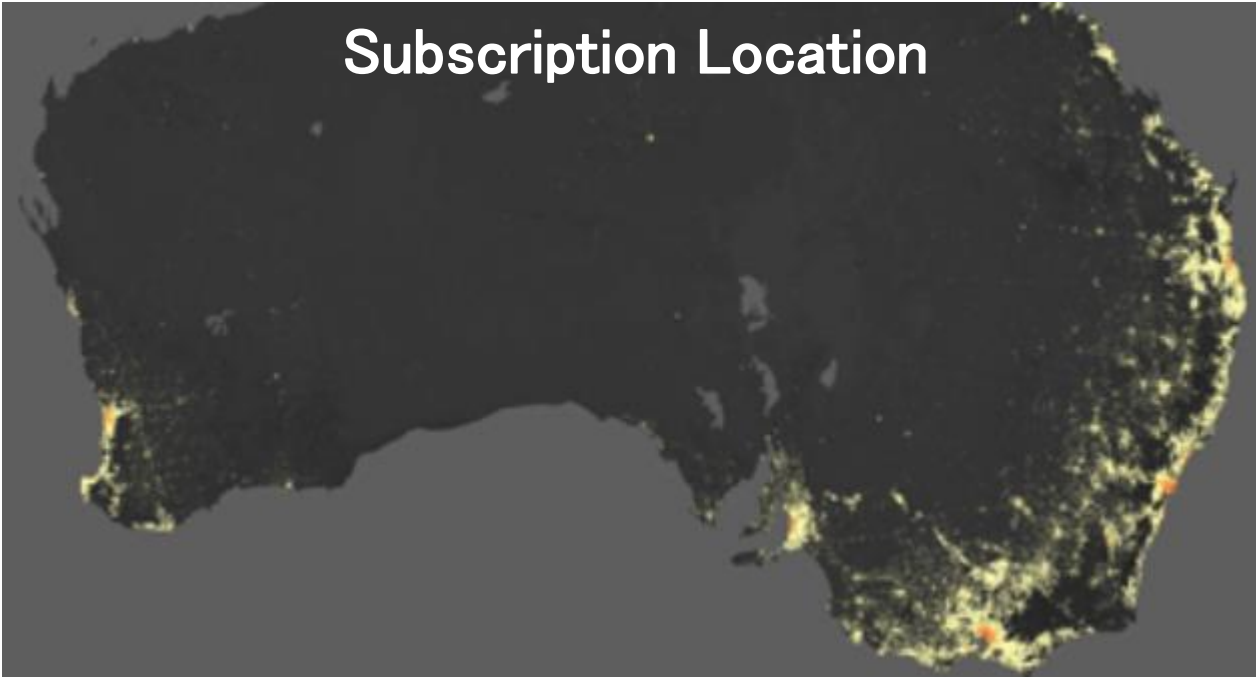
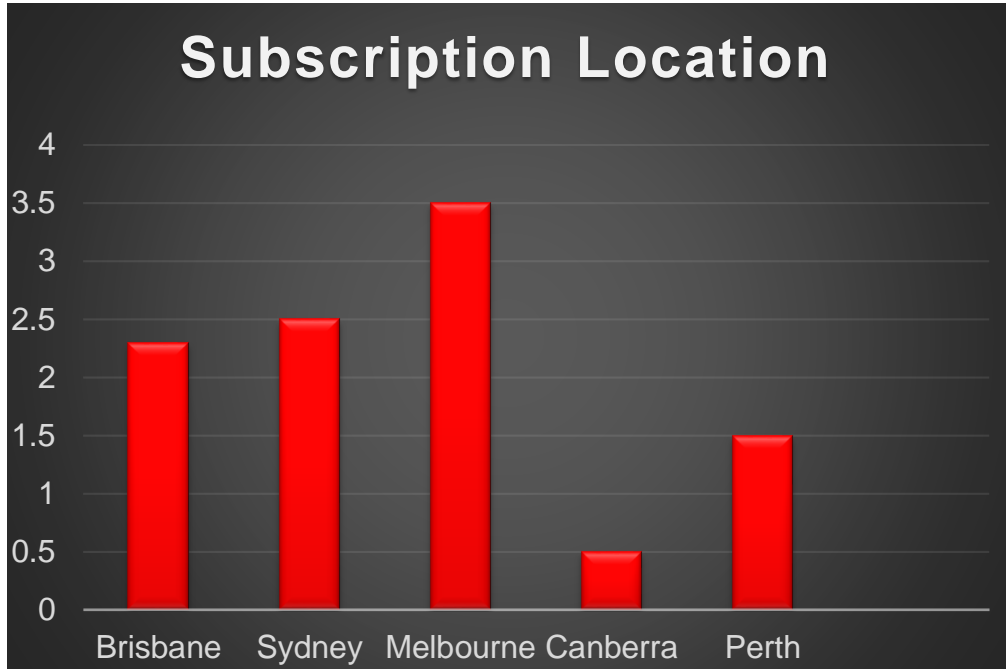
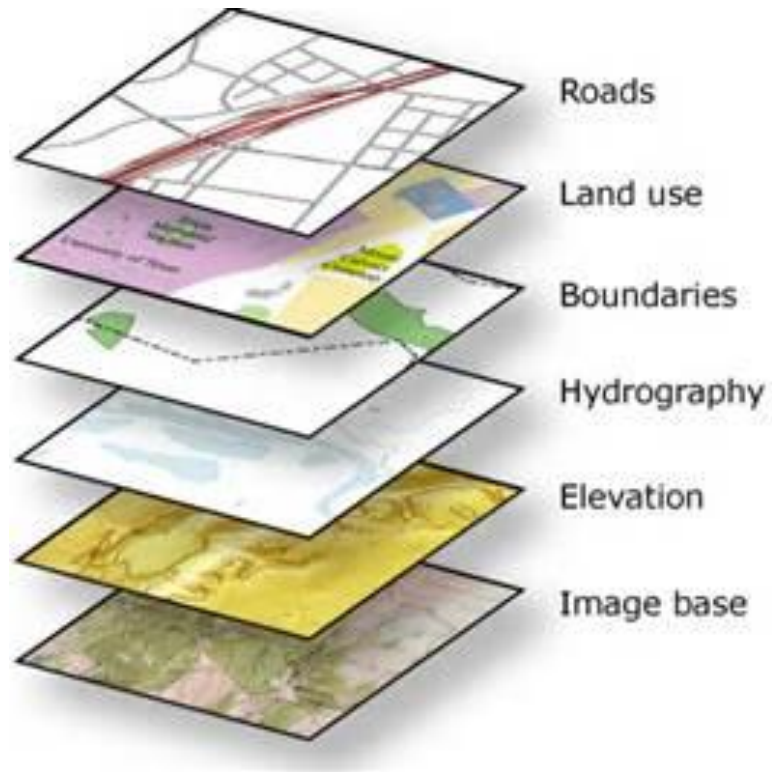




**Not Interested in spatial data?
Let me change your mind!**



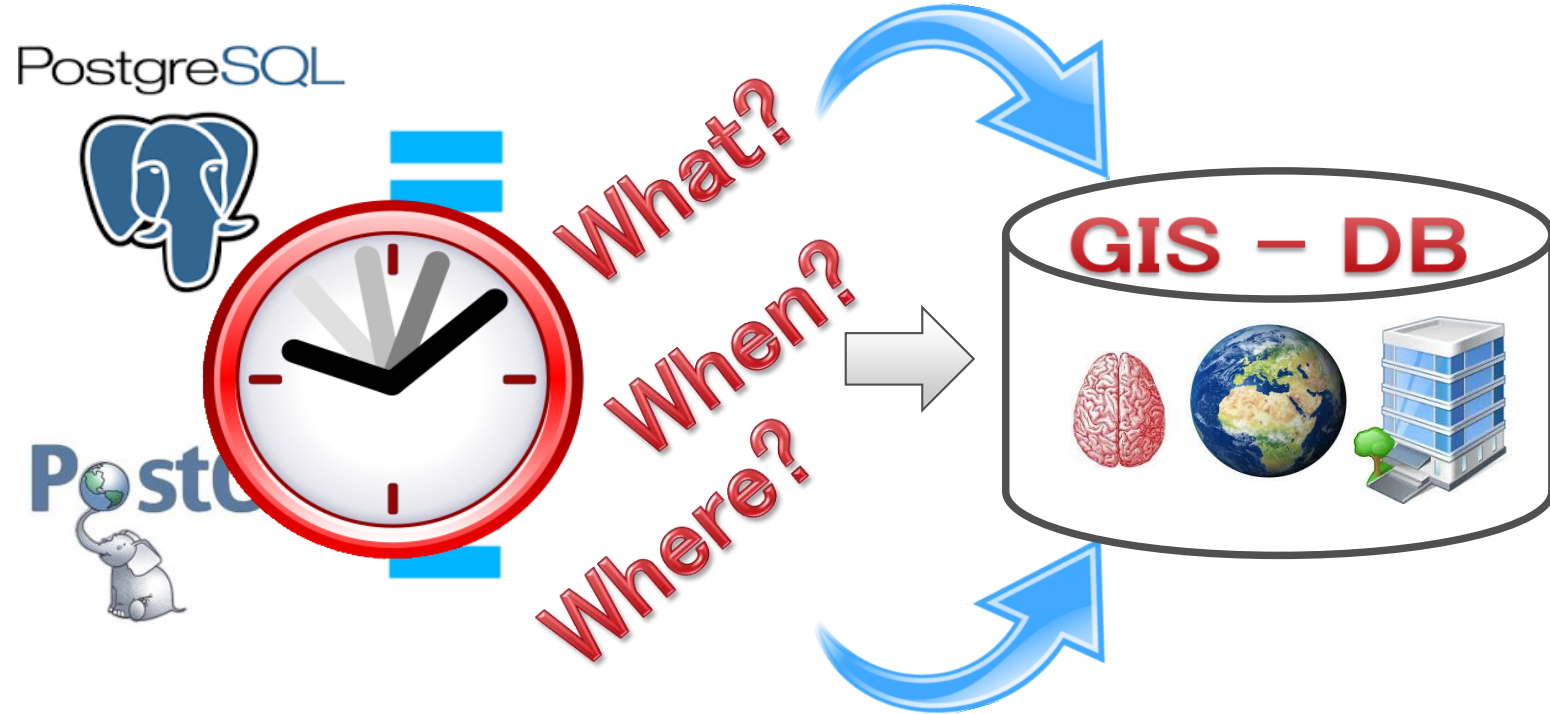
What is a Geographical Information System?



