

The Various Meanings of Uncertainty

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Uncertainty and Nuclear Emergencies

- Much uncertainty throughout:
 - Planning
 - Response
 - Recovery
- Acknowledged for decades
- ... but still not really addressed
- Moreover, uncertainty is not a single concept

A Range of Uncertainties

- **stochastic** uncertainties: i.e. physical randomness
- **epistemological** uncertainties: i.e. lack of scientific knowledge
- **judgemental** uncertainties: setting of parameter values in codes
- **computational** uncertainties: inaccurate calculations
- **modelling** uncertainties: however good the model is, it will not fit the real world perfectly

- **ambiguities**: ill-defined meaning, e.g. how to define an endpoint
- **partially formed value judgements**: what are the precise objectives in a set of circumstances
- **social and ethical uncertainties**: how expert recommendations are formulated and implemented in society, and what their ethical implications are

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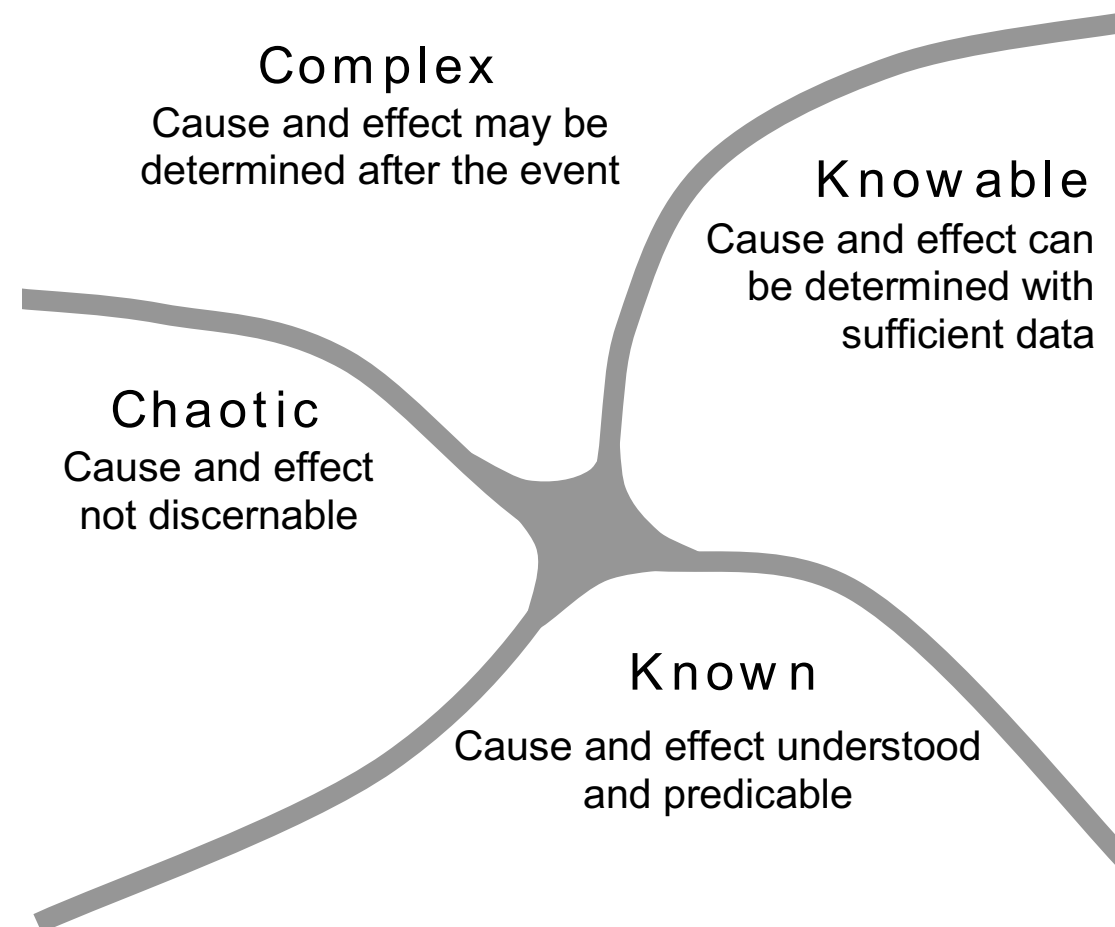
Uncertainties internal to the decision-making

These are only some types of uncertainties!

Uncertainty versus Knowledge

- Uncertainty is the opposite of knowledge
 - **Uncertainty** \longleftrightarrow **Knowledge**
- The Cynefin categorisation of contexts:
 - Relates to decision-making
 - Knowledge of cause and effect
- Typically in an emergency
 - We begin in the Complex or even Chaotic domain
 - As we understand the causes of the event we move into the Knowable domain and eventually into the Known domain.
- We learn both about *what is happening* and *our values* applied to the emergency

Deep Uncertainty



Dealing with *External* Uncertainties

Uncertainty	Examples	Approaches to modelling and analysing
Stochastic (physical randomness)	<ul style="list-style-type: none"> • Occurrence and patterns of precipitation • Actual numbers and locations of the local population at the time of the release • Long term radiation related health effects 	<ul style="list-style-type: none"> • Probability modelling and statistical analysis
Epistemological (lack of scientific knowledge)	<ul style="list-style-type: none"> • Source term characteristics: time profiles of radionuclide mix, energy, etc. • Course and shape of plume and deposition 	<ul style="list-style-type: none"> • Normal uncertainty Probability modelling and statistical analysis • Deep uncertainty Exploration of several scenarios
Judgemental (e.g. setting of parameter values in codes)	<ul style="list-style-type: none"> • Parameters within models and computer codes • Compliance of population with advice on protective measures 	<ul style="list-style-type: none"> • Sensitivity analysis • Monte Carlo analyses
Computational (inaccuracy in calculation)	<ul style="list-style-type: none"> • Accuracy of approximations used in atmospheric dispersion and deposition models 	<ul style="list-style-type: none"> • Bounds from numerical analysis • Probability modelling of error distributions if stochastic approximations or statistical emulation used
Modelling (i.e. however good the model is, it will not fit the real world perfectly)	<ul style="list-style-type: none"> • Discrepancy between model and reality if model based on accurate parameters and data and calculations performed perfectly 	<ul style="list-style-type: none"> • Experience

Dealing with Internal Uncertainties

Uncertainty	Examples	Approaches to modelling and analysing
Ambiguity, Lack of Clarity and Endpoint, Partially Formed Value Judgements (ill-defined meaning)	<ul style="list-style-type: none"> • How should Endpoints be described, what matters • Importance of different attributes in evaluating endpoints 	<ul style="list-style-type: none"> • Stakeholder workshops using facilitation to challenge thinking
Social and ethical (i.e. how expert recommendations are formulated and implemented in society, and what their ethical implications are)	<ul style="list-style-type: none"> • How expert recommendations are formulated and implemented in society • Acceptance of risk • Ethical issues: risk distribution, autonomy, governance, responsibility, transparency • Communication 	<ul style="list-style-type: none"> • Social psychology, mental models, naturalistic observation • Ethical principles of radiological protection • Communication experiments

Thank You