Talking to the Planet: Natural Language × Digital Earth for Disasters

Innovation Summit

The 133rd OGC Member Meeting,

Boulder, Colorado USA

Dr. Steve Liang & Dr. Erin Li
University of Calgary
28 October 2025

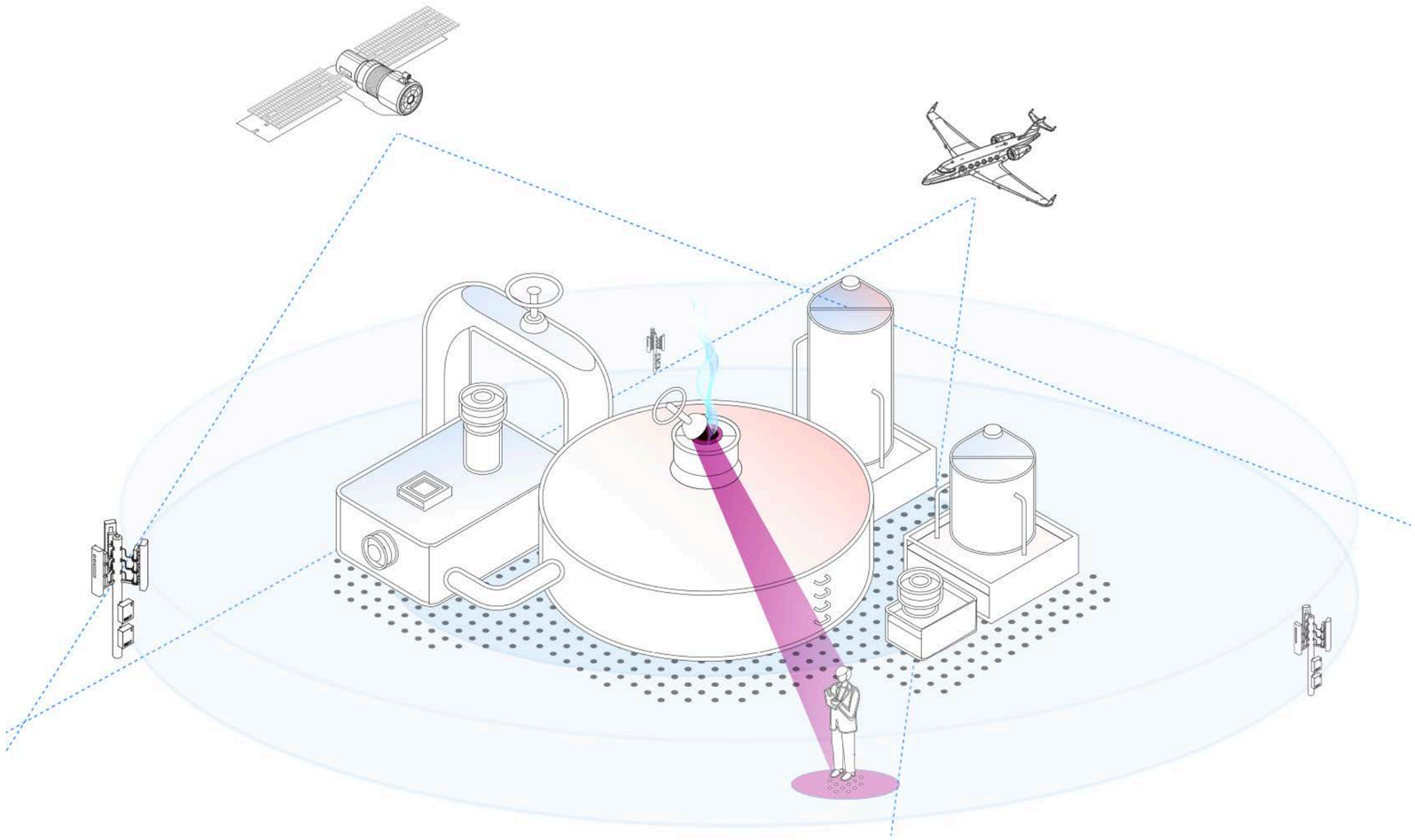
Meeting Host

UCAR
UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

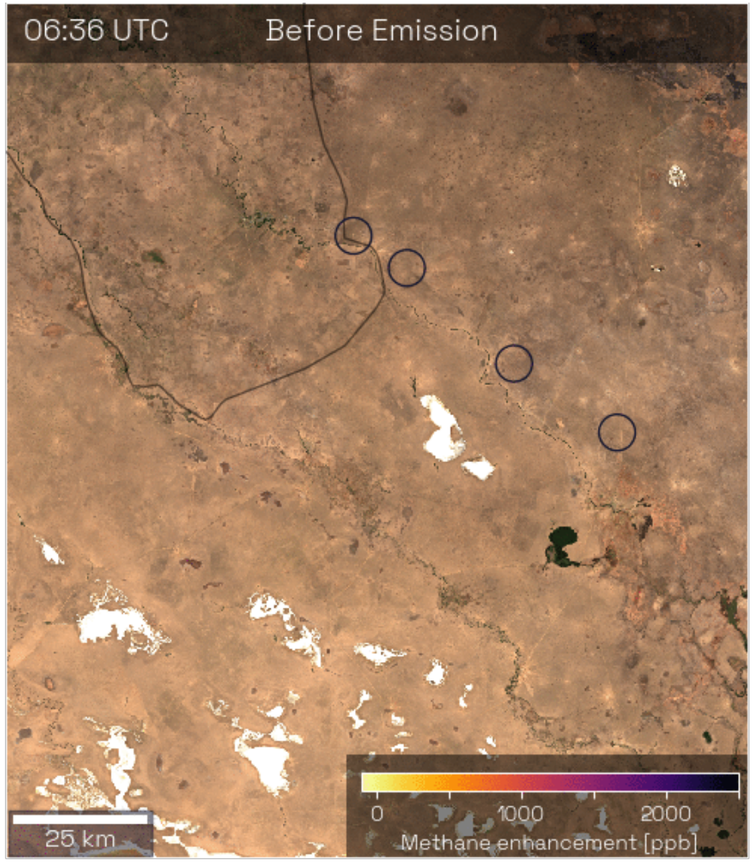
Meeting Sponsor

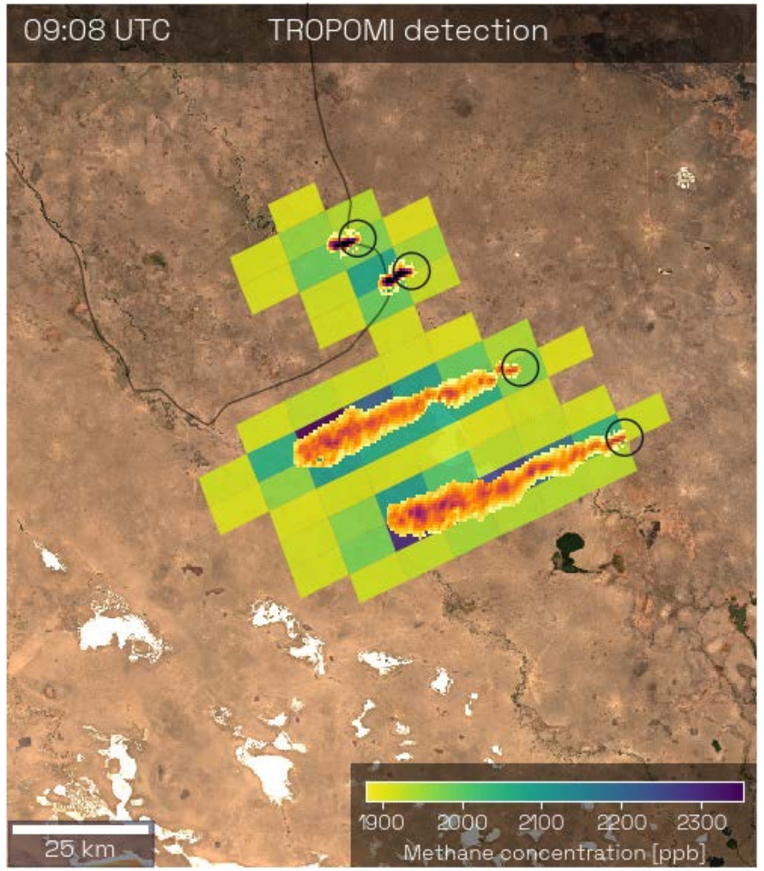
KONGSBERG GEOSPATIAL
Enabling Mission Critical Decisions

