



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

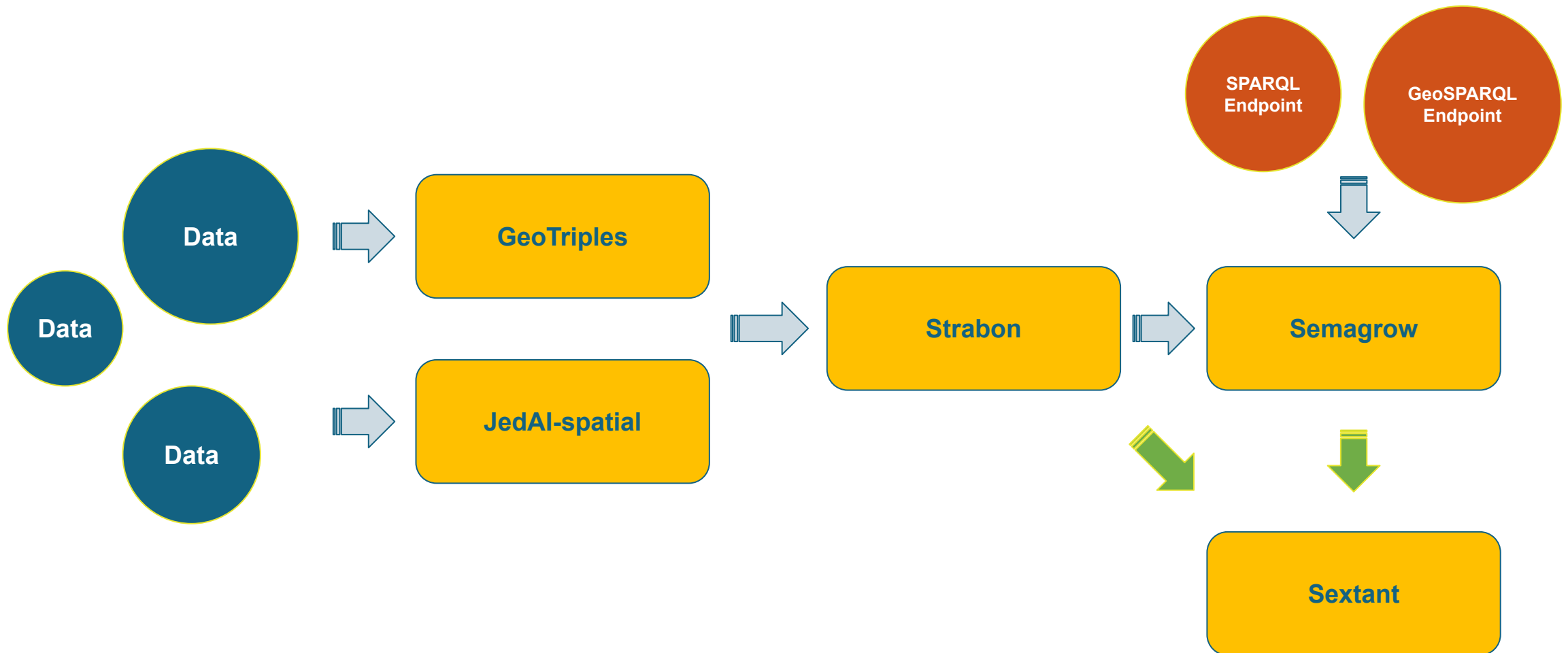

STRABON
THE SPATIOTEMPORAL RDF STORE

JedAI

SemaGrow

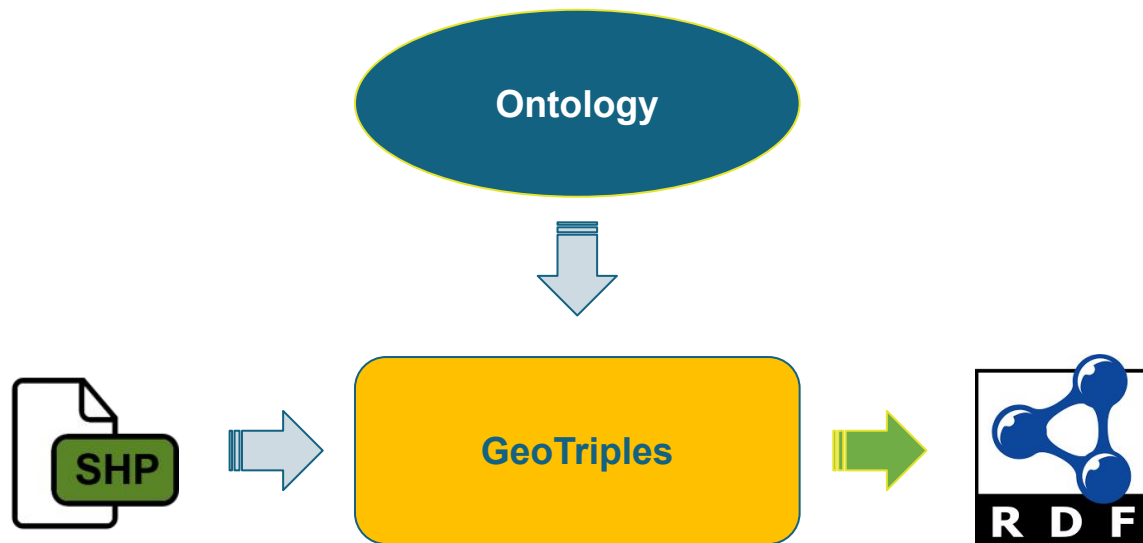
S
SEXTANT

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 rrx: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`}";

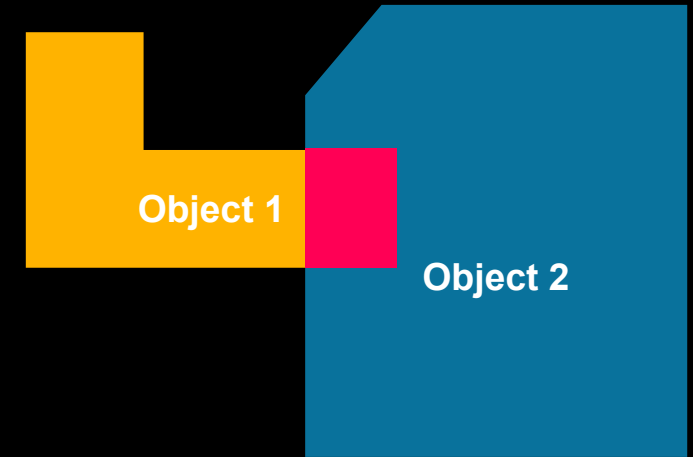
  rr:predicateObjectMap [ #fso:hasStartDate
