Resources for Assessing Confidence and Uncertainty

National Climate Assessment
US Global Change Research Program (USGCRP)
2013 Report

This document has been prepared as a resource for authors of the USGCRP's National Climate Assessment 2013 Report. It describes a process that authors are requested to follow in explaining their level of confidence in 3-4 of the main conclusions of their chapters selected from among the larger set of issues they are addressing. The document includes the following components:

These resources are intended to (1) develop a standardized set of quantitative and word-based expressions for reporting levels of confidence and likelihoods; (2) provide a methodical process to help authors be more systematic in evaluating evidence and reaching collective judgments about confidence and uncertainty; (3) report key aspects of the authors' evaluation of evidence for their main conclusions that may not be included in their chapter but will be useful to those preparing the synthesis report and other summary materials; and (4) provide a more detailed and transparent record of the evidence and logic underlying their main conclusions that may be published as a web-based resource for interested readers of the assessment.

Citation: Moss, R.H., and G. Yohe, 2011: Assessing and Communicating Confidence Levels and Uncertainties in the Main Conclusions of the NCA 2013 Report: Guidance for Authors and Contributors. National Climate Assessment Development and Advisory Committee (NCADAC). Available at <http:/usgcrp.gov>. Contact information: rhm@pnnl.gov (Moss).
The authors thank Virginia Burkett, Baruch Fischhoff, Susan Hassol, Sharon Hays, Anthony Janetos, Robert Lempert, Diana Liverman, Granger Morgan, Susi Moser, and Richard Schmalensee for their comments.

1. Summary of Confidence and Uncertainty Characterization Process

Readers of the report wish to understand how confident lead authors are in the most important findings of their chapters. This guidance recommends an approach to standardize confidence levels and uncertainty characterization in the National Climate Assessment (NCA). The approach applies to the 3-4 most important findings in your chapter from among the larger set you evaluated. Follow the steps carefully to assess your confidence in your most important conclusions, using the checklist provided in Appendix 1 to guide and verify your assessment.

1. Frame the issue, keeping in mind one or more types of stakeholder decisions the information is intended to inform.

2. Rate the evidence base, evaluating the type, amount, quality, and consistency of evidence. Summarize the level of evidence as strong, moderate, suggestive, or inconclusive.

3. Considering the full gamut of evidence, formulate well-posed conclusions. For quantitative estimates, report a range in which you judge there is a 90 percent chance that the true value falls and then develop a "best estimate" if there is enough evidence to warrant it. Describe high consequence, low probability impacts that may fall outside the 90 percent range.

4. Identify key uncertainties and briefly describe what research, monitoring, etc., are needed to improve the evidence.

5. Given the potential uses of the information identified in step 1, assess your confidence in the conclusion by considering (i) the quality of the evidence (from step 2) and (ii) the level of agreement among experts with relevant knowledge. Use the confidence rating and graphic from Figure 1.

6. If you wish to indicate how likely a particular outcome is, use the terms *and* ranges in Figure 2. It is okay to use just the numerical ranges, but do not use the words alone since they have no standardized meaning. Note that the boundaries between these categories are "fuzzy". In estimating how likely an outcome is, consider the climate information provided in the relevant regional or national climate change "trends and outlook" document for the B1 and A2 scenario (or another source, if you prefer).

7. Prepare a traceable account of a sentence to a paragraph in length for each of your most important findings that describes in simple language the main factors that support the conclusion and your level of confidence.

2. Assessing and Communicating Confidence Levels and Uncertainties in the Main Conclusions of the NCA 2013 Report: Guidance for Authors and Contributors.

Guidance Document

Introduction

These summary guidelines recommend an approach to standardize assigning levels of confidence and characterizing uncertainty for author teams preparing the National Climate Assessment (NCA). The guidelines are written in a condensed, summary style intended to provide practical advice to assessment participants. More detailed guidance is available from a variety of sources listed in a short bibliography at the end of the document.

Effective uncertainty characterization (UC) is more than quantification of uncertainties in model results or reporting uncertainties documented in existing studies. UC needs to start with clear framing in which information is being developed to inform a specific question or class of questions (ideally framing will involve stakeholders who are the intended users). UC should also include identification of useful quantitative indicators or metrics, appraisal of the knowledge base, evaluation of relevant uncertainties in the context of the question or problem, and reporting of sources of confidence and uncertainty. UC depends on systematic review of the full gamut of available information that incorporates multiple perspectives and is transparent with respect to the information used, the standards of evidence applied, and the confidence of the authors in their results. This broader approach to UC is necessary to develop socially robust knowledge for climate change decision-making that is appropriate for the diverse stakeholders and high decision stakes associated with this issue. This approach to UC will enable users to have an understanding of the reliability of the various conclusions of the report, given that the evidence base will vary for each.

