13th Annual Winter Weather Experiment
Buffalo Blizzard of 2022

Reuters

Mike Ginnick WFO Elko

NYSDOT

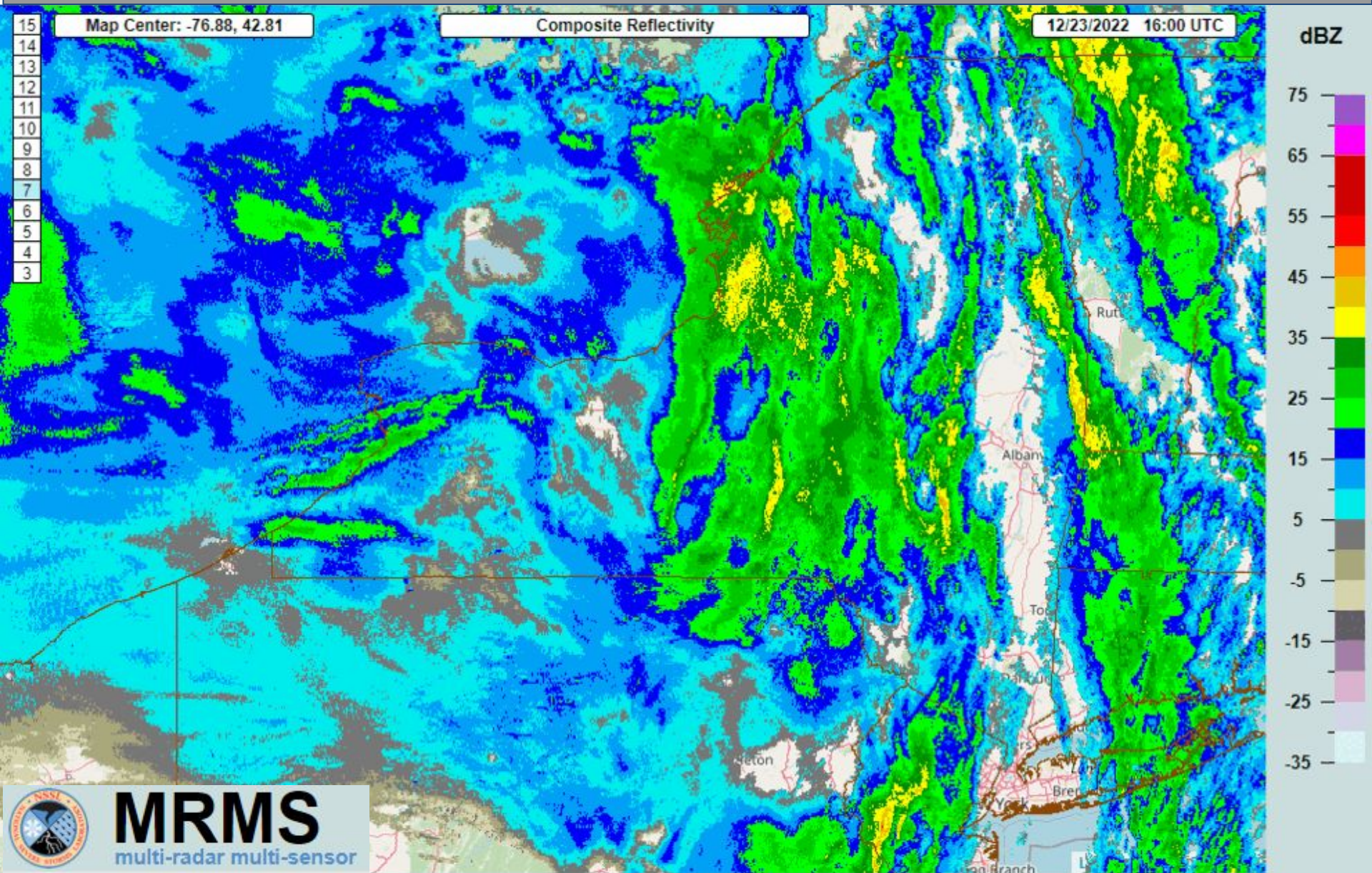
Case Overview

- Synoptic overview and mesoanalysis
- Observations- What happened in the event and what were the forecast challenges?
- Day 3 Evaluation -
  - 24-hr Snowfall model analysis (GFS model output & NBM Deterministic output)
  - NBM 24-hr exceedance probabilities
  - NBM 6-hr snowfall
  - Day 3 Discussion
- Day 2 Evaluation -
  - 24-hr Snowfall model analysis (GFS model output & NBM Deterministic output)
  - NBM 24-hr exceedance probabilities
  - NBM 6-hr snowfall
  - Day 2 Discussion
- Day 1 Evaluation -
  - 24-hr Snowfall model analysis (HRRR, GFS, & NBM Deterministic output)
  - NBM 6-hr snowfall
  - Day 1 Discussion
- Circle Back to Forecater Confidence -
  - Extreme Forecast Index (EFI) & Shift of Tails (SOT)
- Final Thoughts

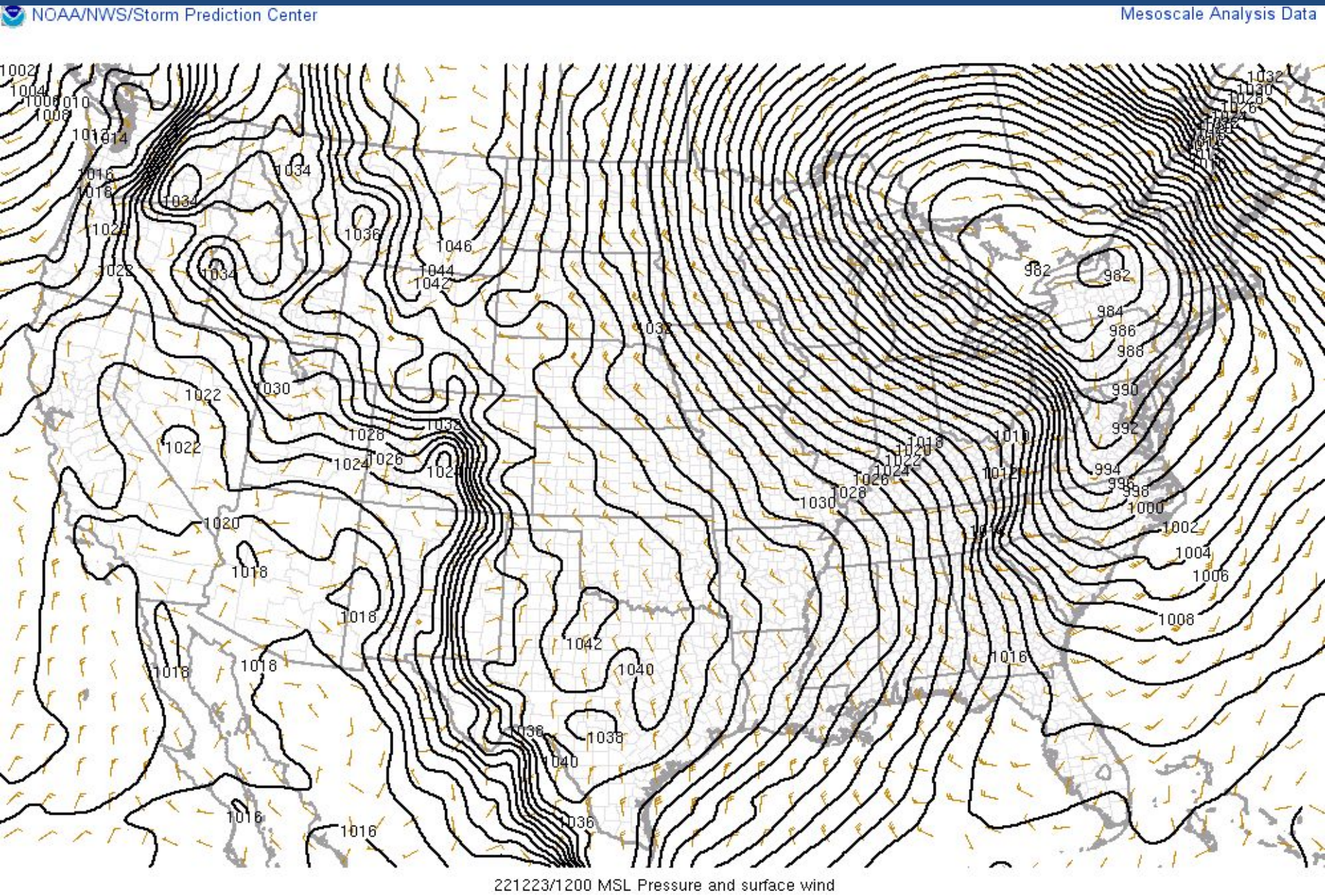
Event Weather Briefing

- Synoptic Overview
  - Radar Loop
  - Surface Pressure Loop
  - 500-mb Heights & Vorticity
  - 850-mb Heights/Winds, Mixing Ratio & Temperature
- Mesoscale Overview
  - Dendritic Growth Zone
  - Boundary Layer RH, SFC to 850 mb Temp Difference
- Observations
  - Lake Ice Cover & Temperature
  - Brief Seiche Slide
  - 24-hr Observations
  - 6-hr Observations
  - Mesoscale Discussions from event.

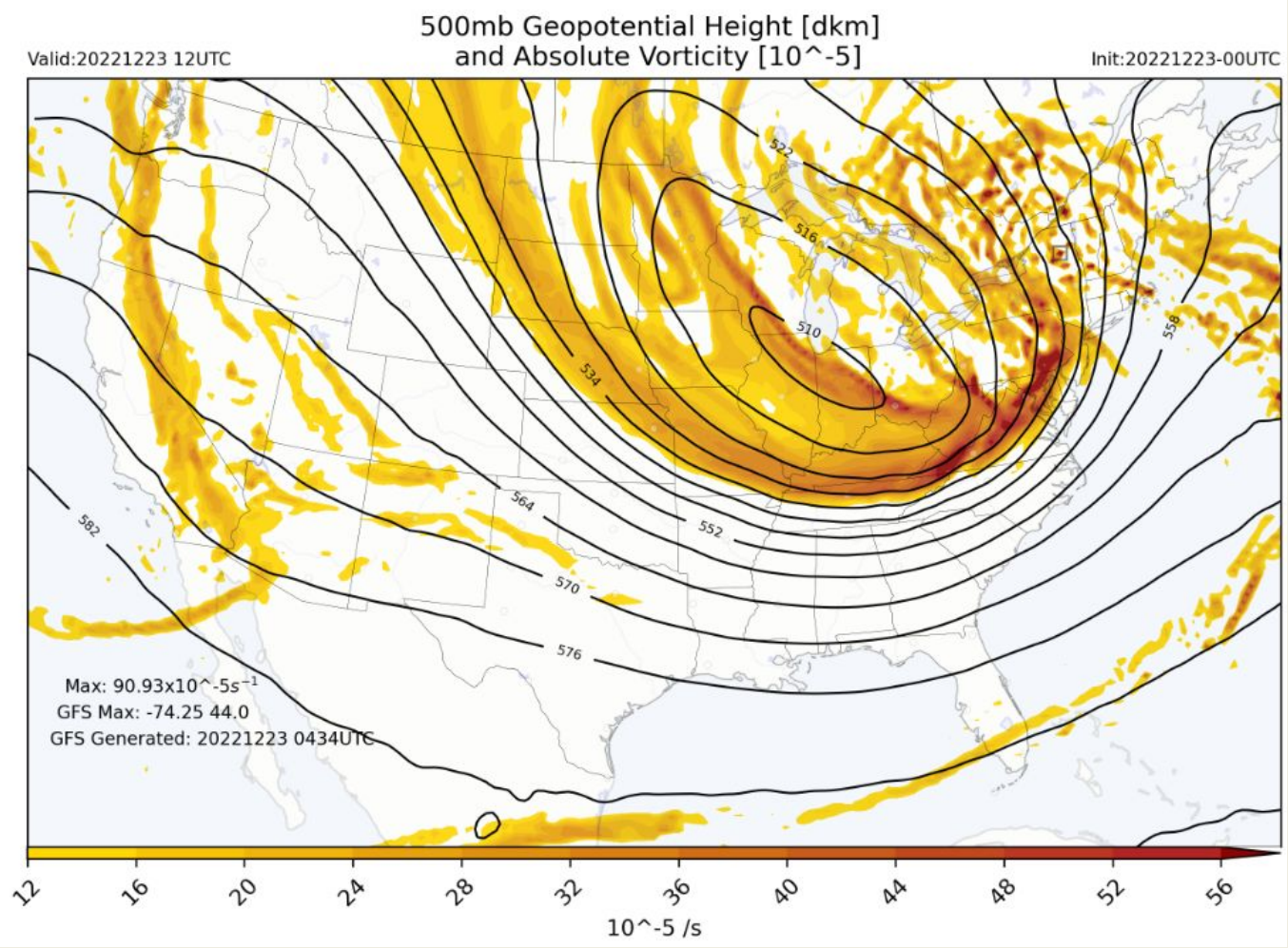
16Z (11AM) DECEMBER 23rd - 12Z (7AM) DECEMBER 24TH



Surface Pressure Loop

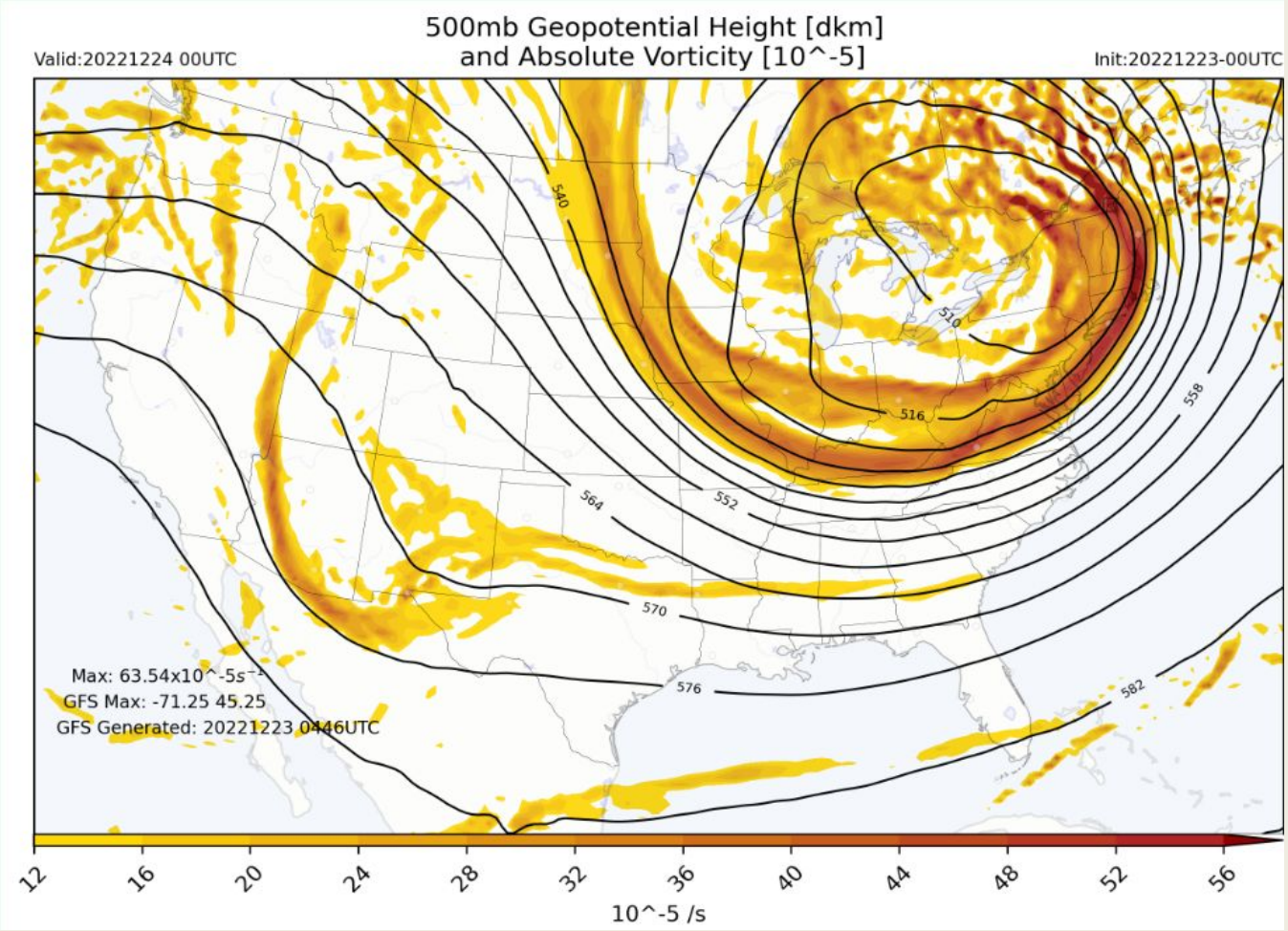


500 mb Heights and Vorticity



Deepening negatively tilted upper level trough with Absolute Vorticity Anomalies working through the Great Lakes.

