Analyzing the Potential Connection of Climate Indices with Significant South Carolina Snow Events

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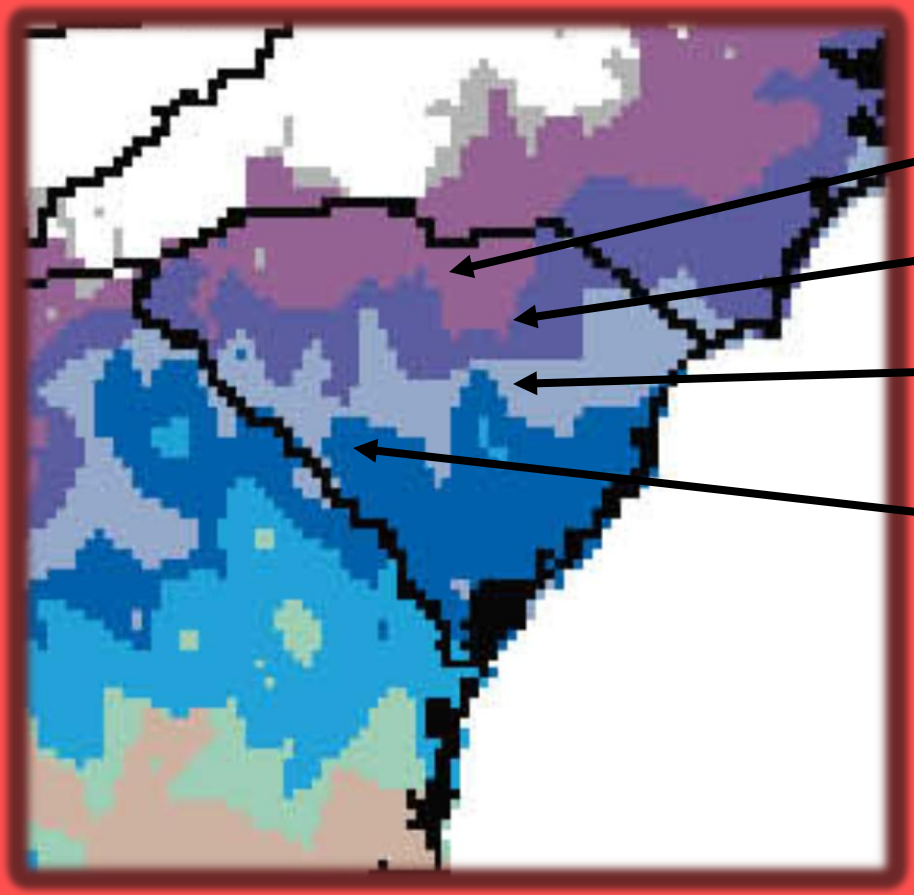
Snowfall Probability



Average Yearly Snowfall Around NC/SC/GA

	30 Year Normals	POR Avg.
• Greer	4.7 in.	5.5 in.
• Charlotte	4.3 in.	5.4 in.
• Wilmington	1.7 in.	1.5 in.
• Columbia	1.5 in.	1.8 in.
• Augusta	0.9 in.	1.1 in.
• Charleston	0.5 in.	0.5 in.

Snow (MRI) (Fuhrmann & Konrad)
MRI = mean recurrence interval

>1 inch – every year/Charlotte

>1 inch – every 2 years/Columbia

>1 inch – every 3 years/Augusta

>5 inches – every 3 years/Charlotte

>5 inches – every 16 years/Columbia

>5 inches – every 45 years/Augusta

“Best” Snow Producing Storm Tracks

- Typical surface low track is across the central Florida peninsula with an area of high pressure centered W to N of the area.
- Mid/Upper Levels – closed low just west of the area across Mississippi/Alabama.
- Split Mid/Upper Level Flow across the U.S. & Canada. (Northern/Southern Branch of the Jet Stream)

Events ≥ 1 in

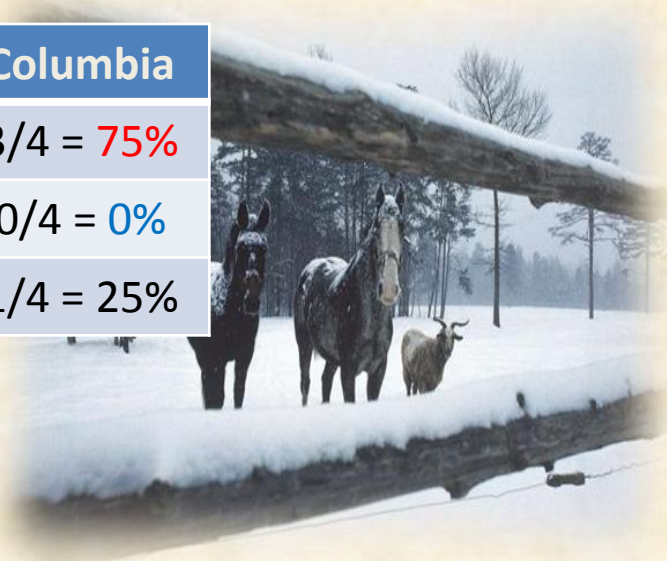
ENSO Phase	Charleston	Columbia
El Nino	4/8 = 50%	8/22 = 36%
La Nina	1/8 = 13%	7/22 = 32%
Neutral	3/8 = 38%	7/22 = 32%

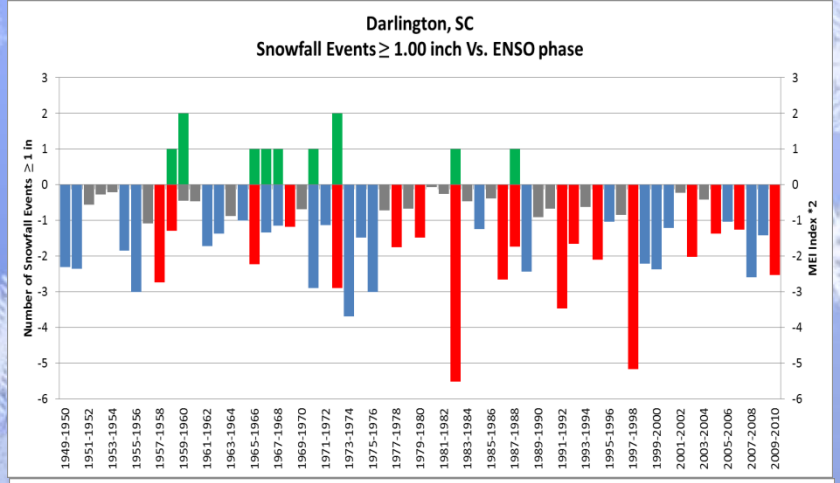
Events ≥ 3 in

ENSO Phase	Charleston	Columbia
El Nino	2/4 = 50%	6/12 = 50%
La Nina	0/8 = 0%	3/12 = 25%
Neutral	2/4 = 50%	3/12 = 25%

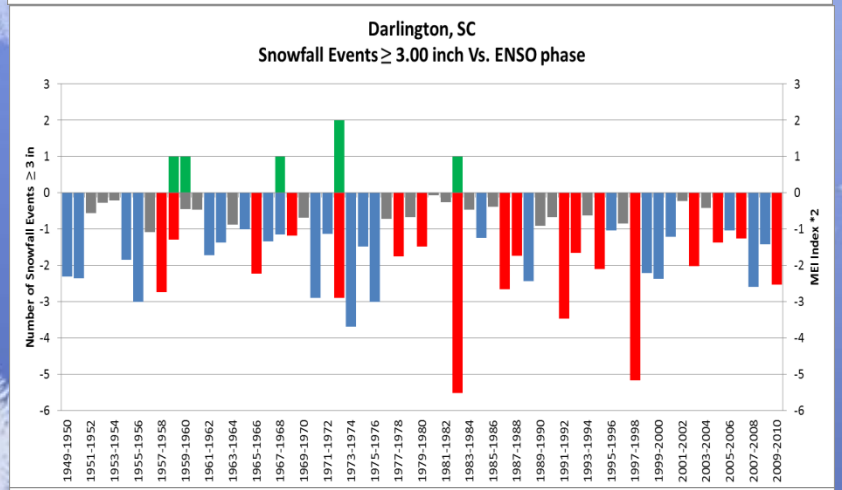
Events ≥ 5 in

ENSO Phase	Charleston	Columbia
El Nino	1/2 = 50%	3/4 = 75%
La Nina	0/2 = 0%	0/4 = 0%
Neutral	1/2 = 50%	1/4 = 25%

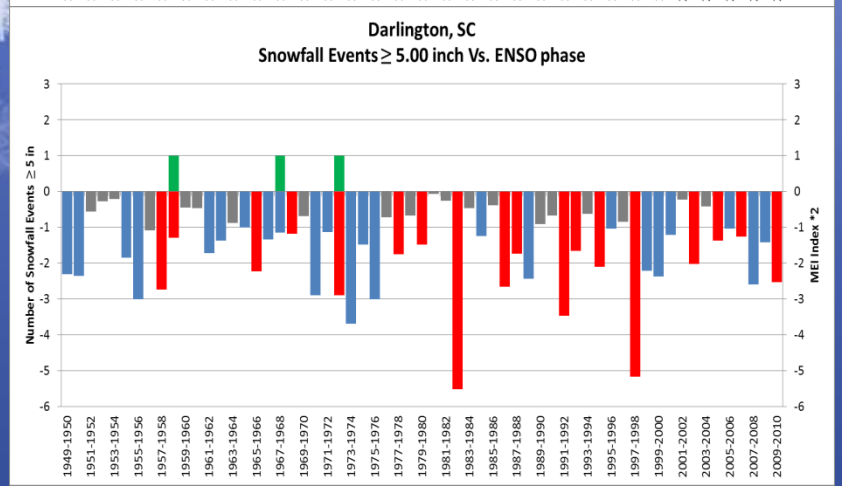




El Nino – 5/9 – 56%
La Nina – 3/9 – 33%
Neutral – 1/9 – 11%

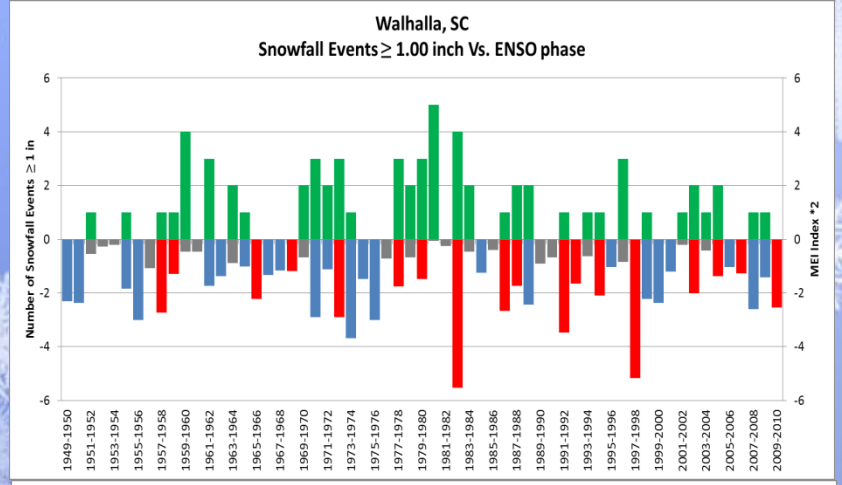


El Nino – 3/5 – 60%
La Nina – 1/5 – 20%
Neutral – 1/5 – 20%

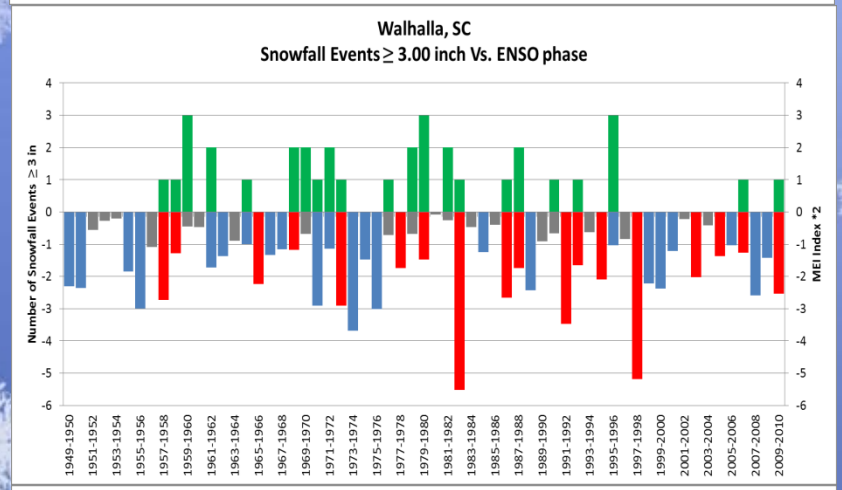


El Nino – 2/3 – 67%
La Nina – 1/3 – 33%
Neutral – 0/3 – 0%

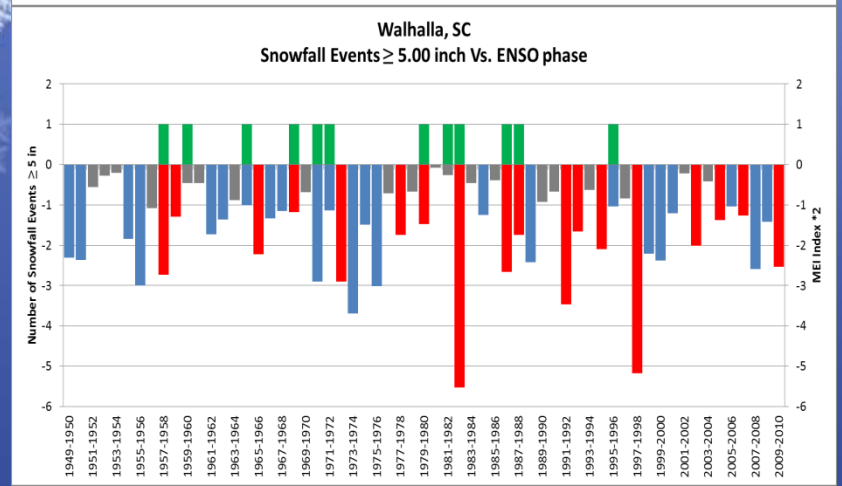
D A R L I N G T O N



El Nino – 12/33 – 36%
La Nina – 10/33 – 30%
Neutral – 11/33 – 33%



El Nino – 11/22 – 50%
La Nina – 5/22 – 23%
Neutral – 6/22 – 27%



El Nino – 6/12 – 50%
La Nina – 4/12 – 33%
Neutral – 2/12 – 17%

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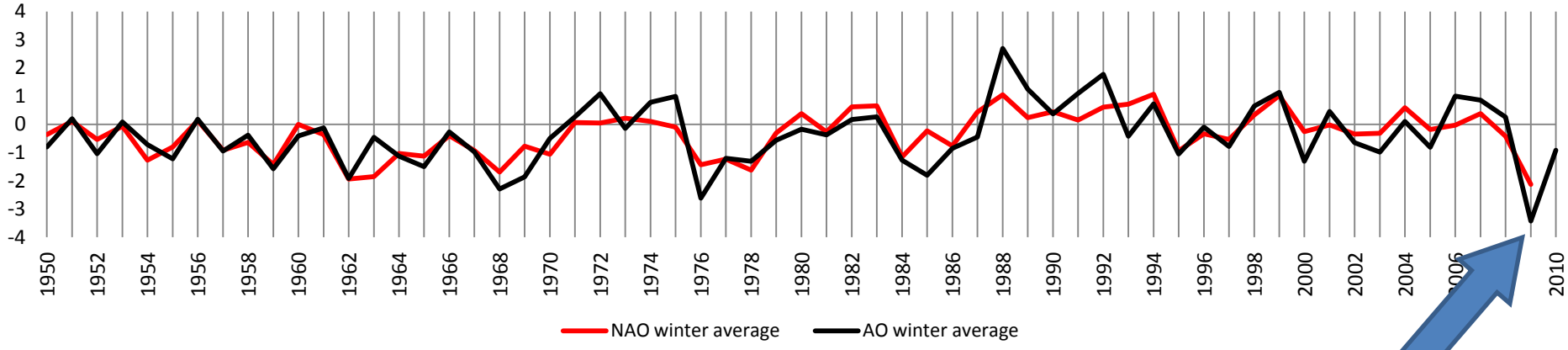
NAO and AO DJF Averages from 1950-2010

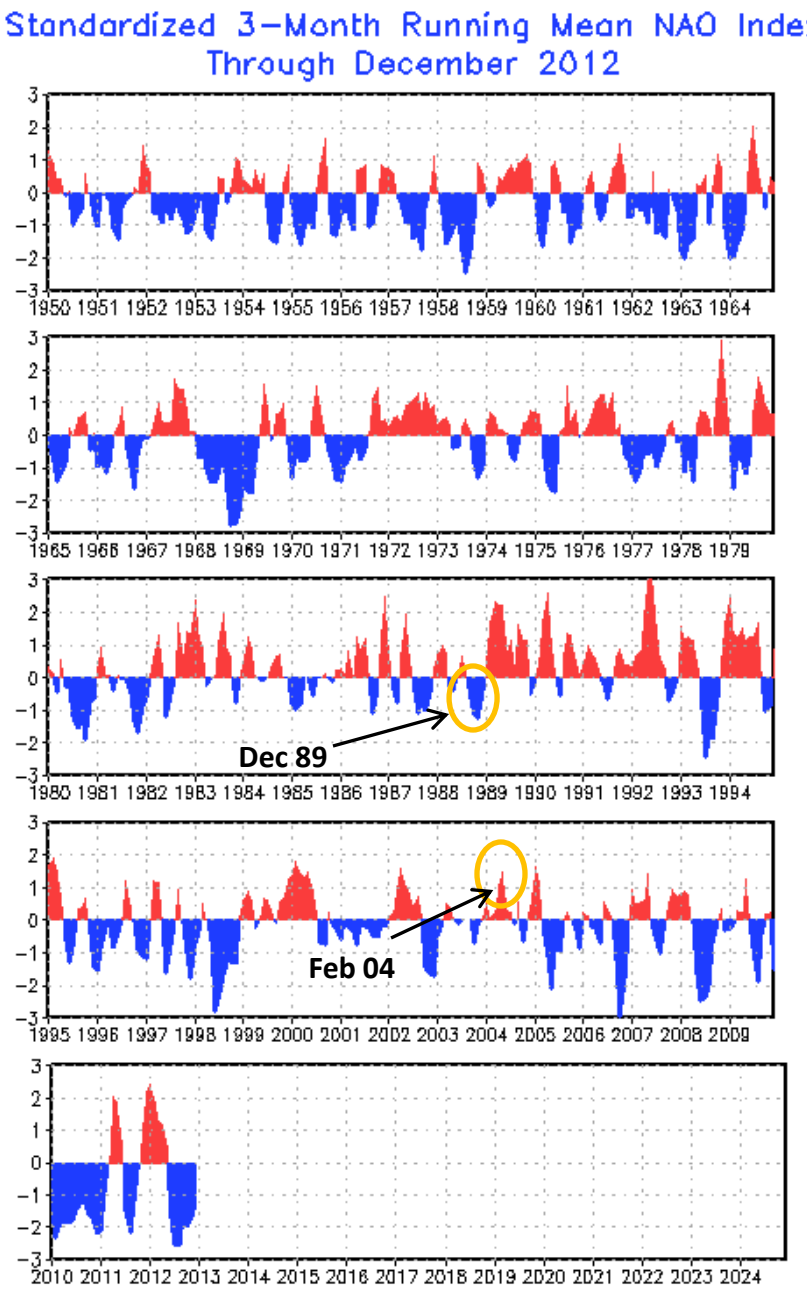


The NAO and AO weren't really a topic of conversation until…

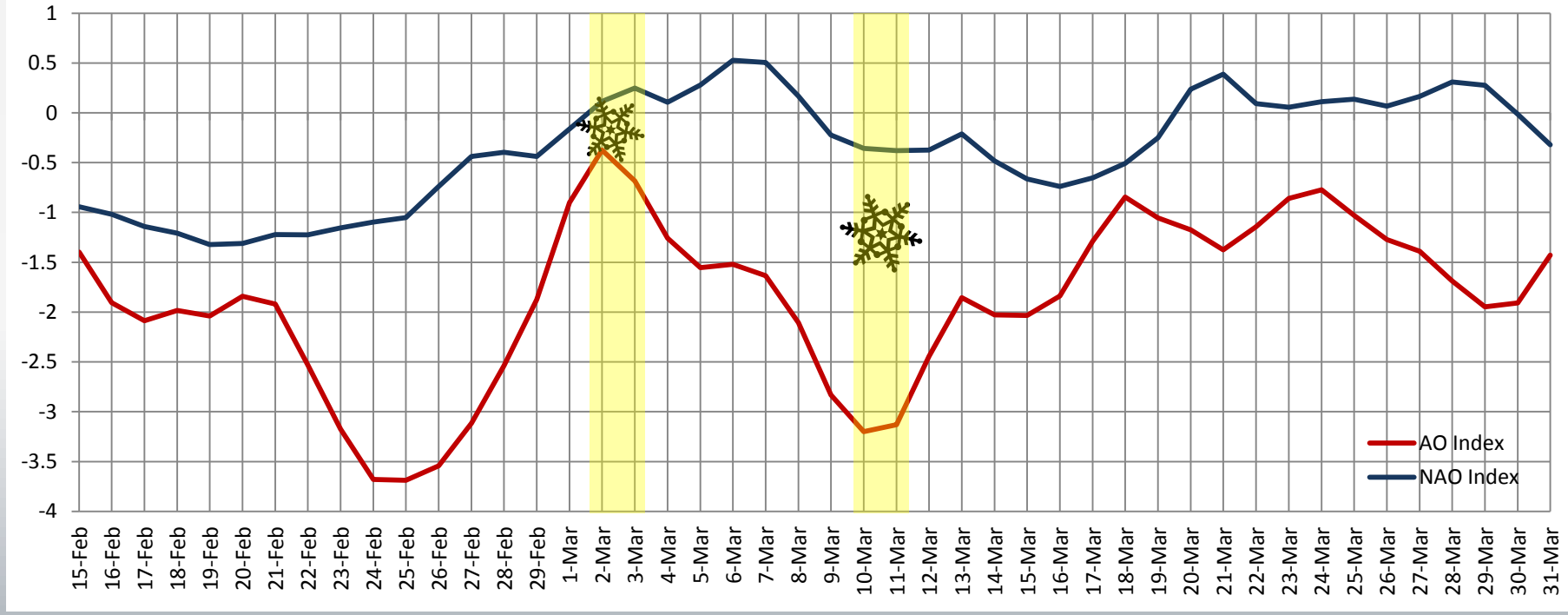
Which happened to be our 2nd coldest winter in Columbia (based on avg Tmax)

With the exception of the AO having larger fluctuations, the patterns look very similar.

