NOCTURNAL CONVECTION INITIATION: CLIMATOLOGY AND FORECAST CHALLENGE OR *EINE KLEINE NACHTKONVECTION*

(with apologies to W. A. Mozart)

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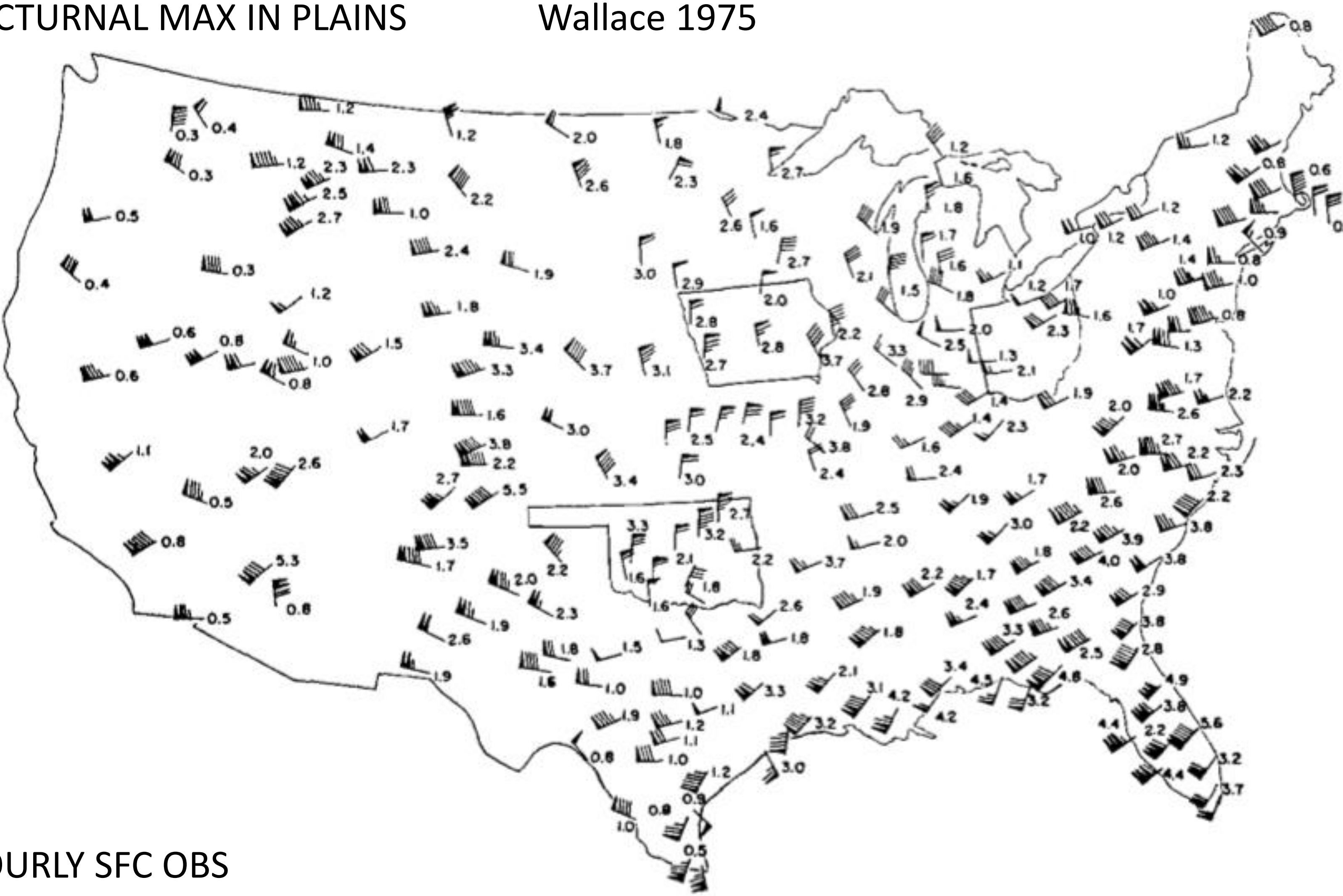
PECAN Planning Meeting

1. CLIMATOLOGY OF NOCTURNAL CI

2. EXAMPLES OF ORGANIZATION OF NOCTURNAL CONVECTIVE SYSTEMS

3. FORECASTING ISSUES

• NOCTURNAL MAX IN PLAINS Wallace 1975



HOURLY SFC OBS

FIG. 2. The diurnal cycle in the thunderstorm frequency during the summer season. Plotting conventions as in Fig. 1.

FIG. 1. Normalized amplitude and phase of the diurnal cycle in the total frequency of precipitation, including trace events for the summer season (June–August). Normalized amplitude is indicated by the configuration of barbs on the tails of the arrows, where each half barb represents 5%, each full barb 10%, and each triangular flag 50%. Stations with circles around them have normalized amplitudes less than 2.5%. Phase is indicated by the orientation of the arrows. An arrow pointing from the north indicates a midnight maximum (local time); one pointing from the east indicates a 0600 maximum, etc. The numbers plotted next to the stations represent the 24-hour mean frequencies in terms of percent of hours with precipitation.

