Space, uncertainty and the challenge of simulation modelling using minimum information requirements: implications for rural land management in relation to diffuse agricultural pollution

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European Union and U.K. context

The move from ‘end of pipe’ treatment to addressing the problem at ‘source’

The things that matter are not just people: ecosystem integrity

Scaling up: move away from site specific restoration

Holistic analysis: recognise contradictory objectives

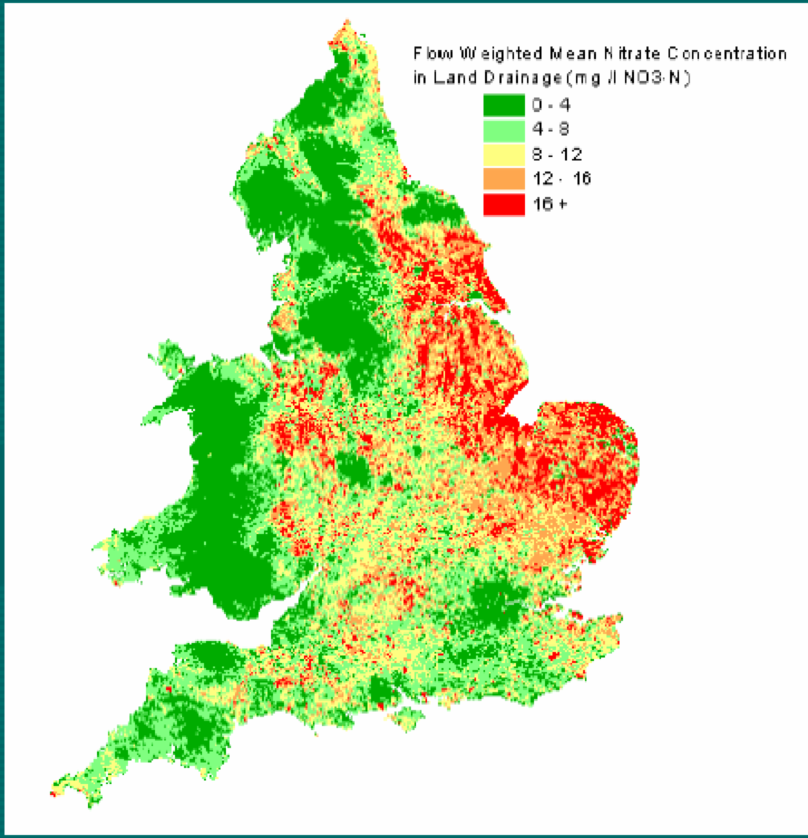
The nature of diffuse pollution

The nature of diffuse pollution

- Diffuse pollution has some special characteristics:
  - spatially-*distributed*
  - spatially-*structured* (landscape arrangement)
  - time-varying
  - above ground *and* below ground
- The severity of the problem is *emergent* at points in space and time even though the causes may be extensive and hidden from view
- e.g. eutrophication in the UK: costs c. £58-89 million/year (Pretty *et al.*, 2003)

Modelling and diffuse pollution

- Characteristics of diffuse pollution mean that modelling has become a key policy tool for deciding what to do where:
  - Can’t measure everywhere
  - Making the invisible visible
  - e.g. MAGPIE



Defra, 2002. The Government's Strategic Review of diffuse water pollution from agriculture in England: Agriculture and Water: A Diffuse Pollution Review, Chapter 4.

Aims and structure

- 1. Present (yet another) landscape scenario model for diffuse pollution, this one grounded in *risk* and *connectivity*
- 2. Move on from seeing model as a tool to thinking through the role of modelling (critically) in the rural environment

1. A model for identifying what to do where

- There is a gap between
  - The scientific desire to capture the detailed space-time dynamics of system response
  - The practical need to target land management
- Many landscape simulation models are *spatial oxymorons*
  - Based on excellent physics, chemistry and biology
  - But are applied at such a coarse resolution and with so much boundary condition and parameter uncertainty that the fundamentals are lost
  - Space is downgraded

1. A model for identifying what to do where

An approach that has sufficient science should recognise that:

1. Sources of risk are predominantly associated with distributed patterns of land use: ***spatial signal***
2. Riskiness is controlled by the rate at which risk is acquired by water associated with surface and shallow subsurface flows: ***catchments are large and complex spatial filters*** **(Kirchner)**
3. Riskiness is moderated by the level of connectivity along the flow path: ***the filter is spatially structured through connectivity***
4. Establishing risk in ***absolute*** terms is a challenge
    a. Uncertainties due to exact land management practices
    b. Uncertainties in nature of connectivity and process rates
    c. Uncertainties due to dynamism and time dependence
5. Connectivity in space and connectivity in time can be related (an ergodic hypothesis): ***measures of spatial connectivity implicitly have a temporal component***
6. Biology is space ***and time*** integrating

