Investigation of the Cold Episode of December 1989: Comparison with Other Cold Episodes in Florida

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Introduction

In late December 1989, an enormous dome of cold Arctic air streamed south from Canada moving across the plains of the United States and into the southeast, covering Florida with an extremely frigid air mass (Figure 1). From December 23 through 25, daily temperature records were set in cities across the entire eastern U.S, including many in Florida. The freeze caused major damage to fruits and vegetables in Florida. Over the eastern third of the country, December 1989 went into the record books as the coldest December of the century.

This report presents the results of an investigation into this cold air episode. The report also presents an objective analysis of the December 1989 episode compared with other cold air episodes that have occurred in Florida. This report presents data which ranks the cold episodes based on several cold episode indicators. Conclusions are presented along with long-range forecasts of the next two winters.

In the winter, cold air masses will occasionally move south from northern Canada into the U.S. and produce cold air episodes as far south as the Florida peninsula. Usually, these cold spells are brief and only rarely produce freezing temperatures for any length of time in the peninsula of Florida. However, they will on occasion be severe enough to drop temperatures below freezing and for extended periods of time.

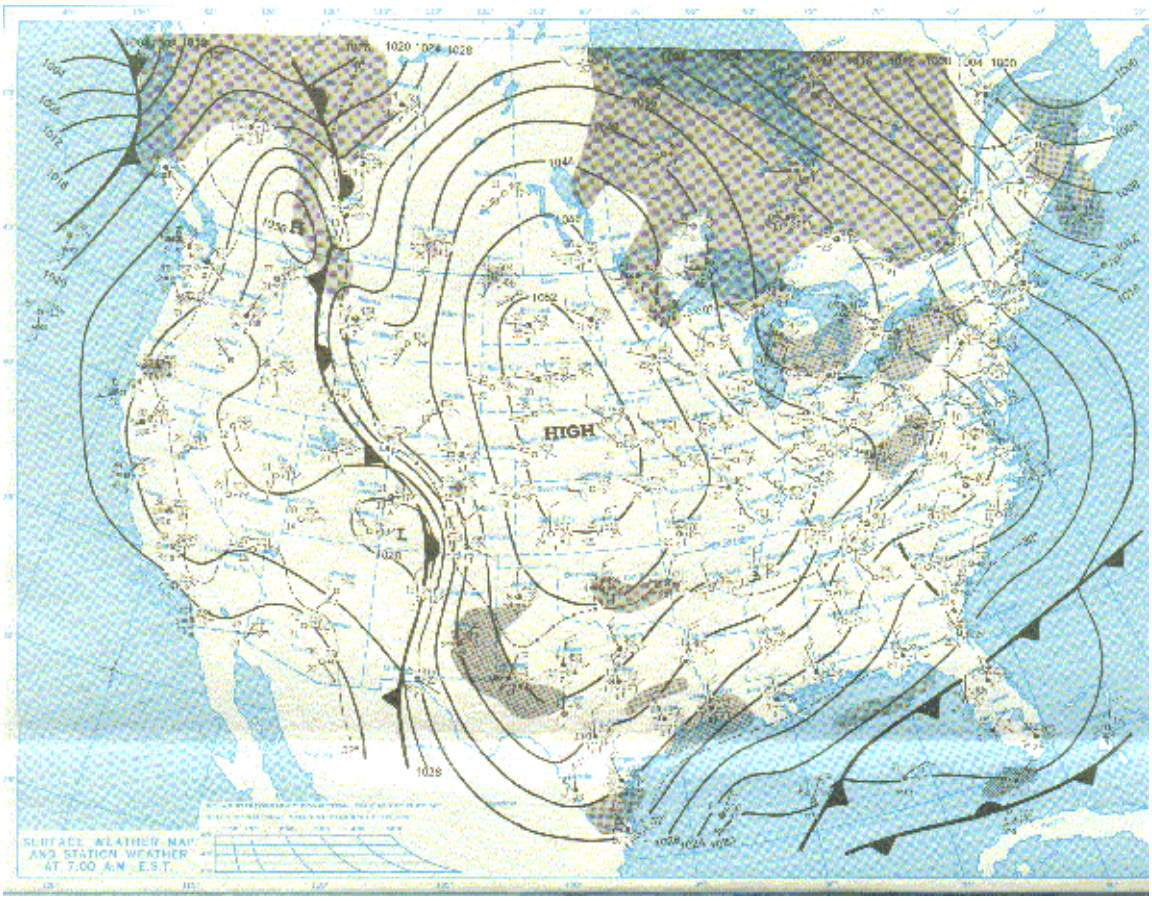

Figure 1. Weather map on December 22, 1989 showing the large cold dome of high pressure over the plains of the United States as it prepares to invade Florida.

