Common frame of reference (CFR) for dealing with uncertainties and communication about uncertainties

Meaning Common frame of reference

The central theme of the Autumn School (October 8-10, 2012) was dealing with and communicating about uncertainties, in climate- and socio-economic scenarios, in impact models and in the decision making process. The lectures and discussions contributed to the development of a common frame of reference for dealing with uncertainties. The common frame contains the following:

- Common definitions (p. 2);
- Common understanding and aspects on which we disagree (p. 3-4);
- Documents that are considered important by all participants (p.5-6);
- Do's and don'ts in dealing with uncertainties and communicating about uncertainties (p.7-8);
- Recommendations (p.9).

The common frame of reference is meant to help *researchers in climate adaptation* to work together and communicate together on climate change (better interaction between disciplines). It is also meant to help researchers to explain to others (e.g. decision makers) why and when we agree and when and why we disagree, and on what exactly.

''We'' in this common frame refers to the participants of the Autumn School 2012.

COMMON DEFINITIONS

Uncertainty = Uncertainty can be defined as any departure from complete deterministic knowledge of the relevant system (based on Walker et al., 2003). Uncertainty is not simply a lack of knowledge, because an increase in knowledge might lead to an increase of knowledge about things we don't know, and thus increase uncertainty.

Note 1: Some examples of definitions given by the participants at the start of the Autumn School, to illustrate that uncertainty is often defined differently:

- *Uncertainty refers to ambiguity of a system due to changes in its components;*
- *Uncertainty is whatever hinders a prediction from being reliable either because it cannot be or is not taken into account due to assumptions, scenarios, choices (including acceptable risk), public interests, supporting data or unprecedented experiences;*
- *A degree of how sure or unsure one is about something (direction, magnitude), depending on what is known (known knowns and known unknowns);*
- *A degree of a limited knowledge about a system;*
- *The inability to accurately predict a future state or event;*
- A person is uncertain if s/he lacks confidence about the specific outcomes of an event. Reasons for this lack of confidence might include a judgment of the information as incomplete, blurred, inaccurate, unreliable, inconclusive or potentially false. Source: Refsgaard et. Al. (2007), based on Klauer & Braun (2004).

Robustness =
If using the term robustness, make clear whether you are referring to a system or to decisions:

- Robust systems: a system keeps functioning well under a large range of possible future developments (related to natural variability and/or climate change and/or socio-economic processes).
- Robust decisions: these decisions result in measures that work well under a large range of possible future developments.

Note 1: The term "Robust models" is often used too. However it's the system which the model describes which can be robust. Then the outcomes of the model will be little sensitive to changes in model input (if the model describes the system well).

Note 2: When using the term, specify (a) what system robustness refers to; and (b) what kinds of developments the system or decision is robust for.

Note 3: Some examples of definitions given by the participants at the start of the Autumn school, to illustrate that robustness is often defined differently:

- *Model robustness is the extent to which (model) results are stable when inputs or model parameters are changed;*
- *Robustness of the climate/atmosphere system is the extent to which the atmosphere and climate remain stable under (anthropogenic) pressures;*
- *A situation when a system is less sensitive to any internal/external changes;*
- *Strategy which includes building with ecosystem services, behavioral change, institutional reform, and risk spreading via financial instruments;*
- *(A system) performing well under different conditions: the average, the extreme, the expected, the unexpected.*

COMMON UNDERSTANDING

The main reasons why we consider it important to take uncertainties into account (to assess and communicate about uncertainties) are:

- The ethical reason: Our goal as scientists is to improve humanity's understanding of the world, and that can only be accomplished when we communicate those factors that could make our findings limited or uncertain;
- The strategic reason: Communicating uncertainty enhances our credibility, in particular when that uncertainty diminishes the apparent importance of our work;
- The economic reason: In many cases, decision-makers can achieve superior outcomes when they take uncertainties into account;
- The altruistic reason: Communicating the limitations and uncertainties inherent in our findings helps other scientists to formulate important research questions.

Can a common typology of uncertainties be useful?

- It could improve communication between people, both those engaged in research as in decision-making, if we all use the same typology, because we can be more specific;
- Useful to know where uncertainty comes from;
- The typology could give directions on how to deal with it: Useful to know whether it is an uncertainty that can be expressed in a probabilistic way;
- You can refer to it in a paper (you can easily point out which uncertainties you have and which you have not addressed).

Note 1: Most agree on that a common typology will improve communication among disciplines, although we should probably use a few common typologies, as the usefulness of the typology differs per discipline and type of user.
Note 2: A common typology might be most useful for professional users. If you are addressing the general public or a stakeholder who is new to the subject a typology might not be that helpful as it needs explanation. Stories of uncertainties that illustrate the different types of uncertainties and which have a human element, might be more effective in that case.

