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Publication date:
2015

Document Version
Peer reviewed version

[Link back to DTU Orbit](#)

Citation (APA):

Kaspersen, P. S., Høegh Ravn, N., Arnbjerg-Nielsen, K., Madsen, H., & Drews, M. (2015). Influence of urban land cover changes and climate change for the exposure of European cities to flooding during extreme precipitation. Poster session presented at European Climate Change Adaptation Conference 2015, Copenhagen, Denmark.

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Influence of urban land cover changes and climate change for the exposure of European cities to flooding during extreme precipitation



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Abstract

In this paper we present a methodology suitable for investigating the relative and combined influence of urban land cover changes and climate change for the exposure of cities to pluvial flooding. A combined hydrological-hydrodynamic modelling and remote sensing approach enables the quantification of the flood risk relative to changes in imperviousness and climate change. The methodology is evaluated for the Danish city of Odense, but is easily applicable for the majority of cities within Europe, as it relies on open source data for the European continent.

Results from Odense show that urban development during the past 30 years caused an increase in flood exposure that is comparable to what is expected in the RCP4.5 (+2°C) climate scenario.

This poster is based on the following paper:
Skougaard Kaspersen, P., Høegh Ravn, N., Arnbjerg-Nielsen, K., Madsen, H and Drews, M (2015). Influence of urban land cover changes and climate change for the exposure of cities to flooding during high-intensity precipitation. Proceedings of the International Association of Hydrological sciences (IAHS), 92, 1-7, 2015.