Data Analysis

What I did for this analysis was to develop a list of cold episode indicators. These indicators were based on temperature data collected at various weather observing locations in the state of Florida. Once the cold episode indicators were developed, temperature data was then extracted from the data archives. The indicators are:

- *Heating degree-days.* A heating degree-day is used as an indication of fuel consumption where one heating degree-day is given for each degree that the daily mean temperature departs below the base of 65° F. The heating degree-day data was summed over the length of an episode to determine the episode's severity and to compare with other episodes.
- *Number of hours at or below the freezing temperature of 32° F*. Hourly weather observations are recorded and archived for the major weather observation stations. During a cold episode the number of hours below or equal to the freezing level (32°F) indicates the severity and strength of the cold episode because it gives a good indication of the duration of the very cold temperatures.
- *Lowest daily maximum temperature observed during a particular episode*. Daily maximum and minimum temperatures are archived for each observing station. Extremely low daily maximum temperatures indicates the prevalence of cold air and the lack of normal afternoon heating during a cold episode.
- *Lowest daily minimum temperature observed during a particular episode*. Extremely low daily minimum temperatures indicate the absolute extreme cold temperature. The extreme low temperatures are usually reached on clear, cloudless mornings just before sunrise on the second or third day of the episode. The very sharp drop in temperature usually lasts for only a few hours.
- *Lowest daily mean temperature observed during a particular episode*. The mean temperature is the average of the daily maximum and minimum temperature. The mean temperature is used to compute heating degree-days and is a good indicator of the severity of a cold episode because it indicates extreme cold temperatures over an entire day not just for one morning or afternoon.

For the purpose of measuring energy use the two indicators which are the most important are the heating degree-days and the number of hours below freezing. These indicators measure severity and length of cold episode.

Data

Data were analyzed from several different Florida weather observing stations to determine the dates of the major cold episodes. The stations used for this investigation are shown on the map in Figure 2.

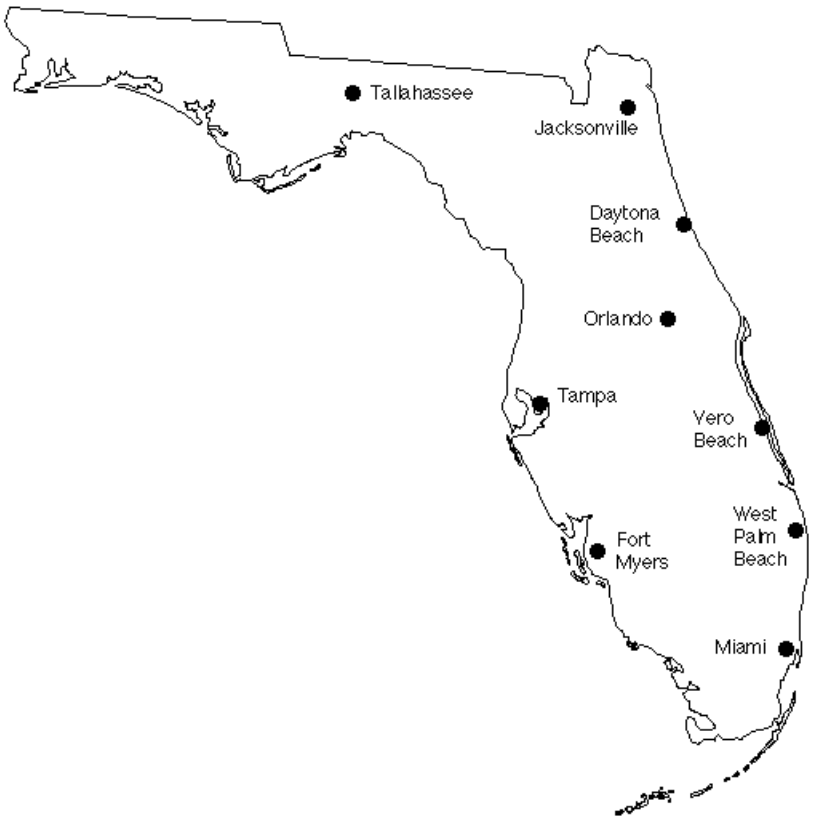

Figure 2. Map showing Florida weather data locations used in this investigation.

