

Midwest Winter Storm February 16 - 17, 2023 12Z to 12Z

WPC Winter Weather Experiment

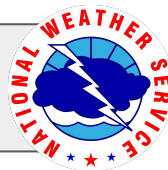
LANTERN Case Study

March 14, 2023

Zach Uttech

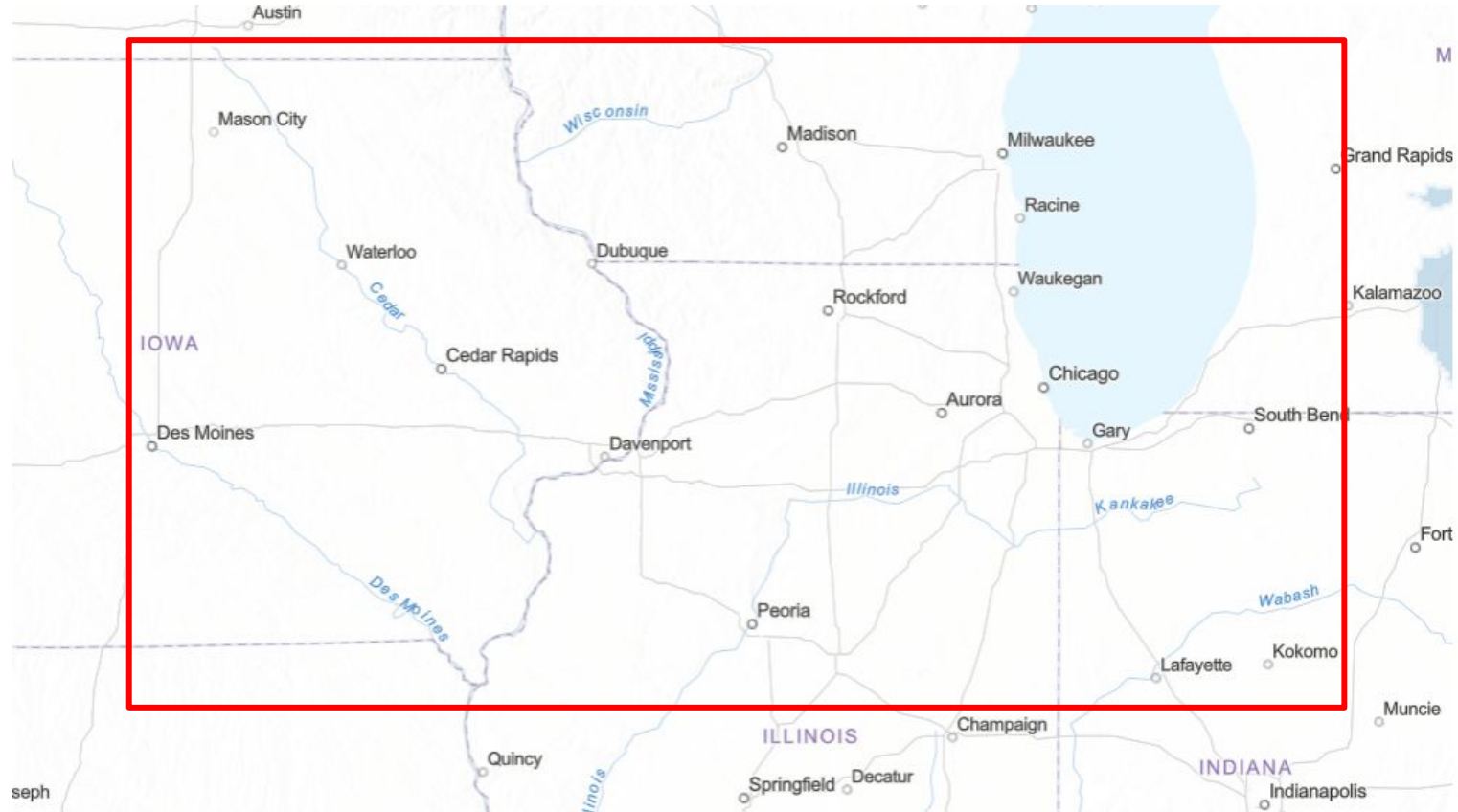
- **Meteorological Overview (2/15 - 2/17)**
 - Upper air to surface analysis
 - Model forecast anomalies and observed soundings
- **NWS Snow Forecasts and Headlines**
- **NOHRSC Observed Snowfall Analyses**
- **NBM 4.1 Snowfall Review: Day 3 to 1 (84 hrs, 60 hrs, and 36 hrs)**
 - Surveys and discussion questions

February 16 - 17, 2023
12Z to 12Z



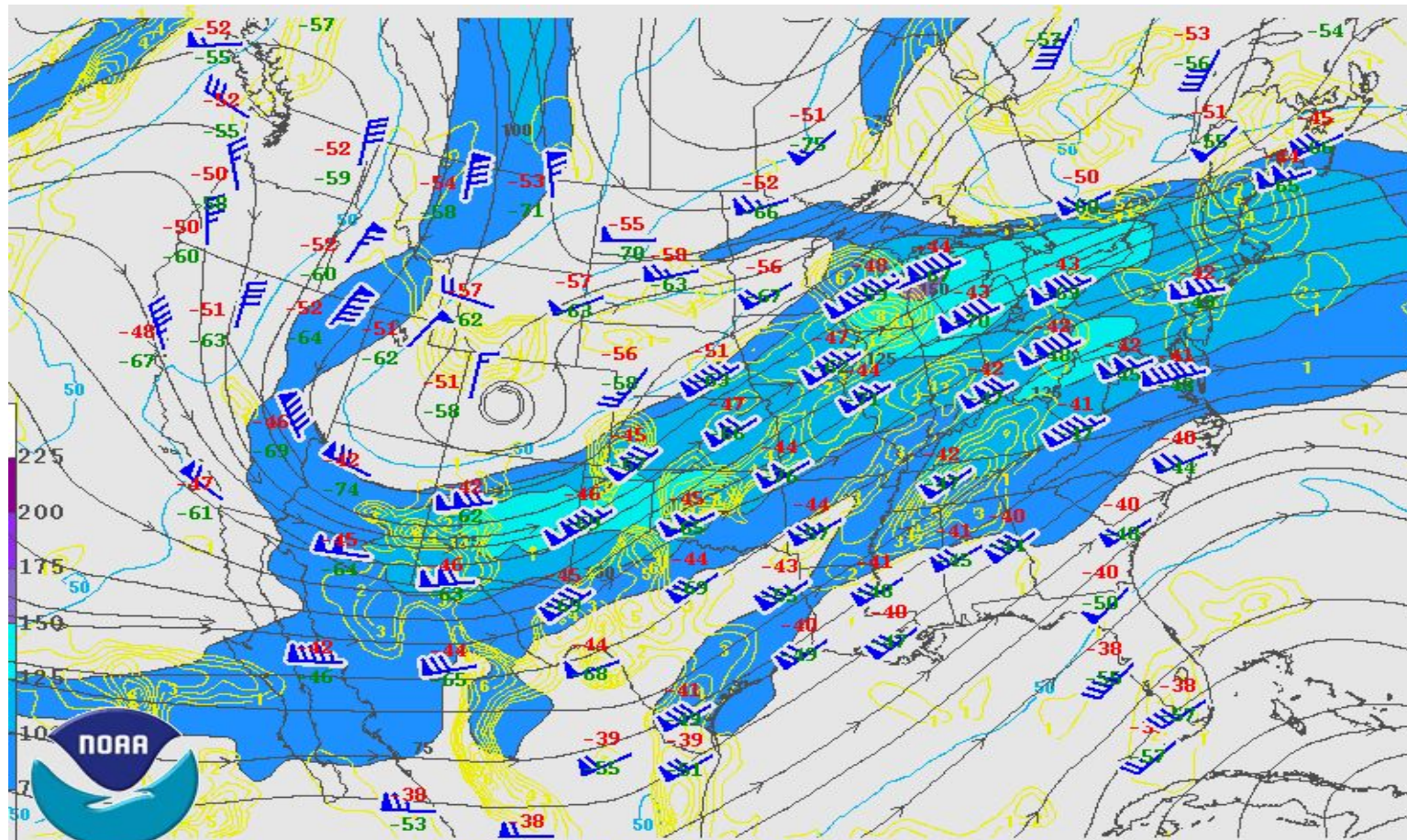
Area of Interest

Winter Weather Experiment
NBM 4.1 Evaluation



300mb Analysis - 2/16/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

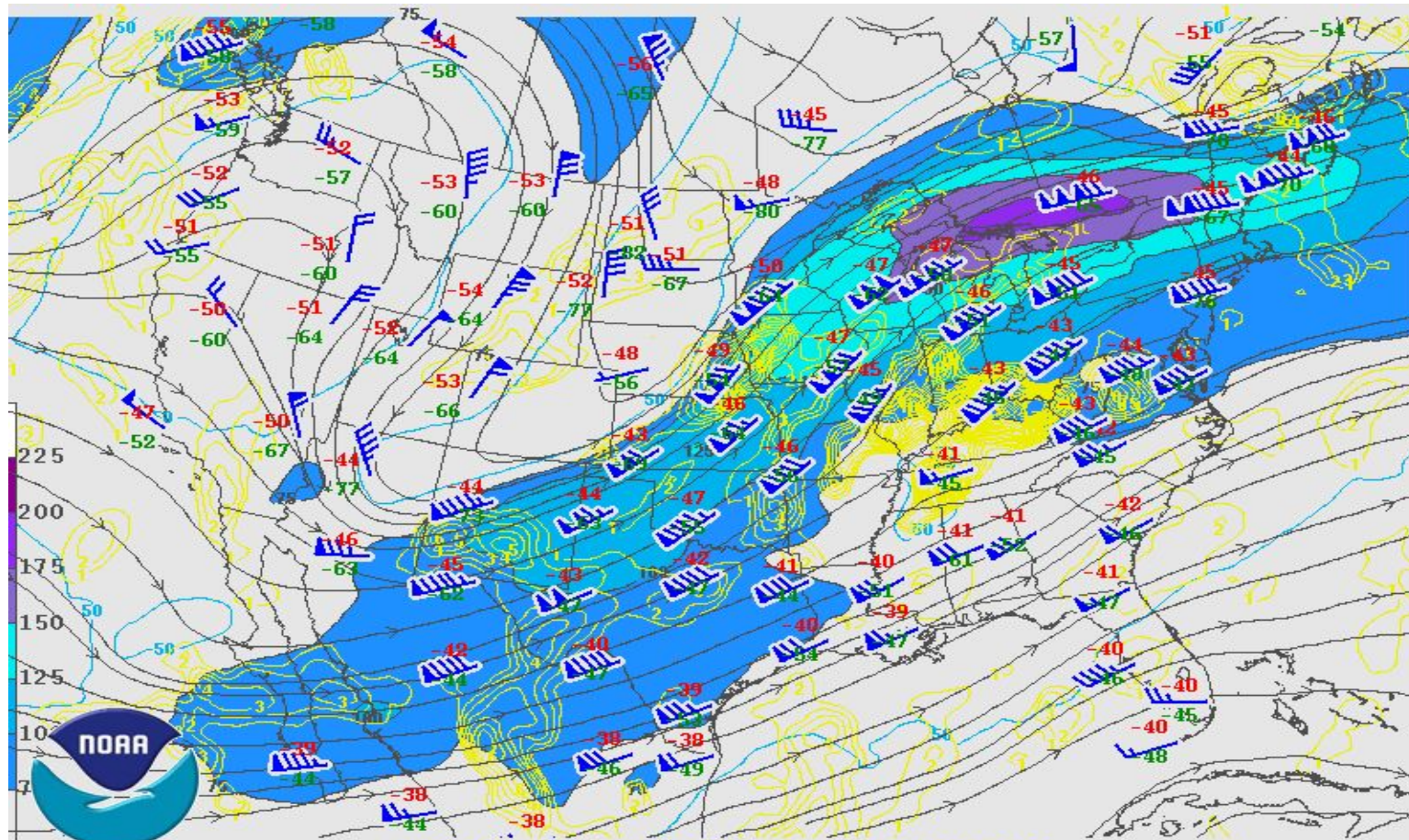


National Weather Service
Storm Prediction Center

230216/0000 300 MB UA OBS, ISOTACHS, STREAMLINES, DIVERGENCE

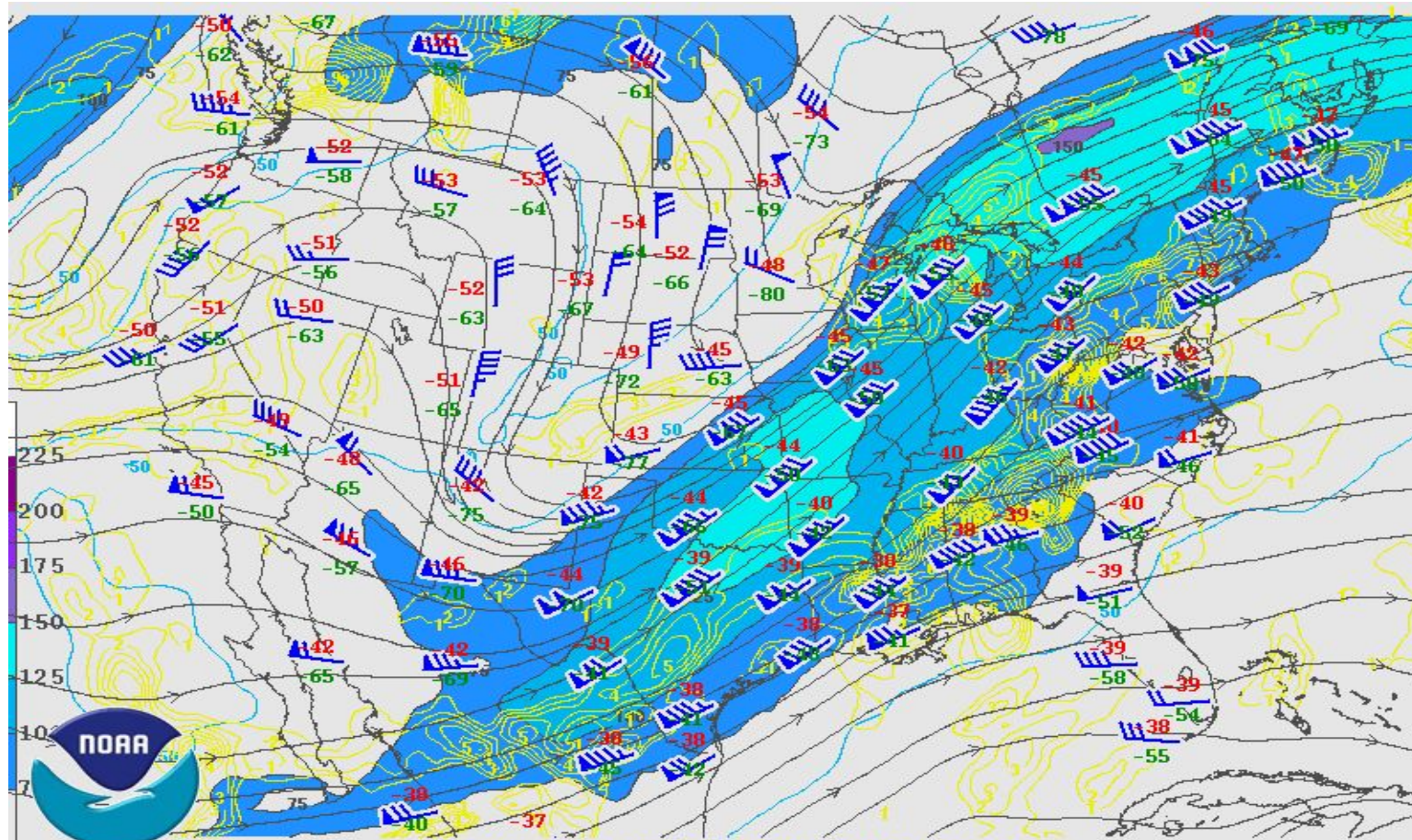
300mb Analysis - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation



