An Update to the Warm-Season Convective Wind Climatology of KSC/CCAFS

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Background

- 17-year (1995-2011), warm-season (May-Sep) Kennedy Space Center / Cape Canaveral Air Force Station convective wind climatology
- Initially developed as an update to the 4-year climatology by Sanger (1999)
- 1995-2003 warning level (≥35kt) convective events by Loconto *et al.* (2006)
- 1995-2005 all convective events by Cummings *et al.* (2007)
- 2006-2007, 2008-2011 convective events added by Ander *et al.* (2009) & Laro (2011), Laro (2012), respectively

Additional Previous Research

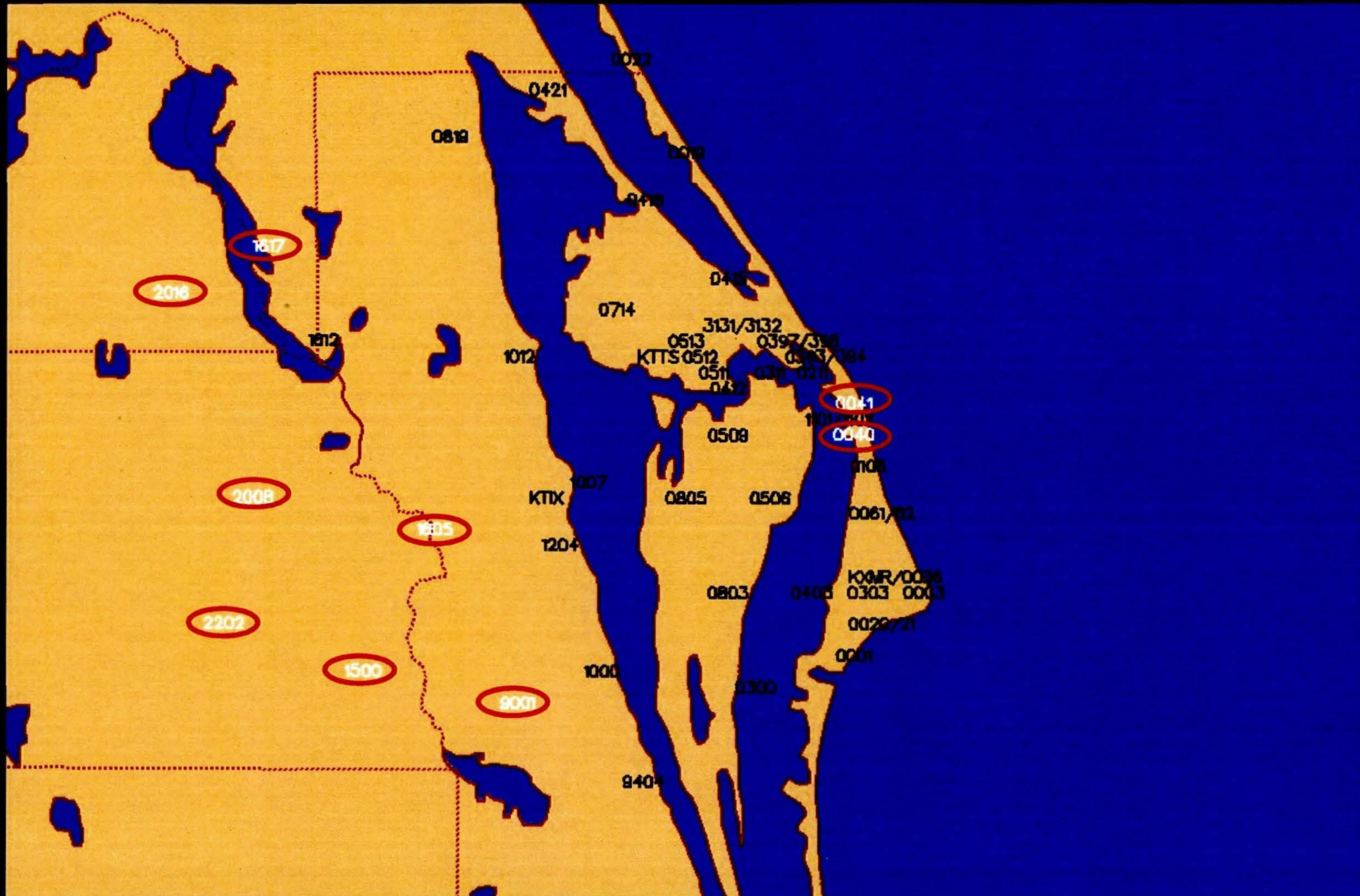
- Cummings (2007) – Case study of 23 Jul 2005 event
- Dupont (2007) – Case study of 31 Aug 2005 event
- Dinon *et al.* (2008) – Developed a radar climatology
- McCue (2010) – Evaluation of convective wind forecasting techniques and development/evaluation of new statistical forecasting methods based on 1500Z* KXMR soundings
- Rennie (2010) – Evaluation and introduction of statistical convective wind forecasting techniques using WSR-88D methods
- Harris (2011) – Evaluated use of dual-polarization radar techniques (updraft melting layer height) in forecasting strength of convective winds
- Anderson (2011) – Evaluation of McCue (2010) results and additional development of statistical forecasting techniques

Wind Tower Network

- 30 km x 40 km area around KSC/CCAFS
- 5-minute wind data from 82 anemometers across 36 towers (heights of 12, 20, 54, 60, 90, 145, 162, 204, 295 ft)
  - Originally 45 towers, 9 did not meet data availability thresholds (≥70% over entire climatology, without a single month below 65%)
  - Most low data availability towers were significantly west of KSC/CCAFS
  - Koermer and Roeder (2008) showed that data from the westernmost towers were of little significance in anticipating convective winds at KSC/CCAFS

- 1995-2003 tower data provided & prepared by the NASA Applied Meteorology Unit (AMU)
- 2004-2011 raw 5-minute tower data provided by Computer Sciences Raytheon (CSR)

CCAFS/KSC Wind Tower Network



Map of KSC/CCAFS weather towers used to collect wind data for this climatology. Only data from towers with black numeric identifiers were used in this study. Towers with white identifiers were eliminated due to low data availability.

Additional Data

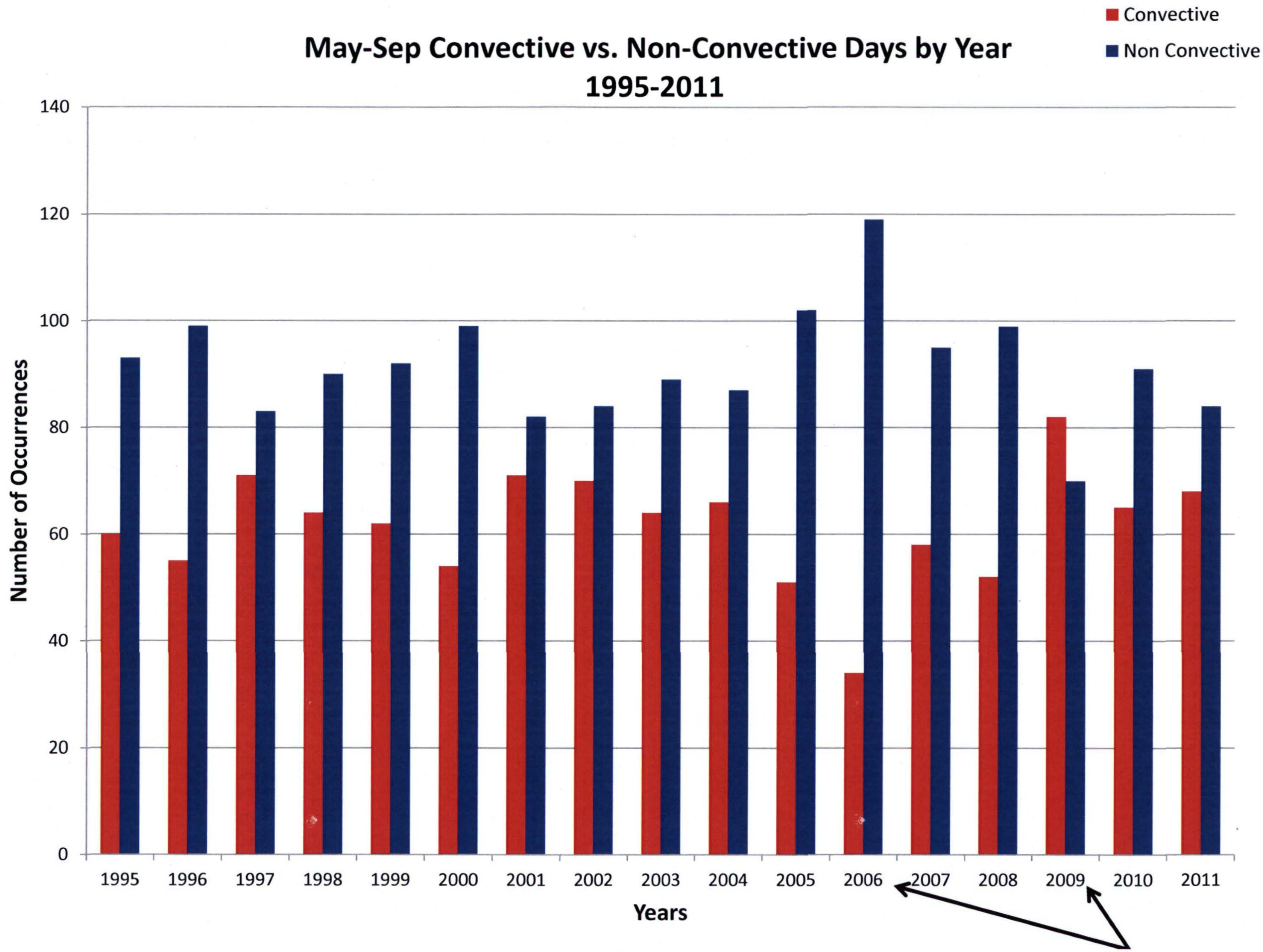
- Added WSR-88D NEXRAD radar data from National Weather Service-Melbourne (MLB) and Tampa (TBW) from NCDC in 2007
- GOES satellite data
- KXMR soundings
  - 1995-2007 raw data obtained from CSR, were not encoded according to old WMO dewpoint depression convention
    - Soundings from GTS transmissions prior to Nov. 2007: RH ≤ 20% automatically set dewpoint depression = 30°C
- Surface observations from KTTS, KXMR, KTIX, KCOF
- Unisys tropical system archives
- Plymouth State Weather Center Archives

