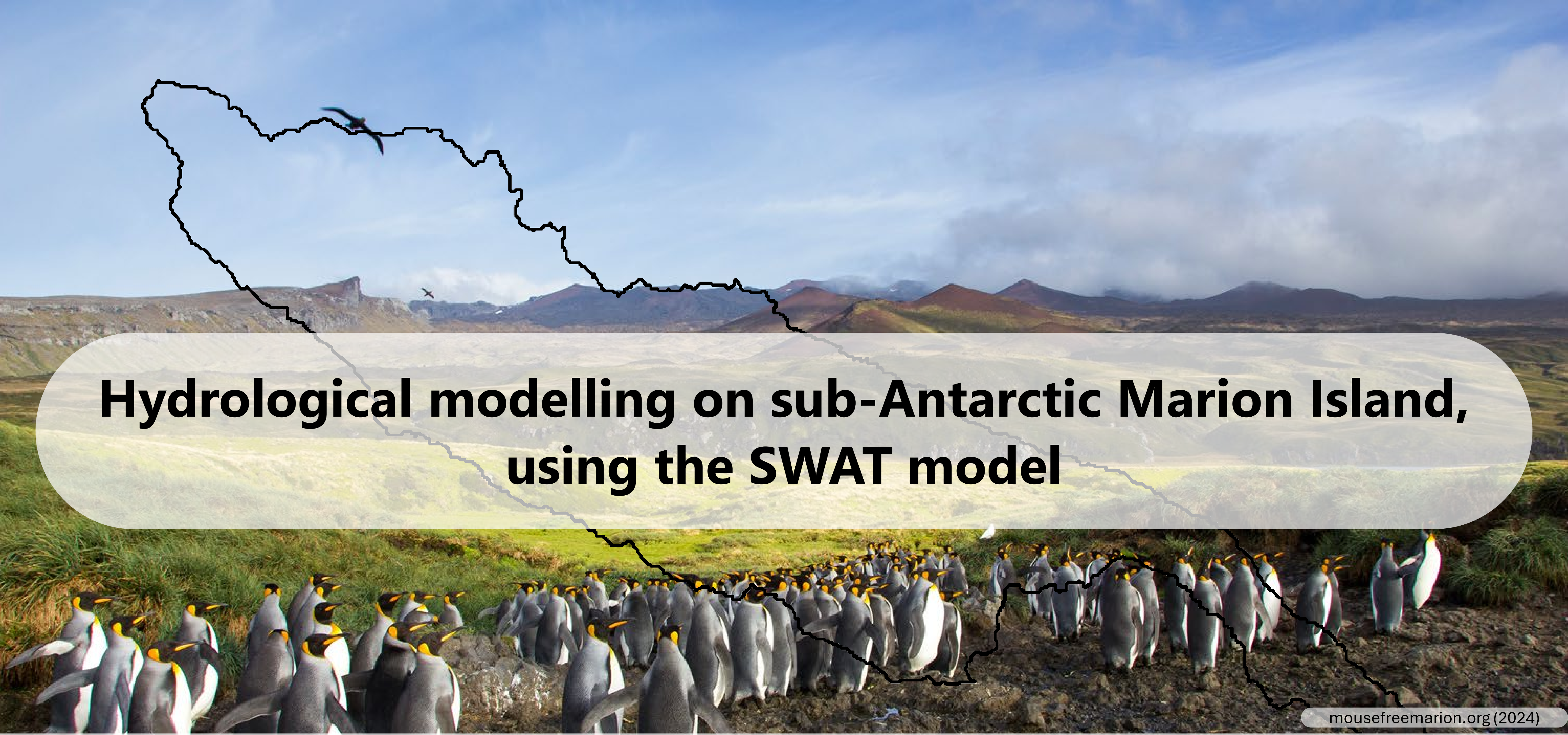

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Hydrological modelling on sub-Antarctic Marion Island, using the SWAT model

Colby Leigh Weiss - (colbyweiss101@gmail.com)

