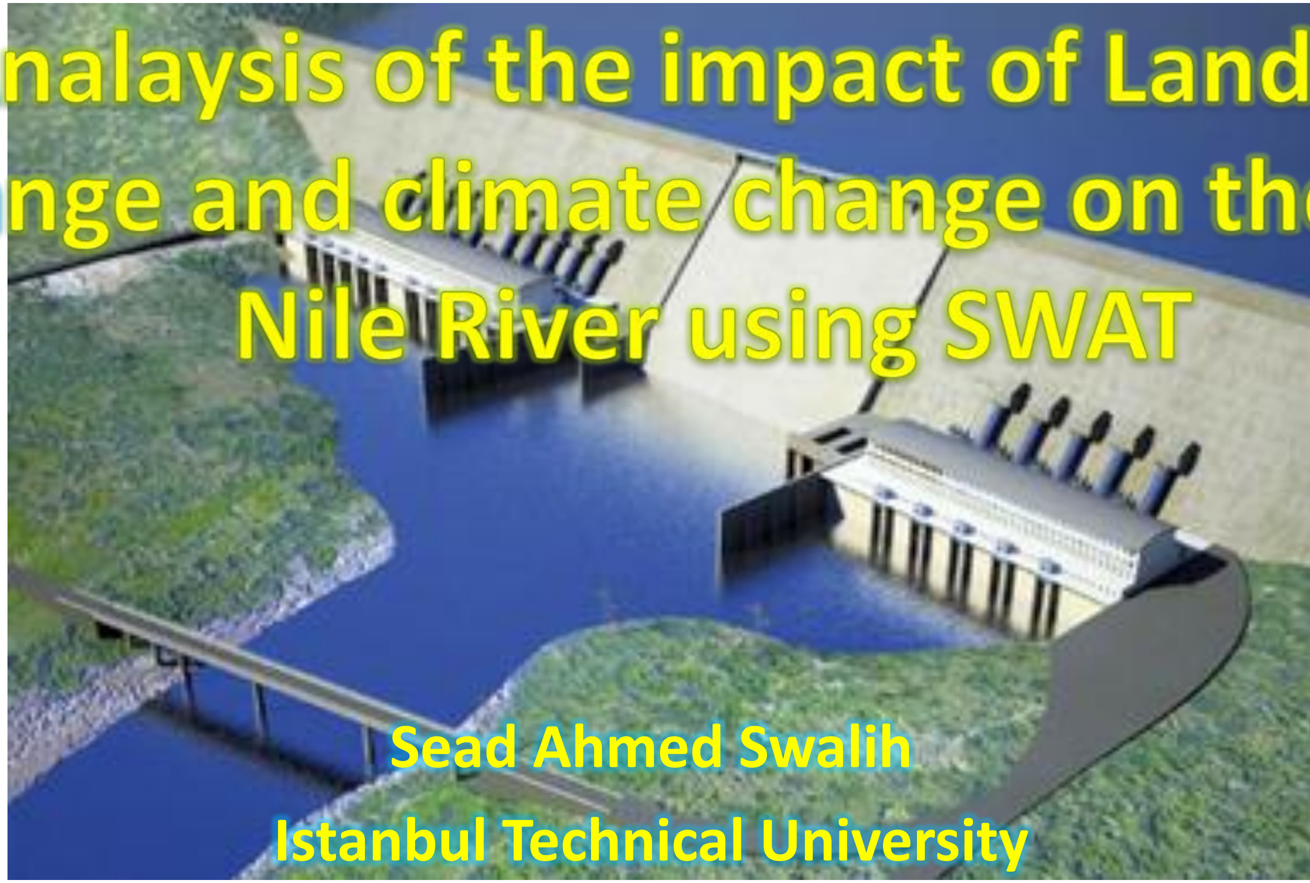
Analaysis of the impact of Land use change and climate change on the Blue Nile River using SWAT



Sead Ahmed Swalih

Istanbul Technical University

August 2020

1 **Introduction**

2 Problem statement and objectives

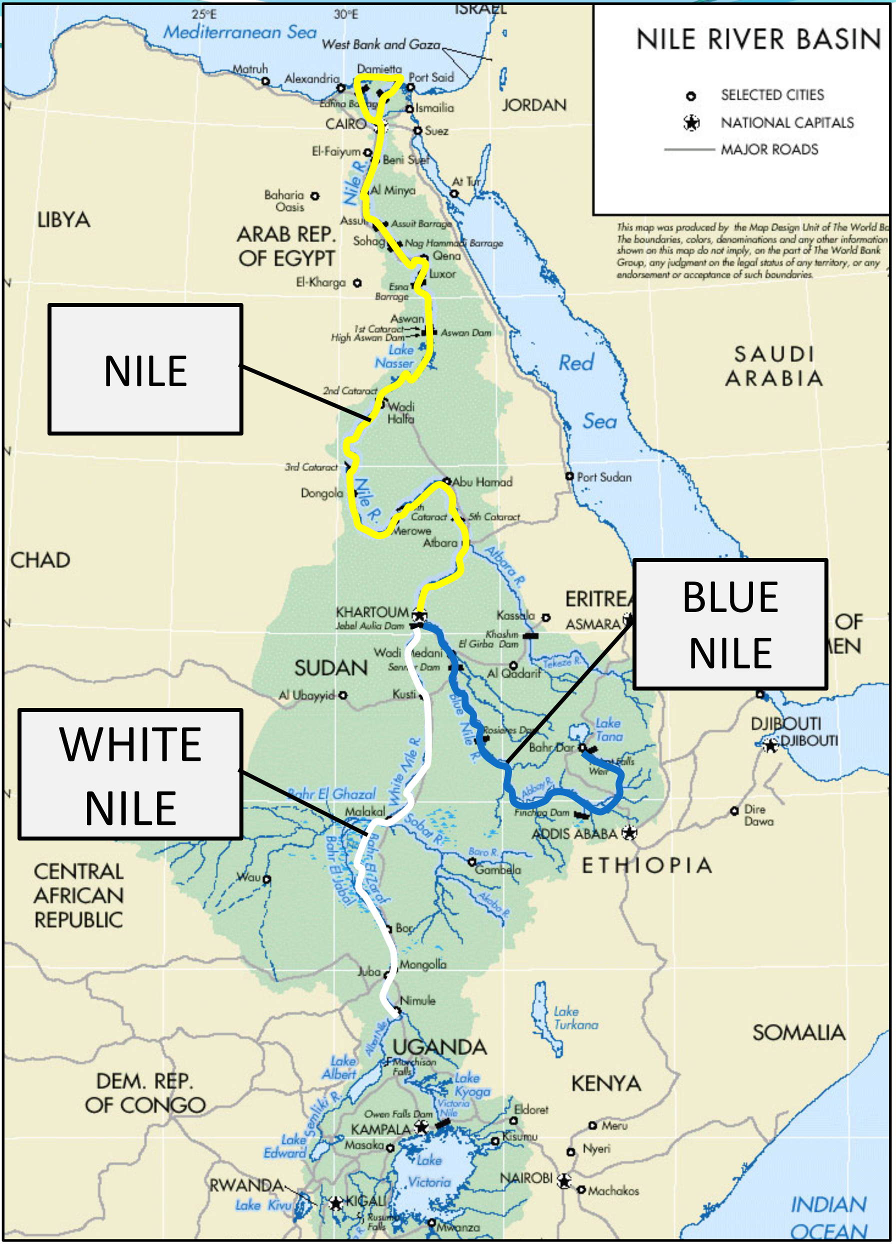
3 Materials and methods

4 Results and discussion

5 Conclusion and recommendations

Introduction

- World's climate - changing & expected to continue in the coming century
- Africa - most vulnerable to climate change and variability
- The Nile basin, the largest basin in Africa – high topographic and climatic variability
    - Increase vulnerability



Analysis of the impact of land use change and climate change on Blue Nile river using SWAT

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Problem statement

- **high development** on the Nile, i.e. construction of the Aswan Dam, Sennar, and Rosieres reservoirs for irrigation and hydropower generation
- **increased demand** for irrigation and hydropower Ethiopia - GERD
- **high vegetation degradation** in Ethiopia, i.e. deforestation, results in land use change
- **ecosystem degradation** due to massive utilization of river waters in Sudan and Egypt, eg. loss of biodiversity
- **increasing water demand** upstream **+ climate change** and land use change

Objectives

- Assessing the dynamics of climate in the Basin
- Projecting basin hydrology using climate change and land use change scenarios to assess their impacts