- The key feature of the GIS system is to organise lots of data into one or a few simple geographic view(s)
- Geographic views are generally built by putting together a set of what are referred to as map layers

Why a geospatial database ?

- PostgreSQL is a relational database; doesn't know anything about storing geometry
- PostGIS is an extension that adds powerful geometric storage, search and manipulation



Co-ordinate systems

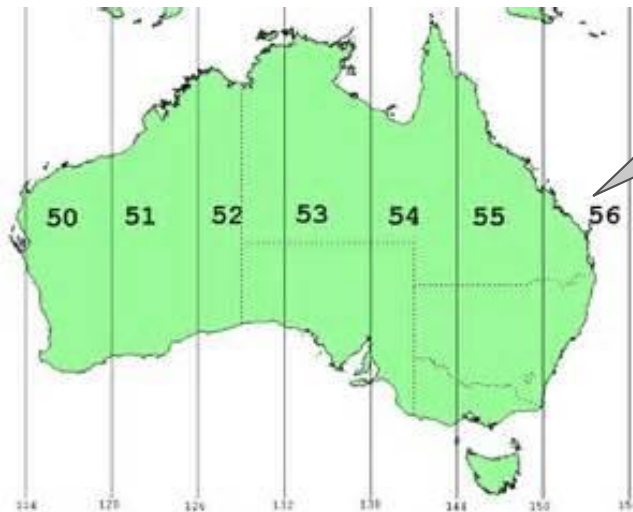
- Geographic Co-ordinate system (spherical based)

- Eg: WGS1984



**Brisbane 27.4698° South
153.0251° East**

**Brisbane in UTM is 56J
6861256N 502648E**

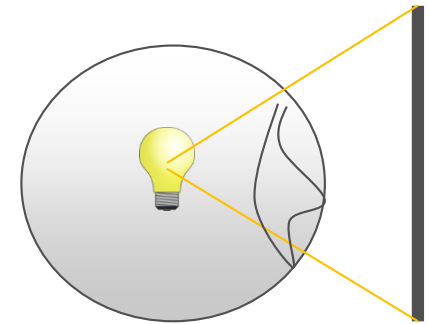
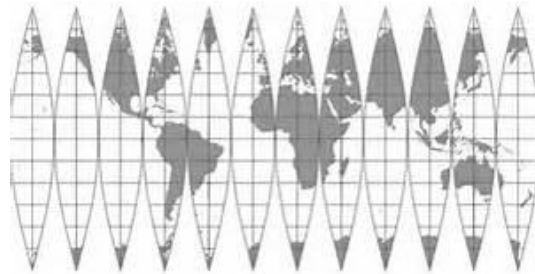
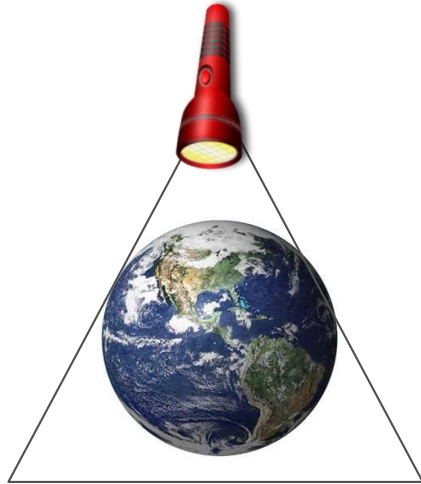


- Projected Co-ordinate system (two dimensional based)

- Eg: Universal Transverse Mercator (UTM)

Projections

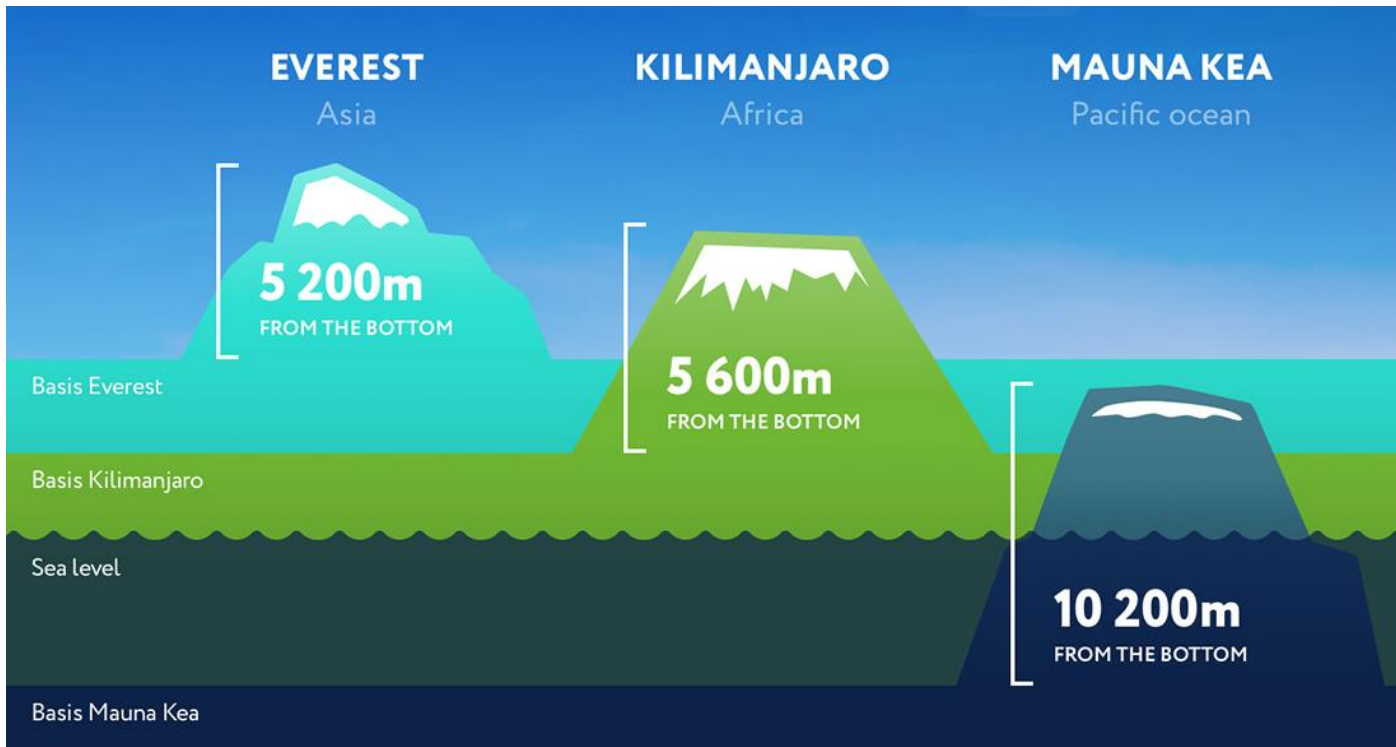
- Different projections can represent the object (earth) differently.



- European Petroleum Survey Group (EPSG) created the most commonly used SRID codes.
 - Must know the SRID for the geometry data to be accurate

Datum

- Point of reference for measurements
 - Many different datum for different geographic areas, and new more accurate ones replace older ones



Is Everest the highest mountain in the world?

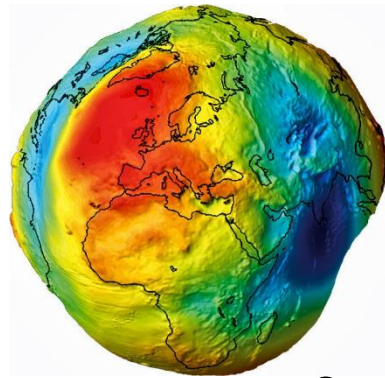
They are only models

- Models are a simplification of the real world

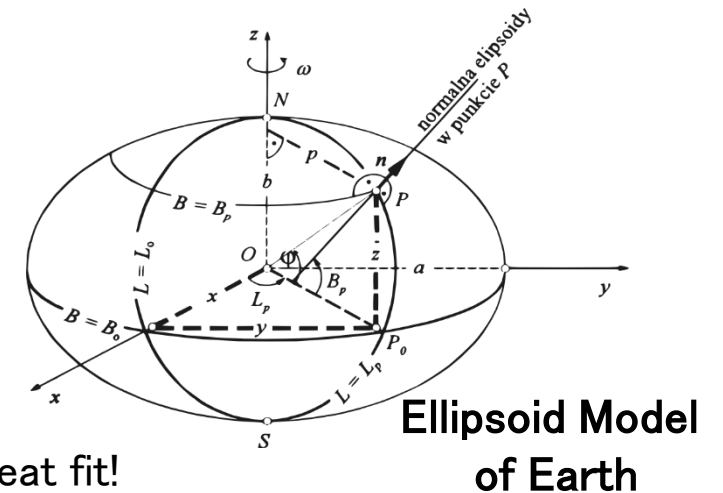
- Assist our understanding
- Faster to process calculations

But ...

