

Abstract

Diapycnal mixing determines the rate of vertical circulation in fjords and oceans, and is therefore important for e.g. oxygen conditions in the deepwater of fjords, and for the climate of the earth. Internal waves are believed to be important for the diapycnal mixing in fjord basins and in the deep ocean due to their ability to transport energy and vertical shear away from the well-mixed boundary layers at the sea-surface and bottom, into the more quiescent interior. Neither diapycnal mixing, nor internal waves are resolved in ocean models, and therefore need to be parameterised in order to obtain reliable results.

In this thesis experimental and theoretical methods are used to study some elements of the internal wave generation at large scales, the subsequent transfer of energy to smaller scales, and the final small-scale mixing.

It is shown that the dynamics of the two lowest-frequency internal seiches in Gullmar Fjord, Sweden, are rather well described by a simple three-layer model. Studies of the forcing mechanisms show that the internal seiches are forced both by local wind over the fjord, and density variations outside the fjord. An observed upward phase propagation associated with the internal seiches is thought to be related to downward propagation of oblique internal waves, losing their energy to turbulence and mixing after near-critical reflection from the gently sloping bottom in the inner fjord. This hypothesis is supported by the fact that variations in observed basin water mixing occur concurrently with large variations in the internal seiche intensity. An energy budget for the investigated period indicates that the internal seiches contribute with about 36 % of the total energy for the mixing.

A theoretical model is set up for fluctuating, subinertial, barotropic flow of a stratified fluid through a strait with an escarpment. At sufficiently low frequencies, it is shown that the barotropic flow across the escarpment transfers energy to baroclinic, geostrophic flows along the escarpment, forcing an internal Kelvin wave in the deep part of the strait. The corresponding resistance on the barotropic flow, caused by the internal wave generation, happens to be similar in magnitude to that caused by the purely barotropic, geostrophic control mechanism.

In a theoretical study about mixing efficiencies in patchy geophysical systems it is shown that the large-scale mixing efficiency is smaller in a system with patchy turbulence than the efficiency of the turbulence within each patch. The difference may be up to a factor of two. The reason is that some of the potential energy, gained by turbulent mixing within a patch, is lost during the advective redistribution of the mixed fluid, following the mixing event in the patch. Since the commonly used values of the mixing efficiency for large-scale, patchy, geophysical systems are mainly derived from laboratory experiments on homogeneous turbulence, it is suggested that these are too large and should be replaced by the smaller efficiency suggested in the last paper of this thesis.

Keywords: Gullmar Fjord, seiches, internal waves, diapycnal mixing, stratification, internal wave generation, Kelvin waves, geostrophy, turbulence, patchy, intrusion.