Figure 1

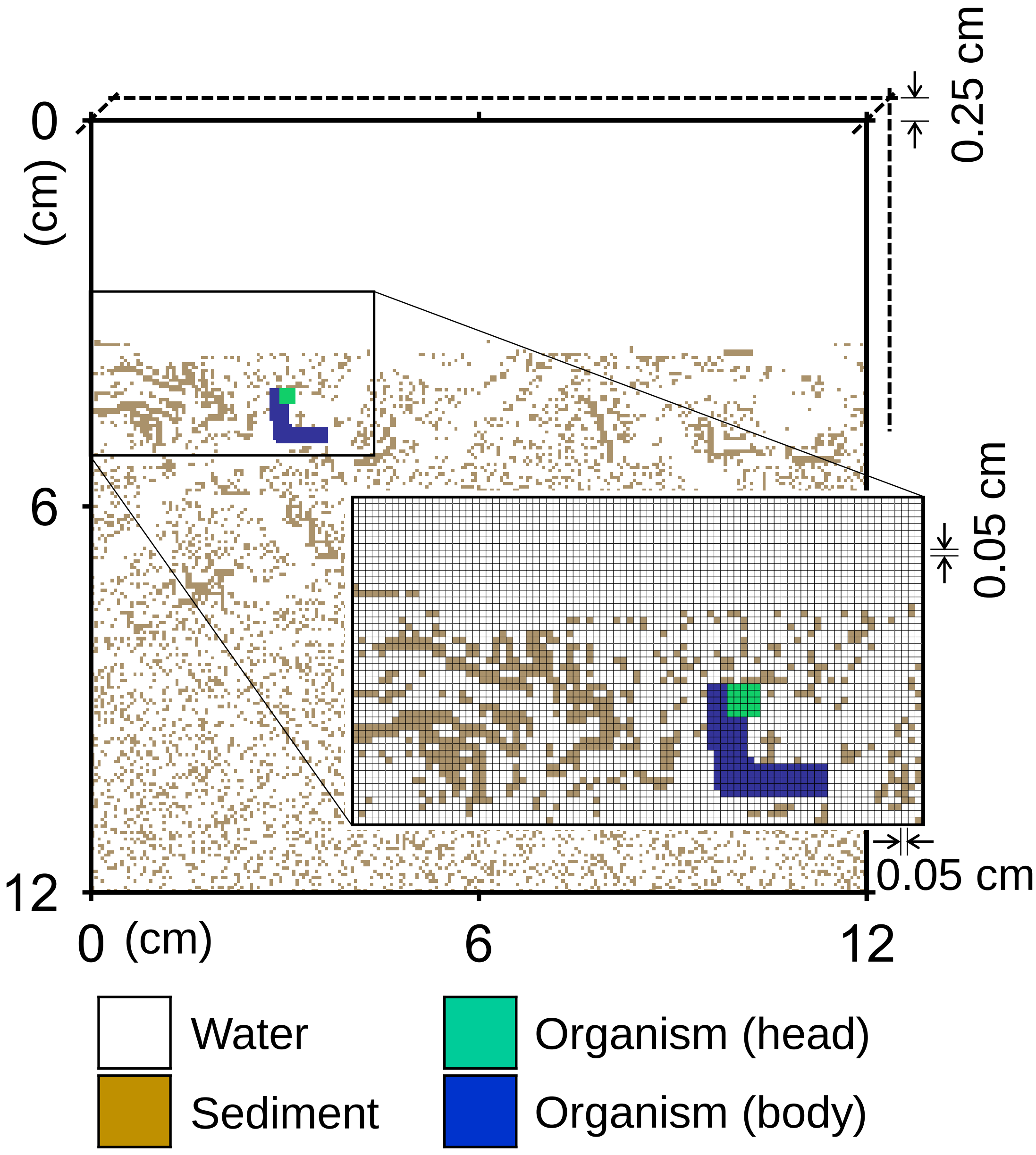

Figure 1: Illustration of grid on which the behavior of benthic organism is simulated by the Lattice-Automaton Bioturbation Simulator (LABS). Note that the left and right boundaries of the grid are continuous. Shown in lower right is a magnified view where each grid cell (0.05×0.05 cm^2) can be seen. Dashed lines are drawn to show the implicit width of the system with which the 2D grid system can be converted to a 3D system.

Figure 2

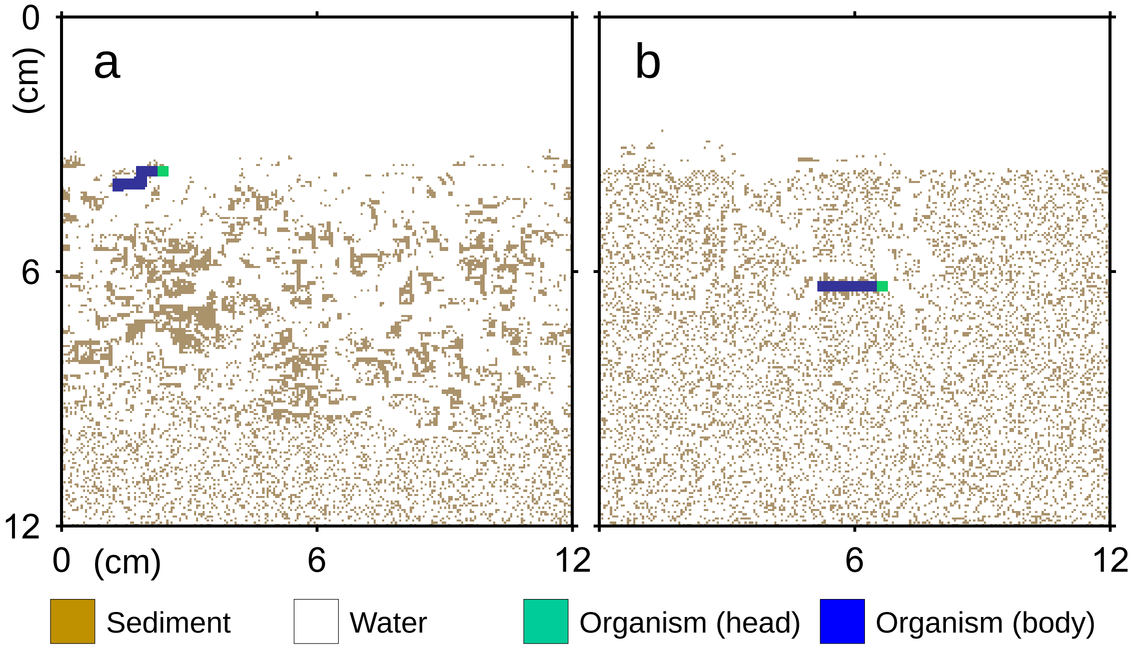

Figure 2. Geometry of burrows after 1-year simulations by the original LABS (oLABS) with different rules on the preferable direction of organisms' movements. In (a), the preferable direction is where more labile organic matter exists. In (b), an additional rule is imposed upon the rules in (a), that organisms with greater gut fullness prefer to move in the direction where more water exists.

