Leaning Into Partnerships for Future Snow Squall Innovations

NROW 2024
Albany, NY

UNIVERSITY AT ALBANY
State University of New York

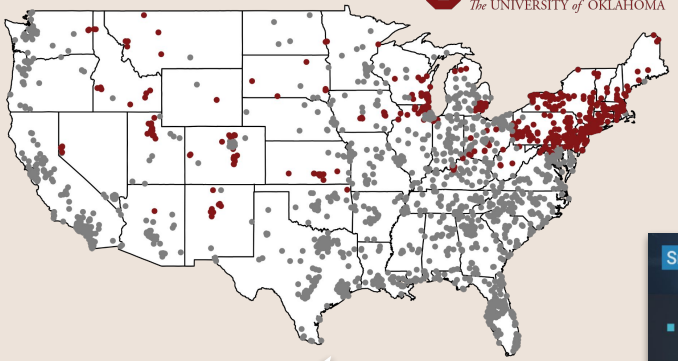
Greg DeVoir
Lead Meteorologist
Central Pennsylvania Weather Forecast Office
NWS State College, PA

Abby Bitterman
Research Associate
Institute for Public Policy & Research Analysis
University of Oklahoma

John Banghoff
Lead Meteorologist
Central Pennsylvania Weather Forecast Office
State College, PA

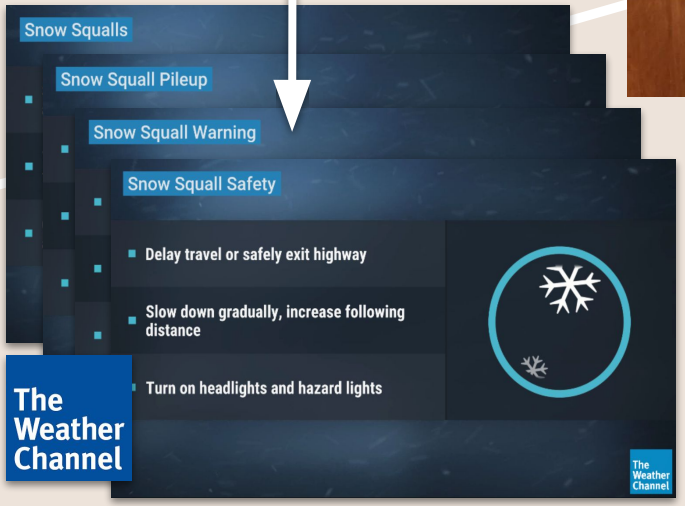
Leaning Into Partnerships for Future Snow Squall Innovations

INSTITUTE FOR PUBLIC POLICY RESEARCH & ANALYSIS
The UNIVERSITY of OKLAHOMA



Snow Squall Social Science Research to Guide Future Education & Outreach

Snow Squall Graphics & Immersive Mixed Reality



HOFSTRA UNIVERSITY

Developing a Virtual Reality Simulation for Snow Squalls

Testing public awareness, understanding, and intended response to snow squall warnings after 5 years in use

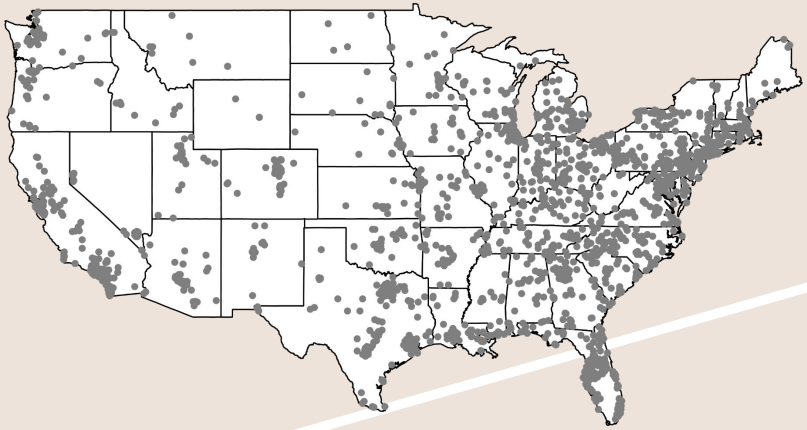
And 2 years of collecting survey data

Abby Bitterman[1], Anna Wanless[1], Makenzie Krocak[1,2], & Joe Ripberger[1]

[1]OU Institute for Public Policy Research and Analysis
[2]NOAA/National Severe Storms Laboratory

INSTITUTE FOR PUBLIC POLICY RESEARCH & ANALYSIS
The UNIVERSITY of OKLAHOMA

Methods

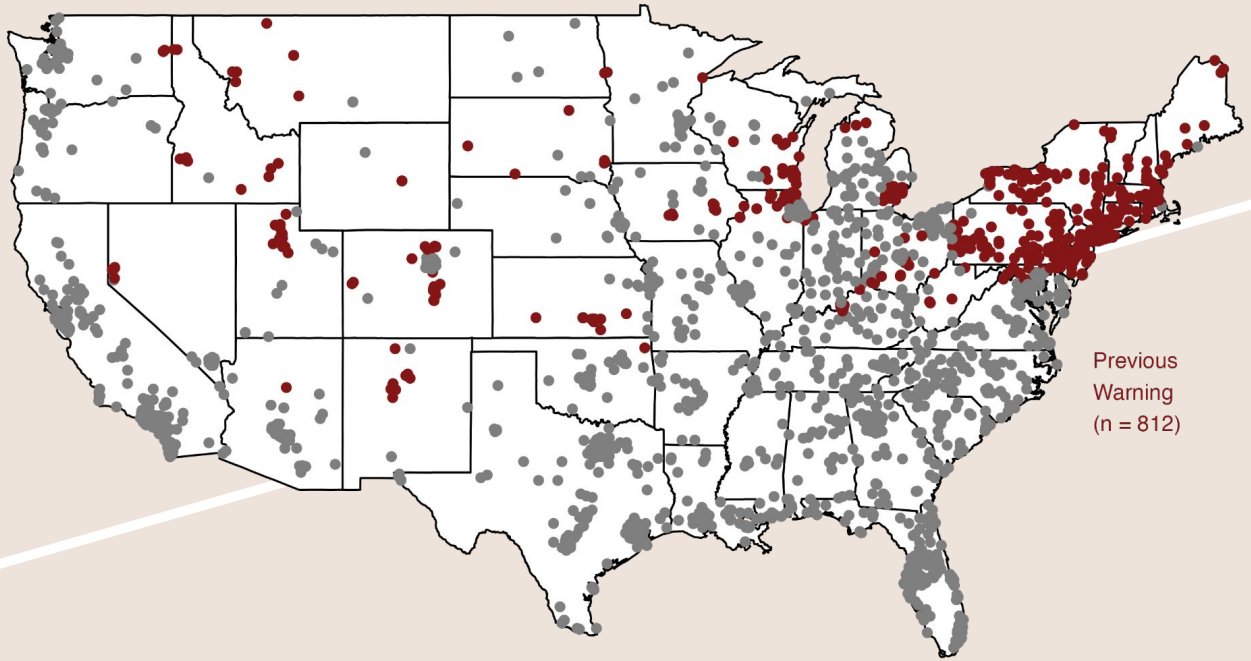


Winter Weather and Society Surveys 2022 & 2023 (WW22, WW23)

- WW22
  - Sample size: 1,423 U.S. adults
  - Fielded: June 13-26, 2022
  - Average completion time: 19 minutes
- WW23
  - Sample size: 1,459 U.S. adults
  - Fielded: October 26-November 6, 2023
  - Average completion time: 20 minutes

Snow squall questions were developed in consultation with NWS State College

812 respondents live in an area that *has* received a snow squall warning before



The importance of testing...

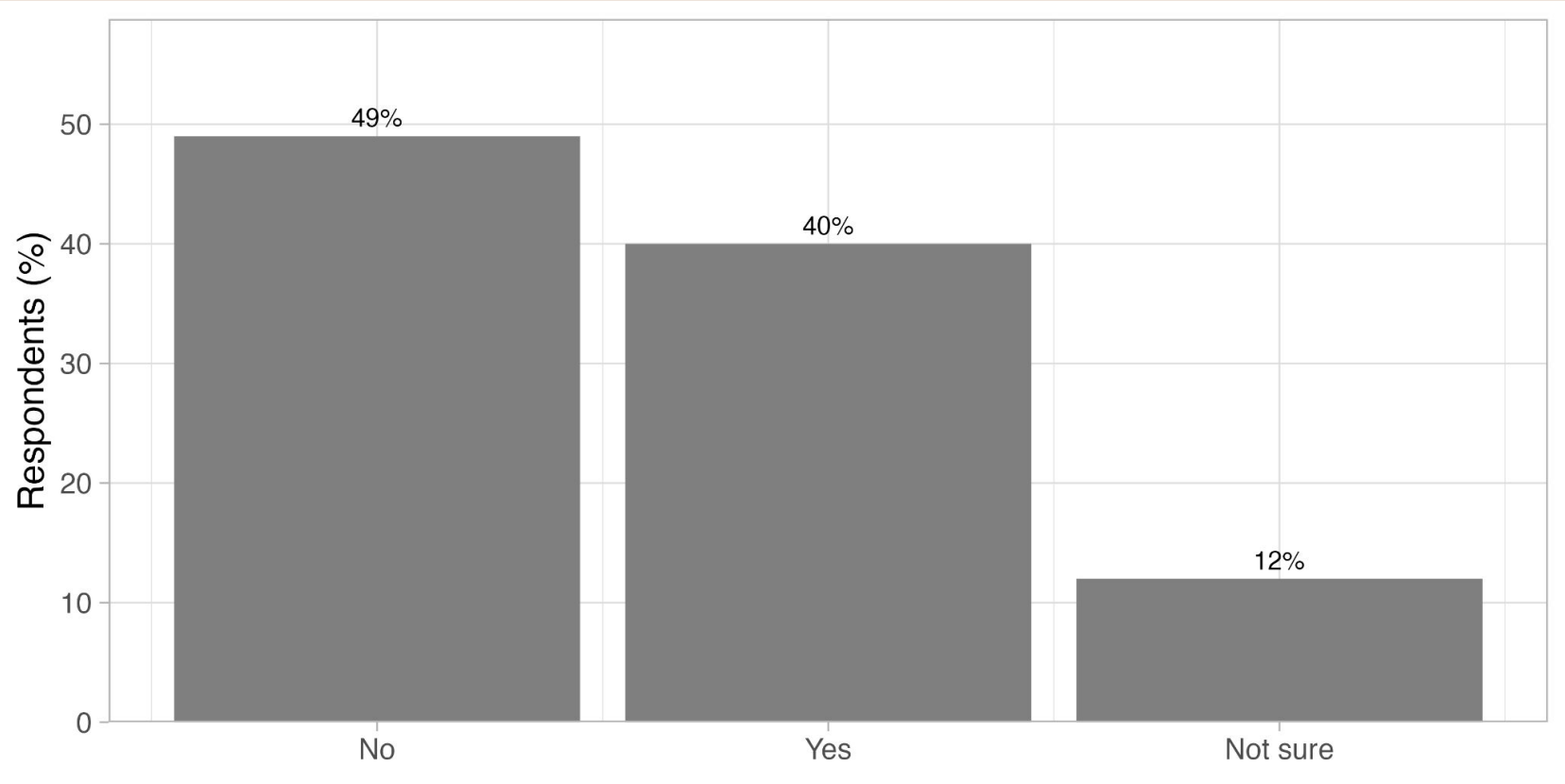
- Awareness
  - Fairly new: this product has been in use for 5 years
    - Have members of the public heard of snow squall?
  - Are public campaign efforts reaching their target audiences?

- Understanding
  - Do members of the public know what snow squall is?

