Geophysical Research Abstracts
Vol. 14, EGU2012-12096, 2012
EGU General Assembly 2012

Mean Lagrangian drift in continental shelf waves

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The time- and depth-averaged mean drift induced by barotropic continental shelf waves (CSW's) is studied theoretically for idealized shelf topography by calculating the mean volume fluxes to second order in wave amplitude. The waves suffer weak spatial damping due to bottom friction, which leads to radiation stress forcing of the mean fluxes. In terms of the total wave energy density $\bar{E}$ over the shelf region, the radiation stress tensor component $\bar{S}_{11}$ for CSW's is found to be different from that of shallow water surface waves in a non-rotating ocean. For CSW's, the ratio $\bar{S}_{11}/\bar{E}$ depends strongly on the wave number.

The mean Lagrangian flow forced by the radiation stress can be subdivided into a Stokes drift and a mean Eulerian drift current. The magnitude of the latter depends on the ratio between the radiation stress and the bottom stress acting on the mean flow. When the effect of bottom friction acts equally strong on the waves and the mean current, calculations for short CSW's show that the Stokes drift and the friction-dependent wave-induced mean Eulerian current varies approximately in anti-phase over the shelf, and that the latter is numerically the largest. For long CSW's they are approximately in phase. In both cases the mean Lagrangian current, which is responsible for the net particle drift, has its largest numerical value at the coast on the shallow part of the shelf.

Enhancing the effect of bottom friction on the Eulerian mean flow, results in a general current speed reduction, as well as a change in spatial structure for long waves. Applying realistic physical parameters for the continental shelf west of Norway, calculations yield along-shelf mean drift velocities for short CSW's that may be important for the transport of biological material, neutral tracers, and underwater plumes of dissolved oil from deep water drilling accidents.