ON THE SHORT- AND LONG-TERM SPM VARIATIONS IN THE SCHELDT ESTUARY

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ABSTRACT

Recently there has been a growing interest in the question whether or not the Scheldt estuary may evolve towards a hyper-turbid system. Typical for such a regime shift is an increase in suspended particle matter (SPM) over a time scale of several decades. In this research we studied the historical evolution of SPM in the Scheldt estuary by the analysis of data over a period of 18 years (1995-2013). We looked at the effect of the tide, riverine discharge, seasons and sediment disposal (short-term) in order to understand the effect of these physical parameters on the SPM signal and its historical evolution (long-term).

Keywords: Scheldt estuary; suspended particle matter (SPM); historical evolution; tide; riverine discharge

1. INTRODUCTION

This study is part of a larger project called ‘mud balance Sea Scheldt’. The project aims to improve the system knowledge of mud and mud behavior in the Scheldt estuary, and assesses the implications on the evolution of estuarine habitats. This requires of thorough analysis of literature, measurements and modeling results, in this way leading to the identification of ‘mud sources’ and ‘mud sinks’ in the estuary. Moreover, a number of management questions (*e.g., is there a long-term increase in SPM?*) are tackled in this project. Present study focuses on the historical evolution of SPM (based on data analysis) and looks at the effect of several physical parameters (e.g., tide, riverine discharge) on the SPM signal.

2. METHODOLOGY

SPM is intensively monitored along the Scheldt estuary and several type of databases are available. The most extensive database contains surface SPM data which were sampled at random time steps (tide-independent). The dataset covers the entire estuary (Figure 1, red dots) and starts in 1995.

In order the evaluate the tide-independent surface SPM dataset in function of the different physical parameters we developed an algorithm which relates the time step of SPM sampling with: (1) the time step of the tidal phase (based on the time difference with the nearest extrema), (2) the neap-spring tide cycle (determined by the tidal range), and (3) the riverine discharge (based on daily values). Moreover, we evaluated the long-term evolution of SPM.

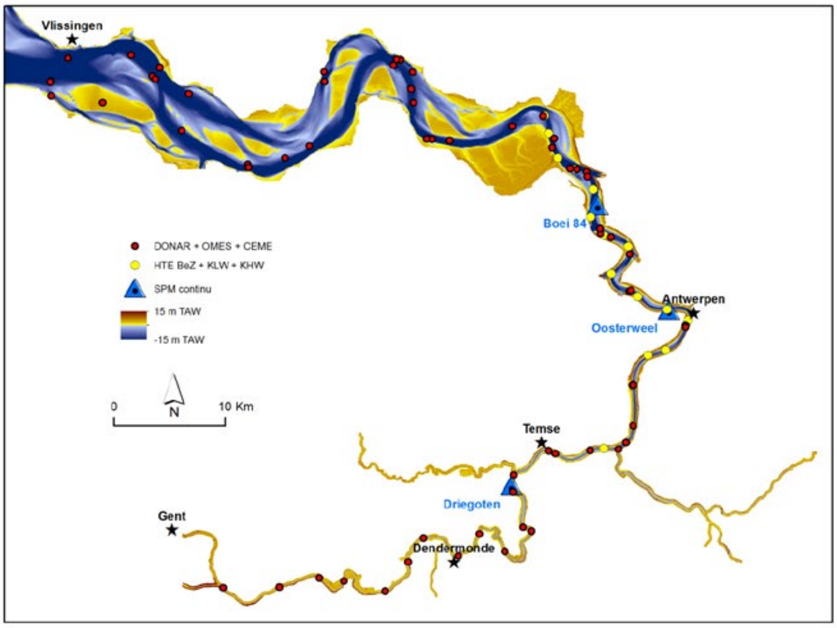

Figure 1. SPM measuring locations along the Scheldt estuary

3. RESULTS AND DISCUSSION

The tide has a clear influence on the SPM signal. Within the short-term of an individual tide we observe lower SPM values just after slack water (Figure 2). At this time flow velocities are strongly reduced which explains the decrease in SPM. As flow velocities increase, higher SPM values are observed. In the Sea Scheldt (i.e. the part of the Scheldt 58-160 km from the mouth) we hereby observe higher SPM values during ebb than during flood, suggesting an ebb-dominated sediment transport. On the longer-term of a neap-spring tide cycle we observe an increase in SPM with increasing tidal range (Figure 3). In general the surface SPM concentration during neap tide is 0.8-0.9 times the median SPM concentration (i.e. the median value of all SPM measurements), while during spring tide this is a factor 1.1-1.3.

