Overview of NBM Winter Elements

Andrew Just - CRH STI, Sarah Perfater - AFS
Kevin Scharfenberg - FDTD, Jim Nelson - WPC STI

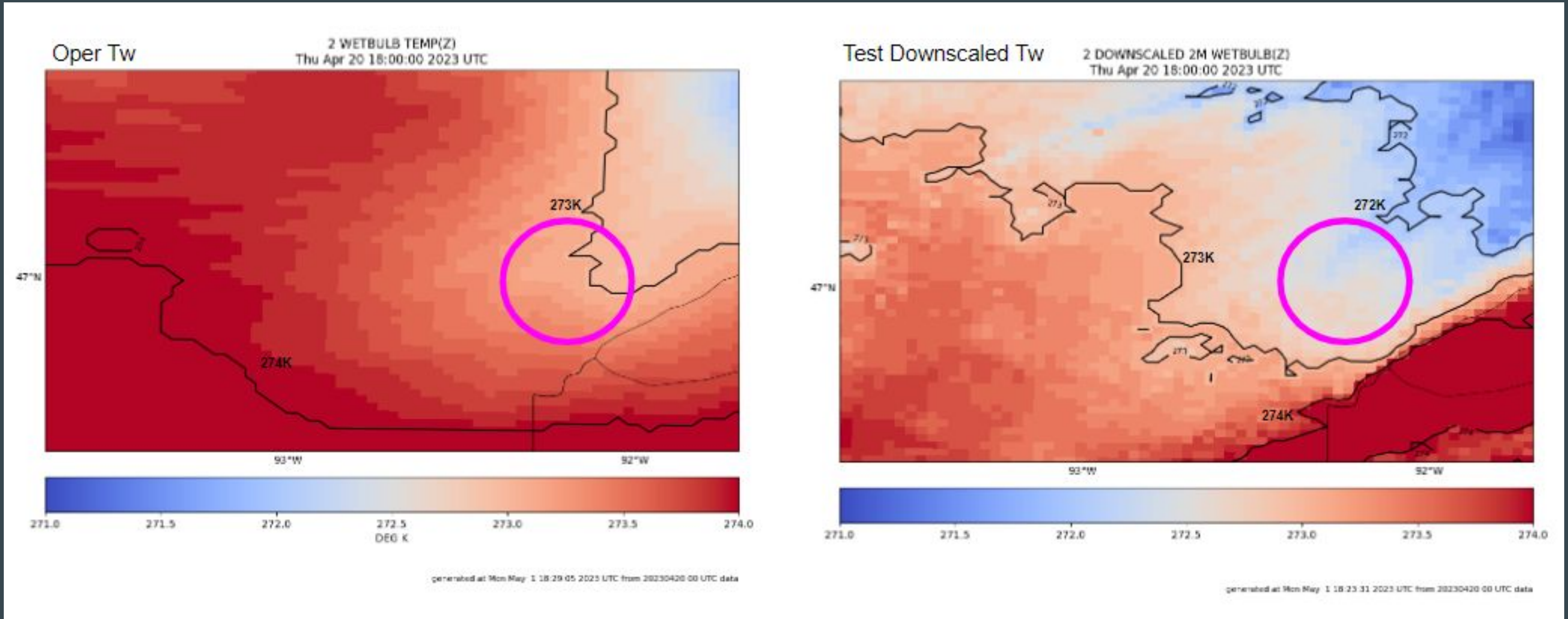
To ask questions or provide feedback on the NBM, please e-mail national.blend.feedback@noaa.gov or post a note on the NBM VLAB forum

NBM V4.2 Proposed Changes (slide in update progress)

- Updated Cobb SLR and snow melt methodology to be applied to all members
- Compute Downscaled Wet-Bulb temperature to utilize in Snow/Ice calculations. This is done by computing the difference between downscaled T and raw T.
  - Method applied to ECMWF Ensemble, GEFS and SREF (i.e. coarser model resolution)
  - Downscale Wet-bulb temperature applied in the FRAM for 1 and 6 hour ice accumulation
- For a given member: if the DMO p-type is rain, the elevation is below the snow level and the downscaled temperature is below freezing, change the rain to freezing rain

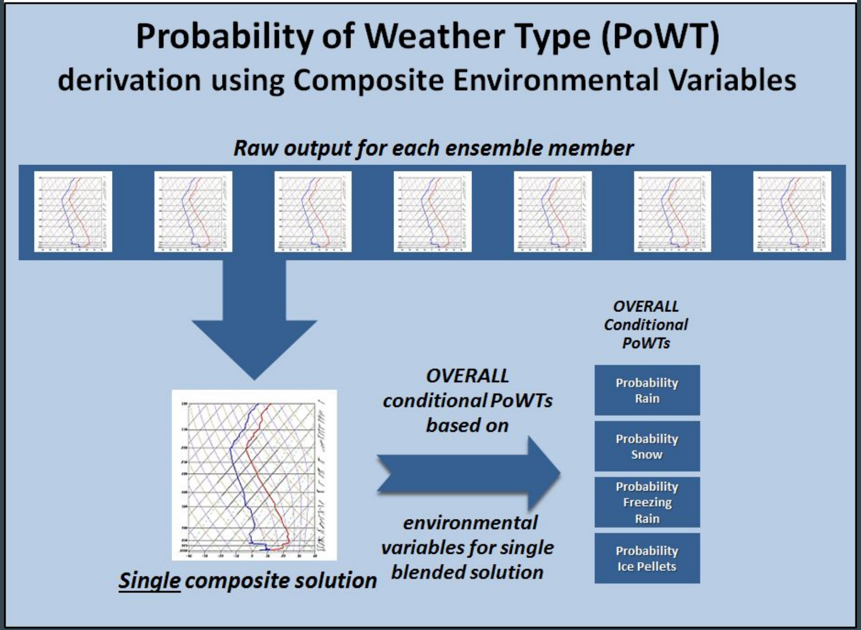
Example of the Downscaled Tw change

Applied to an ECMWF Ensemble member over DLH’s area, 18Z 2023 Apr 20



History/Evolution of NBM Precip Type, Snow and Ice - V3.0 & 3.1

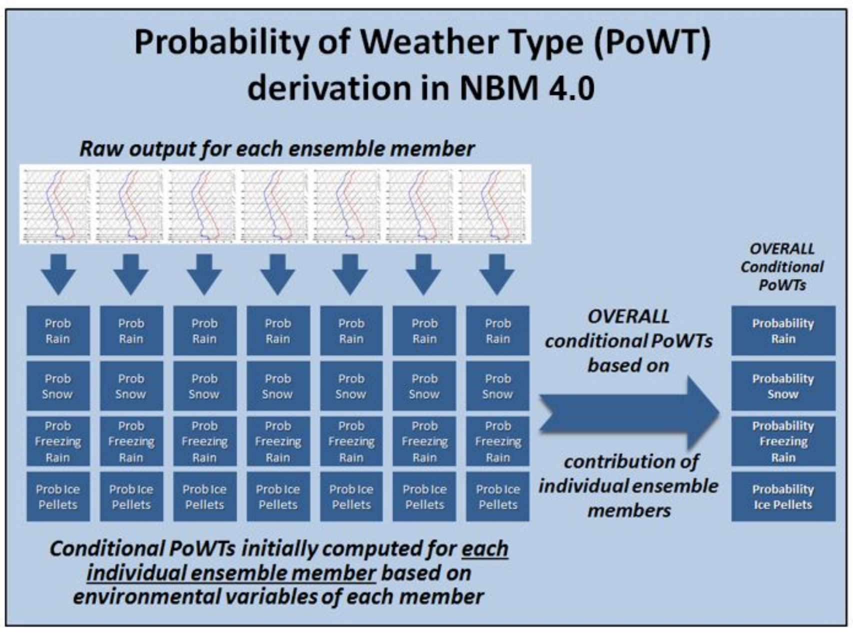
- V3.0: Precipitation type elements, Snow and Ice Accumulation introduced
  - Computed using top-down for members with sufficient vertical resolution
  - 18 members in short term, 8 in extended
  - Top-Down variables blended then precipitation type, SLR, snow and ice derived (see image at right)
  - URMA bias correction used to downscale
  - Snow uses newly provided SLR, Ice derived from FRAM
- V3.1: No change



Major issue with this approach: Does NOT reflect Environment Uncertainty & extremely problematic for Bimodal situations. Therefore can result in the wrong IDSS Message.

History/Evolution of NBM Precip Type, Snow and Ice - V3.2 & 4.0

- V3.2
  - Precip type approach changed to Bourgouin from WFO LOT research (WAF article)
  - Precipitation type, SLR, snow and ice derived for each member, then blended applying weights (see image at right) - fixes major issue noted in V3.0 and 3.1
  - URMA bias correction used to downscale
  - No change in membership
- V4.0: No change



Issues with this approach: Small membership relative to other NBM elements continues, will produce false freezing rain due to URMA bias correction and dry NBM members

NBM V4.1 Precip Type Computation

- 100 members in short term, lowering to 81 in extended
  - ECMWF and GFS ensembles comprise most members
  - 100 due to both software limitations and number of models in NBM that have precip type
- Utilizes dominant precipitation type (a.k.a. DMO) from each member
  - Shifts precipitation type derivation to model, saving NBM post processing time
  - Removal of vertical level limitation allows for expansion of membership
  - Important Note: precipitation type only provided where member produces precipitation => results in switch from conditional in past NBM versions to now unconditional
  - More information on each member's DMO technique is in an Appendix at the end of this presentation
- WPC downscaling technique adjusts precipitation type if needed
  - Changed from the URMA bias correction in previous versions
  - Needed for mountainous terrain
  - Utilizes the snow level from member sounding and incorporates surface temperature
  - More information contained in an Appendix at the end of this presentation
- Final precipitation type probabilities based on number of members out of total available for that forecast hour producing each type.
  - Members are expert weighted, with more weighting to CAMs in short term

Conditional vs Unconditional for P-type - What's the difference?

Reference: MetED training on Joint and Conditional Probability

Conditional: "assuming precipitation occurs, probability of each precipitation type is…"

With conditional, each precipitation type can have a probability of 100%

Unconditional: "Probability of each type where precipitation is forecast"

With unconditional, all precipitation type probabilities including the probability of no precipitation add up to ~100%

Individual member weighting - Version 4.0

NBM v4.0	Hour Ranges					
Model %	1-16	17-19	20-42	43-60	61-84	84+
CMCE	1	1	1	5	5	7
CMC GDPS	2	2	2	10	15	17
CMC RDPS	3	3	3	15		
GEFS Mean	1	1	1	5	5	8
GFS	3	3	3	10	15	19
HRRR	15					
HRRRX	7	18	18			
NAM NEST	12	15	15	20		
NAM	3	3	3	10	17	
HiResW ARW	11	12	13			
HiResW FV3	13	14	15			
HiResW Mem2	13	14	15			
RAP	7	5				
RAPX	3	3	5			
NAVGEMD	2	2	2	5	10	10
NAVGEME	1	1	1	3	5	5
ECMWFE Mean	1	1	1	5	8	12
ECMWFD	2	2	2	12	20	22

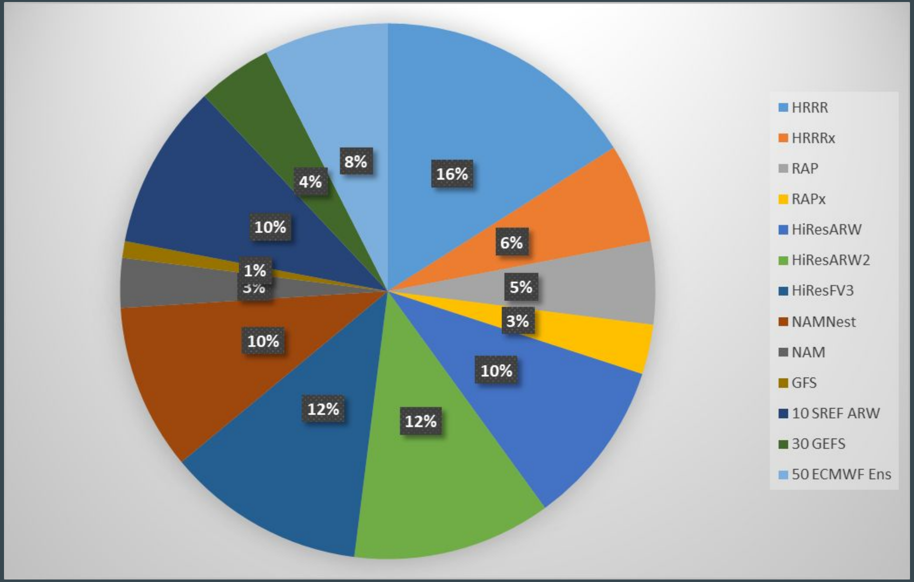
NOTE: Ensemble Means Only. Weightings are in %'s

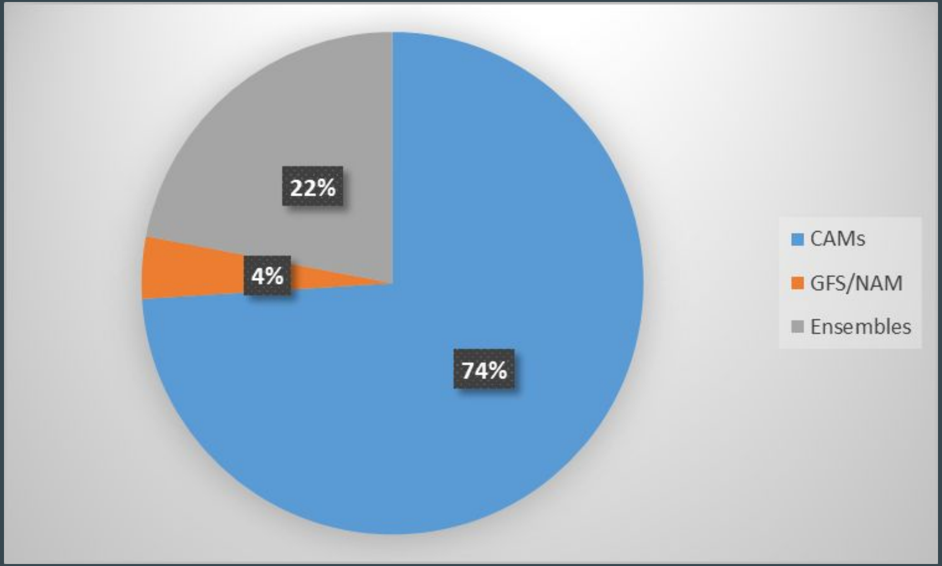
Individual member weighting - Version 4.1

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

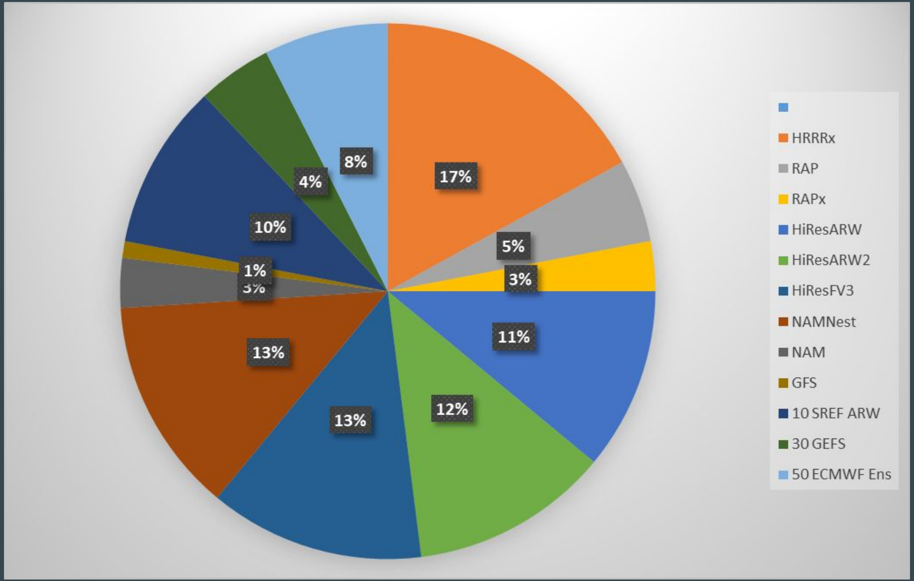
NOTE: The following NBM Members are not included because they don't have DMO precipitation type available to NBM: ECMWF Deterministic, RDPS, REPS, GDPS, GEPS, NAVGEMD, NAVGEME, ACCESS-G and ACCESSGE

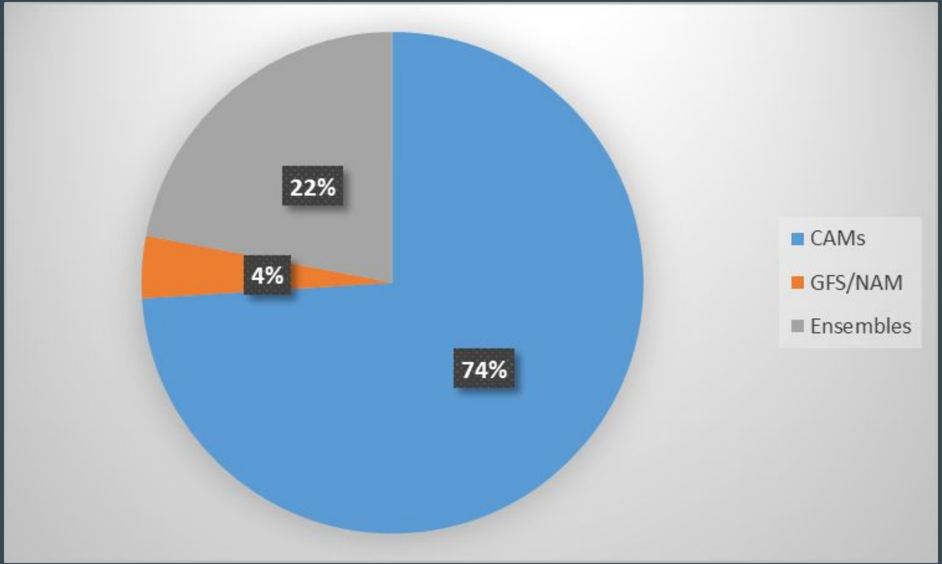
V4.1 Member Weighting - by Model Type - Hours 1-16



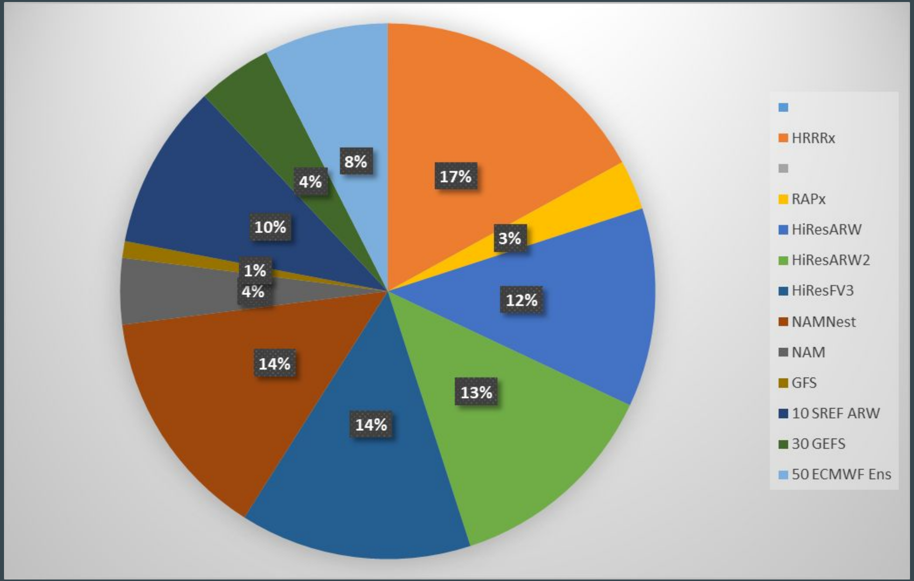


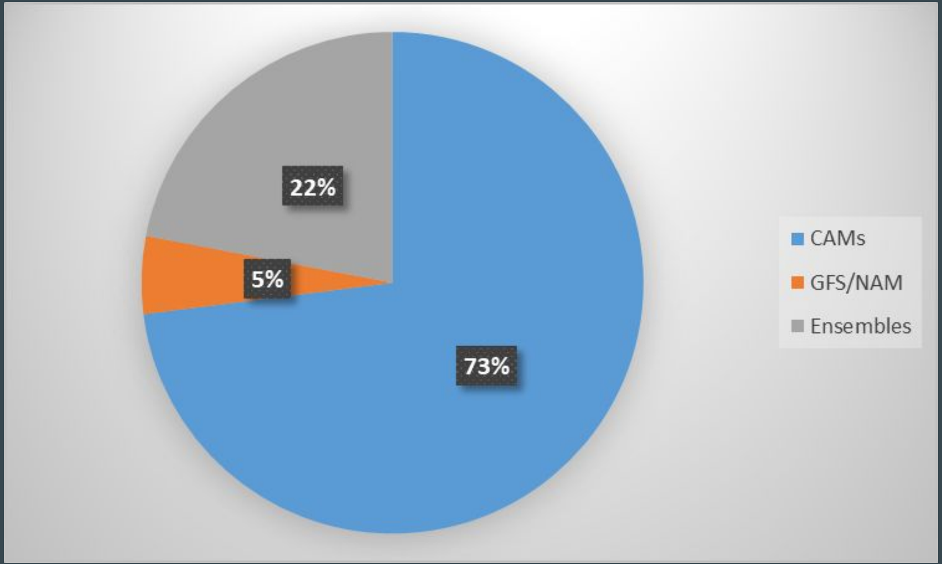
V4.1 Member Weighting - by Model Type - Hours 17-19



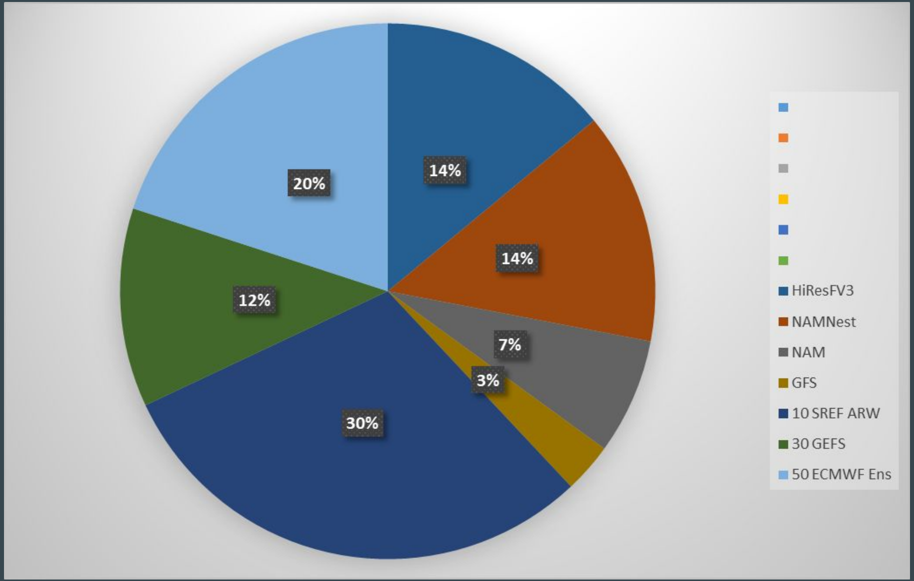


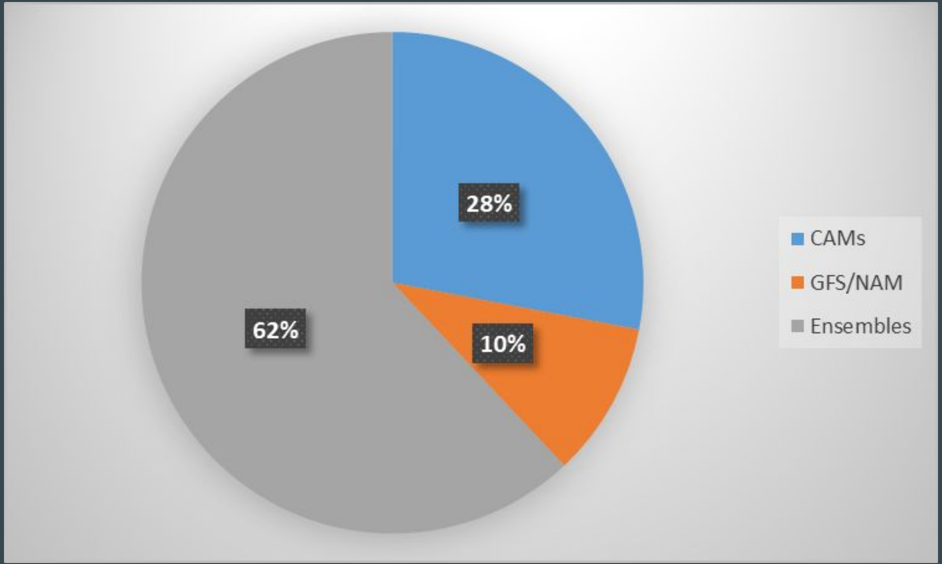
V4.1 Member Weighting - by Model Type - Hours 20-42



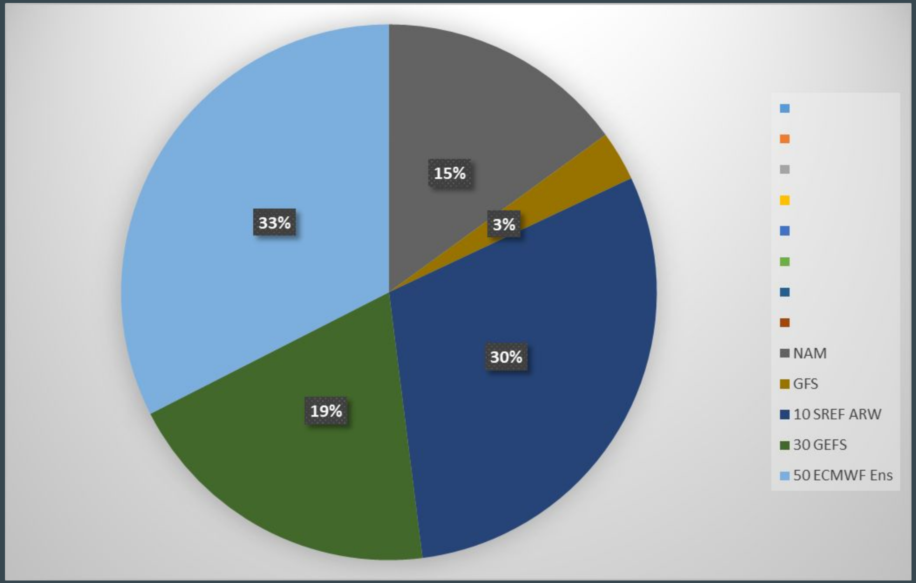


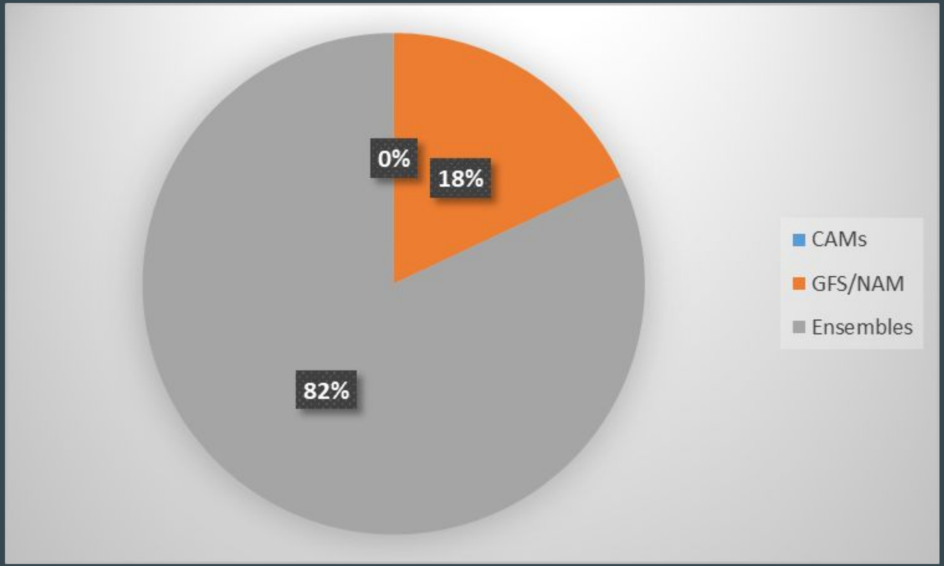
V4.1 Member Weighting - by Model Type - Hours 43-60



