Understanding Decision-Making During Severe Weather: Examining Responses to Geographic Reference Classes, Tornado Warnings, and Probabilistic Hazard Information

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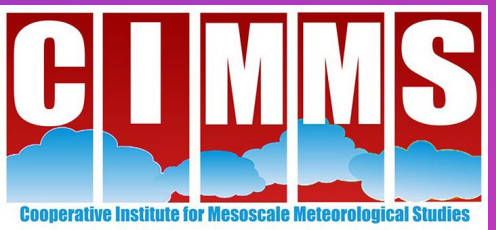

Outline

- ✔ Building a program of research
- ✔ General study methodologies
- ✔ Study specifics and high-level findings
- ✔ Conclusions & Practical implications
- ✔ Future directions

Building a Program of Research

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What did I come here to do?

- ✔ Gaps in the literature:
  - How should probabilistic hazard information (PHI) be formatted?
  - What ***is*** the reference class of probabilistic forecast information?
- ✔ Goal: How is PHI understood and used by laypersons in decision-making? How can PHI be effectively communicated to the public?
  - Original research
  - Extend lab's end-user research to the public
  - Multi-disciplinary approach

How did I tackle this feat?!

- ✓ Series of studies balancing methodologies, theoretical perspectives, and collaboration
- ✓ Examined the decision-making trade-off between highly localized and higher probability tornado threat information (Study 1)
- ✓ Assessed the impact of warning message components on decisions and psychological appraisals of warnings (Study 2)
- ✓ Extended JTTI work to directly assess public reactions to PHI (Study 3)

What makes my work unique?

- ✓ Inclusion of psychological difference measures
- ✓ Different cultural lens
- ✓ Mixed methods approaches (e.g., experimentation, focus groups)
- ✓ New methods (for me) including decision trials
- ✓ New statistical techniques
- ✓ Intentional focus on public decision-making w/ diverse samples
- ✓ Integration of discipline-spanning theoretical perspectives

Let's Talk Research: Bird's Eye View

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General Methodology Overview: Participants

- ✔ *N* = 3,991 participants (all studies combined)
- ✔ Proportionately sampled from NWS Regions (Studies 1 & 3) and "tornado-prones states" as defined by SPC (2016; Study 2)
- ✔ Nationally representative across several demographics
  - Age, gender, race, ethnicity, education, income

Storm Prediction Center (2016). Average Annual Number of Tornadoes Per State (2005-2014). https://www.spc.noaa.gov/wcm/

General Methodology Overview: Designs

- ✔ Mixed experimental designs (all studies)
  - Manipulated independent variables
  - Random assignment to experimental conditions
  - Both between- and within-subjects variables
- ✔ Inclusion of individual psychological difference measures
  - Numeracy, need for cognition, need for closure

General Methodology Overview: Procedures

- ✔ Informed consent
- ✔ Demographics
- ✔ Individual difference and background questions
- ✔ Experimental Stimuli
- ✔ Primary dependent measures and other questions
- ✔ Wrap-up: manipulation checks, exit questionnaire, debriefing

General Results Overview

- ✔ Variety of statistical techniques:
  - Multiple regressions
  - Analysis of Variance (ANOVAs)
  - Frequency analyses
  - Content Analyses

