Urbanization Effects On Extreme Precipitation in the Netherlands

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Introduction:

Human life is more directly affected by precipitation than any other atmospheric phenomenon (Levizzani et al., 2002); thus, detecting changes in precipitation has become a critical research focus in recent decades (Hanel and Buishand, 2010).
Buishand et al., (2013) concluded that precipitation over the Netherlands had increased by approximately 26% during the period from 1910 to 2013.

Hurk et al. (2014) reported that the intensity of extreme precipitation in the western regions (which includes the most urbanised areas) was greater than that in the other regions of the Netherlands.

In addition to the effects of urbanised regions, Ter Maat et al. (2013) investigated the combined effects of forestation and topography on the maximum rainfall in the Netherlands and found that highly elevated forest areas in the middle of the country received more precipitation compared with surrounding areas. This study investigates the variability in extreme precipitation and its spatial change trends patterns across the Netherlands. Further, the link between land cover type and changes in precipitation pattern was considered.

Methodology:

- In-situ data:
  KNMI rain gauges and European Climate Assessment
- Period I: 1961- 2013, Period II: 1961-1990, Period III: 1984- 2013
- Indices:
  Climate Change Indices from ETCCDI
- Interpolation:
  Ordinary Kriging at 1 km resolution
- Trend:
  Ordinary Least Squares
- Classification of stations:
  Remote sensing data in land use
- Creating the subsets:
  Spatial gridding method

Results:

All of the extreme precipitation indices indicate that conditions became wetter in the Netherlands during the period from 1961 to 2013. A greater monthly, seasonal and annual P1 amounts occur in the urban areas relative to the nonurban areas for the three studied periods except for in summer and July.

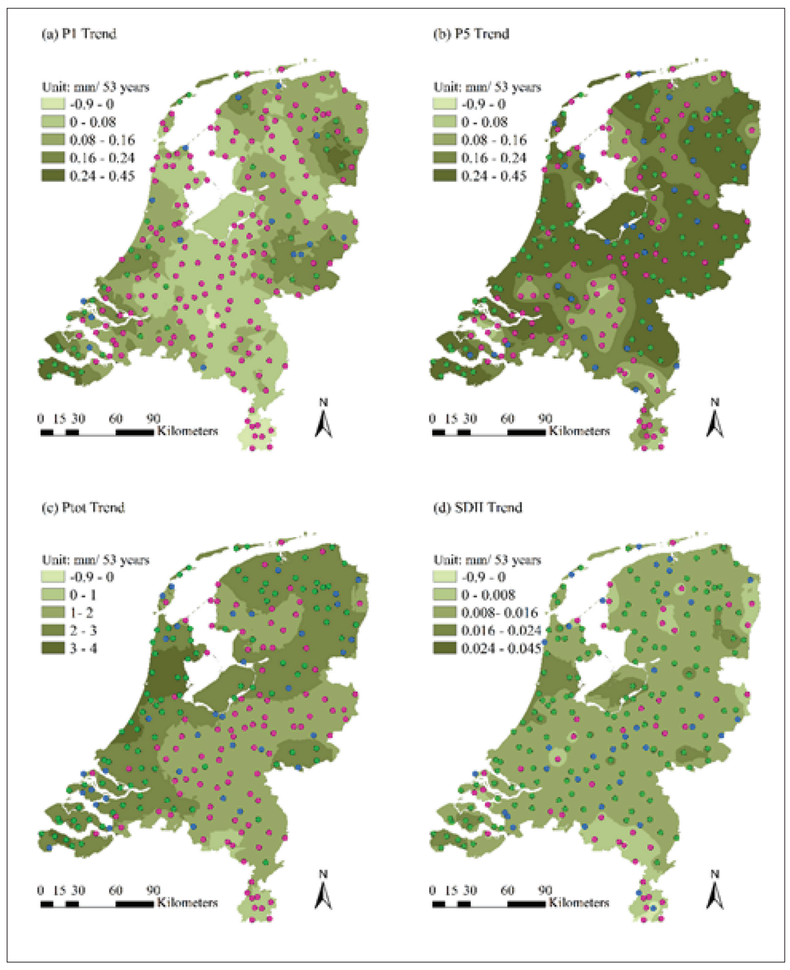

Figure 1. Trends in the wetness indices (P1 trend (a), the P5 trend (b), Ptot trend (c), and SDII trend (d)). Green circles indicate the 5% statistical signifi cant level and blue circles indicate the 10% statistical signifi -cant level (red circles indicate statistical signifi cance with less than 90% confi dence).