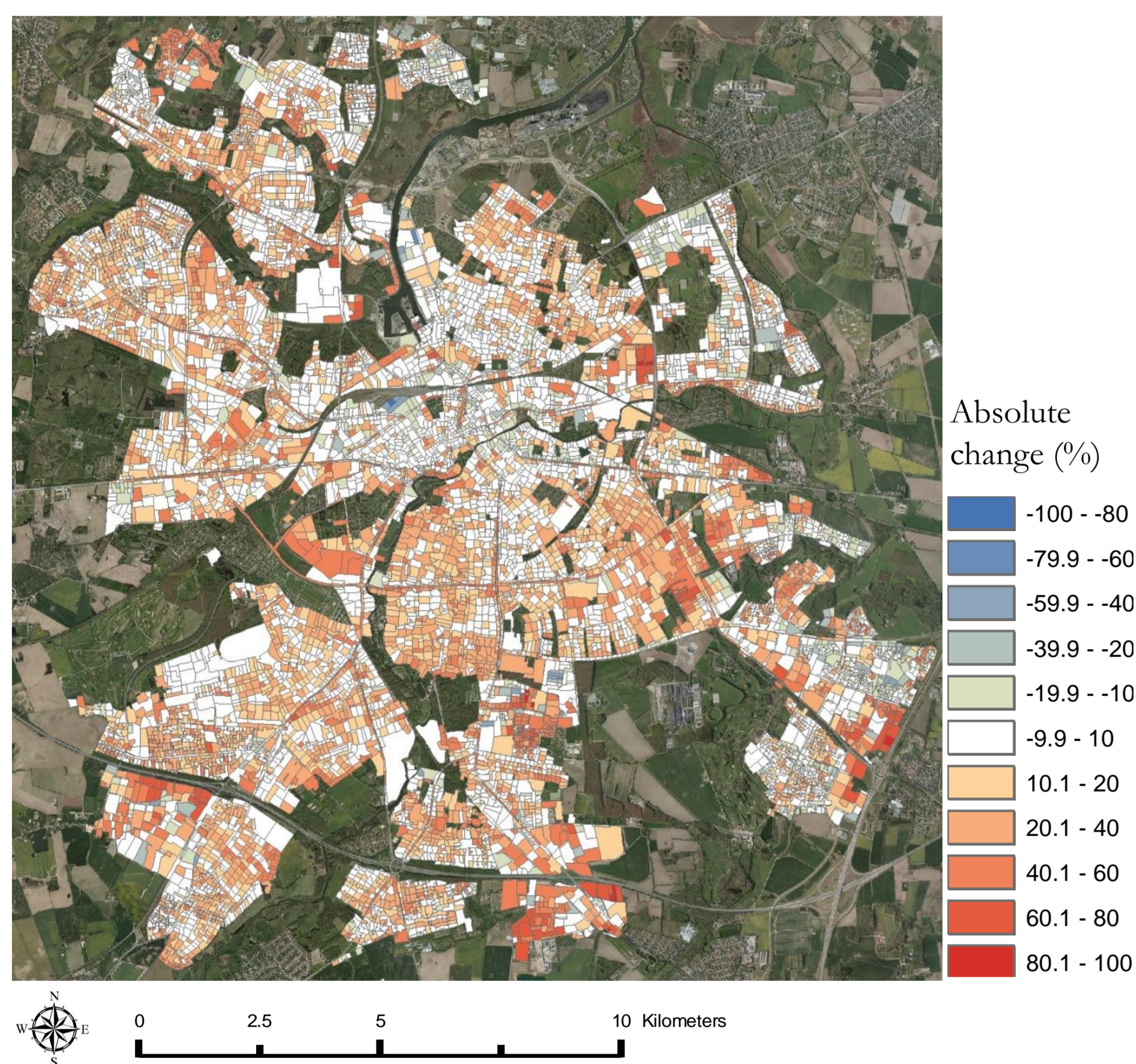
INTRODUCTION

The extent and location of impervious surfaces, such as roads, buildings, parking lots and other paved areas, within urban areas strongly affects the amount and velocity of run-off during high-intensity rainfall and consequently influences the exposure of cities towards flooding (Arnold and Gibbons, 1996). Also, climate change is expected to exacerbate urban flood risk as heavy precipitation is projected to increase in intensity and frequency over many areas of the globe, including central, northwest and northern Europe (IPCC, 2012). If present urban development trends towards increasing IS fractions continues (Angel et al., 2011), this is expected to further aggravate the risk of pluvial flooding. On the other hand the introduction of more pervious surfaces could serve as adaptation to climate change. Hence, detailed knowledge of the importance of both urban land cover changes and climate change for the risk of urban areas towards flooding provides substantial insight into how to plan for future climate proof cities.

