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Potential impacts of warming climate on future water resources and hydropower production in a glacierized catchment in Western Himalaya

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Materials from Shirsat et al. (2021)

❑ Study Area

Study Area: 3 MW Aleo-1 and 4.8 MW Aleo-2 Power projects near Manali

Meteorological station: Bhuntar

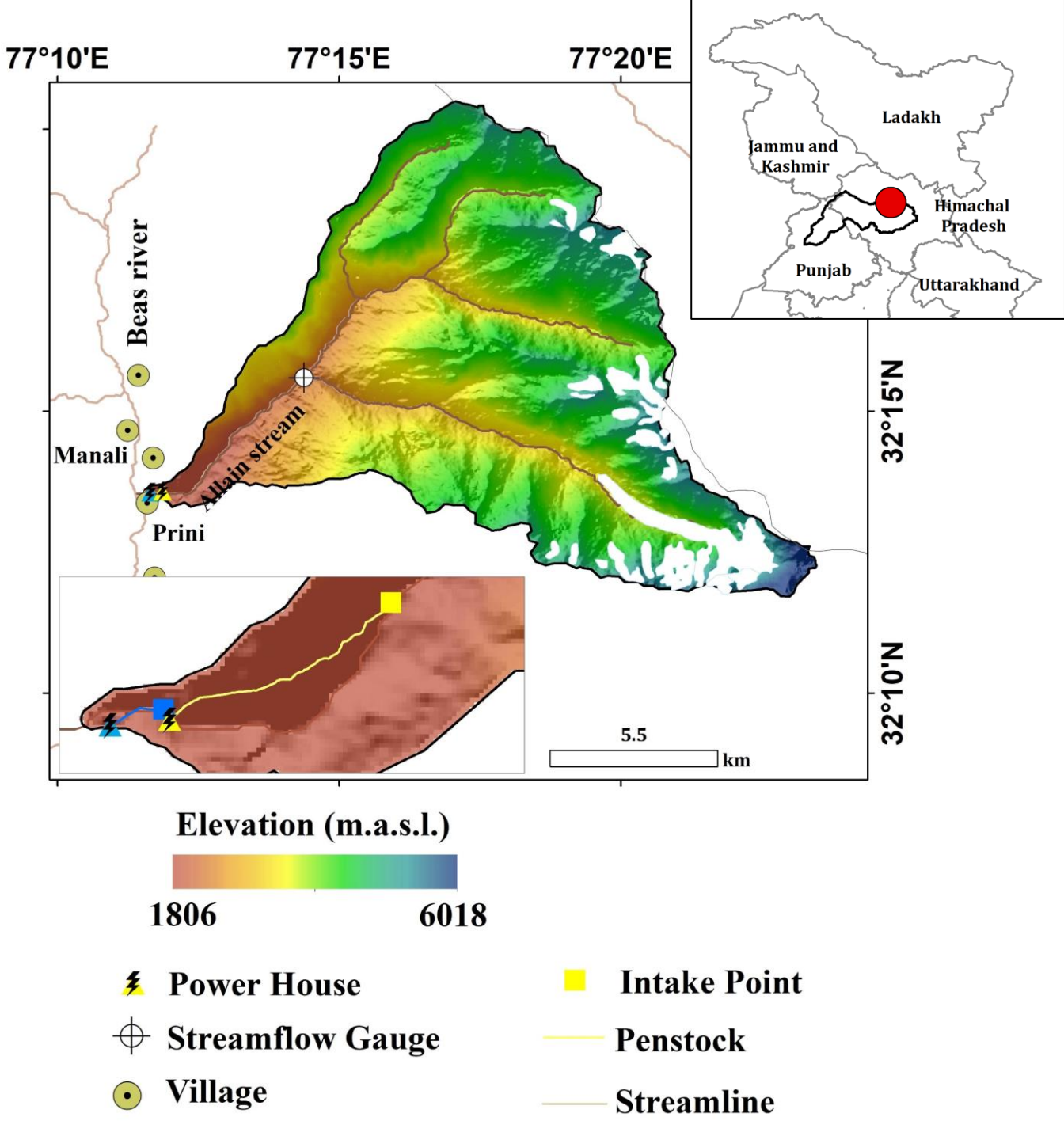
Precipitation Regime: Equal contribution of westerlies and Indian Summer Monsoon

