

A sediment budget for the Rhine-Meuse estuary: importance of dredging and the North Sea sediment flux

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Project summary

The Rhine- Meuse estuary (RME) is comprised of a complex network of tidally influenced channels which provide access to multiple ports and harbours such as Rotterdam. The decline in sediment availability over the past 50 years has caused the erosion of many of the branches, whilst dredging activity further removes sediment from the system. These branches will be further altered by sea level rise and changing discharge in the future. To predict how the sediment dynamics and availability will change, first a complete sediment budget for the recent past and present is needed (Figure 1). Here we calculate a sediment budget for 2000-2018 using which updates and expands on prior work in the area, with new insights from digital elevation models (DEMs). Overall we compute a negative sediment budget for the area which matches previous observations in the RME. Since 2012 there is a clear increase in dredging volumes in the estuary which suggests that sediment circulation and sediment import at the mouth has been changing in recent years.

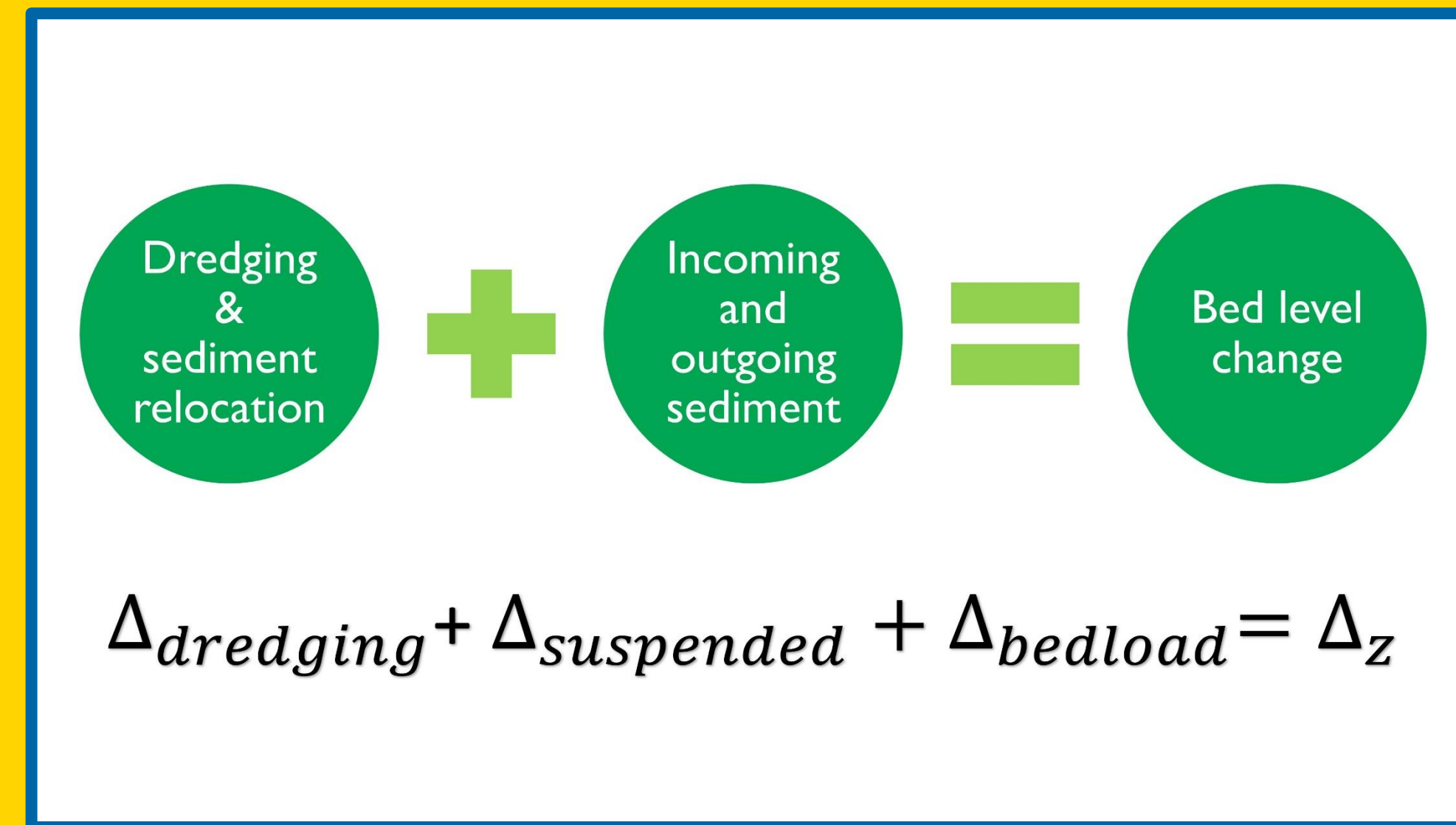


Figure 1: Equation used for creating sediment budgets

Dredging and sediment relocation ($\Delta_{dredging}$)

Dredging targets both branches and the ports and harbours of the RME. Dredged sediment is either sold or relocated. It is relocated off the coast (90%) or in specifically designed sites called sluffers (10%). Thus dredged material is assumed to be completely removed from the area for our sediment budget. There has been a clear increase in the amount of dredging in the ports and harbours in recent years (Figure 2) which we propose is linked to changing sediment circulation and possibly changing sediment import at the mouth since the construction of the Maasvlakte 2.

