Reinforcing the AI4EU Platform by Advancing
Earth Observation Intelligence, Innovation & Adoption

Linked Data Tools and the EarthQA engine in AI4Copernicus

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Why Linked Data?

The vision of **linked data** is to go from a Web of documents to a Web of data:

- Unlock open data dormant in their silos
- Make it available on the Web using Semantic Web technologies (HTTP, URIs, RDF, SPARQL)
- Interlink it with other data (e.g., from the European data portal)

SPARQL and GeoSPARQL

- SPARQL is the standard Query Language for RDF and a W3C Recommendation.

- GeoSPARQL is a standard for representation and querying of geospatial linked data for the Semantic Web from the Open Geospatial Consortium (OGC).

Query Example in GeoSPARQL

Find all potato fields in “Kirchberg” area that are less than 2km away from Elbe river.

```
SELECT DISTINCT ?field
WHERE
{
  ?field fso:hasLabelName "Potato"^^xsd:string.
  ?field geo:hasGeometry ?fieldGeometry.
  ?fieldGeometry geo:asWKT ?fieldWKT.

  ?aoi rdf:type gadm:AdministrativeUnit3.
  ?aoi gadm:has_NAME_3 "Kirchberg".
  ?aoi geo:hasGeometry ?aoiGeometry.
  ?aoiGeometry geo:asWKT ?aoiWKT.

  FILTER (geof:sfContains(?aoiWKT, ?fieldWKT))

  ?river hydro:hasName "Elbe"^^xsd:string.
  ?river hydro:hasNode ?riverPart.
  ?riverPart geo:hasGeometry ?riverPartGeometry.
  ?riverPartGeometry geo:asWKT ?riverPartWKT.

  FILTER (geof:distance(?fieldWKT, ?riverPartWKT, uom:metre) < 2000)
}
```

