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Institute for Integrated Management of Material Fluxes and of Resources

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Assessing the Impact of Soil Data Resolution on Streamflow Prediction with SWAT in a Mesoscale Headwater Basin of Sri Lanka

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Soil & Water Assessment Tool | SWAT **Conference**

10-12 July 2024 | Strasbourg, France

Outline

Background

Methodology

Study Area

Model set-up

Impact on HRUs

Impact on streamflow simulation

Takeaway

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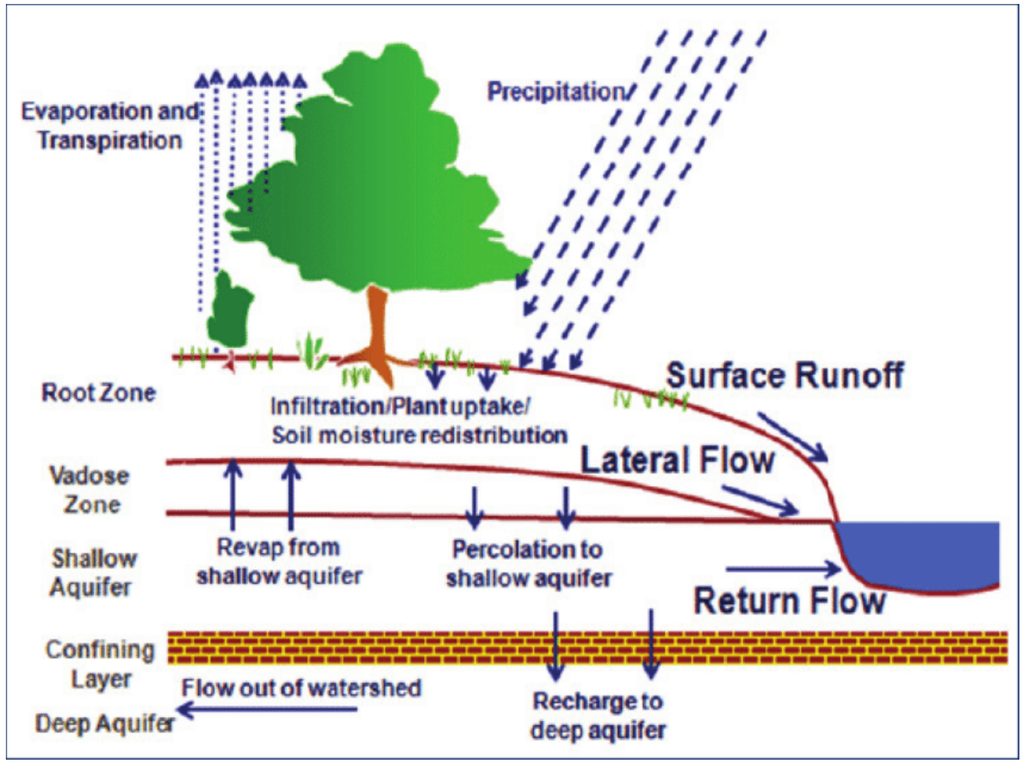
Background

- **Significance of Hydrological Models**
  - Hydrological models are vital tools for comprehending watershed dynamics and the influence of human activities on water resources (Bevan, 2001).
- **Critical Role of Soil Data**
  - **Soil data** is essential for accurate hydrological cycle representation and model performance (Nearing et al., 2005).
  - Coarse spatial resolution of global digital soil maps introduces substantial uncertainties in model outputs despite rigorous calibration efforts (Thompson et al., 2011).
- **Advancements in Digital Soil Mapping**
  - Recent developments in **high-resolution digital soil maps** significantly enhance model accuracy (Zhu et al., 2001).
  - These advancements enable better decision-making to tackle global water resource and environmental challenges (Grunwald et al., 2011).



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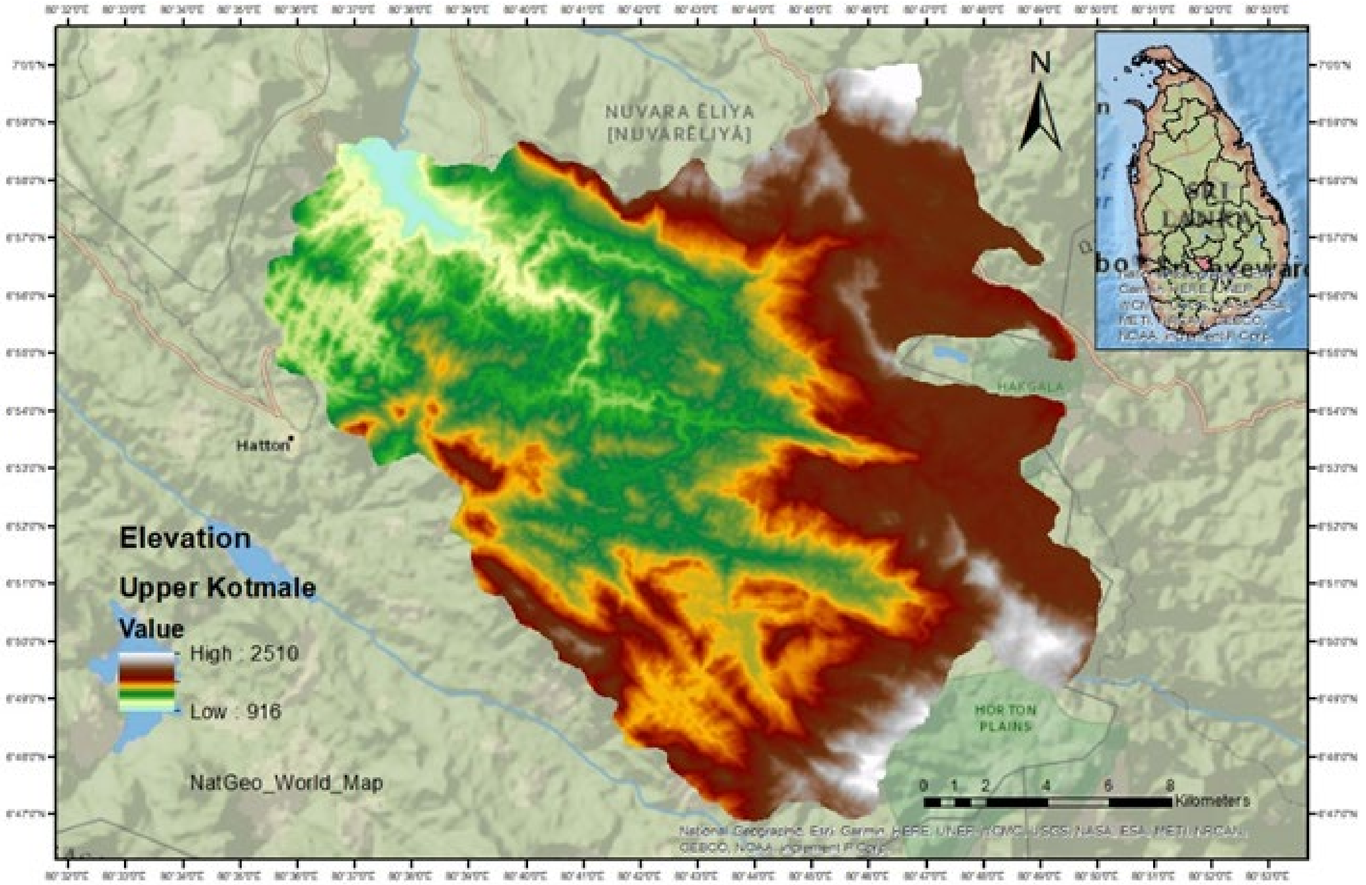
Case Study Area – Upper Kotmale

