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Relationship between Water and Sediment Dynamics at Mariakerke Beach

Introduction

The Belgian coast is highly vulnerable to storms, combining high water levels and large waves, with a serious risk of flooding of the densely inhabited. The Flemish Government established a Masterplan for Coastal Protection (2011) to reinforce the weak coastal sections and guarantee the required safety levels in case of a catastrophic storm event. These are realized through sustainable coastal protection measures, with a lower impact on the environment respect to the traditional ones, a the sand nourishment. To evaluate the efficiency, safety and sustainability of the nourishment, Mariakerke beach, located in west of Oostende, has been selected for a full scale pilot experiment oh shoreface nourishment and it is intensively monitored. This study aims to improve the knowledge about the dynamics of the investigated area, with a special focus on the relationships between hydrodynamics and sediment dynamics in this area.

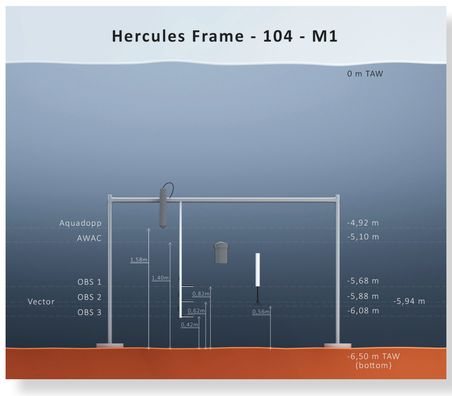
Field Measurements

Waves, currents, suspended sediment concentrations (SSC) and water level are monitored at four locations: two at Raversijde area (Section 100) and two at Mariakerke area (Section 104); and at the depths of -3.5 m and -6.5 m TAW. At each location, a frame is deployed with instruments to measure the hydrodynamics for the entire water column (AWAC and Aquadopp ©Nortek) and in one fixed point (Vector ©Nortek) and sediment concentration (Optical Backscatter Sensors – OBS) at three different depths within the first 1 meter above the seabed.

