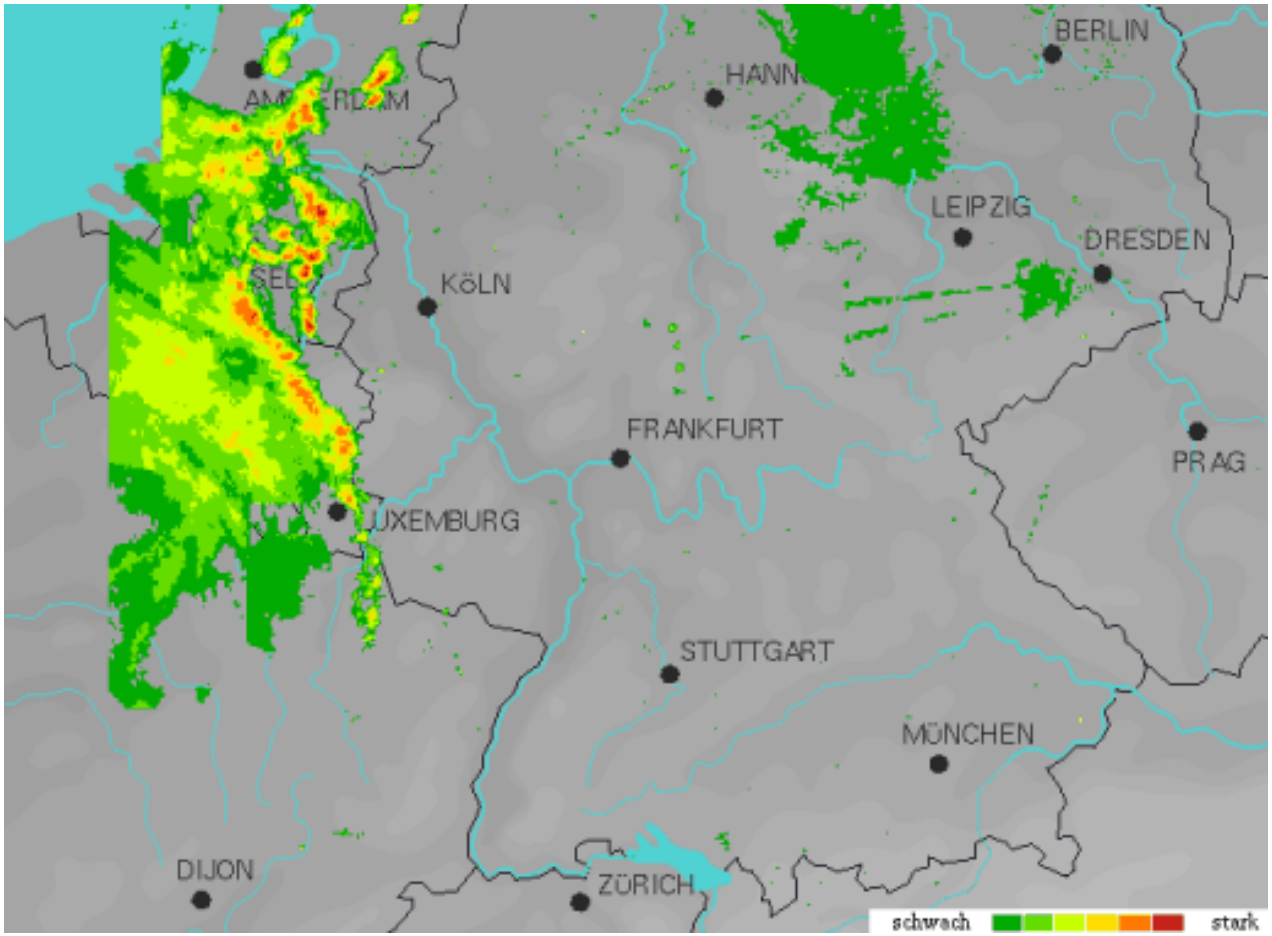
Cold-season derechos in Central Europe

Christoph Gatzen

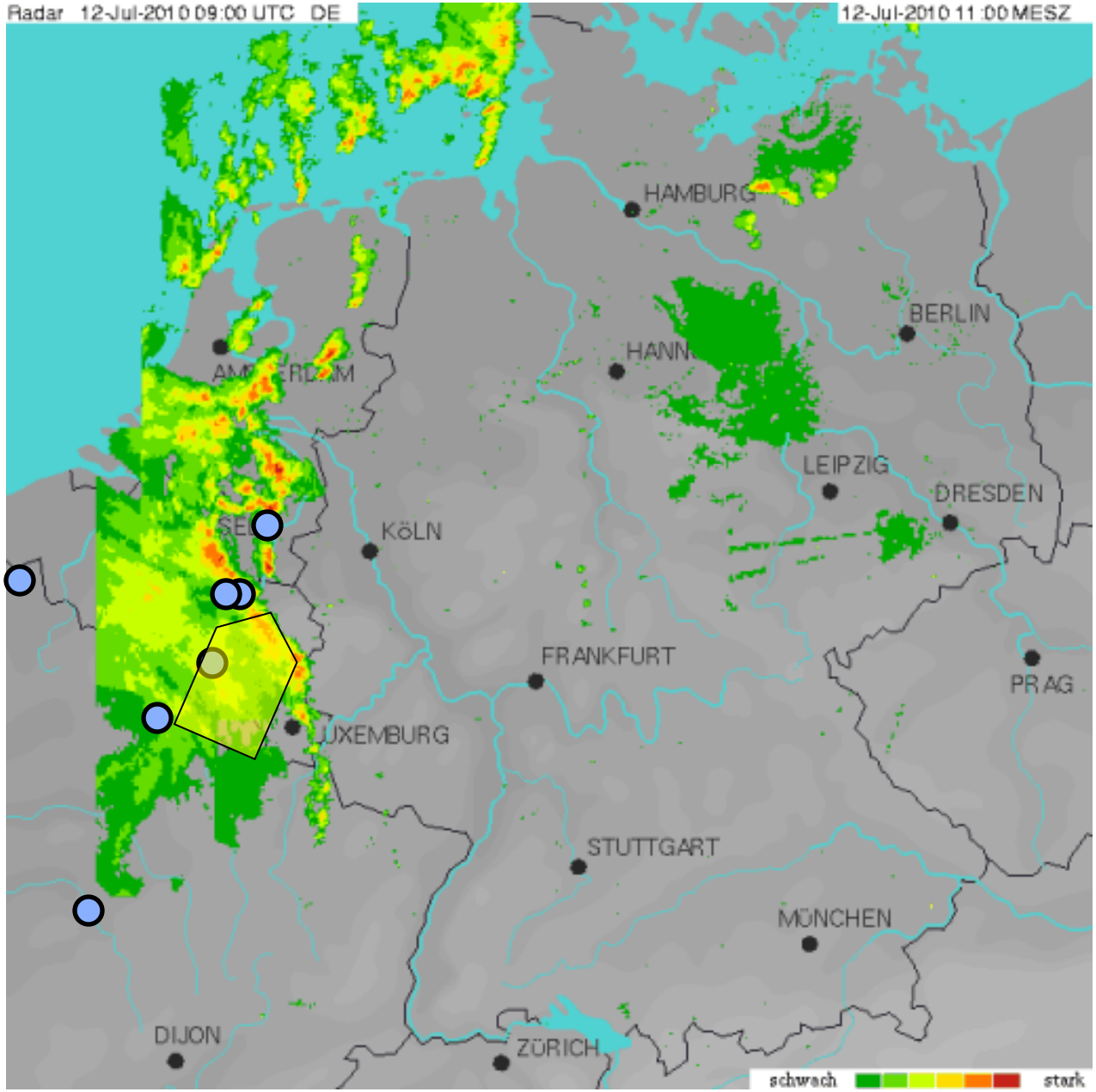
Estofex

Derechos: Widespread convective wind storms

Johns and Hirt, 1987

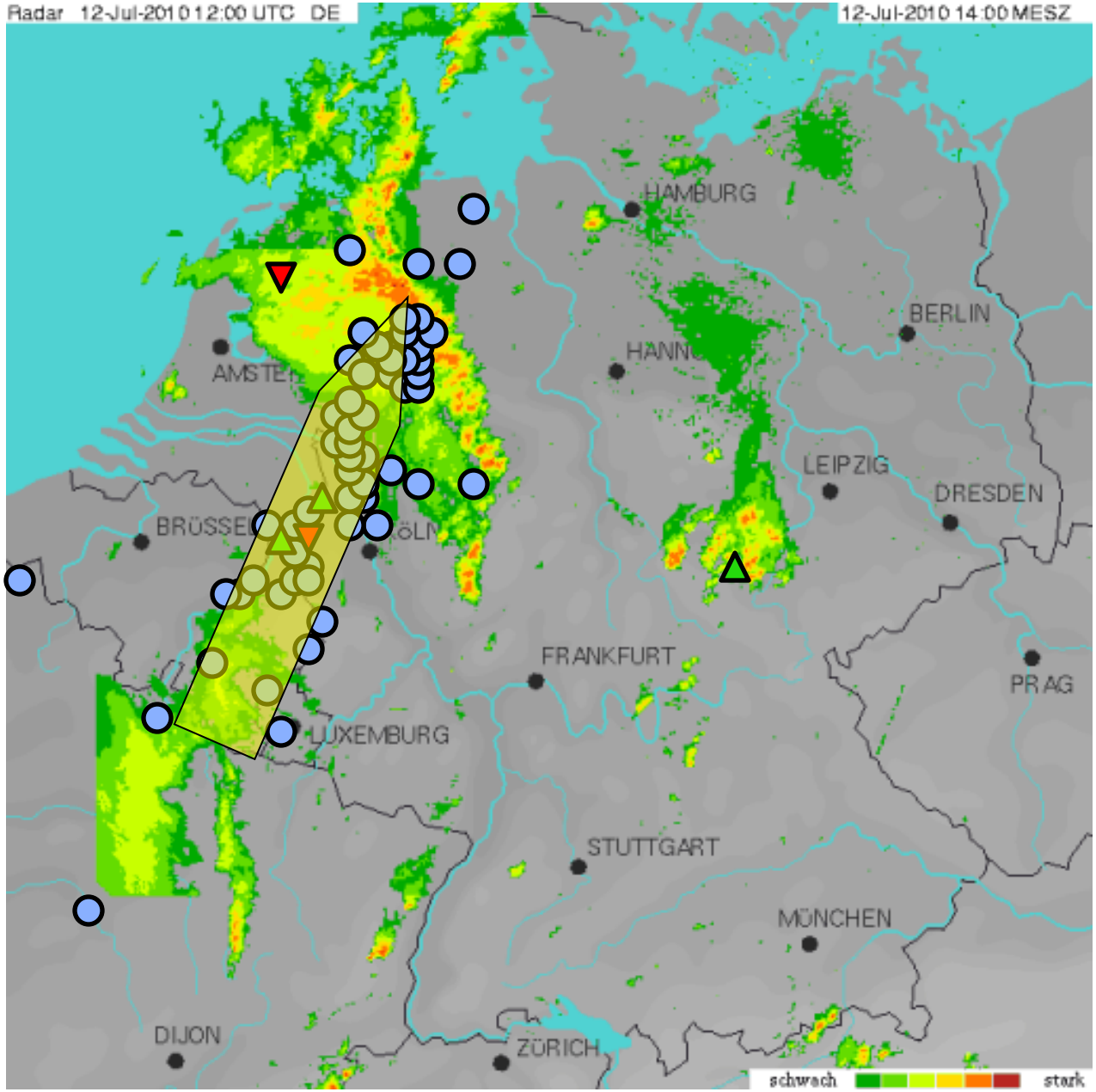


2010/07/12 0900 UTC



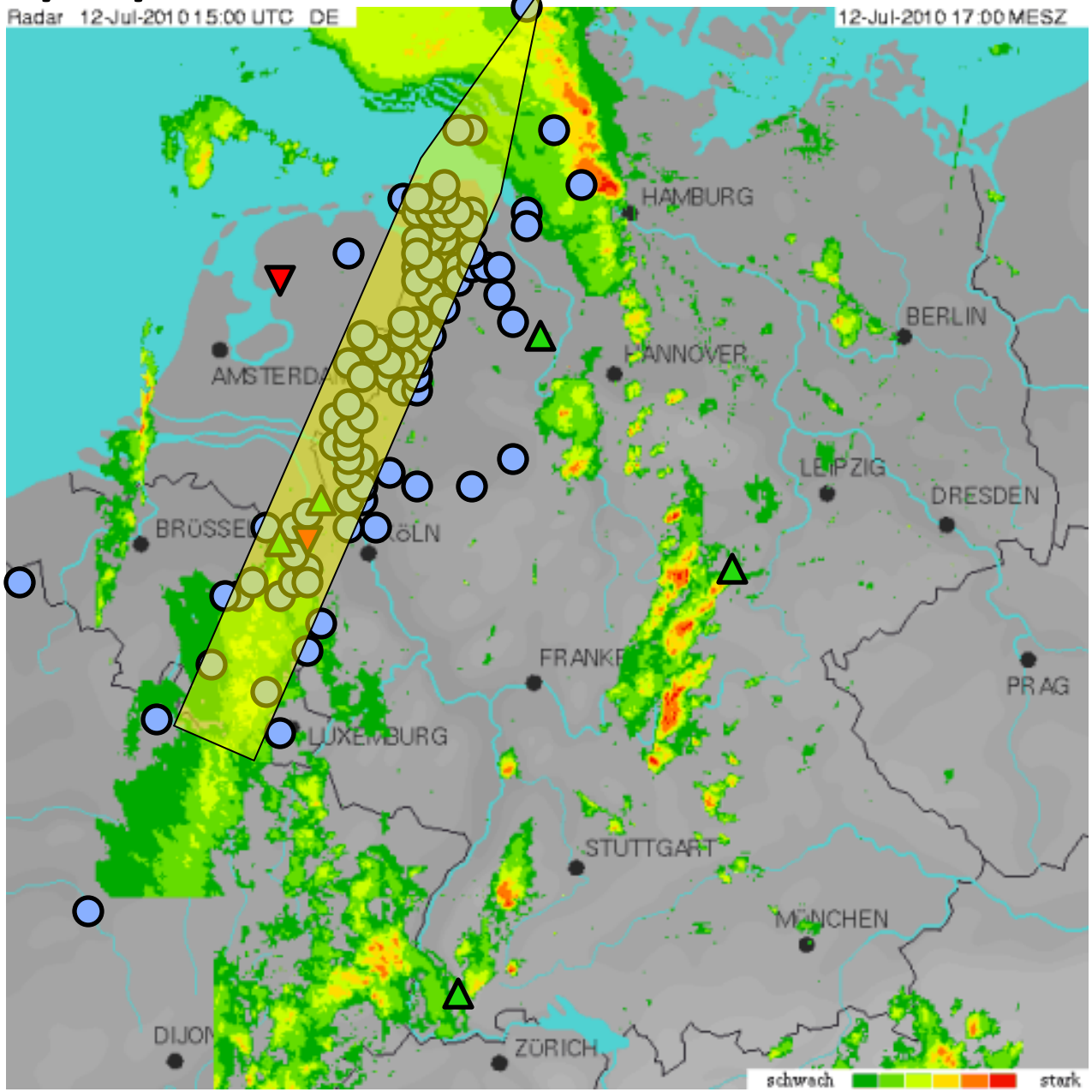
- Gust 25+m/s
- Tor
