Evaluation of future climate change impacts on hydrologic processes in the Peruvian Altiplano region using SWAT

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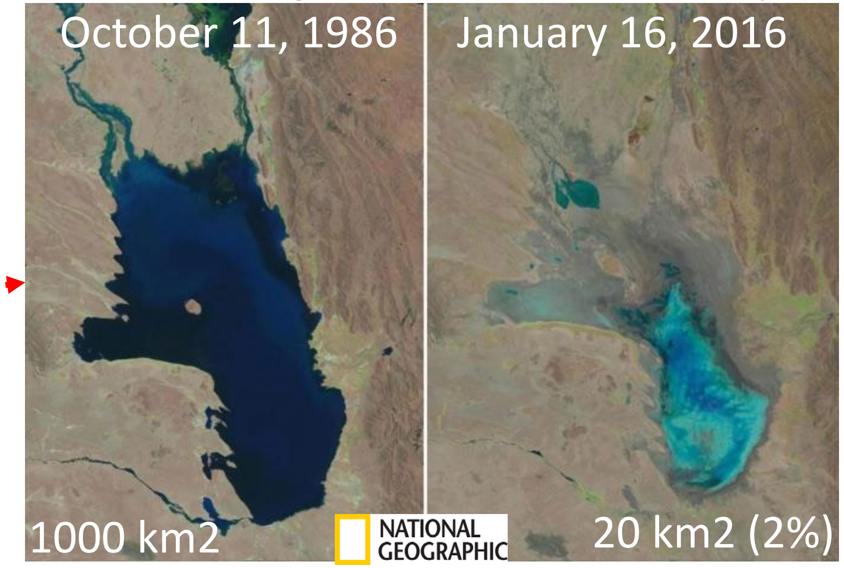
Introduction and research questions

- **Is the SWAT model outputs consistent for complex terrain Andean Basins?**

(Not only discharge but baseflow for instance)

Satellite images of Bolivia's Lake Poopó

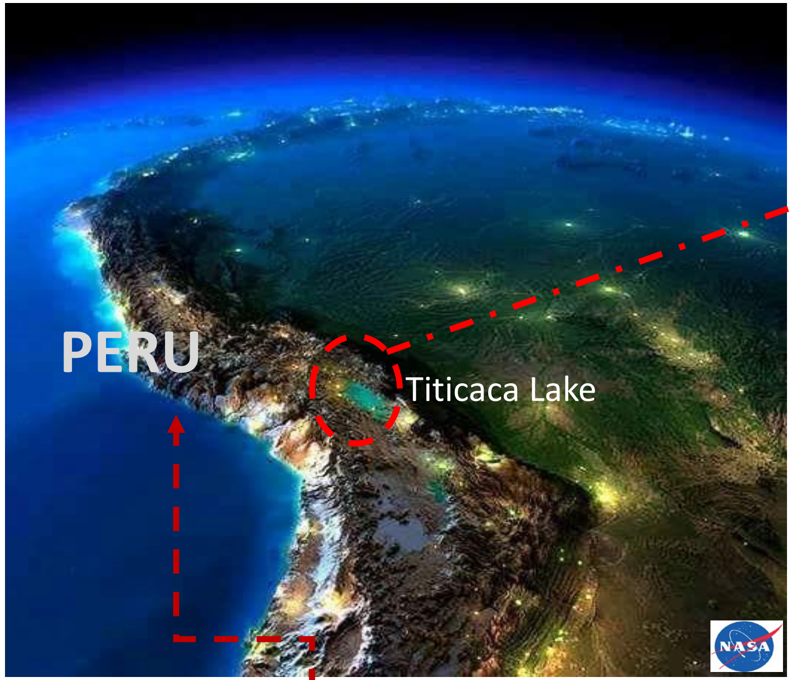


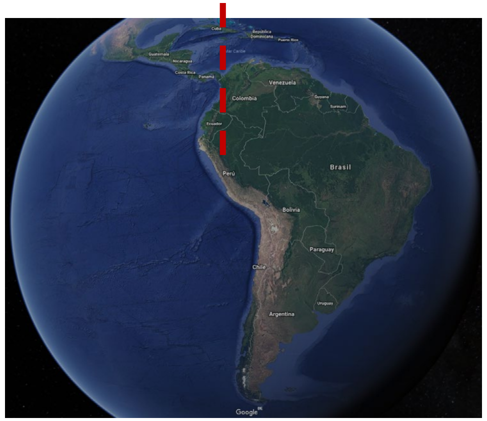
- **What is the impact of changing climate to the hydrological response?**

Objective

This study aims to assess the hydrological response to climate changes in 5 basins draining into the Titicaca Lake in Peru, the largest lake in South America and the world’s highest navigable lake.

