SPC Winter Weather

WPC Winter Weather Experiment Seminar
1/25/204

Andrew Lyons NOAA NCEP Storm Prediction Center

Storm Prediction Center
Norman, Oklahoma

A Little about SPC…
More than just severe

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- Well known for Convective Outlooks, Thunderstorm Outlooks, Mesoscale Discussions (MCDs) and Convective Watches in the lower 48.
- 22 full-time forecasters
- Also produce D1-D8 Fire Weather forecasts for the CONUS.
- **Winter Weather MCDs**
    - *7 Mesoscale Assistants.*

Source: NYT

SPC Winter Focal Point duties

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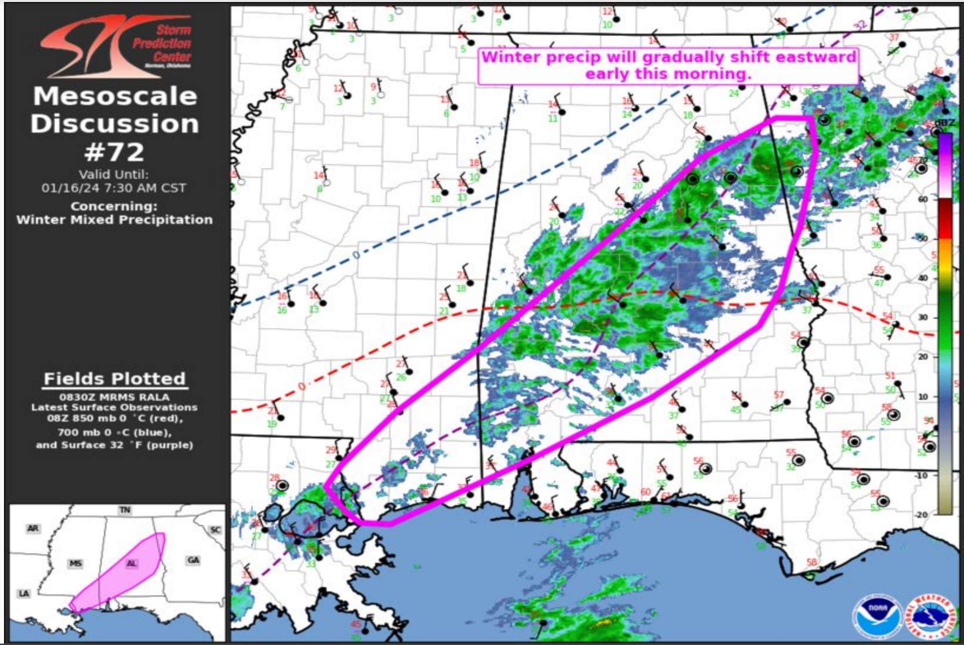
- Help issue Winter Weather products with the staff.
- Devise training and update forecasting practices.
- Stay current on available research and new techniques.
- Devise new products, ideas and research topics.
- Coordinate with WPC WFOs and HQ.



Winter Weather MCDs

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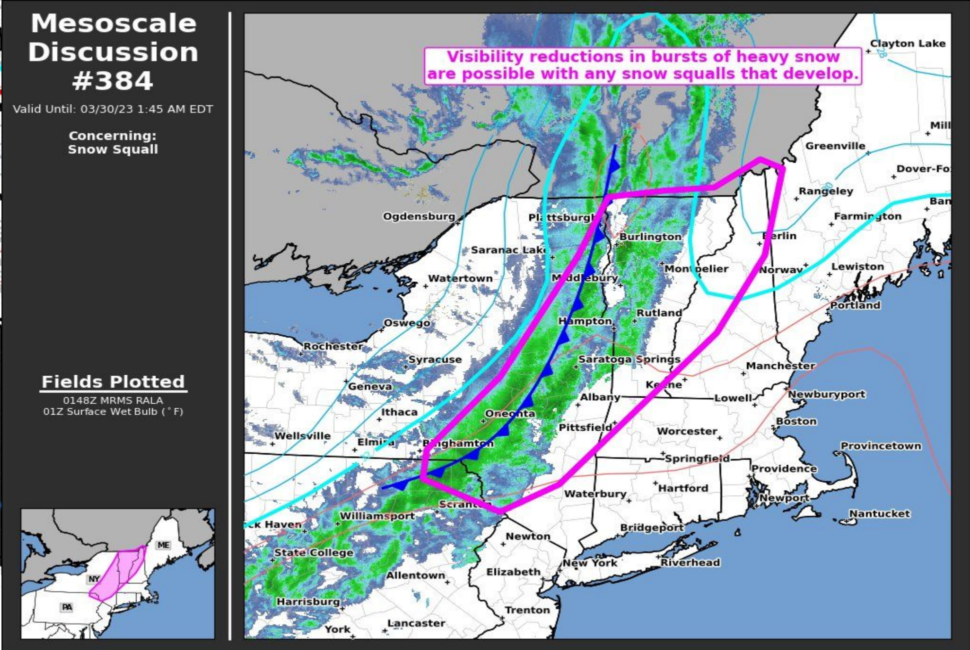
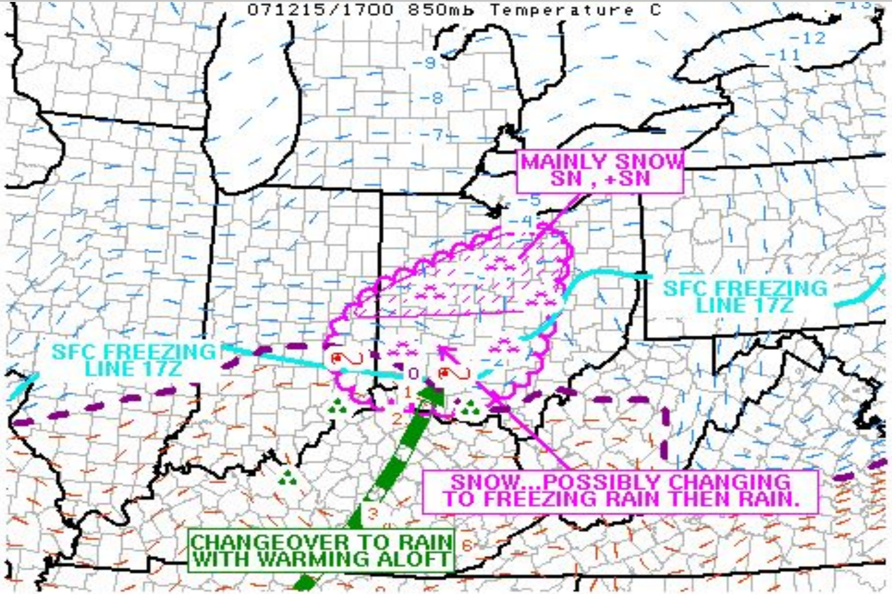


Dept. Commerce NOAA National Weather Service

Winter Weather MCD Background

- All precipitation criteria are rate based.
- Other criteria include wind speeds and visibility. (*Details to follow*)
- Aware of local climatology
  - Extreme or unusual occurrence of winter Weather.
- Aim for lead times of “several hours” with durations of 4-6 hours.



