High-Resolution Rapid Refresh Model-Based Verification of Snow Squall Prediction in the High Plains and Mountain West

19TH CONFERENCE ON MOUNTAIN METEOROLOGY VIRTUAL MEETING

QUESTIONS: 13 JULY 2020, 3:20 PM MDT

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NOAA/NWS COLLABORATIVE SCIENCE TECHNOLOGY, AND APPLIED RESEARCH (CSTAR): NA19NWS4680005

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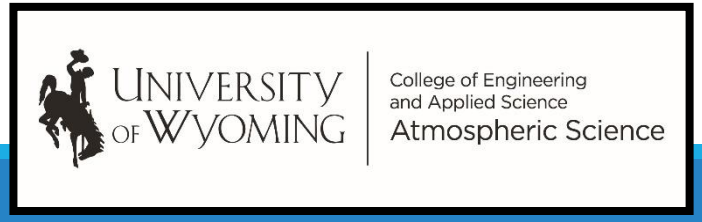


Outline

- Background
- Objective
- Method
- Results

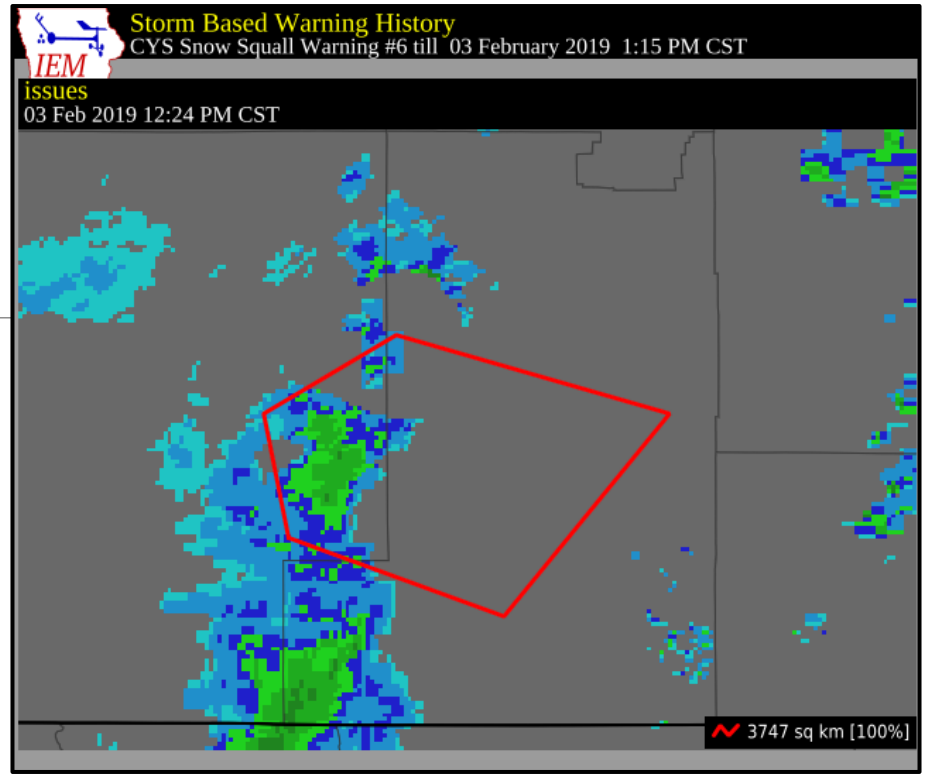
Background

What is a snow squall?

- Snow squalls are mesoscale convective features that produce gusty winds and heavy snow
- Brief bursts of heavy snow accompanied by gusty surface winds are characterized by a rapid onset and near-zero visibility
- Falling temperatures can produce a flash freeze
- Can have deadly road consequences

20200224 - https://twitter.com/AspenSnowmass/status/1232064276770123776

NWS Warnings



- National Weather Service (NWS) forecasters have recently been encouraged to issue short-fused warnings for Snow Squalls
- Snow Squall Warning Issuance Criteria:
  - Condition 1: Visibility 1/4SM or less in snow with sub-freezing ambient road temperatures.
  - Condition 2: Plunging temperatures behind an arctic front sufficient to produce flash freezes, along with a significant reduction in visibility from falling and/or blowing snow
- 2019-2020 Snow Squall Warnings:
  - 230 warnings from 29 WFOs

Forecasting Snow Squalls

- Peter Banacos, Andrew Loconto, & Gregory DeVoir developed a parameter to forecast snow squalls – **SQSN**

- Key drivers are low-level: Moisture, Instability, & Momentum

$$\mathrm{SNSQ} = \left(\frac{\overline{RH}_{sfc-2km} - 60\%}{15\%}\right) * \left(\frac{4K - (\theta_e|_{2km} - \theta_e|_{sfc})}{4K}\right) * \left(\frac{\left\|\vec{V}\right\|_{sfc-2km}}{9ms^{-1}}\right)$$