Supervisor: Prof J. J. le Roux

Co-supervisors: Dr E. M. Rudolph & Prof D. W. Hedding

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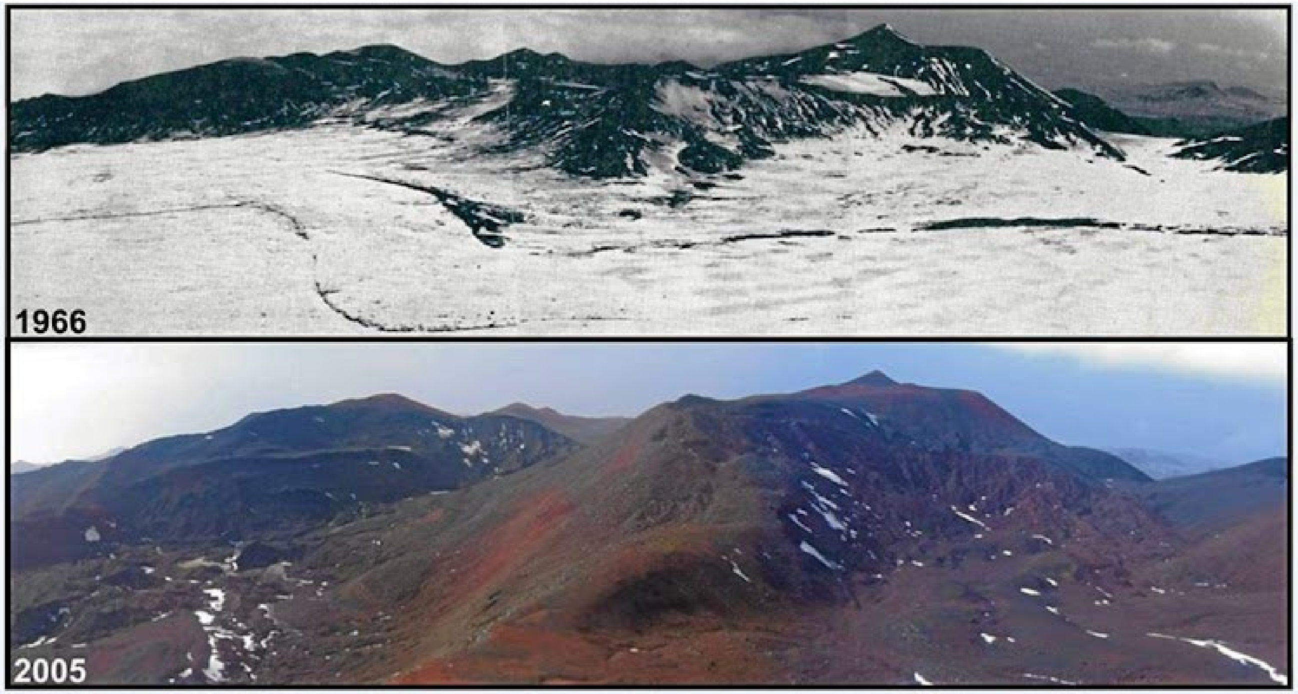
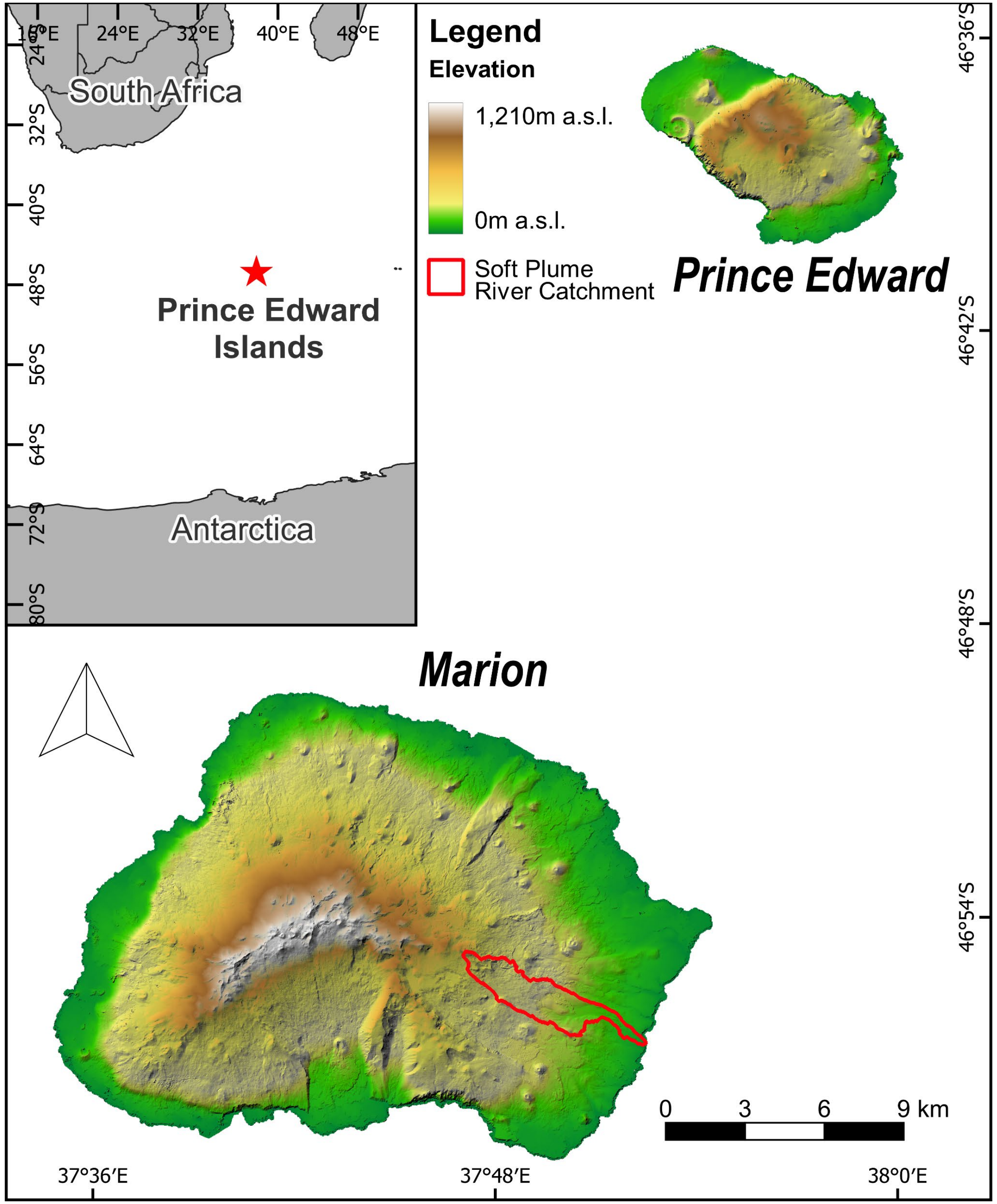
Introduction

- Impacted greatly by climate change
  - Decrease in precipitation (Hedding *et al.*, 2015)
  - Increase in temperature (Smith, 2002; Nel *et al.*, 2023)





Introduction

- Climate Change → affect hydrology → natural ecosystems
- No previous studies on the hydrology - leaves a chasm of unknown
- Possibility to predict future hydrological changes

Possible hydrological impacts associated with climate change:
- Streamflow
- Groundwater recharge
- Nutrient & sediment migration
- Evapotranspiration

Vegetation die back
and mire lake dry out

Research Aim and Objectives

AIM:

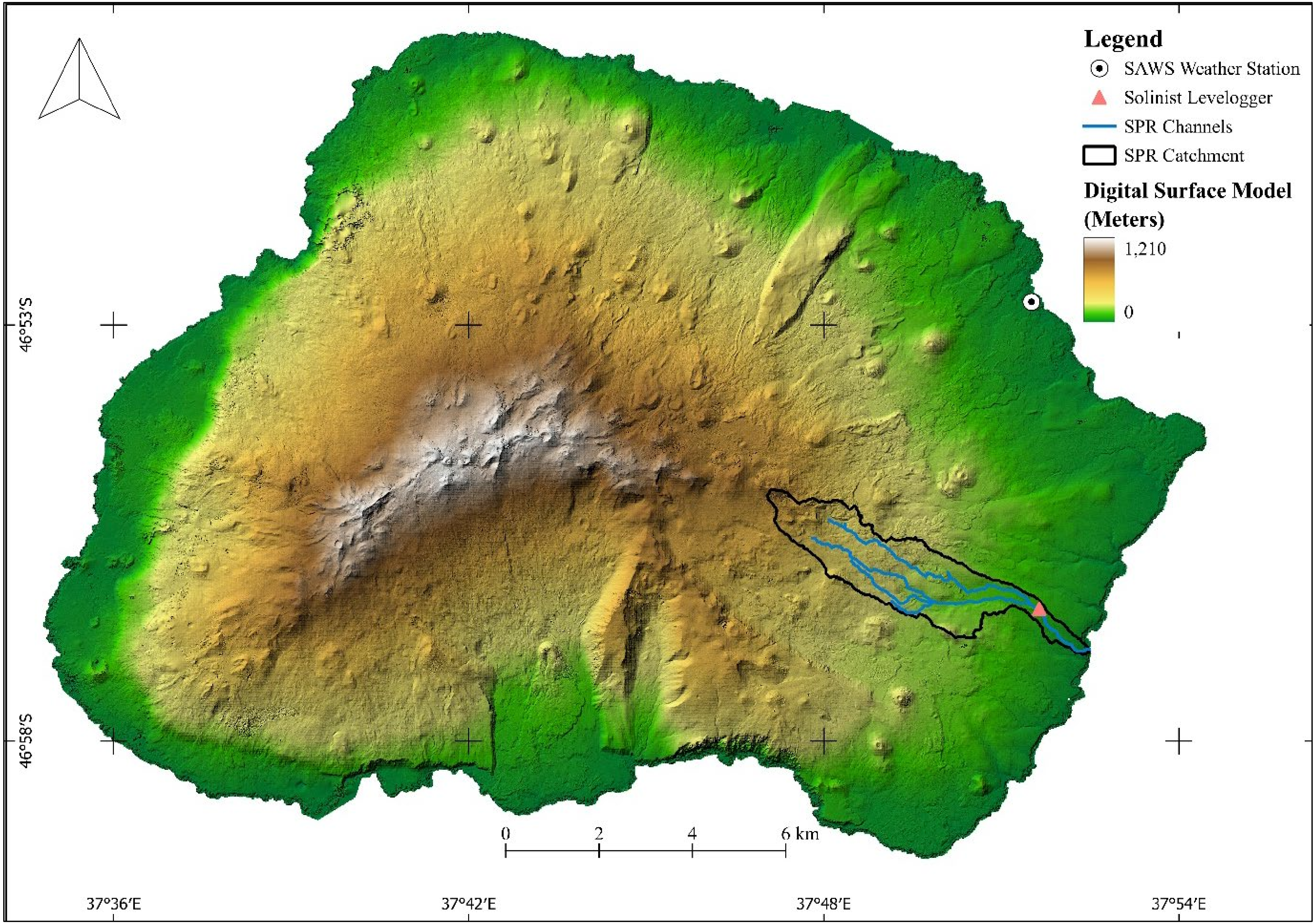
- Hydrologically model the Soft Plume River catchment on Marion Island using the SWAT+ model and provide a prediction for future hydrology under a climate change scenario.

