Near-source detection of lowest and very high modes of internal tide in comparison with the JCOPE-T ocean circulation model

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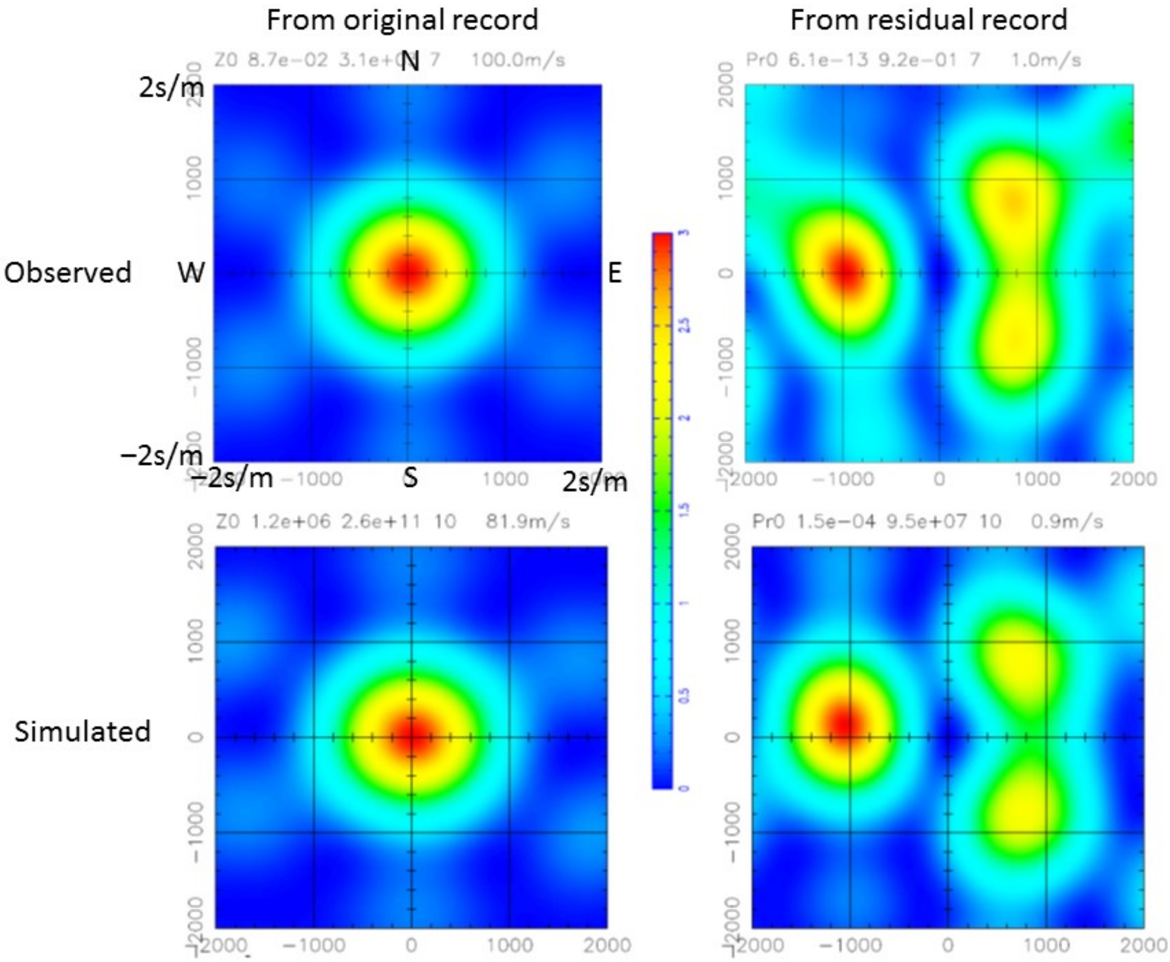
We detected persistent generation of the lowest mode of the M2 internal tide by the array of ocean bottom pressure gauges, which was deployed on the eastern slope of Aogashima Is. of the Izu Ridge at depths 1500 - 2200 m in the period May 2014 - May 2015. We measured the horizontal phase speed and propagating direction of the M2 internal tidal wave by a slant-stacking technique under the plane wave approximation. The measurement shows a phase speed of 1 m/s in the offshore direction normal to the Izu Ridge. This is, to our knowledge, the first quantitative measurement of horizontal propagation of internal tidal wave by an ocean bottom array of pressure gauges. The PSD (power spectral density) of the M2 internal tide is about 0.03 % of the PSD of the M2 external tide. There is a clear positive correlation in PSD between the internal and external tides, indicating that the observed internal tide is generated along the slope somewhere between the ridge crest and our array by conversion of the external tide.

In order to examine the consistency of the above observational result with a state of art tide-resolving ocean general circulation model (JCOPE-T), we analyzed the synthetic bottom pressure records for this model using the same method with the same array configuration in the same period as for the observed data. The analysis detected a clear signal of eastward propagation of the M2 internal tide with amplitude and speed comparable to those of the observation (Fig. 1). By successively moving the hypothetical array upslope from the observational site, we found a location at which the propagating direction of the simulated internal wave is reversed. This location can be regarded as a generation site of the mode-1 internal tide. The simulated temperature fluctuation field tuned to the M2 frequency range shows how unique this location is. For example, the 11˚C isotherm above this location undergoes semidiurnal vertical oscillation, the disturbance of which propagates both eastward and westward with an approximate speed of 1 m/s.

In this area, an extensive MCS (multi-channel seismic) survey was carried out in 2008.
The longest EW survey line passes right through our pressure gauge array. This legacy MCS data were reanalyzed to obtain ocean acoustic reflection images, which largely consist of reflections from high-mode tidal beams (vertical wavelengths around 30m). We compared the longest EW reflection profile to the simulated temperature fluctuation profile along the same line. Although the seismic profile delineates the spatial distribution of very high-mode tidal beams while the simulated profile describes the temperature disturbances due to very low modes of internal tide, their overall patterns commonly indicate a largest cell of the mode-1 internal tide with the source longitude at ~140˚E and a half horizontal-wavelength of ~50 km. The wave field near the generation site appears to be rich in high-mode internal waves carried with and created from the lowest several modes of internal tides generated at the source.

Keywords: internal tide, ocean bottom observation, seismic oceanography, ocean circulation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From residual record
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Pr0 6.1e−13 9.2e−01 7 1.0m/s
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Pr0 1.5e−04 9.5e+07 10 0.9m/s
Observed
Simulated
N
S
W
E
2s/m
−2s/m
−2s/m
2s/m
−2000
−1000
0
1000
2000