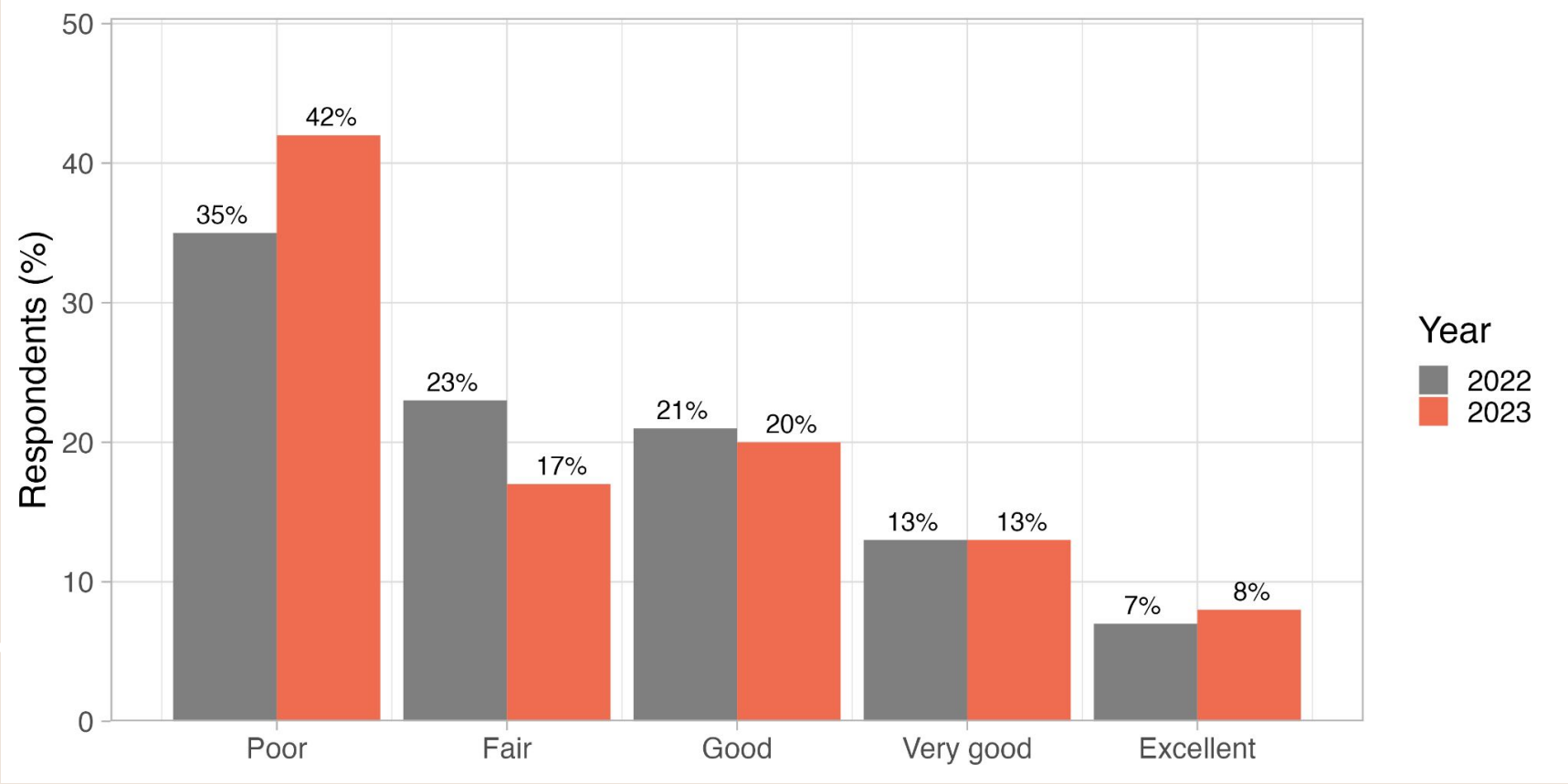
- Intended response
  - What actions would someone take if they received a snow squall warning?
  - Do members of the public know the recommended actions to take after receiving a snow squall warning?

- Above all, it is important to take stock of whether and how educational campaigns are impacting members of the public

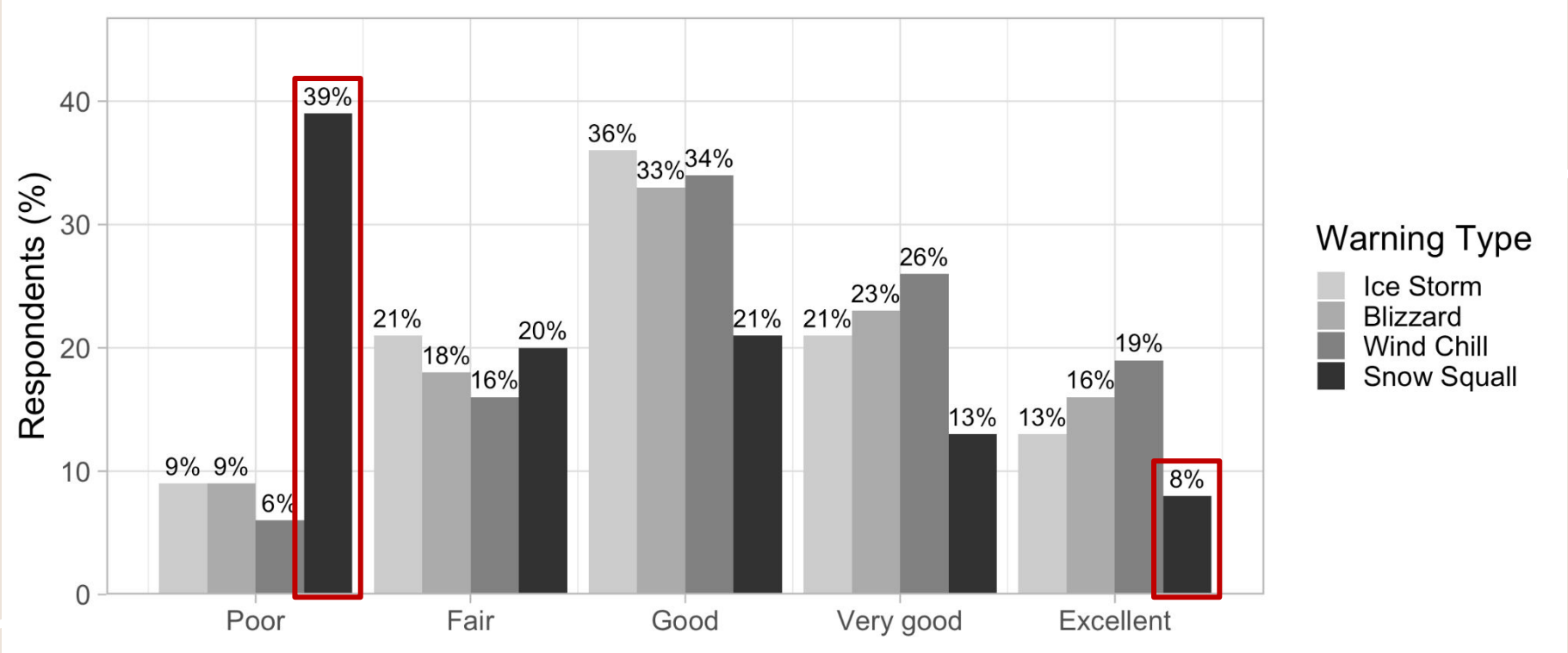
Have you heard of a *snow squall* warning?



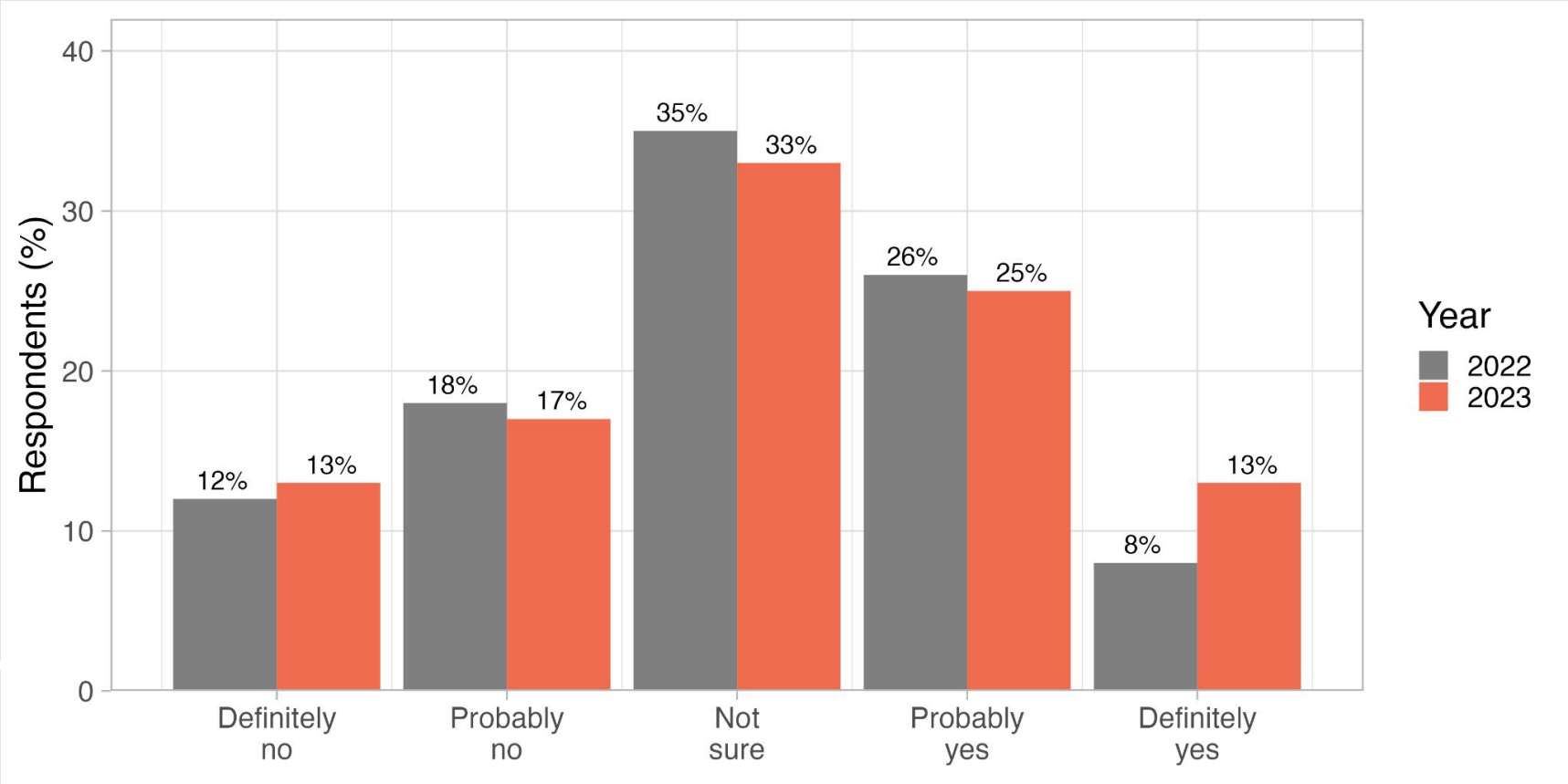
How would you rate your understanding of *snow squall* warnings?



How does understanding compare across other types of winter weather warnings?



Are you confident that you would receive a *snow squall* warning if one were issued while you were driving on a highway or interstate?



