Geosemantics, Linked Spatiotemporal Data, and Geo-Ontologies I

Krzysztof Janowicz
STKO Lab
University of California, Santa Barbara, USA

ICCL Summer School 2013: Semantic Web - Ontology Languages and Their Use


Before We start

What to Expect?

Topics

- Sources of geo-data
- **Understand and be able to use geo-data**
- Why geo-semantic matters
- Understand (and value) heterogeneity
- **Get an idea of geo-processing workflows**
- Selected research topics(*)

Style

- Interactive
- **Examples-driven(/**)
- Excursus-based overview of selected topics
- Slides as references, no need to cover them all.

(*) if time permits

(/**) these examples should be entertaining but still realistic
The geo-atom $\langle x, Z, z(x) \rangle$ can account for object and field based views

- $x$ is a point in 4D space-time, $Z$ is an observable property, and $z(x)$ is the intensity of the property at $x$.

- We will first cover spatial reference systems and mapping, then dive into the representation of geo-data, and finally discuss selected topics about semantic reference systems.
Motivating Example: Linked Spatiotemporal Data Map

- A Plate Carrée map showing point-like geo-features from the Linked Data Web. What can we say about coverage and data quality?
- We will revisit this example frequently
A textbook view on data and Geographic Information Systems (GIS)

- Expect the following coverage in pages $a \gg d \geq c \gg b$
- Attribute accuracy is still underdeveloped ($\rightarrow$ semantics)
Displacement can be quantified as position error wrt higher-order measures.

Compute RMSE & error distribution; recall: 1mm map error = 100m at 1:100K.

Leaving the definitions of CRS aside, this part is semantics-free.
Logical Consistency & Constraint Checking

- Inconsistencies can be discovered via (topological) rules
- Most GIS and geo-gatabases implement such checks
Logical Consistency & Constraint Checking

- Inconsistencies can be discovered via (topological) rules
- Most GIS and geo-databases implement such checks
- Temporal aspects are equally important as spatial aspects
Logical Consistency & Constraint Checking

- **Inconsistencies** can be discovered via (topological) rules.
- Most GIS and geo-gatabases implement such checks.
- **Temporal** aspects are equally important as spatial aspects.
- **Geo-ontologies** required for more complex rules, e.g.,
  
  \[
  \text{aground}(\text{vessel}_i) \rightarrow \text{swrlb : reassess}(\text{waterbody}_j) \quad [\text{SWRL+built-ins}]
  \]
Completeness: Note the specific patterns in social media
Social Media as Baseline: Twitter Map

60 minutes of (real-time) tweets.

Have you noticed the different base map?
Geography and the Earth Science

- Geography is not what you learned in school, e.g., memorizing capitals ;-) 

- Geography is the science that studies the landscapes, the features, the inhabitants, and the phenomena of the Earth and the interaction among them.

- Different interconnected branches such as physical geography, human geography, geographic information science.

- Geography is the unique bridge between social sciences, natural sciences, and information sciences.

- As example, faculty members at UCSB’s geography department have PhDs in Ecology, Mathematics, Geography (1), Geoinformatics, Architecture, Psychology, Oceanography, Hydrology, Meteorology, Civil Engineering, Economics, Geodesy, Geology, and so forth.

- Earth Science is an all-embracing term for sciences related to our planet.
The **science, art, and practice** of making and reading maps.

There are many different types of maps, e.g., thematic vs topographic maps. Some maps can be very abstract.

Creating maps involves cartographic generalization and **abstractions**.

The notion of **scale** is central to an understanding of cartography and the representation of geo-features.

**Cartometry** is the science of measurement from maps.

Very long history in **navigation**, today’s scope is broader.

Teaches useful survival skills ;-)
The Waldseemüller map (1507) is like *Cartography in a nutshell*, can you see why?
There Are Many Type of Maps

This cartogram shows the unique visitors to the Semantic Web journal Web page in June 2013 proportional to the size of the country of origin.