SPC MCD #2224

Heavy Snow MCDs Criteria

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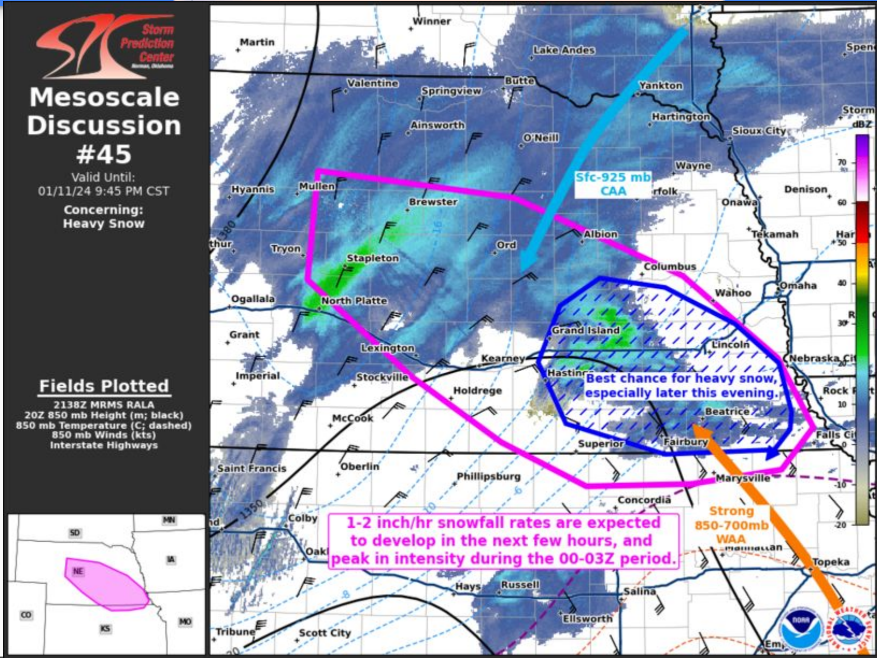
- *Mesoscale precipitation systems expected to produce snowfall rates of at least **one inch per hour** for **two hours** or longer at elevations **below 4000 feet MSL**.*
- *Mesoscale precipitation systems expected to produce snowfall rates of at least **two inches per hour** for **two hours** or longer at elevations between **4000-8000 ft MSL** or in **lake-effect** areas. MDs should focus outside the higher passes of the Rockies, Cascades, and Sierras since heavy snowfall is common across these regions.*
- *Climatologically **rare** events, especially in terms of the time of year, amounts or geographic location.*
- *Changes in mesoscale conditions that will result in a rapid decrease or cessation of a heavy mesoscale snow event.*



Heavy Snow MCDs

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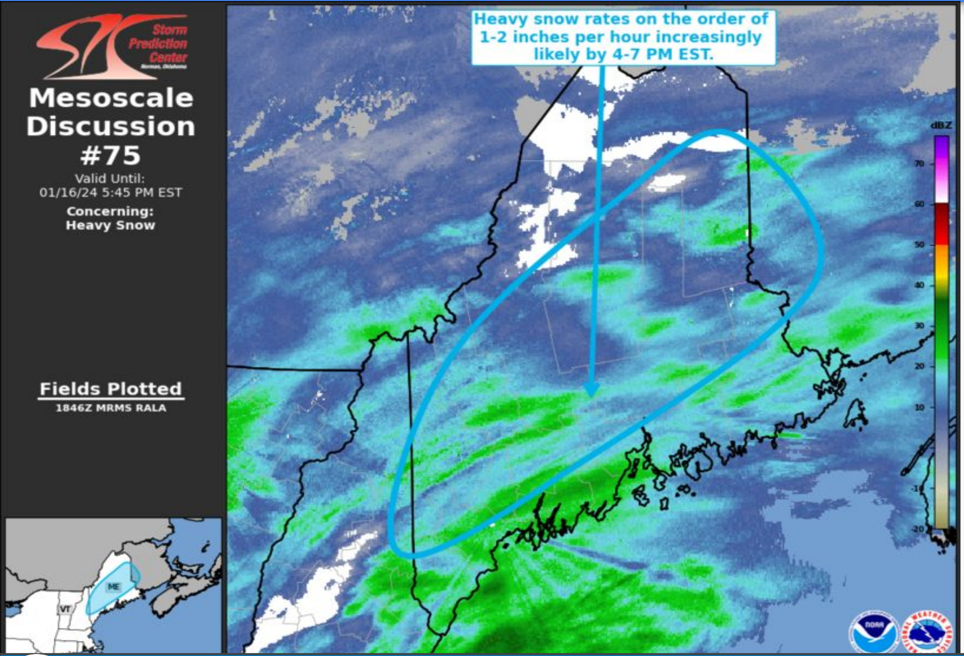

- Look for targets of opportunity using ingredients based forecasting.
- Mesoscale banding and timing
  - Upright and slant-wise instability
  - Localized convergence features
  - Frontogenetical forcing
  - Radar and Surface observations
- Mesoscale tools
  - HREF (Rates, Exceedance Probs, Convec…)
  - OPRH (Omega*PWAT*RH)
  - CAMs
  - NSHARP (P-Type, Rates)

Heavy Snow MCDs (Lake Effect)

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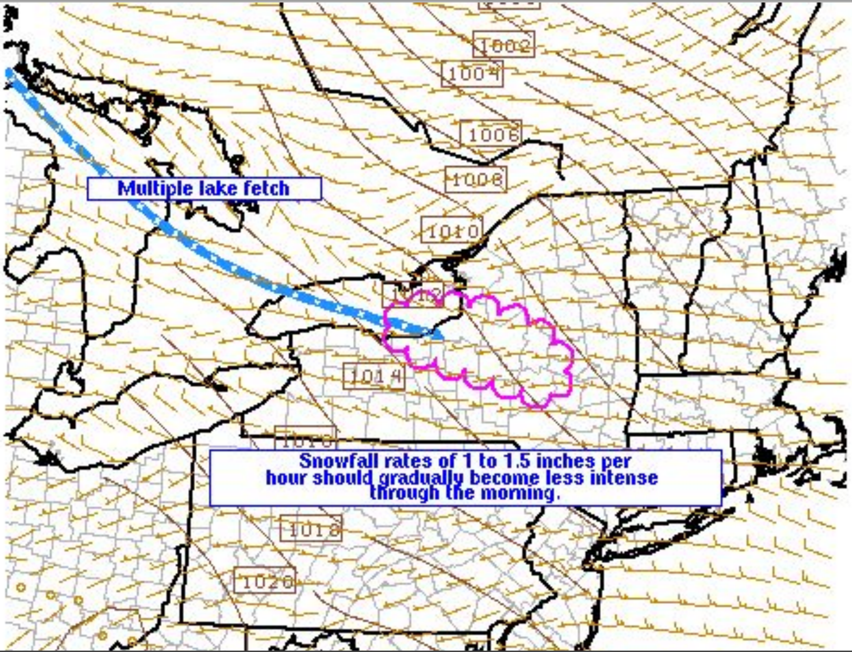

- Mesoscale corridors of very heavy snow that can be disruptive and potentially deadly to end users. (Buffalo, NY 22')
- Target lead times of several hours with MCD durations of 4-6 hours.
- Occasional updates as bands change location/intensity.
- Heavy reliance on mesoscale analysis, CAMs (HREF), and observed/hi-res model soundings.

