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The proposed parametrizations of air-sea momentum and heat transfer applicable to from low to extreme wind speeds

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Recent field and laboratory observations indicate the variation of drag coefficient with wind speed at high winds behaves different from that under low-to-moderate wind conditions. By taking wave development into account, a parameterization of sea surface aerodynamic roughness applicable to from low-to-moderate wind to extremely-high wind is proposed on the basis of Makin (2005)'s model with sea spray effect. The relationship between drag coefficient and wind speed by the proposed parameterization agrees well with the existing field and laboratory observational data. It is shown that, under low-to-moderate wind conditions so that the sea spray effects could be neglected, the nondimensional aerodynamic roughness increases with the wave age gradually and then decreases with the wave age. While under high wind conditions the drag coefficient decreases with increasing wind speed due to the modified logarithmic wind profile by the effect of spray droplets which are produced by bursting bubbles or wind tearing breaking wave crests. In addition, the drag coefficients reach their maximum as 10-m wind speed is between 25 to 33 m s-1 for all wave developments. Taking into account the effect of wave state on whitecap coverage, a sea spray generation function (SSGF) for bubble-derived droplets is presented. Combined it with the wave-state-dependent SSGF for spume droplets, a SSGF applicable to both bubble-derived and spume droplets with wave state effects included is obtained. Applying the proposed SSGF to Andreas (1992)'s method for estimating sea spray heat flux and considering the thermodynamical feedback of sea spray, an algorithm to estimate wave state affected sea spray heat flux is proposed. Given the atmospheric and oceanic environment, sea spray heat flux estimated with the proposed algorithm increases with wind speed, wave age and windsea Reynolds number as well.