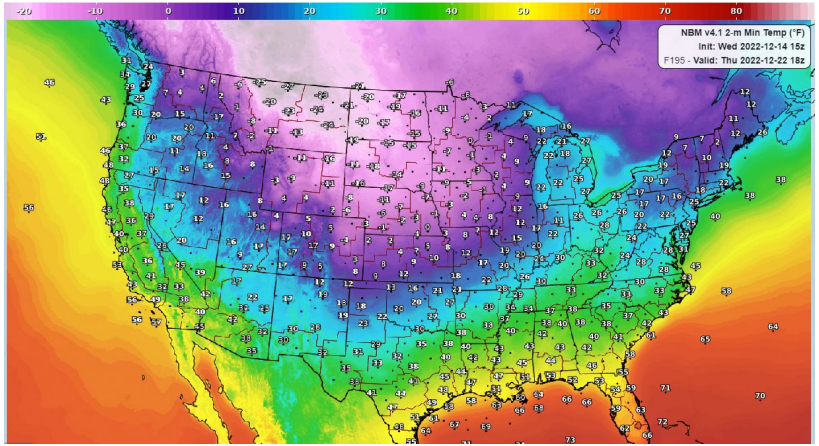
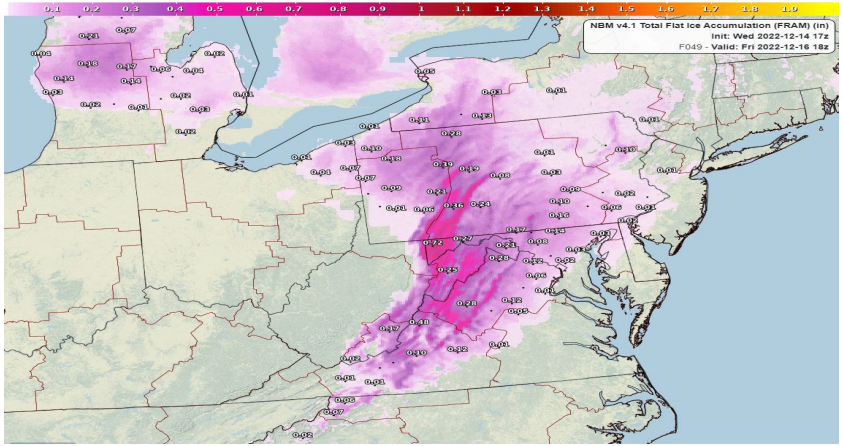
National Blend of Models (NBM) v4.2 Upgrades and Improvements





David Rudack, Robert James, Sarah Perfater, Geoffrey Manikin, Andy Just

NWS/OSTI/MDL Silver Spring, MD

Notable Upgrades for NBM v4.2

(1) New probabilistic Quantile Mapping-based (QM) 10m instantaneous wind speed and wind gust percentiles and exceedance values (CONUS)

(2) Corrected Mixing Height calculation now dependent upon URMA surface terrain height rather than the RAP model surface height (CONUS)

(3) Elimination of “lattice-like” features in the NBM blended snow amount guidance by introducing smoothing to the European Centre for Medium-Range Weather Forecasts, Ensemble (ECMWFE), Global Ensemble Forecasting System (GEFS), and Short-Range Ensemble Forecasting System (SREF) QM precipitation amount Cumulative Distribution Functions (CDFs) (CONUS, Alaska)

(4) Modified the Snow Liquid Ratio (SLR) calculation by taking into account the melting of snow where temperatures are at or above freezing at the surface and removed the 25% reduction factor to each model input SLR value (CONUS, Alaska)

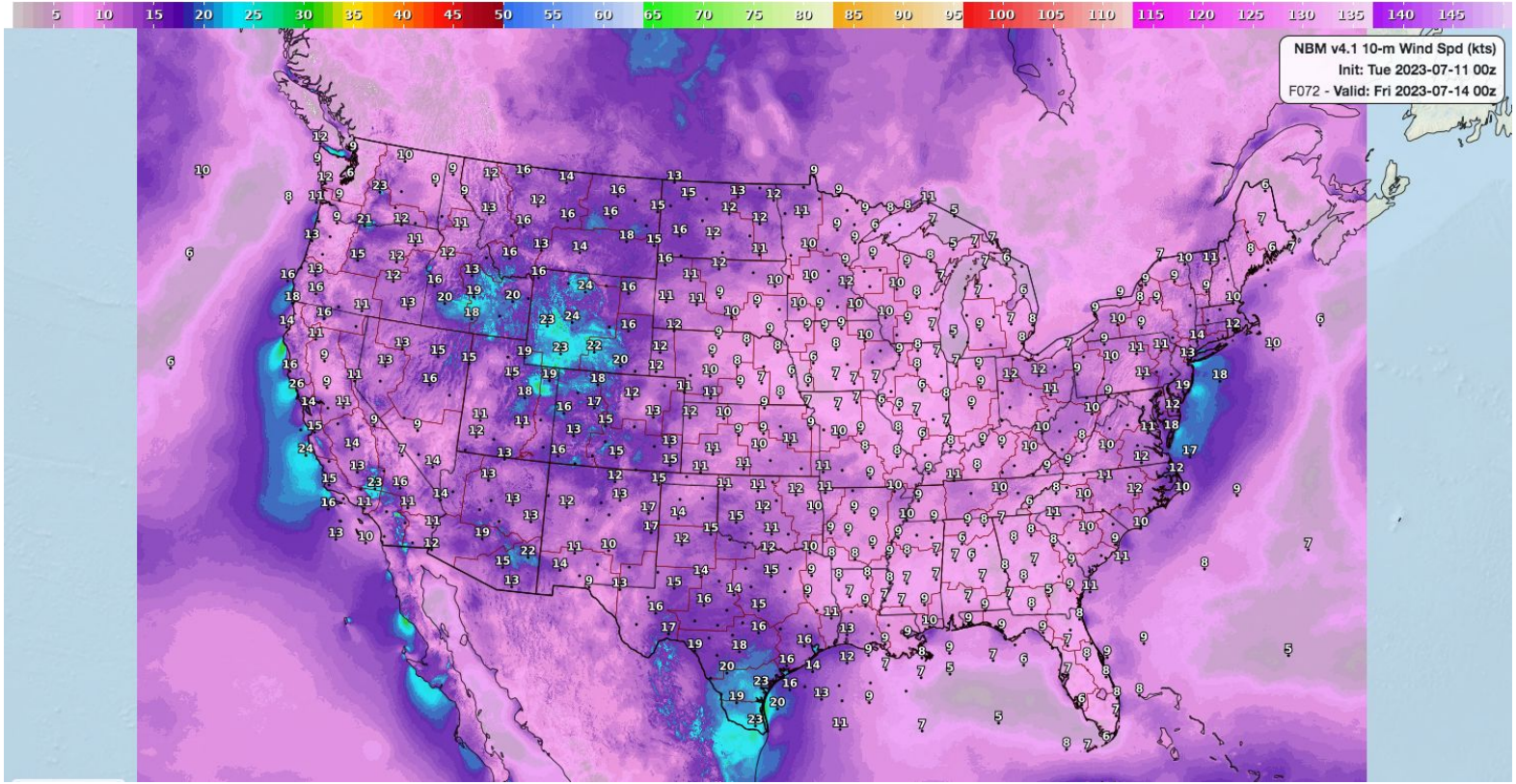
(5) Downscaled wet bulb temperature for ECMWFE, GEFS, and SREF models for improvement in ice accumulations (CONUS, Alaska)

(6) Introduced smoothing to the ECMWFE, GEFS, and SREF precipitation amount CDFs. This modification was made to support the winter weather product note above which uses these model inputs (CONUS, Alaska, Hawaii, Puerto Rico, Oceanic)

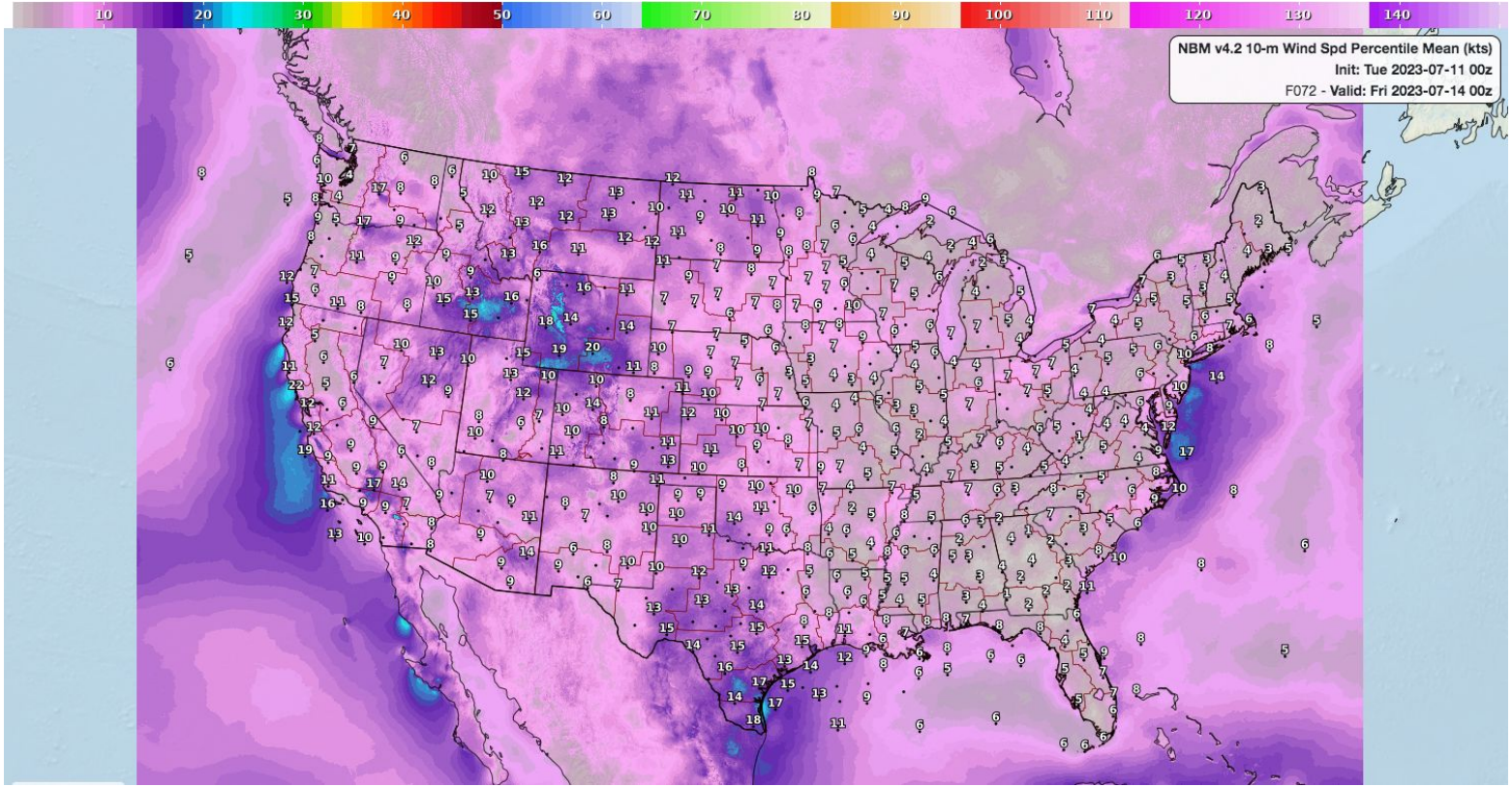
Quantile Mapped probabilistic 10m instantaneous wind speed and wind gust

- This probabilistic product has been created in response to Fire Weather needs in the Field and will assist with IDSS.
- 10m instantaneous Quantile Mapped wind speed and wind gust percentiles are now being generated at 0000-, 0600-, 1200-, and 1800 UTC
- Deterministic 10m wind speed and wind gust are now being replaced by the Quantile Mapped mean wind speed and wind gust, respectively.

