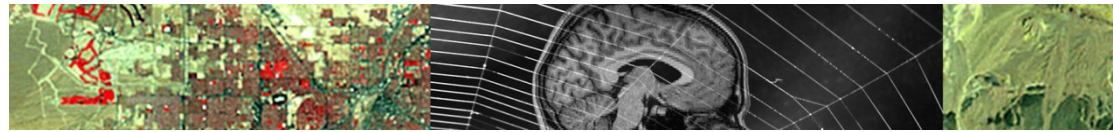


# Exploring Digital Earth

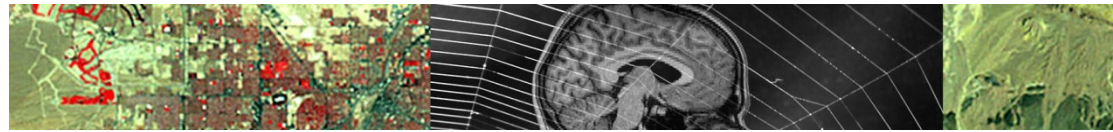
Michael F. Goodchild  
University of California  
Santa Barbara



## Some explaining to do



- “What a curious career”
  - Nevill Mott, Cavendish Professor of Physics, University of Cambridge, 1965



# PART I

- HOW I CAME TO BE A GEOGRAPHER



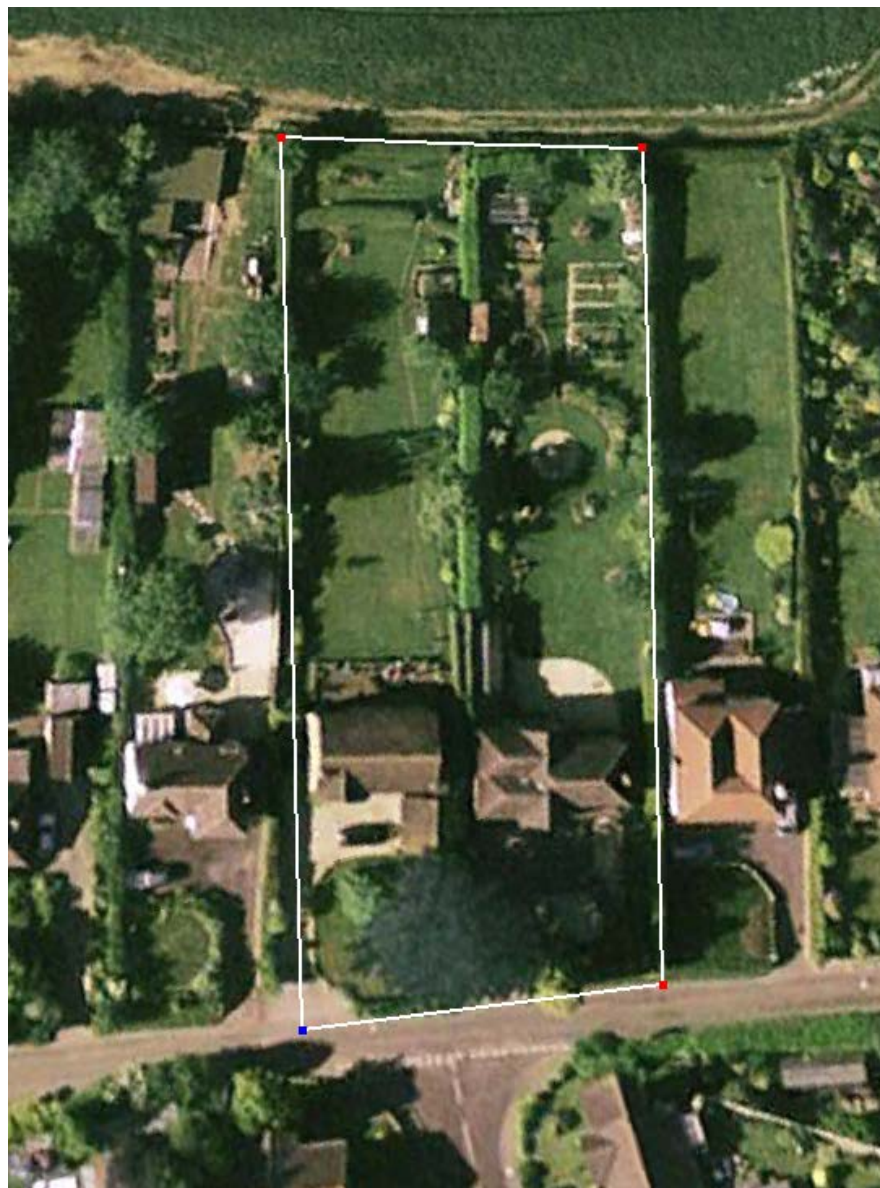


Z.3 SOUTH PETHERTON

COPYRIGHT  
A. S. WOULD



Compton Way, Compton Road,  
South Petherton, Somerset, UK





Compton Road



Exit Street View

Compton Road

© 2009 Google

© 2012 Google

Google earth

[Report a problem](#)