Figure 3

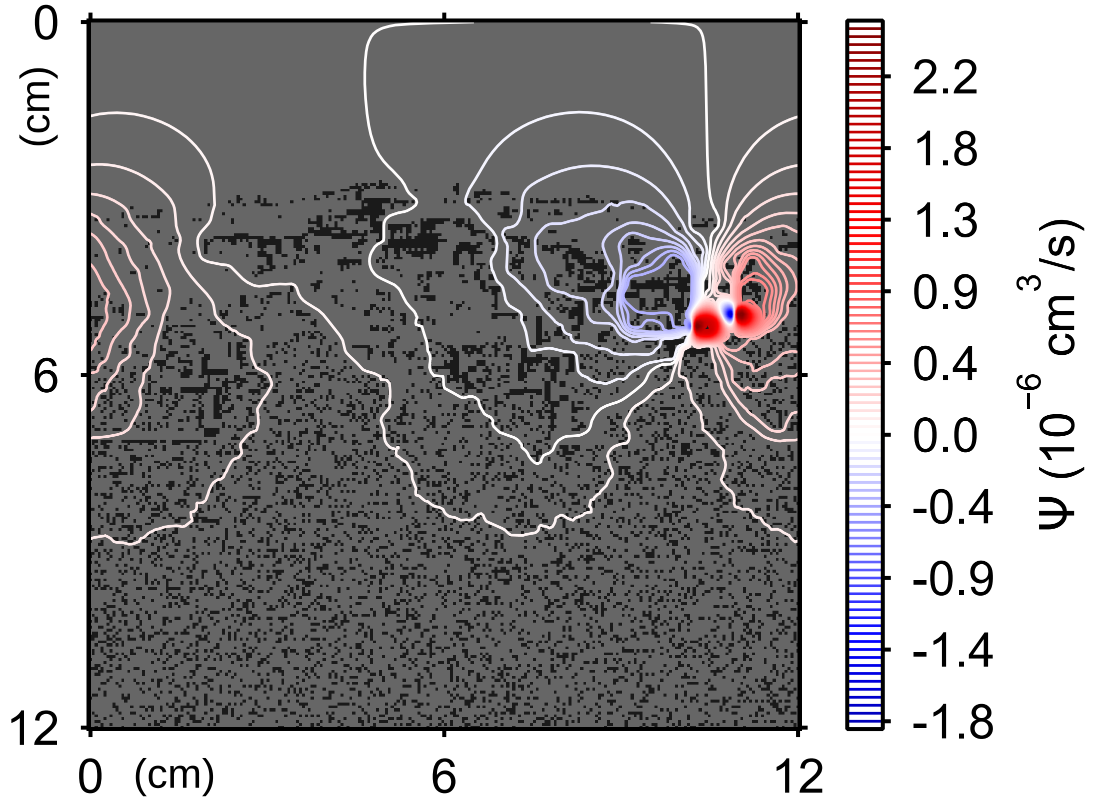

Figure 3. Stream function calculated at 150 model days from the start of simulation by the extended LABS (eLABS) with the default settings (Section 3).

Figure 4

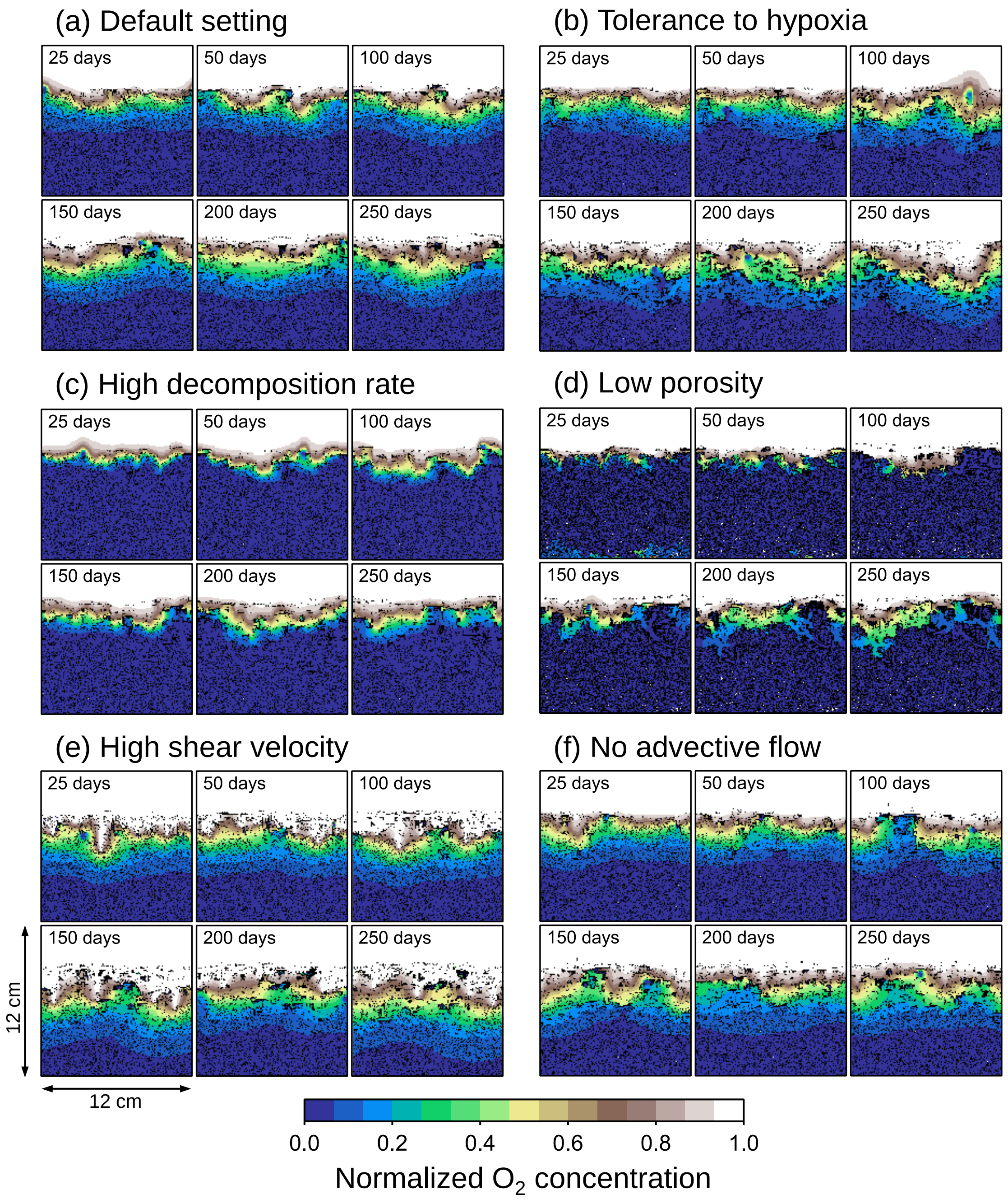

Figure 4. Time evolution of oxygen profiles calculated by 1-year simulations by eLABS. Six different simulations were conducted (Section 3.1): (a) with the default settings, (b) assuming organisms to have tolerance to oxygen-depleted conditions but otherwise the default settings, (c) with ten times higher rate for aerobic decomposition of organic matter but otherwise the default settings, (d) with 0.6 of porosity but otherwise the

default settings, (e) with ten times higher shear velocity but otherwise the default settings, and (f) without the deterministic water flow calculation with otherwise the default settings. Shown are the profiles of oxygen concentration normalized to the constant boundary value (2.2×10^{-4} mol L^{-1}) at the top layer of the grid at 25, 50, 100, 150, 200 and 250 model days from the start of the simulations.