Freezing Rain & Mixed Precip

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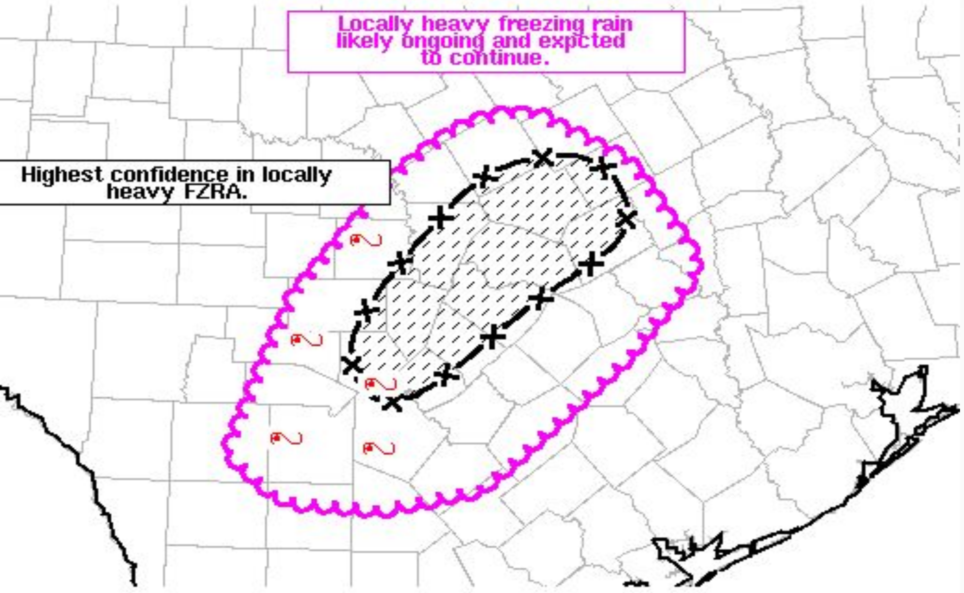
- Observed and model soundings critical for finding corridors of mesoscale icing.
- Extensive annual training from SPC experts on P-type discrimination using Dual-pol radar.
- Mesoscale tools
    - HREF QPF
    - QPF/FRAM ice probabilities

Freezing Rain & Mixed Precip



SPC MCD #0122

- *Freezing rain events producing* ***≥ 0.06 inch*** *of water-equivalent precipitation within a* ***three-hour period****; a freezing rain event.*
- *Phase change occurrence to/from a freezing rain scenario. This could include situations where:*
    - *Snow/sleet changes to freezing rain or vice versa, or*
    - *Rain changes to freezing rain or vice versa.*
- *Climatologically* ***rare*** *events, especially in terms of the time of year, amounts or geographic location.*
- *Rapid decrease or cessation of a freezing rain event.*

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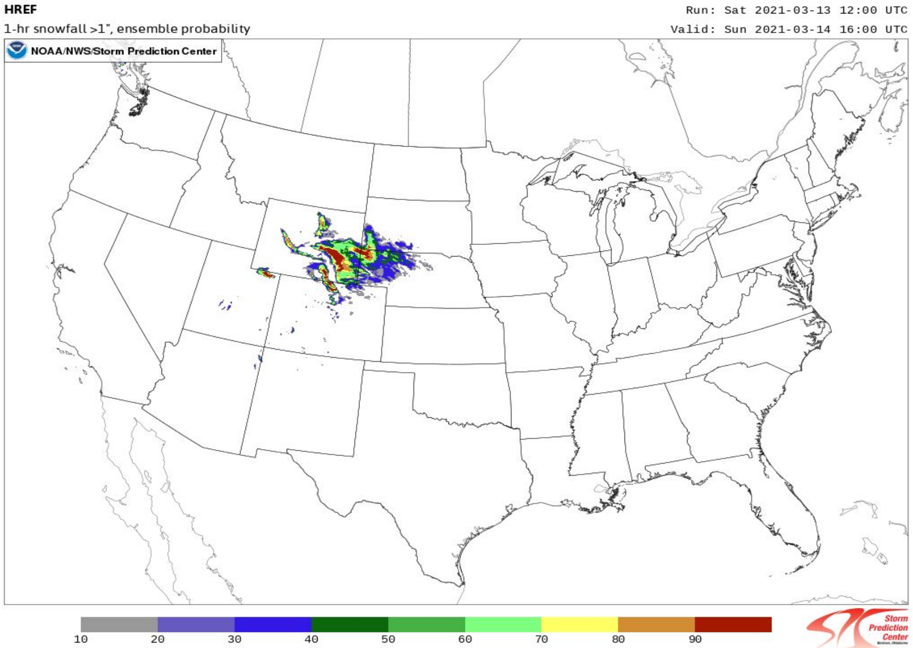
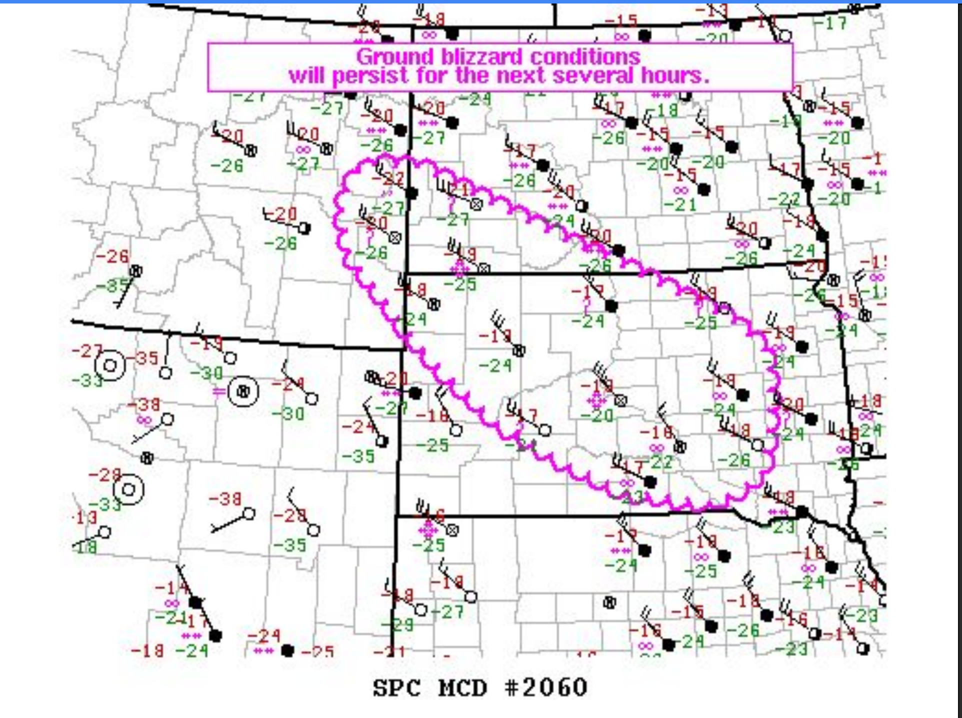
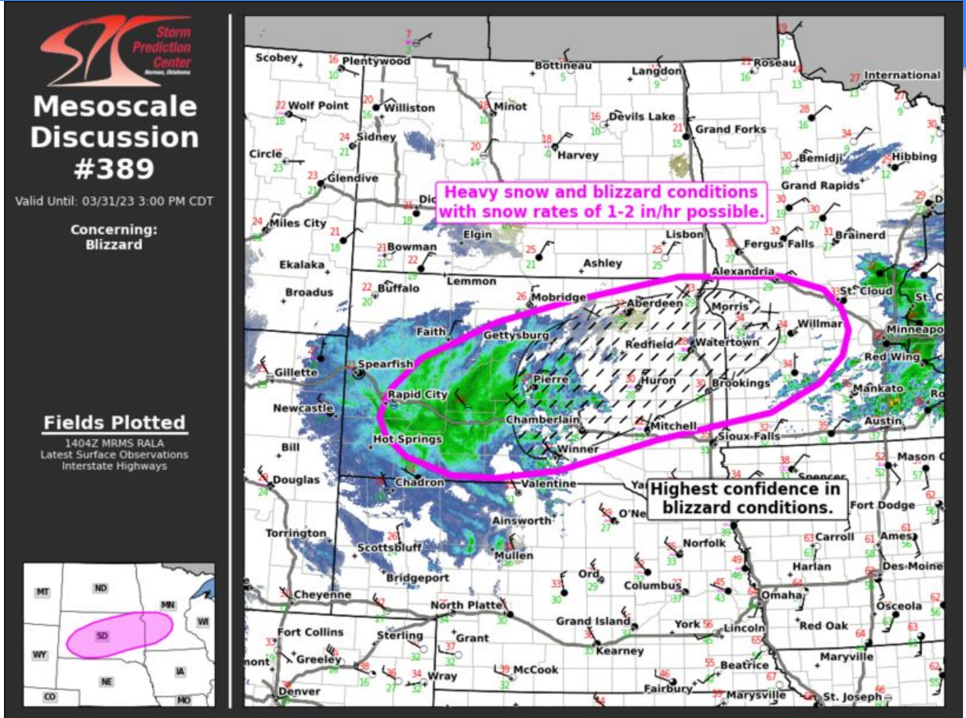
Blizzard MCDs