Parameter Calibrated to 1.0

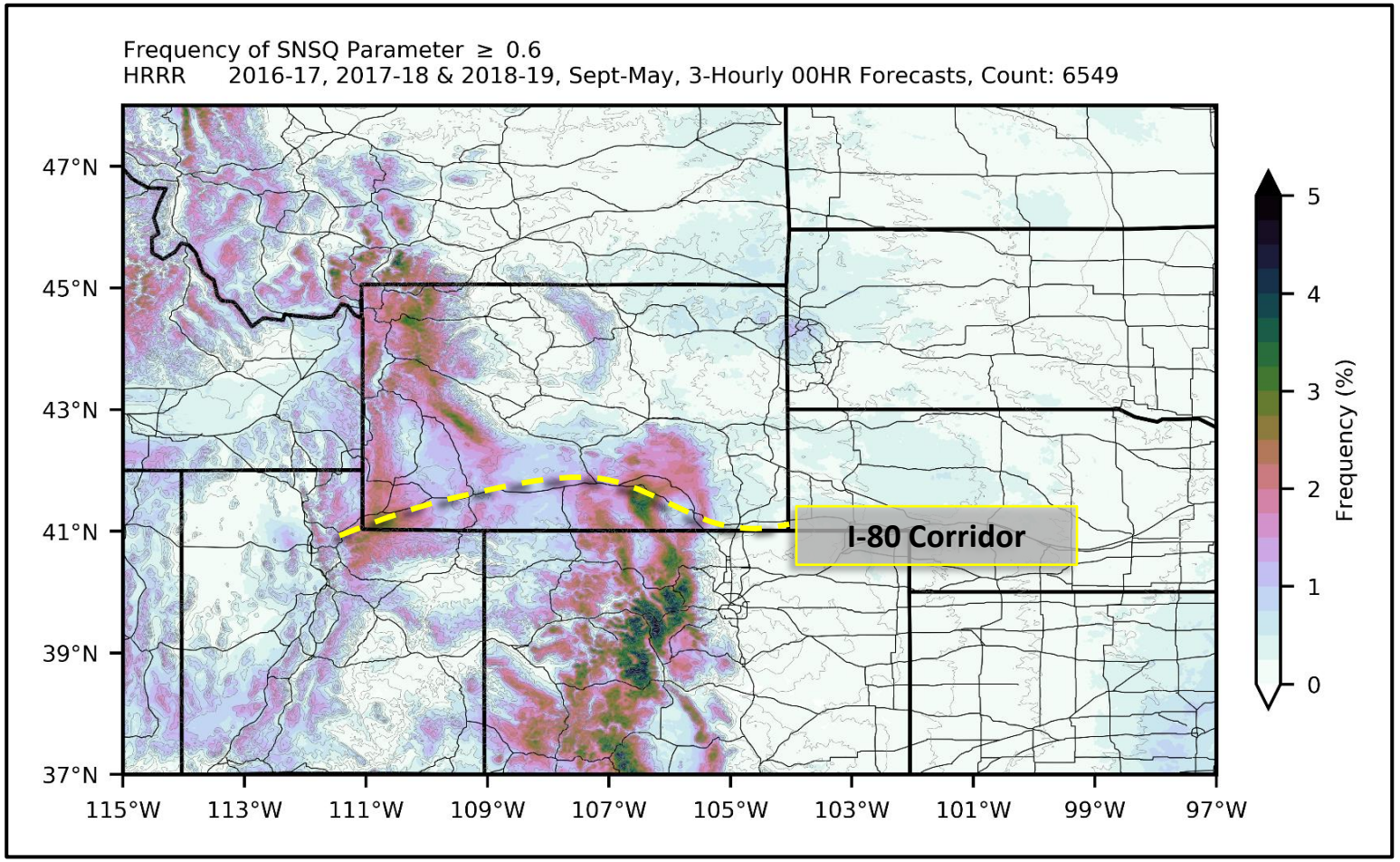
0-2 km Mean Relative Humidity (Set to 0 if negative)

0-2 km Instability (Set to 0 if negative)

0-2 km Mean Wind Speed

Spatial Distribution of Elevated SNSQ

- Along and upstream of mountain ranges are susceptible to increased frequencies of SQSN
- Snow squalls are common along the heavily trafficked I-80 in Wyoming



