SONICS:
A new Peruvian hydrological dataset of simulated daily streamflow for flood monitoring and forecasting

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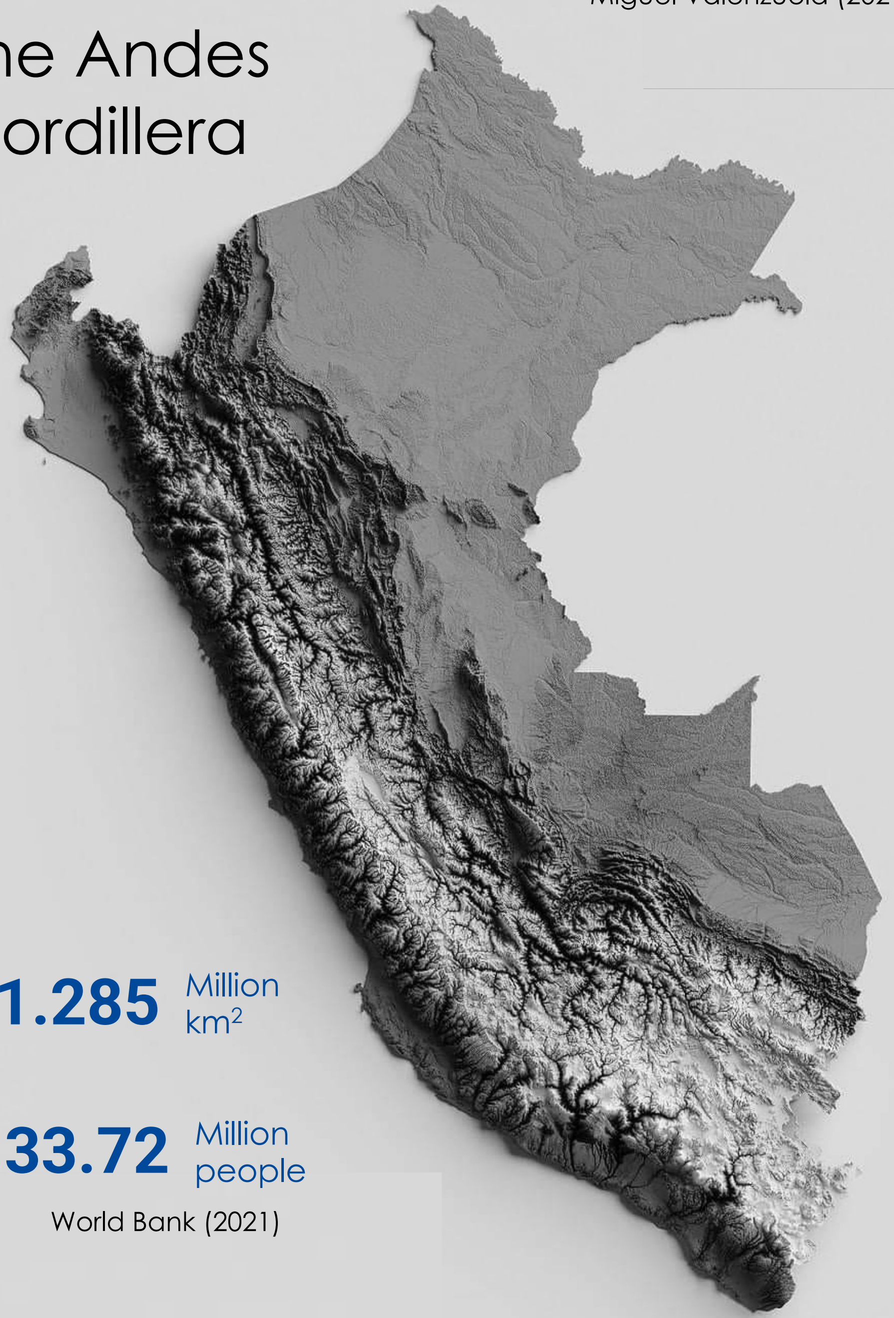
May 2023

¿WHERE IS PERU?



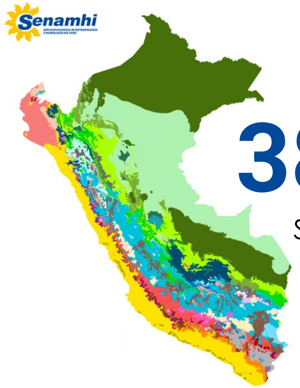
The Andes Cordillera

1.285 Million km^2

33.72 Million people

World Bank (2021)

CONTEXT



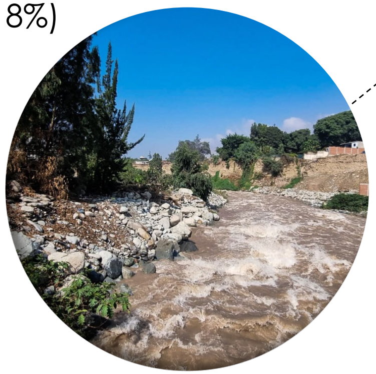
38 climates

SENAMHI (2020)

03 hydrographic slopes

Atlantic
(97.27%)

Pacific
(2.18%)