    rr:predicate fso:hasStartDate;
    rr:objectMap [
      rr:datatype xsd:dateTime;
      rr:template "2021-09-01T00:00:00";
    ];

  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`"; ];
  rr:subjectMap [
```

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> .`

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

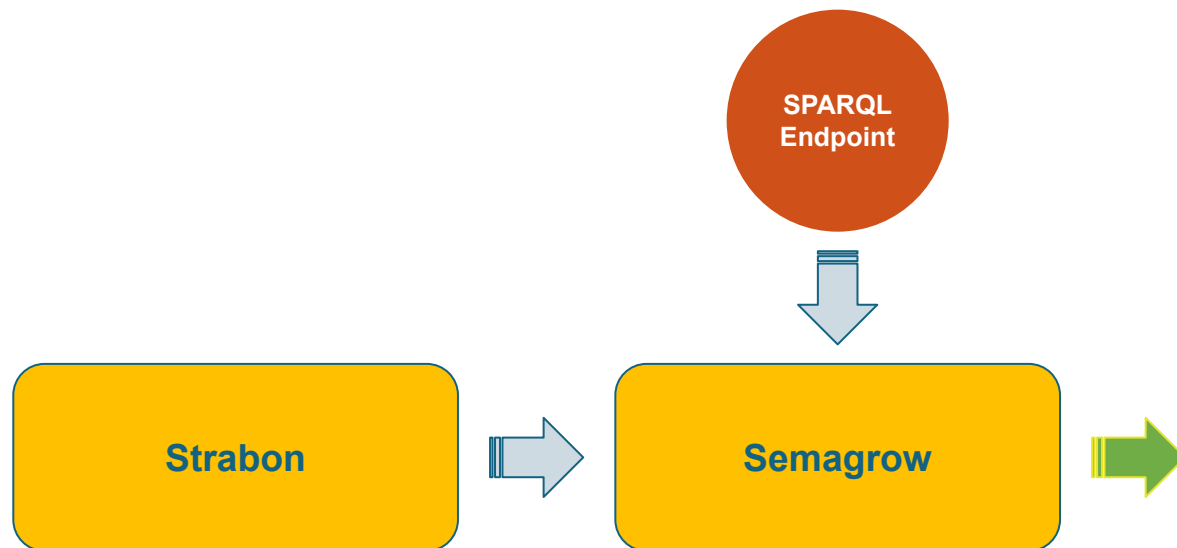
1

```
SELECT ?x  
WHERE {  
  ?x geo:asWKT ?wkt .  
