City University London

The University for business and the professions

ISDE

Digital Earth, GIS and the safety of society

David Rhind

22 May 2006

Contents

- The geography of risk
- A reminder of some recent disasters – natural and man-made
- How can GIS help?
- A worked example: London
- The private sector interest: insurance example
- Convincing people to take action: another example
- Conclusions

Digital Earth

‘Digital Earth is a visionary concept for the virtual representation of the Earth that is spatially referenced and interconnected with digital knowledge archives from around the planet with vast amounts of scientific, natural, and cultural information to describe and understand the Earth and human activities ‘

This is a technologist’s approach to means, not to ends. I will deal with one of the 2 biggest problems – ‘the safety of society’

The geography of risk

- Recent series of well-publicised disasters, both natural and man-made across the world
- *All disasters happen somewhere – affects nature, impact and response*
- Scientists seeking to identify areas of natural risk must deal with the geography of risk
- Geography is therefore central to both planning and countering disasters
- GIS + Digital Earth almost a necessary – but far from sufficient -tool

The media impact

- First duty of state is to protect citizens but
- Instantaneous communications now can lead to public distrust of leaders very quickly if no effective action (e.g. Katrina)

Some recent natural disasters

City University London

The 26 December 2004 tsunami killed over 200,000 people

Other major disasters caused by earthquakes:

2003 Bam, Iran – kills 26,000

2001 Gujarat, north-west India - kills more than 20,000

1976 Tangshan, China - kills 242,000

1923 Tokyo - kills 140,000

BANDA ACEH

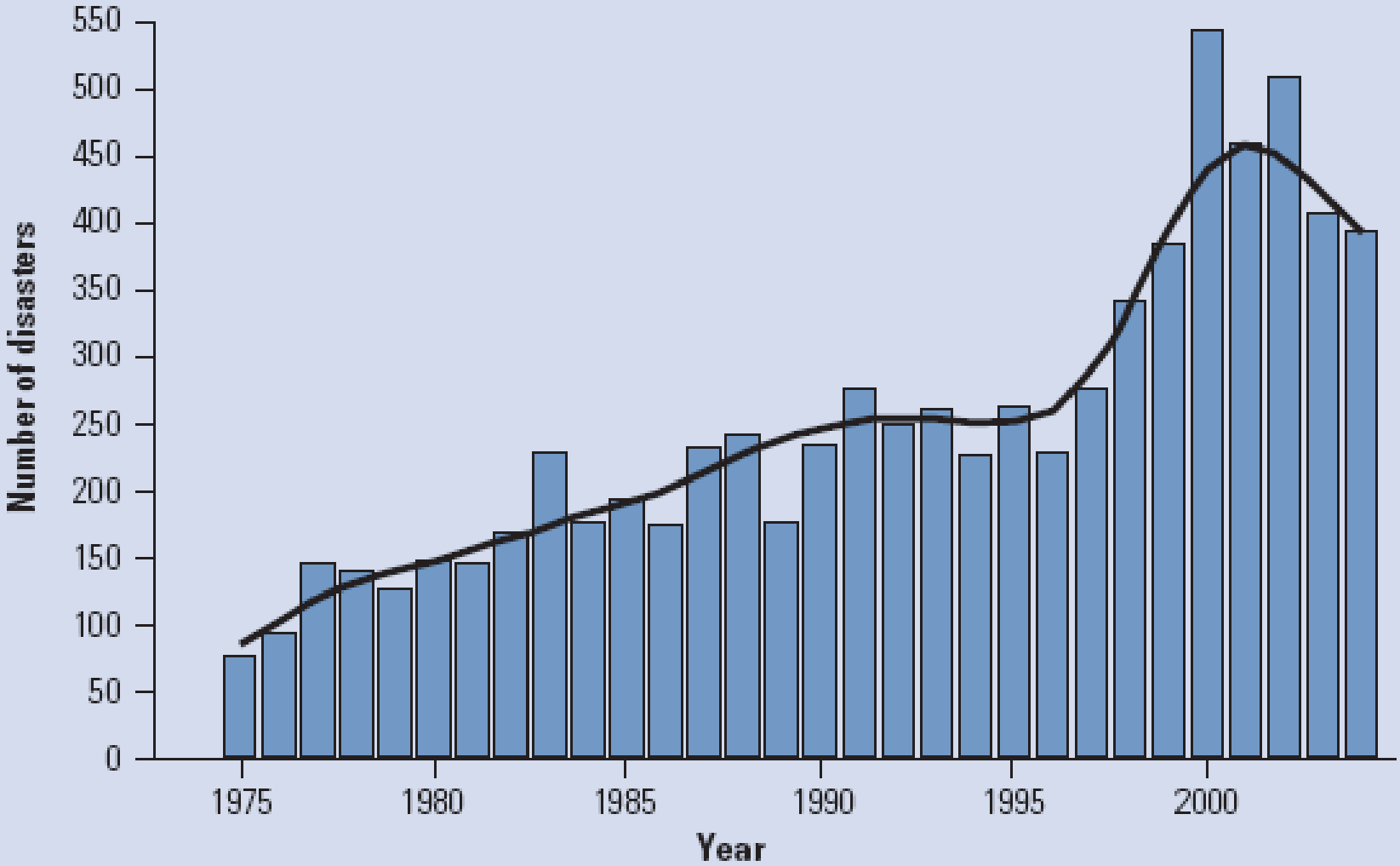
A Thai Navy boat was washed inland by the tsunami, coming to rest approximately one mile (1.5km) inland from Khao Lak beach


GETTY I

Scenes from Hurricane Katrina – New Orleans taken from BBC web site

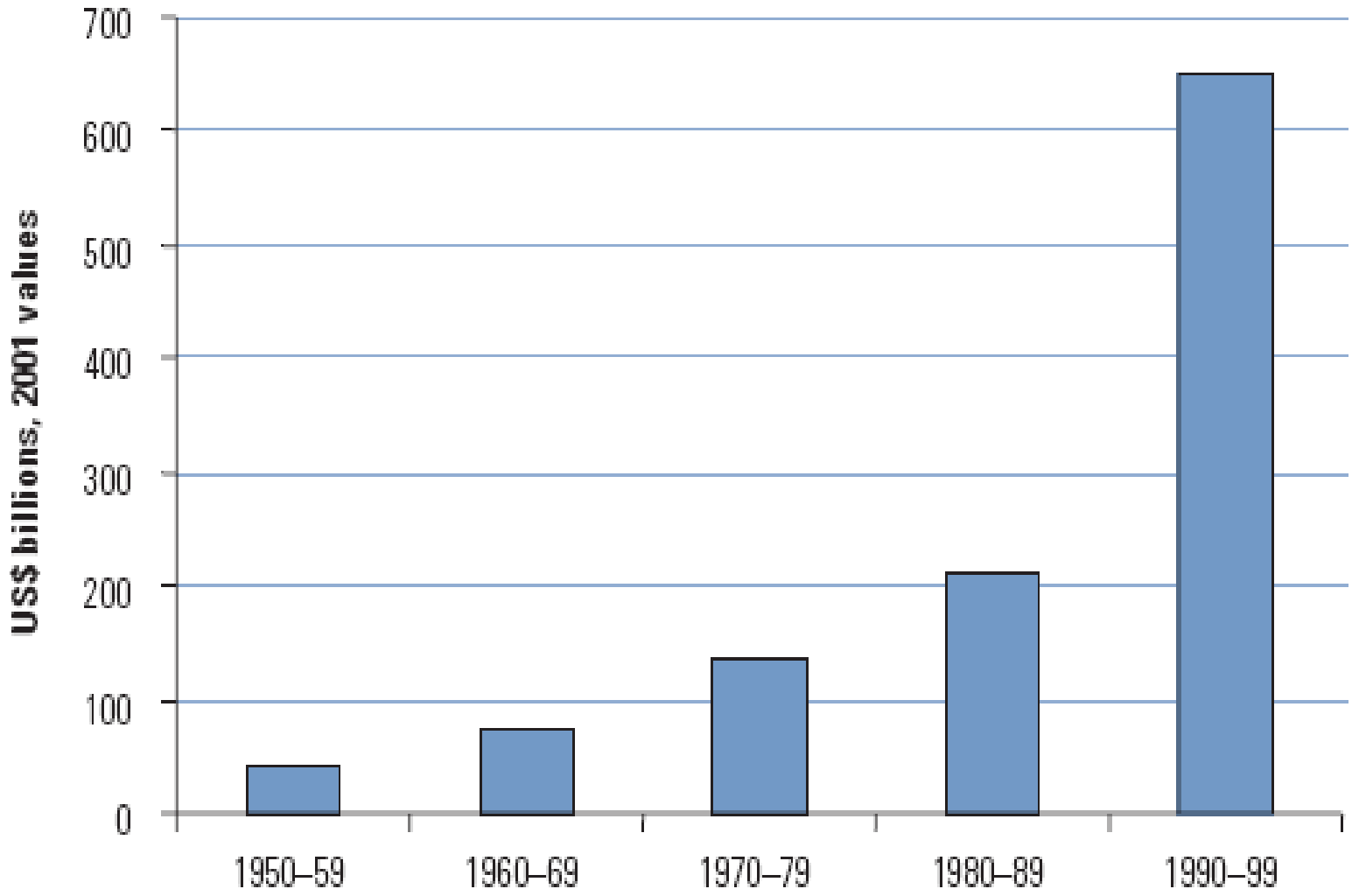
Box 1.1: Why Do Natural Disasters Seem to Be Increasing in Number?