Study area





South America

Titicaca lake drainage system

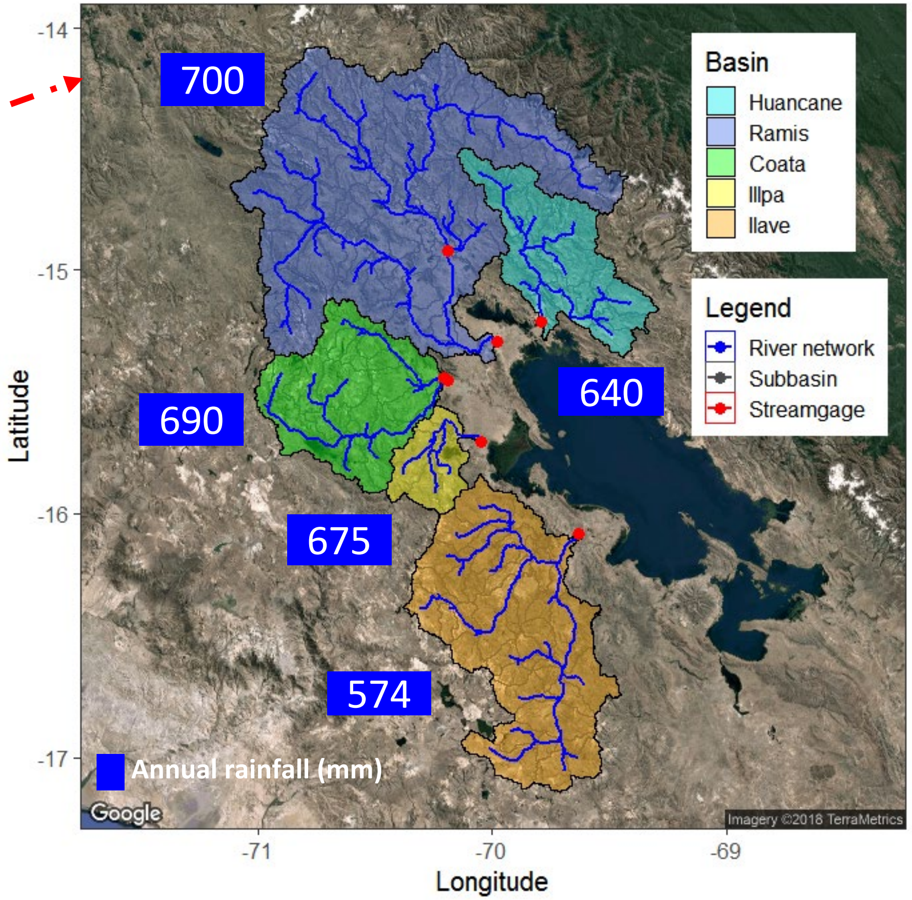


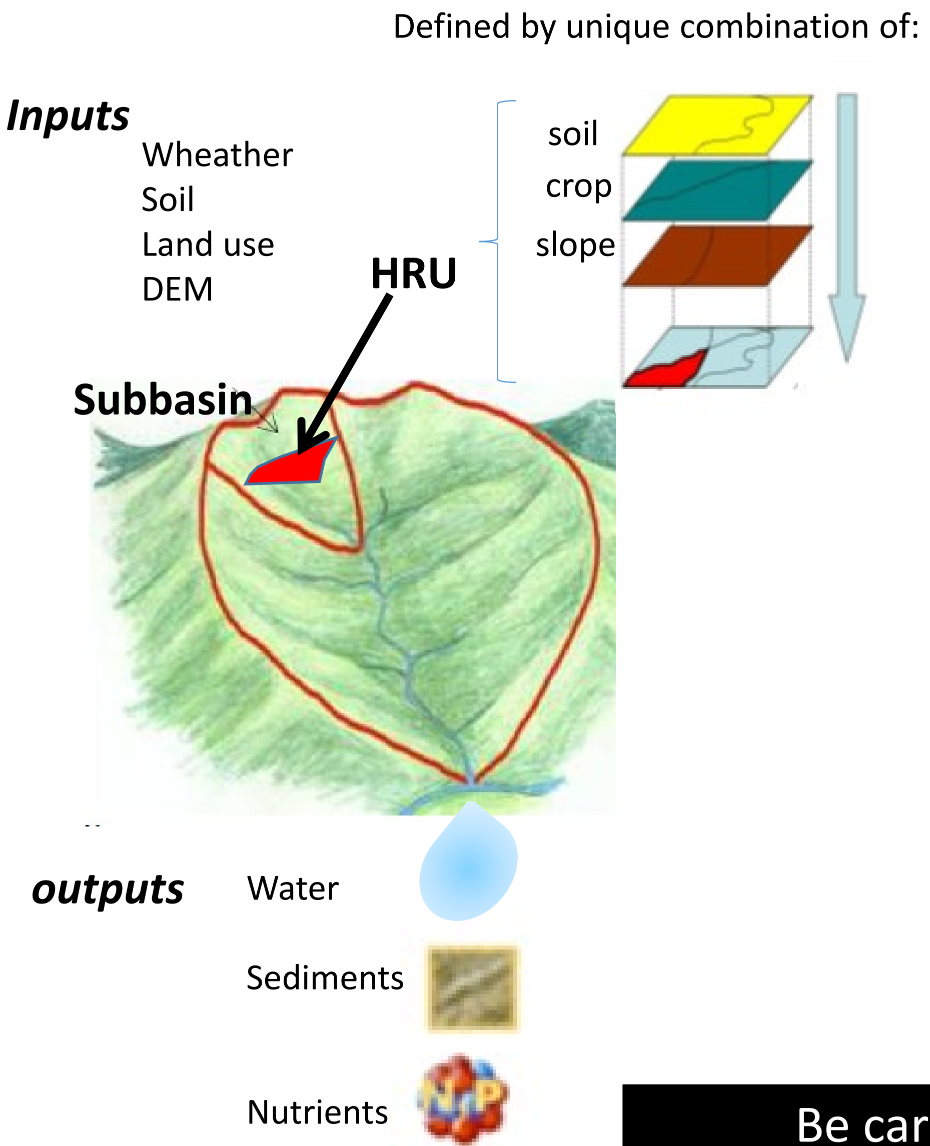
Figure: Basins and hydrological stations network

Precipitation:

650 mm/year

(>80 % ; October – March)