- They have compromises, flaws and inaccuracies
- Always a compromise of speed with visible errors



Geoid earth



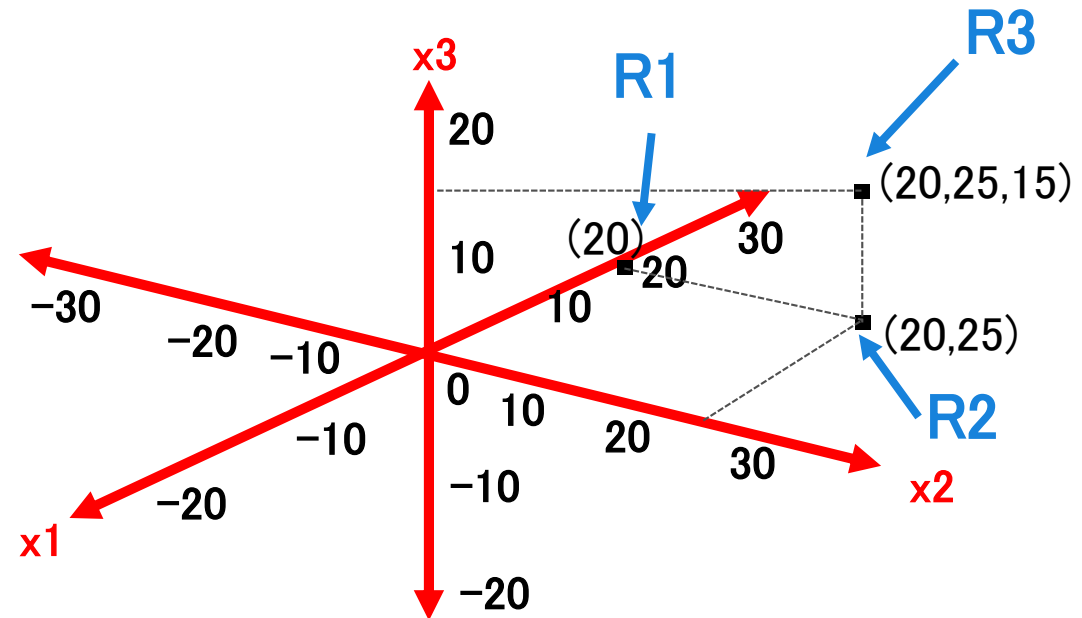
Not a great fit!

What will happen to distances and shapes?

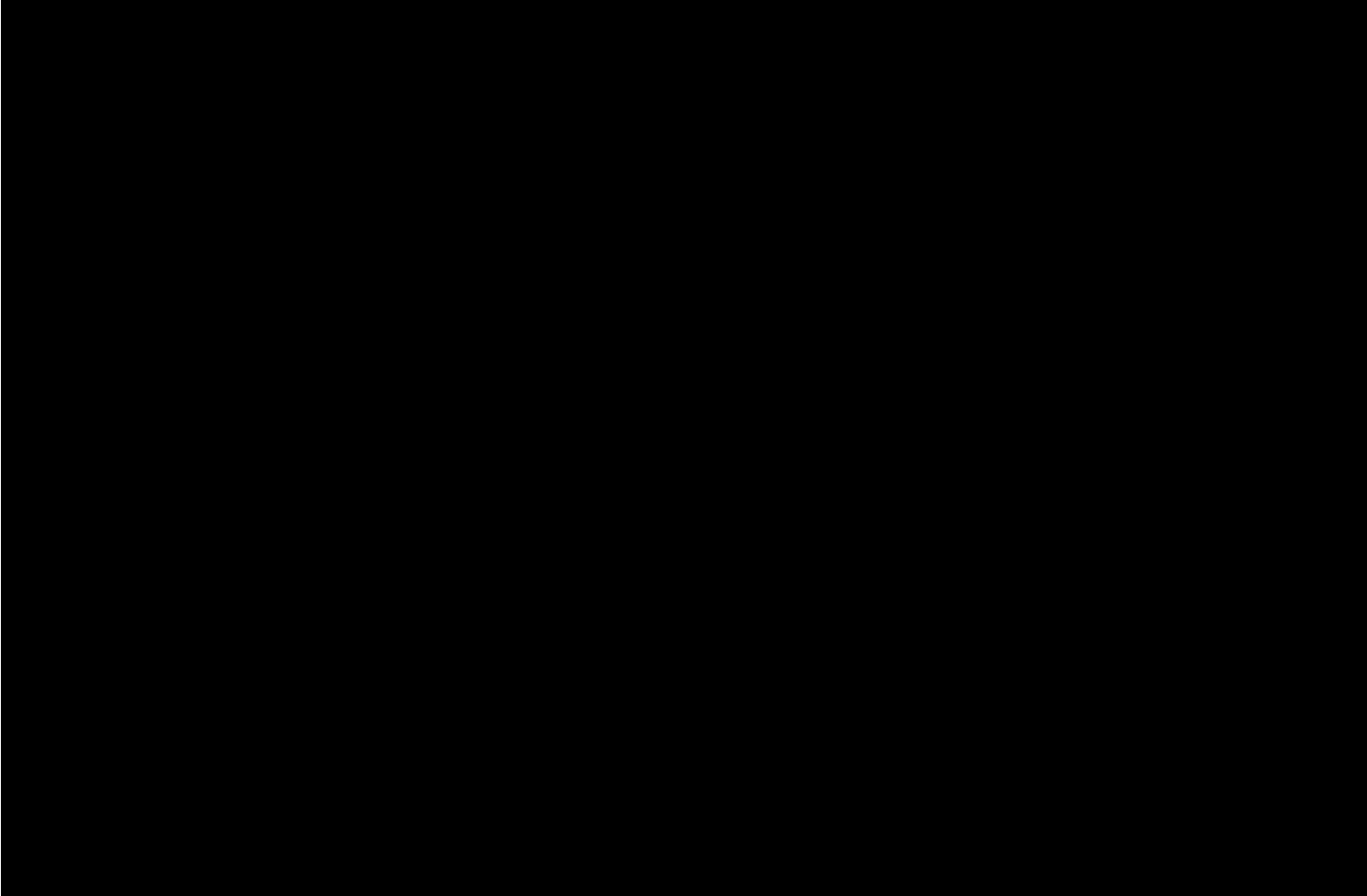
GEOMETRY Type

■ Represents a feature in the Euclidean coordinate system

- R1 – one dimension (line)
- R2 – two dimensions (plane)
- R3 – three dimensions (space)



Smart City Singapore



- **Postgis stored objects and functions**

PostGIS Types

■ Geometry

```
Create table myfirstgeometry (id integer, name text, road geometry);
```

Insert into myfirstgeometry values

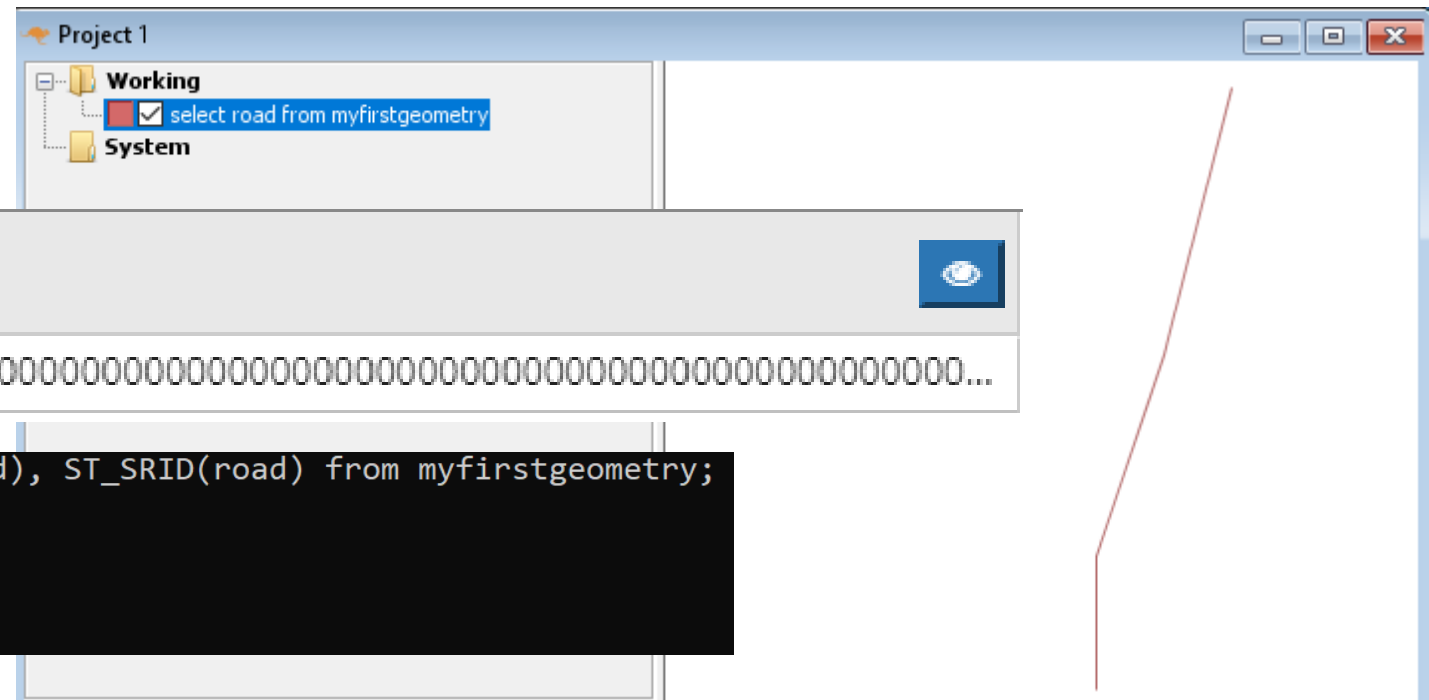
```
(1, 'Smith', ST_GeomFromText('LINESTRING(0 0,0 2,1 5, 2 9)'));
```

