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The Interaction between QLCSs and Marine Atmospheric Boundary Layers

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Quasi-linear convective systems (QLCSs) can pose a substantial threat to coastal cities and communities, such as those along the eastern United States. For example, the 10 September 2010 QLCS that moved over New York City was responsible for 2 tornadoes (EF0; EF1) and a microburst with peak winds of 123 mph, resulting in 1 fatality [National Climatic Data Center (NCDC) Storm Data] and substantial property damage throughout New York City. Due to its location, this was a high impact event regardless of the relatively low intensity of the tornadoes. No severe thunderstorm or tornado watch was issued prior to the event and a tornado warning was issued only a few minutes prior to the development of the first tornado, giving local residents limited time to react.

Predicting the evolution of QLCSs crossing coastal boundaries is a challenge. As these organized convective storms move from inland regions to over coastal waters, their evolution can be influenced by spatial gradients in temperature, moisture, and wind as they interact with coastal sea breeze boundaries and the associated marine atmospheric boundary layers (MABL). Previous research (Lombardo and Colle 2012; Lombardo and Colle 2013) has shown that offshore atmospheric instability is not the dominant variable influencing coastal QLCS evolution; QLCSs that decay moving offshore are associated with larger offshore instability than events that maintain their intensity over the coastal waters. This contradicts the assumption that QLCSs decay offshore due to reduced instability over the relatively cool coastal waters. A previous analysis of two coastal QLCS case studies has shown that the evolution of coastal QLCSs as they cross the coastal boundary is related to the forcing mechanism along the leading convective line; the offshore decaying storm remained surface based while the sustaining storm became forced by an elevated cold-pool bore hybrid as it moved over the coastal waters (Lombardo and Colle 2013). Additional analyses are required to evaluate the robustness of these results.

The current work uses the Cloud Model 1 (CM1; Bryan and Fritsch 2002) to systematically explore the physical processes controlling the interaction between QLCSs and MABLs under a phase space of representative environmental conditions in an idealized setting. Fundamental questions include (1) Under what environmental conditions (land, ocean) do QLCSs decay and sustain their intensity as they move offshore? (2) What forcing mechanisms are associated with the different QLCS evolutions (i.e. cold-pool, gravity wave, bore)? (3) How do QLCS characteristics (i.e. speed, intensity) evolve as they move offshore?