On-demand assessment of spatial and temporal variability of sediment transport parameters, Belgian and southern Dutch part of the North Sea

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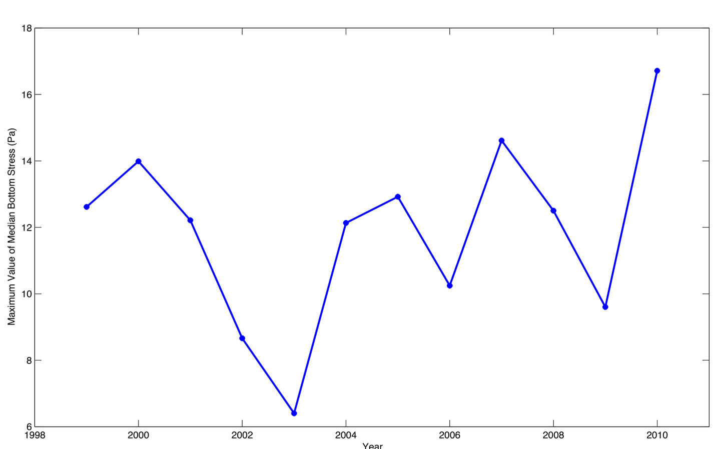
INTRODUCTION

Assessment of the natural spatial and temporal variability of the seabed is not straightforward. Mostly, variations are described only at a local level and in many cases the regional context is missing, rendering sound interpretations on the driving forces impossible. Moreover, the envelope of natural variation is not known, and it becomes very hard to distinguish naturally- from anthropogenic-induced variability.
In this study we use long-term and statistically sound data-analyses of most relevant sediment transport parameters, relevant for the Belgian and southern Dutch part of the North Sea. As a case study the variability in bottom shear stress was selected, as this parameter is critical in the processes that govern the natural variability in sediment transport and bottom morphology. Also, Belgium proposed mean bottom shear stress as an indicator of changes in hydrographic conditions to assess Good Environmental Status within Europe's Marine Strategy Framework Directive.

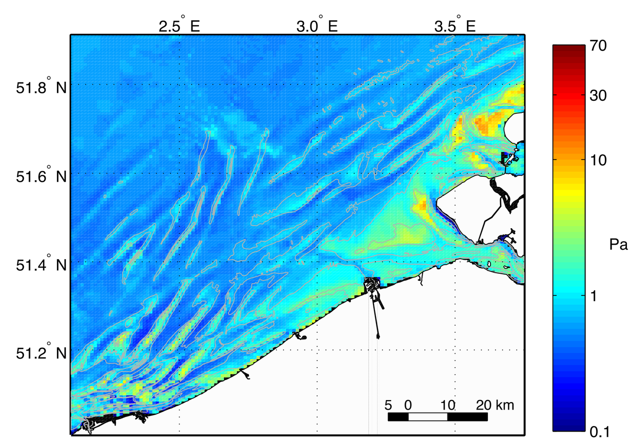
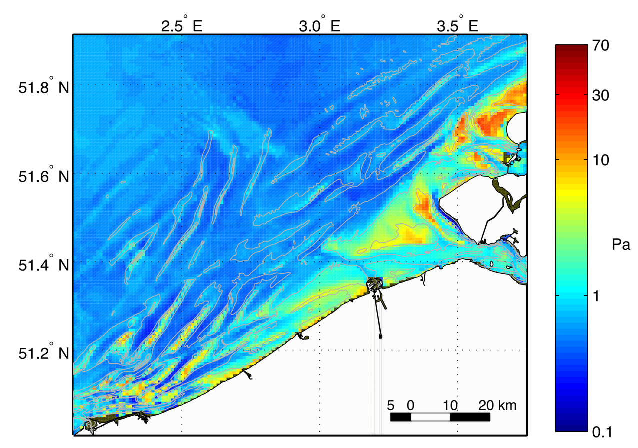
MODEL DATA

