Communicating uncertainty in climate & weather forecasts

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"It has long been conventional wisdom in the climate change research and policy community that any perception by the public **that there is uncertainty*** in the science behind climate change and its attribution to human actions [will be] **the death knell** for effective policy-making to combat it." – Patt & Weber, 2014

* Ambiguity or imperfect knowledge about future weather events *or* the precise extent, time-scale, and consequences of climate change
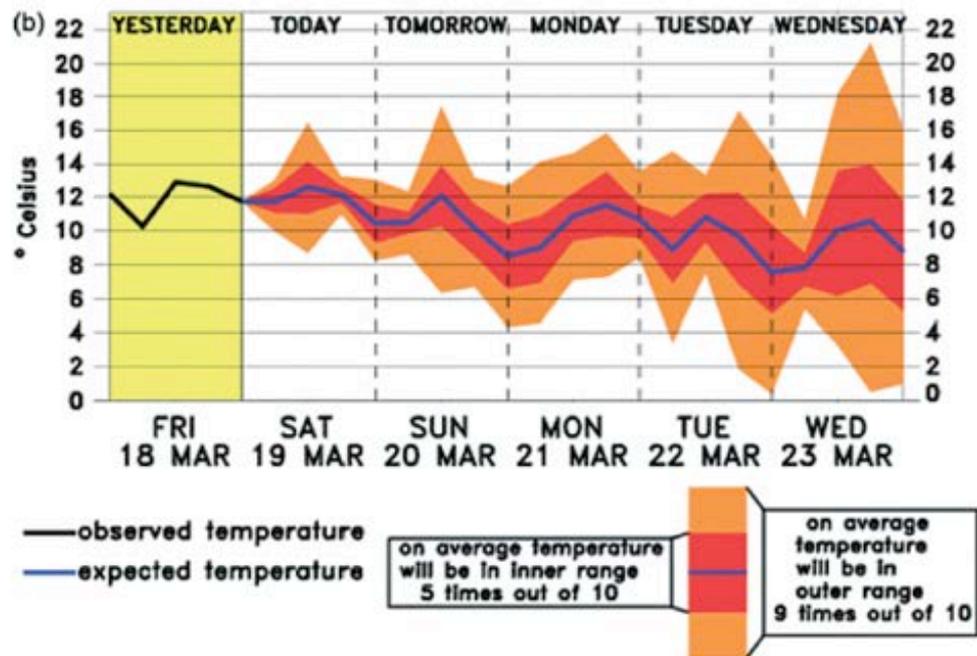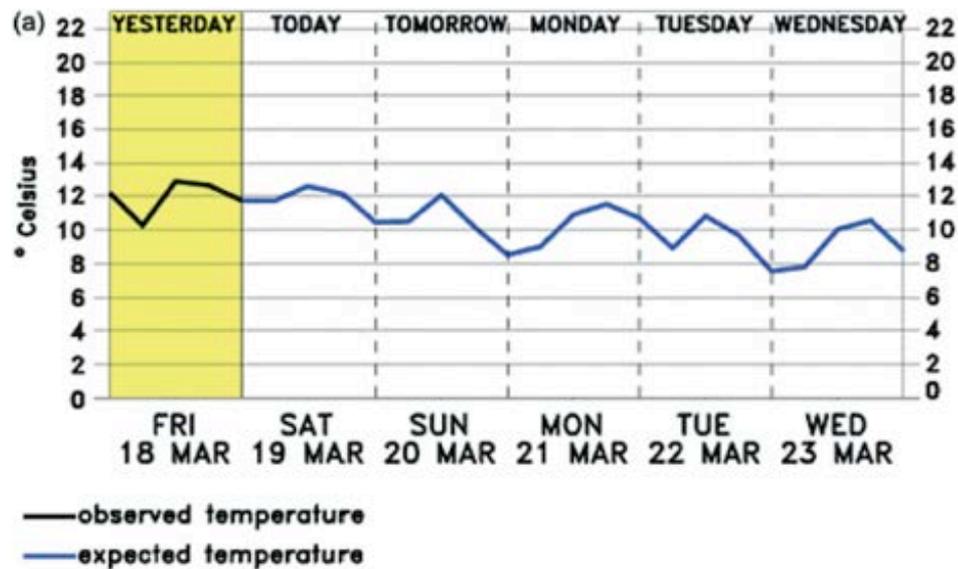
Adapted from Morss et al., 2008 & Morton et al., 2011

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Uncertainty & Decisions

This aerial photo was taken from a helicopter above Grand Forks, N.D. during the 1997 Red River flood. *STEPHEN JAFFE/AFP/Getty Images*

(a)

(b)

observed temperature
expected temperature
on average temperature will be in inner range 5 times out of 10
on average temperature will be in outer range 9 times out of 10

Roulston & Kaplan, 2009; also see NRC, 2006; Roulston et al., 2006

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Uncertainty = Incompetence?