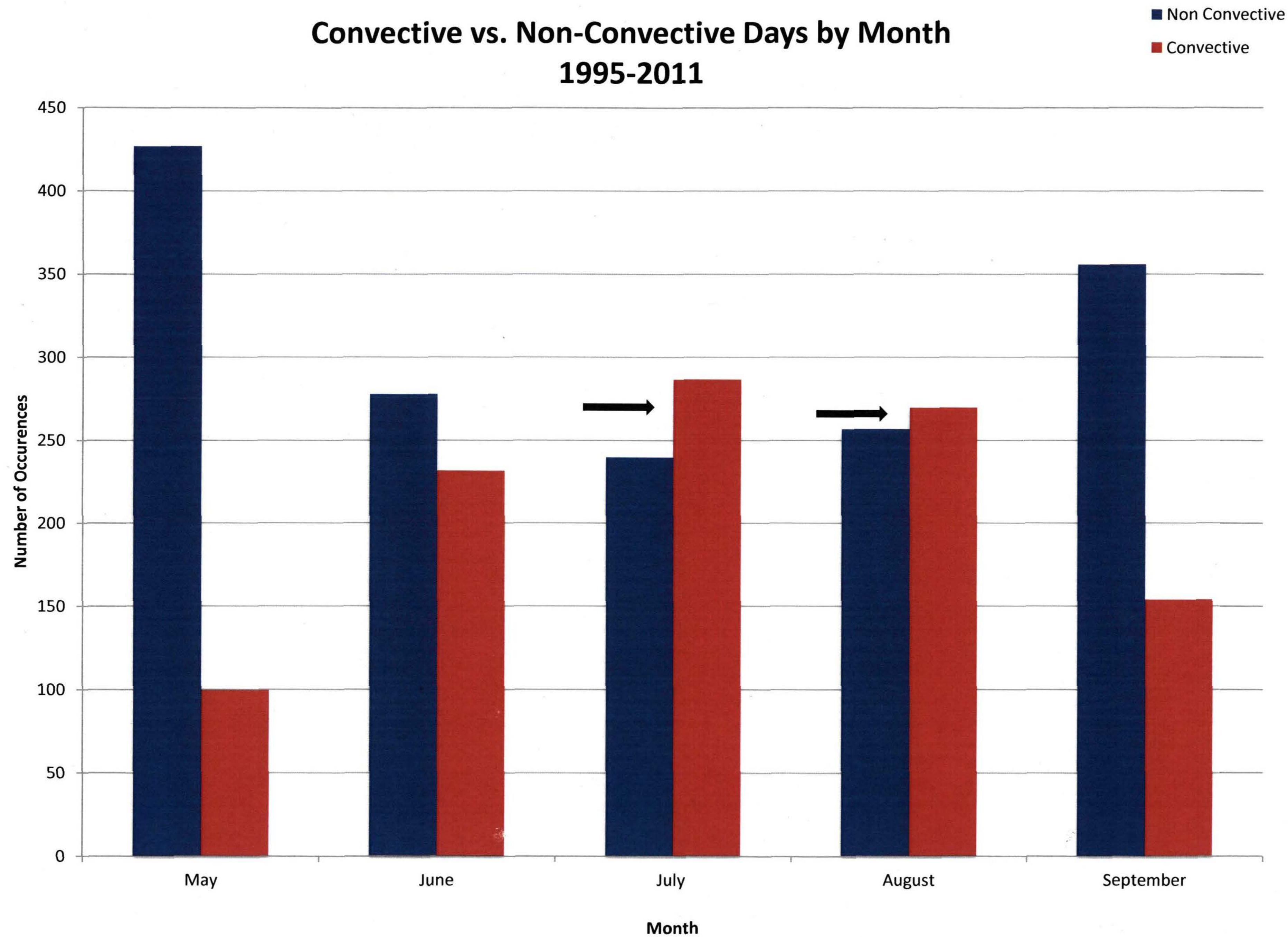
Identification of Convective Periods

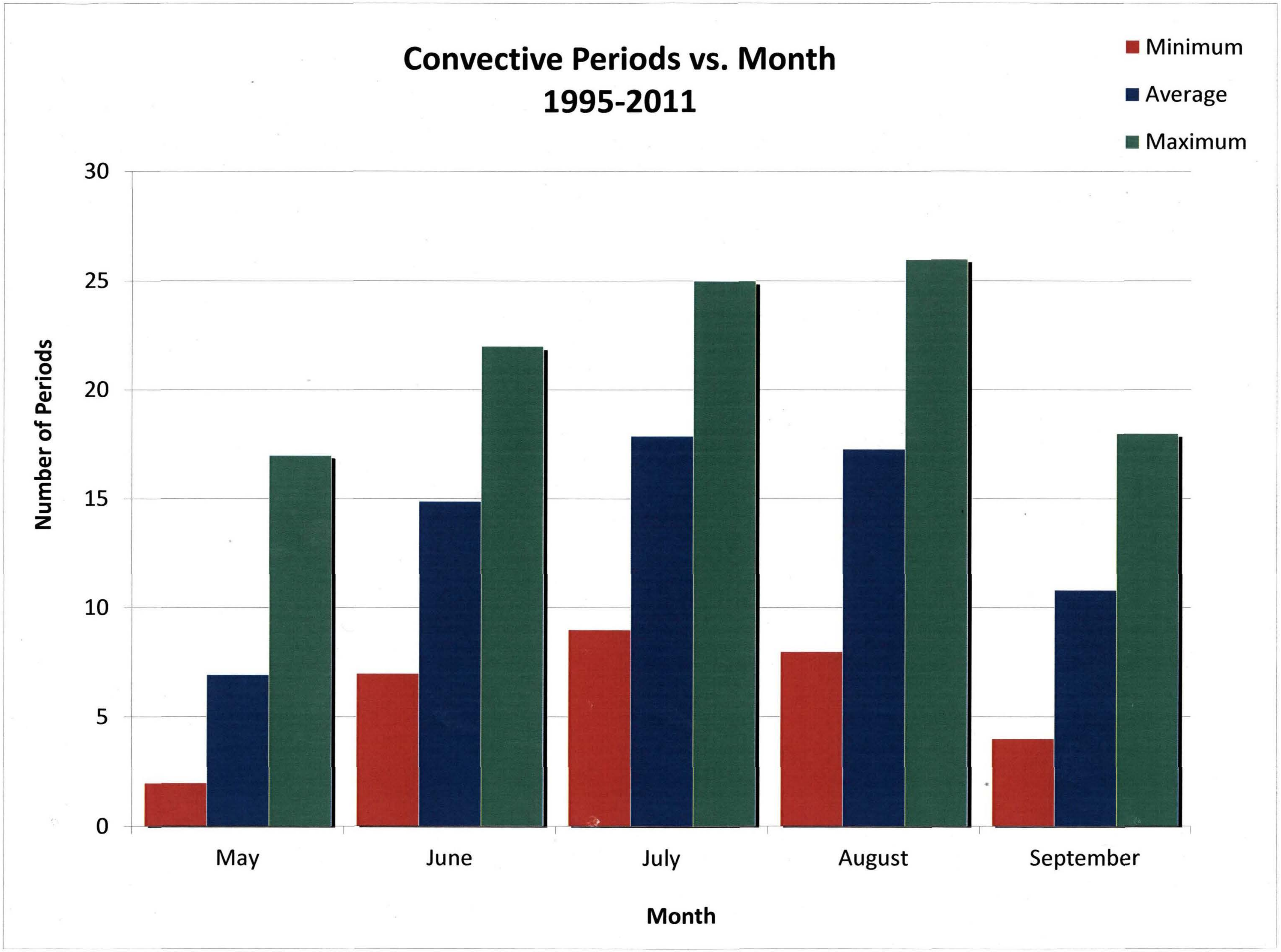
- Begins at top of the hour when convection first occurs in the area, ends at the top of the hour after the last evidence of convection in the area, and is followed by a ≥6 hr break in convective activity (Cummings *et al.* 2007)
- NWS-KMLB NEXRAD radar base reflectivity images refine start and end times using a 40 dBz threshold
- Strong synoptic pressure gradients (fronts, nearby tropical systems) eliminated from the climatology
- 1100 identified in the 17-year climatology