So how *do* the AO and NAO affect snowfall here? Are there any consistent patterns? We know NAO and AO are temperature drivers and the negative phase yields colder temperatures, but what happens when we break it down to the scale of the actual snowfall event?


Standardized 3-Month Running Mean NAO Index
Through December 2012
Dec 89
Feb 04

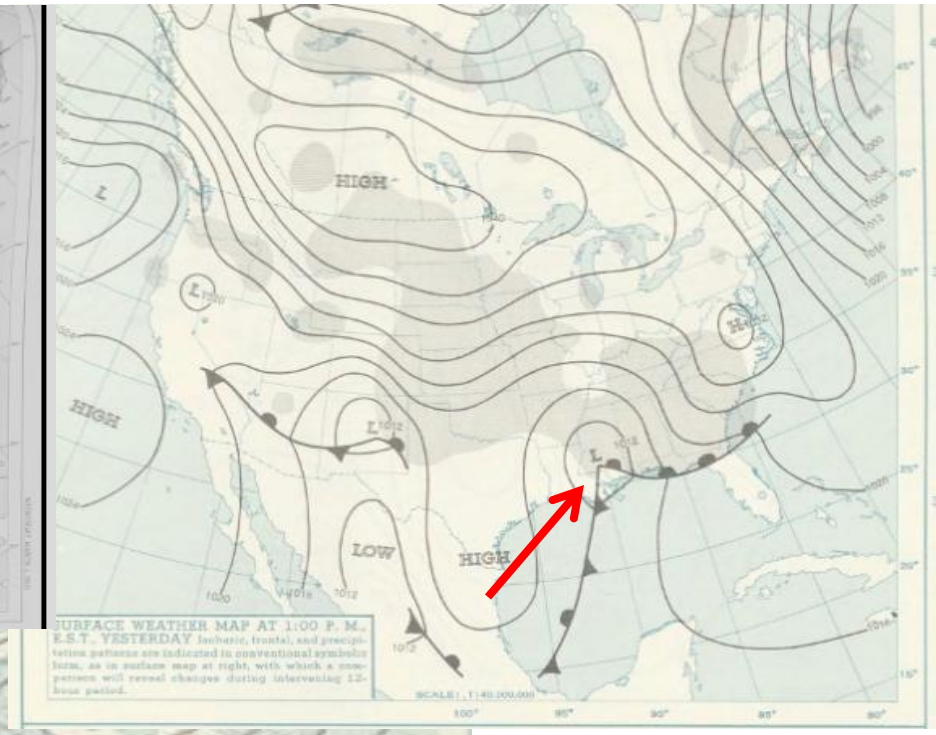
March 2-3 and 10-11, 1960

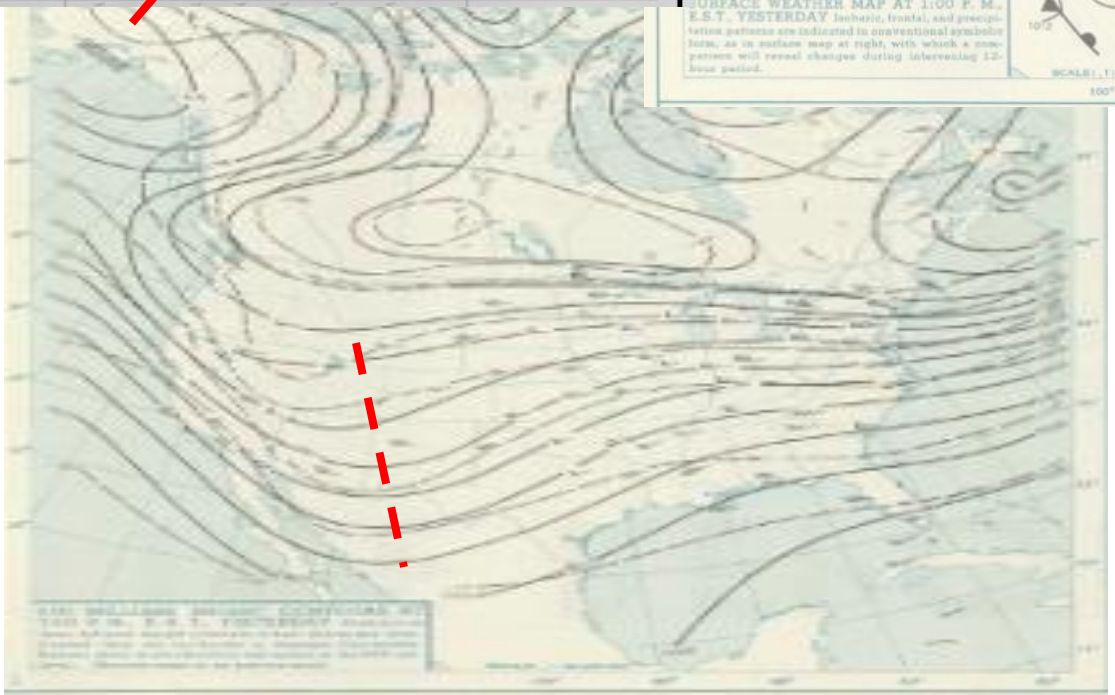


- 2 separate events – statewide, but highest accumulations in the upstate
- Landrum – 8.5”
- Greenville AP – 6”
- Spartanburg – 5.3”
- Clemson – 6”
- Sumter – 6”
- ENSO neutral

