The Analysis of Urban Growth and Surface Permeability informed by Earth Observation Data

Lead Supervisor: Dr Alex Hagen-Zanker, University of Surrey, Department of Civil and Environmental Engineering
Email: a.hagen-zanker@surrey.ac.uk

Co-supervisor: Dr Belen Marti-Cardona, University of Surrey, Department of Civil and Environmental Engineering

External Advisor: Dr Michael Hutchins, Center for Ecology and Hydrology, Wallingford, UK

Approximately 90% of the UK's population lives in urban areas. This percentage has increased steadily since the 1950's, and the urban population is forecasted to keep growing. At the same time, floods are becoming more frequent and this trend is expected to continue under climate change. These trends combined have put the spotlight on the interaction of urbanization, climate change and flood risk

A myriad of interconnected human activities take place in the cities and affect the urban environment. Urban planners and managers face the challenge of making those activities and associated mobility feasible, while ensuring environmental health and safety. This challenge demands effective monitoring tools to understand the functioning of spatial and temporal urban systems as well as to predict future trends.

Satellite images are widely used for monitoring of the environment in multiple disciplines. However, the applicability in urban environments is limited by the complexity of surface materials found in cities as well as the fragmented and dynamic use of urban areas. Medium resolution satellite images present complex signals, where the measured value in a single pixel represents a mix of textures and materials. High resolution images, on the other hand, often are insufficiently refined to capture the urban material complexity. As a consequence, the classification error in common methods has been found to be in the order of magnitude of the urban changes expected over a few decades, severely complicating the analysis of temporal change (see Fig. 1).

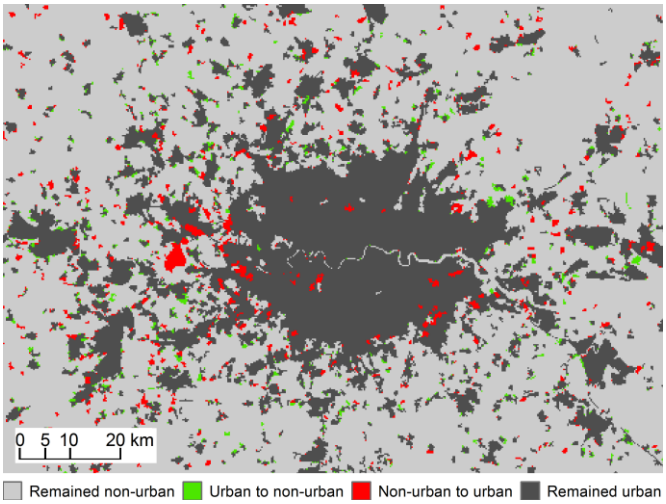

Figure 1. The growth of London 2000-2006 according to the EEA CORINE database

The aim of this project is to develop integrated tools for the mapping, analysis and forecasting of processes of urban growth and densification, with a focus on the increase in paved area and its effects on surface permeability.

The work is organized into three main objectives, to be realized on a common set of three case studies drawn from urban areas in the UK.

Objective 1: Classification of urban extent and surface permeability: This work starts with a review of concepts and methods for the interpretation of earth observation data, with a specific focus on data integration methods for accurate mapping of paved land at the urban scale and quantification of uncertainty. The classification will apply a land cover typology that is simultaneously relevant to surface permeability and urban growth processes.

Objective 2: Analysis of trends in urban growth and surface permeability: This work starts by reviewing concepts and methods in urban change analysis. Using data from the UK census as well as satellite images, the change analysis will consider both the growth of urban extent and different aspects of densification. The sensitivity of a variety of metrics to classification errors will be investigated and robust descriptive indicators of urbanization trends will be proposed.

Objective 3: Urban growth and surface permeability forecasting: This work will apply existing frameworks for forecasting land use change through spatial simulation. In order to manage and understand the uncertainty associated with the forecasts, recent methods developed in support of environmental modelling will be brought into practice. The hydrological impact of impermeability will be quantified in terms of peak flow increase, so attenuation measures such as Sustainable Urban Drainage Systems can be accounted for accordingly.

Training opportunities:

The candidate will work directly with both supervisors who will provide specific training in the following aspects:

- Spatial analysis and geographical information science;
- Remote sensing, image processing and classification;
- Urban change modelling;
- Hydrological modelling

Through the process of pursuing the PhD research, the candidate will develop transferrable skills that are highly valuable in today's information society. Furthermore he/she will gain knowledge at the interface of urbanization and hydrology, which is pertinent to global challenges in a rapidly urbanizing world under pressure of climate change.

Student profile:

The ideal candidate has excellent quantitative and computational skills. The project requires creativity and systematic thinking to relate abstract concepts to physical and social processes. The project will require the students to engage with large datasets and use machine learning and statistical methods as well as exploratory and visualization methods.

The candidate should be able to demonstrate experience and interest in at least one of the following areas: urban studies, hydrology, and geographical information science.