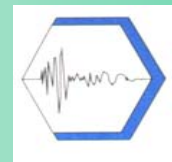




**Resources for the Future, Harvard Center
for Risk Analysis, and
Carnegie Mellon's Department of
Engineering and Public Policy
Workshop**
Expert Judgment: Promises and Pitfalls

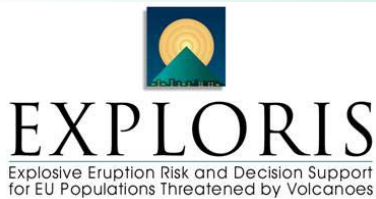
Washington DC 13-14 March 2006

**Expert judgment elicitation
and decision-making: some
real world applications**



Willy Aspinnall
Aspinnall & Associates
University of Bristol

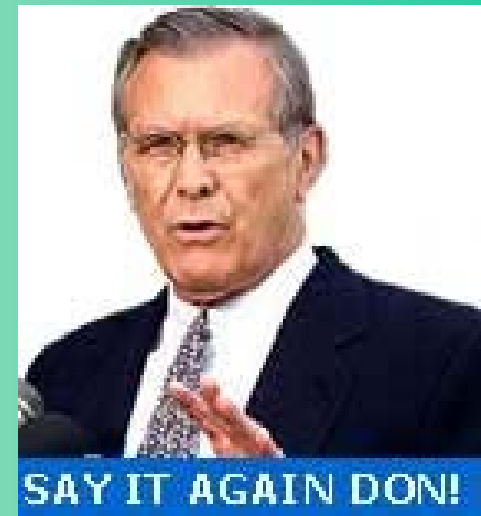
With acknowledgments to colleagues
in many projects:



However, the views expressed are mine,
and not necessarily shared by others.



**Don Rumsfeld illuminates the
issues.....**

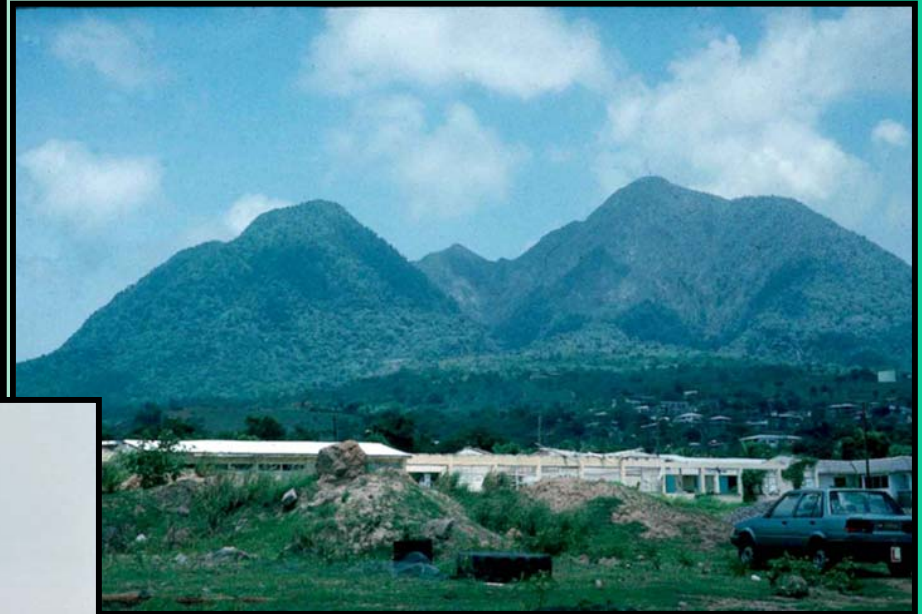


"There are knowns. There are things we know that we know. There are known unknowns - that is to say, there are things that we now know we don't know but there are also unknown unknowns. There are things we do not know we don't know. So when we do the best we can and we pull all this information together, and we then say well that's basically what we see as the situation, that is really only the known knowns and the known unknowns. And each year we discover a few more of those unknown unknowns."

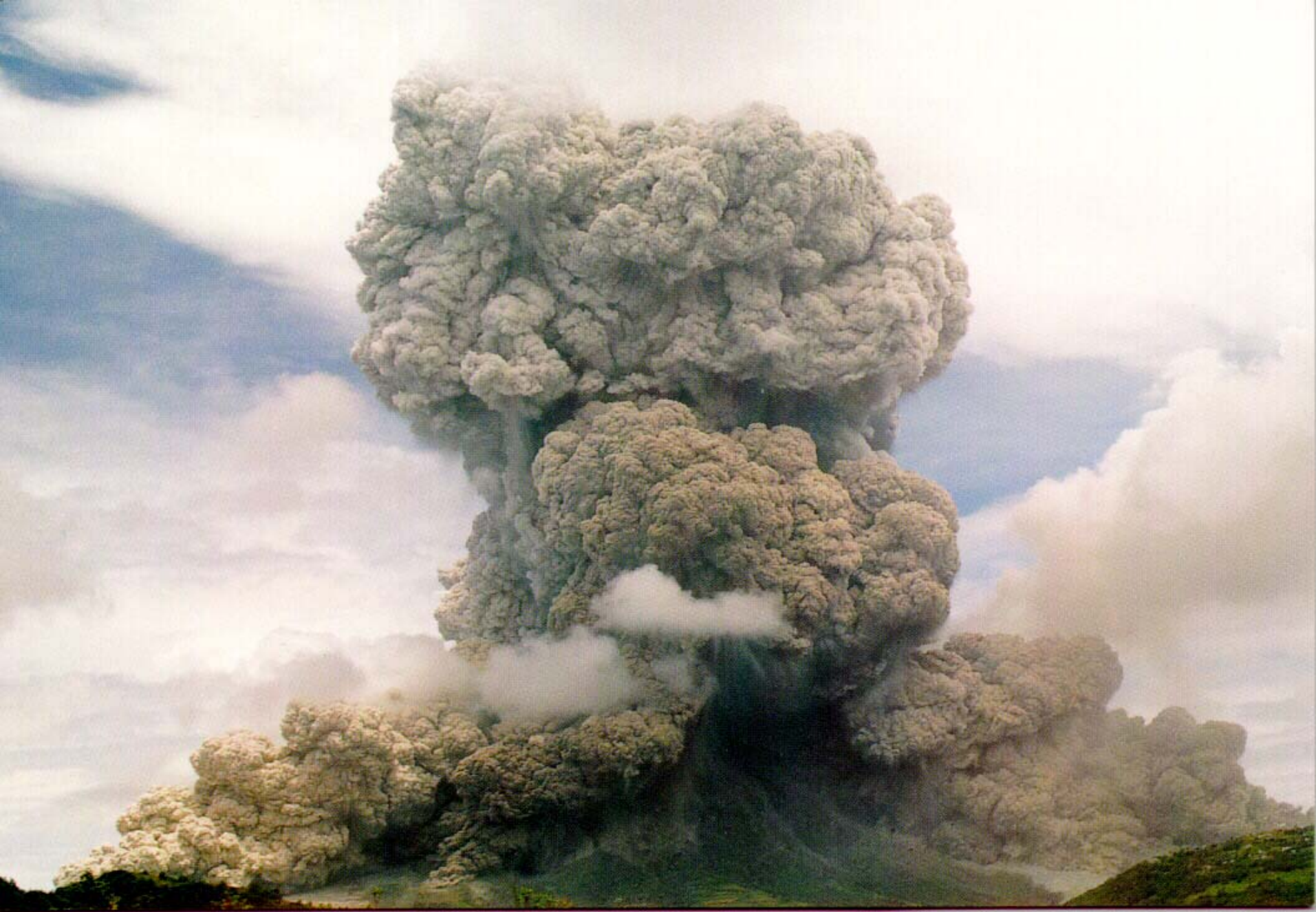
18 June 2003



Soufrière Hills volcano,
Montserrat, in
former times.....



...and in July 1995,
unrest develops



Over two years, activity escalated..... (here, a Vulcanian explosion from Fall 1997)



The volcano produced life-threatening pyroclastic flows

With devastating effects:



**An important location for
volcanologists.....a supply
of cold beers**

**.....until the fridge
ceases to work!!!**

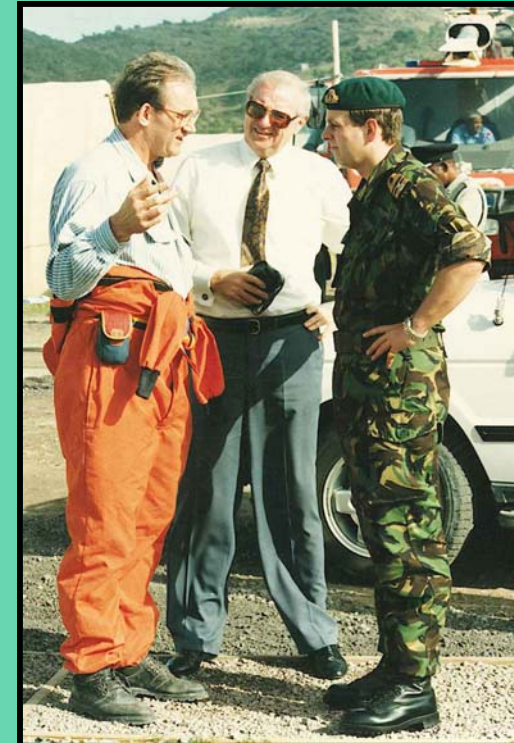
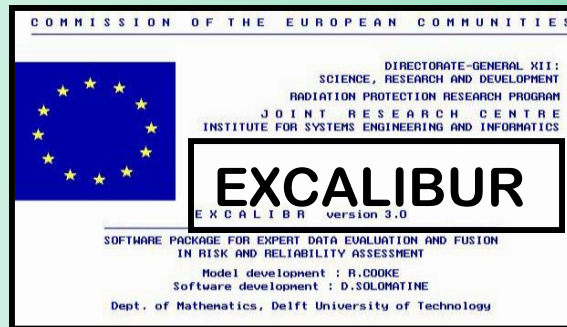


Prompted by the Guadeloupe 1976 experience....



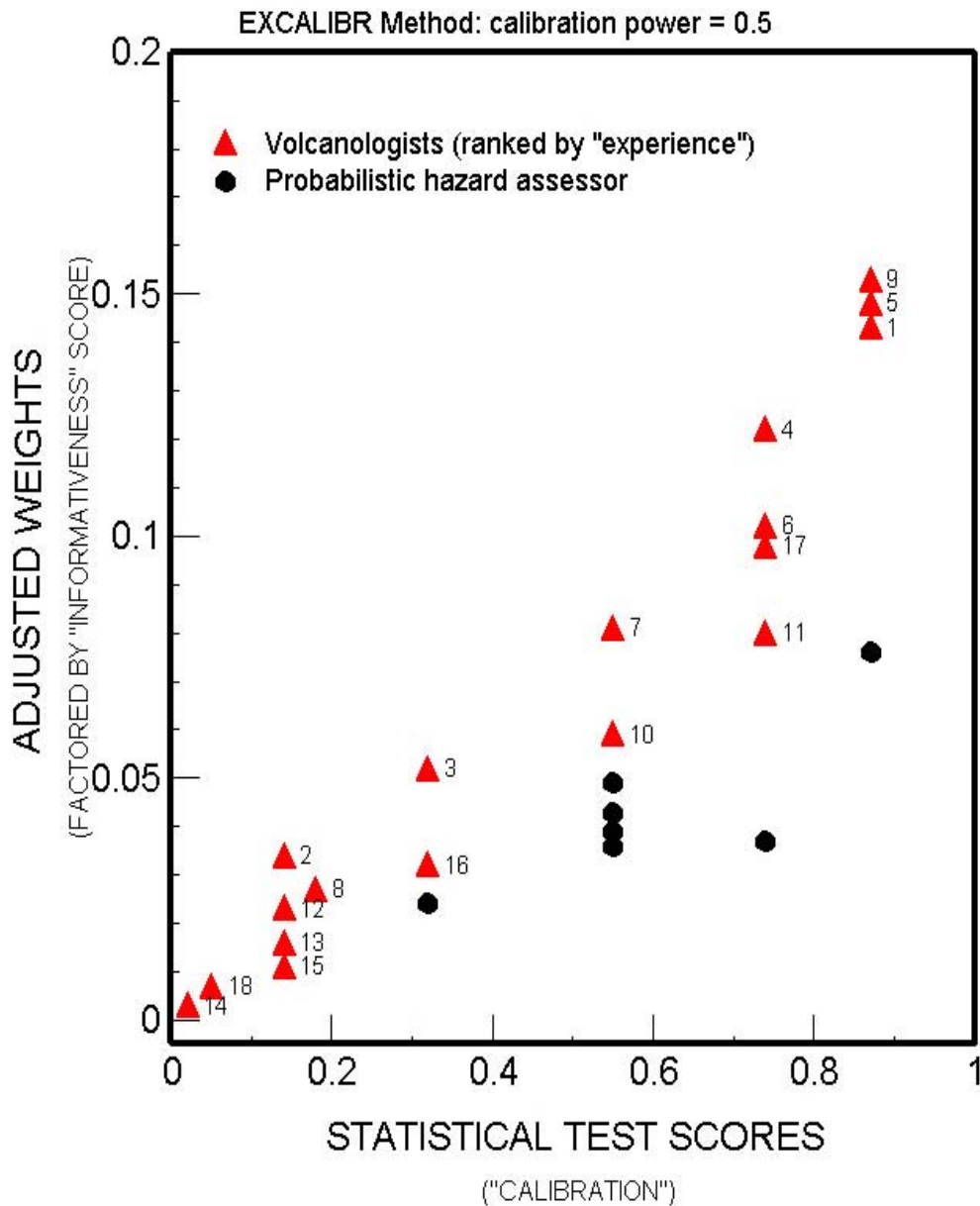
....in Montserrat, we put in place a formalised procedure for providing scientific advice to the authorities

.....using a procedure developed originally for the European Space Agency



Cooke, R. (1991) *Experts in Uncertainty*, OUP.

