Assessing potential impacts of climate change on hydrologic processes and nitrogen export in the Miyun Reservoir Basin, China

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Research background

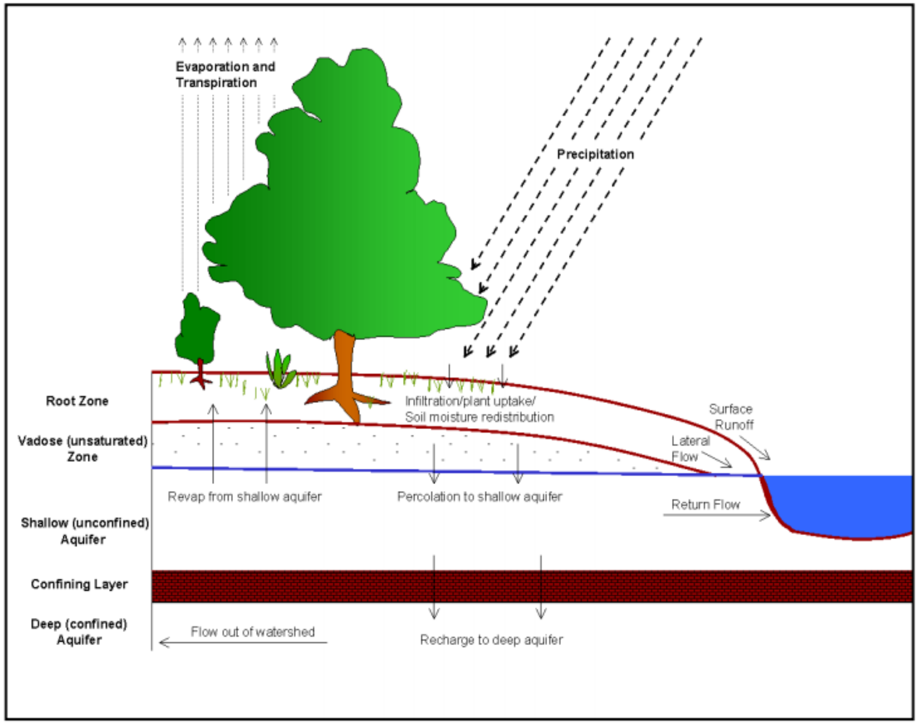
- The global warming not only brings about changes in the hydrological cycle, but also affects water quality with possible negative impacts on natural systems. The impact of climate change on water resources and environment is a global concern.

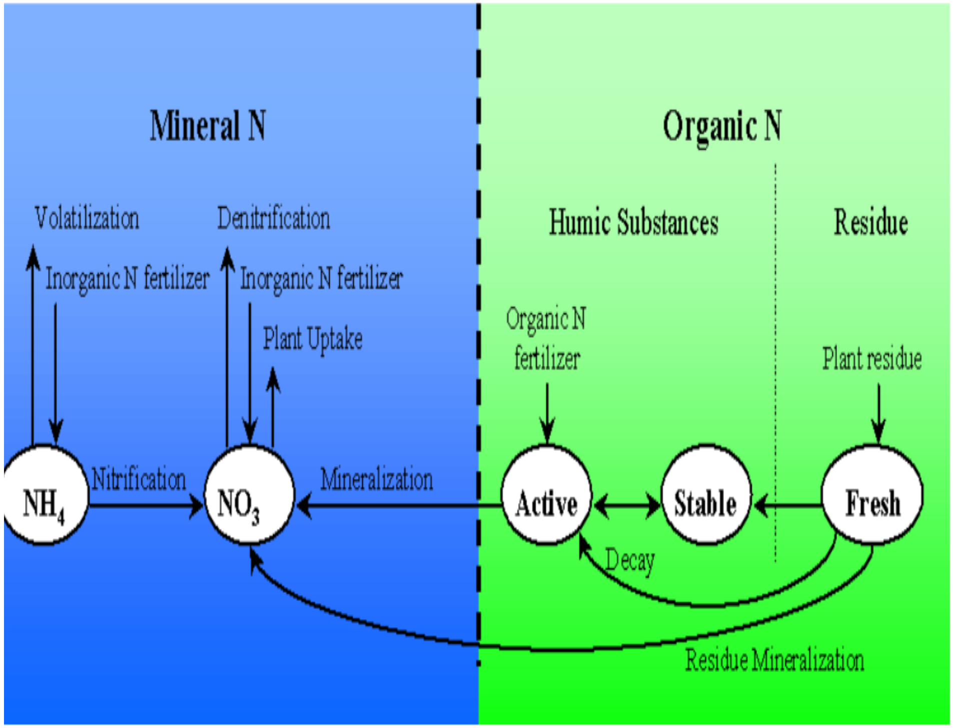
Research background

- The Miyun Reservoir Basin is the main sources of surface water supply for the city of Beijing. Due to climate change and human activities, streamflow into the Miyun Reservoir has decreased drastically over the past 50 years, seriously affecting Beijing's water supply. Meanwhile, the water quality of Miyun reservoir is at medium-eutrophication situation, which is mainly caused by the non-point source pollution (NPS) in the watershed.

