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Along-stream evolution of Gulf Stream volume transport and water properties from underwater glider observations

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The Gulf Stream is the western boundary current in the subtropical North Atlantic and a principal component of the upper limb of the Atlantic Meridional Overturning Circulation. Thus, it plays an important role in poleward heat and volume transport, as well as in the redistribution and modification of various water masses. Despite its importance in the climate system, many details of the Gulf Stream's increase in volume along the US East Coast and the associated entrainment of various water masses are not well known due to a paucity of sustained subsurface measurements within and near the Gulf Stream. Observations from more than 30 Spray autonomous underwater glider missions comprising over 22,000 profiles and more than 180 distinct cross-Gulf Stream transects collected between 2004 and the present fill a 1,500-km-long gap in sustained subsurface measurements; they provide concurrent measurements of hydrography and velocity in and near the Gulf Stream over more than 15 degrees of latitude between Florida and New England. These observations are used to characterize the along-stream evolution of Gulf Stream volume transport including classification by water properties. Remotely formed intermediate waters (i.e., Antarctic Intermediate Water (AAIW) and upper Labrador Sea Water (uLSW)) are significant components of Gulf Stream transport. AAIW is formed at high southern latitudes and enters the Gulf Stream through the Florida Strait, while uLSW is formed through deep convection in the Labrador Sea and encounters the Gulf Stream at Cape Hatteras as the uppermost layer of the Deep Western Boundary Current. Though it is well known where AAIW and uLSW initially encounter the Gulf Stream, their distribution, advection, and modification within the Gulf Stream remain poorly resolved. The extensive glider observations are used to characterize the evolution and intermittency of AAIW and uLSW pathways within and near the Gulf Stream, including effects of near-bottom mixing and the mechanisms by which uLSW crosses isobaths to arrive over the O(1000)-m-deep Blake Plateau south of Cape Hatteras. This first look at Gulf Stream transport by water class and the three-dimensional pathways followed by intermediate water masses within the Gulf Stream provides a reference for global circulation models to replicate.