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Recent Radar Observations of Wave-like Features Interacting with Quasi-linear Convective Systems

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1. Introduction & Background

The environmental set-up for cool season quasi-linear convective systems (QLCS) is one that is also often conducive to wave generation, such as internal gravity waves, ducted gravity waves, solitary waves or Kelvin-Helmholtz waves. These waves are usually observed interacting with the linear system as distinct horizontal lines of weak to moderate reflectivity or areas of enhanced reflectivity that appear to be larger pieces of energy moving through the atmosphere. The reflectivity features are observed propagating through the QLCS faster than the background wind. Numerous cases of potential interactions have been observed via the WSR-88D network in the Southeastern United States. Three recent cases are presented here.

During and after the wave interaction, some or all of the following was observed:

1). a localized change in the reflectivity structure of storm cells within the QLCS,

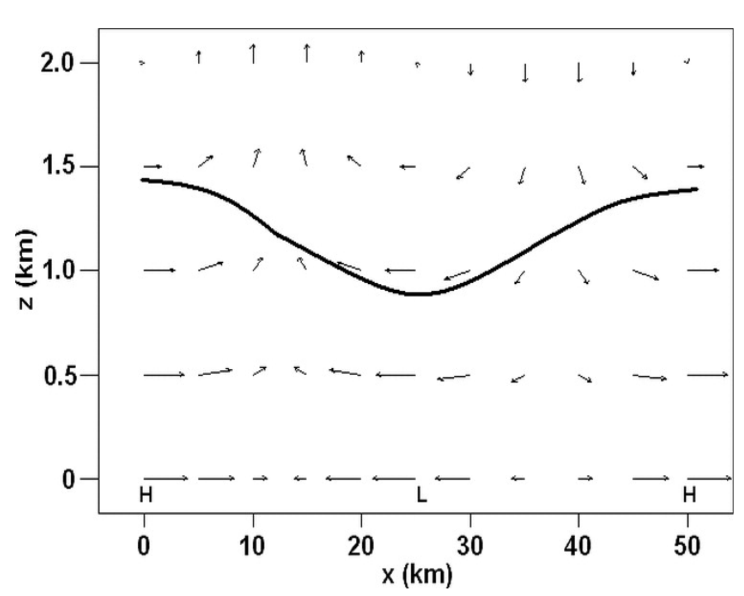
2). a localized change in the speed and direction of the linear system,

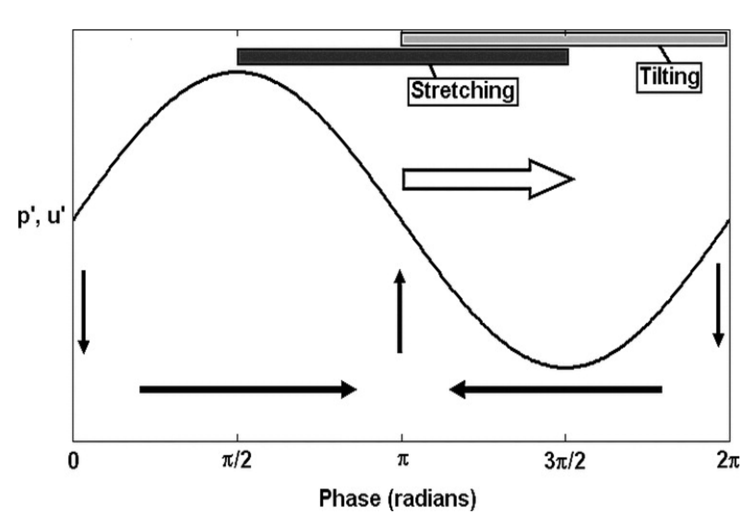
3). the formation (or strengthening if already present) of a low-level mesocyclone and possibly tornadogenesis,

4). a clustering of damaging wind reports.

Changes in reflectivity structure, speed, and direction of the linear system were often manifested as the formation of localized bowing segments or the development of a line-echo wave pattern.

Previously, Coleman and Knupp (2008) found that interactions of ducted gravity waves with preexisting mesocyclones can increase the vorticity of the mesocyclone through convergence-divergence and perturbation wind shear associated with the wave.





