# 5 Address Scientific and Climate Uncertainties

## WHY ARE THERE UNCERTAINTIES IN CLIMATE SCIENCE?

As with other branches of science, climate science involves scientific uncertainty. Beyond that, however, uncertainty in climate science derives from the many complex forces that govern the earth's climate, from the axis of the planet's rotation to the changing composition of the atmosphere. Although scientists have gained significant insight into how the climate system functions, they do not have 100% confidence in their climate change projections—and they never will. What they can do, however, is make predictions based on the best available data, quantifying the uncertainties associated with those predictions.

Several areas of uncertainty exist in climate change prediction. One is due to the lack of complete knowledge of how the climate works, which will lessen with further study. Other uncertainty is due to natural variability in the climate system, which will not go away. And an additional element of uncertainty is due to the inability to predict human behavior and its cumulative impact on the earth's climate.

Future climate predictions depend on a number of changing variables in much the same way future traffic predictions do. Both systems operate under a certain level of volatility and uncertainty, but that does not prevent either climate scientists or traffic analysts from making forecasts with the information on hand. Although traffic forecasts days into the future may seem hard to trust, as are future climate projections for some people, both are determined by algorithms based on mass data from varying sources. A unique, location-specific model can provide greater accuracy for both traffic and climate scenarios. But with both systems, full certainty comes when it is already too late and one is in a jam.

## THE PROBLEM WITH SCIENTIFIC UNCERTAINTY: THE HUMAN NEED FOR PREDICTABILITY

Because humans have a great need for predictability, uncertainty can be uncomfortable. Predictability helps people feel safe and secure, whereas uncertainty can lead to anxiety.[42] Predictability offers survival value. It provides control, helps people avoid threats to their physical and material well-being, and frees them from fear and anxiety. Furthermore, it allows people to plan and budget for the future. However, the human capability to prepare can be impaired by uncertainty.

Particularly when talking about complex topics like global climate change, it is important to find effective ways to communicate inherently uncertain information.

Too often discussions of climate science uncertainty convey the mistaken impression that scientists are hopelessly confused about this complicated subject, when in fact the uncertainties about exactly how much warmer the planet will be in 100 years do not change the very high confidence scientists have that human-made emissions of greenhouse gases are warming the planet and are likely to continue doing so.

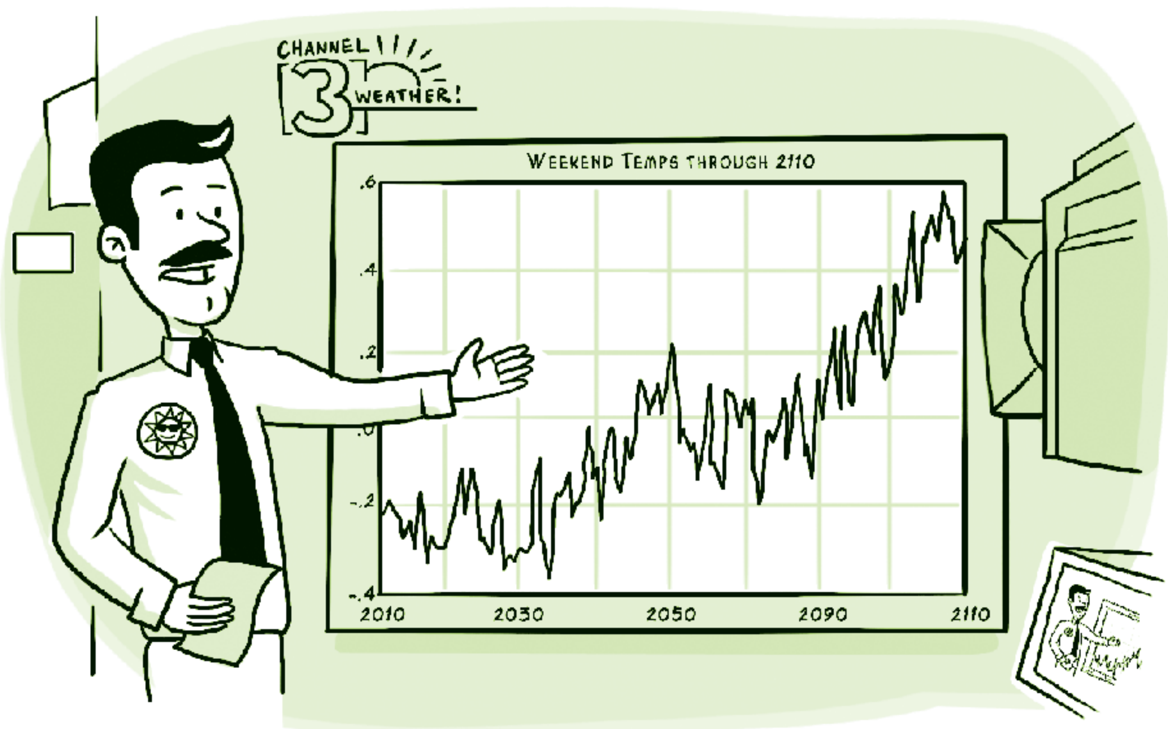
To address this problem, IPCC scientists developed a "confidence terminology" to communicate estimates of uncertainty via everyday language. For example, "very high confidence" was used to refer to a prediction that has at least a nine out of ten chance of being correct. Other such terms included "high," "medium," "low," and "very low" confidence. "Very low confidence" referred to a prediction that had less than a one out of ten chance of being correct.

