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CONVECTION IN BAMEX DURING AN ACTIVE SUBTROPICAL JET PERIOD

by

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1. INTRODUCTION:

The Bow Echo and Mesoscale Convective Vortex Experiment (BAMEX) was conducted from 18 May to 7 July 2003. Information on the BAMEX scientific objectives can be found online: (http://www.mmm.ucar.edu/bamex/science.html). The experiment was conducted out of the Mid America Airport (MAA) located approximately 40 km east of St. Louis, Missouri. The period 5-14 June 2003 was noteworthy because an unusually strong subtropical jet (STJ) was situated from the east-central Pacific eastward to the lower Mississippi Valley. The purpose of this paper is to present the results of a preliminary analysis of the impact of this strong STJ on the evolution of convective systems within the BAMEX domain. As part of this analysis, a brief case study of a long-lived mesoscale convective vortex (MCV) that originated from a transient disturbance embedded in the STJ will also be presented.

The first comprehensive documentation of the STJ was presented by Krishnamurti (1961). He showed that the winter STJ was marked by three distinct 200 hPa wind maxima over the Northern Hemisphere subtropics. He also showed that these STJ wind maxima were situated in the crests of subtropical ridges and suggested that diabatic heat sources in the tropics likely played an important role in anchoring the STJ wind speed maxima downstream of these diabatic heat sources. Recent work (e.g., Iskenderian 1995) has documented that long mid- and upper-level cloud plumes emanating from the tropics are signatures of the STJ over eastern ocean basins and the adjacent continents. Another important attribute of the STJ is that it can serve as a baroclinic waveguide (e.g., Hoskins and Ambrizzi 1993; Hoskins and Hodges 2002) and as a source of Rossby wave breaking in jet-exit regions (e.g., Thorncroft et al. 1993; Black and Dole 2000; Shapiro et al. 2001).

2. DATA AND SOURCES:

The data used in this study was obtained from the BAMEX data Web site (http://www.joss.ucar.edu/cgi-bin/catalog/bamex/ops/index) and archives at the University at Albany. Global 1.0° x 1.0° GFS grids, available four-times daily, were used for all diagnostic calculations.

3. RESULTS:

The composite time-mean and anomalous 200 hPa vector wind for the period 5-14 June 2003, constructed from the NOAA Climate Diagnostics Center interactive Web site at http://www.cdc.noaa.gov, are shown in Figs. 1a,b, respectively. These figures show that this 10-day period is dominated by an anomalously strong STJ that extends from the eastern Pacific eastward to Texas and then northeastwards to New England and Atlantic Canada. A coupled jet signature is evident over the middle Mississippi Valley. Eastward-moving transient disturbances that were embedded in the STJ over the eastern Pacific acted to trigger mesoscale convective systems (MCSs) and MCVs east of the southern Rockies after they moved inland over the southwestern US. These transient disturbances are readily seen by superimposing the 300 hPa absolute vorticity over the 500-200 hPa thickness as shown in Figs. 2a,b.

At 1200 UTC 9 June, four distinct and regularly spaced 300 hPa vorticity maxima are strung out along the STJ from east-northeast of Hawaii to southwestern Arizona (Fig. 2a). By 1200 UTC 10 June, the leading vorticity maximum has reached eastern New Mexico and the Texas panhandle. Inspection of available satellite imagery shows that there was little cloudiness associated with regions of cyclonic vorticity advection by the thermal wind ahead of these transient disturbances while they were over the eastern Pacific and the southwestern US (not shown). It was only when the area of ascent associated with cyclonic vorticity advection by the thermal wind ahead of the leading 300 hPa vorticity center reached the Texas panhandle that a squall line was triggered in the presence of increasingly moist and unstable air (not shown).

The tracks of 19 MCSs, MCVs, squall lines and bow echoes that formed in the BAMEX region during the period 5-14 June are shown in Fig. 3 while the statistics on each event are summarized in Table 1. Track number 12 in Table 1 is a long-lived MCV that originated over northeastern Texas and southeastern Oklahoma at the poleward end of a squall line near 0600 UTC 11 June. This MCV moved northeastward while maintaining its identity and reached northeastern Ohio near 0000 UTC 13 June 2003.