Archives of weather data are maintained by the National Climatic Center (NCC) in Asheville, NC. The records kept by NCC vary depending on whether the stations are classified as first-order or second-order stations. First-order stations are located at the six to eight major cities in Florida. NCC has processed the data for different purposes and produced various archives on CD-ROM and has stored the data on various websites.

Several different sources of the data were used to obtain daily, hourly, and record temperatures. Periods of records varied at different stations for the different data archives. Table 1 lists

- the data used for this investigation,
- the source of the data, and
- the period of record of the data.

Daily maximum and minimum records start at 1948 for most stations but there were some exceptions. Hourly data records begin in 1960.

After studying the archives of daily, hourly, and record data covering the past 50 years and producing the cold episode indicator data, I identified 17 cold episodes. Cold episodes were defined as extreme low temperature occurrences that affected all locations in Florida for two days or more.

Cold episode indicator data was compiled for six locations across the state. After compiling the indicator data, each episode was ranked at each location. The data for Miami, Tampa, Jacksonville, Orlando, Tallahassee, and Daytona Beach are presented in Tables 2, 3, and 4. These locations are representative of weather conditions for all areas of the Florida peninsula. Additional data showing record low daily mean temperatures for nine stations across Florida is presented in Table 5.

Table 1. Sources of data along with the Period of Record for each weather observing station used in this investigation.

	Stations	Period of Record	Data Source
Daily	Tallahassee	1948-98	World WeatherDisc, Weather Disc Assoc., Inc, Seattle, WA
	Jacksonville	1948-98	
	Orlando	1974-98	
	Tampa	1933-98	
	Miami	1948-98	
Hourly	Tallahassee	1961-98	Solar and Meteorological Surface Observation Network 1961-1990, Vol I: Eastern U.S., Ver. 1.0, Sep 1993, National Climatic Data Center, Asheville, NC. Hourly United States Weather Observations, 1990-1995, NOAA/National Climatic Data Center/ U.S. EPA, Asheville, NC, Oct 1997
	Jacksonville	1961-98	
	Daytona Beach	1961-98	
	Tampa	1961-98	
	Miami	1961-98	
Record	Tallahassee	1948-98	Southeast Regional Climate Center Climate Calendar, http://water.dnr.state.sc.us/climate/sercc/products/climate_calendars
	Jacksonville	1948-98	
	Tampa	1933-98	
	Orlando	1974-98	
	Daytona Beach	1948-98	
	Vero Beach	1965-98	
	West Palm Beach	1948-98	
	Ft. Myers	1931-98	
	Miami	1948-98	

Results

The data presented in the Tables 2, 3, and 4 show the following:

- The cold episode indicator -number of hours less than or equal to the freezing temperature of 32°F- marks the December 1989 cold episode as the most severe cold spell on record throughout the entire Florida peninsula. December 1989 ranked first in Miami, Jacksonville, and Tallahassee and second in Tampa and Daytona Beach compared to other cold episodes on record. The number 1 ranking for this indicator is significant because the number of hours at or below freezing indicates not only the severity but also the persistence of a cold episode.
- The cold episode indicator -heating degree-days- also showed that the December 1989 cold episode was the most severe because it ranked first at Miami and Orlando, second at Tampa and Tallahassee and third at Jacksonville. No other episode ranked as severe when considering the entire Florida peninsula.
- The cold episode of December 1989 in south Florida and particularly in the Miami area was clearly the coldest on record. All of the cold weather indicators rank this episode number 1. Of particular significance is the low daily mean temperature. The daily mean temperature of 38°F on December 24, 1989 was the all-time record for lowest daily mean temperature in Miami. The daily mean temperature on December 25, 1989 was 43°F which tied a record for the third coldest mean temperature. Table 5 show the record low means at nine locations in Florida. The three most southerly locations (Miami, Ft. Myers, and West Palm Beach) had their all-time low mean temperature on December 24, 1989. The data supports that this cold episode was extreme and persisted for more than just one extreme cold morning or one cold day.
- For central Florida (Tampa, Orlando, and Daytona Beach), the cold episode of December 1989 ranks near the top based on the key cold weather indicators compared to other episodes. It is ranked first or second in the two key energy usage indicators-heating degree-days and hours below freezing. Tampa recorded 32 hours at or below freezing, while Daytona Beach recorded 40 hours in December 1989. During the December 1983 cold episode in Tampa and the January 1985 cold episode in Daytona Beach the temperature fell to freezing or below for 41 hours.
- For north Florida (Jacksonville and Tallahassee), the cold episode of December 1989 ranks as one of the coldest based on the key cold weather indicators. It was first at both locations for hours below freezing and second and third for heating degree-days at Tallahassee and Jacksonville, respectively. For the other cold weather indicators December 1989 does not rank as cold as other cold episodes (e.g. January 1977, December 1983, or January 1985). However, it easily ranks near the top in cold episode severity. Over a four-day period in December 1989 Jacksonville recorded 73 hours and Tallahassee 66 hours at or below freezing.

