Spatial Database Management
GEP 664 / EES 79903

Class #12: Rasters, Other Database Formats

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Today's Topics

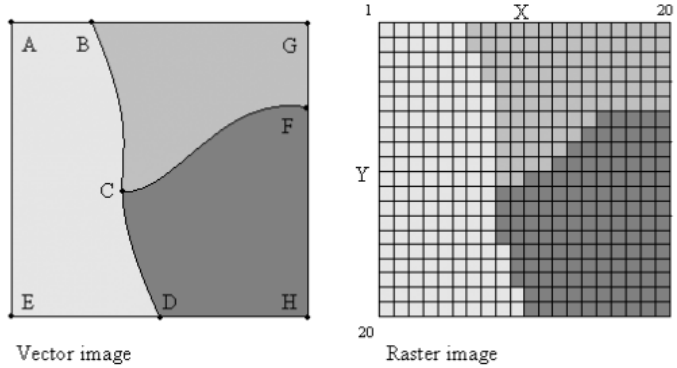
Rasters

SQLite / Spatialite

ArcGIS

Next Class

Rasters



Vector		
Polygon ID	Coordinates	Soil Type
1	A,B,C,D,E	Chalk
2	B,C,F,G	Clay
3	C,F,H,D	Gravel

Raster	
Grid Ref.	Item
x=1, y=1	Chalk
X=2, y=1	Chalk
X=3, y= 1	Chalk
X=4 ... etc.	...
X=20, y=20	Gravel

Image from http://www.arts-humanities.net/wiki/gis_geographic_information_system_archaeology

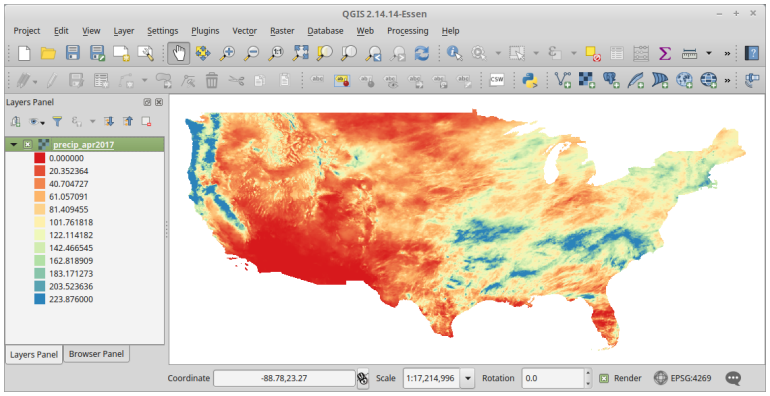
Rasters in PostGIS

Spatial databases are largely a vector-based world. Raster support is recent.

- All imported data is converted and stored in a PostGIS raster format
- Rasters have their own internal tables (raster_columns) and functions
- Tables typically consist of rows where each row is a tile, and the raster column for that row contains all the pixels
- Alternative to storing raster in the database is storing it outside, with a reference table in the db

Example - PRISM Data

We'll use some monthly precipitation data from PRISM as an example - `http://prism.oregonstate.edu/`



Importing Data

Use the raster2pgsql command line tool, stored in the bin folder in your installation of PostgreSQL.

- Windows users: this would be in: Program Files - PostgreSQL - 9.4 - bin
- Windows users must navigate to that folder in the command line to run the program
- Mac and Linux users can execute the program from any location in the shell
- Make life simpler: move import files to a temporary folder near the top of your directory tree
- The GDAL command line tool can be used to get info about rasters and do preprocessing before import

raster2pgsql

Use switches to set options. Type raster2pgsql to see them all.

```
raster2pgsql -s 4269 -C
C:\workspace\prism\PRISM_ppt_provisional_4kmM3_201704_bil.bil
precip_apr2017 | psql -h localhost -U postgres -p 5432 -d gep664
```

- Run the tool, -s specifies the SRID for the layer, -C enforces common db constraints
- (adding -R after srid would keep the file outside the db)
- Provide full path to the import file, followed by name of new table in the db (can also specify schema.table)
- Add a pipe | followed by switches to connect to the database in psql: -h host, -U username, -p port, -d database