Table 1
BAMEX Convective Systems during the Period 5-14 June 2003

Number	Start Date/Time	End Date/Time	Character
1	5/00Z	5/20Z	MCS
2	5/14Z	5/23Z	MCV
3	5/23Z	6/11Z	MCS
4	6/10Z	6/13Z	MCV
5	6/18Z	6/22Z	Bow Echo
6	7/00Z	7/07Z	MCS
7	7/15Z	7/19Z	MCV
8	8/11Z	8/18Z	Bow Echo
9	8/17Z	9/00Z	Squall Line
10	10/01Z	10/23Z	Bow Echo
11	10/21Z	11/02Z	Bow Echo
12	11/06Z	12/23Z	MCV
13	11/19Z	12/00Z	Squall Line
14	12/00Z	12/07Z	Bow Echo
15	12/03Z	12/12Z	Squall Line
16	12/17Z	13/02Z	Bow Echo
17	12/17Z	12/22Z	Bow Echo
18	12/07Z	13/18Z	MCV
19	13/19Z	14/03Z	MCS

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In order to document the life cycle of this MCV, we show in Figs. 4a-f maps of surface potential temperature, winds and present weather for selected times. At 1200 UTC 10 June, at which time the leading disturbance in the STJ is approaching the Texas panhandle (Fig. 2b), a strengthening southerly flow is developing over northern Texas and Oklahoma (Fig. 4a). At the same time a wind shift line extends southwestward from a cyclone located in southern Minnesota to the Oklahoma panhandle. Although horizontal confluence is evident in the surface wind field along the eastern edge of the Texas panhandle, no organized area of precipitation has yet developed. By 2100 UTC 10 June the surface cyclone has moved to western Wisconsin and the trailing wind shift line has reached the Texas panhandle (Fig. 4b). A noteworthy mesoscale cyclonic circulation center is situated in a baroclinic zone at the tail end of the trailing wind shift line over northwestern Texas while a strengthening southerly flow continues over Oklahoma.

By 0600 UTC 11 June the surface cyclone has moved to lower Lake Michigan, the trailing wind shift line has weakened (it is only barely evident along the Kansas-Missouri border), and showers and thunderstorms have erupted in eastern Oklahoma (Fig. 4c). The first hint of a weak surface mesolow is seen over extreme northwestern Arkansas at this time. It is the surface reflection of an MCV apparent in radar imagery at the north end of a developing squall line (not shown). This surface mesolow is better defined over southeastern Missouri at 2100 UTC 11 June (Fig. 4d). Note also the surface boundary that extends south-southeastward from the surface mesolow. Also of interest at this time is the analyzed baroclinic zone that stretches from a surface low over western Lake Erie westward to just south of Lake Michigan and from there southwestward to Missouri. This surface baroclinic zone appears to be locally enhanced in the area of northerly flow off the cold waters of Lake Michigan.

By 0600 UTC 12 June the surface mesolow and associated MCV have moved northeastward to extreme southern Illinois and Indiana, and are in the process of linking with the surface baroclinic zone settling southward through central Illinois and southwestern Indiana (Fig. 4e). By 2100 UTC 12 June the aforementioned surface mesolow has continued moving northeastward and is now situated over northern Ohio (Fig. 4f). The area of cyclonic circulation associated with the mesolow has strengthened and expanded as the mesolow has attached itself to the aforementioned surface baroclinic zone and acquired frontal structure by 2100 UTC 12 June (Fig. 4f).

In order to document our long-lived MCV, we show in Fig. 5 a time series of winds from the Conway, Missouri, profiler for the period 1000-2100 UTC 11 June. MCV passage occurs between 1100 and 1300 UTC 11 June as low-level southeasterly winds swing around to light northerly above 1.5 km MSL. Of interest is the upshear tilt associated with this MCV as judged by the deepening northerlies that reach to 6 km by 2100 UTC 11 June. Finally, we show to composite radar reflectivity images in Figs. 6a,b, respectively. The first image, valid 2230 UTC 11 June (Fig. 6a), shows an MCV near the border of southeastern Missouri and southern Illinois. Of interest is the appearance of a new band of convection organizing in western Kentucky and central Tennessee in the inflow region to the MCV. By 0545 UTC 12 June the MCV, now in extreme southern Illinois and Indiana, has developed a precipitation band with embedded convection that extends well northeast of the circulation center (Fig. 6b). This radar signature is consistent with the development of a warm front structure as the MCV begins to attach itself to the baroclinic zone along the southern edge of the Great Lakes (Fig. 4e).

4. CONCLUSIONS:

The 5-14 June 2003 period during BAMEX featured an anomalously strong STJ across the southern US from California to the lower Mississippi Valley. Multiple convective disturbances originated over the BAMEX domain in conjunction with transient disturbances embedded in the STJ. The regularity of these embedded transient disturbances over the eastern Pacific suggests that barotropic instability may have played a role in their origin. Once these transient disturbances were inland and east of the Rockies, they acted to trigger organized convective systems, probably in response to an increase in the Rossby penetration depth in response to decreasing stability and increasing moisture.