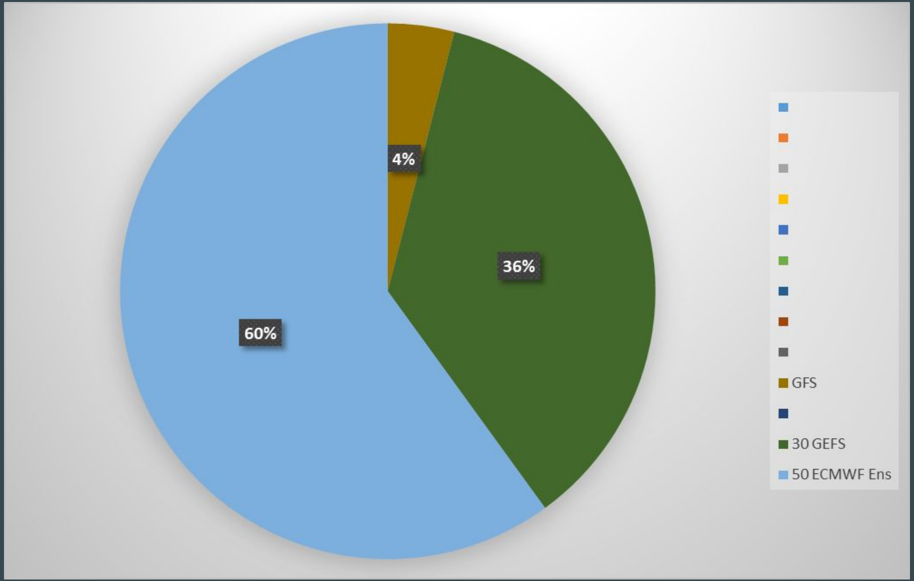


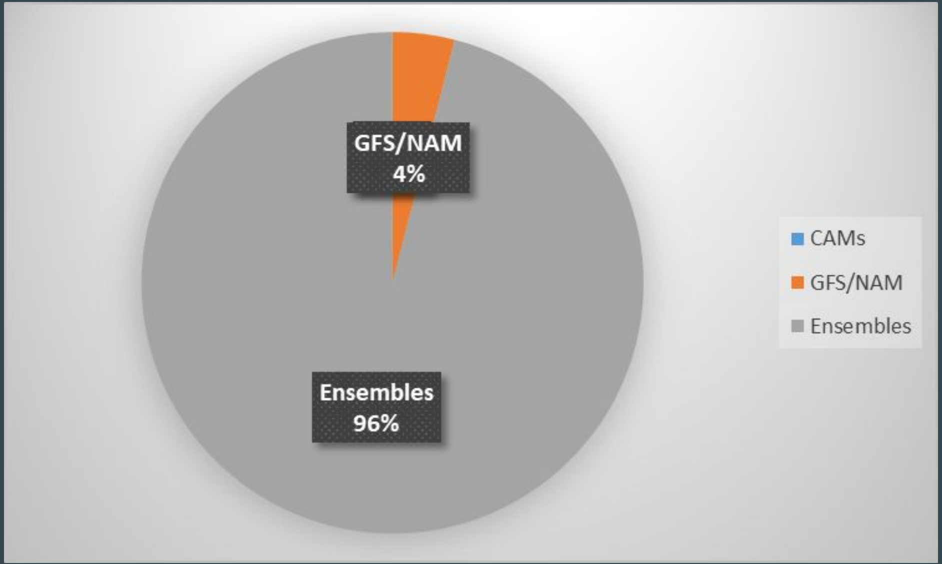
V4.1 Member Weighting - by Model Type - Hours 61-84





V4.1 Member Weighting - by Model Type - Hours 84+





NBM V4.1 Snow Ratio Computation

- Follows the 4.1 precipitation type membership. Weighting applied to deterministic output only.
- See table at right for methods employed
  - Chosen methods go back to previous versions based on the National SmartInit Team's separate Snow Ratio team Recommendations.
- In NBM 3.2 & 4.0, a 25% reduction was applied to the final outcome. That was removed for V4.1 during the 2021-2022 winter, but post 21-22 winter verification showed a need to reinstate it, and that was done in May 2022.
- New with NBM V4.1: Probabilistic Snow Ratio (5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles)

Model	Snow Ratio Techniques
HRRR	50% Cobb, 50% MaxTAloft
HRRRX	50% Cobb, 50% MaxTAloft
RAP	50% Cobb, 50% MaxTAloft
RAPX	50% Cobb, 50% MaxTAloft
HiResARW	50% Cobb, 50% MaxTAloft
HiResARW2	50% Cobb, 50% MaxTAloft
HiResFV3	50% Cobb, 50% MaxTAloft
NAM	33% Cobb, 33% MaxTAloft, 33% Roebber
NAMNest	50% Cobb, 50% MaxTAloft
10 SREF ARW	50% Cobb, 50% MaxTAloft
GFS	33% Cobb, 33% MaxTAloft, 33% Roebber
30 GEFS	33% Cobb, 33% MaxTAloft, 33% 850-700mb thickness
50 ECMWF Ens	33% Cobb, 33% MaxTAloft, 33% 850-700mb thickness

Cobb method for SLR - changes implemented 2022 Mar 24th

- A more conservative temperature to snow-ratio curve has been introduced to correct for an overall high bias in early testing of NBM v4.1.
- The layer snow-ratio is now calculated using the average of a T, T+1, T-1. Overall, it's a more robust approach and gives much more realistic gradients of SLR in near 0^0C situations where sleet is likely to mix with snow at times.
- The square-root of the vertical velocity field is now used as the weighting factor to determine the SLR. Layers with a downward velocities are now set to a value of (1 cm/s) so that they can minimally contribute to the total SLR if the layer RH is high.
- The calculation now uses vertical levels between 925mb and 300mb. Previously, the calculation used levels between 900mb and 100mb. The calculation is truncated if any pressure level is below ground.
- Additionally, to allow for Cobb to work on lower vertical resolution models (e.g. GEFS, ECMWFE, and SREF data), available mandatory level data has been logarithmically interpolated to produce 25 mb resolution soundings. That's the same vertical resolution used in the other full resolution models. (Note: implemented March 24th)

Please reference the Appendix section at the end of the Presentation for more about the Cobb method, which details even more about these changes. A change example can be found in the Apr 13 snow event.

NBM V4.1 Snow Level Calculation

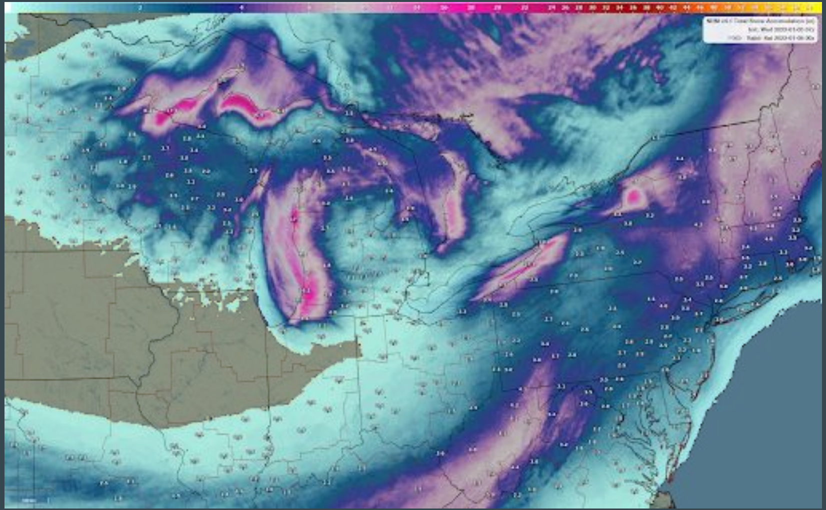
- Snow Level definition remains the same, Tw=0 + 0.5C
- Follows the 4.1 precipitation type membership. Weighting applied to deterministic output only
- New with NBM V4.1: Probabilistic Snow Level (5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles)
- *NOTE: Does not account for diabatic effects like the melting term when persistent moderate to heavy precipitation can lower snow levels*

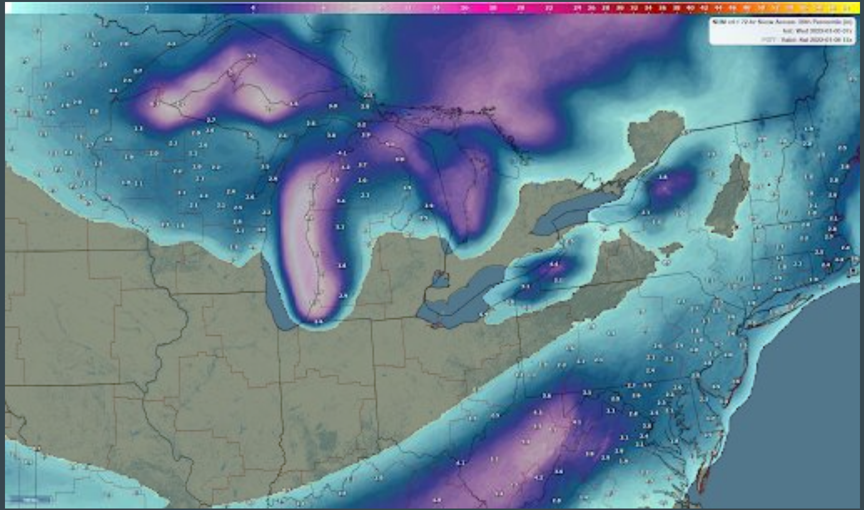
Snow, Sleet and Ice Accumulation

- Follows the 4.1 precipitation type membership
- *** 2022 Mar 15 change *** For QPF input:
  - Utilizes NBM QMD downscaled QPF of each ensemble member (GEFS, ECMWFE, and SREF - 90 of the 100 inputs)
  - Raw QPF output for remaining members
- Utilizes downscaled temperature of each member
  - Not the URMA bias correction as in past NBM versions
  - Downscaling approach similar to GFE smartInits utilizing high res topography
- Like V4.0, each member Snow (Snow + Sleet) and Ice are computed and then blended.
  - 2 to 1 ratio applied for Sleet
  - Deterministic output applies the p-type weighting to that blend
  - Ice Accumulation still uses the Freezing Rain Accumulation Model (WDTD training, info sheet)
- New with NBM V4.1: Probabilistic (5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles)
  - One hour Snow Accumulation
  - Six hour Snow Accumulation
  - Six hour Ice Accumulation

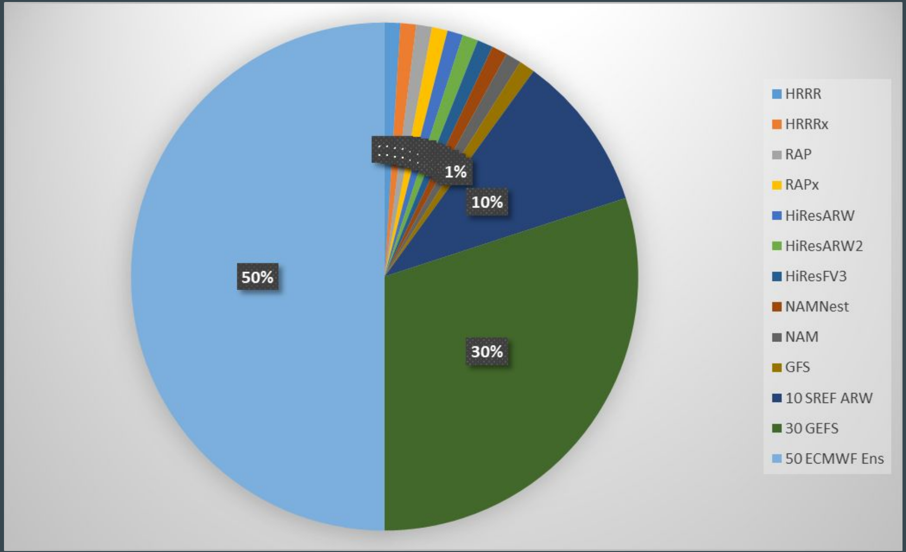
Caution: Deterministic vs Probabilistic Accumulations

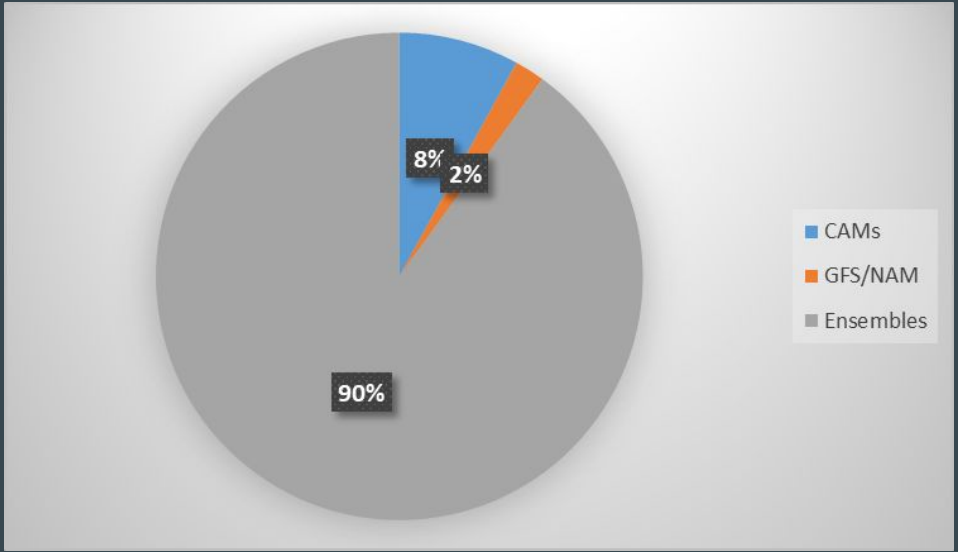
The weighting of 4.1 precipitation types shown earlier again ONLY applies to the deterministic accumulations. Probabilistic snow/ice accumulations use equal weighting. An example of the weighting impact is shown below, comparing the deterministic total snow that weights CAMs higher (left) vs the 50th percentile total snow (right).





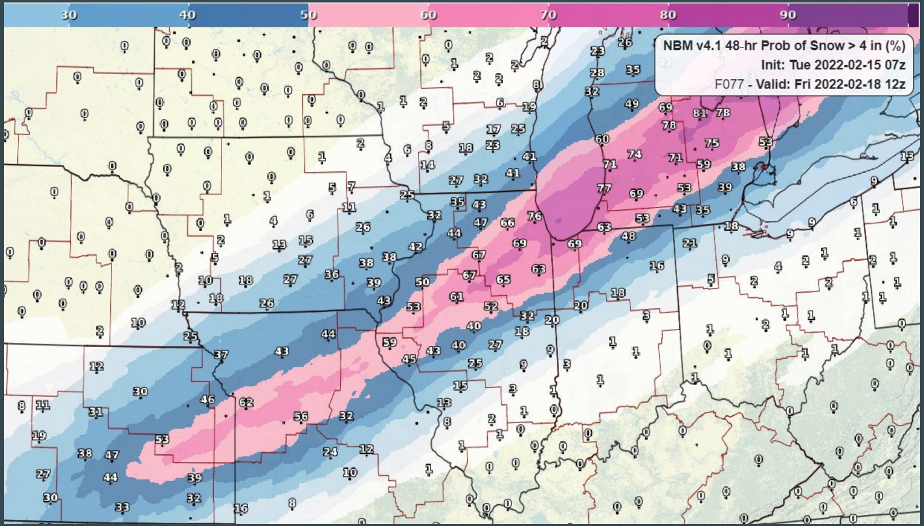
V4.1 Probabilistic Snow/Ice Member Weighting - by Model Type - applies to ALL forecast hours

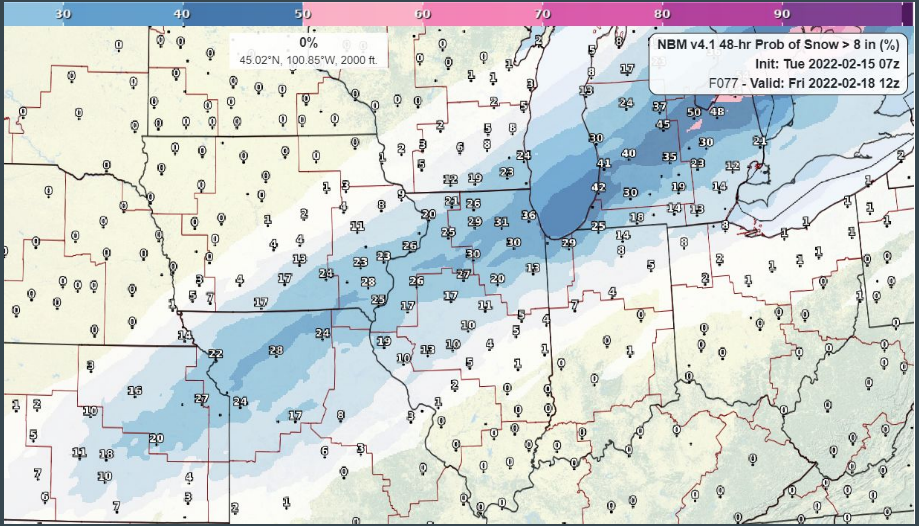




V4.1 Prob Snow graphics for Feb 16-18, 2022

Notice in MO, IA and IL, the axis of prob snow > 8” is farther north than axis of prob snow > 4.” Why? The stronger & colder solutions produce a broader swath of snow, and that position the higher amounts farther north. Meanwhile, The weaker & warmer solutions do not produce as much snow, but overlap with the lower amounts from the stronger camp of solutions. Thus this is meteorologically and statistically consistent.





Improvements already observed

- In extended:
  - Increased membership producing a more realistic 10th percentile for snow
  - For probabilities of exceedance for snow and ice: More coherent and without the “stairsteps” that were evident in V4.0 caused by the low membership
- Significant reduction in freezing rain and ice accumulation in situations where soundings display loss of ice

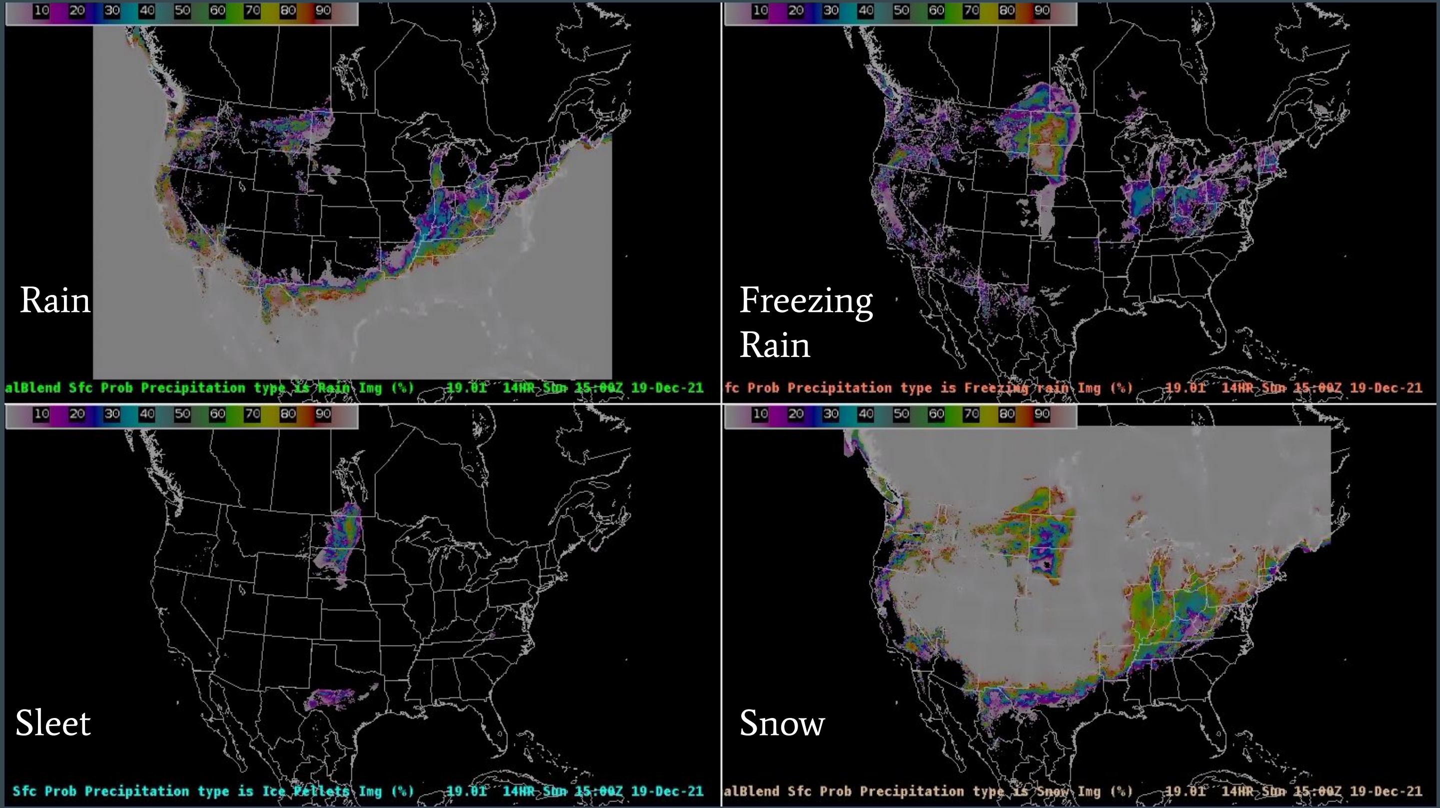
Some items to evaluate with V4.1

- Lake effect
- Upslope snow
- Freezing drizzle in dry slots or upslope regimes
- Freezing rain in mountainous areas, especially Pacific Northwest and Appalachians
- Distribution of precipitation type in extended
- Snow to Liquid Ratio performance vs 4.0
- Improved consistency with NBM QPF and PoP compared to V4.0, since those have more members and are derived from QMD process

Sample Cases for Comparing V4.0 to V4.1

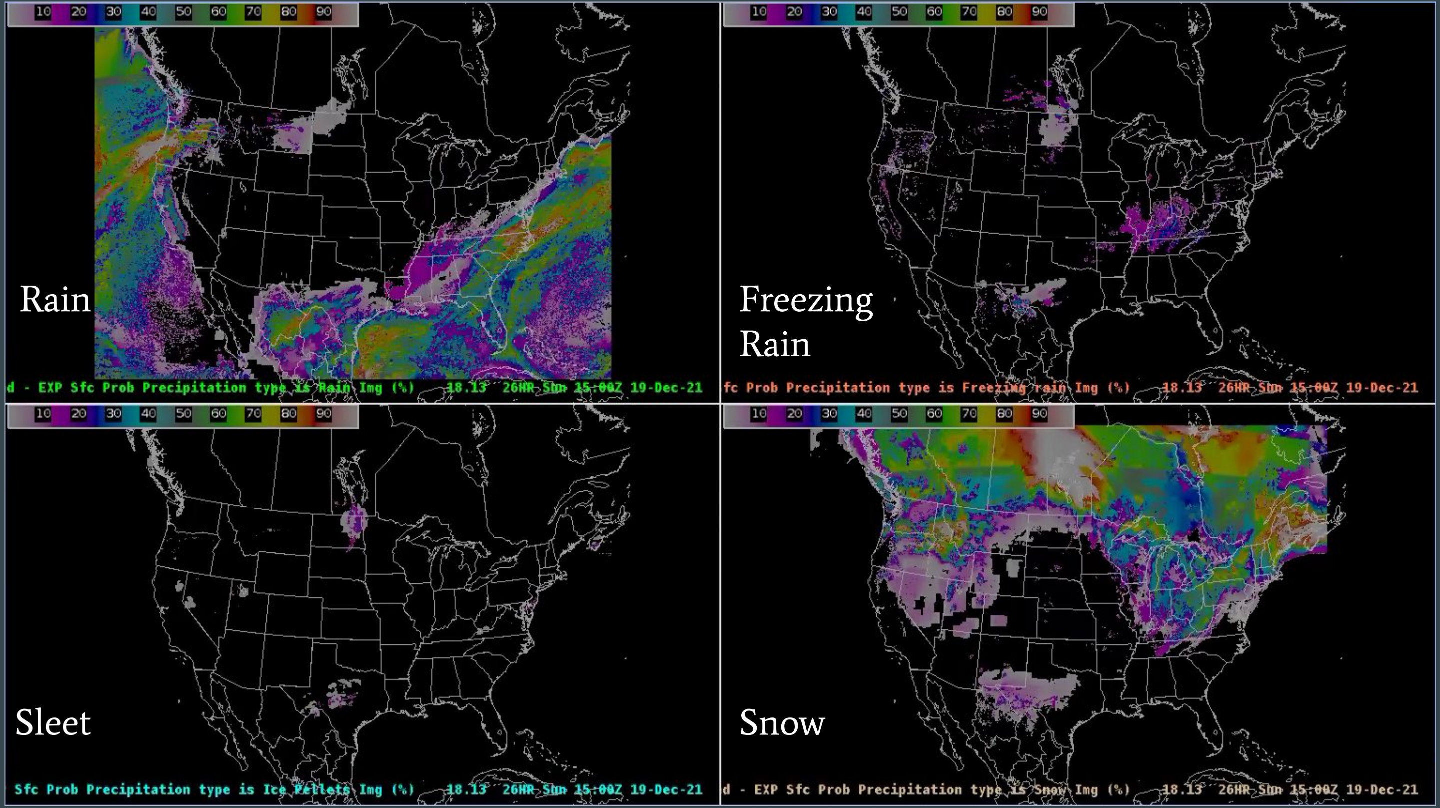
Early Feb 2023 ice storm case

Precipitation Type Comparison - V4.0



Remember, this is Conditional, "assuming precipitation occurs, probability of each type"

Precipitation Type Comparison - V4.1



This is Unconditional, "Probability of each type where precipitation is forecast"

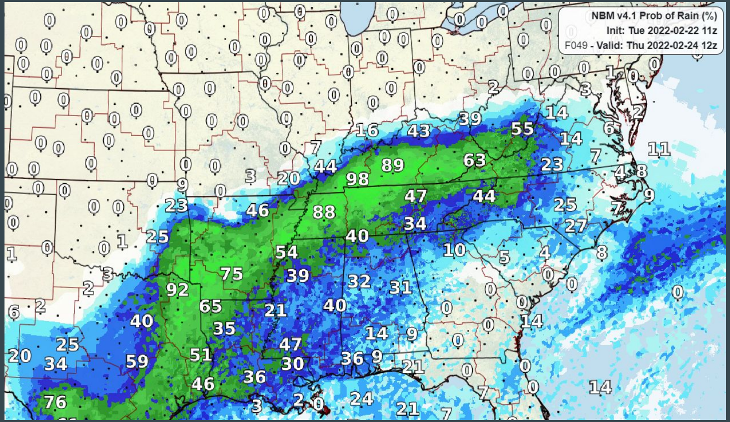
NOTE

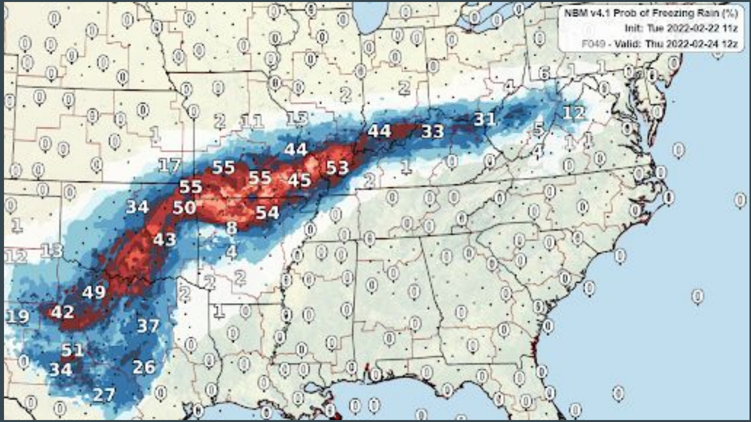
Capability to view V4.1 in AWIPS came with a National SmartInit Team release in January 2022

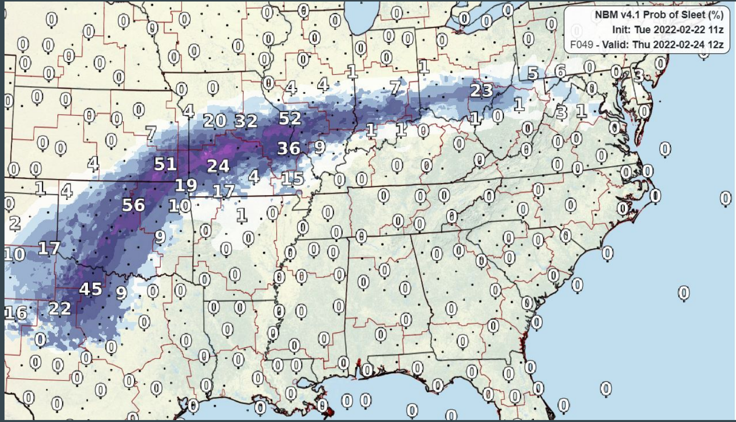
Mixed Precipitation Event - Feb 24, 2022