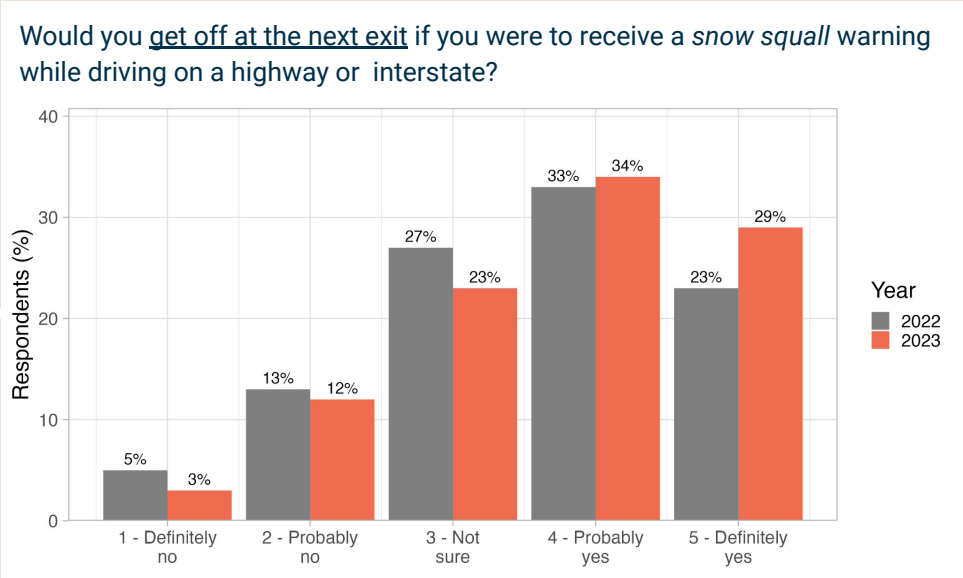
In a few words, please describe what you would do if you were to receive a *snow squall* warning while driving on a highway or interstate

"Try to get where I was going but if I was far away I'd pull off to somewhere else"

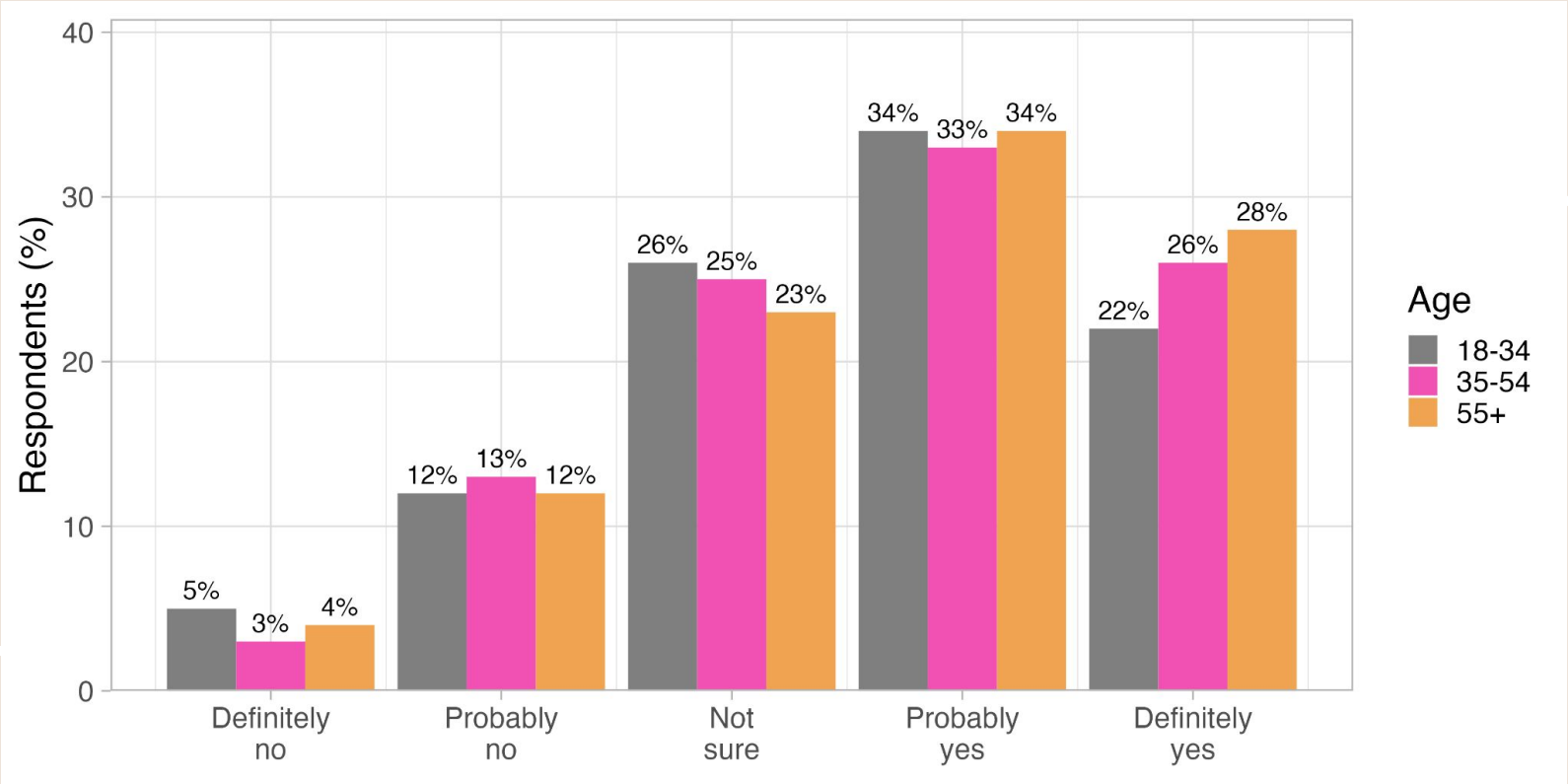
"I would look for a place to pull over and wait it out"

"Try to get home"

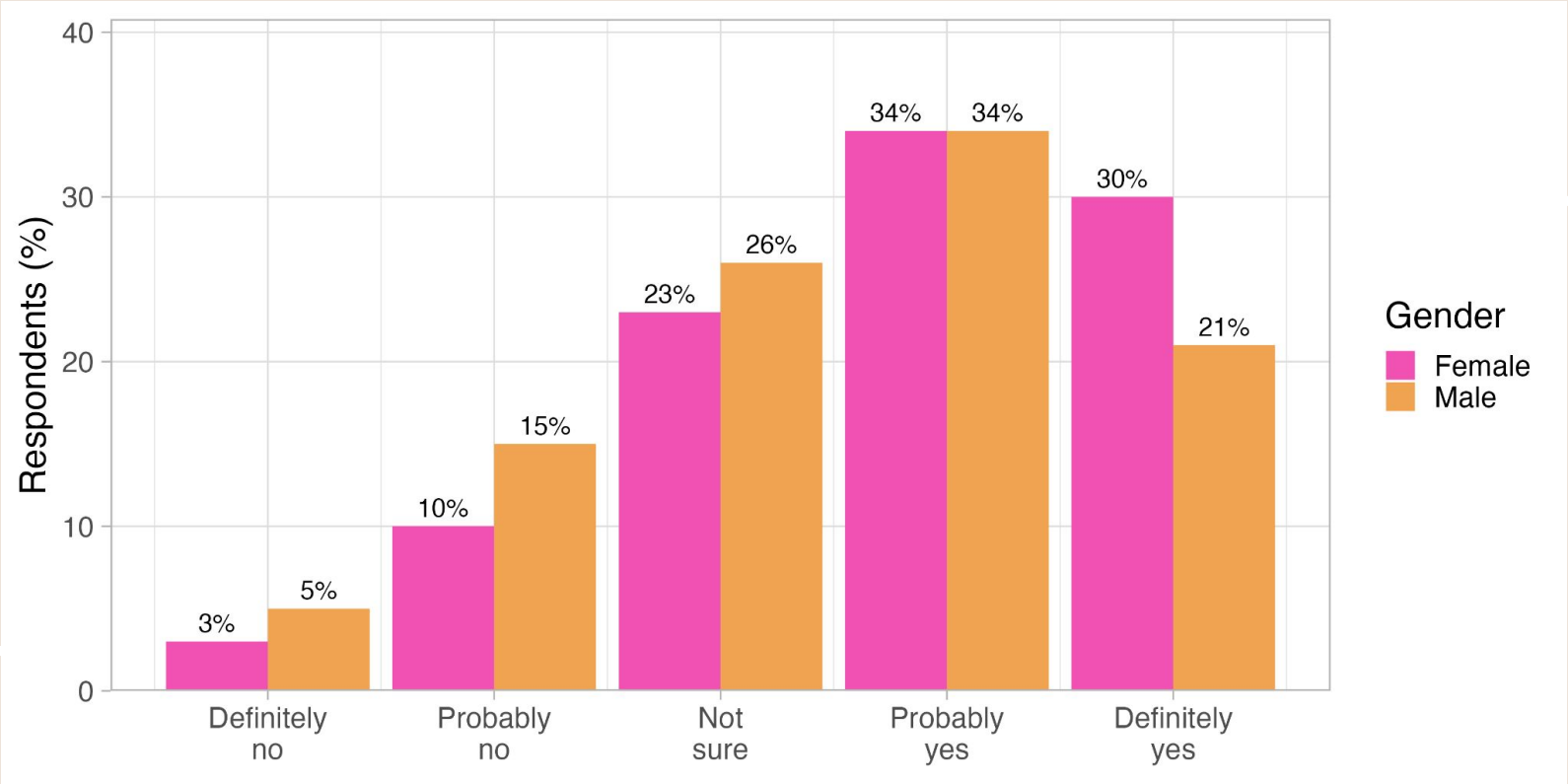
"I don't know"
"Google it"



Would you get off at the next exit if you were to receive a *snow squall* warning while driving on a highway or interstate?



Would you get off at the next exit if you were to receive a *snow squall* warning while driving on a highway or interstate?



Weather Channel Collaboration

Matt Sitkowski, PhD | Science Editor in Chief

Snow Squalls

- Short-lived burst of heavy snow and gusty winds
- Visibility can be quickly reduced to near-zero
- Can lead to high-speed car wrecks and pileups

Snow Squall Warning

- Sudden onset of life-threatening travel conditions expected
- Heavy snow, gusty winds, and a rapid drop in visibility
- Issued similarily to severe thunderstorm and tornado warnings

Snow Squall Pileup

- If possible, drive slowly to the front of the pileup
- If stopped, do not stand outside vehicle, keep seatbelt on
- If you can do so safely, get as far away from the roadway

Snow Squall Safety

- Delay travel or safely exit highway
- Slow down gradually, increase following distance
- Turn on headlights and hazard lights

Immersive Mixed Reality

Developing a Snow Squall Virtual Reality Simulation

2024 Road to Zero Community Traffic Safety Grant Recipient:

Fostering Improved Public Awareness of Snow Squall Driving Danger with Virtual Reality

NWS State College meteorologist testing out a VR simulation of roadway flooding.

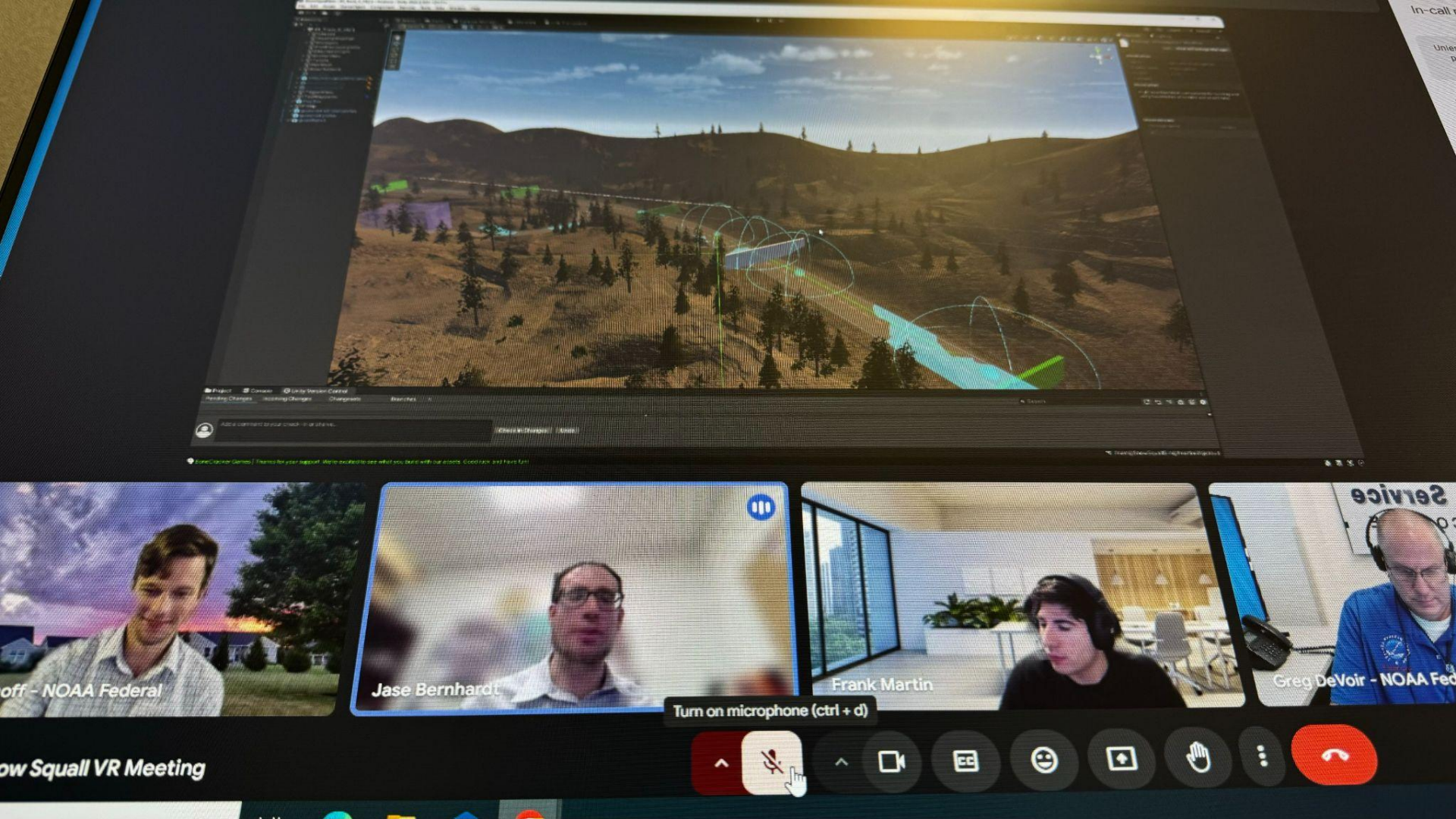
Team from Hofstra University and NWS State College developing a VR simulation to simulate what it's like to drive into a snow squall with deployment goal of 2025.