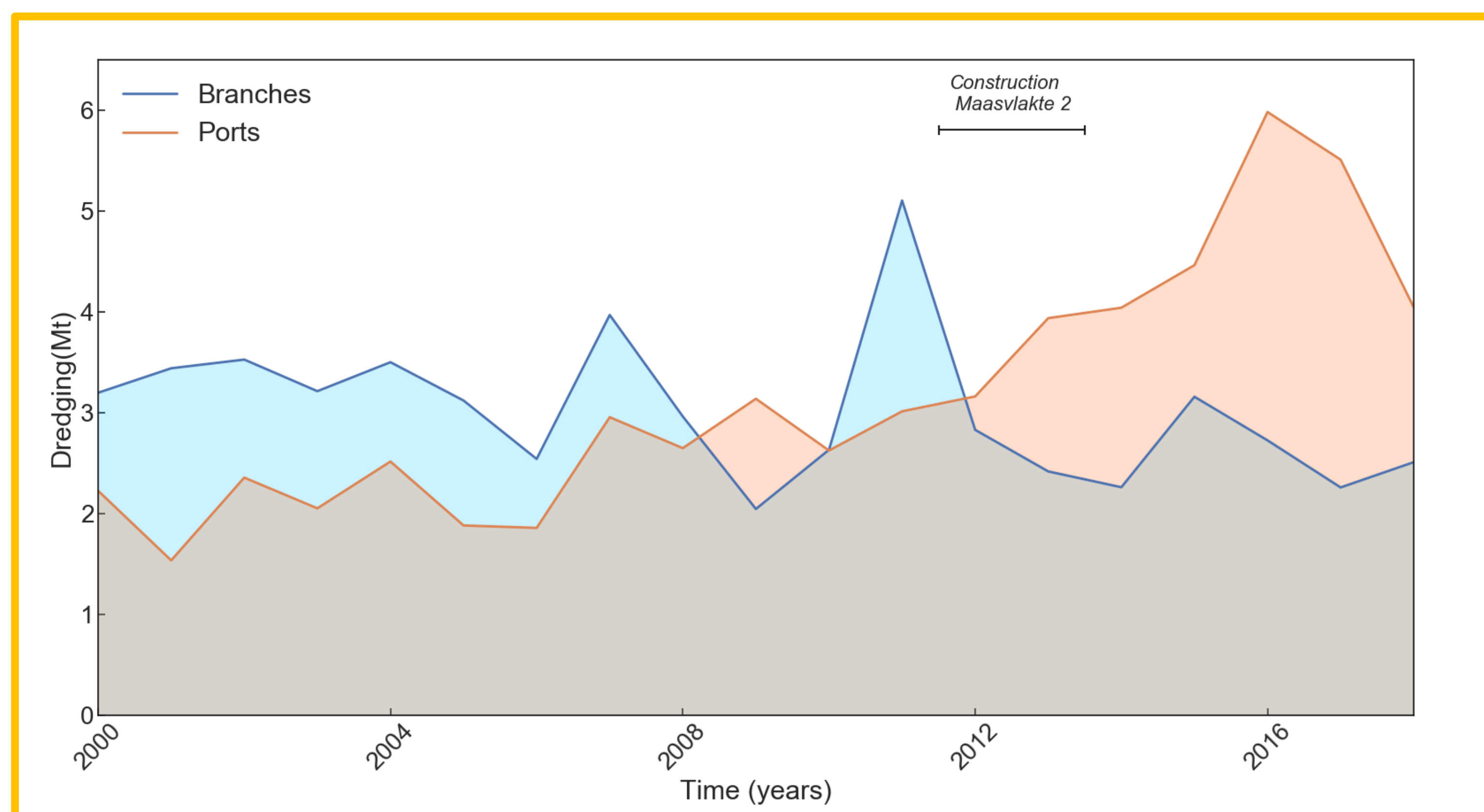


Figure 2: Dredging amounts for the branches and the ports and harbours in the RME for 2000-2018

Study area & recent branch elevation trends(Δ_z)

Figure 4 shows average change in bed elevation for the RME between 2000-2018. It is clear that the northern and central branches e.g. Nieuwe Maas and Oude Maas are eroding while the southern branches (Hollands Diep and Haringvliet) are sedimenting.



Figure 4: Average change of bed elevation(cm) between 2000-2018

Incoming and outgoing sediment ($\Delta_{suspended}$ and $\Delta_{bedload}$)

The system is fed by three main rivers upstream the Maas, Waal and Lek. Of these, the Waal is the most important source of sand and silt for the RME. At the coastal boundary sediment is discharged at the Haringvliet sluices, but primarily sediment is exchanged at the boundary with the North Sea at the Nieuwe Waterweg. The largest unknown in the sediment budget is the amount of sediment coming into the system at the North Sea boundary which in previous budgets relies on sediment-discharge relations from the 1980s or is used as a closing term.