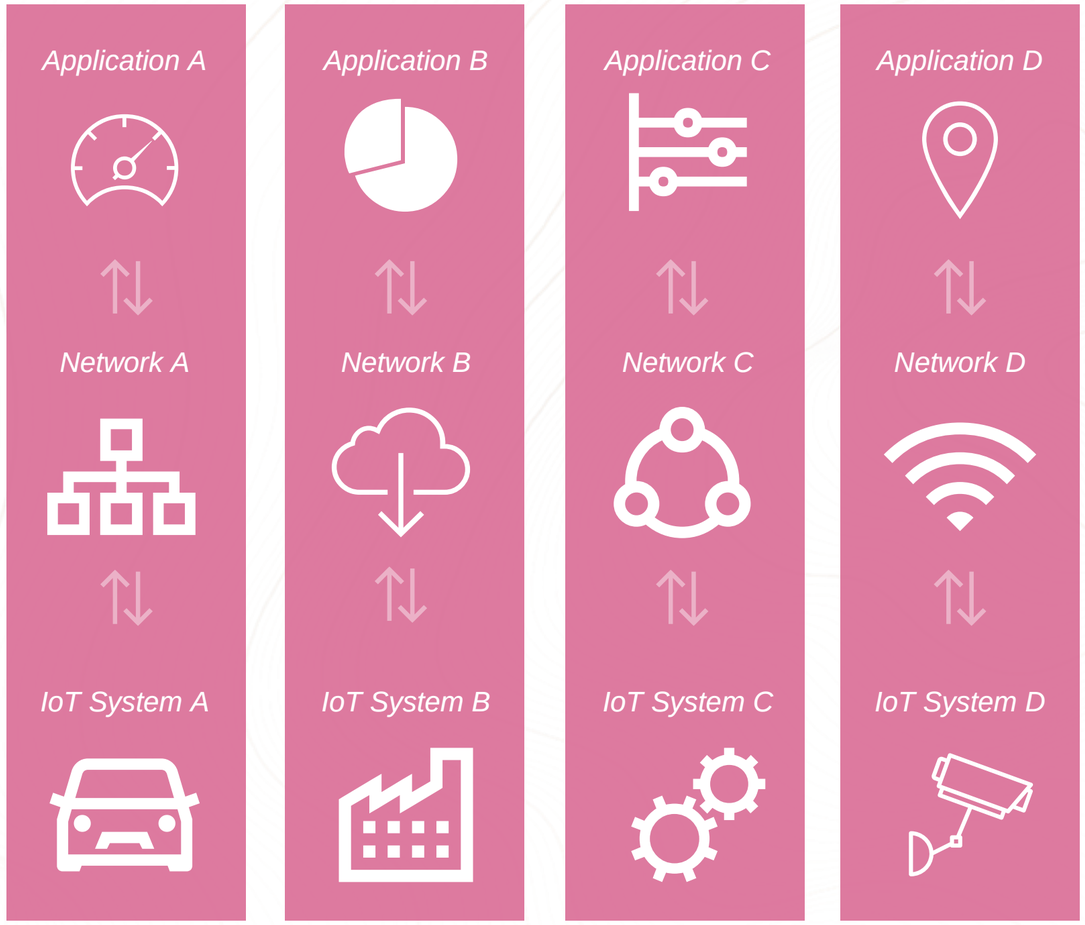
The Sensor Web: the vital Nervous System of Digital Earth



