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A combined remote-sensing and flood-modelling approach for assessing the impacts of urban development and climate change on exposing European cities to pluvial flooding

Per Skougaard Kaspersen (1), Martin Drews (1), Nanna Høegh Ravn (2), Karsten Arnbjerg-Nielsen (3), and Henrik Madsen (4)

(1) Management Engineering, Technical University of Denmark, Denmark , (2) LNH Water, (3) Environmental Engineering, Technical University of Denmark, Denmark , (4) DHI

The economic and human consequences of the flooding of urban areas caused by extreme precipitation events have increased rapidly over the past decades. Key factors that affect the risks to urban areas include the densification of assets within cities and the general expansion of urban areas. In this study, we present a combined remote-sensing and flood-modelling approach, which is used to examine the impacts of recent urban development patterns and climate change on the exposure of four European cities to pluvial flooding: Odense (Denmark), Vienna (Austria), Strasbourg and Nice (France). The four cities used to demonstrate the utility and replicability of this approach represent different climatic conditions, trends in urban development and topographical characteristics. The combined remote-sensing and flood-modelling approach is used to simulate the extent of pluvial flooding for historical (1984) and present-day (2014) urban land cover and a range of extreme precipitation events, representing both current and future climatic conditions. Changes in urban land cover are estimated using Landsat satellite imagery for the period 1984–2014. Impervious surfaces, as an indicator of urban areas, are quantified through regression modelling using vegetation indices from Landsat 5 (historical) and 8 (present-day). We combine the remote-sensing analyses with regionally downscaled estimates of precipitation extremes of current and expected future climate to enable 2-D overland flow simulations and flood hazard assessments. The relative impact of urban development and climate change is quantified by examining the differences in flooded areas between the different simulations.

For all four cities, we find an increase in flood exposure corresponding to an observed absolute growth in impervious surfaces of 7–12% during the past 30 years of urban development. The increases in flooded areas per 1 % increase in imperviousness vary considerably between the different cities, from 4-10 % in Odense to 0-2 % in Nice. This is attributed to differences in soil infiltration properties and historical trends in urban development. We find that the impact of climate change on extreme precipitation (and consequently flood exposure), as projected by ten GCMs using the RCP4.5 and RCP 8.5 scenarios, is similar to that caused by urban development, although with some variation between geographies.

Lastly, to demonstrate the added value of our combined approach in terms of urban planning, risk management and climate adaptation, we consider also the potential development of urban drainage systems. A conceptual model of the urban drainage system, resembling present-day design values, is compared to an urban drainage system with an increased capacity, accommodating observed changes in imperviousness due to urban development. Upgrading the urban drainage system relative to the urban development is found to be an effective adaptation measure as it is seen to fully compensate for the increase in runoff caused by additional sealed surfaces.

The study described in the above abstract is presented in depth in: Hydrol. Earth Syst. Sci., 21, 4131-4147, 2017 https://doi.org/10.5194/hess-21-4131-2017