Communicating Geographical Uncertainty

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Spatial Uncertainties in Crises

Although we are concerned with radiological accidents at civil nuclear plant, the issues that we discuss are important in managing many types of crises

- Natural Disasters:
  - Volcanic ash clouds
  - Floods
  - Drought and famine
  - Earthquakes
  - Hurricanes
  - …
- Industrial Accidents:
  - Nuclear accidents
  - Chemical spills
  - …
- Epidemics:
  - Swine flu, zika
  - Animal and crop disease
- Food safety
  - Contaminated food chains
- Lost aircraft
- ….

Communication with Decision Makers

- Building and analysing spatio-temporal models is hard
- But that is not what we wish to discuss
- Rather:

How do we communicate spatial-temporal uncertainty to decision makers?

Spatial Uncertainty is difficult

- Spatial distributions are dependent
  - Usually neighbouring points have similar values
- Uncertainty of what?
  - At a point: what’s there? properties/composition?
  - A boundary: where is it? what does it bound/separate? hard/soft?
  - Hunter and Beard (1992) recognised over 150 possible sources of error/uncertainty when dealing with spatial data.
- Things move over time
  - Data does not necessarily become available in a simple way relative to the movement of objects

Communicating uncertainty is difficult

- Difficult to scientists; more difficult to lay public
- System 1 vs System 2 thinking
  - System 1: subconscious intuitive interpretation of and reaction to uncertainty
  - System 2: analytic explicit modelling
- Cultural dimension
- There has been much work on the effective communication of uncertainty and risk outside the spatial-temporal domain

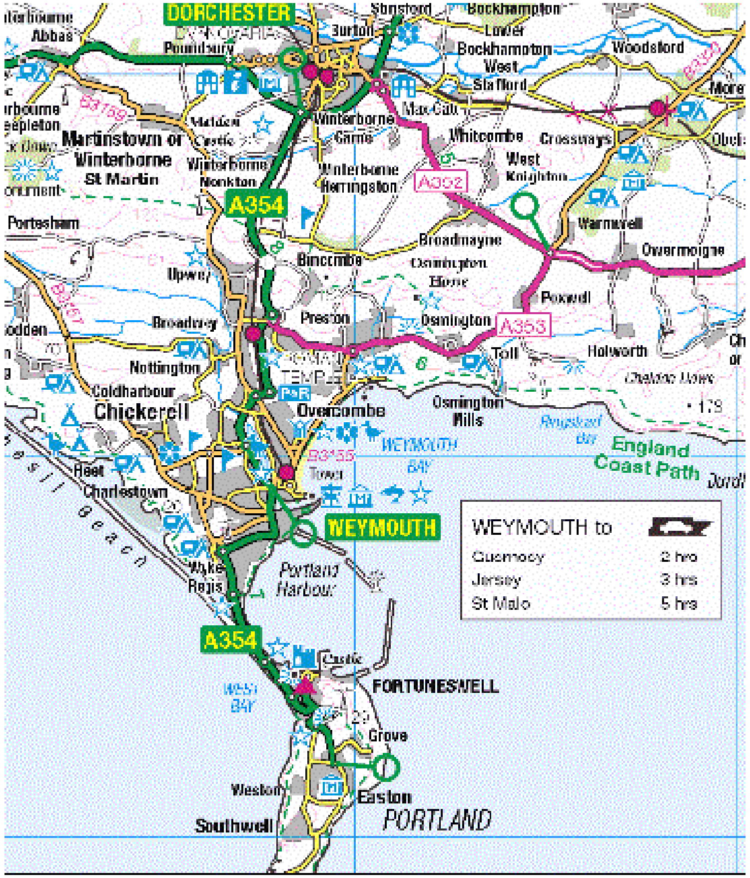
  But not in it ….

MacEachren et al (2005) Challenges

- understanding the components of uncertainty and their relationships to domains, users, and information needs;
- understanding how knowledge of information uncertainty influences information analysis, decision making, and decision outcomes;
- understanding how (or whether) uncertainty visualization aids exploratory analysis;
- developing methods for capturing and encoding analysts' or decision makers' uncertainty;
- developing representation methods for depicting multiple kinds of uncertainty;
- developing methods and tools for interacting with uncertainty depictions;
- assessing the usability and utility of uncertainty capture, representation, and interaction methods and tools.