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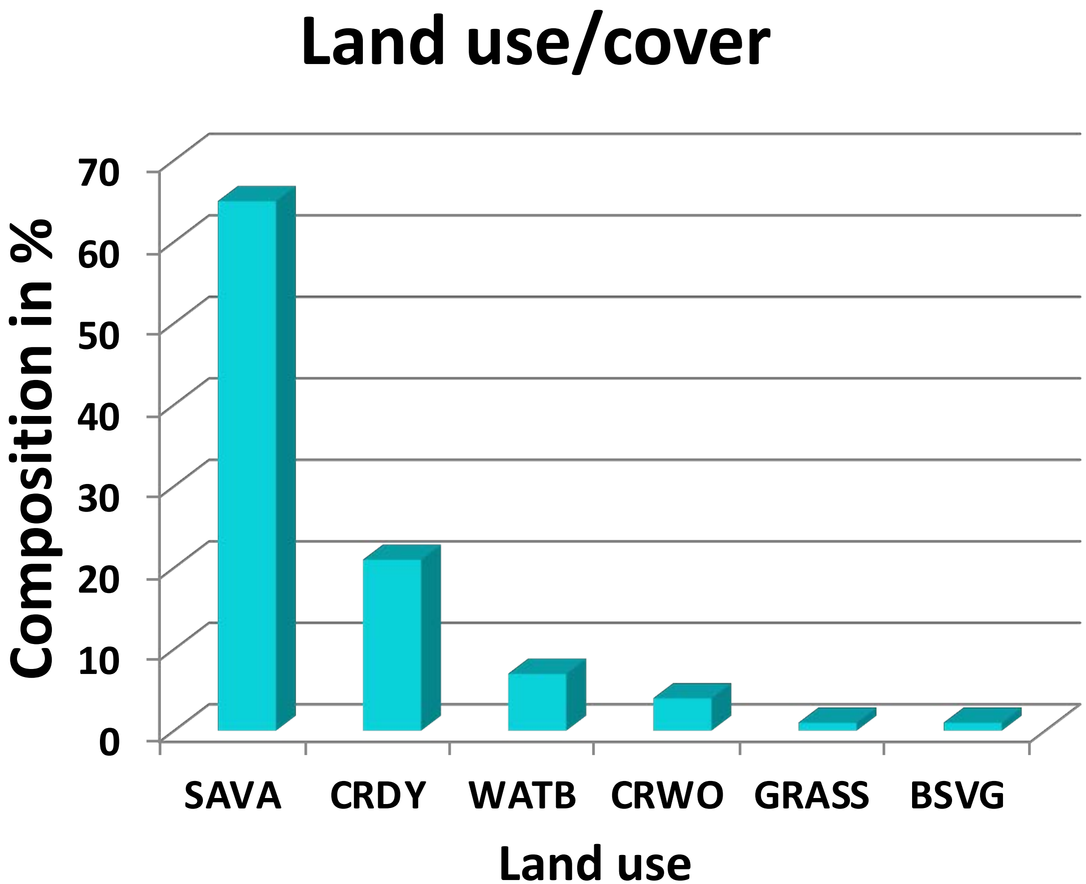
Study area

- Blue Nile (in Amharic Abbay/in Arabic the Al Bahr al-Azraq)
  - 1529 km long (longest in the world)
  - elevation of the basin varies from 4000m (little Abbay) to 700m at foot of the plateau
  - contribute for 60 % flow of Nile
  - crucial for thesurvival of downstream countries

The Blue Nile River

Analysis of the impact of land use change and climate change on Blue Nile river using SWAT

Study area cont'd



SAVA – Savanah forest

CRDY – Crop land/Dry land

WATB – Water body

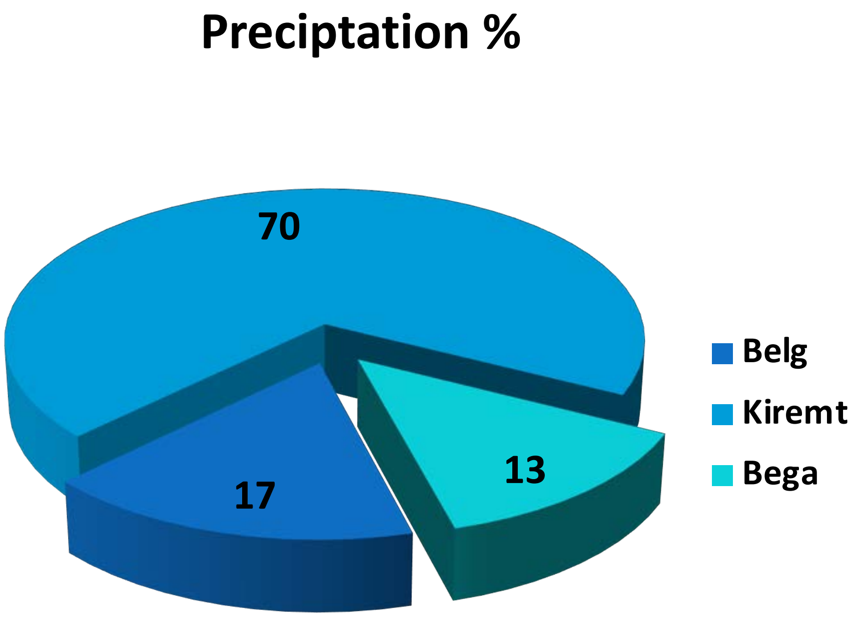
CRWO – Crop land/Wood land

GRASS – Grassland

BSVG – Bush land vegetation

Study area cont'd

- Climate varies from humid to semiarid
    - Kiremt …(Jun-Sept)
    - Bega ……(Oct-Jan)
    - Belg …….(Feb-May)
- For the year 1961-1990,
    - Annual preciptation was **1200mm** to**1600mm**
    - Annual temprature-was **18.3°C** (2°C seasonal variation)

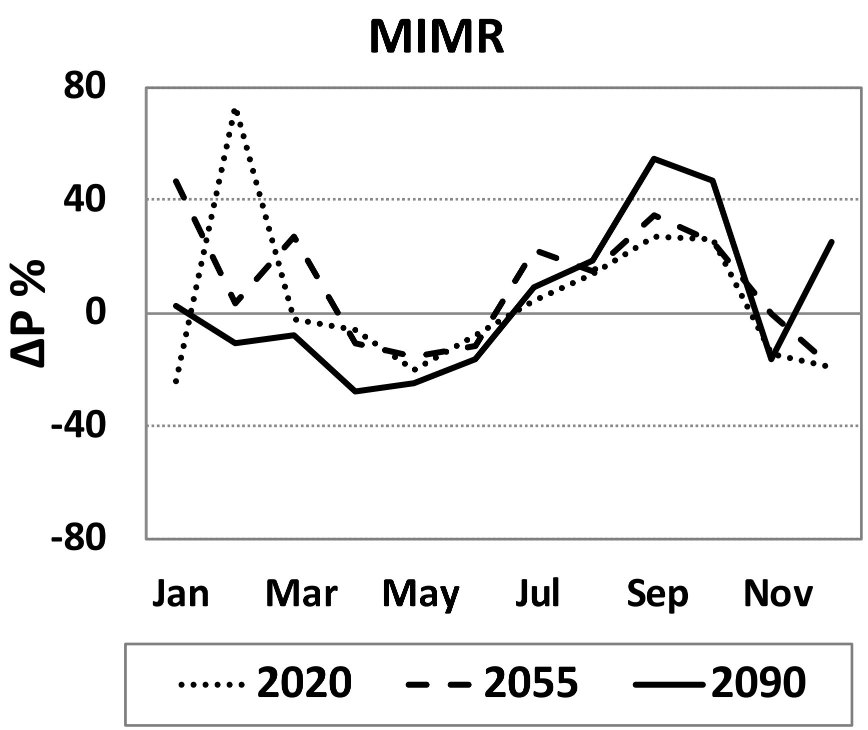


Materials

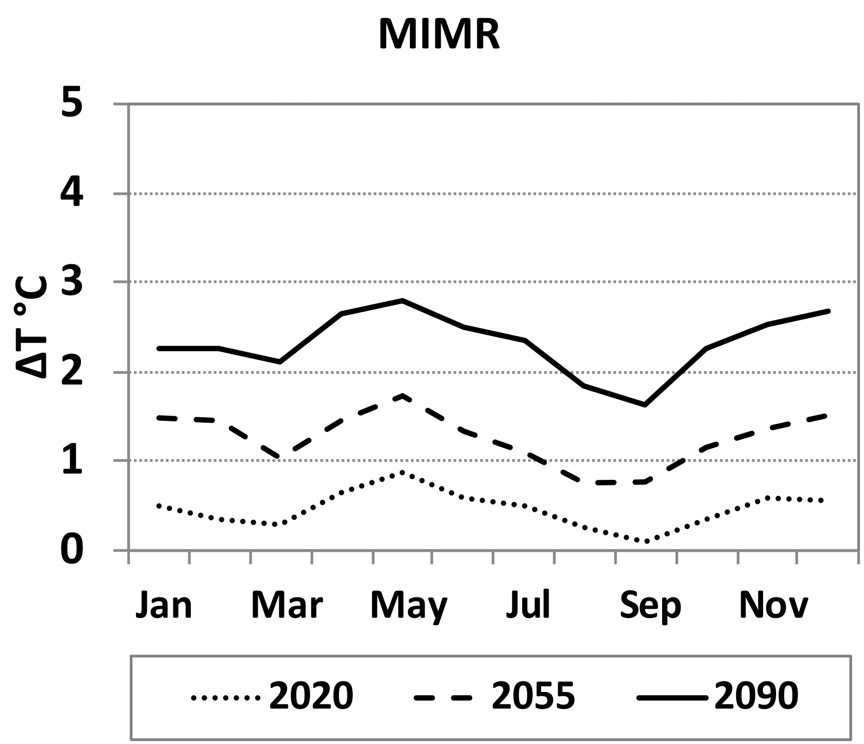
- **Climate change scenario data**
  - Source: IPCC data distribution centre
  - SRES-AR4 scenario runs of six AOGCMs were chosen
    - BCM2_BCCR … abbreviated as BCM2 (Norway)
    - CSIRO_MK3 ……. “ “ CSMK3 (Australia)
    - INMCM3 ……….. “ “ INCM3 (Russia)
    - GISAOM ……….. “ “ GIAOM (USA)
    - MIROC3_2HI ….. “ “ MIHR (Japan)
    - MIROC3_2MED.. “ “ MIMR (Japan)
  - Preciptation and Temprature projections for *2020, 2055* and *2090* were analysed for storylines A1B and B1