Linked Data Tools in AI4Copernicus

GeoTriples

STRABON

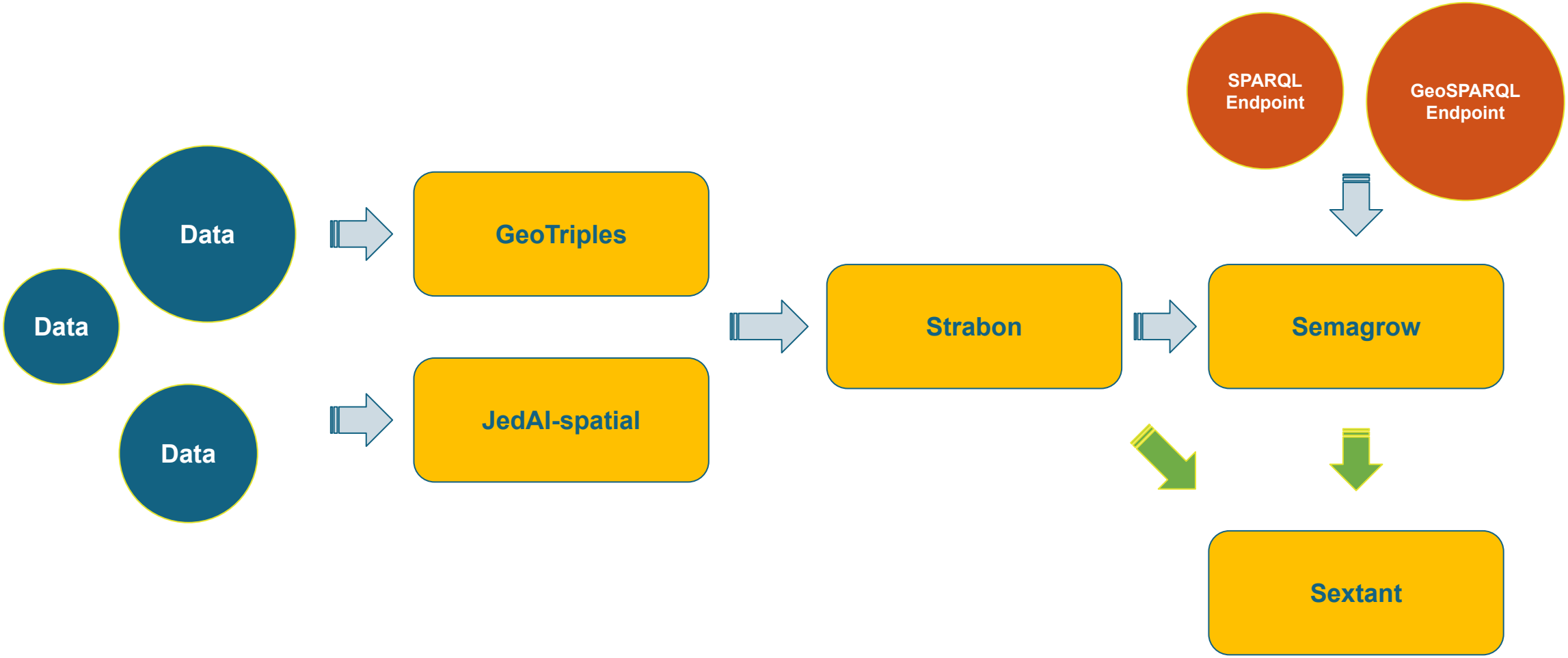
THE SPATIOTEMPORAL RDF STORE

JedAI

SemaGrow

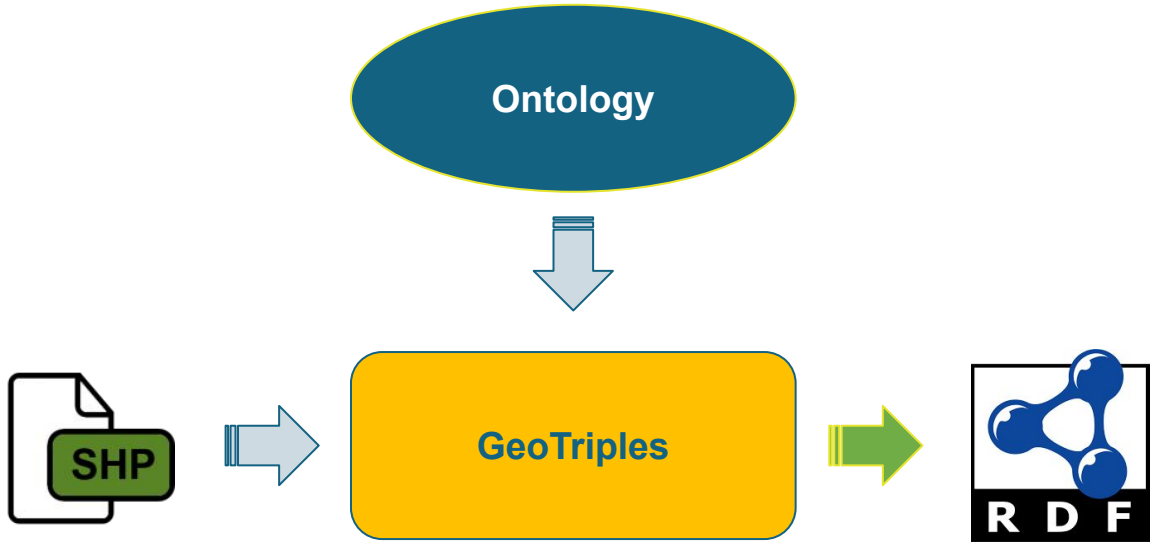
SEXTANT

Linked Data Pipeline



GeoTriples

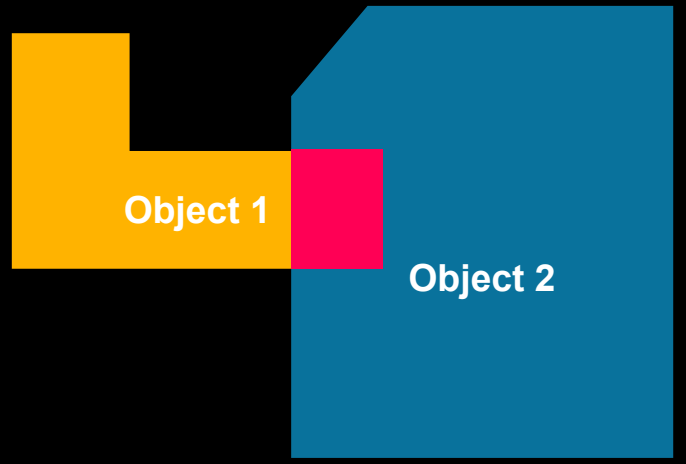
We use GeoTriples to transform the data into the RDF format, utilizing an ontology.




```
@prefix fso: <http://ai.di.uoa.gr/fs/ontology/>.
@prefix fsr: <http://ai.di.uoa.gr/fs/resource/>.
@prefix geo: <http://www.opengis.net/ont/geosparql#>.

map:DOURO_precipitation_09_2021_geometry
    rr:logicalTable [ rr:tableName "`DOURO_precipitation_09_2021`"; ];

    rr:subjectMap [
        rr:template "http://ai.di.uoa.gr/fs/resource/PREC_PR_M9_2021{`gid`}_Geometry";

   rr:predicateObjectMap [
        rr:predicate ogc:asWKT;
        rr:objectMap [
            rr:datatype ogc:wktLiteral;
            rrx:function rrxf:asWKT;
            rrx:argumentMap
            (
                [ rr:column "`the_geom`"; ]
            )
        ];
    ];
    .

map:DOURO_precipitation_09_2021
    rr:logicalTable [ rr:tableName "`DOURO_precipitation_09_2021`"; ];
    rr:subjectMap [
        rr:class fso:FoodSecurityObservation; #rdf:type fso:FoodSecurityObservation
        rr:template "http://ai.di.uoa.gr/fs/resource/FSObservation_PR_M9_2021{`gid`}";

    rr:predicateObjectMap [   #fso:hasStartDate
        rr:predicate fso:hasStartDate;
        rr:objectMap [
            rr:datatype xsd:dateTime;
            rr:template "2021-09-01T00:00:00";
        ];
    ];

    rr:predicateObjectMap [   #fso:hasEndDate
        rr:predicate fso:hasEndDate;
        rr:objectMap [
            rr:datatype xsd:dateTime;
            rr:template "2021-09-30T00:00:00";
        ];
    ];
.

map:DOURO_precipitation_09_2021_WaterAvailability
    rr:logicalTable [ rr:tableName "`DOURO_precipitation_09_2021`"; ];
```

JedAI-spatial

We use JedAI-spatial to detect spatial links between datasets. The resulting triples, allow us to materialize the spatial intersections in these datasets, which lowers the query execution times for those queries that utilize these links.



<Object1> ex:intersects <Object2> .

1

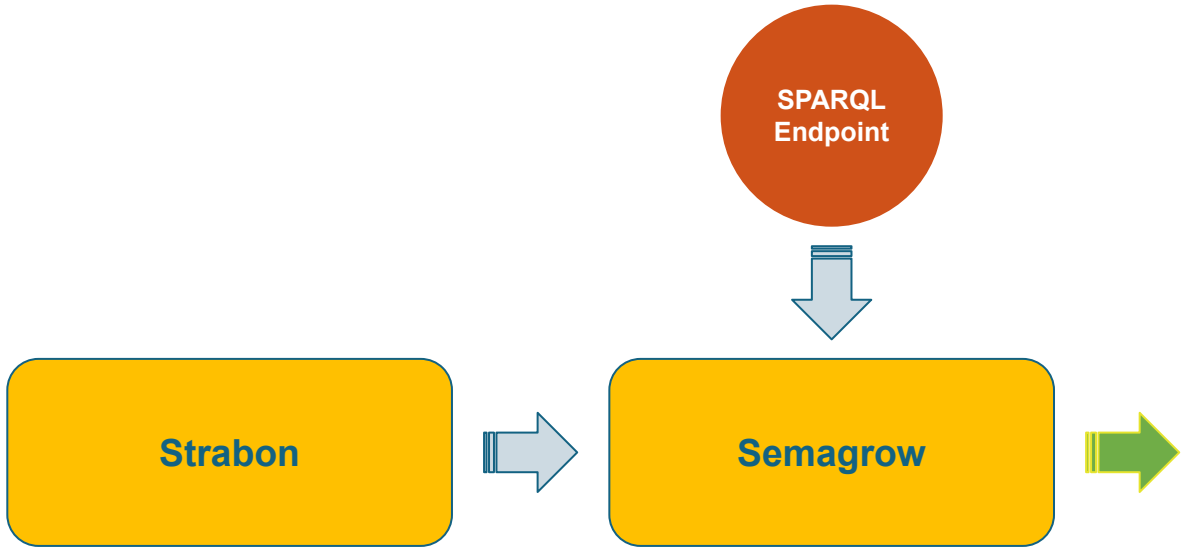
```
SELECT ?x
WHERE {
        ?x ex:intersects ex:Athens .
}
```