Additional QC & Refining of Convective Periods

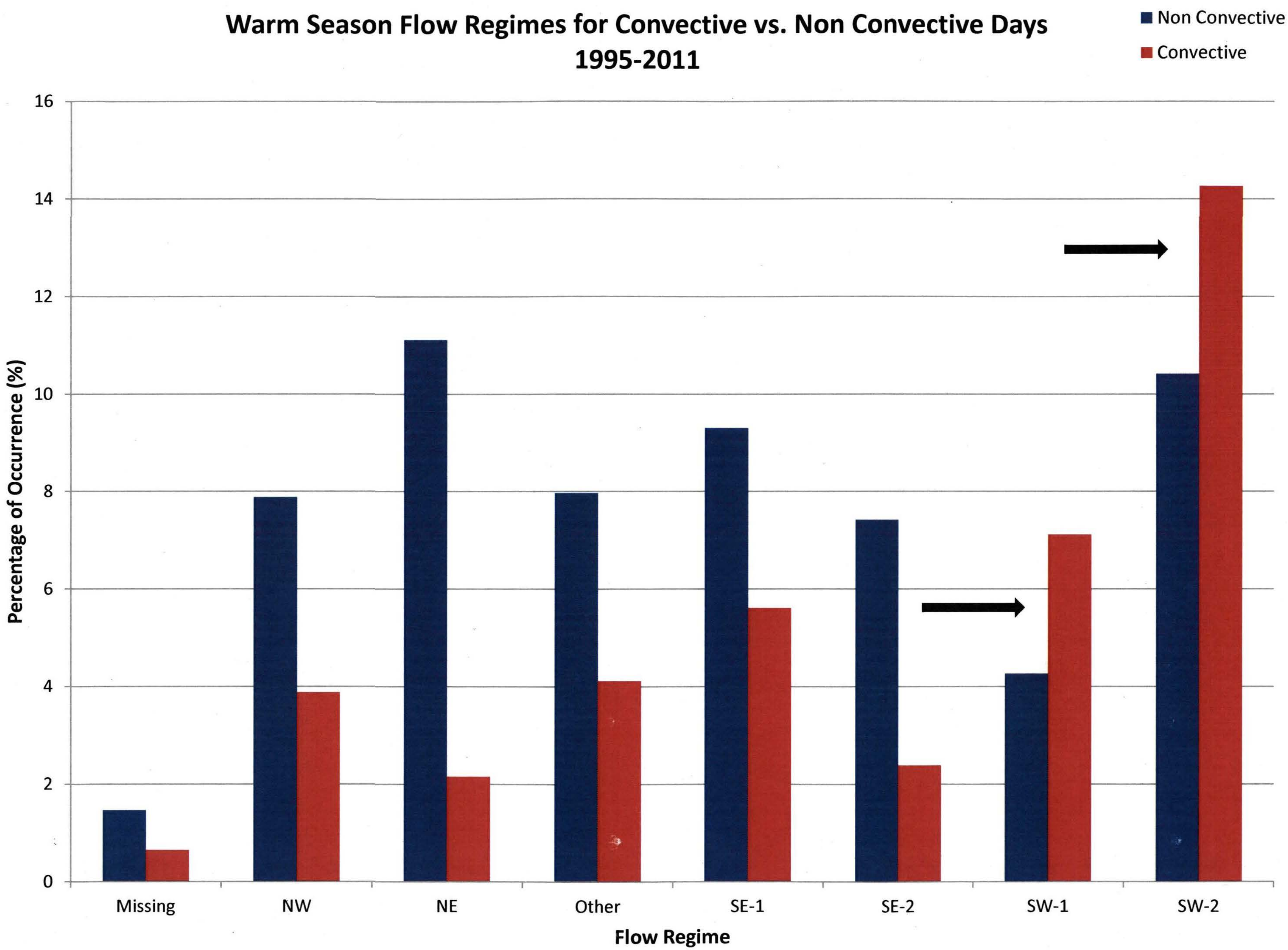
- Further refined start and end times of convective periods using KMLB NEXRAD radar 40 dBz threshold
  - 6-hour break rule allowed some convective periods to be broken down into multiple events, while others were merged
- Identified gaps in KMLB radar data where KTBW could be substituted
- Identified incorrectly counted convective periods which crossed between months
- Remaining synoptic events identified and removed from the climatology
- Updates to climatological statistics and figures

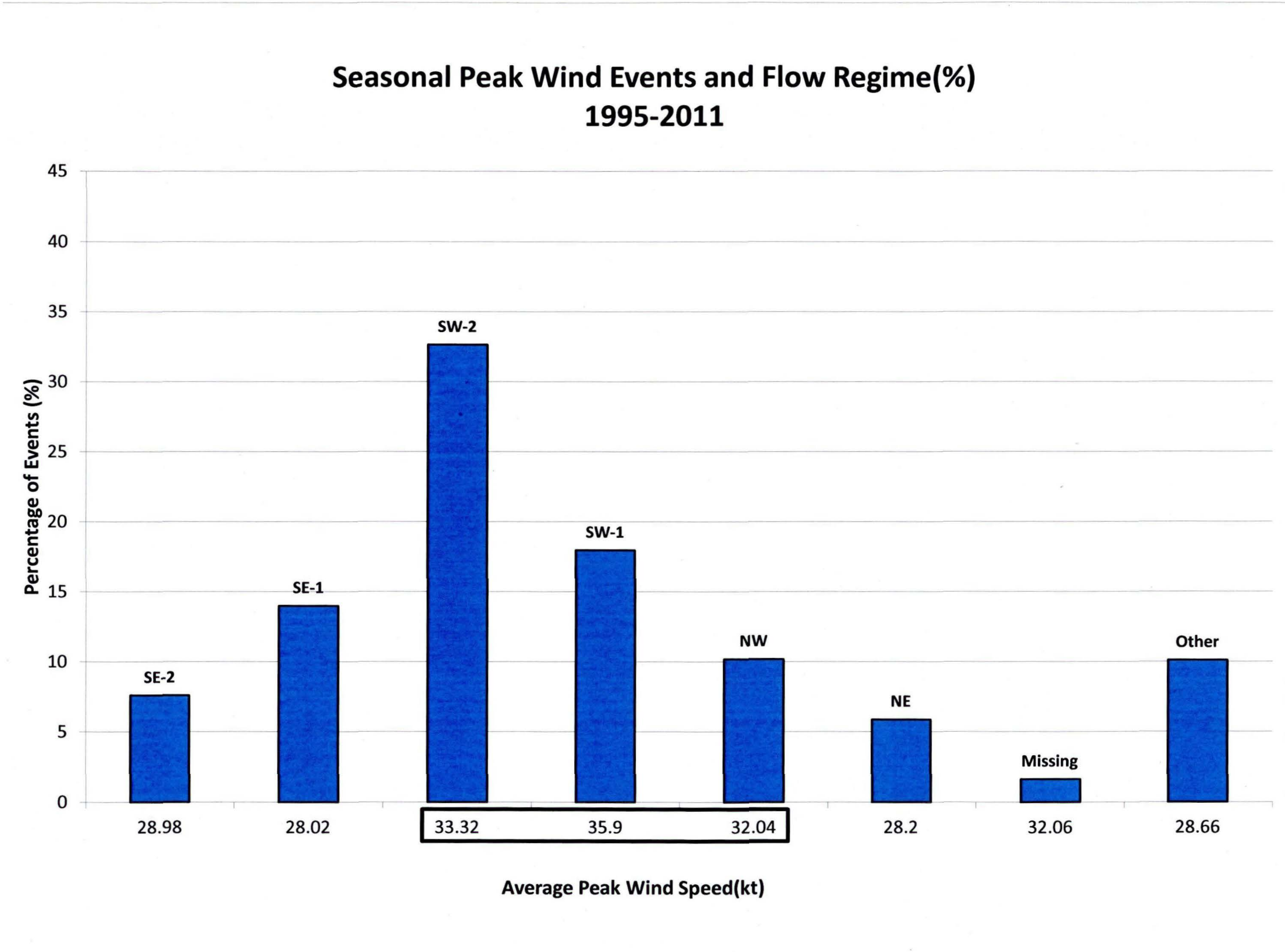

May-Sep Convective vs. Non-Convective Days by Year
1995-2011
Convective
Non Convective
Number of Occurrences
0
20
40
60
80
100
120
140
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Years


