The role of small-scale sediment topography for oxygen flux across the diffusive boundary layer

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ABSTRACT: At the scale of centimeters or millimeters, marine sediment surfaces are sculptured into complex three-dimensional landscapes. A detailed study of fluxes through the diffusive boundary layer (DBL) therefore requires concurrent information on the surface structure. Using natural sediment in a laboratory flume, we investigated the impact of small-scale sediment topography on diffusive oxygen flux through the DBL. Topographic maps of the sediment surface with 0.1 mm horizontal resolution were acquired with a custom-made optical technique, and immediately afterward the oxygen diffusion field across the sediment-water interface was measured with microsensors in known orientation within the described topography. A method was developed to calculate the three-dimensional diffusive flux through the DBL, based on the combination of vertical O2 microprofiles and the high-resolution topographic data. Even though the sediment surface investigated was elaborately sculptured by fauna, the combined influence of increased surface area and horizontal concentration gradients within the DBL induced less than 10% difference between one-dimensional and three-dimensional diffusive flux calculations. The relatively low impact of surface topography is explained by the geometry of the diffusion field, as well as effects of the rapid diffusion of O2 at small scales.