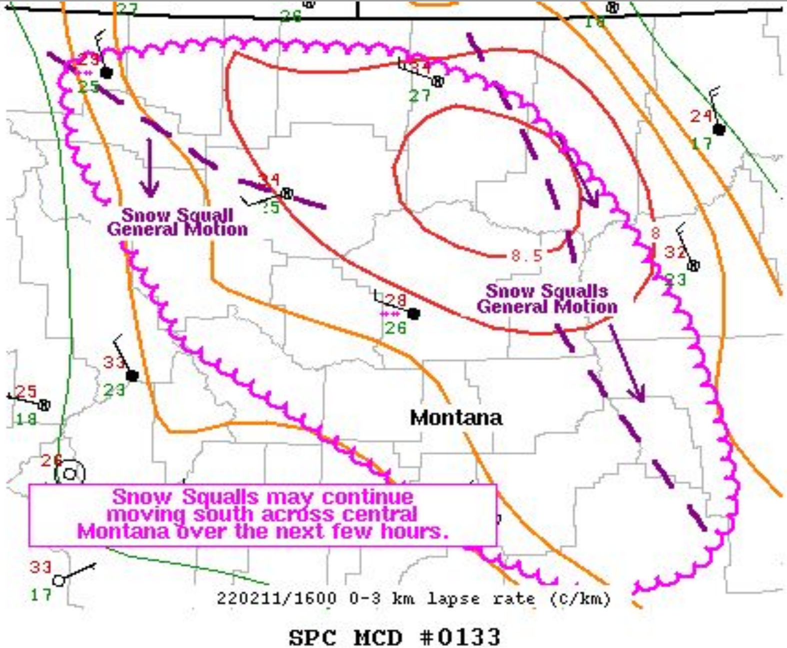
- *Initiation of mesoscale blizzard conditions (**i.e., visibilities ≤ 1/4 mile in snow/blowing snow and winds in excess of 35 mph, expected concurrently to last at least three hours**). This includes non-precipitating ground blizzards*
- Same general ingredients-based philosophy as other types.
- Heavily reliant on observational data and mesoscale trends.
  - ASOS/Mesonet reports
- HREF joint probabilities

Blizzard MCD Examples





Snow Squall MCDs



- *Shallow mesoscale convective systems that, while not necessarily producing one inch per hour rates for at least two hours in any one location, cause localized snowfall rates of at least one inch per hour, along with **visibility reductions ≤ 1/2 mile, an increase in winds, and decrease in temperature**. Special consideration should be given to squalls during higher impact times (e.g., rush hour).*
- *Changes in mesoscale conditions that will result in a rapid decrease or cessation of a snow squall.*

SPC Winter MCD Climatology 2013-2023

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- Heavy Snow: 293 (27/yr)*
- Blizzard: 29 (3/yr)
- Freezing Rain: 107 (10/yr)
- Winter Mixed Precip: 139 (13/yr)
- *Snow Squall [2021-2023]: 33 (11/yr)*
  - * Snow Squall header was officially added in 2021.
  - Snow Squall MCDs were included within Heavy Snow prior.
- Total approx: 64 Winter MCDs/yr

SPC Snow Squall Research

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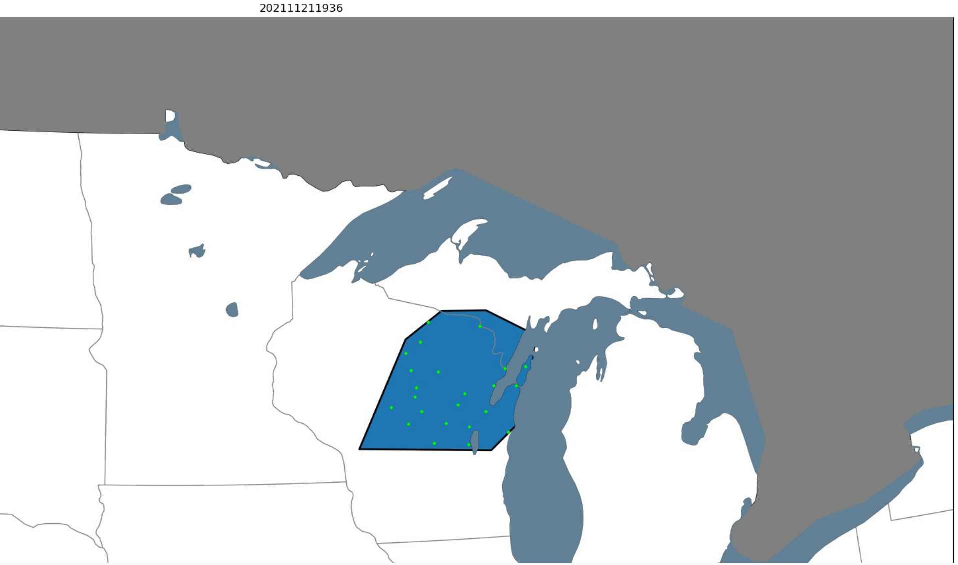
MCD with contained METAR Stations



- Verifying SPC Snow Squall MCDs
- More challenging than it sounds with rate criteria and lack of observations.
- Snow Squall criteria are loose by design for use in multiple situations
- Verification needs to be objective, repeatable, and add value to the forecasting process.