500 mb Heights and Vorticity



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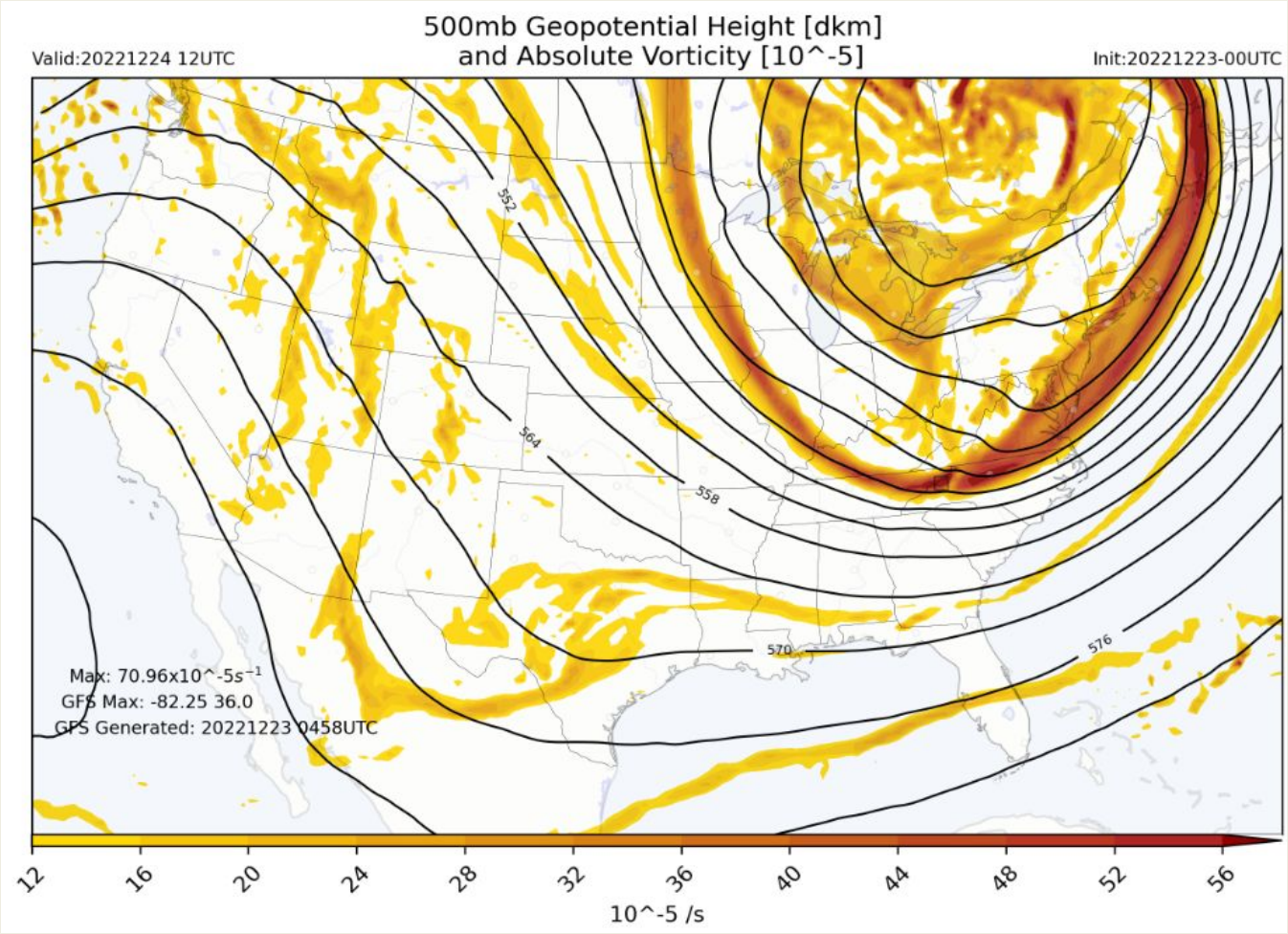
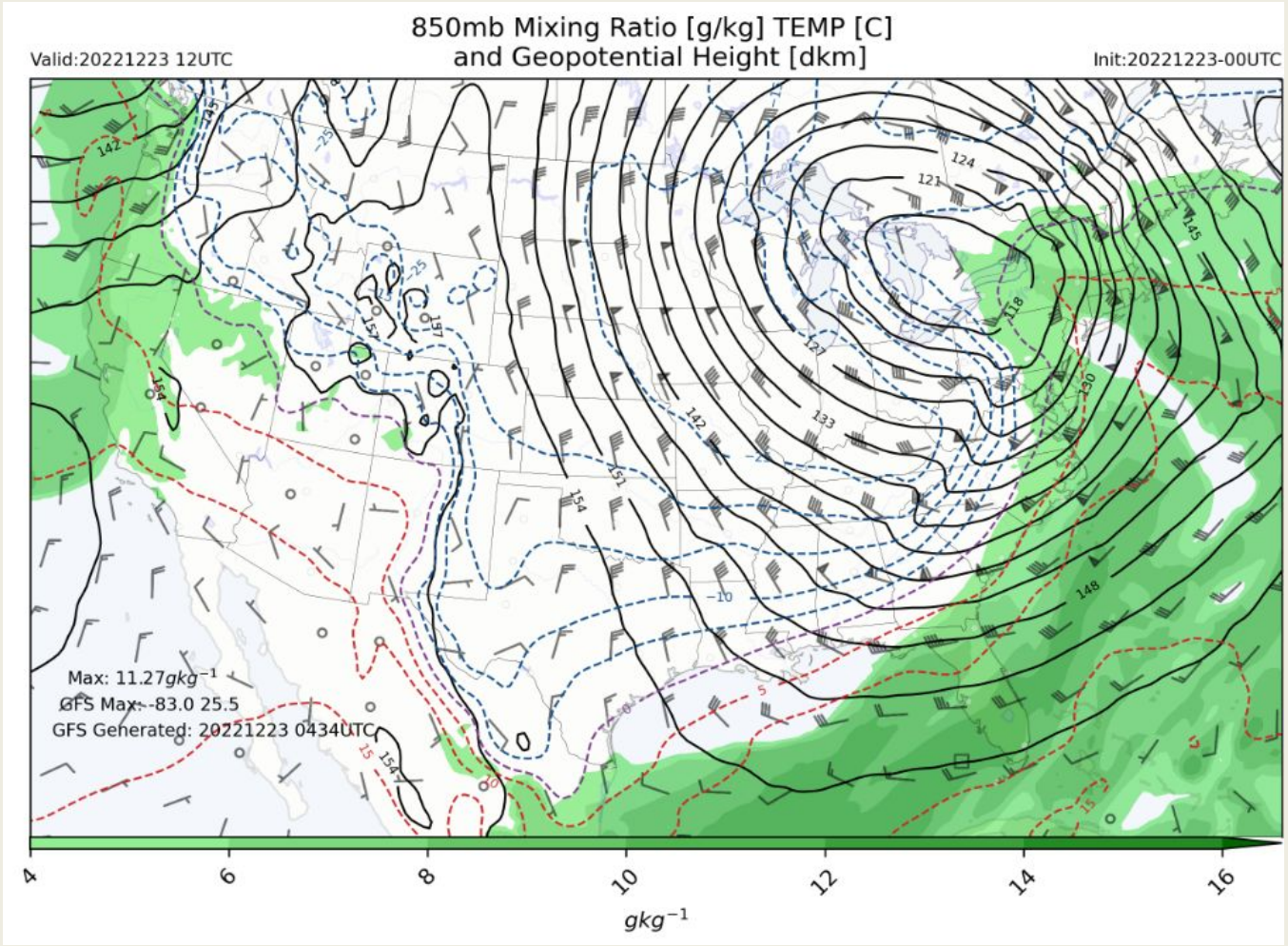
500 mb Heights and Vorticity



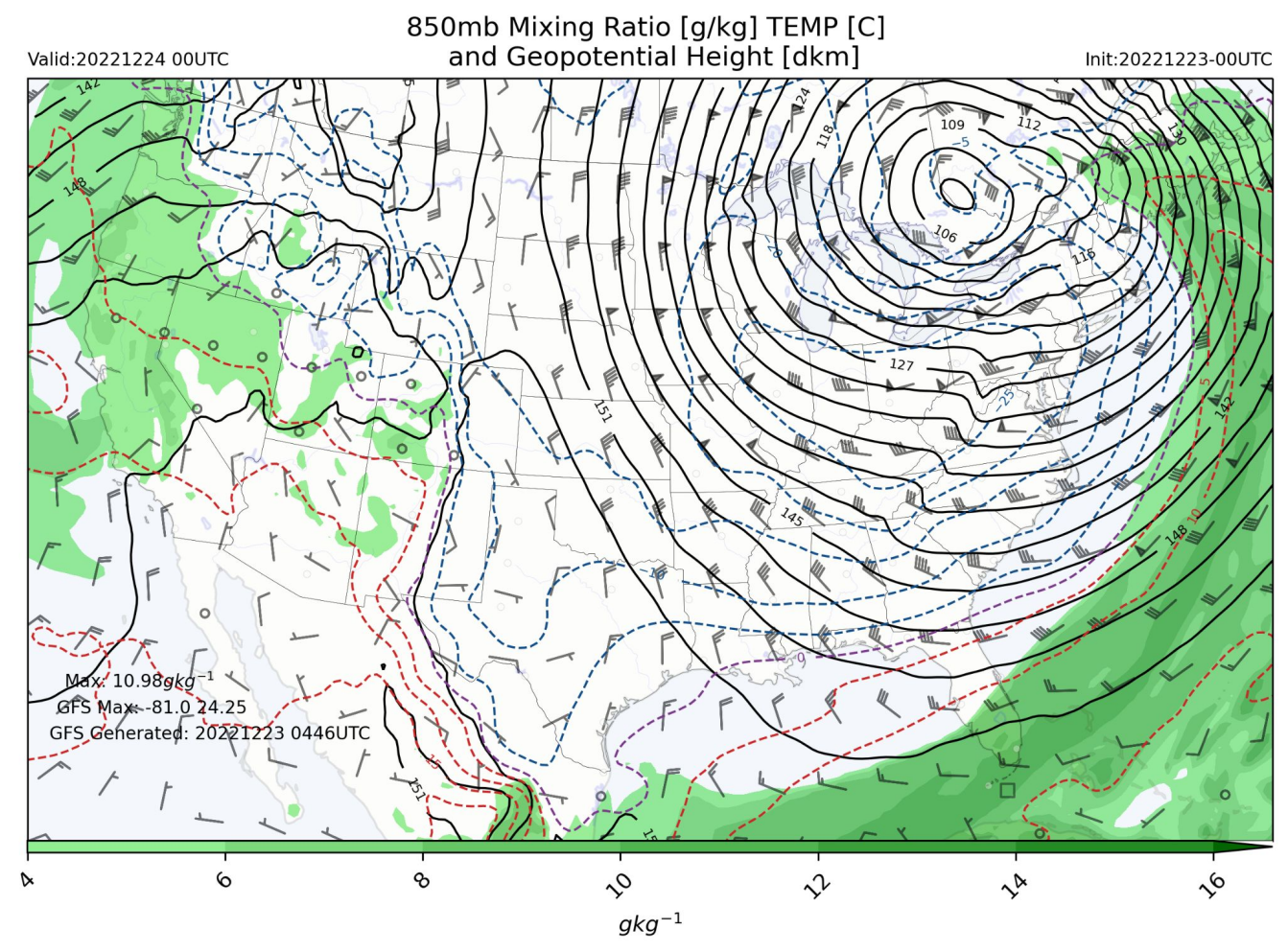
Deepening negatively tilted upper level trough with Absolute Vorticity Anomalies working through the Great Lakes.

850 mb Heights/Winds, Mixing Ratio and Temperature



A front continues to push to the east. 850-mb winds start off southwesterly and primarily staying in that direction.

850 mb Heights/Winds, Mixing Ratio and Temperature



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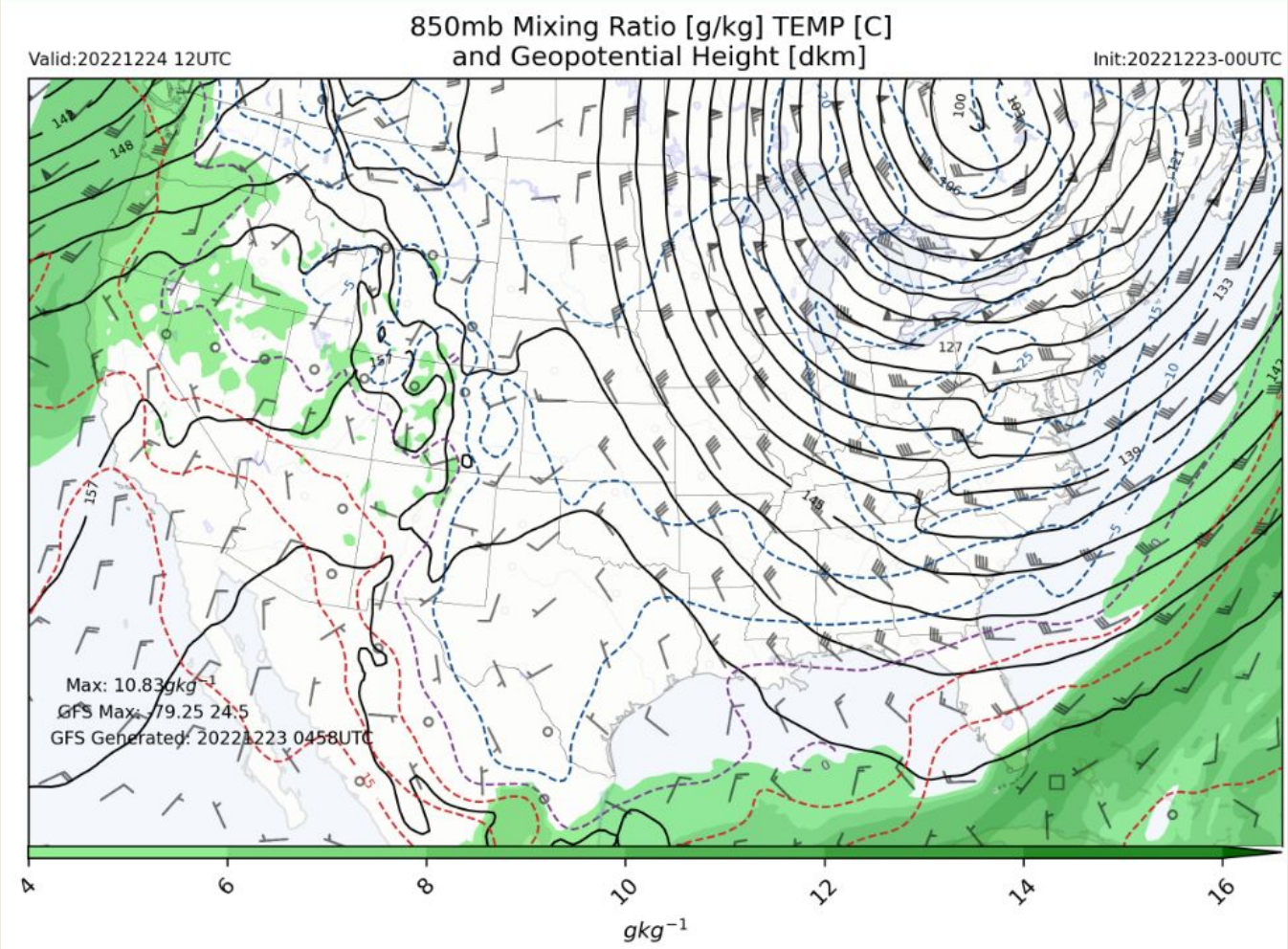
850 mb Heights/Winds, Mixing Ratio and Temperature



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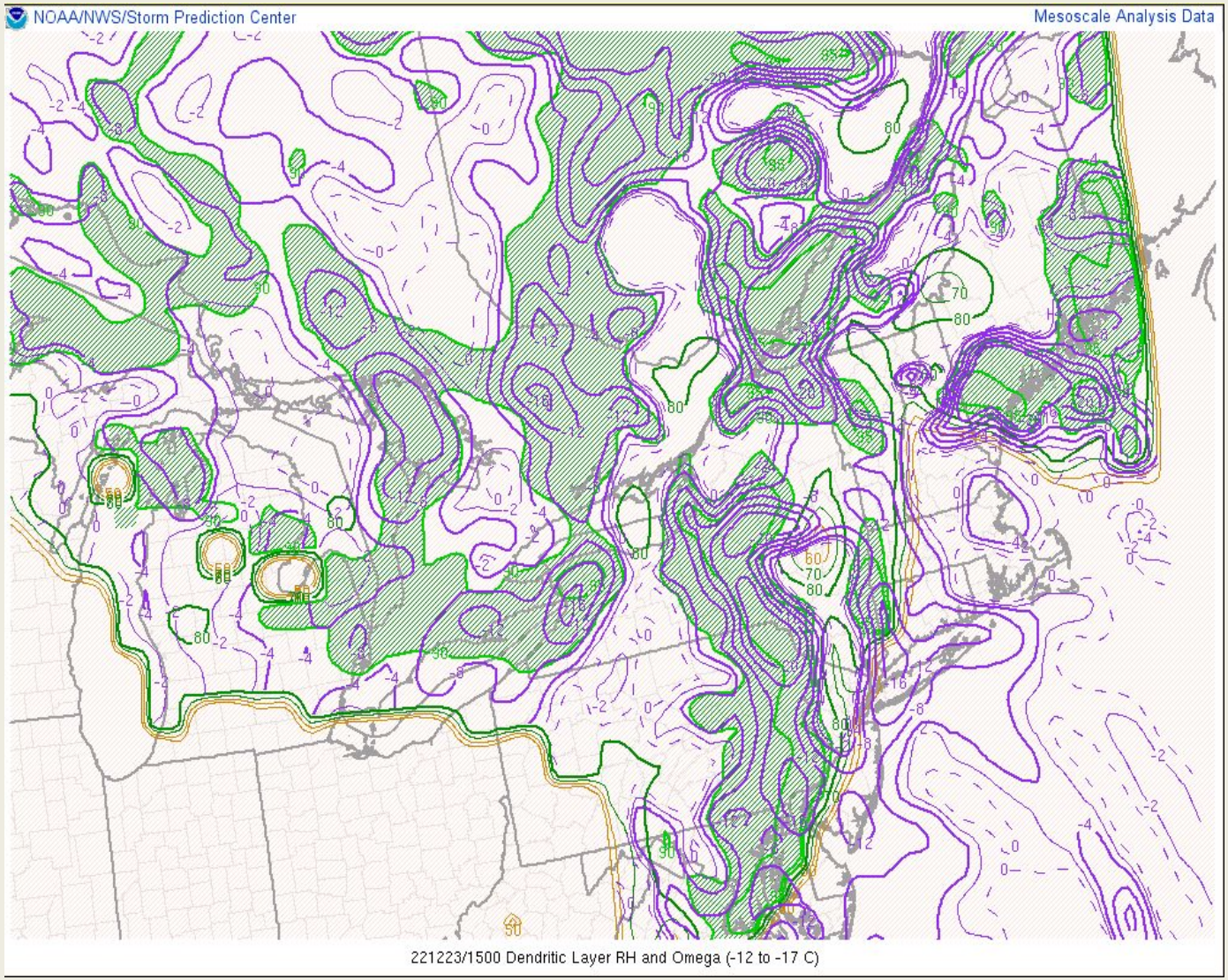
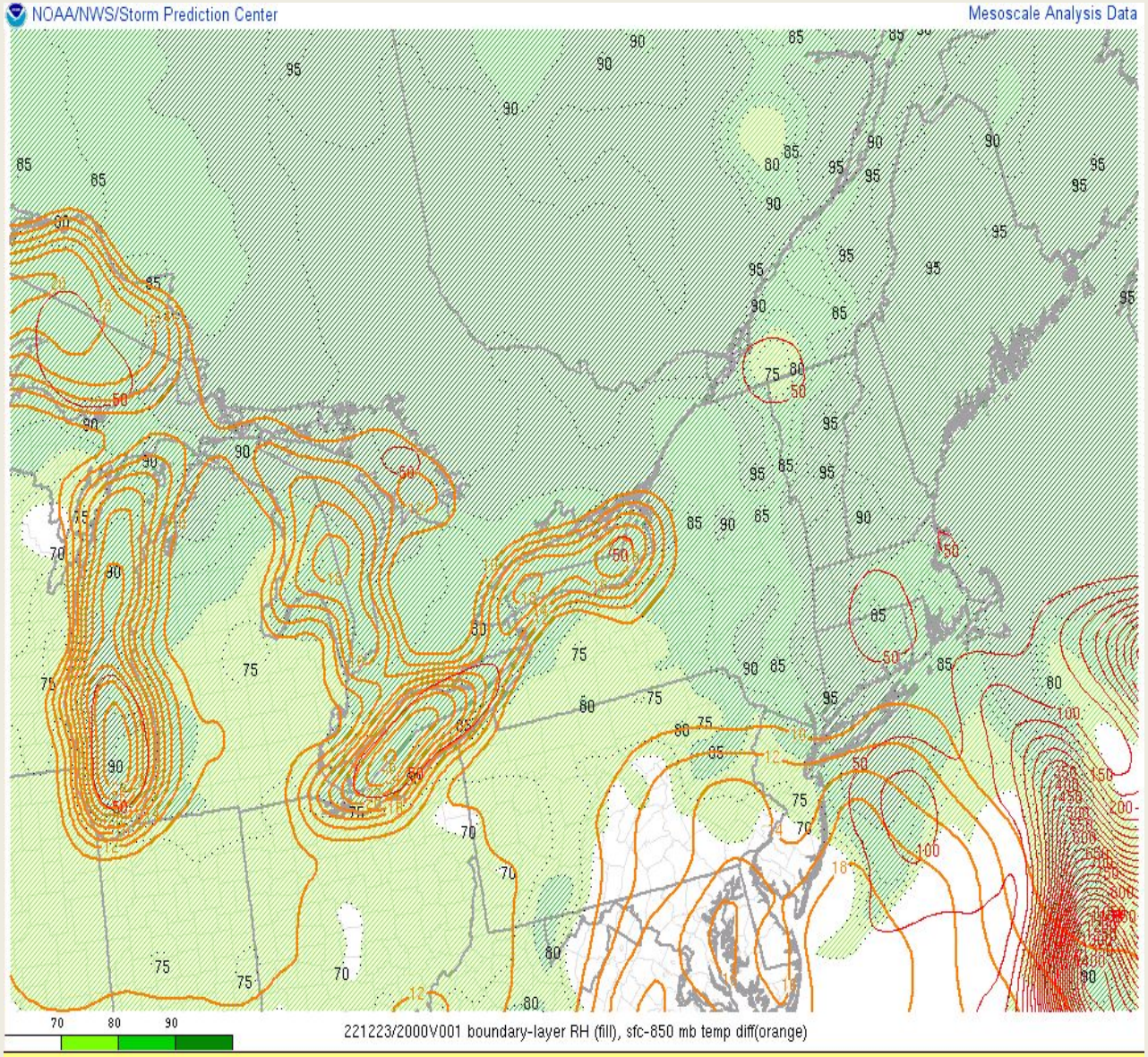
Dendritic Layer RH, & Omega (-12 to -17 C)



Favorable Omega (lift) over Lake Erie, Co-located with favorable RH (moisture).

