ESCAPE FROM MODEL LAND: THE DANGERS OF OVER-CONFIDENCE IN MATHEMATICAL MODELS AND HOW TO AVOID IT

Dr Erica Thompson, Senior Policy Fellow in Ethics of Modelling and Simulation, LSE Data Science Institute

Webinar

Thursday, 21 October, 10:00 BST

A Word From Today's Chairman

Professor Michael Mainelli

Executive Chairman

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Today's Agenda

- 10:00 – 10:05 Chairman's Introduction
- 10:05 – 10:25 Keynote Presentation – Dr Erica Thompson
- 10:25 – 10:45 Question & Answer

Today's Speaker

Dr Erica Thompson

Senior Policy Fellow in Ethics of Modelling and Simulation

LSE Data Science Institute

Escape from Model Land

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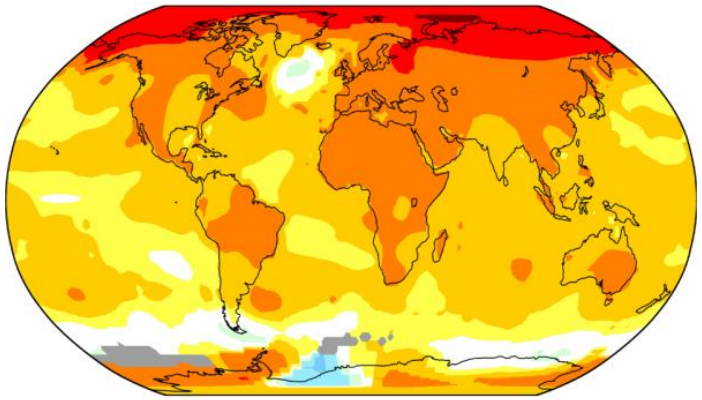
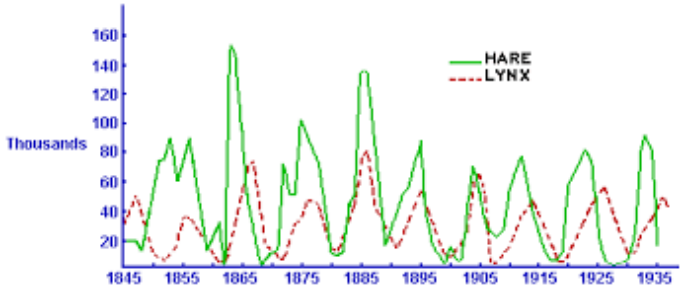
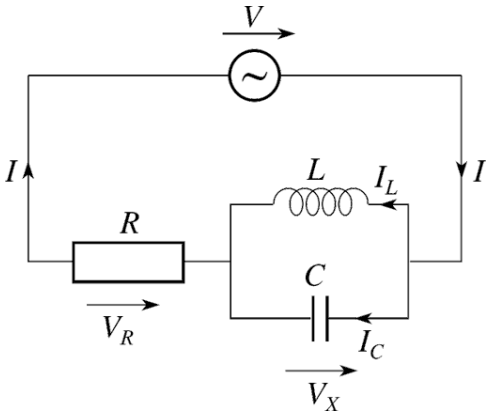
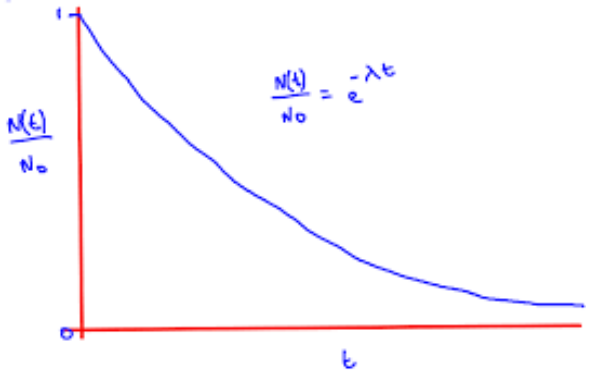
Entering Model Land

