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# A turbulence closure scheme in the wave boundary layer and its application in a coupled model

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Air-sea interactions are important for weather and climate predictions since they control the momentum and energy transfer between the atmosphere and the ocean. In current models, the momentum flux in the atmospheric boundary layer is estimated by turbulence closure models which were developed heavily based on measurements over land. However, those turbulence closure models often fail to capture the momentum flux and wind profile in the marine atmospheric boundary layer due to wave impacts. In this study, we proposed a new turbulence closure model to estimate the wind stress in the wave boundary layer from viscous stress, shear-induced turbulent stress, wind-sea induced stress, and swell-induced upward stress, separately. The misalignment between the wind stress and wind is also considered in the model. Single-column simulations indicate that 1) the swell-induced upward momentum flux increases the surface wind and changes the wind direction, 2) the misalignment between the upward momentum flux and wind has a more significant impact on the wind profile than that from the downward momentum flux, and 3) the impact of swell-induced upward momentum flux decreases with atmospheric convection. The proposed closure scheme was implemented into an atmosphere-wave coupled model. A month-long simulation over the ocean off California shows that the surface wind can be altered up to 5% by ocean surface gravity waves.