Table 2. The extremes for cold episode indicators for Jacksonville and Tallahassee along with the rank of each indicator compared to other cold episodes. The indicators shown are heating degree-days (HDD), the number of hours less than or equal to 32°F (Hrs ≤ 32°F), the low daily maximum (Low Max), the low daily minimum (Low Min), and the low daily mean temperature (Low mean). The heating degree-days and the hours below freezing are over 4 days during the episode. The maximum, minimum, and mean are the lowest daily value during the episode. Dashes (-) indicate the data were not available.

	Jacksonville										**Tallahassee**									
Episode Dates	HDD	*rank*	Hrs ≤ 32°F	*rank*	Low Max (°F)	*rank*	Low Min (°F)	*rank*	Low mean (°F)	*rank*	HDD	*rank*	Hrs ≤ 32°F	*rank*	Low Max (°F)	*rank*	Low Min (°F)	*rank*	Low mean (°F)	*rank*
Jan 26-29, 1940	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec 12-13, 1957	106	*10*	-	-	41	*10*	17	*6*	33	*12*	109	*13*	-		42	*14*	20	*14*	32	*14*
Feb 4-5, 1958	87	*16*	-	-	45	*14*	27	*16*	38	*16*	100	*16*	-	-	37	*10*	23	*15*	32	*14*
Jan 23-24, 1960	109	*9*	-	-	45	*14*	25	*15*	35	*15*	114	*12*	-	-	43	*15*	24	*16*	34	*16*
Dec 12-14, 1962	119	*6*	48	*6*	38	*7*	12	*3*	25	*4*	132	*6*	61	*4*	36	*7*	10	*3*	23	*4*
Jan 14-15, 1964	103	*12*	29	*12*	40	*8*	22	*14*	32	*11*	118	*11*	34	*10*	39	*11*	16	*11*	30	*11*
Jan 27-31, 1966	102	*13*	33	*9*	41	*10*	20	*12*	31	*9*	127	*7*	47	*8*	32	*3*	12	*5*	22	*2*
Jan 8-11, 1970	133	*4*	60	*3*	35	*5*	19	*8*	28	*5*	145	*1*	63	*2*	36	*7*	12	*5*	26	*7*
Jan 20-21, 1971	98	*15*	31	*11*	45	*14*	19	*8*	34	*14*	107	*14*	30	*12*	45	*16*	11	*4*	31	*13*
Jan 18-20, 1977	142	*1*	71	*2*	33	*3*	19	*8*	21	*2*	143	*2*	63	*2*	36	*7*	16	*11*	26	*7*
Jan 11-14, 1981	113	*7*	42	*8*	42	*12*	13	*4*	30	*8*	124	*9*	42	*9*	40	*12*	8	*2*	29	*10*
Jan 11-12, 1982	106	*10*	32	*10*	36	*6*	17	*6*	33	*12*	127	*7*	34	*10*	33	*5*	14	*9*	24	*4*
Dec 25-27, 1983	137	*2*	59	*4*	30	*1*	11	*2*	21	*2*	138	*5*	57	*5*	29	*2*	14	*9*	22	*2*
Jan 21-24, 1985	131	*5*	55	*5*	30	*1*	7	*1*	19	*1*	140	*4*	52	*7*	28	*1*	6	*1*	17	*1*
Jan 28-29, 1986	102	*13*	24	*13*	42	*12*	16	*5*	29	*6*	104	*15*	29	*13*	41	*13*	13	*7*	30	*11*
Dec 23-26, 1989	**134**	***3***	**73**	***1***	**33**	***3***	**20**	***12***	**29**	***6***	**143**	***2***	**66**	***1***	**32**	***3***	**13**	***7***	**25**	***6***
Feb 4-5. 1996	111	*8*	46	*7*	40	*8*	19	*8*	31	*9*	123	*10*	54	*6*	35	*6*	16	*11*	28	*9*

