Seasonal variations in climate and the performance of stormwater collection systems

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Summary (700 characters)
This study presents an assessment of precipitation-based climate indices for the city of Bergen, Norway, with focus on the link between seasonal variations of climate indices and generated stormwater. The assessment is performed on historical data as a first step to climate change impact assessments. Because the selected climate indices are based on daily precipitation amounts, the computational need is lowered and the assessment can serve as a supplement to impact studies that investigate changes in sub-daily precipitation extremes.

Introduction
Traditionally, the stormwater in the city of Bergen, Norway, has been collected in a combined sewer system with limited capacity and with combined sewer overflows (CSOs). To reduce with capacity problems and pollution from CSO discharge, the municipality has a clear strategy to separate the system. The new system should be designed to handle a changing climate.

Climate projections from Global Climate Models are the primary source for information on the future climate. However, GCMs need to be spatially downscaled (e.g. Maraun et al., 2010) and, depending on the application, temporally downscaled (e.g. Nguyen, Nguyen, & Cung, 2007) to be useful in impact studies. Water managers often lack the resources to perform such studies and would benefit from more practical tools. New tools, such as the R package ‘esd’ for statistical downscaling of seasonal or annual statistics, is developed for this purpose (Benestad, Mezghani, & Parding, 2015).

As a first step to analyzing the impacts of climate change, an assessment of historic climate in terms of seasonal statistics and their implications for stormwater generation is performed. The intent of the study is to explore whether or not climate indices may be of interest for stormwater management and planning.

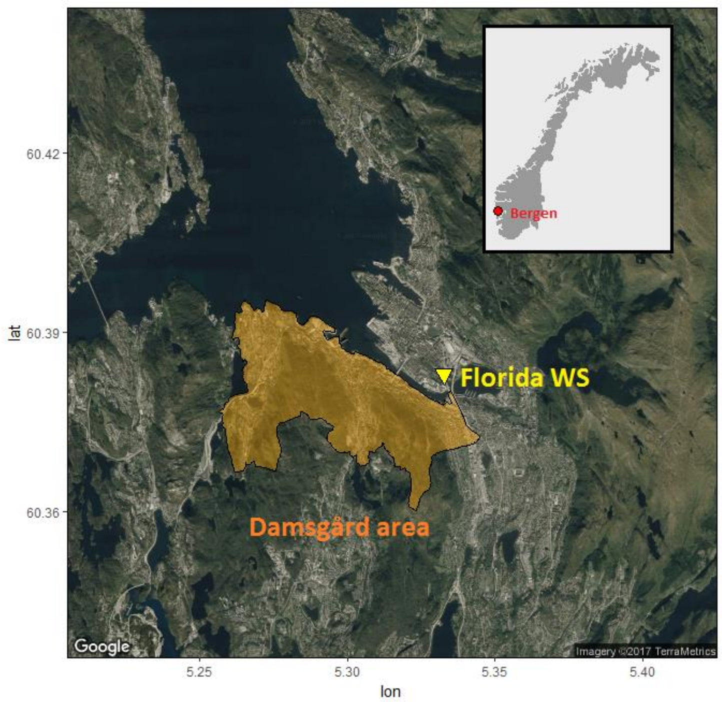

Figure 1: Overview of the study area, Damsgård in the city of Bergen, Norway.

Materials and Methods

Records of daily precipitation from the Florida Weather Station in Bergen (Fig. 1) were used to assess the seasonal statistics, expressed through a set of climate indices from the ETCCDI's list of 27 core indices (ETCCDI, 2013). The selected indices were: 1) Monthly maximum 1-day precipitation (Rx1day), 2) Monthly maximum consecutive 5-day precipitation (Rx5day), and 3) Monthly count of days when precipitation>20mm (R20mm). Furthermore, precipitation data on 1-minute resolution from the same weather station were available for a 10-year period (2003-2013) and used as input to a stormwater model for a subcatchment of the Damsgård area in Bergen (Fig. 1) (see BINGO 2015 for model description).

Results

Fig. 2 depicts the density of the climate indices by seasons. The rightward shift of SON and DJF density curves illustrate distinct seasonal variations. By observing the area under the curves it is evident that the occurrence of the more 'extreme' extremes are more plausible in seasons SON and DJF (e.g. Rx1day>50mm, etc.). This is also observed in Figure 3(a) showing the densities for maximum monthly peak flows (QxPeak). However, for QxPeak, the variations between seasons MAM, SON, and DJF are similar to those found for precipitation indices, while JJA has moved rightward with respect to MAM. Furthermore, Figure 3(b) shows the flood duration curves derived from the flow in the outlet pipe of the system. A clear distinction between the wet seasons (SON and DJF) and the dry seasons (MAM and JJA) is observed.

