Projected changes in flood-frequency in Bagmati river, Nepal

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Climate change impact assessment

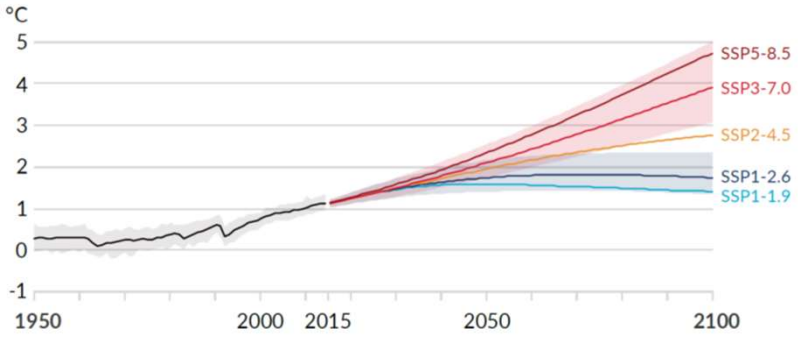
- Climate change is one of the most critical global environmental issues, specially for developing countries like Nepal
- Nepal has high climatic variation (less than 300 mm to more than 5500 mm annual precipitation); about 80% of precipitation during June-September
- Nepal is highly vulnerable to climate change and has already experienced changes in temperature and precipitation at a faster rate than the global average
- Understanding of changes in precipitation and river discharge in future is highly important towards mitigating implications of climate change on various sectors with focus on flood disaster

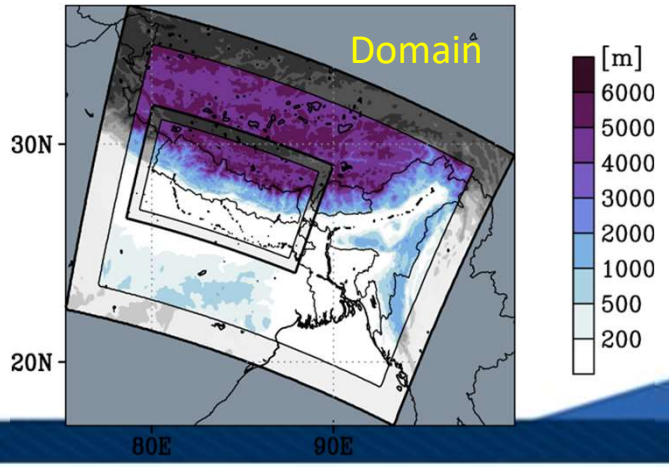
Urban flood under climate change

- Urban flooding is frequently reported as a result of anthropogenic activities like climate change, unplanned growth and development in floodplains
- Rainfall-runoff-inundation simulation is important in formulating both structural and non-structural measures for managing flood risk and minimizing various damages
- Climate change is considered one of main reasons behind increasing flood events in Kathmandu valley
- Change in precipitation extremes and peak river discharge were analysed in Bagmati river basin which covers Kathmandu valley, Nepal

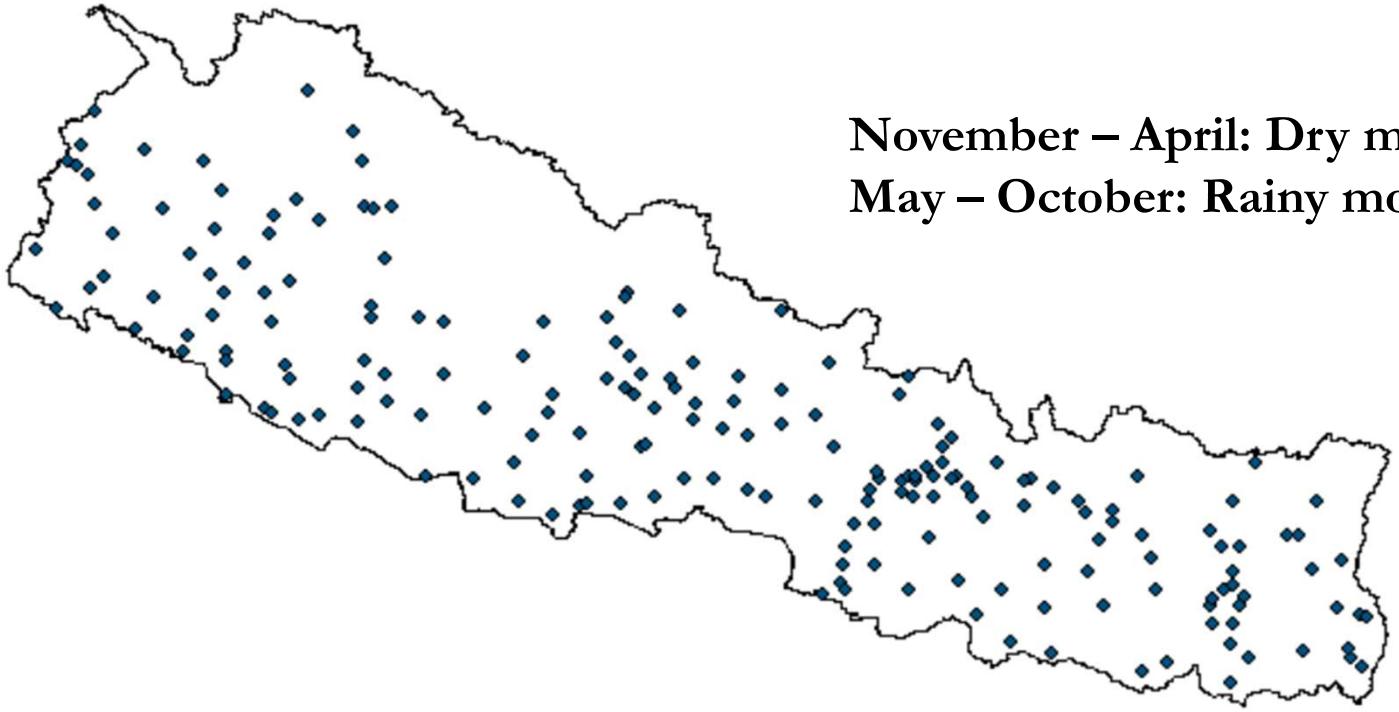
Precipitation projections

- Dynamical Downscaling of Climate (Precipitation) Projection Data of MRI-AGCM3.2 Output using Earth Simulator
- NonHydrostaticRegional Climate Model (NHRCM)
- Present climate (1980-2000); Future Climate (2080-2100)
- Climate Change Scenario: SSP5-8.5 (Very high GHG emission)





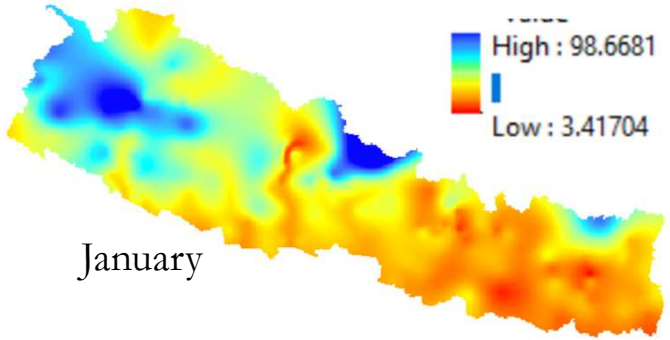
Precipitation assessment



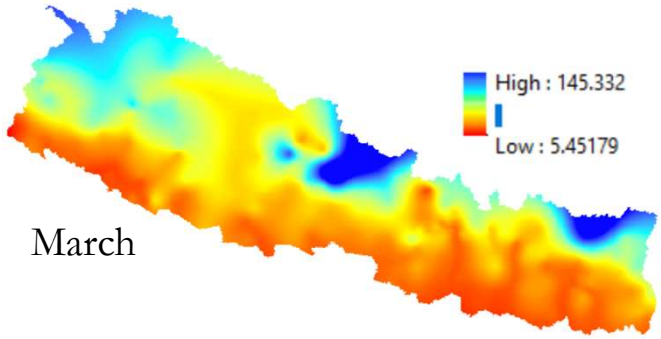
November – April: Dry months
May – October: Rainy months

197 meteorological stations with observation data for 1980-2000 period

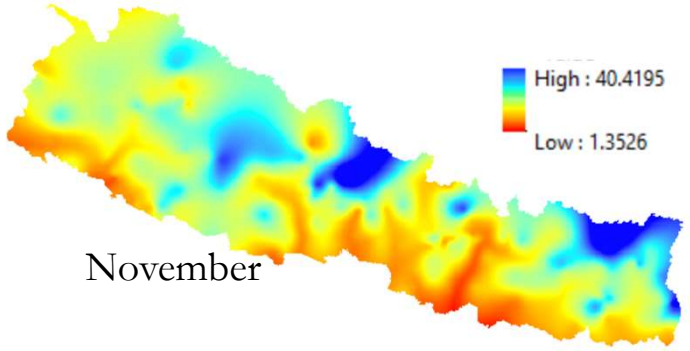
Monthly mean observation precipitation (**Dry season**)