Three objectives:

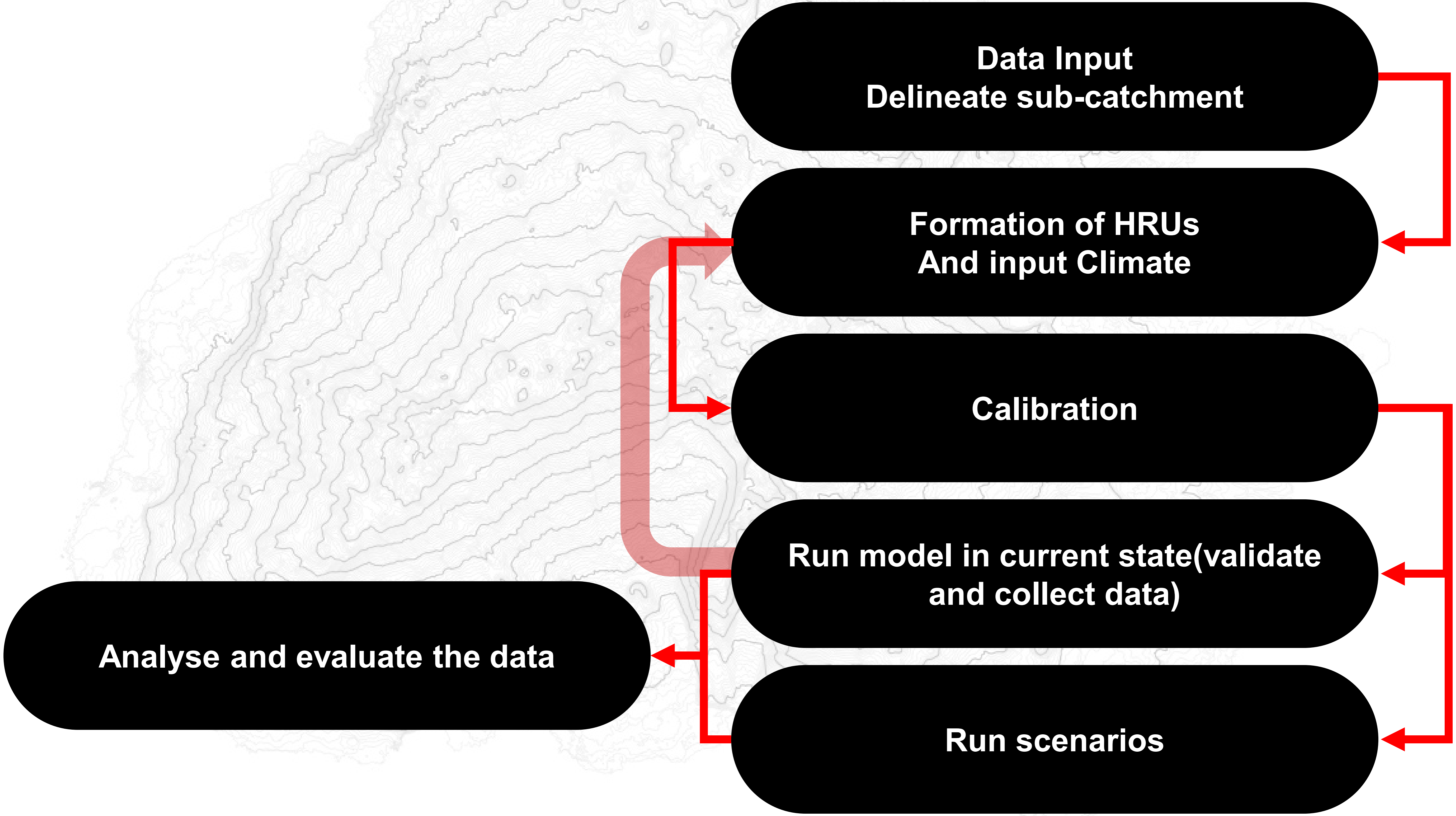
1. Hydrologically model the Soft Plume River catchment on Marion Island in the sub-Antarctic, using the SWAT model.
2. Calibrate and validate the hydrological model, using the available streamflow data.
3. Model a climate change scenario on the Soft Plume River catchment using a selected climate model from the Coupled Model Intercomparison Project Phase Six (CMIP6) to determine the possible effects that future climate change may have on the catchment's hydrology.