lat: 50.950311° lon: -2.816471° elev: 183 ft

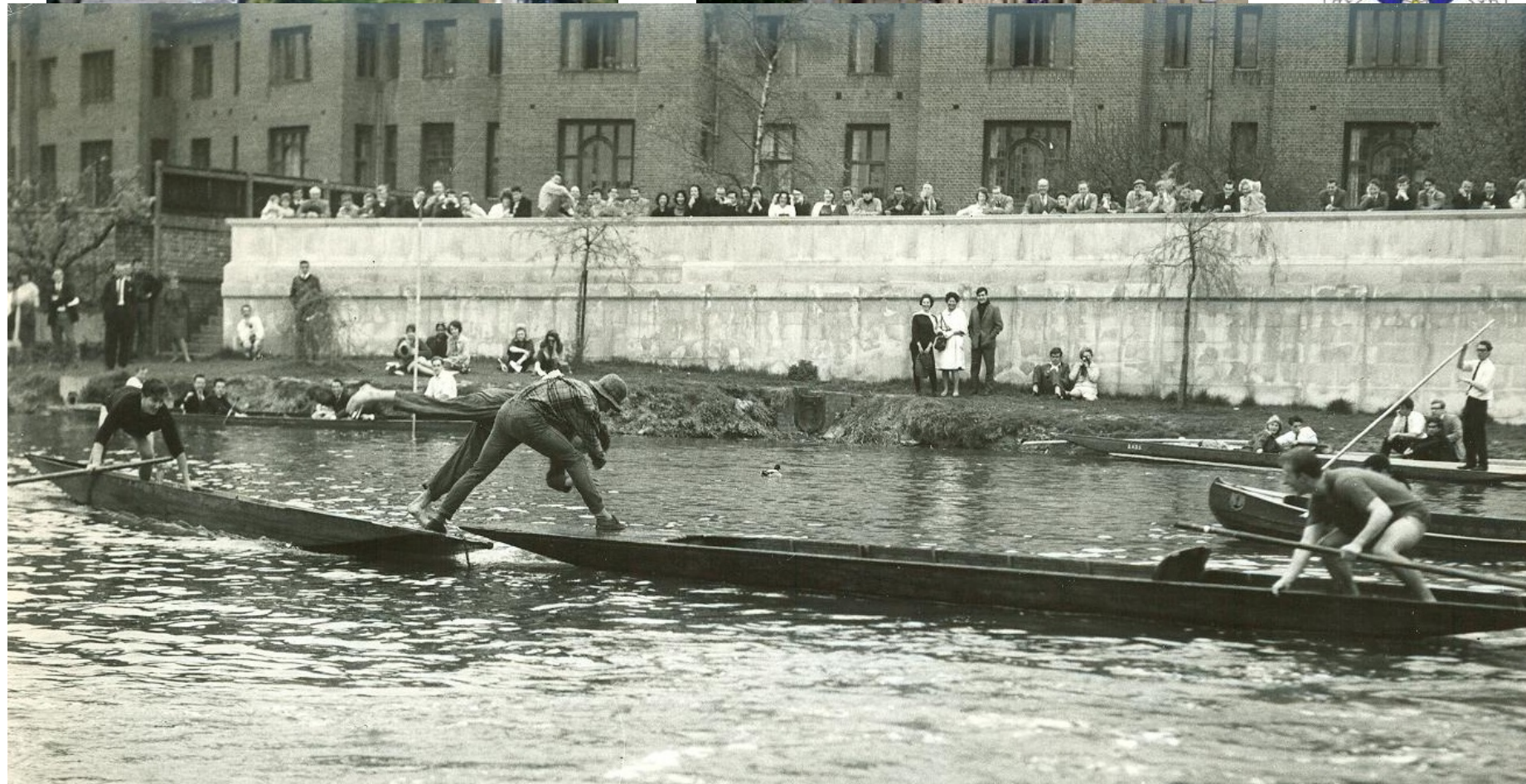
Eye alt: 189 ft





Taunton School, Taunton, Somerset, UK









McMASTER UNIVERSITY  
HAMILTON, ONTARIO, CANADA

DEPARTMENT OF GEOGRAPHY  
HAMILTON COLLEGE

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If you remain interested, please apply. You are in no respect committed. Your application will be in competition with others, of course. Send the application forms to me. I would like a, a list of your courses at G.C.E. A & Scholarship level. b, a list of the courses you have read & will read at Cambridge - with some sort of marks.

c, two references from Cambridge doors.

d, a brief note from the President or what sort of the Cambridge Caring Club, summarising your abilities and experience.

e, the completed McMaster application form.

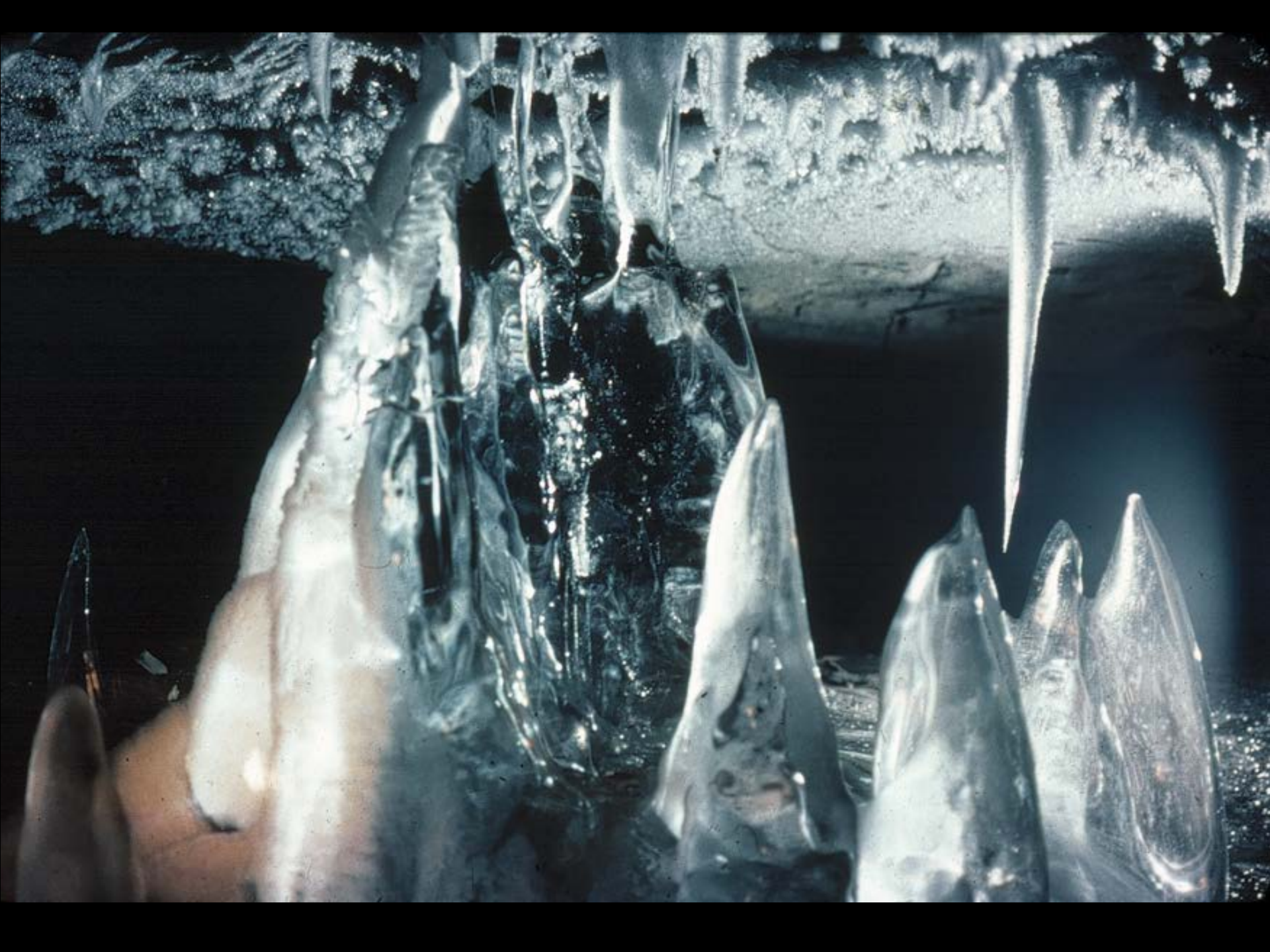
I hope that we shall hear from you.

Yours sincerely,

Derek Ford.

P.S. Geor I forgot. We are buying c. 300 feet of ladder, 600 of sundry notes. Your lighting is paid for. This summer I will be buying my assistant's wet suits - so we defray a lot of normal caring expenses. DF











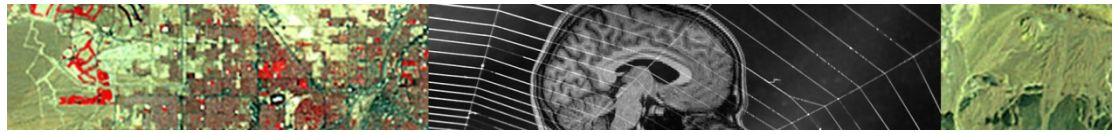










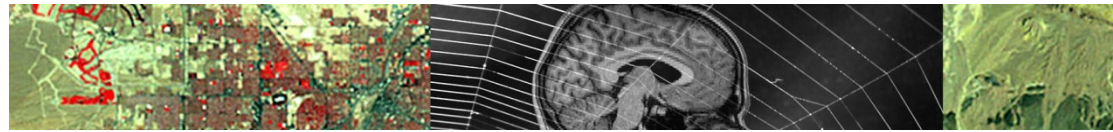


## PART II

- HOW I LEARNED TO LOVE GEOGRAPHY



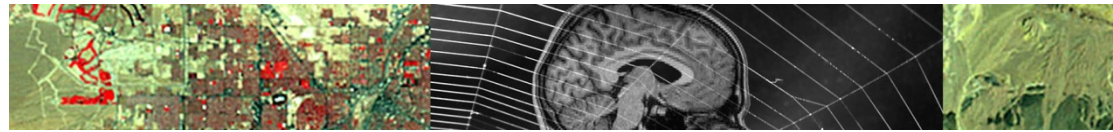
McMaster University, Hamilton, Ontario, Canada



## A physicist's reaction

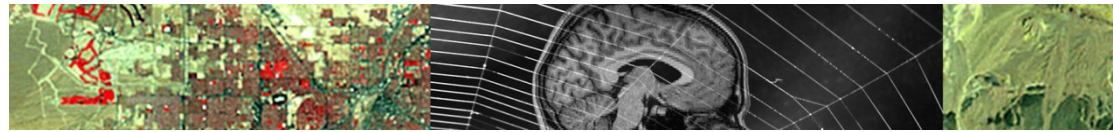
- Gerry Rushton's Urban Geography
  - but the assumptions of Central Place Theory aren't true!
  - but unless we accept them we can't progress!
- The objective is not an  $R^2$  of 1 but to get as far as possible from an  $R^2$  of 0
  - science is like an island of objective purity in a sea of vague subjectivity





