Large-Scale Precursors to Major Lake Effect Snowstorms Lee of Lake Erie

Hannah E. Attard

Ross A. Lazear

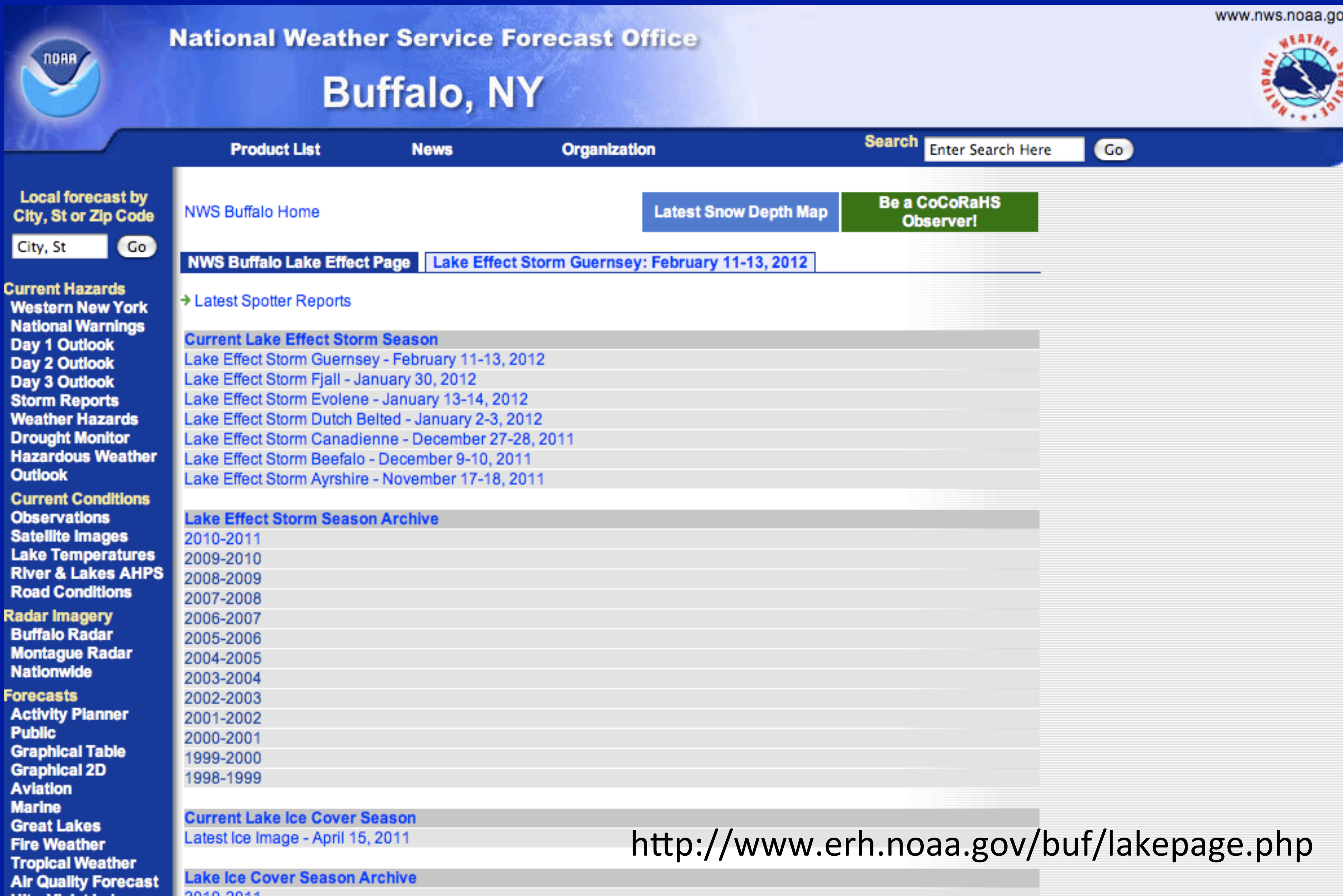
Department of Atmospheric and Environmental Sciences

University at Albany

Motivation

- Undergraduate honors thesis research
- Grew up in Buffalo, New York living through lake effect snowstorms off Lake Erie
- Interested in:
  - linking this mesoscale feature to the large scale global pattern
  - Identifying a dominant pattern in the days prior to major events

Initial Case List



http://www.erh.noaa.gov/buf/lakepage.php

Case List

Criteria to be a named storm:

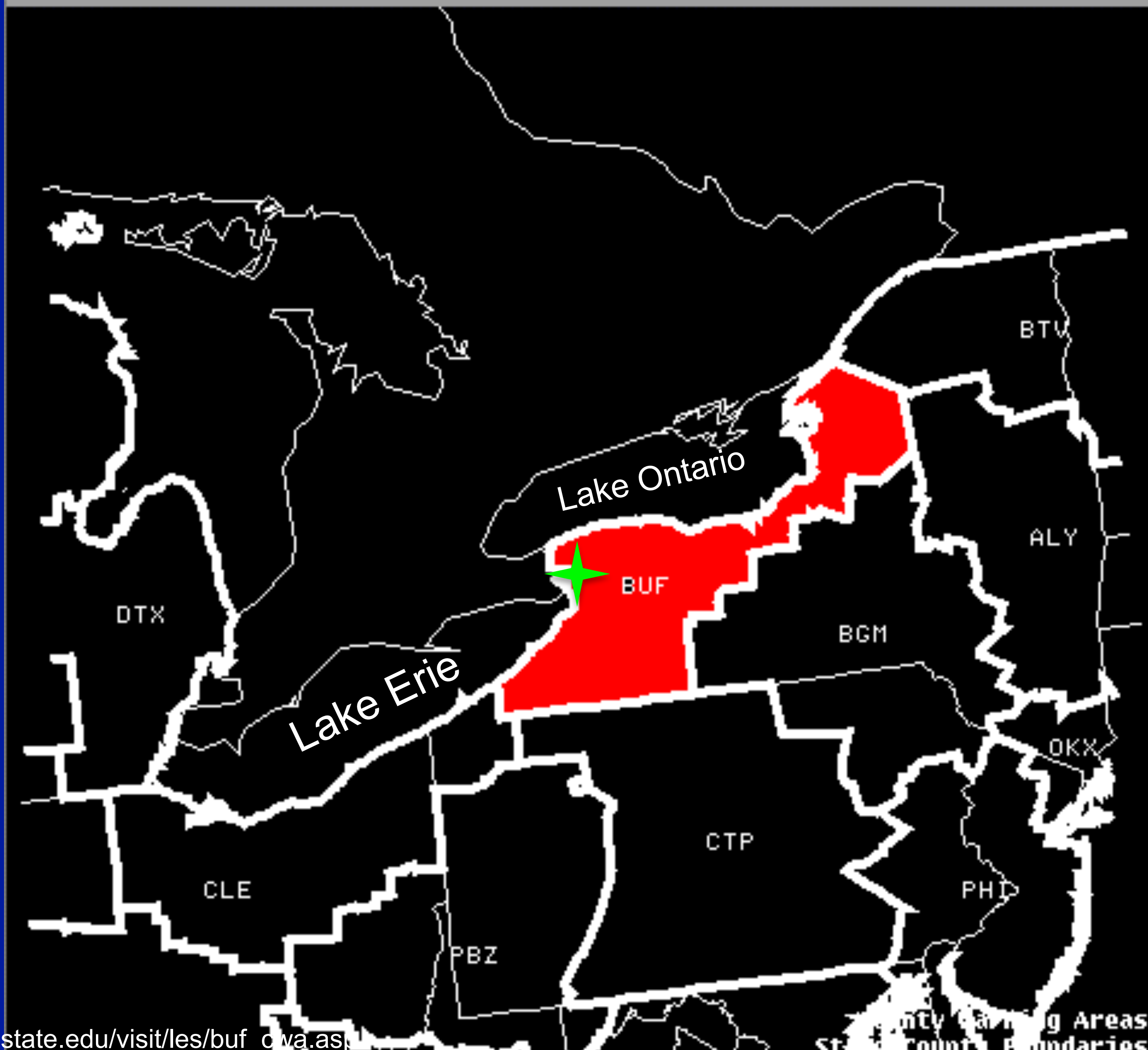
- All or primarily lake effect snow
- 7-8 inches at one location in 24 hours
- In County Warning Area

-Steve Mclaughlin, NWS Buffalo forecaster

Our Criteria for "major" Lake Effect Storm:

- At least 24 h and 12 inches of snow
- Purely lake effect
- Occur off Lake Erie

Buffalo County Warning Area



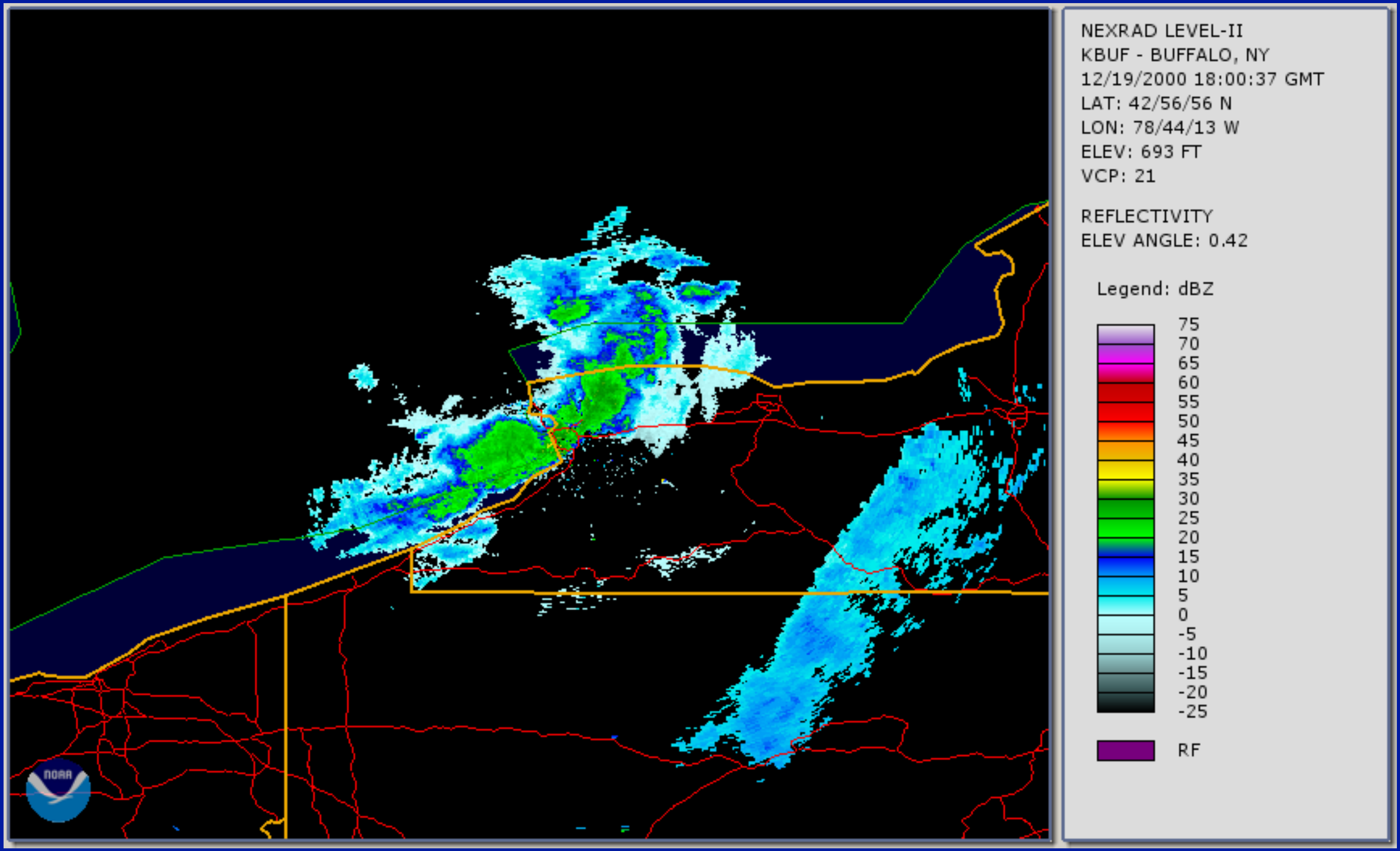
http://rammb.cira.colostate.edu/visit/les/buf_cwa.asp

Methodology to Determine Case List

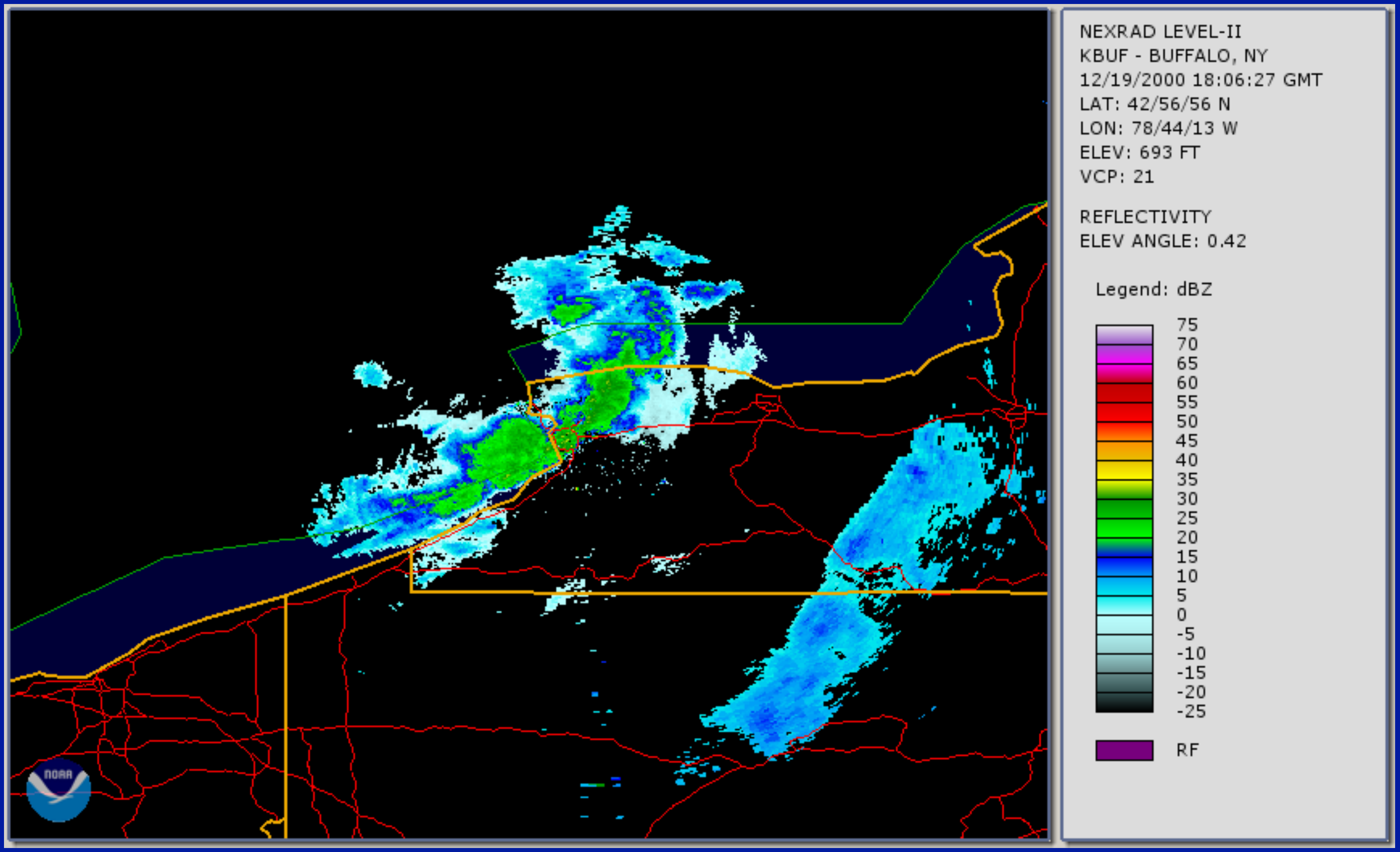
1. Recorded all named cases that lasted at least 24 hours, produced at least 12 inches of snow, and occurred off Lake Erie (**62 cases**)
2. Used composite radar data to determine if it was pure lake effect (**52 cases**)
3. Determined the start and end time to the nearest 6 h (00Z, 06Z, 12Z, 18Z)
4. Any case that occurred within 7 days of the previous case was discounted **(31 cases)**

Example of a good radar case: 19 December 2000

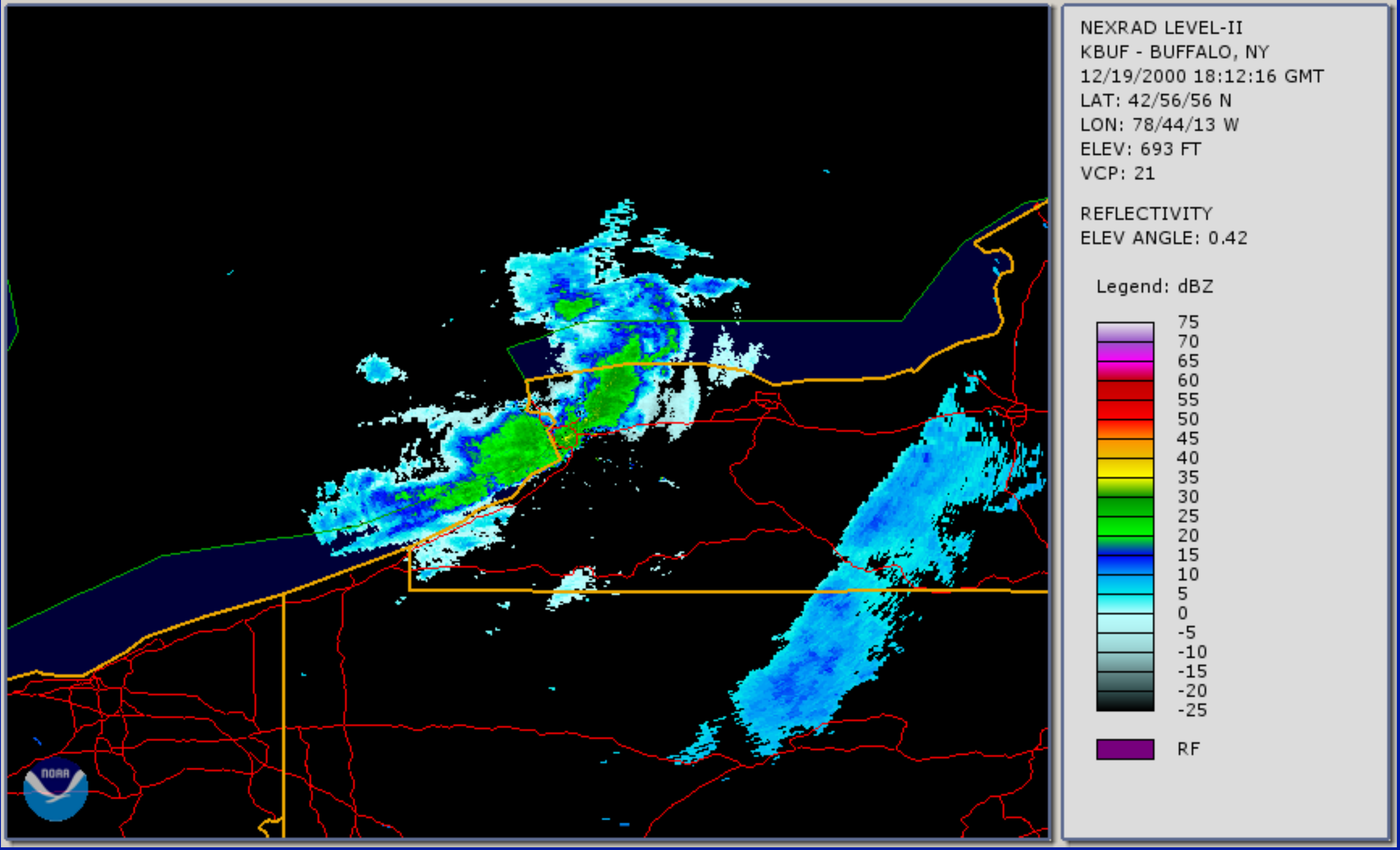
Example of a Good Case: 1800 UTC 19 December 2000



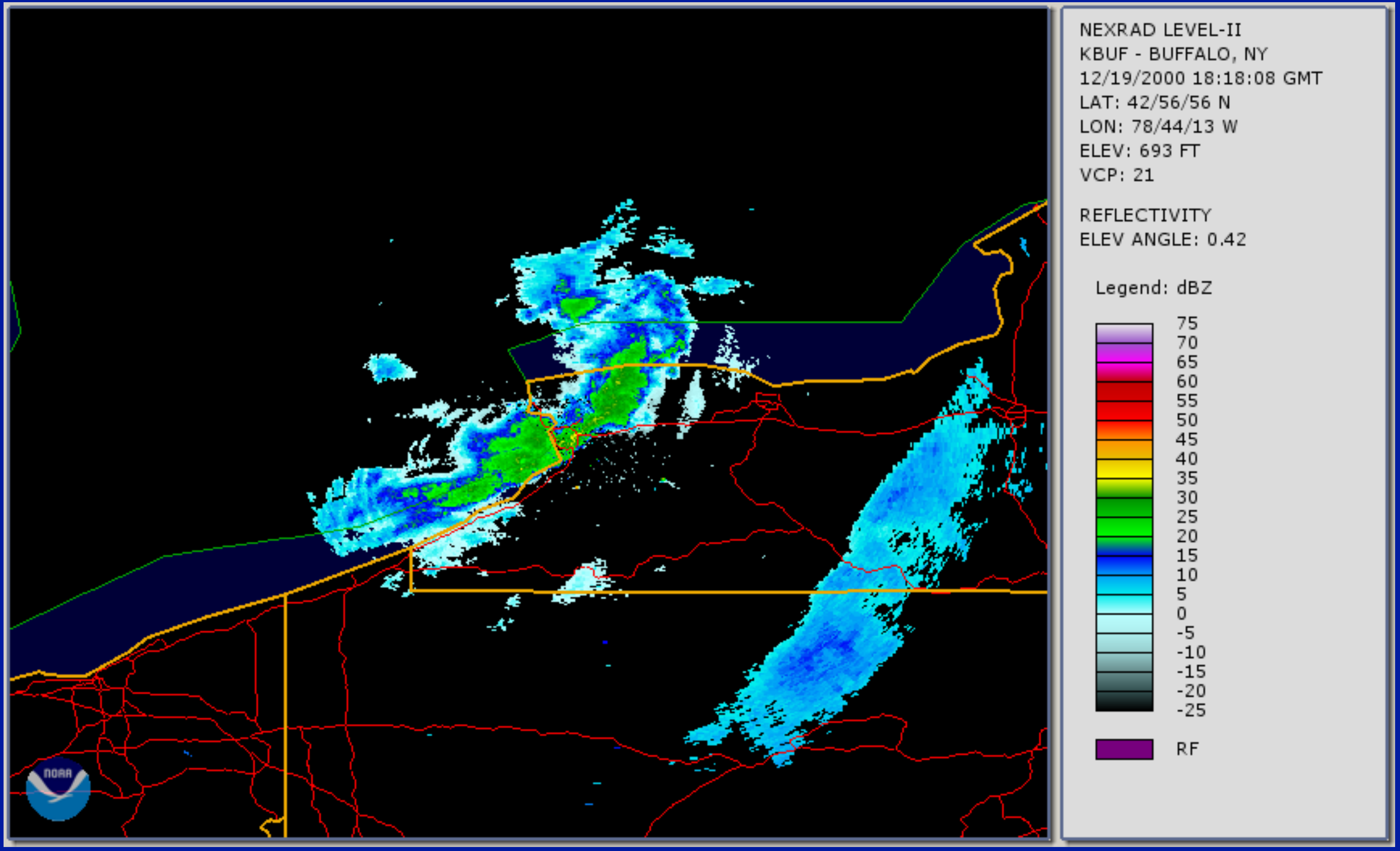
Example of a Good Case: 1806 UTC 19 December 2000



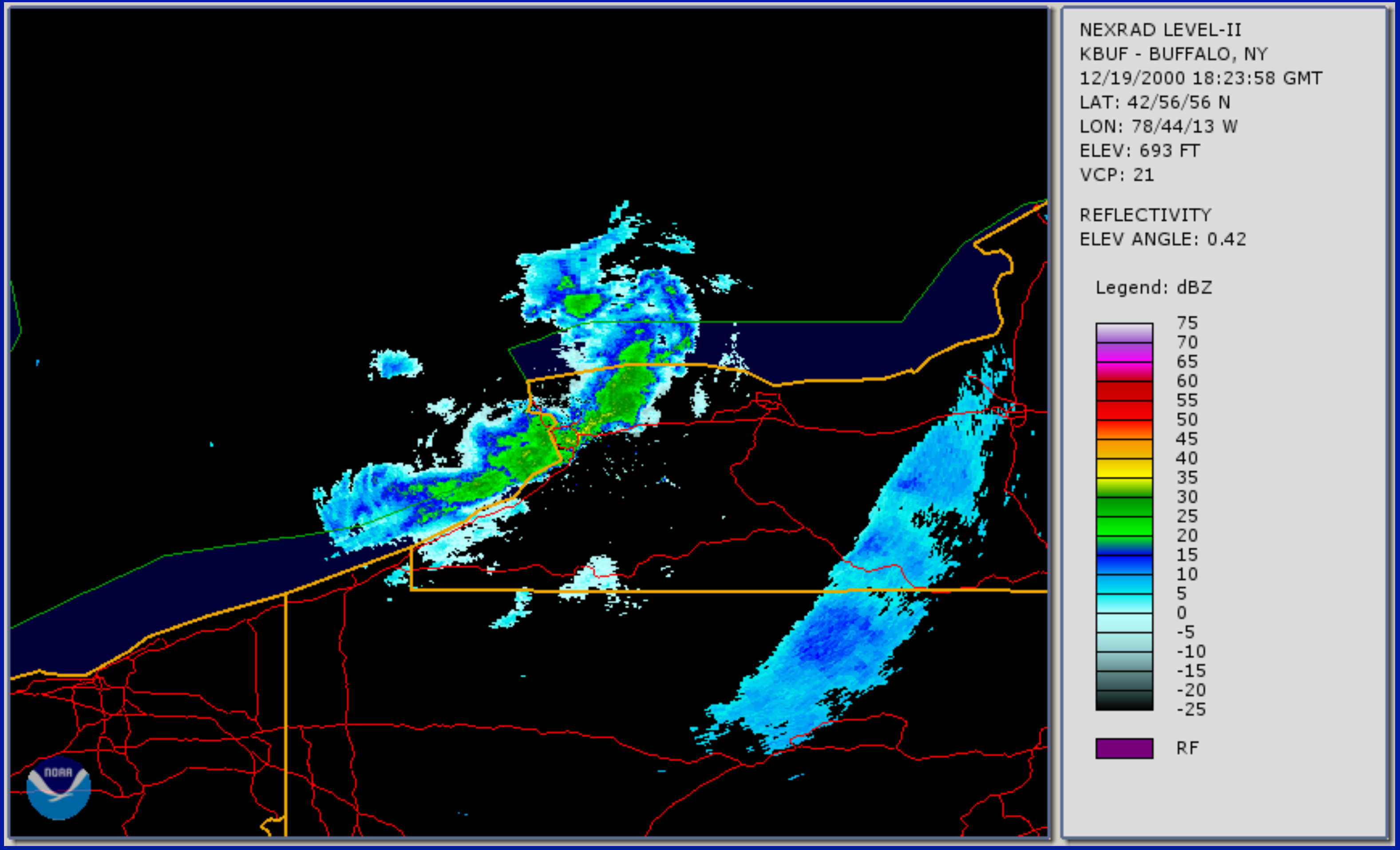
Example of a Good Case:
1812 UTC 19 December 2000



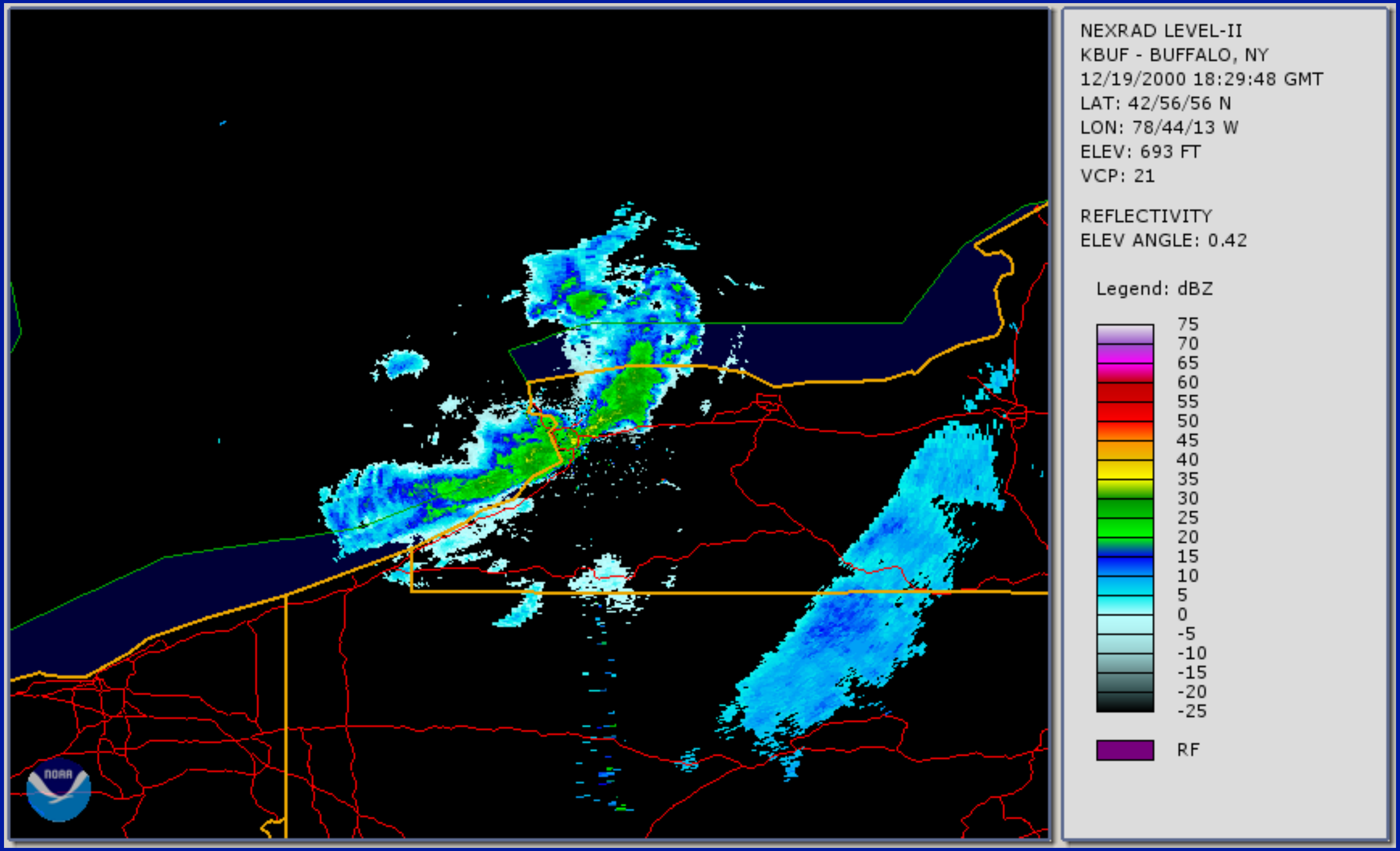
Example of a Good Case:
1818 UTC 19 December 2000



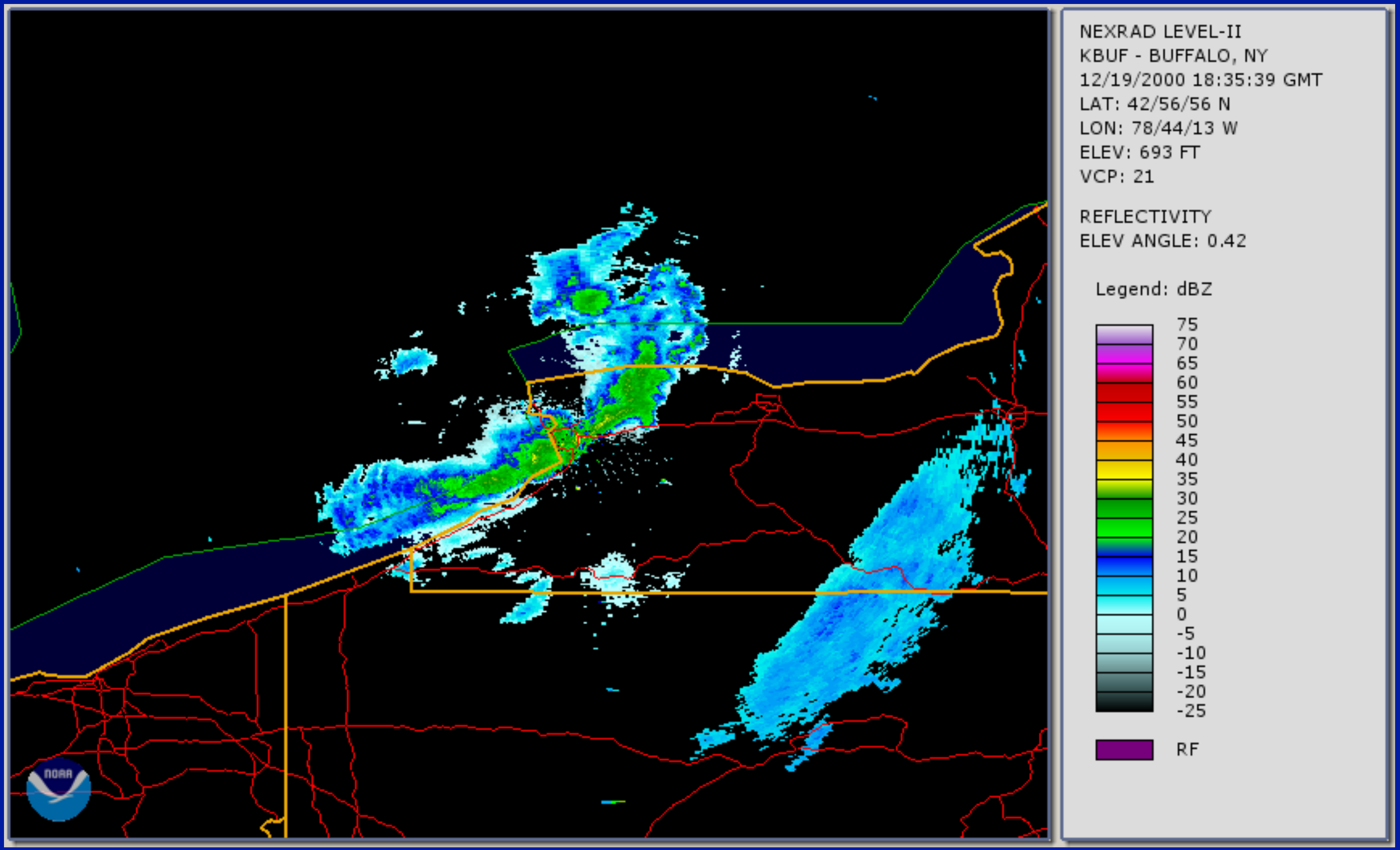
Example of a Good Case:
1823 UTC 19 December 2000