ELICITATION WEIGHTS FOR INDIVIDUAL SCIENTISTS

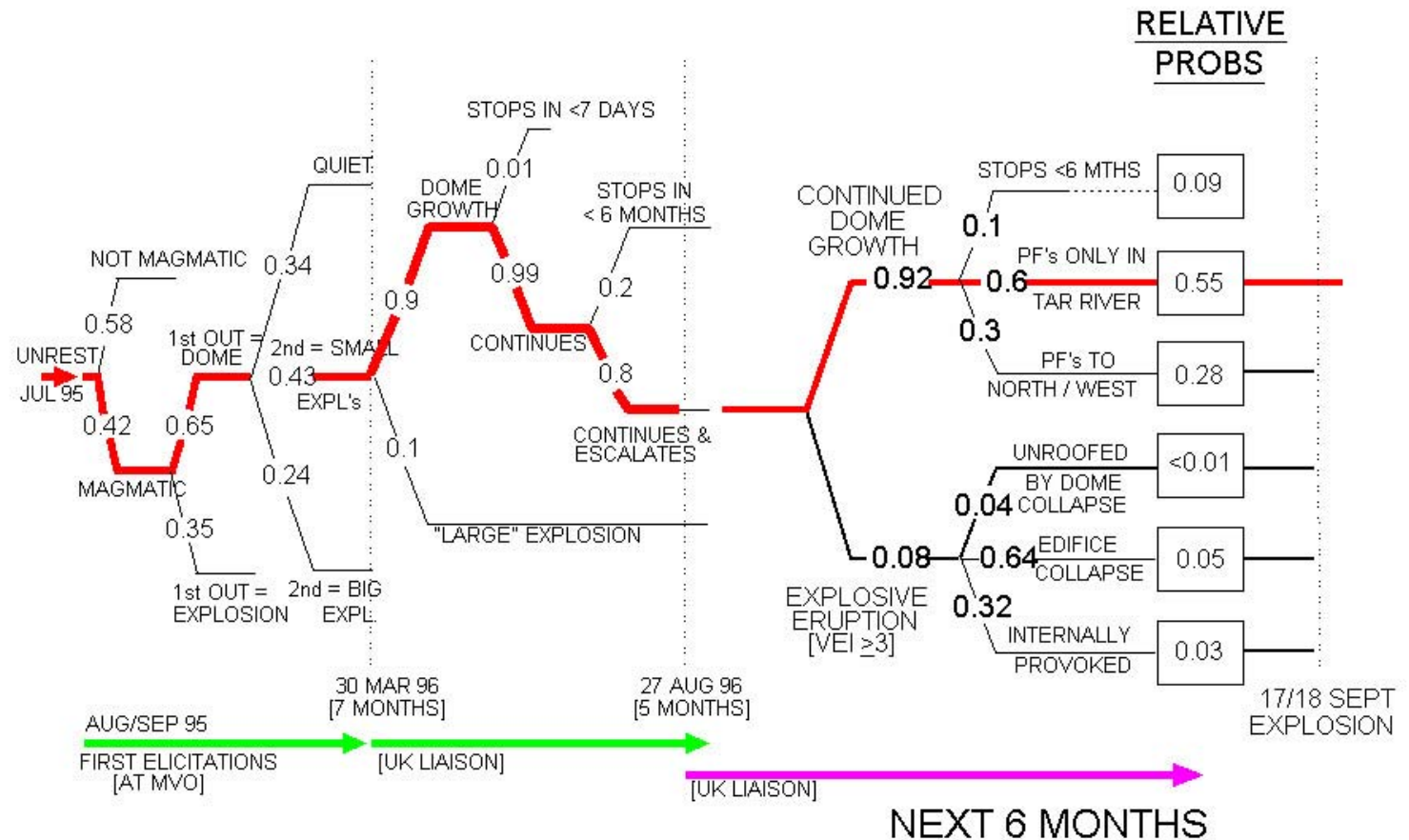


EXCALIBUR: computing volcanologists' individual weights.....


.....a manifesto for 'grey beards'

Structured elicitations used to populate event probability trees.....

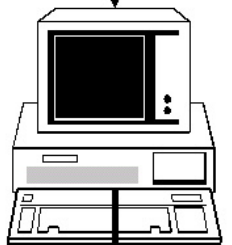
MONTSERRAT VOLCANO CRISIS EVENT PROBABILITY TREE - UPDATE 27 AUG 96



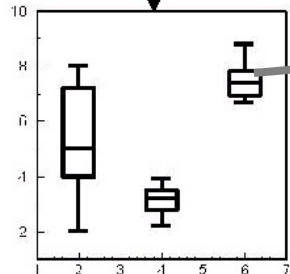
Monte Carlo simulation of potential casualty risks using parameter uncertainty distributions from probability tree



↓



↓



Pinit[x] = prob initiating event occurs
 CP1 = prob of hazard in direction of pop. are
 CP2 = reach Excl Zone boundary
 CP3 = prob. launch height sufficient to clear
 CP4 = test min. time is exceeded, given requ
 CP5 = prob. Eruption doesn't stop within 6 n
 Cin = switch in/out of model (sensitivity tests)

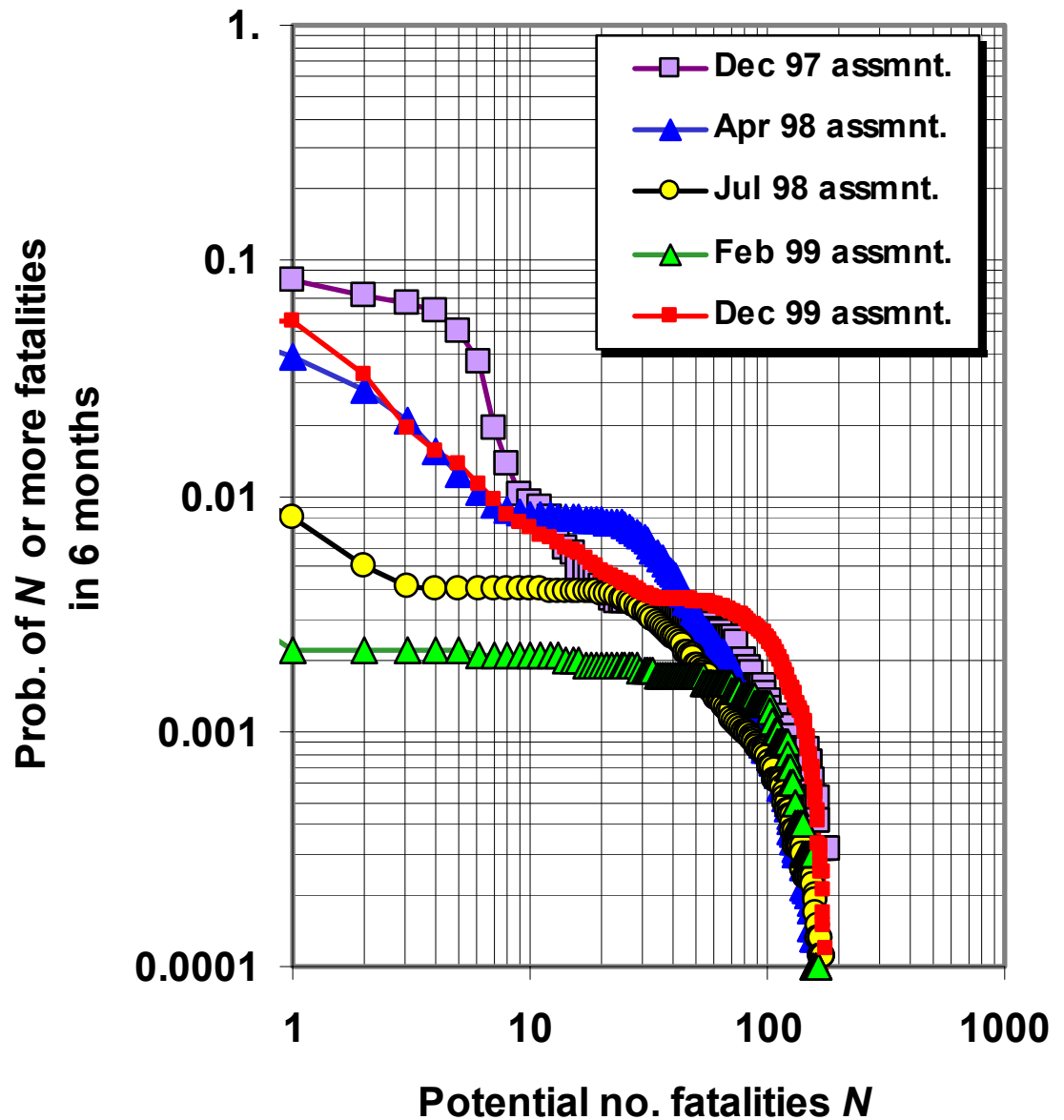
Scenario	CP1	CP2	CP3	CP4	CP5	Cin	Event Prob	IMP7	IMP6	IMP5	IMP4	IMP3a	IMP3b
0							0.641						
1 Zone	1	1.000	1	1	1	0.9683	0	0.000E+00	0.00000	0.00000	0.02000	0.00667	0.00153
11	0.086	0.6934	1	1	1	0.9683	1	3.710E-02	0.00000	0.00000	0.05000	0.06000	
23 Excl Zone	0.332	1	0.332	1.00	0.9683	1	6.890E-02	0.00000	0.00000	0.02000	0.00667	0.00153	
21	0.100	1	1	1.00	0.9683	1	5.394E-02	0.00000	0.00000	0.12500	0.12500	0.04500	
22 to Nw	0.01	1	1	1.00	0.9683	1	1.043E-02	0.00000	0.00000	0.19967	0.12500	0.05000	
33 Excl Zone	0.500	1	0.667	1	0.9683	1	1.765E-01	0.00000	0.00000	0.02000	0.00667	0.00153	0.00153
31	0.009						0.00000	0.00000	0.10000	0.19967	0.05000		
32	0.002						0.00000	0.00000	0.75003	0.33214	0.12500	0.03167	
43 Excl Zone	0.750						0.00000	0.00000	0.03000	0.01000	0.00230	0.00153	
41	0.050						0.00000	0.00000	0.33214	0.50000	0.15001	0.03167	
42	0.041						0.00000	0.00000	0.94833	0.50000	0.19967	0.12500	
51	0.082						0.00000	0.00000	0.10000	0.03167			
62 Zone	0.750						0.00000	0.00000	0.00000	0.03167	0.03167	0.03167	
61	0.150						0.00000	0.00000	0.33214	0.15001	0.12500		
72	0.750						0.00000	0.00000	0.00000	0.05000	0.01020	0.00500	
73	0.750						0.00000	0.00000	0.00000	0.03167	0.03167	0.03167	
71	0.332						0.00000	0.00000	0.50000	0.40000	0.33214	0.15001	
82	0.850						0.00000	0.00000	0.00000	0.40000	0.06667	0.01500	
83 Zone	0.750						0.00000	0.00000	0.00000	0.03167	0.03167	0.03167	
81	0.500						0.00000	0.00000	0.85000	0.85000	0.75003	0.40000	
91	0.1						0.00000	0.00000					
92	0.9						0.00000	0.00000					
93	0.3						0.00000	0.00000					
94	1						0.00000	0.00000					