- Hail 2+ cm

2010/07/12 1200 UTC



- Gust 25+m/s
- Tor
- Hail 2+ cm

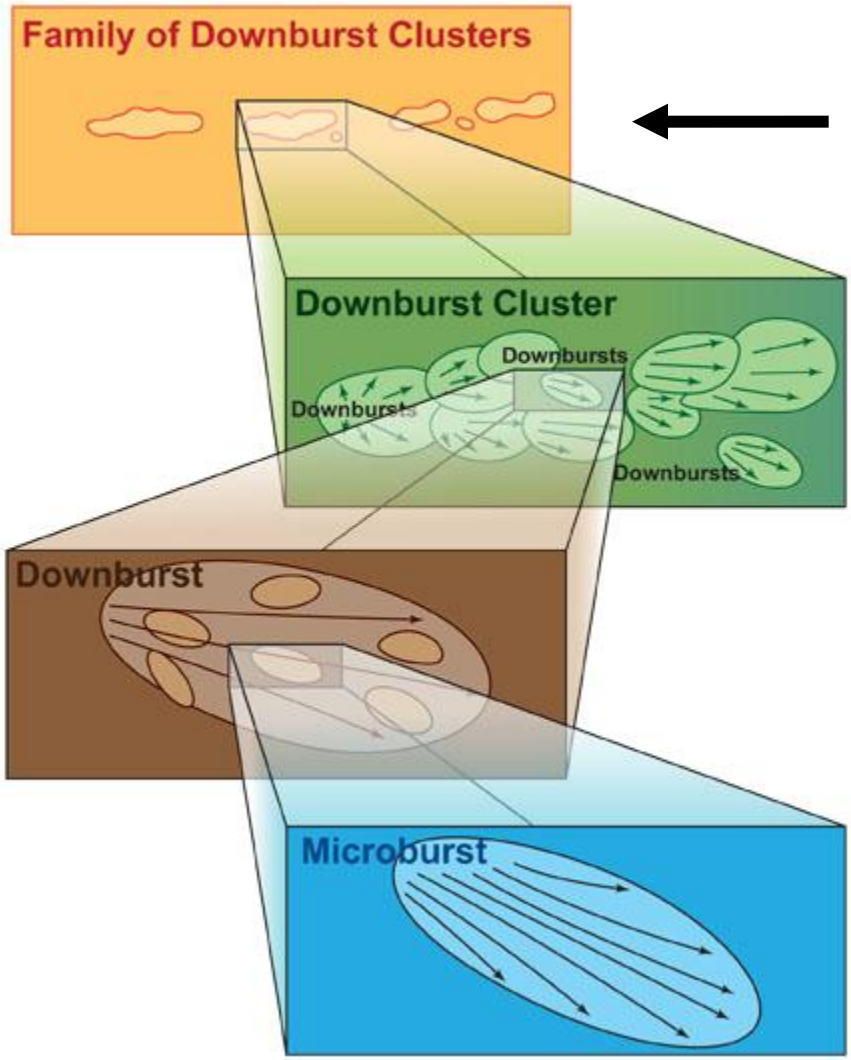
2010/07/12 1500 UTC



- Gust 25+m/s
- Tor
- Hail 2+ cm

Helgoland, 2010/07/12 1330 UTC

Derecho-definition



Major axis length:
400 km

Fujita, T. T., and R. W. Wakimoto, 1981

Fig. SPC web site (Johns, Evans, and Corfidi)