"If they can't predict the week's weather accurately, how can they possibly predict long-term climate changes?"
- Common refrain

"How come you can't even figure out if there is a risk or not? You say it causes cancer. Well, is there a risk or is there not a risk?" Johnson & Slovic, 1995

Depends on:

Beliefs about science
→ Explain: uncertainty is a part of science; sources; what's being done.

Frewer et al., 2002; Johnson & Slovic, 1995; Kahan et al., 2012; Kuhn, 2000; Patt & Gwata, 2002

(Un)certainty = Incompetence?

"Certainty" is just as dangerous

… & People prefer transparency

Frewer et al., 2002; Morss et al., 2008

> Forecasts were deterministic, and the first year that events did not unfold exactly as predicted, people stopped trusting them.
> Patt & Gwata, 2002, citing Orlove & Tosteson, 1999; also see O'Brien et al., 2000

Uncertainty = Lack of Consensus?

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

FACTS   ARTICLES   NASA'S ROLE   SOLUTIONS
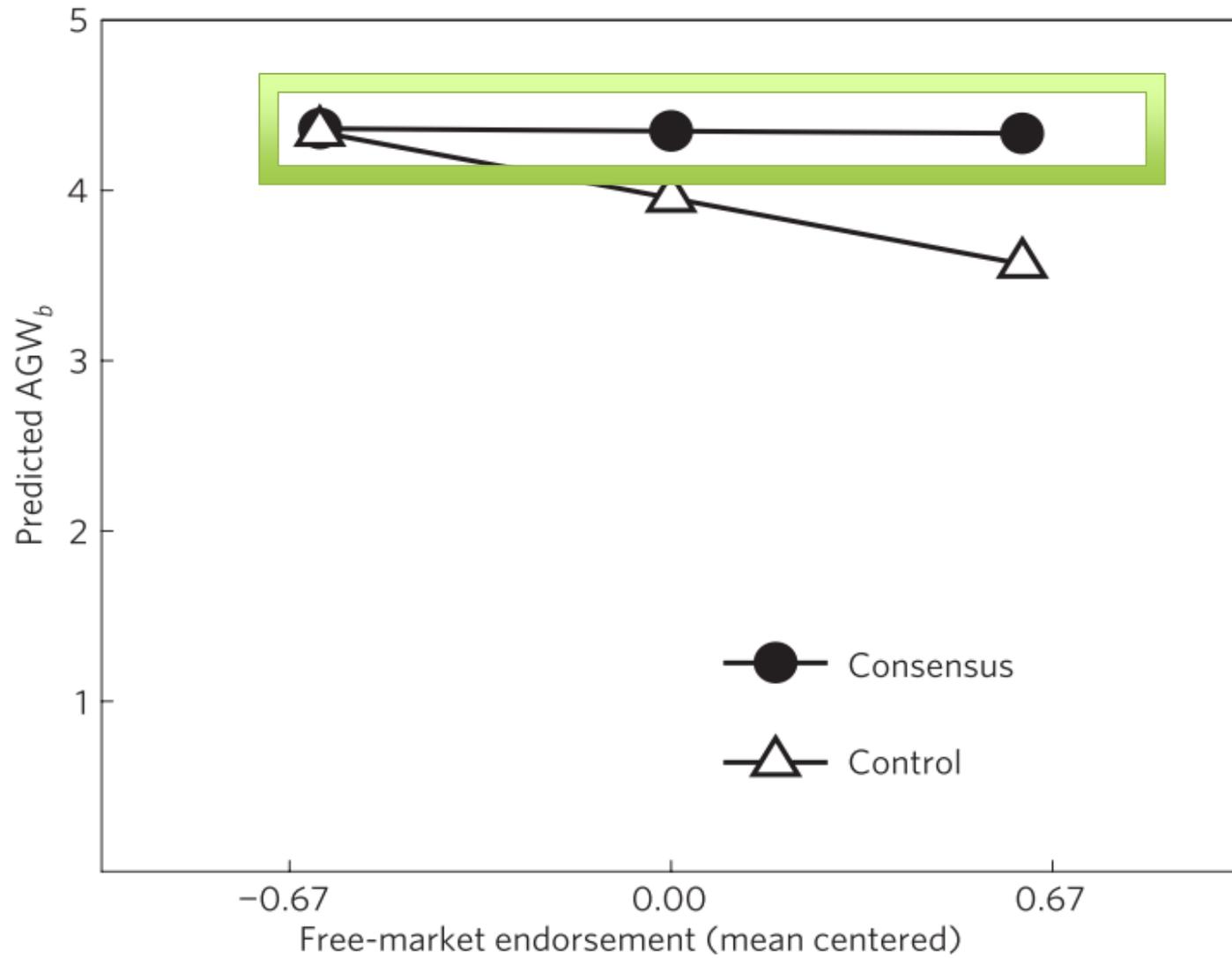
Consensus: 97% of climate scientists agree

"Voters believe there is no consensus about global warming within the scientific community"

– Luntz, 2003, cited in Boykoff, 2008

Perceived consensus predicts:
- Belief in climate change
- Support for climate policy