A particularly long-lived MCV formed over Oklahoma near 0600 UTC 11 June at the northern end of a squall line that was triggered by a transient disturbance embedded in the STJ. This MCV could be tracked northeastwards to Ohio. It was noteworthy for its upshear tilt, for growing upscale, and for strengthening as it attached itself to a surface baroclinic zone situated just to the south of the Great Lakes. As the MCV attached itself to the surface baroclinic zone it also acquired frontal structure. The surface potential temperature gradient was locally enhanced in the warm frontogenesis region and where northerly flow off the cold waters of lake Michigan surged southward.

5. ACKNOWLEDGEMENT:

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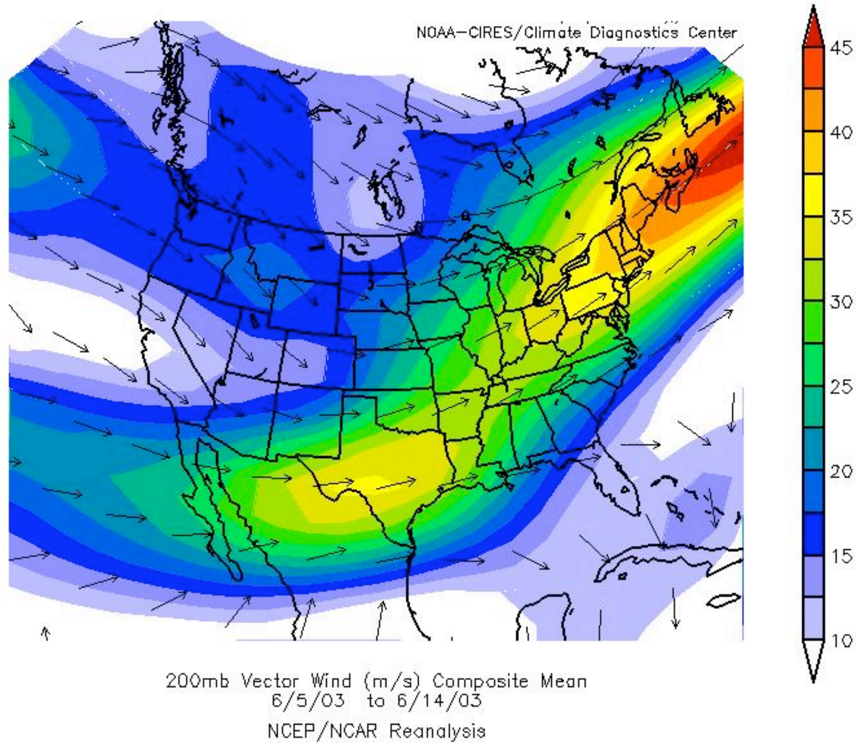


Fig. 1a: Composite mean 200 hPa winds (m s^{-1}) and wind vectors for 5-14 June 2003. Source: http://www.cdc.noaa.gov.

