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LATInsights: LLM-Powered Conversational Agents for Geospatial Climate Analytics

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BACKGROUND & MOTIVATION

The Implementation Gap

Despite the abundance of high-resolution Earth Observation (EO) data, urban planners face significant barriers in its application for climate resilience:

- **Technological Complexity:** Heterogeneity of formats (COGs, STAC) and metadata requirements.
- **Analytical Bottleneck:** GIS expertise is often siloed from decision-making processes.
- **Integration Challenges:** Combining LST, Tree Cover Density, and Socio-economic data requires specialized pipelines.



PROBLEM STATEMENT

Core Research Question:

Can Large Language Models (LLMs) act as robust intermediaries to democratize complex geospatial analytics while maintaining scientific determinism and transparency?

Current PSS Limitations

Traditional Planning Support Systems (PSS) often rely on rigid interfaces that fail to capture the iterative, exploratory nature of urban design.

The LLM Hallucination Risk

Standard LLM deployments lack "ground truth" geospatial awareness, leading to plausible but factually incorrect climate assessments.

PROPOSED FRAMEWORK: LATInsights

We propose a decoupled agentic architecture designed to bridge the gap between semantic reasoning and deterministic geospatial computation.

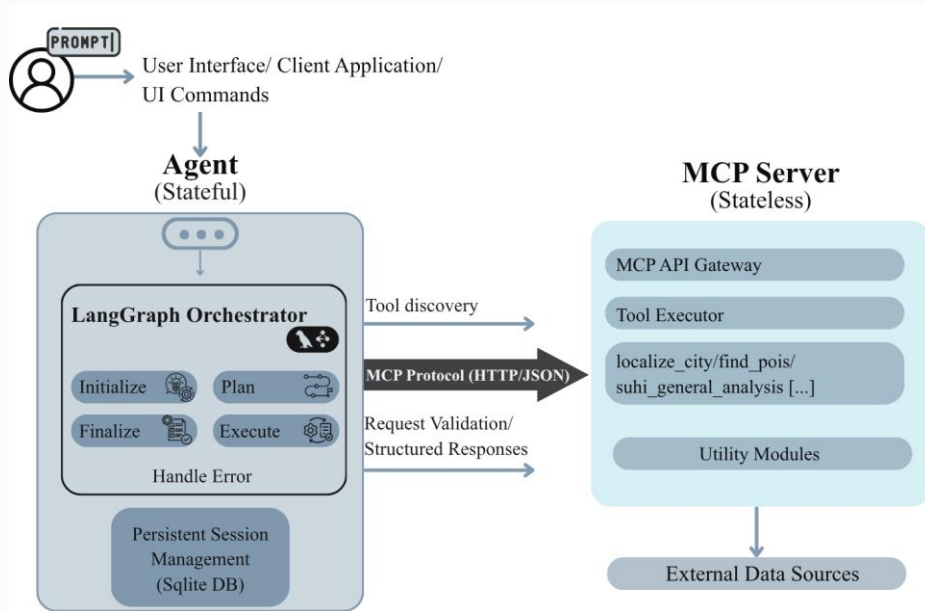
Agentic Reasoning

Stateful orchestration using **LangGraph** to maintain conversation memory and iterative planning logic.

Geospatial Toolchain

Stateless execution of scientific tools via the **Model Context Protocol (MCP)** ensuring reproducible results.