Boundary Layer RH, Surface to 850 mb Temperature Difference



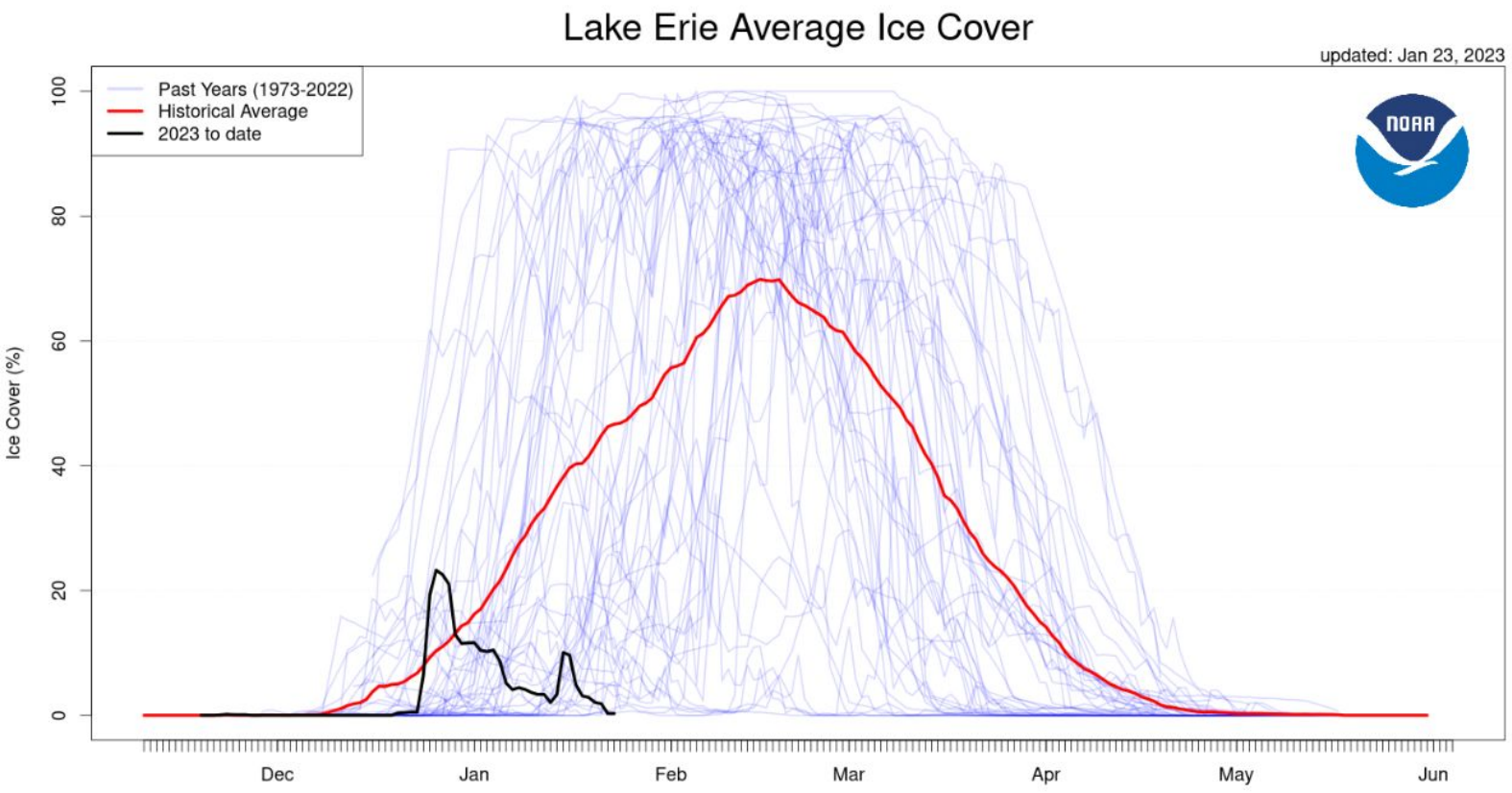
Lake induced CAPE (red) co-located with favorable sfc-850 mb temperature difference (orange).

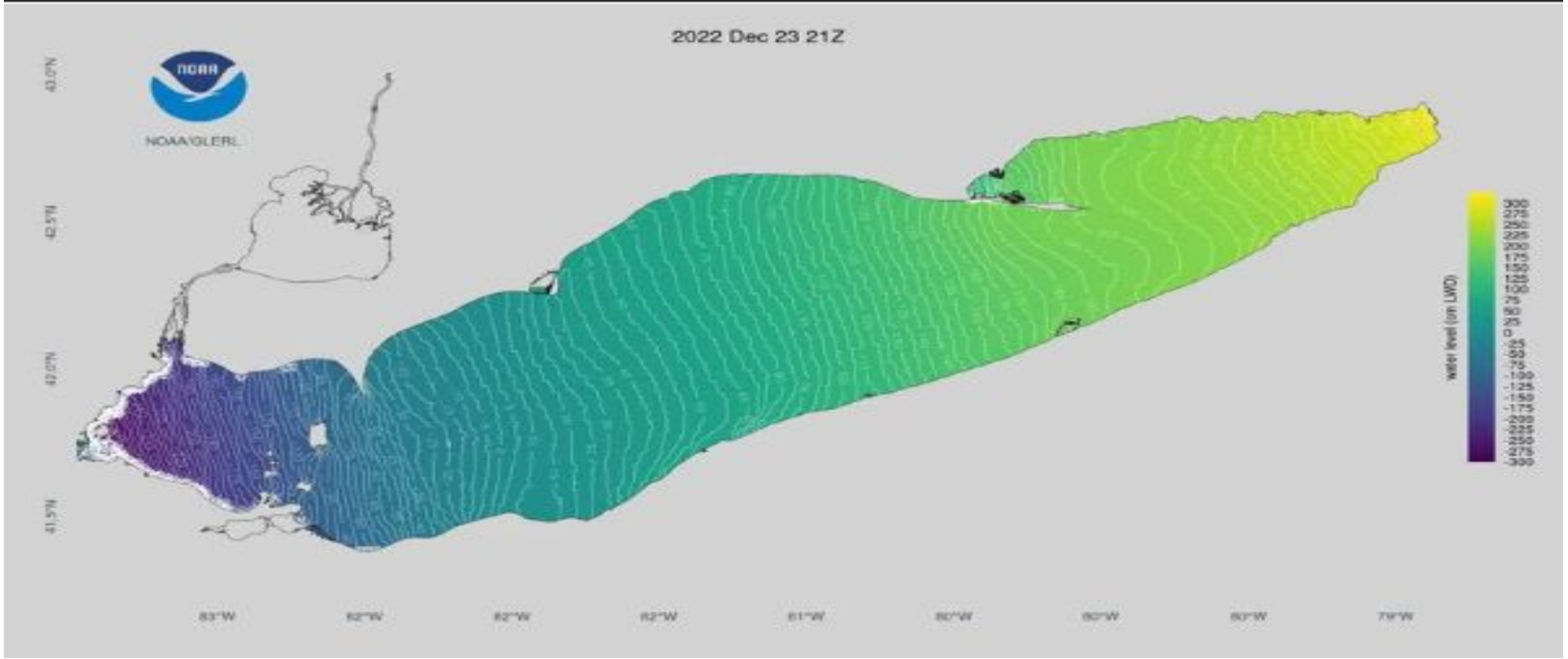
Lake Erie

The Lake Erie water temperature is officially taken at the **Buffalo Water Treatment Plant** located on Lake Erie at the entrance to the Niagara River. The reading is taken at a depth of 30 feet.

This data is unofficial.

December	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2015	46	46	47	46	46	46	45	45	45	45	45	45	45	46	46	46	46	45	44	43	42	42	44	44	45	44	44	43	43	42	42
2016	47	47	44	46	47	45	44	44	42	42	41	41	41	40	38	34	37	37	35	34	34	34	34	34	37	34	37	36	34	34	34
2017	45	45	45	45	45	44	44	43	43	43	42	42	40	39	39	39	38	38	38	37	37	38	38	38	36	34	33	33	33	33	33
2018	43	43	44	42	43	43	42	41	40	40	40	39	39	40	40	40	40	39	39	39	39	39	38	38	37	38	38	38	38	39	39
2019	45	43	43	43	43	42	42	42	43	41	42	41	40	40	40	40	40	39	37	38	38	37	37	38	37	38	38	38	38	38	38
2020	46	46	45	45	44	44	43	43	43	43	43	43	43	43	42	42	42	42	41	41	41	41	41	41	40	39	39	39	39	39	38
2021	43	43	43	42	40	40	40	40	44	44	46	45	43	44	44	44	42	40	41	39	40	41	41	41	41	42	41	40	39	39	39
2022	45	45	43	43	42	42	45	45	45	43	44	44	43	43	43	43	43	42	42	40	40	40	40	33	33	33	33	33	33	35	34



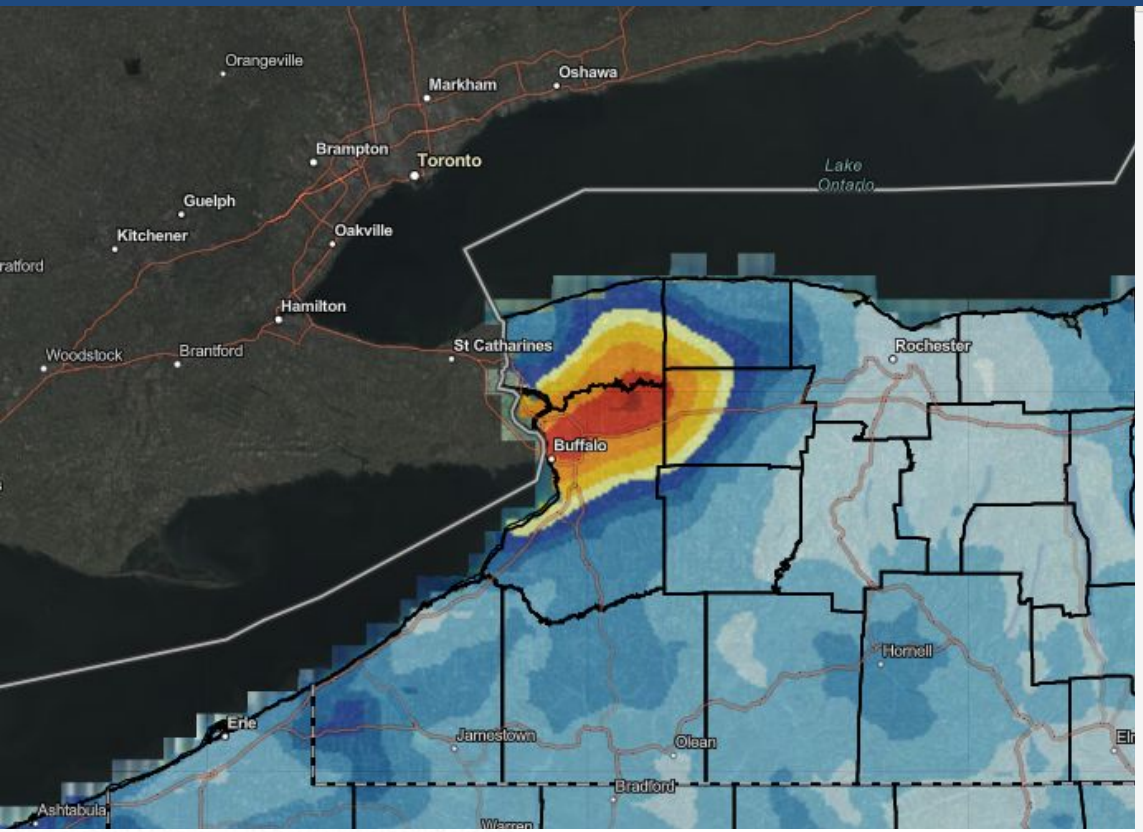


Tom Niziol
@TomNiziol · **Follow**

Crazy scenes. At the west end of Lake Erie the docks are standing out of the water while at the east end waves are crashing ashore. #winter #storm

9:45 AM · Dec 23, 2022

Observed 24-HR Snowfall (NOHRSC) & PNS From WFO BUF

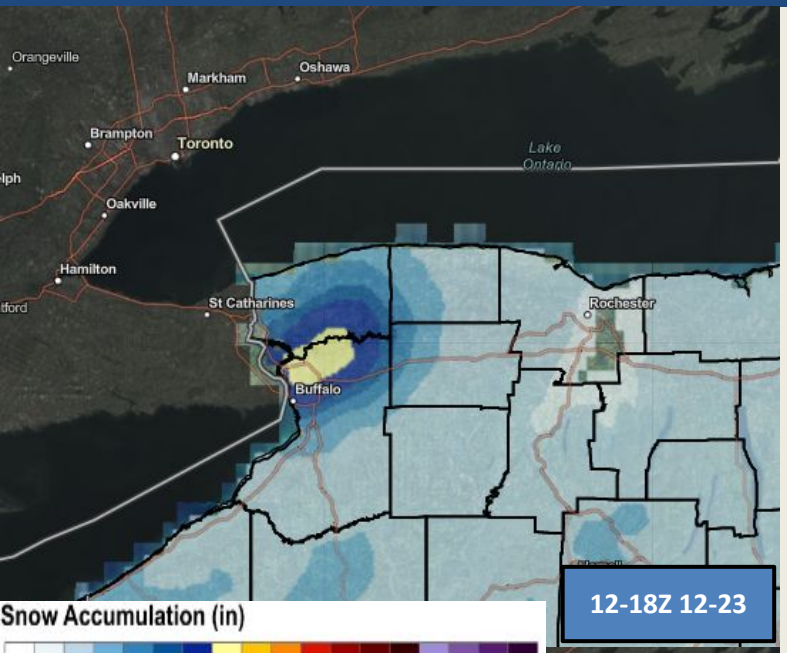


Public Information Statement
National Weather Service Buffalo NY
806 AM EST Sat Dec 24 2022

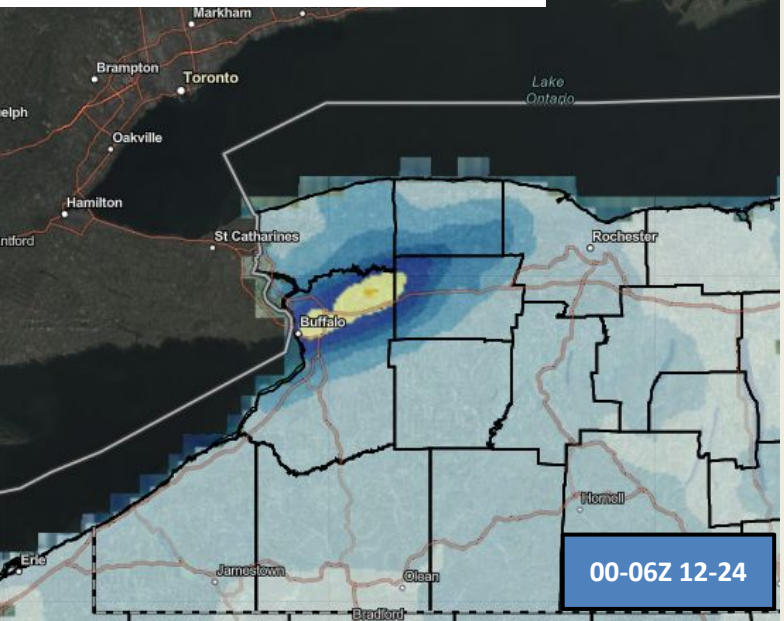
...STORM TOTAL SNOWFALL REPORTS...