Major tributary of the Mahaweli river

- **Latitudes:** 36°27’ - 37°58' N
- **Longitudes:** 108°41’-110°29' E
- **Length:** 70 km
- **Basin area:** 571.2 km^2
- **Elevation:** 916 - 2510 msl
- **Annual rainfall:** 1800 - 2500 mm
- **Annual temperature:** 8.8 –24.2 °C
- **Capacity of Reservoir:** 174 Mi cm^3
- **Capacity of Hydropower Generation:** 134 MW

Rainfall seasons

- **Wet season:** May - December
- **Dry season:** January - April



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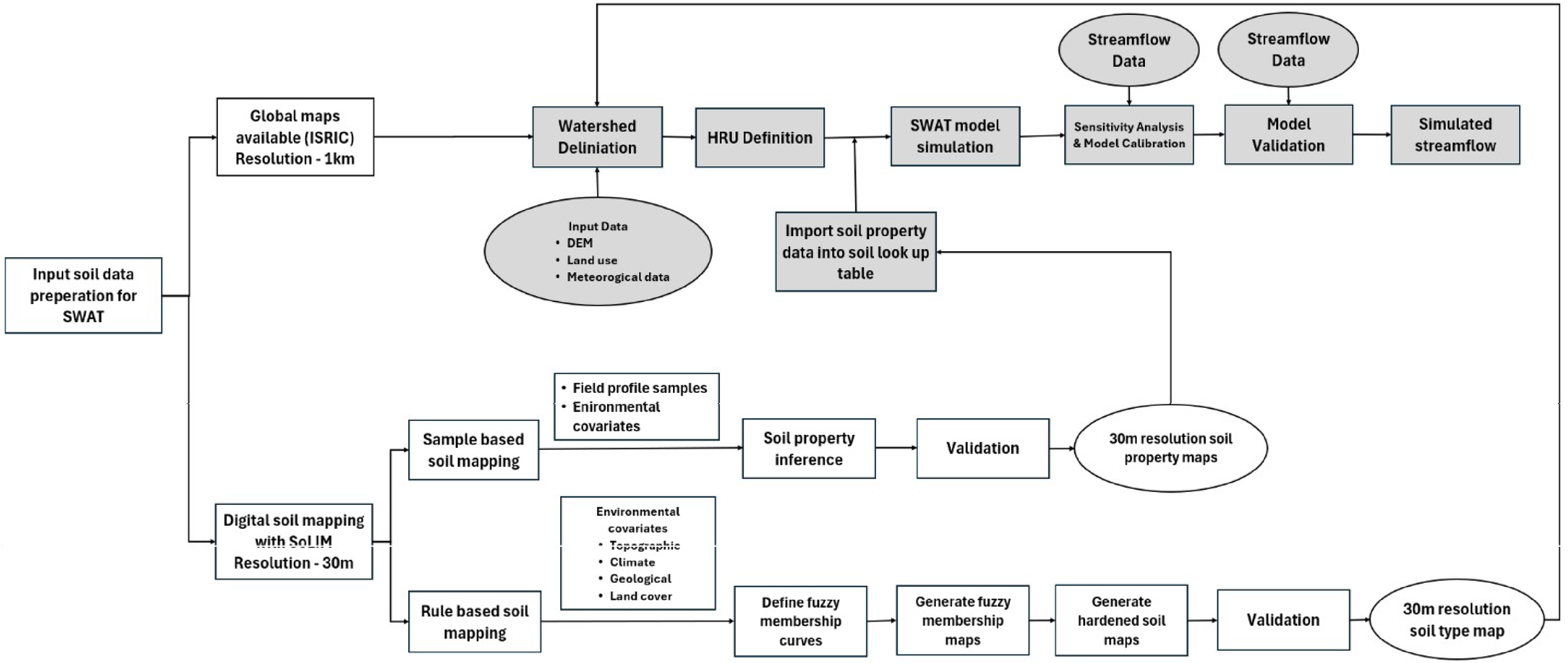
Methodology



