Abstract

This thesis deals with circulation in sill fjords and turbulent mixing, with a focus on numerical modeling. The major topics are net circulation in an open-ended system, turbulent entrainment into dense overflows, deep-water turbulent diffusion and turbulence closure schemes. Special reference is made to a system of fjords on the Swedish west coast.

The focus on sill fjords is motivated by the wide spectrum of oceanographic processes occurring in these coastal inlets. Because of restricted exchange with exterior water masses, coupled with local river input, fjords exhibit large spatial gradients in hydrographic and biochemical properties. The deep basin water is subject to renewals and stagnation. Renewals are a result of inflows caused by coastal upwellings, and tend to be episodic events dominated by advective processes and entrainment. Between renewals the deep water is trapped behind the sill, causing stagnation, during which only interior turbulent mixing can affect the deep water properties.

The thesis is based on four papers. Paper I deals with an open-ended Swedish fjord system. Direct and indirect current measurements are presented which indicate a net through-flow in a counterclockwise direction. Using long-term hydrographic observations and a process-oriented box model it is shown that the throughflow is primarily forced by the along-coast steric height difference between the ends of the fjord system. Though density driven currents through the deeper entrance dominate the exchange at large, periods of reversing net flow may significantly influence the northern basins. In Paper II a specific renewal event in a small Swedish sill fjord is investigated, with focus on the entrainment of resident water by inflowing juvenile water and its parameterization. A 1-D numerical model is used together with observations to show the large impact of entrainment on the post-renewal state of the fjord. The likely effect of this mixing on the occurrence of subsequent renewals is emphasized. The subject of Paper III is weak turbulent mixing in stagnant fjord basin. A model is proposed in which the internal wave energy, generated by the interaction of the barotropic tide with the sill topography, is added as a source term in the equation for the turbulent kinetic energy in a second-order turbulence closure scheme. The model is shown to agree with observations in two Scandinavian fjords. Finally, in Paper IV an alternative parameterization of the turbulent length scale, as well as a modification of the stability functions used in second-order turbulence closure schemes, are proposed. The resulting one-equation eddy viscosity model, to be used in geophysical applications, is validated against a number of data sets and compared to the k-ε model.

Keywords: fjord circulation, steric height, deep water renewal, stagnation, bottom plume entrainment, turbulence modeling, internal wave mixing, turbulent length scale, stability functions