Publication

LinkClimate: An Interoperable Knowledge Graph Platform for Climate Data

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Introduction

- Climate change is a pressing global issue that requires advanced tools to study its impacts.
- Climate data, such as temperature, precipitation, and wind, is collected globally but stored in disconnected systems.
- Current challenges:
  - Researchers struggle to integrate data from multiple sources.
  - Cross-domain analysis (linking climate data with geography or human activities) is difficult.
- **LinkClimate** aims to overcome these challenges by creating a unified knowledge graph for integrated data analysis.

Objectives

- An open online KG populated with NOAA climate data as a means of providing context to data, thus increasing the platform's explainability, which is often lacking in many automation systems.
- Integration of heterogeneous data sources e.g. climate, with geographic (OpenStreetMap) and encyclopedic (Wikidata) source through use of Linked Data Principles.
- Regular, automated synchronization of heterogeneous data into the KG.
- A Web interface to assist climate researchers in exploring and using the platform.

Data Sources

- **NOAA (National Oceanic and Atmospheric Administration)**:
  - Provides historical daily climate data, including meteorological variables like temperature, precipitation, and wind.
- **OpenStreetMap (OSM)**:
  - Supplies geographic data such as weather station locations, boundaries, and nearby geographic features.
- **Wikidata**:
  - Offers encyclopedic information, linking geographic features with detailed context like administrative regions, nearby water bodies, and more.

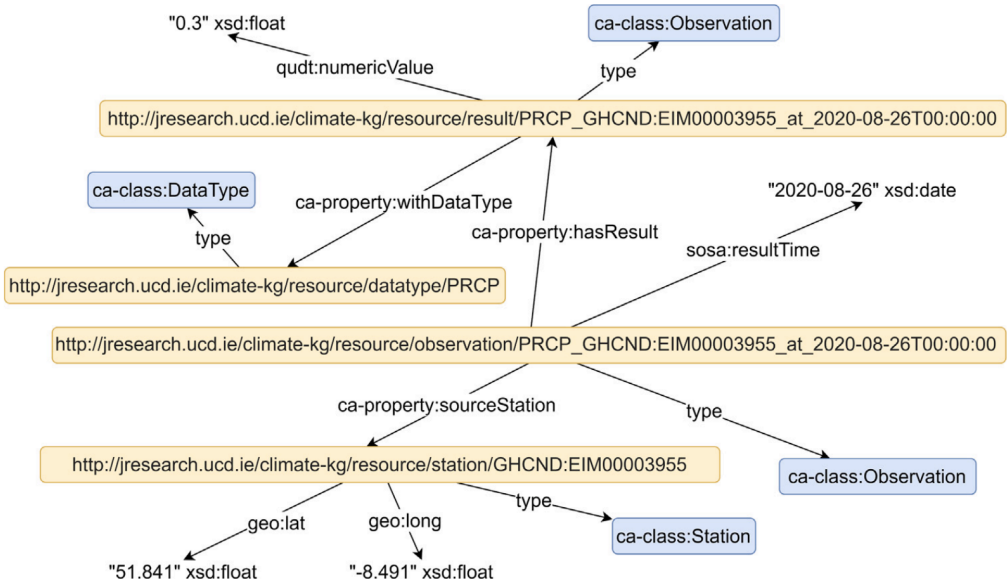
Climate Analysis Ontology (CA Ontology):

- Climate data from NOAA APIs (e.g., temperature, precipitation, wind) is inherently unstructured or loosely structured.
- CA Ontology provides a schema that transforms this data into a structured format with meaningful relationships. For example:
  - A weather station (class: Station) records temperature data (class: Observation) at a specific time (property: resultTime) and location (property: isLocatedIn).
- CA Ontology aligns data from different sources by using common vocabularies. This ensures that datasets from NOAA, OpenStreetMap, and Wikidata can be integrated seamlessly.

Workflow

1. Data is requested from NOAA's APIs.
2. The CA Ontology is then used to structure and introduce semantics to the raw data.
3. OpenStreetMap-based geographic information, such as counties and cities of climate stations, is integrated to enrich the KG.
4. The data is stored as RDF triples in a triple-store database.
5. Data is accessible via web endpoints. Also, a SPARQL endpoint allows users to query the data.

In Action - Web Endpoint



In Action - SPARSQL

```
BASE <http://jresearch.ucd.ie/climate-kg/>
PREFIX ca_property: <http://jresearch.ucd.ie/climate-kg/ca/property/>
PREFIX wdt: <http://www.wikidata.org/prop/direct/>

SELECT ?sta ?wb
WHERE{
  ?sta a <ca/class/Station> ;
       ca_property:hasAddress ?addr .
  ?addr ca_property:county | ca_property:city ?loc .
  ?loc ca_property:referenceTags/ca_property:wikidata ?wd .
  SERVICE <https://query.wikidata.org/sparql> {
  ?wd wdt:P206 ?wb .
  }
}
```

Listing 1: A sample query that retrieves stations near any water body (recorded in Wikidata)

Figure 2: Link Climate Query

Usability Testing

- A web interface was developed for non-expert users, featuring an intuitive GUI and SPARQL query guidance.
- Usability testing involved asking 7 questions from 31 participants, with positive feedback.
- Average scores for usability questions ranged from 3.94 to 4.33 (on a 5-point scale).
- Users found the platform effective for querying climate data, though some suggested improvements for the interface.

Benefits and Applications:

- **For Researchers**:
  - Reduces the time and effort required to integrate diverse datasets.
  - Simplifies complex queries across multiple domains.
- **For Policy Makers**:
  - Supports evidence-based decision-making with data-driven insights.
- **Future Applications**:
  - Expanding into related domains like air quality, oceanography, and urban development.
  - Enabling large-scale climate impact studies across regions.

Challenges and Future Work

- **Challenges**:
  - Managing the complexity of integrating diverse data types (e.g., satellite data, socio-economic indicators).
  - Ensuring consistent data quality and maintaining up-to-date information.
- **Future Enhancements**:
  - Extend the CA Ontology to include more data types like remote sensing and NetCDF-formatted data.
  - Develop a more user-friendly web interface to make the platform accessible to non-technical users.
  - Integrate GeoSPARQL for better spatial queries and analysis.