Table 3. The extremes for cold episode indicators for Miami and Tampa along with the rank of each indicator compared to other cold episodes. The indicators shown are heating degree-days (HDD), the number of hours less than or equal to 32°F (Hrs ≤ 32°F), the low daily maximum (Low Max), the low daily minimum (Low Min), and the low daily mean temperature (Low mean). The heating degree-days and the hours below freezing are over 4 days during the episode. The maximum, minimum, and mean are the lowest daily value during the episode. Dashes (-) indicate the data were not available.

	Miami										**Tampa**									
Episode Dates	HDD	rank	Hrs ≤ 32°F	*rank*	Low Max (°F)	*rank*	Low Min (°F)	*rank*	Low mean (°F)	*rank*	HDD	*rank*	Hrs ≤ 32°F	*rank*	Low Max (°F)	*rank*	Low Min (°F)	*rank*	Low mean (°F)	*rank*
Jan 26-29, 1940	-	-	-	-	-	-	-	-	-	-	88	*4*	-	-	40	*3*	26	*12*	34	*5*
Dec 12-13, 1957	40	12	0	-	51	*3*	35	*8*	43	*3*	54	*17*	-	-	46	*8*	26	*12*	37	*9*
Feb 4-5, 1958	42	11	0	-	58	*12*	35	*8*	48	*13*	65	*12*	-	-	54	*16*	24	*6*	39	*16*
Jan 23-24, 1960	48	7	0	-	58	*12*	34	*7*	47	*12*	64	*13*	-	-	52	*15*	30	*17*	42	*17*
Dec 12-14, 1962	50	6	0	-	55	*11*	35	*8*	45	*8*	81	*6*	25	*5*	44	*7*	18	*1*	31	*3*
Jan 14-15, 1964	50	9	0	-	50	*2*	36	*14*	44	*4*	64	*13*	11	*11*	43	*6*	27	*10*	37	*9*
Jan 27-31, 1966	30	16	0	-	60	*15*	35	*8*	50	*14*	68	*10*	15	*9*	48	*11*	24	*6*	37	*9*
Jan 8-11, 1970	61	2	0	-	51	*3*	35	*8*	44	*4*	89	*2*	24	*6*	42	*5*	24	*6*	35	*7*
Jan 20-21, 1971	40	12	0	-	54	*10*	35	*8*	45	*8*	68	*10*	20	*8*	48	*11*	23	*5*	38	*13*
Jan 18-20, 1977	59	3	2	*3*	52	*6*	31	*3*	44	*4*	81	*6*	32	*2*	40	*3*	26	*12*	34	*5*
Jan 11-14, 1981	53	5	1	*4*	53	*7*	32	*4*	45	*8*	79	*8*	28	*4*	46	*8*	22	*4*	36	*8*
Jan 11-12, 1982	37	14	0	-	54		33	*5*	51	*16*	74	*9*	15	*9*	46	*8*	24	*6*	37	*9*
Dec 25-27, 1983	47	8	0	-	51	*3*	33	*5*	44	*4*	90	*1*	41	*1*	38	*1*	19	*2*	29	*1*
Jan 21-24, 1985	56	4	7	*2*	53	*7*	30	*1*	42	*2*	83	*5*	23	*7*	60	*17*	21	*3*	30	*2*
Jan 28-29, 1986	43	10	0	-	54	*9*	36	*14*	45	*8*	60	*16*	8	*13*	50	*14*	26	*12*	38	*13*
Dec 23-26, 1989	**70**	**1**	**10**	***1***	**45**	***1***	**30**	***1***	**38**	***1***	**89**	***2***	**32**	***2***	**39**	***2***	**24**	***6***	**32**	***4***
Feb 4-5. 1996	36	15	0	-	59	*14*	37	*16*	50	*14*	64	*13*	10	*12*	48	*11*	25	*11*	38	*13*

