Expanding the Nebraska Winter Severity Index

Thomas Kauzlarich[1], Curtis Walker[2], Liang Chen[1], Mark Anderson[1]
[1]Department of Earth and Atmospheric Sciences, University of Nebraska – Lincoln
[2]NSF National Center for Atmospheric Research (NSF NCAR) – Boulder

Introduction and Motivation

Winter Severity Indices (WSIs) enable state Departments of Transportation (DOTs) to gauge hazardous winter weather on spatial and temporal scales. The Nebraska Winter Severity Index (NEWINS) provided an independent framework for assessing a winter season's severity by categorizing individual winter storms (Walker et al. 2019). However, NEWINS, like most WSIs, are used as a historical tool rather than predictive. For Nebraska DOT (NDOT), a predictive winter severity index framework was developed leveraging the previously developed NEWINS. This new predictive winter severity index framework, hereafter referred to as NEWINS-P, translates the NEWINS categorial framework into predictive modeling and expands NEWINS to include both in-storm and post-storm weather hazards.

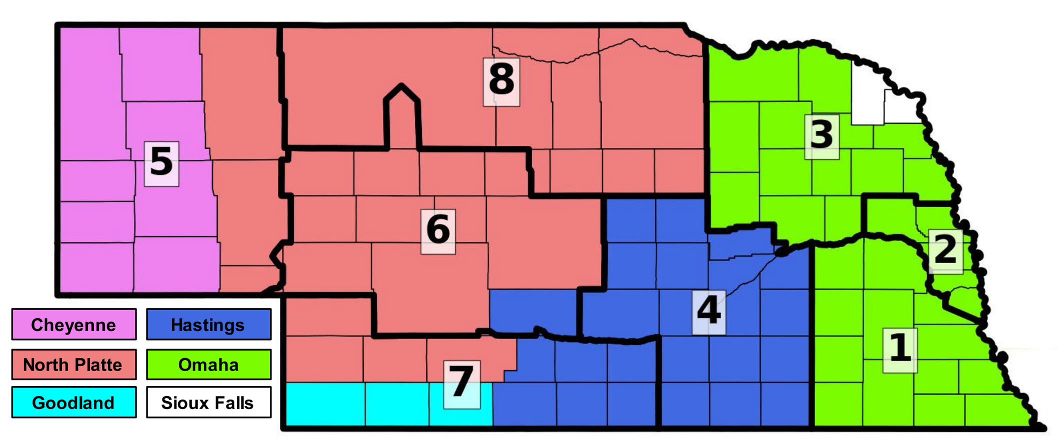

Figure 1. The eight NDOT maintenance districts overlaid onto the six color-coded NWS county warning areas.

Data and Methods

- Selected case study analyses from the 2018–19 through 2022–23 winter seasons using the National Digital Forecast Database (NDFD) have been completed. The 13–17 Dec 2022 Blizzard is presented here.
- Archived 6-h data were used to achieve a historical perspective of NDFD
- Input from NWS forecast offices (WFOs) are used to generate the NDFD data. The NDFD data were then used to evaluate NEWINS-P spatially and temporally across Nebraska (Fig 1).
- The multi-component NEWINS-P (listed below) uses the following NDFD parameters: snow/ice accumulation, quantitative precipitation forecast, and surface wind speed.
  - Snow severity index (NEWINS-S)
  - Precipitation type
  - Ice accumulation
  - Blowing snow (during precipitation)
  - Drifting snow (after precipitation)

