

# Probabilistic scenarios have a history. . .

- At the turn of the century, there was a co-evolution of thinking regarding probabilistic climate futures

**correspondence**

## Probabilities will help us plan for climate change

*Without estimates, engineers and planners will have to delay decisions or take a gamble.*

Sir—In his Commentary “What is ‘dangerous’ climate change?”, Stephen Schneider<sup>1</sup> argued that—in the absence of unambiguous expert advice—decision-makers will produce their own probability estimates about future climate change within the large range of projections provided by the Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report, and that this is worse than using informed estimates provided by relevant experts. On the other hand, Grubler and Nakicenovic<sup>2</sup> in a subsequent Correspondence, “Identifying dangers in an uncertain climate”, argue that providing well-founded probability estimates is difficult or impossible because, although probabilities in the natural sciences are based on repeated experiments and frequencies of measured outcomes, this is not the case in the socio-economic sciences. However, this frequentist basis for probabilities in predictions of an unknown future is not possible in the Earth sciences either, since there will only be one real outcome, which cannot be measured now. Probability estimates of future conditions on Earth based on modelling are not frequentist, but essentially bayesian<sup>3</sup>, in that they are based on prior knowledge or assumptions embodied in the various models and inputs.

Various authors have shown that such estimates for global warming are possible<sup>4,5</sup> by deriving single-peaked probability distributions. On the other hand, Grubler and Nakicenovic<sup>2</sup> obtain a bimodal probability distribution of carbon dioxide emission amounts for the year 2100, which they attribute to a bifurcation in technological development pathways. If this bimodal distribution were combined with other factors to derive a probability distribution for global warming, it would almost certainly be smoother, but could still differ significantly from the other distributions.

Thus, although probability estimates are needed, methods for deriving probabilities require further development<sup>6</sup>. Some authors have suggested that in the meantime we should rely on increasing robustness<sup>7</sup> or resilience<sup>8</sup> in developing mitigation and adaptation responses. But without well-founded probability estimates, these strategies still tacitly assume some estimates of likelihood to limit the magnitude of their responses in relation to costs.

In fact, a risk-management approach requires not an assessment of the probability of a particular amount of greenhouse-gas emission or global warming at some future time, but rather an estimate of the likelihood of exceeding an identified critical impact threshold<sup>9</sup>. This integrates the probabilities from the least climate change up to the critical level, and is much more robust with respect to the underlying assumptions.

In the IPCC Third Assessment Report discussed in ref. 1, the uncertainties in projections of global surface warming by 2100 derive almost equally from uncertain emissions and uncertain climate science. Thus if critical thresholds for impacts lie in the top half of the predicted range of global warmings, these are much more likely to be avoided if decision-makers attempt to follow socio-economic development pathways that will reduce emissions. The virtue of the range of socio-economic development pathways explored by IPCC in ref. 1 is that it suggests that there are viable plausible socio-economic futures that will achieve this goal. Such development pathways may still lead to appreciable warming by 2100 and beyond, which can be avoided only by stringent climate policies.

Without probability estimates,

**Vital parameters need to be in print**

Sir—In an effort to condense Letters to *Nature* in the printed version of the journal, there is a risk that some of the critical information necessary for an independent judgement of the quality of biological structural information may be omitted, appearing only in the Supplementary Information available in the online version. These indicators are: the resolution of the structure determination; the ‘free R factor’ (an unbiased metric of agreement between the experimental X-ray diffraction data and the derived molecular model); and the Ramachandran analysis (the only independent measure of a model’s stereochemical reasonableness).

In some cases, this critical information—which takes little space—is excluded, whereas non-essential information, such as the location of the synchrotron beamlines where the diffraction data were collected and the names of standard programs used to determine the structure, is included in the printed version. It is often inconvenient to have to access the Internet while reading a paper in print, in order to obtain these essential quality indicators.

The crystallographic community has had a welcome change of heart on agreement about validation criteria for structural models—critical use of the indicators I have mentioned above—and on data availability via deposition in publicly available databases. Given that *Nature* has fully supported this shift, should the journal not also enforce minimal, accessible reporting of a structure’s quality indicators in the printed versions of papers, rather than allowing authors to deposit all this information in the online-only format of Supplementary Information?

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*Nature’s* policy is to include in the printed versions of its papers sufficient technical information to allow an interested reader to appreciate the experiments that have been performed, along with the most critical experimental data. We would therefore normally expect essential structural parameters to be included in the published version of papers rather than as part of the Supplementary Information only. However, this is always assessed by *Nature* on a case-by-case basis—Editor, *Nature*.