Cartograms use the fact that people are familiar with the size and shape of countries to distort those characteristics by the attribute space.
There’s no Such Thing as a True Map

- Dashed lines are disputed; observe how borders change
- See Goodchild’s video at: www.ia.ucsb.edu/pa/display.aspx?pkey=2770
There's no Such Thing as a True Map

- Dashed lines are disputed; observe how borders change
- See Goodchild's video at: www.ia.ucsb.edu/pa/display.aspx?pkey=2770
What are these points? What do they represent?

How do we assign point-locations to geo-features?

See http://stko.geog.ucsb.edu/pictures/lstd_map.png
The Earth is not a perfect sphere. It is an **oblate spheroid**. Due to the fact that Earth is spinning about its axis, centripetal forces cause it to be fatter than it is tall.

*(The term ellipsoid is used interchangeably with spheroid.)*
The Geoid – Physical Model based on Gravity

- While the ellipsoid is a geometric model, the geoid is the physical model based on a surface of equal gravitational pull.

- The geoid is required to introduce elevation to cartography.

→ It is still not the real surface of the earth.
SURFACE vs GEOID vs ELLIPSOID

What about terrain, mountains, and valleys?

Remark: if the Earth (with all its mountains and trenches) would be reduced to the the size of a bowling ball, it would be smoother than a bowling ball.
Best (Local) Fit

Table 3.1: Official ellipsoids. Radii may be specified more precisely than the 0.1 meter shown here (from Snyder, 1987 and other sources).

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Equatorial Radius, $r_1$ (meters)</th>
<th>Polar Radius, $r_2$ (meters)</th>
<th>Flattening Factor, $f$</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airy</td>
<td>1830</td>
<td>6,377,563.4</td>
<td>6,366,256.9</td>
<td>1/299.32</td>
<td>Great Britain</td>
</tr>
<tr>
<td>Bessel</td>
<td>1841</td>
<td>6,377,397.2</td>
<td>6,366,079.0</td>
<td>1/299.15</td>
<td>Central Europe, Chile, Indonesia</td>
</tr>
<tr>
<td>Clarke</td>
<td>1866</td>
<td>6,378,206.4</td>
<td>6,366,583.8</td>
<td>1/294.98</td>
<td>North America, Philippines</td>
</tr>
<tr>
<td>Clarke</td>
<td>1880</td>
<td>6,378,249.1</td>
<td>6,366,514.9</td>
<td>1/293.46</td>
<td>Most of Africa; France</td>
</tr>
<tr>
<td>International</td>
<td>1924</td>
<td>6,378,388.0</td>
<td>6,366,911.9</td>
<td>1/297.00</td>
<td>Much of the world</td>
</tr>
<tr>
<td>Australian</td>
<td>1965</td>
<td>6,378,160.0</td>
<td>6,366,774.7</td>
<td>1/298.25</td>
<td>Australia</td>
</tr>
<tr>
<td>6RS80</td>
<td>1980</td>
<td>6,378,137.0</td>
<td>6,366,752.3</td>
<td>1/298.26</td>
<td>Worldwide</td>
</tr>
<tr>
<td>WGS84</td>
<td>1984</td>
<td>6,378,137.0</td>
<td>6,366,752.3</td>
<td>1/298.26</td>
<td>Worldwide</td>
</tr>
</tbody>
</table>
**Datums – Reference Surfaces**

Horizontal Datum consists of

- Reference ellipsoid (with coordinate system)
- Set of surveyed reference points on the surface
  - E.g., North American Datum of 1983 (NAD 83)
  - World Geodetic System of 1984 (WGS 84)

- Vertical Datum (to determine elevation)
  - North American Vertical Datum of 1988 (NAVD88)
Examples of Datum Shifts