Location	Amount	Time/Date	Provider
...New York...			
...Allegany County...			
Rushford	1.0 in	0630 AM 12/24	COOP
...Cattaraugus County...			
Cattaraugus 3W	2.0 in	0700 AM 12/24	COOP
Olean	1.3 in	0730 AM 12/24	COOP
Allegany State Park	1.2 in	0700 AM 12/24	COOP
...Chautauqua County...			
Mayville 0.2 ESE	5.0 in	0700 AM 12/24	COCORAHS
Gerry 0.8 N	2.5 in	0730 AM 12/24	COCORAHS
Jamestown 4ENE	1.0 in	0700 AM 12/24	COOP
Falconer 0.3 WSW	1.0 in	0700 AM 12/24	COCORAHS
Dunkirk 1S	1.0 in	0700 AM 12/24	COOP
Fredonia 0.8 WNW	0.5 in	0500 AM 12/24	COCORAHS
...Erie County...			
Buffalo Airport	27.6 in	0800 AM 12/24	Official NWS Obs
Lancaster	11.5 in	0650 AM 12/24	Trained Spotter
Boston 2.5 NE	3.0 in	0700 AM 12/24	COCORAHS
Hamburg 0.4 WSW	2.8 in	0700 AM 12/24	COCORAHS
Glenwood 1.0 SE	1.0 in	0700 AM 12/24	COCORAHS
...Niagara County...			
North Tonawanda	14.5 in	0700 AM 12/24	COOP
Youngstown 2 NE	1.2 in	0700 AM 12/24	COOP

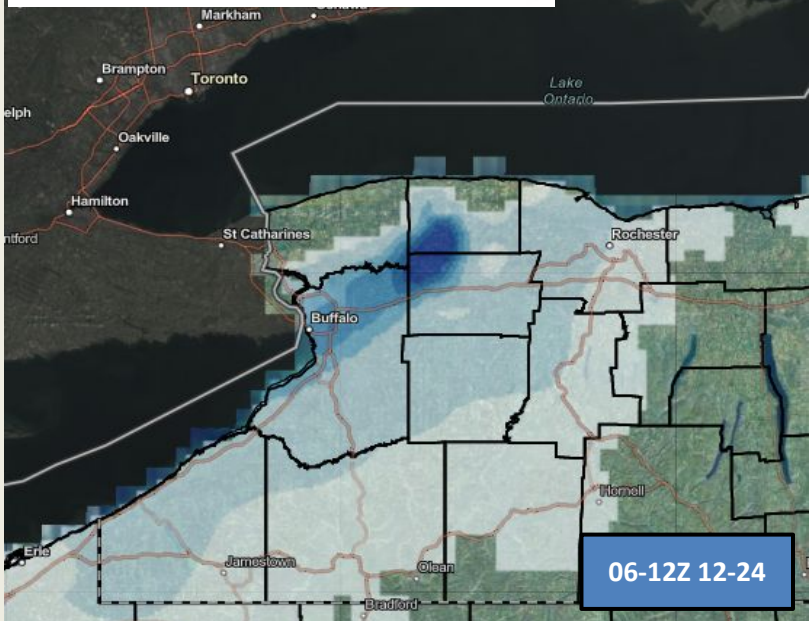
Observed 6 Hour Snowfall (NOHRSC)



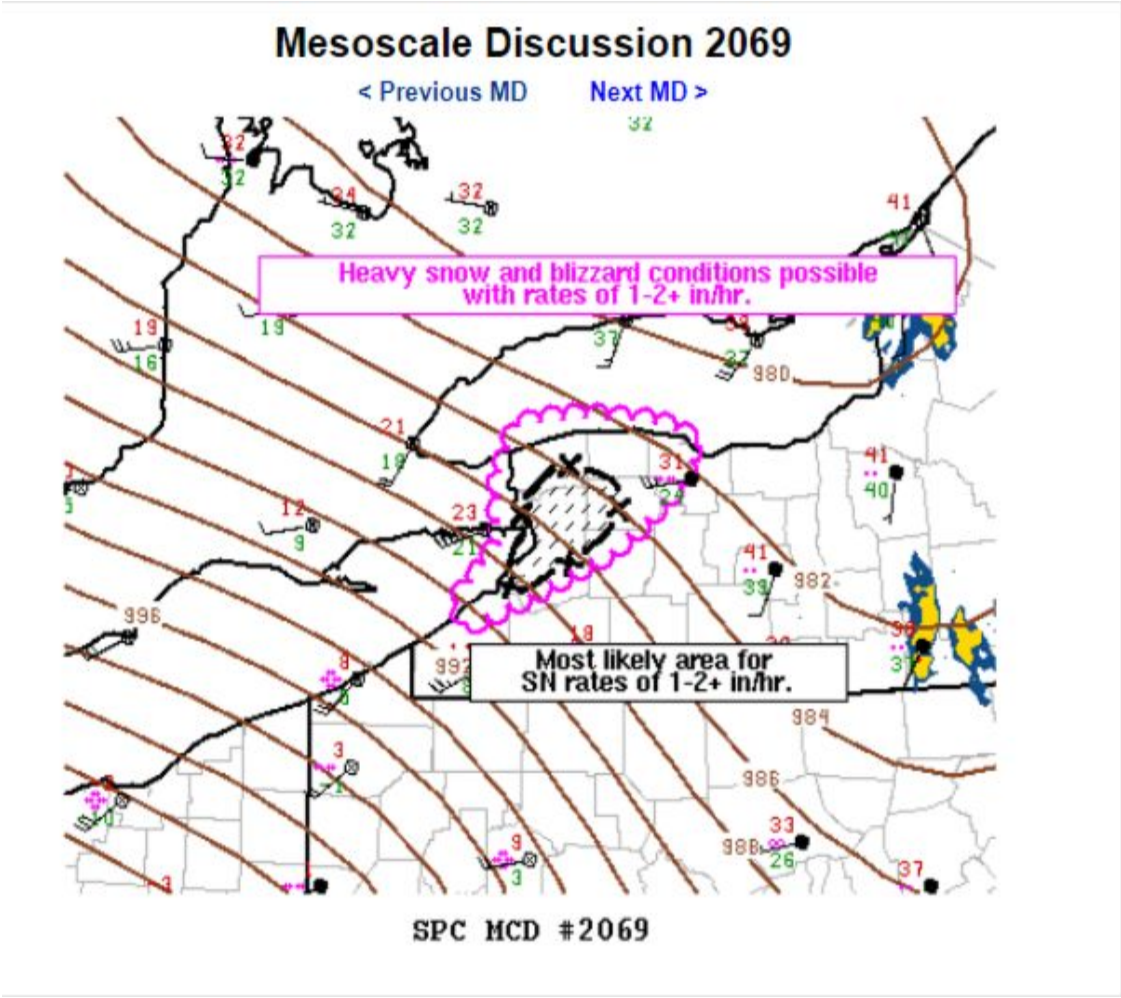
6-8 inches fell multiple times in 6 hour intervals.



Areas received snowfall rates approaching 2”/hr.



Mesoscale Discussion 2069



Mesoscale Discussion 2069
NWS Storm Prediction Center Norman OK
0951 AM CST Fri Dec 23 2022

Areas affected...western New York State

Concerning...Heavy snow

Valid 231551Z - 232145Z

SUMMARY...Heavy snow with lake-enhanced rates of 1-2+ in/hr and localized blizzard conditions possible through much of the afternoon.

DISCUSSION...In the wake of a strong surface low and cold front moving across the northeastern US, snow is forecast to increase in intensity and persists across portions of western NY State through much of this afternoon. Over the last 90 min, snow has increased in intensity with below 1/4 mile visibility and heavy snow reported at several locations along the eastern shores of lake Erie. As the surface low is forecast to drift slowly northeastward, low and mid-level winds are expected to become more southwesterly with time, aligning more favorably with the lake axis. Significant lake-enhancement of ongoing snow is expected within the post-frontal arctic airmass. Rates of 1-2 in/hr with localized rates greater than 2+ in/hr are possible. In addition to the heavy snow, the strong fetch of low-level southwesterly flow will be enhanced by strong surface pressure gradients along the backside of the surface low. Numerous gusts greater than 50 mph have been noted across western NY State in the last 2 hours. Localized blizzard conditions are likely along the immediate lake shore, where heavy blowing snow and strong wind gusts to 50-60 mph will likely persist well into the afternoon.

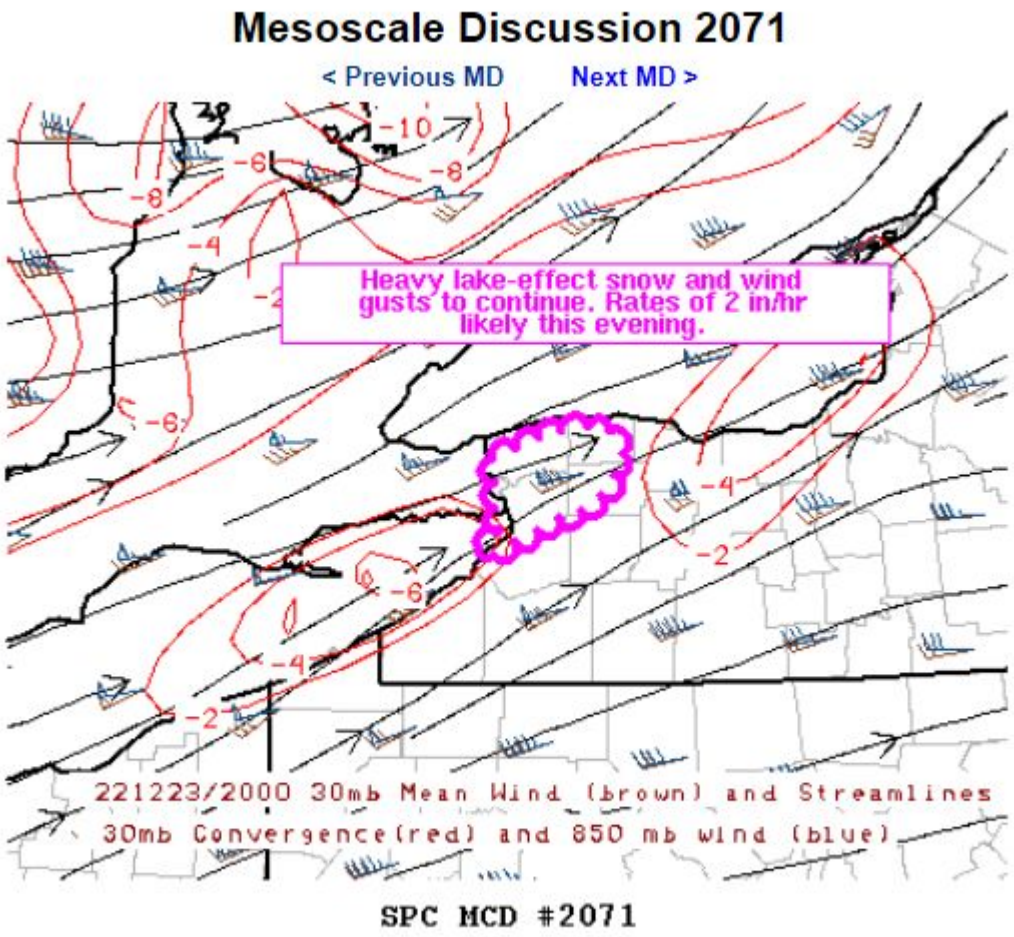
..Lyons.. 12/23/2022

...Please see www.spc.noaa.gov for graphic product...

ATTN...WFO...BUF...

LAT...LON 43397899 43457851 43427796 43387781 43277759 43097778
42927800 42757828 42607871 42527890 42447912 42387930
42377938 42457945 42637930 42807911 42937913 43117915
43397899

Mesoscale Discussion 2071



Mesoscale Discussion 2071
NWS Storm Prediction Center Norman OK
0347 PM CST Fri Dec 23 2022

Areas affected...western New York State

Concerning...Heavy snow

Valid 232147Z - 240245Z

SUMMARY...Heavy lake-effect snow and localized blizzard conditions to continue this evening. Rates of 2 in/hr possible.

DISCUSSION...As of 21:45 UTC, regional radar showed a well-developed lake-effect snow band ongoing across the eastern shores of Lake Erie. A post-frontal arctic airmass with strong southwesterly flow is evident on the Buffalo VAD/VWP with a well-defined 60-70 kt low-level jet parallel to the lake axis. Strong convergence and warm lake temperatures will continue to support banding and heavy snow across the eastern shores through this evening. Rates of 2 in/hr will be possible within the primary band close to the lake shore where convergence and convective effects are strongest. In addition, the strong winds aloft will continue to support strong surface gusts greater than 50 mph through this evening. Localized blizzard conditions are expected along the immediate lake shore where heavy falling and blowing snow will support zero visibility.

..Lyons.. 12/23/2022

...Please see www.spc.noaa.gov for graphic product...

ATTN...WFO...BUF...

LAT...LON 43167899 43297859 43327821 43157807 42997819 42897833
42837855 42787869 42747881 42647902 42667911 42787895
42837897 43167899

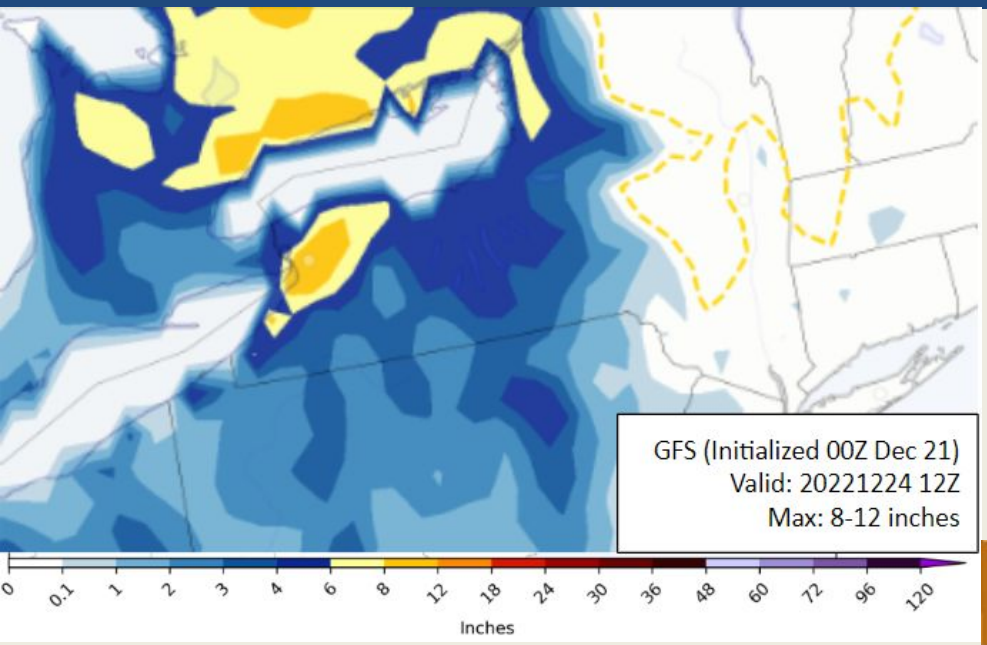
Day 3 Evaluation

- GFS model output
- NBM deterministic output
- NBM 24 hour exceedance probabilities
- NBM 6 hour snowfall December 23-24

Link to survey will appear in the chat.

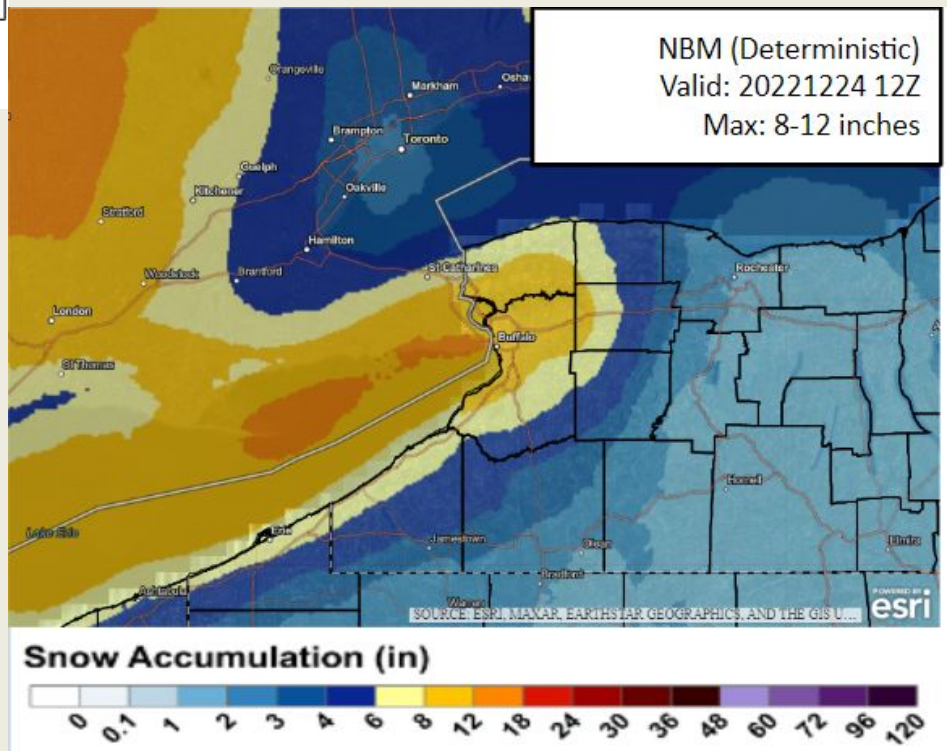
24-hr Snowfall Model Analysis:

Day 3 Forecast: December 20

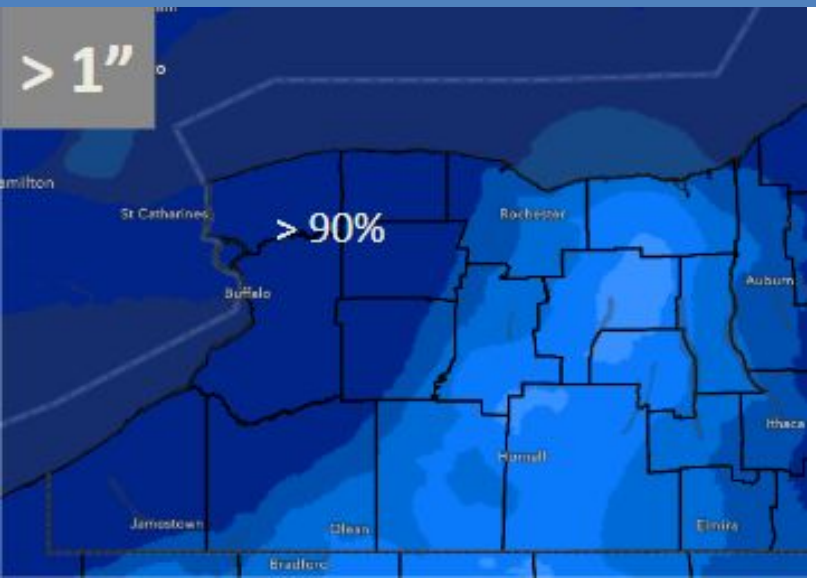


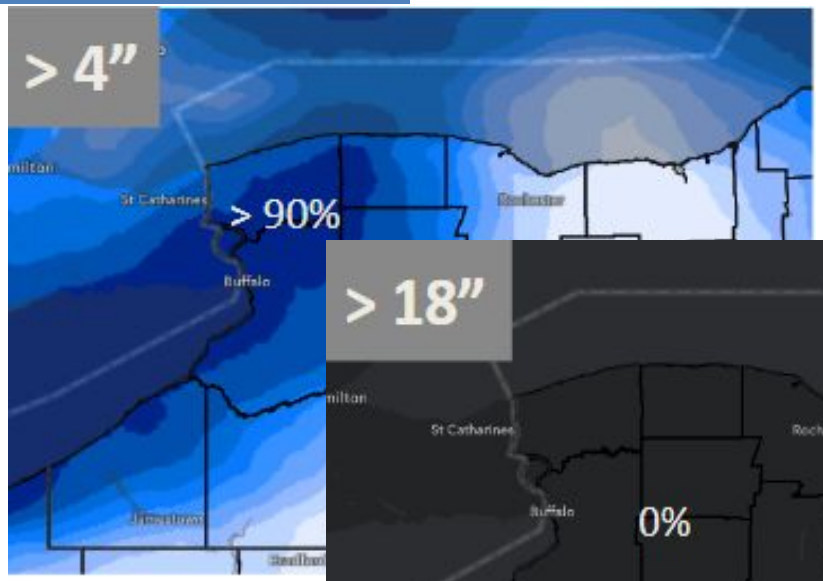
GFS modeled a band 3 days out, centered around or just south of metro Buffalo, modeling 8-12 inches in the 24 hours ending 12Z on 12-24-22

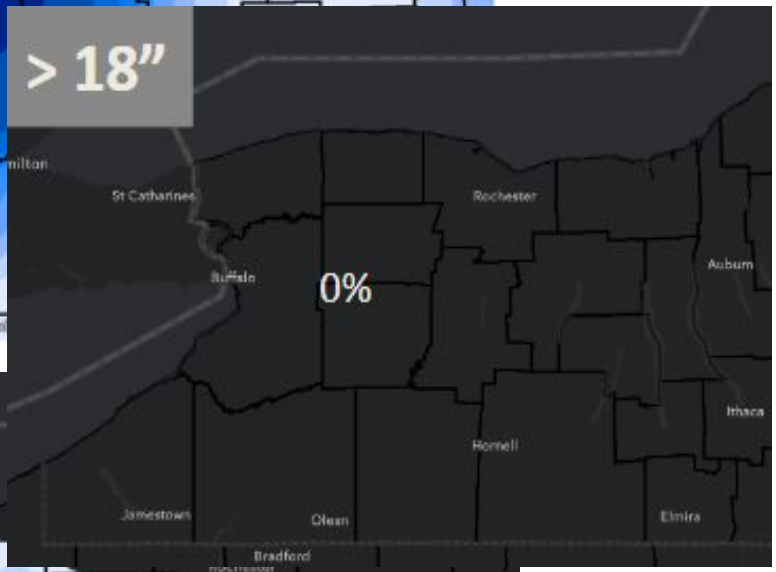
NBM V4.1	Hour Ranges					
Model %	1-16	17-19	20-42	43-60	61-84	84+
HRRR	16					
HRRRX	6	17	17			
RAP	5	5				
RAPX	3	3	3			
HiResARW	10	11	12			
HiResARW2	12	12	13			
HiResFV3	12	13	14	14		
NAM	3	3	4	7	15	
NAMNest	10	13	14	14		
10 SREF ARW	1/mem	1/mem	1/mem	3/mem	3/mem	
GFS	1	1	1	3	3	4
30 GEFS	0.15/mem	0.15/mem	0.15/mem	0.4/mem	0.65/mem	1.2/mem
50 ECMWF Ens	0.15/mem	0.15/mem	0.15/mem	0.4/mem	0.65/mem	1.2/mem