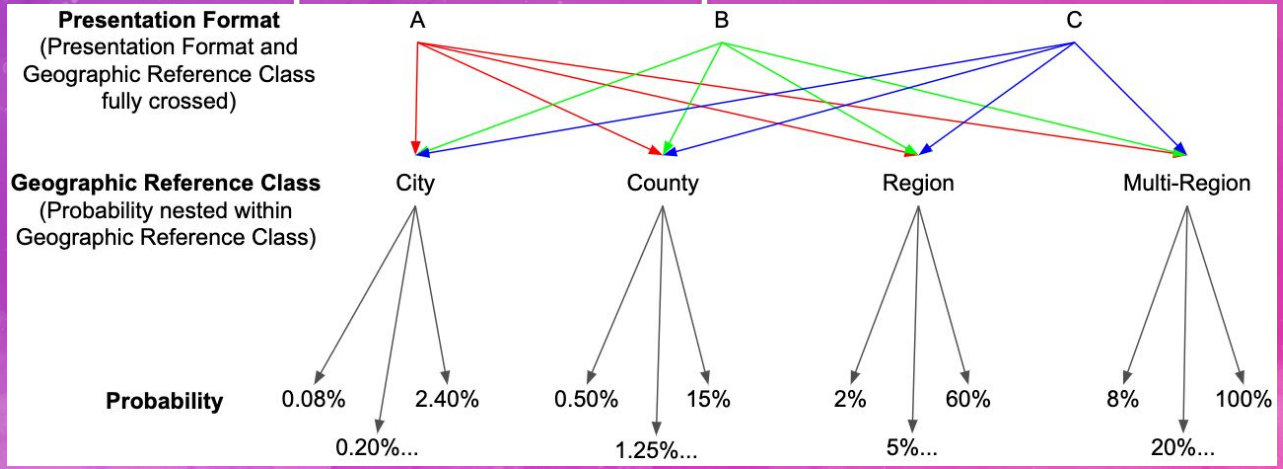
Drilling Down: Study Specifics and High-Level Findings

Study 1 Aims

- ✔ Address reference class concern
- ✔ Understand the trade-off between geographic specificity and forecast probability in protective decisions
- ✔ TWEIP Funding (via Dr. Klockow-McClain)

Study 1: Methodology

- ✔ *N* = 440 participants from NWS Regions & nat'lly representative
- ✔ 4 (geographic reference class) x 12 (probability) x 3 (forecast presentation format: probabilistic, categorical, combination) mixed, nested experimental design



Study 1: Methodology

- ✓ Demographics & Psychological questionnaires
- ✓ Experimental stimuli presented:
  - Presented set of images that corresponded to one geographic reference class and varied in forecast and presentation format
  - Answered questions, including decisions to take action
  - After completing an entire geographic set, responded to the next set…and so forth…until all geographies were complete

According to the Storm Prediction Center (SPC) Convective Outlook, there is a **Moderate Risk** of a tornado **today in the Quad County Area**, which corresponds to a **30% chance** of a tornado **in the Quad County Area.** Based on the information provided, how likely are you to take preparatory action today in response to the potential tornado threat?

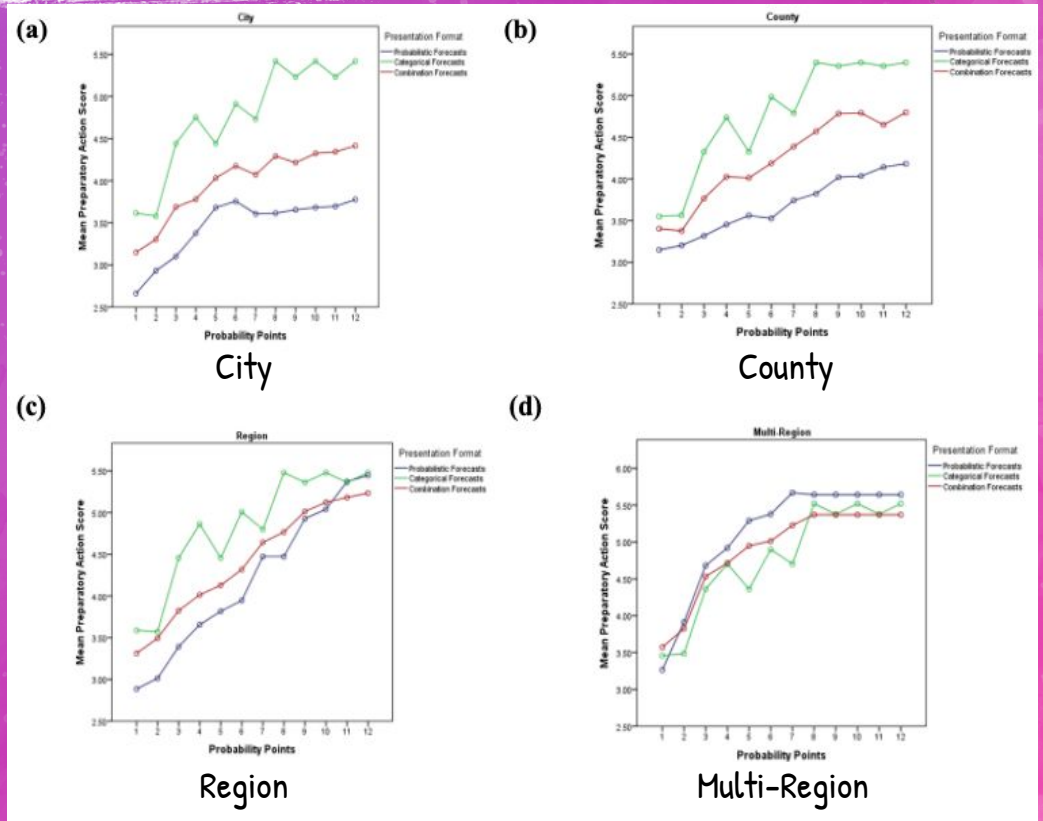
Extremely Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Extremely Likely
-3	-2	-1	1	2	3