New Jersey control point, successive datum transformations applied

<table>
<thead>
<tr>
<th>Datum</th>
<th>Longitude (W)</th>
<th>Latitude (N)</th>
<th>Shift (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAD27</td>
<td>74° 12' 3.86927&quot;</td>
<td>40° 47' 0.76531&quot;</td>
<td>36.3</td>
</tr>
<tr>
<td>NAD83 (1983)</td>
<td>74° 12' 2.39240&quot;</td>
<td>40° 47' 1.12726&quot;</td>
<td>0.04</td>
</tr>
<tr>
<td>NAD83 (HARN)</td>
<td>74° 12' 2.39069&quot;</td>
<td>40° 47' 1.12762&quot;</td>
<td>0.05</td>
</tr>
<tr>
<td>NAD83 (CORS96)</td>
<td>74° 12' 2.39009&quot;</td>
<td>40° 47' 1.12936&quot;</td>
<td>0.95</td>
</tr>
<tr>
<td>WGS84 (S1150)</td>
<td>74° 12' 2.39720&quot;</td>
<td>40° 47' 1.15946&quot;</td>
<td></td>
</tr>
</tbody>
</table>

In all cases the same physical location.
(Cartesian) Plane Coordinate Systems

Coordinates:
- (3,12)
- (8,10)
- (14,5)
- (5,1.5)
- (1,8)

Attributes:
- Lot #: 1347
- Street: Willow Lane
- Town: Hopkins
Geographic north is determined as the location (in the northern hemisphere) where the *axis of rotation* of the Earth meets the surface.
Geographic Coordinate Systems: Equator & Prime Meridian

- The equator is the widest circle mid-way between the north and south pole which is at a right angle to the polar axis.
- The prime meridian is the longitudinal origin set by (international) convention in 1884 and intersects the Royal Greenwich Observatory in England.
The Prime Meridian (1884)
THE EARTH IN GEONAMES
**Factforge: The Earth on the Linked Data Web**

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>rdfs:seeAlso</td>
<td>dbpedia:Earth, <a href="http://sws.geonames.org/6295630/about.rdf">http://sws.geonames.org/6295630/about.rdf</a></td>
</tr>
<tr>
<td>rdfs:isDefinedBy</td>
<td><a href="http://sws.geonames.org/6295630/about.rdf">http://sws.geonames.org/6295630/about.rdf</a></td>
</tr>
<tr>
<td>rdfs:label</td>
<td>Earth@en, Globe@en, World@en</td>
</tr>
<tr>
<td>skos:altLabel</td>
<td>Earth@en, Globe@en, World@en</td>
</tr>
<tr>
<td>dc:type</td>
<td>geo-ont:LENGTH, geo-ont:L.AREA</td>
</tr>
<tr>
<td>do-term:type</td>
<td>geo-ont:LENGTH, geo-ont:L.AREA</td>
</tr>
<tr>
<td>geo-pos:long</td>
<td>0</td>
</tr>
<tr>
<td>geo-pos:lat</td>
<td>0</td>
</tr>
</tbody>
</table>

*Factforge* is a platform for linked spatiotemporal data. It provides an RDF dataset for the Earth, allowing for querying and exploration of spatial information on the Web of Data. The dataset is structured using geospatial ontologies and includes information about places like Earth, Globe, and World, along with their geographic coordinates.
Gulf of Guinea

From Wikipedia, the free encyclopedia

The Gulf of Guinea is the northeasternmost part of the tropical Atlantic Ocean between Cape Lopez in Gabon, north and west to Cape Palmas in Liberia. The intersection of the Equator and Prime Meridian (zero degrees latitude and longitude) is in the gulf.

Among the many rivers that drain into the Gulf of Guinea are the Niger and the Volta. The coastline on the gulf includes the Bight of Benin and the Bight of Bonny.

