Earth Observation Data and AI Integration: Unveiling the Spatial Impact of Wildfire Pollution in Los Angeles

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EO TOOL: Copernicus Browser

EO DATA: Sentinel-5P

Abstract:

Earth observation data contains vast amounts of valuable information that enhance comprehension of environmental changes and support informed decision-making regarding our planet. The Copernicus Browser is a powerful online platform designed to facilitate the visualisation and analysis of these data. Meanwhile, the advancement of artificial intelligence (AI) is transforming numerous fields. This case study presents a scenario demonstrating how AI can assist in the spatial analysis of imagery data related to wildfires in Los Angeles, obtained from the Copernicus Browser.

Background:

Many atmospheric gases, including carbon monoxide (CO), nitrogen dioxide (NO2), sulphur dioxide (SO2), and methane (CH4), are invisible and cannot be detected without specialised instruments. These gases play a crucial role in atmospheric chemistry and air quality monitoring. Understanding their spatial distribution is essential for mitigating air pollution and its impact on human health and climate change.

The Sentinel-5P satellite, launched as part of the European Union’s Copernicus programme, provides high-resolution atmospheric composition data. It utilises the Tropospheric Monitoring Instrument (TROPOMI) to detect pollutants such as CO, NO2, SO2, CH4, and ozone (O3) with unprecedented accuracy.

The Copernicus Browser is a powerful online platform designed to facilitate the visualization and analysis of Earth observation data collected by Sentinel satellites. One of its key features is the ability to download satellite imagery, which can then be analysed using external platforms such as GIS software or AI-driven tools to extract meaningful insights.

Advancements in artificial intelligence (AI) have unlocked new possibilities for analysing these images. By leveraging AI-powered image recognition and automated text generation, the spatial distribution of pollutants can be detected automatically, with corresponding analyses generated in real time. This synergy between AI and satellite imagery significantly enhances decision-making in environmental management and policy development.

The following scenario illustrates how this integration works.

Scenario:

In January 2025, Southern California experienced a series of catastrophic wildfires that had a profound impact on the region. The crisis began on 7 January, when multiple fires ignited across Los Angeles County, spreading rapidly due to hurricane-force Santa Ana winds exceeding 100 miles per hour. These fires collectively led to the evacuation of over 200,000 residents and the destruction of more than 57,000 acres of land. The financial toll was unprecedented, with Swiss Re estimating global insurance industry losses at USD 40 billion, potentially making these the most expensive wildfires in U.S. history.

Beyond the direct financial impact, wildfires significantly affect atmospheric carbon monoxide (CO) levels. In the atmosphere, CO contributes to the formation of ground-level ozone, a major component of smog, which can degrade air quality and harm ecosystems. Prolonged exposure to CO can also pose severe health risks, including impaired oxygen transport in the bloodstream, leading to dizziness, confusion, and, in extreme cases, fatal poisoning. Monitoring the distribution of CO is therefore vital. To achieve this, we first obtained satellite imagery from the Copernicus Browser (phase 1) and then processed it using an AI-powered chatbot, Meerkat 01, to generate an analysis (phase 2).

Phase 1: Obtaining satellite imagery from the Copernicus Browser

To obtain relevant information, Sentinel-5P Carbon Monoxide (CO) imagery for 7 January 2025 (the start date of the wildfires) was retrieved using the Copernicus Browser. This online platform provides access to satellite imagery from various Copernicus missions, including Sentinel-5P, which specialises in atmospheric monitoring.

The process began by accessing the Copernicus Browser. After logging in, the "Go to Place" field was used to locate the target region by entering "Los Angeles County, United States of America”, and then zoom in to the area of interested. Once the area of interest was defined, the "Visualise" panel on the left side of the interface was used to select "Atmosphere and Air Pollution" under the "Configurations" section. Next, the Sentinel-5P Data Collection was accessed, and Carbon Monoxide (CO) was selected.

