Glider Observations of Sediment Resuspension During Storm Conditions

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/ MOTIVATION

Despite its importance, the mechanisms controlling sediment resuspension and transport on continental shelves during storm are still poorly understood. Improve knowledge about the sediment resuspension and transport are of prime importance to help predict the fate of sediment as well as of pollutants that are introduced onto the shelf and which might be reworking and off-shelf export (Bosnic et al., 2017; Ferré et al., 2010).

The aim of this study is to assess: (i) the dynamic of sediment resuspension, and (ii) physical processes driving resuspension in the Gulf of Lions (GoL) shelf (NW Mediterranean) (Fig. 1).

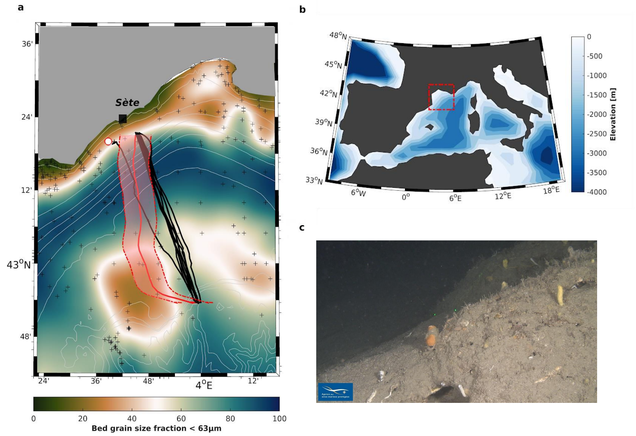

Figure 1: a) Map of the shelf surface sediment characteristics of the central part of the Gulf of Lions around the glider track, interpolated from the granulometric samples (black crosses). The location of the coastal buoy (circle), the meteorological station (black square), and the glider track (solid black and red lines) are also indicated. The red solid line indicates the glider sections during a marine storm. (b) Western Mediterranean, the Gulf of Lions is localized by a red square. (c) Image* of Muddy sands of the outer-shelf (yellow patch in Fig. 1a) at 100 m depth.

/ SAMPLING STRATEGY

An extensive investigation of the widest part of the Gulf of Lions shelf was conducted in the framework of the French program CHIFRE (Coastal High Frequency Response to Extreme Events). An autonomous underwater Slocum glider equipped with a CTD (Conductivity, Temperature, Depth), an optical payload, and a RDI 600 kHz phased array ADCP (Acoustic Doppler Current Profiler) was deployed in February-March 2018. The sampling strategy was adapted to target a continuous observation period of more that 30 days, in order to increase the probability of capturing sporadic meteorological events, such as storm and floods, which are key elements of sediment dynamics in coastal areas.

* Agence des aires marines protégées, COMEX, GIS Posidonie, Equipe scientifique – MEDSEASCAN 2008-2012 – Programme de reconnaissance des têtes de canyons de la Méditerranée française.

/ PRELIMINARY RESULTS

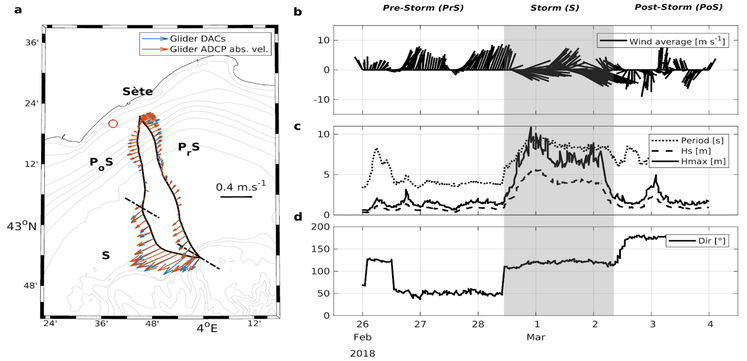

Figure 2: a) Depth average current (arrows) and cross-shelf glider tracks from 02/26 to 04/04. b) Wind speed and direction time-series at the Météo France station (black square in Fig. 2a). By convention, wind direction indicates its origin. c) and d) Buoy time-series (red circle in Fig. 1a) of significant wave height (Hs), maximum wave height (Hmax), wave period, and wave direction (Dir).