Materials cont'd

- Preciptation change



- Temprature change



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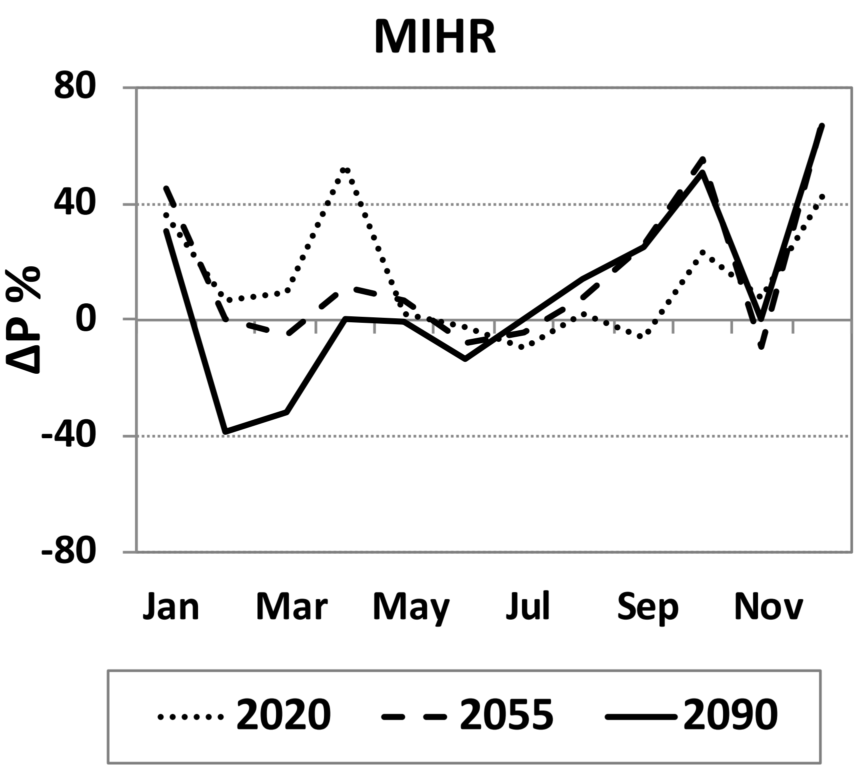
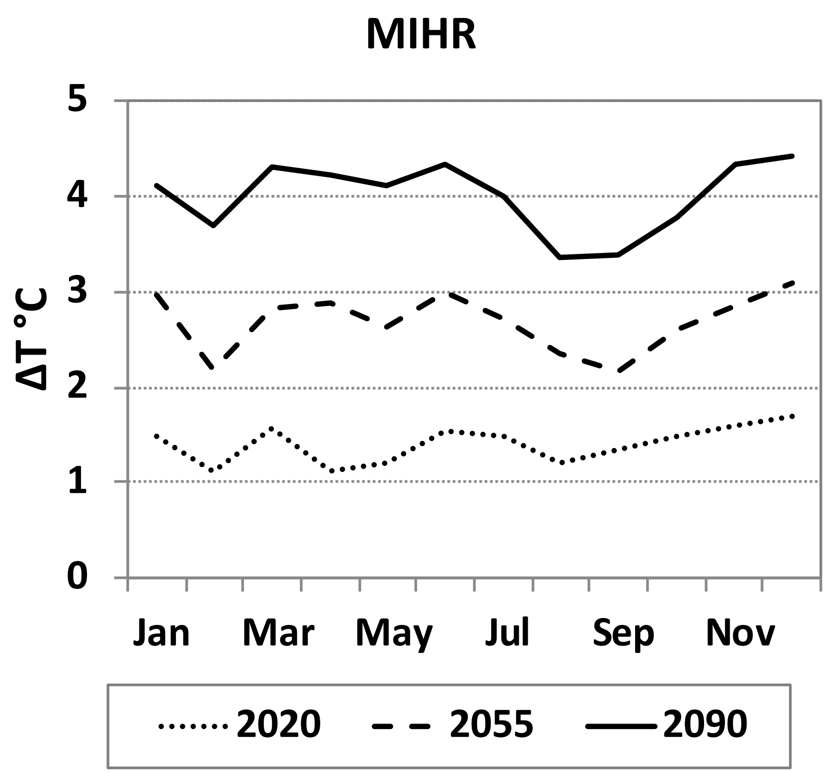
Materials cont'd

- Preciptation change



- Temprature change



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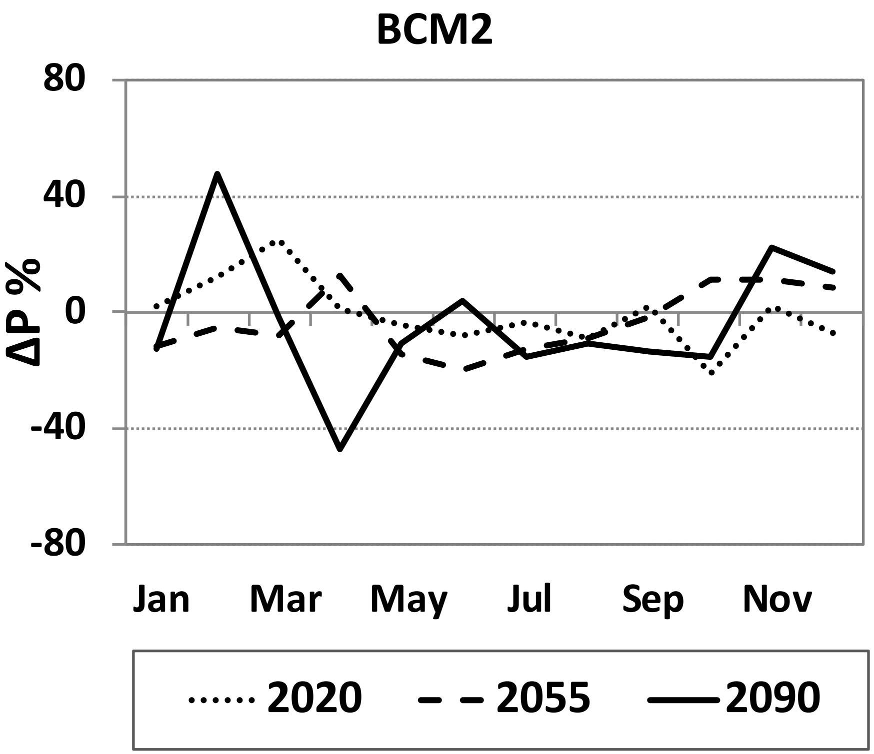
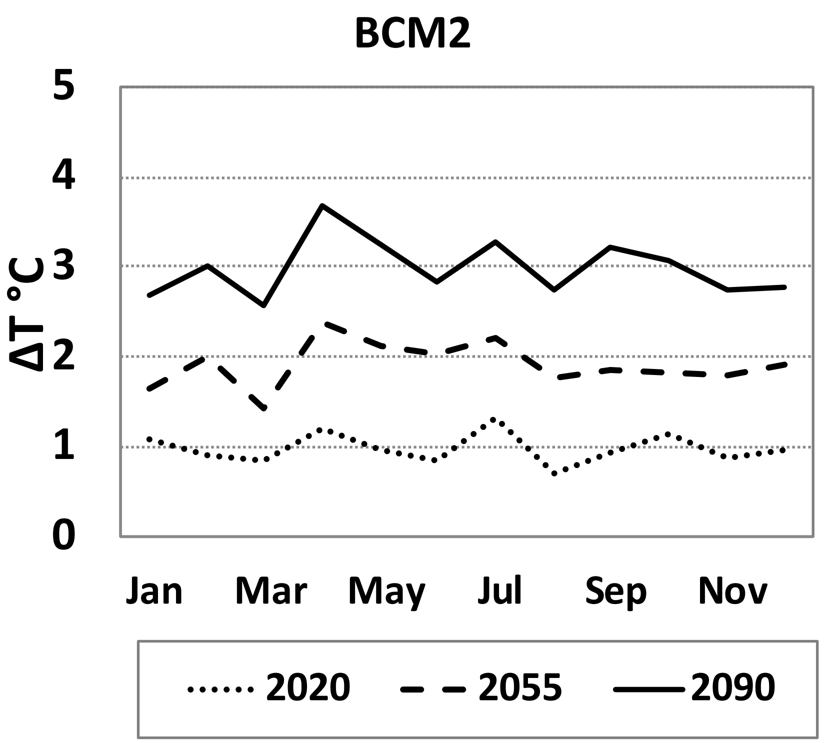
Materials cont'd

- Preciptation change



- Temprature change



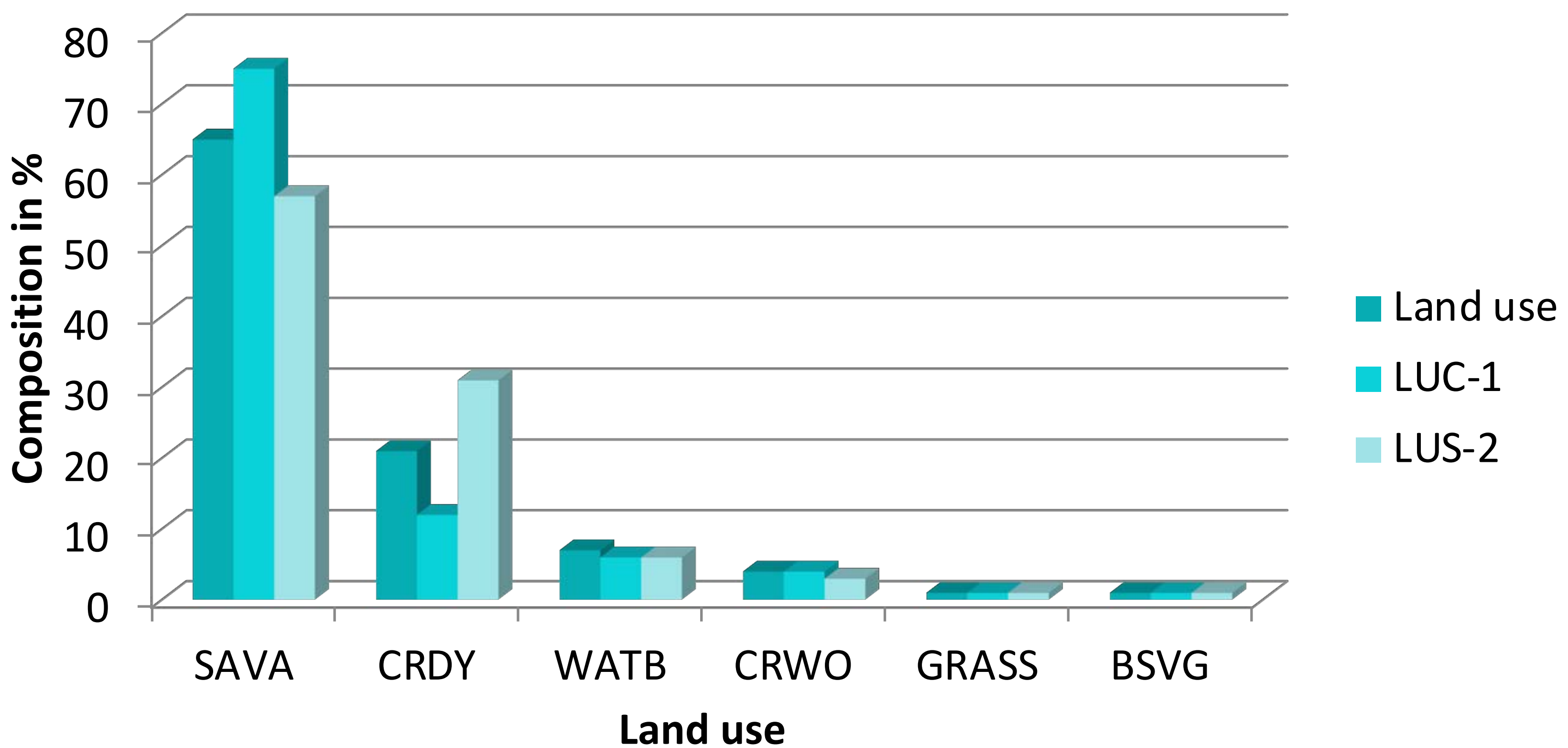
Analysis of the impact of land use change and climate change on Blue Nile river using SWAT