Derecho hazards

- Outdoor activities
- Traffic
- Electrical outages
- Large tree blow downs

Some high-impact events

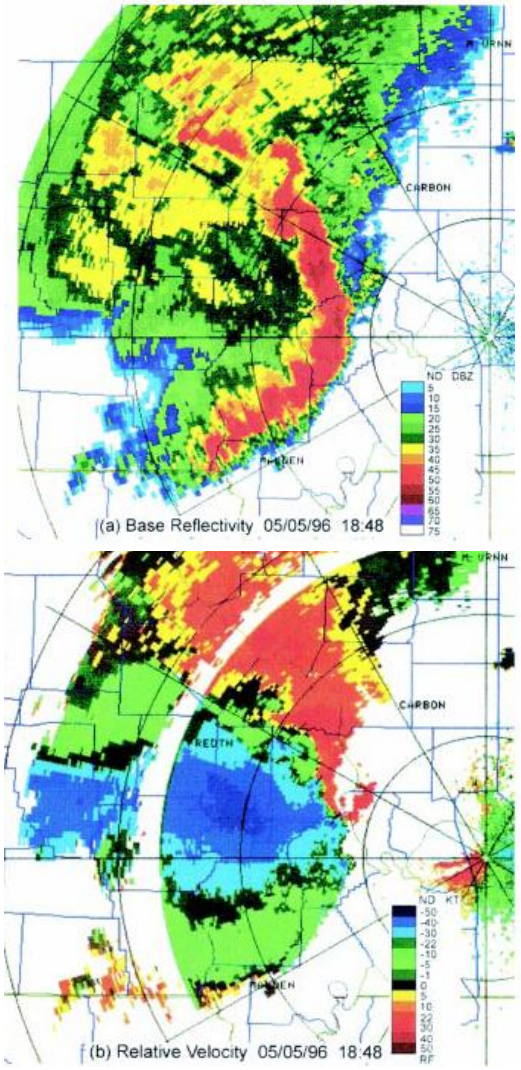
- 9 June 2014 "*Düsseldorf Bow Echo"* (220 km):
  6 fatalities, 67 injured, insurance loss 3500 M
- 1 March 2008 "*Emma Derecho"*:
  14 fatalities, insurance loss 750-1300 M
- 10 July 2002 "*Berlin Derecho"*:
  8 fatalities, 50 injured, insurance loss 10 M
- 6 July 2001 "*Strasbourg Derecho"*:
  12 fatalities

