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Software Release Document

An interactive application to support disaster management activities during the prevention and preparedness phase

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Download page:

https://github.com/Ricky-HU96/WO-CIAO_SE4GEO-2025-Project

Version	Date	Change
1.0	April 22,2025	First submitted version

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1. Introduction

1.1 Purpose of the Document

This document provides a comprehensive guide for the release of the Interactive Web GIS for Disaster Management application. It outlines system requirements, installation steps, running instructions, and known limitations to ensure stakeholders and users can deploy and operate the software effectively.

1.2 Overview of the Software

The SE4GEO Air Quality Analysis Dashboard, also known as "Dati Lombardia Dashboard", is a web-based platform for visualizing and exploring air pollution data collected from heterogeneous sensor networks across the Lombardy region. Key features include:

Interactive maps displaying real-time and historical pollutant concentrations on geospatial layers.

Time-series plots and statistical summaries for selected sensors or regions.

Heatmaps and contour maps illustrating pollution hotspots and spatial distribution.

Exportable reports and charts to support environmental monitoring and policy-making.

2. System Requirements

To ensure stable operation of the **Dati Lombardia** Dashboard in production environments, this section details the hardware, software, and network requirements.

2.1 Hardware Requirements

Server Processor (CPU):

Minimum 8 physical cores; recommended 16 cores or more (e.g., Intel Xeon Gold 6248, AMD EPYC 7502).

Hardware virtualization support for deployment in VMs or container platforms.

Memory (RAM):

At least 32 GB; recommended 64 GB or more for high-concurrency queries and large-scale historical data analysis.

Memory frequency ≥ 2666 MHz to reduce latency.

Storage:

Enterprise-grade SSD with a capacity of at least 1 TB.

Recommended RAID 10 configuration for improved I/O performance and redundancy.

IOPS ≥ 10,000; sustained write throughput ≥ 500 MB/s.

Network Interface (NIC):

Minimum 1 Gbps Ethernet; recommended 10 Gbps for high-throughput scenarios.

Support for multiple queues (MPQoS) and traffic shaping.

2.2 Software Dependencies

Operating System (OS):

Ubuntu Server 20.04 LTS or newer.

CentOS 8 Stream or Rocky Linux 8 are also supported.

Database:

PostgreSQL 13 or later.

PostGIS 3+ extension for geospatial data storage and queries.

Backend Framework:

Python 3.9 or later (Python 3.10 recommended).

Flask 2.x with extensions such as Flask-RESTful and Flask-Migrate.

Frontend and Visualization:

Jupyter Notebook 6.x or higher for interactive analysis.

Leaflet.js 1.7 or higher for map rendering.

Plotly.js 2.0 or Python Plotly library for charting.

Python Libraries:

The project uses the following Python libraries for data access, analysis, and visualization:

SQLAlchemy and GeoAlchemy2 for ORM and spatial queries pandas and numpy for data processing

scikit-learn for clustering and spatial analysis

joblib for parallel processing

Flask-RESTful and Flask-Migrate for API design and database migrations

GIS Tools:

GDAL/OGR 3.2 or higher for importing shapefiles and GeoJSON.

Tippecanoe (optional) for generating vector tiles.

2.3 Network Requirements

Internet Connectivity:

Stable, high-speed connection with at least 100 Mbps bandwidth.

Latency below 50 ms to ensure fast map service loading.

Firewall and Ports:

Open port 5000 for the API service and port 8888 for Jupyter Notebook.

If using HTTPS, open port 443 and install a valid SSL certificate.

Bandwidth and Throughput:

Additional bandwidth for serving map tiles and vector tiles; recommended at least 200 Mbps or a CDN for tile distribution.

Other Considerations:

Support for reverse proxy (Nginx/Apache) and load balancing (e.g., HAProxy).

In container deployments, ensure compatibility with overlay network plugins.

3. Installation and Running

3.1 Step-by-Step Installation

Find the Folder:

Click the following link to find the software folder:

Download

Create Python Environment:

Set up a Python virtual environment using the built-in venv module and activate it. Upgrade the package installer and manually install the required Python packages, including Flask (with Flask-RESTful and Flask-Migrate), SQLAlchemy, GeoAlchemy2, pandas, numpy, scikit-learn, and joblib.