  ex:Athens geo:asWKT ?wktA .  
  
  FILTER (geof:sfIntersects (?wkt, ?wktA))  
}
```

2

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

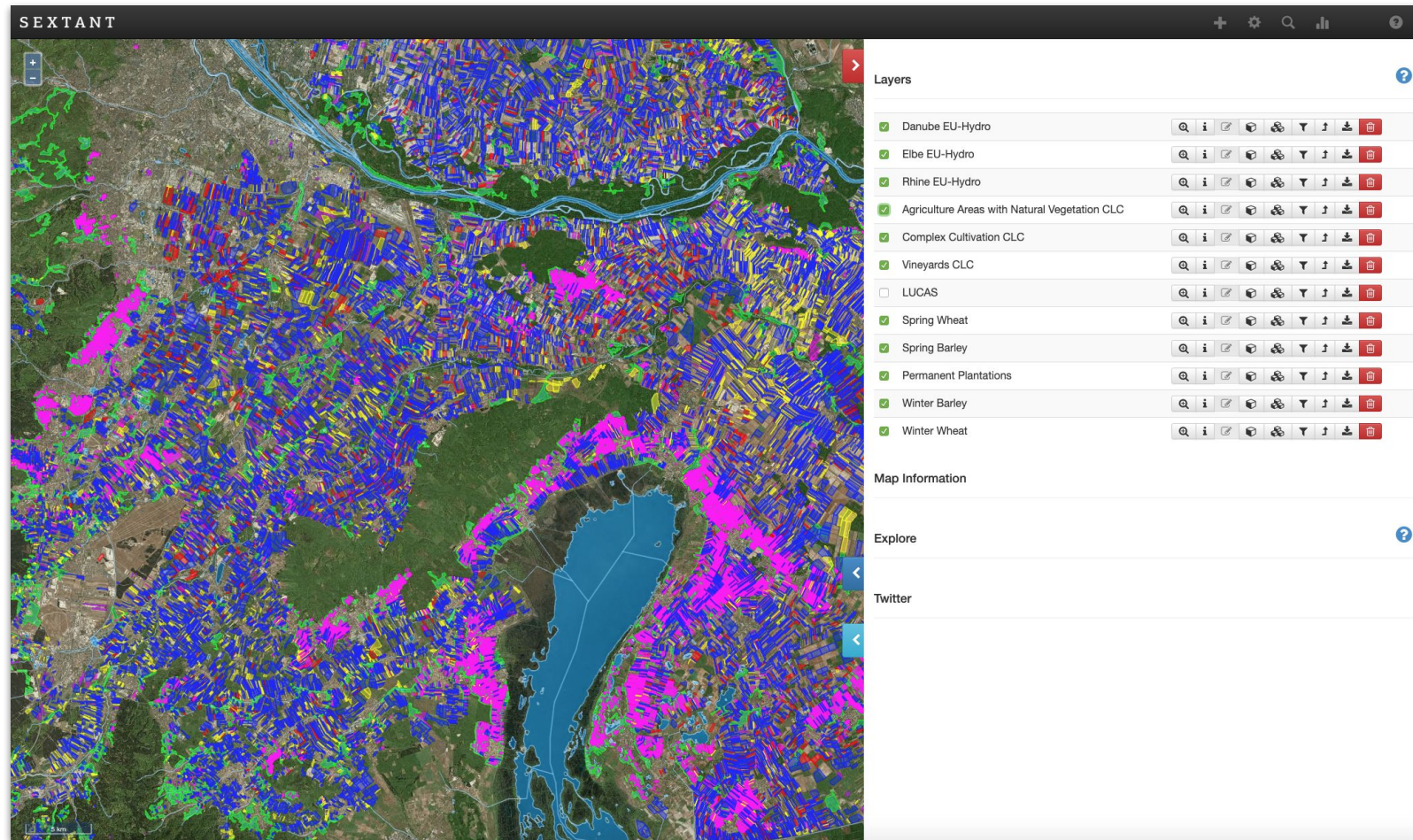
  ?aoi rdf:type gadm:AdministrativeUnit3.
