

**Communicating uncertainty in
weather forecasts: Results from
a survey of the U.S. public**

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Overview of talk

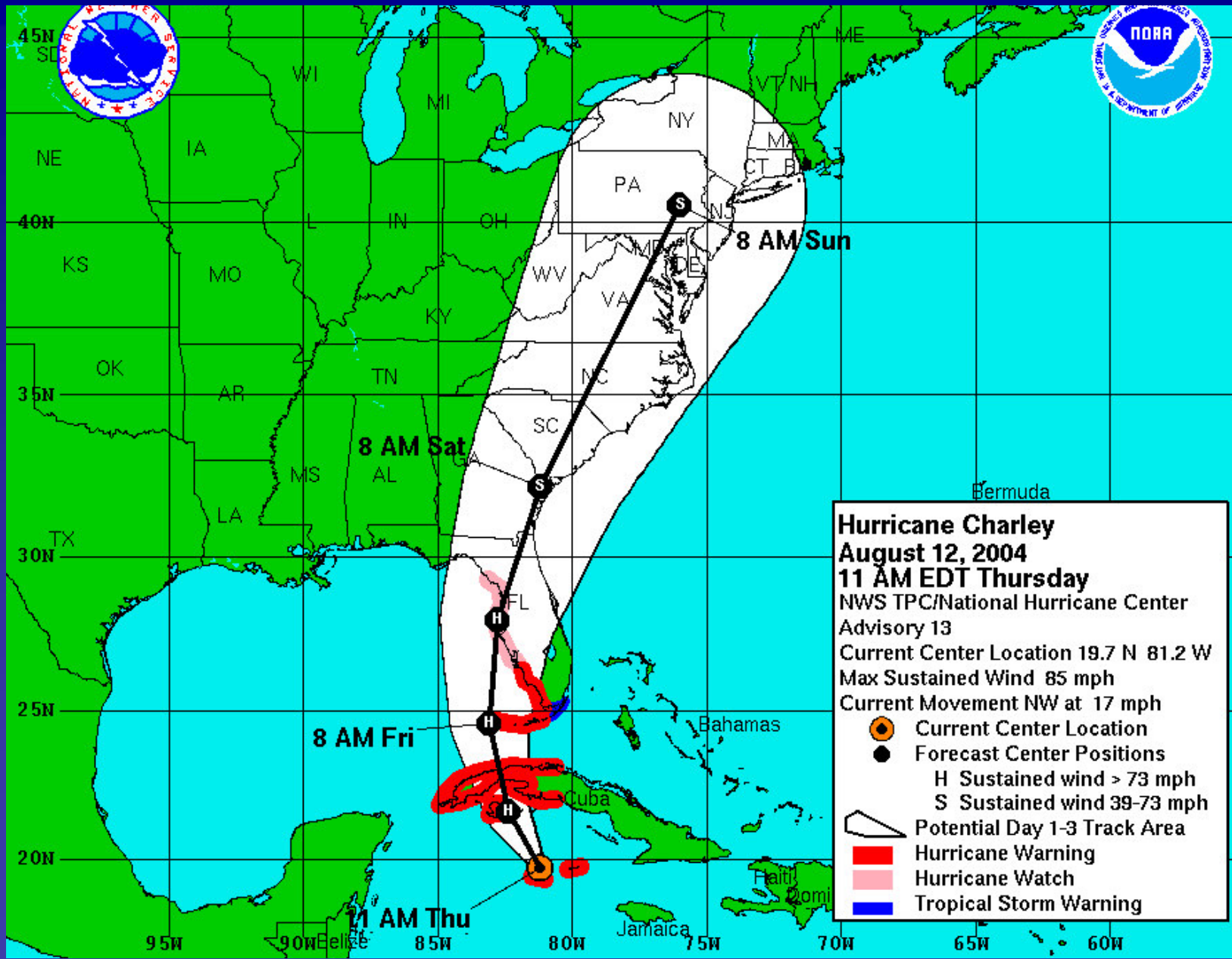
- Motivation, approach
- Nationwide survey to assess the public's views on
 - everyday weather forecasts
(Lazo et al., *BAMS*, in preparation)
 - weather forecast uncertainty
 - weather forecast uncertainty information
(Morss et al., *Weather and Forecasting*, in press)
- Ongoing and future work
- Discussion