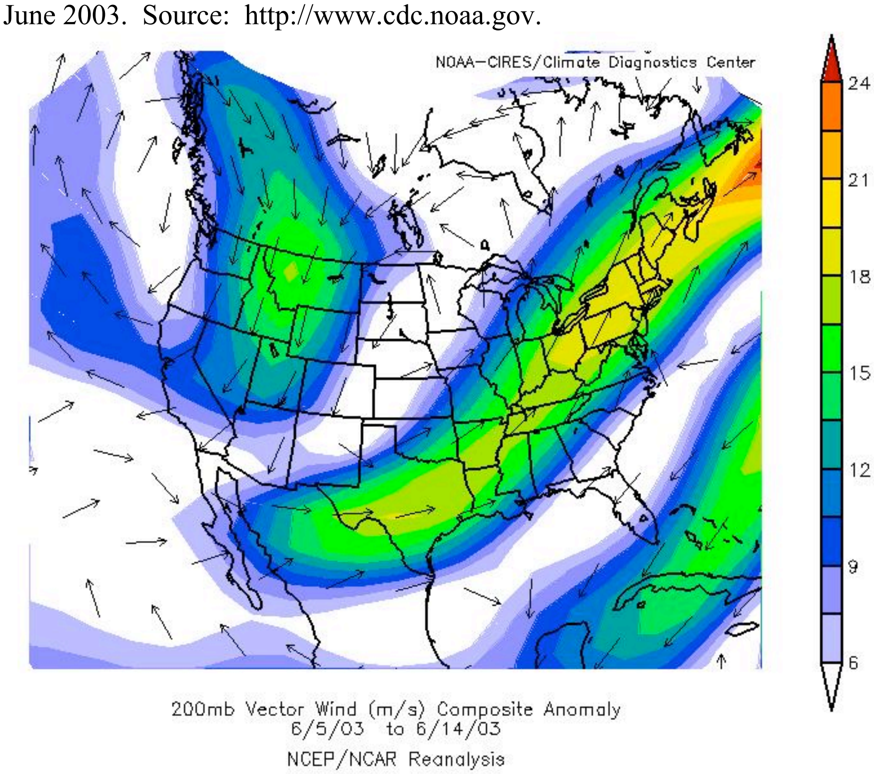


Fig. 1b: As in Fig. 1a except for anomalous 200 hPa winds and wind vectors.

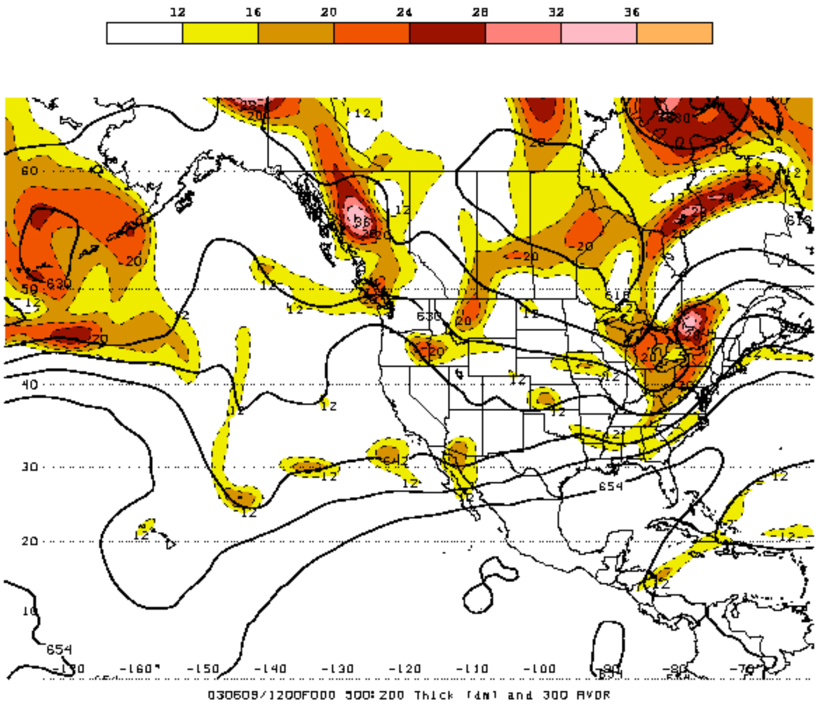


Fig. 2a: 500-200 hPa thickness (solid, every 6 dam) and 300 hPa absolute vorticity (shaded according to the color bar for values of 12 x 10^{-5} s^{-1} and greater) for 1200 UTC 9 June 2003.

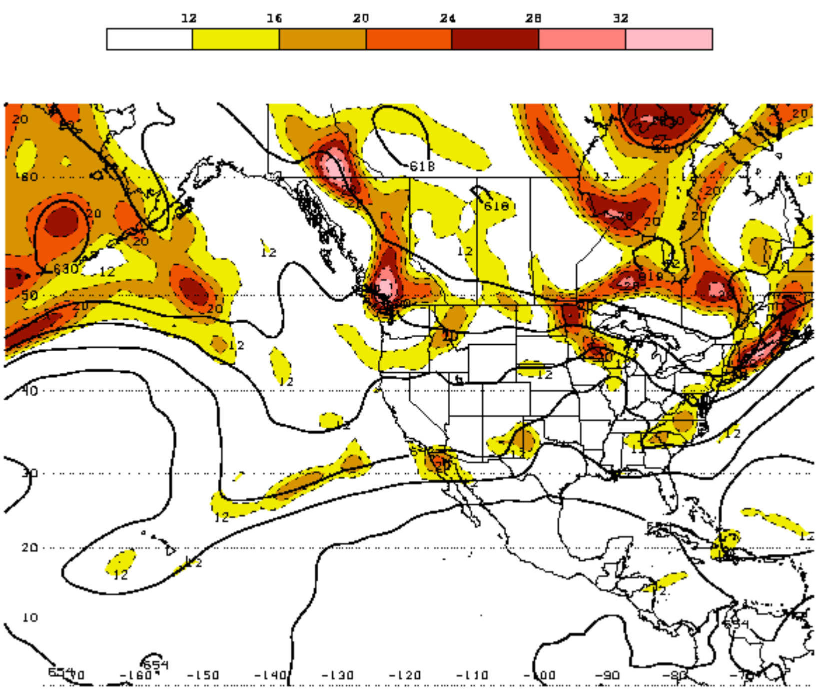


Fig. 2b: As in Fig. 2a except for 1200 UTC 10 June 2003.