Convective vs. Non-Convective Days by Month
1995-2011
Non Convective
Convective
Number of Occurences
450
400
350
300
250
200
150
100
50
0
May
June
July
August
September
Month

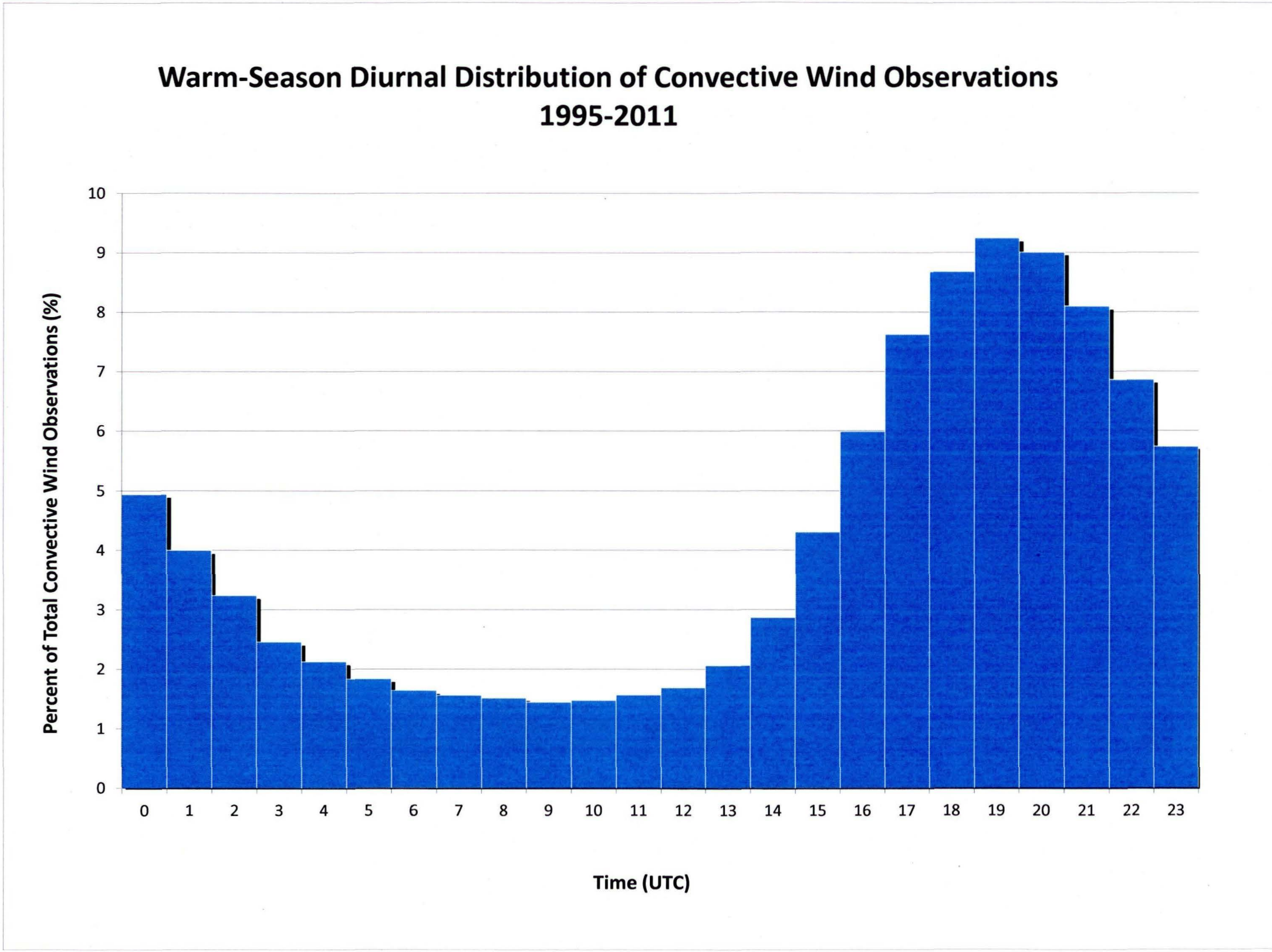

Convective Periods vs. Month
1995-2011
Minimum
Average
Maximum
30
25
20
15
10
5
0
Number of Periods
May
June
July
August
September
Month

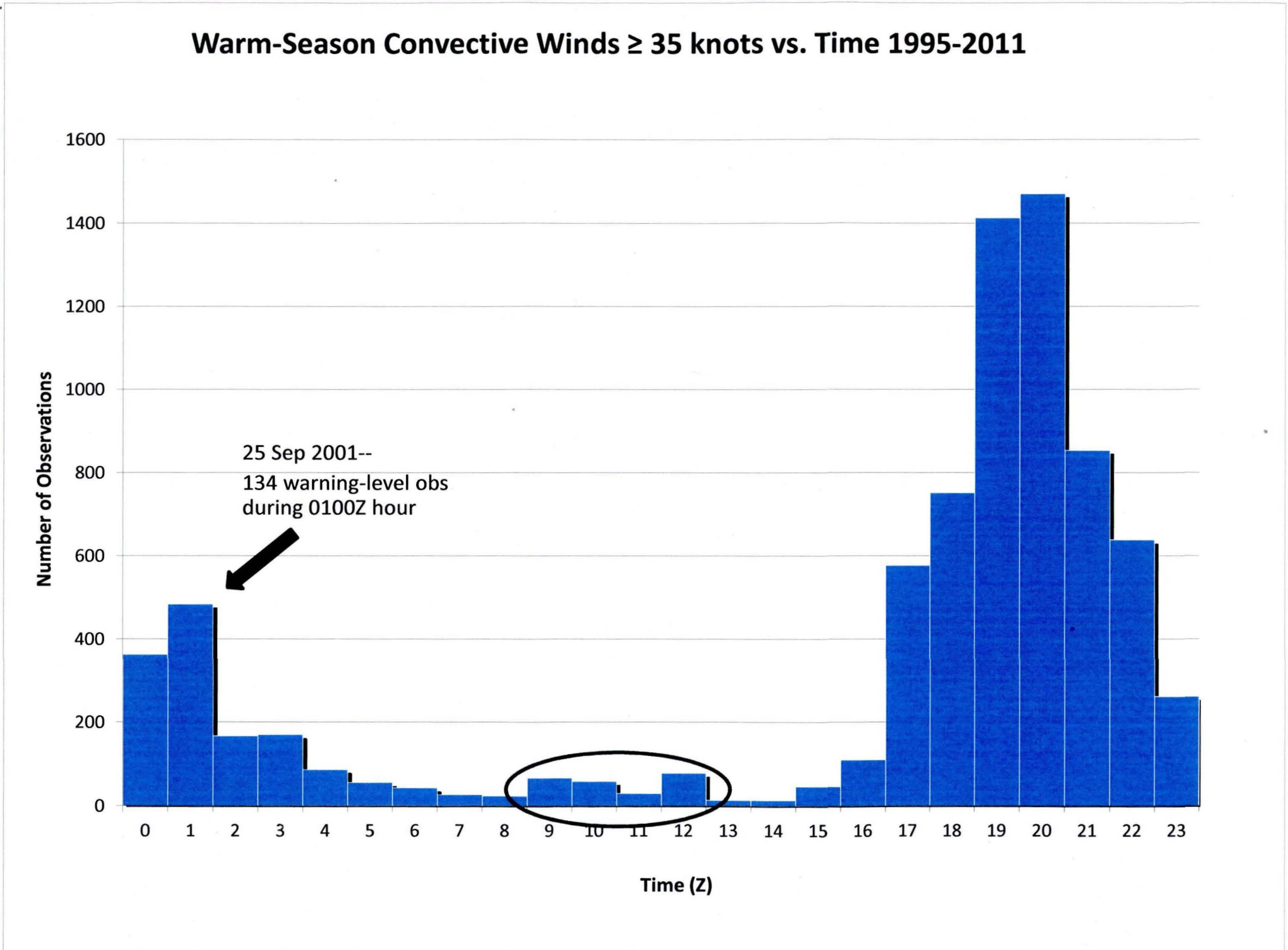
FLOW REGIME	SUBTROPICAL RIDGE POSITION
SW-1	Subtropical ridge south of Miami
SW-2	Subtropical ridge between Miami and Tampa
SE-1	Subtropical ridge between Tampa and Jacksonville
SE-2	Subtropical ridge north of Jacksonville
NW	Subtropical ridge far to south and extending far into Gulf of Mexico and stronger than normal
NE	Subtropical ridge far to north and extending into SE US and much stronger than normal
Other	Subtropical ridge position not defined
Missing	Missing synoptic data to determine flow regime


