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Interactive comment on "A model for the benthic-pelagic coupling of silica in estuarine ecosystems: sensitivity analysis and system scale simulation" *by* S. Arndt and P. Regnier

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Response to anonymous Referee ♯1

Specific comments: Page 769, line 3ff: The silica measurements presented in the ms. have been performed on samples taken in the period between February 2000 and August 2001. The model, however, simulates the summer period of 2003. This simulation period was chosen due to the prevailing, extremely dry conditions, hypothesized to favor the influence of the benthic-pelagic coupling on silica dynamics. The time difference between measurements and simulation results makes their direct comparison meaningless, since the benthic silica dynamics strongly depends on the

primary production dynamics in the overlaying water column, which reveals a strong variation in magnitude from year to year. The measurements reveal nevertheless a general seasonal trend of dissolved silica dynamics which is well captured by the model. They illustrate also that data alone, characterized by a coarse spatial and temporal resolution, can not cope with the temporal variability and the strong spatial heterogeneity of the benthic-pelagic coupling in the estuary (see also response to referee ♯2).
We added a reference to the measurement period on page 769, line 3. *Measurements of interstitial silica profiles at two shallow intertidal sites along the estuarine gradient (February 2000-August 2001; Waarde km 60, Appels km133) merely capture8230;*

Technical corrections: We increased the size of the listed figures.

Response to anonymous Referee ♯2

The system-scale simulation provides an example of application of the benthic model, which is of general applicability, to a well-constrained estuarine system. This simulation not only illustrates the model's abilities, but provides also insights on the type of data which are required to constrain the magnitude of the benthic-pelagic coupling in estuaries. The Scheldt estuary has been chosen because a pelagic model for the primary production dynamics for the summer period of 2003 was available (Arndt et al., 2007). It has been hypothesized that the benthic recycling fluxes in this estuary might support a part of the pelagic primary production during the silica depletion in summer, especially during the extremely dry summer month in 2003 (Desmit, 2005; Van Damme et al., 2005; Muylaert et al., 2000). In addition, the pelagic model provides well constrained forcing functions (e.g. PBSI deposition flux, PDSI concentration) for the benthic model. The uncertainty in silica recycling fluxes associated to the internal

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benthic model parameters could thus be estimated on the basis of a comprehensive sensitivity study.

The importance of the benthic-pelagic coupling has been evaluated on the basis of a few benthic flux measurements which are typically conducted on easily accessible, shallow intertidal flats. These sites, however, favor deposition and are thus generally characterized by relatively high benthic silica fluxes. An extrapolation of these measured fluxes to the system scale may therefore result in an overestimation of the total benthic silica flux and lead to different conclusions than those presented here. Struyf et al. (2005), for instance, argued that the recycling of biogenic silica may supply almost half of the total silica load in the main river channel of the Scheldt based on an extrapolation of observed silica fluxes from the sediments of a tidal freshwater marsh to the total area of the tidal freshwater marshes in the estuary. Similarly, a maximum benthic silica flux of $4.2\ mmol\ m^{-2}\ d^{-1}$ can be estimated from vertical silica profiles measured at Appels in October 2000. The extrapolation of this flux to the total area of the tidal freshwater reaches results in a benthic recycling flux of $8.8 \cdot 10^4\ mol\ d^{-1}$. This estimate exceeds the riverine silica input ($2.8 \cdot 10^4 - 8.8 \cdot 10^4\ mol\ d^{-1}$) during the peak stage of the silica depletion period in mid-August (12.08.2003-18.08.2003) and represents ca. 29$\%$ of the total silica influx in August 2003. An integration of the measured flux over the whole simulation period (June-November) would amount to a total input of $5.9 \cdot 10^7$ mol Si from the benthic compartment, representing 21$\%$ of the total silica input over this period, a value which is much higher than the estimate based on our RTM simulations.

Our system-scale results reveal that the benthic environment is extremely heterogeneous. Fig. 8 illustrates that the dynamics of the benthic return flux shows quantitatively and qualitatively different patterns between sites. Even if one focuses on intertidal flats (S1, S3) where very similar hydrodynamic conditions are encountered, pronounced differences in fluxes which are mainly driven by the production dynamics

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in the overlaying water column can be observed. An extrapolation of local fluxes to the system scale or even to morphologically similar environments is thus questionable. Furthermore, an extrapolation of maximum estimates to calculate the supply fluxes of silica available to sustain primary production does not account for the delayed response of the benthic fluxes to the deposition peak. Our simulation showed that the period of highest primary production and thus highest deposition fluxes is characterized by a strong silica limitation in the whole production area. However, highest benthic silica fluxes are reached at the end of the depletion period. Therefore, the influence of the benthic environment might also be overestimated if this delay is ignored. The importance of the benthic flux for the system scale dynamics is thus difficult to asses on the basis of field observations or simplified models which do not account for the spatio-temporal variability in the benthic dynamics.

We modified parts of the manuscript and added one figure to to highlight the problems associated with an extrapolation of measured, local fluxes and to emphasize that the proposed reactive transport model approach is particularly suitable to simulate benthic-pelagic coupling on the scale of an estuarine system.

Interactive comment on Biogeosciences Discuss., 4, 747, 2007.