From Raw Observations to Actionable Events





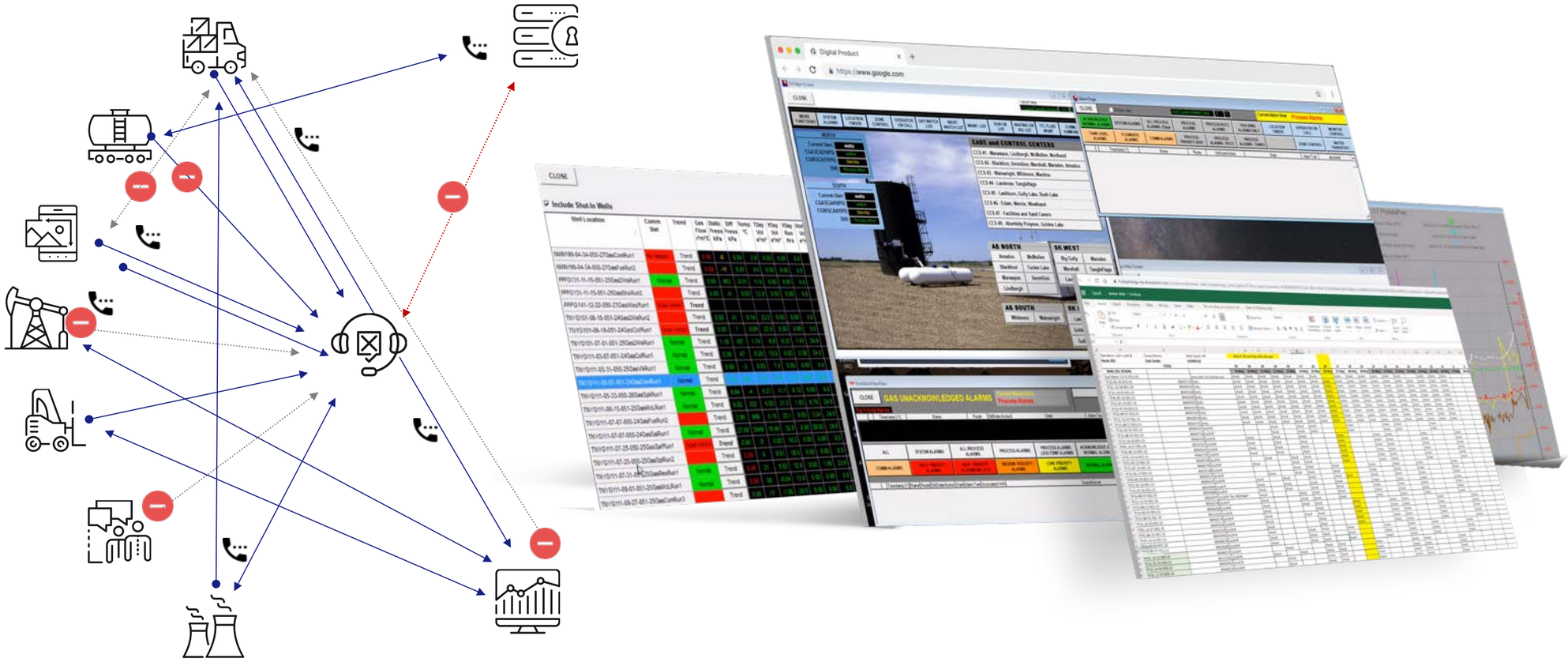


Today's IoT systems are still siloed and fragmented.

It's like your body being a network of sensors where your eyes, ears, and hands never share what they sense.