Configure Database:

Create a new PostgreSQL database named se4geo, connect to it, and enable the PostGIS extension to support geospatial data. Then update the config.py file to specify the DATABASE_URL along with appropriate user credentials.

Initialize Database Schema and Seed Data:

Execute the database migration script to create all required tables and schema structures, then run the data seeding script to populate the database with initial region, province, and PIR metadata

Import OSM Map Data:

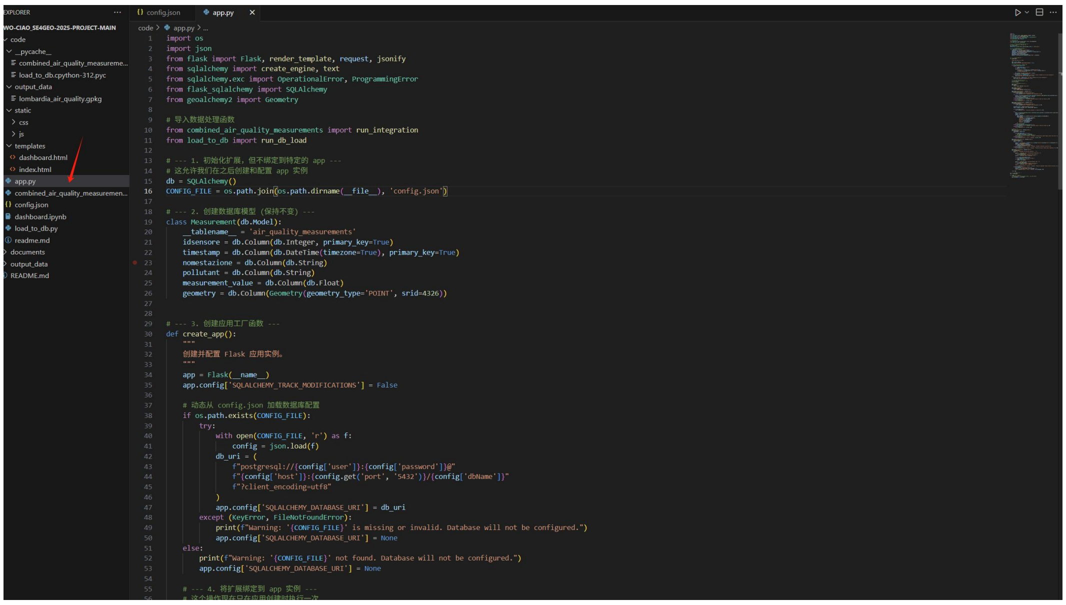
Execute the provided script to import OpenStreetMap boundary and tile datasets into the spatial database, preparing the geographical layers for visualization.

3.2 Basic Usage Instructions

3.2.1 Start the Backend API

Open the Folder in VS code and run the file:

open the folder and find the file called " app.py " , double-click the file to start the server.