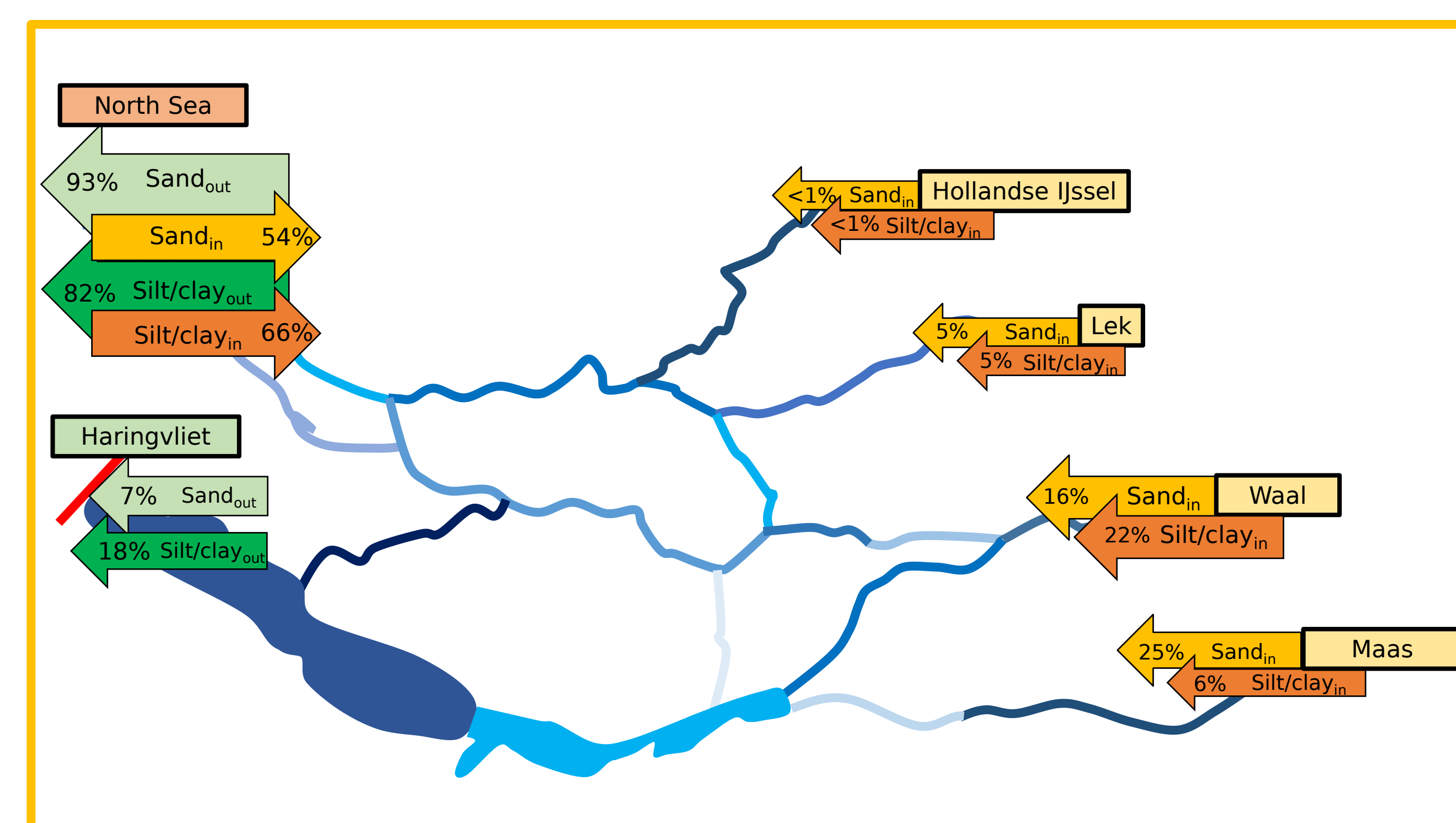


Figure 3: Incoming and outgoing fluxes for the RME based on the work of Becker (2015) and Frings et al. (2019)

Comparing the two methods

The sediment budget of the Rhine-Meuse delta is decreasing over time, rapidly in recent years due to increased dredging. Different values for the North Sea flux can cause severe changes to the budget. Dredging is the main control that determines the measured sediment budget. The budget from the multibeam bathymetry is more variable. This is linked to the various margins of error when combining the seasonal DEMs into one yearly value.