Objective

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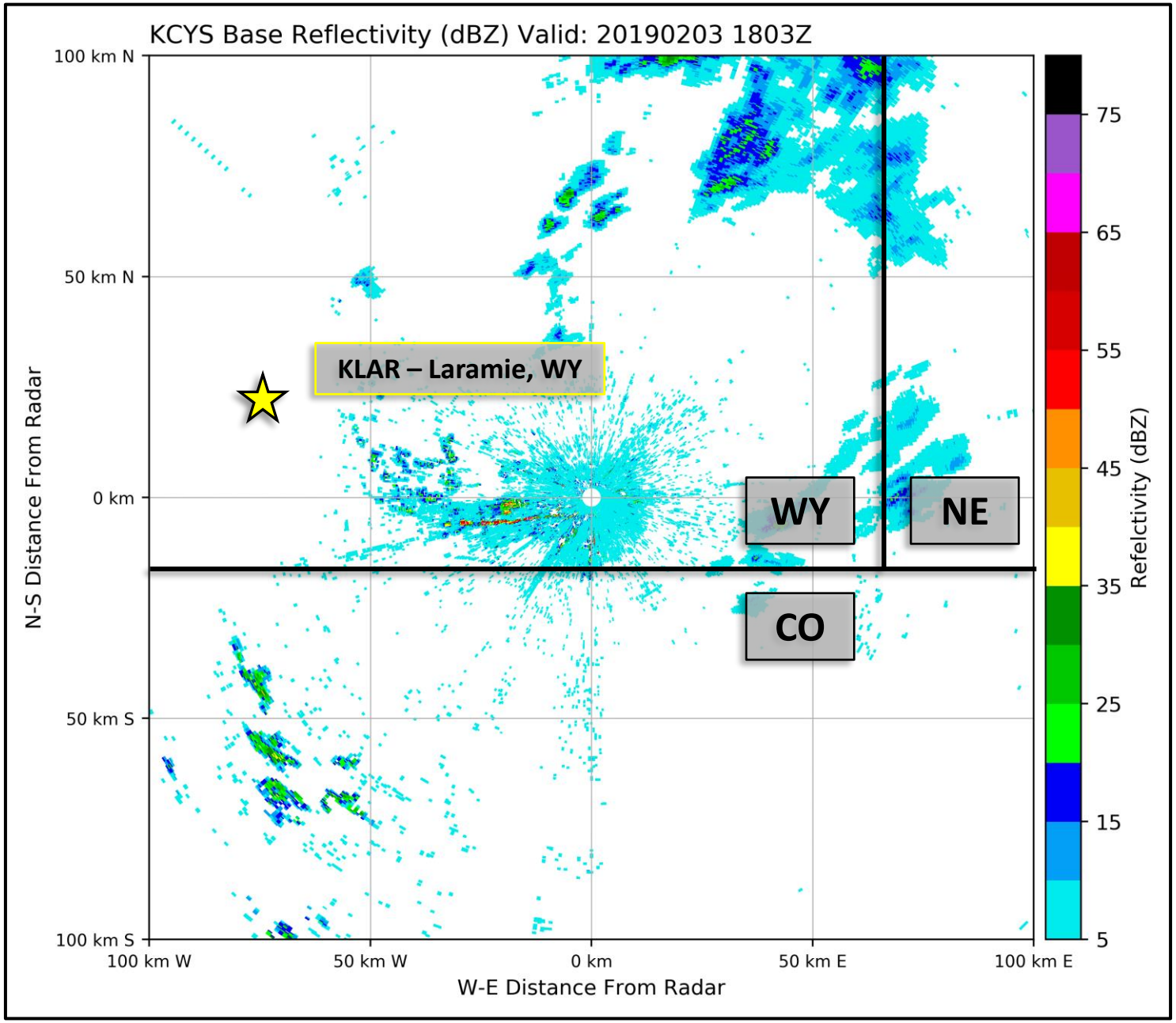
- Examine the accuracy of HRRR forecasts for the occurrence and intensity of snow squalls
  - Examine skill of SNSQ for the High Plains & Mountain West
- Develop a HRRR-based snow squall product and to use HRRR output for real-time prediction of snow squalls