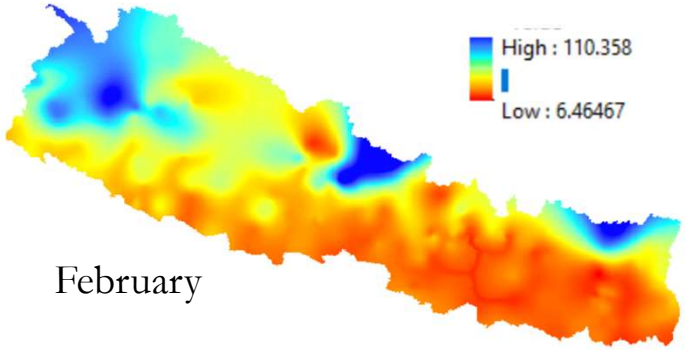
January



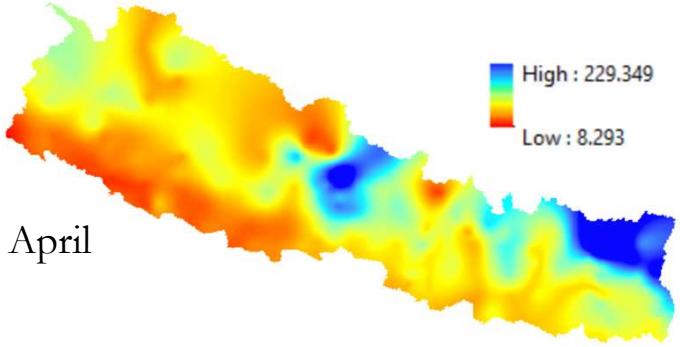
March



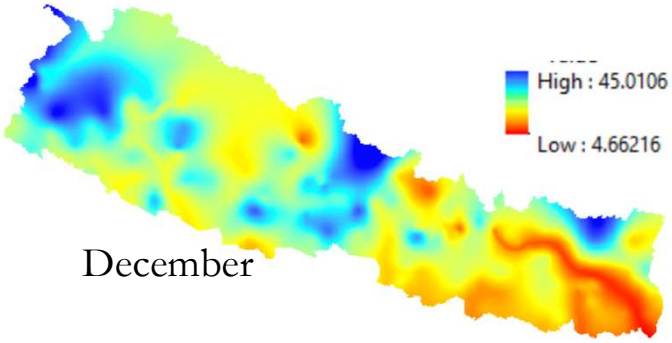
November



February



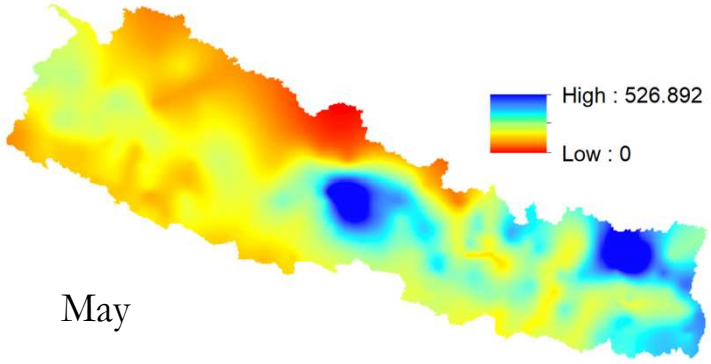
April



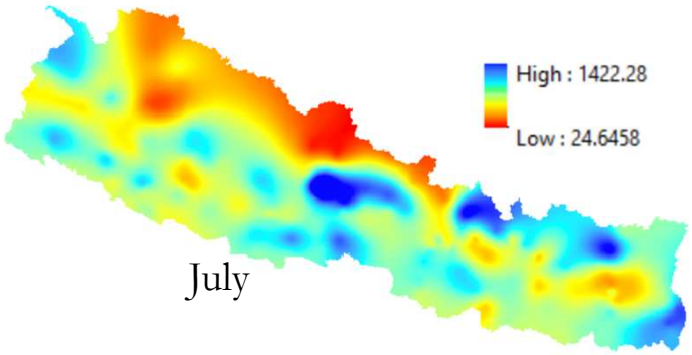
December

Present climate (1980 – 2000)

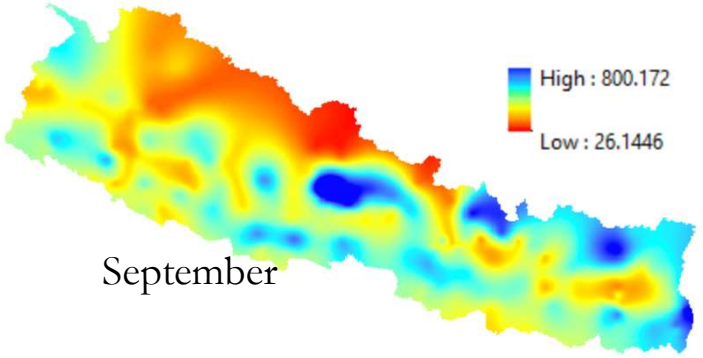
Monthly mean observation precipitation (**Wet season**)



