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The Effect of SST Gradients on Atmospheric Frontogenesis

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It is thought that gradients in the SST affect the development of extratropical cyclones and their associated atmospheric fronts in two ways. First, SST gradients may be imprinted on the overlying atmosphere through surface sensible and latent heating, producing regions of baroclinicity on which extratropical cyclones may develop or intensify. In this way, long-lived SST gradients may play a part in maintaining the storm track. Second, individual extratropical fronts and cyclones may be modified locally by the sensible and latent heat fluxes associated with the SST pattern. In the work presented here, an analytic model is developed and used to explore the second of these two effects. The model predictions are compared with atmospheric fronts in the North Atlantic identified in the ERA-I reanalyses.

Given a sufficiently simple prescribed wind field, the thermodynamic equation (written in terms of potential temperature) including the effects of surface sensible heating can be integrated exactly. Two particular examples are discussed. The first describes a straight atmospheric front passing over a straight SST front. The second describes a moving atmospheric vortex and the evolution of the associated warm and cold fronts as they pass over an SST front.

The key result from these calculations is that the SST gradient per se is relatively unimportant in determining the solution. Rather, it the difference between the SST and the overlying atmospheric temperature (which determines the surface sensible heat flux) that most affects the solution. Consequently, the net effect on a cold front crossing an SST gradient from the cold side towards the warm side is strong frontolysis.