Figure 5

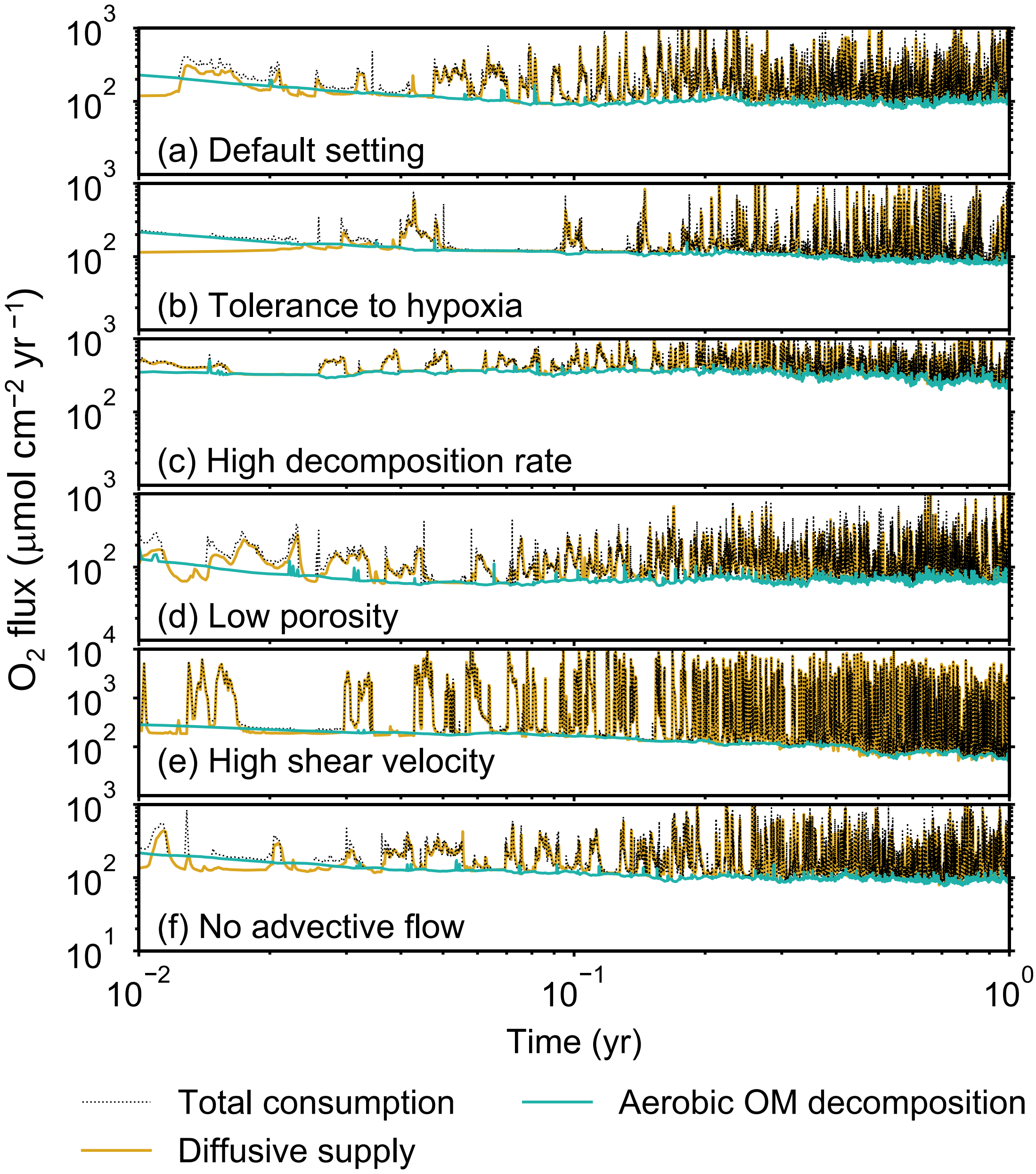

Figure 5. Time evolution of oxygen fluxes obtained from 1-year simulations by eLABS. See Section 3.1 and caption of Fig. 4 for the details on simulations (a–f). Black dotted curves represent the total oxygen consumption fluxes, orange curves the fluxes of oxygen supply via molecular plus eddy diffusion, and green curves the oxygen consumption fluxes through aerobic degradation of organic matter. Note that the scale of vertical axis is different in (e).

Figure 6

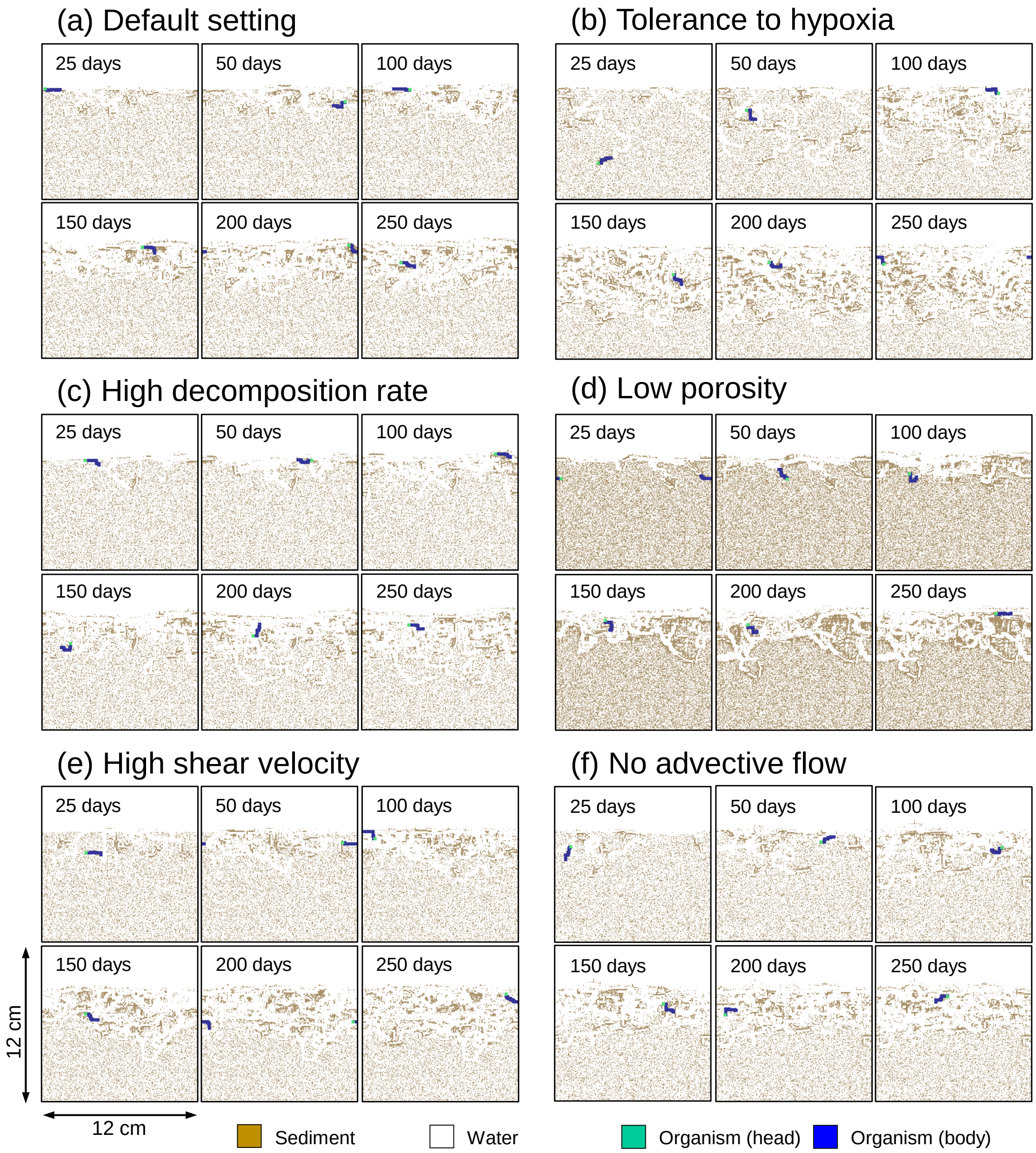

Figure 6. Time evolution of burrow geometry obtained from 1-year simulations by eLABS. See Section 3.1 and caption of Fig. 4 for the details on simulations (a–f). Shown are burrow geometries at 25, 50, 100, 150, 200 and 250 model days from the start of the simulations.