Ding et al., 2011; Lewandowsky et al., 2013; Rolfe-Redding et al., 2012

Lewandowsky et al., 2013

Consensus: 97% of climate scientists agree

AMERICAN SCIENTIFIC SOCIETIES

Statement on climate change from 18 scientific associations

"Observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver." (2009)[2]

American Association for the Advancement of Science

"The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society." (2006)[3]
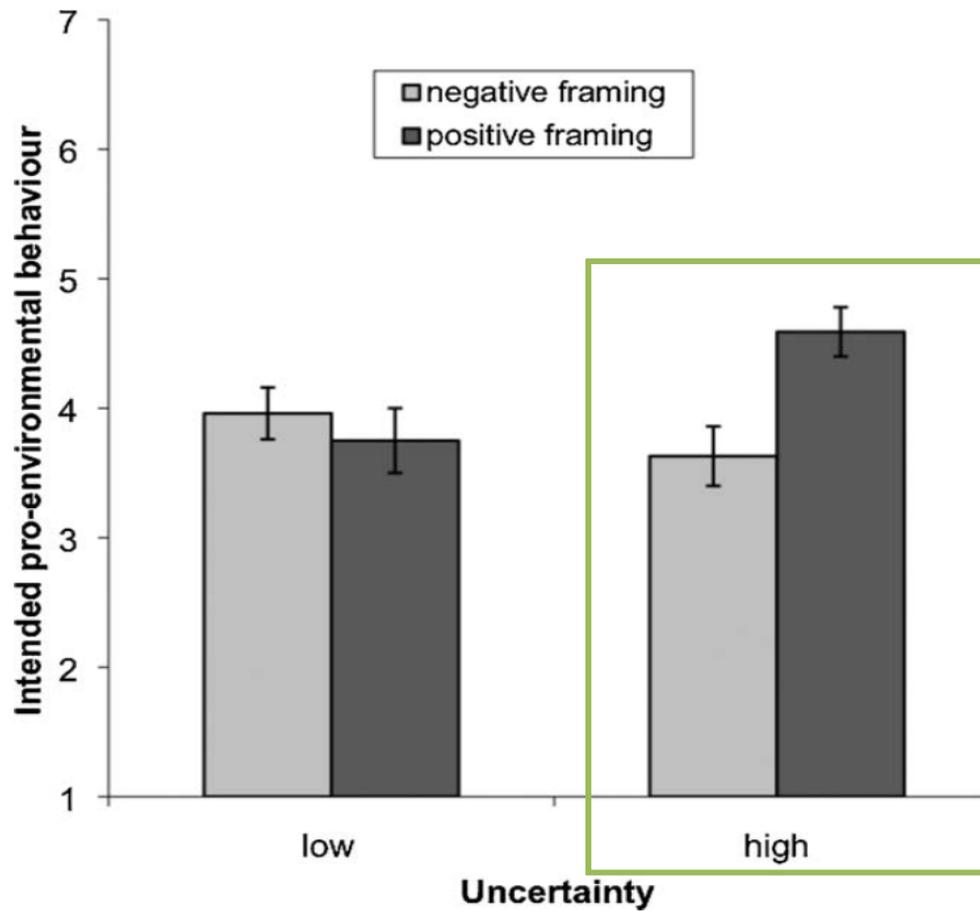
American Chemical Society

"Comprehensive scientific assessments of our current and potential future climates clearly indicate that climate change is real, largely attributable to emissions from human

Uncertainty → Inaction?

- Emotional: Ambiguity aversion
    - → Action items, high efficacy
    - → No-regrets strategies
    - → Beyond fear appeals

Fig. 2. The effects of uncertainty and framing of climate change predictions on intended pro-environmental behaviour (Study 2).

Morton et al., 2011

Uncertainty → Inaction?

- Emotional: Ambiguity aversion
  → Action items with high
efficacy
  → No-regrets strategies
  → Beyond fear appeals

- Reasoned: Wait for more info
  → Explain: Irreducible
     uncertainty
  → Uncertainty increases
     expected damages

Ellsberg, 1961; Gifford & Comeau, 2011; Morton et al., 2011;
O'Neill & Nicholson-Cole, 2010; Lewandowsky et al., 2014; Opitz-
Stapleton et al., 2011; Rolfe-Redding et al., 2012

Uncertainty → Confusion?

- One approach: "simplify"
- Better: build capacity

> " Risk communicators learned that only when information users became experts in their own right, and were treated as such, would credibility and legitimacy not suffer.
> – Patt & Gwata, 2002 "

Uncertainty → Confusion?

- One approach: "simplify"
- Better: build capacity

→ Communicate the right information
→ Communicate the information "right"

Communicate the right information

More information ➜ more informed audience?

" Your 10-year risk of cardiovascular disease is 14.523%. "

Zikmund-Fisher, 2012

Instead:
    1) Define the decision
    2) Determine the relevant (uncertainty) information
    3) Convey that information "right"

Communicate the information "right"
Verbally?

