Mergers between squall lines and isolated supercell thunderstorms are powerful phenomena that can produce severe weather conditions, including tornadoes and large hail. Such mergers can lead to the formation of a bow echo, a pattern of cloud and precipitation that is characteristic of severe thunderstorms.

Idealized Simulations of Mergers Between Squall Lines and Isolated Supercell Thunderstorms

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Background and motivation

Mergers between squall lines and isolated supercells pose a challenge in understanding the evolution of these extreme storms. Idealized simulations are used to study these mergers, allowing for detailed analysis of key processes that contribute to severe weather.

Overview of idealized merger simulation

The simulation involves two main components: the supercell and the squall line. The supercell is initialized as a strong updraft, while the squall line is a continuous line of convection. The merger process involves the interaction of these two systems, leading to the formation of a bow echo.

Squall line cold pool evolution

- Outflow from the squall line reaches the supercell's front, leading to a decrease in temperature. This cools the air ahead of the supercell.
- The supercell's updraft transports warm air, raising temperatures in its vicinity. This change in temperature at the front of the supercell is crucial for the development of the bow echo.

Low-level vorticity evolution

- Multiple strong vortices develop along the front of the squall line during the merger, increasing the intensity of the cold pool.
- Lower-level vortices develop as the supercell and squall line merge, increasing the vorticity in the region.
- Merging of smaller vortices leads to the formation of a single, large-scale vortex.

Conclusions and implications

Idealized simulations capture the salient features of observed squall line-supercell mergers, revealing some of the key processes at work. Specifically:

- The merger produces a precipitation region, leading to a local increase in squall line intensity. This results in the supercell being preserved during the merger and playing a dominant role in the merged system.
- Following the merger, an increase in low-level vorticity in the vicinity of the merged system results from tilting of baroclinically generated horizontal vorticity by the remnant supercell updraft.
- The merger produces an increase in convective intensity, producing strong updrafting. This produces a precipitation region near the leading edge of the merged system, driving a strong outflow jet that leads to post-merger bowing.
- The evolution of the merged system reveals some of the key processes at work, providing insights into the dynamics of these extreme events.