Warm Season Flow Regimes for Convective vs. Non Convective Days
1995-2011
Non Convective
Convective
Percentage of Occurrence (%)
16
14
12
10
8
6
4
2
0
Missing
NW
NE
Other
SE-1
SE-2
SW-1
SW-2
Flow Regime



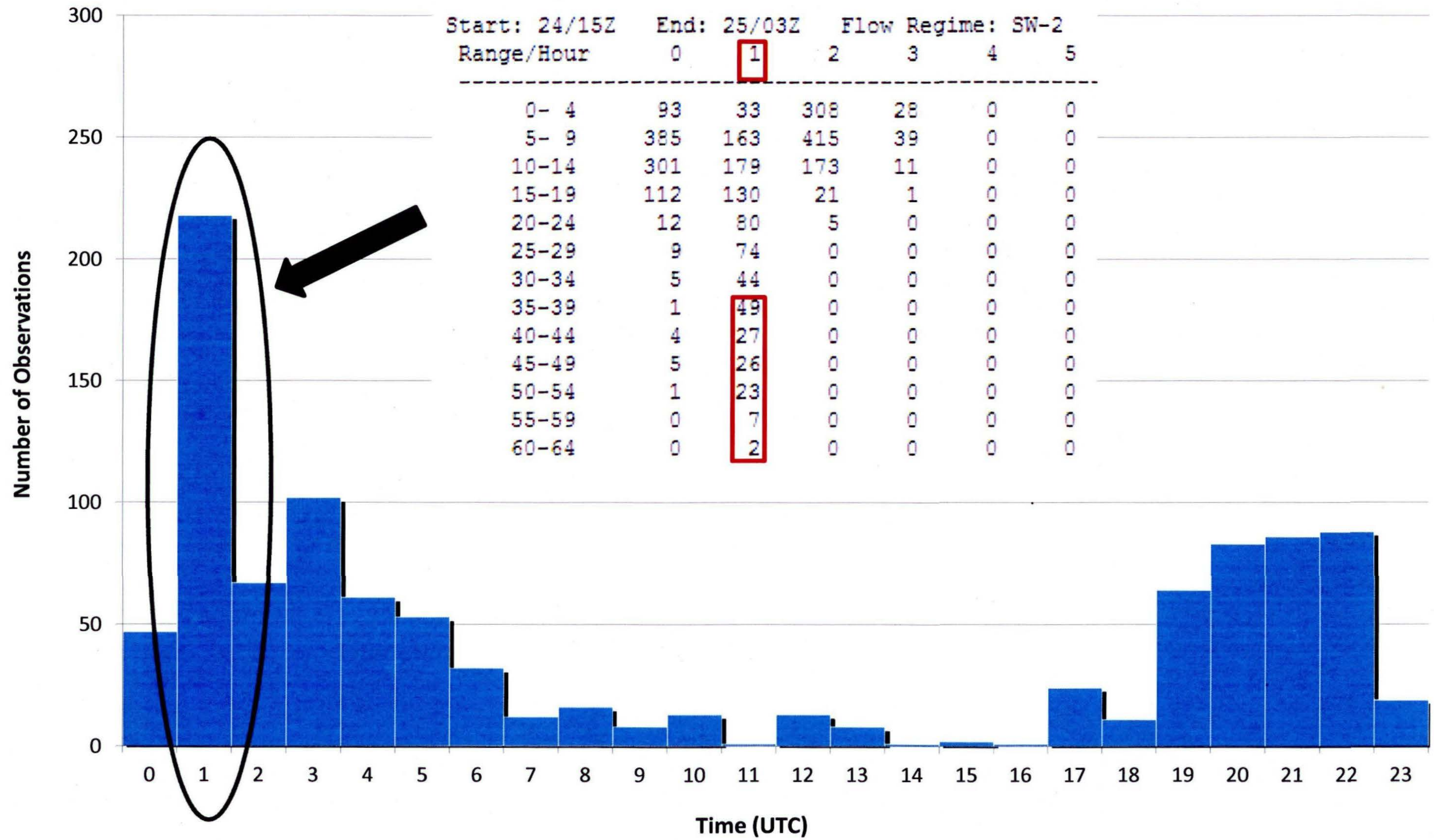
Seasonal Peak Wind Events and Flow Regime(%)
1995-2011
45
40
35
30
25
20
15
10
5
0
Percentage of Events (%)
SE-2
SE-1
SW-2
SW-1
NW
NE
Missing
Other
28.98
28.02
33.32
35.9
32.04
28.2
32.06
28.66
Average Peak Wind Speed(kt)


Warm-Season Diurnal Distribution of Convective Wind Observations
1995-2011
Percent of Total Convective Wind Observations (%)
0
1
2
3
4
5
6
7
8
9
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time (UTC)



Warm-Season Convective Winds ≥ 35 knots vs. Time 1995-2011
Number of Observations
1600
1400
1200
1000
800
600
400
200
0
25 Sep 2001--
134 warning-level obs
during 0100Z hour
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time (Z)

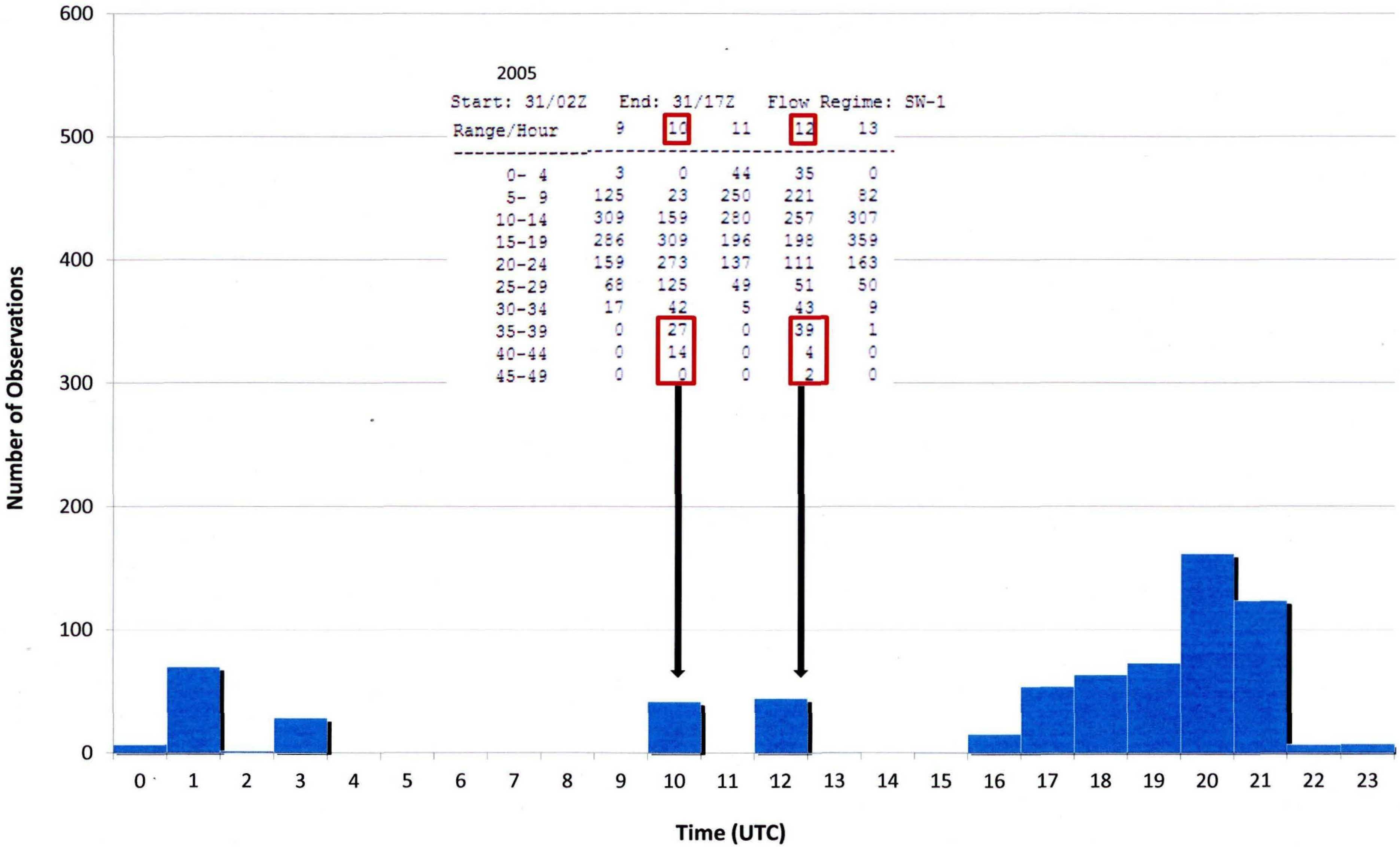
September Convective Winds ≥ 35 knots vs. Time
1995-2011