Left Image: Airflow vectors and an isentrope (heavy solid curve) in the *x*-*z* plane for a ducted gravity wave. Divergence is largest near the surface, with convergence ahead of the wave ridge and divergence ahead of the wave trough. Perturbation wind shear is maximized near the top of the duct, with positive perturbation shear centered in the wave trough and negative perturbation shear centered in the ridge. Pressure perturbations associated with the wave are also indicated (Coleman and Knupp 2008).

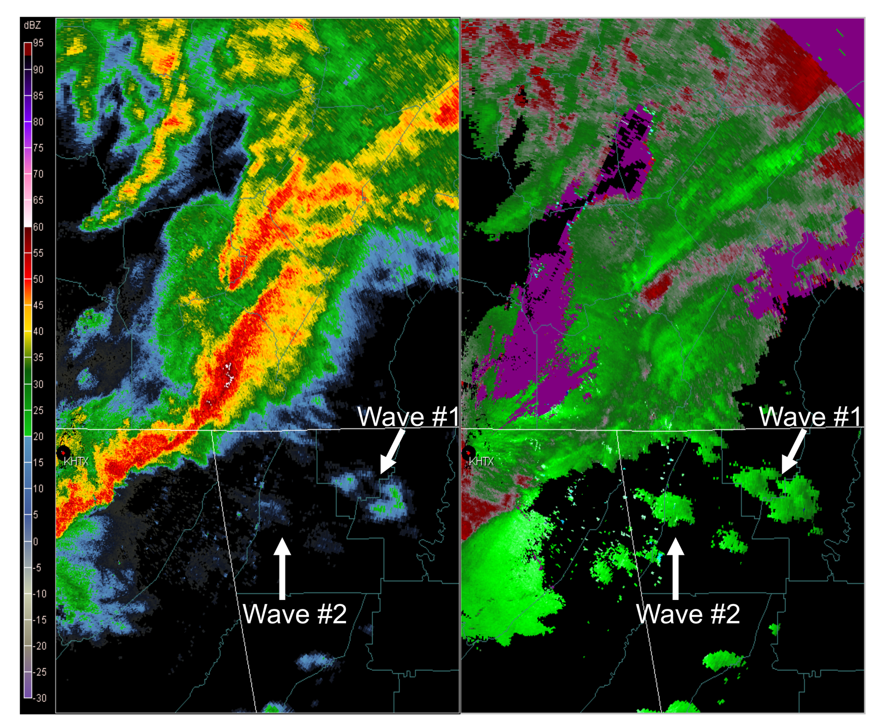
Right Image: The image on the right shows regions of positive wave-induced stretching and tilting, relative to the wave phase, during a mesocyclone-wave interaction (Coleman and Knupp 2008)

It is hypothesized that similar dynamics are involved during wave interactions with QLCS and such interactions may be an important component for some "spin-up" tornadoes along the leading edge of linear systems. Additionally, pressure perturbations associated with the wave(s) (see left image above) may act to tighten the pressure gradient along the line, enhancing the rear inflow. This might be the cause of many observed localized bowing segments and damaging wind reports associated with QLCS-wave interactions.