Table 4. The extremes for cold episode indicators for Orlando and Daytona Beach along with the rank of each indicator compared to other cold episodes. The indicators shown are heating degree-days (HDD), the number of hours less than or equal to 32°F (Hrs ≤ 32°F), the low daily maximum (Low Max), the low daily minimum (Low Min), and the low daily mean temperature (Low mean). The heating degree-days and the hours below freezing are over 4 days during the episode. The maximum, minimum, and mean are the lowest daily value during the episode. Dashes (-) indicate the data were not available.

	Orlando										**Daytona Beach**									
Episode Dates	HDD	rank	Hrs ≤ 32°F	*rank*	Low Max (°F)	*rank*	Low Min (°F)	*rank*	Low mean (°F)	*rank*	HDD	*rank*	Hrs ≤ 32°F	*rank*	Low Max (°F)	*rank*	Low Min (°F)	*rank*	Low mean (°F)	*rank*
Jan 26-29, 1940	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec 12-13, 1957	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb 4-5, 1958	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jan 23-24, 1960	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec 12-14, 1962	-	-	-	-	-	-	-	-	-	-	-	-	38	*4*	-	-	-	-	-	-
Jan 14-15, 1964	-	-	-	-	-	-	-	-	-	-	-	-	17	*12*	-	-	-	-	-	-
Jan 27-31, 1966	-	-	-	-	-	-	-	-	-	-	-	-	23	*9*	-	-	-	-	-	-
Jan 8-11, 1970	-	-	-	-	-	-	-	-	-	-	-	-	33	*6*	-	-	-	-	-	-
Jan 20-21, 1971	-	-	-	-	-	-	-	-		-	-	-	19	*11*	-	-	-	-	-	-
Jan 18-20, 1977	91	*2*	-	-	38	*4*	20	*2*	31	*4*	-	-	37	*5*	-	-	-	-	-	-
Jan 11-14, 1981	81	*5*	-	-	46	*6*	20	*2*	35	*5*	-	-	30	*7*	-	-	-	-	-	-
Jan 11-12, 1982	68	*6*	-	-	46	*6*	23	*6*	38	*7*	-	-	23	*9*	-	-	-	-	-	-
Dec 25-27, 1983	86	*4*	-	-	36	*1*	20	*2*	29	*2*	-	-	40	*2*	-	-	-	-	-	-
Jan 21-24, 1985	91	*2*	-	-	36	*1*	19	*1*	28	*1*	-	-	41	*1*	-	-	-	-	-	-
Jan 28-29, 1986	68	*6*	-	-	45	*5*	26	*7*	36	*6*	-	-	25	*8*	-	-	-	-	-	-
Dec 23-26, 1989	**94**	***1***	-	-	**37**	***3***	**22**	***5***	**30**	***3***	-	-	**40**	***2***	-	-	-	-	-	-
Feb 4-5. 1996	63	*8*	-	-	50	*8*	27	*8*	39	*8*	-	-	12	*13*	-	-	-	-	-	-

Conclusions and Future Cold Episodes

Based on the total area covered and the duration of the cold episode of December 1989, my conclusion is that the December 1989 cold episode was the coldest on record for the Florida peninsula. Extensive weather records begin in 1948.

For south Florida, the cold episode of December 1989 was very clearly the coldest on record.

In central and north Florida, the data indicate that it was one of the coldest on record. Other cold episodes produced lower temperatures. However, based on key measurements of temperature used to gauge energy usage -heating degree-days and hours at or below freezing-one can argue that December 1989 was the coldest on record even in central and north Florida.

In the future, cold episodes will occur in the state of Florida. Predicting when these episodes will occur, how severe they will be, and how long they will last is beyond the capabilities of meteorologists and climatologists at this point. NOAA's Climate Prediction Center makes long range forecasts for up to 15 months in the future. Their forecasts for winter 1999-2000 and early winter 2000-2001 predict above normal temperatures for Florida (Figures 3 and 4). If these warm winters occur, they would continue a trend of no significant cold episodes that has occurred during the 1990's.