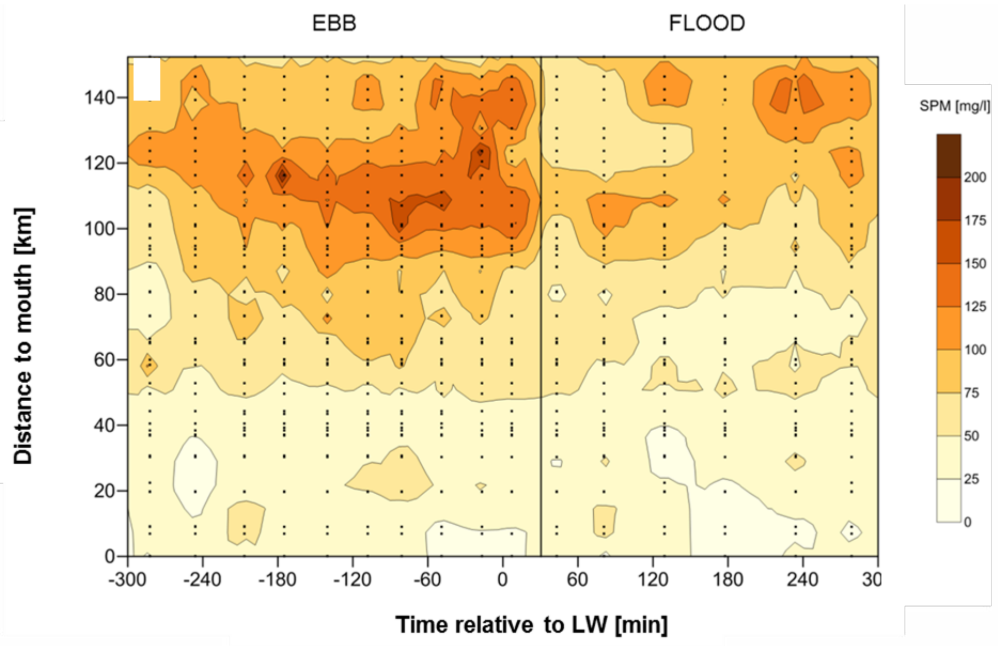

Figure 2. Relationship between the tidal phase (relative to LW) and the surface SPM along the Scheldt estuary. Vertical line which separates the ebb and flood phase represents the time of low water slack.

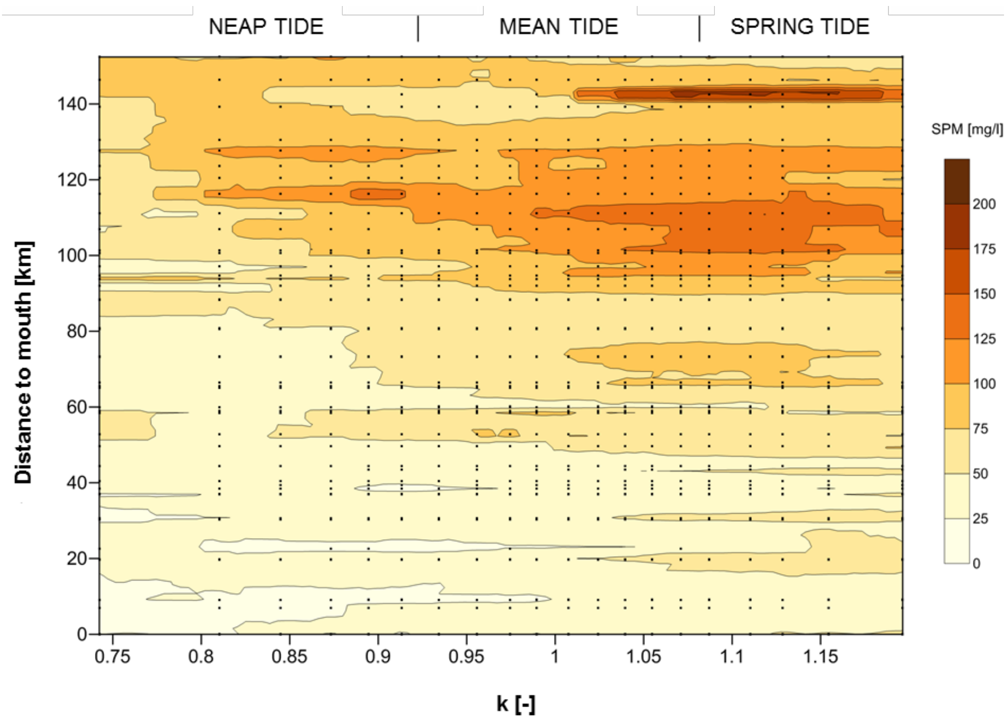

Figure 3. Relationship between the k-value (i.e. the ratio between the observed tidal range and the mean tidal range) and the surface SPM along the Scheldt estuary.