[illegible]

```
pgdu=# SELECT name, ST_GeometryType(road), ST_NDims(road), ST_SRID(road) from myfirstgeometry;
```

name	st_geometrytype	st_ndims	st_srid
Smith	ST_LineString	2	0

(1 row)



Well Known Text (WKT)

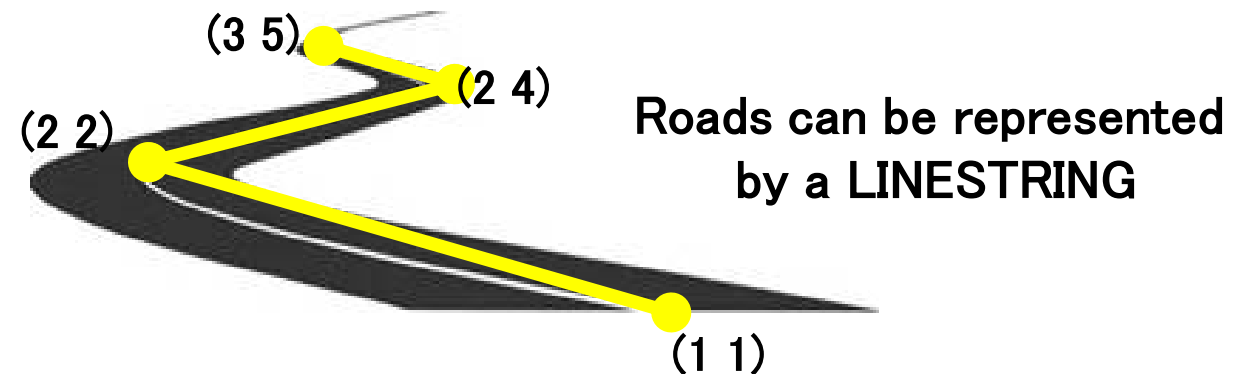
■ Point(7 8)

- A point identify a location in a coordinate space



■ LINESTRING(1 1,2 2,2 4,3 5)

- A path between locations in a coordinate space



Well Known Text (WKT)

■ POLYGON(1 1,2 2,2 4,3 5)

- An area specified by a number of points



Exterior ring (no interior)

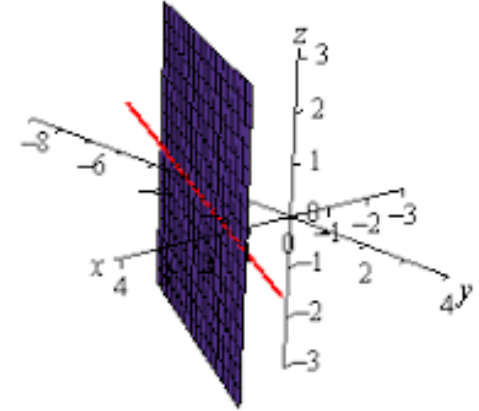
POLYGON(1 1,2 2,2 4,3 5,...,7 8, 9 12)

Exterior and interior rings
POLYGON((1 1,2 2,2 4,3 5,...,7 8, 9 12),
(3 2,4 4,5 4,...,4 6))



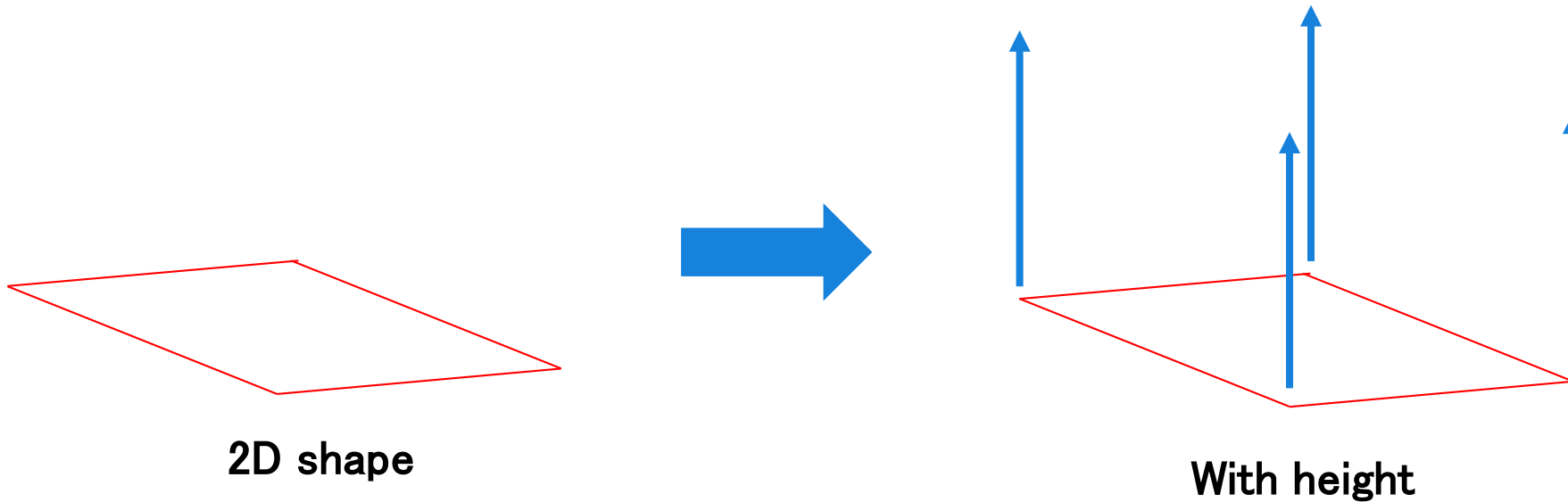
3 Dimensions

- PostGIS geometry supports three coordinate dimensions, but not volumetric geometry
- PostGIS geometry also supports polyhedral surfaces, which are lots of 2 dimensional geometry surfaces linked together in a three dimensional co ordinate system (again not volumetric)



3 Dimensions

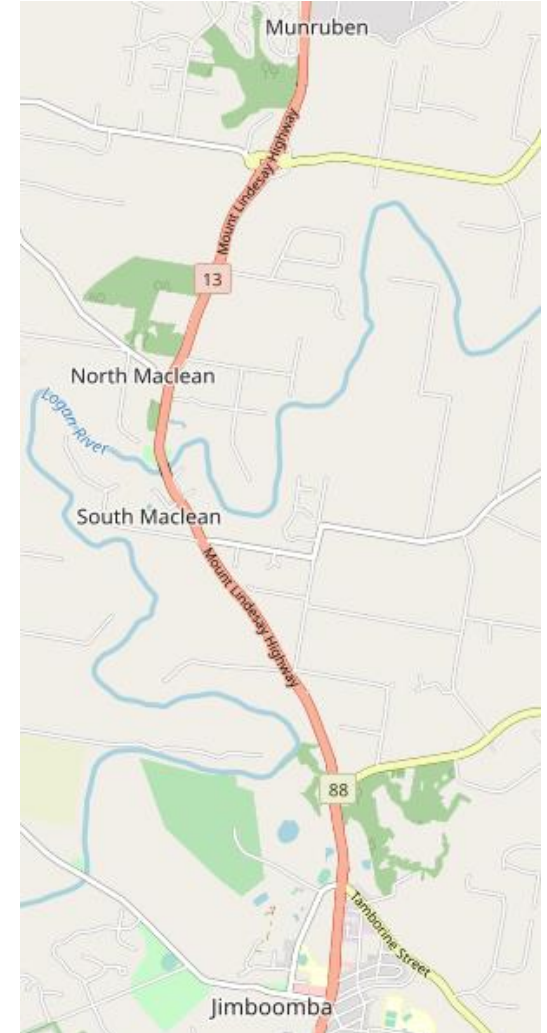
- PostGIS geometry has x, y, z and the M value



Measuring Distance

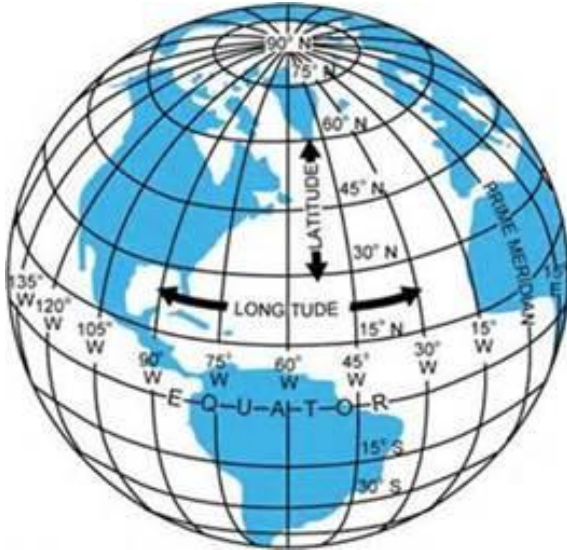
- How many motorcycle club members are within 15kms of Mount Lindesay Highway

```
SELECT count(distinct m.id) as total
FROM member m
  INNER JOIN planet_osm_roads as r
    ON ST_Dwithin(m.location, r.way, 1000 * 15)
WHERE r.name = 'Mount Lindesay Highway';
```