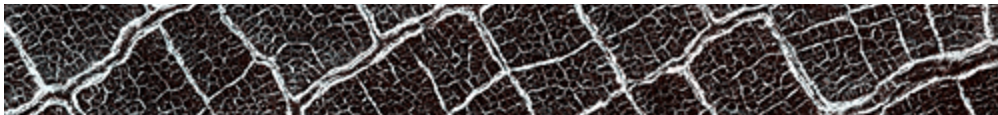
# The morphological approach

- Is this a moraine or a landslide?
  - “oh what a lovely fine-grained brown silt”
- Science searches for general truths rather than unique description
  - the Hartshorne/Schaefer debates
  - nomothetic vs idiographic
  - Vareninus’s general and special geography
  - place-based analysis
    - general principles but varying parameters



# Geomorphology as a science

- More in the style of physics
- Scheidegger's *Theoretical Geography*
- Simple, striking geometric patterns



<http://www.>

[http://www.flickr.com/photos/banco\\_imagenes\\_geologicas/5020977911/](http://www.flickr.com/photos/banco_imagenes_geologicas/5020977911/)



$$R = \rho v L / \mu$$

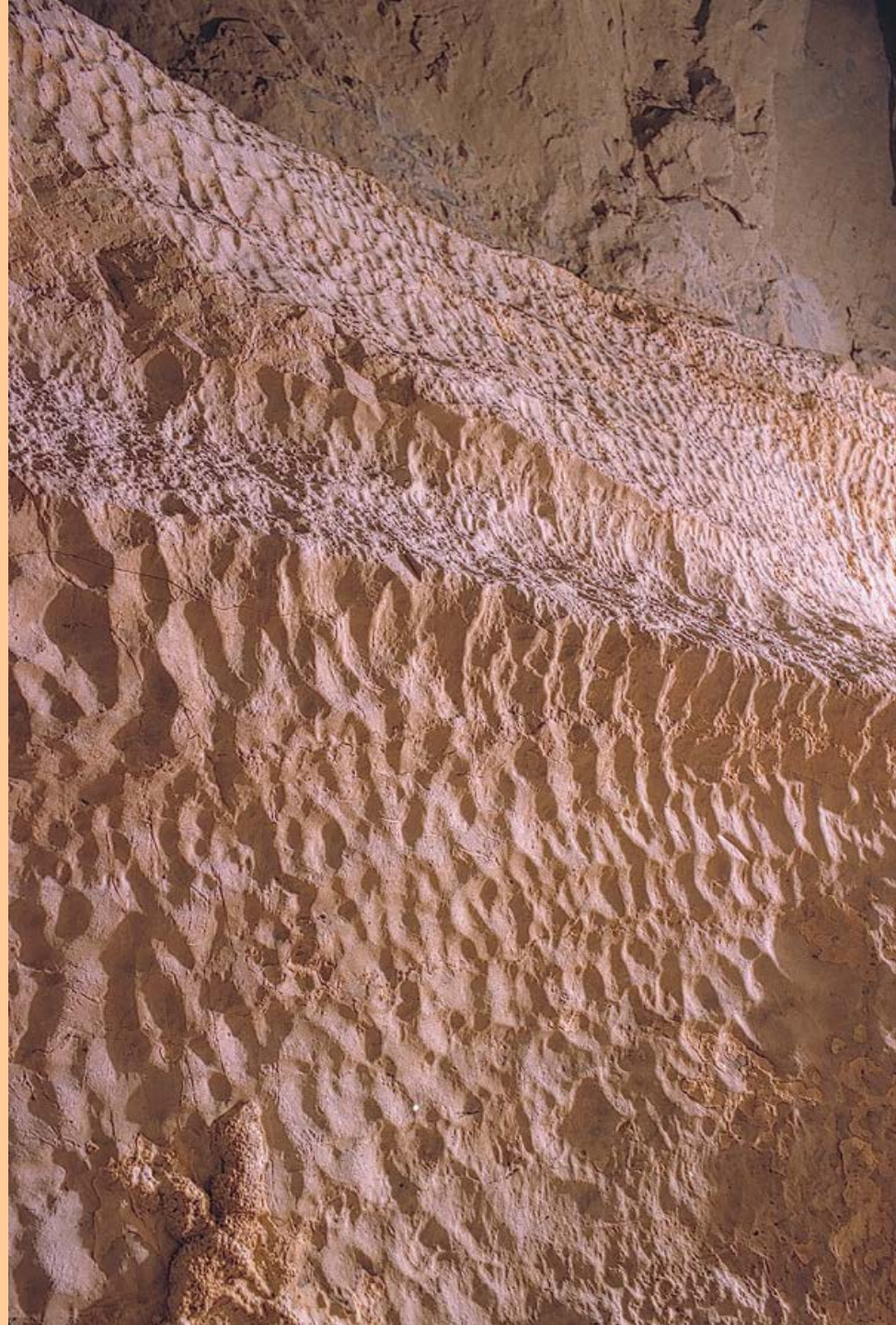
$R$  is a constant

$\rho$  is the fluid density

$v$  is the fluid's velocity

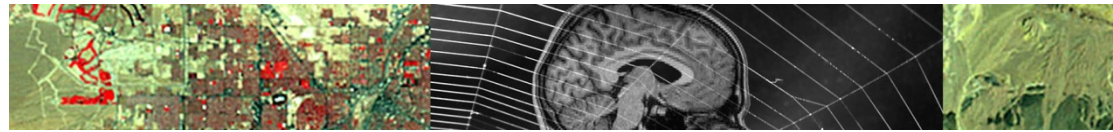
$L$  is a characteristic length

$\mu$  is the fluid's viscosity





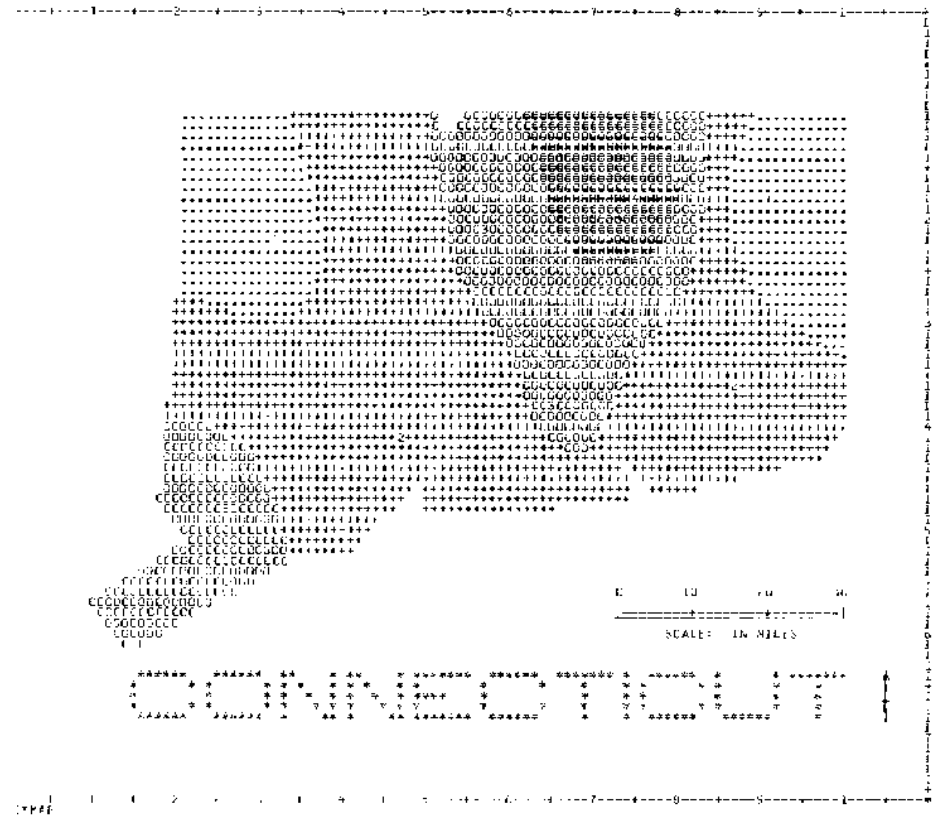
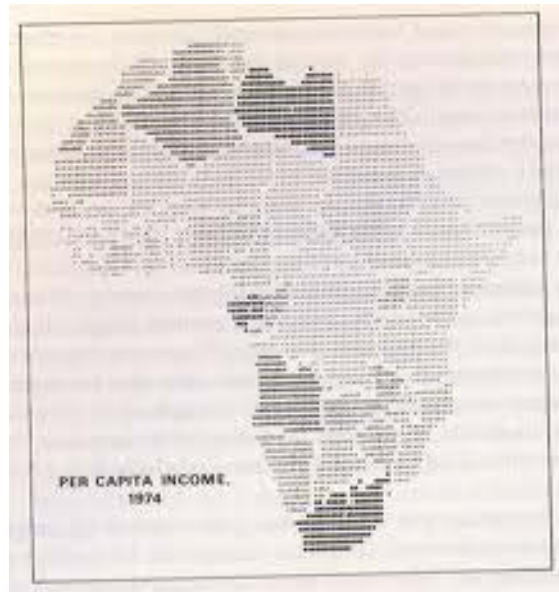




