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A numerical study on the impacts of parasitic capillaries on gravity-dominant waves

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Capillary ripples riding on longer gravity-dominant carrier waves are commonly observed on ocean surfaces. These parasitic capillary waves, with length scales ranging from a few centimeters down to fractions of millimeters, can significantly enhance energy dissipation of the carrier waves. Their presence can also change the flow processes within the sublayer immediately beneath the ocean surface, and accordingly, significantly influence the transport of gas and heat across the air-sea interface. In this contribution we will present our recent efforts in understanding the formation mechanism and potential impacts of parasitic capillaries on a gravity-capillary wave by use of numerical simulations based on first-principle formulation in both conservation equations and boundary conditions. The simulation result reveals that the formation of parasitic capillaries is triggered by a localized pressure disturbance on the forward face near the crest attributed to the presence of surface tension and a maximum surface curvature, and subsequently develops an oscillatory train of capillary waves. Immediately underneath the capillary wave train, vortices with opposite orientations are observed to be shed from the ripple crests and troughs, and form vortical layers in the otherwise potential flow field underneath the gravity-dominant surface wave. These induced vortical layers are found to be responsible for the strong enhancement of energy dissipation as well as the modification of surface renewal processes governing the gas and heat transports.