Density of information

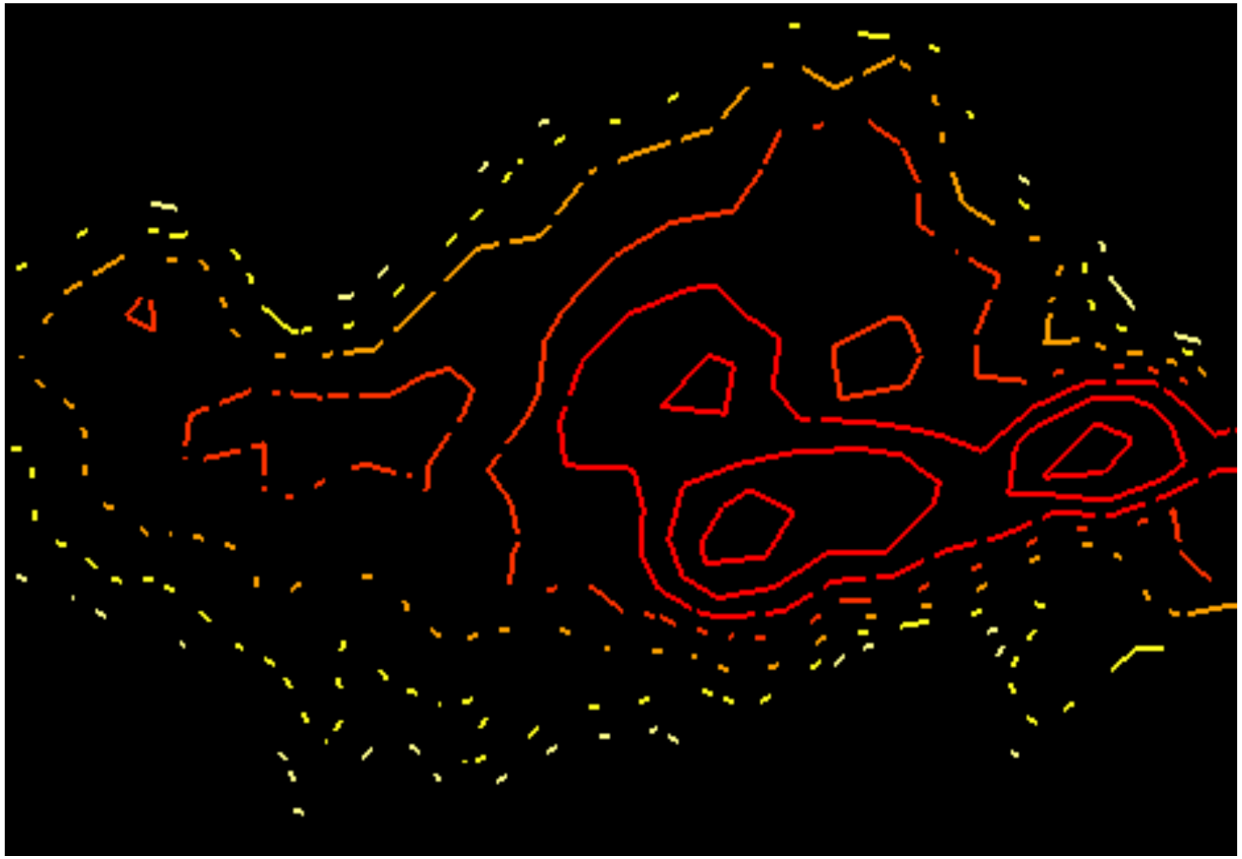
- Chapman, Ehrenberg and others advised that 3 or 4 messages in a statistical table or figure were plenty. Any more confused more than enlightened
- What is the density of information in a map?
- Remember that people believe maps are accurate.
  So showing uncertainty on a map is going to be hard.



