Knowing Where via Knowledge Graph-based GeoEnrichment

Querying the KnowWhereGraph and Geovisualization

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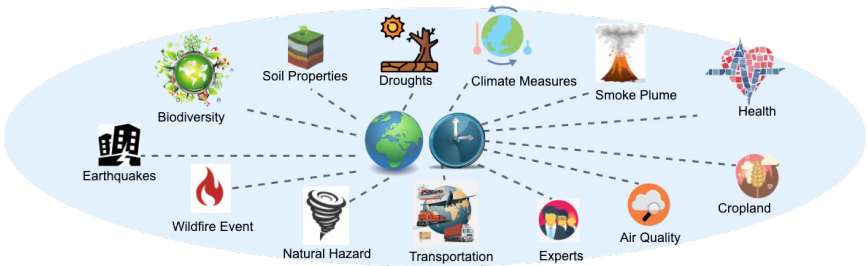
Outline

- Introduce key areas of the KWG schema
- Cover common query patterns for spatial-temporal data
- Showcase of a disaster relief map, built on top of KWG data

Data in KnowWhereGraph

- Synthesis of 30+ datasets, over 12 billion triples
- Including observations of natural hazards, soil properties, demographics, health, etc.

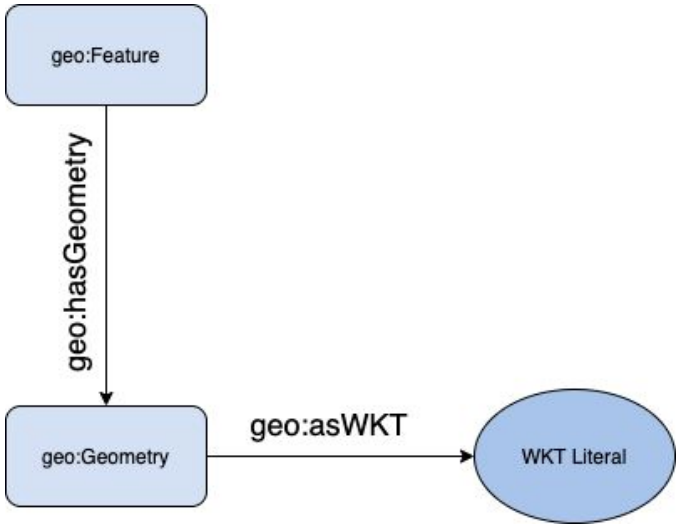


Thematic Datasets					Place-Centric Datasets		
Dataset Name/ Theme	**Source Agency**	**Key Attributes**	**Spatial Coverage**	**Temporal Coverage**	**Place-Centric Dataset**	**Defining Authority**	**Spatial Coverage**
Soil Properties	USDA	soil type, farmland class	Targeted regions in US	Current	S2 Cells	Google	Lvl 9 (Global), Lvl 13 (US),
Wildfires	USGS, USDA, USFS, NIFC	wildfire type, burn severity, num. acres burned, contained date	US	1984–current	Global Administrative Regions	University of Berkeley, Museum of Vertebrate Zoology and the International Rice Research Institute	Global
Earthquakes	USGS	magnitude, length, width, geometry	Global (mag. over 4.5)	2011-01-01 to 2022-01-18			
Climate Hazards	NOAA	injuries, deaths, property damages	US	1950–2022			
Expert - Covid-19 Mobility	Direct Relief (DR)	name, affiliation, expertise	Global	2021	US Federal Judicial District	DoJ, ESRI	US
Expert - General	KWG, UC System, DR, Semantic Scholar	name, affiliation, expertise with spatiotemporal scopes	Global	unlimited	National Weather Zones	NOAA	US
Cropland Types	USDA	crop types (raster data)	US	2008-2021	FIPS Codes	NRCS	US
Air Qual. Obs.	U.S. EPA	AQI value, CO concentration	US	1980–2022	Designated Market Area	Nielen	US
Smoke Plumes	NOAA	daily smoke plumes extent	US	2010-2022	ZIP	ZCTA	US
Climate Observations	NOAA	temperature, precipitation, PDSI, PHSI	US	1950 - 2022	Climate Division	NOAA	US
Disaster Declaration	FEMA	designated area, program, amount approved, program designated date	US	1953 - 2022	Census Metropolitan Area	US Census	US
Smoke Plume Extents	NOAA	Smoke extent	US	2017 - 2022	Drought Zone	NDMC, USDA,NOAA	US
BlueSky Forecasts	Bluesky	PM10, PM5	US	2022-03-07	Geographic Name Information System	USGS	US
Transportation (highway network)	DOT	road type, road length, road sign	US	2014			
Public Health Observations	CDC, US Census, University of Wisconsin Population Health Institute	below poverty level, diabetes, obesity, mental health provider rate, annual mammogram, vaccinated, injury death	US	2017, 2021			
Public Health Infrastructure	HIFLD	pharmacies, hospitals, dialysis centers, public health departments	US	2017 - 2022			
Social Vulnerability	CDC/ATSDR	social vulnerability index	US	2018			
Hurricane Tracks	NOAA	max wind speed, min pressure	US	1851-2020			