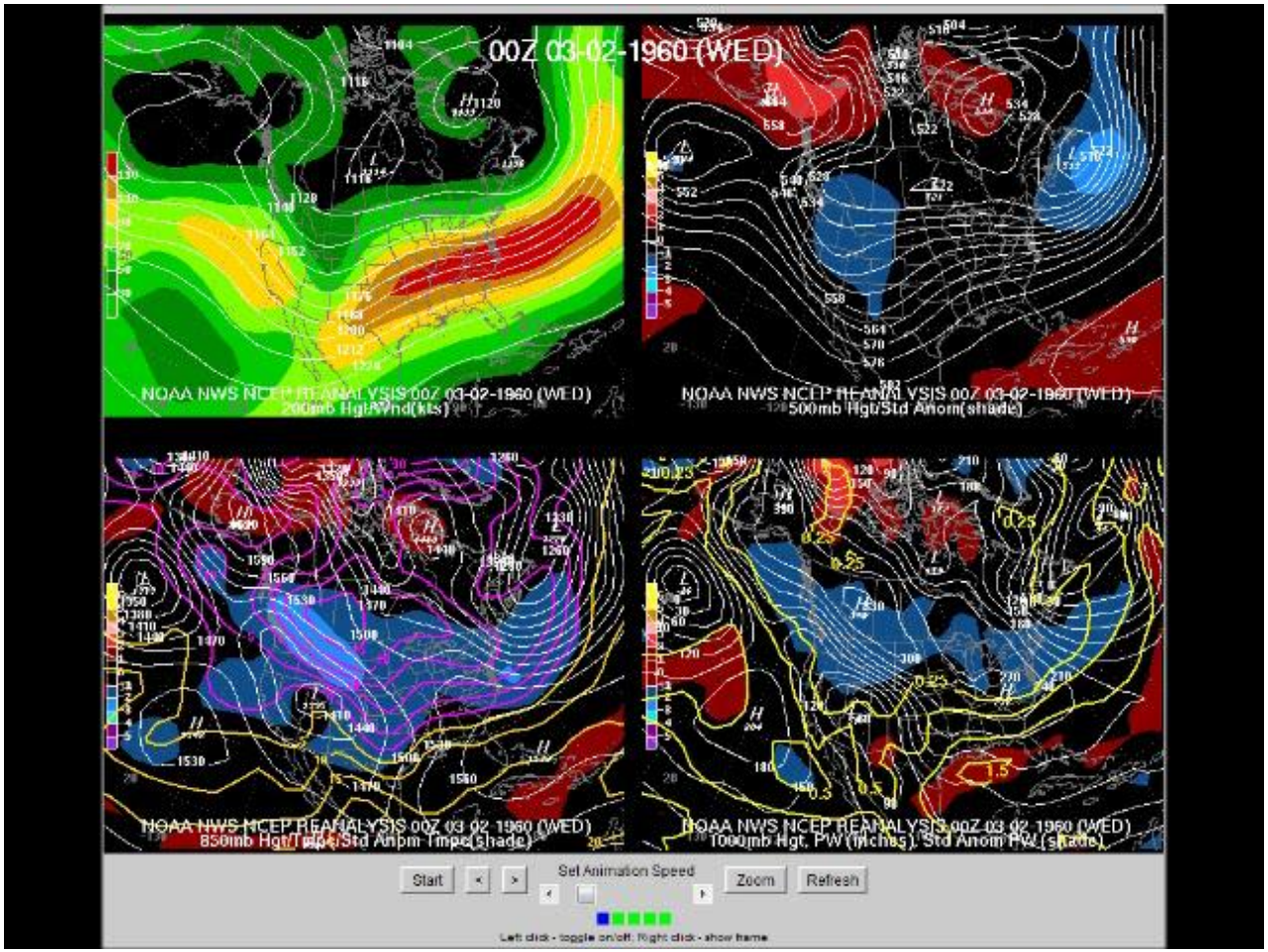
1-Day Max Totals

March “2”-3, 1960

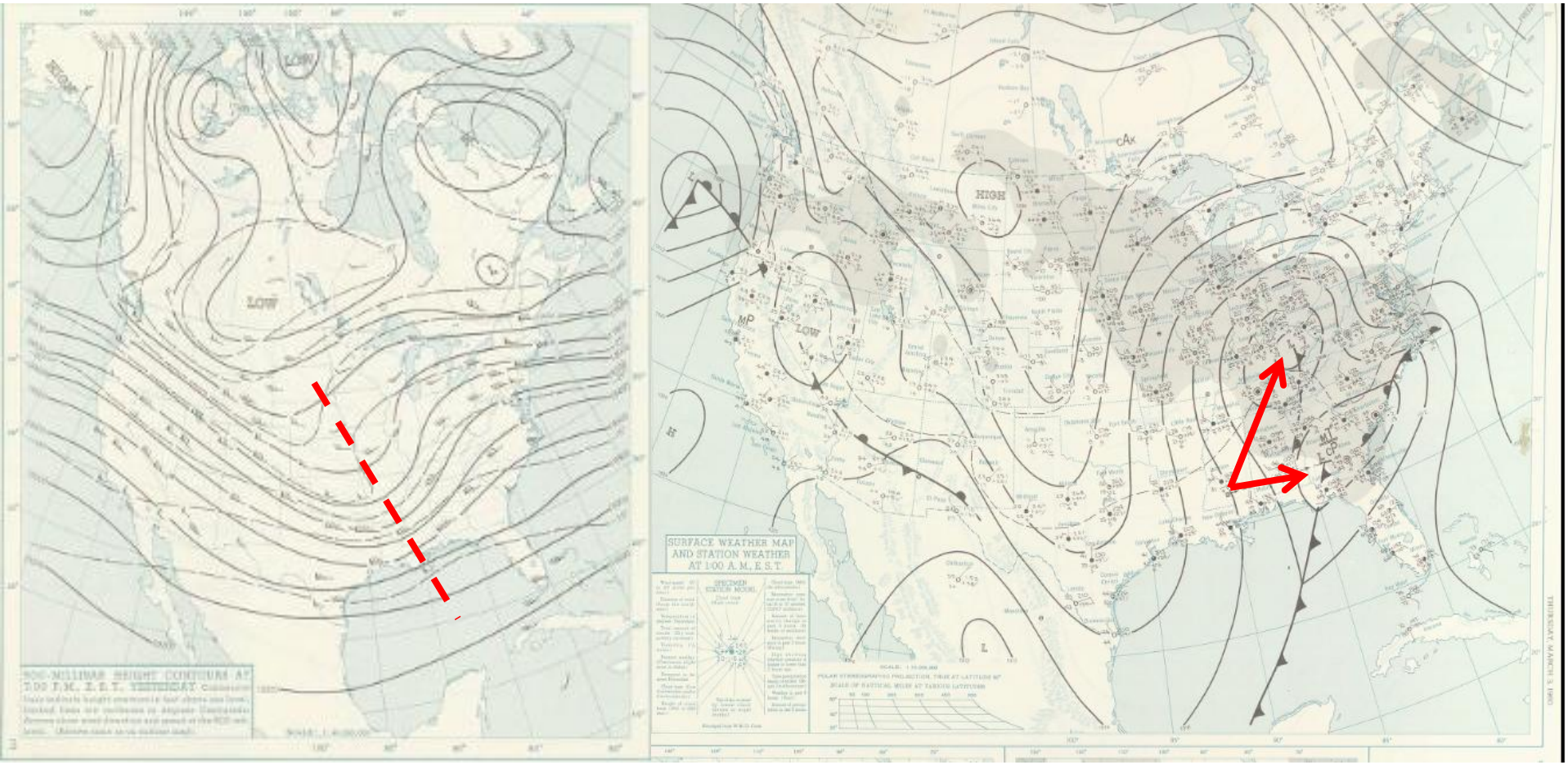




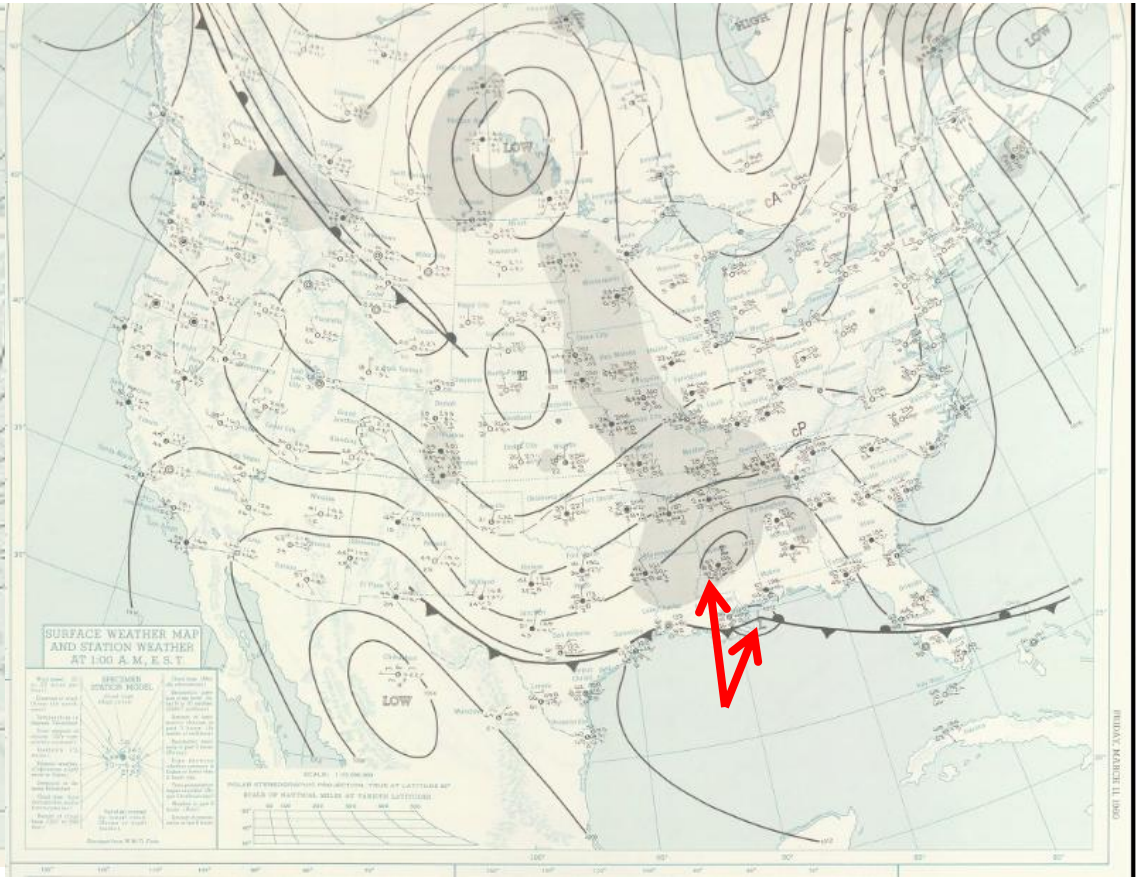
March 2-3, 1960



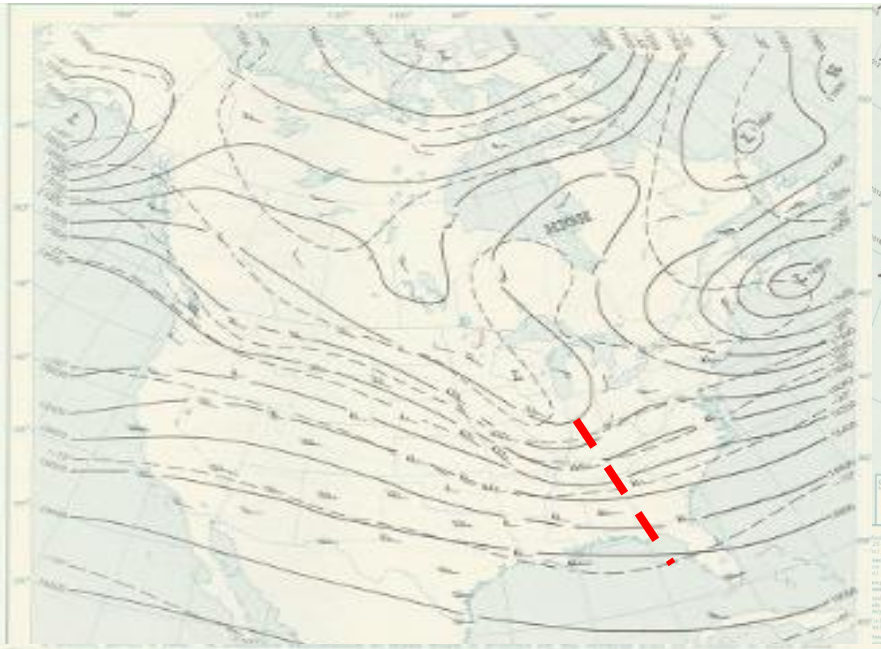
March 2 – “3”, 1960

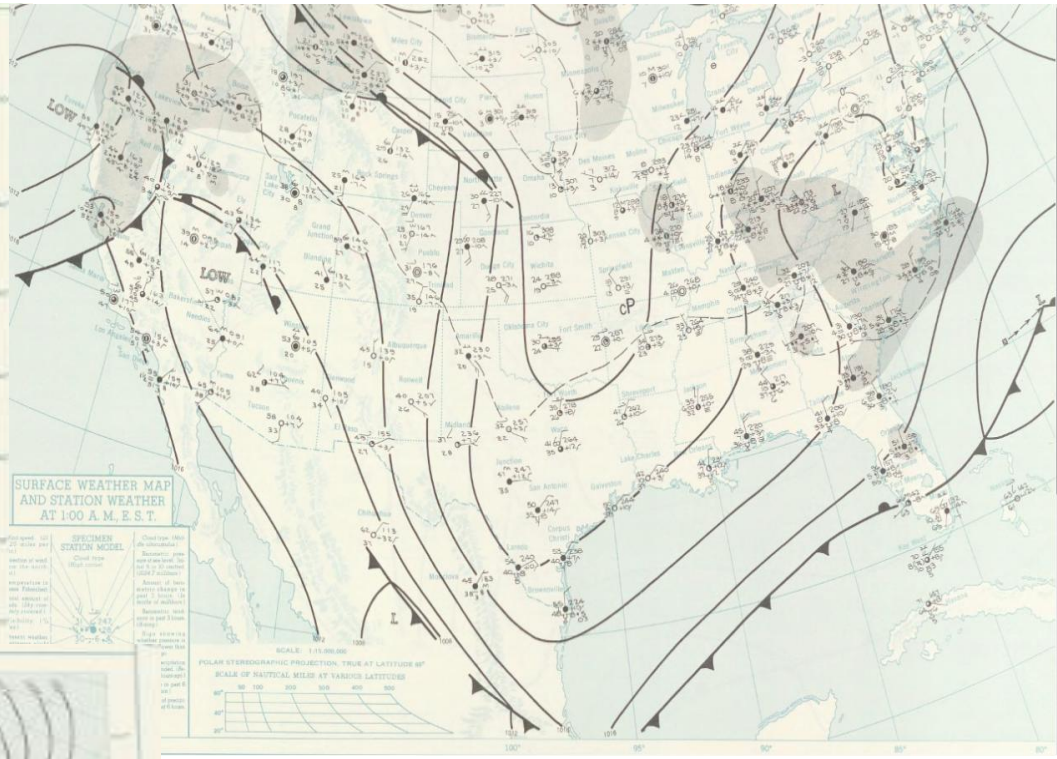


March “11”-12, 1960

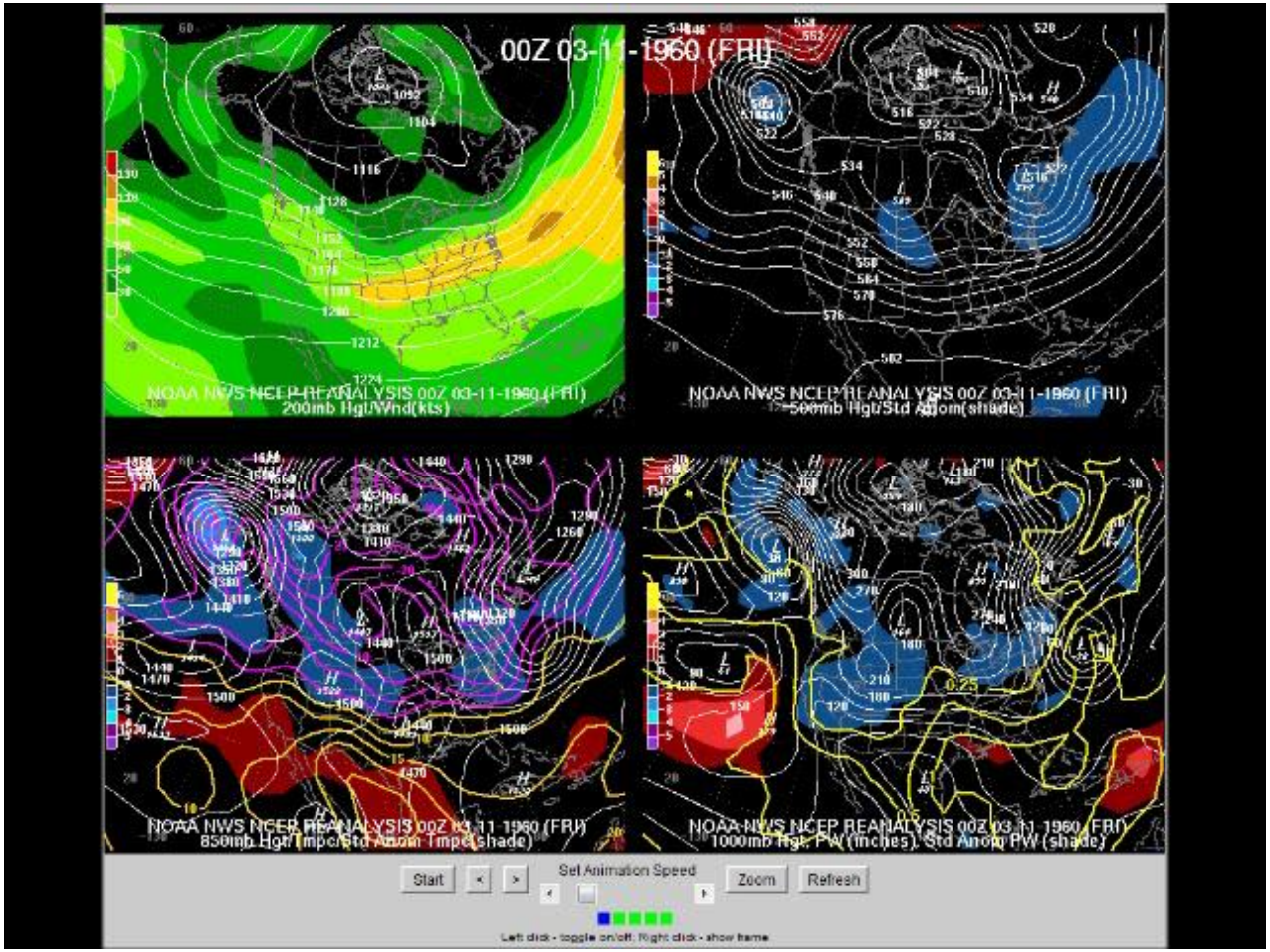


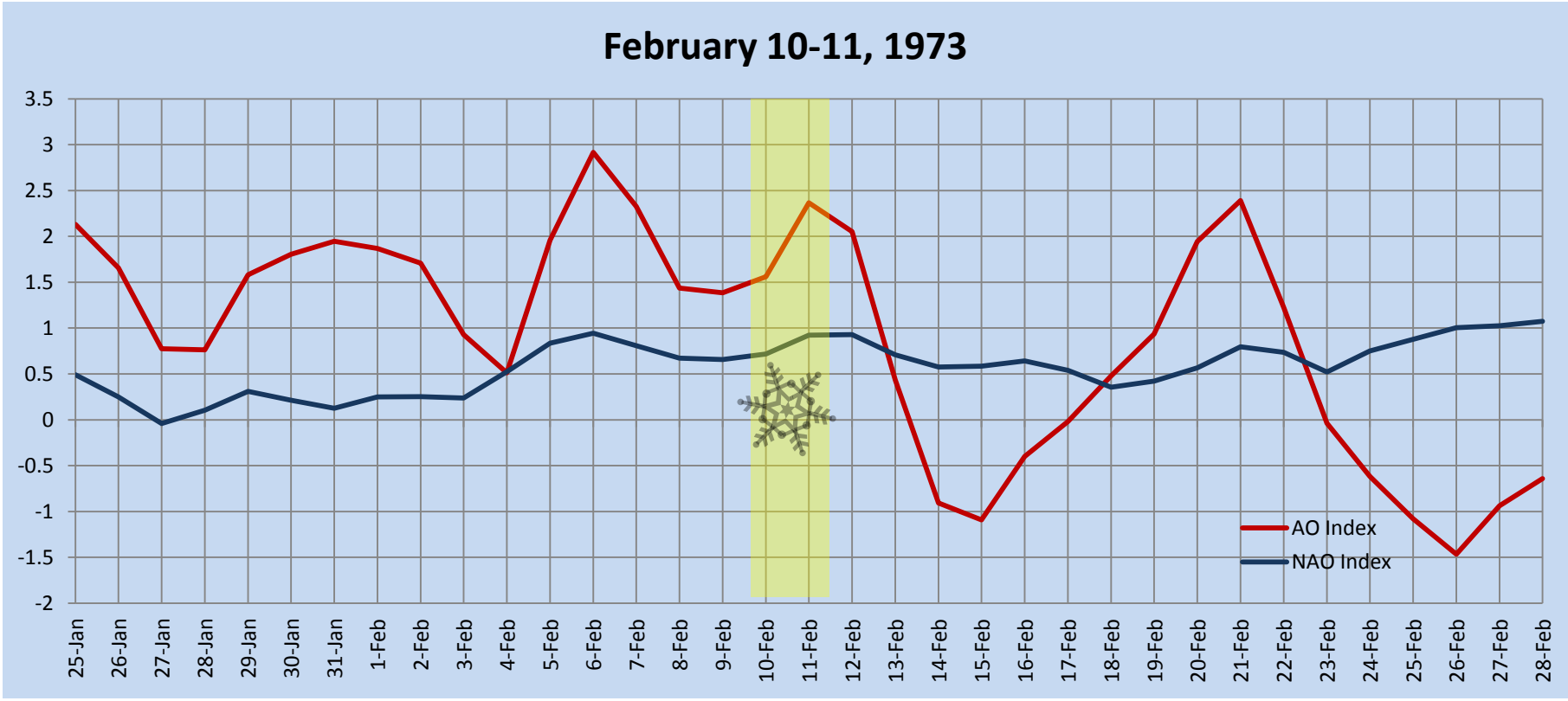
March 11- “12”, 1960





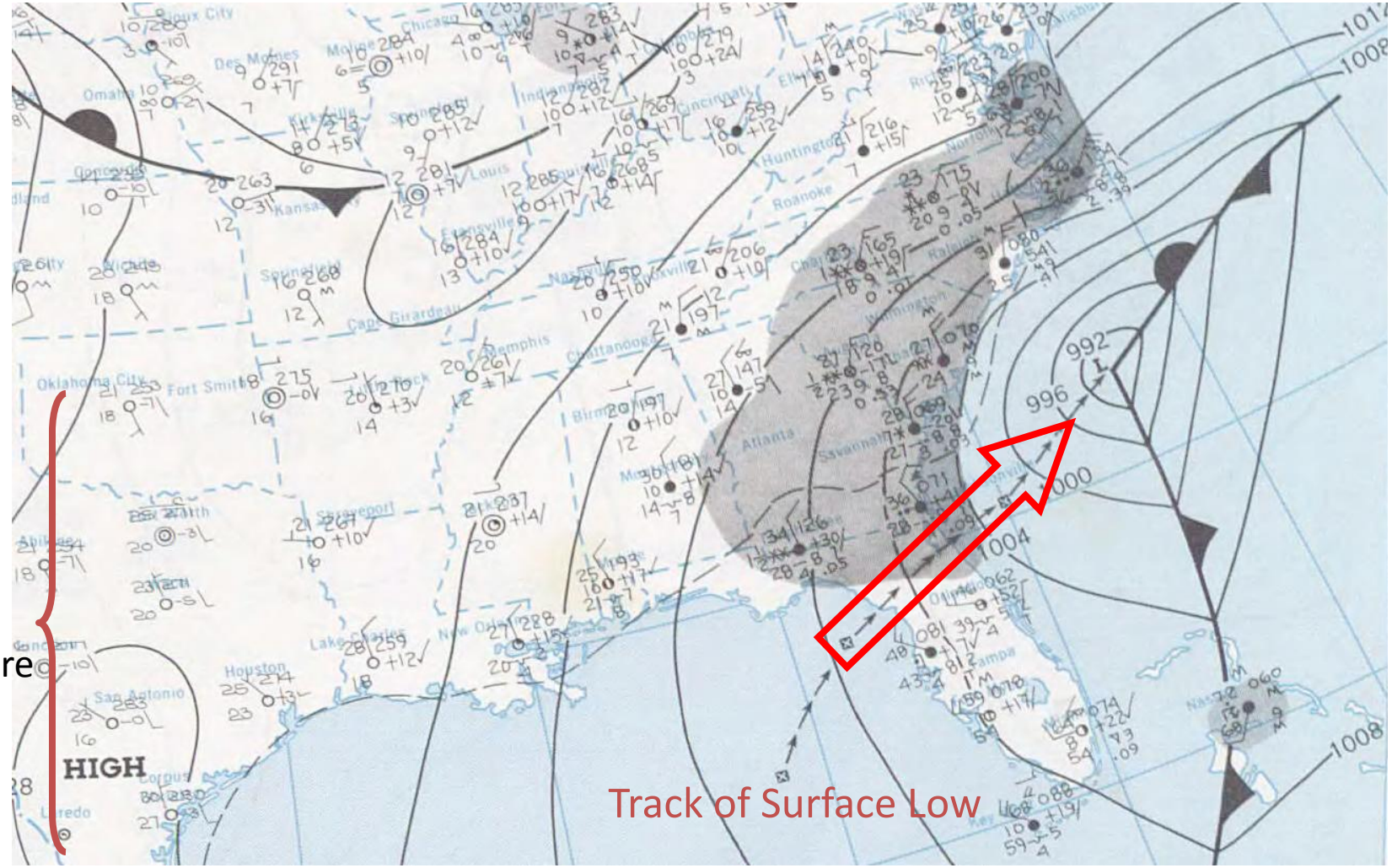
March 11-12, 1960



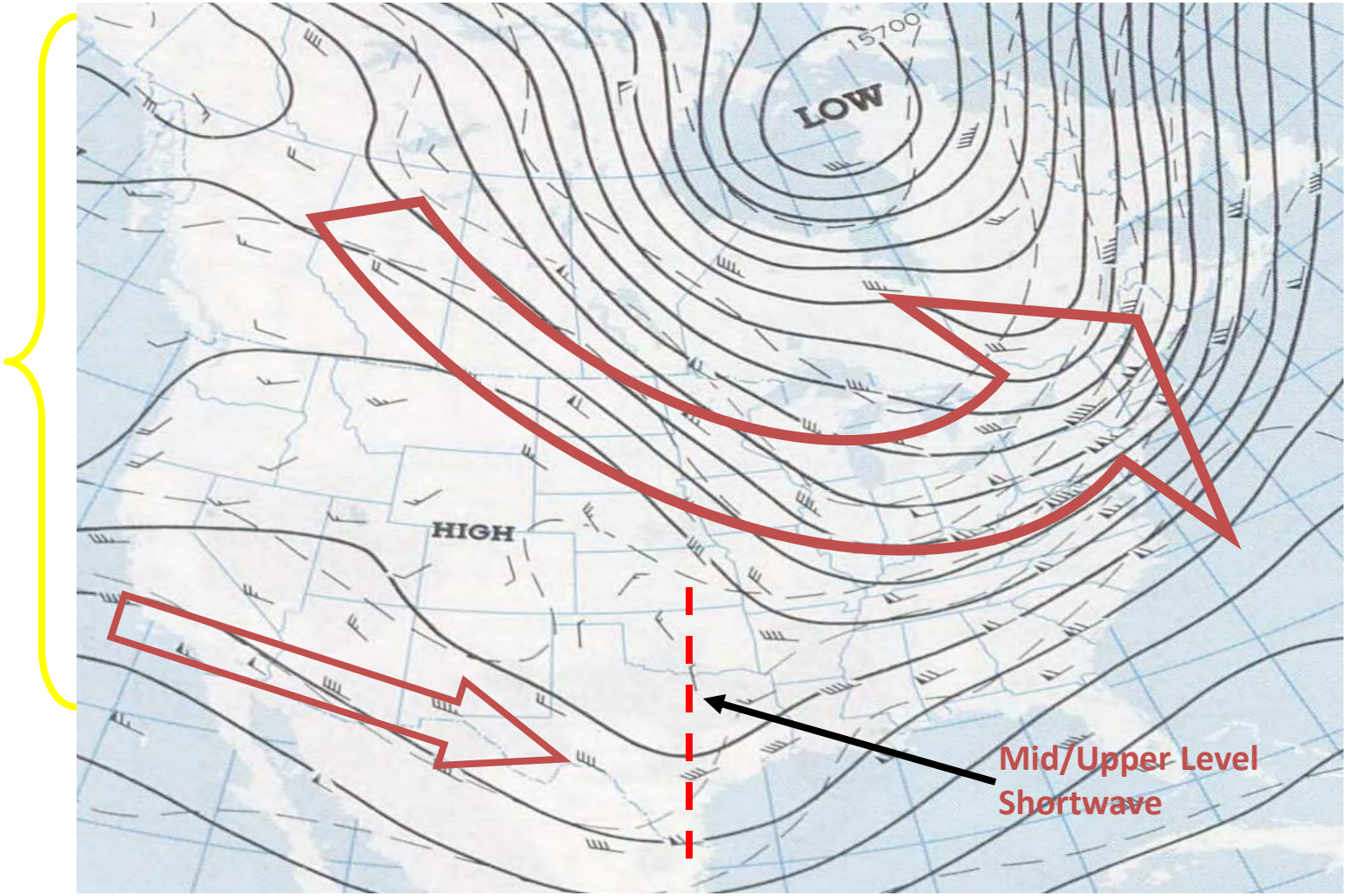


* Highest snowfall on record
* All-time 24-hr state record – Rimini – 24”
* 12.3 in at Columbia metro
* Largest 24-hr total -> 15.7”
* Largest event total -> 16”
* The only other time Columbia received more than 10 inches was 1899
* Charleston record 7.1”
* El Nino

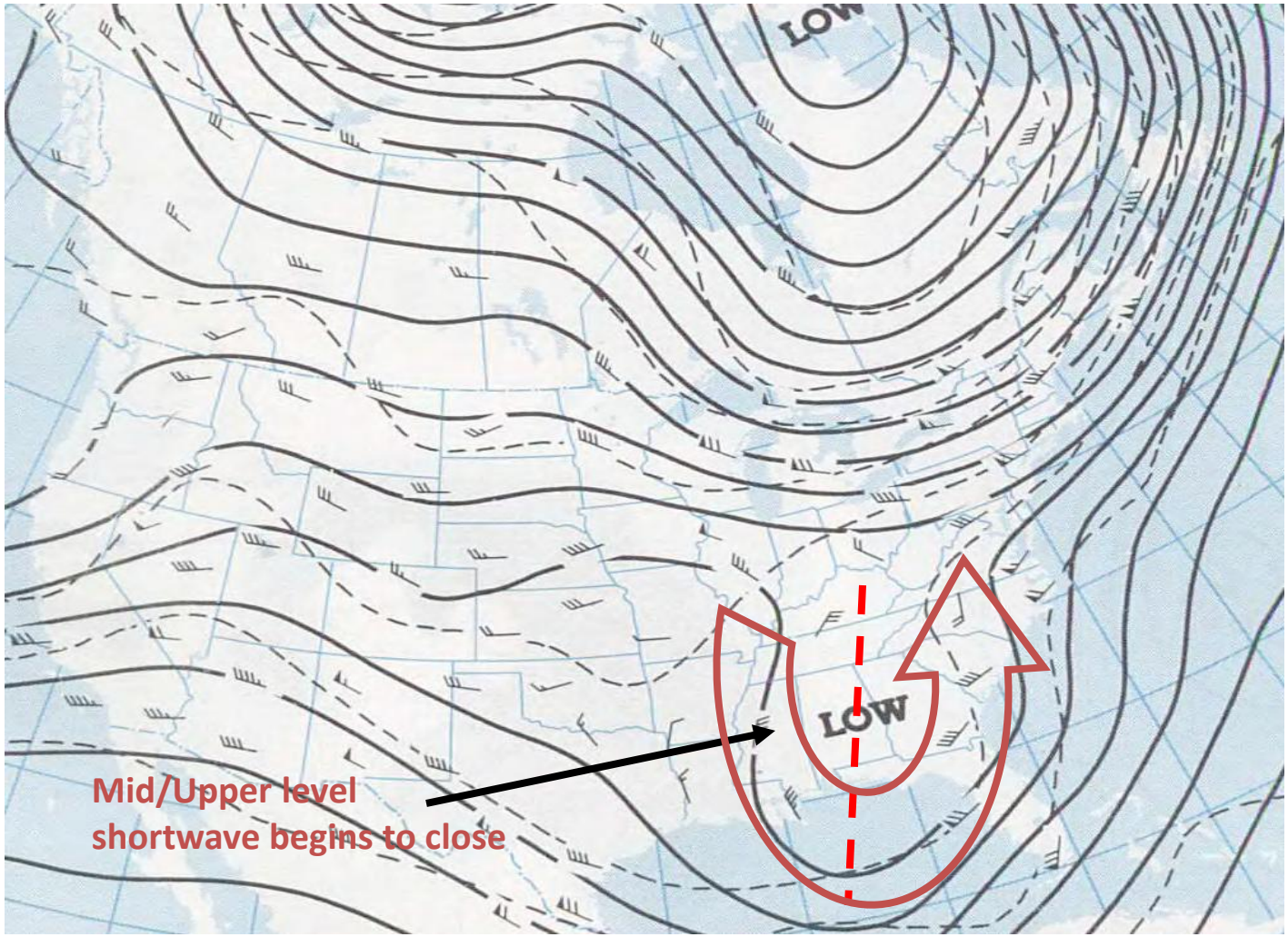
Feb 9th-10th, 1973 (10/12z)