Catchment area: 140.3 km^2

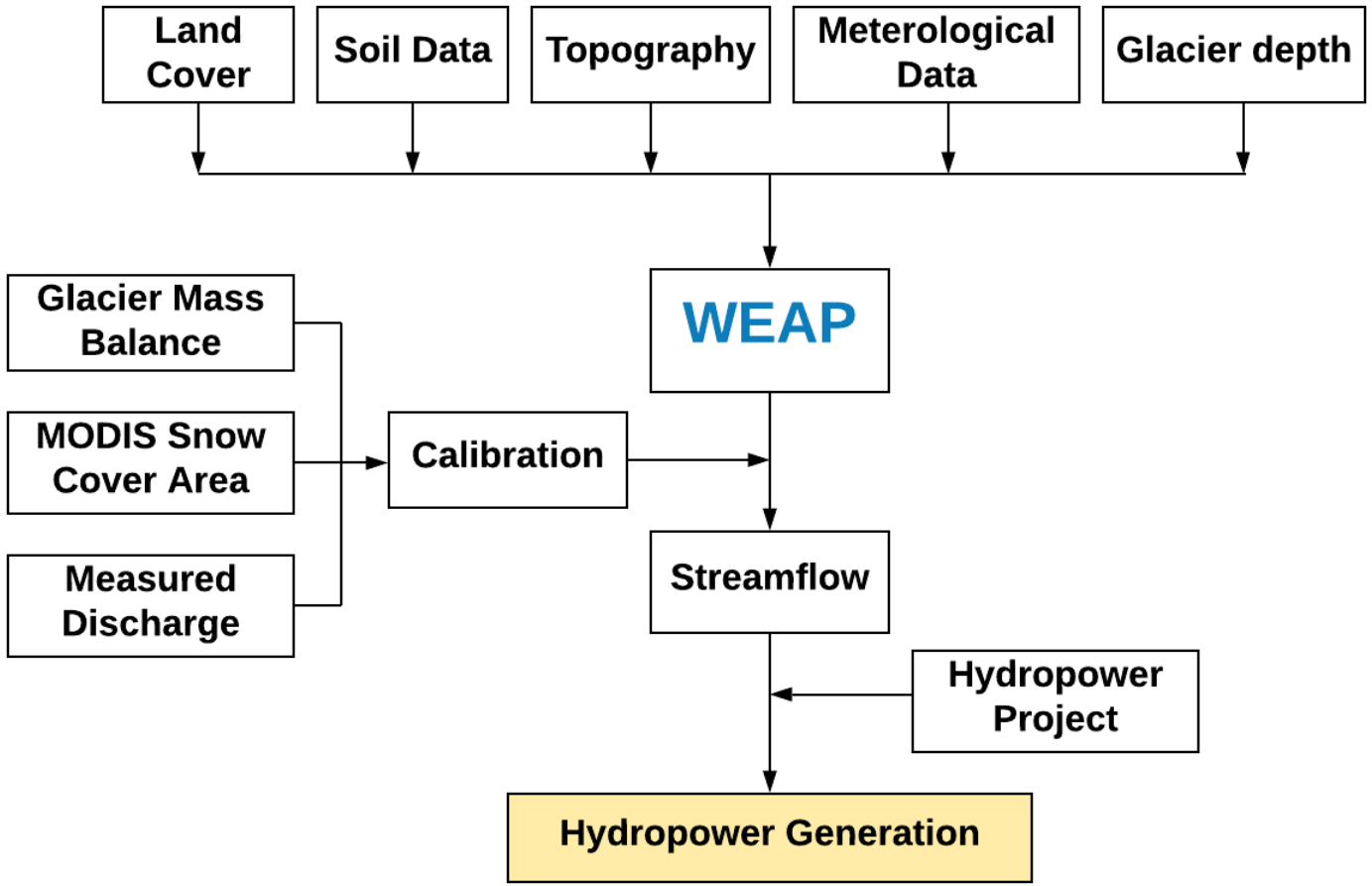
Altitudinal Variation: 1806-6018 m

Glacier area: 10.9 km^2

Mean annual SCA: 64%



❑ Data and Methodology



Water Evaluation and Planning (WEAP) model
www.weap21.org

Meteorological Station: Bhuntar

Satellite data:

ASTER DEM, MODIS SCA,

INSAT Cloud mask, Global land cover 30,

NASA SSE Wind speed and relative humidity at 2m,

Harmonized world soil database, RGI

Model Setup: Historical- 1984-2018

Future- 2041-2060, 2081-2100

Climate Projections:

Ensembles of 5 Global climate models in RCP4.5 and 8.5

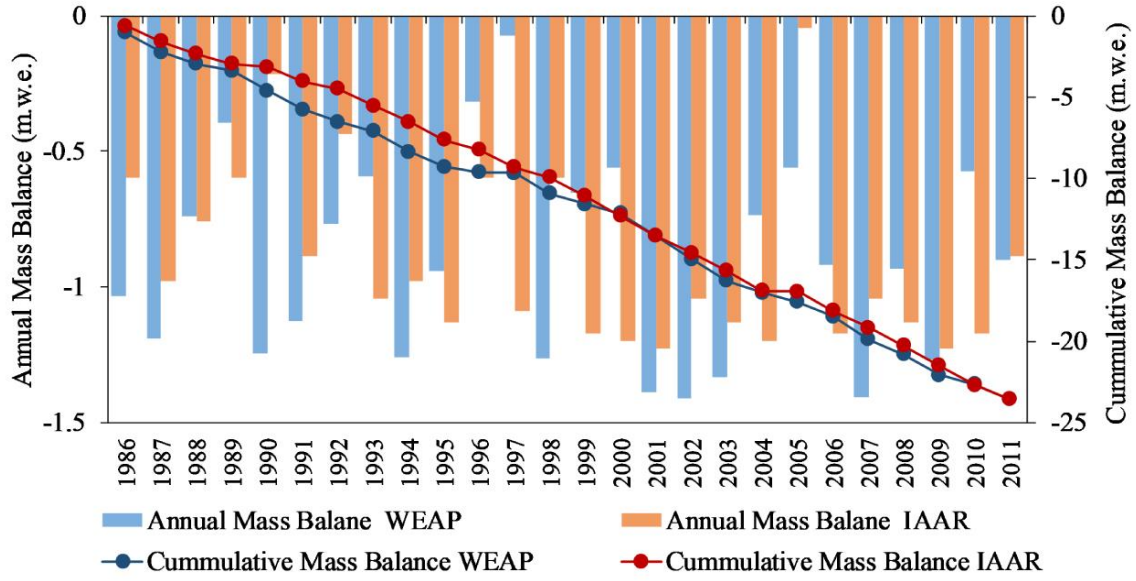
INMCM4, CanESM2, IPSL-CM5A-LR, GFDL-CM3 and MIROC5