Several factors contribute to the apparent increase in the number of reported disasters.



Source: EM-DAT: The OFDA/CRED International Disaster Database-www.em-dat.net-Université Catholique de Louvain, Brussels.

Figure 1.1: The Cost of Disaster Damage Is Rising



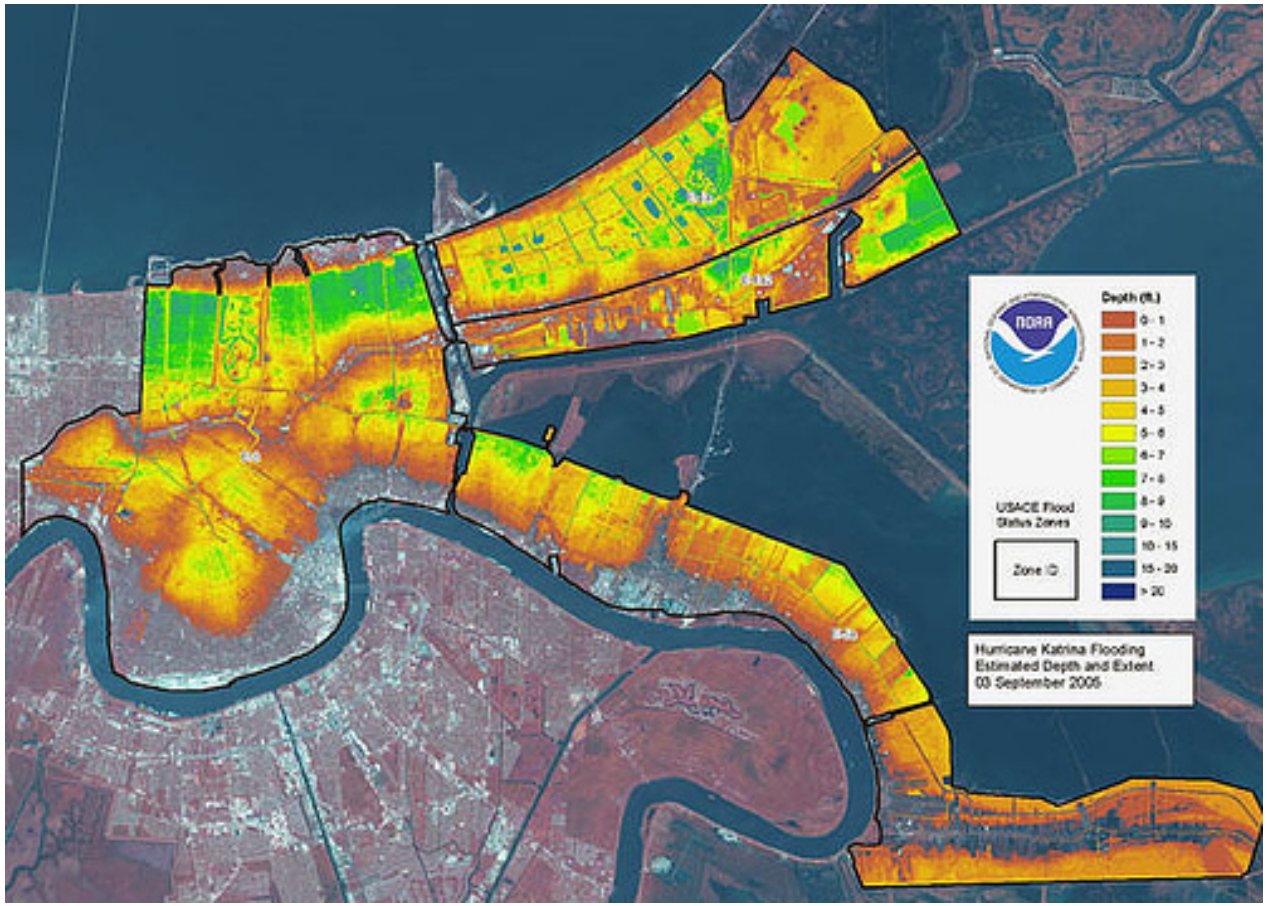
Source: IMF 2003.

Note: Data are for "great" disasters, in which the ability of the region to help itself is distinctly overtaxed, making interregional or international assistance necessar

The geography of natural disasters

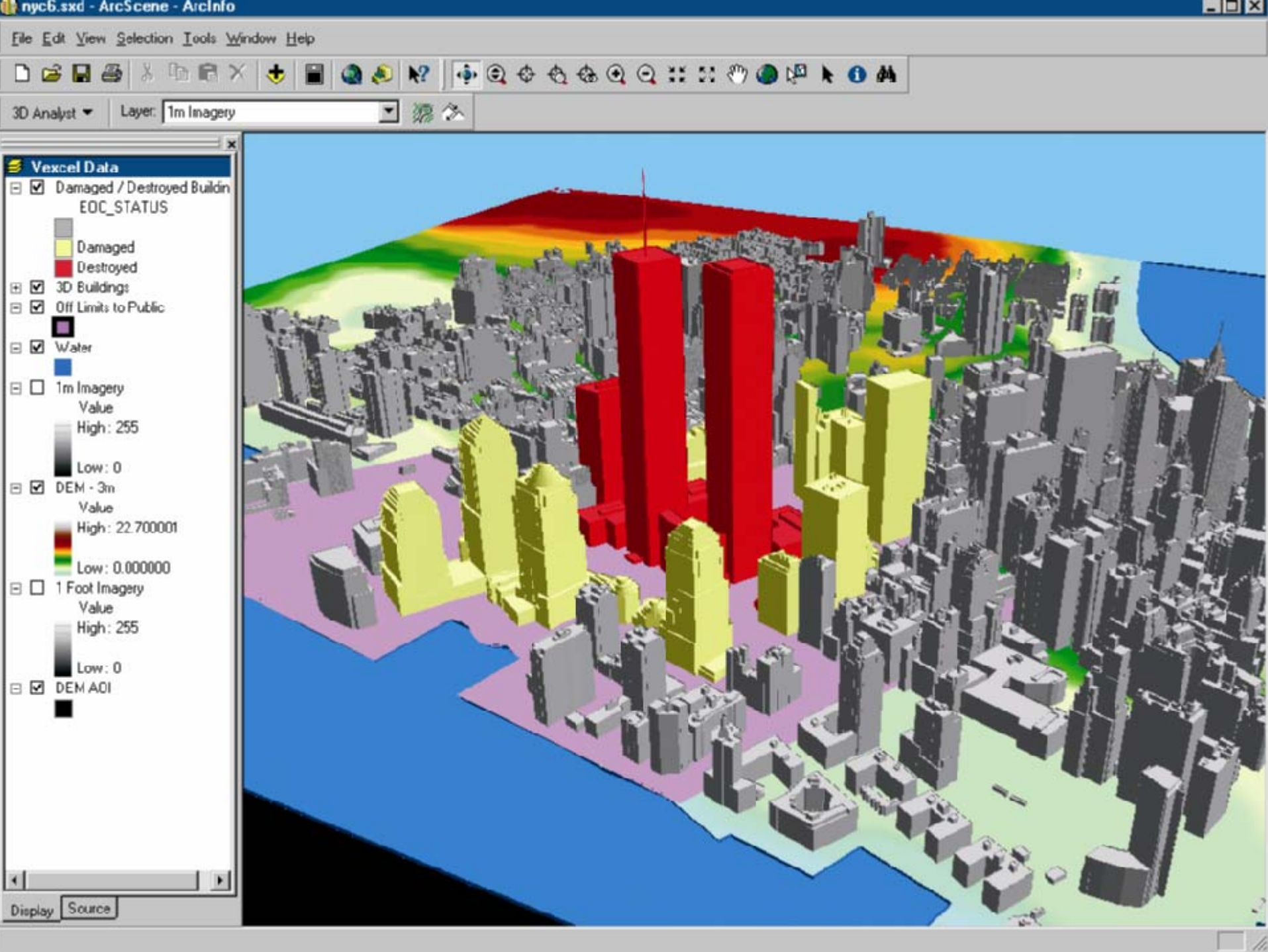
- 98% of the 211 million people affected by natural disasters from 1991 to 2000 were in developing countries (see http://www.worldbank.org/ieg/naturaldisasters/docs/natural_disasters_evaluation.pdf)
- GIS can really help (see http://www.mapaction.org/)

GIS use ‘in anger’:



Lidar image of water depth after Katrina in New Orleans
http://www.flickr.com/photos/gisuser/43339456/in/set-839589/
http://www.gisuser.com/content/view/6945/28/

Some recent man-made disasters


nyc6.sxd - ArcScene - ArcInfo
File Edit View Selection Tools Window Help
3D Analyst
Layer: 1m Imagery
Vexcel Data
Damaged / Destroyed Buildin
EOC_STATUS
Damaged
Destroyed
3D Buildings
Off Limits to Public
Water
1m Imagery
Value
High : 255
Low : 0
DEM - 3m
Value
High : 22.700001
Low : 0.000000
1 Foot Imagery
Value
High : 255
Low : 0
DEM AOI
Display
Source

Disasters caused by man or natural forces?