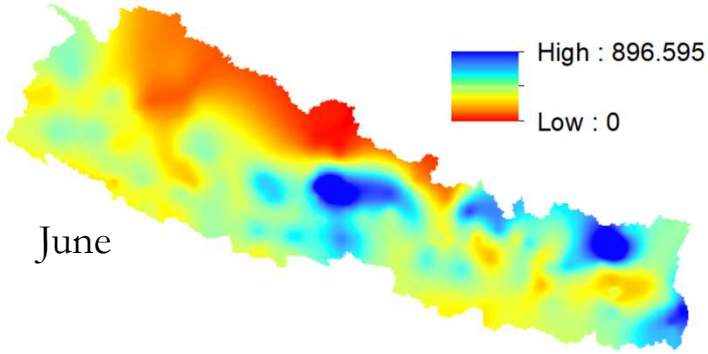
May



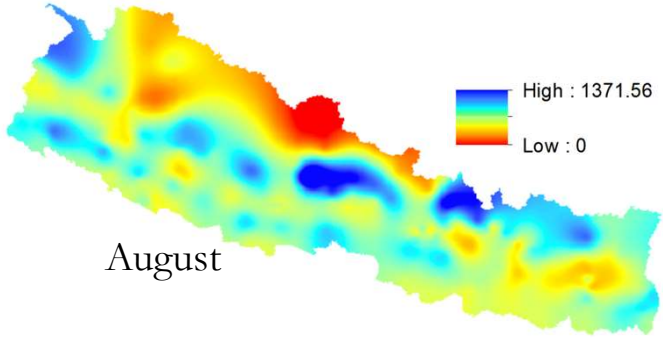
July



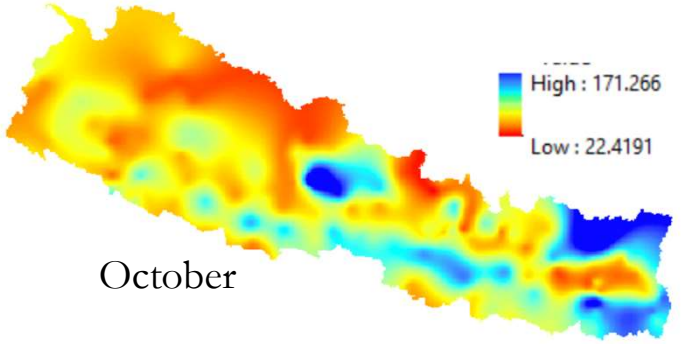
September



June



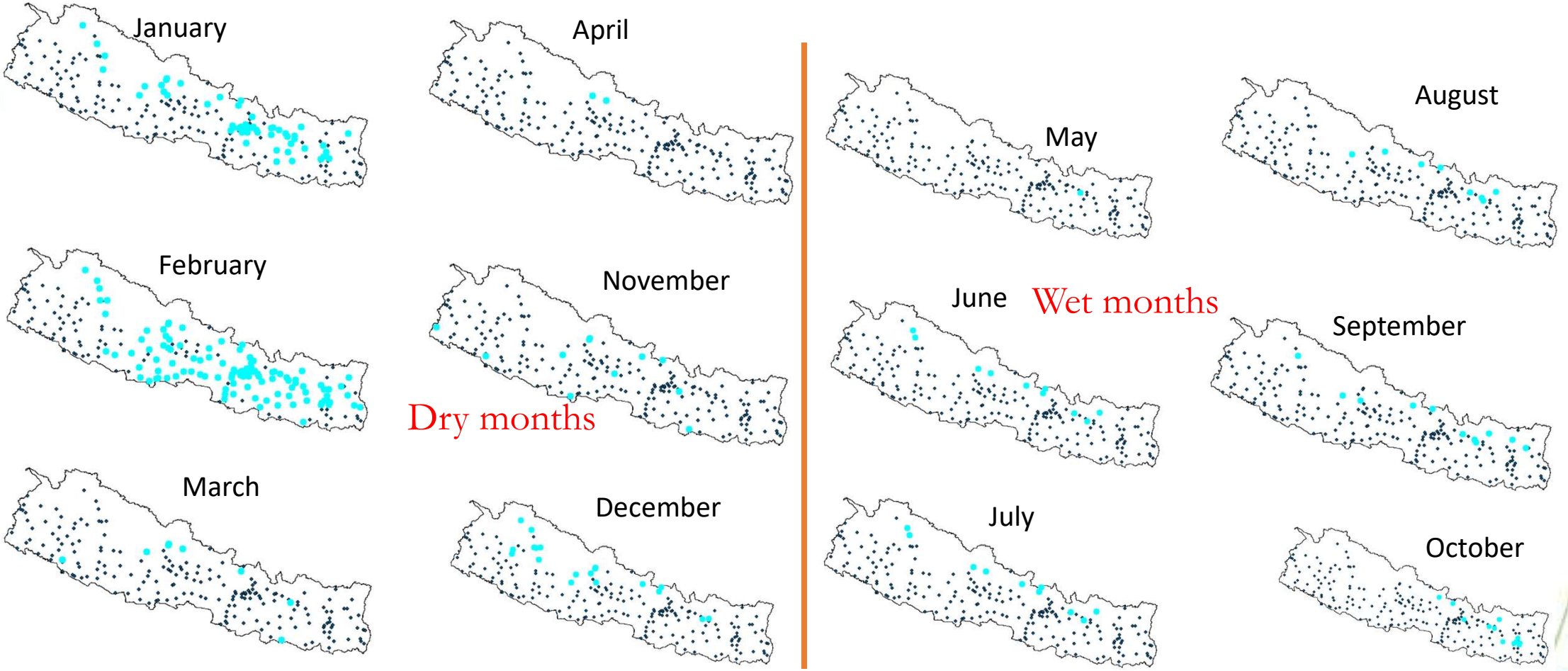
August



October

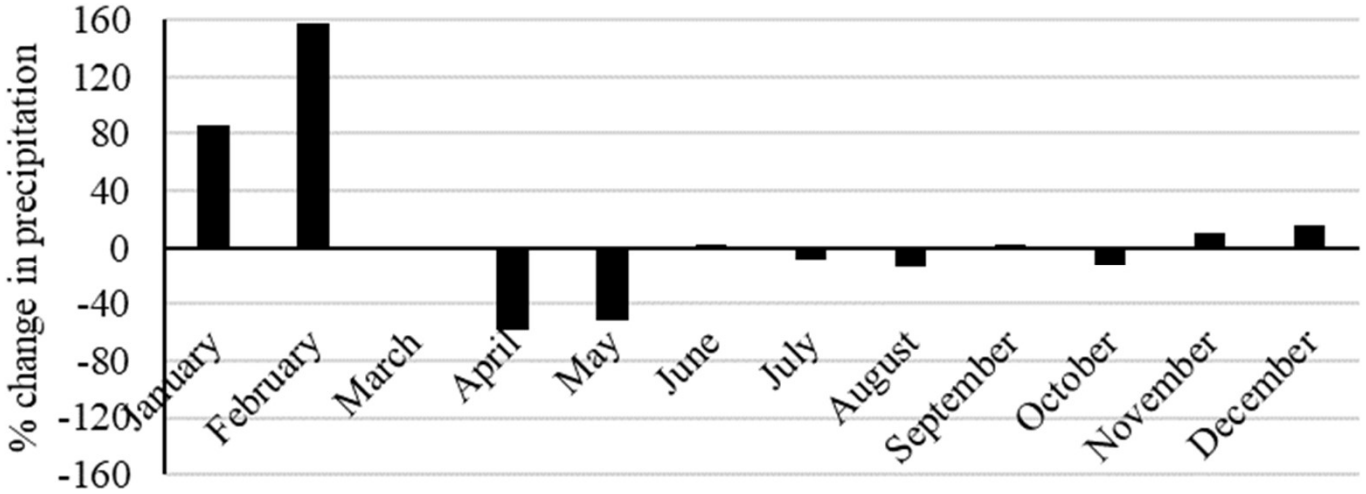
Present climate (1980 – 2000)

Comparison of monthly mean Observation and RCM precipitation



Stations with more than 100% bias in monthly mean precipitation over 1980-2000

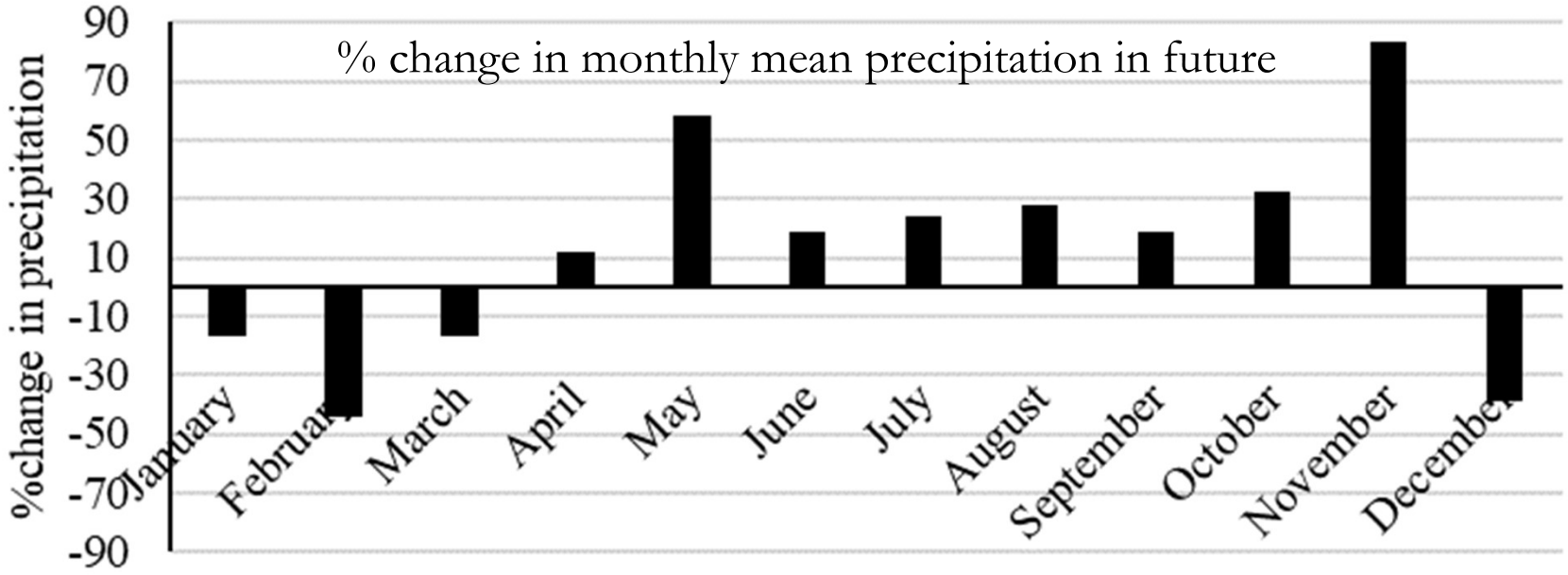
Comparison of monthly mean Observation and RCM precipitation



% change in **monthly mean** observation and RCM precipitation over 1980-2000

- RCM precipitation was found relatively overestimated over Observation data
- January and February (both dry months) were found to have greater biases
- Upper (high mountain) region stations were primarily found with higher biases

% change in future monthly mean precipitation with 1980-2000 and 2080-2100 periods

