Presenting and Communicating Uncertain Information

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Outline

- Uncertainty
  - Count (and confuse!) the meanings
- Uncertainty in the early phase
- Results from an ADMLC project
- Discussion
Uncertainty

What do we mean by uncertainty?
Uncertainty

- Knight 1921
  - Uncertainty vs risk
  - no probabilities vs probabilities available

- Berkeley and Humphreys 1982
  - Seven distinct meanings of uncertainty

- French 1995:
  - Ten distinct meanings of uncertainty
Uncertainty

**Problem Formulation**
- What might happen/what can we do?
- What do you mean by that?
- What might someone else do?

**Analysis and Exploration**
- How good is our knowledge (Epistemological *and* Aleatory)?
- How are our beliefs and preferences going to change?
- Are our judgements accurate enough?
- How good are our calculations?

**Interpretation and Implementation**
- How good is our model at describing the world?
- How good is our model at describing us (risks include values)?
- Have we done enough analysis to decide and take action?
Uncertainty

- Knight 1921
  - Uncertainty vs risk
  - no probabilities vs probabilities available

- Berkeley and Humphreys 1982
  - Seven distinct meanings of uncertainty

- French 1995:
  - Ten distinct meanings of uncertainty
  - and I missed some ...!!!!
    - how accurate is the data?
  - Can rephrase, combine or separate the questions
Uncertainty is not just about knowledge
Simplify to 6 questions

<table>
<thead>
<tr>
<th>Question</th>
<th>SCIENCE</th>
<th>VALUES</th>
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</thead>
<tbody>
<tr>
<td>What are our concerns?</td>
<td></td>
<td></td>
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<tr>
<td>– (lack of) understanding of world</td>
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<td>What are we trying to achieve?</td>
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<tr>
<td>– values &amp; objectives</td>
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<td>What might we do to achieve this/these?</td>
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<tr>
<td>– actions/strategies</td>
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<td>What might happen out there?</td>
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<td>– uncertainties about external world</td>
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<td>What might result?</td>
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<tr>
<td>– consequences</td>
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<td>How much does it matter if it does?</td>
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<td>– impact</td>
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Dealing with Uncertainty

- Uncertainty is a portmanteau, ill-defined term
- Change focus from defining uncertainty to how we should deal with uncertainty
- Recognise that different types of uncertainties may need different approaches
  - Discussion to resolve ambiguity & formulate issues
  - Probability modelling to deal with stochastic behaviour and learning from data
  - ....
Uncertainty in the Early Phase

What uncertainties do the emergency managers need to deal with?
There are lots!!!!!
Uncertainties in predicting the atmospheric spread of radioactivity

...and then the plume uncertainty feeds into a variety of models that predict the dose, each introducing further uncertainties.
Uncertainties in Dose models

- Plume Uncertainty
  - Spatial-temporal
  - Radionuclides mix
  - Ground level
  - Radiation
  - Deposition

- Ground Contamination
  - Resuspension

- Internal Dose
  - Modelling and Computational errors
  - National Population

- External Dose
  - Local Population
  - Behaviour

- Health Effects
  - Direct Radiological
  - Stress

Other pathways:
- Hydrological
- Human activity
- Wildlife
- ….
Key uncertainties

- **Weather**
  - Tempting to think ensemble methods give us a handle on *all* the meteorological uncertainties

- **Source term**
  - cause, radionuclide mix, time profile, energy, ....
  - Uncertainty may be *deep*, i.e.
    no data; no agreement between experts; no time

Note that any modelling will take time:

So model output may conflict with current data

⇒ more uncertainty!
The ADMLC project

Review of Best Practice in and to further develop Principles for Presenting Uncertain Information in Radiological Emergencies

More specifically: how do we communicate the uncertainty to SAGE and thence COBR in a timely manner.
Project Structure

- Partners University of Warwick, PHE, Met Office

Outline
- Workshop 1. Simulation of Emergency with SAGE to understand current processes and issues
- Developing guides to better communication and consultation (including Workshop 2)
- Workshop 3. Simulation of Emergency with SAGE using new guidelines and evaluation
- Reports and advice
The 1st Workshop

- Held end Sept 2014
- Participants drawn from: across government and its agencies.
  - DH, PHE, Met Office, Cabinet Office, ONR, DECC, DEFRA, FSA, EA, Home Office, MoD, GOScience, Rimnet, SAGE Secretariat.
- Hypothetical release at hypothetical site using a set of past but real weather conditions
- All calculations were run on ‘operational’ software and models
- Workshop did not run in real time and was facilitated with interruptions for broad discussion
Results from workshop

- Chief Scientist needs to understand issues in SAGE and then take these through to COBR in 45-60 minutes.

- Focus on ‘reasonable worst case’
  - How bad can it get
  - But no clear agreement on how to develop a reasonable worst case
    - Except definitely not the worst possible case
    - But some participants demanded that it must be such that it cannot get worse!!!

- Avoidance of thinking about uncertainty

- Timing of availability of information was unanticipated
  - Current data more recent than current model output

- Belief that experts are expert and will not misinterpret plots or data
Possible way forward: multiple scenarios

Select 4 or 5 scenarios that are 'interesting' in some sense. A scenario may be interesting because, e.g.:

- It represents a worst case of some form -- useful for bounding possibilities in risk
- It represents a best case of some form – balances worst case and introduces the idea of the cost – especially social & health cost – of some measures
- It represents a likely case in some sense – helps in setting reasonable expectations.
- It assumes some particular event happens or does not -- useful if a key event (e.g. second release) is pretty much unpredictable and shrouded in deep uncertainty.
- It emphasises a qualitatively different type of outcome (e.g. agricultural vs immediate human health).
Possible way forward: multiple scenarios
The 3rd Workshop

- Participants again were effectively SAGE
- Developed a new hypothetical accident and presented 4 distinct scenarios
  - Combinations of short and prolonged releases with different weather conditions (arrival of front)
  - Some releases affected population centres
  - Some had very significant effects on agriculture.
- Presented the information and let them discuss it in ‘real time’ 45mins
Dose bands (effective dose)
Results

- Discussion broadened at first, but then focused down on scenario 6 as the reasonable worst case
  - It had not been designed as such

- Only a few probabilities were given, but even so a conditional probability was interpreted as an absolute probability
  - If the reactor is not capped, there is a 50-50 chance of a very bad release....

- Only health effects were considered even though one scenario could put a substantial part of UK arable and dairy production into food bans
Issues

- Supporting decision making in the early phase
  - Building and analysing spatio-temporal models is hard
  - Communicating spatial-temporal uncertainty to decision makers may be harder?
  - Doing both in the urgency of the early phase even harder!

- As analysts we need to think much more carefully about uncertainty
  - Potential for confusion and inappropriate methods because it is an ill-defined term
  - And we need to deliver on the promises made after Chernobyl & Fukushima
  - CONFIDENCE Project

- Assuming away uncertainty through single scenarios, especially reasonable worst cases, is not the way forward
Thank you

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