Soil and Water Assessment Tool (SWAT) - USDA



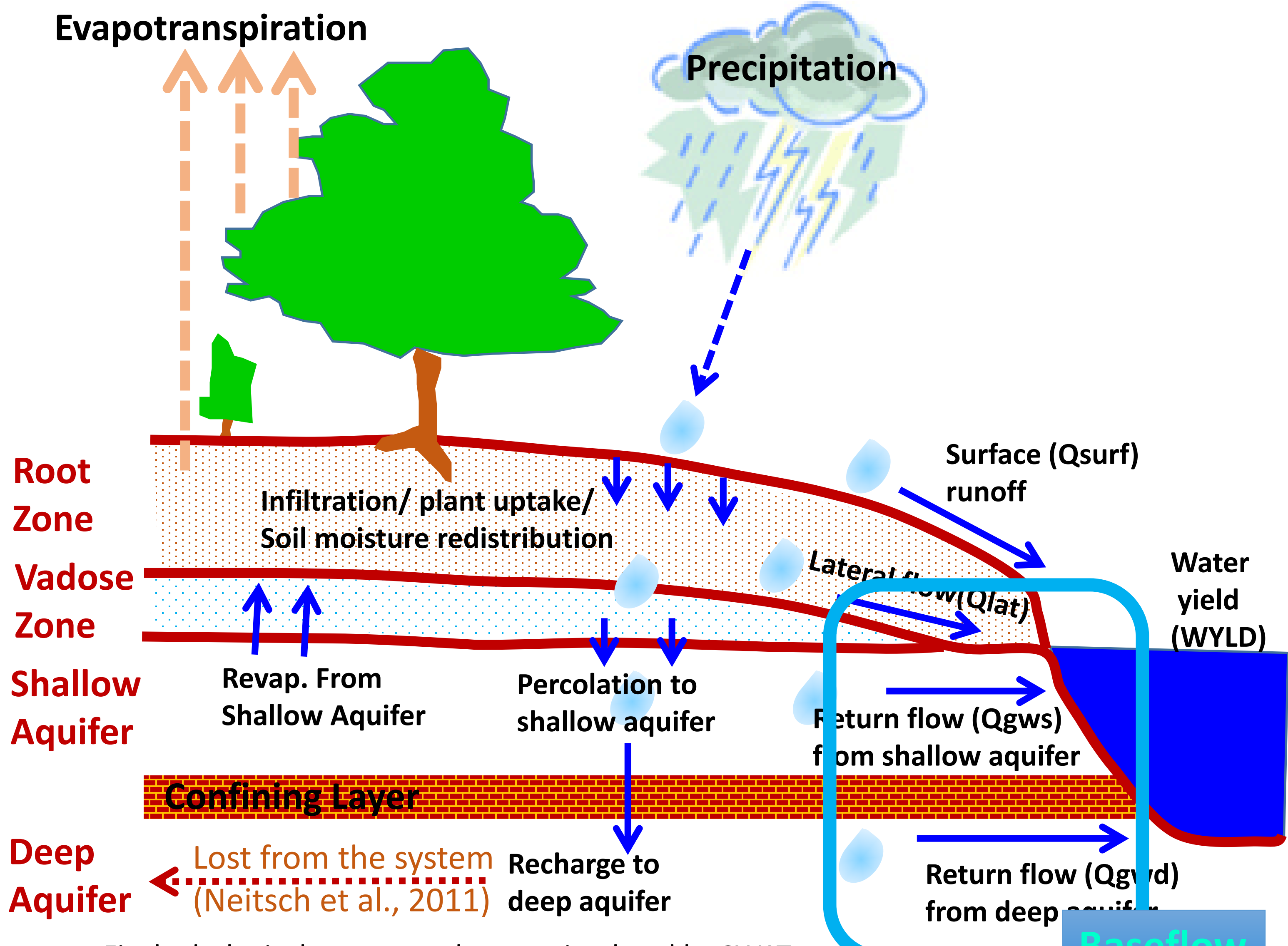


Fig. hydrological processes that are simulated by SWAT

Be careful with SWAT Check program in the baseflow index estimation

Calibration methodology: Multi-objective Process-Based sensitivity analysis.

ification

Towards the consistent hydrological simulation using SWAT model.
Case Study: Vilcanota Andean basin in Peru

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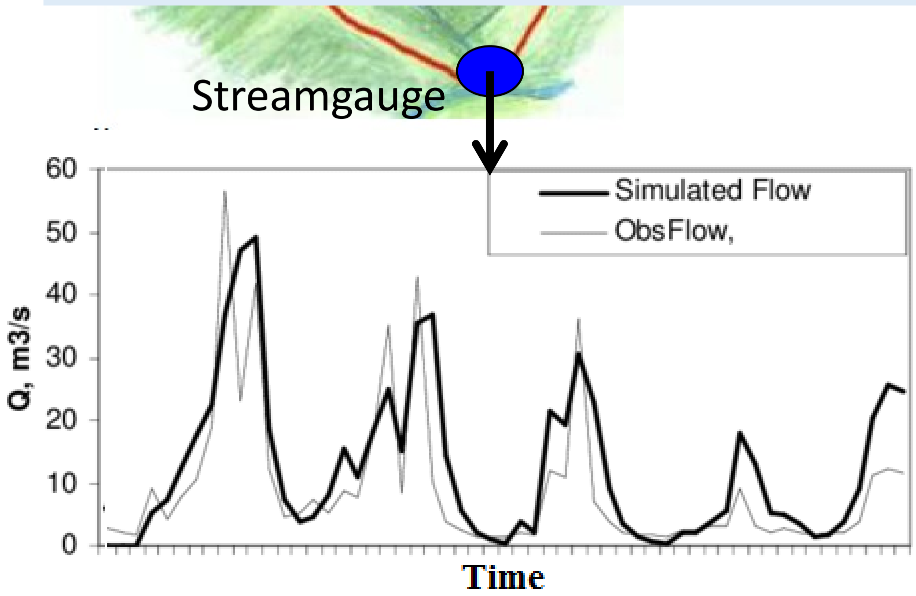
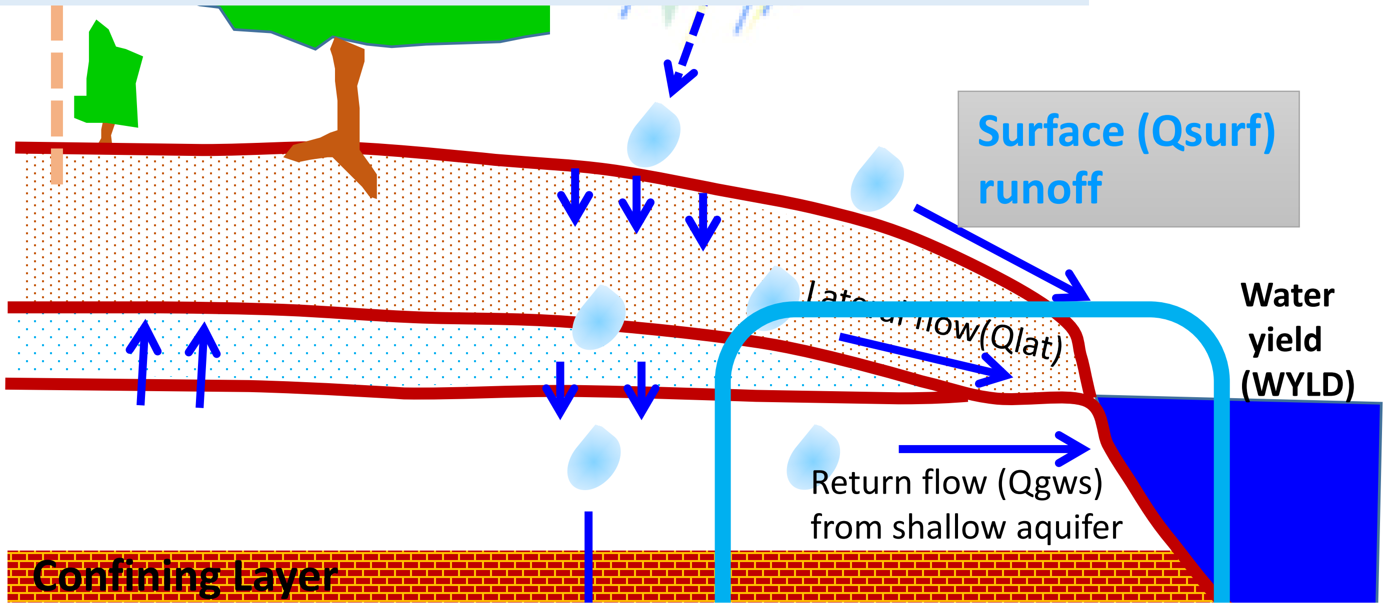


Desired values:
NSE=1, PBIAS=0%



SWAT_BFI (BF/WYLD) equal to BFI estimated by the baseflow filter program (BFLOW)