Study 1: High-Level Findings

Categorical forecast trend looks similar across multiple geographies

Combined forecasts led to greater preparatory action than probabilistic forecasts at all city and county, and most regional probability points. Reversed trend for multi-region

Participants were more likely to take action at a lower probability and at a much faster (steeper) rate for the region and multi-region locations than for the city and county locations



Study 1: High-Level Conclusions

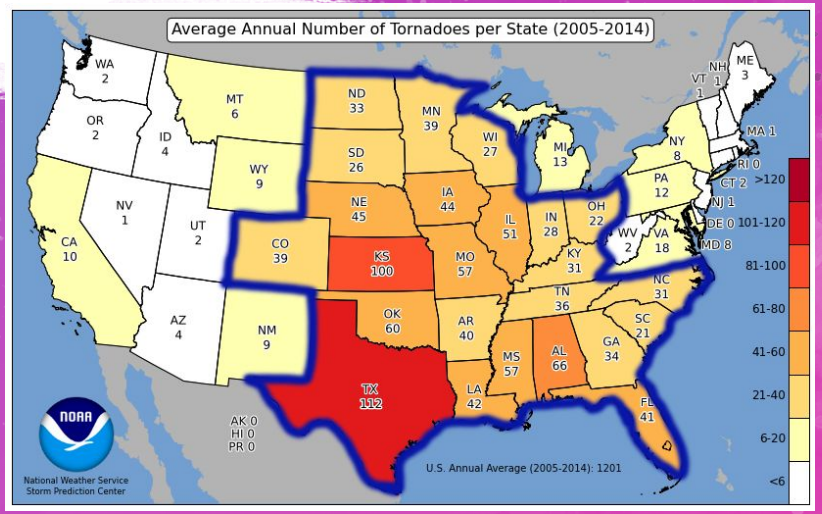
- ✔ Contradicts previous findings that people are more responsive at local levels; probabilities were too small
  - Local forecasts need to be more "tangible;" supports storm-based PHI
- ✔ Presentation format matters

Progression from Study 1 to Study 2

- ✓ Wanted to add more social psychology
- ✓ Better understand if people were responding to the threat or the action, and whether they were being rational or emotional
- ✓ Dig more into the warning itself
- ✓ TWEIP Funding (via Dr. Klockow-McClain)

Study 2: Methodology

- N = 548 participants from tornado-prone states & nat'lly representative (2 data runs)
- 7 (forecast) x 2 (impact statement) between-subjects experimental design



		Factor 2: Impact Statement	
		Traditional Impacts	Sig. Severe Impacts
Factor 1: Likelihood of Occurrence	Deterministic Forecast	A	B
	5%	C	D
	25%	E	F
	45%	G	H
	50%	I	J
	65%	K	L
	85%	M	N

Study 2: Methodology

- ✓ Demographics & Psychological questionnaires
- ✓ Experimental stimuli presented:
  - Presented warning message and graphic that varied in forecast and impacts
  - Answered questions, including decisions to take action and cognitive/affective threat and action appraisals
    - Cognitive: susceptibility, severity, self-efficacy, response efficacy
    - Affective: fear arousal, fear of action

As you read the following information and respond to the questions that follow, please imagine that a storm is approaching **Newfield County** and the **city of Summercrest**, which is **where you live**. **This storm may be capable of producing a tornado**. In response to this threat, you receive an alert containing the following information from the National Weather Service:

The National Weather Service in Summercrest has issued a

***Tornado Warning For...**
Newfield County in Southwestern Centralia...

*Until 6:00 PM CST.