2

```
SELECT ?x
WHERE {
        ?x geo:asWKT ?wkt .
        ex:Athens geo:asWKT ?wktA .

        FILTER (geof:sfIntersects (?wkt, ?wktA))
}
```

Strabon and Semagrow

Once the data is in the RDF format, we use the system Strabon to store them. Semagrow can federate Strabon with external SPARQL endpoints to answer queries that involve more data sources.



Find all potato fields in “Kirchberg” area that are less than 2km away from Elbe river.

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  FILTER (geof:sfContains(?aoiWKT, ?fieldWKT))

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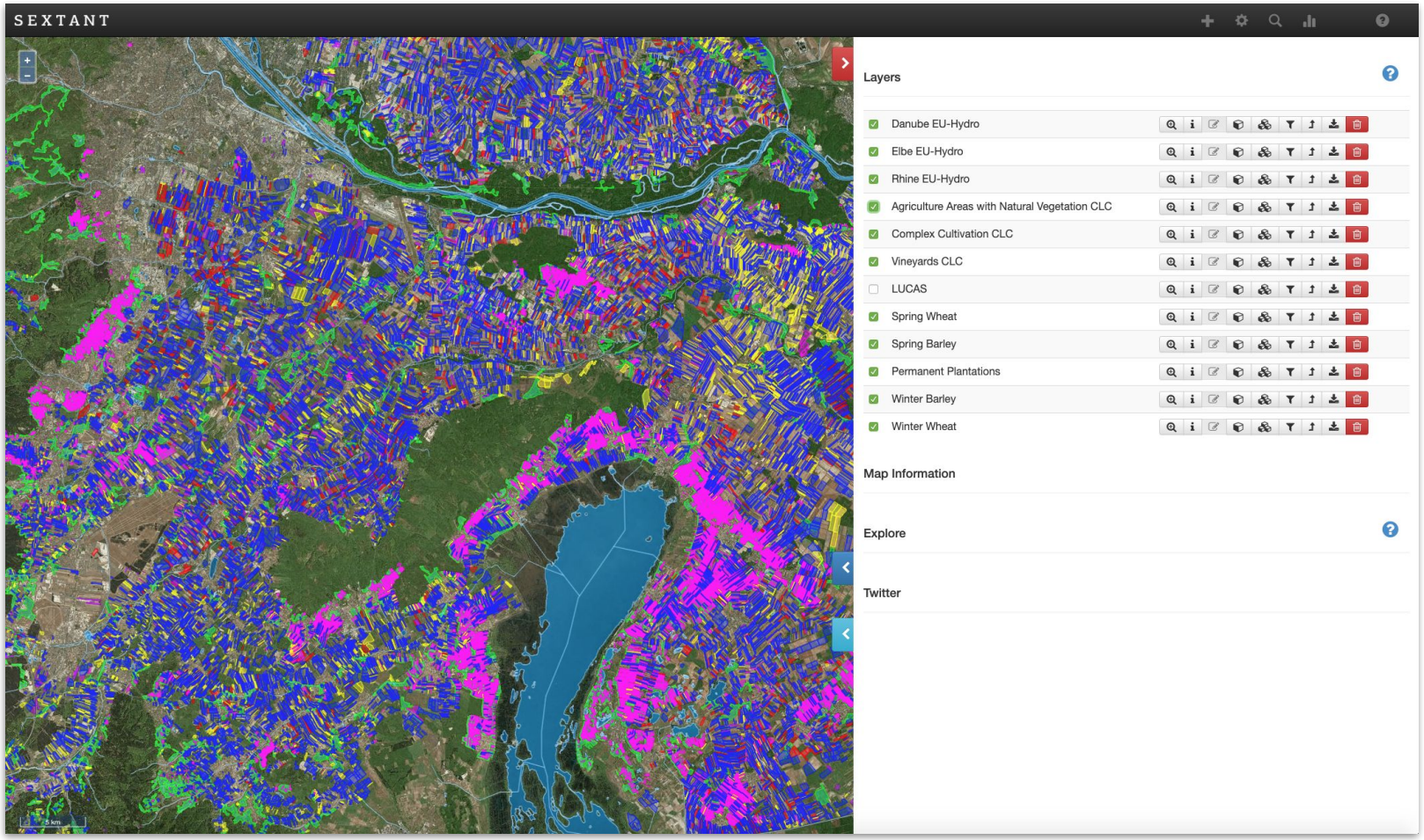
  ?river hydro:hasNode ?riverPart.
  ?riverPart geo:hasGeometry ?riverPartGeometry.
  ?riverPartGeometry geo:asWKT ?riverPartWKT.

