DYNAMICS OF INTERNAL TIDES – RESULTS FROM PROCS

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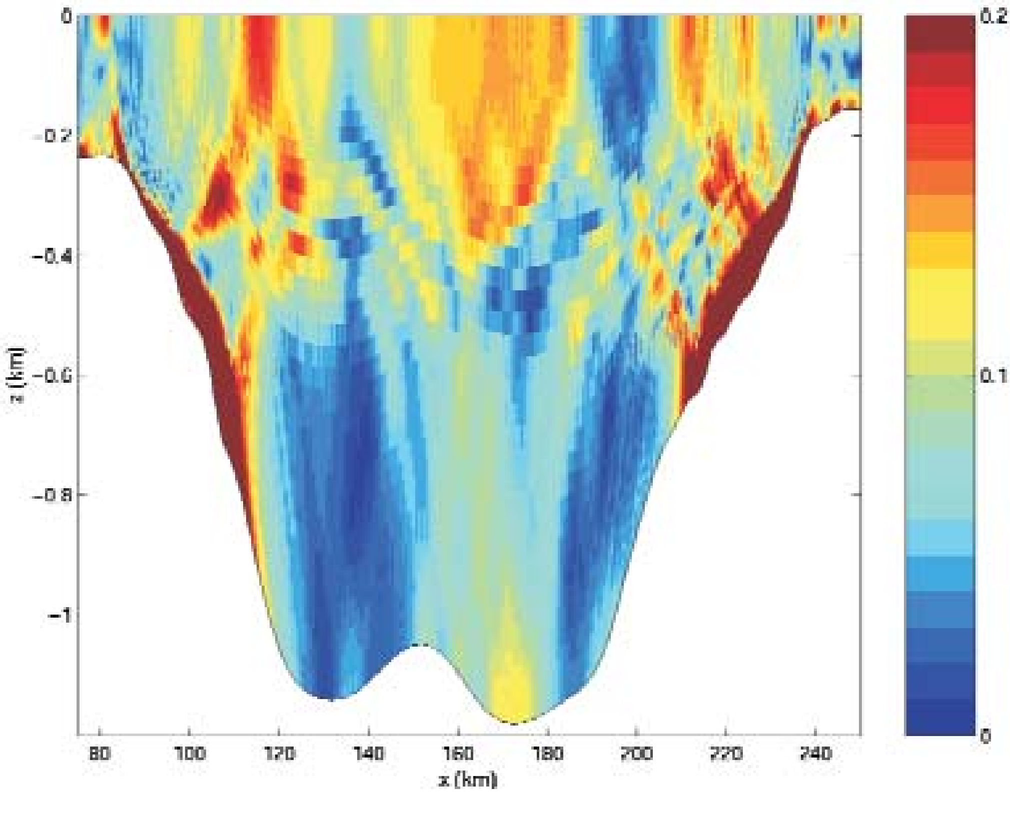
Internal tides, and internal waves in general, create an `inner unrest' in the ocean. Their generation takes place mainly within the upper layer of the ocean (the surface for wind-induced near-inertial waves, and near the shelf-break for internal tides), but since the internal-wave energy propagates not only horizontally but also vertically, they provide energy to the deeper regions of the ocean as well. Here they act as agents for mixing (secret agents one would say, for the precise mechanism is still to be disclosed), which, in turn, is essential to maintaining the large-scale circulation.