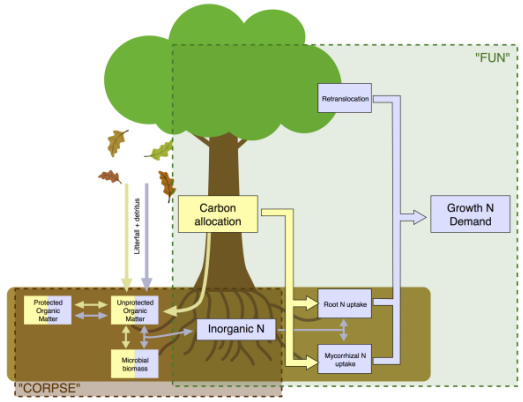


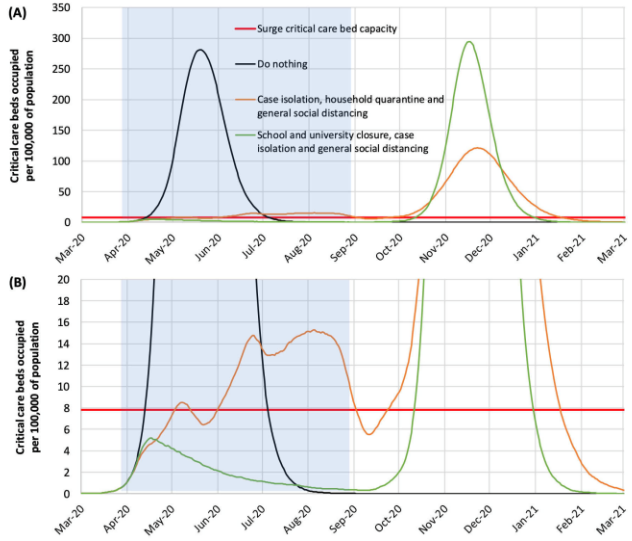




In Model Land, all of your assumptions are true







I am interested in models which **tell us something we didn't already know**, that we can use to **make forecasts** and inform **real-world** action

1. Not all confidence is quantitative

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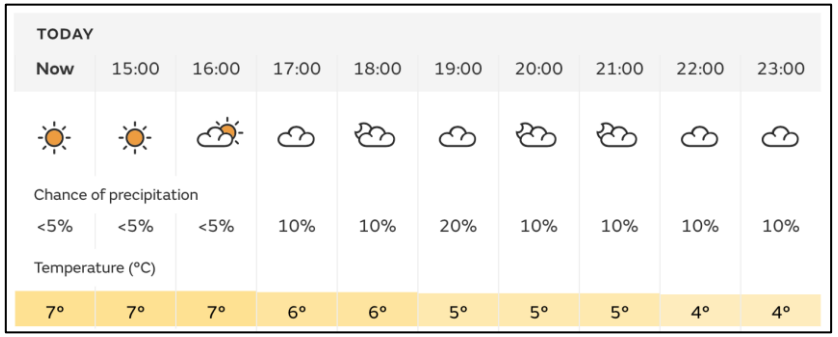
Confidence in forecasts

1. From experience (quantitative and qualitative)



TODAY									
Now	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Chance of precipitation									
<5%	<5%	<5%	10%	10%	20%	10%	10%	10%	10%
Temperature (°C)									
7°	7°	7°	6°	6°	5°	5°	5°	4°	4°

2. From informed judgements about the quality of the model
   - How well does it do in reproducing observations or expected behaviours?
   - How well does it represent the “laws of physics” or domain knowledge?
   - Does it give results that look about right?
   - Does it simulate important things well?

Weather up to a couple of weeks ahead

Covid modelling <3 weeks ahead

Traffic modelling

In **weather-like forecasting questions**, we have a useful source of out-of-sample data (waiting 24 hours) and we can do direct quantitative forecast evaluation.

> *"when there was a forecast of an 80% chance of rain, rain then occurred on 72% of occasions"*

Life insurance?

FX

Sporting outcomes

In **climate-like forecasting questions**, we are "flying blind"; extrapolating beyond the applicability of sample data. Direct forecast evaluation is not possible: we must also consider the degree of confidence warranted by the quality of the model.

> *"the model reproduces well the observed spatial and seasonal patterns of rainfall in East Asia"*

Covid modelling >3 weeks ahead

Pension modelling

Climate beyond a couple of years ahead

Presidential elections

Extreme events of any kind

Poll

In your own work, are you mainly interested in weather-like forecasting questions or climate-like forecasting questions?

- More weather-like
- More climate-like
- Both equally
- Neither (do explain afterwards)

2. All Models Are Wrong

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“All models are wrong”

“All models are approximations. Assumptions, whether implied or clearly stated, are never exactly true.
All models are wrong, but some models are useful.
So the question you need to ask is not "Is the model true?" (it never is) but "Is the model good enough for this particular application?”

George Box

How can we understand the limits of applicability of our imperfect models?
How can we inform real-world decisions with imperfect models?