  FILTER (geof:distance(?fieldWKT, ?riverPartWKT,
uom:metre) < 2000)
}
```

Visualize queries in Sextant



Accessing EO datasets made easy

EO dataset discovery should be like searching with Google and it should also target non-expert EO data users!

Query Example in GeoSPARQL

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  ?riverPart geo:hasGeometry ?riverPartGeometry.
  ?riverPartGeometry geo:asWKT ?riverPartWKT.

  FILTER (geof:distance(?fieldWKT, ?riverPartWKT, uom:metre) < 2000)
}
```
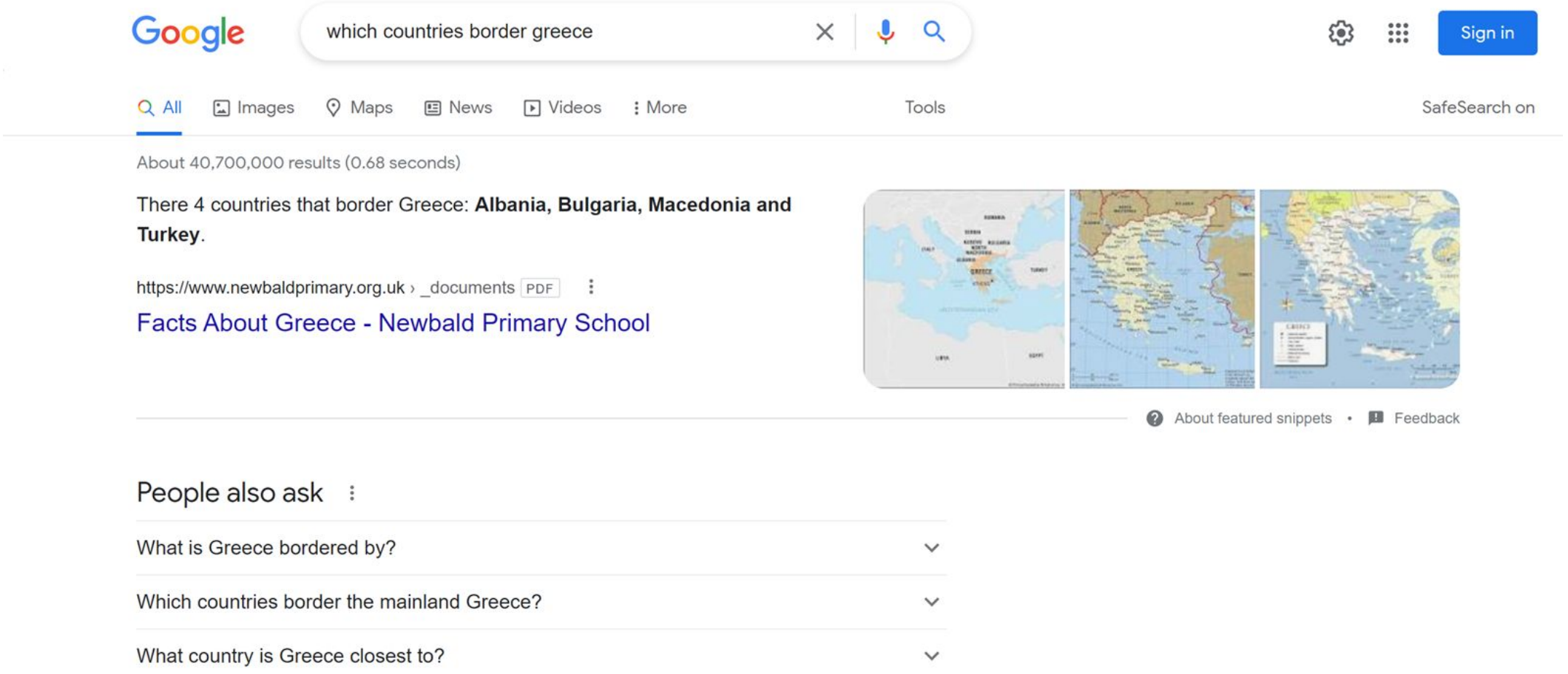
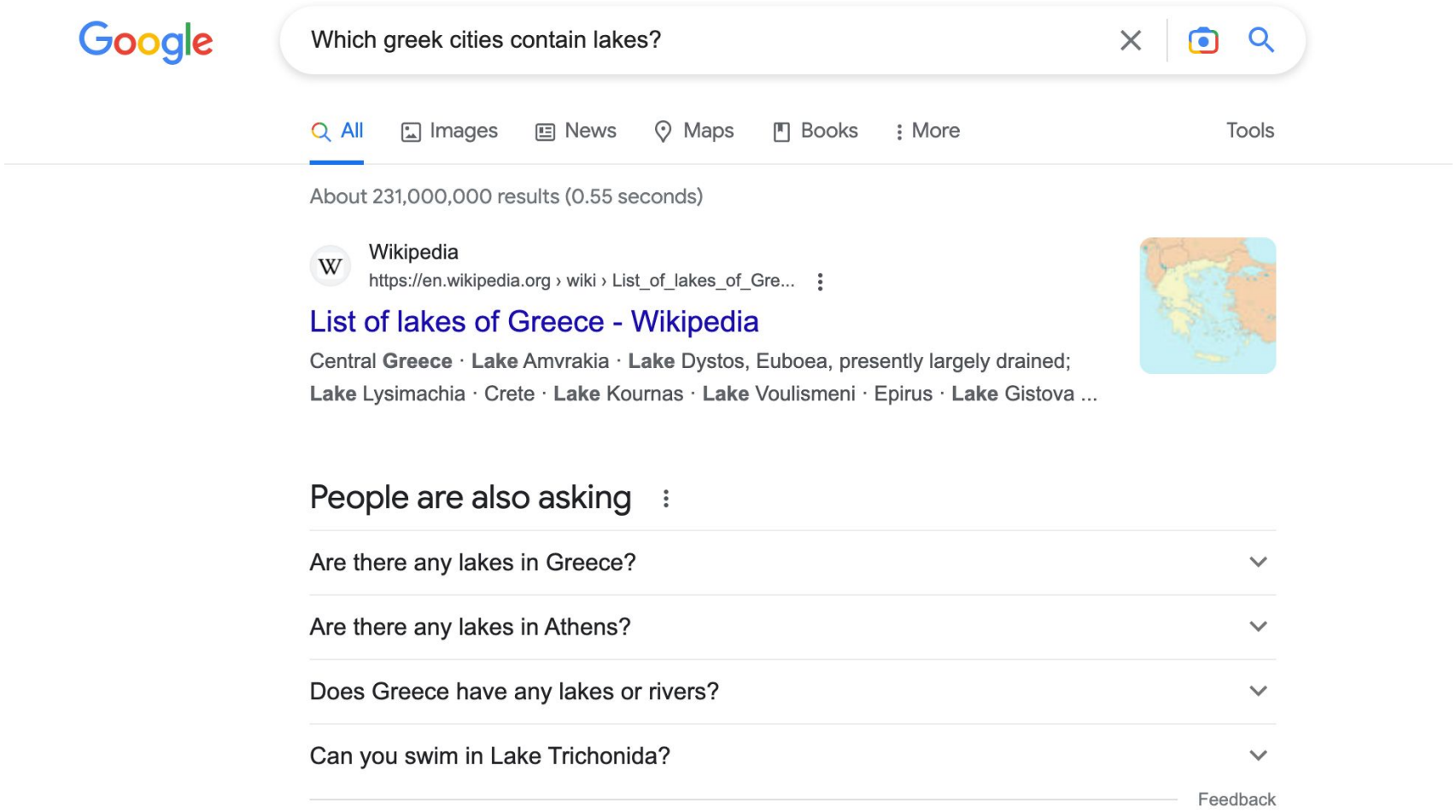
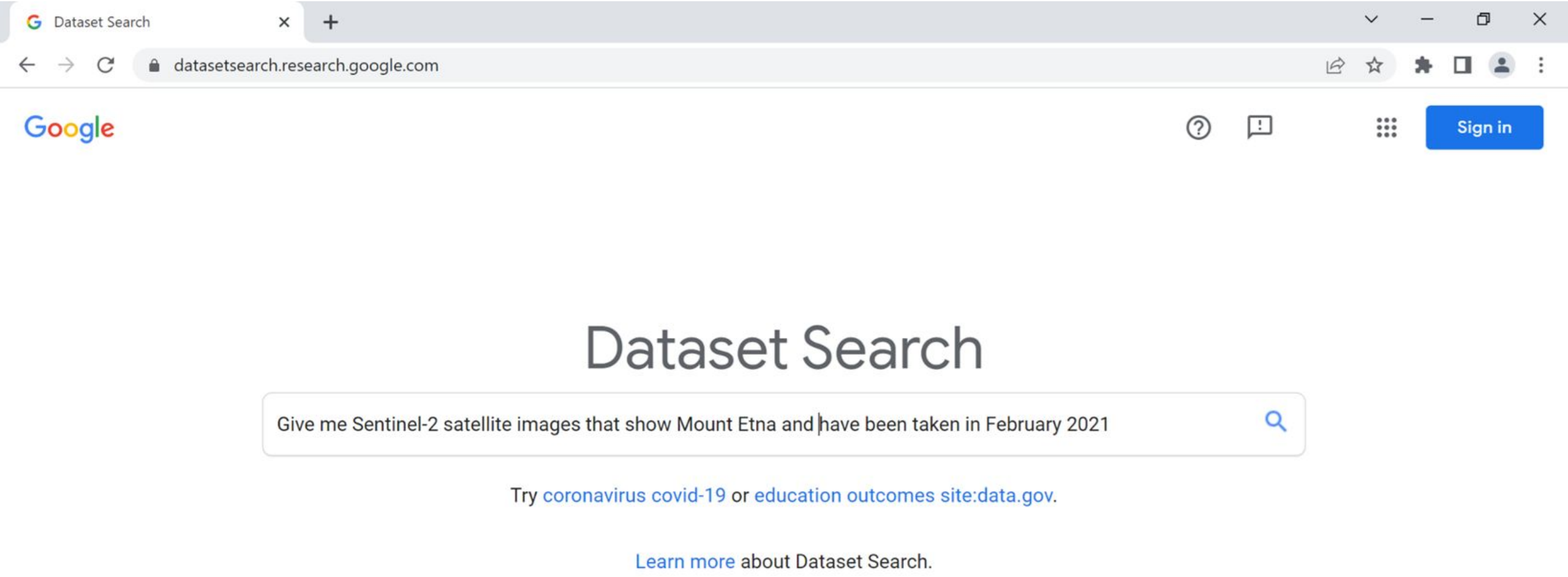