Method

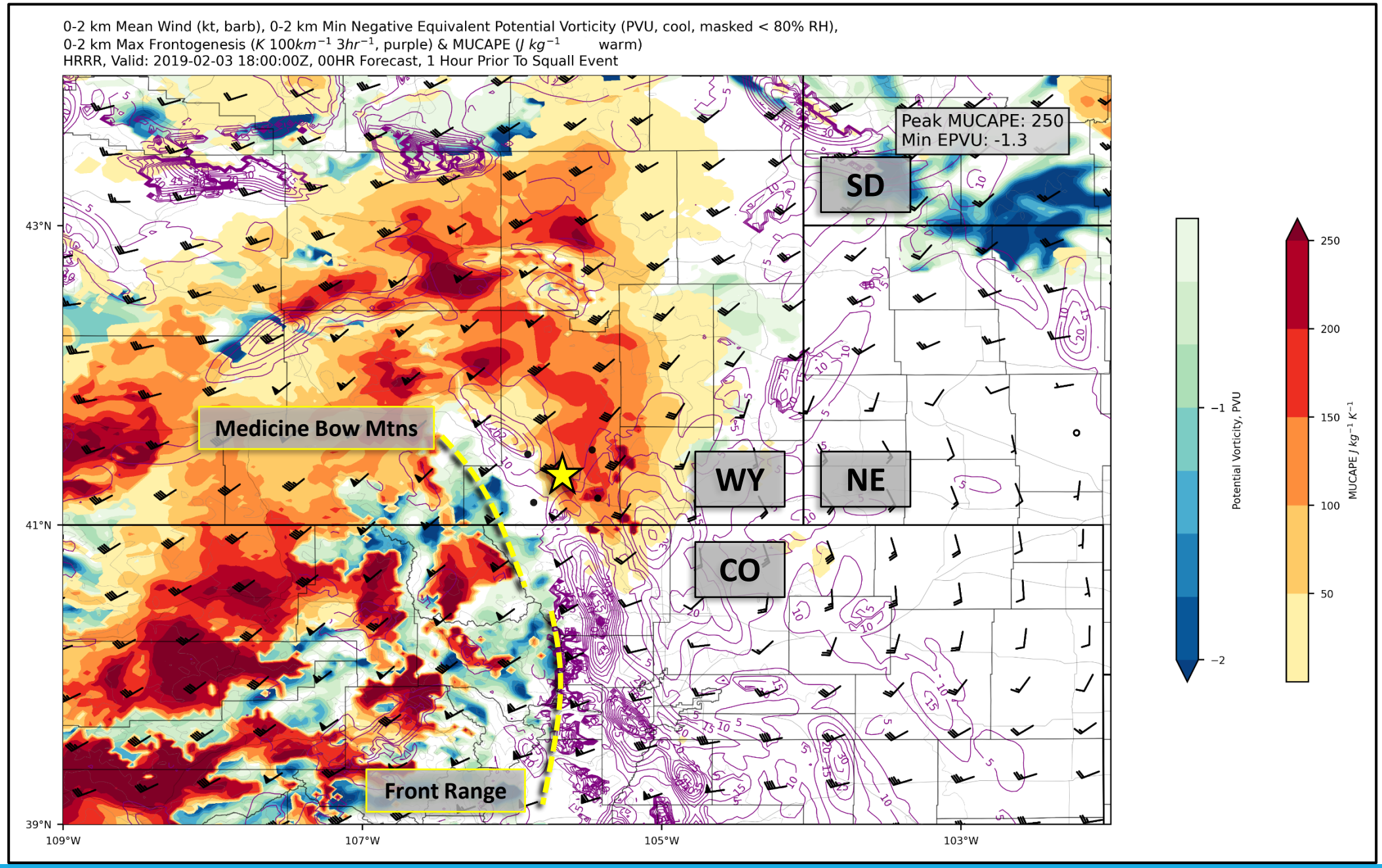
Build a database of snow squalls

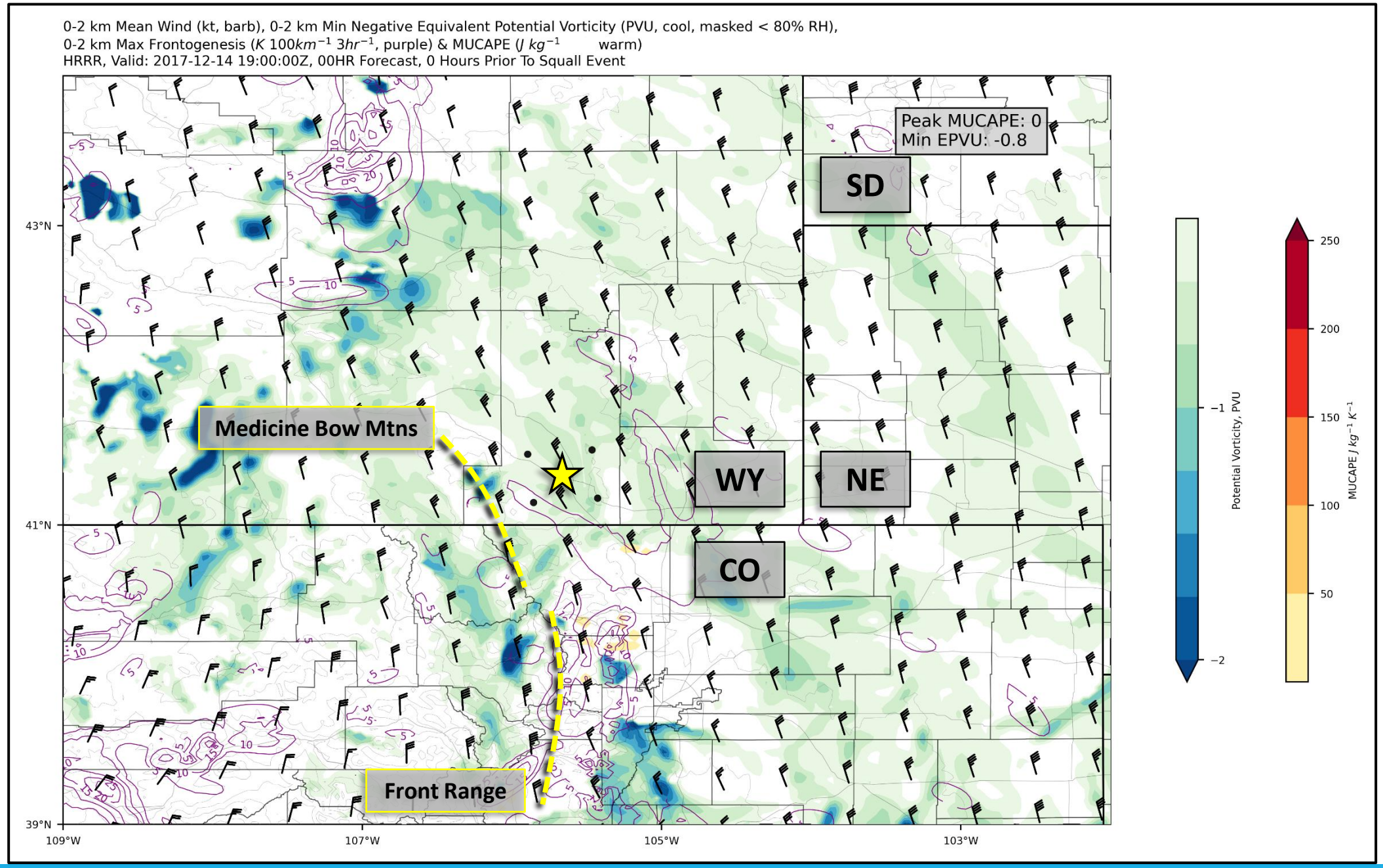
- Following Banacos, P. C., A. N. Loconto, and G. A. DeVoir, 2014
  - Search observation data at select ASOS stations from 2016/17-2019/20 cool seasons (Sept-May)
  - Routine METAR, special and five-minute observations
  - Apply threshold present weather, visibility, wind speed, and duration requirements
- Identify convectiveness of possible cases
  - Identify convectiveness via radar
  - Identify convectiveness via modeled instability