Goal is to promote improved public awareness of and preparedness for this hazardous weather phenomenon.

HOFSTRA UNIVERSITY

Principal Investigator:
Jase E. Bernhardt
Associate Professor of Geology, Environment, and Sustainability

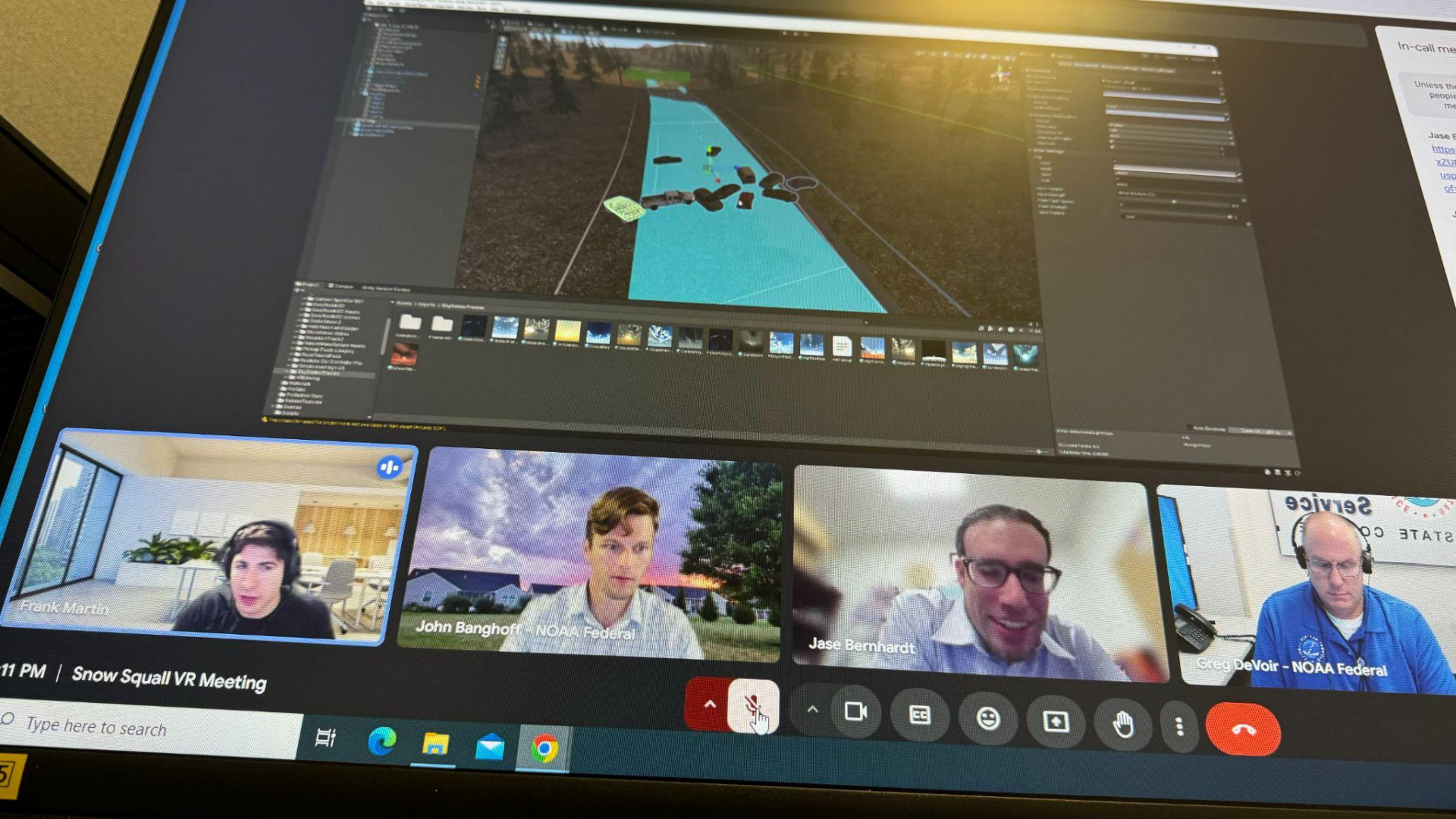
NATIONAL WEATHER SERVICE
STATE COLLEGE, PA


off - NOAA Federal
Jase Bernhardt
Frank Martin
Greg DeVoir - NOAA Fed
Turn on microphone (ctrl + d)
ow Squall VR Meeting


In-call messages
NEW TEXT
AA Federal
Jase Bernhardt
Frank Martin
Greg DeVoir - NOAA Federal
Turn on microphone (ctrl + d)
all VR Meeting


NEW TEXT
In-call messages
A Federal
Jase Bernhardt
Frank Martin
Greg DeVoir - NOAA Federal
Turn on microphone (ctrl + d)
VR Meeting


NEW TEXT
In-call messages
Jase Bernhardt
Jase Bernhardt
Frank Martin
Greg DeVoir - NOAA Federal
Turn on microphone (ctrl + d)
VR Meeting


Frank Martin
John Banghoff - NOAA Federal
Jase Bernhardt
Greg DeVoir - NOAA Federal
11 PM | Snow Squall VR Meeting
Type here to search

Extra Content

References

Banacos, P. C., A. N. Loconto, and G. A. DeVoir, 2014: Snow Squalls: Forecasting and Hazard Mitigation. *J. Operational Meteor.*, **2**(12), 130-151.

Banacos, P.C., G. A. DeVoir, B. Watson, A. N. Loconto, and D. J. Nicosia 2019: R2O: Development of NWS Snow Squall Warnings. Preprints, 9th Conference on the Transition of Research to Operations, Phoenix, AZ. Amer. Meteor. Soc..

DeVoir, G., 2004: High impact sub-advisory snow events: The need to effectively communicate the threat of short duration high intensity snowfall. Preprints, 20th Conf. on Weather Analysis and Forecasting/16th Conf. on Numerical Weather Prediction, Seattle, WA, Amer. Meteor. Soc., 10.2. [PDF]

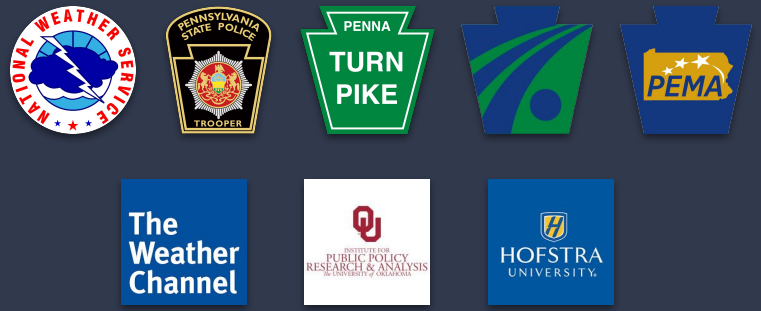
Milrad, S. M., J. R. Gyakum, E. H. Atallah, and J. F. Smith, 2011: A diagnostic examination of the eastern Ontario and western Quebec wintertime convection event of 28 January 2010. *Wea. Forecasting*, **26**, 301–318.

Lukinbeal, A. 2024: Western Montana Snow Squall Climatology and Synoptic Patterns, 2000–2020, J. Operational Meteor., 12 (2), 18-26, doi: https://doi.org/10.15191/nwajom.2024.1202.

Lundstedt, W., 1993: A method to forecast wintertime instability and non-lake effect snow squalls across northern New England. NOAA/NWS Eastern Region Tech. Attach. 93-11A, 7 pp.

Pettegrew, B. P., P. S. Market, R. A. Wolf, R. L. Holle, and N. W. S. Demetriades, 2009: A case study of severe winter convection in the Midwest. *Wea. Forecasting*, **24**, 121–139.

What is *your* "snow squall" problem?



There is no safe place on a highway during a snow squall.

Michael Jurewicz

SCIENCE OPERATIONS OFFICER
NWS STATE COLLEGE, PA
MICHAEL.JUREWICZ@NOAA.GOV

John Banghoff

LEAD METEOROLOGIST
NWS STATE COLLEGE, PA
JOHN.BANGHOFF@NOAA.GOV

Abby Bitterman

RESEARCH ASSOCIATE
INSTITUTE FOR PUBLIC POLICY & RESEARCH ANALYSIS
ABBYBITT@OU.EDU

Download the snow squall graphics for use at your office!

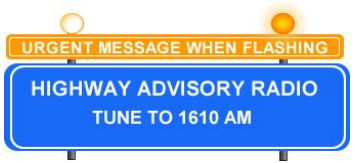
NOAA Account

Non-NOAA Account

Strategies for HISA Events

Mitigation of Severe Snow Squall Impacts

- Notify PennDOT/State Police when squalls are imminent via phone calls or Special Weather Statements (SPS)
- Activate Dynamic Messaging Signs
- Pre-treat highways
- Reduce traffic speeds (flashing lights)



GOAL: Prevent additional pileups on I-80 and eventually expand those efforts, with goal of an EAS-alerted warning

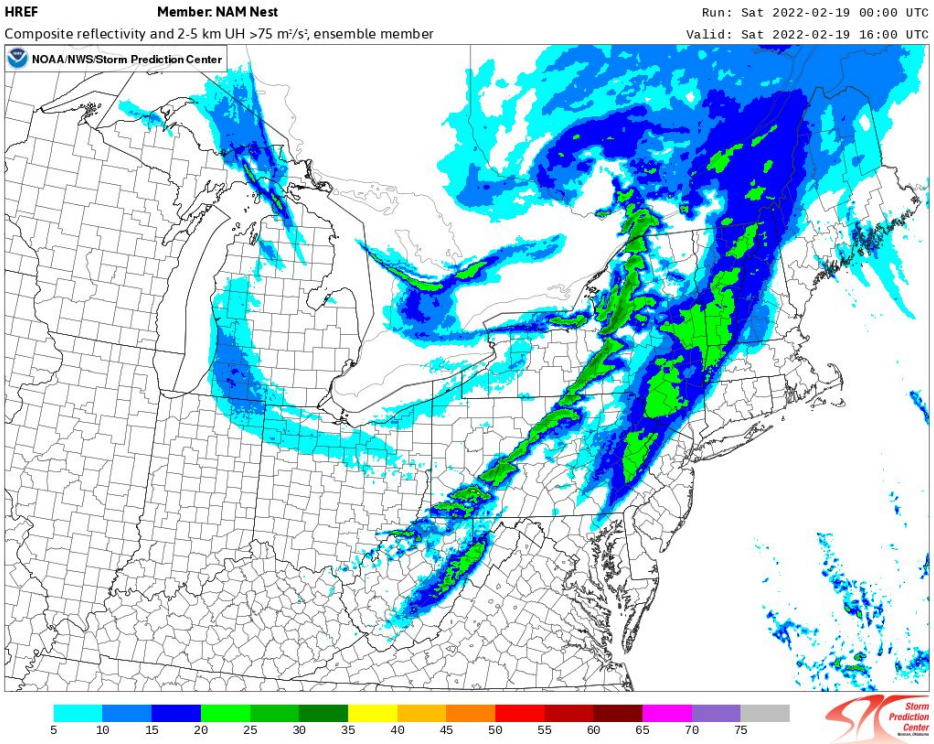
Other Notable Snow Squall Pileups in PA

- 22 February 2001 – 2 to 3 inches of snow in less than 2 hours throughout central and northern mid-Atlantic states
  - Numerous chain reaction accidents - 300 vehicle pileup north of Washington D.C.
- 28 December 2001 - Lake Effect Snow Squall (Loganton, PA); 8 Dead
- 5 January 2003 – 1 to 3 inches of snow in less than 3 hours across south central PA (midday Sunday - church services)
- 10 February 2008 - Hazleton, PA: I-81
  - 68-vehicle pileup
  - 1 dead, dozens injured
  - Snow squall with arctic front.