GeoSPARQL

Overview

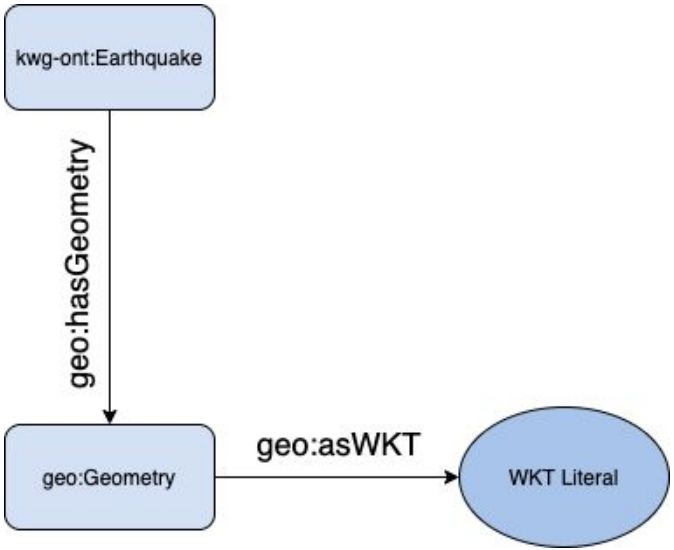
- Open data model for describing geometries
- Contains classes for things that geometries can belong to - Feature
- Contains relations connecting geometries to features



GeoSPARQL

KWG Integration

- Hazards, roads, and, hospitals are subclasses of geo:Features
- Geometries can therefore be queried uniformly across hazards/roads/places



GeoSPARQL

- Example of a *kwg-ont:Earthquake*

subject	predicate	object
kwgr:Earthquake.ak0115aiaea0	kwg-ont:hasTemporalScope	kwgr:time.ak0115aiaea0
kwgr:Earthquake.ak0115aiaea0	geo:hasGeometry	kwgr:geometry.point.ak0115aiaea0
kwgr:Earthquake.ak0115aiaea0	rdf:type	kwg-ont:Earthquake
kwgr:Earthquake.ak0115aiaea0	rdf:type	geo:Feature
kwgr:Earthquake.ak0115aiaea0	rdfs:label	"Earthquake near Anchor Point, US at 2011-04-25T19:29:15.921Z."
kwgr:Earthquake.ak0115aiaea0	sosa:isFeatureOfInterestOf	kwgr:EarthquakeObservationCollection.ak0115aiaea0