Mechanism of change in nitrogen loading under the changing climate

- The pollutant-loaded capability of surface runoff, lateral flow, sediment generated in the land phrase into streams
- The biogeochemical cycle: such as the alteration of mineralization, the nitrate absorbed by crop, transformation of different forms of nitrogen in streams.





Methodology

Hydrologic model / SWAT

NCEP, GCM output | Downscaling technique

Local climatic variables

1971

Establishment of Statistical relationship

in the Mid-century (2045-2064) and 13% in the late-century (2080-2099)

1990

Validation of Statistical relationship

2000

1990

Model calibration and validation

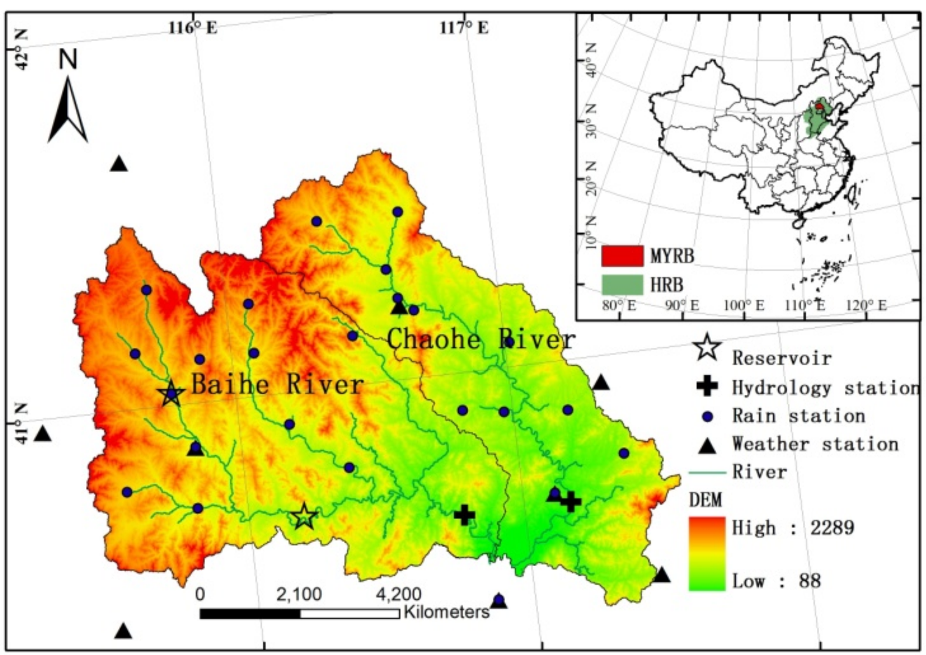
2005

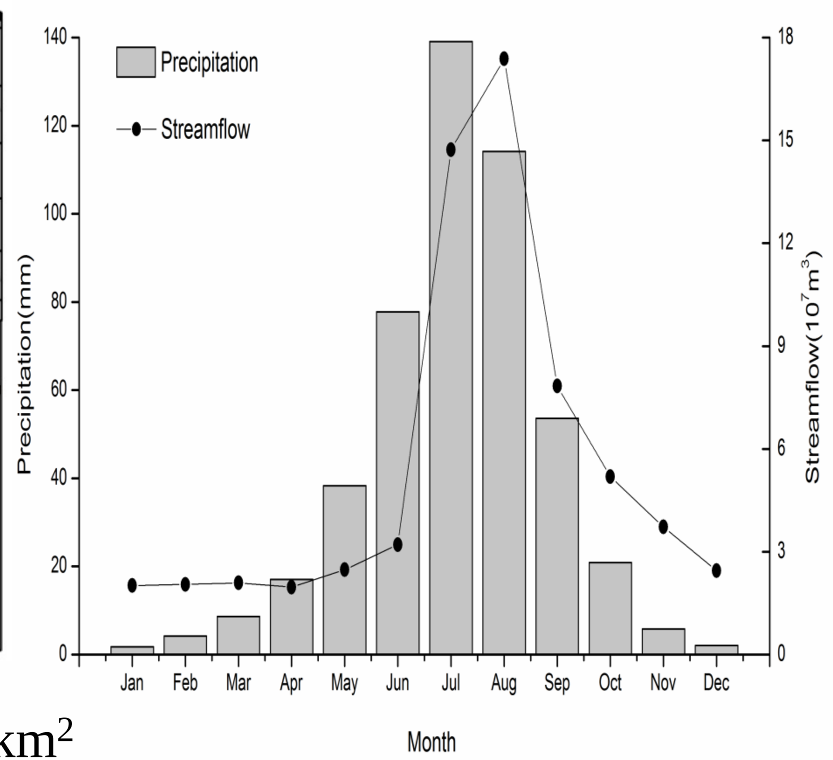
Future projection for precipitation and temperature in the early-century(2015-2034), mid-century(2045-2064) and late-century(2980-2099)

future

The potential impacts of climate change on hydrologic processes and nitrogen export in the watershed