The date selection tool was then used to manually enter 7 January 2025 to retrieve satellite observations for that day. With the dataset and date selected, the "Download Image" function on the right-hand side of the interface was used to obtain the satellite imagery in PNG format, providing a high-resolution output of CO distribution.

By following above steps, the necessary information on CO levels over Los Angeles and surrounding areas for 7 January 2025 was successfully obtained (Figure 1).

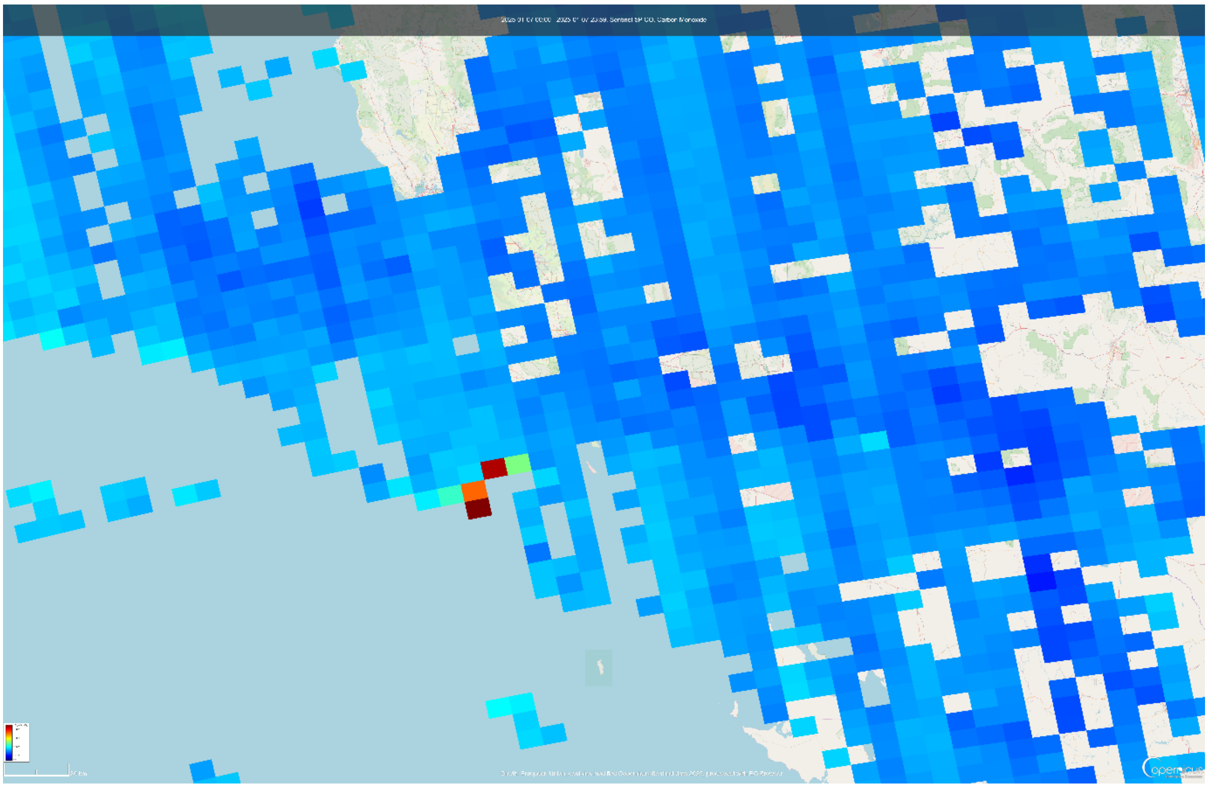


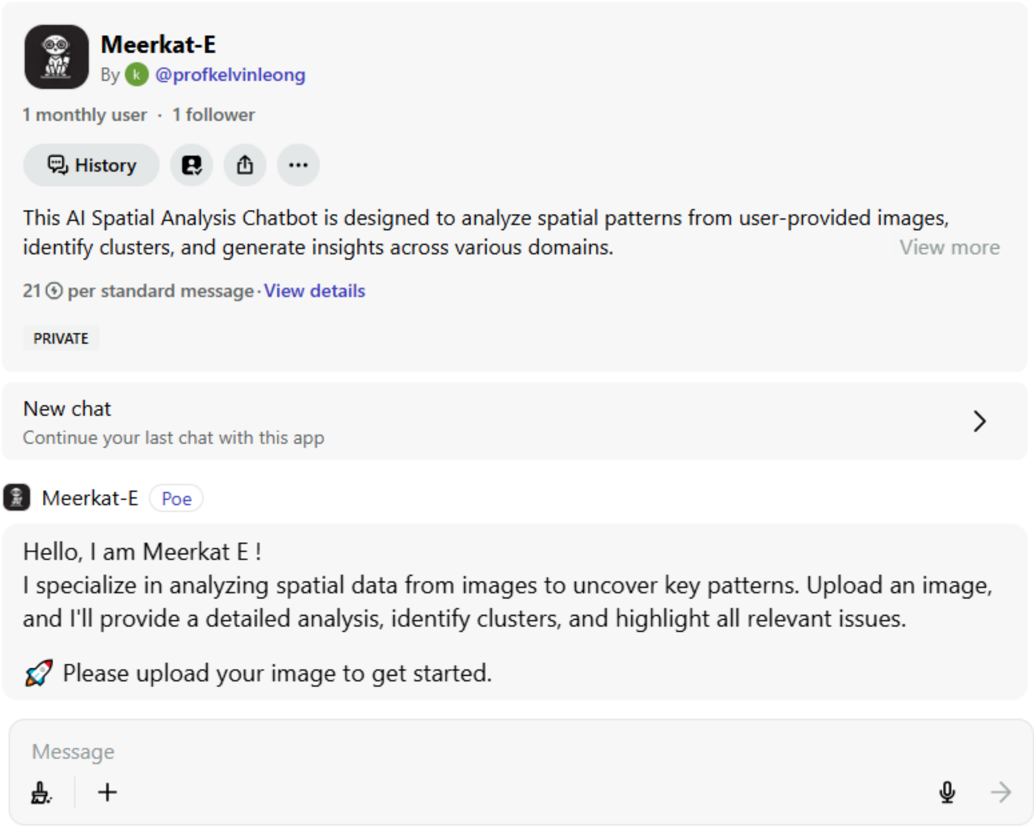
Figure 1: CO levels over Los Angeles and surrounding areas for 7 January 2025.

Phase 2: Analysing the satellite imagery with the AI-powered chatbot, Meerkat E

To demonstrate how AI can be used to analyse satellite imagery from the Copernicus Browser, the downloaded satellite image (Figure 1) was uploaded to a self-developed AI-powered chatbot, Meerkat E, for spatial analysis.

Meerkat E was built using Gemini 2.0-Flash as the foundation for its large language model (LLM), with carefully designed prompts to guide its analysis of uploaded images. In practice, developers and analysts can create their own AI-powered chatbots by selecting their preferred LLM and customizing prompts to suit their specific needs.

Meerkat E is freely accessible via the link (https://poe.com/Meerkat-E), although a registered account is required to use the service. Figure 2 illustrates the user interface of Meerkat E. To utilize the service, users simply need to upload an image to the message field and click the send message icon. The analysis is then conducted automatically.



