Geophysical Research Abstracts
Vol. 17, EGU2015-10174-2, 2015
EGU General Assembly 2015

Tidally-driven exchange at the European shelf break

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The exchange across the shelf break is restricted as the topographic slope limits the geostrophic flow to following isobaths, meaning the exchange between the open ocean and shelf seas is dependent on processes that break the assumptions in geostrophy, by for by not being in steady state. Using the thickness-weighted volume transport, usually invoked in the open ocean, we show that the covariance of thickness and velocity can drive a volume transport across the shelf break, usually referred to as the bolus transport. We propose that the internal tide drives a covariance resulting in a transport of both volume and tracers, analogous to the Stokes Drift. Whilst these transports are smaller than the mean velocity they can make a substantial contribution to the cross shelf component. Support for the theoretical framework is provided by a series of near shelf break moorings in the Celtic Sea and Malin Shelf deployed in the summers of 2012 and 2013 respectively, under the FASTNEt project. The thickness-weighted volume transports have been calculated for each of the moorings, including the bolus transport. The strength of this transport is strongly dependant on the strength of the internal tide, with the highly energetic Celtic Sea showing an on shelf bottom layer transport velocity of order 1 cm s^{-1}, whereas the less energetic Malin Shelf shows a bottom layer transport velocity of order 0.01 – 0.1 cm s^{-1}. These are comparable to the bolus velocities predicted by simple two layer linear internal wave theory. The mooring bolus transport also shows an M4 period, equivalent to the product of two M2 periods, reinforcing that the bolus transport is tidally-driven. These bottom layer transports can make a significant contribution to the lateral supply of nutrients required to support the enhanced productivity in shelf seas. Integrating the bottom layer transports from the moorings to the whole of the Celtic Sea shelf break gives a total volume transport of approximately 1 Sv or a nitrate flux of 8 Kmol s^{-1}, equivalent to the vertical supply over a 100km wide adjacent shelf.