People's Attitudes about Weather Forecasts and Forecast Uncertainty Information

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NCAR Societal Impacts Program

ATEC Forecasters’ Training
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The forecast high temperature for Boulder tomorrow is 56°F.

What do you think the actual high temp will be?

a) 56°F
b) 55-57°F
c) 54-58°F
d) 51-61°F
e) 46-66°F
How much confidence do you have in forecasts for weather 5 days from now?

- Very low
- Low
- Medium
- High
- Very high
Motivation: What we know

Numerous weather forecasts are provided daily, and are of great benefit! But...

...the weather community and its partners are always looking to provide better information in better ways to better serve the range of users of forecast and warning information.
Motivation: What we don’t know

• Little (publicly available) good, reliable, valid data-based knowledge about people’s attitudes and behaviors regarding weather forecast information, including forecast uncertainty

• Interest in providing uncertainty information, but we have limited understanding of how to do this effectively
We’re all well intentioned

• We have LOTS anecdotal information ... and preconceived notions!
• We have LOTS of questions!
• What can we and can’t we generalize?

People gamble for money, on sports, etc. They definitely understand and want odds.

People don’t want uncertainty. We developed a product with uncertainty information, and my users didn’t want it.

Does it really matter if we improve our Day 7 forecast by 1 degree?

Are people less confident in forecasts that flip-flop? Will they sacrifice some accuracy for consistency?
Moving forward...

• Tremendous amount of knowledge — concepts, methodologies, theories, tools — from the social sciences that can and should be integrated in partnership with meteorology!
  – Communication, sociology, psychology, economics, decision science, geography, anthropology, etc.

• Couple results with *user-centric* product development efforts and testing

*Provide effective forecast and warning information that people actually want and use rather than what we think they do (or should) want and use*
Survey design and implementation

- Nationwide, controlled-access web survey of U.S. public
- Pre-tested during development and implementation
- Respondent population:
  - is geographically diverse with responses from every state
  - has similar gender and race distribution to the U.S. public
  - is slightly older and more educated

*N=1520 completed responses, but 3.6% of people say they never use weather forecasts; this analysis based on N=1465 responses*
Survey questions

• Some questions based on previous survey research; some developed to investigate fundamental research questions

• Included questions about:
  – Sources, perceptions, uses, and values of weather forecast information
  – Perceptions of, interpretations of, and preferences for weather forecast uncertainty information
  – Use of weather forecast uncertainty information
  – Weather salience (Alan Stewart, U. of Georgia)
  – Demographics, weather-related behavior
There is a science to doing surveys!

### Online Research Survey

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

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

[continue]
Weather forecast questions

- From where and how often do people get weather forecast information?
- What times of day do people get forecasts?
- For what reasons do people get forecasts?
- What weather forecast parameters are important to people?
- For what locations or regions do people get forecasts?
- What is people’s willingness to pay for forecasts?

*(See Lazo et al. 2009 for all results)*
How often do you get forecasts from the sources listed?

- Response options → recoded to lower-bound quantitative count of sources per month
  - Rarely or never → 0 times per month
  - Once or more a month → 1
  - Once a week → 4
  - Two or more times a week → 8
  - Once a day → 30
  - Two or more times a day → 60
Mean # of forecasts obtained monthly

- Local TV
- Cable TV
- Commercial or public radio
- Other webpages
- Newspapers
- NWS webpages
- Friends, family, co-workers, etc.
- NOAA Weather Radio
- Cell phone, PDA, pager, etc.
- Telephone weather info source

Average respondent gets weather forecasts 115 times per month.

Nearly 226 million U.S. adults → 300 billion+ forecasts per year!*

* Accounts for 3.6% of respondents who never use weather forecasts.

N=1465
Use of weather forecasts

- Simply knowing what the weather will be like
- Planning how to dress self or children
- Planning weekend activities
- Planning travel
- Planning yard work or outdoor house work
- Planning social activities
- Planning getting to work or school
- Planning job activities

N=1465
Importance of weather parameters

- When precip will occur
- Chance of precip
- Where precip will occur
- Type of precip
- High temp
- Amount of precip
- Chance of amount of precip
- Low temp
- Wind speed
- Humidity levels
- Time of day high temp will occur
- Time of day low temp will occur
- How cloudy it will be
- Wind direction

N=1465
Forecast uncertainty questions

• How much confidence do people have in different types of weather forecasts?

• Do people infer uncertainty into deterministic forecasts and, if so, how much?

• How do people interpret a type of uncertainty forecast that is already commonly available and familiar: probability of precipitation forecasts?

• To what extent do people prefer to receive deterministic vs. uncertainty-explicit forecasts?

• In what formats do people prefer to receive forecast uncertainty information?

(See Morss et al. 2008 for all results)
Confidence in weather forecasts

Forecast Lead Time

- < 1 day
- 1 day
- 2 day
- 3 day
- 5 day
- 7-14 day

Confidence Levels:

- Very high
- High
- Medium
- Low
- Very low

N=1465
Suppose the forecast high temperature for tomorrow for your area is 75°F. What do you think the actual high temperature will be?
Interpretation of PoP

• ~ 90% of respondents received close-ended version of the question (N=1330)

• ~10% of respondents received open-ended version of the question (N=135)

• 2 versions of close-ended question
  – One with percentage probability (60%)
  – One with NWS non-numerical text equivalent (“likely”)
Suppose the forecast says, “There is a 60% chance of rain tomorrow.”

What do you think best describes what the forecast means?