Figure 7

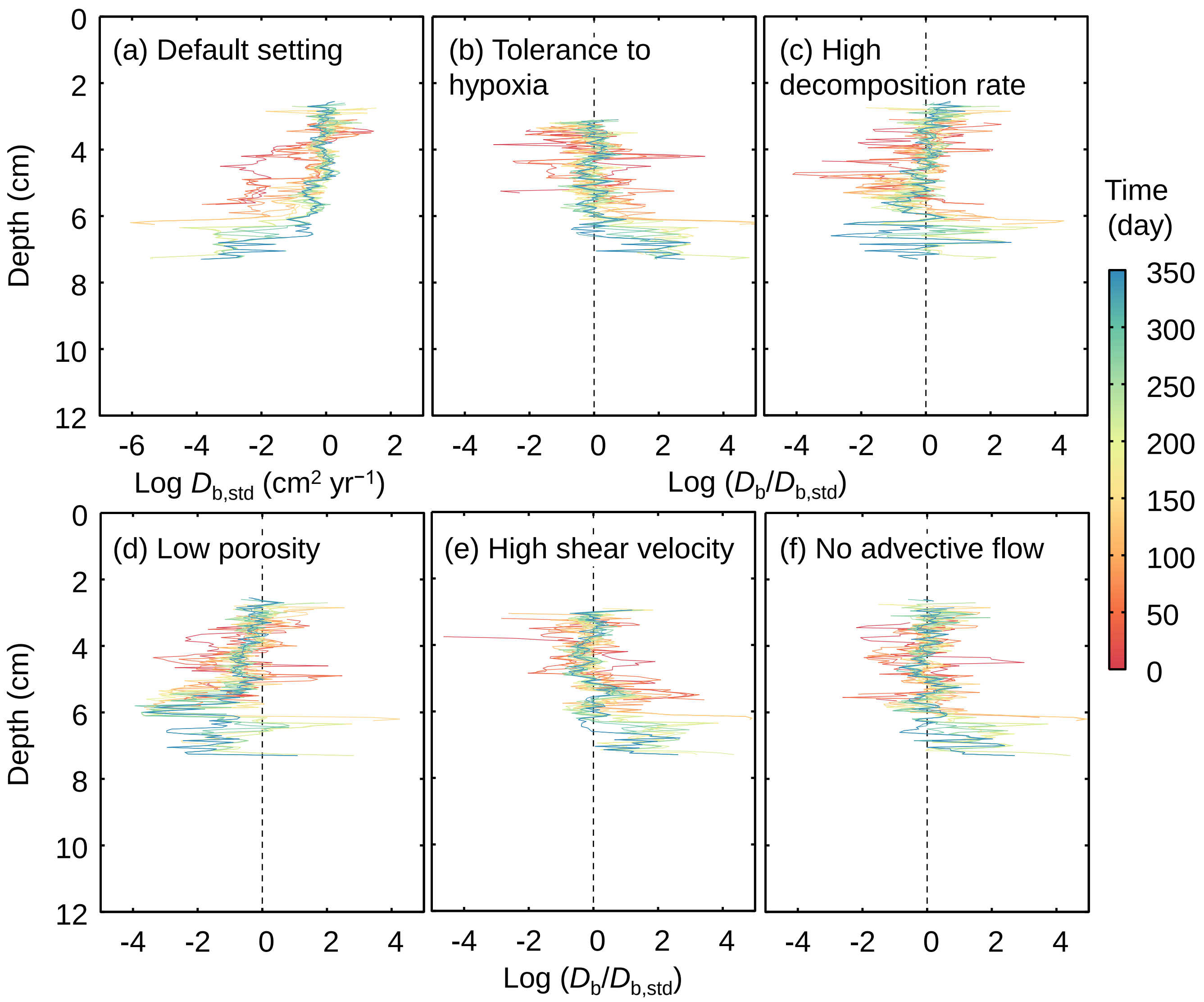

Figure 7. Time evolution of biodiffusion coefficient (D_b) obtained from 1-year simulations by eLABS. See Section 3.1 and caption of Fig. 4 for the details on simulations (a–f). Note that the D_b values are presented only for simulation (a) (denoted as $D_{b,std}$); for other simulations (b–f), the ratios of D_b values to those in (a) ($D_b/D_{b,std}$) are shown to facilitate comparison and dashed vertical lines are references to denote $D_b = D_{b,std}$. Plotted are these values/ratios at 25, 50, 75, …, 350 model days from the start of the simulations.