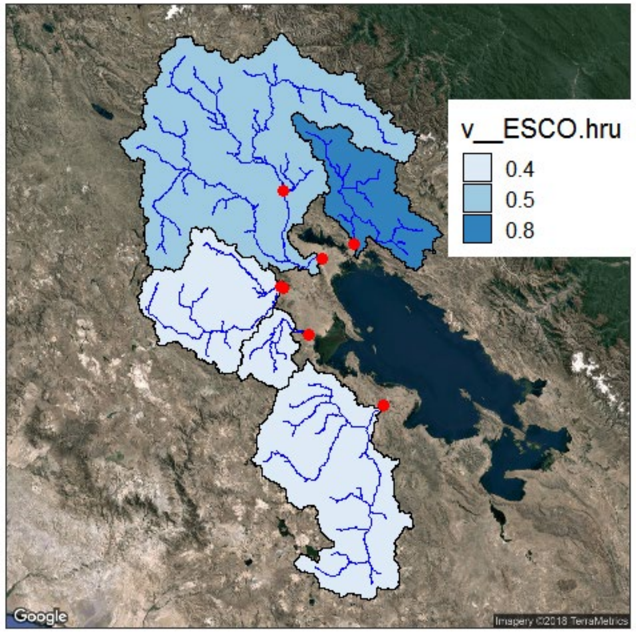
Data used to setup SWAT

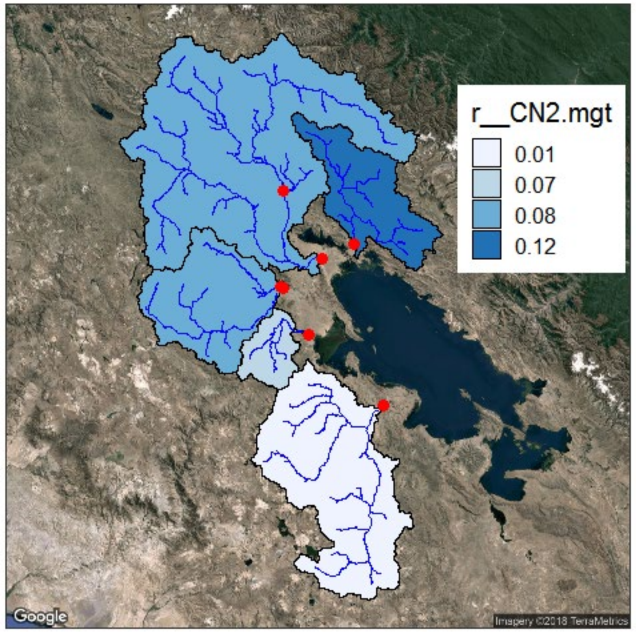
Table : Data type, resolution and data source

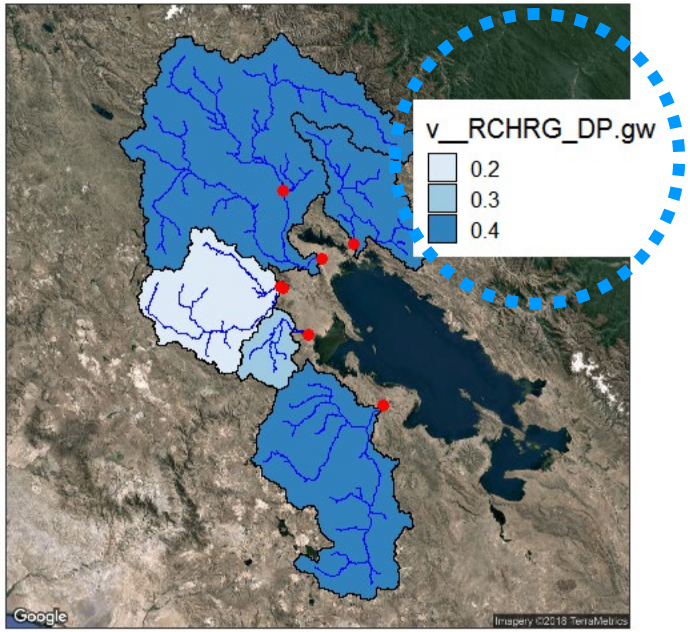
Type of data	Resolution	Source	Link
• Tmax, Tmin and Prec (PISCO product) • Hydrological data	Daily, 5 km 1981-2016	SENAMHI	http://www.senamhi.gob.pe/
• SRTM DEM	90 m	CGIAR-CSI	http://srtm.csi.cgiar.org/
• Land cover	300 m	ESA CCI-LC	http://maps.elie.ucl.ac.be/CCI/viewer/
• Soil map	1:5 000 000	FAO-1995, 2003	http://www.waterbase.org/download_data.html

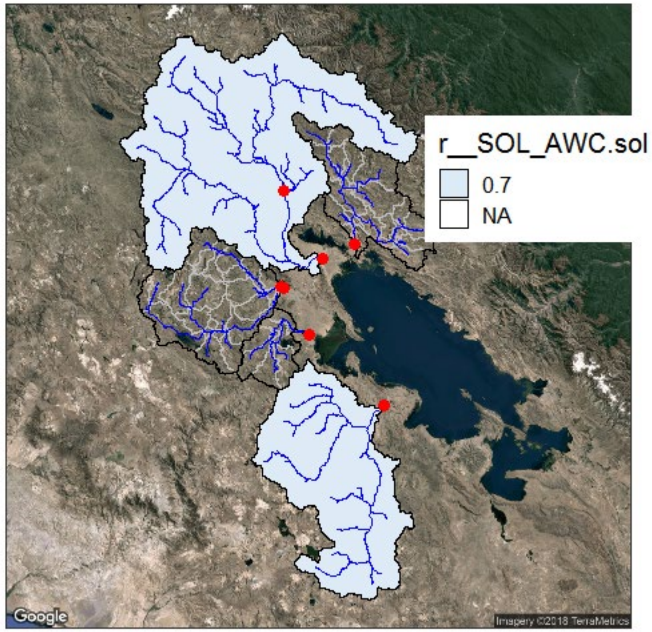
PISCO: Peruvian Interpolated data of the SENAMHI's Climatological and Hydrological Observations