Motivation

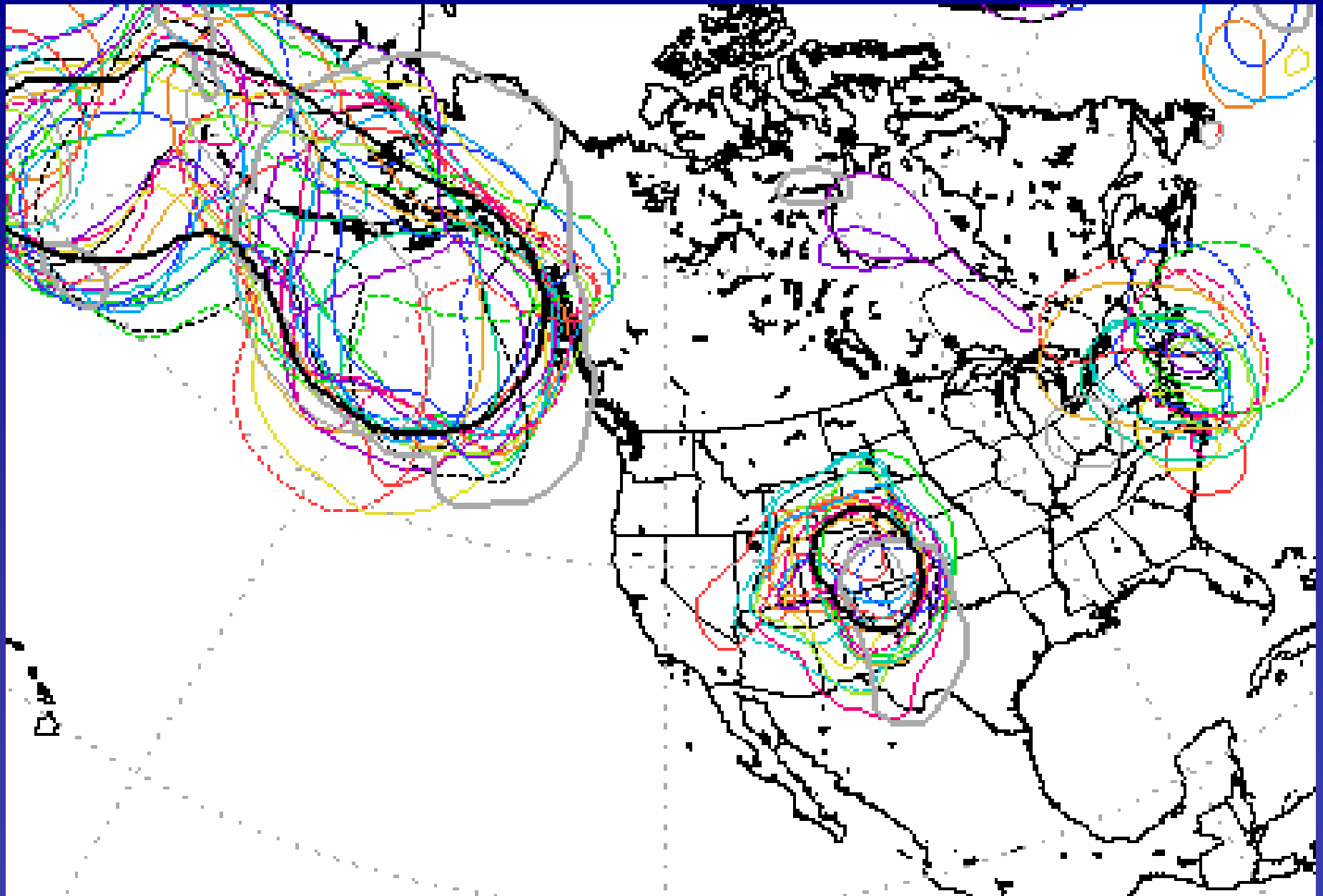
- Weather forecasting community wants to *provide useful weather forecasts and communicate forecast information effectively*
- Doing so requires *understanding users' forecast information needs, perceptions, interpretations, preferences, and uses*
- In context of NWS mission → audience for NWS forecasts includes intermediaries, specific user groups, and *public*

Motivation: Communicating uncertainty

- Weather forecasts are inherently uncertain ...
And many users realize forecasts are imperfect ...
But most current weather forecast information provided to the public is deterministic
- Interest in providing uncertainty information ...
But it is challenging to do so effectively
- Community and NWS attention, e.g.:
 - National Research Council study (2006)
 - AMS Ad Hoc Committee on Uncertainty Forecasts
 - NOAA/NWS Forecast Uncertainty Steering Team
 - WMO Guidelines on Communicating Forecast Uncertainty (2008)



(Hurricane Charley – August 2004)



(Winter weather – December 2007)

Gaps between forecasts generated and those received and used \Rightarrow

- Why don't people understand forecasts?
- Why don't people use forecasts?

Gaps between forecasts generated and those received and used ⇒

- Why don't people understand forecasts (the way we think they should)?
- Why don't people use forecasts (the way we think they should)?

Gaps between forecasts generated and those received and used ⇒

- How do people perceive and interpret forecasts?
- How do people use forecasts?
- How can we improve and communicate forecasts in ways that benefit interpretation and use?

Use social science / interdisciplinary research techniques

Frame from societal / use perspective

Study objectives

- To help the meteorological community in effectively providing weather forecast information, including uncertainty
 - by building empirical knowledge about what people think, want, use, etc.
 - starting with fundamental questions, “everyday” weather
- This understanding can help guide future work, aid user-oriented product development efforts

Study design and data

- Nationwide survey of U.S. households, implemented on Internet in November 2006
- Controlled-access, web-based implementation, with respondents provided by survey sampling company
- Analysis based on N=1465 respondents
- Respondent population is geographically diverse and similar to U.S. public, but somewhat older, wealthier, more educated