Figure 8

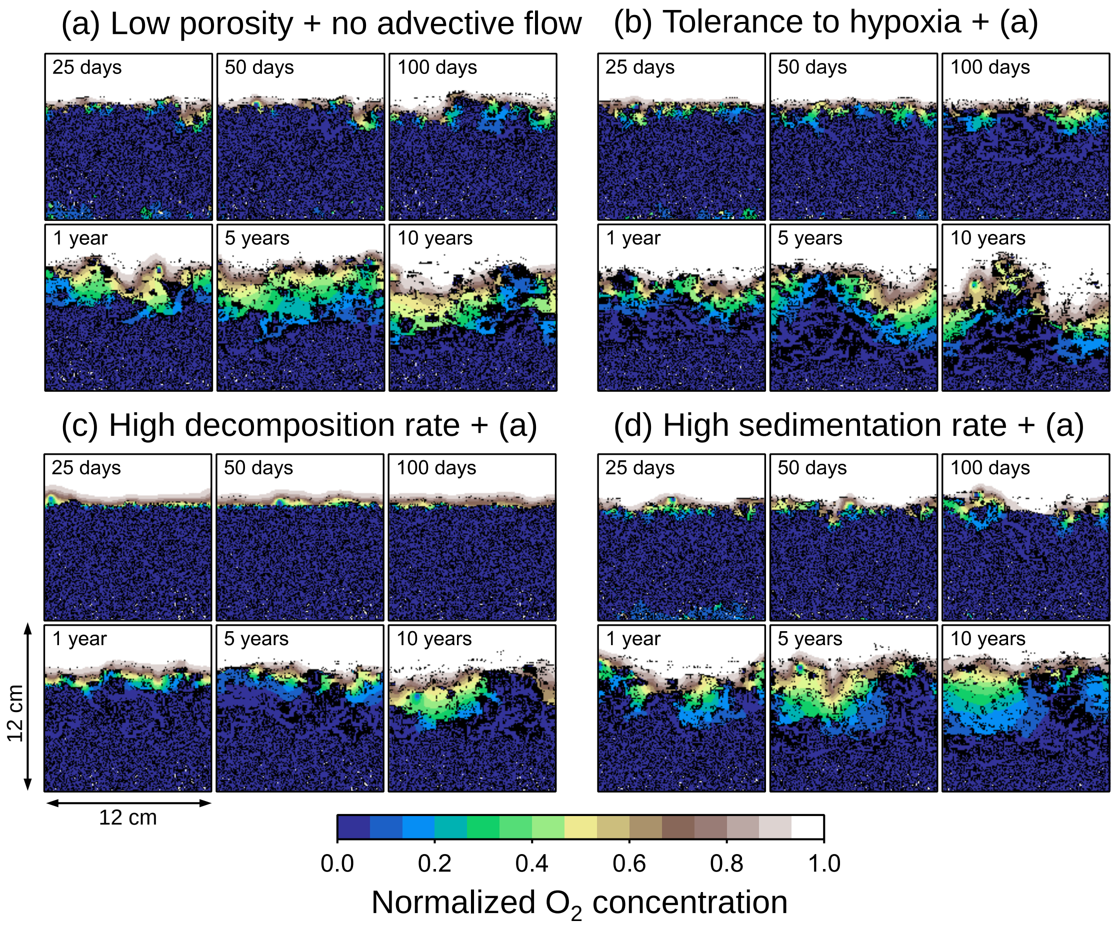

Figure 8. Time evolution of oxygen profiles calculated by 10-years simulations by eLABS. Four different simulations were conducted (Section 3.2): (a) with low porosity and no advective water flow, but otherwise the default settings, (b) additionally assuming organisms to have tolerance to oxygen-depleted conditions, (c) with ten times higher rate for aerobic decomposition of organic matter but otherwise the same settings as in (a), and (d) with ten times higher sedimentation rate but otherwise the same settings as in (a). Shown are the profiles of oxygen concentration normalized to the constant boundary value (2.2×10^{-4} mol L^{-1}) at the top layer of the grid at 25, 50 and 100 model days and 1, 5 and 10 model years from the start of the simulations.

Figure 9

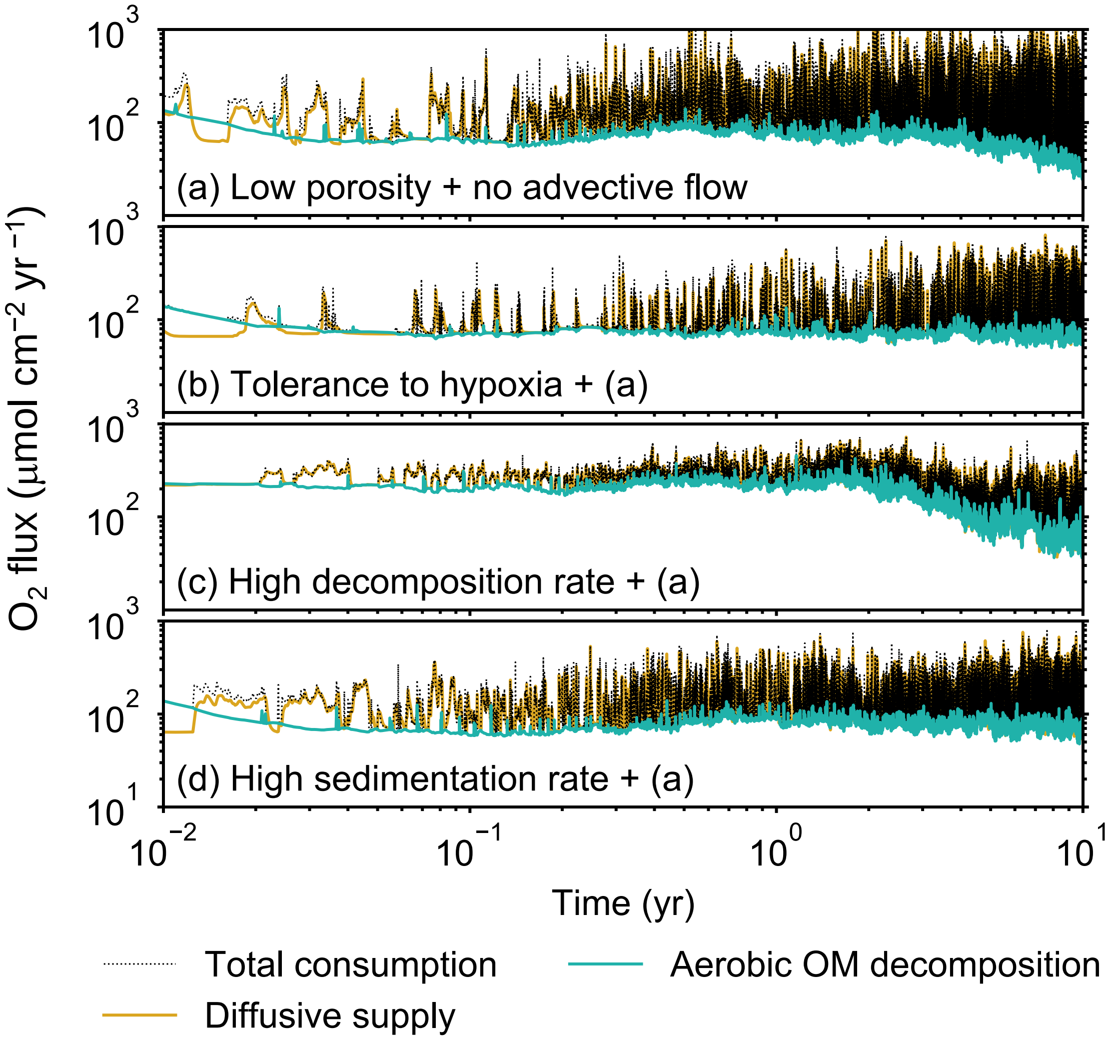

Figure 9. Time evolution of oxygen fluxes obtained from 10-years simulations by eLABS. See Section 3.2 and caption of Fig. 8 for the details on simulations (a–d). Black dotted curves represent the total oxygen consumption fluxes, orange curves the fluxes of oxygen supply via molecular plus eddy diffusion, and green curves the oxygen consumption fluxes through aerobic degradation of organic matter.