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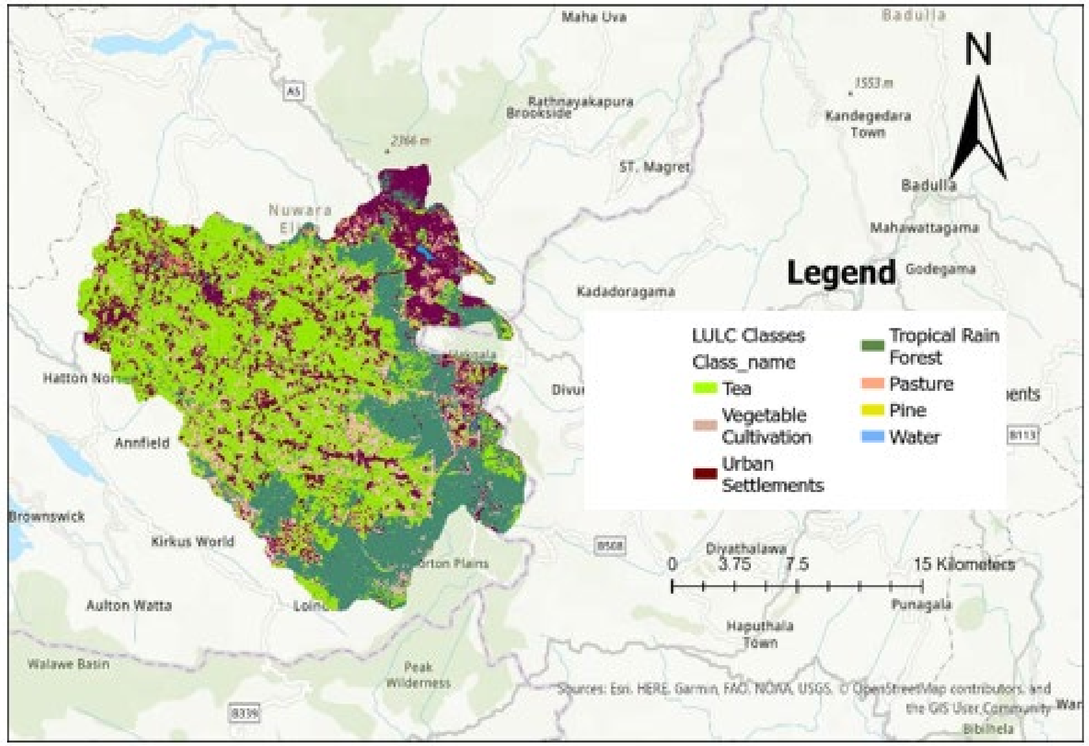
SWAT model set-up

Data	Source	Spatial Resolution
Meteorological Data	Department of meteorology, Sri Lanka	Station
Streamflow	Irrigation department, Sri Lanka	Station
DEM	USGS - SRTM	30m
Land Use/ Land Cover	LandSAT (USGS)	30m
Soil	ISRIC	250m
	Digital soil mapping	30m



SoLIM model set-up

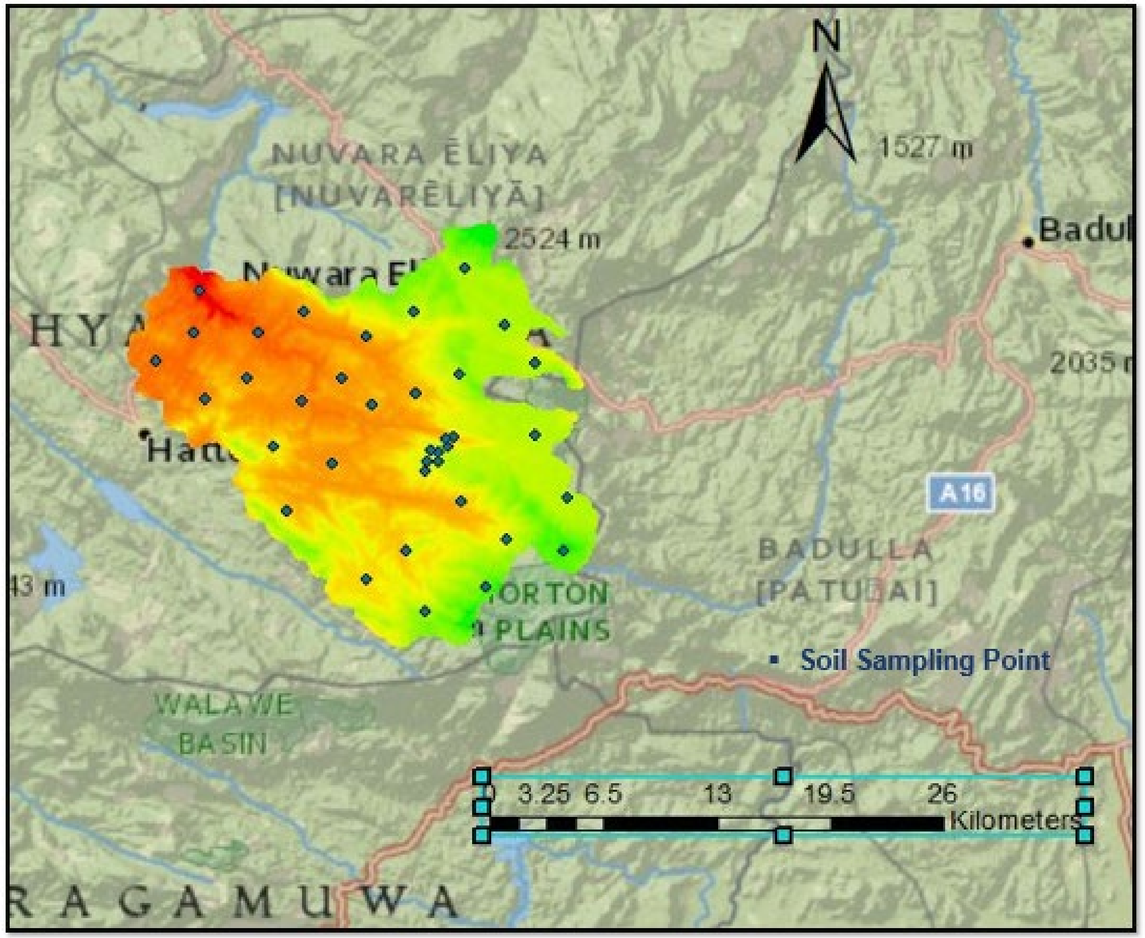
1.Topographic Covariates

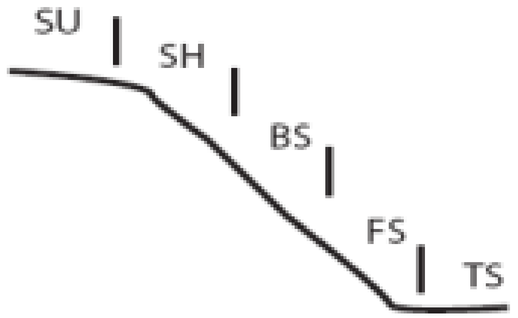
1. Elevation
2. Slope
3. Aspect
4. Profile curvature
5. Planform Curvature