Results from a 12-year long hindcast (1999-2010) were used to assess the spatial and temporal variability of sediment transport. Wave hindcasts for the period were obtained using the SWAN model, which was coupled with the results from a hydrodynamic model. The boundaries for the wave model were obtained from two larger scale WAM models covering the entire North Sea. The currents and water elevations were obtained from two-dimensional hydrodynamic models. Currents and waves were used by the sediment transport model MU-SEDIM, calculating the total load, under the influence of the local hydrodynamic conditions. Model output resulted in 30 minutes time step sediment transport parameters (bottom stress, bottom geometry, total load and bottom evolution) on a 750 m grid resolution.

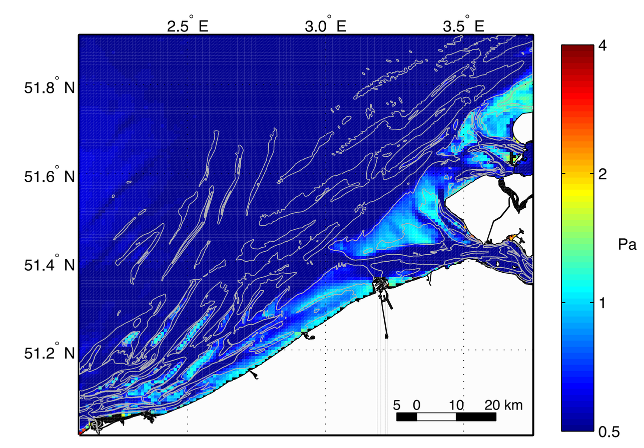
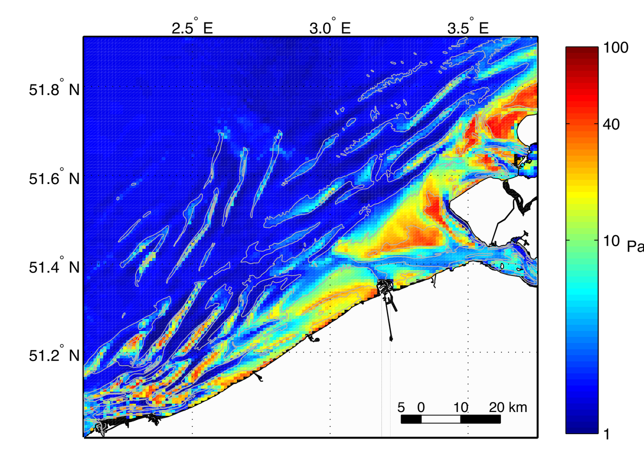
STATISTICAL ANALYSIS



Maximum value of the spatially averaged median value of maximum bottom shear stress. Highest value in 2010.