300mb Analysis - 2/17/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

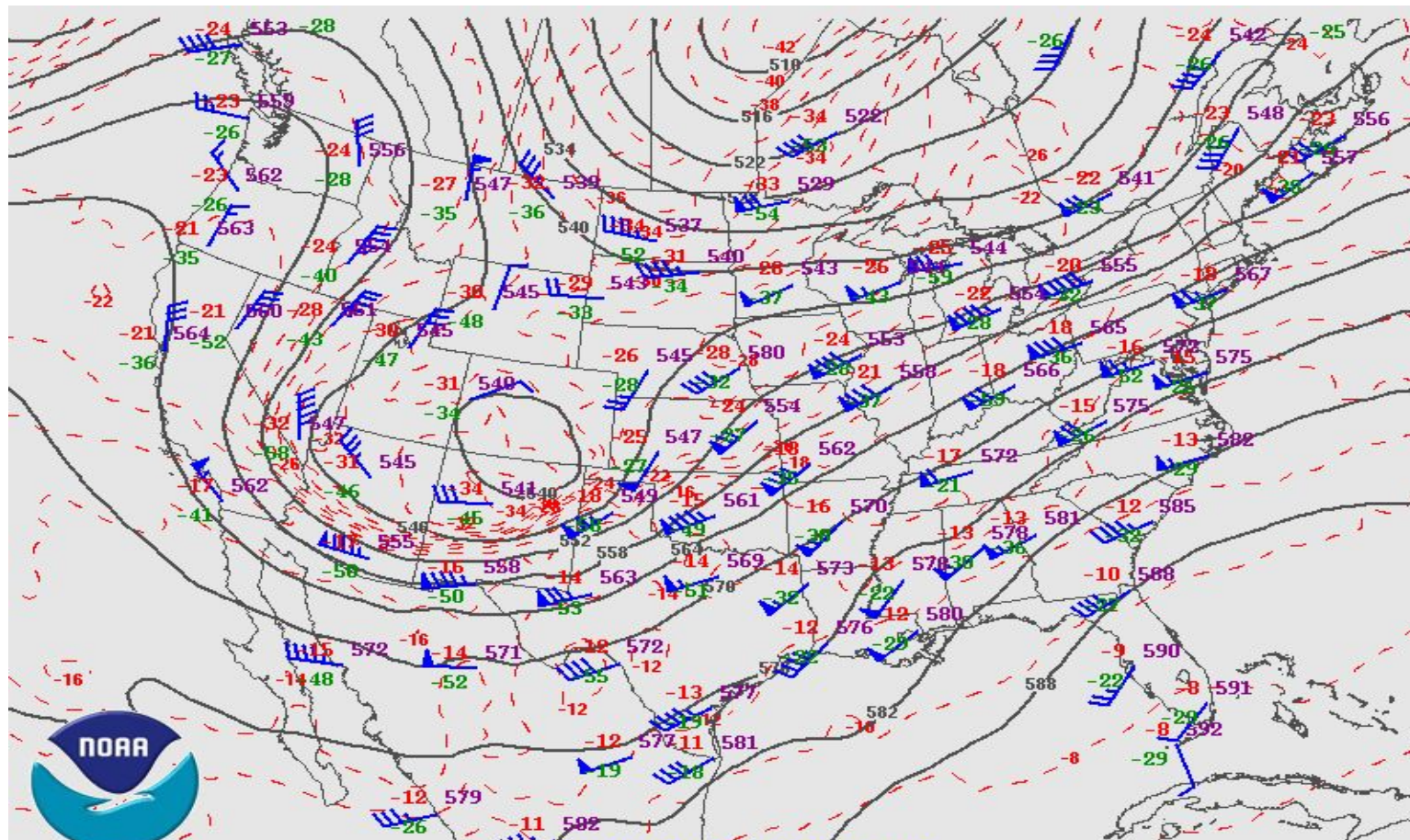


National Weather Service
Storm Prediction Center

230217/0000 300 MB UA OBS, ISOTACHS, STREAMLINES, DIVERGENCE

500mb Analysis - 2/16/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

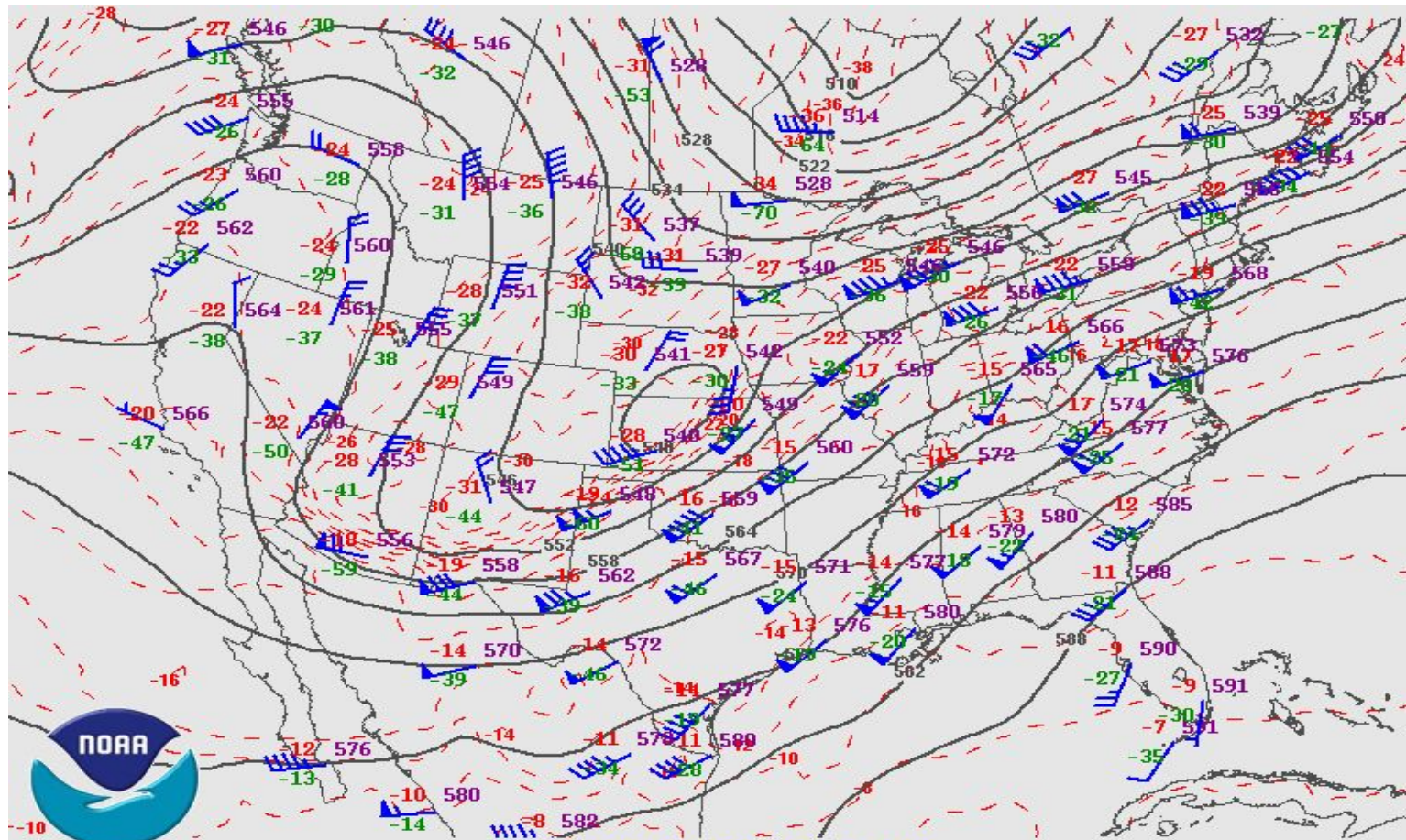


National Weather Service
Storm Prediction Center

230216/0000 500 MB UA OBS, HGHTS, and TEMPS

500mb Analysis - 2/16/23 12Z

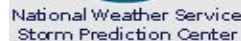
Winter Weather Experiment
NBM 4.1 Evaluation



National Weather Service
Storm Prediction Center

230216/1200 500 MB UA OBS, HGHTS, and TEMPS

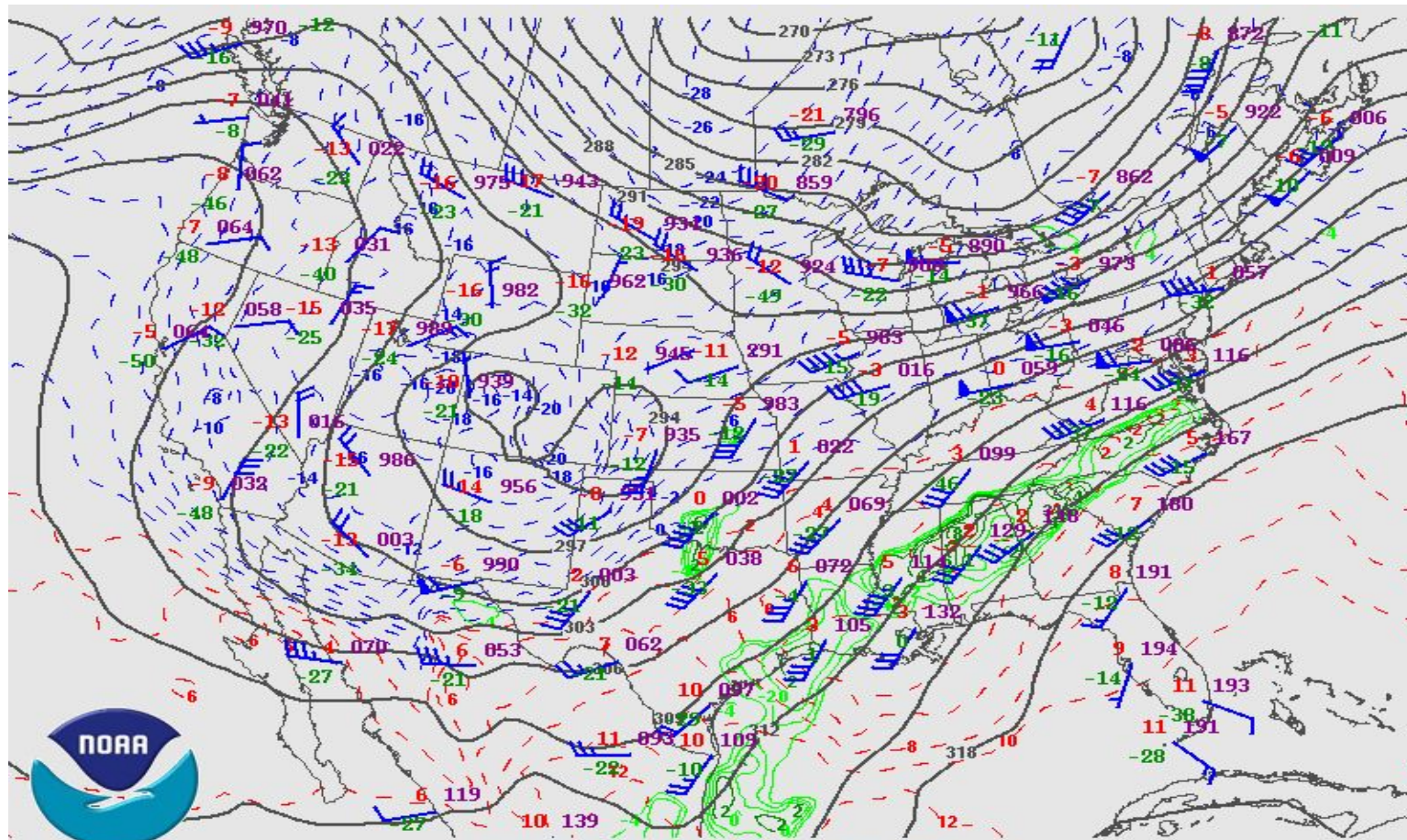
Winter Weather Experiment NBM 4.1 Evaluation



