Geophysical Research Abstracts, Vol. 7, 00625, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00625

Dense water cascades across the shelf break and their role in shaping the climate

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Dense water overflow off continental shelves (cascading) is one of the contributing processes of shelf-deep ocean exchange, and of topical interest to climate studies and nutrient fluxes. Cascading is the motion of dense water, which is formed by cooling, evaporation or freezing in the surface layer, along a sloping sea bottom to a greater depth. Cascading is an efficient way of communication between the coastal and deep ocean. How important is the impact of cascades on water properties in the deep ocean? To attempt this question, we have identified distinct physical mechanisms that drive cascades in various climate zones and carried out statistical analysis of 61 confirmed cases world-wide, including 25 cases in the Arctic seas, 12 at mid-latitudes, 7 in sub-tropical and tropical regions, and 17 off the Antarctic shelves. From data analysis and relevant theories we estimated transport rates between shelves and deep waters due to the process of cascading.

It was found that in 66% of cases, cascades delivered colder and fresher; and in 28% cases delivered warmer and saltier water to the deep ocean. In 50% of cases, temperature contrasts facilitated cascading, sometimes (28%) with assistance from salinity. Temperature contribution is predominant in tropics, sub-tropics and mid-latitudes, while salinity input prevails in polar regions. On average, the density contrast between the dense water plumes and ambient water is 0.37 kg/m3; it can be as much as 2 kg/m3 on some Arctic shelves. A very approximate global estimate based on our findings and previous studies is of order 3-3.5 Sv or average.