❑ Model calibration and validation

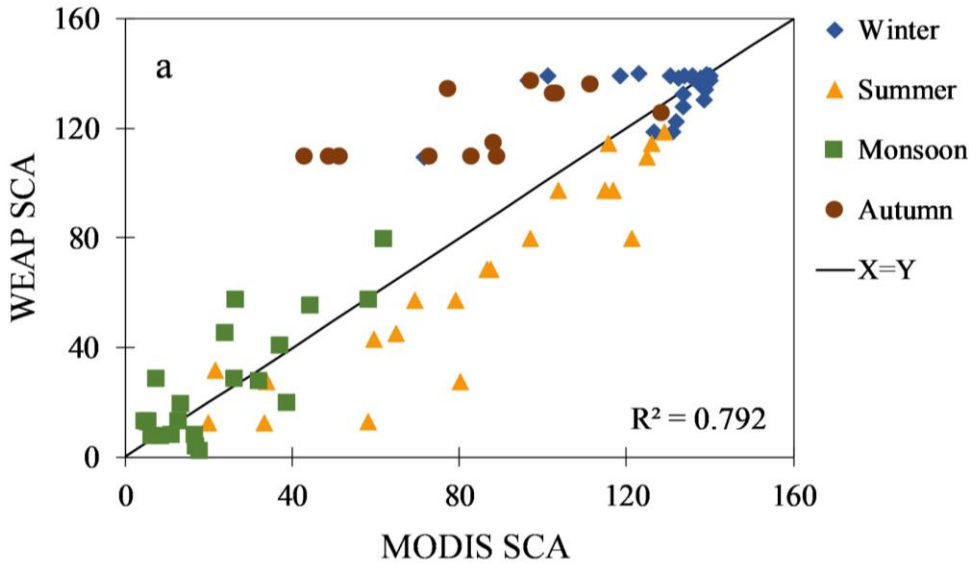
1. Glacier mass balance

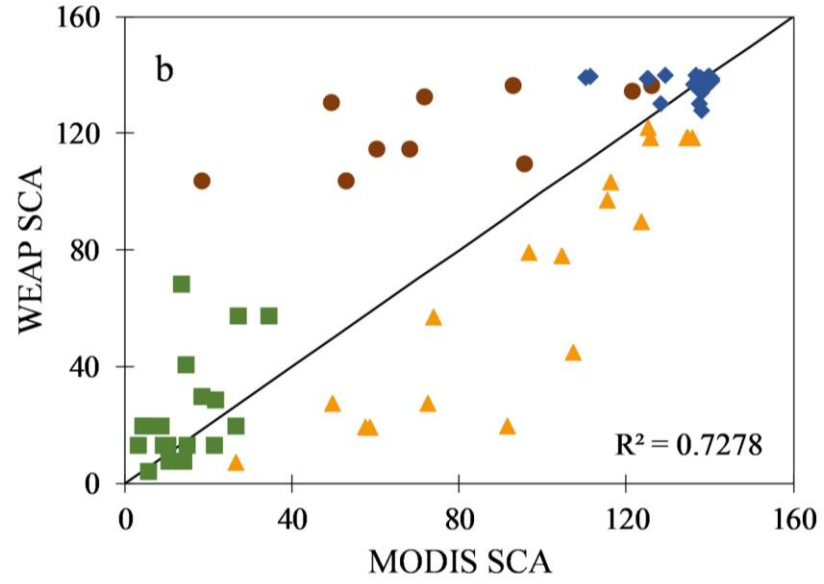
Calibration
Mass loss WEAP
-12.2 mwe
Mass loss IAAR
-12.3 mwe