Useful typologies of uncertainties

- Levels (indicate how difficult it is to describe uncertainty) (see table 1)
- Sources
  - (Natural) variability;
  - Lack of (system) understanding, inherent complexity
  - Varying perceptions, preferences (ambiguity)
- Locations (for model-based analysis): (where?: in input?, in model? in output?)

Based on: Suraje Dessai and Jeroen van der Sluijs (2007) Box 1.2 Levels of uncertainty, p.12

Note 1: For policy makers the levels could be of most value as these indicate how difficult it is to describe uncertainty. The source and location might be less relevant for them.
Note 2: In scientific literature typologies for varying perceptions is not given a lot of attention yet.

Table 1: Description of the various levels of uncertainty

	Level 1	**Level 2**	**Level 3**
Description	*> Often the term statistical uncertainty is used* • Possible to describe with probabilities • Statistically quantifiable	*> Often the term scenario[1] uncertainty is used* • Know about possible outcomes, regularly/often not possible to describe with probabilities • A range in the outcomes (with or without ranking) due to different underlying assumptions	*> Often the terms deep uncertainty or recognized ignorance are used* • We can not quantify nor use probabilities • We know there could be surprises • We know neither the mechanisms, functional relationships nor statistical properties • We do not agree on or do not know the (future) valuation of the outcomes
Examples	• The mean yearly precipitation in the current climate in the Netherlands and the 95% confidence interval	• The future change in mean winter precipitation in the Netherlands (it is more probable that it will increase than decrease)	• Collapse of West-Antarctic ice sheet

Shared task in communication uncertainties

Assuming that:

- Policy makers want the include scientific results into policy making;
- Scientists want their work to be used by society

Policy makers and scientists both have a task in communication about science: scientists in trying to understand policy makers (e.g. their information needs and how they use information) and explaining in a clear way their research, policy makers in making clear what is relevant to them and trying to understand scientists.

Communication between scientists and decision makers requires a lot of effort (from both the scientists and decision makers) due to the differences in knowledge, framing, scales on which they operate usually (practical versus conceptual, short versus long term, local versus international), lack of familiarity with each other's working environment…..

No agreement on how far scientists should go in communication

Although everyone wants scientific results to be used by decision makers, there is no agreement on how far scientists should go in communication. It ranges from limited efforts (too much simplification touches upon integrity of researcher), up to much effort (societal responsibility). Emphasizing or de-emphasizing uncertainties can also be used strategically (by both scientists and policy makers).

Results of scientific work should be communicated to decision makers and also the uncertainties included. However, not everyone has the skills (and willingness) to invest much time in communication: it is by some considered as a task for specialized persons.

Note 1: Everyone has the power to improve his or her skills at communication.

Note 2: How far scientists should go in communication depends strongly on the situation. In some situations uncertainties are more relevant for policy makers then in other situations (see Wardekker et al., 2008). Idem for different target groups (see Kloprogge et al., 2007).

[1] In this document, 'scenario' is referring to: a plausible and often simplified, description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. (We are not referring to policy scenarios).

SHARED DOCUMENTS

Terminology

- Uncertainty Terminology (version 1.0)
  J.H. Kwakkel, M.J.P. Mens, A. de Jong, J.A. Wardekker, W.A.H. Thissen and J.P. van der Sluijs (2011) *Knowledge for Climate report*

Types of uncertainties

- Uncertainty and Climate Change Adaptation – a Scoping Study
  Suraje Dessai and Jeroen van der Sluijs (2007) report NWS-E-2007-198, *Copernicus Institute*, Utrecht University
  - Box 1.2 Levels of uncertainty (Source: Walker *et al.* 2003, Janssen *et al.* 2005), p.12
  - Chapter 3, Decision making frameworks for adaptation to climate change, p. 23–43
  - Chapter 4, Methods and tools to assess climate change uncertainties relevant for adaptation, p. 44–58
- More is not always better: Coping with ambiguity in natural resources management
  M. Brugnach, A. Dewulf, H.J. Henriksen and P. van der Keur (2011) *Journal of Environmental Management* **92** 1, pp. 78–84
- Frame-based guide to situated decision-making on climate change
  Joop de Boer, Arjan Wardekker and Jeroen P. van der Sluijs (2010) *Global Environmental Change* **20** 3, pp. 502–510
- Defining Uncertainty – a conceptual basis for uncertainty management in model-based decision support
  W.E. Walker, P.Harremoes, J. Rotmans, J.P. van der Sluijs, M.B.A. van Asselt, P. Janssen and M.P. Krayer von Krauss (2003) *Integrated Assesment* **4** 1, pp. 5–17
- The Potential to Narrow Uncertainty in Regional Climate Predictions
  Ed Hawkins and Rowan Sutton (2009) *Bulletin of the American Meteorological Society* **90**, pp. 1095–1107