SCIMAP: NERC, EA, Defra, Eden Rivers Trust

The point at which a diffuse pollution emerges
(we see these and so do not need to predict them)

To sub-catchments
and catchments

To the drainage network

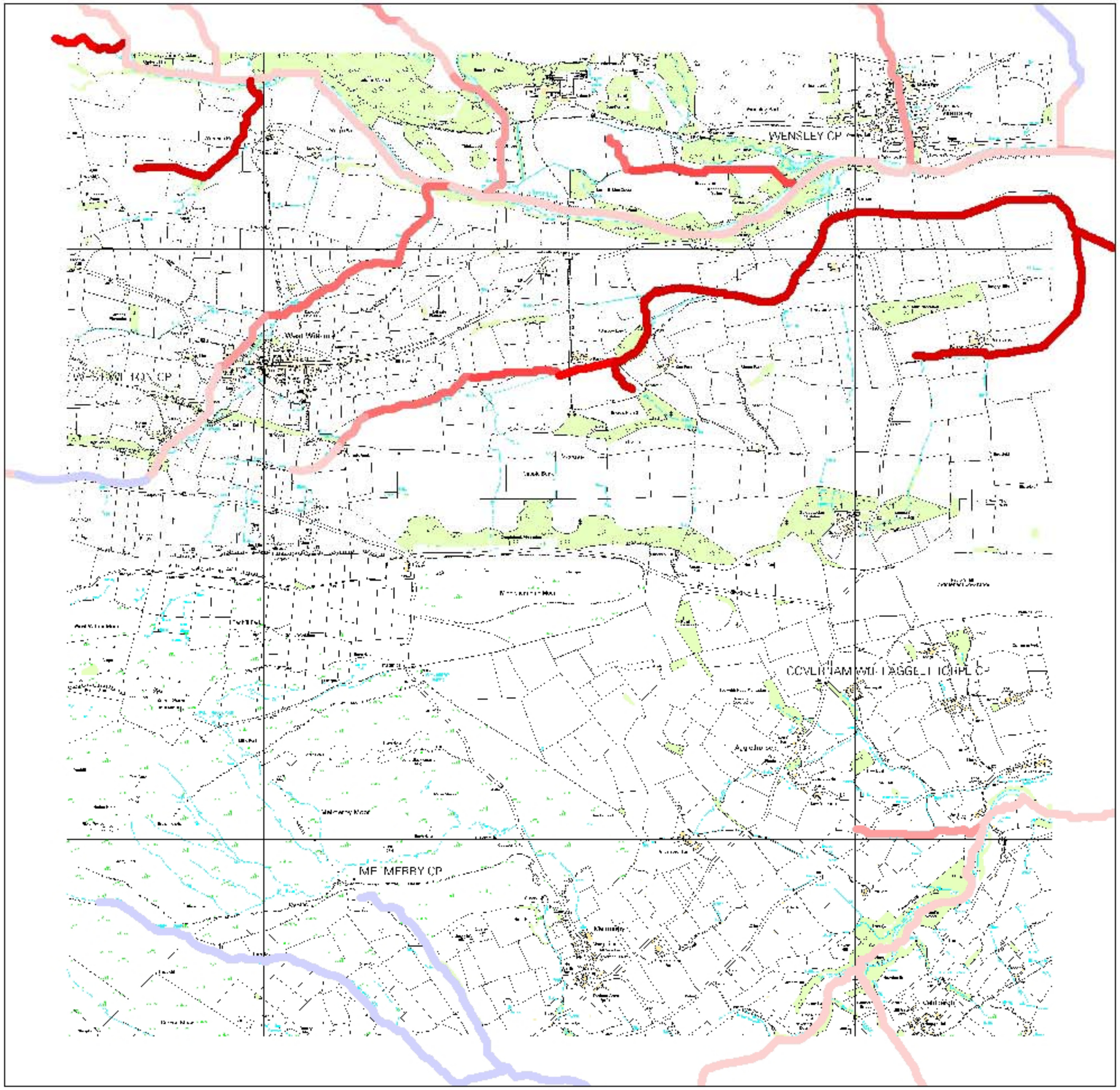
This is integrated through
the field scale (the management unit)

Which sub-catchments
need most attention?

Which farms
need most attention?

Which fields
need most attention?