Courtesy BBC

Disaster planning and recovery: technology often seen as the solution

After Katrina, integrated networks and GIS are crucial
by Michael Arnone, FCW.COM Published on Sep. 19, 2005

'The slow, disorganized response by federal, state and local emergency responders to Hurricane Katrina has prompted state and county information technology officials to think more creatively *about how to deploy technology* when evacuating populous areas before and after major disasters.'

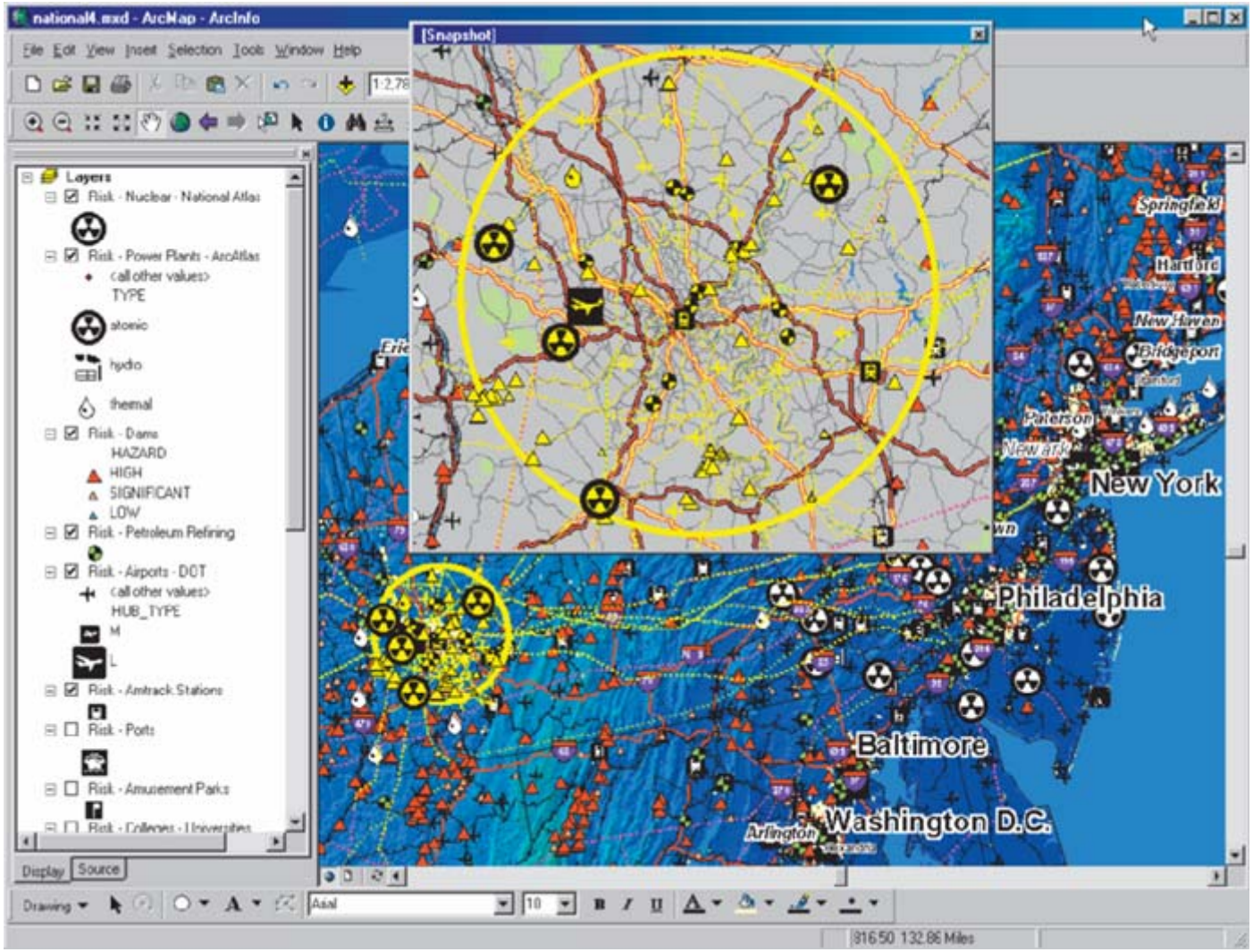
Technology very important BUT the big issue is planning, risk assessment, management, organisation and governance

Some US examples of risk, then a case study from London

GIS can certainly help in…

- *Phase 1: risk assessment* (e.g. via science, surveillance, intelligence integration)
- *Phase 2: preparedness*
- *Phase 3: mitigation*
- *Phase 4: response*
- *Phase 5: recovery*

Key facilities in NE USA



Some US critical infrastructures

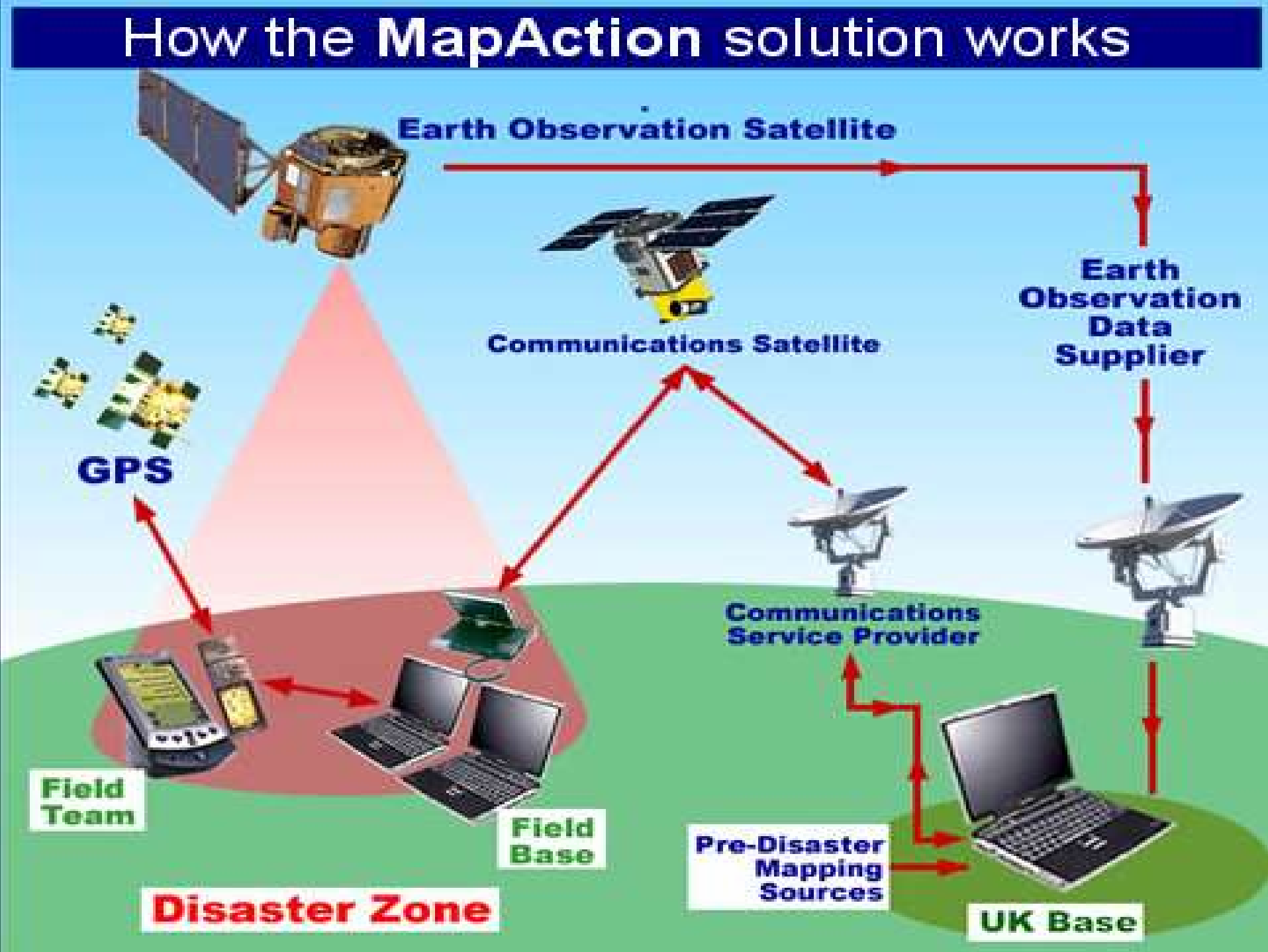
Sector	Example assets	Public accessibility
Water	Drinking water facilities	Substantial
Energy	Nuclear, oil plants	Limited to medium
Transport	Bridges, tunnels, pipelines Internet backbone	Substantial Medium/ substantial
Banking, finance	Financial exchanges, utilities	Substantial/ medium