Predicting Snow Squall Mode

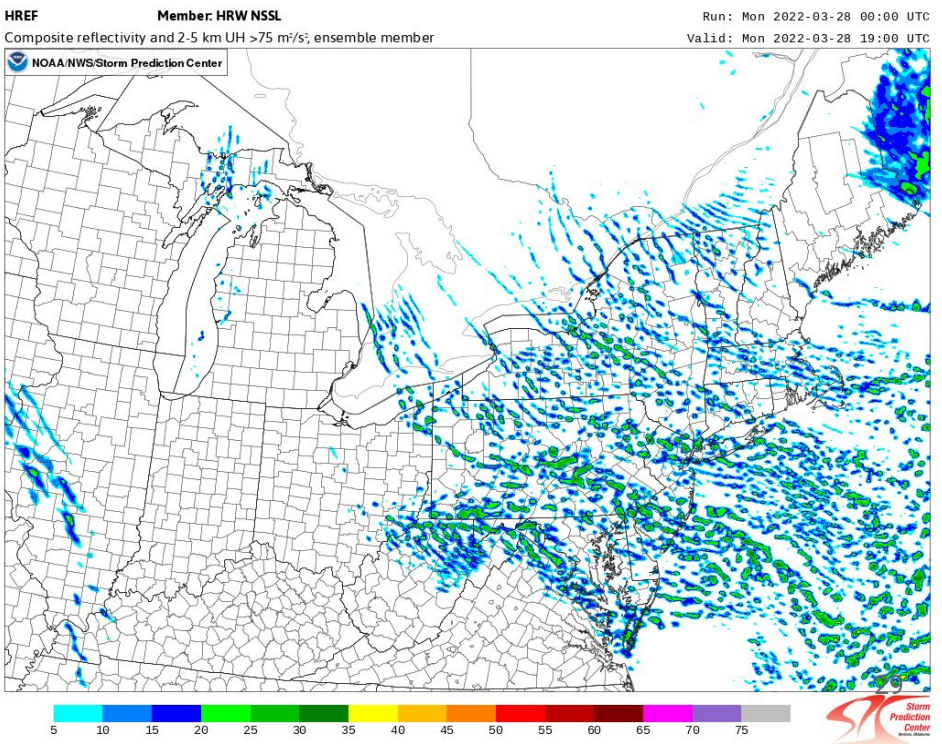
Linear

00Z NAM Nest 19 Feb 2022 (VT 16Z 19 Feb 2022)



Cellular

00Z NAM Nest 28 Mar 2022 (VT 19Z 28 Mar 2022)



Forecasting Linear vs. Cellular Storm Mode

Key discriminator: convergence of the **isallobaric wind** (Banacos and DeVoir 2013)

- Strong cold fronts with intense isallobaric gradients (large pressure fall-rise couplets) are most likely to produce linear, **single-band** snow squalls
- If the snow squall parameter (SNSQ > 1) presents itself in a narrow band along a cold front, a single linear band is favored

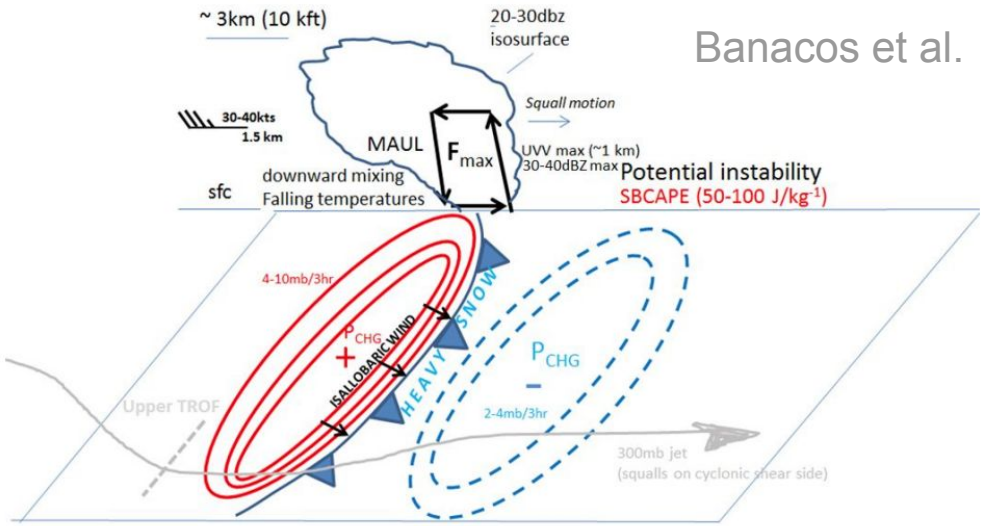
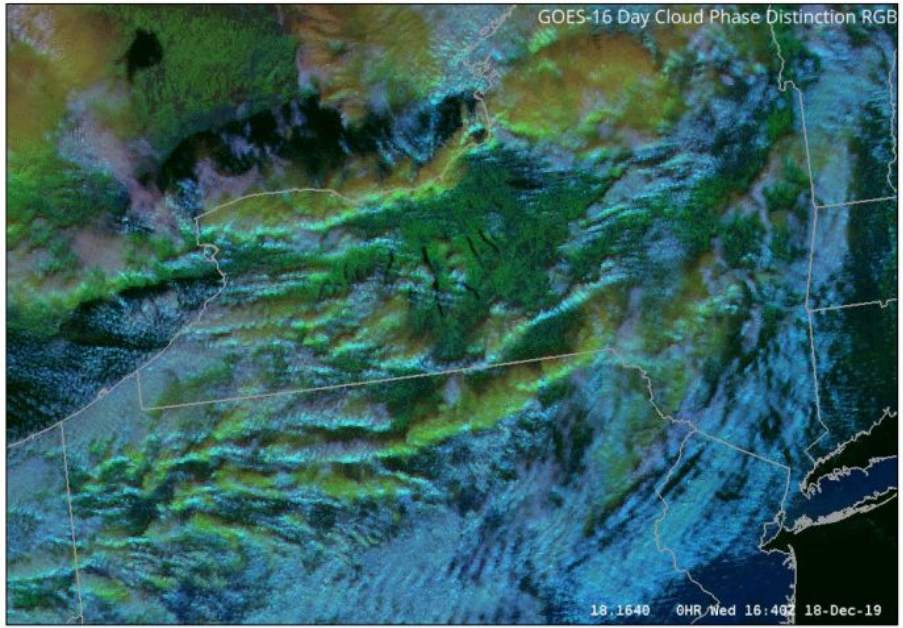


Figure 5. Quasi-Linear Convective System (QLCS) snow squall conceptual model, as presented in NWS training slide. P_{CHG} refers qualitatively to sea-level pressure changes, with positive (negative) changes in red (blue). SBCAPE refers to surface-based convective available potential energy (J kg^{-1}). F_{max} is the location of a low-level, thermally direct, frontogenetic circulation. MAUL stands for moist absolute unstable layer (Bryan and Fritsch 2000), and UVV is the location of maximum upward vertical velocity. Representative radar reflectivity values are shown in dBZ.

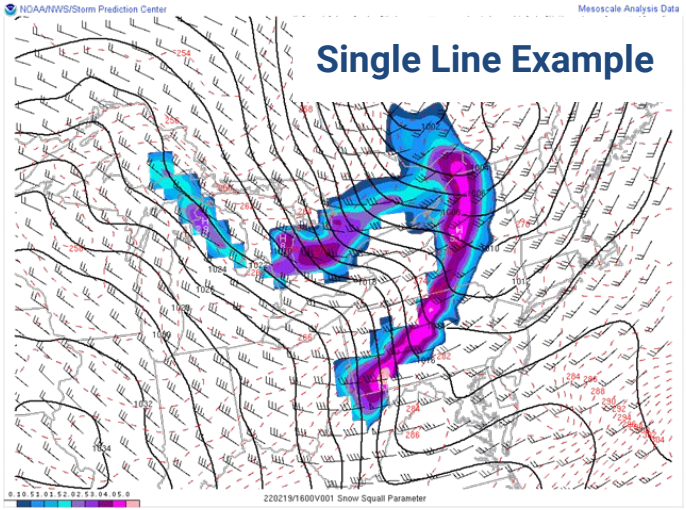
Impact of Instability-Shear Balance on Snow Squall Organization

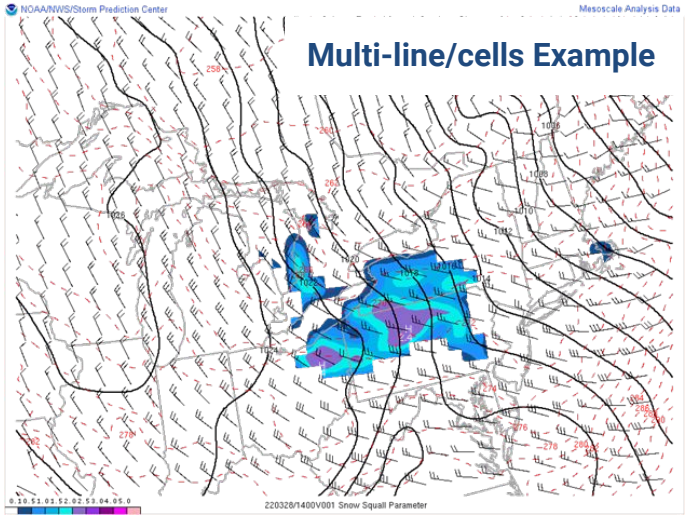
- Increasing instability (more CAPE and/or deeper cloud bearing layer) tends to favor cellular convection
- Increasing wind shear in the cloud bearing layer tends to favor linear over cellular convection
- Example scenario: Flow-parallel streamers in the morning transition to a cellular structure late in the morning as the unstable boundary layer becomes deeper



Forecasting Linear vs. Cellular Storm Mode

- **Strong wind shear** and instability in the **absence of a strong isallobaric gradient** may result in **multiple linear bands instead** of just one.
- High instability and **lesser wind shear** results in **cellular** snow squalls (think Bulk Richardson Number)
- Area of SNSQ parameter > 1 typically larger / less focused in cellular squall cases

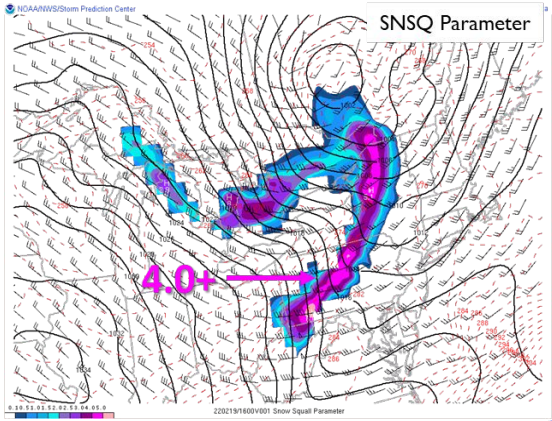


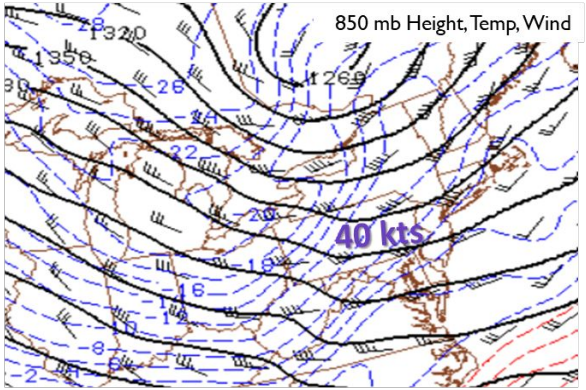


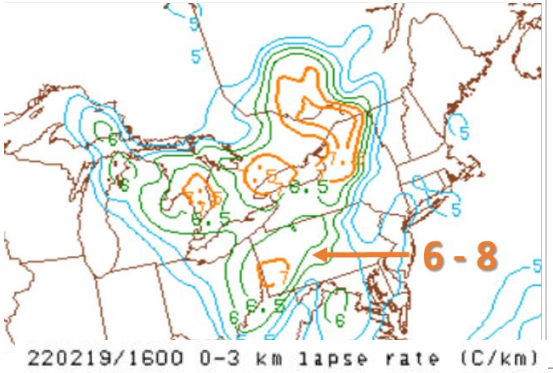
Case Study: Strongly Forced

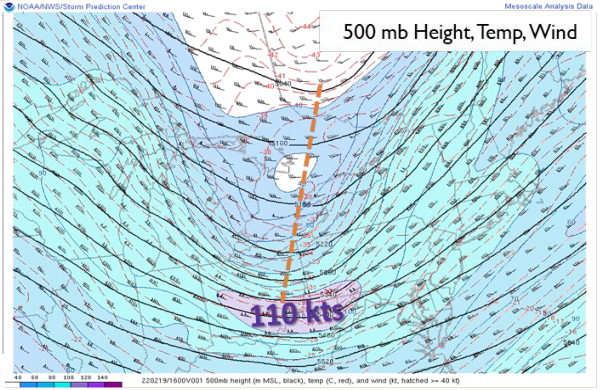
Example of a **strongly forced** case

- A shortwave trough in the upper levels was moving into western PA, with a speed max of 110 kts at 500 mb within the base of the trough.
- At 850 mb, RAP analysis shows 40 kts of SW flow. There was 60 kts of 0-3 km SW shear.
- Lapse rates in the 0-3 km layer were 6+°C/km by 1600 UTC and continued to increase in the afternoon.
- The snow squall parameter was 4+ along a narrow corridor at the leading edge of a tight Theta-e gradient near the surface