The Niger River in particular deposited organic sediments out to sea over millions of years which became crude oil.[citation needed] The Gulf of Guinea region, along with the Congo River delta and Angola further south, are expected to provide around a quarter of the United States' oil imports by 2015[citation needed] This region is now regarded as one of the world's top oil and gas exploration hotspots.[citation needed]

Contents [hide]

1 Name
2 Geography
3 Islands in the Gulf of Guinea
  3.1 Annobón
  3.2 Bioko
  3.3 Corisco
  3.4 The Elbens
  3.5 São Tomé and Príncipe
4 See also
5 References
A query for the population count of places within a 300 miles radius of a specific place:

SELECT distinct ?place ?populationCount
WHERE {
    geo-pos:lat ?lat ; geo-pos:long ?long .
    ?place omgeo:nearby(?lat ?long "300mi");
    ptop:populationCount ?populationCount.
}
Map projections are mathematical transformations between geographic coordinates and plane coordinates.

Graticule on sphere → Projected graticule
**DISTORTION DURING MAP PROJECTION**

- **Ellipsoidal surface**
- **Map surface**

- **Distance** $\overline{ab} < \overline{AB}$
- **Distance** $\overline{de} > \overline{DE}$
The Scale Factor and Lines of True Scale

- Scale factor (SF) = Actual Scale/Principal Scale
- Note how dramatically the scale changes
- Consequences for reading distance (area, and direction) from a map
Projection does Matter
Some More Consequences

What happens to geo-features at +/-180? What happens to the poles?

→ There is nothing such as the best projection, you have to use the projection that works best for your data.
Map Projections

Map projections by developable surface

Map projection by perspective
Map Projection By Aspect

Cylindrical

Equatorial  Transverse  Oblique

Conical
**Tangent and Secant Projections**

**Planar Projections**
- **Tangent Case**
  - Point of tangency
  - $SF = 1$ at point of tangency
  - $SF > 1$

**Cylindrical Projections**
- **Tangent Case**
  - Largest scale
  - $SF = 1$ at line of tangency
  - Scale Exact

**Secant Case**
- Line of tangency
- $SF < 1$
- $SF > 1$
- Smallest scale
- $SF = 1$ at lines of tangency

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*Geosemantics, Linked Spatiotemporal Data, and Geo-Ontologies I*  
Krzysztof Janowicz
No flat map can be both equivalent and conformal.
Visualizing Distortions: Tissot’s indicatrix

Mollweide equal area pseudocylindrical
Customizing Errors

No need to use just one projection.
**Universal Transverse Mercator**

- Takes advantage of the Transverse Mercator projection’s properties
- **Distortion is minimized** along a central meridian that goes from pole to pole
- Actually, the projection is made **secant**
- 60 zones cover 84N to 80S
- UPS Polar stereographic projection covers the poles
- Scale factor ranges between 0.9996 and 1.0004
Why are the poles not covered?
**Copernicus (lunar crater)**

From Wikipedia, the free encyclopedia

Copernicus is a lunar impact crater named after the astronomer Nicolaus Copernicus, located in eastern Oceanus Procellarum. It is estimated to be about 600 million years old, and typifies craters that formed during the Copernican period in that it has a prominent ray system.

**Contents**
- [1] Characteristics
- [2] Names
- [3] Satellite craters
- [4] See also
- [5] References
- [6] External links

**Characteristics**

Copernicus is visible using binoculars, and is located slightly northwest of the center of the Moon's Earth-facing hemisphere. South of the crater is the Mare Insularum, and to the south-south west is the crater Reinhold. North of Copernicus are the Montes Carpatus, which lie at the south edge of Mare Imbrium. West of Copernicus is a group of dispersed lunar hills. Due to its relative youth, the crater has remained in a relatively pristine shape since it formed.

The circular rim has a discernible hexagonal form, with a terraced inner wall and a 30 km wide, sloping rampart that descends nearly a kilometer to the surrounding mare. There are three distinct terraces visible, and arc-shaped landslides due to slumping of the inner wall as the crater debris subsided.

Most likely due to its recent formation, the crater floor has not been flooded by lava. The terrain along the bottom is hilly in the southern half while the north is relatively smooth. The central peaks consist of three isolated mountainous rises climbing as high as 1.2 km above the floor. These peaks are separated from each other by valleys, and they form a rough line along an east-west axis. Infrared observations of these peaks during the 1990s determined that they were primarily composed of the mafic form of olivine.

