Uncertainy in climate science and climate policy

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Plan

Uncertainty in climate science and climate policy

Climate Model Ensembles

Tipping points

In fact, as Freeman, Wagner and Zechauser (2015) have shown, over the past decade our uncertainty over climate sensitivity has actually increased

Robert S. Pnidyck, The Use and Misuse of Models for Climate Policy

Physicists like dynamical systems

$$\frac{\mathrm{d}x}{\mathrm{d}t} = F(x, E(t), \psi)$$

$$\mathrm{d}x = F(x, E(t), \psi)\,\mathrm{d}t + G(x, E(t), \psi) \circ \mathrm{d}\omega$$

- Physicists construct and interpret F, G in terms of causal processes and feedbacks (mechanisms)
- They consider that the vector x contains enough information about itself for predicting its evolution

Assumptions $\neq$ Judgements

Modelling requires idealisations, abstractions and approximations

These are not judgements on uncertainty,
not even judgements on the real world !

Model critique requires out of the box thinking

- information on sensitivity (robustness / fragility)
- knowledge on the development history, purpose, implementation

Bayesian Analysis

We may chose to communicate uncertainty on climate forecasts with Bayesian probabilities.

$$\text{Posterior} = \frac{\text{Likelihood} \times \text{Prior}}{\text{Marginal Likelihood}}$$

- Can be thought of as an extension of Aristotelian logic
- Updates probabilities in a coherent way
- It *does not* say what probability should be !

Bayesian inference guarantees coherence, not good judgements.

It is easier to get a precise probability in a closed world
It is tricky to quantify the probability of a surprise

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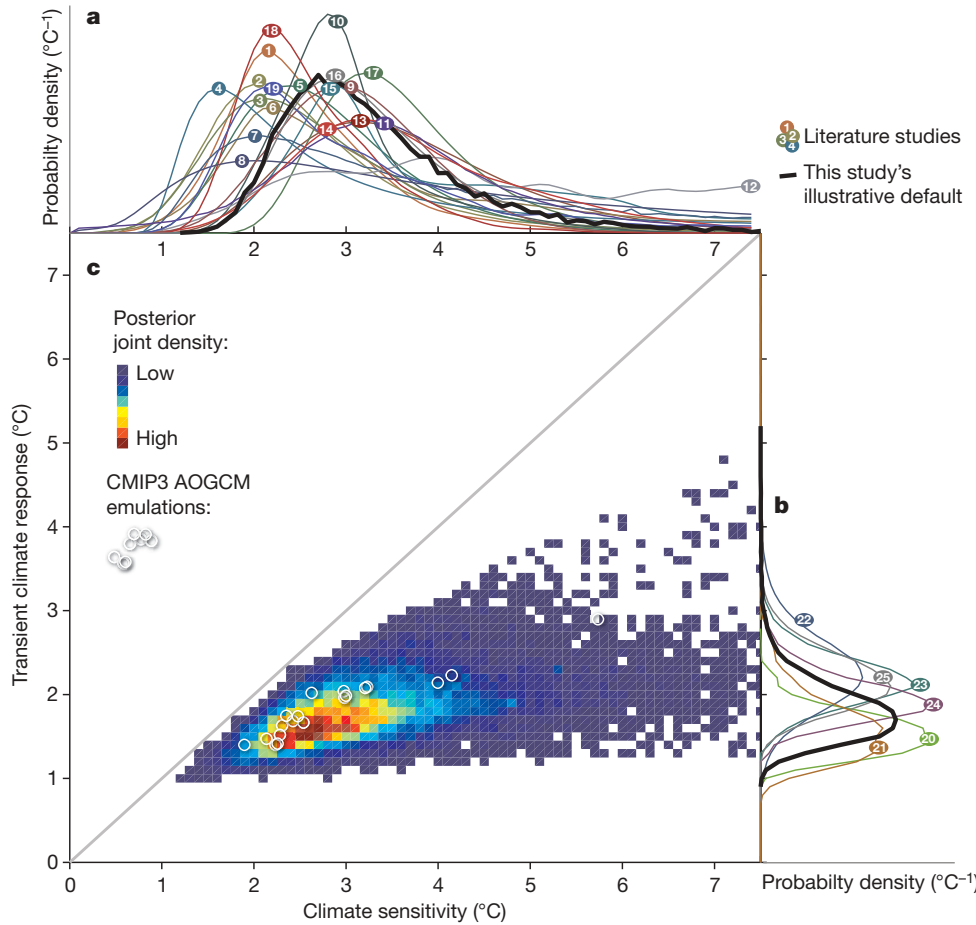

M. Meinshausen et al. In: *Nature* (2009). DOI: 10.1038/nature08017

The IPCC quote:

This [CMIP] range provides a basis for quantifying uncertainty in the projections

but

"because the number of models is relatively small, and the contribution of model output to public archives is voluntary, the spread of the projections is neither systematic nor comprehensive"

Collins et al. 2013, AR5WGI chapter 12, p. 1036

The population of model ensembles cannot be sampled efficiently

- A GCM is effectively an assemblage of modules and parameterisations
- GCM $= \{O_i, A_j, L_k, C_l\}$ where $O_i = \{t, s, \ldots\}$

$$\text{POSTERIOR} \propto \text{LIKELIHOOD} \times \text{PRIOR} \tag{1}$$

We also need to sample "values"

- Philosophers (Parker, Winsberg, and others) tell *us* that climate models are value-loaded
- (non-traceable) history of tuning, quality check, release cycle, metrics, priorities load models with non-estemic values

  Climate models are becoming evermore complex and increasingly relied upon to inform climate change adaptation. Yet progress in model development is lagging behind in many of the regions that need the information most, including in Africa

R. James et al. In: *Bulletin of the American Meteorological Society* (2018). DOI: 10.1175/bams-d-16-0090.1

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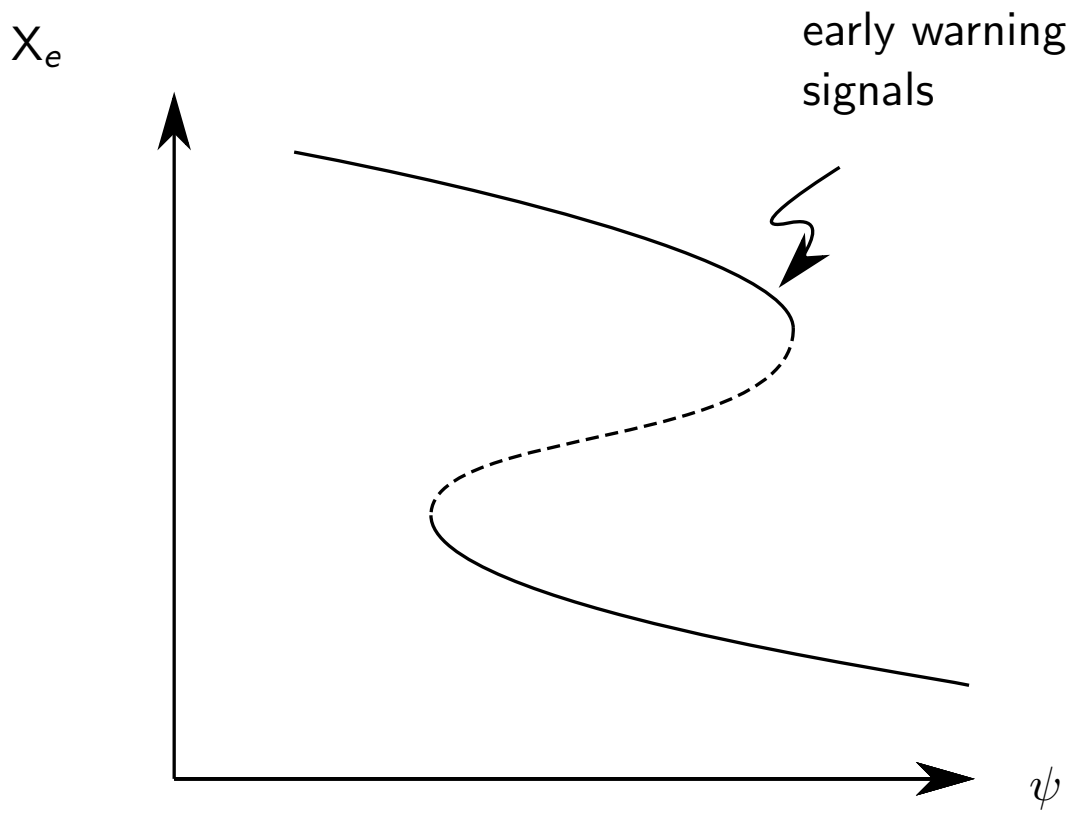
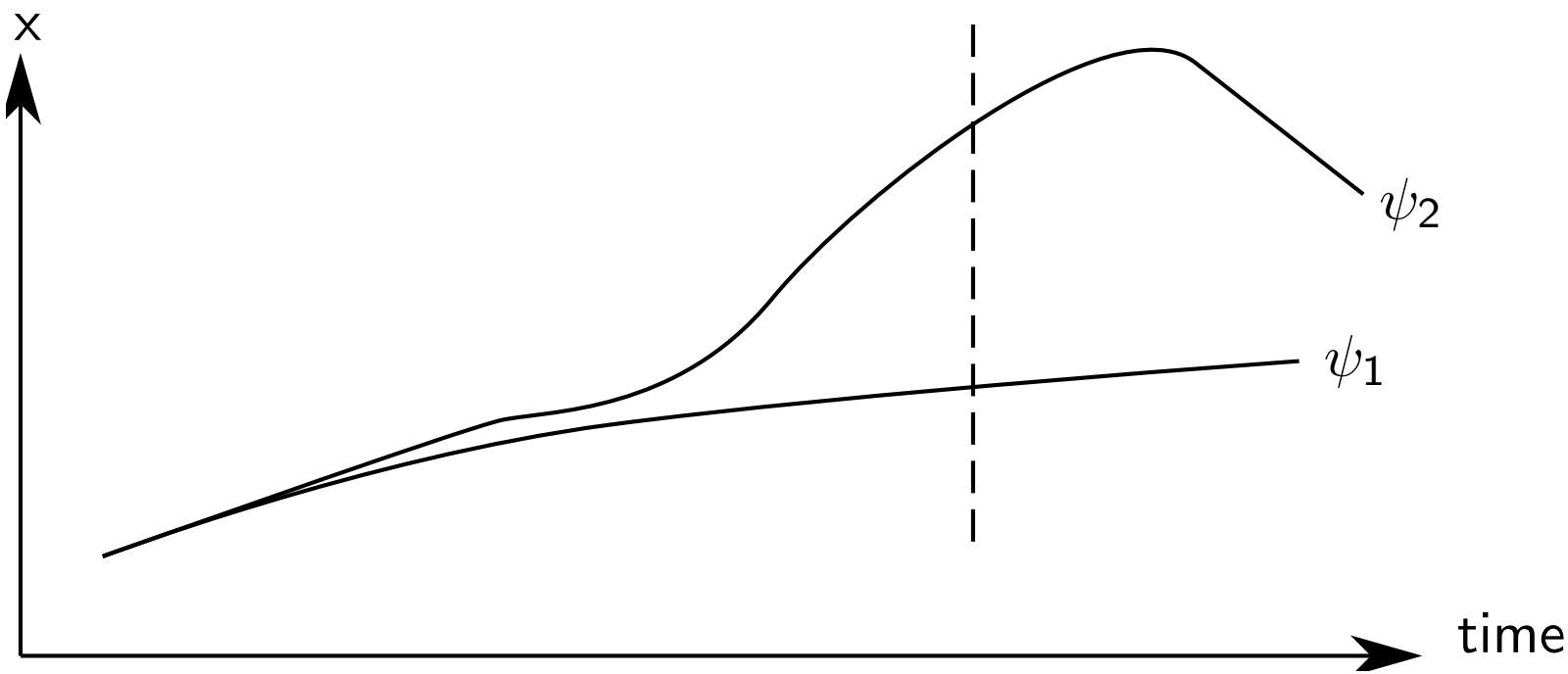
We use to call these: bifurcations