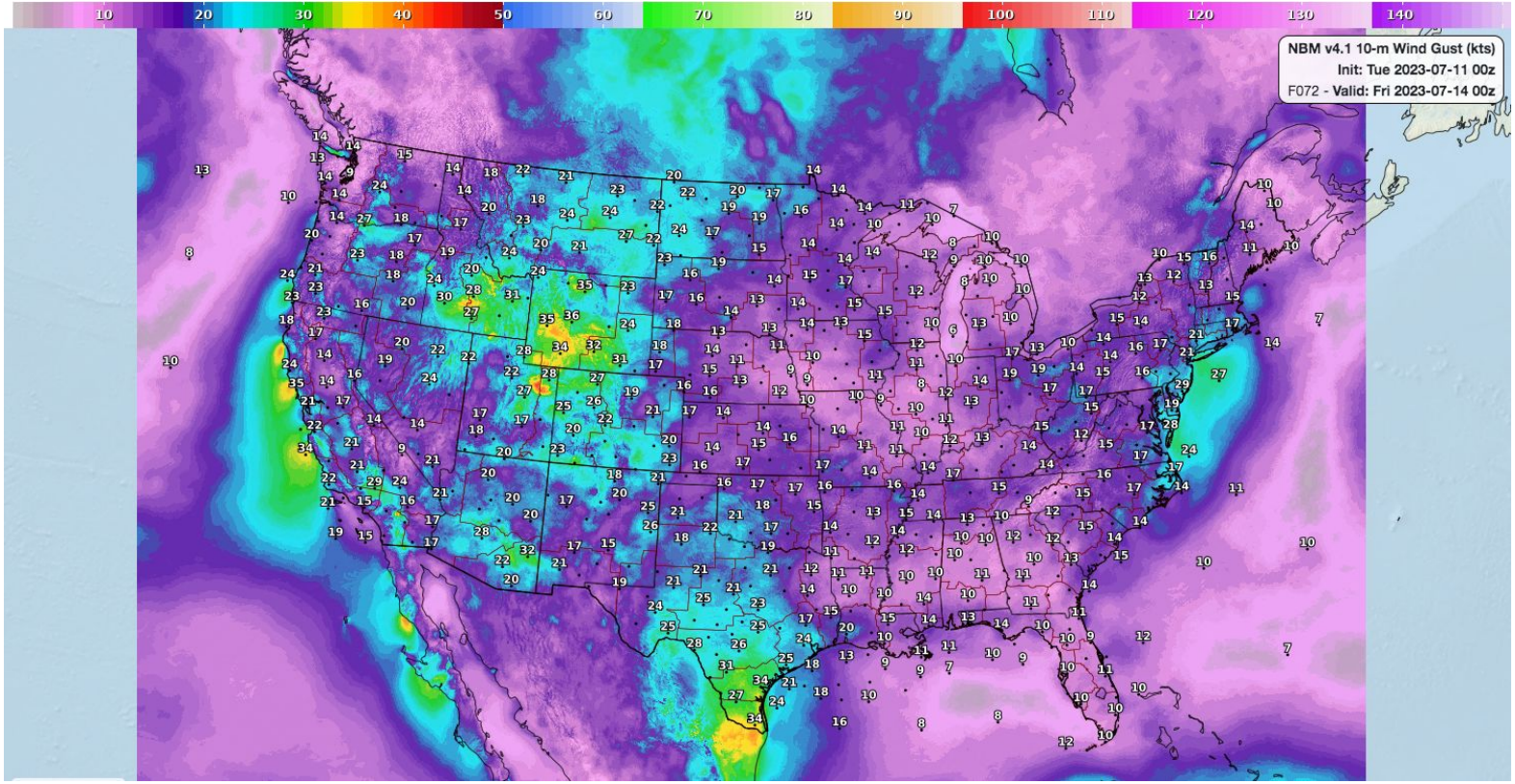
NBM v4.1 10m Wind Speed (72h Projection)



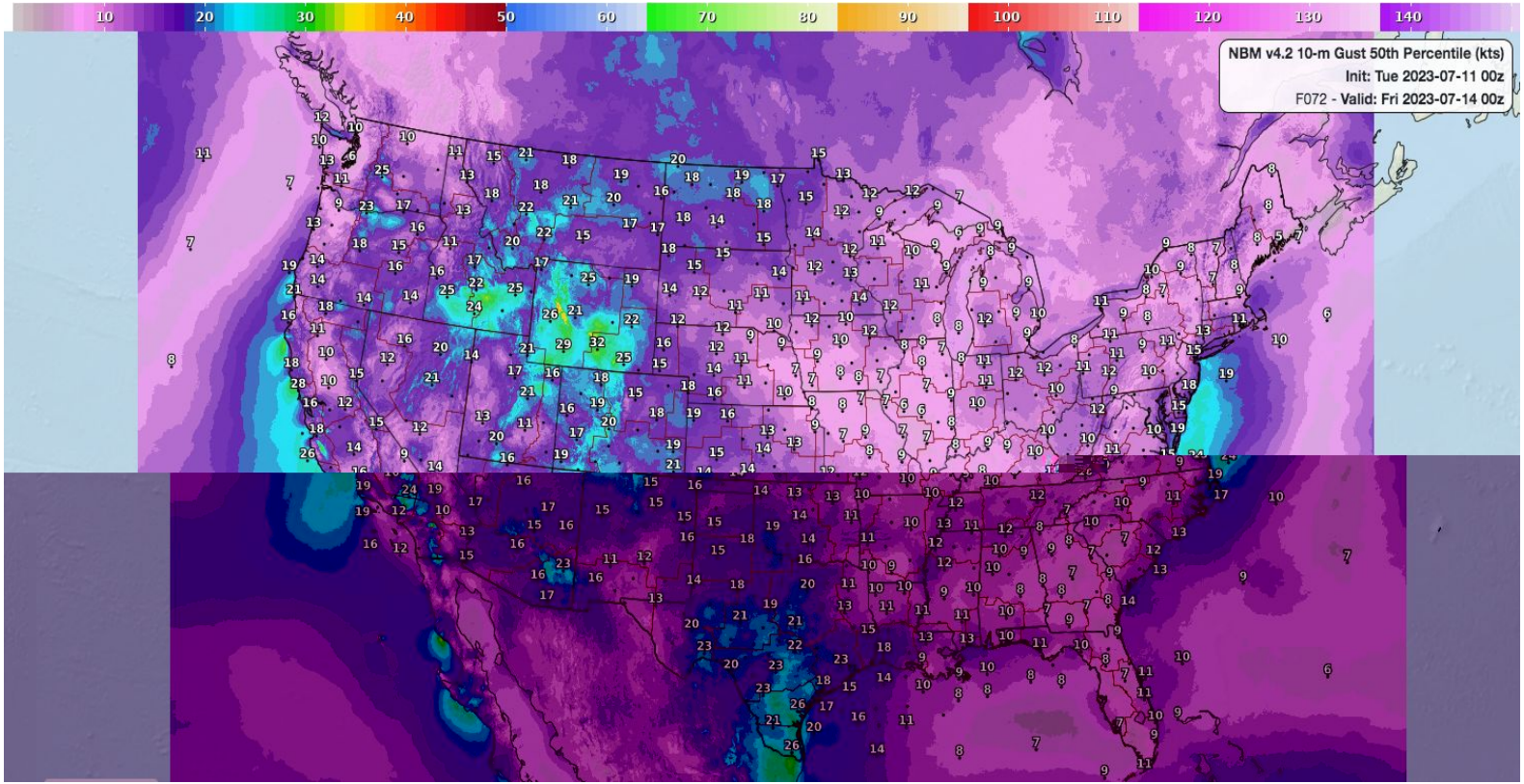
NBM v4.2 Quantile Mapped 10m Mean Wind Speed (72h Projection)



NBM v4.1 10m Wind Gust (72h Projection)



NBM v4.2 Quantile Mapped 10m Mean Wind Gust (72h Projection)

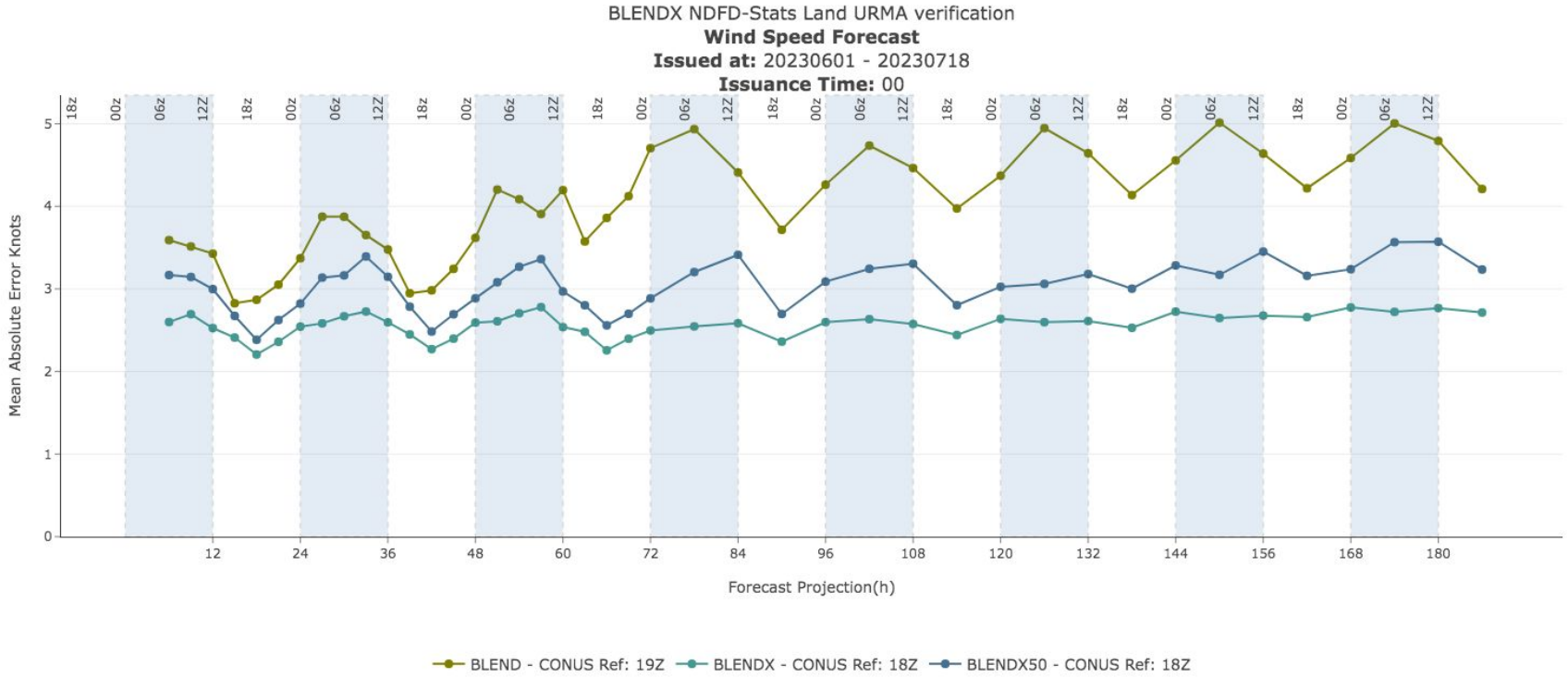


Preliminary Gridded Verification of QM 10m Wind Speed and Wind Gust

Three products are verified on the subsequent eight slides:

BLEND = Operational (NBM v4.1) deterministic 10m Wind Speed or Wind Gust
BLENDX = Development NBM v4.2 QM Mean of 10m Wind Speed or Wind Gust
BLENDX50 = Development NBM v4.2 QM 50th percentile of 10m Wind Speed or Wind Gust

