



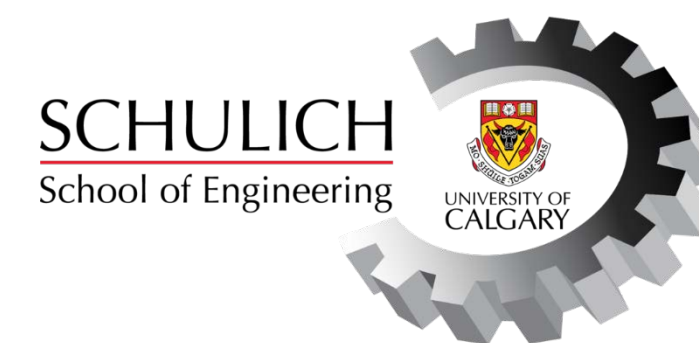
Natural Language to DGGS-Aware Methane Insights with a Multi-LLM-Agent Framework



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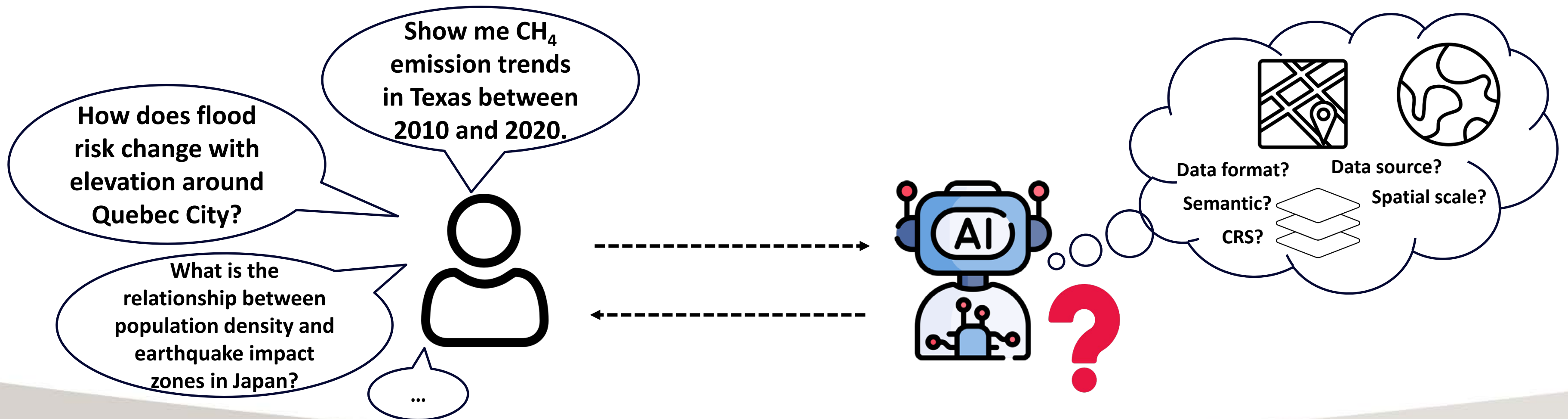
Feb 21, 2026