Validation
Mass loss WEAP
-11.4 mwe
Mass loss IAAR
-11.3 mwe



2. MODIS Snow Cover Area





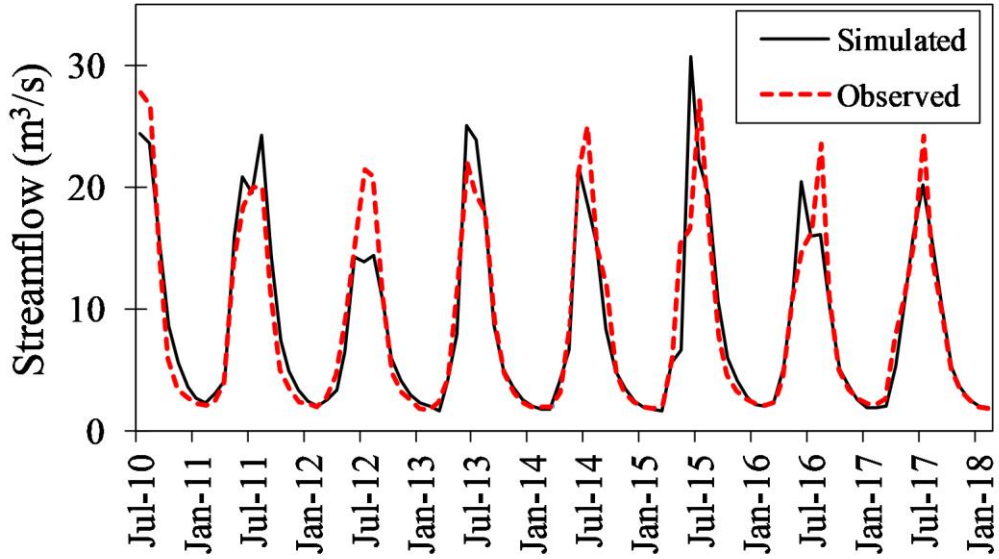
3. Measured discharge

NSEc= 0.84

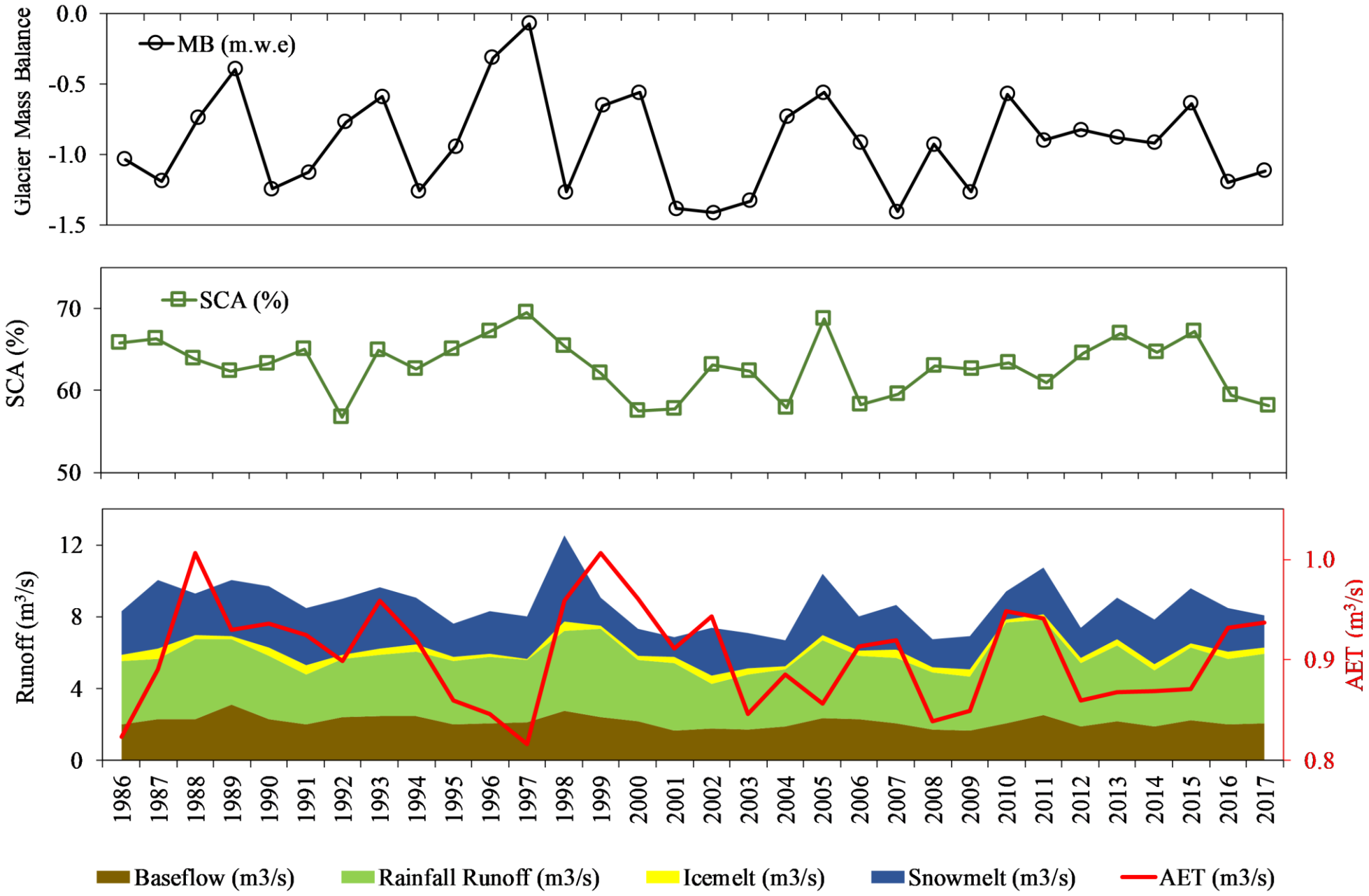
NSEv= 0.82

PBIASc= -0.31

PBIASv= -1.13

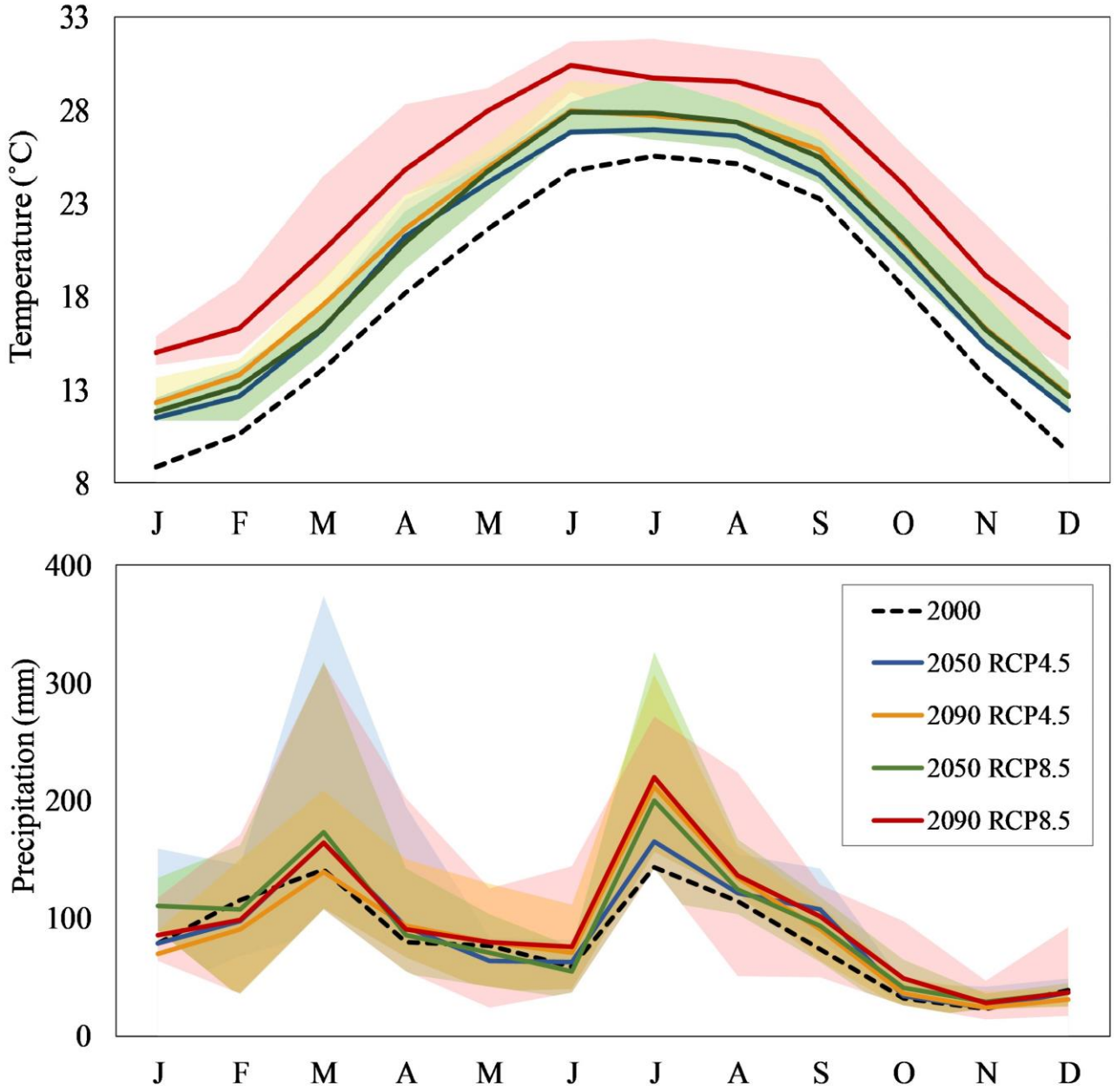


❑ Results: Hydrological Regime



- Contribution of snow and glacier melt= **18-44**%