Sheet1 Sheet2 Sheet3 Sheet4 Sheet5 Sheet6 Sheet7 Sheet8 Sheet9 Sheet10

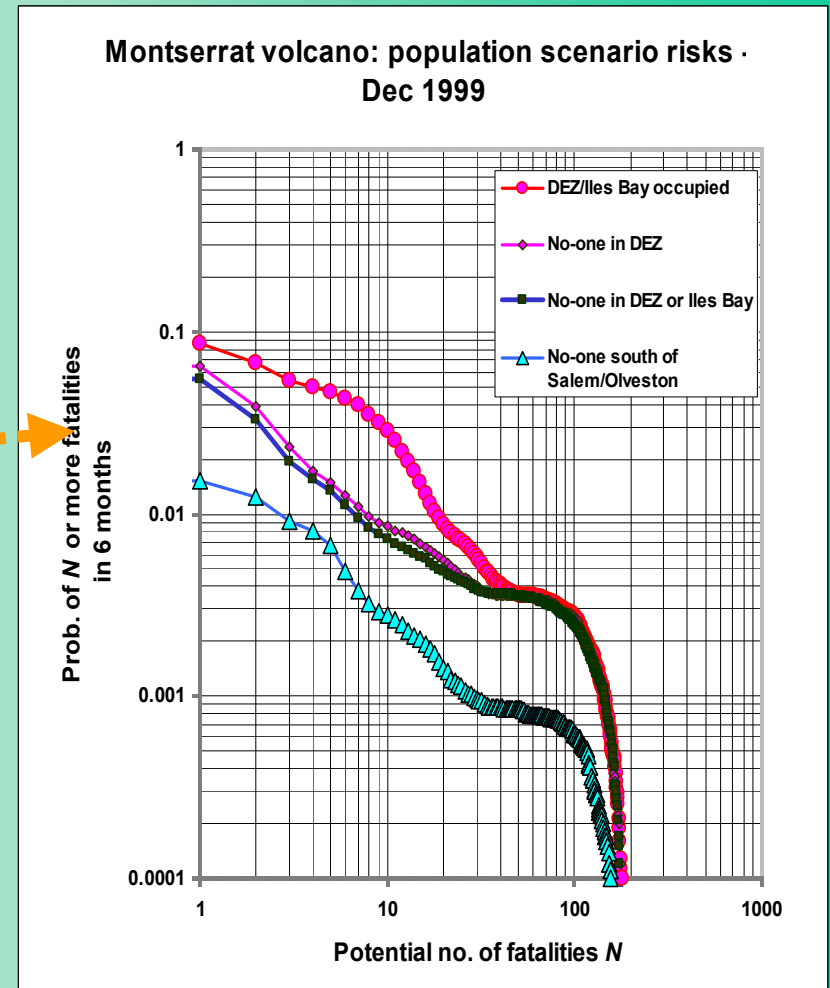
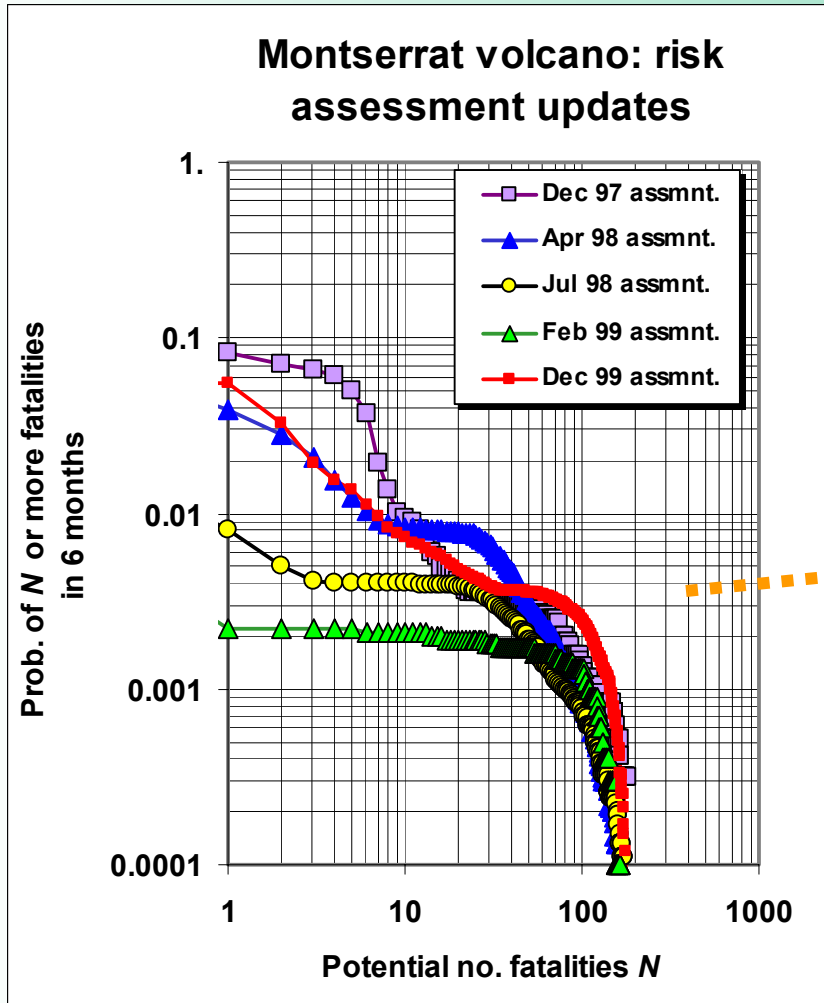
Select destination and press ENTER or choose Paste

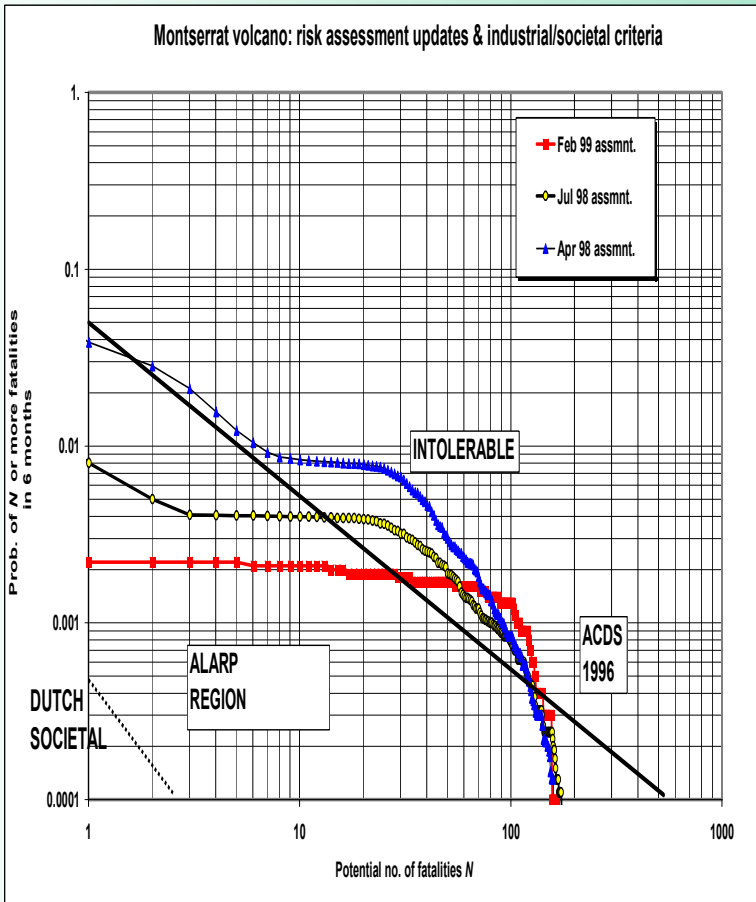
.....producing so-called F-N casualty exceedance risk curves, expressing societal risk levels at different probabilities:

Montserrat volcano: risk assessment updates



Population risk curves: regular updates,..... and decision inputs for mitigation by staged evacuation

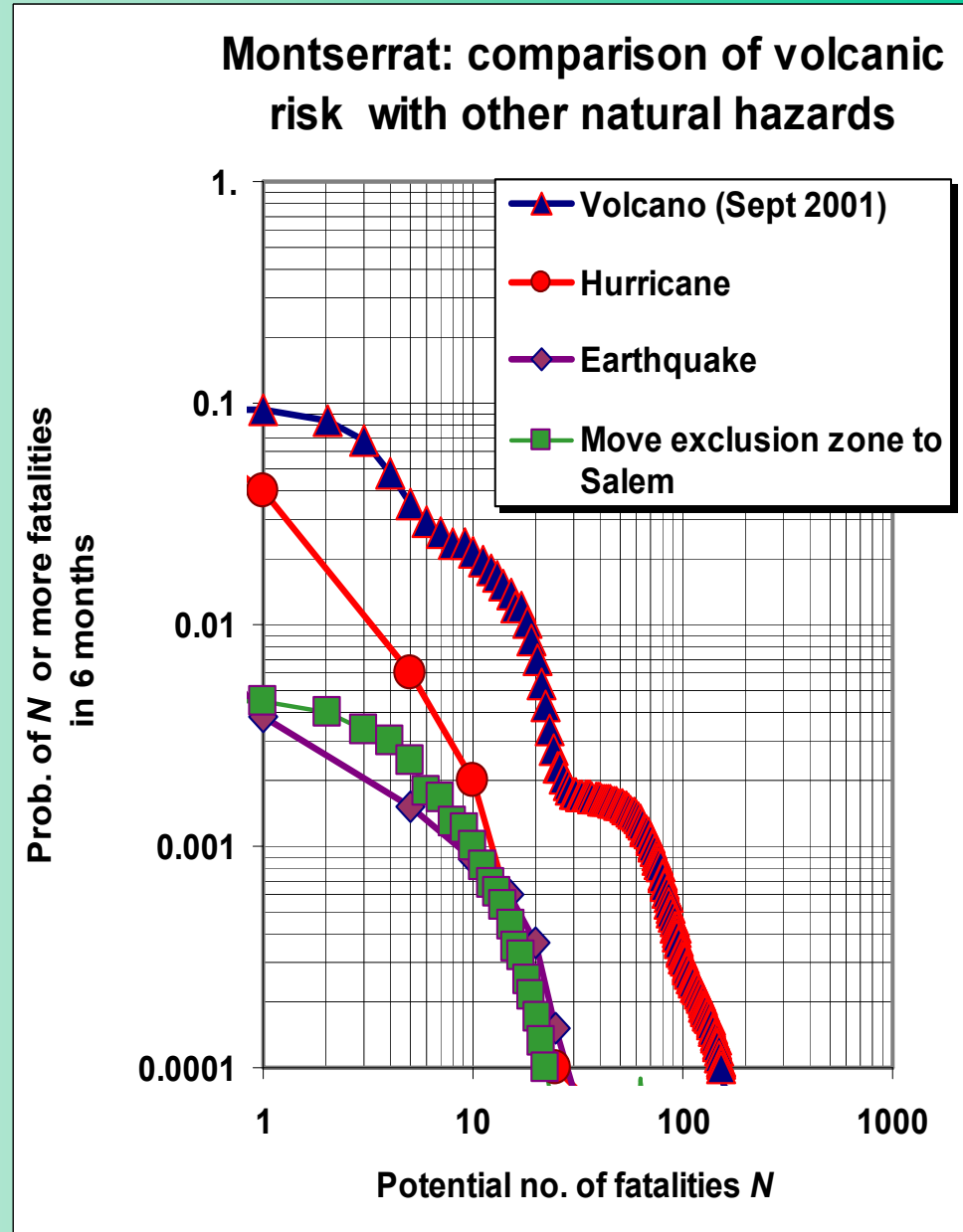




Comparative “acceptable” risk levels:

industrial criteria...

or relative exposure to other natural hazards??





By mid 1997, the growing dome poses an increasing direct threat to the airport....



..then a deadly collapse occurs on 25 June 1997



The collapse buries several villages.....



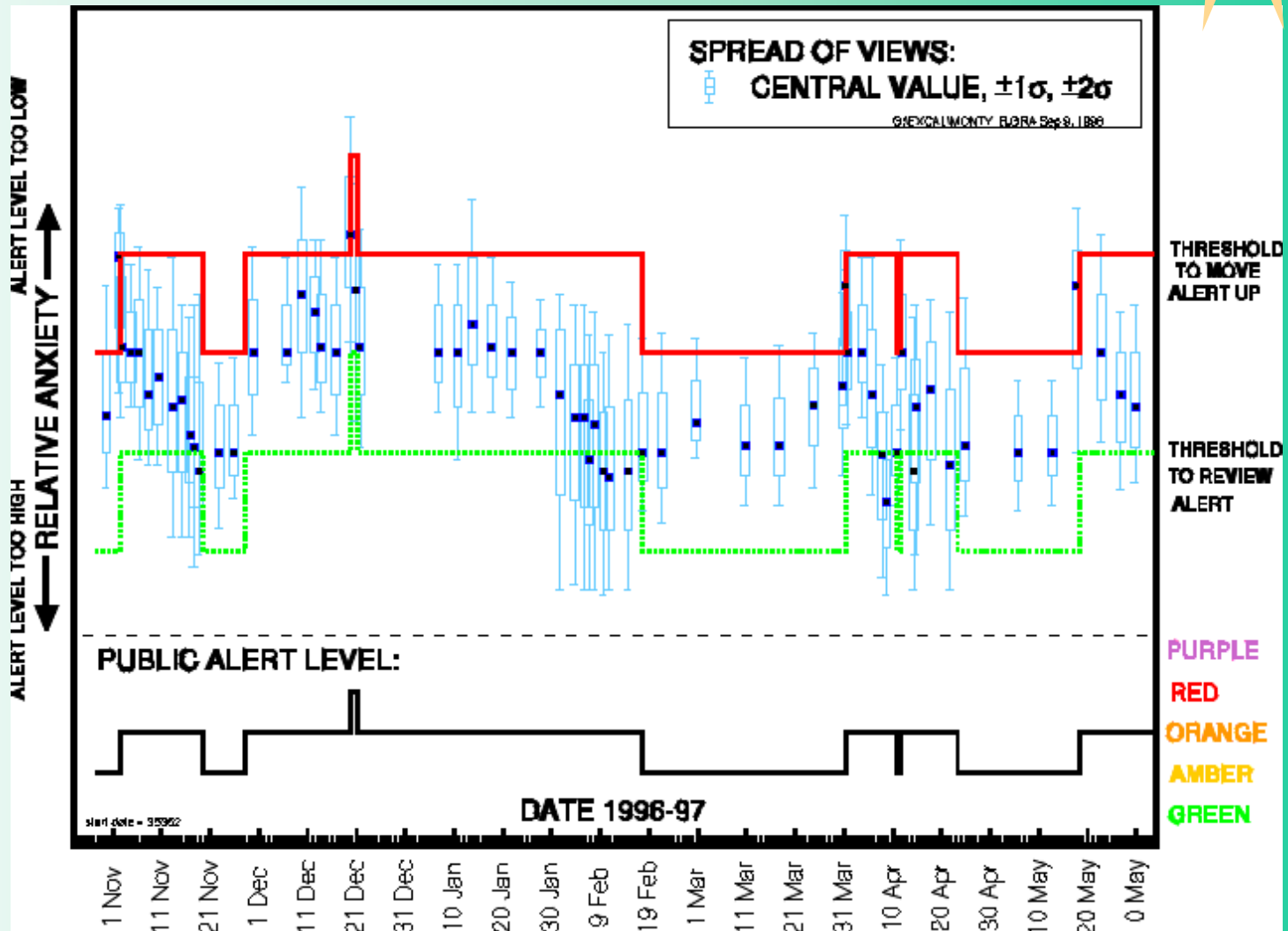
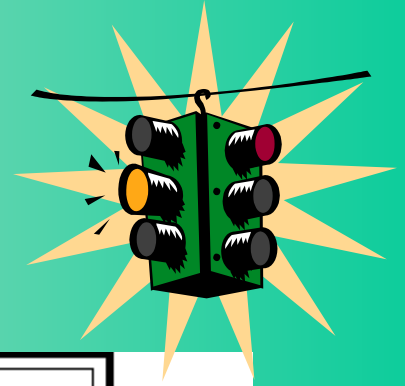
.....with nineteen fatalities and a number of other persons injured in the Danger Zone

But, many of the population were intent on living with an erupting volcano: hazard zones were drawn for crisis micro-management



“...this island is exactly the wrong size for an eruption...”

