AI4DiTraRe: Towards LLM-Based Information Extraction for Standardising Climate Research Repositories

Leibniz ScienceCampus
Digital Transformation of Research

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Leibniz Institute for Information Infrastructure

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AI 4 Scholarly Communication, Bridge @ AAAI, 25th-26th February 2025

DiTraRe = Digital Transformation of Research

Leibniz Science Campus

Leibniz ScienceCampus
Digital Transformation of Research

Regional growth core to **establish new research branch**.

FIZ Karlsruhe – Leibniz Institute for Information Infrastructure
+
Karlsruhe Institute of Technology (KIT)

- Planned as a **4+4 years** project (start: September 2023).
- Funded by the Leibniz Association + FIZ KA + KIT.
- Analyse the process of **digitalisation of research**.
- Multilevel **interdisciplinary** approach.
- Very broad, general scope.

DiTraRe Use Cases

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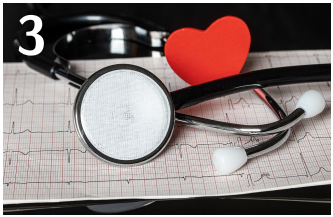
Sensitive Data in Sports Science

KIT Institute of **Sports and Sports Research**

Chemotion Electronic Lab Notebook

KIT Institute of **Biological and Chemical Systems**



AI in Biomedical Engineering

KIT Institute of **Biomedical Engineering**

Publication of Large Datasets

KIT Institute of **Meteorology and Climate Research**

Managing and publishing in the petabyte era

UC4: Publication of large datasets (climate research)

An example: Infrared Atmospheric Sounding Interferometer (IASI) data.

- Instrument on the MetOp satellite.
- Collects data on atmospheric temperature and humidity.
- Current size of IASI full retrieval product: 25 TB (15 GB per day).
- No exploration of data possible (i.e. map).
- RADAR(4KIT) currently doesn't enable download of sub-files.

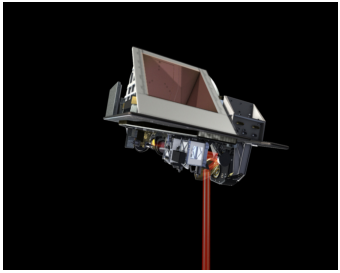


Figure: Infrared radiation directed into the IASI instrument. *Credit: ESA.*

Managing and publishing in the petabyte era

UC4: Publication of large datasets (climate research)

- Climatologists harvest their data from multiple sources:
  - ground-based observatories and stations
  - balloons
  - aeroplanes
  - satellites

Figure: *Credit: KIT-IMKASF*

The problem of standardisation

UC4: Publication of large datasets (climate research)

- Extracting knowledge from these huge datasets is challenging.
- Proper synchronisation of datasets, integrating different data formats, and mapping standards is needed.
- Different standards → metadata inconsistencies.
  - I.e. datasets including identical measurements but tagged inconsistently (e.g., *Latitude/Longitude* vs. *Geocoordinates*).
- Data reusability and interoperability is strongly limited.
  - Climate research requires cross-repository analyses.

→ *AI4DiTraRe goal in UC4: Support creation of a uniform data management platform.*

Idea: LLMs to the rescue

UC4: Publication of large datasets (climate research)

- Leveraging LLMs for metadata standardisation is a promising route.
- Effective at:
  - Recognising patterns.
  - Resolving ambiguities in natural language description.
  - Generating standardised metadata entries.

Idea: LLMs to the rescue

UC4: Publication of large datasets (climate research)

- Leveraging LLMs for metadata standardisation is a promising route.
- Effective at:
  - Recognising patterns.
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  - Generating standardised metadata entries.
- An idea of a novel LLM-based tool for extracting and harmonising metadata in climate research repositories.

Earth Data Portal

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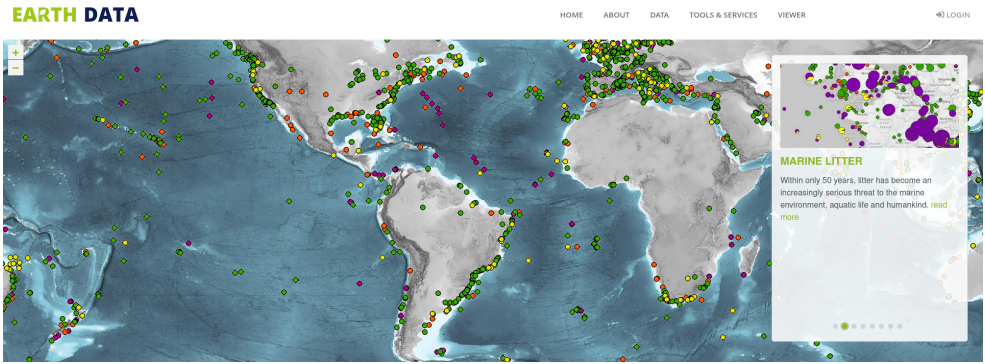
- Collaborative platform for discovering, visualising, and downloading environmental sciences data.
- Provide access to reusable datasets to enhance research efficiency.