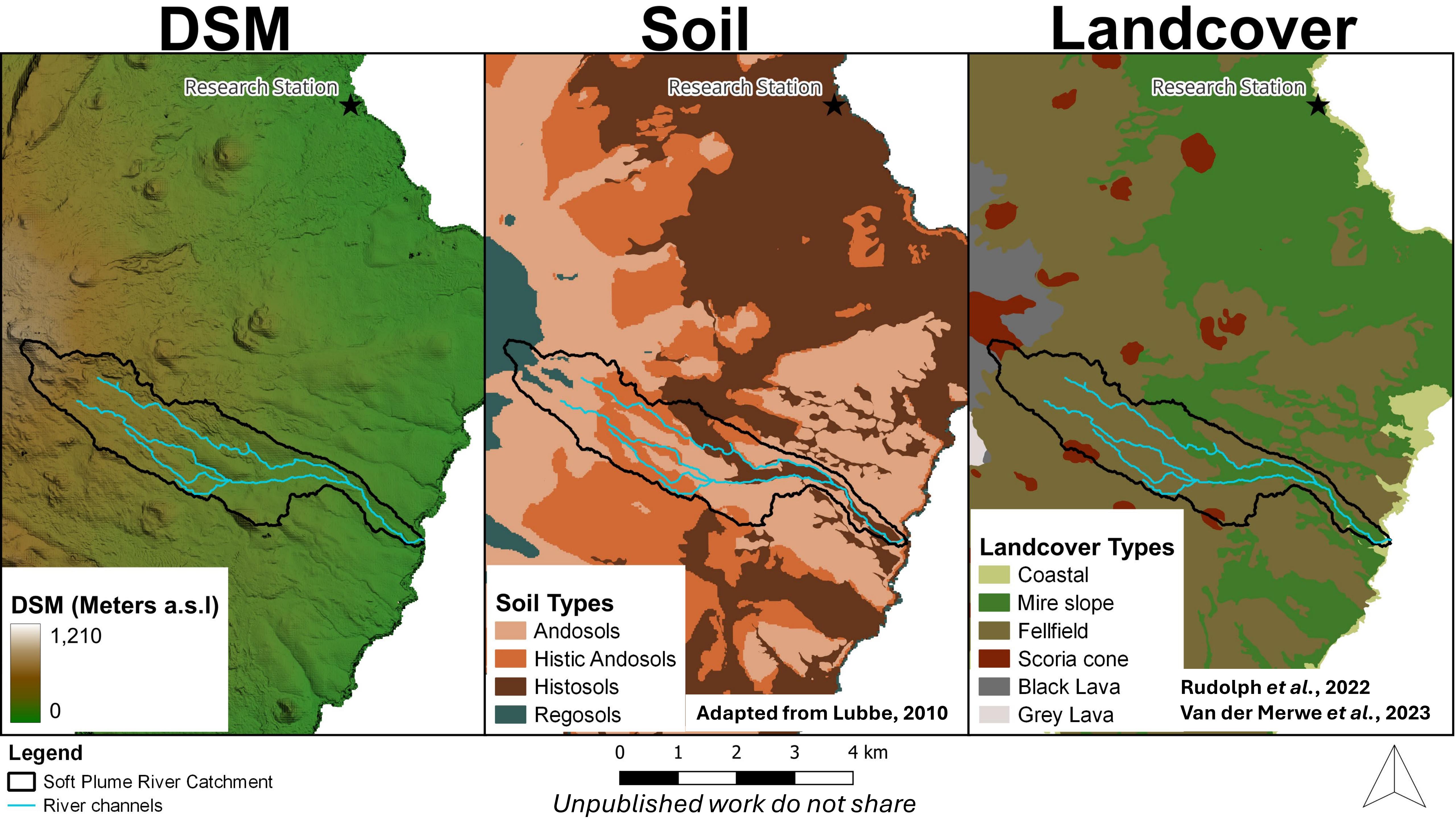
Study Site

- 740ha
- Grey & black lava & scoria cones
- Only perennial river on MI
- 650 m.a.s.l. – 10 m.a.s.l.
- 1865mm



Methodology - Data





DSM
Soil
Landcover
Research Station
Research Station
Research Station
DSM (Meters a.s.l)
1,210
0
Soil Types
Andosols
Histic Andosols
Histosols
Regosols
Adapted from Lubbe, 2010
Landcover Types
Coastal
Mire slope
Fellfield
Scoria cone
Black Lava
Grey Lava
Rudolph et al., 2022
Van der Merwe et al., 2023
Legend
Soft Plume River Catchment
River channels
0 1 2 3 4 km
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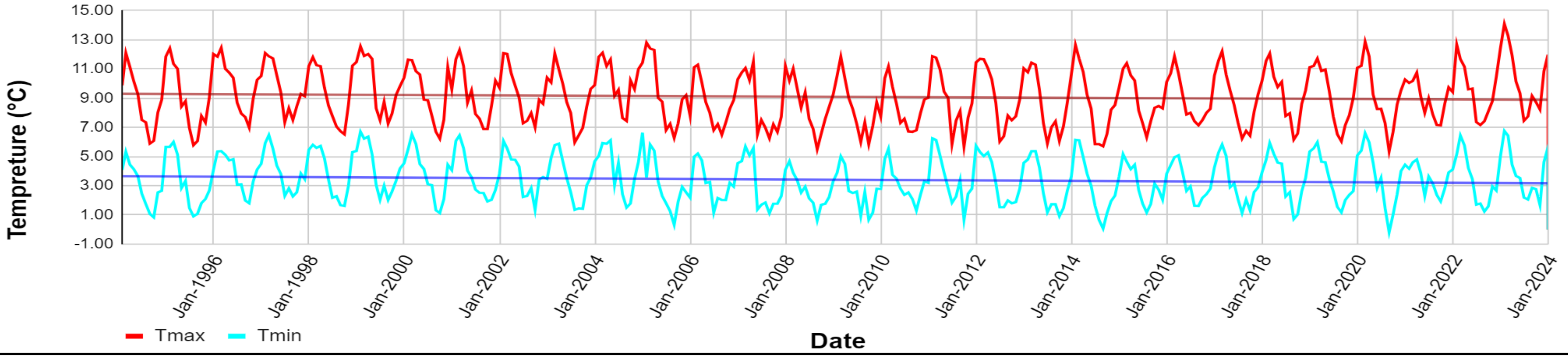
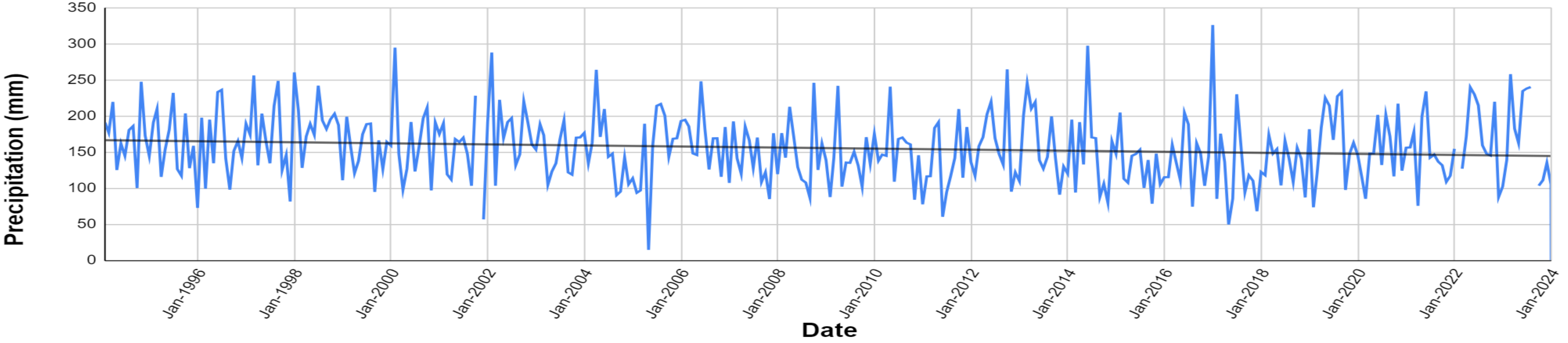
Meteorological Data