Chapter teams will be assessing a broad set of important issues or questions in their work. The approach defined below should be applied to the 3-4 most important issues in each chapter from among this larger set. You might consider these as the main questions you will include in the executive summary or your chapter or that you would recommend for inclusion in the synthesis report.

Use the checklist in Appendix 1 to verify that you have followed the process and to report your confidence and uncertainty assessment for each of the 3-4 main issues. The information in the checklist is intended to be useful to your author team. It will also be used in preparing the synthesis report and may be published online as supplementary information for interested users of the assessment.

Recommended UC process for each of your main 3-4 conclusions

1. *Frame the issue, keeping in mind one or more types of stakeholder decisions the information is intended to inform.* Consider specific issues or decisions that some set of stakeholders is facing so that the question is focused and the answers are useful. Identification of the decisions or issues is best done in consultation with stakeholders, but many authors have been interacting with stakeholder groups on an ongoing basis and can draw on this experience or previous assessments that have engaged stakeholders directly.

2. *Rate the evidence base, evaluating the type, amount, quality, and consistency of evidence. Summarize the level of evidence as strong, moderate, suggestive, or inconclusive.* This initial evaluation will help you decide how to develop a conclusion and identify an appropriate level of precision.

- What types of information are available? Examples: research-quality observations, data for operational purposes, theories, model results, elicitations, expert judgment, survey data.
- How much information is available? Example considerations: number of independent studies, multiple data sets, model ensembles.
- How good is the information? Example criteria: accuracy and continuity of observational data, model evaluation, use of accepted methods, transparency and thoroughness of documentation, availability of peer reviewed journal articles or reports.
- How consistent is the information? Example considerations: similar conclusions persistently reached in the literature, assumptions controlled (e.g., use of similar scenarios), standardized methods or reporting.

3. *Considering the full gamut of evidence, formulate well-posed conclusions.*

- For quantitative estimates, report a range in which you judge there is a 90 percent chance that the true value falls. This is important so we know how wide a range you are providing. Then develop a "best estimate" if there is enough evidence to warrant it. Describe high consequence, low probability impacts that may fall outside the 90 percent range.
- State your conclusions clearly and specifically. For example, "the number of extreme rainfall events will increase" is not well posed without additional information. This conclusion should include such additional information as a quantitative definition of extreme rainfall, the location, season, and time period for which the statement applies, and the climate scenario (or level of climate change) assumed.
- Be aware of a tendency for assessment teams to converge on a conclusion and become overconfident in it. A strategy some groups have used to minimize this problem is to have each individual write down his or her conclusions to the key questions before starting work as a group, and to compare and discuss these answers as the first step in reaching a collective conclusion.

4. *Identify key uncertainties and briefly describe what research, monitoring, etc., are needed to improve the evidence.*

- Sources of uncertainty vary depending on the topic and thus no single typology can be provided as a guide for NCA authors. Report uncertainty in important information sources (e.g., observations, data, model projections), or problem framing (e.g., disagreements over concepts or indicators).
- Focus your evaluation on how uncertainties affect the evidence base for decision making.
- Discuss what new research, data collection, or modeling is needed to increase confidence and improve the evidence base.

5. *Given the potential uses of the information identified in step 1, assess your confidence in the conclusion by considering (i) the quality of the evidence (from step 2) and (ii) the level of agreement among experts with relevant knowledge. Use the confidence rating and graphic from Figure 1.*

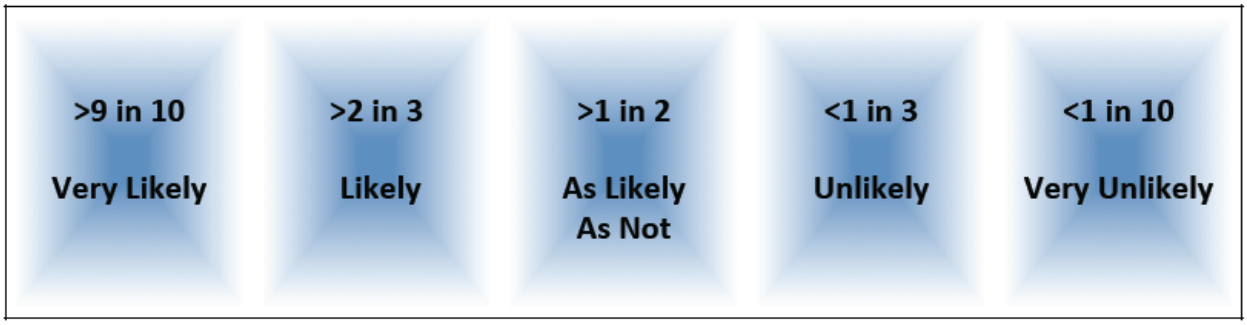
- Evaluation of confidence is a subjective process. However it can be made systematic and meaningful to users if based on a methodical evaluation of the type, amount, quality, and consistency of evidence and the degree of agreement among experts with relevant knowledge and experience.
- Different combinations of factors affecting the strength of evidence and level of agreement can be associated with each confidence level, as indicated in Table 1.
- Use the assigned confidence level and its associated graphical confidence index to report your findings.