Geospatial knowledge is *partly* supported by Google



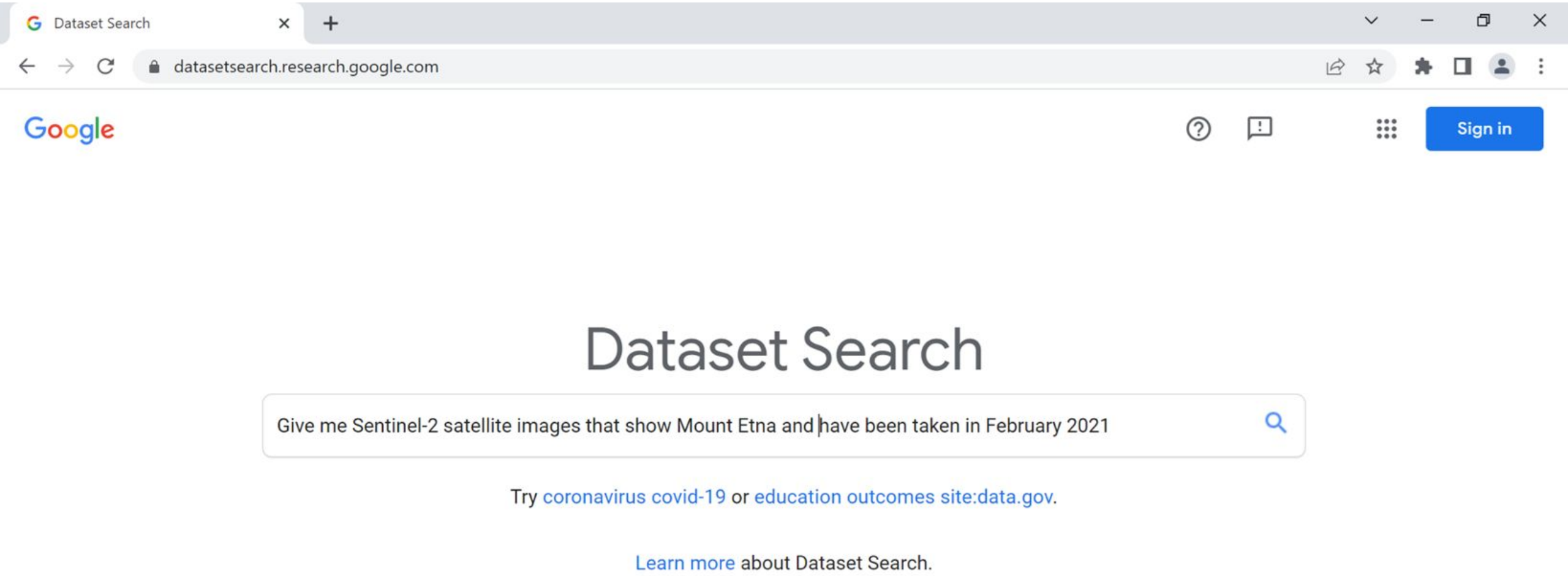
Geospatial knowledge is *partly* supported by Google



No Answer!


