A Climatology of Derecho-Producing Mesoscale Convective Systems in the Central and Eastern United States, 1986–95. Part I: Temporal and Spatial Distribution

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ABSTRACT

In 1888, Iowa weather researcher Gustavus Hinrichs gave widespread convectively induced windstorms the name "derecho". Refinements to this definition have evolved after numerous investigations of these systems; however, to date, a derecho climatology has not been conducted.

This investigation examines spatial and temporal aspects of derechos and their associated mesoscale convective systems that occurred from 1986 to 1995. The spatial distribution of derechos revealed four activity corridors during the summer, five during the spring, and two during the cool season. Evidence suggests that the primary warm season derecho corridor is located in the southern Great Plains. During the cool season, derecho activity was found to occur in the southeast states and along the Atlantic seaboard. Temporally, derechos are primarily late evening or overnight events during the warm season and are more evenly distributed throughout the day during the cool season.

1. Introduction

In 1888, Iowa weather researcher Gustavus Hinrichs gave widespread convectively induced windstorms the name "derecho" (Hinrichs 1888). Refinements to this definition have evolved after numerous investigations of these systems (e.g., Howard et al. 1985; Johns and Hirt 1985, 1987; Johns et al. 1990). A derecho includes any family of downburst clusters with temporal and spatial continuity and a major axis length of at least 400 km (Fujita and Wakimoto 1981; Johns and Hirt 1987, hereafter JH87). Derechos are produced by midlatitude mesoscale convective systems (MCSs) and occur throughout the Great Plains and eastern United States.

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In final form 19 June 1998.

Investigations of derecho-producing MCSs (hereafter DMCS) have primarily dealt with single events and mesoanalysis of the near-storm environment (Johns 1993; Przybylinski 1995; Bentley and Cooper 1997). These investigations have identified two primary structures of DMCSs: serial and progressive (JH87). A serial DMCS consists of individual segments of a squall line and is often associated with strong surface low pressure centers. Given the dynamic environment normally producing serial DMCSs, they can occur at any time of the year. Progressive DMCSs, on the other hand, form in conjunction with strong low-level instability and a weaker dynamic environment. They form primarily during the warm season (May–August) when convective instability is the greatest. Numerical models have also been developed to determine the internal dynamics that sustain these systems (Rotunno et al. 1988; Schmidt 1991; Weisman 1990, 1992, 1993).

The resulting loss of property from severe thunderstorms ranges from $1 billion to $3 billion annually (Golden and Snow 1991). Due to the potential hazard to life, property, and agriculture produced by derechos, it is important to understand how, when, and where these systems form. It is also important to educate the public on the severity of a derecho so they can take steps to mitigate the potential hazards of these systems as they approach. Although derechos are not as life threatening as tornados, on average they affect a larger portion of the population and inflict more minor to moderate damage over a much larger area.

A synoptic climatology of derecho events east of the Rocky Mountains was conducted in order to provide a much-needed foundation for linking advancements made from case studies and numerical investigations. Determining the spatial distribution, location, orientation, and timing of DMCSs will likely assist in resolving the environment that produces and sustains these events. To date, a synoptic climatology of the derecho has not been performed. A 4-yr study of derechos has yielded insights into the spatial distribution and synoptic scale processes initiating and sustaining these events (JH87). The JH87 study documented 70 derechos that occurred during the warm season (May–August) for the period 1980–83. In fact, results of this study have been used to refine the definition of a derecho. The JH87 study will be used as a comparison to the following climatology.

After an initial review of relevant research into MCSs, criteria were developed to identify derecho events from archived convective wind reports during the period 1986–95. The derecho events identified were then mapped annually and seasonally in order to construct spatial and temporal distributions of these events. Further examination entailed determining regional corridors of derecho activity by season. During the analysis it became evident that derecho events tended to cluster seasonally by location and orientation. Analysis of these corridors was conducted to determine temporal and spatial similarities.

2. Identification of derechos

Methodology already proposed to identify derechos using Storm Data (i.e., JH87) was utilized in this analysis. However, slight modifications were made to the criteria in order to facilitate analyses of a large dataset. Data used in this investigation were derived from one primary source: the Storm Prediction Center's online database of severe convective wind gusts (> 26 m s^{-1}). For the purpose of this study, a wind event is identified as a derecho if six criteria are met (Table 1). Like JH87, there must be a concentrated area of convectively induced wind gusts greater than 26 m s^{-1} that has a major axis length of at least 400 km. The wind reports must also have chronological progression. However, the proposed criteria restricts the temporal criteria to no more than 2 h elapsing between successive wind reports. The proposed criteria also add a spatial restriction allowing a maximum of 2° of latitude or longitude separating successive wind reports. By restricting the bounds on the time interval and distance between successive wind reports, multiple damage swaths are assured to be emanating from the same MCS. Once a potential derecho is identified, wind reports compos-

TABLE 1. Criteria used to identify derecho events utilizing data and wind reports.

JH87 criteria	Proposed criteria
There must be a concentrated area of convectively induced wind gusts greater than 26 m s^{-1} that has a major axis length of at least 400 km.	Same
The wind reports must have chronological progression.	Same
No more than 3 h can elapse between successive wind reports.	No more than 2 h can elapse between successive wind reports.
There must be at least three wind reports of either F1 damage or wind gusts greater than 34 m s^{-1} separated by at least 64 km.	Not used
The associated MCS must have temporal and spatial continuity.	The associated MCS must have temporal and spatial continuity with no more than 2° of latitude or longitude separating successive wind reports.
Multiple swaths of damage must be part of the same MCS as indicated by National Weather Service radar summaries.	Multiple swaths of damage must be part of the same MCS as seen by temporally mapping the wind reports of each event.

ing the event are mapped and visually inspected to further ensure temporal and spatial continuity. Thus, derechos can be identified without having to refer to subsequent radar and satellite imagery. Another modification involves eliminating the requirement that three wind reports of F1 damage (wind gusts greater than 34 m s^{-1}) separated by at least 64 km be identified. Our refinement of the criteria is not unique. Earlier investigations refined the original meaning of derecho (Hinrichs 1888) using the definition of a family of downburst clusters: a series of downbursts produced by one storm system as it travels at least 400 km (Fujita and Wakimoto 1981). There is no reference to wind threshold criteria, other than severe wind gusts, in this definition.

To determine whether the proposed criteria accurately identify derechos, previously identified events between 1986 and 1995 were examined. Eleven formerly studied events satisfied the new criteria for inclusion into the dataset (Table 2). All but one previously published derecho event for the period 1986–95 met the currently established criteria. This substantiated the use of these criteria in the investigation. The event that did not meet the criteria was a proposed DMCS that occurred over the northern Great Plains that produced reported wind burst swaths that were over 2 h apart (Abeling 1990).

3. The spatial distribution of derechos

a. *Comparison to JH87*

In comparing the general distribution of DMCS events, both datasets were gridded and mapped. For the current investigation, a derecho event is counted if a wind report along the path is located within a 1.83° × 1.83° grid cell. If several wind reports from the same derecho event are located in a grid cell, only one event is counted. The JH87 frequency was redrawn and contoured using their original 2° × 2° grid cell spacing. The contour scale was changed to ensure consistency with this climatology.

A number of interesting features are illustrated when comparing the warm season distribution of derechos in this climatology to the JH87 investigation. One striking feature is the locations of the relative maxima in derecho events (Fig. 1). In the JH87 study, a corridor existed from the upper Midwest to the Ohio Valley. In this climatology there exists a maximum in the Ohio Valley; however, the primary maximum of derechos occurs in the southern Great Plains. A region in central Oklahoma recorded 15 derecho events during the 10-yr period. Emanating from this region are two primary corridors. One runs from Oklahoma and Kansas eastward through central Missouri, while the other extends southeastward into Texas and Louisiana. Previous investigations into the climatology of severe thunderstorm events have also found that the greatest overall severe thunderstorm frequency occurs in eastern Kansas, Oklahoma, and central Texas (Kelly et al. 1985). The JH87 distribution indicates a southeastward corridor. However, there is a significant discrepancy when comparing both derecho distributions.