Will we have a cold episode like the one that hit Florida in December 1989? At some point in the future, statistical probabilities favor its occurrence. Will it happen in the near future, say the next 5-10 years? It is certainly a possibility. However, the cold episode of 1989 was the coldest in south Florida in 50 years of record keeping and, based on hours below freezing, the coldest in the rest of the state in the last 40 years. Given the trend of the warmer 1990's along with the extreme cold of 1989, it is my opinion that the probability is low that a cold episode such as December 1989 will occur in the near future.

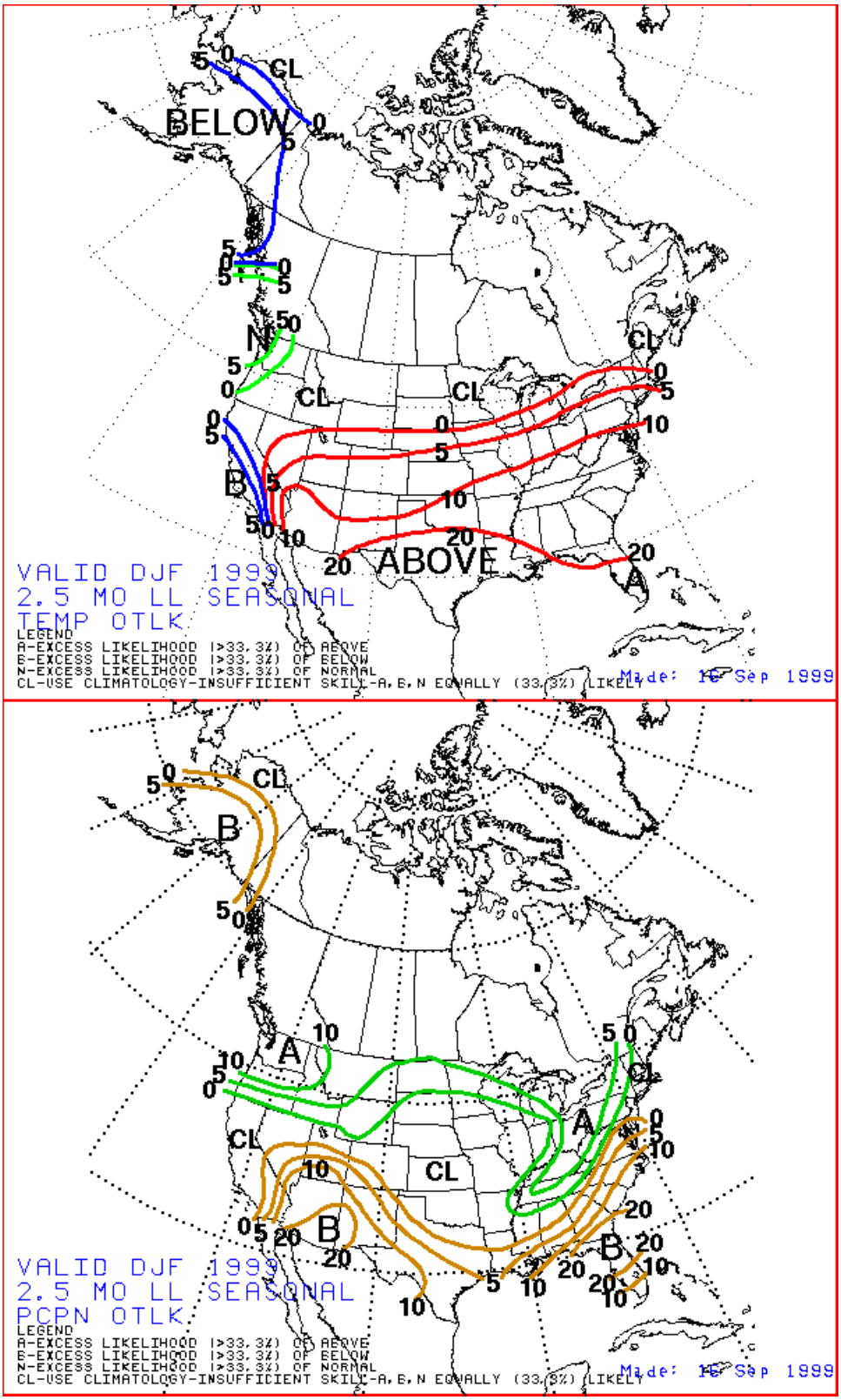

Figure 3. NOAA Climate Prediction Center forecast for temperature (top) and precipitation (bottom) for December, January, and February 1999-2000.