Dataset Search
datasetsearch.research.google.com
Google
Sign in
Dataset Search
Give me Sentinel-2 satellite images that show Mount Etna and have been taken in February 2021
Try coronavirus covid-19 or education outcomes site:data.gov.
Learn more about Dataset Search.

No Answer!



…or Return Sentinel2 images from lakes that are within cities

EarthQA

- EarthQA accepts questions in natural language (English) that ask for EO datasets having certain properties and returns links to such datasets. The properties can refer to satellite image metadata and relevant geographical knowledge from the KG DBpedia.
- Example questions:
  - Find Sentinel-1 products that show Etna in March 2018.
  - Find Sentinel-2 MSI products with cloud cover below 10% during March 2017 / 2018
  - Find Sentinel-3A Water Full Resolution (WFR) products with the data collected in January 2018.
  - Retrieve all GRD Sentinel-1 images that cover the Black Sea and have been taken during the period 1/06/19-1/15/19.

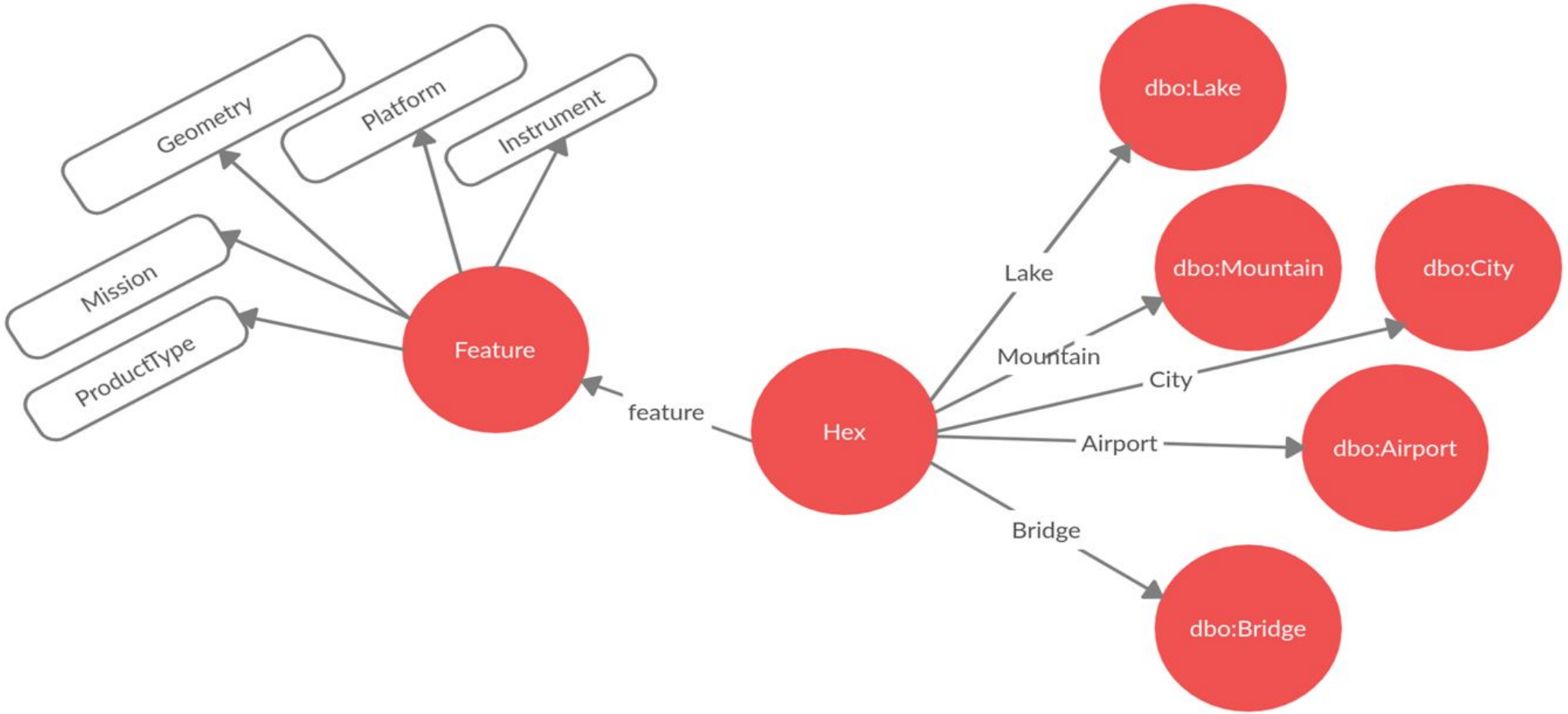
EarthQA and KGs

Knowledge graphs (KGs) are directed graphs consisting of **entities (nodes)** and **binary relations (edges)** between them.