Wind speed, humidity, and solar radiation

Objective 2

Calibration

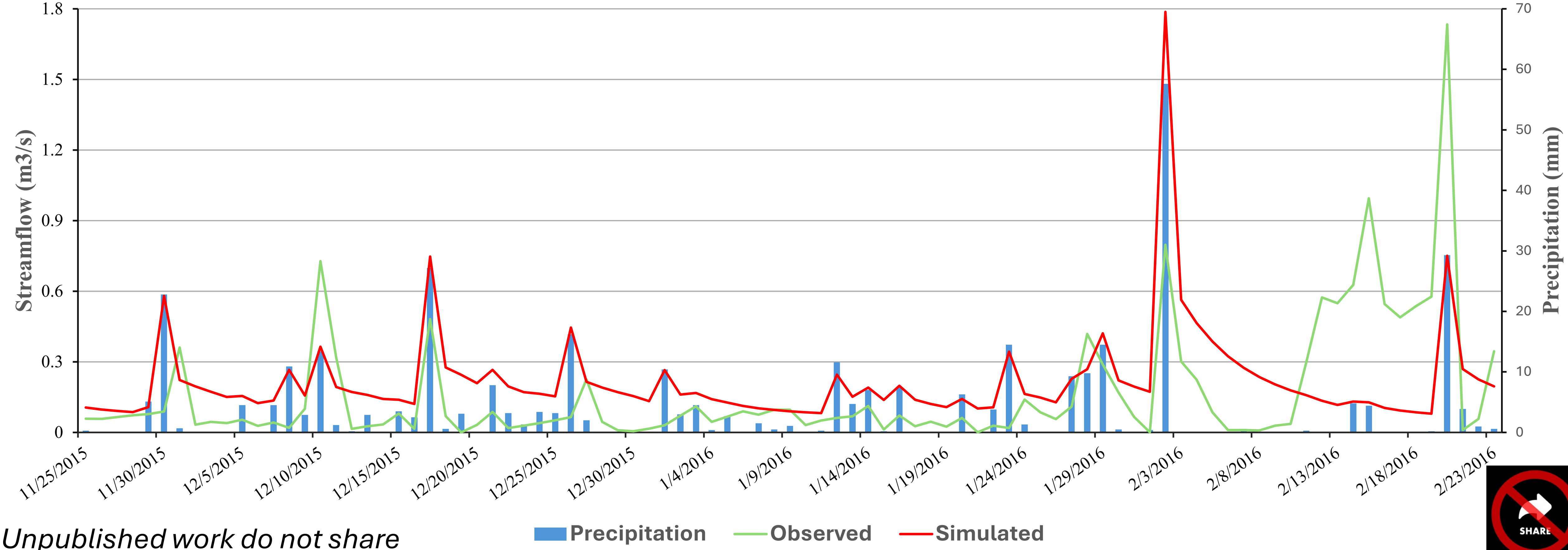
25th November 2015 → 23rd February 2016

Model preformed poorly to average

- **NSE = 0.17 = Poor**
- **KGE = 0.28 = Good**

Parameters Altered:

- Curve Number
- Soil saturation level
- Min level of GW when flow from aquifer occurs
- Soil evaporation coefficient