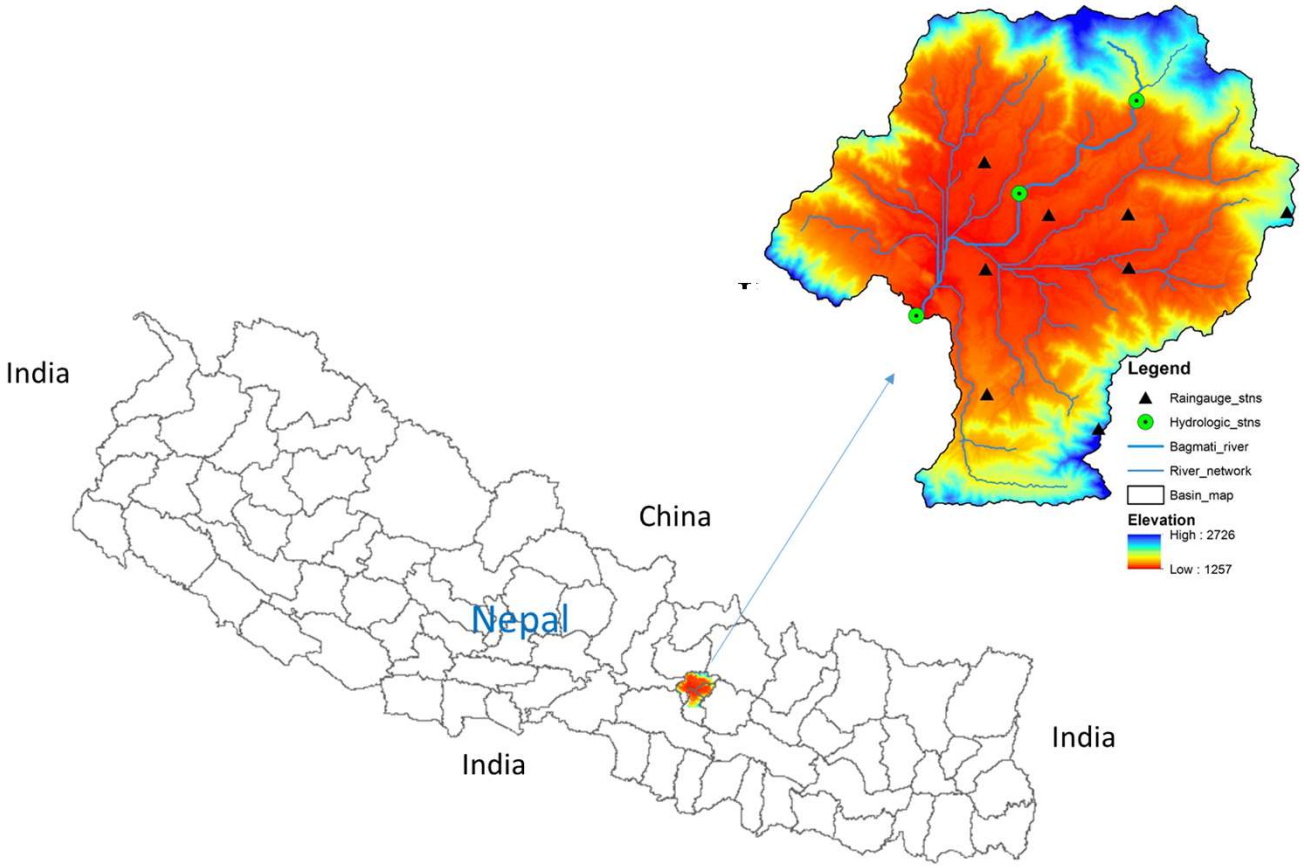


In general, wet months are projected with increasing precipitation and dry months with decreasing precipitation in future.

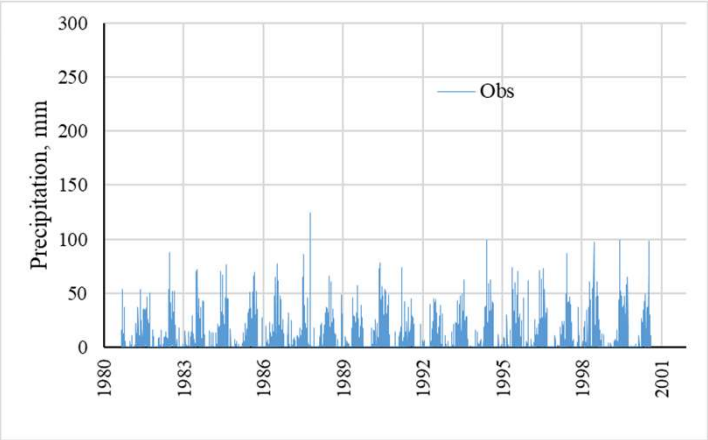
Flood-Frequency Analysis

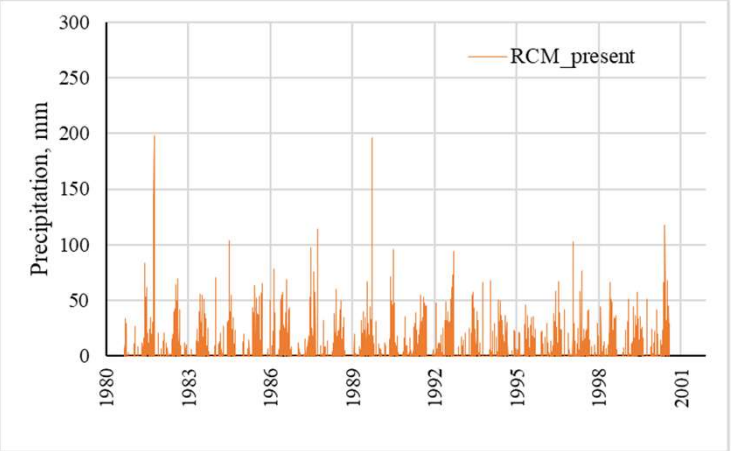
Rainfall-runoff modeling

Bagmati river basin upstream of Khokana;
Catchment area is 593 km^2

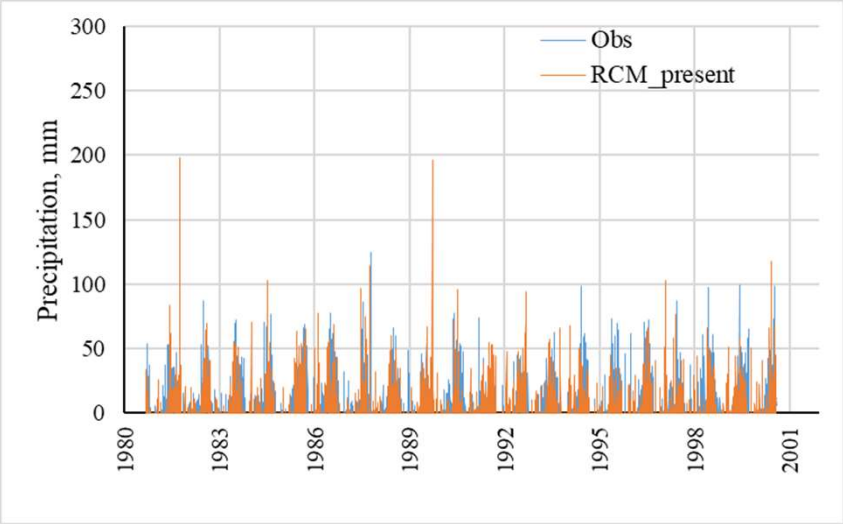


Observation and RCM daily precipitation over 1980-2000 period



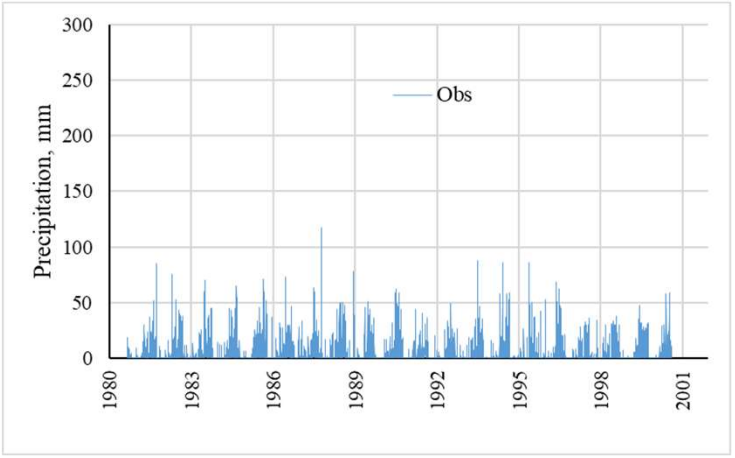


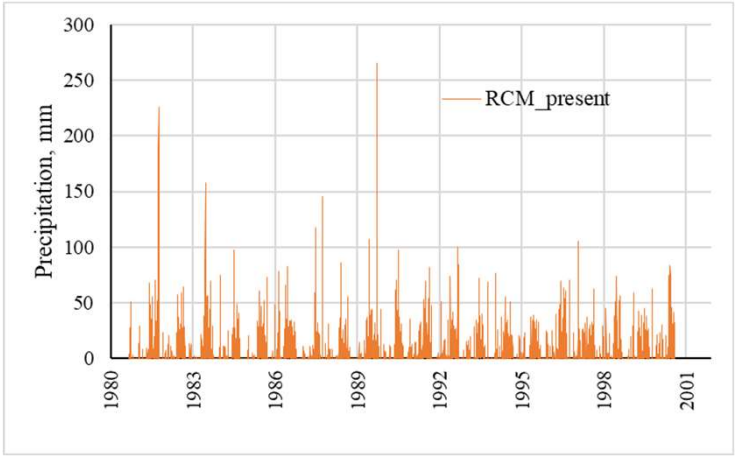
Comparison for Kathmandu Airport station (#1030)