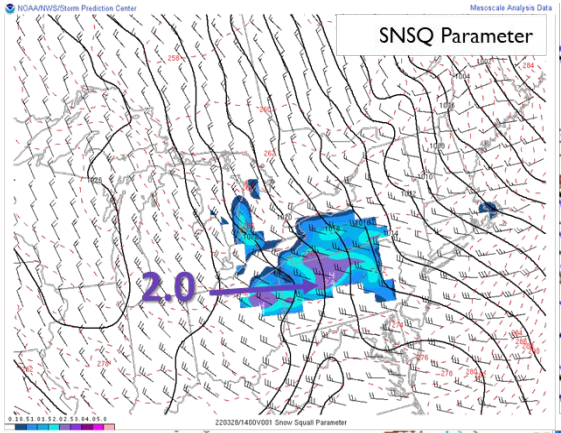


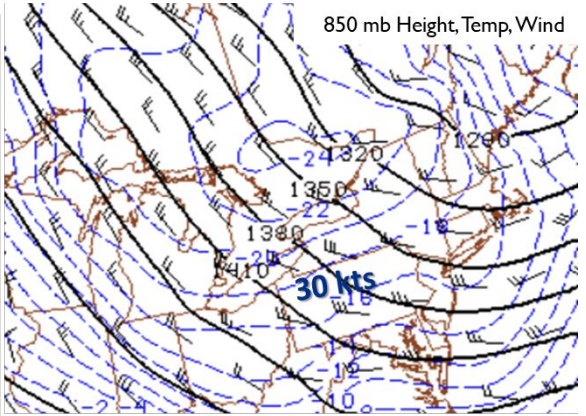


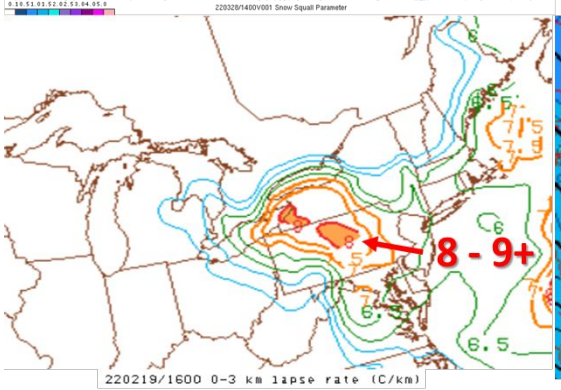
Case Study: Weakly Forced

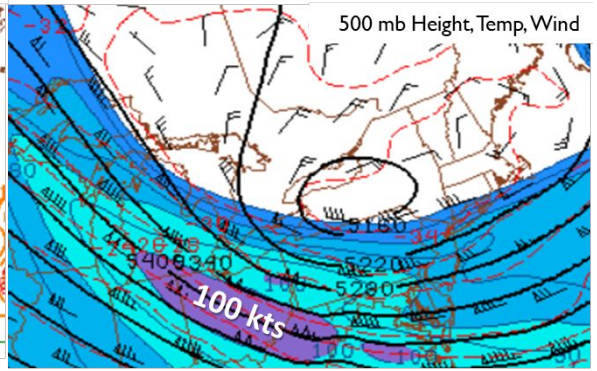
Later in the season, the Mar 28, 2022 snow squall event was characterized by **very high instability** with **less shear and forcing**.

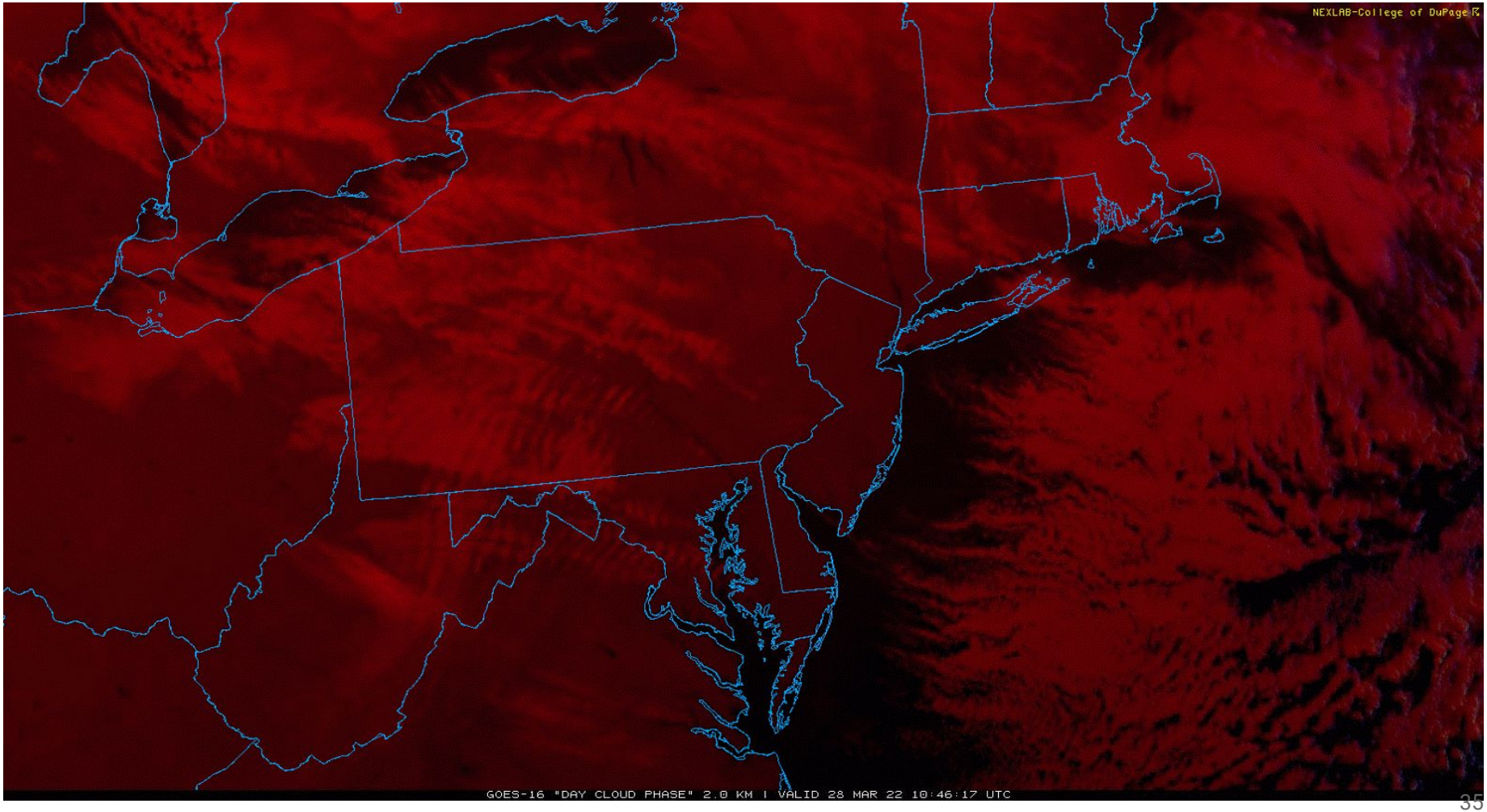
Despite occurring in late March, temperatures on this day were some of the coldest of the entire winter. Low level lapse rates were 8+ °C/km by noon EDT, and increased to 9+ °C/km shortly thereafter. A 500 mb closed low was situated over western NY, with an associated cold pol aloft. A vort max was noted over western Lake Ontario at sunrise. Winds were from the NW at around 30 kts at 850 mb. Shear was not as strong as during the Feb case.







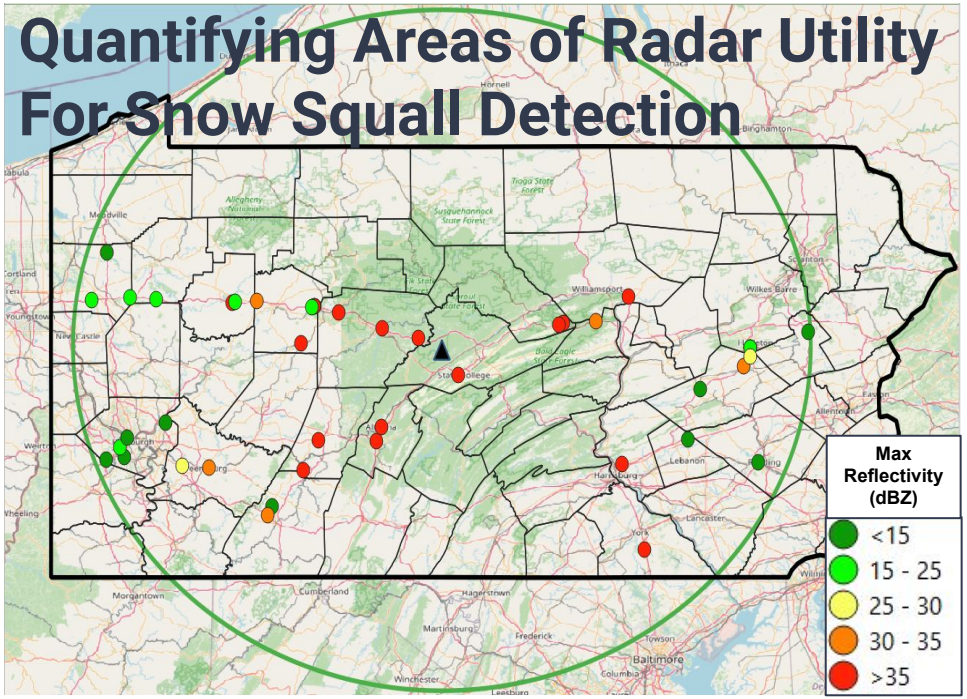



NEXLAB-College of DuPage
GOES-16 "DAY CLOUD PHASE" 2.0 KM | VALID 28 MAR 22 10:46:17 UTC