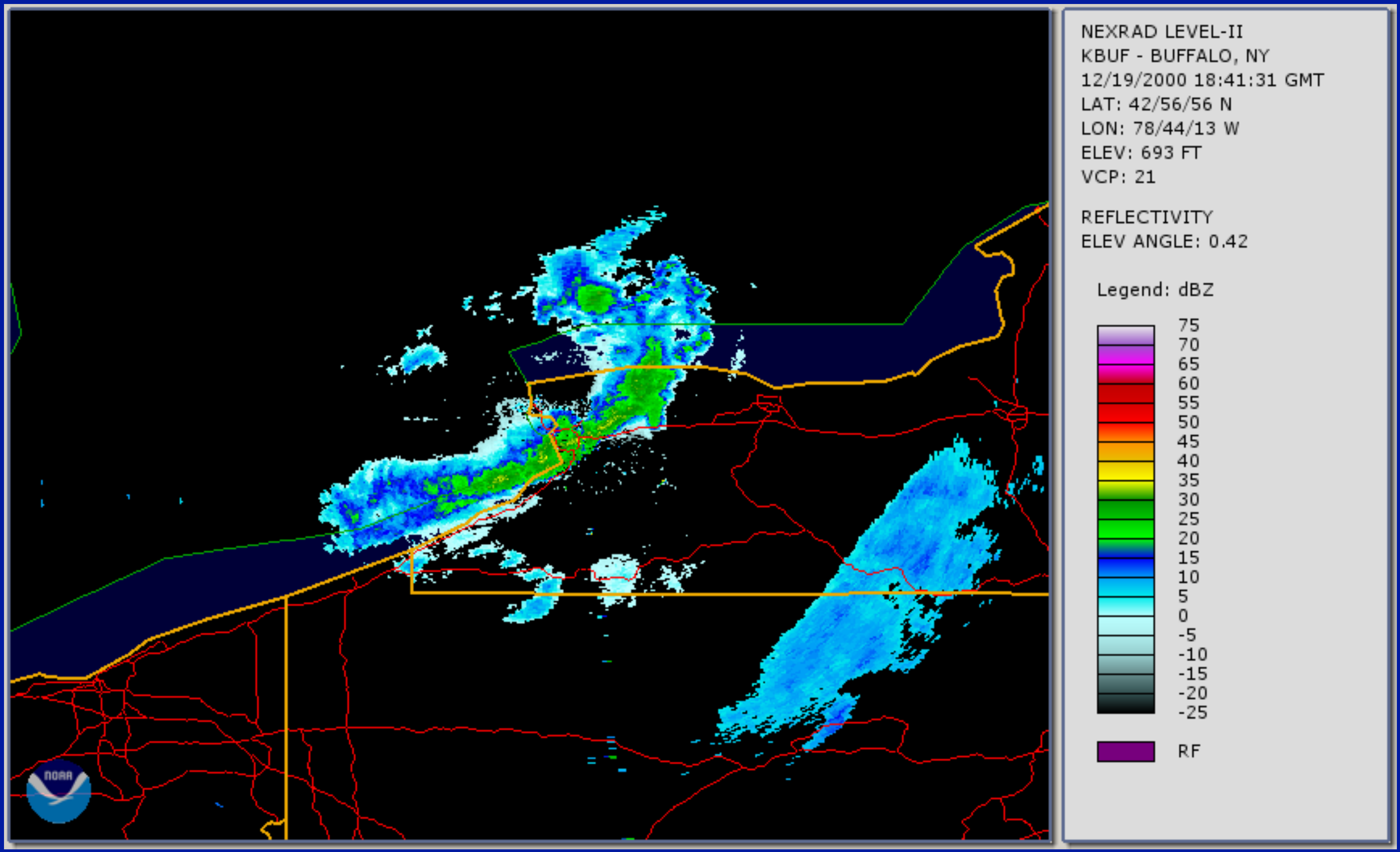
Example of a Good Case: 1829 UTC 19 December 2000



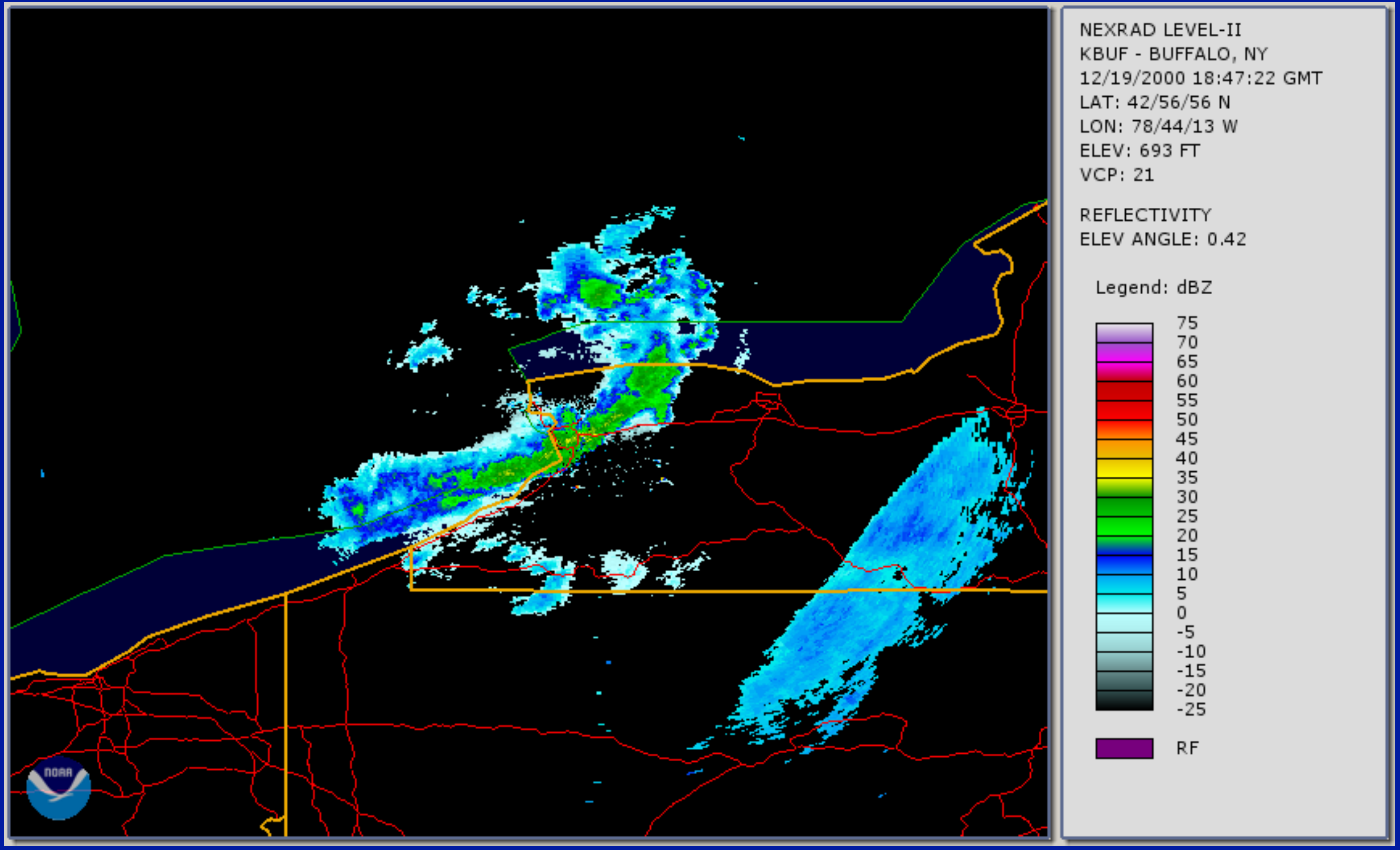
Example of a Good Case:
1835 UTC 19 December 2000



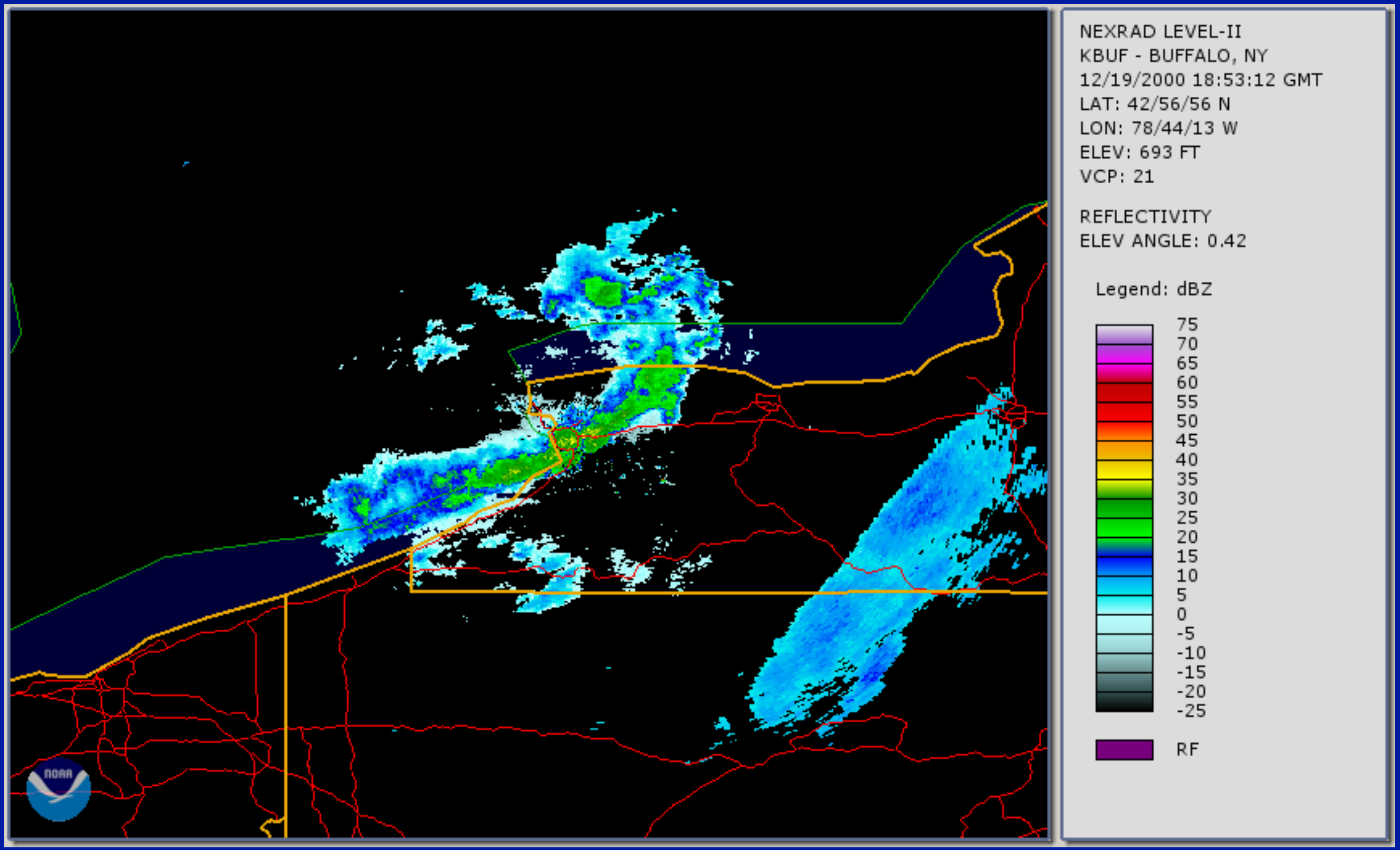
Example of a Good Case:
1841 UTC 19 December 2000



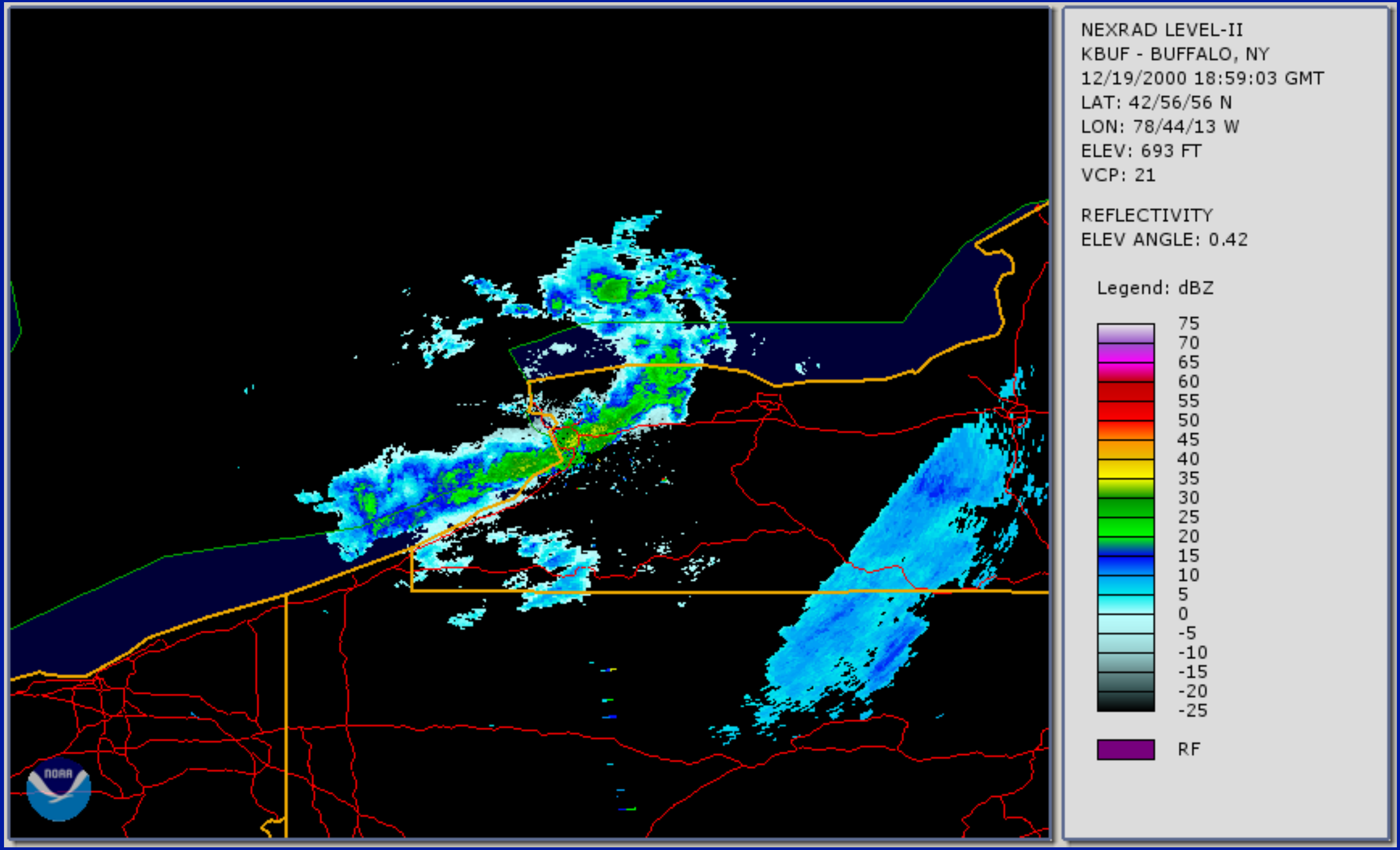
Example of a Good Case:
1847 UTC 19 December 2000



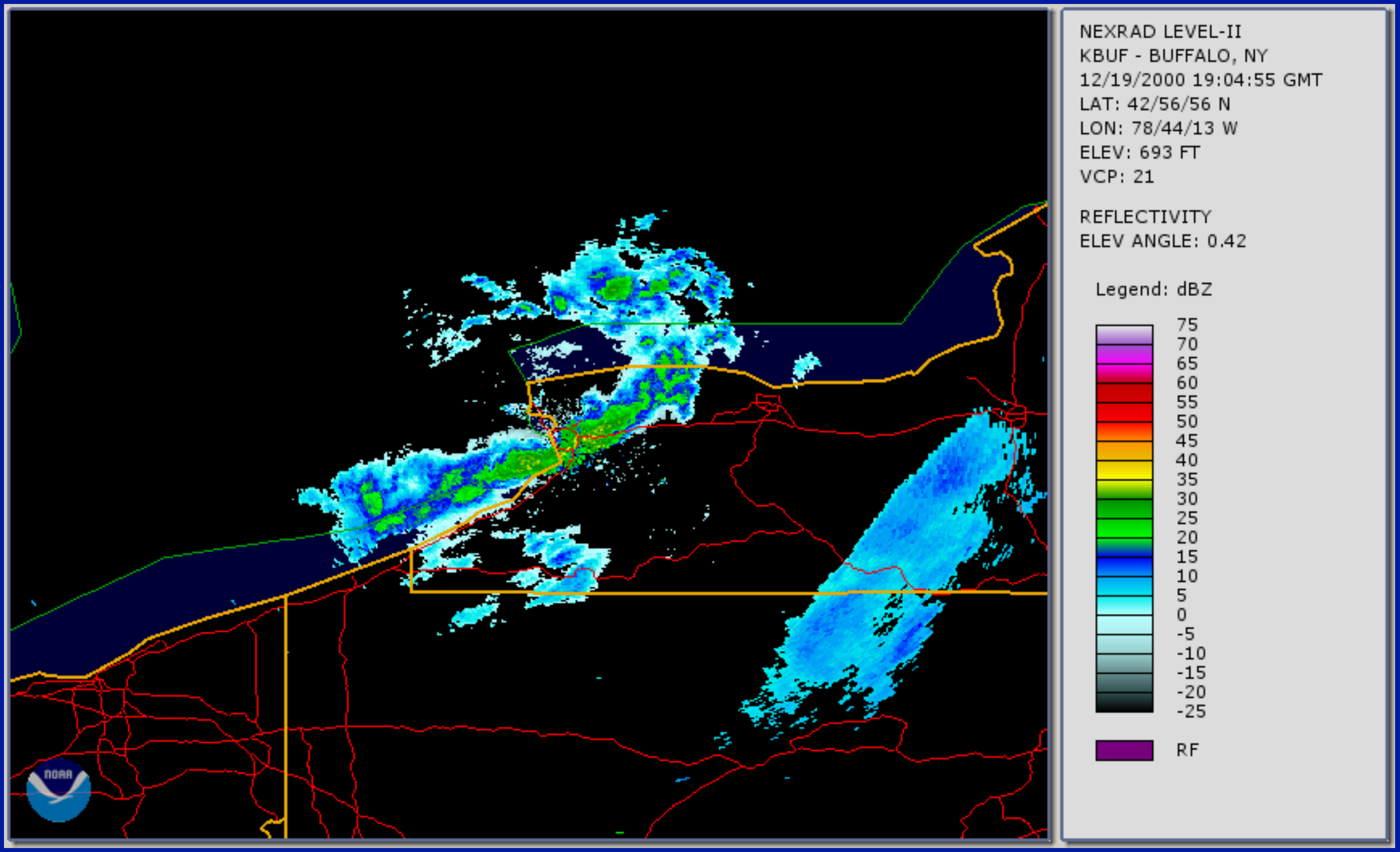
Example of a Good Case: 1853 UTC 19 December 2000



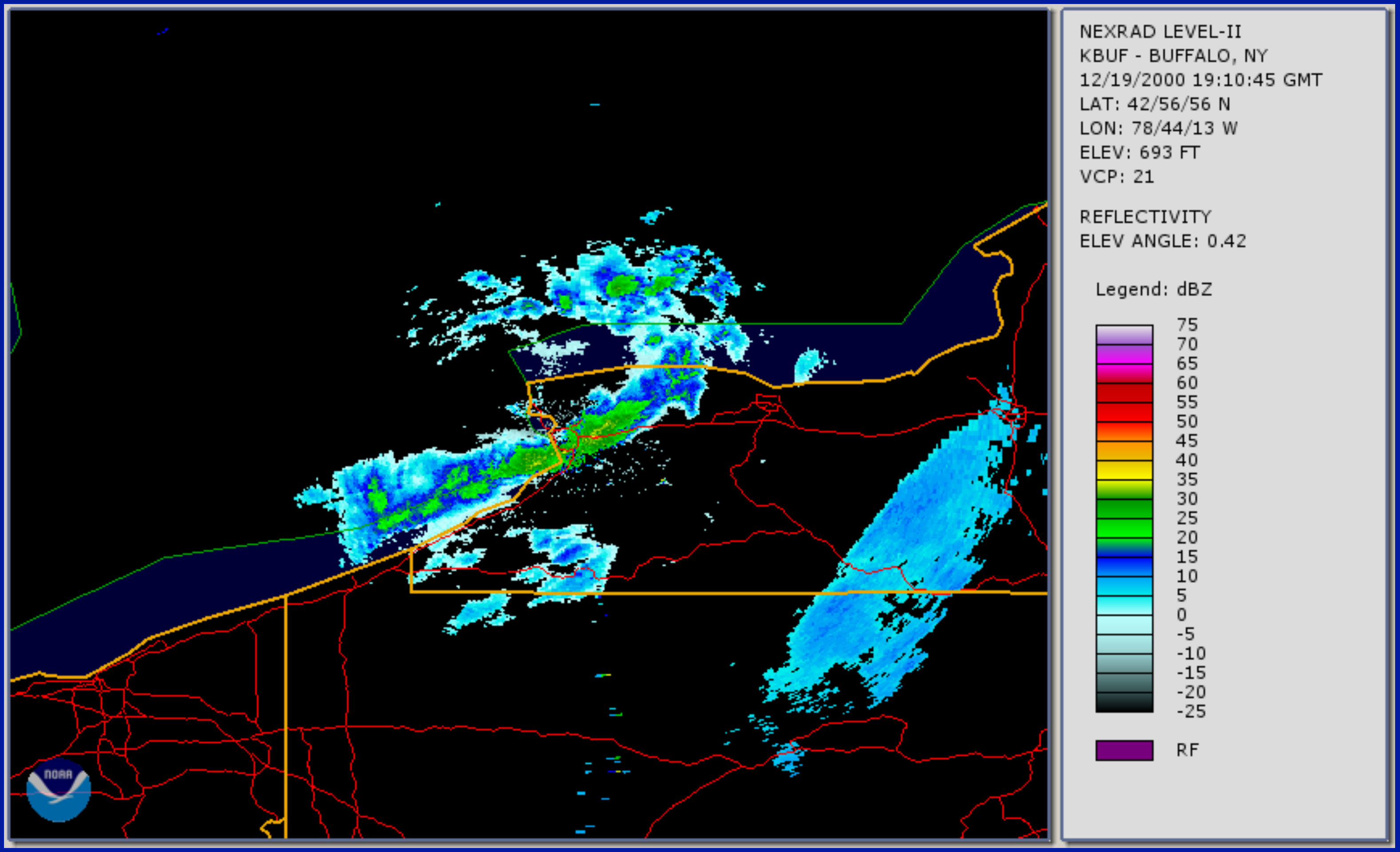
Example of a Good Case: 1859 UTC 19 December 2000



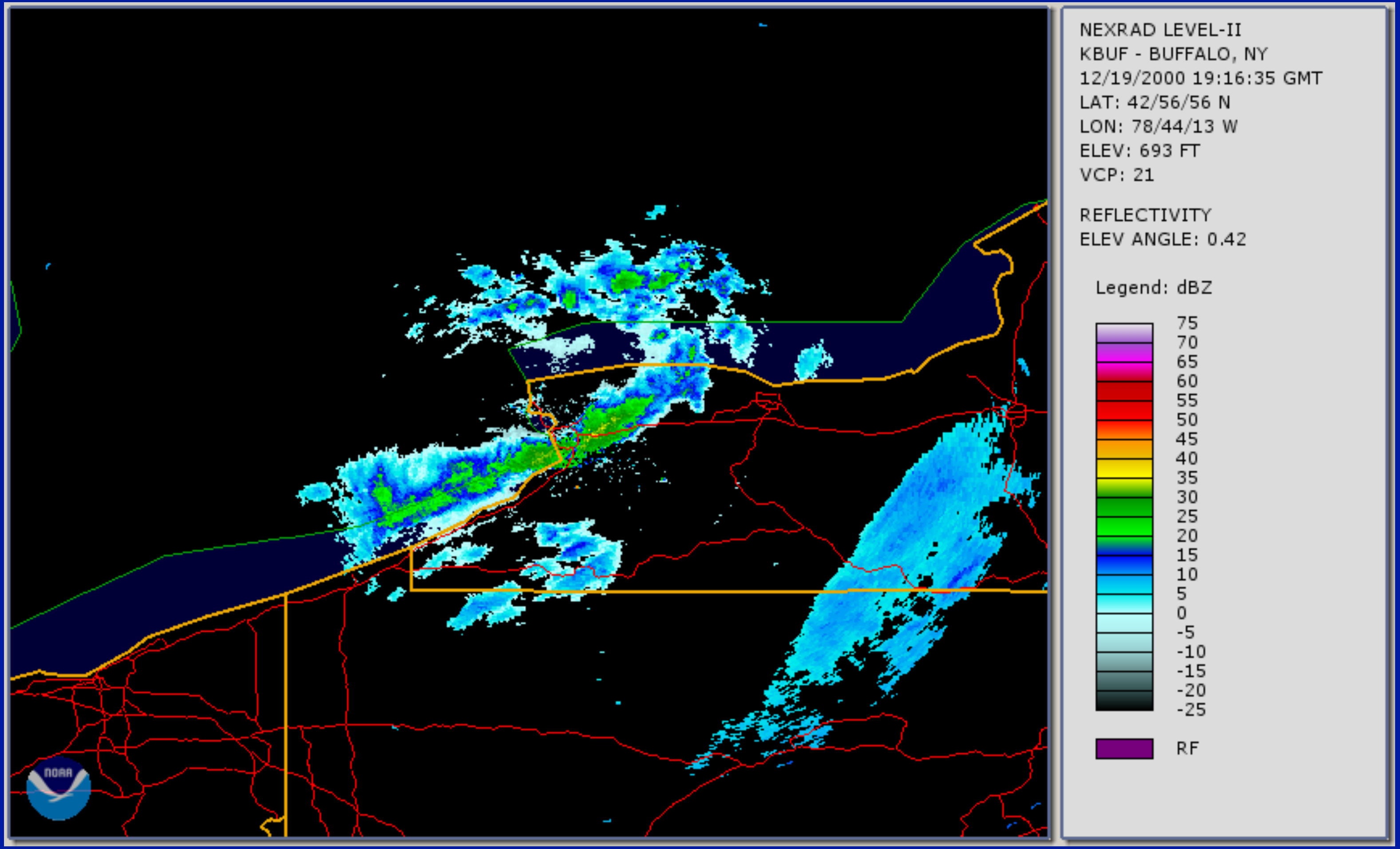
Example of a Good Case:
1904 UTC 19 December 2000



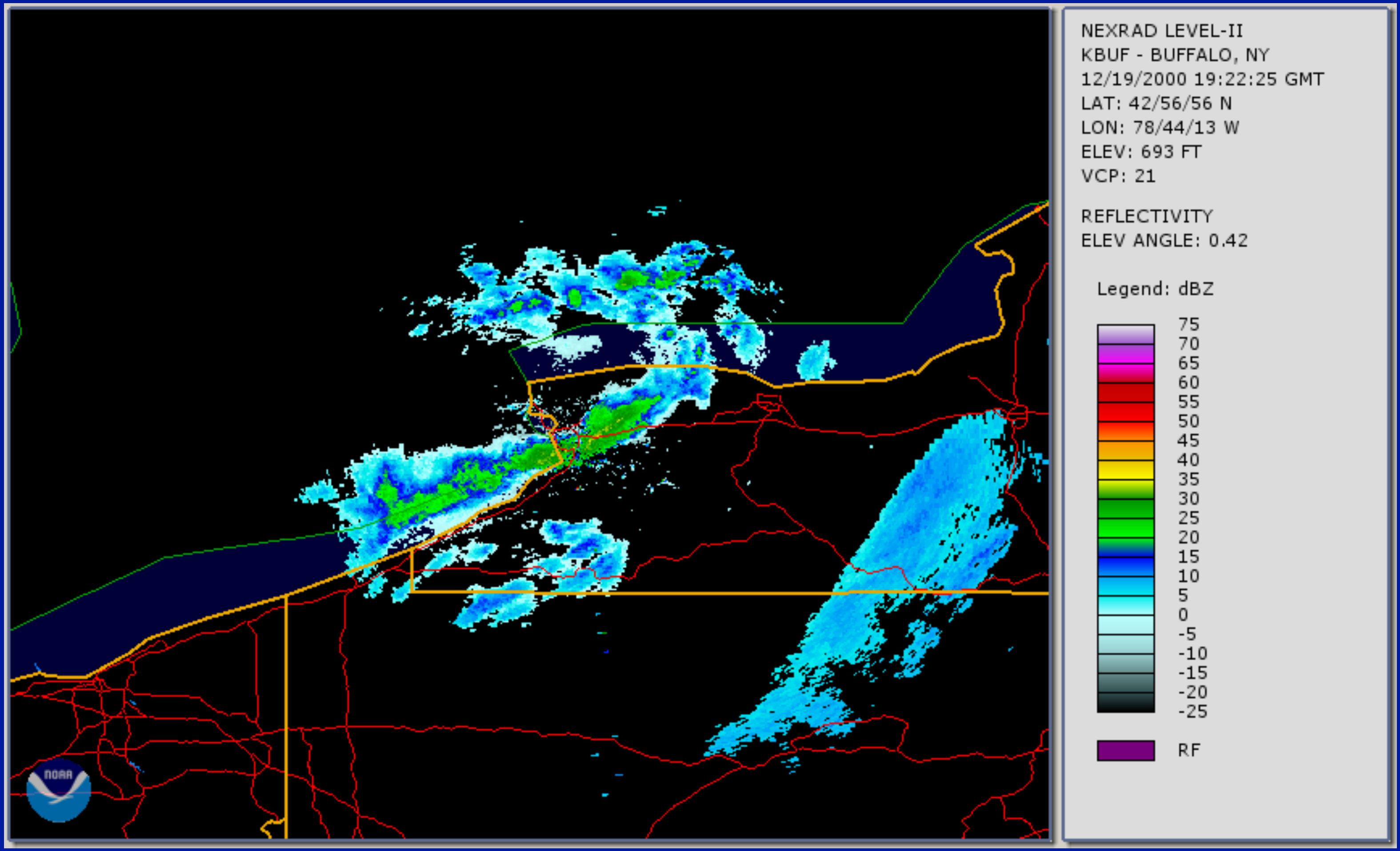
Example of a Good Case: 1910 UTC 19 December 2000



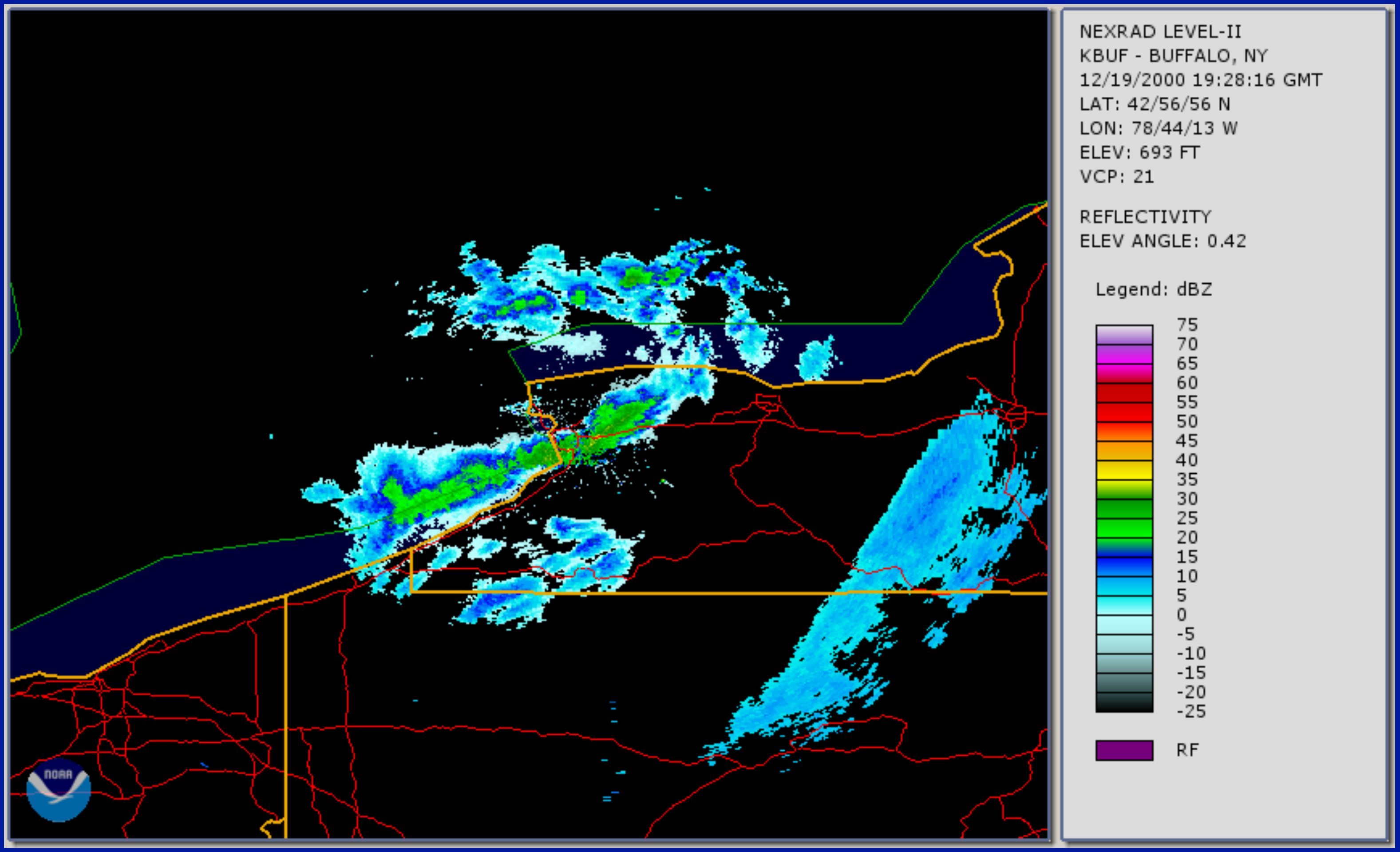
Example of a Good Case:
1916 UTC 19 December 2000



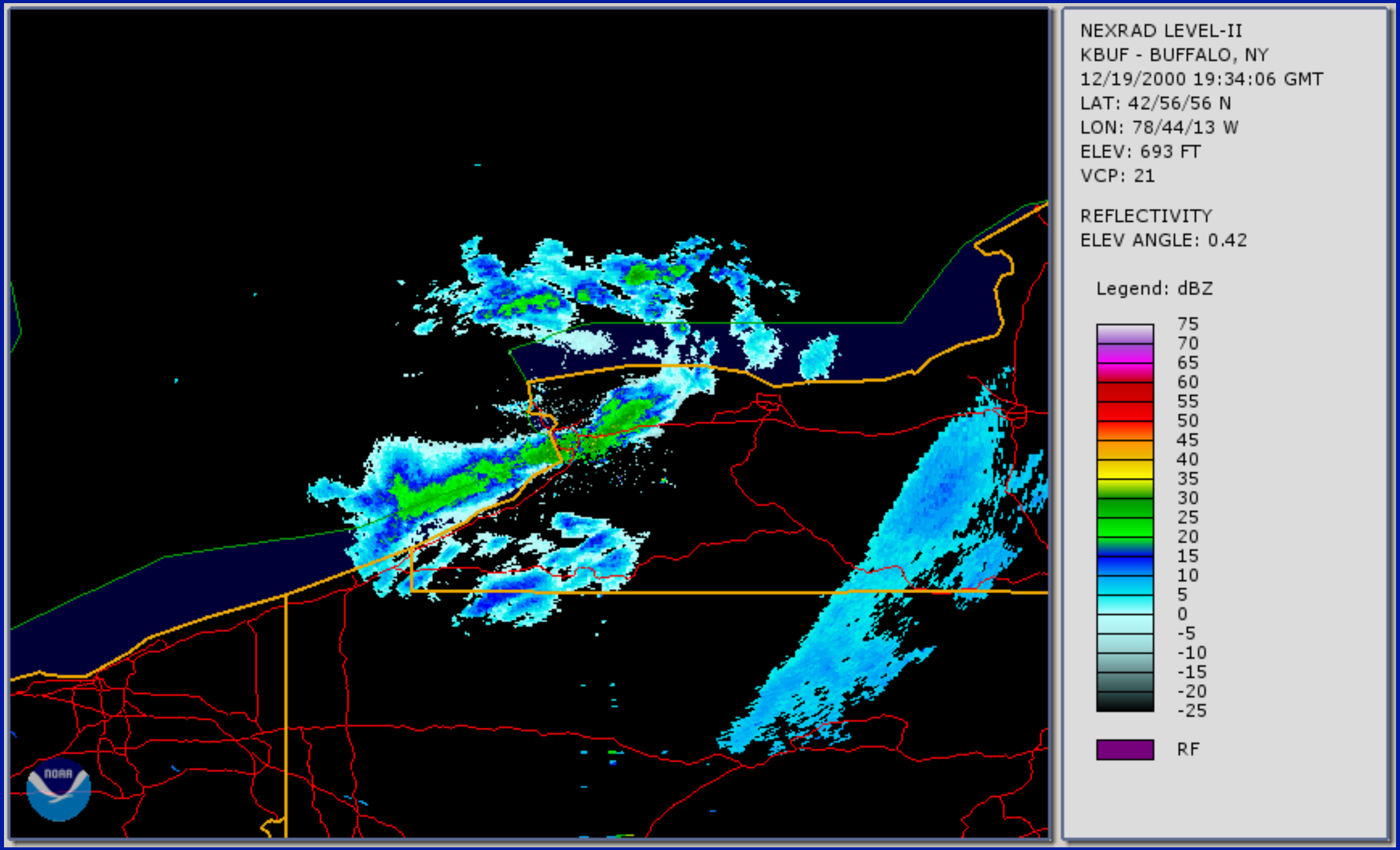
Example of a Good Case:
1922 UTC 19 December 2000