Moreover, we found that riverine discharge plays an important role in the formation of the estuarine turbidity maximum (ETM). If the riverine discharge is low (typical during summer and autumn), a distinct zone of elevated suspended sediment concentrations forms at a distance 100-140 km from the mouth (Figure 4). At higher riverine discharges (around 60 m³/s which is typical for winter conditions) SPM concentration are lower in the upstream parts of the estuary. Flow velocities in the downstream direction are then sufficiently large to transport the suspended solids. However a zone with increased SPM concentrations still occurs at 100-120 km from the mouth. Remarkably, SPM concentrations in the upstream part again increase at extreme high discharges (a discharge >96 m³/s only occurs in 10% of the cases). At these peak discharges the SPM concentration in the river is clearly larger which leads to higher SPM values in the upper part of the estuary.

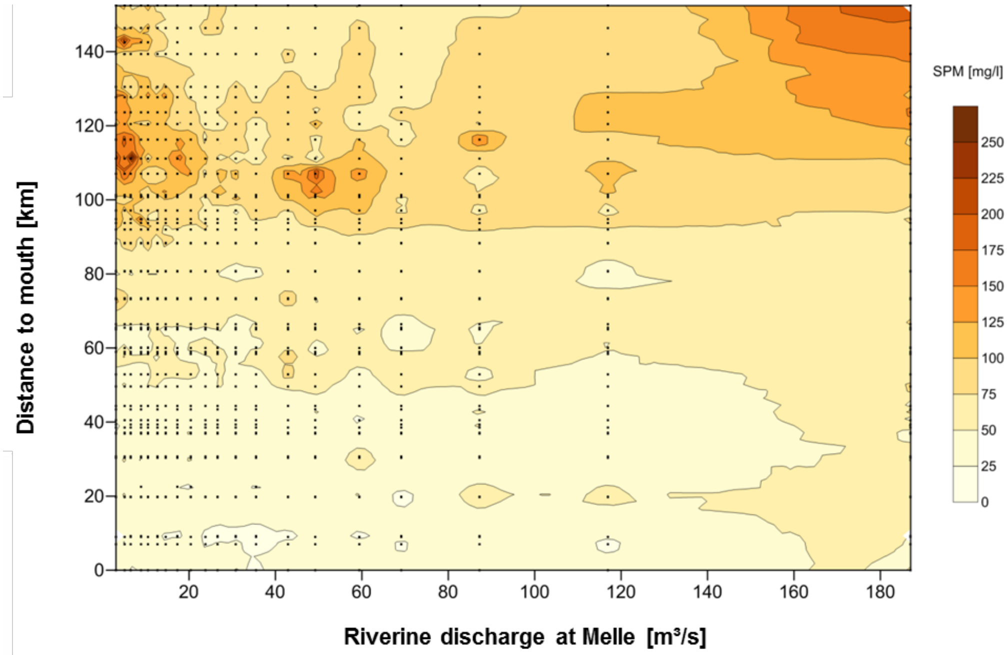

Figure 4. Relationship between the riverine discharge at Melle and the surface SPM along the Scheldt estuary

In the long-term (1995-2013) there is no significant increase or decrease in SPM in the Sea Scheldt. However we do observe an alternation of periods with higher and lower suspended sediment concentrations (Figure 5, red and green circles). Higher SPM values are hereby associated with periods of lower riverine discharge and vice versa (cf. red and green circles in Figure 5 and Figure 6). Riverine discharge thus not only affects the SPM signal on the daily or seasonal scale, but also has an effect in the longer term of years. Our study demonstrates the strong correlation between the physical parameters and the SPM signal, and emphasis that long-term trend analysis of SPM should always be interpreted with care, and in function of the historical changes of the forcing physical parameters.