Convective Disturbances: 5-14 June 2003

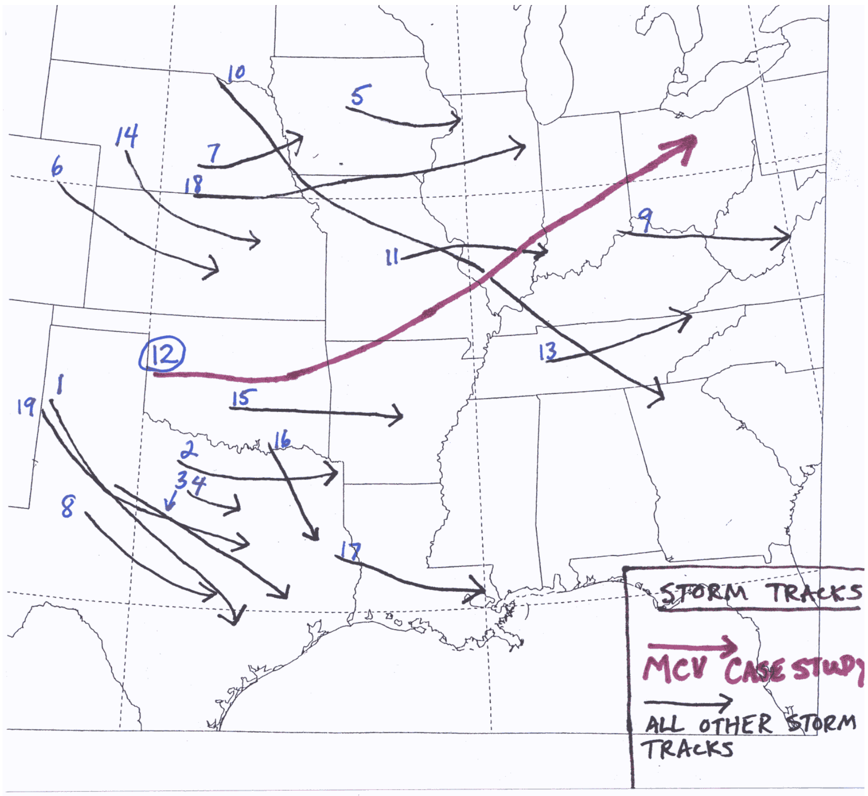