Based on high-resolution images from Lunar Orbiter 5, Terry W. O'Keefe of the U.S. Geological Survey described the crater as having...
Copernicus Crater In the GeoHack Toolserver

Coordinates on the Moon: 9° 42' 0" N, 20° 0' 0" W (9.7°, -20°)
Copernicus is a lunar impact crater named after the astronomer Nicolaus Copernicus, located in the eastern Oceanus Procellarum. It is estimated to be about 800 million years old, and typifies craters that formed during the Copernican period in that it has a prominent ray system.

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Most likely due to its recent formation, the crater floor has not been flooded.
Copernicus Crater Data from DBpedia

About: Copernicus (lunar crater)
An Entity of Type: place, from Named Graph: http://live.dbpedia.org, within Data Space: live.dbpedia.org

Copernicus is a prominent lunar impact crater named after the astronomer Nicolaus Copernicus, located in eastern Oceanus Procellarum. It is estimated to be about 800 million years old, and typifies craters that formed during the Copernican period in that it has a prominent ray system.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbpedia-owl:LunarCrater/diameter</td>
<td>90.0</td>
</tr>
<tr>
<td>dbpedia-owl:abstract</td>
<td>Copernicus is a prominent lunar impact crater named after the astronomer Nicolaus Copernicus, located in eastern Oceanus Procellarum. It is estimated to be about 800 million years old, and typifies craters that formed during the Copernican period in that it has a prominent ray system.</td>
</tr>
<tr>
<td>dbpedia-owl:depth</td>
<td>3800.000000000000 (xsd:double)</td>
</tr>
<tr>
<td>dbpedia-owl:diameter</td>
<td>9300.000000000000 (xsd:double)</td>
</tr>
<tr>
<td>dbprop:caption</td>
<td>Lunar ray crater Copernicus from Apollo 12. NASA photo.</td>
</tr>
<tr>
<td>dbprop:decimal</td>
<td>20 (xsd:integer)</td>
</tr>
<tr>
<td>dbprop:depth</td>
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<tr>
<td>dbprop:diameter</td>
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<tr>
<td>dbprop:eorw</td>
<td>W</td>
</tr>
<tr>
<td>dbprop:equinym</td>
<td>dbpedia:Nicolaus_Copernicus</td>
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<tr>
<td>dbprop:latitude</td>
<td>9 (xsd:integer)</td>
</tr>
<tr>
<td>dbprop:longitude</td>
<td>20 (xsd:integer)</td>
</tr>
<tr>
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</tr>
<tr>
<td>dcterms:subject</td>
<td>category:Impact_craters_on_the_Moon</td>
</tr>
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<td>geos:point</td>
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</tr>
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<td>rdfs:comment</td>
<td>Copernicus is a prominent lunar impact crater named after the astronomer Nicolaus Copernicus, located in eastern Oceanus Procellarum. It is estimated to be about 800 million years old, and typifies craters that formed during the Copernican period in that it has a prominent ray system.</td>
</tr>
<tr>
<td>rdfs:label</td>
<td>Copernicus (lunar crater)</td>
</tr>
<tr>
<td>geo:lat</td>
<td>9.700000000000 (xsd:float)</td>
</tr>
<tr>
<td>geo:long</td>
<td>20.0000000000 (xsd:float)</td>
</tr>
</tbody>
</table>
Source of Error

- **Your turn:** what causes the grid?
Geocoding is the process of converting non-spatial location data into corresponding spatial representations.

Geoparsing is the process of assigning geographic identifiers (e.g., geographic coordinates) to textual data, e.g., from a travel blog.
**Geocoding** is the process of converting non-spatial location data into corresponding spatial representations.