SENSORUP

Labor Intensive, Slow Response, Costly Mistakes



MULTIPLE **DATA SILOS**

NO **REAL-TIME VISIBILITY**

NO **EARLY WARNINGS**

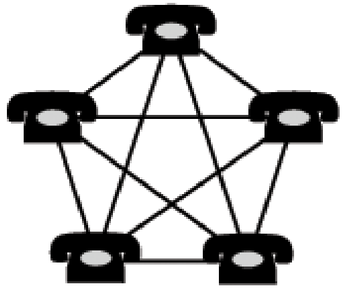
NO **AUTOMATION**

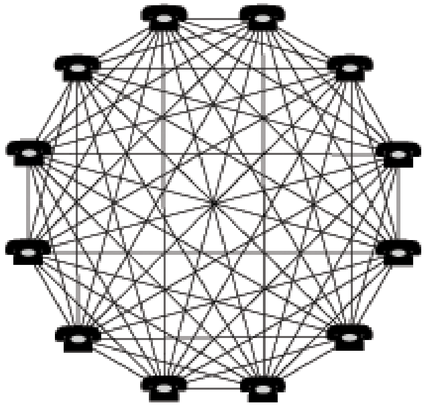
COMPLICATED **PROCESSES**

AD HOC **COMMUNICATION**

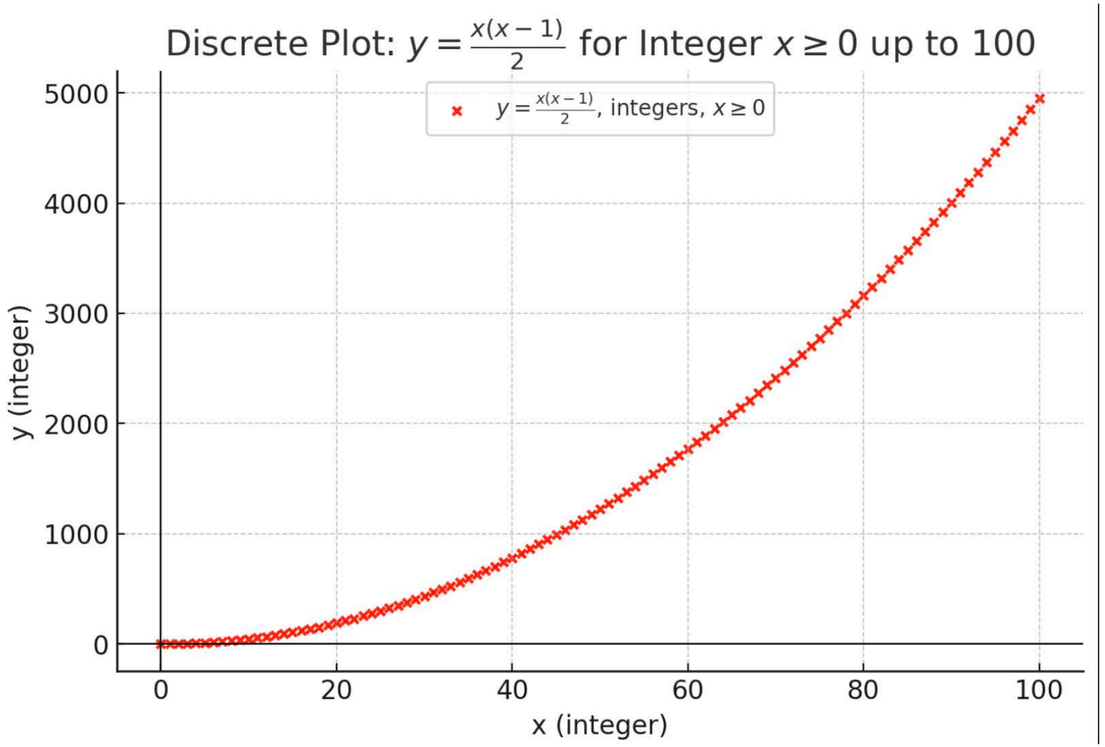
HUMAN **ERRORS**

Too Many Sensors, Too Much Manual Glue





number of edges = n(n-1)/2



OGC: Codifying the Glue;