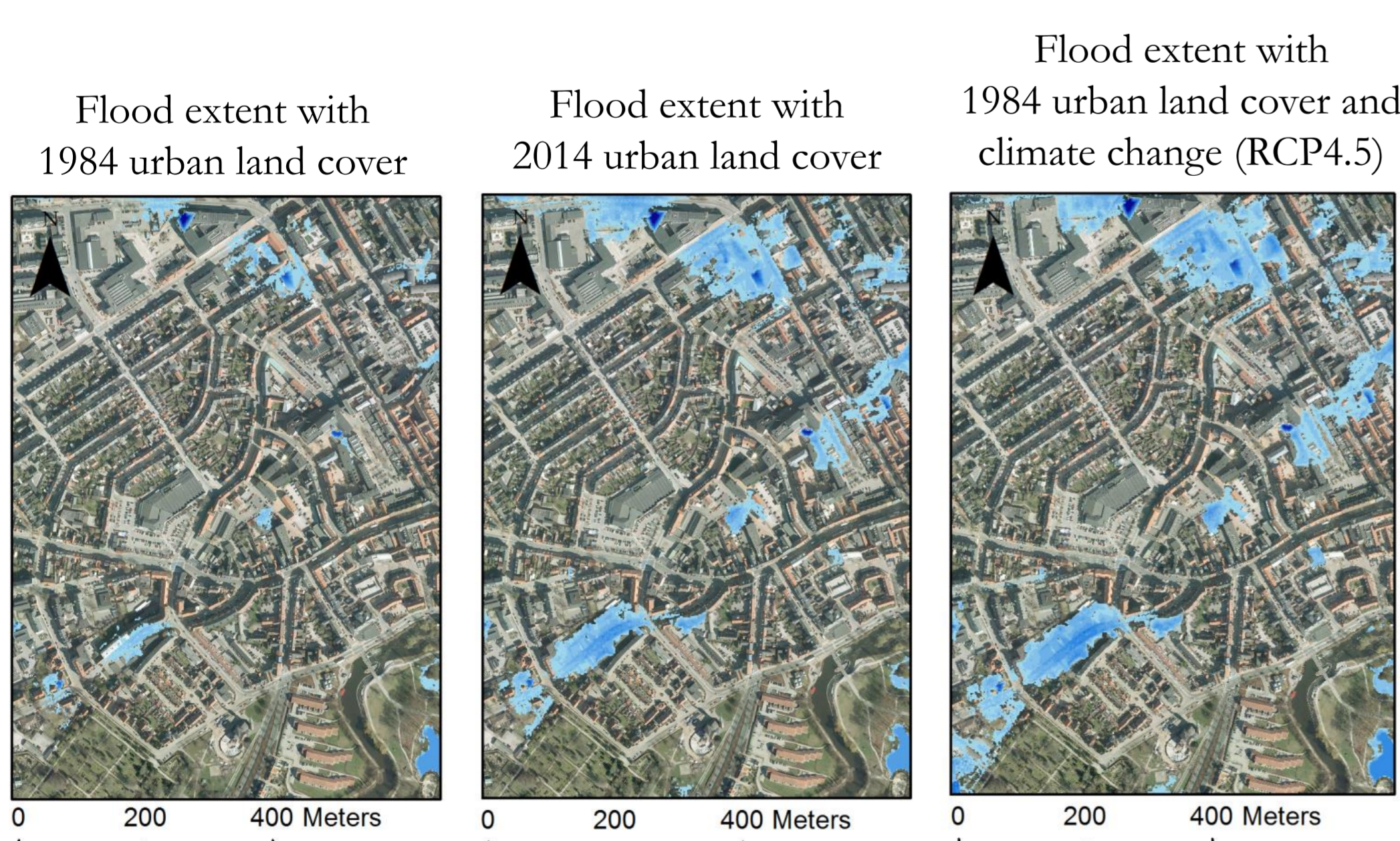
METHODOLOGY

Estimated changes in impervious surfaces (proxy for urban development) based on Landsat satellite imagery covering the period 1984–2014 are combined with regionally downscaled estimates of current and expected future rainfall extremes to enable 2-D overland flow simulations and flood hazard assessments. The relative and combined impacts of urban land cover changes and climate change towards the exposure of Odense to pluvial flooding is investigated by simulating the occurrence of 5 distinctive high-intensity precipitation events (RP10, RP20, RP50, RP100, RP1000) under both current and future climate (RCP4.5, RCP 8.5) and for historical (1984) and current (2014) urban land cover. The hydrodynamic flow module in the MIKE21 software (MIKE By DHI) is used to simulate flooding during the individual high-intensity rainfall events. The primary outputs of the flood model are maps showing the maximum flood depth and extent for each individual simulation. A cross comparison of the multiple flood maps enables a quantification of the relative importance of land cover changes as compared to climate change.