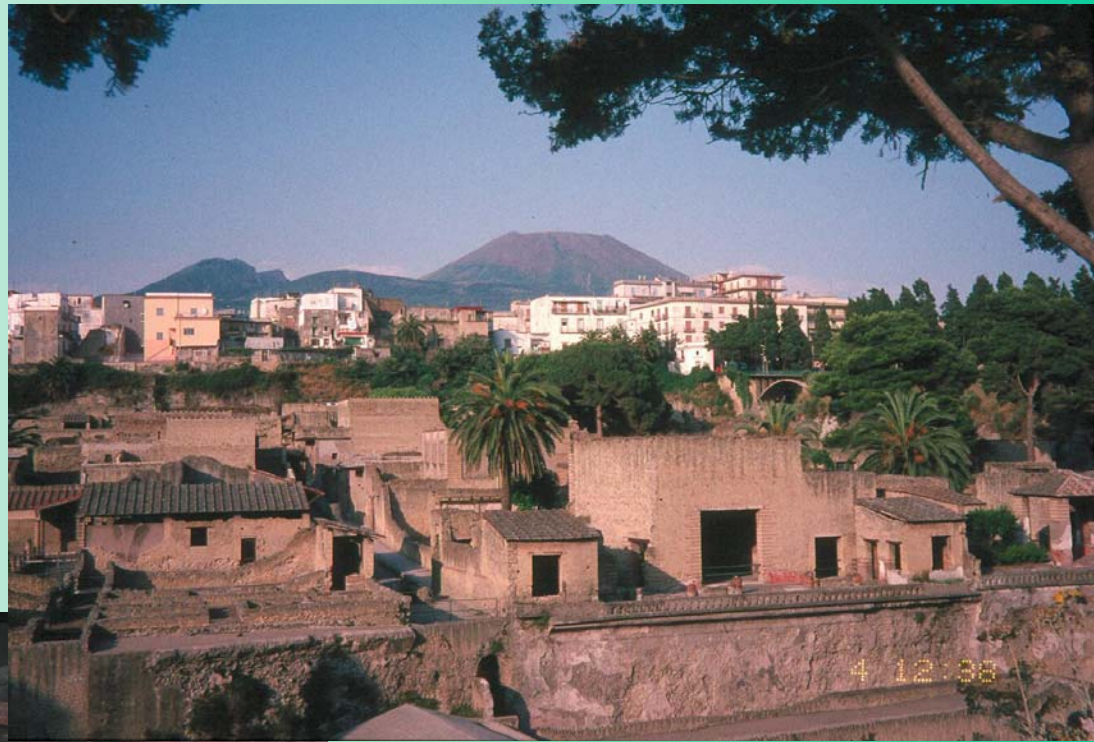
..... elicitation used to aid prompt decisions on public alert levels:



**Mid-2005, after ten years activity, pyroclastic flows and lahars have destroyed much of central Plymouth and southern Montserrat
...and this volcano continues to be restless**



**To Italy, Pompeii and
Hercalaneum.....**

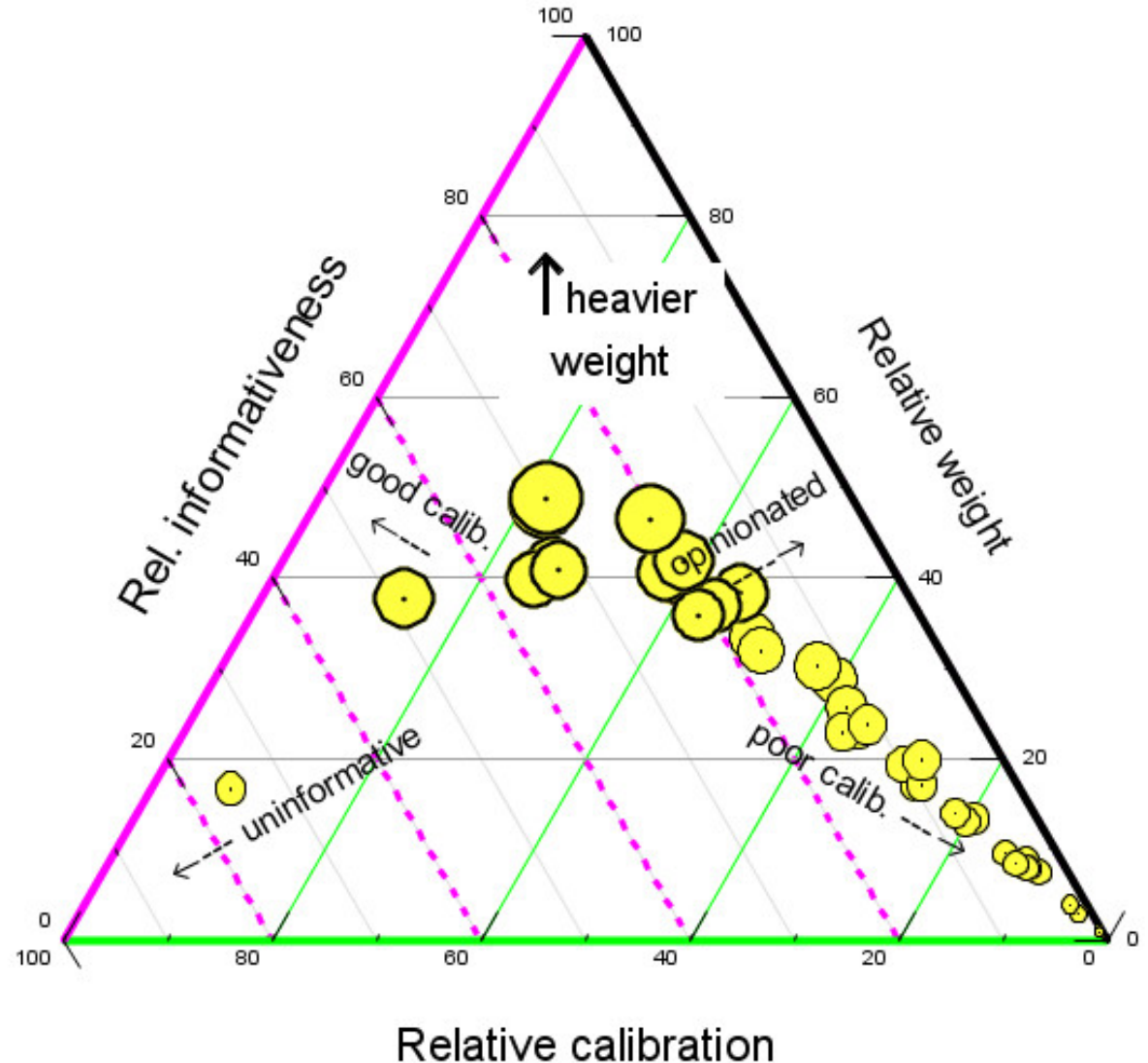


**.... and Mount Vesuvius - a
sleeping future threat**



**The city of Naples,
Italy.....increasingly
built-up in “Red Zone” –
making Vesuvius
probably the highest
‘risk’ volcano in the world**

Relationship of experts relative weights to informativeness and calibration

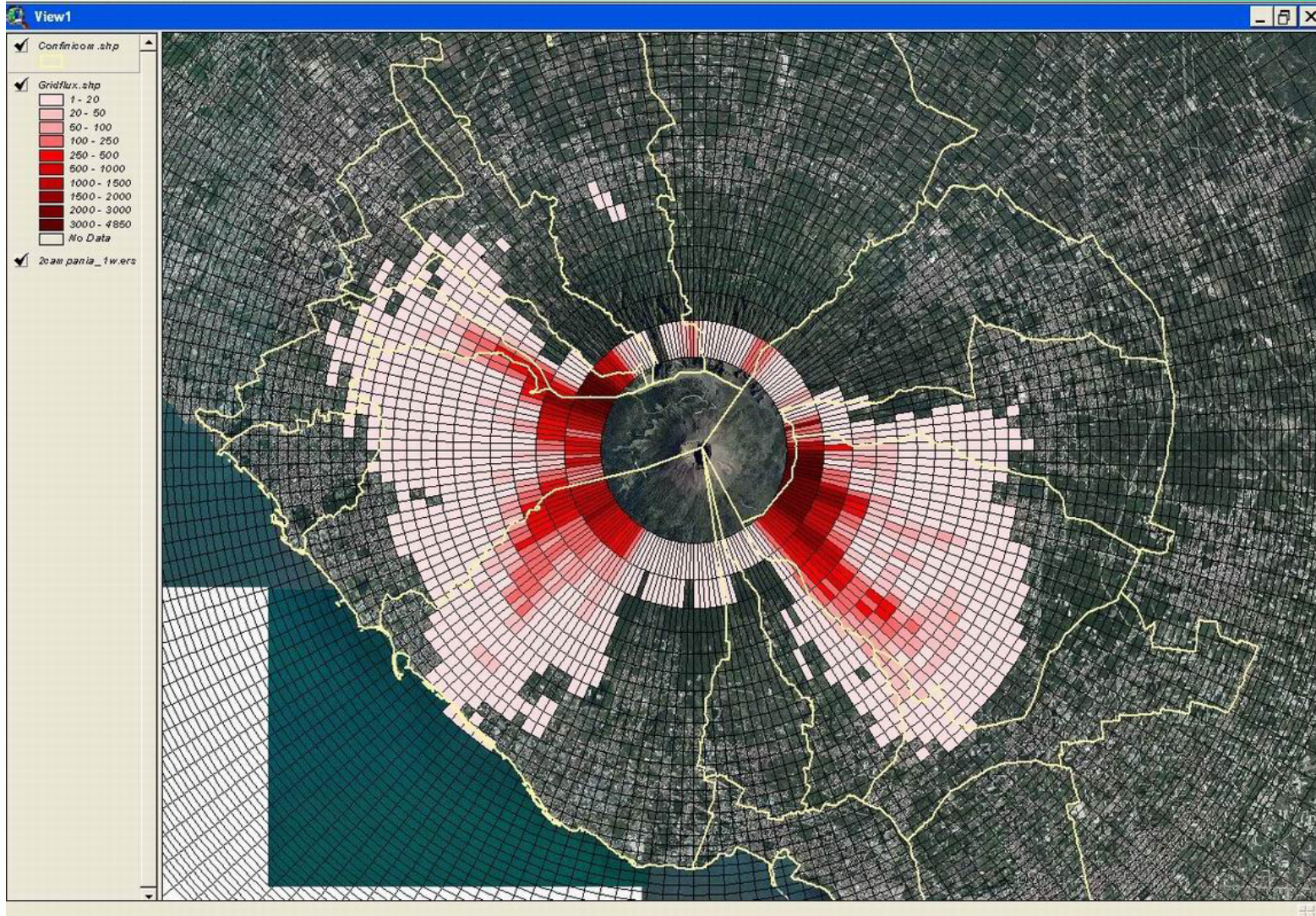


The European Community is sponsoring a major multi-disciplinary study into assessing the risk from the next eruption of Vesuvius.

The EXCALIBUR approach is being used to assign weights to experts.....