Materials cont'd

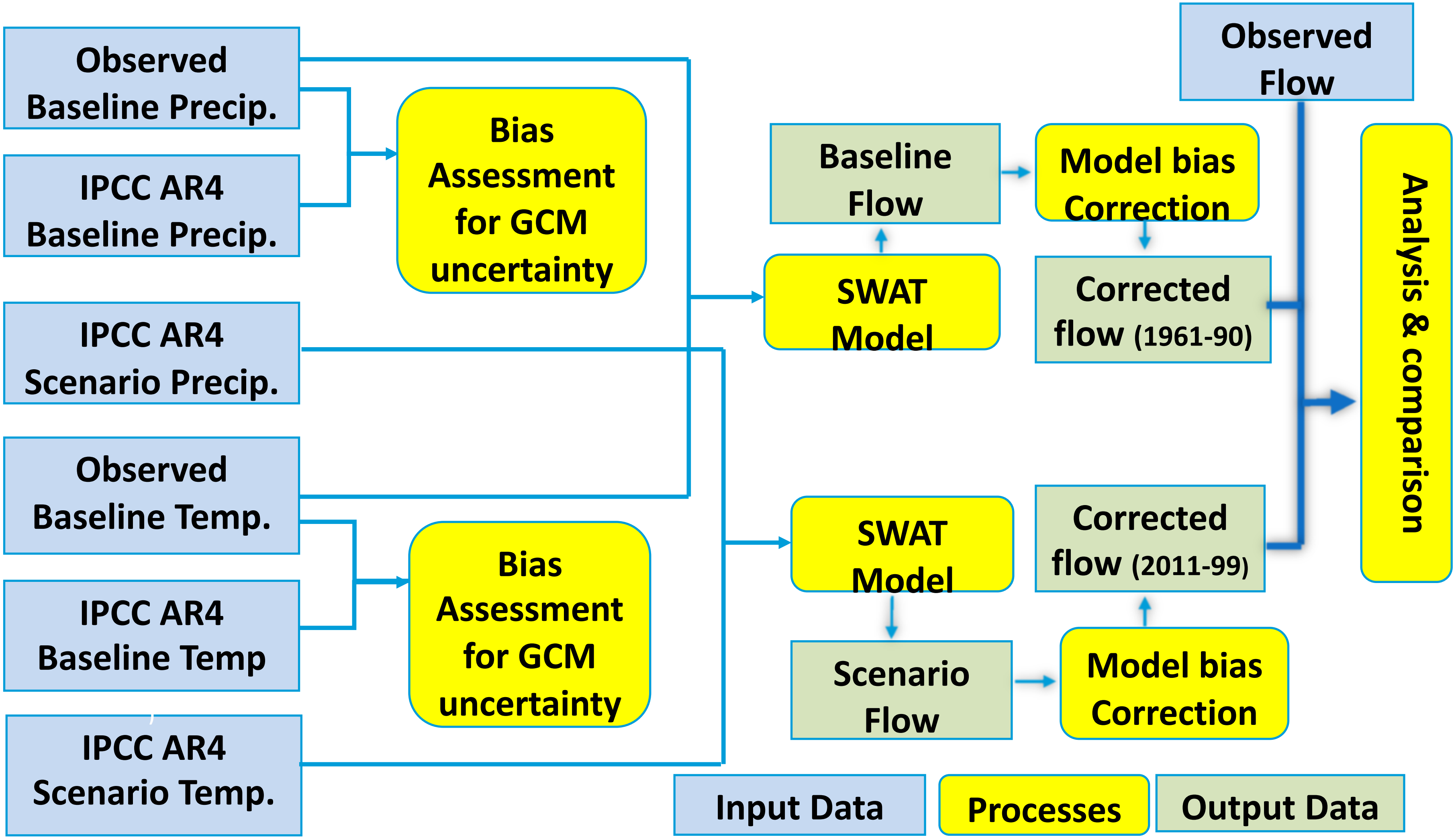
- **Land use and cover (LUC) change scenario data**
  - Two hypothetical LUC scenarios for 2080 assuming ***± 10%*** change on ***savana forest***
  - It has also been assumed that change in SAVA (savana) cover will be compensated by CRDY (crop land/ dry land)
    - LUS-1……. Land use scenario 1 - 10% increase in SAVA
    - LUS-2 …… « « « 2 - 10% decrease «

Materials cont'd

- **Change in land use percentage**



Methods



Observed Baseline Precip.
IPCC AR4 Baseline Precip.
IPCC AR4 Scenario Precip.
Observed Baseline Temp.
IPCC AR4 Baseline Temp
IPCC AR4 Scenario Temp.
Bias Assessment for GCM uncertainty
Bias Assessment for GCM uncertainty
SWAT Model
SWAT Model
Baseline Flow
Scenario Flow
Model bias Correction
Model bias Correction
Corrected flow (1961-90)
Corrected flow (2011-99)
Observed Flow
Analysis & comparison
Input Data
Processes
Output Data

Approaches

- Model evaluation
- Climate change anaysis
- Land use and cover (LUC) change analysis
- Land use change analysis coupled with climate change

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Results

- **Model evaluation**
- Climate change anaysis
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Results cont'd

Annual yield

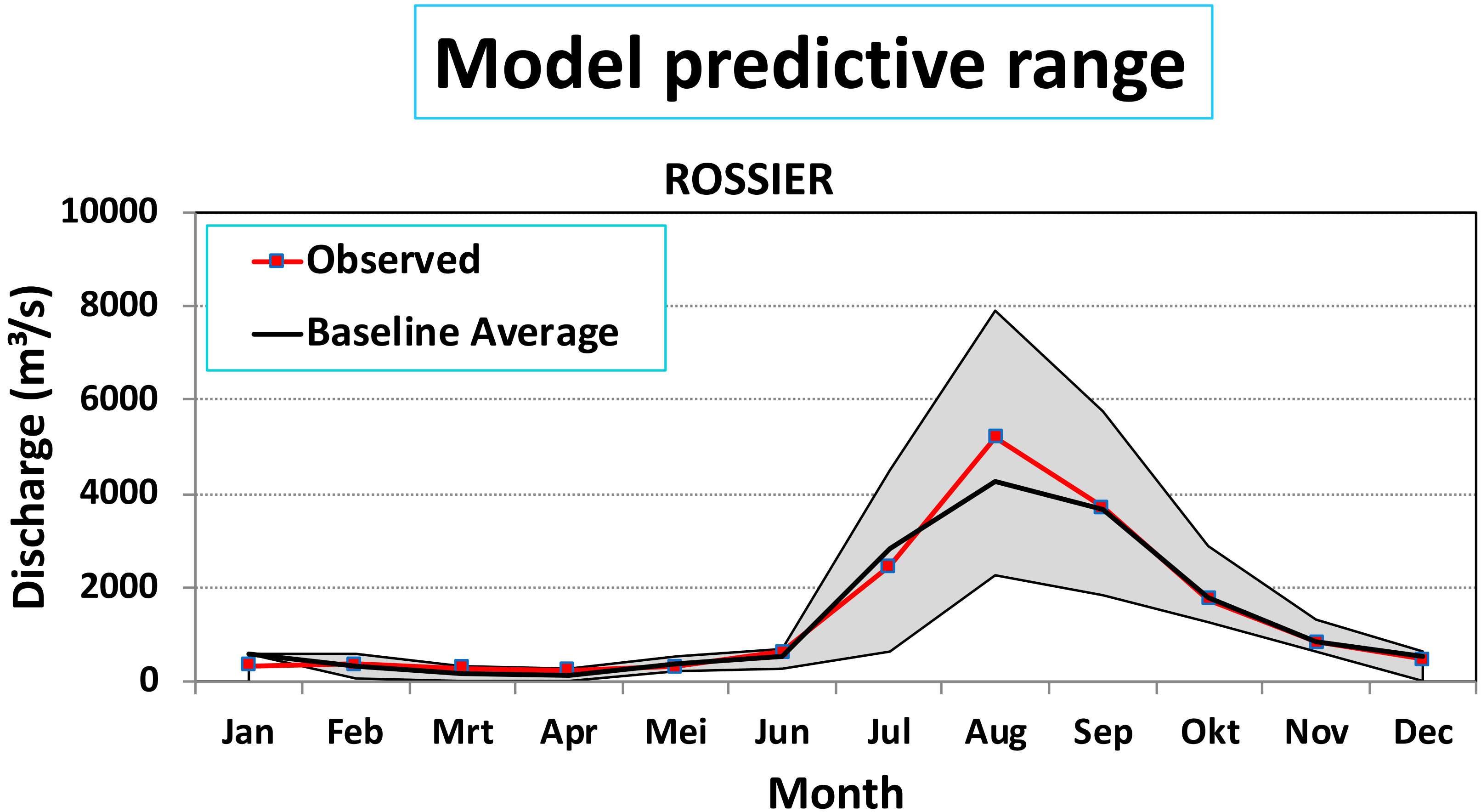
	Period	Preciptation (mm)	Annual Water Yield (mm)		Discrepancy %
			Actual	SWAT	
Rosieres					
Calibration	1973-1978	866.4	251.1	252.4	-0.5%
Validation	1979-1982	971.2	199.0	180.1	9.5%