  ?aoi gadm:has_NAME_3 "Kirchberg".
  ?aoi geo:hasGeometry ?aoiGeometry.
  ?aoiGeometry geo:asWKT ?aoiWKT.

  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)
}
```

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

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)
}
```

Geospatial knowledge is *partly* supported by Google

Google

which countries border greece

Sign in


All Images Maps News Videos More Tools SafeSearch on

About 40,700,000 results (0.68 seconds)

There 4 countries that border Greece: **Albania, Bulgaria, Macedonia and Turkey.**

<https://www.newbaldprimary.org.uk> > _documents PDF

[Facts About Greece - Newbald Primary School](#)



People also ask

- What is Greece bordered by?
- Which countries border the mainland Greece?
- What country is Greece closest to?

Geospatial knowledge is *partly* supported by Google

The screenshot shows a Google search interface. At the top left is the Google logo. The search bar contains the text 'Which greek cities contain lakes?'. To the right of the search bar are icons for clearing the search, image search, and a magnifying glass. Below the search bar are navigation links: 'All' (selected), 'Images', 'News', 'Maps', 'Books', 'More', and 'Tools'. The search results show 'About 231,000,000 results (0.55 seconds)'. The first result is from Wikipedia, titled 'List of lakes of Greece - Wikipedia', with a URL 'https://en.wikipedia.org › wiki › List_of_lakes_of_Gre...'. To the right of the text is a small map of Greece. Below the main result is a section titled 'People are also asking' with four related questions, each with a dropdown arrow: 'Are there any lakes in Greece?', 'Are there any lakes in Athens?', 'Does Greece have any lakes or rivers?', and 'Can you swim in Lake Trichonida?'. At the bottom right of the results section is a 'Feedback' link.

Google

Which greek cities contain lakes?

× |

All Images News Maps Books More Tools

About 231,000,000 results (0.55 seconds)

Wikipedia
https://en.wikipedia.org › wiki › List_of_lakes_of_Gre...

List of lakes of Greece - Wikipedia

Central **Greece** · **Lake** Amvrakia · **Lake** Dystos, Euboea, presently largely drained;
Lake Lysimachia · Crete · **Lake** Kournas · **Lake** Voulismeni · Epirus · **Lake** Gistova ...

People are also asking :

Are there any lakes in Greece?

Are there any lakes in Athens?

Does Greece have any lakes or rivers?

Can you swim in Lake Trichonida?

Feedback

No Answer!

The screenshot shows a web browser window with a single tab titled "Dataset Search". The address bar displays "datasetsearch.research.google.com". The Google logo is in the top left, and a "Sign in" button is in the top right. The main heading "Dataset Search" is centered. Below it is a search bar containing the text "Give me Sentinel-2 satellite images that show Mount Etna and have been taken in February 2021". To the right of the search bar is a magnifying glass icon. Below the search bar, there is a suggestion: "Try [coronavirus covid-19](#) or [education outcomes site:data.gov](#)." At the bottom, there is a link: "[Learn more](#) about Dataset Search."

No Answer!

