Box TS.3 | Deliberative and intuitive thinking are inputs to effective risk management

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When people—from individual voters to key decision makers in firms to senior government policymakers—make choices that involve risk and uncertainty, they rely on deliberative as well intuitive thought processes.

- **Deliberative** thinking is characterized by the use of a wide range of formal methods to evaluate alternative choices when probabilities are difficult to specify and/or outcomes are uncertain. They can enable decision makers to compare choices in a systematic manner by taking into account both short and long-term consequences. A strength of these methods is that they help avoid some of the well-known pitfalls of intuitive thinking, such as the tendency of decision makers to favour the status quo. A weakness of these deliberative decision aids is that they are often highly complex and require considerable time and attention. Most analytically based literature, including reports such as this one, is based on the assumption that individuals undertake deliberative and systematic analyses in comparing options.
- However, when making mitigation and adaptation choices, people are also likely to engage in **intuitive** thinking. This kind of thinking has the advantage of requiring less extensive analysis than deliberative thinking. However, relying on one's intuition may not lead one to characterize problems accurately when there is limited past experience. Climate change is a policy challenge in this regard since it involves large numbers of complex actions by many diverse actors, each with their own values, goals, and objectives. Individuals are likely to exhibit well-known patterns of intuitive thinking such as making choices related to risk and uncertainty on the basis of emotional reactions and the use of simplified rules that have been acquired by personal experience. Other tendencies include misjudging probabilities, focusing on short time horizons, and utilizing rules of thumb that selectively attend to subsets of goals and objectives. [2.4]
- By recognizing that **both deliberative and intuitive** modes of decision making are prevalent in the real world, risk management programmes can be developed that achieve their desired impacts. For example, alternative frameworks that do not depend on precise specification of probabilities and outcomes can be considered in designing mitigation and adaptation strategies for climate change. [2.4, 2.5, 2.6]
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The ability of models to mimic nature is achieved by *simplification* choices that can vary from model to model in terms of the

- fundamental numeric and algorithmic structures,
- forms and values of parameterizations, and
- number and kinds of coupled processes included.

- Simplifications and the
- interactions between parameterized and resolved processes

induce 'errors' in models, which can have a leading-order impact on projections.

It is possible to characterize the choices made when building and running models into

- structural—indicating
  - the numerical techniques used for solving the dynamical equations,
  - the analytic form of parameterization schemes and
  - the choices of inputs for fixed or varying boundary conditions—
- and parametric—indicating
  - the choices made in setting the parameters that control the various components of the model.

The community of climate modellers has regularly collaborated in producing coordinated experiments forming multi-model ensembles (MMEs), using both global and regional model families, for example,

- CMIP3/5 (Meehl et al., 2007a, 24/39 models, see WG1AR5_all_final.pdf), ENSEMBLES (Johns et al., 2011) and Chemistry–Climate Model Validation 1 and 2 (CCM-Val-1 and 2) (Eyring et al., 2005), through which structural uncertainty can be at least in part explored by comparing models, and
- perturbed physics ensembles (PPEs, with e.g.,
  - Hadley Centre Coupled Model version 3 (HadCM3; Murphy et al., 2004),
  - Model for Interdiciplinary Research On Climate (MIROC; Yokohata et al., 2012),
  - Community Climate System Model 3 (CCSM3; Jackson et al., 2008; Sanderson, 2011)),

  through which uncertainties in parameterization choices can be assessed in a given model.

As noted below, neither MMEs nor PPEs represent an adequate sample of all the possible choices one could make in building a climate model. Also, current models may exclude some processes that could turn out to be important for projections (e.g., methane clathrate release) or produce a common error in the representation of a particular process. For this reason, it is of critical importance to distinguish two different senses in which the uncertainty terminology is used or misused in the literature (see also Sections 1.4.2, 9.2.2, 9.2.3, 11.2.1 and 11.2.2).

- A narrow interpretation of the concept of model uncertainty often identifies it with the **range of responses of a model ensemble**. In this chapter this type of characterization is referred as ***model range*** or ***model spread***.
- A broader concept entails the recognition of a fundamental uncertainty in the representation of the real system that these models can achieve, given their necessary approximations and the **limits in the scientific understanding of the real system** that they encapsulate. When addressing this aspect and characterizing it, this chapter uses the term ***model uncertainty***

The relative role of the different sources of uncertaint

1. model,
2. scenario and
3. internal variability

as one moves from short- to mid- to long-term projections and considers different variables at different spatial scales has to be recognized (see Section 11.3). The 3 sources exchange relevance as the time horizon, the spatial scale and the variable change.