Synoptics

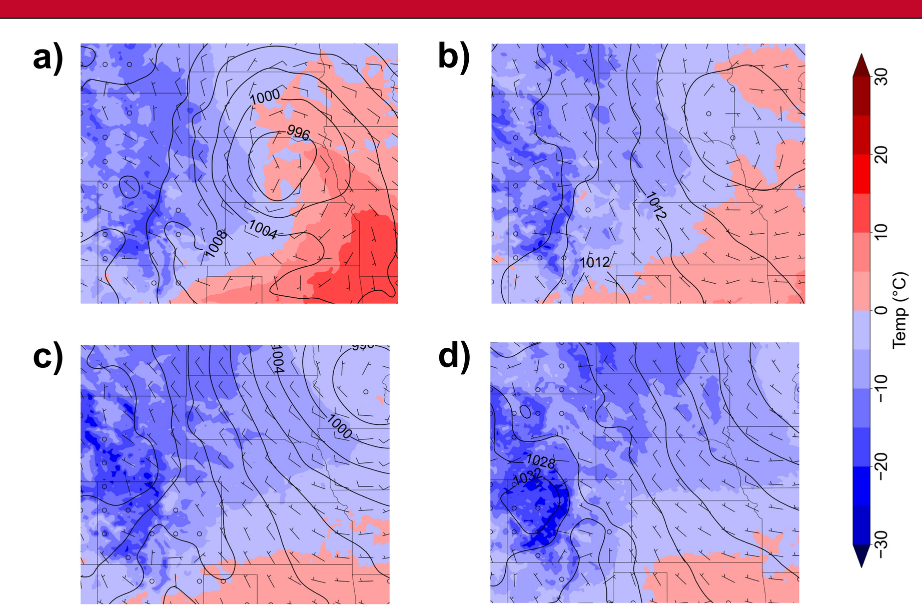

Figure 2: RAP reanalysis data for surface mean sea level pressure (hPa), temperature (°C), wind speed (ms[-1]), and wind direction (°) valid a) 00 UTC 14 Dec 2022, b) 00 UTC 15 Dec, c) 00 UTC 16 Dec, and d) 00 UTC 17 Dec. Note that after the passage of the Colorado low, winds remain strong.

Results

The NEWINS-P spatial forecasts from the 00 UTC 13 Dec 2022 model run showcase the different weather hazards forecasted for a winter storm. During the peak of the winter storm (Fig 3), high NEWINS-S categories and blowing snow concerns are forecasted across western Nebraska. After the storm departed (Fig 4), drifting snow concerns developed as strong winds persisted well after the snow had stopped.