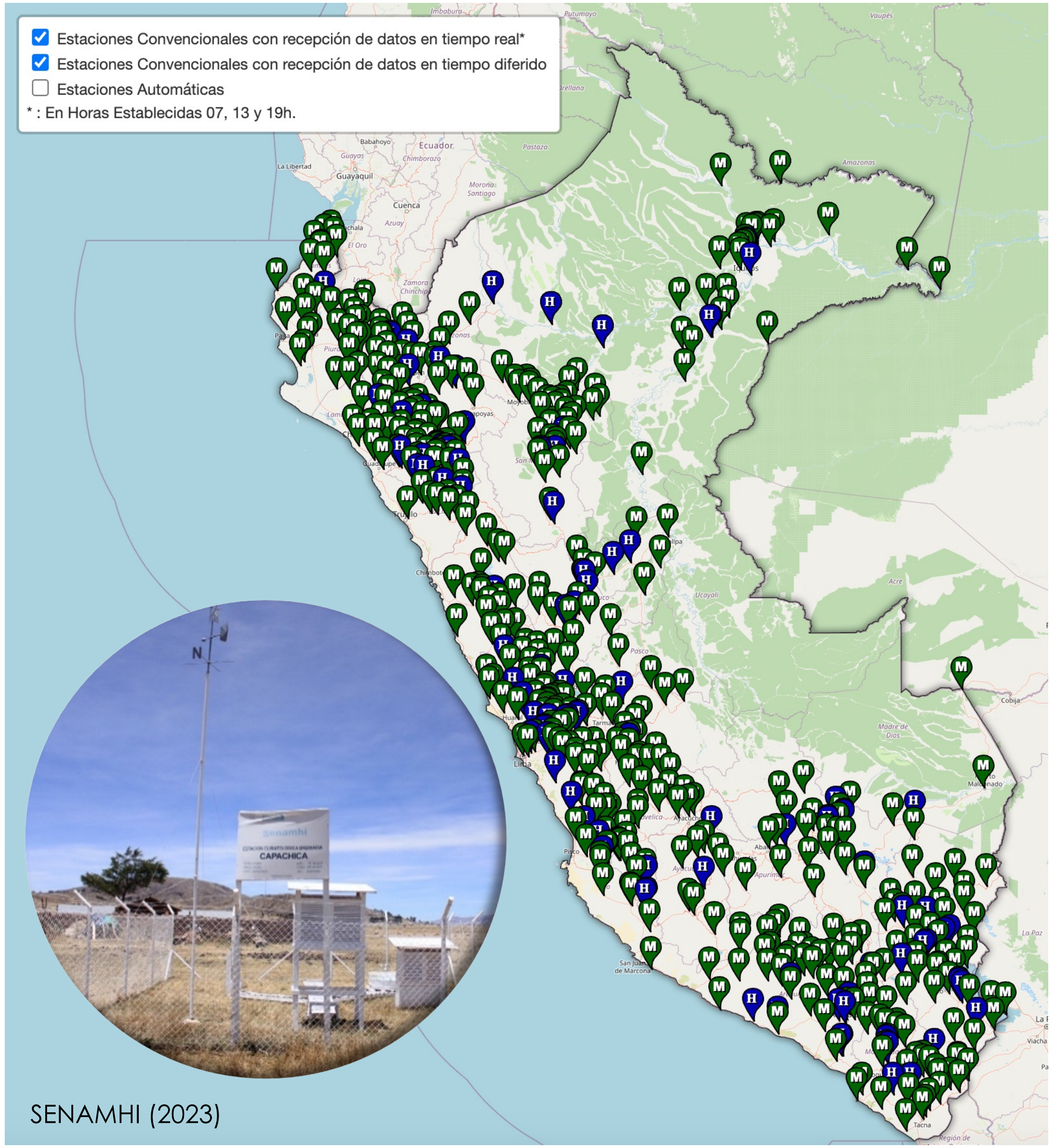


Titicaca
(0.56%)

Floods in the
Northwest
Coast of Peru
(March 2023)

HYDROMETEOROLOGICAL NETWORK IN PERU

Conventional stations



SENAMHI (2023)

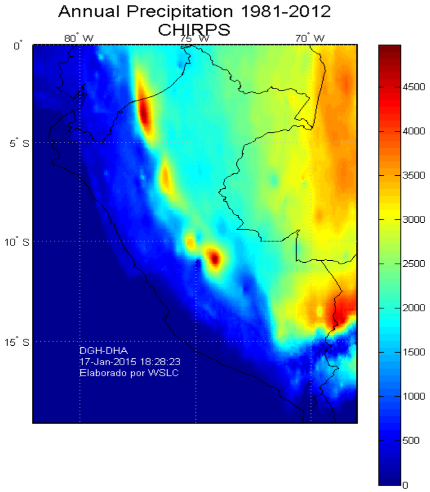
Automatic stations

SENAMHI (2023)

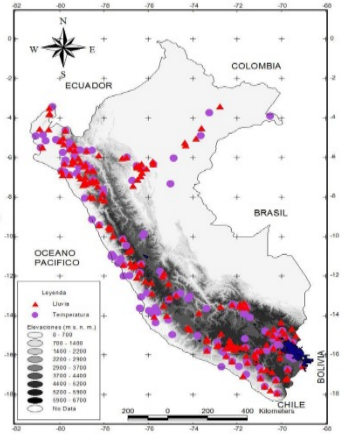
BUILDING GRIDDED HYDROMETEOROLOGICAL DATA

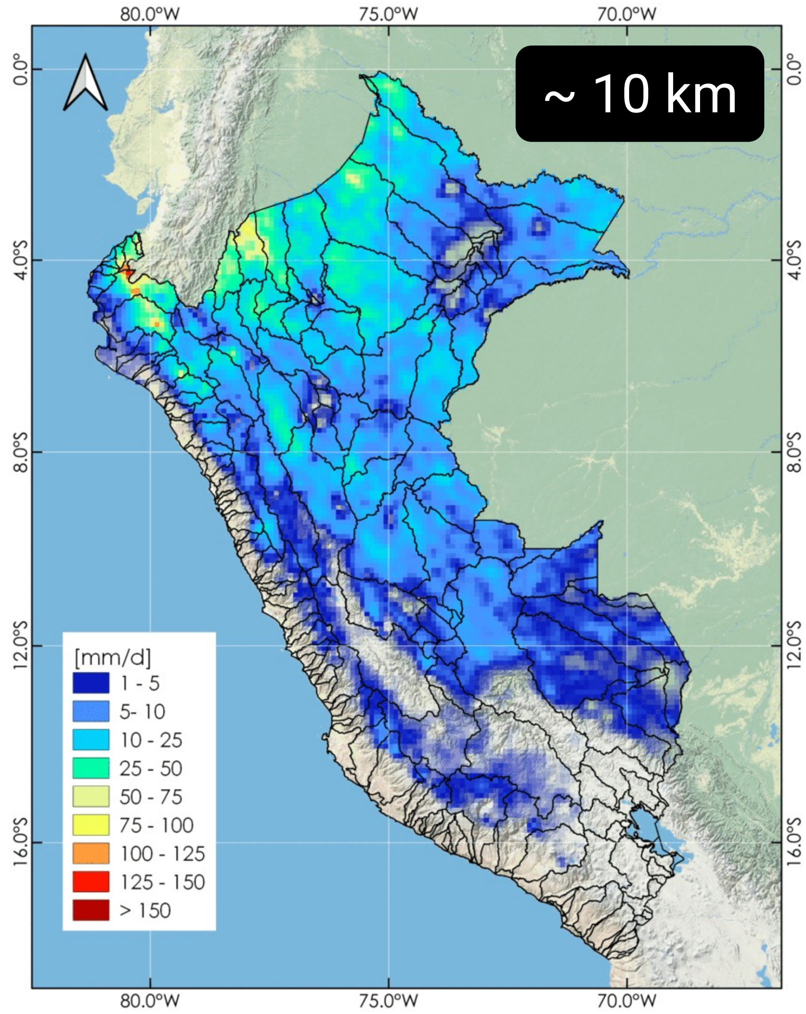
PISCO

Peruvian **I**nterpolated data of **S**ENAMHI's **C**limatological and Hydrological **O**bservations



MERGING





- Gridded precipitation → **PISCOpr** → at DAILY and MONTHLY time scale → Aybar et al. (2019).
- Gridded evapotranspiration → **PISCOeo-pm** at DAILY time scale → Huerta et al. (2022).