Further analysis of the synoptic environment in place during months of maximum derecho occurrence from 1980 to 1983 explains this discrepancy. Figure 2 depicts both the average and actual 500-hPa height pattern for June and July. Anomalous ridging over the southern Great Plains produced a favorable 500-hPa flow pattern for producing northwest-flow severe weather outbreaks from the northern Great Plains into the Ohio Valley (Johns 1984). This caused an increase in derecho activity along the northern derecho corridor and a decrease in activity over the southern Great Plains during 1980. At least 29 events, or 41% of the

TABLE 2. Previously identified derecho events that also satisfy the proposed criteria for inclusion into this investigation.

Derecho event	Investigator(s)
14–15 July 1995	Bentley (1997)
7 March 1995	Geerts et al. (1996)
1 July 1994	Barlow (1996)
15 April 1994	Przybylinski et al. (1996)
8–9 July 1993	Bentley and Cooper (1997)
8 June 1993	Przybylinski et al. (1995)
7 July 1991	Przybylinski (1995)
9 April 1991	Duke and Rogash (1992)
4 May 1989	Smith (1990)
28 July 1986	Johns and Leftwich (1988)
10 March 1986	Przybylinski (1988)

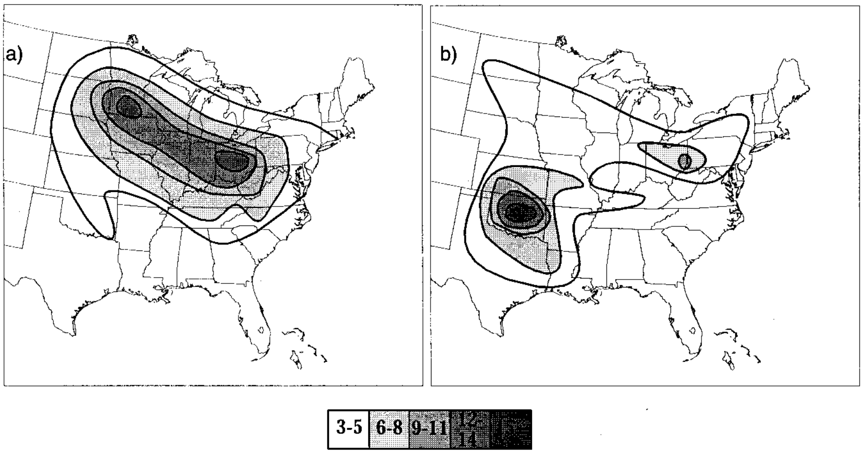


FIG. 1. (a) Total number of derechos occurring during the warm season, 1980–83 (JH87). (b) Total number of derechos occurring during the warm season, 1986–95.

total number of derechos identified by JH87, occurred during periods of strong ridging in the southern Great Plains. As shown, utilization of a longer time period identifies a prominent southern maximum during the warm season.

b. Entire year

When examining the spatial distribution of derecho events for all seasons within the 10-yr climatology, three main frequency axes are evident (Fig. 3). One axis is located through Ohio and Pennsylvania. This one somewhat relates to the JH87 northwest-flow derecho axis. Another high-frequency axis stretches from Oklahoma into central Kentucky. Finally, a third axis stretches from Oklahoma southeastward across the Gulf Coast states and into the Carolinas. This axis combined with the central one produces the overall frequency maximum of derecho events in Oklahoma.

Overall, the spatial distribution of derecho events resembles the spatial distribution of the frequency of thunderstorm wind gusts greater than 35.5 m s^{-1} (Kelly

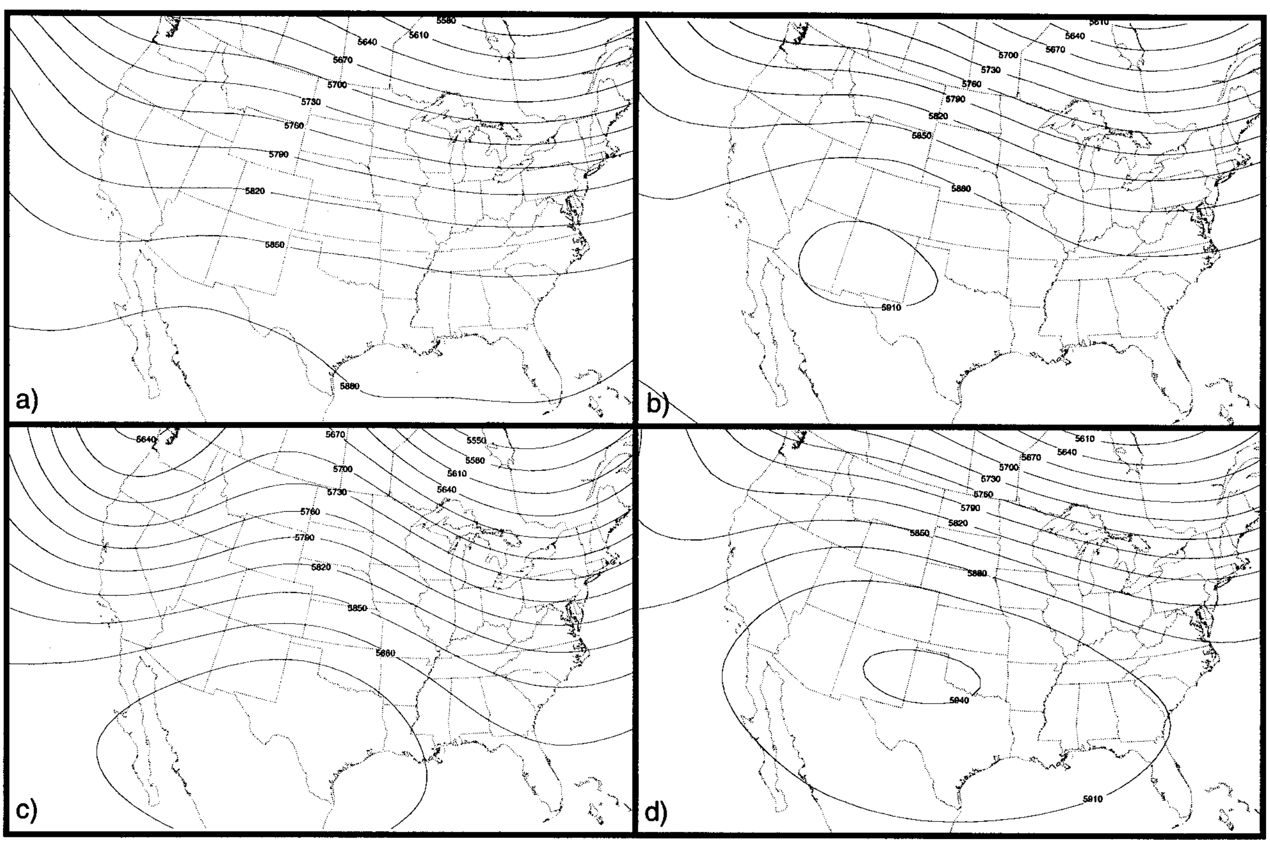


FIG. 2. (a) Average 500-hPa height contours for June 1975–95. (b) Average 500-hPa height contours for July 1975–95. (c) 500-hPa height contours for June 1980 when seven derechos were identified by JH87. (d) 500-hPa height contours for July 1980 when 10 derechos were identified by JH87.