Raster Column

```
SELECT *
FROM raster_columns;
```

r_table_cat name	r_table_schema name	r_table_name name	r_raster_col name	srid integer	scale_x double precision	scale_y double precision	blocksize_x integer	blocksize_y integer
gep664	public	precip_apr2017	rast	4269	0.041666666667	-0.041666666667	1405	621

same_alignment boolean	er	regular_blocking integer	num_bands boolean	pixel_types	locking boolean	num_bands integer	pixel_ty text[]	extent geometry
t		f	1	{32BF}		{-9999	{f}	0103000020AD10

Pixel Statistics - Summaries

ST_SummaryStats takes the raster band as input

```
SELECT (stats).*
FROM (
SELECT ST_SummaryStats(rast,1) AS stats
FROM precip_apr2017)
AS summary;
```

	count bigint	sum double precision	mean double precision	stddev double precision	min double precision	max double precision
1	481631	38578215.1567372	80.0991114706845	57.7787504812905	0	1026.9560546875

Pixel Statistics - Histogram

ST_Histogram takes the raster band and number of summary buckets as input

```
SELECT (stats).*
FROM (
SELECT ST_Histogram(rast,1,6) AS stats
FROM precip_apr2017)
AS summary;
```

	min double precision	max double precision	count bigint	percent double precision
1	0	171.159342447917	449245	0.932757650566512
2	171.159342447917	342.318684895833	31140	0.0646553066559254
3	342.318684895833	513.47802734375	1074	0.00222992290778625
4	513.47802734375	684.637369791667	161	0.000334280808336673
5	684.637369791667	855.796712239583	9	1.86865048138513e-05
6	855.796712239583	1026.9560546875	2	4.15255662530028e-06

Creating and Clipping

Clip the raster using geometry of state boundaries (from the Census TIGER files) and store in a new table. Spatial index must be created on convex hull of the raster.

```
CREATE TABLE ny_precip_apr2017 (
rid serial PRIMARY KEY,
rast raster);

INSERT INTO ny_precip_apr2017(rid, rast)
SELECT p.rid, ST_CLIP(p.rast, s.geom)
FROM precip_apr2017 p, state_bndy s
WHERE s.stusps='NY';

CREATE INDEX ny_precip_apr2017_idx ON ny_precip_apr2017
USING gist( ST_ConvexHull(rast) );
```

Adding Constraints

Check the raster catalog after loading and no constraints exist. Add constraints to update the catalog, and check again.

```
SELECT * FROM raster_columns;
```

r_table_catalog name	r_table_schema name	r_table_name name	r_raster_column name	srid integer	scale_x double precision	scale_y double precision	blocksize_x integer	blocksize_y integer	same_alignment boolean
gep664	public	ny_precip	rast	0					f
gep664	public	precip_ap	rast	4269	0.041666666667	-0.041666666667	1405	621	t

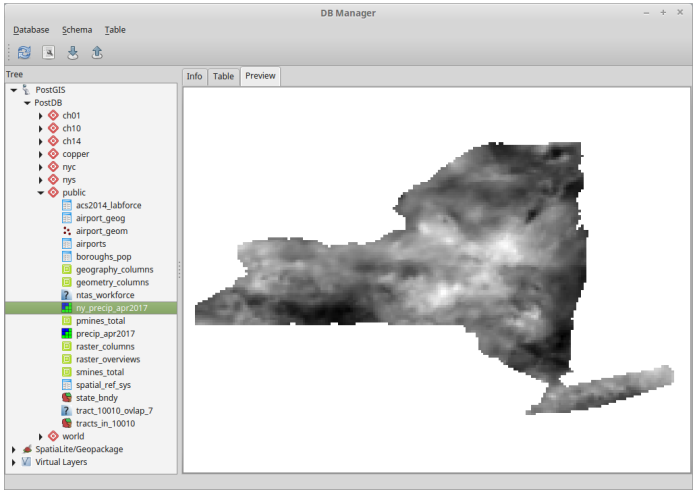
```
SELECT AddRasterConstraints('ny_precip_apr2017'::name,
'rast'::name);
SELECT * FROM raster_columns;
```

r_table_catalog name	r_table_schema name	r_table_name name	r_raster_column name	srid integer	scale_x double precision	scale_y double precision	blocksize_x integer	blocksize_y integer	same_alignment boolean
gep664	public	ny_precip	rast	4269	0.041666666667	-0.041666666667	193	110	t
gep664	public	precip_ap	rast	4269	0.041666666667	-0.041666666667	1405	621	t

Constraints are applied to the entire table; if you are loading multiple rasters (tiles) into one table, don't apply constraints until everything is loaded.