**Geoparsing** is the process of assigning geographic identifiers (e.g., geographic coordinates) to textual data, e.g., from a travel blog.
**Accuracy, Is More Always Better?**

- Latitude 34.4380920294581
- Longitude -119.830931065789

<table>
<thead>
<tr>
<th></th>
<th>1 Degree Lat /</th>
<th>Long</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>110.574 km</td>
<td>111.320 km</td>
</tr>
<tr>
<td>15°</td>
<td>110.649 km</td>
<td>107.551 km</td>
</tr>
<tr>
<td>30°</td>
<td>110.852 km</td>
<td>96.486 km</td>
</tr>
<tr>
<td>45°</td>
<td>111.132 km</td>
<td>78.847 km</td>
</tr>
<tr>
<td>60°</td>
<td>111.412 km</td>
<td>55.800 km</td>
</tr>
<tr>
<td>75°</td>
<td>111.618 km</td>
<td>28.902 km</td>
</tr>
<tr>
<td>90°</td>
<td>111.694 km</td>
<td>0.000 km</td>
</tr>
</tbody>
</table>

- Use the cosine as approximation (e.g., 111.320 * cos(45))
- So what about 34.4380920294581 -119.830931065789 ?
<table>
<thead>
<tr>
<th>Decimal places</th>
<th>Degrees</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>111km</td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
<td>11.1km</td>
</tr>
<tr>
<td>2</td>
<td>0.01</td>
<td>1.11km</td>
</tr>
<tr>
<td>3</td>
<td>0.001</td>
<td>111m</td>
</tr>
<tr>
<td>4</td>
<td>0.0001</td>
<td>11.1m</td>
</tr>
<tr>
<td>5</td>
<td>0.00001</td>
<td>1.11m</td>
</tr>
<tr>
<td>6</td>
<td>0.000001</td>
<td>0.111 m</td>
</tr>
<tr>
<td>7</td>
<td>0.0000001</td>
<td>1.11cm</td>
</tr>
<tr>
<td>8</td>
<td>0.0000001</td>
<td>1.11mm</td>
</tr>
</tbody>
</table>

- Even less at 34N!
- In almost all cases adding more than 4-6 decimal places is **misleading**
- How many decimal places should be used for geocoding buildings?
Be Careful with Centroids
Gazetteers are place name (toponym) directories containing names (N), spatial references/footprints (F), feature types (T), and additional information for named geographic places.

**Minimum functionality**
- N $\rightarrow$ F (lookup)
- N $\rightarrow$ T (type-lookup)
- F (x T) $\rightarrow$ N (reverse-lookup)

**Further functionality**
- Harvesting (spanning over multiple gazetteers)
- Geoparsing and geocoding
- Classification of geographic feature types (ontology)

**Temporal dimension:** current and historical names and types.
Gazetteer Query Examples

- Lookup: Goleta → 34.440556, -119.813611
- Type-lookup: Goleta → Populated Place
- Reverse-lookup: 34.41254, -119.84813 x University → UCSB
- Harvesting: Find all historical populated place (T) in PA (N) using the Gazetteers G1,...,Gn.
- Geoparsing and geocoding: Extract all toponyms from the web page XYZ and return their spatial footprints.
- Ontology: Münster x Waterbodysub → Aasee, Werse,...
- Ontology: Münster x River_{sim} → Aa, Dortmund-Ems Canal,...
GETTY THESAURUS OF GEOGRAPHIC NAMES
**Santa Barbara (inhabited place)**

**Coordinates:**
Lat: 40° 13’ 00” N degrees minutes Lat: 40.2167 degrees decimal degrees
Long: 018° 04’ 00” E degrees minutes Long: 18.0667 degrees decimal degrees

**Names:**
Santa Barbara (preferred, C,V)
Masseria Santa Barbara (C,V)

**Hierarchical Position:**
- World (facet)
- ..., Europe (continent) (P)
- ... Italy (nation) (P)
- ........ Apulia (region) (P)
- ........... Lecce (province) (P)
- .............. Santa Barbara (inhabited place) (P,U)

**Place Types:**
inhabited place (preferred, C)

**Sources and Contributors:**
Masseria Santa Barbara........... [VP]
........................................ NGA/NIMA database (2003-)
Santa Barbara........... [VP Preferred]
........................................ NGA/NIMA database (2003-)
**Subject:** .... [VP]
........................................ NGA/NIMA database (2003-) -128288