Survey questions

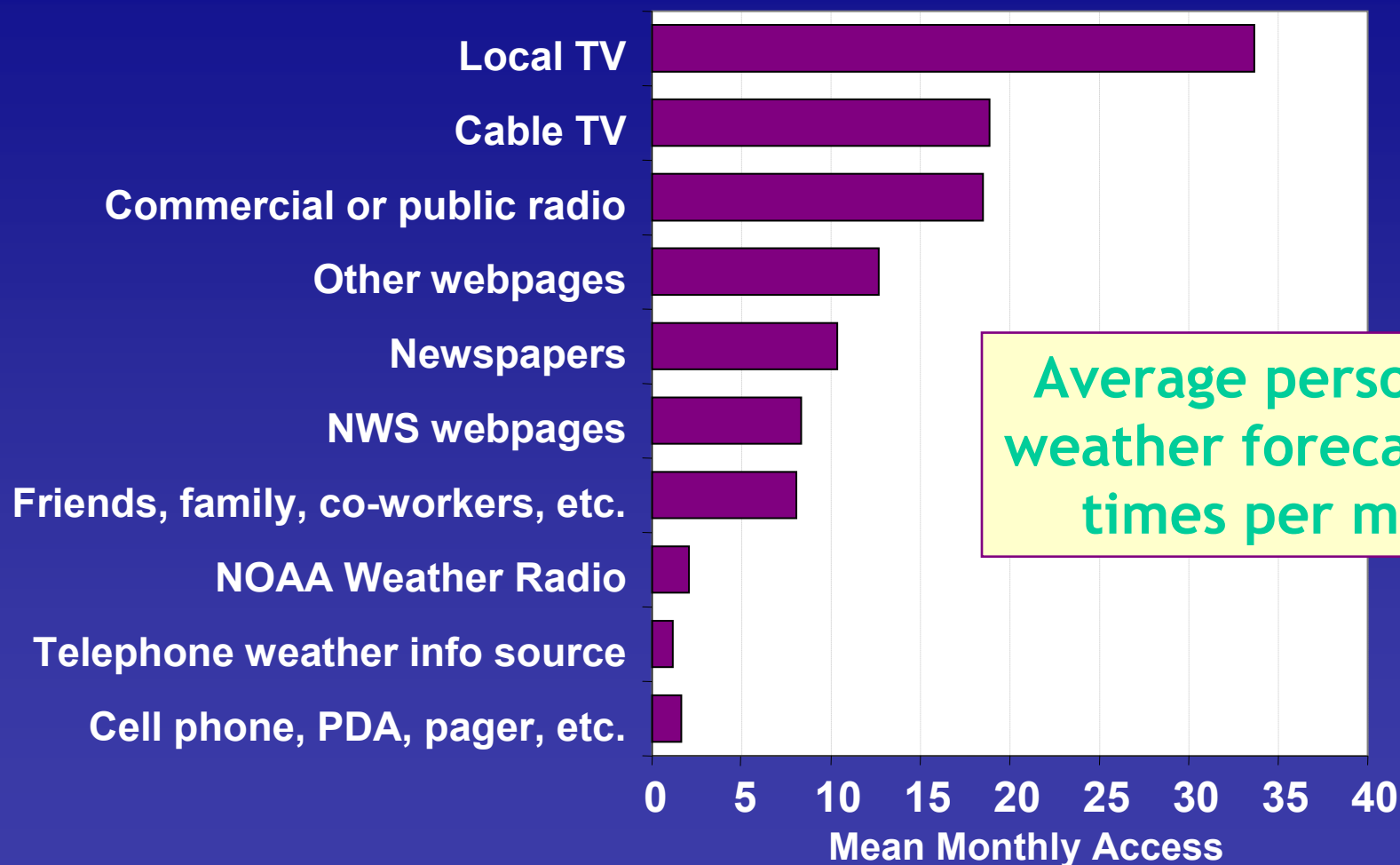
- Survey questions: some based on previous research, some to explore unaddressed aspects of forecast uncertainty communication
- Survey developed iteratively, pre-tested
- Survey questions on people's
 - sources, perceptions, uses, and value of weather forecast information
 - perceptions of, interpretations of, and preferences for weather forecast uncertainty information
 - use of weather forecast uncertainty information
 - “weather salience” (A. Stewart)
 - demographics

How often do you get weather forecasts from the sources listed below?

	Rarely or never	Once or more a month	Once a week	Two or more times a week	Once a day
Commercial or public radio	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Telephone (dial-in) weather information source	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Newspapers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cable TV stations (e.g., CNN, The Weather Channel)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Local TV stations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Friends, family, co-workers, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cell phone, personal desk assistant (PDA), pager, or other electronic device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other webpages	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
National Weather Service (NWS) webpages	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
NOAA Weather Radio	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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How often do you get weather forecasts from the sources listed below?



Average person gets weather forecasts 115 times per month

With over 226 million U.S. adults, this totals to over 300 Billion forecasts accessed a year

How important is it to you to have this information as part of a weather forecast?

Most important

- *Precipitation: When, where, type, chance (PoP)*
~70% of responses: very or extremely important
- *High temperature*
- *Amount of precipitation*
- *Low temperature*
- Wind speed
- Humidity
- Cloudiness
- Wind direction