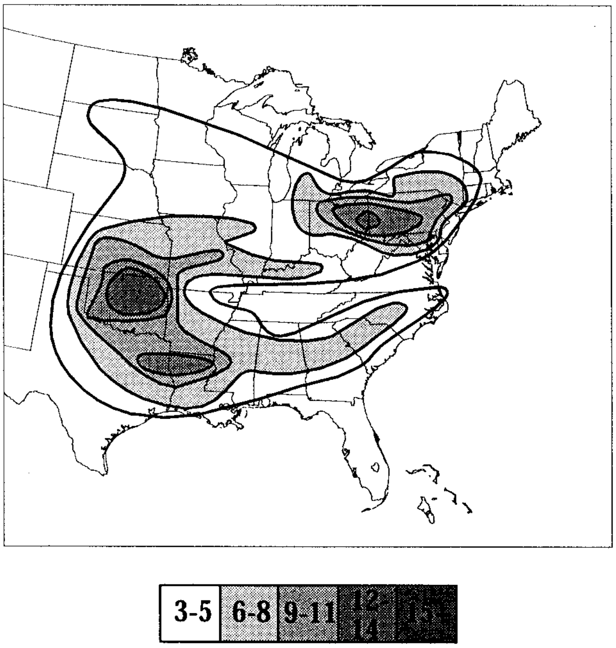


FIG. 3. Total number of derechos occurring during the entire year, 1986–95.

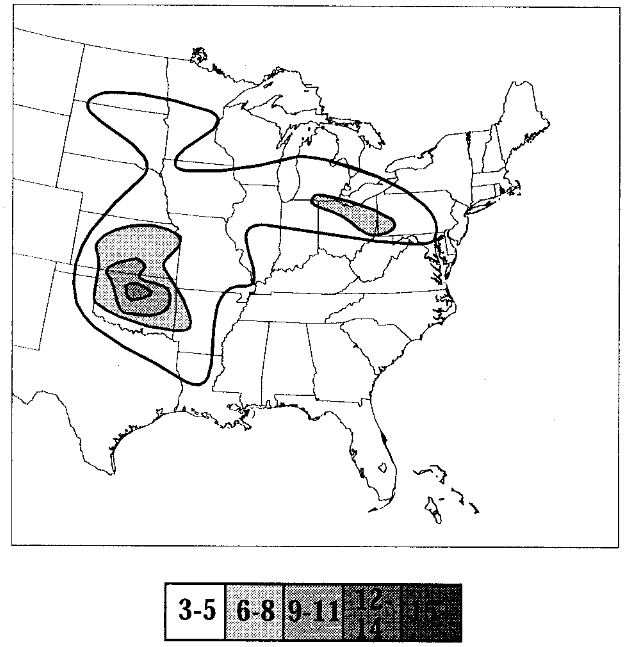


FIG. 4. Total number of derechos occurring during the summer, 1986–95.

et al. 1985). Both distributions contain relative maximums in northern Ohio. They also contain high-frequency corridors that stretch from Oklahoma and Kansas east into Missouri and south into Texas and Louisiana.

c. *Summer: June–August*

Two primary regions make up the summer derecho distribution (Fig. 4). One is along the axis of northwest-flow severe weather outbreaks running through northern Ohio, with some evidence of an extension into the Midwest and Dakotas, while another more significant maximum is located in Kansas and Oklahoma. Derechos forming this maximum generally progress due south, characteristic of the southward-burst type of MCS (Porter et al. 1955). The southern region appears to be the primary location for derechos to develop during the entire warm season (May–August).

When characterizing events by location and orientation, four corridors of derecho activity were identified by looking at individual tracks. To qualify as a corridor, there must be at least four events that have similar regional and orientation characteristics. The southeastward-moving northern tier events are oriented parallel to the axis of northwest-flow severe weather outbreaks (Fig. 5). This was the prominent region of derecho occurrence during the JH87 investigation. DMCSs in this corridor appear to be most prominent in June and July, with 79% of the events occurring at this time. This is also the most active corridor with 31% of all summer derechos being southeastward-moving northern tier events. These derechos are also characterized by rather long durations (on average, 11 h) and tracks. They seem to favor late evening or overnight development, more characteristic of nocturnal mesoscale convective complexes (Maddox 1980).

The next most active region is located in the central and southern Great Plains (Fig. 6). These southward-burst type DMCSs encompass 24% of all summer events. Southward-burst DMCSs occurred throughout the summer months and produced the longest duration derechos of the season (on average 12.2 h). They also appear to favor initiating during the late morning to afternoon hours, in distinct contrast to other summer DMCSs.

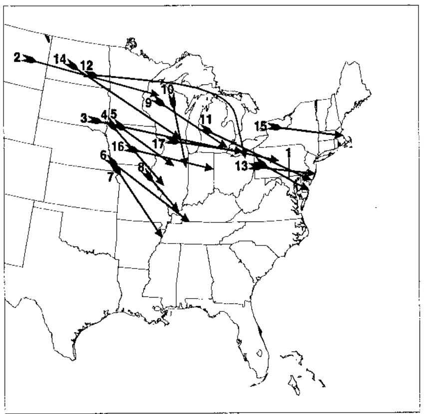
Northeastward-moving Great Plains events, primarily developing off the front range of the Rocky Mountains, form another prominent corridor (Fig. 7). Twenty percent of summer DMCSs were Plains events that, contrary to previous findings, move northeastward instead of southerly (JH87). Great Plains DMCSs occurred in the early summer with 83% developing in either June or July. Overall, these derechos were of slightly shorter duration (on average 8.8 h) than derechos in other summer corridors. The DMCSs appear, however, to be closely linked to nocturnal MCCs, since they tend to form in the overnight hours.

Although only four events make up the corridor, northeastward-moving Ohio Valley DMCSs combine with northern tier events to produce the secondary maximum in warm season derecho occurrence in Ohio and western Pennsylvania (Fig. 8). With a derecho duration of, on average, 9 h, these DMCSs formed exclusively in the late afternoon or early evening, indicative of the importance of the diurnal heating cycle. This corridor consists of 7% of summer DMCSs.

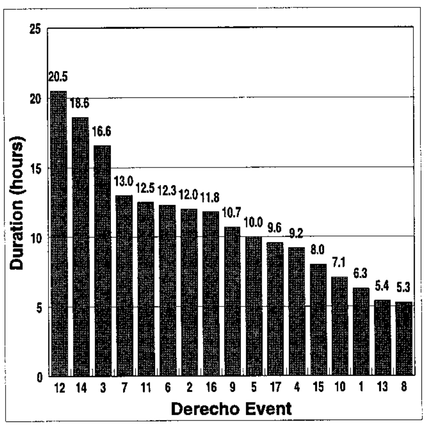
Summer also marks the season of highest derecho occurrence with 54 identified during the 10-yr period (Fig. 9). July is the month of greatest derecho activity with 28 identified. After July, the activity quickly decreases with only nine events in August.

