Characterizing the chaotic nature of ocean ventilation

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Ventilation of the upper ocean plays an important role in climate variability on interannual to decadal timescales by influencing the exchange of heat and carbon dioxide between the atmosphere and ocean. The turbulent nature of ocean circulation, manifest in a vigorous mesoscale eddy field, means that pathways of ventilation, once thought to be quasi-laminar, are in fact highly chaotic. We characterize the chaotic nature of ventilation pathways according to a nondimensional "filamentation number," which estimates the reduction in filament width of a ventilated fluid parcel due to mesoscale strain. In the subtropical North Atlantic of an eddy-permitting ocean model, the filamentation number is large everywhere across three upper ocean density surfaces—implying highly chaotic ventilation pathways—and increases with depth. By mapping surface ocean properties onto these density surfaces, we directly resolve the highly filamented structure and confirm that the filamentation number captures its spatial variability. These results have implications for the spreading of atmospherically-derived tracers into the ocean interior.