Congress: Water engineering for a sustainable environment, Vancouver, Canada, 9-14th August 2009, 2009.

Alomar, M., Sanchez-Arcilla, A., and González-Marco, D.: Coastal wave storms. Observations and simulations in the NW Mediterranean, in: 10th Plinius Conference: Mediterranean Storms, Nicosia, Cyprus, 22-24 September 2008, 2008.

7 Future work

This work is part of a PhD thesis which aims to better understand wave generation and dissipation processes in the study region in order to improve wave forecasts in this coastal zone. Eventually, this knowledge will be used within the RIMA project to define a risk index for the different coastal activities such as port and marine operations, fish farming, recreational and fishing activities, etc.

The work presented here concluded with the need to understand the source of under-prediction associated to KOM's formulation in SWAN, and the urgency to study the source of inaccuracy in JAN's formulation. Consequently, a better understanding of the model and an in-depth study of the observations is needed.

Indeed, it is essential to go back to the observations and to study in detail the generation and growth processes of wave storms. The instrumental record presented in this work is very valuable in terms of the quantity and the quality of the observations: wave information was available at up to three instruments at increasing distance, and within 60km, from the coast. The study of the wave growth curves in such variable conditions, and their deviation from the theoretical growth laws, will be the first steps to assess the accuracy of the parameterizations of the wave models in this region. During the period of measure two typical storm events were recorded (northwest and east), which study in detail would provide valuable information about these kinds of energetic events. Bimodal storms were also observed and, although the instrumental records are less complete, valuable information can be obtained from its study in-depth. Unfortunately, wind data in the sea and more directional measurements are lacking. Nonetheless, the available data will be further studied to understand the wave generation and growth that took place during the period considered. To start with, additional data from a meteorological station at Tarragona's harbour will be analyzed, and directional wave information at A-dw(D) will be processed. These data were unfortunately not available at the time of this work, but will be included shortly.

Further data analysis will first focus on different aspects such as:

- To study the data along the instrumental transect and compare it with the theoretical wave-growth curves.
- To analyze and compare the directional spectra at E-iw(D) and A-dw(D) to identify the different wave trains registered during the wave record available.
- To study the directionality of each frequency and search for slanting fetch effects. The role of wind and wave direction on wave growth will also be considered in detail.

- To assess the role of bimodal spectra in regional wave growth.

Afterwards, and once the instrumental data is fully analyzed, the focus will be on assessing the performance of the high-resolution wind and wave models in predicting the fully-developed sea conditions recorded during storm 4. Because eastern swell are being generated as far as Corsica and Sardinia, for this future simulation the wave model will be nested into a coarser regional model of the western Mediterranean.

Besides, aiming to improve the deficiencies of the high resolution wave model identified in this work, and following the research line started, further work will include:

- To assess the effect of the different wind field on the predictions at all the instruments along the transect, and not only at the most offshore station.

- To better understand the generation and dissipation formulations in SWAN to identify the sources of error (i.e. convergence problems) of the implemented formulations, including the JAN formulation.

- To identify the reason the model is still under-predicting the integrated wave parameters, H_s and T_p, and to study the importance of changing WiD and the variability of the wind field on increasing H_s.

- To assess the performance of the model in predicting the directional spectra.

- To adapt the model code (parameterizations) to better predict wave generation and propagation in the region of study.

- To assess a pre-operational implementation of the high-resolution model in the study region.

Overall, further work aims to better understand generation and growth mechanisms in highly variable regions and to improve wave modelling in the NW Mediterranean.

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