Near-inertial internal waves observed in the vicinity of an anticyclonic eddy in the southwestern East Sea (Japan Sea)

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Background

- The local frequency (f) is about 19.8 hour at ECI.
- Tides and tidal currents are weak in the interior of the East Sea (Japan Sea).
- Energetic NIWs have been observed in the deep water of the East Sea (Japan Sea), especially they have an annual cycle with winter intensification corresponding to seasonal wind (Mori et al., 2005).
- Byun et al. (2010) revealed near-inertial motions observed at ECI and their interactions with a mesoscale anticyclonic eddy.
- Whitt and Thomas (2015) and Jing et al. (2017) analyzed the energy exchange between mesoscale eddies and wind forced near-inertial waves using modified damped slab model including the geometric flow.

Data and Method

- Currents ~ 75 kHz upward-looking ADCP (8 bin, 30 min interval).
- Temperature ~ Total 7 depths between 100 and 400 m from SBE39.
- 1.5° x 1.5° ECMWF Wind (6 hour interval).
- HYCOM + NCOFA Global 1/12° analysis (GLBu08/ecsp 90.8).
- MLD, temperature, salinity, horizontal velocity (daily).
- AVISO SLA + MDT (Choi et al., 2008).

Method

- NIWs extracted by 4th Butterworth band-pass filter with cut-off frequency [0.85f, 1.15f].
- The effective Coriolis frequency \( f_e \) is given by \( f_e = f + \frac{u}{2L} \times f \) (Main assumption: \( \beta \approx 0 \)).
- Slab model is applied with amplitudes suggested by Niwa and Hibiya (1999).
- Modified slab model including geometric flow (Main assumption: \( \beta \ll \frac{u}{2L} \times f \)).

Results

- Observed large-amplitude near-inertial kinetic energy in Oct 2011.
  - High near-inertial kinetic energy is observed.
  - Persistent about 10 days.
  - Penetrate down to 250 m.
  - Estimated \( C_{spread} \) = 18 m/day.

- Predominant downward propagating near-inertial energy.
  - Predominant upward phase (downward energy) propagation.
  - Deepening of 2°C isotherm when the amplitude of NIWs is enhanced.
  - Significant NIWs above 300 m and weak semidiurnal and diurnal currents below 100 m.

- Wavenumber-frequency spectra during the Event.

- Wind – Causative forcing inducing near-inertial waves.
  - Similar patterns of predicted and observed NIWs.
  - Previously, 2-D spectra shows clockwise rotation in near-inertial band during the Event indicating wind-induced NIWs.
  - The larger damping parameter, the higher NIWs amplitude in MLD.
  - Reasonable damping parameter ~ 4 day.

Influence of mesoscale background flow field on NIWs

- NIWs have been observed in the deep water of the Japan Sea.
- NIWs seem to be involved in the mixing process.
- Reasonable damping parameter ~ 4 day.

Summery

- This study focused on enhanced NIWs during October in 2011 above 250 m in the East Sea (Japan Sea).
- The observation captured high near-inertial energy, which persisted about 10 days with the maximum currents reached over 22 cm/s and estimated vertical propagation speed is 18 m/day.
- Slanted phase line and wavenumber-frequency spectra also confirmed clockwise downward near-inertial currents, which presumably generated by intermittent wind forcing at the surface.
- Since the simple damped slab model is only considered MLD and wind stress, modified slab model including geostrophic currents were applied to identify role of mesoscale flow field.
- From modified slab model and minimum frequency results, it was confirmed that the mesoscale background field quite contributes to the propagation and energy amplification of NIWs.
- However the reason why enhanced near-inertial energies are found after the Oct. 27 is not figured out.
- NIWs seem to be involved in the mixing – when NIWs are enhanced, the 2°C isotherm was deepened.
- NIWs favorable condition in interior during the Event.

References


PICES 2017 Annual Meeting, September 22 – October 1, 2017, Vladivostok, Russia