Dealing with uncertanties

- More is not always better: Coping with ambiguity in natural resources management
  M. Brugnach, A. Dewulf, H.J. Henriksen and P. van der Keur (2011) *Journal of Environmental Management* **92** 1, pp. 78–84
- Frame-based guide to situated decision-making on climate change
  Joop de Boer, Arjan Wardekker and Jeroen P. van der Sluijs (2010) *Global Environmental Change* **20** 3, pp. 502–510
- Uncertainty and Climate Change Adaptation – a Scoping Study
  Suraje Dessai and Jeroen P. van der Sluijs (2007) report NWS-E-2007-198, *Copernicus Institue*, Utrecht University
- Exploring the quality of evidence for complex and contested policy decisions
  Jeroen P. van der Sluijs, Arthur C. Petersen, Peter H.M. Janssen, James S. Risbey and Jerome R. Ravetz (2008) *Environmental Research Letters* **3**, 024008
- Uncertainty in the environmental modelling process – A framework and guidance
  Jens Christian Refsgaard, Jeroen P. van der Sluijs, Anker Lajer Højberg and Peter A. Vanrolleghem (2007) *Environmental Modelling & Software* **22** 11, pp. 1542–1556
- Agreeing to disagree: uncertainty management in assessing climate change, impacts and responses by the IPCC
  Rob Swart, Lenny Bernstein, Minh Ha-Duong and Arthur Petersen (2009) *Climatic Change* **92** 1–2, pp. 1–29
- Website with additional information on methods and examples
- Website of Climate-Adapt has several examples on climate change adaptation
- Designing Adaptive Policy Pathways for Sustainable Water Management under Uncertainty: Lessons Learned from Two Cases
  Marjolijn Haasnoot, Jan H. Kwakkel and Warren E. Walker (2012) *Third International Engineering Systems Symposium CESUN 2012*, Delft University of Technology, 18–20 June 2012
- The future shocks: On discontinuity and scenario development
  Ph.W.F. van Notten, A.M. Sleegers and M.B.A. van Asselt (2004) *Technological Forecasting & Social Change* **72**, pp. 175–194
- Scenarios in environmental and energy assessment Frans Berkhout (2009) lecture slides
  Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam
- A Perspective-Based Simulation Game to Explore Future Pathways of a Water-Society System Under Climate Change

Pieter Valkering, Rutger van der Brugge, Astrid Offermans, Marjolijn Haasnoot and Heleen Vreugdenhil (2012) *Simulation & Gaming*, published online 12 June 2012

- Guidance for Uncertainty Assessment and Communication: Tool Catalogue for Uncertainty Assessment
  J.P. van der Sluijs, P.H.M. Janssen, A.C. Petersen, P. Kloprogge, J.S. Risbey, W. Tuinstra, M.B.A. van Asselt, J.R. Ravetz, RIVM/MNP Utrecht University & RIVM, 2004

Communication of uncertainties

- Uncertainty Communication – Issues and good practice
  Penny Kloprogge, Jeroen P. van der Sluijs, Arjan Wardekker (2007) report NWS-E-2007-199 *Copernicus Institute*, Utrecht University
- Guidance for uncertainty assessment and communication
  Hans Visser, Arthur C. Petersen, A.H.W. Beusen, P.S.C. Heuberger and P.H.M. Janssen (2006) report 550032001, *Netherlands Environmental Assessment Agency*, Bilthoven
- How to communicate uncertainty?
  part of the website of *Climate-Adapt, European Climate Adaptation Platform*
- Uncertainty communication in environmental assessments: Views from the Dutch science-policy interface
  Arjan Wardekker, Jeroen van der Sluijs, Peter Janssen, Penny Kloprogge, Arthur Petersen (2008) Environmental Science & Policy, 11 7, pp. 627-641.
- Narrowing the climate information usability gap
  Lemos et al., Nature Climate Change, October 2012, doi: 10.1038/NCLIMATE1614.

DO'S AND DON'TS

For dealing with and communication of uncertainties

Do's

Start/during the project

- Know your target audience and adjust the communication to the target audience (e.g. sometimes it may be better to talk about risks or margins than about uncertainties);
- Persist to make sure the question of the target audience is clear; Be aware of the question behind the question. What is the purpose of the information?;
- Researcher and stakeholder (e.g. policy maker) should agree about which uncertainties are relevant; Also mutual understanding about how scientist/policymakers deal with uncertainties is needed;
- Be aware that you have to find a good balance between doing your research thoroughly and being quick. For policy makers it's important to be able to incorporate new scientific information in time in the policy cycle. To give qualitative information (but still, scientifically well underpinned) can help out;
- Intensify the contact between scientists and policy makers to reduce the gap between supply and demand; Organize the interface between policy makers and scientists;

  Note 1: There are several models in which the interface can be organized. A recent study by Lemos et al. (2012), Narrowing the climate information usability gap, (Nature Climate Change, October 2012, doi: 10.1038/NCLIMATE1614) reviews several possibilities.
- In case of ambiguity (several valid frames): choose your strategy depending on the assumptions you make (is there a correct frame?; is there willingness to negotiate?, can you ignore other frames?). Brugnach et al. (2011);
- Check which method you could use to deal with uncertainties. Both for analysis (Dessai and Van der Sluijs, 2007) as for the adaptation strategy.

