Implementation and Evaluation of the WRF-Hydro Model for Hydrometeorological Forecasting in the Piura River Basin, Peru

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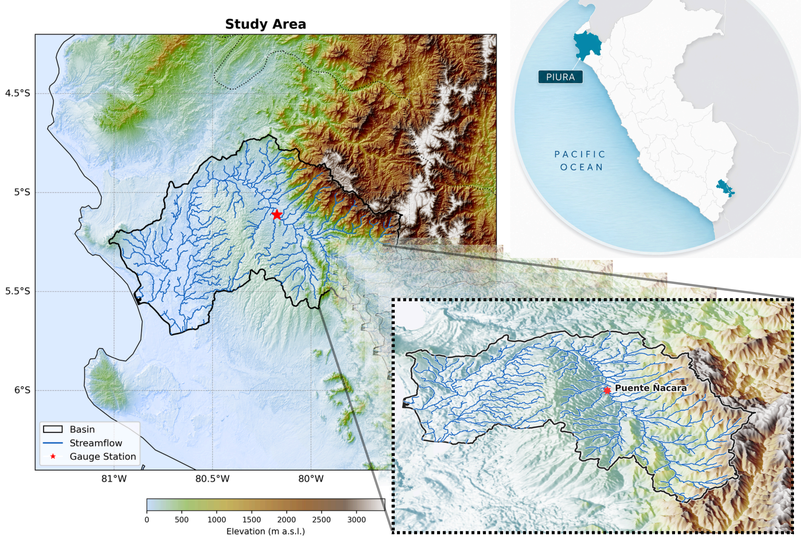
I.- Overview on the Study Area



The Piura River Basin is an exorheic basin of the Pacific slope, characterized by a steep upper catchment and a low-relief alluvial lower basin. This geomorphological transition controls runoff generation, sediment transport, groundwater interaction, and flood hazard, especially during intense rainfall episodes linked to El Niño.

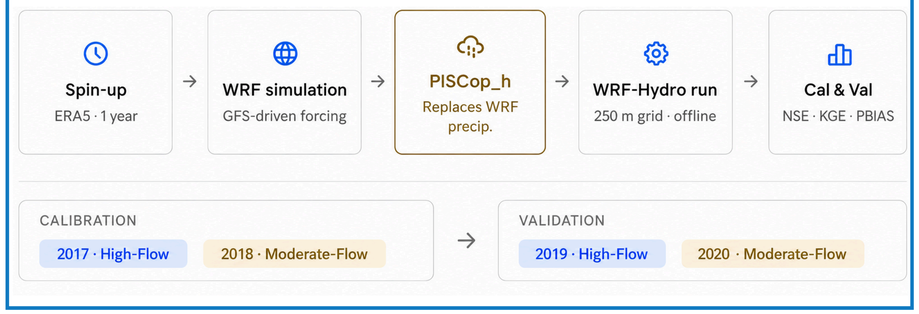
Hydrological Regime Characteristics

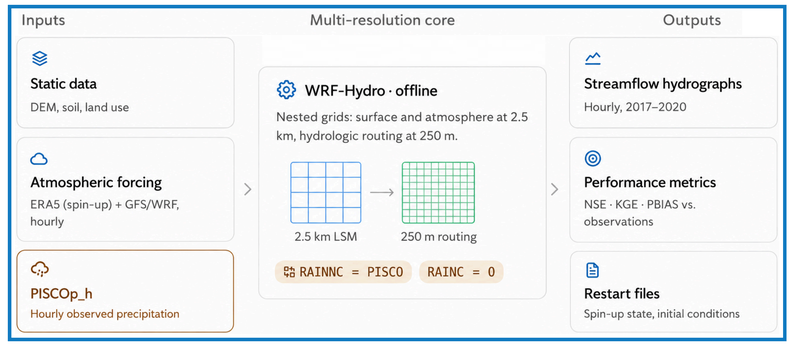
- The Piura River Basin exhibits a highly seasonal and event-driven hydrological response, with rapid runoff generation and extreme flood peaks during intense rainfall events.
- Low-gradient alluvial plains in the lower basin amplify flooding and channel instability through slow flow propagation, extensive inundation, and frequent channel avulsions under El Niño conditions.