Verified for all cases



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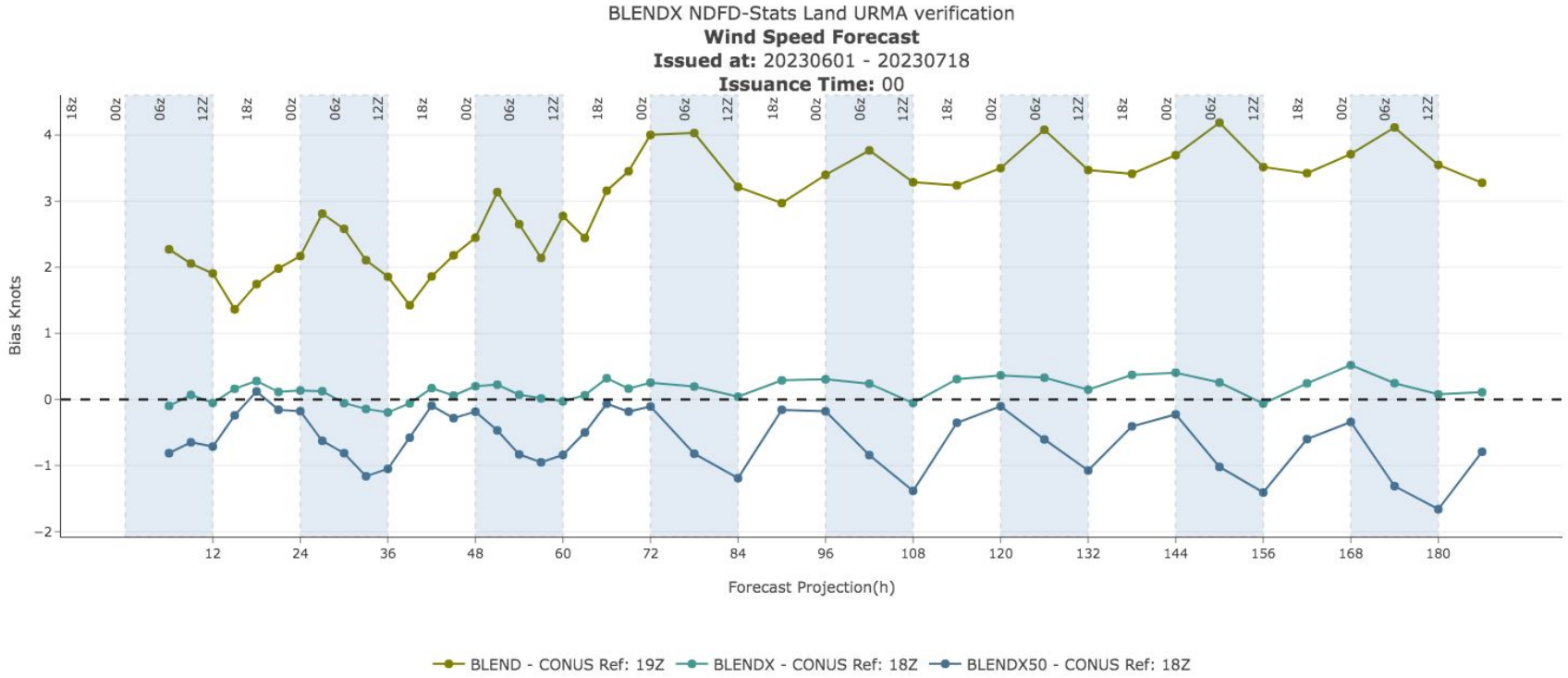
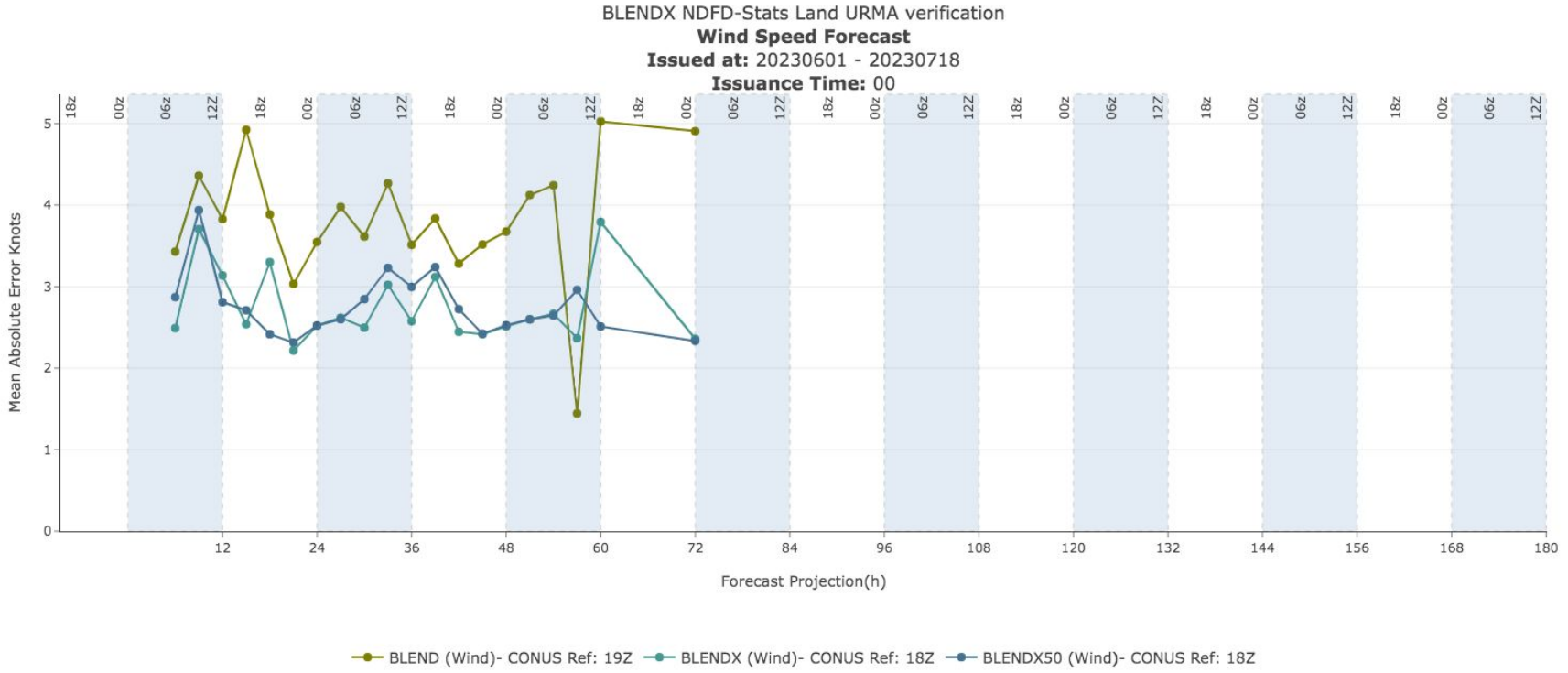


Verified only for cases where a Watch, Warning, or Advisory was issued by the NWS



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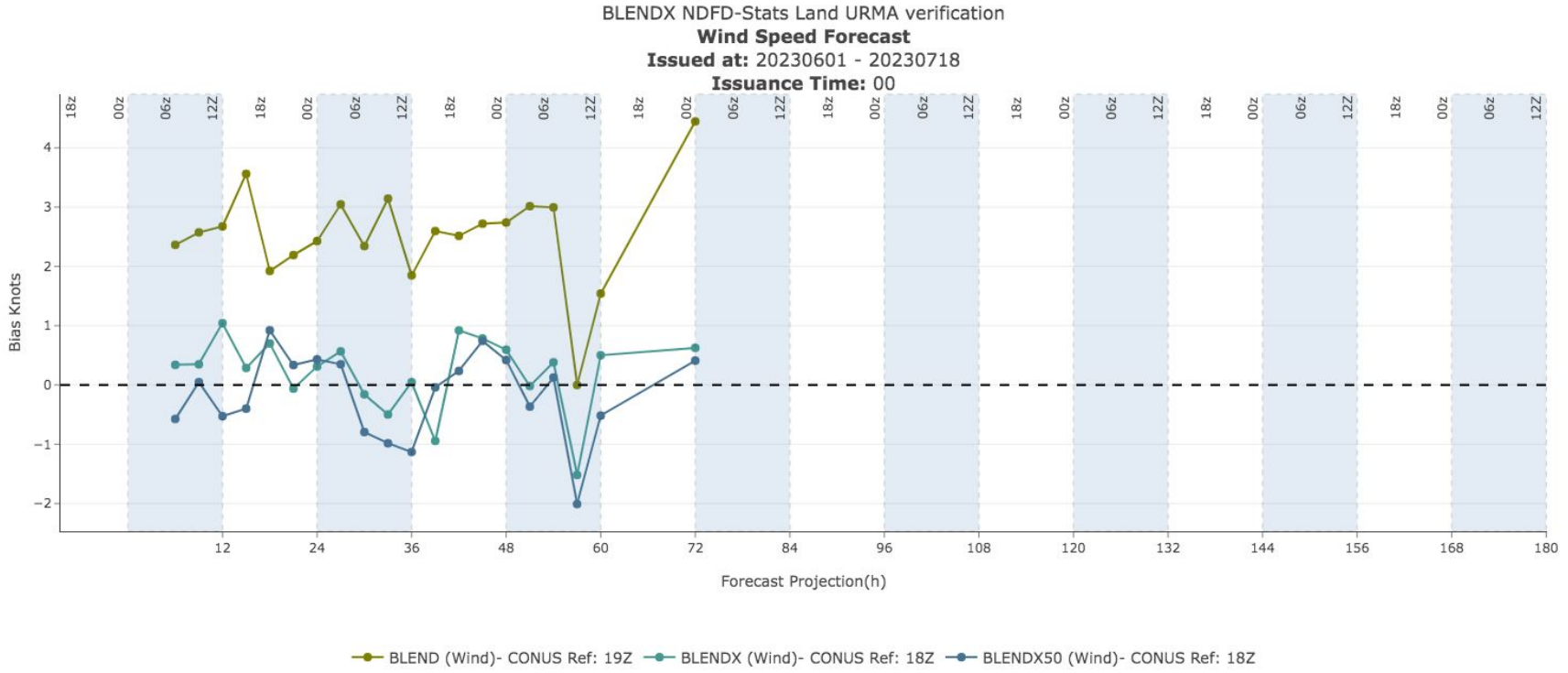