- Contribution:
  Rainfall runoff (43%)
  Snowmelt (28.3%)
  Glacier melt (3.8%)
  Baseflow (25%)
- Positive correlation of precipitation and streamflow
- Low flow years= high glacier melt

❑ Results: Climate change scenarios



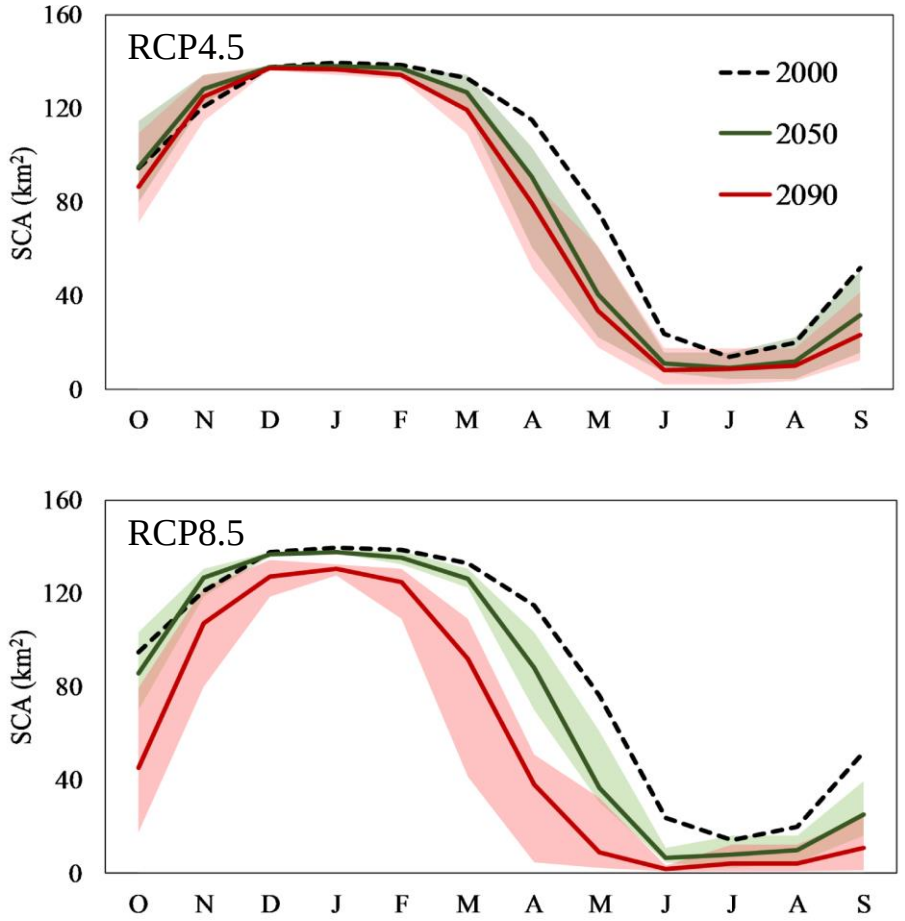
RCP 4.5	2041-2060	2081-2100
temperature change(°C)	1.2 - 2.9	1.6 - 3.8
precipitation change(%)	-10.8 - 36.3	-4.1 – 23.1