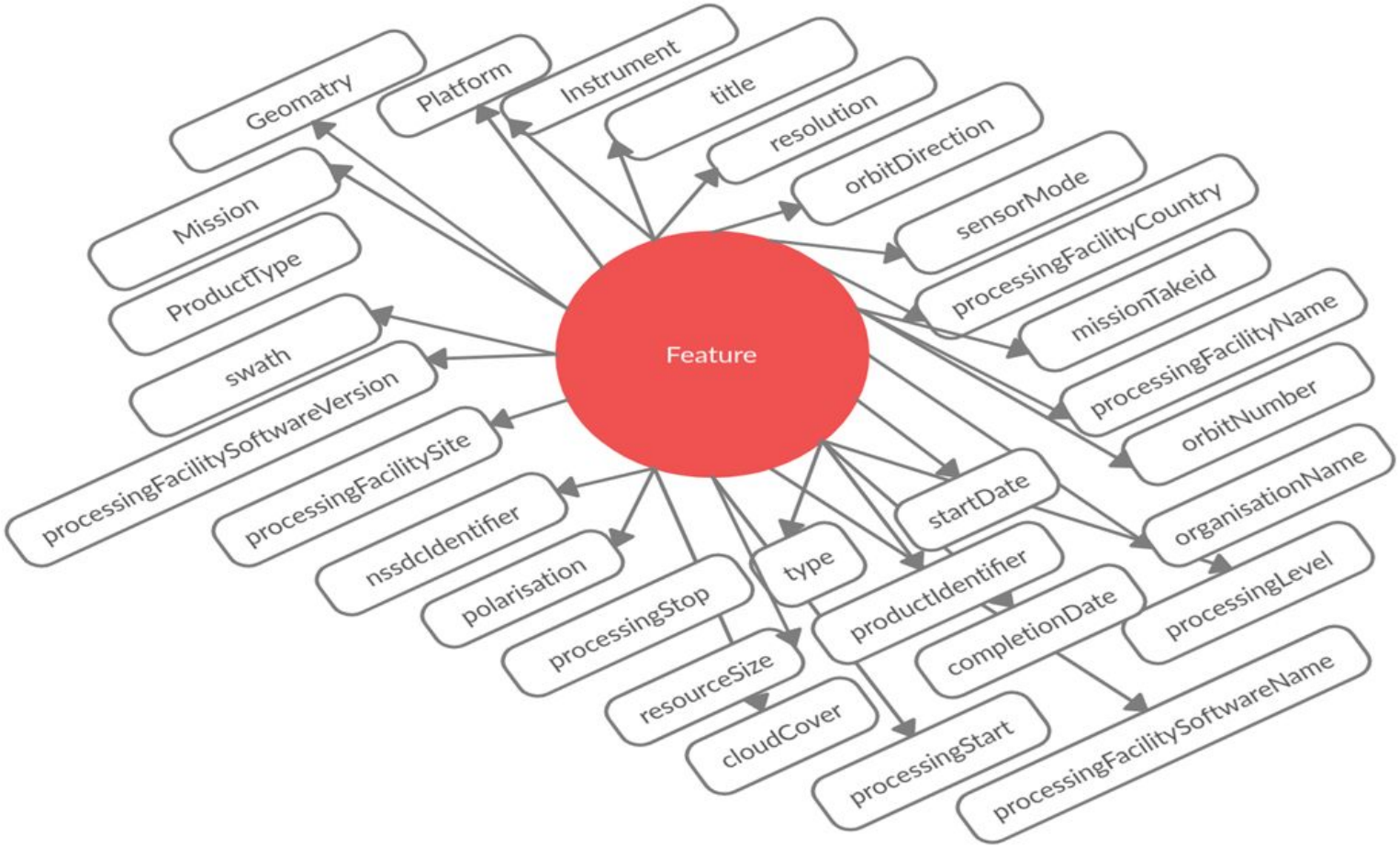
EarthQA is based on:

- A **knowledge graph encoding metadata of EO products from the CREODIAS archive.**
- The **knowledge graph DBpedia** (only point geometries – latitude and longitude – are represented).