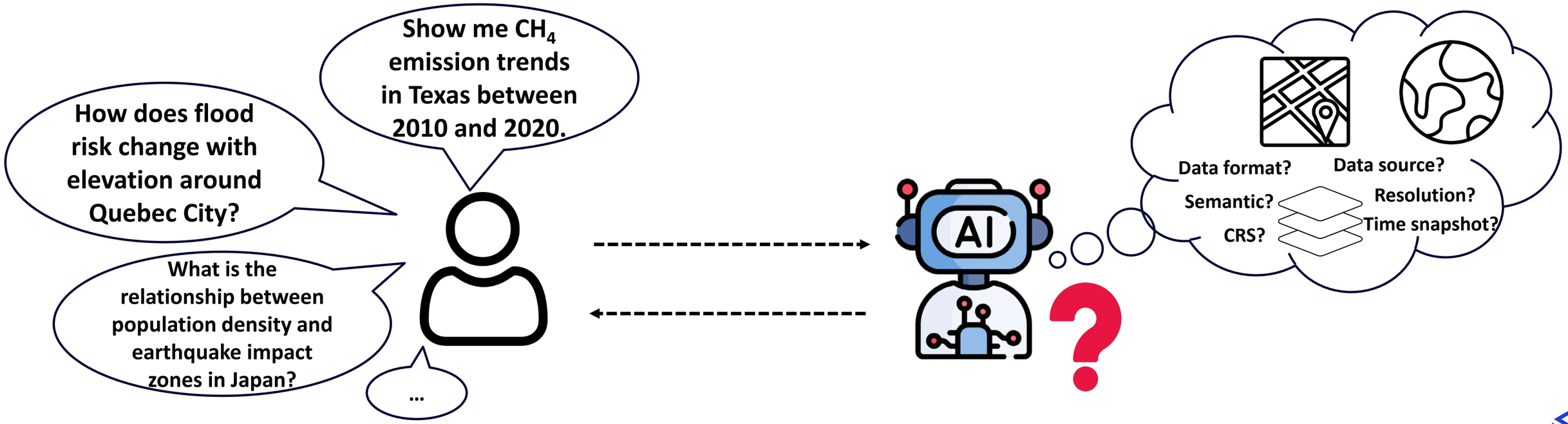
AI Agents: Spreading It at Scale

SENSORUP

Motivation

Multi-source spatial data fragmentation

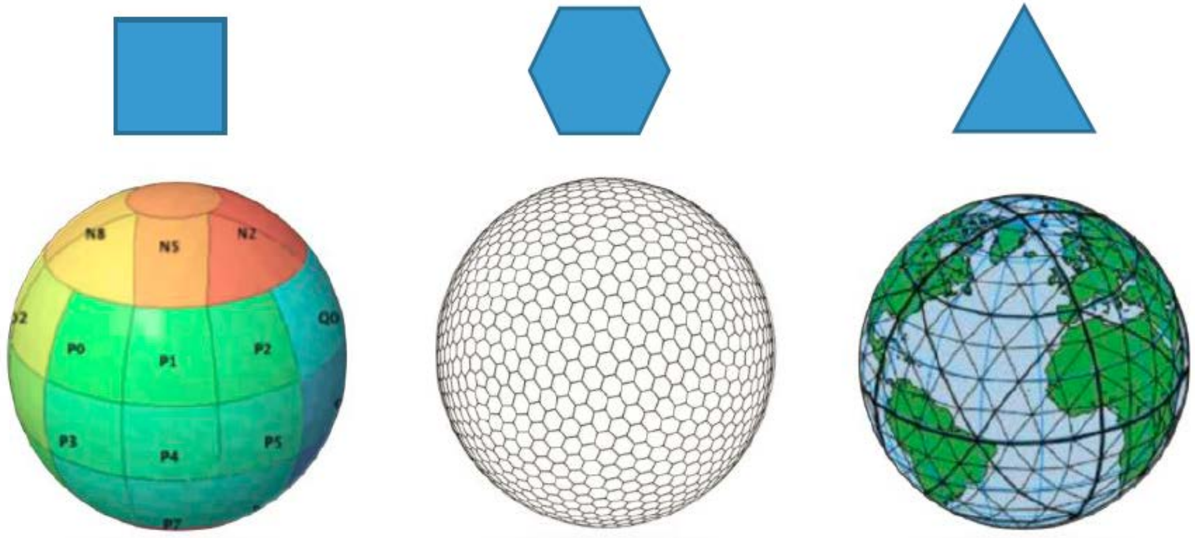
- Spatial data today sits across multiple platforms.
- Inconsistent CRSs, file formats, spatial resolutions, time snapshots, semantics, etc.
- Data chaos slows analysis and decisions before/during/after events.
- AI models struggle to reason over such inconsistencies - standardization is the core.