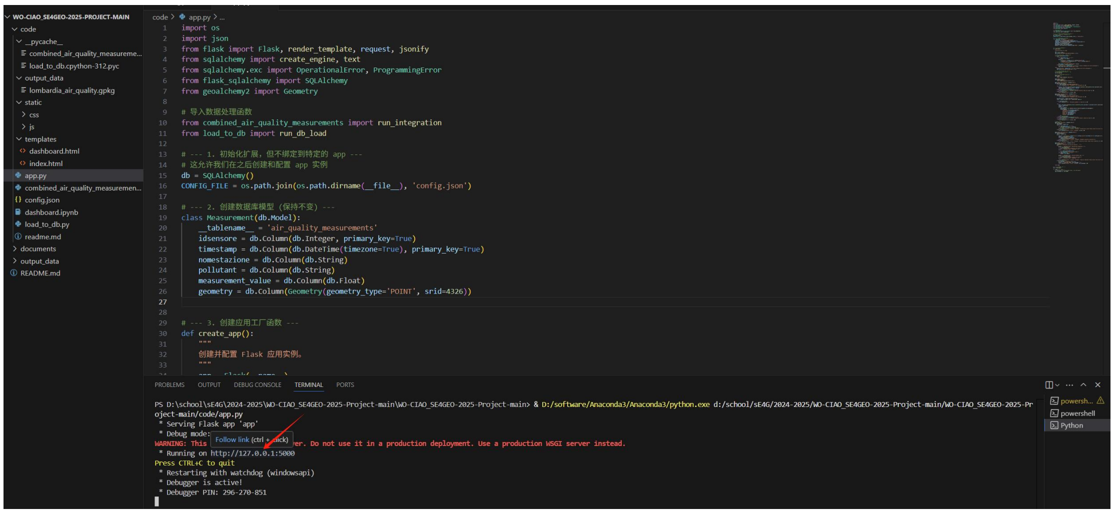


```python
import os
import json
from flask import Flask, render_template, request, jsonify
from sqlalchemy import create_engine, text
from sqlalchemy.exc import OperationalError, ProgrammingError
from flask_sqlalchemy import SQLAlchemy
from geoalchemy2 import Geometry

# 导入数据处理函数
from combined_air_quality_measurements import run_integration
from load_to_db import run_db_load

# --- 1. 初始化扩展，但不绑定到特定的 app ---
# 这允许我们在之后创建和配置 app 实例
db = SQLAlchemy()
CONFIG_FILE = os.path.join(os.path.dirname(__file__), 'config.json')

# --- 2. 创建数据库模型 (保持不变) ---
class Measurement(db.Model):
    __tablename__ = 'air_quality_measurements'
    idsensore = db.Column(db.Integer, primary_key=True)
    timestamp = db.Column(db.DateTime(timezone=True), primary_key=True)
    nomestazione = db.Column(db.String)
    pollutant = db.Column(db.String)
    measurement_value = db.Column(db.Float)
    geometry = db.Column(Geometry(geometry_type='POINT', srid=4326))


# --- 3. 创建应用工厂函数 ---
def create_app():
    """
    创建并配置 Flask 应用实例。
    """
    app = Flask(__name__)
    app.config['SQLALCHEMY_TRACK_MODIFICATIONS'] = False

    # 动态从 config.json 加载数据库配置
    if os.path.exists(CONFIG_FILE):
        try:
            with open(CONFIG_FILE, 'r') as f:
                config = json.load(f)
            db_uri = (
                f"postgresql://{config['user']}:{config['password']}@"
                f"{config['host']}:{config.get('port', '5432')}/{config['dbName']}"
                f"?client_encoding=utf8"
            )
            app.config['SQLALCHEMY_DATABASE_URI'] = db_uri
        except (KeyError, FileNotFoundError):
            print(f"Warning: '{CONFIG_FILE}' is missing or invalid. Database will not be configured.")
            app.config['SQLALCHEMY_DATABASE_URI'] = None
    else:
        print(f"Warning: '{CONFIG_FILE}' not found. Database will not be configured.")
        app.config['SQLALCHEMY_DATABASE_URI'] = None

    # --- 4. 将扩展绑定到 app 实例 ---
    # 这个操作现在只在应用创建时执行一次
```

Figure 1: app.py startup

Open the Browser:

In your browser's address bar, type " :http://127.0.0.1:5000" and press Enter to access the main page of the software



```
import os
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    measurement_value = db.Column(db.Float)
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# --- 3. 创建应用工厂函数 ---
def create_app():
    """
    创建并配置 Flask 应用实例。
    """
```
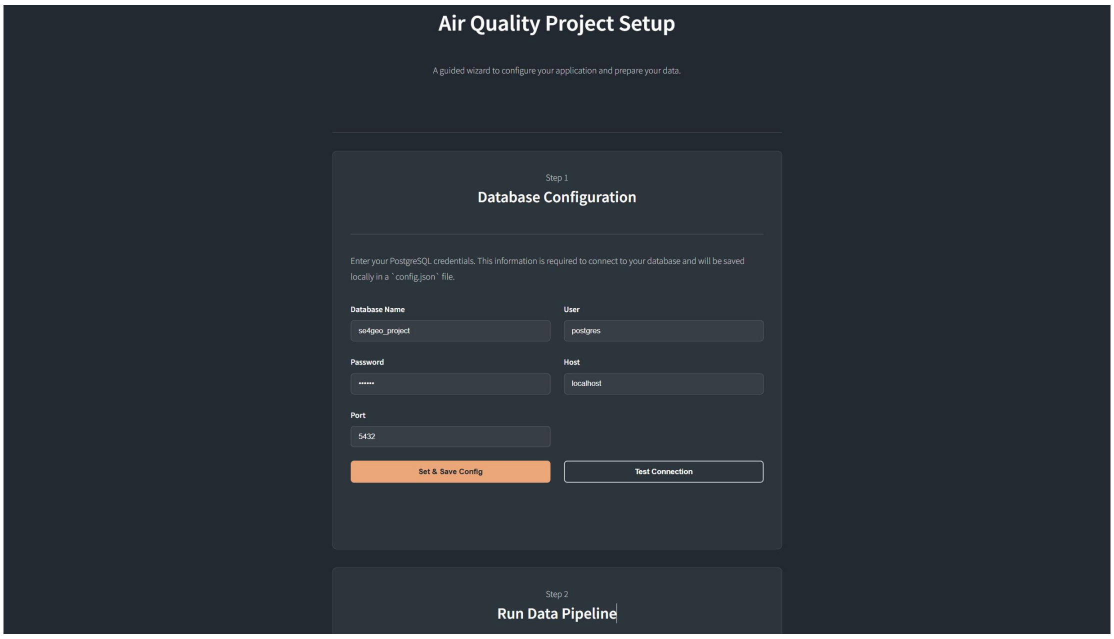

```
PS D:\school\sE4G\2024-2025\WO-CIAO_SE4GEO-2025-Project-main\WO-CIAO_SE4GEO-2025-Project-main> & D:/software/Anaconda3/Anaconda3/python.exe d:/school/sE4G/2024-2025/WO-CIAO_SE4GEO-2025-Project-main/WO-CIAO_SE4GEO-2025-Project-main/code/app.py
 * Serving Flask app 'app'
 * Debug mode:
WARNING: This                  er. Do not use it in a production deployment. Use a production WSGI server instead.
 * Running on http://127.0.0.1:5000
Press CTRL+C to quit
 * Restarting with watchdog (windowsapi)
 * Debugger is active!
 * Debugger PIN: 296-270-851
```

Figure2: Browser

3.2.2 Open the Web Interface

Launch in browser:



Air Quality Project Setup

A guided wizard to configure your application and prepare your data.

Step 1

Database Configuration

Enter your PostgreSQL credentials. This information is required to connect to your database and will be saved locally in a `config.json` file.

Database Name	**User**
se4geo_project	postgres
Password	**Host**
••••••	localhost
Port	
5432	

Step 2

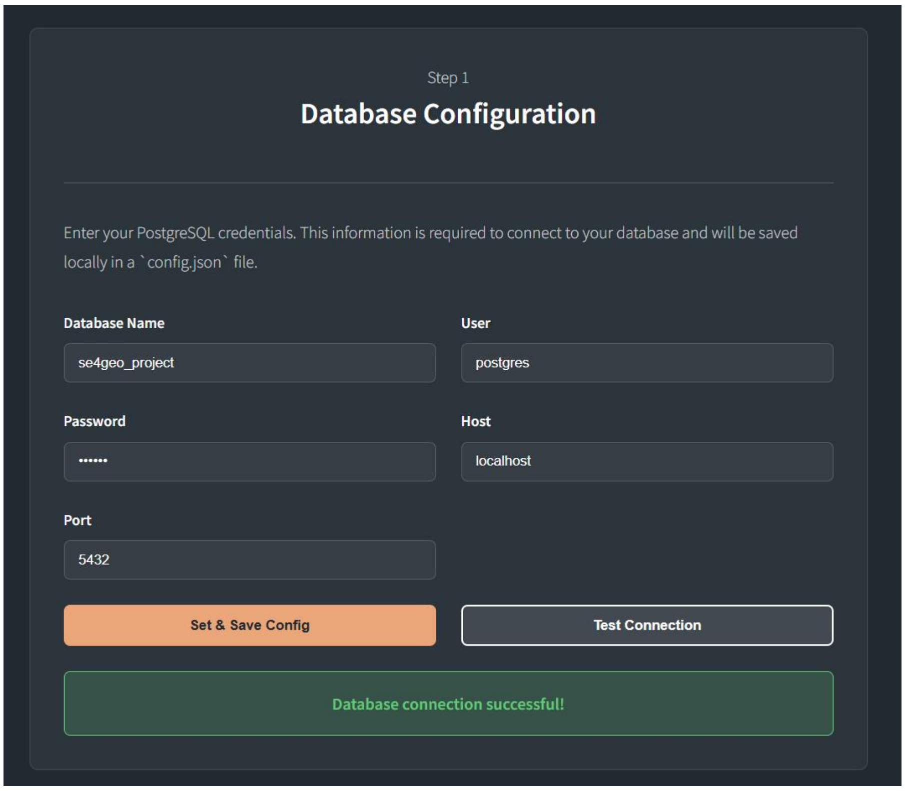
Run Data Pipeline

Figure 3: Main login page

3.2.3 Configure Database Connection

Click Set Database, enter host, port, user, password

Click Test Connection


Step 1

Database Configuration

Enter your PostgreSQL credentials. This information is required to connect to your database and will be saved locally in a `config.json` file.