2. Climate Covariates

3. Land cover Covariates

4. Geological Covariates





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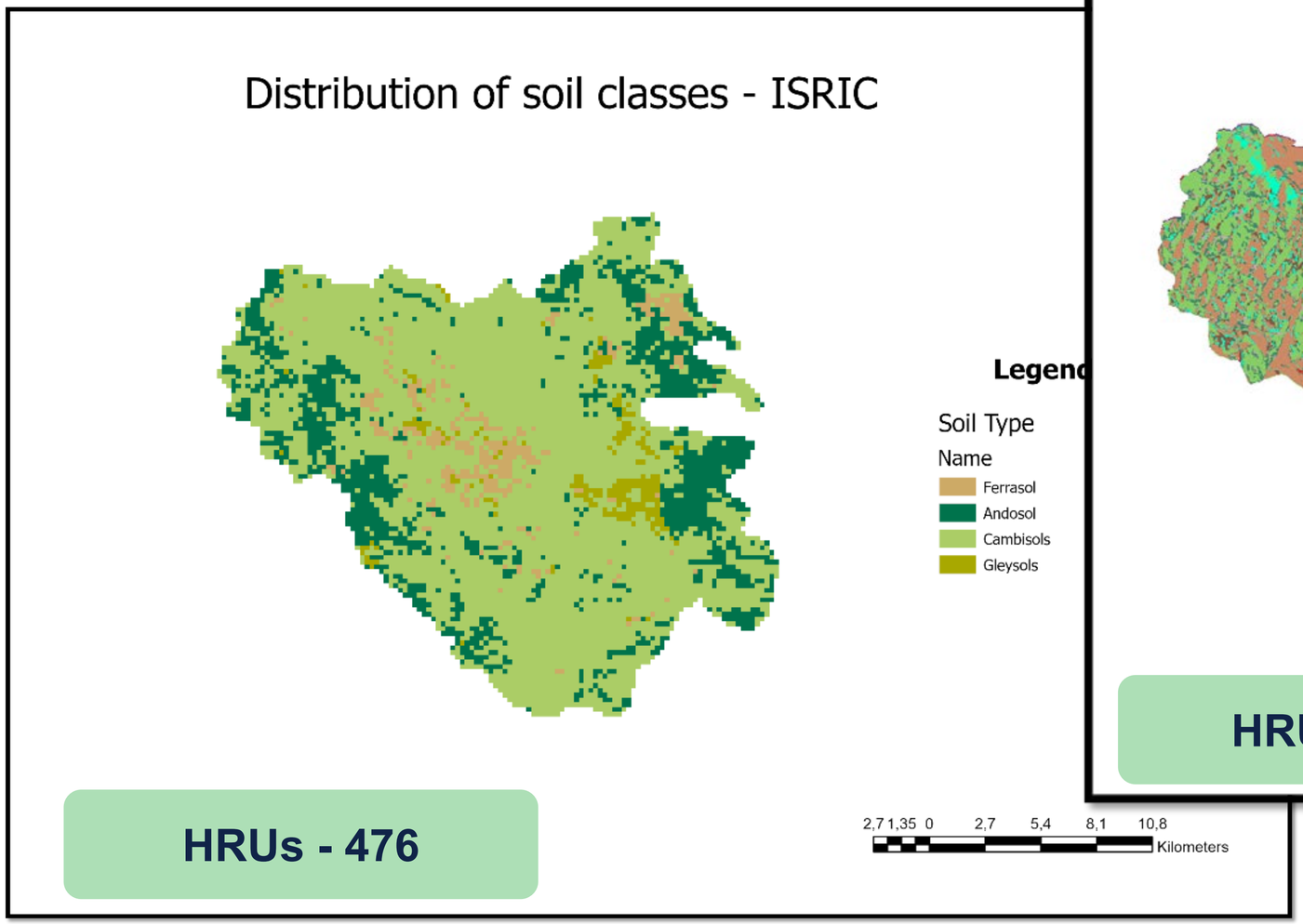
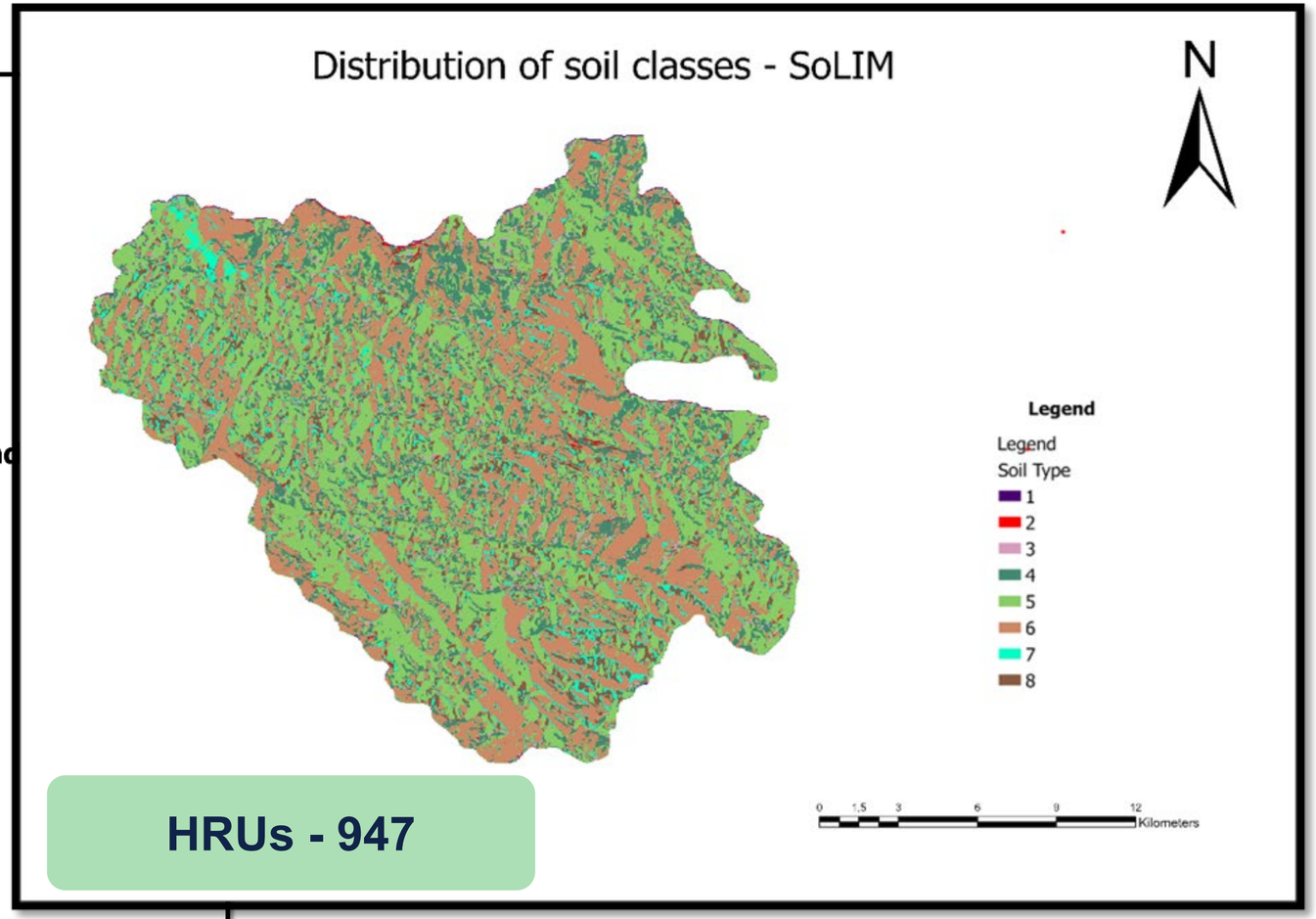
Impact of soil data on hydrologic response units