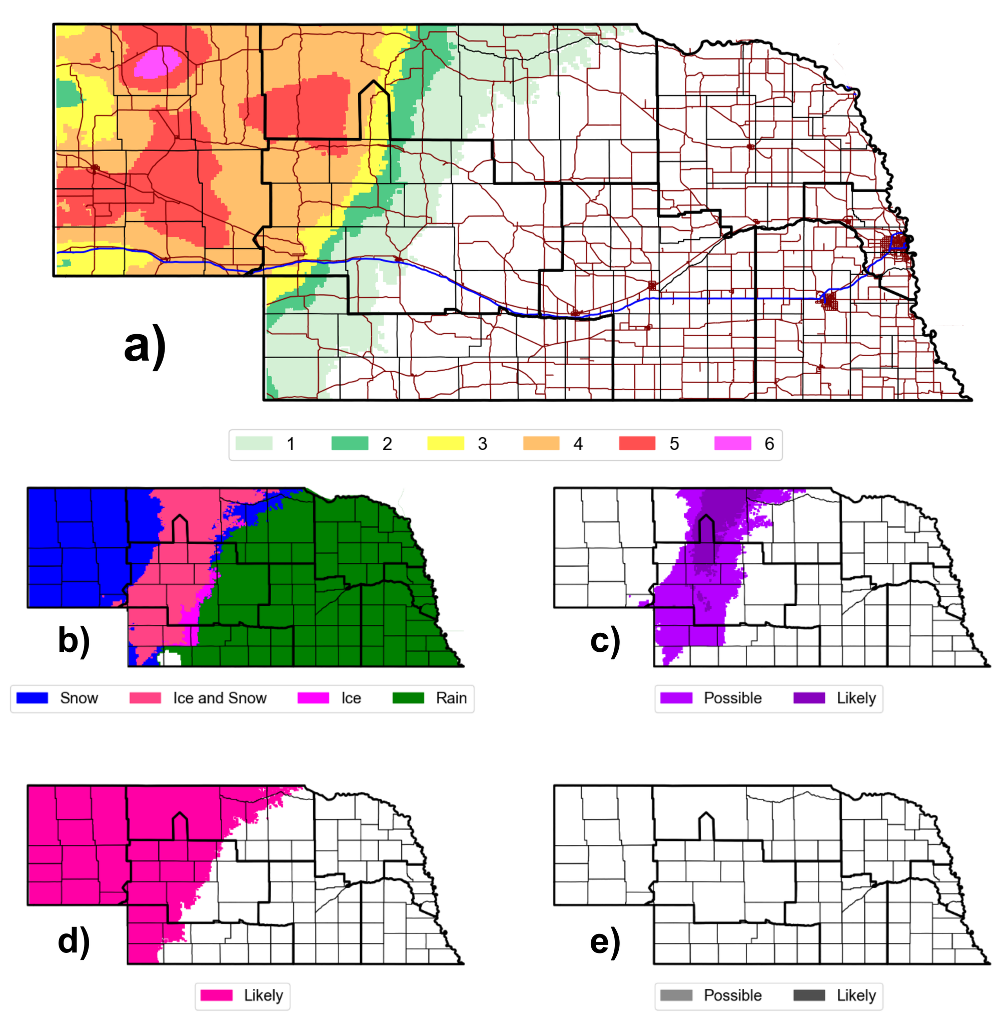

Figure 3: The 18-h NEWINS-P forecast from the 00 UTC 13 Dec 2022 model run: a) NEWINS-S, b) precipitation type, c) ice accumulation, d) blowing snow, and e) drifting snow.

