Transmission of oxygen concentration fluctuations through the diffusive boundary layer overlying aquatic sediments

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ABSTRACT: Even though the O_2 concentration in the diffusive boundary layer overlying natural aquatic sediments usually varies over time, microprofiles with little or no error bars are abundant in the literature. These temporal concentration fluctuations are not accounted for in the conceptual models used to describe the diffusive boundary layer, and their effects on phenomena investigated through microprofile measurements are unclear. This paper focuses on concentration fluctuations in the diffusive boundary layer above a marine sediment. One microsensor was inserted into a laboratory flume from below and positioned with the sensing tip precisely at the sediment surface. A second microelectrode was deployed from above through the flowing water column and positioned within the diffusive boundary layer directly above the tip of the lower sensor. Time series of the fluctuating O_2 concentration at the two points were measured simultaneously with the two sensors and demonstrated a tight coupling of concentration fluctuations across the diffusive boundary layer. A dynamic model accounting only for molecular diffusion plus zero-order O_2 consumption within the sediment explained the observed coupling through the diffusive boundary layer and enabled calculation of instantaneous O_2 profiles from the top of the true diffusive boundary layer to the depth of O_2 penetration. Model results confirmed that concentration fluctuations were linked from the top of the true diffusive boundary layer down to about 0.5 mm sediment depth. The transient profiles moved back and forth, without losing the general shape derived from the averaged steady state O_2 distribution. Apart from this description of the temporal structure of the diffusive boundary layer, the model shows that concentration fluctuations in the layer do not necessarily indicate turbulence within the true diffusive boundary layer. This dynamic description is used to discuss experimental procedures when measuring microprofiles.