STUDY DOMIAN INCLUDING TRANSBOUNDARY BASINS

11913

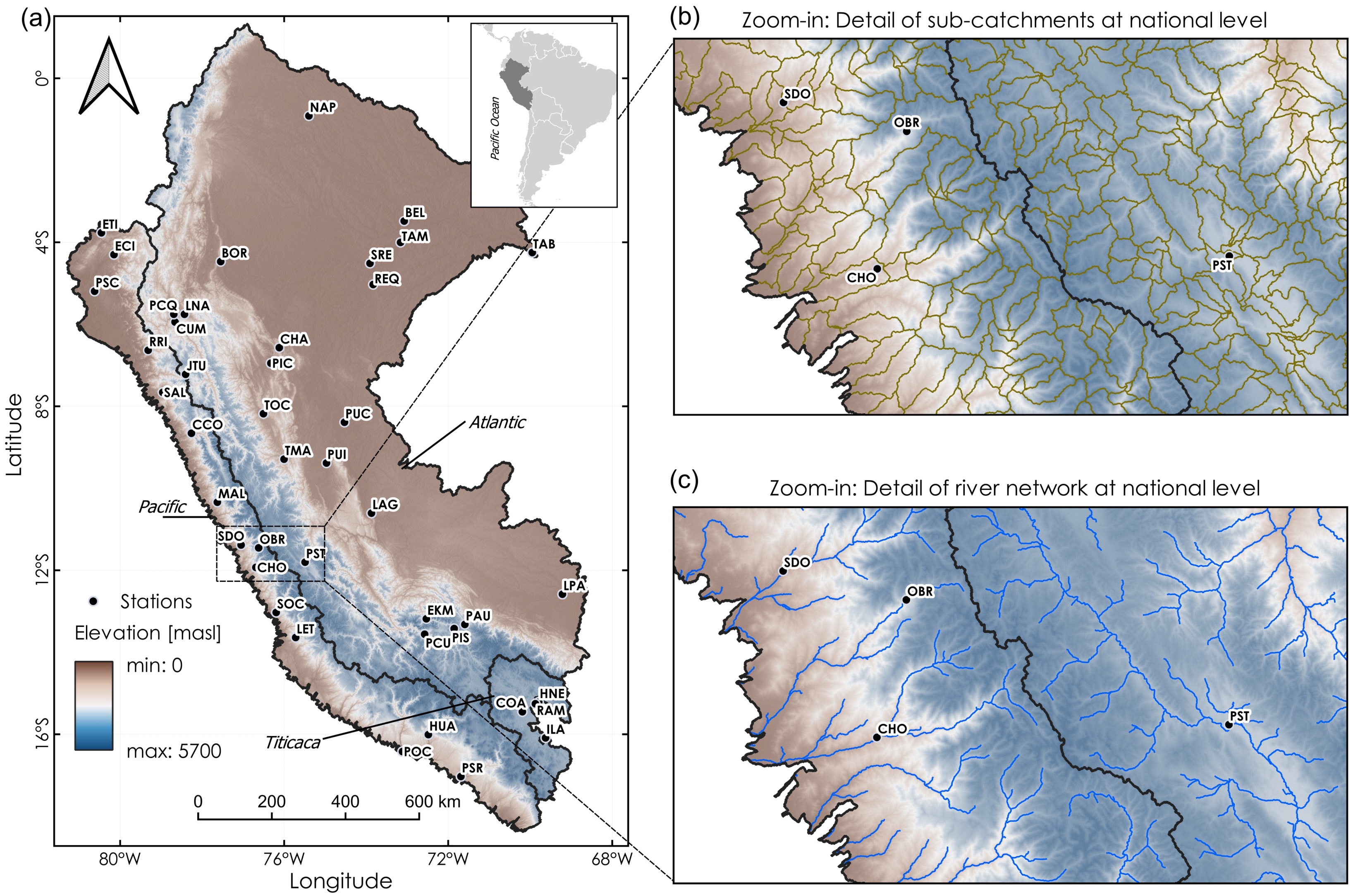
Sub-catchments and river reaches

43

Fluviometric stations

27%

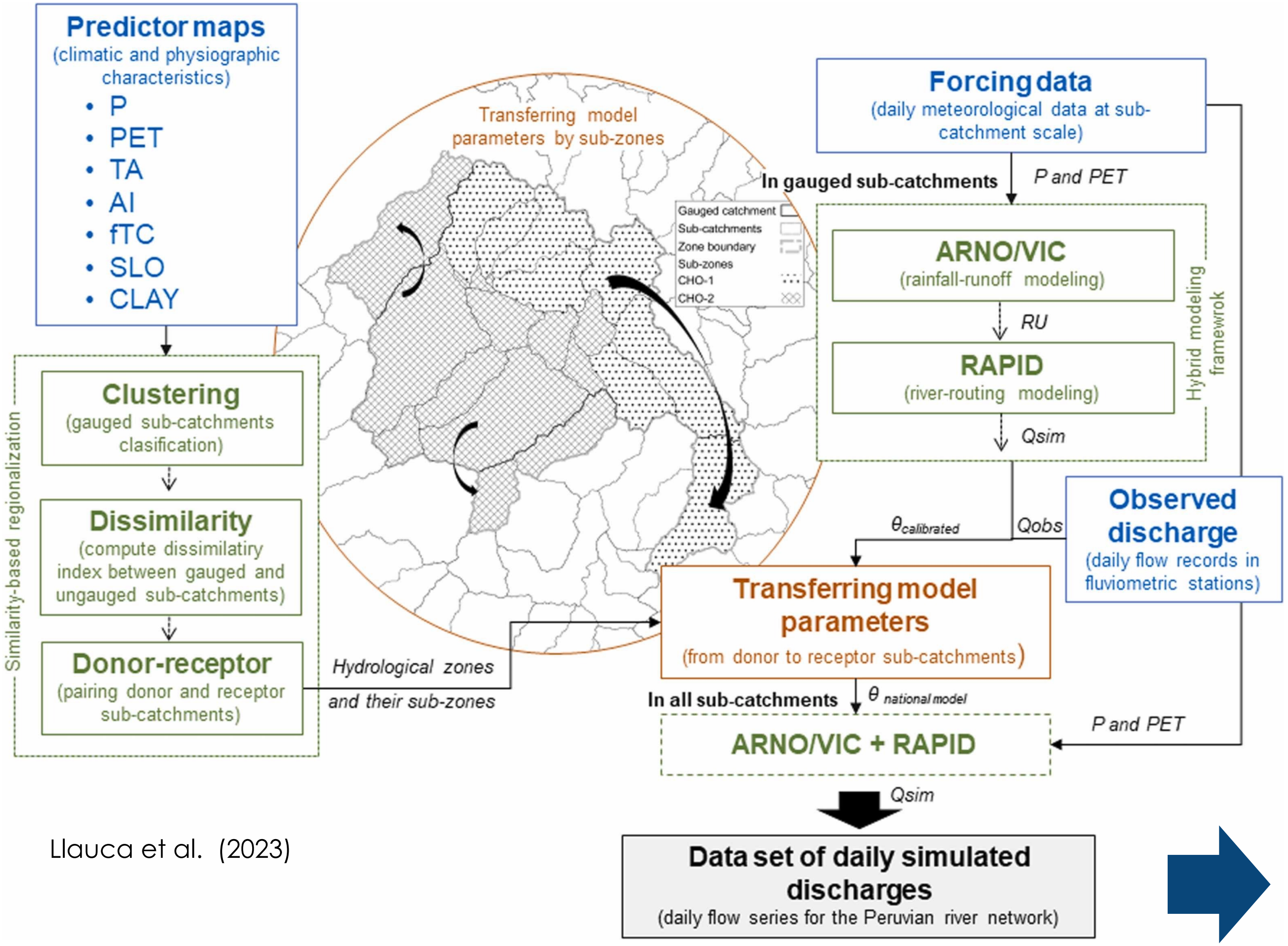
Ungauged areas



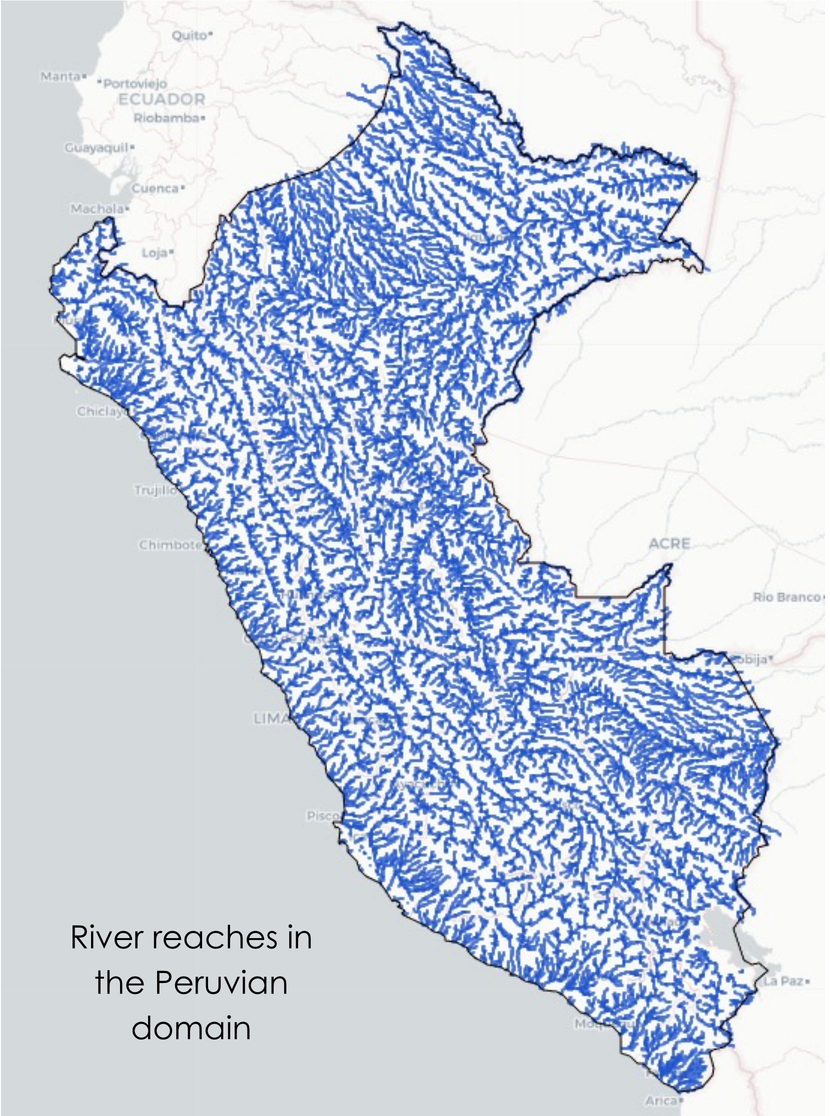
- We include transboundary basins with Ecuador and Colombia.

Llauca et al. (2023)

METHODOLOGY



Llauca et al. (2023)



River reaches in the Peruvian domain

https://hllauca.github.io/PISCO_HyD_ARNOVIC_map/Identificar_COMID.html

HYDROLOGICAL REGIONALIZATION APPROACH