*At 5:02 PM CST, a severe thunderstorm capable of producing a tornado was located 11 miles southwest of Summercrest, moving northeast at 65 MPH toward the city.

Hazard...Tornado.

Source...Radar indicated rotation.

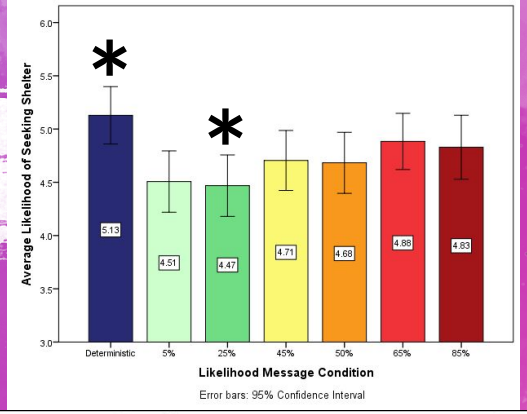
*There is a **45% chance** of a tornado **in the next hour in Summercrest**. Because of this risk potential, a tornado warning has been issued by the National Weather Service.

*Significant Severe Impacts...The tornado could cause **significant severe damage.** The tornado could be **especially destructive (EF2 or above).** The tornado is capable of widespread significant wind damage. **You are in a life-threatening situation.** Flying debris may be **deadly** to those caught without shelter. Mobile homes will be **destroyed. Considerable damage** to homes, businesses and vehicles **is likely. Complete destruction is possible.**

*Precautionary / Preparedness Actions...
Take cover now! Move to a basement or an interior room on the lowest floor of a sturdy building. Avoid Windows. If you are outdoors, in a mobile home, or in a vehicle, move to the closest substantial shelter and protect yourself from flying debris. Do not wait to see or hear the tornado. For your protection, move to an interior room on the lowest floor of a building.

Study 2: High-Level Findings

- Likelihood of tornado occurrence significantly impacted the likelihood participants would seek shelter
  - Highest under deterministic forecast, but could be due to poor calibration
  - Probabilities could help calibration
- Both cognitive and affective appraisals were important to sheltering decisions
- Opposing danger control and fear control responses
  - More positive perceptions of sheltering increased intentions
  - More message derogation decreased intentions



Predictor	*B*	*SE*	ΔR^2
Step 1: Demographic Covariates			.04*
Male	-0.26*	.12	
Having a home shelter	0.29†	.15	
Access to a community shelter	0.30*	.12	
Step 2: Previous Experiences			.03**
Previous experience with severe storms	0.06†	.03	
Tornado risk prone perceptions – City/Town	0.05*	.03	
Shelter under warning	0.14†	.08	
Step 3: Individual Differences			.00
No significant predictors			
Step 4: Cognitive and Affective Appraisals			.25***
Susceptibility	0.22***	.05	
Self-Efficacy	0.17***	.05	
Fear arousal	0.22***	.05	
Danger Control	.01†	.00	
Fear Control – Derogation	-0.16*	.08	

Note. $N = 503$. *B* = unstandardized regression coefficient, *SE* = standard error, ΔR^2 = change in coefficient of determination.

† $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$.