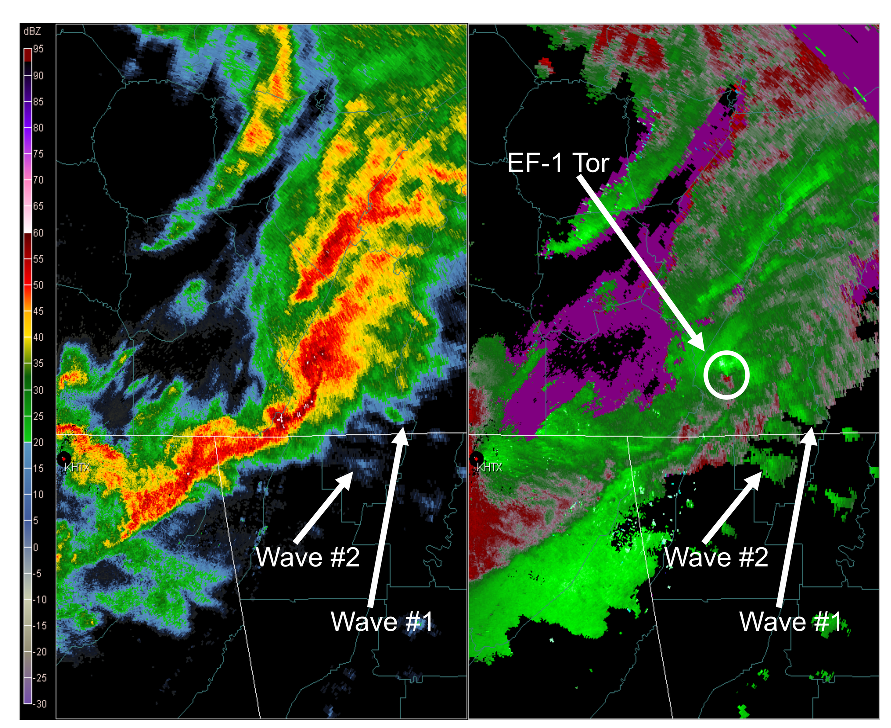
2. Recent Cases

a) Feb. 28, 2011

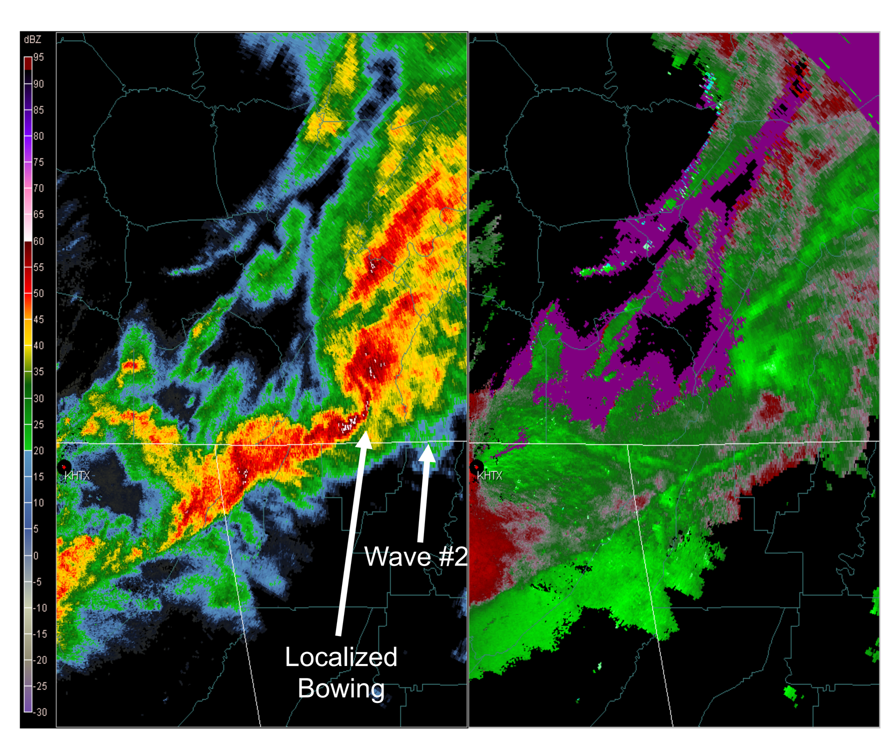
Numerous wave features were observed on KHTX propagating from the southwest near 35 m s^{-1} ahead of and within a broken line of thunderstorms. Wave interactions were associated with at least 3 tornadic circulations, localized bowing segments and straight line wind damage near Chattanooga, TN. Additionally, the broken line tended to consolidate after the interactions.