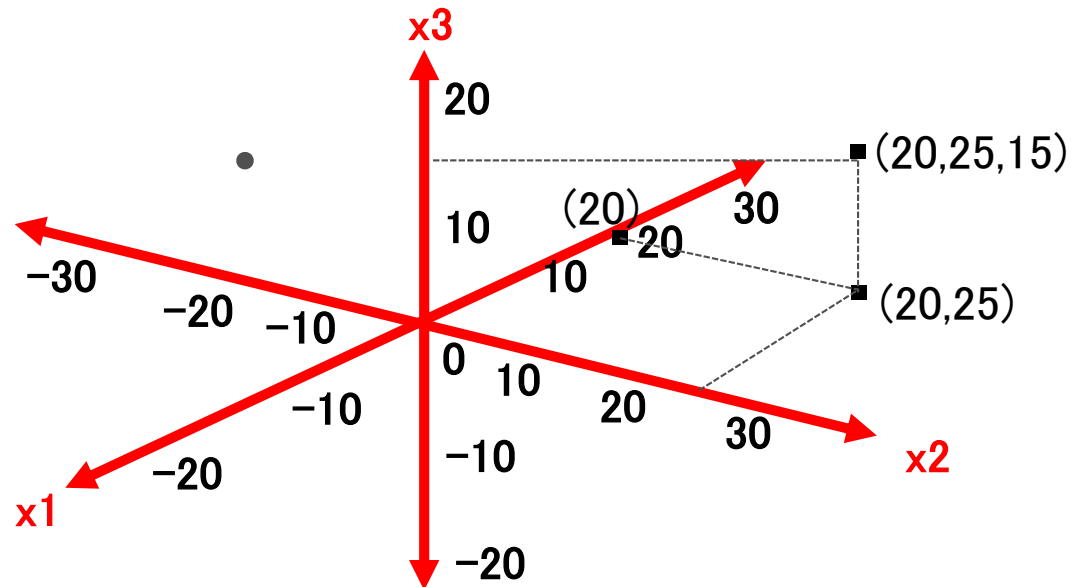
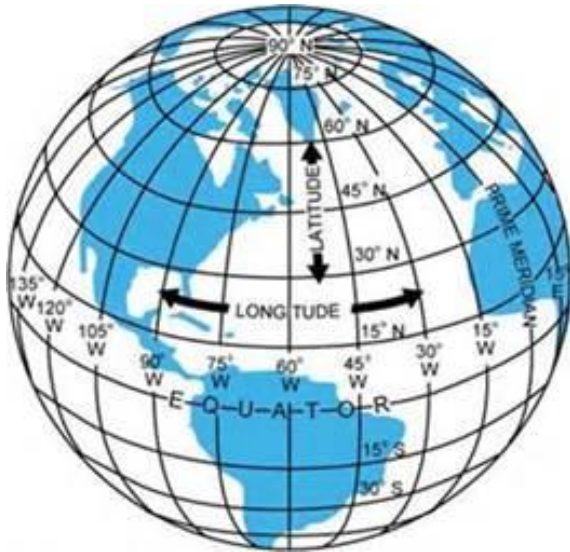
GEOGRAPHY Type

- Represents a feature in a spherical/Ellipsoid co-ordinate system
 - Measurements work off of Datum's which vary depending on the co-ordinate system used



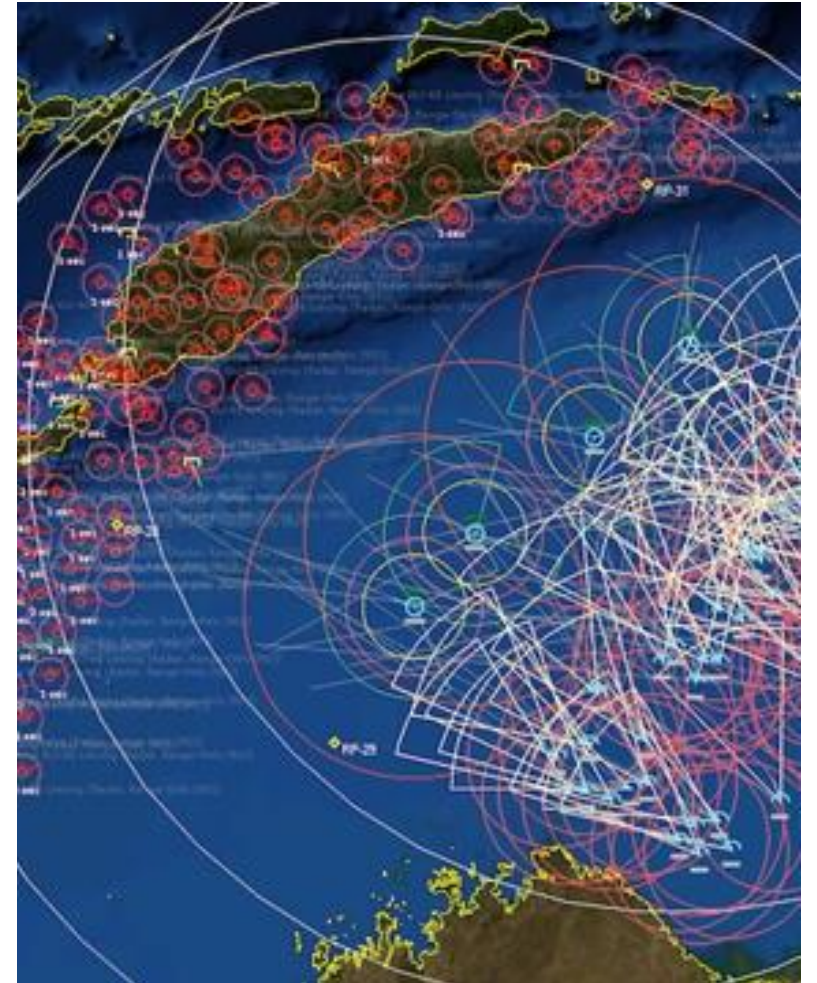
GEOGRAPHY versus GEOMETRY

- Both could be used to represent a geographical location on our earth
 - Functions that work on geography types tend to return values that we are familiar with (areas in square kilometres, distances in kilometres). Geometry types would return square degrees.
 - Geometry has a richer set of functionality at present



Useful applications for PostGIS (Geography)

■ Navigation



Measuring



Sydney
151.2093 East
-33.8688 South

Singapore
103.8198 East
1.3521 North

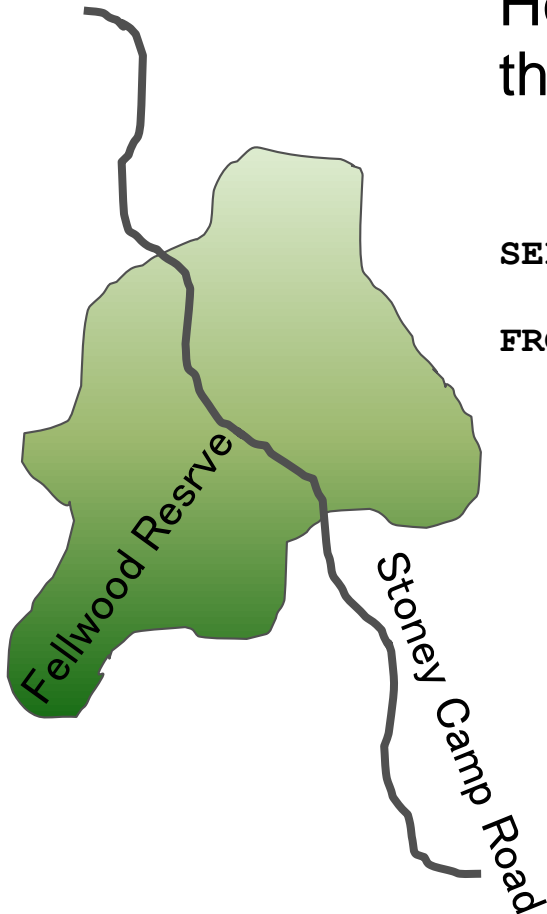
```
st_length(st_geogfromtext('linestring(103.8198 1.3521,151.2093 -33.8688)'));
```

```
st_length_spheroid(st_geomfromtext('linestring(103.8198 1.3521,151.2093 -33.8688)')  
, 'SPHEROID["GRS_1980",6378137,298.257222101]');
```

```
st_distance(st_geogfromtext('point(103.8198 1.3521)')  
,st_geogfromtext('point(151.2093 -33.8688)')));
```

Intersections

- ST_Intersects – Returns true if one geometry intersects another
- ST_Intersection – Returns the geometry of the intersected area



How much of Stoney Camp Road goes through Fellwood Reserve?

```
SELECT
    ST_Intersection(g.reserve,g.road) AS intersection
FROM
    (
        SELECT way FROM reserves
            WHERE name = 'Fellwood Reserve') AS reserve,
        SELECT way FROM roads
            WHERE name = 'Stoney Camp Road') AS road
    ) AS g;
```

Contains and Within

■ `ST_Contains(Obj_A.geom, Obj_B.geom)`

■ True When

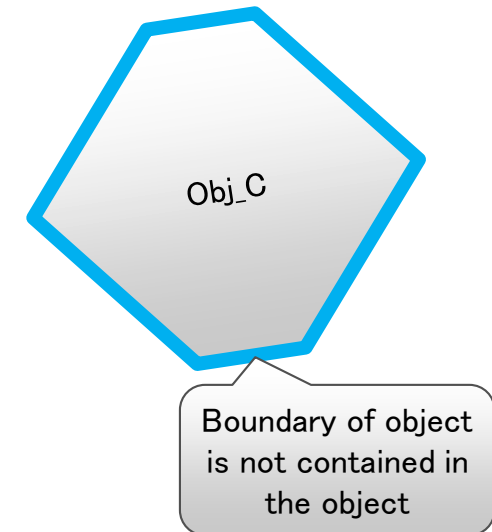
- Obj_B has no points in the **exterior** of Obj_A
- Obj_B must have at least one point in the **interior** of Obj_A

■ `ST_Contains(Obj_C, ST_Boundary(Obj_C)) = False`

■ `ST_Within(Obj_A.geom, Obj_B.geom)`

■ Inverse of `ST_Contains`

■ `ST_Within(A,B) = ST_Contains(B,A)`



Covers and CoveredBy

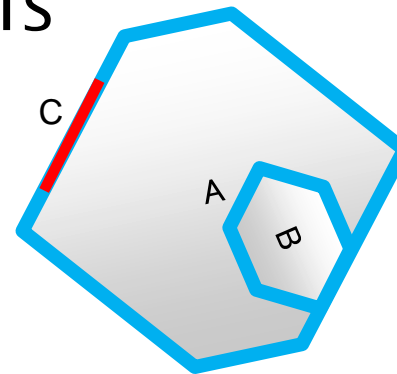
■ ST_COVERS

■ Similar to ST_Contains except that

- Obj_B has no points in the exterior of Obj_A
- Obj_B must have at least one point in the interior **or boundary** of Obj_A

