GIS

What, Why, How

GIS

- Geographical Information Science
  - Not just computerised maps

- Data Capture ('EO' – though often = just physical/RS)
  - Survey: GPS, EDM, Laserscanner
  - RS: Aerial/Satellite, but also other sensors, Sensor Networks
  - Primary Data, Secondary Data (verification techniques/theory/PAI)

- Analysis, 2D Map – Cartography, also whole field of (Geo)Visualisation, (incl. 3D)

- Visualisation can also permit further analysis
  - Exploratory (Spatial) Data Analysis – EDA/ESDA

GIS – Three or Four Kinds

- Desktop Application / Full Package
- Web Mapping / Feature Server / Server GIS
- Web Browser with GIS Tools / Thick Client
- Apps, Mashups, APIs – Distributed GIS

Spatial Phenomena

- Land Use – Urban, Rural, Building Types
- Flood Risk, Water Transport, Soil Type
- Topography – Elevation, Slope, Aspect
  - How does topog' affect 'occurrence' in landscape
- People – Travel to work, shop, emergency services

Modelling

- Conceptual Models
  - To understand world, predict conditions at locations in time and/or space
- Mathematical Models
  - Numerical models where formalised - some idealised, some less so
- Data Models
  - Structure and flow of information in time and space
- Spatial Data – often (not always) represented in maps
  - (Lots of) Data with spatial component, some attempts to address time too
- Computerised Spatial Data -> Quick *Spatial* Analysis over wide extent
  - GIS – Geographical Information Science (and/or Systems)

GIS History / Software

- Geography Techniques (by hand) pre 1960s: John Snow, Minard's Map (Napoleon)
- Forestry – Canada (+E Africa) - CGIS
  - First GIS – Roger Tomlinson 1960+, operational from 1971+
- USA – Government Organisations: USGS, US Forest Serv, others incl. CIA
- Academia
  - **Edinburgh** – GIMMS 1970+ (Sold from 1973), MSc GIS 1985+
  - Harvard – Computer Graphics and Spatial Analysis Lab 1965
- ESRI 1969 Env. Consultancy – Arc/Info 1982 -> ArcView Desktop 1995 -> ArcGIS 1999
- Physics/Space (Moon landings) later CAD/Utilities – LaserScan/Intergraph 1969
- Demographics/Consultancy – MapInfo 1986
- OpenSource – GRASS, Quantum GIS (QGIS), gvSIG, … link to DBMS
- Web GIS – WMS, WFS, Google Maps, Google Earth, OGC, OpenStreetMap

Data Types

- Vector – Discrete Entities *within* space
  - Points
  - Lines
  - Polygons
- Raster – Contin’s Field/Surface *across* space
  - Elevation
  - pH
  - Growth Pot’l as secondary data based on above

Attributes

- Vector – Multiple Attributes (Properties)
  - Attributes are of each feature (point, line, poly)
- Raster – Single Attribute (Value) e.g. pH
  - Each cell has a different value of this attribute
  - BUT! Can also have in turn *Value Attributes* e.g. 1 = Acid, 7 = Neutral, 14 = Alkaline
  - BUT! Again only one per value!

Model Framework to use – 1?

- Q. For mapping HGVs across Europe?
  - Ans: Lines – A Linear Network (Vector)
  - Lorries constrained to linear road network
  - Each road can have multiple attributes: speed limit, length, width, number of lanes

Model Framework to use – 2

- Q. To model flow/drainage in moorland?
  - Ans: Raster Grid – A continuous surface
  - Each cell can have a flow direction
  - Need multiple spatially co-incident grids to combine in order to achieve end result (answer)