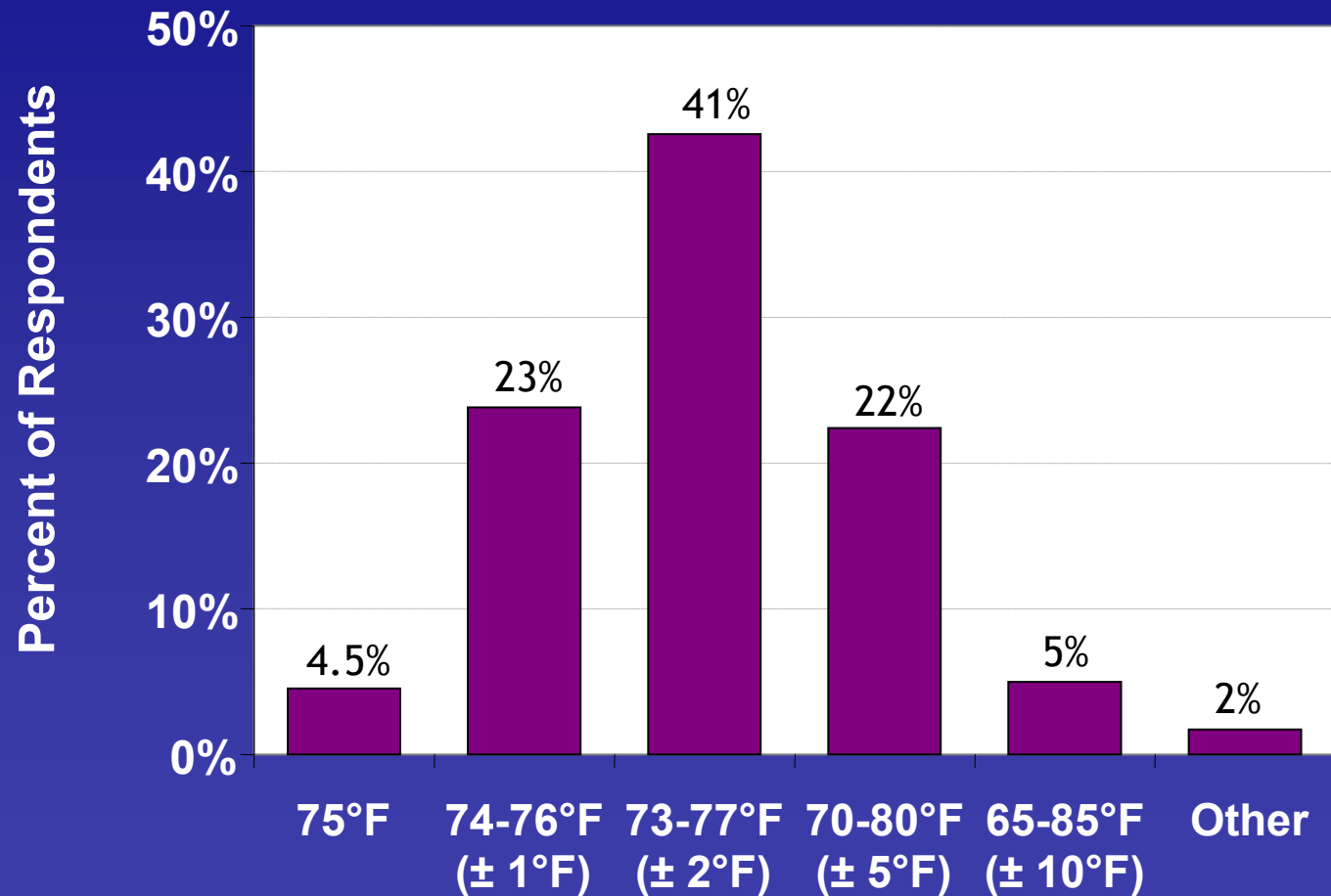
Least important

Uncertainty research questions

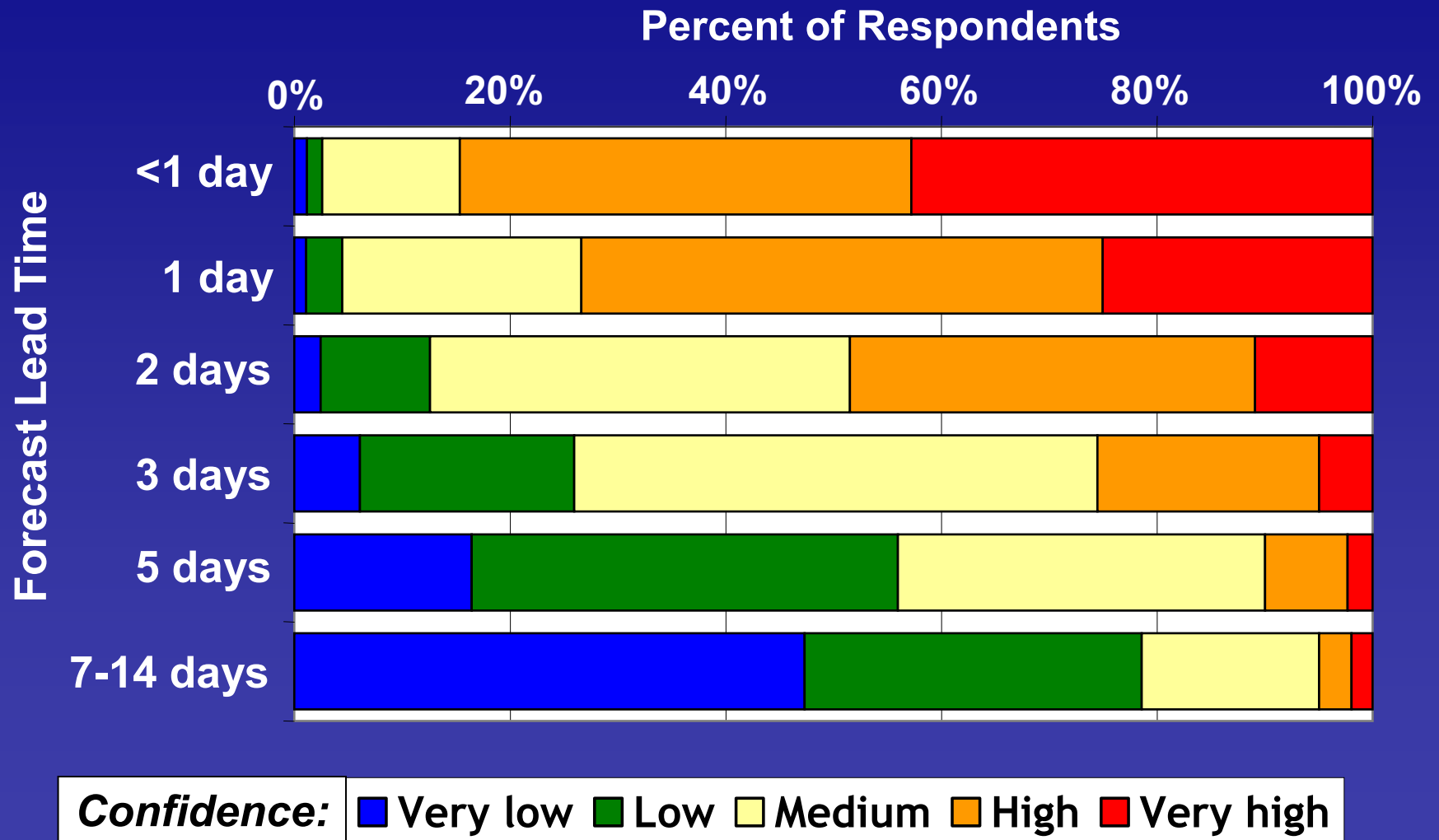
- Do people infer uncertainty into deterministic forecasts?
If so, how much? *PERCEPTIONS*
- How much confidence do people have in different types of weather forecasts?
- How do people interpret a type of uncertainty forecast that is already commonly available: Probability of Precipitation (PoP) forecasts? *INTERPRETATIONS*