SPC Snow Squall Research

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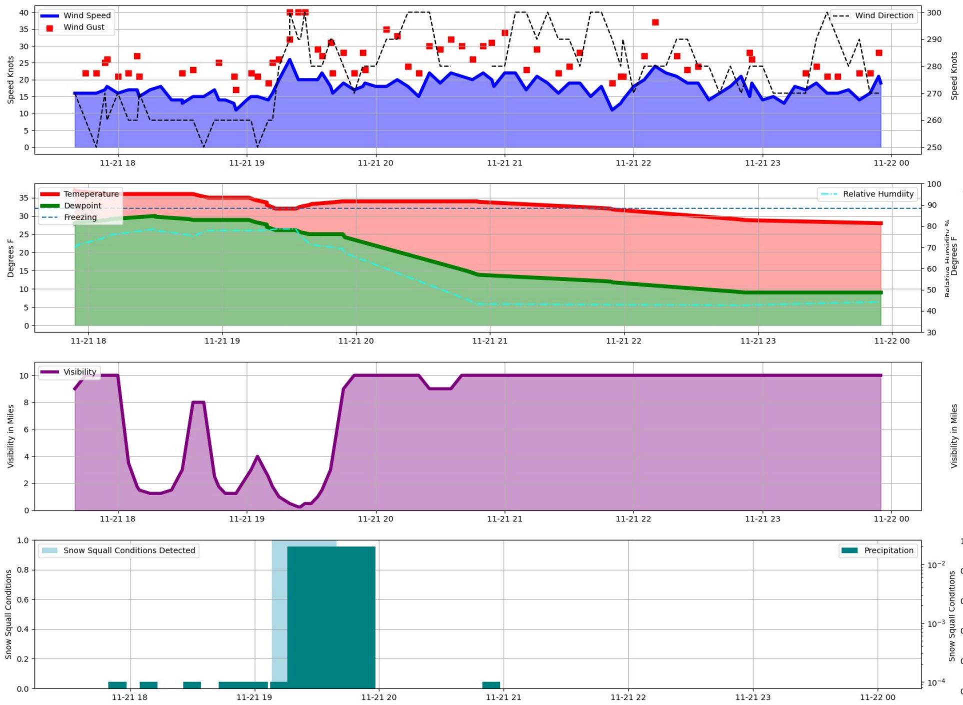
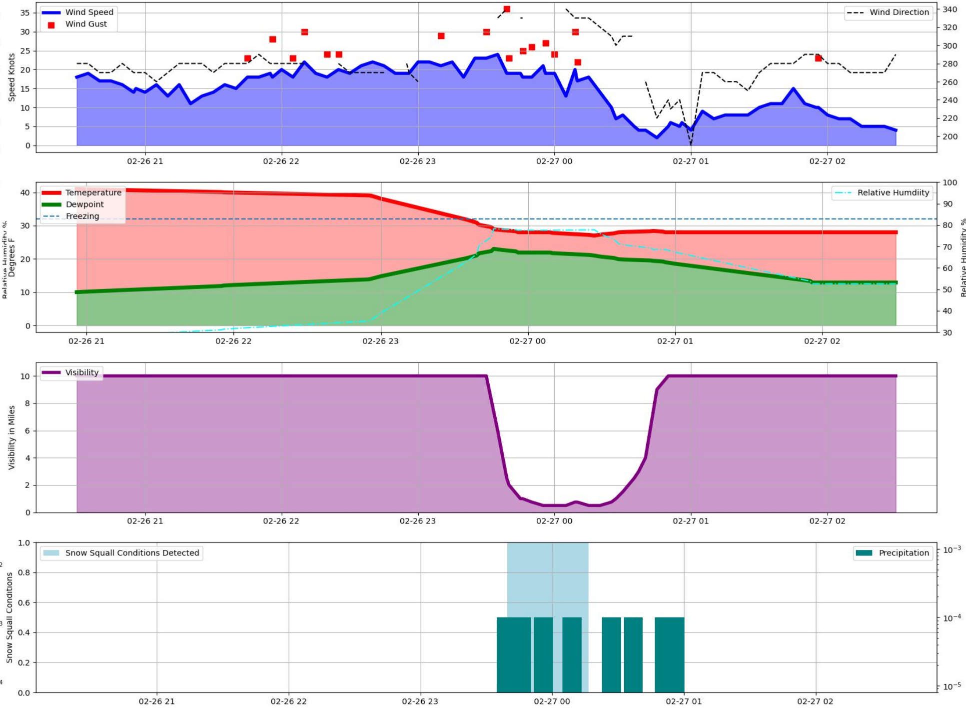
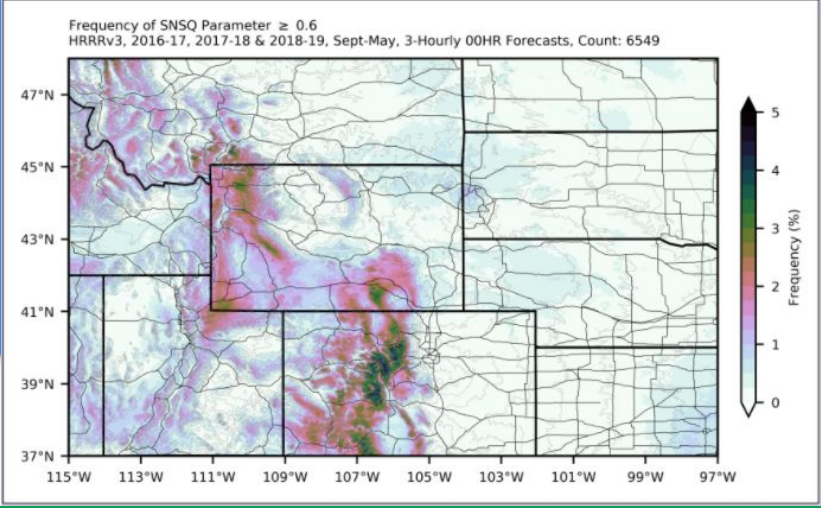
KAUW



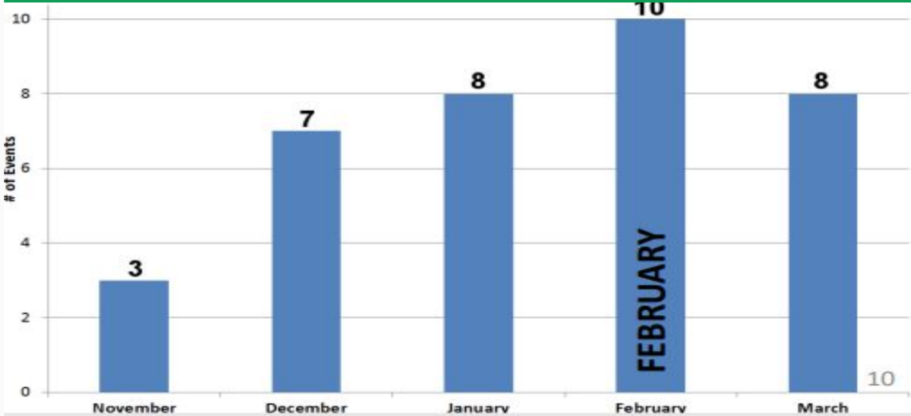


Snow Squall Background (Climatology-ish)

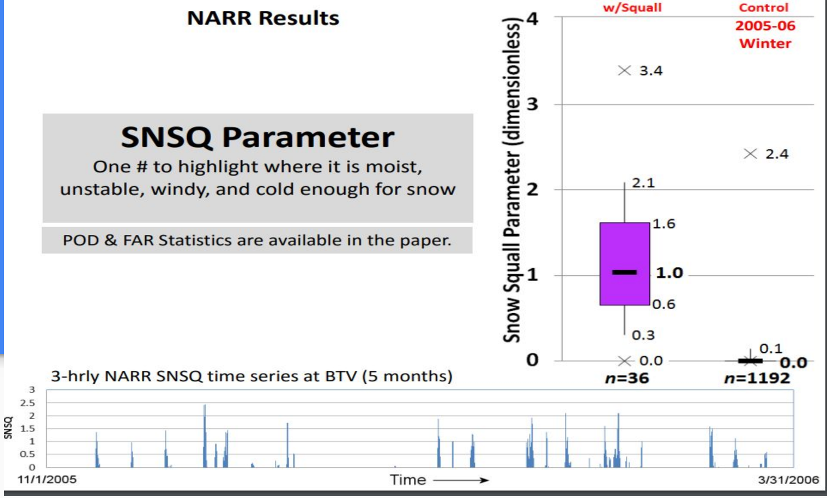
- Possible throughout the cold season across much of the US.
- Occur with increasing frequency in Fall and variably through Winter.
  - Shoulder season migratory jet influences.
- Very little is known about the distribution and occurrence of snow squalls.
  - Often associated with a strong cold front.
  - Eastern US squalls potentially influenced by lake effect processes (Great Lakes and Atlantic)
- Tied to the diurnal cycle of instability and humidity but can occur overnight or early AM.