Spatial Co-incidence – Map Layers

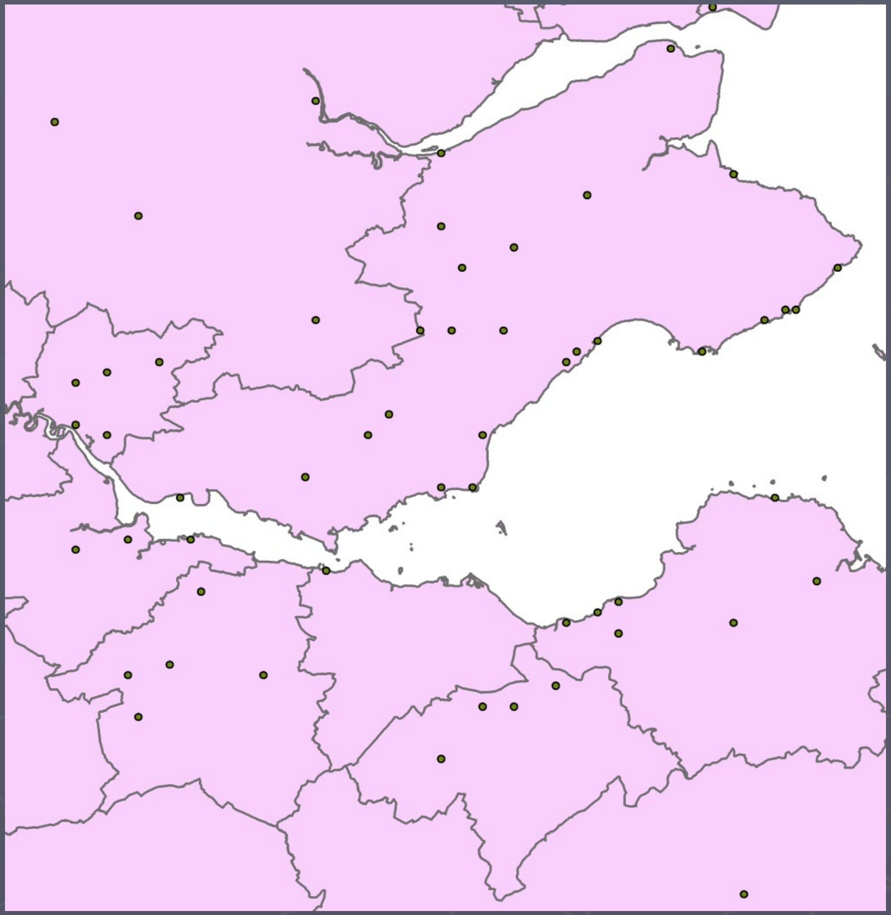
- Combination of spatial and aspatial (often numerical) manipulation of data
- Grids lie on top of each other. Co-incident cells can then be combined numerically to give result.
- GIS all about combining info from different *Layers*
- *Layers form a stack – but usually only in model – multiple measures found in same x,y,z (cell) location*
  - E.g. elevation, pH, salinity – each of these in different grid layer

Overlay – Attribute Transfer

- Can convert between raster + vector but limited and tend to be treated in isolation but can be viewed together easily
- Can however easily combine vector layers – mathematical combination of geometry – easy to cut-up and intersect => Vector Overlay
- Vector Overlay all about Attribute Transfer

Overlay – Point in Polygon

- Which district has the most towns?
  - Count the number of town points in each district poly
- In which district does this town lie?
  - Attribute (verb) each town with the name of the district polygon in which it falls
- Points 'lie on top' of solid coloured polys in our stack



Overlay – Polygon Overlay

- Degree of overlap between different districts/zones/catchment areas
- E.g. *Erase* SSI polygons from potential Golf Course polygons (unless you are a Trump)
- Intersect pollution zones with population zones (> 10,000 pop) to get danger zones!

Co-ord’te Reference Systems (CRS) – Map Projections, Datums

- Spatial Data can be measured/located in:
  - Angular Units – Lat, Long, e.g. 56º23'4" (dms), 56.38º (dd)
  - Linear Units – Flat Grid-based: Easting, Northing, e.g. metres, ft
- Spherical (Angular) = 'Geographic' CRS (unprojected)
- Flat Planar (Linear) = 'Projected' CRS, e.g. BNG, UTM
- All CRS based on a reference datum – a model of the Earth’s surface/shape. This MUST be correctly defined, for any later projection (curved to flat) to WORK correctly.
- If collecting GPS data in Britain, we want to end up in BNG but MUST define source data as WGS84 datum / geographic sys as THAT is what the GPS uses. Once source data defined we can project to BNG.

