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Double-diffusive layer formation

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Double-diffusive convection plays an important role in geo- and astrophysical applications. The special case, where a destabilising temperature gradient counteracts a stabilising solute gradient leads to layering phenomena under certain conditions. Convectively mixed layers sandwiched in diffusive interfaces form a so-called stack. Well-known double-diffusive systems are observed in rift lakes in Africa and even from the coffee drink Latte Macciatto. Stacks of layers are also predicted to occur inside massive stars and inside giant planets. Their dynamics depend on the thermal, the solute and the momentum diffusivities, as well on the ratio of the gradients of the opposing stratifications. Since the layering process cannot be derived from linear stability analysis, the full nonlinear set of equations has to be investigated. Numerical simulations have become feasible for this task, despite the physical processes operate on a vast range of length and time scales, which is challenging for numerical hydrodynamical modelling. The oceanographically relevant case of fresh and salty water is investigated here in further details. The heat and mass transfer is compared with theoretical results and experimental measurements. Additionally, the initial dynamic of layering, the transient behaviour of a stack and the long time evolution are presented using the example of Lake Kivu and the interior of a giant planet.