BOTTOM SHEAR STRESS IN THE GULF OF LION GENERATED BY WAVES AND CURRENTS

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Abstract

Simulations of both currents and waves for the entire year 2001 are performed in order to assess their statistical contribution to the erosive potential over the shelf of the Gulf of Lion. Bottom circulation patterns are also analysed in response to wind forcing.

Keywords : Waves, Currents, Gulf Of Lions.

Models descriptions

The hydrodynamic processes are modelled using the MARS-3D code [1, 2], a three-dimensional model with reduced (s) vertical co-ordinates. The model is forced by atmospheric conditions (modelled wind field and solar fluxes given by Météo-France), diurnal river discharges, and lateral fluxes and elevations at the open boundaries. The applied model has a resolution of 1.2 km and 30 vertical levels. Wave fields are modelled in the Western Mediterranean Sea with the resolution of 0.1° using the third generation wind-wave model WAVEWATCH-III [3] forced by Météo-France wind fields.

Statistics on bottom shear stress

In order to determine the origin of current induced bottom shear stress (τ_c) in response to wind forcing, an analysis has been done separating continental winds (on-shore winds) and marine winds (off-shore winds) for the entire year 2001. The probability of occurrence of high bottom shear stress greater than 0.04 N/m^2 linked to one of these wind origins has been calculated (figure 1). The 0.04 N/m^2 value corresponds to the mean critical shear stress of erosion observed by Shaff et al. [4, 5] on the superficial layer of fine sediment on the Gulf of Lion shelf. The bottom shear stress in this study refers to the skin friction component of the total bottom shear stress, considering that this study is applied to sediment dynamics.

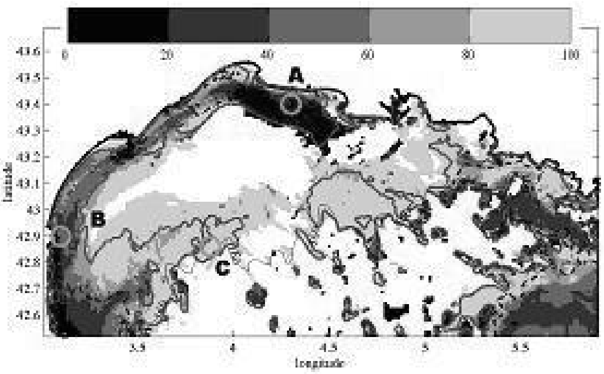

Fig. 1. Origin of bottom shear stress generated by currents. Probability (%) of having, simultaneously, bottom shear stress greater than 0.04 N/m^2 and off-shore winds (direction from 45° to 225°). The dotted line corresponds to the iso-probability τ_c >0.04 N/m^2 equal to 1%, the continuous line corresponds to 0.2%. The white area corresponds to zero probability. The 160 m isobath (slope) is plotted.

It clearly appears that on the top of the shelf break (circle c), strong currents may occur during south-eastern wind storms (bright area).

The probability for the shear stress to reach the critical value is nevertheless low (in the order of 0.1%) Near the coast, marine winds have a greater influence (further from the shore). Continental winds are also able to mobilise bottom water layers in some coastal locations. For instance, upwelling cells, described by Millot [6] in front of the Petit Rhône, are however mainly active during Mistral or Tramontane wind events (black area, circle A). For that case, the probability of occurrence of erosion is about 1%.

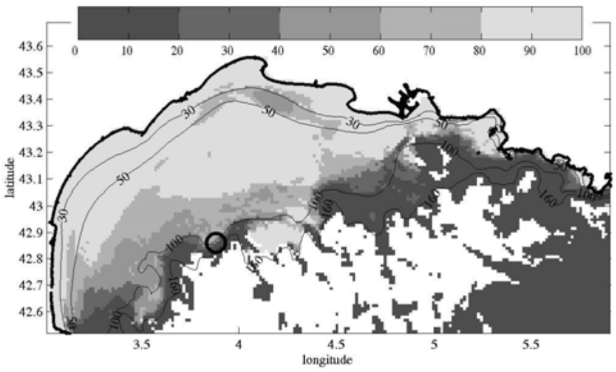

Fig. 2. Probability of having a wave induced bottom shear stress greater than the stress induced by current when the total friction (τ_{cw}) is greater than the critical value of 0.04 N/m^2 (τ_w >τ_c and τ_{cw} >0.04 N/m^2). Isobaths 30, 50, 100 and 160 m are plotted.

The analysis of wave induced bottom shear stress (τ_w) for year 2001 shows that the effect of waves dominates the effect of currents on most of the shelf when total skin friction (τ_{cw}) is high (>0.04 N/m^2) (figure 2). Nevertheless, current seems to be dominant on the external shelf near the top of the slope (between 100 and 160 m). At 100 m depth, swell can exceptionally have an effect on the bottom during big storms. Waves with significant height of 5 m and mean period of 12 s may also generate a bottom shear stress of 0.04 N/m^2 in this relatively deep area.

Conclusion

This study has underlined the effect of winds on the bottom circulation patterns of water and sediment. Marine winds are able to induce sediment transport and erosion on most of the shelf because of simultaneous generation of strong coastal current and efficient swell. Continental winds (Mistral and Tramontane) appear to have erosive potential exclusively along the shore and essentially in the upwelling cells. These winds are however associated to wind waves of low amplitude and, in this way, they will probably not constitute the major forcing process of the sediment transport on the shelf of the Gulf of Lion.

References

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