Study 2: High-Level Conclusions

✔ Communication implications:

- Make it "personal"
- Continuing to emphasize efficacy of sheltering and communicating other protective options
- Stressing the dangers without overly scaring people or "hyping"

Progression from Study 2 to Study 3

- ✔ Build on communicating forecast uncertainty in previous study and end-user research
- ✔ Dive more deeply into what PHI could actually look like for public consumption
- ✔ CIMMS DDRF Funds (Lead PI)

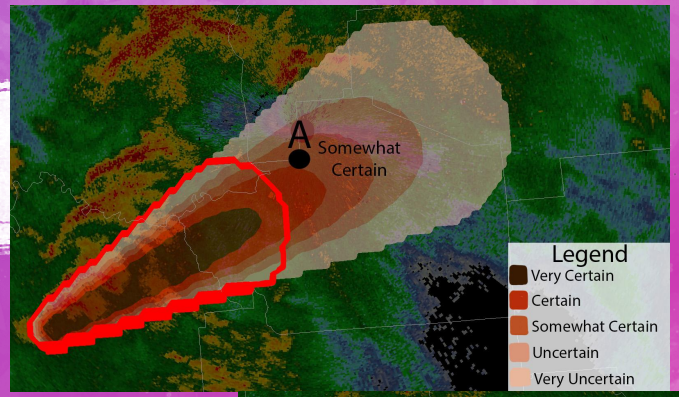
Study 3: Methodology

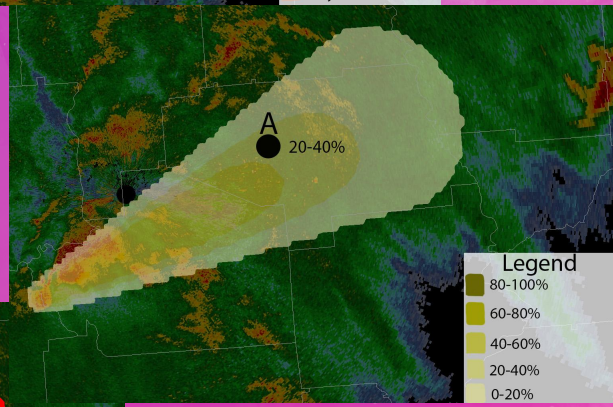
- N = 3,003 participants from NWS Regions & nat'lly representative
- 3 (warning philosophy) x 2 (hazard) x 2 (storm probability) x 4 (labeling scheme) mixed experimental design

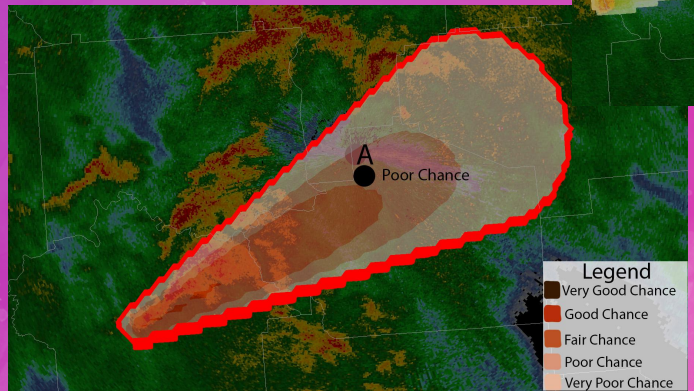
Storm Probability (W/In)	High				Medium			
	Labels (B/T)							
Warning Philosophy (B/T)	Probability	Likelihood	Chance	Certainty	Probability	Likelihood	Chance	Certainty
No Warning	A	D	G	J	A	D	G	J
Partial Warning	B	E	H	K	B	E	H	K
Full Warning	C	F	I	L	C	F	I	L

Study 3: Methodology

- ✓ Demographics & Psychological questionnaires
- ✓ Experimental stimuli presented:
  - Viewed one experimental image, answered a series of questions and then repeated the process (4 images total)