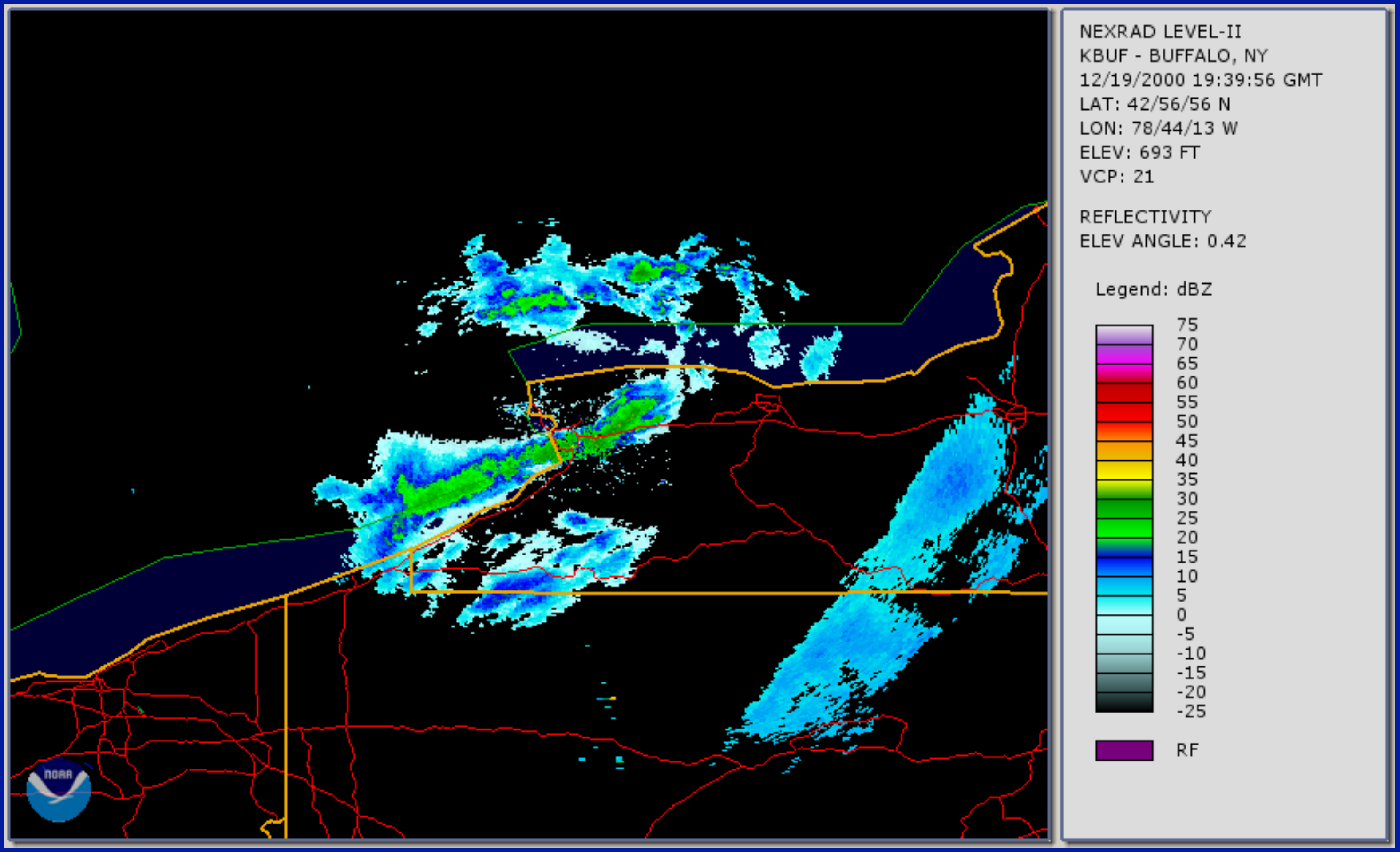
Example of a Good Case: 1928 UTC 19 December 2000



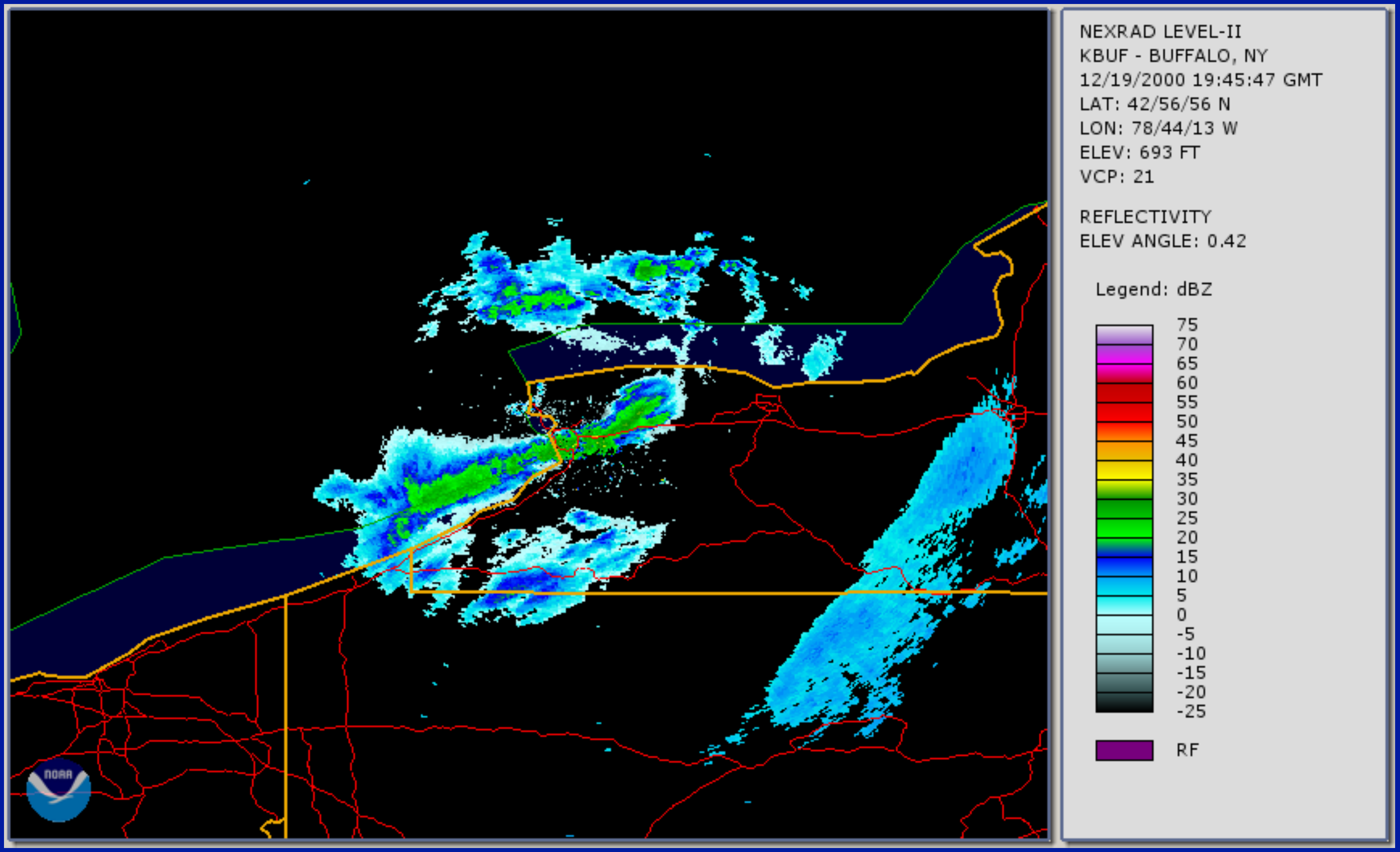
Example of a Good Case: 1934 UTC 19 December 2000



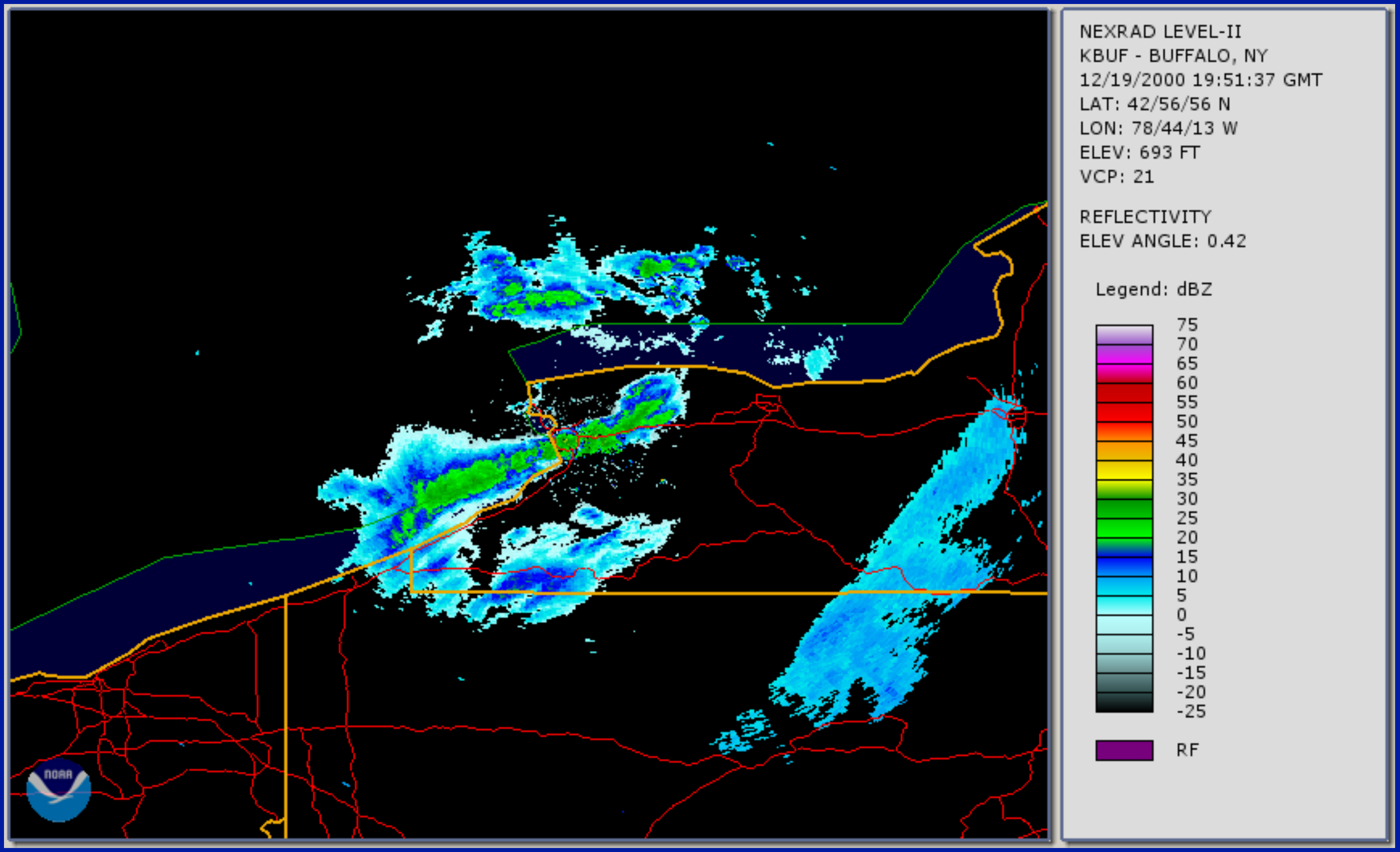
Example of a Good Case:
1939 UTC 19 December 2000



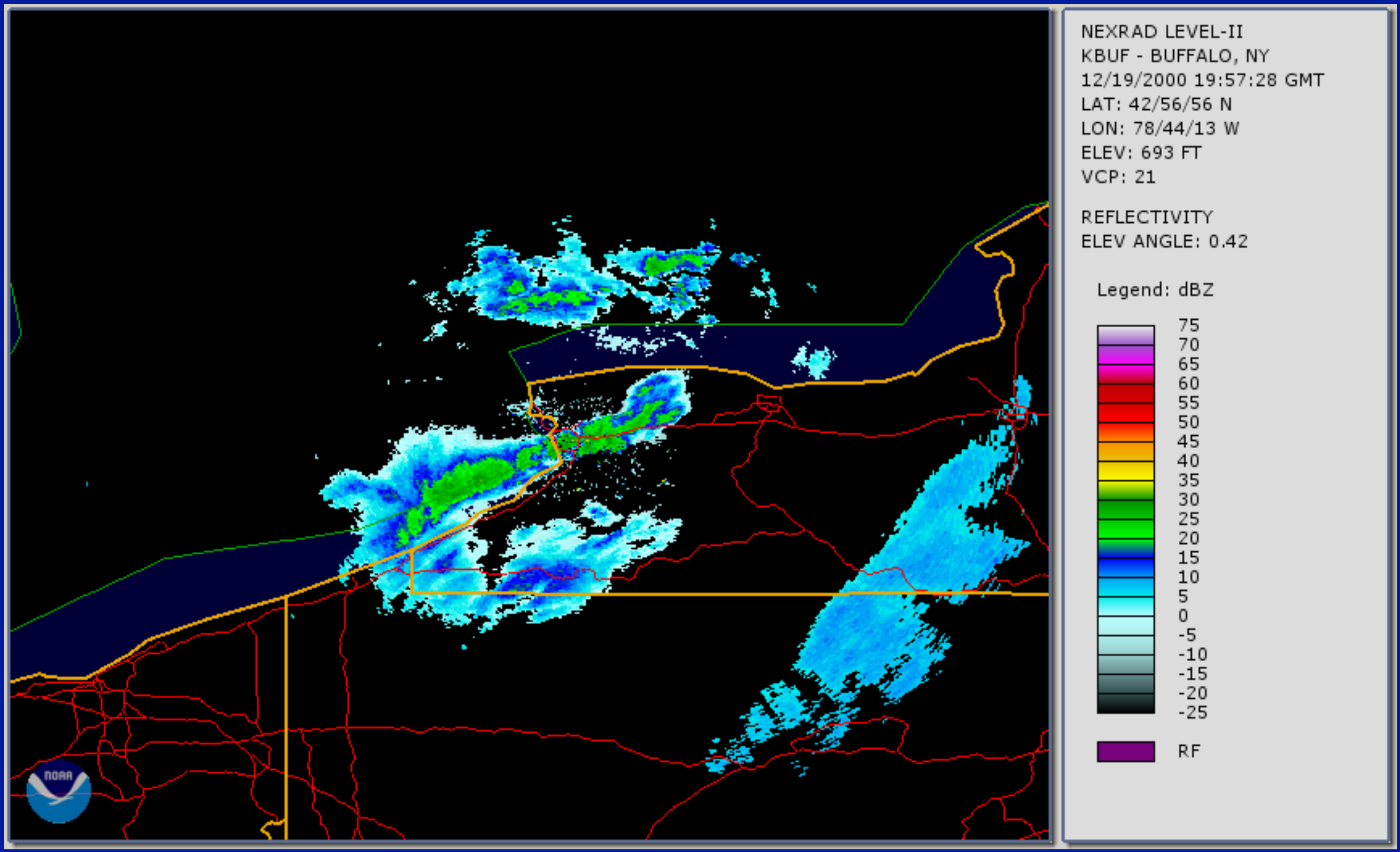
Example of a Good Case: 1945 UTC 19 December 2000



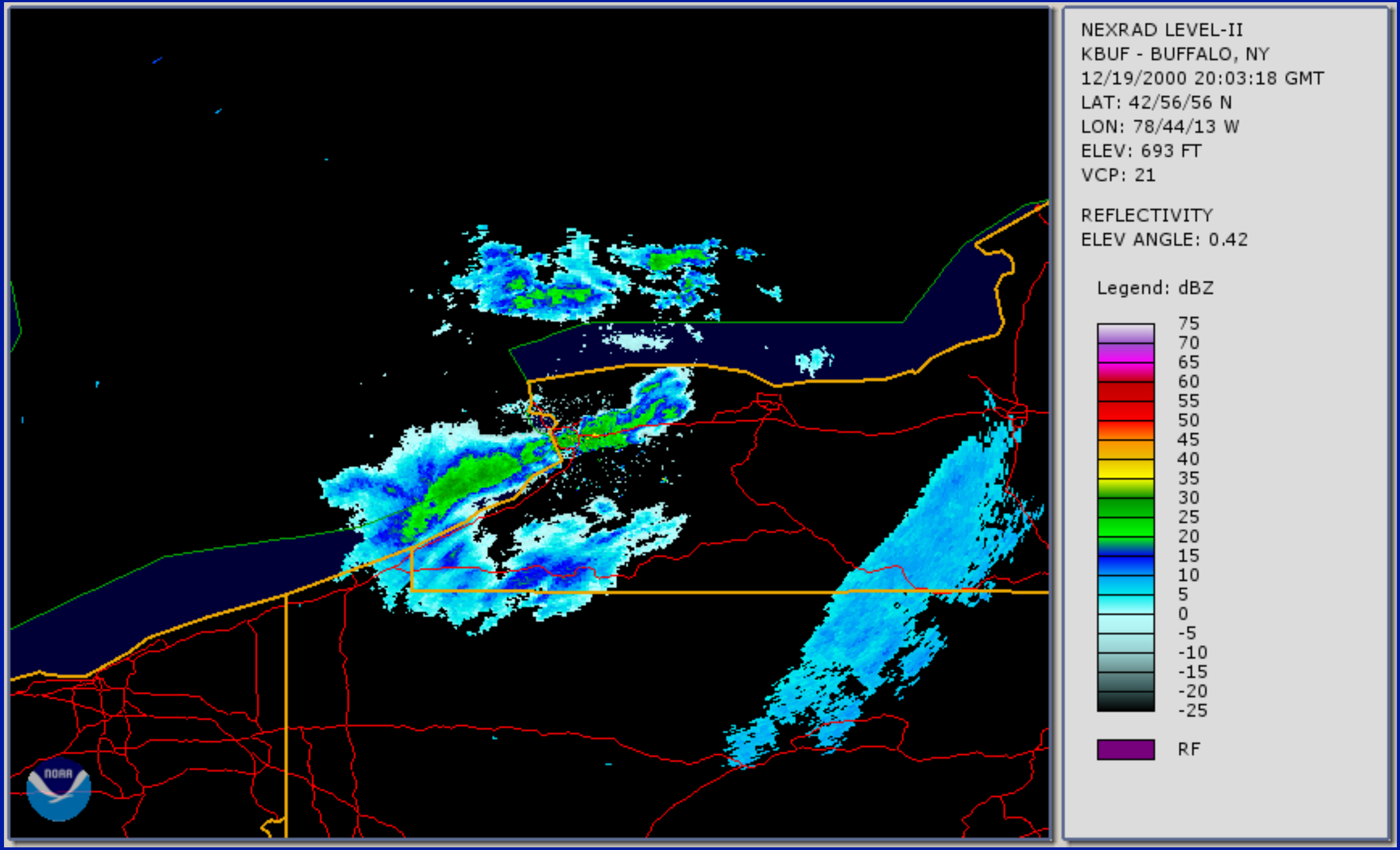
Example of a Good Case: 1951 UTC 19 December 2000



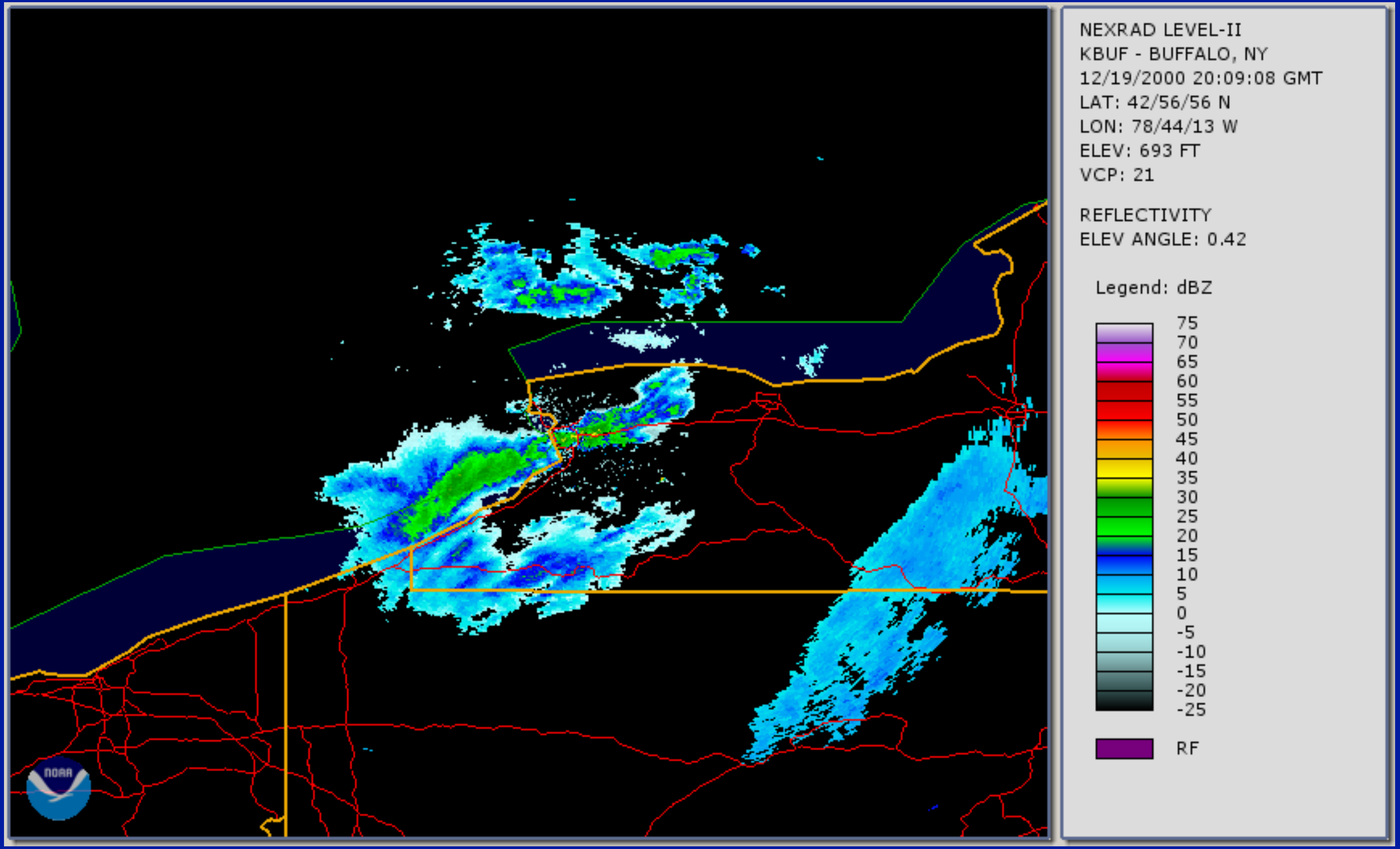
Example of a Good Case:
1957 UTC 19 December 2000



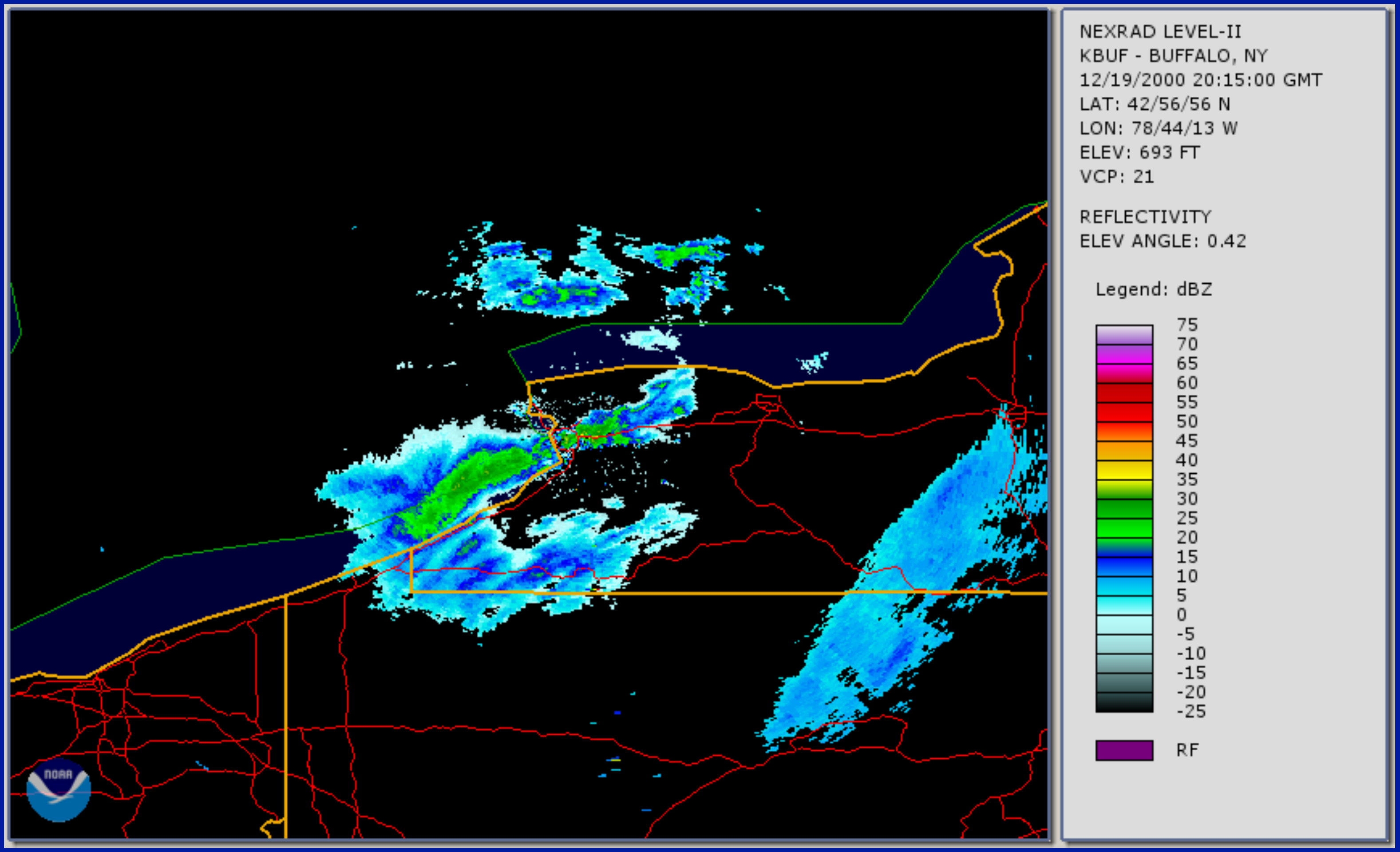
Example of a Good Case: 2003 UTC 19 December 2000



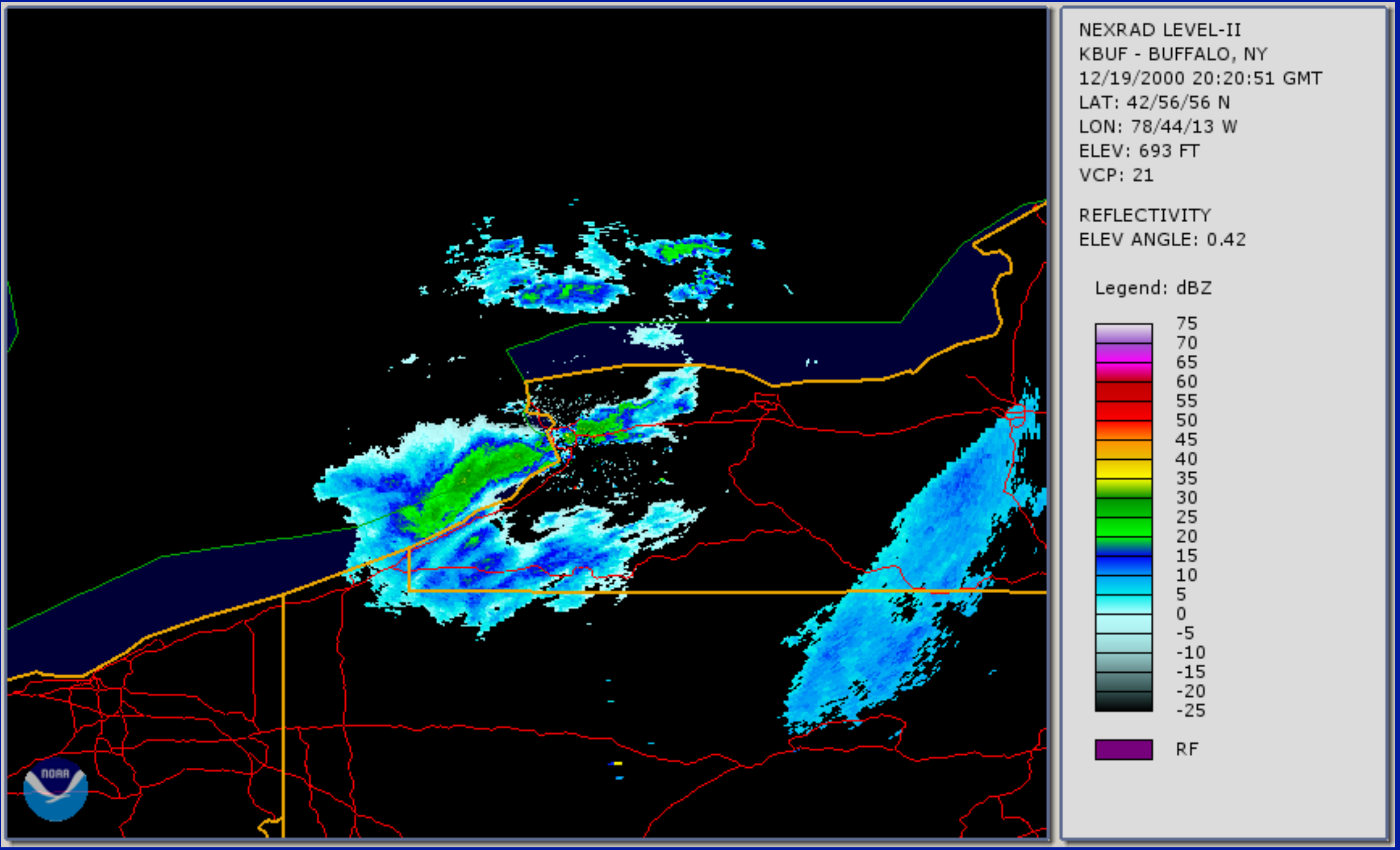
Example of a Good Case: 2009 UTC 19 December 2000