Problems with displaying Geographical Uncertainty

- Displaying location uncertainty may/will enlarge the visual impact and hence the apparent seriousness of what is displayed
- Information overload: maps are already very busy with information.
  - ‘Solved’ by heavy reliance on agreed conventions and symbols
- Adding location, quantity, temporal, etc. uncertainty to any of this information increases the amount of information to be absorbed
  - No agreement (yet) on conventions and symbols
  - Probably need to strip out much of the other information on the maps to make way for that on uncertainties – easy in principle, not so much in practice.

One possible convention



Spatial uncertainty is encoded as gaps in contour lines. The more uncertain, the larger the gaps. (Pang, 2011)

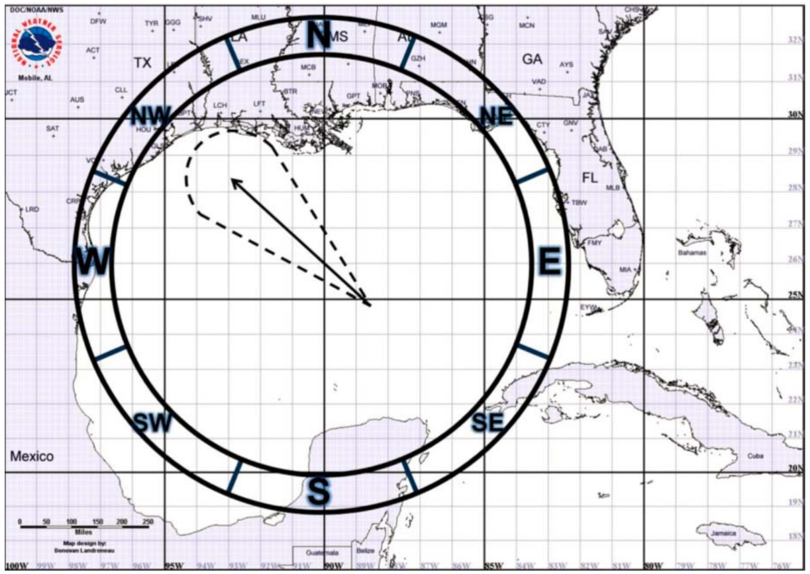
Looks like a plume, but to be effective would need the centreline to be much more certain than it is likely to be (or everything would be finely dotted!)

Moreover probably risks enlarging impact

Hurricane tracks (Wu et al, 2014)

The results of this study provide mixed evidence for people's ability to comprehend probabilistic information about hurricanes.

- They understand uncertainty on track, including base rates.
- But participants' judgments were affected by an irrelevant factor, hurricane intensity
- And hurricanes are easier to deal with than a radiation accident



Maps plus verbal descriptions

- Could present a map with a plume on it and provide a commentary saying how likely it is and what the likely variations might be.
- However, there is a lot of evidence that qualitative descriptions of uncertainty risk considerable misinterpretation
- Even with a 'probability lexicon' such as the IPCC produce for climate change, misunderstandings are possible, especially if the lexicon is not used consistently in the 'day job'

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.
- Hypothetical release at hypothetical site using a set of past but real weather conditions
- All calculations were run on the software and models that would be used (NAME and PACE)
- Information provided was as present
- Workshop did not run in real time and was facilitated with interruptions for broad discussion

Information provided

- A ‘reasonable worst case’
  - ‘as bad as it might get’
- Plots over time showing deposition and doses
- Introduced some small conflict by also showing plots produces by a different set of software (RODOS)