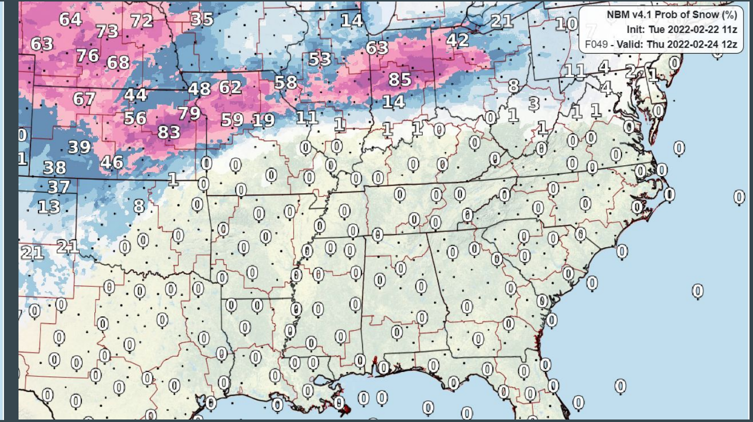
4 panel view to show how all four precipitation types align at a single forecast hour

22.11Z NBM V4.1 at 12Z Thu



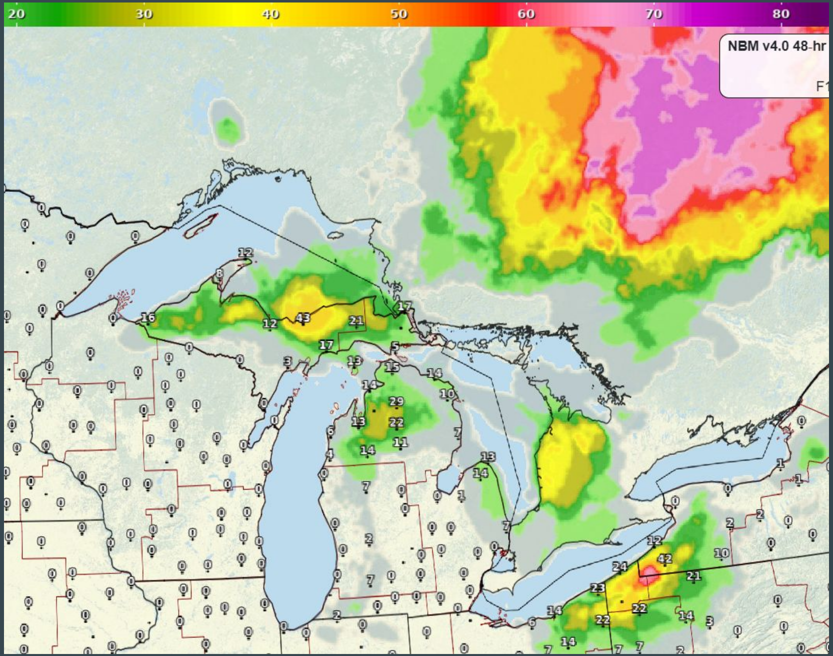




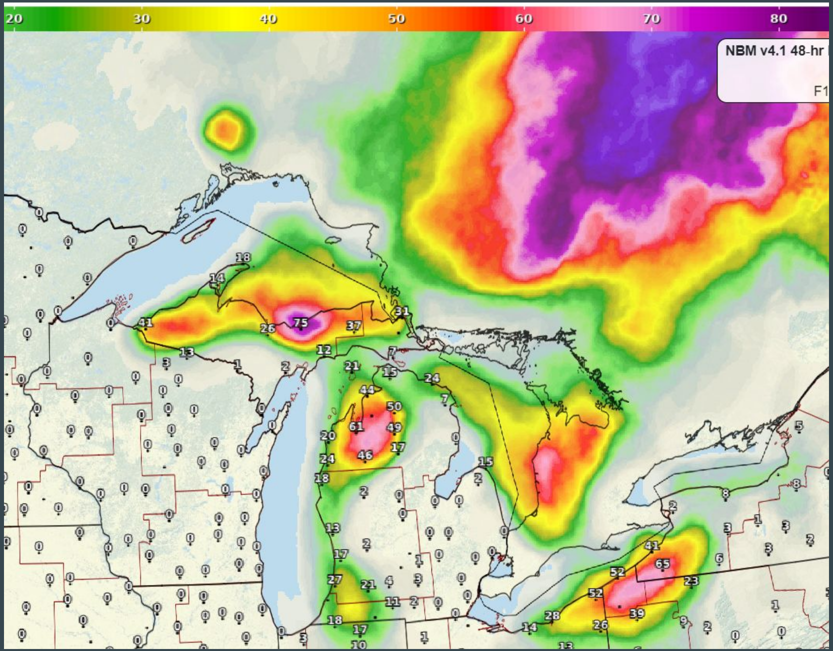


Comparison of Lake Effect - V4.0 vs V4.1

NBM V4.0 2021 Nov 19 01Z cycle

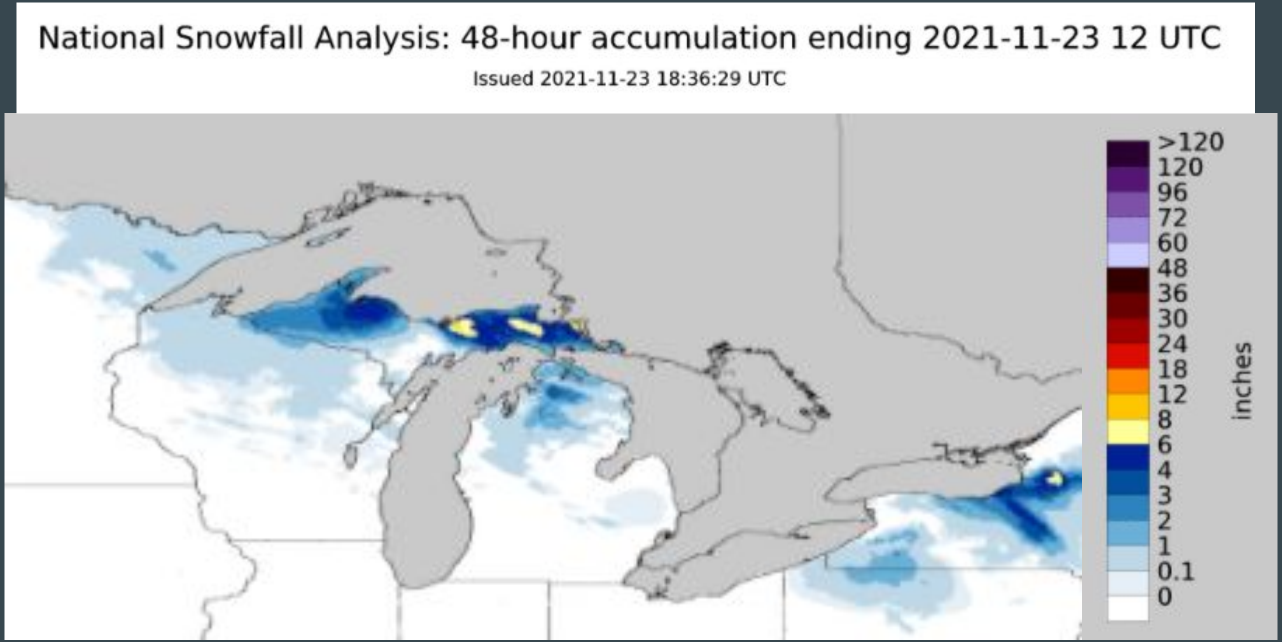


NBM V4.1 2021 Nov 19 01Z cycle



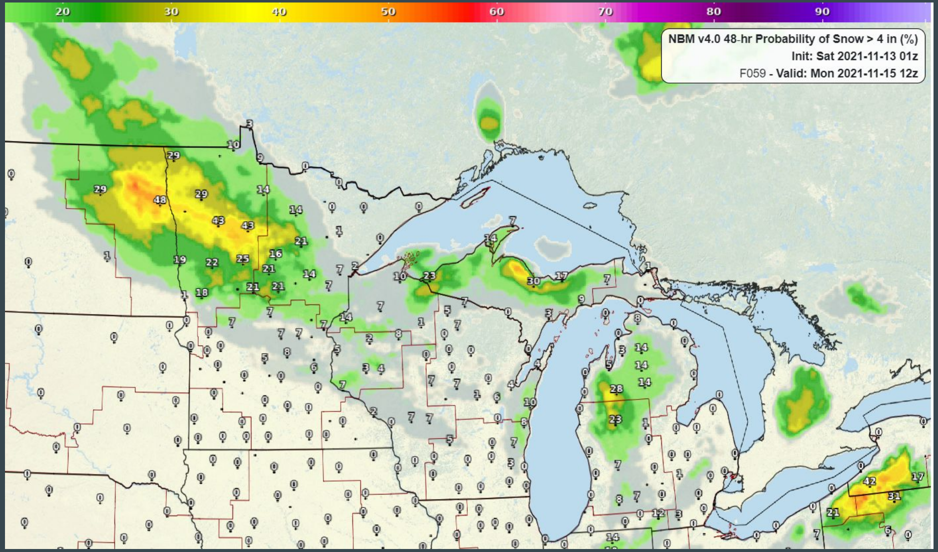
48 hour Probability of Snow > 4” valid 12Z Nov 21 - 12Z Nov 23

Observed Snowfall from NOHRSC

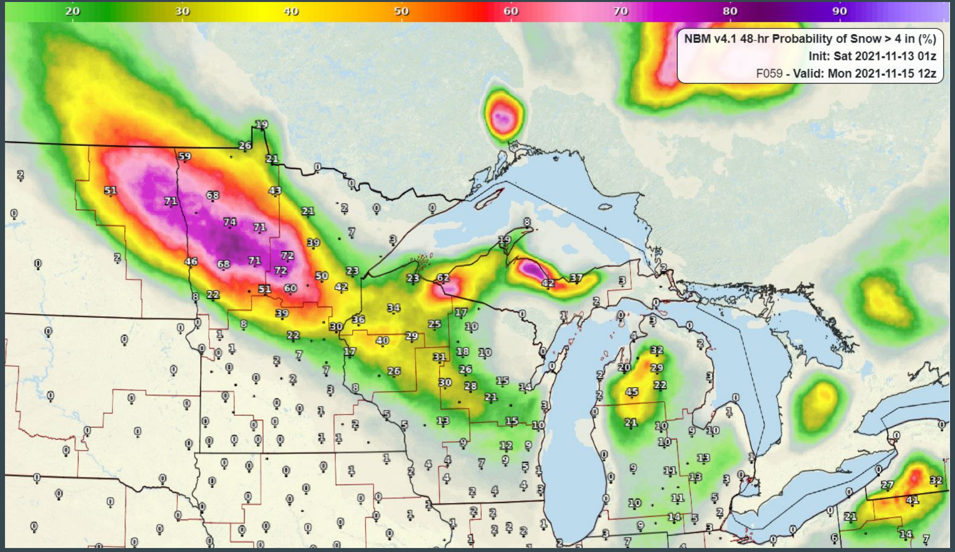


V4.0 and V4.1 Synoptic Snow and Lake Effect

NBM V4.0 2021 Nov 13 01Z cycle

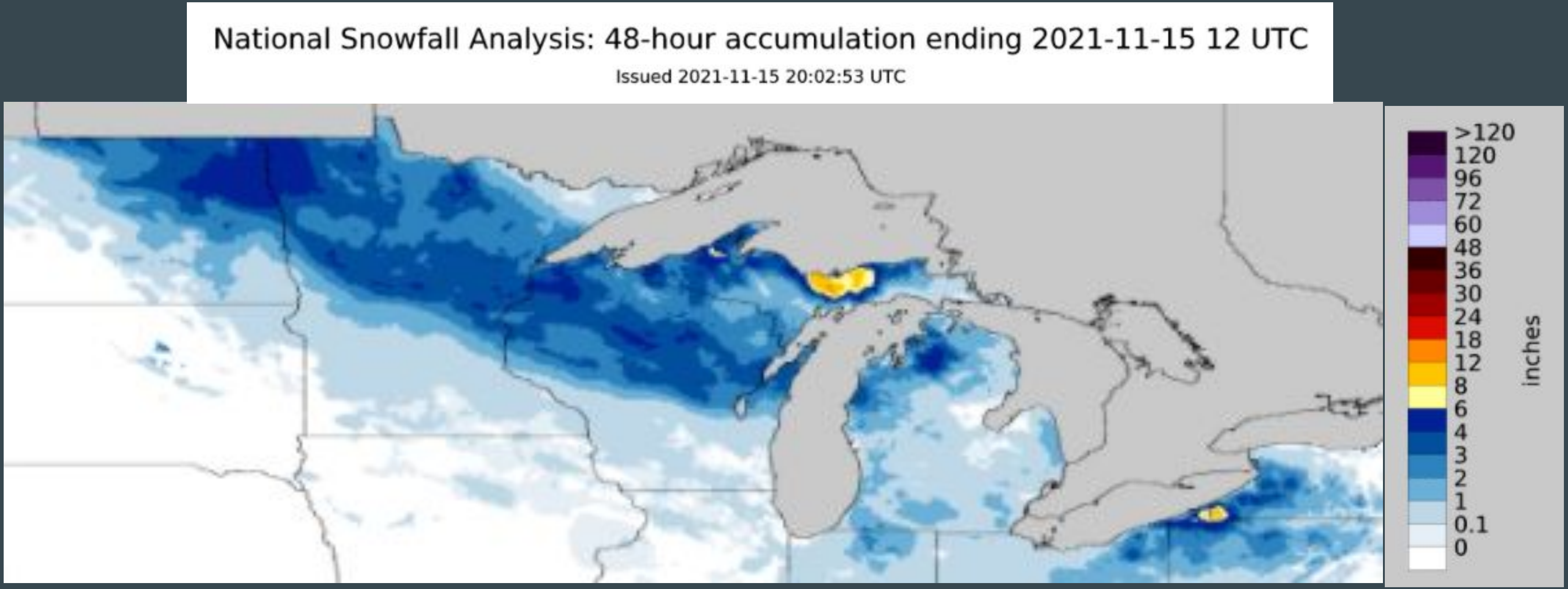


NBM V4.1 2021 Nov 13 01Z cycle



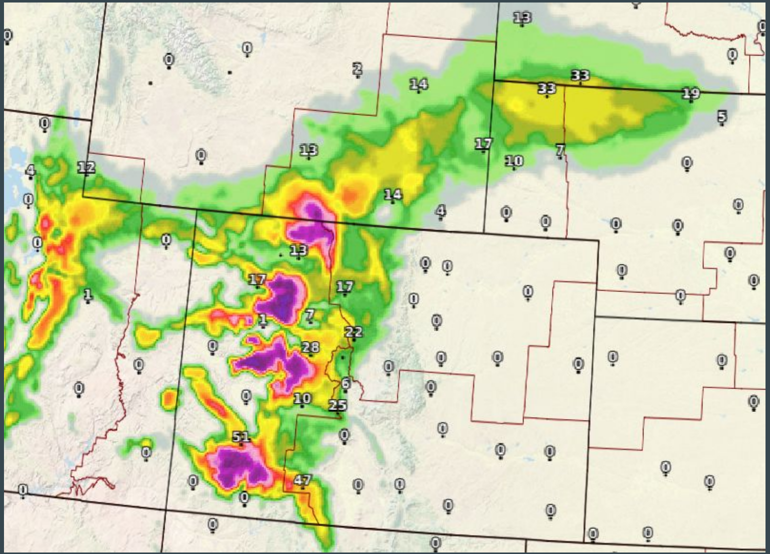
48 hour Probability of Snow > 4” valid 12Z Nov 13 - 12Z Nov 15

Observed Snowfall from NOHRSC

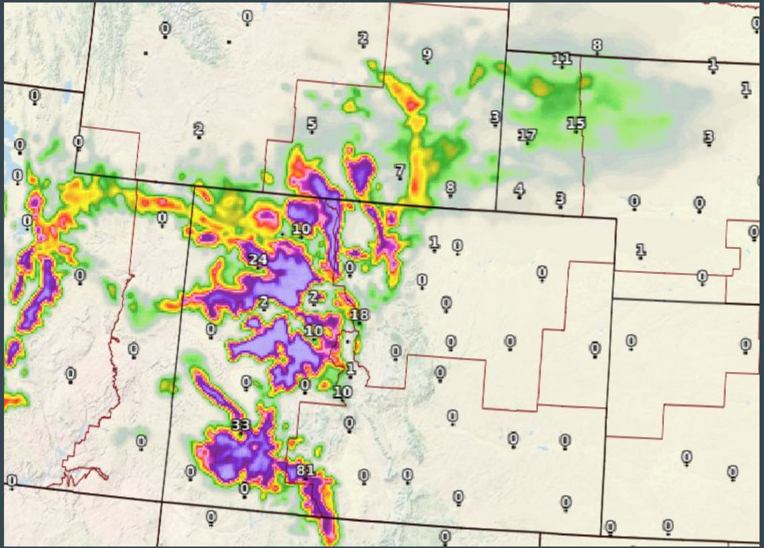


V4.0 and V4.1 Mountain Snow example

NBM V4.0 2021 Dec 08 07Z cycle

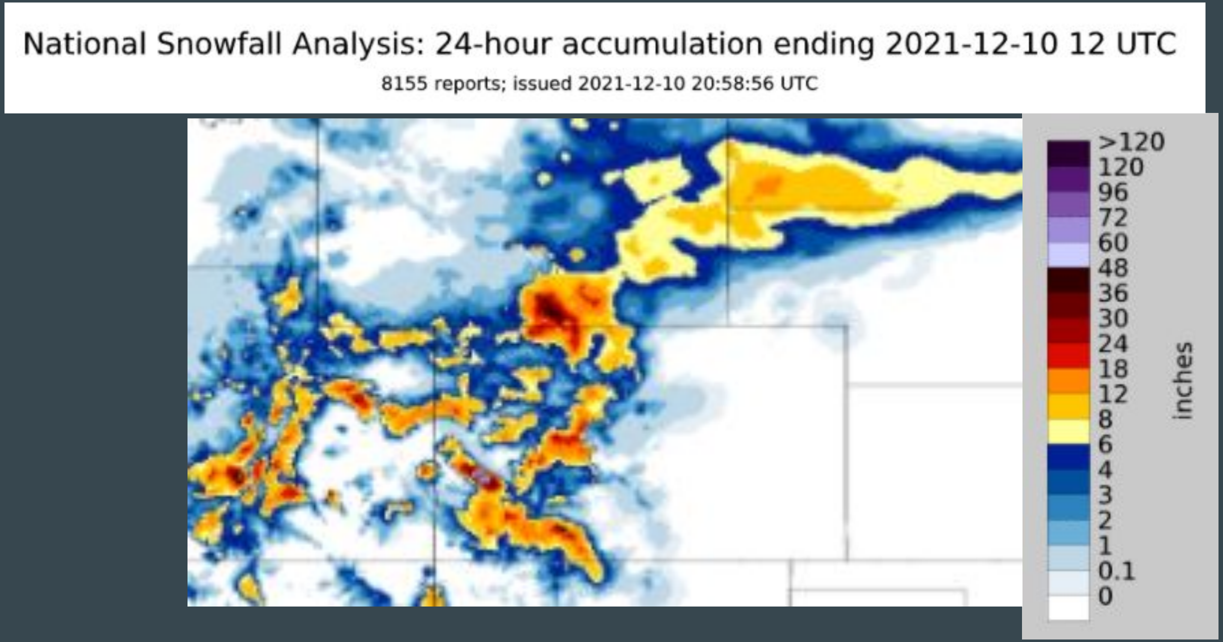


NBM V4.1 2021 Dec 8 07Z cycle



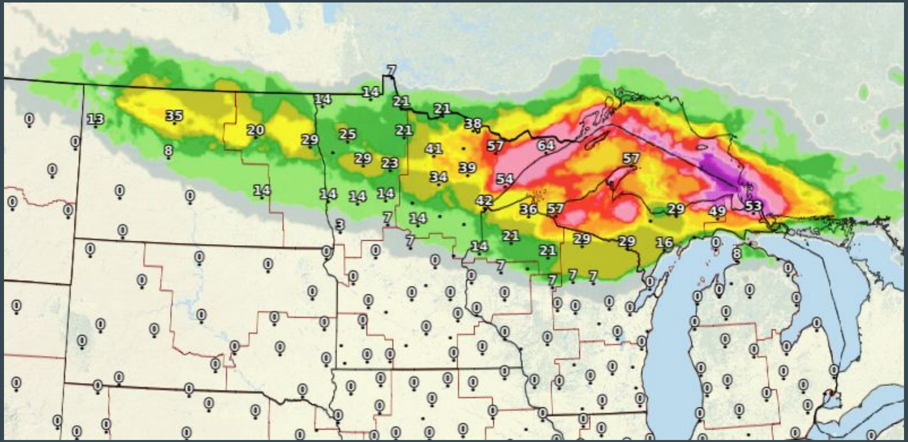
24 hour Probability of Snow > 8” valid 12Z Dec 9 - 12Z Dec 10

Observed Snowfall from NOHRSC

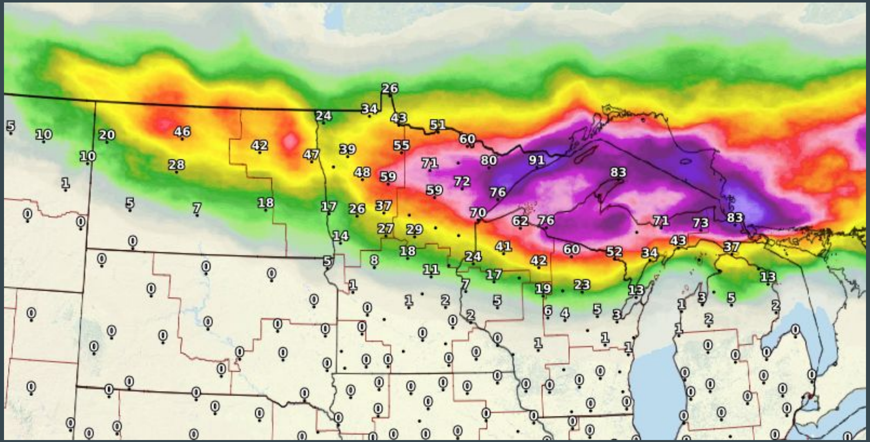


V4.0 and V4.1 Combined System and Lake Effect Snow

NBM V4.0 2021 Dec 3 13Z cycle

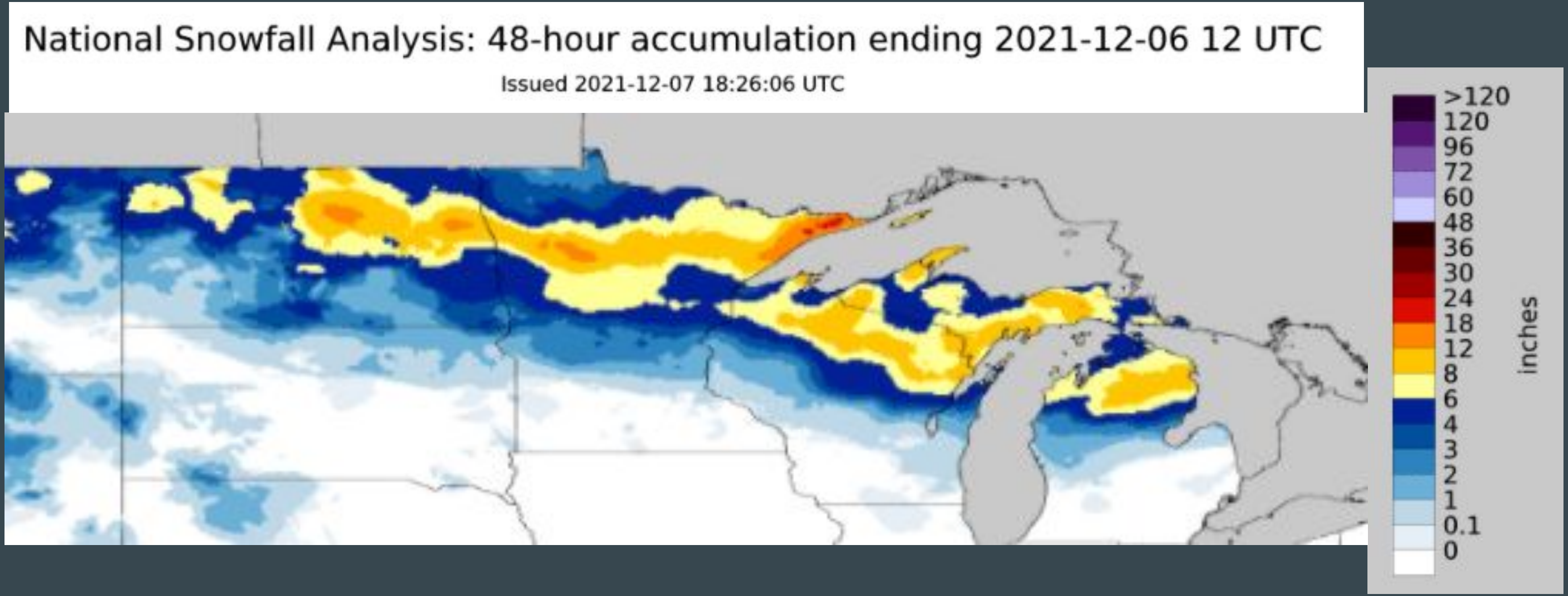


NBM V4.1 2021 Dec 3 13Z cycle



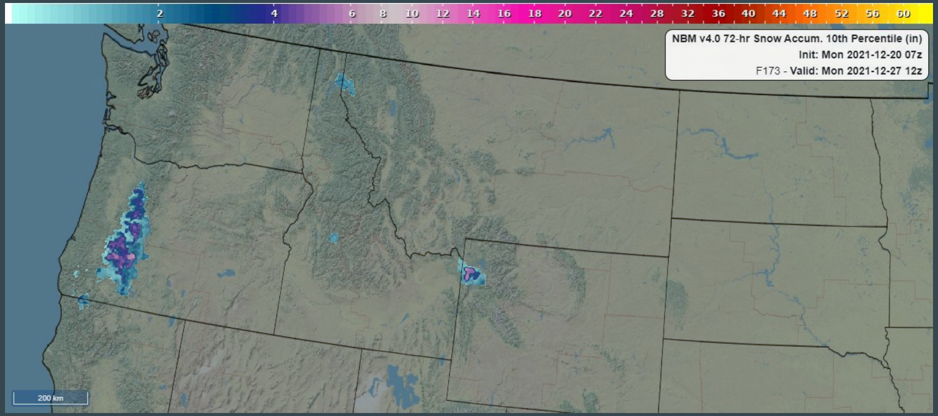
48 hour Probability of Snow > 8” valid 12Z Dec 4 - 12Z Dec 6