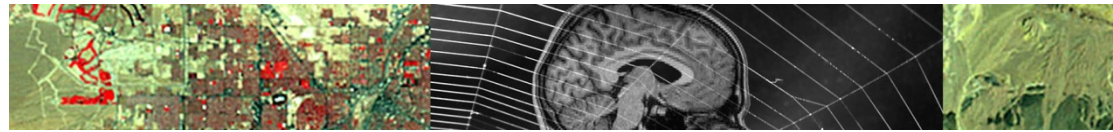
# Stochastic processes

- Horton's Law of Stream Numbers
  - Shreve's explanation of random topology
- Central places as random point patterns
- Random partitionings of space
  - the map as a stochastic process
- Mandelbrot's fractals
  - *How Long Is the Coast of Britain?*
- Both human and physical processes

# May 1967: 2-week workshop on SYMAP at Harvard







## PART III

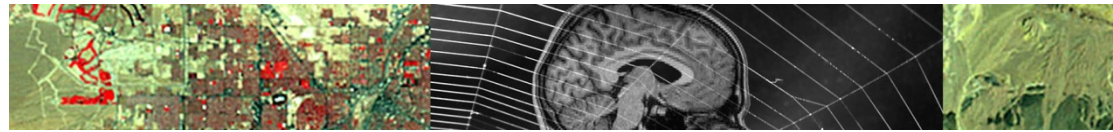
- TESTING THE GIS WATERS



The University of Western Ontario, London, Ontario,  
Canada

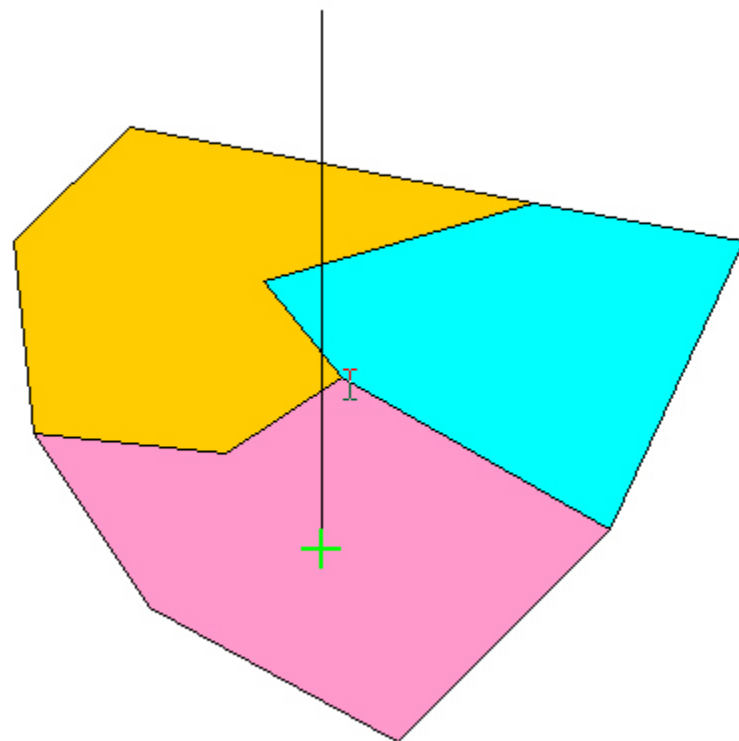
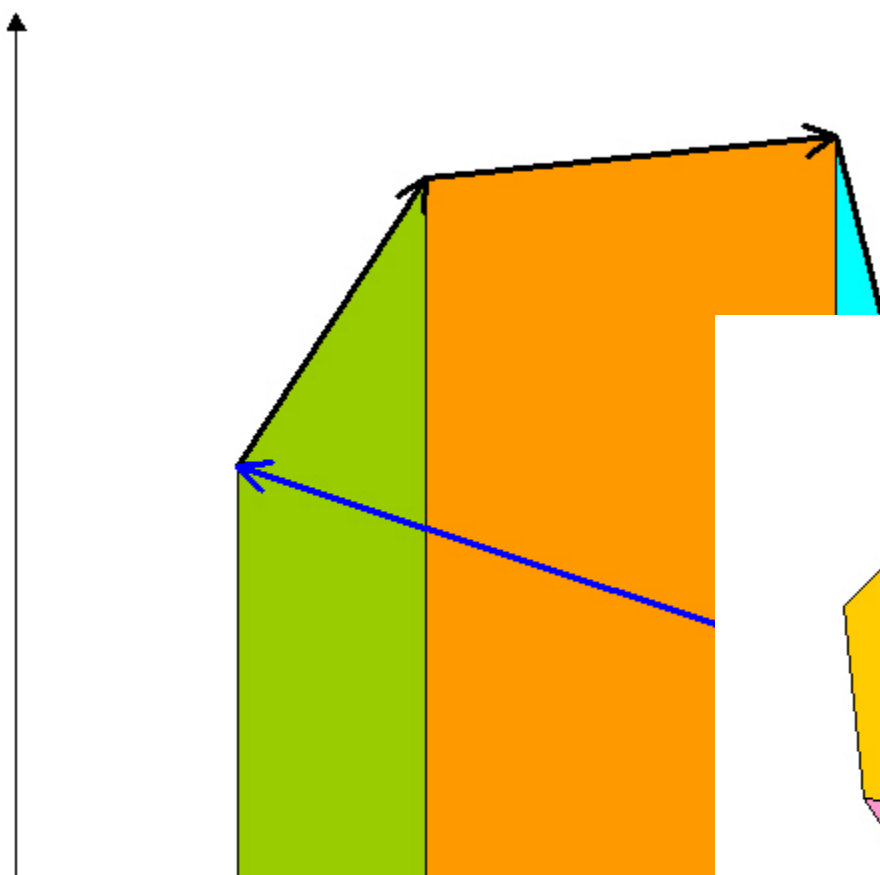






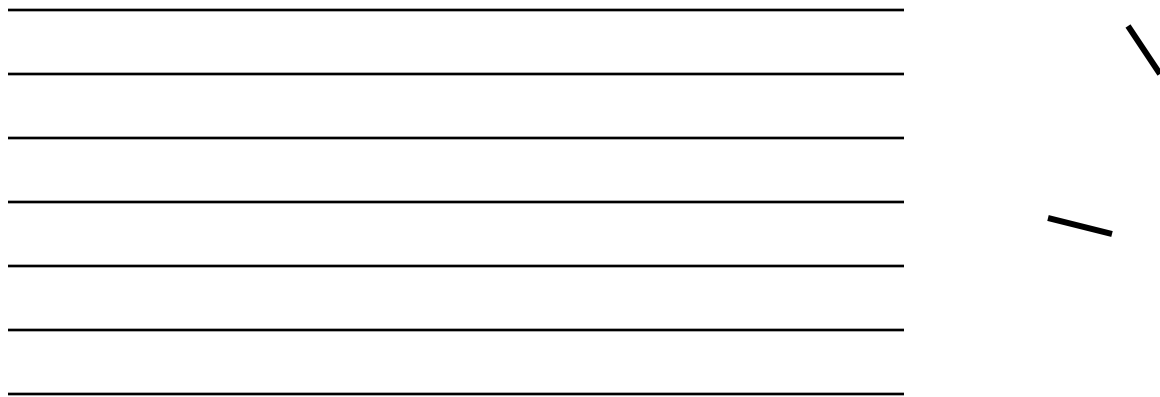
# Why the attraction of GIS?