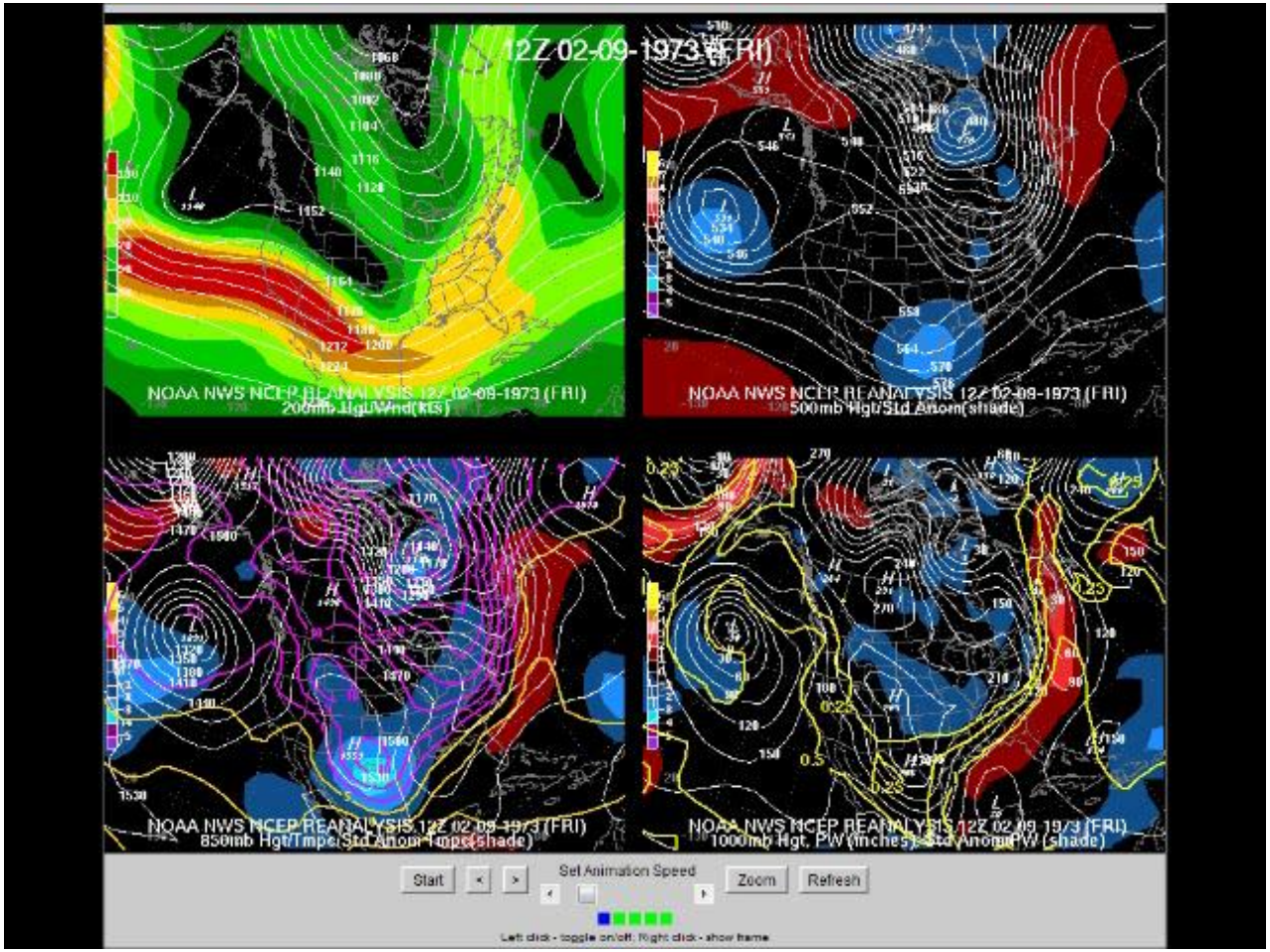
Feb 9th, 1973 (500 mb/12z)



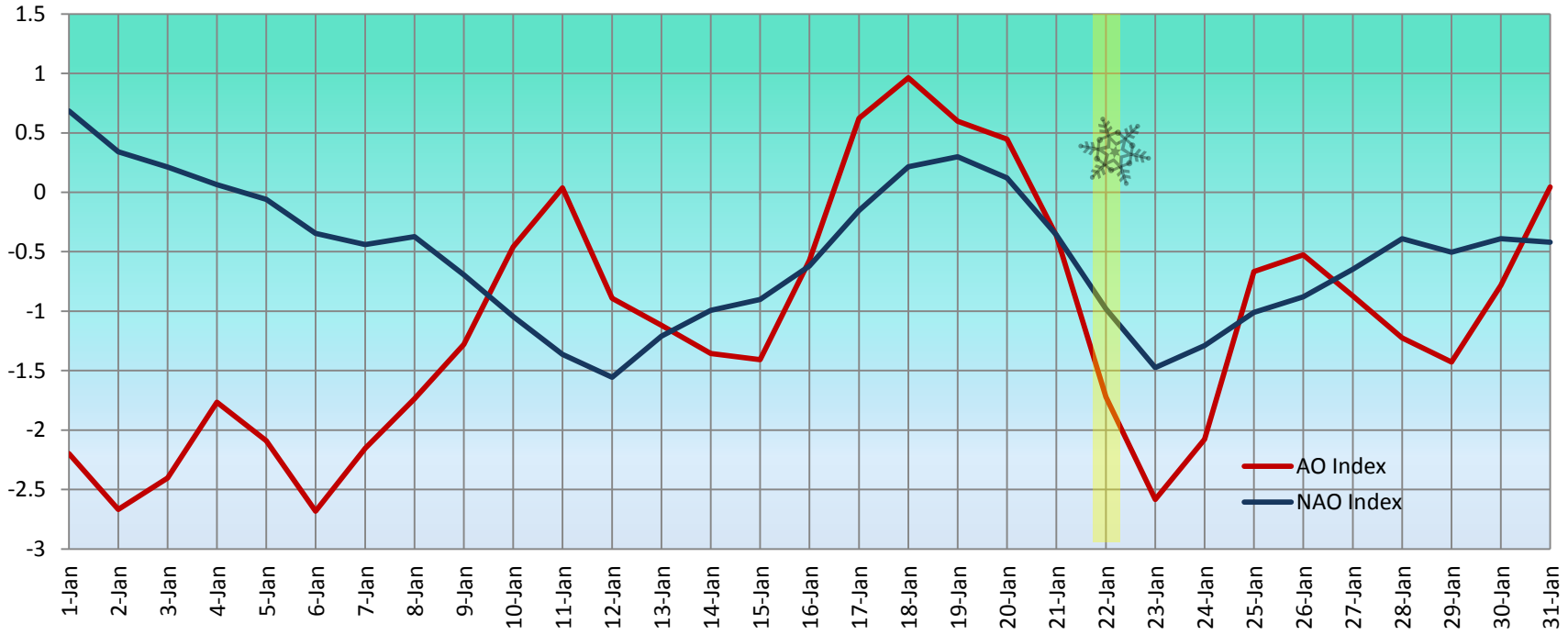
Feb 10th, 1973 (500 mb/12z)



February 9-10, 1973

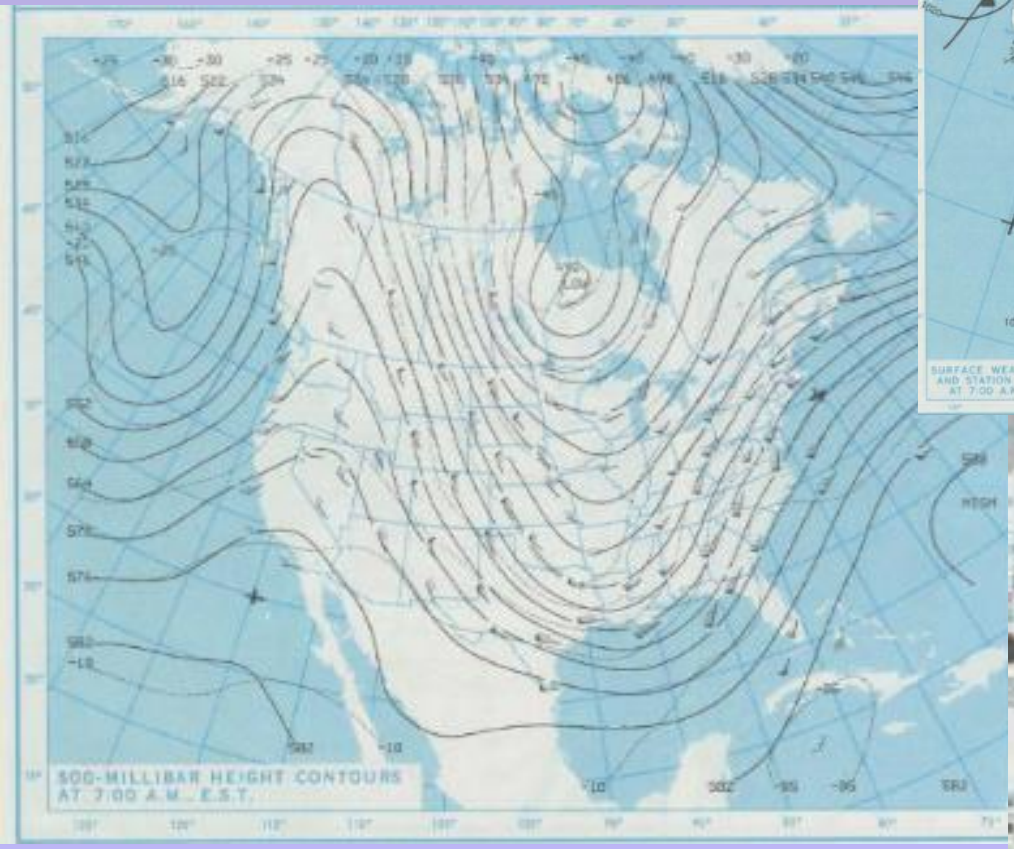


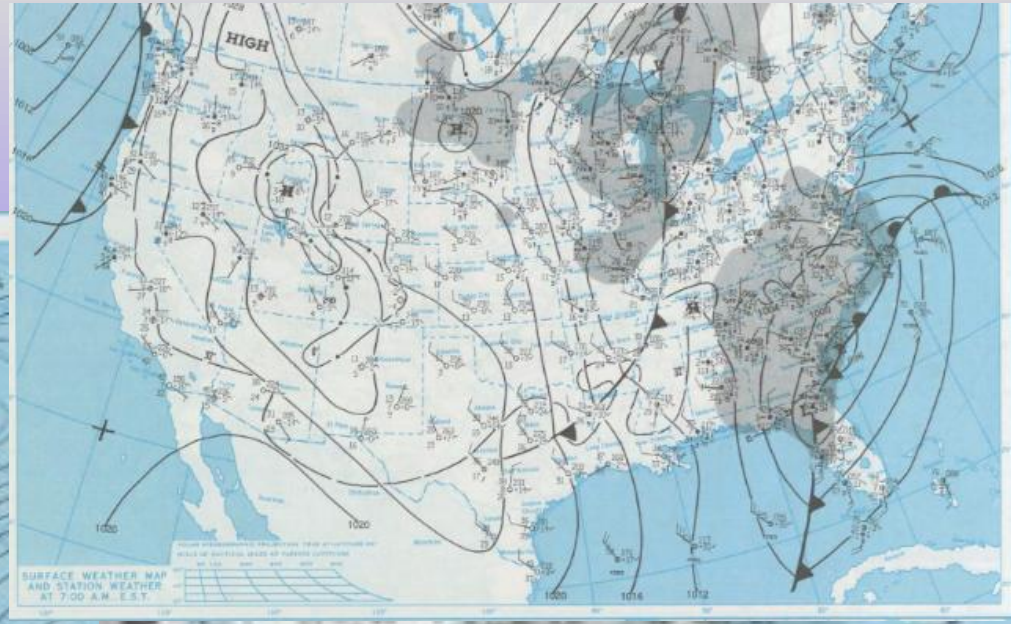
January 22, 1987



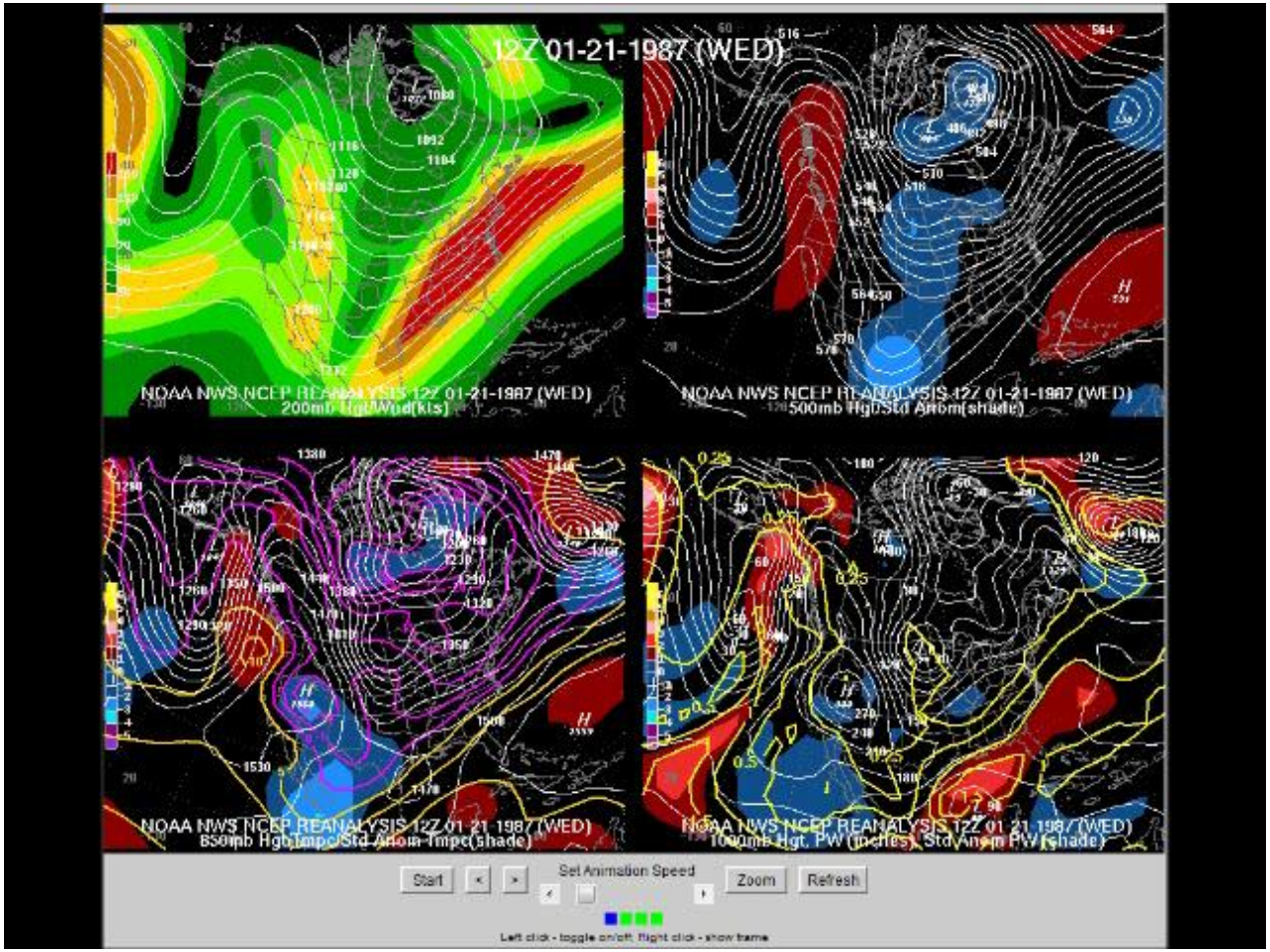
* Highest totals in the upstate
* GSP – 10.2”
* Pickens – 8.5”
* Anderson – 7.3”
* Columbia did not get any snow from this event, but received 0.8” 5 days later
* El Nino