Example of a Good Case: 2015 UTC 19 December 2000

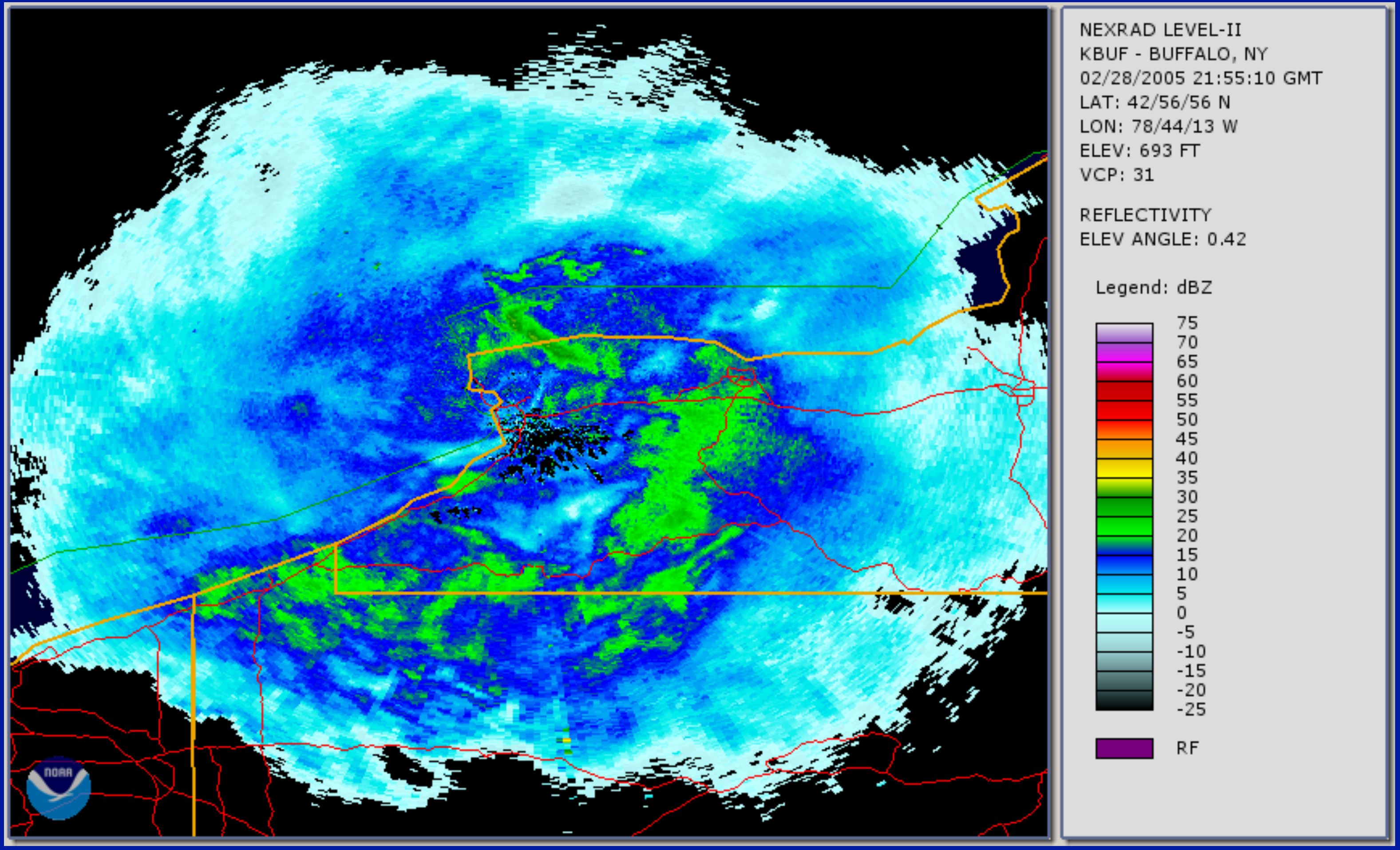


Example of a Good Case:
2020 UTC 19 December 2000

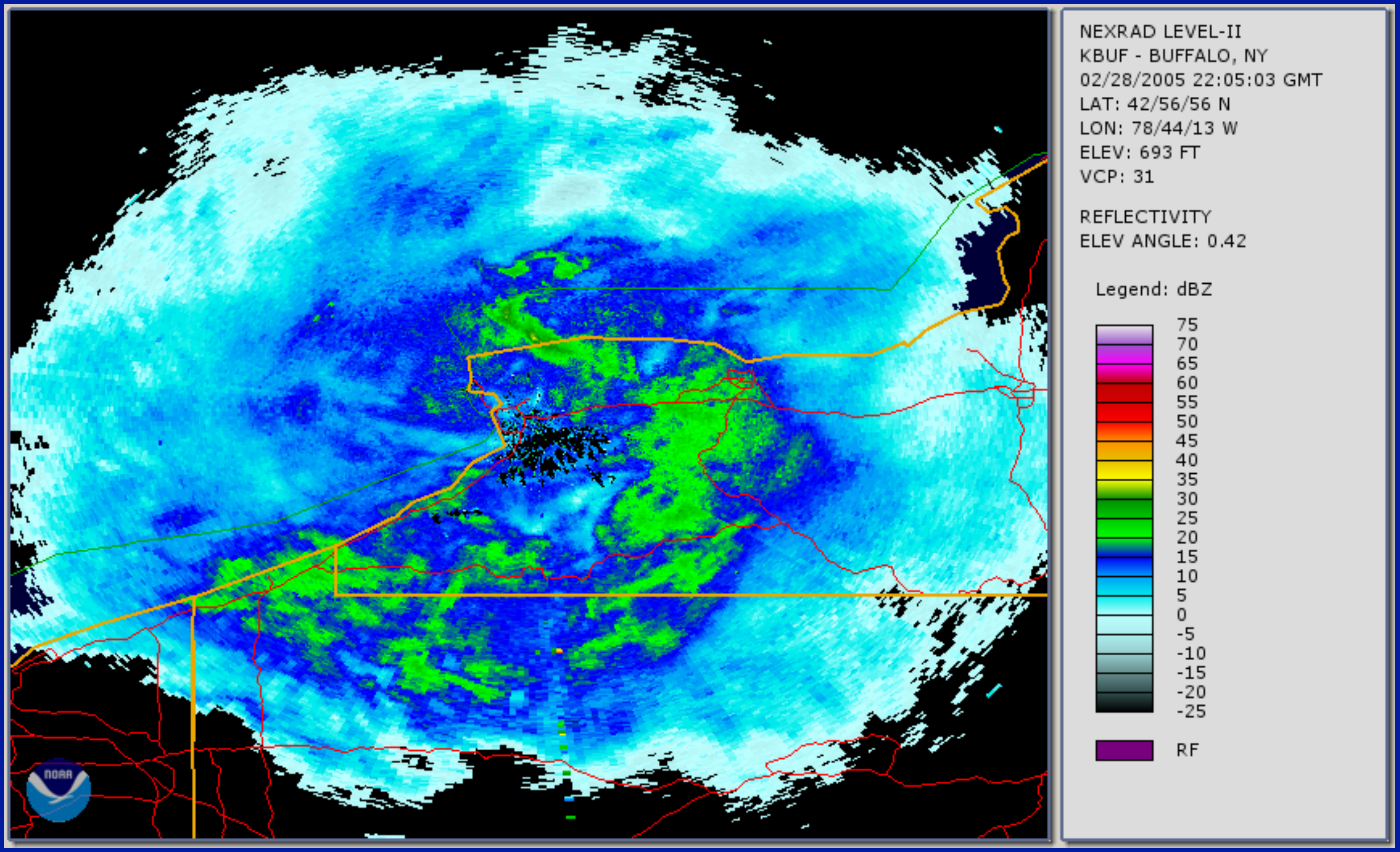


Example of a discounted radar case: 28 February 2005

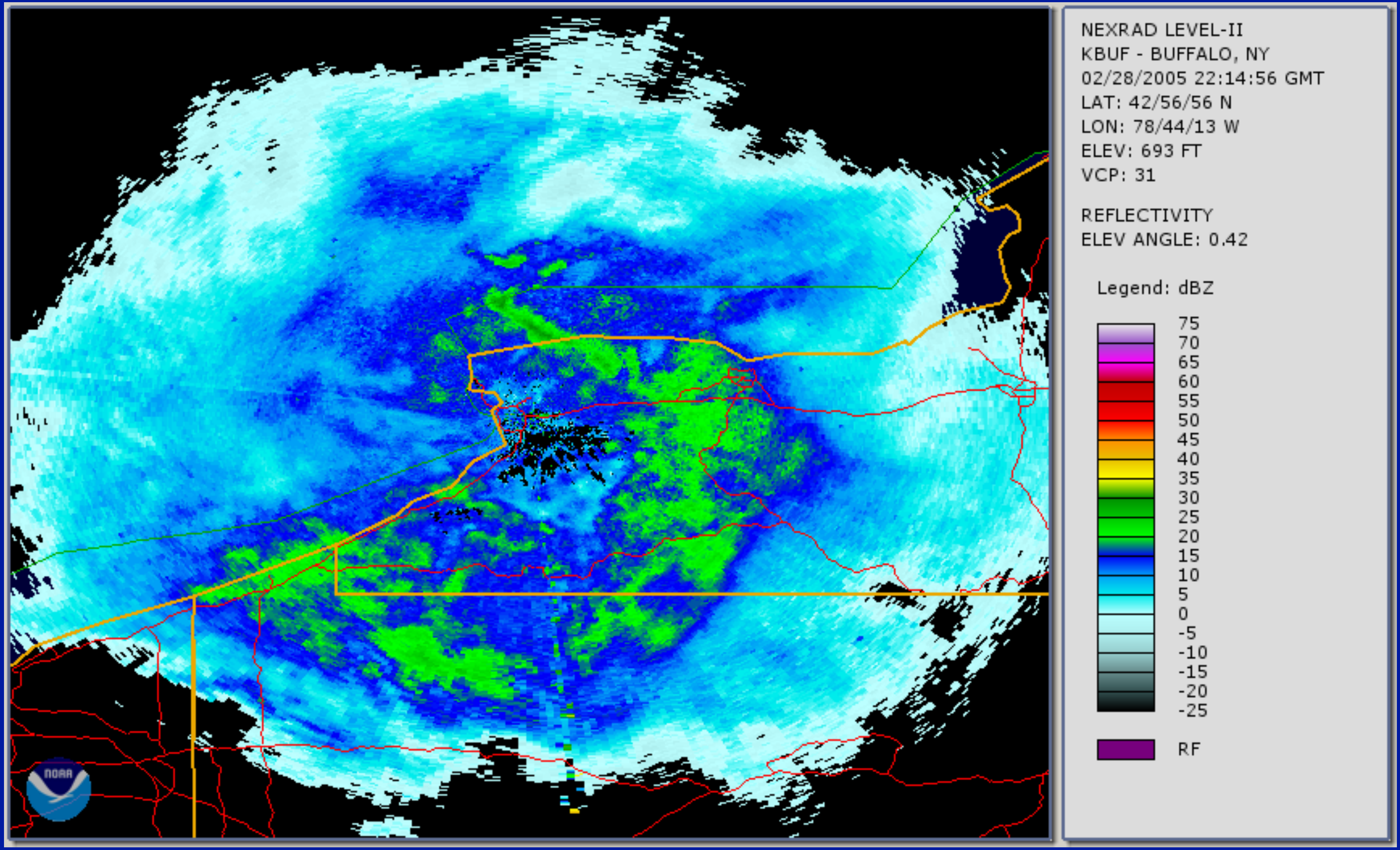
Example of a Discounted Case:
2155 UTC 28 February 2005



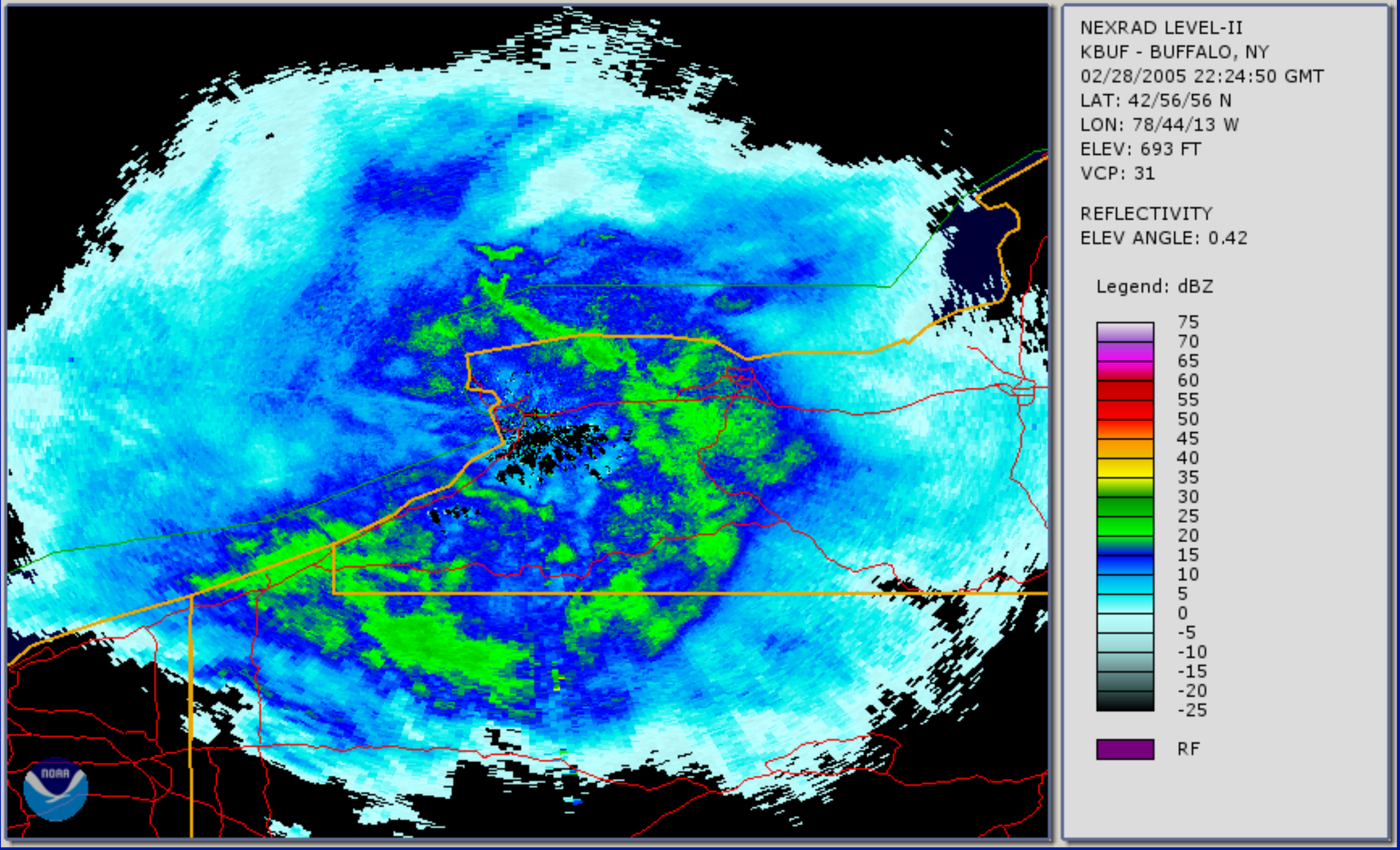
Example of a Discounted Case: 2205 UTC 28 February 2005



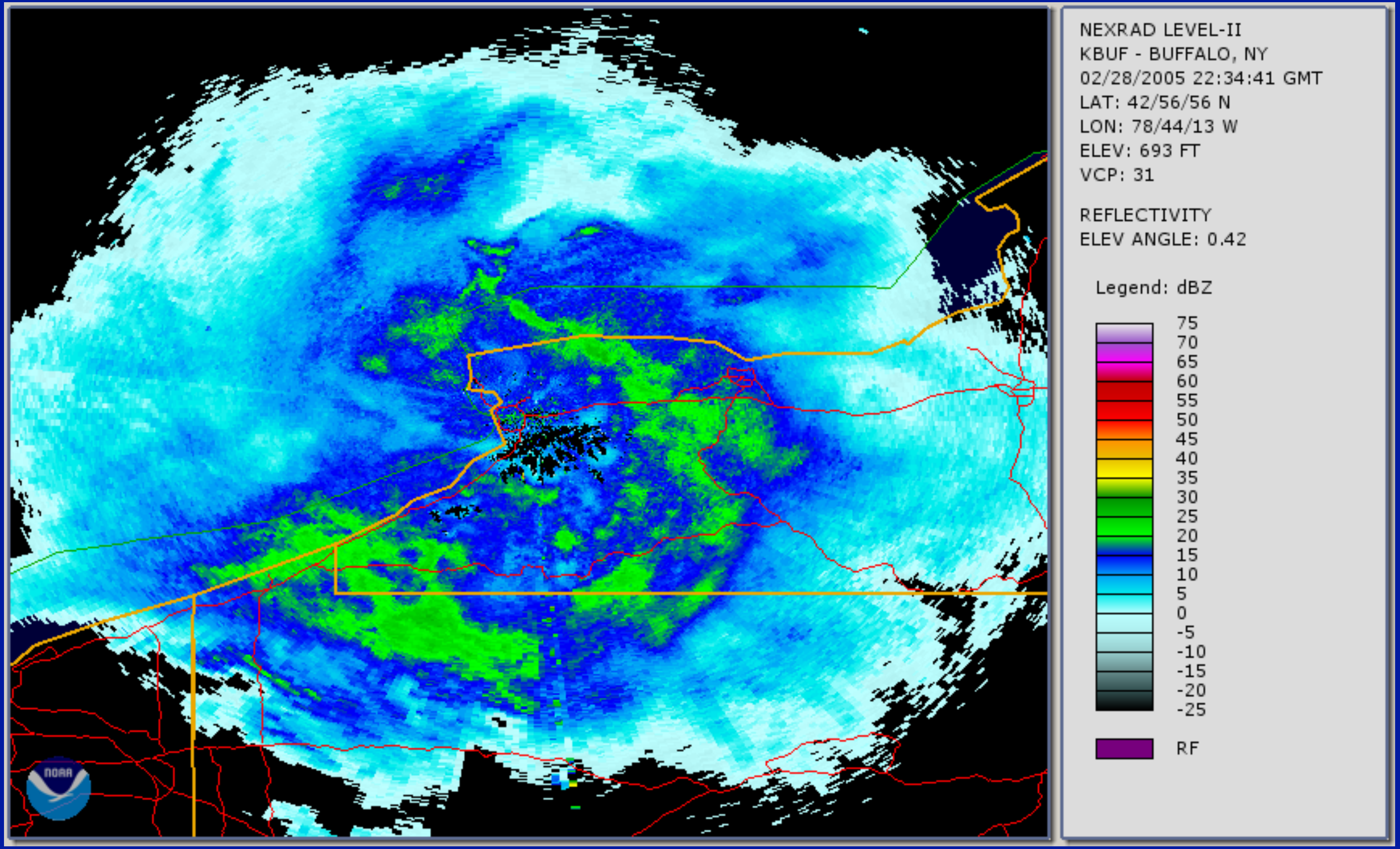
Example of a Discounted Case: 2214 UTC 28 February 2005



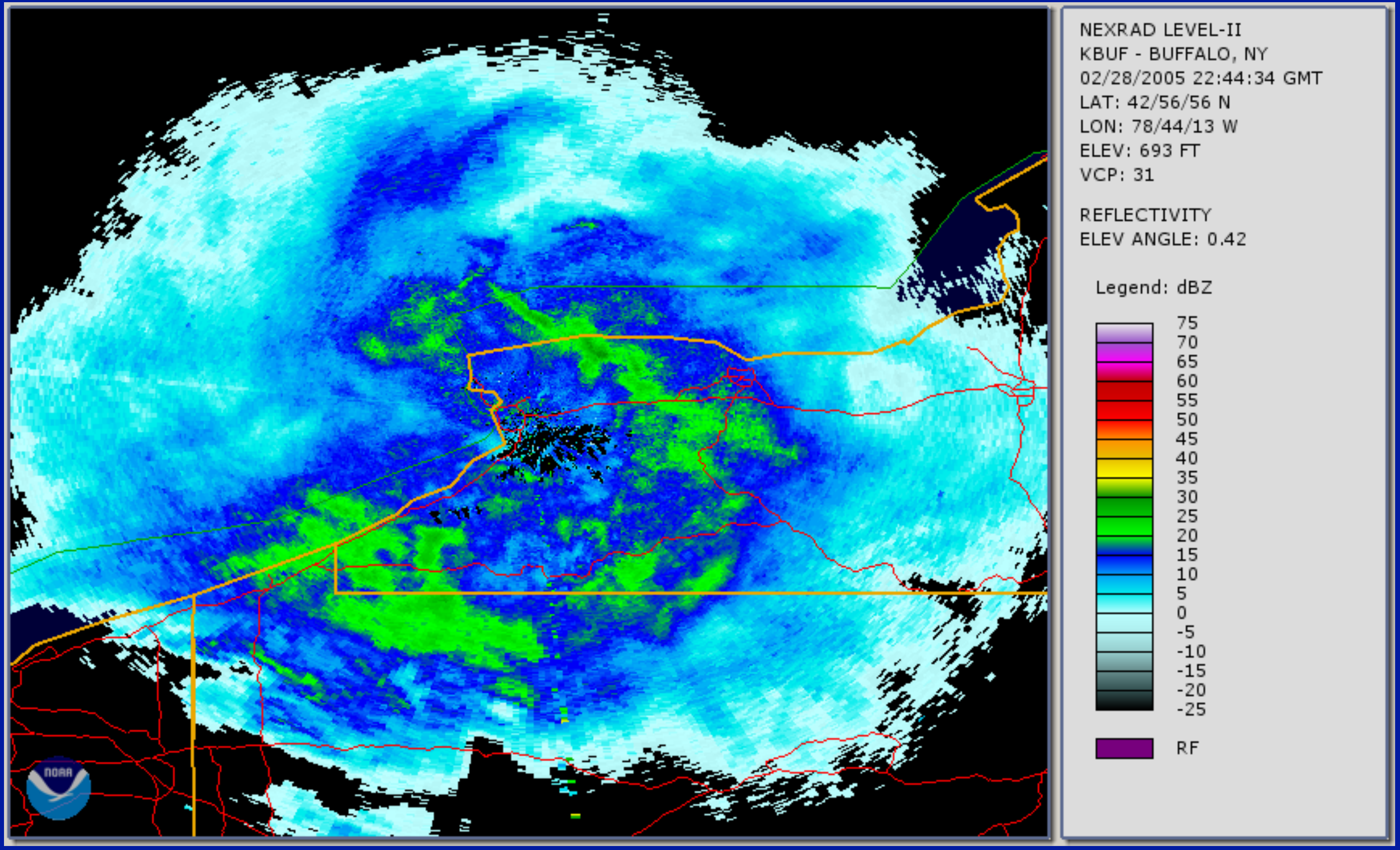
Example of a Discounted Case: 2224 UTC 28 February 2005



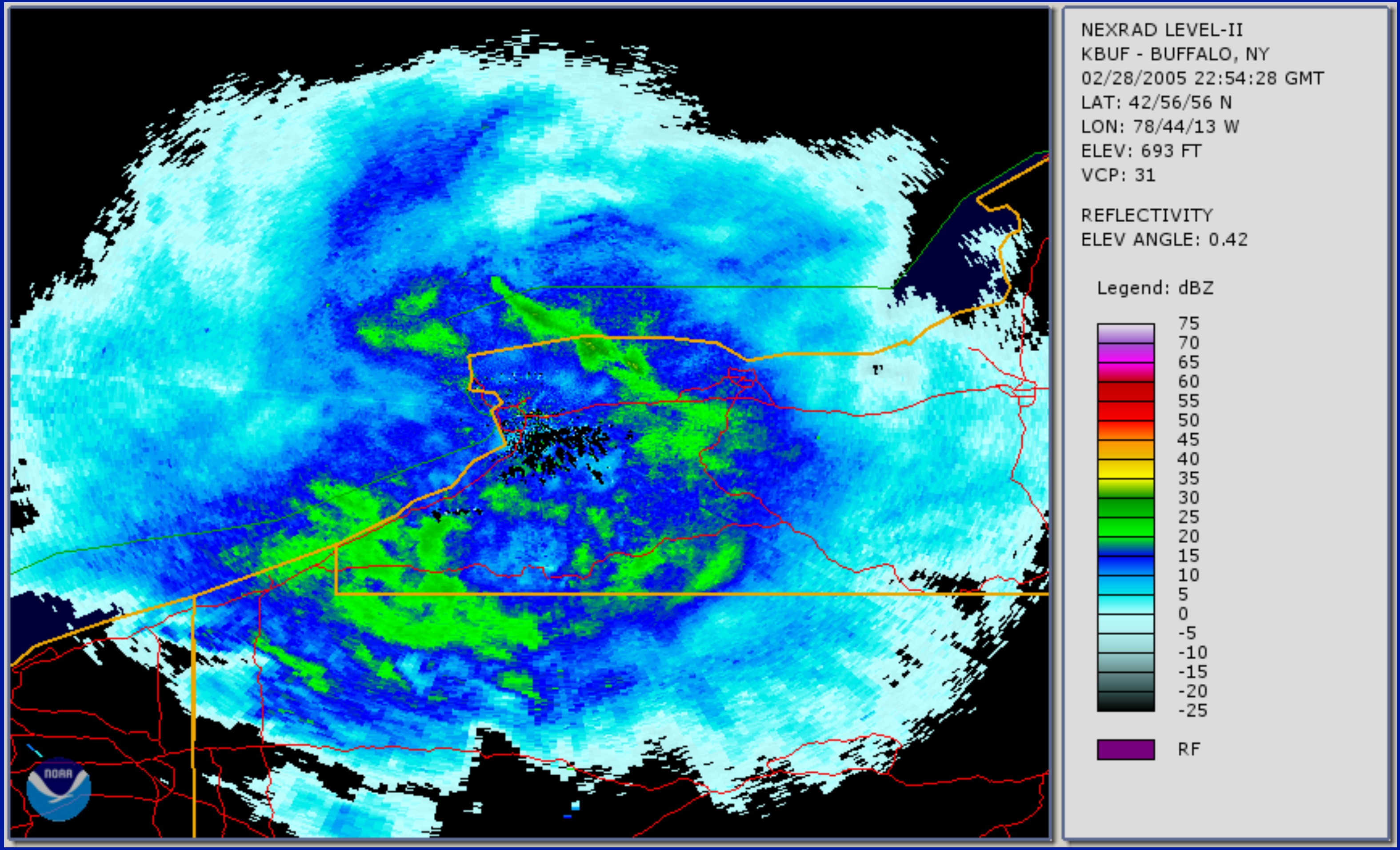
Example of a Discounted Case: 2234 UTC 28 February 2005



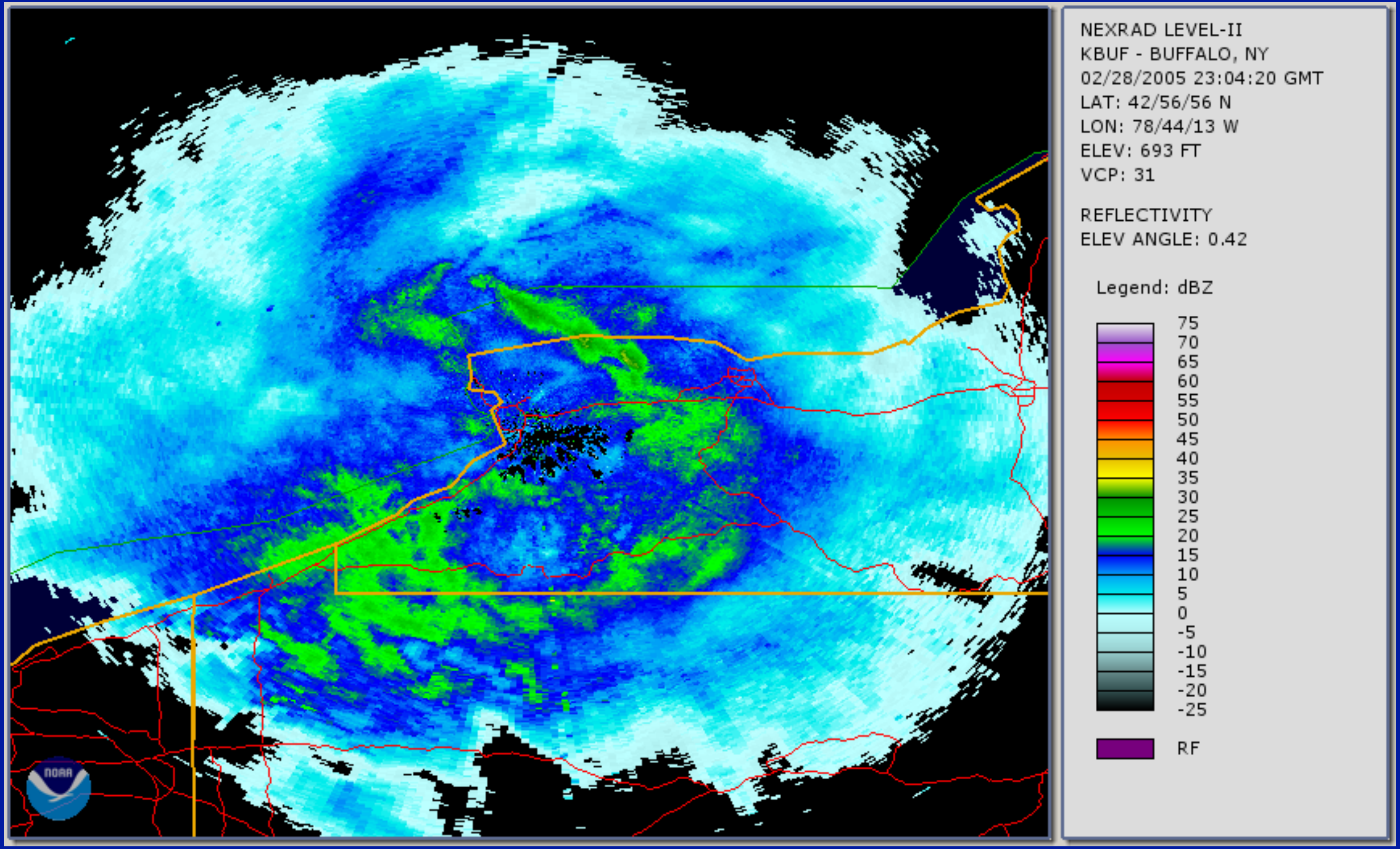
Example of a Discounted Case: 2244 UTC 28 February 2005



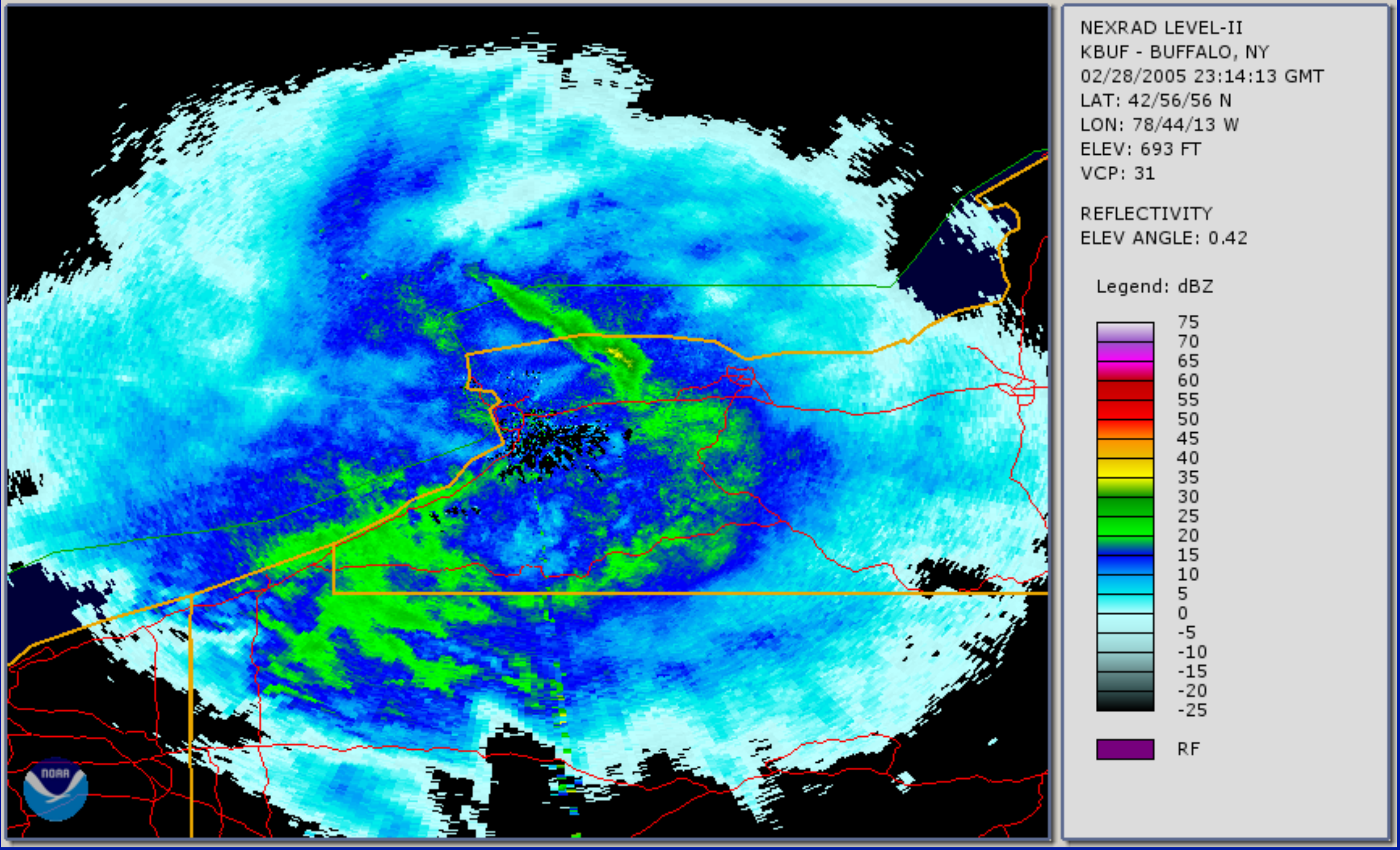
Example of a Discounted Case: 2254 UTC 28 February 2005



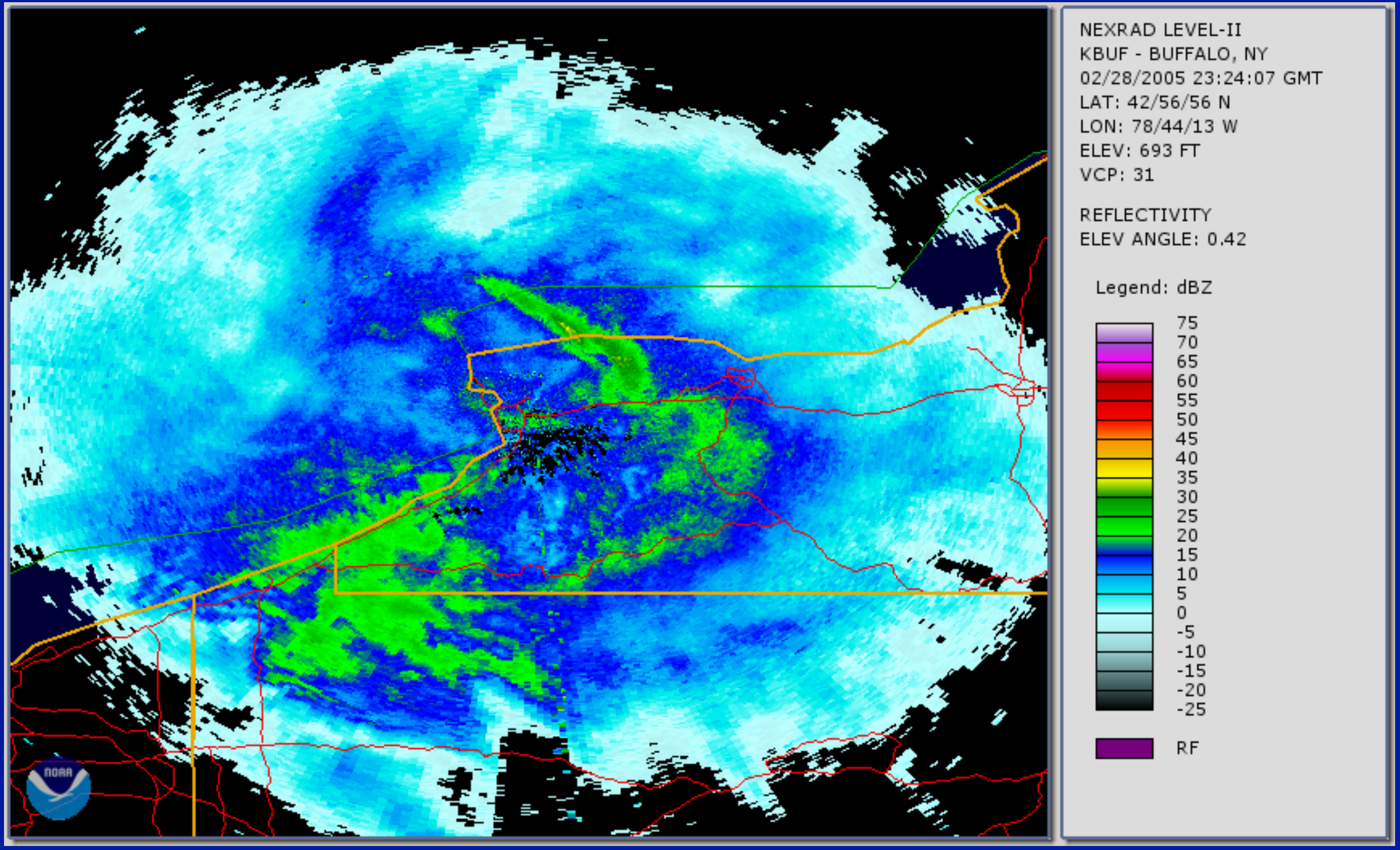
Example of a Discounted Case: 2304 UTC 28 February 2005