Results cont'd

Statistical indices

	Annual mean flow (m^3/s)		Variance (m^3/s)		NSE	R^2
	Actual	SWAT model	Actual	SWAT model		
Rosieres						
Calibration	1509.4	1516.9	41.7	42.7	0.89	0.89
Validation	1196.5	1082.3	38.3	33.5	0.83	0.86

Results cont'd



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Results cont'd

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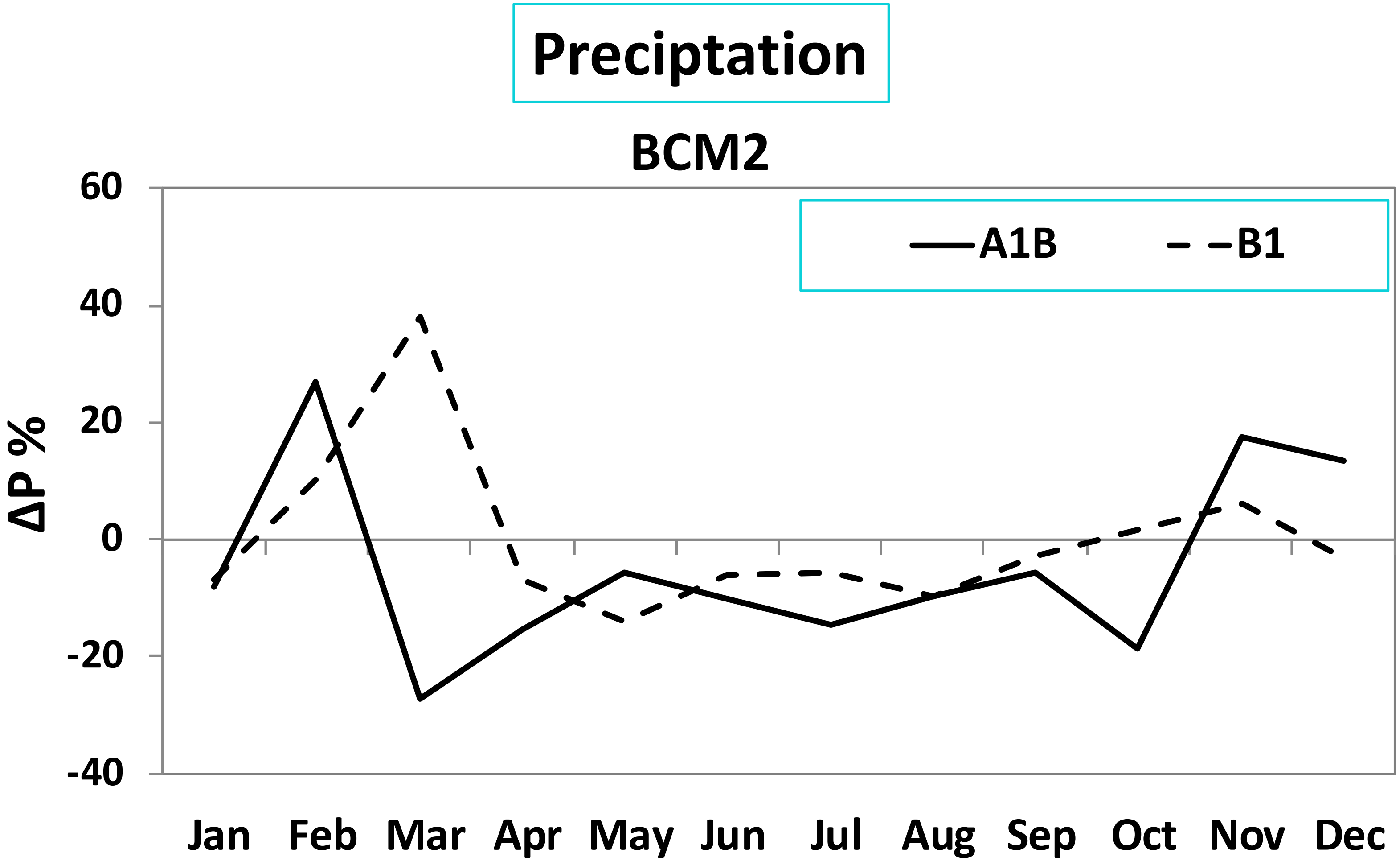
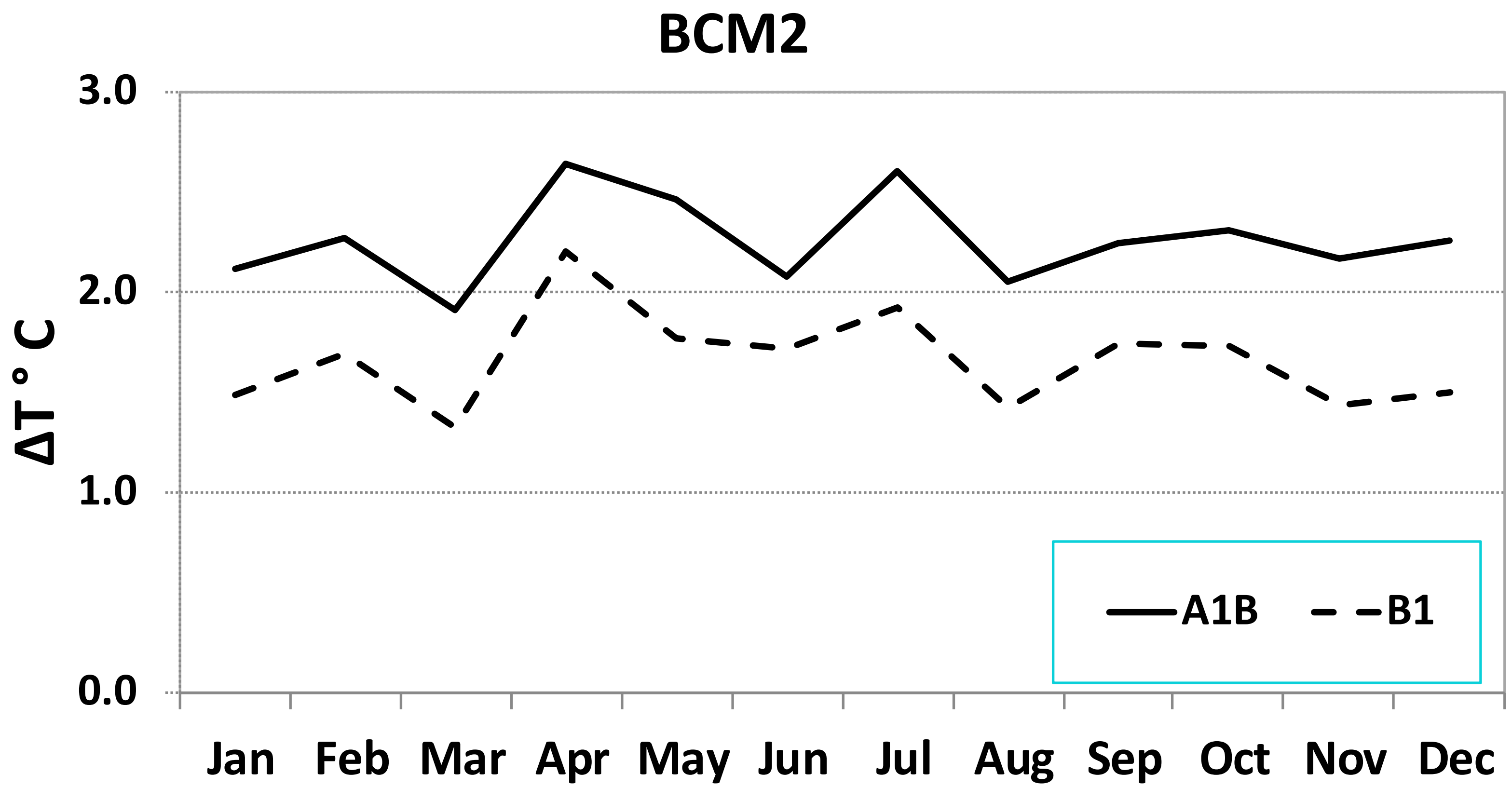
Results cont'd