Motivation

DGGS is “A Spatial Reference System that uses a Hierarchical Tessellation of cells to Partition and Address the Globe. ” https://www.ogc.org/standards/dggs/

- Discrete -- a finite number of cells
- Global -- a grid that completely covers the Earth’s surface
- Grid -- a tessellation of space into a uniform arrangement of cells
- System -- a grid that can be subdivided into smaller cells

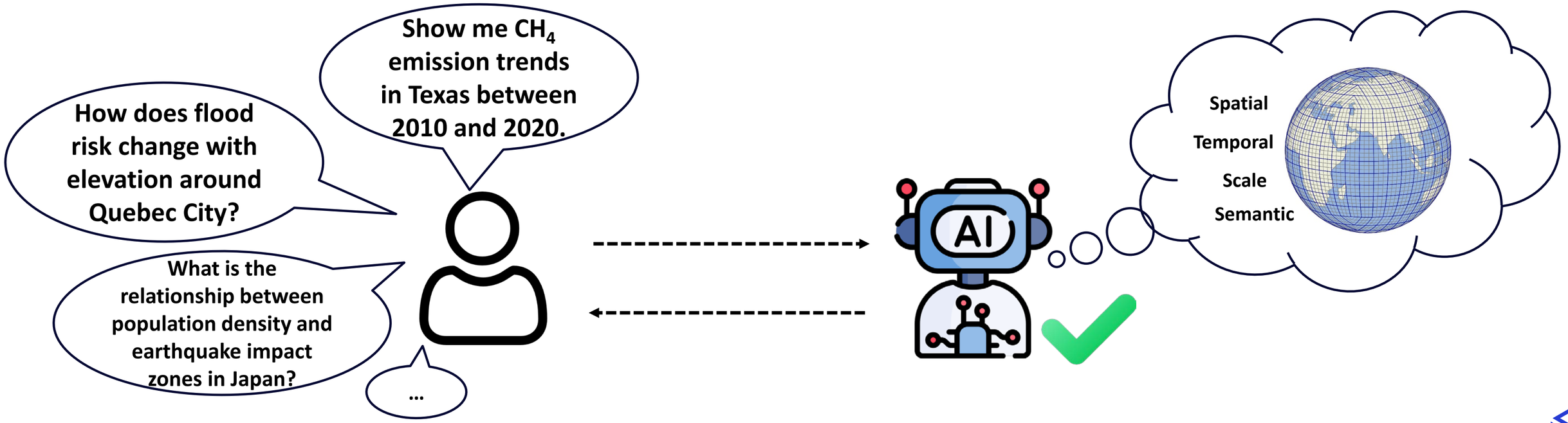


rHEALPix ISEA3H QTM

Motivation

DGGS as a standardized reference system

- Spatial: Equal-area global grid with cell index.
- Temporal: Enables consistent change analysis with fixed cell locations.
- Scale: Hierarchical structure supports zooming and aggregation.
- Semantic: Common feature schema & attribute alignment.



Research objective

Assumption

AI has tremendous potential, but only when built on a foundation of standardized, high-quality data. Emerging standards such as DGGS provide the spatial and semantic infrastructure needed to unlock that potential.

Objective

To develop a scalable geospatial intelligence framework that integrates DGGS and generative AI for automated extraction, normalization, spatial indexing, and visualization of environmental data from heterogeneous sources, demonstrated through a methane emissions use case.