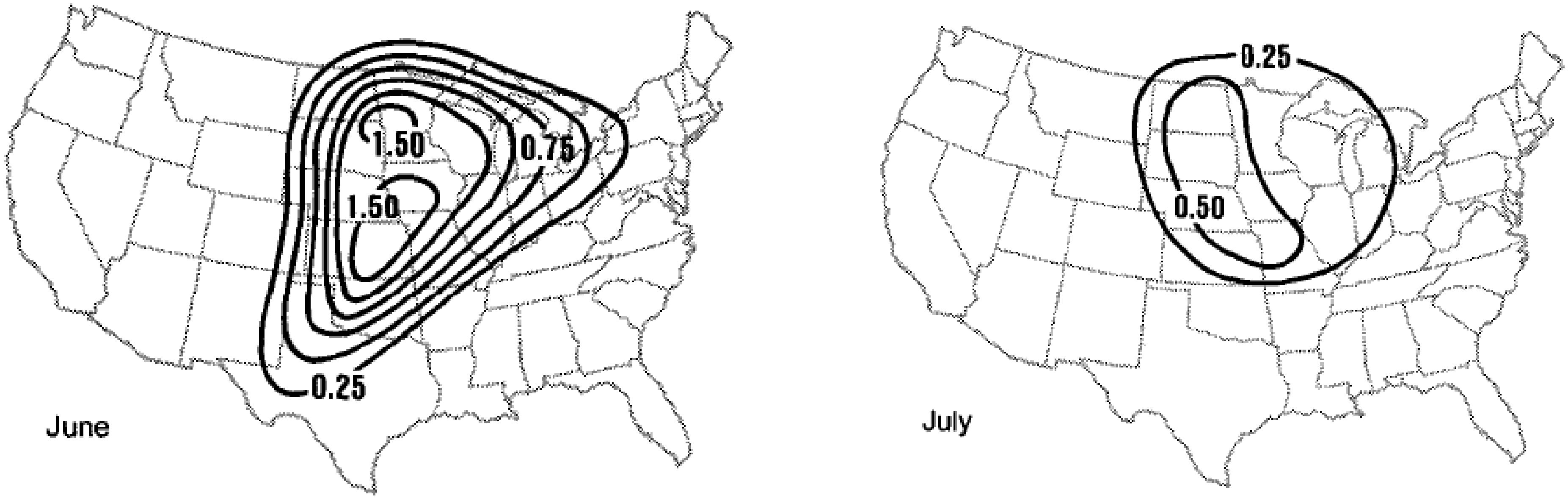
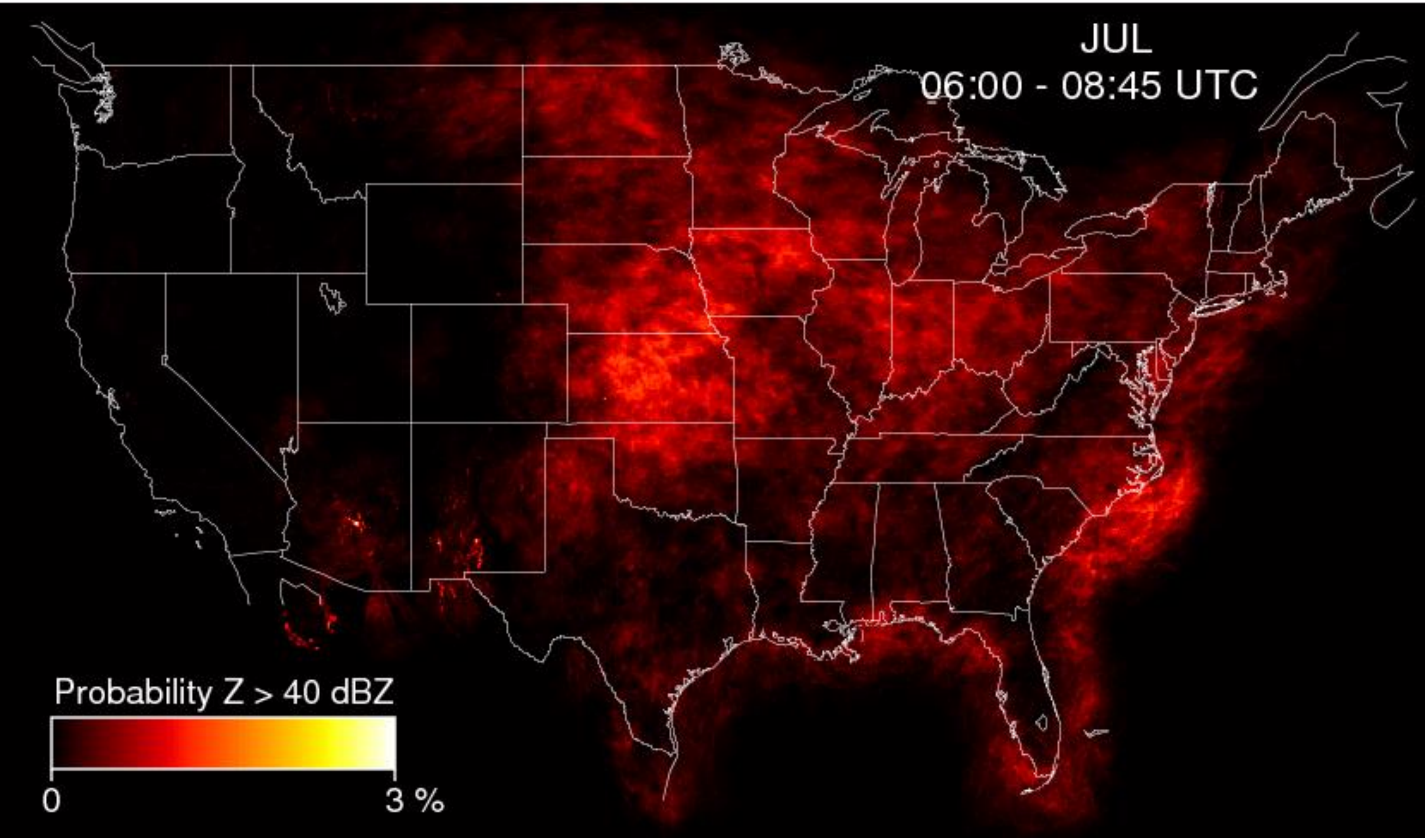


FIG. 3. The number of elevated thunderstorms (reports/station), by month, identified over the 4-year period.

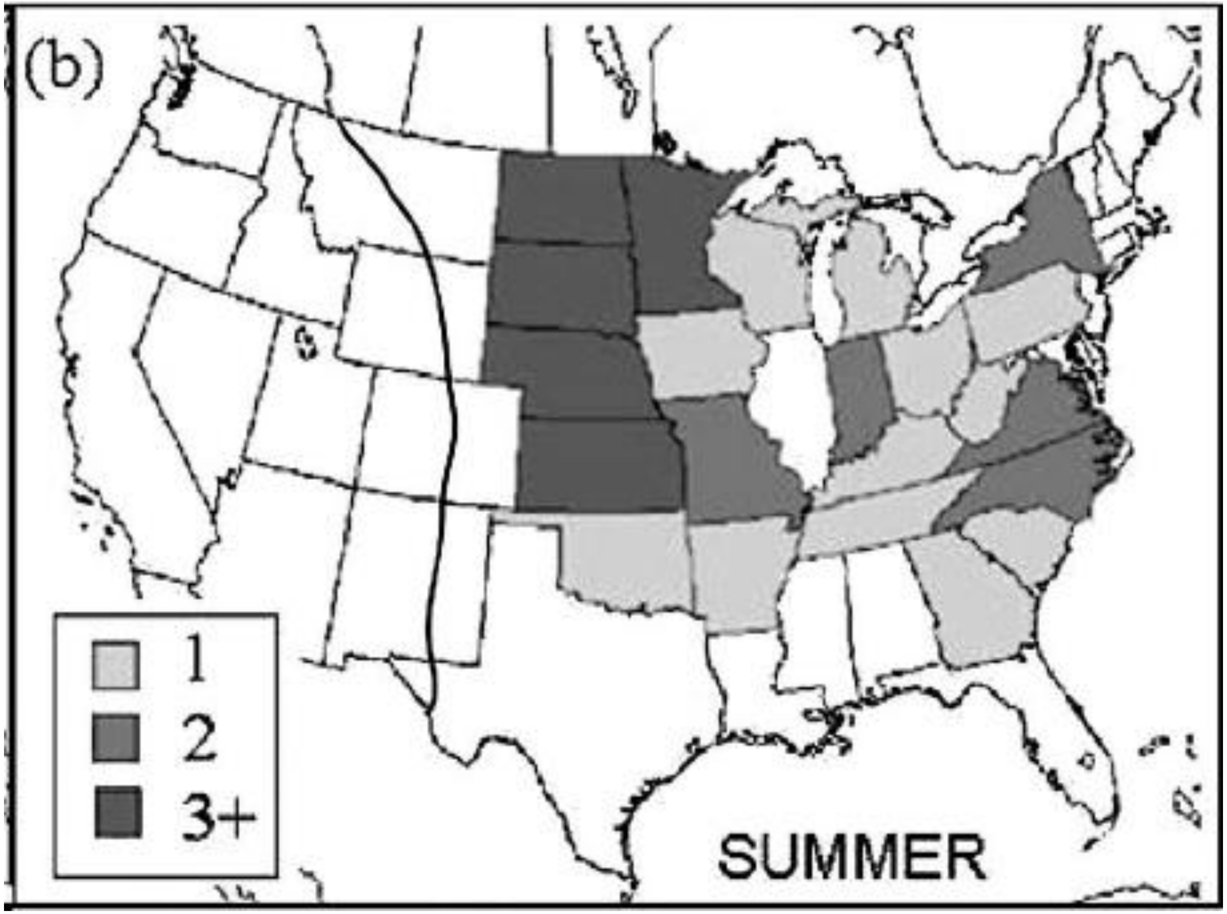
- MAX IN ELEVATED STORMS DURING THE SUMMER OVER KS – NE AND DAKOTAS

Colman 1990

RADAR CLIMATOLOGY FOR JULY: MAX OVER KS



From Fabry (2012)



DISTRIBUTION OF ELEVATED (NO SFC-BASED CAPE) SEVERE STORM CASES, SUMMER: 1983 - 1987
Horgan et al. 2007

- ELEVATED *AND* SEVERE MAX, KS AND N'wd

(courtesy of Dylan Reif)