Study area





Drainage area: 15,400 km^2

Climate: a temperate continental monsoon climate

Annual mean precipitation: 487mm

Average temperature:5.7°C

Downscaling

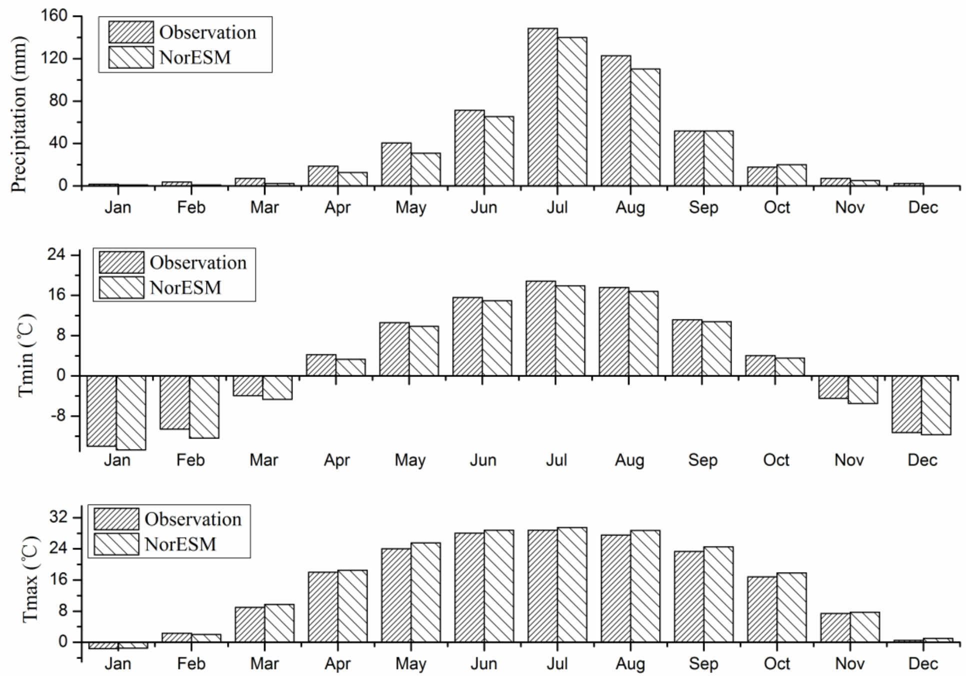
GCM: MPI-ESM-LR

Emission scenario: RCP 4.5

(a middle emission scenario)

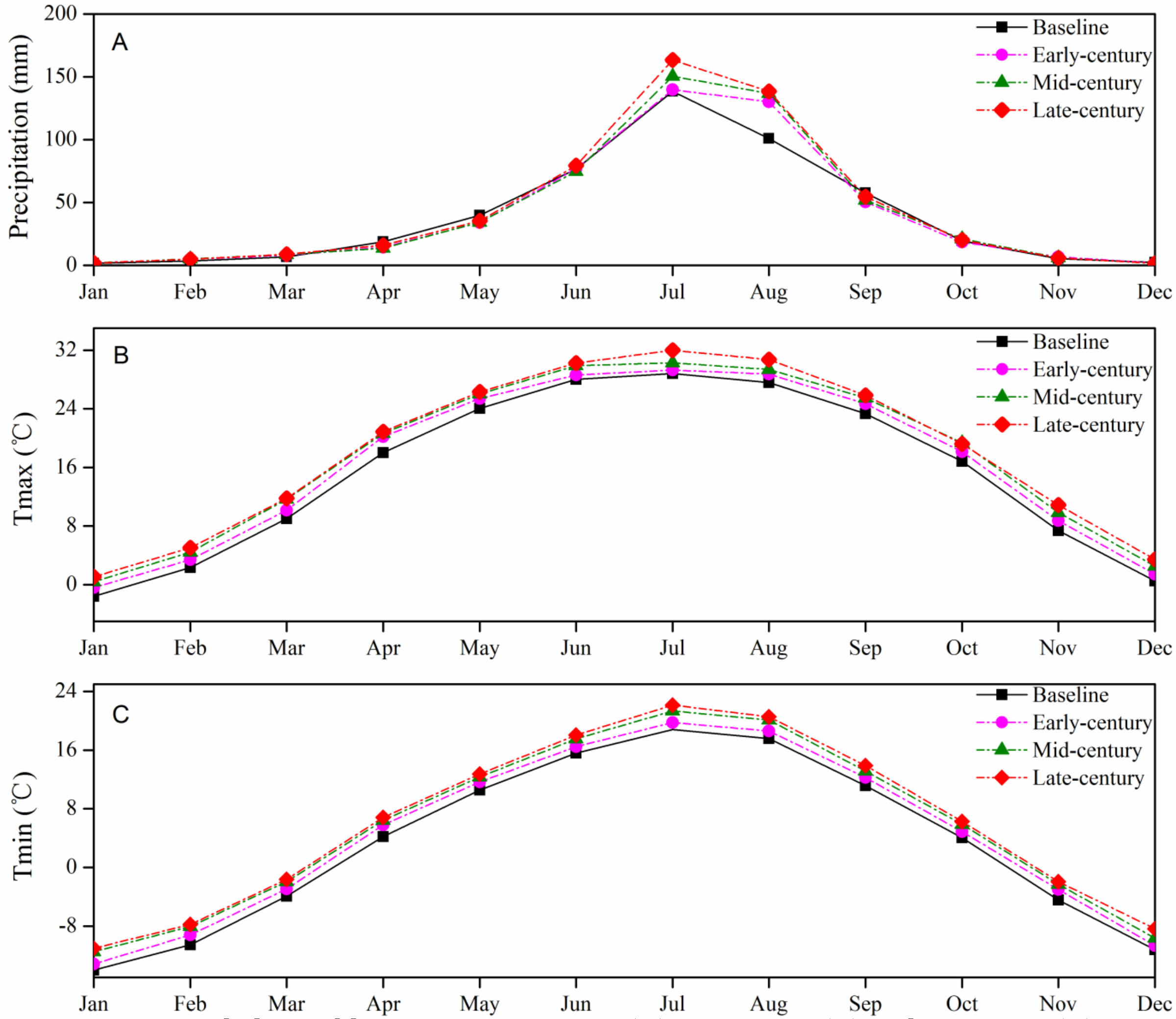
Statistical downscaling method:

SDSM



Observed and downscaled mean monthly, precipitation (up), Tmin (middle) and Tmax (bottom) for the period 1991-2000 in the watershed

Expected future climate change

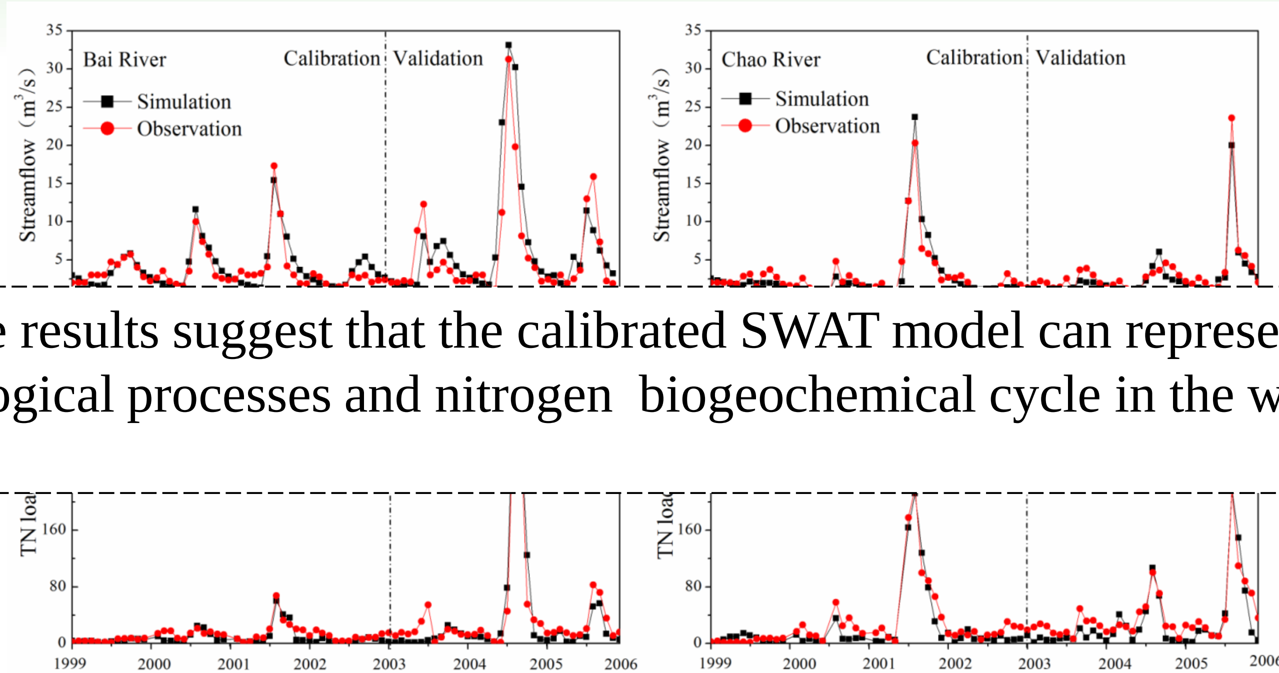


Downscaled monthly mean precipitation (A), maximum (B) and minimum (C) during the the 2020s (2011–2040), 2050s (2041–2070), and 2080s (2071–2100), and observed values for the baseline period (1986-2005)

Compared with baseline period, the future Tmax would increase 1.37°C in the early-century, 3.13°C in the Mid-century and 5.06°C in the late-century respectively, and the Tmin would increase 1.03°C, 2.13°C and 4.15°C, respectively.