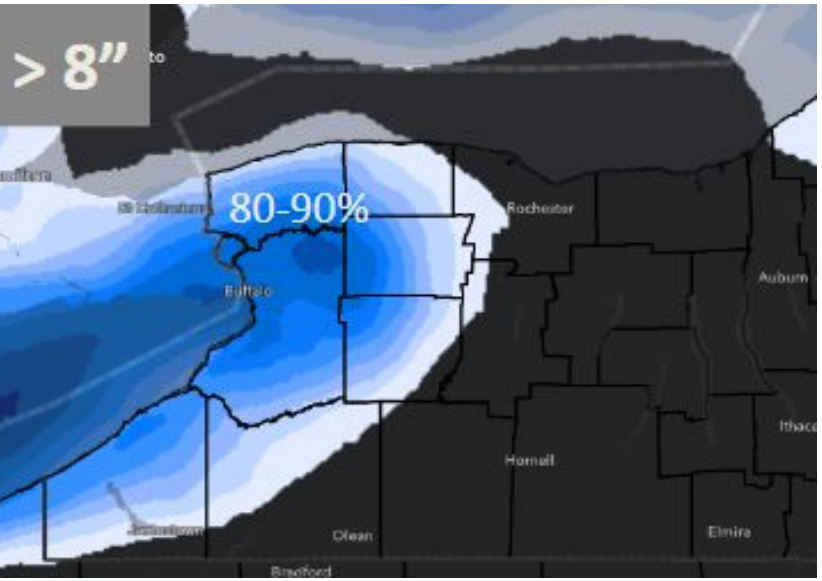


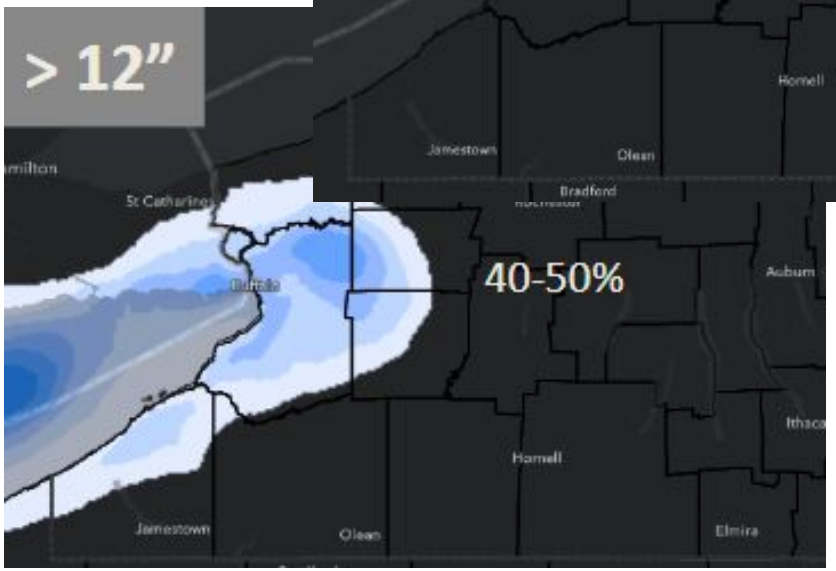
Day “2.5” or 60 hr NBM (probabilistic)
24 hour Exceedance Probabilities

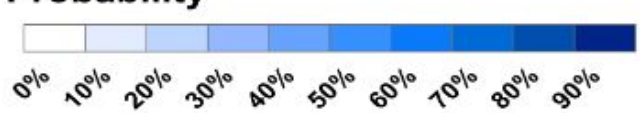




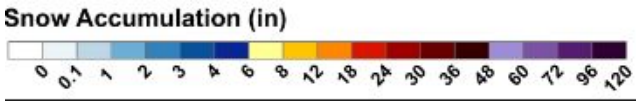


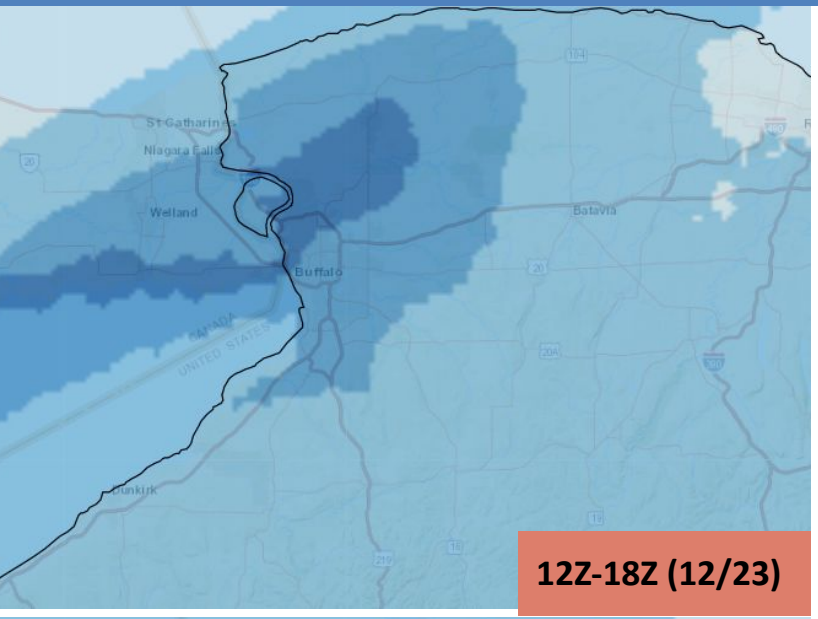






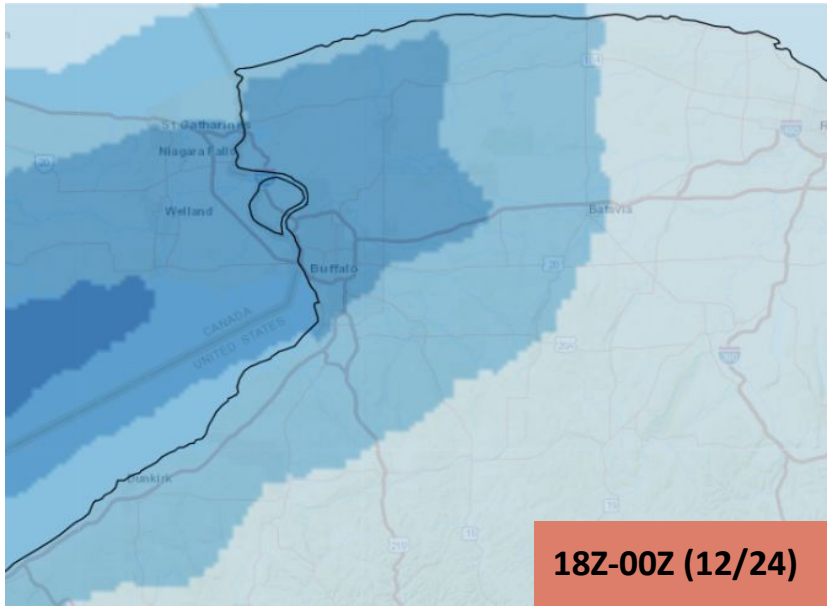
Day 3 NBM
6 Hour Snowfall December 23rd-24th



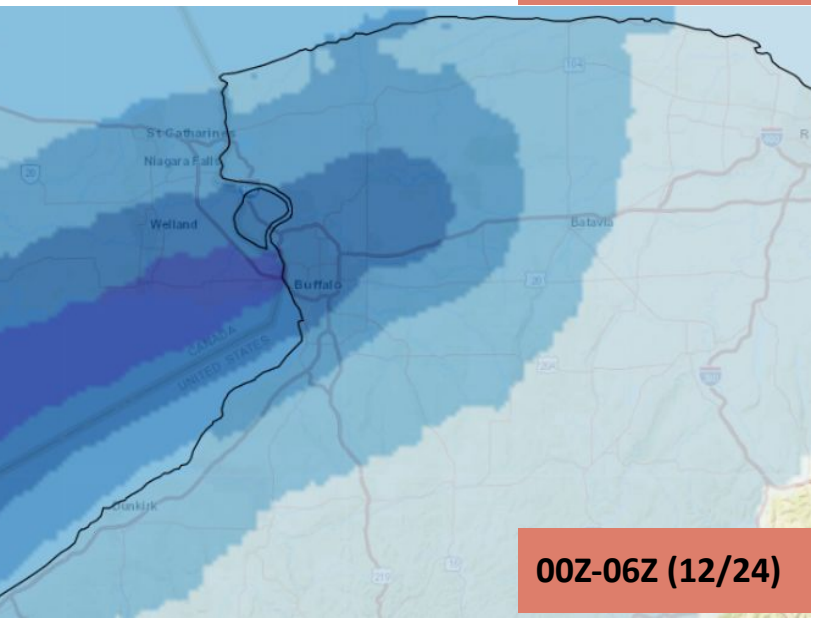


12Z-18Z (12/23)

NBM was forecasting 3-4” of snow in any given 6 hour window on Day 3

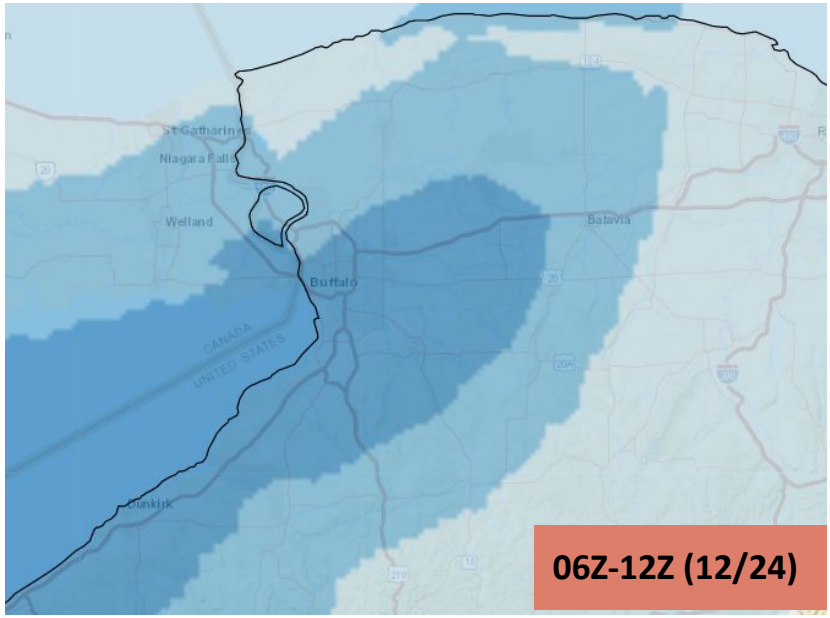


18Z-00Z (12/24)



00Z-06Z (12/24)

This is the equivalent of a snow rate of 0.5-0.67”/hr



06Z-12Z (12/24)

Day 3 Discussion

- Thoughts on higher end probabilities?
- What % would a forecaster need to see in the >18” field to find it reasonable to share/message?
- Looking at the 6 hour amounts of 2-3 or 3-4” does this change confidence in the 24 hour totals?
- When does a forecaster or office typically utilize probabilistic graphics? 24hr,48,72, 3-5 days?

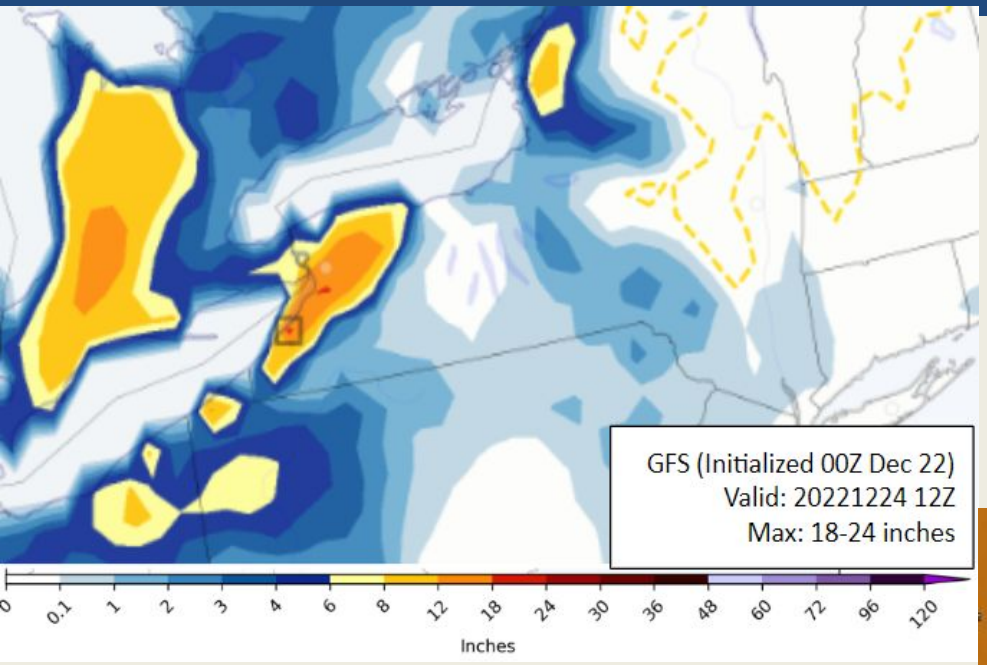
Day 2 Evaluation

- GFS model output
- NBM deterministic output
- NBM 24 hour exceedance probabilities
- NBM 6 hour snowfall December 23-24

Link to survey will appear in the chat.

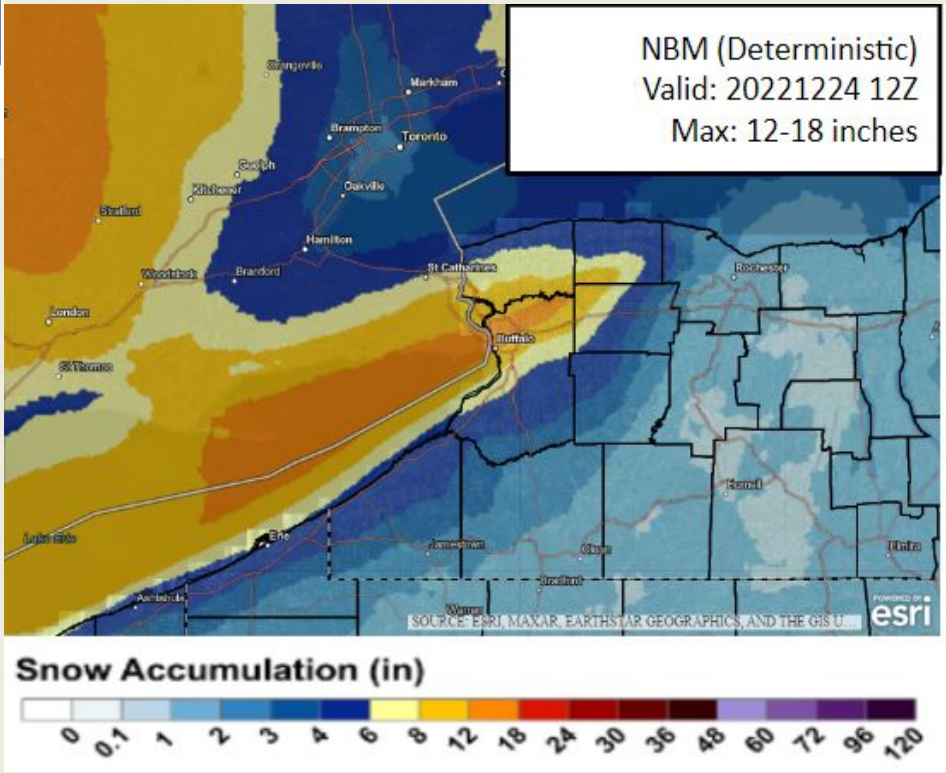
24-hr Snowfall Model Analysis:

Day 2 Forecast: December 21

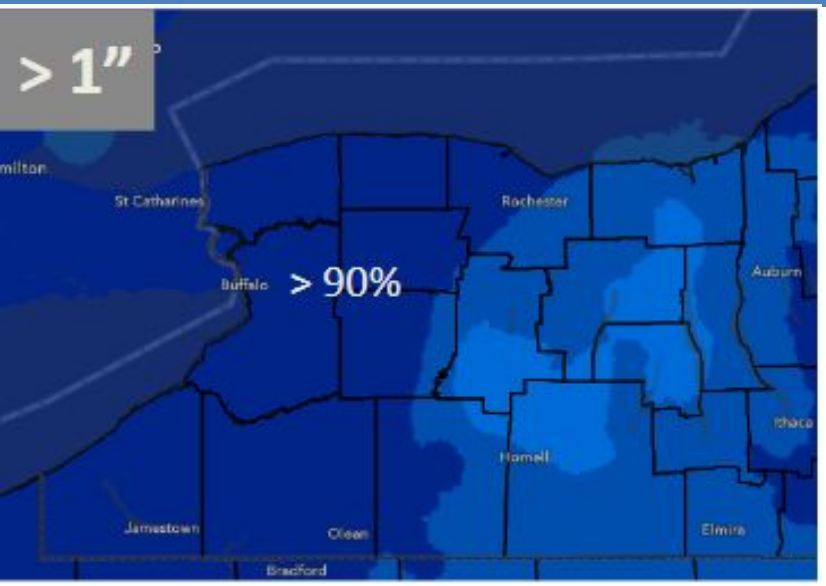


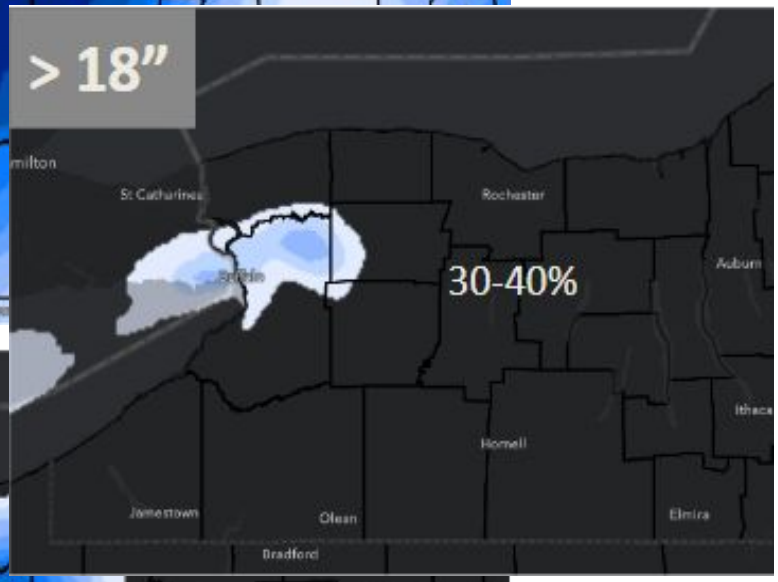
GFS modeled a band 2 days out, centered around or just south of metro Buffalo, modeling 12-18 inches, with isolated pockets of 18-24" in the 24 hours ending 12Z on 12-24-22