Climatic and Physiographic characteristics:

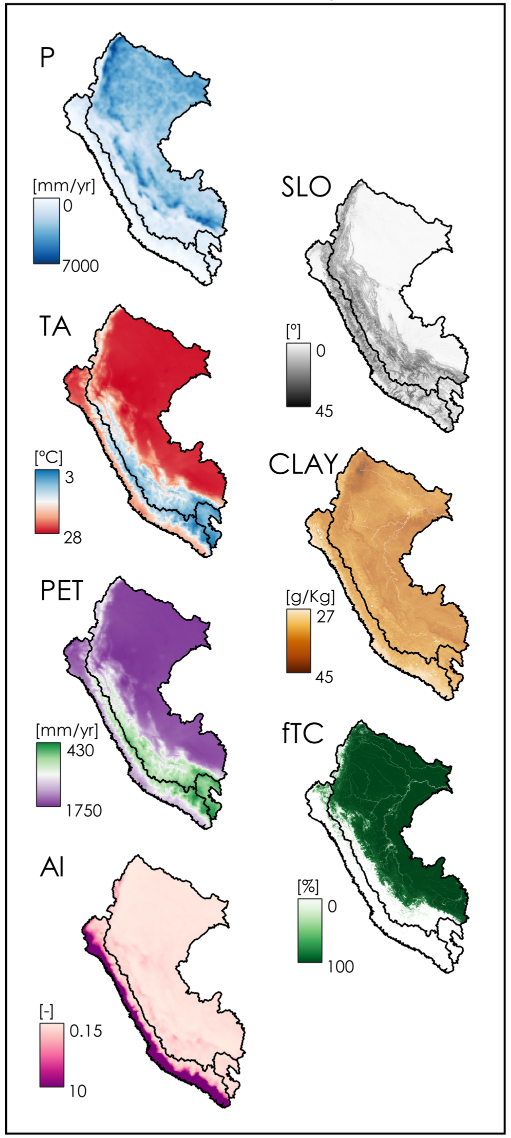
Variable	Units	Variable	Resolution
P	mm/ year	Mean annual precipitation	0.1°
PET	mm/ year	Mean annual potential evapotranspiration	0.1°
AI	-	Aridity index	0.1°
TA	°C	Mean air temperature	0.1°
fTC	%	Fraction of forest cover	30 m
SLO	°	Surface slope	90 m
CLAY	g/Kg	Soil clay content	250 m

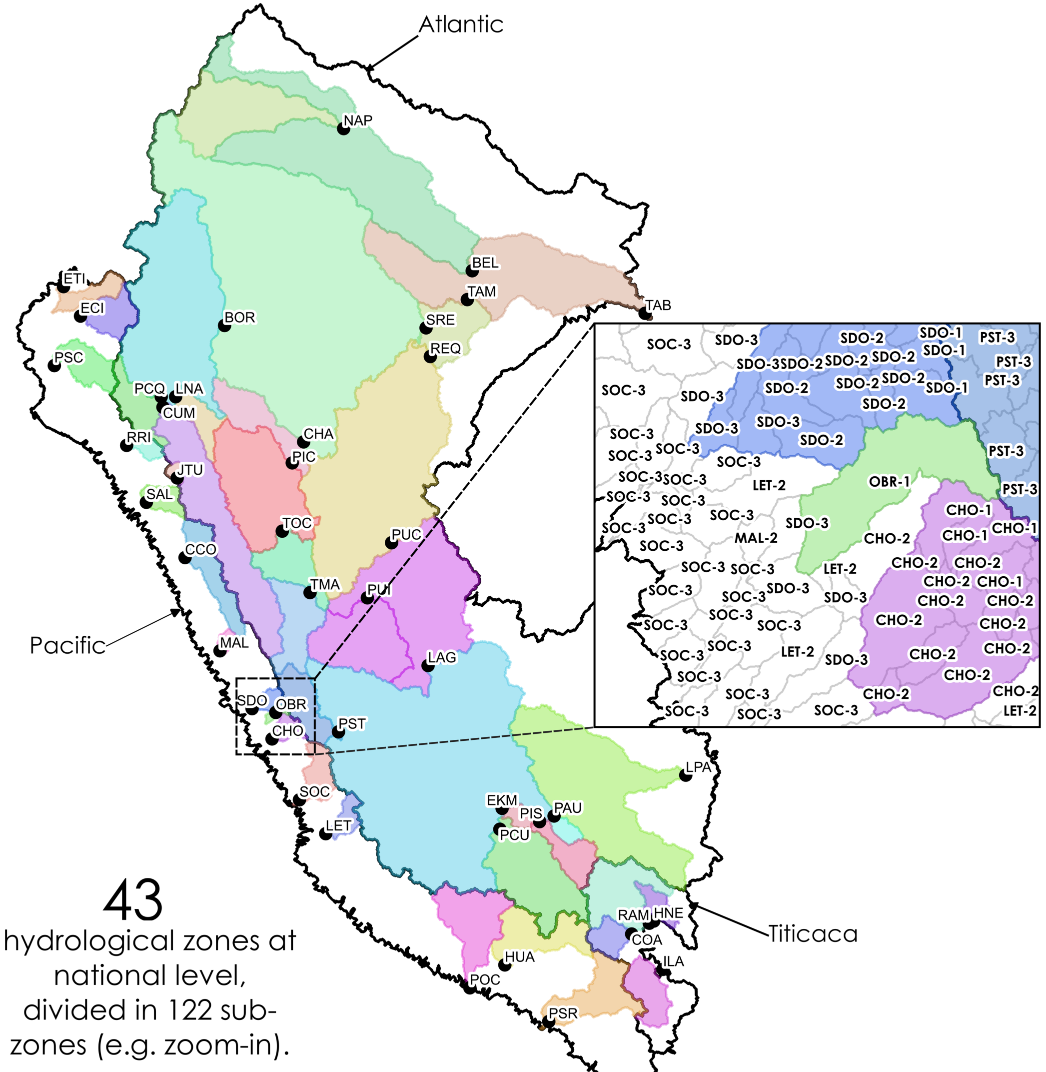
Dissimilarity index (S):

$$S_{i,j} = \sum_{p=1}^{7} \frac{\left|Z_{p,i} - Z_{p,j}\right|}{IQR_p};$$

Beck et al. (2016)