GeoSPARQL

- Example of a *kwg-ont:NOAAFlood*
  - Despite coming from a different dataset, its geometry is obtained the same way as a kwg-ont:Earthquake

subject	predicate	object
kwgr:hazard.100313.600897	kwg-ont:hasNarrative	"The Southgate Street underpass was flooded. A car was stuck in the floodwaters."
kwgr:hazard.100313.600897	kwg-ont:hasSegment	kwgr:segment.100313.600897
kwgr:hazard.100313.600897	kwg-ont:hasTemporalScope	kwgr:interval.201509300745_201509300845EST
kwgr:hazard.100313.600897	kwg-ont:sfWithin	kwgr:Earth.North_America.United_States.USA.22.14_1
kwgr:hazard.100313.600897	kwg-ont:sfWithin	kwgr:s2.level13.9936071264911228928
kwgr:hazard.100313.600897	geo:hasDefaultGeometry	kwgr:geometry.linestring.100313.600897
kwgr:hazard.100313.600897	geo:hasGeometry	kwgr:geometry.linestring.100313.600897
kwgr:hazard.100313.600897	rdf:type	kwg-ont:NOAAFlood
kwgr:hazard.100313.600897	rdf:type	geo:Feature
kwgr:hazard.100313.600897	rdf:type	sosa:FeatureOfInterest
kwgr:hazard.100313.600897	rdfs:label	"NOAAFlood Occurred in WORCESTER from 2015-09-30-0745 to 2015-09-30-0845, EST"
kwgr:hazard.100313.600897	sosa:isFeatureOfInterestOf	kwgr:impact.100313.600897

Querying GeoSPARQL

Two pieces to the query pattern:

- The KWG class
- The GeoSPARQL ontology pattern

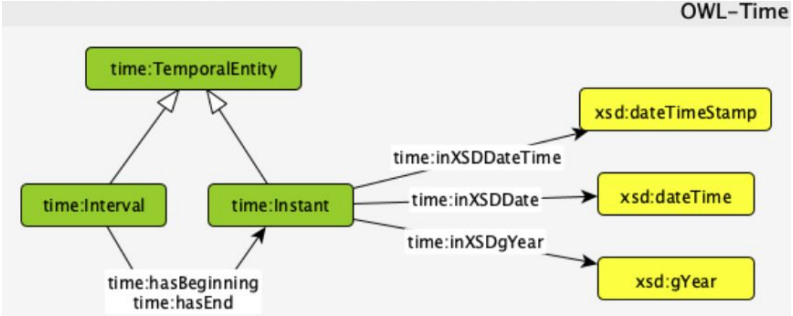
```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
select ?fire ?name ?wkt where {
    ?fire rdf:type kwg-ont:MTBSFire .
    ?fire rdfs:label ?name .
    ?fire geo:hasGeometry ?geo .
    ?geo geo:asWKT ?wkt .
}
```

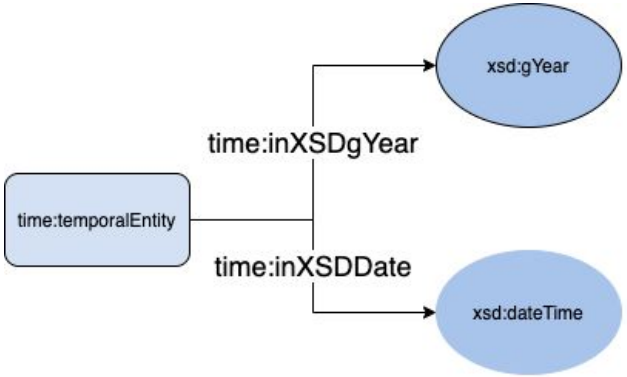
fire	name	wkt
kwgr:mtbsfire.TX2974810065020080208.CARTA_VALLEY.2008	"CARTA VALLEY Fire (MTBS) Occurred in 2008"	"POLYGON ((-100.6402585 29.7432491, -100.6405742 29.7417005 …))"
kwgr:mtbsfire.TX3031110088720110413.MCPHERSON.2011	"MCPHERSON Fire (MTBS) Occurred in 2011"	"POLYGON ((-100.8869753 30.3675565, -100.8867877 30.3674102 …))"

