HEXAGON

Harnessing the ancient elements: A modern approach to environmental resilience

White paper

Introduction

In ancient Greek philosophy, the world was viewed as a harmonious blend of four fundamental elements: earth, water, air and fire. These elements were believed to be the essential building blocks of everything in existence, each contributing to the balance and dynamics of the natural world. This understanding not only shaped early scientific thought, but also inspired countless generations to explore the intricate relationships between these elements and the environment.

Today, as we face the pressing challenges of climate change, the wisdom of these ancient elements offers a framework for innovative solutions. Using innovative capabilities, such as urban digital twins and advanced simulations, we can address the impacts of these elements in our contemporary world.

This white paper will explore how urban digital twins leverage the power of modern technologies like computational fluid dynamics (CFD) and AI to anticipate and mitigate the challenges posed by earth, water, fire and air, ensuring a more sustainable and resilient future.

Earth: Unveiling urban heat islands

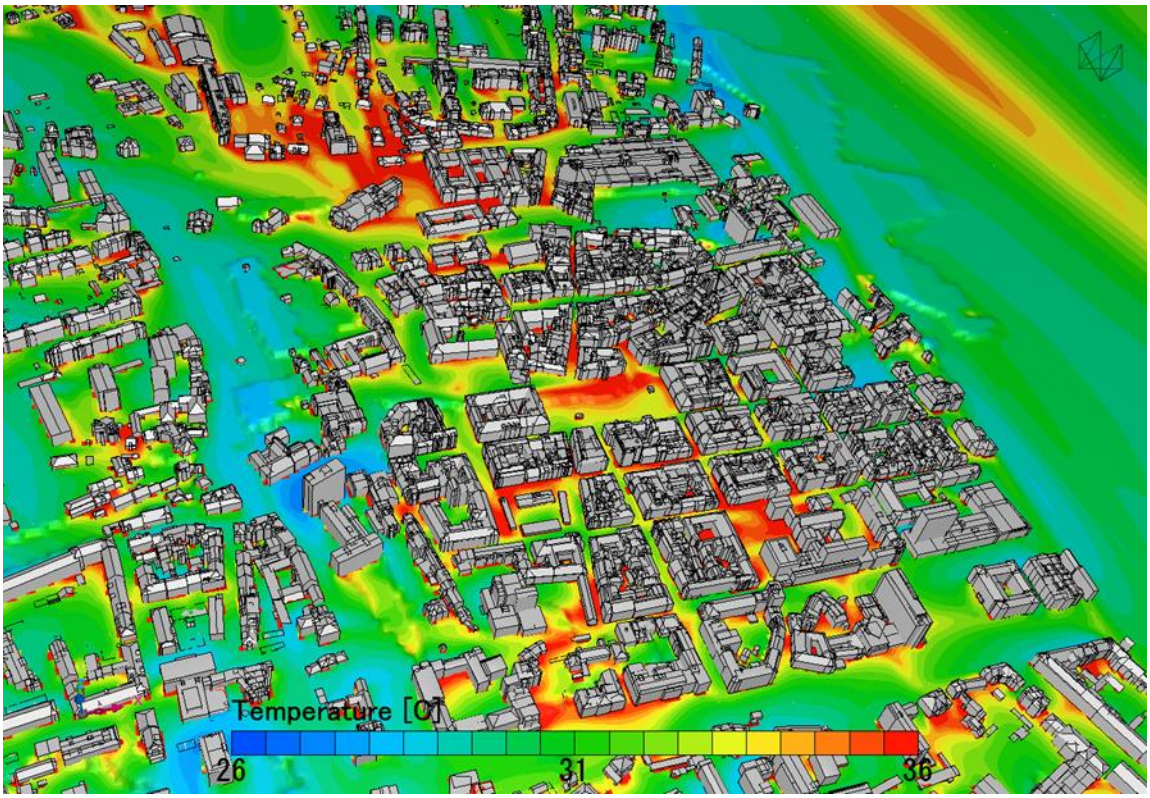
Cities are vibrant hubs of human activity, but they also face the challenge of urban heat islands (UHIs) — areas significantly warmer than their rural surroundings due to human activities and infrastructure. An urban digital twin is a powerful tool for detecting and mitigating these heat islands.

To effectively address the UHI effect using an urban digital twin and other analysis tools, a comprehensive set of data is needed. This data helps planners understand the factors contributing to a UHI and develop strategies to mitigate it.