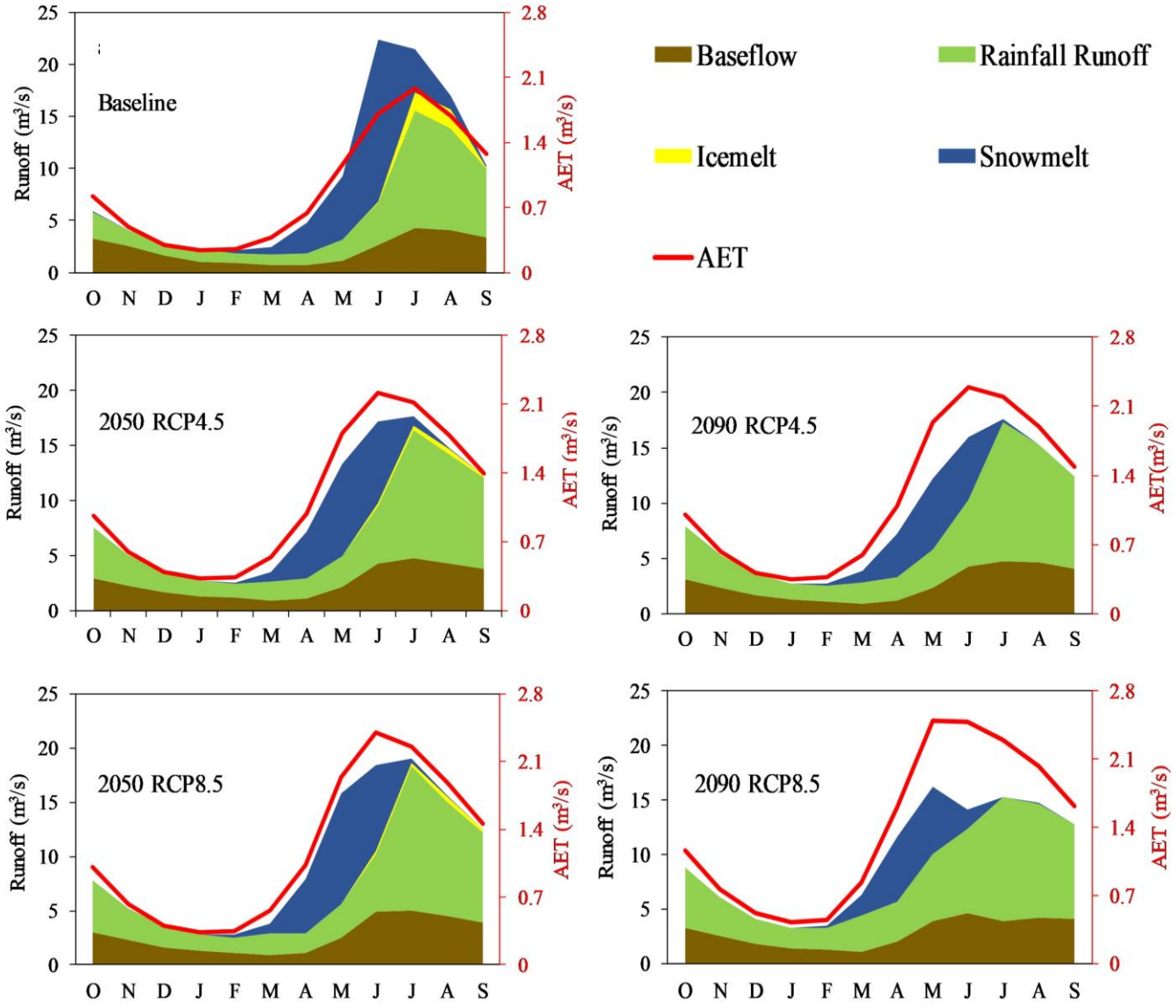
RCP 8.5	2041-2060	2081-2100
temperature change (°C)	1.7-3.5	4.2-7.6
precipitation change (%)	3.1-22.3	-10.3 – 56.3

Baseline for climate projections: 1986-2005

❑ Results: Future Hydrological Change

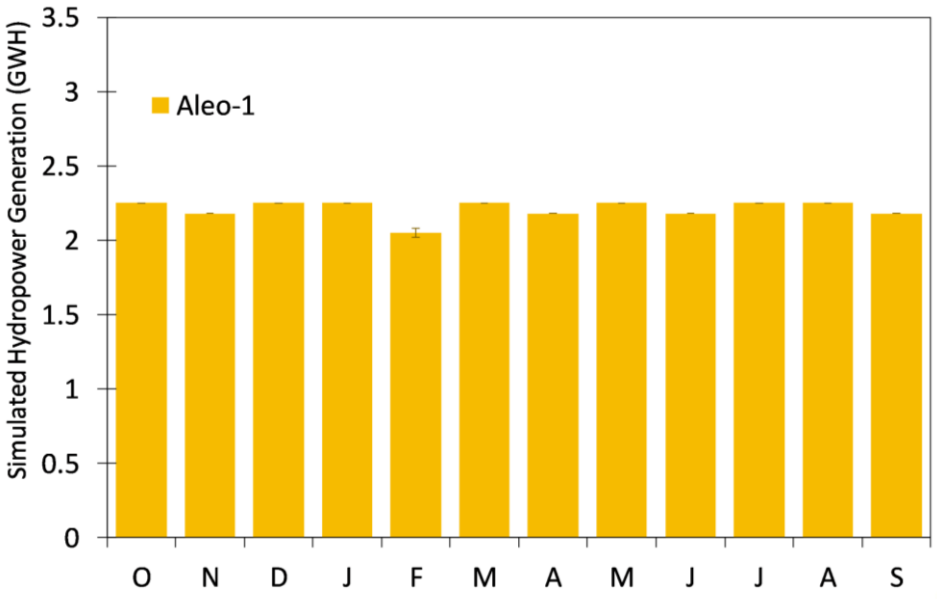
Glaciers lose about 83-86% of the mass by 2050 and disappear entirely by 2090
MB in baseline: -0.88
MB in 2050 (RCP4.5): -1.22 to -1.55
MB in 2050 (RCP8.5): -1.24 to -1.62