- To what extent do people prefer to receive deterministic forecasts vs. those that express uncertainty?
- In what formats do people prefer to receive forecast uncertainty information? *PREFERENCES*

Suppose the forecast high temperature for tomorrow for your area is 75°F.

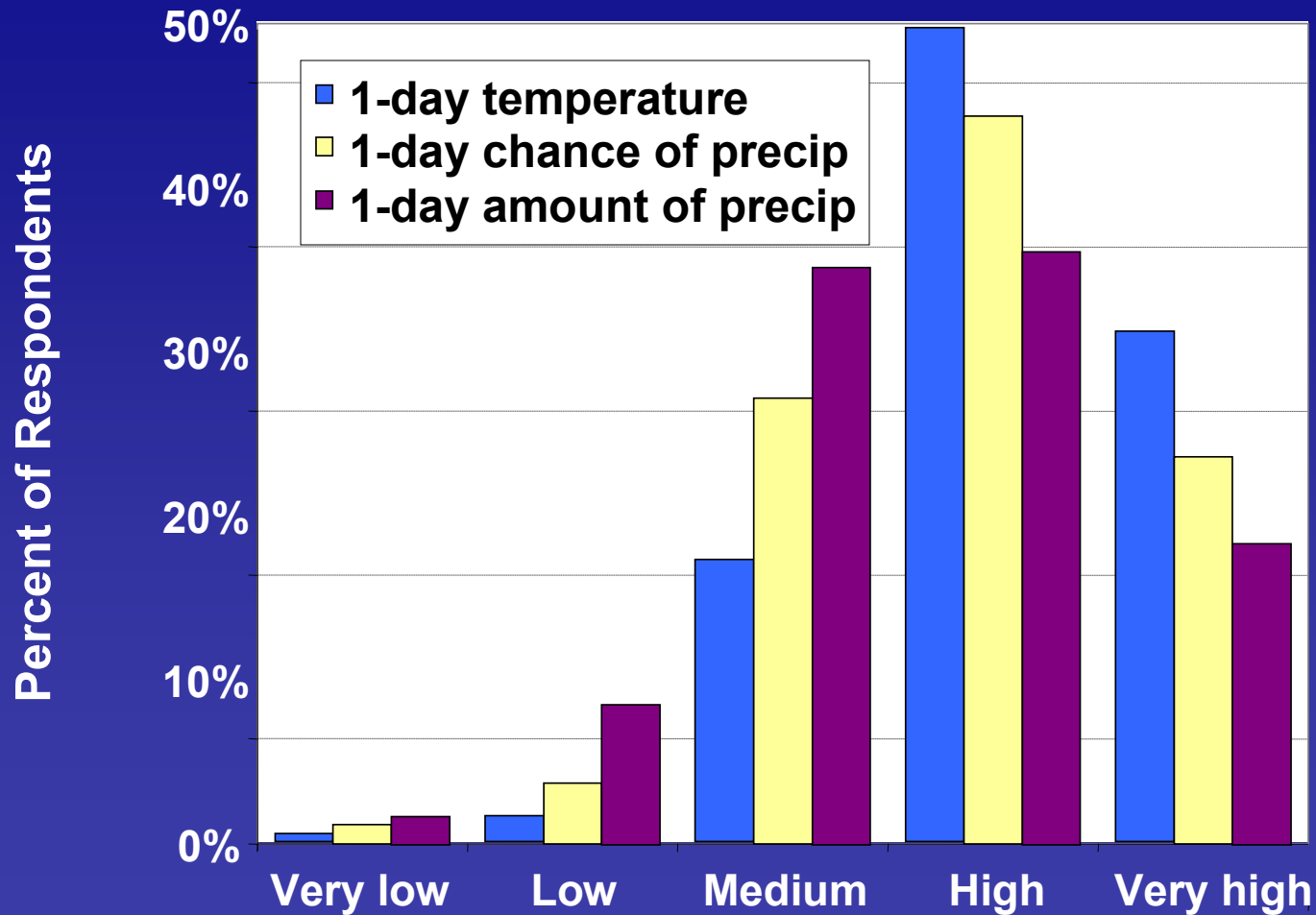
What do you think the actual high temperature will be?