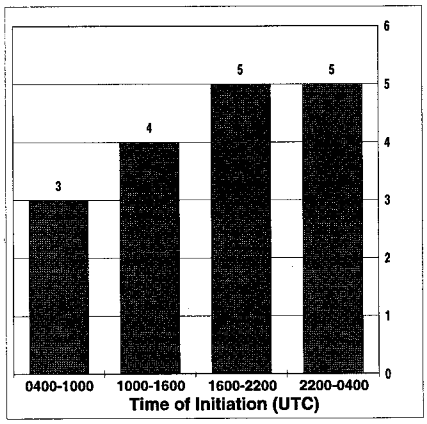
d. Spring: March–May

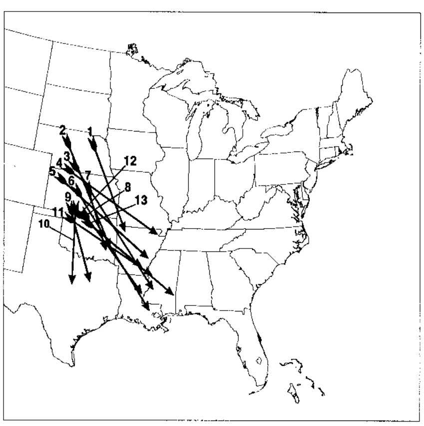
Transition from a cool season distribution to the summer



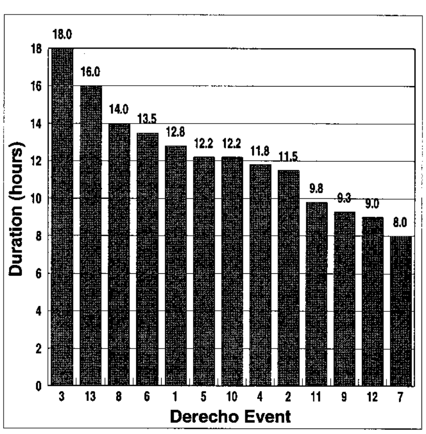
Derecho Event	Date	Derecho Event	Date
1	8/15/88	10	8/28/95
2	7/12/95	11	7/15/95
3	7/7/91	12	7/13/95
4	7/28/86	13	7/10/92
5	6/29/93	14	7/27/95
6	6/7/95	15	7/14/95
7	6/26/94	16	7/2/92
8	7/31/93	17	6/17/92
9	7/20/87		







Derecho Event	Date	Derecho Event	Date
1	8/19/87	8	7/2/89
2	7/1/94	9	7/1/87
3	6/7/94	10	8/17/94
4	8/1/86	11	6/14/92
5	8/3/92	12	7/26/95
6	6/19/92	13	6/9/94
7	6/5/94		



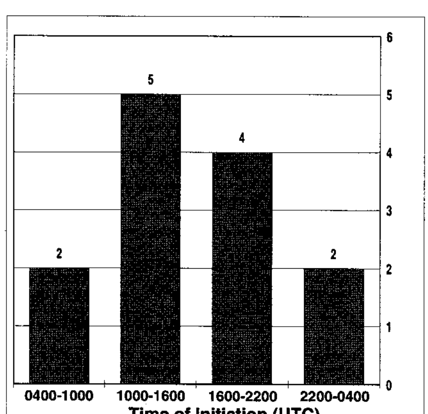
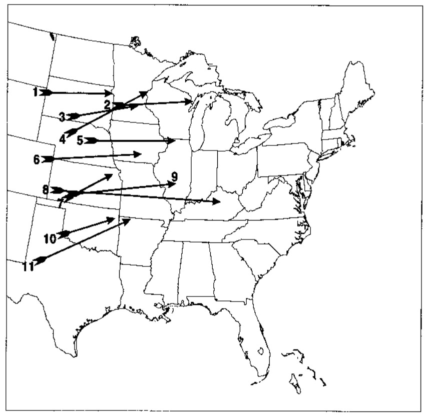


FIG. 5 (top). Summer season, southeastward-moving northern tier derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

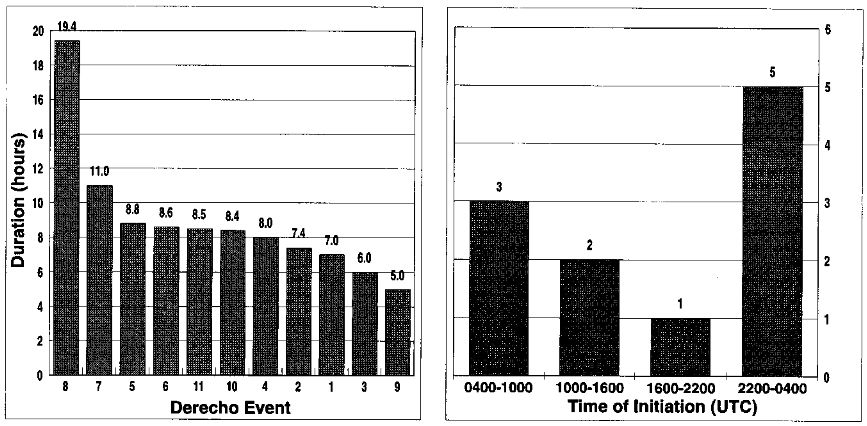
FIG. 6. Summer season, southeastward-moving central and southern Great Plains derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

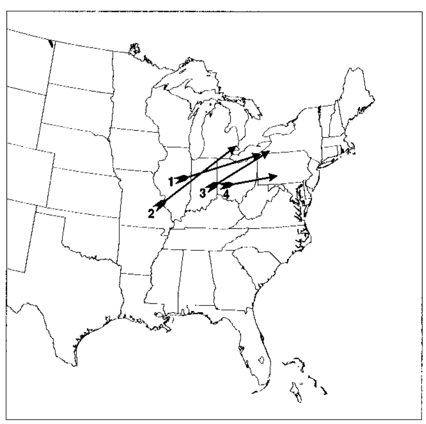
distribution occurs during these months. Early in the period, primary derecho activity is located from eastern Texas through the Gulf Coast (Fig. 10). As May approaches, derecho activity increases in Oklahoma, Kansas, and Missouri. Coincidentally, a second maximum develops in the Ohio Valley along the Ohio–Pennsylvania border. These two regions eventually make up the primary corridors during the summer. A total of 37 derecho events were identified during the spring with a considerable increase in activity during May (Fig. 9).

Figure 11 illustrates a northeastward-moving southern Great Plains corridor. These derechos, primarily forming in April and May, are of average duration (on average 8.7 h) and tended to develop in the late afternoon or overnight hours. The DMCSs encompass 22% of all spring events. This corridor is likely the early season equivalent of the summer season Great Plains derecho corridor (Fig. 7). Orientation, average duration, and



Derecho Event	Date	Derecho Event	Date
1	7/11/94	7	6/8/95
2	8/25/94	8	7/5/87
3	6/16/92	9	7/12/87
4	7/11/87	10	6/4/95
5	8/5/89	11	6/9/93
6	7/8/93		





Derecho Event	Date	Derecho Event	Date
1	6/29/87	3	8/2/87
2	6/8/93	4	7/10/93

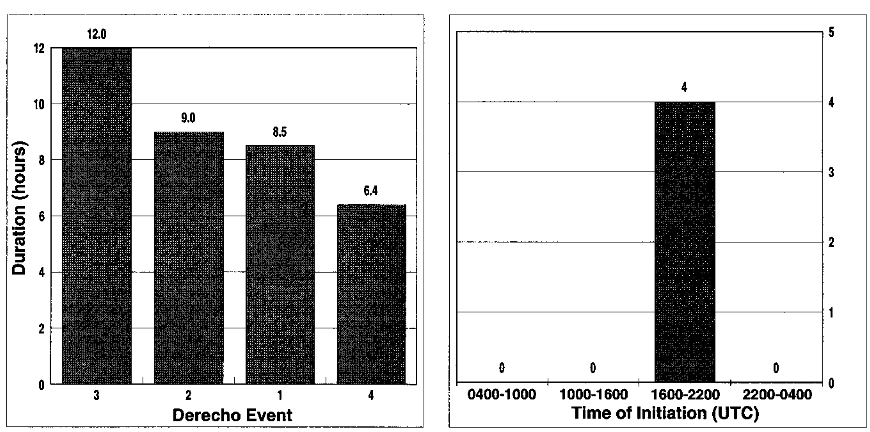


FIG. 7 (top). Summer season, northeastward-moving Great Plains derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

FIG. 8. Summer season, northeastward-moving Ohio Valley derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