Presenting information

- Determine the main message, don't overload the audience with information, present only the relevant information. Clearly indicate key info you're trying to communicate;
- Offer the information gradually, tailored to the needs of the user (progressive disclosure of information);
- Give examples and tell stories of uncertainties (involving what you observed, what you failed to observe, and so on), which have a human element (99% of what people actually remember is stories that involve people).
- Explain how the information can be used;
- Watch out for issues that distort the proportions in graphs/maps, such as a broken axis/off set;
- Linking to the impact of the result on the target audience is helpful; e.g. policy goals, risks, good/bad outcomes;
- Always ask for feedback to check whether the visualization results in the right interpretation.

Don'ts

- Don't give information about probabilities if you can't (for example of the scenarios themselves, as scenarios are typically used if probabilities can't be given), even though decision makers ask for probabilities;
- Don't average scenarios; Different values for one variable, coming from different scenarios, make uncertainty for this variable visible (in stead of showing only one value);
- Don't take over the chair of the policymaker: scientists should deliver the scientific information, policy makers should make the decision;
- Don't focus only on model uncertainties. Take also different perceptions into account.
- Do not only focus on uncertainties (model/perceptions), but also highlight what is certain. Only focussing on uncertainties could paralyze decision makers;
- Don't present outcomes as more certain then they are;

- Don’t put too much information in a single graph/map (e.g. show the mean or the standard deviation. Don’t show them both in the same graph/map, because you will lose the overview).

Specific do’s per level

Level 1	**Level 2**	**Level 3**
What can scientists do? • More measurements • Use of stochastic models • Long time series • Use reliable (calibrated) PDF from statistical or dynamic model • Extreme statistics *What can decision makers do?* • Risk analysis (adaptation/policy)	*What can scientists do?* • Analyze/specify where quantifiable • Reduce uncertainties: do more research and monitoring • Develop scenarios • Which scenarios to use depends on the purpose, but always span a considerable part of the relevant uncertainties. • Determine relevance of uncertainties *What can decision makers do?* • Sensitivity analysis • Adaptation pathways (adaptation/policy) • Use a range of scenarios to test robustness • What are costs if the event occurs? What are costs of trying to prevent? If costs of prevention are very low, then immediately prevent! If damage costs of the event are zero, then let it go!	*What can scientists do?* • Increase research efforts to obtain more knowledge • Develop extreme scenarios/wild cards • Use a very broad set of possible futures (Exploratory Modeling and Analysis) • Investigate whether impacts will be dramatic or not and what responses might be available or when thresholds of irreversible change might be passed or even might have been passed. • Explore (and assess) alternative strategies, e.g. by making a system more resilient or robust, developing adaptive policies, including flexibility, etc. • Monitoring *What can decision makers do?* • Use of extreme scenarios (not clear if they could happen)? • Delay decision, explore how long you can wait to take action. • Arrange insurances, negotiate with other stakeholders. • Think about what ‘risks’ you are willing to accept, what price you want to pay for preventing certain consequences. • Promote monitoring and research

RECOMMENDATIONS

Recommendations regarding dealing with uncertainties

1. There is a need for a **useful typology for social sciences** including decision-making: it would be good to have a typology of ambiguity.

2. **Help with finding the right method**: There is a large number of combinations of types of uncertainties, methods to deal with them analytically, and (policy) strategies to follow in light of them. It would be useful to have some ranking, or a list with advantages and disadvantages of each method and a sort of matching of uncertainty situations, policy attitudes, and policy strategies in order to determine which method to use when.

   Note 1: > A good description of pitfalls, strengths en limitations *of a selection* of analysis methods (error propagation, Monte Carlo analysis, sensitivity analysis, etc.) is given in the RIVM/MNP Guidance for Uncertainty Assessment and Communication, Tool Catalogue for Uncertainty Assessment: J.P. van der Sluijs, et al. (2004).

3. There is more information needed on **methods that can be used for uncertainties related to human actions** (ambiguity, framing, perception, risk aversion).
   Note 1: Theme 7 Governance of Adaptation of Knowledge for Climate will be consulted to give additional references to the Digital Reader on this subject.

4. **Community of users**: a platform to discuss methods and exchange experiences in dealing and communication with uncertainties is needed. Not clear yet in which form this community should exchange experiences.