# A Model Study on the Generation of Internal Tides by Tidal Flows Over a Submerged Seamount in the Channel

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**Abstract.** It is known that the submerged seamount/ridge is a source for the generation of internal tides. In this paper, a three-dimensional two-layer model is set up to study the generation of internal tides by tidal flows over a submerged seamount/ridge in the channel. Several numerical experiments with different topographic features, upper layer depths, tidal flows and background currents are carried out to study the variations of the induced internal tides. It is shown that, for the specific stratification, the seamount feature, the slope, the initial upper layer depth and the imposing driven force determine the Froude number near the seamount peak. Once when the Froude number is supercritical, the associated maximum amplitude of the induced internal tide is so large that the internal tide begins to disintegrate, which brings about severe variations of the current velocity and the water elevation fields, and the associated induced baroclinic tidal energy around the seamount peak is much larger than the barotropic one. The Richardson number greater than 1/4 is a criterion for stability of shear flow. Since the maximum tidal velocity changes within $0 \sim 360°$ with time in a period around the seamount peak, the induced internal tide does not stride the seamount peak before it disintegrates, which is different from the two-dimensional modeled results. The asymmetrical slope of the submerged seamount is a mechanism for the asymmetrical internal tide generation.

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# 1   Introduction

The sill straits among the Luzon Strait are the sources for the generation of internal solitary waves (Fig. 1, literature [1,2]). It is interesting that almost all internal solitary waves are observed to propagate westward to the northern South China Sea (SCS), whilst few are observed to propagate eastward to the Pacific [3]. Zheng et al. [4] suggested that the eastward propagating disturbances have no chance to grow up into internal solitary waves, so that they hardly appear on the east side of the submarine ridges in the eastern Luzon Strait. According to the numerical results based on a two-dimensional (i.e., in the directions of $x$ and $z$) composite model in the Luzon Strait [2], it is shown that only when the amplitude of an internal tide is large enough would a train of internal solitary waves be induced, and a constant mean westward background flow in the Luzon Strait has a great damping effect on the amplitude of the induced internal tide toward the Pacific, thus the induced internal tide toward the Pacific has no chance to grow up into internal solitary waves. However, some questions about this asymmetrical propagation of the internal solitons in the Luzon Strait remain unknown, e.g., according to the previous studies [5,6], the background current in the Luzon Strait is not always westward, which may not support the conclusion by Cai et al. [2] that the westward propagation of the induced internal solitons is due to the westward background current. Therefore, is there any other key factor affecting the asymmetrical propagation of the internal solitons in the northern SCS?

Usually the problem on the generation and propagation of internal solitary waves is separated into a "generation phase", for which the hydrostatic approximation is applied [7,8], and a "propagation phase", for which a nonhydrostatic description is required [9, 10]. To simplify the question, we limit our study to the generation of internal tides, since Cai et al. [2] showed that only when the amplitude of the induced internal tide is large enough could a train of internal solitary waves be released and propagate away from the source. Thus, if we could reveal some characteristics of the asymmetrical distribution of the internal tide generation, we may find the key factor affecting the asymmetrical propagation of internal solitons.

The submerged seamount or ridge is a source for the generation of internal tides, e.g., Dushaw et al. [11] found that the significant semidiurnal internal tide in the deep ocean far away from the north of Hawaiian Islands is generated over the Hawaiian Ridge, and it is testified by the three-dimensional POM model study [12]. Numerical modeling around Fieberling Guyot in response to tidal flows [13,14] had been carried out before. Recently, there are some three-dimensional continuously stratified layers models studies on the internal waves generation by different bottom topographies [15–18]. However, the horizontal distributions of the induced barotropic and baroclinic tidal energies by submerged seamounts or ridges, especially in a sill channel, have still not been clearly revealed by them.

In this paper, we try to study the above problem based on a three-dimensional two-layer model forced by barotropic tidal flows. We limit our simulation domain to the