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Mixing and bottom friction: parametrization and application to the surf zone

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Wave breaking has been observed to impact the bottom boundary layer in surf zones, with potential impacts on bottom friction. Observations in the inner surf zone have also shown a tendency to an underestimation of the wave-induced set-up when using usual model parameterizations. The present study investigates the possible impact of wave breaking on bottom friction and set-up using a recently proposed parameterization of the wave-induced turbulent kinetic energy in the vertical mixing parameterization of the wave-averaged flow.

This parametrization proposed by Mellor (2002) allows us to take account the oscillations of the bottom boundary layer with the wave phases thanks to some additional turbulent source terms. First, the behavior of this parameterization, is investigated by comparing phase-resolving and phase-averaged solutions. The hydrodynamical model MARS (Lazure et Dumas, 2008) is used for this, using a modified k-epsilon model to take account the Mellor (2002) parametrization. It is shown that the phase averaged solution strongly overestimates the turbulent kinetic energy, which is similar to the situation of the air flow over waves (Miles 1996). The waves inhibits the turbulence and the wave-averaged parametrization is not able to reproduce correctly this phenomenom. Cases with wave breaking at the surface are simulated in order to study the influence of surface wave breaking on the bottom boundary layer. This parametrization is applied in the surf zone for two differents cases, one for a planar beach and one other for a barred beach with rip currents. The coupled model MARS-WAVEWATCH III is used for this (Bennis et al, 2011) and for a realistic planar beach, the mixing parameterization has only a limited impact on the bottom friction and the wave set-up, unless the bottom roughness is greatly enhanced in very shallow water, or for a spatially varying roughness. The use of the mixing parametrization requires an adjustement of the bottom roughness to fit the observations probably due to the expression of the additional source of turbulent kinetic energy. For an idealized barred beach, the results given by the mixing parametrization are compared with others from parametrizations that take account the wave effects on the bottom friction via the wave orbital velocity, and no via the turbulent kinetic energy as in Mellor (2002). The vertical profile of the rip current is significantly modified by the bottom friction parametrization, while the feedback of the waves on the flow (ie. two-way mode) changes the pattern of the rip currents in comparison with the one-way mode.