230217/0000 500 MB UA OBS, HGHTS, and TEMPS

700mb Analysis - 2/16/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

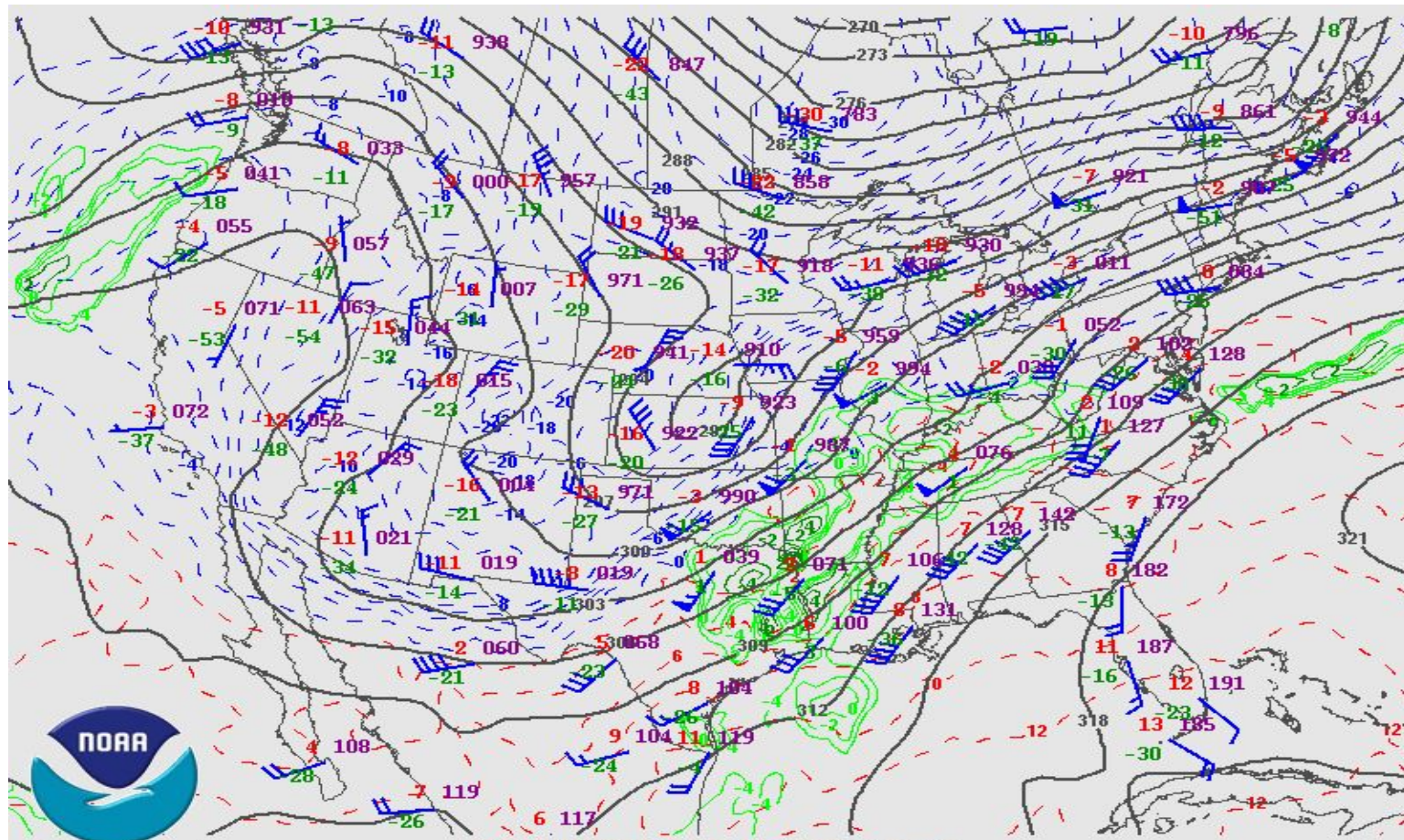


National Weather Service
Storm Prediction Center

230216/0000 700 MB UA OBS, HGHTS, TEMPS, Td>=-4

700mb Analysis - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation

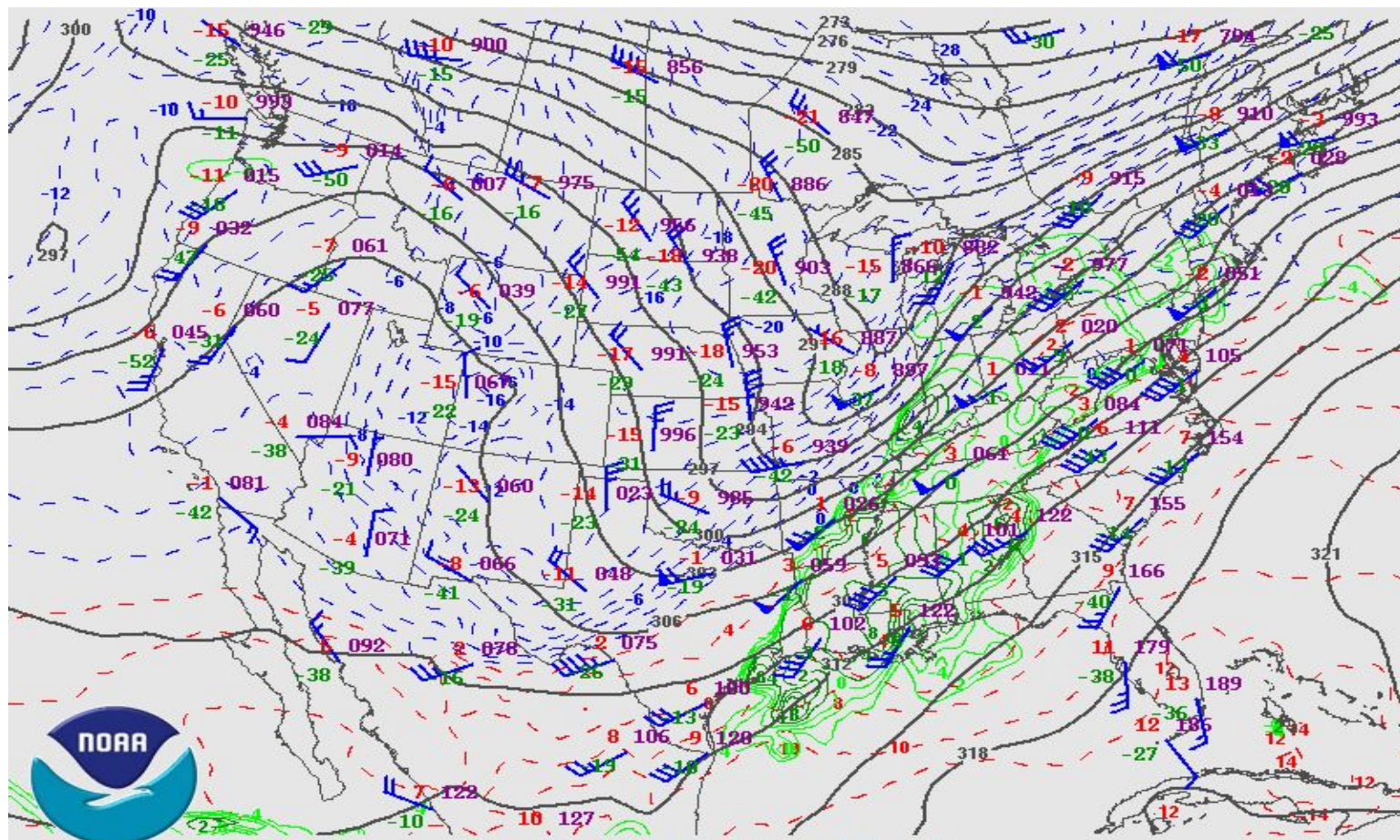


National Weather Service
Storm Prediction Center

230216/1200 700 MB UA OBS, HGHTS, TEMPS, Td>=-4

700mb Analysis - 2/17/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

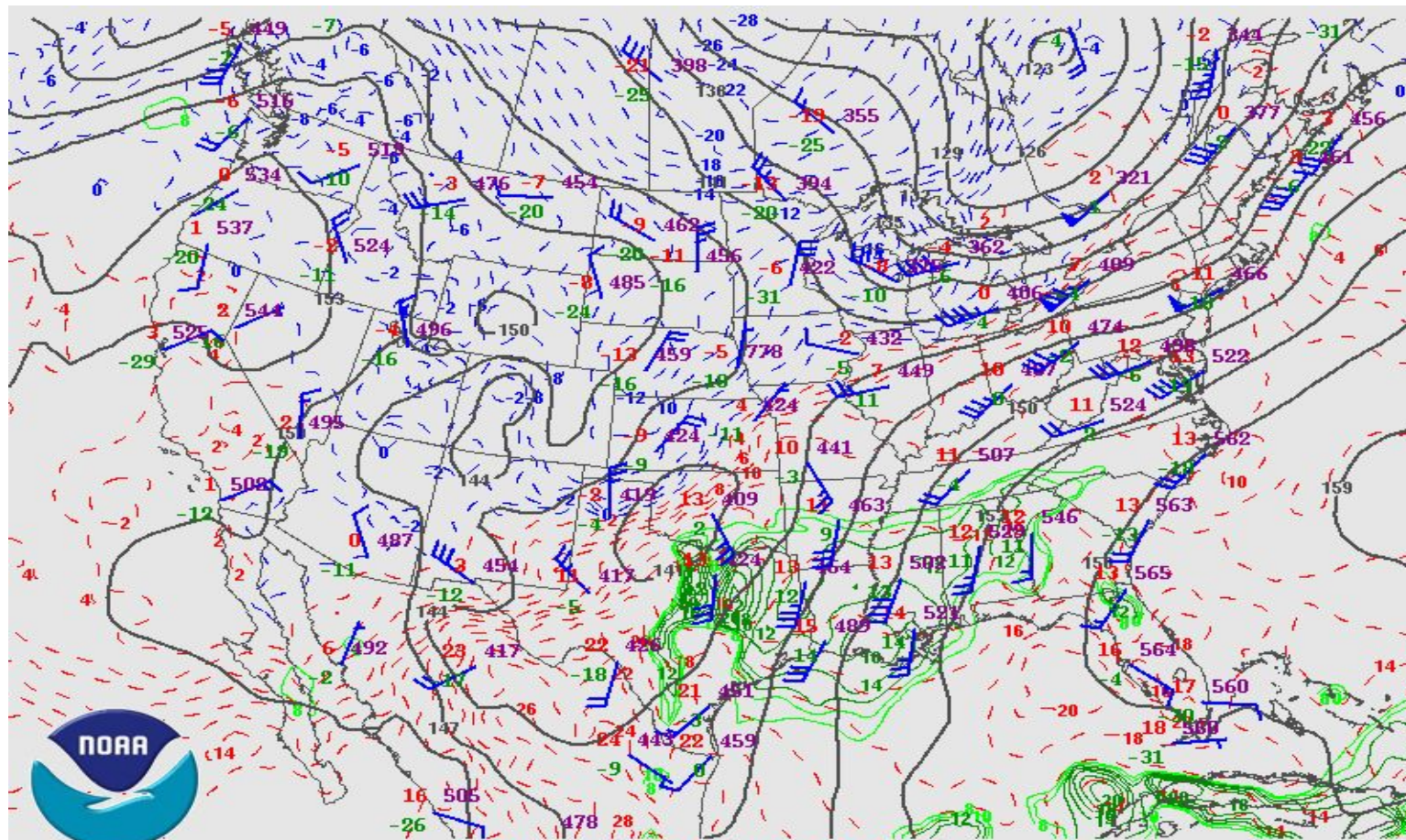


National Weather Service
Storm Prediction Center

230217/0000 700 MB UA OBS, HGHTS, TEMPS, Td>=-4

850mb Analysis - 2/16/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

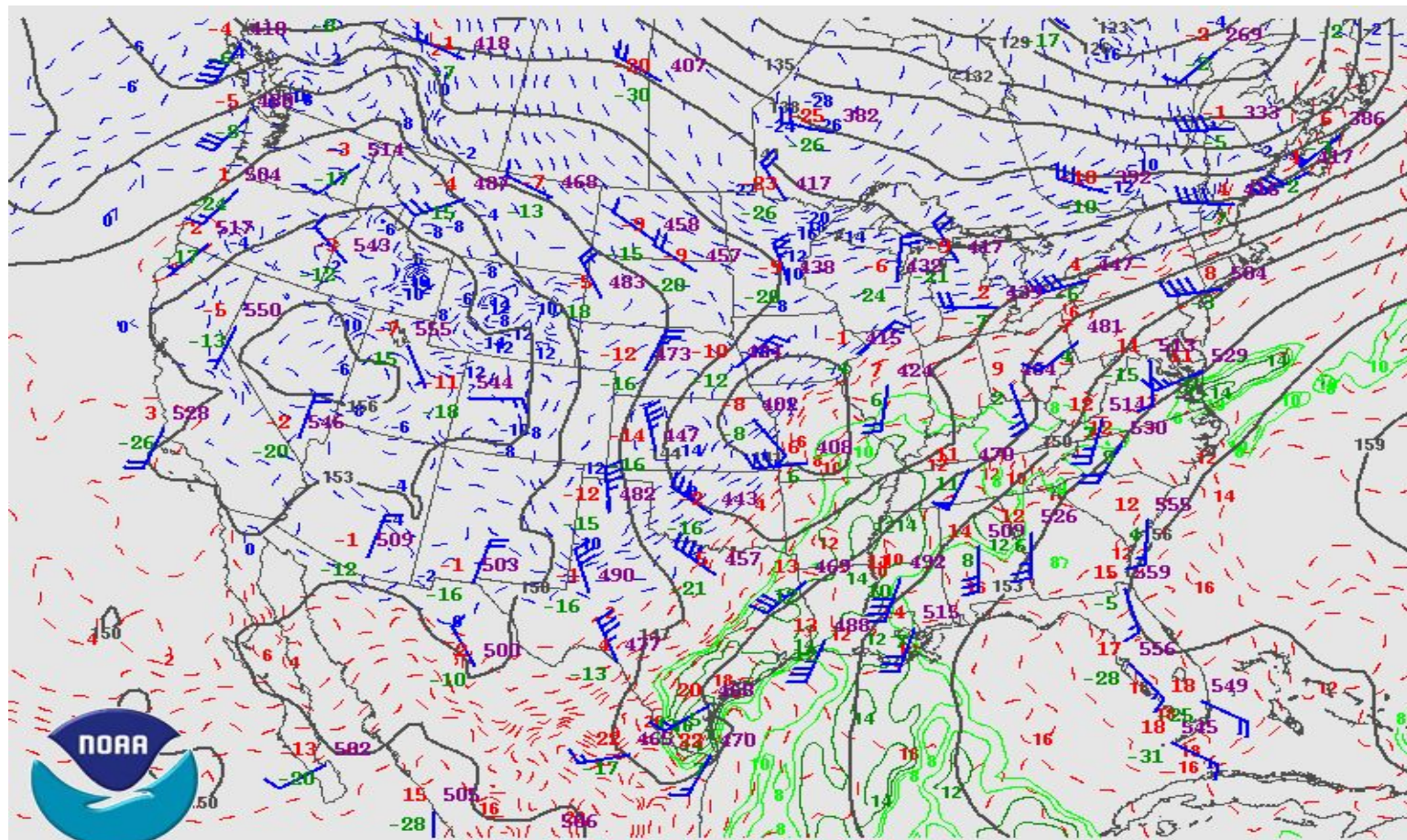


National Weather Service
Storm Prediction Center

230216/0000 850 MB UA OBS, HGHTS, TEMPS, Td>=8

850mb Analysis - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation

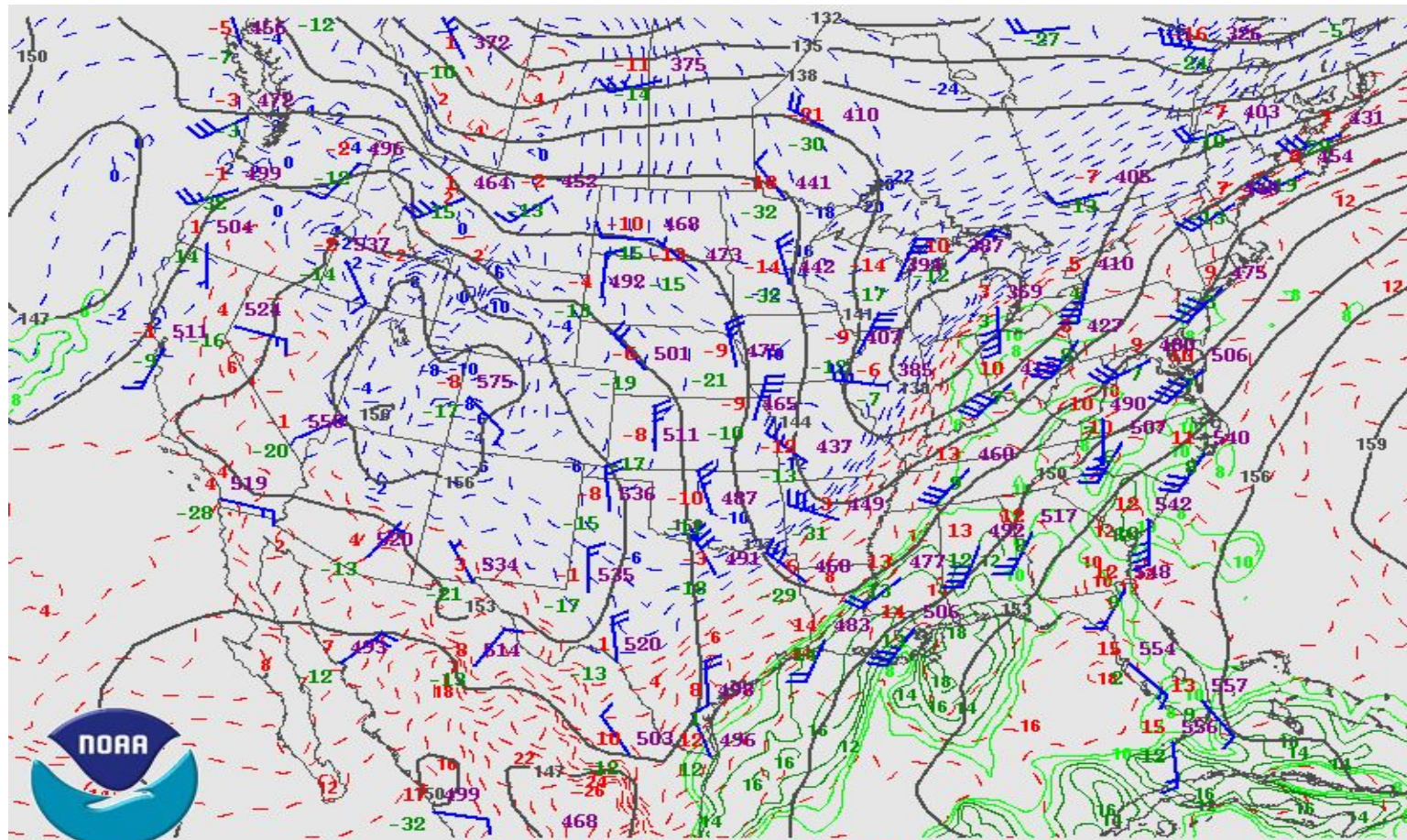


National Weather Service
Storm Prediction Center

230216/1200 850 MB UA OBS, HGHTS, TEMPS, Td>=8

850mb Analysis - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation



National Weather Service
Storm Prediction Center

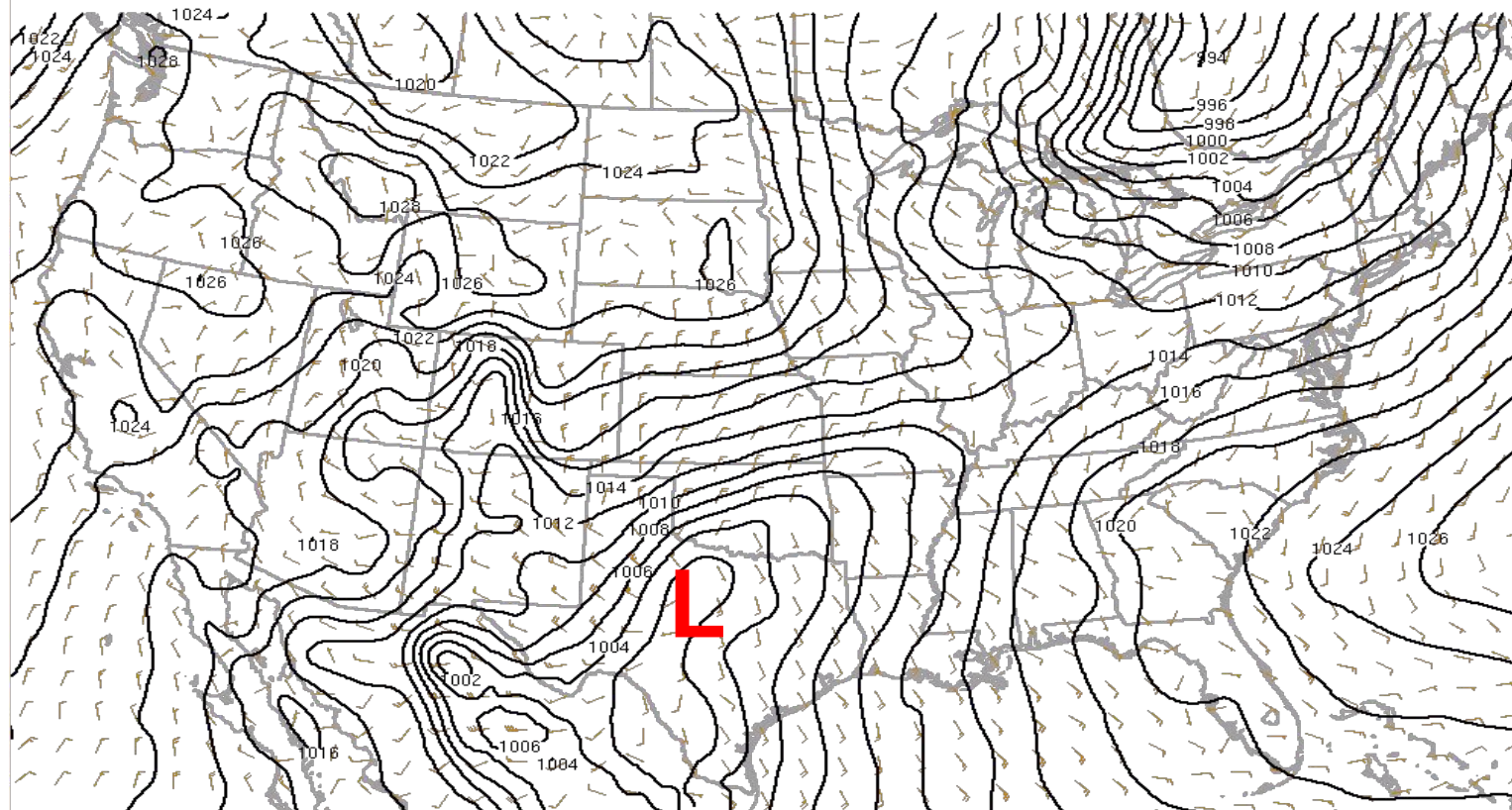
230217/0000 850 MB UA OBS, HGHTS, TEMPS, Td>=8

MSLP Analysis - 2/16/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

NOAA/NWS/Storm Prediction Center

Mesoscale Analysis Data



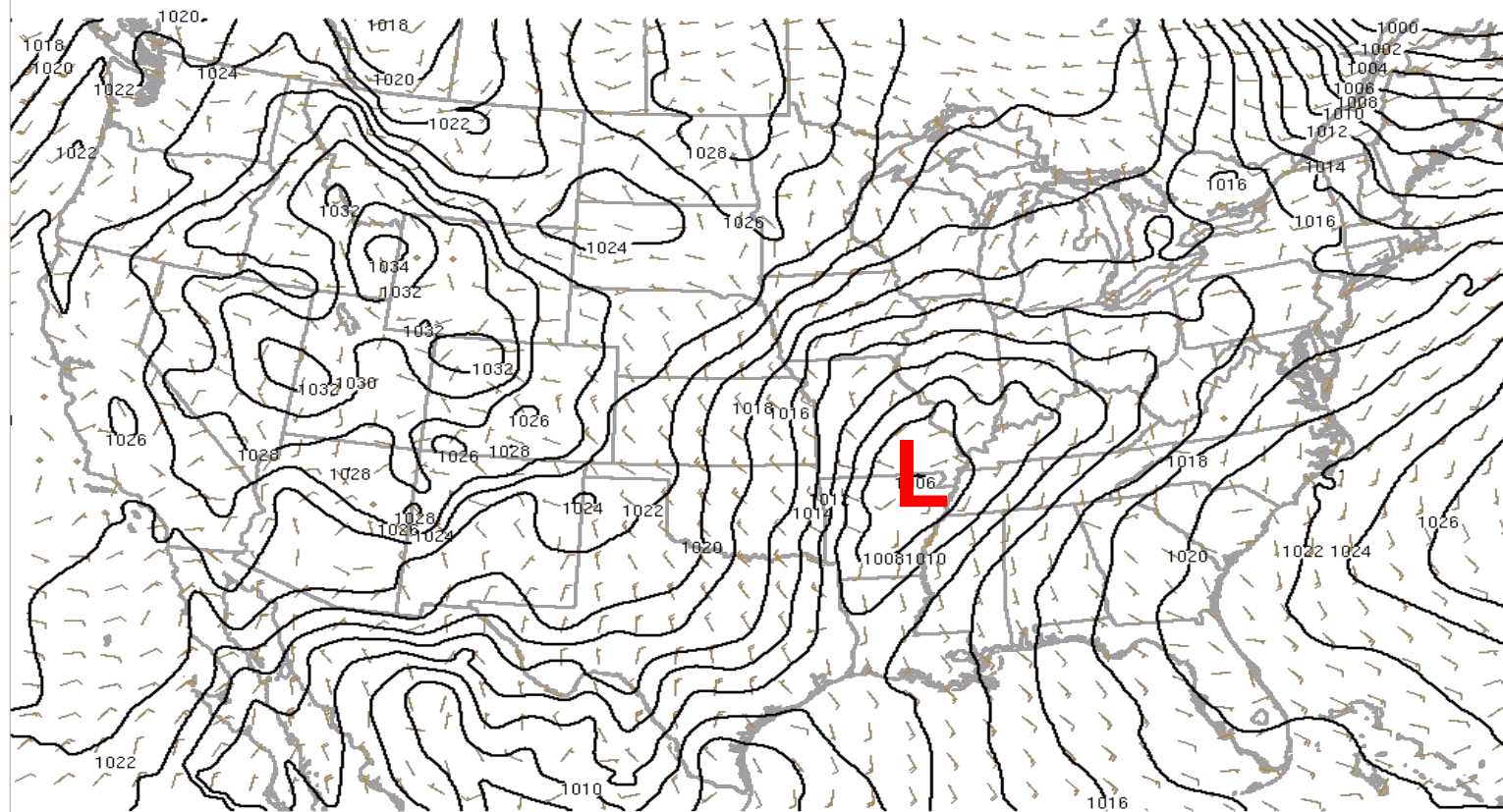
230216/0000 MSL Pressure and surface wind

MSLP Analysis - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation

NOAA/NWS/Storm Prediction Center

Mesoscale Analysis Data



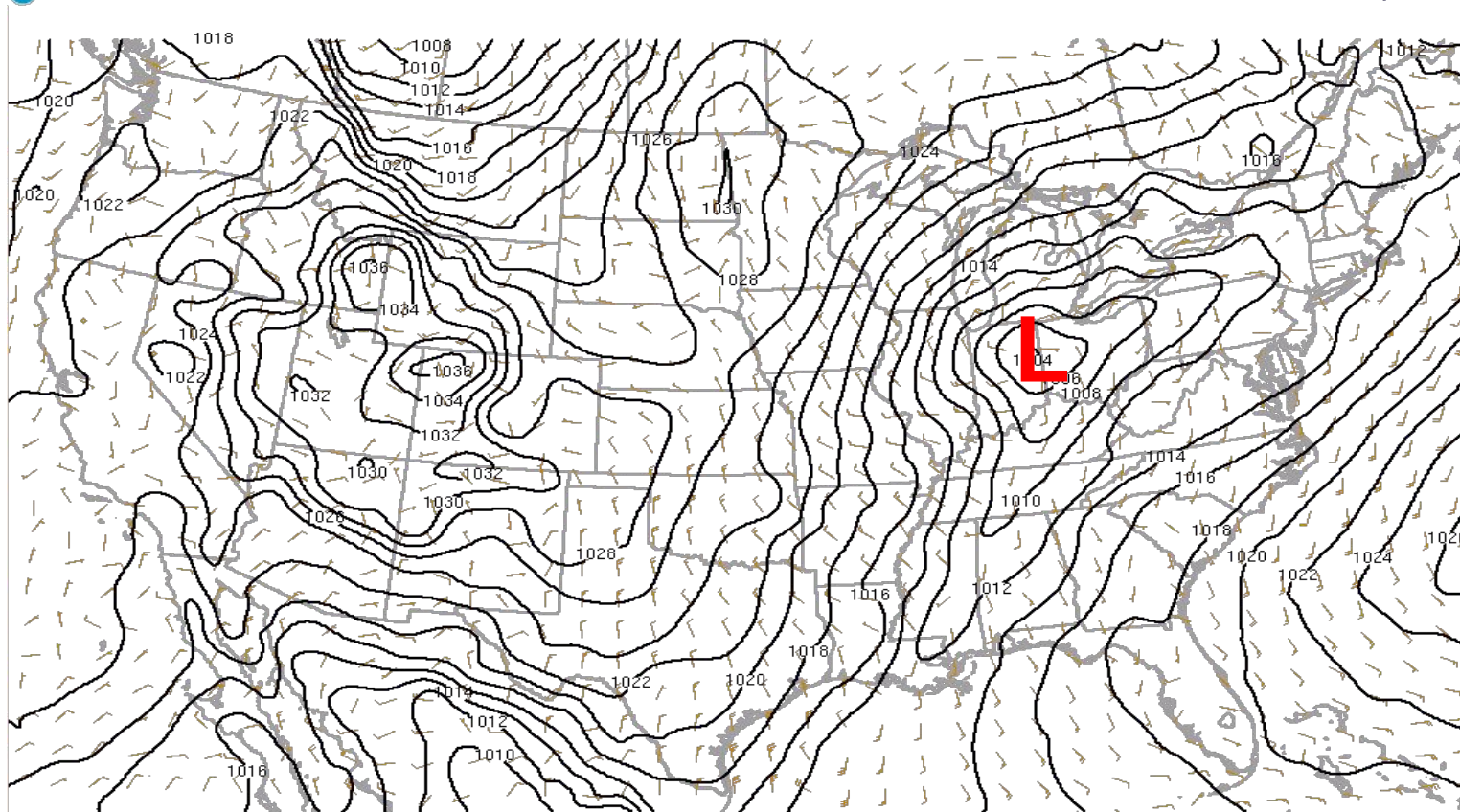
230216/1200 MSL Pressure and surface wind