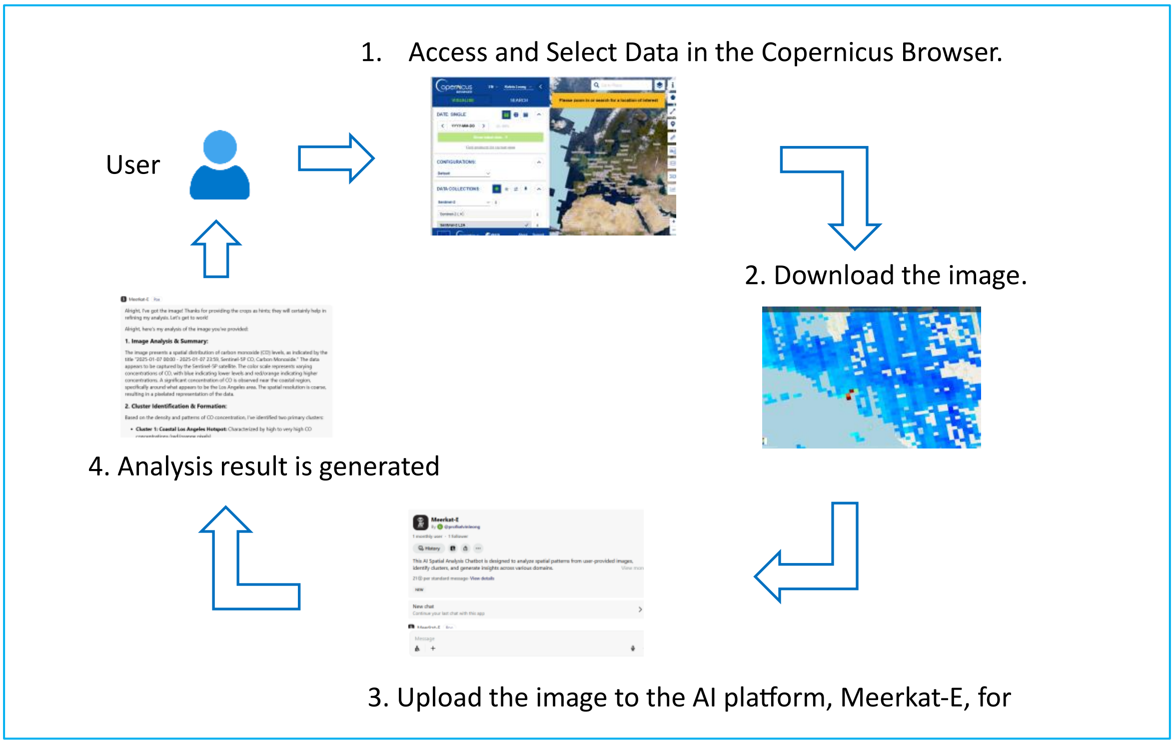
This AI Spatial Analysis Chatbot is designed to analyze spatial patterns from user-provided images, identify clusters, and generate insights across various domains.

Hello, I am Meerkat E !
I specialize in analyzing spatial data from images to uncover key patterns. Upload an image, and I'll provide a detailed analysis, identify clusters, and highlight all relevant issues.

🚀 Please upload your image to get started.

Figure 2: User interface of Meerkat E.

The entire analysis process can be summarized as a cyclical workflow, as illustrated in Figure 3.



Alright, I've got the image! Thanks for providing the crops as hints; they will certainly help in refining my analysis. Let's get to work!

Alright, here's my analysis of the image you've provided:

1. Image Analysis & Summary:

The image presents a spatial distribution of carbon monoxide (CO) levels, as indicated by the title "2025-01-07 00:00 - 2025-01-07 23:59, Sentinel-5P CO, Carbon Monoxide." The data appears to be captured by the Sentinel-5P satellite. The color scale represents varying concentrations of CO, with blue indicating lower levels and red/orange indicating higher concentrations. A significant concentration of CO is observed near the coastal region, specifically around what appears to be the Los Angeles area. The spatial resolution is coarse, resulting in a pixelated representation of the data.