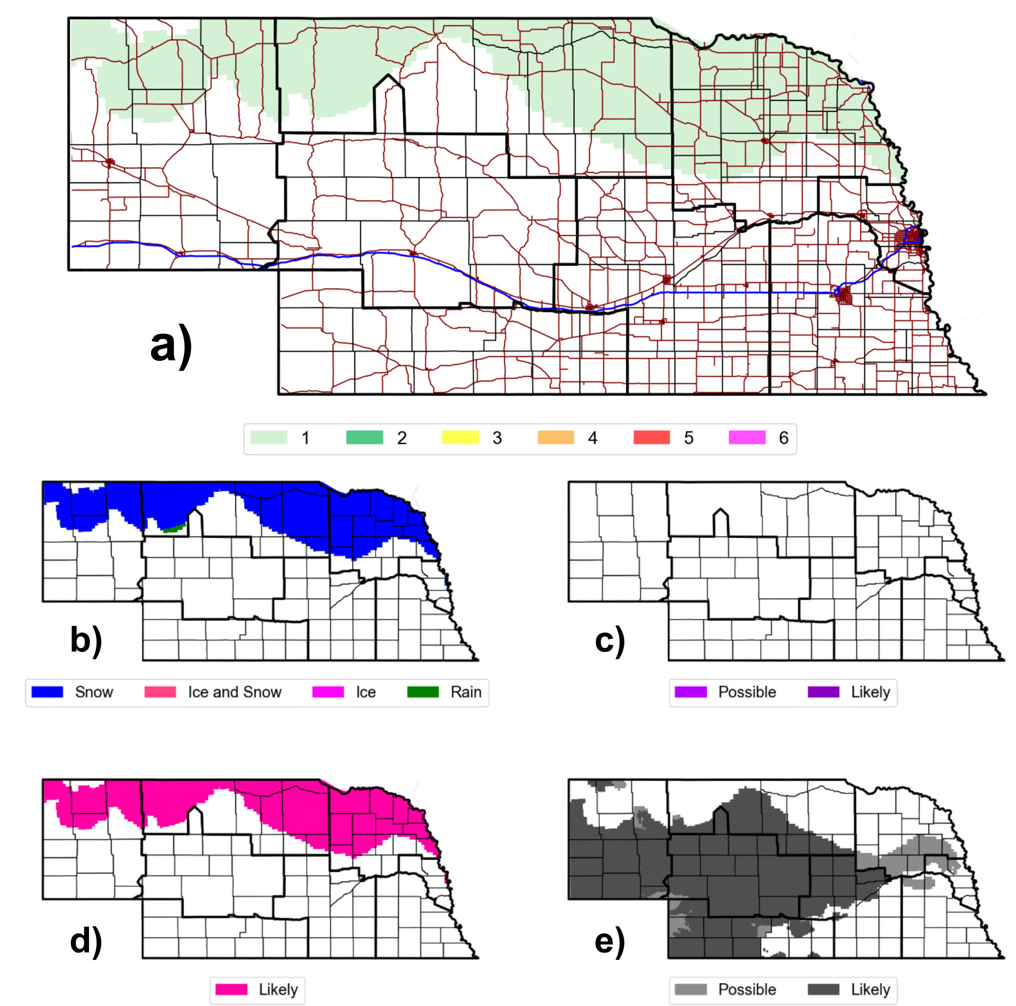

Figure 4: The 66-h NEWINS-P forecast from the 00 UTC 13 Dec 2022 model run: a) NEWINS-S, b) precipitation type, c) ice accumulation, d) blowing snow, and e) drifting snow.

The forecasts can also be represented temporally as a NEWINS-P meteogram (Ngram) for any location. The Chadron Ngram (Fig 5) highlights the in-storm weather hazards associated with the blizzard such as heavy snowfall and blowing snow concerns. Between 00 UTC 13 Dec and 06 UTC 15 Dec, NEWINS-S categories first increase, maximizing at a 5, and then decrease as snow tapers off before hovering around Category 1 as light snow persists. Coincident with NEWINS-S, blowing snow is also forecasted. Afterward, drifting snow is forecasted when the NEWINS-S category is 0. Focusing on a location further south, Kimball's Ngram plot (Fig 6) highlights the post-storm weather hazards with multi-day drifting snow concerns forecasted from 18 UTC 14 Dec to 00 UTC 16 Dec, as winds stay elevated.

