Geophysical Research Abstracts,
Vol. 11, EGU2009-6521-2, 2009
EGU General Assembly 2009

Hybrid Kelvin-edge wave mode with a zero group velocity and its role in tidal dynamics

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A full set of long waves trapped in the coastal ocean over a variable topography includes a zero (fundamental) mode propagating with the coast on its right (left) in the Northern (Southern) hemisphere. This zero mode resembles a Kelvin wave at lower frequencies and an edge wave (Stokes mode) at higher frequencies. At the intermediate frequencies this mode becomes a hybrid Kelvin-edge wave (HKEW), as both rotational effects and the variable depth become important. Furthermore, if the shelf is wide enough, the group velocity of this hybrid mode becomes zero. It is found that in mid-latitudes a zero group velocity occurs at semi-diurnal (tidal) frequencies when the shelf width is 270-290 km. This notion motivated a set of numerical experiments using the Regional Ocean Modeling System (ROMS) when the incident HKEW with a semi-diurnal period propagates over a wide shelf (300 km or wider) and encounters a narrowing shelf so that the group velocity becomes zero at some alongshore location. The numerical experiments have demonstrated that the wave energy increases at this location while the alongshore energy flux is substantially reduced further downstream or is even completely blocked. Instead of propagating alongshore, the wave energy radiates offshore in the form of Poincare modes. Thus, we conclude that the shelf areas where the group velocity of HKEW becomes zero are characterized by the increased tidal amplitude and (consequently) high tidal energy dissipation. This behavior is qualitatively consistent with the dynamics of semi-diurnal tides on wide shelves narrowing in the direction of tidal wave propagation, including the East China Sea and the Patagonia shelves. In particular, both M2 and S2 harmonics exhibit strong amplification at the entrance of the Taiwan Strait but their amplitude abruptly drops downstream of the strait.