Surface dynamical response to SST anomalies under different wind conditions at mid-latitudes

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ABSTRACT

The response of the atmosphere to sea surface temperature (SST) anomalies is explored in an idealized configuration representative of a storm track above a stationary ocean. The SST field is composed of a mid-latitude large-scale frontal zone and mesoscale and submesoscale (30-300km) SST anomalies. A simplified model of the atmospheric surface layer is developed that allows to understand how two important processes, i.e. pressure adjustment within the boundary layer and vertical mixing of momentum, affect the atmospheric response. The norm of the time averaged wind is found to be proportional to down-wind SST gradients for wavelengths larger than 200 km, in good agreement with a pressure adjustment mechanism. For shorter wavelengths, the response tends toward a linear wind-SST relationship in agreement with downward mixing mechanism. Sensitivity of the response to the large-scale background wind is explored. At mesoscales, surface divergence and boundary layer vertical velocities are found to be proportional to Laplacian boundary layer temperature. Due to temperature advection by the mean flow, this response is shifted downstream of the SST Laplacian but is quite distinct from the one inferred from a linear wind-SST relationship. In general, wind stress divergence resembles down-wind SST gradients, but it is also modulated by boundary-layer temperature Laplacian in a proportion depending on the mean surface wind speed. In conclusion, it is found that both vertical momentum mixing and pressure adjustment mechanisms affect surface wind and wind-stress divergences.