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On the shelf water cascading in the Irminger Sea

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Descending (cascading) of dense shelf waters down the continental slopes contributes to the ventilation of intermediate and deep waters at many locations around the world ocean. Cascading events were observed off the shelves of Antarctica, in the Arctic seas, at mid-latitudes and in the subtropics and the tropics. In the northern North Atlantic, where mixing of arctic and subarctic waters and intense wintertime cooling produce dense waters over the Greenland shelf, shelf water cascading was suggested to be at the origin of the so-called East Greenland Spill Jet – a narrow bottom-intensified current confined to the shelf break and the upper part of the East Greenland slope in the northwestern Irminger Sea. However, the potential contribution of dense shelf water cascading to intermediate and deep water formation in the region has not been documented yet.

We present observational evidence that shelf water cascading in the northwestern Irminger Sea is a prominent mechanism affecting the intermediate and deep water properties in the Western Boundary Current. Using a comprehensive dataset consisting of 31 hydrographic sections carried out in the western Irminger Sea between the Denmark Strait and Cape Farewell in 1997–2008, we found clear signatures of shelf water cascading down the East Greenland slope to depths of more than 1000 m. Summer observations at 66°N, southwest of the Denmark Strait, revealed episodic presence of anomalously cold ($\theta < 2$°C) dense ($\sigma_0 > 27.80$ kg/m^3, up to 27.89 kg/m^3) shelf waters carried by the East Greenland Current at depths of 250–400 m. Given the much lower densities of the surrounding slope waters, the high density of the shelf waters makes them capable to cascade down the continental slope. Clear hydrographic signatures of such cascading were found downstream, at Faxafloi section ($\sim$64°N), where the cold fresh shelf waters reached the layer of the Nordic overflow-derived deep waters ($\sigma_0 > 27.80$ kg/m^3). An intense along-path mixing with surrounding waters in the Western Boundary Current dilutes the cold fresh waters descended from the shelf, so that farther downstream, nearby Cape Farewell (59–60°N), traces of the upstream shelf water cascading are less clear, but still distinguishable at the intermediate to deep levels. The likely mechanisms behind the dense water formation at the East Greenland shelf, southwest of the Denmark Strait, will be discussed, as well as the potential contribution of the shelf water cascading to the intermediate and deep water export from the Irminger Sea.