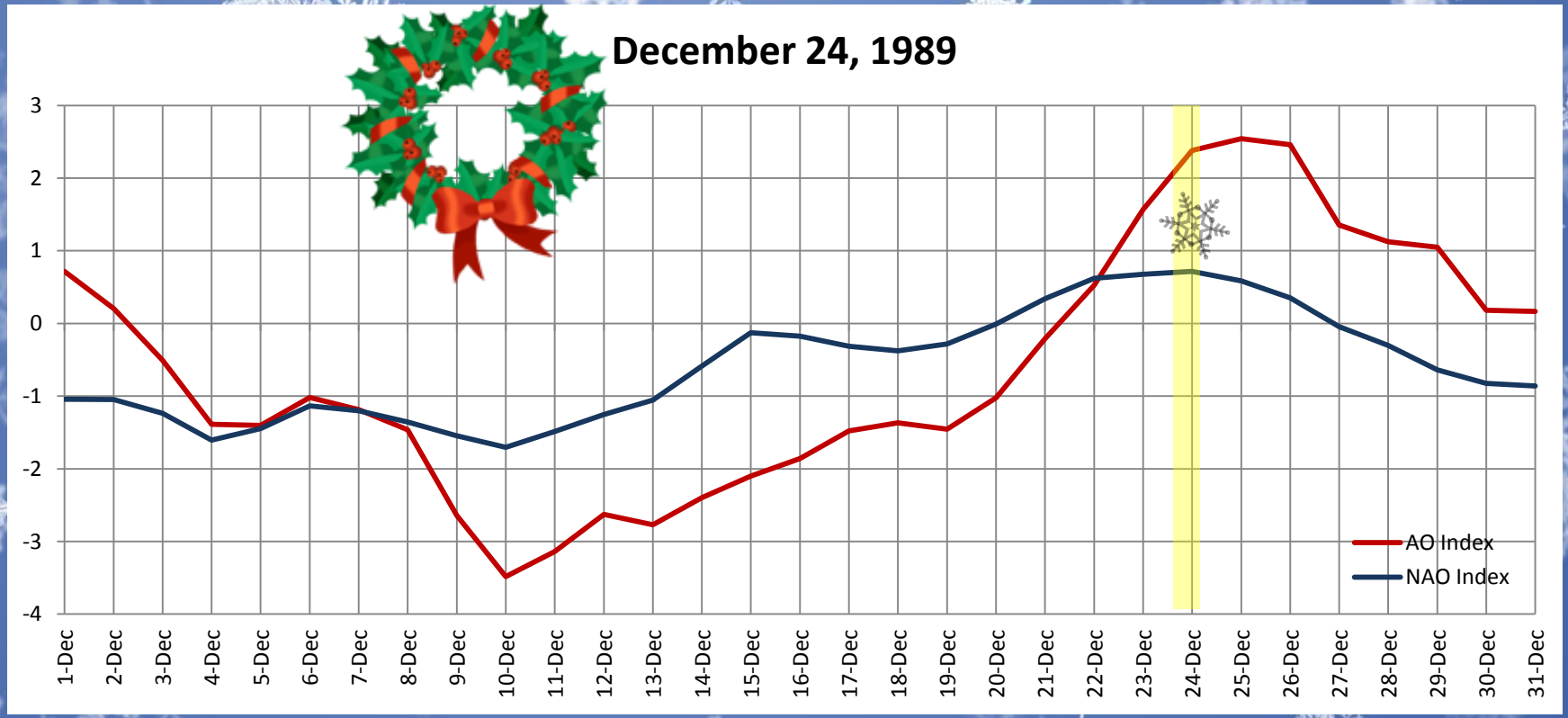
January 22, 1987





January 22, 1987



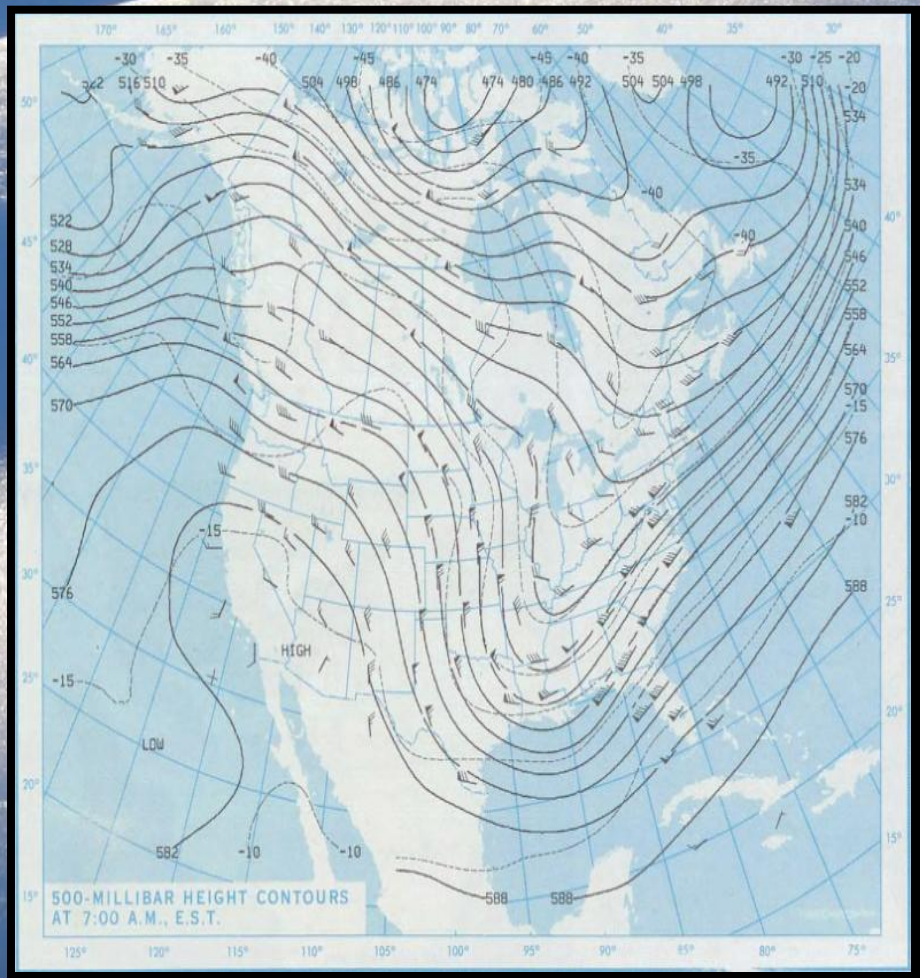


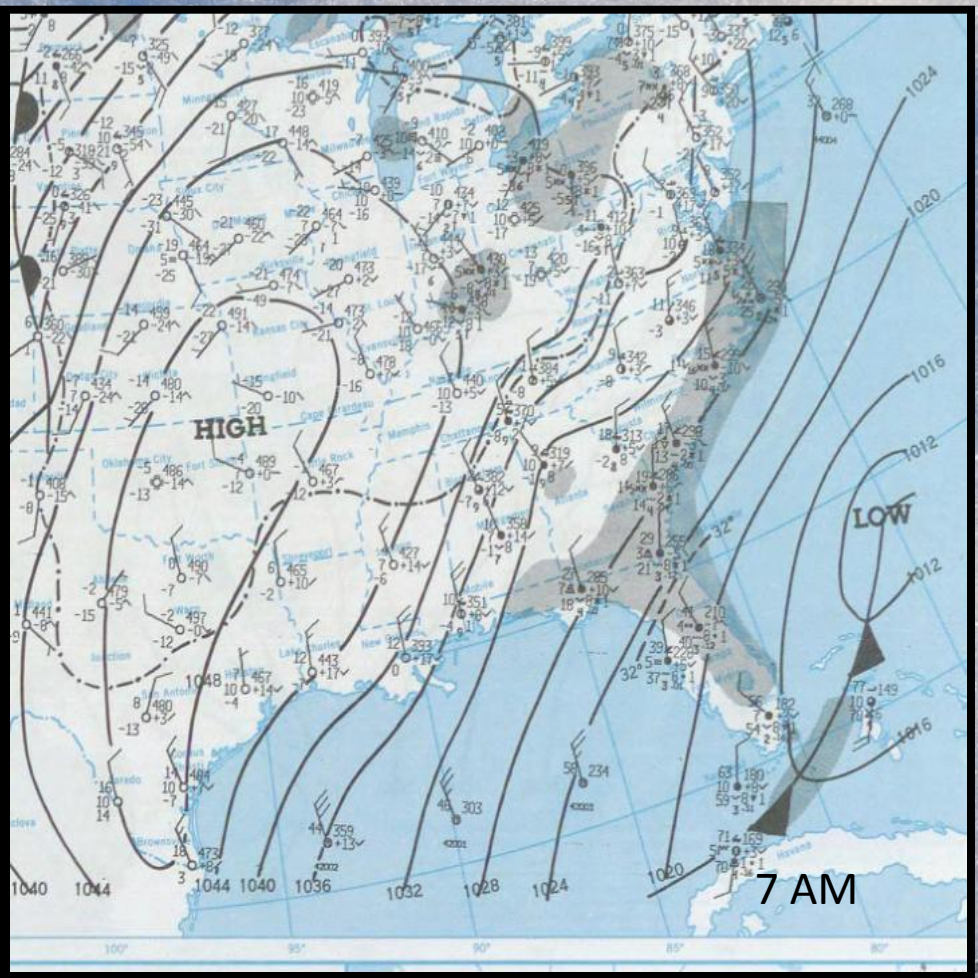
* Coastal/Lowcountry storm
* Some parts of Charleston received 8" – first white Christmas and coldest Christmas – high of 18°F
* Winds gusted to 60 mph, wave heights off NC coast as high as 34 ft
* ENSO neutral

Wilmington, NC

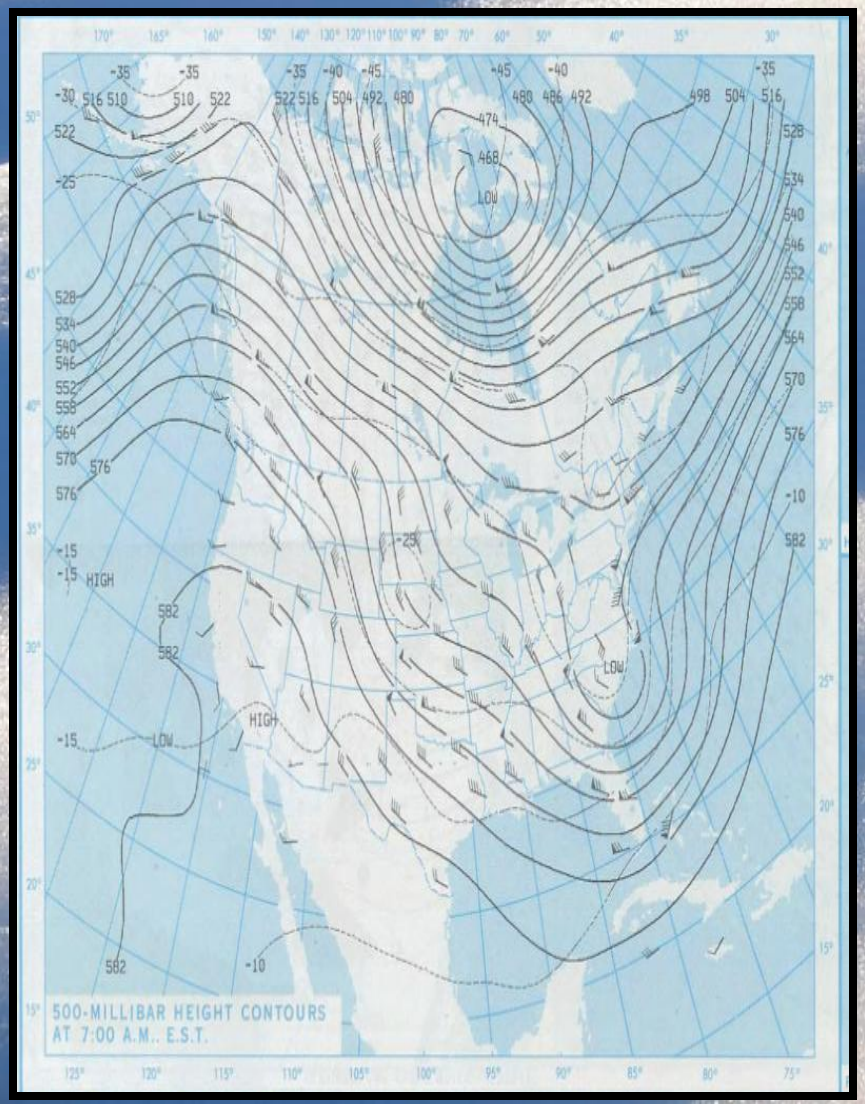
Image source: StarNews: http://www.myreporter.com/?p=6088