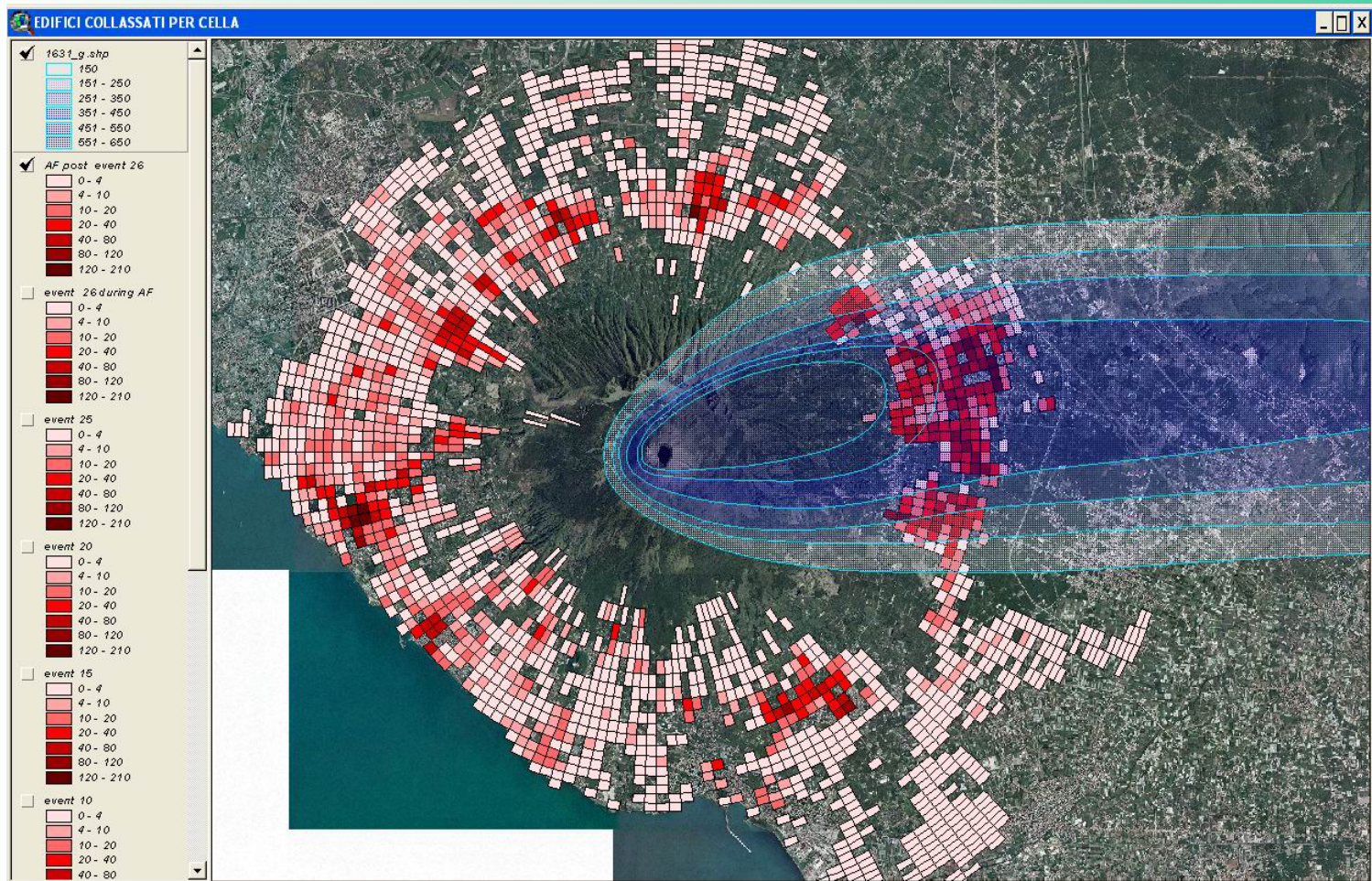
.....using expert judgment in combination with latest GIS and numerical modelling techniques



Pyroclastic flow hazard

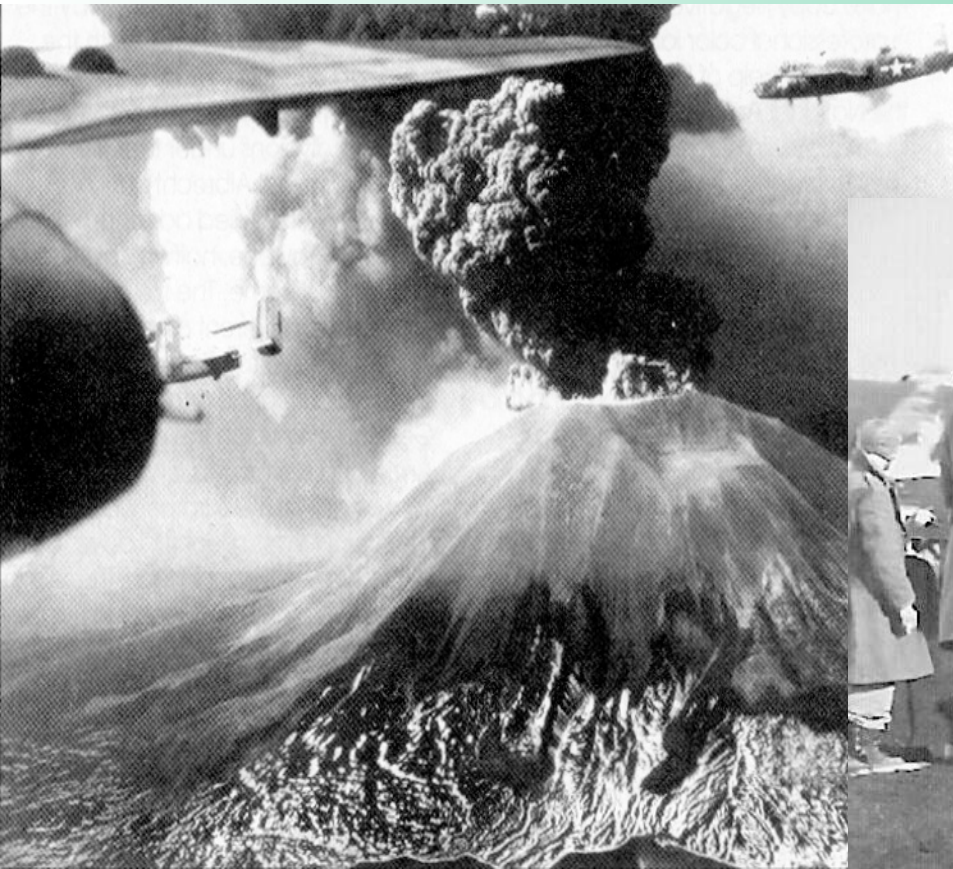


Building damage prediction and ashfall plume modelling



Combined seismic and ashfall
impacts

Last Vesuvius eruption was in 1944...



..... methods for quantifying potential risks from future eruptions of Vesuvius are being developed with EXCALIBUR, for optimal risk management in a future eruption -

.....so we will know how many shovels to order !!

....expert elicitation, from volcanoes to civil aviation.....



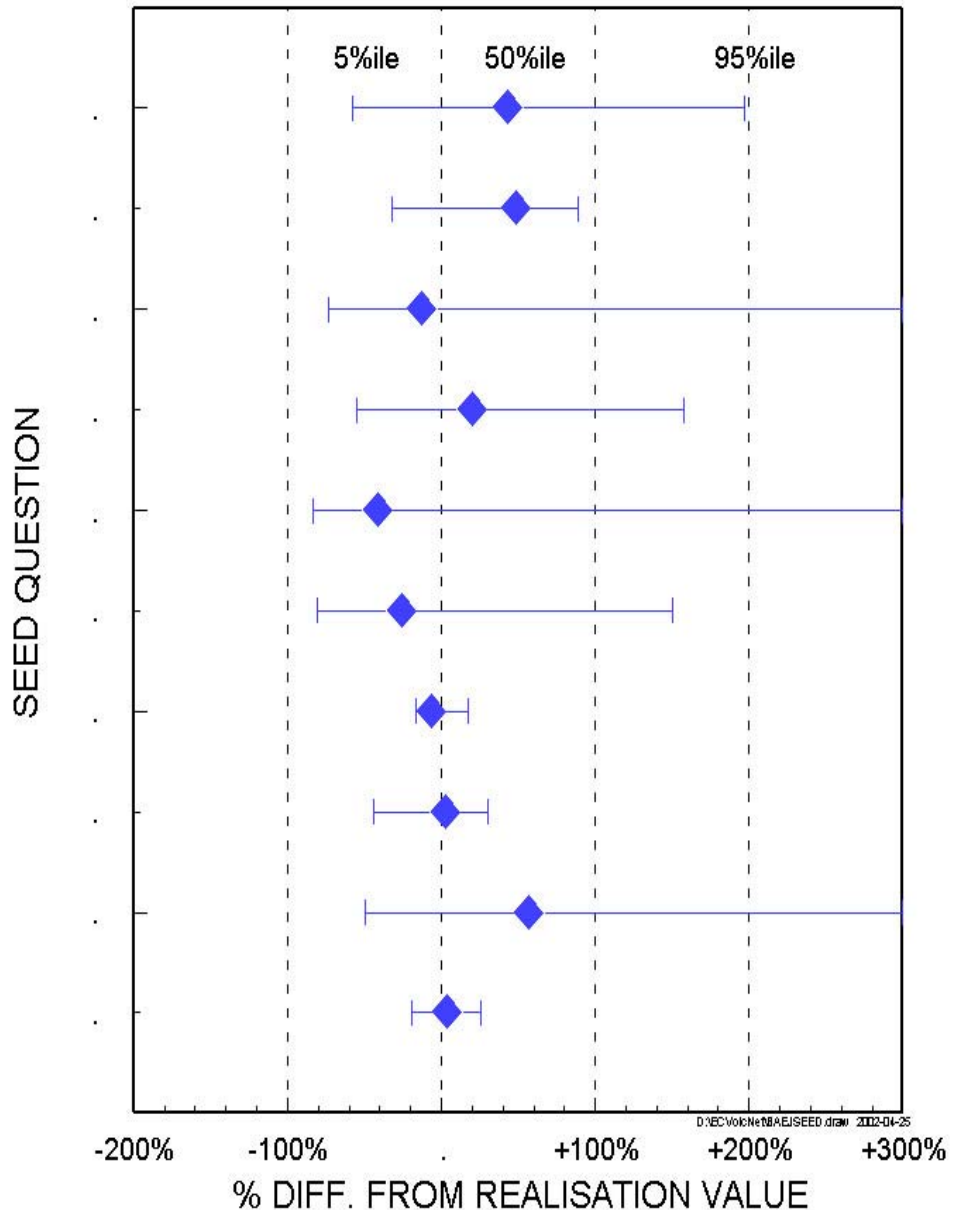
Mount Pinatubo eruption, 1991,
and Clark AFB, Philippines