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- **Argument : Probabilities can improve the decision-relevance of climate science and assessment**
  - IAM: Global policy context
  - IAV: Impacts, adaptation, and risk



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# The probabilistic IAV cottage industry

## Global Discontinuities

## Watershed Hydrology



Climate change and the new world economy: Implications for the nature and timing of policy responses

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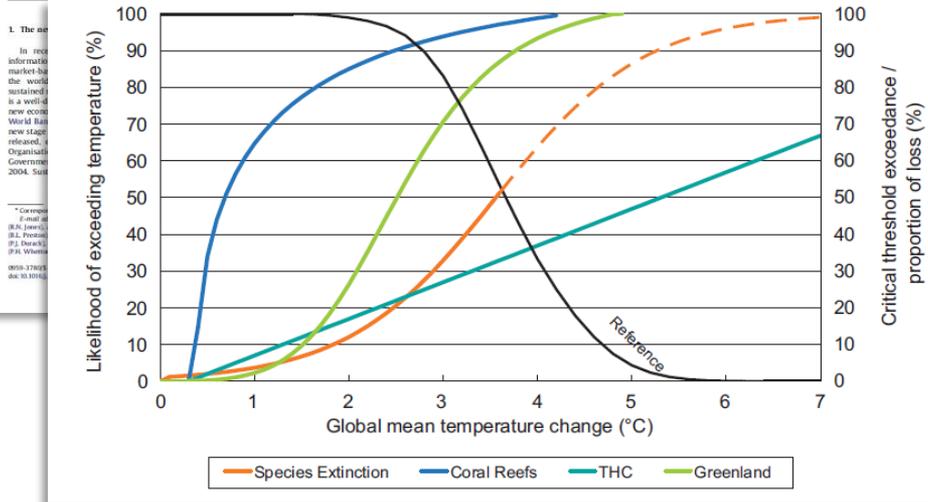
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### ABSTRACT

The world has recently moved to a new economic growth path, driven by the rapid growth of developing country economies. How this new path affects the vulnerability of key biophysical systems and its resulting policy implications are assessed using a risk-based approach. Greenhouse gas emissions based on current policies are projected to 2030, with aggressive reductions from 2030 to 2100. Probabilities for global mean temperature in 2100 are applied to damage functions for four key vulnerabilities. Five conclusions are reached: CO<sub>2</sub> emissions grow by 3.15 petagrams over 2006–2030. Atmospheric CO<sub>2</sub> concentration levels >900ppm CO<sub>2</sub>e and warming of 2.2–4.7 °C are attained by 2100. The four key vulnerabilities face a very high risk of adverse outcomes. The current policy mix cannot adequately manage these risks, which can be reduced but not eliminated by early global action. Furthermore, the Intergovernmental Panel on Climate Change's (IPCC) Special Report for Emission Scenarios (SRES) no longer provide a reliable tool for medium-term analysis in the new economy. Measures to reduce global fossil fuel consumption, accelerate the diffusion of existing non-fossil fuel technologies and to hasten the development of new technologies are urgently needed.

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Evaluating sources of uncertainty in Australian runoff projections

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### Abstract

Generating estimates of the future impacts of climate change on human and natural systems is confounded by cascading uncertainties which propagate through the impact assessment. Here, a simple stochastic rainfall-runoff model representing 238 river basins on the Australian continent was used to assess its included global mean temperature change, seasonality of runoff, rainfall and evaporation catchments, with several regions having big global and regional scales) was identified as sensitive to climate changes also influenced generally negligible. Collectively, these run-time-scales is largely a function of adequacy © 2008 Elsevier Ltd. All rights reserved.

Keywords: Climate change; Runoff; Water resources

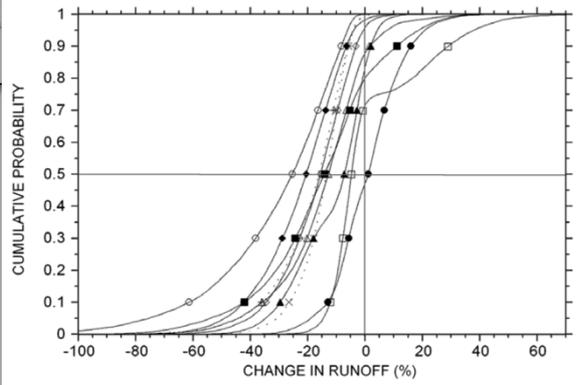
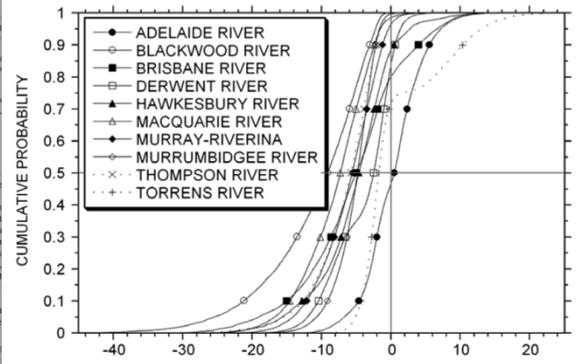
### 1. Introduction

The security of Australia's water identified as one of the most vulnerable Australian environment to the effects of This vulnerability emerges from a combination including the aridity of the continent and inter-decadal variability in climate intensive use of existing resources, potential in future climatic conditions, and growth (24.36). Given this known vulnerability, it is better understanding the risk that cause significant adverse consequences resources management.