Observed Snowfall from NOHRSC

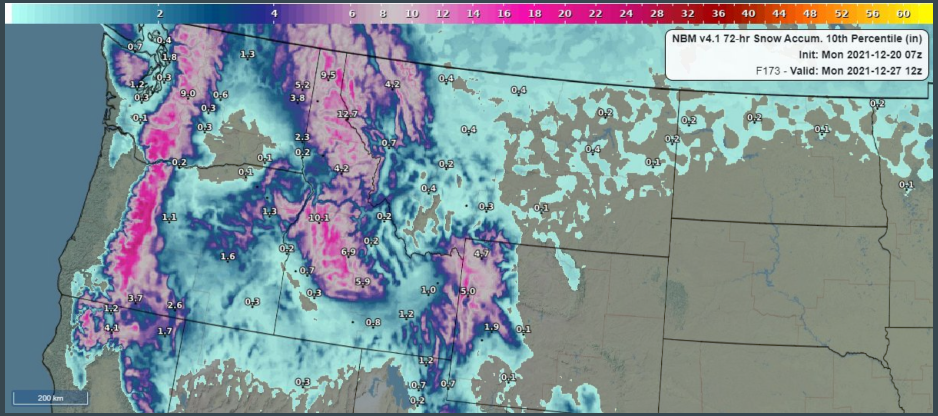


V4.0 and V4.1 10th Percentile 72hr Snowfall Accumulation

NBM V4.0 2021 Dec 20 07Z cycle



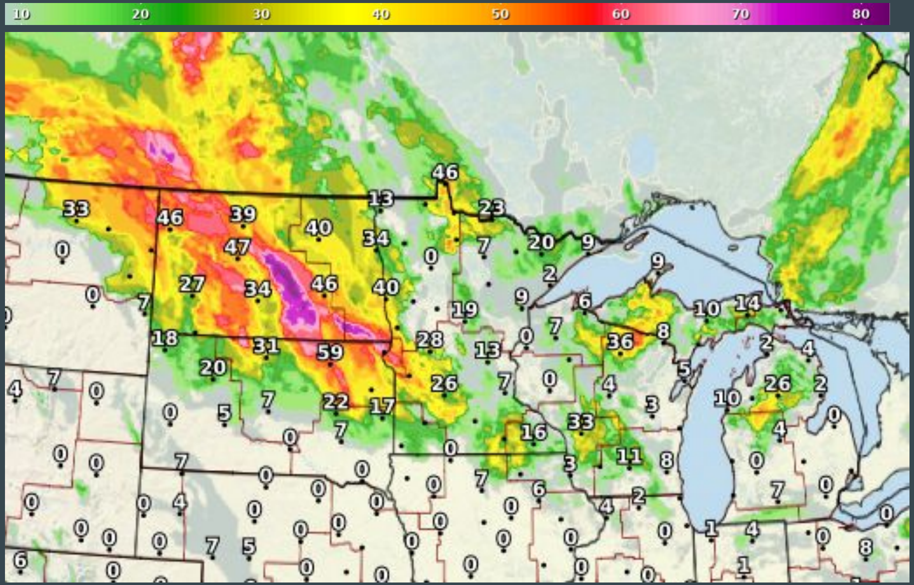
NBM V4.1 2021 Dec 20 07Z cycle



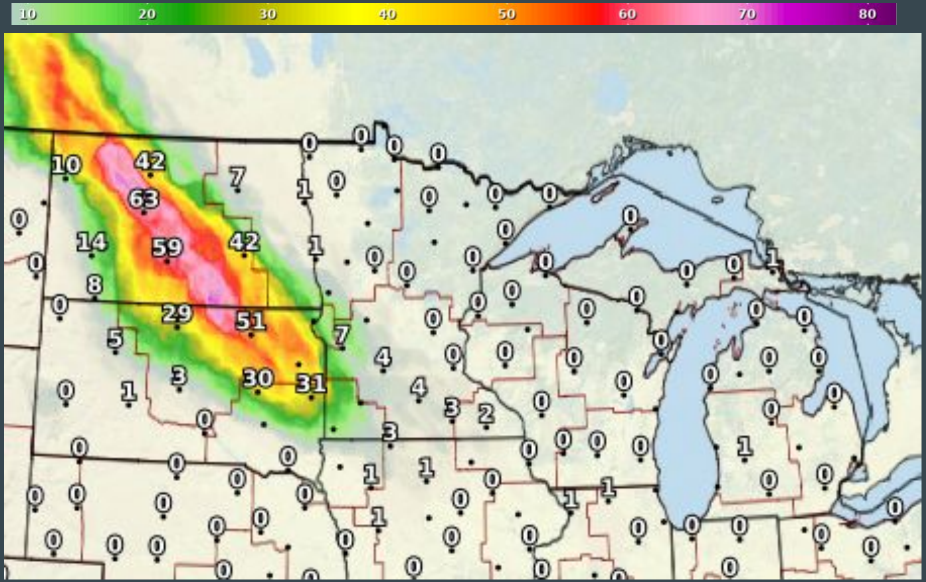
Valid 12Z Dec 24 - 12Z Dec 27

Light Icing

NBM V4.0 2021 Nov 12 07Z cycle

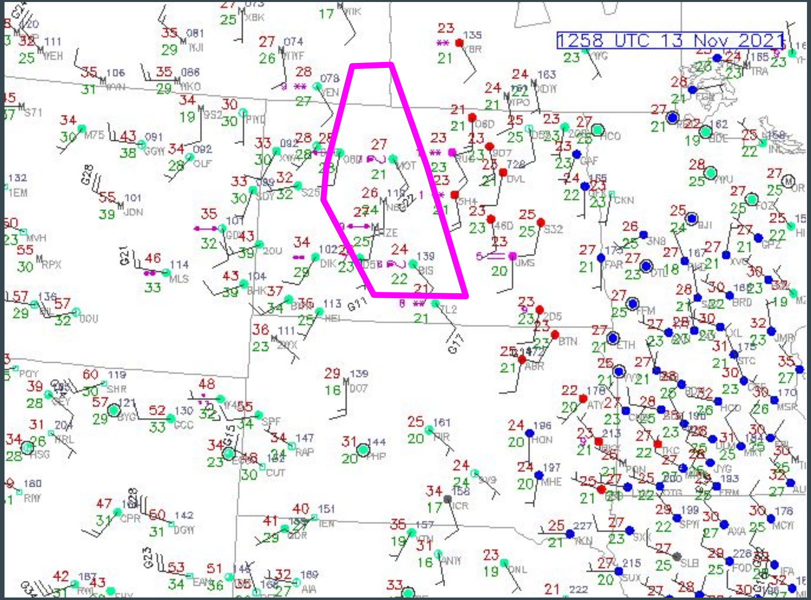


NBM V4.1 2021 Nov 12 07Z cycle



Probability of Ice Accum > 0.01” valid 06Z Nov 13 - 06Z Nov 14

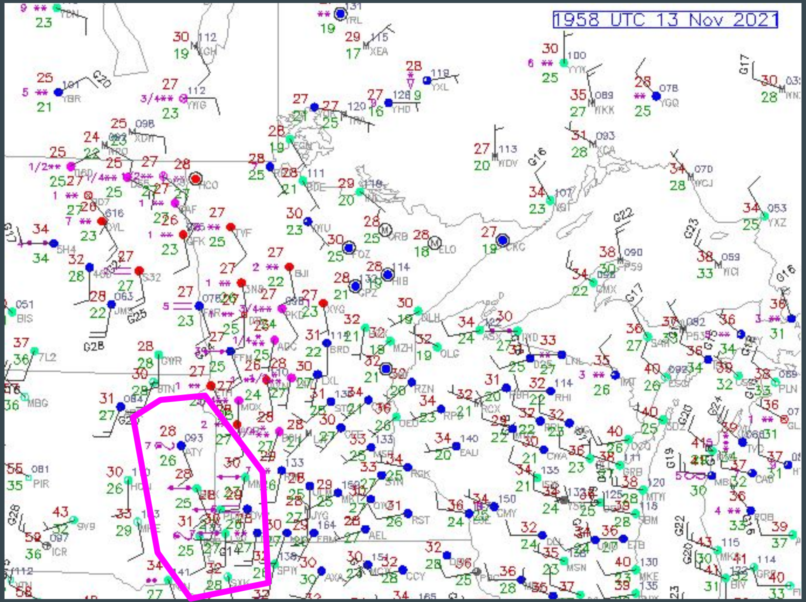
Noteworthy Observations for Light Icing Case



KMOT 131754Z 26015G21KT 10SM OVC018 04/01 A2957 RMK AO2 SLP036 60002 I6007 T00390006 10039 21033 56033

KBIS 131752Z 20007KT 10SM CLR 04/01 A2968 RMK AO2 SLP071 60009 I1000 I6008 T00390011 10039 21050 56028

IceAccum between 12-18Z: Minot reported 0.07” and Bismarck reported 0.08”



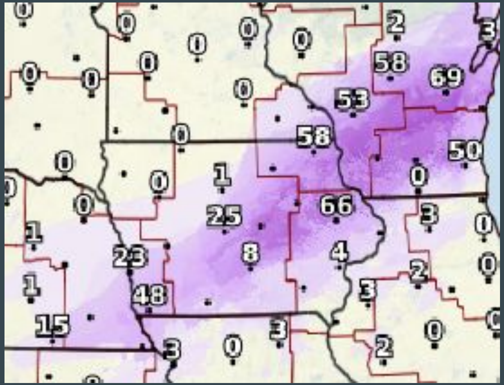
KATY 132353Z AUTO 21011KT 10SM BKN070 M01/M02 A2967 RMK AO2 SLP070 60002 I6002 T10111022 11006 21039 56020

KFSD 132356Z 21006KT 10SM BKN110 BKN210 01/M02 A2976 RMK AO2 SLP096 60003 I6002 T00111017 10017 21011 58013

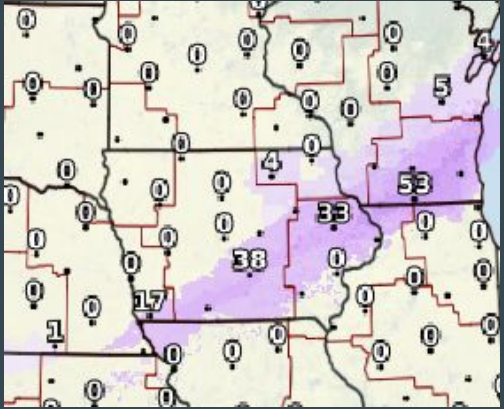
IceAccum between 18-00Z: Sioux Falls and Watertown SD both reported 0.02” Not shown, Aberdeen SD between 12-00Z reported 0.06”

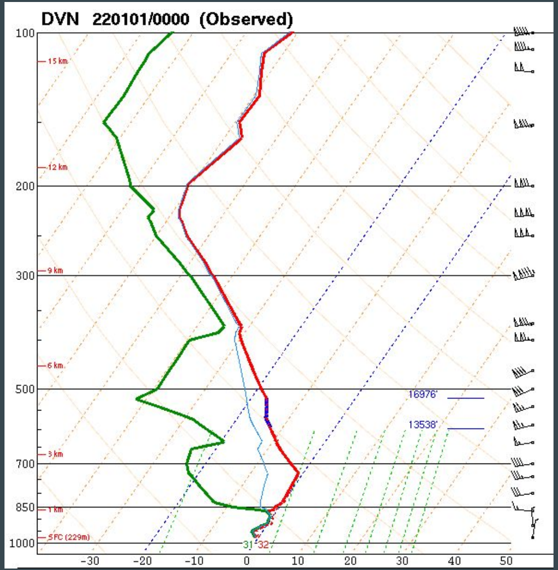
Freezing Drizzle case - 2022 Jan 1 00Z

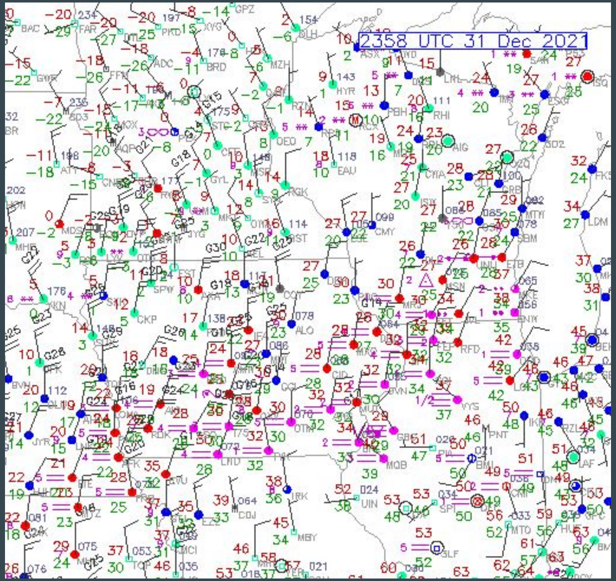
Prob ZR NBM V4.0 2021 Dec 30 21Z cycle



Prob ZR NBM V4.1 2021 Dec 30 21Z cycle





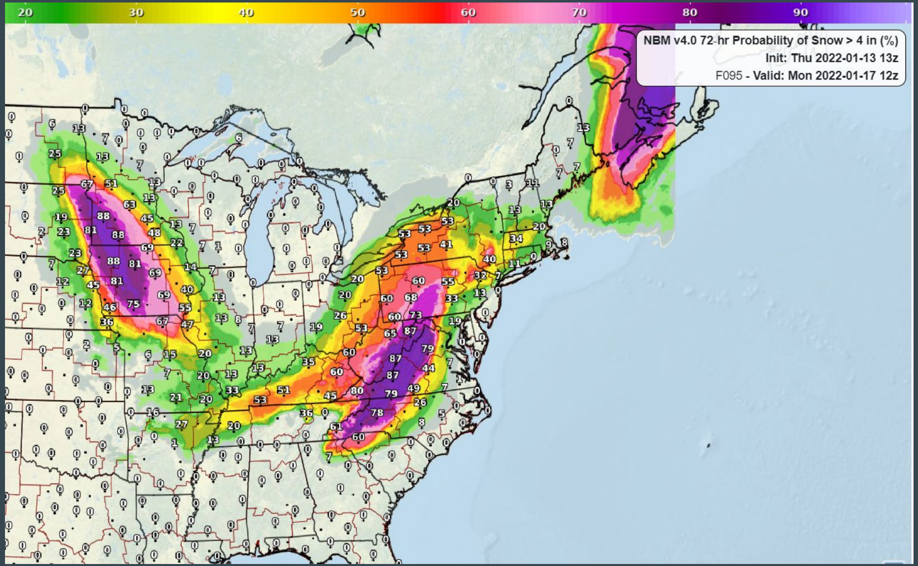


KCID 312352Z AUTO 01012KT 5SM BR OVC007 M02/M02 A2970 RMK AO2 SLP068 I1001 I6013

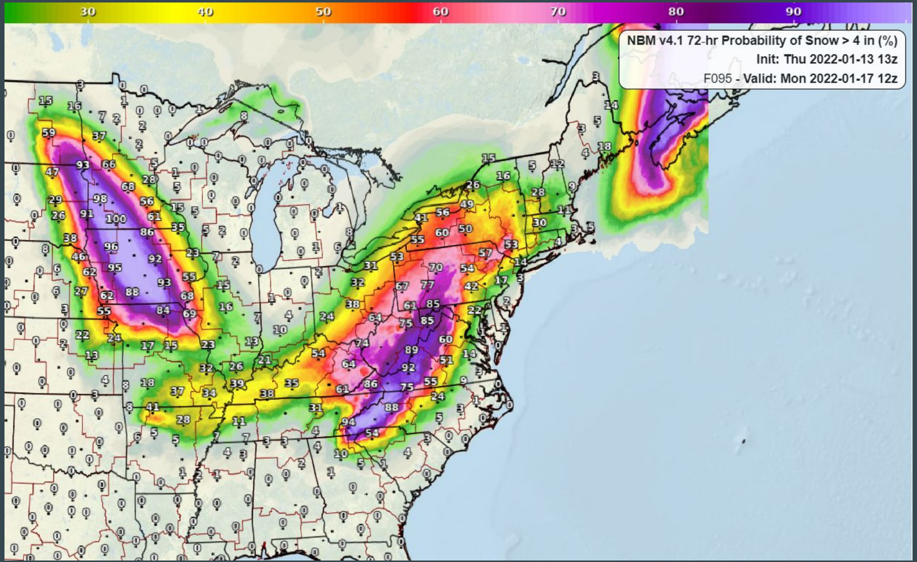
KDVN 312352Z AUTO 01010KT 2 1/2SM BR OVC004 00/M01 A2968 RMK AO2 UPE2254B05E14 SLP055 P0000 60000 I1001 I6009 T00001011 10000 21011 53027

Winter Storm: 2022 Jan 14-17   Snow Probabilities

NBM V4.0 2021 Jan 13 13Z cycle



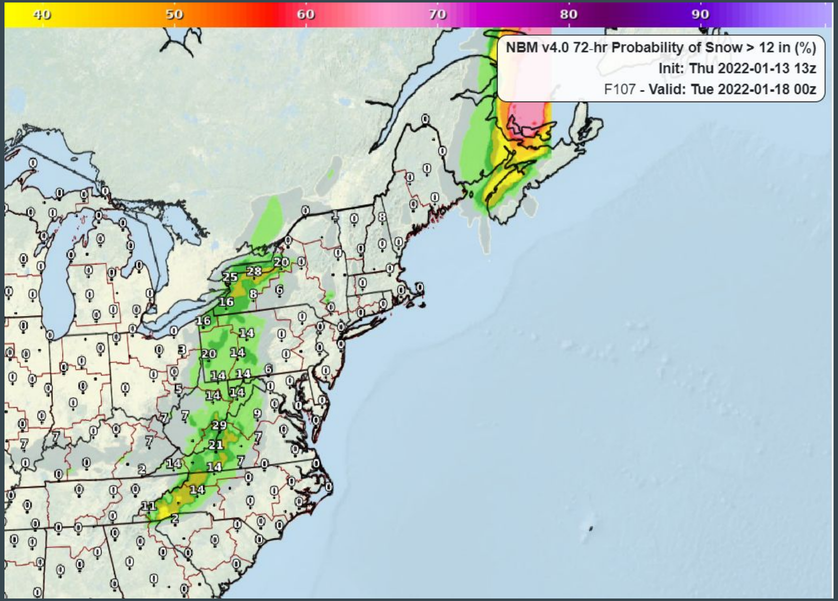
NBM V4.1 2021 Jan 13 13Z cycle



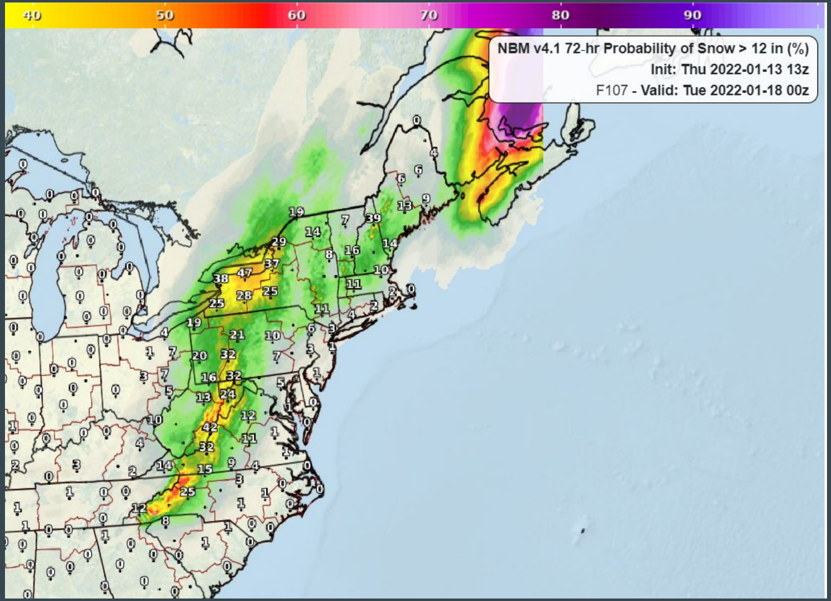
Probability of Snow > 4” valid 12Z Jan 14 - 12Z Jan 17

Winter Storm: 2022 Jan 14-17 Snow Probabilities

NBM V4.0 2021 Jan 13 13Z cycle



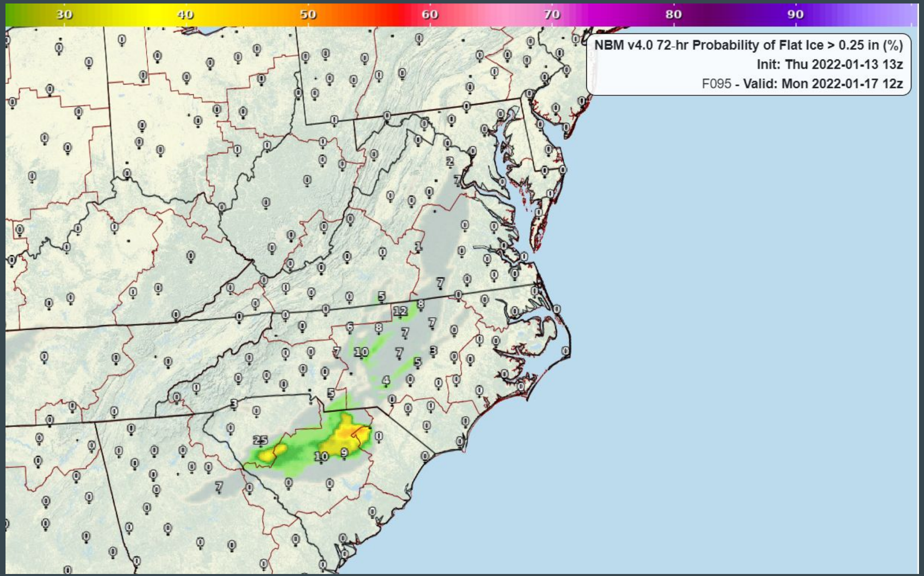
NBM V4.1 2021 Jan 13 13Z cycle



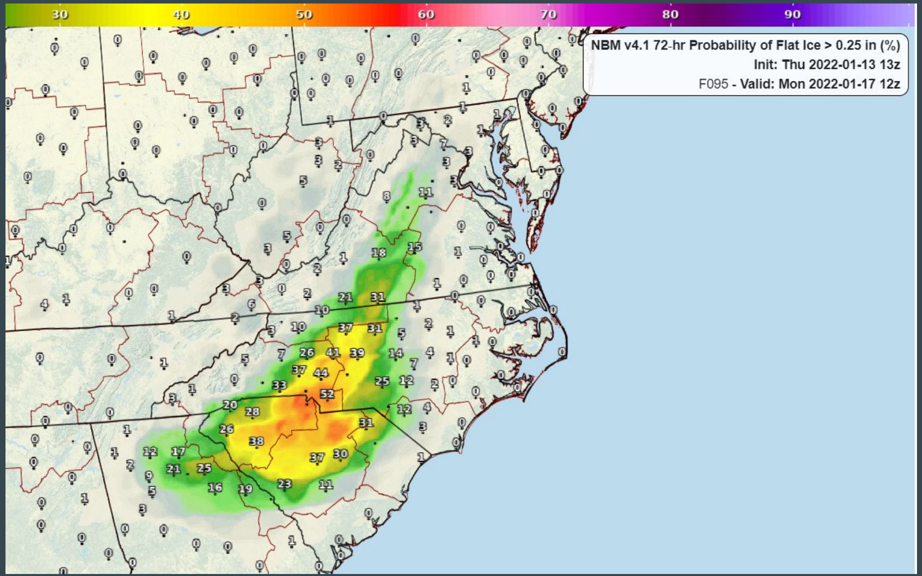
Probability of Snow > 12” valid 00Z Jan 15 - 00Z Jan 18

Winter Storm: 2022 Jan 14-17   Ice Probabilities

NBM V4.0 2021 Jan 13 13Z cycle



NBM V4.1 2021 Jan 13 13Z cycle



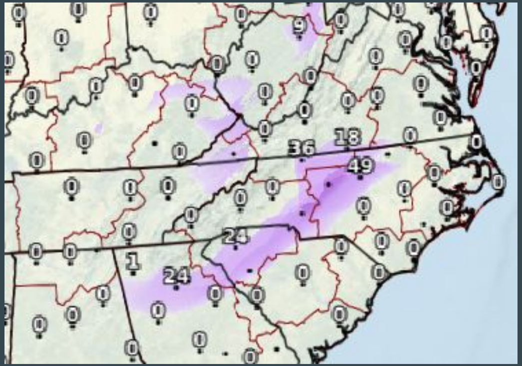
Probability of Ice Accum > 0.25” valid 12Z Jan 14 - 12Z Jan 17

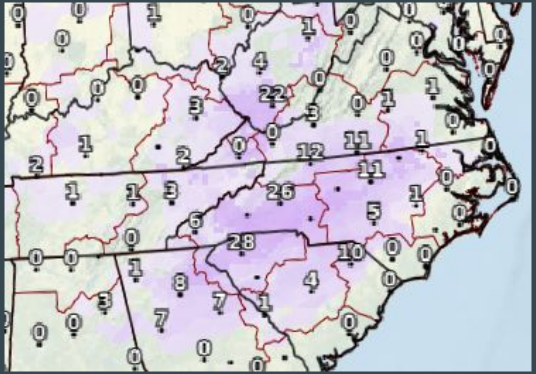
Winter Storm: 2022 Jan 14-17 Freezing Rain and IP Probabilities