II- Aim of this Study

- Implement WRF-Hydro V5.2 as a distributed hydrological modeling framework for extreme flood simulation in the Piura River Basin.
- Develop a hybrid forcing strategy combining WRF outputs with PISCOp_h hourly gridded precipitation observations.
- Calibrate the model using 2017 (high-flow) and 2018 (moderate-flow) conditions, and independently validate performance during 2019 (high-flow) and 2020 (moderate-flow) using NSE, KGE, and PBIAS.
- Assess the future operational potential of WRF-Hydro for flood forecasting applications at SENAMHI.

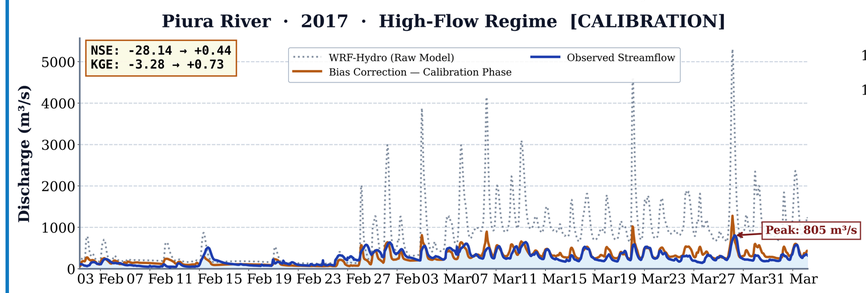
III- Methods

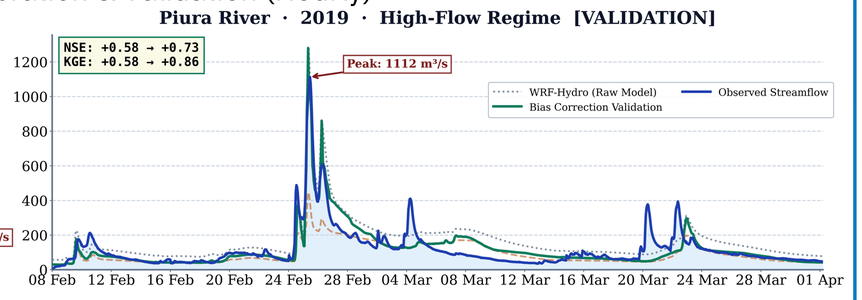


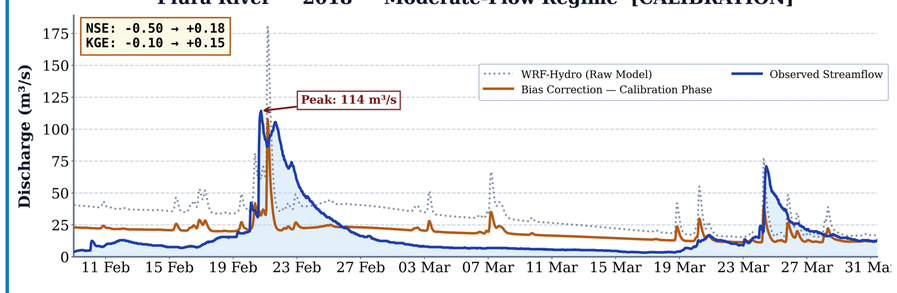


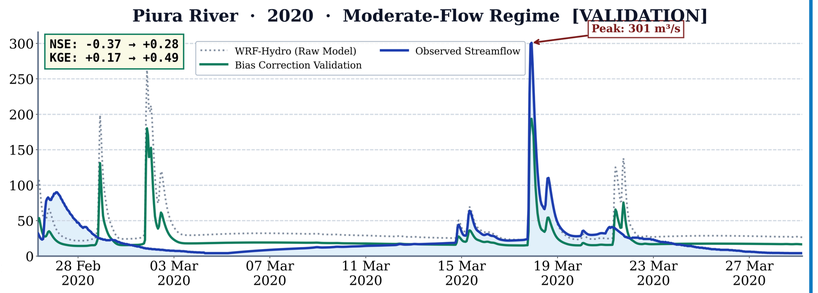
IV - Results

WRF-Hydro V5.2 · Calibration & Validation (Hourly)