BTV 10 Year Climatology 3.6 events per year



SNSQp Banacos et al., 2014

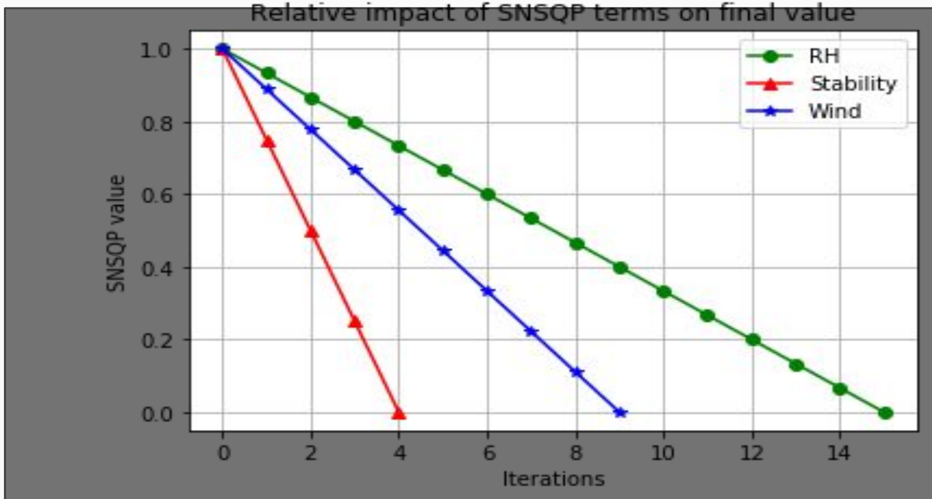


Snow Squall Parameter = ((0-2km mean RH - 60%) / 15%) X

((4 - 2km_delta_theta-e) / 4) X

(0-2km mean wind / 9 m s^{-1})

- Good at discriminating between environments favorable for heavy banded snow squalls ahead of cold fronts in the NE US.
- **Extremely sensitive** to small changes in stability that may be represented poorly even by hi-res NWP and observations.
  - Change of 1 K in 0-2km Θe lapse rate reduces the final value by 25%.
  - Also sensitive to changes in low-level winds.



Snow Squall Research

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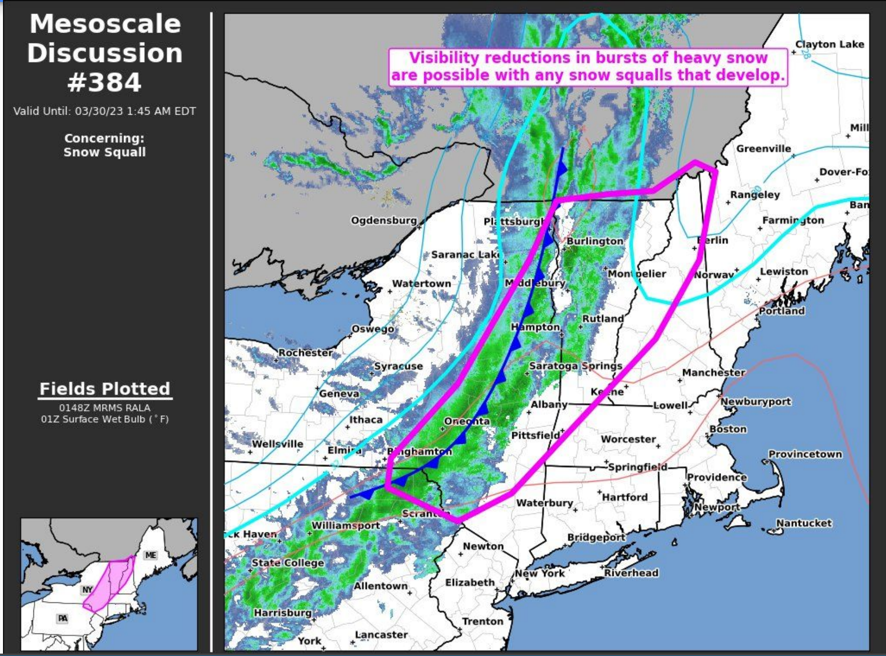
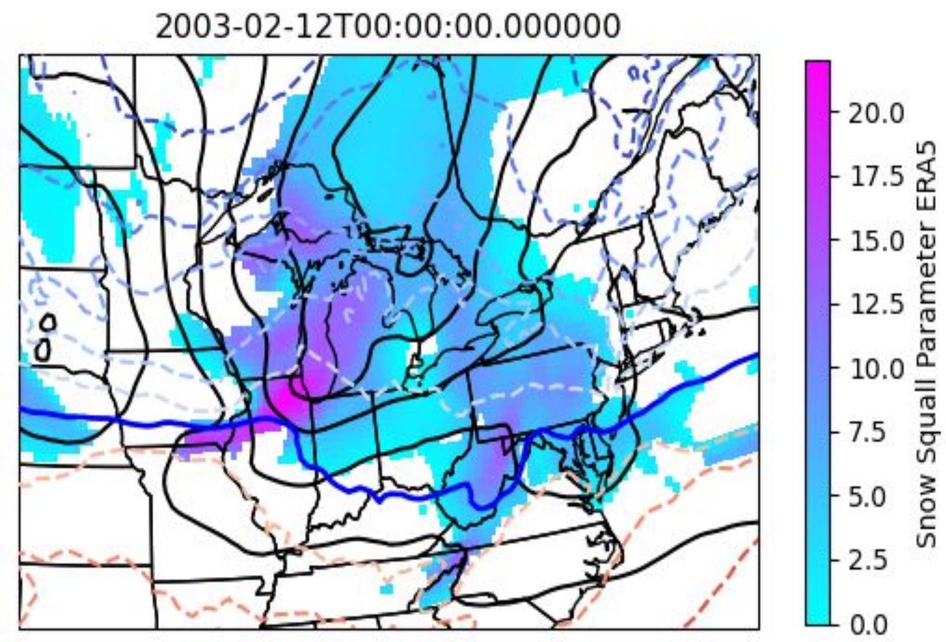
- More questions than answers, like all good research.
- How many Snow Squalls are we missing?
- Are we adding forecast value with the current implementation?
- How well do we verify other winter MCDs?

SPC Snow Squall Research

- Snow squalls are a recent focus to a lot of the NWS.
- No known climatology exists across the entire CONUS.
- Joint SPC/WPC/WFO project focuses on a synthetic climatology using the Snow Squall Parameter and capturing events.
- Goal is to help provide context to forecasters when dealing with potential snow squalls.



Snow Squall Parameter Climatology



- Synthetic Climatology of SNSQp can inform users about typical snow squall environments to aid in forecasting.
- When and where they occur.
- Based on the idea of using composite parameters as environmental proxies.
- Partners:WFO CTP WFO BTV and WPC

