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Baroclinic Instability: the physical transport route through stratification

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Baroclinic instability is the open ocean mechanism through which available potential energy is released. It can be broken down into quasi-geostrophic flow along sloping density surfaces at the mesoscale, ageostrophic filamentary flow at the sub-mesoscale and turbulent diapycnal mixing transforming water masses and re-stratifying the water column. All these components and thus baroclinic instability as a whole can be viewed as a mechanism responsible for transporting biogeochemical material vertically through the oceanic stratification. High resolution modelling studies have indicated that dynamic small scale flows associated with oceanic fronts and eddies are a dominant component of this mechanism for the observed patchiness of marine algae (phytoplankton) blooms. High resolution observations have shown that sub-mesoscale flows ($\sim$5-20 km scale) may provide both the fertilisation mechanism for nutrient depleted surface waters and a subduction mechanism for the rapid export of phytoplankton biomass to the deep ocean. We present multidisciplinary analyses of the data from examples of these studies in which we have the first direct observations of the sub-mesoscale transport of phytoplankton and nutrients. These data confirm this transport is constrained by the requirement to conserve angular momentum, expressed in a stratified water column as the conservation of potential vorticity.