85% of critical infrastructure owned by private sector

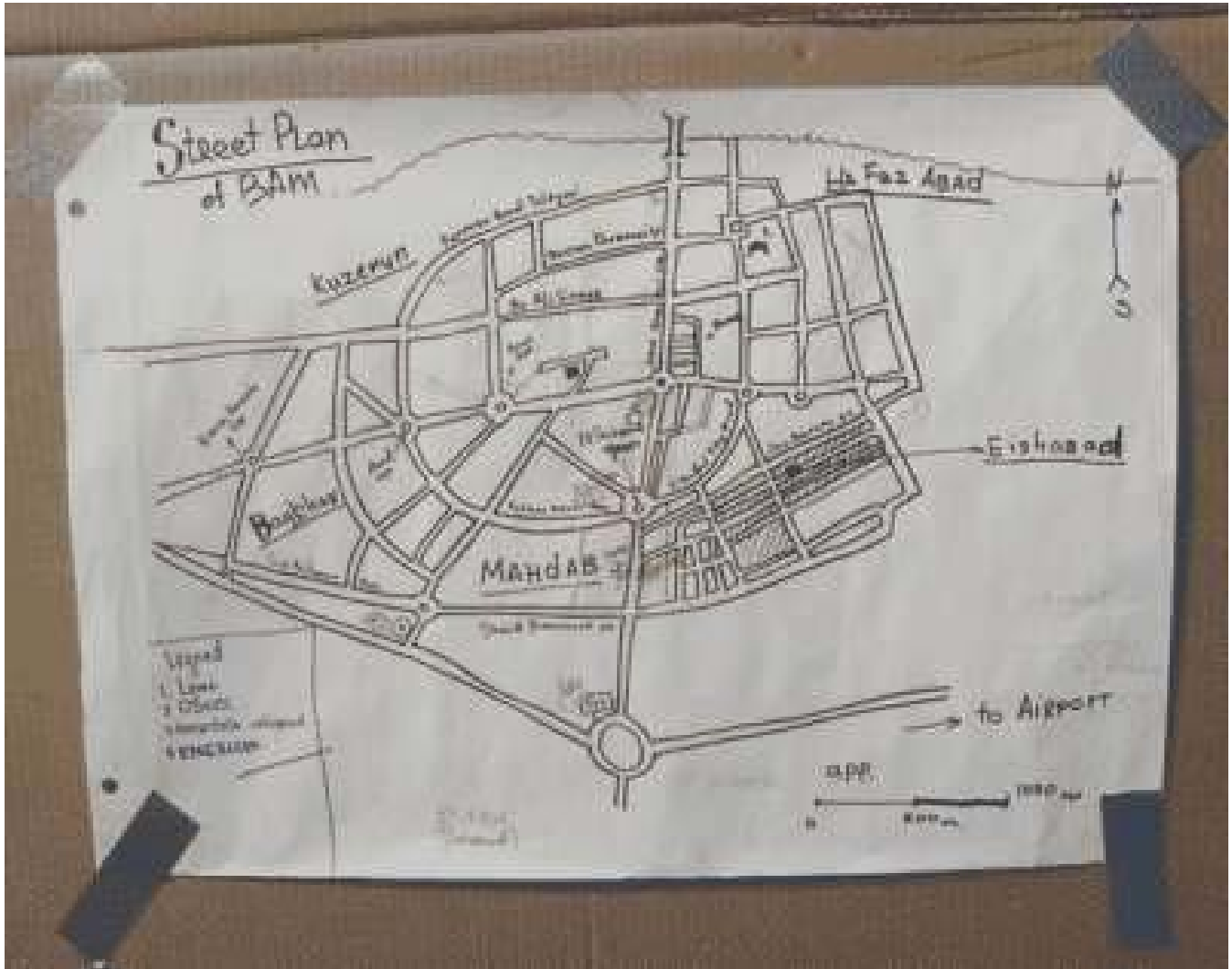
Practical help after disasters – 2 examples

- MapAction teams of volunteers
- International collaboration in data assembly and supply from space agencies

How the **MapAction** solution works



http://www.mapaction.org/

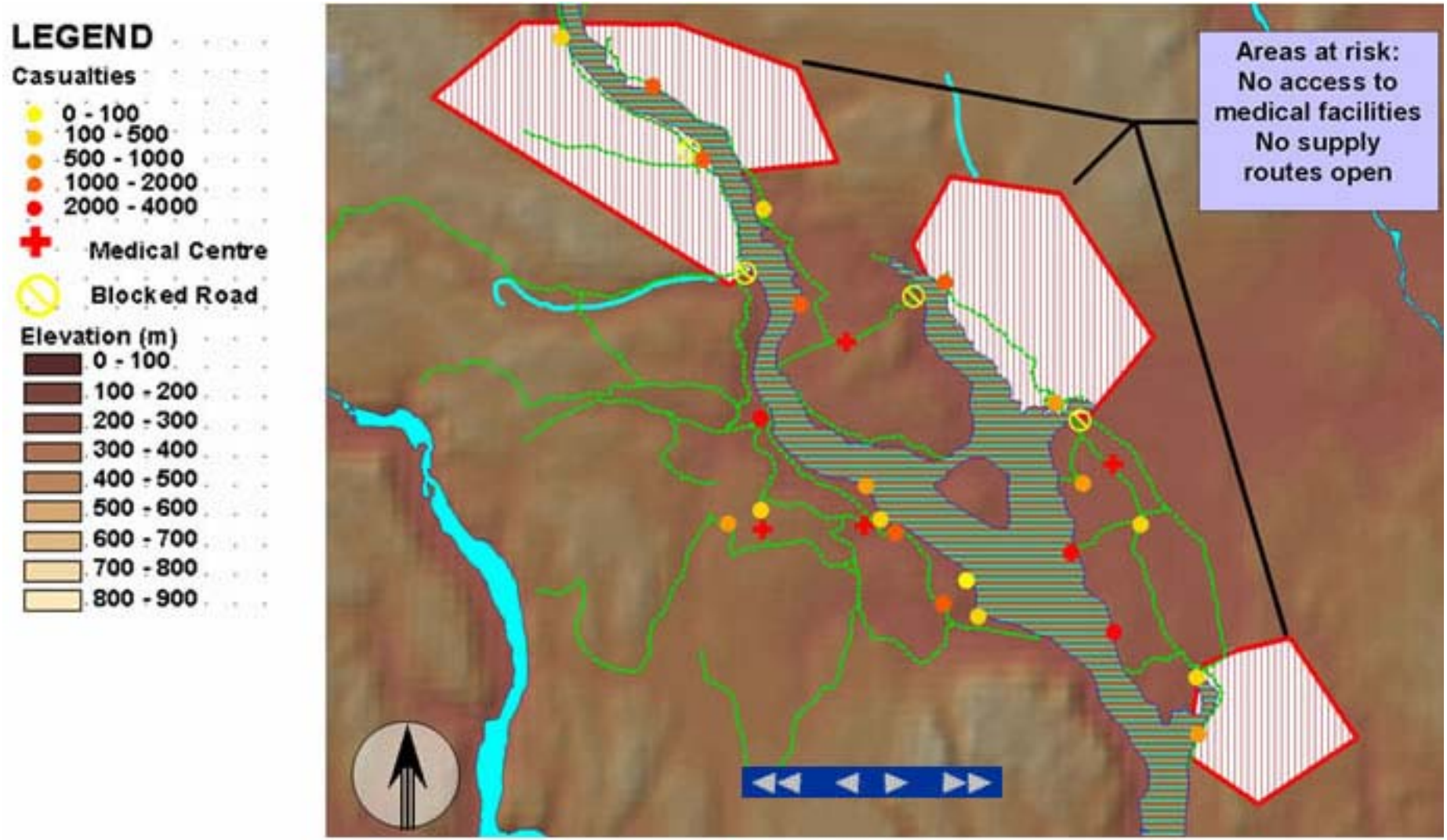


Example of on-line maps

115 Situation Overview (high_res) 20th October 2005. (

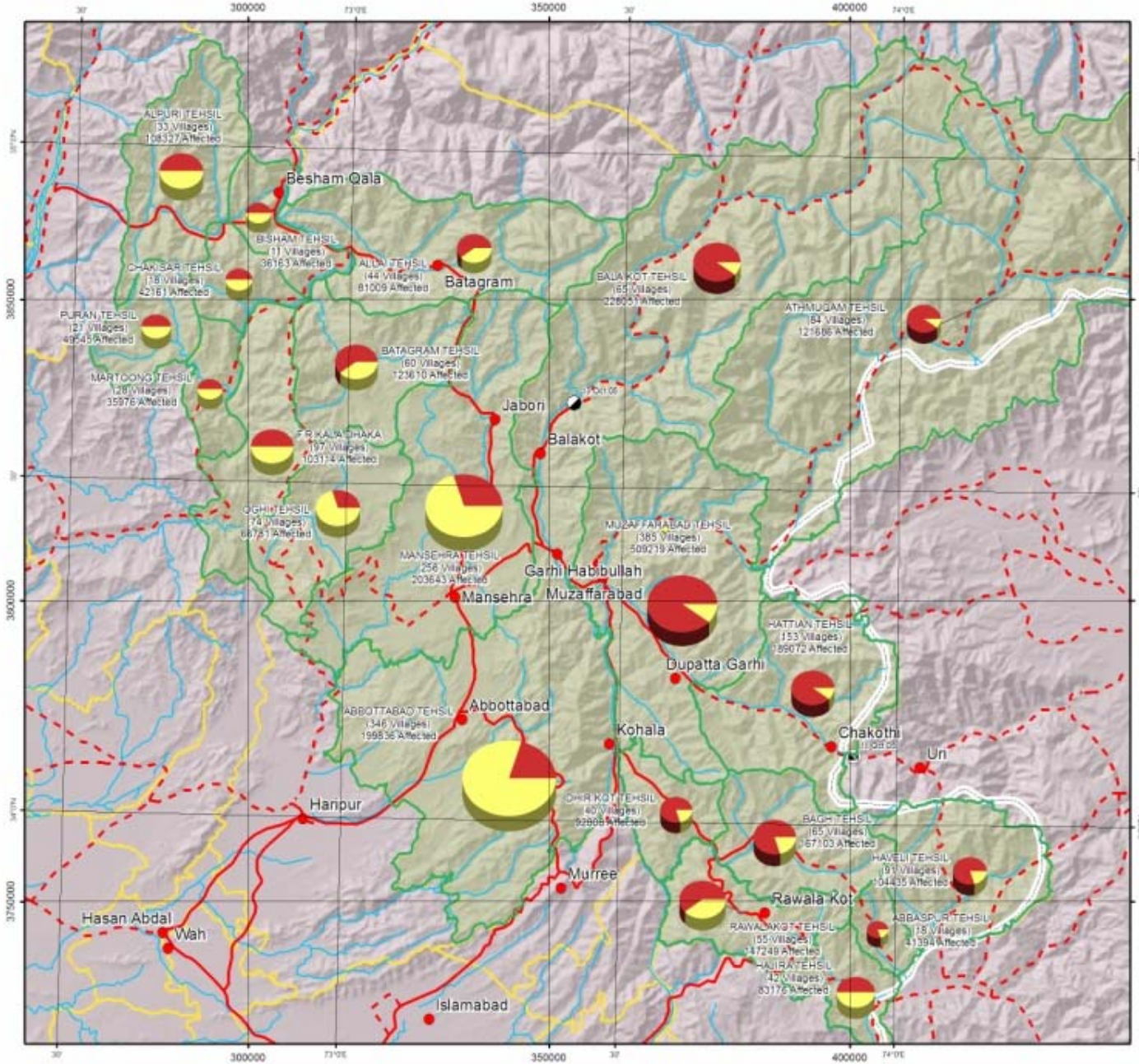
Title: Situation overview map
Reference: T115/1
Date: 20th October 2005
Size: 463KB
Scale:
Source: MapAction
Status: Daily Update
Keywords: Roads, Towns, Affected Areas, Epicentre, Overview, Muzzafarabad
Abstract:
"Daily overview map showing known road status and selected towns and localities in affected areas."
Hits: 1865