HRUs - 476



HRUs - 947

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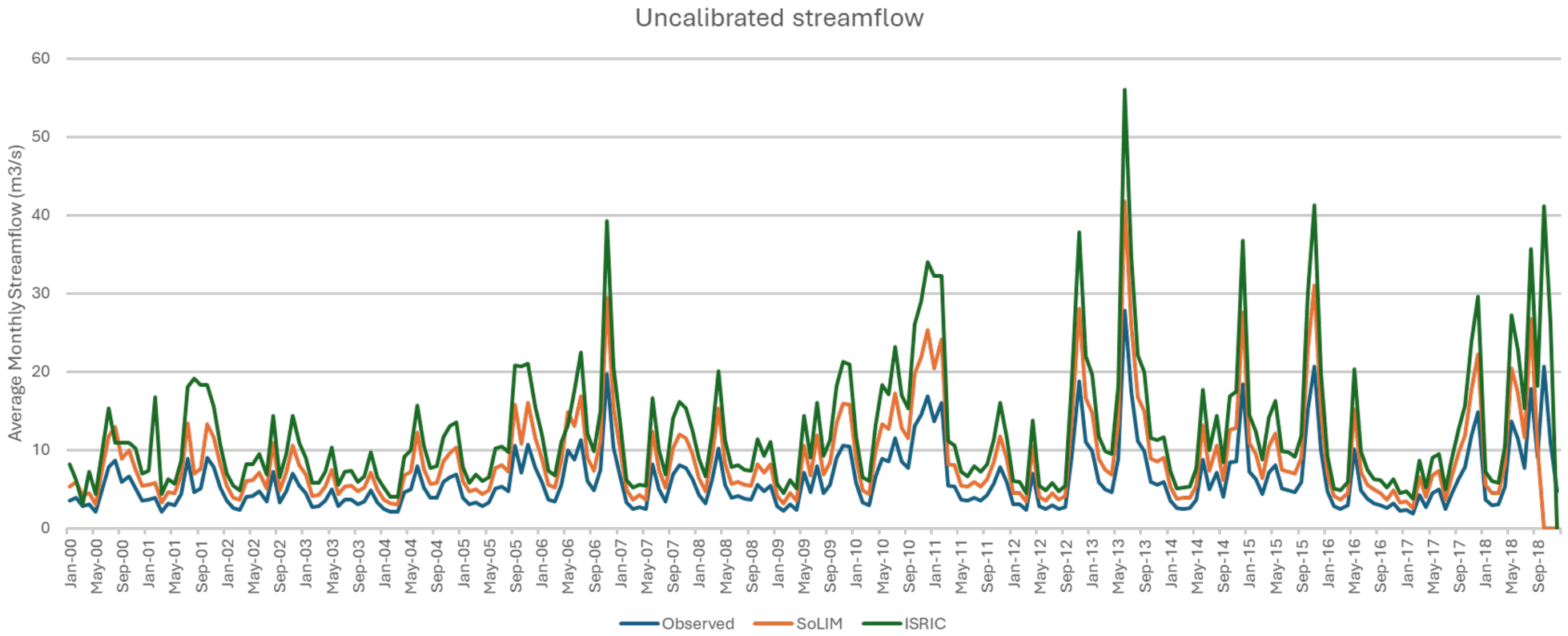
Impact of soil data resolution before calibration



Uncalibrated data provide a better visualization of the importance of soil data resolution in hydrological modeling

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Soil & Water Assessment Tool | SWAT

Sensitivity analysis

Parameters	Description	P-Value	
		SoLIM	ISRIC
CN2	Initial SCS runoff curve number	0.00	0.00
SOL_K	Saturated hydraulic conductivity	0.01	0.01
CH_N2	Manning coefficient for the channel	0.01	0.01
ALPHA_BF	Baseflow alpha factor	0.01	0.01
BD	Soil bulk density	0.02	0.02
GW_DELAY	Ground water delay time	0.05	0.06
CH_N1	Manning coefficient for tributaries	0.07	0.08