As for precipitation, a significant increase in precipitation in summer (July and August) is projected. Compared with the baseline monthly average precipitation, the downscaled precipitation indicated a increase of 3% in the early-century (2015-2034), 7% in the Mid-century (2045-2064) and 13% in the late-century (2080-2099).

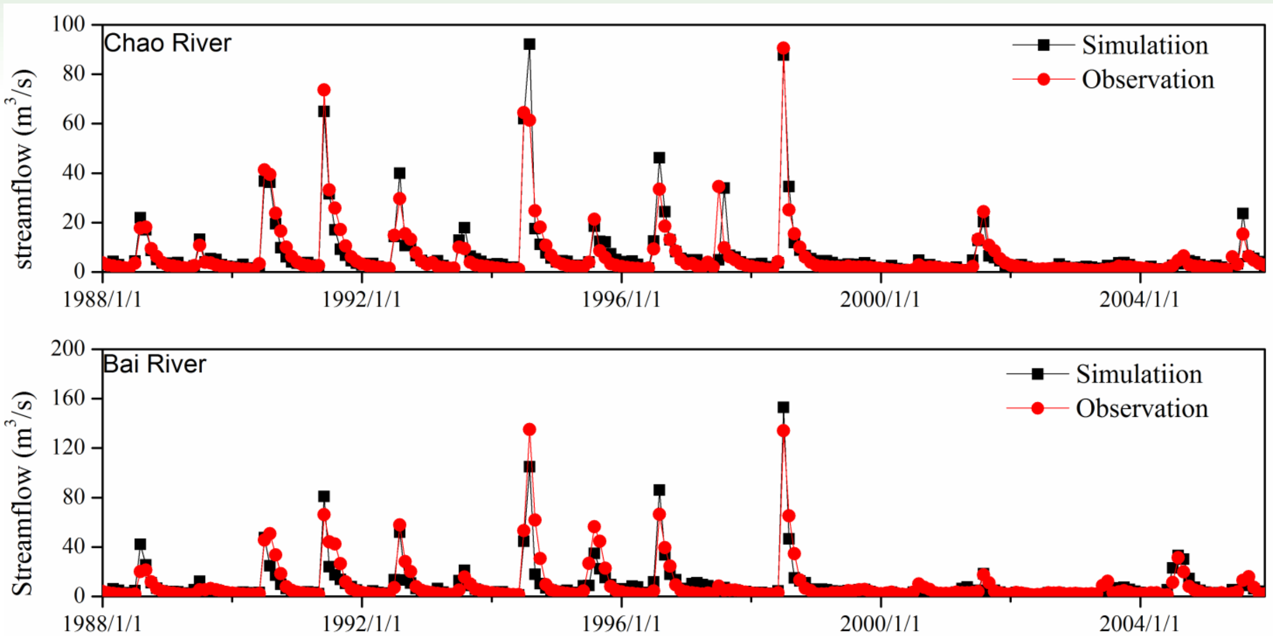
The performance of SWAT



The results suggest that the calibrated SWAT model can represent the hydrological processes and nitrogen biogeochemical cycle in the watershed.

Item	Bai River				Chao River			
	Calibration period		Validation period		Calibration period		Validation period	
	R^2	Nash	R^2	Nash	R^2	Nash	R^2	Nash
Streamflow	0. 81	0. 79	0. 77	0. 64	0. 89	0. 83	0. 80	0. 71
TN load	0. 75	0. 62	0. 90	0. 79	0. 87	0. 72	0. 88	0. 77

