Marine Engineering and East Med. currents and waves — an attempt to acquire a wholesome understanding from theoretical, numerical modelling and field measurement perspectives

Any engineering and scientific problem can be approached from various directions. One create its mathematical representation and inspect it directly using accurate numerical methods with high performance computers. Another can approximate these equations in order to enable an easier inspection of its physical properties or allow for real-time operational use. Other approaches include detailed laboratory measurements in order to isolate (as much as possible) effects of different parameters in a controlled environment. If the problem relates to field conditions, it can be measured in the field with the benefit of observing its natural occurrence but with the difficulty of an uncontrolled environment and the noisiness of field conditions.

All the above approaches have their advantages and disadvantages, but it is clear that a combination of these approach can provide a more complete investigation. MEPLab aims to advance the field of marine engineering and our knowledge on ocean waves and currents in the East Mediterranean region using such a multifaceted approach. The talk will present some of the directions taken to reach this goal by combining theory, modelling and field measurements. The second part of the talk will present works on the topics of nonlinear shoaling of wind waves, infra-gravity waves related to harbour agitations and waves of even lower frequencies, which relate to shelf- and bay-scale oscillations.

Nonlinear wave interactions have a significant effect on the wave spectra in the near-shore region with great importance to coastal engineering design. And yet, their calculation still poses significant modelling challenges. Deterministic nonlinear models that account for these interactions are numerically expensive, and hence mostly used for limited computation areas that results in losing a significant part of the spectral evolution effects. Stochastic phase-averaged wave models are commonly used for this purpose as they are efficient enough for resolving large enough computation areas, but they have limited capabilities in accounting for nonlinear shoaling effects. A new nonlinear stochastic formulation extending these models to the nearshore environment will be presented.

Infra-gravity waves are waves that lie outside of the wind-wave spectral regime. They are related to longer wave periods of few tens to few hundreds of seconds. Even though their wave heights are an order of magnitude lower than the ones in the wind wave spectral peak, their comparably large wavelengths (O(1-10km) depending on the bottom depth) can largely influence marine conditions due to basin resonances, harbor agitations and their influence on beach morphology. Their primary generation mechanisms are related to shoaling and breaking of the nearshore wave field. Thus, the focus of most previous related works has been limited to coastal areas. Based on the analysis of pressure cell measurements, we show evidence of IG wave generation by deep sea storms and present a new mechanism connecting seemingly unrelated phenomena of the comparably slow wind gusts and very fast IG waves. A simulation of IG wave generation, combining reflection of nearshore generated IG waves and deep water generation, shows good agreement with deep water measurements in the Pacific.

Sea level elevation observations ADCPs, tide gauges and wave staves indicate the existence of persistent low-frequency oscillations on the Israeli continental shelf. The dominant frequencies are shown to be consistent with extremely high nonlinear nearshore tide harmonics and shelf resonance models. A shallow water numerical model of Haifa Cape to Achziv shelf edge shows that this constellation enables energy trapping and occurrence of resonating standing waves. It has been found that the resonance periods fit also the ones of tsunami and metro-tsunami events with capability to deep-to-shallow signal increase of up to two orders of magnitude(!) indicating Haifa Bay and Naharia areas to be extremely vulnerable to such events.