Database Name: se4geo_project

User: postgres

Password: ••••••

Host: localhost

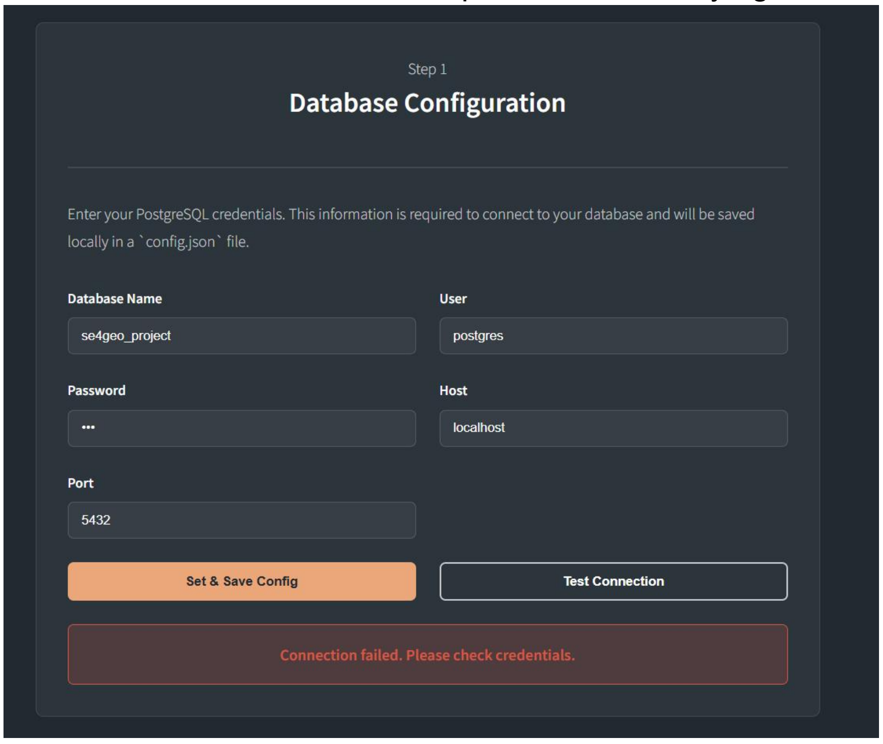
Port: 5432

Database connection successful!

Figure 4: Connection successful

If the connection is successful, proceed to the next step.

If the connection fails, check the database parameters and try again.


Step 1

Database Configuration

Enter your PostgreSQL credentials. This information is required to connect to your database and will be saved locally in a `config.json` file.

Database Name: se4geo_project

User: postgres

Password: •••

Host: localhost

Port: 5432

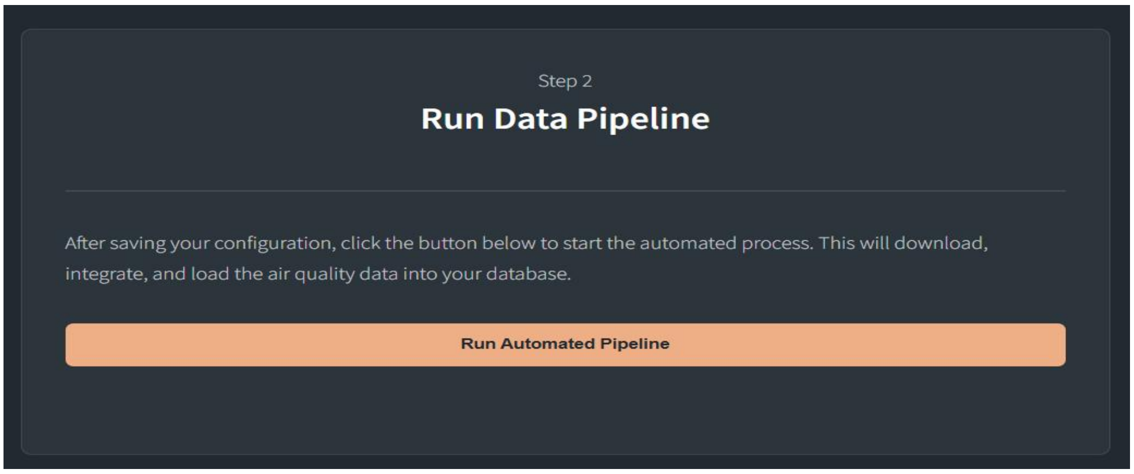
Connection failed. Please check credentials.