KHTX Reflectivity & SRV at 1908 UTC



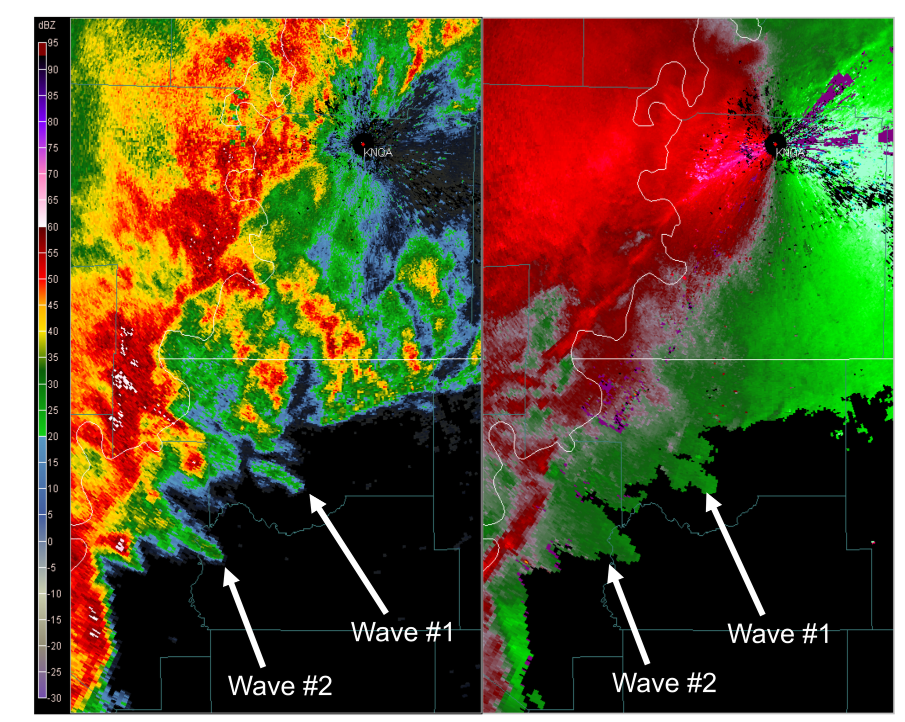
KHTX Reflectivity & SRV at 1921 UTC



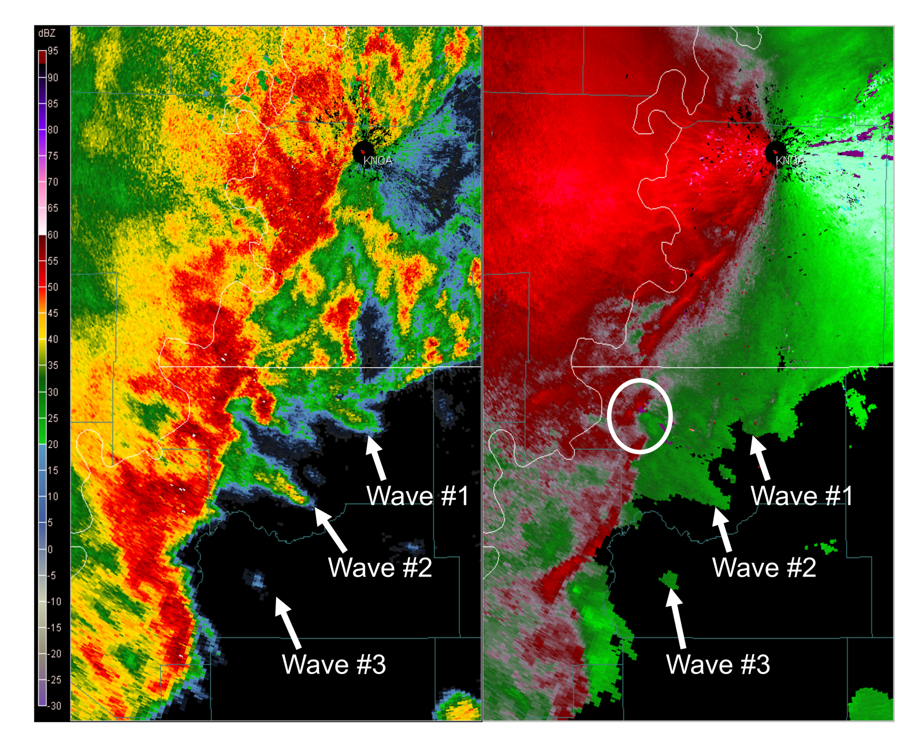
KHTX Reflectivity & SRV at 1929 UTC

c) April 4, 2011

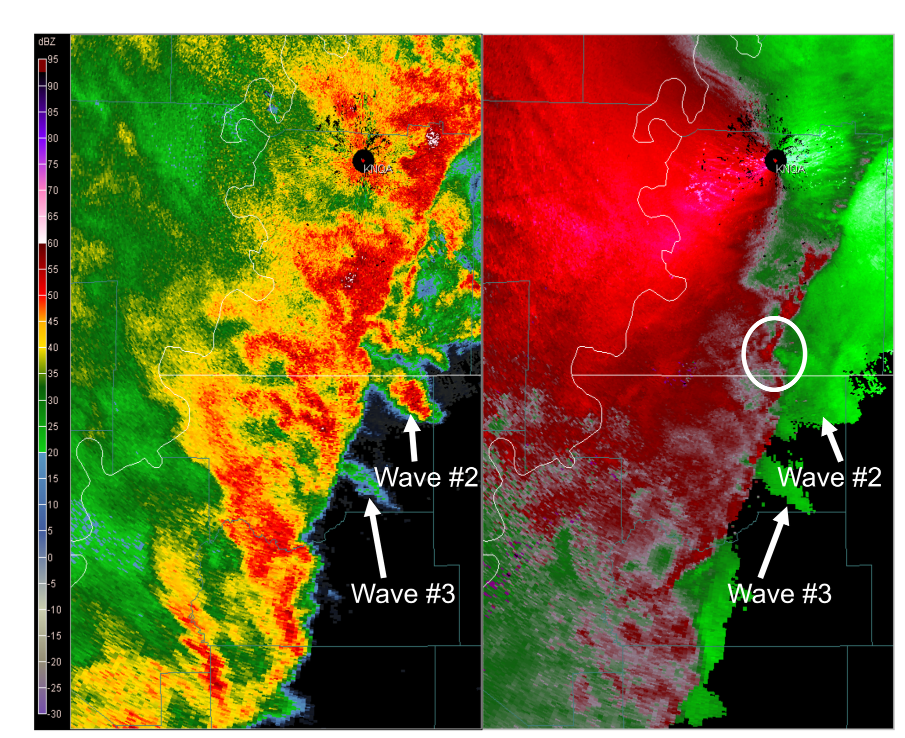
Wave features were observed on KNQA propagating from the southwest at near 35 m s^{-1} ahead of and along a QLCS. Interactions between the linear system and apparent waves were coincident with the development of several areas of cyclonic rotation. No tornadoes were reported, however, numerous instances of damaging winds were associated with the rotation features and interactions.