**Santa Barbara (inhabited place)**

**Coordinates:**
Lat: 34° 25’ 00” N degrees minutes Lat: 34.4167 degrees decimal degrees
Long: 119° 41’ 00” W degrees minutes Long: -119.6633 degrees decimal degrees

**Note:** Located on Pacific Coast at base of Santa Ynez Mountains; developed as port & market center; suffered earthquake in 1925; was attacked by Japanese submarine in 1942; today’s economy is based on tourism; once was rich in early Amerindian artifacts.

**Names:**
Santa Barbara (preferred, C,V) ........... named after Santa Barbara, patron saint of mariners, by Sebastian Vizcaino in 1602

**Hierarchical Position:**
- World (facet)
- ..., North and Central America (continent) (P)
- ........ United States (nation) (P)
- .......... California (state) (P)
- .......... Santa Barbara (county) (P)
- .......... Santa Barbara (inhabited place) (P)

**Place Types:**
inhabited place (preferred, C) ........... visited by explorer Juan Cabrillo in 16th cen., Spanish presidio built 1782, mission dedicated 1786
city (C) ............ incorporated in 1850
county seat (C) ............ for citrus & cattle
cultural center (C) ............ for citizens & heritage
religious center (C) ............ since establishment of mission of Santa Barbara 1786 & as western headquarters of Franciscan Order
resort center (C) ............ after construction of Southern Pacific railroad in 1887
university center (C)

**Sources and Contributors:**
Santa Barbara........... [BHA, GRLPSC, VP Preferred]
........................................ Canby, Historic Places (1984), II, 826
........................................ Encyclopaedia Britannica (1988), X, 424
Serving Linked Data from the **authoritative** Ordnance Survey (UK).
Serving Linked Data based on a variety of volunteered and authoritative sources.
Serving Linked Data based on the volunteered OpenStreetMap project.
Of the millions Linked Data geo-features from different sources, some will refer to the same places ...

To utilize and integrate the myriads of existing data sources requires identity hooks; in GIScience geometry is a typical hook.
Hausdorff Distance As Example

\[ d_H(X, Y) = \max\{ \sup_{x \in X} \inf_{y \in Y} d(x, y), \sup_{y \in Y} \inf_{x \in X} d(x, y) \} \]

In the PostGIS database: 

```sql
SELECT st_hausdorffdistance('LINESTRING (130 0, 0 0, 0 150)'::geometry, 'LINESTRING (10 10, 10 150, 130 10)'::geometry); -> 14.142
```

- A simple measure of how similar two geometries are
- **Not** suitable for complex geo-feature conflation / identity matching
- Recently used for *(semantic) trajectory* similarity
Buffer Snapping

Always use buffers for computations.
(Semantic) Conflation

Remark: these Santa Barbara centroids are over 60 miles apart
(Semantic) Conflation

(Remark: these Santa Barbara centroids are over 60 miles apart)
**Semantic Conflation**

(Remark: these Santa Barbara centroids are over 60 miles apart)
Spatial Joins

Spatial join match operations in ESRI’s ArcGIS

- **INTERSECT** – The features in the join features will be matched if they intersect a target feature. This is the default.

- **WITHIN_A_DISTANCE** – The features in the join features will be matched if they are within a specified distance of a target feature. Specify a distance in the Search Radius parameter.

- **CONTAINS** – The features in the join features will be matched if a target feature contains them. The target features must be polygons or polylines. [...] 

- **COMPLETELY_CONTAINS** – The features in the join features will be matched if a target feature completely contains them. Polygon can completely contain any feature. Point cannot completely contain any feature, not even a point. Polyline can completely contain only polyline and point.

- **CLOSEST** – The feature in the join features that is closest to a target feature is matched. See the usage tip for more information.

- ...

(The text is quoted from http://help.arcgis.com/en/arcgisdesktop/10.0/)