Analyzing the Impacts of Urbanization on Watershed Streamflow

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INTRODUCTION

Background

➢ Population growth is driving land surface change in the form of urbanization across the world. Urban development within watersheds can bring about significant changes to hydrological processes. It is an essential issue to provide holistic assessments of changes in streamflow due to urbanization at the watershed level.

➢ The influences of economic development and distribution of urban area within a watershed on streamflow regimes is still not fully understood.

Objectives

➢ To investigate the influences of economic development patterns during 1990-2010 by analyzing 54 urbanized catchments in China.

➢ To clarify the impacts of urban area and urban positioning within a watershed on streamflow seasonality.

STUDY CATCHMENTS

➢ 54 catchments in China were selected to investigate the relationship between annual runoff coefficient and urban development patterns during 1990-2010.

➢ 38 catchments in three metropolitan areas in the USA were selected to analyze the impacts of urban area and urban positioning within a watershed on streamflow seasonality.

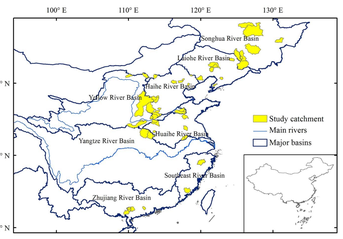

Fig. 1 Study catchments in China

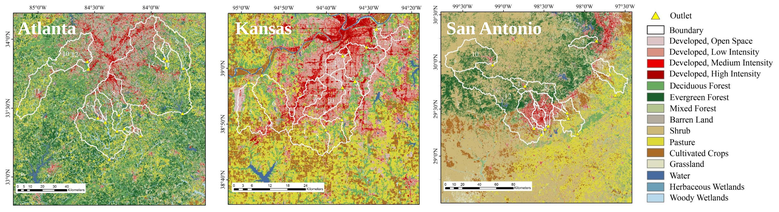

Fig. 2 Study catchments in the USA

RESULTS AND DISCUSSION

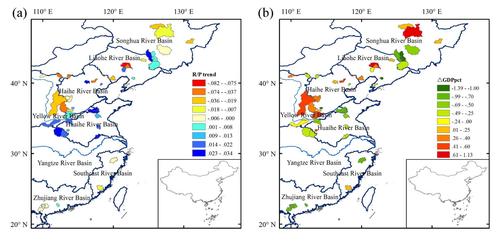

Fig. 3 (a) The R/P trend and (b) ΔGDP_{pct} of the study catchments

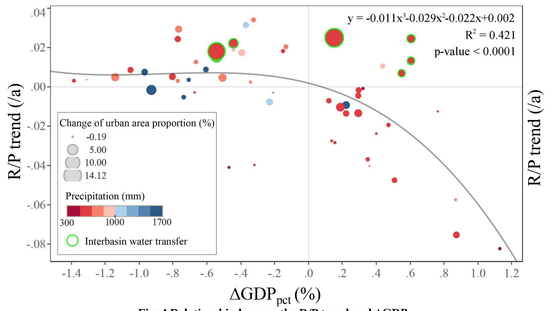

Fig. 4 Relationship beween the R/P trend and ΔGDP_{pct}

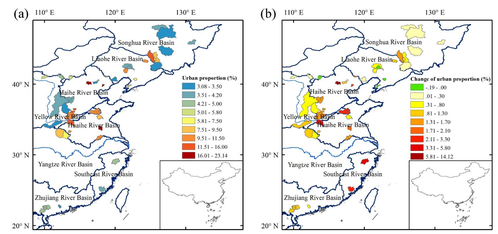

Fig. 5 (a) urban proportion and (b) change of urban proportion of the study catchments during 1990-2010

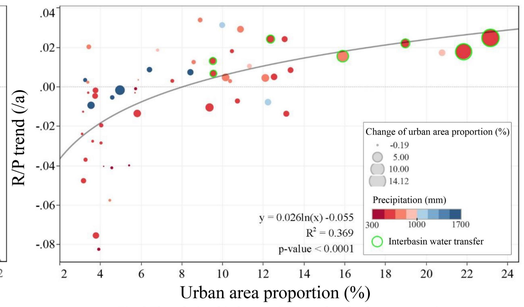

Fig. 6 The relationship beween R/P trend and urban proporation

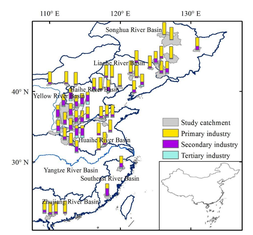

Fig. 7 Water consumption of the three main industries in the study catchments

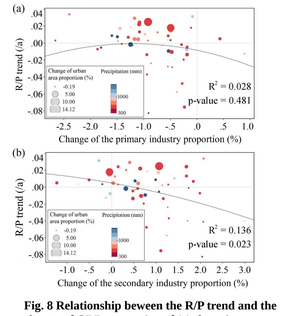

Fig. 8 Relationship beween the R/P trend and the change of GDP proportion of (a) the primary industry (b) the secondary industry

➢ The impacts of urbanization on the interannual variation of runoff coefficient were shown in Fig. 3 to Fig. 6.

➢ Fig. 8(a) and (b) exhibites the relationship beween the R/P trend and the change of GDP proportion of the primary industry and the secondary industry, respectively. It can be seen that compared to the combination of the primary industry and secondary industry (i.e., Fig. 4), individual industry has little impact on the R/P trend.