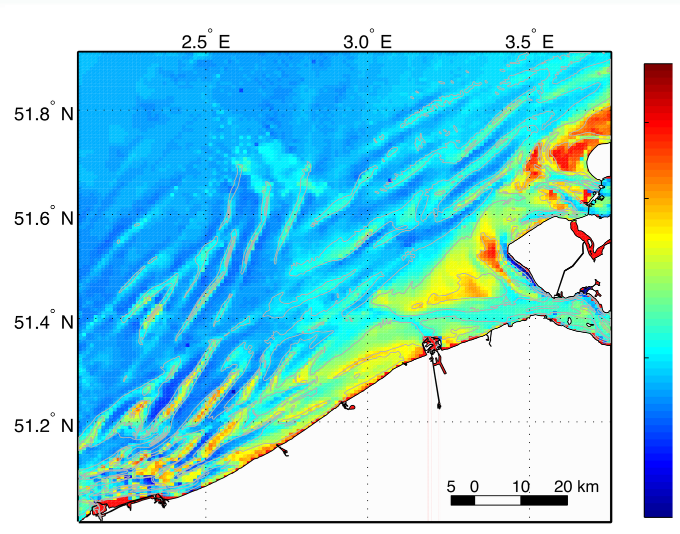
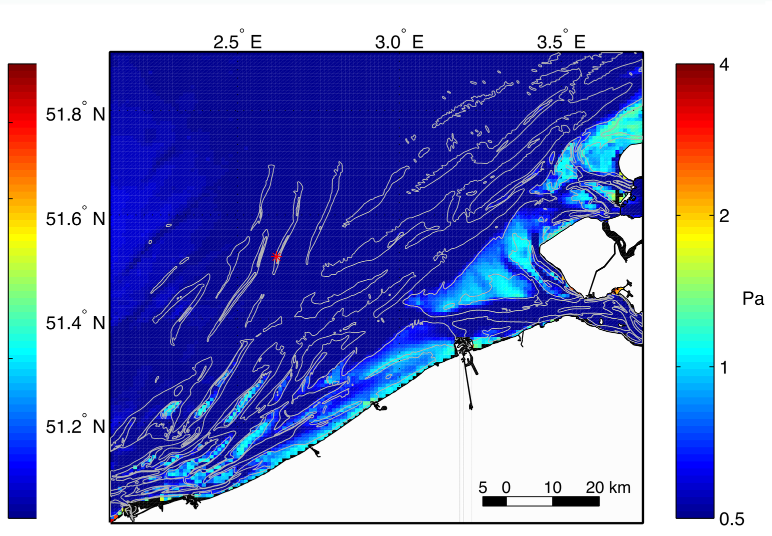
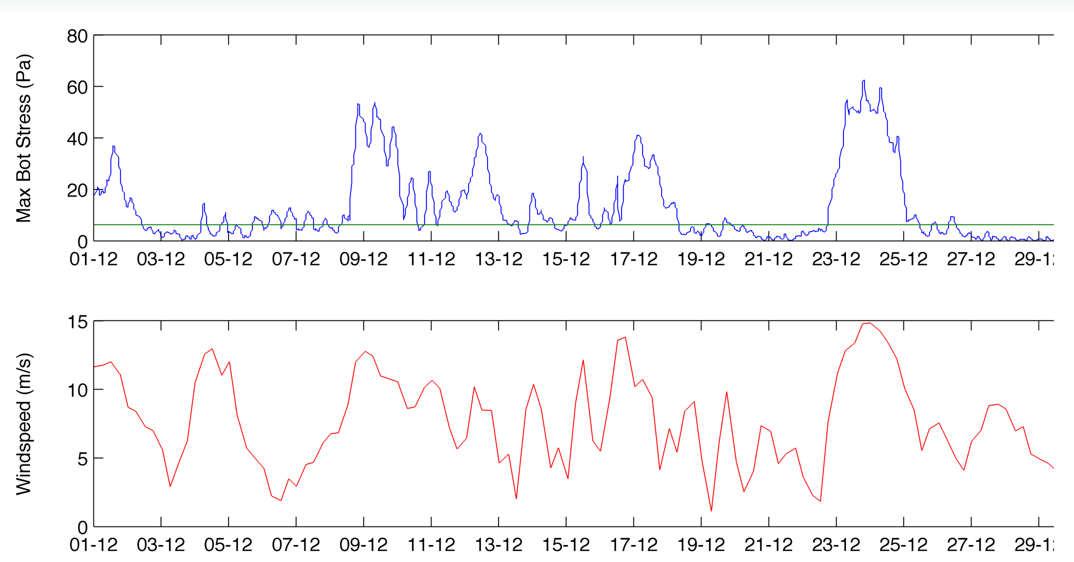
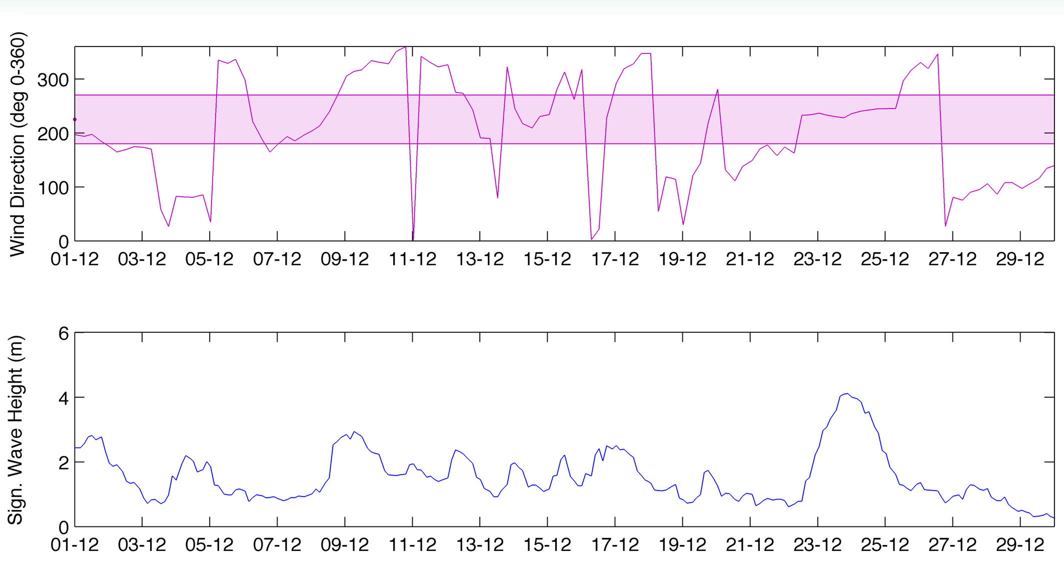
The yearly median (left) and half of the interpercentile range (hIPR, half the difference between the 84th and 16th percentile - right) were calculated. Maps show spatial distribution of the maximum bottom shear stress for 2010.