The screenshot shows a web browser window with the Google Dataset Search page. The browser's address bar shows the URL `datasetsearch.research.google.com`. The Google logo is in the top left, and a 'Sign in' button is in the top right. The main heading is 'Dataset Search'. Below it is a search bar containing the text: 'Give me Sentinel-2 satellite images that show Mount Etna and have been taken in February 2021'. To the right of the search bar is a magnifying glass icon. Below the search bar, there is a suggestion: 'Try [coronavirus covid-19](#) or [education outcomes site:data.gov](#)'. At the bottom of the search area, there is a link: '[Learn more](#) about Dataset Search.'

...or Return Sentinel2 images from lakes that are within cities

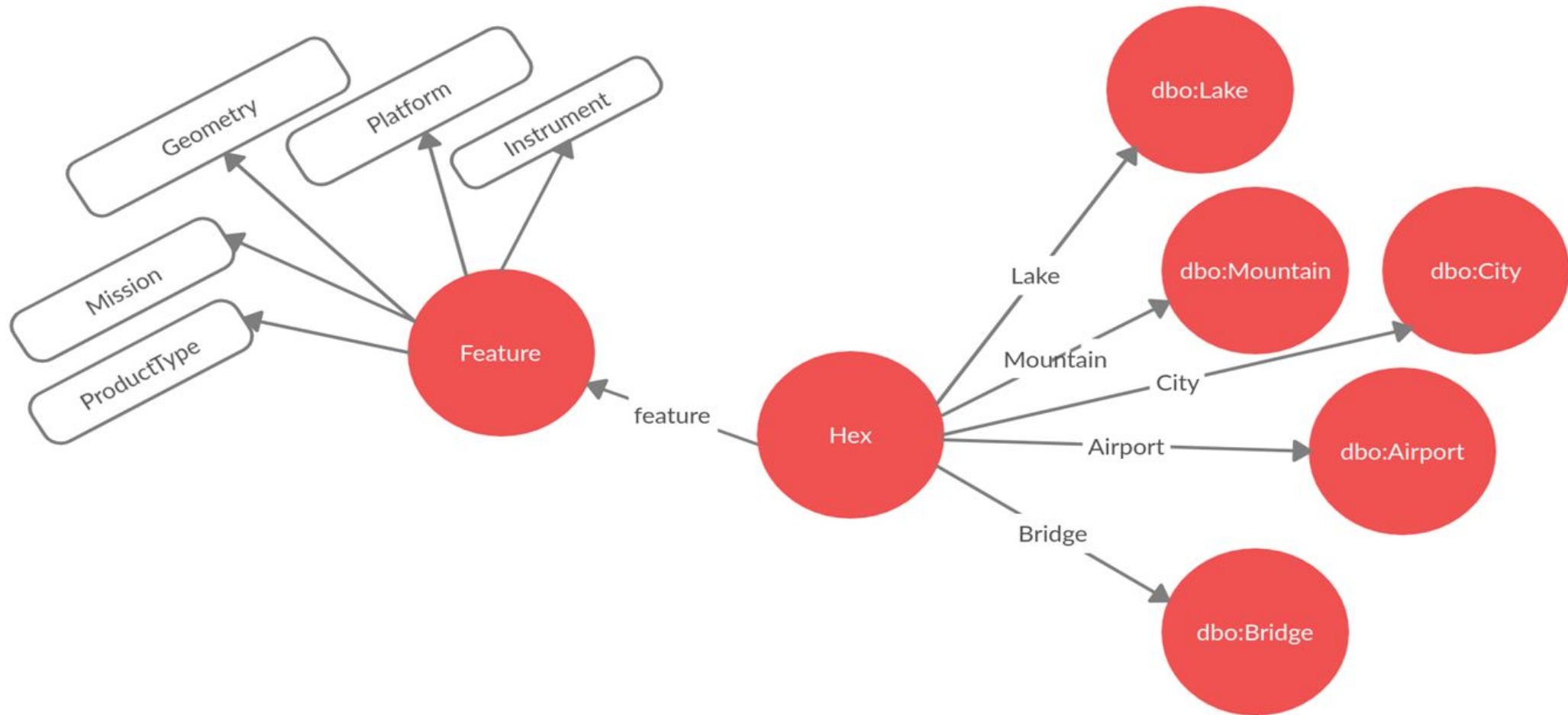
- EarthQA accepts **questions in natural language (English)** that ask for EO datasets having certain properties and returns links to such datasets. **The properties can refer to satellite image metadata and relevant geographical knowledge from the KG DBpedia.**
- Example questions:
 - Find Sentinel-1 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**.