There can be substantial
local variability, at the
within-field scale, in
hydrological function



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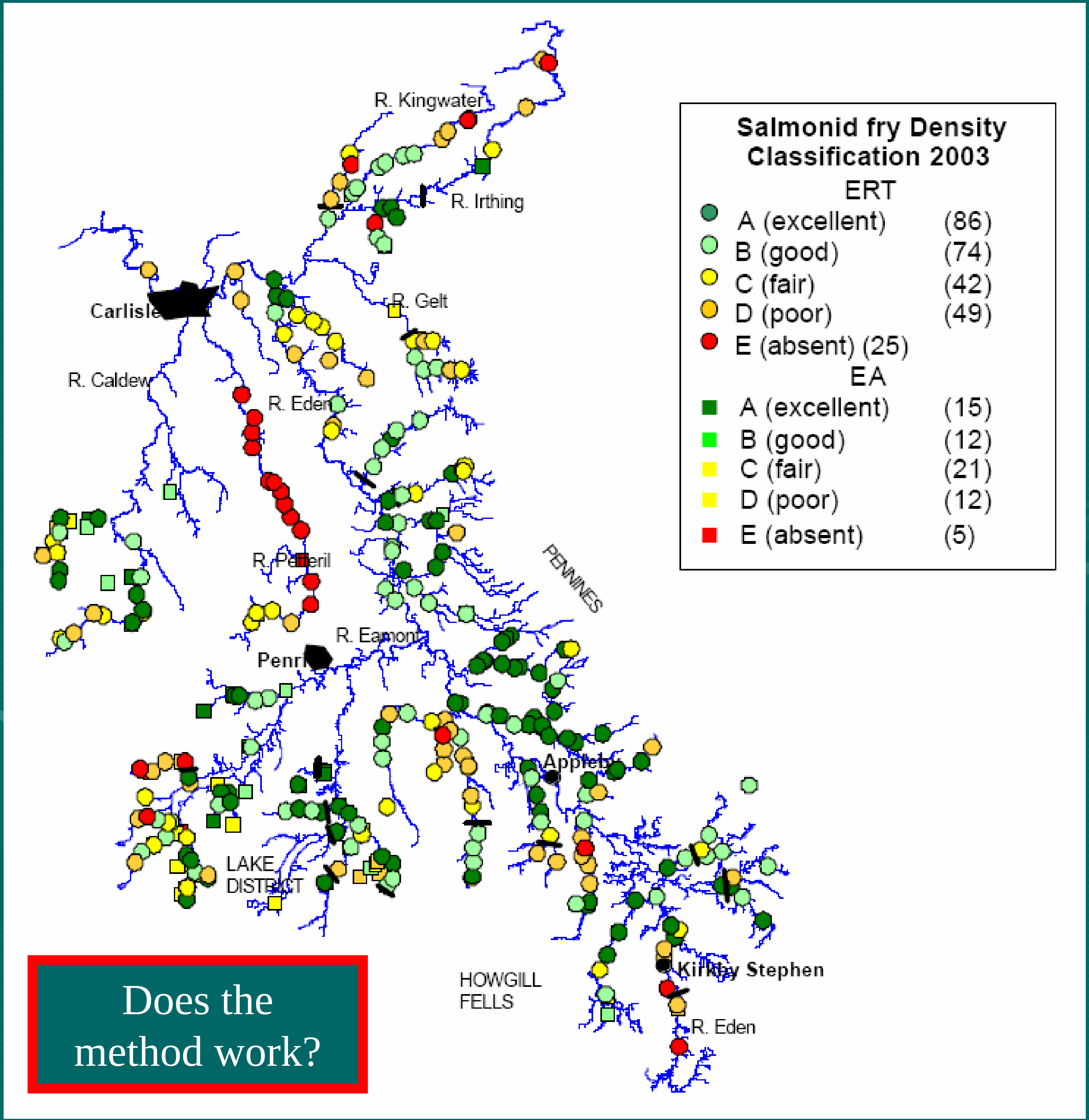
Key