In cases where probabilistic estimates could be made, the IPCC also used "likelihood terminology" to define the likelihood of an outcome or result. "Virtually certain" had the highest likelihood with a greater than 99 percent probability, while "likely" denoted only a 66 percent or more probability of occurrence.[43]

Although such terms have greatly permeated public discourse on climate change, there is evidence that suggests people interpret such probability descriptors more subjectively than scientists intend.

For example, in a recent report's Summary for Policymakers, the IPCC stated, "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG [greenhouse gas] concentrations."[44] From the use of the term "very likely" in this sentence, the IPCC meant that there is a 90 percent or greater likelihood that emissions of greenhouse gases from human activities have caused most of the global average temperature increase since the mid-20th century.

But in a study by researchers at the University of Illinois at Urbana-Champaign, people assigned lower likelihood values to the IPCC's descriptors compared




**"So yes, Dan and Kathy, as you can see it looks like it'll be up and down until 2109, but you're certainly going to want to think about abandoning the planet after that...."**

to what the IPCC actually meant. In other words, research subjects thought the scientific evidence of climate change was less conclusive, as conveyed by the IPCC's probability terms, than what the scientists had really reported. Among other recommendations, the researchers suggested that the IPCC consider including the associated range of probabilities whenever a probability descriptor is used, rather than only publishing a key to the terminology.[45]

# HOW TO COMMUNICATE CLIMATE CHANGE UNCERTAINTY

Climate change uncertainties vary in type and significance, and they are difficult to convey without seeming to minimize the importance or understanding of the issue. One of the first key tasks for communicators is to put that uncertainty into context by helping audiences understand what is known with a high degree of confidence and what is relatively poorly understood.

In particular, scientists found that the general public interprets certain common words differently than do the scientists who used them.

## THE NEED FOR PRECISION

Table 4 on page 27 shows a list of common words used to describe climate change that mean different things to scientists and the general public.[46]

Jargon filled explanations of uncertainty can easily undermine a scientist's message. For example, Senator Jim Inhofe asserted in a speech to the Senate that, "statements made by the National Academy of Sciences (NAS) cannot possibly be considered unequivocal affirmations that man-made global warming is a threat."[47] As evidence, he quoted the National Academy of Sciences 2001 report, dwelling on such phrases as "considerable uncertainty in current understanding," "estimates should be regarded as tentative and subject to future adjustments," "because of the large and still uncertain level of natural variability," "uncertainties in the time histories of various forcing agents," "cannot be unequivocally established."

Such phrases can easily translate as unreliable climate science to the greater public. Using the word *considerable* to describe uncertainty creates a disparity in meaning between common language and science. What quantity is "considerable"? This word is subject to varying interpretations. Similarly, the word *error* means *mistake* to most people, which is wholly different from the scientific definition of "error." Discussing uncertainty with unspecific language can lead to an unintentional overstatement and consequent criticisms.

Most critically, communicators should suggest neither more, nor less scientific certainty about climate change than actually exists. When significant uncertainty remains about a specific effect, they should explain why that uncertainty exists (e.g., the systems involved are so complex that science has yet to understand them sufficiently).

## INVOKE THE "PRECAUTIONARY PRINCIPLE"

It is also important to recognize and emphasize that scientific uncertainty alone is not an adequate justification for inaction or business-as-usual policies and behaviors. Rather, it suggests that, at a minimum, it would be prudent to develop contingency plans and adopt adaptive management strategies. This would be in accordance with the "precautionary principle," which holds that action should be taken to reduce the risk of harm to the public from potential threats such as climate change, despite the absence of 100 percent scientific certainty about all aspects of the threat.

The precautionary principle has been considered internationally, including the 1992 United Nations Framework Convention on Climate Change, which states that countries should "take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures…"

Governor Arnold Schwarzenegger of California referred to the principle with a metaphor when he said: "If 98 doctors say my son is ill and needs medication