Results cont'd

Temprature



Results cont'd

GCM uncertainty

Bias

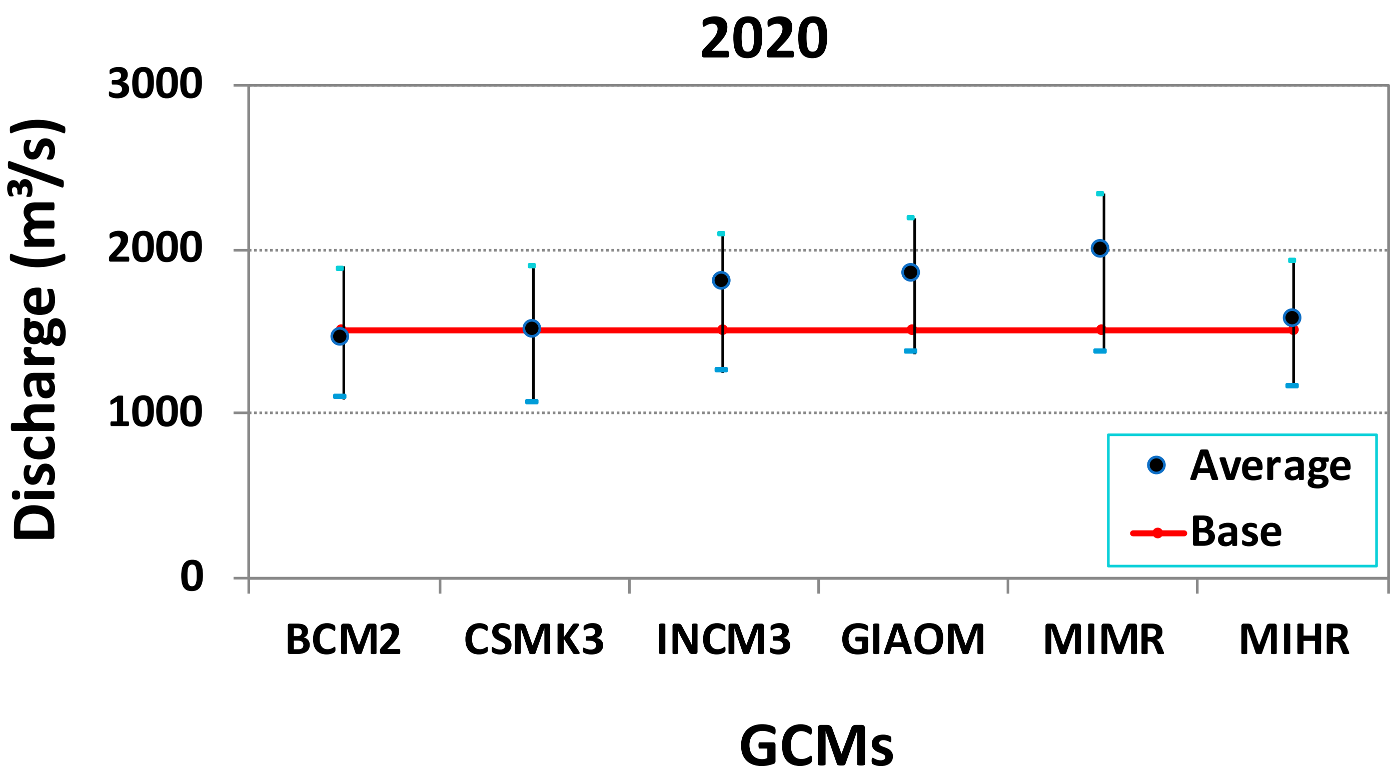
	BCM2	CSMK3	INCM3	GIAOM	MIMR	MIHR
Bias (kg/m^2*s)	0.22	**-0.80**	**-0.85**	**-1.01**	0.44	0.36
RMSE	2.45	2.55	2.41	2.70	2.48	2.43

Water yield

GCM	Scenario	Anual water Yield (mm)				ΔP	ΔTav	
		Baseline	2020	2055	2090	(%)	(°C)	ΔWYLD %
BCM2	A1B	252.4	223.4	186.3	165.7	-4.8	2.3	**-24**
	B1	252.4	215.5	208.7	190.7	0.1	1.7	**-19**
MIMR	A1B	252.4	298.7	307.6	391.4	6.4	1.5	32
	B1	252.4	304.9	281.5	311.0	3.2	1.2	19
MIHR	A1B	252.4	234.6	276.1	271.6	15.4	2.9	3
	B1	252.4	241.0	283.8	244.6	10.5	2.5	2