NBM V4.0 2021 Jan 13 13Z cycle

NBM V4.1 2021 Jan 13 13Z cycle

Sleet

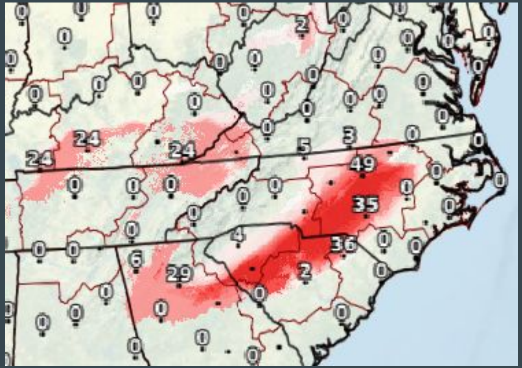


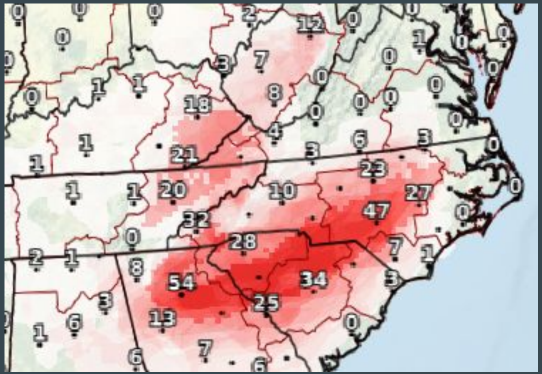


Sleet

Valid 18Z Jan 16

Freezing Rain

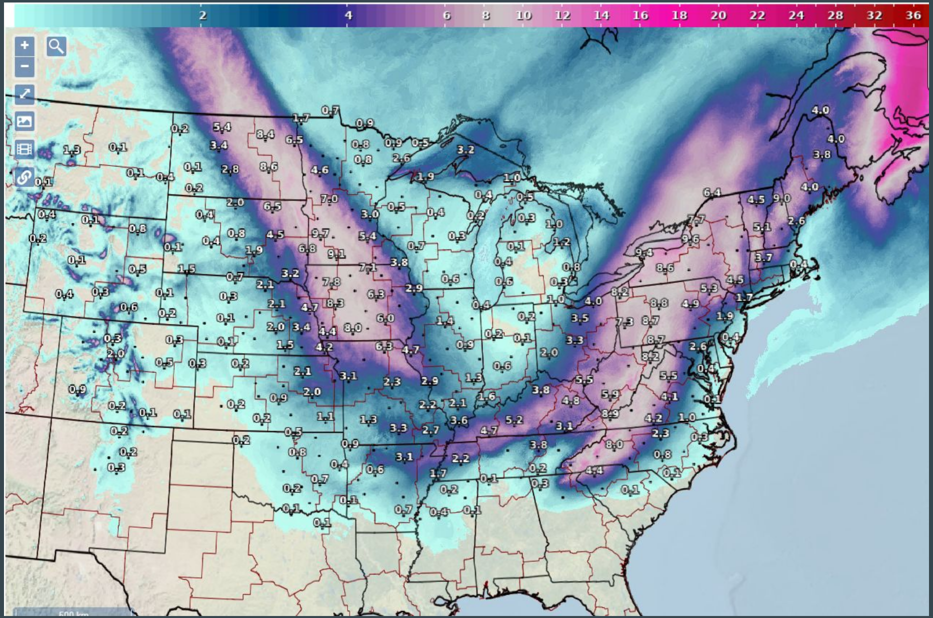




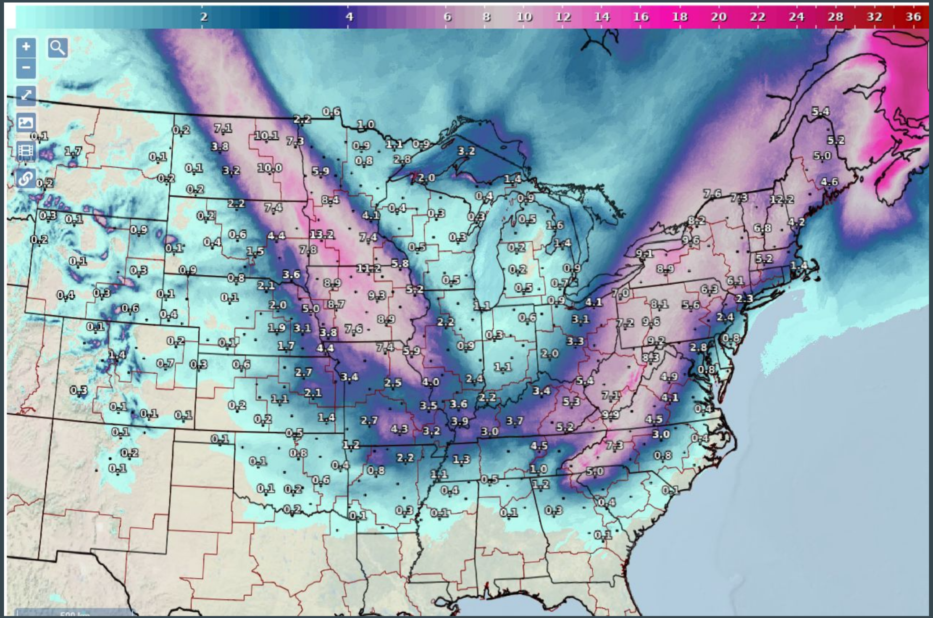
Freezing Rain

Winter Storm: 2022 Jan 14-17   Total Snow

NBM V4.0 2021 Jan 13 13Z cycle

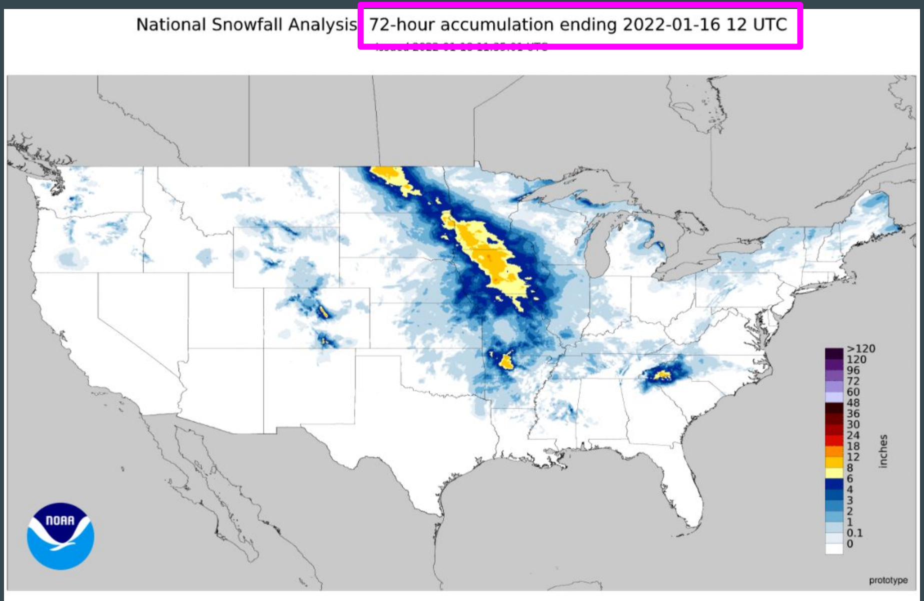


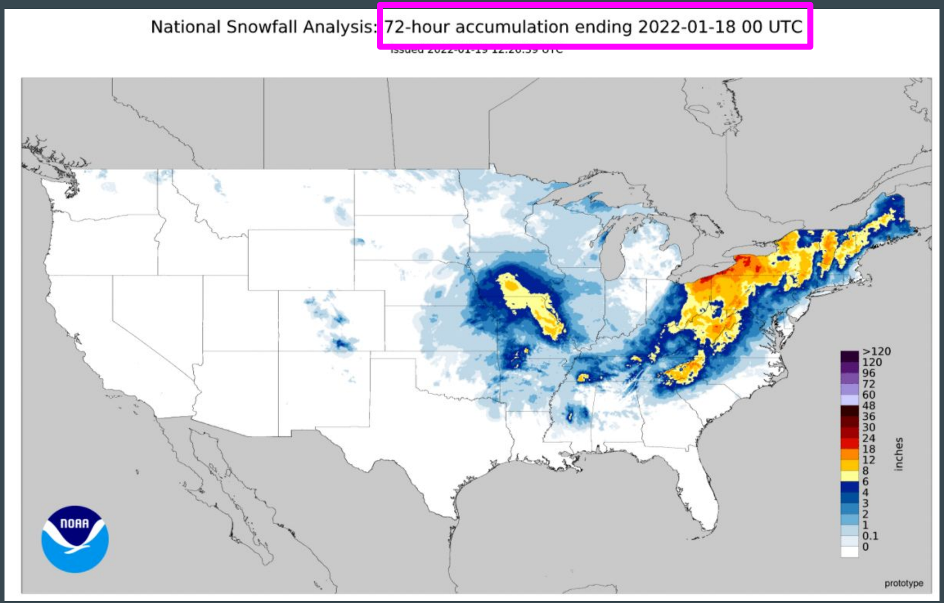
NBM V4.1 2021 Jan 13 13Z cycle



Total Snow Accumulation valid 12Z Jan 13 - 00Z Jan 18

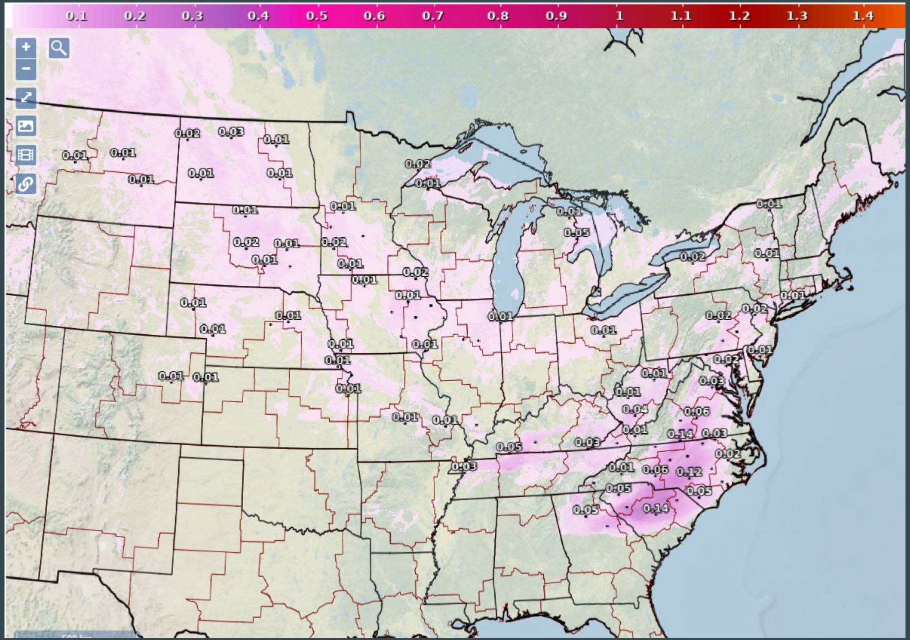
Observed Snowfall from NOHRSC



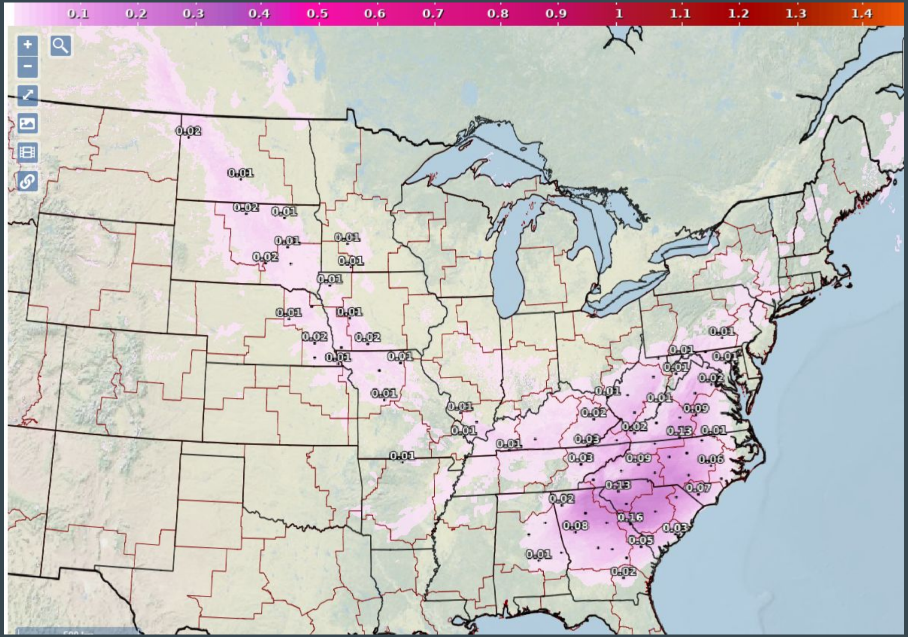


Winter Storm: 2022 Jan 14-17   Total Ice

NBM V4.0 2021 Jan 13 13Z cycle



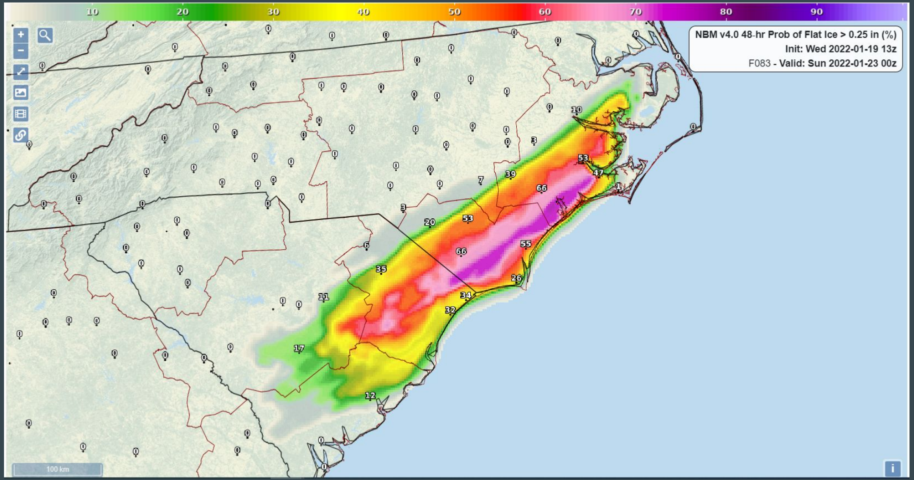
NBM V4.1 2021 Jan 13 13Z cycle



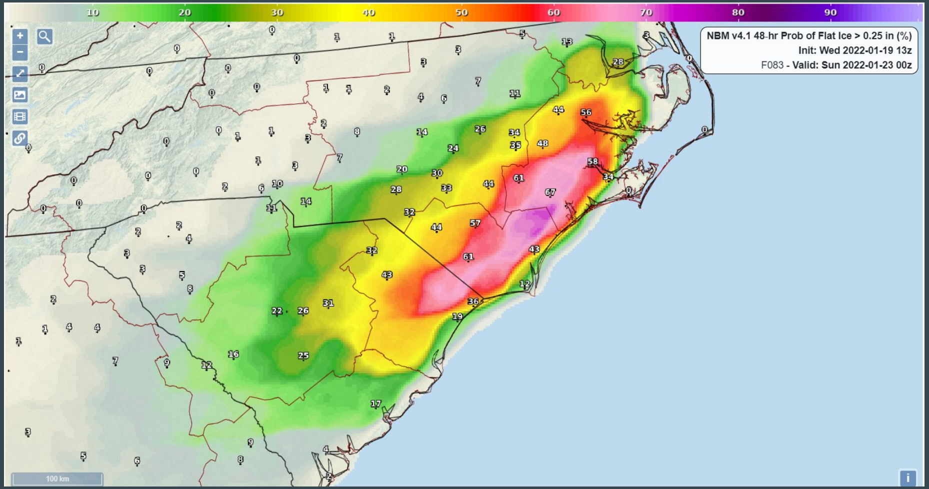
Total Ice Accumulation valid 12Z Jan 13 - 00Z Jan 18

Ice event Carolina Coasts Jan 21-22 2022 - Prob Ice

NBM V4.0 2021 Jan 19 13Z cycle



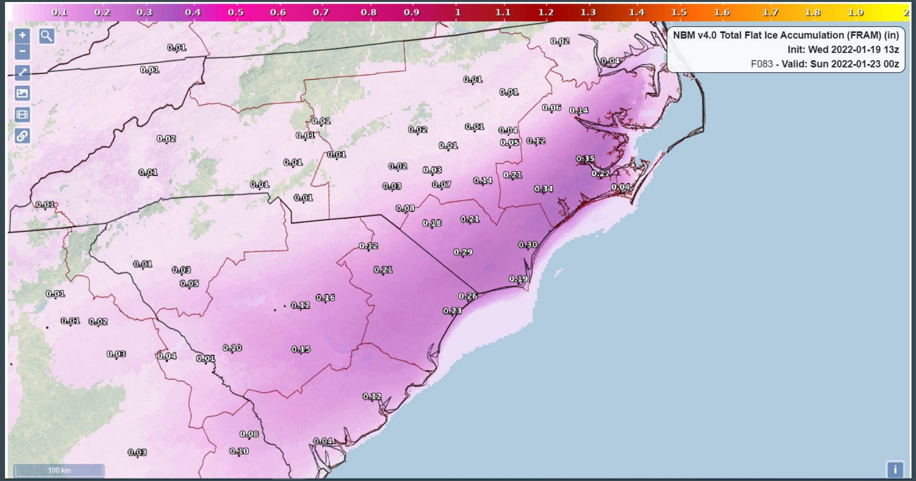
NBM V4.1 2021 Jan 19 13Z cycle



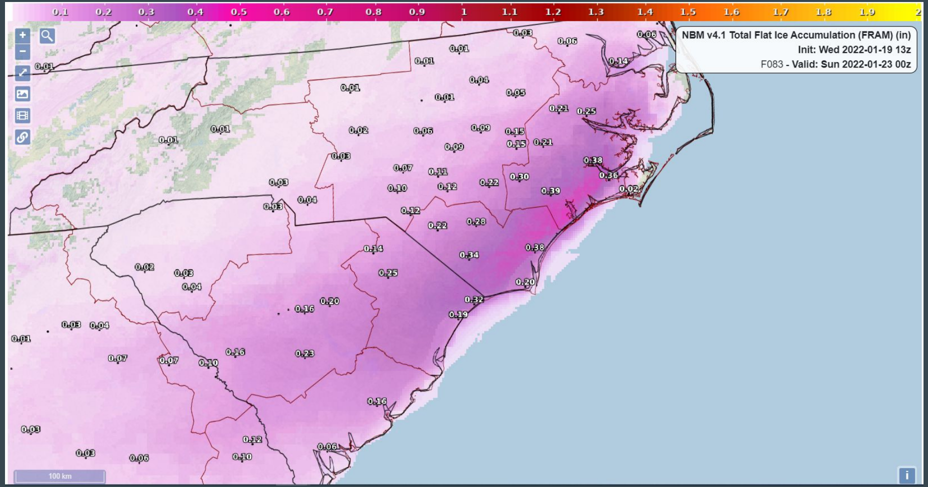
Probability of Ice Accum > 0.25” valid 00Z Jan 21 - 00Z Jan 23

Ice event Carolina Coasts Jan 21-22 2022 - Total Ice

NBM V4.0 2021 Jan 19 13Z cycle



NBM V4.1 2021 Jan 19 13Z cycle



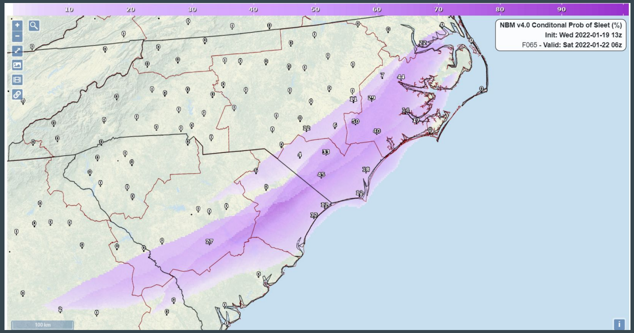
Valid 12Z Jan 19 - 00Z Jan 23

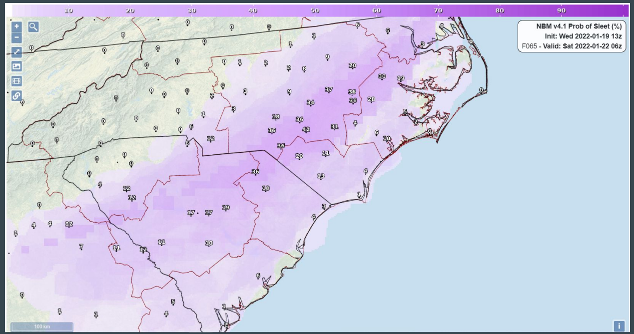
Ice event Carolina Coasts Jan 21-22 ZR and IP Probabilities

NBM V4.0 2021 Jan 19 13Z cycle

NBM V4.1 2021 Jan 19 13Z cycle

Sleet

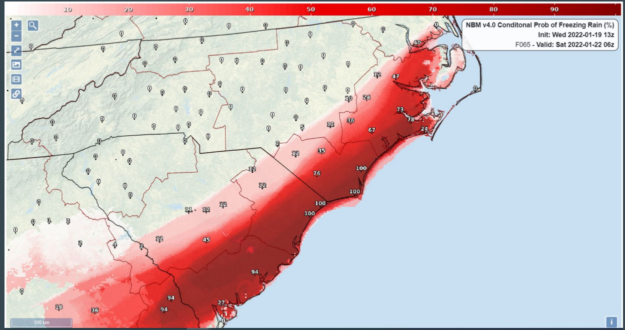


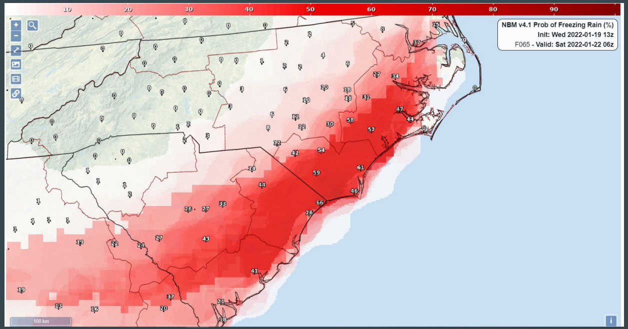


Sleet

Valid 06Z Jan 22

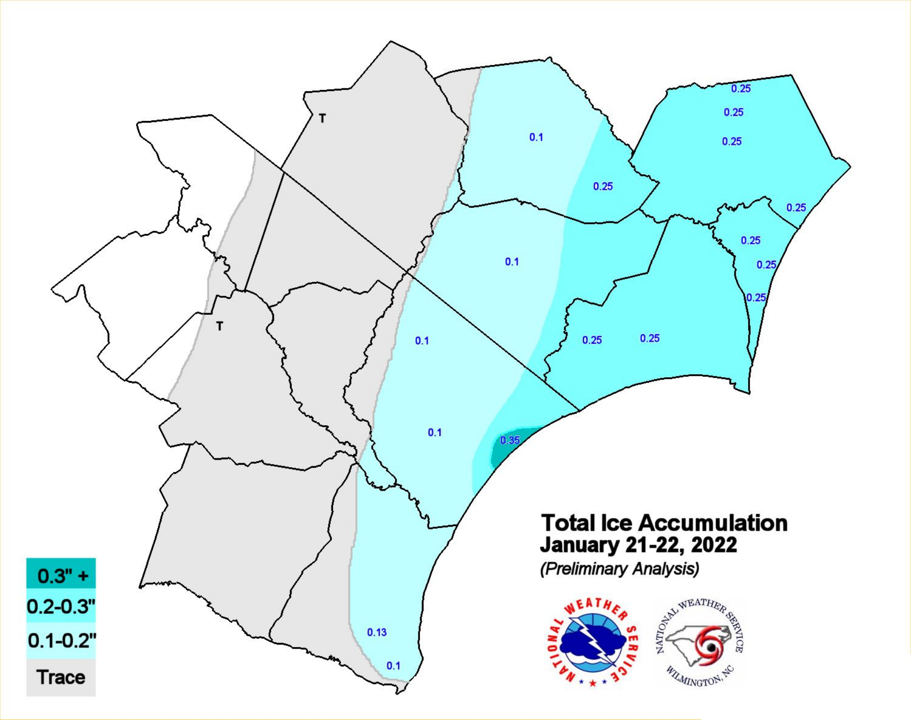
Freezing Rain

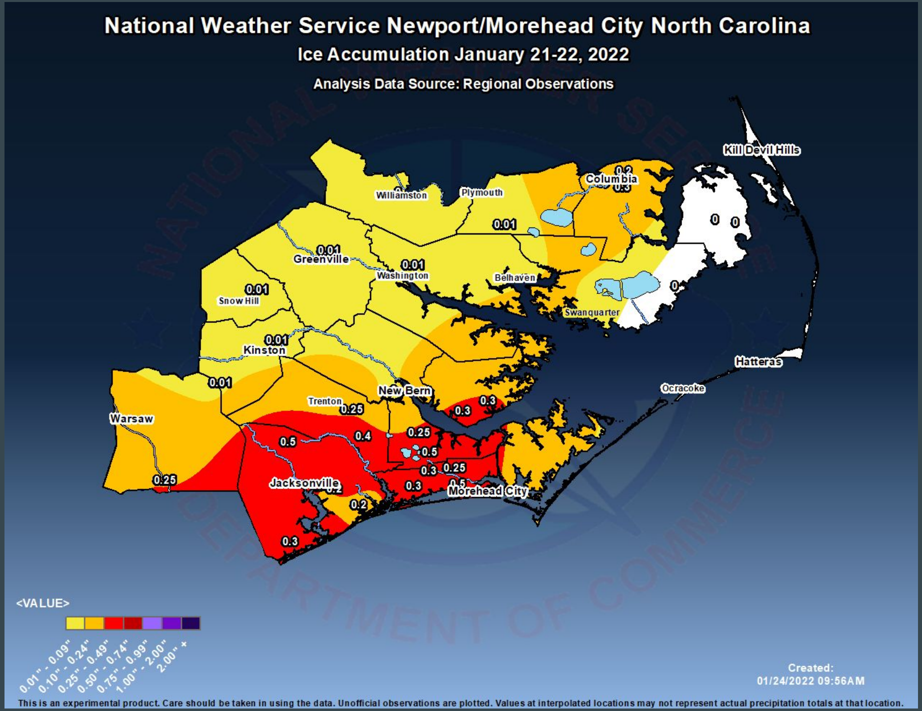




Freezing Rain

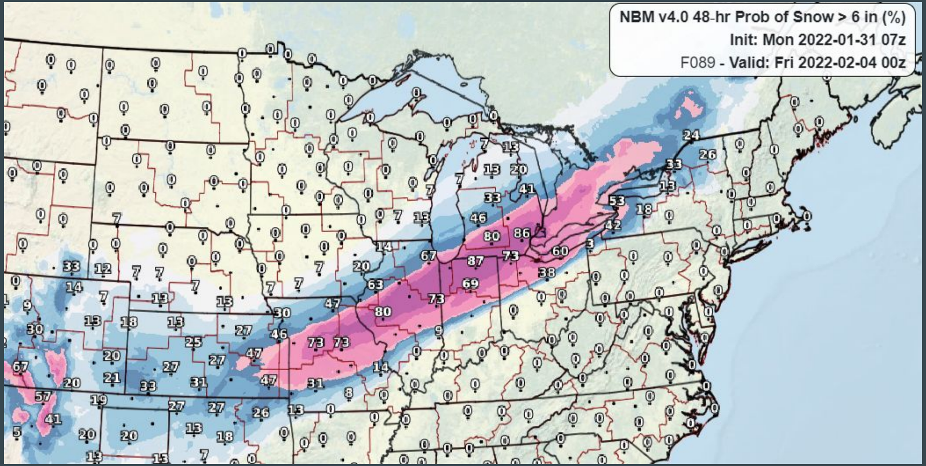
Observed Ice Accumulation (courtesy NWS ILM and MHX)



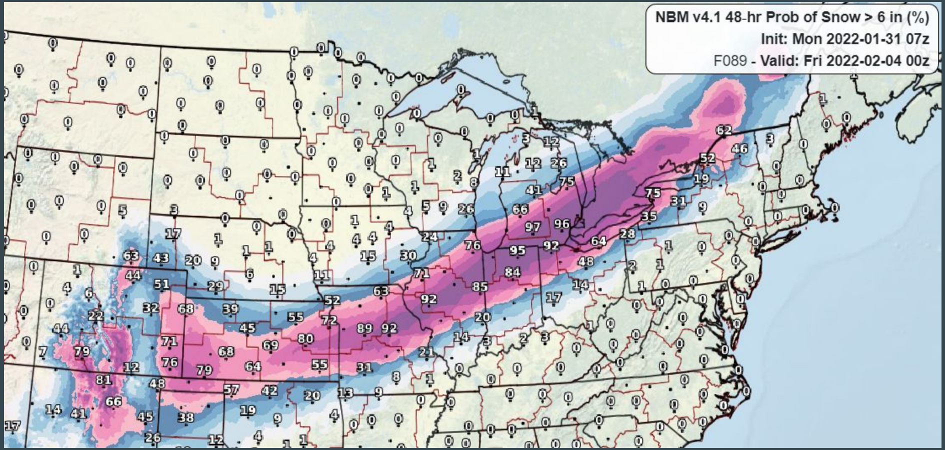


How does the NBM handle this? Look at Prob Exceedance

Comparing V4.0 vs V4.1 for > 6” snow between 00Z Wed - 00Z Fri. Probabilities very similar except in KS where 4.1 is notably higher.



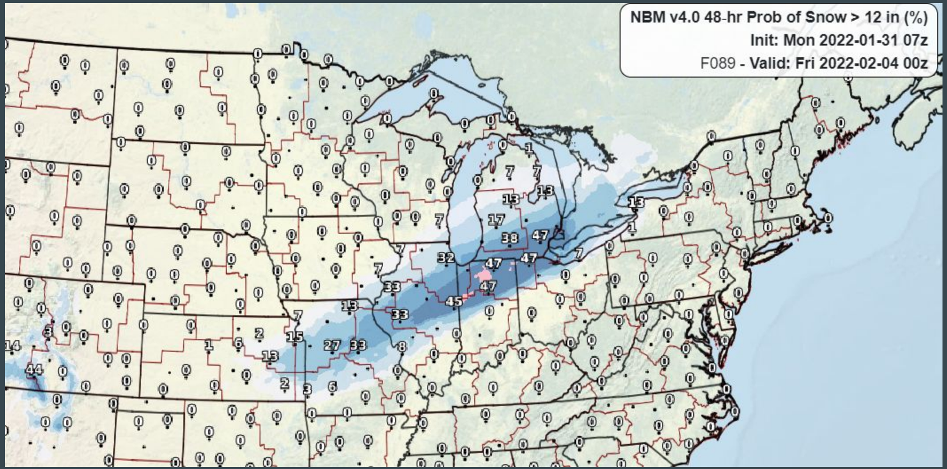
31.07Z NBM 4.0



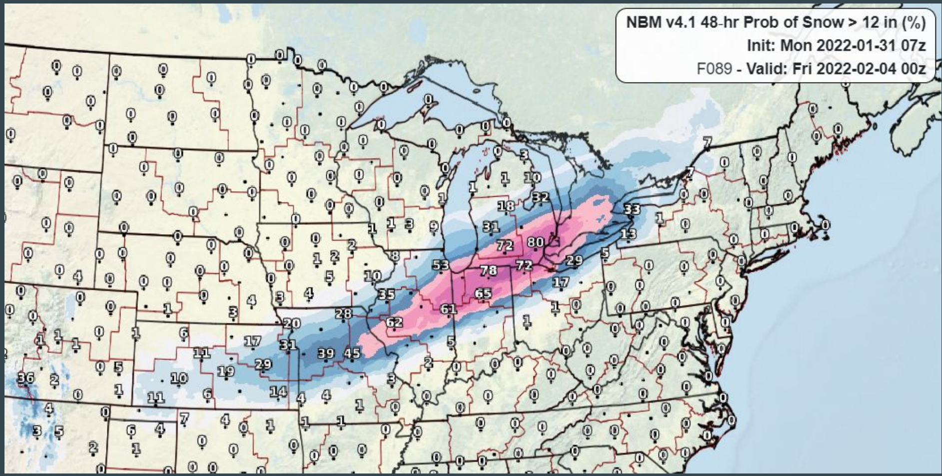
31.07Z NBM 4.1

How does the NBM handle this? Look at Prob Exceedance

Comparing V4.0 vs V4.1 for > 12” snow between 00Z Wed - 00Z Fri. Noteworthy that 4.1 probabilities are much higher, despite a larger ensemble membership in 4.1.



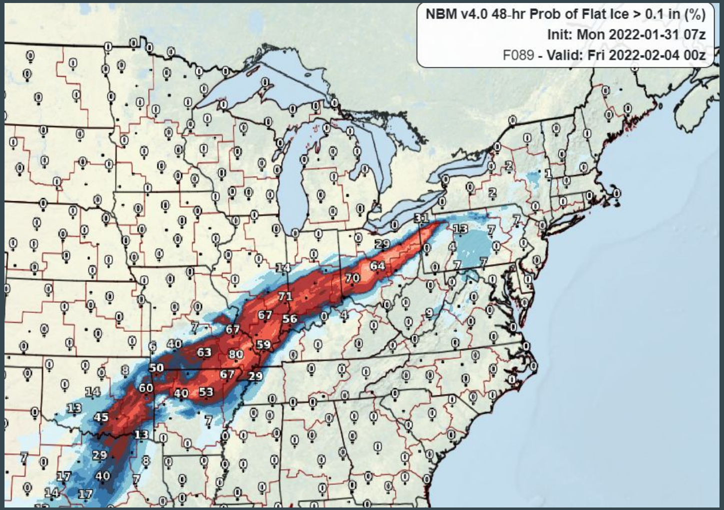
31.07Z NBM 4.0



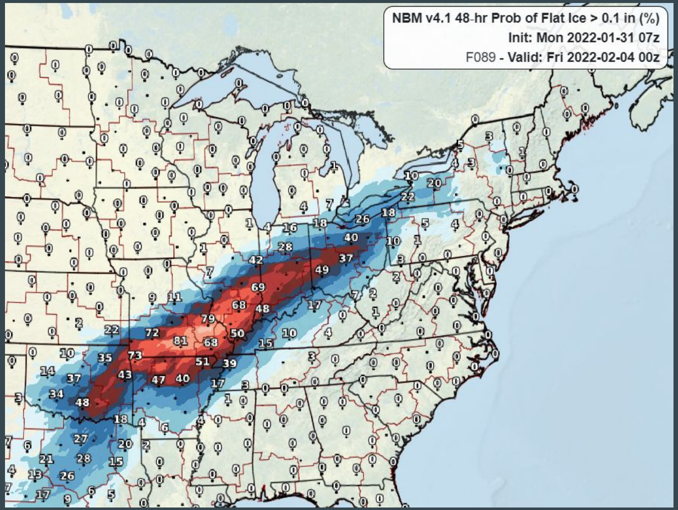
31.07Z NBM 4.1

How does the NBM handle this? Look at Prob Exceedance

Comparing V4.0 vs V4.1 for > 0.1” ice between 00Z Wed - 00Z Fri. Both have a similar appearance and magnitudes are close too.