Formation Location: KS MAX

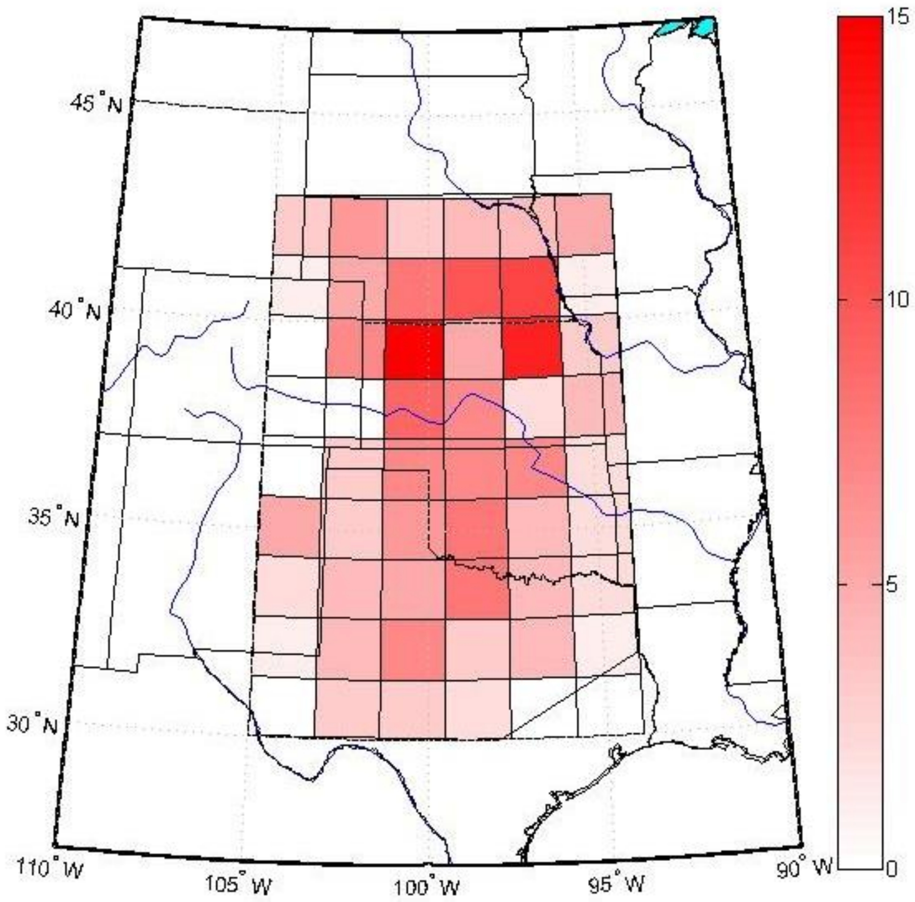
APRIL – JULY, 1996 – (APRIL) 2006

NEAR ANOTHER SYSTEM,
OR COULD HAVE ORIGINATED
JUST BEFORE/AFTER NIGHTFALL

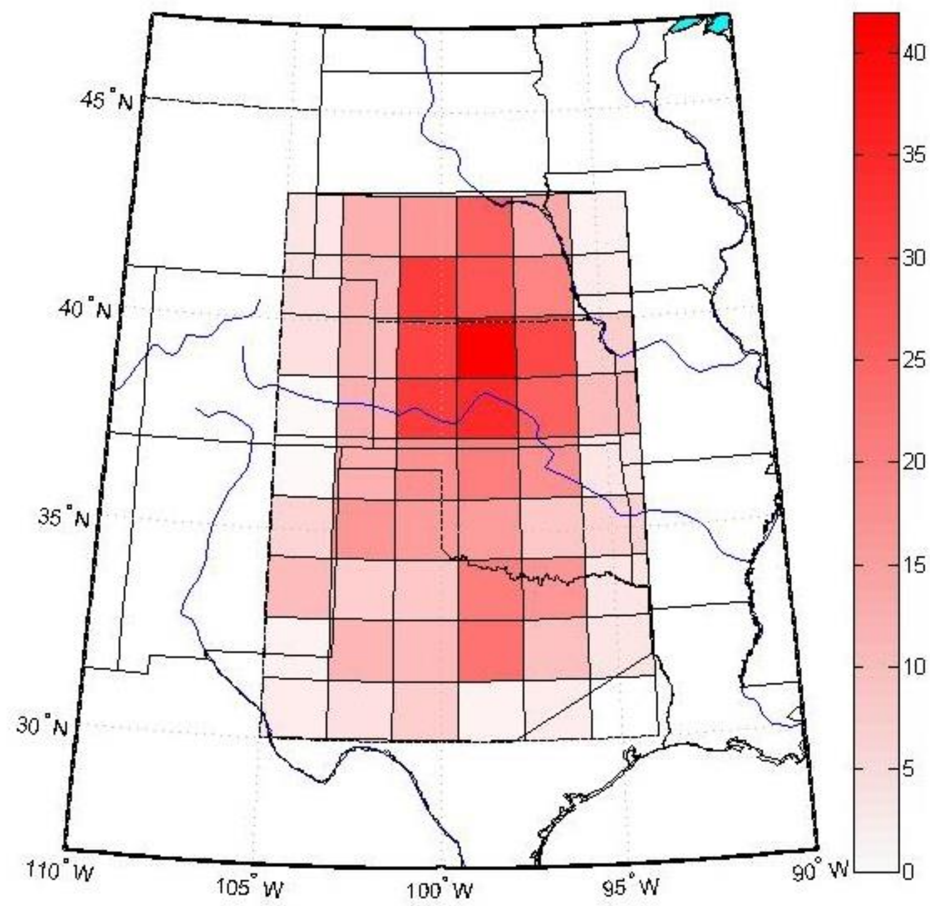
233

724

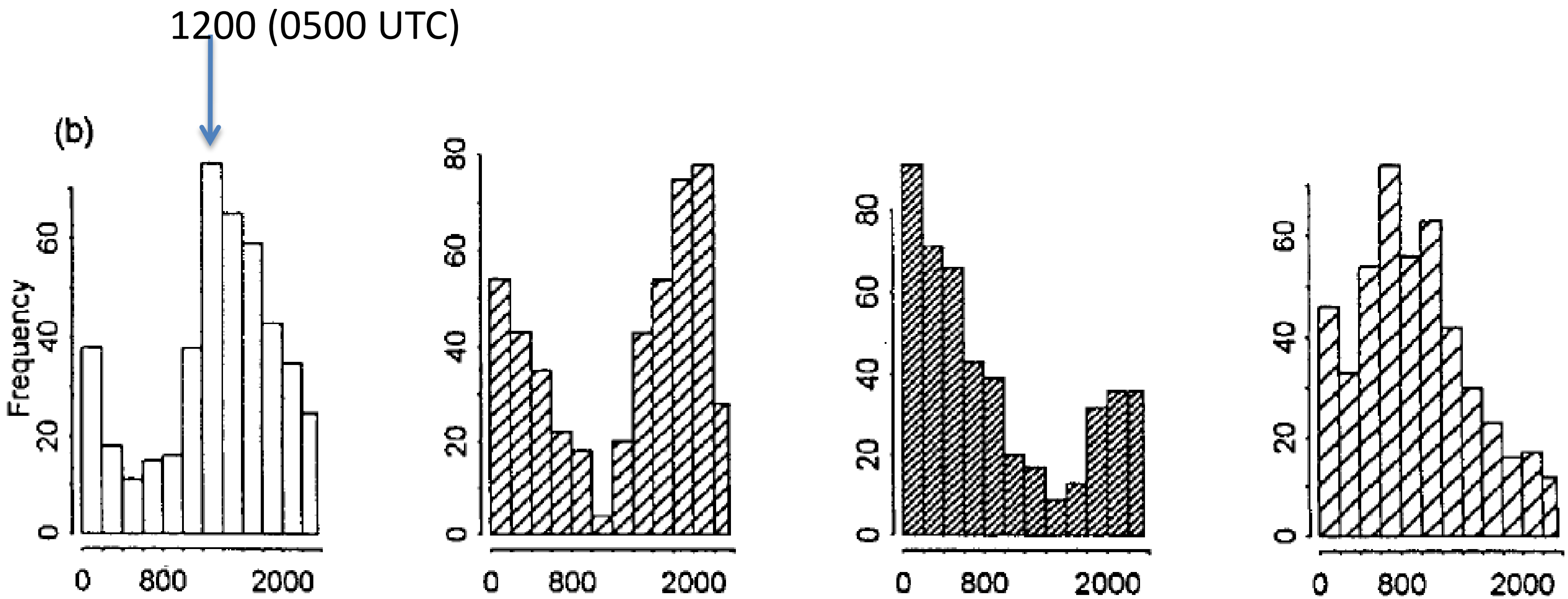
Definite Starting Location



Marginal Starting Location



SATELLITE BASED (1986 – 87)



FIRST STORMS | INITIATION (MCCs) | MAX. EXTENT | THAT'S ALL FOLKS!