How much confidence do you have in forecasts ...?



How much confidence do you have in forecasts ... ?



Interpretation of PoP

- Builds on previous related work by Murphy et al. (1980), Gigerenzer et al. (2005), others
- Asked all respondents about 2 PoP forecasts:
 - “There is a 60% chance of rain tomorrow”
 - “Rain likely tomorrow”
- Two versions of each question:
 - Closed-ended: ~90% of respondents
 - Open-ended: ~10% of respondents (“Explain in your own words”)

Suppose the forecast is “There is a 60% chance of rain tomorrow”.

Which of the options do you think best describes what the forecast means?

Response option (N=1330)	Percent of respondents
It will rain tomorrow in 60% of the region.	16%
It will rain tomorrow for 60% of the time.	10%
It will rain on 60% of the days like tomorrow.*	19%
60% of weather forecasters believe that it will rain tomorrow.	23%
I don't know.	9%
Other (please explain)	24%

* Technically correct interpretation, according to how PoP forecasts are verified (Gigerenzer et al. 2005)

PoP: Open-ended interpretations

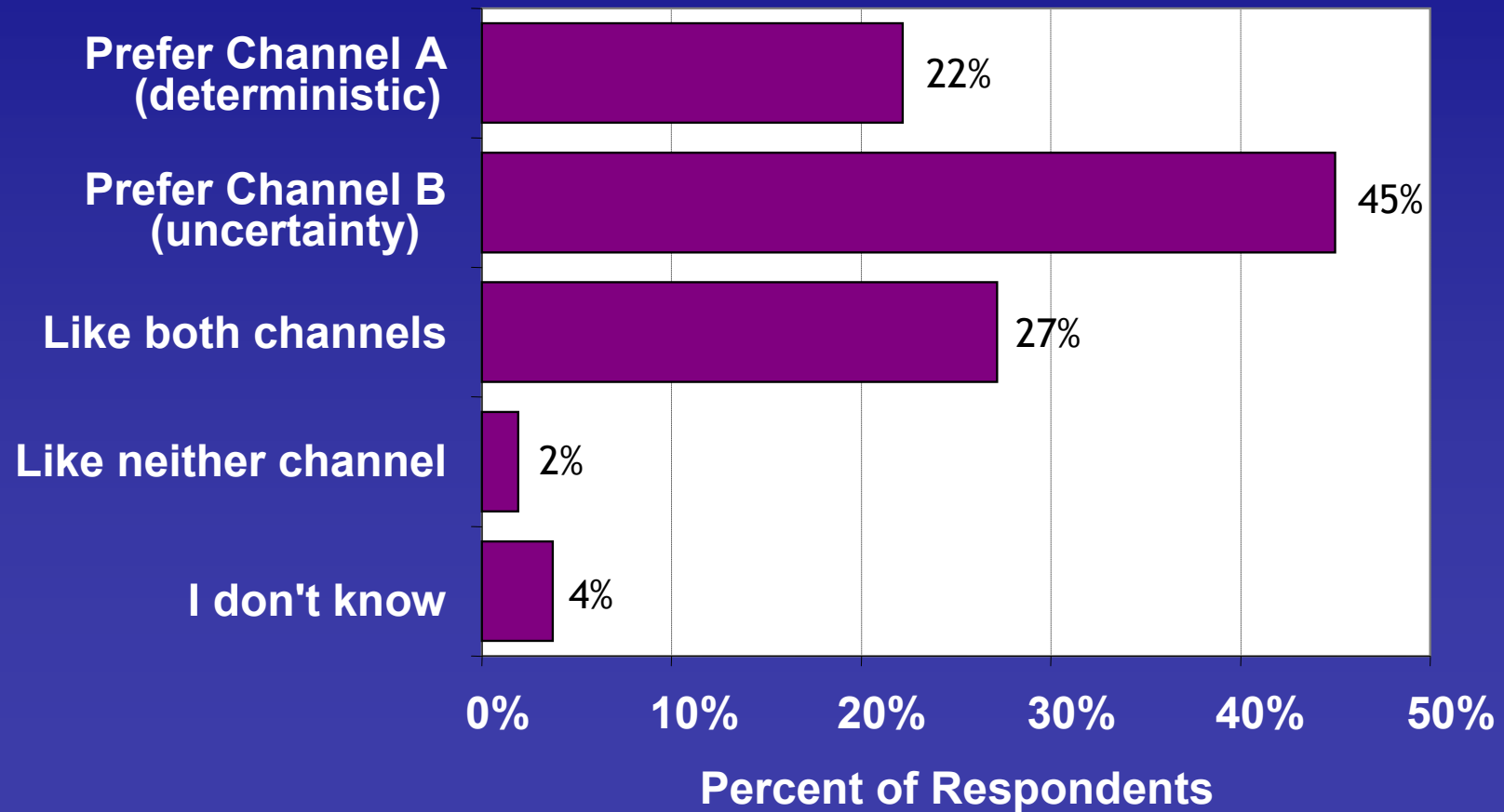
- Many responses repeat PoP, without clarification
- Few offered options from multiple choice version
- Variety of other responses, some from “personal” or “use” perspective
- Most people don't know technically correct definition of PoP — 60% chance of what?
 - But asking about PoP from a meteorological perspective may have limited relevance ...
People must infer what the forecast means for their interests