SWAT Soil & Water Assessment Tool

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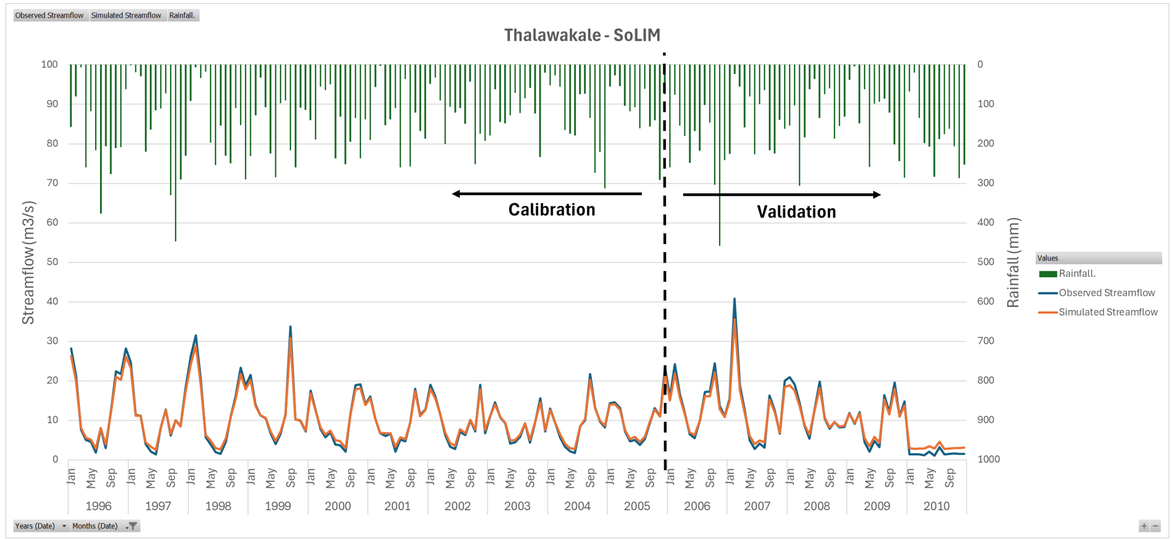
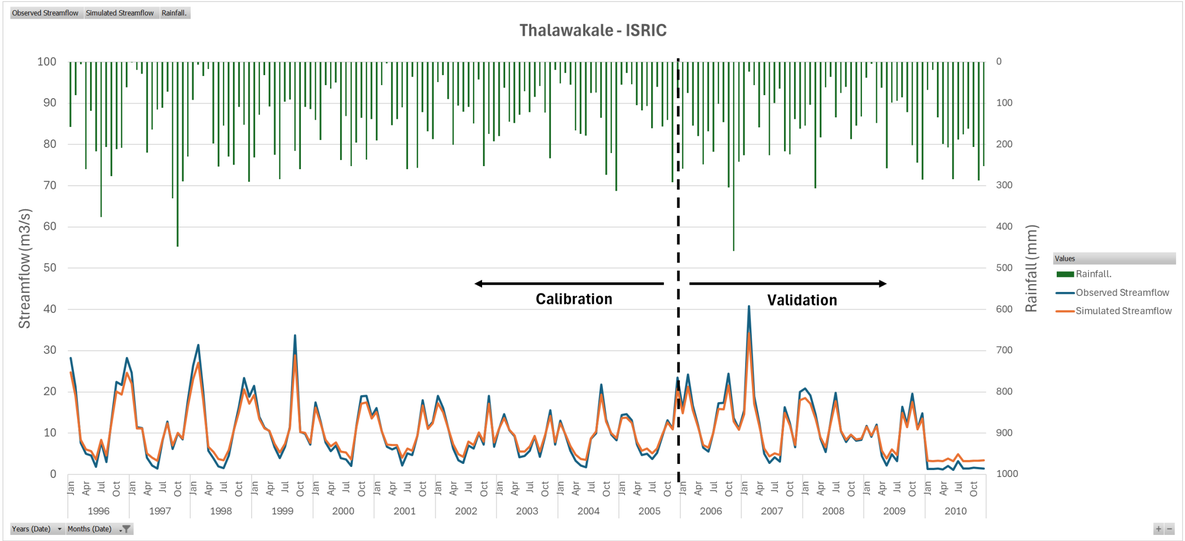
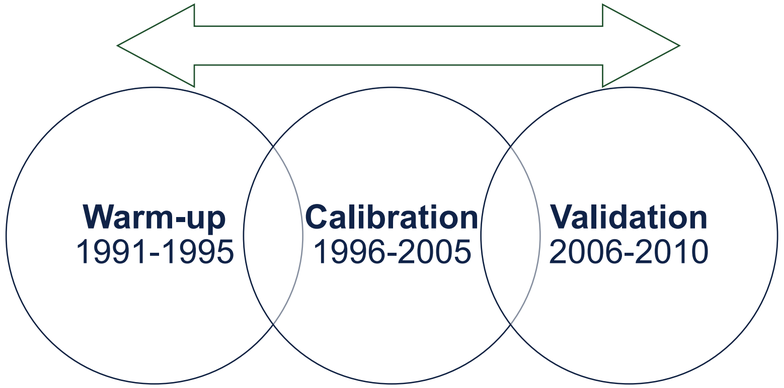
Impact of soil data on model calibration and validation







Performance Indicator	SoLIM		ISRIC	
	Calibration	Validation	Calibration	Validation
NSE	0.81	0.74	0.77	0.71
R	0.91	0.90	0.88	0.87
R2	0.83	0.81	0.79	0.76

