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Did a "warm surge" of Gulf Stream water during the 1990s drive major hydrographic changes in the western subpolar gyre?

Zoe Jacobs (1), Jeremy Grist (2), Bob Marsh (1), Simon Josey (2), and Bablu Sinha (2)

(1) University of Southampton, United Kingdom (zlj1e13@soton.ac.uk), (2) National Oceanography Centre Southampton, United Kingdom

The throughput of subtropical waters to the subpolar region in the North Atlantic is evident in both observations and models. Using Lagrangian methods, this throughput has been found to be much less than North Atlantic Current (NAC) transport of around 20 Sv. Water parcels residing in the subtropical gyre (STG) are understood to largely recirculate within this region before entrainment into the NAC, reaching the subpolar gyre (SPG) after about 5 years, while faster (<1 year) direct transport of Gulf Stream (GS) waters into the SPG, via the NAC, has remained elusive. Here, we compute large ensembles of particle trajectories using currents from an eddy-resolving model hindcast, to explore the direct pathways of GS waters, starting from the Florida Straits at 26oN at depths ranging from the surface to 300 m. In agreement with previous findings, the greatest throughput to the SPG occurs via a sub-surface pathway. The timescale for this direct pathway is as short as 3 months, and after 1 year, up to 50% of tracked particles reside in the SPG (here defined as north of 50oN). This SPG-bound % reaches a maximum for particles released at 200m in the Florida Straits. The SPG % was also found to vary on interannual timescales, with a greater sub-surface throughput occurring from the late-80s to the late-90s (reaching a maximum of 68% in 1993), followed by a steady decline until 2009 (minimum of 35%). This variation could be a delayed response to the winter North Atlantic Oscillation (NAO), with a sustained positive index observed from the late-80s to mid-90s. This surge of subtropical waters from 1987-1996 may have led to an increase in the temperature (>1 oC) and salinity (>0.1 psu) in the western SPG, which was followed by cooler (-1.5 oC), fresher (-0.5 psu) conditions during 1997-2009 that coincided with a lower % of GS waters travelling north in the NAC. The "warm surge" trajectories were also found to travel via a deeper pathway, arriving in the SPG up to 50 m deeper, compared to the later period.