Improving Communication of Weather Forecast Uncertainty: A Path Forward

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Forecast uncertainty in context

- People understand that weather forecasts are uncertain (and so is everything else)
Suppose the forecast high temperature for tomorrow for your area is 75°F.

What do you think the actual high temperature will be?

Morss, Demuth, Lazo (Weather and Forecasting, 2008)
Forecast uncertainty in context

- People understand that weather forecasts are uncertain (and so is everything else)
- People can make decisions under uncertainty (using uncertainty information)
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?

<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 (Gigerenzer et al. 2005)

Morss, Demuth, Lazo (Weather and Forecasting, 2008)
Probability of Precipitation (PoP)

- Open-ended interpretations of PoP
  - Many responses repeat PoP, without clarification
  - 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 ~70% of respondents said PoP was very or extremely important information in a forecast
  - Can people use and obtain value from information that they don’t fully understand?
Whether/how forecast uncertainty information is used

More
“sophisticated”
user

Less
“sophisticated”
user

“Expert”
user

“Non-expert”
(general public)
user
Whether/how forecast uncertainty information is used

Ability and tools to use quantitative (or complex) uncertainty information

More engaged with weather forecasts / uncertainty

More interested

More qualitative use of uncertainty information

Less engaged

Different perspectives on different risks

Less interested
Improving uncertainty communication

- Different people interpret information and risks differently (sometimes counterintuitively)
If a flash flood warning is issued, how likely is flash flooding in the next 24 hours?

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>46%</td>
</tr>
<tr>
<td>Forecasters</td>
<td>78%</td>
</tr>
<tr>
<td>Local officials</td>
<td>49%</td>
</tr>
<tr>
<td>Media</td>
<td>68%</td>
</tr>
</tbody>
</table>
If a flash flood warning is issued, how likely is flash flooding in the next 24 hours?

<table>
<thead>
<tr>
<th>Group</th>
<th>Likelihood of Flash Flooding (%)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>0% - 0.1%</td>
<td>46%</td>
</tr>
<tr>
<td>Forecasters</td>
<td>0.2% - 1%</td>
<td>78%</td>
</tr>
<tr>
<td>Local officials</td>
<td>2% - 10%</td>
<td>49%</td>
</tr>
<tr>
<td>Media</td>
<td>11% - 20%</td>
<td>68%</td>
</tr>
<tr>
<td></td>
<td>21% - 30%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31% - 40%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>41% - 50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>51% - 60%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>61% - 70%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>71% - 80%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>81% - 90%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>91% - 100%</td>
<td></td>
</tr>
</tbody>
</table>

*Morss, Mulder, Lazo, Demuth (2015)*
Improving uncertainty communication

- Different people interpret information and risks differently (sometimes counterintuitively)
  - These interpretations, along with many other factors, influence use of weather information

- Giving people more / more accurate / more detailed information is often *not* the answer

- Instead, meet people where they are
  - Understand (and appreciate) their perspective
  - Test forecast products! (early and often)
Lessons from risk communication research and practice (adapted from Fischhoff 1995)

Developmental stages in risk communication:

1. “All we have to do is get the numbers right”
2. “All we have to do is tell them the numbers”
3. “All we have to do is explain what we mean by the numbers”
4-5. All we have to do is show them that it has value
6. “All we have to do is treat them nice” (when communicating)
7. “All we have to do is make them partners”
How do we advance weather risk communication?

Ask questions such as:

- How (potentially) important is weather forecast uncertainty for a decision, when?
- What aspects of forecast (un)certainty are most important for people to know or understand?
- What other information is important?
- And how do we best communicate that?
  - to different audiences
  - given the complexity of real-world information communication, risk interpretations, and decision making
Traditional Hazard/Disaster Cycle: Response to a Weather Forecast/Warning

- Preparedness & Warning
- Mitigation
- Recovery
- Response

3 days before landfall

Forecasted area of risk
Forecasted area of risk:

- Coastline
- Storm 5 days before landfall
- 3 days before landfall
- 12 hours before landfall

Recovery, Response, Mitigation, & Warning:

EVENT
How do we communicate weather forecasts and warnings effectively in the “modern information environment”?

- Storm 5 days before landfall
- Forecasted area of risk
- 3 days before landfall
- 12 hours before landfall

Social information network
Coastline
If you hear a flash flood warning and you are outdoors, you should ______

<table>
<thead>
<tr>
<th>Option</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move to higher location</td>
<td>85%</td>
</tr>
<tr>
<td>Move to different location</td>
<td>10%</td>
</tr>
<tr>
<td>Avoid risky areas</td>
<td>9%</td>
</tr>
<tr>
<td>Assess situation</td>
<td>4%</td>
</tr>
<tr>
<td>Be alert</td>
<td>2%</td>
</tr>
<tr>
<td>Seek more information</td>
<td>0.5%</td>
</tr>
<tr>
<td>Depends</td>
<td>3%</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0.5%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
</tr>
</tbody>
</table>

Morss, Mulder, Lazo, Demuth (2015)
If you hear a flash flood warning, you should ...

<table>
<thead>
<tr>
<th>Climb to safety.</th>
<th>Go to higher ground.</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Get to higher ground and hold on.”</td>
<td>“Get to high ground. Climb tree.”</td>
</tr>
<tr>
<td>“Run like nuts.”</td>
<td>“Get as high as possible.”</td>
</tr>
<tr>
<td>“Keep your eyes open ...”</td>
<td>“Move ... out of canyon areas.”</td>
</tr>
<tr>
<td>“Be cautious.”</td>
<td>“Stay away from creeks and rivers.”</td>
</tr>
</tbody>
</table>

“It depends on where you are?”

“Have high ground picked out nearby and go to it if you see the water and debris coming.”

“Think! Assess vulnerability of location and act accordingly ...”

Morss, Mulder, Lazo, Demuth (2015)
Rapid evolution of hazard + spatial variability + situation-dependent vulnerability

 Complexity and uncertainty in protective decision making

“Keep your eyes open ...”

“No ... go haywire.”

“Be cautious.”

“Move ... out of canyon areas.”

“Stay away from creeks and rivers.”

“Have high ground picked out nearby and go if you see the water and debris coming.”

“Think! Assess vulnerability of location and act accordingly ...”

Morss, Mulder, Lazo, Demuth (2015)
Communicating weather forecast uncertainty more effectively requires understanding:
- Forecast and uncertainty estimation capabilities
- How audiences perceive weather-related risks, obtain and interpret information, and make decisions (in theory and in reality)

Concepts and knowledge from risk communication, economics, and other social sciences can help:
- But weather forecast and warning communication also presents its own challenges
Moving forward ...

- “[People] want to know three things: what does it mean to them, what does it mean to their family, and what do they need to do right now. And so don’t speak like a meteorologist. Tell me what we need to know.” (television meteorologist interviewee, Demuth et al. 2012)

- Learn how to improve communication of (un)certainty, impacts, and risks
  - Understand not just what to communicate in a specific situation, but also why