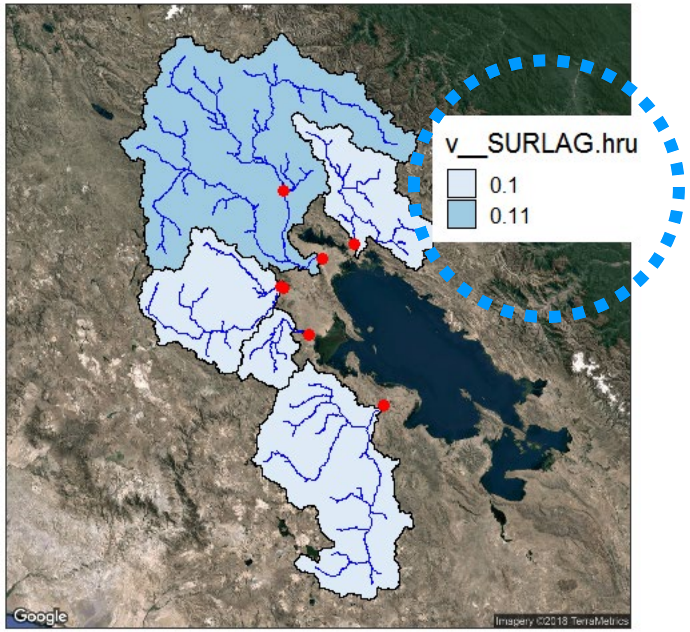
Calibrated parameters





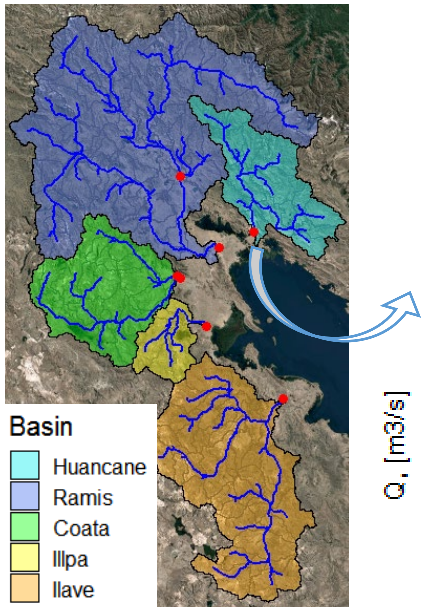




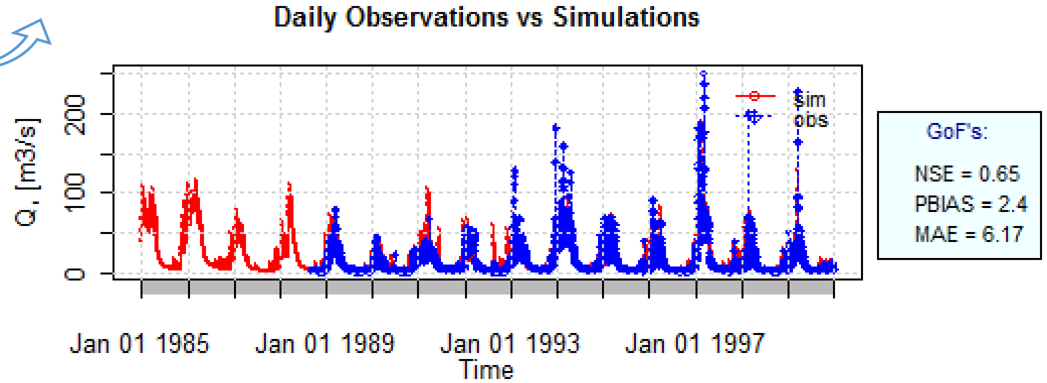


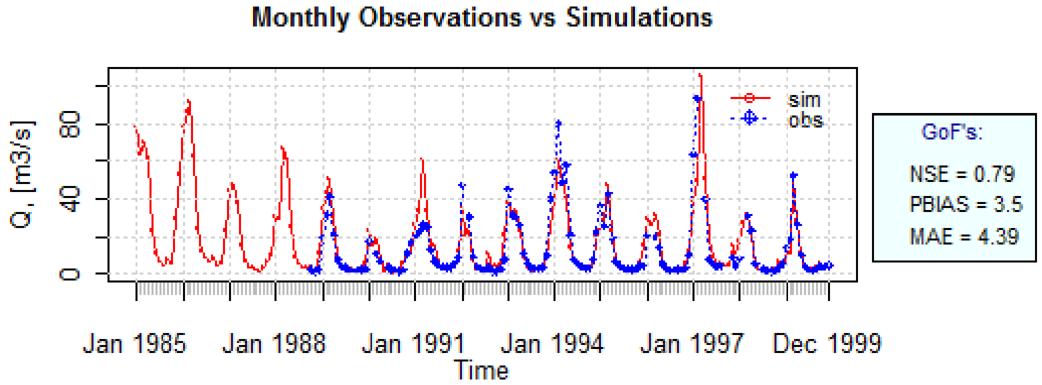
- ESCO and SOL_AWC to control the Etr
- CN2 for surface runoff and baseflow partition contrasting with BFI_BFLOW
- SURLAG to improve the discharge dynamics (high peaks)
- RCHRG_DP to increase the return flow from deep aquifer to channels to improve sim. Q during long dry season

Observed versus simulated hydrograph

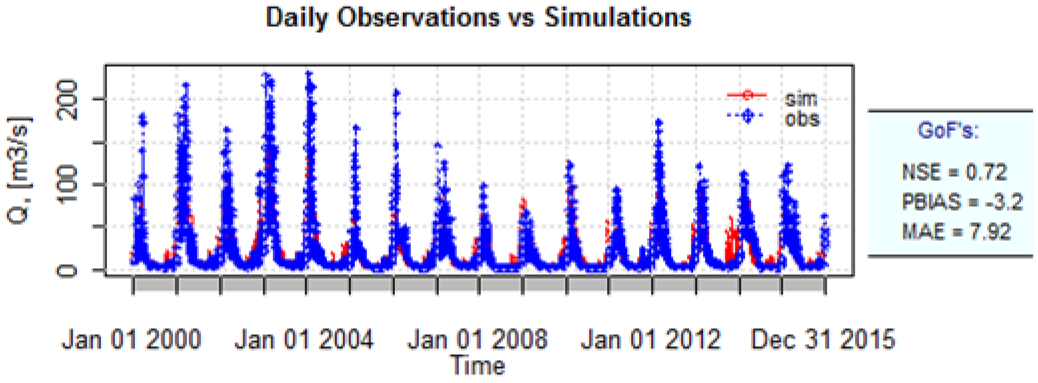


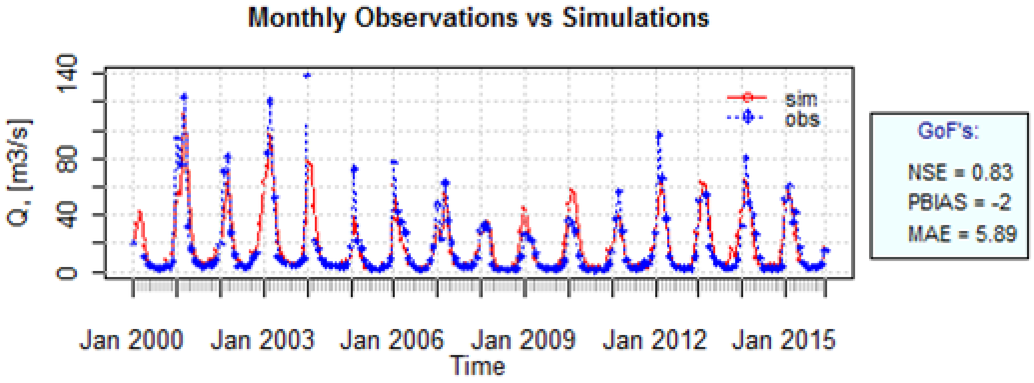
- **Results for Huancane river basin at Puente Huancane hydrological station.**