Land Use Weighted Risk Concentration

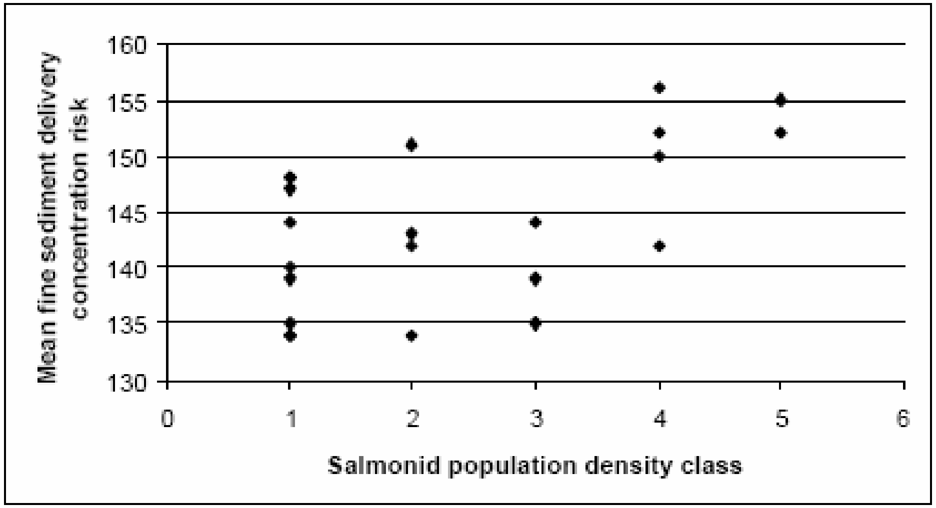
- -1.0 - -0.5 Std. Dev.
- -0.5 - 0.0 Std. Dev.
- Mean
- 0.0 - 0.5 Std. Dev.
- 0.5 - 1.0 Std. Dev.
- 1.0 - 1.5 Std. Dev.
- 1.5 - 2.0 Std. Dev.
- 2.0 - 2.5 Std. Dev.
- 2.5 - 3.0 Std. Dev.
- > 3 Std. Dev.