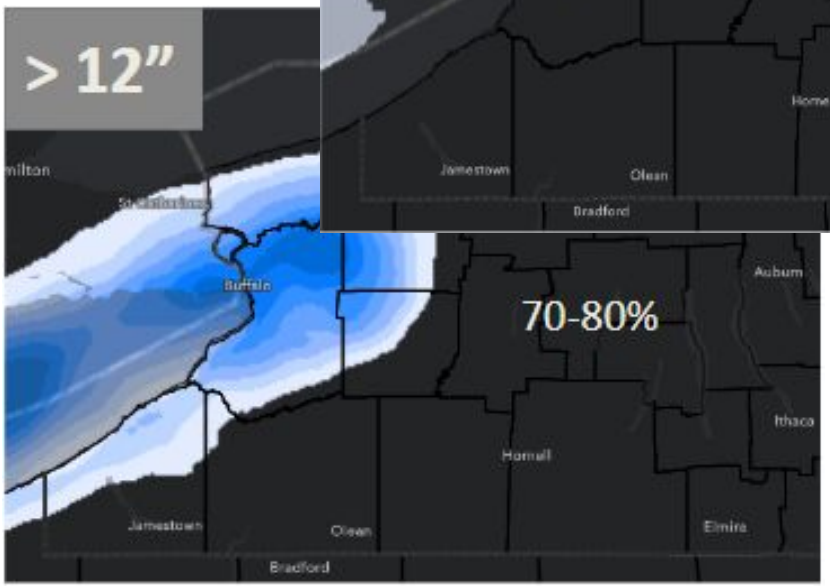
NBM V4.1	Hour Ranges					
Model %	1-16	17-19	20-42	43-60	61-84	84+
HRRR	16					
HRRRX	6	17	17			
RAP	5	5				
RAPX	3	3	3			
HiResARW	10	11	12			
HiResARW2	12	12	13			
HiResFV3	12	13	14	14		
NAM	3	3	4	7	15	
NAMNest	10	13	14	14		
10 SREF ARW	1/mem	1/mem	1/mem	3/mem	3/mem	
GFS	1	1	1	3	3	4
30 GEFS	0.15/mem	0.15/mem	0.15/mem	0.4/mem	0.65/mem	1.2/mem
50 ECMWF Ens	0.15/mem	0.15/mem	0.15/mem	0.4/mem	0.65/mem	1.2/mem

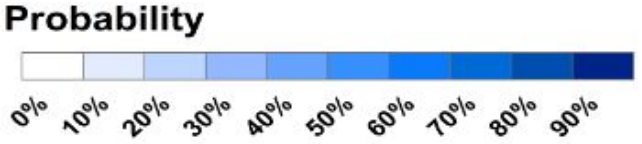


Day “1.5” or 36 hr NBM (probabilistic)
24 hour Exceedance Probabilities

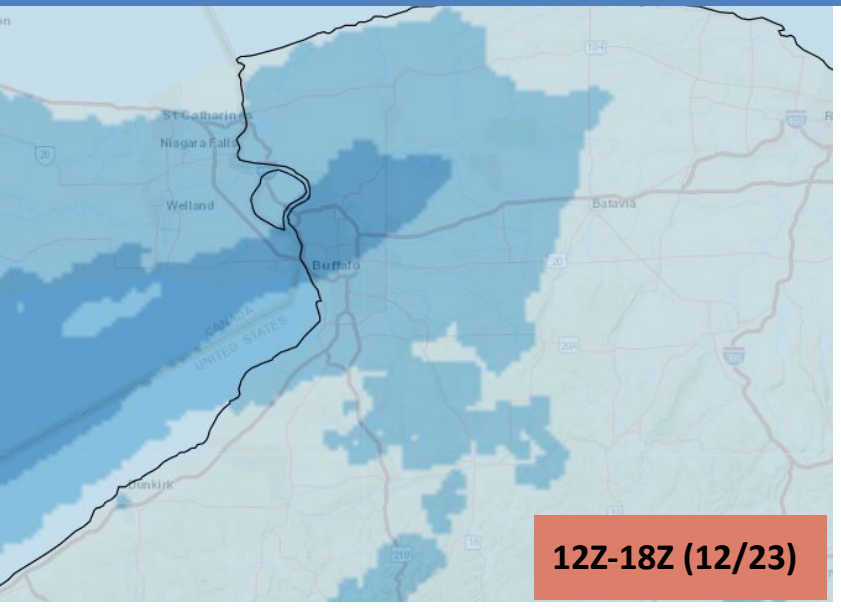




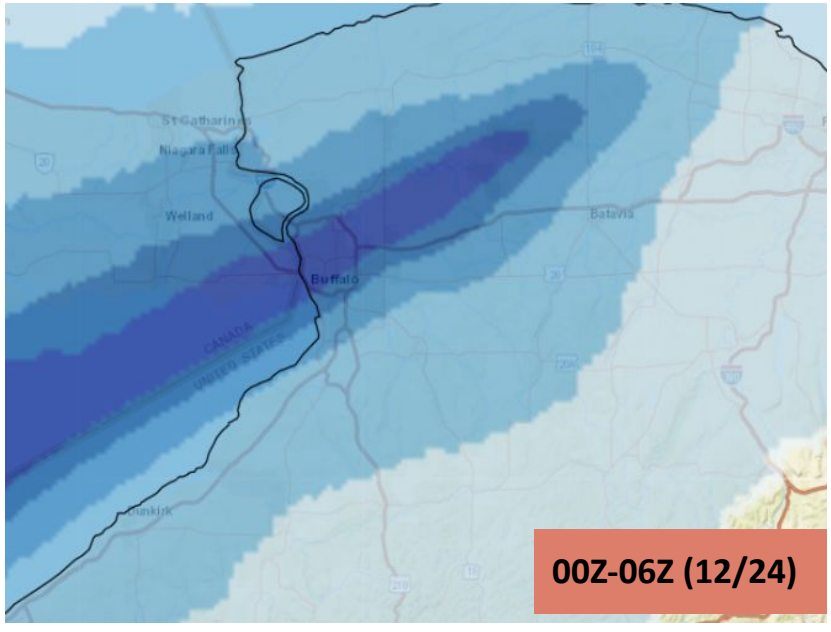




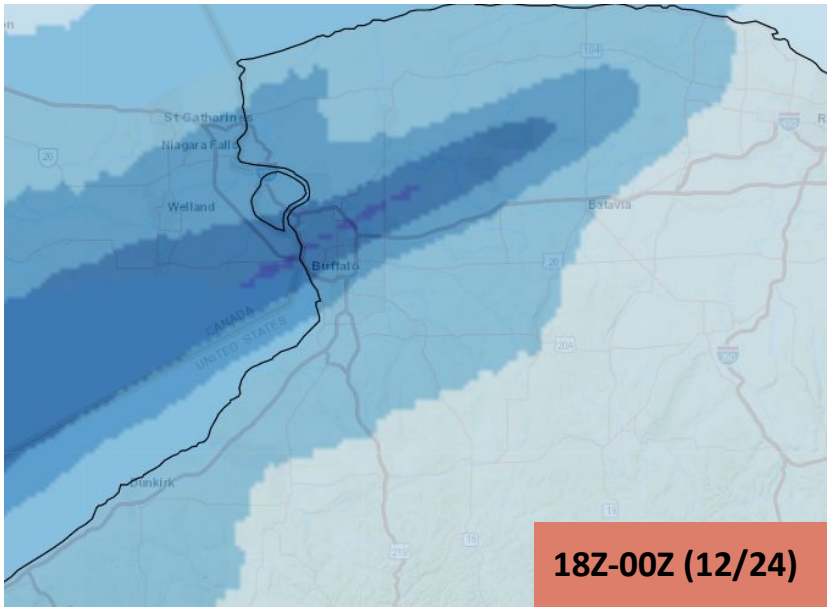
Day 2 NBM
6 Hour Snowfall December 23rd-24th

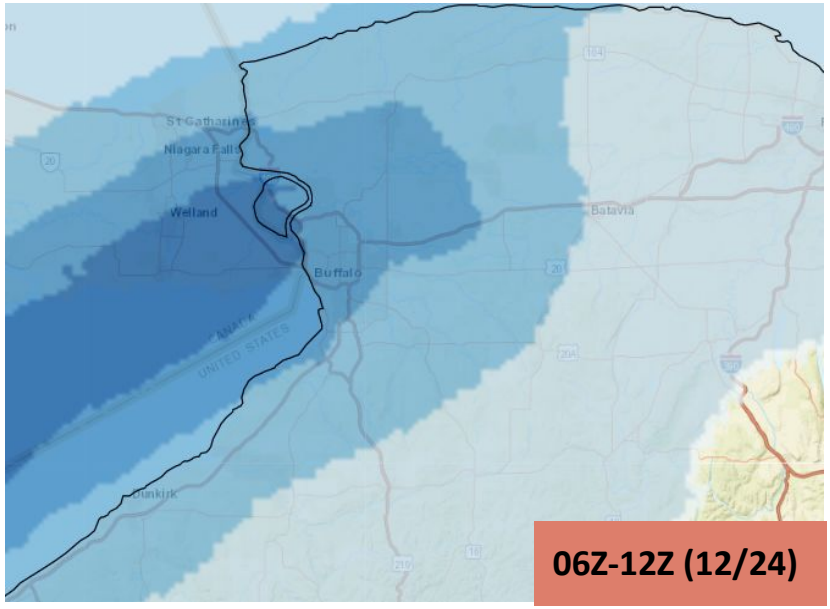


Day 2 NBM started picking up on inland extent and banding. The heaviest 6-hr snowfall forecast now being 4-6".



This is the equivalent of a snow rate of 0.67-1.0"/hr





Day 2 Discussion

- Thoughts on higher end probabilities?
- Is 30-40 % enough in the >18” field to be reasonable to share/message?
- Looking at the 6 hour amounts of 3-4” or 4-6” does this change confidence in the 24 hour totals?

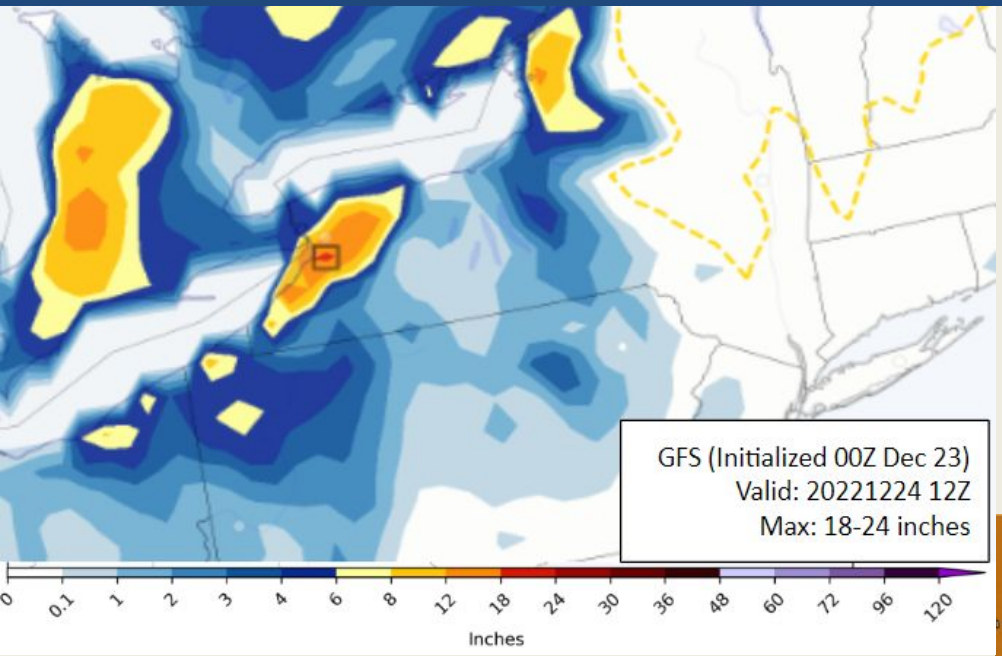
Day 1 Evaluation

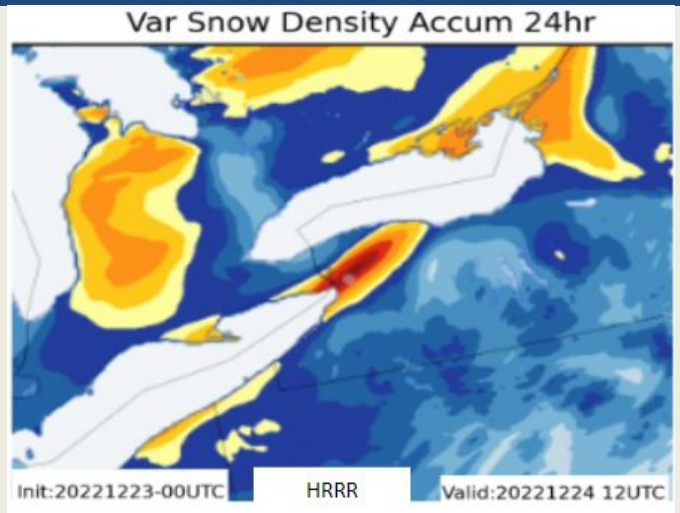
- GFS 24-hr model output
- NBM 24-hr deterministic output
- HRRR 24-hr model output
- NBM 6 hour snowfall December 23-24

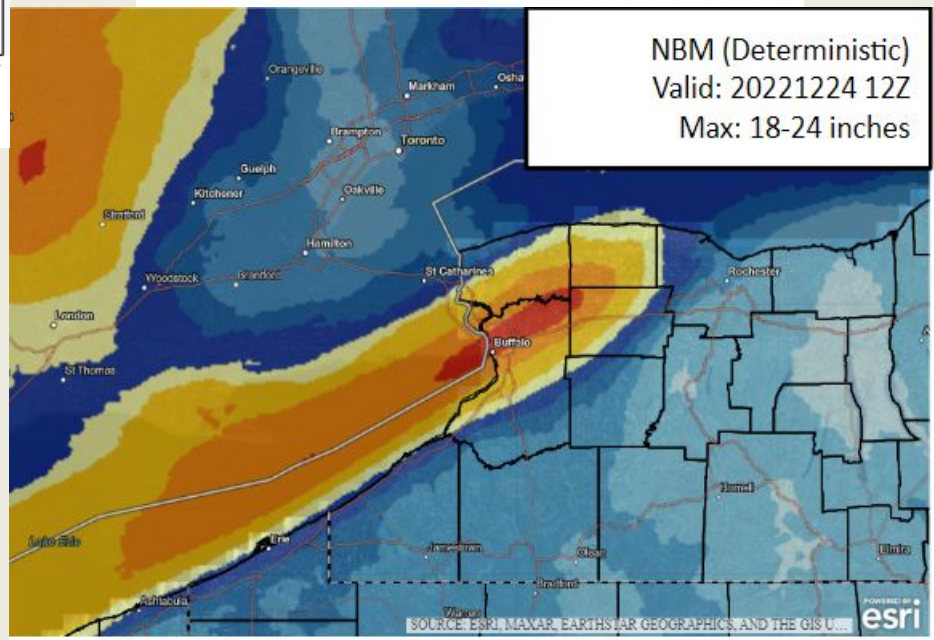
Link to survey will appear in the chat.

24-hr Snowfall Model Analysis:

Day 1 Forecast: December 22

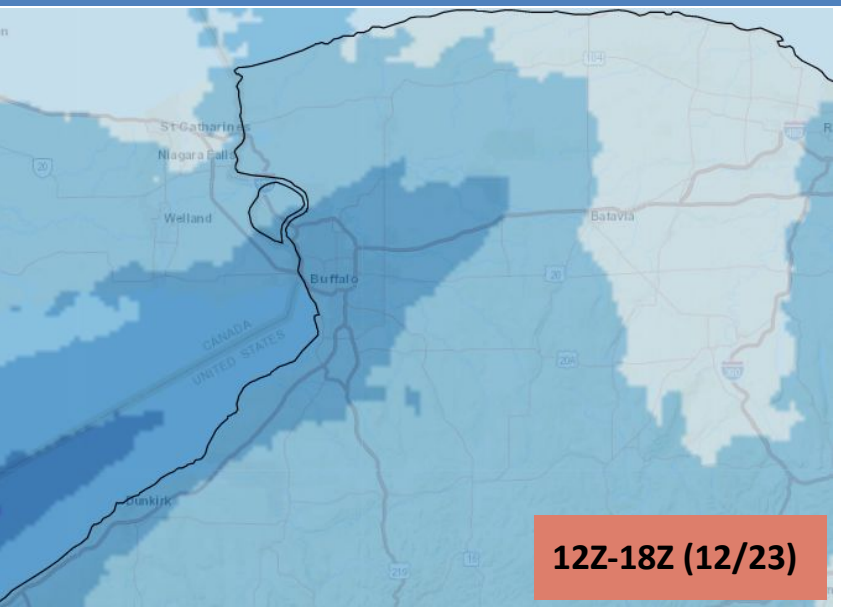




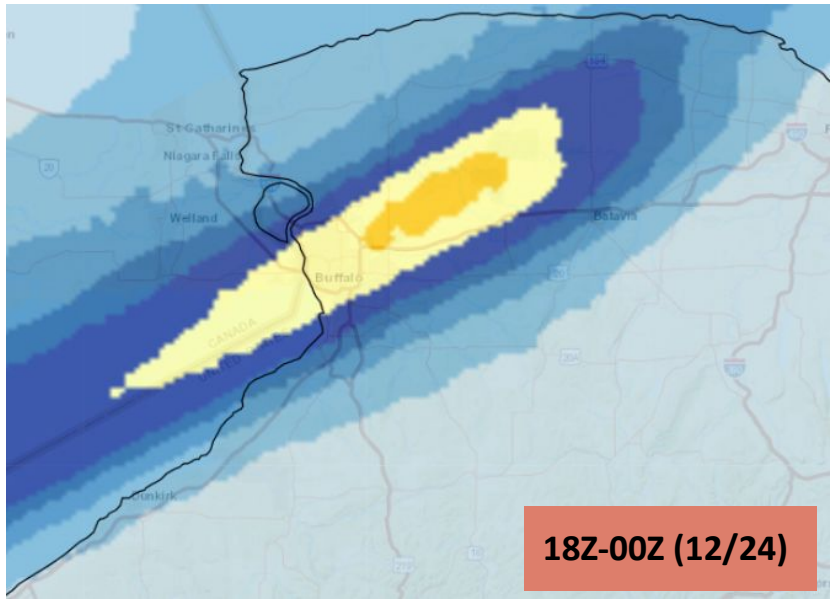


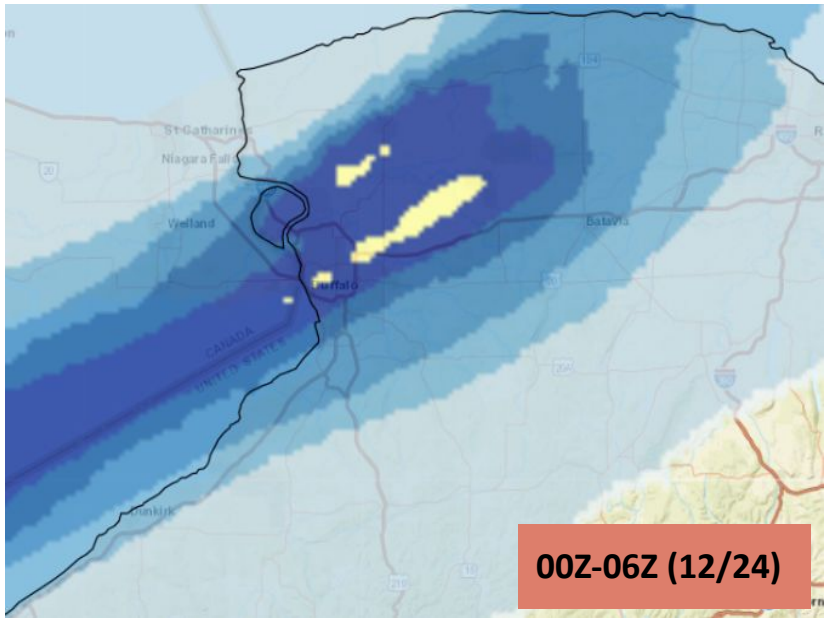
NBM V4.1	Hour Ranges					
Model %	1-16	17-19	20-42	43-60	61-84	84+
HRRR	16					
HRRRX	6	17	17			
RAP	5	5				
RAPX	3	3	3			
HiResARW	10	11	12			
HiResARW2	12	12	13			
HiResFV3	12	13	14	14		
NAM	3	3	4	7	15	
NAMNest	10	13	14	14		
10 SREF ARW	1/mem	1/mem	1/mem	3/mem	3/mem	
GFS	1	1	1	3	3	4
30 GEFS	0.15/mem	0.15/mem	0.15/mem	0.4/mem	0.65/mem	1.2/mem
50 ECMWF Ens	0.15/mem	0.15/mem	0.15/mem	0.4/mem	0.65/mem	1.2/mem