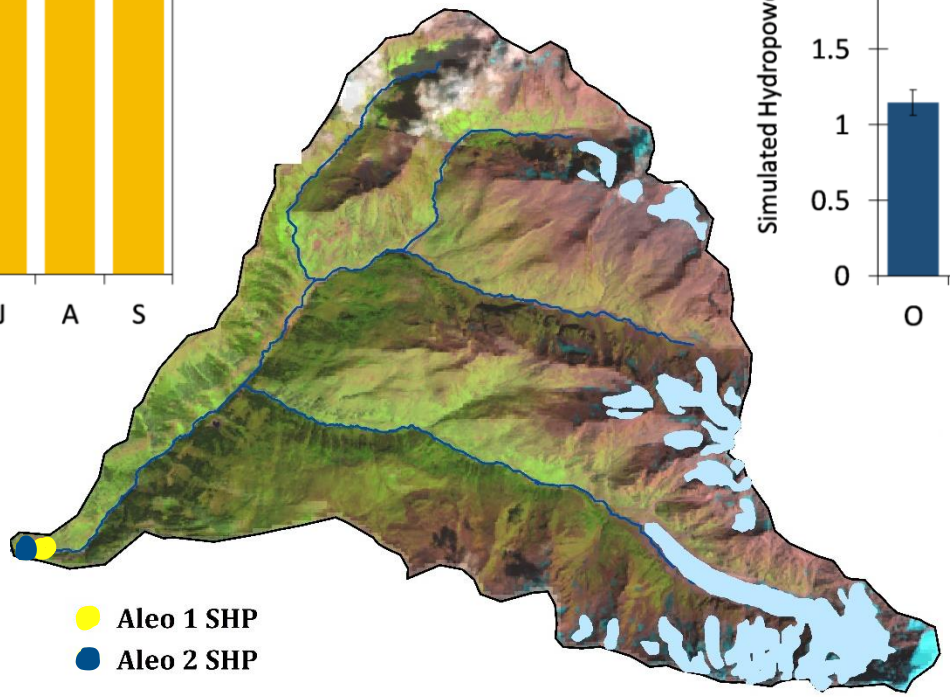


❑ Results: Present Hydropower Production

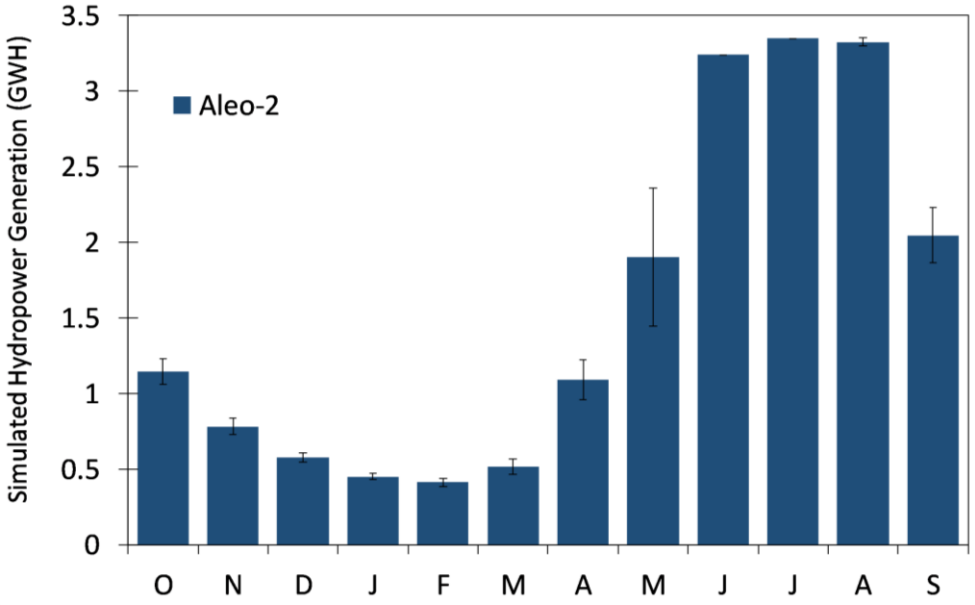
Aleo-1
Installed capacity: 3MW
Net Head: 290.4 m
Designed Discharge: 1.33 cumec



Annual Hydropower Generation:
26.54 GWh



Aleo-2
Installed capacity: 4.8 MW
Net Head: 36.3 m
Designed Discharge: 15.8 cumec