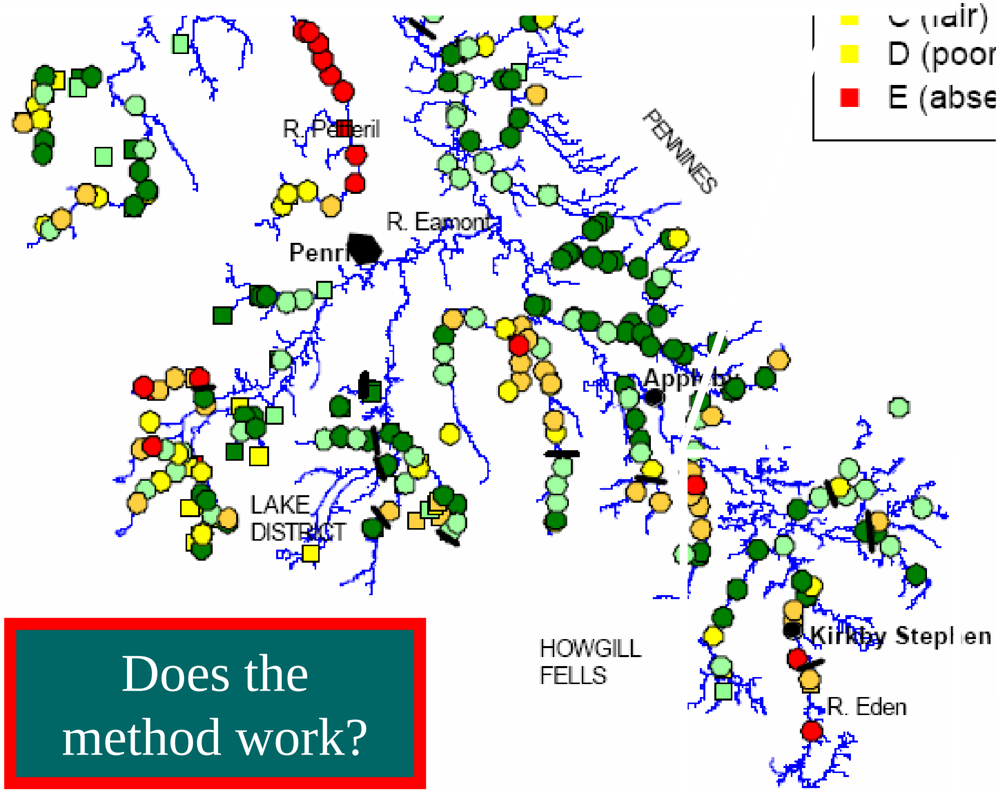
0 0.5 1 2 Kilometers

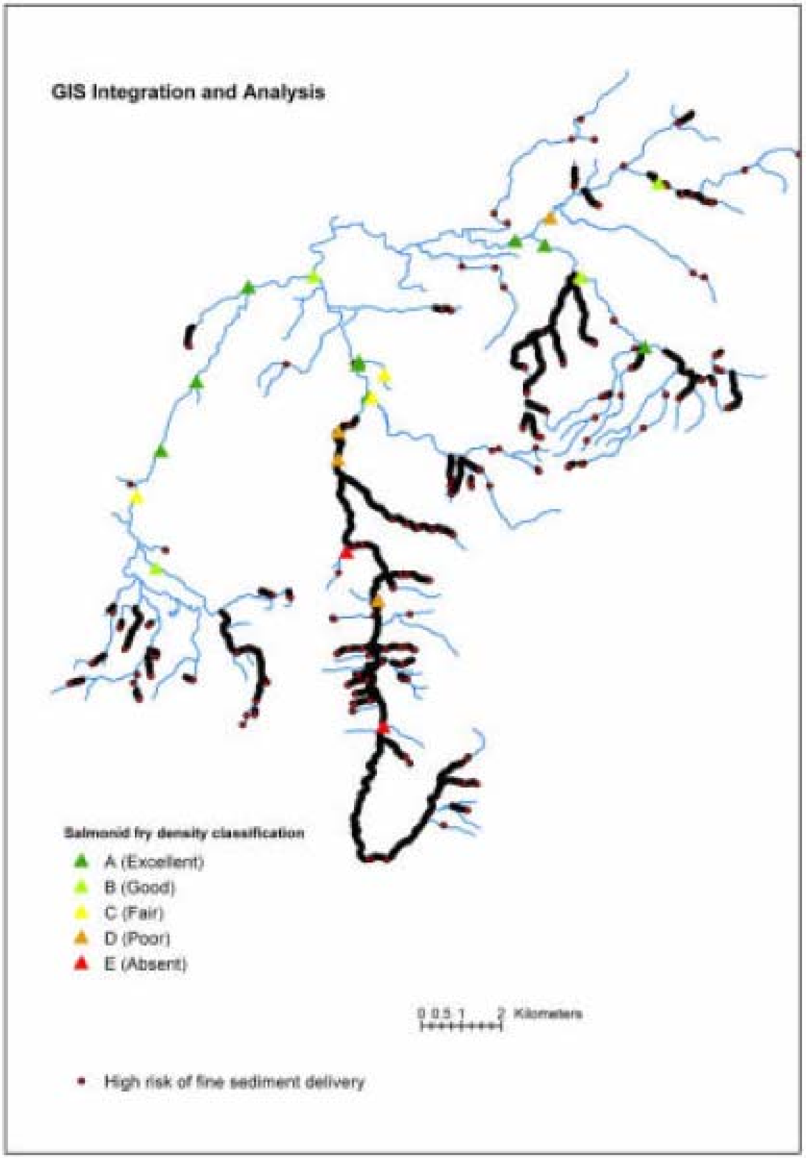


Does the method work?

Acknowledgement: Eden Rivers Trust







Does the method work?

2. Thinking critically …

- Most modelling would normally stop here and pass the model onto policy makers
- This is where we need to think much more critically about the knowledge framework within which models are situated
- The remaining argument …
  - Models as problems framed
  - The thorny problem of validating models in space
  - Models and the generation of knowledge controversies

2. Thinking critically … (a)

- Problem framing:
  - Goffman (1974, 10), the frame is a "principle of organisation" out of which "definitions of a situation are built up" (Goffman, 1974, 10).
  - Models are problems framed as all models contain the crucial steps of *perceptualisation* and then *conceptualisation*
  - Law (2004) and Law and Urry (2004) – there is a process of *enactment* here
    - particular modellers (within particular knowledge networks) create particular models (*objects*) and in so doing define the world that is modelled
  - Callon (1998): and the '*sociology of translation*'

2. Thinking critically …

A traditional realist framework

The world

The system

The model

The modeller

The

The problem is defined by the modeller and does not exist independently from the modeller

