Using Satellite Data to Derive An Empirical Model for Surface Wind Stress Response to SST Forcing Induced by Tropical Instability Waves (TIWs) in the Eastern Equatorial Pacific

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High-resolution space-based observations reveal significant two-way air-sea interactions associated with tropical instability waves (TIWs); their roles in budgets of heat, salt, momentum and biogeochemical fields in the tropical oceans have been recently demonstrated. However, dynamical model-based simulations of the atmospheric response to TIW-induced sea surface temperature (SST_{TIW}) perturbations remain a great challenge due to the limitation in spatial resolution and realistic representations of the related processes in the atmospheric planetary boundary layer (PBL) and their interactions with the overlying free troposphere. Using microwave remote sensing data, an empirical model is derived to depict wind stress perturbations induced by TIW related SST forcing in the eastern tropical Pacific Ocean. Wind data are based on space-time blending of QuikSCAT-DIRTH satellite observations and NCEP analysis fields; SST data are from the Tropical Rainfall Measuring Mission (TRMM) microwave imager (TMI). These daily data are first subject to a spatial filter of 12 moving average in the zonal direction to extract TIW-related wind stress ($\boldsymbol{\tau}_{TIW}$) and SST_{TIW} perturbations. A combined singular value decomposition (SVD) analysis is then applied to these zonal-high-pass filtered $\boldsymbol{\tau}_{TIW}$ and SST_{TIW} fields. It is demonstrated that the SVD-based analysis technique can effectively extract TIW-induced co-variability patterns in the atmosphere and ocean, acting as a filter by passing wind signals that are directly related with the SST_{TIW} forcing over the TIW active regions. As a result, the empirical model can well represent TIW-induced wind stress responses as revealed directly from satellite measurements (e.g., the structure and phase), but the amplitude can be underestimated significantly. Validation and sensitivity experiments are performed to illustrate the robustness of the empirical $\boldsymbol{\tau}_{TIW}$ model. Further applications are discussed for taking into account the TIW-induced wind responses and feedback effects that are missing in large-scale climate models and atmospheric reanalysis data, as well as for uncoupled ocean and coupled meso-scale and large-scale air-sea modeling studies.