The Good

- Accessible, provides context

- Laypeople use it with each other

The Bad

- Numeric preferred

- Individual differences

- Context effects

→ *Combine verbal and numeric*

Bonnefon & Villejoubert, 2006; Budescu et al., 2009; Lipkus, 2007; Patt & Schrag, 2003; Visschers et al., 2009; Wallsten et al., 1986

Communicate the information "right"
Verbal Expressions

- Common stem (e.g. "likely")
- Consistent mapping framework

Table 1. Likelihood Scale	
Term*	**Likelihood of the Outcome**
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

* Additional terms that were used in limited circumstances in the AR4 (*extremely likely* – 95-100% probability, *more likely than not* – >50-100% probability, and *extremely unlikely* – 0-5% probability) may also be used in the AR5 when appropriate.

Mastrandrea et al., 2010; Budescu et al., 2009

Communicate the information "right"
Verbal Expressions

- Common stem (e.g. "likely")

- Consistent mapping framework

- Pretest

Visschers et al., 2009

Communicate the information "right"
Numeric Expressions

- **Use consistent...**

  - Expression types (%, odds, x out of y, ...)

    In the past 100 years, there have only been 3 severe floods. But there is a 50% chance of a severe flood in the next 10 years.

    Spiegelhalter et al., 2011

Communicate the information "right"
Numeric Expressions

- **Use consistent…**
  - Expression types
  - Denominators

	% Correct
	USA
5. Which of the following numbers represents the biggest risk of getting a disease? 1 in 10, 1 in 100, or 1 in 1,000?	75.3

Galesic & Garcia-Retamero, 2010

Communicate the information "right"
Numeric Expressions

What does this mean?

TUE Aug 4 — 87° 65° AM Thunderstorms 50%

"There is a 50% chance of rain on Tuesday."

...50% **of what?**

Transparent: *"It rains on 50% of days with conditions like Tuesday."*

www.weather.gov
Gigerenzer et al., 2005

10th percentile:
Likely to be exceeded every 9 in 10 yr

50th percentile:
Likely to be exceeded every 5 in 10 yr

90th percentile:
Likely to be exceeded every 1 in 10 yr
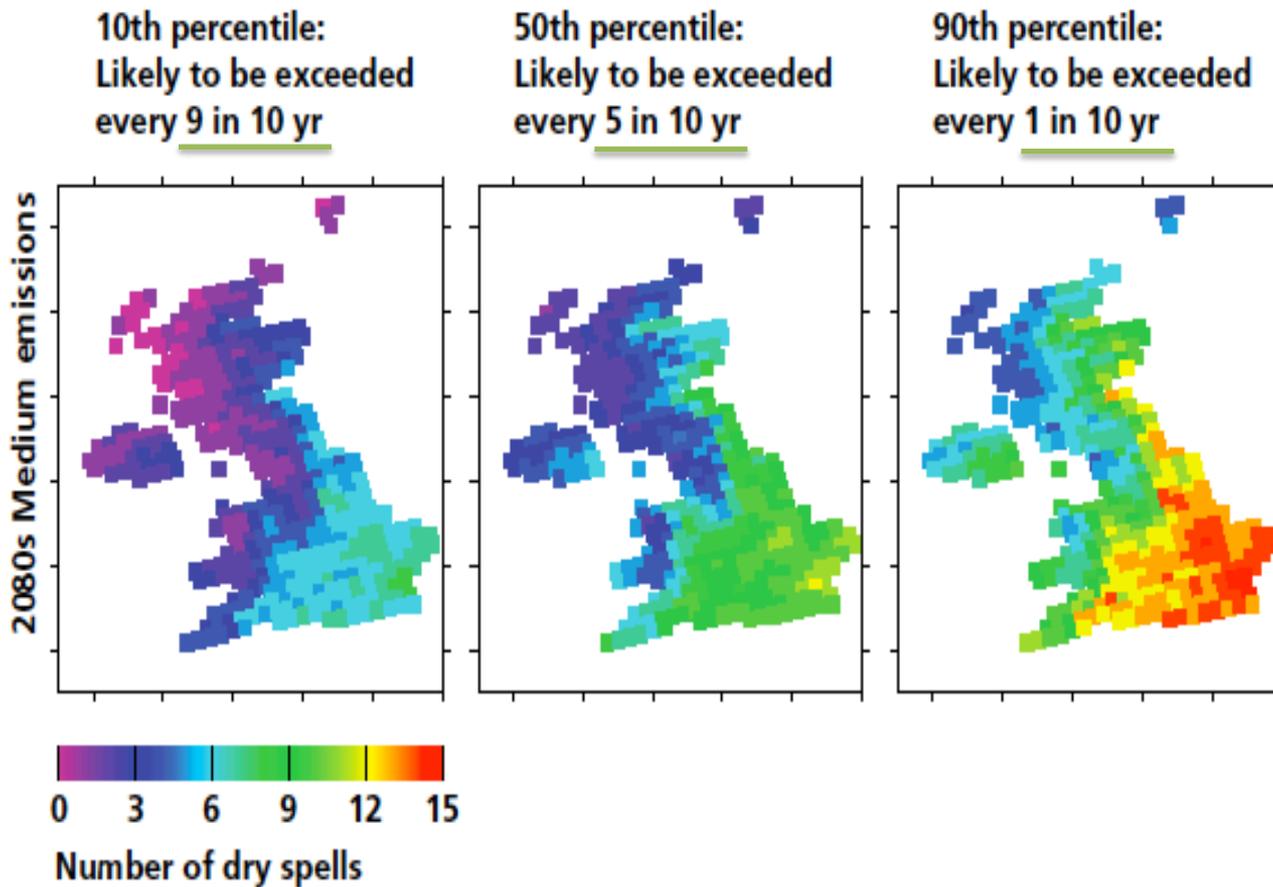
Figure 25: Numbers of dry spells longer than 10 days annually, estimated by the Weather Generator.