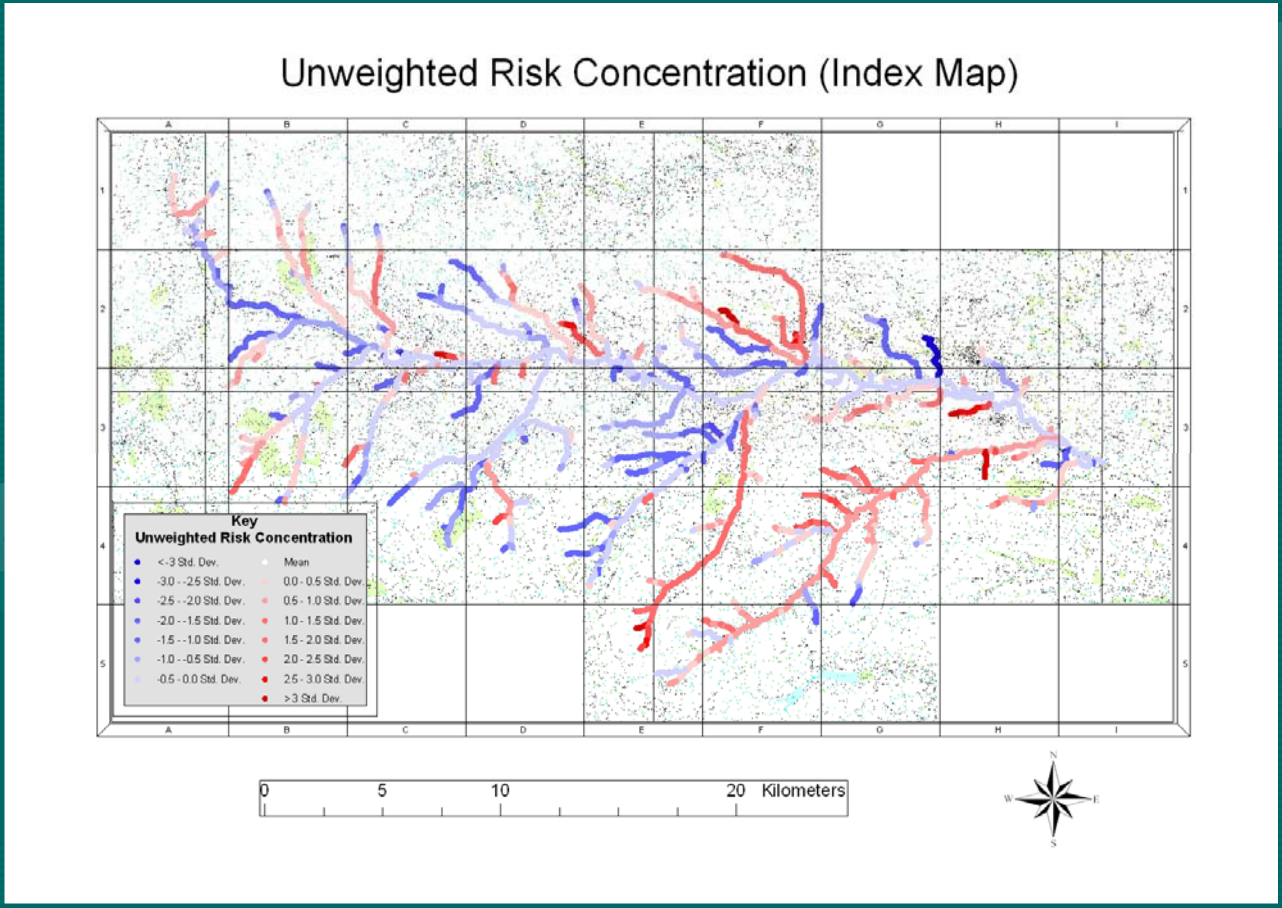
2. Thinking critically … (a)

‘Physically-based distributed hydrological modelling’

- the physics is in there,
- but the model is applied over a spatial resolution that is so coarse (> 10m, commonly >50 m, even up to 2 km…) that the physics is largely irrelevant
- and we can go to our beds happy that our physics is correctly derived from fundamental equations
- Certain set of ‘scientific’, social, commercial etc. influences that make us frame the model as physically-based

