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- Introduction

Introduction





- Introduction

Who is Ian?

- A geospatial consultant at Astun Technology
- A developer of GeoTools and GeoServer
- Someone who helps people who are wrong on the internet





Why do I (we) need to know this stuff?

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Why do I (we) need to know this stuff?

Projections, Coordinate Reference Systems, and all that Jazz

- Projected vs. Geographic
- Coordinate Reference System (CRS) / Spatial Reference System (SRS)
- Spherical, Ellipsoid, Geoid, Datum





Why do I (we) need to know this stuff?

Map Projection(s)

In cartography, a map projection is a way to flatten a globe's surface into a plane in order to make a map. This requires a systematic transformation of the latitudes and longitudes of locations from the surface of the globe into locations on a plane. All projections of a sphere on a plane necessarily distort the surface in some way and to some extent. Depending on the purpose of the map, some distortions are acceptable and others are not; therefore, different map projections exist in order to preserve some properties of the sphere-like body at the expense of other properties.

Wikipedia





Why do I (we) need to know this stuff?

Geoids and Datums







Why do I (we) need to know this stuff?

Common Projections







Why do I (we) need to know this stuff?

Local Projections



OSGB National Grid



OSGB National Grid





Seriously, I just want to draw a map!

Seriously, I just want to draw a map!





What do you want to show?



Consider the newly, independent Republic of Sussex, it has acquired missiles with a range of 1000km and 5000km, where can it threaten?





Easy (but wrong)





Convert degrees to metres?

Everyone Wikipedia knows that 1 degree is 111 km
So 1000km = 1000/111km = 9.009009 degrees

Buffer	- •
Parameters Log	Buffer
Input layer	This algorithm computes a buffer area for all the features in an input layer, using a fixed or dynamic distance.
Distance 9.009009 @ C degrees A C Segments 5	The segments parameter controls the number of line segments to use approximate a quarter circle when creating rounded offsets. The end caps type parameter controls how line endings are handled in the buffer. The join style parameter specifies whether round, miter or beveled joins should be used when offsetting corners in a line. The mitter limit parameter is only applicable for mitter join styles, and controls the maximum distance from the offset curve to use when
End cap style Round	
Join style Round •	
Miter limit	
Dissolve result Buffered	
[Create temporary layer]	creating a mitered join.
0%	
? Help Run as Batch Process	□ <u>C</u> lose ∉Run



Wrong answer



So I need metres - Web Mercator!





Still not right?



Centre the projection on Sussex











Conclusions

- Never calculate a buffer in degrees
- Never do any geographical analysis in Web Mercator
- Try to find an equal area projection if and only if your process is related to the area of the unit





Spherical Geometry Fun





Which line is shortest?



JN LOGY

Distances

- On a Plane
 - Given two points (x_1, y_1) and (x_2, y_2)

•
$$d = \sqrt{((x_1 - x_2)^2 + (y_1 - y_2)^2)}$$

- On a Sphere
 - Given two points (λ_1, ϕ_1) and (λ_2, ϕ_2)

 $\Delta \sigma = \arctan \frac{\sqrt{(\cos \phi_2 \sin(\Delta \lambda)^2 + (\cos \phi_1 \sin \phi_2 - \sin \phi_1 \cos \phi_2 \cos(\Delta \lambda))^2)}}{\sin \phi_1 \sin \phi_2 - \cos \phi_1 \cos \phi_2 \cos(\Delta \lambda)}$

• $d = r\Delta\sigma$

On an Ellipsoid



 Use GeographicLib (C.F.F. Karney, Geodesics on an ellipsoid of revolution, arXiv:1102.1215 (Feb. 2011))



How many degrees do the angles of a triangle sum to?

Consider the WGS:84 points:

- POINT(0 0)
- POINT(90 0)
- POINT(0 90)





A right angle triangle?





Or a right angle in every corner?





Conclusion

- Spherical geometry will make your head hurt
- There is a reason Euclid (and everyone else) avoided it
- Where possible transform to a local cartesian projection
- Otherwise be **very** careful with your assumptions
- Use some else's code Do Not Write this yourself





Why doesn't my data show up (where I expect it)?