Start: 24/15Z End: 25/03Z Flow Regime: SW-2

Range/Hour	0	1	2	3	4	5
0- 4	93	33	308	28	0	0
5- 9	385	163	415	39	0	0
10-14	301	179	173	11	0	0
15-19	112	130	21	1	0	0
20-24	12	80	5	0	0	0
25-29	9	74	0	0	0	0
30-34	5	44	0	0	0	0
35-39	1	49	0	0	0	0
40-44	4	27	0	0	0	0
45-49	5	26	0	0	0	0
50-54	1	23	0	0	0	0
55-59	0	7	0	0	0	0
60-64	0	2	0	0	0	0

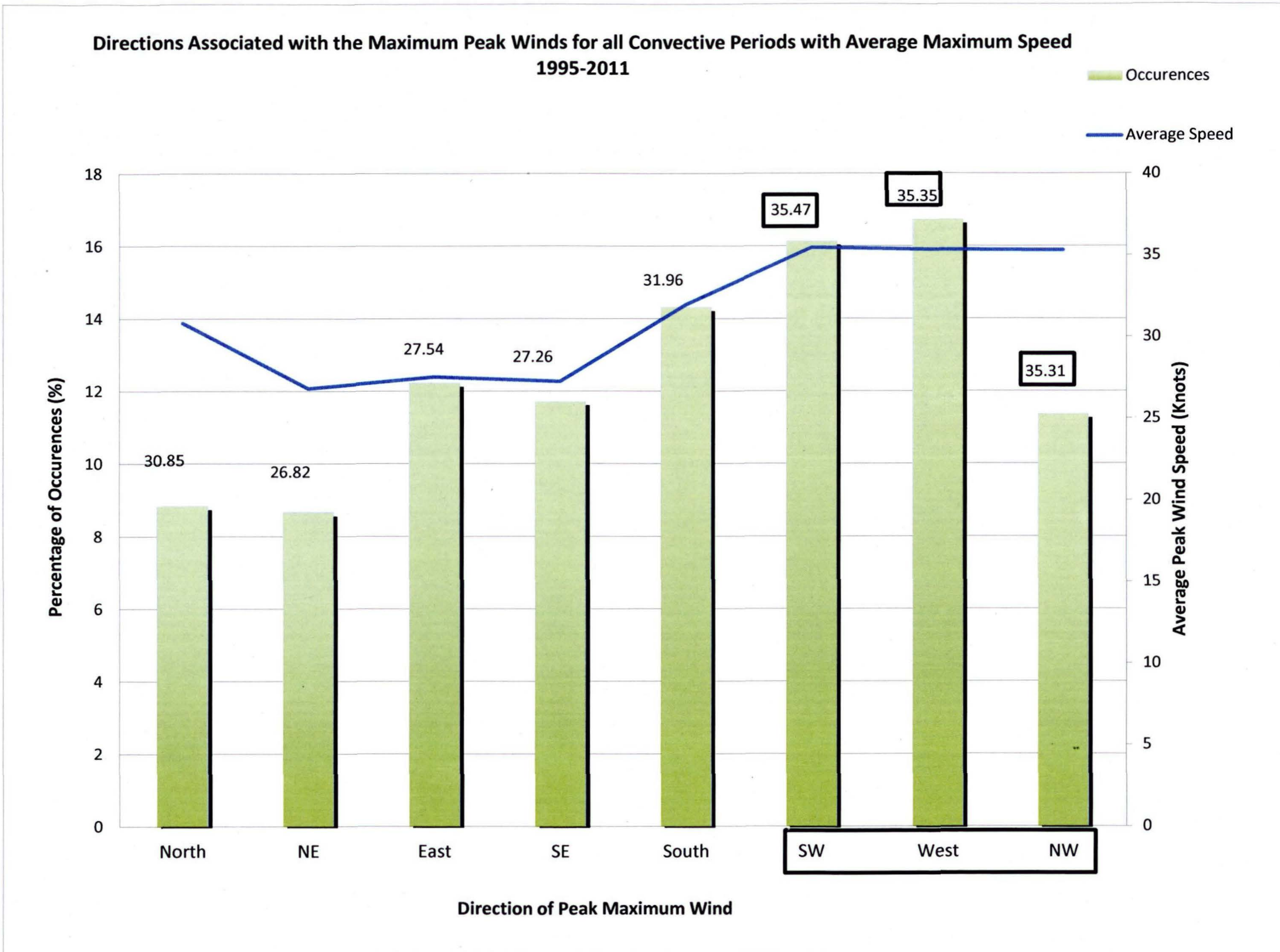
May Convective Winds ≥35 knots vs. Time
1995-2011



2005

Start: 31/02Z End: 31/17Z Flow Regime: SW-1

Range/Hour	9	10	11	12	13
0- 4	3	0	44	35	0
5- 9	125	23	250	221	82
10-14	309	159	280	257	307
15-19	286	309	196	198	359
20-24	159	273	137	111	163
25-29	68	125	49	51	50
30-34	17	42	5	43	9
35-39	0	27	0	39	1
40-44	0	14	0	4	0
45-49	0	0	0	2	0