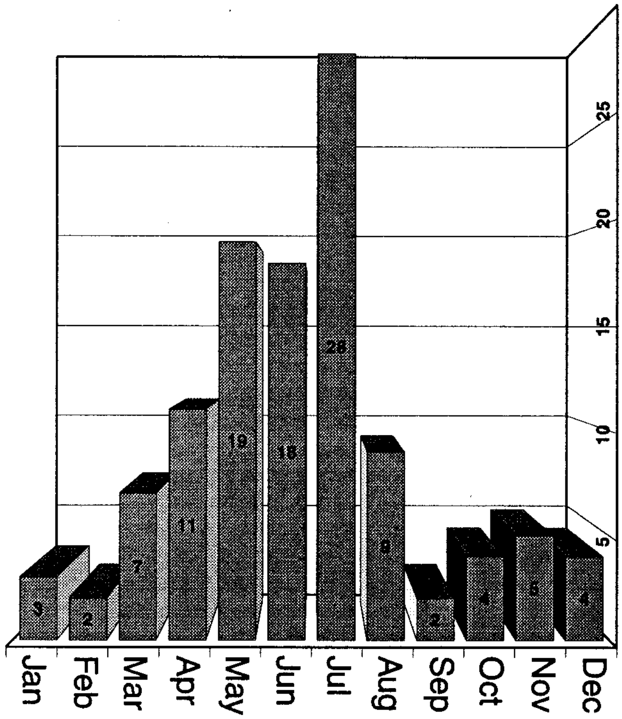


FIG. 9. Total number of derechos occurring during each month, 1986–95.

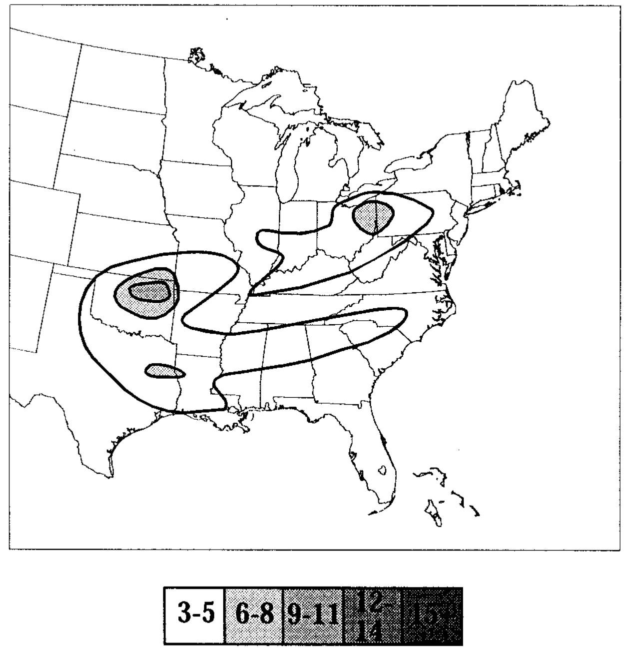
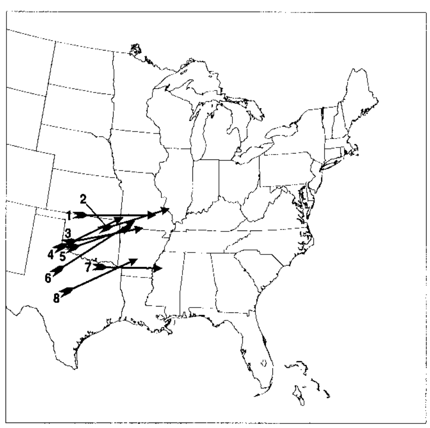


FIG. 10. Total number of derechos occurring during the spring, 1986–95.

time of initiation are similar for both regions.

Northeastward-moving Ohio Valley events make up 19% of all spring DMCSs (Fig. 12). The derechos were long duration (on average 11.7 h) events that favor late evening or overnight development. It is unclear whether the DMCSs in this corridor are similar to summer Ohio Valley events (Fig. 8). Spring Ohio Valley events tend to be of longer duration, form



Derecho Event	Date	Derecho Event	Date
1	5/8/95	5	4/17/95
2	4/16/93	6	5/23/95
3	3/10/86	7	4/13/91
4	5/17/93	8	5/4/91

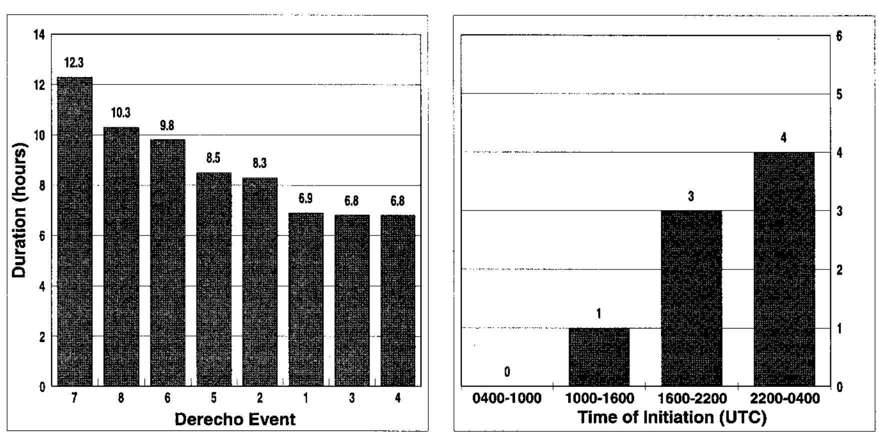
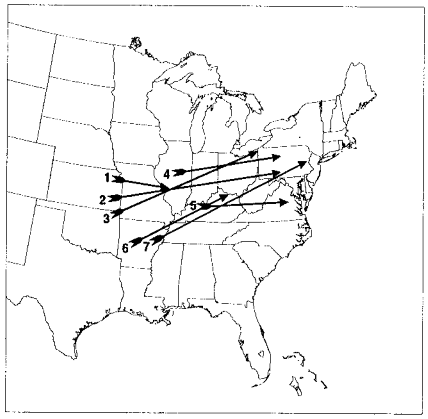


FIG. 11. Spring season, northeastward-moving southern Great Plains derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

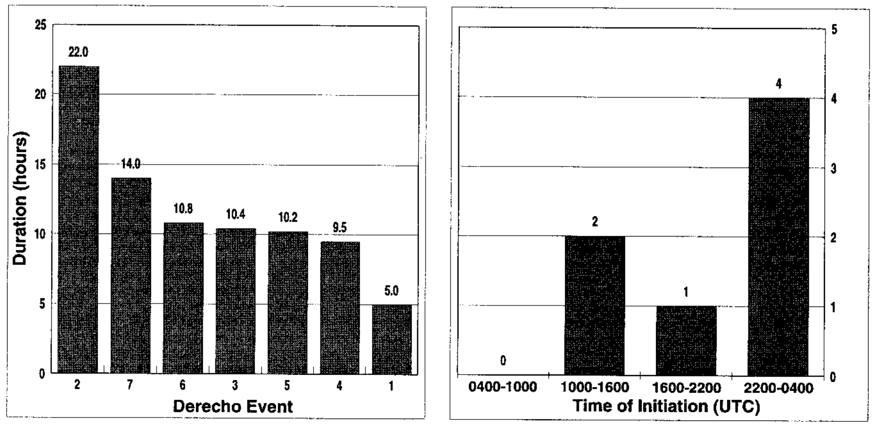
early in the season, and develop in the late evening.