Annual Hydropower Generation:
18.83 GWh

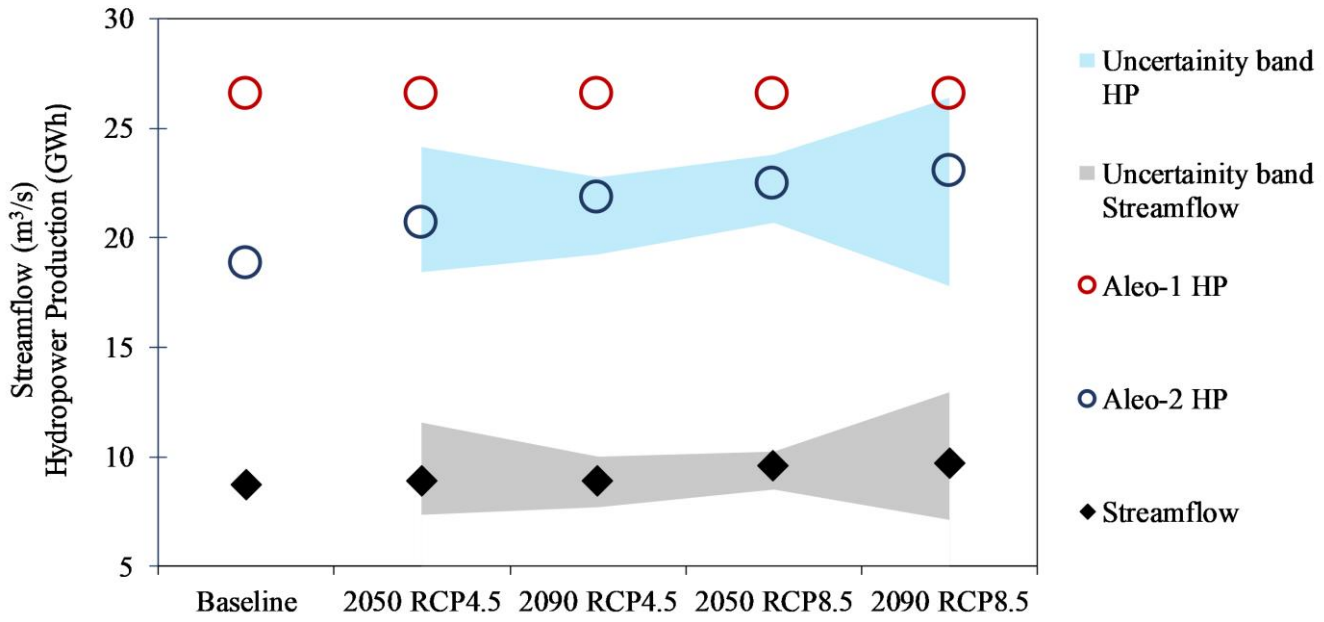
❑ Results: Future Hydropower Production

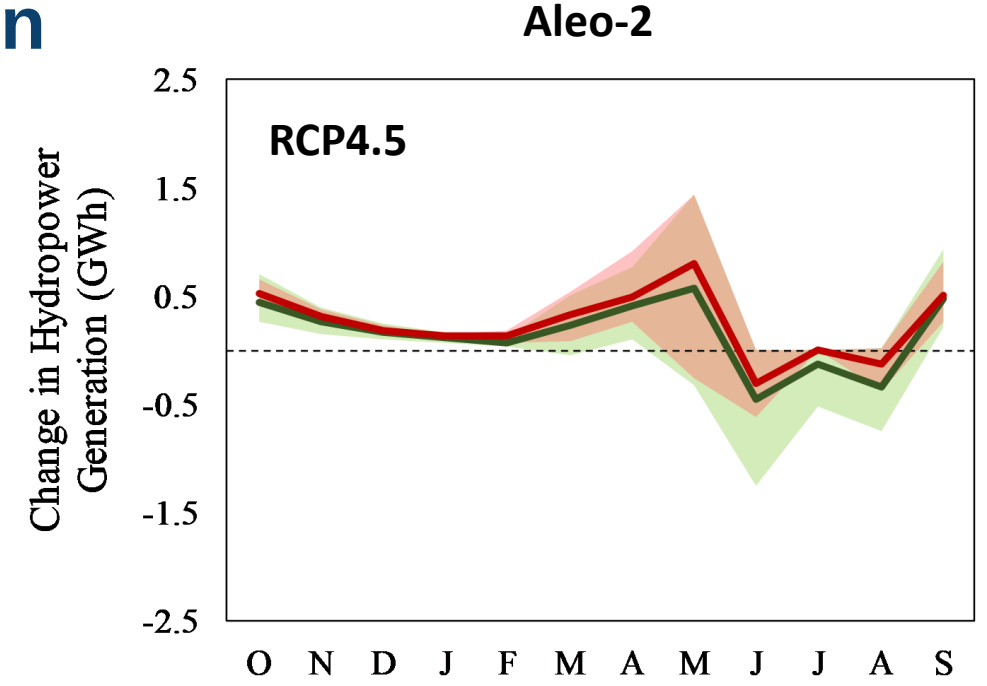
The total streamflow in the future has broad uncertainty in magnitude and direction

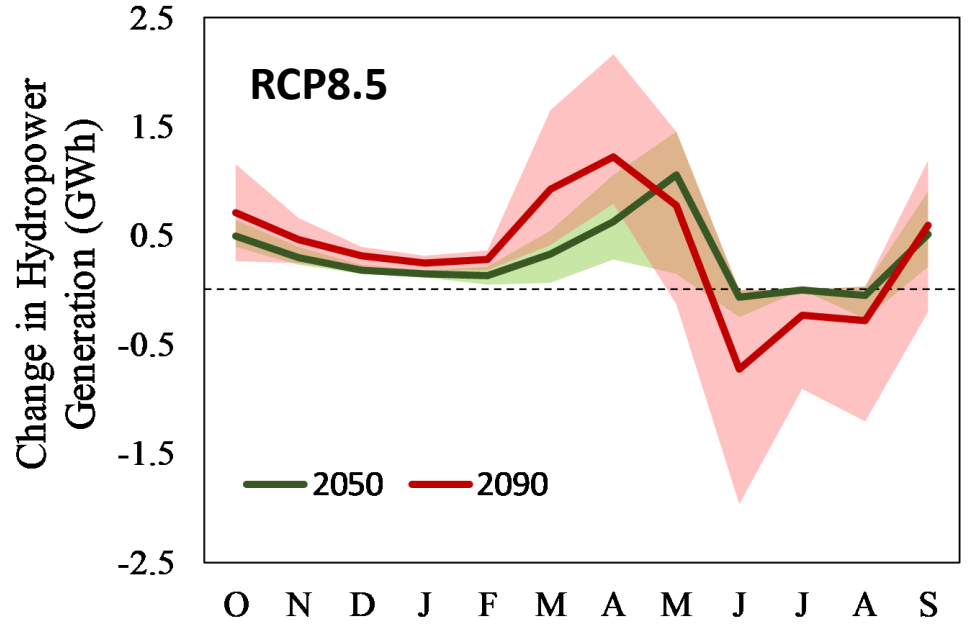
Differing sensitivity of the two power projects to climate change

Aleo-1 power production is unaffected by climate-change induced changes

Aleo-2 annual power production changes by 2 to 21% (RCP4.5) and -5 to 40% (RCP8.5) by the end of the century







❑ Conclusion

- **While there is a steady temperature increase in all climate change scenarios, future precipitation is more uncertain**
- **Uncertainty in climate change projections is significant and should be accounted in robust decision making**
- **The simulated streamflow shows complex relationships between the hydrological response and the future climate with broad uncertainty in the magnitude and direction.**
- **A shift in the seasonality (increased power potential of low flows) is prominent in all the climate change scenarios**
- **Future hydropower generation will be influenced by both future runoff and plant design**
- **Climate-adaptive designs and planning of small hydropower projects in Himalaya to achieve energy security**


Western Himalaya, 2017 (PC- Pradeep Srinivasalu)









Thank you for your interest!

Shirsat, T. S., Kulkarni, A. V., Momblanch, A., Randhawa, S. S., & Holman, I. P. (2021). Towards climate-adaptive development of small hydropower projects in Himalaya: A multi-model assessment in upper Beas basin. Journal of Hydrology: Regional Studies, 34, 100797.

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