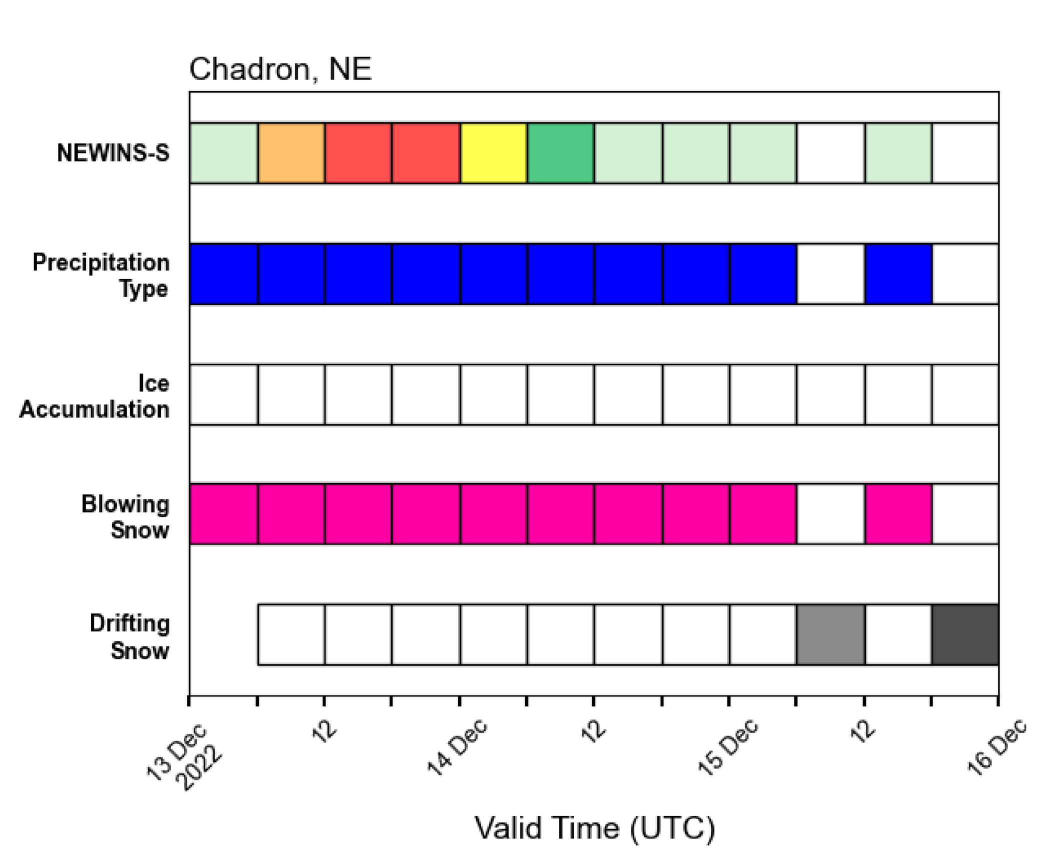

Figure 5: Ngram forecast from the 00 UTC 13 Dec 2022 model run for Chadron, NE. Valid times when data are missing are left blank.

