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Water mass transformation in the Greenland Sea during the period 1986-2016

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The Greenland Sea is among the few regions of the global ocean where deep convection, forming dense intermediate and deep water masses, takes place during winter. This process replenishes the deep ocean with oxygen and is important for maintaining its thermohaline properties. Several studies have documented significant changes in the convective activity in the Greenland Sea during the past few decades. In particular, the convection has been limited to the upper 2000 m since the cessation of deep and bottom convection in the 1980s. By analyzing historical hydrographic measurements from ships, autonomous profiling floats, and instrumented seals for the period 1986 to 2016, we find that a new, less dense class of intermediate water started forming in the Greenland Sea gyre in winters 1993-94 and 1994-95. The preceding winters were characterized by shallow (< 300 m) convection that resulted from a combination of anomalously fresh near-surface layers that increased the stability of the upper part of the water column and weak atmospheric forcing. The subsequent deeper convection marked the beginning of a pronounced change in the hydrographic structure of the upper 2000 m in the Greenland Sea that is still ongoing. Sensitivity studies, using a one-dimensional mixed-layer model, suggest that the deeper convection was primarily a result of reduced water column stability due to higher near-surface salinities. Since it first started forming in winter 1993-94, this less dense class of intermediate water has been the main product of convection in the Greenland Sea, and its volume has expanded in line with generally increased depths of convection over the past 10-15 years.