■ Not a OGC standard

■ ST_CoveredBy – inverse of ST_Covers

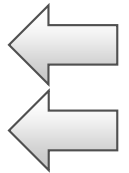


ST_Contains(A,B)= True

ST_Covers(A,B) = True

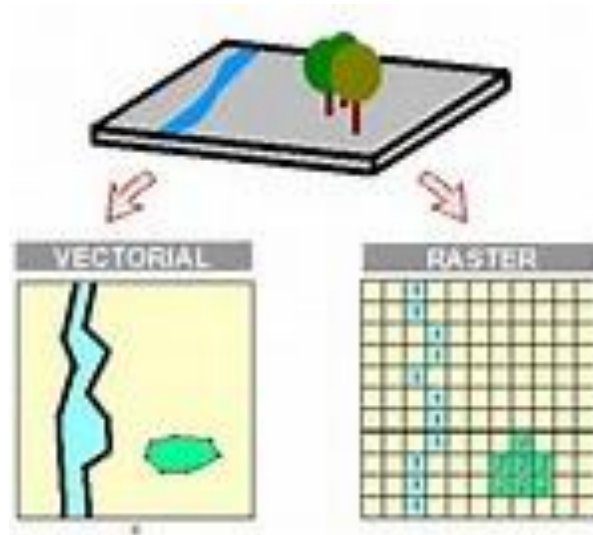
ST_Contains(A,C)= False

ST_Covers(A,C) = True



Raster Types

- Raster data is similar to a bunch of different coloured cells (like pixels on your computer screen)
- Each cell is a store for numeric data, and can store more than just colours
- Cells don't need to be the same shape, but we try to keep them that way for more efficient processing

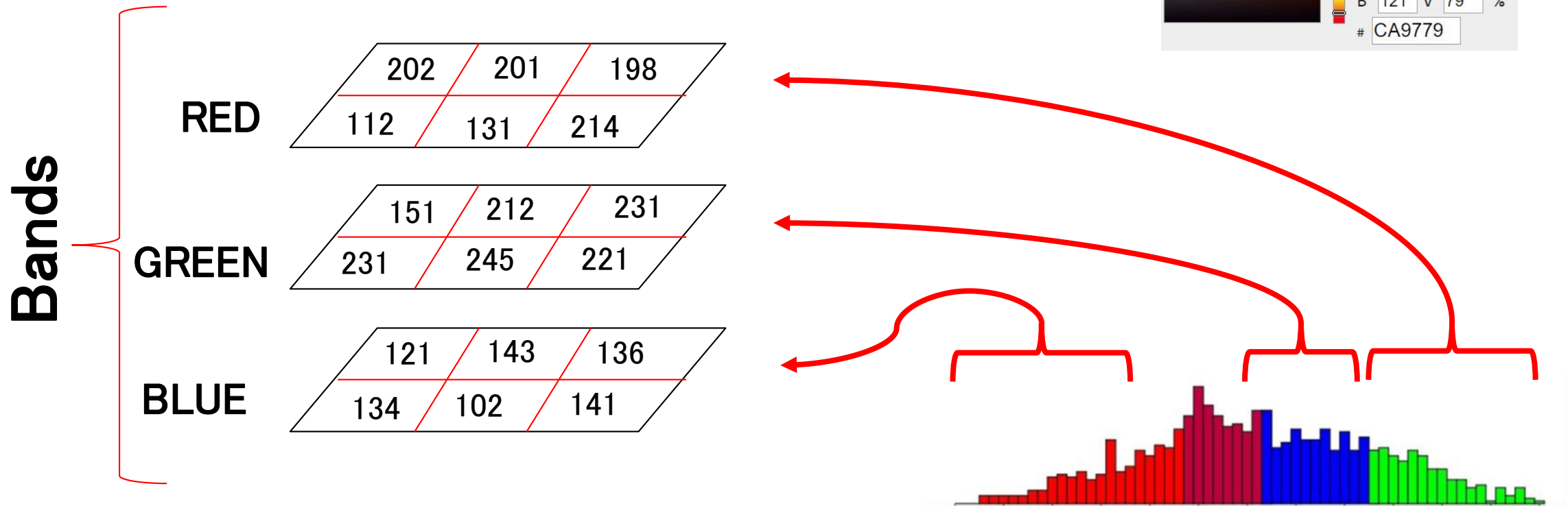


Raster Types

- Each bit of data that a cell can store is referred to as a band or channel
- Rather than trying to store one very large raster, it can be broken into tiles with cells arranged into rows and columns
- Typically satellite images are raster
- Often used as a base from which vector objects can be created

Raster Type Properties

- Width and Height - measured in cells
- Bands – at least one and can have hundreds



Raster Type Properties

- Width and Height - measured in cells
- Bands – at least one and can have hundreds
- Spatial Reference System – an SRID gives the reference system
- Cell Width and Height – relates to real life measurement
 - eg 5 meters wide by 10 meters high
- Cell Scale – required to identify the location of a particular cell relative to spatial co-ordinates
 - In the above example of 5M X 10M the scale would be $x=1:5$ and $y=1:10$ (normally measured from top left corner of a tile)
- Skew – 0 means no skew, but if one is supplied it refers to the angle that the raster is rotated to

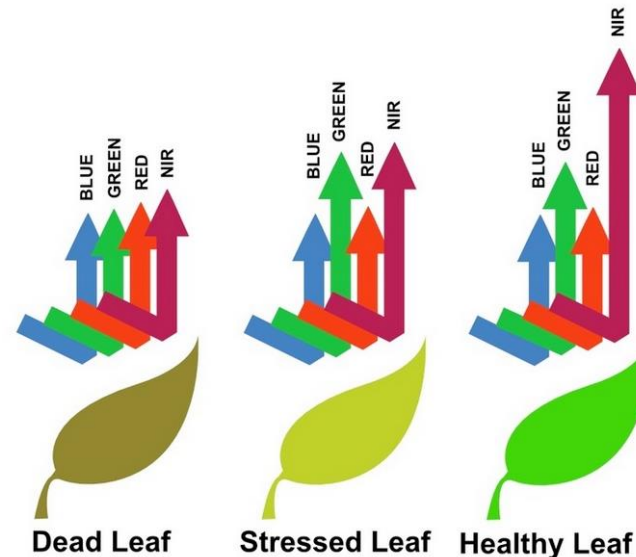
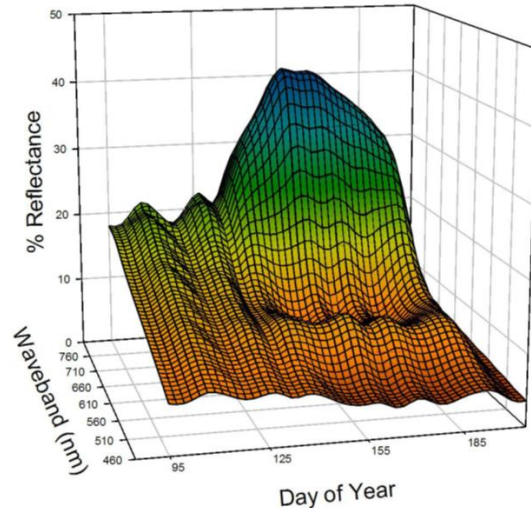
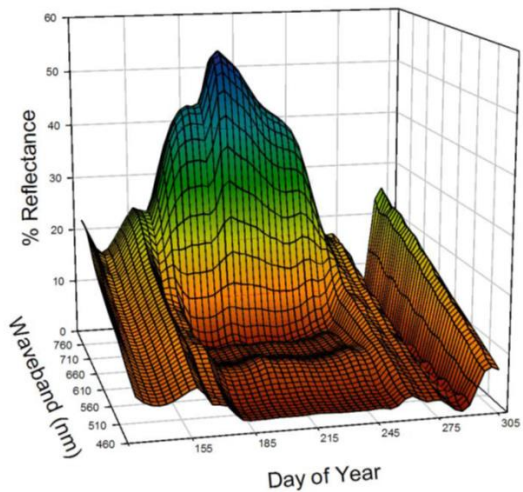
Useful applications for PostGIS (RASTER USAGE)

■ Precision agriculture



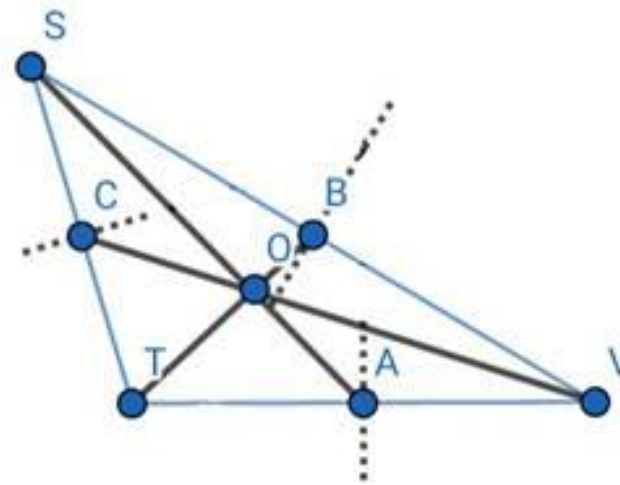
Useful applications for PostGIS (RASTER USAGE)