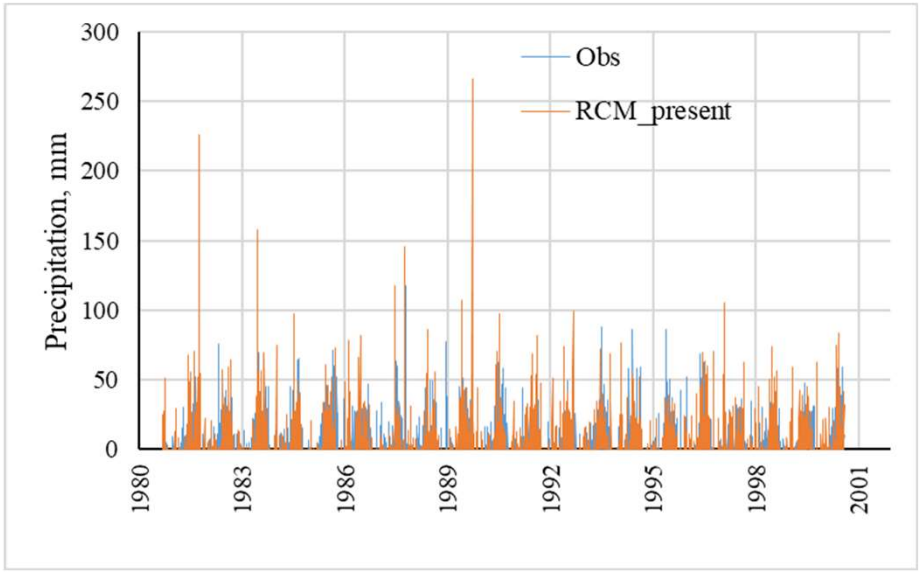
- RCM precipitation values were found with greater peaks.
- Precipitation with more than 100 mm were found for 1- and 7-days for Observation and RCM series respectively.
- Highest precipitation was found to be 124.4 and 198.5 for Observation and RCM series respectively.

Observation and RCM daily precipitation over 1980-2000 period





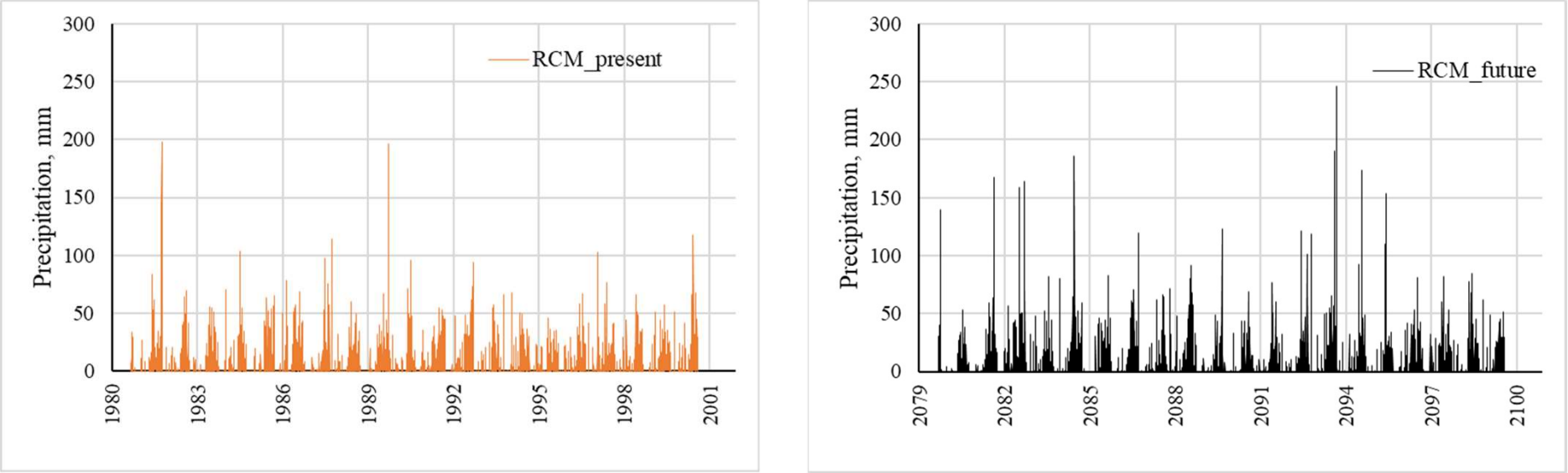
Comparison for Khumaltar station (#1029) inside Kathmandu valley



- Again, RCM precipitation values were found with greater peaks.
- Precipitation with more than 100 mm were found for 2- and 8-days for Observation and RCM series respectively.
- Highest precipitation was found to be 118 and 265.9 for Observation and RCM series respectively.

Change in RCM daily precipitation over 1980-2000 and 2080-2100 period

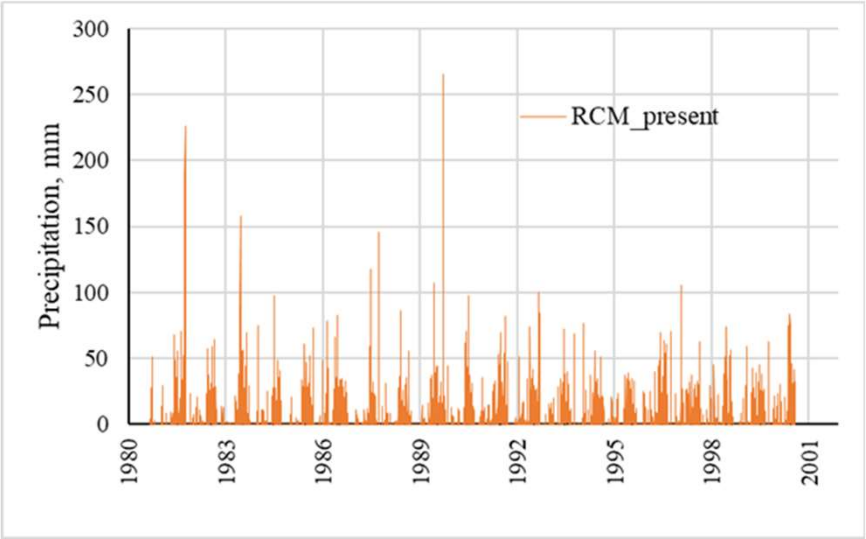
Comparison for Kathmandu Airport station (#1030)

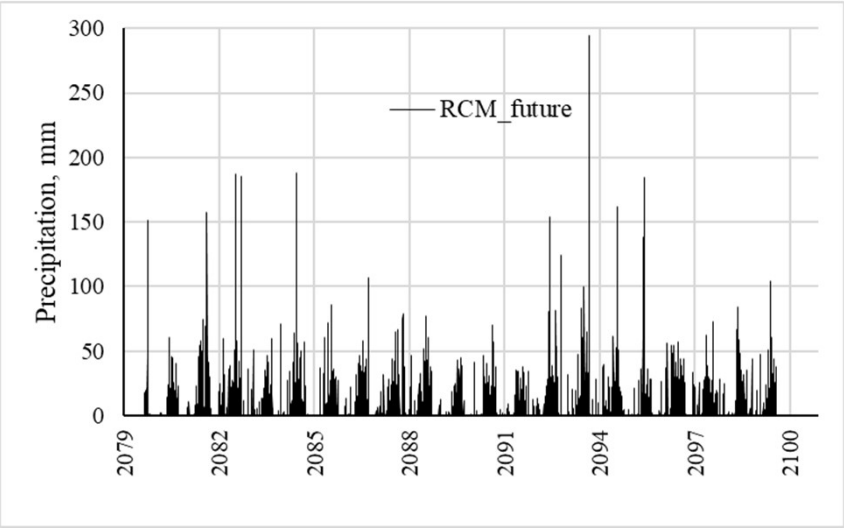


- Future RCM precipitation values were found with greater peaks.
- Precipitation with more than 100 mm were found for 7- and 16-days for present and future RCM series respectively.
- Highest precipitation was found to be 198.5 and 245.9 for Present and future RCM series respectively.

