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Dynamics of jet-type fjordic system: observations and theoretical modelling

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The baroclinic tidal regime of the fjord Loch Etive (Scotland) is studied. Analysis is performed on the basis of both in situ data and numerical simulations, with the use of a fully-nonlinear non-hydrostatic fine-resolution model. It was found that the crest of the sill, which separates Loch Etive into inner and outer parts, and where water depth is about 10 m, is subjected to a supercritical flow regime with maximum Froude numbers in excess of 5. Strong supercritical conditions lead to the formation of flow separation just above the sill's crest. As is inherent to jet-type fjordic systems, this, in turn, leads to a weak nonlinear baroclinic wave response. On the other hand, observations and numerical results also revealed the presence of linear internal tidal waves with amplitudes up to 10 m several kilometers from the constriction. It was found that the linear baroclinic tidal waves are excited over a section of the inner flank of the sill, at depth below 30 m, where local Froude number is substantially less than unity.

In terms of the classification suggested by Stigebrandt and Aure (1989) viz. the separation of all fjords into two categories - jet-type or wave-type, Loch Etive possess characteristics of both. A very weak non-linear response due to strong supercritical conditions with flow separation over the sill is combined with quite remarkable linear signal produced by the rest part of the obstacle. In this respect Loch Etive can be referred to a ''hybrid-type" fjord, and we suggest that many jet-type fjords should correctly fit into this new category.

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