Figure 5: Connection failed

Then click “Set & Save Config”.

3.2.4 Initialize Data

Click “Run Automated Pipeline” to automatically execute backend migrations, seed metadata ,and import OSM boundary data.



Step 2

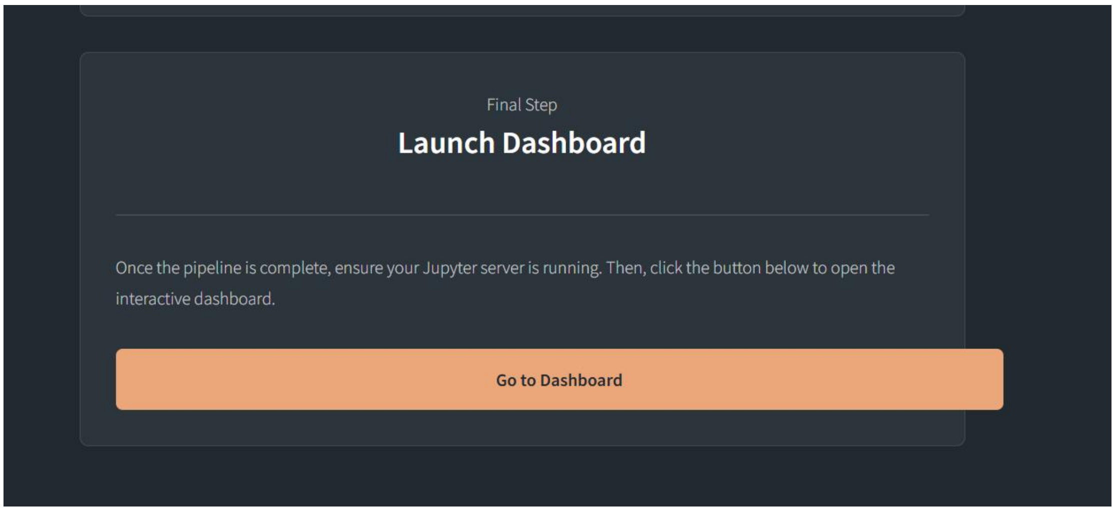
Run Data Pipeline

After saving your configuration, click the button below to start the automated process. This will download, integrate, and load the air quality data into your database.

Figure 6: Run Data Pipeline

3.2.5 Access the Dashboard

Click Go to Dashboard to view interactive maps



Final Step

Launch Dashboard

Once the pipeline is complete, ensure your Jupyter server is running. Then, click the button below to open the interactive dashboard.