Confronting imperfect models with data

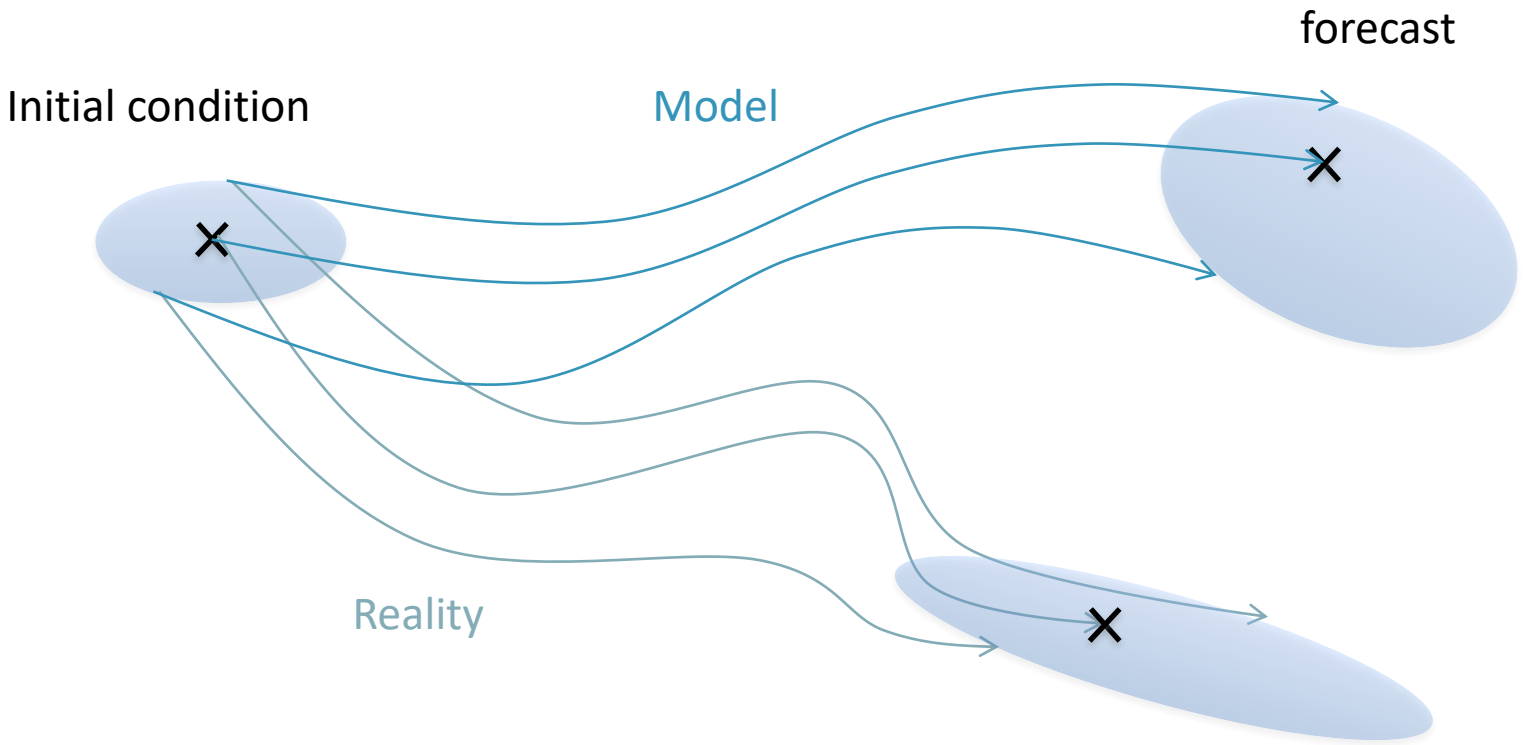
Models

Confronting imperfect models with data

Reality

Calibration
Model selection
Bias/variance trade-offs
One model to rule them all?
The Cat That Looks Most Like A Dog

Butterflies and Hawkmoths



The Butterfly Effect

In Model Land

Uncertainties via model sensitivity analysis
Limits timescale but not accuracy

The Hawkmoth Effect

In gap between Model Land and real world

Structural uncertainties in models
Limits timescale **and** accuracy

3. Models and Experts are Inseparable

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Models and Experts

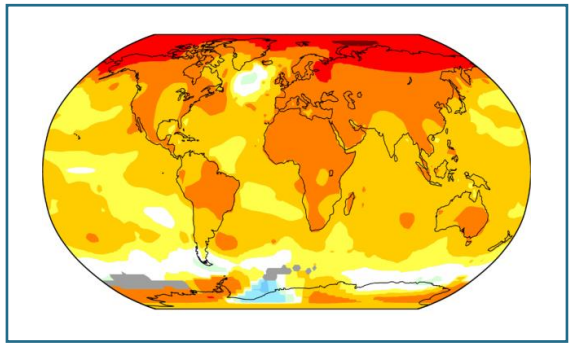
Expert

What to include?
How to represent?
How to tune/calibrate?
How to evaluate?