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Objective 2

Validation

3rd May 2016 → 4th July 2016

Model preformed poorly to average during validation

- **NSE = 0.13 = Poor**
- **KGE = 0.29 = Good**

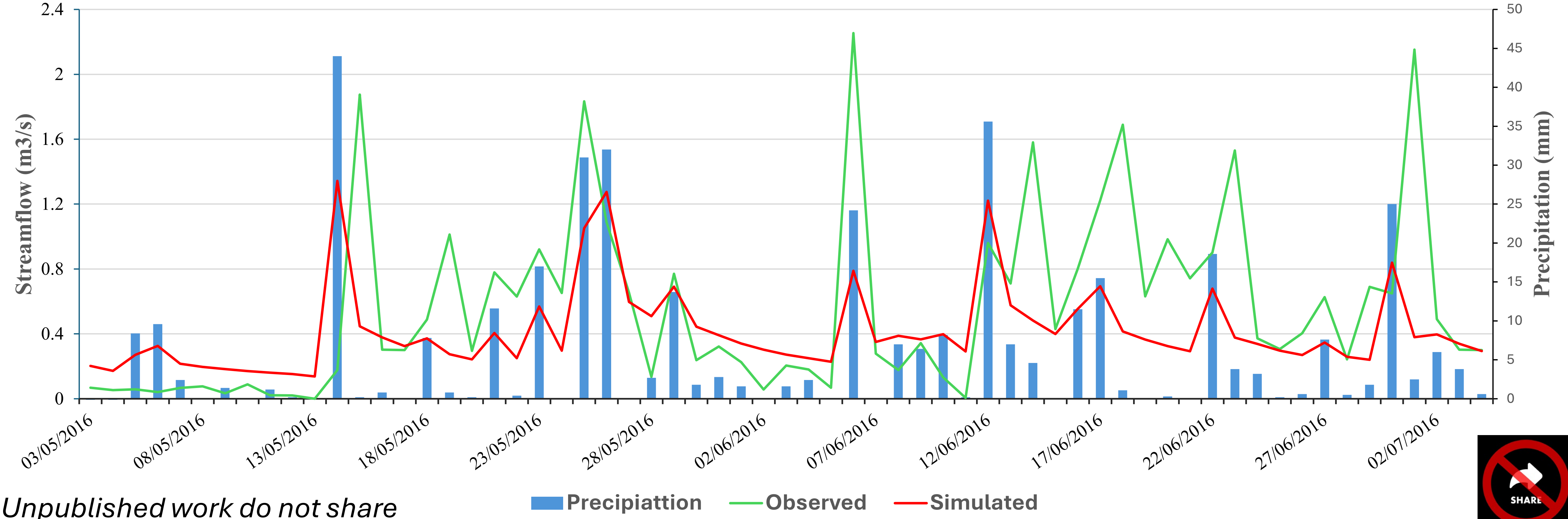

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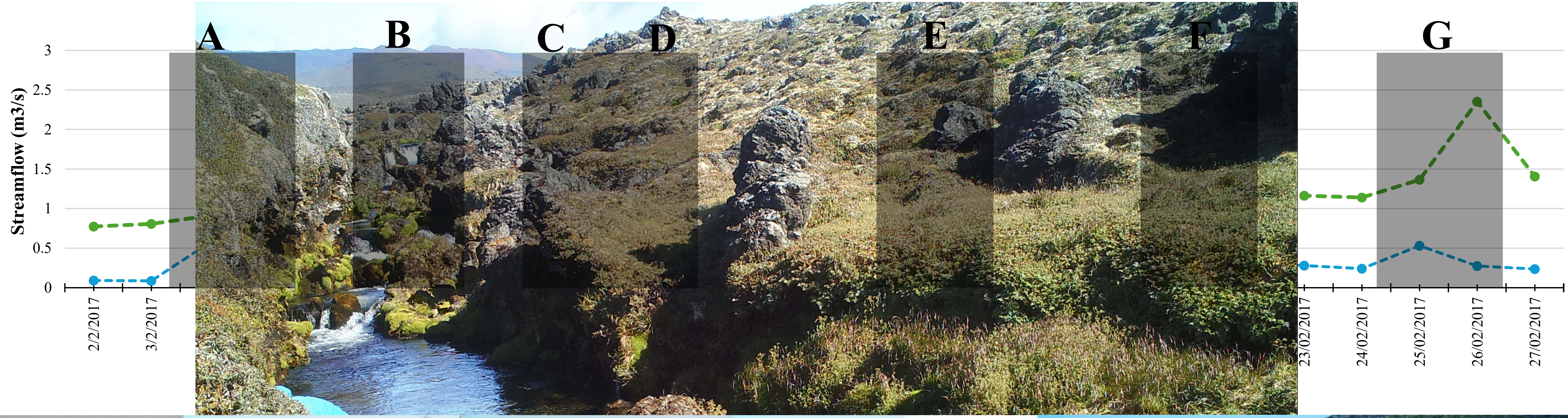
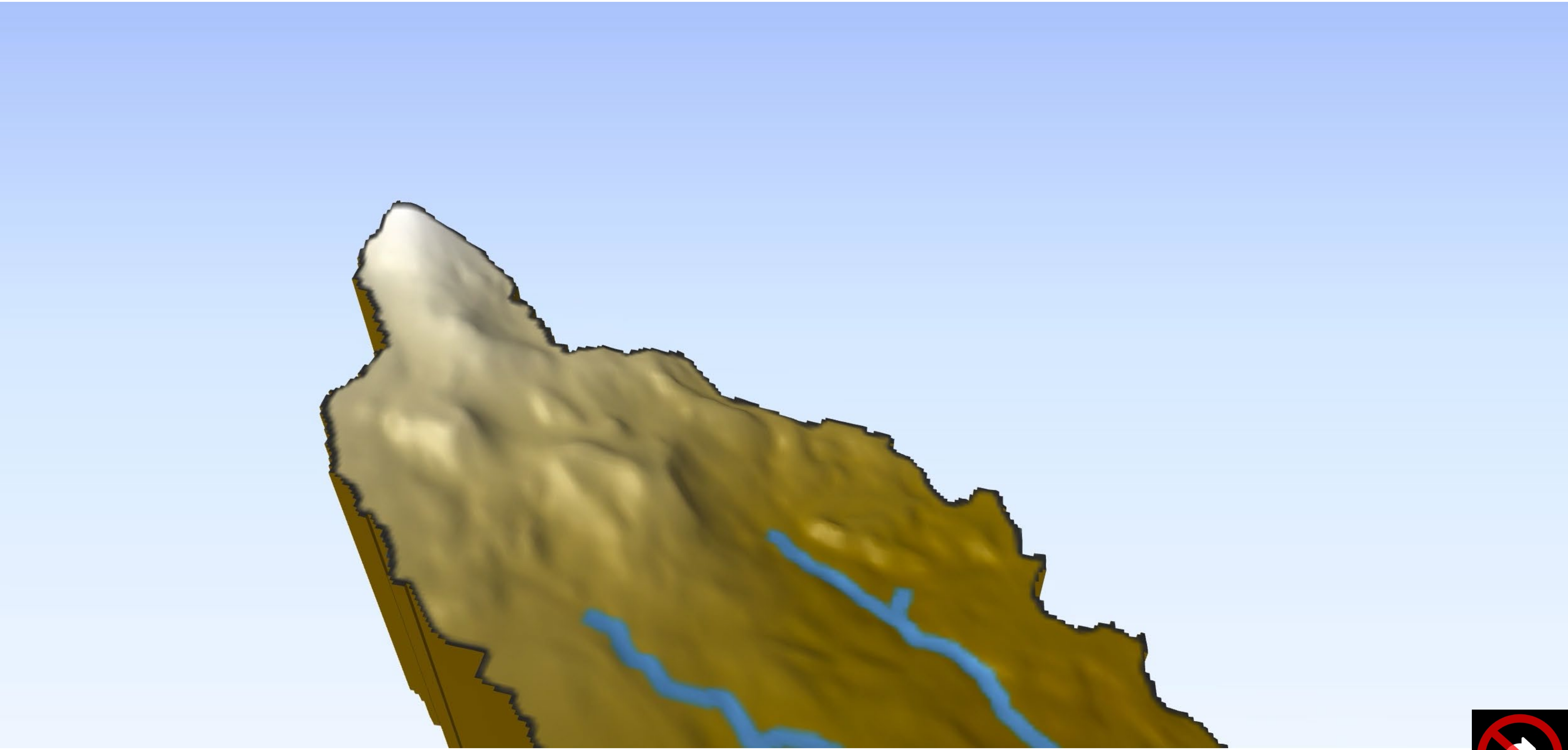
Image based evaluation



Objective 1

Hydrological Results



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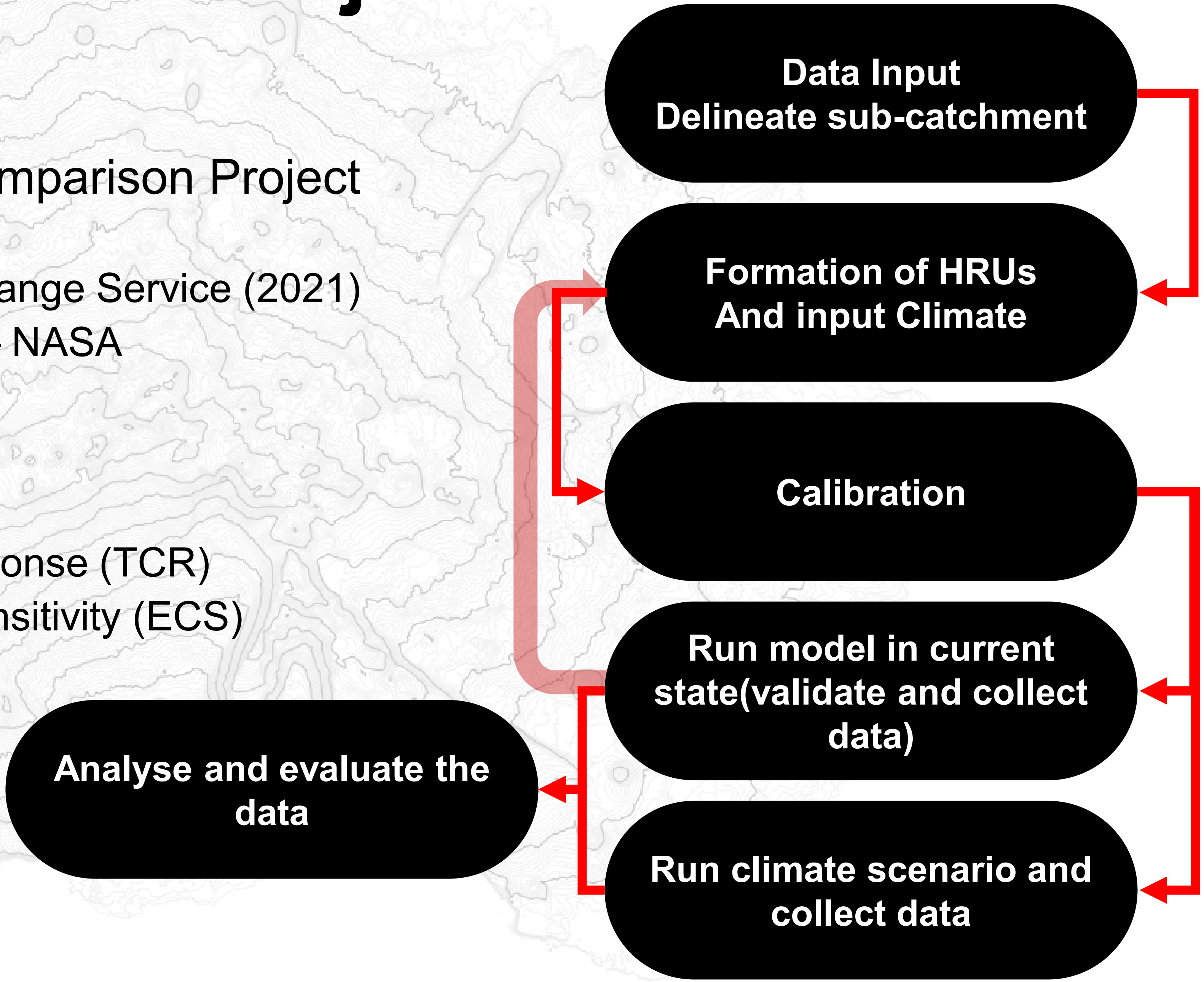
Climate Scenario – Objective 3