2080s Medium emissions

0 3 6 9 12 15

Number of dry spells

Communicate the information "right"
Numeric Expressions

- **Use consistent…**

  - Expression types

  - Denominators

- **Specify the reference class**

19 NOVEMBER 1995

THE SUNDAY TIMES *magazine*

Official announcement:

"Contraceptive pills double the risk of venous thromboembolism!"

UK Committee on the Safety of Medicines, 1995

KISS OF DEATH
Is the Pill doomed?

Gigerenzer et al., 2007
Slide adapted with permission from Wolfgang Gaissmaier

Transparent format:

"Contraceptive pills increase the risk of venous thromboembolism from 1 out of every 7,000 women to 2 out of every 7,000 women."

Heat-related deaths will rise 257% by 2050 because of climate change

Number of heat-related deaths projected to increase in UK as temperature rise, with elderly people most at risk

Original Study: Hajat et al., 2014

Heat deaths / 100K
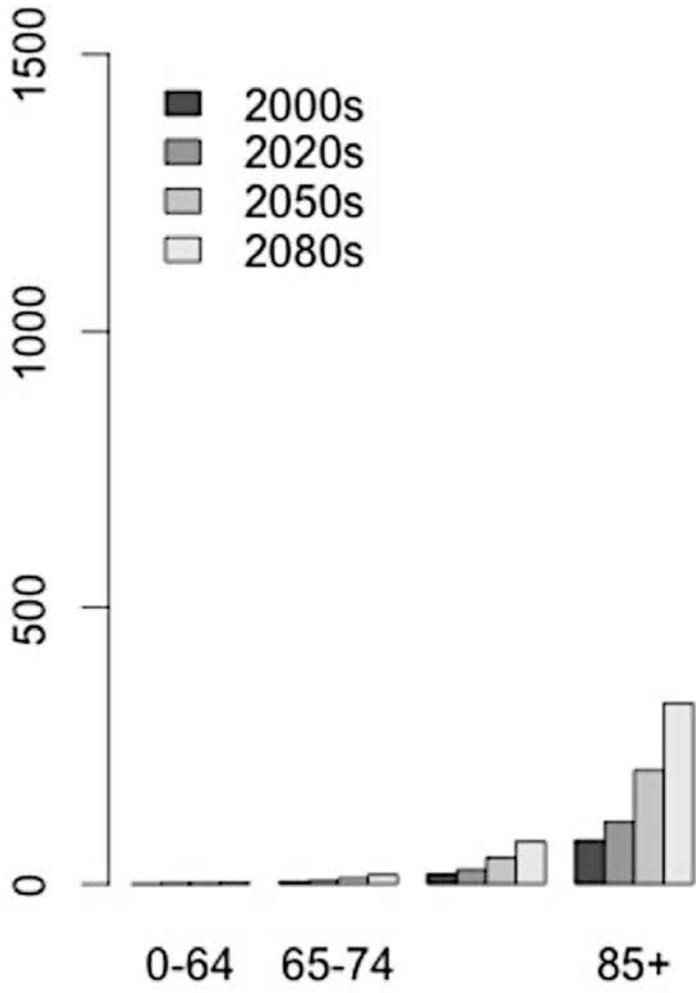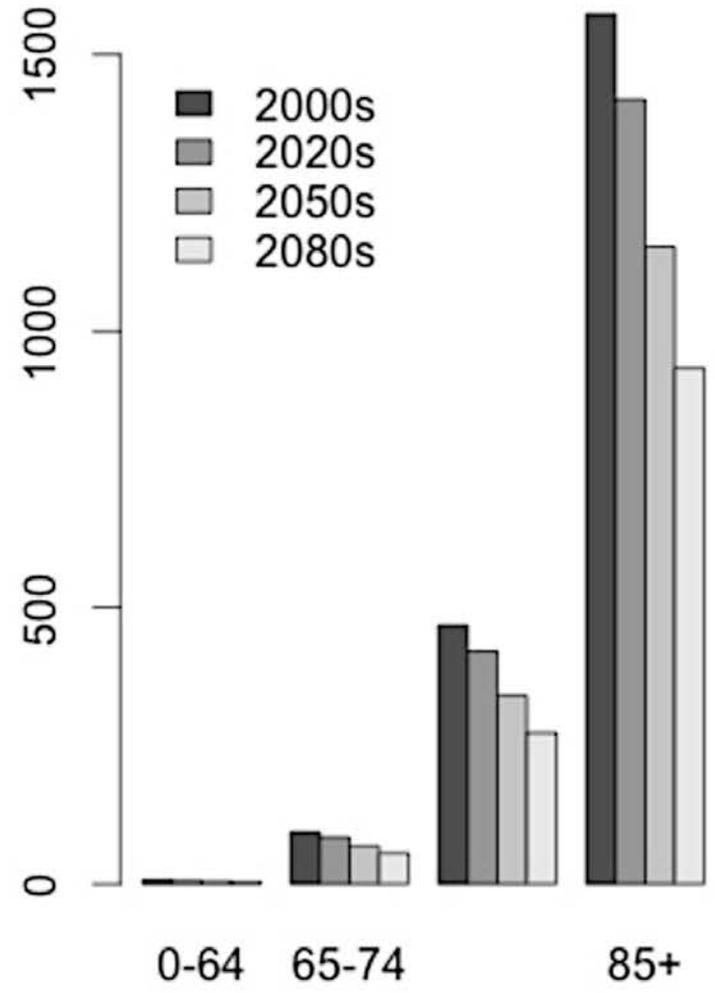
Legend: 2000s, 2020s, 2050s, 2080s

