Uncertainty: Weather & Climate

H₂O: USGS
Dual-coding Learning Theory

Allan Paivio
Canadian Psychologist
1969
Trends in Regular News Sources

Regularly Watch

- Local TV news
- Nightly network news
- Cable news
- Weekday morning news
- Sunday morning talk show

Regularly Read

- Daily newspaper
- Weekly community newspaper
- News magazines
- Magazines like New Yorker/Atlantic

Regularly Get News Online

- Online for news 3+ days a week
- Search engines
- Political blogs

PEW RESEARCH CENTER June 8-28, 2010. Q28aF1,bF1,k,o,p, Q30a-d, Q41, Q43, Q46 based on total.*

* Search engine use and general news online three or more days a week. All other trends are percent who use “regularly.”
Extended Forecast
Washington, DC

SUN
60% 60%

MON
63°

TUE
56°

WED
72° 30%

THU
65°

FRI
59°

SAT
61°

Uncertainty

VIEW 7 DAY INTERACTIVE
Detailed Humidity, UV Index, Dewpoint, Sunrise, Winds and more...
What is a 60% chance of Rain?

• A. 60% of the **day** will be wet?
  – or

• B. 60% of the **area** will be wet?
  – or

• C. 60% chance of .01” **at one spot**
60% chance of rain today.

Out of 100 days with the same atmospheric conditions it will rain* on 60 out of those 100 days

..............................................................40 of the days will be DRY!

* >0.01 inch at a given spot.
<table>
<thead>
<tr>
<th>Range (High)</th>
<th>Numeric Expression</th>
<th>Linguistic Expression</th>
<th>Colored Icon</th>
<th>Arrow Icon</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
<td>Absolutely Impossible</td>
<td>![Red Icon]</td>
<td>![Down Arrow]</td>
</tr>
<tr>
<td>0-.9</td>
<td>5%</td>
<td>Rarely</td>
<td>![Red Icon]</td>
<td>![Down Arrow]</td>
</tr>
<tr>
<td>.9-.18</td>
<td>14%</td>
<td>Very Unlikely</td>
<td>![Orange Icon]</td>
<td>![Down Arrow]</td>
</tr>
<tr>
<td>.18-.27</td>
<td>23%</td>
<td>Fairly Unlikely</td>
<td>![Yellow Icon]</td>
<td>![Down Arrow]</td>
</tr>
<tr>
<td>.27-.36</td>
<td>32%</td>
<td>Somewhat Unlikely</td>
<td>![Green Icon]</td>
<td>![Down Arrow]</td>
</tr>
<tr>
<td>.36-.45</td>
<td>41%</td>
<td>Uncertain</td>
<td>![Green Icon]</td>
<td>![Down Arrow]</td>
</tr>
<tr>
<td>.45-.54</td>
<td>50%</td>
<td>Tossup</td>
<td>![Green Icon]</td>
<td>![Up Arrow]</td>
</tr>
<tr>
<td>.54-.63</td>
<td>59%</td>
<td>Better Than Even</td>
<td>![Green Icon]</td>
<td>![Up Arrow]</td>
</tr>
<tr>
<td>.63-.72</td>
<td>68%</td>
<td>Rather Likely</td>
<td>![Green Icon]</td>
<td>![Up Arrow]</td>
</tr>
<tr>
<td>.72-.81</td>
<td>77%</td>
<td>Quite Likely</td>
<td>![Green Icon]</td>
<td>![Up Arrow]</td>
</tr>
<tr>
<td>.81-.90</td>
<td>86%</td>
<td>Highly Probable</td>
<td>![Green Icon]</td>
<td>![Up Arrow]</td>
</tr>
<tr>
<td>.90-1</td>
<td>95%</td>
<td>Almost Certain</td>
<td>![Green Icon]</td>
<td>![Up Arrow]</td>
</tr>
<tr>
<td>1.0</td>
<td>100%</td>
<td>Absolutely Certain</td>
<td>![Green Icon]</td>
<td>![Up Arrow]</td>
</tr>
</tbody>
</table>
Completing the Forecast: Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts

National Research Council

Would it be useful for you to see the probability of rain or thunderstorms on the StormCenter4 forecast graphic?

<table>
<thead>
<tr>
<th>Choice</th>
<th>Votes</th>
<th>Percent of 5895 votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5710</td>
<td>97%</td>
</tr>
<tr>
<td>No</td>
<td>185</td>
<td>3%</td>
</tr>
</tbody>
</table>

Thank you for taking the time to fill out our survey!
Where?
Hurricane Uncertainty
Cone of Uncertainty
Misinterpretations of the “Cone of Uncertainty” in Florida during the 2004 Hurricane Season

by Kenneth Broad, Anthony Leiserowitz, Jessica Weinkle, and Marissa Steketee

Rigorous pretesting, including insights from social science, could improve hurricane forecast graphics aimed at the general public.
“... social science... could improve hurricane graphics ....”

