Quantifying mantle Helium fluxes using multi-tracer data assimilation

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One of the exciting new discoveries of the GEOTRACES observational programme are the pronounced deep-ocean trace element and isotope (TEI) plumes originating from hydrothermal vents along mid-ocean-ridges that have been found in all ocean basins. Shape and extent of the plumes, as well as the actual TEI concentrations in the plumes result from the combined effects of biogeochemical and physical processes, with water-mass circulation and mixing playing a crucial role. Inferences about source strengths or reaction rates in the plumes therefore depend on knowledge of the physical transports and normally require require the use of models.

Here I use a global, coarse-resolution ocean model previously fitted to geostrophic shear estimates and to data of ten hydrographic parameters and tracers to simulate the ^{3}He and ^{4}He distributions resulting from the release of mantle helium from mid-ocean-ridges. The model is in very good agreement with ^{14}C and CFC data and has realistic global ocean overturning strength as well as water mass formation and transport rates. It is found that previously published global mantle ^{3}He fluxes are too high by a factor of about two. In the model, optimal agreement of modelled $\delta^{3}He$ with data is achieved for a global flux of 450 ± 50 mol $^{3}He\ year^{-1}$. The formulation of He source strengths proportional to ridge spreading rates appears compatible with data. A model/data misfit analysis shows significant and large-scale $\delta^{3}He$ underestimation in the southwestern Pacific centred over the Lau Backarc Basin (ca. 179°W/20°S). These misfits disappear in a setup with 30 of the 450 mol $year^{-1}$ global total ^{3}He flux released in the Lau Basin over a depth range between 1250 and 2500 m. Such He flux contributions are missing in present mantle He source compilations. Hydrothermal fluxes of other TEIs can be calculated from He fluxes on the basis of TEI:He ratios measured close to the sources.