Day 1 NBM
6 Hour Snowfall December 23rd-24th

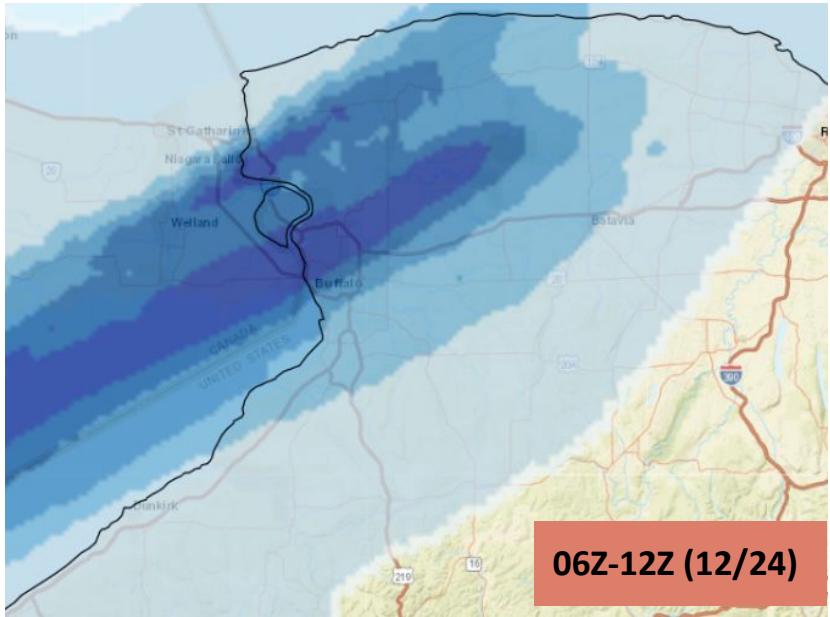


Day 1 NBM maintains inland extent and banding. The heaviest 6-hr snowfall forecast now being 8-12”.





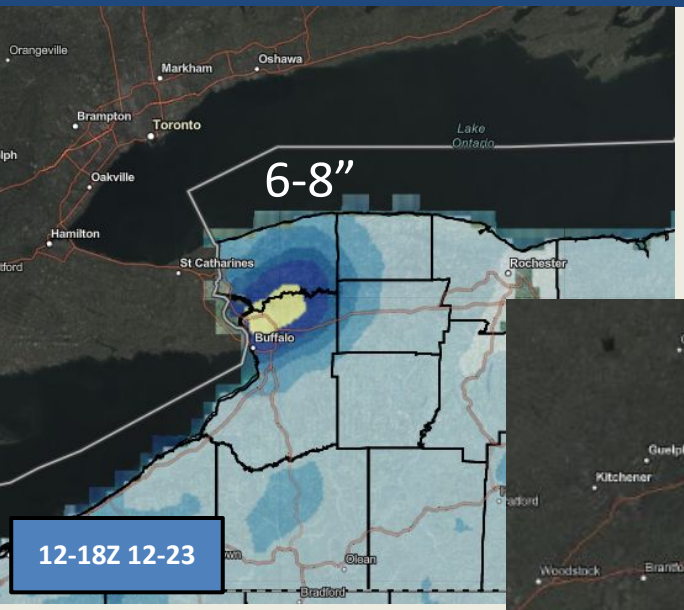
This is the equivalent of a snow rate of 1.33-2.0”/hr

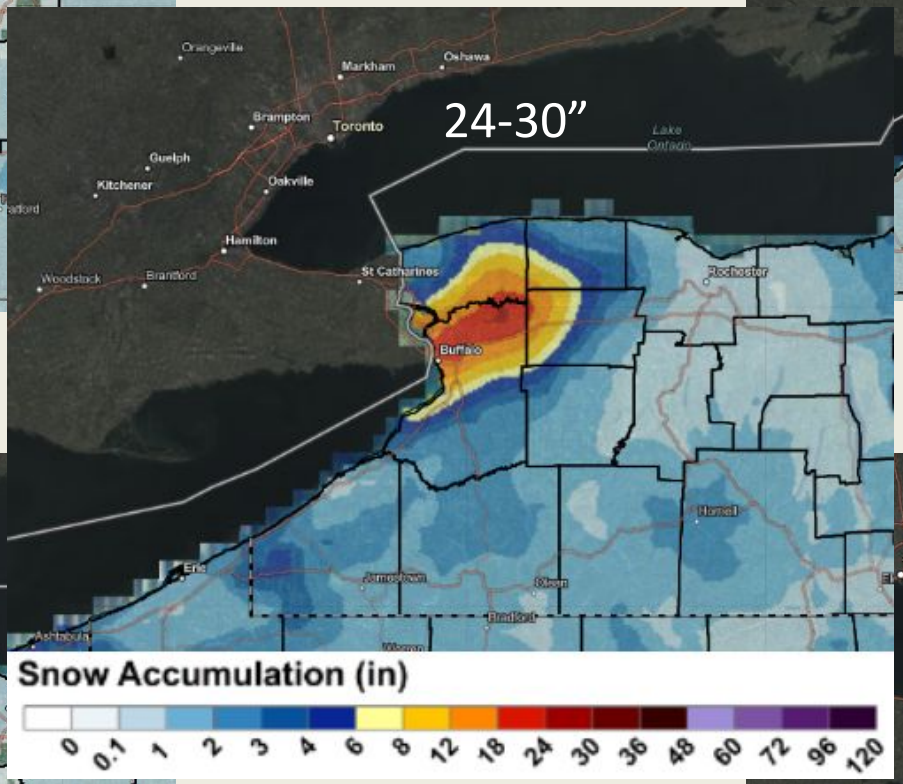


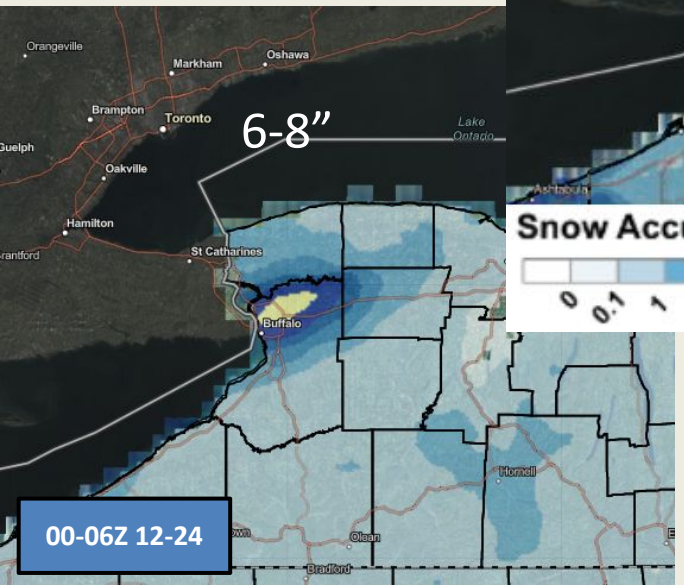
Day 1 Discussion

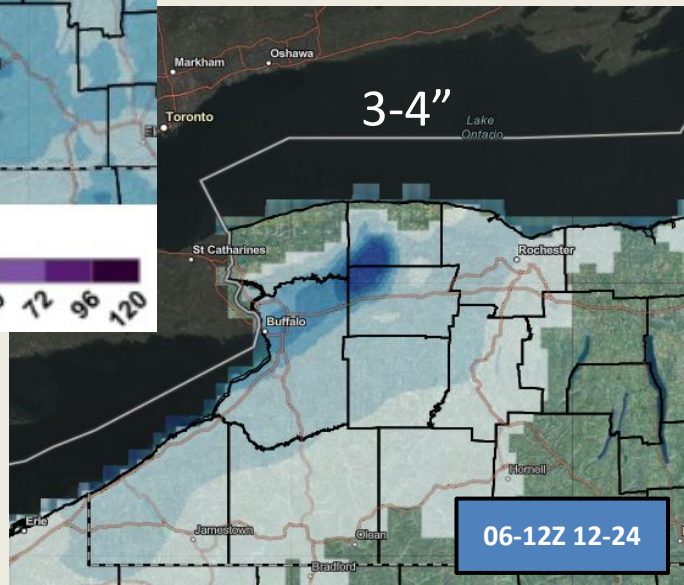
- Thoughts on increase in forecasted snowfall
- How would this affect messaging ahead of a holiday and weekend?
- Looking at the 6 hour amounts of 6-8” or 8-12” does this change confidence in the 24 hour totals?
- Would the forecaster discredit the increase just 1 day out?

Observed 24-HR & 6-HR Snowfall









What is EFI & SOT

- EFI compares the model forecast to the model climate, and gives a good idea of how unusual an upcoming event is expected to be.
- EFI = + 1 when all ENS members forecast values are at or above the maximum M-climate
- EFI = - 1 when all ENS members forecast values are at or below the maximum M-climate
- **Important note:** EFI is not probability, but they combine how many members are extreme and how extreme those members are into one number.

“Significant values” of EFI may be considered to be:

- Values below 0.5 are not plotted and typically are not significant.
- EFI of 0.5 to 0.8 or -0.5 to -0.8 signify an unusual event.
- EFI values above 0.8 or below -0.8 signify a very unusual or extreme event.

Shift Of Tails (SOT)

SOT tells you how extreme an event could be by looking at how extreme the top 10% of the ensemble membership is.

Two Ingredients for high SOT:

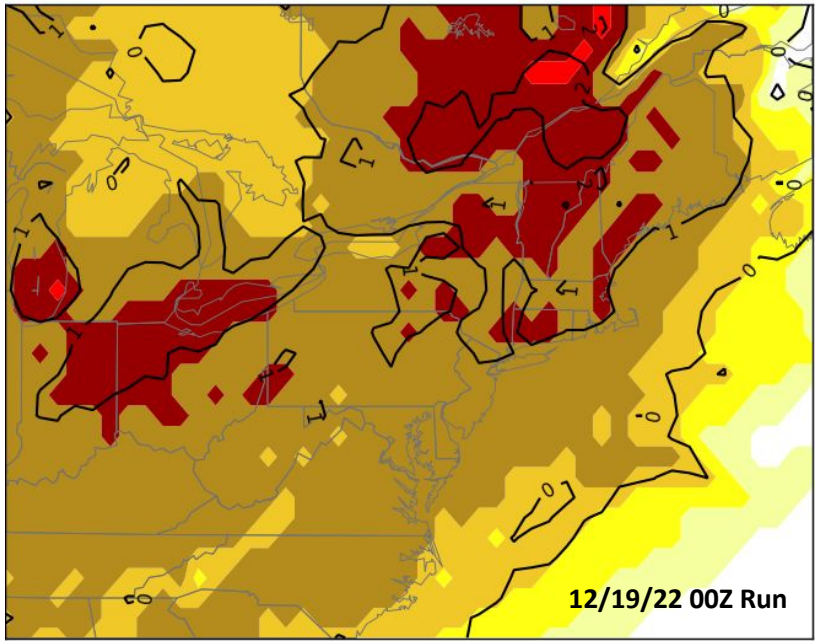
1. A 90th percentile ensemble forecast that is larger than the 99th percentile of the model climate (a really extreme forecast)
2. And/or a small difference between the model climate 90th and 99th (a climate without dramatic extremes).

SOT Explanation continued.

- Values of SOT range from 0-10.
- **STID has found that SOT values of <1 are very common and not that informative** over what you get from EFI.
- **SOT values of 2, or certainly of 5,8, or 10, indicate that a truly extreme event is possible.** (Low probability but potentially high impact event).

Day of the Winter Storm Watch

ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Wind-Gust
96-120-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



EFI values over Lake Erie continuously show 0.80-0.95 co-located with SOT of 1. This indicates wind gusts have the potential to have extreme impacts.

222 PM EST Tue Dec 20 2022

...WINTER STORM WATCH IN EFFECT FROM FRIDAY MORNING THROUGH MONDAY MORNING...

* WHAT...A rapid switch from rain to snow with sharply falling temperatures into the teens will result in a flash freeze on Friday. From Friday afternoon through most of the weekend, very strong winds, heavy lake effect snow and significant blowing and drifting snow will be possible. Winds could gust as high as 65 mph Friday into Friday night. Localized blizzard conditions are possible.

* WHERE...Niagara, Orleans, Erie, Genesee, Wyoming, Chautauqua, and Cattaraugus counties.

* WHEN...From Friday morning through Monday morning.

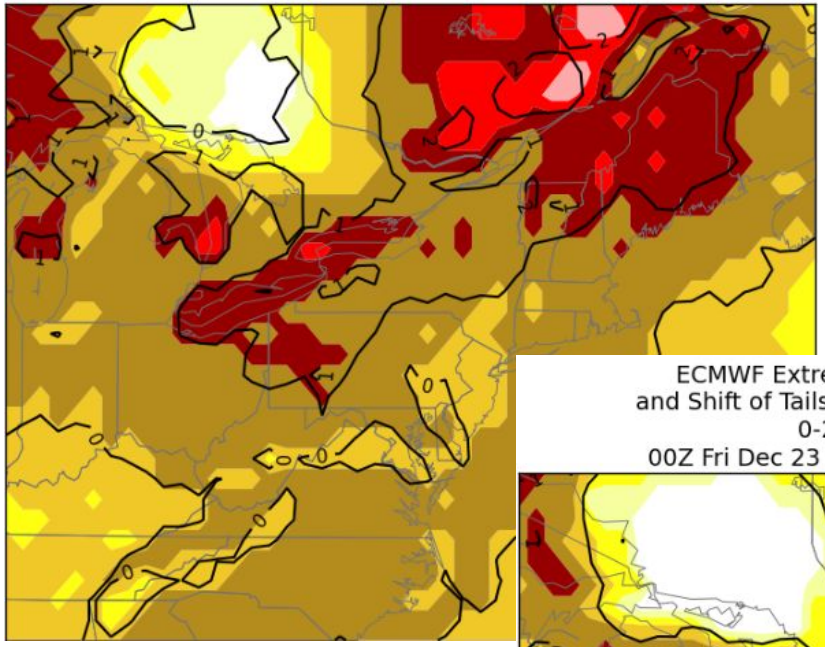
* IMPACTS...Travel for the holiday weekend, including Friday, could be very difficult to impossible at times. Areas of blowing snow could significantly reduce visibility with whiteouts and localized blizzard conditions possible. The most persistent and worst conditions will be where lake effect snow is most widespread, which is still uncertain at this time. Winds this strong could cause tree damage and power outages. Cold wind chills as low as 10 to 20 below zero this weekend could cause frostbite on exposed skin in as little as 30 minutes.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

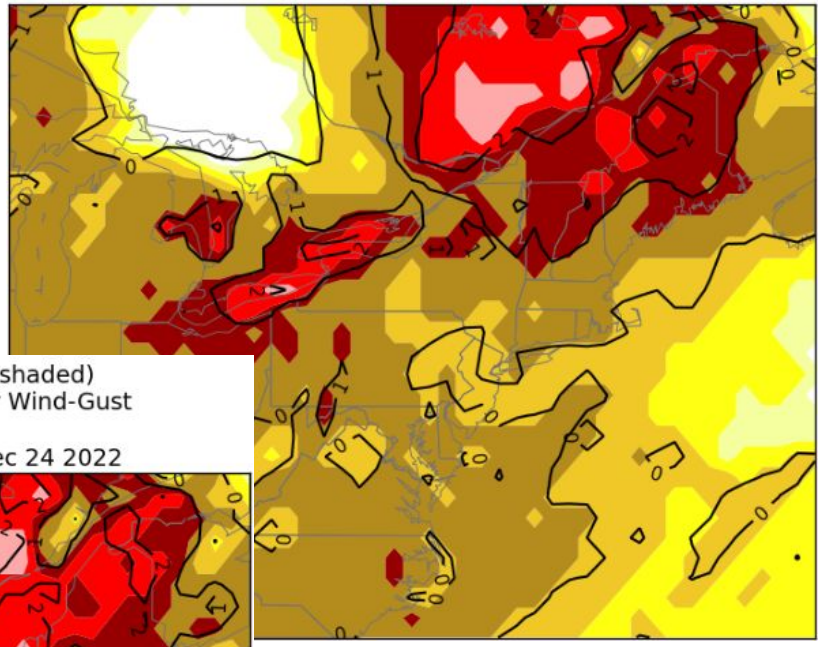
Begin needed preparations at home or with your vehicle. Travel may become difficult or impossible at times this holiday weekend, so plan accordingly.

