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The improvement of ocean and climate models through surface wave: From mean state to long-term variations

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The ocean surface mixed layer (ML) determines the lower atmospheric boundary conditions, and controls mass, momentum and energy fluxes across the air-sea interface. Incorrect parameterizations of the ocean mixing processes essentially render the atmospheric and oceanic dynamics to be either decoupled or coupled incorrectly. Because the ocean covers three quarters of the global surface, it is essential that we correctly model the ocean ML, so that we can better simulate and predict the climate. However, the simulated mixing layer depth is always too shallow for nearly all ocean circulation models especially for summer season. As the mixing process is essentially an energy balance problem, surface waves, as the most energetic motions in the ocean, should play a controlling role. Unfortunately, in most ocean dynamics studies, wave motions have always been treated separately from the ocean circulation. To overcome this shortcoming, we have established a new scheme on the non-breaking wave-induced vertical mixing (Bv) that will correct the systematic error of insufficient mixing. We observed this kind of non-breaking surface wave-induced vertical mixing in laboratory experiments, in-situ observations in lake and ocean already. The new scheme of Bv has enabled the mixing layer to deepen, and a much better agreement with observed climatologic data. Different OGCMs such as POM, ROMS, MOM4, POP and HIM show similar improvements in global ocean. Besides, the Bv has also been used to study the temperature and salinity distribution with amazingly good agreement with observations in China Sea and adjacent area (http://www.agu.org/journals/ss/CHINASEAS1/). Then we examine the effects of Bv on climate models, CCSM3 and FGCM0. Both two climate models show dramatic improvements from mean state to long-term variations. For example, the tropical biases, which in fact a common problem for all climate models without flux correction, are much improved. All above suggest that the surface wave should be an important clue to improve the performance of climate models.