Predictor maps





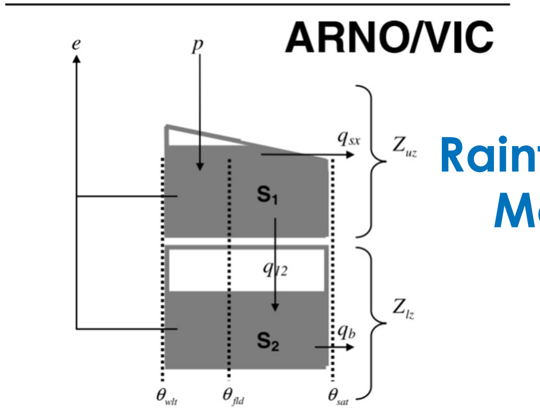
43
hydrological zones at national level, divided in 122 sub-zones (e.g. zoom-in).

Llauca et al. (2023)

HYBRID HYDROLOGICAL MODELING FRAMEWORK

FRAMEWORK FOR UNDERSTANDING STRUCTURAL ERRORS (FUSE)

Clark et al. (2008)



Rainfall-Runoff Modeling → **Routing Modeling**

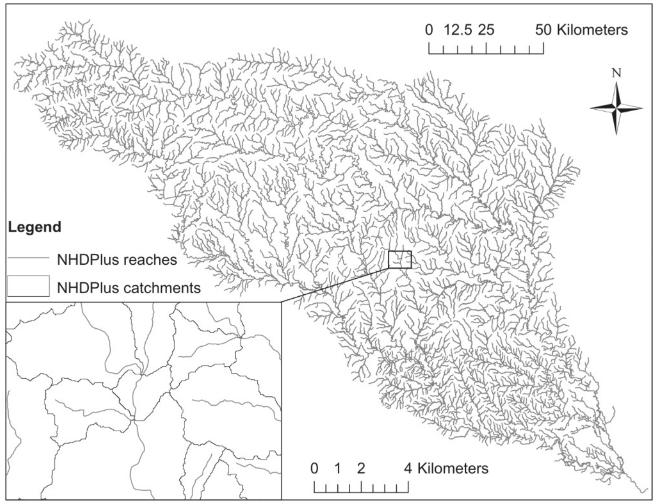
Table 3
ARNO/VIC model parameters and defined upper and lower bounds.

Parameter	Description	Units
MAXWATER1	Depth of upper soil layer	mm
MAXWATER2	Depth of lower soil layer	mm
FRACTEN	Fraction total storage in tension storage	-
RTFRAC1	Fraction of roots in the upper layer	-
PERCRTE	Percolation rate	mm/day
PERCEXP	Percolation exponent	-
BASERTE	Baseflow rate	mm/day
QB_POWR	Baseflow exponent	-
AXV_BEXP	ARNO/VIC *b* exponent	-
TIMEDELAY	Time delay runoff	days

Source:Adapted from (Lane et al. (2019).

ROUTING APPLICATION FOR PARALLEL COMPUTATION OF DISCHARGE (**RAPID**)

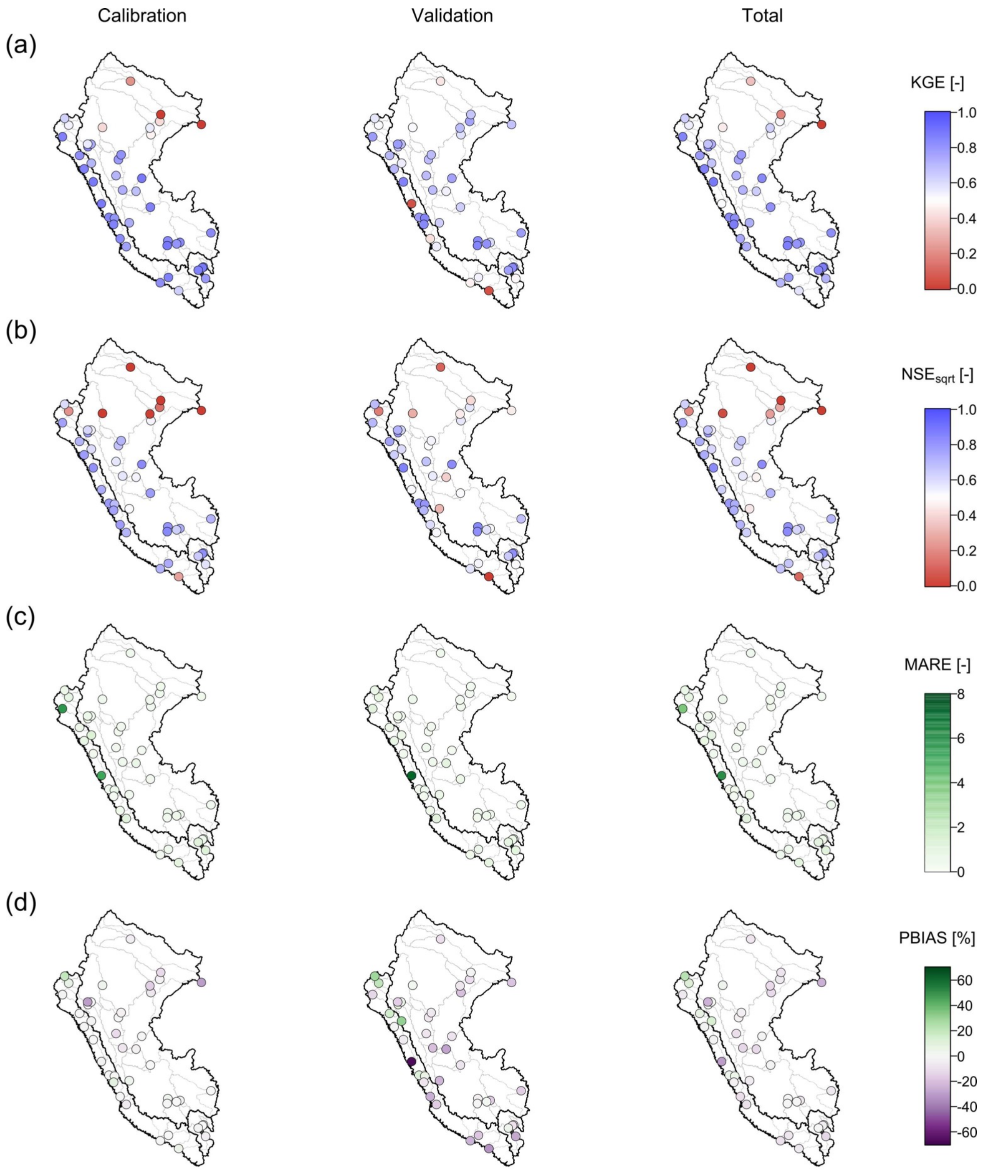
David et al. (2011)