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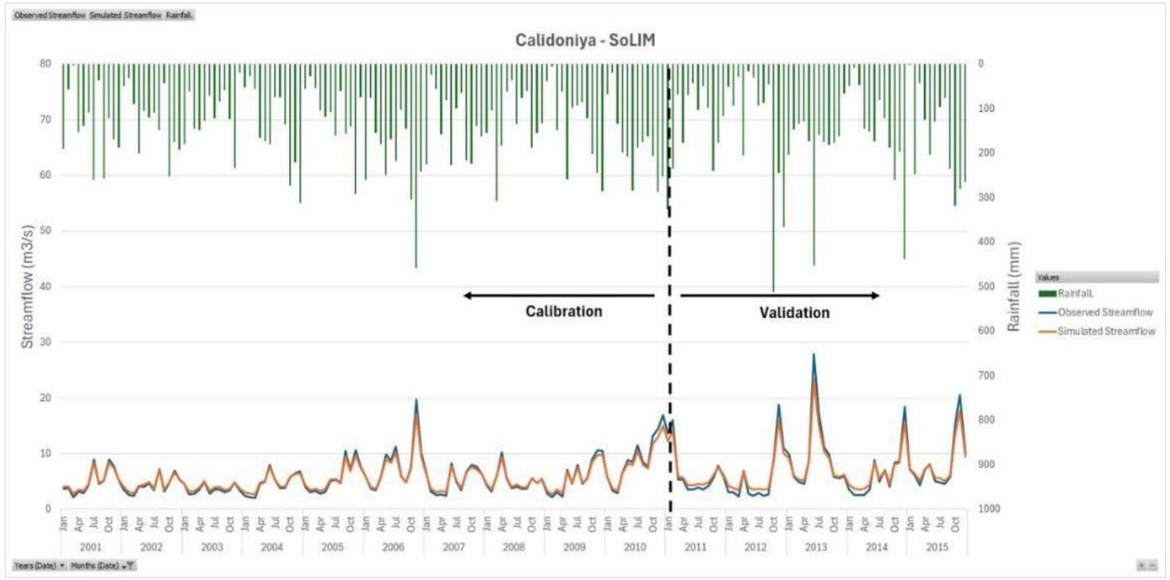
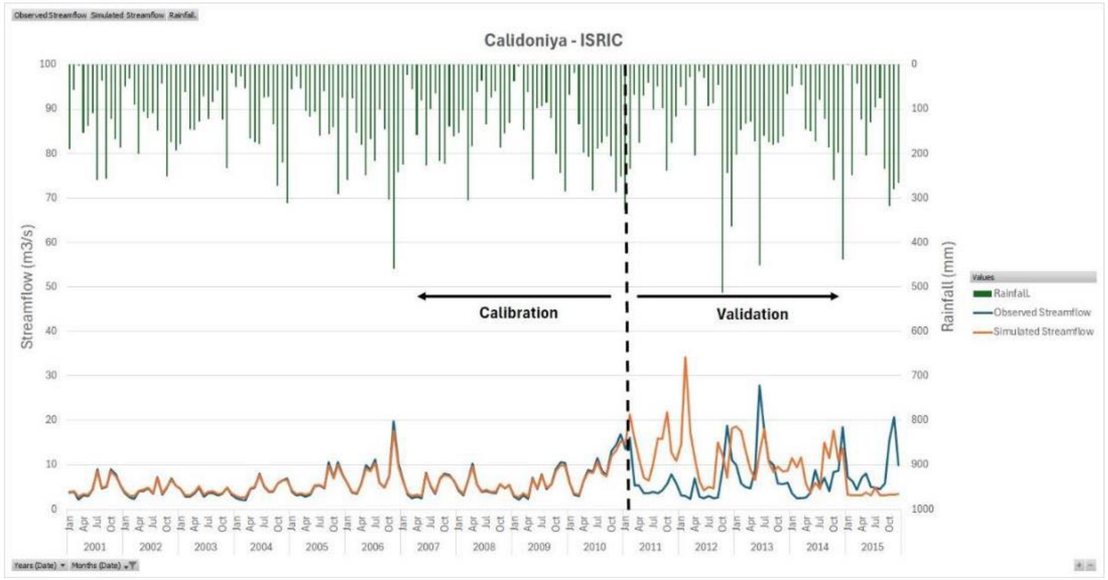
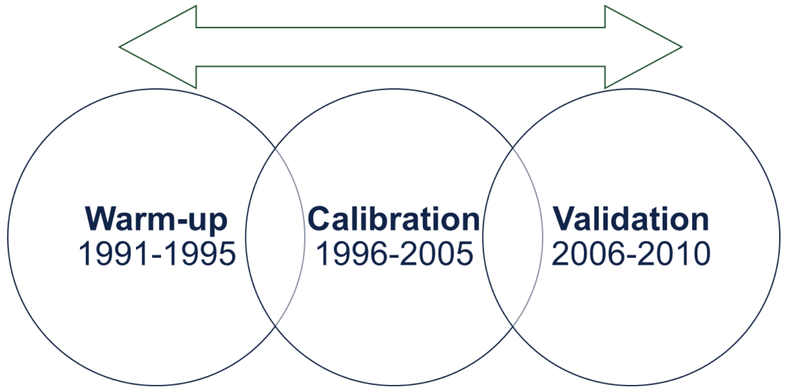
Impact of soil data on model calibration and validation







Performance Indicator	SoLIM		ISRIC	
	Calibration	Validation	Calibration	Validation
NSE	0.79	0.71	0.76	0.61
R	0.88	0.87	0.84	0.81
R2	0.77	0.75	0.71	0.56