The performance of SWAT



Performance of streamlflow for SWAT during 1988-2005

Item	Chao River		Bai River	
	R^2	Nash	R^2	Nash
treamflow	0. 88	0. 87	0. 84	0. 84

Expected future change of streamflow

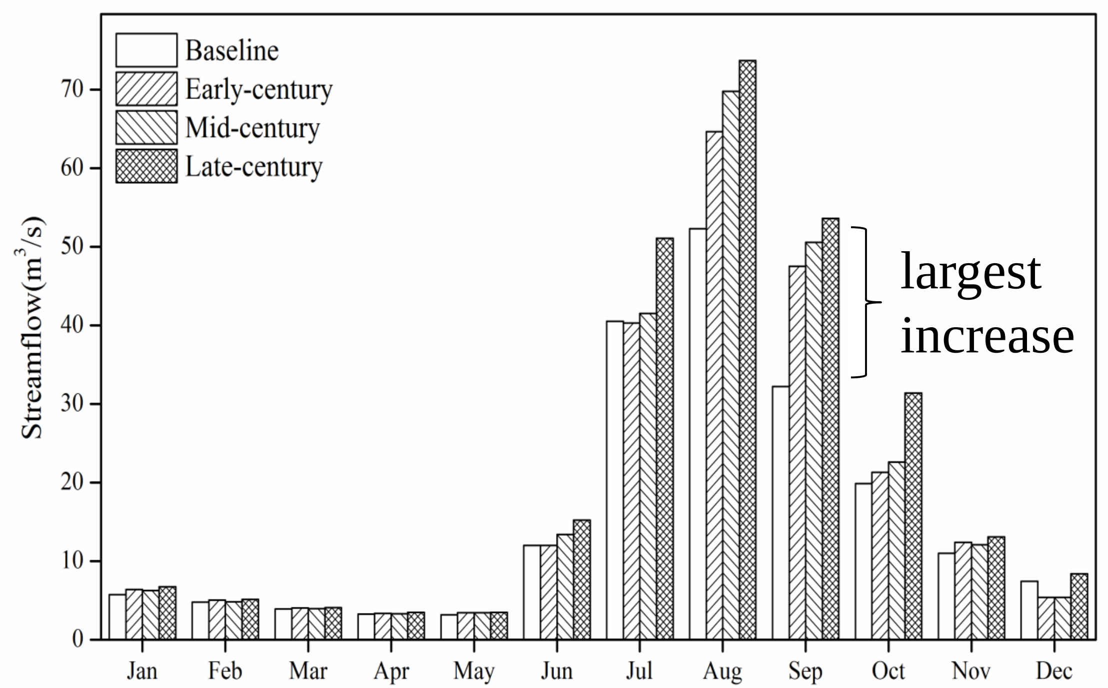


Figure SWAT predicted changes in monthly average streamflow for the baseline(1986-2005), early-century, mid-century and late-century at the hydrological outlet in the watershed.

Yearly discharge predicted by SWAT model would increase by 14.7 % in the early-century, 20.5% in the Mid-century, 36.9% in the late-century compared with the average baseline discharge (16.4 m^3/s).

The **largest increase in average flows** were projected to occur in September for all future periods with a increase of 47.5%, 56.9% and 66.3% for early-century, mid-century and late-century, respectively.

Future change of hydrologic processes

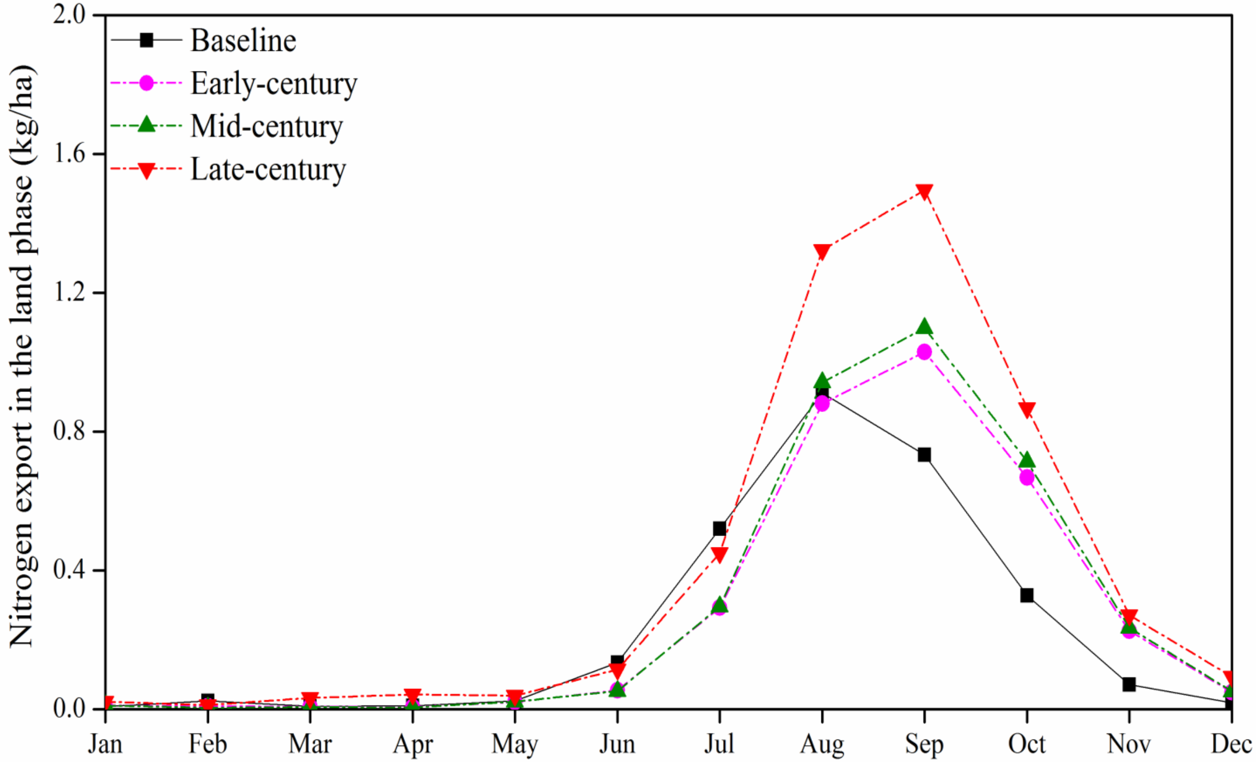
Table Effects of future climate change on selected hydrologic processes