The hIPR normalized by the median value (NIPR - left) was used as a measure of normalized variance. The 95th percentile (i.e., the value exceeded by 5% of the observations - right) was used as a measure of extreme values.

Considering the entire period 1999-2010, the highest spatial average of the yearly median bottom stress was found in 2010 (top left figure). In that year, a maximum number of NE wave events with significant wave heights of more than 2 m was found. 17 events took place, which could explain, at least in part, why the yearly median of the maximum bottom stress in 2010 was 10 % higher than in the second highest year. Highest multi-year median values in bottom stress were found on the Flemish Banks, the Belgian coastal area, the Vlakte van de Raan and off the Dutch Schouwen-Duiveland, the shallowest areas in the Belgian and southern Dutch part of the North Sea.

WINTER 2010: LARGEST VARIABILITY

The large variability in maximum bottom stress (median – left, NIPR – right of Winter 2010) is shown in a time series of Winter 2010 as this season showed the highest variability throughout the year. An offshore location, on the Oosthinder sandbank (51.52°N, 2.62°E, red star on right map), with high temporal variability was selected. For this period a median maximum bottom stress of 6.29 Pa was calculated with values up to 60 Pa (± 10 times higher). *In-situ* data, available in the area, showed values of up to 4 Pa under normal spring tidal conditions, hence illustrating the overall agitated conditions of Winter 2010. Most striking in the figure of the time series is the correspondence of high bottom stresses with longer periods of NE wind directions (shaded area).

CONCLUSIONS

An on-demand queryable sediment transport database has been created, covering the Belgian and southern Dutch part of the North Sea. It spans the period 1999-2010, but is expandable in time. Future applications are wide-spread and can include the estimation of the regeneration or recovery potential of the seabed, based on the natural deposition character of the area. It will also provide insight into the areas that are naturally more erosive, hence more vulnerable to the impact of human activities. With direct relevance to Europe's Marine Strategy Framework Directive, future work will concentrate also on the development of envelopes of natural variability, critical to distinguish naturally- versus anthropogenically-induced sediment dynamics.
There is scope to develop an on-line extraction tool to easily request time series on sediment transport parameters, and its associated statistical parameters.

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