X-axis: 0-64, 65-74, 85+

Y-axis: 0, 500, 1000, 1500

Cold deaths / 100K

Legend: 2000s, 2020s, 2050s, 2080s

X-axis: 0-64, 65-74, 85+

Y-axis: 0, 500, 1000, 1500

Source: David Spiegelhalter; http://understandinguncertainty.org/more-deaths-due-climate-change-or-maybe-not

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Communicate the information "right"
Numeric Expressions

- **Use consistent…**
    - Expression types
    - Denominators
- **Specify the reference class**
- **Use absolute risk change**, not relative

Communicate the information "right"
Framing Effects

"It is **70-90%** likely that 2°C of warming **will** cause severe changes to regional weather patterns."

vs.

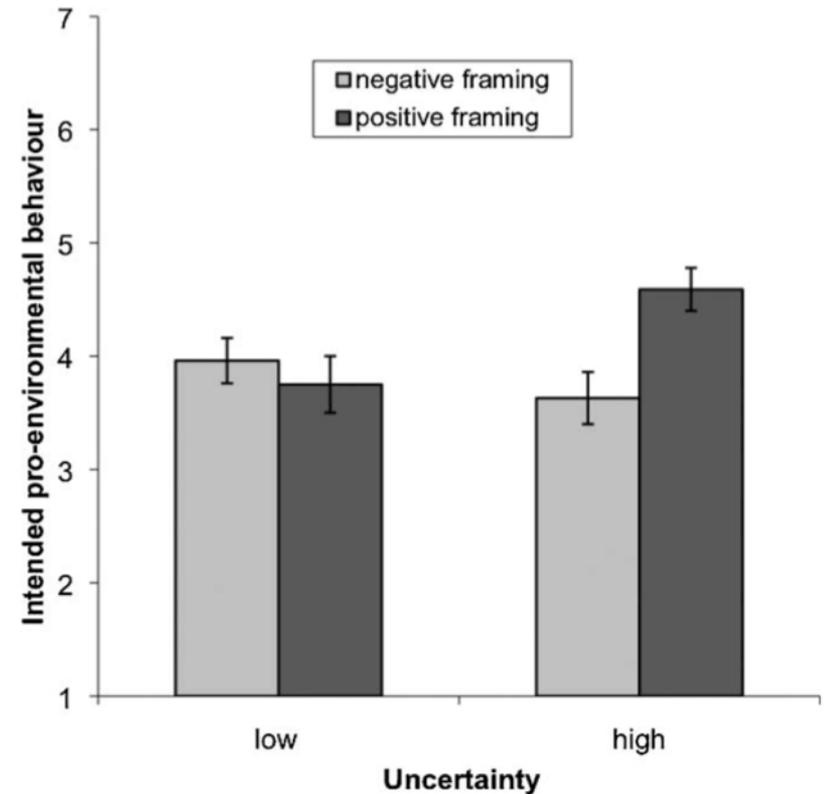"It is **10-30%** likely that 2°C of warming **will not** cause severe changes to regional weather patterns."

Fig. 2. The effects of uncertainty and framing of climate change predictions on intended pro-environmental behaviour (Study 2).

Statements adapted from Morton et al., 2011

Communicate the information "right"
Framing Effects

"It is **70-90%** likely that 2°C of warming **will** cause severe changes to regional weather patterns."

vs.

"It is **10-30%** likely that 2°C of warming **will not** cause severe changes to regional weather patterns."