2. Cluster Identification & Formation:

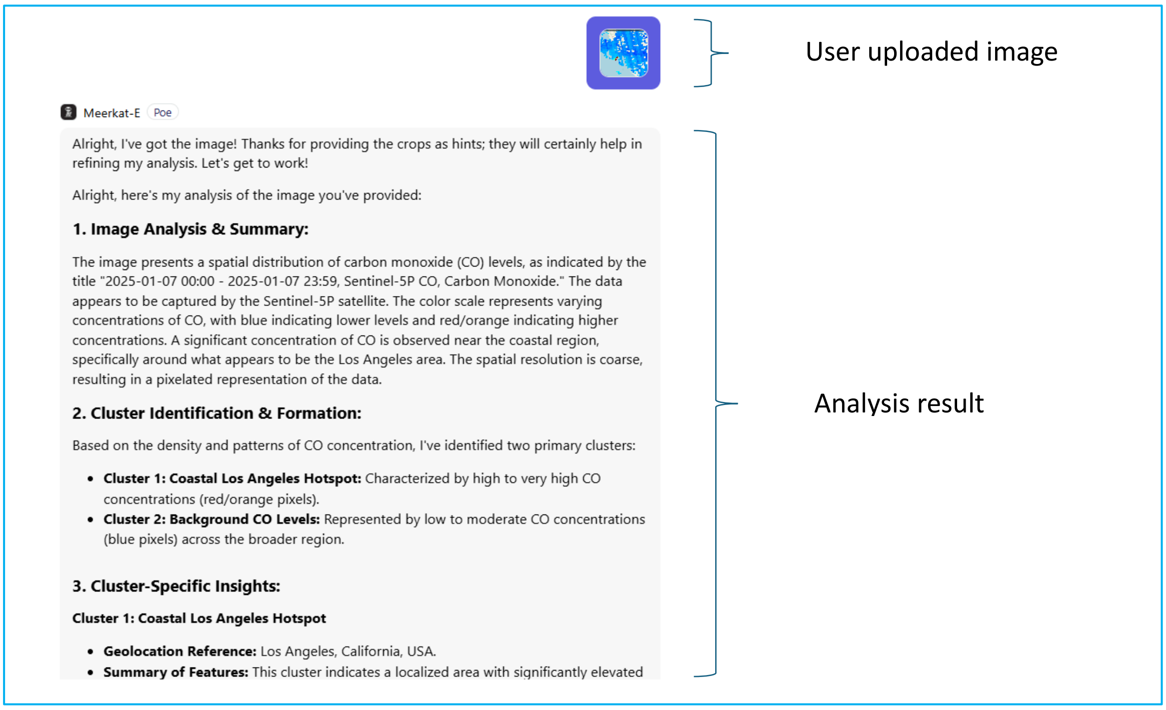
Based on the density and patterns of CO concentration, I've identified two primary clusters:

- **Cluster 1: Coastal Los Angeles Hotspot:** Characterized by high to very high CO concentrations (red/orange pixels)

Figure 3: The Cyclical Workflow of the Analysis Process.

Analysis result:

The analysis result generated by the AI platform, Meerkat-E, are presented in a conversation format, as illustrated in Figure 4.



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- **Cluster 2: Background CO Levels:** Represented by low to moderate CO concentrations (blue pixels) across the broader region.

3. Cluster-Specific Insights:

Cluster 1: Coastal Los Angeles Hotspot

- **Geolocation Reference:** Los Angeles, California, USA.
- **Summary of Features:** This cluster indicates a localized area with significantly elevated

Figure 4: The Cyclical Workflow of the Analysis Process.

Below is the full analysis result generated by Meerkat E for the uploaded image.

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3. Cluster-Specific Insights:

Cluster 1: Coastal Los Angeles Hotspot

- ***Geolocation Reference:*** *Los Angeles, California, USA.*

- ***Summary of Features:*** *This cluster indicates a localized area with significantly elevated carbon monoxide levels. Los Angeles is a major metropolitan area with a large population and diverse economic activities, including transportation, industry, and port operations. Land use is a mix of dense urban development, industrial zones, and transportation infrastructure. Demographic distribution is diverse, with high population density.*
- ***Potential Causes:*** *The elevated CO levels could be attributed to a combination of factors:*
    - ***Traffic Congestion:*** *High vehicle traffic in the Los Angeles metropolitan area is a major source of CO emissions.*
    - ***Industrial Activity:*** *Industrial facilities and port operations in the area may release CO as a byproduct of their processes.*
    - ***Wildfires:*** *Although the image is from early January, lingering effects or new smaller fires could contribute. Recent wildfires in the Los Angeles area have been noted to cause significant air quality issues.*
    - ***Inversion Conditions:*** *Meteorological conditions, such as temperature inversions, can trap pollutants near the ground, leading to localized high concentrations.*