Uncertainty research questions

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If so, how much? *PERCEPTIONS*
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Suppose you are watching the local evening news

- Channel A: high temperature will be 76°F tomorrow
- Channel B: high temperature will be between 74°F and 78°F tomorrow.



Suppose the high temperature tomorrow will probably be 85°F. However, a cold front may move through, in which case the high would only be 70°F.

Would you like the forecast given this way?

The high temperature tomorrow...

...will be 85°F (**deterministic**)

...will most likely be 85°F, but it may be 70°F (**WITHOUT explanation**)

...will most likely be 85°F, but it may be 70°F, because a cold front may move through (**WITH explanation**)

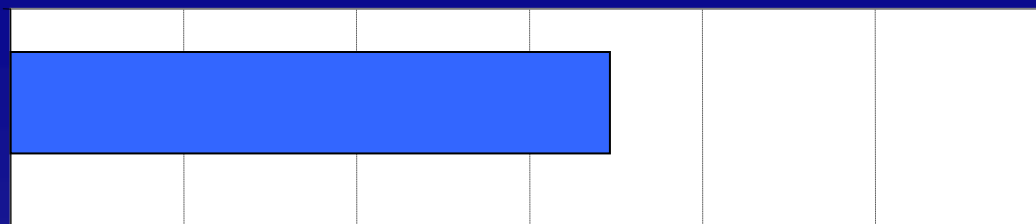
...will be between 70°F and 85°F

...will be between 70°F and 85°F, because a cold front may move through

80% chance it will be 85°F, 20% chance it will be 70°F

80% chance it will be 85°F, 20% chance it will be 70°F, because a cold front may move through