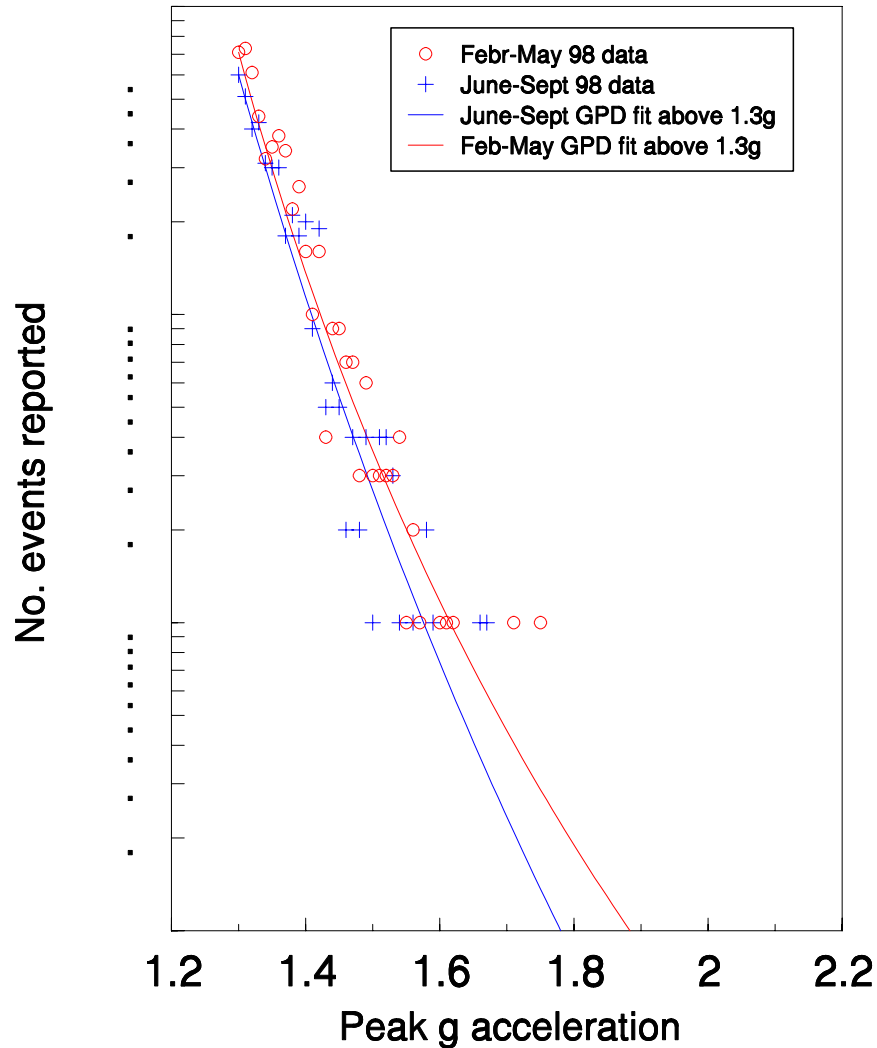
**The British Airways
experience.....**

**BRITISH AIRWAYS SESMA DATA:
COMPARISON OF EXPERT JUDGEMENTS
WITH KNOWN VALUES FOR SEED QUESTIONS**



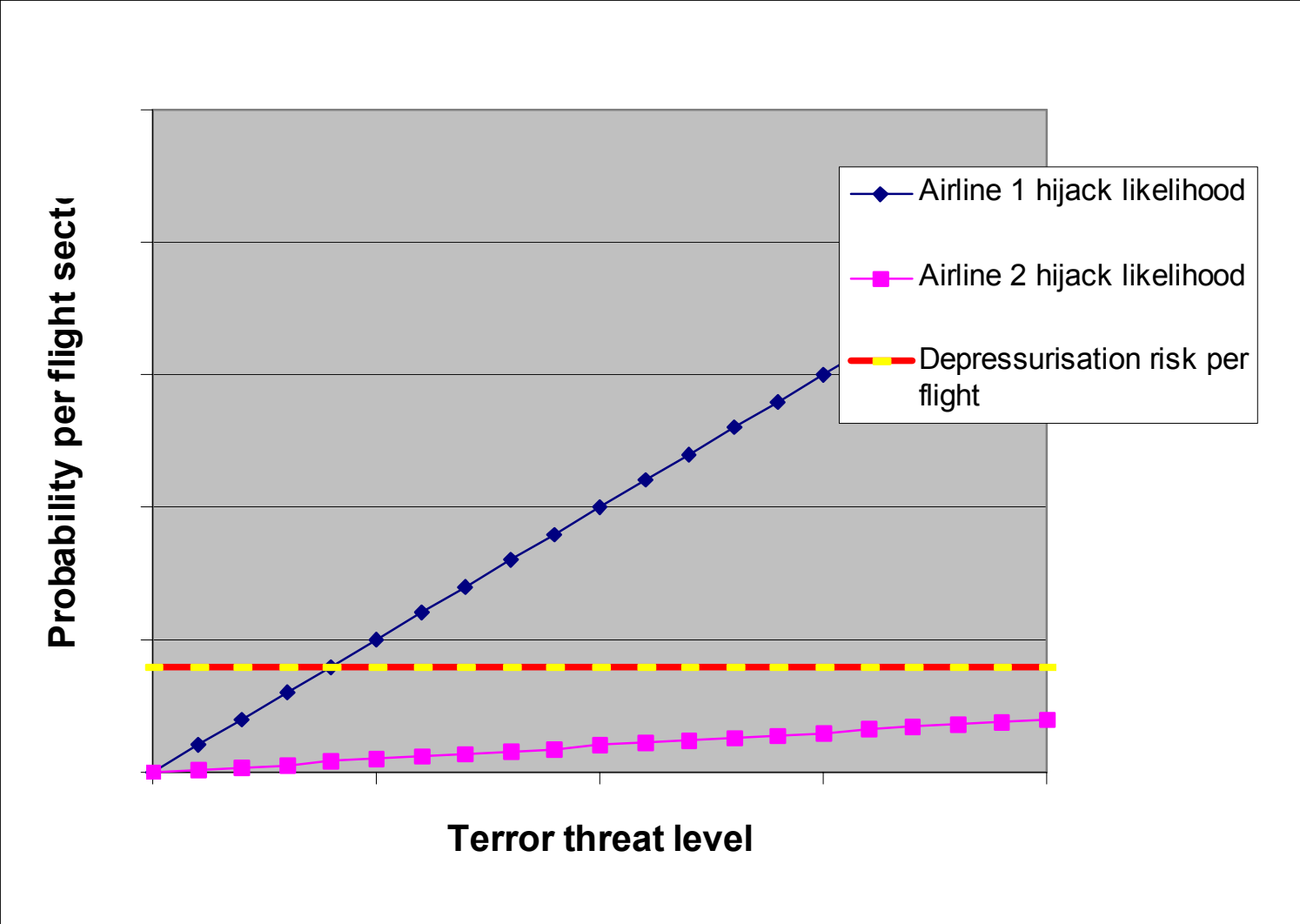


BA Heavy Landings



Moral: don't let sales people dictate operational procedures, without first checking the consequences....

Cockpit intrusion risk *versus* de-pressurisation risk





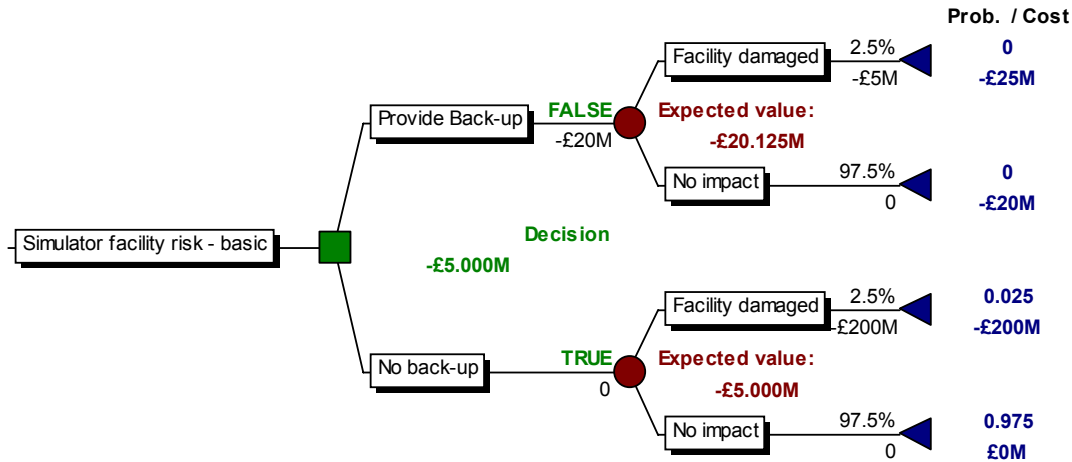
**The British Airways
Cranebank Simulator Facility
near Heathrow Airport.....**



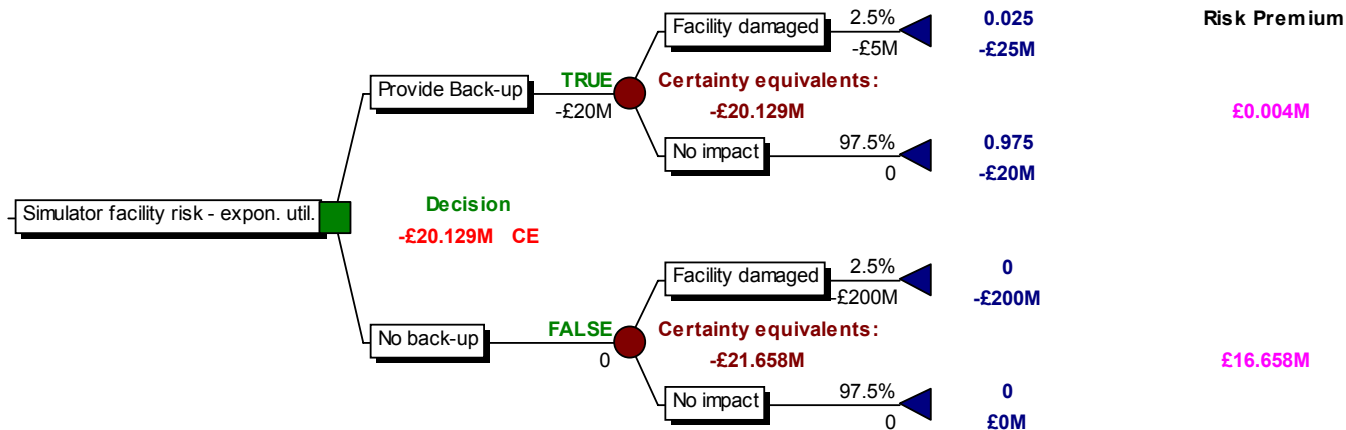
**...risks of severe economic losses if
damaged by a crashing aircraft**

Cranebank Aircraft Impact Risk - Decision-making with Utility Functions

In Tree #1, as shown below, the optimal path is the lower branch, since it has the lower expected cost.

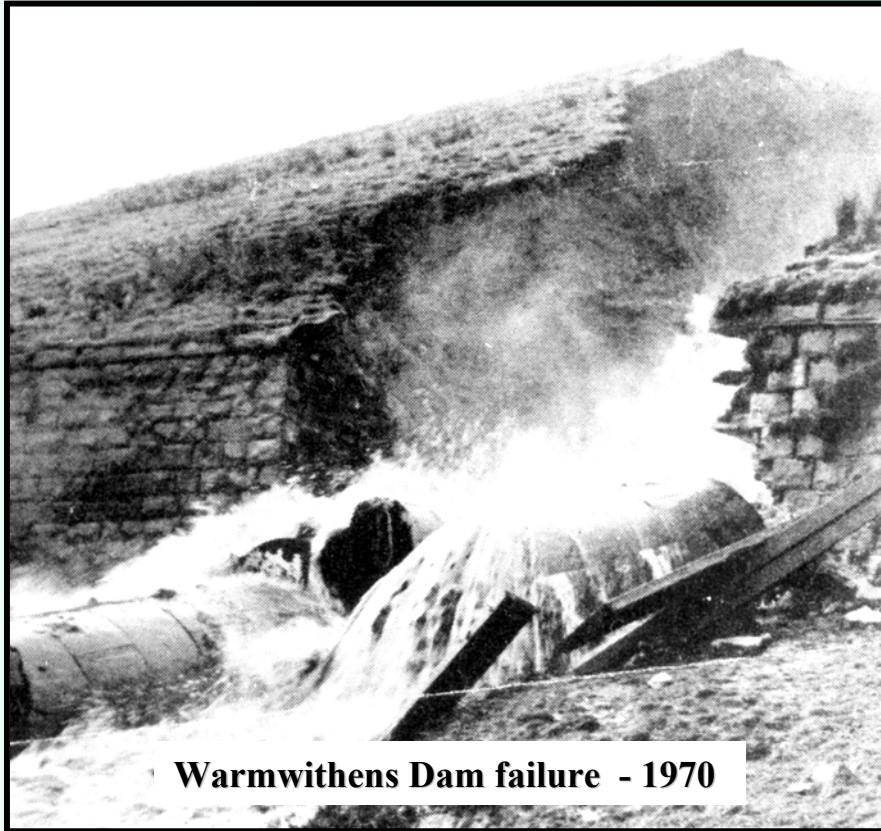


Tree #2, as shown below, has a different optimal path when an exponential utility function with $R=75$ is applied. The decision is marginal at this value of R , but becomes firmer if a more risk averse attitude is adopted (e.g. $R < 75$). The output values displayed in the cells are now the "certainty equivalents" of the nodes, rather than expected values.



Decision tree using expert judgements on impact risk, utility and risk aversion

From air to water.....



Warmwithens Dam failure - 1970

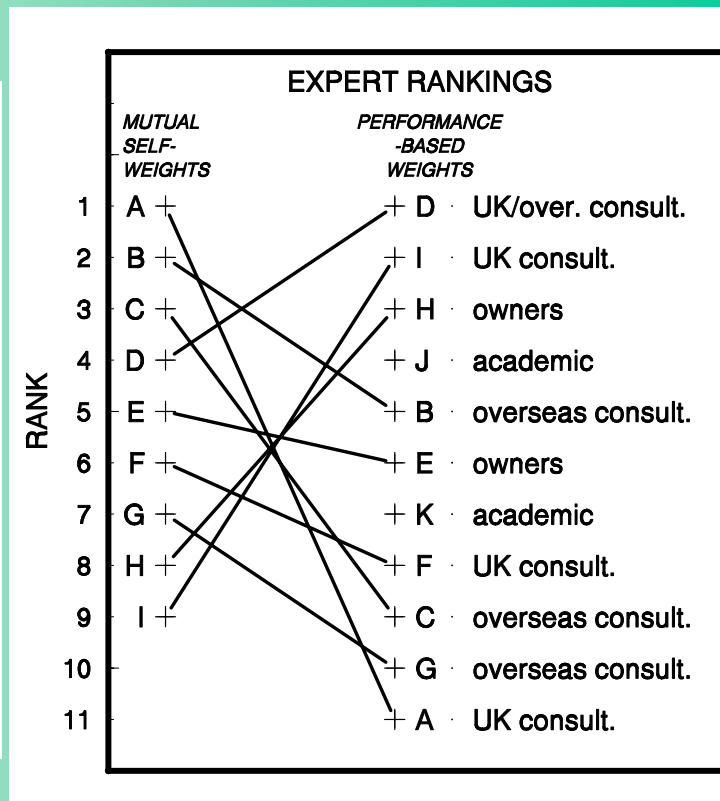
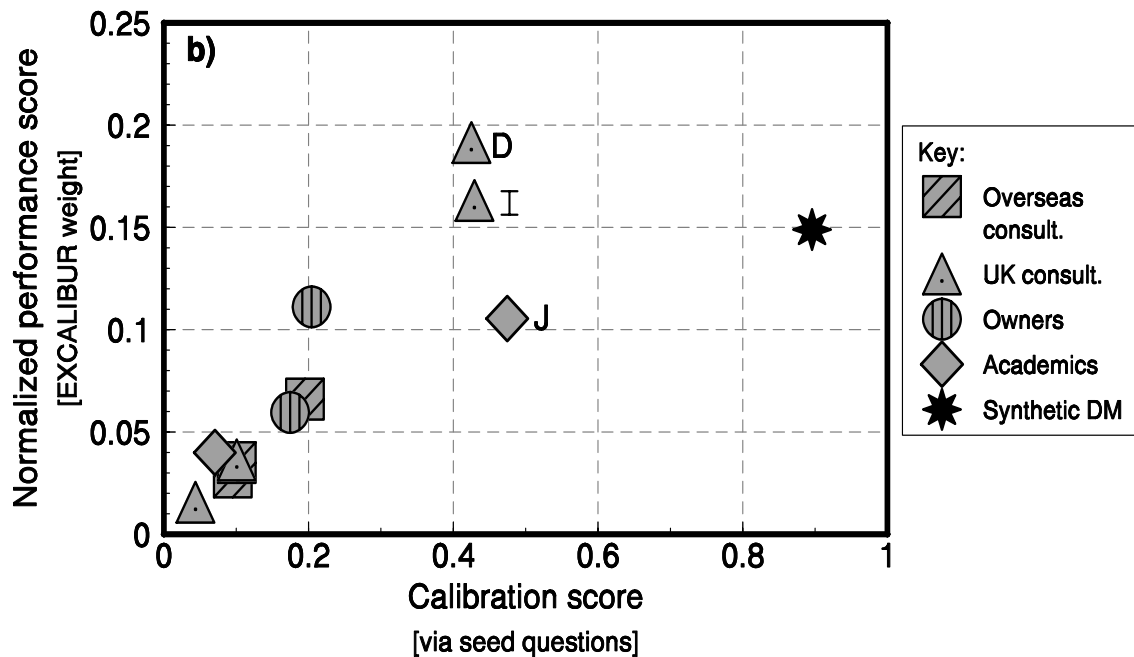