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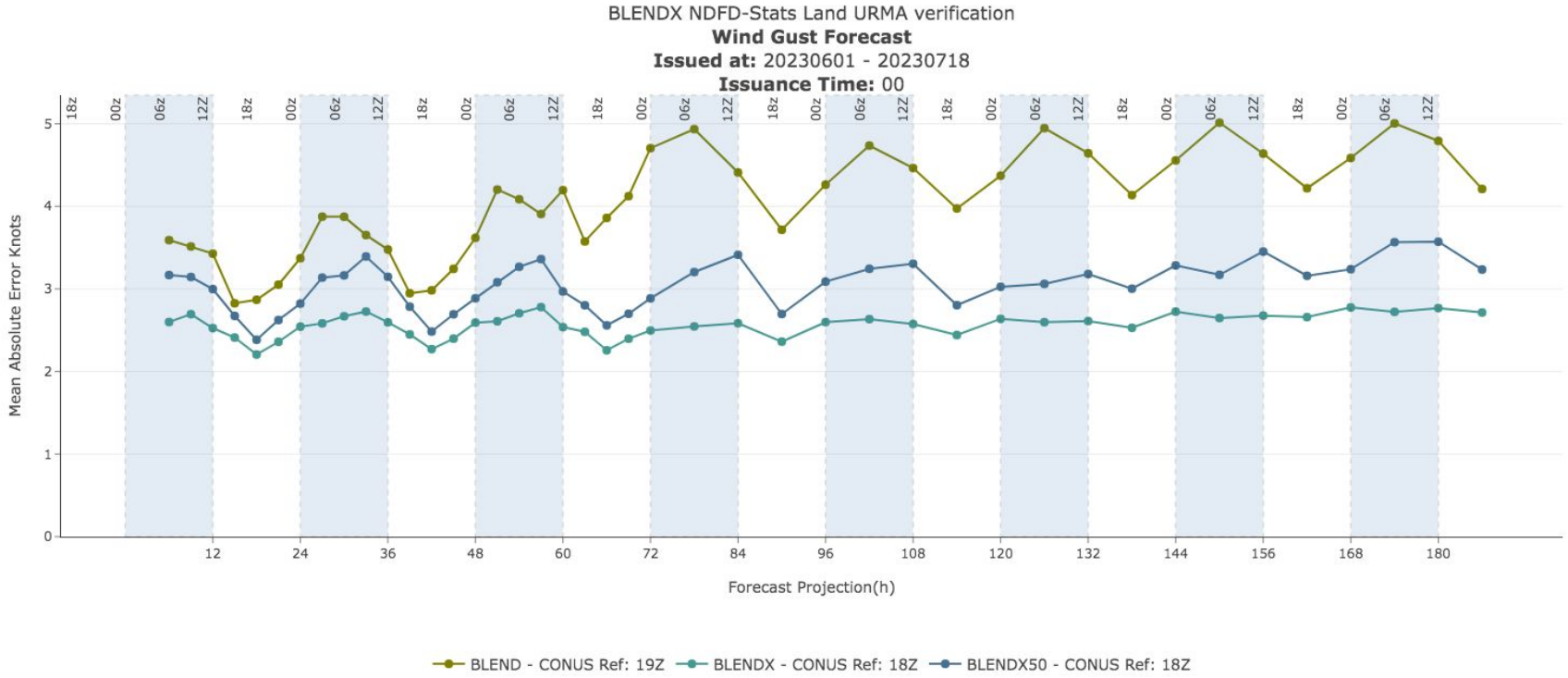

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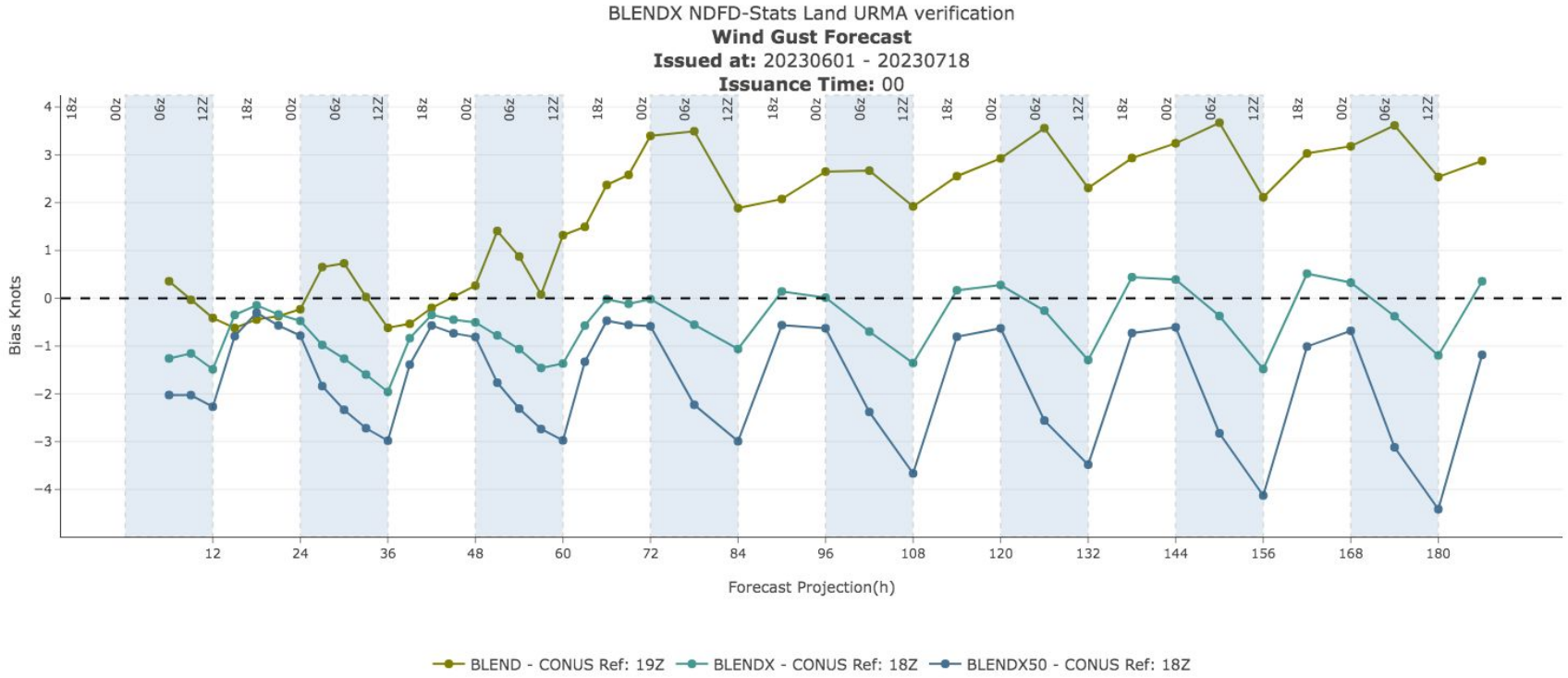
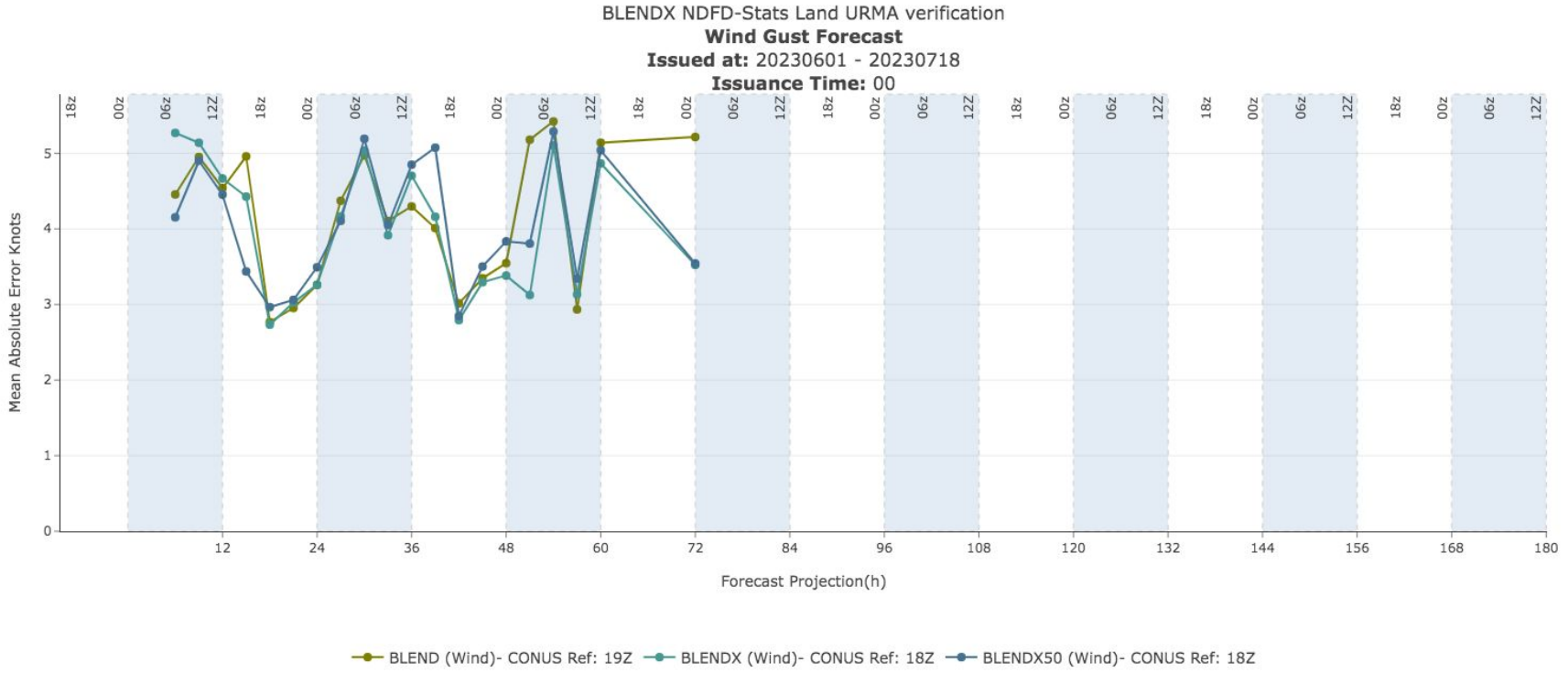
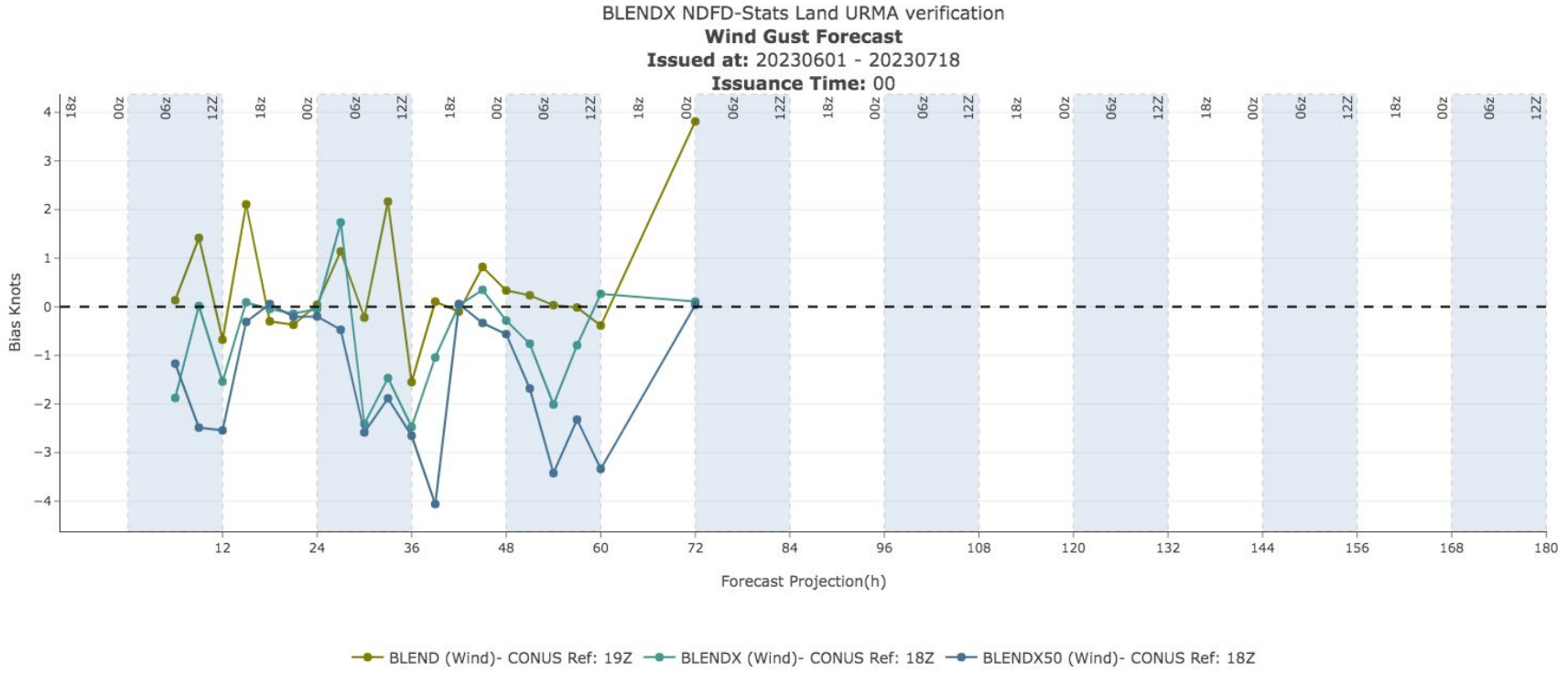