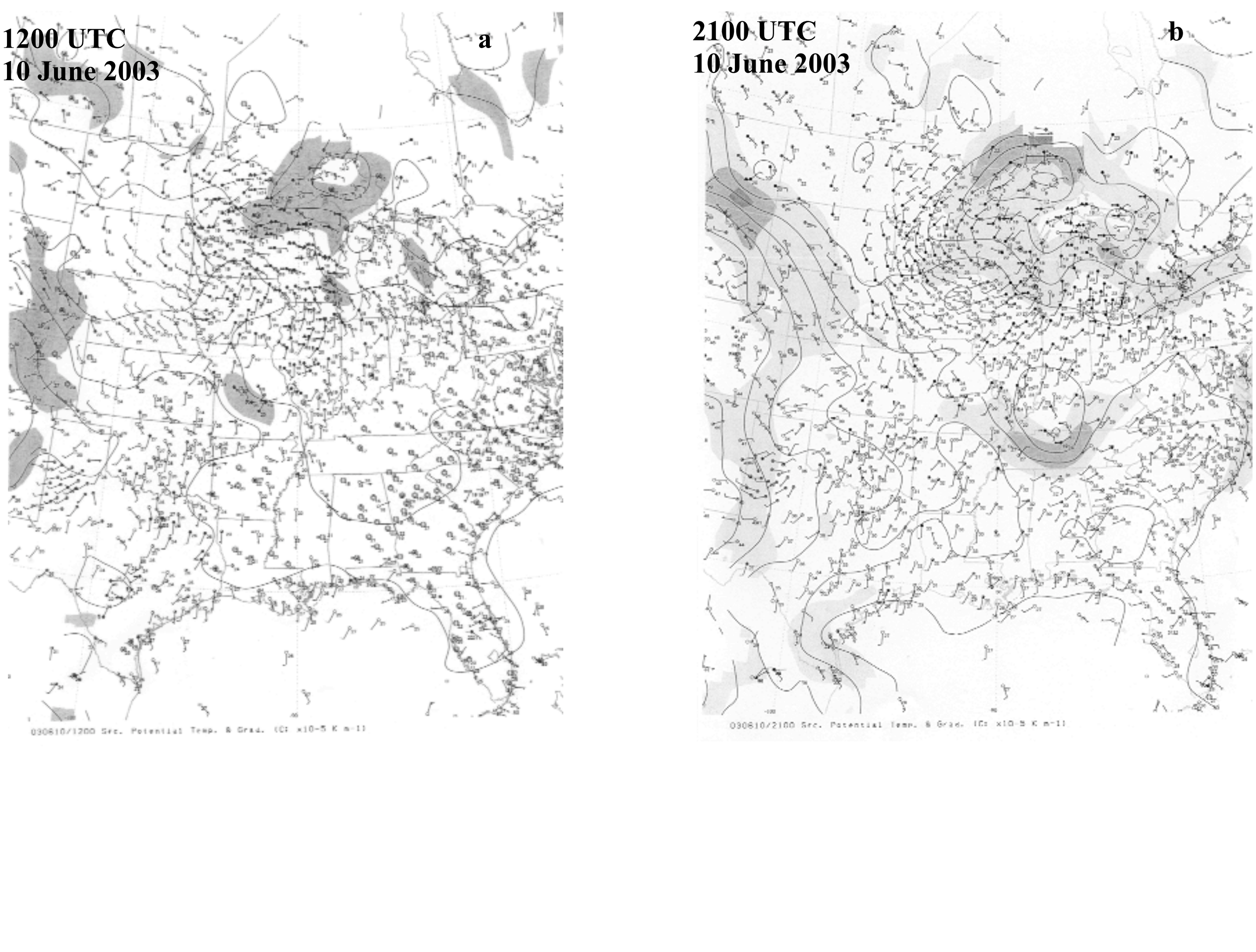
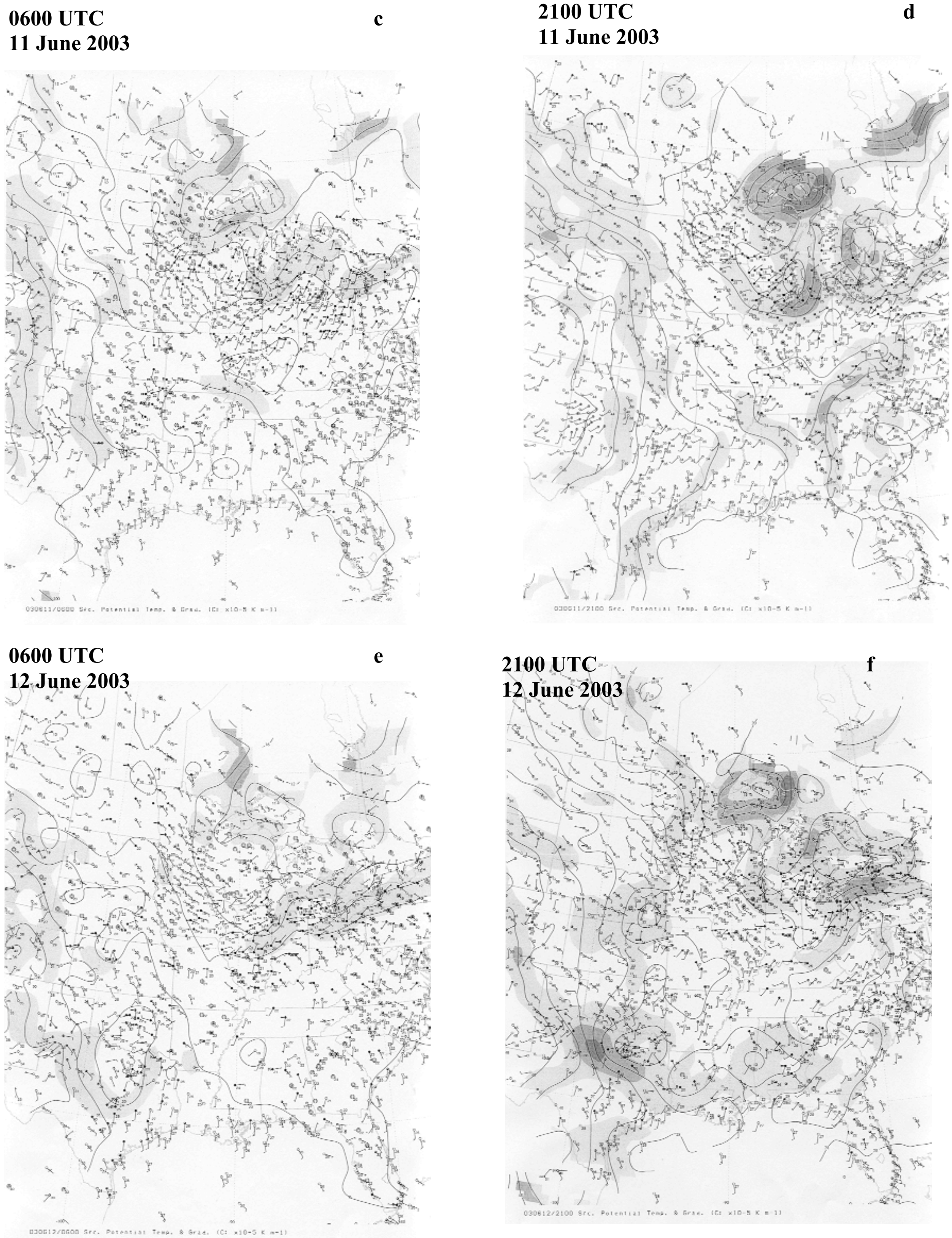