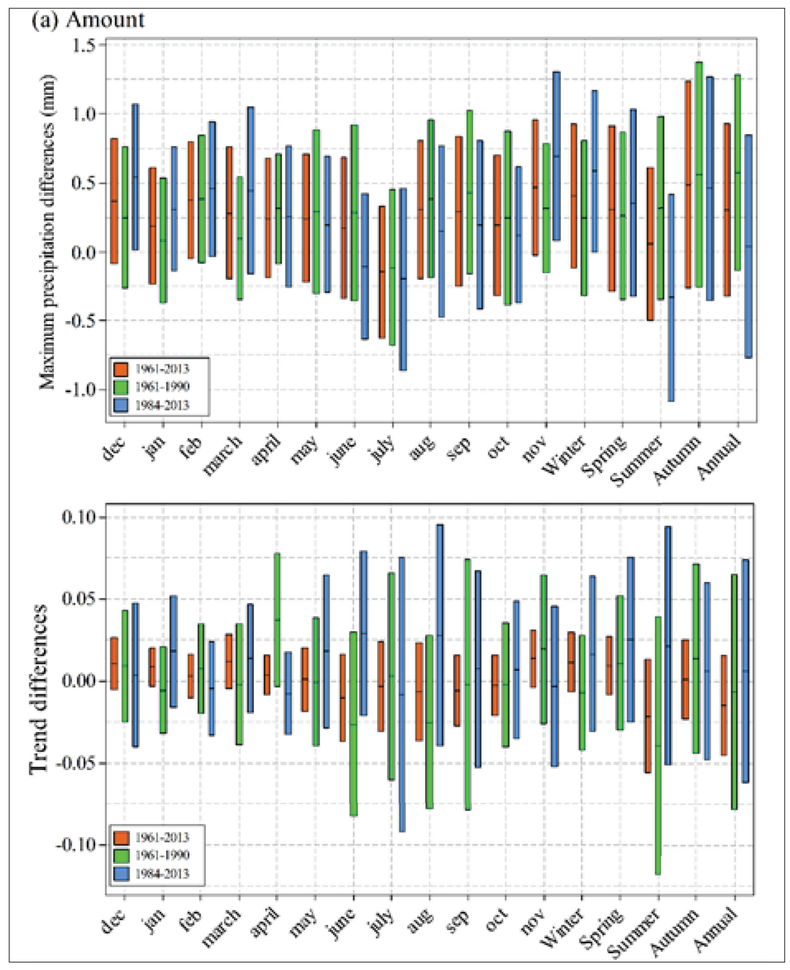

Figure 3. P1 amount (panel a) and trend (panel b) differences between urban and nonurban areas at the 95% confi dence interval for period I (red box), period II (green box), and period III (blue box)

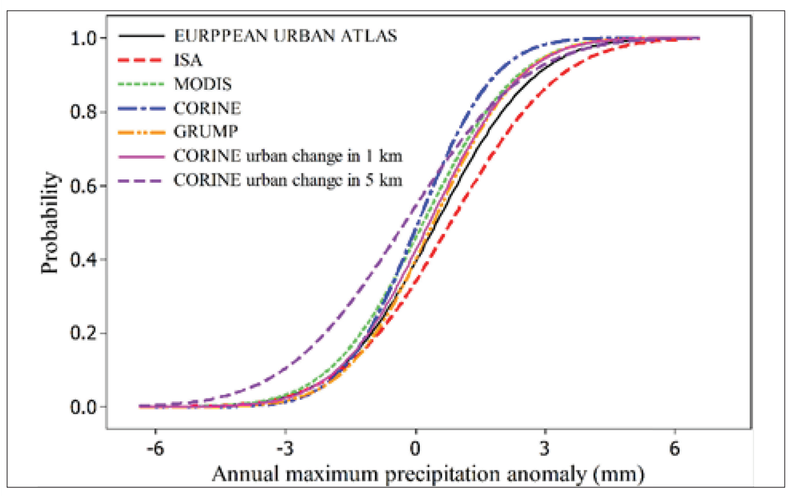

Figure 2. Cumulative probability distribution of the annual P1 differences between the urban and nonurban station subsets for different urban proxy types (1961-2013).

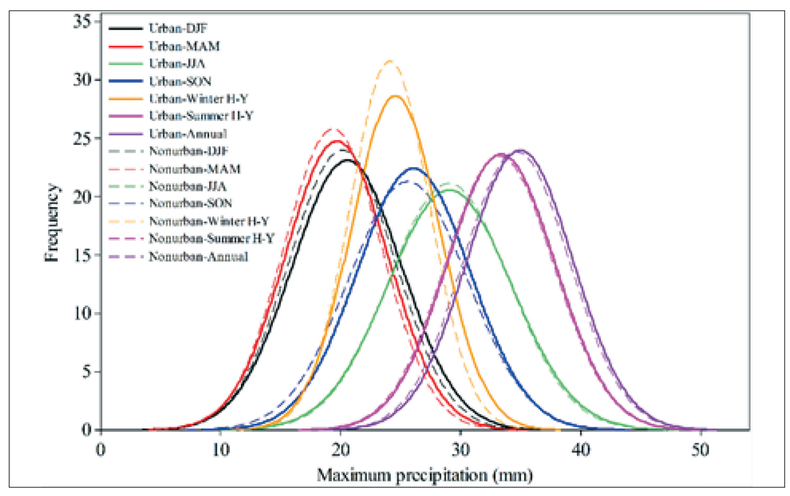

Figure 4. Probability density functions of the annual and maximum seasonal precipitation (mm) over the 53-year period

The smaller subsets (derived from the ISA and European urban atlas) are characterized by a greater density of significant differences, and they show that the median of the probability density distribution curve is shifted more to the right in the restrictive urban stations. The summer season receives a larger P1 amount compared with that of the other seasons. Moreover, the annual and seasonal P1 amplitudes in the urban area are greater than that in the nonurban area except for in the winter (DJF) and autumn (SON) seasons.

Conclusions:

The extreme precipitation events did not distribute homogeneously over the study area. The wetness indices with more distribution changes indicated significant of different trend signals, especially in the urbanised areas in the west of the country. The moderate extreme (ratio between P95tot and Ptot) showed that there is an overall positive trend except for the southeast corner of the country. It indicates that the extreme precipitation has a faster disproportional increasing trend than the annual total precipitation amount over the Netherlands. There are more annual maximum precipitation events in the southwest and middle of the country than in other parts of the country over the last 53 years. The considerable increase in the maximum precipitation over the rapid urban development area reflects the anthropogenic impacts on precipitation extremes. The difference in the seasonal P1 amounts and trends between the urban and nonurban areas over the last 53 years is larger in the winter half-year than in the other seasons. The urban signal increased maximum precipitation intensity and variation across the Netherlands.

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For more information

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