Mesoscale organization

Radar view

Reflectivity

Relative Velocity



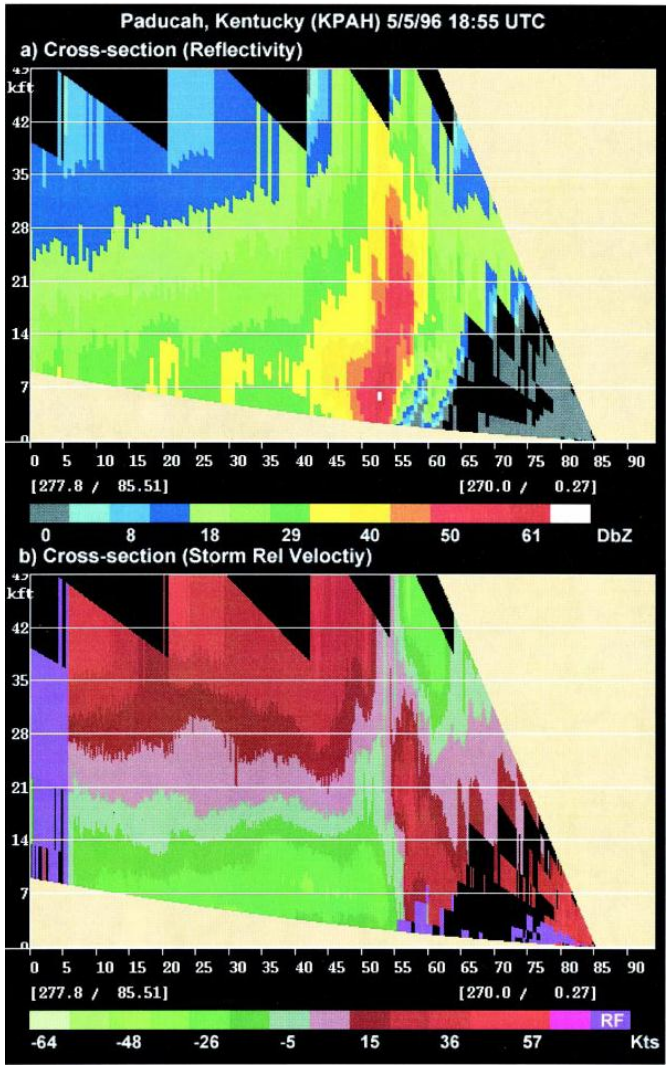


Fig. Przybylinski, 2000

Conceptual model

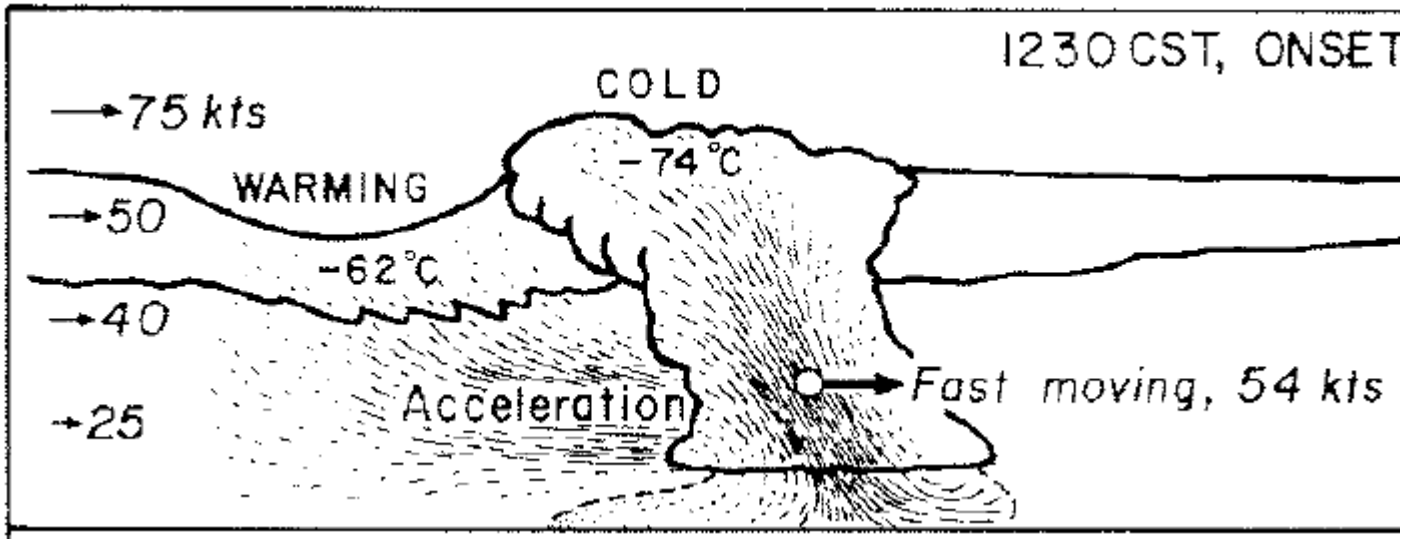


Fig. Fujita, 1978

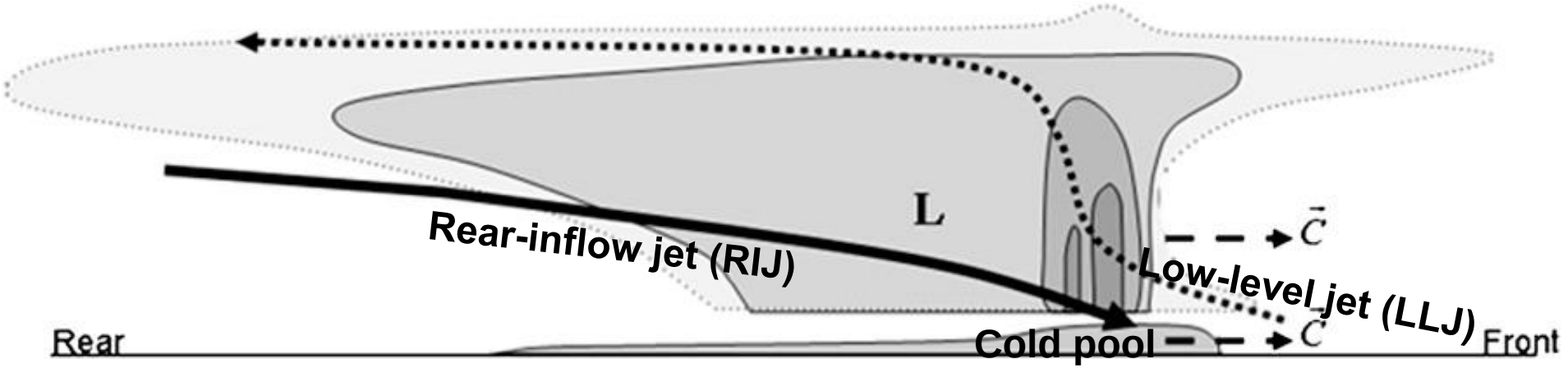


Fig. Mahoney, Lackman, and Parker, 2009

Increasing cold pool speed

PGA: Pressure gradient acceleration

VAu', VAv': Vertical advection of perturbation wind

VAū: Vertical advection of environmental flow

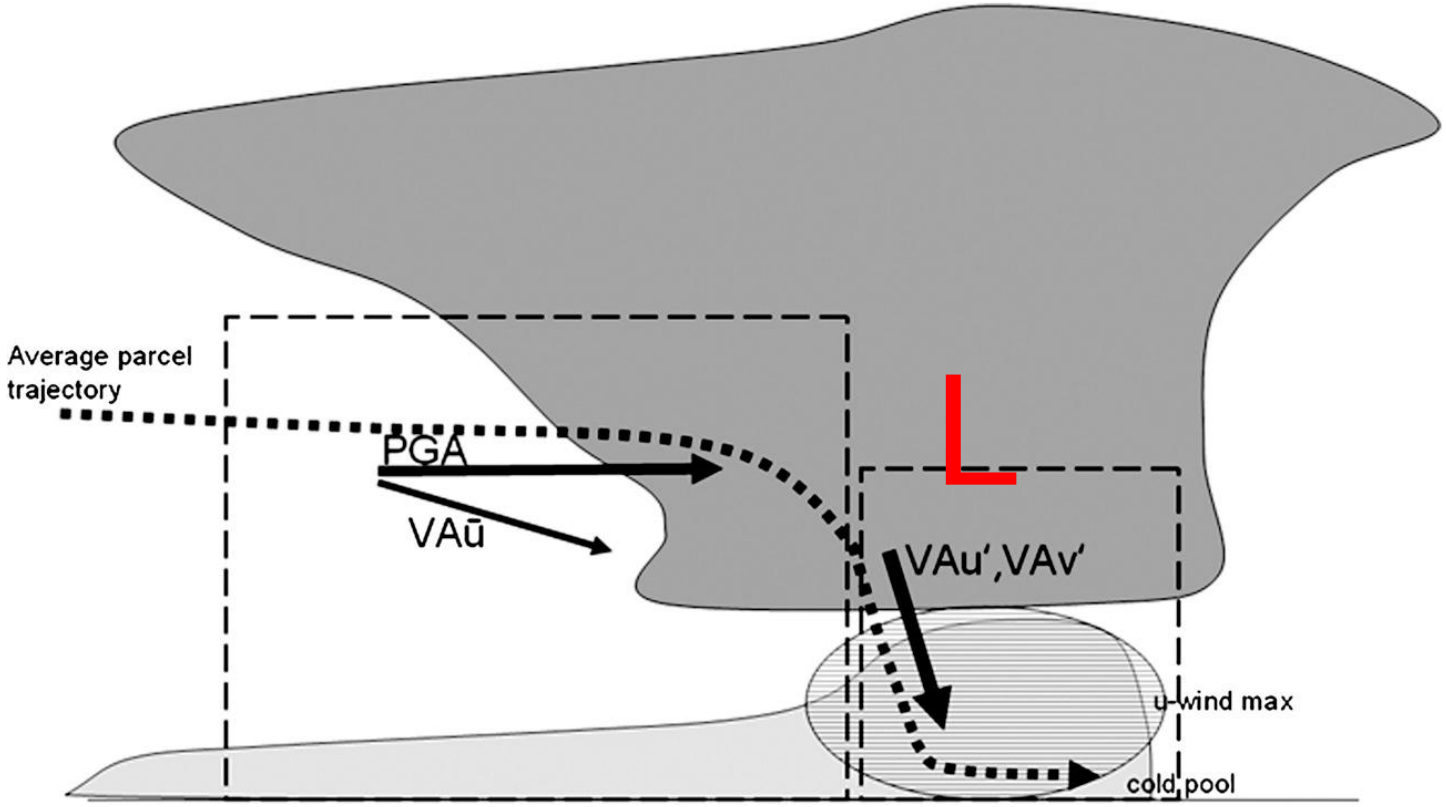


Fig. Mahoney, Lackman, and Parker, 2009

Idealized model studies

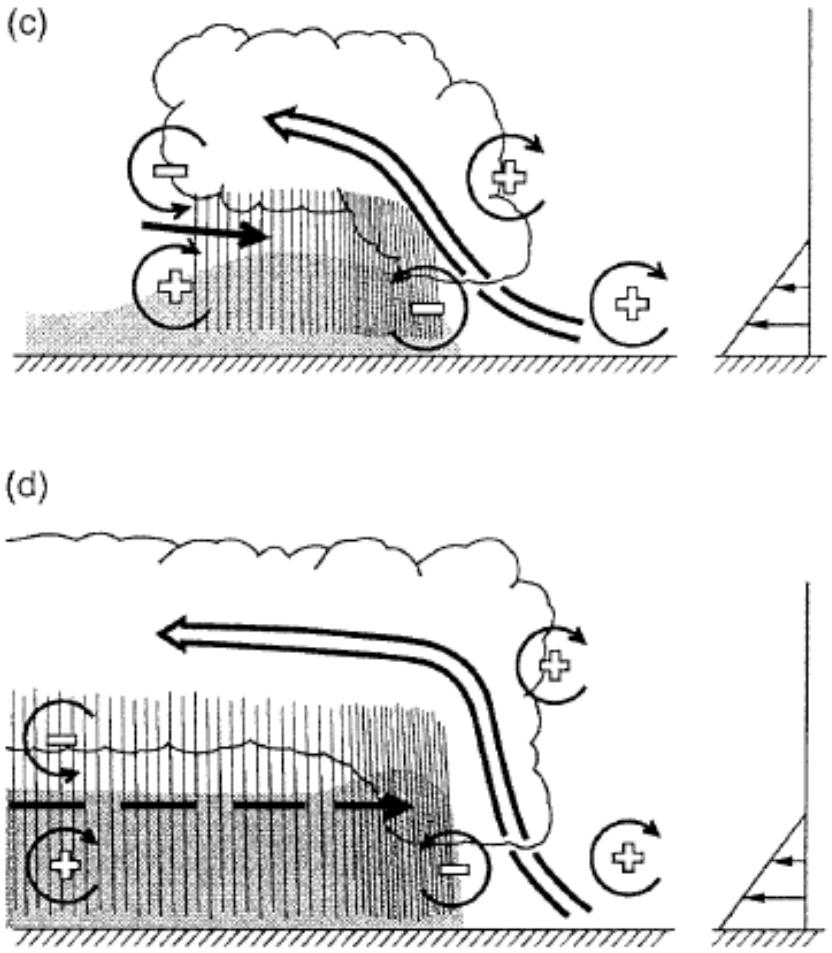


Fig. Weisman 1993

Rotunno, Klemp, Weisman, 1988 (RKW theory): Balance of cold pool and shear circulations

RKW and storm environments

- RKW is not confirmed by proximity soundings

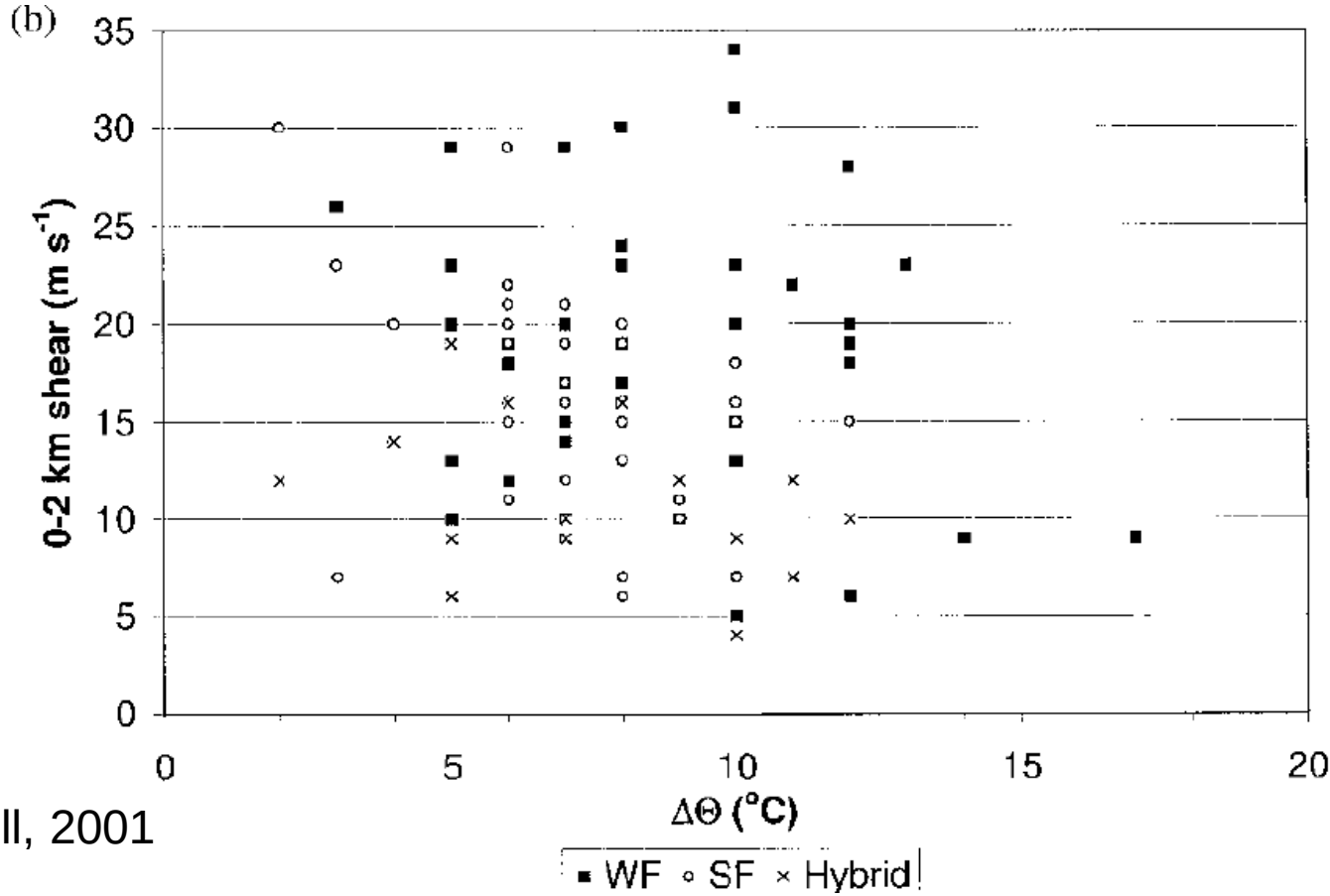


Fig. Evans and Doswell, 2001

What do observational studies tell?