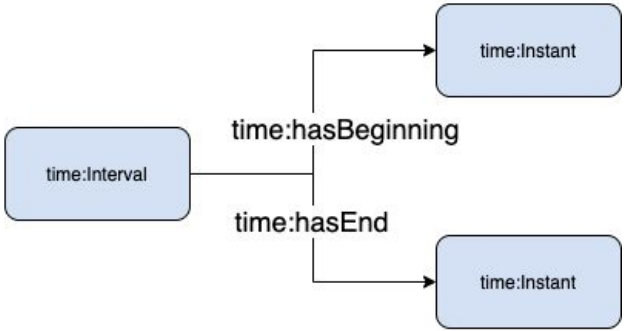
OWL-Time

Two important patterns:

- time:temporalEntity
- time:Interval







OWL-Time

Querying a time:temporalEntity:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX time: <http://www.w3.org/2006/time#>
select ?fire ?name ?year where {
    ?fire rdf:type kwg-ont:MTBSFire .
    ?fire rdfs:label ?name .
    ?fire kwg-ont:hasTemporalScope ?temporal_scope .
    ?temporal_scope time:inXSDgYear ?year .
    FILTER(?year >= "2018"^^xsd:gYear)
}
```

Querying a time:Interval:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX time: <http://www.w3.org/2006/time#>
select ?name ?begin_date ?end_date where {
    ?fire rdf:type kwg-ont:NOAAHurricane .
    ?fire rdfs:label ?name .
    ?fire kwg-ont:hasTemporalScope ?temporal_scope .
    ?temporal_scope time:hasBeginning ?begin .
    ?begin time:inXSDDate ?begin_date .
    ?temporal_scope time:hasEnd ?end .
    ?end time:inXSDDate ?end_date .
}
```

OWL-Time

Results of searching for hurricanes and their time frames

	name	begin_date	end_date
1	"NOAAHurricane Occurred in MANU'A from 2005-02-14-1500 to 2005-02-16-1200, SST"	"2005-02-14"^^xsd:date	"2005-02-16"^^xsd:date
2	"NOAAHurricane Occurred in SWAINS from 2005-02-24-1500 to 2005-02-26-1500, SST"	"2005-02-24"^^xsd:date	"2005-02-26"^^xsd:date
3	"NOAAHurricane Occurred in COASTAL BROWARD from 2005-07-08-1600 to 2005-07-10-1200, EST"	"2005-07-08"^^xsd:date	"2005-07-10"^^xsd:date
4	"NOAAHurricane Occurred in COASTAL COLLIER from 2005-07-08-1600 to 2005-07-10-1200, EST"	"2005-07-08"^^xsd:date	"2005-07-10"^^xsd:date
5	"NOAAHurricane Occurred in COASTAL DADE from 2005-07-08-1600 to 2005-07-10-1200, EST"	"2005-07-08"^^xsd:date	"2005-07-10"^^xsd:date