- Drone flight path management
- Spectral (RGB) image analysis

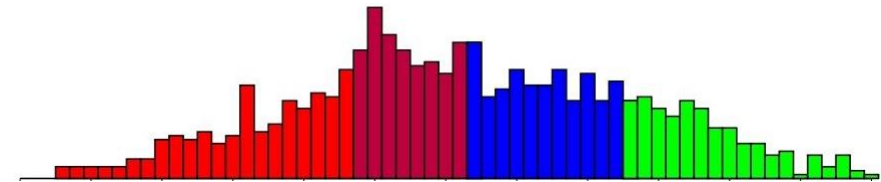


Useful PostGIS Functions

- ST_MapAlgebra
- ST_Colormap
- ST_PixelAsPoint
- ST_Contains
- ST_Histogram
- ST_AsJPEG / ST_asTIFF



0	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
1	17	33	49	65	81	97	113	129	145	161	177	193	209	225	241
2	18	34	50	66	82	98	114	130	146	162	178	194	210	226	242
3	19	35	51	67	83	99	115	131	147	163	179	195	211	227	243
4	20	36	52	68	84	100	116	132	148	164	180	196	212	228	244
5	21	37	53	69	85	101	117	133	149	165	181	197	213	229	245
6	22	38	54	70	86	102	118	134	150	166	182	198	214	230	246
7	23	39	55	71	87	103	119	135	151	167	183	199	215	231	247
8	24	40	56	72	88	104	120	136	152	168	184	200	216	232	248
9	25	41	57	73	89	105	121	137	153	169	185	201	217	233	249
10	26	42	58	74	90	106	122	138	154	170	186	202	218	234	250
11	27	43	59	75	91	107	123	139	155	171	187	203	219	235	251
12	28	44	60	76	92	108	124	140	156	172	188	204	220	236	252
13	29	45	61	77	93	109	125	141	157	173	189	205	221	237	253
14	30	46	62	78	94	110	126	142	158	174	190	206	222	238	254
15	31	47	63	79	95	111	127	143	159	175	191	207	223	239	255



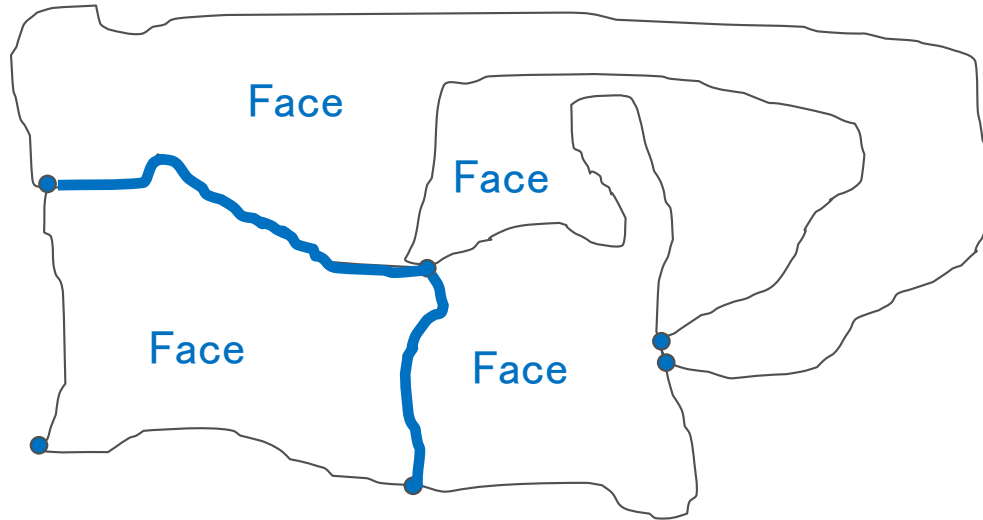
Topology

■ Topology

- Topology types maintain the relationship between spatial features
- Understands the impact of modifying a spatial object
- Became a significant component of PostGIS in version 2.0
- Installed as an extension
 - Create extension postgis_topology

Topology

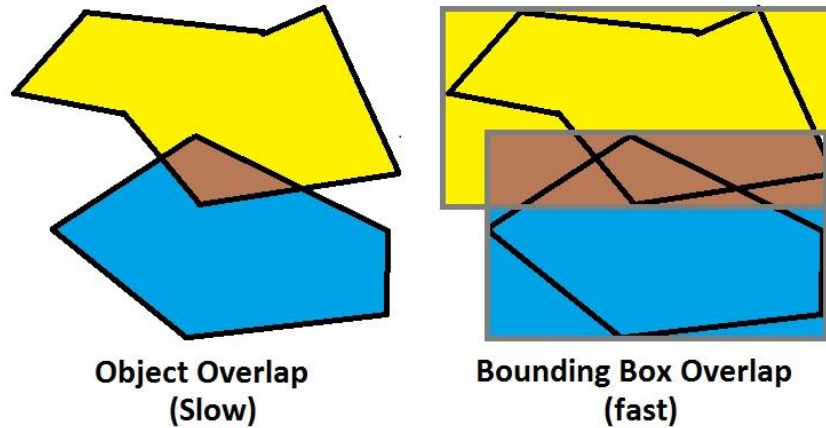
- Every intersection is a node
- Edges are shared (not separate entities like with a geometry polygon)
- Faces share nodes and edges



PostGIS Indexes

■ Spatial Indexes

- Generalised Search Tree (GIST) – need to specify as PostgreSQL implements extended indexes that allow a B-Tree to be created on any type for example



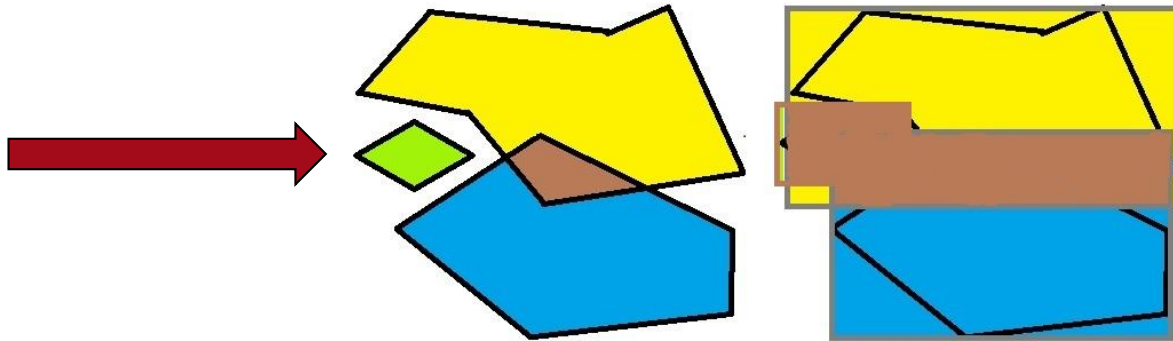
If we use the default B-Tree

If we use the GIST

Spatial Database

■ Spatial Indexes

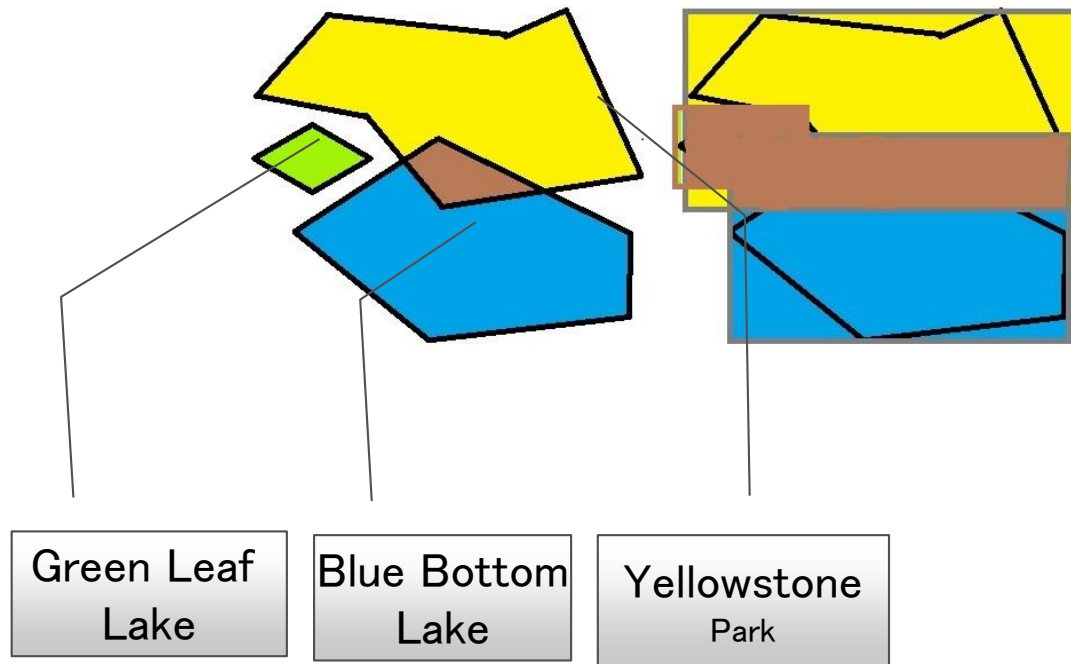
- Generalised Search Tree (GIST)



Spatial Database

■ Spatial Indexes

■ Generalised Search Tree (GIST)