- **Future Climate Data**
  - Coupled Model Intercomparison Project Phase 6 (CMIP6)
    - Copernicus Climate Change Service (2021)
    - Thrasher *et al.* (2021) – NASA
  - Model selection
    - Useable data
    - Transient Climate Response (TCR)
    - Equilibrium Climate Sensitivity (ECS)
    - Historical data
  - **MRI-ESM2-0**



Objective 3

Hydrological Changes

Water Balance Components	Change (%)
Precipitation	-31.84
Surface Runoff	-47.68
Lateral Flow	-4.31
Total Water Yield	-46.55
PET	-36.44
Evapotranpiration	-25.61
Percolation	-3.30
Deep Aquifer Recharge	-3.29
Groundwater Recharge	-3.30
Revap	-44.57
Groundwater Storage	1.74
Return Flow	-2.24
	Change (%)
Streamflow	-34.13

Change from current conditions (1997 – 2024) to future conditions (2050-2099)

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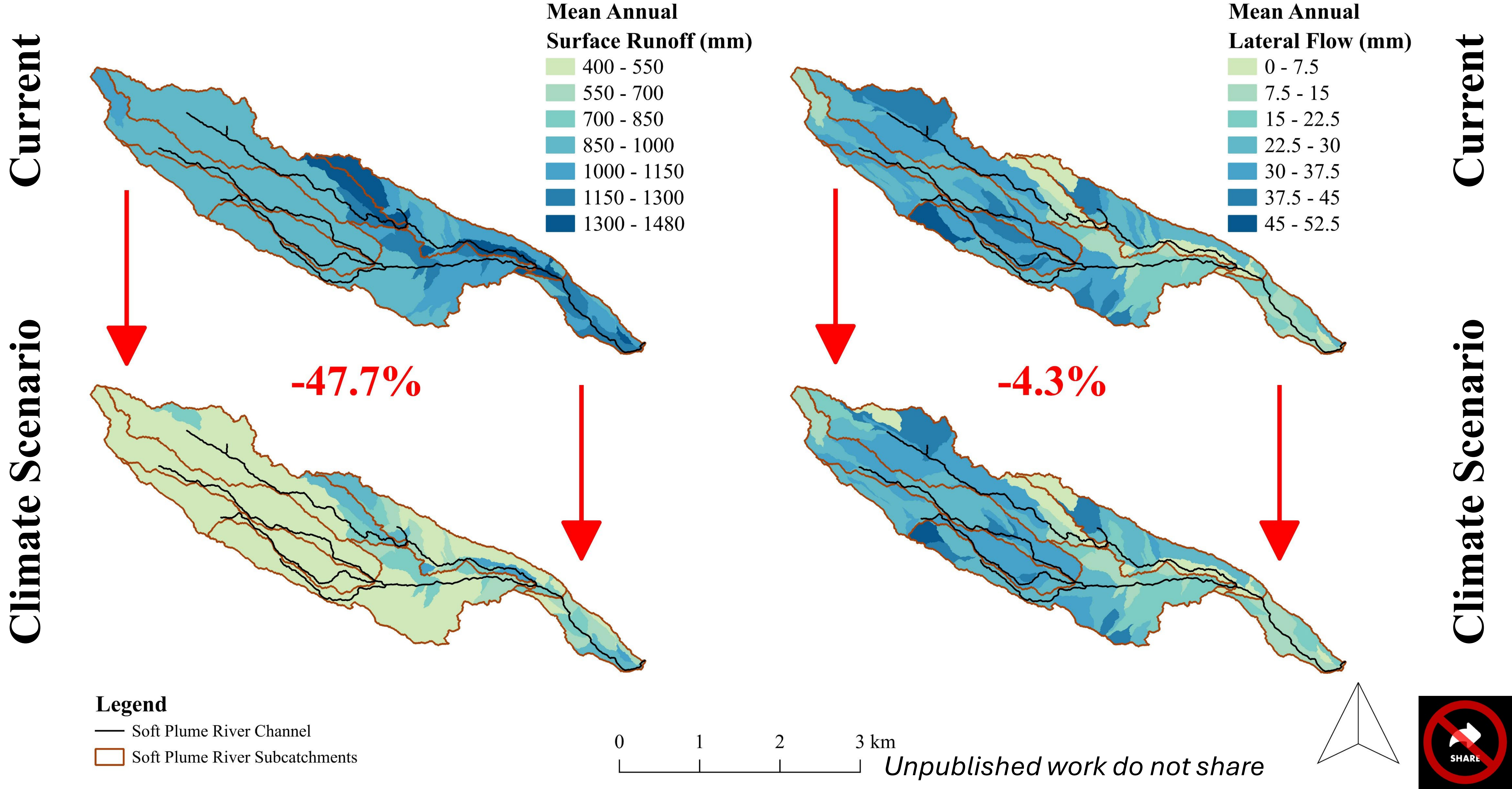
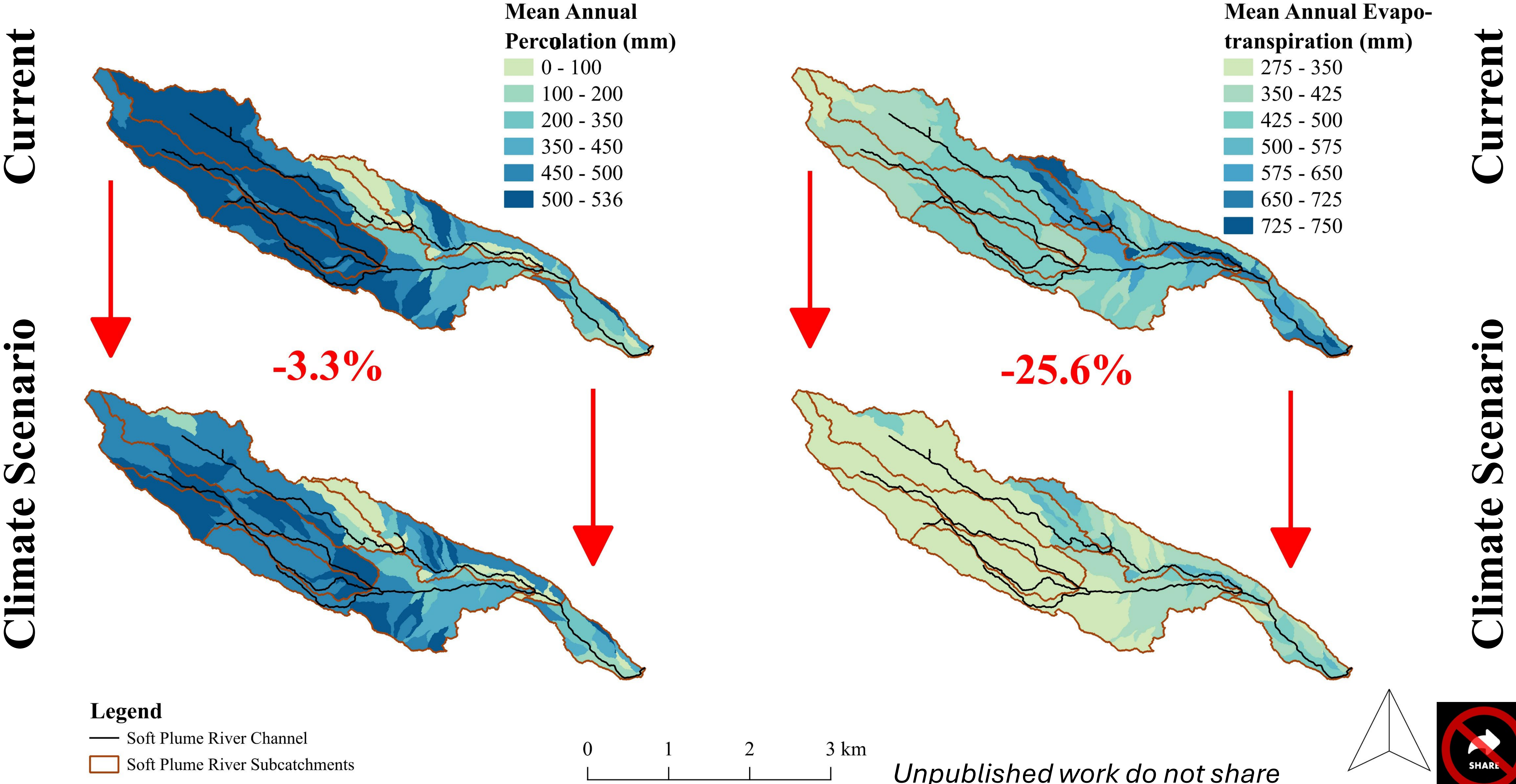
Objective 1 & 3