Surface and air temperatures can be collected through network sensors, the analysis of surfaces with satellite imagery and the use of remote sensing tools to identify hotspots. This includes analysing land cover, bodies of water, buildings and material types.

By simulating city environments, CFD models can analyse how heat is absorbed and dissipated across different materials and structures. This allows urban planners to identify hot spots and implement cooling strategies, such as increasing green spaces or using reflective materials.

The result? Cooler, more livable cities that contribute to reducing the overall urban heat footprint.



Hexagon's CFD simulation shows the heat islands in an urban environment.

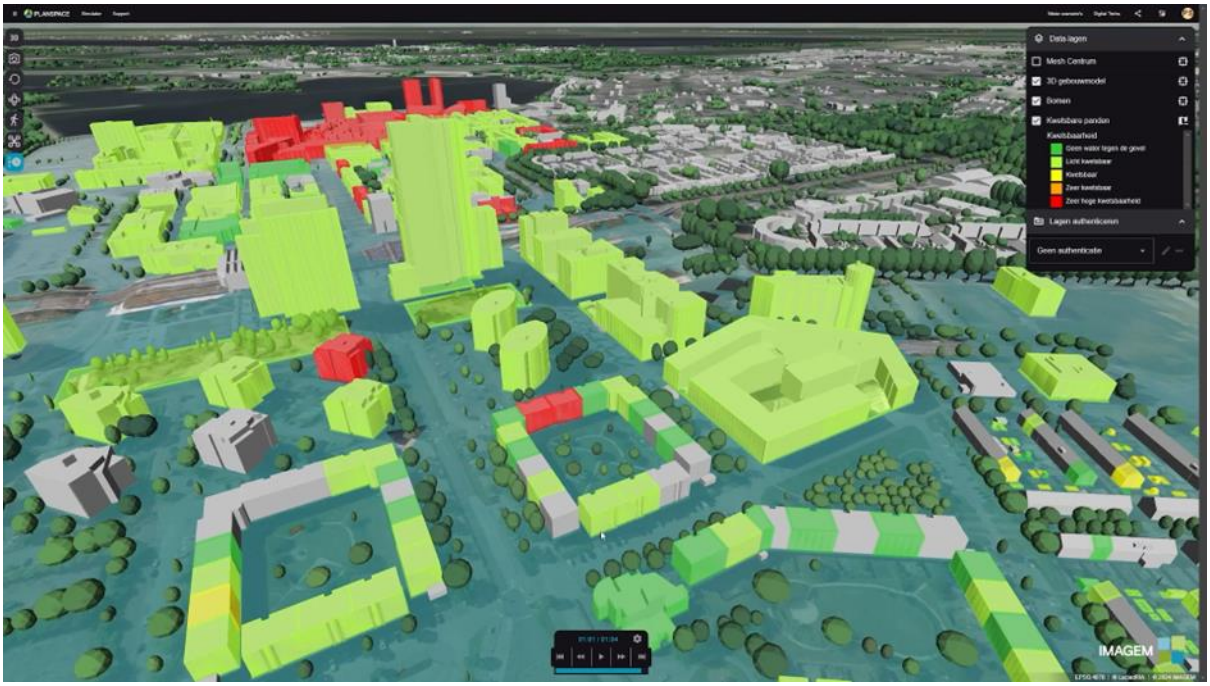
Water: Navigating the waters of flood simulation

As climate change intensifies, the risk of flooding becomes an ever-present threat to communities worldwide. Increasingly frequent heavy rainfall and downpours lead to significant flooding, causing damage to property, disrupting infrastructure and posing risks to public health. Municipalities around the globe face the challenge of preparing for these events and ensuring timely warnings and protections for residents and visitors.

Urban digital twins, combined with advanced hydrodynamic models, and all the information previously mentioned, provide invaluable insights into flood dynamics. By creating virtual representations of urban environments enriched with dynamic models, policymakers and experts can visualise where flooding is likely to occur and how water might spread through cities. These simulations offer a detailed view of potential flood impacts, such as areas where water might pool after heavy rain, which access roads could be blocked, where water might breach thresholds and even how high water levels could rise against building facades.

By reducing complexity through the integration of automated 3D city models with interactive simulations, urban digital twins offer a clear picture of potential flooding impacts to everyone — from policymakers to residents. This knowledge empowers decision-makers to design more effective flood defences, implement early warning systems and take proactive measures to safeguard communities and save costs.