MapAction output



Pakistan Earthquake Disaster Overview Affected Population

Reference number: T023/1
Created: 15 Oct 2005, 1220hrs



Map production
Produced by MapAction in support of the UNDAC team. The boundaries and names shown on this map do not imply official endorsement or acceptance.
www.mapaction.org - mapaction.fieldbase@gmail.com

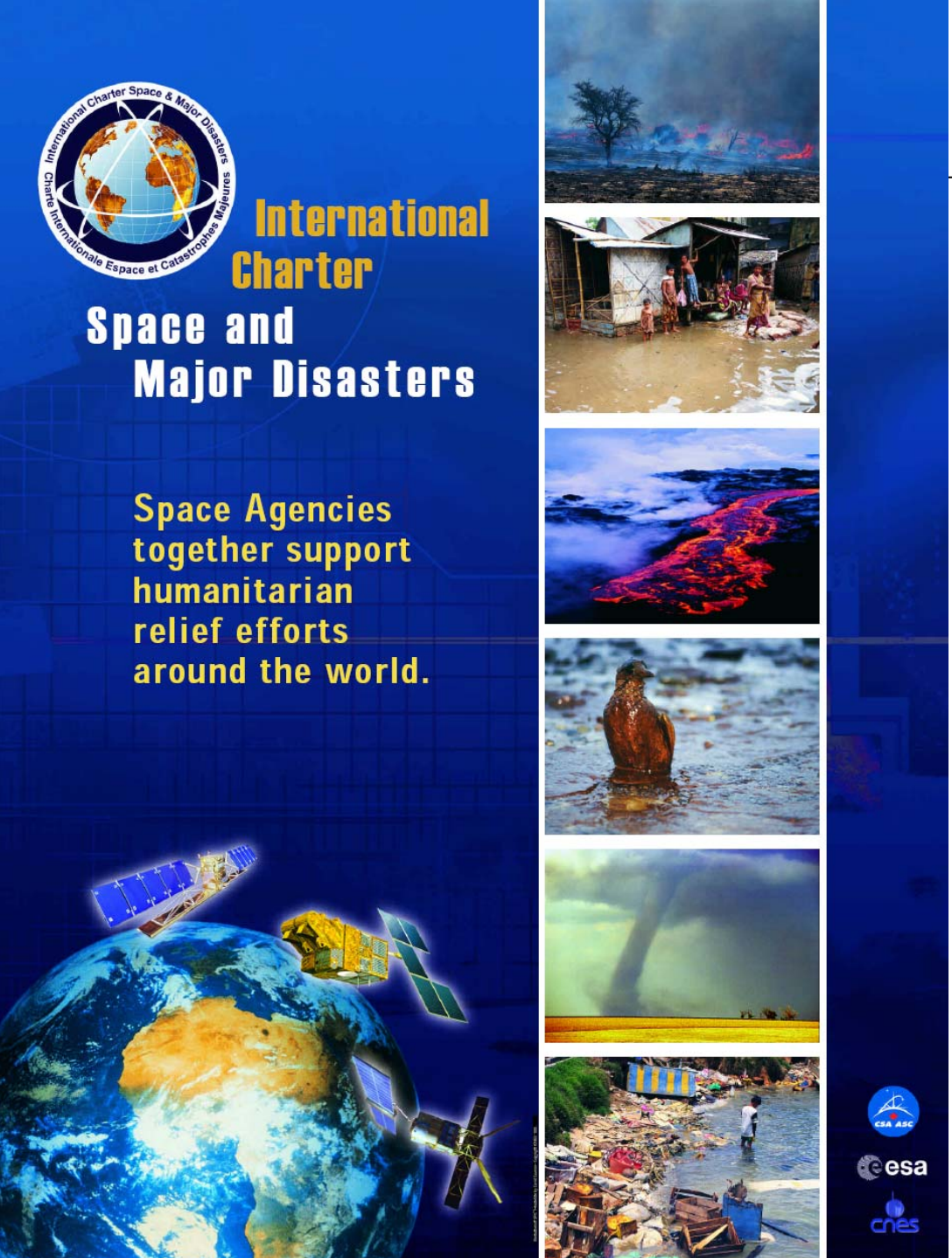
Data sources:
Roads and District boundaries: GIST
Terrain: SRTM
EQ epicentre: USGS

Co-ordinate system
UTM zone: 43 North - Datum: WGS84

0 2.5 5 10 15 20
Kilometres

MapAction

MapAction is grateful for the support of the Vodafone Group Foundation

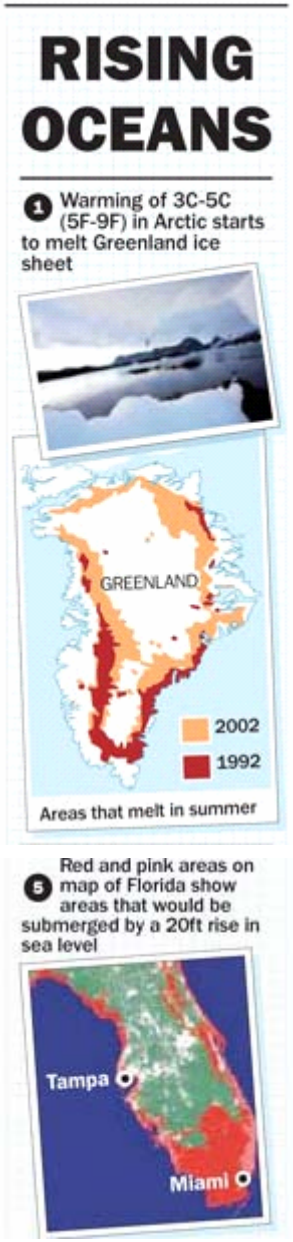


http://www.disasterscharter.org/main_e.html

An example of international collaboration in disaster support

London's importance to UK economy

- City of London is world's most successful financial centre (2005 Report)
- Huge strengths also in health, law, creative industries and academia
- London = hub of global networking (e.g. students)
- London annually exports c £20bn to rest of UK economy
- ..so what happens in London has major implications for rest of UK



London 'under water by 2100' as Antarctica crumbles into the sea

By Mark Henderson, Science Correspondent

The Times 24 March 2006

DOZENS of the world's cities, including London and New York, could be flooded by the end of the century, according to research which suggests that global warming will increase sea levels more rapidly than was previously thought.

The first study to combine computer models of rising temperatures with records of the ancient climate has indicated that sea levels could rise by up to 20ft (6m) by 2100, placing millions of people at risk.

