GIS Concepts

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1 GIS

1.1 What is GIS

- GIS is a tool
- Used in conservation modelling, lunar mapping, crime mapping etc. Anything with spatial data
- GIS is esentially a database with a spatial component. E.g Latitude and longitude Can use it to answer spatial questions
- Not a fancy form of analysis. (use R etc)
- Geographic information - Any piece of data that can be located in space using : A set of coordinates and a known coordinate system
- Generally will be using spherical coordinates (always remember north south east west direction in the coordinates)

1.2 Longitude and Latitude

- Latitude - An angle above or below the equator
- Points of equal latitude for a parallel, distance between parallels is constant
- Longitude - An angle around the equator.
- Points of equal longitude form a meridian. Distance between meridians varies

1.3 Geographic Coordinate systems

- Earth is not exactly a sphere
- 1 in 298 flattening
- Estimated coordinate systems (Datum) have varied over the years
- Datum (Geographical coordinates system) matters as different datum would give different angles to the same location
- Earth's not quite an ellipsode wither as distribution of mass is uneven and dynamic.
- Now often use GEOIDs. Gravitational measurments. These start with a surface of equal gravitational force. Then up and down are perpendicular to the local geoid. A level surface is tangent to the local geoid
- Since 1984 have been using WGS 1984. This combines datum and geiods giving a standard global coordinate system
- Uses modern satalite data to provide ellipsoid measurements and gravity model. (Used by GPD). Prime meridian is at

$$0^o 5.31\text{"} E! \tag{1}$$

- The fit between a geoid and datum varies in space. Global model works well on average but countries have developed their own local datum
- British national grid uses OSGB 36 datum. Same latitude and longitude but different datum. In some places WGS up to 70m East and 70m South of OSGB 36. This shift varies nationally

1.4 Spherical geometry and projected coordinates

- Lots of GIS involves finding distance between points. So need to use length along great circles
- Need to use sperical geometry. Same for areas
- As not spere though we need to use Ellipsoid geometry

- Impossible to project a sphere onto a plane without distortion. Ellipsoid surface of the Earth isflat enough in small scale (around 10km) but not larger
- When looking for a projection want to try and preserve: shape, area, distance and direction. Ususally can only preserve one
- Tissot indicatrix - Place circles on the Earths suface and then can see how they are distorted in the map.
- One method is to treat longitude and latitude as x and y - This stretches the poles a lot

1.5 Projected coordinate systems

- projection onto a flat plane. Preserves only distance from a central point. Looks very distorted
- Cylindrical projection. Preserves area
- Mercator projection. Preserves shape but not area etc
- Fuller Dymaxion projection. Tries to preserve shape and distance but loses direction in the process
- Many many others

2 2 types of geographic data we will come across

2.1 Raster data

- An image covering a continuous surface. Made up of individual pixels, each with a value (either categorical or continuous). Has a resolution and needs an origin and coordinate system

2.2 Vector data

- A set of features containing one of:
  - Individual points
  - sets of connected points forming lines or polygons
  - Needs a coordinate system

- Coordinates of points are a recise location, but may have precision or accuracy information. Features may have an attribute table

3 Remote Sensing

3.1 Introduction

Mapping landscapes by hand allows you to get a very fine level of detail but it is exspensive, slow and inconsistent. Thus we often use remote sensing (using satilites and imagary to produce maps). Remote sensors can be passive e.g look at reflected solar radiation, using photographs
Or active: emit and sense reflections

- LiDAR (light)
- RADAR (microwaves)
- Detect alteration in reflected light
- Trip time gives height

Active methods are often expensive so often use the passive types.

3.2 Reflection

- Albedo: The proportion of radiation reflected from a surface
- Texture and angle strongly affect albedo so need to take account of this
- Monochrome images: Different objects have different albedos.
  Construct maps by looking at contrast, texture and edgesmote sensing won't just use visible light. Will use multispectra imaging
  - The albedo of a surface varies with the wavelength of the radiation
  - different surfaces have different reflective profiles
  - Composed of multiple layers recording reflectance in different wavelengths

3.3 Using Satellites

- Height of satellite orbits affect the field of view. Also sycronise the angle of the sun so that reflection is the same for all readings
- Spatiotemporal resoultion - Low Earth orbits provide a high spatial resolution. Norrow path widths, samll scenes and less frequent images. Satellite costellations can increase temporal resolution
- Spectral resolution - Determined by the satellite mission, constrained by absorbtion of radiation by the atmosphere. Light gathering sets resolution and band width
- Different satellites have recorders for different wavelengths providing different spatial resolution

3.4 Using the images

- Georeferencing - Where is the image?
- Orthorectification - Remove perspective and terrain effects.
- Calibration - Convert the sensor value (relative wavelengths) to an actual reflectance value
- Atmospheric correction - aerosols and water vapour can all impose spectral biases on reflected light and vary on a daily basis. I.e harder to see around clouds etc. Know something through a cloud won't ve reflecting as much as that which isn't
- Earth observation products - use satellite data to produce derived maps using standardised algorithms, map land surface at global scale. Temporal scales: daily to annual, resolution: 250m to ¿ 8km. Validation: many have pixel by pixel accuracy
- Vegetation indicies - Simple, direct calculated from sensor values: Normalised difference vegetation index and the enhanced vegetation index (looking at how many leaves there are in an area)
- Digital elevattion models - Give height of the land
- Fire signatures - looking for a peak in infra-red radiation. Burned areas - change detection in successive images around fire pixels

- land cover - Spectral signatures differ between surfaces so should be able to pick up different types of surfaces. Can also look at the temporal change of the land surface i.e how the surface is in summer and winter.
  - Ground signalling ties spectral signatures to habitats.
  - Profiles can then be used to classify pixels to habitats
- Productivity - Plants use light to store carbon. If we know the amount of photosynthetically active light absorbed, the radiation conversion efficiency (given by teperature and humidity) and the respiration costs then we can predict gross and net primary productivity.
  - remotely sensed reflected light
  - ground measured incident light
  - Biome based models for: conversion efficieny and respiration