Verified only for cases where a Watch, Warning, or Advisory was issued by the NWS



Verified only for cases where a Watch, Warning, or Advisory was issued by the NWS



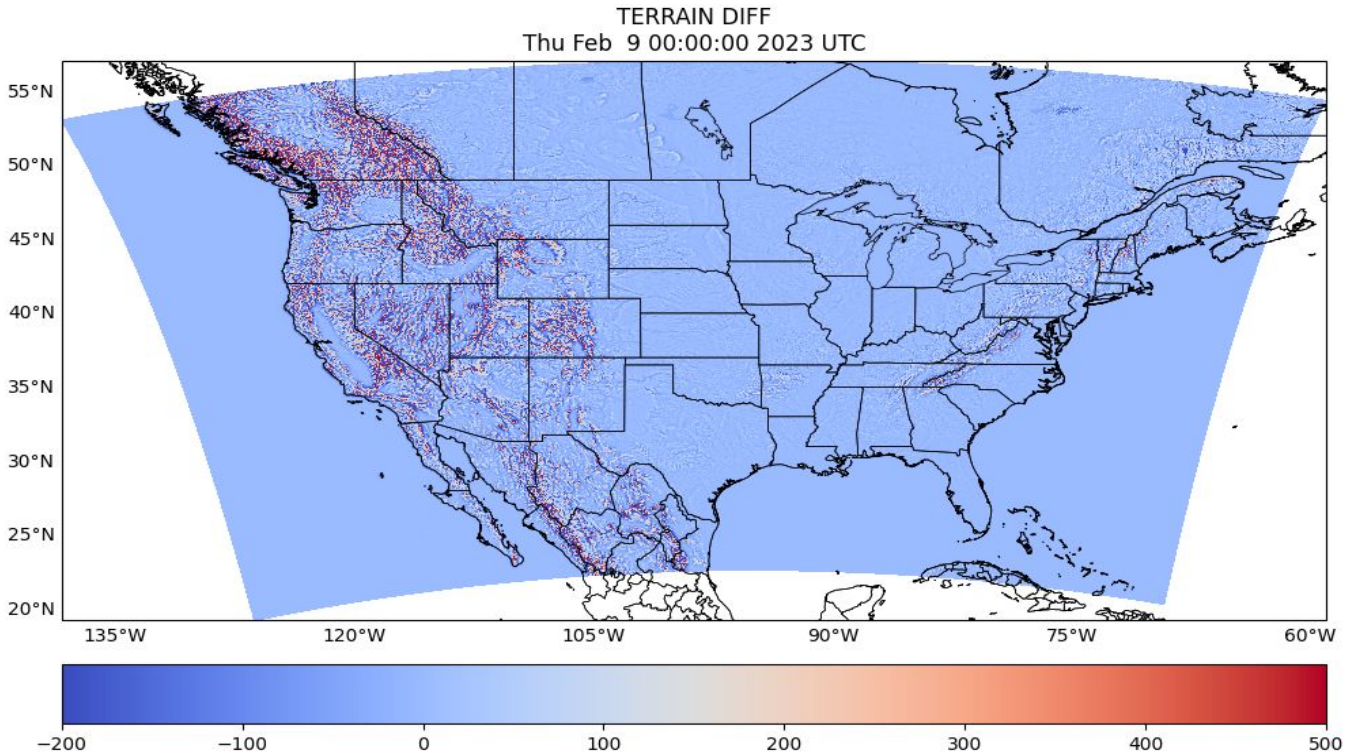
NBM v4.2 Mixing Height Adjustment

Overview of NBM Mixing Height

- Mixing Height is calculated via one of two methods, depending on the input model
  - Modified Stull Method
    - Accounts for the buoyant effects of moisture due to use of virtual potential temperature
    - Stull method is based on SmartInits Python code, and was first used in NBM v3.1
    - Models using Stull method: GFS, RAP, NAM, NAM Nest
  - PBL Height as a proxy
    - Models using PBL Height: HRRR, HRRRX, WRF-ARW, WRF-MEM2, HIRESFV3, ECMWFD, ECMWFE
- Starting in NBM v4.1, Mixing Height is bias-corrected to the RAP analysis

Terrain Difference between RAP and the URMA Unified Terrain

NBM v4.2 is now incorporating the difference between the RAP and URMA Unified terrain height in the calculation of Mixing Heights. This is a more accurate depiction of the true Mixing Height above the surface. Note the terrain detail in the subsequent four slides.



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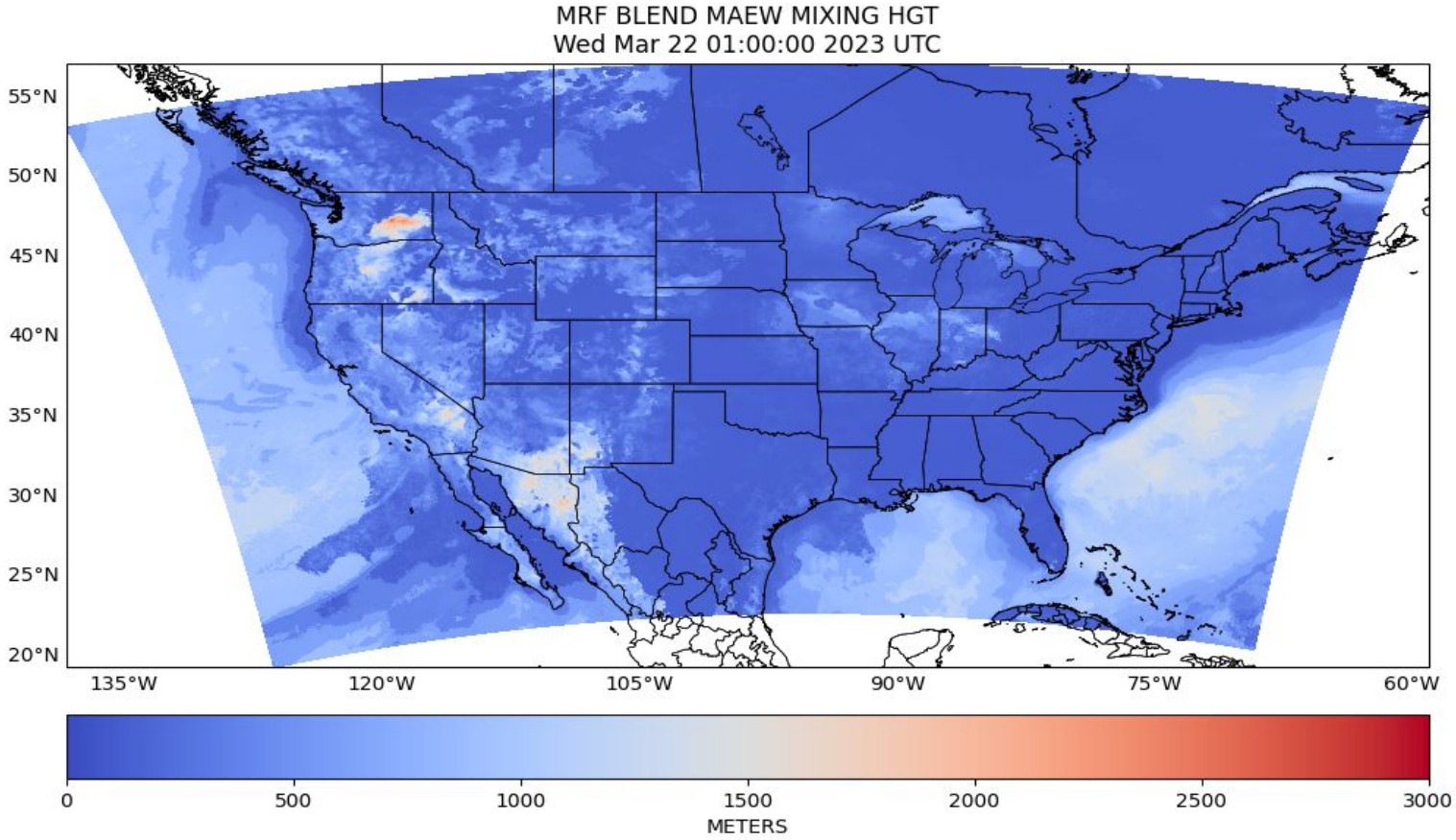

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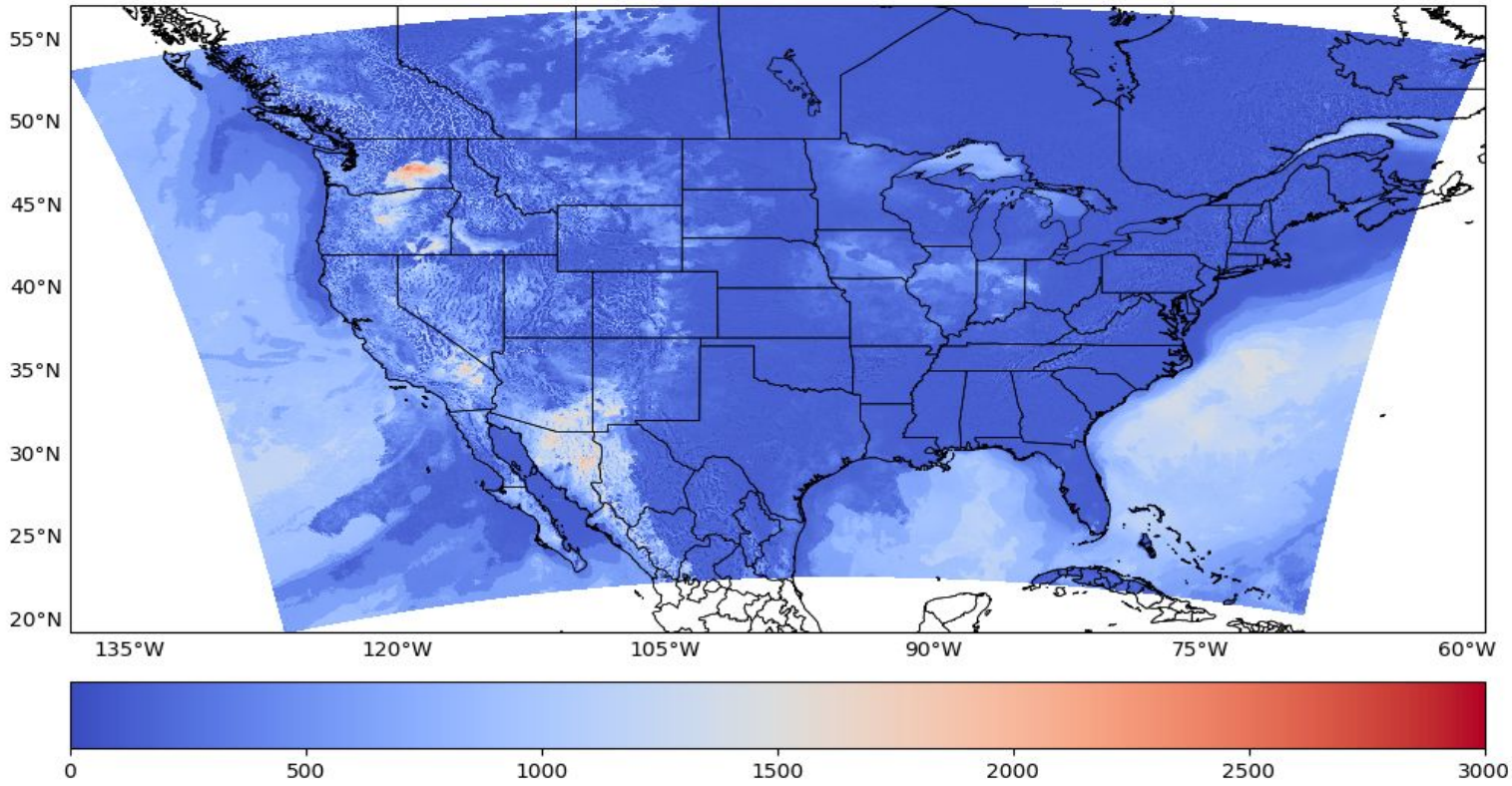
MRF BLENDED, TERR ADJ MIXHGT
Wed Mar 22 01:00:00 2023 UTC