Figure 1:

Confidence Level	Example combinations of factors that could contribute to this confidence evaluation
High	Strong evidence (established theory, multiple sources, consistent results, well documented and accepted methods, etc.), high consensus
Medium High	Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus
Medium Low	Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought
Low	Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts

6. If you wish to indicate how likely a particular outcome is, use the terms and ranges in Figure 2. It is okay to use just the numerical ranges, but do not use the words alone since they have no standardized meaning. In estimating how likely an outcome is, consider the climate information provided in the relevant regional or national climate change "trends and outlook" document for the B1 and A2 scenario (or another source, if you prefer).

Figure 2: Standardized Likelihood Expressions



- As suggested in the risk framing guidelines, report subjective likelihoods for high consequence, low probability events, explaining your level of confidence and its rationale. Use the standardized ranges below if you wish. Likelihoods can be based on evaluation of model results, statistical sampling methods or other quantitative analyses, elicitations, or expert judgment. This information will be important for risk framing.
- The boundaries between these categories are "fuzzy".
- A recurring debate among authors of assessments is whether there is "sufficient" information available to quantify likelihoods. What constitutes sufficiency is a value judgment by the authors related to their level of comfort in reporting findings at a particular point in time before evidence meets an often-unspecified confidence level. Scientists almost always want to have more information than is available and need to consider whether the information available to them is sufficient to inform a better decision.

7. *Prepare a traceable account of a sentence to a paragraph in length for each of your most important findings that describes in simple language the main factors that support the conclusion and your level of confidence.* Describe evidence used, its quality, the ranges of estimates or interpretations in the literature, assumptions, and the level of agreement. For descriptions of projected impacts, specify the scenario of climate change being used.

3. Checklist for Confidence and Uncertainty Assessment

(To be completed for each of a chapter's 3-4 main conclusions)

Brief statement of conclusion, referenced to report or chapter:

1. Framing and stakeholder information needs

One or more types of stakeholder decisions (or uses of the information) have been considered in formulating the conclusion.

Yes No

2. Initial evaluation of evidence

An evidence rating has been assigned, considering the type, amount, quality, and consistency of evidence. In light of the use of the information, the evidence is:

Strong Moderate Suggestive Inconclusive

3. Preparation of conclusion

The conclusion reflects the diversity of evidence. For quantitative estimates of relevant parameters or metrics, a range is provided (in which there is a 90% chance the true value falls), and a "best estimate" is given, if warranted. High consequence outliers have been considered,

Fully Partially

4. Identification of key uncertainties

Sources of uncertainty and steps for improving the information base have been identified.

Fully Partially Limited extent

5. Assessment of confidence based on evidence and agreement

In light of the potential uses of the information, a confidence level has been assigned.

High Moderate Fair Low

6. Indication of how likely it is that an outcome or event will occur

If you indicate how likely an event is to occur, the standardized numerical ranges and likelihood words have been used.

>9 in 10 Very Likely | >2 in 3 Likely | ~1 in 2 Likely as Not | <1 in 3 Unlikely | <1 in 10 Very Unlikely

7. Traceable account:

4. Bibliography and Resources

This short bibliography includes references consulted in preparing these guidelines, additional resources for authors, and contributions to the decision analysis research literature and its application to climate science that may be of interest. This is far from a complete list of relevant references and is not intended as a catalog of relevant information.

Budescu, D. V., S. Broomell, et al. (2009). "Improving Communication of Uncertainty in the Reports of the Intergovernmental Panel on Climate Change." Psychological Science **20**(3): 299-308.

CCSP (2009). Best Practice Approaches for Characterizing, Communicating, and Incorporating Scientific Uncertainty in Decisionmaking. A Report by the Climate Change Science Program and the Subcommittee on Global Change Research. M. G. Morgan, H. Dowlatabadi, M. Henrionet al. Washington, DC, National Oceanic and Atmospheric Administration**:** 96.