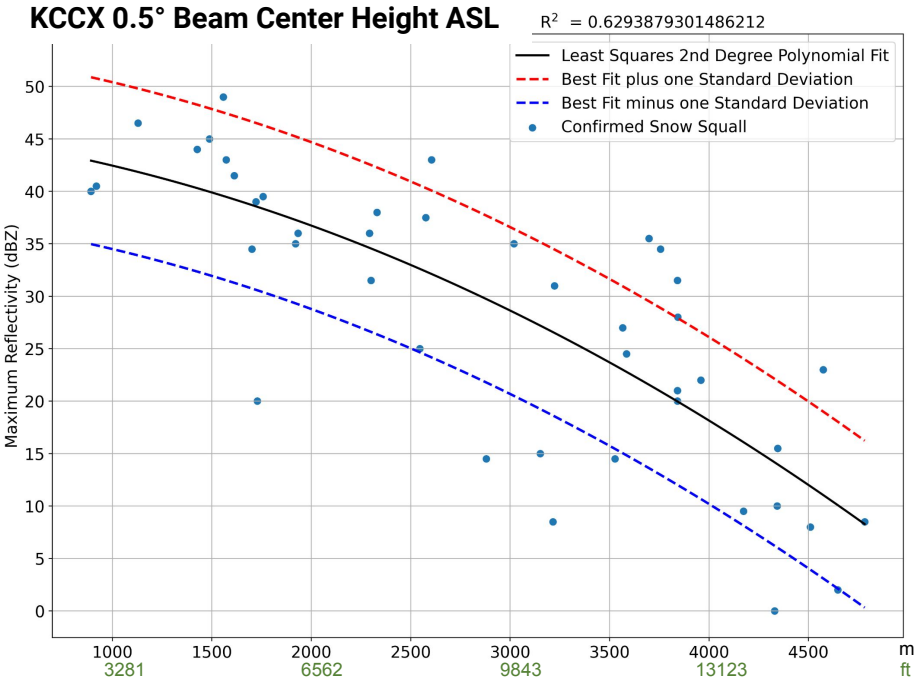
Flash Freeze Considerations

- Flash freezes are possible when snow squalls occur with **sub-freezing air temperatures**, even if the ambient road temp is well above freezing
  - If the road temp starts off above freezing, snow will initially melt and then potentially freeze as temperatures drop
  - If the road temp starts off below freezing, a flash freeze can still occur due to the frictional warming effects from the pressure of traffic driving over the snow
- Flash freezes *may* be unlikely when the antecedent *air temperature is well above freezing* (no known cases in our area)
  - Transportation impacts still possible with low visibility and wet road surfaces
- Commercial trucks will travel for as much as 0.5 mile after applying the brakes on an icy road. **If a flash freeze is likely** in an area with truck traffic, **consider being flexible with the 0.25 mile criteria for SQW issuance**
  - In addition, turbulent fluid flow around moving traffic can locally reduce visibility on the roadway. 1/2 SM at an ASOS can easily translate to 1/4 SM for a motorist

Radar Range of Utility for Snow Squalls



A small dataset of "known" snow squall pileups was combined with a larger dataset of 2008-2016 PennDOT accidents to find a total of 43 pileups (each having 4+ vehicles) that occurred in snow squalls within 200 km of the KCCX radar. We found the maximum KCCX reflectivity within a 15 km (9.3 mi) radius and +/- 15 minutes from crash time for each accident.



Maximum reflectivity for each accident was plotted as a function of lowest beam height above sea level (ASL; figure above), and also as a function of several other variables including distance from the radar, beam height above ground level (AGL), etc. The line of best fit was calculated for each relationship, along with the +/- 1 standard deviation around the best fit line.

Radar Range of Utility for Snow Squalls

Merged POD Model

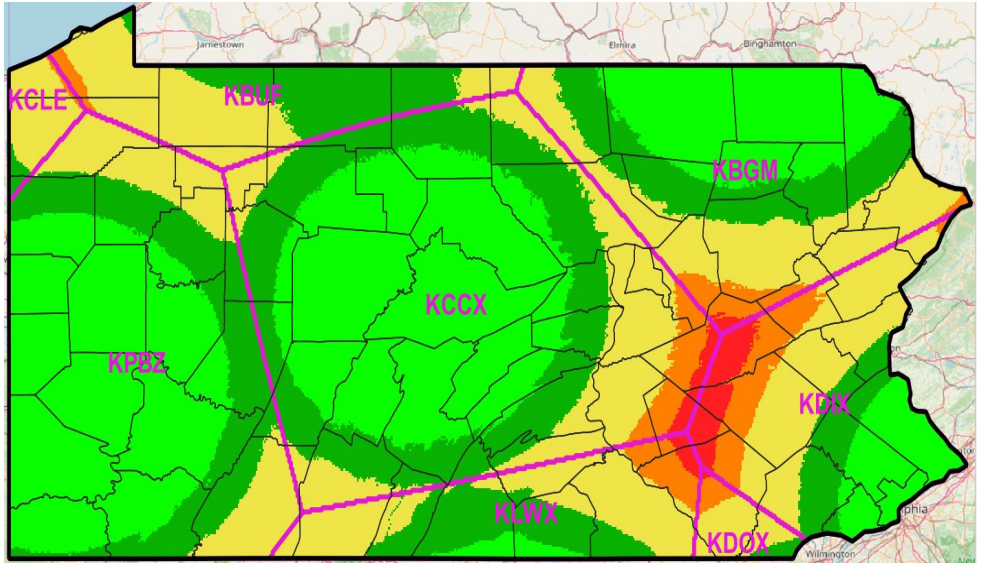
Our sample size is too small to know which POD model is best – the model tuned to Radar Distance or the models tuned to Beam Height ASL/AGL. At this time, we average them together to get a *Merged POD Model*.

The Merged POD Model for the 30-dBZ threshold can be combined with the lowest available radar beam polygons in one operational aid to show forecasters what warning tools to rely on over any portion of Pennsylvania.

Key Takeaways

In the middle of central PA we can rely heavily on KCCX, which will show at least 30 dBZ reflectivity in high-impact snow squalls 80%+ of the time.

Between Lancaster and Schuylkill counties in east-central PA, relying on a 30 dBZ threshold will only result in a POD of 30-50%. This is where other tools must be employed, such as MRMS height of the 18 dBZ echo top, satellite imagery, and surface obs.



Merged POD Model

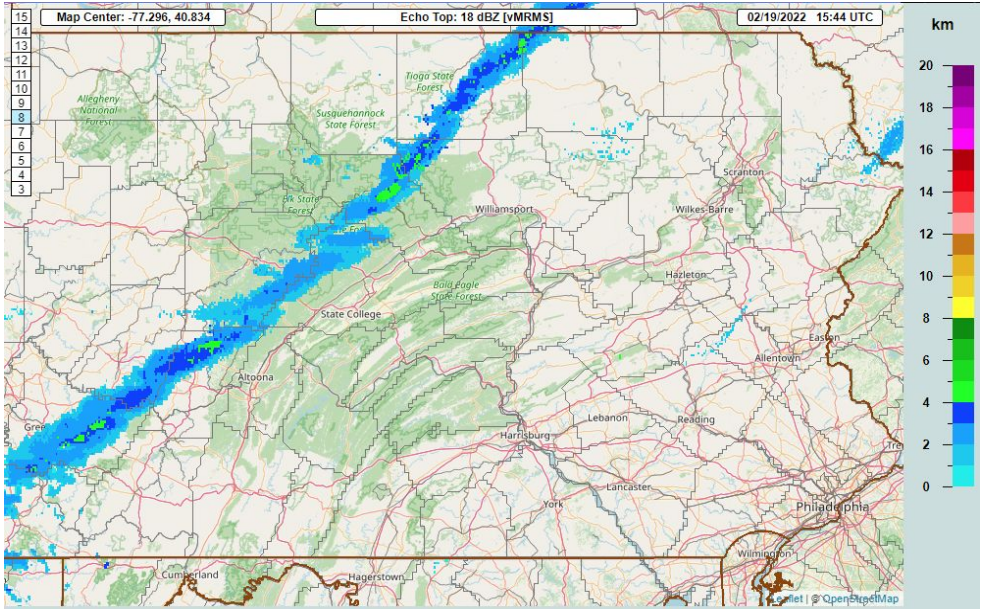
Equal-weight average of POD models using Radar Distance, Beam Height ASL, and Beam Height AGL

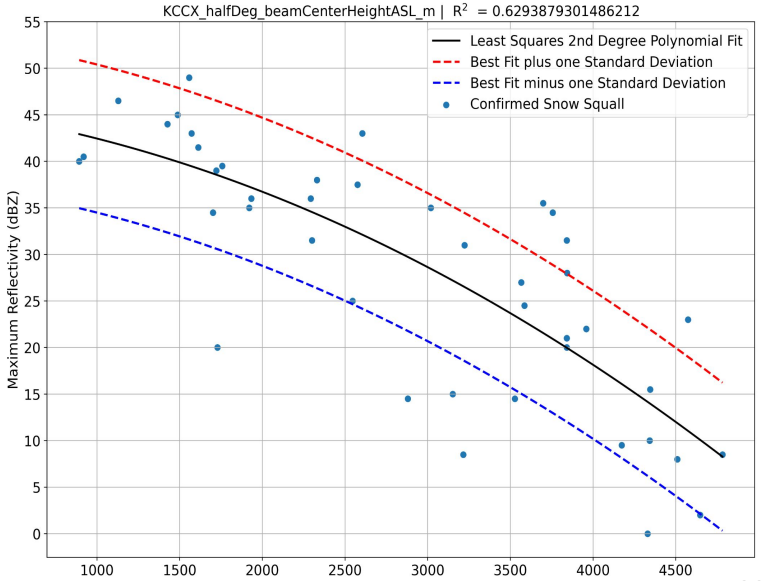
Lowest available radar beam (overlaid)

POD (%) Using 30 dBZ
- <= 35.0000
- 35.0000 - 50.0000
- 50.0000 - 75.0000
- 75.0000 - 87.0000
- > 87.0000

Alternatives to the 30 dBZ threshold

- Sample the max reflectivity and see where it lands on the scatter plot of high-impact snow squalls (right)
- Look for MRMS 18 dBZ echo top > 2 km (below)
- Rely more on sfc obs and spotter reports
- Use satellite imagery





CAMPAIGN STRATEGY:

GOAL: We want a powerful tagline/slogan.

Gain vs. loss framing: If advocated behavior is not performed, undesirable outcome will happen.

What is the bottom line?

There is no safe place on a highway during a snow squall.

Now that we have our slogan, what else do we need?

Visualization to convey the risk.

Photo of crash scene? Powerful depiction, but perhaps triggering. Getting permission to use crash photos is difficult/expensive.

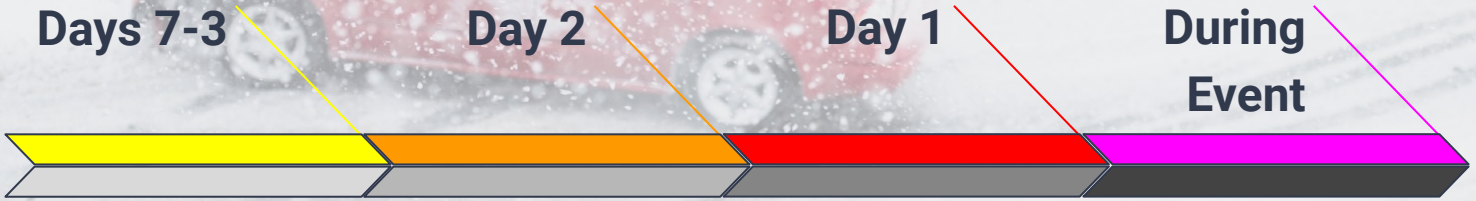
After a 2+ years of spinning our wheels, **we received a chance Facebook message from William van Aacken with the missing piece for our campaign:** several videos from his Tesla as he drove through a snow squall & pileup in Oshkosh, WI.