Results from workshop

- 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

Issues

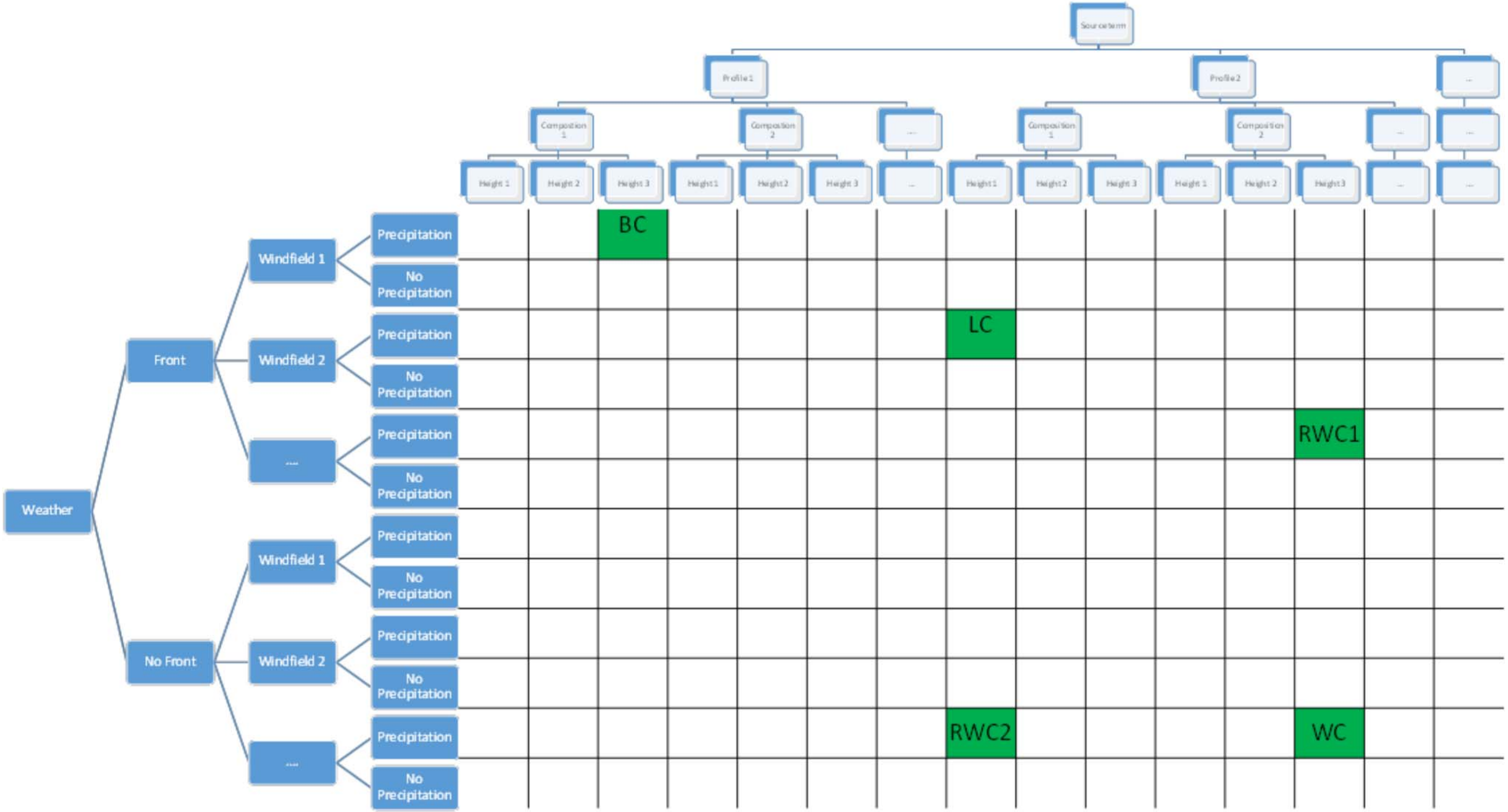
- Chief Scientist needs to understand issues in 45-60 minutes and then brief senior ministers immediately.
- No quantitative assessments of uncertainty available.
  - Some participants thought it might be useful to define a *verbal* scale of uncertainty
  - But we have noted issues with such scales
- Single reasonable worst case
  - Negative framing? Affects risk attitude?
  - Ignores some possible outcomes: e.g. windshift may lead to major agricultural impact
  - Ignores negative effects of potentially unnecessary countermeasures
- Many participants believed that ‘experts do not make errors’
- Trivial perhaps, but these cause problems of understanding
  - Maps not aligned; inconsistent labelling
  - Too many contours, negligible doses shown
  - Shading may not reflect seriousness

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



Thank you

For further information, see Chapters 2 and 4 of our Report:

Presenting Uncertain Information in Radiological Emergencies

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