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

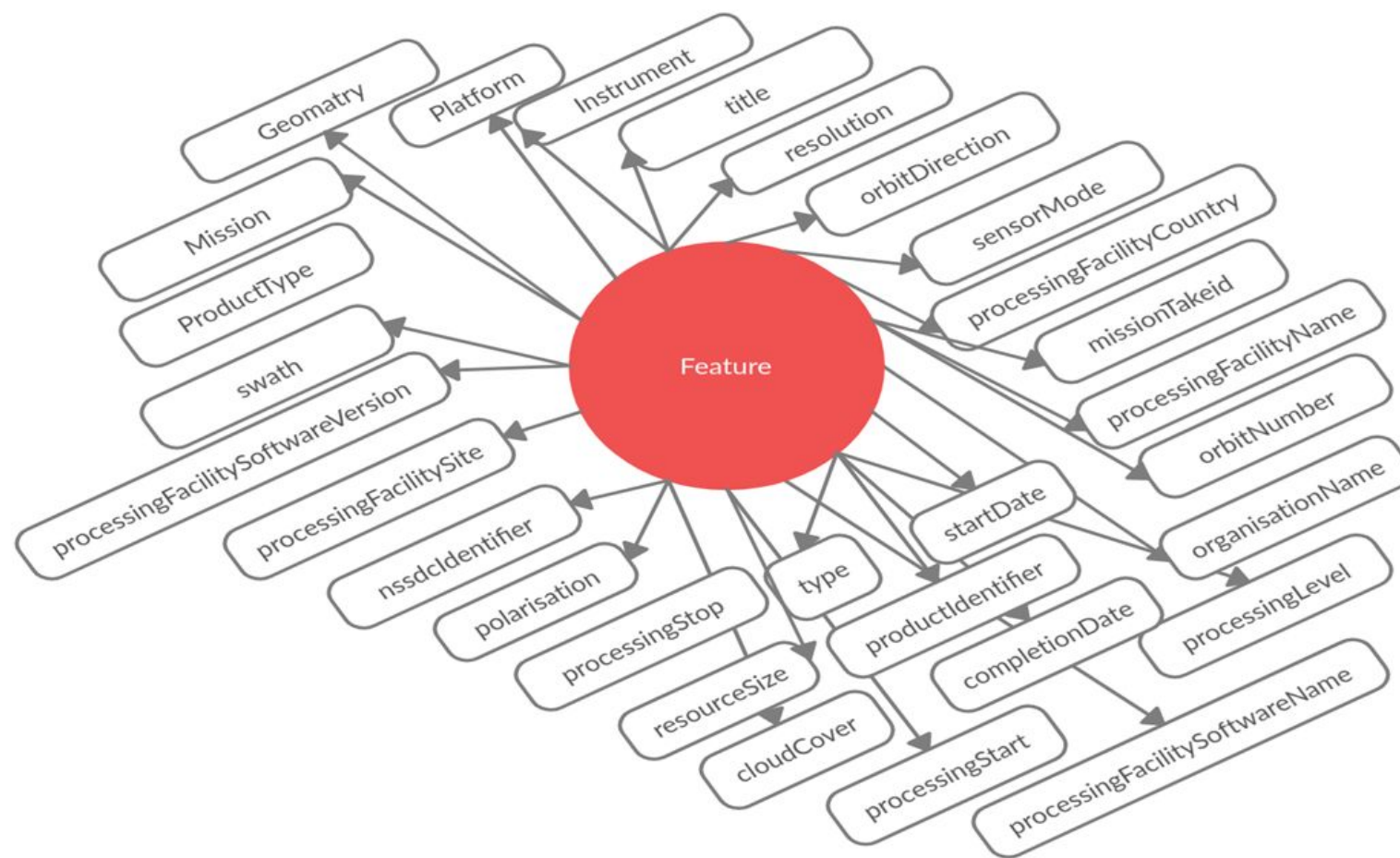
EarthQA is based on:

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

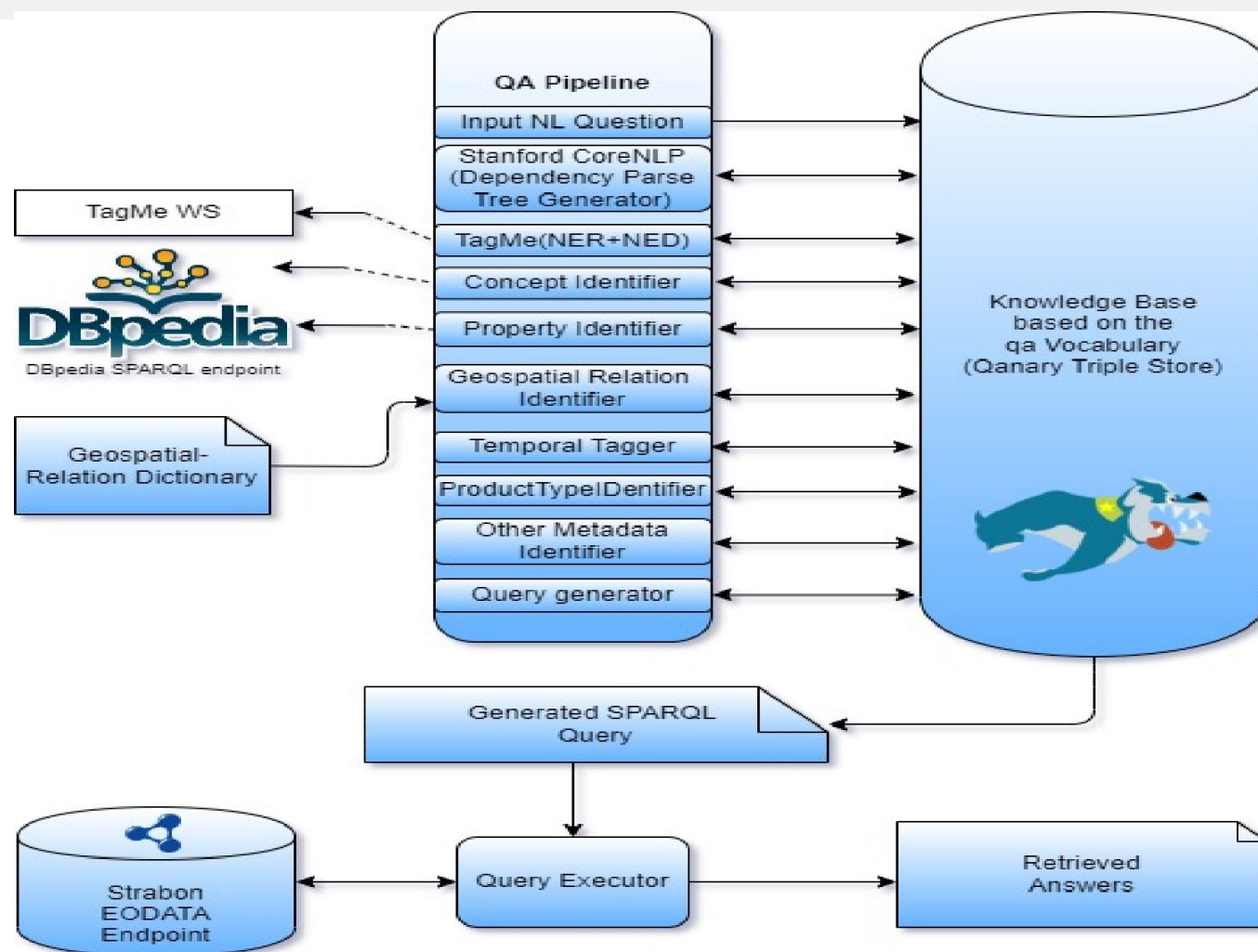
EarthQA Knowledge Graph



EarthQA Knowledge Graph