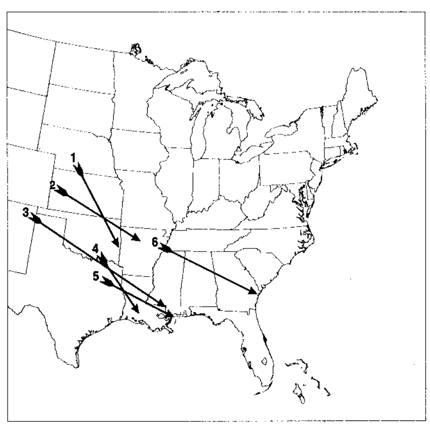
There does appear to be a correlation between southern Great Plains events and the summer southward-burst DMCS (Figs. 13 and 6). Like southward-burst systems, southern Great Plains derechos are of longer duration (on average 9.8 h), form primarily in the late morning to late afternoon, and track southeastward into the southern gulf states. Also, this corridor does not appear to become active until late April or May and encompasses 16% of spring derechos.

Unique to the spring and cool season is the southeastern DMCS corridor (Fig. 14). This corridor is made up of longer duration (on average 12.4 h) northeastward-moving derechos that form primarily in the morning. Given this preferred formation time and the fact that most of these events occur in March, southeastern DMCSs likely form under the dynamic pattern (JH87). Southeastern derechos make up 14% of spring events.



Derecho Event	Date	Derecho Event	Date
1	5/16/95	5	5/18/95
2	4/14/94	6	3/12/86
3	4/26/94	7	4/9/91
4	3/10/86		





Derecho Event	Date	Derecho Event	Date
1	4/13/86	4	5/29/94
2	5/22/89	5	5/27/90
3	5/4/89	6	5/15/95

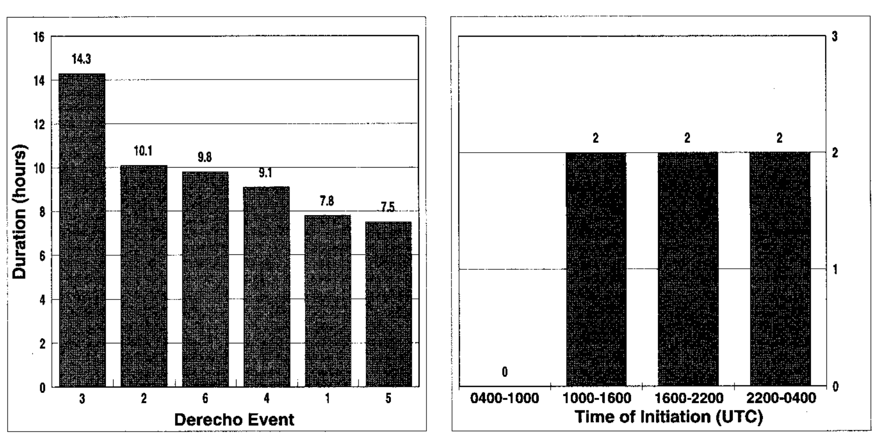


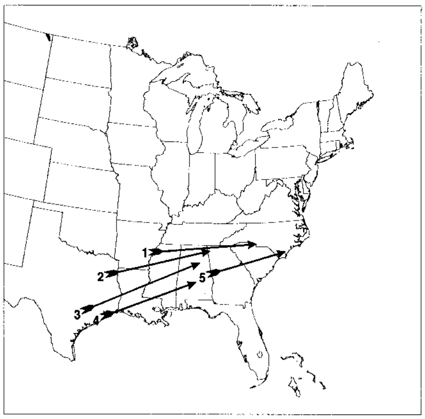
FIG. 12 (top). Spring season, northeastward-moving Ohio Valley derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

FIG. 13. Spring season, southeastward-moving southern Great Plains derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

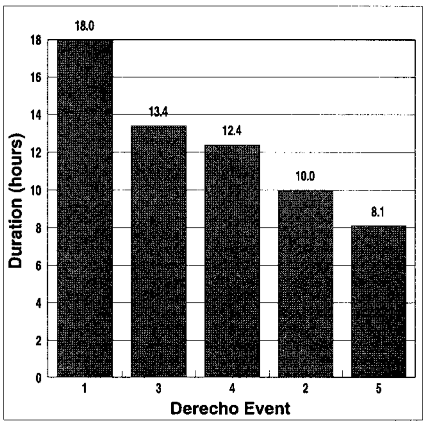
A northeastern corridor of DMCSs appears to develop in April and May (Fig. 15). These northeastward-moving events may be linked to summer Ohio Valley events as both tend to develop in the late afternoon (Fig. 8). Northeastern derechos are of shorter duration (on average 7.2 h) and make up 11% of spring activity. They also contribute to the warm season relative maximum of derecho activity in Ohio and western Pennsylvania.

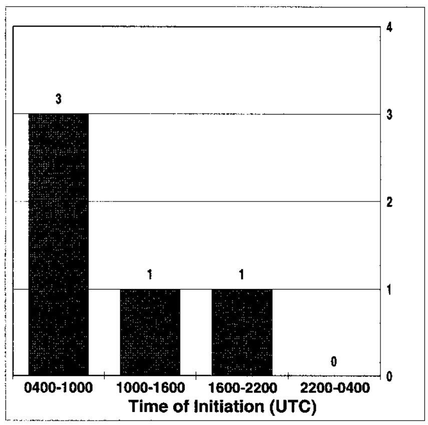
e. Cool season: September–March

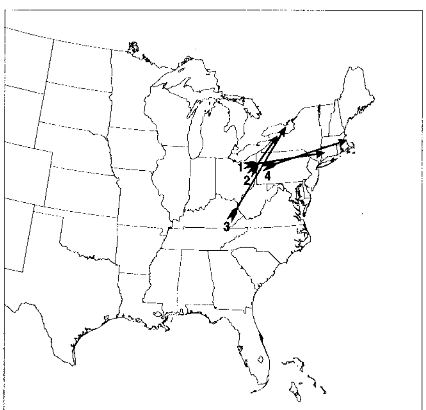
Although, as anticipated, the frequency minimum in derecho activity occurs during the cool season, there appear to be two main relative maximums. One is located along the Gulf Coast from eastern Texas through Alabama, while a second runs from northern Virginia to western Connecticut (Fig. 16). A total of 20 derecho events were identified during these months, making this period the time when derecho activity reaches a minimum across the country (Fig. 9).



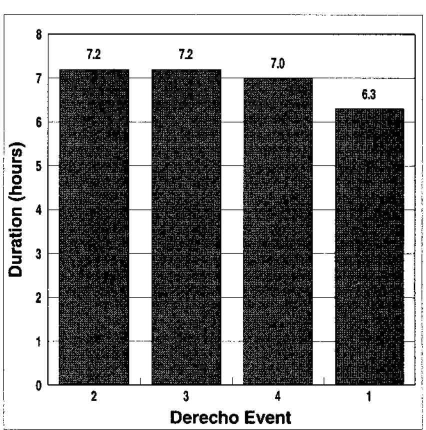
Derecho Event	Date	Derecho Event	Date
1	4/4/89	4	3/9/94
2	3/27/94	5	5/5/89
3	3/7/95		







Derecho Event	Date	Derecho Event	Date
1	5/24/95	3	4/25/93
2	5/1/91	4	4/4/95



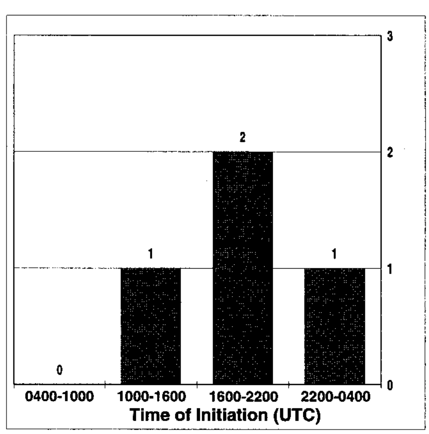


FIG. 14 (top). Spring season, southeastern derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