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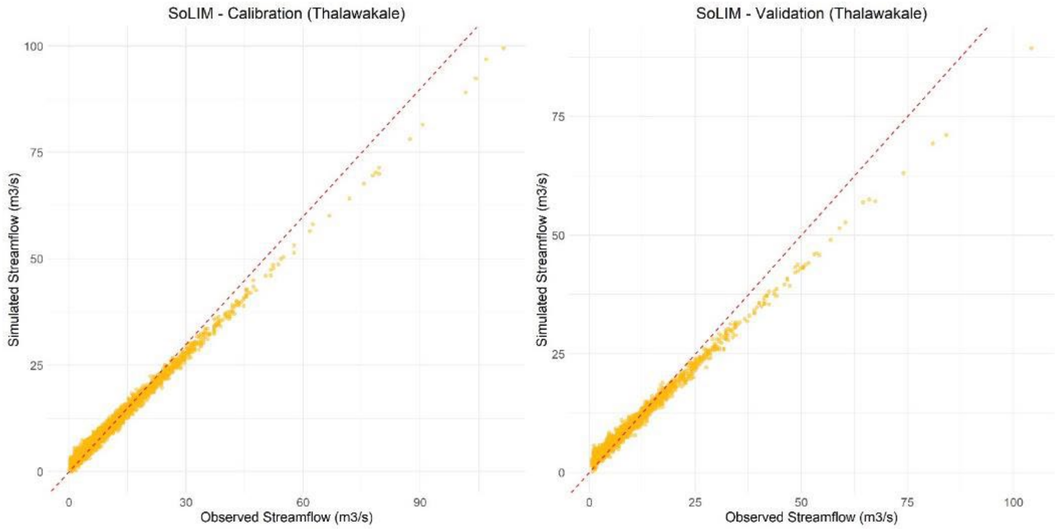
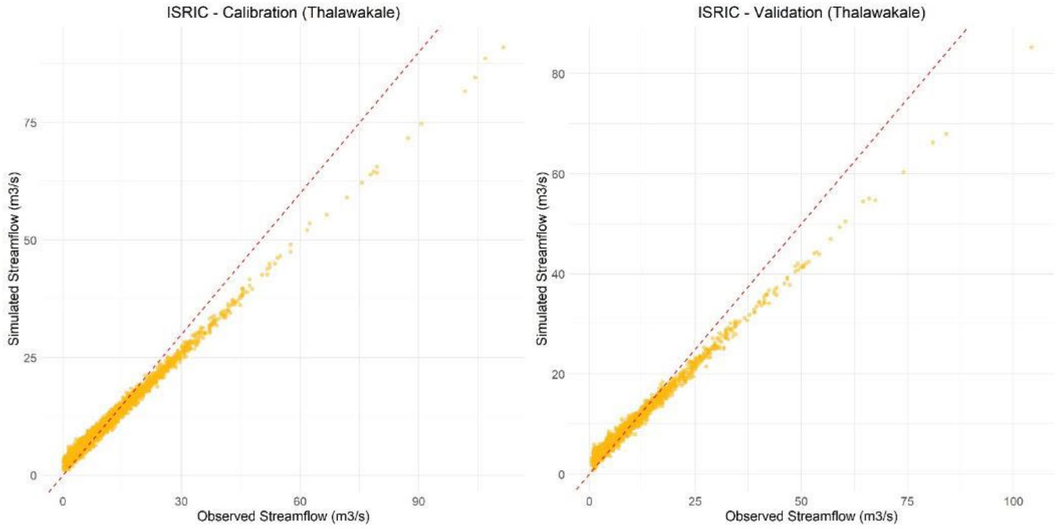
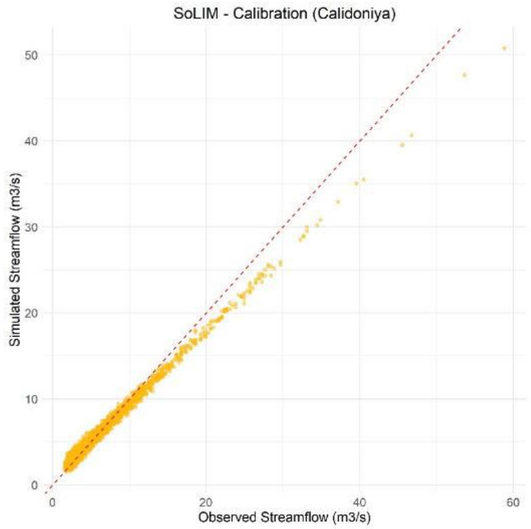
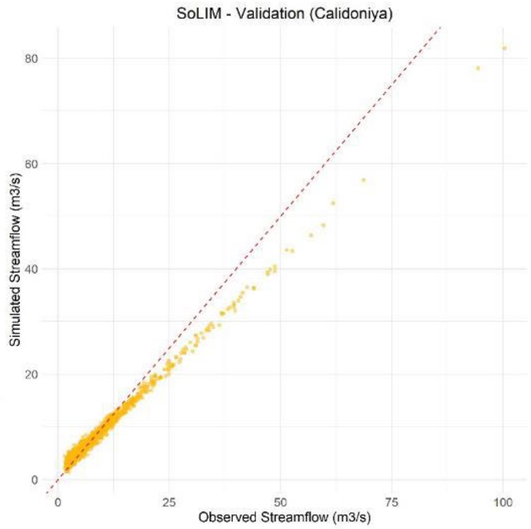
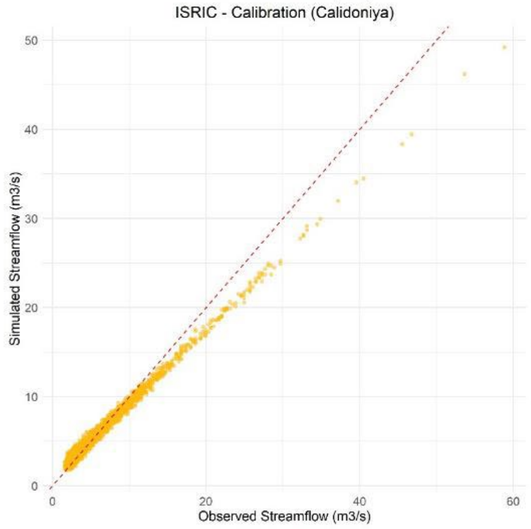
Model Performance

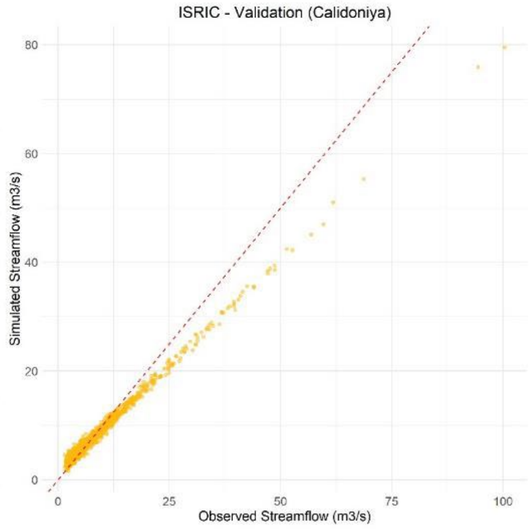












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Summary and Key Takeaways

Summary

- Resolution of soil maps used as input for SWAT significantly influences the number of HRUs delineated within the model.
- Lower resolution of global soil data tends to overpredict streamflow before calibration compared to high-resolution soil data.
- Despite initial discrepancies, both high-resolution and low-resolution soil data can be calibrated to produce satisfactory streamflow simulations.

Takeaways

- Resolution of soil data used in SWAT is crucial for maintaining the accuracy of water flux simulations. Hence, high-resolution soil data provides detailed spatial information, leading to more precise modeling of hydrological processes.
- High-resolution soil data simplifies the calibration and validation process. Detailed soil information allows for more accurate adjustment of model parameters, reducing the effort required to achieve satisfactory model performance.
- Utilizing high-resolution soil data improves model performance.

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