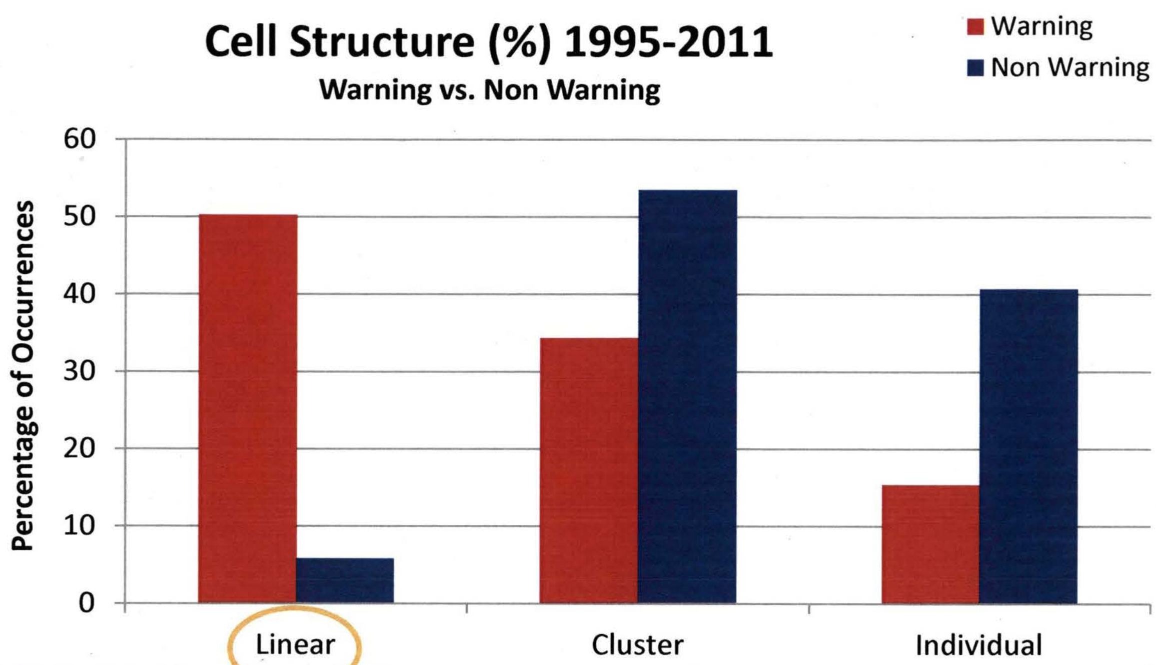


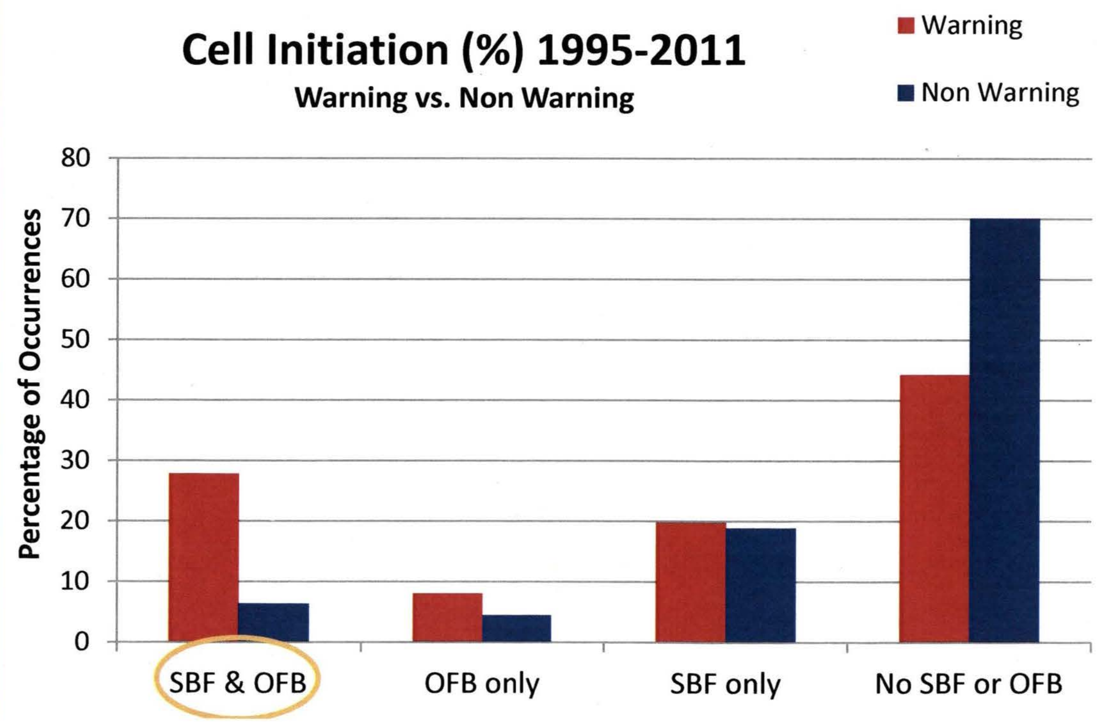
Directions Associated with the Maximum Peak Winds for all Convective Periods with Average Maximum Speed
1995-2011
Occurences
Average Speed
Percentage of Occurences (%)
Average Peak Wind Speed (Knots)
0
2
4
6
8
10
12
14
16
18
5
10
15
20
25
30
35
40
30.85
26.82
27.54
27.26
31.96
35.47
35.35
35.31
North
NE
East
SE
South
SW
West
NW
Direction of Peak Maximum Wind

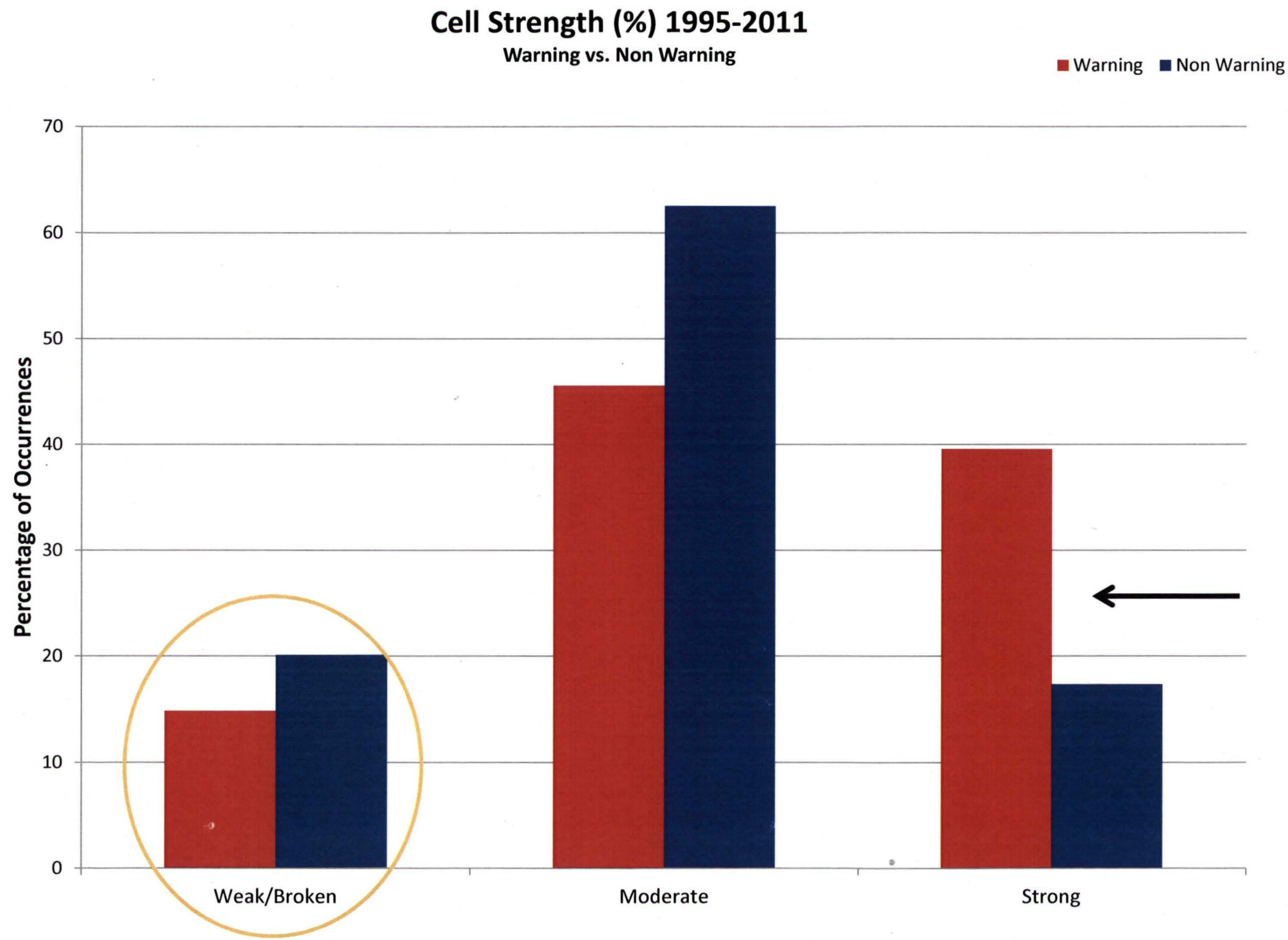
Radar Studies

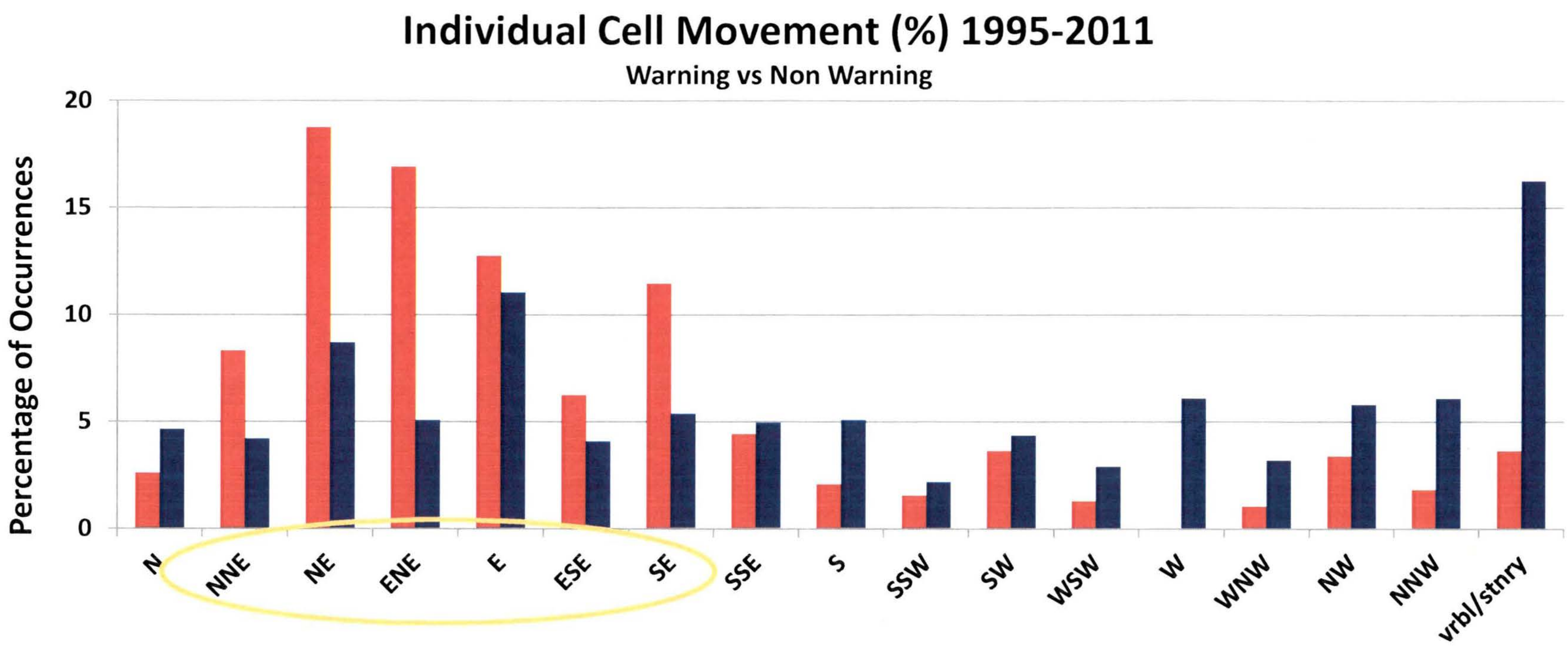
Cell Initiation	Cell Structure	Cell Strength	Group Movement	Individual Cell Movement	Location of MPW
Sea Breeze Front (SBF)	linear	weak/broken (<45 dBz)	16 cardinal wind directions	16 cardinal wind directions	behind
Outflow Boundary (OFB)	individual	moderate (45-55 dBz)	variable/ stationary	variable/ stationary	overhead
SBF & OFB	cluster	strong (>55 dBz)			ahead
No SBF or OFB					