Period	PREC (mm)	SURQ (mm)	LATQ (mm)	PERC (mm)	SW (mm)	WYLD (mm)	ET (mm)	PET (mm)
Baseline	470.3	14.7	17.2	21.4	15.6	50.8	423.5	1064.0
Early-century	486.9	15.7	19.1	27.0	16.8	58.7	440.0	1226.6
Mid-century	507.4	16.9	20.2	29.5	18.0	62.9	451.0	1245.4
Late-century	531.9	20.6	21.3	33.8	18.4	71.0	461.3	1254.0

Baseline=1986-2005, Early-century=2015-2034, Early-century=2045-2064, Early-century =2080-2099

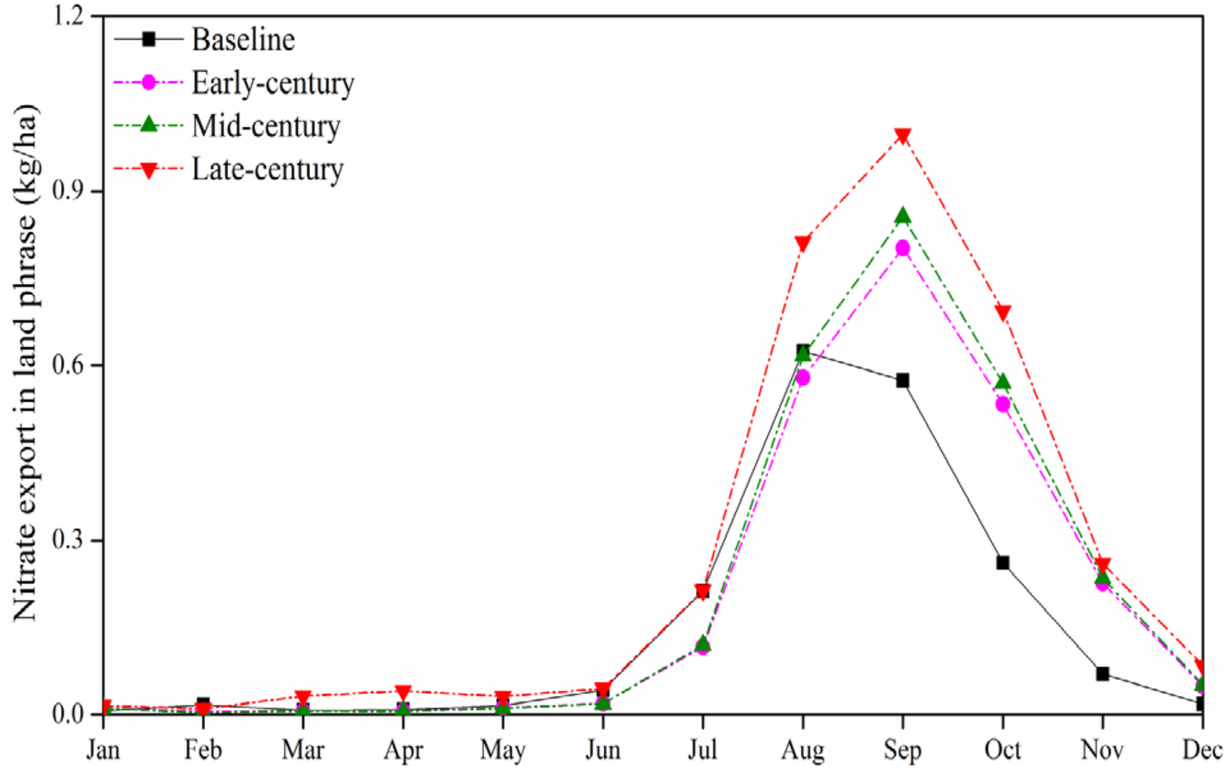
PREC precipitation, SURQ surface runoff, LATQ lateral flow into stream, PERC percolation below root zone, SW soil water, WYLD water yield, PET evapotranspiration, ET potential evapotranspiration