Observational studies

Derecho environments:

- High low-level moisture (almost always)
- Strong low-level WAA (always)
- A strong low-level jet (almost always)

Observational studies

Derecho environments:

- 250 hPa divergence (almost always)

Observational studies

Derecho environments:

- Steep lapse rates (high CAPE)

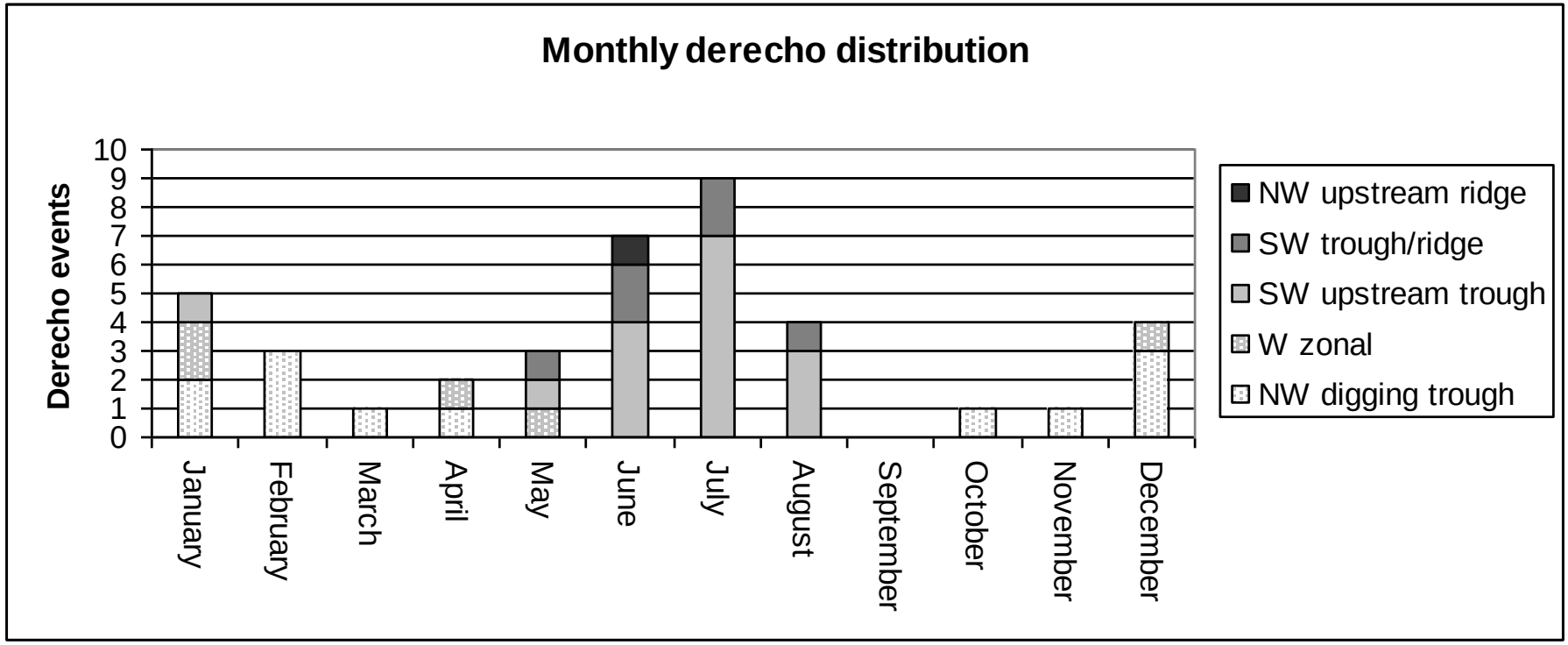
or

- Strongly-forced at 500 hPa

German Derecho Climatology

- Wind gust data of the German Weather Service between 1997 and 2014
- Analysis of possible events using additional wind reports (Meteogroup, European Severe Weather Database ESWD)
- Analysis of radar data
- 40 derechos were found:

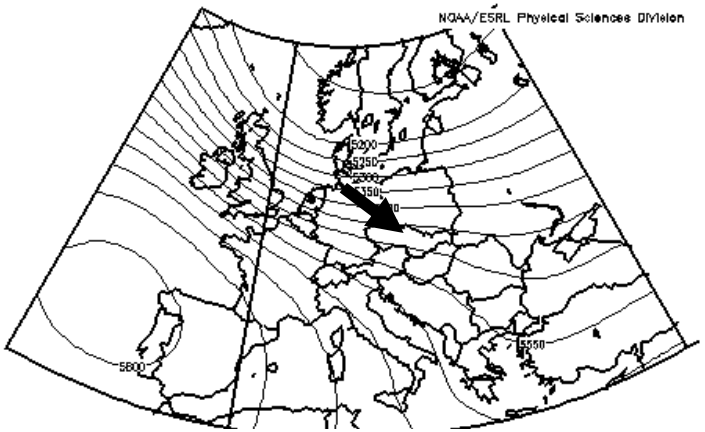
Derechos and mid-level flow (Germany 1997-2014)

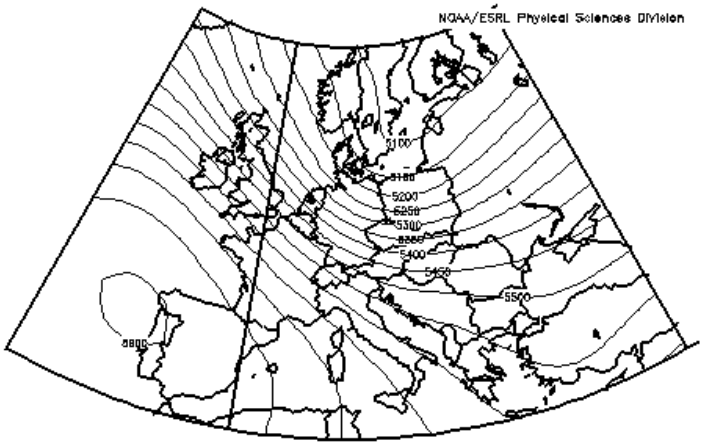


Synoptic flow in derecho events

Cluster:
Digging trough

11.04.1997 00
05.02.1999 18
28.12.2001 06
28.01.2003 06
14.12.2003 18
19.11.2004 06
12.02.2005 12
18.01.2007 12
22.02.2008 12
01.03.2008 00