- **CO**
  - DEN
  - FNL
  - GJT
- **ID**
  - PIH
- **SD**
  - RAP
- **UT**
  - OGD
  - SLC
- **WY**
  - LAR
  - LND
  - RIW



Steiner, M., R.A. Houze, and S.E. Yuter, 1995: Climatological Characterization of Three-Dimensional Storm Structure from Operational Radar and Rain Gauge Data. *J. Appl. Meteor.*, **34**, 1978–2007, 1995


0-2 km Mean Wind (kt, barb), 0-2 km Min Negative Equivalent Potential Vorticity (PVU, cool, masked < 80% RH),
0-2 km Max Frontogenesis (K 100km⁻¹ 3hr⁻¹, purple) & MUCAPE (J kg⁻¹ warm)
HRRR, Valid: 2019-02-03 18:00:00Z, 00HR Forecast, 1 Hour Prior To Squall Event
Peak MUCAPE: 250
Min EPVU: -1.3
SD
WY
NE
CO
Medicine Bow Mtns
Front Range
43°N
41°N
39°N
109°W
107°W
105°W
103°W
Potential Vorticity, PVU
−1
−2
MUCAPE J kg⁻¹ K⁻¹
250
200
150
100
50


0-2 km Mean Wind (kt, barb), 0-2 km Min Negative Equivalent Potential Vorticity (PVU, cool, masked < 80% RH),
0-2 km Max Frontogenesis (K 100km⁻¹ 3hr⁻¹, purple) & MUCAPE (J kg⁻¹ warm)
HRRR, Valid: 2017-12-14 19:00:00Z, 00HR Forecast, 0 Hours Prior To Squall Event
Peak MUCAPE: 0
Min EPVU: -0.8
SD
WY
NE
CO
Medicine Bow Mtns
Front Range
43°N
41°N
39°N
109°W
107°W
105°W
103°W
Potential Vorticity, PVU
−1
−2
MUCAPE J kg⁻¹ K⁻¹
250
200
150
100
50

Analyze Skill of Current Forecast Methods

- Compare known snow squall cases against SNSQ derived from archived 00-HR High-Resolution Rapid Refresh Model analyses

Results

Results

- 594* Total cases from 2016/17 – 2019/20 cool seasons identified via observations
  - 364 Identified as driven by convective instability
  - 230 Identified as driven by dynamic instability
  - 114 Identified as non-convective
  - *Cases are under active review