Kenneth BROAD,
Anthony LEISEROWITZ,
Jessica WEINKLE,
Marissa STEKETEE
Max Mayfield, Director of Nat’l Hurricane Center “that was a very good forecast.”

(Stone 2005, in Broad, et al. 2007)
Residents of Punta Gorda did not understand the NOAA graphical message!
“a very good forecast.”

i.e. Punta Gorda was inside the cone.
Cone of Uncertainty

A Blob?

Red Curve?
Hurricane Forecast Cone:

The cone = probable track of the center of hurricane

Based on the past 5 years,

60-70% of the time the “eye” will be within the cone
Hurricane Zeta

Cat 3:
Winds: 120

Major wind damage

Listen to local officials

Compare L vs. R

Hurricane Isabel
September 16, 2003
5 PM EDT Tuesday
Advisory 43
Current Center Location 27.6 N 71.6 W
Max Sustained Wind 105 mph
Current Movement 8 mph

NOAA National Weather Service
National Hurricane Center
528 N.W. 16th Street
Miami, FL 33137
Tel: 305-260-8787
Fax: 305-260-8035

Disclaimer
Credits
Information Quality
Glossary

Privacy
Freedom of Information
Access

Career Opportunities
Uncertainty “processing” at 50 mph!
Threat area for Thur. 8th
expecting Cat.3
winds = 120 mph
Storm surge
tide: 12 ft

Listen to local officials

Wind path is 80 miles wide

Today Wed 5 PM 24
Keep it Simple & Relevant

- 150 mph winds =

4”/hour rainfall =

20’ waves =

TWC: Lyons
Tornado Risk (uncertainty)
Climate Forecast: 1 month

33.3 to 30.05% chance A,
33.4 to 39.9% chance N,
33.3 to 30.05% chance B

50% chance A,
33.3% chance N,
16.7% chance B

26.7% chance A,
33.3% chance N,
40% chance B
Climate Every Day

<table>
<thead>
<tr>
<th>ALMANAC</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TODAY</td>
<td>32°</td>
<td>28°</td>
</tr>
<tr>
<td>NORMAL</td>
<td>34°</td>
<td>20°</td>
</tr>
<tr>
<td>RECORD</td>
<td>60°</td>
<td>-7°</td>
</tr>
<tr>
<td>1977</td>
<td>1951</td>
<td></td>
</tr>
<tr>
<td>Sunrise</td>
<td>7:14</td>
<td>Sunset</td>
</tr>
</tbody>
</table>
1st Rule: KNOW YOUR AUDIENCEs

Group 1: In-reach / Outreach
- policy relevance &/or societal applications

Group 2: Public Media

Group 3: Formal Education
- Colleges, High Schools, K-12

Group 4: Informal Ed
- Museums
- Zoos
- Aquaria

modified from D. Herring
5 categories of TV Meteorologists

What is the Cause of Climate Change?

- Natural
- Natural AND Human
- Human
- Not happening
- Don't Know

GMU Survey Winter 2011
FIGURE 1 | Proportion of the U.S. Population in the Six Americas, May 2011

- Alarmed: 12%
- Concerned: 27%
- Cautious: 25%
- Disengaged: 10%
- Doubtful: 15%
- Dismissive: 10%

Proportion represented by area

Source: Yale/George Mason University
Uncertainties of Climate Beliefs (a few samples)

Concentrated 27%: GW is real. Don’t see personal threat.

Cautious 25%: Think that scientist disagree.

Disengaged 10%: (Apathetic) haven’t thought about it. Isn’t it far in the future?

Doubtful 15%: Have actively thought about it. How can humans cause it. Isn’t it natural?
Uncertainties

1. Is it Real? (happening now and here?)

2. Is it Bad?

3. Is it caused by Humans?

4. Do Scientists Agree?

5. What can we do?

+ others
### Susan Hassol: Climate science word “meanings”

<table>
<thead>
<tr>
<th>Scientific term</th>
<th>Public meaning</th>
<th>Better choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>enhance</td>
<td>improve</td>
<td>intensify, increase</td>
</tr>
<tr>
<td>aerosol</td>
<td>spray can</td>
<td>tiny atmospheric particle</td>
</tr>
<tr>
<td>positive trend</td>
<td>good trend</td>
<td>upward trend</td>
</tr>
<tr>
<td>positive feedback</td>
<td>good response, praise</td>
<td>vicious cycle, self-reinforcing cycle</td>
</tr>
<tr>
<td>theory</td>
<td>hunch, speculation</td>
<td>scientific understanding</td>
</tr>
<tr>
<td>uncertainty</td>
<td>ignorance</td>
<td>range</td>
</tr>
<tr>
<td>error</td>
<td>mistake, wrong, incorrect</td>
<td>difference from exact true number</td>
</tr>
<tr>
<td>bias</td>
<td>distortion, political motive</td>
<td>offset from an observation</td>
</tr>
<tr>
<td>sign</td>
<td>indication, astrological sign</td>
<td>plus or minus sign</td>
</tr>
</tbody>
</table>
How is climate different?
Climate vs. Weather
Man is tipping the odds* with CO2
Consensus of Climate Scientists

97 out of 100 climate experts think humans are changing global temperature

Doran et al 2009, Anderegg et al 2010

- High resolution JPEG (1024 pixels wide)
Analogies: Medical 1

When you are sure about climate change, then tell me.