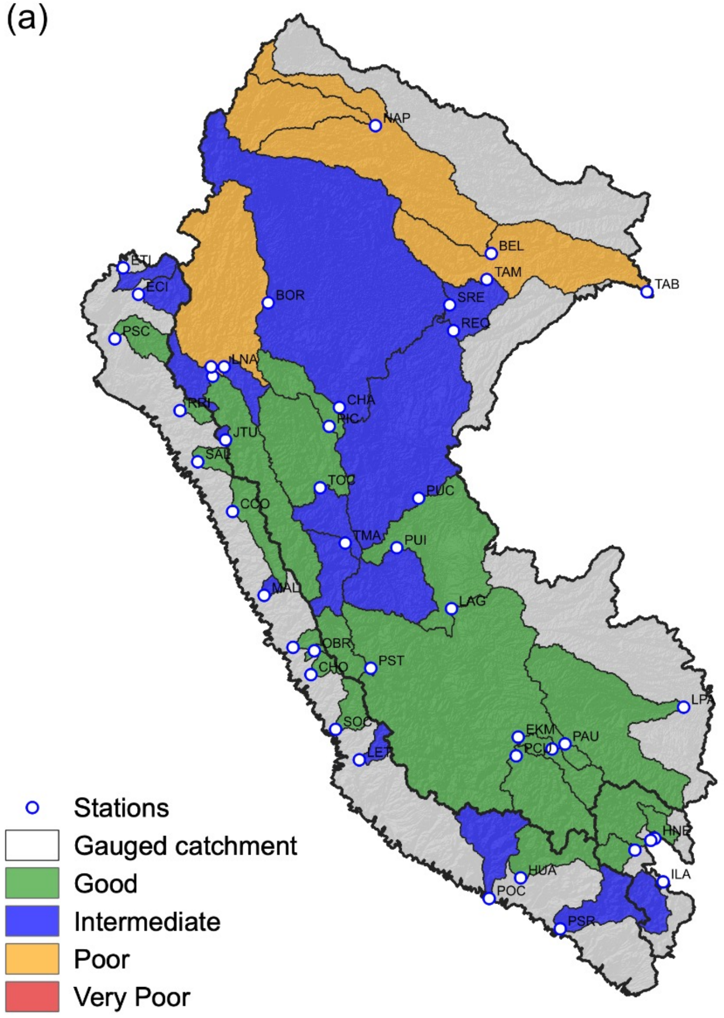


Matricial Muskingum rearrange:

$$[I - C_1 \bullet (N - T)] \bullet Q(t + \Delta t) = b(t) + T \bullet C_1 \bullet Q(t + \Delta t);$$