- **CO**
  - DEN
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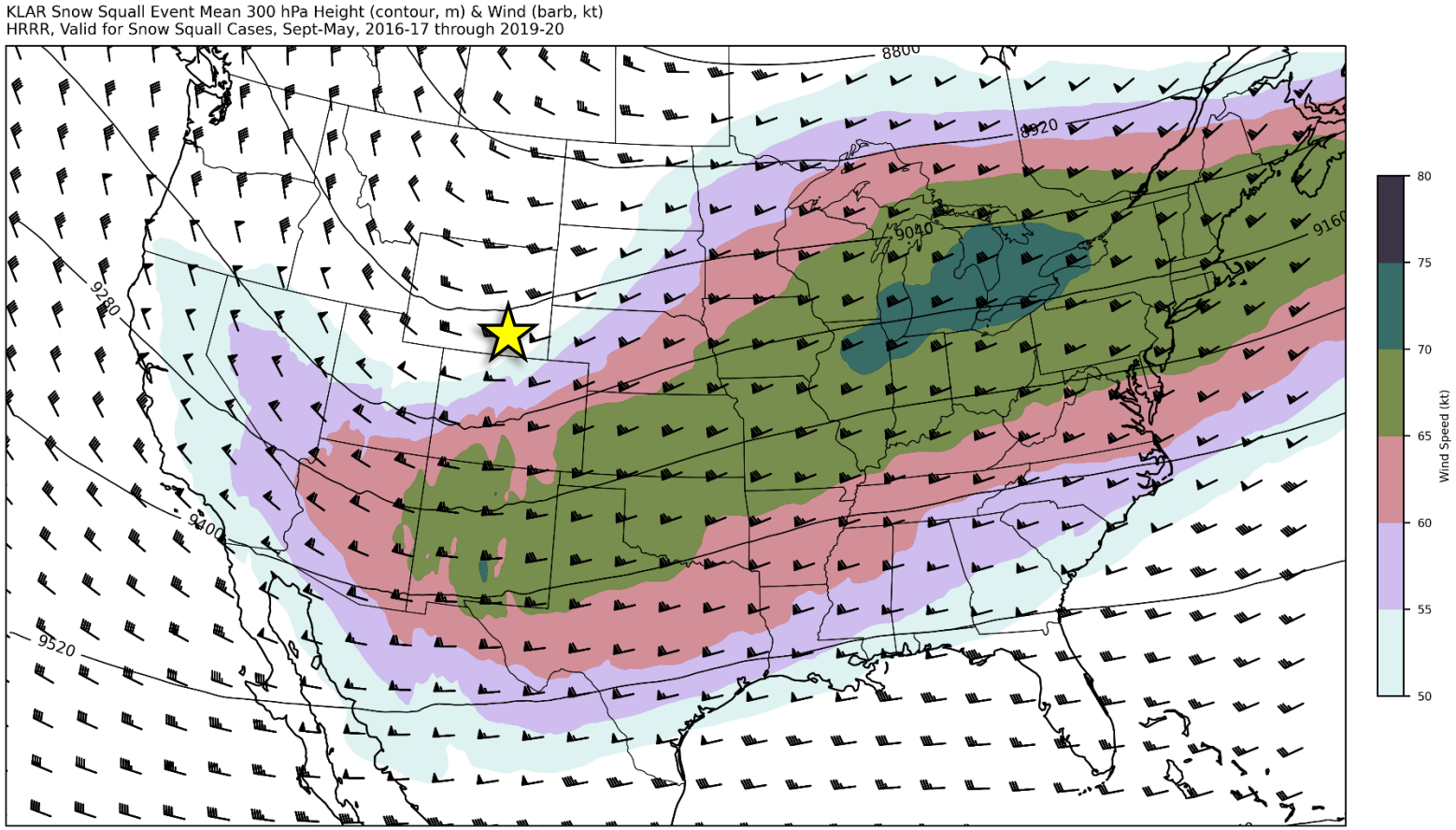
  - GJT
- **ID**
  - PIH
- **SD**
  - RAP
- **UT**
  - OGD
  - SLC
- **WY**
  - LAR
  - LND
  - RIW

Results

- Composite heights and winds for all KLAR cases
  - Site is on the cyclonic side of a 300 hPa jet maximum
  - Site lies upstream of the 700 hPa trough axis, and within the thermal trough