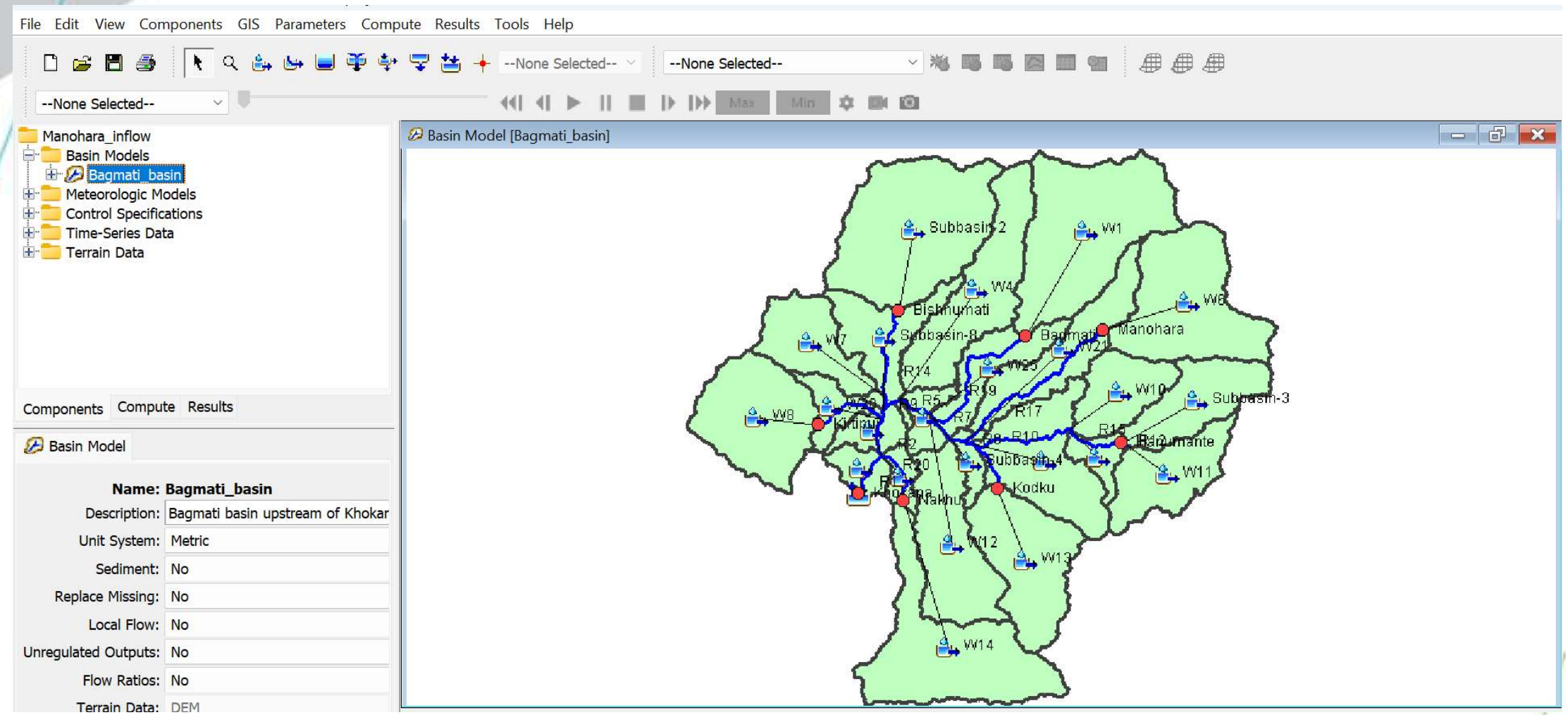
Change in RCM daily precipitation over 1980-2000 and 2080-2100 period

Comparison for Khumaltar station (#1029) inside Kathmandu valley



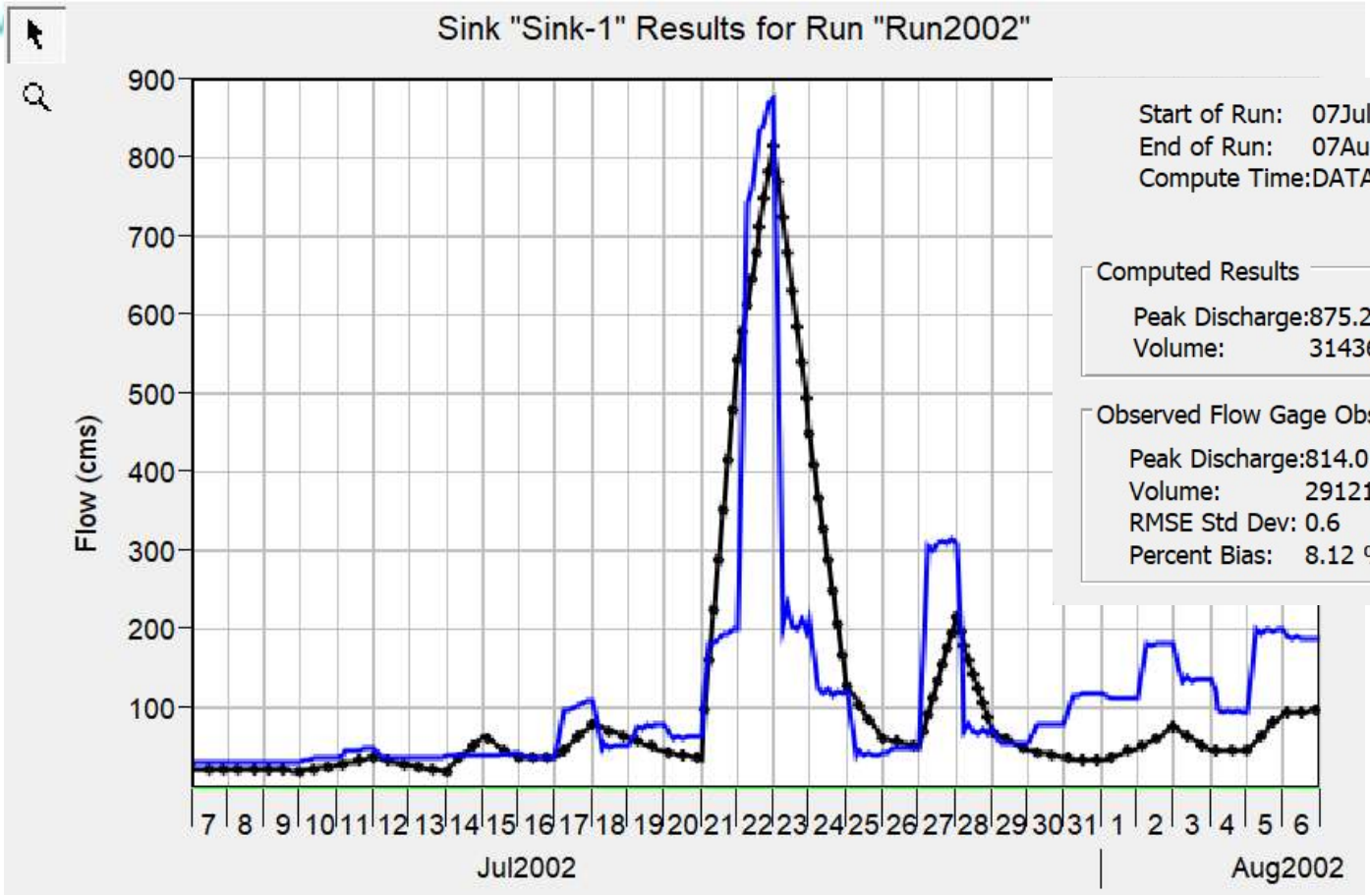


- Future RCM precipitation values were found with greater peaks.
- Precipitation with more than 100 mm were found of 8- and 16-days for present and future RCM series respectively.
- Highest precipitation was found to be 265.9 and 294.5 for Present and future RCM series respectively.



HEC-HMS Basin Model

Calibration (July – August, 2002)



Start of Run: 07Jul2002, 00:00
End of Run: 07Aug2002, 00:00
Compute Time: DATA CHANGED, RECOMPUTE

Basin Model: Bagmati2002
Meteorologic Model: Met 2002
Control Specifications: Control2002