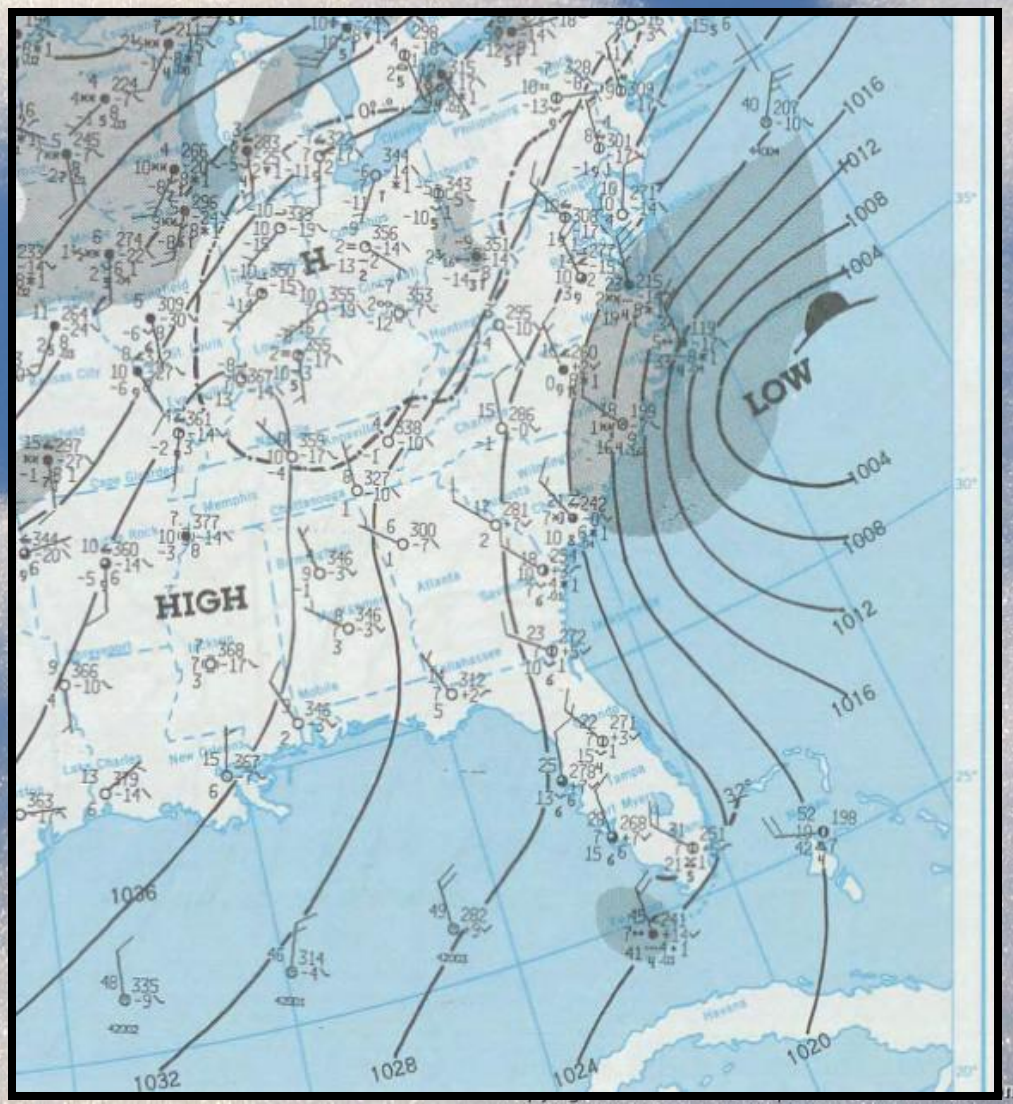
December 23-24, 1989

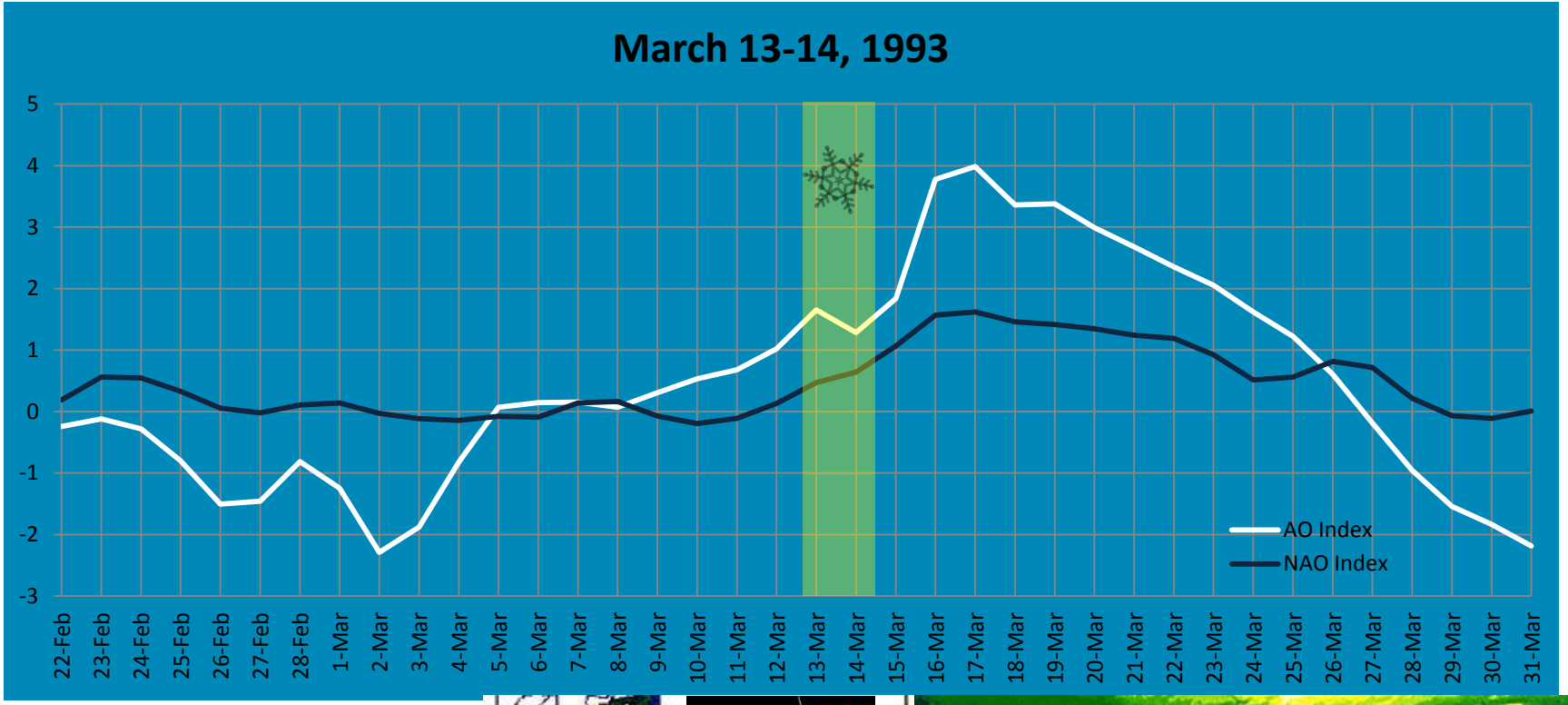




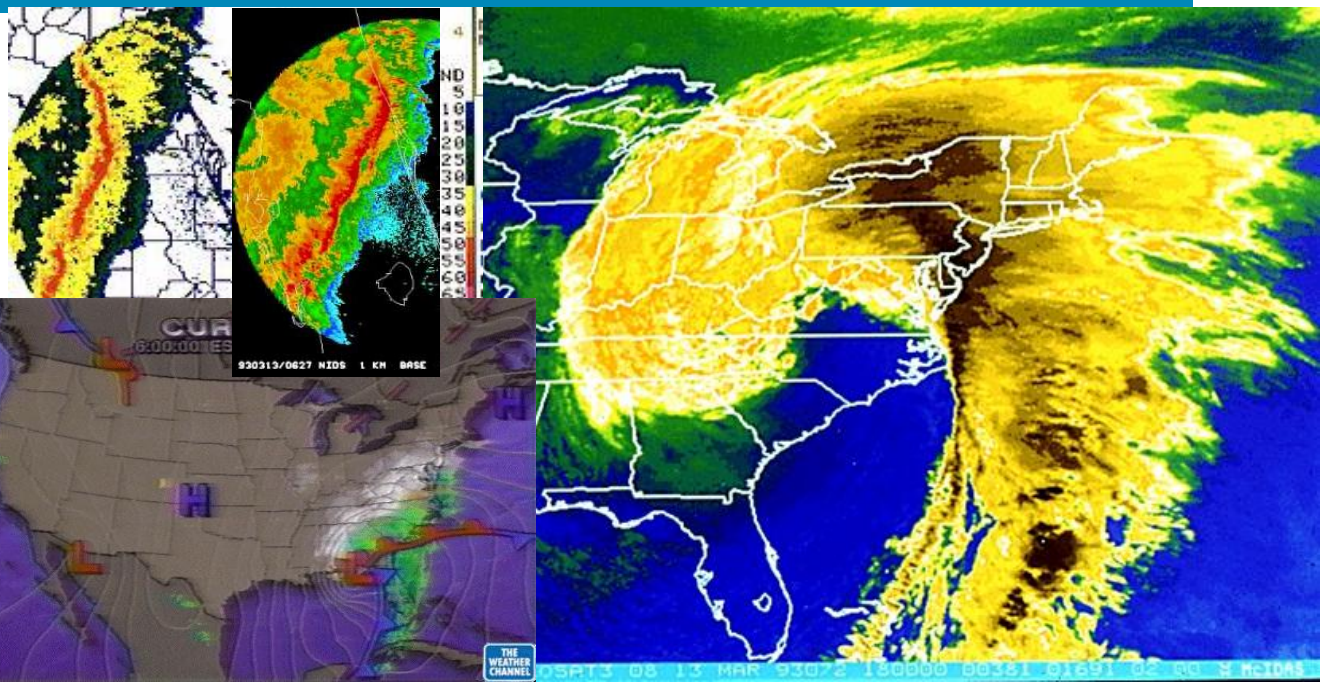
December 23-24, 1989

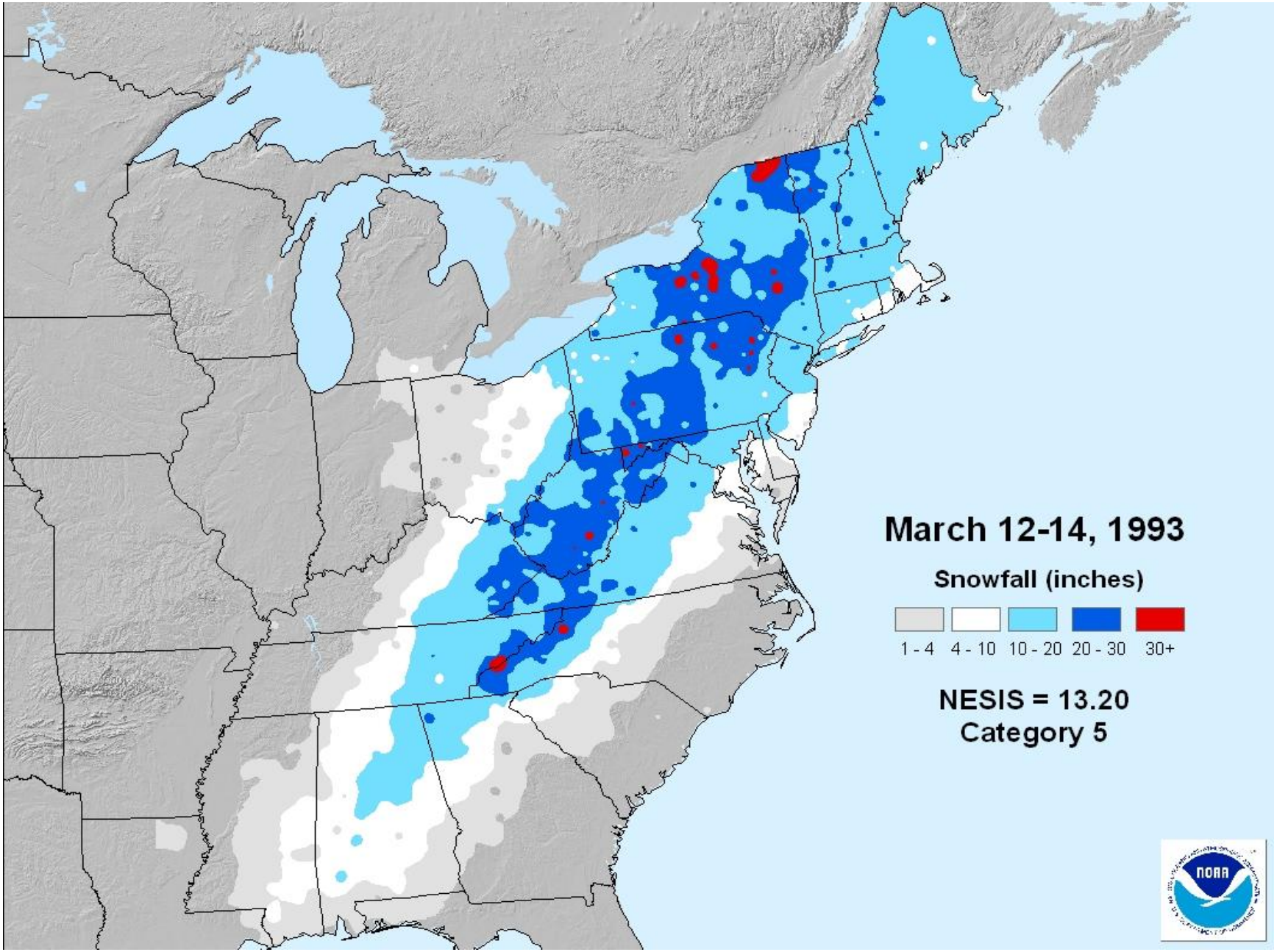




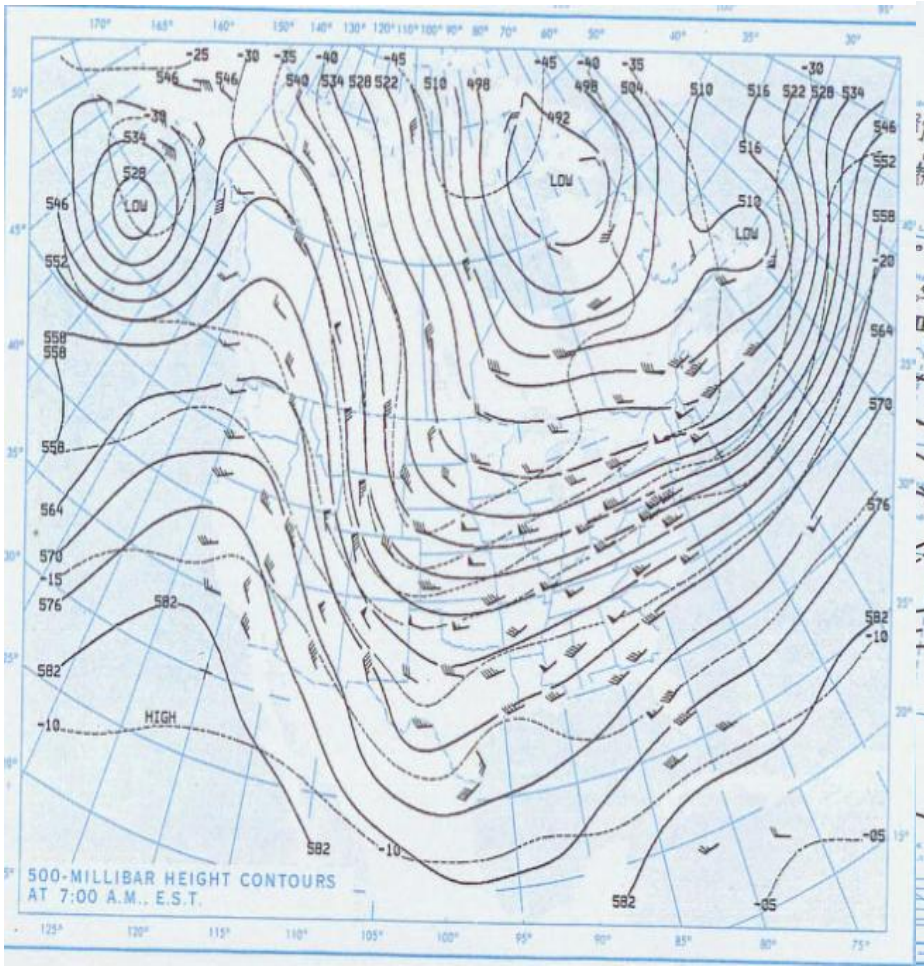


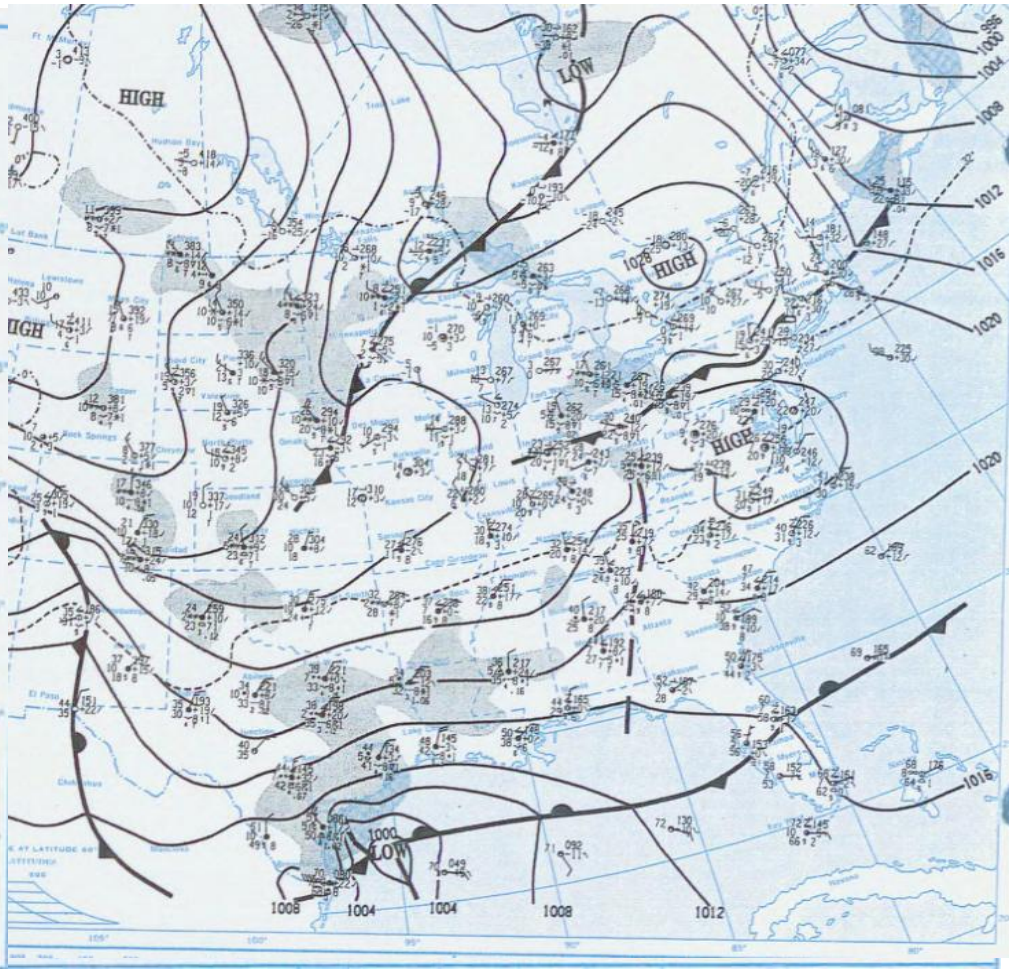
* Storm of the Century/93 Superstorm
* 4” in FL panhandle
* Hurricane force wind gusts
* More people drowned than in Hugo and Andrew combined
* Record low barometric pressures
* 11 tornadoes
* Total of 310 deaths
* El Nino



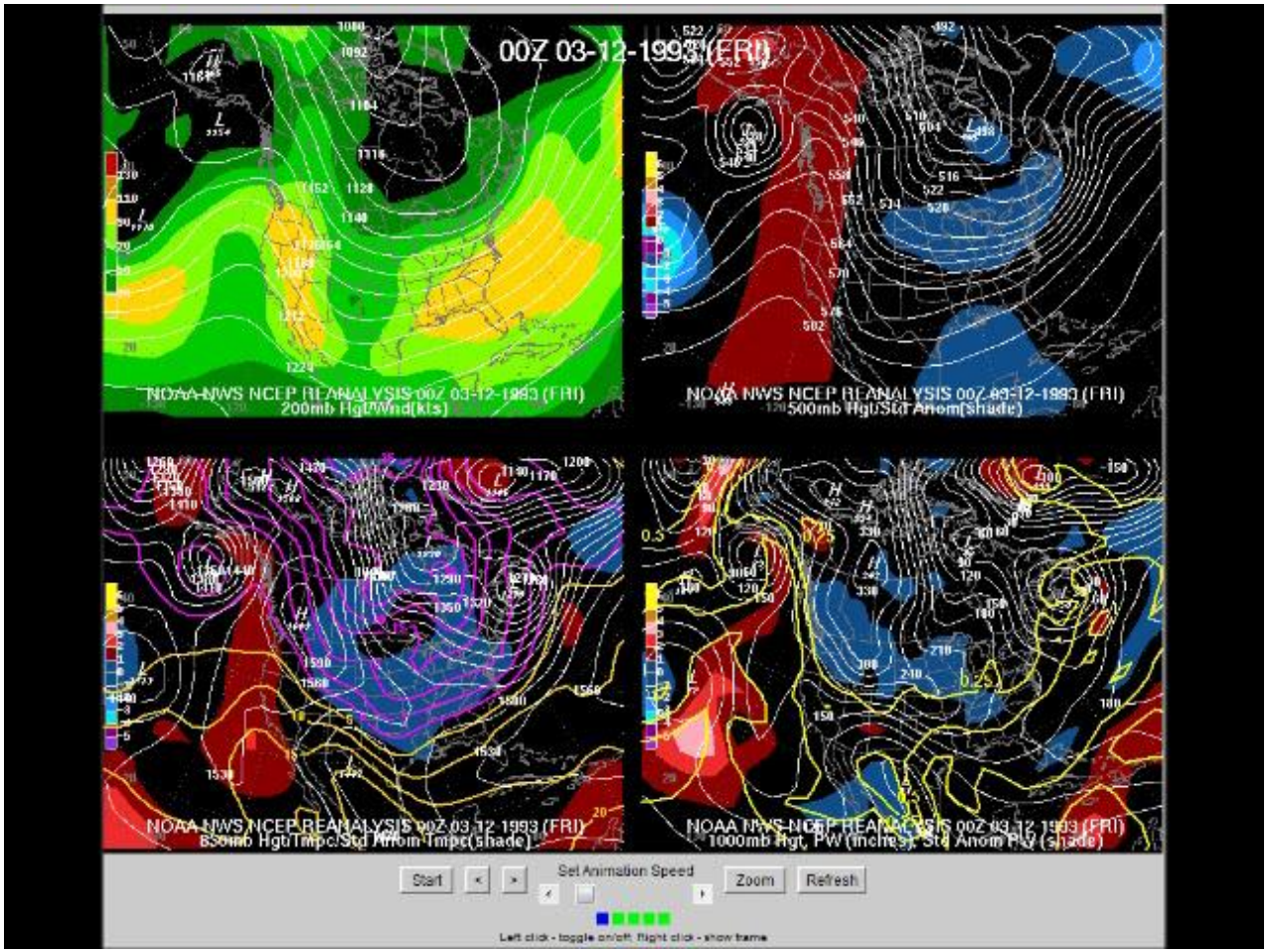

March 12-14, 1993
Snowfall (inches)
1 - 4
4 - 10
10 - 20
20 - 30
30+
NESIS = 13.20
Category 5
NOAA

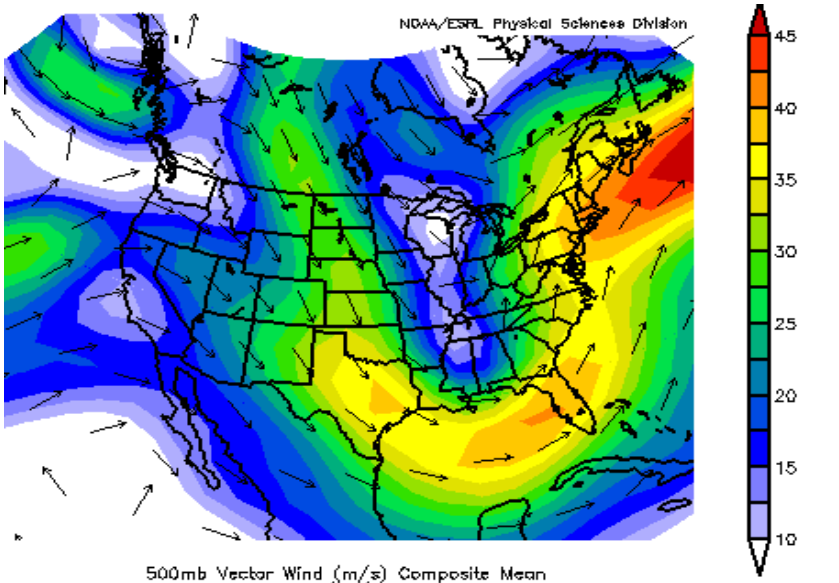
March 12, 1993 7:00 AM



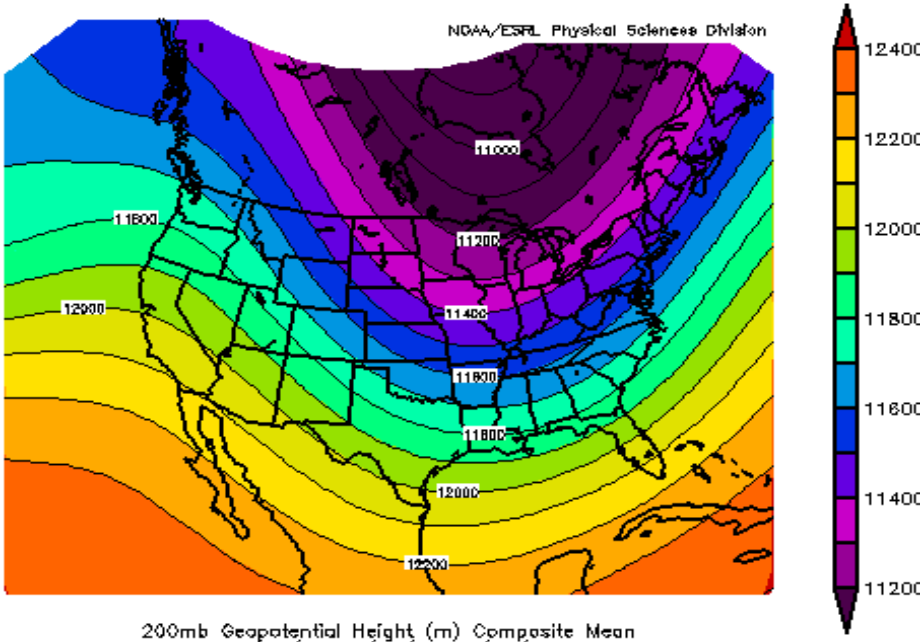


March 13-14, 1993

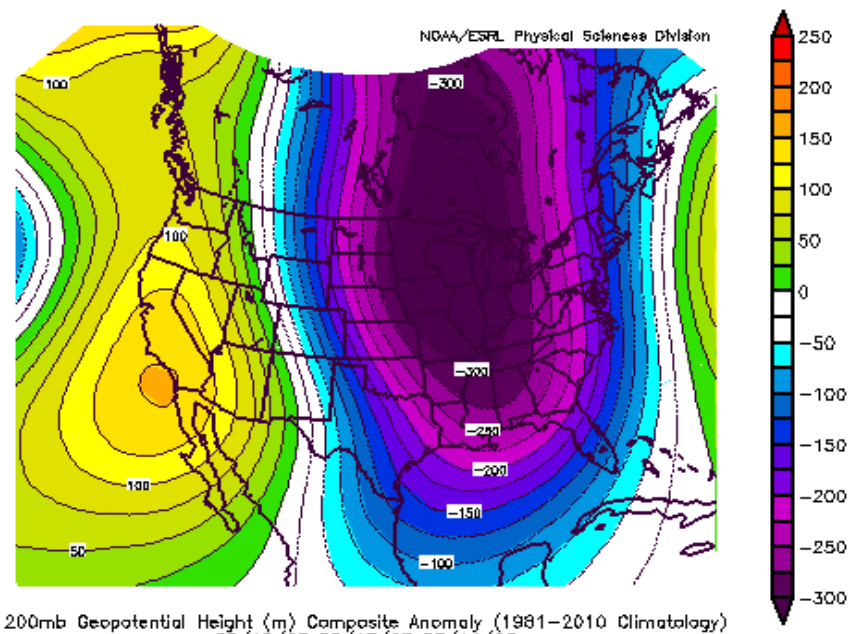




500mb Vector Wind (m/s) Composite Mean
03/13/93
NCEP/NCAR Reanalysis

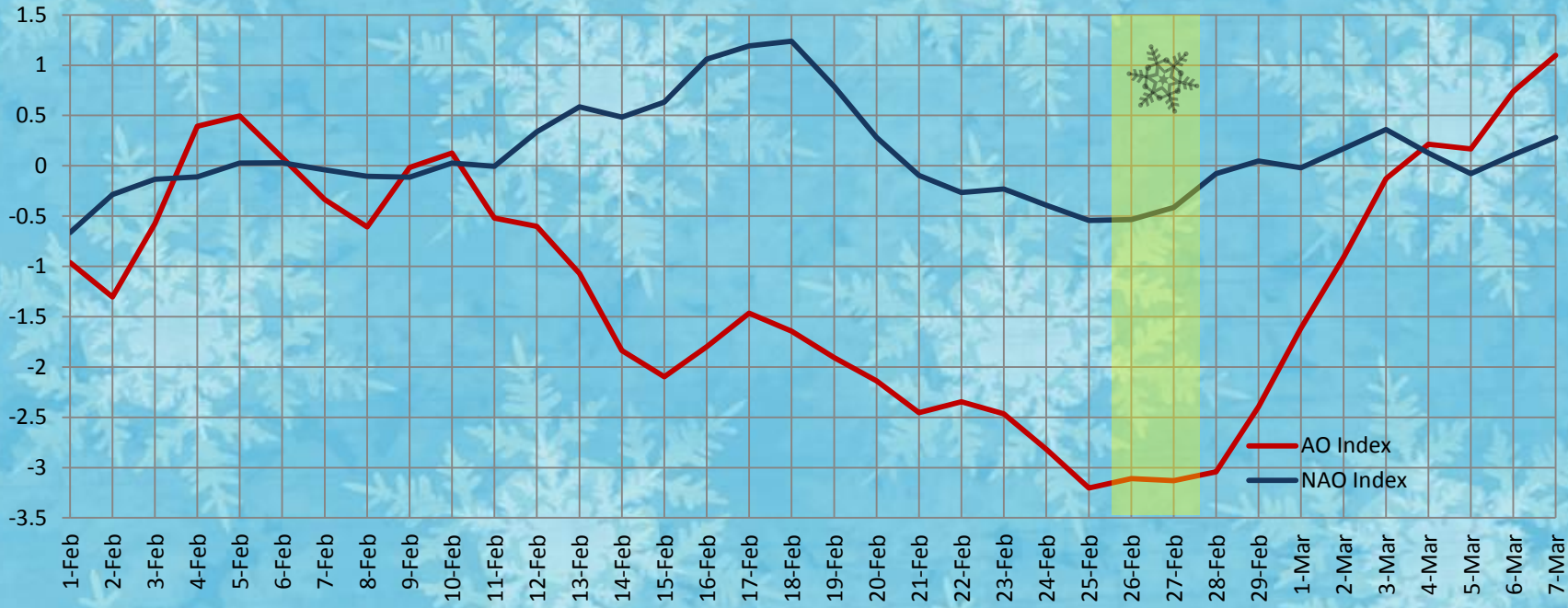


200mb Geopotential Height (m) Composite Mean
03/12/93 03/13/93 03/14/93
NCEP/NCAR Reanalysis