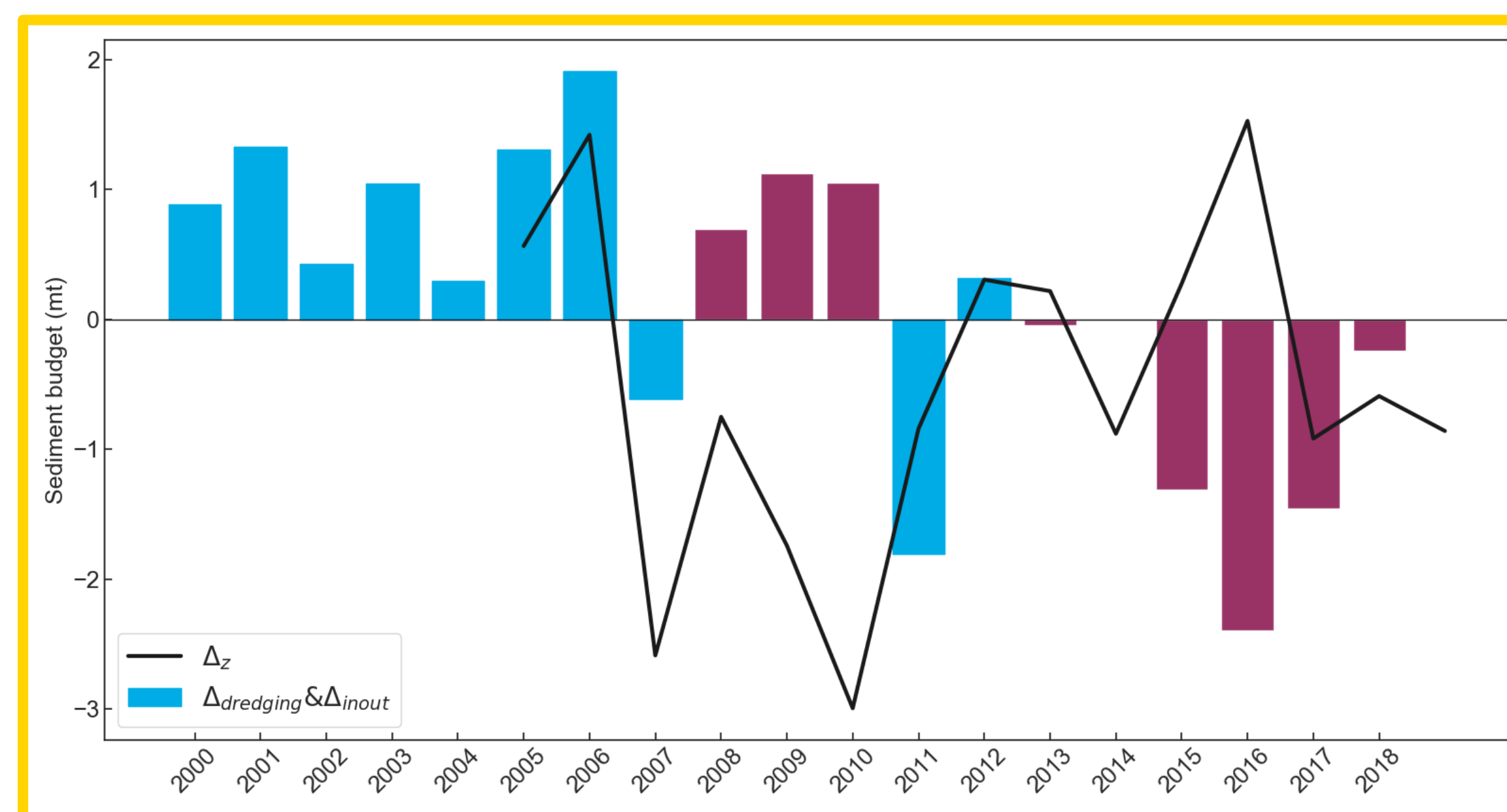


Figure 5: The sediment budget for the Rhine-Meuse delta as calculated using multibeam survey data and measured dredging and flux data. Note the DEM data is missing the influence of the dredging of the ports and harbours. Single beam measurements (pre-2005) are available but excluded based on their error margin.

References

- Becker, A. (2015). *Sediment in be(weging)*. 1208925-000, Deltares.
Frings, R., Hillebrand, G., Gehres, N., Banhold, K., Schriever, S. and Hoffmann, T. (2019). *From source to mouth: Basin-scale morphodynamics of the Rhine River*. Earth-Science Reviews.

The Rhine-Meuse estuary has a negative sediment budget. The main cause of this negative budget is increased dredging activity in recent years. Sustainable sediment management in the future is therefore crucial to combat the negative effects caused by this lack of sediment which locally affects some branches more than others.

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