With urban digital twins, cities can navigate the waters of uncertainty and build resilience against nature's rising tides, protecting lives and property in the process.



Hexagon partner IMAGEM's flood prediction solution: buildings in red are at risk of flooding in the simulated scenario.

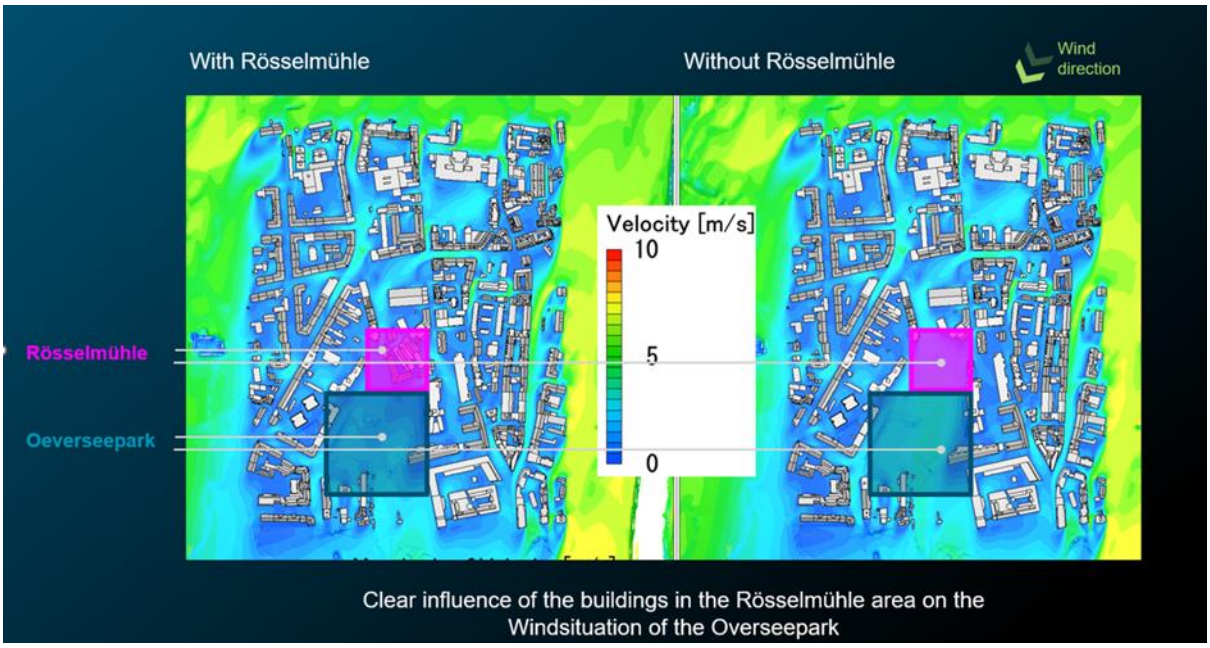
Air: Optimising urban airflow

Analysing airflow in cities involves understanding how air moves through urban environments, which is crucial for addressing issues like pollution dispersion, thermal comfort and energy efficiency.

This analysis requires a combination of data collection and advanced modelling techniques. Data such as wind speed and direction at different heights, atmospheric humidity and pressure and solar radiation, together with building and infrastructure data (heights, shapes, materials, etc.) can be combined in an urban digital twin. And by using CFD simulations, planners are offered a window into the invisible world of airflow within their cities.

By modelling how air moves through urban environments, cities can identify areas prone to wind tunnels or pollutant accumulation. Armed with this information, city planners can optimise building designs and street layouts to enhance natural ventilation and reduce pollution hot spots.

The result is cleaner, healthier air for city dwellers, contributing to a more sustainable urban future.



This graphic shows airflow prediction with and without the Rösselmühle building in a city in Austria.