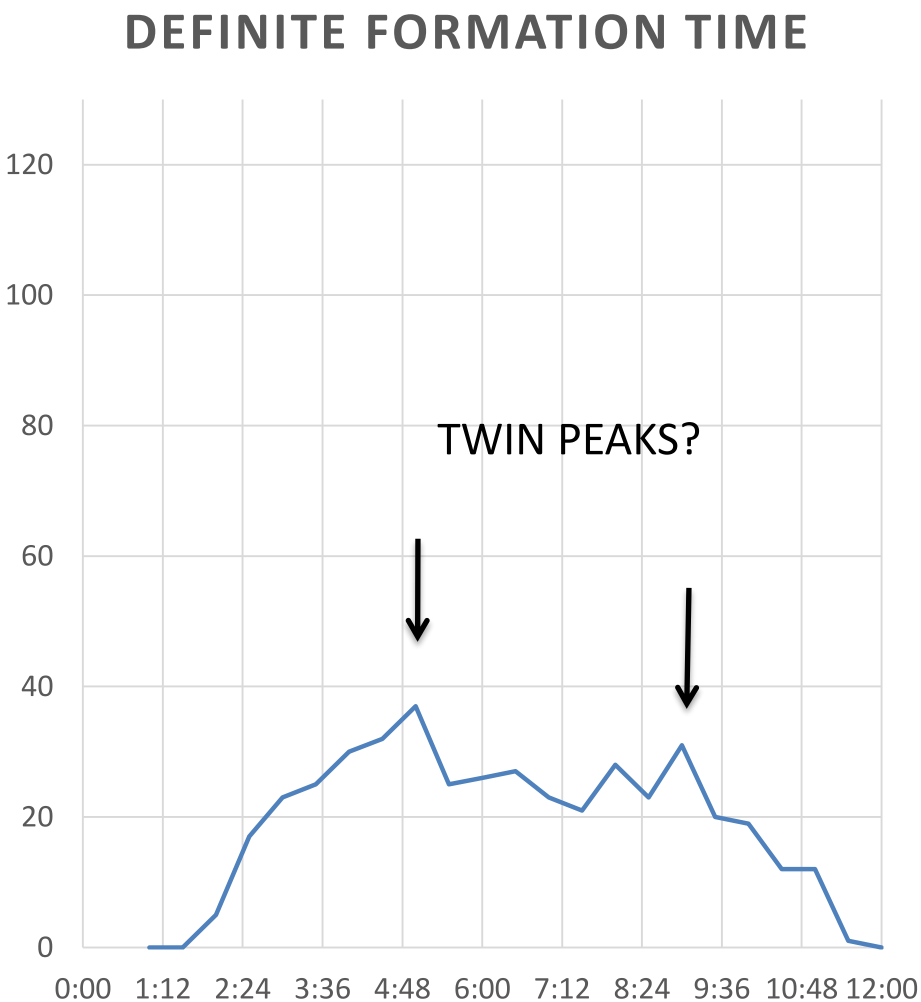
LIFE CYCLE OF MCCs FOR THE NORTHERN HEMISPHERE (LST)

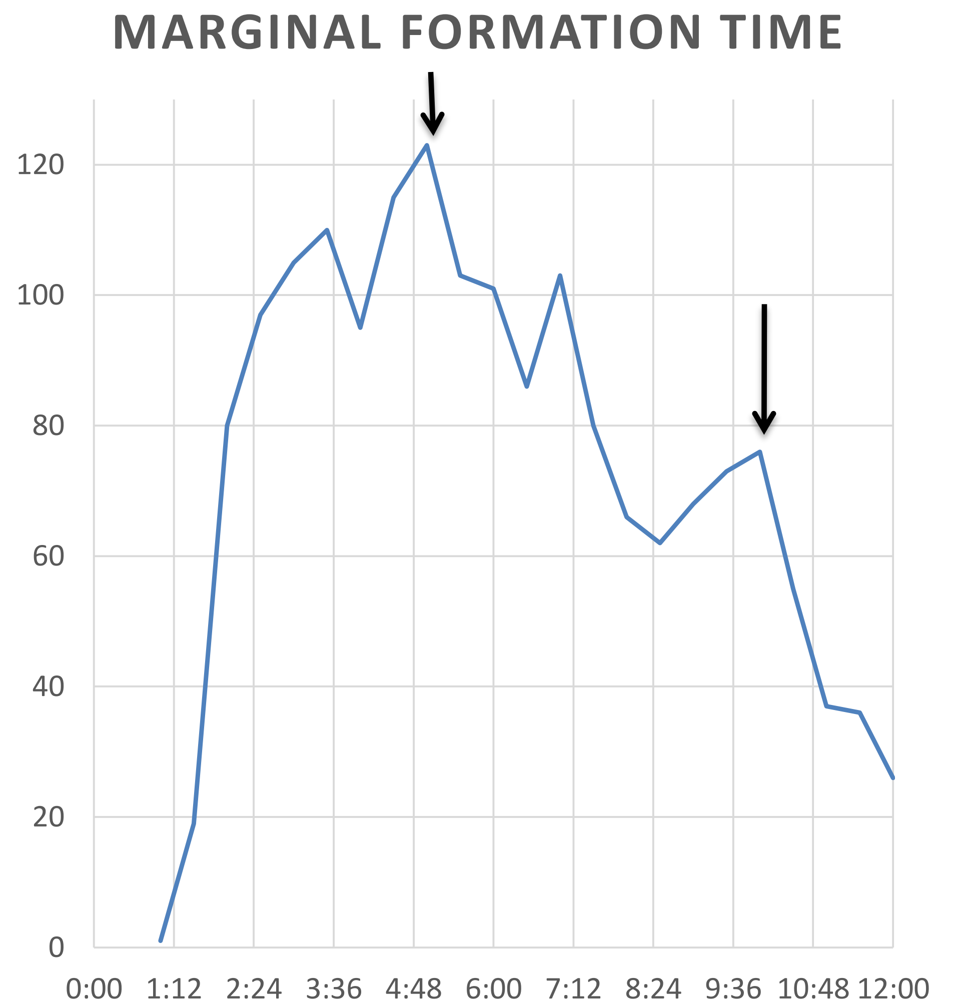
- CI MAX AT 0500 UTC (MIDNIGHT)

Laing and Fritsch 1997

(courtesy of Dylan Reif)