The threat comes from melting ice sheets in Greenland and Antarctica, which scientists behind the research now believe are on track to release vast volumes of water significantly more quickly than older models have predicted

The real science behind it

Paleoclimatic Evidence for Future Ice-Sheet Instability and Rapid Sea-Level Rise

Jonathan T. Overpeck, Bette L. Otto-Bliesner, Gifford H. Miller, Daniel R. Muhs, Richard B. Alley and Jeffrey T. Kiehl

Science 24 March 2006: Vol. 311. no. 5768, pp. 1747 – 1750

(see also other articles in same issue)

London's flooded areas – if we had no flood defences

Courtesy CASA

But we also face threats from human activity

Scenes in London 7 July 2005

Courtesy: BBC

City University London

Contents:

Command and control protocol

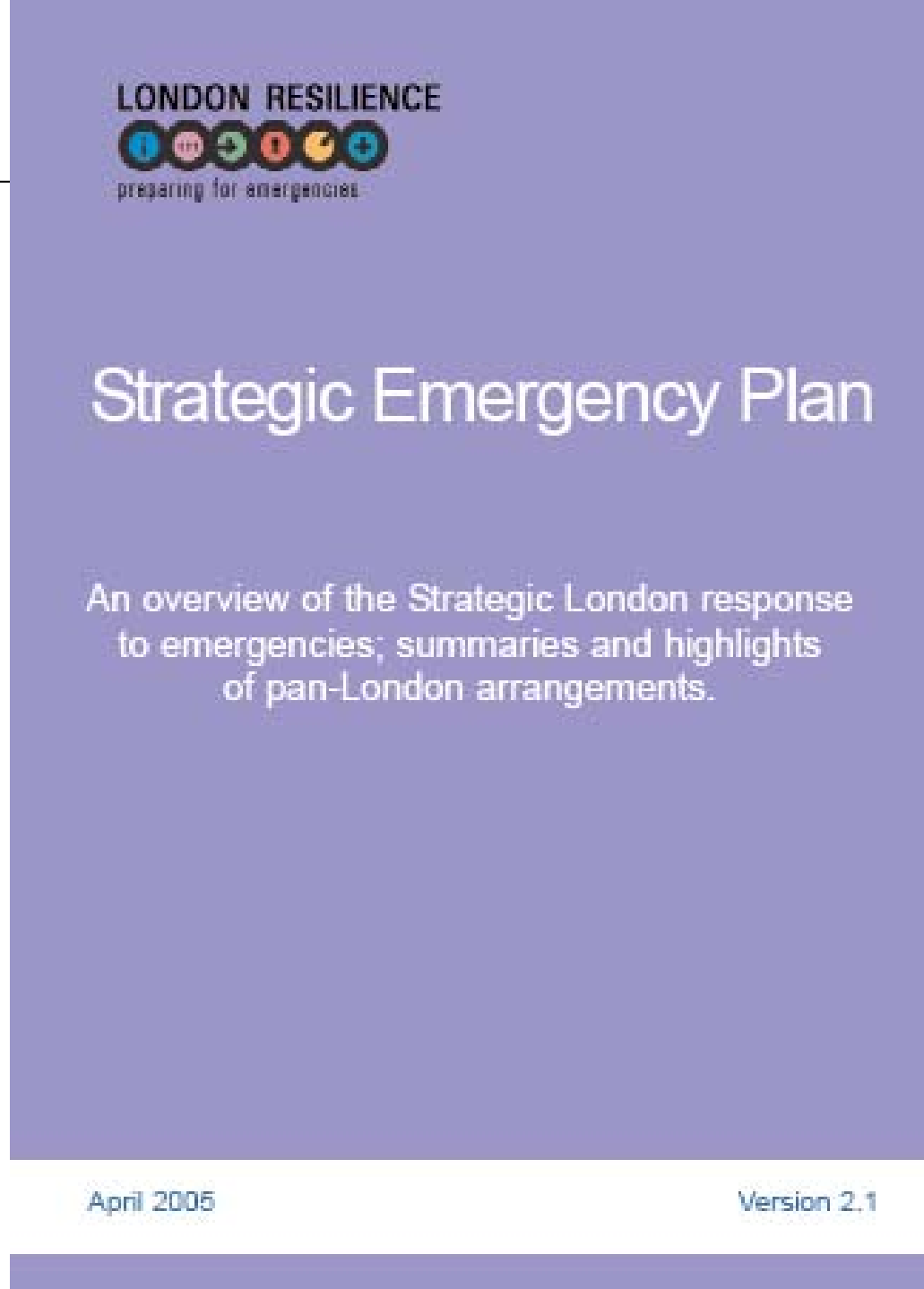
Media / public information protocol

Mass fatality plan

Large scale evacuation

Site clearance

Disaster fund



Organisational complexity - SCC

Metropolitan Police	Joint Health Advisory Cell
City of London Police	Local Authority Gold
British Transport Police	London Underground
MOD Police	Transport for London
Military Liaison Officer London Region	Network Rail
London Fire Brigade	Port of London Authority
London Ambulance Service	Transco (gas utility)
Government Liaison Team	National Grid (electricity)
London National Health Service Primary Care Trust	Thames Water (water utility) British Telecom

Conclusions based on London experience

- The nature of the management arrangements are crucial in dealing with disasters - particularly with many different organisations involved
- Repeated practice in response crucial but risk assessment, scenario planning, etc also vital
- GIS can play a valuable role: real time operations, 3D capability, people/place integration would improve matters
- but leadership, management and human factors most important

Risk, GIS and the insurance industry

Risk and risk transfer

When faced with risk there are three commonly available options:

–Avoidance

–Acceptance

–Transfer

Risk Transfer - the basic principle of insurance

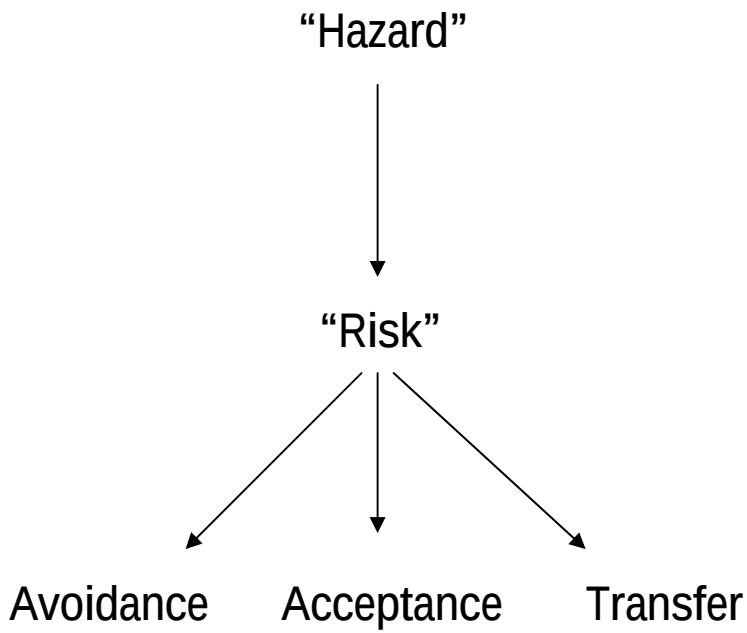
–A common pool of premiums is collected from many insureds

–Losses of the few are then paid from the common pool

–The contribution to the pool must reflect the amount of risk that each insured brings to the pool

–Risk can be transferred from individuals to an insurance company

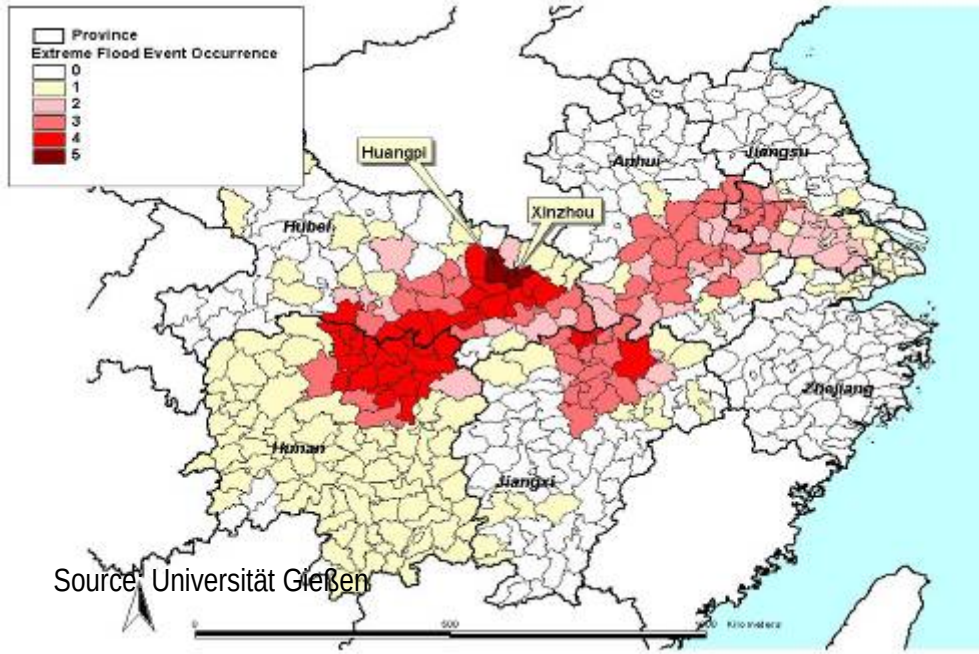
–Risk accepted by the insurance company may be transferred again to a reinsurance company



Courtesy of Willis Analytics

The spatial element of risk quantification

- Risks can include natural perils (e.g typhoon, flood, earthquake) or other catastrophic events (e.g. terrorism)
- Acceptance of risk in return for premium by an insurer or reinsurer requires an assessment of the amount of that risk
- To do this it is important to understand:
  - The hazard
  - Its impact on the insurable items
- Both hazard and insured items will vary spatially and temporally
- Geography (e.g. relative location) is the common link
- Insurers are faced with the same risk decision options as the original insured
- The decision will often be aided by use of risk assessment techniques