Figure 10

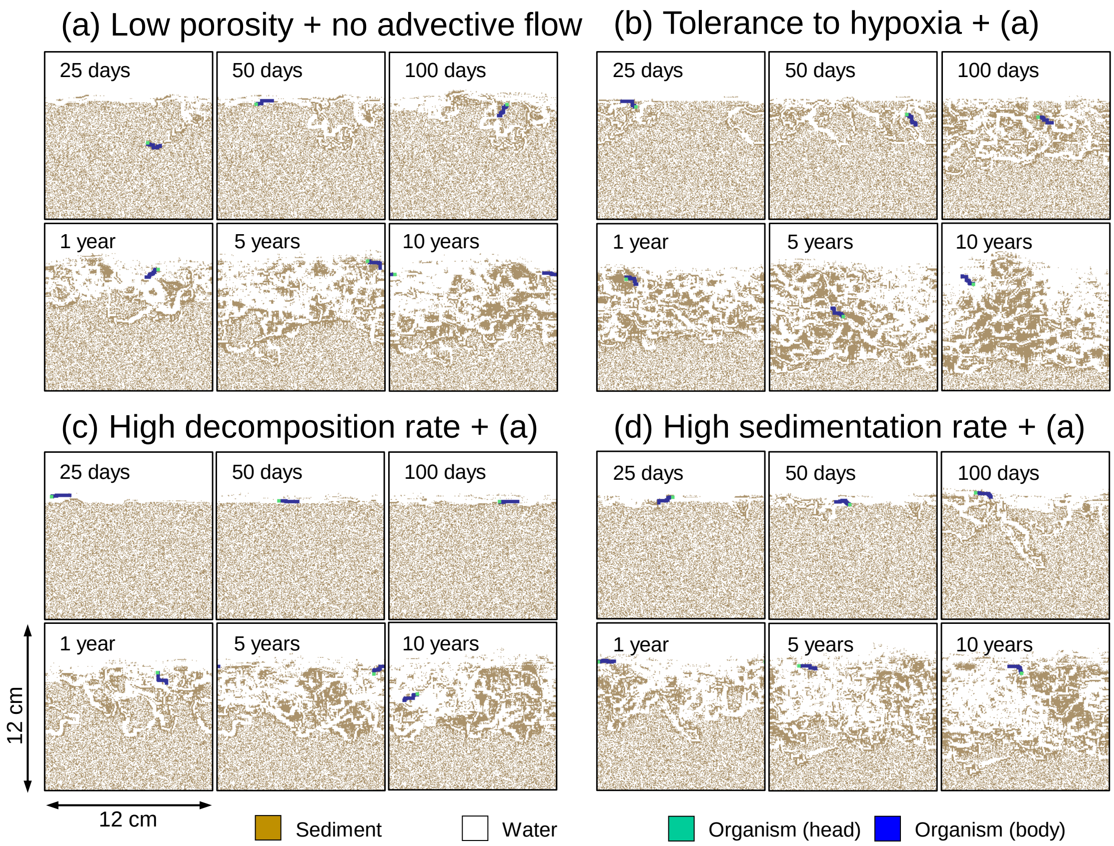

Figure 10. Time evolution of burrow geometry obtained from 10-years simulations by eLABS. See Section 3.2 and caption of Fig. 8 for the details on simulations (a–d). Shown are burrow geometries at 25, 50 and 100 model days and 1, 5 and 10 model years from the start of the simulations.

Figure 11

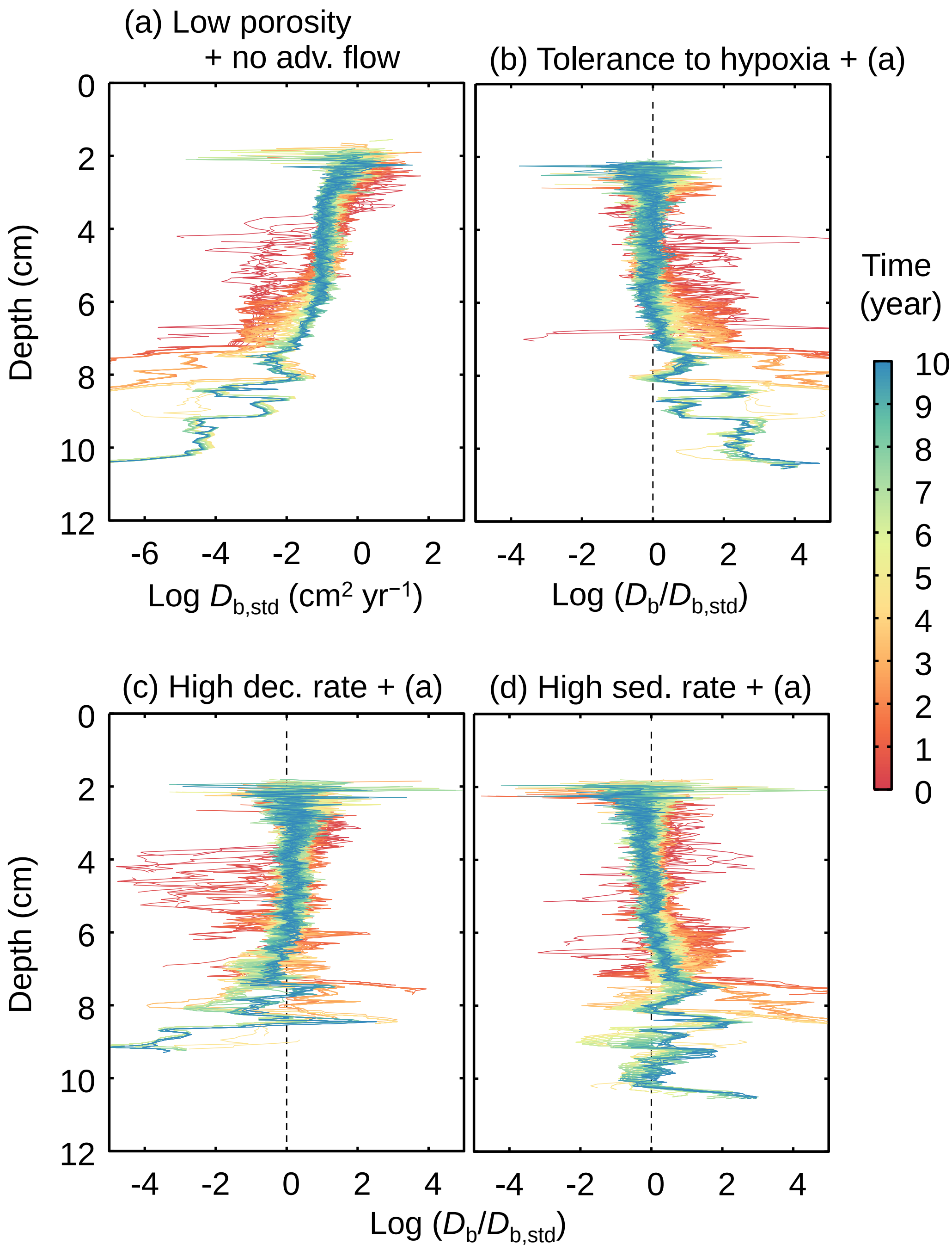

Figure 11. Time evolution of biodiffusion coefficient (*D_b*) obtained from 10-years simulations by eLABS. See Section 3.2 and caption of Fig. 8 for the details on simulations (a–d). Note that the *D_b* values are presented only for simulation (a) (denoted as *$D_{b,std}$*); for other simulations (b–d), the ratios of *D_b* values to those in (a) (*D_b/$D_{b,std}$*)

are shown to facilitate comparison and dashed vertical lines are references to denote D_b = $D_{b,std}$. Plotted are these values/ratios at 25 model days to 10 model years from the start of the simulations with intervals of 25 model days.