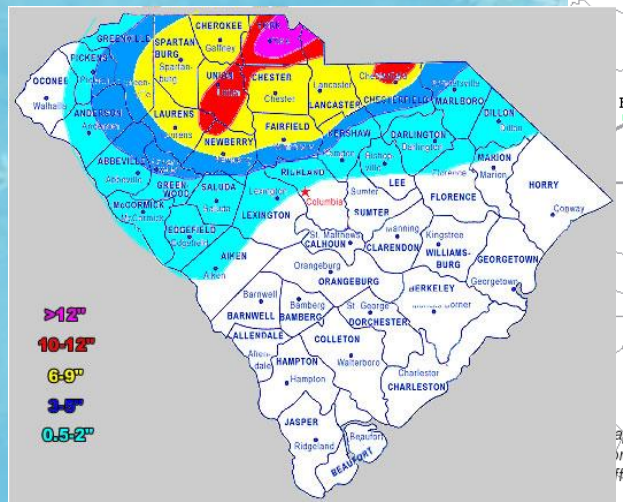


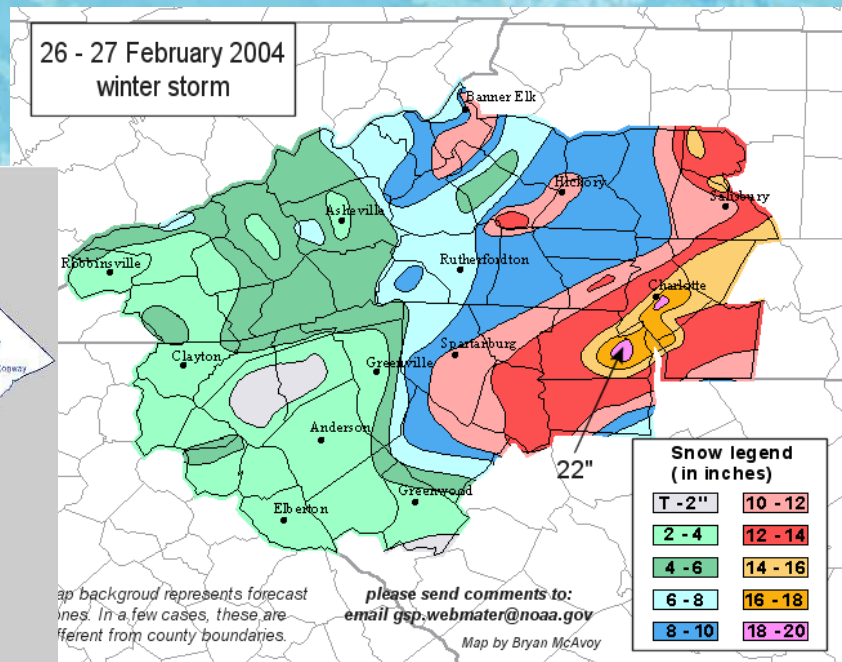
200mb Geopotential Height (m) Composite Anomaly (1981-2010 Climatology)
03/12/93 03/13/93 03/14/93
NCEP/NCAR Reanalysis

February 26-27, 2004

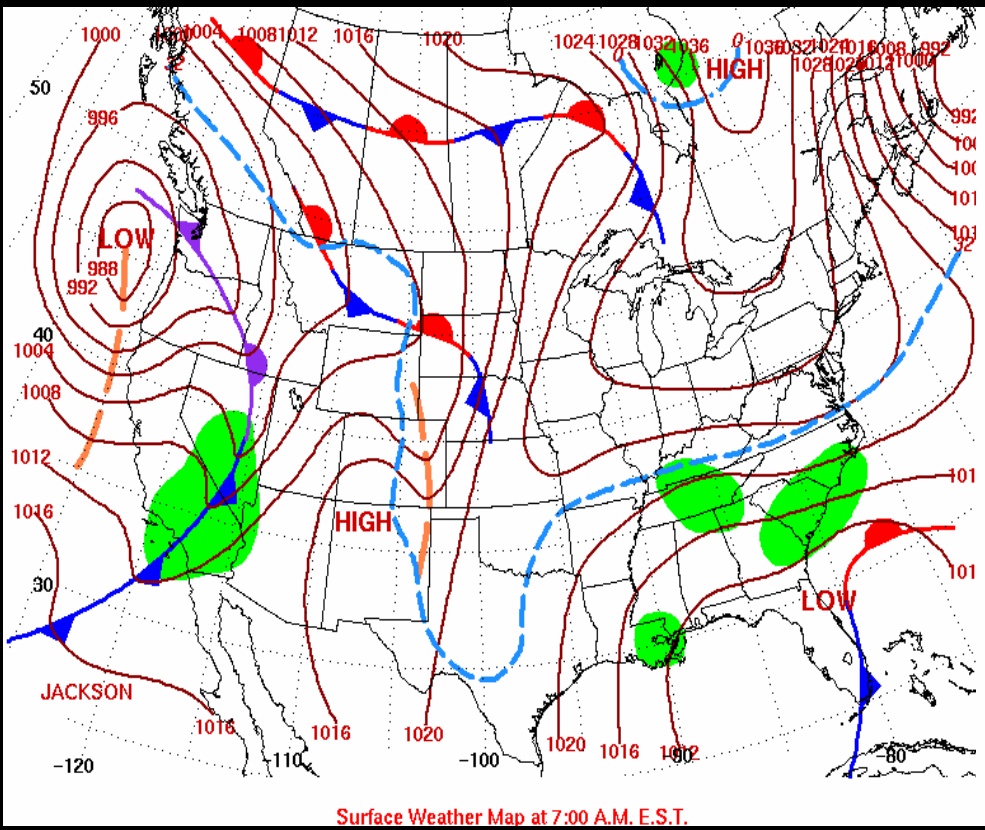


* Midlands/piedmont
* Winthrop University 1-day max of 10.3”
* Catawba – 13.5”
* Union – 7.5”
* Santuck – 7.2”
* Rock Hill – 18” in 24 hr
* ENSO neutral

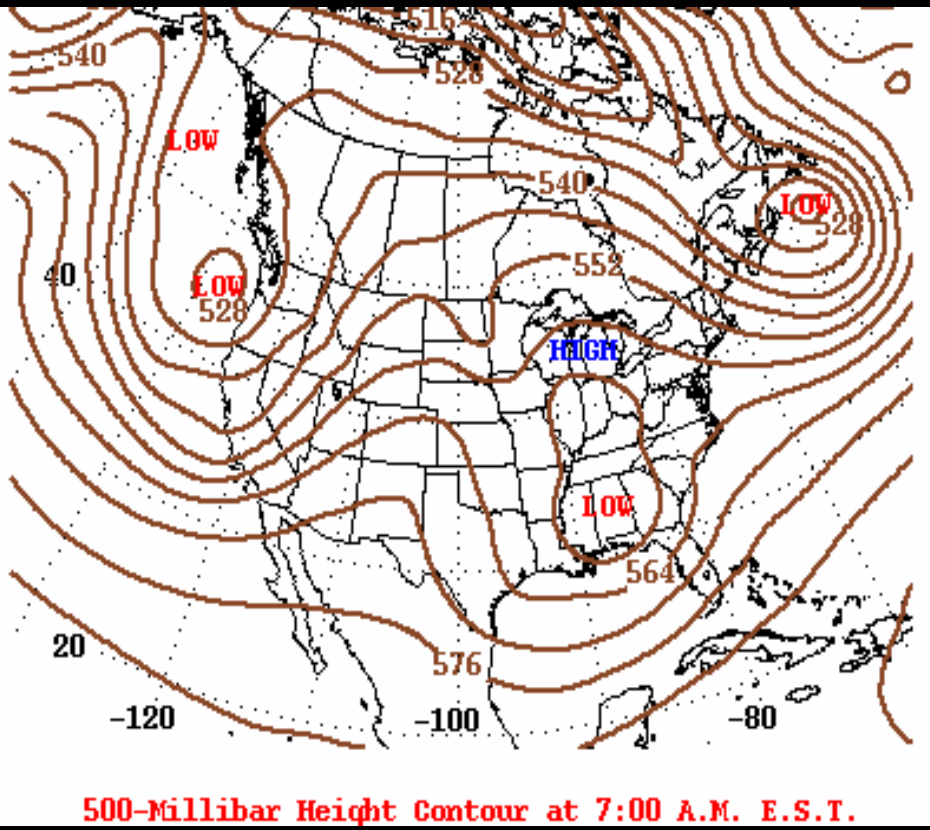




February 26th, 7:00 A.M. EST

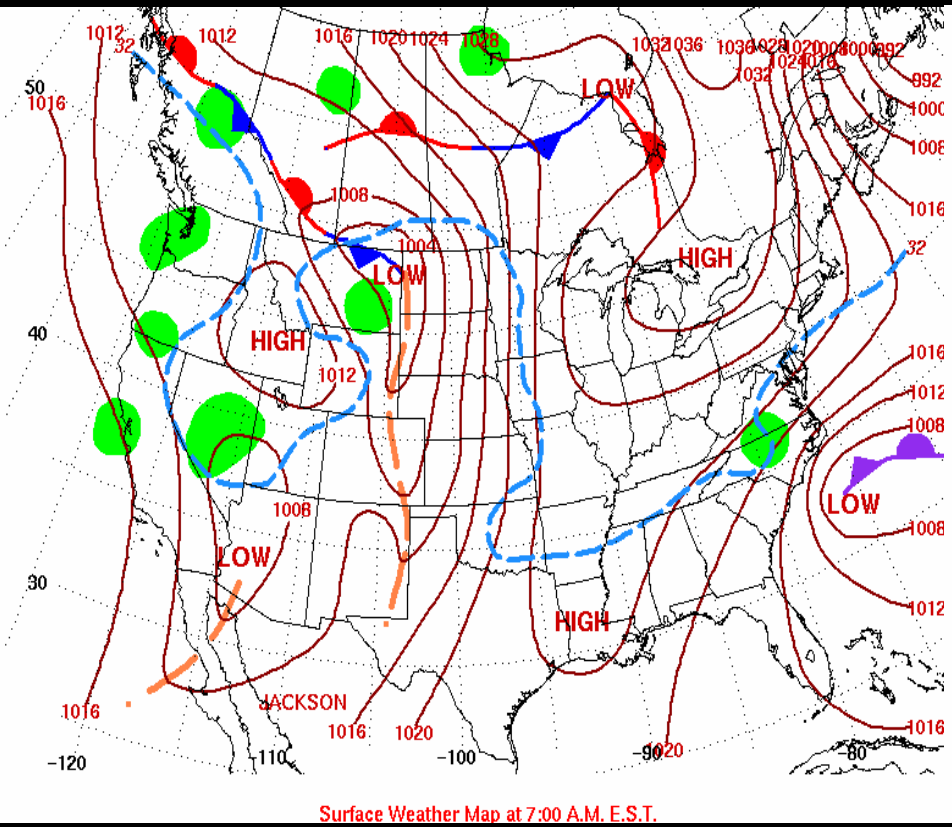


Surface Weather Map at 7:00 A.M. E.S.T.

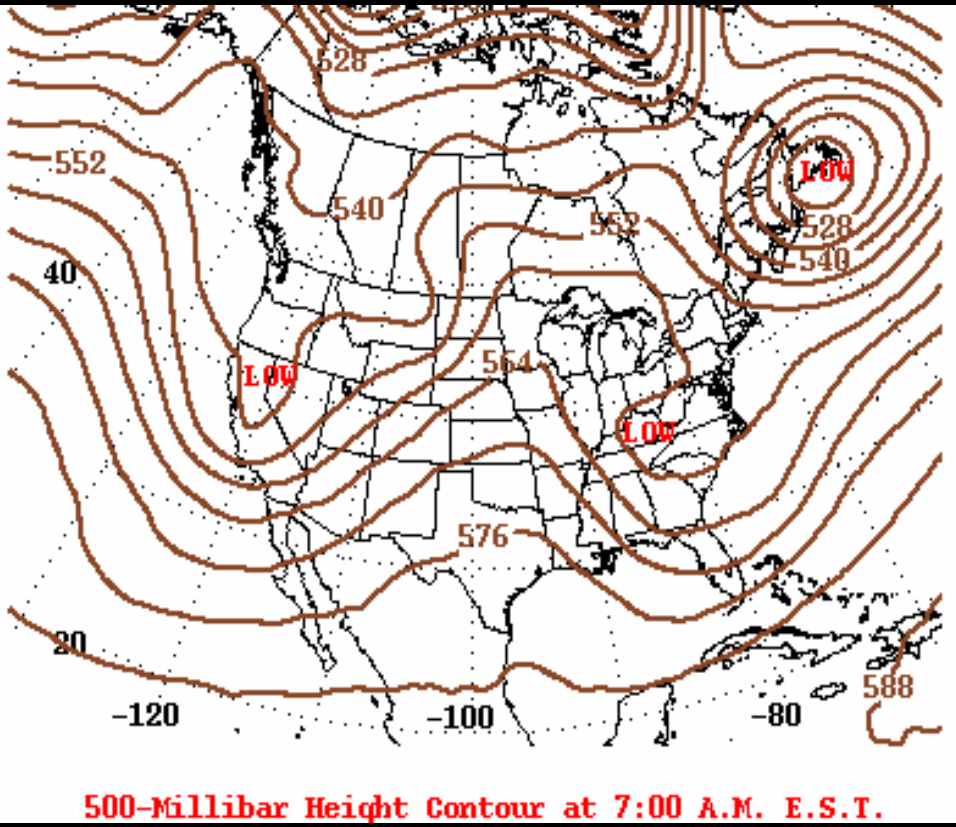


500-Millibar Height Contour at 7:00 A.M. E.S.T.

February 27th, 7:00 A.M. EST

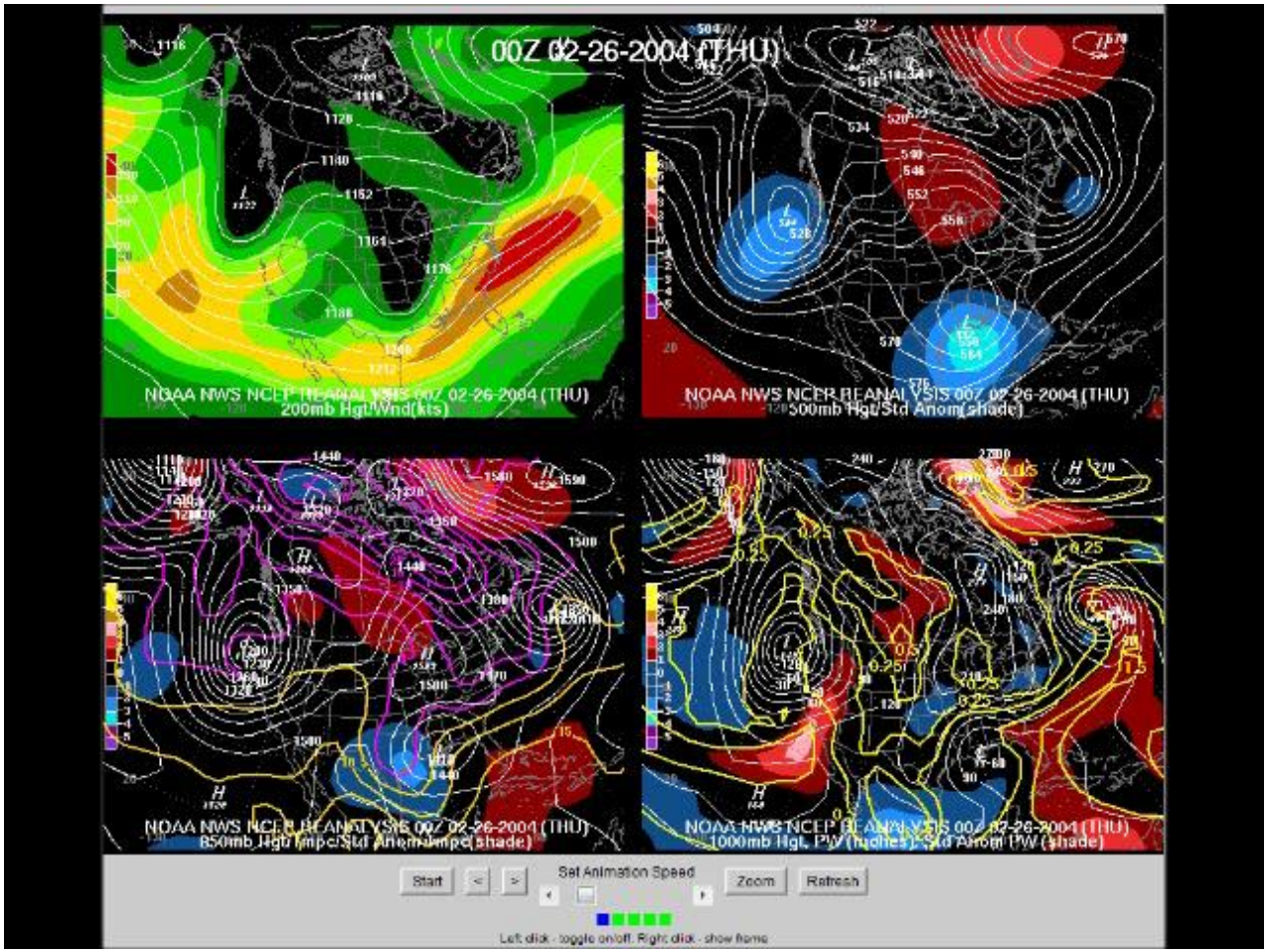


Surface Weather Map at 7:00 A.M. E.S.T.

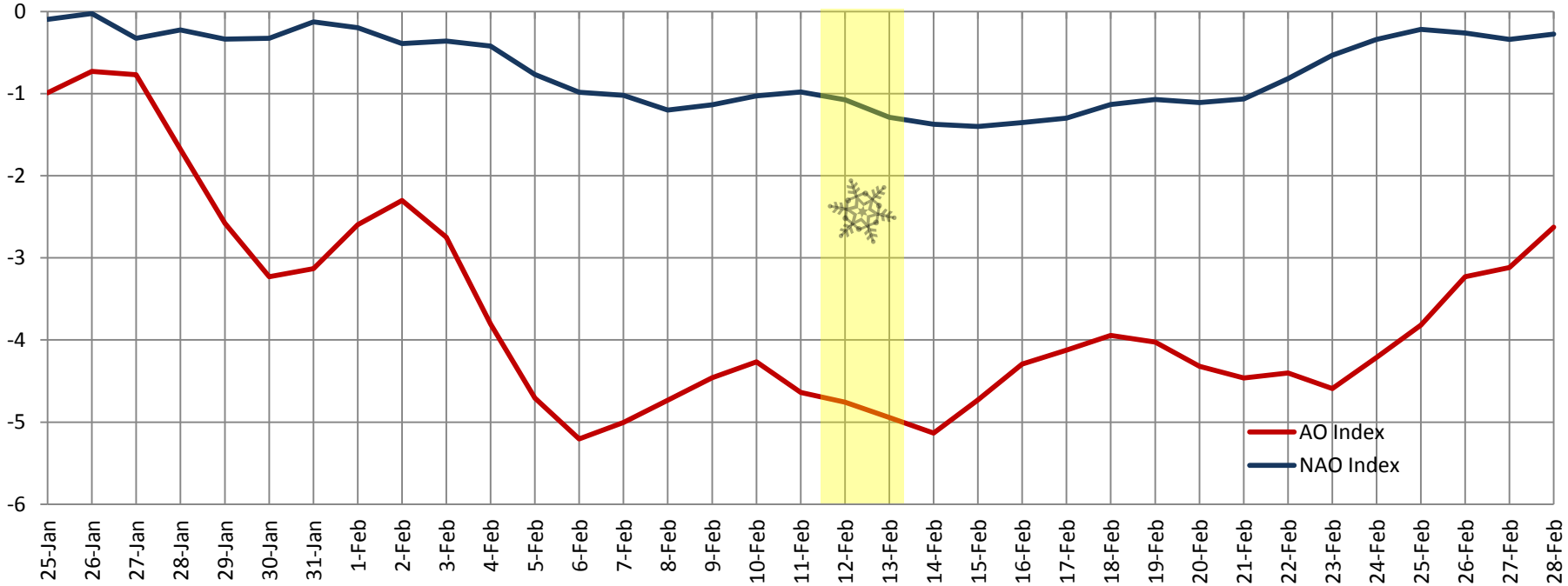


500-Millibar Height Contour at 7:00 A.M. E.S.T.