FIG. 15. Spring season, northeastern derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

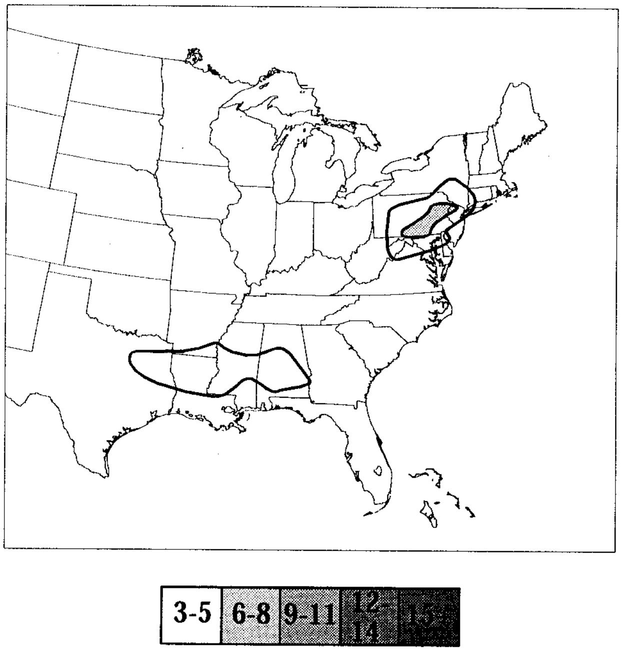


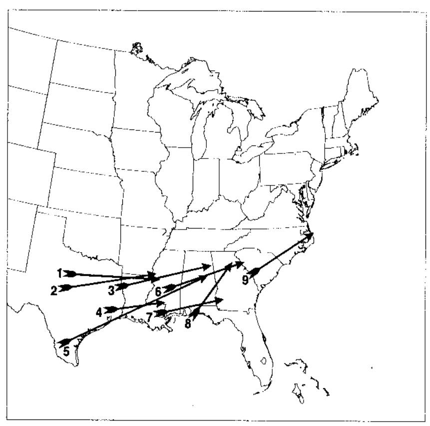
FIG. 16. Total number of derechos occurring during the cool season, 1986–95.

The derecho tracks making up the primary cool season corridor illustrate systems that develop along the southern Gulf Coast and Texas and then move northeastward through the southeast (Fig. 17). These derechos have an average duration of 10 h and appear to be linked to the spring southeastern events (Fig. 14). Both corridors' DMCSs tend to form in the cool season or early spring, develop in the morning, and move northeastward. Southeastern DMCSs make up 45% of all cool season events.

What appears to be a unique cool season DMCS corridor is located in the mid-Atlantic region (Fig. 18). These shorter duration (on average 6.6 h) events primarily form in October and November. They also favor late morning to late afternoon development and are confined to the Atlantic seaboard. Given this distribution, it appears the advection of warm moist air off the coastal waters may play a role in the formation of these events. These systems made up 25% of all cool season events. In a 28-yr climatology of nontornadic severe thunderstorm events, a relative maximum in the frequency of severe thunderstorm winds was also located in the mid-Atlantic region (Kelly et al. 1985). Evidence suggests derechos occurring in this corridor may be responsible for this frequency maximum.

4. Temporal distribution of derechos

Figure 19 shows that the time of initiation of most derechos is closely associated with the diurnal heating cycle. More than half of the events (68) occurred between 0400 and 1600 UTC. This resembles the JH87 study that found that the majority of the events occur late in the day. However, contrary to the JH87 study is the relatively large number of events that initiated between 1000 and 1600 UTC. As shown, nearly 26% of the events initiated during this time period,



Derecho Event	Date	Derecho Event	Date
1	12/19/87	6	2/10/90
2	11/4/94	7	12/3/90
3	12/12/93	8	2/22/90
4	1/13/95	9	1/7/95
5	11/16/87		

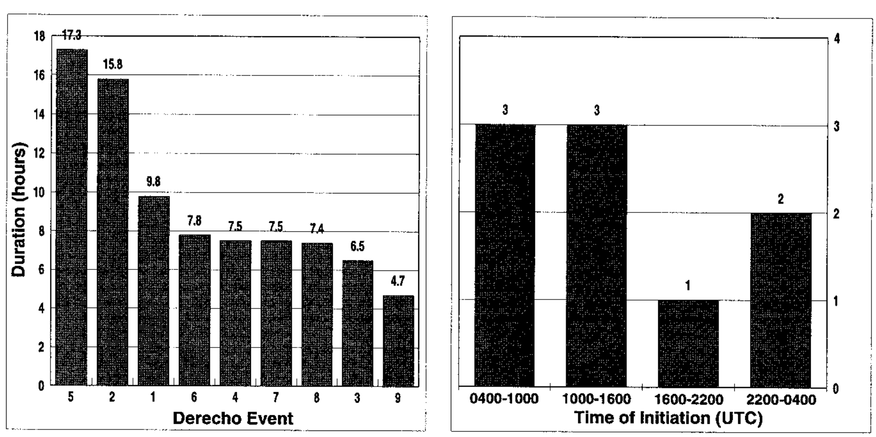
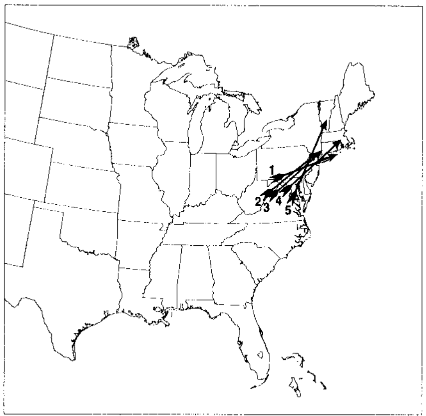


FIG. 17. Cool season, southeastern derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).



Derecho Event	Date	Derecho Event	Date
1	10/14/95	4	10/17/90
2	11/1/94	5	11/16/89
3	1/14/92		

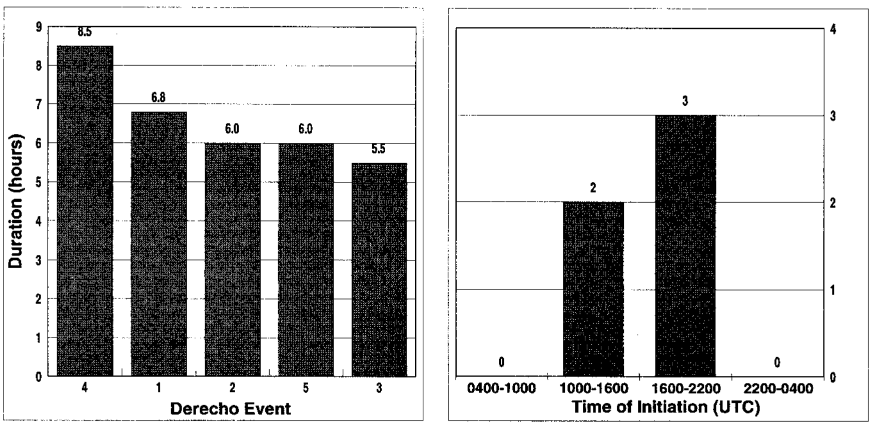


FIG. 18. Cool season, Atlantic seaboard derechos for 1986–95. From upper left to lower right: individual event tracks, day of initiation, temporal length (calculated by finding the time difference between the first and last wind reports), and number of events beginning during 6-h time periods (calculated from time of first wind report).

while JH87 found only 13% developed during the same 6-h period. Many of these events are cool season or early spring events that were excluded in the JH87 study.