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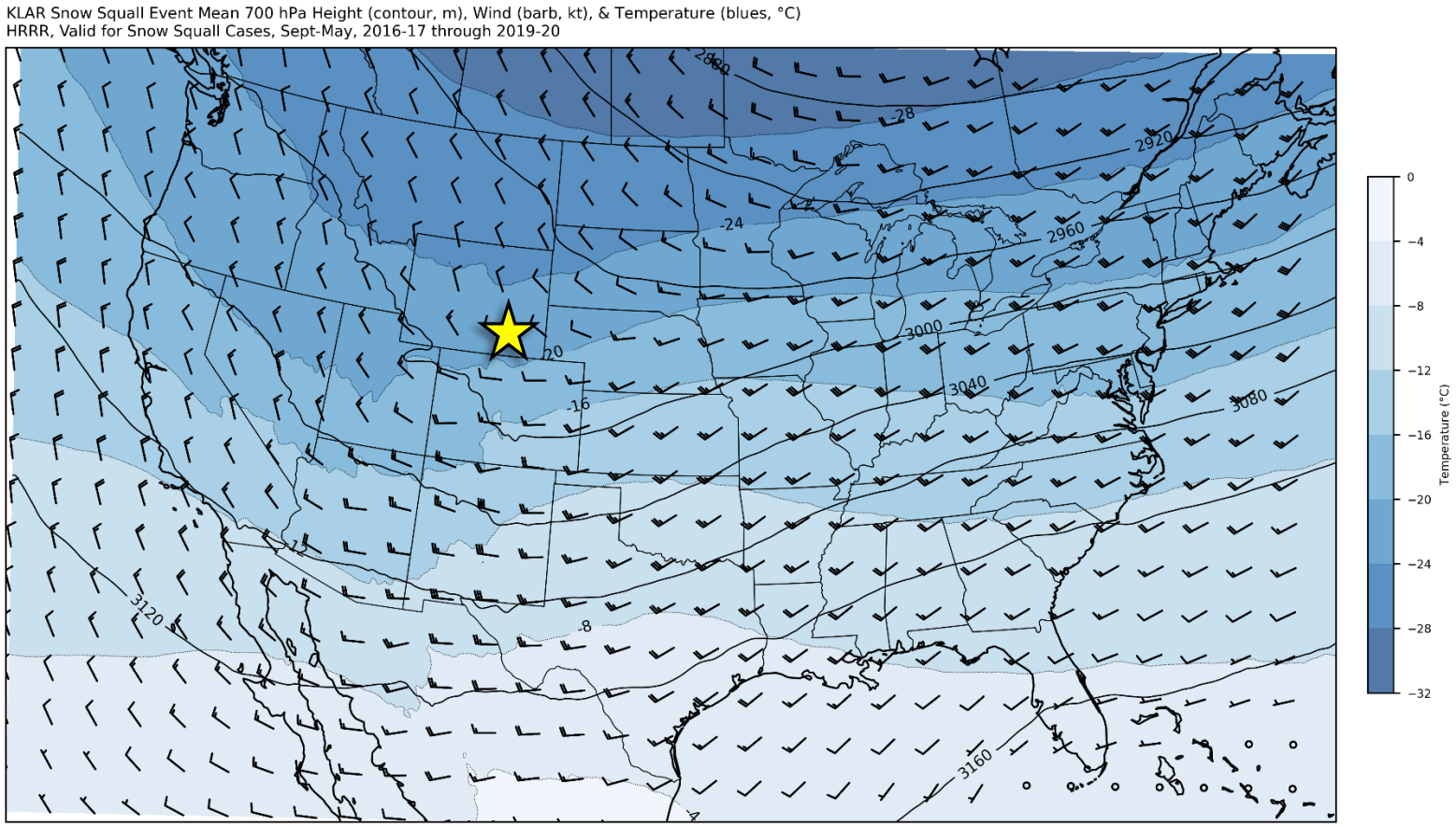
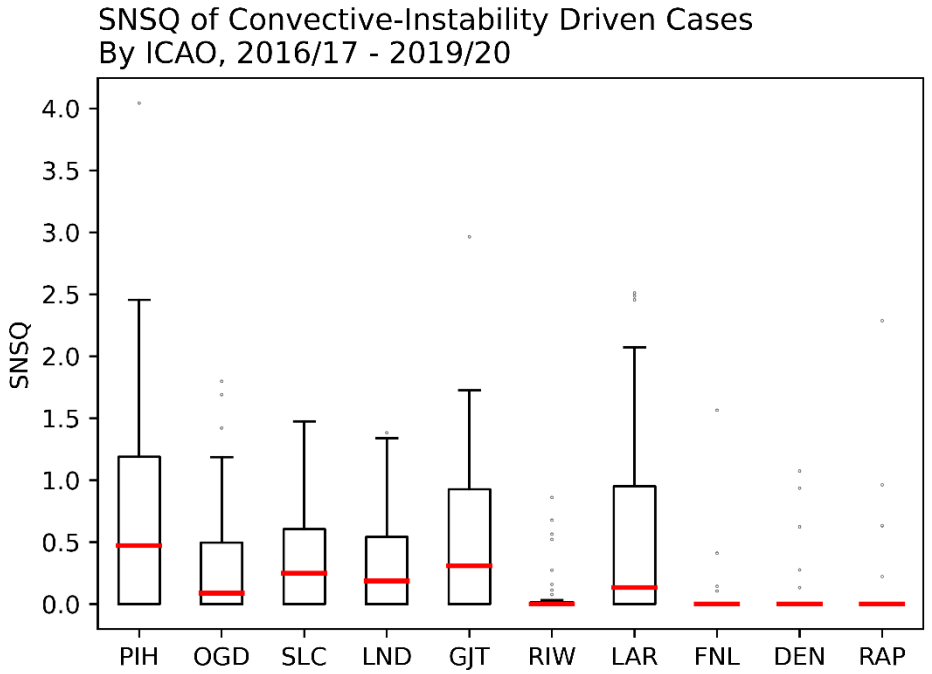
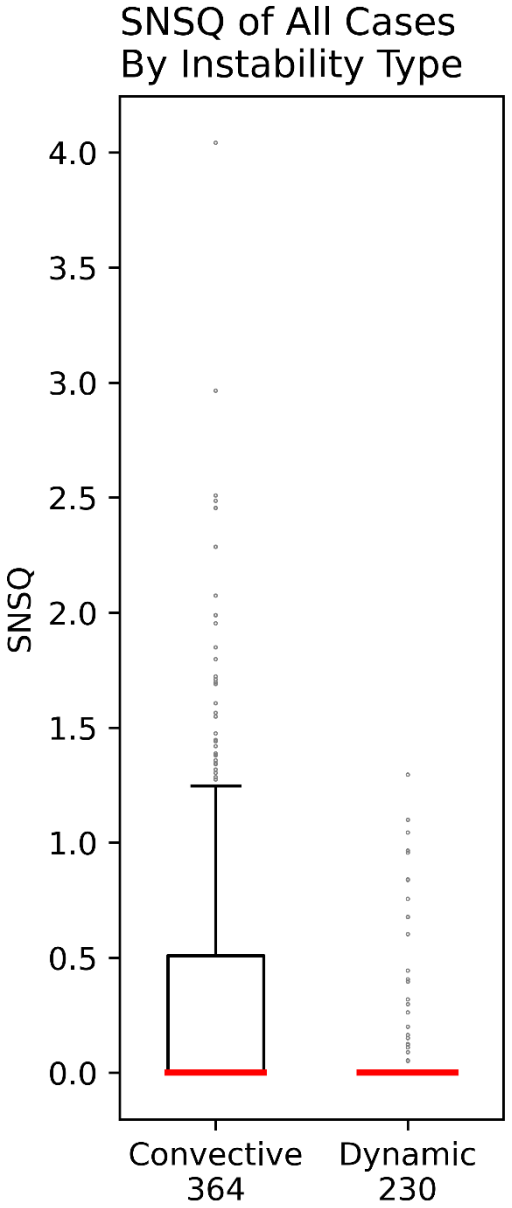