Volume Units: ○ MM ● 1000 M3

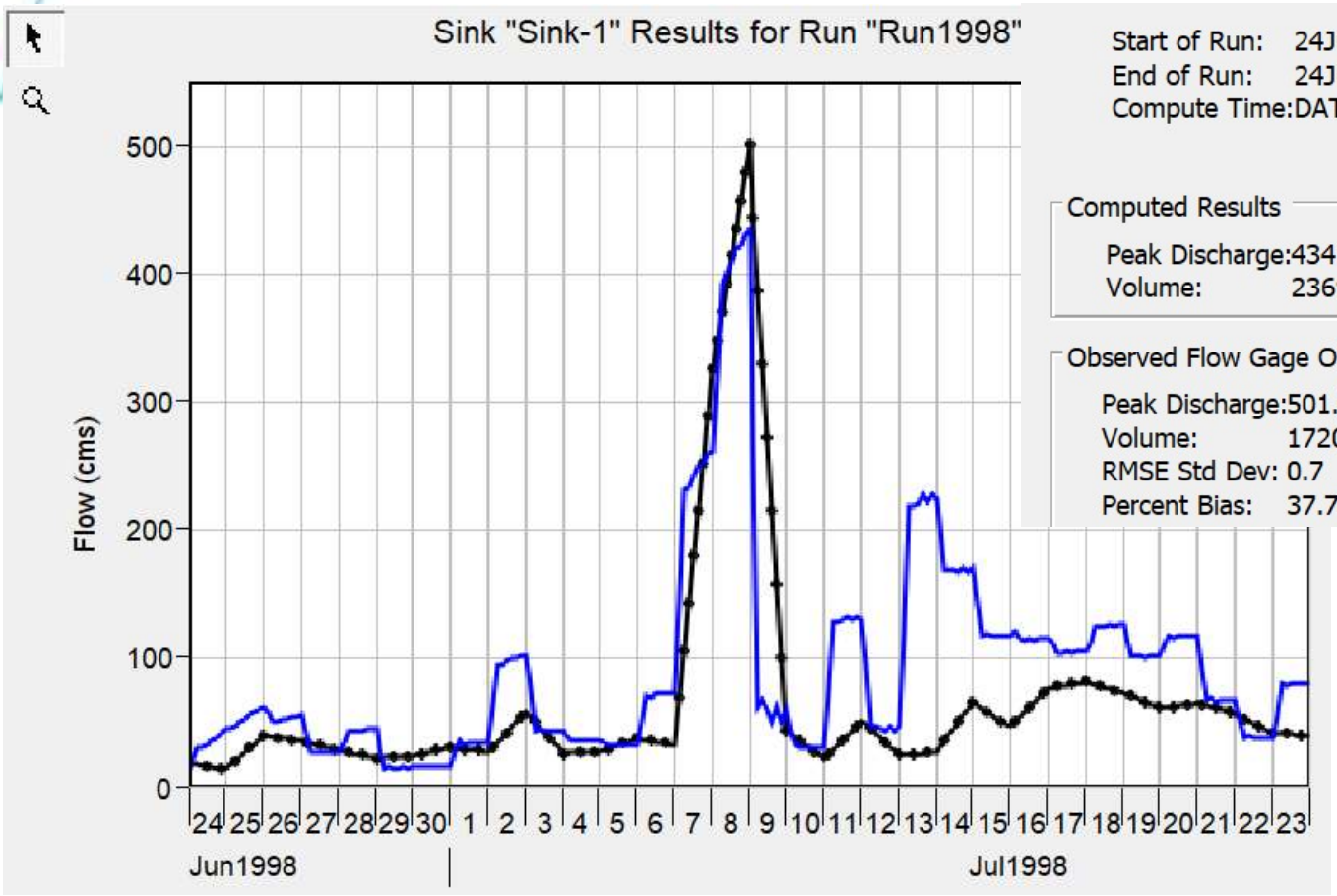
Computed Results

Peak Discharge: 875.2 (M3/S)
Volume: 314369.0 (1000 M3)
Date/Time of Peak Discharge: 23Jul2002, 00:00

Observed Flow Gage Obs_dis_khokana

Peak Discharge: 814.0 (M3/S)
Volume: 291211.2 (1000 M3)
RMSE Std Dev: 0.6
Percent Bias: 8.12 %
Date/Time of Peak Discharge: 23Jul2002, 00:00
Nash-Sutcliffe: 0.631

Validation (June – July, 1998)



Start of Run: 24Jun1998, 00:00
End of Run: 24Jul1998, 00:00
Compute Time: DATA CHANGED, RECOMPUTE

Basin Model: Bagmati1998
Meteorologic Model: Met 2002
Control Specifications: Control1998

Volume Units: ○ MM ● 1000 M3

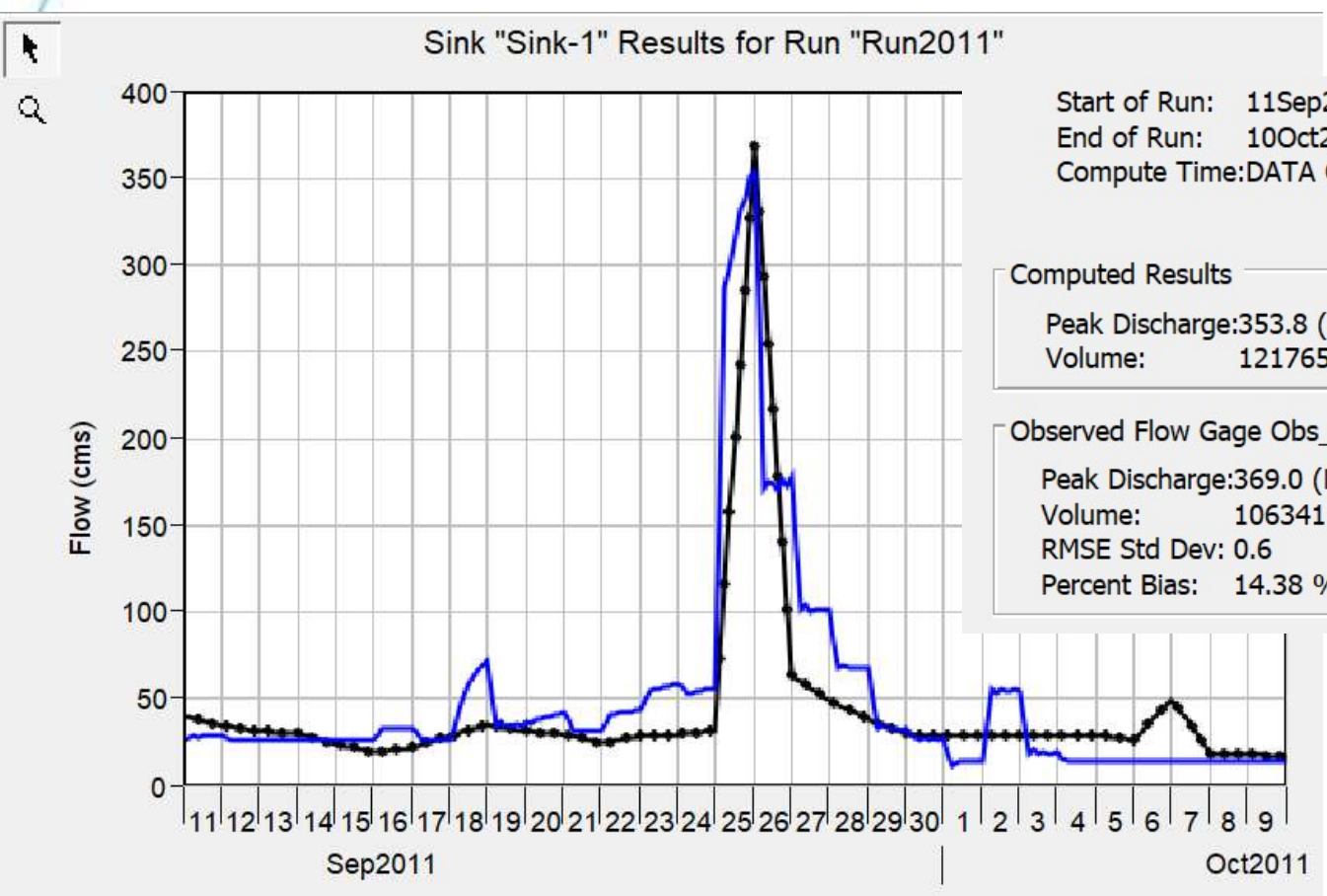
Computed Results

Peak Discharge: 434.0 (M3/S)
Volume: 236923.7 (1000 M3)
Date/Time of Peak Discharge: 09Jul1998, 00:00

Observed Flow Gage Obs_dis_khokana

Peak Discharge: 501.0 (M3/S)
Volume: 172018.1 (1000 M3)
RMSE Std Dev: 0.7
Percent Bias: 37.78 %
Date/Time of Peak Discharge: 09Jul1998, 00:00
Nash-Sutcliffe: 0.459

Validation (Sept. – Oct., 2011)



Start of Run: 11Sep2011, 00:00
End of Run: 10Oct2011, 00:00
Compute Time: DATA CHANGED, RECOMPUTE

Basin Model: Bagmati2011
Meteorologic Model: Met 2002
Control Specifications: Control2011