Used formally, risk is the product of consequence and likelihood (2019). While

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Sheehan et al. (2008)

Preston and Jones (2008)

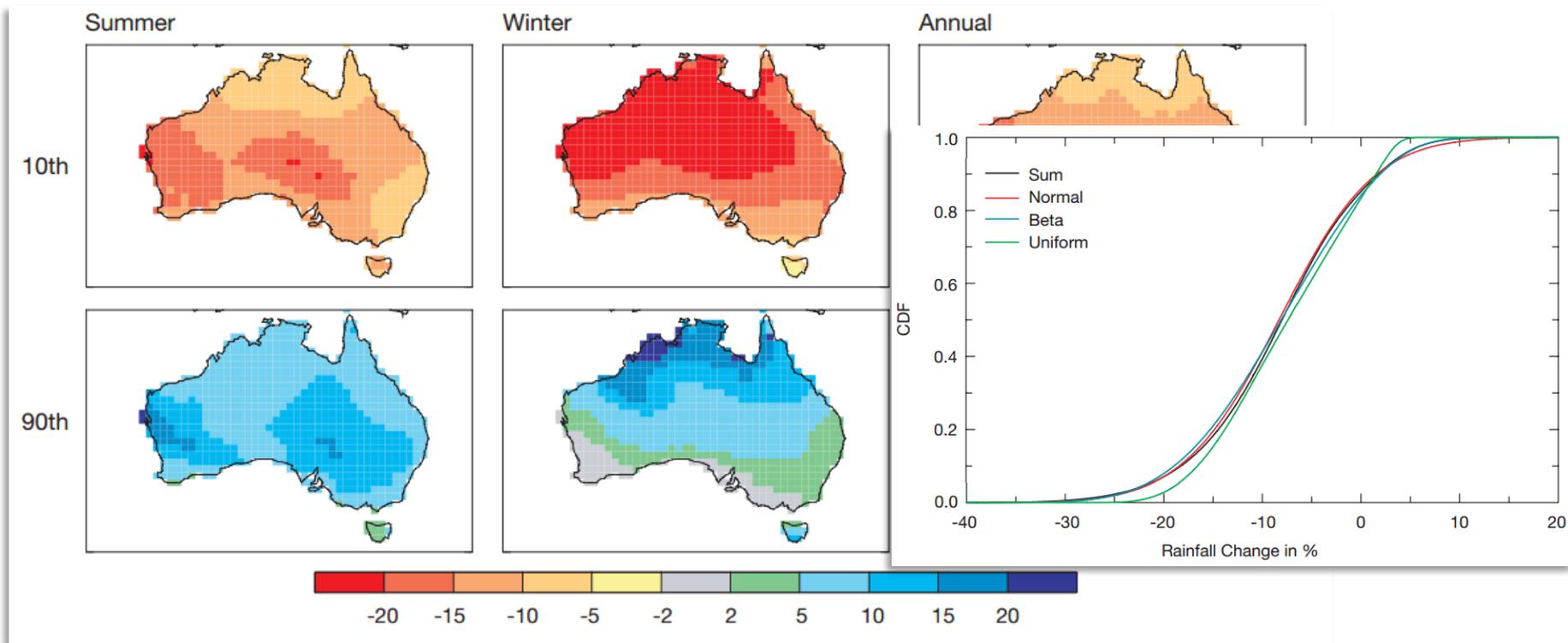


# Despite interest in probabilities, there is no shortage of cautionary messages

- **Gay and Estrada (2010):** *“Objective probabilities about future climate are a matter of opinion”*
- **Jones (2004):** *“it is not wise to directly attach likelihoods to individual scenarios and is probably not valid in any case.”*
- **Smith and Chandler (2010):** *“there are compelling reasons for discounting, if not entirely dismissing, some model results”*
- **Dessai (2008, personal communication):** *“No”*

# Out of the cottage, into the factory

- In 2007, Australia published national probabilistic climate projections (akin to UKCIP09)
  - Pattern scaling approaches with model weighting
  - Conditional probabilities for each SRES forcing scenario



# Lessons

- **Yes, probabilistic information is very attractive to researchers and practitioners**
- **Yet, probabilistic climate scenarios have failed to penetrate deeply into the IAV community:**
  - Lack of best practice
  - User rather than developer of climate scenarios
  - Significant non-climate uncertainties
  - Dependent upon process models
  - Uncertainty often suggests ambiguity (communication?)
  - Significant contribution from bottom up, qualitative research
  - Strong influence of subjective probabilities in risk assessment
  - Lack of capacity – you can build it, but they may not come