Results

- SNSQ performs as a predictor of convective instability driven snow squalls
  - 0-2 km instability is a key ingredient
- SNSQ Parameter struggles as a predictor of dynamic instability driven snow squalls
- Across the 10 examined locations, the SNSQ performs best at ICAOs that lie on the climatologically windward side of their respective mountain ranges (with exceptions)

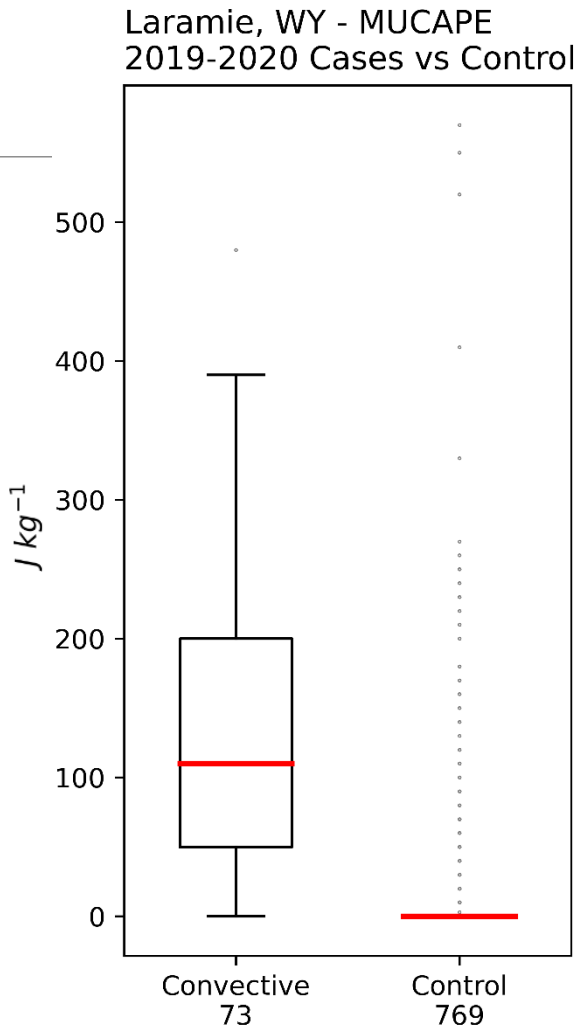


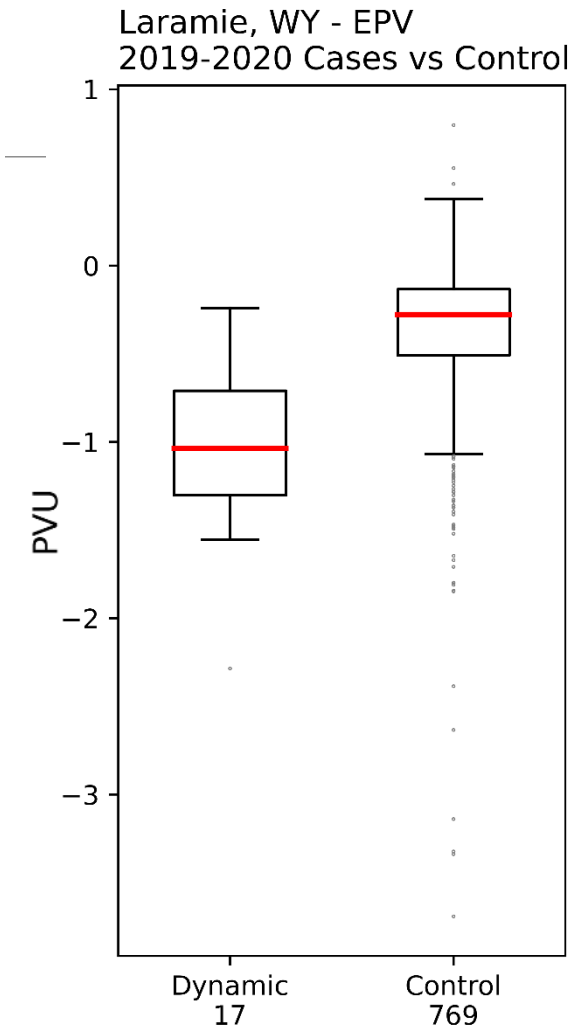


Results

- Control group:
  - HRRR, 6-Hourly, 00HR Analyses
  - October 2019 – April 2020
  - Minimum 1 hour prior-to or after squall

- Case group:
  - 2019-2020 KLAR snow squalls
  - Max (Min) local MUCAPE (EPV)





Summary

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- Snow squalls are mesoscale convective features that produce gusty winds, heavy snow, low visibility, and flash freezes
- By supplementing observation searches with a convectiveness filter, we can build a robust snow squall case dataset across multiple ASOS, AWOS, and DOT sites.
- Via a developing case dataset, most snow squalls in the high plains and mountain west are convective instability driven, and the snow squall parameter has skill in forecasting these events
- Snow squalls not driven by convective instability are less frequent, but may be captured in a forecast parameter by incorporating dynamic instability variables