Relative to the ECMWF reforecasts from a 5 week period (2001 - 2022)
centered on the week this forecast was initialized

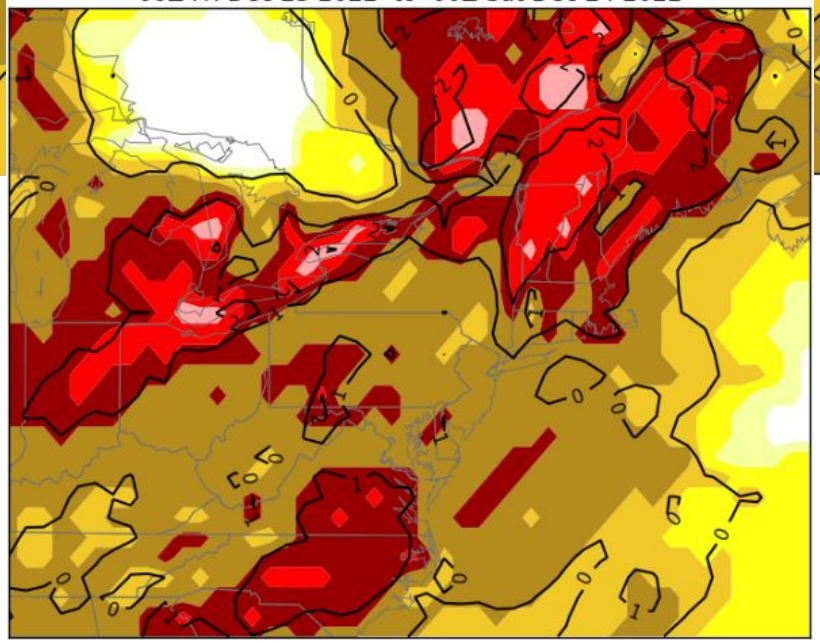
ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Wind-Gust
48-72-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Wind-Gust
24-48-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



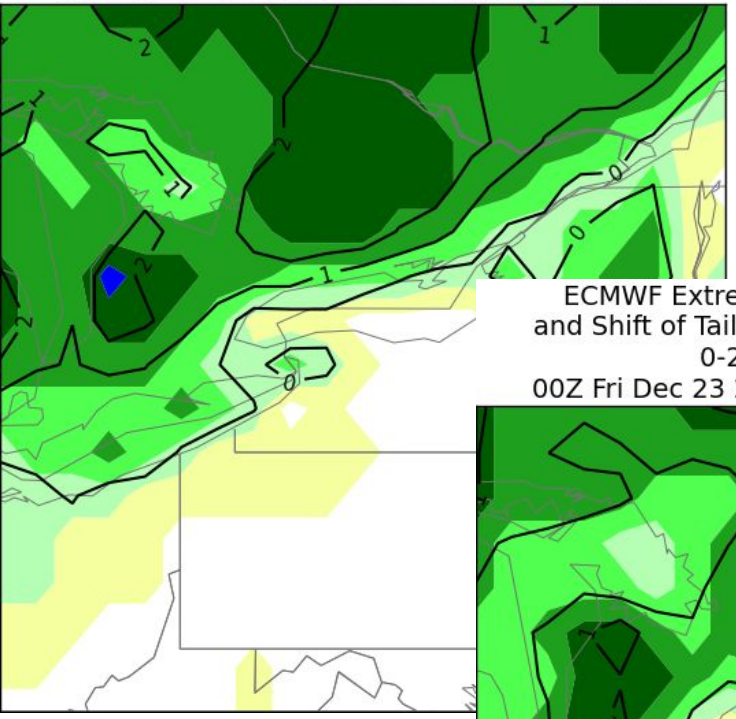
ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Wind-Gust
0-24-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



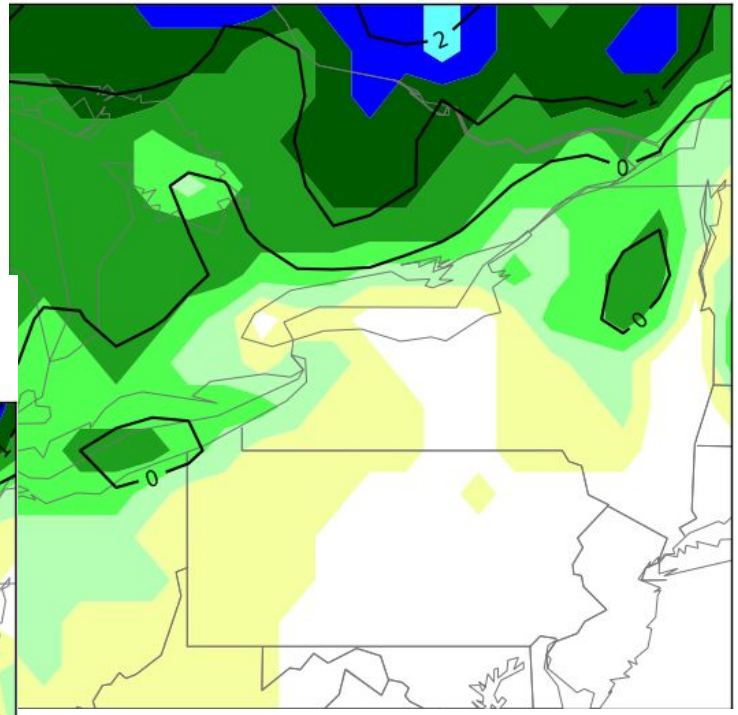
EFI values over Lake Erie continuously show 0.90-1.0 co-located with SOT of 1-2 indicate wind gusts have the potential to have extreme impacts.

Relative to the ECMWF reforecasts from a 5 week period (2001 - 2022)
centered on the week this forecast was initialized

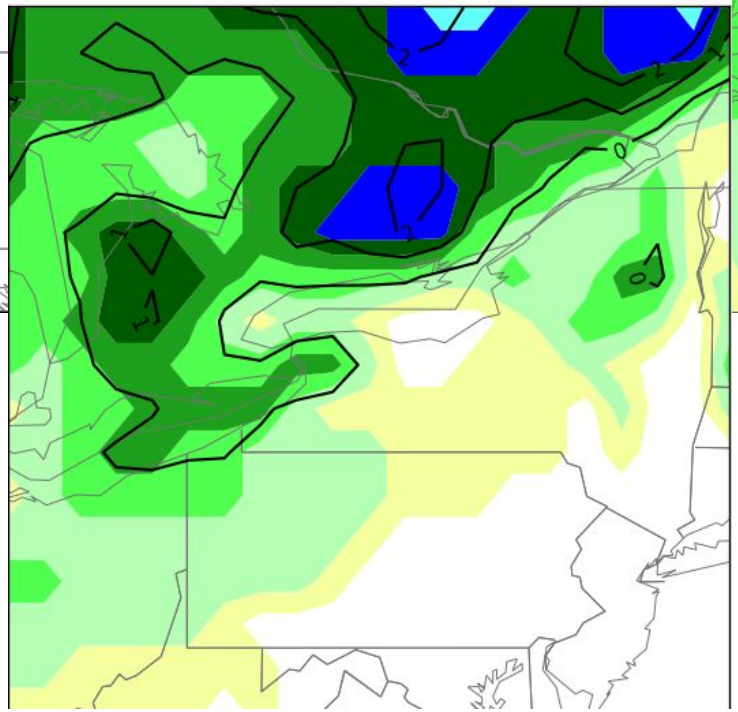
ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Snowfall
48-72-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Snowfall
24-48-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



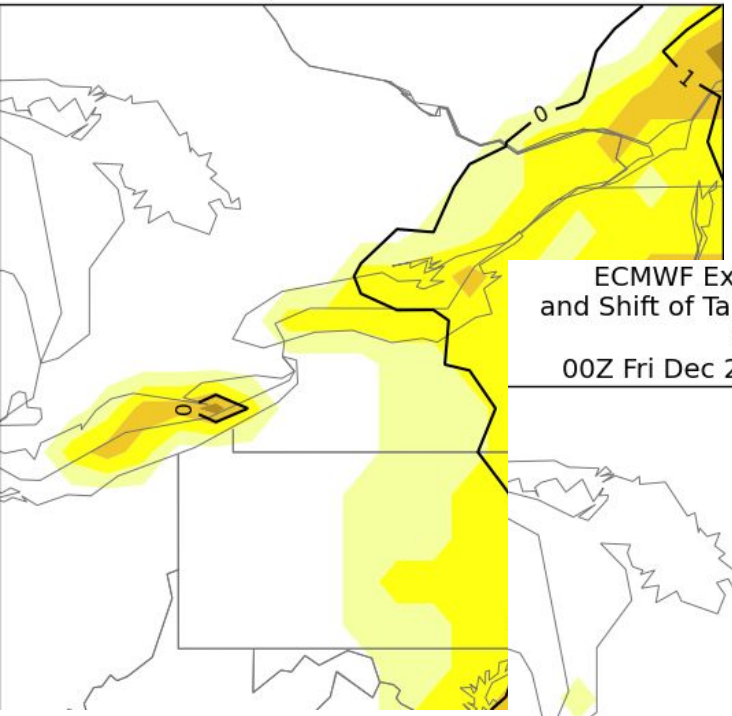
ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Snowfall
0-24-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



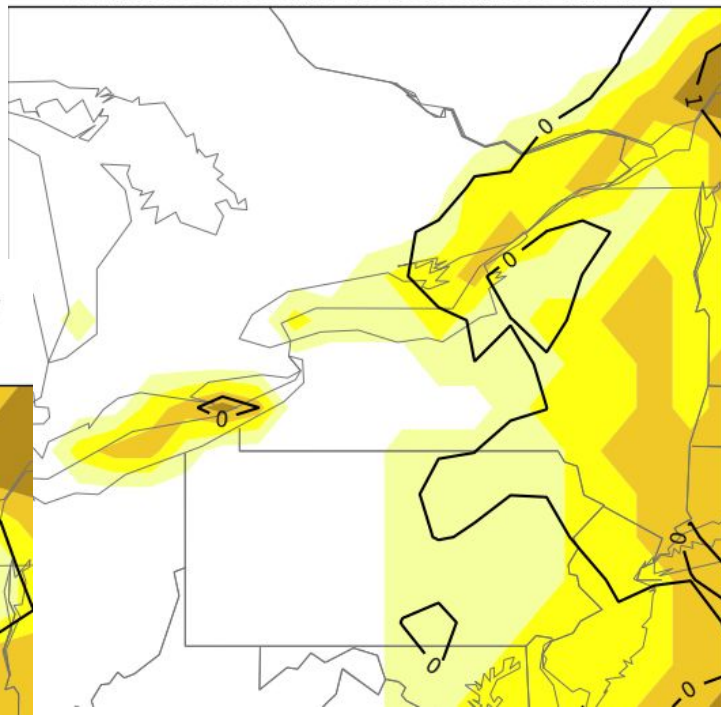
With SOT values less than 1 they really don't add any further detail then the EFI. EFI values over Lake Erie show values of 0.70-0.90 which may alert the forecaster to an unusual to very unusual event for snow.

Relative to the ECMWF reforecasts from a 5 week period (2001 - 2022)
centered on the week this forecast was initialized

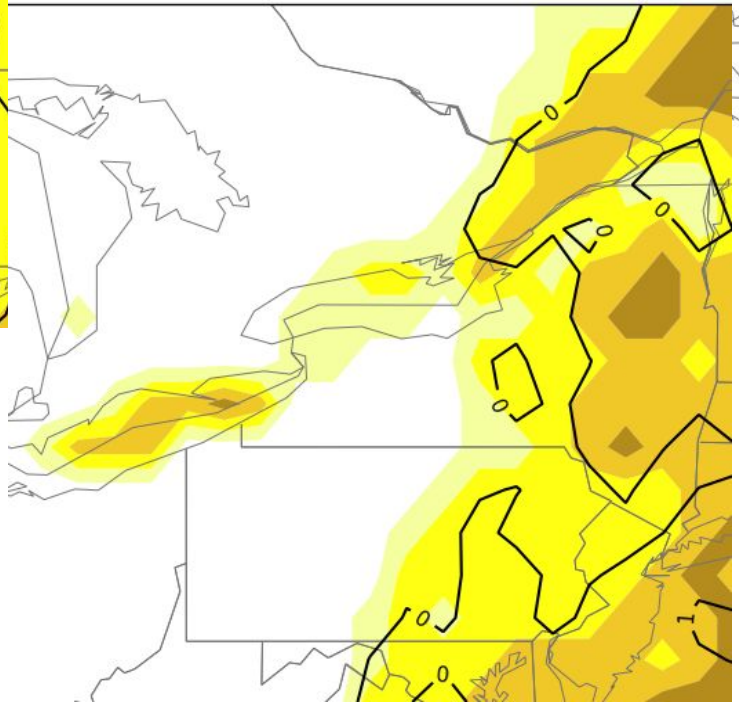
ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for CAPE-Shear
48-72-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022



ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for CAPE-Shear
24-48-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022

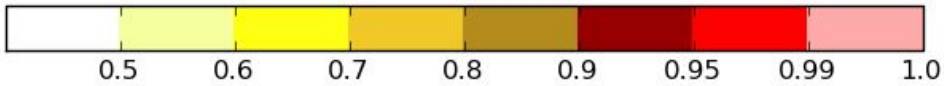


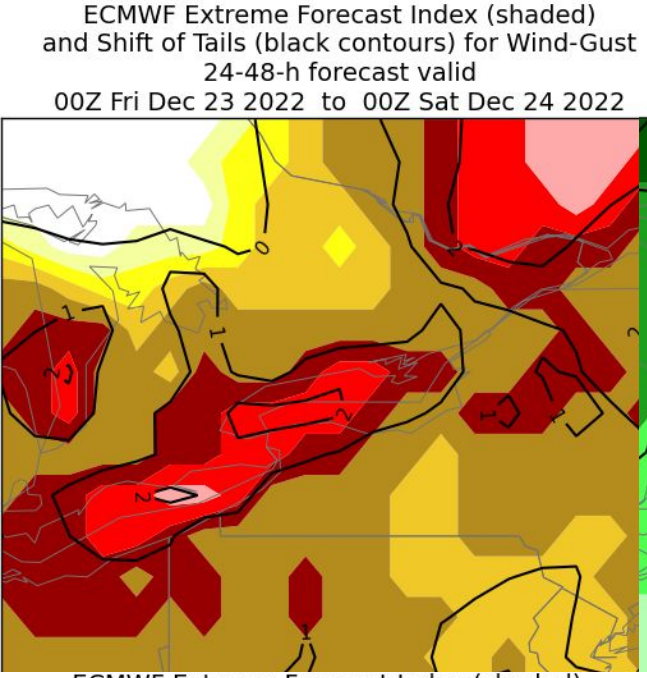
ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for CAPE-Shear
0-24-h forecast valid
00Z Fri Dec 23 2022 to 00Z Sat Dec 24 2022

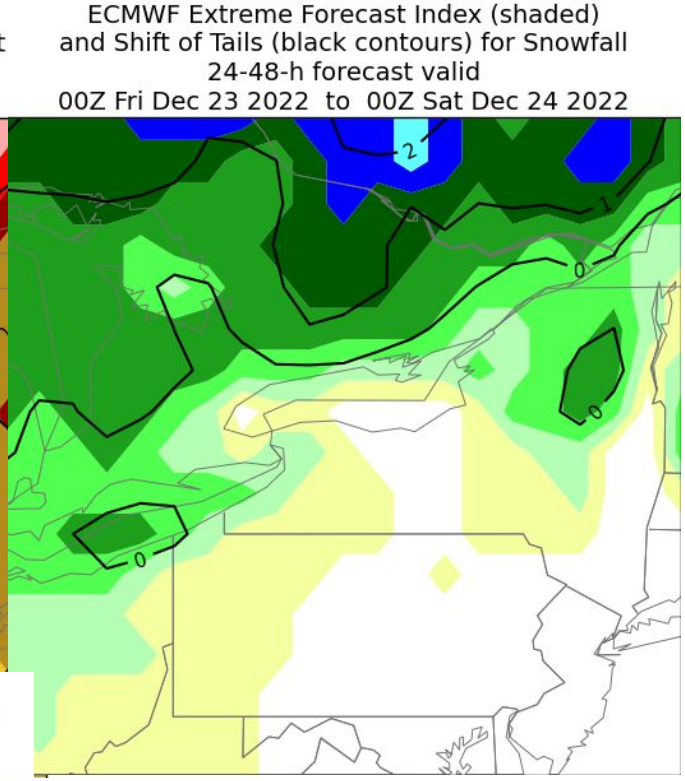


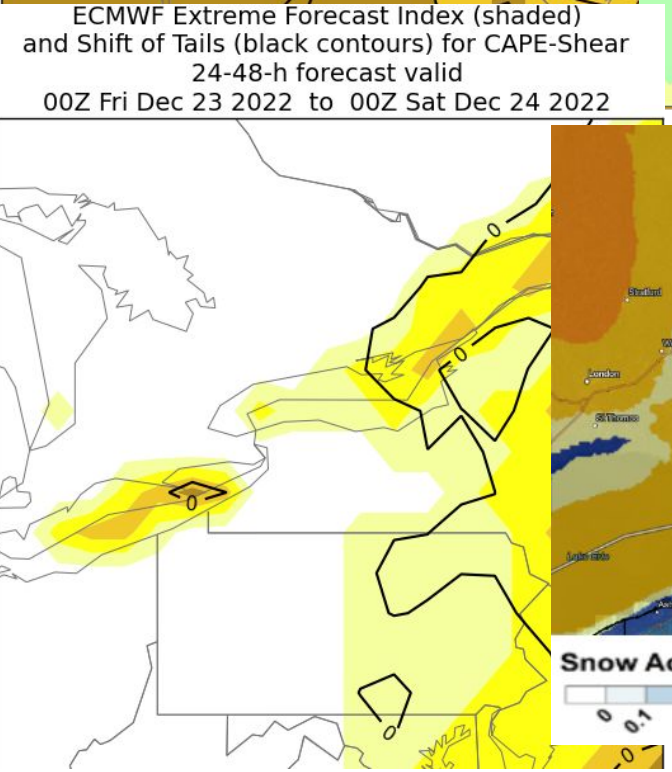
With SOT values less than 1 they really don't add any further detail then the EFI. EFI values over Lake Erie show values of 0.60-0.90 which may alert the forecaster to an unusual to potentially extreme event for cape shear.

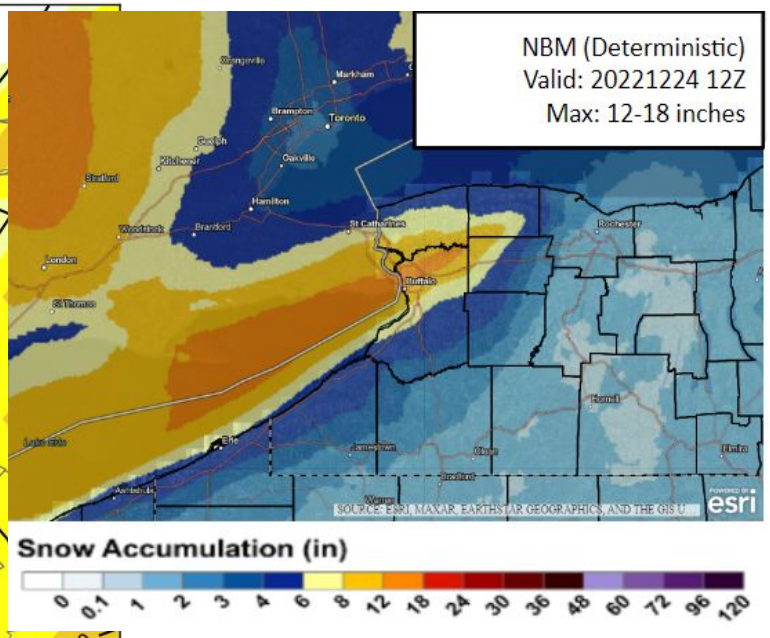
Relative to the ECMWF reforecasts from a 5 week period (2001 - 2022)
centered on the week this forecast was initialized











354 AM EST Thu Dec 22 2022

...BLIZZARD WARNING IN EFFECT FROM 7 AM FRIDAY TO 7 AM EST SUNDAY...

* WHAT...Blizzard conditions expected. Total snow accumulations of 1 to 3 feet. Winds gusting as high as 70 mph Friday and Friday night. A rapid switch from rain to snow with sharply falling temperatures into the teens and single digits will result in a flash freeze on Friday. Blizzard conditions will develop Friday afternoon lasting into Saturday night.

* WHERE...Niagara, Orleans, Erie, and Genesee counties.

* WHEN...From 7 AM Friday to 7 AM EST Sunday.

* IMPACTS...Travel will be very difficult to impossible at times. Widespread blowing snow could significantly reduce visibility. Very strong winds could cause extensive tree damage and numerous power outages. The cold wind chills as low as 10 to 20 below zero could cause frostbite on exposed skin in as little as 30 minutes.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Strong winds will cause significant blowing and drifting snow, frequently reducing visibilities to zero. Travel is strongly discouraged.

Final Thoughts

- Throughout the event the NBM was slightly underperforming in snowfall forecast until Day 1.
  - This could have been because of the NBMs model weights from Day 3 to Day 2 and even Day 2 to Day 1.
- What are some things that could have contributed to this issue?
  - Latent Heat Release - How did NBM handle the thermodynamics of this feature. Lake temperature dropped 7 degrees and lake Ice increased 20%
  - Was this in fact all latent heat release or was some of the cooling lake water a result of upwelling from the 10 foot seiche?


CENTER
LANE
ONLY