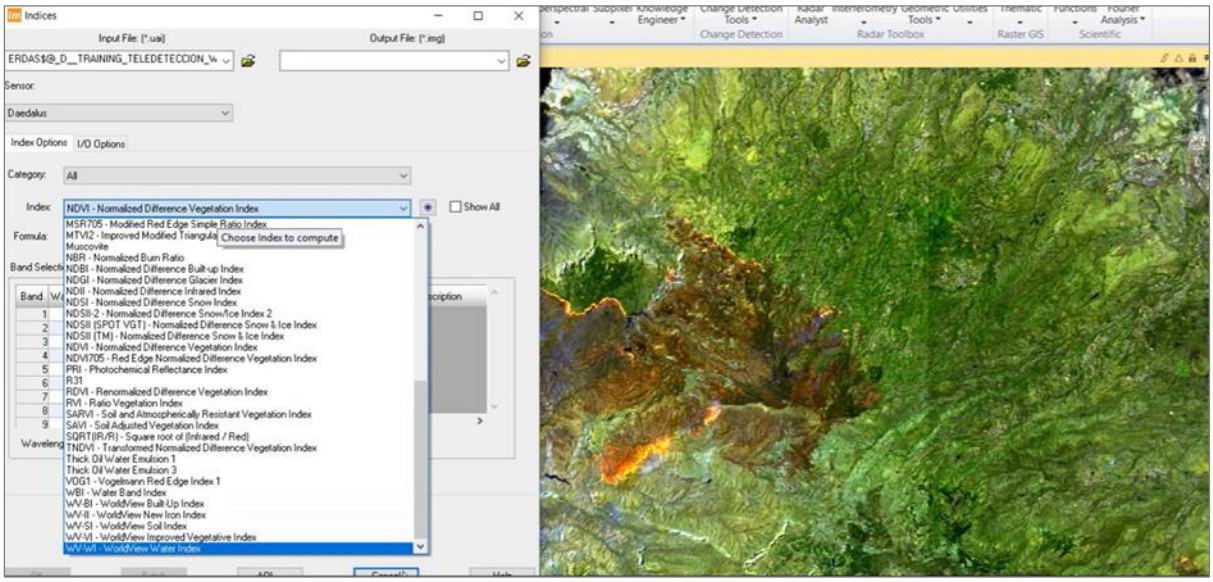
Fire: Identifying fire-prone areas with advanced monitoring

Wildfires pose a significant threat to ecosystems, human settlements and infrastructure. With the increasing frequency and intensity of these fires due to climate change, the need for proactive management has never been more critical. Advanced monitoring solutions are revolutionising the ability to predict and prevent these devastating events.

These solutions use satellite imagery to extract crucial data about vegetation and moisture content, combining it with meteorological data to assess fire risk.

With satellite images, we can monitor changes in land cover over time, extracting information about vegetation types, density and health, which influence fuel availability and flammability.

By continuously monitoring these variables, together with historical climate data, and integrating this information with topographic data, elevation, slope and GIS data, an urban digital twin can identify areas with a high probability of fire, allowing for timely and strategic interventions.



Various indexes available in ERDAS IMAGINE help city planners detect fire-prone areas.

The integration of real-time data into a user-friendly dashboard provides continuous fire risk assessment through interactive charts and maps. This enables strategists and field crews to access vital information on the go, even in areas without internet access, ensuring they can make informed decisions to protect people and assets.

By leveraging this technology, communities and organisations can categorise risks and implement preventative measures to safeguard lives and property. Proactive management of high-risk areas through vegetation management and strategic resource allocation can significantly mitigate the impact of wildfires.

Using advanced monitoring and urban digital twin technology, cities can enhance their preparedness and response to fire threats, ensuring a safer and more resilient environment for residents and visitors.

Conclusion

In the face of modern environmental challenges, the ancient Greek perspective of the four fundamental elements — earth, water, air and fire — offers a timeless framework for understanding and addressing the world around us. By integrating this wisdom with cutting-edge technologies such as urban digital twins, CFD and AI, cities can develop innovative solutions to mitigate the impacts of climate change.

From cooling urban heat islands to simulating flood risks to optimising urban airflow and predicting fire-prone areas, these technologies empower planners to create more sustainable and resilient communities. By embracing the synergy between ancient insights and modern technology, cities can navigate the complexities of the environment and build a future that harmonises with nature's elemental forces. This holistic approach not only safeguards our present, but also ensures a thriving world for generations to come.

Learn more

Discover how Hexagon can power your city’s urban digital twin.

About Hexagon

Hexagon is the global leader in precision technologies at any scale. Our digital twins, robotics and AI solutions are transforming the industries that shape our reality.

Hexagon’s Safety, Infrastructure & Geospatial division improves the resilience and sustainability of the world’s critical services and infrastructure. Our solutions turn complex data about people, places and assets into meaningful information and capabilities for better, faster decision-making in public safety, defense, transportation, government and physical security. Learn more at hexagon.com and follow us @HexagonAB.