20% 80%

Statements adapted from Morton et al., 2011

Communicate the information "right"
Numeric Expressions

- **Use consistent**…

  - Expression types

  - Denominators

- **Specify the reference class**

- **Use absolute risk change**, not relative

  - And/or include base rate

- **Give part-to-whole** relationships

Communicate the information "right"
Graphics

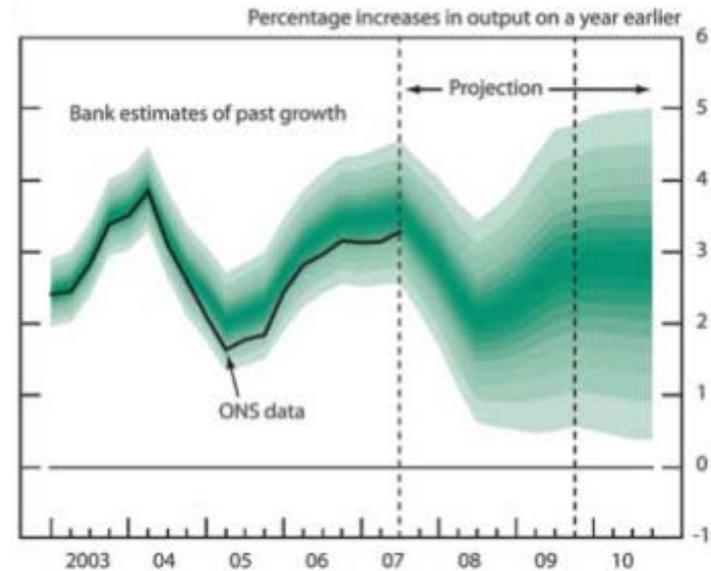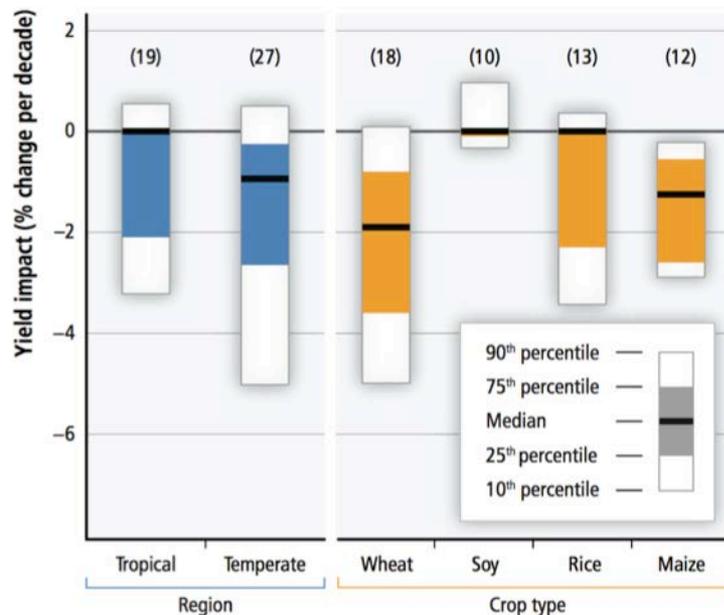- *Most likely value*
- *Range of likely values*
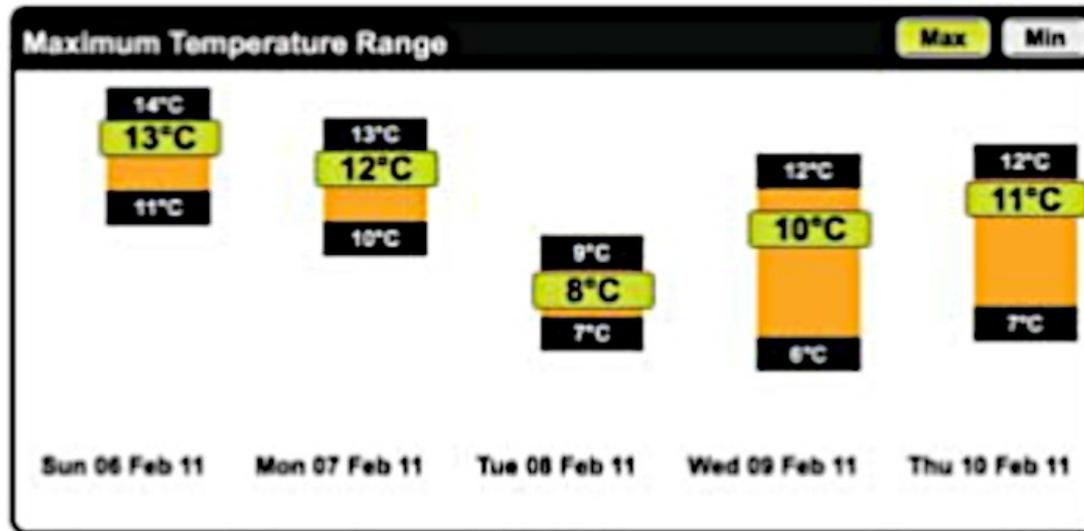
UK Met. Office, cited in Spiegelhalter et al., 2011
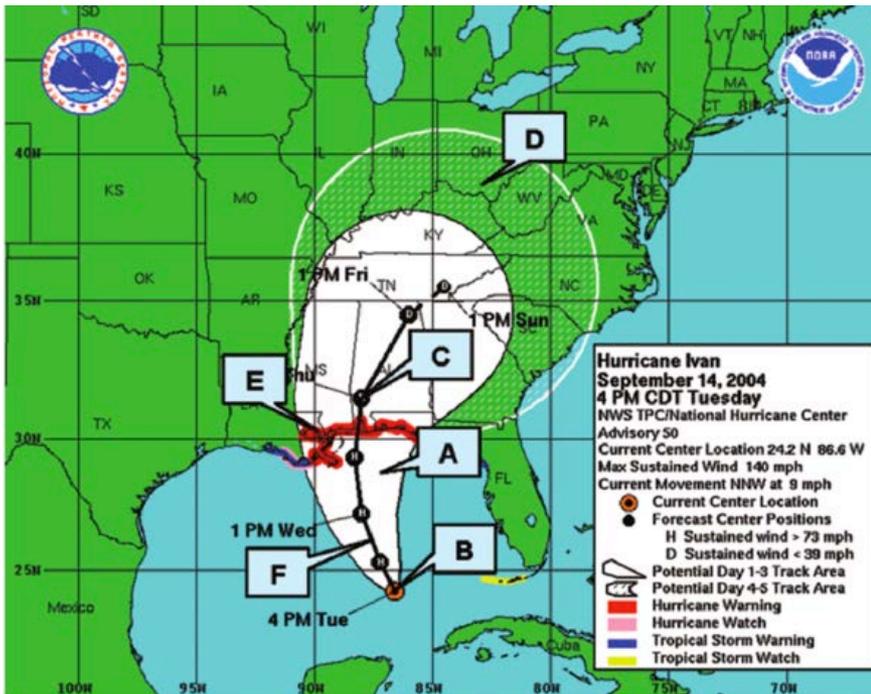
Communicate the information "right"
Graphics