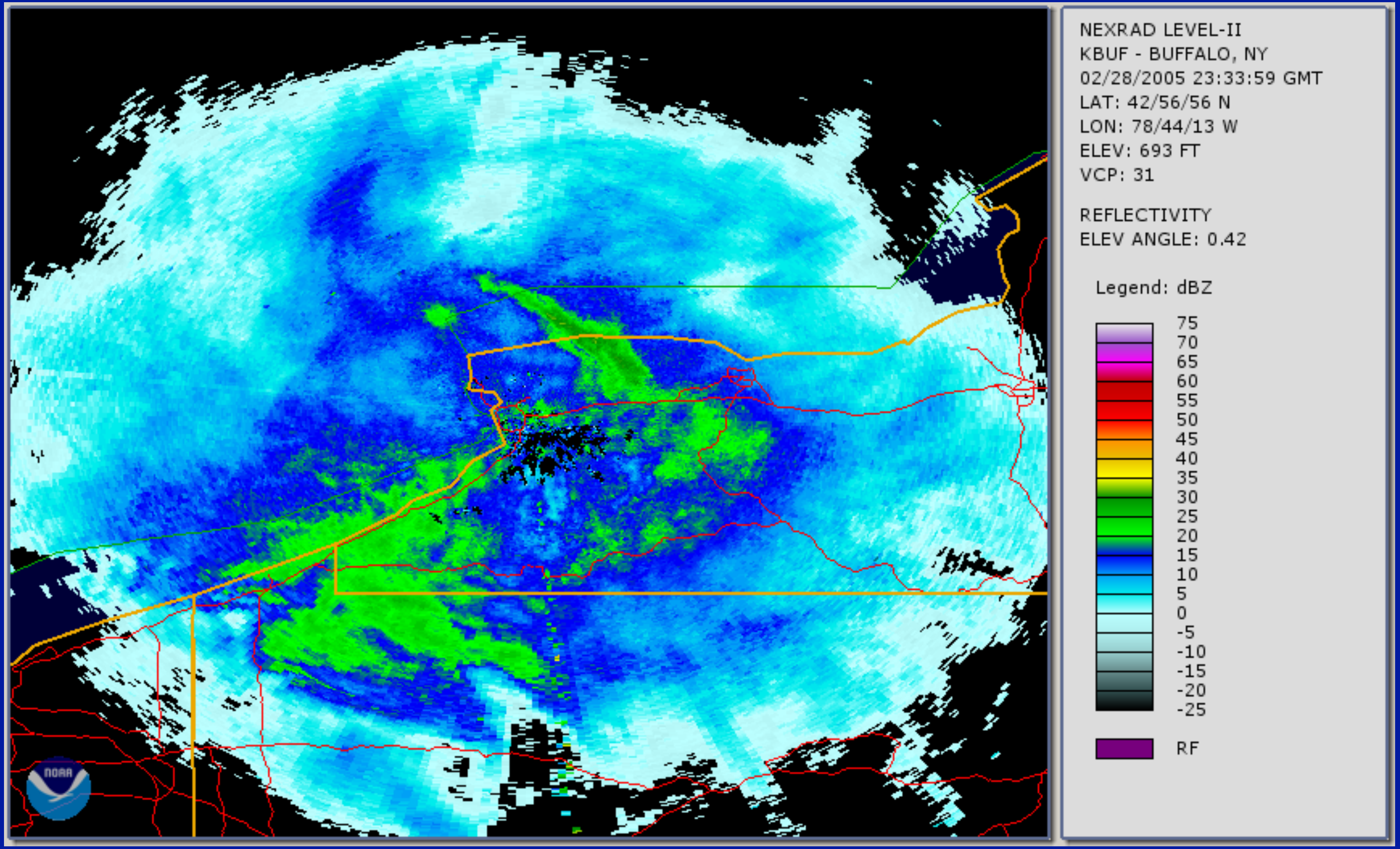
Example of a Discounted Case: 2314 UTC 28 February 2005



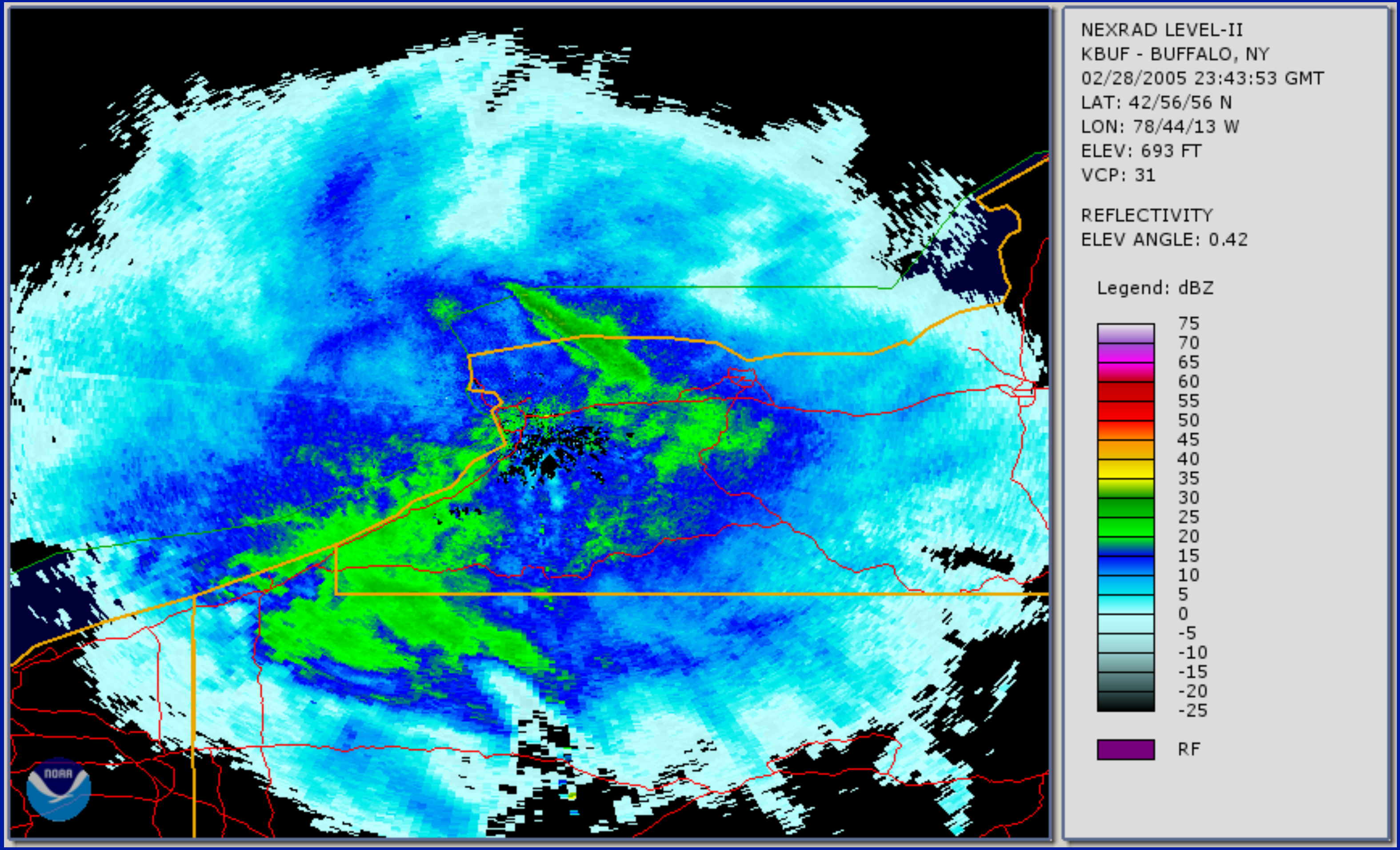
Example of a Discounted Case: 2324 UTC 28 February 2005



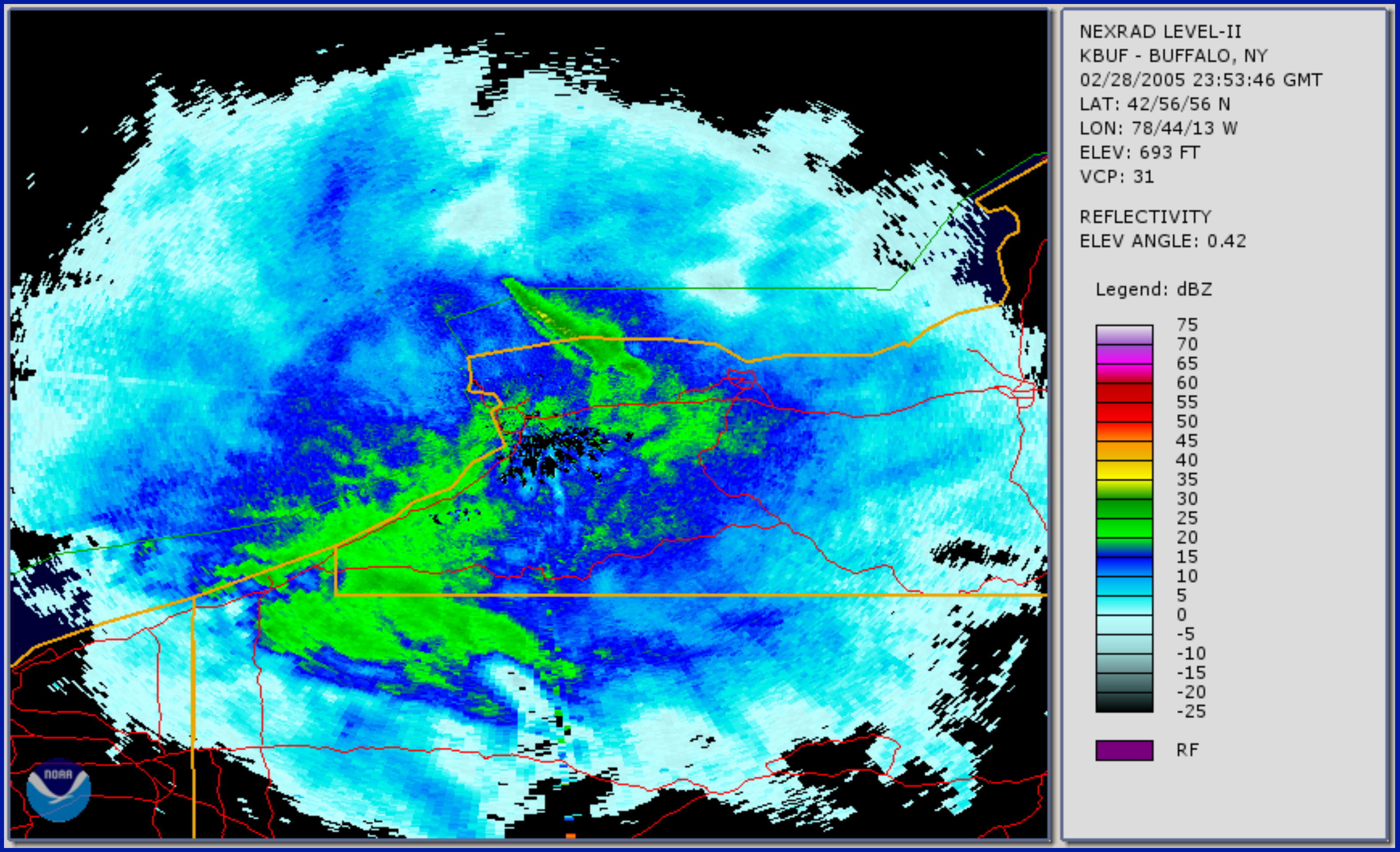
Example of a Discounted Case: 2333 UTC 28 February 2005



Example of a Discounted Case: 2343 UTC 28 February 2005



Example of a Discounted Case: 2353 UTC 28 February 2005



Methodology to Determine Case List

1. Recorded all named cases that lasted at least 24 hours, produced at least 12 inches of snow, and occurred off Lake Erie (**62 cases**)
2. Used composite radar data to determine if it was pure lake effect (**52 cases**)
3. Determined the start and end time to the nearest 6-hour (00Z, 06Z, 12Z, 18Z)
4. Any case that occurred within 7 days of the previous case was discounted **(31 cases)**

Case Categories

- All Cases **(31)**
- Length:
  - 24-42 hours **(20)**
  - >42 hours (**11)**
- Time of Year
  - January, February, March, April **(15)**
  - October, November, December **(16)**
- Type:
  - Shore Parallel **(24)**
  - Wind Parallel **(7)**

Case Categories

- All Cases (31)
- Length:
  - 24-42 hours (20)
  - >42 hours (11)
- Time of Year
  - January, February, March, April (15)
  - October, November, December (16)
- Type:
  - Shore Parallel (24)
  - Wind Parallel (7)

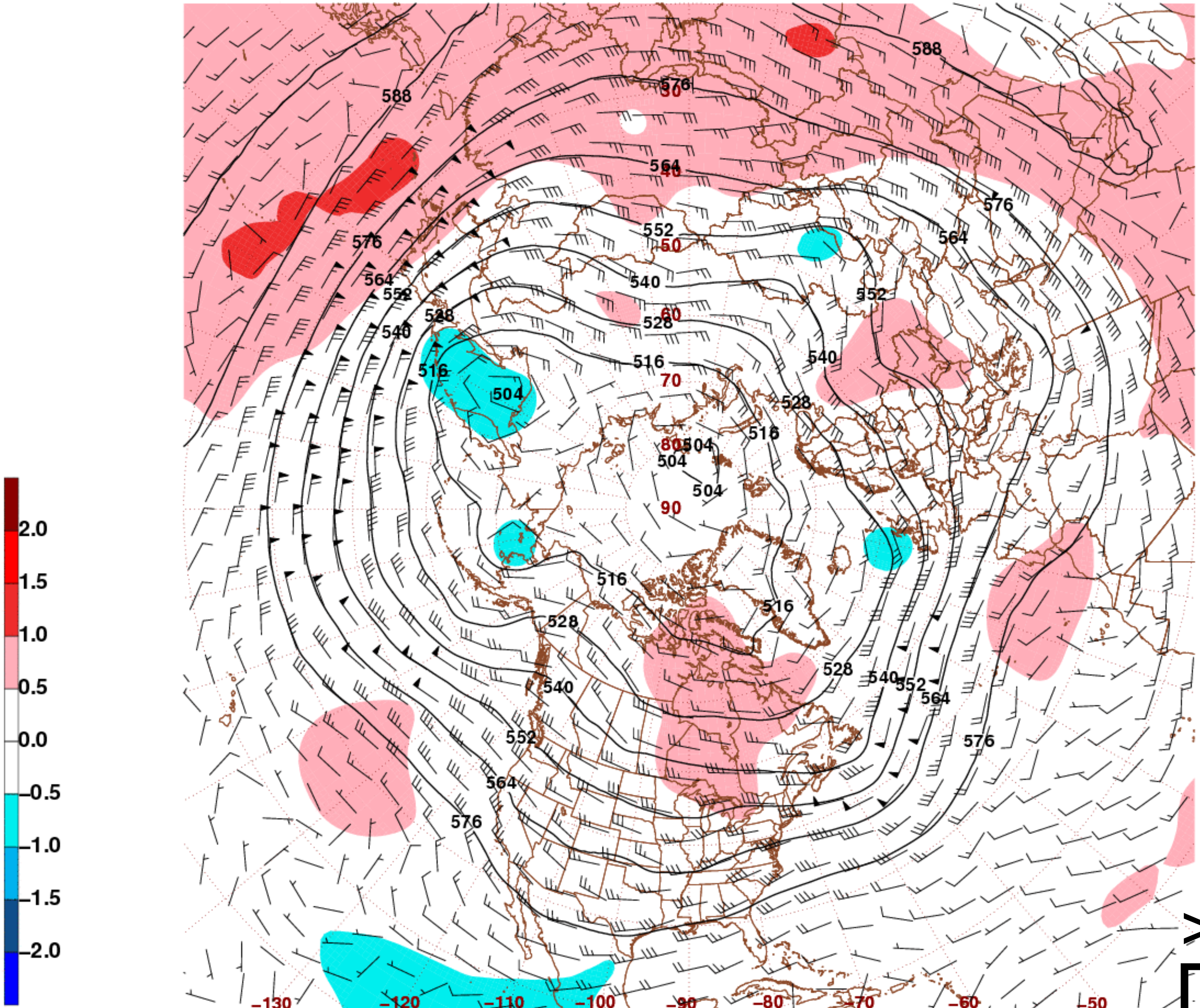
Data

- Climate Forecast System Reanalysis (CFSR) data was used to make composites for each of the previous categories
  - Sea level pressure
  - 500 hPa height and wind
  - 300 hPa height and wind
  - 850 hPa temperature, height, and wind

Data

- NCEP/NCAR Reanalysis Data
  - Years included in climatology: 1979-2008
  - Standardized Anomalies for
    - Sea level pressure
    - 850 hPa temp
    - 500 hPa height