Fig. 3: Tracks of the 19 convective disturbances during 5-14 June 2003 and listed in Table 1. Track 12, shown in red, marks the long-lived MCV of 11-13 June 2003.





Figs. 4a-f: Surface potential temperature (solid contours every 4 K and plotted numbers in °C), winds, sky conditions and present weather for (a) 1200 UTC 10 June, (b) 2100 UTC 10 June, (c) 0600 11 June, (d), 2100 11 June, (e) 0600 UTC 12 June, and (f) 2100 21 June. The potential temperature gradient is shaded every 2.5°C $(100\ km)^{-1}$ beginning at 2.5°C $(100\ km)^{-1}$.

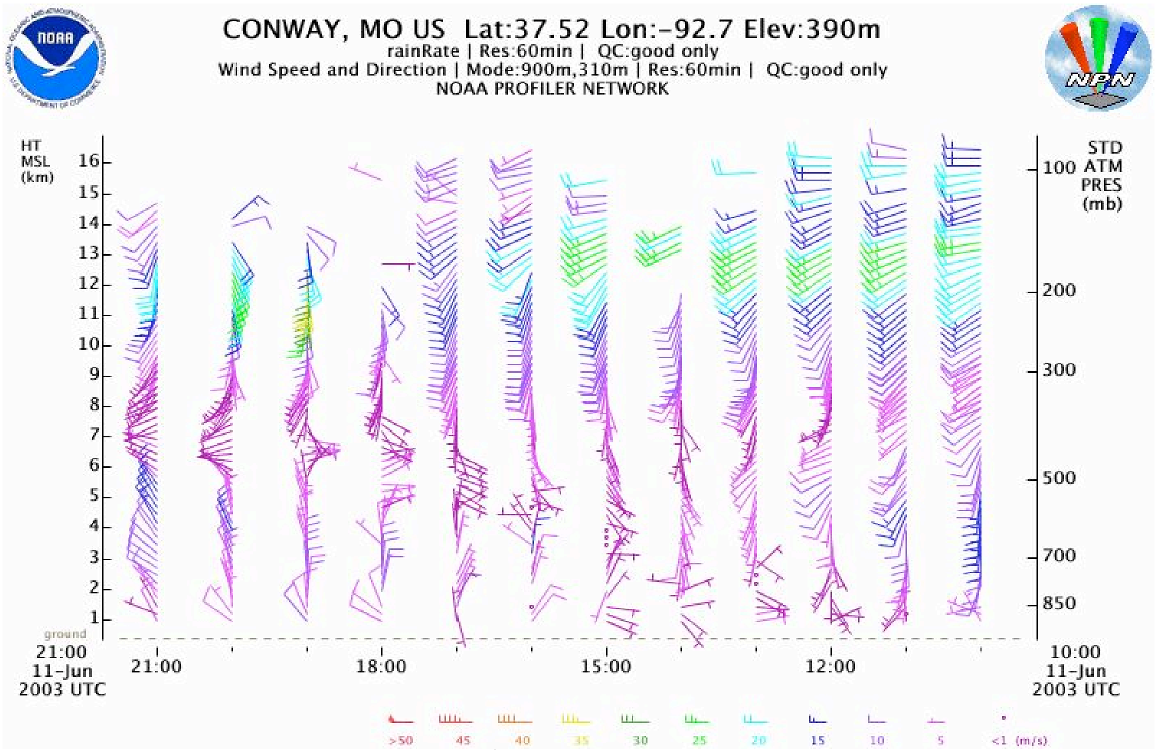


Fig. 5: Time series of profiler winds (m s^{-1}) for Conway, Missouri, for the period 1000-2100 UTC 11 June 2003.

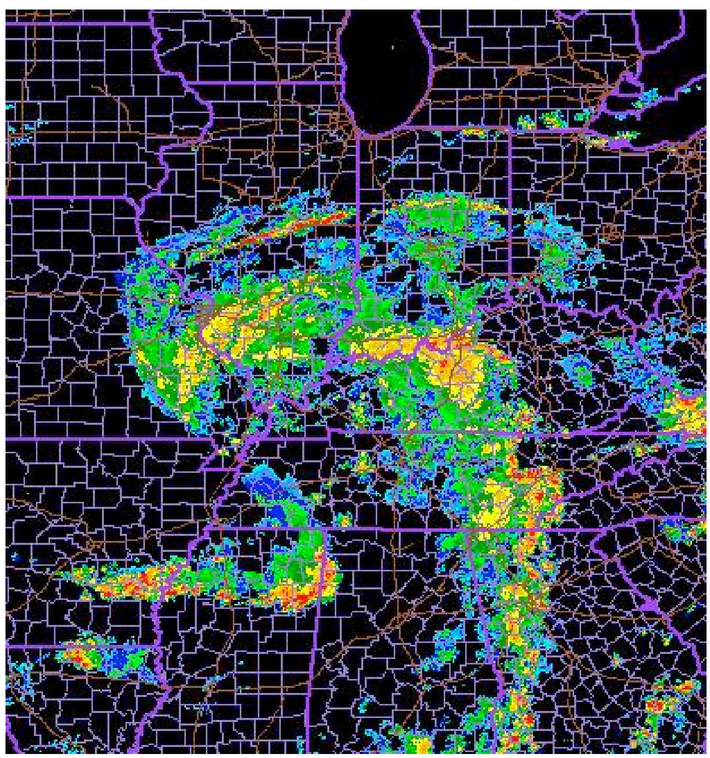


Fig. 6a: Composite base reflectivity image for 2230 UTC 11 June 2003.

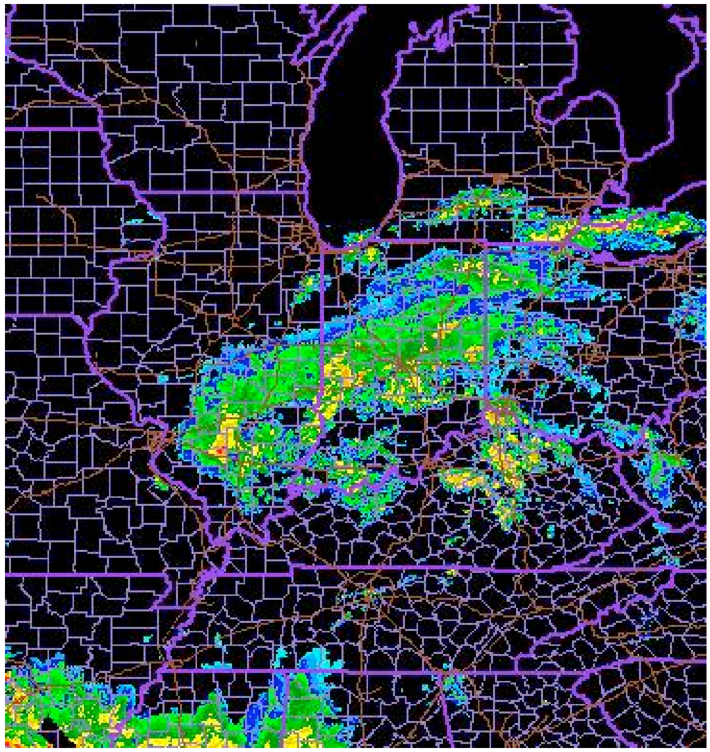


Fig. 6b. As in Fig. 6a except for 0545 UTC 12 June 2003.