Will be 85°F

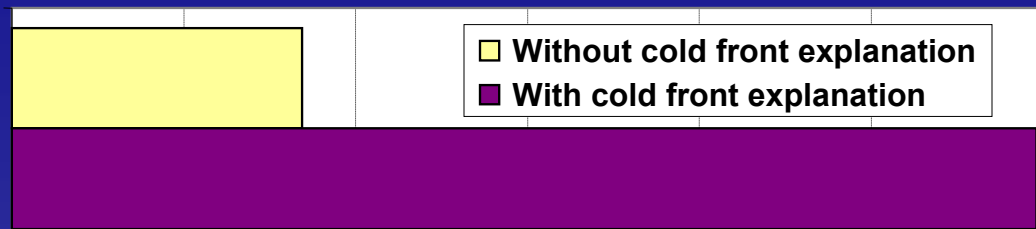


0% 10% 20% 30% 40% 50% 60%

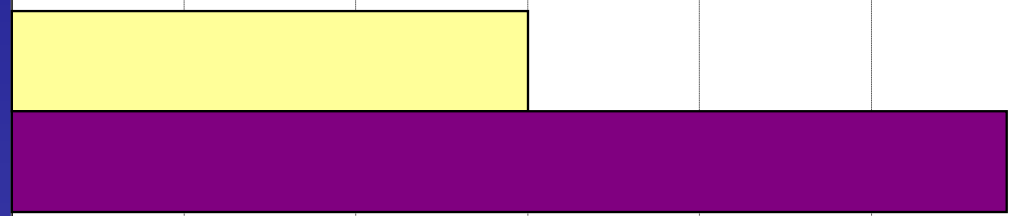
Deterministic
~35%

Deterministic
only ~7%

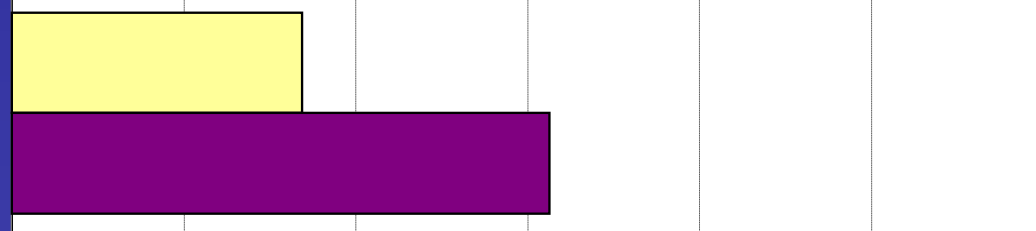
Most likely 85°F
but may be 70°F



Between 70-85°F



80% chance 85°F
20% chance 70°F



0% 10% 20% 30% 40% 50% 60%

Percent of Respondents Who Like Format

Uncertainty
>90%

Uncertainty
only ~63%

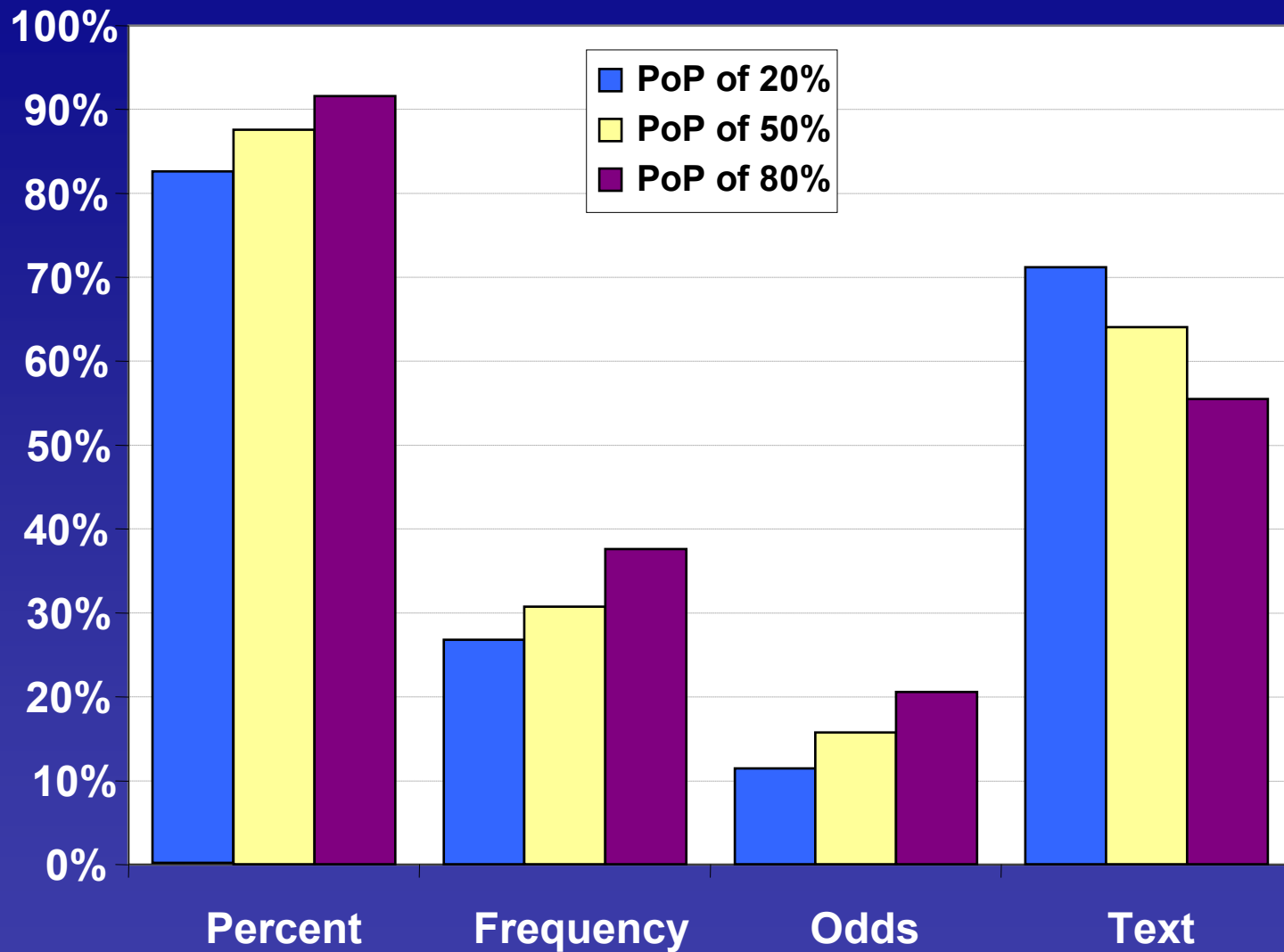
All the choices below are the same as a probability of precipitation of 20%.

Do you like the information given this way?

- Chance of precipitation is **20%** → Percent
- There is a **1 in 5 chance** of precipitation → Frequency
- The **odds are 1 to 4** that it will rain → Odds
- There is a **slight chance** of rain tomorrow → Text

*Asked this question 3 ways --
using PoPs of 20%, 50%, and 80%
with corresponding text descriptions from NWS*

Percent of Respondents Who Like Format



N = 489, 489, 487

Summary of results

- Most people think weather forecasts are uncertain
- Most people have some understanding of relative uncertainty in forecasts
- Most people don't know the technical definition of Probability of Precipitation – but ...
 - PoP is important to many people
 - People have built sufficient understanding of PoP through experience?
- Majority of people like uncertainty forecast information, and many prefer it
- Need to understand people's communication preferences

Implications for communication

- Explicit communication of everyday weather forecast uncertainty
 - may not reduce forecasters' credibility
 - is desired by some and acceptable to many
 - may augment people's general notions of forecast uncertainty with situation-specific information
- Ask not whether people understand uncertainty forecast information precisely, but whether they can interpret it well enough to find it useful?
- Key: developing “effective” communication formats

Future work

- Further analysis of data from this survey (including geospatial analysis)
- Further interdisciplinary research on
 - Interpretations of and preferences for various communication formats (including graphics), for different weather types (including high-impact)
 - People's use of uncertainty information in decisions
- Integrate results with meteorological knowledge to improve forecast communication ⇒
Iterative, dynamic process that connects learning from forecast users with product development

Questions?

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