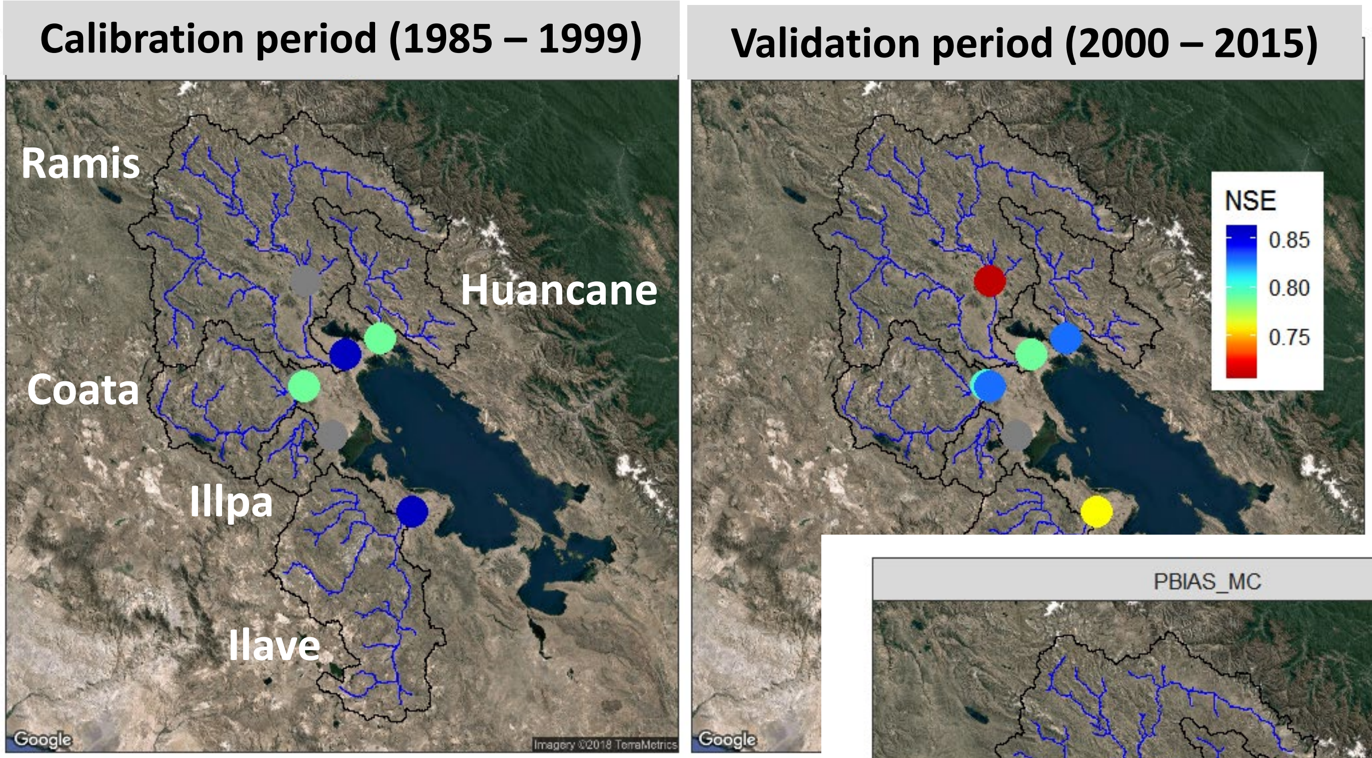
Calibration period (1985 – 1999)



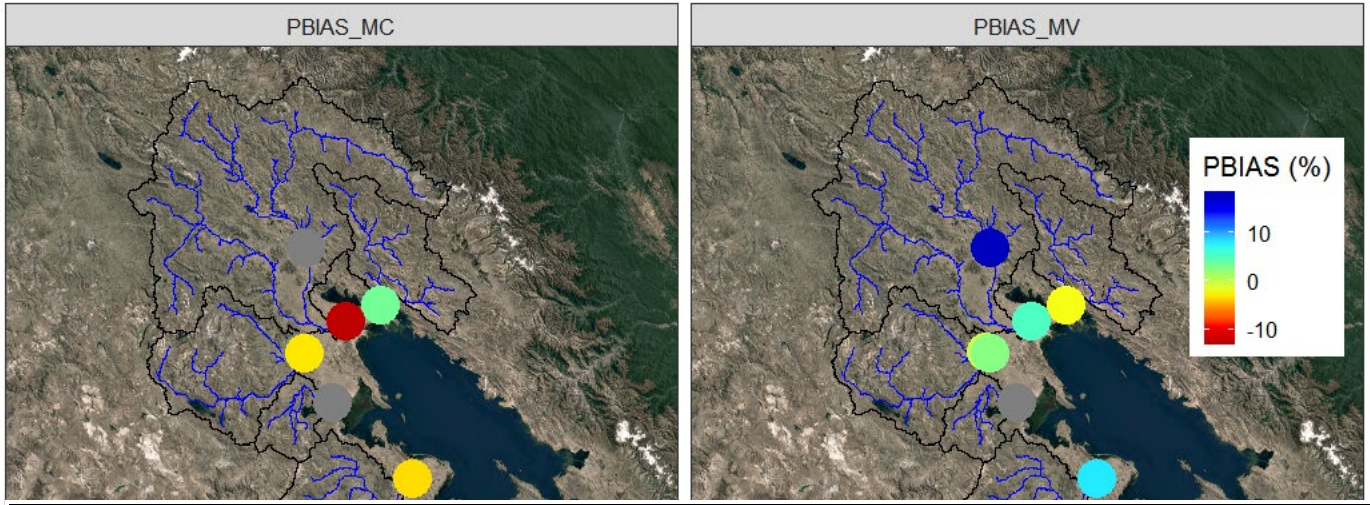


Validation period (2000 – 2015)

Model performance statistics (calibration and validation)