Tesla footage from 2020 Wisconsin snow squall.
-William Van Aacken

www.weather.gov/ctp/snowsquall

#SnowSquallSafetyPA

Snow Squall Messaging Timeline

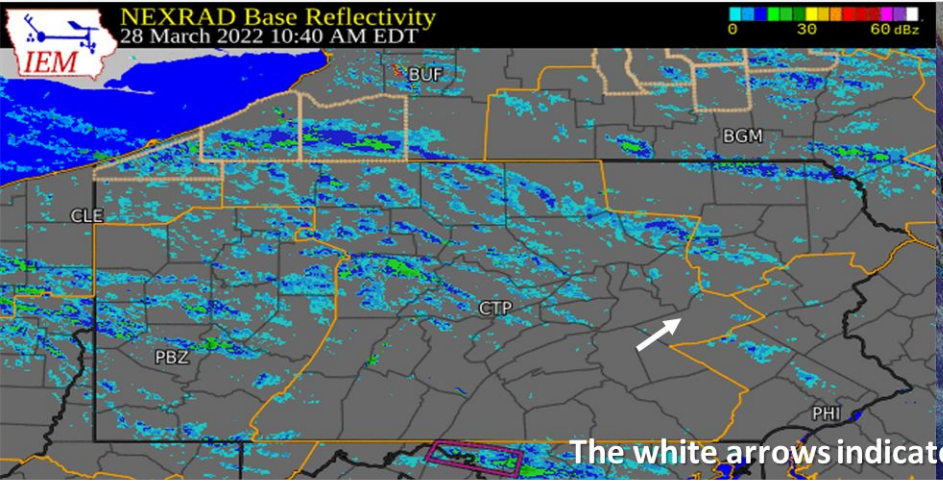


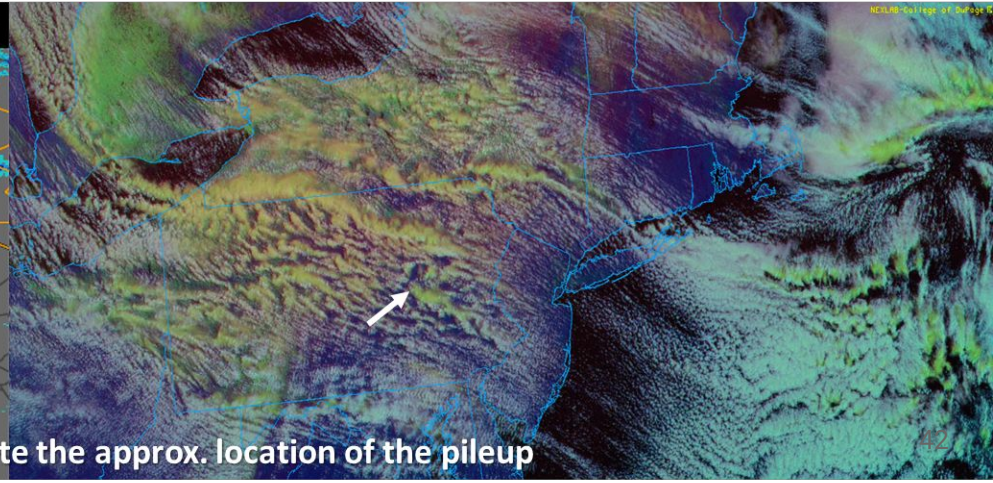
Forecast Focus	***Heads Up.***	***Get Ready!***	***Take Action!!***
Snow Squall Parameter > 1 (CIPS & AWIPS)	HWO & AFD	Special Weather Statement	SQWs - IBW tag?
Preparedness & Safety Graphics	Pathfinder Chat	DSS Briefing Update	RWIS Webcams & Flash Freeze
	DSS Briefing?	Communicate with DOT/PTC	Share webcams
	WPC Key Messages		SQWs go to X automatically
	Social Media Posts		RadarScope Loops

Crash Video

This video contains content that viewers may find disturbing.

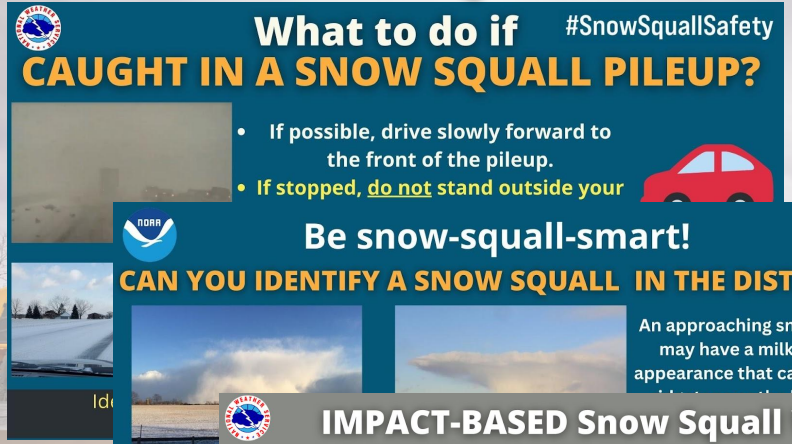
6 deaths & 24 injuries





The white arrows indicate the approx. location of the pileup

Subsequent Safety Campaign Updates:



IMPACT-BASED Snow Squall Warnings

From now on, Snow Squall Warnings will trigger Wireless Emergency Alerts (WEAs) only in the most significant instances.

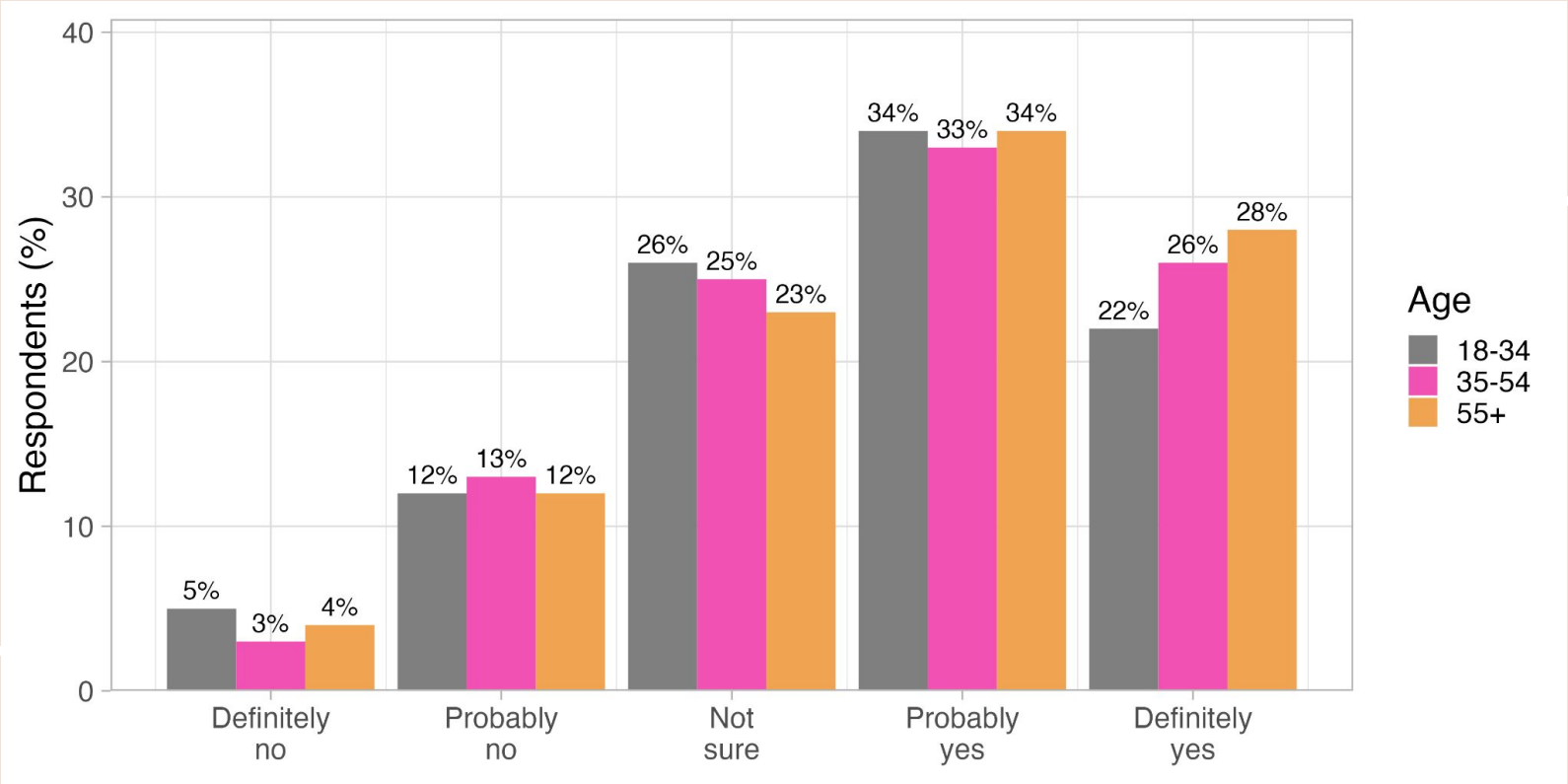
If a you receive a Snow Squall Warning via Wireless Emergency Alert, delay travel or exit the highway at the next opportunity.

SNOW SQUALL WARNING IMPACT TAG	Explanation	Wireless Emergency Alert?
General (No Tag)	To be used during the overnight hours OR for snow squall conditions in which the threat to safe travel will be reduced if drivers reduce speed and increase stopping distance	No
Significant	**Used only when snow squalls pose a *substantial* threat to safe travel.**	Yes

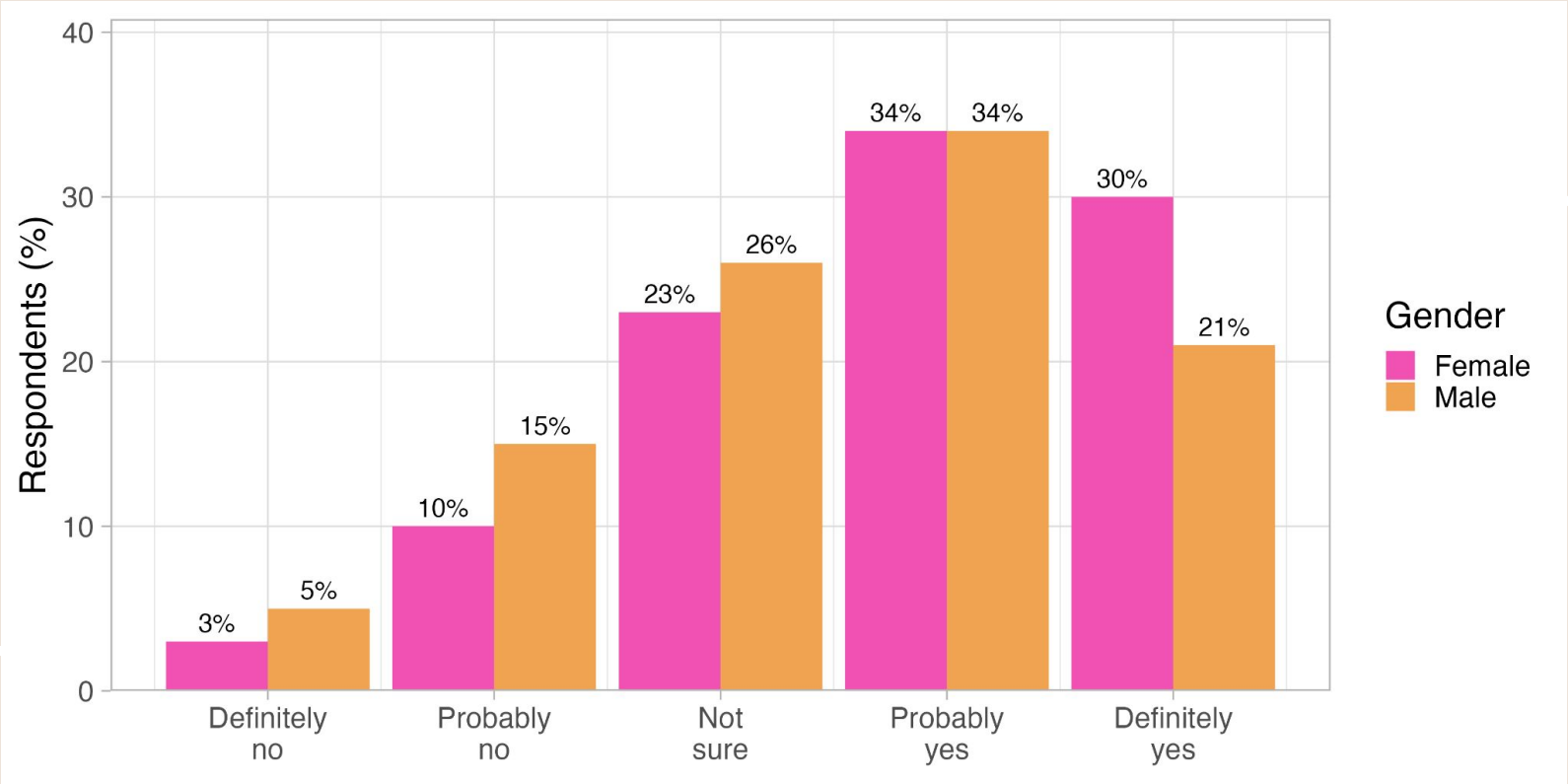
www.weather.gov/ctp/snowsquall

#SnowSquallSafetyPA

Would you get off at the next exit if you were to receive a *snow squall* warning while driving on a highway or interstate?



Would you get off at the next exit if you were to receive a *snow squall* warning while driving on a highway or interstate?



Snow Squall Safety

https://youtu.be/JqX1_ZPPVS8

A coordinated message from

The National Weather Service
Pennsylvania Emergency Management Agency
Pennsylvania Department of Transportation
Pennsylvania Turnpike Commission
Pennsylvania State Police