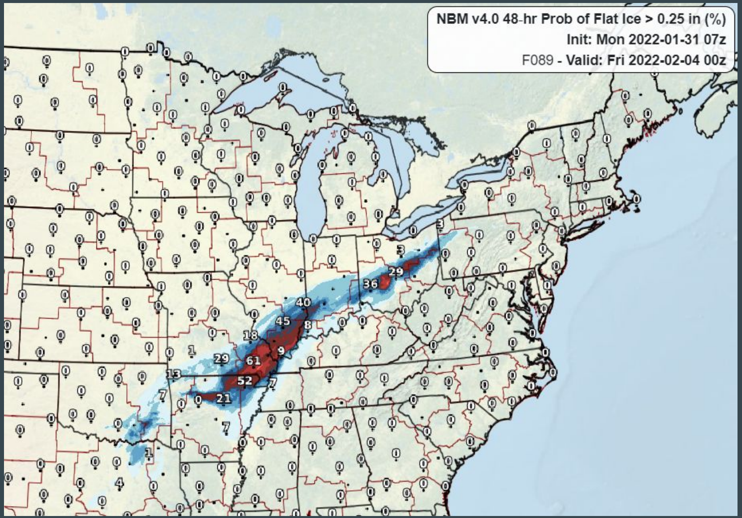
31.07Z NBM 4.0



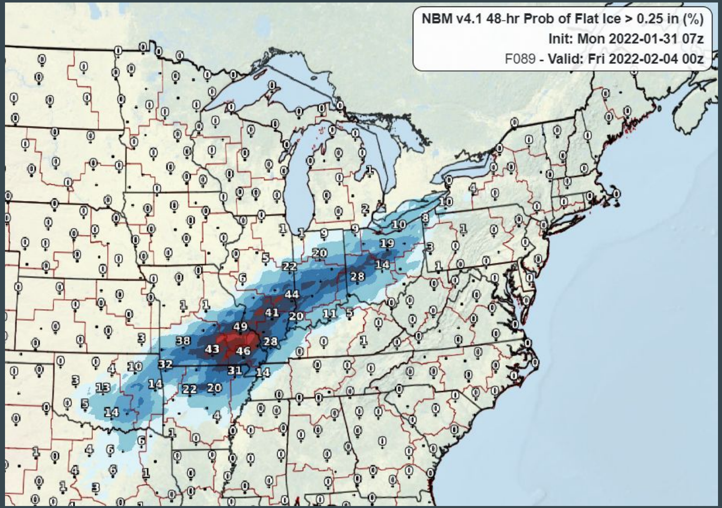
31.07Z NBM 4.1

How does the NBM handle this? Look at Prob Exceedance

Comparing V4.0 vs V4.1 for > 0.25” ice between 00Z Wed - 00Z Fri. Main difference is the probabilities are more spread out in 4.1, a reflection of the larger ensemble.



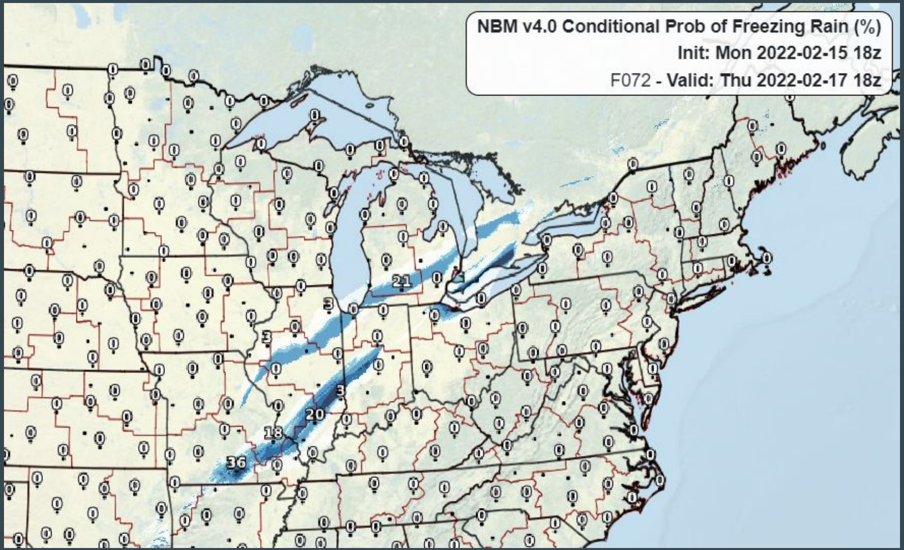
31.07Z NBM 4.0



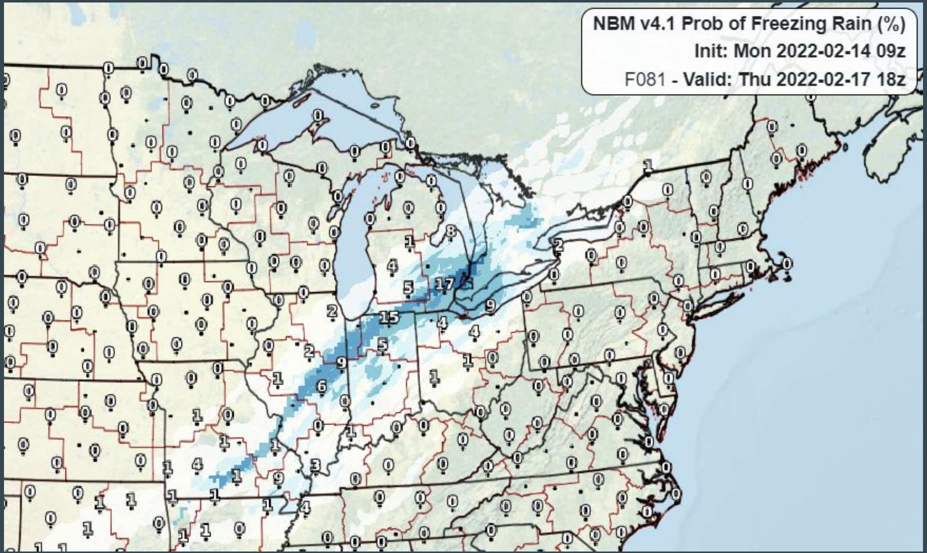
31.07Z NBM 4.1

Mixed Precipitation Event - Feb 17, 2022

While these are different cycles, the small membership issue in v4.0 is very apparent



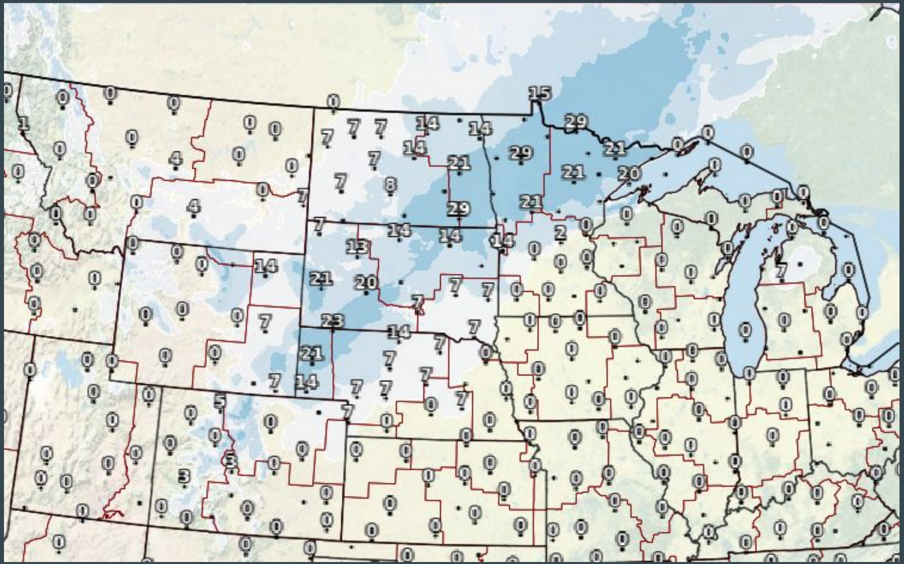
14.18Z NBM 4.0



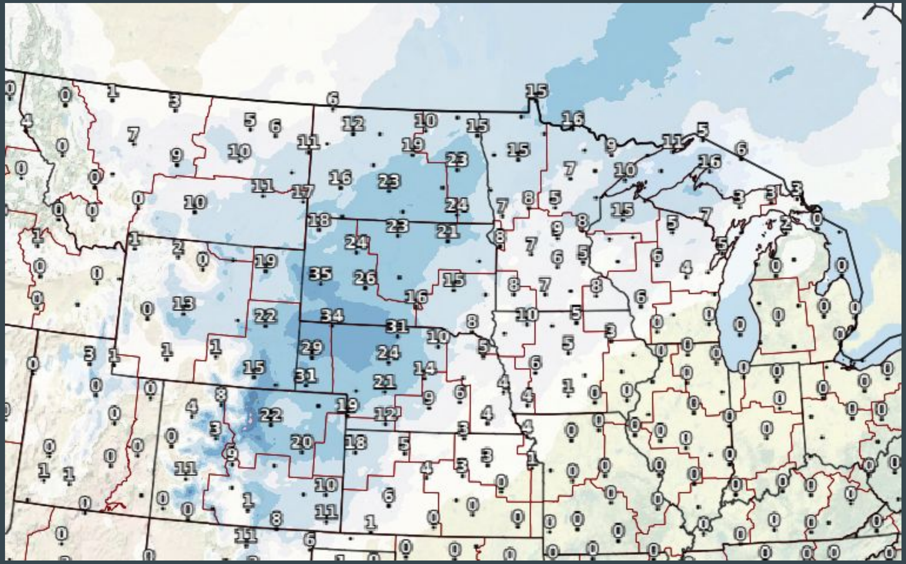
14.09Z NBM 4.1

Evolution of Apr 13-14 snow event

48 hour Snow Probability > 8”
From 06.12Z NBM cycle for 00Z Apr 13 - 00Z Apr 15



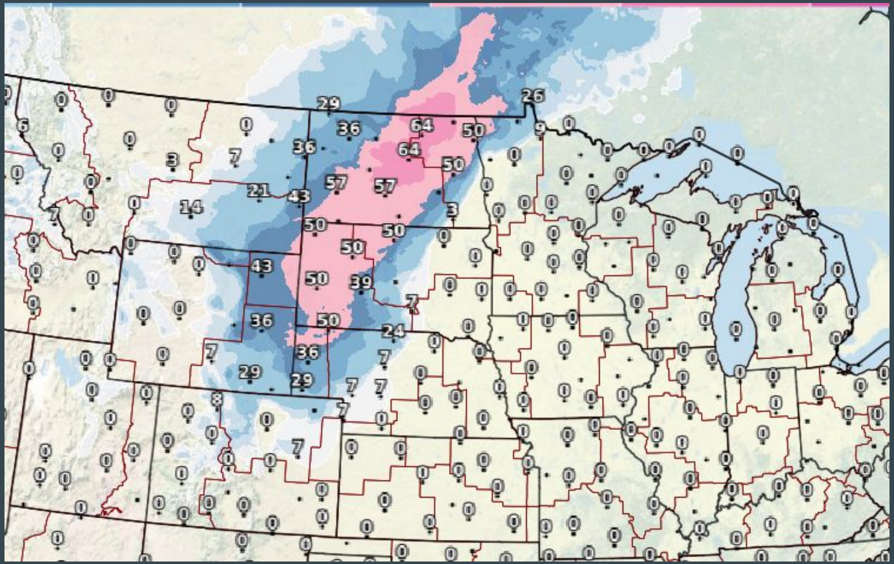
NBM V4.0



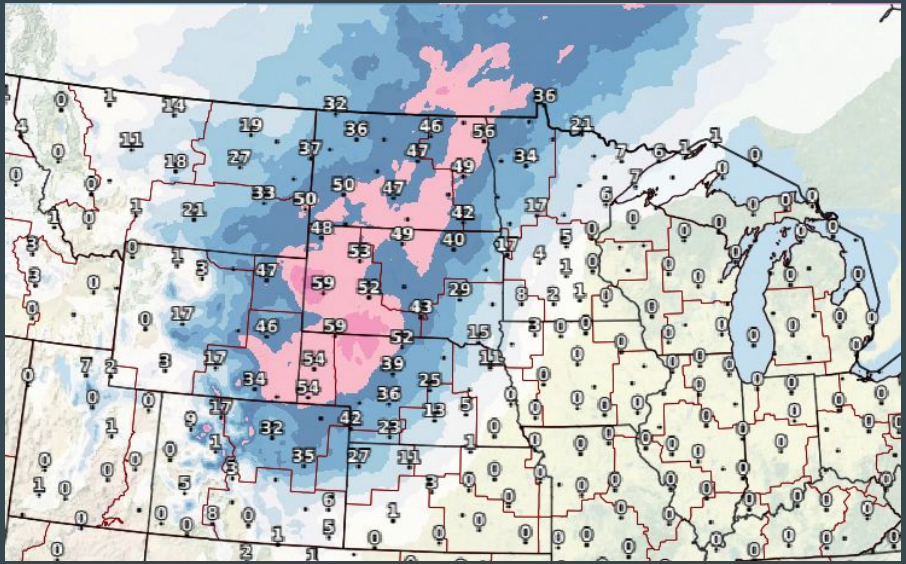
NBM V4.1

Evolution of Apr 13-14 snow event

48 hour Snow Probability > 8”
From 08.12Z NBM cycle for 00Z Apr 13 - 00Z Apr 15



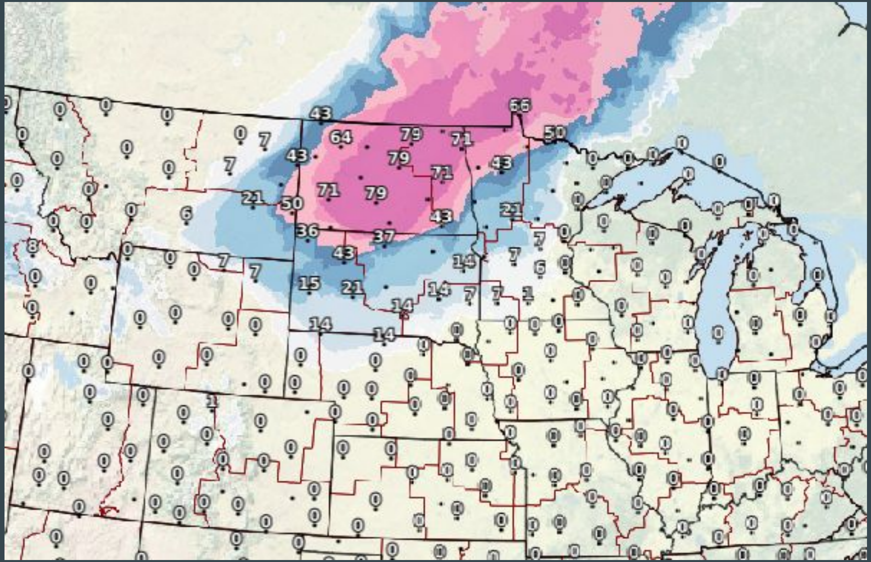
NBM V4.0



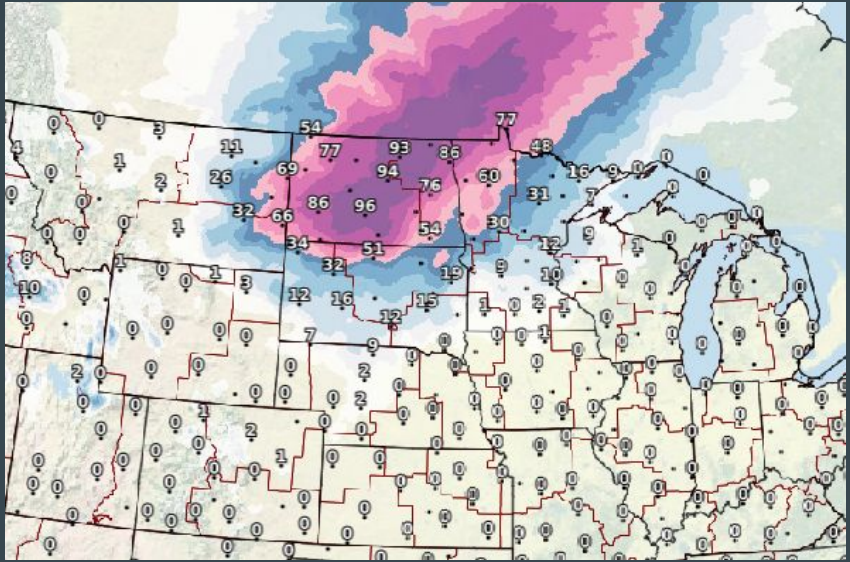
NBM V4.1

Evolution of Apr 13-14 snow event

48 hour Snow Probability > 8”
From 10.12Z NBM cycle for 00Z Apr 13 - 00Z Apr 15



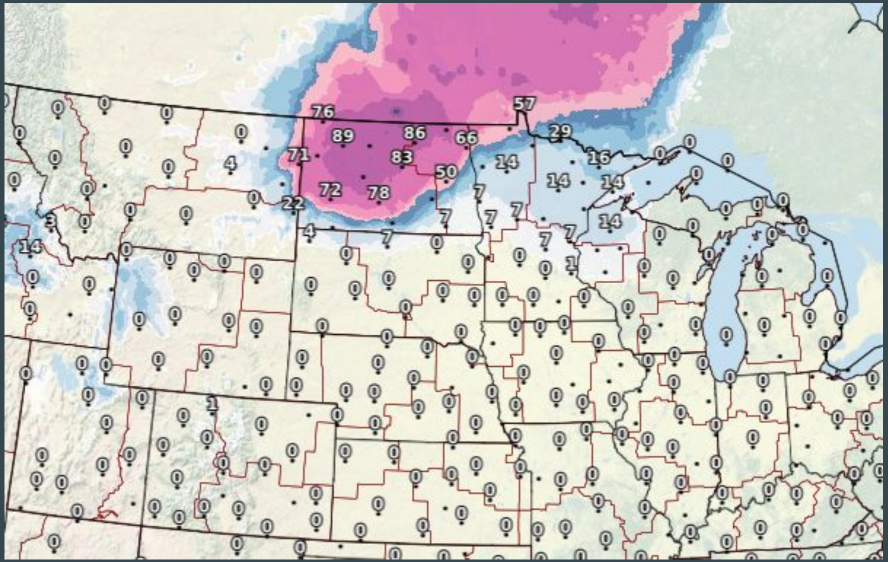
NBM V4.0



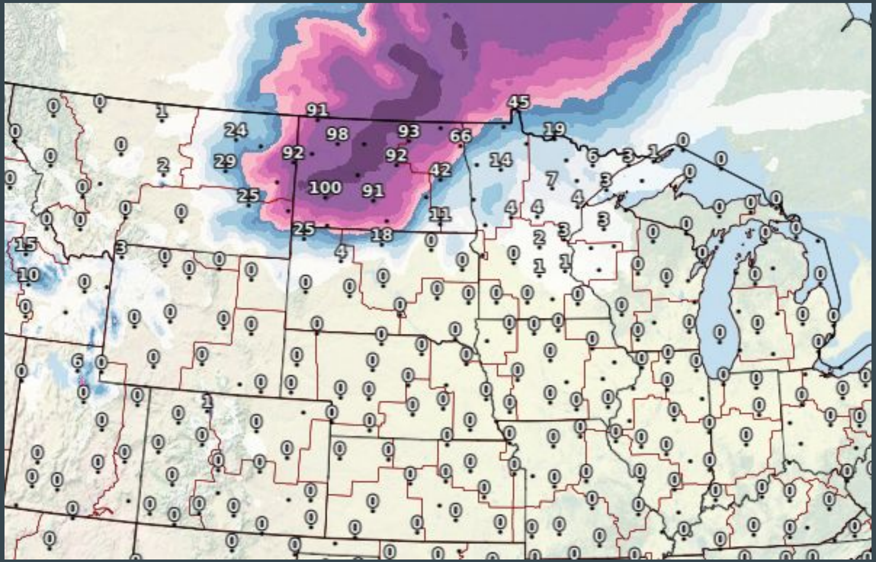
NBM V4.1

Evolution of Apr 13-14 snow event

48 hour Snow Probability > 8”
From 12.07Z NBM cycle for 00Z Apr 13 - 00Z Apr 15



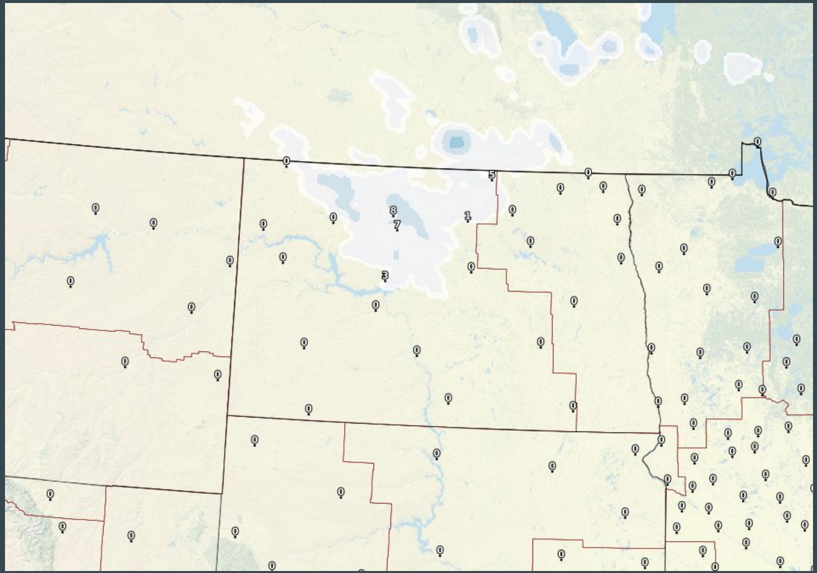
NBM V4.0



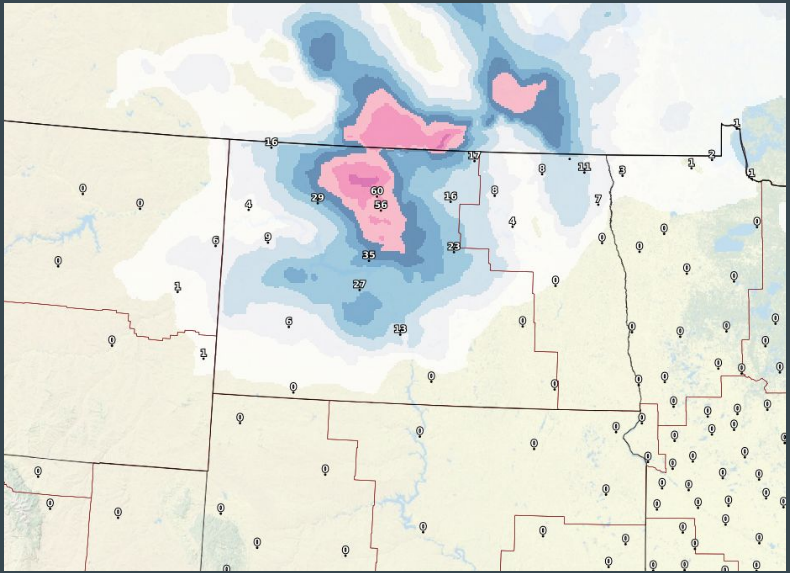
NBM V4.1

Evolution of Apr 13-14 snow event

48 hour Snow Probability > <u>30”</u>
From 12.07Z NBM cycle for 00Z Apr 13 - 00Z Apr 15