SYSTEM ARCHITECTURE: TWO-TIER APPROACH



Tier 1: Agent Service

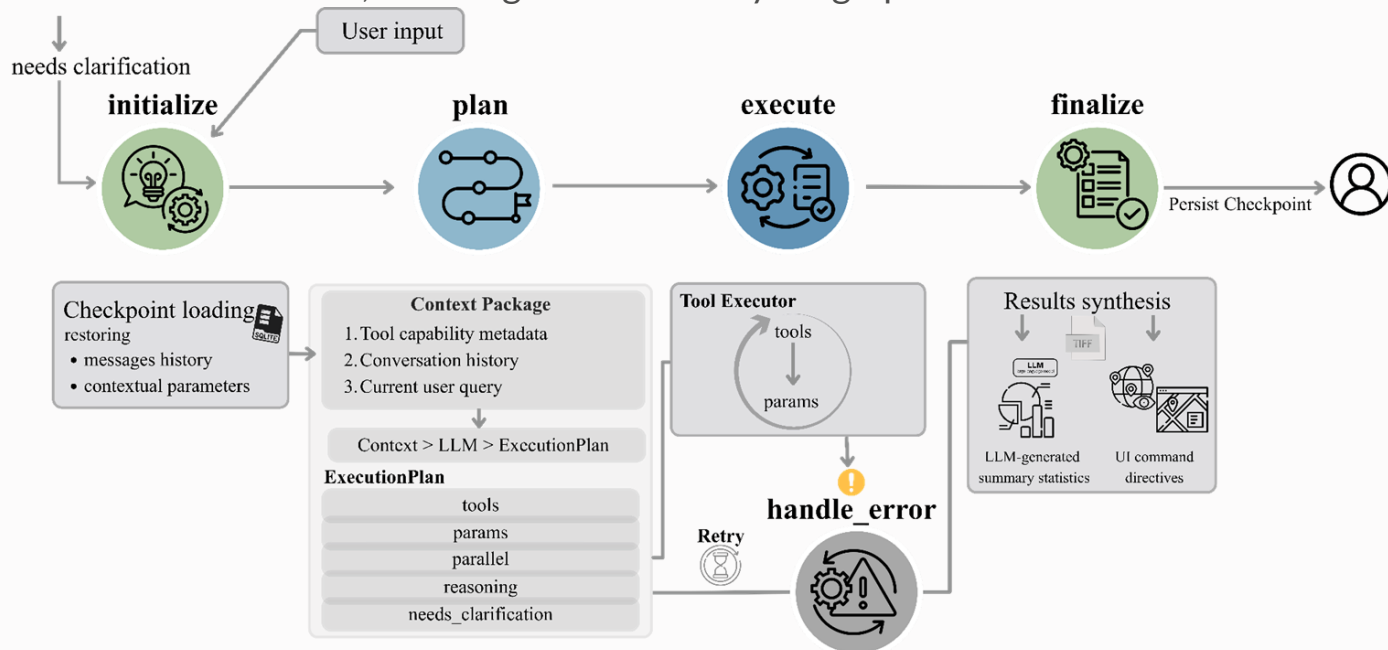
Managed by a ReAct-based agent that parses natural language queries into structured execution plans (JSON).

Tier 2: MCP Server

Provides a standardized interface for Python-based geospatial tools (Rasterio, PySTAC, Shapely) without exposing internal logic to the LLM.

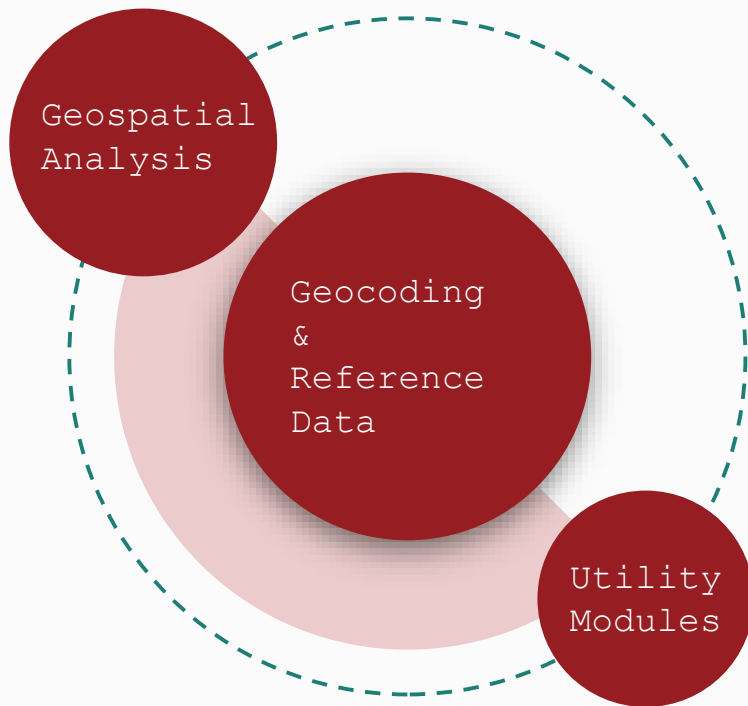
ORCHESTRATION & STATE MANAGEMENT

To avoid linear execution failure, LATInsights utilizes a cyclic graph structure with conditional routing:



GEOSPATIAL TOOLCHAIN INTEGRATION

The system integrates specialized tools as MCP resources, ensuring that the LLM only handles "intent" while the server handles "data":



CASE STUDY: VIA NEERA, MILAN

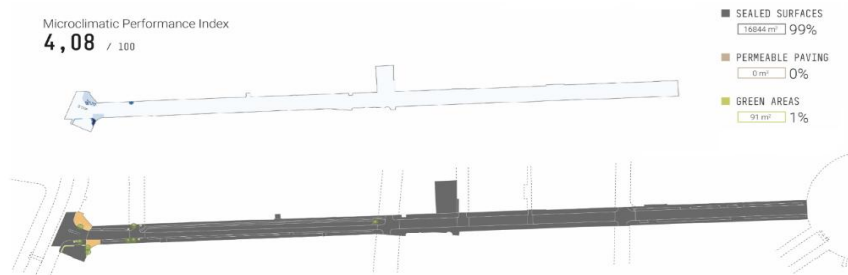
Context & Setup

Validation conducted on a 1.2km urban corridor in Milan, characterized by high thermal stress and low canopy cover.

- Target: 1.2km cycling corridor connecting Piazza Lima to Viale Abruzzi
- Serves approximately 12,000 daily commuters in Milan's Loreto district
- Current conditions: 99% sealed surfaces, 0% tree canopy, MPI = 4.08/100



(a)



(b)

CASE STUDY: VIA NEERA, MILAN

Context & Setup

Challenge

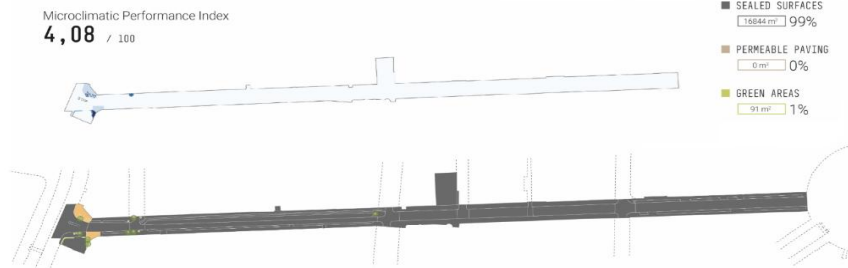
Extreme thermal stress discouraging cycling adoption during summer months

Objective

- > Use LATInsights to simulate the impact of cycling lane + integrated greening infrastructure
- > Evaluate three intervention scenarios via conversational queries (NL interface)



(a)

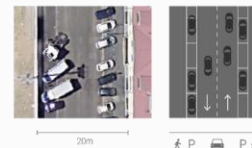


(b)

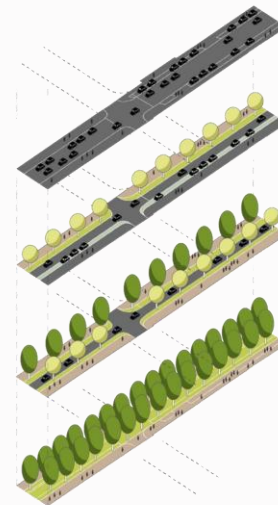
EMPIRICAL RESULTS: SCENARIOS ANALYSIS

Scenario	Intervention Logic	Observed LST Reduction	Canopy Coverage $\Delta\%$
S0 (Baseline)	Existing asphalt-heavy state	0.0°C (Ref)	0%
S1 (Moderate)	Parking removal + single tree line	-1.2°C	+15%
S2 (Aggressive)	Total pedestrianization + dual canopy	-2.8°C	+42%
S3 (Max Greening)	Full pedestrianization + green spine	-3.5°C	+60%