Michael Ghil, informal

The autonomous bifurcation



The non-autonomous bifurcation



The history of the tipping point metaphore

- Mainly used in the 1960's in the context of political intervention related to racial segregation
- Popularised in this context by Gladwell (2000) who uses the language of epidemics
- Used around 2005 (Katerina)
  - a critical decision with disastrous consequences (Michael Brown)
  - a tipping element (J. Schellnhuber)
  - a non-return point (J. Hansen)

- T. M. Lenton et al. In: *Proceedings of the National Academy of Sciences* (2008). DOI: 10.1073/pnas.0705414105 introduces a definition of tipping point with a *political time* and an *ethical time*. List of tipping points are obtained by *expert ellicitation*

- Increasingly used in the mass-media. Criticised for conveying fear and anxiety (the "global tipping point") (e.g., Russil et al.)

ref.: C. Russill. In: *Wiley Interdisciplinary Reviews: Climate Change* (2015). DOI: 10.1002/wcc.344 and previous works by this author

A decision management proposal

- "Surprise events" challenge the decision-making strategy
- By definition, they are not expected
- Hard, even dangerous to take probabilities too seriously / estimate cost
- What is important is to *recognise* and *anticipate* action (cf. aeroplane instructions)

References:

This is shared work with Jonty Rougier and Julie Jebeile

- Rougier J. and M. Crucifix (2018), Uncertainty in Climate Science and Climate Policy, Climate Modelling, (None) 361–380 doi:10.1007/978-3-319-65058-6_12
- J. Jebeile and M. Crucifix, "Climate models for multi-model ensembles: mathematical representations and expert judgements" , submitted.
- M. Crucifix, "Is the Concept of 'Tipping Point' Helpful for Describing and Communicating Possible Climate Futures? YES : It draws attention to the possibility of inadequate response to non-incremental change", for Hulme,M. (ed.) (2020) Contemporary Climate Change Debates: A Student Primer Abingdon: Routledge