Figure 7: Launch Dashboard

3.2.6 Query Air Quality Data

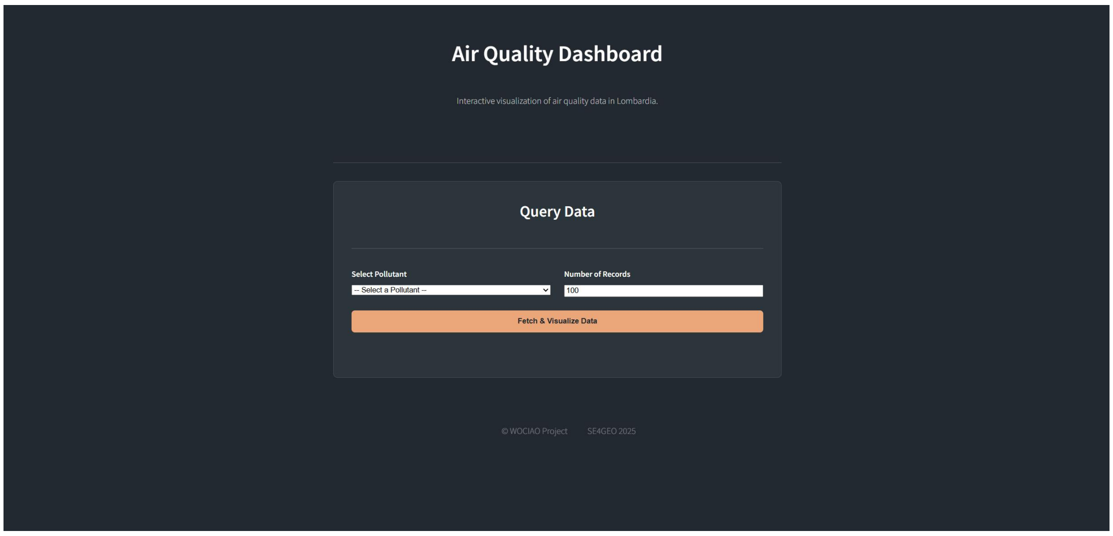
Use the Query Data panel:

Select Pollutant: Choose the pollutant type (e.g., Ammoniacal Nitrogen).

Number of Records: Specify the maximum records to retrieve (e.g., 100).

Click Fetch & Visualize Data.

A success alert confirms the fetched record count.


Air Quality Dashboard

Interactive visualization of air quality data in Lombardia.

Query Data

Select Pollutant: -- Select a Pollutant --

Number of Records: 100

Figure 8: Query Data

3.2.7View Data

Data Table

The Data Table displays retrieved records with columns:

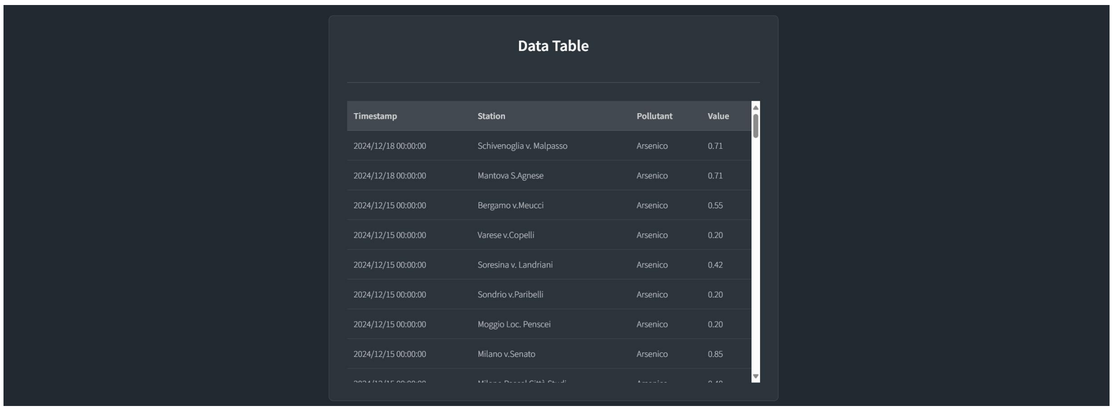
-Timestamp

-Station

-Pollutant

-Value

Supports scrolling for large datasets.


Data Table

Timestamp	Station	Pollutant	Value
2024/12/18 00:00:00	Schivenoglia v. Malpasso	Arsenico	0.71
2024/12/18 00:00:00	Mantova S.Agnese	Arsenico	0.71
2024/12/15 00:00:00	Bergamo v.Meucci	Arsenico	0.55
2024/12/15 00:00:00	Varese v.Copelli	Arsenico	0.20
2024/12/15 00:00:00	Soresina v. Landriani	Arsenico	0.42
2024/12/15 00:00:00	Sondrio v.Paribelli	Arsenico	0.20
2024/12/15 00:00:00	Moggio Loc. Penscei	Arsenico	0.20
2024/12/15 00:00:00	Milano v.Senato	Arsenico	0.85

Figure 9: Data Table view

Visualize Geographic Distribution

The dashboard renders a Leaflet.js map within the #map-container element.

Sensor locations are displayed as color-coded circle markers reflecting pollutant concentration.

A choropleth layer can be toggled to illustrate spatial gradients across administrative regions.

Clicking or hovering on markers shows a popup with station name, timestamp, pollutant, and value.

The map supports pan and zoom controls for detailed geographic exploration.

