Quasi-Stationary Convective Systems Forming Perpendicular to, and Above the Cold Pools of, Strong Bow Echoes

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Introduction

- Certlak (2009) examined cold pool-induced convection behind bow echoes, and showed that the convection (primarily along the periphery of the cold pool).
- This study looks at circumstances in which back-building convection forms perpendicular to, and above the cold pool region of, strong bow echoes (i.e., not along the cold pool boundary).
- We refer to this phenomenon as a “bow and arrow” because, on radar imagery, the two convective regions resemble an archer’s bow and arrow.
- Cases were found using Hurrell's diagrams and archived radar observations.
- A total of 18 cases have been found, but only 3 are being used for this study.
- 15 September 2010 Case:
  - Used NCEP's NAM analyses as initial and boundary conditions.
  - Created simulations using the Advanced Research version of the Weather Research and Forecasting (WRF) model, version 3.2.
  - Used grids with horizontal grid spacing of 27 km, 9 km, and 3 km.
- 8 May 2009 and 18 June 2006 Cases:
  - Used NCEP’s 3-hour high-resolution forecast data.
  - Horizontal grid spacing: 3 km (8 May 2009) and 4 km (18 June 2006).
- All 3 Cases:
  - Used the Rapid Update Cycle (RUC) program to display and analyze results.

Why is This Important?

- To gain an accurate forecast, a statistical model needs to correctly predict multiple environmental conditions and resulting convective processes that take place before and throughout the duration of the bow and arrow phenomenon.
- The “arrow” is usually an area of strong convection that is capable of creating a vast amount of large hail, causing damage to trees and roofs.
- Simulations of several cases are analyzed in an attempt to identify common environmental conditions prior to the development of the back-building convection, in addition to understanding the mechanism responsible for initiating and maintaining the convective flow.

Results

18 June 2006

- A convective arrow formed behind this bow echo on 18 June 2010, resulting in 9 hail reports in northwestern Iowa, at the same time the arrow was over that region. Reports included golf-ball sized hail, causing damage to trees and roofs.
- A 575 hPa vertical motion plot is used to locate areas of greatest updraft within the arrow, where arrows are chosen to show the air parcels’ horizontal and vertical motion over the indicated 7-hour time period.
- Particles originate out of both the southwest, and the west-northeast before entering the “arrow” updraft.
- Particles reach a height and then rapidly rise in the last hour.
- Instantaneous radar images (0600 UTC)
  - 850 hPa temperature and winds (0400 UTC)
  - Diagnostics over central Kansas (0800 UTC)
  - A convective arrow formed behind this bow echo on 18 June 2010, resulting in 9 hail reports in northwestern Iowa, at the same time the arrow was over that region. Reports included golf-ball sized hail, causing damage to trees and roofs.

15 September 2010

- Same process used, as with the 18 June 2006 case, but the 550 hPa level is chosen because this level showed the strongest updrafts.
- Particles originate out of the west, southwest, and south.
- Particles reach a height, and then rapidly rise in the last hour.
- Instantaneous radar images (1500 UTC)
  - 850 hPa temperature and winds (1400 UTC)
  - Instantaneous images show area of interest (9 May 2009)

8 May 2009

- Same process used, as with the 18 June 2006 case, but the 550 hPa level is shown because this level showed the strongest updrafts.
- Parcels originate out of the southeast.
- Parcels gradually rise between 800 hPa and 700 hPa, and rapidly rise near the 700 hPa level.
- Instantaneous radar images (1500 UTC)
  - 850 hPa temperature and winds (1400 UTC)
  - Instantaneous images show area of interest (9 May 2009)

Conclusions

- Some common environmental characteristics of the bow and arrow phenomena include:
  - Convergence of wind from the southwest and southwest-northwest winds in the area where the arrow forms.
  - Graded isotropic lifting just above the surface, then strong vertical motion as air approaches the near-surface cold pool.
  - Evidence of surface-based CAPE for air approaching from the southwest.
  - Convergence of south-northwesterly and north-northerly winds in the area where the arrow forms.
  - Graded isotropic lifting just above the surface, then strong vertical motion as air approaches the near-surface cold pool.
  - Evidence of surface-based CAPE for air approaching the southwest.
  - Convergence of wind out of the southwest & west.
  - Evidence of a strong low-level jet.
  - Strong wind speeds on either side of the arrow region, causing horizontal shear, and possibly the orientation of the arrow.
  - Graded isotropic lifting, and then a sharp lift in the area of strong updraft (shown in the vertical motion above).
  - No CAPE for surface based parcels, but a great amount of instability (>3000 J/kg) for elevated parcels (shown in the lifting region).

Future Work

- Create images with greater temporal resolution to analyze plots between hours.
- Use ensemble runs to determine differences in model initial conditions between model runs that detect the bow and arrow, and those that do not.
- Attempt to determine the exact causes for the updrafts in the arrow region, possibly using idealized simulations.

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