Figure 12

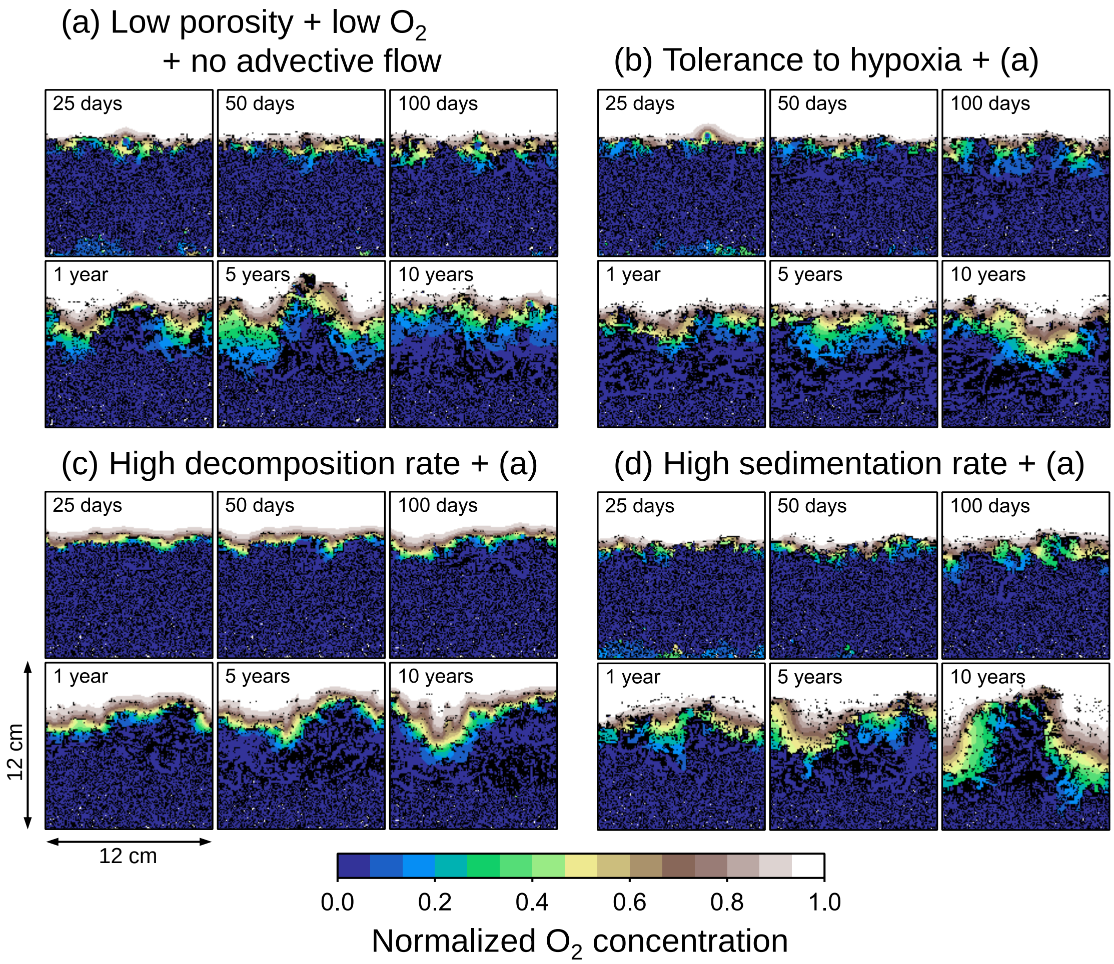

Figure 12. Time evolution of oxygen profiles calculated by 10-years simulations by eLABS. Four different simulations were conducted (Section 3.3): (a) with low porosity, no advective water flow and ten times lower oxygen concentration for seawater, but otherwise the default settings, (b) additionally assuming organisms to have tolerance to oxygen-depleted conditions, (c) with ten times higher rate for aerobic decomposition of organic matter but otherwise the same settings as in (a), and (d) with ten times higher sedimentation rate but otherwise the same settings as in (a). Shown are the profiles of oxygen concentration normalized to the constant boundary value (2.2×10^{-5} mol L^{-1}) at the top layer of the grid at 25, 50 and 100 model days and 1, 5 and 10 model years from the start of the simulations.

Figure 13

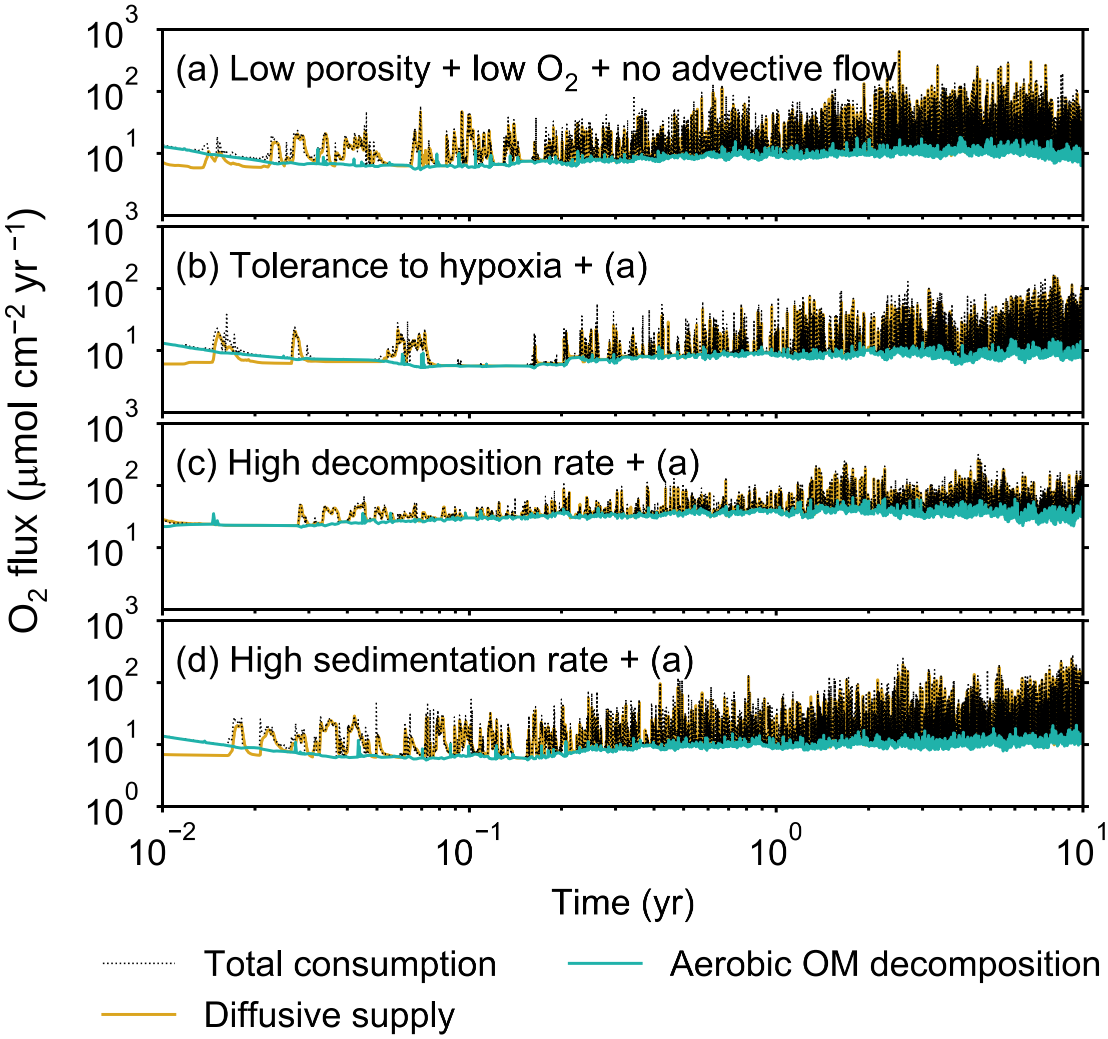

Figure 13. Time evolution of oxygen fluxes obtained from 10-years simulations by eLABS. See Section 3.3 and caption of Fig. 12 for the details on simulations (a–d). Black dotted curves represent the total oxygen consumption fluxes, orange curves the fluxes of oxygen supply via molecular plus eddy diffusion, and green curves the oxygen consumption fluxes through aerobic degradation of organic matter.