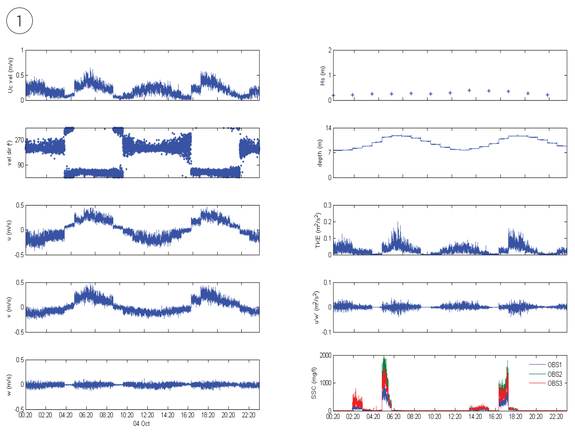
Hercules frame, before deployment

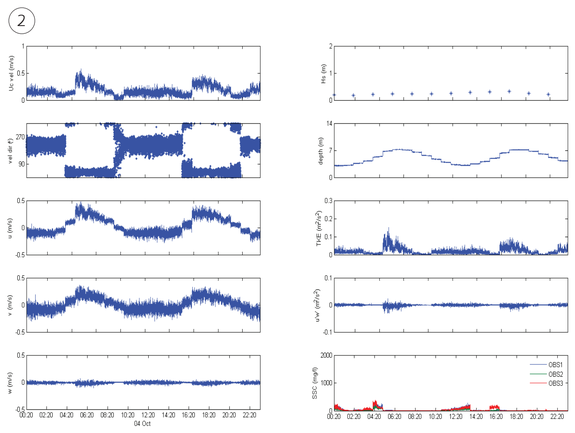
Data and Methods

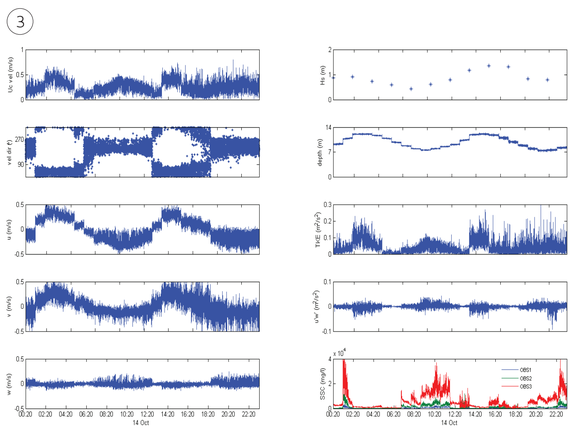
A field campaign took place in Mariakerke between 23/09-14/10/ 2015. We focused on the Vector and OBS time series, analyzing the results of 18 day of simultaneous measurements of 10 minutes, collected every hours.
The Vector reports velocity current data in ENU components (East, North and Up). From them, the turbulent kinetic energy (TKE), the Reynolds stress and current direction were calculated. These were related to the water level variations and the SSC to examine the effects of the hydrodynamics conditions on the distribution patterns of suspended sediment concentrations.



Measurement Scheme from the frame "Hercules" , on the Section 104 at a depth of -6,5 m TAW







1) Hydrodynamic conditions and SSC at -6.5 m TAW (Hercules), on 04/10/2015

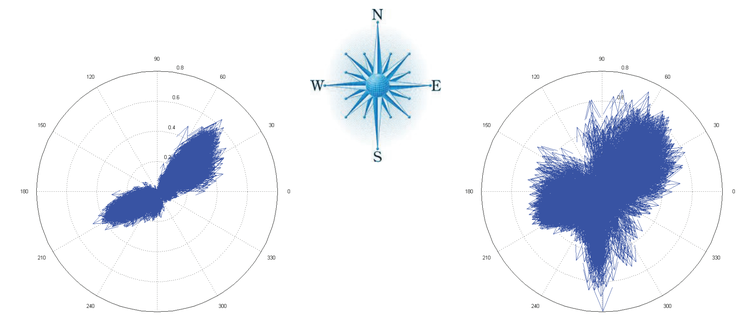
2) Hydrodynamic conditions and SSC at -3.5 m TAW (Hylas I), on 04/10/2015

3) Hydrodynamic conditions and SSC at -6.5 m TAW (Hercules) on 14/10/2015 Storm event occurring.

Mariakerke - Topographic map in 2015 and location of the instruments.

Observations

The dynamics of water and sediments are strongly affected by the tide induced currents.
During normal weather conditions the tide induced-currents show a strong and sudden inversion in direction, during which the velocity component and the TKE values are near zero.
In absence of large waves and strong wind, the SSC at -6.5 m TAW show one or two peaks per day, corresponding exactly to the rising tide. From the OBS at -3.5 m TAW, the peaks in SSC can be found in correspondence with lower water level.
The higher energy levels correspond to the high water level, when the currents direction at the Vector depth, is regularly set toward East North-East.
The SSC can strongly change with the distance from the seabed, but not always decreasing with the distance from the bottom, as expected. However, the peaks in concentration are not strictly related to the peak in TKE.
During the stormy days, the direction of currents is not so clear and regular. The vertical component increases and thus the turbulence. The two peaks in SSC corresponding to the rising tide are reinforced. However, there is also a strong movement of sediments in correspondence to the low tide level, the peak in TKE and an higher value of the Reynolds stress. At larger depth, the relationship between the three OBSs is still regular and decreasing from the bottom going up. The SSC seems to be not strictly related to the higher values of TKE. Higher values of SSC were found at -6.5 m depth than at -3.5 m TAW.



Distribution of currents direction at a distance of 0.56 m from the bottom. The first picture is referred to normal hydrodynamic conditions, the second one is referred to a storm event.

Final Considerations

Larger sediment suspension is not strictly connected to the higher levels of TKE. During normal hydrodynamic conditions, the major force driving to higher concentration of suspended sediment seems to be the water level rising and probably the turbulence induced by the change in the currents direction due to the tide. However, a global view to the data shows that the larger values of SSC are connected also to the highest waves. During the analyzed campaign just one storm event occurred, but research is still ongoing to analyze data from other field campaigns. Our future work aims to correlate the wave induced currents and peaks in SSC in order to derive sediment transport in the study zone. Spatial variation of the SSC, both along and cross-shore is of particular interest to identify the coastal stretches where the currents are stronger and the motion of sediment could be critically large leading to beach erosion.