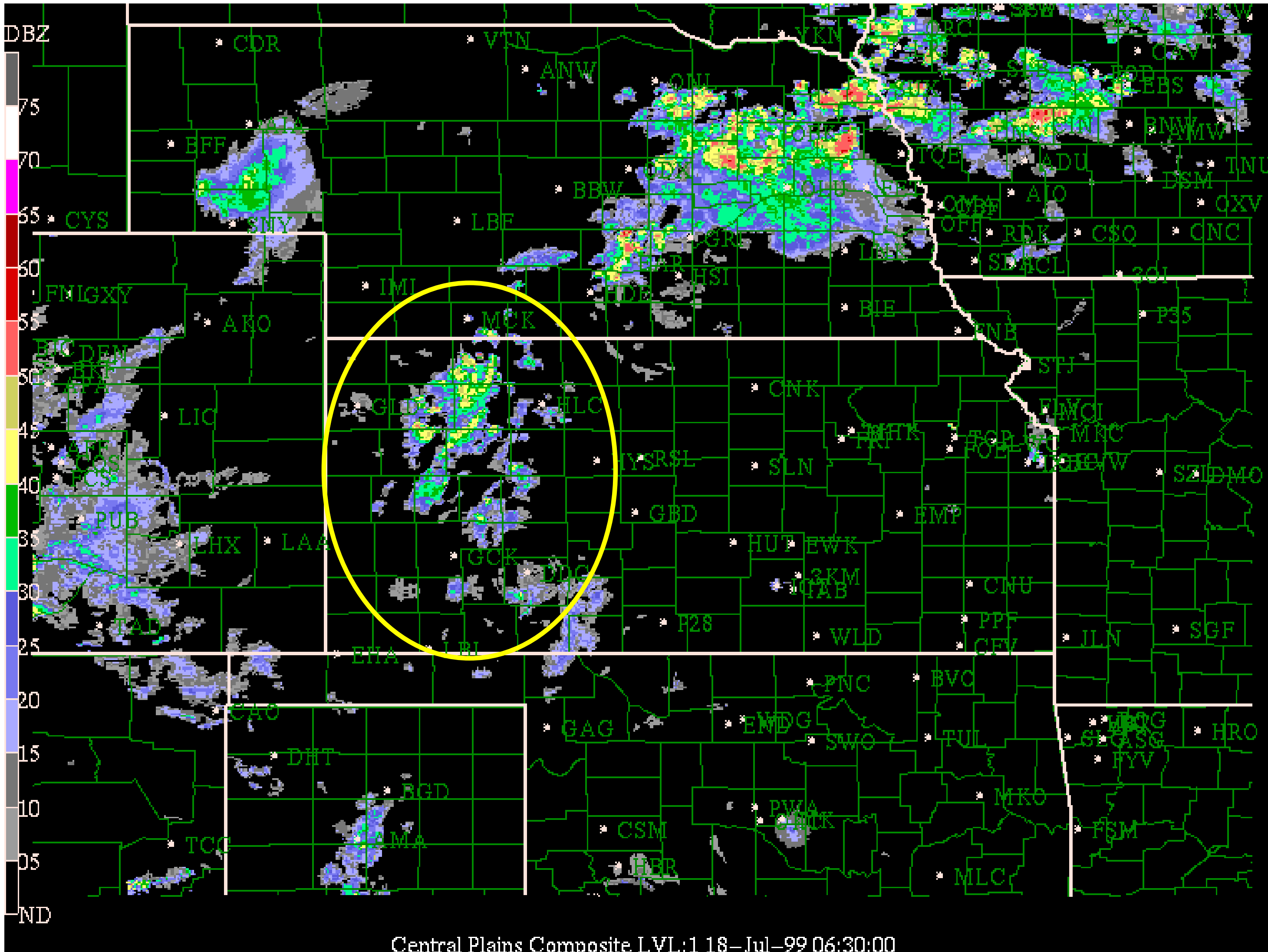
Formation Time (UTC)





(courtesy of Dylan Reif)

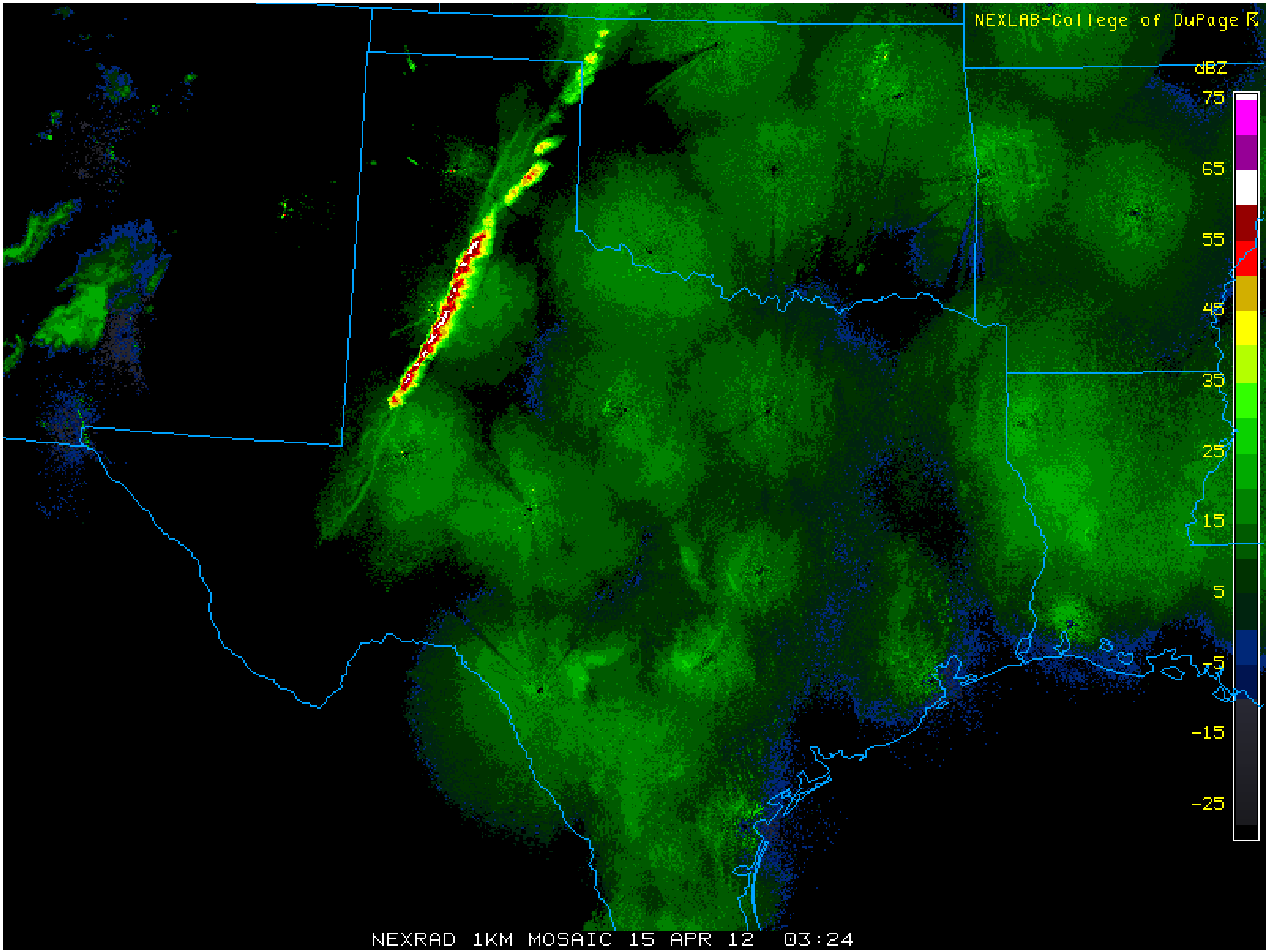
Areal



July 18, 1999

(courtesy of Dylan Reif)