Motivation

Multi-source spatial data fragmentation

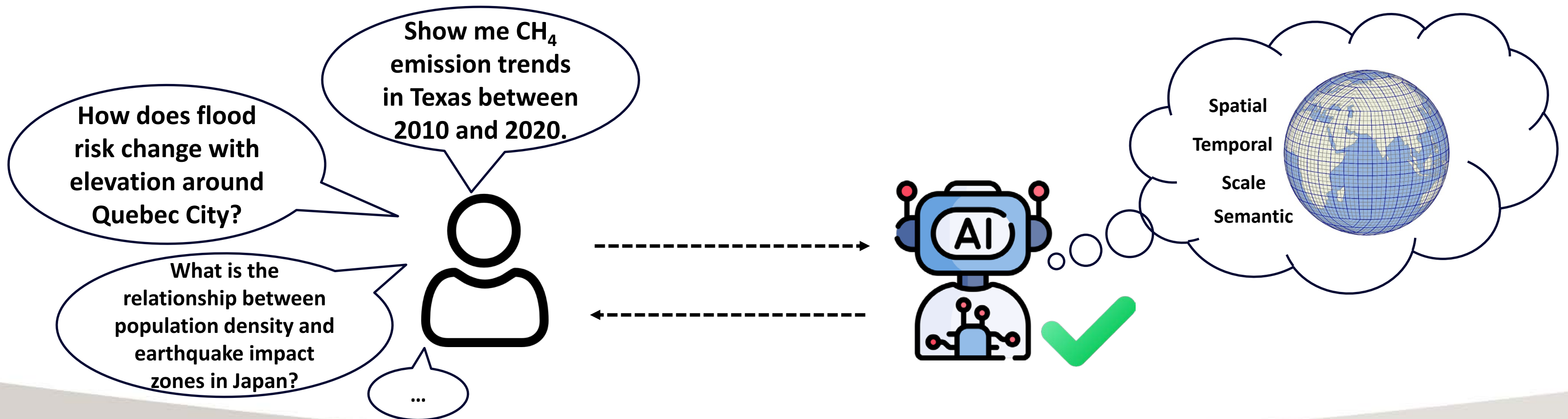
- Spatial data today are scattered across multiple platforms and standards.
- Inconsistent coordinate reference systems, file formats, spatial resolutions, etc.
- Data chaos slows decisions before/during/after events.
- AI models struggle to reason over such inconsistencies.



Motivation

Discrete Global Grid Systems (DGGS) as a standardized reference system

- **Spatial**: Equal-area global grid unifies coordinate systems.
- **Temporal**: Enables consistent time-indexed snapshots for change analysis.
- **Scale**: Multi-resolution hierarchy supports zooming and aggregation.
- **Semantic**: Common feature schema & attribute alignment.



Research objective

- *To Build: DGGS-grounded **multi-agent** NL geospatial analytics*
- *To Study: **DGGS** as the grounding and provenance layer for **GenAI***
- *To Show: **Methane** emissions case study (multi-inventory, multi-scale, traceable)*