KWG Spatial Model

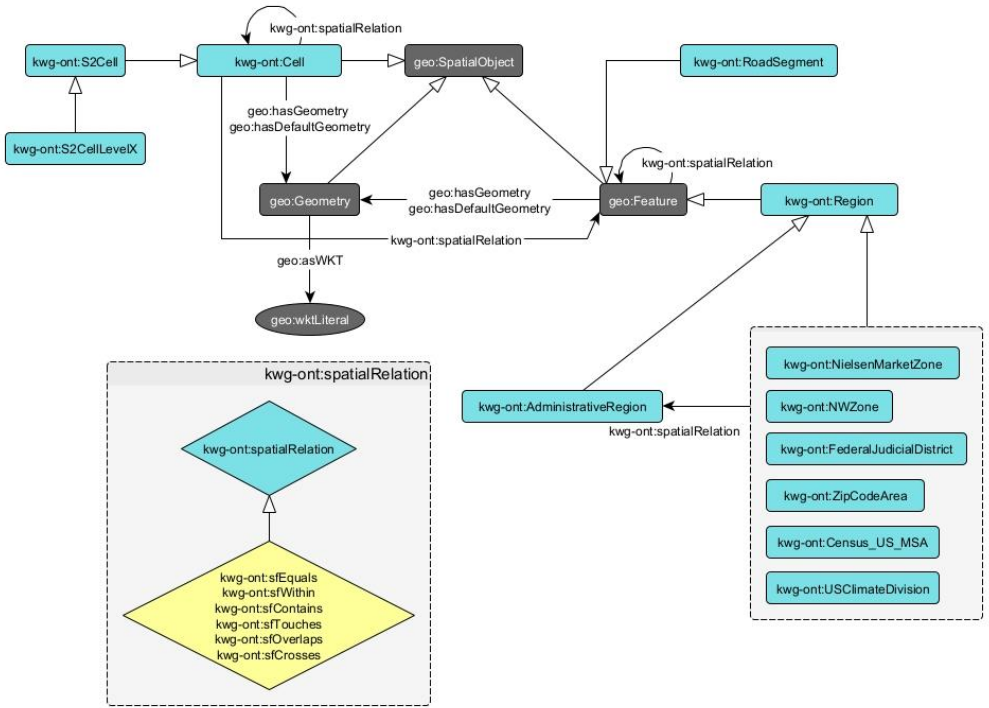
- KWG supports 8 different types of places
- Administrative regions can be broken down into further levels
    - Level 1: Country
    - Level 2: State
    - Level 3: County

	Spatial Scope	Number of Instances	Number of Statements
Administrative Region	Global	194,442	8,763,702
KWG S2 Cell (level 13)	U.S.	12,170,000	912,538,520
National Weather Zone	U.S.	3,811	6,633,201
Federal Judicial District	U.S.	94	6,998,138
Designated Market Area	U.S.	206	7,210,178
Zip Code Area	U.S.	31,985	9,781,344
Census Metropolitan Area	U.S.	938	4,323,903
Climate Division	U.S.	344	9,003,782

KWG Spatial Model

Similar to GeoSPARQL and OWL-Time, KWG provides classes and relations:

- The classes on the right are all geo:Features
- The spatial relations are used to relate features of interest to them



Spatial-Temporal Search

Query combines:

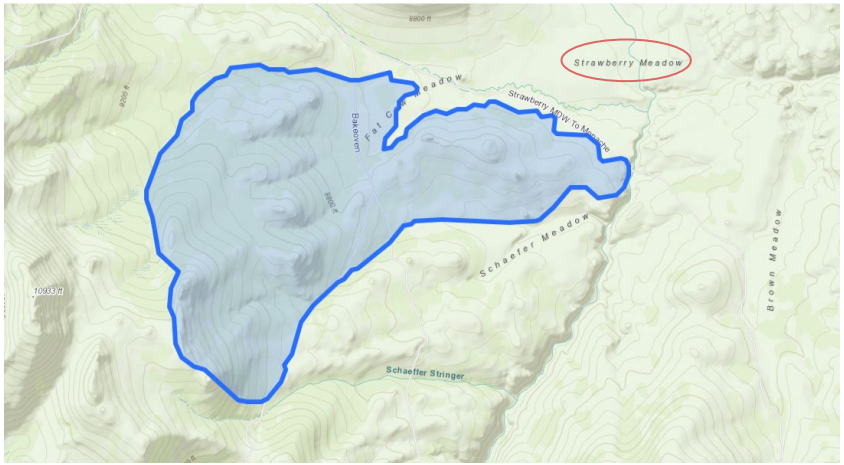
- GeoSPARQL
- OWL-Time
- KWG Ontology
- ***Example***: Searching for hazards in California after 2018