Ebi, K. (2011). "Differentiating theory from evidence in determining confidence in an assessment finding." Climatic Change **108**(4): 693-700.

Funtowicz, S. O. and J. R. Ravetz (1990). Uncertainty and Quality in Science for Policy. Dordrecht, Kluwer.

Ha-Duong, M. (2008). "Hierarchical fusion of expert opinions in the Transferable Belief Model, application to climate sensitivity." International Journal of Approximate Reasoning **49**(3): 555-574.

IAC (2010). Climate Change Assessments: Review of the Processes and Procedures of the IPCC. Amsterdam, InterAcademy Council**:** 101.

Janssen P H M, P. A. C., van der Sluijs J P, Risbey J S and R. J. R (2005). "A guidance for assessing and communicating uncertainties." Water Sci. Technol. **52**: 125.

Kandlikar, M., J. Risbey, et al. (2005). "Representing and communicating deep uncertainty in climate-change assessments." Comptes Rendus Geosciences **337**(4): 443-455.

Manning, M. R. (2003). "The Difficulty of Communicating Uncertainty." Climatic Change **61**(1): 9-16.

Mastrandrea, M. D., C. B. Field, et al. (2010). Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties. Geneva, Intergovernmental Panel on Climate Change.

Mearns, L. (2010). "The drama of uncertainty." Climatic Change **100**(1): 77-85.

Morgan, M. G. and M. Henrion (1990). Uncertainty : a guide to dealing with uncertainty in quantitative risk and policy analysis. Cambridge ; New York, Cambridge University Press.

Morgan, M. G. and D. W. Keith (1995). "Subjective Judgements by Climate Experts." Environmental Science & Technology **29**: 468-476.

Moss, R. H. and S. H. Schneider (1996). Characterizing and Communicating Scientific Uncertainty: Building on the IPCC Second Assessment. Characterizing and Communicating Scientific Uncertainty, Aspen, Colorado, Aspen Global Change Institute.

Moss, R. H. and S. H. Schneider (2000). Uncertainties in the IPCC TAR: Recommendations To Lead Authors For More Consistent Assessment and Reporting. Cross-Cutting Issues in the IPCC Third Assessment Report. R. Pachauri, and Taniguchi, T. Tokyo, Global Industrial and Social Progress Research Institute for IPCC.**:** 33-52.

Netherlands Environmental Assessment Agency (MNP) (2003-2008). RIVM/MNP Guidance on Uncertainty Assessment and Communication. http://www.nusap.net/sections.php?op=viewarticle&artid=17

Nordhaus, W. D. (1994). "Expert Opinion on Climatic Change." American Scientist **82**: 45-51.

NRC (2009). Informing Effective Decisions in a Changing Climate. Washington, DC, National Academies Press.

NRC (2010). Informing an Effective Response to Climate Change. Washington, DC, National Academies Press.

NUSAP.NET: Website resource for exchange of views and education in sustainability, precaution, post normal science, knowledge quality assessment, and the management of uncertainty. http://www.nusap.net/

Olsen, J. r., K. Christensen, et al. (2010). Making Inference and Making Decisions An Introduction to Epidemiology for Health Professionals, Springer New York. **1:** 123-127.

Patt, A. (2007). "Assessing model-based and conflict-based uncertainty." Global Environmental Change **17**(1): 37-46.

Pidgeon, N. and B. Fischhoff (2011). "The role of social and decision sciences in communicating uncertain climate risks." Nature Clim. Change **1**(1): 35-41.

Pittock, A. B., R. N. Jones, et al. (2001). "Probabilities will help us plan for climate change." Nature **413**(6853): 249-249.

Pontius, R. G. and N. Neeti (2009). "Uncertainty in the difference between maps of future land change scenarios." Sustainability Science **5**(1): 39-50.

Reilly, J., P. H. Stone, et al. (2001). "Uncertainty and Climate Change Assessments." Science **293**(5529): 430-433.

Schenk, N. and S. Lensink (2007). "Communicating uncertainty in the IPCC's greenhouse gas emissions scenarios." Climatic Change **82**(3): 293-308.

Schneider, S. H. (2002). "Can we Estimate the Likelihood of Climatic Changes at 2100?" Climatic Change **52**(4): 441-451.

Tol, R. S. J. (2003). "Is the Uncertainty about Climate Change too Large for Expected Cost-Benefit Analysis?" Climatic Change **56**(3): 265-289.

van der Sluijs J P, C. M., Funtowicz S O, Kloprogge P, Ravetz J R and R. J. S (2005). "Experiences with the NUSAP system for multidimensional uncertainty assessment in model based foresight studies." Water Sci. Technol. **52**: 133.