QGIS Support

Rasters cannot be added to projects from the Browser or through the Add PostGIS layers interface. Use the Database Manager to preview and add raster layers.



Raster Processing

These functions modify the underlying pixels of the raster.

ST_Transform : convert from one SRS for another

ST_Rescale : changes pixel size by specifying specific pixel size

ST_Resize : similar to rescale, except you specify percentage of the original

ST_Resample : changes pixel size by specifying width and height for entire raster

ST_Reclass : change the actual value of the pixels

For expanded details on raster analysis and processing, see *PostGIS in Action* Chapter 12 (Chapter 7 just covers the basics)

Conversion and Exporting

- ST_AsRaster converts vectors to rasters
- There are several functions for converting rasters to vectors. Create convex hulls, envelopes, or actual polygons.
- There are several functions for exporting rasters. There are specific functions for common image formats (like ST_AsTiff) or the ST_AsGDALRaster for 20 other formats.

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SQLite

SQLite is a public-domain, file-based database that was specifically created for easily deploying and embedding databases in software applications.

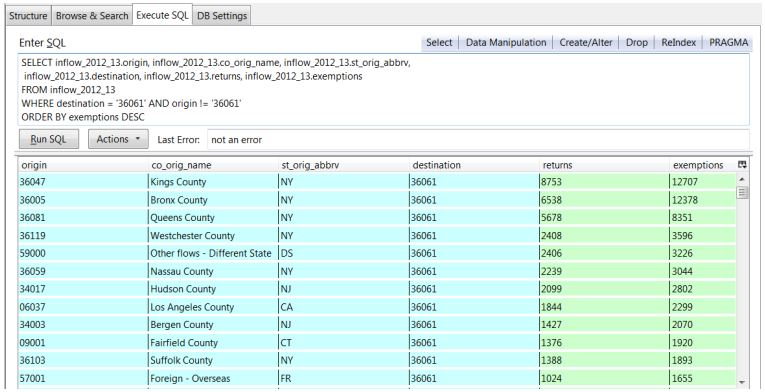
- Originally released in 2000, widely used
- Implements most of the SQL-92 standard
- Uses PostgreSQL as a reference platform
- Does not use a client-server database engine; it is embedded into end programs or used as a stand-alone database
- Uses data type affinities for columns, rather than strict types

SQLite Tools

SQLite : Command-line program from the project developers

SQLite Manager : Free plugin for the Firefox Browser

SQLite Browser : Free desktop program



Spatialite

Spatialite is the open source spatial extension to SQLite, similar to how PostGIS is the spatial extension to PostgreSQL.

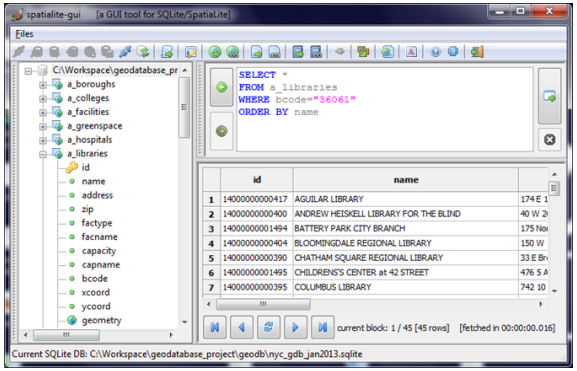
- Originally released in 2008
- Uses the same OGC standards for spatial SQL as PostGIS
- Roughly equivalent to PostGIS in supporting vector geometry
- No equivalent geography type, but there are functions for calculating geodetic distance
- Limited (but growing) support for rasters and topology

Spatialite Tools

Spatialite CLI : Command-line program from the project developers

Spatialite GUI : Graphic interface from the project developers

QGIS : Through the Database Manager



SQLite Pluses

- Very easy to create and deploy
- File-based, so easy to copy and move around
- Provides many of the relational database benefits that shapefiles lack
- Provides the ability to do SQL and spatial SQL
- Can easily be tapped into with scripting and programming languages

