

Beta-plane arrested topographic wave as a linkage of open ocean forcing and mean shelf circulation

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Abstract:

The sea surface height (SSH) anomaly outside the shelf break (due to the basin-scale wind field) propagates westward on the flat shelf due to planetary Rossby wave and down-shelf due to the topographic Rossby wave, which transmit the SSH anomaly to the shelf and form a pressure field over there, thus produce the shelf circulation through the geostrophic balance. A nondimensional parameter Pe_β , termed as the β Péclet number was developed to signify the characteristics of open ocean-shelf interaction. $Pe_\beta \equiv D_\beta/\alpha$ is determined by the ratio of long-wave-limit planetary to topographic Rossby wave speeds, i.e., the β drift D_β , and the linear Ekman number α . On the western boundary shelf, due to the westward planetary Rossby wave, open ocean pressure propagates shoreward as $Pe_\beta > 1$, and shelf circulation peaks where Pe_β drops to 1. At this location, the planetary β effect is balanced by the bottom friction. $Pe_\beta = 1$ must occur either on the shelf or on the coastal wall when $Pe_\beta > 1$ is observed at the shelf edge. Whereas, on the eastern boundary shelf, $Pe_\beta < 0$, the pressure anomaly is removed from the shelf, and hence the inductive circulation decays rapidly from the shelf edge. This β effect is robust on gently sloping meridional shelves. For zonal shelves, the planetary β increases the effective bottom slope on the northern boundary shelf but decreases it on the southern one, in a sense of potential vorticity conservation. However, this effect could be less significant in reality, given the complex dynamics involved. The above mechanism can explain the dynamics driving the Taiwan Warm Current in the East China Sea and its bifurcation around 28°N.

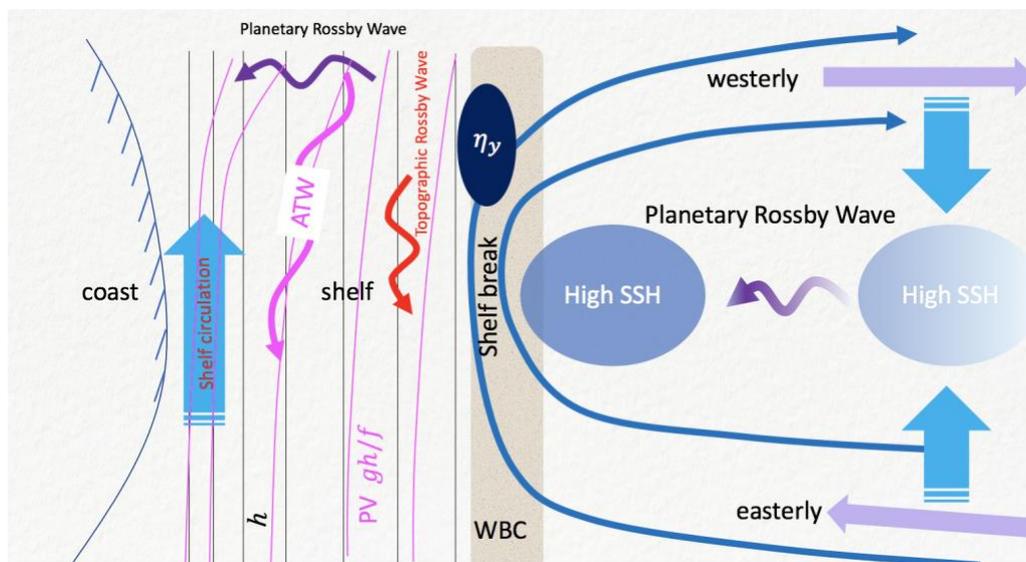


Figure: Schematic diagram of β -plane ATW theory