Experimental Studies of Internal and Near-bed Dynamics of Restricted Exchange Flows

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The presence of natural topographic flow obstructions (e.g. sand bars or submerged sills) can have a strong controlling effect on the intrusion of saline marine waters into semi-enclosed brackish estuarine impoundments or stratified fjordic basins. Results are presented from a series of experiments conducted at LEGI Grenoble, under the EU FP7 Hydralab IV Initiative, to investigate the internal and near-bed dynamics of salt water intrusions across a submerged, rigid, trapezoidal-shaped obstruction. This obstruction separated the sea-side basin from the semi-enclosed fjord/estuary impoundment. Two experimental configurations were considered: (i) a fjordic case, where the dynamics of gravity-driven saltwater intrusions across the obstruction were investigated for different fjordic basin stratifications; and (ii) an estuarine case, where the saltwater intrusion was opposed by a counter-flowing surface fresh water layer. Experimental measurements focused on obtaining high-resolution velocity and density profiles in the vicinity of the obstruction to observe and quantify both interfacial mixing and boundary layer processes under a range of parametric forcing conditions (i.e. variable saline and fresh water flow rates; density differences). Detailed synoptic velocity fields were also measured across the obstruction through particle image velocimetry (PIV) to aid qualitative and quantitative interpretation of these internal and near-bed flow processes. Within the fjordic runs, the results concentrated on defining the nature of interactions between the saltwater intrusion and the stratification within the fjordic basin (i.e. generation of internal waves and mixing). For the estuarine experiments, the internal dynamics of the net exchange flow across the obstruction were investigated, with a focus on defining the specific parametric conditions under which saline intrusions could become arrested, through erosion of the intrusion nose at the bed boundary, by the freshwater outflow layer. In this regard, it is anticipated that the study findings will provide an important step towards achieving improved representation of interfacial mixing and boundary layer processes within semi-enclosed estuaries and fjords, which are poorly represented in current numerical models.