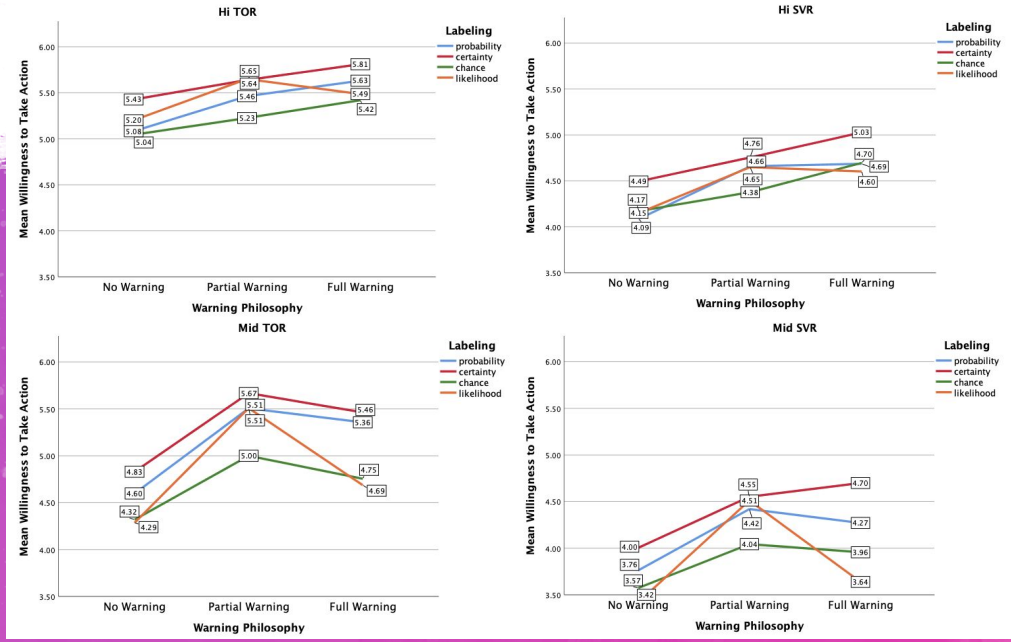


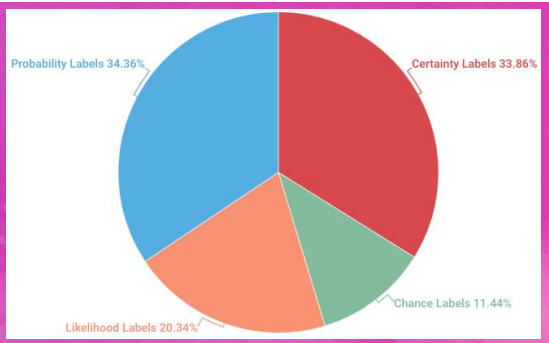




Study 3: High-Level Findings

- Tornado hazard and high storm prob led to more action
- No warning led to less action
- Certainty labels led to most action
- Relation between warnings and labels varies by hazard/storm prob
- Participants preferred certainty and probability labels
- Drawbacks:
  - Color scheme
  - Missing context





Study 3: High-Level Conclusions

- ✔ Tornadoes prompt more action, even with no warning and low prob
- ✔ Complex relations among warnings, labels, hazards, and storm probabilities
  - May not be a "one size fits all" fix
  - Implications for importance of warning proximity to location
- ✔ Certainty labels most effective for encouraging action and chance labels least effective
- ✔ PHI graphics are usable, but would not stand-alone

Tying it Together: Practical Implications and Future Directions

Taken Together...

- ✔ Collaborative approach taken
- ✔ Better understanding of the role of individual differences in protective decisions
- ✔ Insight into what works (probabilistic forecasts, warning philosophy) and what *doesn't* work (impact statements, labeling schemes) for communicating forecast uncertainty
- ✔ Working knowledge that can inform other studies' and product designs

What's Next?!

- ✔ Continue building this program of research, especially in addressing the needs of vulnerable communities
- ✔ Incorporate findings into NOAA HWT Emergency Manager Experiment
- ✔ Work on publications (1 under review, 1 in preparation, and 1 in queue)

What else do I do here, though?

- ✔ CIMMS Diversity & Inclusion Committee Member
  - Inequities Within A&GS Project
- ✔ Peter Lamb Postdoc Selection Committee Member
- ✔ SIG Affiliates Working Group Member
- ✔ NOAA HWT Emergency Manager Experiment
- ✔ NOAA Cooperative Science Center for Atmospheric Sciences & Meteorology (NCAS-M) Ombudsman (and liaison for EM exp.)

Thank you so much!

Questions, comments, and/or concerns?

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