Cluster 2: Background CO Levels

- ***Geolocation Reference:*** *Broader Southern California region.*
- ***Summary of Features:*** *This cluster represents the general background levels of carbon monoxide across the region. Land use varies from urban to agricultural and natural landscapes. Economic activities are diverse, including agriculture, tourism, and smaller urban centers.*
- ***Potential Causes:*** *The background CO levels are likely due to:*
    - ***Regional Transportation:*** *Emissions from vehicles across the wider Southern California area.*
    - ***Agricultural Activities:*** *Certain agricultural practices can contribute to CO emissions.*
    - ***Natural Sources:*** *Natural processes, such as wildfires (even small ones), can release CO into the atmosphere.*

4. Impact Assessment:

Impact on Human Health: *Elevated CO levels, as seen in Cluster 1, can have significant health impacts. Carbon monoxide interferes with the blood's ability to carry oxygen, leading to:*

- ***Short-term Effects:*** *Headaches, dizziness, nausea, and fatigue.*
- ***Long-term Effects:*** *Cardiovascular problems, neurological damage, and increased risk for vulnerable populations (children, elderly, and those with pre-existing conditions).*
- ***Mortality:*** *In extreme cases, high CO concentrations can be fatal.*

Impact on the Environment: *While CO is a relatively short-lived pollutant, it contributes to air pollution and can indirectly affect the environment. It plays a role in the formation of ground-level ozone, a major component of smog, which damages vegetation and ecosystems.*

Impact on Local Economies:

- ***Healthcare Costs:*** *Increased respiratory and cardiovascular illnesses lead to higher healthcare costs.*
- ***Lost Productivity:*** *Sick days and reduced productivity due to illness impact the economy.*
- ***Tourism:*** *Poor air quality can deter tourists, affecting the hospitality sector.*
- ***Agriculture:*** *Smog can damage crops, reducing agricultural yields and revenue.*

Long-term Opportunities, Challenges, and Sustainability Concerns:

- ***Opportunities:*** *Investment in clean transportation (electric vehicles, public transit), renewable energy, and sustainable industrial practices can reduce CO emissions and improve air quality.*
- ***Challenges:*** *Balancing economic growth with environmental protection, addressing transportation needs in a sustainable manner, and mitigating the impacts of climate change (which can exacerbate wildfires) are key challenges.*
- ***Sustainability Concerns:*** *Ensuring long-term air quality improvements requires sustained effort, policy support, and technological innovation.*

5. Recommendations:

Cluster 1: Coastal Los Angeles Hotspot

- ***Immediate Actions:***
    - ***Air Quality Alerts:*** *Issue public health advisories when CO levels spike, advising vulnerable populations to limit outdoor activities.*
    - ***Traffic Management:*** *Implement temporary traffic restrictions or promote public transportation during peak hours to reduce congestion.*
    - ***Emergency Response:*** *Ensure that emergency services are prepared to respond to CO poisoning incidents.*
- ***Long-Term Targeted Recommendations:***
    - ***Sustainable Land Use Planning:*** *Promote mixed-use development and prioritize public transportation to reduce vehicle miles traveled.*
    - ***Infrastructure Resilience:*** *Invest in electric vehicle charging infrastructure and expand public transit options.*
    - ***Economic Diversification:*** *Support the growth of clean industries and reduce reliance on polluting industries.*
    - ***Disaster Preparedness:*** *Develop and implement wildfire prevention and management strategies.*
    - ***Governance Improvements:*** *Strengthen air quality regulations and enforcement.*

Cluster 2: Background CO Levels

- ***Immediate Actions:***
    - ***Public Awareness Campaigns:*** *Educate the public about the sources and health impacts of CO and promote measures to reduce emissions.*