February 26-27, 2004

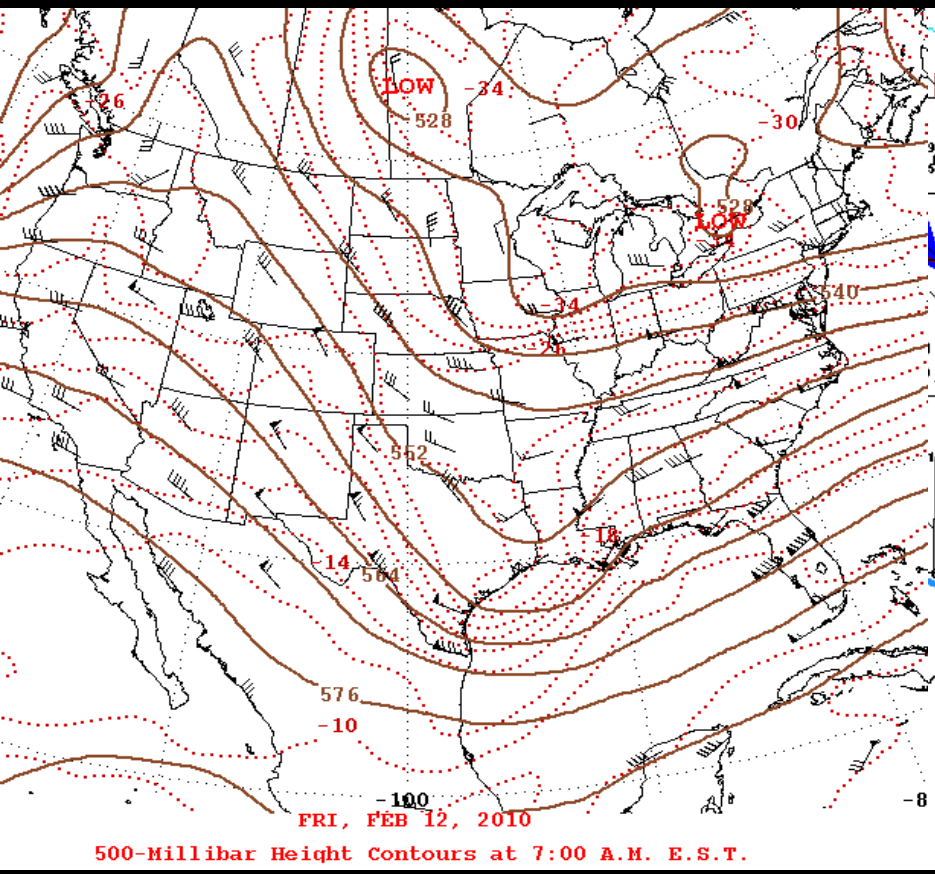


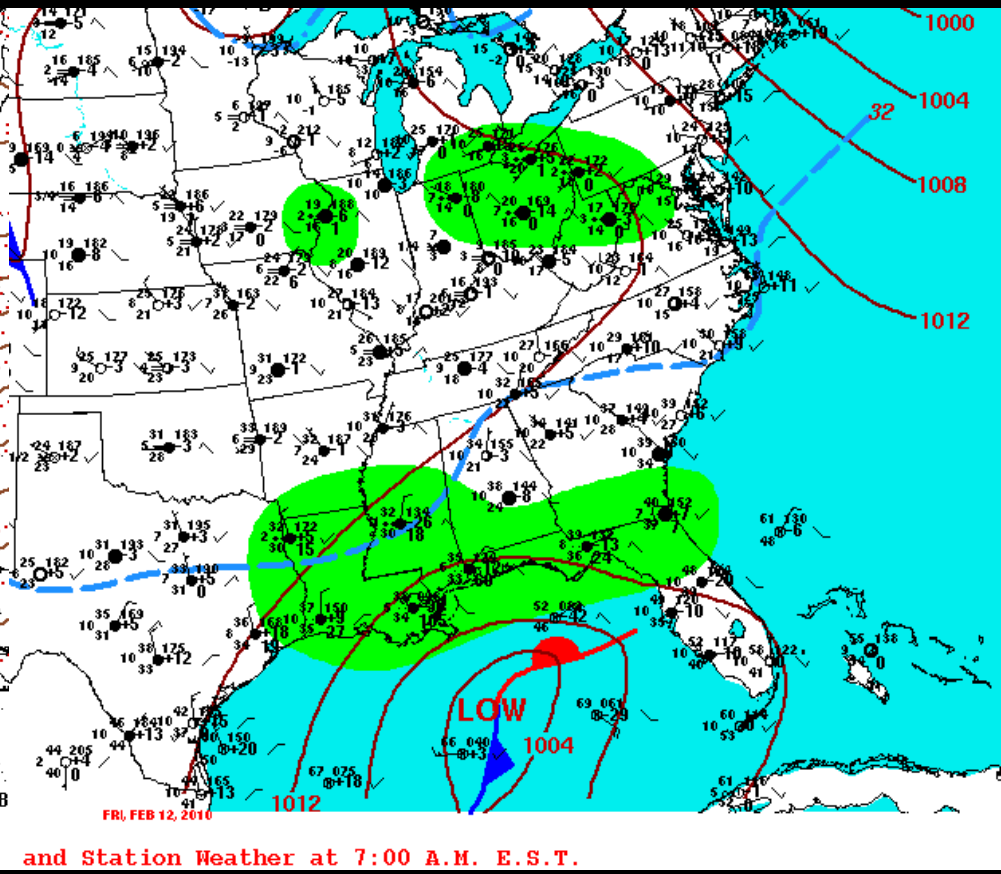
February 12-13, 2010



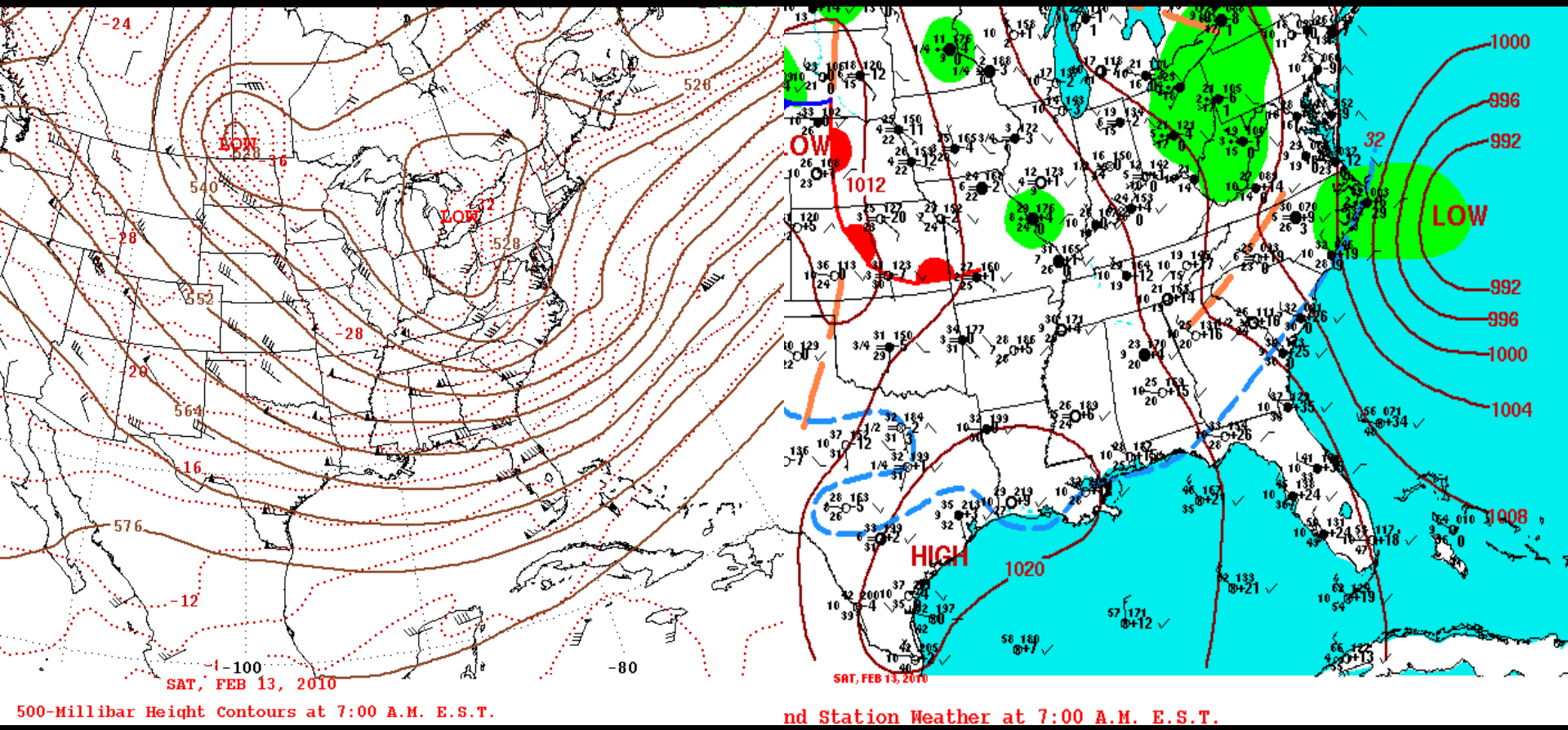
* Statewide
* Columbia metro AP (NWSFO) 8.6”
* 6th heaviest on record in Columbia
* El Nino

February 12, 2010 7:00 AM EST

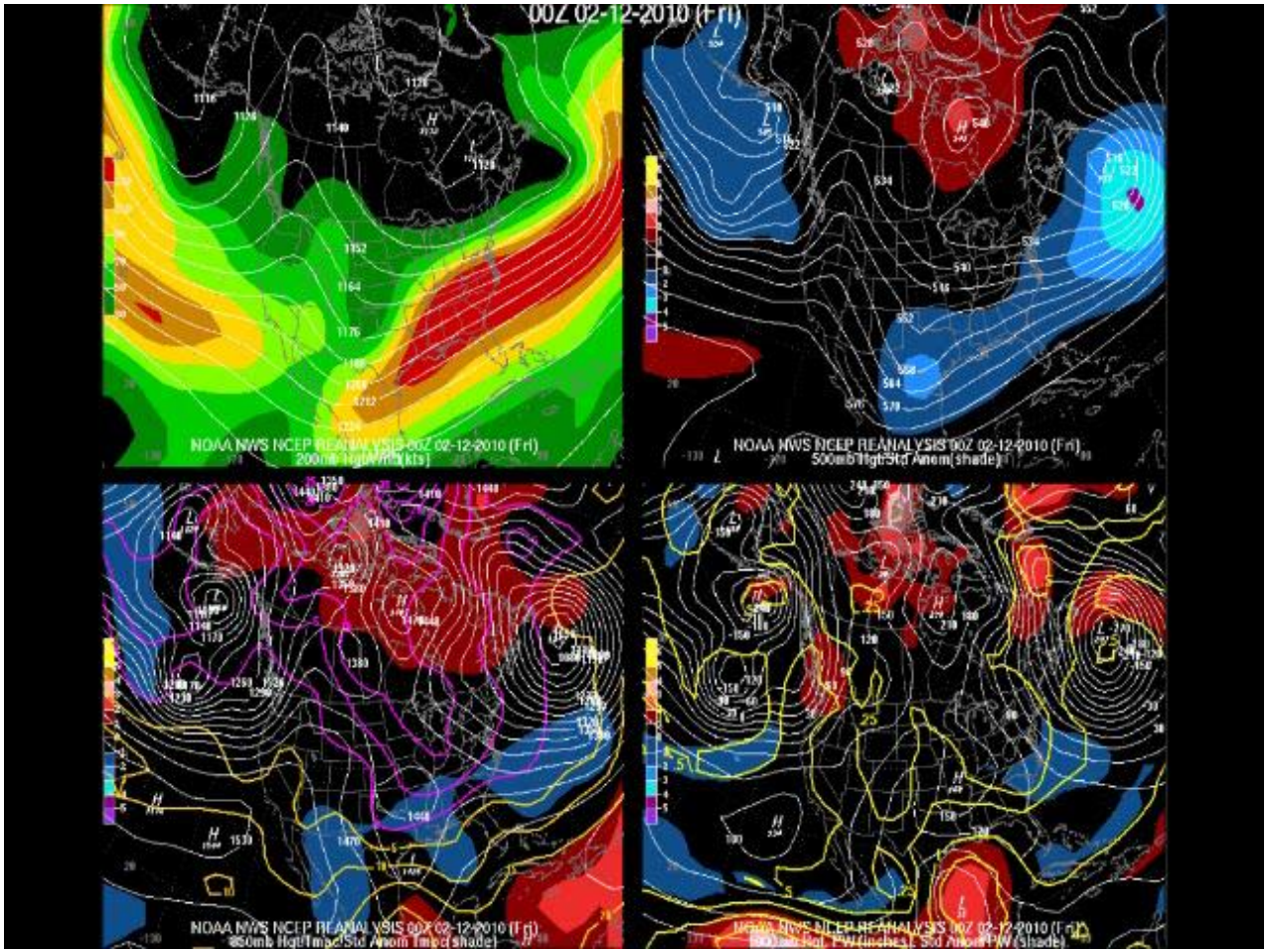


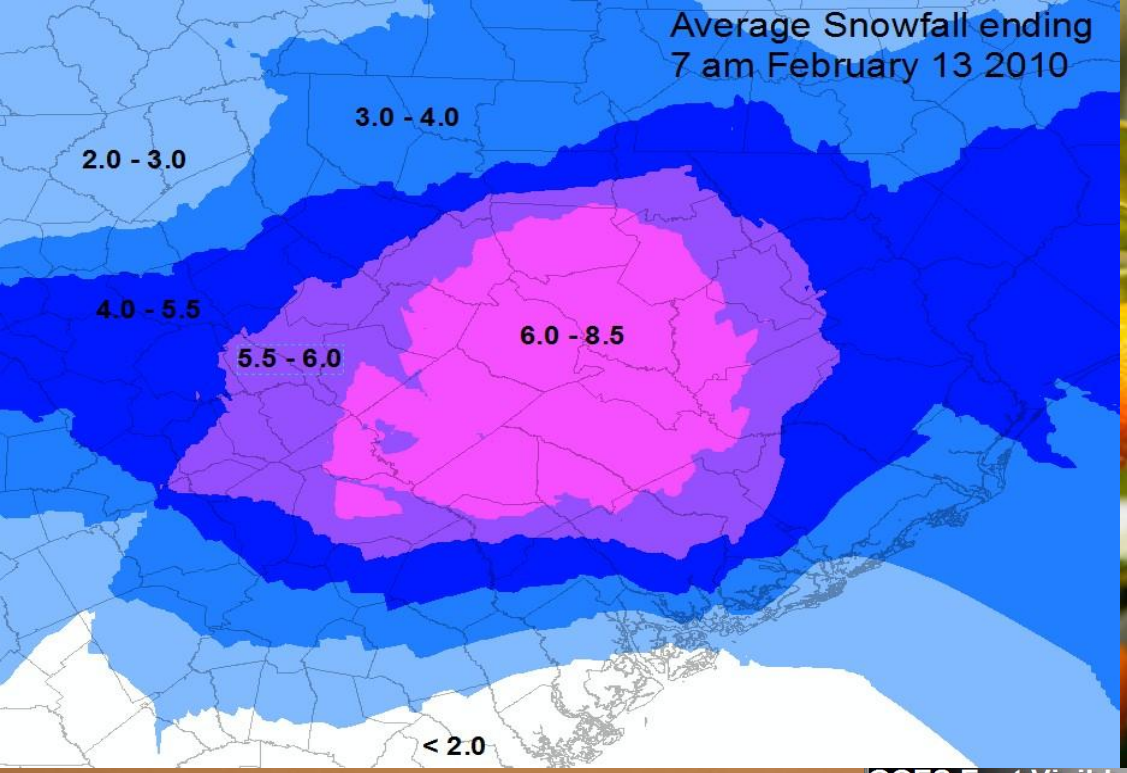


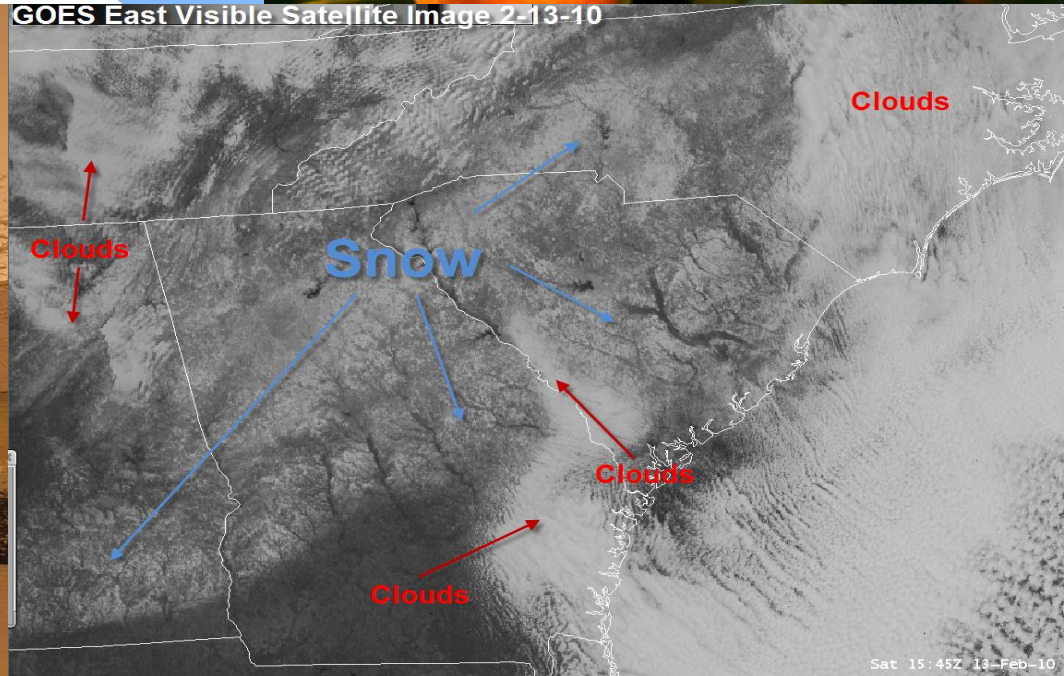
February 13, 2010 7:00 AM EST



February 12-13, 2010




Average Snowfall ending
7 am February 13 2010
3.0 - 4.0
2.0 - 3.0
4.0 - 5.5
6.0 - 8.5
5.5 - 6.0
< 2.0


GOES East Visible Satellite Image 2-13-10
Clouds
Clouds
Snow
Clouds
Clouds
Sat 15:45Z 13-Feb-10

Snowfall Event	ENSO (ONI)	ENSO (MEI)	AO	AO trend	NAO	NAO trend
March 2-3, 1960	-0.17	-0.0305	-0.5275	↑	0.182	↑
March 10-11, 1960	-0.17	-0.0305	-3.1655	↓	-0.368	↓
February 10-11, 1973	1.20	1.164	1.9625	→	0.821	→
January 22, 1987	1.23	1.212	-1.721	↓	-0.981	↓
December 24, 1989	-0.07	0.188	2.381	↑	0.716	↑
March 13-14, 1993	0.47	1.183	1.4685	↑	0.558	↑
February 26-27, 2004	0.2	0.103	-3.1195	↓	-0.475	↓
February 12-13, 2010	1.37	1.455	-4.8515	↓	-1.182	↓

- Generally, larger snowfall events are more likely to occur during El Nino events, especially in coastal areas.
- Although the magnitude of NAO/AO index may differ, trend is the same in all cases and both are always in phase.
- During the days leading up to snowfall events occuring during positive (negative) AO and NAO, the AO/NAO became more positive (negative).
- Maybe it's not only important to look at the sign of the AO/NAO, but also consider how it changes through time
- Future research:
  - better understanding of how shifts in AO/NAO indices affect U.S. weather and the timescales (for forecasting)
  - investigation of the lag time between daily indices and temperature

Thank You