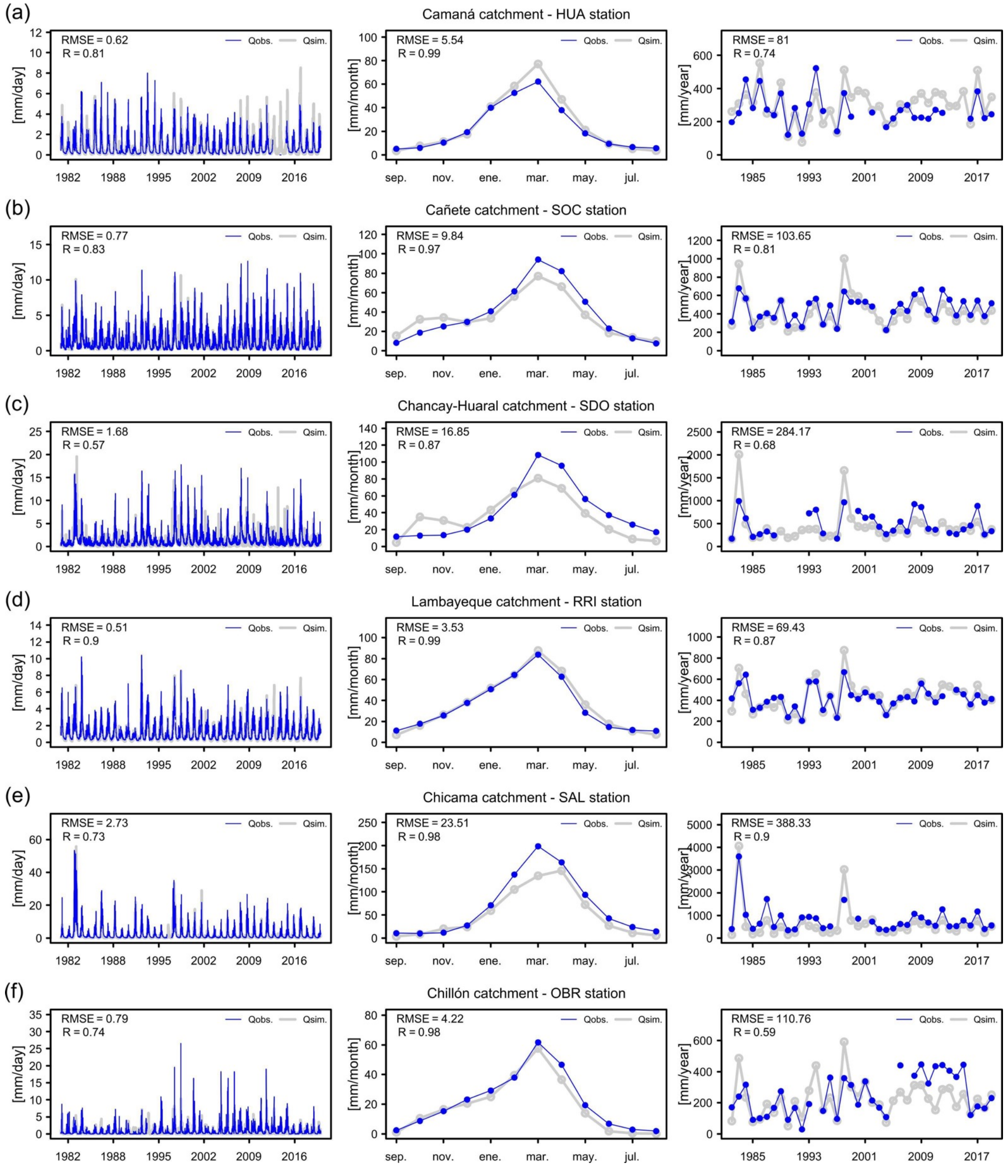
MODEL PERFORMANCE AND CROSS VALIDATION

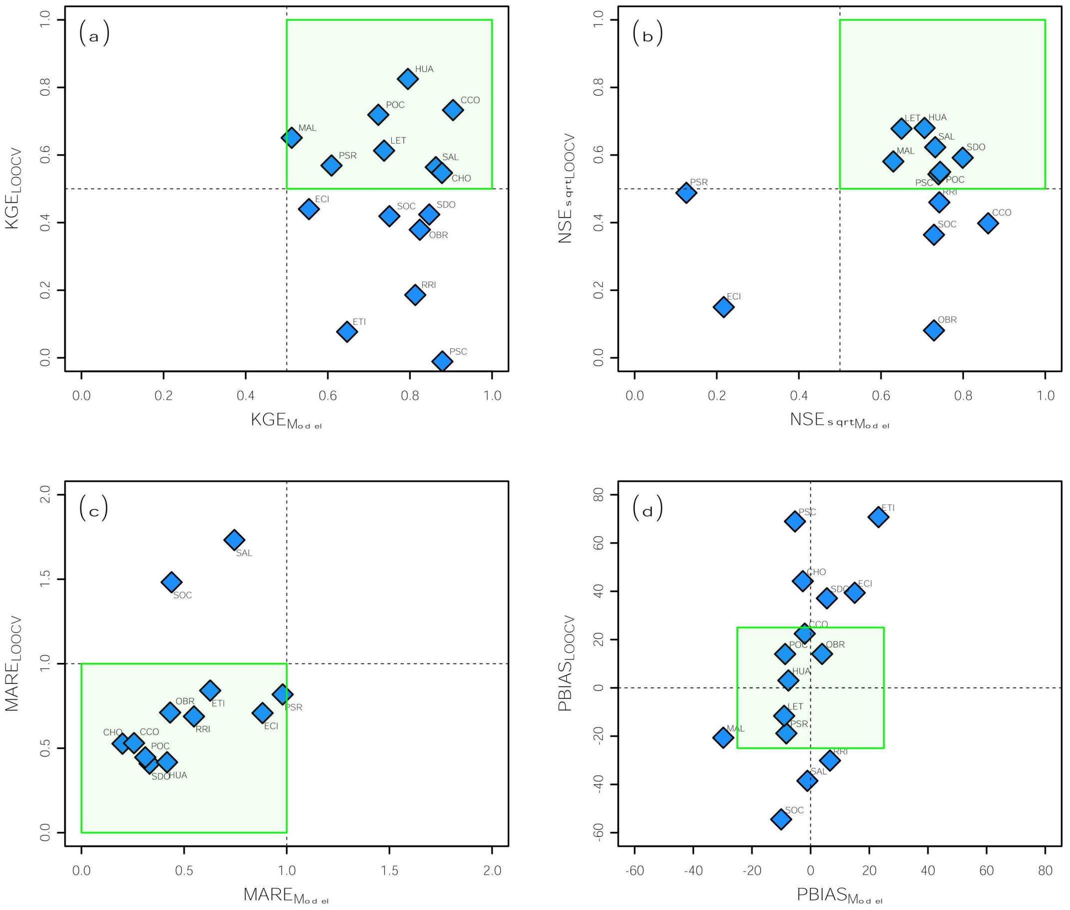




Llauca et al. (2023)