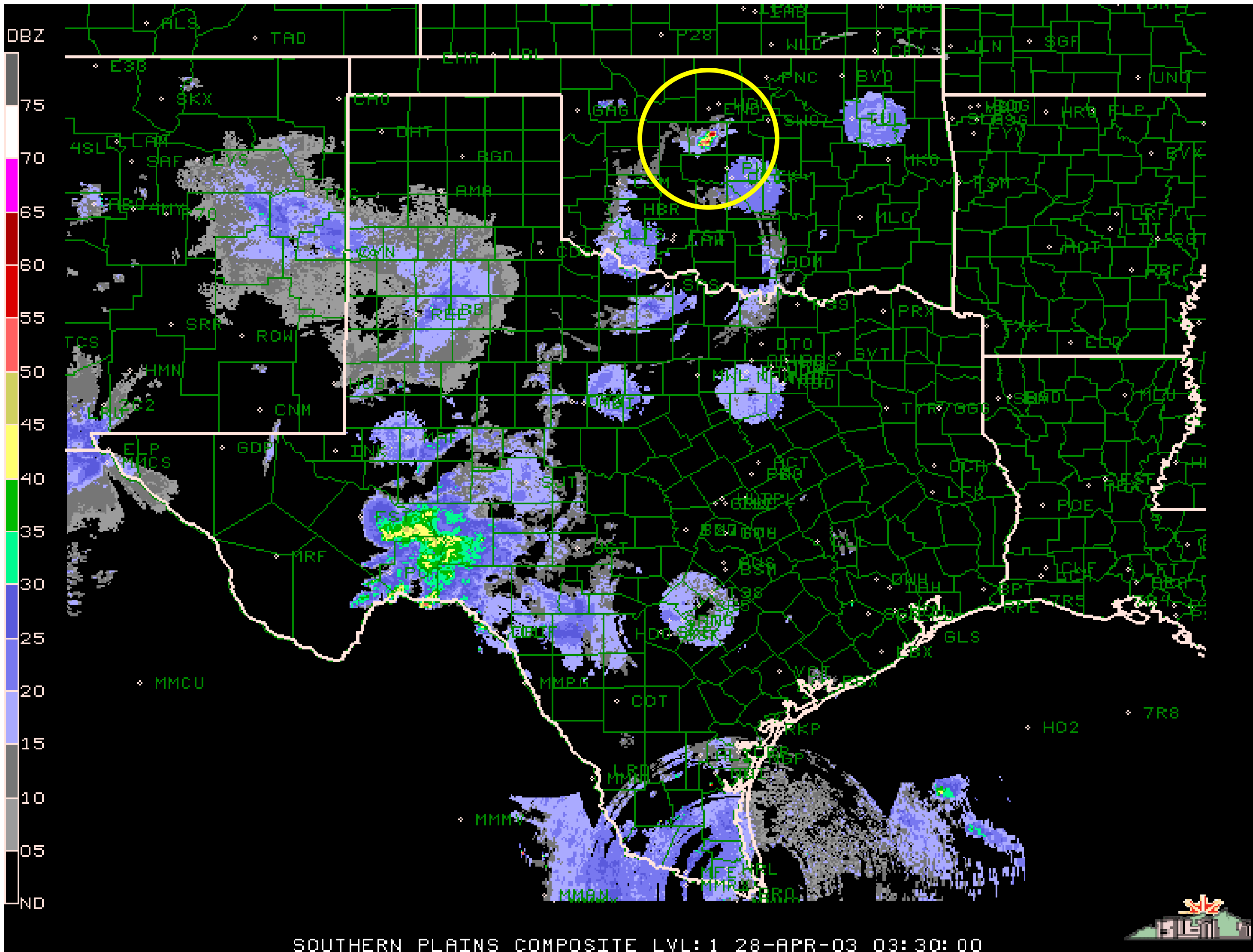
Linear



April 15, 2012

(courtesy of Dylan Reif)

Single Cell

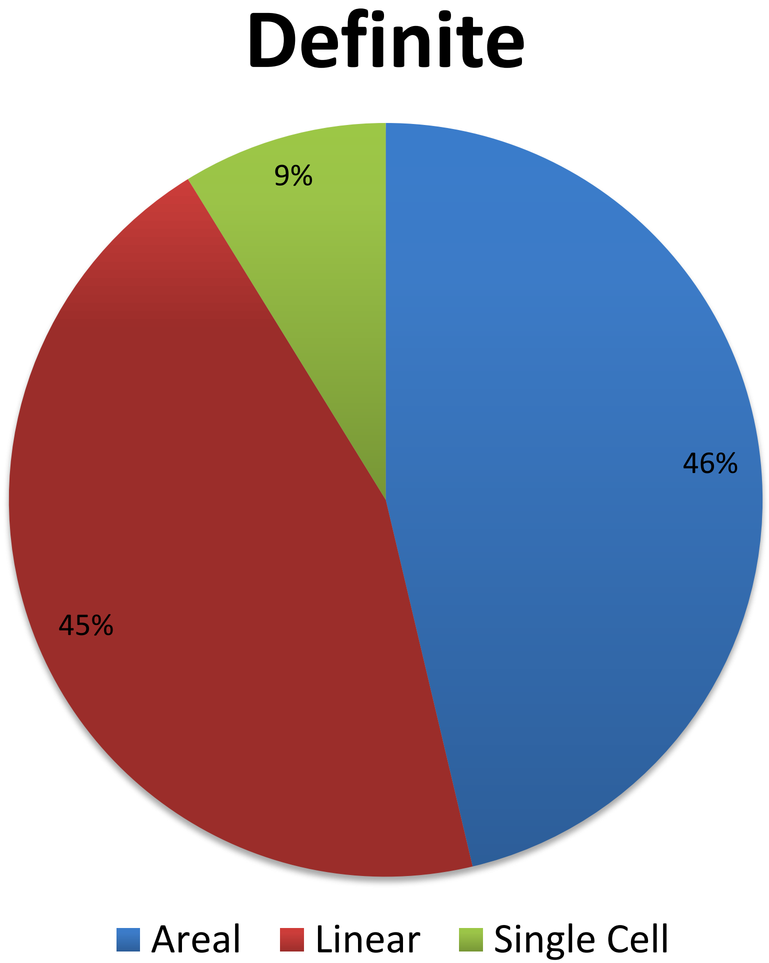


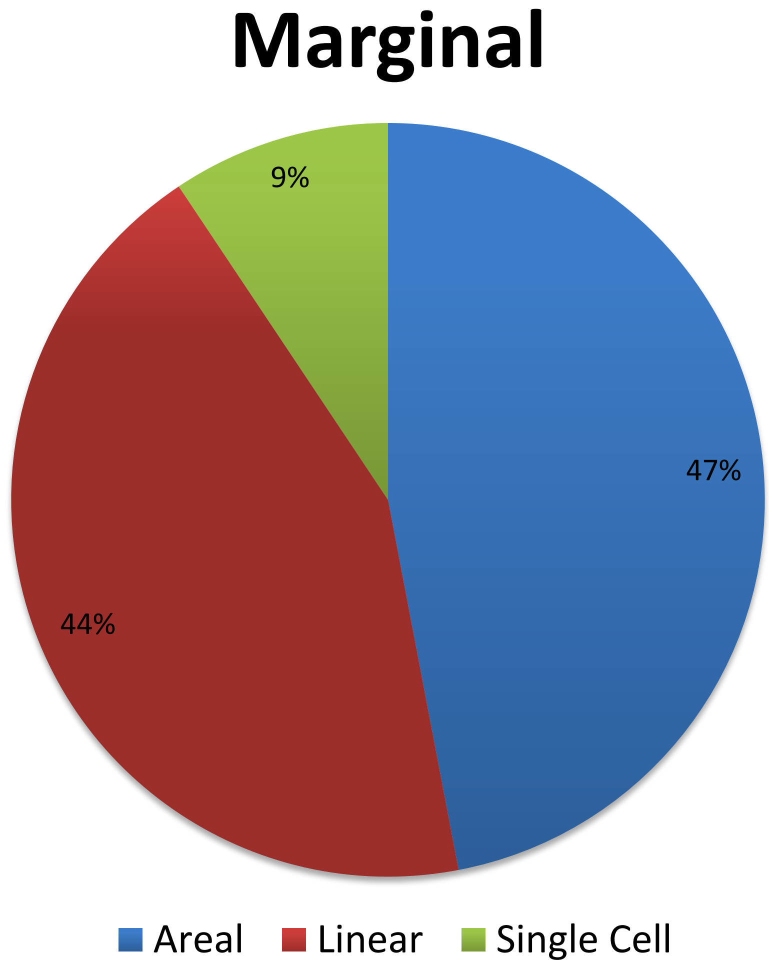
April 28, 2003

(courtesy of Dylan Reif)

Types of Storms:

MOSTLY DIVIDED UP BETWEEN LINES AND AREAL





FORECASTING ISSUES

- NOCTURNAL CONVECTION

  1. BOUNDARY-LAYER BASED?

     - SFC TEMPERATURE AT NIGHT NOT LIKELY TO BE HIGH ENOUGH TO REACH CONVECTIVE TEMPERATURE

     - SFC AIR COULD BE LIFTED TO REACH LFC:

       FRONTS – THERMALLY DIRECT VERTICAL CIRCULATION

       GUST FRONT/OUTFLOW BOUNDARIES – ASCENT AT LEADING EDGE – BAROCLINICALLY GENERATED HORIZONTAL VORTICITY

       WHEN IS ASCENT SUFFICIENT FOR CI?

       RKW THEORY? ROLE OF ENVIRONMENTAL SHEAR NORMAL TO GUST FRONT/OUTFLOW BOUNDARY?