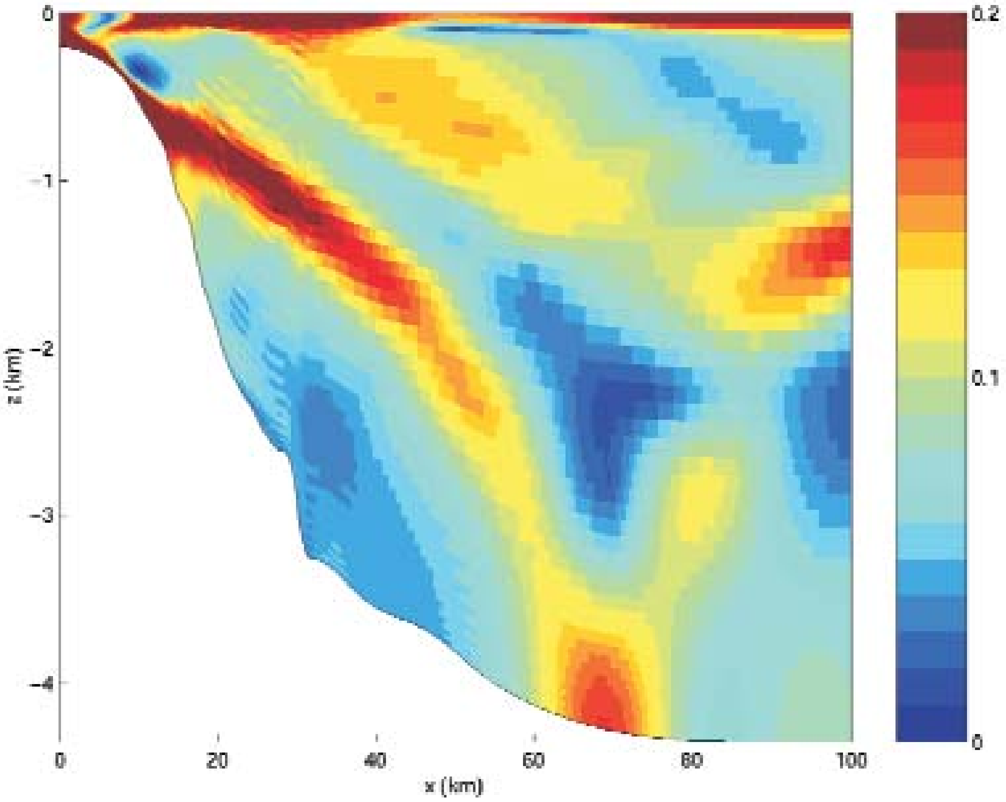
Much is still unknown about the way the internal tides propagate through the ocean. For example, recent NIOZ-work (theoretical and laboratory studies) revealed the hitherto unknown phenomenon of internal-wave attractors: in (almost) closed basins the internal-wave energy may become confined to a closed trajectory, due to repeated reflections at side-walls. This phenomenon, if it were to exist in the ocean, would have very noticeable implications, not only for physical processes like mixing, but also for related aspects like nutrient fluxes, nepheloid layers etc. One of the principal motives behind the PROCS project was to investigate this in channel-shaped basins, like the Faeroe-Shetland Channel and Rockall Trough.

The observations showed that in the Faeroe-Shetland Channel strong internal-tide currents were present along the slopes, between 300 and 600m depth. A numerical internal-tide generation model was developed and used to further interpret these measurements. The model result, involving both the lunar and solar semi-diurnal tides, indeed shows intensified currents in the same region. Also, a complicated web of internal-tide trajectories can be identified; it appears that multiple reflections within the channel do occur, but that fully developed attractors do not arise here, because the wave-energy escapes onto the shelves. It was also found that the phase of spring-neap cycles, in the internal tide, is very sensitive to variations in the background conditions, like the stratification; this provides a possible clue to the occurrence of intermittency, and implies a large degree of unpredictability. The same model was applied to the Bay of Biscay, where the dynamics is simpler in that the oceanward propagating tides do not encounter `side-walls', and hence do not return. In the model, the downward propagating beam, which is known from observations, is well reproduced. In its later evolution, when the beam, after its reflection at the bottom, propagates upward and encounters the thermocline, high-frequency large-amplitude waves can be generated, so-called internal solitary waves. The study in this project has led to an explanation of this phenomenon in terms of scattering; and it



Result from the numerical model: the amplitude of the cross-slope internal-tide current (in m/s) in a cross-section of the Faeroe-Shetland Channel; intensified currents are seen along the upper part of the slope, at the right-hand (i.e. Shetland) side between 300 and 600m depth, in accordance with the observations.

was shown that it will not take place if the thermocline is weak (Bay of Biscay, during winter), or very strong (tropical regions). The analysis of these processes has thus provided a new insight into how the internal-wave energy, which is initially concentrated around the near-inertial and tidal frequencies, can be transferred to higher frequencies, and thus help `fill' the internal-wave spectrum.



The amplitude of the cross-slope internal-tide current (in m/s) in the Bay of Biscay. The downward propagating beam, emanating from the shelf-break, is most prominent; it later reflects at the bottom (near x=70km), after which the energy propagates upward.