Examining the average length of a derecho event by season shows the spring season contains the longest-track derechos, with April being the month with the longest average derecho track of 833 km (Fig. 20). The average damaging wind track of summer derechos is nearly the same. Cool season derechos are typically shorter (597 km), which supports previous findings that derechos forming in a dynamic pattern (i.e., serial) are also shorter lived (JH87). Most derecho events identified exhibited average tracks well above the 400-km threshold, with only January and September events averaging less than 500 km.

Wide variance exists when examining derecho events by year. Only one derecho event was identified during the Central Plains drought year of 1988, while 1995 had 25 events (Fig. 21). The summer of 1995 was characterized by an expansive anticyclone that developed over the eastern United States. Unusually large amounts of warm, moist air were advected into the central and northern Great Plains, then over the top of the ridge into the Great Lakes region (Bentley 1997). This provided a favorable low-level environment for derecho development as regions of localized forcing moved around the periphery of the ridge. From 1986 to 1993, however, the number of events remained fairly steady.

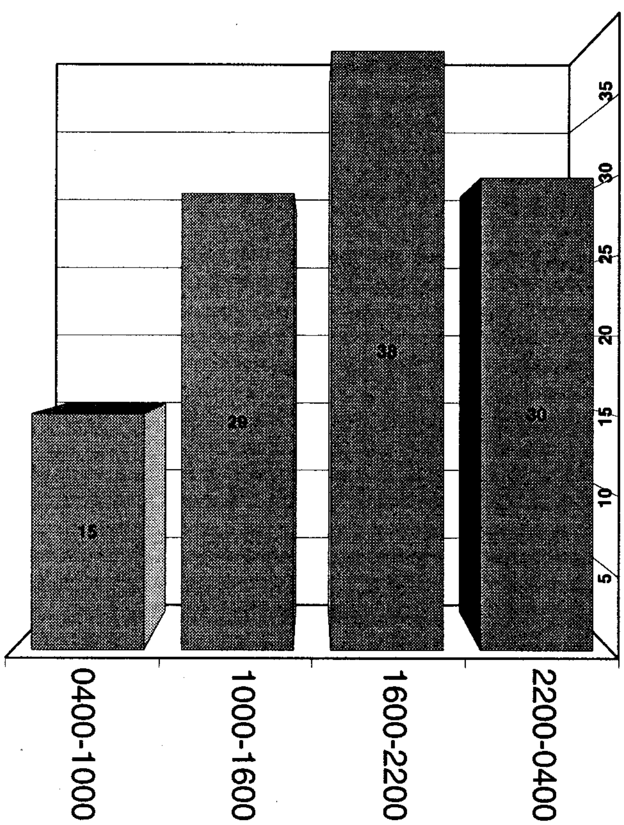


FIG. 19. Number of events beginning during 6-h (UTC) time periods (calculated from time of first wind report), 1986–95.

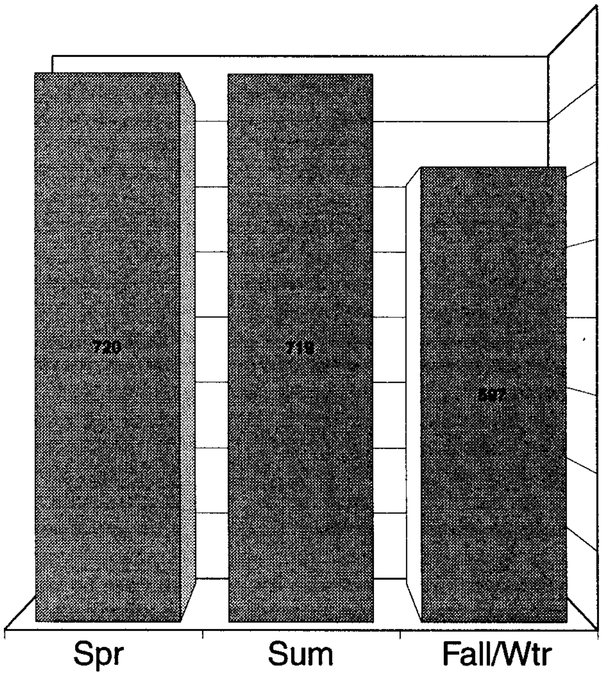


FIG. 20. Seasonal average length (km) of damaging wind (> 26 m s^{-1}) swaths produced by derechos, 1986–95.

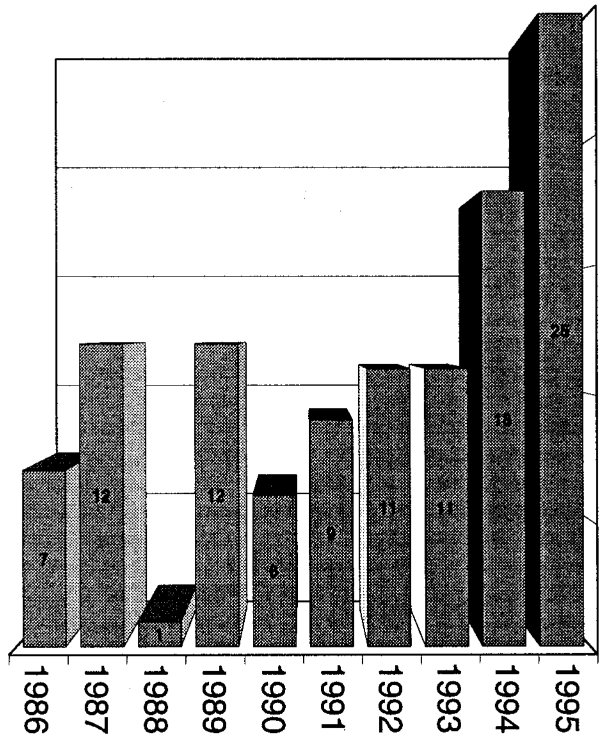


FIG. 21. Annual frequency of derechos identified in this investigation.

5. Conclusions

As shown, the spatial distribution of derechos varies considerably when examining these events by season. In general, there is a northward movement of the main derecho corridor as the year progresses. During the cool season derecho activity is confined to the Gulf Coast states with a secondary maximum in eastern Pennsylvania. The warm season exhibits two main frequency regions, one in the northern Ohio Valley and another in the southern Great Plains.

Contrary to previous investigations, this climatology shows that the primary region of maximum derecho activity is in Oklahoma with several seasonal corridors beginning in this region. The southward-burst, central, and southeastern spring and summer season corridors all emanate from the southern Great Plains.

The average distance, as measured by damaging wind swath, shows that warm season events typically have longer major axis lengths than cool season events. Previous findings have concluded that serial derechos, the predominant cool season system, do not last as long as progressive derechos (JH87). Thus, cool season events should exhibit shorter major axis lengths.

Derechos also exhibit wide temporal variance. Summer is the season of major derecho activity; however, cool season derechos are not uncommon, even in the mid-Atlantic states. The synoptic-scale environment appears to be very important in determining frequencies and locations of derechos. A favorable synoptic pattern in 1995 assisted in producing 25 events, while the Great Plains drought of 1988 kept derecho activity to a minimum. In addition, when examining the orientation and location of individual events, it is clear that synoptic-scale processes influence DMCS development, movement, and dissipation. Regions of localized forcing and instability are dependent on the larger-scale synoptic environment in place.

Research into the synoptic environment during derecho events in each corridor is currently ongoing in order to illuminate the different mechanisms important for DMCS formation during different times of the year. This research will incorporate findings of this climatology in order to determine if similarities in the synoptic environment exist between DMCS events within each corridor. A closer examination of DMCSs affecting the Central Great Plains will be conducted under a COMET (Cooperative program for Operational Me-

teorology, Education, and Training) Partner's Grant with the authors and S. Byrd, Science and Operations Officer, NWSFO Omaha/Valley Nebraska.

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