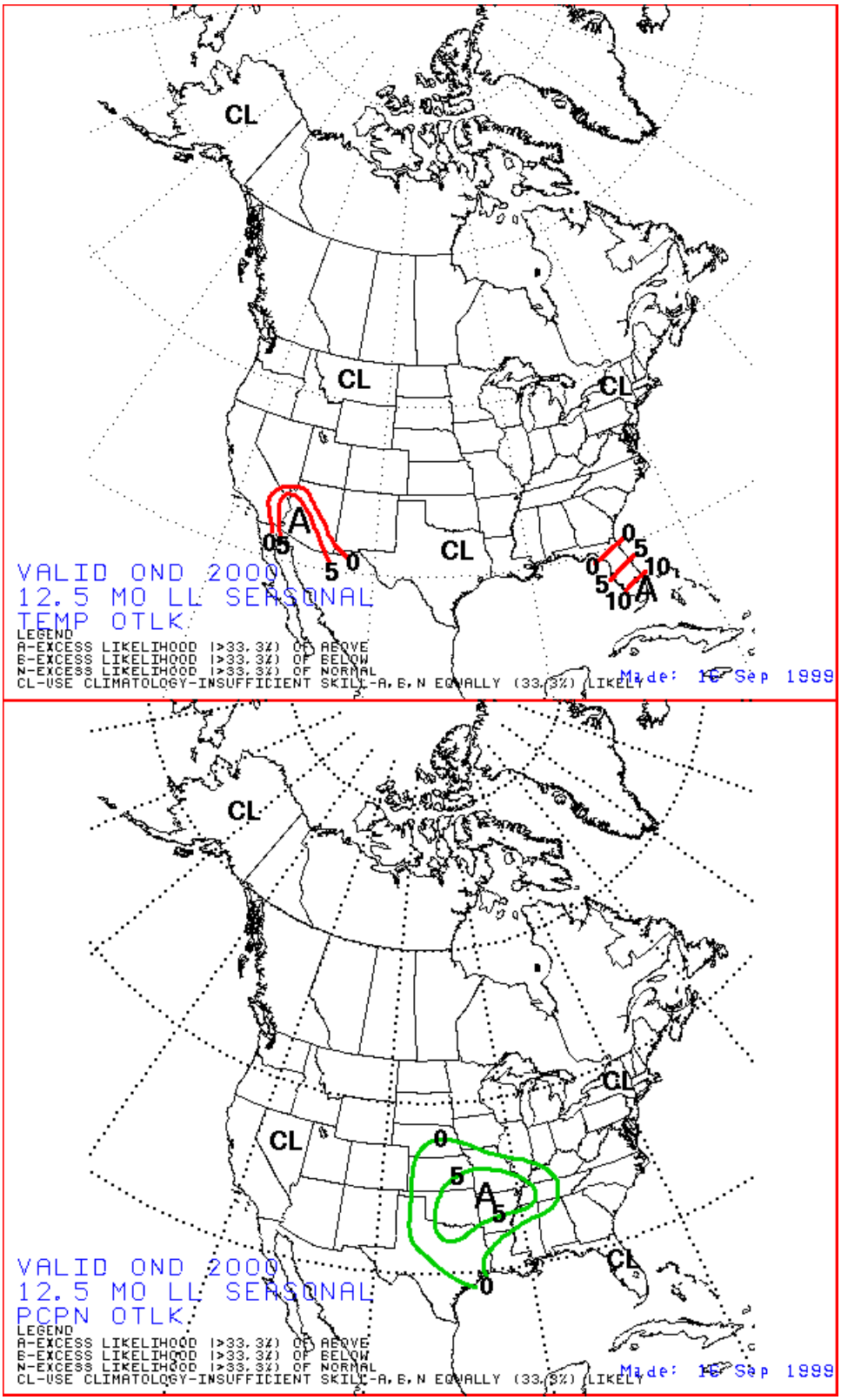

Figure 4. NOAA Climate Prediction Center forecast for temperature (top) and precipitation (bottom) for October, November, and December 2000.

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