- Why put maps in a computer?
- Dr Chip Ross went to Environment Canada
- Practical applications
  - interest in Ottawa, consulting in Toronto
    - locating restaurants for Wendy's
    - redesigning school catchment areas in London
- Elegant algorithms
- Statistical geometry



# Buffon's needle

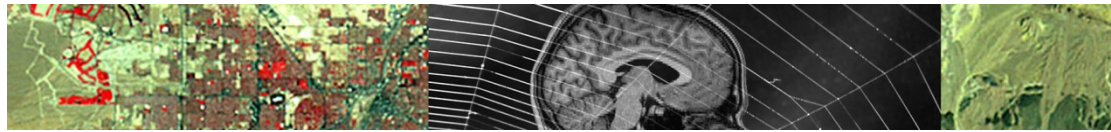
- Consider a needle of unit length
  - dropped randomly onto a set of parallel lines unit distance apart
  - probability that the needle will intersect a line?





# Analytical results

- $p(\text{intersection}) = 2/\pi = 0.6366$
- Experimental determination of  $\pi$ 
  - 5<sup>th</sup> decimal place
  - $\sqrt{npq}/np = 10^{-5}$
  - $n \sim 10^{10}$
- lines  $s$  units apart, needle length  $l$ 
  - $p = 2l / \pi s$
- relevance to GIS?

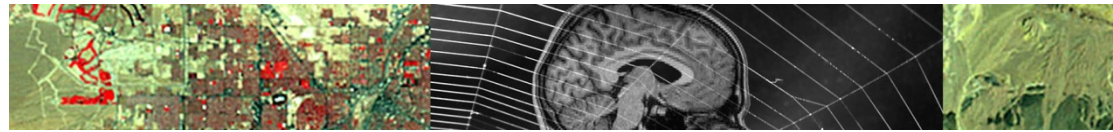


## PART V

- WELCOME TO PARADISE



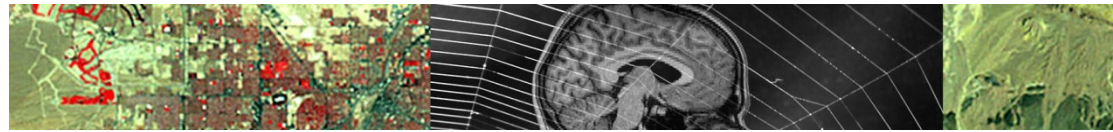




# The National Center for Geographic Information and Analysis

- UCSB, The University at Buffalo, the University of Maine
- NSF base funding \$10 million 1988 to 1996
- Develop GIS as an engine for scientific research
- Promote its use across the sciences
- Increase the supply of people trained in its use





## Gore: *Earth in the Balance* (1992)




- “I believe we need a Digital Earth, into which we can embed vast quantities of geographically referenced information”
- A search engine for Earth-related data



## Search

## Where?

Help

☒ Anywhere Or Or locate your area here   ☐ Data must fall completely inside area

## What?

Help

Keywords:

Match:

- ☒ Exact phrase  
☐ Any word  
☐ All words

Data Category:

Scale/Coverage:

Type/Format:

## When?

Help

☒ Anytime☐ Data for time period  
(yyyymmdd)From: To: ☐ Data updated recently  
(yyyymmdd)After: 

Sort results by:

IDECE - Mozilla Firefox

Archivo Editar Ver Ir Marcadores Herramientas Ayuda

http://www.geoportal...

Comenzar con Firefox Últimas noticias ScienceDirect

Google

IDECE  
Infraestructura de Dades Es...

Presentació | Documentació | Notícies

catàleg de dades  
servidor de mapes  
geoserveis  
market place  
pàgines grogues

Mapa de Catalunya

1. QUÈ

Cerca Ràpida

Temes  
Elevació (altimetria, batimetria, ...)

Paraules Clau  
(Totes les paraules)

Nom de l'organització  
Departament de Medi Ambient

Tipus  
(Tot Tipus)

2. ON

		Nord
Oest	1.512	41.901
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Transfiriendo datos desde scorpio.icc.es

Inicio

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Infraestructura de Dades Es

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- catàleg de dades
- servidor de mapes
- geoserveis
- market place
- pàgines grogues



## 1. QUÈ

## Cerca Ràpida

## Temes

Elevació (altimetria, batimetria,

### Paraules Clau

(Totes les paraules) ▼

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2. ON

Nord

## Oest

1.512

41.901



41.100

Sud

Neteja

Ordenar per títol

Transfiriendo datos desde scorpio.icc.es



## Interactive Map



## Search for Data

## GeoPortalNI.com at a glance

## Publish

## Information Toolkit

GeoPortalNI.com is an exciting new initiative designed to provide access to geospatial data and information in Northern Ireland. For help use the [Quick Start Guide](#).

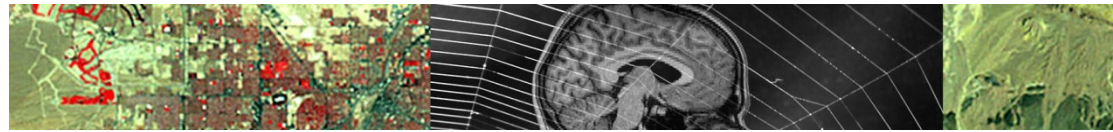
- **Topographic Mapping and Imagery**
- **Administrative and Political Boundaries**
- **Elevation and Derived Products**
- **Positioning Infrastructure**
- **Transportation Networks**
- **Utility Networks**
- **Demographic and Societal**
- **Health and Social Services**
- **Business and Economic**
- **Agriculture**
- **Environment and Conservation**
- **Flora and Fauna**
- **Geological and Geophysical**
- **Planning and Land Use**
- **Inland Water Resources**
- **Built Environment**
- **Oceans and Estuaries**
- **Climate and Atmospheric Science**
- **Military and Intelligence**

In support of 

[Home](#) | [Search](#) | [About This Site](#) | [Information Toolkit](#) | [Map Viewer](#)

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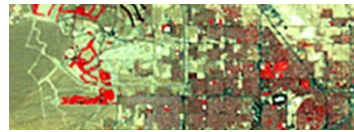
Please use the [Contact Form](#) for any questions or comments.