Dr.: ‘Well, I am very concerned about your heart condition. I think you should be on a low cholesterol diet and exercise.

Would anybody say to their doctor ‘If you can't tell me precisely when am I going to have the heart attack and how severe it will be.’ then why should I change my lifestyle?'

Inspired by Stephen Schneider, Ph.D.

climatebites.org/
Insurance Companies & Risk

• “When you are certain, come back and talk to us.””

• That is not the way it works in any other form of life.

• In climate we have pretty good ideas about what could happen. We do not have the detailed picture and we are not going to for several decades.
• What we are doing is taking a risk with the life support system of the earth and humans have to decide if we want to slow that down."
Extreme Weather: “is a preview”

The science tells us that we will see more and more extreme weather as the earth warms. Think of today's extreme weather as a "sneak preview" of what lies ahead on our current path.

Recently, Kevin Trenberth, Jim Hansen and a number of other leading climate scientists have stopped saying the standard line

"Extreme weather has many causes, and there's no way to tell whether warming caused this event," and begun emphasizing instead that warming almost certainly contributed to the event

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Saying global warming isn't real because last winter was cold and snowy, is like saying that spring's not happening because Friday was cooler than Monday. You have to look at the longer trend.

We tend to overestimate the probably of events that are current or easy to remember
Computer Models

“Essentially, all models are wrong, but some are useful” — George E. P. Box

Climate scientists are NOT trying to make 'absolute' predictions; what scientists are really doing is trying to identify, within given probabilities, the outcomes that are likely to result in a variety of circumstances.

Quantifying uncertainties is important in all scientific research: without an estimate of confidence, a result cannot be placed in context, cannot be given meaning. But it is essential in climate science because climate is, by definition, the statistics of weather: and statistics is the science of uncertainty.

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Family Safety 1

Would you put your grandkids on an airplane that 97% of aerospace engineers declared unsafe, because you heard 3% say "no problem, it's perfectly sound?"
"If 97 doctors say my son is ill and needs medication and two say, 'No, he doesn't, he is fine,' I will go with the ninety-seven. It's common sense - the same with global warming. We go with the majority, the large majority."

Schwarzenegger's original quote refers to 98% instead of 97% due to rounding. To be conservative, we corrected this to 97.

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Science is a jigsaw puzzle not a house of cards.

The evidence for human-caused climate change is not a house of cards that will collapse as soon as one piece is taken away. It's more like a mountain of pebbles: scrape a couple of pebbles off the top, but the mountain is still there.

Scientific knowledge accumulates bit by bit, over decades of laborious research. Gradually, the overall picture emerges. Even if you remove a few pieces, the overall picture doesn't change.
Mother Nature is neither Republican nor Democrat.

Mother Nature is just chemistry, biology and physics.

That's all she is. You cannot sweet-talk her. You cannot spin her.

Mother Nature is going to do whatever chemistry, biology and physics dictate”

"Mother Nature always bats last, and she always bats 1.000" — Rob Watson
CO2= steroids for the atmosphere

"Just as steroids make the baseball player stronger and increase his chances of hitting home runs, greenhouse gases are the steroids of the climate system, they increase the chances of record breaking heat to occur compared to record breaking cold."

—Dr. Gerald Meehl, UCAR

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## Overcoming Barriers:

<table>
<thead>
<tr>
<th>Goal</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earn Confidence</td>
<td>Easy</td>
</tr>
<tr>
<td>Create Awareness</td>
<td>✔</td>
</tr>
<tr>
<td>Deepen Understanding</td>
<td></td>
</tr>
<tr>
<td>Gain Satisfaction</td>
<td></td>
</tr>
<tr>
<td>Motivate Enactment</td>
<td></td>
</tr>
</tbody>
</table>

K. Rowan: CAUSE Model of Risk Communication
Political Beliefs and World Views

• People tend to push back when presented information that appears to challenge their predominant group (tribe) view.
• Birds of a feather flock together.
• The status of their group needs to be protected.
Certainties

1. It is Real! (happening now and here?)
2. It is Bad!
3. It is caused by Humans!
4. Scientists Agree!
5. We can do something!