Snow Squall Parameter Climatology

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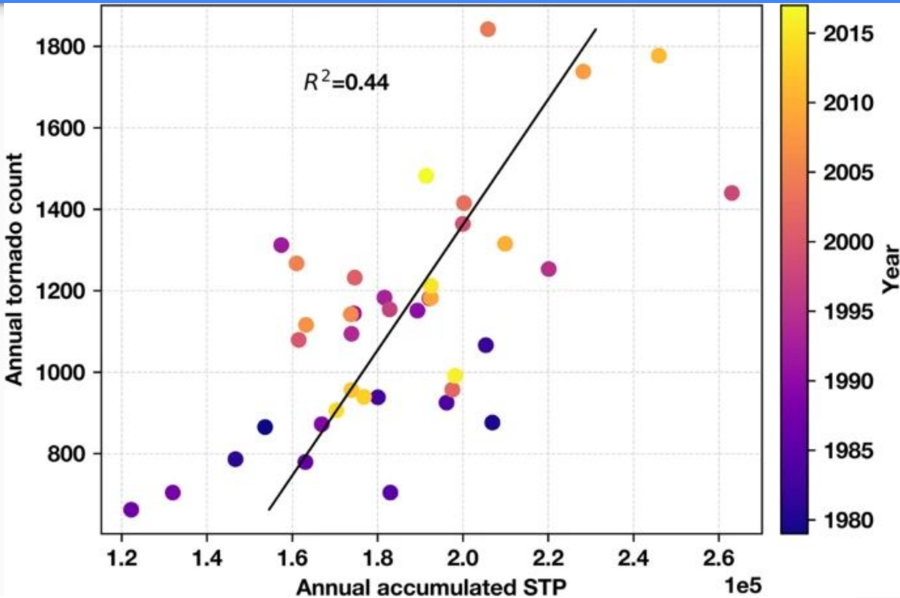
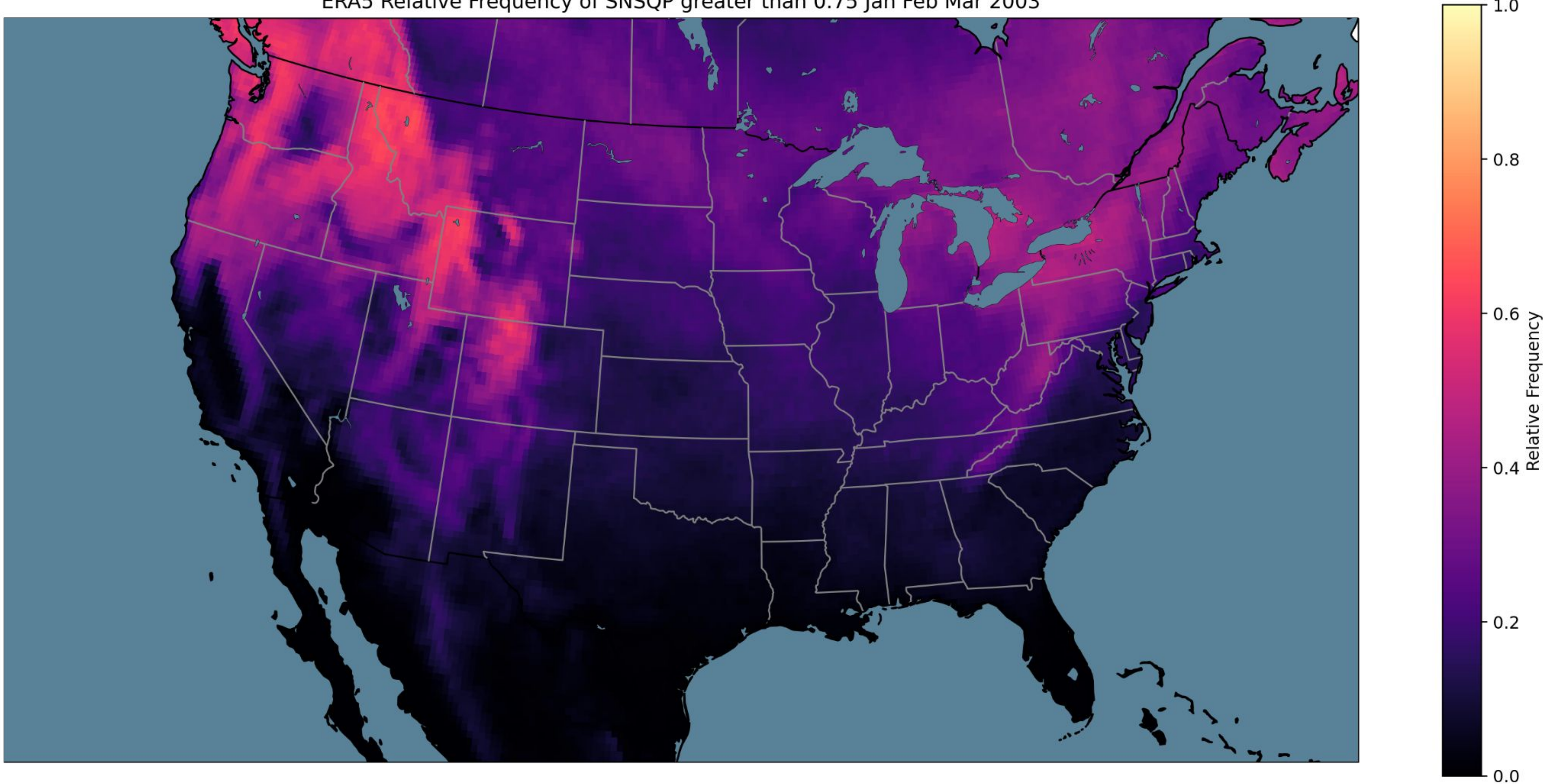
- Snow Squall environments laborious for climo when looking at observations. (i.e., *Radar, Satellite, METARs, etc.)*
- Gridded Reanalysis or objective analysis schemes are faster and of sufficient resolution.
- ERA5
- RAP-based Mesoanalysis



Gensini, V.A., Brooks, H.E. Spatial trends in United States tornado frequency. *npj Clim Atmos Sci* 1, 38 (2018). https://doi.org/10.1038/s41612-018-0048-2

ERA5 Relative Frequency of SNSQP greater than 0.75 Jan Feb Mar 2003



Snow Squall Research Future?

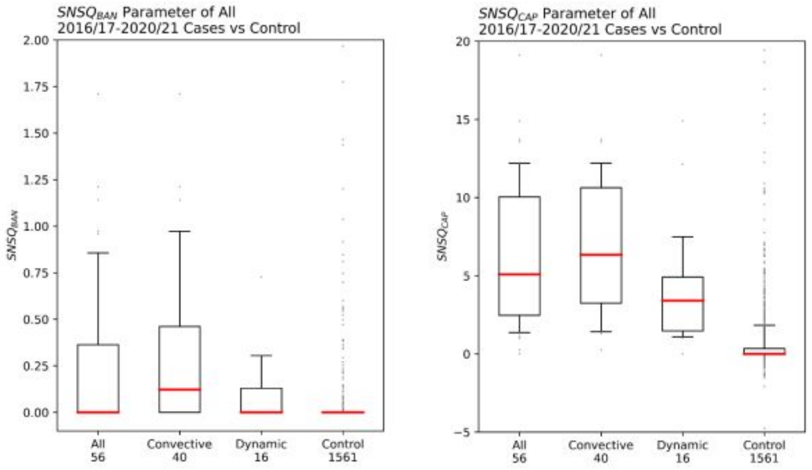


Fig. 10: As Fig. 9, but for distributions of $SNSQ_{BAN}$ (left) and $SNSQ_{CAP}$ (right).

Capella, R., Geerts, B., Lebo, Z. J., Collins, E. M., Cox, R., & Lyons, A. (2020, July 13). High-Resolution Rapid Refresh Model-Based Verification of Snow Squall Prediction in the High Plains and Mountain West. Paper presented at the 19th Conference on Mountain Meteorology Virtual Meeting. NOAA/NWS Collaborative Science, Technology, and Applied Research (CSTAR): NA19NWS4680005, Department of Atmospheric Science, University of Wyoming.

- *Some research indicates the SNSQP <u>may not</u> perform as well in other parts of the country or with different modes.*
- High Plains and intermountain west commonly affected by convective/banded snow showers with <u>snow squall-like conditions.</u>
- Capella et al. (2020), examined different sources of potential instability including Equivalent Potential Vorticity as a forcing mechanism.