EarthQA – Software Architecture



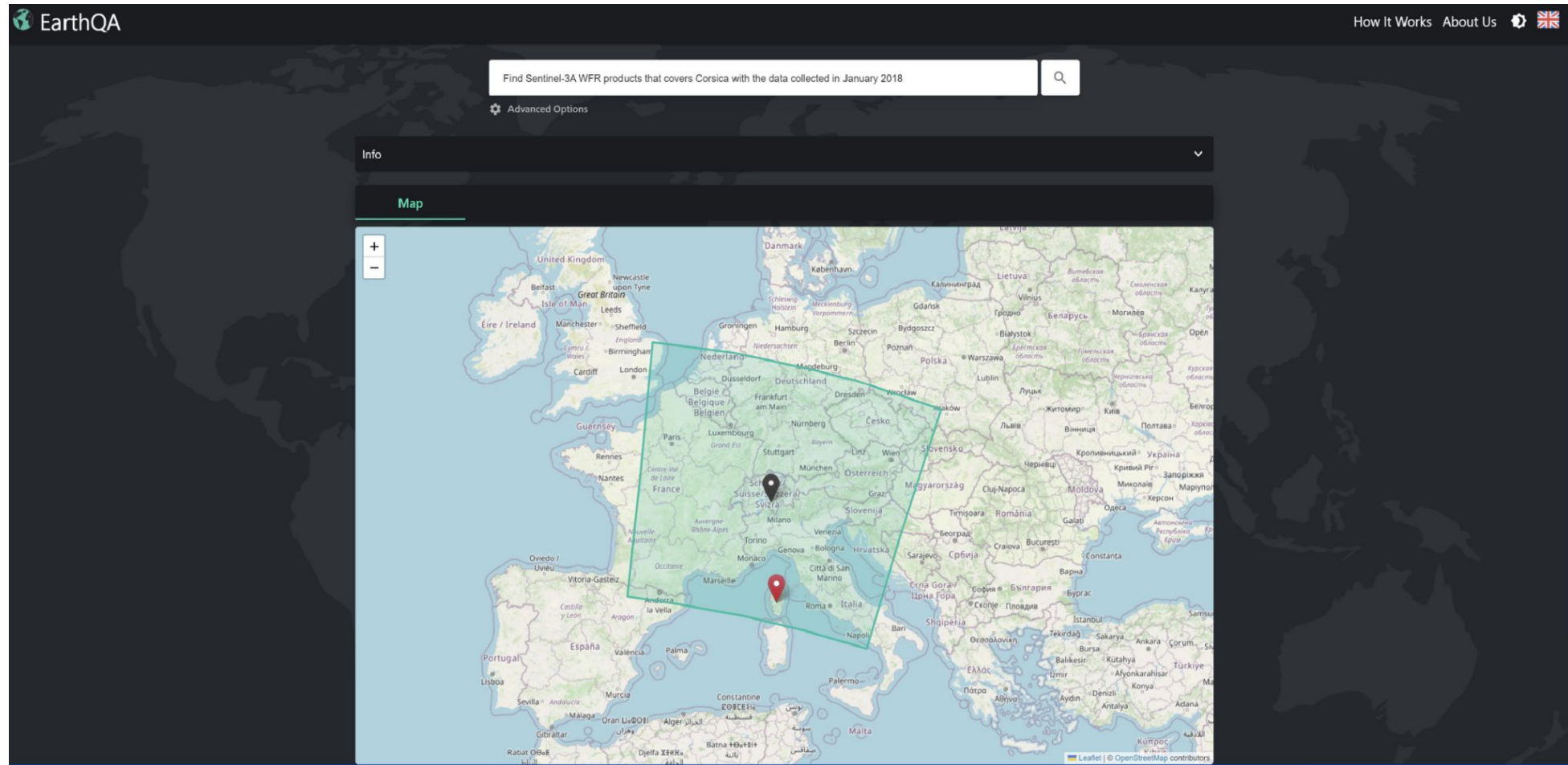
Example

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!

Any Questions?



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a Thales / Leonardo company Space



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for the World®

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ECMWF



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BLUE
sight conseil



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