MSLP Analysis - 2/17/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

NOAA/NWS/Storm Prediction Center

Mesoscale Analysis Data



230217/0000 MSL Pressure and surface wind

Sfc Temp Analysis - 2/16/23 13Z

Winter Weather Experiment
NBM 4.1 Evaluation

HREF

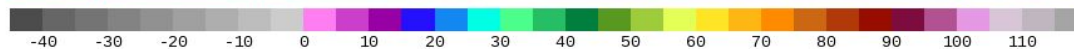
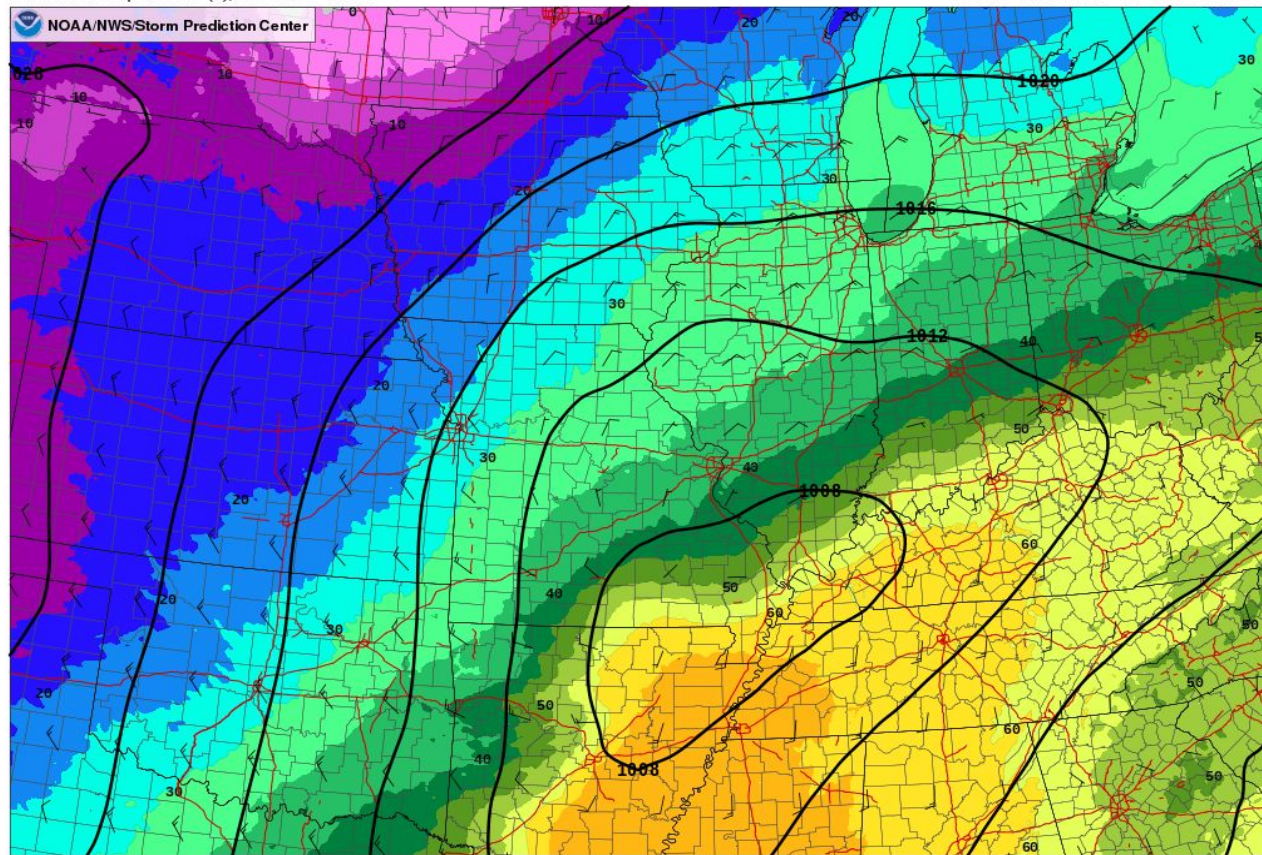
MN[MSLP] (mb)

MN[10 m Vh] (kt)

Run: Thu 2023-02-16 12:00 UTC

2 m AGL Temperature (F), ensemble mean

Valid: Thu 2023-02-16 13:00 UTC



PWAT Analysis - 2/16/23 13Z

Winter Weather Experiment
NBM 4.1 Evaluation

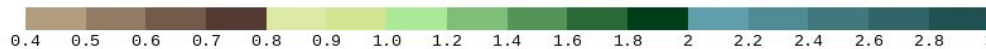
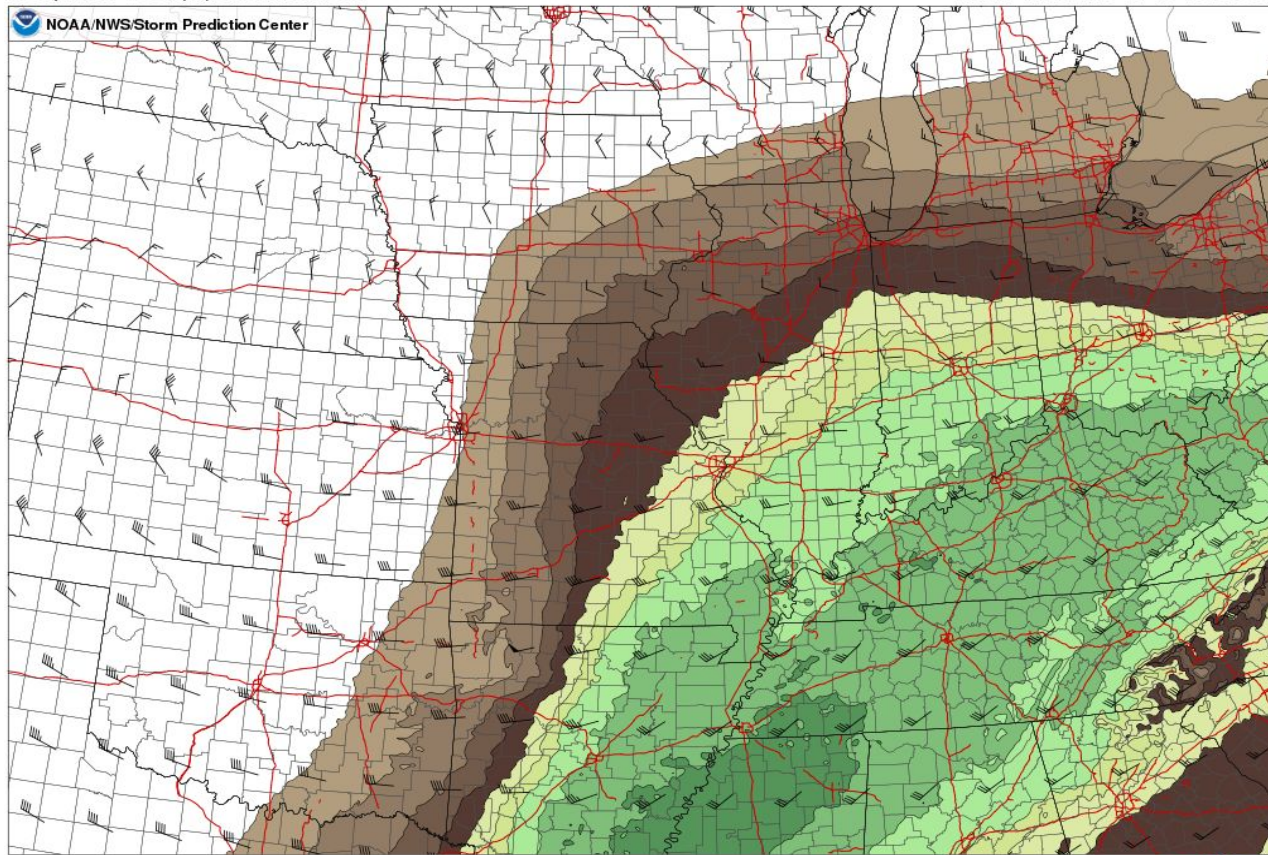
HREF

MN[Storm motion] (kt)

Run: Thu 2023-02-16 12:00 UTC

Precipitable Water (in.), ensemble mean

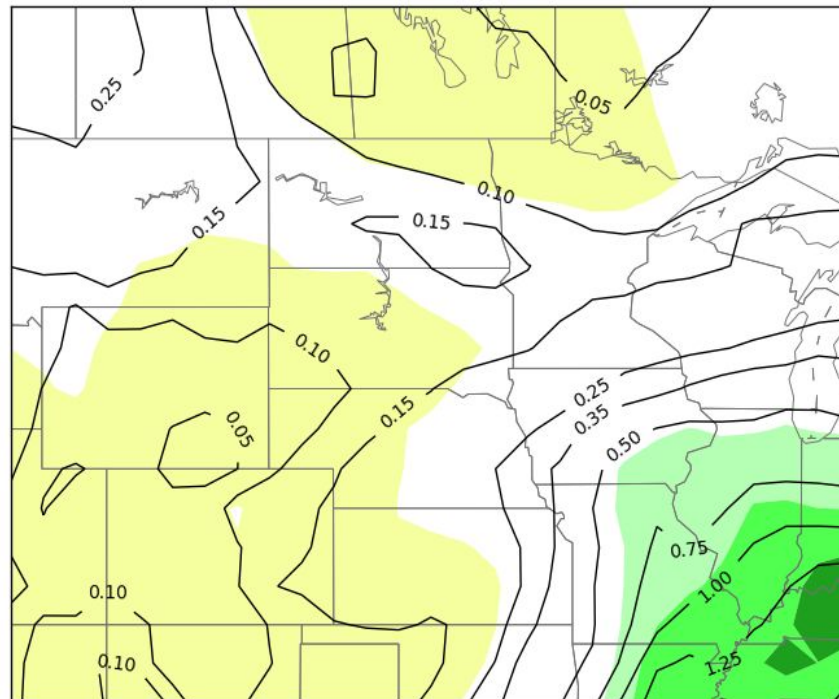
Valid: Thu 2023-02-16 13:00 UTC



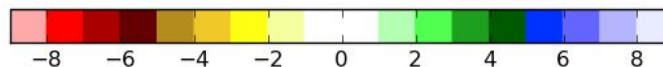
NAEFS PWAT Anomalies - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation

NAEFS Mean Precipitable Water (in) and Standardized Anomaly
HOUR 000 - VALID 12:00 UTC Thu Feb 16 2023



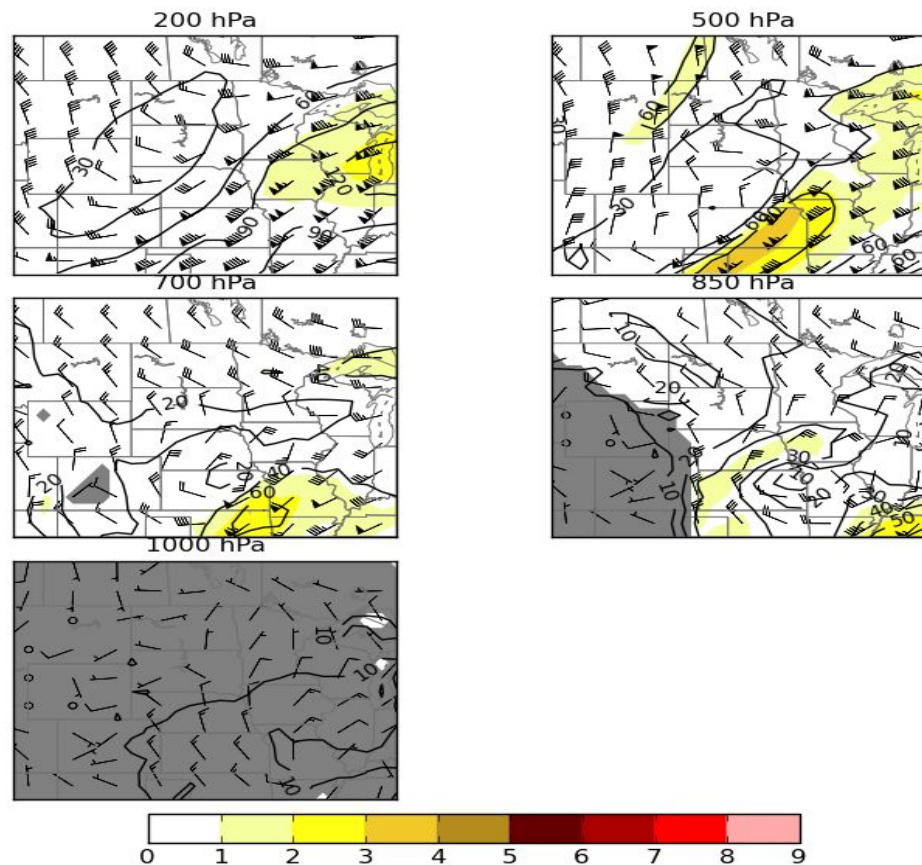
Relative to the 06-Feb to 27-Feb 1979-2009 CFSR climatology



NAEFS PWAT Anomalies - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation

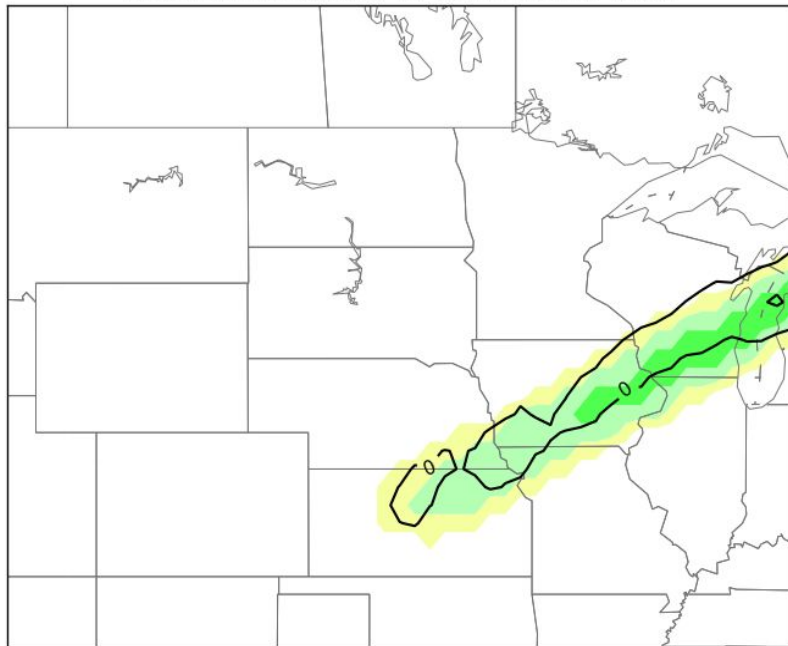
NAEFS Mean Wind Speed (kt) and Standardized Anomaly
HOUR 000 - VALID 12:00 UTC Thu Feb 16 2023



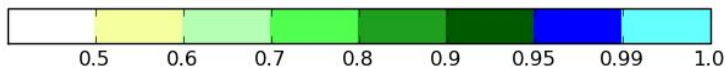
ECMWF Extreme Forecast Index

Winter Weather Experiment
NBM 4.1 Evaluation

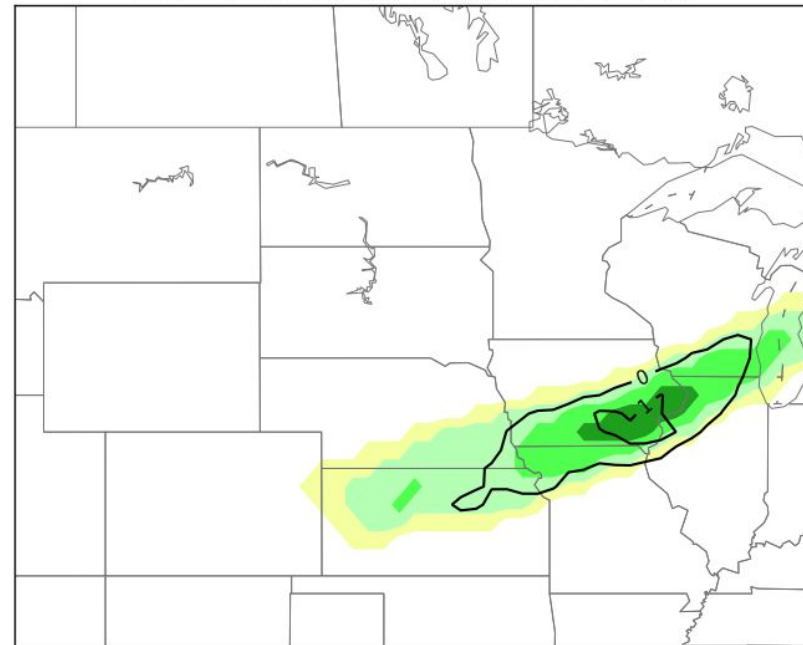
ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Snowfall
60-84-h forecast valid
00Z Thu Feb 16 2023 to 00Z Fri Feb 17 2023



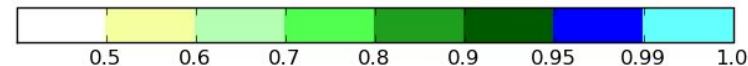
Relative to the ECMWF reforecasts from a 5 week period (2002 - 2023)
centered on the week this forecast was initialized



ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for Snowfall
24-48-h forecast valid
00Z Thu Feb 16 2023 to 00Z Fri Feb 17 2023



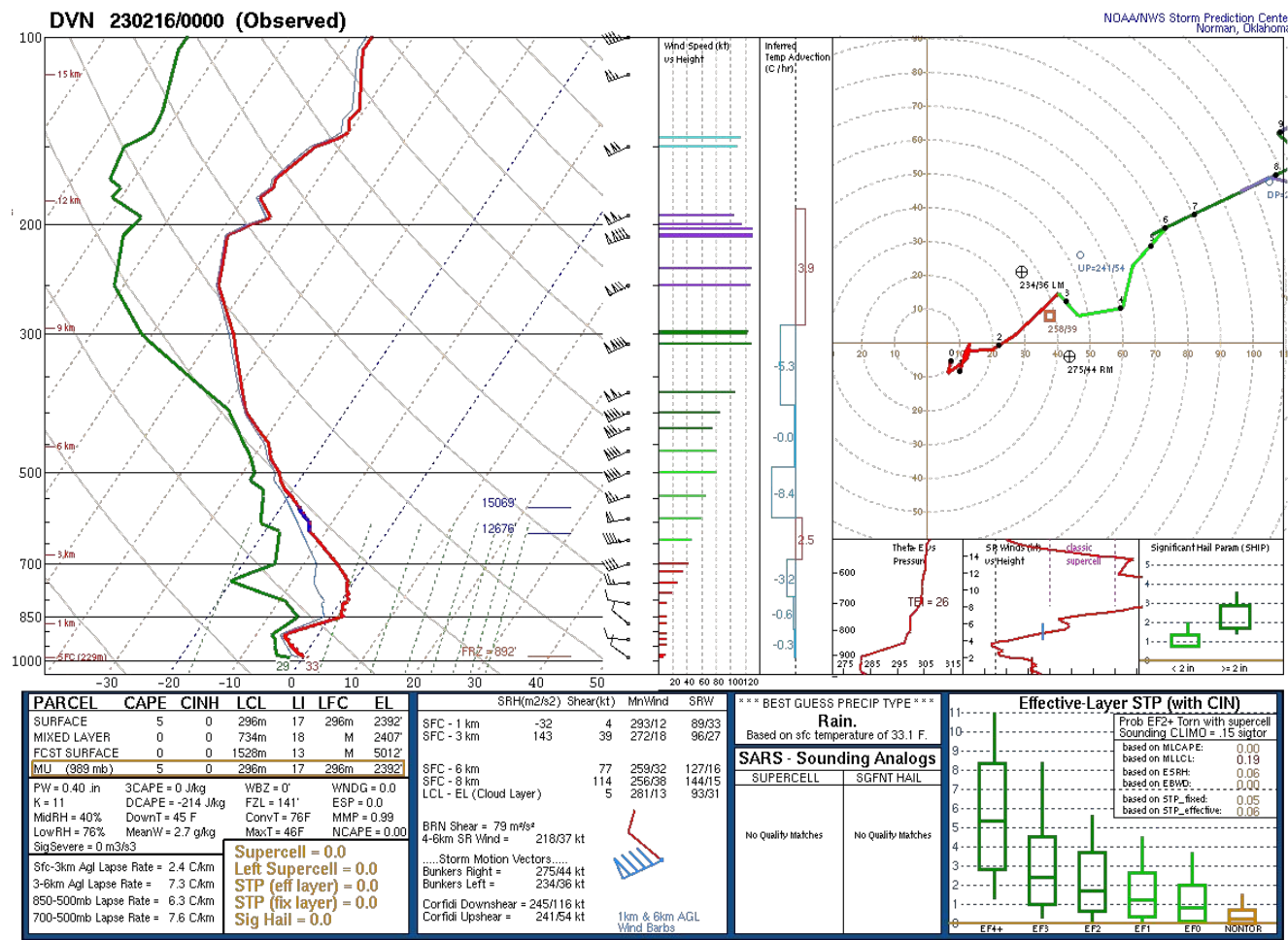
Relative to the ECMWF reforecasts from a 5 week period (2002 - 2023)
centered on the week this forecast was initialized