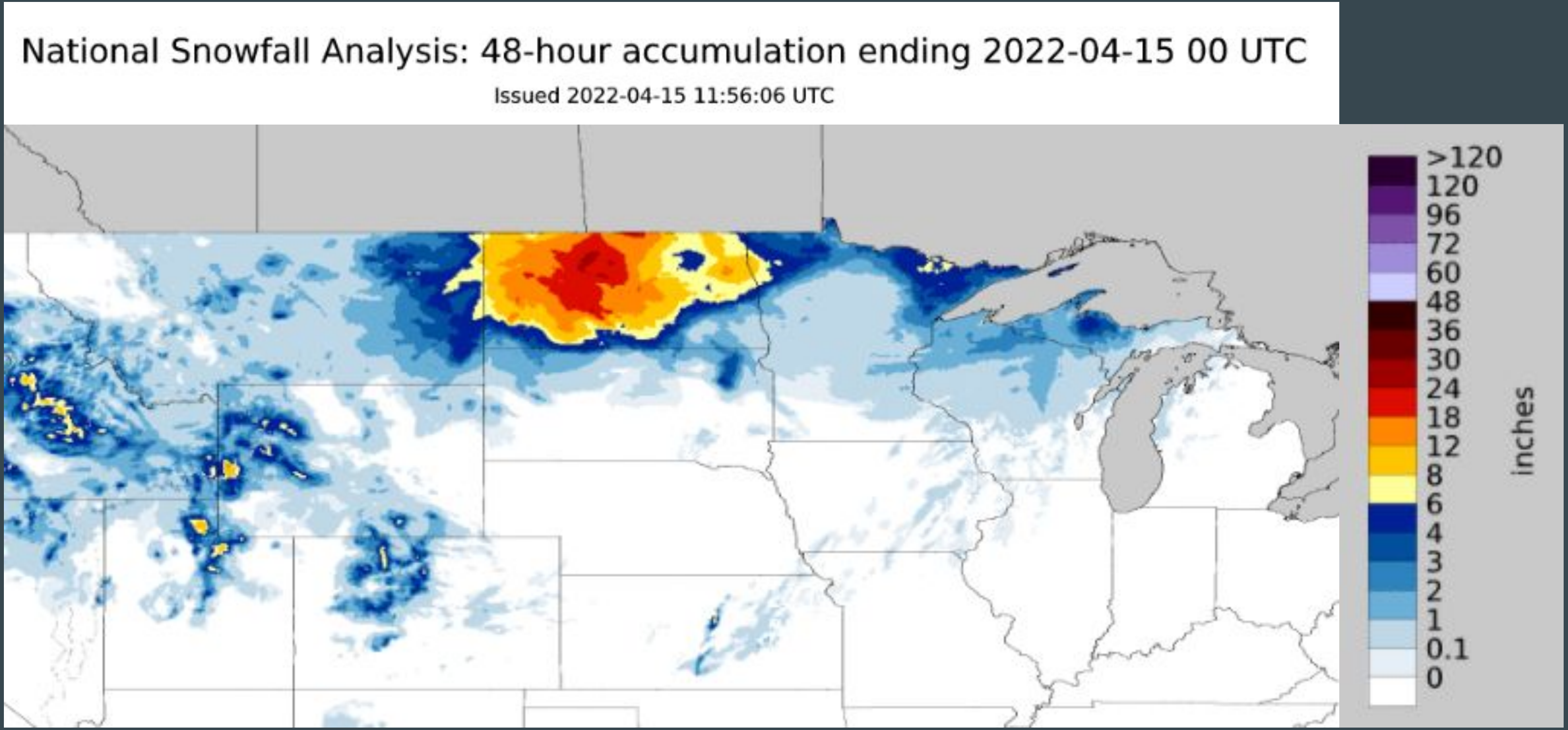


NBM V4.0

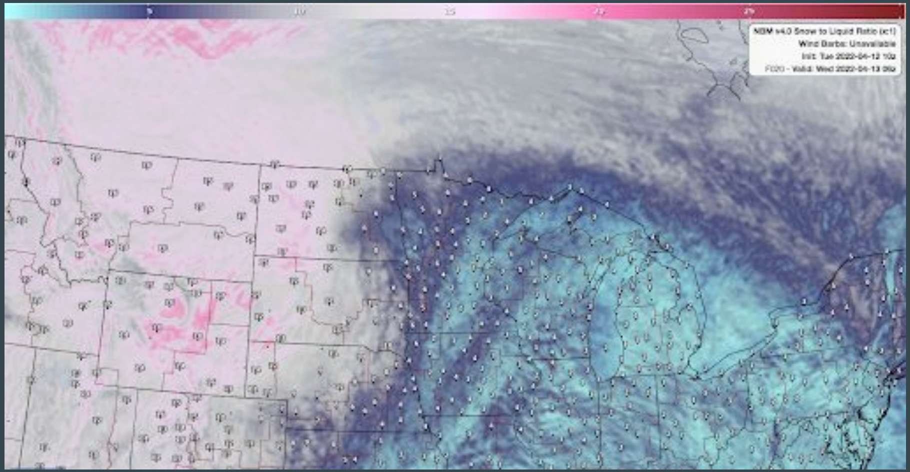


NBM V4.1

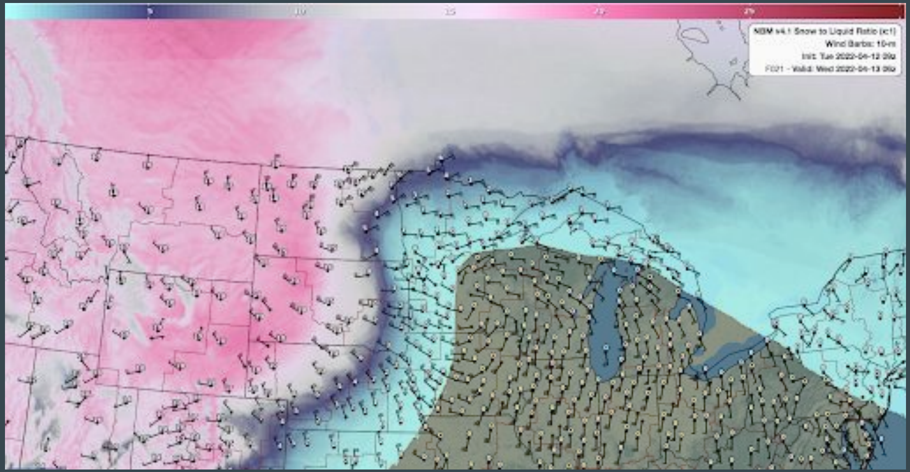
Observed snowfall - per NOHRSC v2



SLR change example: 10Z Apr 12 NBM cycles for 06Z Apr 13

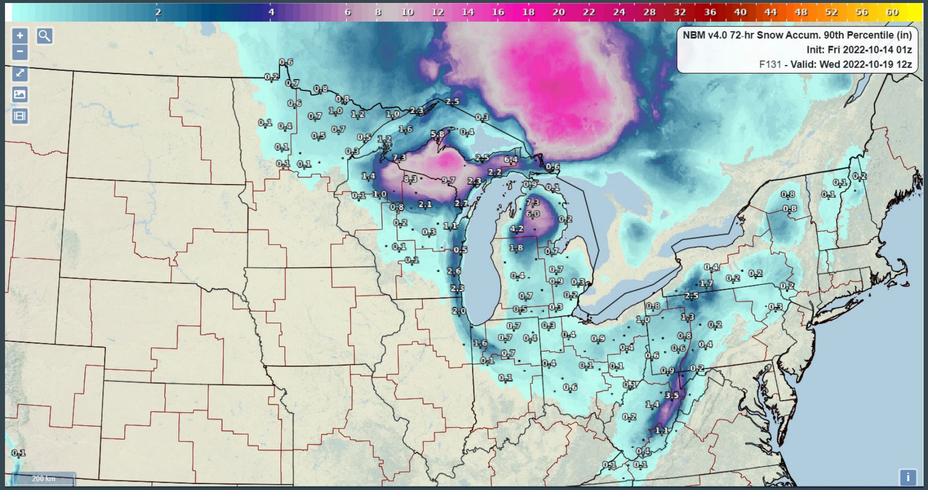


NBM V4.0

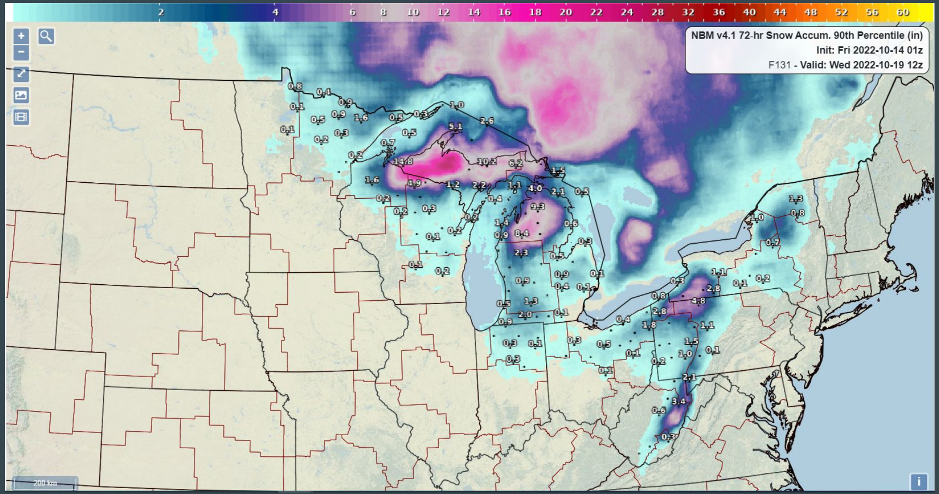


NBM V4.1

NBM v4.0 vs v4.1 90th percentile comparison
01Z Oct 14 NBM cycles for 12Z Oct 16 - 12Z Oct 19



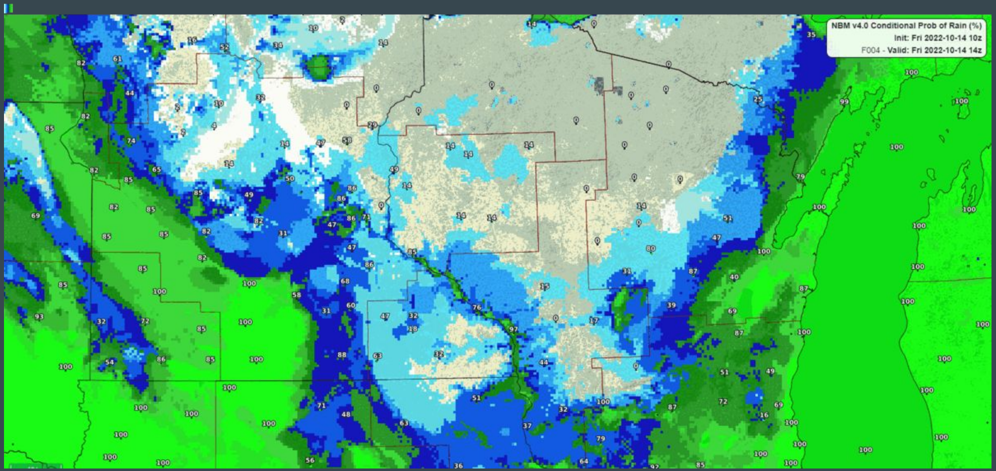
NBM V4.0

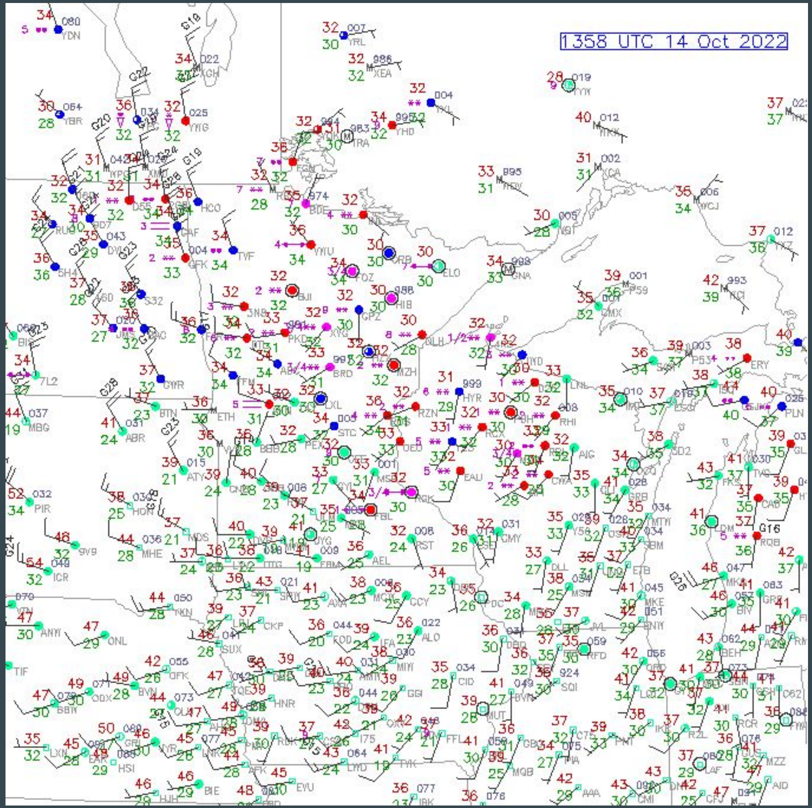


NBM V4.1

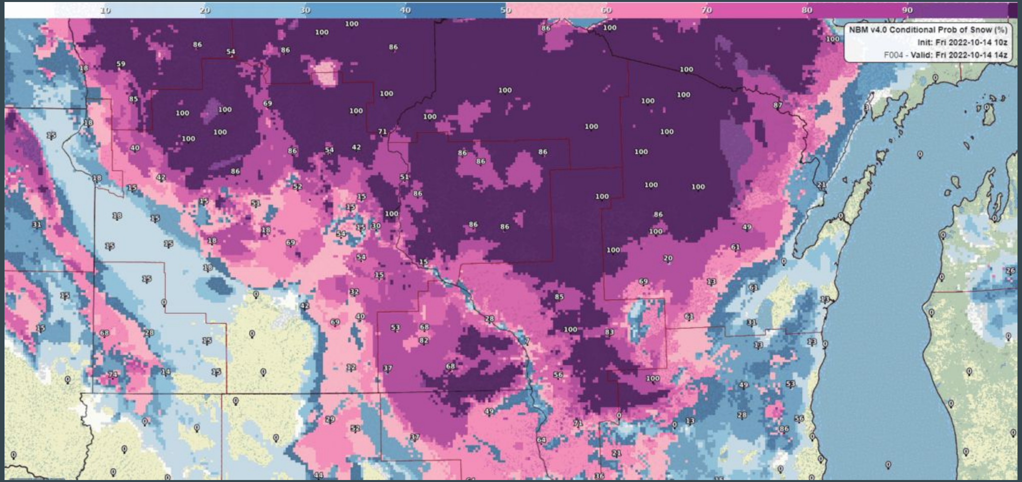
Remember there are a lot more members in v4.1 at this time range

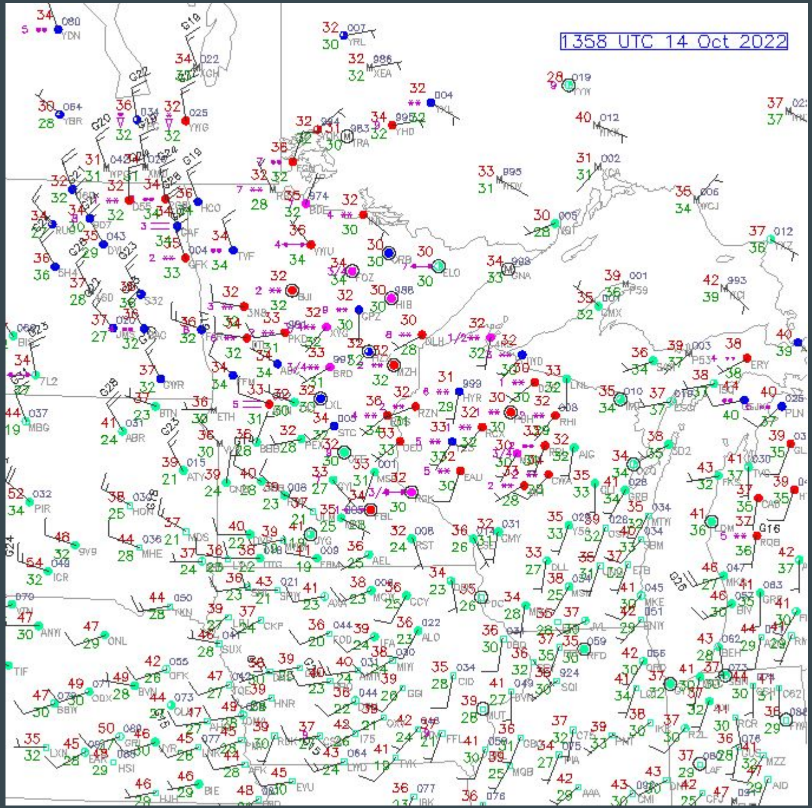
P-type comparison 2022 Oct 14 - Prob Rain at 14Z





P-type comparison 2022 Oct 14 - Prob Rain at 14Z

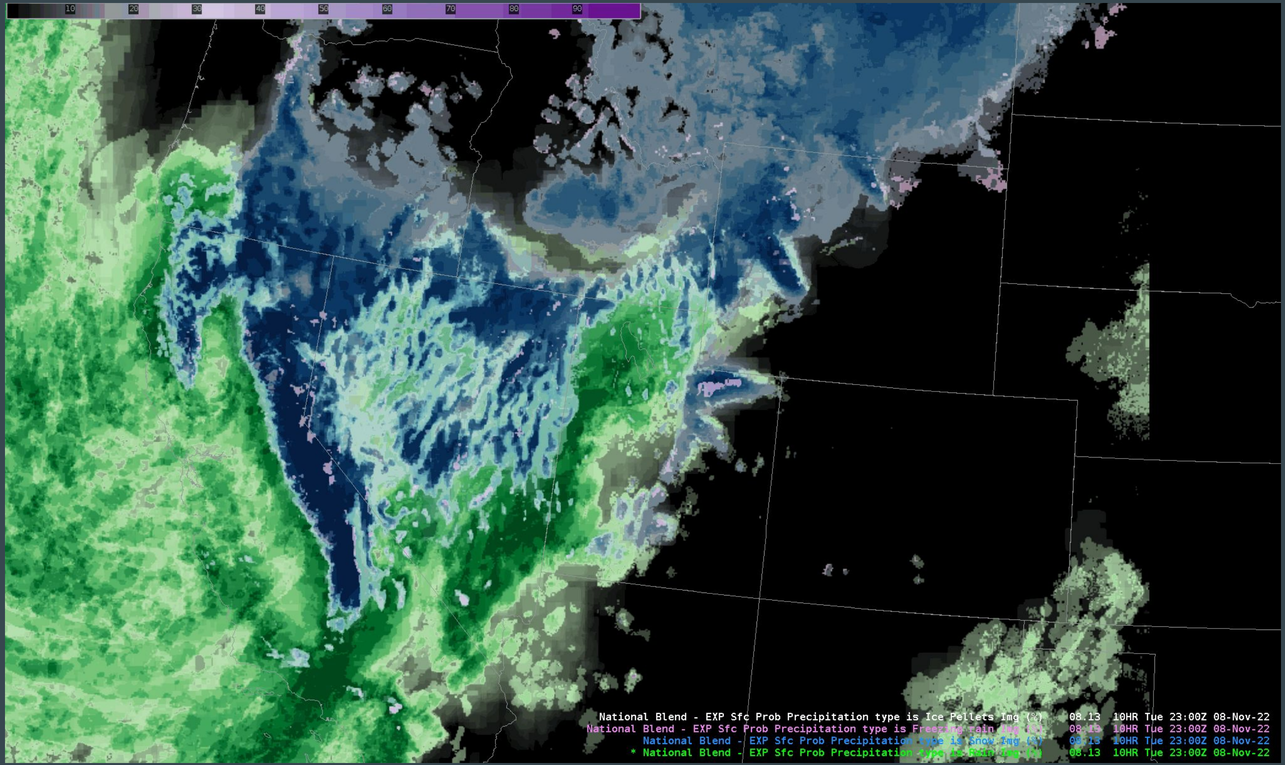




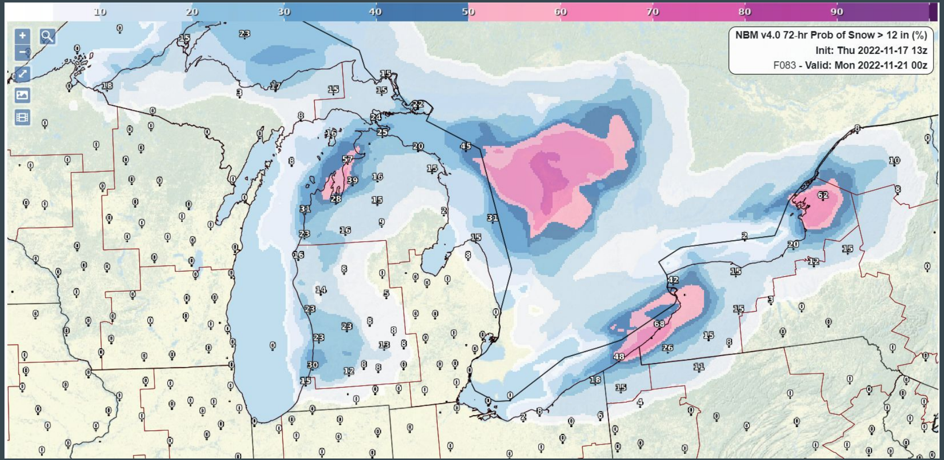
NBM v4.1 p-type viewed in AWIPS - 10 to 30 hr forecast

2022 Nov 08.13Z cycle of V4.1 forecast for 2022 Nov 9

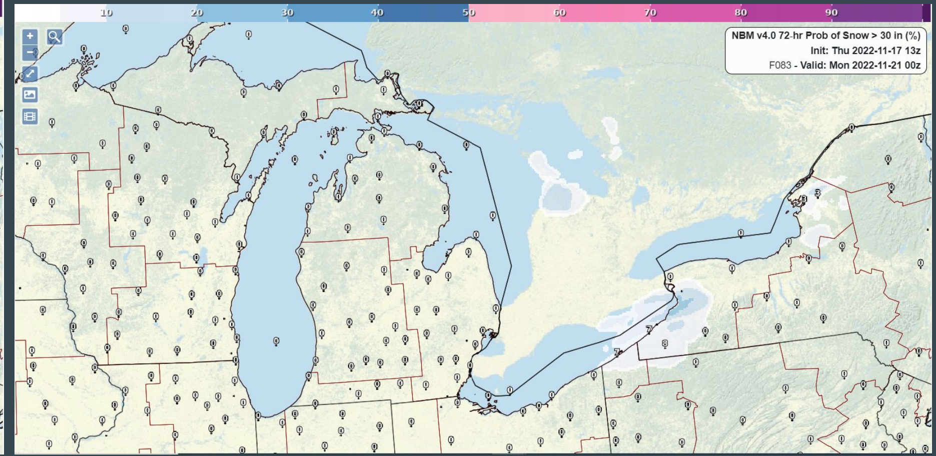
While there is some freezing rain depicted in valley locations, values are very low and predominantly the event is rain/snow



Heavy Lake Effect Snow Event Nov 18-20, 2022 - NBM V4.0

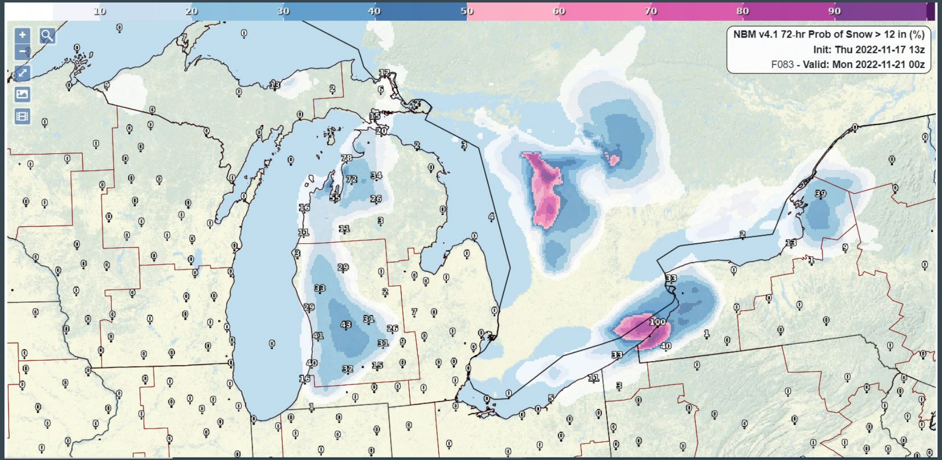


17.13Z V4.0 Prob > 12" from 00Z Nov 18 - 00Z Nov 21

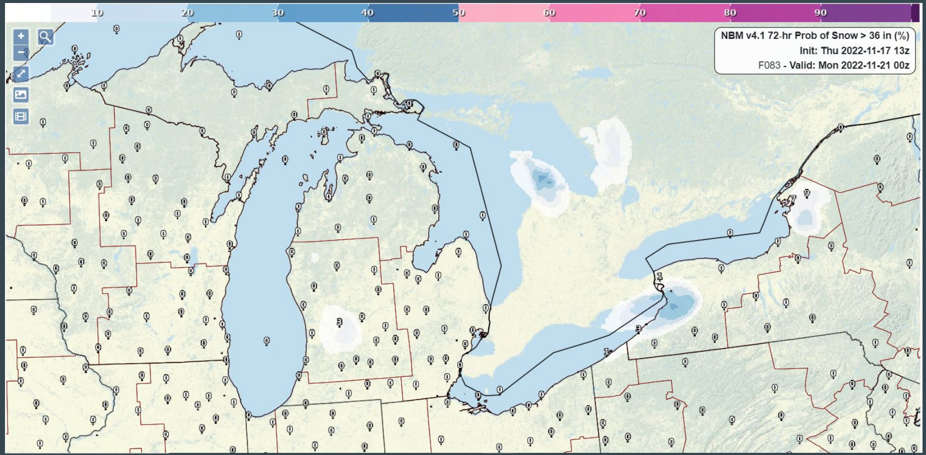


17.13Z V4.0 Prob > 30" from 00Z Nov 18 - 00Z Nov 21

Heavy Lake Effect Snow Event Nov 18-20, 2022 - NBM V4.1

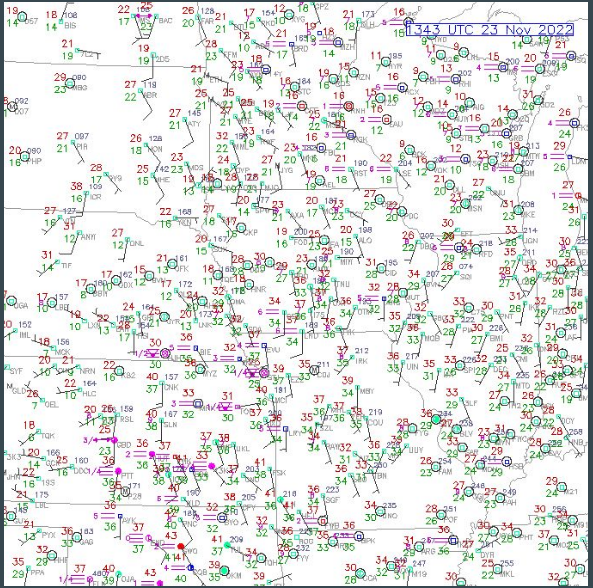


17.13Z V4.1 Prob > 12” from 00Z Nov 18 - 00Z Nov 21

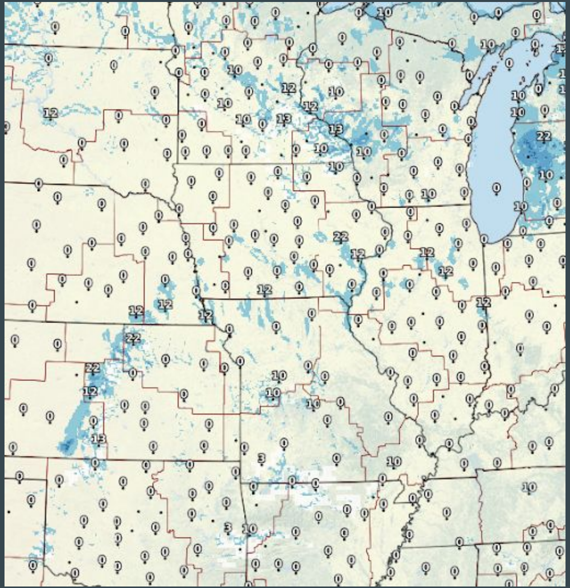


17.13Z V4.1 Prob > 36” from 00Z Nov 18 - 00Z Nov 21

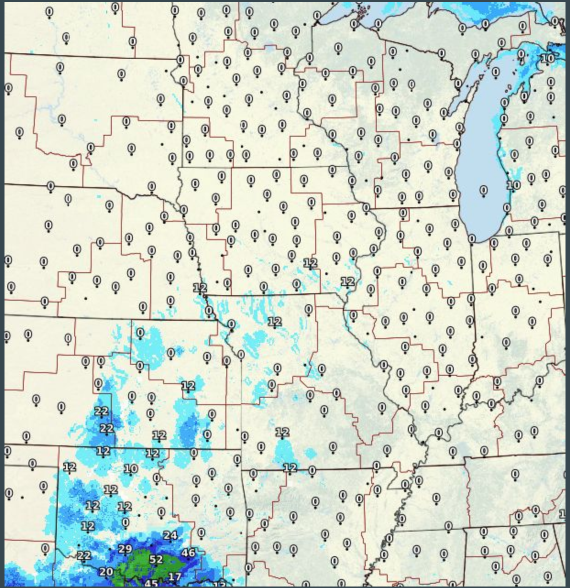
Detection of Radiational & Valley Fog in p-types in V4.1



2022 Nov 23 13Z observations



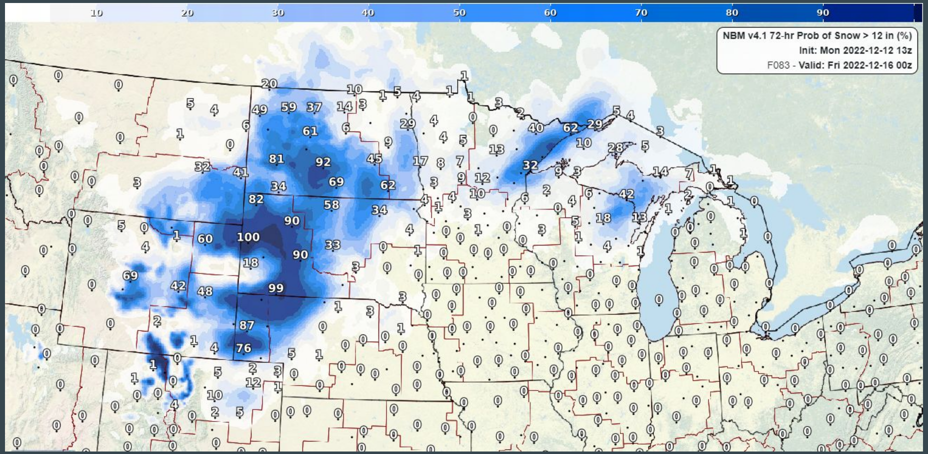
2022 Nov 23 12Z v4.1 prob ZR valid for 13Z



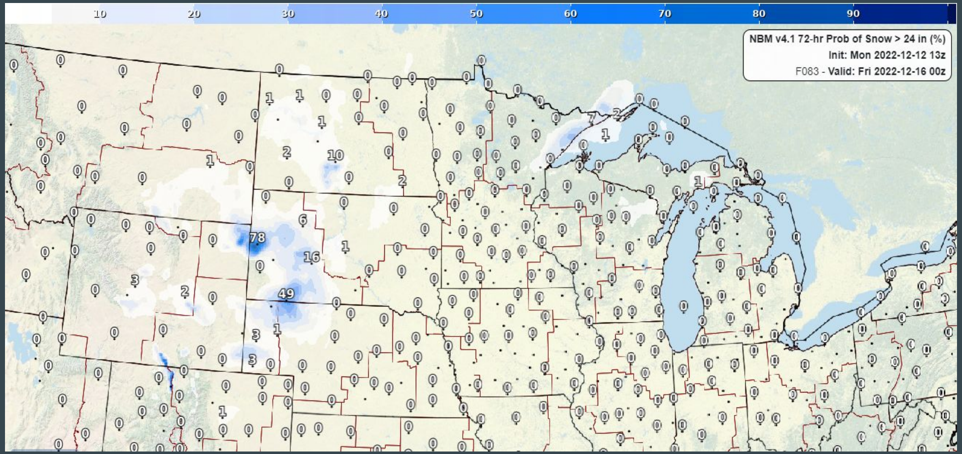
2022 Nov 23 12Z v4.1 prob R valid for 13Z

Note the detail too - river valleys and more!