- ***Long-Term Targeted Recommendations:***
    - ***Sustainable Land Use Planning:*** *Encourage smart growth principles to minimize urban sprawl and reduce transportation emissions.*
    - ***Economic Diversification:*** *Support sustainable agriculture practices and promote eco-tourism.*
    - ***Disaster Preparedness:*** *Implement regional wildfire prevention and management plans.*
    - ***Governance Improvements:*** *Strengthen regional air quality monitoring and management efforts.*

Summary and Conclusion

This case study demonstrates the integration of artificial intelligence (AI) with Earth observation (EO) data to analyse the spatial distribution of carbon monoxide (CO) in Los Angeles following the January 2025 wildfires. Using the Copernicus Browser, Sentinel-5P satellite imagery for 7 January 2025 was retrieved to assess CO concentration levels in the affected areas. This satellite image was then processed using Meerkat E, an AI-powered chatbot, which conducted a spatial analysis and identified distinct clusters of pollution distribution. One of Meerkat E's most valuable features is its ability to autonomously detect key elements such as pollution, urban density, and land use, and then assess their environmental, economic, and societal impacts.

The analysis identified two primary clusters of CO concentration. The Coastal Los Angeles Hotspot exhibited the highest levels of CO, driven by a combination of wildfire emissions, vehicular congestion, industrial activities, and meteorological factors such as temperature inversions. The Background CO Levels cluster covered the broader Southern California region, where lower but still significant CO levels were attributed to transportation, agriculture, and natural sources. By distinguishing these clusters, Meerkat E provided a detailed assessment of how wildfire-driven pollution interacts with existing urban and industrial emissions, offering insights into both short-term environmental impacts and long-term pollution trends.

Beyond identifying pollution patterns, the analysis also examined their implications for human health, the environment, and local economies. Elevated CO levels can pose severe health risks, particularly for vulnerable populations, by impairing oxygen transport in the bloodstream, leading to dizziness, confusion, and in extreme cases, fatal poisoning. Environmentally, CO contributes to the formation of ground-level ozone, exacerbating smog and damaging ecosystems. Economically, prolonged air pollution increases healthcare costs, reduces workforce productivity, and negatively affects industries such as tourism and agriculture.

It is important to recognize that, as with all generative AI models, the wording and structure of the AI-generated analysis may vary. However, although the linguistic presentation may change, the fundamental insights remain consistent and valuable. AI-generated analyses should be used as an adaptive and supplementary resource, where human expertise plays a crucial role in validating and refining outputs to ensure accuracy and applicability.

The synergy between EO data and AI-powered analysis is reshaping environmental monitoring and decision-making. EO data from Sentinel satellites, such as Sentinel-5P, provides high-resolution atmospheric measurements that offer critical insights into pollution trends, climate change, and disaster impacts. In this context, AI can serve as a valuable independent advisor to analysts and researchers. AI-generated insights can challenge assumptions, help triangulate different viewpoints and inspire new ways of thinking about data. This fresh approach enhances the objectivity and depth of environmental assessments, ultimately improving the quality of decision-making.

Looking ahead, the integration of Earth Observation (EO) data and AI is expected to become even more seamless, enabling automated monitoring and anomaly detection without human intervention. This advancement will allow AI to forecast environmental trends such as wildfire spread, air quality deterioration, and extreme weather events, thereby enhancing preparedness and mitigation efforts. Furthermore, AI-driven decision support systems could refine environmental policy by providing automated risk assessments, tailored mitigation strategies, and real-time policy recommendations that adapt to evolving conditions.

Furthermore, the potential for integrating AI into EO hardware is an exciting frontier. Future EO satellites could incorporate AI-powered onboard processing, allowing data to be analysed directly in space before being transmitted to Earth. This would significantly reduce transmission costs, improve response times for disaster management, and enhance the efficiency of satellite-based monitoring.

As this case study has demonstrated, AI enhances the interpretation of satellite data, accelerates the identification of critical pollution patterns, and provides actionable recommendations that support effective decision-making. Although AI-generated analyses may vary in wording and format, their ability to provide data-driven insights makes them invaluable to a wide range of stakeholders, including policymakers, researchers, urban planners, and environmental agencies.