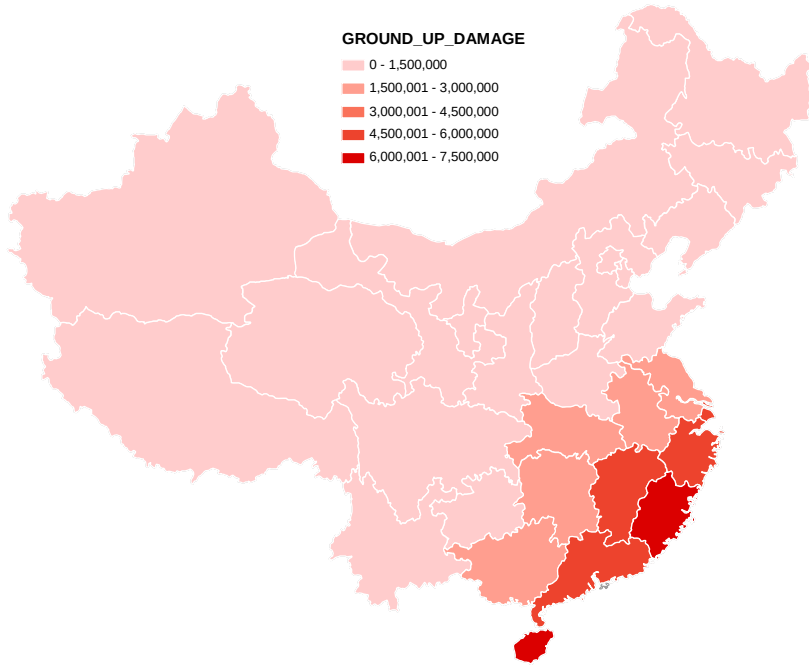


Source: Universität Gießen

Courtesy of Willis Analytics

Risk assessment tools

- Insurers and reinsurers will attempt to quantify their risk by means of risk assessment tools
- Data defining relative hazard intensity (e.g. wind speed, flood depth, seismic data) can be combined with data describing the insured items (e.g type and value at risk) to provide estimates of potential losses
- Tools commonly in use include:
  - Catastrophe models
  - Exposure accumulation techniques
  - Risk mapping
- Each utilises data containing a geospatial component
- Spatial analysis techniques and locational data are the key to risk modelling and assessment

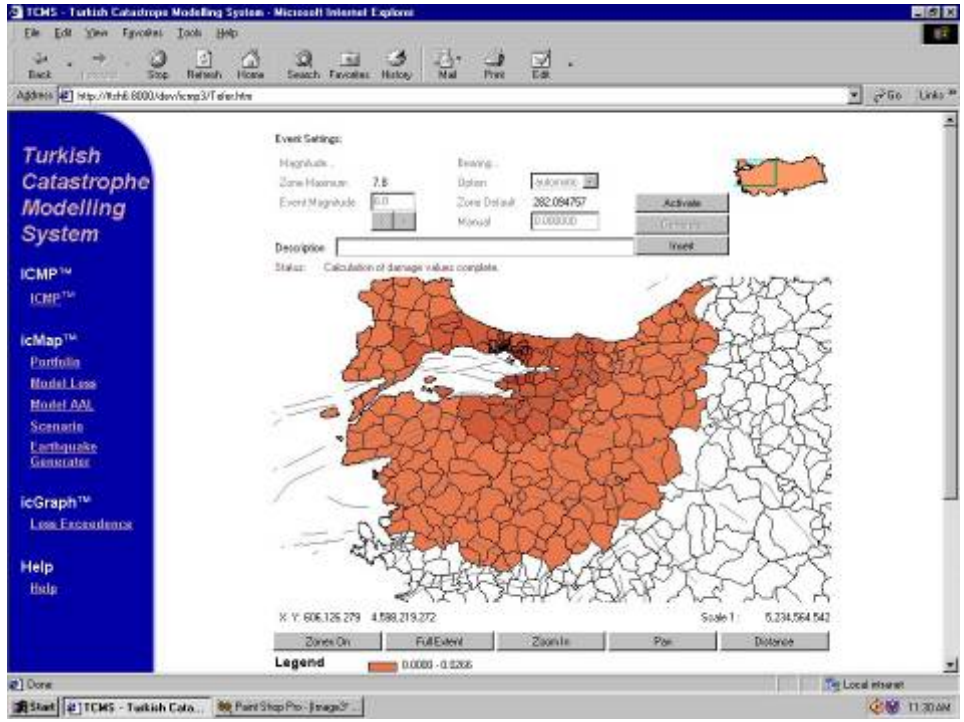


Example of output from a typhoon catastrophe model

Courtesy of Willis Analytics

Application of risk assessment by insurers

- Actions taken by insurers / reinsurers through risk management techniques include:
- Planning and disaster response when they occur (e.g. event loss estimation)
- Risk acceptance mitigation (e.g. differential premium pricing by hazard zonation)
- Portfolio management (e.g. concentration of growth in geographical areas less subject to particular hazards)
- Risk transfer decisions (e.g. reinsurance purchase) – e.g. via catastrophe models