## Gore: Digital Earth speech, 1998

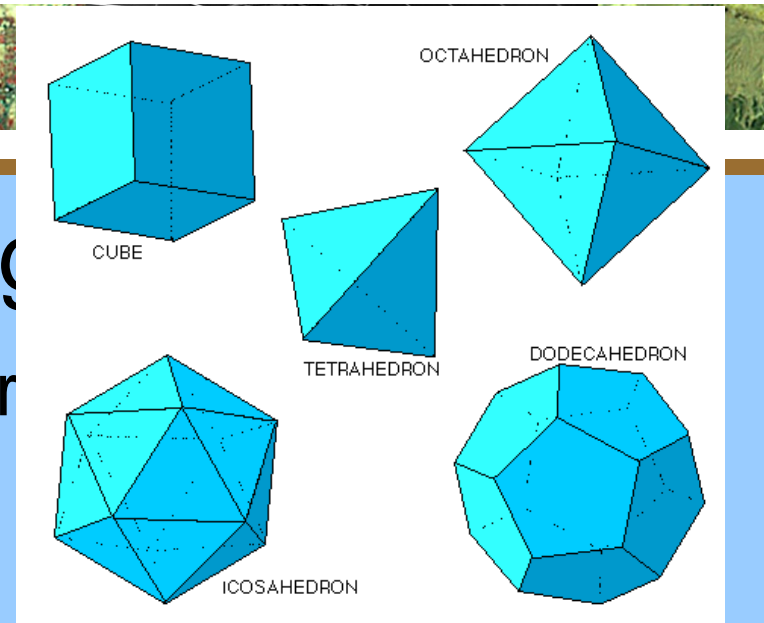
- “Imagine, for example, a young child going to a Digital Earth exhibit at a local museum. After donning a head-mounted display, she sees Earth as it appears from space. Using a data glove, she zooms in, using higher and higher levels of resolution, to see continents, then regions, countries, cities, and finally individual houses, trees, and other natural and man-made objects. Having found an area of the planet she is interested in exploring, she takes the equivalent of a ‘magic carpet ride’ through a 3-D visualization of the terrain.”