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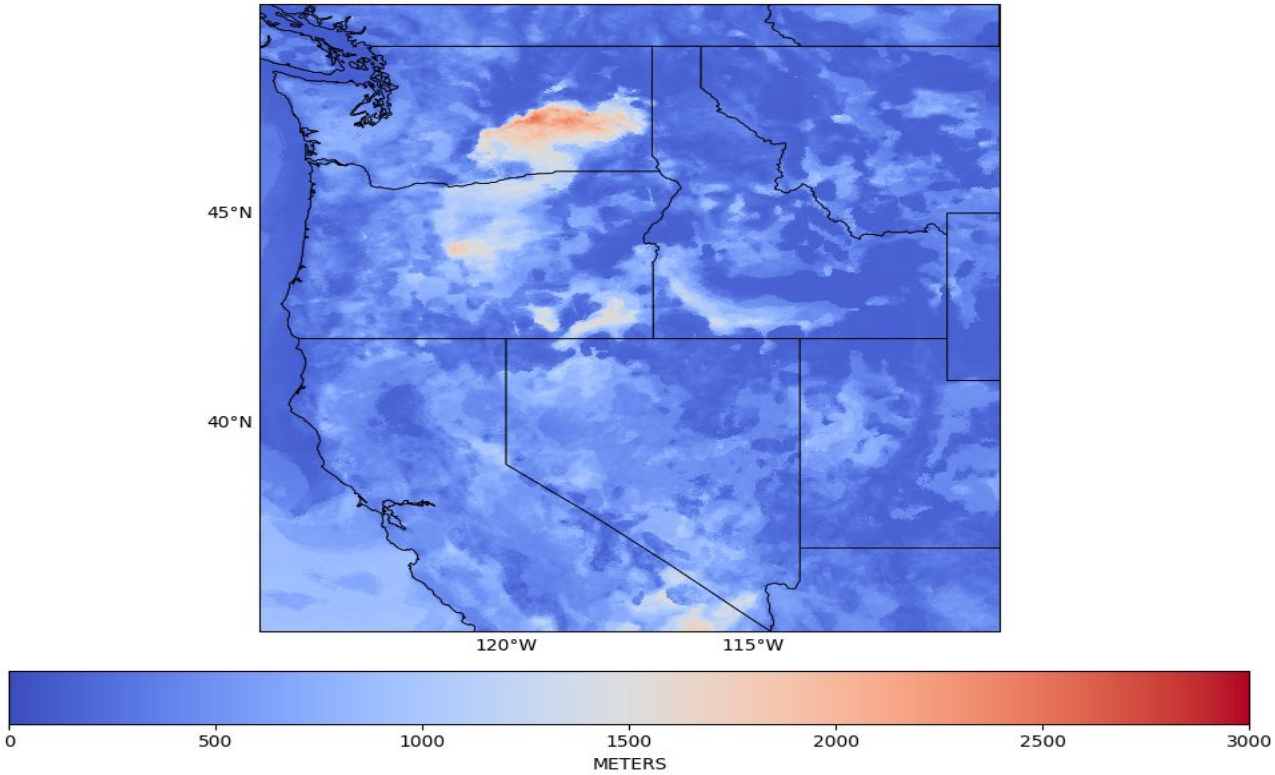
MRF BLEND MAEW MIXING HGT
Wed Mar 22 01:00:00 2023 UTC



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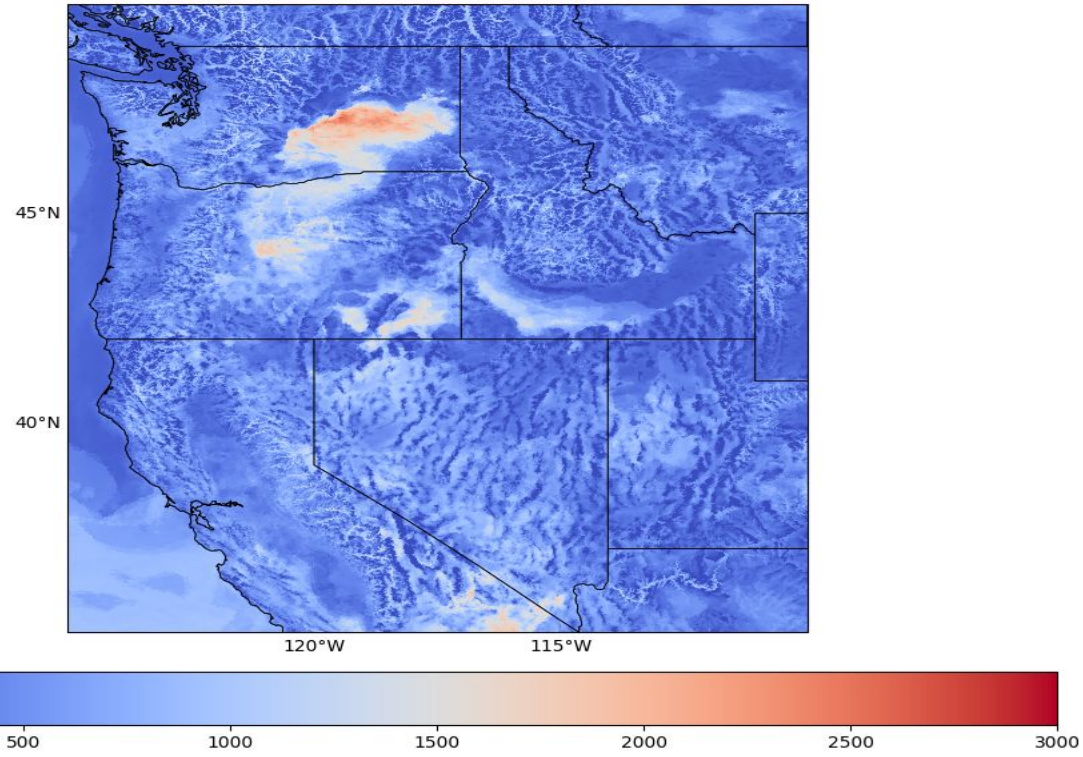
Wed Mar 22 01:00:00 2023 UTC



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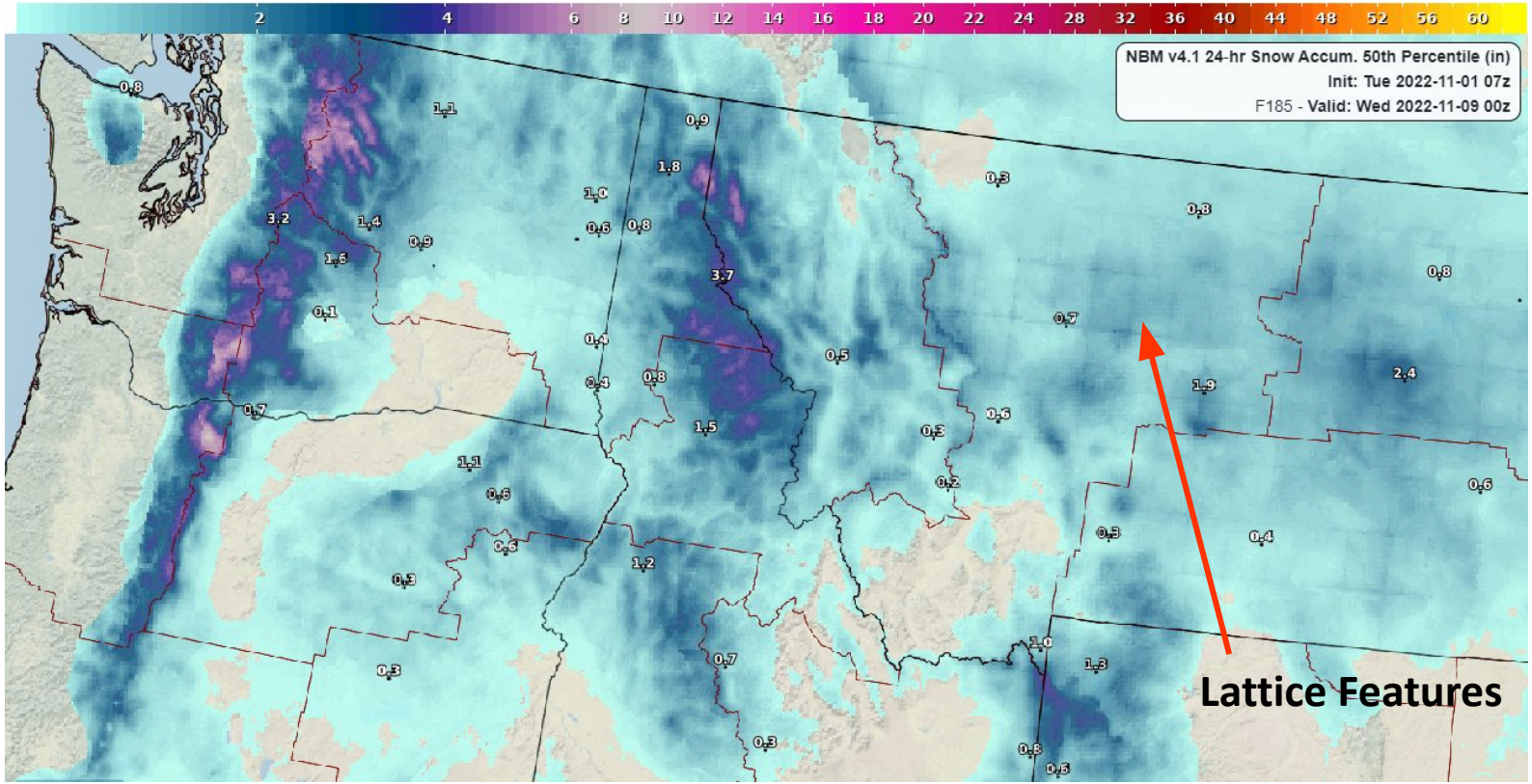
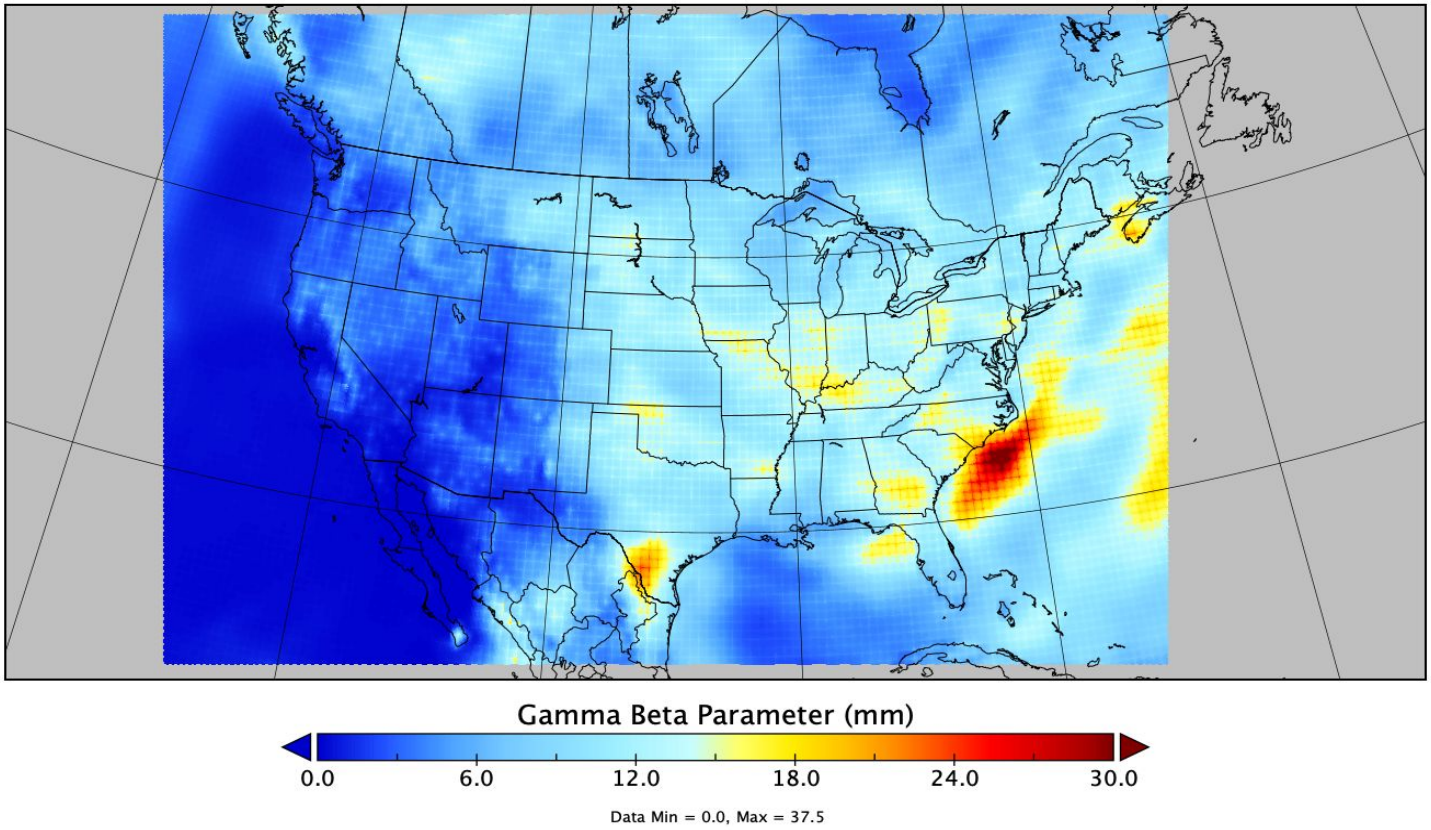
Removal of lattice features in the NBM snow/ice product

