Atmospheric response to changes in sea surface temperature: insights from an analytical model

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The dynamical coupling between wind, waves and currents is known to occur on a wide range of scales, and is often associated to a thermodynamical coupling, resulting from the strong SST gradients associated with oceanic surface current fronts. In this work, we focus on the thermodynamical coupling by presenting an analytical model reproducing literature-based numerical simulations of the Marine Atmospheric Boundary Layer (MABL) over a SST front, with wind blowing from its cold to warm side. Turbulence is parametrized through a varying diffusion coefficient. Unlike an standard Ekman layer, the diffusion coefficient is parabolic on the vertical direction and its mean value is decoupled from the MABL height. SST changes act on the magnitude and shape of the diffusion coefficient, and by a horizontal pressure gradient in the MABL momentum balance. The model enables to characterize different dynamical regimes in the MABL, which are interpreted through non-dimensional numbers. Depending on the regime and the scale of the SST front, the response of the MABL in terms of divergence is found to be different, and can be computed analytically. This works sets a first step to model the changes in surface roughness across an SST front, which should also include wave-current interactions and wave breaking modulations, and which contribute to modify locally the momentum and heat fluxes across a front. This framework is a step to advance the quantitative interpretation of upper ocean dynamics from their high resolution signature in satellite measurements.