Tide- and typhoon-induced nonhydrostatic wave trains in deep seas

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1. Introduction

Oceanic wave trains with waves 2-7 km in length have been often observed by satellite-borne Synthetic Aperture Radars (Osbone and Burch, 1980; Helfrich and Melville, 2006). These trains are the surface expressions of internal solitary-like gravity waves (ISWs) at the depth of thermocline. Wave trains of this type are among the largest nonhydrostatic phenomenon in the ocean, and highlight the differences between the dispersion relations of hydrostatic and nonhydrostatic internal gravity waves (Fig. 1). This study consists of two parts. The first part investigates tidally generated ISW trains in a strait in the Indonesian Seas. The second part reports the finding of a new phenomenon. It is shown that ISW trains can be generated by the passage of typhoons across continental shelves.

2. Tide-induced wave trains in the Indonesian Seas

Recent oceanic studies pay significant attention to tidal mixing in the Indonesian Seas as the mixing changes the vertical structure of the Indonesian Throughflow (ITF) and thereby affects the heat transport between the Pacific and Indian Oceans. We investigate tidally generated ISWs in Lombok Strait using a two-dimensional nonhydorstatic model in a vertical plane aligned along the main axis of the strait. The model is forced by barotropic volume fluxes oscillating at the M2 tidal period (12.42 hour). More ISWs are

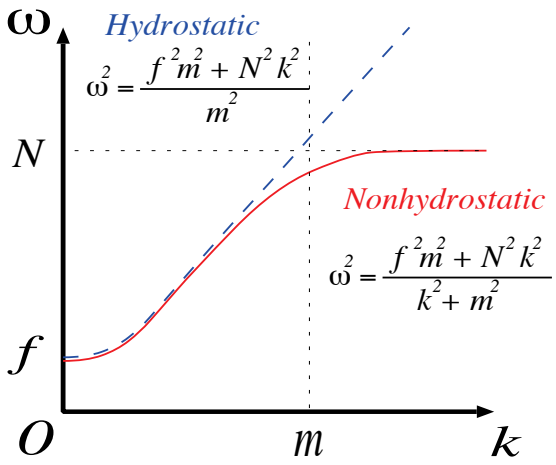

Fig. 1. Hydrostatic (dashed blue) and nonhydrostatic (solid red) dispersion relations of internal gravity waves in linear theory with the symbols ω, N, and f representing wave, buoyancy, and Coriolis frequencies, and k and m the horizontal and vertical wavenumbers.

produced on the north side of the sill where the narrower channel in effect amplifies the disturbances. It is found that the seasonal variability of the ITF regulates the way that the radiated wave energy is partitioned between the two sides of the sill.

3. Typhoon-induced wave trains in the western North Pacific Ocean

Using a coupled atmosphere-ocean nonhydrostatic three-dimensional model, we have performed a hindcast simulation for supertyphoon Haitang which made a landfall in Taiwan on 18 July 2005. Haitang generates two types of internal gravity waves in the ocean. The first type of waves appears in the open regions, and forms the doming of thermocline associated with strong Ekman upwelling. The second type of waves is generated by the interaction of the typhoon and the oceanic bottom topography, and appears after Haitang passes the continental shelf of Taiwan and Okinawa Islands. This second type of waves is more significant than the first type. The eastward propagation of the second type wave eventually forms ISW trains with waves about 5-10 km in length and about 1 hour in period (Fig. 2a). No ISW is formed in another experiment without the nonhydrostatic pressure term (Fig. 2b).

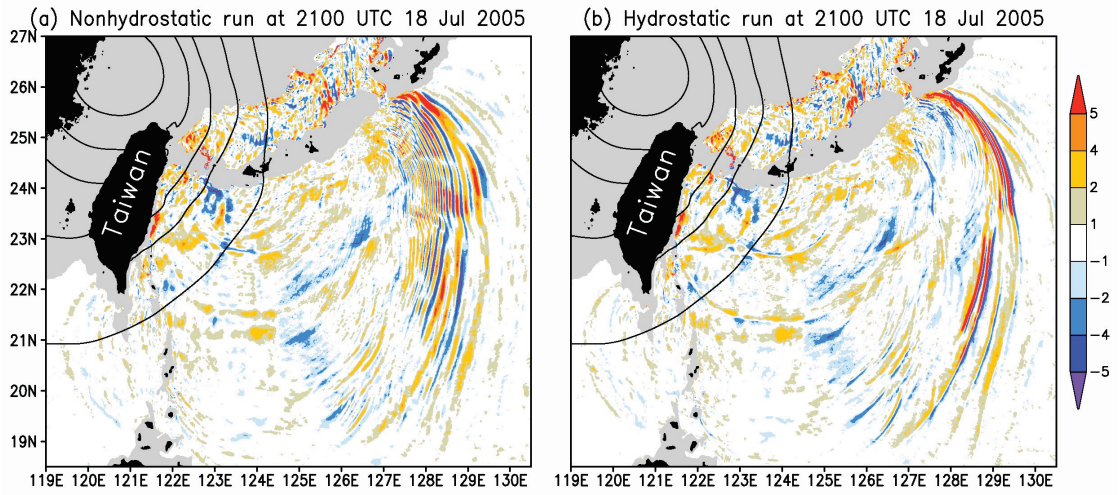

Fig. 2. Distributions of the vertical component of velocity at 1000 m depth [color, mm/s] and the sea surface pressure [contour interval = 5 hPa] in (a) the nonhydrostatic run and (b) the hydrostatic run.

References

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