DVN Sounding - 2/16/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

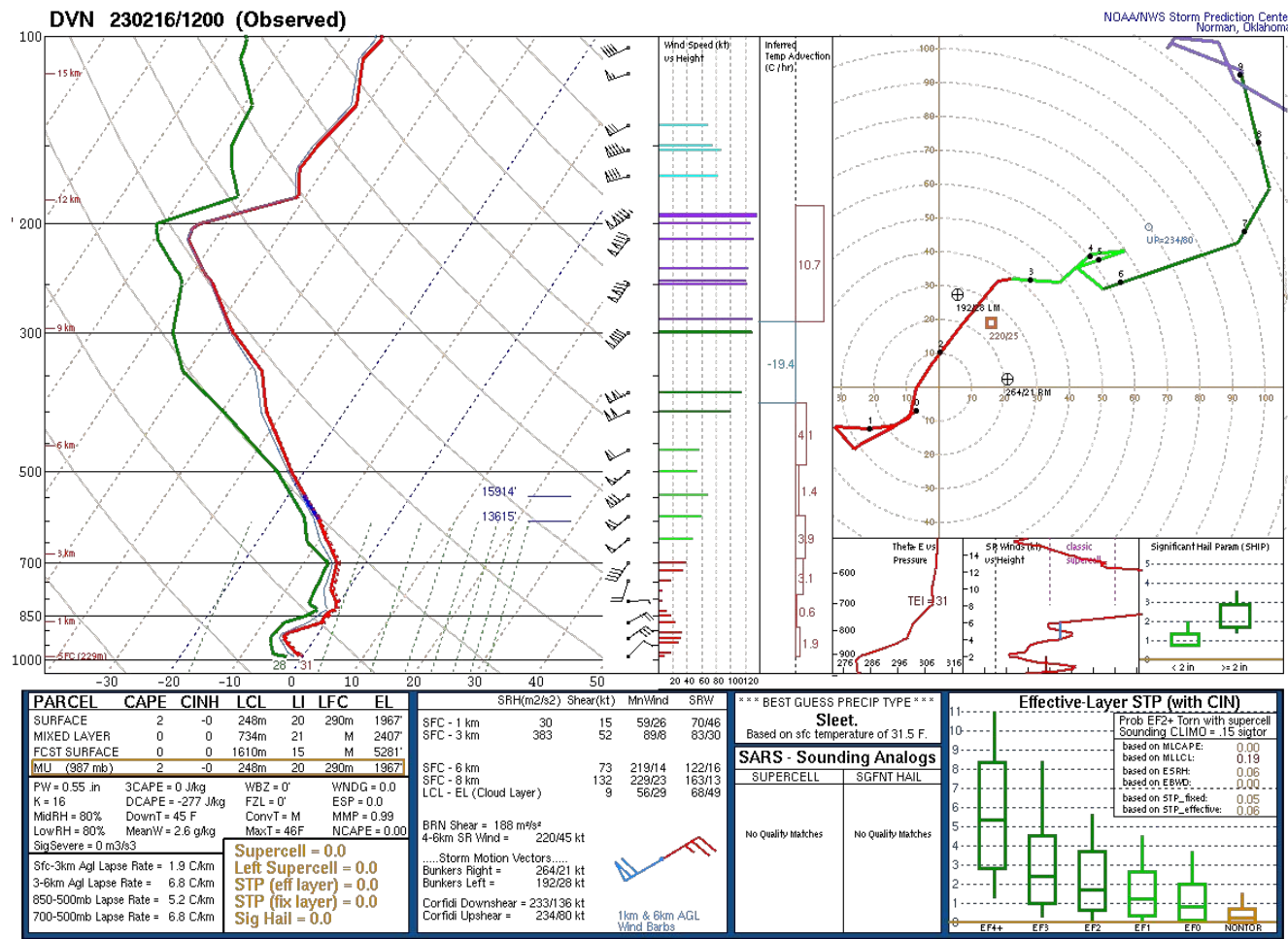
- Warm thermal profile aloft near to slightly above freezing prior to precipitation onset



DVN Sounding - 2/16/23 12Z

Winter Weather Experiment
NBM 4.1 Evaluation

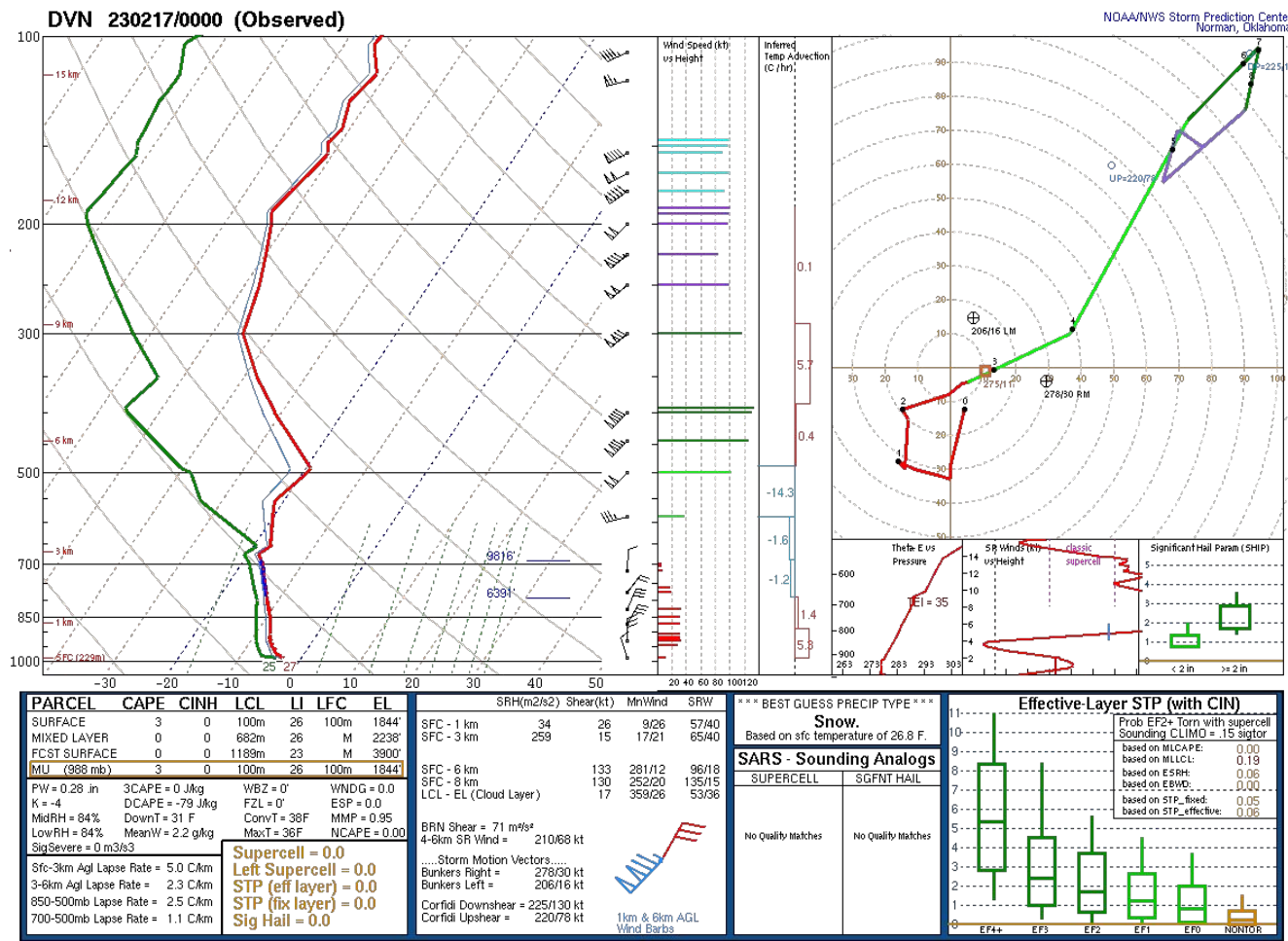
- Temperatures near freezing between 825-850mb as precipitation begins



DEVN Sounding - 2/17/23 00Z

Winter Weather Experiment
NBM 4.1 Evaluation

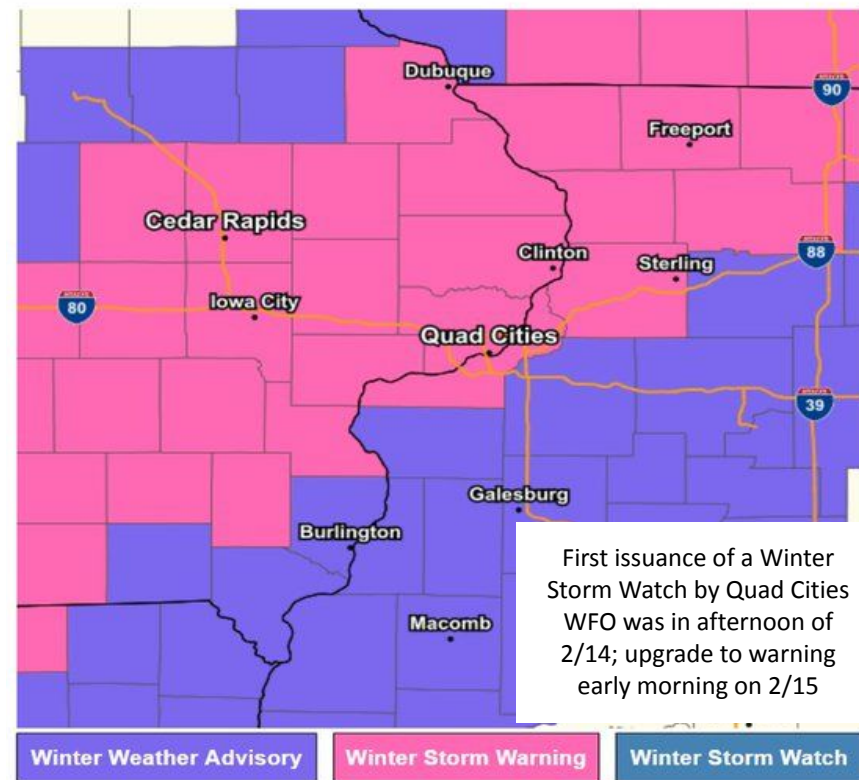
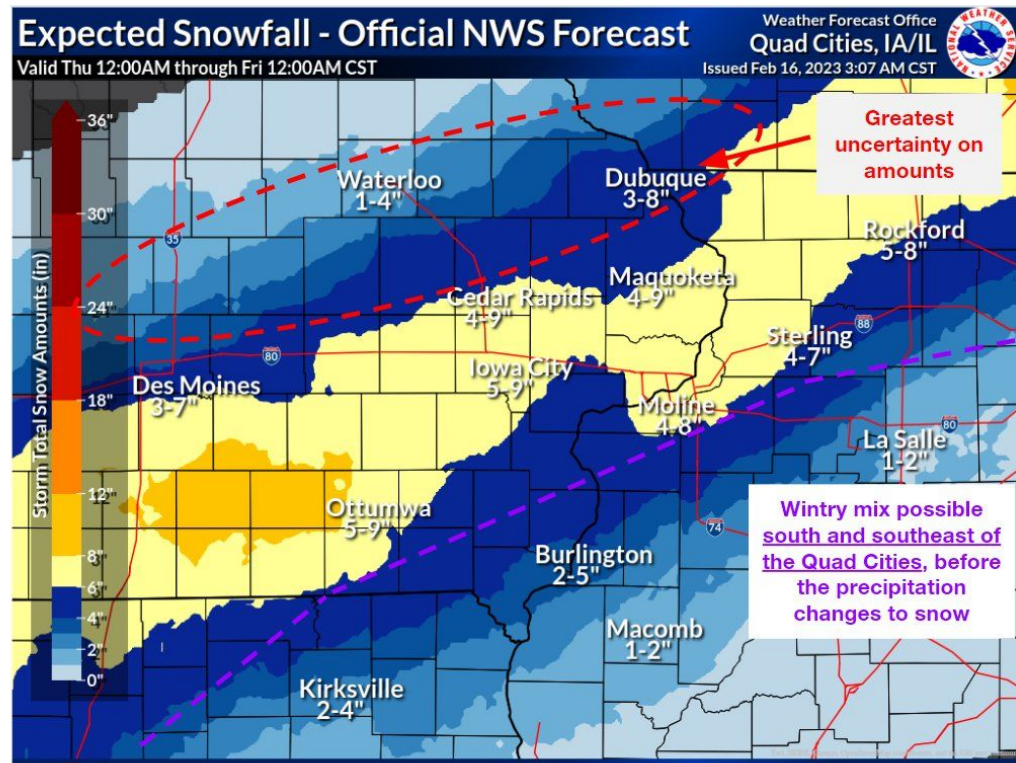
- Significant cooling aloft during the event
- SLRs jumped from near or slightly below 10:1 for the first phase of the event to 30 - 40:1 for the last round of snow late afternoon and evening of 2/16



NWS Snow Forecast and Headlines

Winter Weather Experiment
NBM 4.1 Evaluation

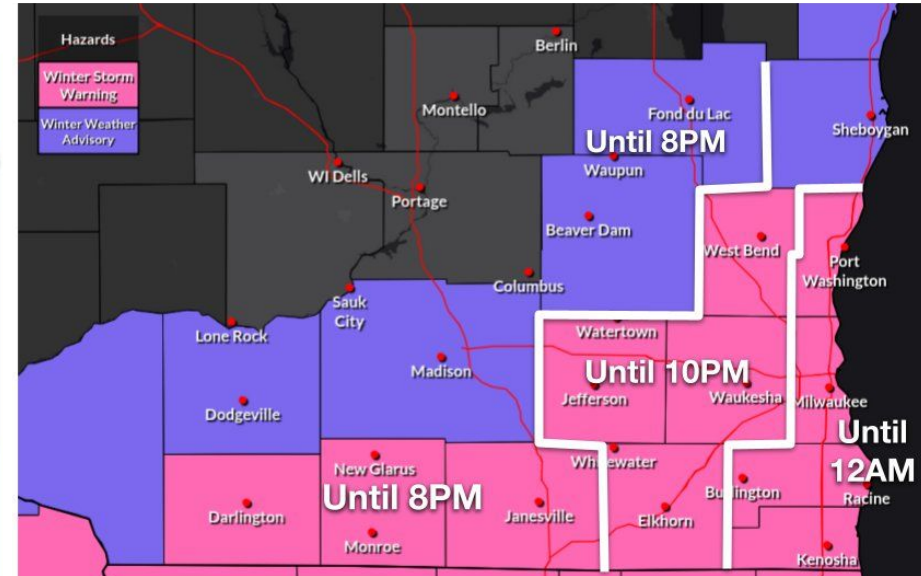
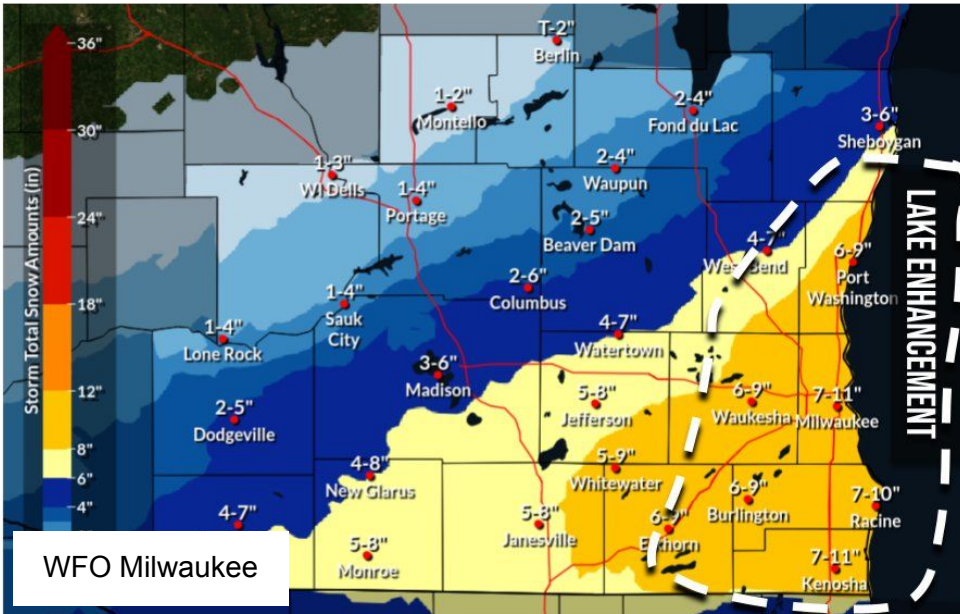
Forecast valid 06Z 2/16 - 06Z 2/17



NWS Snow Forecast and Headlines

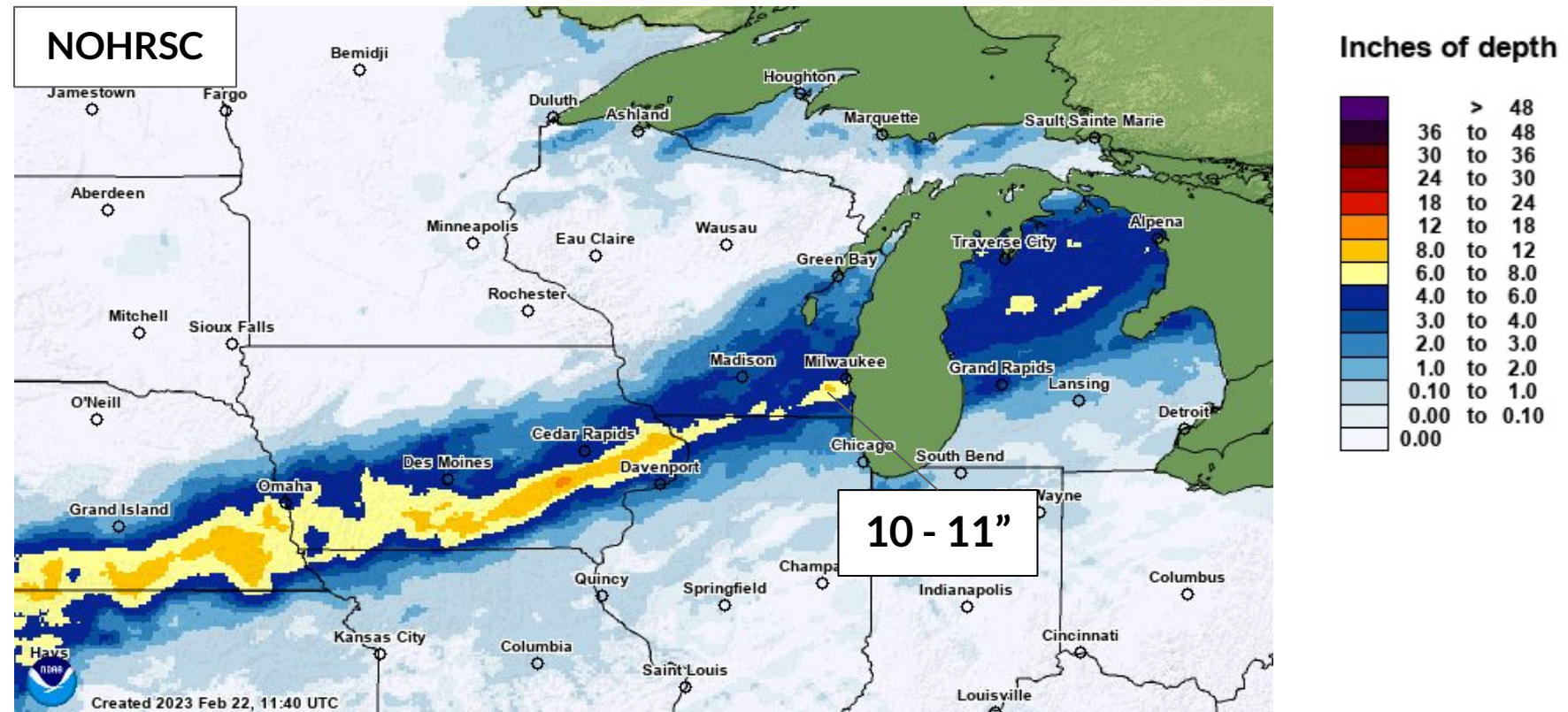
Winter Weather Experiment
NBM 4.1 Evaluation