Dinon *et al.* (2008)

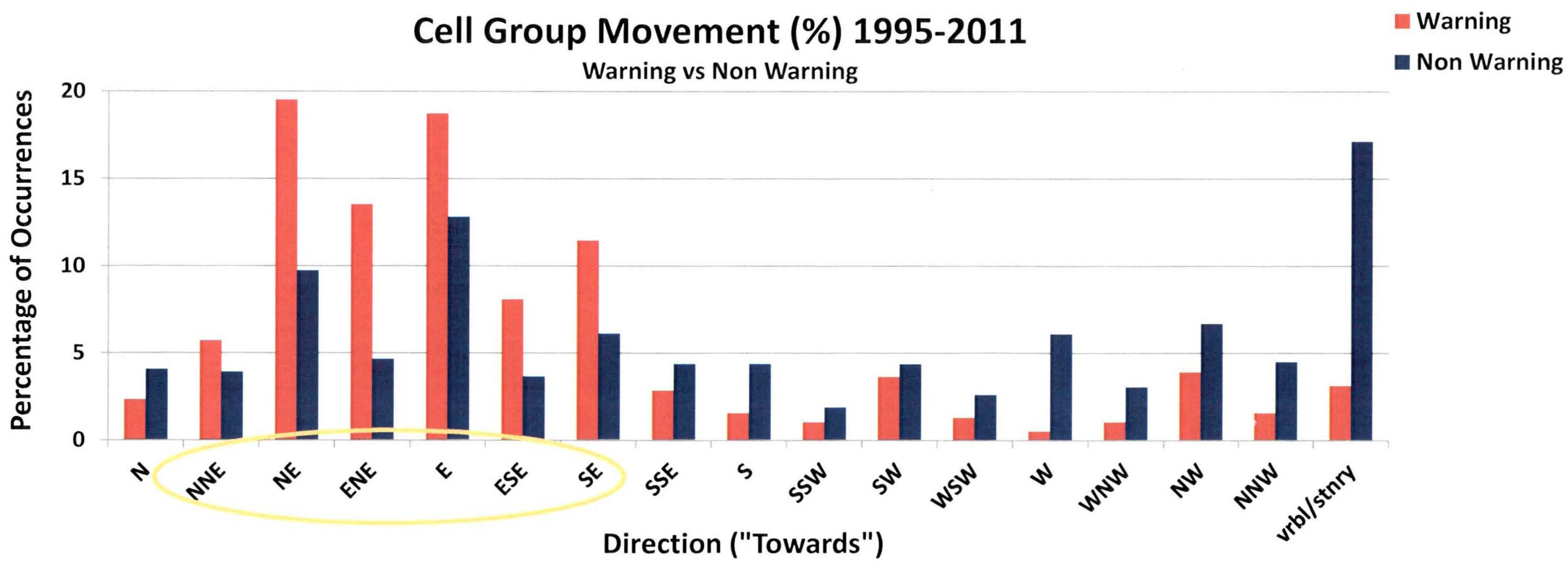

Cell Structure (%) 1995-2011
Warning vs. Non Warning
Warning
Non Warning
Percentage of Occurrences
60
50
40
30
20
10
0
Linear
Cluster
Individual


Cell Initiation (%) 1995-2011
Warning vs. Non Warning
Warning
Non Warning
Percentage of Occurrences
80
70
60
50
40
30
20
10
0
SBF & OFB
OFB only
SBF only
No SBF or OFB


Cell Strength (%) 1995-2011
Warning vs. Non Warning
Warning
Non Warning
Percentage of Occurrences
70
60
50
40
30
20
10
0
Weak/Broken
Moderate
Strong



Individual Cell Movement (%) 1995-2011
Warning vs Non Warning
Percentage of Occurrences
0
5
10
15
20
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
vrbl/stnry



Cell Group Movement (%) 1995-2011
Warning vs Non Warning
Warning
Non Warning
Percentage of Occurrences
0
5
10
15
20
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
vrbl/stnry
Direction ("Towards")

Summary

- Total of 1100 convective events in the 17-year warm-season climatology at KSC/CCAFS
- July and August typically are the peak of convective events, May being the minimum
- Warning and non-warning level convective winds are more likely to occur in the late afternoon (1900-2000Z)
- Southwesterly flow regimes and wind directions produce the strongest winds
- Storms moving from southwesterly direction tend to produce more warning level winds than those moving from the northerly and easterly directions

Future Research Possibilities

- Use of 1000Z KXMR sounding data to forecast occurrence and strength of convective events
- Detailed case studies of individual convective events

References

Ander C. J., A. J. Frumkin, J. P. Koermer and W. P. Roeder, 2009: Study of sea-breeze interactions which can produce strong warm-season convective winds in the Cape Canaveral area. *16th Conf. on Air-Sea Interaction/8th Conf. on Coastal Atmospheric and Oceanic Prediction and Processes*, January, Phoenix, AZ.

Anderson, B.E., 2011. Validation of statistical classification methods for warm-season convective wind forecasting for Cape Canaveral Air Force Station and Kennedy Space Center. M.S. Thesis, Dept. of Atmospheric Science and Chemistry, Plymouth State University, Plymouth, NH.

Cummings, K. A., E. J. Dupont, A. N. Loconto, J. P. Koermer and W. P. Roeder, 2007. An updated warm-season convective wind climatology for the Florida Space Coast. Preprint CD-ROM, *16th Conf. of Applied Climatology*, January, San Antonio, TX.

Dinon, H. A., M. J. Morin, J. P. Koermer, and W. P. Roeder, 2008. Convective winds at the Florida Spaceport: year-3 of Plymouth State research. *13th Conf. on Aviation, Range, and Aerospace Meteorology*, January, New Orleans, LA.

Dupont, E. J., 2007. A case study of a warm-season convective wind period on the Florida Space Coast. Senior Research paper, Dept. of Chemical, Earth, Atmospheric and Physical Sciences, Plymouth State University, Plymouth, NH.

Harris, R.A., 2011. Comparing variable updraft melting layer heights to convective wind speeds using polarimetric radar data. M.S. Thesis, Dept. of Atmospheric Science and Chemistry, Plymouth State University, Plymouth, NH.

Koermer, J. P., and W. P. Roeder, 2008. Assessment of the importance of certain wind towers in the Cape Canaveral AFS/Kennedy Space Center mesonet for predicting convective winds. *13th Conf. onAviation, Range, and Aerospace Meteorology*, January, New Orleans, LA.

Laro, K. L., 2011. Updating the KSC/CCAFS Warm-Season Convective Wind Climatology, *10th Student Conference*, American Meteorological Society, January, Seattle, WA.

References

Laro, K. L., 2012. Warm season convective wind climatology for the CCAFS/KSC area, *2012 Posters on the Hill*, Council on Undergraduate Research, April, Washington, DC.

Loconto, A. N., J. P. Koermer, and W. P. Roeder, 2006. An updated warm-season convective wind climatology for Cape Canaveral Air Force Station/Kennedy Space Center. *12th Conf. on Aviation, Range, and Aerospace Meteorology*, January, Atlanta, GA

McCue, M. H., 2010. Validations and development of existing and warm-season convective wind forecasting tools for Cape Canaveral Air Force Station and Kennedy Space Center. M.S. Thesis, Dept. of Atmospheric Science and Chemistry, Plymouth State University, Plymouth, NH.

Rennie, J.J, 2010. Evaluating WSR-88D methods to predict warm-season convective wind events at Cape Canaveral Air Force Station and Kennedy Space Center. M.S. Thesis, Dept. of Atmospheric Science and Chemistry, Plymouth State University, Plymouth, NH.

Sanger, N., 1999. CCAS microburst climatology. M.S. thesis, Dept. of Meteorology, Texas A&M University, College Station, TX. [Available from College of Geosciences, Texas A&M University, College Station, TX 77843-3148.]

Thank you

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