This long duration glider deployment allowed us to sample a winter marine storm event on the outer-shelf (Storm in Fig. 2a) from 1st to 2nd March. During this storm, southeast winds were recorded. Associated with these winds a peak swell is observed on March 1st (Fig. 2c), with a significant wave height of 6 m, a maximum wave height of 11 m, and a period around 10 s. These characteristics are typical of marine winter storm in the GoL. A wave statistical analysis carried out over a period from 2006 to 2020 showed a return period of 5.4 years for this event.

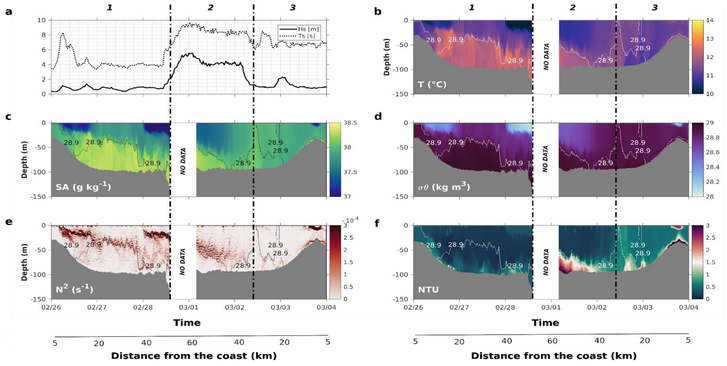

Figure 3: Wave conditions (a), and glider cross-sections of temperature (b), absolute salinity (c), density anomaly (d), Brunt-Väisälä frequency (e), and turbidity (f).

Glider observations show that during pre-storm and early in the storm conditions, when the waves are highest, vertical, mixing of resuspended sediment is limited by the stratification (isopycne 28.9 kg m^{-3}) (Fig. 3). During the storm, erosion of the pycnocline through thickening of the bottom and surface mixed-layers increases vertical mixing of resuspended sediment in the full water column, as observed during post-storm conditions.

Since information on seabed quality was sparse, a sensitivity analysis on bottom roughness values (z0) was performed for the estimation of bottom shear stress (Fig. 4). Figure 4 shows that waves can contribute and even be predominant contribution to bottom shear stress for a z0 of 10^{-3}, which is typical value found in the literature (Soulsby, 1997) for cohesive sediments (Fig. 1c). Intensities of bottom shear stresses explain well the resuspension in the water column.

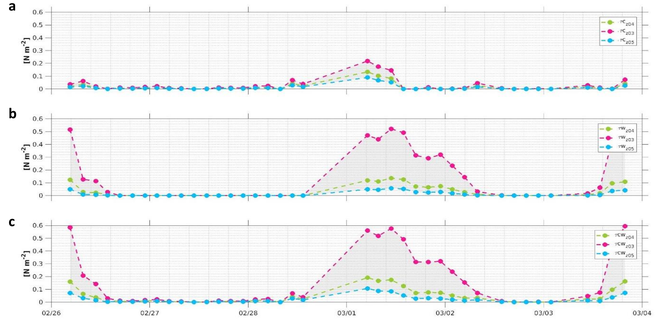

Figure 4: Bottom shear stress induced by current (a), wave (b), and wave-current interaction (c). The blue, green and pink curves correspond to the z0 value of 10^{-5}, 10^{-4}, and 10^{-3} m, respectively used to compute bottom shear stress.

/ CONCLUSION

- Winter marine storm are able to remobilize sediments on the outer-shelf (>80 m depth);
- On the shelf, vertical mixing of resuspended sediment in the water column is controlled by the stratification;
- Observations show for the first time that waves are important forcing for the resuspension on the outer-shelf (>80 m);
- This study highlights the usefulness of glider-ADCP to describe episodic intense processes, such as storm and flood.

/ REFERENCES

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