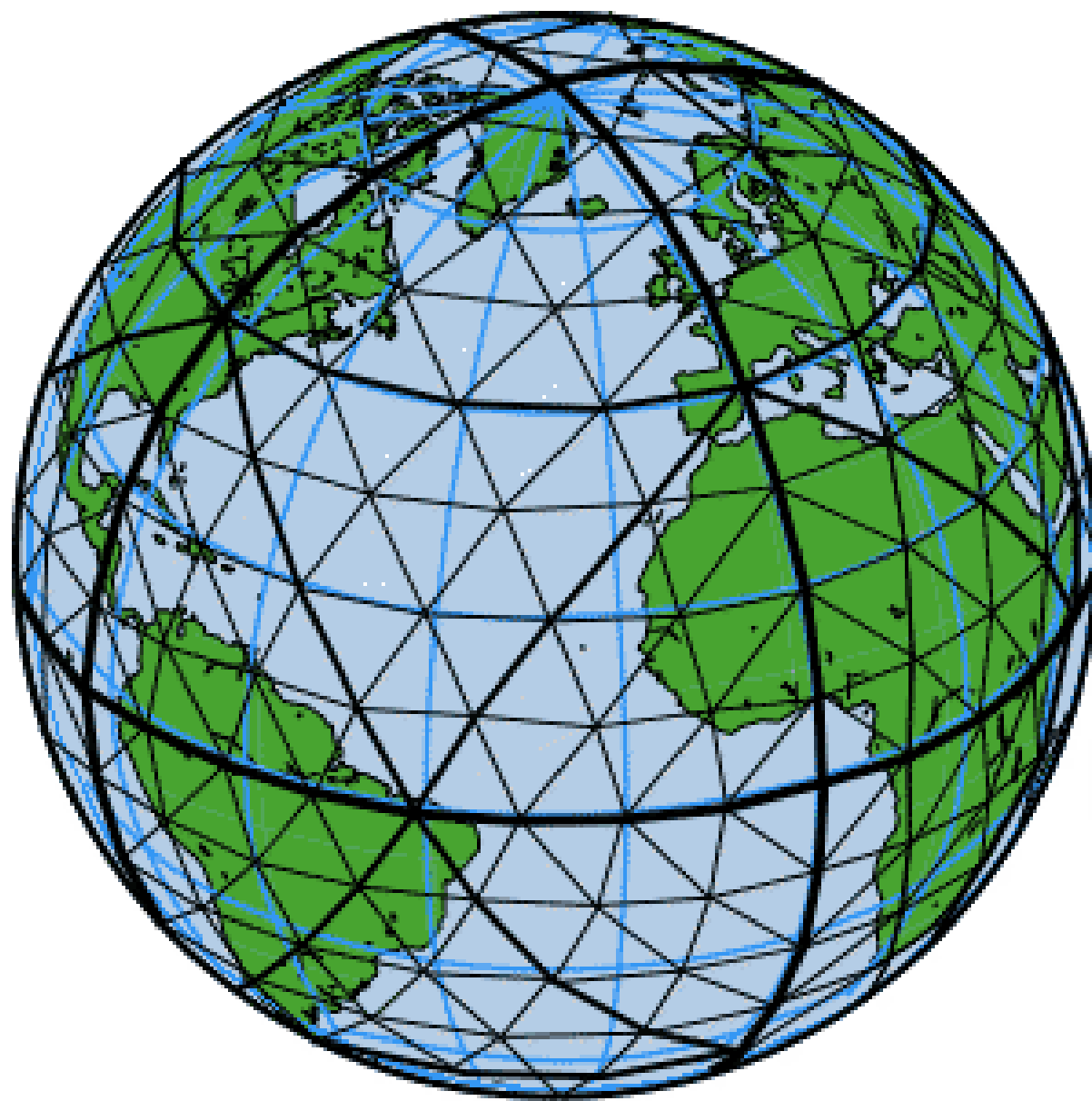


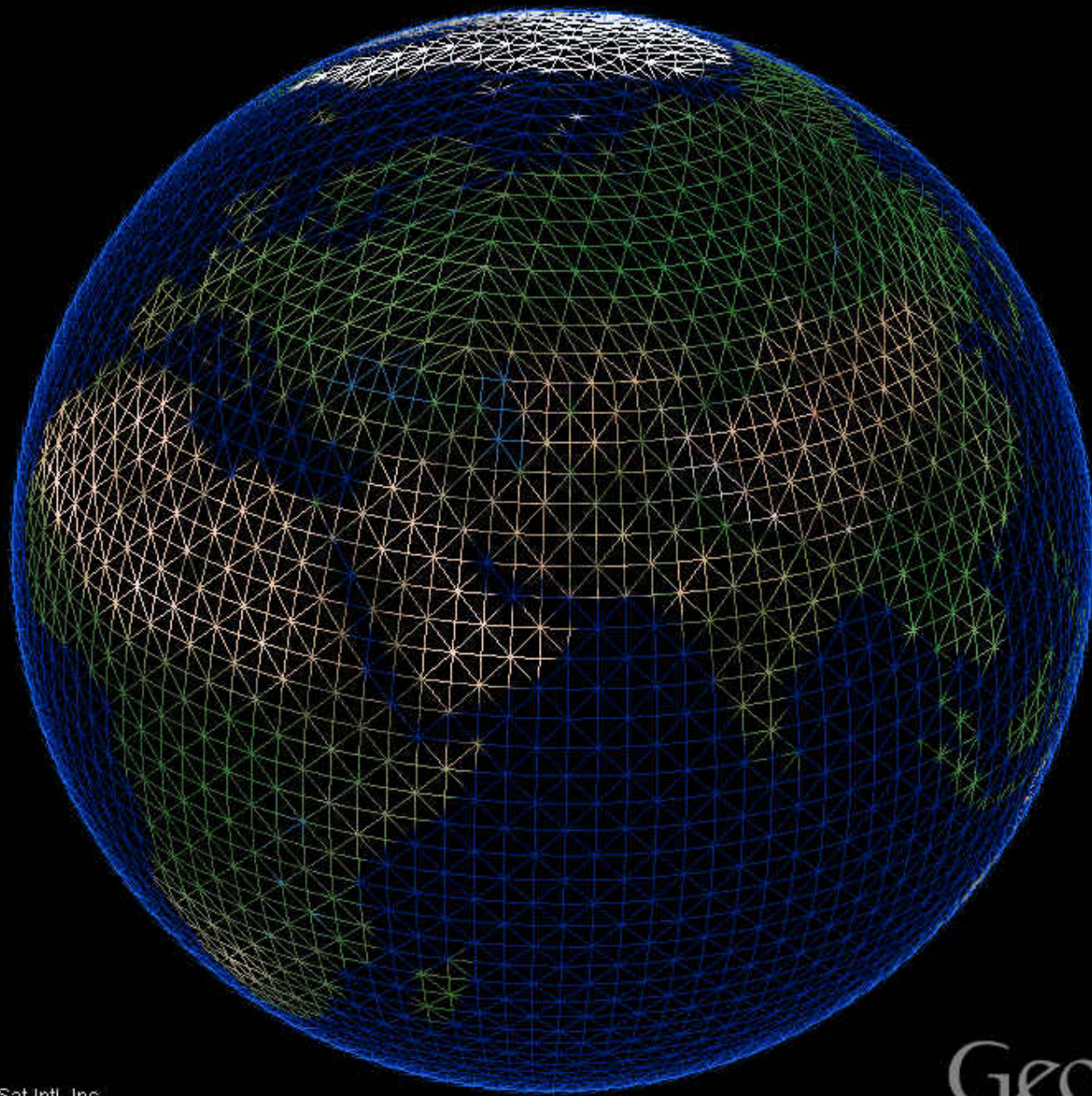


## Grids on the g

- Impossible to tile a cur squares
- Five Platonic solids
  - tetrahedron: 4 triangles
  - cube: 6 squares
  - octahedron: 8 triangles
  - dodecahedron: 12 pentagons
  - icosahedron: 20 triangles







Imagery courtesy of WorldSat Intl. Inc.

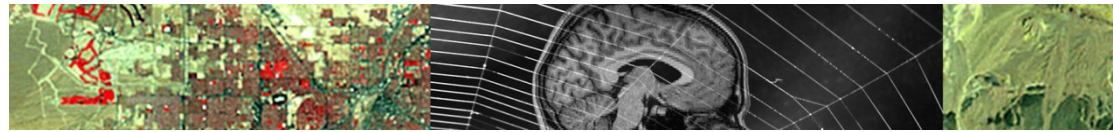
GeoFusion





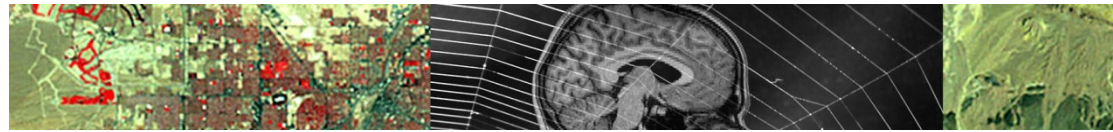
Imagery courtesy of WorldSat Intl. Inc.

GeoFusion



# What should Digital Earth *do*?

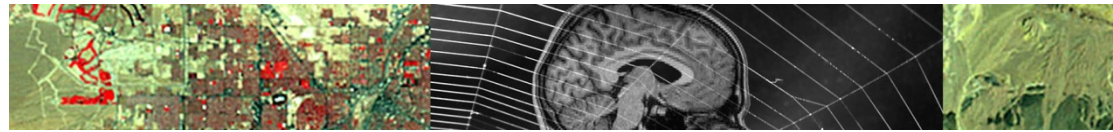
- The use cases of Digital Earth
  - “a magic carpet ride”
  - a method of communicating science
    - mashups
  - more visual, intuitive, subjective version of GIS
    - search for anomalies, interesting patterns
    - search for similarities
  - a source of data
    - geoportal
    - interoperable
    - hidden tiling
    - intuitive interface
    - creative commons



# Digital Earth as a simulation engine

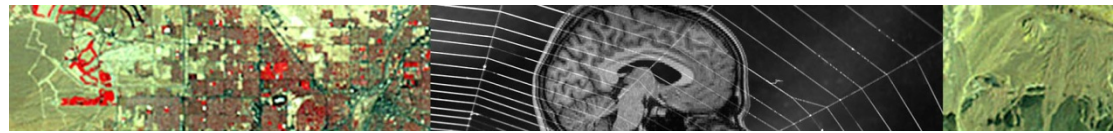
- A platform for transforming the world
  - visualizing the Earth's future
  - in an accessible package
  - a child-of-ten interface
  - what the Earth used to look like
    - and what it will look like in the future





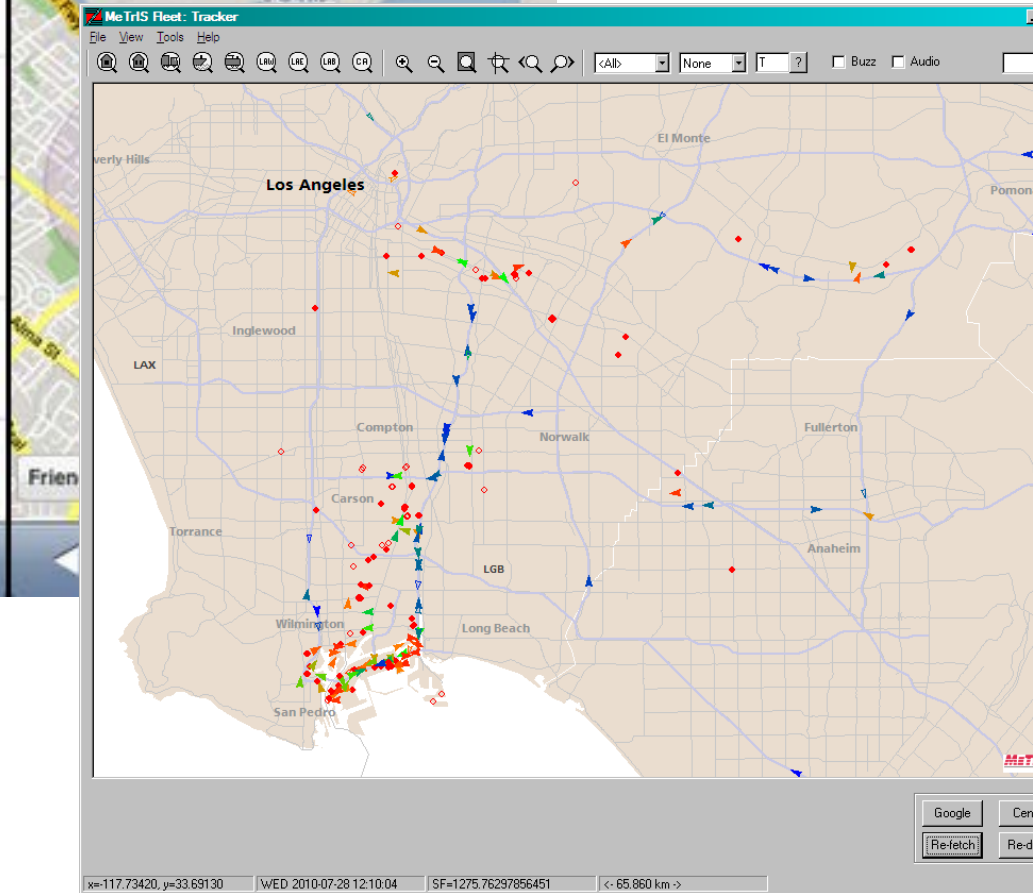
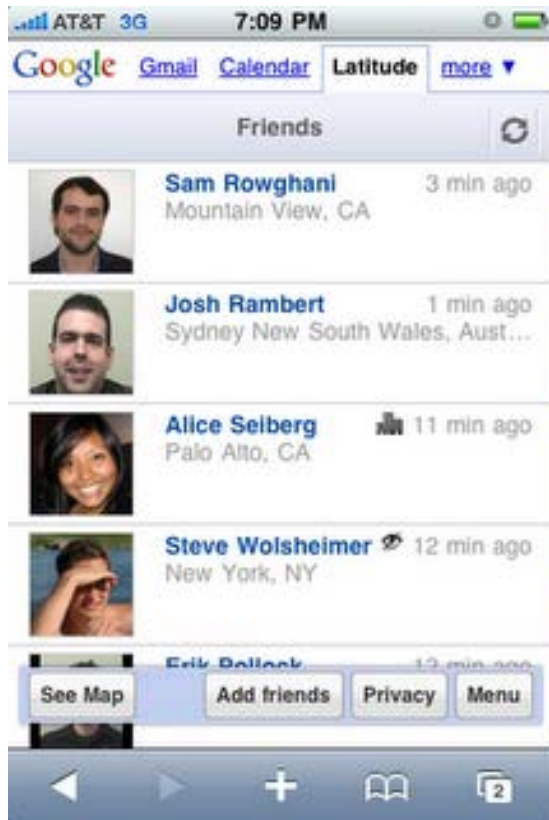
## Broader success