Hydrological Changes



Objective 1 & 3

Hydrological Changes



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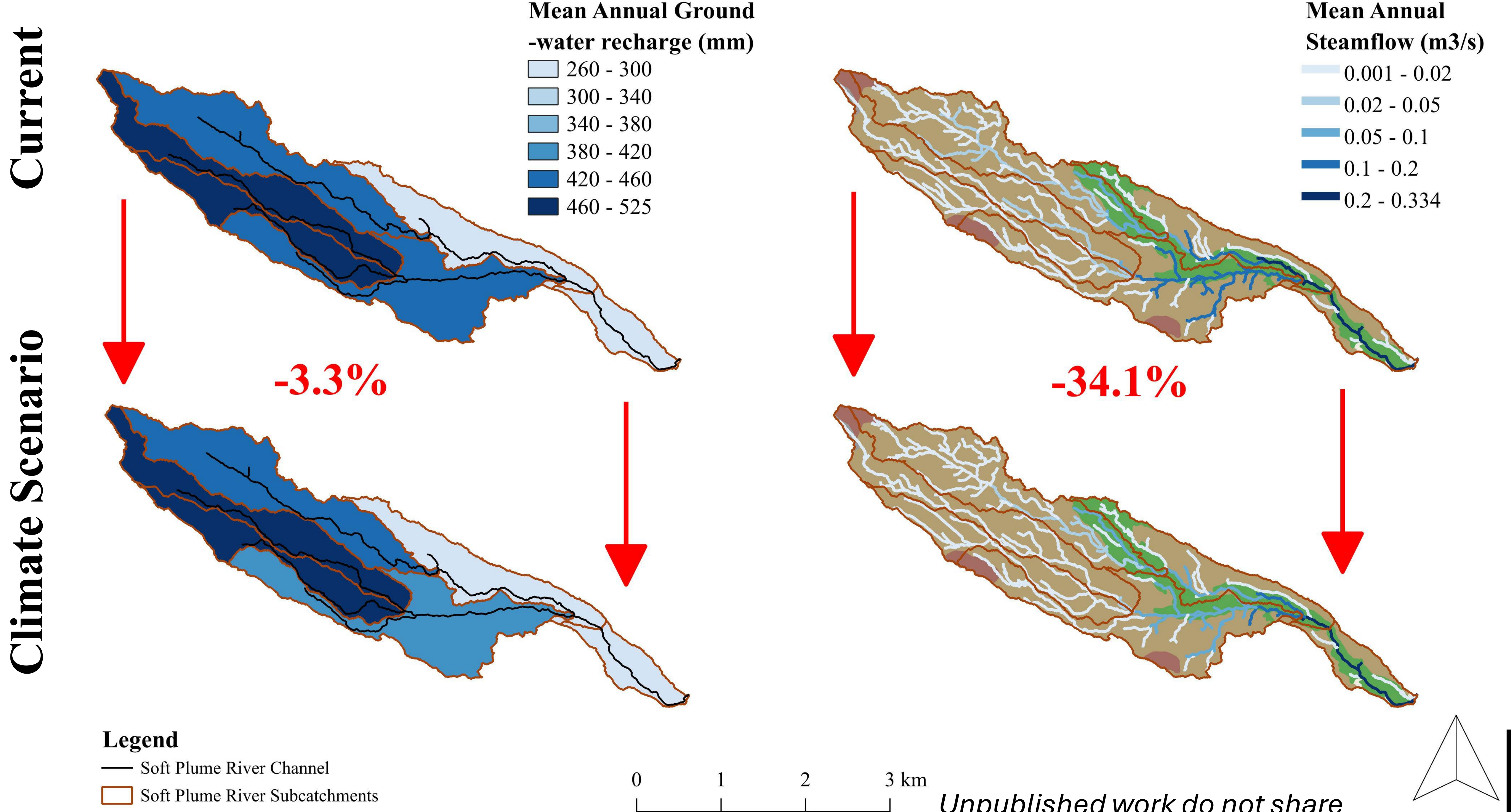
Objective 1 & 3

Hydrological Changes



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Conclusion

- Baseline for future hydrological studies
- Estimated how future climate change can influence islands hydrology and its extent
- What are the draw backs?

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Thank You

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