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Cross-slope exchange between a temperate shelf sea and the North Atlantic Ocean in autumn

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We address the problem of how waters are exchanged between the Celtic Sea and the North Atlantic Ocean. In the interior of the Celtic Sea wind stress forcing governs cross-shelf transport. Westerly winds predominate on the shelf and are favourable for export of shelf waters in the surface, and on-shelf advection of oceanic waters in the bottom. However, at the shelf edge a poleward along-slope current generates off-shelf transport in the bottom layer through an Ekman drain mechanism and opposes wind-driven exchange. In this study cross-slope flow generated by wind-driven Ekman transport and Ekman drain are assessed. Time series recorded at the Central Celtic Sea site during autumn (from the 1st of November 2014 to the 1st of January 2015) of surface wind-stress, hydrography and horizontal water column velocities were combined with hydrographic data obtained from glider and CTD casts to assess transport and exchange between the Celtic Sea and the North Atlantic Ocean. In December evidence of Ekman drain and wind-driven transport were found to occur simultaneously in the cross-shelf direction. Interaction between these processes resulted in a convergence of waters at the shelf edge, forcing shelf and oceanic waters to recirculate onshore in the surface and off-shelf in the bottom layer, respectively, thus preventing cross-slope exchange. On the shelf surface cooling resulted in bottom waters being warmer than in the surface layer. However, the stratified period was maintained due to recirculation of relatively high salinity waters from the outer shelf below fresher waters from the interior of the Celtic Sea. At the shelf edge, off-shelf velocities in the bottom layer due to the Ekman drain process were estimated to be between 0.07 - 0.13 m/s. In the absence of an along-slope current wind-driven Ekman transport governs exchange at the shelf edge resulting in a $\sim$80 km on-shelf intrusion of oceanic waters in the bottom layer during a 7 -8 month period.