Volume Units: ○ MM ◉ 1000 M3

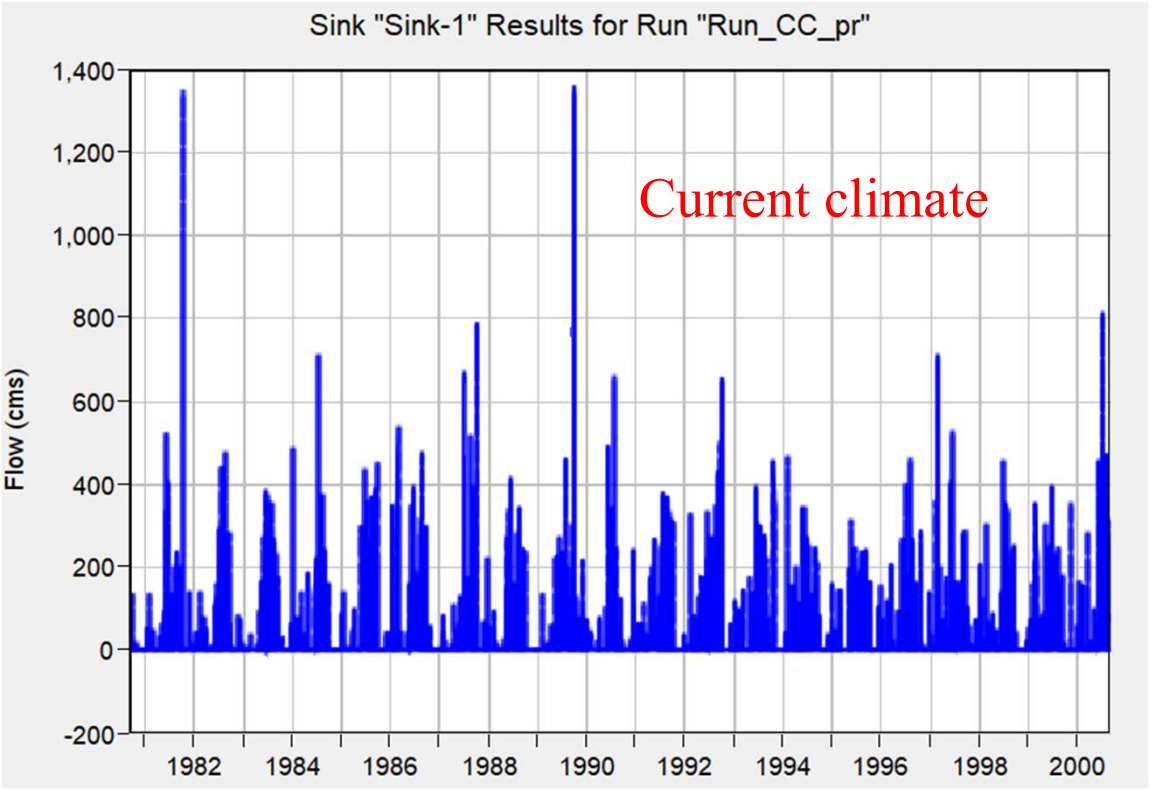
Computed Results

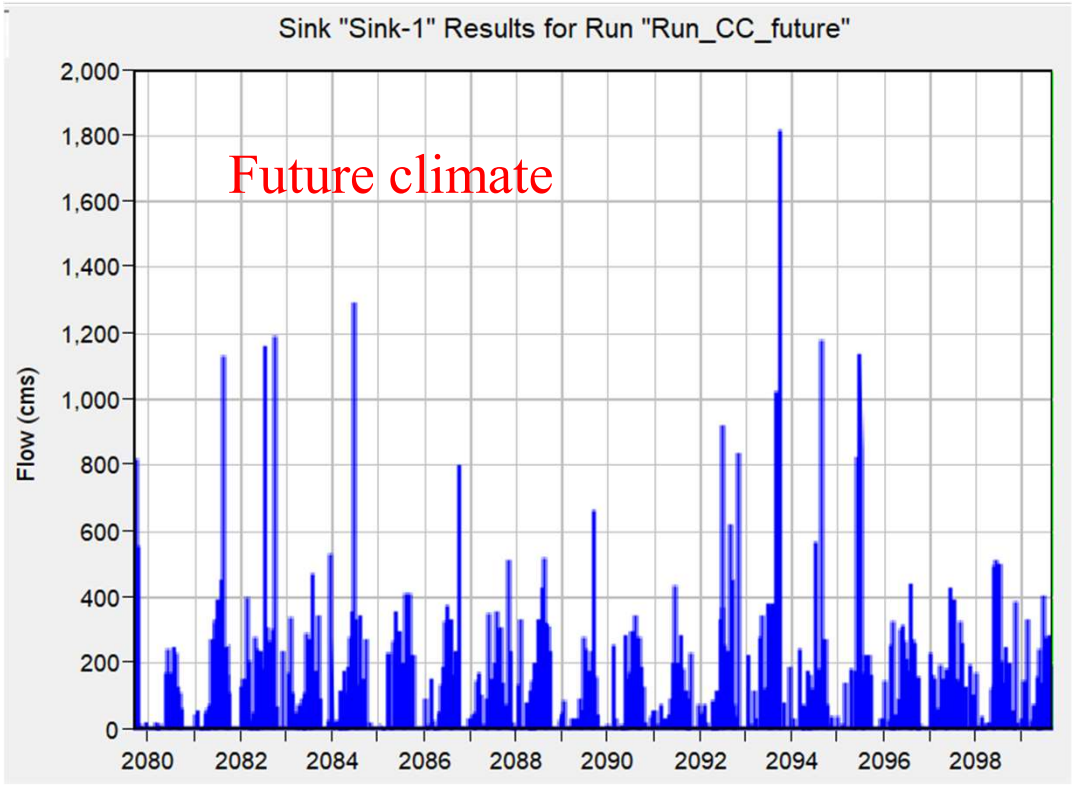
Peak Discharge: 353.8 (M3/S)
Volume: 121765.6 (1000 M3)
Date/Time of Peak Discharge 26Sep2011, 00:00

Observed Flow Gage Obs_dis_khokana

Peak Discharge: 369.0 (M3/S)
Volume: 106341.1 (1000 M3)
RMSE Std Dev: 0.6
Percent Bias: 14.38 %
Date/Time of Peak Discharge: 26Sep2011, 00:00
Nash-Sutcliffe: 0.689

Change in Peak river flow over 1980-2000 and 2080-2100 period

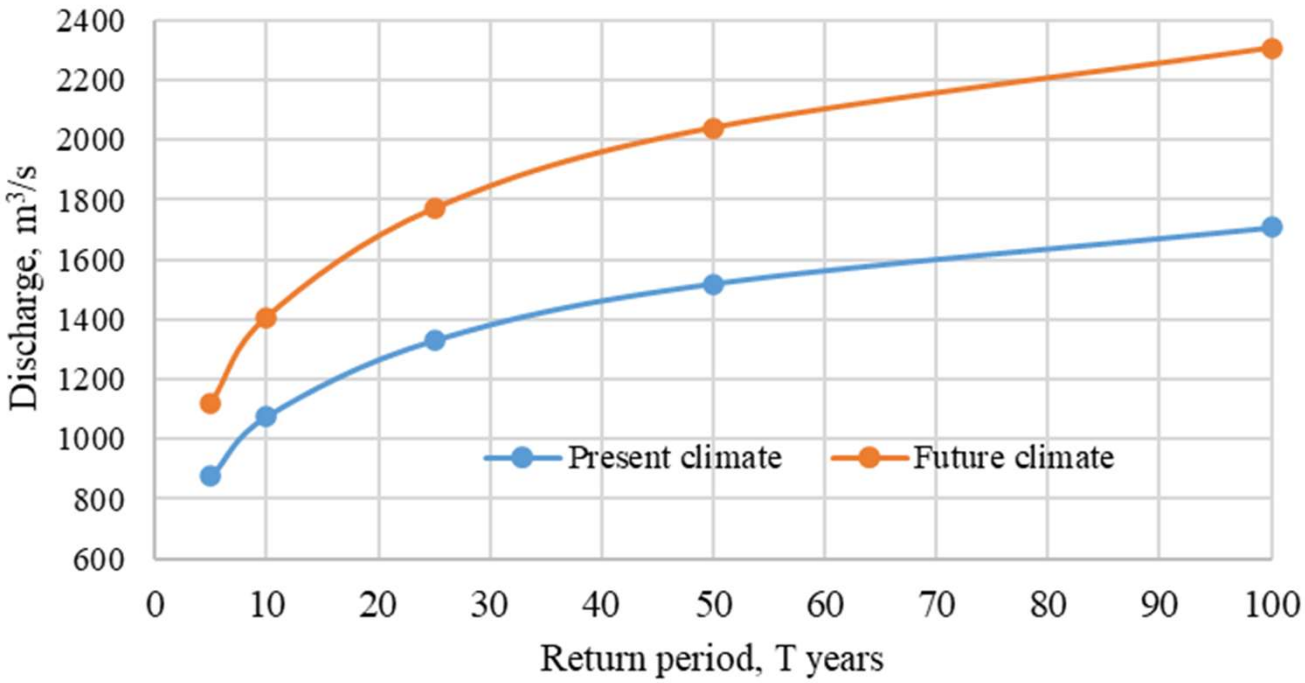




- Greater peaks for future climate condition. Highest discharge for present and future climate conditions was found as 1362 m^3/s and 1818 m^3/s respectively.

Flood-frequency analysis using Gumbel method

Present climate		Future climate	
Year	Q (m^3/s)	Year	Q (m^3/s)
1981	1350.1	2080.0	249.1
1982	479.1	2081.0	1131.7
1983	383.8	2082.0	1189.3
1984	716.6	2083.0	533.6
1985	455.6	2084.0	1294.2
1986	541.8	2085.0	410.4
1987	793.1	2086.0	800.4
1988	415.4	2087.0	510.5
1989	1362.1	2088.0	519.8
1990	663.2	2089.0	665.5
1991	379.6	2090.0	343.7
1992	656.7	2091.0	434.3
1993	460.4	2092.0	920.2
1994	469.2	2093.0	1818.4
1995	317.2	2094.0	1180.6
1996	462.7	2095.0	1140.1
1997	713.0	2096.0	439.4
1998	458.9	2097.0	426.0
1999	397.7	2098.0	511.2
2000	817.3	2099.0	402.0



Return period, T years	Discharge, m^3/s	
	Present climate	Future climate
5	876	1120
10	1077	1408
25	1331	1771
50	1520	2041
100	1707	2308

Conclusive remarks

- Greater precipitation extremes were found for RCM precipitation output. Thus, bias correction is important for better climate change impact assessments.
- The increase in precipitation extremes for future climate condition resulted larger flood risks in Kathmandu valley.