Simple GIS – Google Earth

- Last point less of an issue if using Simple GIS – Google Earth – uses WGS84 lat long; loads in KML files – now often saved by GPS software directly. E.g. GPS Utility. Or just write raw KML or use converter prog.

- Simple annotation / measurement tools etc. but also clever features, e.g. timestamp allows animation/viewing change through time

- Beware – Google ***Maps*** uses its own Mercator projection but you can link to KML URL in Google Maps

- Can make 'mashups': Google Maps, JavaScript, WMS, Scanned Maps

NO pricey GIS package required

Industry Standard - ArcGIS

- ArcGIS: ArcMap – 2D, ArcScene 3D, ArcCatalog, others
- Relatively easy to get started, though can at times be overwhelming! Some similarity to Word/Excel in structure
- ArcToolbox now primary interface to functionality (or command line) though various toolbars (drop-down menus) too
- Beware – from v10 Arc tries to save everything to a default geodatabase in user's home path. In UoE, home path is M: and for undergrads this may still be quite small. Thus must keep some space on M: even if other space available

File Formats

- Shapefile – Actually a set of 3-6 files (min 3)
  - Prob one of most widely used file type – though closed, proprietary format
  - Myfile.shp (*geom*), Myfile.shx, Myfile.dbf (*attrs*), .prj, ...
  - Move each file, or .zip all together at OS; just move the .shp in ArcCatalog
- Geodatabase
  - Single file at OS level – neatly holds all vectors & rasters
  - File Geodatabase now 1Tb (and there are ways to get up to 256 Tb!)
  - In time will likely be the only thing to use (other GIS still use shp for now)
- Coverage (vector); Grid (raster)
  - Older formats you may need to know about
  - Hybrid structure of one folder mygrid and a shared info folder – shared between ALL coverages and grids in a containing folder
  - Move ALL of these at OS – or better still use ArcCatalog only!

Data Storage Theory

- Hybrid Arc/Info model based on storing correct *type* of data in best place for that
- Data can be re-joined when required
- Same principle means store only relevant info in a table of particular feature types and join these at query/display time – also use key tables & numbers to reduce data vols
- Relational DBs good for this and can store spatial data – Many offer spatial extensions with spatial analysis functions

Database Storage

- Can connect GIS to RDBMS for:
  - Better querying
  - Robust storage
  - Multi-user access and sophisticated control (only one user edits electoral district at a time!)
- Examples:
  - ArcSDE – Create GeoDatabase in RDBMS
  - SPIT – Connects QGIS to PostgreSQL(PostGIS)

Open (Source) GIS

- PostGIS, MySQL – Open Source DBMS – implement OGC standards
- OGC – Consortium of 482 Companies/Orgs – Define *Open* Standards
- OSGeo Found'n – Support develop't of op'n source Geospatial software
- GRASS – Orig. US Army, now project of OS Geo
- GDAL (Conversion), GEOS (Geometry), rasdaman (rasters)
- Quantum GIS (QGIS) – Another OSGeo Project
  - MapServer export, OpenStreetMap editor, Run GRASS datasets/tools within
- MapTiler (uses GDAL2Tiles) – Create OpenLayers/Google Maps Tilesets

Web GIS

- Tools – MapTiler, OpenLayers, MapServer, GeoServer
- Developers' Platforms – JavaScript, AJAX, SVG, Java
- Google Earth/Maps, Virtual Earth, Streetmap
- OpenStreetMap, (interesting to compare against OS!)
- OS Get-a-map; OS OpenData (Apr 2010); OpenData API
- Simple User Requirements? – ArcGIS Online

The Future 1 – PDAs, AR, Apps

- Move from mainframe to desktop to distributed desktops, and distributed servers
- PDAs and Phones – ArcPad, GPS Maps
- Augmented Reality – Scan horizon, Utilities
- AIS – Ships, Planes – Track in Google Earth

The Future 2 – LBS, Sensors, Clouds

- Location Based Services, Sensor Networks
- Cloud Computing, Ubiquitous Computing
- Tracking People? Civil Liberties / Freedoms?
- Social inequality – advantaged vs disadvantaged?
- Free/VGI => more folk making bad maps - *noise*?
- But a more skilled-up knowledgeable population…?

Thank You!

Questions?