Centre for Climate Change Economics and Policy

# Is probabilistic climate change information required to inform adaptation to climate change?

Ana Lopez, Leonard A. Smith

Centre for Climate Change Economics and Policy, Centre for the Analysis of Time Series, LSE.

## Introduction:

**Probabilistic climate scenarios are currently being provided to end users, to employ as probabilities in adaptation decision making, with the explicit suggestion that they quantify the impacts of climate change relevant to a variety of sectors. These probabilities however, are sensitive to the assumptions in, and the structure of the modelling approaches used to generate them.**

**It is often argued that stakeholders *require* probabilistic climate change information to adequately evaluate and plan adaptation pathways. In practice, decisions makers rarely require anything beyond a deadline. Nevertheless it is within this context of probability distributions of climate change that we discuss below possible drawbacks of supplying information that, while seemingly robust, is highly dependent on details of the models, data, and statistical methodology used to construct it, and consequently is expected to change in the future. What then are the alternatives? While the answer will depend on the context of the problem at hand, a good approach will be strongly informed by the timescale of the given planning decision, and the consideration of all the non-climatic factors that have to be taken into account in the corresponding risk assessment. Using a water resources system as an example, we illustrate a possible alternative approach to deal with these challenges and make robust adaptation decisions today.**

## I. Are probabilistic projections robust ?

Probabilistic projections depend on data (observations and/or model data), and methodology,
**BUT**

•Relying only on **observations** for future projections can be tricky under a changing climate: if either the duration of observations is short, the system is believed to be nonstationary, or both.
and
Using **model data** for regional/local changes might not be robust:

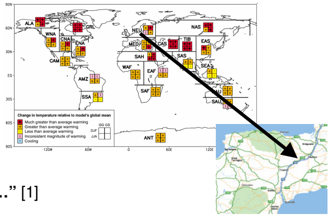
**"There is considerable confidence that climate models provide credible quantitative estimates of future climate change, particularly at continental scales and above ."**

**"Nevertheless, models still show significant errors. Although these are generally greater at smaller scales, important large-scale problems also remain…"** [1]

•Different **statistical methodologies** generate different PDFs of future changes, with the largest differences in the tails (extremes).

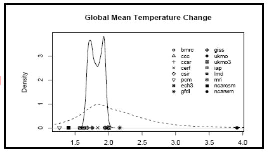
For instance : for global mean temperature change (TCR)[2]

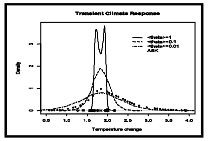
"credible estimates" scales



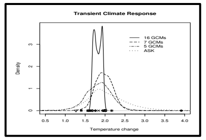
"adaptation" scales

changing statistical model




changing stat model's parameters, same data



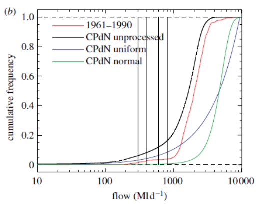

changing sampling, same statistical model

**Thus proposed PDFs are non robust across methods and inputs, particularly in the aspects often likely to influence decision makers (the "tails").**

## II. Why does it matter?

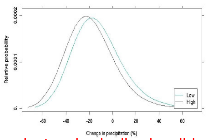
i) Probabilistic projections represent uncertainty conditional on the approach. While we can never capture the full uncertainty, when the probability distributions vary significantly between equally reasonable approaches, they cannot be regarded as robust for decision making. In this case, overconfidence in projections can lead to mal adaptation.

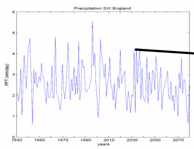
ii) Fit for purpose? Most probabilities are for changes of climate variables at some time slice in the future and for some coarse grained region. But climate variables at the local impact scales, including their correlations at different temporal (i.e., inter-annual) and spatial (i.e., within a catchment) scales, are required for climate impacts of interest to the decision maker.

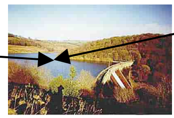



July monthly discharge of Thames at Teddington. Illustration of how meeting environmental flow targets depends on sampling strategy. [3]

RCM scale



Local scale

Is the final product a physically plausible future given the extra manipulations needed to go from the PDF to the decision relevant time series? Can we assign any robust probability of occurrence to this time series?

**Acknowledgments:** The support of the Economic and Social Research Council (ESRC) and of EQUIP is gratefully acknowledged.

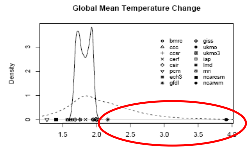
**References:**

[1] Solomon, Qin et al. (2007) "Climate Change 2007: the Physical Science Basis", Cambridge University Press, Cambridge, United Kingdom.

