Part 2 - Reading and discussion on the types of uncertainty in climate modelling

Advise for the teacher: students are divided into three groups, one for each type of uncertainty. After reading the description of each kind of uncertainty (each group has one type of uncertainty assigned), they are then asked to answer three questions, related to their discipline of expertise:

Question 1) Which examples of this type of uncertainty can you identify in your disciplines of expertise?

Question 2) How this kind of uncertainty can be related to complexity and/or to properties of complex systems?

Question 3) How this kind of uncertainty can be related to the study of climate?

After the 3 presentations, the instructors pose the following questions in order to create a space of comparison among the groups: Which differences do you notice among the three kinds of uncertainty? Which similarities?

The pre-service teachers have to fill a scheme made of three circles (each representing a different type of uncertainty, each intersecting with the others and all intersecting at the centre, so as to create 7 different zones) to meta-reflect on the perspectives opened by these issues.

INTRODUCTION

Broadly, uncertainty in climate projections arises from three sources: uncertainty in the social and political conditions that determine future climate forcing; uncertainty in our knowledge on how the climate system response to that forcing (i.e. the change in climate); uncertainty in the actual realization of climate for a particular time window, which is subject to internal variability and to aleatory factors. The nature of these uncertainties is very different (e.g. Dessai & Hulme, 2004).

The first depends primarily on **human actions** and is present in what is called the scenario: the projections are normally made conditional on the scenario.

The second is what is known as an **epistemic uncertainty**; typical uncertainty of scientific investigation, reducible with progress in scientific knowledge and research, controllable but not eliminable.

The third is what is known as an **aleatoric uncertainty**; there is a random element to what will occur, whose probability is known to some extent.

Reflexivity - Uncertainty in future climate forcing

Humans are capable of reflecting critically on the implications of their behaviour and making adjustments in the light of experience (Berkhout et al., 2002)

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If there is a reaction then it can conventionally take two forms: mitigating the problem by reducing greenhouse gas emissions and enhancing sinks, and/or adapting to the problem by devising and enhancing coping strategies to deal with the impacts of a changing climate. By mitigating (or adapting to) the problem, people are changing the future, which would render the scientist's original statement incorrect had he or she attached an estimate of likelihood.

Within the unknowable knowledge sphere it is appropriate to introduce a new category of reflexive uncertainty, which together with stochastic uncertainty provides a comprehensive picture of unknowable knowledge in the context of climate change. Reflexive uncertainty only applies to human systems because natural systems are not reflexive to information about the future (predictions).

Epistemic uncertainty - Uncertainty in our knowledge on how climate response to the forcing

It is not a property of the physical climate system; rather, it is a property of a state of knowledge, or degree of belief, and it can be reduced as knowledge improves. In contrast with aleatoric uncertainty, which is objective, such epistemic uncertainty is subjective (Kanheman & Tversky, 1982)

The extent of the epistemic uncertainty is not particularly well known. First, climate models are imperfect representations of reality and share many deficiencies, thus they may exhibit a collective bias and fail to explore important aspects of climate change. Second, even within the world represented by climate models, the forced circulation response of any particular model is obscured by internal variability.

Aleatoric uncertainty - Uncertainty in the actual realization of climate for a particular time window

Internal variability is a property of the physical climate system, whose random character arises from the chaotic nature of atmospheric and oceanic dynamics, and which can be characterized from observations. The uncertainty from internal variability is fundamentally irreducible (leaving aside the possibility of finite-time prediction from specified initial conditions), and users of climate information need to understand that the mantra of 'reducing uncertainty' is inappropriate in this case; rather, the scientific goal is to better quantify the uncertainty. The magnitude of the uncertainty for any particular quantity can be reduced by taking coarser spatial and temporal averages, but that operation changes and may simultaneously reduce the value of the information provided. Knowledge of internal variability is limited by the finite observational record, and there is uncertainty in how internal variability will respond to global warming.

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Questions

Group 1 – Uncertainty for human behaviour

- Question 1) Which examples of this type of uncertainty can you identify in your disciplines of expertise?
- Question 2) How this kind of uncertainty can be related to complexity and/or to properties of complex systems?
- Question 3) How this kind of uncertainty can be related to the study of climate?

Group 2 – Epistemic uncertainty

- Question 1) Which examples of this type of uncertainty can you identify in your disciplines of expertise?
- Question 2) How this kind of uncertainty can be related to complexity and/or to properties of complex systems?
- Question 3) How this kind of uncertainty can be related to the study of climate?

Group 3 – Aleatoric uncertainty

- Question 1) Which examples of this type of uncertainty can you identify in your disciplines of expertise?
- Question 2) How this kind of uncertainty can be related to complexity and/or to properties of complex systems?
- Question 3) How this kind of uncertainty can be related to the study of climate

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