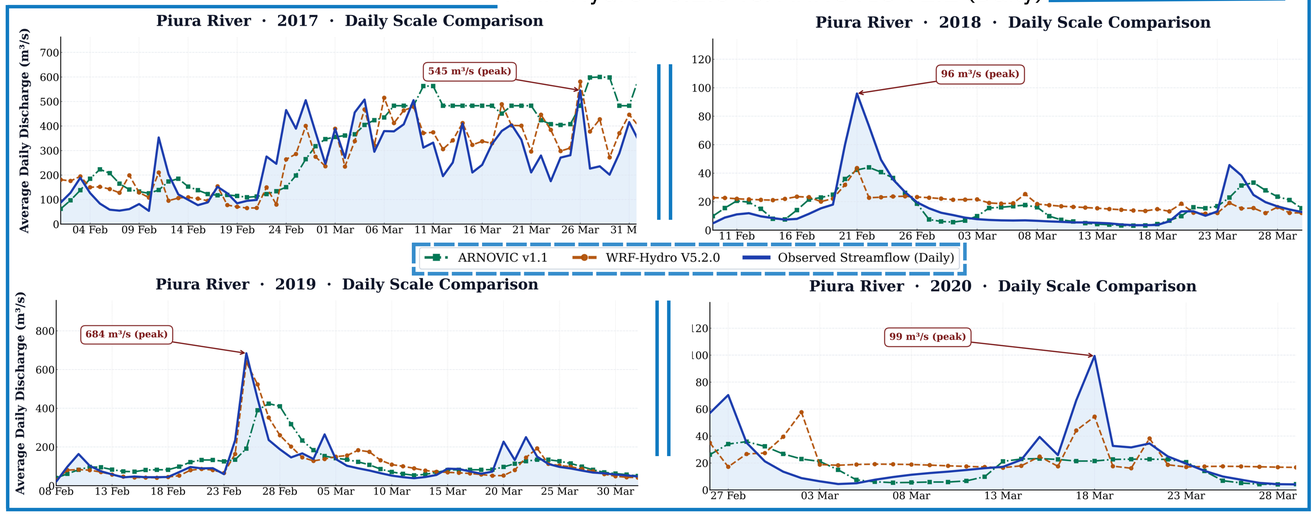








WRF-Hydro V5.2.0 vs. ARNOVIC V1.1 (Daily)



V- Discussion & Preliminary Conclusions

- The hybrid WRF + PISCOp_h approach performs best during high-flow conditions associated with Coastal El Niño events.
- Peak-flow bias is substantially reduced during the 2017 Coastal El Niño, improving PBIAS from +27.2% to +7.9%.
- Model skill decreases under moderate-flow conditions, indicating the need for improved parameter optimization.
- Results highlight the potential of distributed hydrological modeling for future operational flood forecasting applications at SENAMHI.

		WRF-HYDRO V5.2			ARNOVIC V1.1		
Year	Flow Regime	NSE	KGE	PBIAS (%)	NSE	KGE	PBIAS (%)
2017	High-Flow	**0.57**	**0.79**	**+7.9**	−0.45	0.42	+27.2
2018	Moderate-Flow	0.26	0.19	+15.2	**0.63**	**0.56**	**−0.8**
2019	High-Flow	**0.77**	**0.89**	**+1.0**	0.28	0.51	+5.0
2020	Moderate-Flow	**0.24**	**0.30**	**+2.4**	0.20	0.23	−26.3

⚠ Future work: data assimilation, extended simulation period, parameter optimization for moderate-flow regimes, and operational PISCO-driven forecasting!