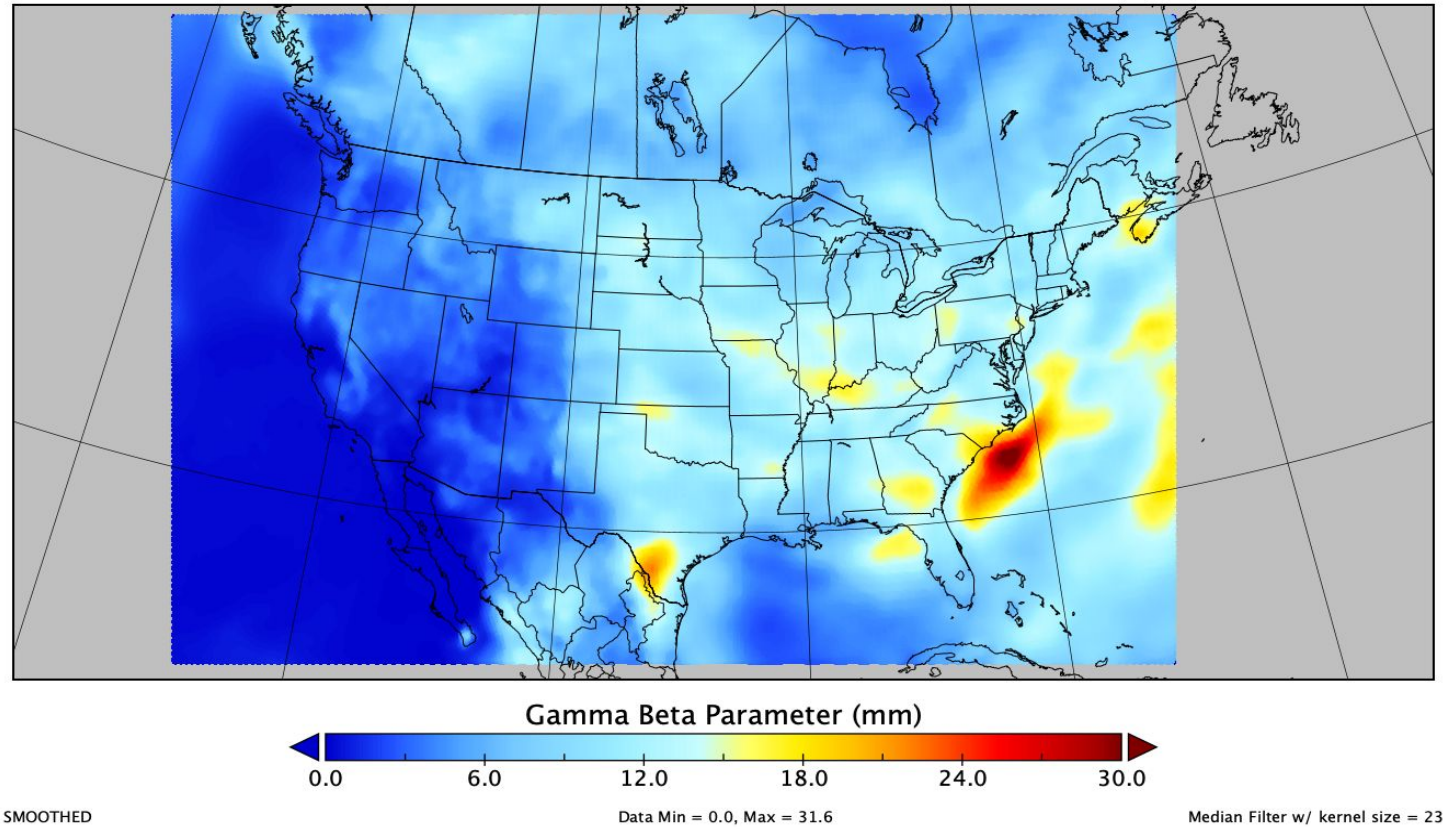
Example 1 of Lattice features in the snow accumulation product



The lattice features are attributable to the QPF CDF used to generate the quantile mapping for snowfall amounts.



The QPF CDF is now smoothed prior to the quantile mapping so that the snowfall probability distribution takes on a smoother appearance.



NBM snow liquid ratio (SLR) improvements in marginal snow environments

NBM Snow Liquid Ratio (SLR) Blends

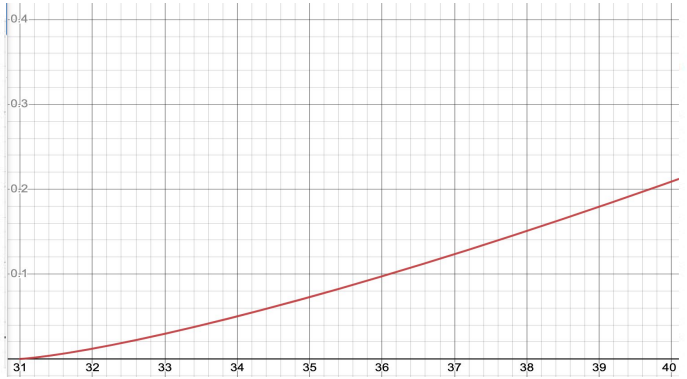
Model	Snow Ratio Techniques
HRRR	50% Cobb, 50% MaxTAloft
HRRRX	50% Cobb, 50% MaxTAloft
RAP	50% Cobb, 50% MaxTAloft
RAPX	50% Cobb, 50% MaxTAloft
HiResARW	50% Cobb, 50% MaxTAloft
HiResARW2	50% Cobb, 50% MaxTAloft
HiResFV3	50% Cobb, 50% MaxTAloft
NAM	33% Cobb, 33% MaxTAloft, 33% Roebber
NAMNest	50% Cobb, 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

NBM V4.2 Proposed SnowMelt Function for “Warm” Snowfall

Experiment 1: Steps to incorporate SLR correction to account for melting snow:

- Calculate each “cloud base” SLR and blend as previous.
- Calculate potential snow melt for falling snow based on the following equation:

$$QPFmelt = \left(\frac{(0.5 \cdot x - 15.50)}{15} \right)^{1.3}$$



- Revise the blended SLR as:

$$SLR_{new} = SLR \times \left[\frac{QPF - QPFmelt}{QPF} \right]$$

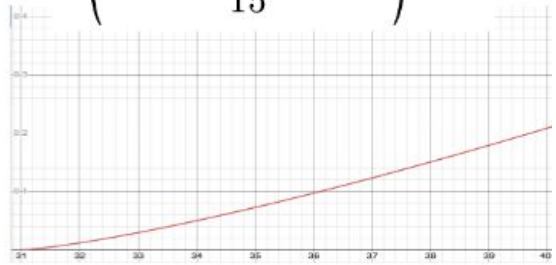
If QPF_{melt} > QPF set SLR_{new} to zero, i.e. there will be no snow accumulation.

- Adjust logic to allow for a p-type of snow with temps ≤ 40F.

Cobb SLR Melting Factor

- The new logic will incorporate idealized melting rates over a range of surface temperatures initially at or above 32F. For physical consistency the melting rate is incorporated into the SLR. The SLR is reduced based on the ratio of melting to accumulating snow QPF fractions. Here are some of the melting rates based on the V4.2 equation.

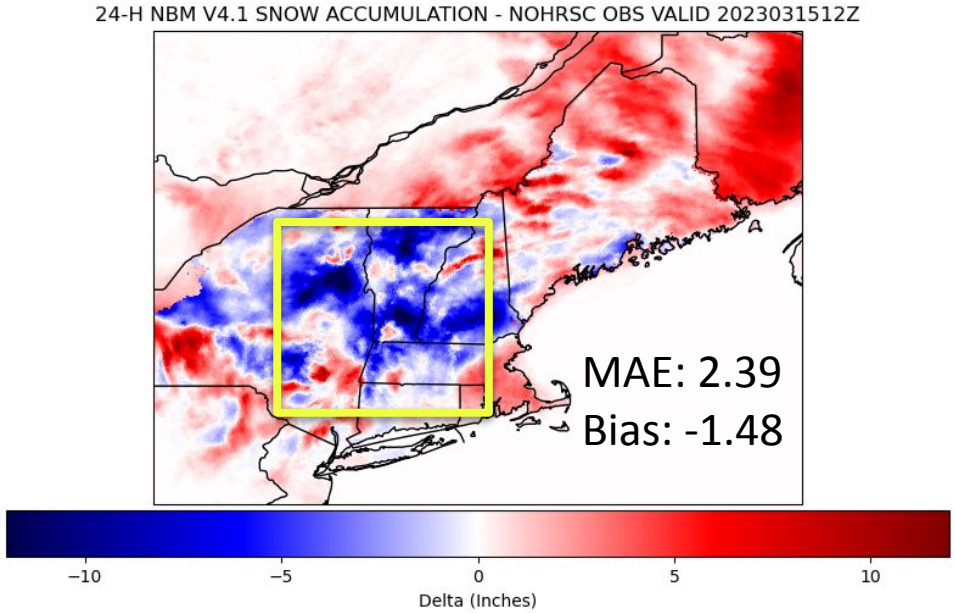
$$\left(\frac{(0.5 \cdot x - 15.50)}{15}\right)^{1.3}$$