KNQA Reflectivity & SRV at 1632 UTC



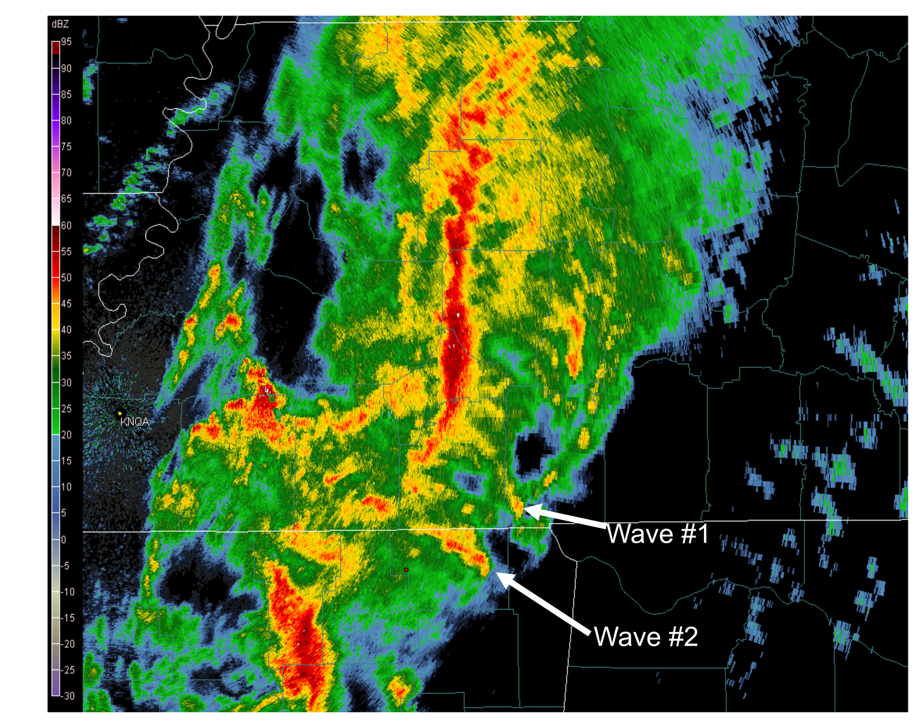
KNQA Reflectivity & SRV at 1641 UTC



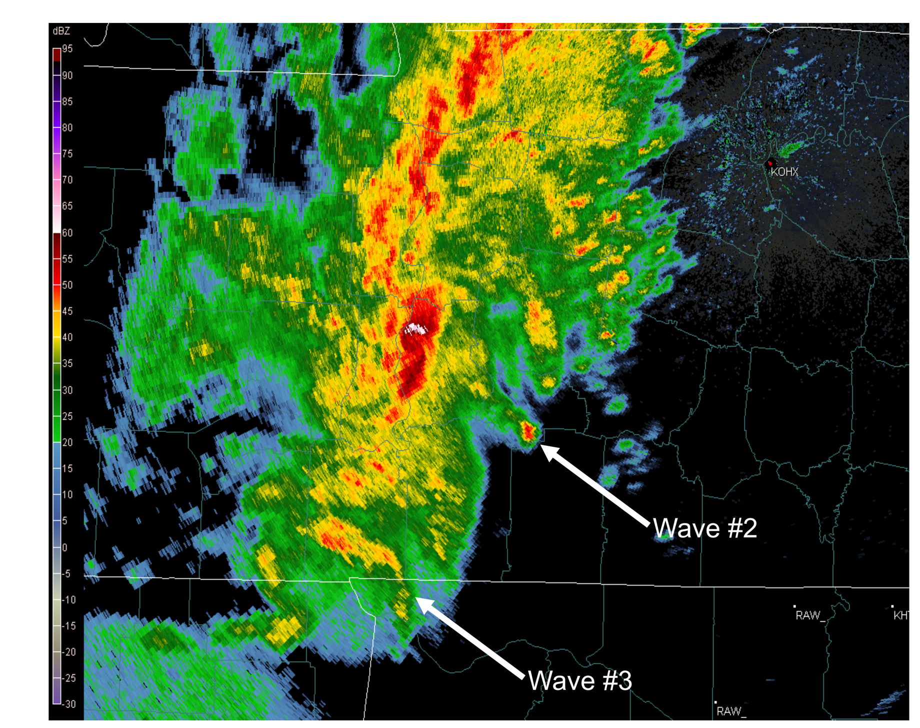
KNQA Reflectivity & SRV at 1655 UTC

a) April 11, 2011

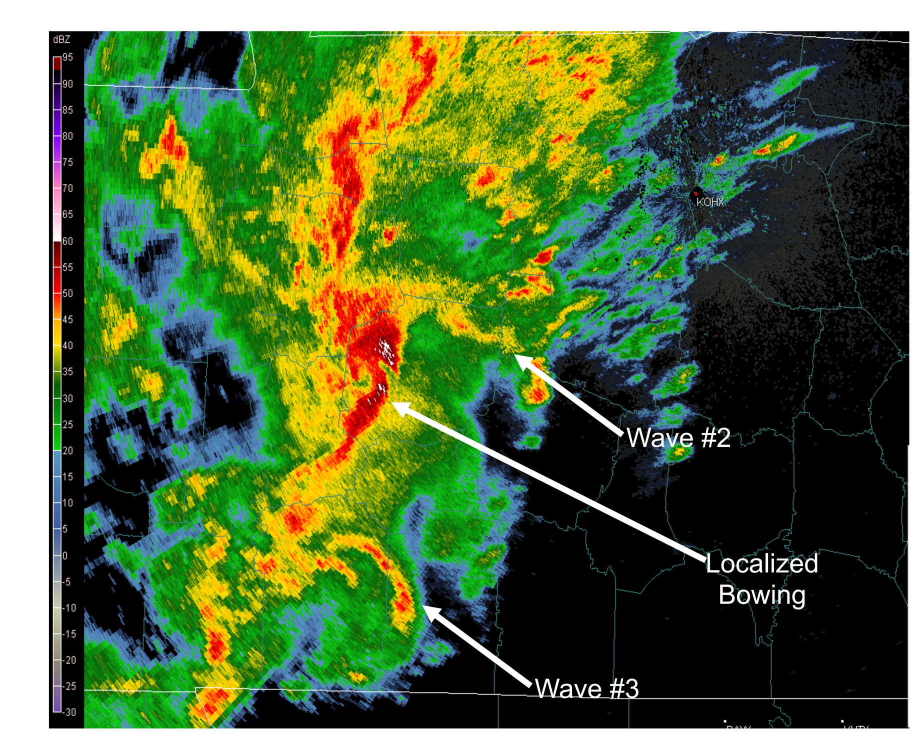
Wave features were observed on KNQA and KOHX propagating from the southwest at near 40 m s^{-1}. After moving through an area of enhanced convection (≥ 50 dBZ), a localized bowing segment developed and damaging wind was reported near 2112 UTC.



KNQA Reflectivity at 2020 UTC



KOHX Reflectivity at 2103 UTC



KOHX Reflectivity at 2125 UTC