Two-Part Work Structure

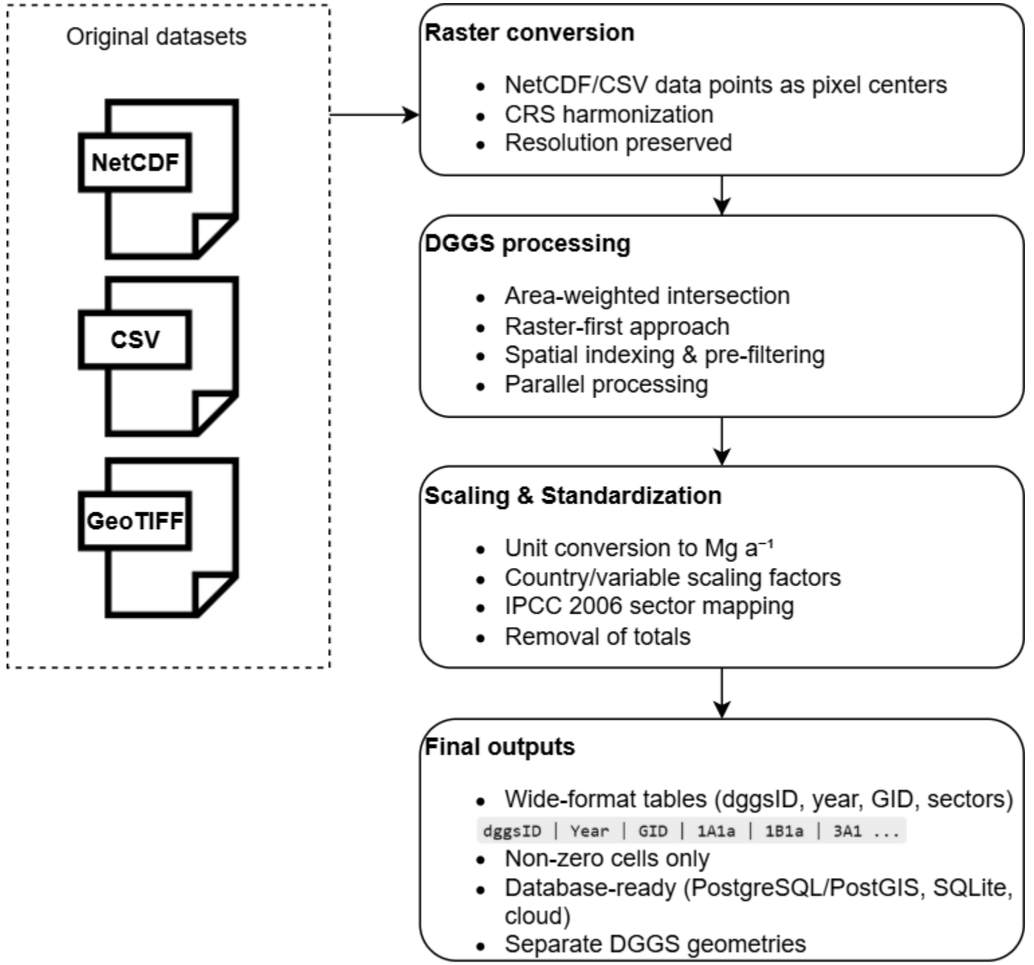
Part 1 – Data harmonization

- Convert multiple emission inventories onto rHEALPix DGGS using DGGAL (https://github.com/ecere/dggal).

rHEALPix = **r**earranged **H**ierarchical **E**qual **A**rea iso**L**atitude **Pix**elization
DGGS = **D**iscrete **G**lobal **G**rid **S**ystems

- Standardize spatial structure, sectoral semantics (to IPCC 2006 scheme), and reporting units (to Mg a^{-1}).
- Apply scaling factor (close to one) to ensure conservation of total emissions.
- Store data in DGGS-indexed relational backend.

➢ Li, M., & Liang, S. (2025). Harmonized Global to Regional Gridded Methane Inventories on rHEALPix DGGS (V1.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.17362125