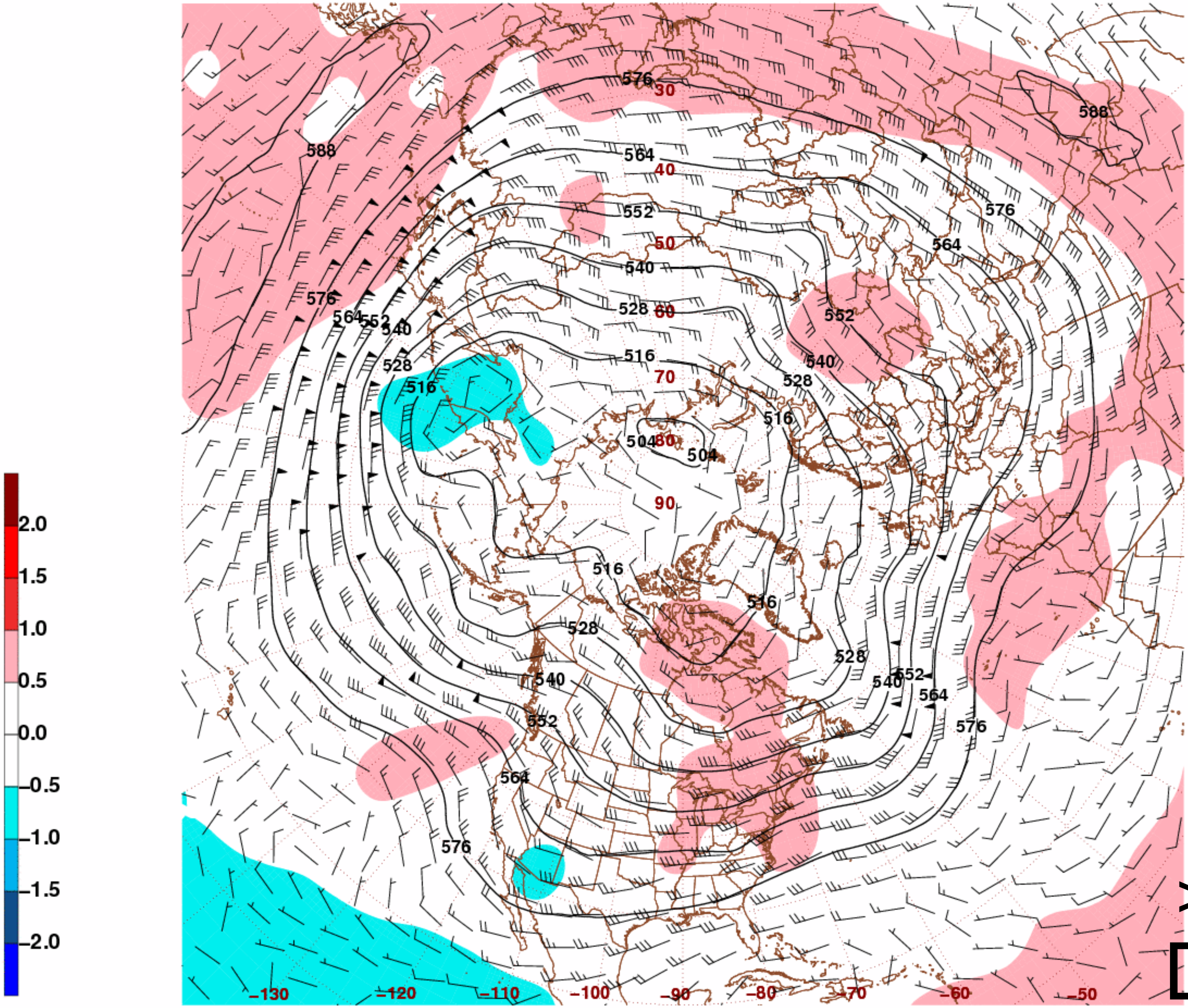
>42 hours



500 hPa Height (dam), Wind (kts) Standardized Anomalies

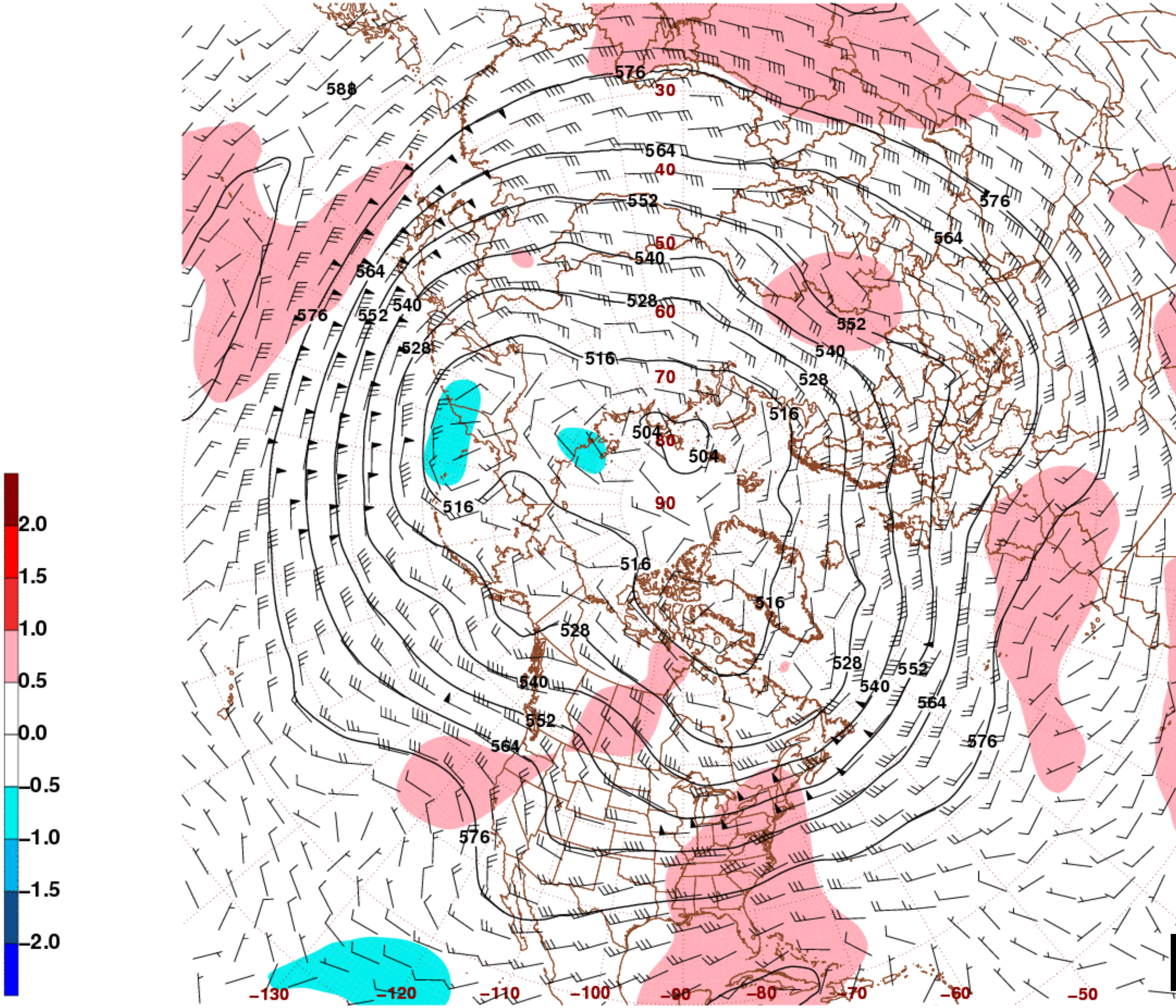
>42 hrs

Day -8



500 hPa Height (dam), Wind (kts) Standardized Anomalies

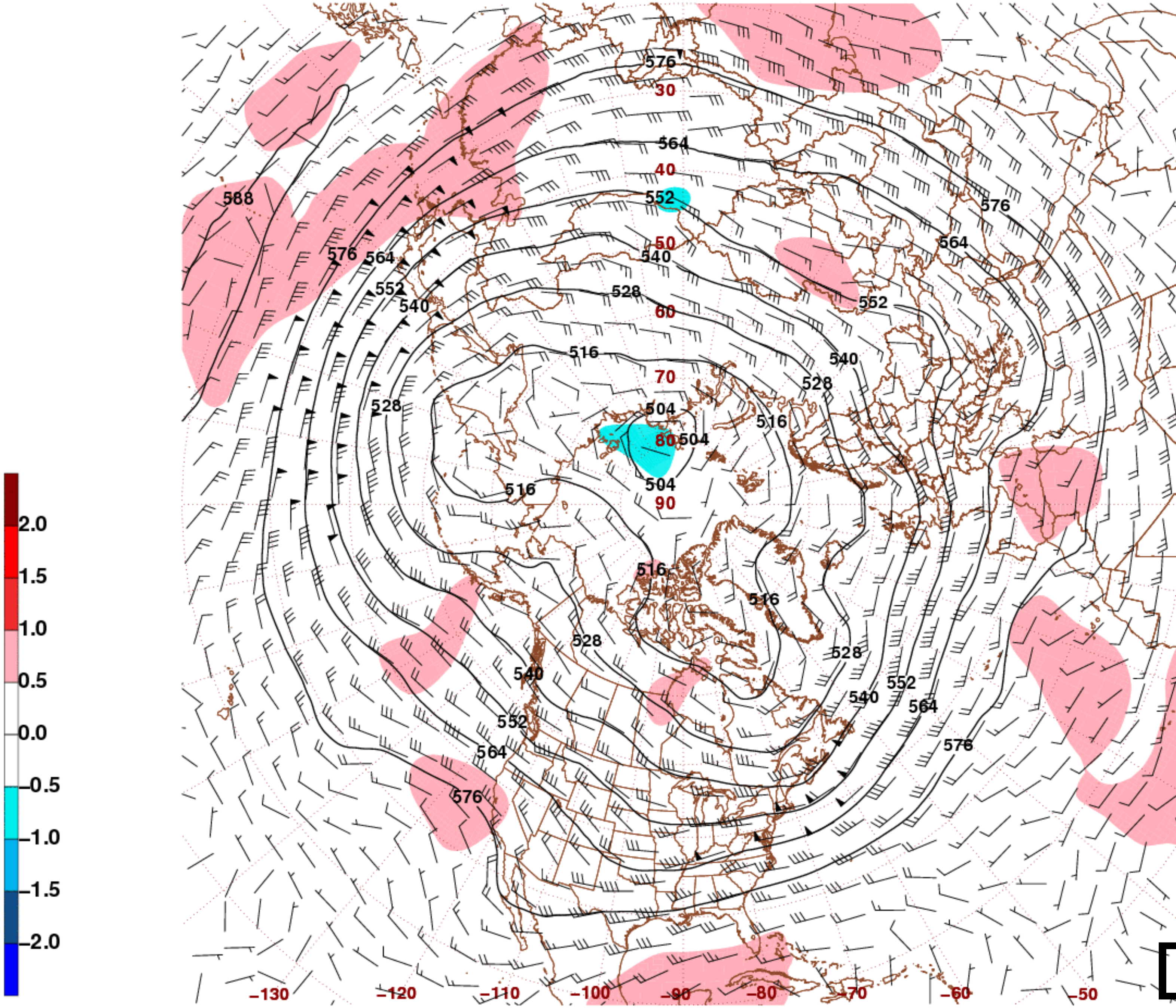
>42 hrs
Day -7



500 hPa Height (dam), Wind (kts) Standardized Anomalies

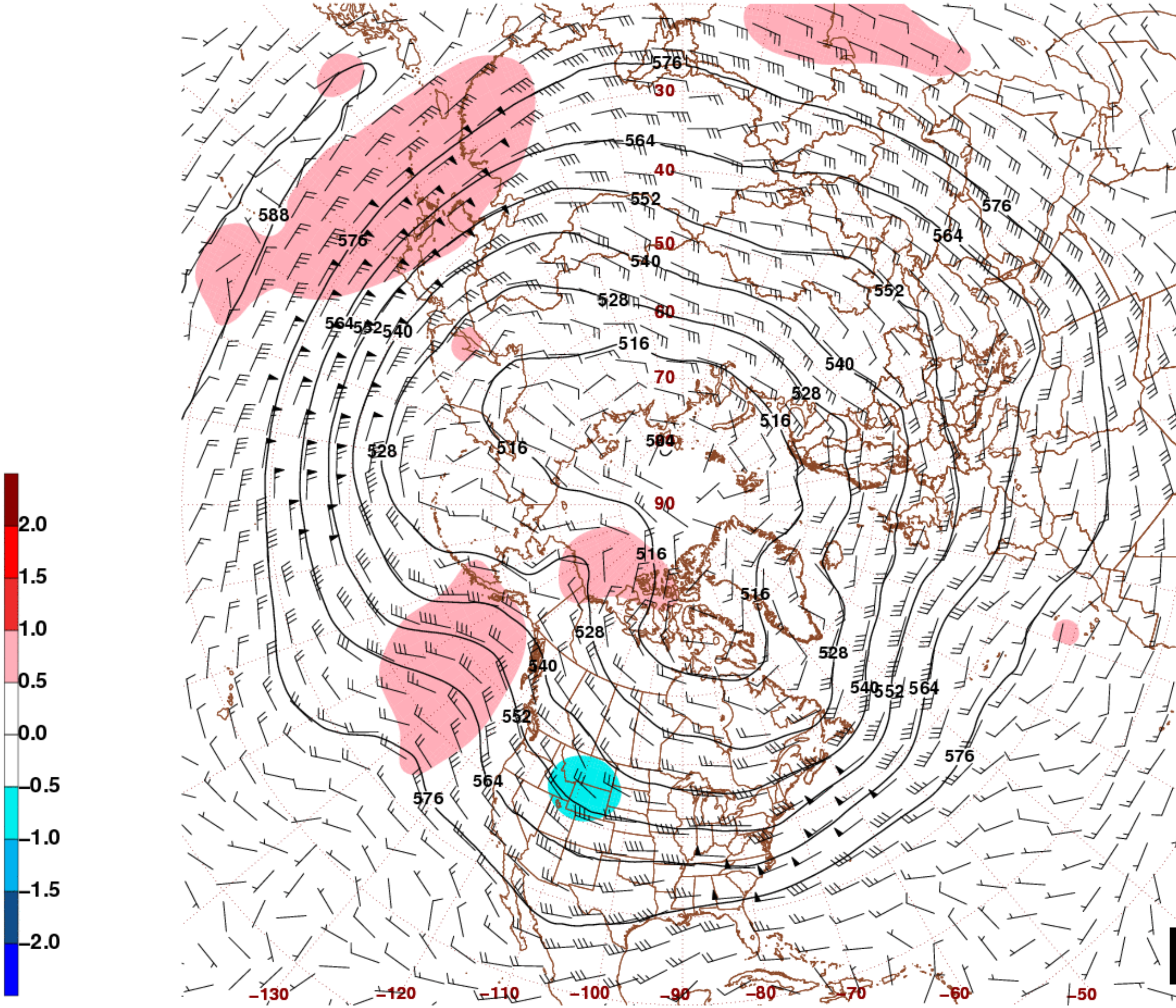
>42 hrs

Day -6



500 hPa Height (dam), Wind (kts) Standardized Anomalies

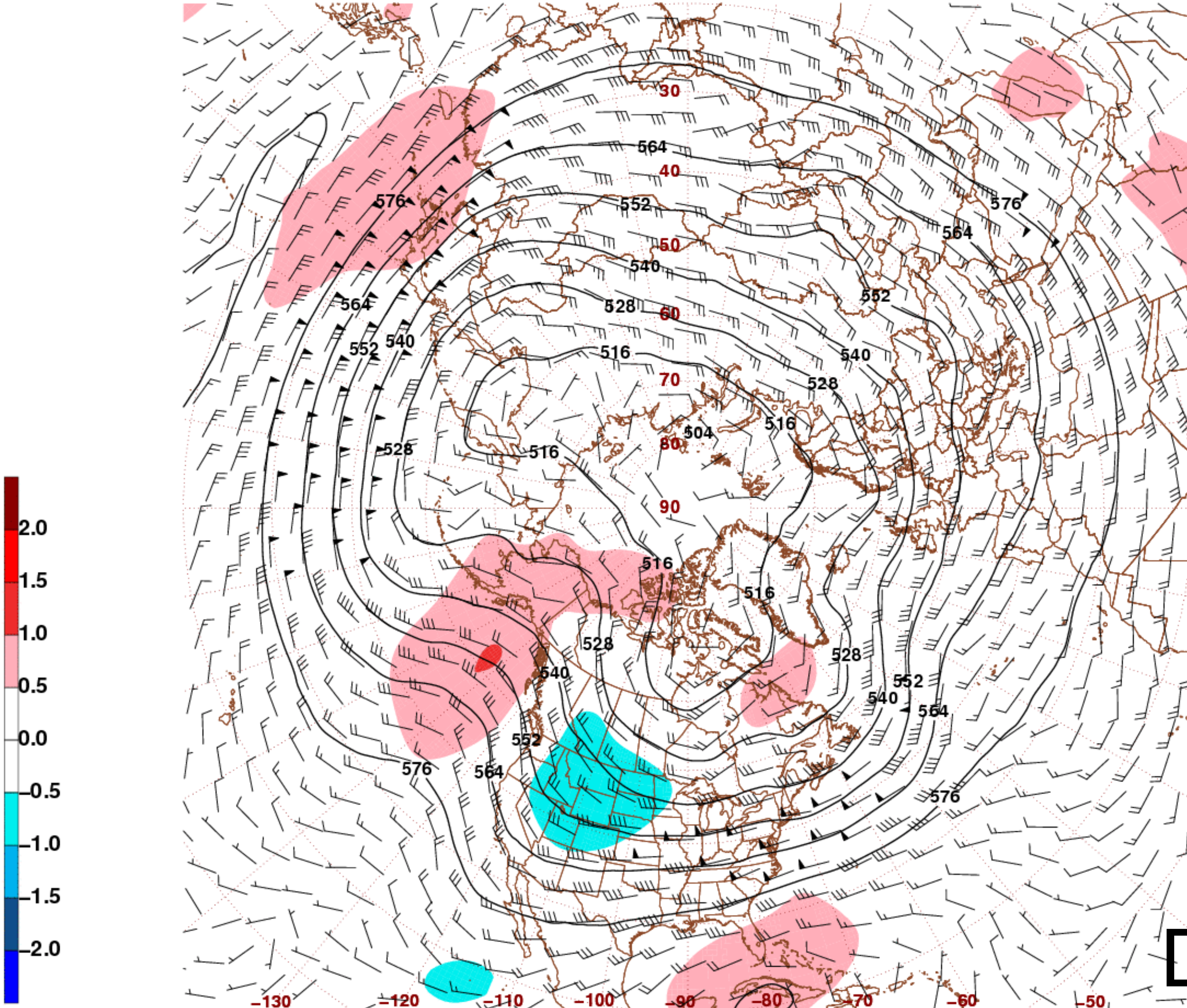
>42 hrs
Day -5



500 hPa Height (dam), Wind (kts) Standardized Anomalies

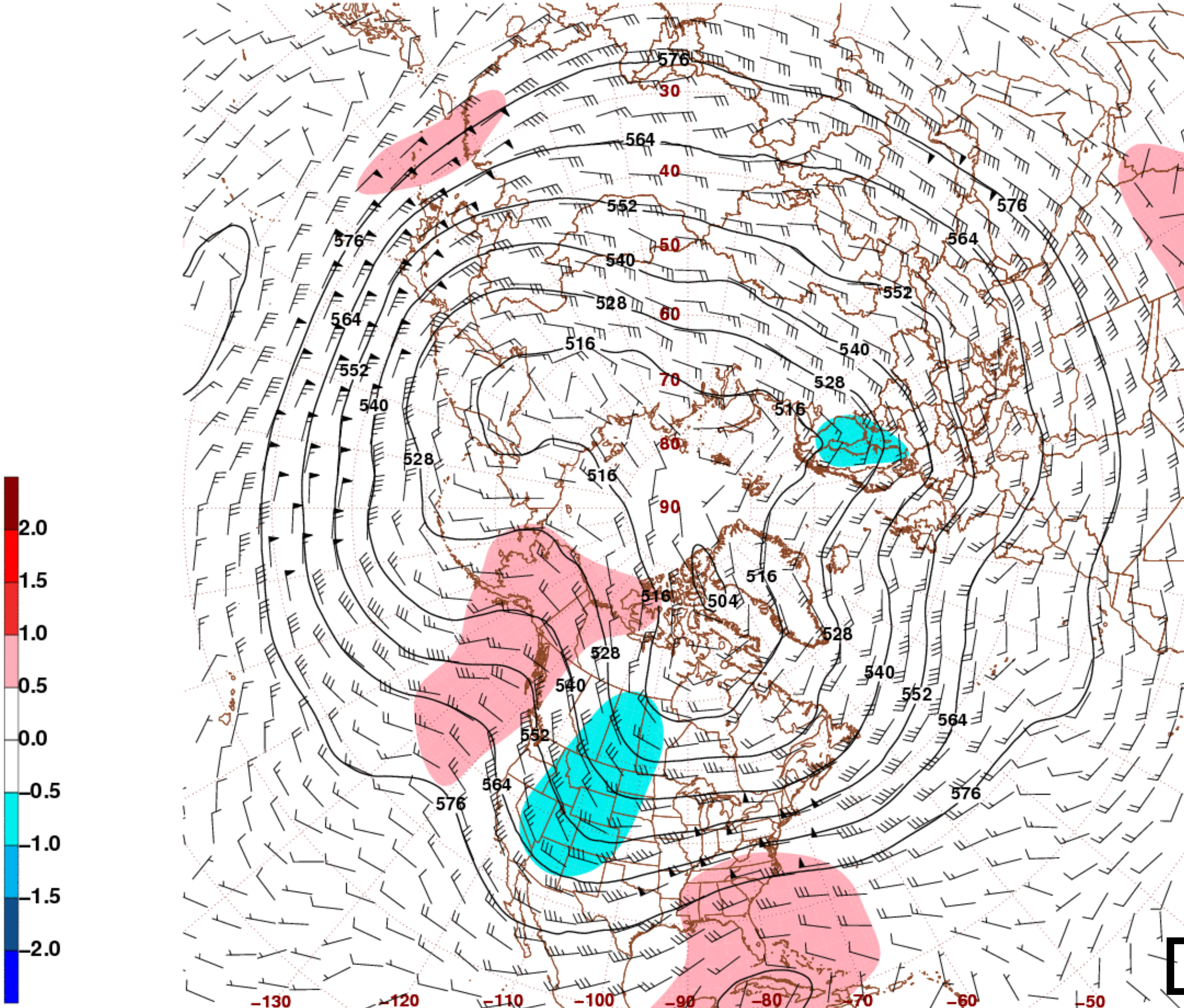
>42 hrs

Day -4



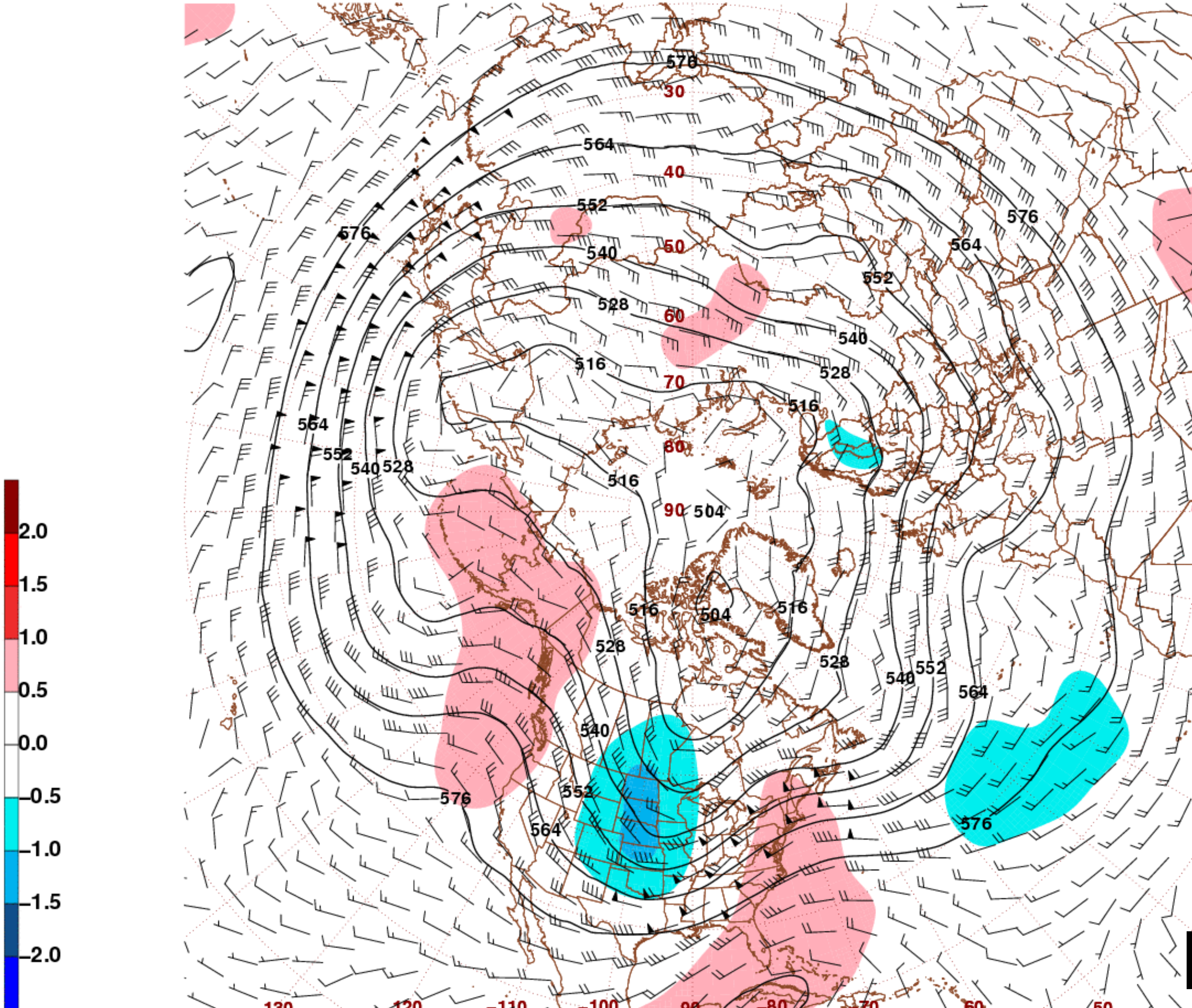
500 hPa Height (dam), Wind (kts) Standardized Anomalies

>42 hrs
Day -3



500 hPa Height (dam), Wind (kts) Standardized Anomalies

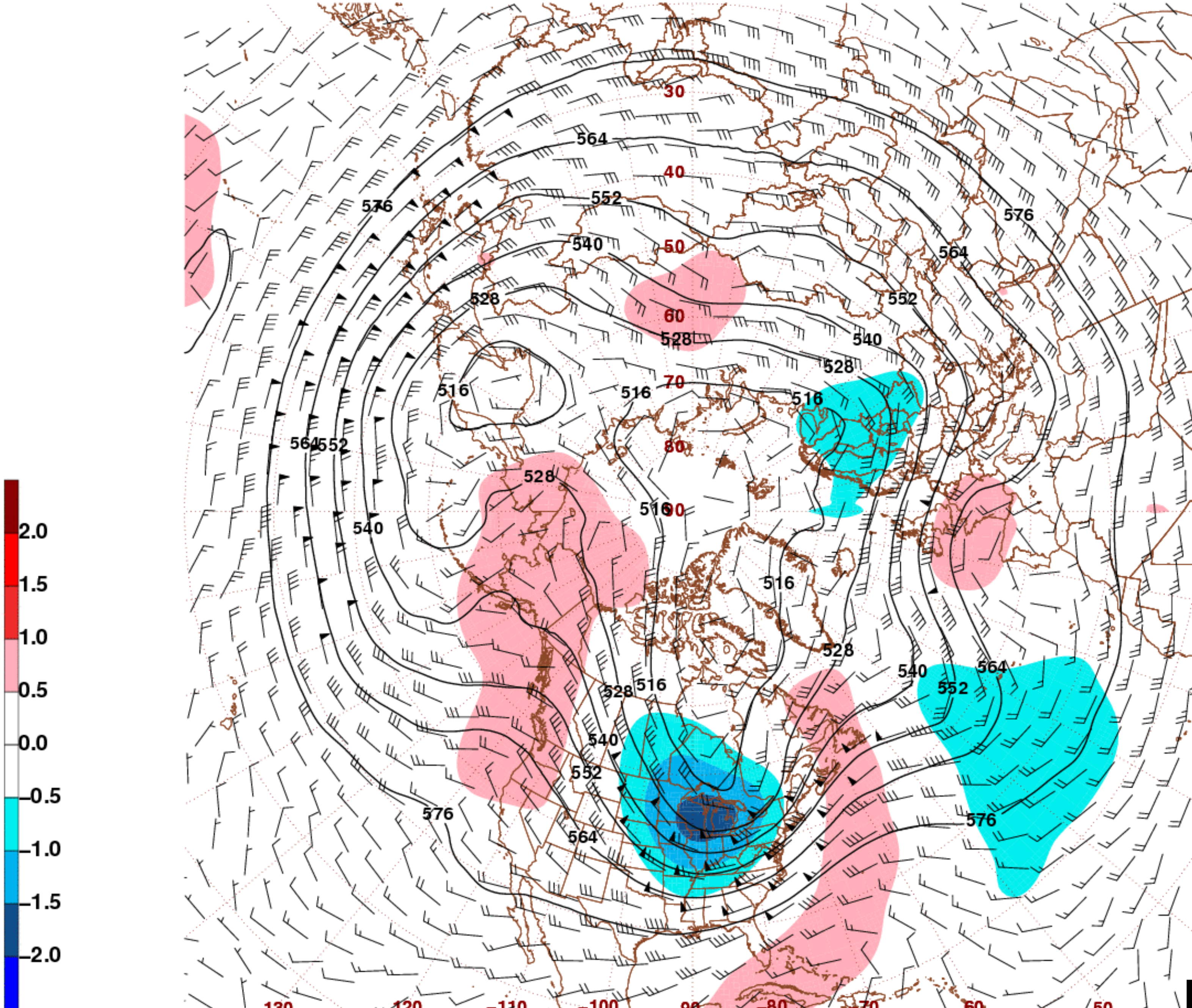
>42 hrs
Day -2



500 hPa Height (dam), Wind (kts) Standardized Anomalies

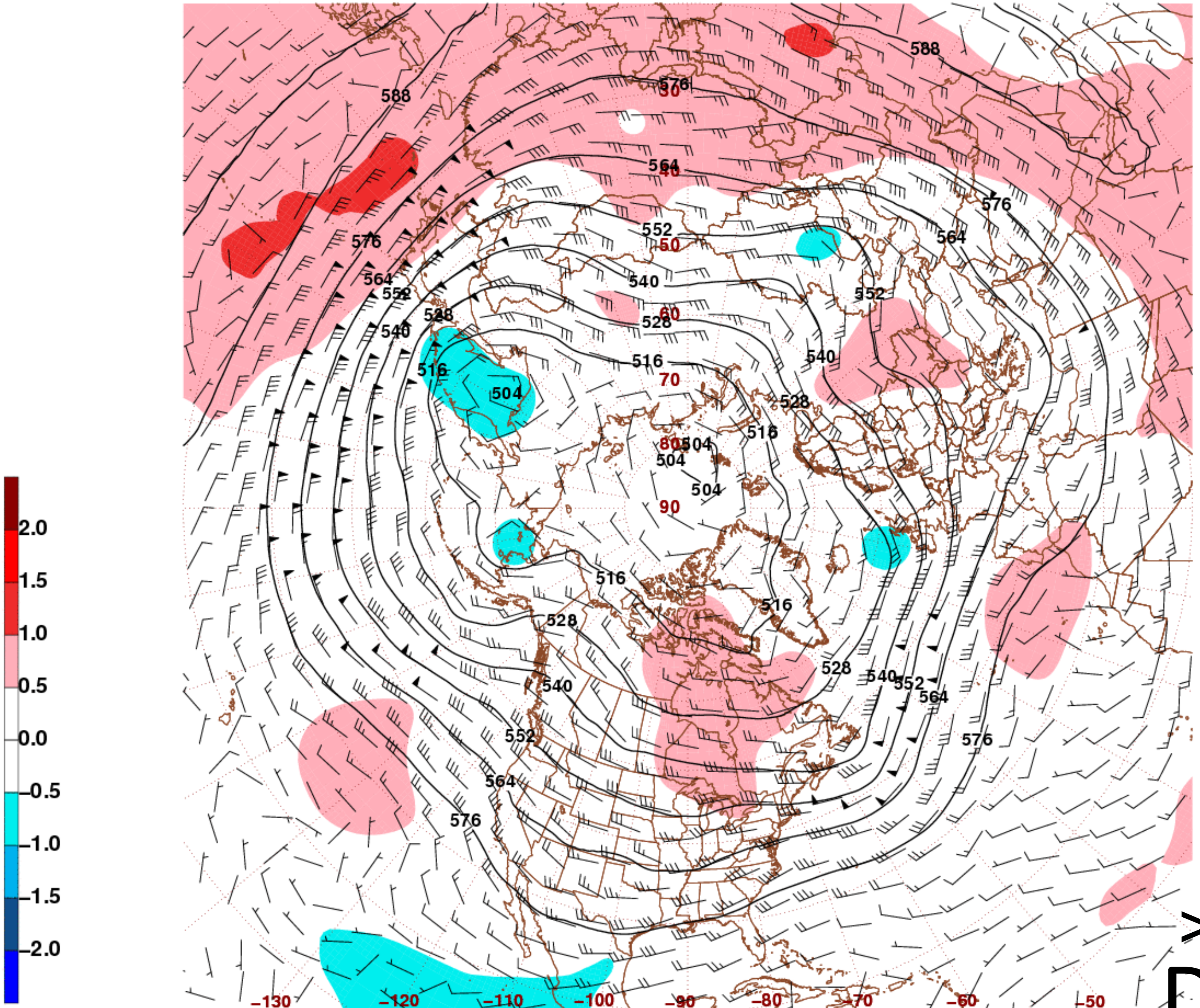
>42 hrs

Day -1



500 hPa Height (dam), Wind (kts) Standardized Anomalies

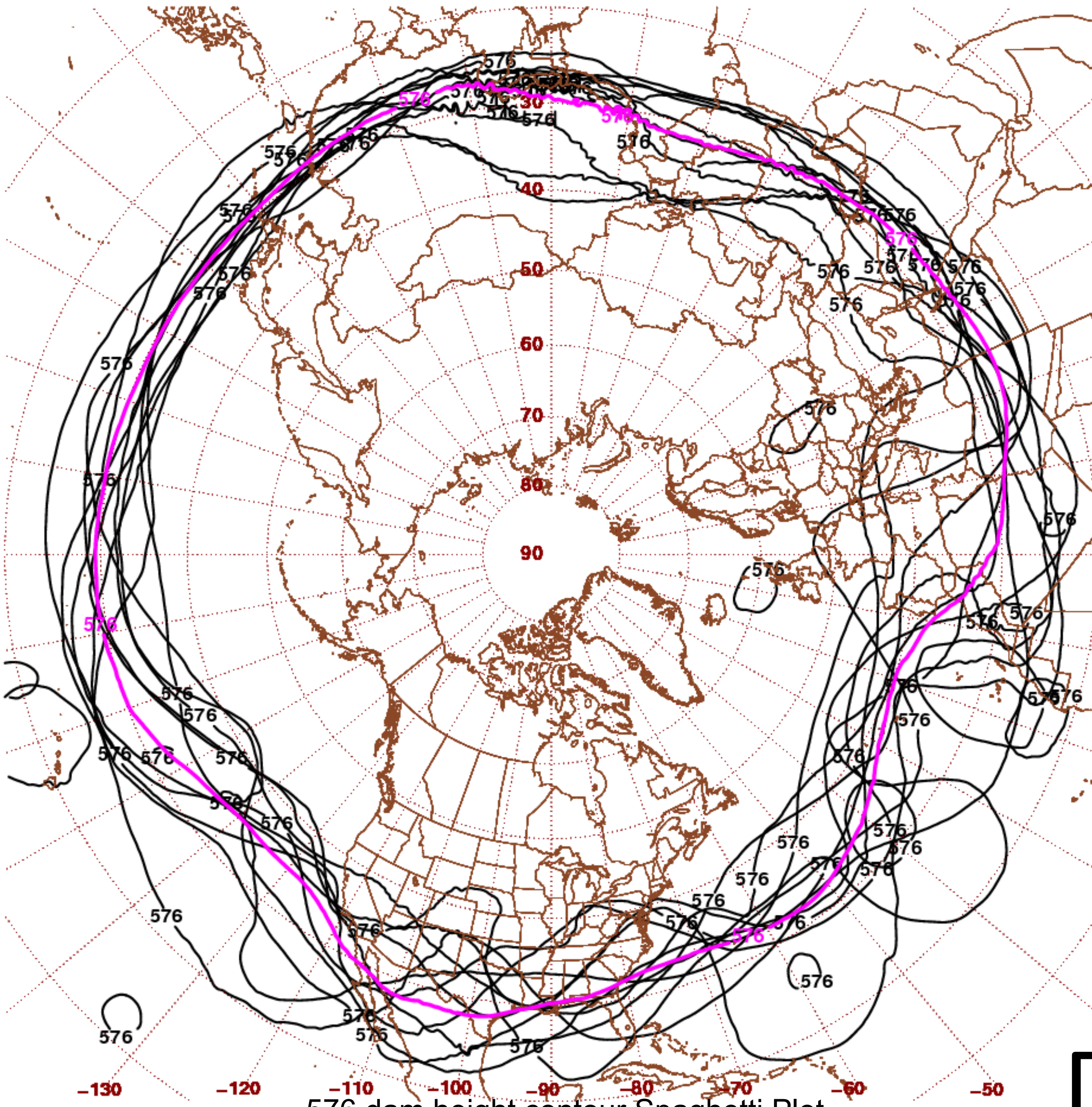
>42 hrs
Day 0



500 hPa Height (dam), Wind (kts) Standardized Anomalies

>42 hrs

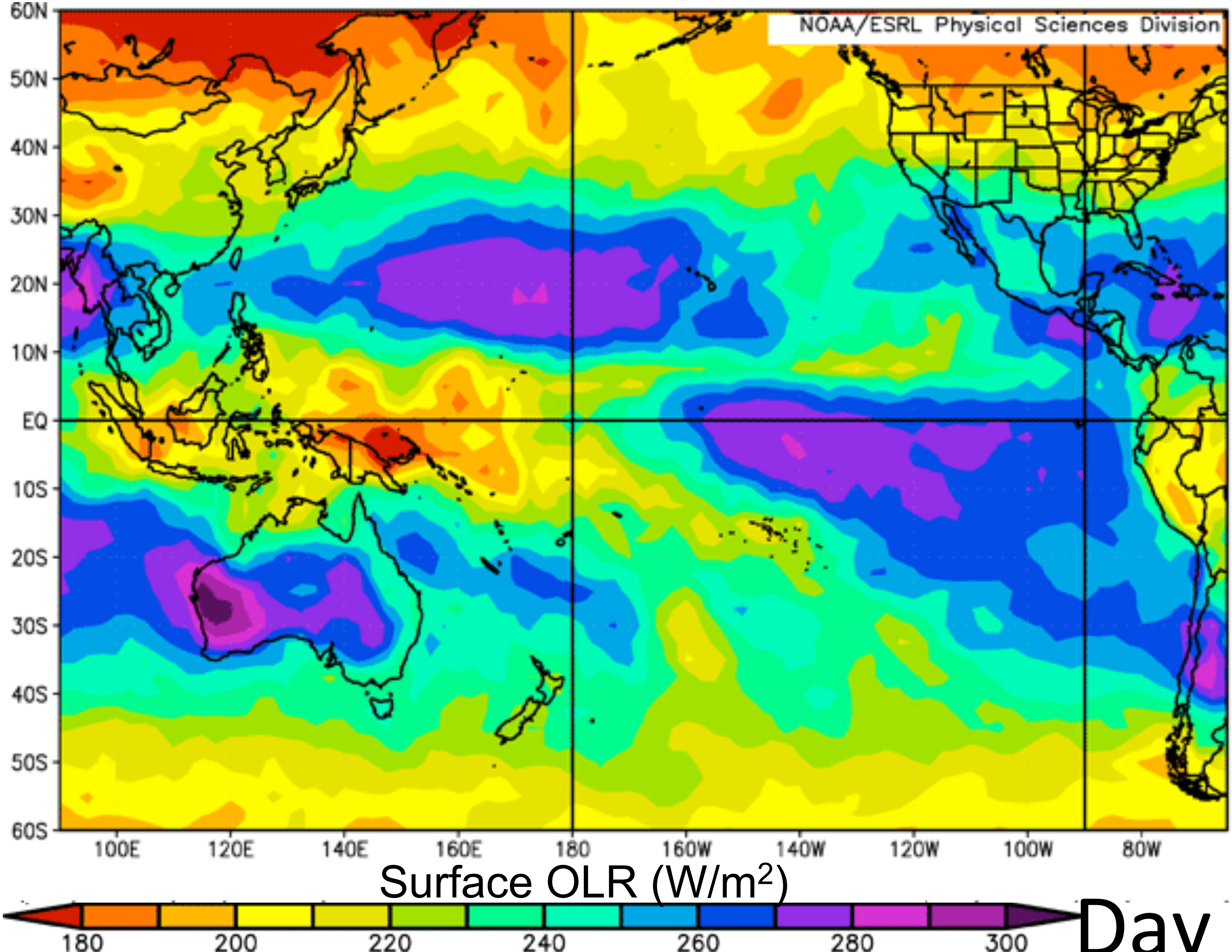
Day -8



576 dam height contour Spaghetti Plot

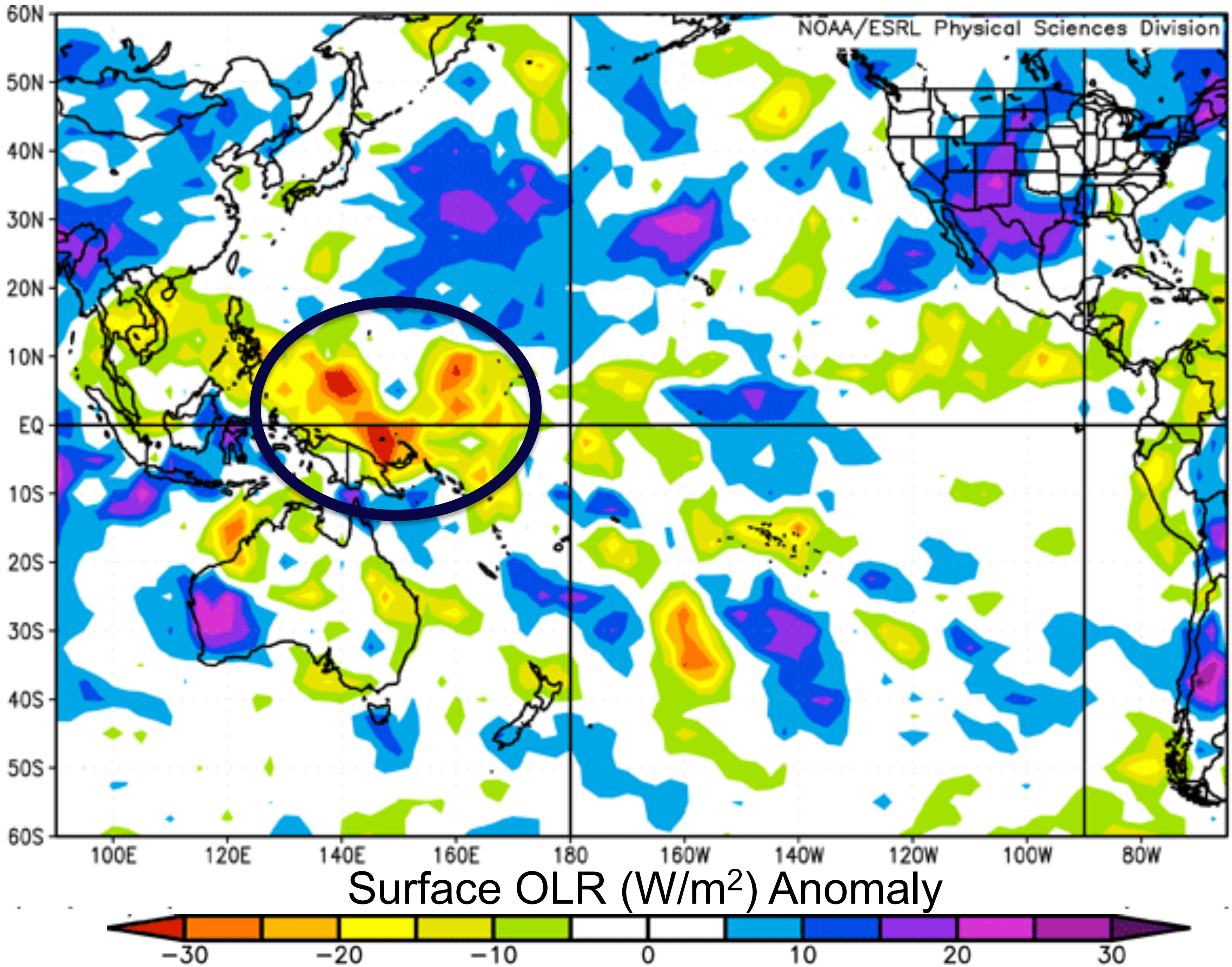
>42 hrs

Day -8

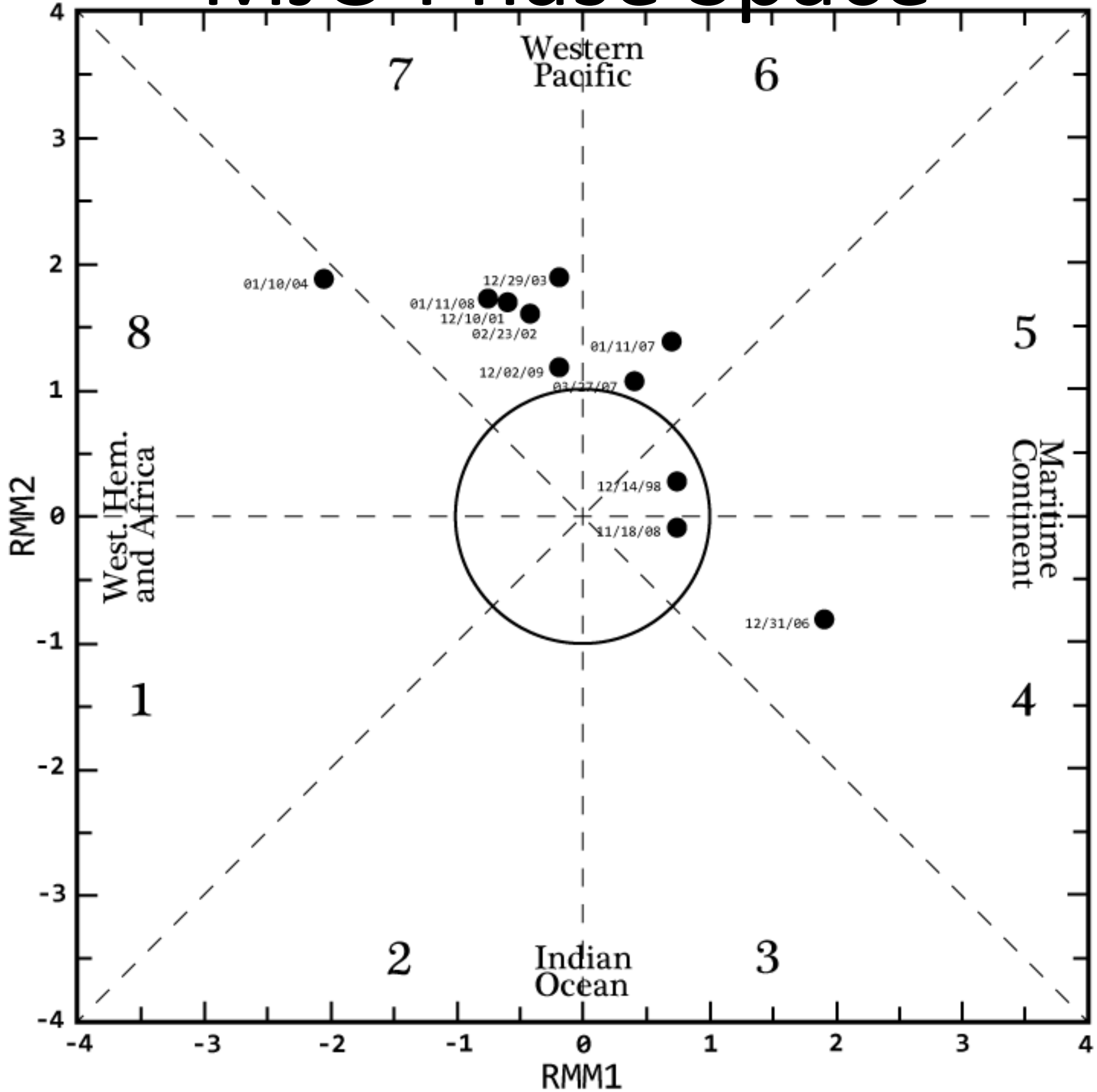


Day -8

http://www.esrl.noaa.gov/psd/data/composites/day/


NOAA/ESRL Physical Sciences Division
60N
50N
40N
30N
20N
10N
EQ
10S
20S
30S
40S
50S
60S
100E
120E
140E
160E
180
160W
140W
120W
100W
80W
Surface OLR (W/m²) Anomaly
−30
−20
−10
0
10
20
30

MJO Phase Space



http://www.bom.gov.au/climate/mjo/

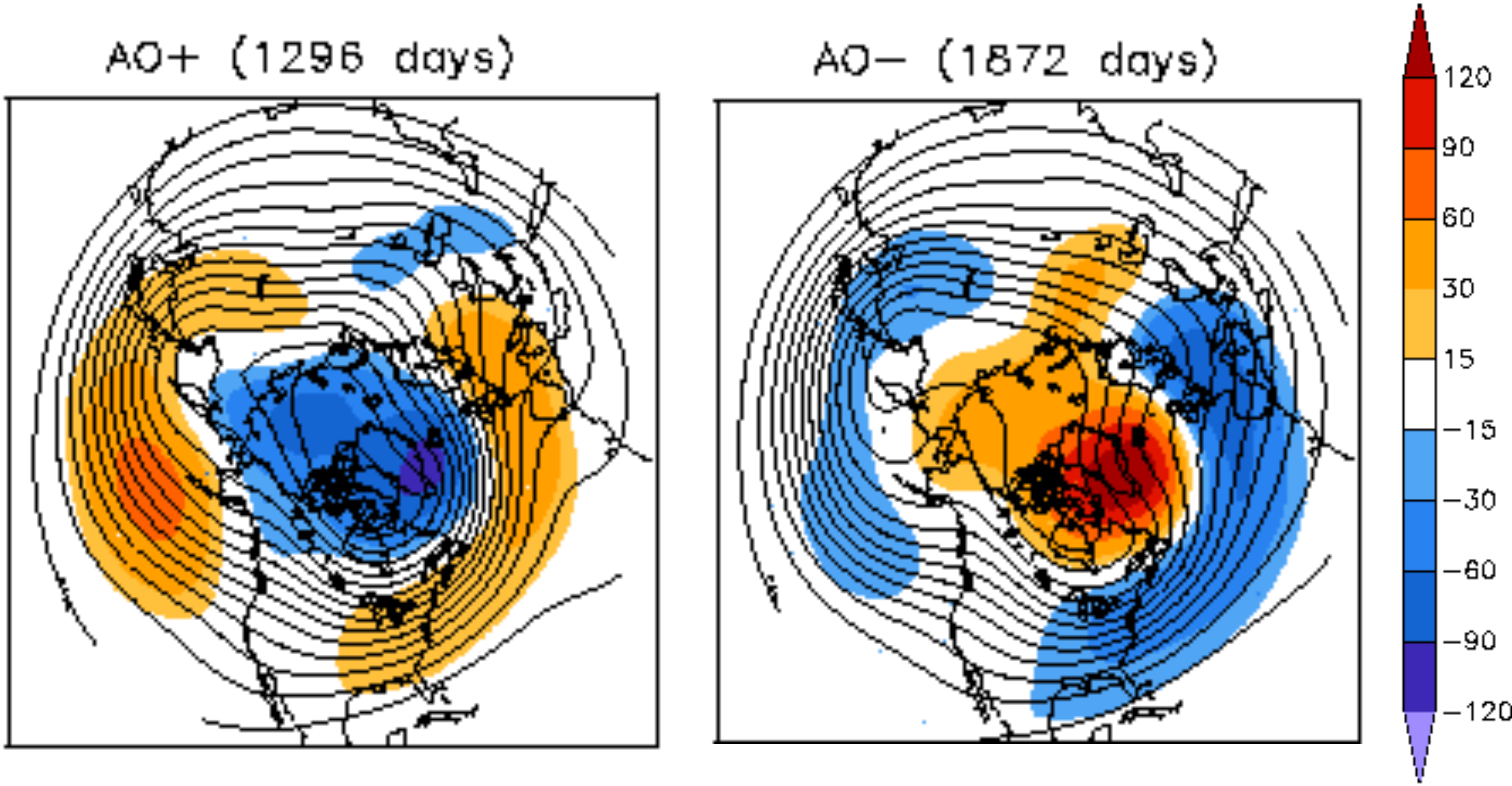
Day -8

Significance of MJO on the Northeast United States

L' Hereux and Higgins 2007

- AO favors a negative tendency when MJO is in phases 6 & 7
- MJO in phases 7 & 8 influences the midlatitude temperature and height anomalies in a way that resembles the negative phase of the AO

DJF 500 hPa Height and Anomaly (m)



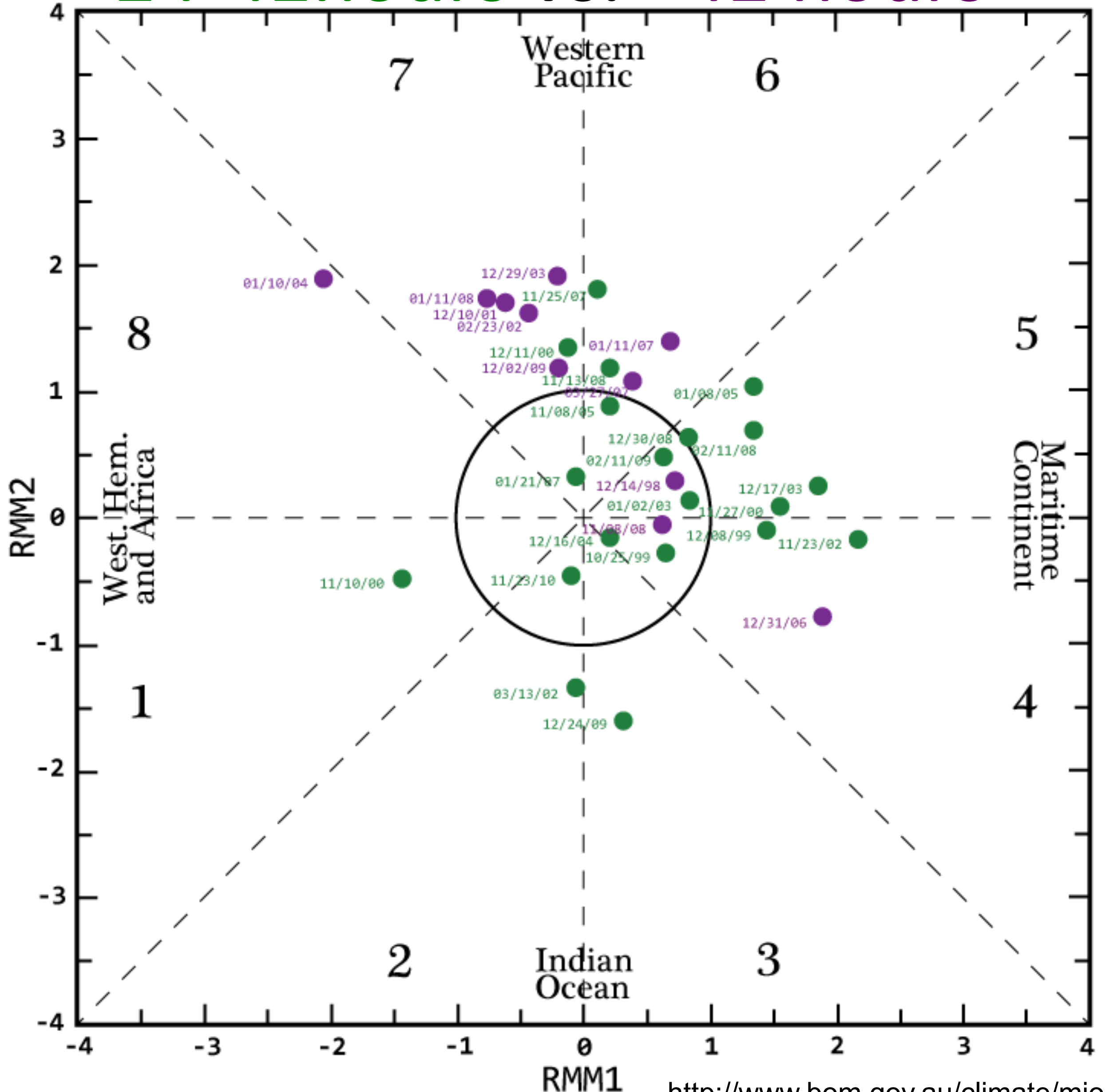
Source: http://www.cpc.ncep.noaa.gov/research_papers/ncep_cpc_atlas/8/figures/z500/DJF.z500.ao.gif

