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Internal Wave Breaking Turbulence as a Nutrient Supplier for Phytoplankton

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The paper describes the effect of internal wave breaking turbulence on the formation of the hydro-physical and biogenic fields in the ocean upper layer. Phytoplankton cells populated in this layer experience enough light to gain a photosynthetic surplus. The amount of the essential nutrients to supply the photosynthetic reaction (such as nitrate, ammonium, phosphate, etc.) is very limited in the upper layer where the nutrients have very low concentrations. But the nutrient concentrations are much higher below the upper layer. The transport mechanism by the internal waves breaking turbulence becomes only mechanism to supply nutrients to phytoplankton cells. Physical models of the upper ocean layer mainly concentrated on the processes at the air-sea interface, surface waves, mixing within the ocean upper layer and the formation its hydro-physical structure including its lower boundary. The last one is relatively narrow seawater layer with the sharp seawater density increase with depth growth. This layer is often called the pycnocline. The dynamical and thermo-dynamical contribution of the pycnocline into the upper layer is routinely ignored because the very strong density stratification makes the lower boundary impermeable for dynamical and thermo-dynamical interactions with the main ocean body below the pycnocline. The exception is only internal waves propagating at the pycnocline. However the internal waves, like the surface waves, break at randomly distributed locations at the pycnocline generating turbulent patches which violate the pycnocline integrity and so its impermeability. The exchange of turbulent energy, heat and biogenic salts between the ocean upper layer and the main body of the ocean below is caused through the random patches of active turbulence within zones of internal wave breaking. The variability of the upper layer temperature, concentration of biogenic salts and the turbulent energy is caused by the turbulence of the breaking zones, its variability and the breaking zones statistics. The turbulent horizontal diffusion of the ocean upper layer spread the non-uniformities of these fields into larger horizontal scales than the breaking zones scales. The simple model examples of the field of internal wave breaking turbulence are presented to provide quantitative evaluations [A. Benilov, 2013. “Impact of Internal Wave Breaking on the Ocean Upper Layer Formation”. Chapter 1, In: “Seawater: Geochemistry, Composition and Environmental Impacts”, Nova Science Publishers, Inc., p. 1-51]. Estimates of the manifestation of the discussed mechanism are shown in the mean values and variances of the surface non-uniformities of the upper layer fields as well in their spectrums.