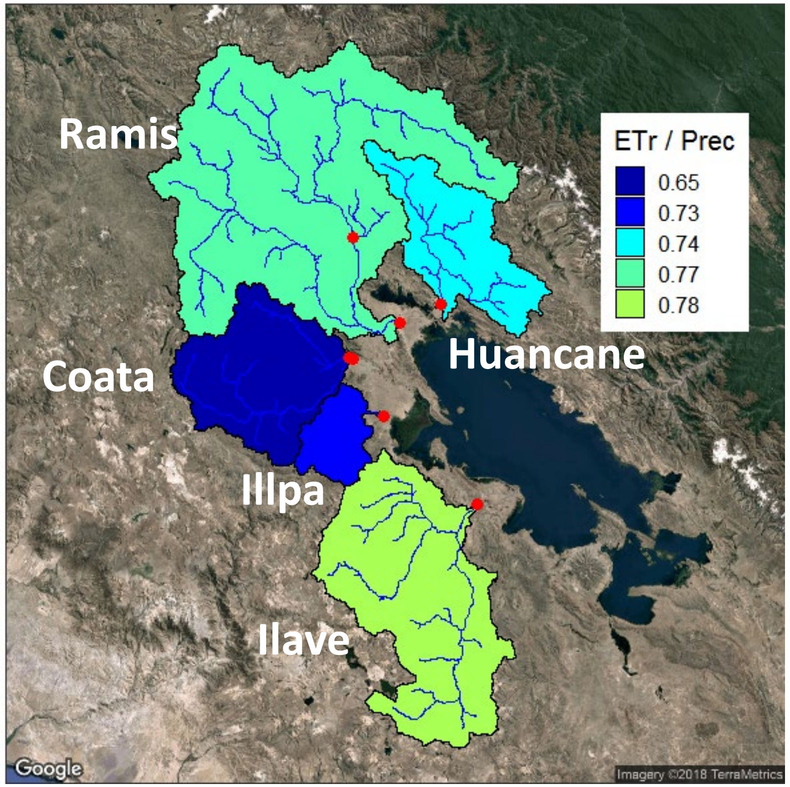
- NSE: Nash Sutcliffe eff. (0.71 – 0.86)
- PBIAS: Percentage of bias (-12 – 17%)



The SWAT model is able to simulate the discharge dynamics

MC (MV) is monthly calibration (validation)

Model performance in water balance components



Baseflow index verification

Basin	BFI_BFLOW	BFI_SWAT	Difference (%)
Huancane	0.66	0.67	1
Ramis	0.73	0.73	0
Coata	0.66	0.65	-1
Illpa		0.66	
Ilave	0.66	0.67	1

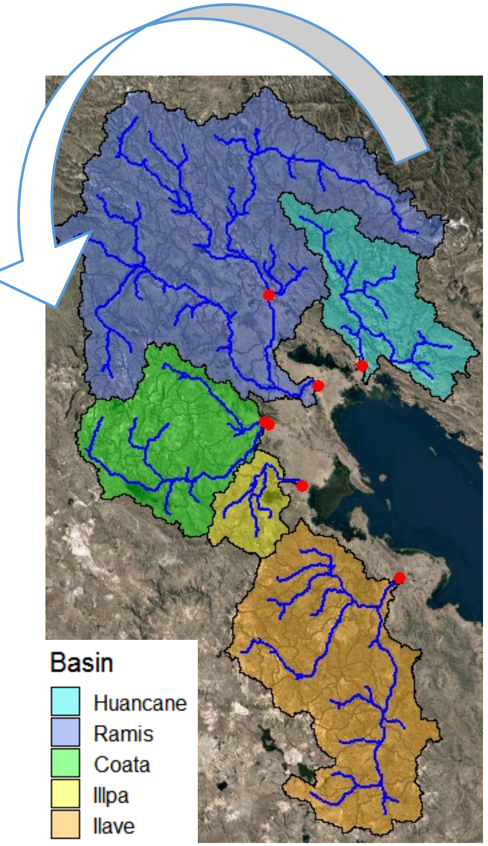
- **Southern basin has higher rate of evapotranspiration**
- **73 % of ETr is lost to the system**

The SWAT model is able to characterize the water balance components

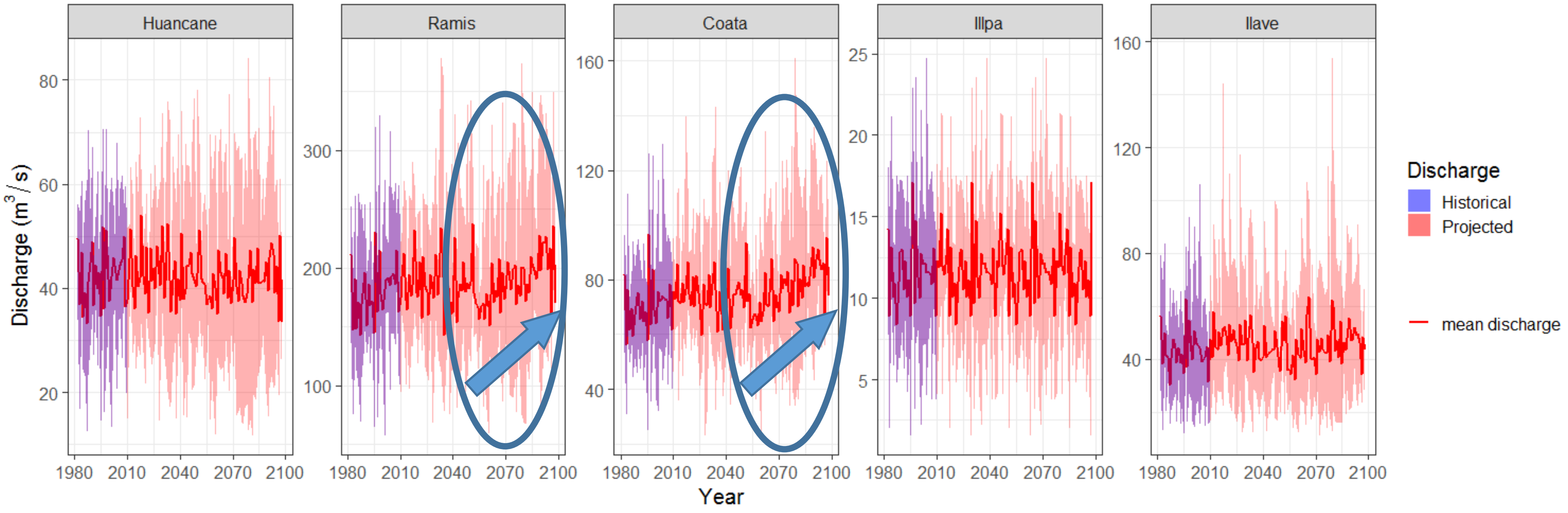
Scenario simulations (RCP 8.5)