Mixed Precip Winter Storm 2022 Dec 13-15

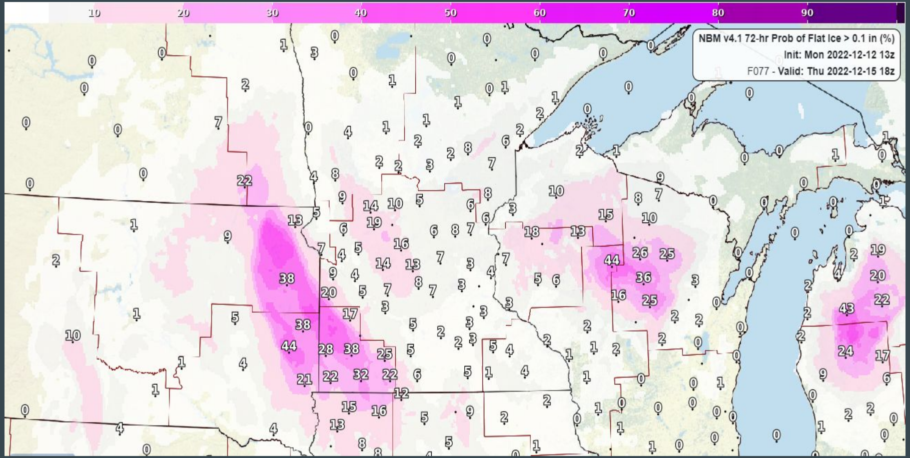


12.12Z V4.1 Prob > 12" from 00Z Dec 13 - 00Z Dec 16

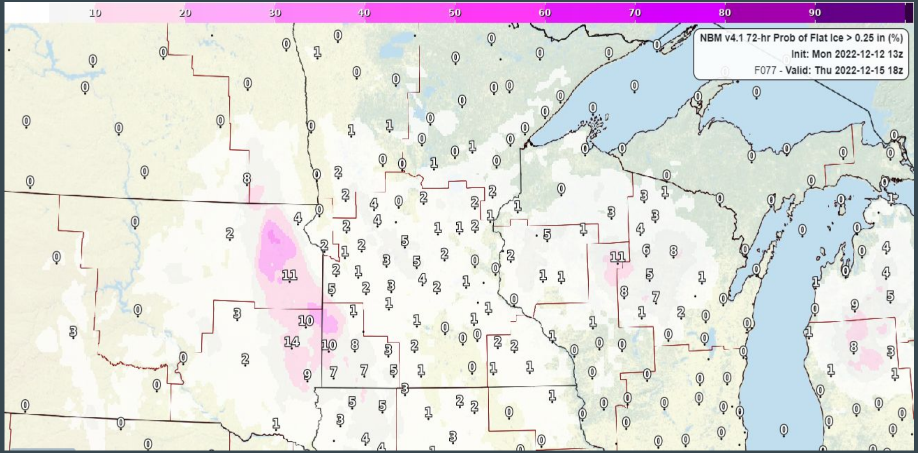


12.12Z V4.1 Prob > 24" from 00Z Dec 13 - 00Z Dec 16

Mixed Precip Winter Storm 2022 Dec 13-15



12.12Z V4.1 Prob > 0.1” from 18Z Dec 12 - 18Z Dec 15



12.12Z V4.1 Prob > 0.25” from 18Z Dec 12 - 18Z Dec 15

To ask questions or provide feedback on the NBM, please e-mail national.blend.feedback@noaa.gov or post a note on the NBM VLAB forum

Appendix: Dominant Precipitation Type Member Calculations

Model	Precipitation Type Method
HRRR	Explicit
HRRRX	Explicit
RAP	Explicit
RAPX	Explicit
HiResARW	NCEP Dominant P-type scheme
HiResARW2	NCEP Dominant P-type scheme
HiResFV3	NCEP Dominant P-type scheme
NAM	NCEP Dominant P-type scheme
NAMNest	NCEP Dominant P-type scheme
10 SREF ARW	NCEP Dominant P-type scheme
GFS	NCEP Dominant P-type scheme
30 GEFS	NCEP Dominant P-type scheme
50 ECMWF Ens	ECMWF Explicit Scheme

More on NCEP Dominant Precipitation Type scheme (especially slides 6-7)

More on ECMWF Explicit Precipitation Type scheme (see section 7.4.4)

Appendix: NBM/WPC Precipitation Type Downscaling: Part 1

- Applied ONLY to lower resolution global ensemble and SREF members (i.e. those with resolution > 20 km).

- To start, smooth the precipitation type binary grids on the native low resolution grid

- Bilinearly interpolate the precipitation type grids to the high resolution grid
  - 2.5-km for CONUS
  - 3-km for AK

- At each grid point, survey the 4 possible precipitation types and select the one with the highest value. Set the precipitation type mask to 1 for the highest valued type and all other types to 0

- ~~Apply PRISM downscaling to each member QPF~~
  - ~~PRISM grids for CONUS and AK from WPC were shared with MDL~~
- Apply QMD QPF to each member (as of mid March 2022)

Appendix: NBM/WPC Precipitation Type Downscaling: Part 2

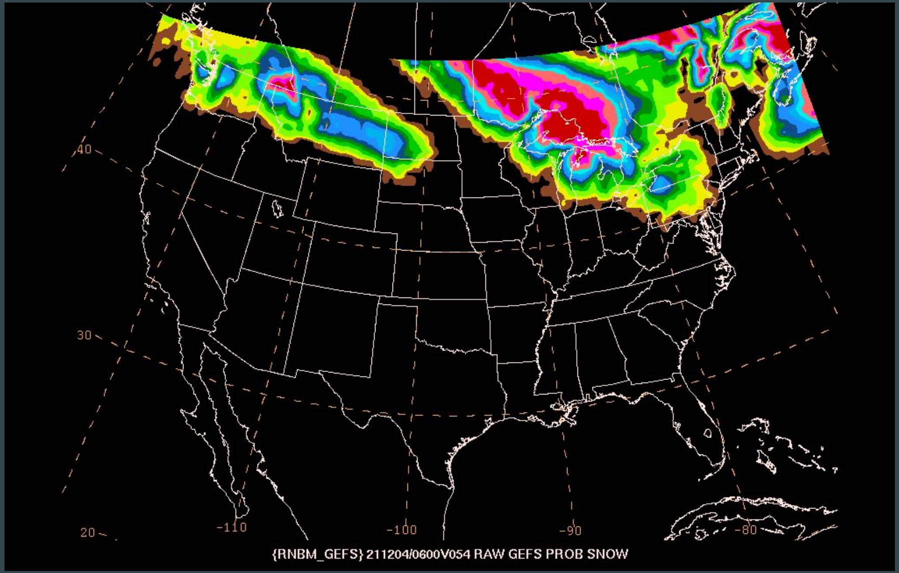
- For each precipitation type, set the precipitation type mask to 0 at grid points where QPF is very light
  - For each lead time examine the 6-hr QPF coincident with and after the current projection
  - For example, for F024, examine the F024 and F030 6-hr QPFs
    - If the F024 and F030 QPF are both less than 0.01” then set the precipitation type masks to 0 for F024
    - If either the F024 or F030 6-hr QPF is greater than 0.01” then do nothing.

- Apply snow level check
  - For each member, compute a unique snow level using the 0.5 C wet bulb isosurface
  - For grid points above the snow level set the precipitation type mask for snow to 1 and all others to 0

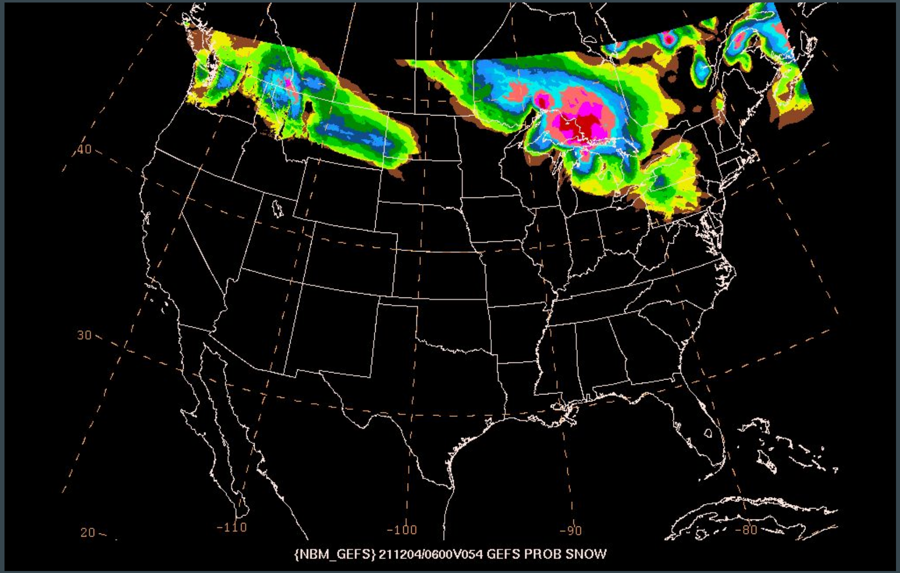
- Apply downscaled temperature check
  - Using the model sounding and high resolution topography compute a downscaled 2-m temperature.
  - Examine each grid point. If the downscaled temperature is warmer than 36 F and at least one precipitation type mask is non-zero, set the type for rain to 1 and all others to 0

Example from WPC using 30 GEFS members

Raw DMO GEFS Prob Snow Ptype

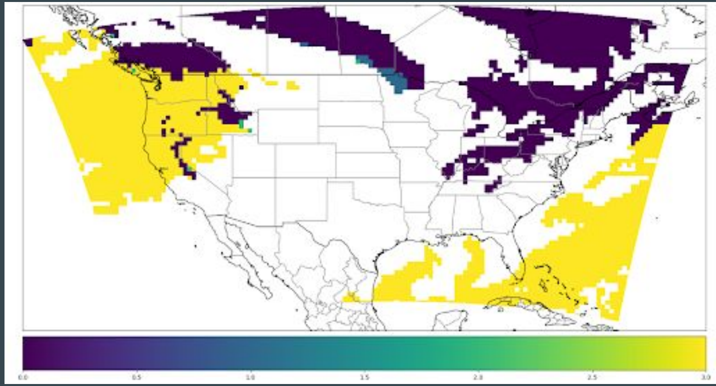


Downscaled GEFS Prob Snow Ptype

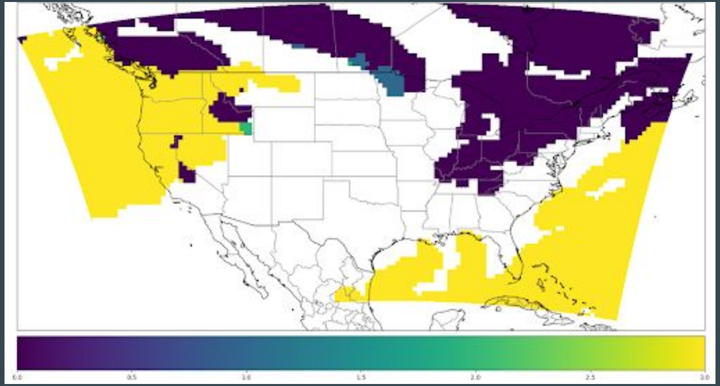


Another example using GEFS member

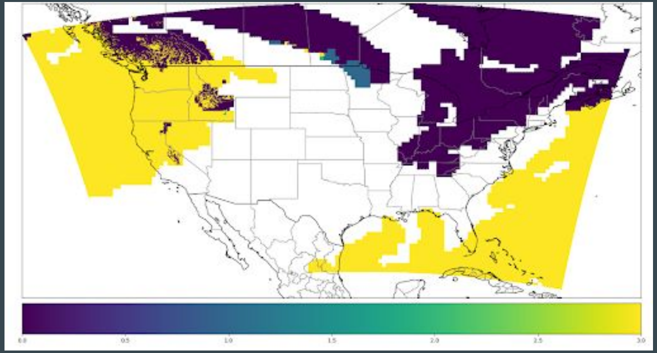
1) raw ptype as value 0,1,2,3 (snow,ice, frzrain,rain)



2) 'smoothed'

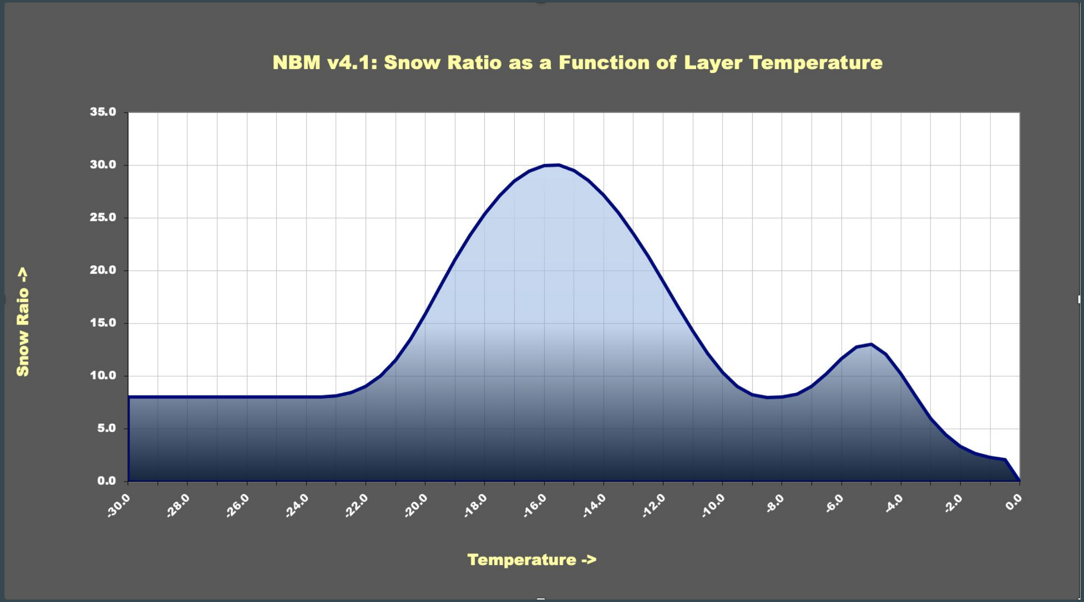


3) convert warm downscaled areas to rain



Cobb method for SLR - Temperature to Snow-Ratio Relationship

- The Cobb SLR method utilizes vertical multiple sounding data (T, RH) levels to diagnose SLR.
- The relationship to the right is used to determine the layer snow-ratio at each level as function of temperature.
- Clouds and snow growth are presumed for RH ≥ 80% (weight = 1.0). The RH weight for lower RH layers equals the square of the RH divided by 6400. So for example, a layer with an RH of 25% would equal a weight of ~0.10 and contribute little to the overall SLR.
- The snow-ratio weight at each layer equals the (RH_{weight}) x (UVV_{weight}). The layer weight divided by the overall sum of the weights from all levels is used to calculate the column SLR. It is done cumulatively in a top-down sense.



Updated layer snow-ratio to temperature curve. Snow-ratios capped at 30:1 (previously 45:1) in the DGZ growth region to eliminate an overall high bias observed in testing.

Cobb method for SLR - Vertical Velocity Weighting

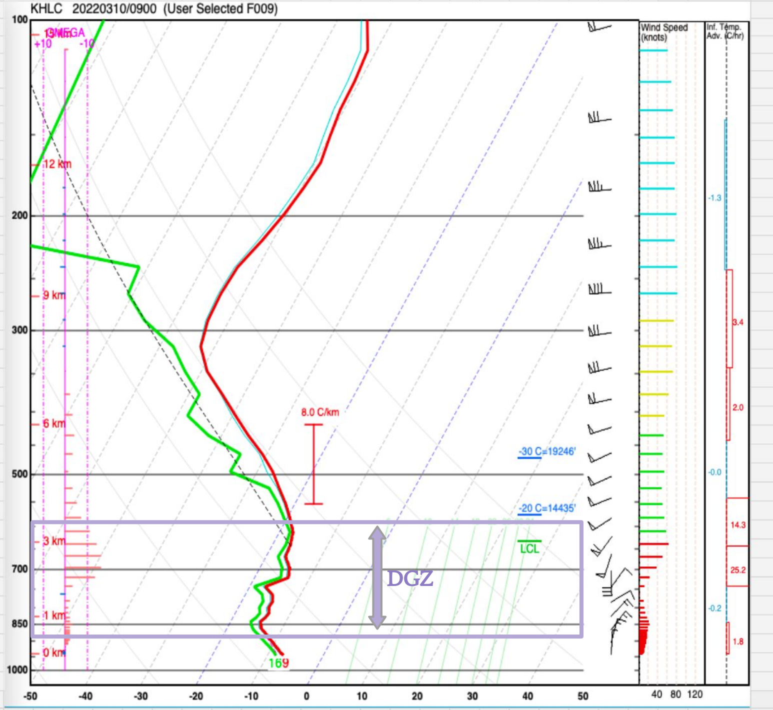
- The Cobb SLR method uses the distribution of vertical velocity (cm/s) as a weighting factor to determine the contribution of the snow-ratio calculated at each layer to the overall SLR.
  - Vertical velocities of hydrostatic models are assumed to be representative of synoptic and mesoscale forcing. Further, that those distribution are relatively smooth in both space in time such that the SLR when multiplied by a period of accumulated precipitation would yield a representative snowfall amount.
  - CAMs have somewhat broken that assumption as they can produce much higher amplitude and rapidly changing vertical velocity fields (e.g. explicit convection, gravity waves). Therefore a snapshot sounding from a CAM may not represent the distribution of synoptic/mesoscale forcing over longer periods leading to errors in diagnosing the SLR.
  - Using the square-root of the vertical velocity at each level in the calculation was found to mitigate this issue in the CAMs while yielding only negligible differences in SLR calculations for the lower resolution hydrostatic models.

Cobb method for SLR - Comparing Old and New Calcs

- **High SLR example from Kansas based on NAM3KM forecast (00Z - F09).**
- Frontogenetical UVV max colocated with deep DGZ.
- Left - shows vertical profile of P, T, RH, W (25mb resolution).
- Middle - shows the old calculation resulting in an SLR of 29:1.
- Right - shows the updated SLR calculation of 21:1 which better matches the observed SLR avg of 23:1 (~ 50 CocoRahs Obs)
- SLR column shows the evolution of the SLR in a top-down sense. NBM now uses the resulting SLR at 925mb or the nearest 25mb layer above ground for higher terrain.
- Surface effects to include melting, blowing, and compaction are not currently part of the calculation.

Hill City, KS (KHLC) 03-10-2022 00Z (F09) NAM3KM				Control Calculation: Old NBM Calculation				Updated Calculation: SLR w/ VV**0.5 & +/- temps			
P(mb)	T(C)	RH (%)	W (cm/s)	SLRw	VVw	RHw	SLR	SLRw	VVw	RHw	SLR
100	-54.8	0	0.5	9	1	0.00	0.0				
125	-51	0	0	9	1	0.00	0.0				
150	-50.1	0	0	9	1	0.00	0.0				
175	-49.5	0	-2.2	9	1	0.00	0.0				
200	-50.8	0	-3.3	9	1	0.00	0.0				
225	-52.7	3	-3.8	9	1	0.00	8.4				
250	-54	9	-5.1	9	1	0.01	8.9				
275	-54.1	16	-3.6	9	1	0.04	9.0				
300	-53.4	34	-2.1	9	1	0.18	9.0	8	1	0.18	8.0
325	-51.7	56	-1.5	9	1	0.49	9.0	8	1	0.49	8.0
350	-48.4	62	0.5	9	1	0.60	9.0	8	1	0.60	8.0
375	-44.1	63	3.5	9	4	0.62	9.0	8	2	0.62	8.0
400	-40.3	42	4.8	9	5	0.28	9.0	8	2	0.28	8.0
425	-36.6	44	6	9	6	0.30	9.0	8	2	0.30	8.0
450	-32.9	58	5.4	9	5	0.53	9.0	8	2	0.53	8.0
475	-29.5	60	3.4	9	3	0.56	9.0	8	2	0.56	8.0
500	-26.7	55	2	11	2	0.47	9.2	8	1	0.47	8.0
525	-24.3	84	4.3	14	4	1.00	10.3	8	2	1.00	8.0
550	-22	88	6.4	18	6	1.00	12.5	10	3	1.00	8.3
575	-20.1	90	8.4	24	8	1.00	15.6	16	3	1.00	9.8
600	-18.4	93	11.8	30	12	1.00	19.4	23	3	1.00	12.5
625	-17.3	94	14.9	33	15	1.00	22.9	27	4	1.00	15.1
650	-16.7	91	17.1	34	17	1.00	25.4	29	4	1.00	17.3
675	-16	89	17.8	35	18	1.00	27.2	29	4	1.00	19.0
700	-14.5	89	16.4	34	16	1.00	28.3	28	4	1.00	20.0
725	-15	87	10.5	35	11	1.00	28.9	29	3	1.00	20.8
750	-16.4	84	0.9	34	1	1.00	28.9	29	1	1.00	21.0
775	-14.7	86	0.6	35	1	1.00	29.0	28	1	1.00	21.2
800	-14.5	86	0.9	34	1	1.00	29.0	28	1	1.00	21.4
825	-14.1	87	1.7	34	2	1.00	29.1	27	1	1.00	21.6
850	-14.2	86	2.6	34	3	1.00	29.2	27	2	1.00	21.8
875	-12.5	88	1.7	28	2	1.00	29.2	21	1	1.00	21.8
900	-10.6	89	1	18	1	1.00	29.1	13	1	1.00	21.6
925	-8.7	91	0	11	1	1.00	28.9	9	1	1.00	21.3
944	-7.3	89	0	8	1	1.00	28.8	9	1	1.00	21.0
975	-9.1	88	-6.9	12	1	1.00	28.6	9	1	1.00	20.8
998	-8.2	91	0	9	1	1.00	28.5	8	1	1.00	20.5
				SLR			28.9	SLR			21.3

Post frontal mid-level frontogensis over central plains. Sounding near peak of event indicated a UVV max coloated within a deep DGZ. This feature was associated with a band of heavier snow that resulted in 6-12 inches w/ SLRs of 23:1. Other areas on either side of the band recieved 3-6 inches of snow with observed SLRs of 18:1. The snow fell primarily overnight with temperatures well below freezing. Winds were generally less than 12 kts throughout the event.

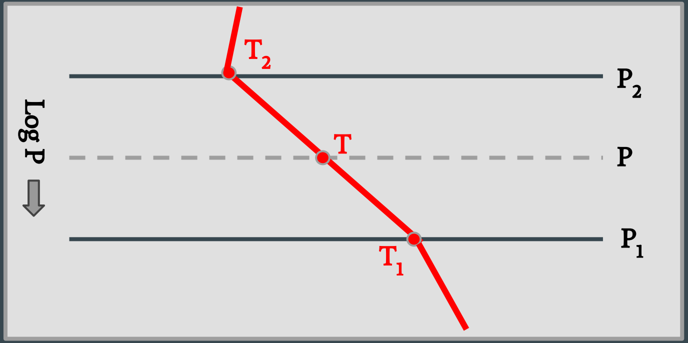


Cobb method for SLR - Logarithmic Interpolation for Ensembles

- Applying Cobb to Ensembles (ECMWFE, GEFS, SREF).
  - The vertical resolution of these data sets is limited to mandatory levels for (P, T, and RH). UVV is only available at 700 and 850 mbs.
  - Logarithmic interpolation is used to estimate (P, T, RH, and UVV) at 25 mb intervals between 925 - 300 mb. UVV is assumed to be zero at mandatory levels where it is missing. This interpolation is the equivalent of picking off data points along a straight line between two temperatures at known levels on a SkewT-LogP diagram

$$y = y_{p1} + \left[\frac{y_{p2} - y_{p1}}{\log \frac{P_2}{P_1}}\right]\left[\log \frac{P}{P_1}\right]$$

Where y is the variable to interpolate (T, RH, UVV) at level P. P_2 and P_1 are mandatory pressure levels immediately above(below) P where y_2 and y_1 are known.



Cobb method for SLR - Interpolated Sounding Comparison

- Example of Full resolution (left) vs interpolated version (right) as test of approach
- Comparisons were made with each representing one of a wide range of SLR scenarios (more are being done as they occur)
- Results were consistently within +/- 2:1 of the control full resolution sounding
- The interpolated data approach appears more robust than determining SLR based on maxTA and H85-H70 Thickness alone
- The logarithmic interpolation approach may also be used to derive other diagnostics fields from the lower vertical resolution ensemble data (fire wx and others).

Pressure level data interpolated to 25mb from native resolution bufr (Bufkit) data file. | SLR from 25mb resolution data

P(mb)	T(C)	RH (%)	W (cm/s)	SLRw	VVw	RHw	SLR
100	-54.8	0	0.5				
125	-51	0	0				
150	-50.1	0	0				
175	-49.5	0	-2.2				
200	-50.8	0	-3.3				
225	-52.7	3	-3.8				
250	-54	9	-5.1				
275	-54.1	16	-3.6				
300	-53.4	34	-2.1	8	1	0.18	8.0
325	-51.7	56	-1.5	8	1	0.49	8.0
350	-48.4	62	0.5	8	1	0.60	8.0
375	-44.1	63	3.5	8	2	0.62	8.0
400	-40.3	42	4.8	8	2	0.28	8.0
425	-36.6	44	6	8	2	0.30	8.0
450	-32.9	58	5.4	8	2	0.53	8.0
475	-29.5	60	3.4	8	2	0.56	8.0
500	-26.7	55	2	8	1	0.47	8.0
525	-24.3	84	4.3	8	2	1.00	8.0
550	-22	88	6.4	10	3	1.00	8.3
575	-20.1	90	8.4	16	3	1.00	9.8
600	-18.4	93	11.8	23	3	1.00	12.5
625	-17.3	94	14.9	27	4	1.00	15.1
650	-16.7	91	17.1	29	4	1.00	17.3
675	-16	89	17.8	29	4	1.00	19.0
700	-14.5	89	16.4	28	4	1.00	20.0
725	-15	87	10.5	29	3	1.00	20.8
750	-16.4	84	0.9	29	1	1.00	21.0
775	-14.7	86	0.6	28	1	1.00	21.2
800	-14.5	86	0.9	28	1	1.00	21.4
825	-14.1	87	1.7	27	1	1.00	21.6
850	-14.2	86	2.6	27	2	1.00	21.8
875	-12.5	88	1.7	21	1	1.00	21.8
900	-10.6	89	1	13	1	1.00	21.6
925	-8.7	91	0	9	1	1.00	21.3
944	-7.3	89	0	9	1	1.00	21.0
975	-9.1	88	-6.9	9	1	1.00	20.8
998	-8.2	91	0	8	1	1.00	20.5
					SLR		21.3

Interpolated Data from mandatory levels to simulate ECMWFe vertical resolution. ECMWF VV only available at 850mb and 700mb. VV below 925mb and above 500mb are set to zero with logarithmic interpolation used between 925mb and 500 mb. | ECMWFe SLR from interpolated mandatory level data.

P(mb)	T(C)	RH (%)	W (cm/s)	SLRw	VVw	RHw	SLR
100	-54.8	0	0.0				
125	-53.5	0.0	0.0				
150	-52.5	0.0	0.0				
175	-51.6	0.0	0.0				
200	-50.8	0	0.0				
225	-51.6	9.9	0.0				
250	-52.2	18.7	0.0				
275	-52.8	26.7	0.0				
300	-53.4	34	0.0	8	1	0.18	8.0
325	-49.8	36.2	0.0	8	1	0.21	8.0
350	-46.4	38.3	0.0	8	1	0.23	8.0
375	-43.2	40.2	0.0	8	1	0.25	8.0
400	-40.3	42	0.0	8	1	0.28	8.0
425	-36.6	45.5	0.0	8	1	0.32	8.0
450	-33.1	48.9	0.0	8	1	0.37	8.0
475	-29.8	52.0	0.0	8	1	0.42	8.0
500	-26.7	55	0.0	8	1	0.47	8.0
525	-24.9	59.9	2.4	8	2	0.56	8.0
550	-23.2	64.6	4.6	8	2	0.65	8.1
575	-21.6	69.1	6.8	10	3	0.75	8.7
600	-20.1	73.4	8.9	16	3	0.84	10.6
625	-18.6	77.5	10.9	22	3	0.94	13.5
650	-17.2	81.5	12.8	27	4	1.00	16.6
675	-15.8	85.3	14.6	29	4	1.00	19.0
700	-14.5	89	16.4	28	4	1.00	20.5
725	-14.4	88.5	13.9	28	4	1.00	21.5
750	-14.4	87.9	11.5	28	3	1.00	22.2
775	-14.3	87.4	9.2	28	3	1.00	22.7
800	-14.3	86.9	6.9	28	3	1.00	23.0
825	-14.2	86.5	4.7	27	2	1.00	23.3
850	-14.2	86	2.6	27	2	1.00	23.4
875	-12.3	87.7	1.7	20	1	1.00	23.3
900	-10.5	89.4	0.8	12	1	1.00	23.1
925	-8.7	91	0.0	9	1	1.00	22.8
950	-8.5	91.0	0.0	8	1	1.00	22.4
975	-8.4	91.0	0.0	8	1	1.00	22.1
998	-8.2	91	0.0	8	1	1.00	21.8
					SLR		22.8

As a comparison, a full 25mb resolution vertical profile and SLR calculation (left) as compared to the sounding (right) that was logarimically interpolated from the mandatory level data (UVV at 850 / 700 mb) along with the SLR calculation. The interpolated soundings SLR was 23:1 vs 21:1 with the full resolution sounding.