- *Most likely value*
- *Range of likely values*
- **Decreasing probability toward interval bounds**

IPCC AR5

Bank of England, cited in Spiegelhalter et al., 2011

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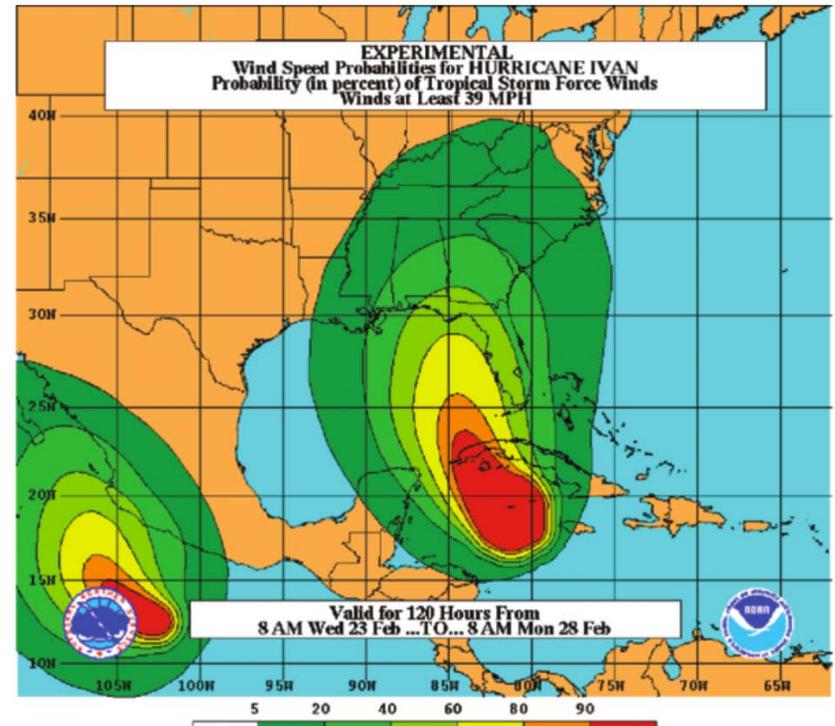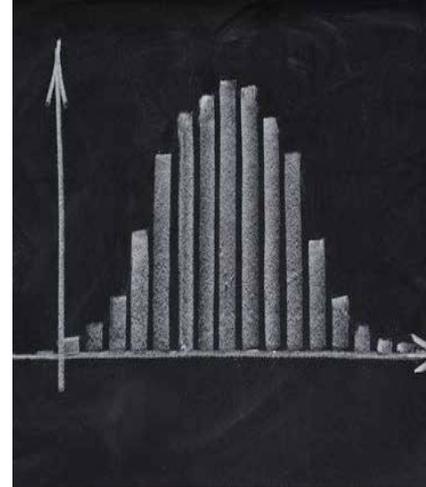# Communicate the information "right"
Graphics

Broad et al., 2007

Fıɢ. 10. Probability of the extent of hurricane- or tropical storm–force winds for Hurricane Ivan in 2004 (online at www.nhc.noaa.gov/feedback-pws-graphics2.shtml).

Where We've Been

- Uncertainty communication and…
  - Perceived incompetence
  - Perceived consensus
  - Motivation to act
  - Comprehension
- Communicating uncertainty
  - Verbally
  - Numerically
  - Graphically

Thank you!

Tarlise Townsend