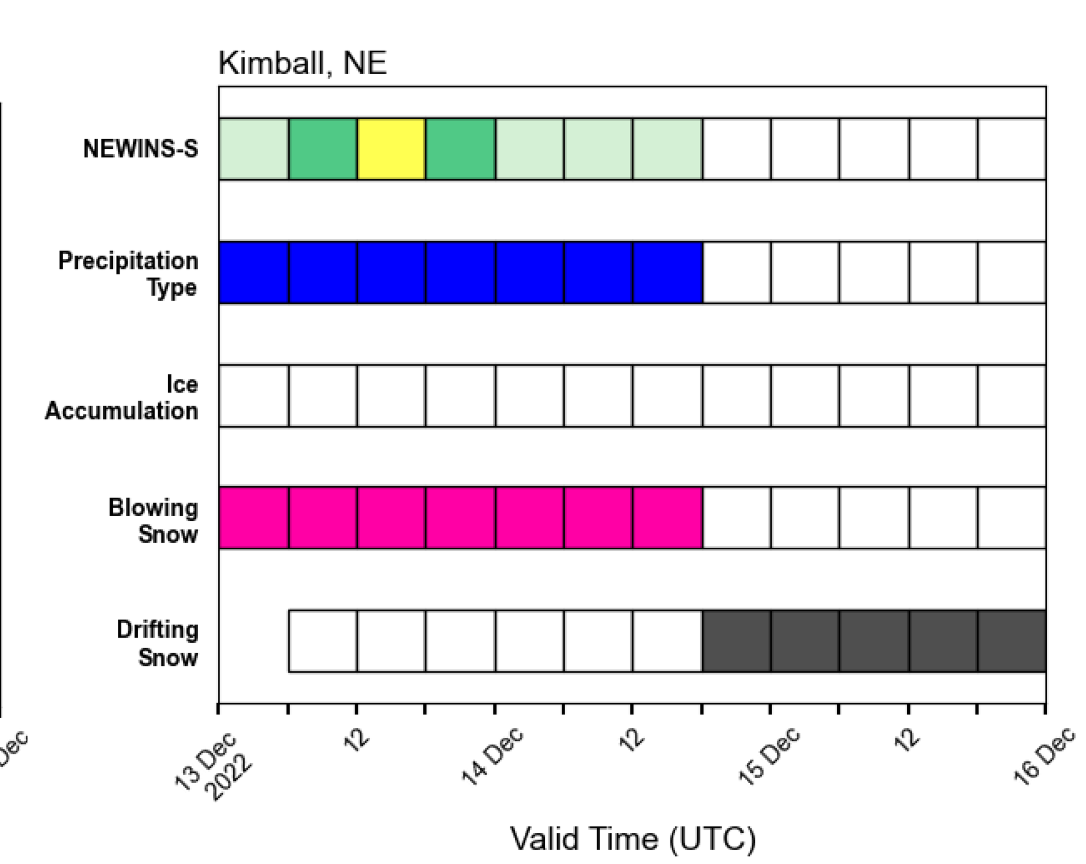

Figure 6: Ngram forecast from the 00 UTC 13 Dec 2022 model run for Kimball, NE. Valid times when data are missing are left blank.

Model Evolution

The forecasted weather conditions change significantly for 18 UTC 13 Dec over the 2.5 days of model runs (Fig 7). The model runs generally show the highest NEWINS-S categories shifting westward with time and the maximum category increasing across western Nebraska. Additionally, the model runs showcase the forecast changes from local adjustments by WFOs. The changes in NEWINS-S for the valid times are visualized through a time series for a given location. The Chadron time series (Fig 8) displays a similar increase in NEWINS-S categories.

