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A modulation source term for short ocean waves numerical modelling

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Short waves (1 to 10 meters wave length) are important for air-sea interactions and remote sensing, but are still badly represented in numerical models. For example the high frequency f^{-5} is not reproduced by existing parameterizations (Zieger et al. 2015). Recent observations of their directional distributions (Leckler et al. 2015 and Peureux et al. 2018) have revealed that the directional bimodality can be very strong , i.e. short waves propagating along two directions 70° away from the wind direction. This behavior is favored by the non-linear 4-wave interactions (Longuet-Higgins 1976). Here we show that the combination of existing wind input and dissipation parameterizations with exact non-linear interactions are unable to produce the strong level of bimodality observed. Based on the observation of short wave breaking modulated by long waves (Guimaraes 2018) using stereo-video imagery, and the numerical analysis of the modulation of short waves by long waves we find that the saturation of short waves can be modulated by a factor $1 + 2MTF\sqrt{mss_{\mathrm{long}}})\cos(\theta - \theta_{long})^2$ where the MTF may be as large 10. The long wave mean square slope is mss_{long}, with a dominant slope direction θ_{long}. Based on this finding we propose a modification of the dissipation parameterization by Ardhuin et al. (2010) in which the saturation is replaced by its expected maximum value over a number of modulation cycles. Preliminary result with a constant MTF show that the f^{-5} and the strong bimodality can be reproduced when the dominant long waves are aligned with the wind. Future work will explore the variability of the MTF magnitude and look into the observations of shorter waves for further verification. Modeled short waves directional distributions are encouraging and support the intervention of modulation in establishing their bimodality.

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