- In absolute terms, internal variability is generally estimated, and has been shown in some specific studies (Hu et al., 2012) to remain approximately constant across the forecast horizon, with model ranges and scenario/forcing variability increasing over time.
- For forecasts of global temperatures after mid-century,
  - scenario and model ranges dominate the amount of variation due to internally generated variability,
  - with scenarios accounting for the largest source of uncertainty in projections by the end of the century.
- For global average precipitation projections, scenario uncertainty has a much smaller role even by the end of the 21st century and model range maintains the largest share across all projection horizons.
- For temperature and precipitation projections at smaller spatial scales, internal variability may remain a significant source of uncertainty up until middle of the 21st century in some regions (Hawkins and Sutton, 2009, 2011; Rowell, 2012; Knutti and Sedláček, 2013). Within single model experiments, the persistently significant role of internally generated variability for regional projections even beyond short- and mid-term horizons has been documented by analyzing relatively large ensembles sampling initial conditions (Deser et al., 2012a, 2012b).

The role of IPCC

... is to assess "the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation,Äù. IPCC scientists are drawn from government and academia, and are divided into three working groups. Working Group I deals with the scientific basis for the climate change forecast. WG II deals with the impacts of climate change on the natural and human world. WG III assesses options for limiting greenhouse gas emissions or otherwise avoiding climate change.

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6.2.3 Uncertainty and the interpretation of large scenario ensembles
The interpretation of large ensembles of scenarios from
(*) different models,
(*) different studies, and
(*) different versions of individual models

is a core component of the assessment of transformation pathways in this chapter. Indeed, many of the tables and figures represent ranges of results across all these dimensions.

There is an unavoidable ambiguity in interpreting ensemble results in the context of uncertainty.

(*) On the one hand, the scenarios assessed in this chapter do not represent a random sample that can be used for formal uncertainty analysis. Each scenario was developed for a specific purpose. Hence, the collection of scenarios included in this chapter does not necessarily comprise a set of "best guesses."

(*) In addition, many of these scenarios represent sensitivities, particularly along the dimensions of future technology availability and the timing of international action on climate change, and are therefore highly correlated.
(-) Indeed, most of the scenarios assessed in this chapter were generated as part of model intercomparison exercises that impose specific assumptions, often regarding long-term policy approaches to mitigation, but also in some cases regarding fundamental drivers like technology, population growth, and economic growth.

In addition, some modelling groups have generated substantially more scenarios than others, introducing a weighting of scenarios that can be difficult to interpret. At the same time, however, with the exception of pure sensitivity studies, the scenarios were generated by experts making informed judgements about how key forces might evolve in the future and how important systems interact. Hence, although they are not explicitly representative of uncertainty, they do provide real and often clear insights about our lack of knowledge about key forces that might shape the future (Fischedick et al., 2011; Krey and Clarke, 2011).

The synthesis in this chapter does not attempt to resolve the ambiguity associated with ranges of scenarios, and instead focuses simply on articulating the most robust and valuable insights that can be extracted given this ambiguity. However, wherever possible, scenario samples are chosen in such a way as to reduce bias, and these choices are made clear in the discussion and figure legends.

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Tipping Points
Table 12.4 I Components in the Earth system that have been proposed in the literature as potentially being susceptible to abrupt or irreversible change. Column 2 defines whether or not a potential change can be considered to be abrupt under the AR5 definition. Column 3 states whether or not the process is irreversible in the context of abrupt change, and also gives the typical recovery time scales. Column 4 provides an assessment, if possible, of the likelihood of occurrence of abrupt change in the 21st century for the respective components or phenomena within the Earth system, for the scenarios considered in this chapter.

Change in climate system component	Potentially abrupt (AR5 definition)	Irreversibility if forcing reversed	Projected likelihood of 21st century change in scenarios considered
Atlantic MOC collapse	Yes	Unknown	*Very unlikely* that the AMOC will undergo a rapid transition (*high confidence*)
Ice sheet collapse	No	Irreversible for millennia	*Exceptionally unlikely* that either Greenland or West Antarctic Ice sheets will suffer near-complete disintegration (*high confidence*)
Permafrost carbon release	No	Irreversible for millennia	Possible that permafrost will become a net source of atmospheric greenhouse gases (*low confidence*)
Clathrate methane release	Yes	Irreversible for millennia	*Very unlikely* that methane from clathrates will undergo catastrophic release (*high confidence*)
Tropical forests dieback	Yes	Reversible within centuries	*Low confidence* in projections of the collapse of large areas of tropical forest
Boreal forests dieback	Yes	Reversible within centuries	*Low confidence* in projections of the collapse of large areas of boreal forest
Disappearance of summer Arctic sea ice	Yes	Reversible within years to decades	*Likely* that the Arctic Ocean becomes nearly ice-free in September before mid-century under high forcing scenarios such as RCP8.5 (*medium confidence*)
Long-term droughts	Yes	Reversible within years to decades	*Low confidence* in projections of changes in the frequency and duration of megadroughts
Monsoonal circulation	Yes	Reversible within years to decades	*Low confidence* in projections of a collapse in monsoon circulations