Cowlyd Reservoir inspection party - 1917

..risk assessment and reservoir safety in the UK

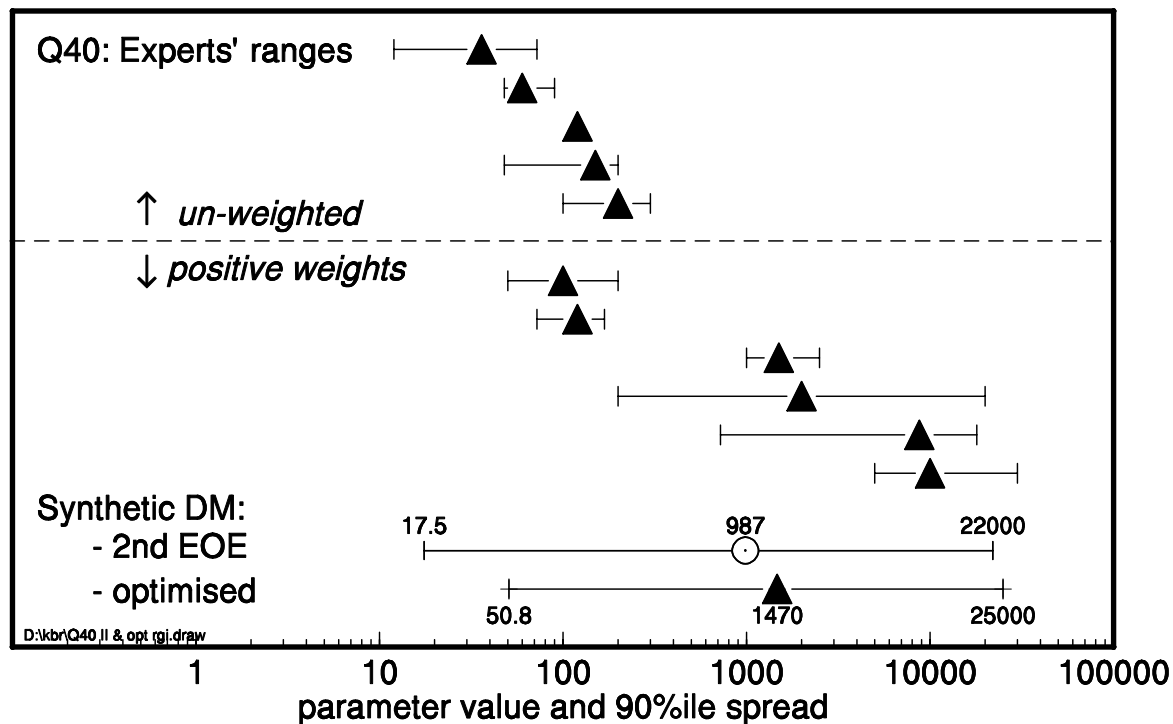
Objective: to developing a generic quantitative model for accelerated internal erosion in Britain's population of 2,500 ageing dams, using elicited quantities for key variables

The reservoir engineers: performance-based scores, and mutual self-weighting rankings



Example of the experts' spreads of opinion for one parameter of interest, and the outcomes obtained by alternative ways of pooling the weighted opinions

Judgments on the time-to-failure (in days from first detection) for the 10%ile slowest cases:



Note the “two schools of thought” effect...and the strong ‘opinionation’ of many experts

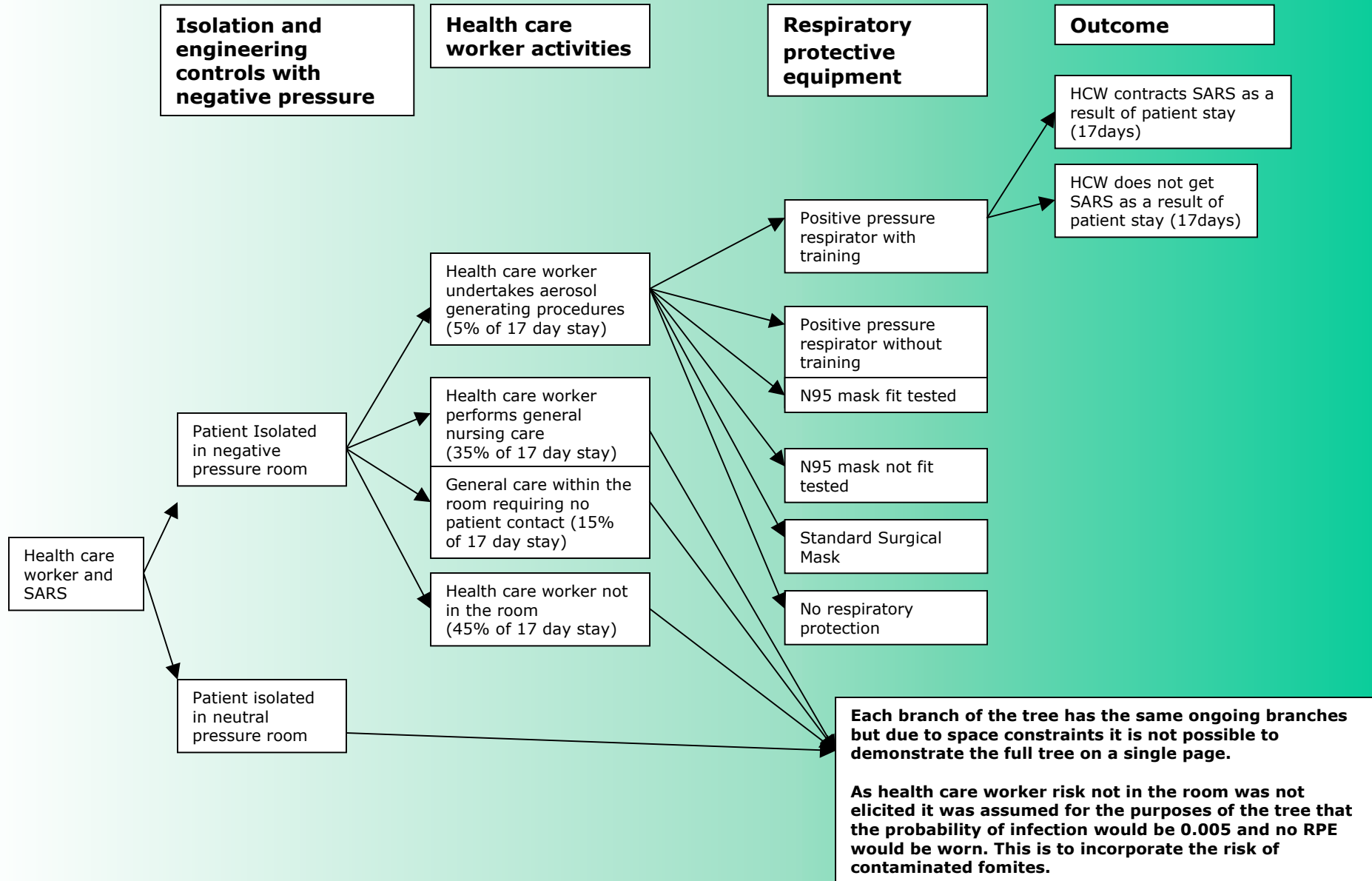
Severe Acute Respiratory Syndrome (SARS)

- **Outbreak in 2003, South East Asia and North America**
- **Atypical pneumonia**
- **Novel virus identified – coronavirus**
- **High proportion of health care workers (*HCW*) affected**

What is most appropriate SARS protection for Health Care Workers?



SARS transmission to health care workers - probabilistic event tree



SARS elicitation outcomes:

- Conventional statistical methods and epidemiological surveys were found to be of limited use in assessing the risks of occupational infectious disease transmission in the SARS epidemic of 2003.
- The elicitation showed that experts believe positive pressure respirators and N95 disposable respirators provide protection, although the factors are lower than. Doubts exist over the benefits of ordinary surgical masks. Negative pressure ventilation of rooms is also expected to be protective.
- The elicitation shows a high level of uncertainty exists in quantifying all aspects of SARS transmission.
- An estimate of annualised death rate in HCWs from SARS by expert elicitation was determined as 8 per 1000 for HCW wearing face fit tested N95 masks - substantially higher than the maximum tolerable occupational risk of 1 per 1000 per year for the UK.
- This indicates additional control measures are required to reduce the probability of infection to a more tolerable level.
- Deriving a hierarchy of risk per procedure requires a more extensive elicitation exercise.

Elicitation of expert opinions for estimating the effects on humans of malicious releases of biological agents

with particular emphasis on quantifying uncertainties.....

Progression of an anthrax case, from Rickmeier et al. 2001 (KAMI approach)

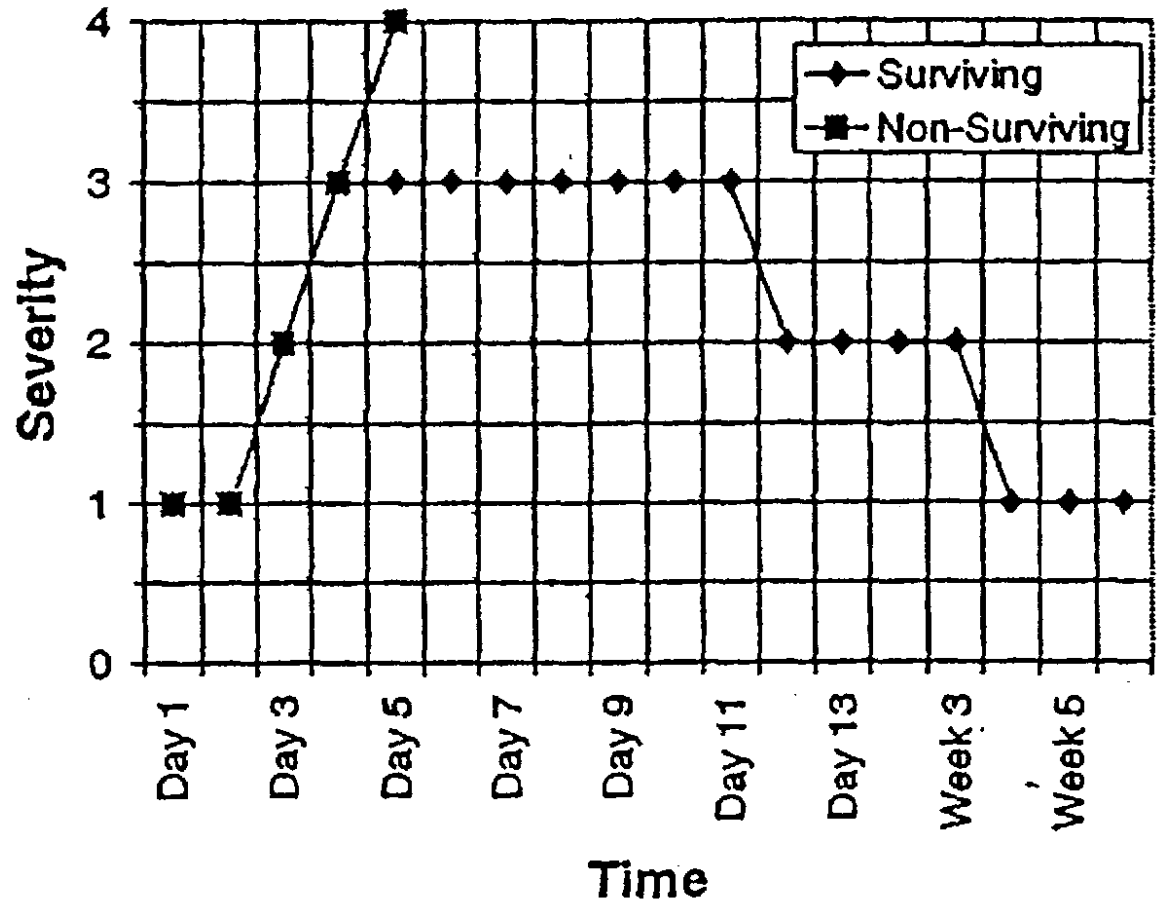
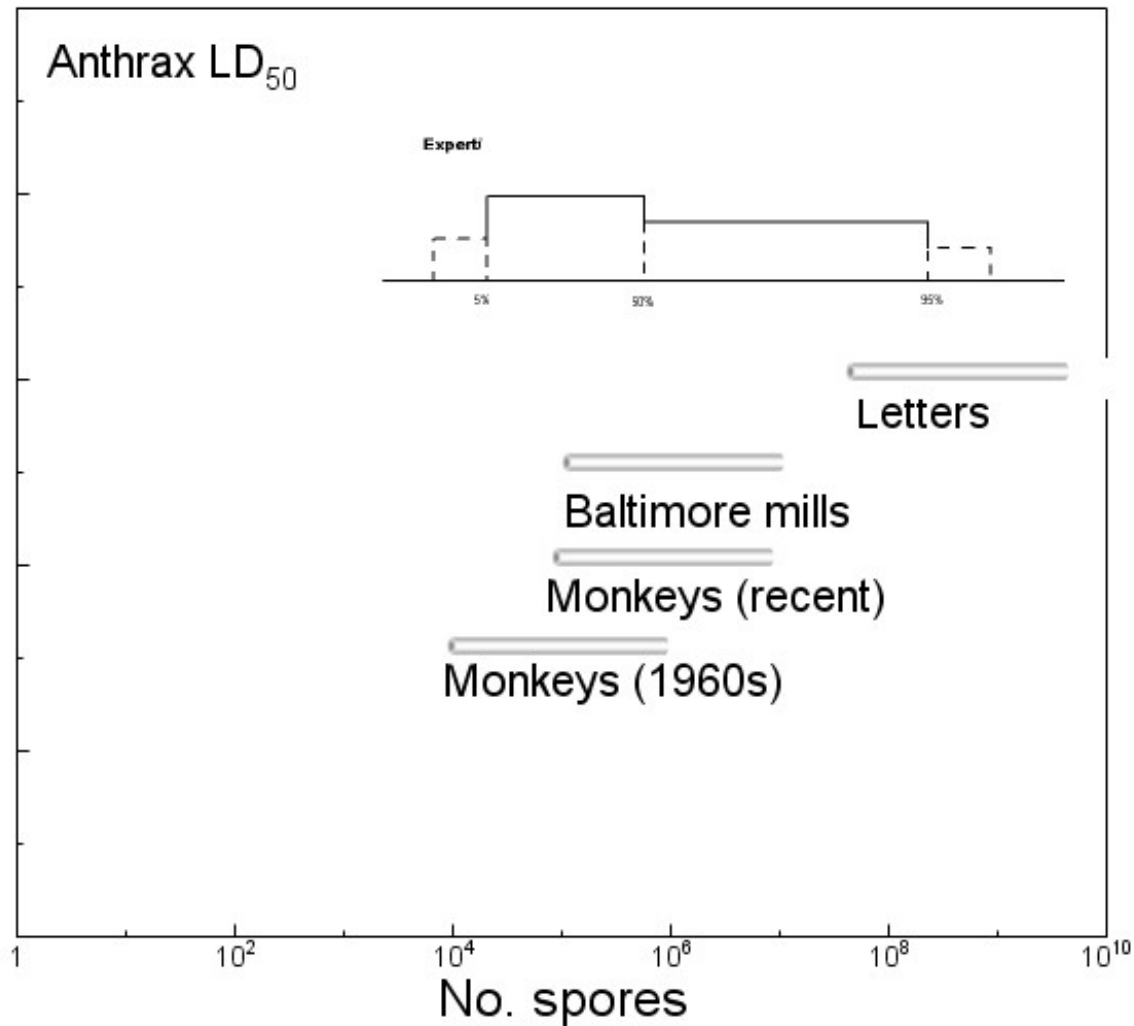