Figure 14

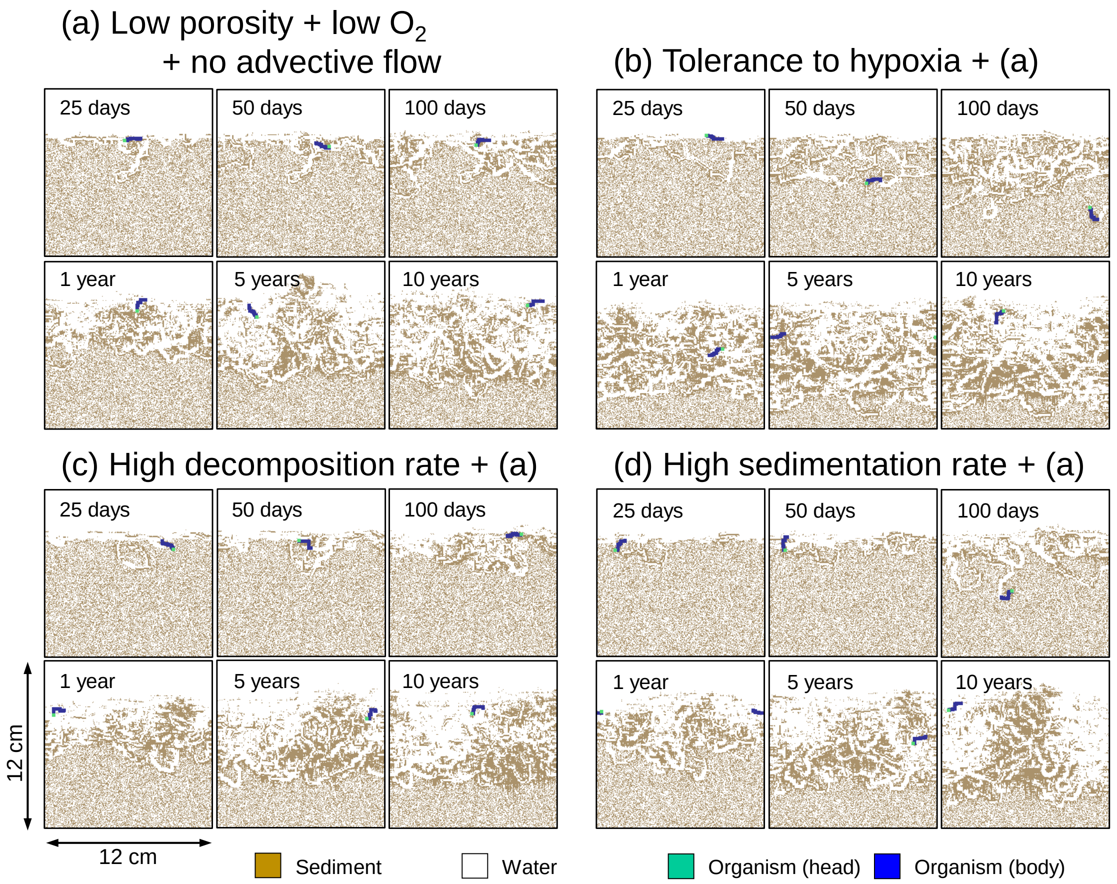

Figure 14. Time evolution of burrow geometry obtained from 10-years simulations by eLABS. See Section 3.3 and caption of Fig. 12 for the details on simulations (a–d). Shown are burrow geometries at 25, 50 and 100 model days and 1, 5 and 10 model years from the start of the simulations.

Figure 15

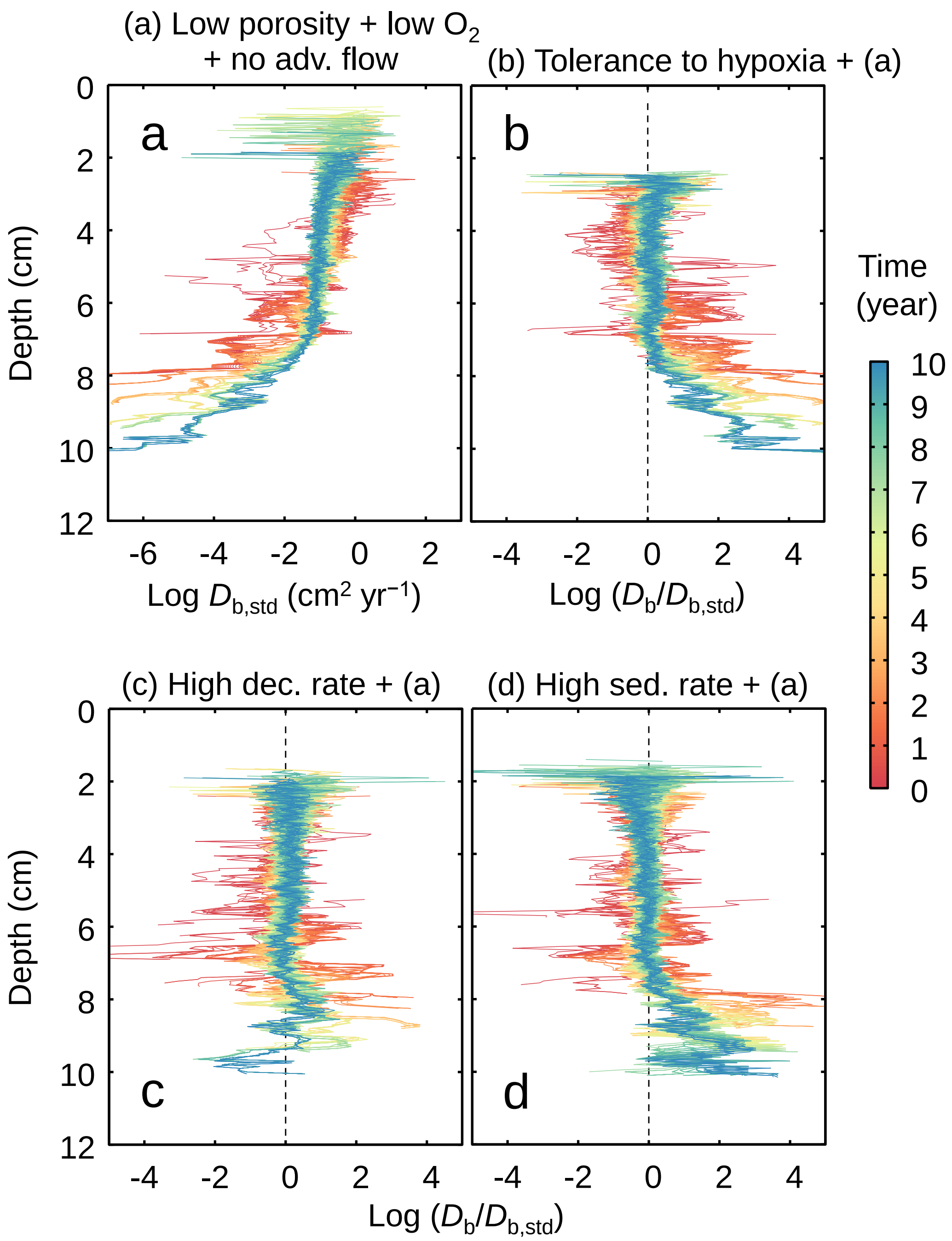

Figure 15. Time evolution of biodiffusion coefficient (D_b) obtained from 10-years simulations by eLABS. See Section 3.3 and caption of Fig. 12 for the details on simulations (a–d). Note that the D_b values are presented only for simulation (a) (denoted as $D_{b,std}$); for other simulations (b–d), the ratios of D_b values to those in (a) ($D_b/D_{b,std}$) are shown to facilitate comparison and dashed vertical lines are references to denote D_b = $D_{b,std}$. Plotted are

these values/ratios at 25 model days to 10 model years from the start of the simulations with intervals of 25 model days.