2. Thinking critically … (a)

SCIMAP: dp is framed as a problem of pollution in rivers



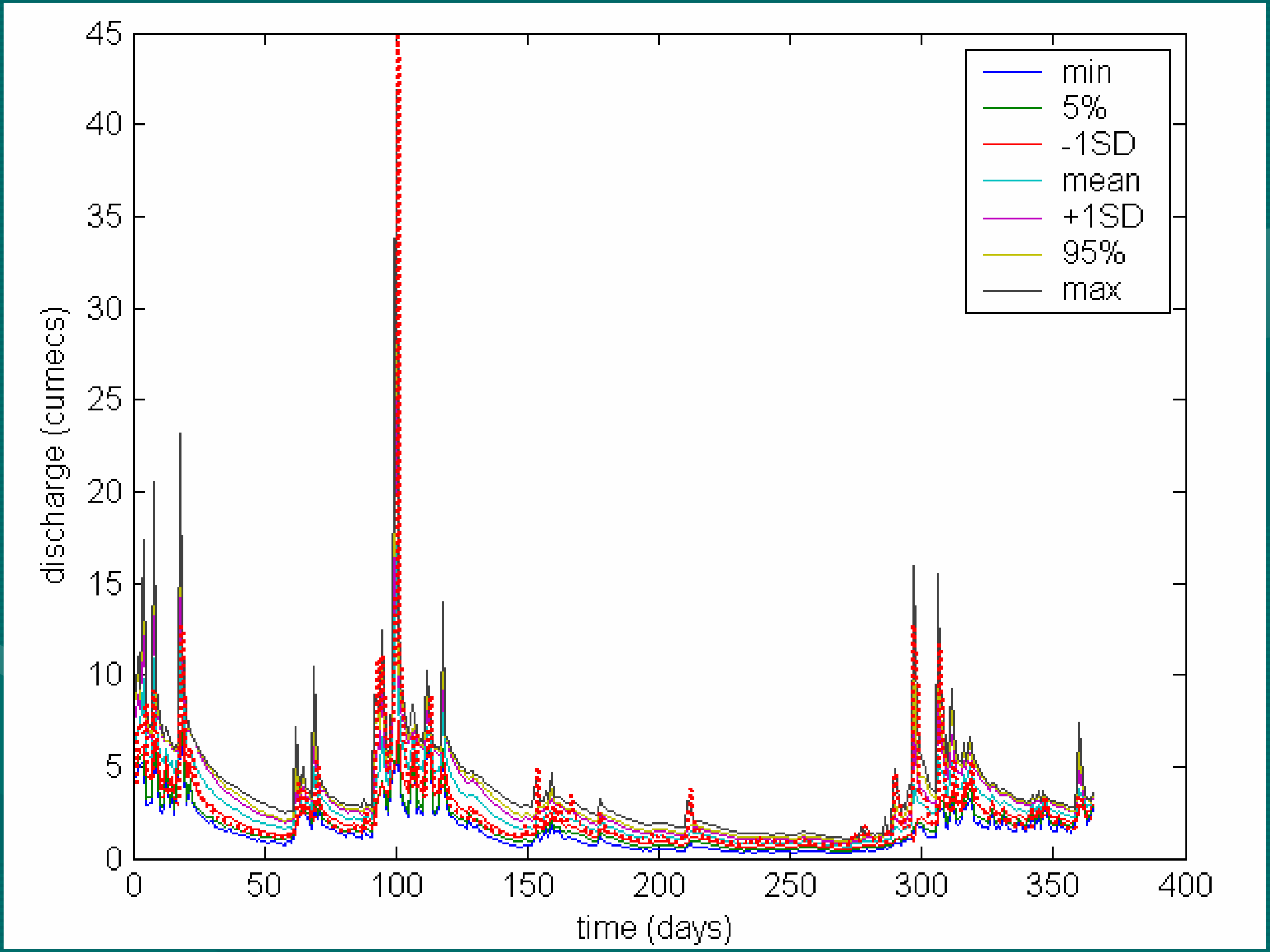
2. Thinking critically … (a)

- Miller (2000): 4 types of framing
  - Storytelling (e.g. the way dp is explained)
  - Modelling (simplification and specification in dp models)
  - Canonisation (the supremacy of certain explanations)
  - Normalisation (institutionalisation of explanations)
- Central to understanding this is a deeper engagement with *knowledge practices*
  - Understanding how particular percepetual models are told, modelled, canonised and normalised, and not others
  - Analysing the naïve vision of 'best practice'
  - Tracing context/contingence in the evolution of networks of understanding leading to particular emergent views