TABLE 4

## Words with Different Meanings to Scientists and the General Public

| SCIENTIFIC WORDS | NON-SCIENTIFIC MEANING | BETTER WORDS |
|---|---|---|
| Enhance | Improve | Intensify, increase |
| Uncertainty | Not knowing | Range |
| Risk | Low-probability event | Probability |
| Error | Wrong, incorrect | Uncertainty associated with a measuring device or model |
| Bias | Unfair and deliberate distortion | Offset from the observed value |
| Positive trend | A good trend | Upward trend |
| Positive feedback | Constructive criticism | Self-reinforcing cycle, vicious circle |
| Theory | A hunch, opinion, conjecture, speculation | Physical understanding of how this works |
| Hypothesis | Conjecture | Framework for physical understanding |
| Sign | Indication | Positive/negative value, plus/minus sign |
| Values | Ethics, money | Numbers, quantity |
| Manipulation | Exploitation | Changes in experimental or model conditions to study the impact of that condition |
| Scheme | Conspiracy | Blueprint |
| Productivity | Working hard | Photosynthesis |
| Anomaly | Abnormal occurrence | The deviation from a long term average |

and two say 'No, he doesn't, he is fine,' I will go with the 98. It's common sense—the same with climate change. We go with the majority, the large majority....The key thing now is that since we know this industrial age has created it, let's get our act together and do everything we can to roll it back."[48] In this example, Schwarzenegger conveyed information about climate change risk and uncertainty in terms his audience could relate to.

The precautionary principle is a key consideration for making decisions under uncertainty, and it is useful to address potential harms that are outside of the environmental arena as well, as the following example illustrates.

## THE BENEFITS OF TALKING ABOUT CLIMATE CHANGE INFORMATION IN GROUPS

Extensive anecdotal evidence from CRED's work with farmers in Africa and its laboratory studies suggest that people may understand probabilistic information better when it is presented to a group, where members have a chance to discuss it, rather than as individuals who have to try to understand it alone.[51]

Group processes allow individuals with a range of knowledge, skills, and personal experience to share diverse perspectives and work together on a problem.

**EXAMPLE**

### Michigan Cherry Growers and Climate Uncertainty

Cherry blossoms have begun to appear seven to ten days earlier in Michigan than they did three decades ago, leaving them susceptible to potentially devastating spring frosts.[49] In 2002, a spring frost destroyed 99 percent of the crop, and cherry farmers wanted to know if these occurrences were likely to increase. They needed to make decisions about their $44 million-a-year-industry despite this climate uncertainty. And because a cherry tree can take up to a decade to bear fruit and typically has only a 20-30 year cycle of productivity, the farmers needed both extended and highly localized climate change information.

Simon Koopmann, commons.wikimedia.org

A group of agricultural experts, economists, climate scientists, and others began working to bring these cherry growers and other stakeholders information about climate change on a very local level. A single concrete climate prediction wasn't feasible. Instead these researchers needed to determine a wide range of climate scenarios for that region extending through the rest of the century. Further, they needed to communicate to the farmers their level of confidence per scenario. The farmers could then decide how to proceed, choosing to invest in wind machines or other frost protection, plant a hardier variety of cherry, switch to a different crop, or get out of farming altogether based on shifts in probability. Their livelihood depends on making sound decisions using the best available, yet still uncertain, scientific information.[50]

Group discussion provides a greater chance that multiple sources of information—both experiential and analytic—will be considered as part of the decision-making process. More energy is devoted to implementing solutions after group discussion. Furthermore, group context increases awareness of social support and activates social goals (see Section 6).

The example (below, left) illustrates how group discussion led to both better understanding of a probabilistic climate forecast and to generation (and eventual implementation) of more sound agricultural coping strategies.

As the example (below, right) shows, communicators should point out the probabilistic nature of climate science models and, when possible, engage and encourage group discussion about the uncertainties associated with climate change.

EXAMPLE

## African Farmers and Climate Information


Carla Roncoli

Over the last decade, CRED researchers have been working with African farmers to interpret climate forecasts for use in agricultural decisions. In one study, farmers who attended climate discussion meetings had more ideas about potential adaptive responses to forecasts than those who did not attend. The study highlighted the importance of discussion as a way to understand and incorporate climate uncertainty into planning. The participatory process facilitated the understanding and use of climate information, allowing group members to pool their ideas and to plan coordinated responses. In several groups, the farmers commented that before they heard the forecast, they were uncertain about what course the seasonal rains would take and hence about what agricultural strategies to pursue. They remained unsure about what was coming and what to do as they heard different opinions voiced at the meetings, but once a consensus was reached, they trusted the forecast, and worked hard and effectively at the particular strategies the group had settled on.[52]

EXAMPLE

## CRED Lab Experiment on Group Learning Processes

In order to study probabilistic learning CRED created a game in which students (either individually or in groups) learned about the probabilities for livestock to have a mosquito-borne illness called Rift Valley Fever (RVF). Students were then asked to play a game in which they bought and sold livestock that may or may not have RVF. In one option, which represented the optimal strategy, students could pay to test the animals before buying them. Students who learned about the probabilistic nature of the risk of RVF in a group were more likely to pay for the test, which maximized the joint outcome in the game, rather than try to achieve greater individual outcomes. The results strongly suggest that effective training requires both a cognitive and social component for people to recognize an optimal strategy.

The groups also showed a greater tendency to reframe information (from analytic to experiential and vice versa); provided additional opportunities to teach and learn from each other; and enabled the development of both social norms and shared goals.[53] Climate change communicators seeking to work with groups should set these as goals for their efforts as well.