2. ELEVATED?

- SLANTWISE ASCENT – NO CAPE
  ABOVE WARM OR STATIONARY FRONTS (GM): SCAPE, SCIN,
  CSI (OR MOIST SYMMETRIC INSTABILITY)
  USUALLY FIND SCAPE ~ 0: NEUTRALITY DUE TO OVERTURNING
  FRONTAL VERTICAL CIRCULATION ENHANCED WHEN
  STRATIFICATION NEARLY NEUTRAL

- BORES/GRAVITY WAVES (BOUSSINESQ) – WAVE MOTION
  ASCENT; STABLE BOUNDARY LAYER MAY INCREASE
  LIKELIHOOD OF BORES/WAVES:
  MUST ANTICIPATE WHEN BORES/GRAVITY WAVES
  WILL BE GENERATED
  MUST ANTICIPATE WHEN AMPLITUDE OF WAVES
  AND WATER VAPOR CONTENT ARE SUFFICIENT
  FOR CI – HOW TO MAXIMIZE VERTICAL
  DISPLACEMENTS? TRAPPING? SCORER PARAMETER

- UPPER-LEVEL TROUGH (FREE SYNOPTIC-SCALE OR DIABATICALLY GENERATED - LATENT HEAT RELEASE OR RADIATION, OVER THE ROCKIES, UPSTREAM) - QG ASCENT: WHEN SUFFICIENT TO LIFT AIR TO LFC? ELEVATED CAPE? SLANTWISE, BUT QG?

- WARM ADVECTION (ABOVE WARM/STATIONARY FRONT - LLJ) – QG ASCENT: WHEN SUFFICIENT TO LIFT AIR TO LFC? ELEVATED CAPE? SLANTWISE, BUT QG?

- SLANTWISE ASCENT FROM FRONTAL CIRCULATION (GM) – *WITH* ELEVATED CAPE
  INTENSITY OF FRONTAL VERTICAL CIRCULATION ENHANCED
    WHEN STATIC STABILITY IS LOW, EVEN IF SCAPE ~ 0

IHOP

- FRONTAL VERTICAL CIRCULATIONS AND GUST FRONT VERTICAL CIRCULATIONS MOST COMMON TRIGGERS OF CI

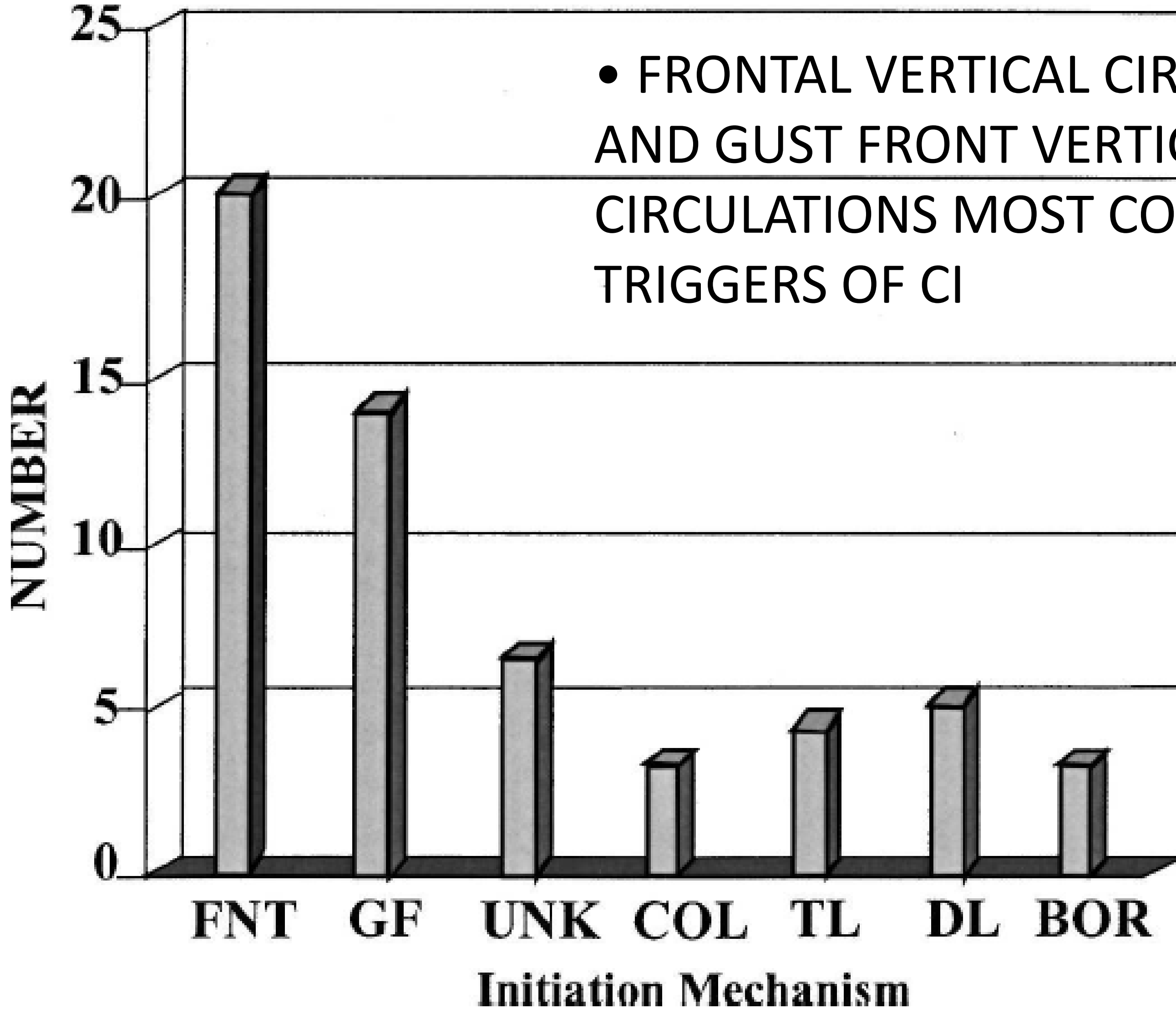
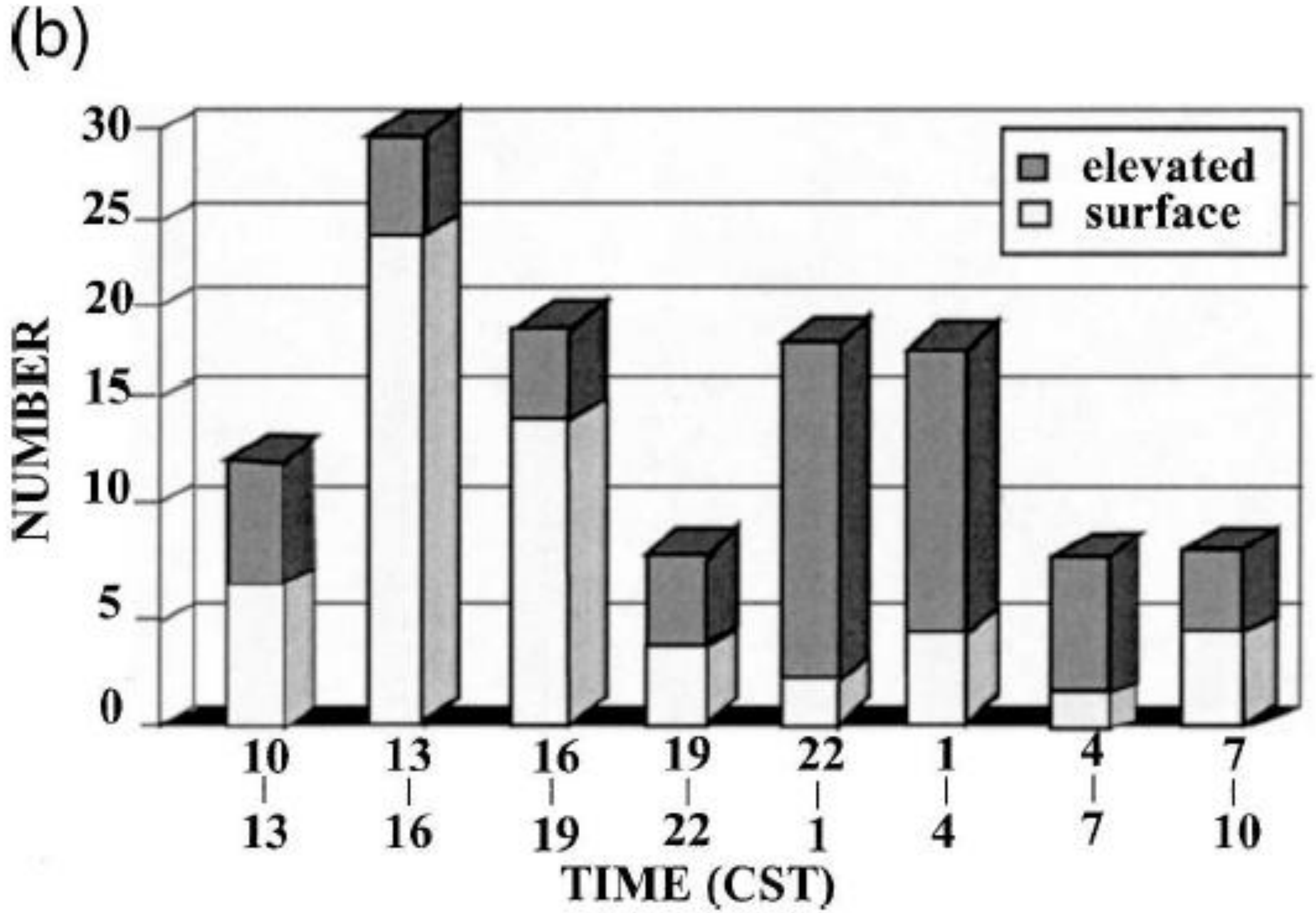


FIG. 4. Number of surface-based initiation episodes classified by initiation mechanism. FNT—frontal, GF—gust front, UNK—unknown, COL—colliding, TL—trough line, DL—dryline, BOR—bore.