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Why doesn't my data show up (where I expect it)?

Shall we play a game?

Where is (51.0, 0.0)?Is it different than (0.0, 51.0)?







Why doesn't my data show up (where I expect it)?







Why doesn't my data show up (where I expect it)?

So nothing - without Metadata!

- EPSG:4326 (WGS84, LAT/LON)
- EPSG:4326 (WGS84, LON/LAT)
- EPSG:2163 (US National Atlas)
- EPSG:32717 (WGS84-UTM17S)
- EPSG:31287 (MGI/ Austria Lambert)
- EPSG:3857 (Web Mercator)





OK, now why don't my layers line up?

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Two Layers in Pennsylvania State Plane









Why don't my map layers line up?

Neither layer came with a .prj file so I guessed PA S :-)
Seems like one is in PA North (ftUS) and the other is PA North (m)







How do I reproject my data

- Don't use Set CRS this just changes the metadata
- Unless there is no metadata in that case it's fine if you know the right value
- Save (export) your data and select the new CRS you would like







When base maps go wrong

Add Natural Earth Coastline (EPSG:4326)



OK, now why don't my layers line up?

Adding in some Open Street Map Background (EPSG:3857)







OK, now why don't my layers line up?

Why don't my map layers line up?

- The projections don't match
- OSM is in EPSG:3857
- I have no idea why QGIS doesn't reproject them but with Quick Map Services it doesn't!





Set the project to EPSG:3857 if you use QuickMapServices







Now you see it...







OK, now why don't my layers line up?

... Now you don't







No projection -> Default projection

- Ordnance Survey believe they don't (always) need to add a projection!
- QGIS default "default" CRS is EPSG:4326 (WGS:84)
- This is the only time you should ever use Set Layer CRS
- Override the default to EPSG:27700 in settings





OK, now why don't my layers line up?







Visit Null Island

- Null Island where the Prime meridian crosses the Equator
- Or where your data is if you tell QGIS that your WGS84 coordinates are in Web Mercator







Conclusion

- Coordinates with out a projection are meaningless numbers
- If there is no projection supplied look in the metadata
- Fix your input data once, don't rely on remembering every time
- Look at the range of the bounding box to give clues
 - \blacksquare +/- 180 and +/- 90 probably a geographic projection
 - +/- 100000000 probably in metres or feet.





Please, just make it stop

Please, just make it stop





I use PostGIS so I can use GEOGRAPHY and ignore all this!

- You can use the geography data type (in exchange for many fewer functions) and much slower performance with most operations (on order of 10 times slower).
- ST_Transform is a fairly cheap process, so it's okay to run it for each geometry if you keep functional indexes on the transformations of the form CREATE INDEX idx_geomt ON sometable USING gist(ST_Transform(geom,some_srid) and then use ST_DWithin(a.geom,

ST_Transform(sometable.geom,some_srid), some

_distance) for distance checking. Now when ST_DWithin is used with the transformed geometry, the function spatial index will kick in to help.



Please, just make it stop

Failing that just be careful

- Try not to store data in formats with out explicit internal metadata about projection
 - Prefer databases, GeoPackage or PostGIS, to Shapefiles or CSV
 - Prefer GeoTiff to World files or ASCII grids
- Never ship a file without a projection and metadata describing it
- Reproject to a relevant projection early in your workflow





└─ Please, just make it stop

Conclusions

- Degrees and Metres
 - Never calculate a buffer in degrees
 - Never do any geographical analysis in Web Mercator
 - Try to find an equal area projection if and only if your process is related to the area of the unit
- Spherical geometry will make your head hurt
 - There is a reason Euclid (and everyone else) avoided it
 - Where possible transform to a local cartesian projection
 - Otherwise be very careful with your assumptions
 - Use some else's code Do Not Write this yourself
- Coordinates with out a projection are meaningless numbers
 - If there is no projection supplied look in the metadata
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Please, just make it stop

The End

 A copy of this talk can be found at http://www.ianturton.com/talks/
 All 6K+ questions about projections on GIS StackExchange https://gis.stackexchange.com/questions/tagged/coordinate-system



