Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02871, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02871
EGU General Assembly 2008

Mixing due to surface-wave breaking

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Breaking of surface gravity waves generates turbulence and causes the entrainment of air at the sea surface, which again may lead to a temperature increase in the breaking region. These processes influence the near-surface buoyancy, and generate a thin layer close to the surface which is statically stable. Dynamically, the wave breaking itself (the loss of mean wave momentum) induces an Eulerian mean current near the sea surface through the action of the virtual wave stress. This current is instrumental in mixing the turbulence induced by breaking downwards. The mixing is affected by the fact that slightly denser particles are entrained into the stable top layer from below during this process. Utilizing the experimental fact that the overall Richardson number is constant in similar mixing problems, we investigate theoretically the growth of the mixed layer due to breaking waves. The results show that the mixing due to a single breaking event penetrates down to a depth which is comparable to the wave height. At this depth the entrainment velocity practically vanishes. This occurs on a time scale that is of the order of the breaking duration time. For multiple breaking events in a steady homogeneous sea state, the average energy dissipation due to breaking must equal the work per unit time by the wind through the form stress. This yields an estimate for the residual eddy viscosity near the surface, and the assessment of the variation of the eddy viscosity with depth.