Forecast valid 12Z 2/16 - 12Z 2/17



48 Hour Observed Snowfall

Winter Weather Experiment
NBM 4.1 Evaluation

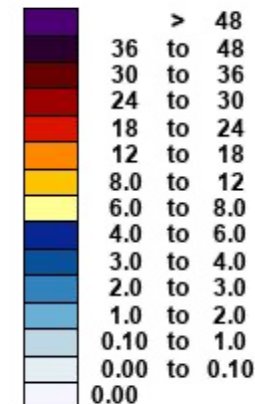


24 hr Observed Snowfall - Previous Day

Winter Weather Experiment
NBM 4.1 Evaluation

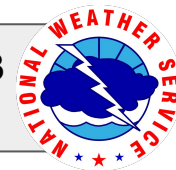
NOHRSC

Inches of depth



5 - 7"

February 15 - 16, 2023
12Z to 12Z



Created 2023 Feb 21, 11:25 UTC

24 hr Observed Snowfall

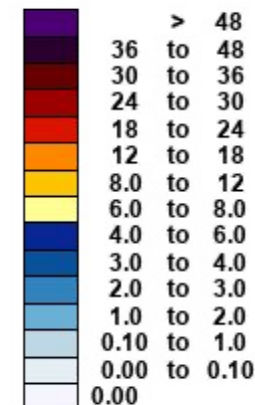
Winter Weather Experiment
NBM 4.1 Evaluation

NOHRSC

8"

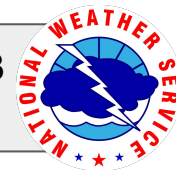
10 - 11"

Inches of depth



Created 2023 Feb 22, 11:25 UTC

February 16 - 17, 2023
12Z to 12Z



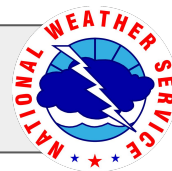
MKE ASOS Observations on 2/16/2023

Winter Weather Experiment
NBM 4.1 Evaluation

Feb 16, 7:38 pm	25	21	85	12	N	17G28 1.50	Lt snow, Blowing snow	BKN013 OVC020
Feb 16, 7:16 pm	26	21	81	13	NNW	17G30 1.00	Lt snow, Blowing snow	OVC015
Feb 16, 6:52 pm	26	22	84	12	N	20G29 0.50	Lt snow, Blowing snow	FEW006 OVC011
Feb 16, 5:52 pm	29	26	89	15	NNE	25G37 0.50	Snow, Blowing snow	VV007
Feb 16, 5:32 pm	30	26	85	17	N	21G37 0.50	Snow, Blowing snow	VV007
Feb 16, 4:52 pm	30	26	85	17	NNE	23G38 0.50	Snow, Blowing snow	FEW007 OVC011
Feb 16, 4:17 pm	30	26	85	17	NNE	22G39 0.50	Snow, Blowing snow	FEW006 OVC011
Feb 16, 3:52 pm	30	26	85	16	NNE	25G39 0.25	Snow, Blowing snow	VV007
Feb 16, 2:52 pm	30	26	85	17	NNE	23G41 0.25	Snow, Blowing snow	VV007
Feb 16, 2:36 pm	30	26	85	16	NNE	24G37 0.25	Hvy snow, Blowing snow	VV006
Feb 16, 2:13 pm	30	27	88	16	NNE	24G38 0.75	Lt snow, Blowing snow	SCT004 OVC011
Feb 16, 1:52 pm	30	26	85	17	NNE	21G33 1.00	Lt snow, Blowing snow	FEW006 OVC013
Feb 16, 12:52 pm	30	25	81	16	NNE	24G37 1.25	Lt snow, Blowing snow	BKN006 OVC012
Feb 16, 12:39 pm	30	26	85	16	NNE	25G37 1.00	Lt snow, Blowing snow	SCT006 BKN012 OVC019
Feb 16, 12:11 pm	30	26	85	17	NNE	21G38 0.50	Snow, Blowing snow	VV006
Feb 16, 12:01 pm	30	26	85	18	NNE	18G36 0.50	Snow, Blowing snow	VV005

- Upper low slightly weakening - open wave with neutral to positive tilt
- Marginal surface temperatures near to slightly above freezing but offset by heavy rates up to 1"/hr of wet snow
- Heaviest axis of QPF (0.50"+) was forecast to be very narrow
- Timing of mixed precipitation changing to snow
- Uncertainty on SLRs, started out near or below 10:1, and ended at over 30:1 in back side deformation zone!

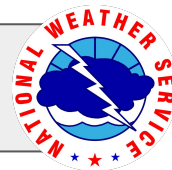
February 16 - 17, 2023
12Z to 12Z



Day 3 Forecast Evaluation

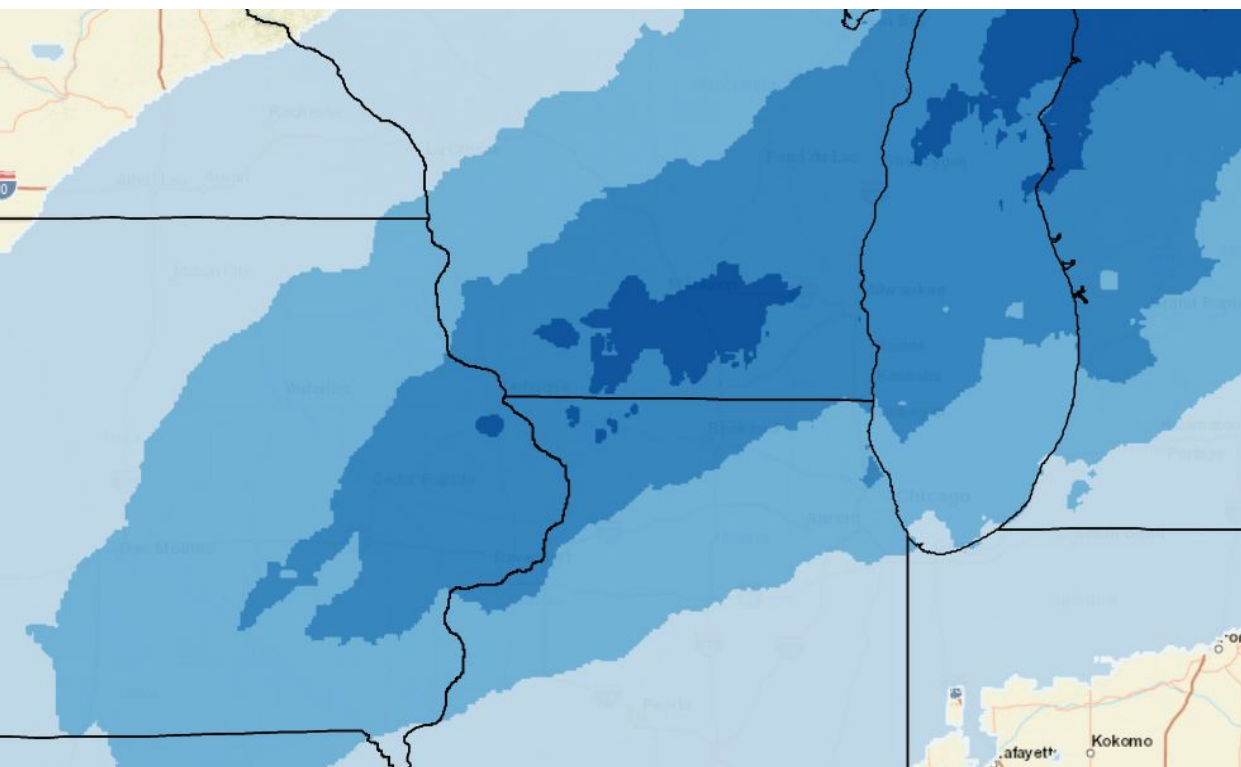
84 hr lead time - 00Z 2/13

February 16 - 17, 2023
12Z to 12Z



Day 3 NBM Deterministic Snow Forecast

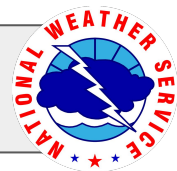
Winter Weather Experiment
NBM 4.1 Evaluation



Snow Accumulation (in)



February 16 - 17, 2023
12Z to 12Z



24 hr Observed Snowfall

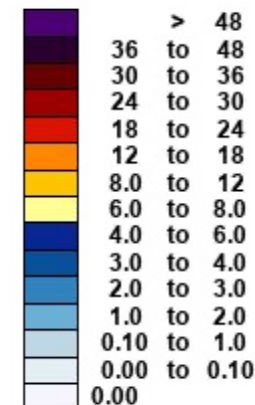
Winter Weather Experiment
NBM 4.1 Evaluation

NOHRSC

8"

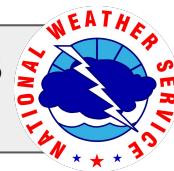
10 - 11"

Inches of depth



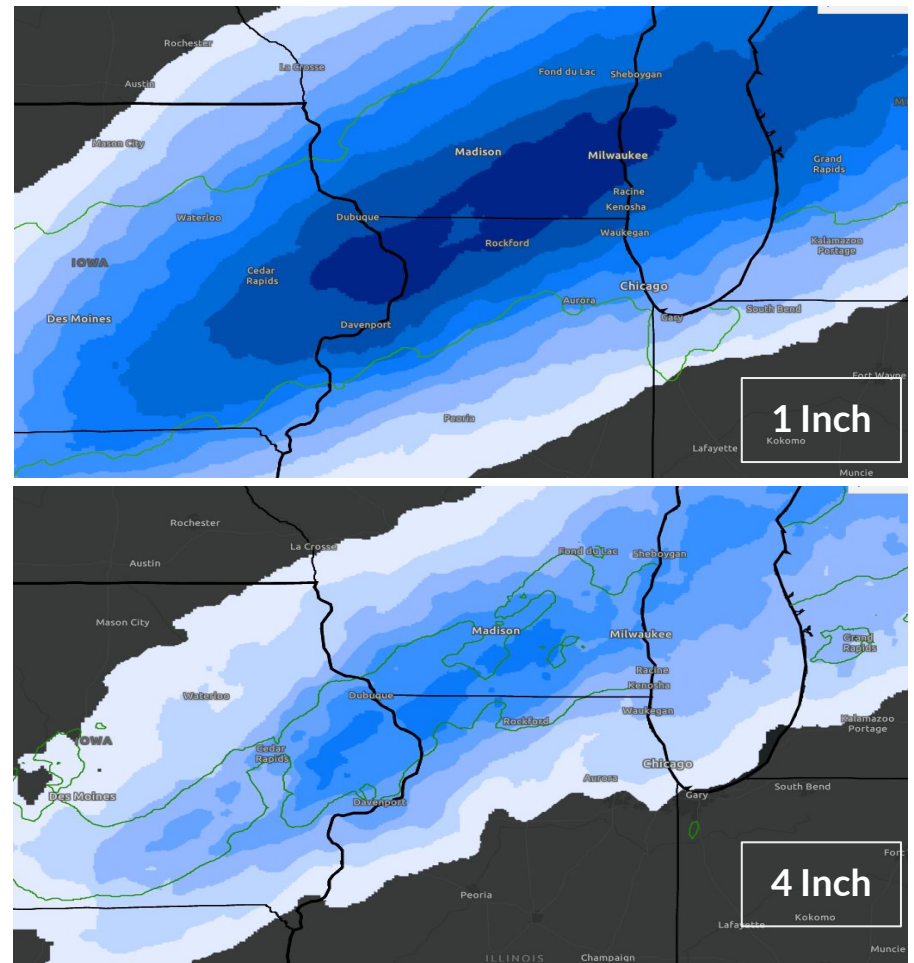
Created 2023 Feb 22, 11:25 UTC

February 16 - 17, 2023
12Z to 12Z



Day 3 NBM Probabilistic Snow Forecast

Winter Weather Experiment
NBM 4.1 Evaluation



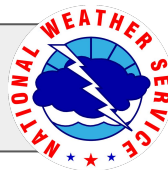
February 16 - 17, 2023
12Z to 12Z

Day 3 Discussion Questions

Winter Weather Experiment
NBM 4.1 Evaluation

- Thoughts on overall spatial extent and higher end probabilities?
- Is there a threshold on Day 3 that influences confidence in a positive or negative way?
- What messaging would be utilized with the current Day 3 probabilities?
- Focus on 6 hr period snowfall forecast: 2/16 12Z - 18Z
 - Did potential for mixed p-type play a role?

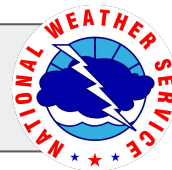
February 16 - 17, 2023
12Z to 12Z



Day 2 Forecast Evaluation

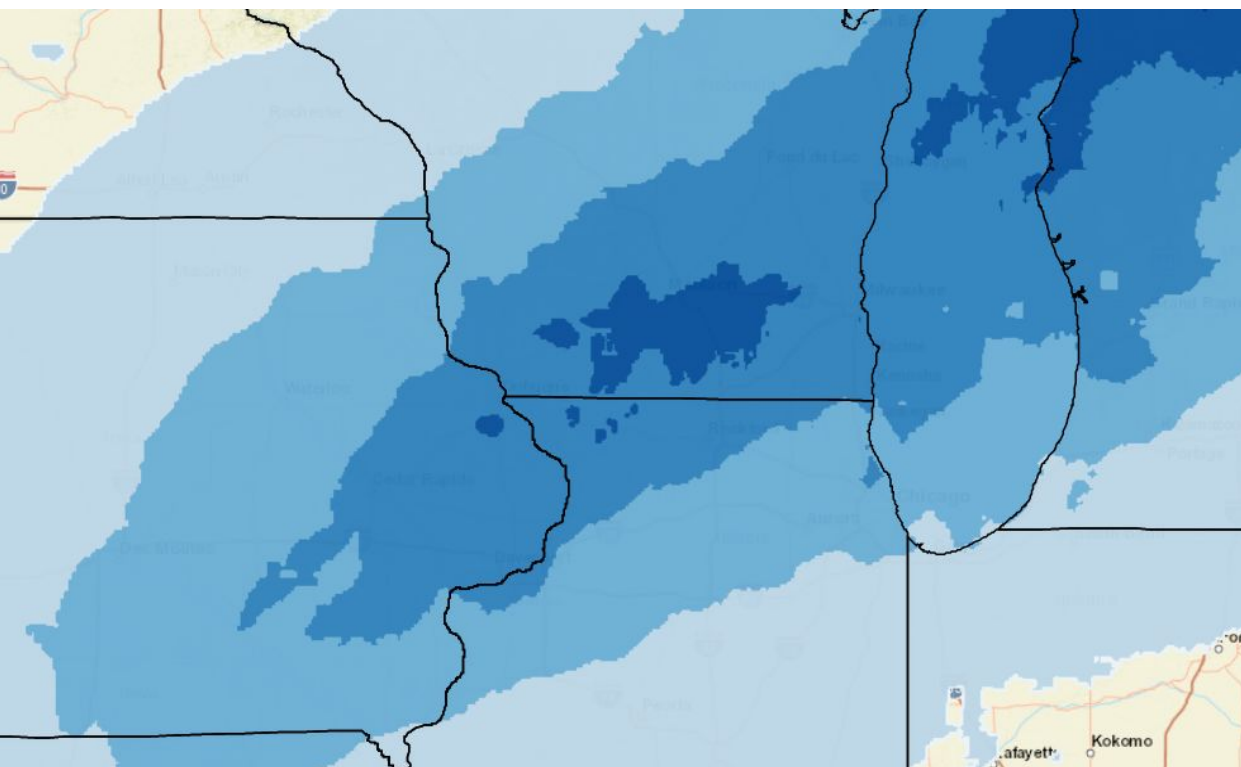
60 hr lead time - 00Z 2/14

February 16 - 17, 2023
12Z to 12Z



Day 3 NBM Deterministic Snow Forecast

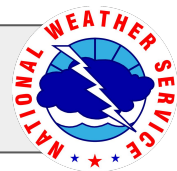
Winter Weather Experiment
NBM 4.1 Evaluation



Snow Accumulation (in)

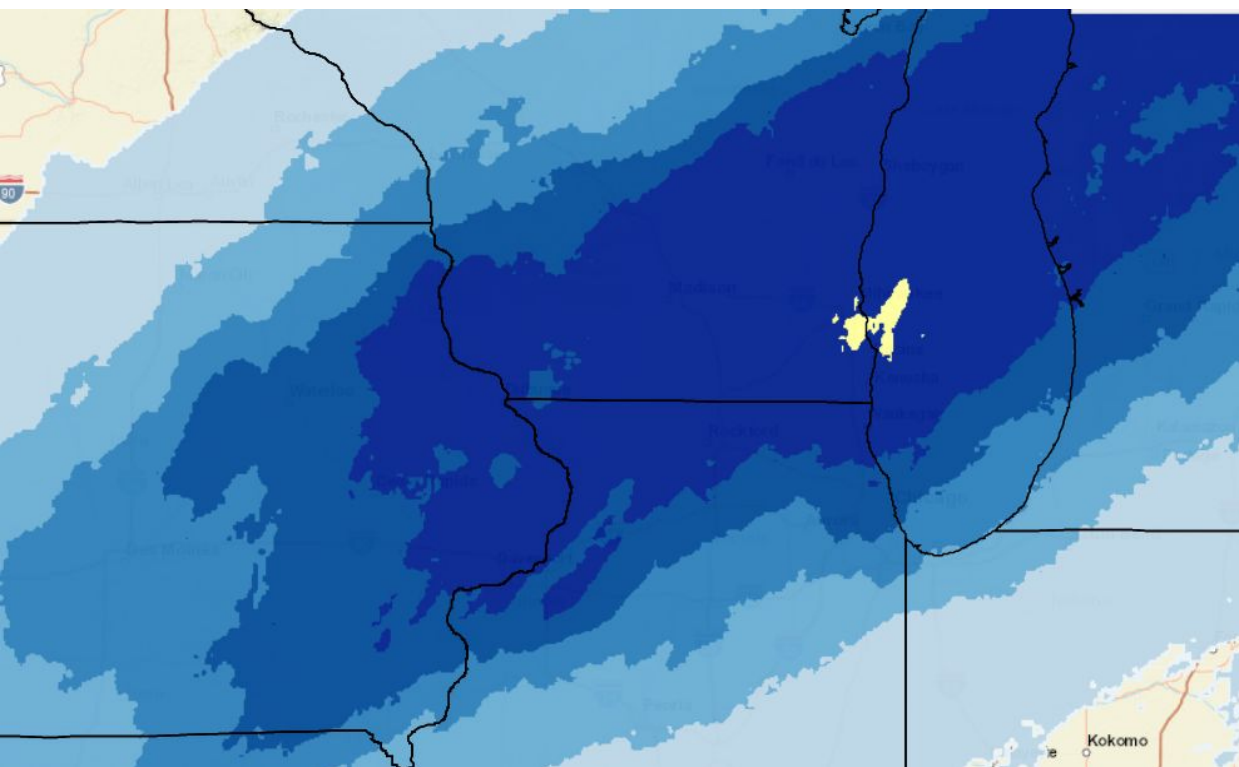


February 16 - 17, 2023
12Z to 12Z



Day 2 NBM Deterministic Snow Forecast

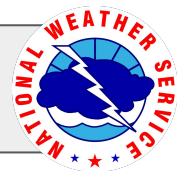
Winter Weather Experiment
NBM 4.1 Evaluation