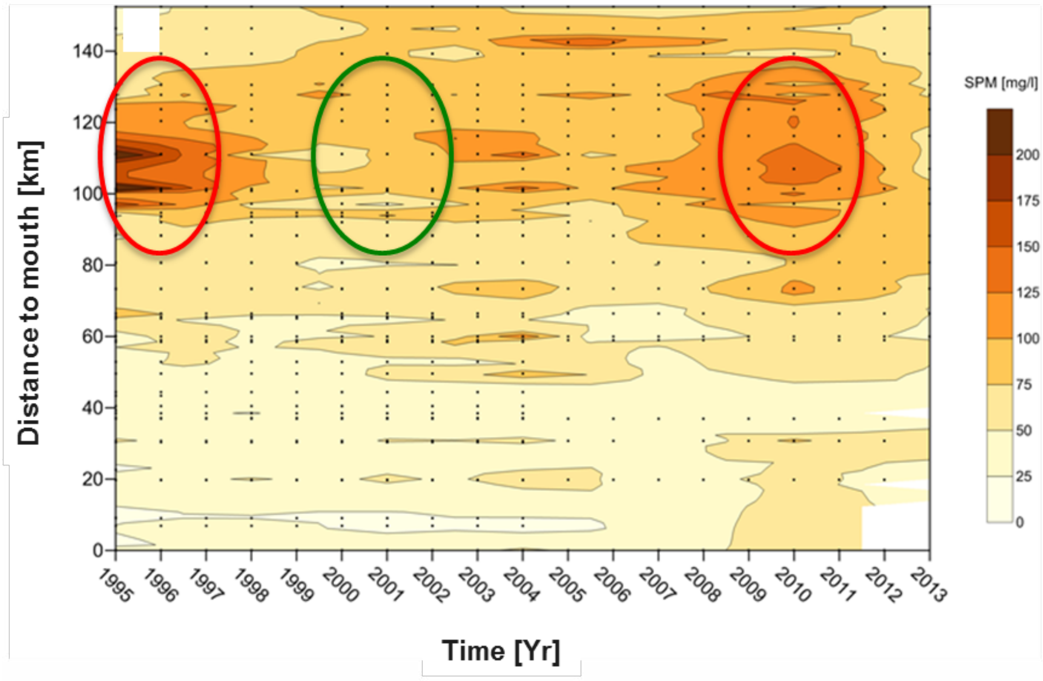

Figure 5. Evolution of surface SPM along the Scheldt estuary over the time period 1995-2013. Red circles indicate periods with higher SPM values in the upstream part of the estuary, the green circle indicates a period with lower SPM values.

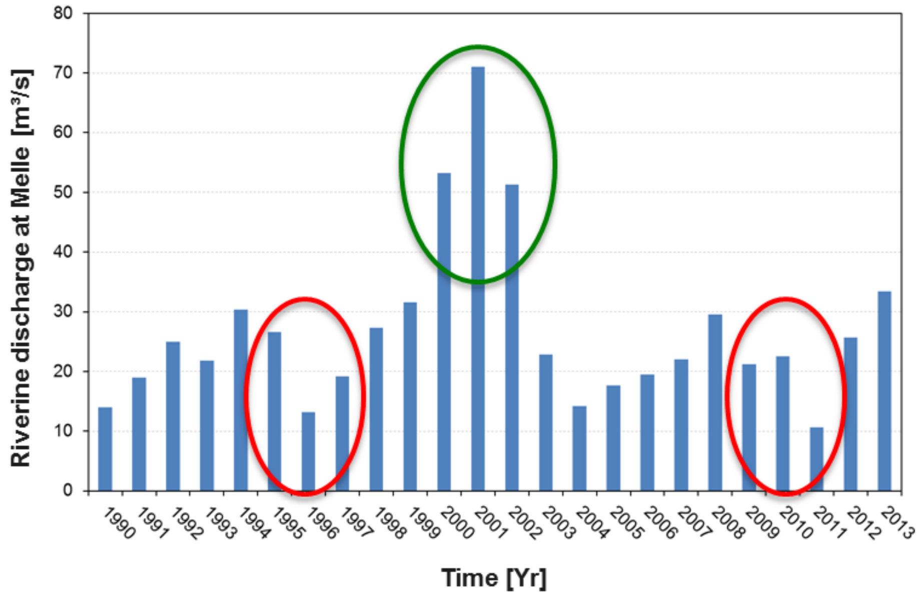

Figure 6. Yearly riverine discharge at Melle.