➢ Fig. 9 to Fig. 13 illustrate the influence of urbanization on the seasonal streamflow metrics (see Table 1) in the Atlanta, Kansas, and San Antonio metropolitan regions.

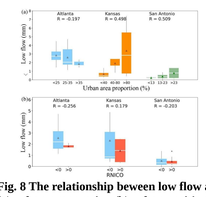

Fig. 8 The relationship beween low flow and (a) urban proporation (b) urban positioning

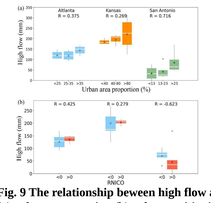

Fig. 9 The relationship beween high flow and (a) urban proporation (b) urban positioning

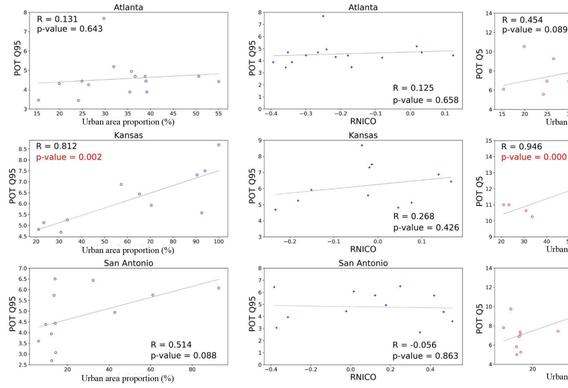

Fig. 10 The relationship beween POT 95 and urban proporation (left); urban positioning (right)

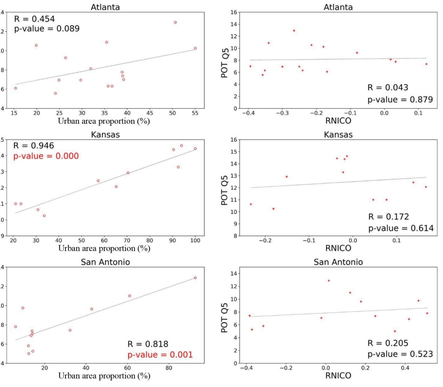

Fig. 11 The relationship beween POT 5 and urban proporation (left); urban positioning (right)

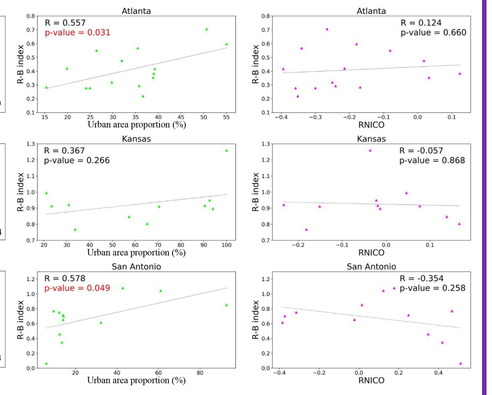

Fig. 12 The relationship beween R-B index and urban proporation (left); urban positioning (right)

DATA AND METRICS

DATA

➢ GDP of the three main industries, land use/land cover data, precipitation, streamflow

METRICS

Fig. 13 Illustration of the GDP calculation for a catchment (the GDP is the sum of Xingye, Yulin and Bobai in this example)

➢ Streamflow metrics and urbanization metrics are listed in Table 1 and Table 2, respectively. Specifically, the change of GDP proportion of the primary and secondary industries (ΔGDP_{pct}) is calculated as follow:

$$\Delta GDP_{pct} = \frac{GDP_{pct,2} - GDP_{pct,1}}{n_2 - n_1} \quad (1)$$

where $GDP_{pct,2}$ and $GDP_{pct,1}$ are the GDP proportion of the primary and secondary industries at the beginning and the end of the study period, respectively.

➢ R/P trend is standardized by its mean value.

Table. 1 Streamflow metrics

Variation	Variables	Description	Resolution	Study period
Interannual variation	R/P trend	Standarized variation trend of runoff coefficient	Annual	1990-2010
Seasonal variation	R-B index	Streamflow flashiness	Daily	2004-2019
	Low flow	Ratio of the sum of the volume of low flow (<Q95) and catchments area.	Daily	2004-2019
	High flow	Ratio of the sum of the volume of high flow (>Q5) and catchments area.	Daily	2004-2019
	POT Q95	Peaks of threshold of low flow	Daily	2004-2019
	POT Q5	Peaks of threshold of high flow	Daily	2004-2019

Table. 2 Urbanization metrics

Variables	Symbol	Description	Unit
The change of GDP proportion of the primary and secondary industries	ΔGDP_{pct}	Change of industrial pattern in a catchment	%
Urban area proportion	$\bar{A}_{pct}$	Urban area proportion of a catchment	%
Change of urban area proportion	ΔA_{pct}	The rate of urbanization in a catchment	%
Relative nearness of imperviousness to the catchment outlet	RNICO	Position of urban area within a catchment	--

SUMMARY

➢ The variation trend of runoff coefficient was negatively correlated with the change of GDP proportion of the primary and secondary industries, and a stronger correlation was found when the proportion of GDP increases.

➢ The variation trend of runoff coefficient was positively correlated with the urban area proportion.

➢ More urbanized catchments exhibited a significantly greater value of high flow, low threshold exceedances, high threshold exceedances, and R-B index.

➢The distribution of urban area within a watershed has little impact on streamflow.

MAIN REFERENCES

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