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The fingerprint of reduced meridional ocean circulation on ^{39}Ar

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Monitoring changes in ocean circulation is critical to investigating and predicting the impacts of anthropogenic climate change. Current monitoring programs, such RAPID and OSNAP, utilize arrays of moored instruments to estimate changes in meridional overturning circulation (MOC) in key regions across the Atlantic. Other geochemical techniques, such as the measurement of CFC's and SF_6, allow for the estimation of transport in the Southern Ocean and North Atlantic since the 1950's. While these methods have greatly advanced our understanding of MOC variability over the 20^{th}-21^{st} century, they are limited due to the relatively short period in which high-quality observations are available.

^{39}Ar holds great potential as an inert and radioactive tracer for changes in ocean circulation and ventilation beyond the current observational record. Recent analytical advances indicate that routine, high-precision measurement of ^{39}Ar in 10-liter samples may be feasible within the next few years. While prior studies have shown that it is possible to accurately model the global distribution of ^{39}Ar, its sensitivity to a MOC reduction – and ability to serve as a fingerprint of ocean circulation change – is unconstrained. **Here, using a series of tracer-enabled climate simulations, we identify a strong reduction in ^{39}Ar in the intermediate to deep North Atlantic and the Southern Ocean under all SSP scenarios.** The reduction in the North Atlantic exceeds the expected decay rate, suggesting a reorganization of water masses within the North Atlantic to the modeled MOC decline. We additionally characterize the relationship between inert gas undersaturation (dXe/Ar) and ^{39}Ar reservoir age, suggesting that stable noble gas measurements may offer a straightforward means of independently correcting for ^{39}Ar reservoir age. Both results further characterize ^{39}Ar as a powerful geochemical proxy and identify key regional hotspots where ^{39}Ar can reveal changes in ocean circulation.