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX time: <http://www.w3.org/2006/time#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
select ?hazard ?hazard_name ?hazard_year ?wkt where {
    ?california rdf:type kwg-ont:AdministrativeRegion_2 .
    ?california rdfs:label "California" .
    ?hazard rdf:type kwg-ont:Hazard .
    ?hazard kwg-ont:sfWithin ?california .
    ?hazard rdfs:label ?hazard_name .
    ?hazard geo:hasGeometry ?geo .
    ?geo geo:asWKT ?wkt .
    ?hazard kwg-ont:hasTemporalScope ?temporal_scope .
    ?temporal_scope time:inXSDgYear ?hazard_year .
    FILTER(?hazard_year >= "2018"^^xsd:gYear)
}
```

Spatial-Temporal Search

From the geometry alone we can characterize a few aspects of the fire:

- It failed to progress into Strawberry Meadow
- It was stopped along the south-western ridge

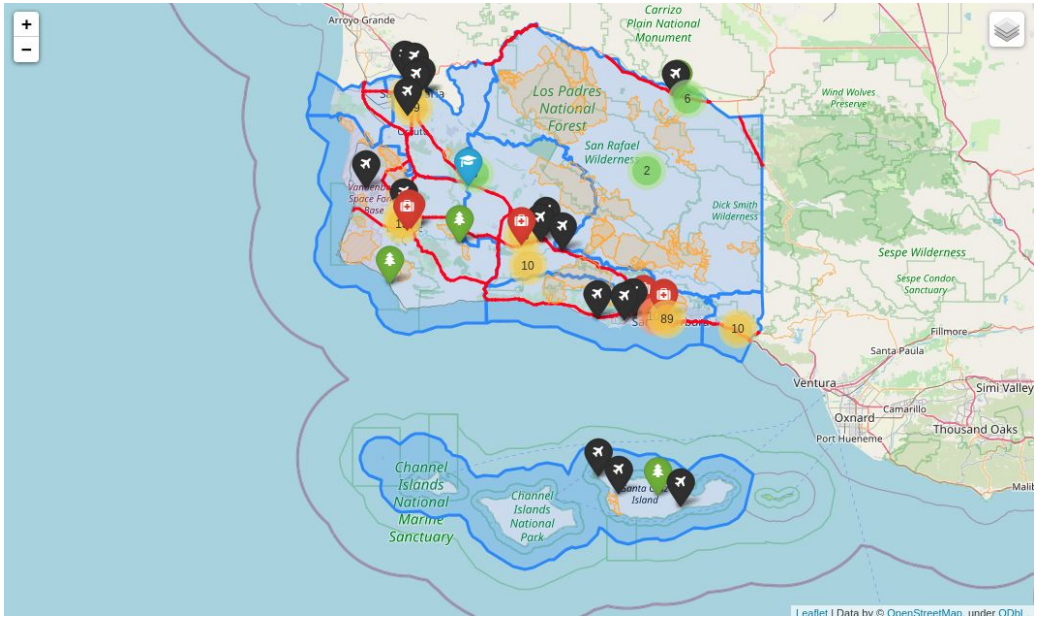


Visualization of the Fat Cow Fire in Tulare, CA

Query Summary

- Understanding the structure of external ontologies and their patterns is essential
- Heterogeneous data can be accessed using similar (and sometimes the same) query patterns
- SPARQL is the standard query language for KWG's database (Ontotext GraphDB)
- KWG's SPARQL endpoint can be found at https://stko-kwg.geog.ucsb.edu/sparql/
- More information about the ontology and synthesized datasets can be found on the project's homepage at https://knowwheregraph.org/

Visualizations - Use Case for Disaster Relief Map



https://nbviewer.org/github/KnowWhereGraph/examples/blob/main/relief_map/map.ipynb