DO transport regimes across the water-sediment interface under low-energetic oscillatory flows

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ABSTRACT

Dissolved oxygen (DO) transfer between bottom sediments and the overlaying water (Water-Sediment Interface, WSI) constitutes an essential coupling for benthic and pelagic ecosystems and influences a wide range of important geochemical processes. Very close to the bed, where turbulent diffusivity becomes negligible, DO fluxes are governed by molecular diffusion and the concentration gradients across the diffusive boundary layer (DBL) and diffusive sediment layer (DSL). The flow regime controls both the mean value and the fluctuations of the DBL thickness (Sánchez-Badorrey et al., 2006).

The influence of the DBL dynamics induced by low-energetic oscillatory flows on the coupled transport of DO across the diffusive boundary and the diffusive sediment layers is analyzed here by means of a 1D unsteady diffusive-reactive mass transport model in an evolving domain. The transport properties of the two diffusive media were assumed different and discontinuous across the WSI. DO consumption in the DBL region was modeled by Michaelis-Menten kinetics. A coordinate transformation is applied to map the evolving domain onto a fixed region and to solve the equivalent coupled transport problem.

Model results show that the fluctuations of the DBL thickness induced by oscillatory flows lead to additional advective transport terms in the in the new coordinate system. The mean value ($\overline{\delta}_D$), the amplitude ($\Delta\delta_D$) and the characteristic time scale (T_D) of the fluctuations of the DBL thickness are found to be key parameters to identify the dominant DO transport regime across the WSI. These findings are consisting with previous numerical results by Chatelain & Guizen (2010) for slow oscillatory motions of monochromatic type. Moreover, the threshold value of the ratio $\Delta\delta_D / \overline{\delta}_D$ for changing the transport regime across the DBL from diffusive-dominant to advective-dominant was found.

The implications of the different transport regimes for the DO balance across the WSI and the DO penetration depth into de DSL will be presented at the conference.

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