- **5 scenarios data provided by ISI-MIP project** (A trend-preserving bias correction)
  (GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC-ESM-CHEM, NorESM1-M)

North to south



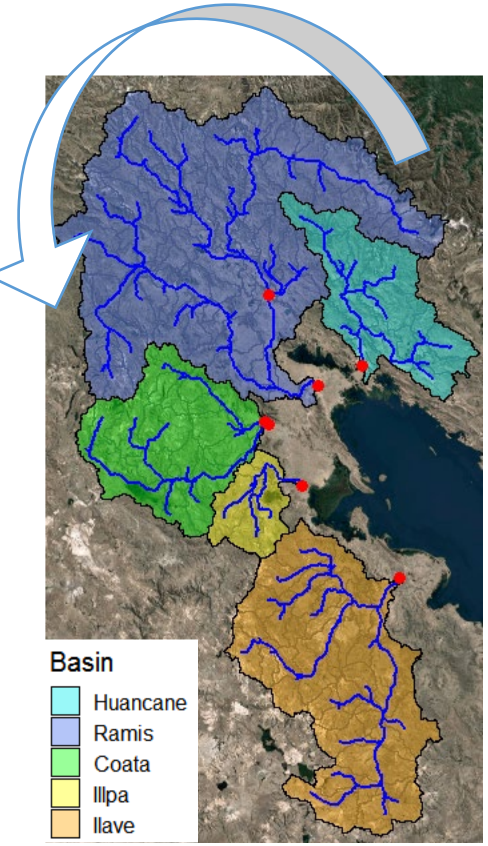
Average discharges during the high discharges season (December to October)

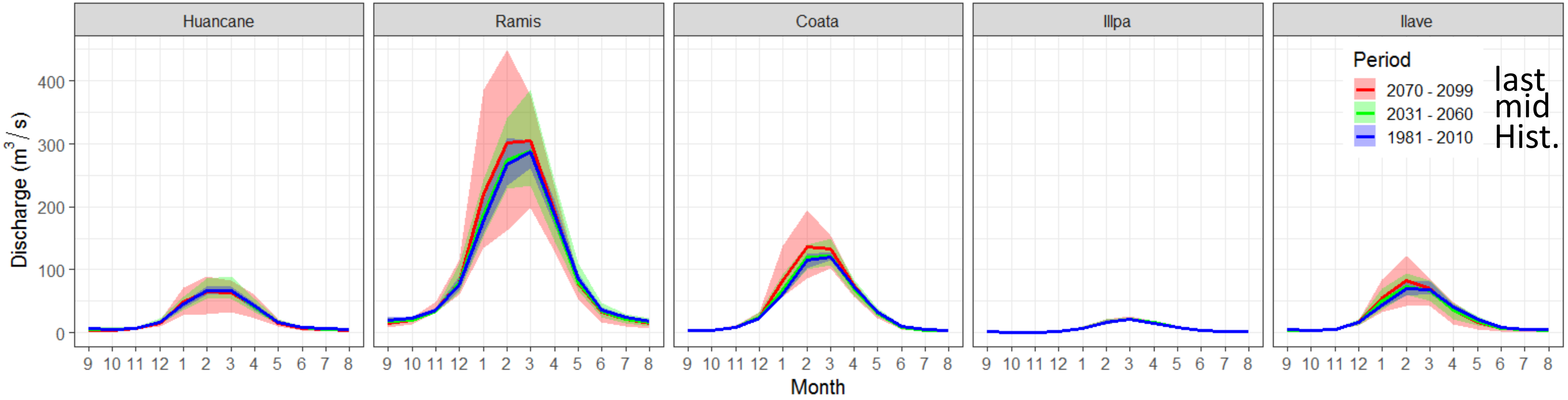


- High uncertainty in discharge simulation based 5 GCMs
- Trend to increase for the last period of the century in Ramis and Coata river basins

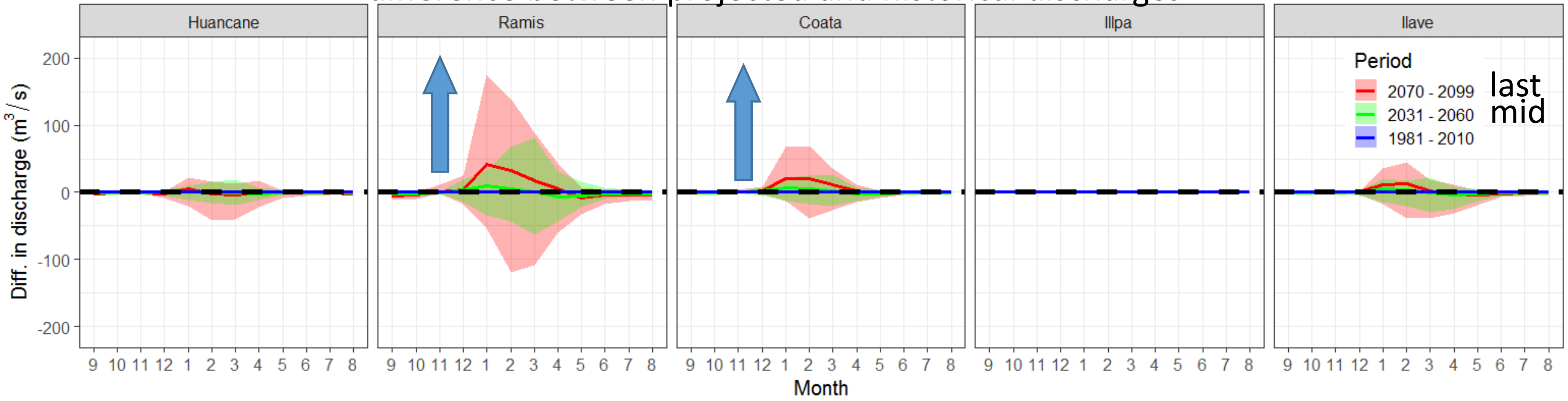
Scenario simulations (RCP 8,5)

Average monthly discharges for historical period (1981 – 2010) and mid (2031-2060) and last (2070-2099) of the century





difference between projected and historical discharges



- **Slight increase of discharges for the last period of the century**

Conclusions

- The SWAT model was able to simulate the discharge dynamics and the water balance components in Andean basins with complex terrain (Basins draining to the Titicaca lake).

- Discharges will increase under changing climate in Ramis and Coata river basins mainly in the last period (2070 – 2099) of the century.

Perspectives

- The next step is to include the greater number of GCMs for better uncertainty estimation of simulated discharges under changing climate.

THANKS