Expert creates model

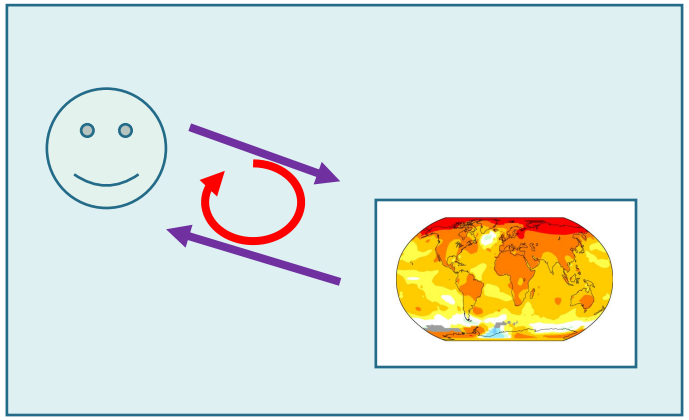
Model creates expert

Play with assumptions
Test hypotheses
Separate system components
Make predictions



Model

Models and Experts: an inseparable system



Expert System

- **Models reflect our expert judgements back at us**
- Model-statements and expert-statements are not substantively different, except that the expert has the opportunity to take account of information from outside Model Land

4. Escaping from Model Land

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Writing about Model Land

- Report model output **as model output**
  "In our model, 90% of model-people are infected by May 1st"
- Report model output **as best available expert opinion**
  "Our model suggests that 90% of people will be infected by May 1st"
- Report model output **and synthesise into real-world judgement**
  "Based on evidence from our model, we expect that 90% of people will be infected by May 1st"

How should decision-maker interpret this?

OK, if we have genuinely incorporated everything into the model and we can think of no way in which it might be wrong

Clear and **accountable** statement about reality; needs further indication of confidence or possible failure modes

Useful to know how confidence is derived

Making decisions informed by models

- There is a gap between Model Land and real world which must be bridged in some way, if we are to make real-world statements.
- Best-case: use previous relevant quantitative out-of-sample observations.
- If previous relevant quantitative observations are not available, consider what other sources of confidence we rely upon.
- The relation between models and domain experts is very complex and model-statements are no less subjective or prone to bias and prejudice than expert statements (if perhaps in slightly different ways)
- Models are very often overconfident (and perhaps experts are too)
- This results in **underestimation of risk**

Regulation of risk using models

- Climate-related financial disclosures
- Solvency II
- Basel III / Basel IV capital requirements
- Use of catastrophe bonds, parametric insurance
- Disaster risk financing generally
- Pensions regulation
- Cyber security?
- Regulation of AI systems?

This risk assessment all takes place in a “climate-like” context.

Are regulators forcing us into Model Land by requiring quantitative answers to these sorts of questions?

What does that mean for accountability?

Do you think model-based approaches tend to systematically underestimate real-world risks?

Poll: Do you work in Model Land?

- I work in Model Land and I have no problem with that
  (eg conceptual work or weather-like situation)
- I work in Model Land because I am **not able** to get out
  (eg not clear how to incorporate expert judgement about model quality; I simply “validate” the model and move on)
- I work in Model Land because I am **not allowed** to get out
  (eg risk manager or regulator requires use of quantitative model only)
- All of my statements are about the real world even where I use models
  (models are only one source of info)

Thanks!

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Comments, Questions & Answers

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Forthcoming Events

- Mon, 25 Oct (16:00-16:45) Privacy By Design Is Essential To Complementing Regulatory Compliance: Privacy Laws Are No Longer Sufficient
- Wed, 27 Oct (18:00-21:00) Back To Work In The City
- Thu, 28 Oct (15:00-15:45) Climate Emergency, Catastrophe; How Bad Is It?
- Fri, 29 Oct (15:00-16:00) Global Security Challenges: Existential Threats & Geopolitics

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