Improved constraints on transit time distributions from argon 39: A maximum entropy approach,

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We use ^{39}Ar in conjunction with CFCs, natural radiocarbon, and the cyclostationary tracers PO_4^*, temperature, and salinity to estimate the ocean's transit-time distributions (TTDs). A maximum-entropy method is employed to deconvolve the tracer data for the TTDs. The constraint provided by the ^{39}Ar data allows us to estimate TTDs even in the deep Pacific where CFCs have not yet penetrated. From the TTDs we calculate the ideal mean age, Γ, the TTD width, Δ, and the mass fraction of water with transit times less than a century, f_1. We also quantify the entropic uncertainties due to the nonuniqueness of the deconvolutions. In the Atlantic the patterns of Γ and f_1 reflect the distribution of the major water masses. At the deepest locations in the North Atlantic $\Gamma \simeq 300^{+300}_{-100}$ years, while at the deepest locations in the South Atlantic $\Gamma \simeq 500^{+200}_{-100}$ years. The Pacific is nearly homogeneous below 2000 m with $\Gamma \simeq 1300^{+200}_{-50}$ years in the North Pacific and $\Gamma \simeq 900^{+200}_{-100}$ years in the deep South Pacific. The Southern Ocean locations have little vertical structure, with Γ ranging from 300 to 450 years with an uncertainty of about $^{+150}_{-40}$ years. The importance of diffusion and path multiplicity as quantified by Δ/Γ has most probable values ranging from 0.2 to 3., but with large entropic uncertainty bounds ranging from 0.2 to 9. For the majority of locations analyzed, the effect of ^{39}Ar is to reduce f_1 and to correspondingly increase Γ by about a century. The additional constraint provided by ^{39}Ar reduces the entropic uncertainties of f_1 by roughly 50% on average. An effort to produce a globally gridded ^{39}Ar data set would greatly help reduce the uncertainty in our knowledge of oceanic transport and ventilation, which in turn would greatly benefit rigorous estimates of the ocean's ability to take up and sequester anthropogenic carbon.