Two-Part Work Structure

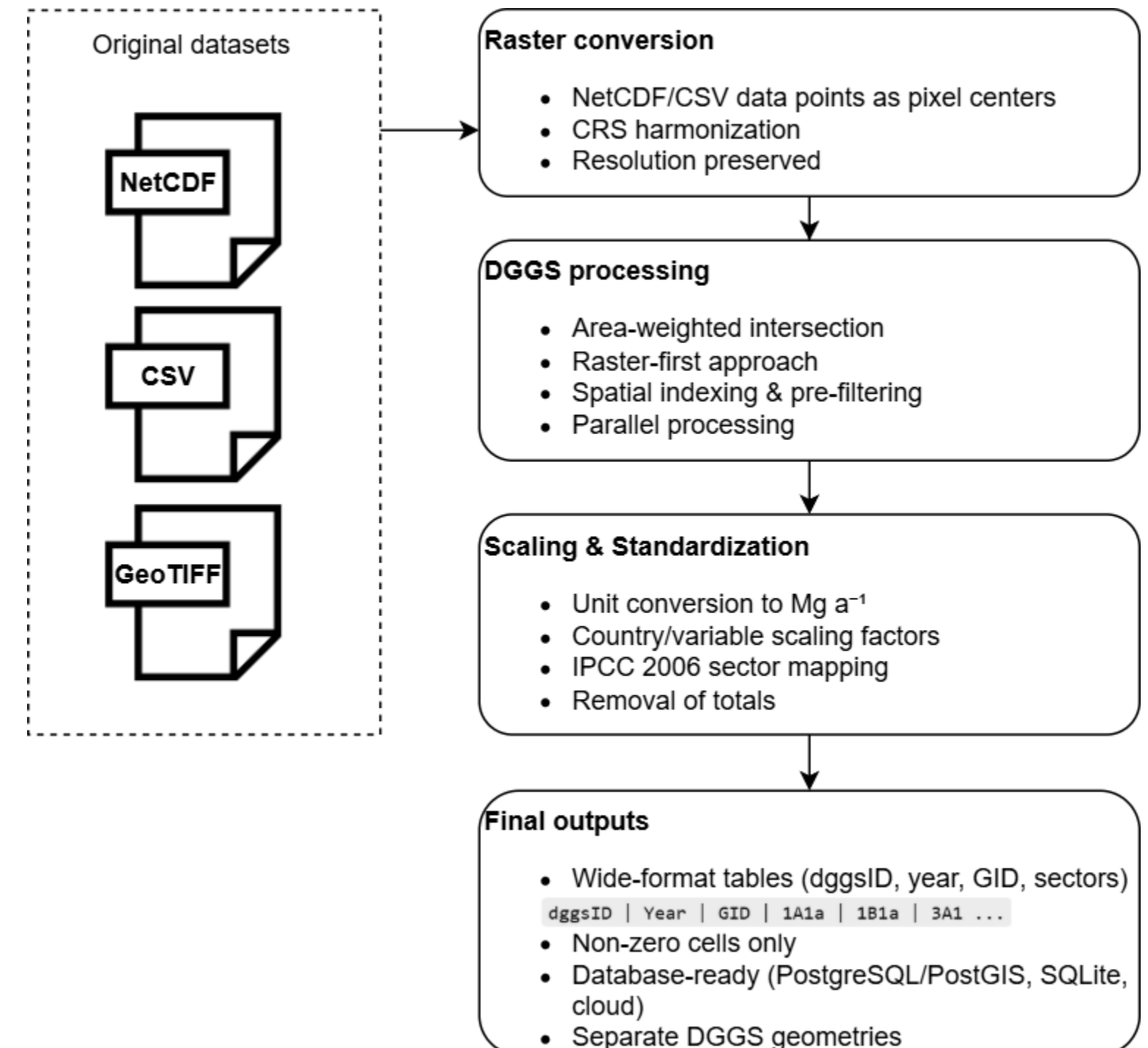
Part 1 – Data harmonization

- Convert **15** emission inventories onto **rHEALPix DGGs** using **DGGAL** (<https://github.com/ecere/dggal>).



rHEALPix = rearranged Hierarchical Equal Area isoLatitude Pixelization
DGGs = Discrete Global Grid Systems