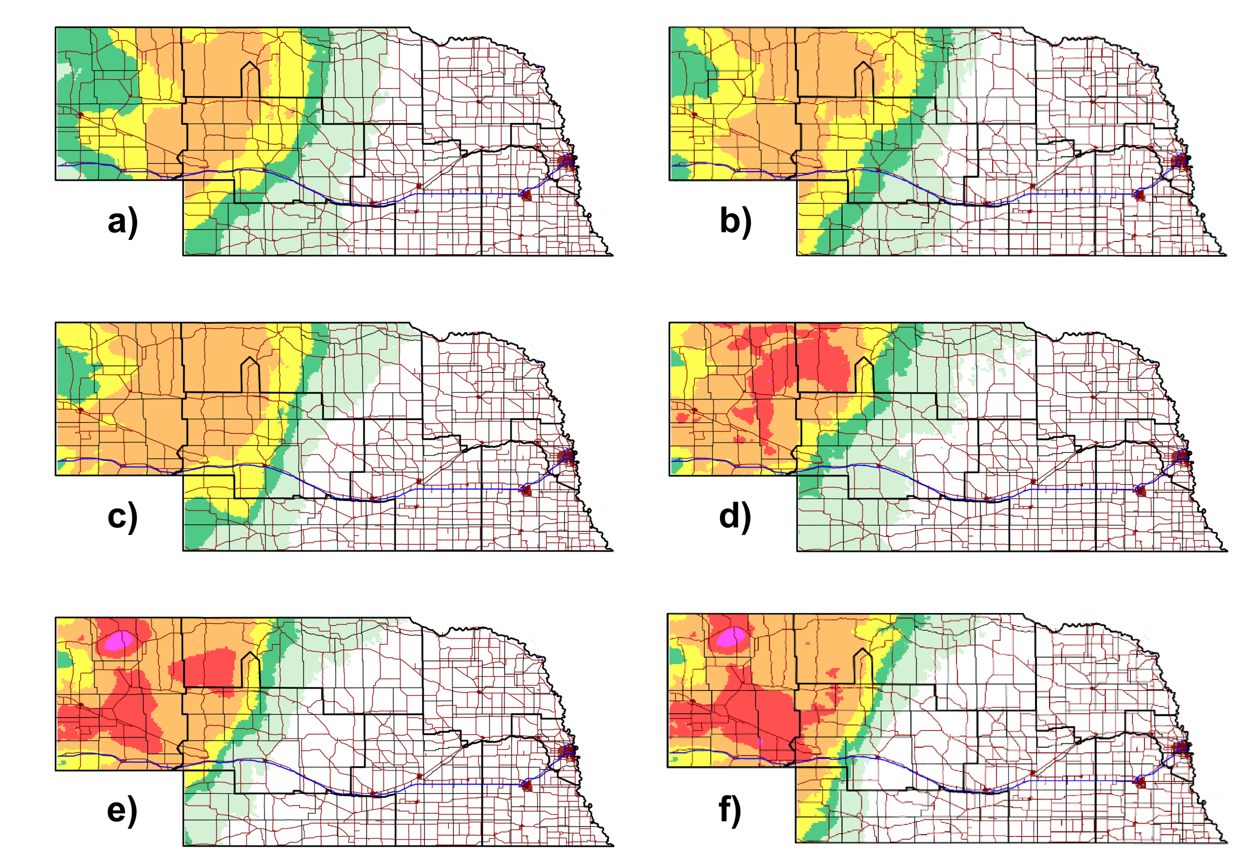

Figure 7: NEWINS-S valid 18 UTC 13 Dec 2022 from six model runs: a) 00 UTC 11 Dec, b) 12 UTC 11 Dec, c) 00 UTC 12 Dec, d) UTC 12 Dec, e) 00 UTC 13 Dec, and f) 12 UTC 13 Dec.

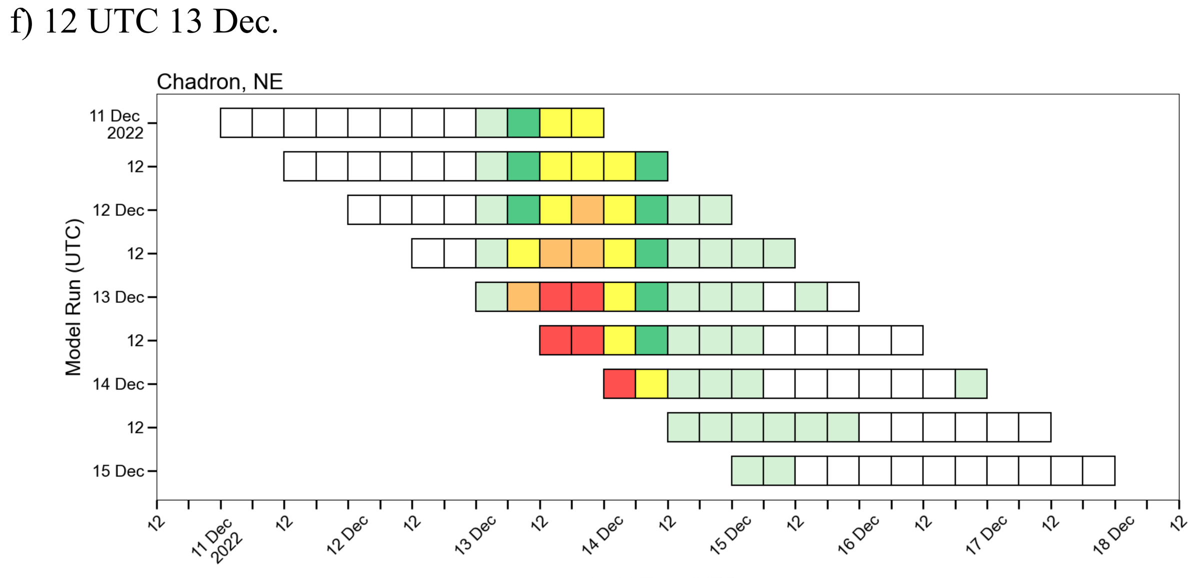

Figure 8: Chadron, NE, NEWINS-S time series for the 00 UTC 11 Dec 2022 to 00 UTC 18 Dec 2022 valid times.

Summary and Conclusions

The NEWINS-P can be used to diagnose upcoming winter storms unlike previous WSIs. The advantages of NEWINS-P are obtaining the spatial and temporal changes for a winter event that can be used for planning purposes for DOTs.

Specifically, the case study analyses have indicated

- NDFD is subject to local adjustments by WFOs
- Spatial changes and time series reveal a severity ramp-up as the event takes place

Acknowledgements

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