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Effects of spatial resolution and temporal offset of air-sea boundary-layer variables on turbulent heat flux estimates

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Air-sea turbulent heat fluxes and their spatial gradients are important to the ocean, climate, weather, and their interactions. Satellite-based estimation of air-sea latent and sensible fluxes, providing broad coverage, require measurements of sea surface temperature, ocean-surface wind speed, and air temperature and humidity above sea surface. Because no single satellite has been able to provide simultaneous measurements of these input variables, they typically come from various satellites with different spatial resolutions and sampling times that can be offset by hours. These factors introduce errors in the estimated heat fluxes and their gradients that are not well documented. As a model-based assessment of these errors, we performed a simulation using a Weather Research and Forecasting (WRF) model forced by high-resolution blended satellite SST for the Gulf Stream extension region with a 3-km resolution and with 30-minute output. Latent and sensible heat fluxes were first computed from input variables with the original model resolutions and at coincident times. We then computed the heat fluxes by (1) decimating the input variables to various resolutions from 12.5 to 50 km, and (2) offsetting the “sampling” times of some input variables from others by 3 hours. The resultant estimations of heat fluxes and their gradients from (1) and (2) were compared with the counterparts without reducing resolution and without temporal offset of the input variables. The results show that reducing input-variable resolutions from 12.5 to 50 km weakened the magnitudes of the time-mean and instantaneous heat fluxes and their gradients substantially, for example, by a factor of two for the time-mean gradients. The temporal offset of input variables substantially impacted the instantaneous fluxes and their gradients, although not their time-mean values. The implications of these effects on scientific and operational applications of heat flux products will be discussed. Finally, we highlight a mission concept for providing simultaneous, high-resolution measurements of boundary-layer variables from a single satellite to improve air-sea turbulent heat flux estimation.