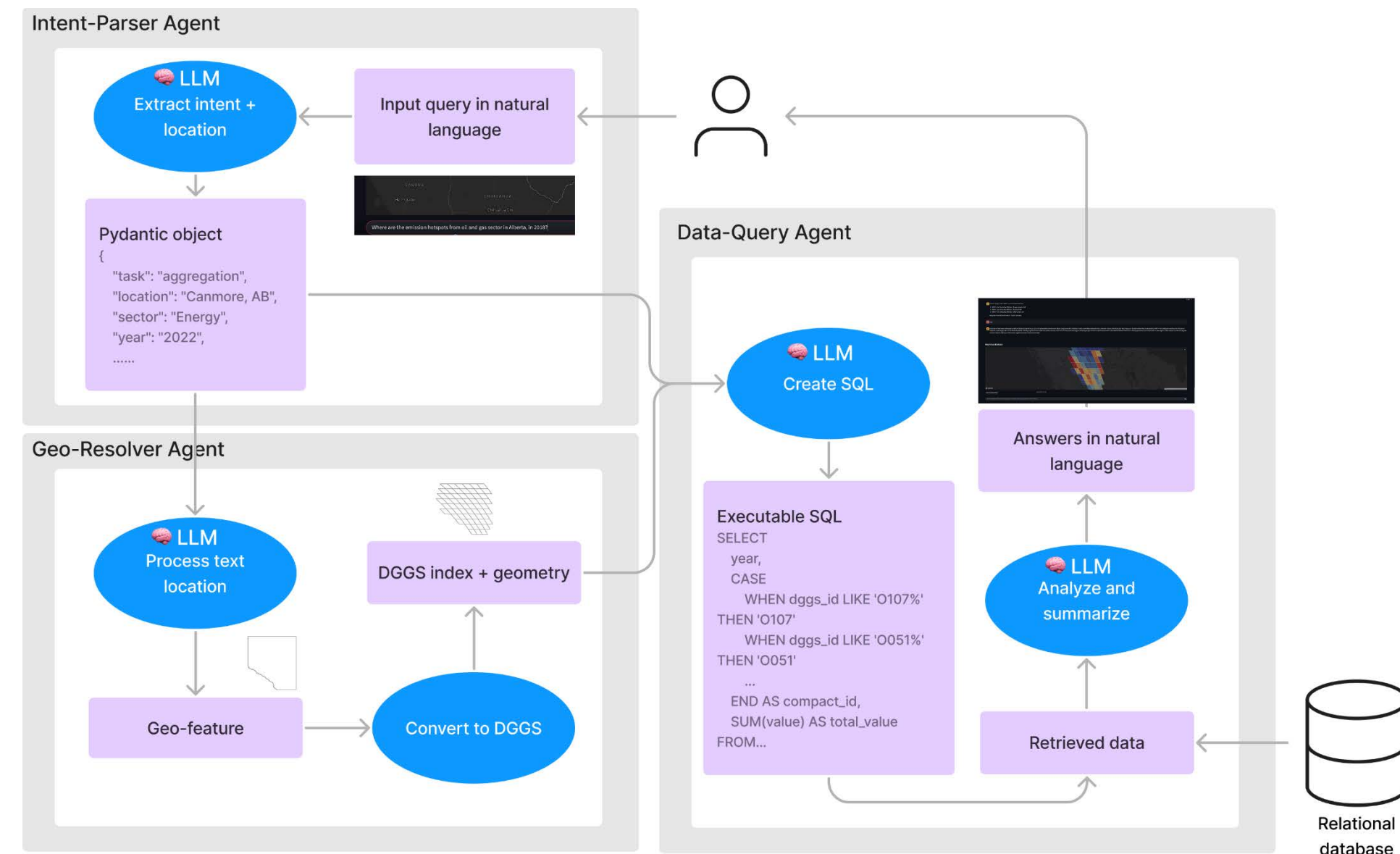
- Standardize **spatial structure, sectoral semantics** (to IPCC 2006 scheme), and **reporting units** (to Mg a^{-1}).
- Apply **scaling factor** (close to one) to ensure conservation of total emissions.
- Store data in DGGs-indexed **relational backend**.
 - Li, M., & Liang, S. (2025). Harmonized Global 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
- Orchestrated by **LangGraph**
 - **IntentParserAgent** extracts task + variables
 - Human-in-the-loop
 - In-session memory
 - Intelligent dataset suggestions
 - **GeoResolverAgent** maps text location → DGGs IDs
 - Nominatim API + Local look-up
 - On-the-fly DGGs conversion by DGGAL
 - **DataQueryAgent** generates SQL → retrieves results → explains answer
 - SQL writing with *@tool*





Demo



Take-home messages

1. **Harmonized gridded inventories:** Released a global-to-regional methane dataset (DOI:10.5281/zenodo.17362125) harmonized by IPCC sectors and indexed with DGGS.
2. **End-to-end DGGS + LLM workflow:** Showed how DGGS-indexed emissions data can drive natural-language querying and automated analysis end to end.
3. **Modular multi-agent design:** Built reusable agents that transfer to other geospatial problems (flood risk, air quality, wildfire, urban forestry).
4. **Explainable, traceable analytics:** DGGS functions as the spatial reference and indexing layer for LLM agents. Every GenAI output is auditable back to DGGS cells.