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Resolution-dependent variations of sinking particle trajectories in general circulation models: Implications for data-model comparison in past climate

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Any type of non-buoyant material in the ocean is transported by currents during its sinking journey. This transport can be far from negligible for typical (plankton) particles with a low sinking velocity. To estimate the lateral transport, the material can be modelled as a set of Lagrangian particles advected by currents that are obtained from Ocean General Circulation Models (OGCMs). State-of-the-art OGCMs are often strongly eddying, providing flow fields with a horizontal resolution of 10km on a daily basis. However, many long term climate modelling studies (e.g. in palaeoclimate) rely on low resolution models that cannot capture mesoscale features. The lower model resolution could influence data-model comparisons using Lagrangian techniques, but this is not properly evaluated yet through a direct comparison.

In this study, we simulate the transport of sinking Lagrangian particles using low (1°; non-eddying) and high (0.1°; eddying) horizontal resolution OGCMs of the present-day ocean, and evaluate the effect of the two resolutions on particle transport. We find major differences between the transport in the non-eddying versus the eddying OGCM (in terms of the divergence of particle trajectories and their mean trajectory). Addition of stochastic noise to the particle trajectory parameterizes the effect of eddies well in some regions (e.g. in the North Pacific gyre).

We recommend to apply sinking Lagrangian particles only in velocity fields with eddying OGCMs, which basically excludes all paleo-simulations. We are currently simulating the equilibrium Eocene (38Ma) climate using an eddying OGCM, to be able to apply these Lagrangian techniques in an eddying ocean of the past. We expect this to lead towards a better agreement between the OGCM and sedimentary fossil microplankton.