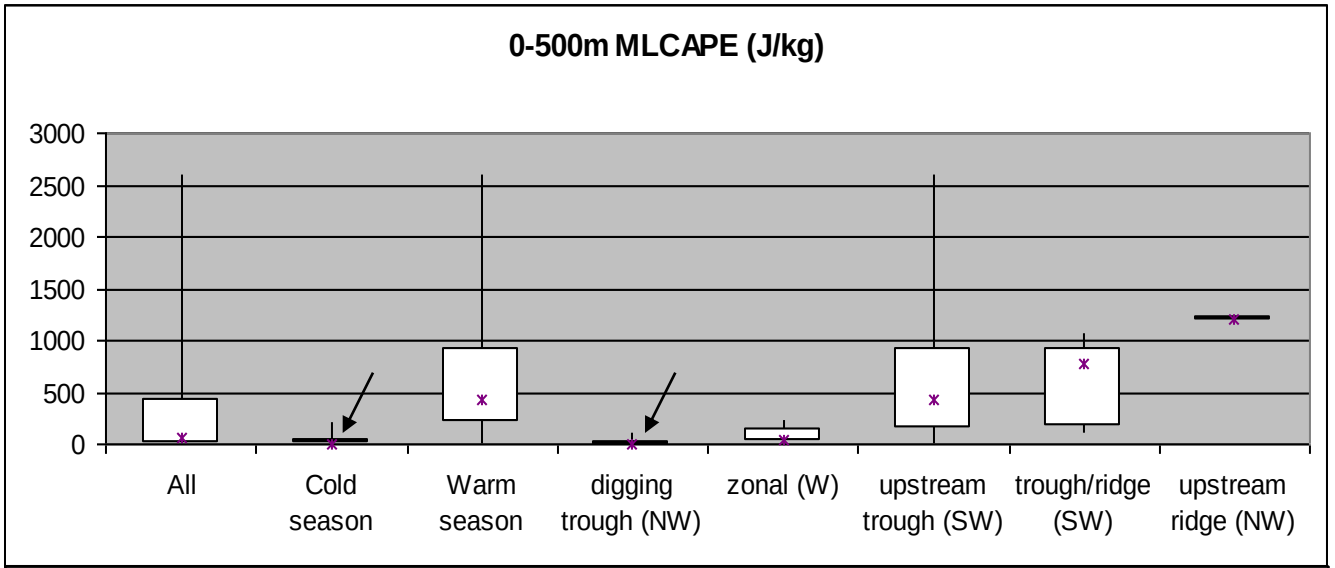


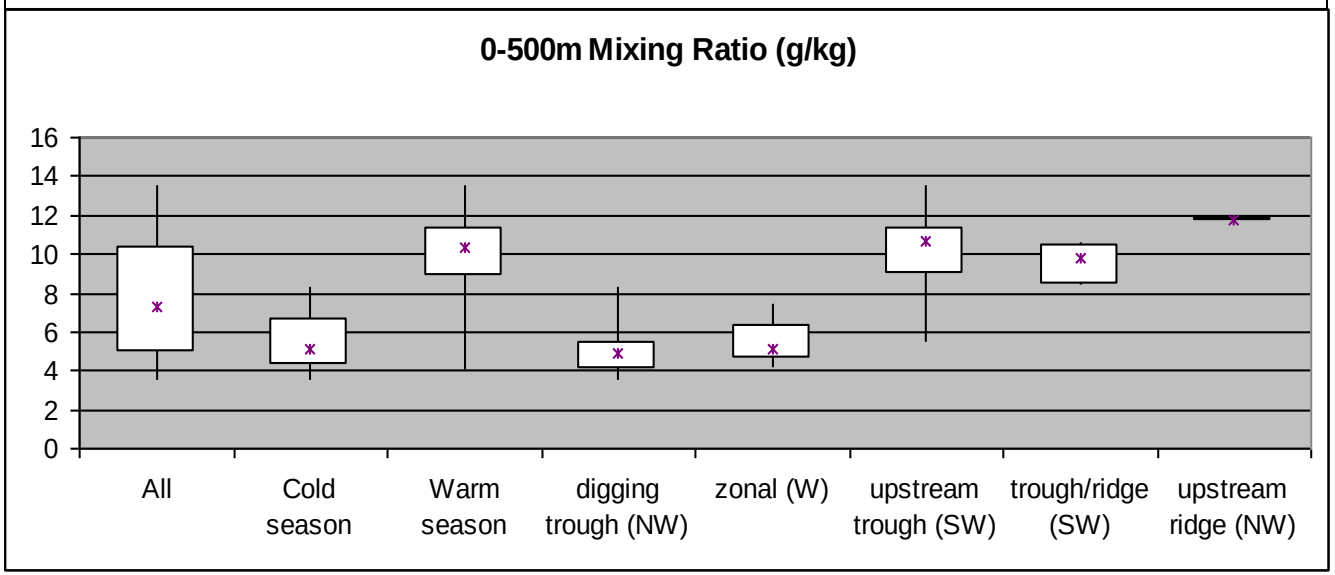


500 hPa: Closest 6-hourly reanalysis before initiation time (top); contours every 50 m
As top + 12 hours (bottom)
http://www.esrl.noaa.gov/psd/data/composites/nssl/hour

CAPE and moisture

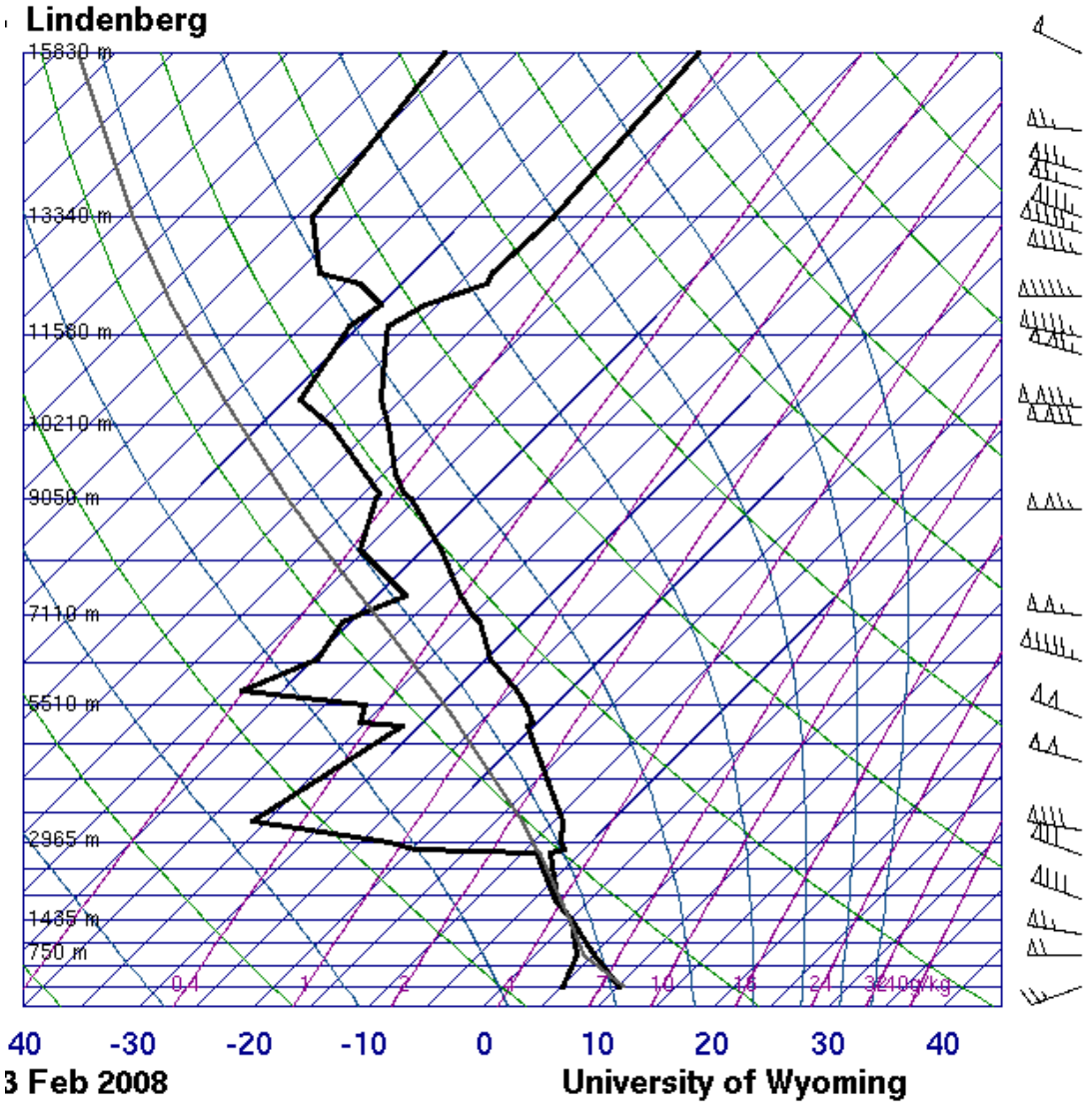
Proximity soundings (167 km / 2 hours)





Lapse rates

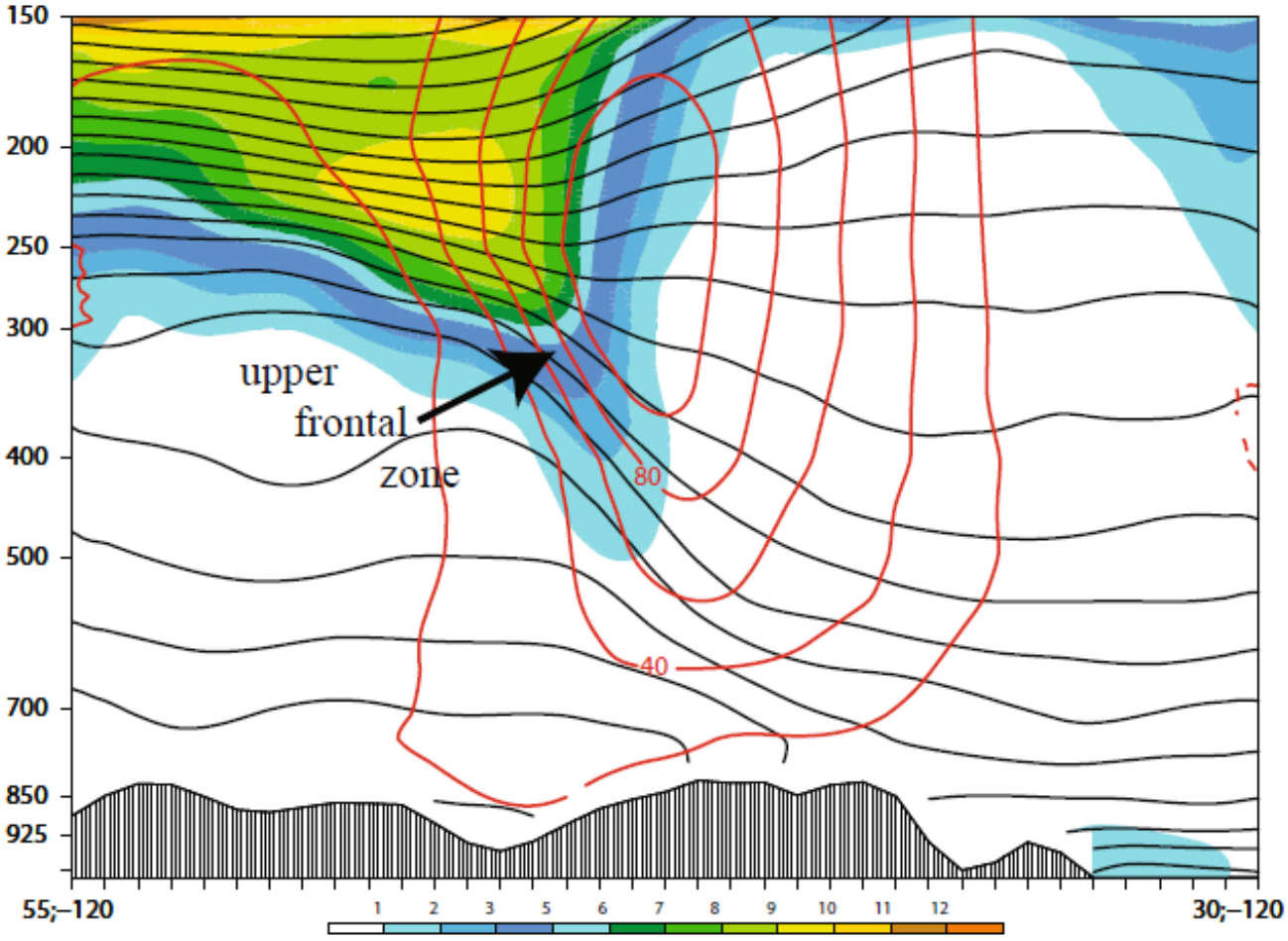
Representative soundings do not indicate steep lapse rates. How can CAPE develop?