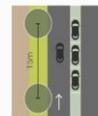
Scenario 0 - current situation



Scenario 2



Scenario 1

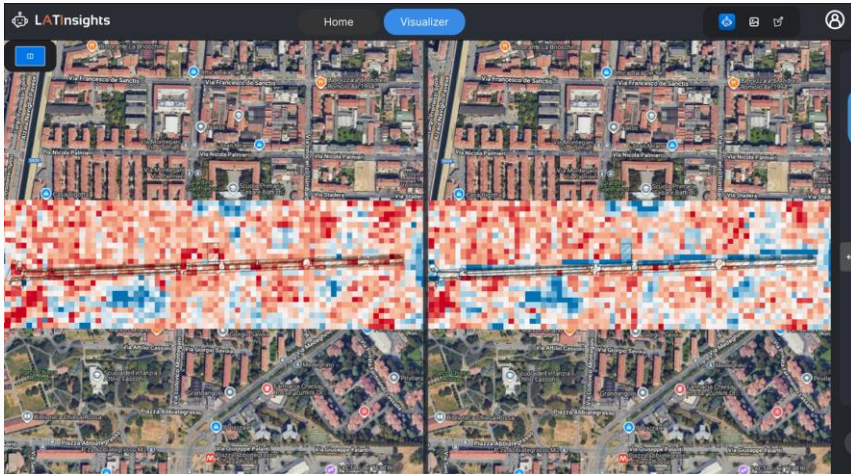


Scenario 3

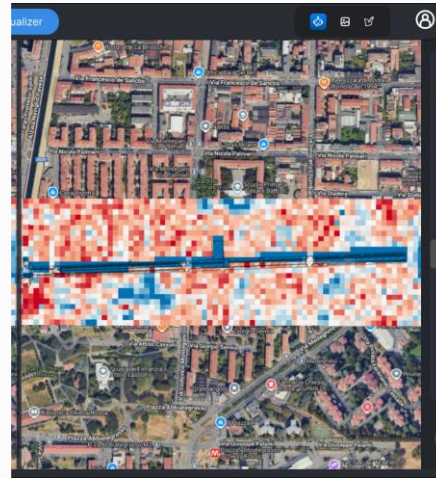


EMPIRICAL RESULTS: SCENARIOS ANALYSIS

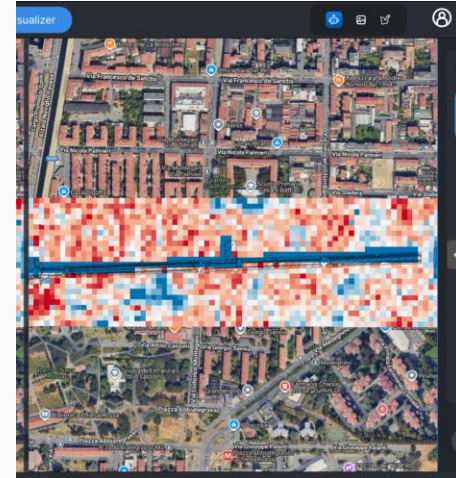
Comparison of scenarios generated through the conversational interface:



S0



S1



CONCLUSIONS & FUTURE WORK

Main Contributions

- **Scalability:** modular MCP tools allow for the integration of new satellite sensors without re-training the core LLM.
- **Explainability:** the agentic workflow provides a step-by-step reasoning trace of how climate insights were derived.
- **Accessibility:** significant reduction in the time-to-insight for non-technical urban stakeholders.
- **Reliability:** three-tier error recovery ensures robust operation in production environments.

Next Steps

Future research will focus on integrating multi-modal inputs, systematic evaluation across diverse urban contexts and data availability, Confidence intervals for climate projections and intervention impacts.

Thank You!

Questions & Discussion