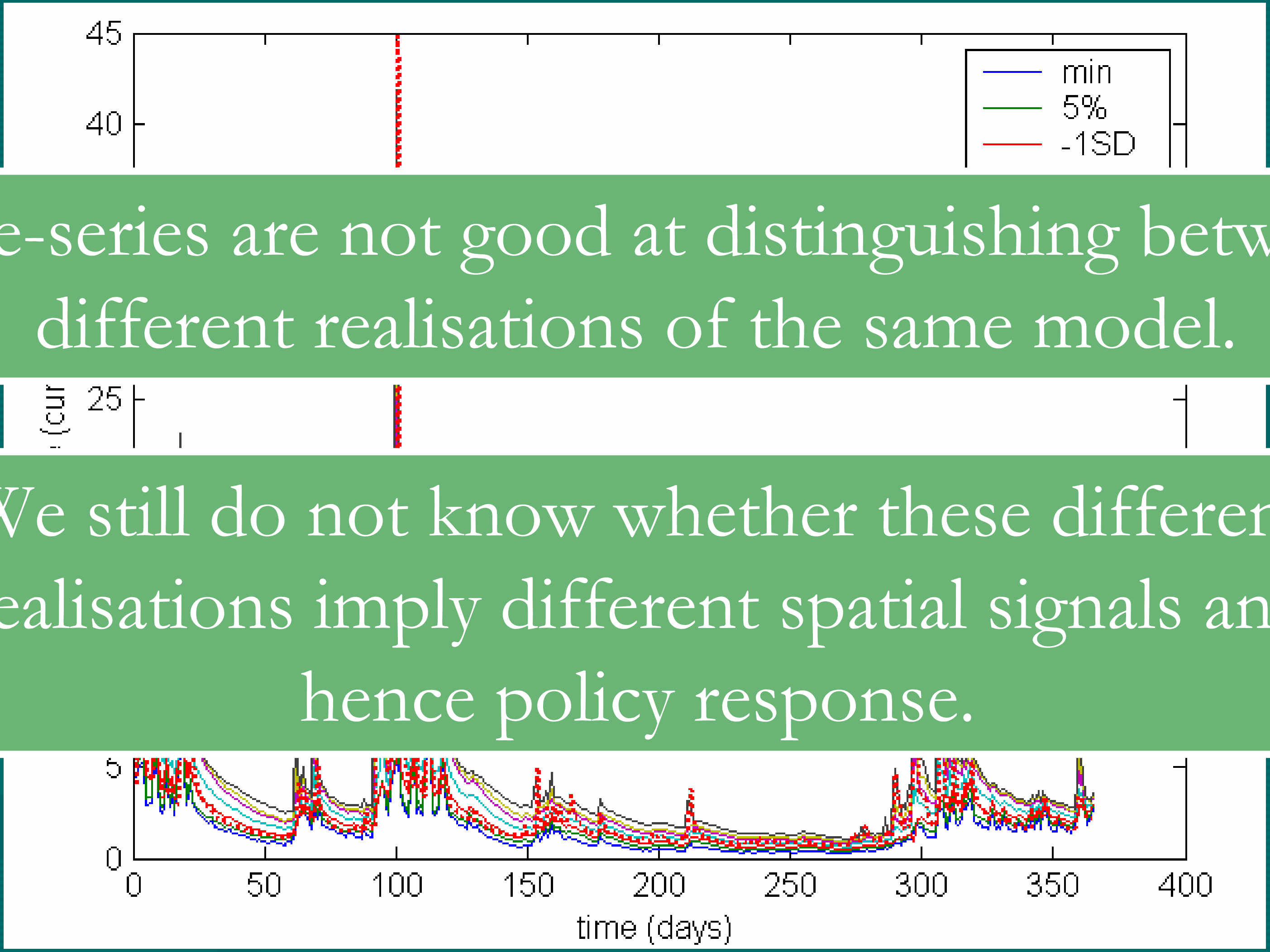
2. Thinking critically … (b)

- Claims to scientific method as the 'get out clause'
  - "This is all very well, if a bit jargonised, but our models have been shown to reproduce reality through validation"
- Validation is a problematic concept (Oreskes *et al*., 1994 – it is commonly leads to '*forced empirical adequacy*'
- Particularly problematic for diffuse pollution models as we largely have to substitute space for time
  - Measuring DP is expensive
  - DP is complex in time
  - Measure DP through time at a restricted number of spatial locations
  - Generally *not* to validate a model but to assess conformity with statutory regulations

2. Thinking critically … (b)



2. Thinking critically … (b)



Time-series are not good at distinguishing between different realisations of the same model.

We still do not know whether these different realisations imply different spatial signals and hence policy response.

2. Thinking critically … (c)

- All this matters
  - DP models are increasingly yielding predictions at the field and sub-field scales
    - They point fingers
  - They operate entirely from remotely-acquired data
    - Those implicated are distanced from the generation of the information itself
  - The spatial detail of these models is readily shown to be wrong when challenged by *local* knowledge
  - Traditionally, *internalised* with scientific debate
  - Now challenged by *externalisation* of both knowledge *and* debate
    - new emphases on freedom of information and digital diffusion

3. Where the CB has got us

- There are interesting issues in terms of science
  - Social science and the problem framing implicit in landscape simulation models (understanding Callon’s ‘translation’ – what, who, how, why?)
  - Natural science and understanding the spatial signatures of these kinds of environmental models (does equifinality matter?)
- But also both inter-disciplinarity and practice

3. Where the CB has got us