Internal waves on the upstream side of a large sill of the Mascarene Ridge: a comprehensive view of their generation mechanisms and evolution

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Abstract

In this paper we aim to clarify the generation of Internal Solitary Waves (ISWs) at work to the east of the Mascarene Plateau (Indian Ocean) using Synthetic Aperture Radar (SAR) imagery and MITgcm fully nonlinear and nonhydrostatic simulations. Realistic representations of stratification and bathymetry are used with asymmetric tidal forcing (including the steady South Equatorial Current which is assumed barotropic in the model) along a 2D transect aligned with the propagation direction of the wave signatures identified in the SAR. The combined flow (i.e. steady and tidal currents) is subcritical with respect to first-mode Internal Waves (IWs), but supercritical with respect to higher wave modes. Different types of nonlinear wave trains with distinct origins (i.e. tidal phase and location) have been identified with the combined aid of model and SAR: 1) large-scale primary mode-1 ISWs evolve from the disintegration of a multimodal baroclinic structure that appears on the upstream side of the sill; 2) mode-2 ISW-like waves that evolve from this same baroclinic structure and are arrested over the sill before being released upstream at the change of flow condition; 3) a large mode-2 lee wave is generated downstream of the sill (i.e. on the west side), which is trapped there during maximum westward tidal flow and released upstream when the tide relaxes; and 4) mode-2 ISW-like waves whose length-scales are O(20 km) appear some 50 km upstream of the sill, after an Internal Tide (IT) beam scatters into the pycnocline, itself originating from critical topography on the leeward (i.e. westward) side of the sill. The underwater sill being investigated is in the mixed-tidal-lee wave regime, where the internal tide release mechanism, lee wave generation and IT beams can coexist. The large-scale mode-2 ISW-like waves that form far upstream from the sill are long-lived features and can be identified in the SAR due to associated short-scale mode-1 ISWs which propagate with the same phase speed, i.e. in resonance. This coupling is also seen in the model, and here it is argued that the formation of those mode-2 ISW-like waves appears to originate from the IT beam after it reflects from the sea surface and interacts with the pycnocline, a generation mechanism referred in the literature as "local generation of ISWs". This IW generation process may be easily overlooked and could be at work in many more regions of the world than previously thought. Deep-Sea Research I 99 (2015) 87–104.

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