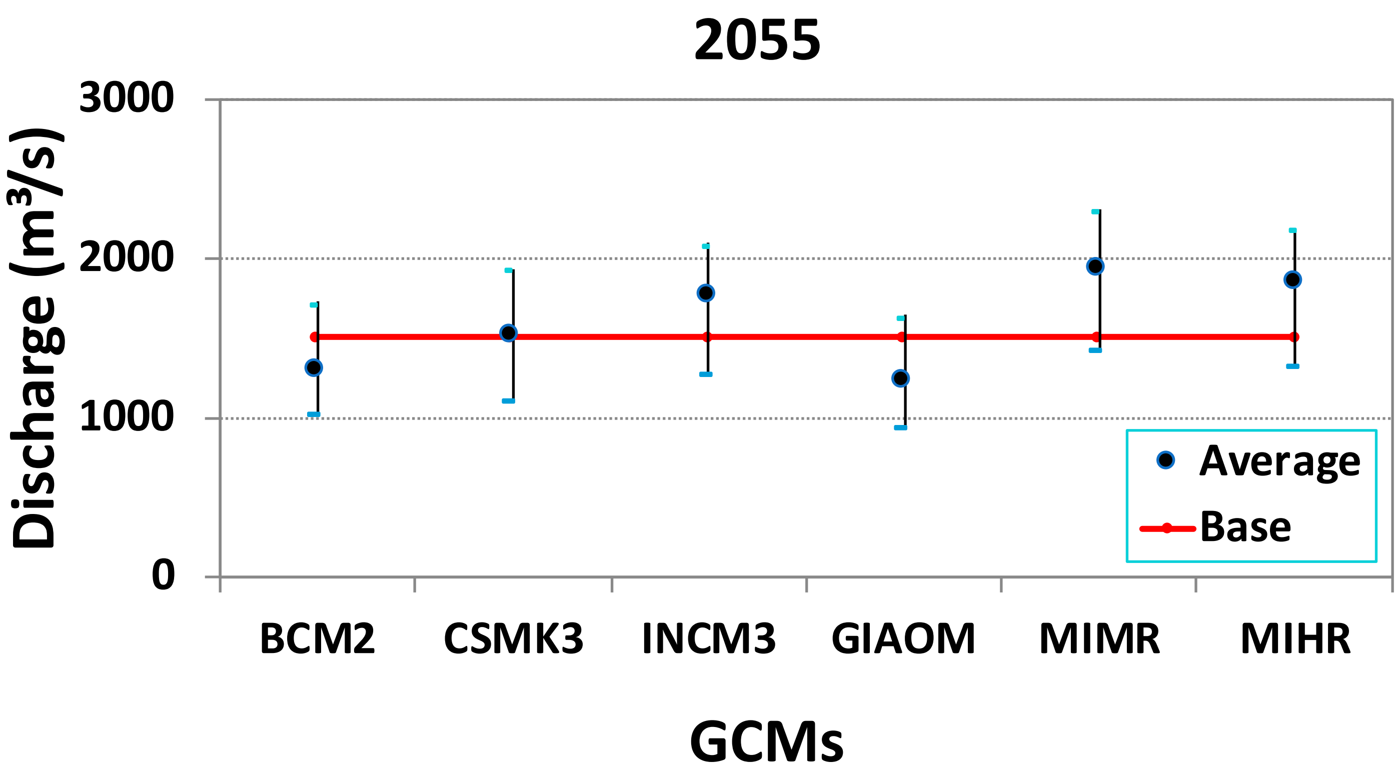
Results cont'd

Average flow change



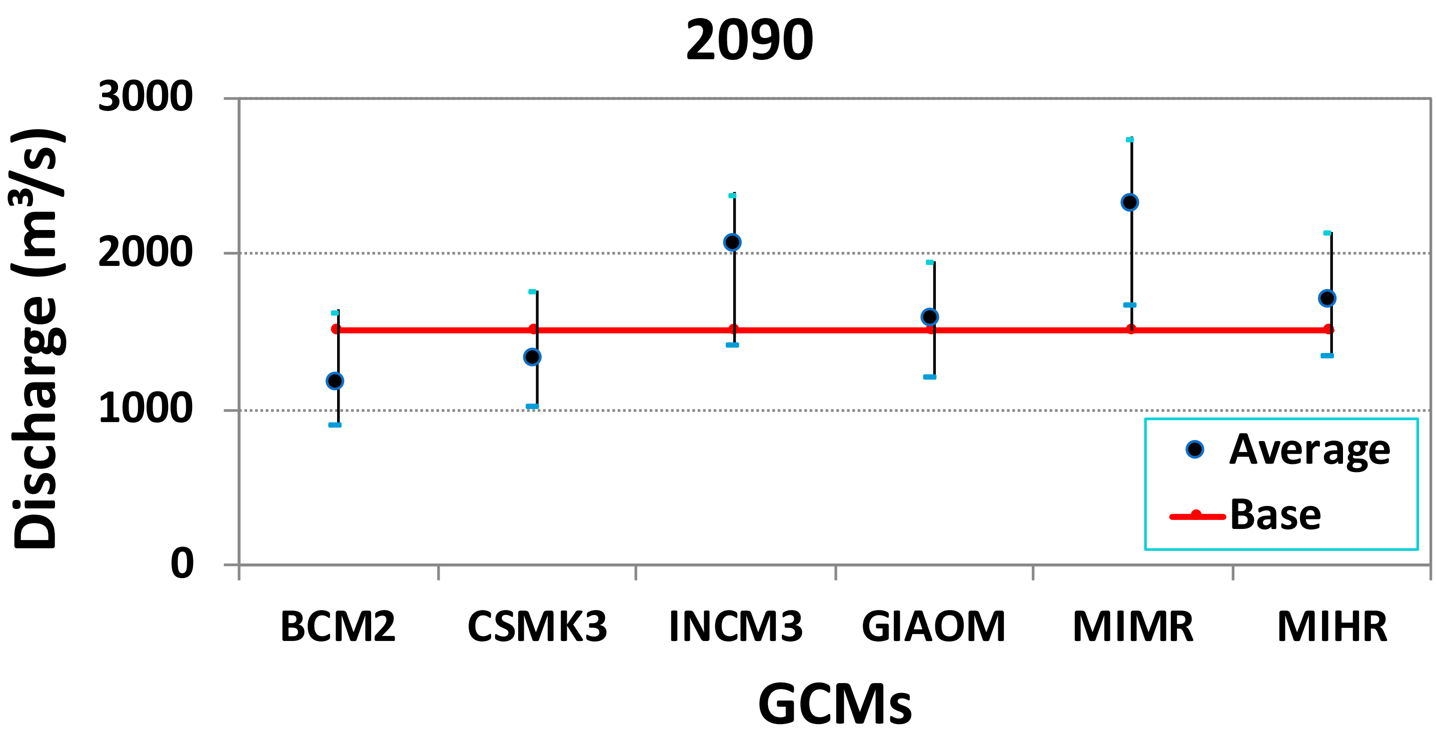
Results cont'd

Average flow change



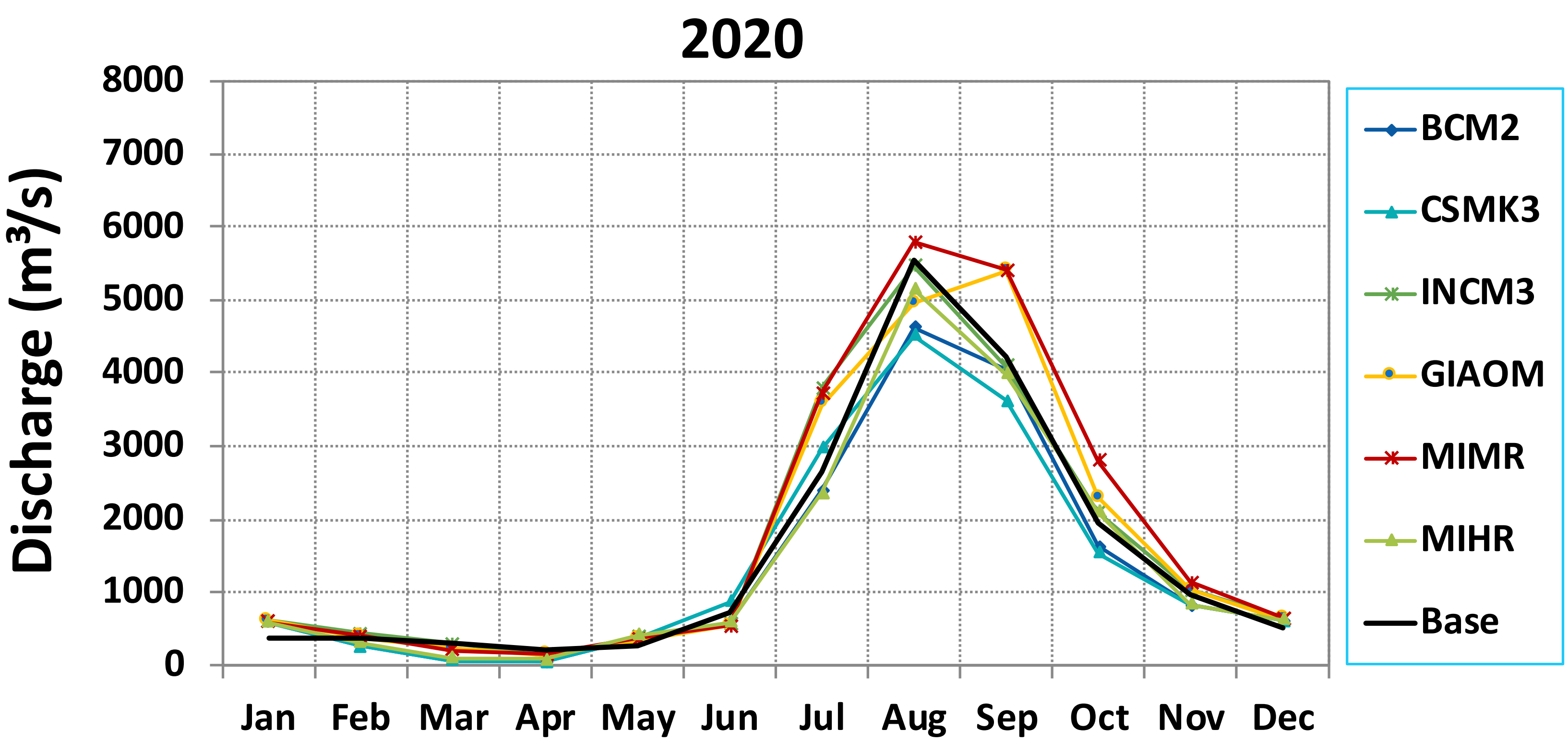
Results cont’d

Average flow change



Results cont'd

Seasonal flow change



Analysis of the impact of land use change and climate change on Blue Nile river using SWAT

Results cont'd

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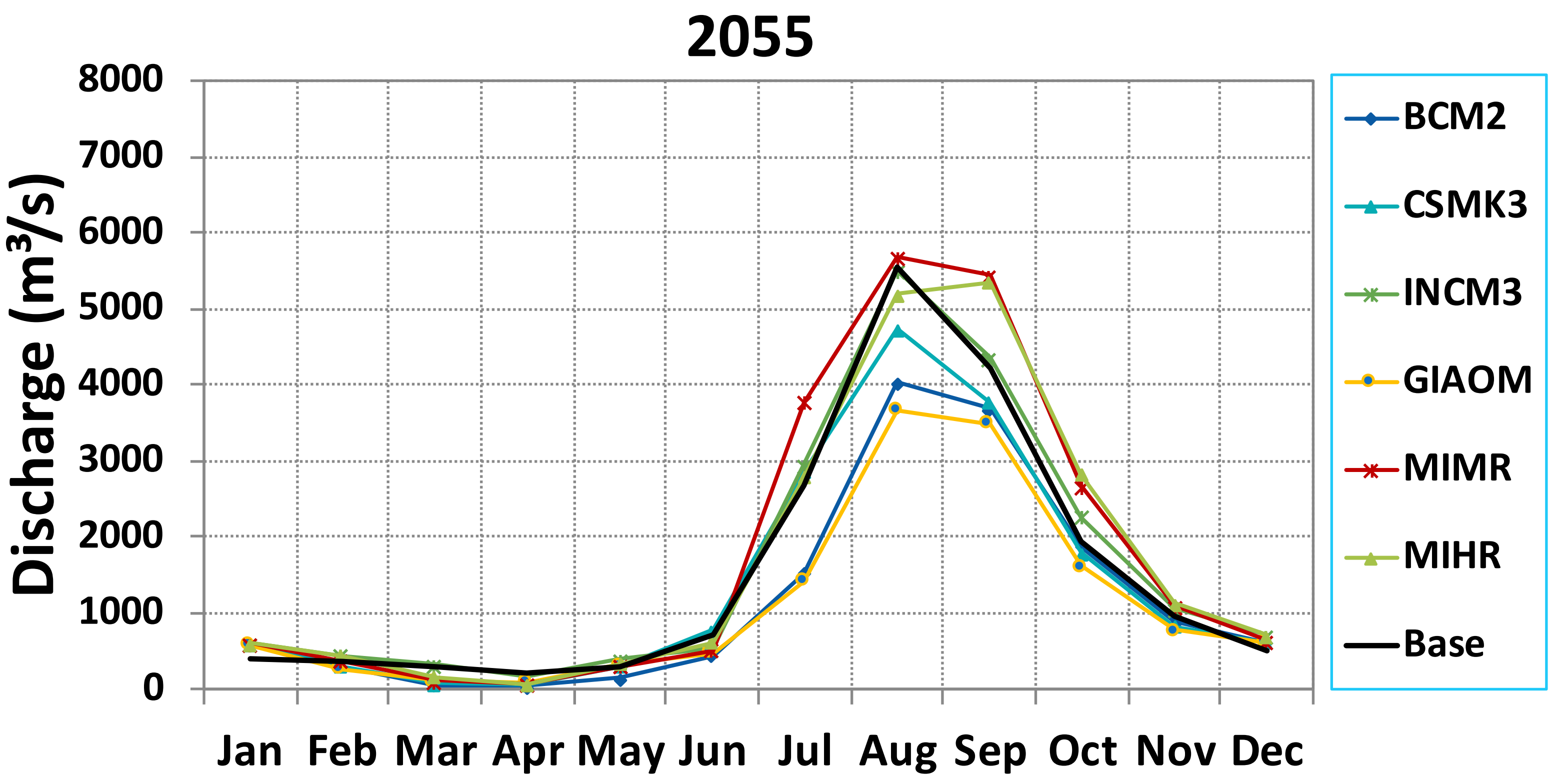

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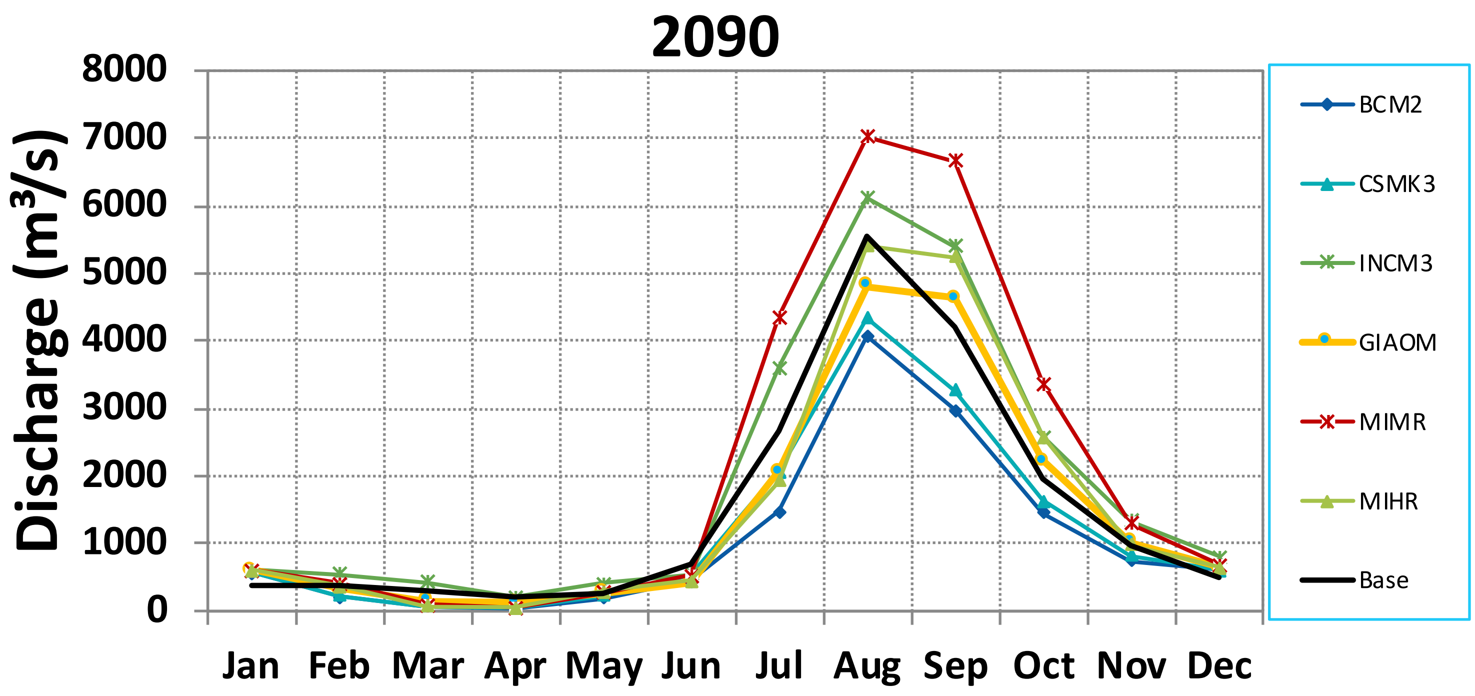

