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# Using a first-order autonomous dynamical system to evaluate residence time of the Greenland freshwater anomaly in the Subpolar Gyre

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Increasing Greenland discharge has contributed more than 5000 $km^3$ of surplus fresh water to the Subpolar North Atlantic since the early 1990s. The volume of this freshwater anomaly is projected to cause freshening in the North Atlantic leading to changes in the intensity of deep convection and thermohaline circulation in the subpolar North Atlantic. This is roughly half of the freshwater volume of the Great Salinity Anomaly of the 1970s that caused notable freshening in the Subpolar North Atlantic. In analogy with the Great Salinity Anomaly, it has been proposed that, over the years, this additional Greenland freshwater discharge might have a great impact on convection driving thermohaline circulation in the North Atlantic with consequent impact on climate. Previous numerical studies demonstrate that roughly half of this Greenland freshwater anomaly accumulates in the Subpolar Gyre. However, time scales over which the Greenland freshwater anomaly can accumulate in the subpolar basins is not known. This study estimates the residence time of the Greenland freshwater anomaly in the Subpolar Gyre by approximating the process of the anomaly accumulation in the study domain with a first order autonomous dynamical system forced by the Greenland freshwater anomaly discharge. General solutions are obtained for two types of the forcing function. First, the Greenland freshwater anomaly discharge is a constant function imposed as a step function. Second, the surplus discharge is a linearly increasing function. The solutions are deduced by utilizing results from the numerical experiments that tracked spreading of the Greenland fresh water with a passive tracer. The residence time of the freshwater anomaly is estimated to be about 10–15 years. The main differences in the solutions is that under the linearly increasing discharge rate, the volume of the accumulated Greenland freshwater anomaly in the Subpolar Gyre does not reach a steady state. By contrast, solution for the constant discharge rate reaches a steady state quickly asymptoting the new steady state value for time exceeding the residence time. Estimated residence time is compared with the numerical experiments and observations.