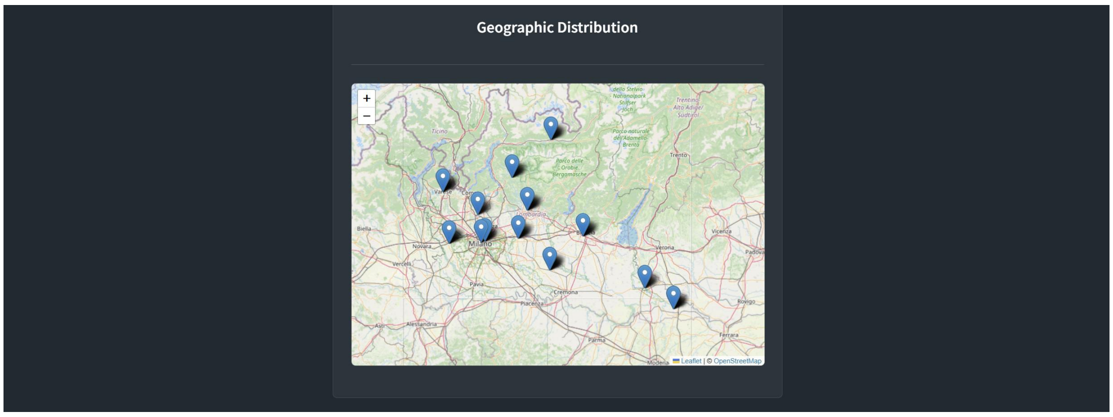


Figure 10: Geographic Distribution map

Analyze Time Series

Time series visualization is rendered in the #chart-container using Chart.js.

The line chart plots pollutant concentration over time for the fetched records.

Users can zoom or drag to focus on specific time intervals.

Tooltips display exact timestamp and value on hover.

A time series chart shows pollutant concentration trends over the selected records.

Zoom and pan controls allow focused analysis on specific intervals.

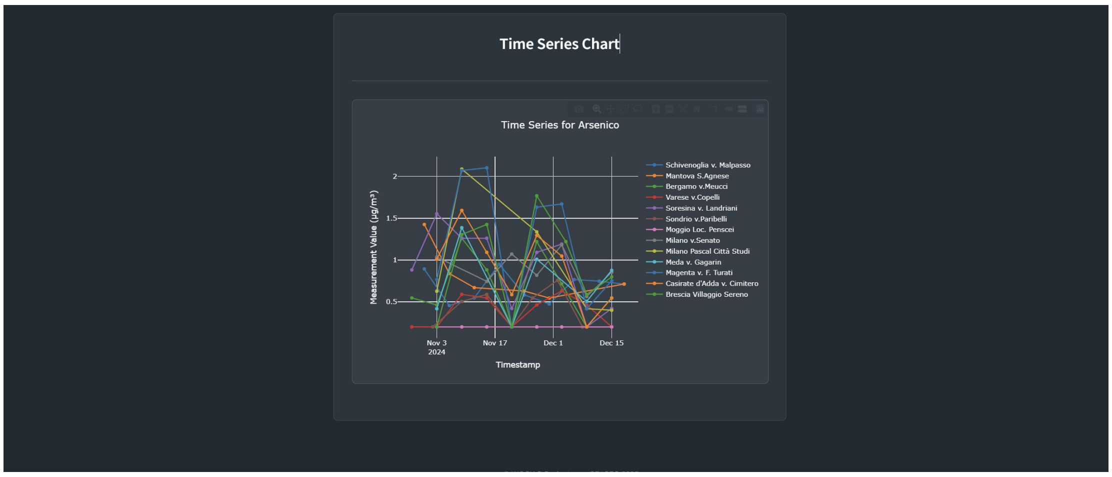


Figure 11: Time Series chart

4. Known Limitations

4.1 Issues

Performance degradation with datasets > 1 million records.

Limited mobile responsiveness.

No real-time data ingestion; manual or scheduled.

Authentication module lacks 2FA.

4.2 Workarounds

Use filtered queries and pagination.

Access via desktop browsers.

Schedule cron job for data updates.

Secure endpoints behind VPN or firewall.

4.3 Planned Fixes

Optimize spatial queries and add indexing.

Implement responsive UI redesign.

Integrate streaming ingest via Kafka.

Add two-factor authentication.