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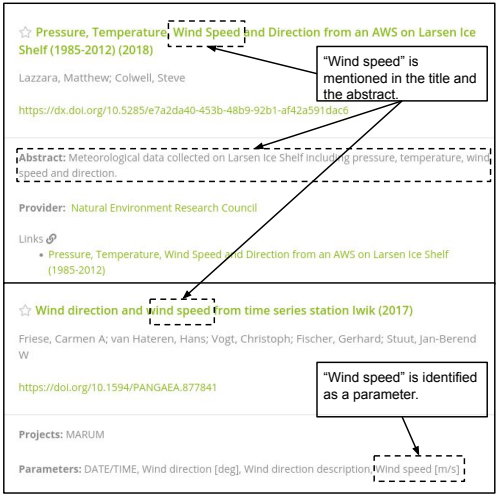

- Abstracts and titles also contain information.
- I.e. *wind speed*.

Preliminary analysis

UC4: Publication of large datasets (climate research)

- API to extract metadata from the Earth Data Portal.
  1. Only datasets imported from the PANGAEA repository are indexed with parameters.
  2. Existing parameters are not standardised.

Preliminary analysis

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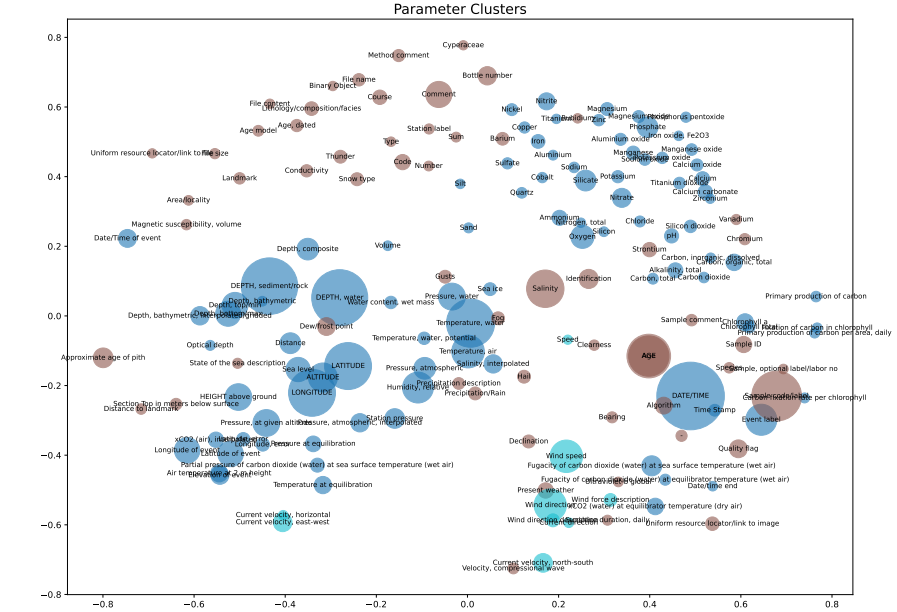
  2. Existing parameters are not standardised.
- Sentence BERT → embeddings of the parameters, semantic similarity of parameters based on cosine similarity of the embeddings.
- DBSCAN → group similar parameters into clusters (bubbles with the same colour).
- Multidimensional scaling → plot the embeddings in two dimensions.
- Size of the bubble represents frequency of the occurence of the parameter.



- Duplicate terms (i.e. *Age/AGE*).
- Nested concepts (i.e. *Wind speed* in *Speed*).

Proposed approach

UC4: Publication of large datasets (climate research)

1. A terminology for dataset parameters.
   - Canonical forms and their variants (e.g. *TEMP* vs *temperature*).
   - Integrate existing terminologies such as PANGAEA.

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2. Automate parameter detection and linking.
   - Dataset: abstracts and structured parameters → train to detect parameters in unstructured text (titles and abstracts).
   - LLMs to map parameters to the reference terminology.

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3. A chatbot for dataset import and retrieval.
   - Assist users with dataset importation tasks (i.e. make suggestions).
   - Improve dataset discovery (i.e. recommend related datasets).

Outlook

UC4: Publication of large datasets (climate research)

- This paper is a vision paper presenting an idea which is currently being developed.
- How to clean up the data for a unified portal?
  - Earth Data Portal has flat categories – different granularities of definitions.
  - How to introduce controlled vocabularies?
  - Combination of historical data and new uploads.
  - PANGAEA repository as the most complete – use it as a training set.
- **Neurosymbolic AI**: ML + symbolic logic

Summary

- DiTraRe = Digital Transformation of Research.
- Ongoing interdisciplinary research.
- **Role of AI** within the process of digitalisation?

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→ DiTraRe Symposium: December, Karlsruhe, Germany

→ Anna.Jacyszyn@fiz-karlsruhe.de

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Thank you for your attention! ☺

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Which LLMs are we going to use?

- On our server we have:
  - Mistral-7B
  - Falcon-7B
  - Llama-7B
- Open LLMs to ensure reproducibility.
- Firstly, we need to prepare a ground truth to evaluate existing LLMs for our task.
  - Any suggestions?