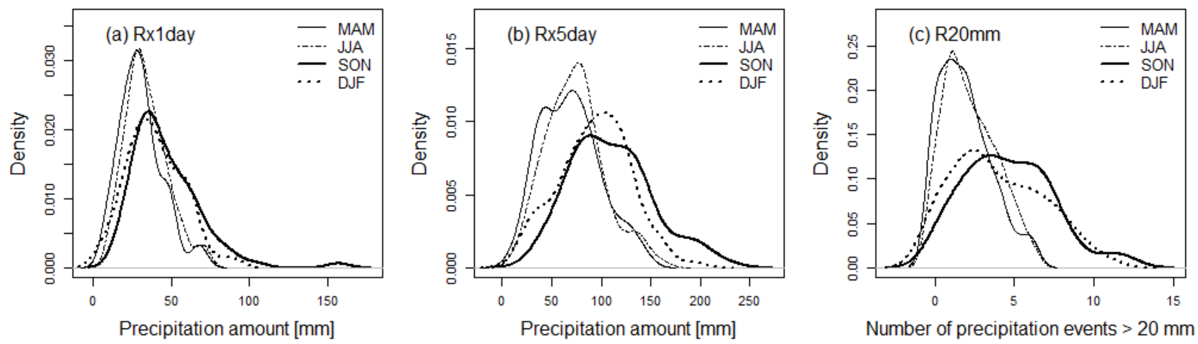

Fig. 2: Kernel density estimates of climate indices by seasons: spring (MAM), summer (JJA), fall (SON) and winter (DJF).

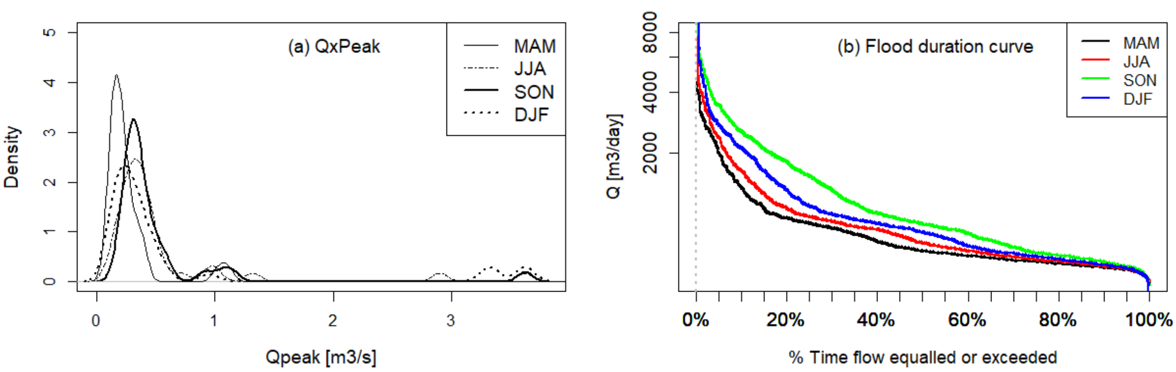

Fig. 3: Characteristics of simulated stormwater in combined pipe at the outlet of the catchment: (a) by Kernel density estimates of QxPeak (monthly maximum of peak flow (m3/s)) and (b) as flood duration curves for daily flow.

Discussion

Both the assessment of climate indices and flood duration curves indicates a clear distinction between the wet seasons, winter and fall, and the dry seasons, summer and spring. Due to this link, projections of climate indices may be used to make informed assumptions about future stormwater volumes. In a combined system like the one investigated in this study, future volumes are of interest because they can constitute a substantial portion of the flow transported to the wastewater treatment plants. Figure 3(a), however, shows that the seasonal variation of peak flows does not mimic the variations found for precipitation indices. This implies that climate indices alone are not sufficient for planning provident stormwater systems, as this would require consideration of design practices that are strongly dependent on peak flow estimates.

Conclusions

Using climate indices to describe future climate is advantageous because there exist practical tools to perform the downscaling and they do not require observational data of fine temporal resolution. This study indicate that, depending on the application, projections of climate indices can be informative for assessing future stormwater volumes. Nevertheless, methods for assessing future peak flows are needed for a holistic stormwater management.

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