<table>
<thead>
<tr>
<th>Response option</th>
<th>Percent of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>It will rain tomorrow in 60% of the region.</td>
<td>16%</td>
</tr>
<tr>
<td>It will rain tomorrow for 60% of the time.</td>
<td>10%</td>
</tr>
<tr>
<td>It will rain on 60% of the days like tomorrow.*</td>
<td>19%</td>
</tr>
<tr>
<td>60% of weather forecasters believe that it will rain tomorrow.</td>
<td>23%</td>
</tr>
<tr>
<td>I don’t know.</td>
<td>9%</td>
</tr>
<tr>
<td>Other (please explain)</td>
<td>24%</td>
</tr>
</tbody>
</table>

* Technically correct interpretation, according to how PoP forecasts are verified

N=1330
Open-ended responses re: PoP

• Many *reiterate* PoP without clarification

• Many describe the chance they’ll *personally experience* rain or *personal implications* for action

• Consistent with other studies, majority of people don’t know *technically correct definition* of PoP...

• ...but asking people to think about PoP from a *strictly meteorological perspective* may have limited value; people still have to translate what it means to them personally!
You are watching the local evening news

- The Channel A weather forecaster says the high temperature will be 76°F tomorrow
- The Channel B weather forecaster says the high temperature will be between 74°F and 78°F tomorrow.

N=1465
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 said “yes”

- PoP of 20%
- PoP of 50%
- PoP of 80%

N = 489, 489, 487
Suppose the high temperature tomorrow will probably be 85°F. A cold front may move through, making the high only 70°F. Would you like the forecast given this way?

The high temperature tomorrow...

<table>
<thead>
<tr>
<th>Option</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>...will be 85°F</td>
<td></td>
</tr>
<tr>
<td>...will most likely be 85°F, but it may be 70°F</td>
<td>(WITHOUT explanation)</td>
</tr>
<tr>
<td>...will most likely be 85°F, but it may be 70°F, because a cold front may move through</td>
<td>(WITH explanation)</td>
</tr>
<tr>
<td>...will be between 70°F and 85°F</td>
<td></td>
</tr>
<tr>
<td>...will be between 70°F and 85°F, because a cold front may move through</td>
<td></td>
</tr>
<tr>
<td>80% chance it will be 85°F, 20% chance it will be 70°F</td>
<td></td>
</tr>
<tr>
<td>80% chance it will be 85°F, 20% chance it will be 70°F, because a cold front may move through</td>
<td></td>
</tr>
</tbody>
</table>
Percent of respondents who said “yes"

- **Will be 85°F**
  - Deterministic ~35%
  - Uncertainty >90%
  - N=1465

- **Most likely 85°F but may be 70°F**
  - Deterministic only ~7%
  - Uncertainty only ~63%
  - N=1465

- **Between 70-85°F**

- **80% chance 85°F, 20% chance 70°F**
Communicating Weather Forecast Uncertainty: An Exploratory Study with Broadcast Meteorologists

Julie Demuth, Betty Morrow, Jeff Lazo
Motivation and methods

• Broadcasters
  – Key users and providers of uncertainty information
  – Recall: people access TV forecasts 50+ times/month
  – Experiential knowledge and perceptions
  – Provide verbal, graphical, and numerical information

• Exploratory focus groups
  – Qualitative data collection
  – Moderated, with interaction among participants
  – 3 sessions, 14 broadcasters @ AMS Broadcast Meteorology Conference (Denver, June 2008)
  – 1.5 hours each, data transcribed, coded
Results: Viewer expectations

- Difference in opinion about whether people want deterministic or uncertainty forecast, when, why

I think that temperature-wise the audience wants that number; they want to see an extended forecast either 5-7 days. If you don’t put it on there, they’ll go to another station that does. [Participant #10]

Well, I don’t think they care if you go for a high of 74 and get 79. That’s not going to be important to them. It’s the weather that’s going to interrupt their plans that they want to know about. [Participant #14]
Results: Viewer expectations

• Although people may want deterministic forecast, they’re also realistic in their expectations.

  What they’re after is my best guess. Now, I think most of them realize that there’s uncertainty in weather. [Participant #3]

  I think the public understands in an honest moment ... that there are always going to be some uncertainties in any forecast. [Participant #1]
Results: Expressing uncertainty

- On-air medium allows broadcasters to explain the forecast situation, to use intonation and non-verbal communication; relationships are important!

If it’s a complicated forecast, I’ll say that I’m not too sure what’s going to happen. But not with the numbers... One way, in our 6-day forecast, the way I set it up, we do 3-day and talk those up. We show 3 tombstones. This is what you can expect the next 3 days. And then at the end I show the other 3, but I just kind of brush those off. And here’s what it might look like 6 days out. So there’s a way of expressing uncertainty without having to get into the numbers and PoPs and stuff like that. [Participant #4]

I think that it doesn’t necessarily hurt your credibility, especially if you’ve been in the market for a fair amount of time to just say, “we don’t really know what’s going to happen with this storm yet.” I think the audience can accept that and not think you don’t know what you’re doing. [Participant #10]
Future work

• This survey is just one snapshot in time!
  – Need to conduct these surveys regularly, to assess changes

• Numerous additional research questions to pursue
  – Influences of people’s weather-related experiences & demographics with people’s attitudes & behaviors for weather forecast information
  – These questions in other contexts (e.g., high-impact weather events)
  – Interpretations and preferences for graphical forecasts, depending on medium
Thank you!

- Julie Demuth (jdemuth@ucar.edu)
- References