SQLite Minuses

- Not intended for direct multi-user access over a network
- Size limitations on files and tables
- Implements just a subset of SQL language
- Spatial support is largely limited to geometry type
- Spatial indexes must be called explicitly
- Limited documentation / tutorials for Spatialite

SQL Features Not Supported

Nothing beyond the SQL-92 standard, and:

- No schemas
- No right or full outer joins
- Limited support for ALTER TABLE (you can only rename and add columns)
- No GRANT and REVOKE as permissions can only be set at the file level, not for users or objects
- No strict data types

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ArcGIS Formats

The ArcGIS formats are proprietary

- Personal Geodatabase is built on MS Access, and is no longer supported
- File Geodatabase is the default, entirely self-contained
- ArcSDE links ArcGIS to a number of large, proprietary databases (SQL Server, Oracle) as well as PostgreSQL

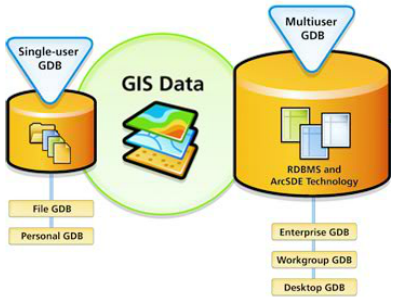
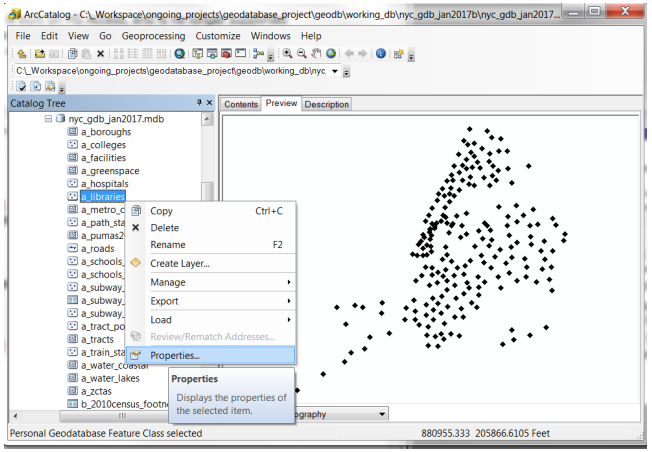


Image source: `http://www.esriuk.com/software/arcgis/geodatabase`

ArcGIS Interface

Interface for working with File and Personal Geodatabases is the ArcCatalog



Geodatabase Pluses

The file geodatabase offers many advantages over shapefiles:

- Gather features and attributes in one container
- Can handle vectors, rasters, and topology
- Easier to enforce integrity and entity constraints
- Create domains, subtypes, and indexes
- Explicitly link features together in relationship classes
- Easy to use GUI interface in ArcCatalog
- Supports access for multiple readers (but not writers)

Geodatabase Minuses

The file geodatabase has drawbacks relative to PostGIS

- Cannot do any SQL or spatial SQL; must use internal Arc tools or an enterprise-level db via ArcSDE
- Issues with backwards incompatibility and forced obsolescence
- As a proprietary format, it does not work well with other open source GIS software

PostGIS Support

You can connect to PostGIS and Spatialite databases via the ArcCatalog (from 10.2 forward), view data, overlay data with other file types, and perform analysis. Creating objects or db administration is problematic or not possible.

PostgreSQL is supported via enterprise-level ArcSDE (the only FOSS option; other options are proprietary).

PostgreSQL Beyond pgAdmin

Remember: PostgreSQL / Postgis is independent from a specific interface. Use what works best. External PostGIS tools (like the shapefile loader) can always be used outside.

- psql : tried and true command-line, takes practice
- pgAdmin 3 : solid GUI for over 12 years, no-longer supported after PostgreSQL 9.6 (but likely to survive)
- pgAdmin 4 : new version released with PostgreSQL 9.6, slicker but problematic
- phpPgAdmin : common web-based client
- DBeaver : one of many independent GUI tools
- QGIS : with the database manager
- OpenJUMP : Favorite GIS package of the *PostGIS in Action* authors for PostGIS

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Due Next Class

The following are due at the beginning of our next class:

Final Project Presentations

Submit your presentations to the Box by 5pm on class day