Wilson and Roberts 2006

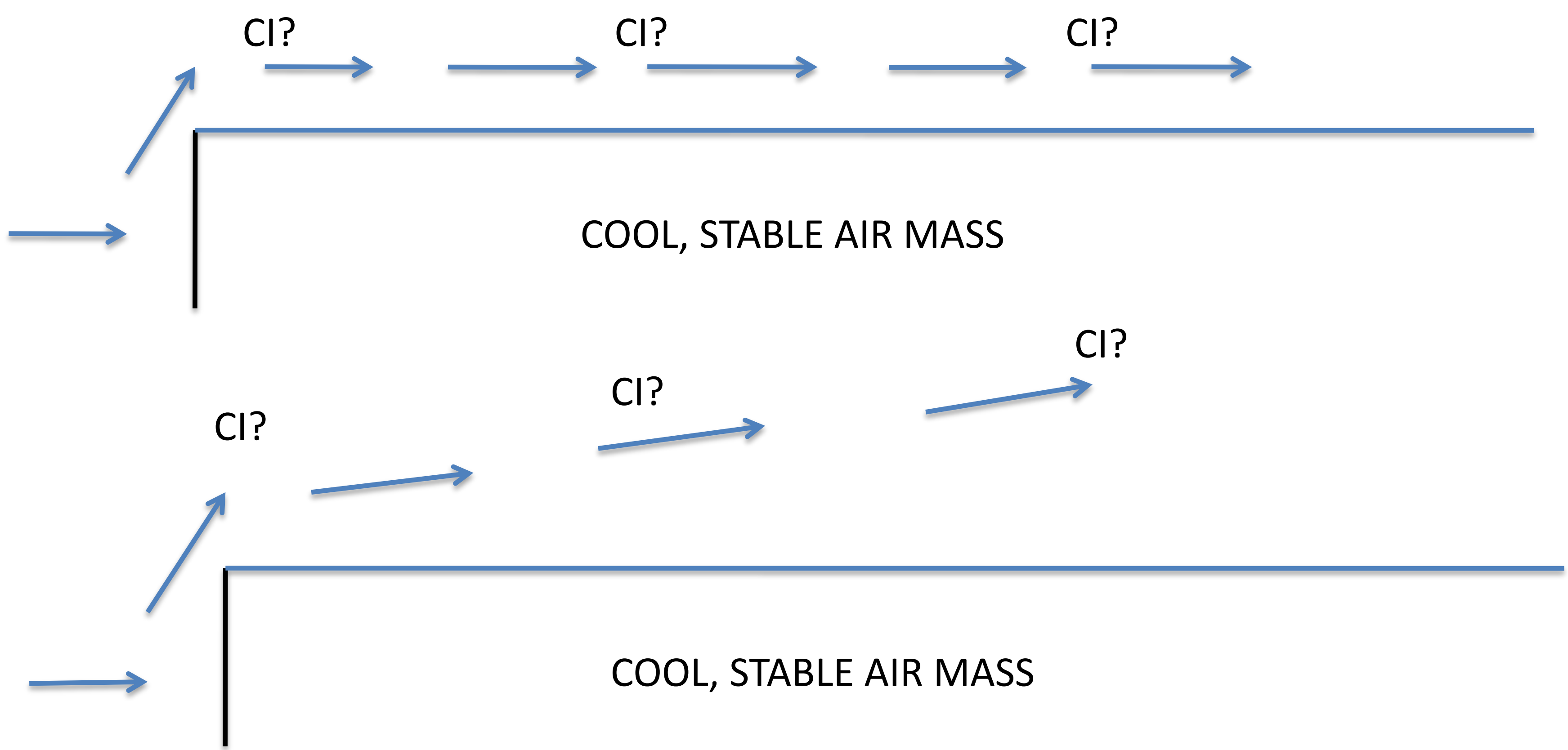
IHOP:
50% OVERALL ELEVATED, BUT MOSTLY ELEVATED AT NIGHT



Wilson and Roberts 2006

• DISTINCTION BETWEEN ELEVATED AND BOUNDARY-LAYER BASED CONVECTION IS NOT ALWAYS CLEAR CUT:

AIR THAT IS LIFTED MAY/PROBABLY HAD ITS ORIGIN IN THE BOUNDARY LAYER IF ONE TRACES THE AIR BACK IN TIME LONG ENOUGH LATERALLY: WHAT IS THE DISTINCTION BETWEEN VERTICAL LIFT AND SLANTWISE LIFT? STATIC STABILITY VS. INERTIAL STABILITY?



MAJOR CHALLENGES FOR FORECASTING ELEVATED, NOCTURNAL CONVECTION:

- *THERE IS NO MESOSCALE NETWORK OF OBSERVING SYSTEMS OF THERMODYNAMIC VARIABLES ABOVE THE BOUNDARY LAYER, AS THERE IS AT THE SFC*

- *VISIBLE SATELLITE IMAGERY CANNOT BE USED TO IDENTIFY CLOUDS THAT MIGHT GROW INTO CONVECTIVE STORMS*

SCENARIOS:

1. THERE IS NO AFTERNOON, PRECEDING CONVECTION, SO NOCTURNAL CONVECTION BEGINS AFTER DARK (*WAIT UNTIL DARK)* WITHOUT ANY RELATION TO ANY OTHER ONGOING/ NEARBY CONVECTIVE ACTIVITY

2. NOCTURNAL CONVECTION IS RELATED TO EARLIER CONVECTION VIA GUST FRONTS/BORES GENERATED BY EARLIER/NEIGBHORING CONVECTION

IF 1, CAN WE FORECAST CI FROM A “CLEAN SLATE”?

IF 2, CAN WE FORECAST GUST FRONTS/BORES AND WHETHER OR NOT THEY WILL BE STRONG ENOUGH FOR CI?

- WE MUST MAKE INFERENCES FROM RADAR DATA:

    LOCATE BORES, GRAVITY WAVES (FINELINES/CONV. SIGS.)
    LOCATE BOUNDARIES ALOFT (CONVERGENCE SIGNATURES)

- WE MUST MAKE USE OF NUMERICAL MODEL FORECASTS

    IF A MODEL SHOWS CI, WILL THERE REALLY BE CI?
    IF A MODEL DOES NOT SHOW CI, WILL THERE REALLY NOT BE ANY CI? SKILL OF CONVECTION ALLOWING MODELS? SKILL OF MODELS WITH PARAMETERIZED CONVECTION?

- IF WE ANTICIPATE WHERE THERE WILL BE CI, THEN WHERE WILL THE BEST LOCATIONS BE TO LOOK FOR SUBSEQUENT GUST FRONTS AND BORES, WHICH WILL THEN IN TURN EFFECT SECONDARY CI?

- BEST PREDICTABILITY FOR FRONTS (SYNOPTIC SCALE), LEAST FOR GUST FRONTS (Wilson and Roberts 2006; IHOP):

  IT WILL BE VERY CHALLENGING TO PREDICT CI FROM GUST FRONTS/BORES USING CONVECTION-ALLOWING MODELS