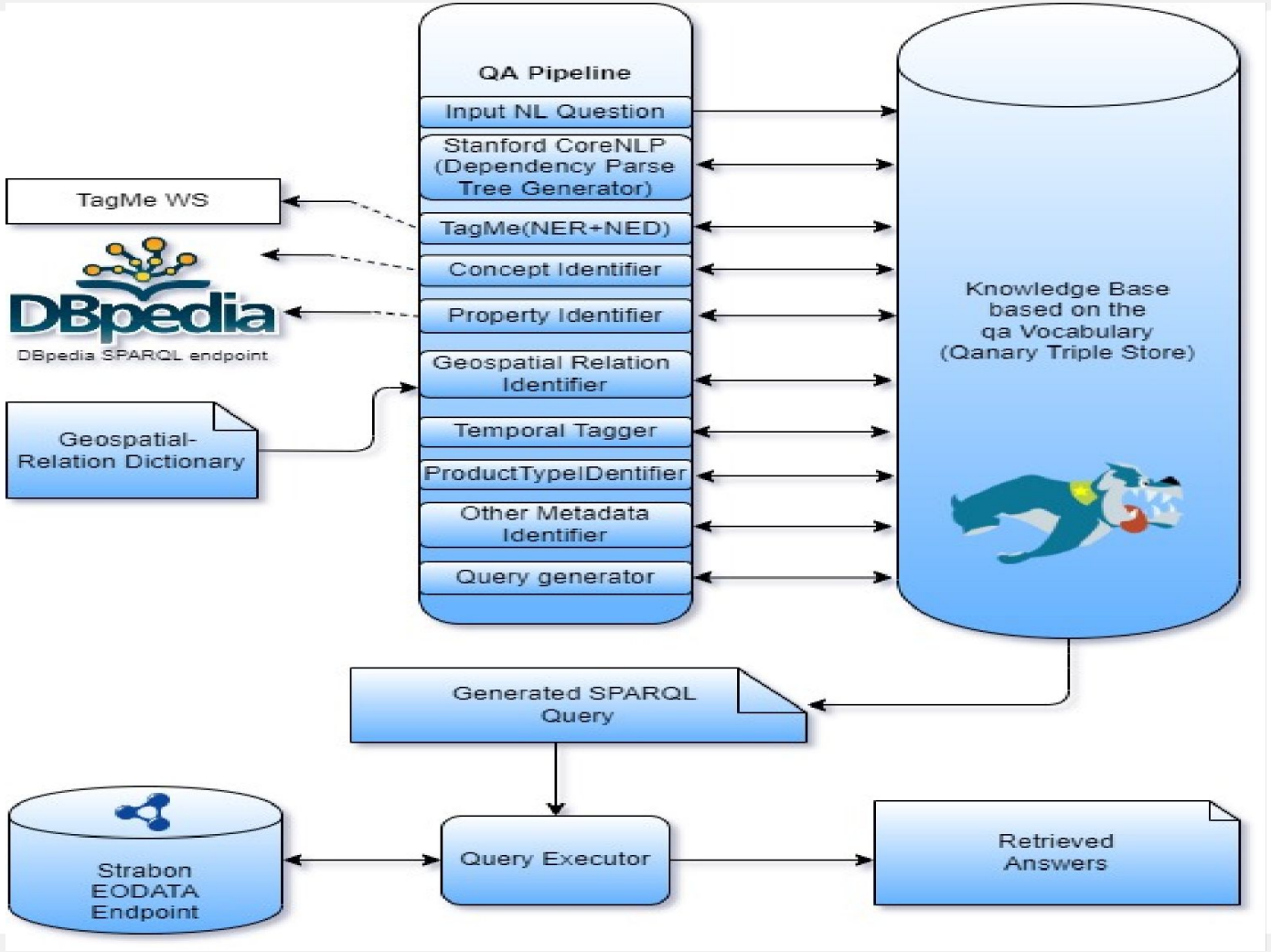
EarthQA Knowledge Graph



EarthQA Knowledge Graph



EarthQA – Software Architecture



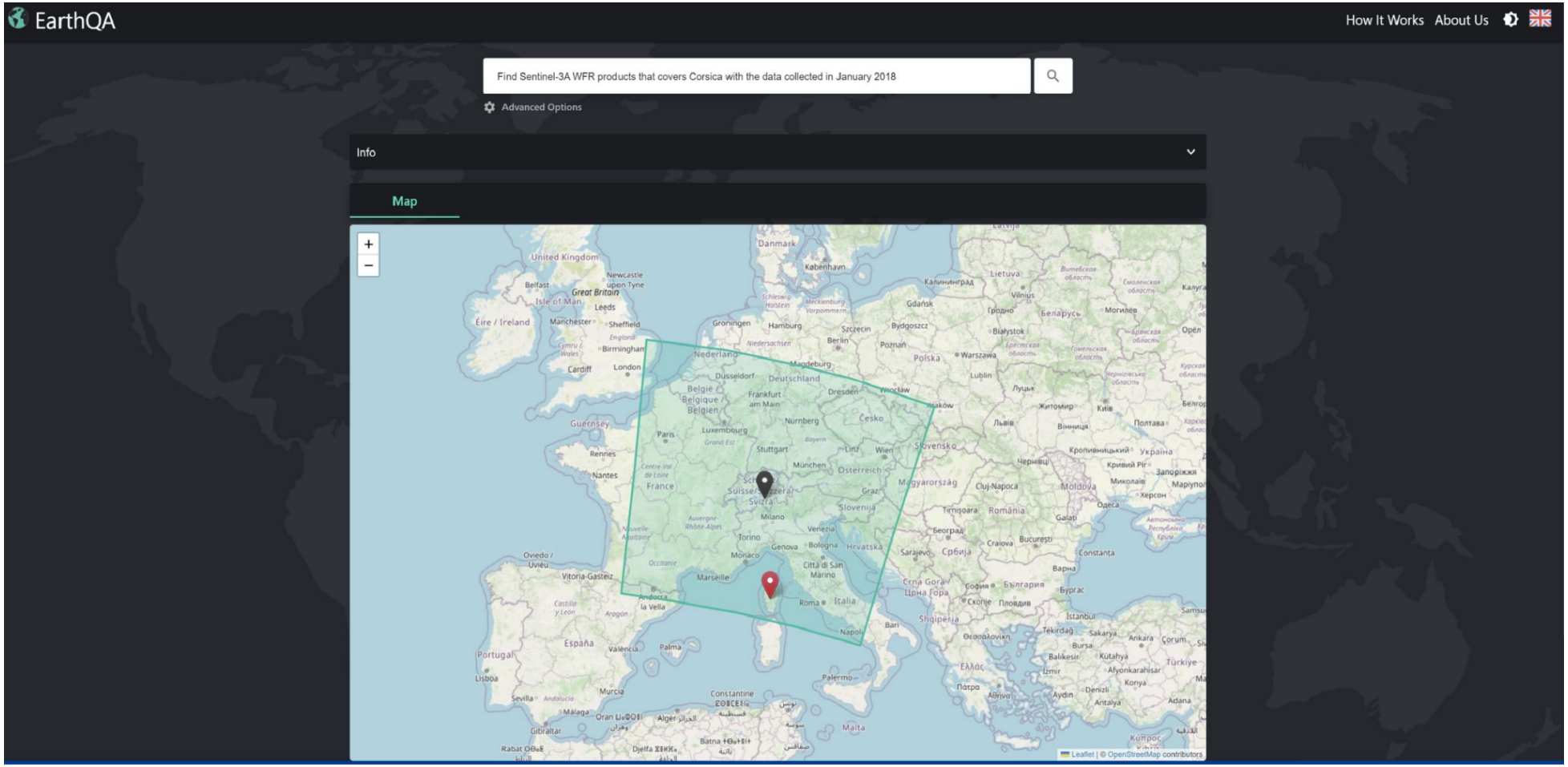
Example

Question: Find **Sentinel-1** products that show **Etna** in **March 2018**

Generated SPARQL Query :

```
Select distinct ?title ?geom where {
        ?hex <http://ws.eodias.eu/metadata/attribute#feature> ?x .
?hex ?pred <http://dbpedia.org/resource/Mount_Etna> .
?x a <http://ws.eodias.eu/metadata/feature> .
?x <http://ws.eodias.eu/metadata/attribute#title> ?title .
?x <http://ws.eodias.eu/metadata/attribute#geometry> ?geom .
?x <http://ws.eodias.eu/metadata/attribute#mission> <http://ws.eodias.eu/metadata/mission/Sentinel-1> .
?x <http://ws.eodias.eu/metadata/attribute#startDate> ?date .
bind(year(?date) as ?year) .  bind(month(?date) as ?month) .
filter(?year=2018 && ?month=03 ) .
} LIMIT 1000
```

EarthQA Demo



Thank You!

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Any Questions?

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