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Results cont'd

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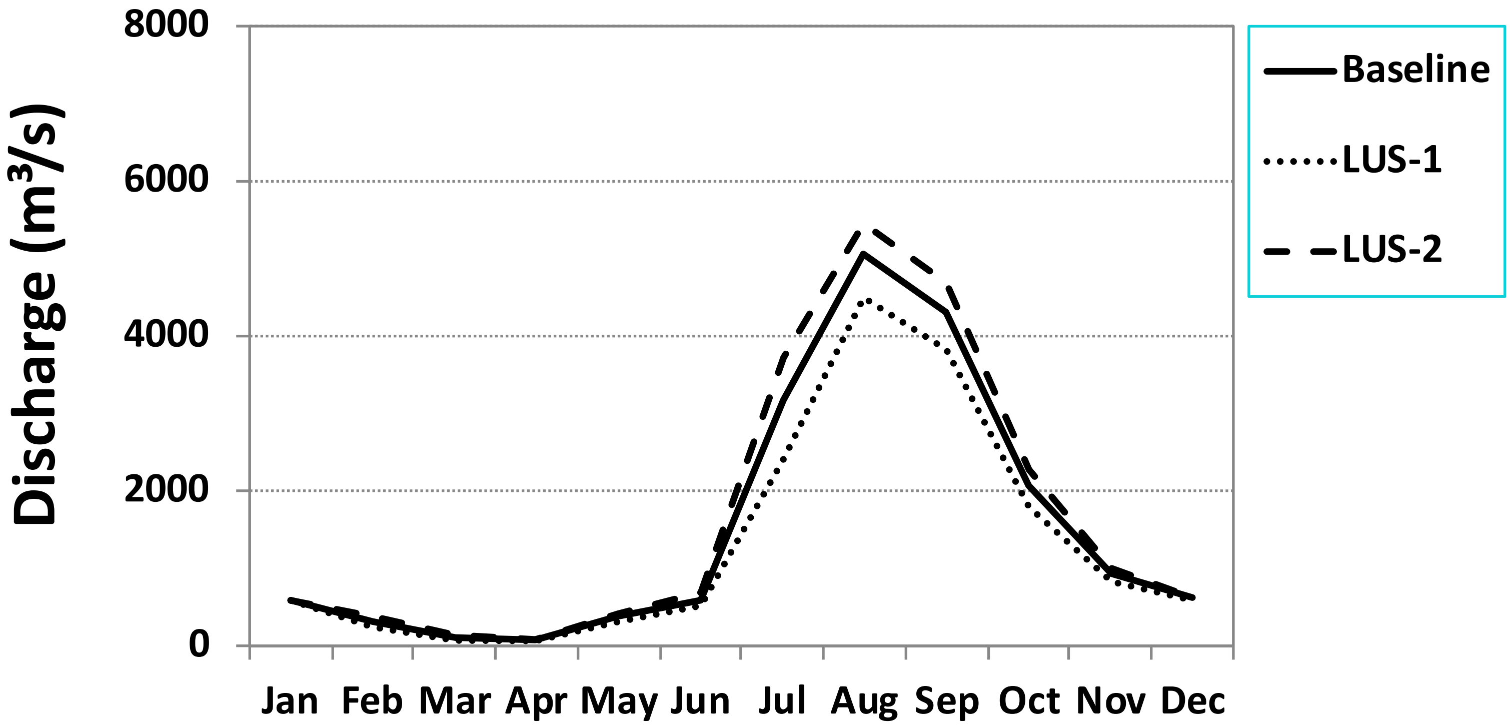
Results cont'd

Annual yield change

Land-use Scenario	Annual WYLD (mm)	Change in Savana forest %	ΔWYLD %
Baseline (1961-90)	223.4	0	**0**
LUS-1 (2080)	189.6	10	**-15**
LUS-2 (2080)	249.9	-8	**12**

Results cont'd

Seasonal flow change



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Results cont'd

Annual yield change

GCMs	LUS	Climate Change		Land use Change	Annual WYLD (mm)	ΔWYLD %
		ΔP%	ΔT%	ΔSAVA%		
BCM2	1	0.1	1.7	10	158.9	**-37.0**
	2	0.1	1.7	-8	216.5	**-14.2**
MIMR	1	3.2	1.2	10	276.7	**9.7**
	2	3.2	1.2	-8	337.1	**33.6**
MIHR	1	10.5	2.5	10	207.8	**-17.6**
	2	10.5	2.5	-8	274.2	**8.7**

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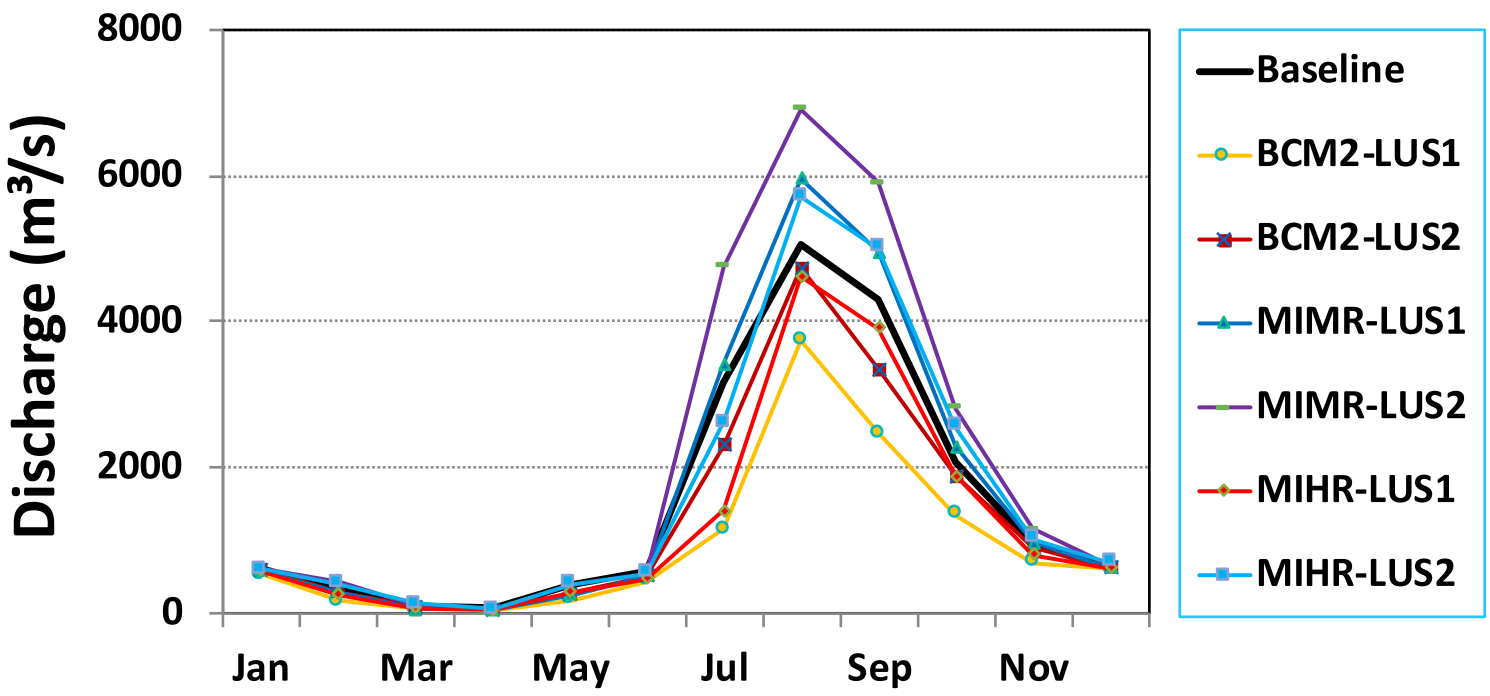
Results cont'd

Seasonal flow change



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Conclusion

- The SWAT model has been successfully evaluated
  - Satisfactory performance - minimum NSE=0.7
  - But high flow predictions were not as good as low flow predictions
- Land use and climate change scenarios - helped to better understand the impact of climate change and land use change on Blue Nile river
- It has been proven that land use and cover (LUC) changes as well as climate change has resulted in significant changes (either by increasing or decreasing) in the hydrology of the basin

Recommendations

- use of long time series and good quality data in the hydrologic models
- investigate the reasons of underestimation of peak flows for Blue Nile
- It will be of great importance to incorporate other factors in the assessment like, sediment transport and water quality analysis.
- Incorporating the newly constructed dam by Ethiopia (GERD) in the already built hydrologic model and analyzing the impact (on development)


Thanks for listening!