- Engagement of the citizen
  - child of 10 in 10 minutes
  - citizen as producer and consumer (*prosumer*)
  - *neogeography*
- A communication medium
  - compare “GIS as media”
  - presenting the results of global science
    - to the citizen, not the shelves of a library
  - the full life cycle of Earth data
  - past, present, and future



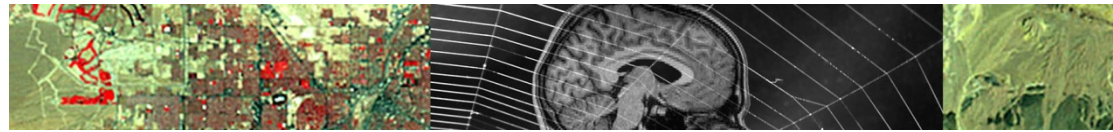
# Interoperability of geolocation

- 34 deg 24 min 42.7 sec North, 119 deg 52 min 14.4 sec West (3m)
- 909 West Campus Lane, Goleta, CA 93117, USA (20m)
- 3811560N, 236150E, Zone 11, Northern Hemisphere (10m)
- NE 1/4, Section 12, Township 23 Range 5 of the Second Principal Meridian (300m)
- National Grid reference 11SKU36151156 (10m)
- Visual identification on a georegistered base map (20m)
- “Mike Goodchild's house” (20m)



It is now technically possible to know where everything is, at all times

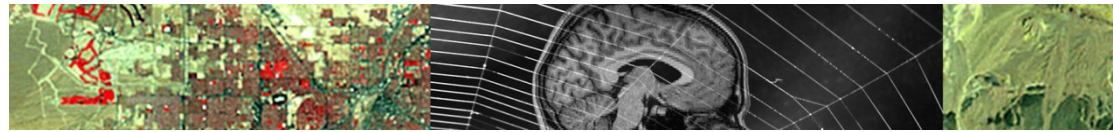




“A spate of burglaries in a Buckinghamshire village had already put residents on the alert for any suspicious vehicles. So when the Google Street View car trundled towards Broughton with a 360-degree camera on its roof, villagers sprang into action. Forming a human chain to stop it, they harangued the driver about the “invasion of privacy”, adding that the images that Google planned to put online could be used by burglars.”

[http://technology.timesonline.co.uk/tol/news/tech\\_and\\_web/article\\_e6022902.ece](http://technology.timesonline.co.uk/tol/news/tech_and_web/article_e6022902.ece)





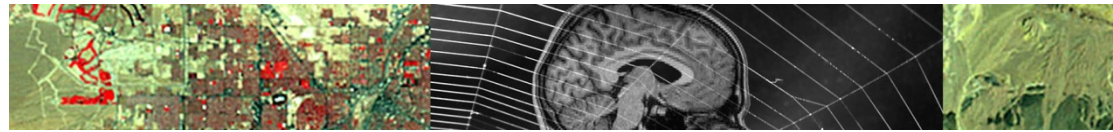
# They already know where you are

- Credit, ATM, store preference card
- Mobile phone
- In-car navigation system
  - real-time congestion



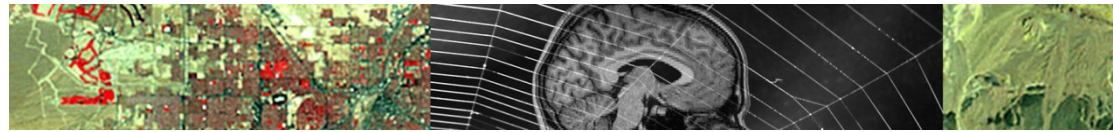






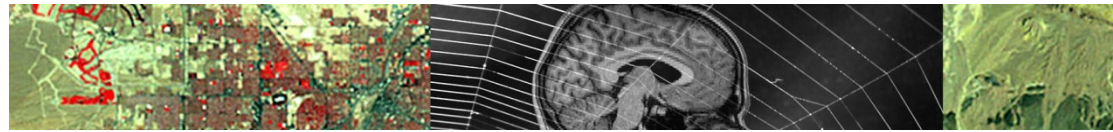
## Where is this headed?

- Not the virtual reality of Gore's speech
  - a separate, mirror world
- An augmented reality
  - in which technology provides information that is beyond our senses
- A world in which physical and virtual realities are fully integrated
  - technology is largely invisible and incomprehensible
  - a new kind of incomplete awareness, control
  - at once exciting, powerful, frightening



## Seven themes

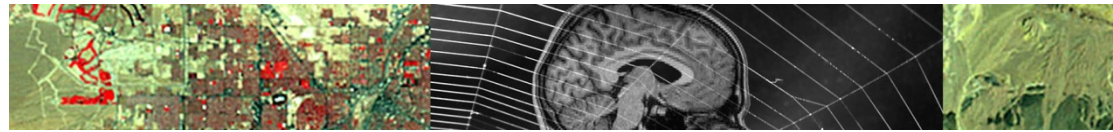
- Constant novelty
  - often from outside the field
  - from other disciplines
- The emotional dimension
  - people love maps
  - they clean up an uncertain and confusing world
  - digital maps are even cleaner
- A Newtonian world
  - no quantum, relativistic effects
  - a rigid frame



## More themes

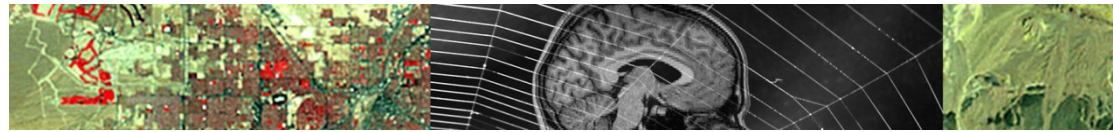
- Practical
  - an academic discipline that is almost always useful
  - an intimate connection to real, practical problems
  - a closely related and increasingly wealthy industry
  - employment opportunities
- Elegant
  - algorithms, topological data structures
  - quadtree indexing





## More themes

- A science
  - general principles and theories
  - solid foundations
  - truths to be discovered about
    - the geographic world
    - the computational world
    - the cognitive world
  - a tool
    - allowing discoveries to be made about scientific domains where the tool is applied

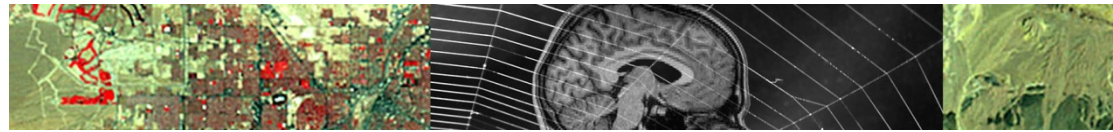


## and last but not least

- Engages with a love of the real world
  - first-hand experience
  - physical and virtual exploration
  - a period of unprecedented mobility







## And the next 20 years?

- The stream of new ideas will continue
  - as new technologies arrive
- We may not know it as GIScience or geomatics
  - location may become a transparent part of systems
- Spatial (and spatiotemporal) will remain special
  - spatial dependence, spatial heterogeneity, scale, uncertainty, privacy, etc.
- Improvements in the technology will allow us to focus more on:
  - the underlying concepts
  - the real world that Digital Earth represents