Significance of MJO on the Northeast United States

L'Hereux and Higgins 2007

- AO favors a negative tendency when MJO is in phases 6 & 7
- MJO in phases 7 & 8 influences the midlatitude temperature and height anomalies in a way that resembles the negative phase of the AO

24-42hours vs. >42 hours



Day -8

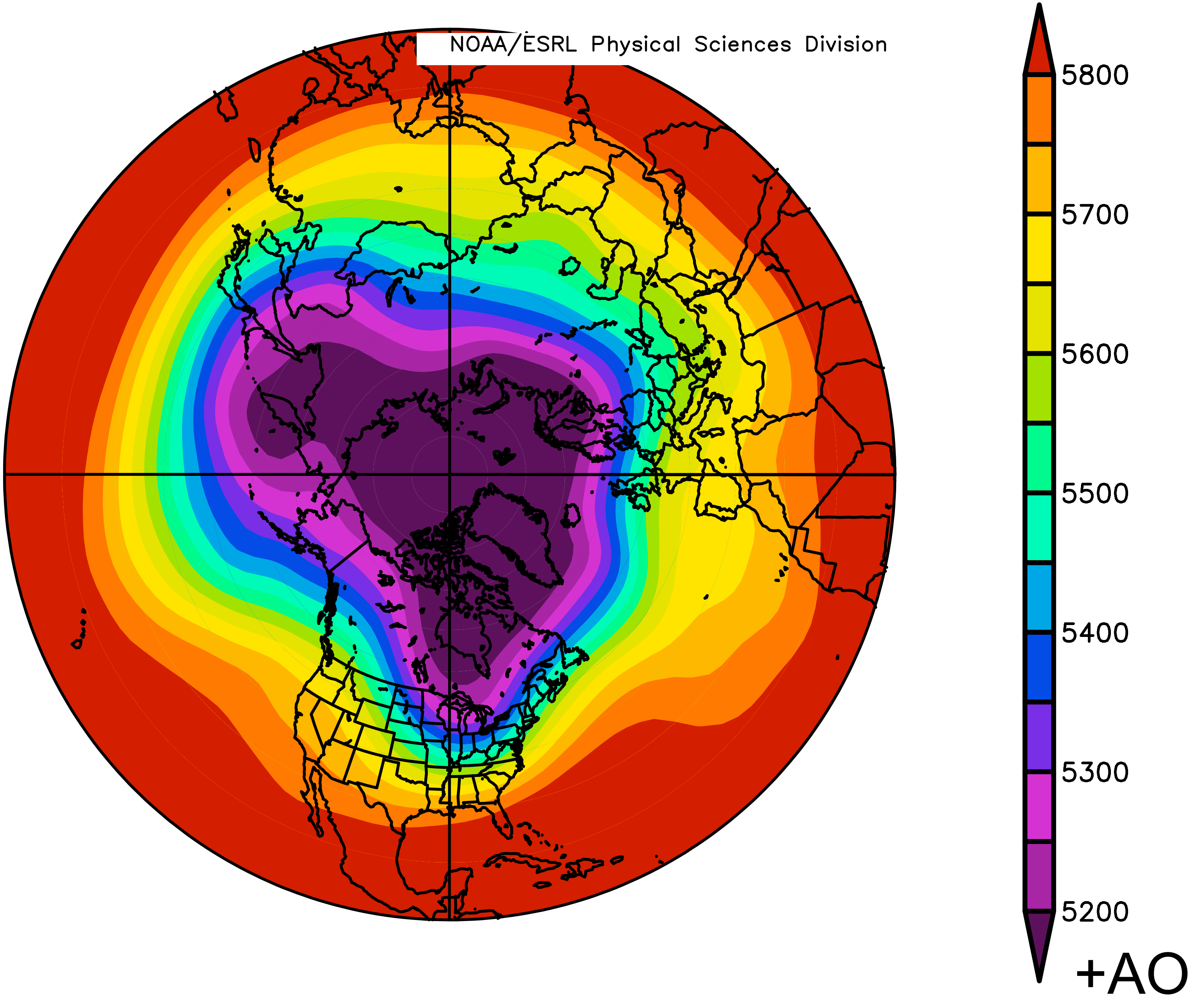
http://www.bom.gov.au/climate/mjo/

MJO Conclusions

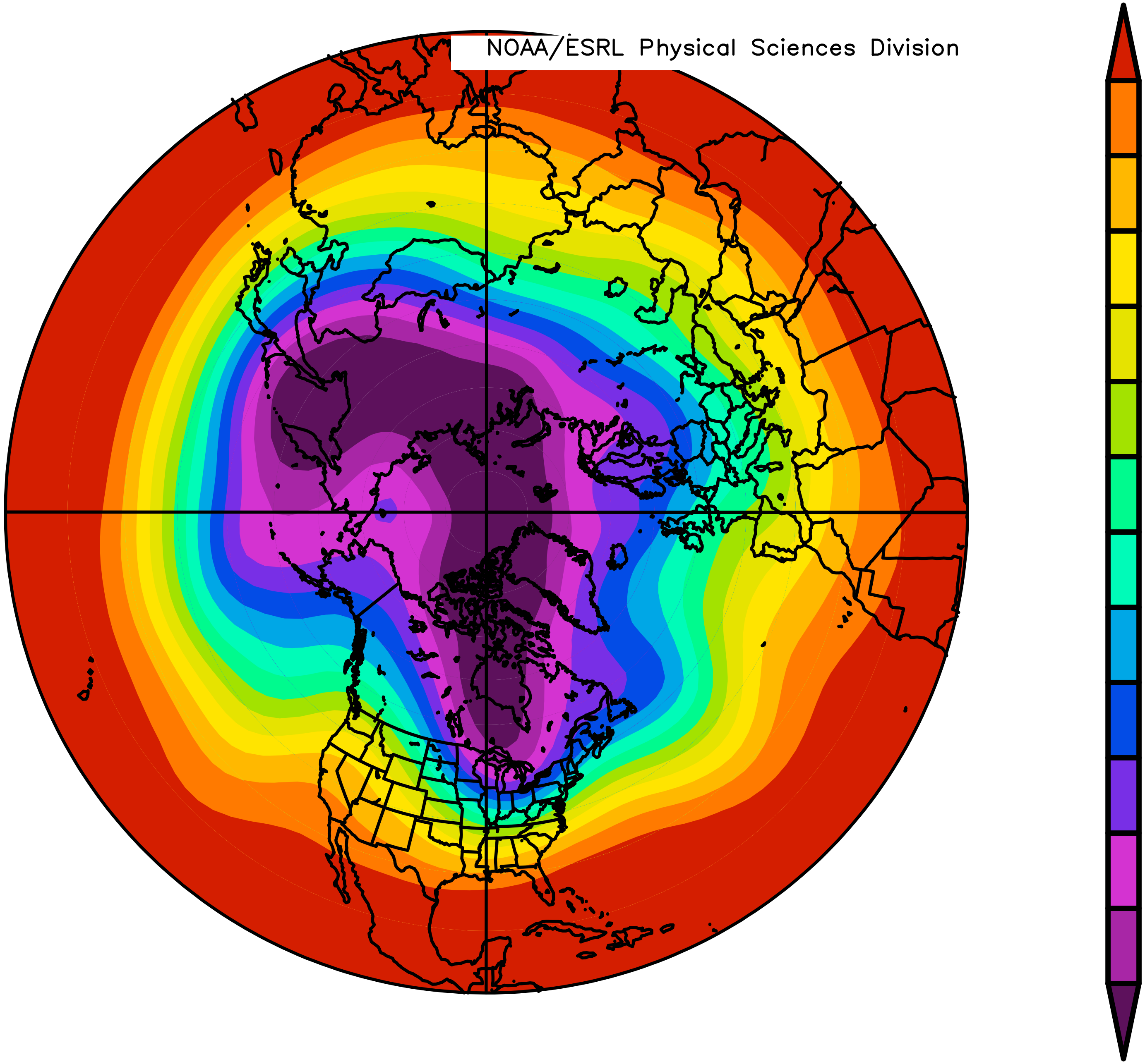
- For cases >42 hours there seems to be an MJO influence in the days prior to onset
- A more subtle MJO signal for 24-42 hour cases
- No obvious similarities in MJO in other categories

Arctic Oscillation

- 15 cases occurred when the AO was POSITIVE on day 0.
- 16 cases occurred when the AO was NEGATIVE on day 0.



500 hPa geopotential height (m)

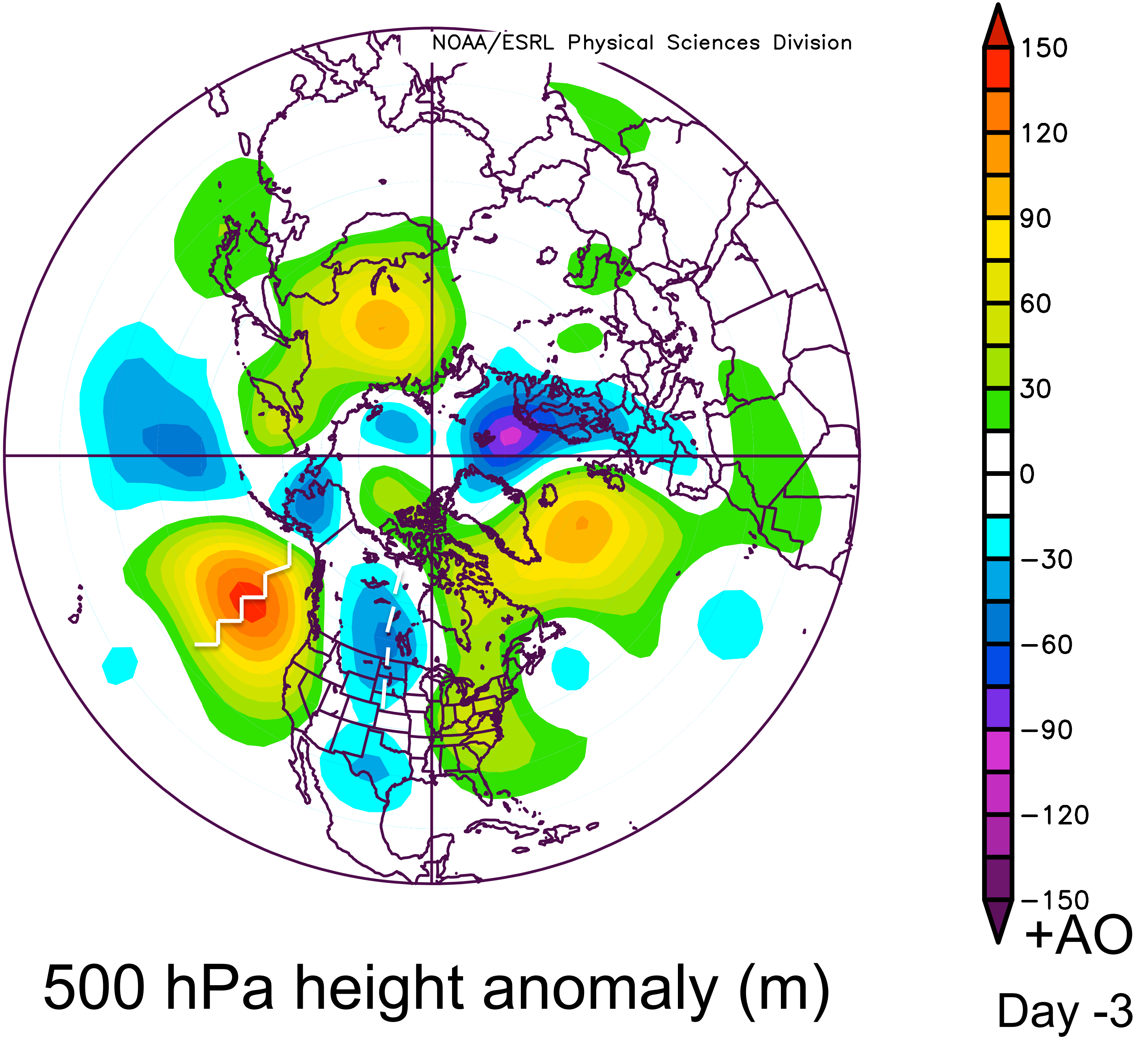


-AO

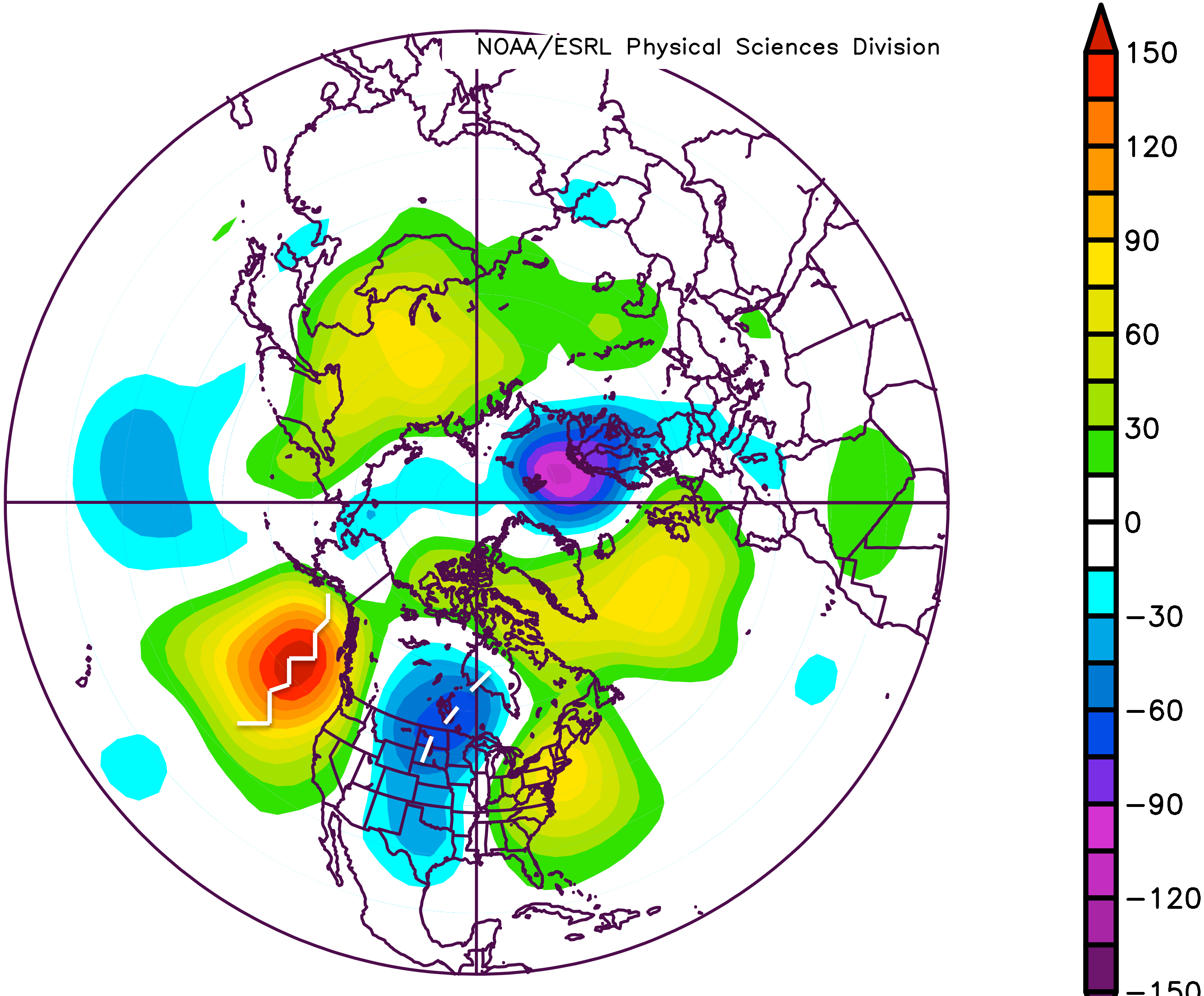
500 hPa geopotential height (m)

Day 0

+AO



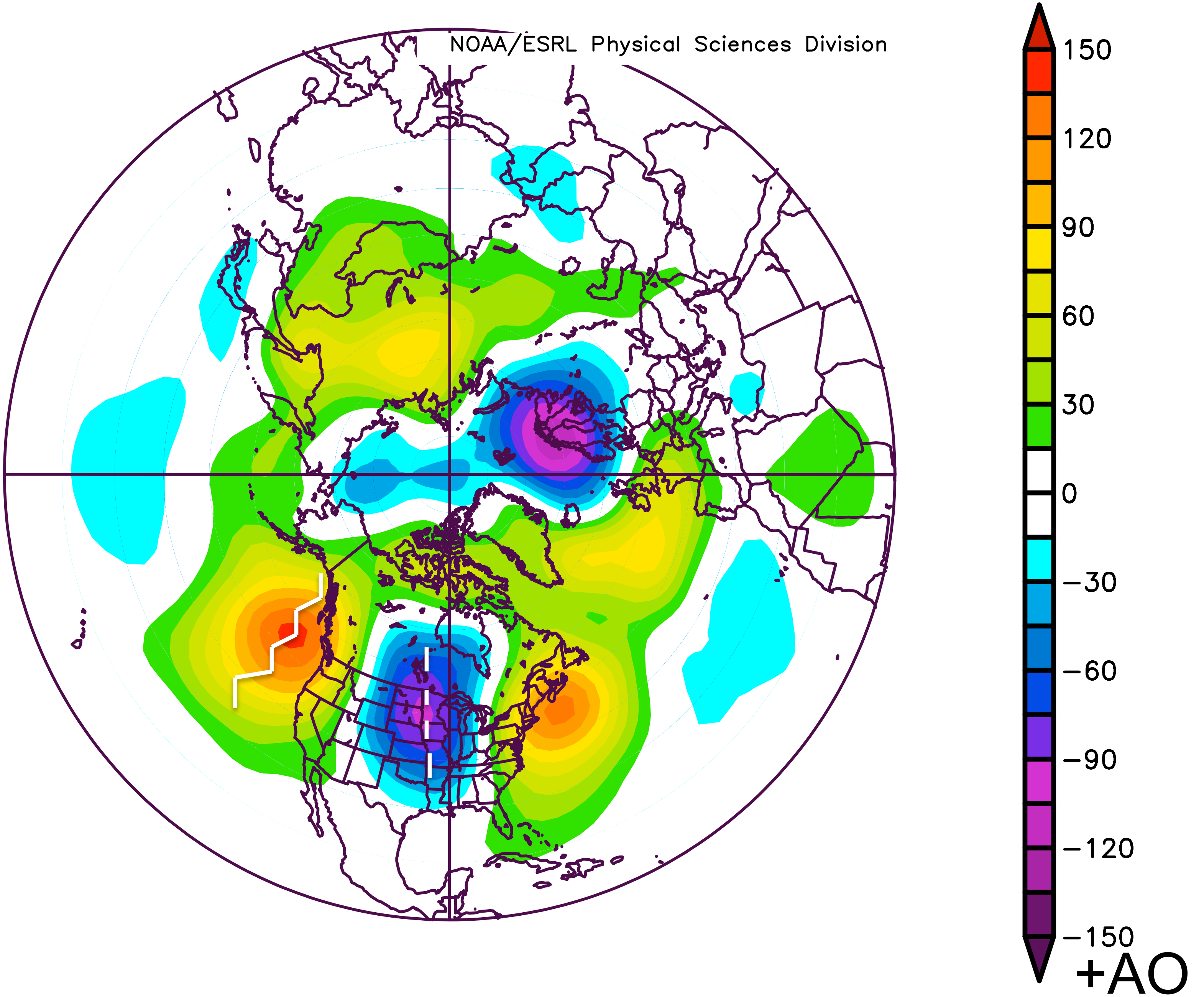
500 hPa height anomaly (m)



+AO

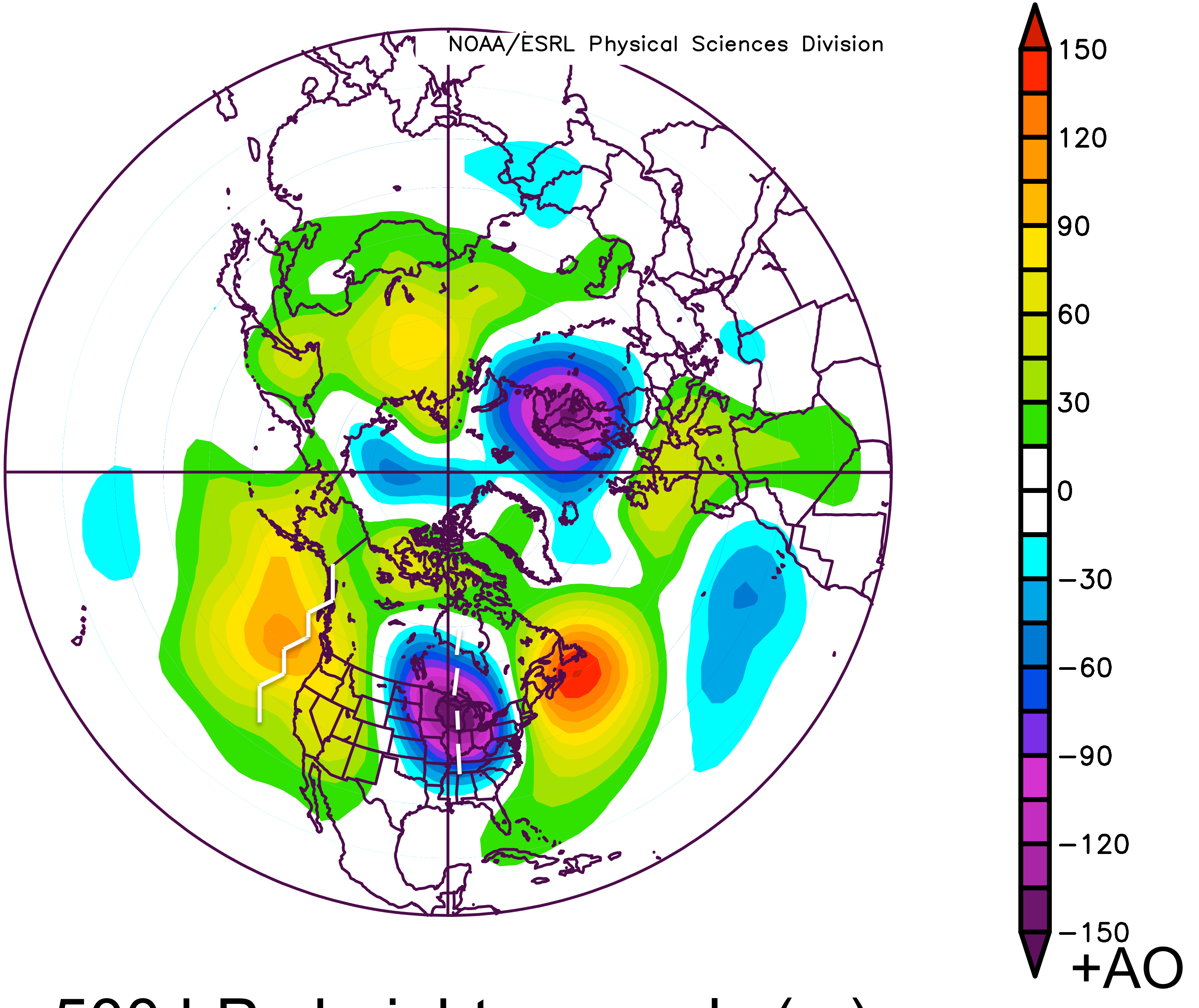
500 hPa height anomaly (m)

Day -2



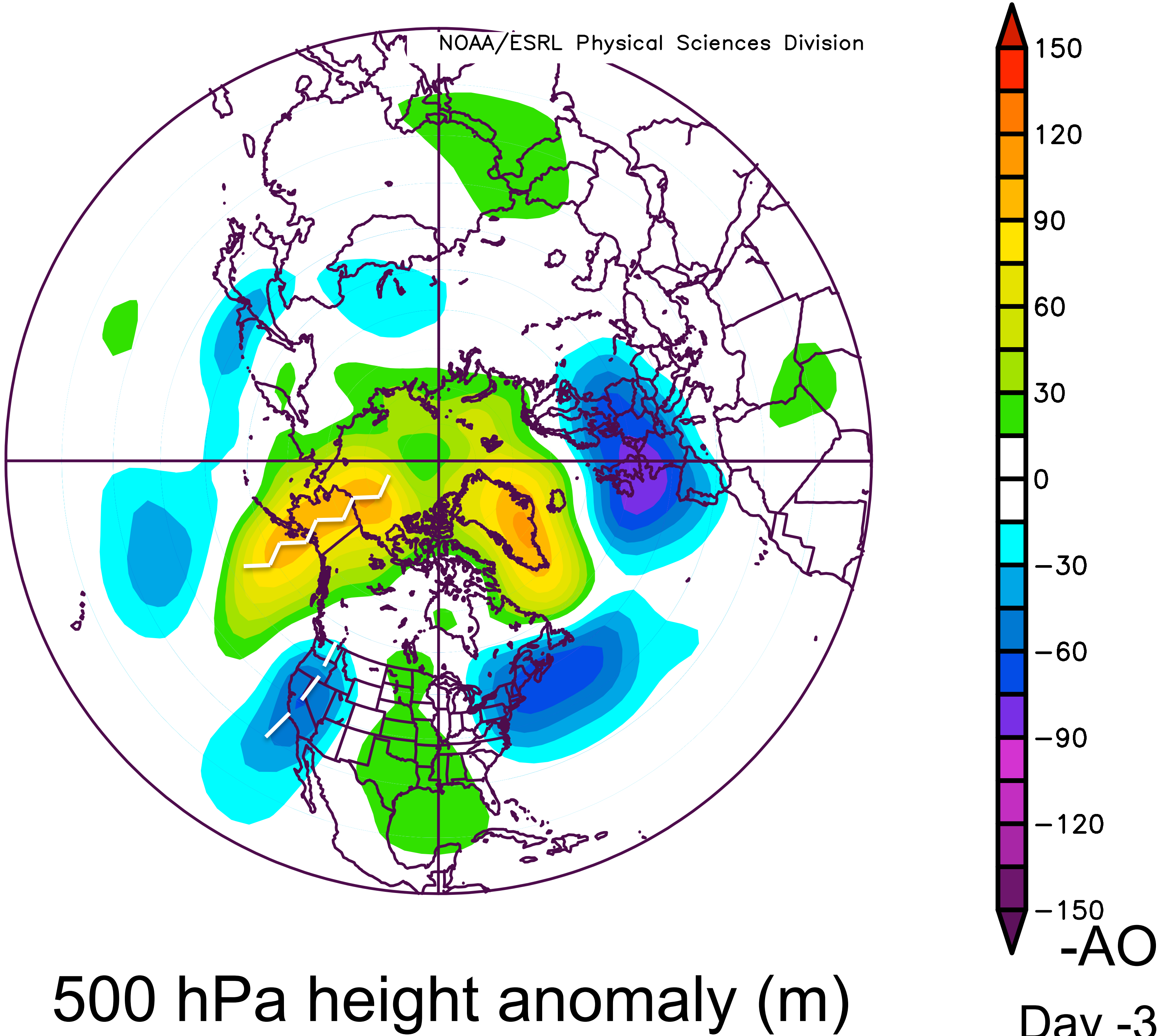
500 hPa height anomaly (m)

Day -1

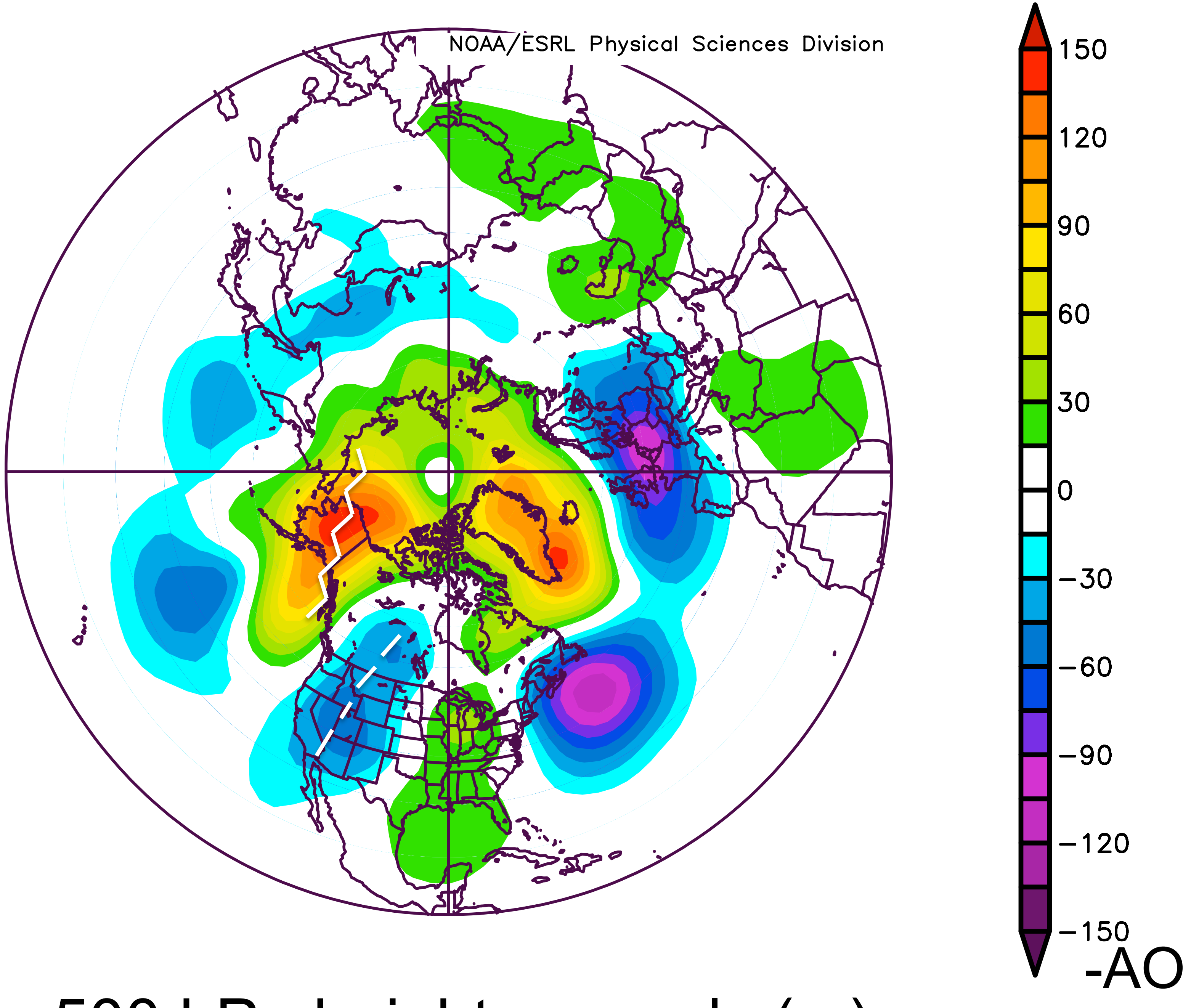


500 hPa height anomaly (m)

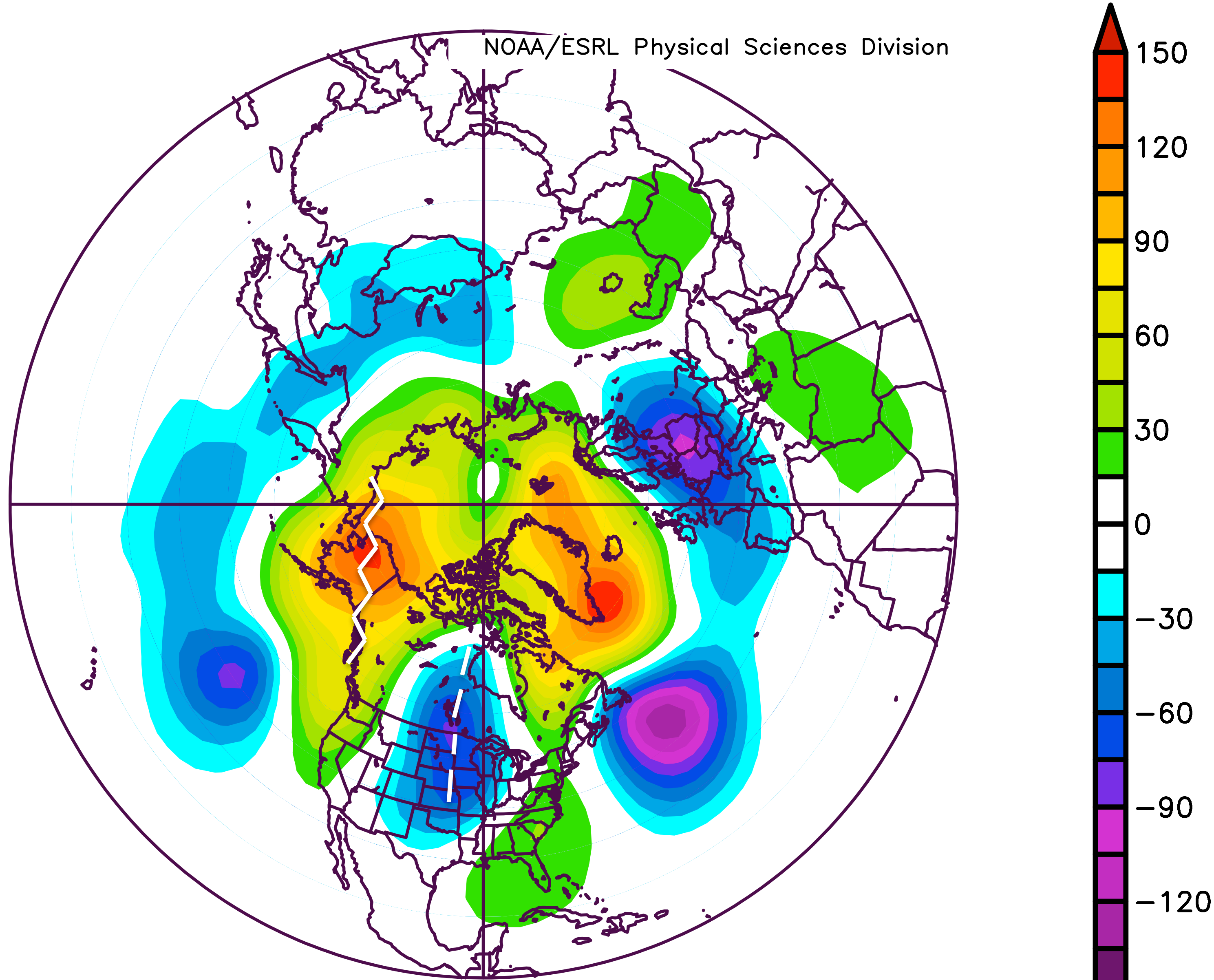
-AO



500 hPa height anomaly (m)