32F	33F	34F	35F	36F	37F	38F	39F	≥40F
0.01	0.03	0.05	0.07	0.09	0.12	0.15	0.18	0.21

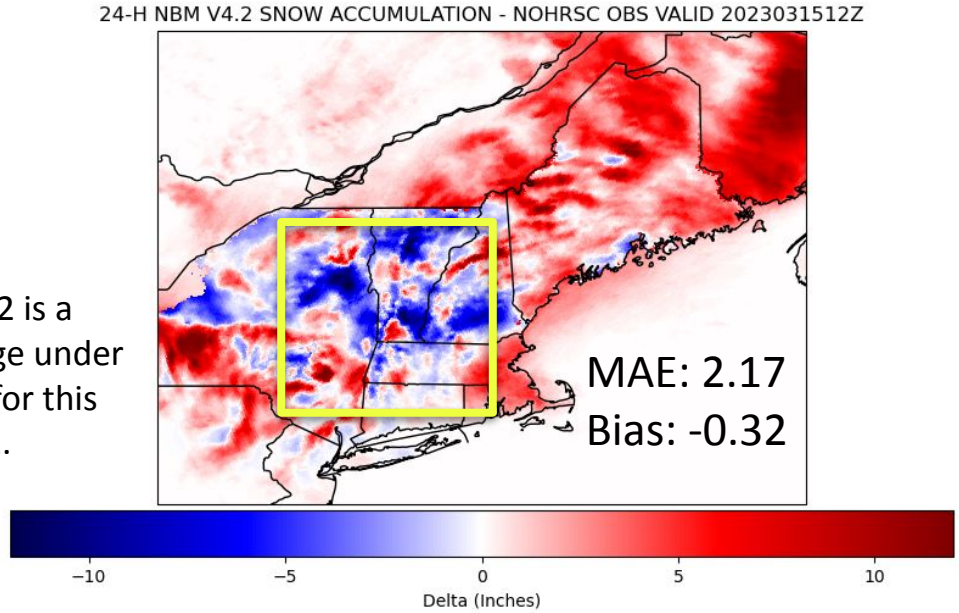
- For example, if the wet bulb temperature was 34F and the hourly precipitation rate (liquid equivalent) was 0.15 in/hr (heavy snow) then the melt would be 0.05 or 33% melt rate. If the SLR was 12:1 it would be reduced (100-33) to 12 x 0.67 ~= 8:1. If instead the temperature was 38F, then melting would equal or exceed snowfall rate and the SLR = 0 (snow melted as fell). Additionally, the relationship will allow for a broader range of outcomes where a p-type of snow is observed at temperatures close to 40F but without accumulation unless rates are extreme.

24h Snow Accumulation Difference between NBM v4.1 and NOHRSC



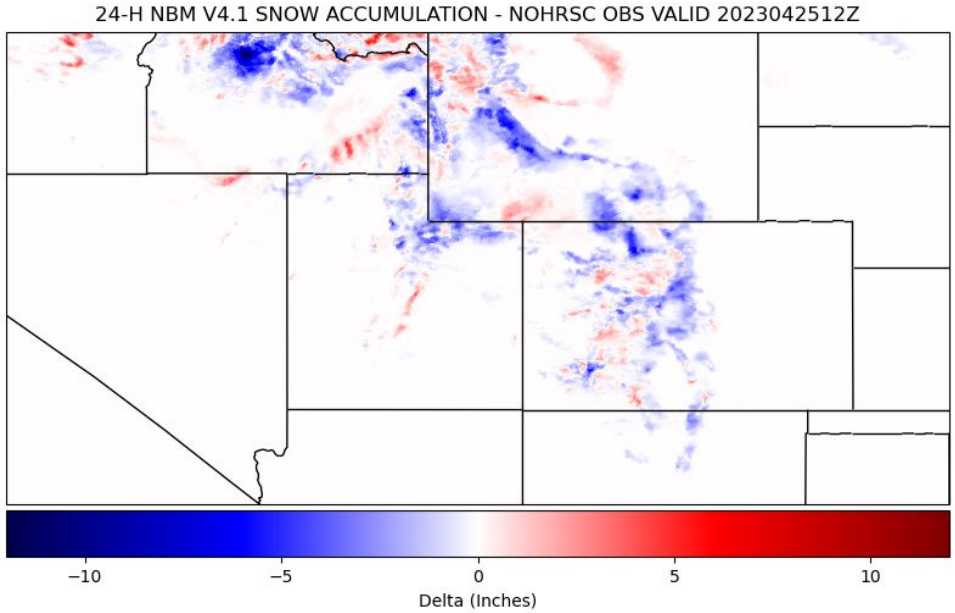
24h Snow Accumulation Difference between NBM v4.2 and NOHRSC

While the MAE for NBM v4.2 is a modest improvement, a large under forecast bias improvement for this event is noted for NBM v4.2.



24h Snow Accumulation Difference between NBM v4.1 and NOHRSC

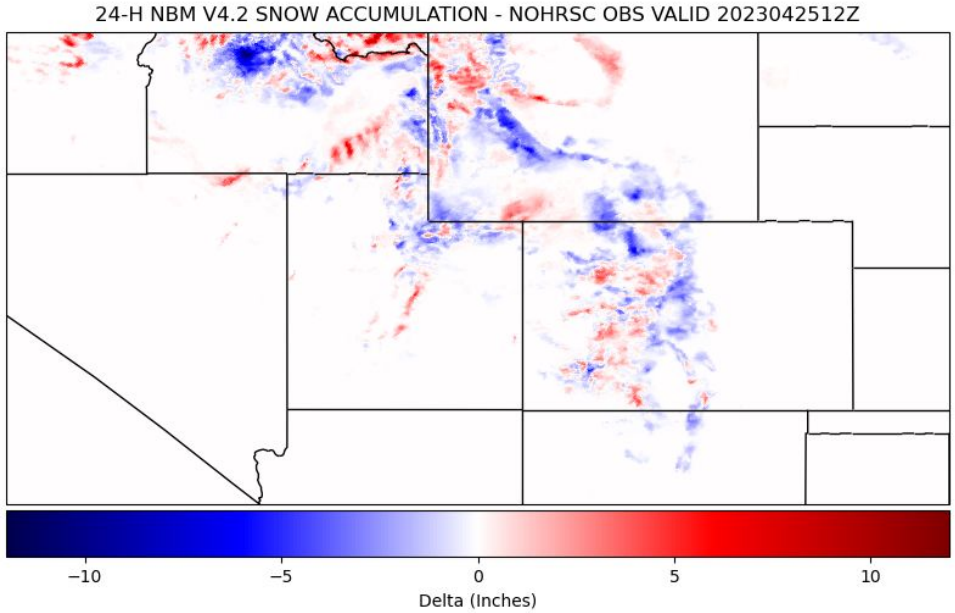
MAE = 0.156 in
Bias = -0.076 in



24h Snow Accumulation Difference between NBM v4.2 and NOHRSC

MAE = 0.162 in
Bias = -0.028 in

While the MAE for NBM v4.1 is a little worse, a modest under forecast bias improvement for this event is noted for NBM v4.2.



Calculating a Downscaled Wet Bulb Temperature from lower Resolution Model Data for NBM Ice Amounts

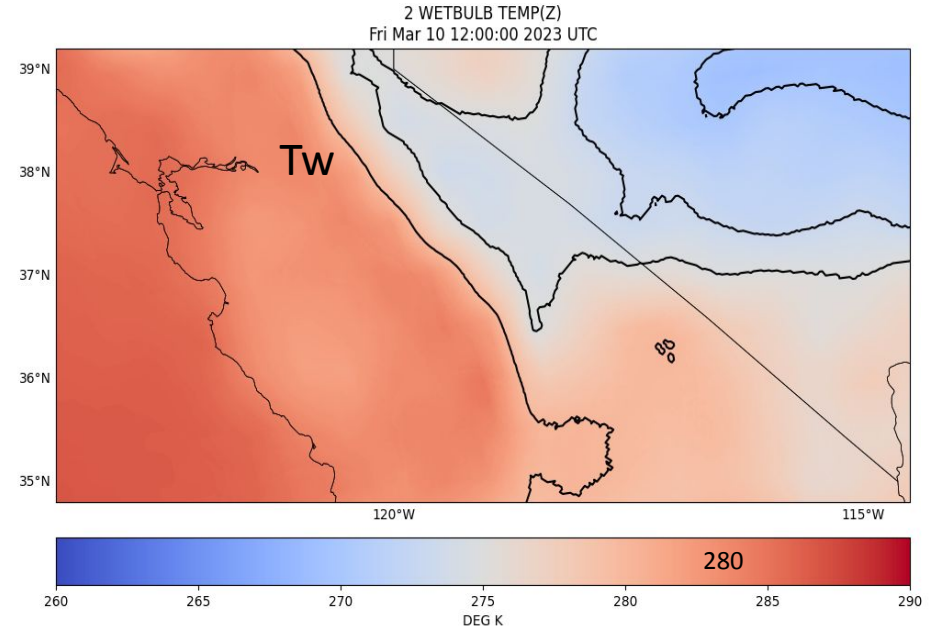
Downscaled Wet Bulb Calculation

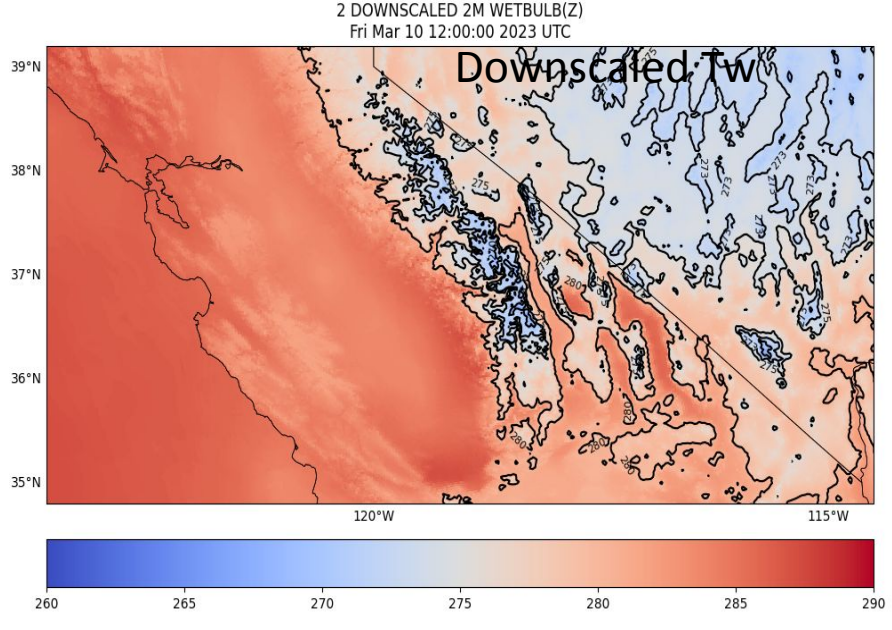
- Downscaled wet bulb computed by subtracting the difference between the non-downscaled temperature and downscaled temperature from the non-downscaled wet bulb (per communication with Dr. Daniel Cobb). That is:
  - delta=(T - DST)
    - T=non-dowscaled temp
    - DST=downscaled temp (obtained from WPC's algorithm based on thermal lapse rates)
  - DSTw=(Tw - delta)
    - DSTw=downscaled wet bulb
    - Tw=non-downscaled wet bulb (from model or computed)
- According to Dr. Cobb, subtracting the temperature difference from the wet bulb should be a reasonably accurate estimate of a downscaled value at least near wet bulb temperatures within +/- 10 degrees F of freezing (~ +/- 5.6 deg K).
- Downscaled wet bulb is applied to the ECMWFE, GEFS, and SREF ensembles only (coarser model resolution).

Case Study

- Examined an atmospheric river event which affected the Sierra Nevada area of CA on/around March 10, 2023.
- Shown is the NBM 0700Z 53-h forecast from 20230308, valid on 20230310 at 1200Z.
  - 24-h snow and ice amounts
- Also shown is the GEFS member p25 0000Z 60-h forecast from 20230308, also valid on 20230310 at 1200Z
  - The non-downscaled and downscaled wet bulb (Tw) temperature is shown for comparison
  - NOTE: the 0000Z GEFS is used in the 0700Z Blend
- Note how the downscaled Tw clearly delineates the terrain relief and smaller-scale features much more than the non-downscaled, which is very smoothed out.
  - The colder downscaled Tw values clearly match where the heaviest snow fell as well as where the ice occurred.

GEFS Member p25 Tw
0000Z 60-h Forecast from 20230308
valid 20230310/12Z
**(NOTE: the 0700Z Blend would use the 0000Z GEFS)





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