Snow Accumulation (in)



February 16 - 17, 2023
12Z to 12Z



24 hr Observed Snowfall

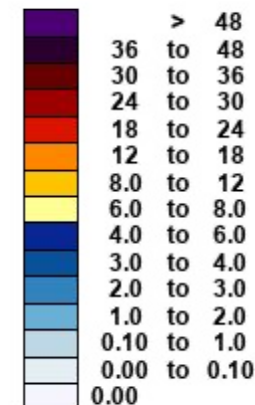
Winter Weather Experiment
NBM 4.1 Evaluation

NOHRSC

8"

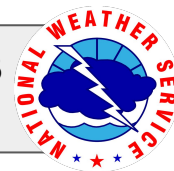
10 - 11"

Inches of depth



Created 2023 Feb 22, 11:25 UTC

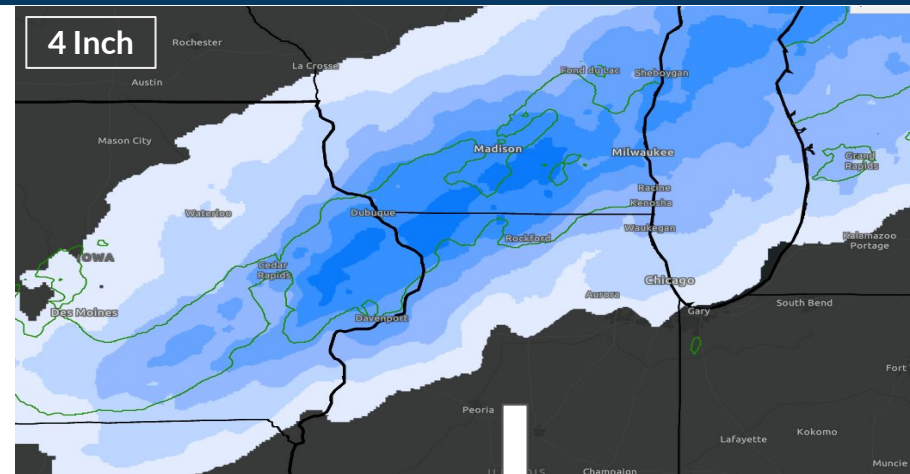
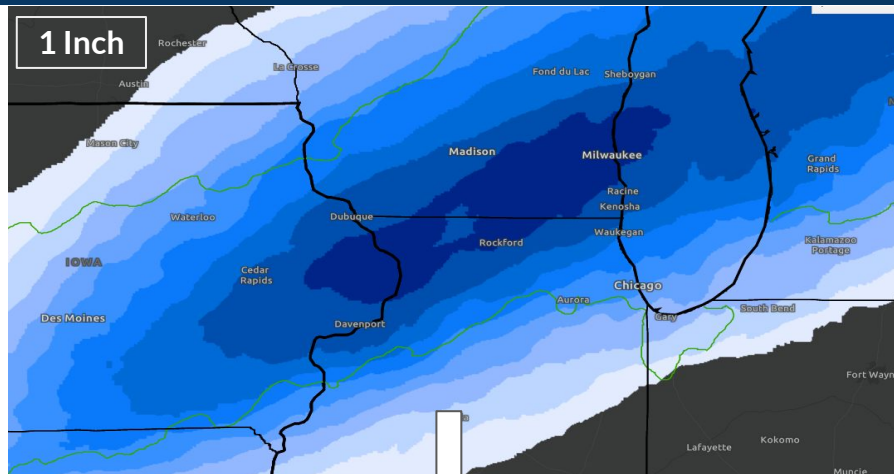
February 16 - 17, 2023
12Z to 12Z



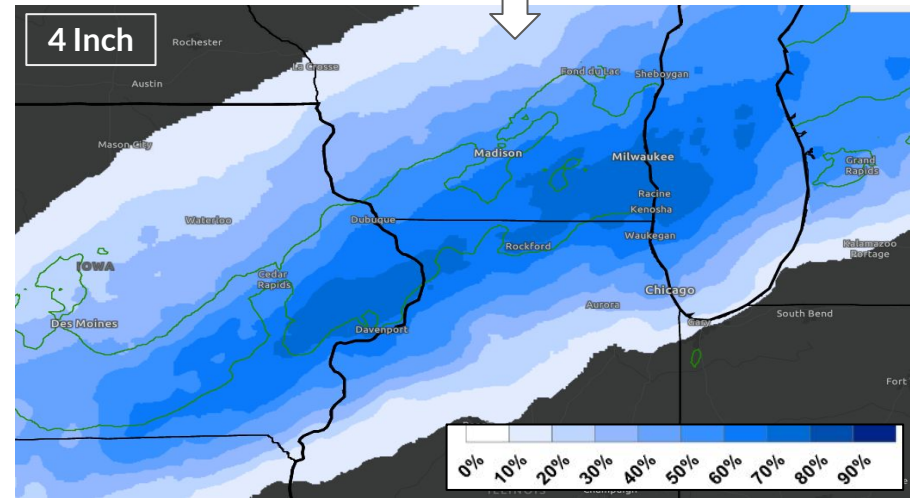
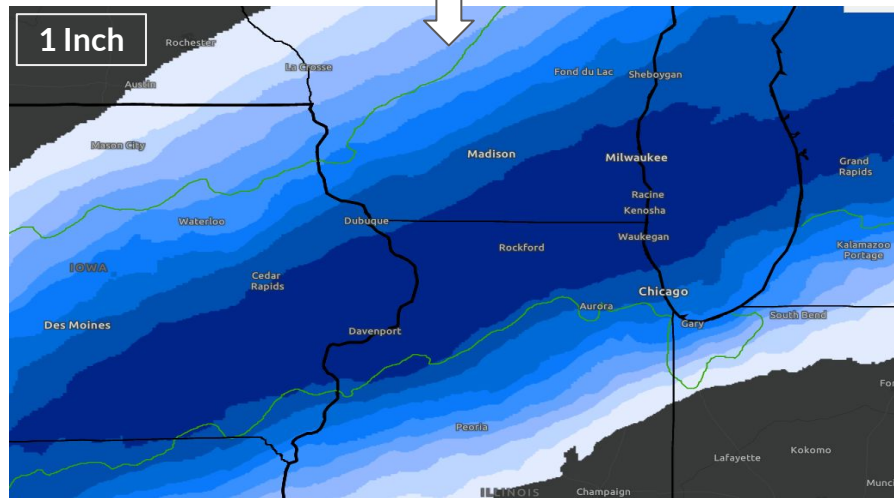
Day 3 to 2 NBM Probabilistic Snow Forecasts

Winter Weather Experiment
NBM 4.1 Evaluation

Day
3



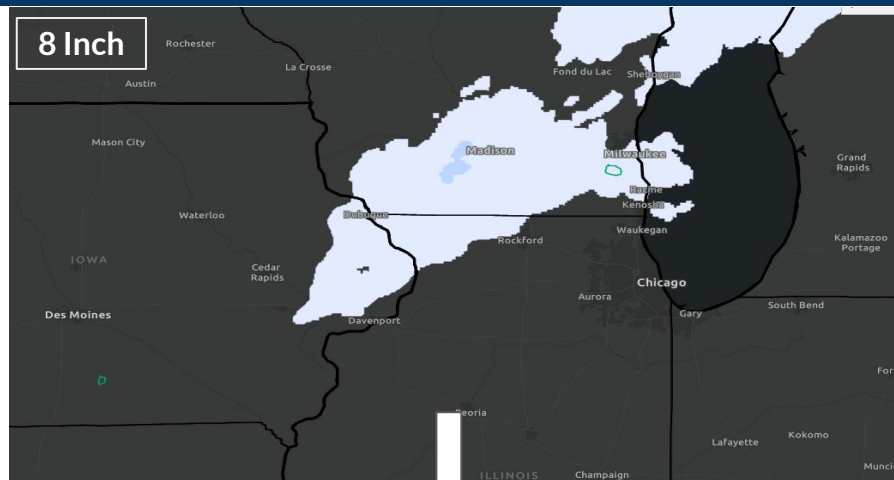
Day
2



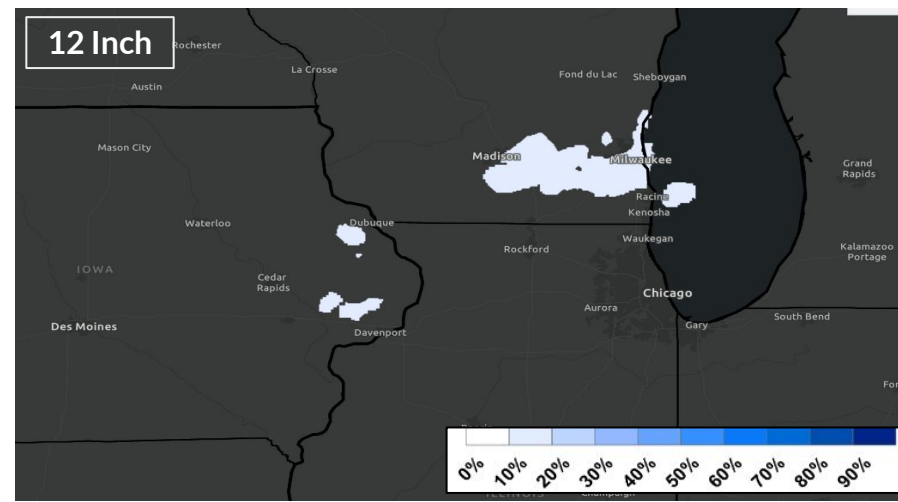
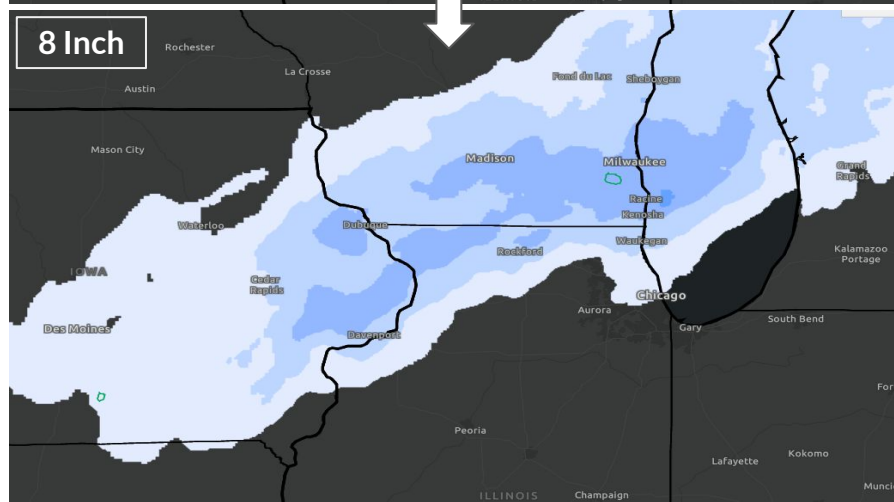
Day 3 to 2 NBM Probabilistic Snow Forecasts

Winter Weather Experiment
NBM 4.1 Evaluation

Day
3



Day
2

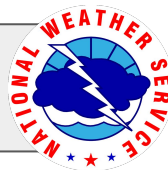


Day 2 Discussion Questions

Winter Weather Experiment
NBM 4.1 Evaluation

- Thoughts on overall spatial extent and higher end probabilities?
- Is there a threshold on Day 2 that influences confidence in a positive or negative way?
- What messaging would be utilized with the current Day 2 probabilities?
- Focusing on 6 hr period snowfall forecast: 2/16 12Z - 18Z
 - Did potential for mixed p-type play a role?

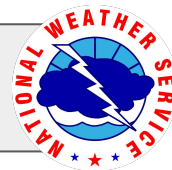
February 16 - 17, 2023
12Z to 12Z



Day 1 Forecast Evaluation

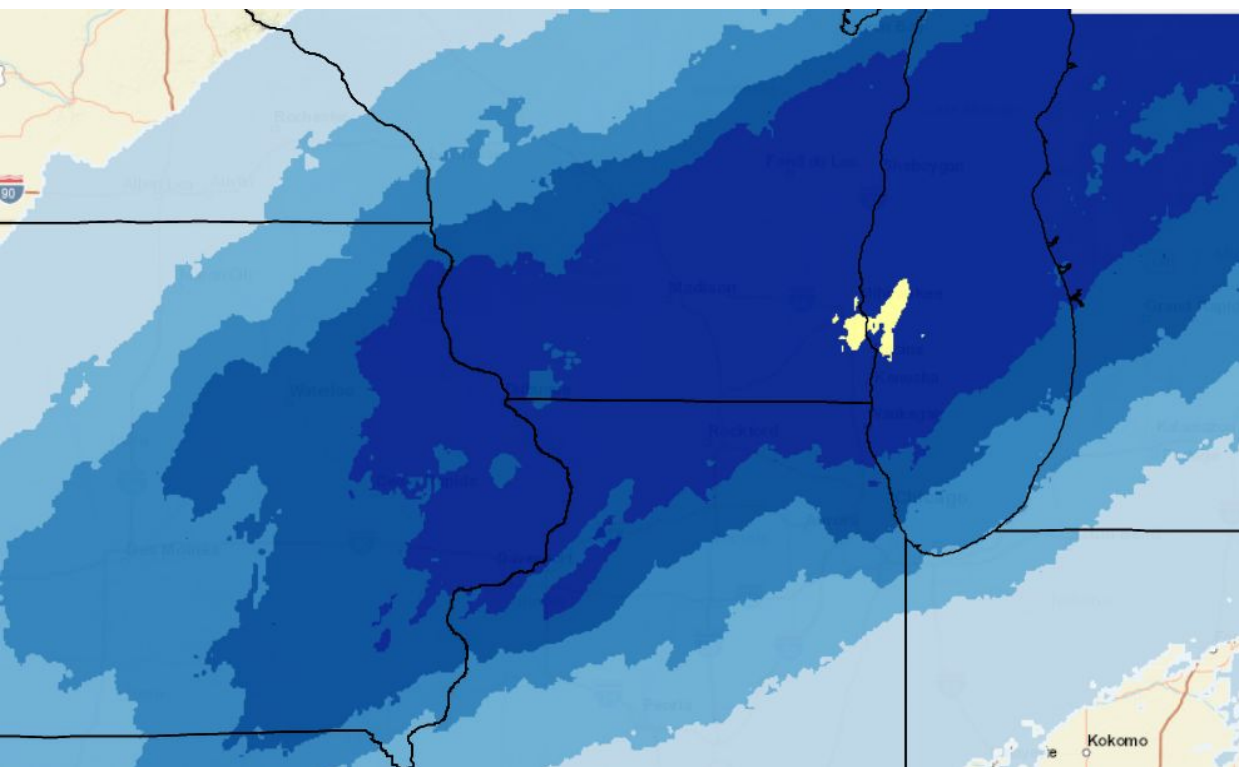
36 hr lead time

February 16 - 17, 2023
12Z to 12Z



Day 2 NBM Deterministic Snow Forecast

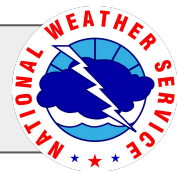
Winter Weather Experiment
NBM 4.1 Evaluation



Snow Accumulation (in)

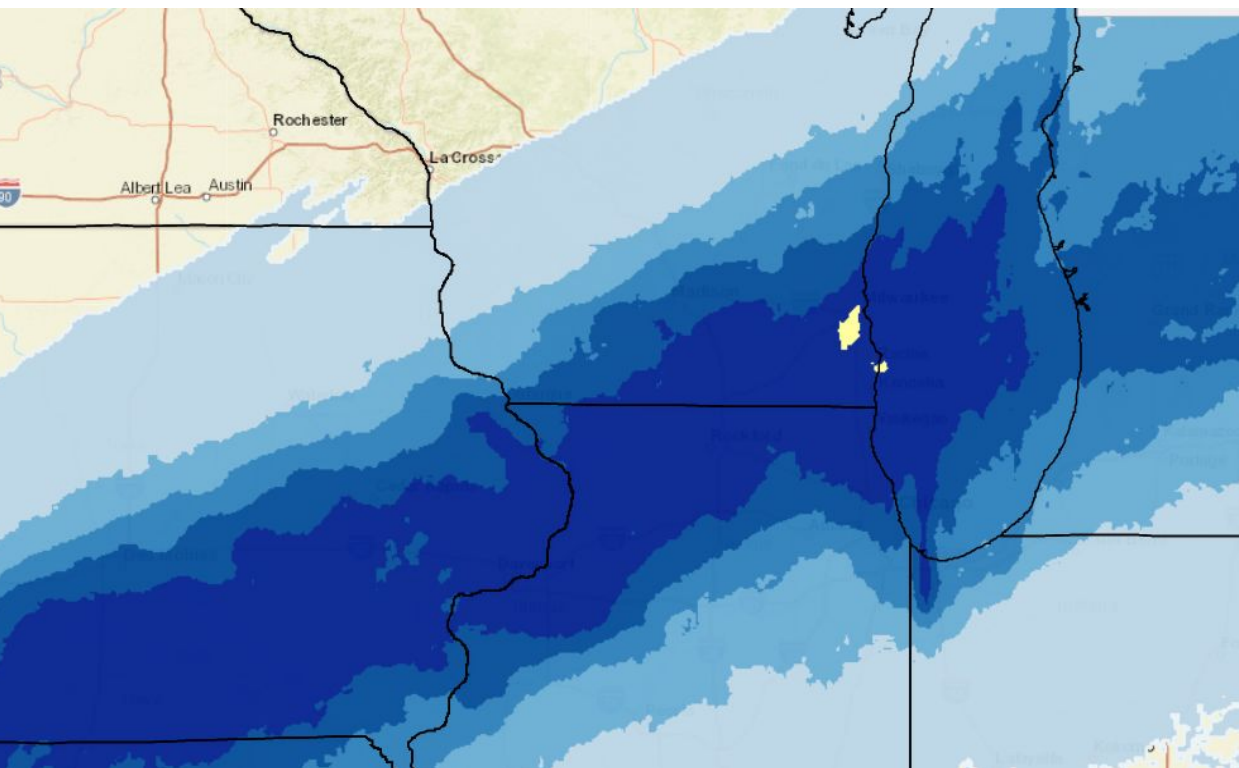


February 16 - 17, 2023
12Z to 12Z



Day 1 NBM Deterministic Snow Forecast

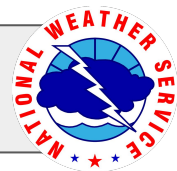
Winter Weather Experiment
NBM 4.1 Evaluation



Snow Accumulation (in)



February 16 - 17, 2023
12Z to 12Z



24 hr Observed Snowfall

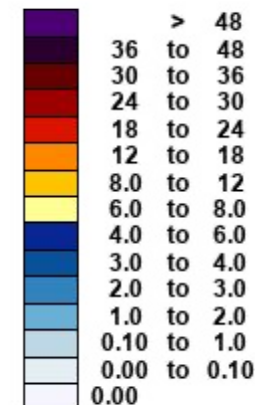
Winter Weather Experiment
NBM 4.1 Evaluation

NOHRSC

8"

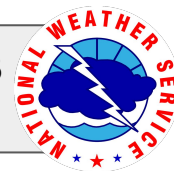
10 - 11"