Future change of nitrogen export in the land phase



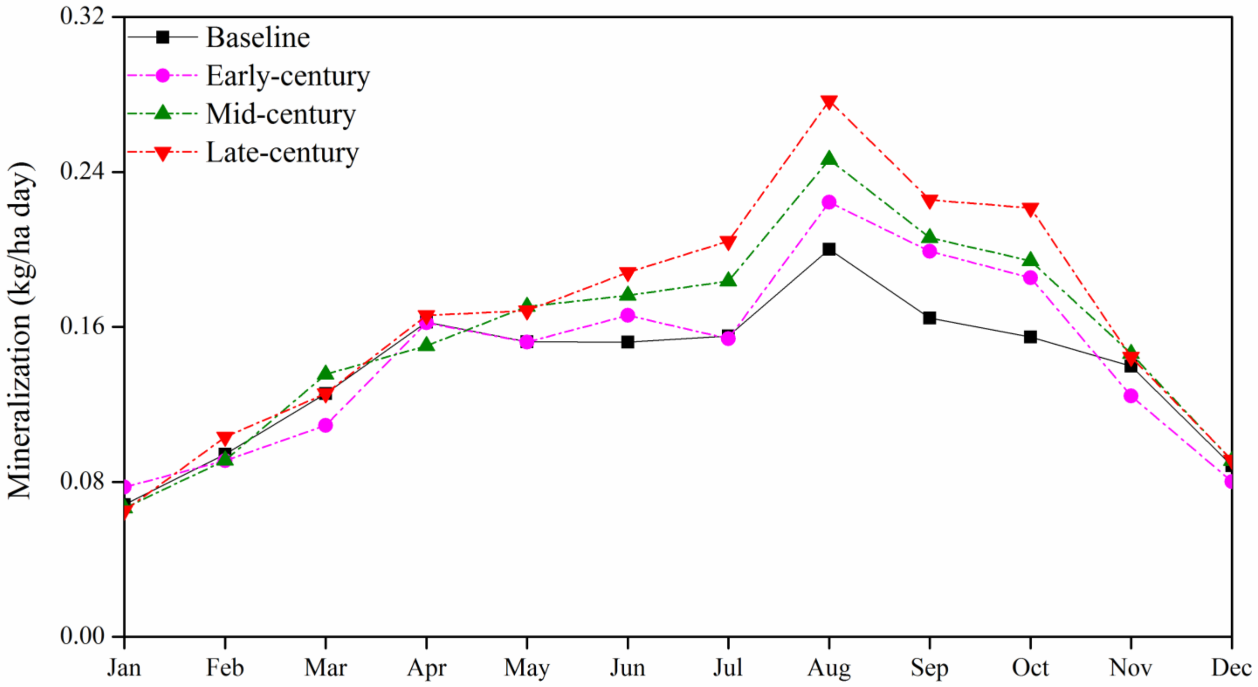
During the baseline period (1986-2005), the nitrogen export in the land phrase into streams was 2.79 kg/ha. Compared with baseline period, nitrogen export would increase by an average of 16.6%, 23.2% and 70.7% in the early-century, Mid-century and late-century, respectively.

Future change of nitrate export in the land phase



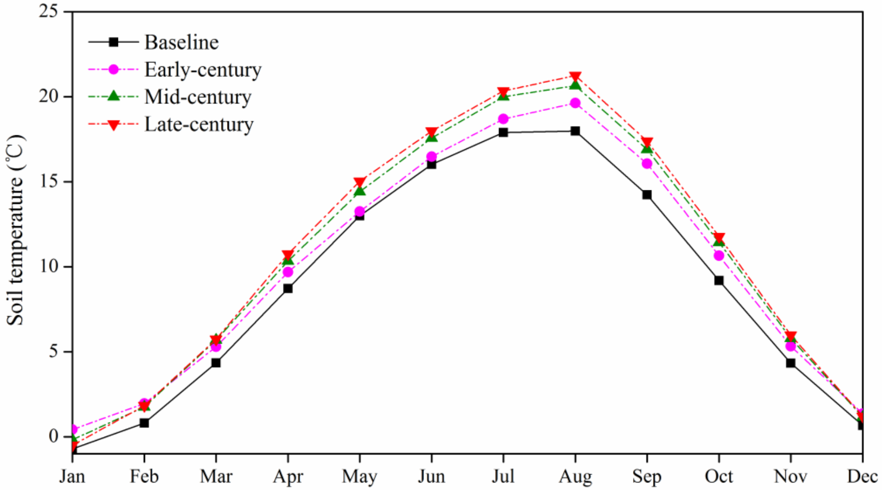
During the baseline period (1986-2005), the nitrate export in the land phrase into streams was 1.86 kg/ha. Compared with baseline period, nitrogen export in the land phrase into streams would increase by an average of 27.3%, 34.6% and 74.1% in the early-century Mid-century, and late-century, respectively.

Future change of nitrogen mineralization



During the baseline period (1986-2005), the nitrogen mineralization in the land phrase was 0.138 kg/ha/day. Compared with baseline period, nitrogen mineralization would increase by an average of 4.0%, 11.6% and 17.3% in the early-century ,Mid-century and late-century, respectively.

Increased temperature and preicipitation may promote mineralization rate of nitrogen.



Discussion

1. Uncertain analysis: hydrological model, GCM, downscaling techniques.

2. Increased mineralization rate of nitrogen will provide more nitrate for crop growth, and increase the risk of the nitrate loss in the watershed.

Conclusion

- The precipitation and temperature would increase in the future,
- Predictions of our integrated model indicate that climate change will affect both hydrological processes and nitrogen cycles: surface runoff, lateral flow, soil water, nitrogen mineralization rate and nitrate flux all will increase significantly in the future, with implications for regional water resources and nitrogen management in Miyun Reservoir Basin.

Thanks for your attention

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Further discussion

When conduct the climate change impact studies, we should make the correct choice for:

1. What kinds of hydrological model should be adopted?

2. Whether the future downscaled climatic variables, especially precipitation, could represent the local precipitation characteristics?

Although the monthly total precipitation can been simulated well for statistical downscaling model, it is still inevitably that the daily precipitation is averaged on the monthly scale. The precipitation characteristic decide the mechanism of runoff generation. Runoff yield under Excess infiltration or saturated storage.