Geophysical Research Abstracts
Vol. 17, EGU2015-10524, 2015
EGU General Assembly 2015

Energetically consistent ocean models (Georg Wüst medal lecture)

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The energy transfers between the three principal dynamical regimes – small-scale turbulence, internal gravity waves and geostrophically balanced motion – are fundamental to the energy cycle of the ocean but poorly understood and quantified. Since the interactions of the dynamical regimes ultimately link the smallest scales to the largest scales by a variety of complex processes, understanding these interactions is mandatory to understand the dynamics of the ocean, to construct models and to predict climate.

Here, an effort is documented to develop an energetically consistent model, in which the energy of the mean model variables interacts with the parameterised dynamical regimes without any spurious energy sources or sinks. This means that the energy available to drive the circulation, e.g. by interior mixing in the ocean, is only controlled by external energy input from the atmosphere and the tidal system and by internal exchanges. Central to the concept is the parameterisation module IDEMIX which predicts and consistently links the sources of internal gravity wave energy in the ocean, its propagation and dissipation. Important components which need further development are physically consistent parameterisations for the dissipation of the geostrophically balanced motion for which different possibilities are explored.

The model performance is validated using idealised and realistic global model configurations. The parameterised internal wave field provides between 2 and 3 TW for interior mixing from the total external energy input of about 4 TW, such that a transfer between 0.3 and 0.4 TW into mean potential energy contributes to drive the large-scale circulation in the model. In contrast, the wind work on the mean circulation contributes by about 1.8 TW to the large-scale circulation.