Inches of depth



Created 2023 Feb 22, 11:25 UTC

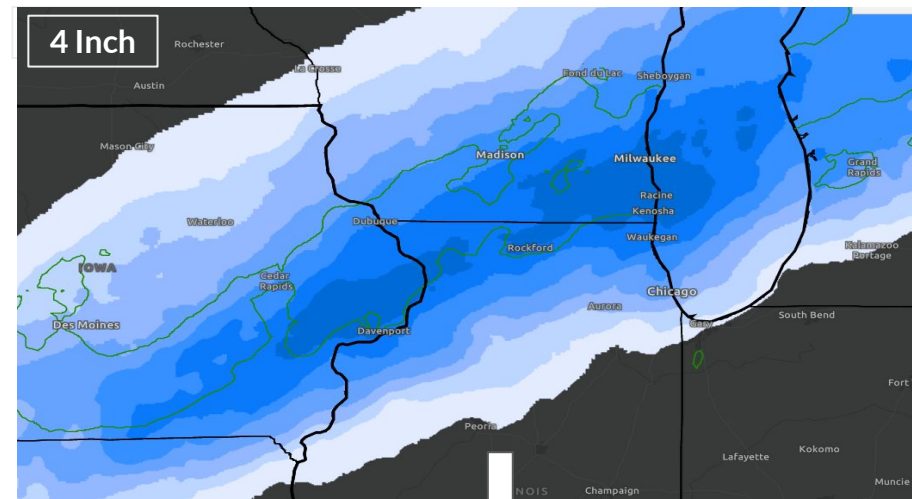
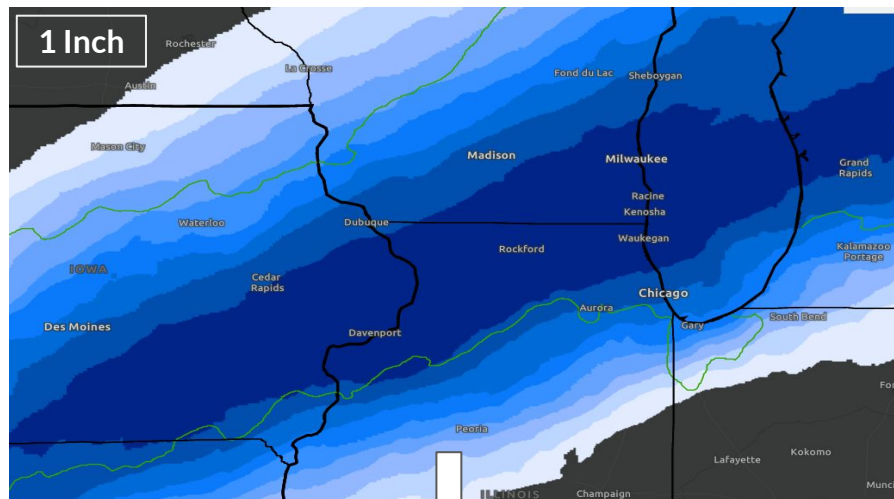
February 16 - 17, 2023
12Z to 12Z



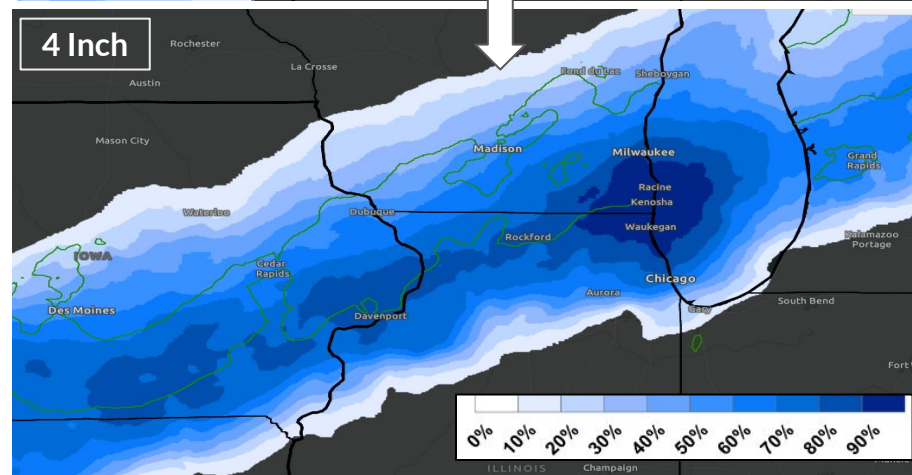
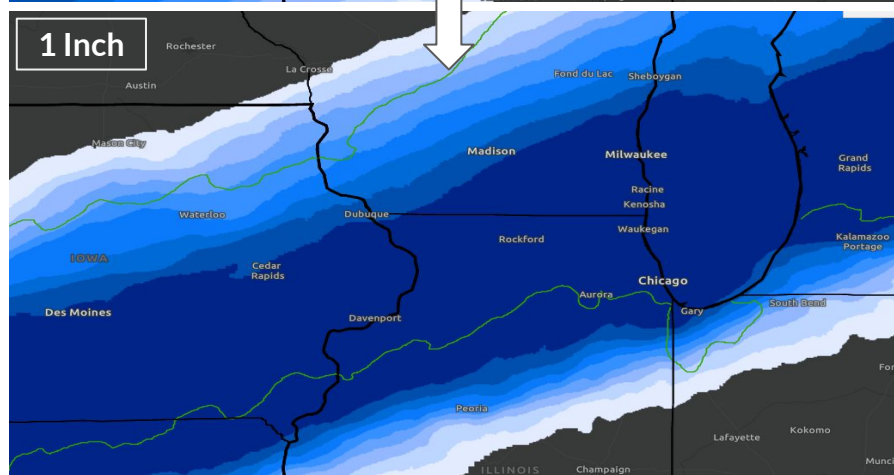
Day 2 to 1 NBM Probabilistic Snow Forecasts

Winter Weather Experiment
NBM 4.1 Evaluation

Day
2



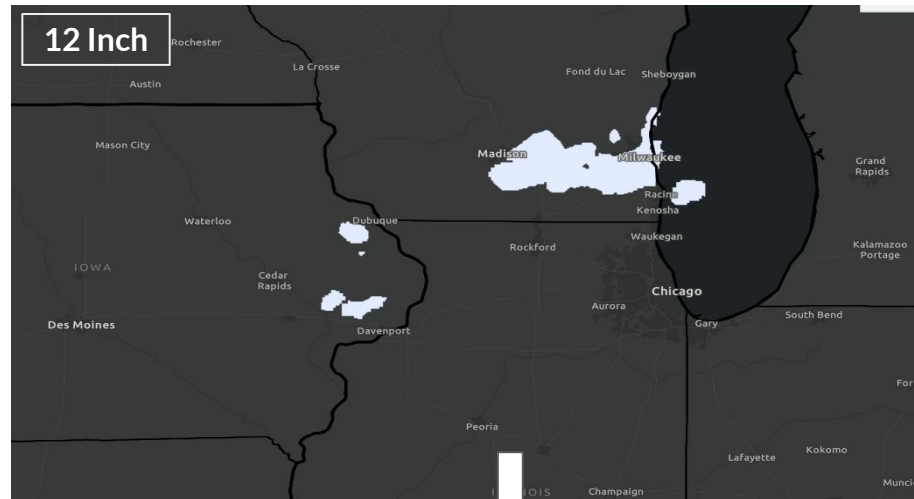
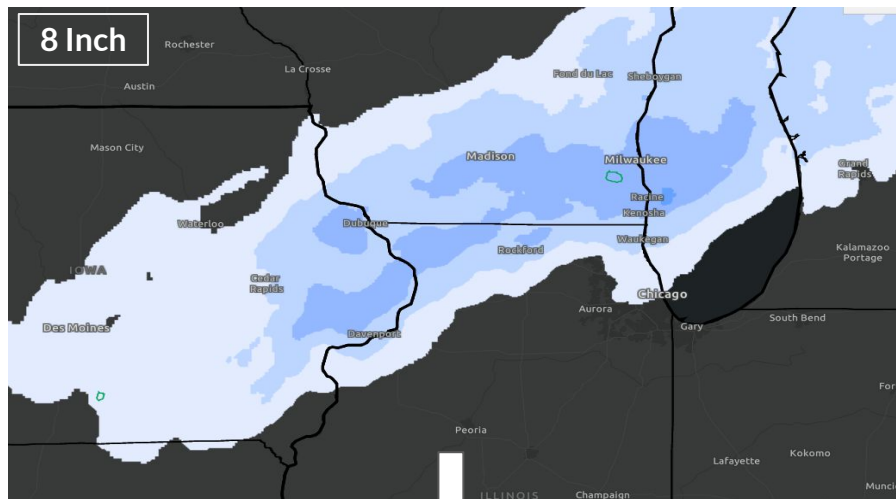
Day
1



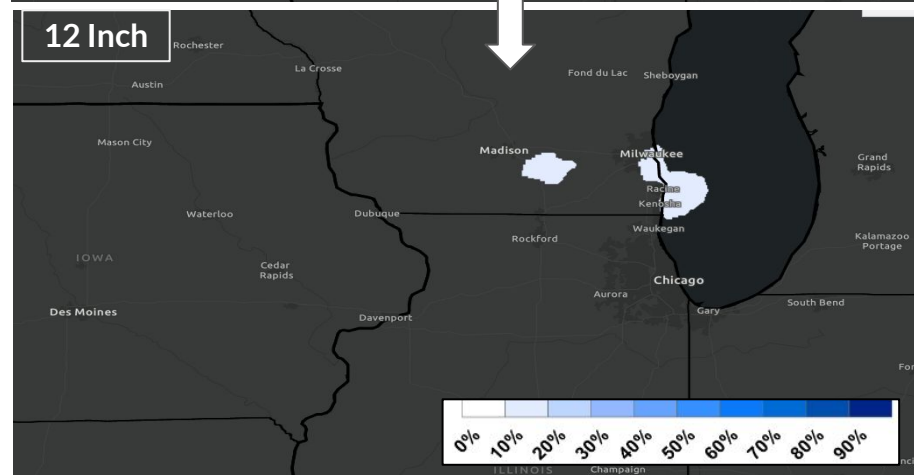
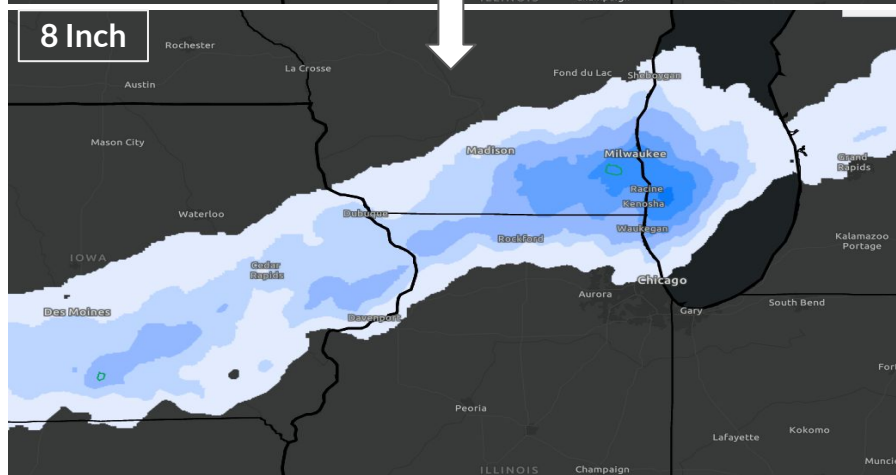
Day 2 to 1 NBM Probabilistic Snow Forecasts

Winter Weather Experiment
NBM 4.1 Evaluation

Day
2

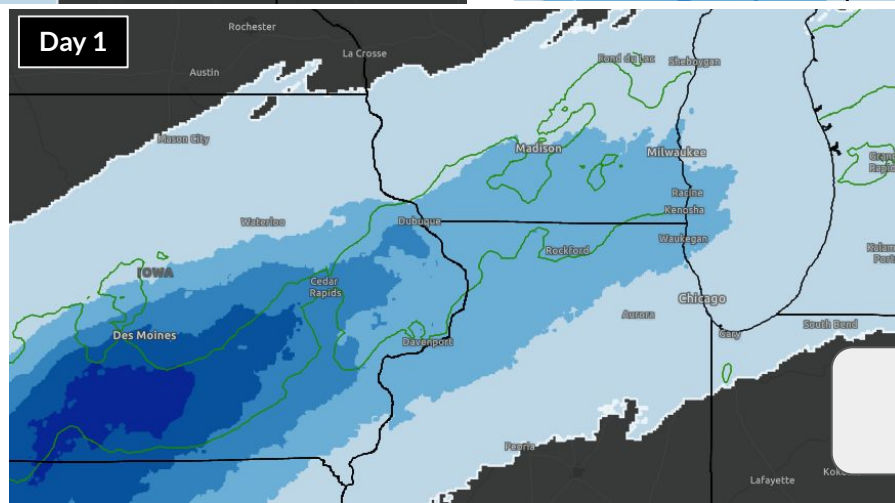
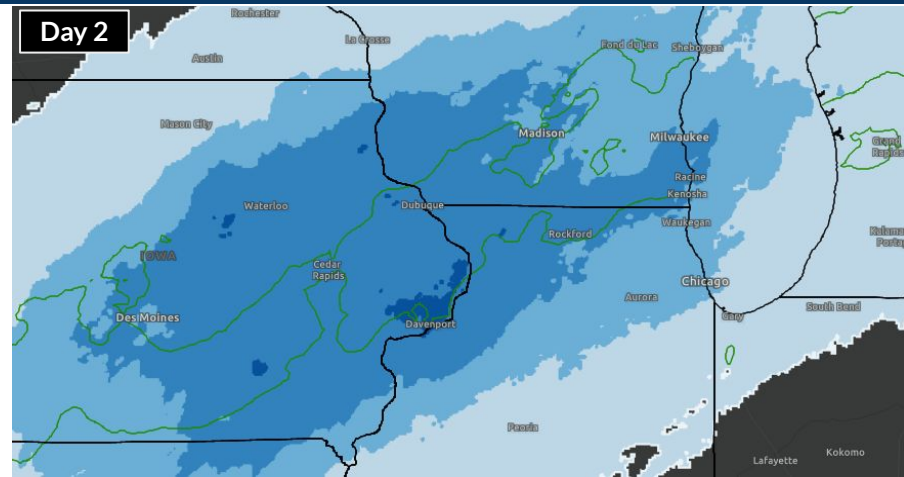
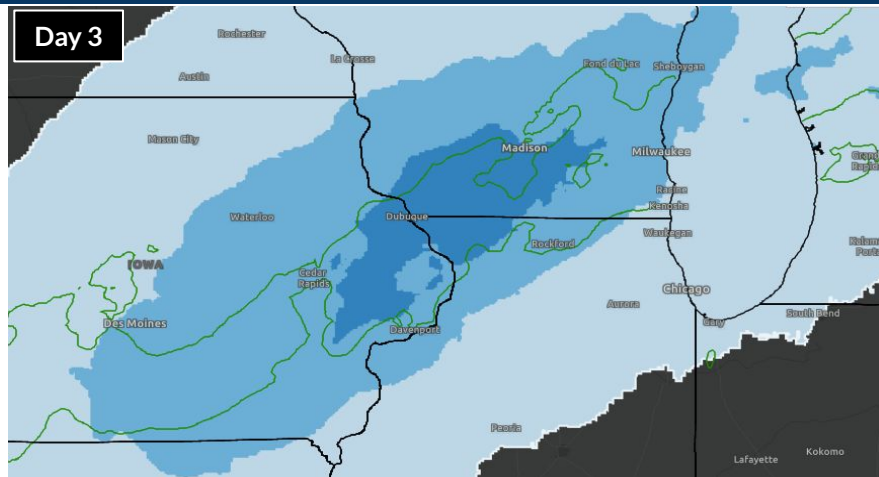


Day
1



Day 3 - 2 - 1 NBM Deterministic Snow Forecast

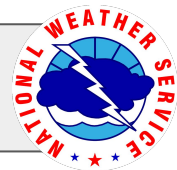
Winter Weather Experiment
NBM 4.1 Evaluation



Snow Accumulation (in)



February 16, 2023
12Z to 18Z

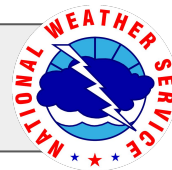


Day 1 Discussion Questions

Winter Weather Experiment
NBM 4.1 Evaluation

- Thoughts on overall spatial extent and higher end probabilities?
- Is there a threshold on Day 1 that influences confidence in a positive or negative way?
- What messaging would be utilized with the current Day 1 probabilities?
- Focusing on 6 hr period snowfall forecast: 2/16 12Z - 18Z
 - Did potential for mixed p-type play a role?

February 16 - 17, 2023
12Z to 12Z



Takeaways - Day 3 Forecast

Winter Weather Experiment
NBM 4.1 Evaluation

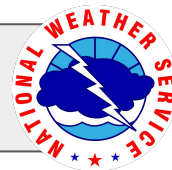
NBM Deterministic Day 3 Forecast (slide 35)

- Good on general placement (eastern Iowa through southern Wisconsin into northern Lower Michigan)
- Forecast values were way too low with greatest under-forecast over portions of south-central Iowa (only forecasting 1 - 2" and 6 - 8" verified)

NBM Probabilistic Day 3 Forecast (slides 37)

- Large area of >90% probability of 1"+ from eastern Iowa into southeast Wisconsin and portions of Lower Michigan, the placement of the higher probs. (60 - 90%) matched up well with NOHRSC verification
- 4"+ snowfall probabilities reached 50 - 60% over eastern Iowa into southern Wisconsin; however not high enough to give much confidence in this event hitting Winter Storm Warning criteria; the 4"+ probabilities were way too low over south-central Iowa (only 10 - 30%)
- 8"+ snowfall probabilities were generally too low (10 - 20%) and non-existent over central Iowa

February 16 - 17, 2023
12Z to 12Z



NBM Deterministic Day 2 Forecast (slide 41)

- Significant increase in forecast snowfall amounts with 4 - 6" now covering a large area; definite improvement over the Day 3 forecast
- Values still too low overall, especially over south-central Iowa
- Since this is a 60 hour forecast there is little CAM influence

NBM Probabilistic Day 2 Forecast (slides 43 and 44)

- Expansion of >90% probability of 1"+ from eastern Iowa into southeast Wisconsin and portions of Lower Michigan; the placement of these higher values is along the southern portion of the 1" observed snowfall contour (NOHRSC)
- Notable expansion of the 60 - 70% probabilities for 4"+ snowfall; however, the axis of highest probabilities is displaced a little too far too the south compared to the NOHRSC verification. Nonetheless, confidence on an impactful winter storm has increased since the Day 3 forecast
- 8"+ snowfall probabilities remain too low (10 - 30%) but have increased in areal coverage from the Day 3 forecast; confidence on reaching 8" or more of snow is low at this stage
- Very low 12"+ probabilities beginning to show up, generally less than 10% and spotty

NBM Deterministic Day 1 Forecast (slide 48)

- Significant southward shift in the snowfall forecast with values now way too low over parts of eastern Iowa, southern Wisconsin, and Lower Michigan; CAMs now incorporated into the deterministic forecast
- Forecast improved over south-central Iowa but at the expense of shifting too far to the south for locations to the northeast
- Values generally still too low with a large band of 4-6" forecast, marginal amounts for hitting Winter Storm Warning criteria. However, strong winds were expected which could push this event toward warning level impacts

NBM Probabilistic Day 1 Forecast (slides 50 and 51)

- Expansion of >90% probability of 1"+ noted again with sizable area extending south of the NOHRSC 1" observed snowfall contour
- 4"+ probabilities now increased to 70-90% along a narrow corridor but the axis is displaced a little too far to the south compared to the observed snowfall; the NBM distribution shifted too far to the south with this Day 1 forecast
- 8"+ snowfall probabilities increased slightly over southeast Wisconsin and south-central Iowa, but with values under 40% did not give much confidence in snowfall totals reaching 8" or more which is what happened in many locations per LSRs
- Very spotty and low probabilities for 12"+ in southern Wisconsin (under 10%), yet there were many reports of around 11" in the southwest portion of the Milwaukee metro. With such low probabilities at the Day 1 lead time, confidence would be very low on the higher end snowfall amounts verifying
- Both the deterministic and probabilistic forecasts shifted too far south, worst impact to the forecast was over northern Lower Michigan