## II. Why does it matter? (continued)

iii) And for high stakes, low probability events: Given that climate models are imperfect and incomplete, even if the previous problems could be overcome, the probability distributions so obtained would not have quantified the likelihood of "Big Surprises".

Can this be quantified? Consider the probability P(X) of an event X occurring. We can write it as




$$P(X) = P(X/A)\,P(A) + \mathbf{P(X/\text{-}A)}\,P(\text{-}A)$$

where A represents the argument (including the theory, the models involved and the calculations) used to calculate the conditional probability P(X/A). P(A) (P(-A)) is the probability of the argument being correct (incorrect). The second term is obviously missing in any estimation of probabilistic climate change projections. But clearly its relative importance increases when P(X/A) is small (high stakes-low probability risks) [4].

**Precisely where probability distributions are strongly dependent on approach and data!**

Furthermore, if we have knowingly omitted evidence in A (specifically, if the *evidence considered* does not take into account all the *evidence)*, the equation above will include additional terms further clouding any application to decision making.

## III. What to do instead?

An alternative approach is to integrate climate risks into the formulation of the adaptation questions, and then look for solutions which are robust across all considerations, including a range of climate outcomes (see for instance [5])

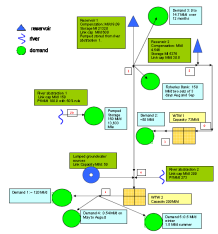
Illustrative example: water resources

**Objective** water company has to meet water demand in its catchment region until the late 21st century at minimum cost.

The decision-maker has **two decision criteria:** a 'failure rate', defined as the number of times supply does not meet demand and the costs of adaptation options that are designed to reduce this rate

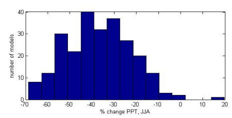
Adaptation options:

- Increasing the storage capacity during high flows,( *BIG*).
- Reducing demand of the largest users by 15%; (*DEM1*).
- Reducing demand for all major demands (1, 2 and 3) by 15% (*allDEM*)
- A combination of the 'BIG' and 'allDEM' options.

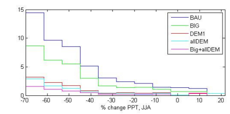



To explore robustness of these options generate ensemble plausible climate futures (river runoff for the catchment)

**Robustness across climate uncertainty**

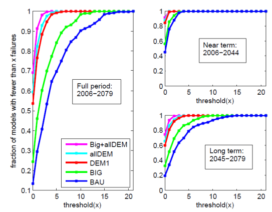



Metric representing a range of plausible climates generated using a PPE. NOT a PDF, only illustrates this range of possible futures.




Performance of adaptation options

**Timing of the decision**




Near term: no advantage from additional storage capacity

Long term: might need extra storage, but can wait and re-evaluate adaptation plan.

**If the available probabilistic information is not expected to be trustworthy, robustness-based decision methods can provide valuable insights.**

[2] Lopez, A., Tebaldi, C., New, M., Stainforth, D., Allen, M. and J. Kettleborough (2006) "Two approaches to quantifying uncertainty in climate change". *Journal of Climate*, 19: 4785.
[3] New. M., Lopez, A., Dessai, S., and R. Wilby (2007) "Challenges in using probabilistic climate change information for impact assessments: an example from the water sector". *Phil.Transactions of the Royal Society, A365,2117-2131.*
[4] Ord,T., Hillerbrand, R. and Sandberg, S. (2008) "Probing the Improbable: Methodological Challenges for Risks with Low Probabilities and High Stakes", Future of Humanity Institute, University of Oxford., and *Journal of Risk Research,* Vol: 13(2) pp. 191-205
[5] Willows,R.I and Connel, R.K. .(2003) "Climate Adaptation: Risk, uncertainty and decision-making" UKCIP Technical Report, UKCIP Oxford; Ranger,,et al. (2010) "Adaptation in the UK: a decision-making process". Report prepared for the Adaptation Subcommittee.
[6] Lopez., A., F. Fung, M. New, G. Watts, A. Weston, R. Wilby, (2010) "From climate model ensembles to climate change impacts: a case study of water resource management in the South West of England", Water Resour. Res., 45, W08419., A. Lopez, R. Wilby, F. Fung, M. New , " Emerging Approaches to Climate Risk Management", in *Modelling the impacts of climate change in water resources*, F. Fung, A. Lopez and M. New, Eds., Blackwell Publishing Ltd., October 2010.