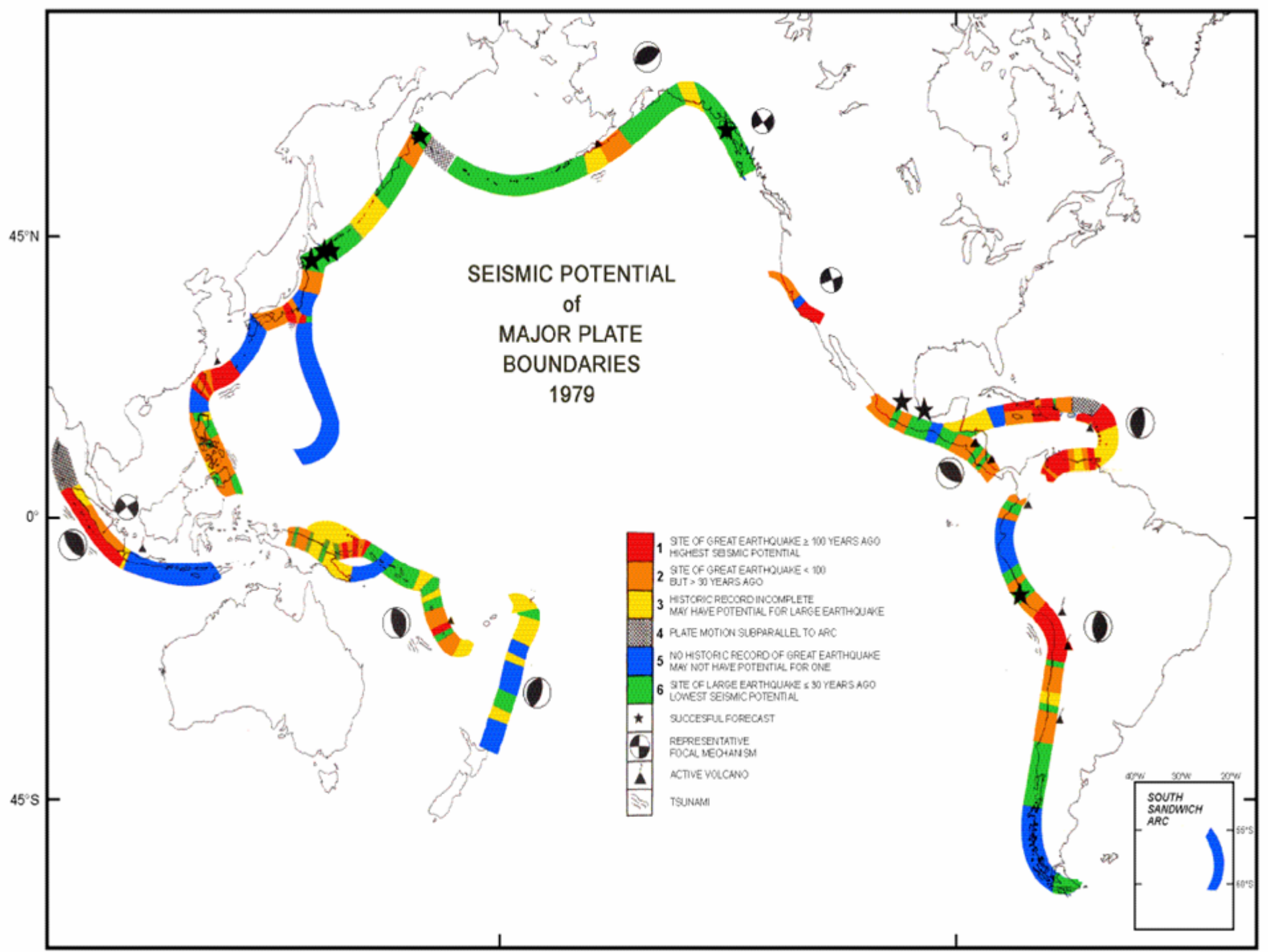


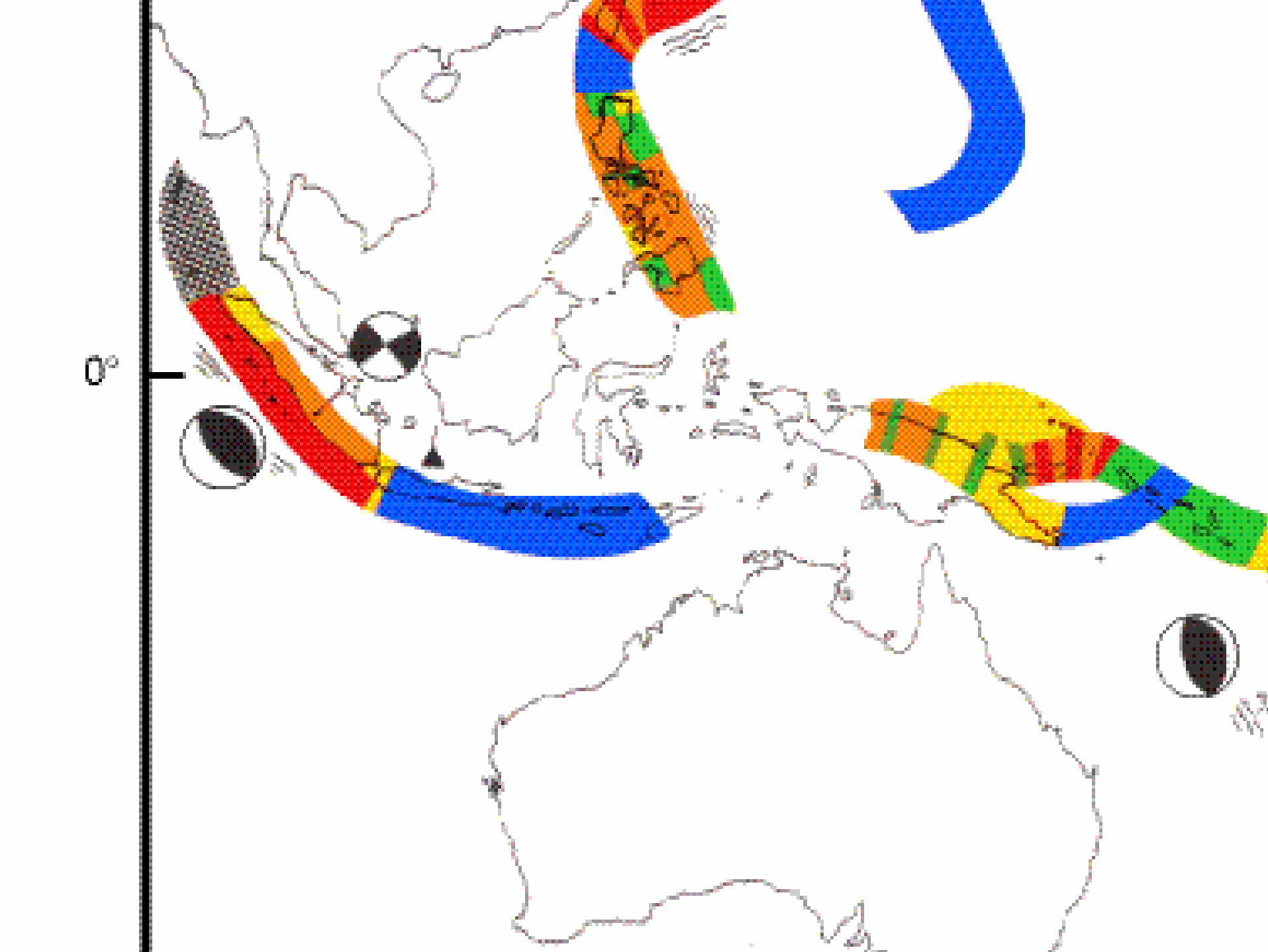
Willis Turkish Catastrophe Management System

Uses GIS technology and spatial databases to produce probabilistic estimates of loss potential to national portfolios of property

Another challenge: convincing people of priorities and potential of GIS

- Science and GIS *may* be necessary for minimising the risks of natural or man-made disasters
- But they are not sufficient of themselves
- An example …..


SEISMIC POTENTIAL
of
MAJOR PLATE
BOUNDARIES
1979
45°N
0°
45°S
1 SITE OF GREAT EARTHQUAKE ≥ 100 YEARS AGO
HIGHEST SEISMIC POTENTIAL
2 SITE OF GREAT EARTHQUAKE < 100
BUT > 30 YEARS AGO
3 HISTORIC RECORD INCOMPLETE
MAY HAVE POTENTIAL FOR LARGE EARTHQUAKE
4 PLATE MOTION SUBPARALLEL TO ARC
5 NO HISTORIC RECORD OF GREAT EARTHQUAKE
MAY NOT HAVE POTENTIAL FOR ONE
6 SITE OF LARGE EARTHQUAKE ≤ 30 YEARS AGO
LOWEST SEISMIC POTENTIAL
SUCCESFUL FORECAST
REPRESENTATIVE
FOCAL MECHANISM
ACTIVE VOLCANO
TSUNAMI
SOUTH
SANDWICH
ARC

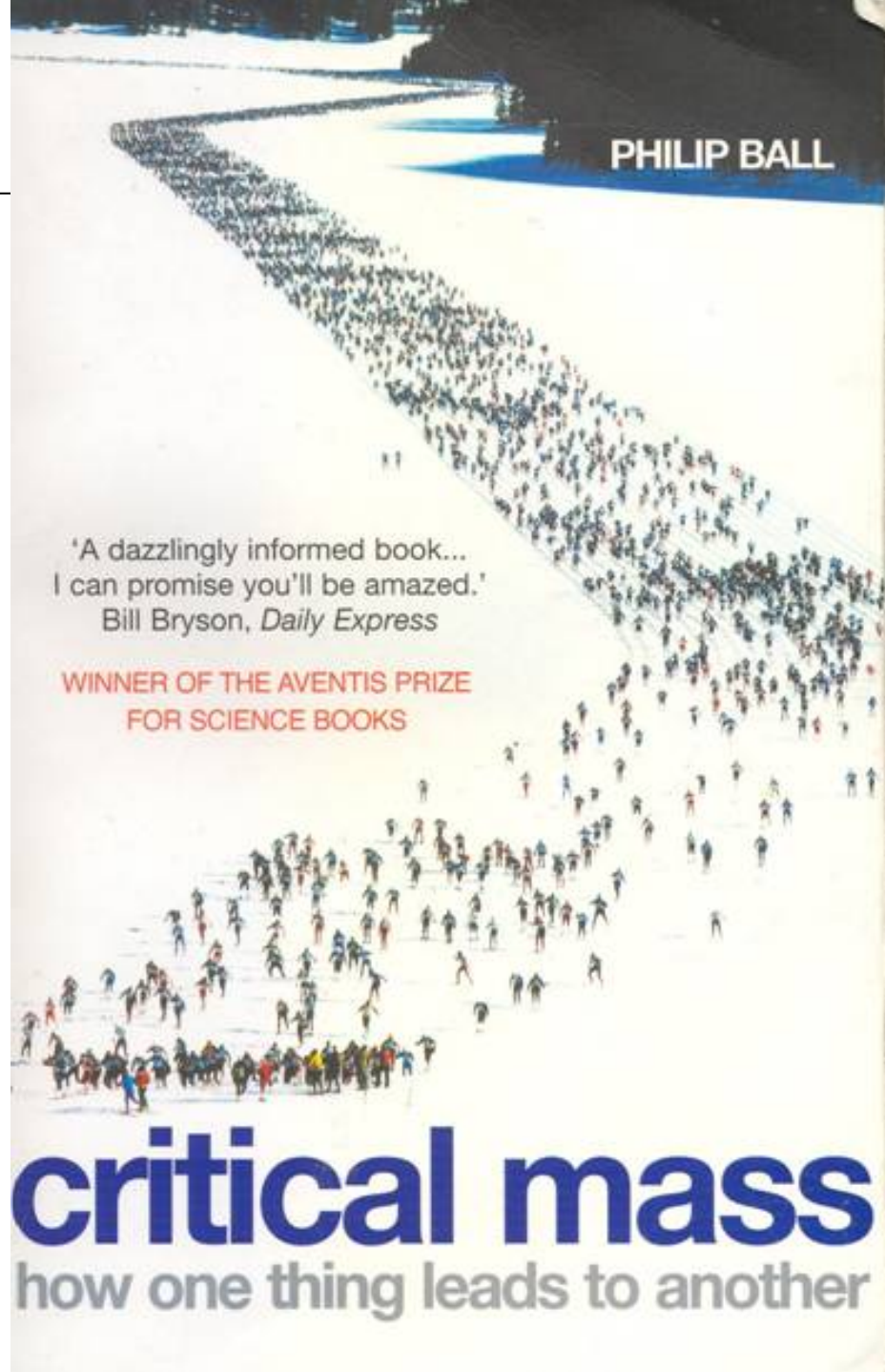

0°


Digital Earth is *really* important, Chancellor

City University London

What kind of science?

Can we integrate the understanding of physical phenomena and human behaviour?



Conclusions

- Big issues are not technology ones – they are scientific, organisational and institutional factors and the ability to convince top people of need for action
- So we need GIS/DE people getting jobs in senior management to embed GIS/GI contributions
- But GIS and GI can play a very valuable role in modelling and illustrating threats
- GIS often the only way of linking data from multiple sources together
- We need GIS/DE systems which can cope with real time monitoring as well as static ‘facts’

Acknowledgements

Thanks are due to the following organisations for use of their images in this lecture:

- AFP, BBC, CASA, DigitalGlobe, the Environment Agency, the Guardian newspaper, Getty Images, Magnum Photos, ONASIA, the journal of Pure and Applied Geophysics (from the paper by McCann et al), The Times, the US Geological Survey, various other newspapers for their 9/11 images, Willis and Wikipedia