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Pseudoadibatic Ice CAPE

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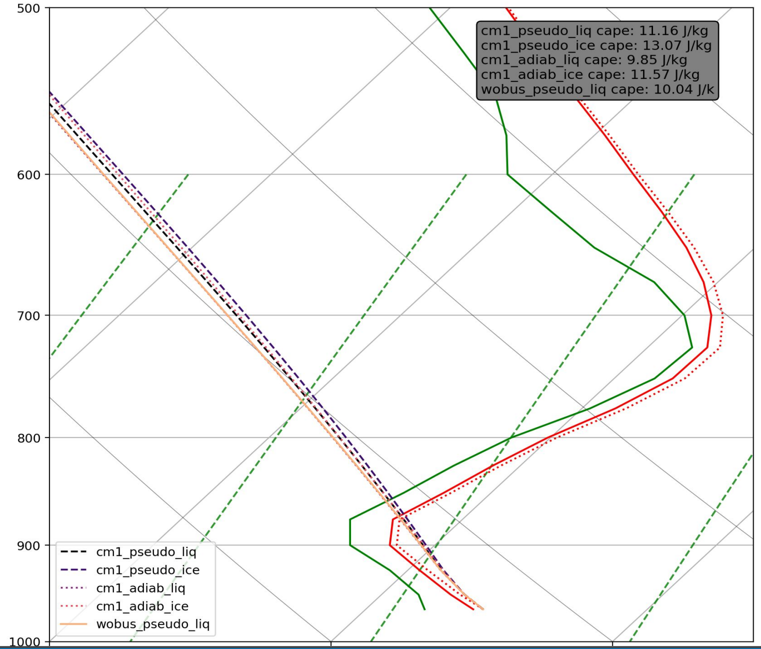
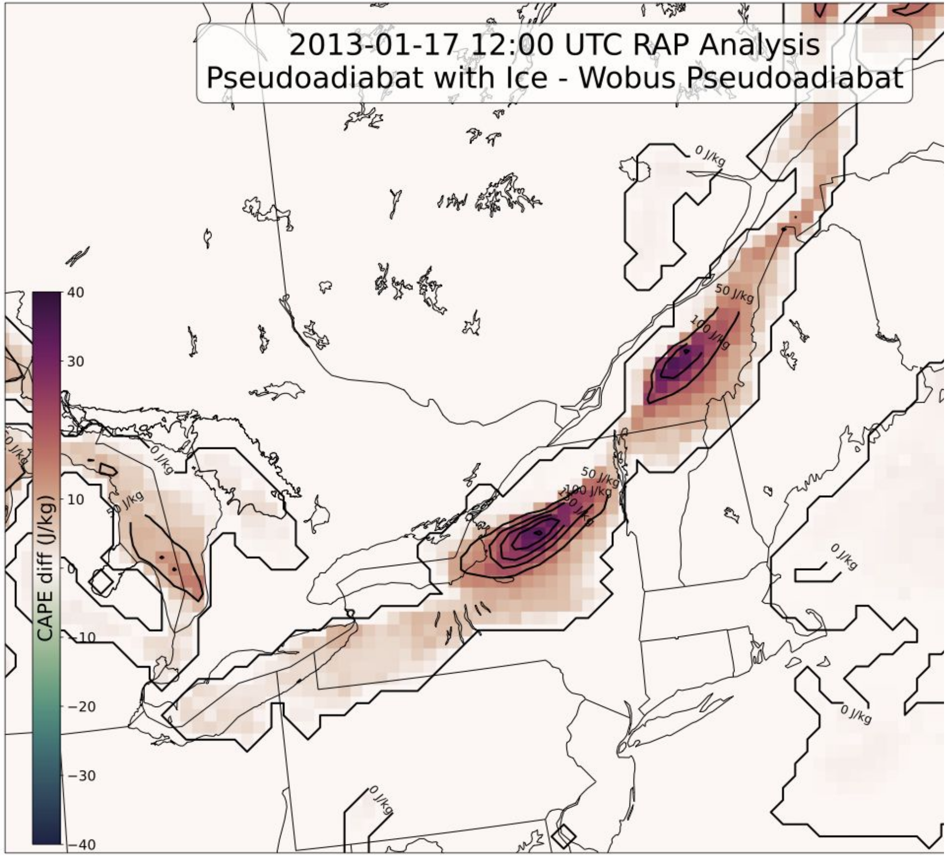
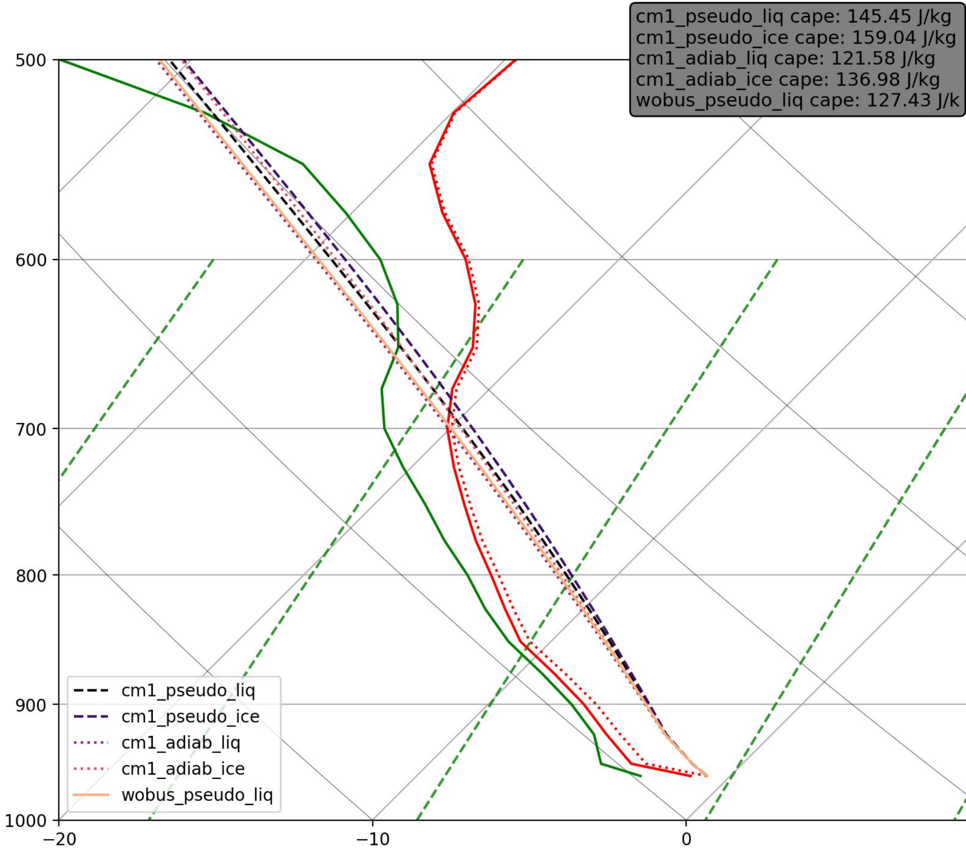
- Can the snow squall parameter or forecasting snow squalls be improved using other techniques?
- Pseudoadiabat CAPE with mixed phases
  - *(Bryan and Fritch 2004)*
  - Most CAPE routines use a simplified latent heat calculation neglecting Ice. Including ice can improve CAPE calcs in freezing environments. (10-20% SBCAPE increase)
- Entrainment CAPE *(Peters et al., 2023)*
  - Accounts for background kinetic energy (SRW) and entrainment when doing buoyancy calculations.



Pseudoadibatic Ice CAPE comparison





Summary

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- SPC's provides forecasts for High-impact winter weather across the CONUS
- Collaborate with local offices, WPC and NWS HQ on high-impact winter events.
- Stay current on new techniques and products with research and yearly training. (Events like this!)

Questions?

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