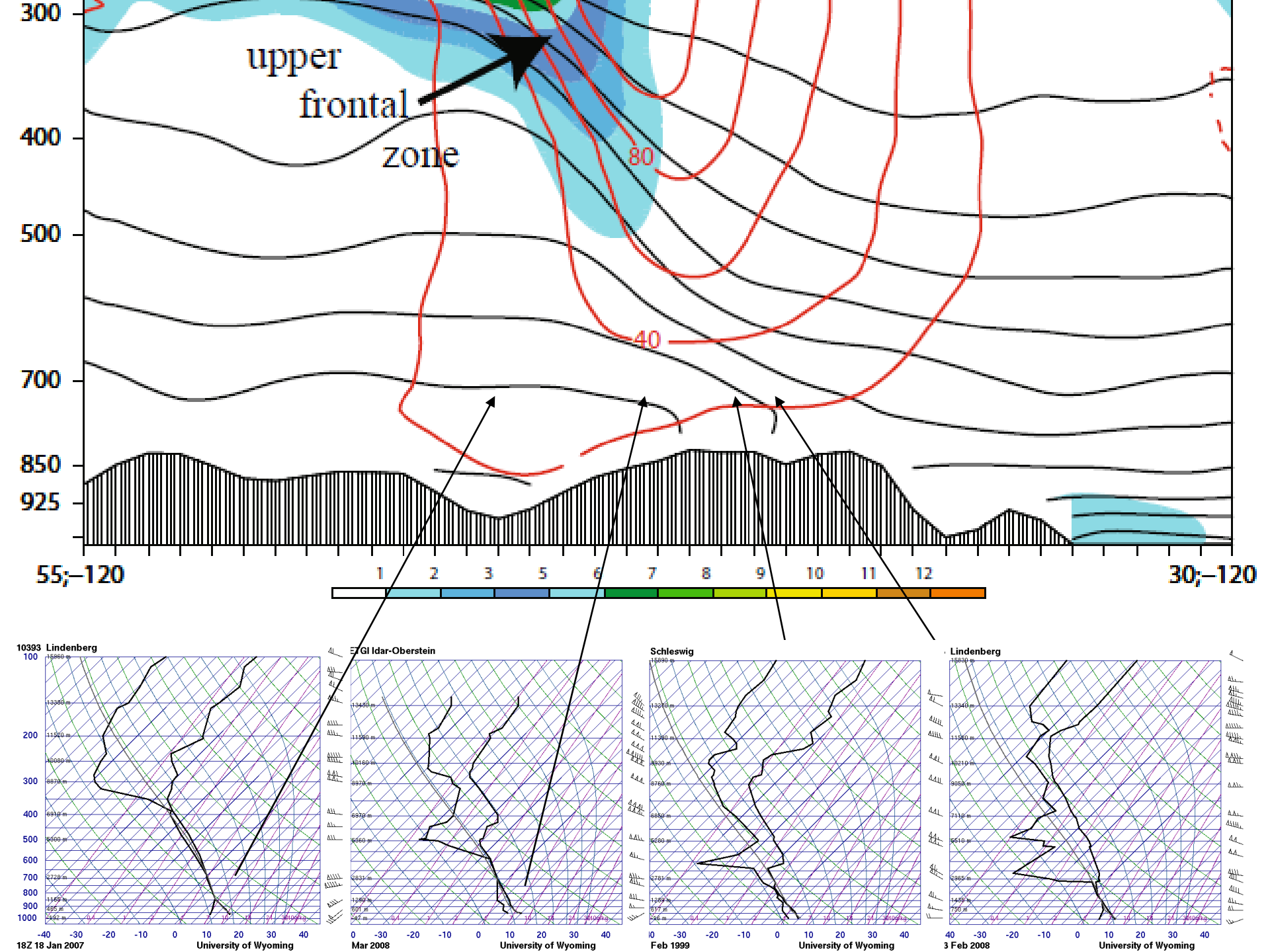
Upper level fronts

- All events formed near an upper tropospheric front:

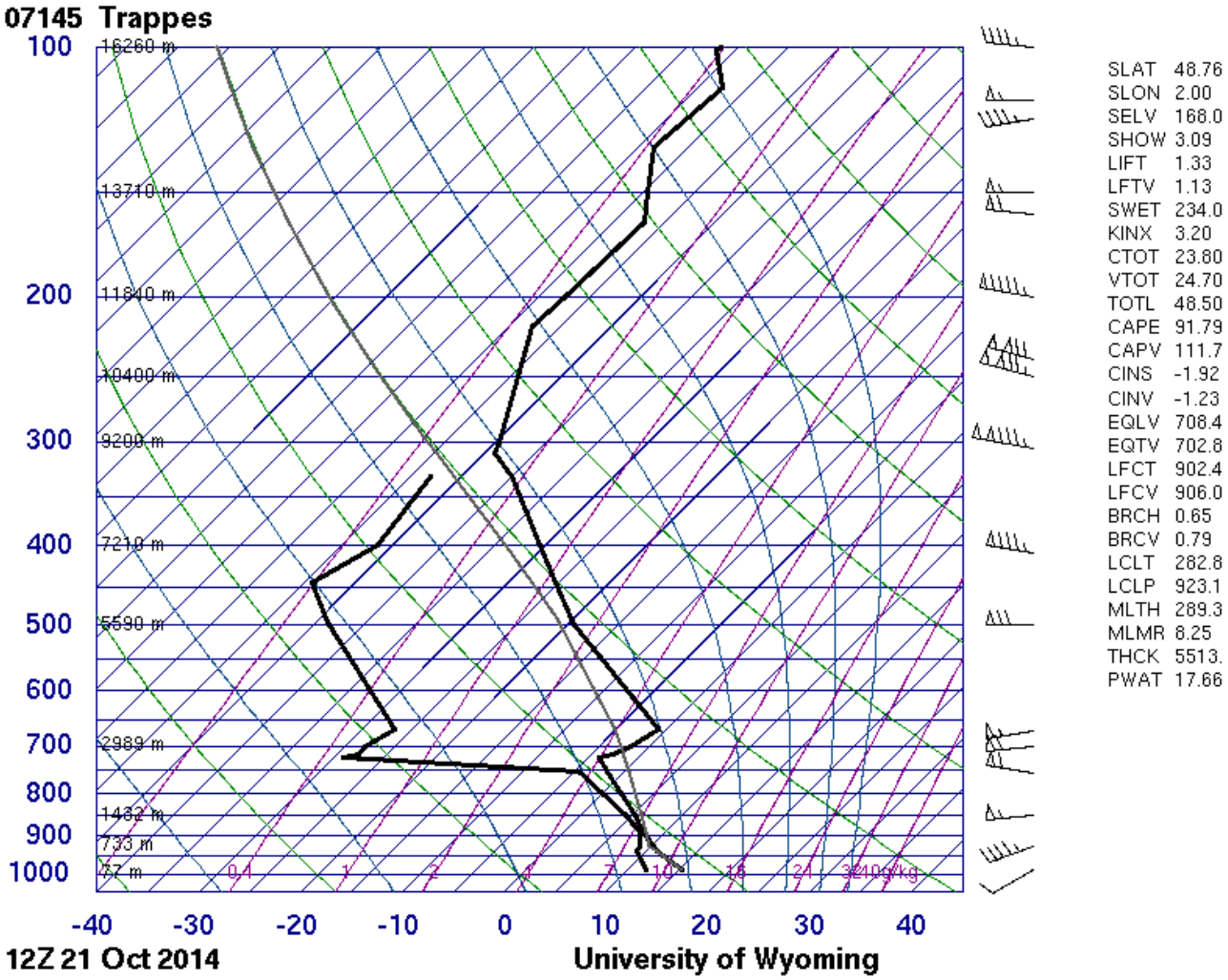
Upper level fronts



North–south cross section through an upper-level jet-front system, based on a short-term NAM forecast valid 18 UTC 25 Aug 2004.
PV (shaded as in legend at bottom of panel), isentropes (black solid contours every 5K), and isotachs (red contours every 20 kt). From Lackman, 2011.

