Enabling EO Methods for Environmental Monitoring in Urban Landscapes

Earth observation methods provide an objective and synoptic means to monitor urban dynamics, and EO-derived products can be used as crucial tools to measure and estimate environmental parameters.

Mads Christensen [A], Emil Møller Rasmussen [B]

A: DHI GRAS B: Copenhagen Municipality

The challenge

Water pollution is a severe problem worldwide and a great concern to city planners aiming to make cities cleaner, smarter and more sustainable. The ability to meet environmental objectives and stringent commitments imposed by legal obligations is hindered by the ability to consistently monitor and measure water resources and pollutants entering waterways.

Impervious areas are one of the most critical parameters affecting the quality of water resources, and urbanization processes have caused a significant increase of impervious surfaces. Roads, rooftops, parking lots, sidewalks, etc. prevent water infiltration and consequently cause rapid runoff in response to rainfall, thus altering the hydrological balance, structure of critical habitats, water quality, and biodiversity of aquatic ecosystems.

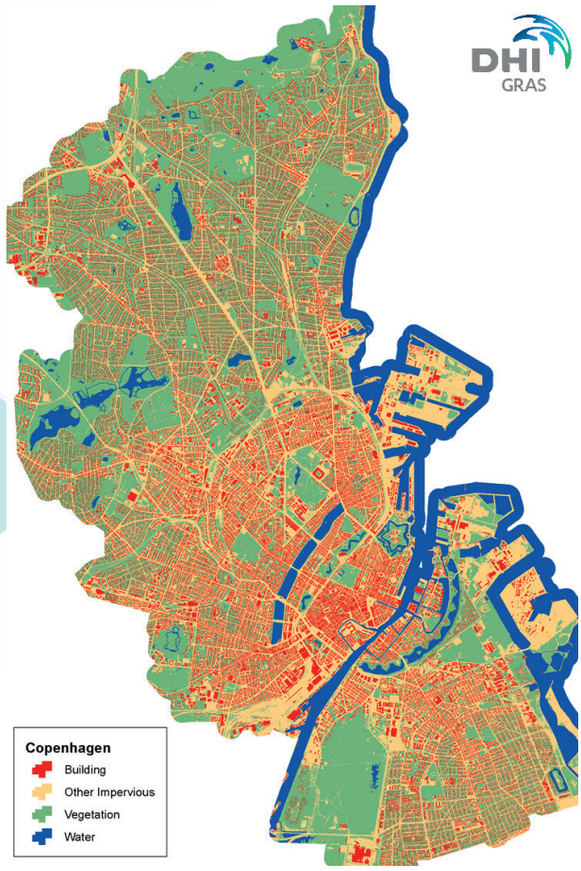
The space-based solution

The ability to consistently and comprehensively monitor impervious surfaces in urban landscapes as well as the composition of these surfaces is critical in order to strengthen the ability of city councils to sustainably manage urban water infrastructure.

Sentinel-2 data (10m) can effectively be used to monitor and map impervious surfaces in urban landscapes and thus provides an objective means to monitor and assess the extent of impermeable areas. Based on a highly automated object-based approach, satellite data can be turned into actionable and seamless information on surface types and degree of permeability, which can be used to assess pollution effects in waterways. These maps can be used to calculate quantities of water and pollutant loading of water coming from the impervious areas

> **Up to date and accurate maps of surface permeability are one of the most important components of rainfall runoff modelling, and satellites provide the most efficient and objective means to consistently map and monitor impervious surfaces.**
>
> *Sten Lindberg, Danish Hydraulic Institute (DHI)*

Deep learning approaches can be used to further analyze high-resolution satellite images to map rooftop segments and distinguish between material types (i.e. green roofs, asphalt shingles, copper roofing, clay tiles) as well as other objects of interest, e.g. solar cells. The ability to identify and map material types in rooftop segments provides critical information that can be used to monitor the concentration of pollutants entering waterways, i.e.



Impervious surface map of Copenhagen, Denmark indicating the coverage of non-permeable surfaces and green areas.

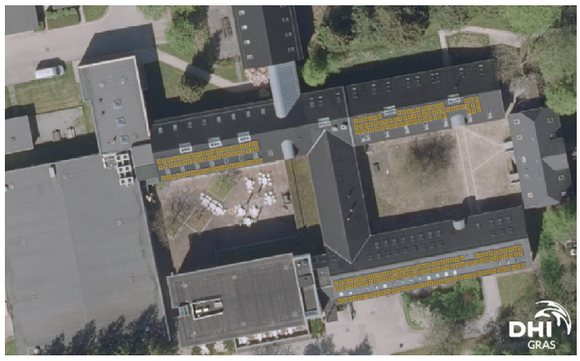
monitoring the concentration of dissolved copper ions in waterways from copper roof sheeting.

Benefits to citizens

Local governments and national authorities need standardized, high-quality spatial information to aid water management policies and strategies for infrastructure planning. Satellite-based approaches to monitor environmental parameters in urban landscapes provide an objective, consistent and cost-efficient means to measure and monitor the condition of water resources.

Data and information on the degree of permeability and information about rooftop material type can aid local authorities to:

1. better understand stormwater pollutant loading in order to identify best management practices;
2. inform sustainable urban spatial planning strategies and regreening activities;



Deep learning approach to automatically segment solar cells on rooftops from very high-resolution satellite imagery.

3. aid city planners in determining where and how storm pipes drain and how it impacts the environment.

Outlook to the future

Urban landscapes will continue to expand to accommodate a growing population, resulting in significant alterations to natural processes and environmental quality. Information from advanced satellite-based analysis is paramount in order to address this challenge. The Sentinel missions have been a game changer when assessing the dynamics in urban environments, and next generation sentinels and other high-resolution sensors will continue to improve the accuracy and precision of satellite-based environmental assessments. The frequent revisit time of the Sentinels will allow city planners to gain insight into the dynamics and environmental condition of urban environments by facilitating the production of recurrently updated information on urban structures. This will allow authorities to make decisions based on near-real time data, rather than on data updated once every 2-3 years. Furthermore, satellite-based mapping of impervious surfaces is an objective and consistent source of information, independent of subjective human interpretation.

Acknowledgements

We thank the European Commission and the European Space Agency for providing Sentinel data through the Copernicus Open Access Hub.