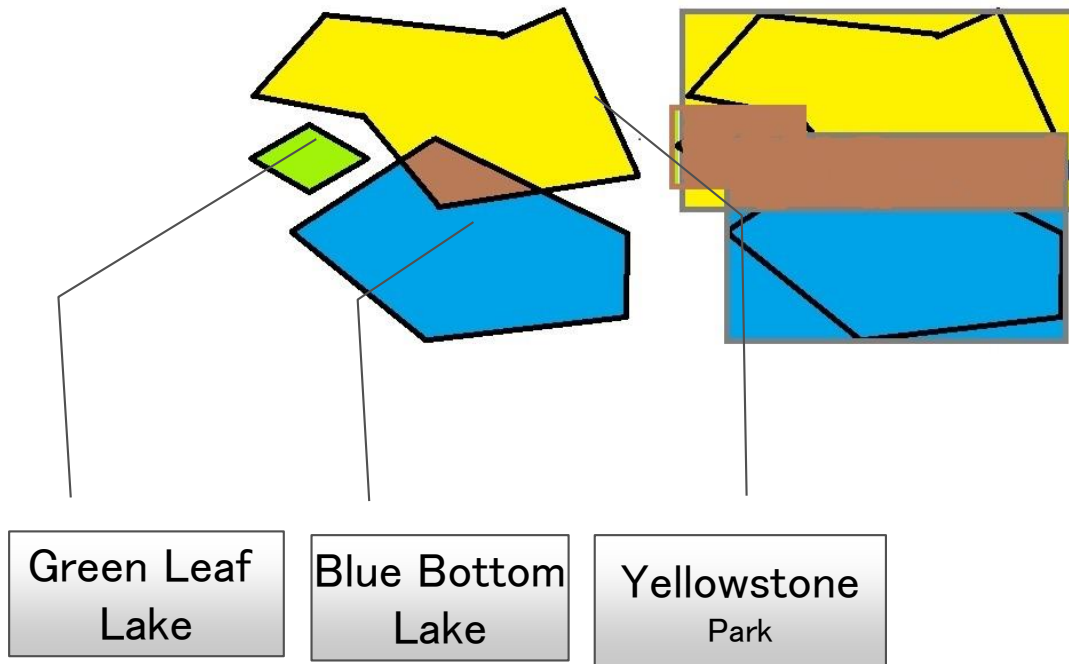
```
SELECT l.name  
FROM lake l, park p  
WHERE l.geom && p.geom;
```

Returns both 'Green
Leaf Lake'
And
'Blue Bottom Lake'

Spatial Database

■ Spatial Indexes

■ Generalised Search Tree (GIST)



```
SELECT l.name  
FROM lake l, park p  
WHERE l.geom && p.geom;
```

Returns both 'Green
Leaf Lake'
And
'Blue Bottom Lake'

```
SELECT l.name  
FROM lake l, park p  
WHERE ST_Overlaps(l.geom,p.geom);
```

Returns only 'Green
'Blue Bottom Lake'

Bounding Boxes and Comparisons

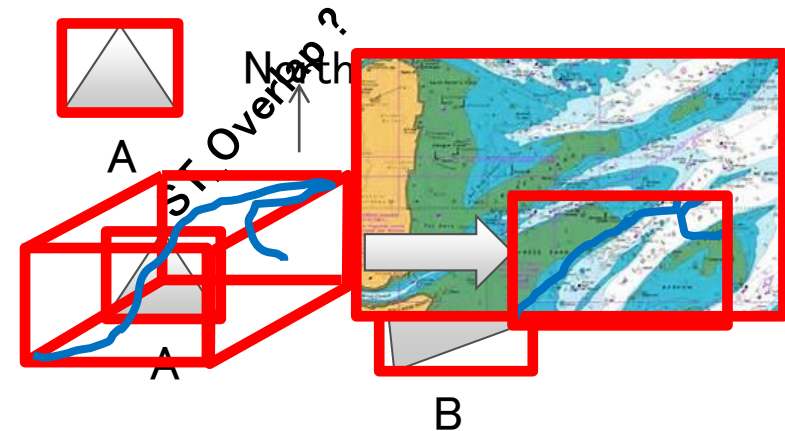
■ GIST indexes

■ All geometries have a bounding box

- Geometry (vector) objects
- Geography (vector) objects
- Raster objects

■ Can easily and quickly be compared

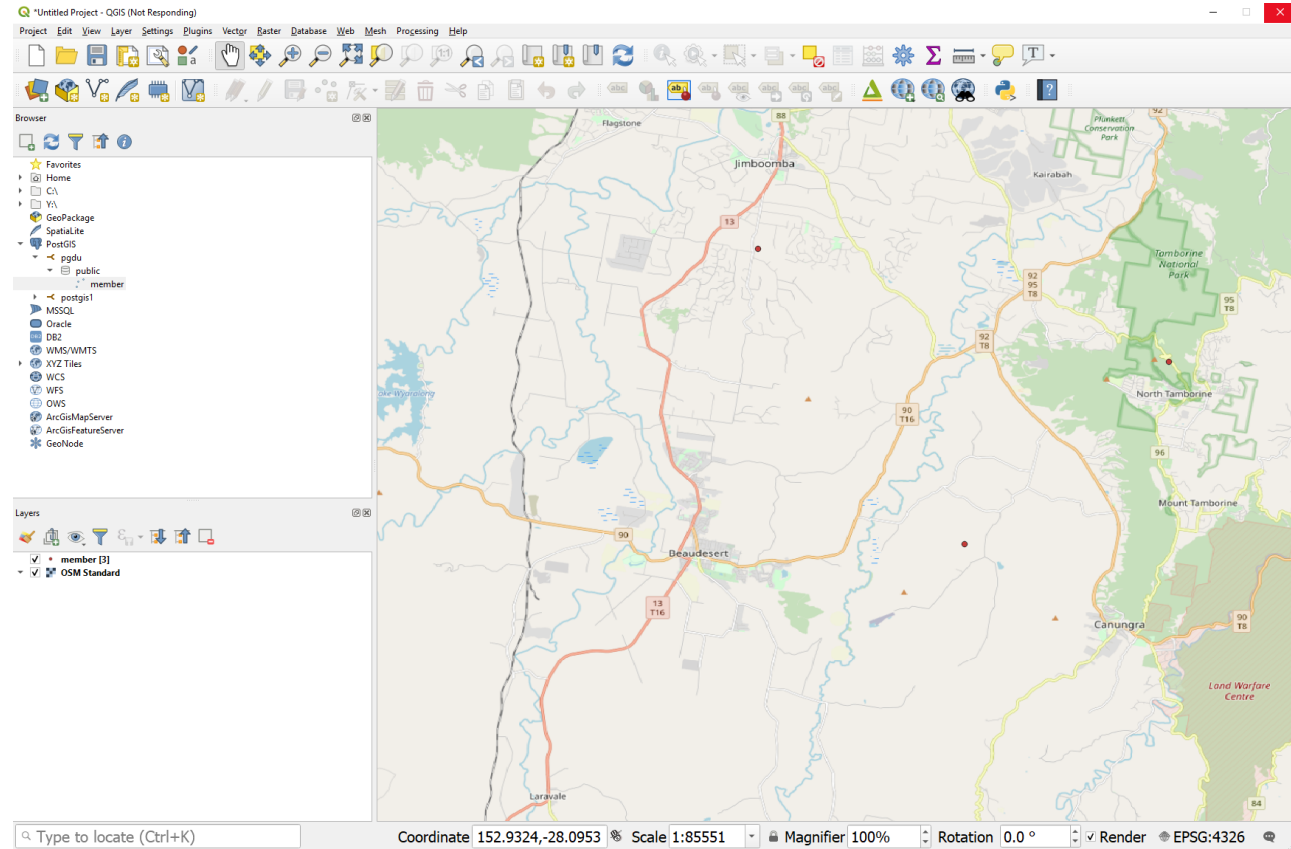
- Is bounding box of geometry **A** West of bounding box of geometry **B** ?
- Raster bounding boxes can be compared with geometry vector bounding boxes
- Geography bounding boxes must be converted to geometry bounding boxes before they can be compared to Geometry or raster types



Visualisation Tools

■ QGIS

■ OpenJump



Loading Data

The screenshot shows the Queensland Government Open Data Portal. The header includes the Queensland Government logo, the text 'Open Data Portal', and navigation links: 'Data', 'News and events', 'Case studies', 'Standards and guidance', and 'Contact'. A search bar is located on the right. Below the header, the breadcrumb 'Home / Datasets' is visible. On the left, there is a sidebar with a list of organizations and their dataset counts: Environment and Sci... (124), Natural Resources... (121), Agriculture and Fis... (49), Transport and Main... (26), State Development... (17), Police (9), Queensland Fire and... (4), Science, Informatio... (4), Government commerci... (3), and State Library of Qu... (2). Below this is a 'Show More Organizations' link. Under the 'Groups' section, 'Maps and geospatial' is selected with 364 datasets, and other groups like 'Sciences' (61) and 'Environment' (37) are also listed. The main content area shows '364 datasets found' and a search bar. A dropdown menu for 'Order by' is set to 'Relevance'. A filter for 'Groups: Maps and geospatial' is applied. Three dataset results are shown, each with a title, description, and a 'BEST' badge: 'Queensland geology regional web map service', 'Queensland geology observations web map service', and 'Queensland geology detailed web map service'.

Queensland Government
Open Data Portal

Data News and events Case studies Standards and guidance Contact Search

Home / Datasets

Organizations

Environment and Sci...	124
Natural Resources...	121
Agriculture and Fis...	49
Transport and Main...	26
State Development...	17
Police	9
Queensland Fire and...	4
Science, Informatio...	4
Government commerci...	3
State Library of Qu...	2

Show More Organizations

Groups

Maps and geospatial	364
Sciences	61
Environment	37

Search datasets...

364 datasets found

Order by: Relevance

Groups: Maps and geospatial

Queensland geology regional web map service
Map Service showing whole of state regional geology data sets maintained by the Department of Natural Resources, Mines and Energy. The data sets are organised by layers...

Queensland geology observations web map service
Map Service showing the location of field sites where primary and tectonic structures have been measured, samples have been collected and isotopically dated, and fossils have...

Queensland geology detailed web map service
Map Service showing whole of state detailed geology data sets maintained by the Department of Natural Resources, Mines and Energy. The data sets are organised by layers...

```
shp2pgsql -I -s 4283 SHAPEFILE.shp DATATABLE |  
psql -U DATABASE_USER -d DATABASE_NAME
```