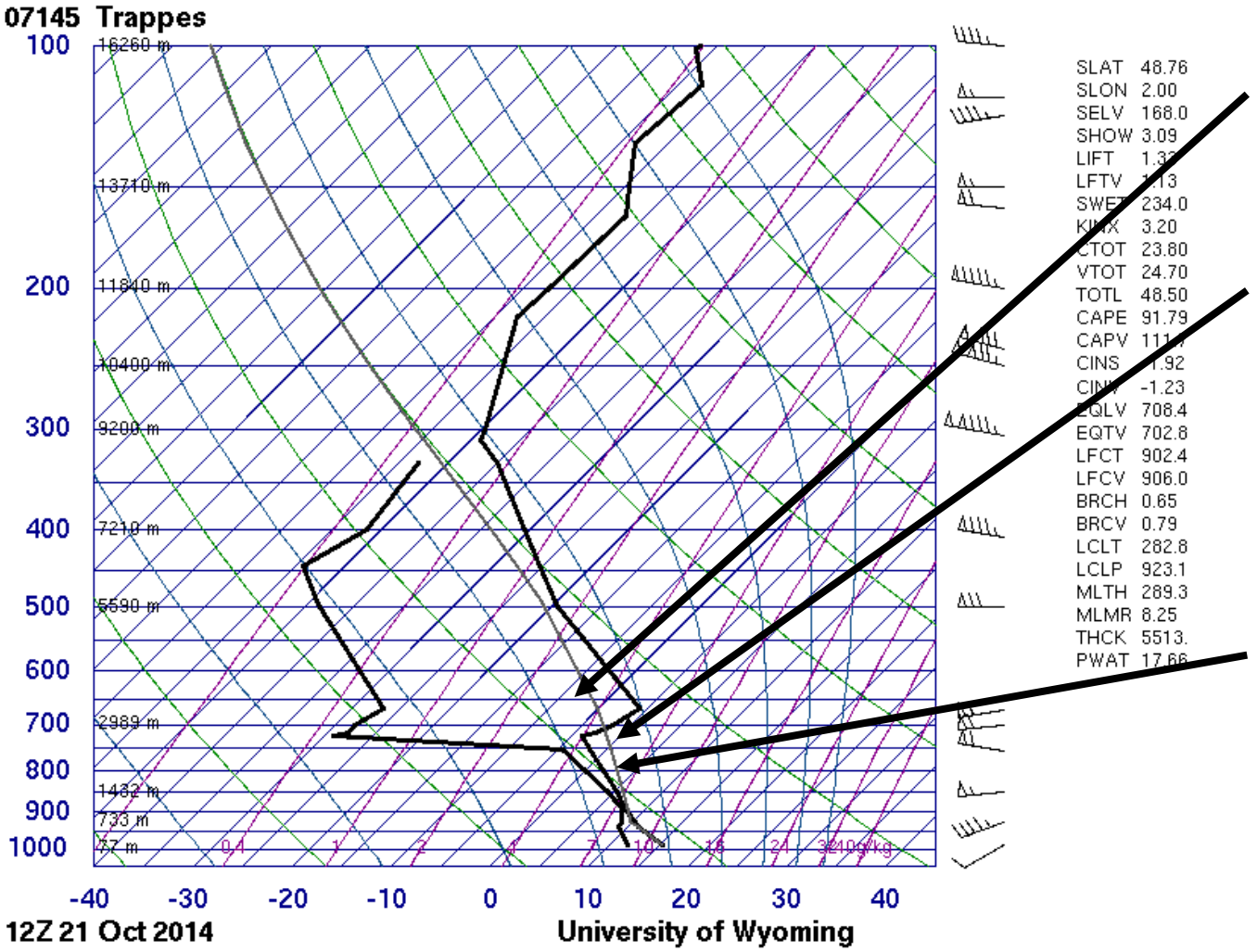

upper
frontal
zone
80
40
300
400
500
700
850
925
55;–120
30;–120
1
2
3
5
6
7
8
9
10
11
12
10393 Lindenberg
ETGI Idar-Oberstein
Schleswig
Lindenberg
18Z 18 Jan 2007
University of Wyoming
Mar 2008
University of Wyoming
Feb 1999
University of Wyoming
3 Feb 2008
University of Wyoming

Proximity sounding of this process



SLAT	48.76
SLON	2.00
SELV	166.0
SHOW	3.09
LIFT	1.33
LFTV	1.13
SWET	234.0
KINX	3.20
CTOT	23.80
VTOT	24.70
TOTL	48.50
CAPE	91.79
CAPV	111.7
CINS	-1.92
CINV	-1.23
EQLV	708.4
EQTV	702.8
LFCT	902.4
LFCV	906.0
BRCH	0.65
BRCV	0.79
LCLT	282.8
LCLP	923.1
MLTH	289.3
MLMR	8.25
THCK	5513.
PWAT	17.66

Proximity sounding of this process

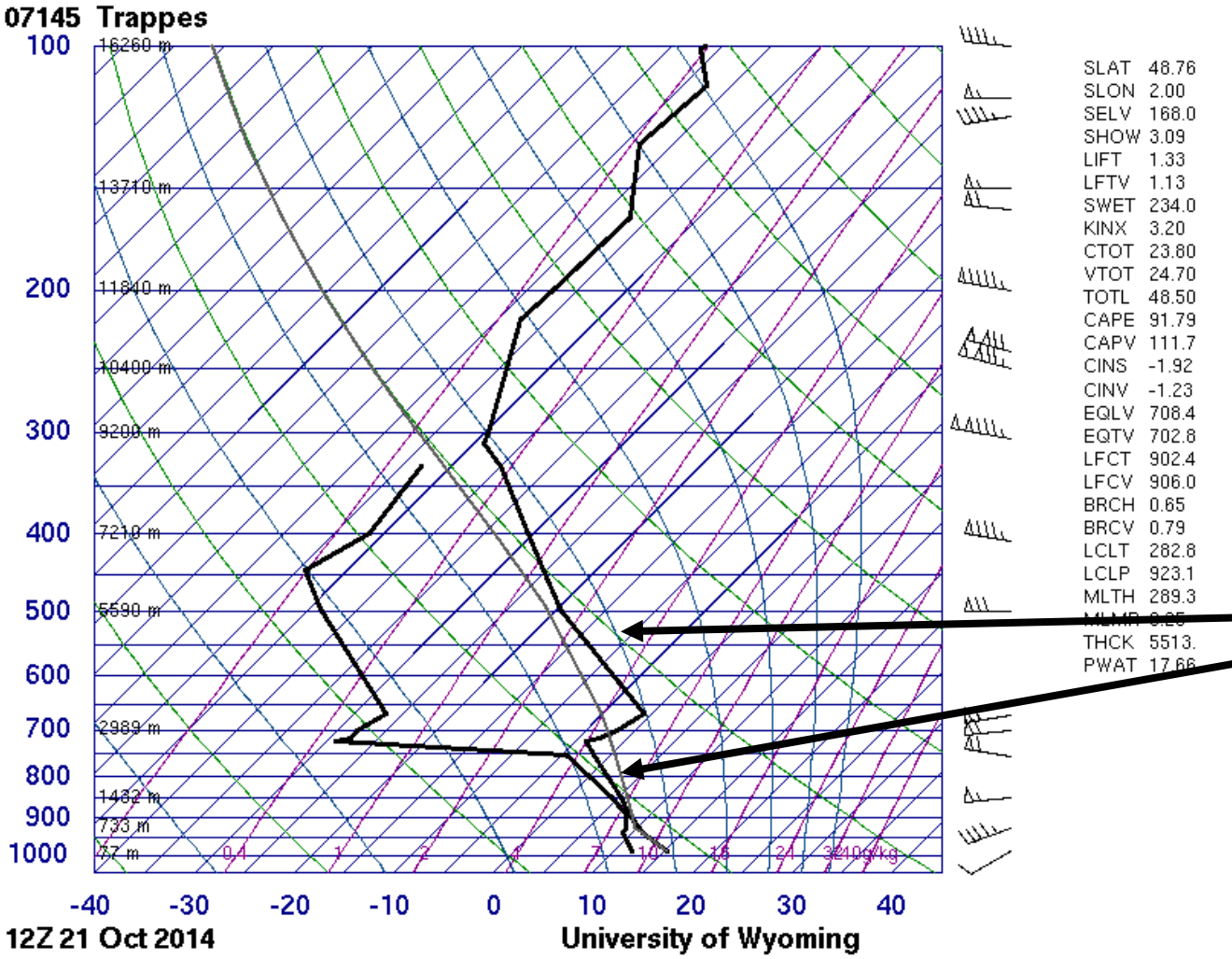


Dry Intrusion: Strong cyclonic vortictiy advection

Upper warm conveyor belt: Strongest differential cyclonic vorticity advection, causing lift

Stretching of the warm conveyor belt increases the low-level lapse rates

Proximity sounding of this process



Differential temperature advection increases deep lapse rates

Example: Emma 1 March, 2008