City development in Odense 1984-2014, measured as changes in impervious surfaces

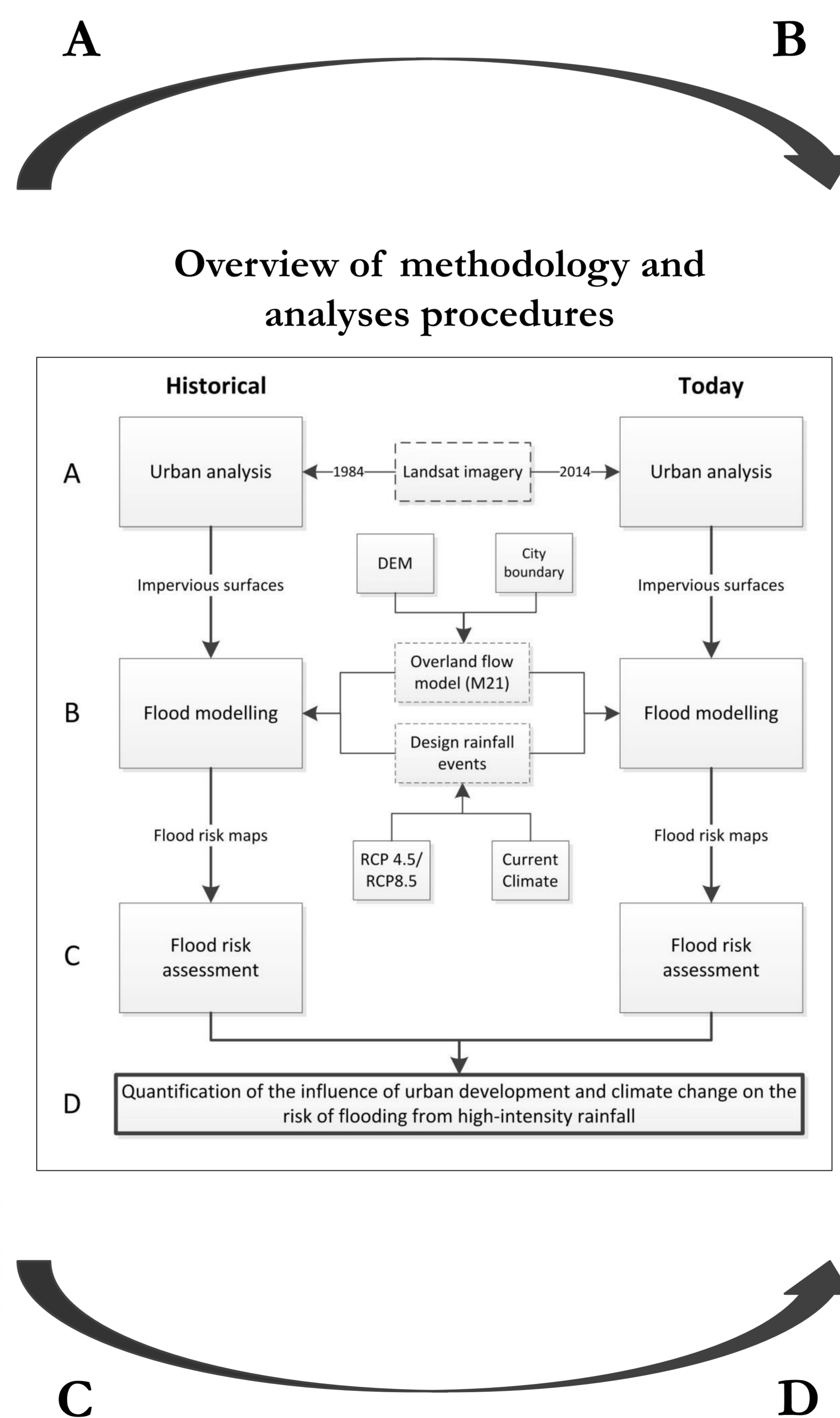


Flooding in the city of Odense during high-intensity precipitation occurring once every 100 years (RP100)