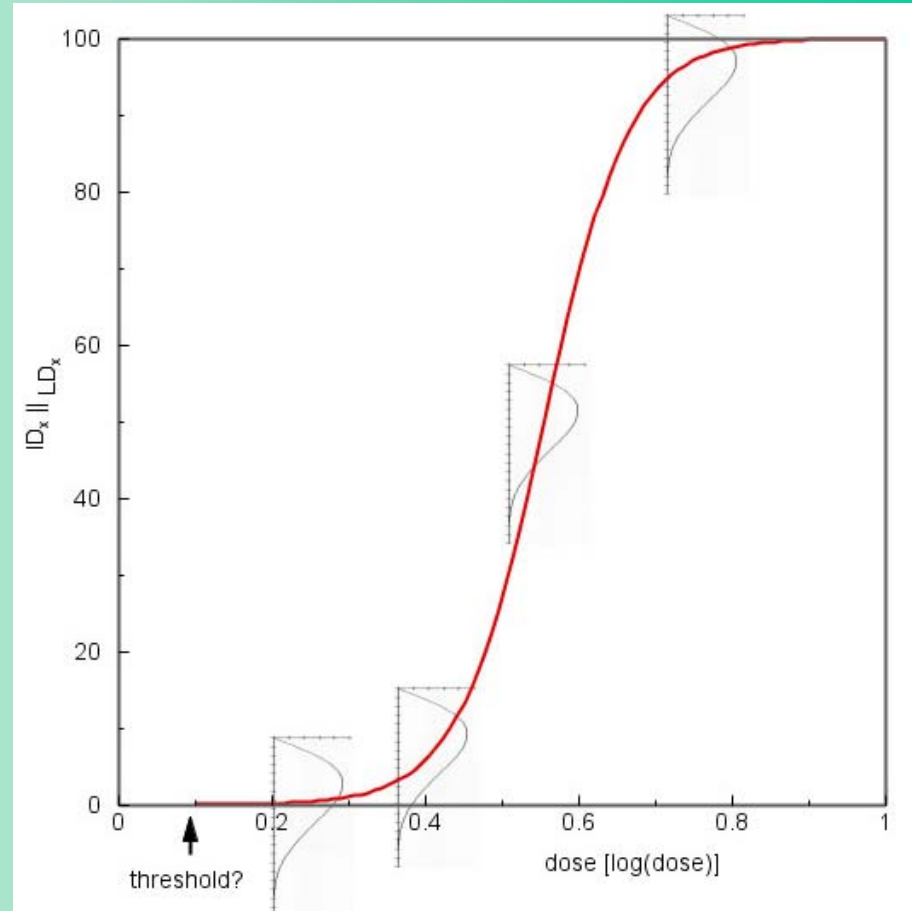
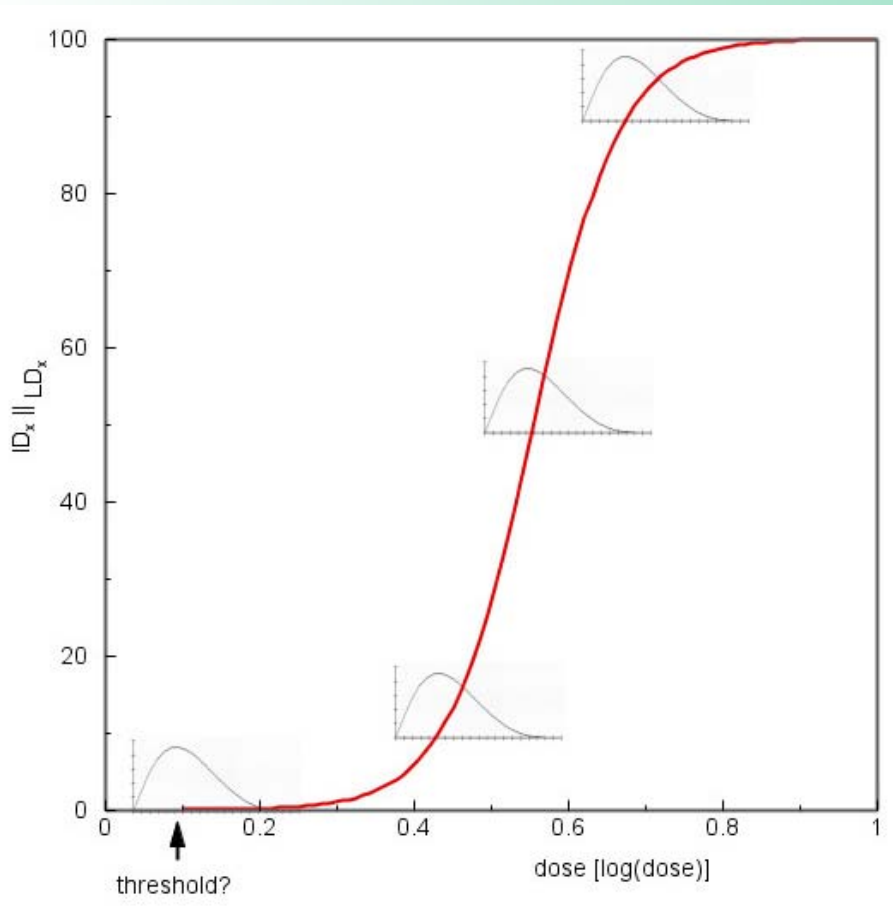
Figure 2. Severity Profile of Disease as a Function of Time

The approach to the anthrax dose-response quantification problem, given limited data from animal experiments and some human exposures....



... elicit judgements from experts to obtain a spread of values for the variable in question.....

...then fit these to a functional form, either by using elicited dose distributions for fixed ID_x values.....



...or ID_x spreads at fixed doses



Important role for formalised expert judgement procedure in communicating science and scientific uncertainty in a volcano crisis:

- **within the scientific community**
- **in advice to governments**
- **in outreach to the public**
- **in dealing with the media**
- **with the law**

Despite great scientific advances, experts are just as uncertain, perhaps more so.....



St Vincent 1902

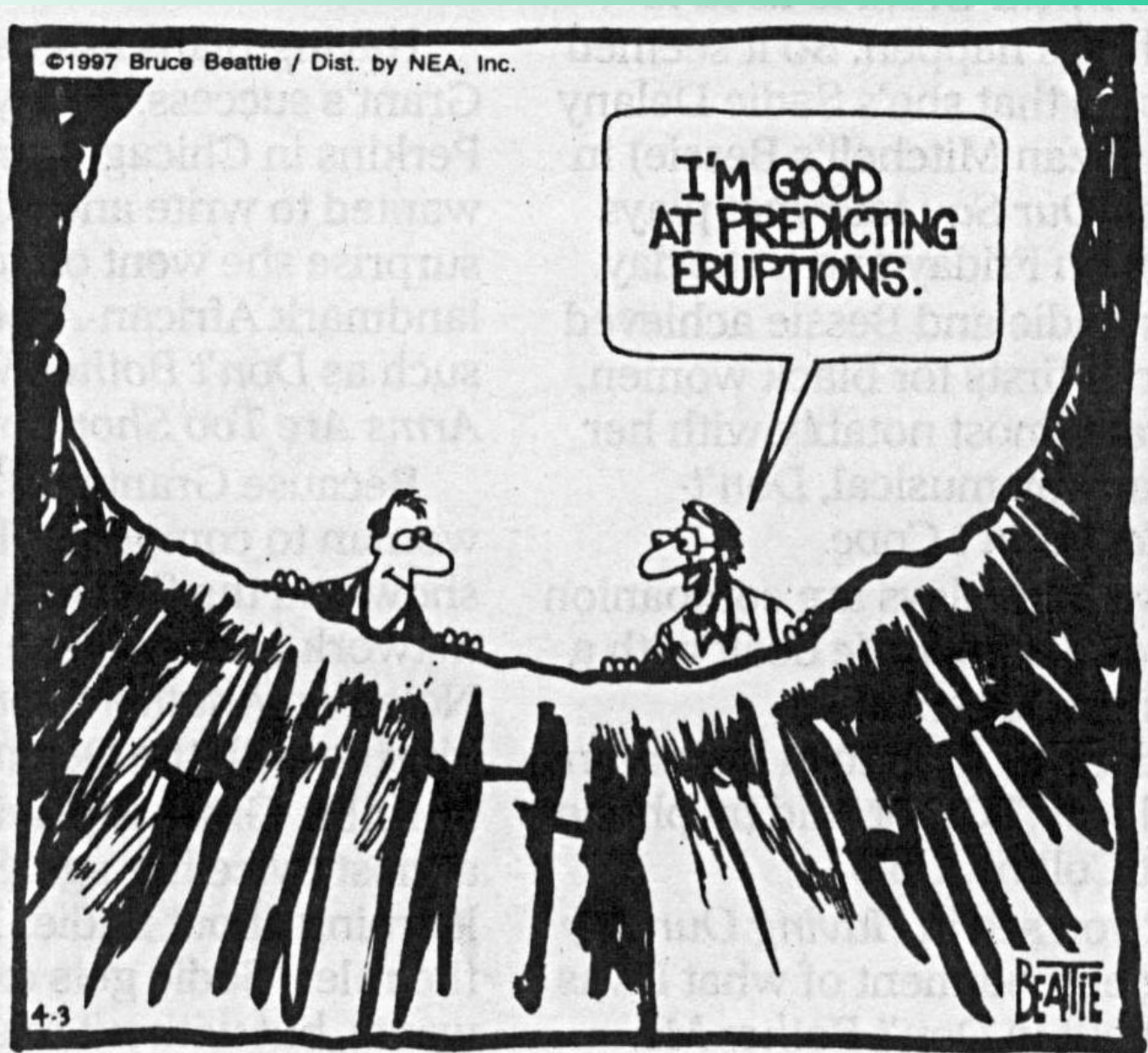
Montserrat 1996




.....we have used the EXCALIBUR structured elicitation procedure with success, accommodating scientific opinions and uncertainties in circumstances demanding urgent decision support.

Famous last words....

of a volcanologist:



A painting depicting a volcanic eruption. In the foreground, two palm trees stand on a dark, rocky shore. The background is dominated by a massive, glowing orange and yellow plume of smoke or ash rising from a volcano, set against a dark, stormy sky. The overall mood is one of natural power and destruction.

Disasters are the only phenomena that
require an explanation
- Dombrovsky (1987)

Nature has much to say, but won't talk
- Zhuang Zhou (300 B.C.)

In almost all circumstances, and at all
times, we find ourselves in a state of
uncertainty
- Bruno de Finetti

Thank you!