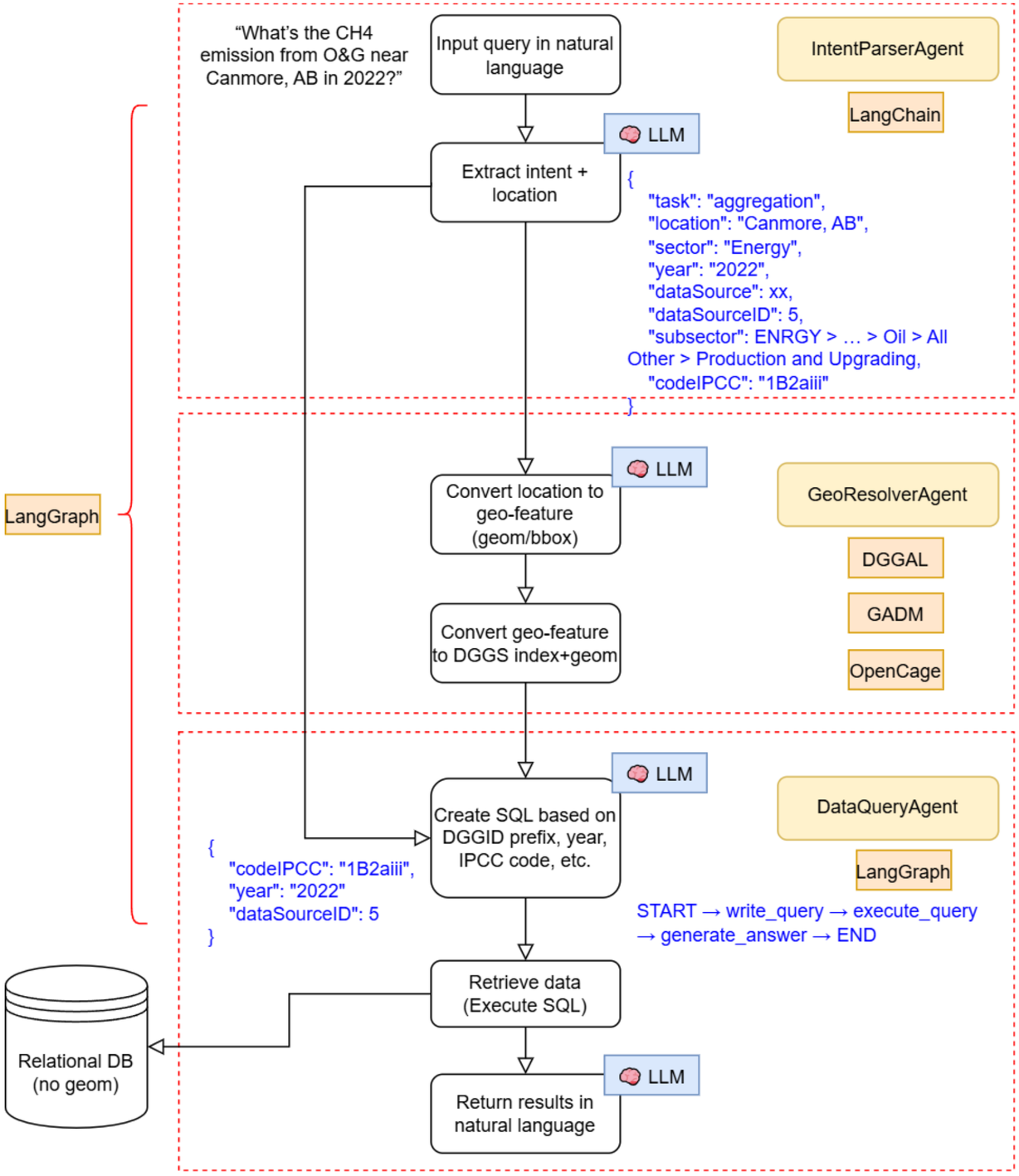


Two-Part Work Structure

Part 2 – Intelligent query system

- Turns natural language into DGGS-aware queries and answers
  - IntentParserAgent extracts task + variables
  - GeoResolverAgent maps text location → DGGS IDs
  - DataQueryAgent generates SQL → retrieves results → explains answer
- Orchestrated by LangGraph

```
├── intent_parsing
├── geo_resolver
├── data_querying
│   ├── _write_query
│   ├── _execute_query
│   └── _generate_answer
└── generate_final_response
```



Methane Query – Streamlit Pro

localhost:8501

Google | Google Maps | Google Drive | Google Chat | Google Photos | G | R | UNB | UCalgary | USherbrooke | PDF | Online Course | Job | Journal | Visa | Vacation | 133rd Member Mee...

Deploy

Multi-Agent Methane Data Query Systems

End session

Map Visualization

No data available for download

Ask about methane emissions, anywhere, any sector, and any year between 1970 and 2022...

Key outcomes

- Harmonized gridded inventories: Developed a global to regional methane emissions dataset (DOI:10.5281/zenodo.17362125), standardized by IPCC sector codes and DGGS spatial index.
- End-to-end DGGS + AI workflow: Demonstrated how DGGS-indexed data can directly power generative AI query and analysis pipelines.
- Explainable and traceable analytics: Each AI-generated result can be traced back to DGGS cells and original data sources, ensuring transparency.
- Modular multi-agent design: Agents are reusable and adaptable to other domains such as flood monitoring, air quality, etc.

Future work

- Domain-agnostic expansion: Extend the framework to other greenhouse gases, pollutants, and climate-related hazards.
- More agentic architecture: Introduce planner–executor loops and potential human-in-the-loop interaction for dynamic reasoning using LangGraph.
- Quantitative evaluation: Establish performance metrics to assess accuracy, efficiency, interpretability, and reliability of agent responses.

THANK YOU

www.ogc.org