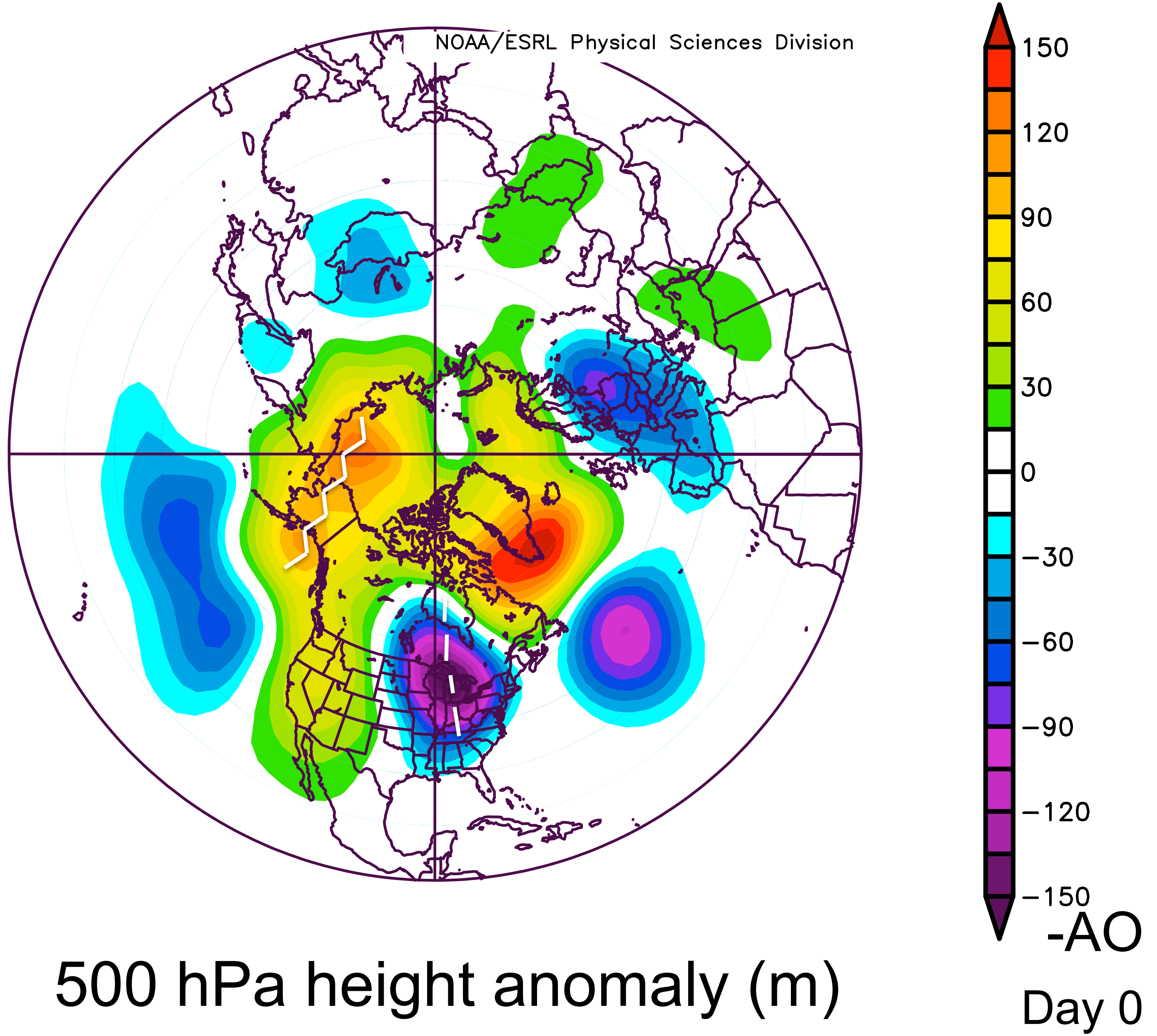


500 hPa height anomaly (m)



500 hPa height anomaly (m)

Day -1



500 hPa height anomaly (m)

AO Conclusions

- When comparing the positive and negative AO cases, there seems to be two different storm tracks in the days prior to onset
- +AO cases are dominated by the trough originating over southern Canada
- -AO cases are characterized by the trough originating over the southwest United States

Future Work

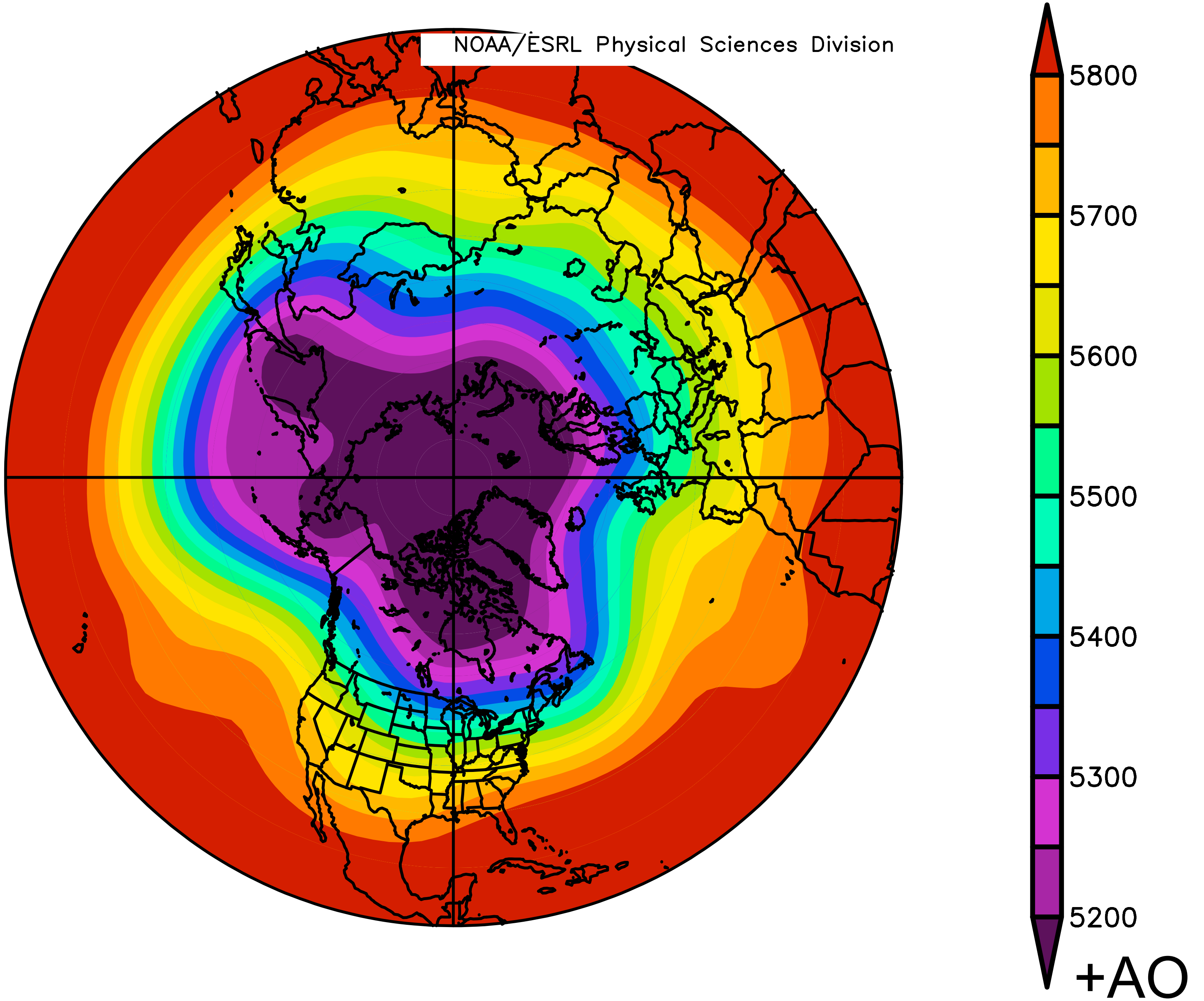
- Look into other teleconnections
- Increase the case list and perform significant statistical testing

Acknowledgments and References

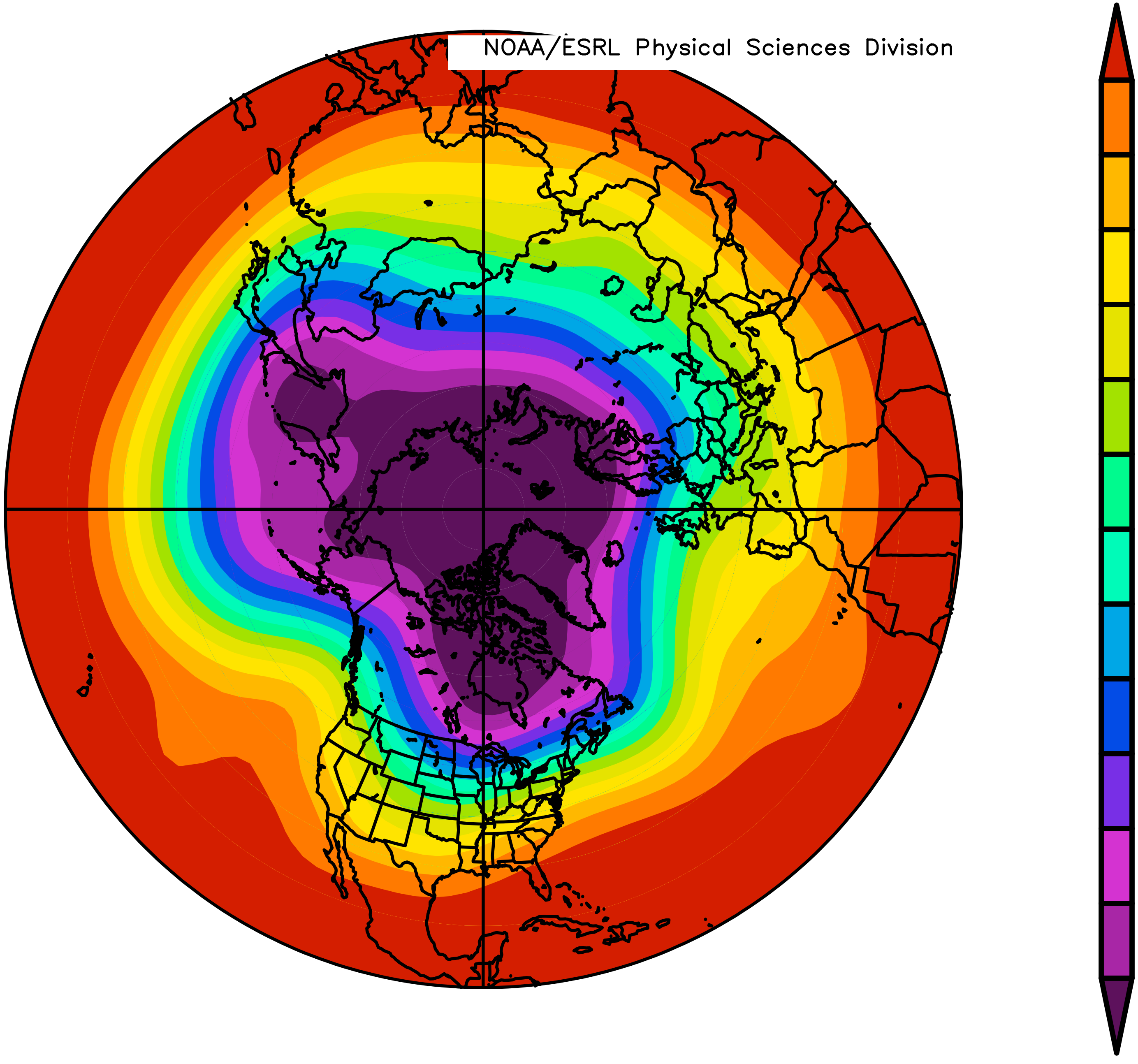
- Thank you:
  - Ross Lazear
  - Jay Cordeira
  - Chris Castellano
  - Dan Panzarella

L'Heureux, M. L. and R. W. Higgins, 2007: Boreal Winter Links between the Madden-Julian Oscillation and the Arctic Oscillation. *J. Climate* **21,** 3040-3050

Extra Slides



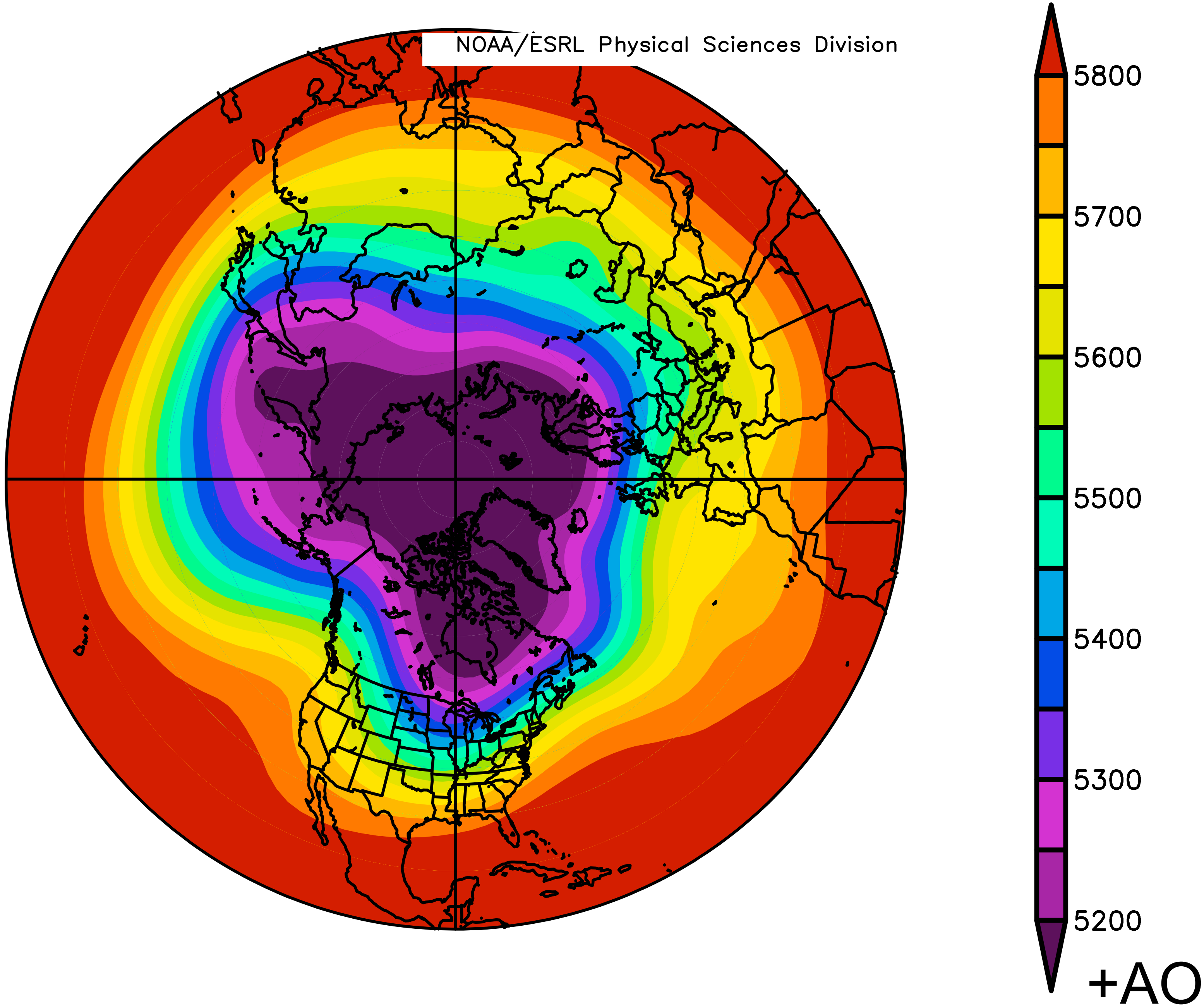
500 hPa geopotential height (m)



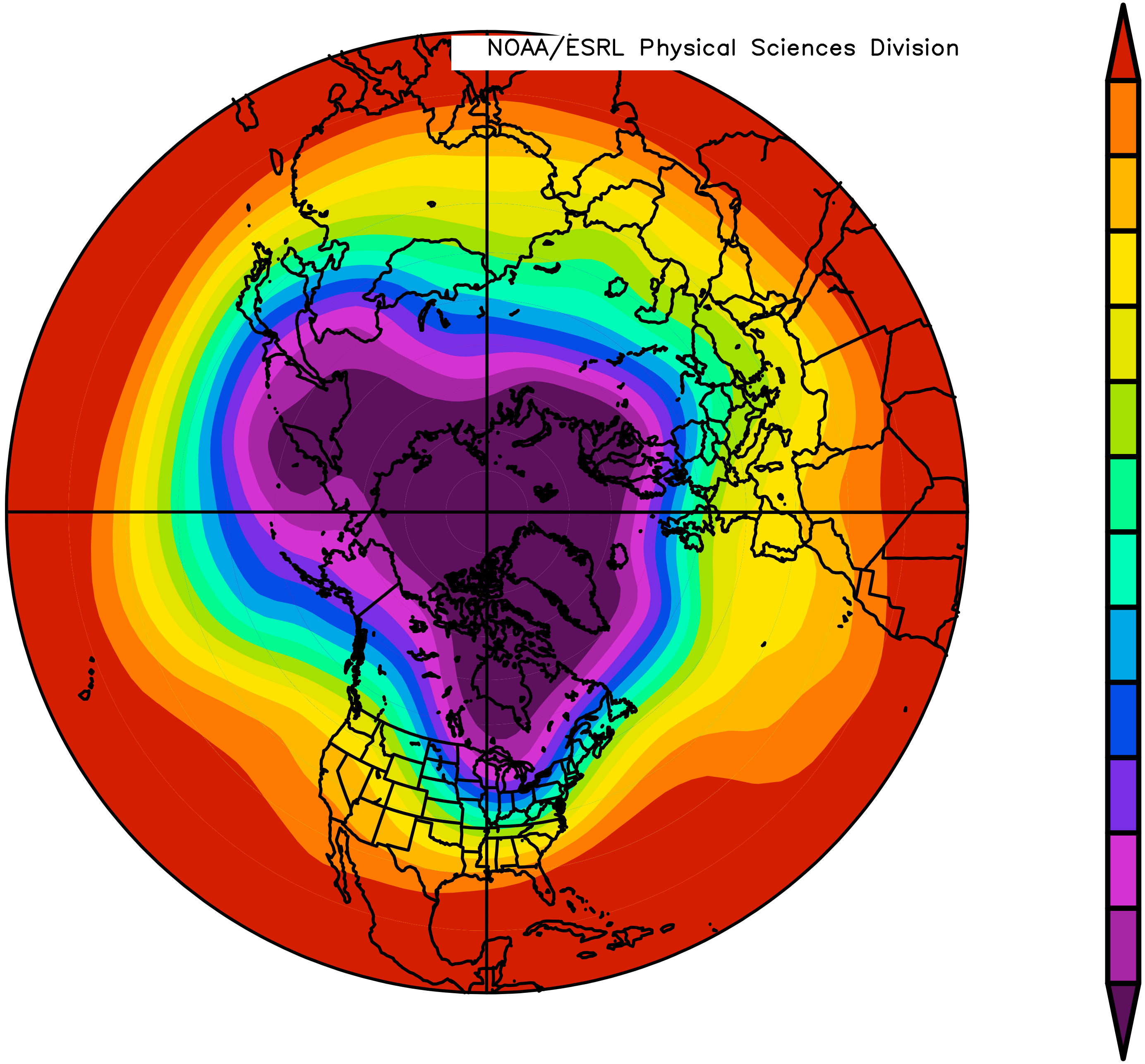
+AO

Day -2

500 hPa geopotential height(m)



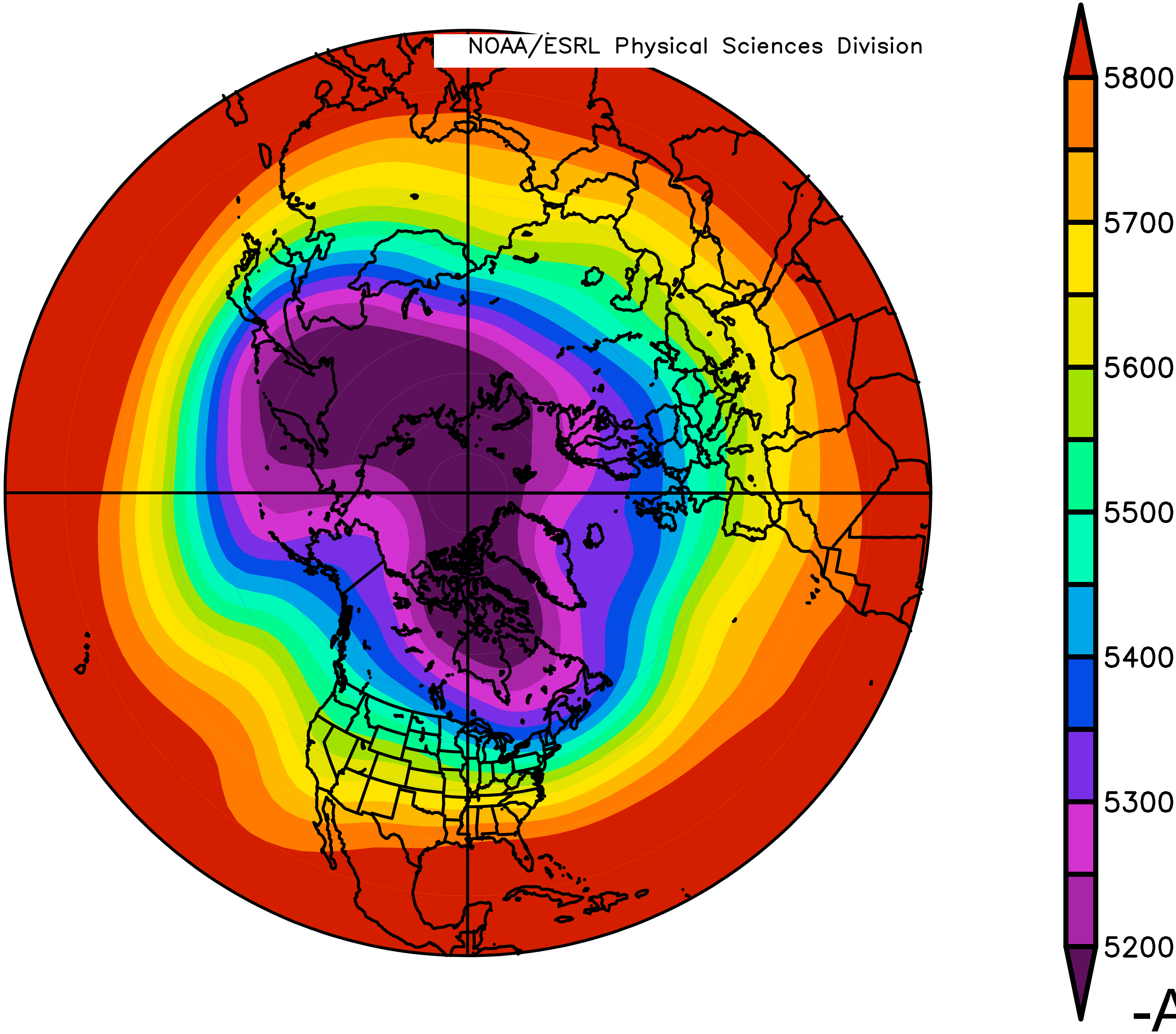
500 hPa geopotential height (m)



+AO

Day 0

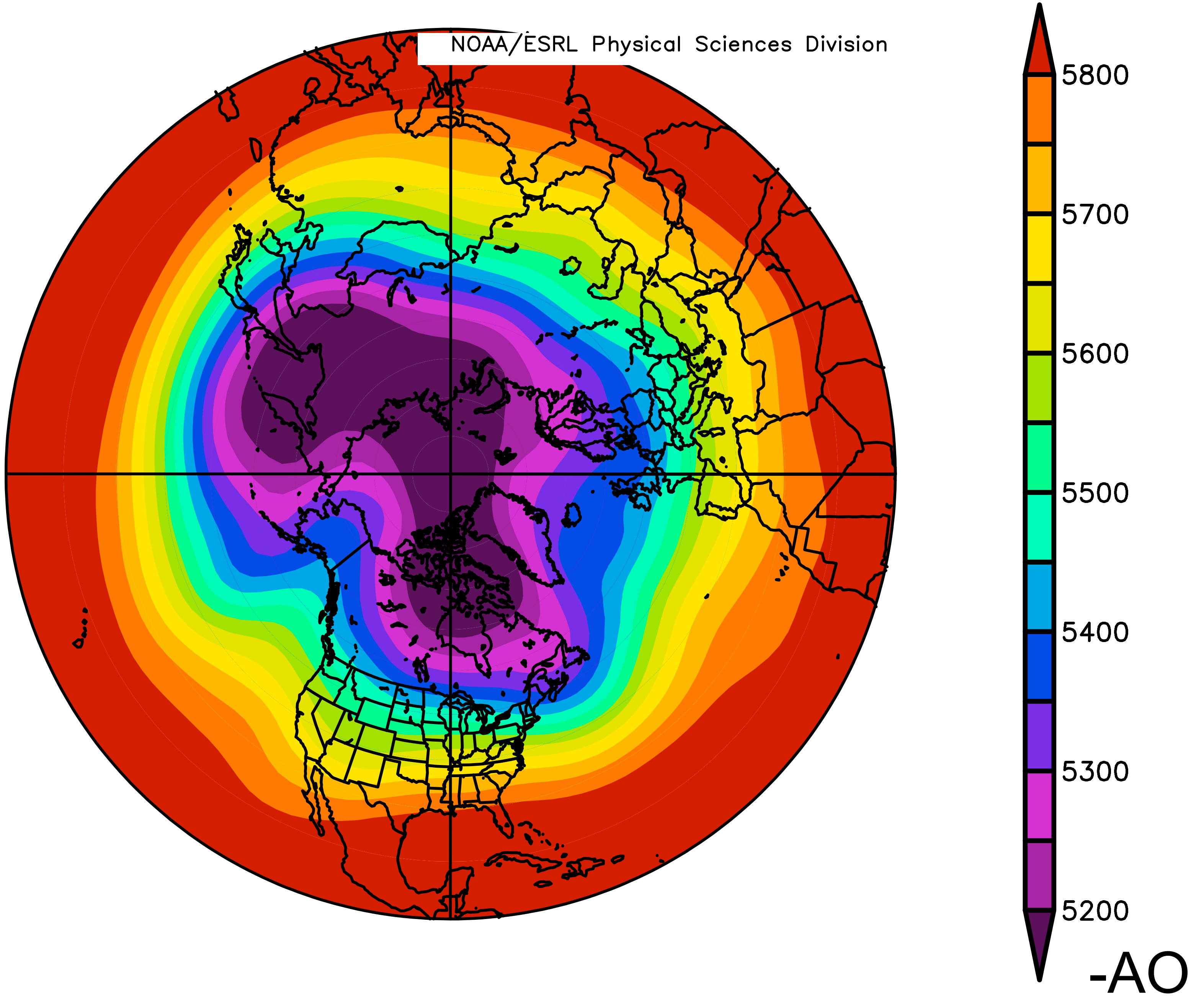
500 hPa geopotential height (m)



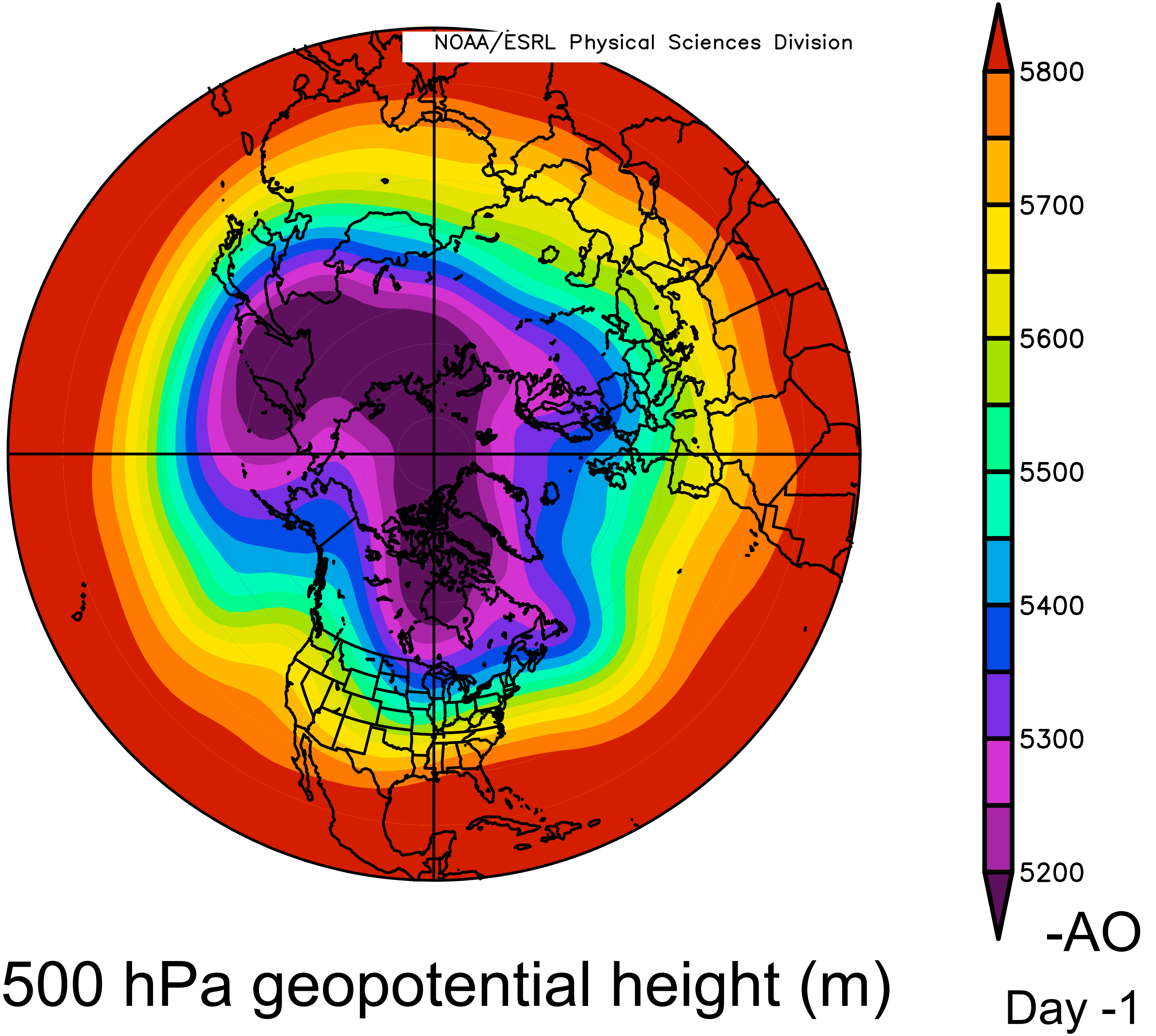
-AO

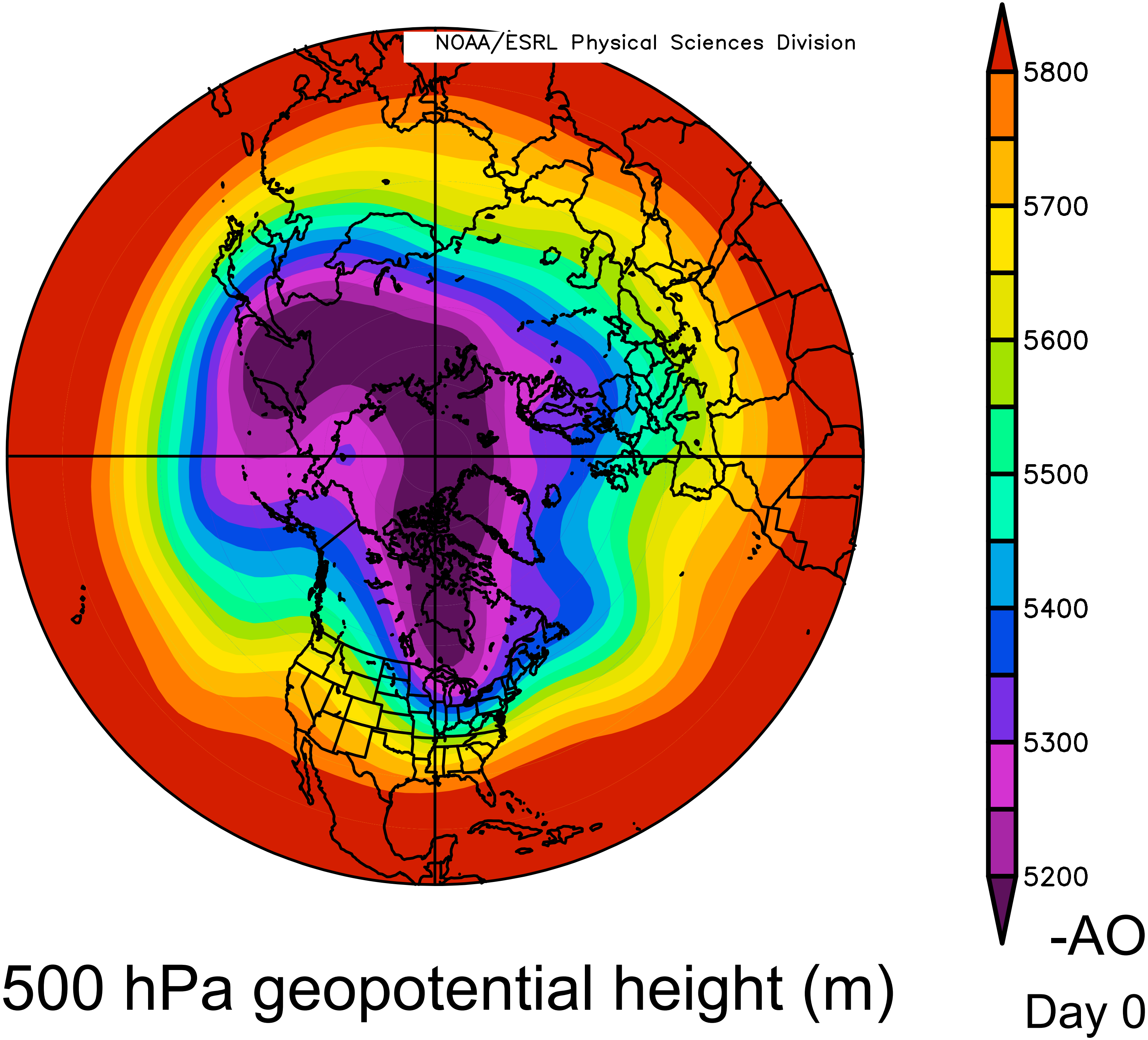
500 hPa geopoential height (m)

Day -3



500 hPa geopotential height (m)


NOAA/ESRL Physical Sciences Division
5800
5700
5600
5500
5400
5300
5200
-AO
Day -1
500 hPa geopotential height (m)



500 hPa geopotential height (m)