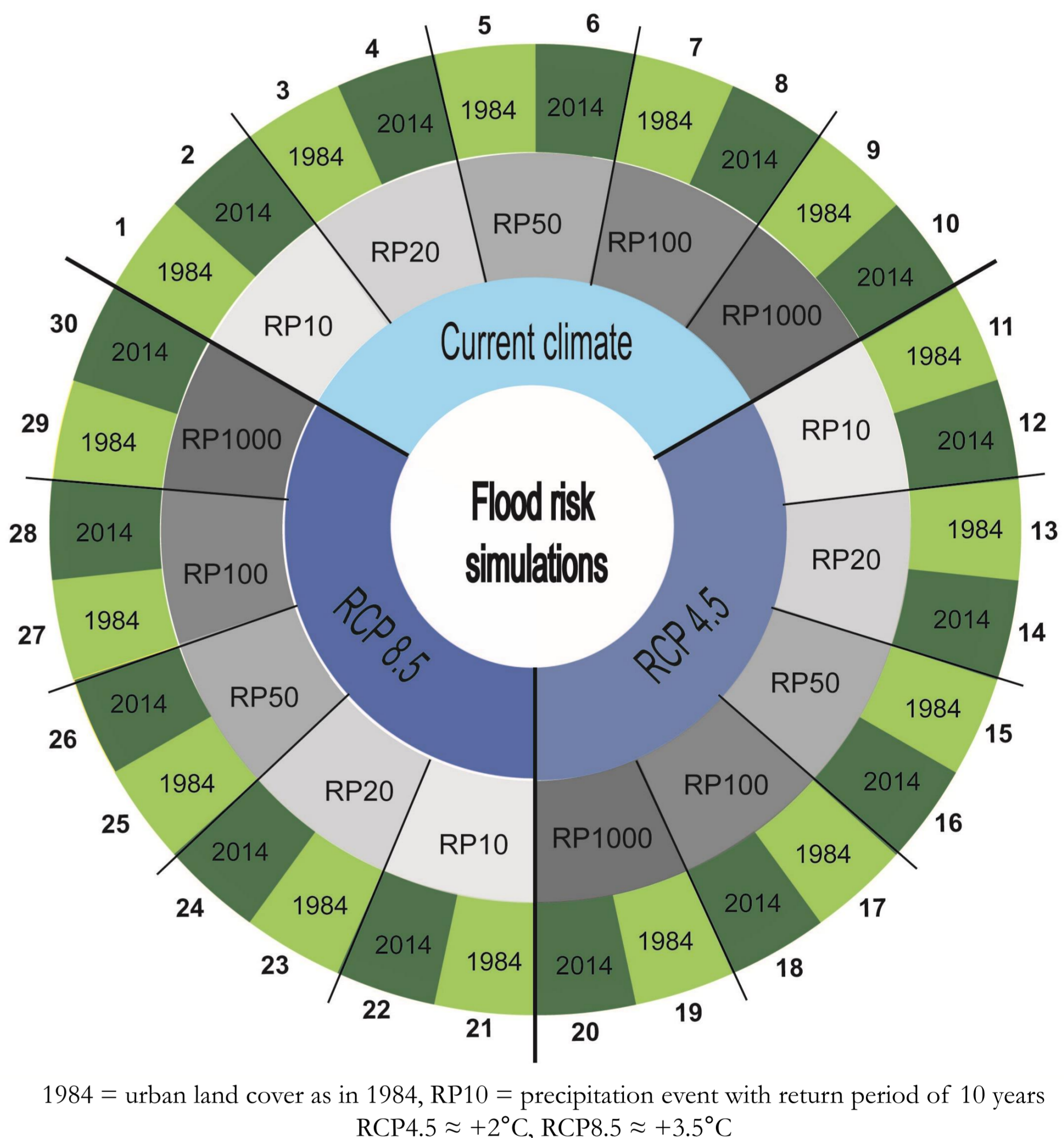


CONCLUSIONS

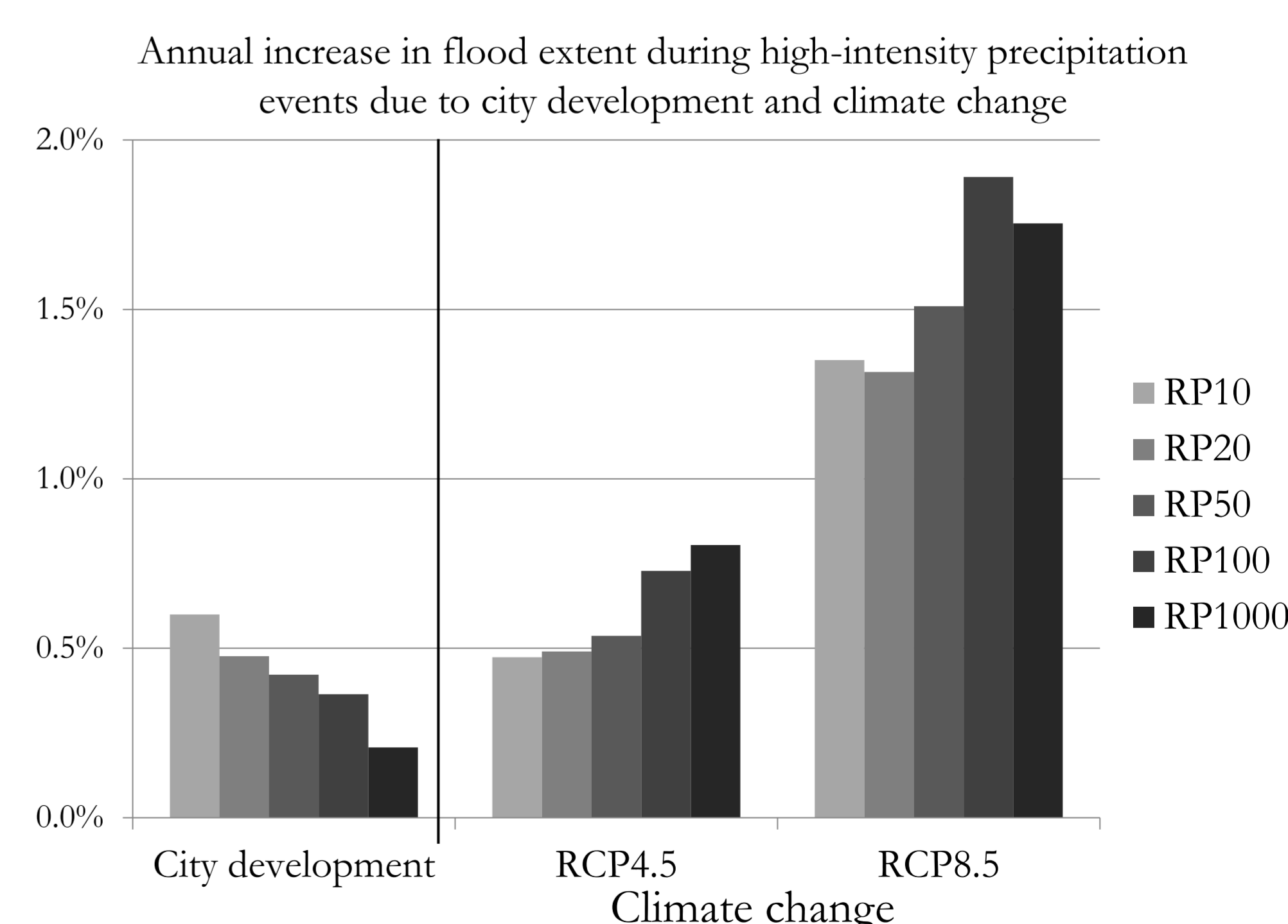
A combined remote sensing and flood modelling approach is developed and applied to quantify the influence of recent urban development and expected climate change on the exposure of cities towards flooding from extreme precipitation. Results show that city development in Odense during the past 30 years caused an increase in flood exposure that is comparable to the RCP4.5 (+2°C) climate scenario. City development is found to be most important for the least extreme events while the opposite is the case for climate change, indicating that both aspects should be considered when planning for climate proof cities.



Flood risk simulations (n = 30) for different high-intensity precipitation events for current and historical land cover and under current and future climate



Influence of city development and climate change for the exposure towards flooding



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