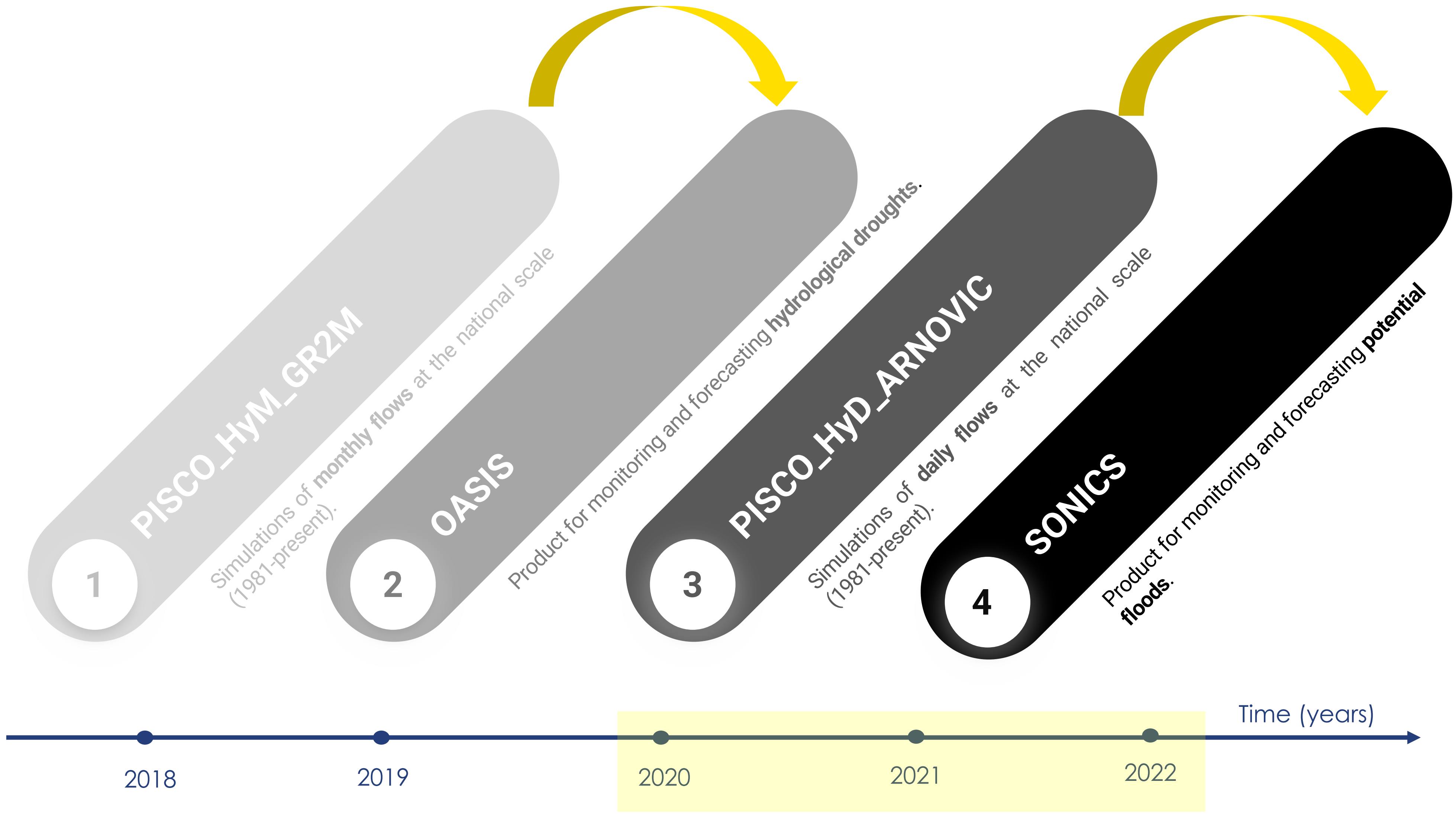
MODEL SIMULATION AND CROSS VALIDATION





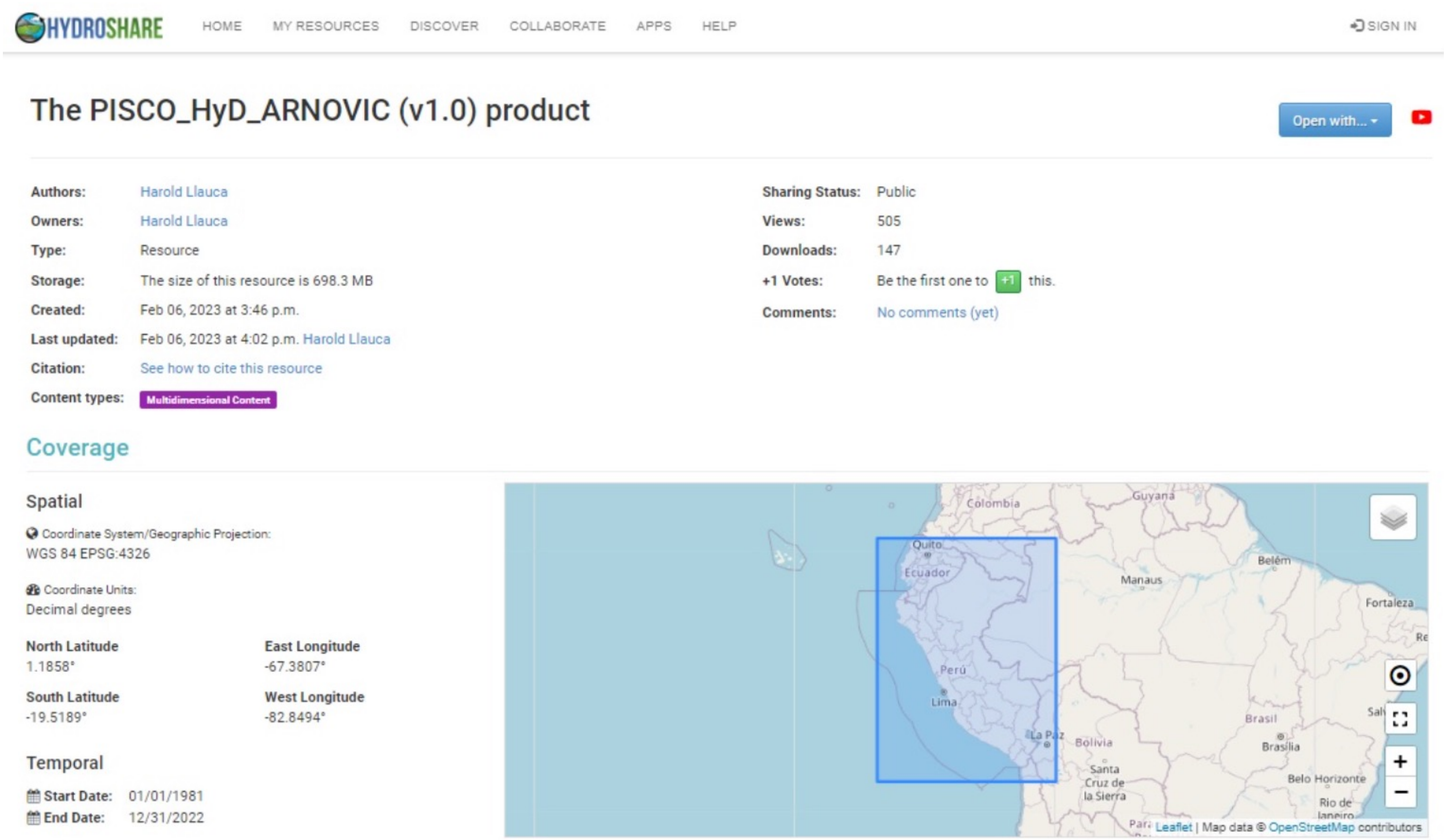
Llauca et al. (2023)

HYDROLOGICAL APPLICATIONS AT NATIONAL SCALE



PISCO_HyD_ARNOVIC (version 1.0)

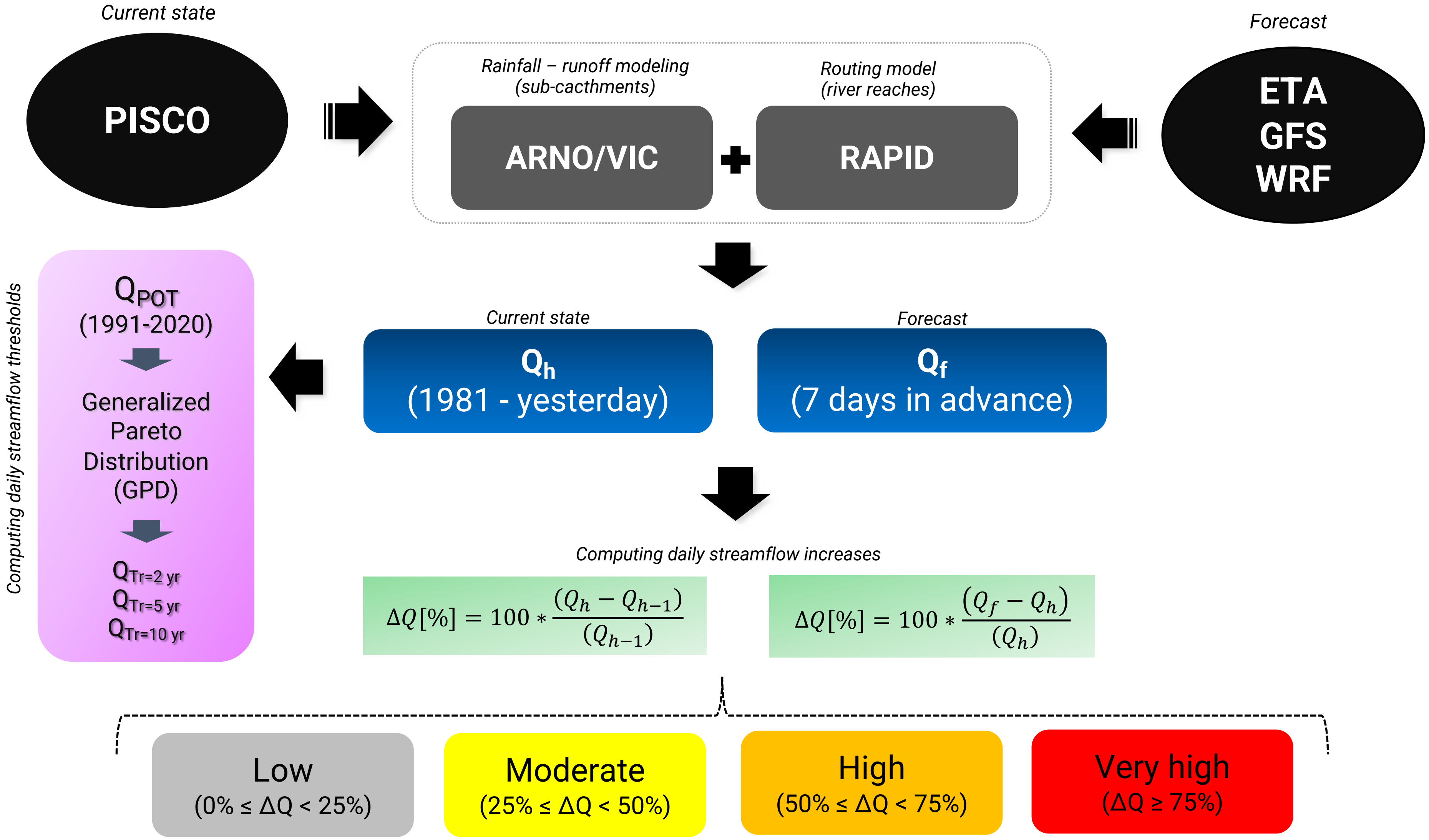
Simulated daily flow series (1981-2022) across the Peruvian domain based on the ARNOVIC+RAPID model




```
dimensions:
  time = 15340;
  comid = 11913;
variables:
  double time(time=15340);
    :axis = "T";
    :units = "seconds since 1970-01-01 00:00:00+00:00";
    :long_name = "time";
    :calendar = "gregorian";

  float qr(time=15340, comid=11913);
    :units = "m3/s";
    :_FillValue = -9999.0f; // float
    :long_name = "Daily discharge for each river reach";

  double comid(comid=11913);
    :axis = "X";
    :units = "unique identifier for each river reach or subbasin";
    :long_name = "comid";

// global attributes:
:title = "Model results from the ARNO/VIC+RAPID model";
:institution = "SENAMHI Peru";
:authors = "Harold Llauca & Karen Leon ";
```

- ❑ This dataset is stored in NetCDF format.

THE SONICS PRODUCT (version 3.1)



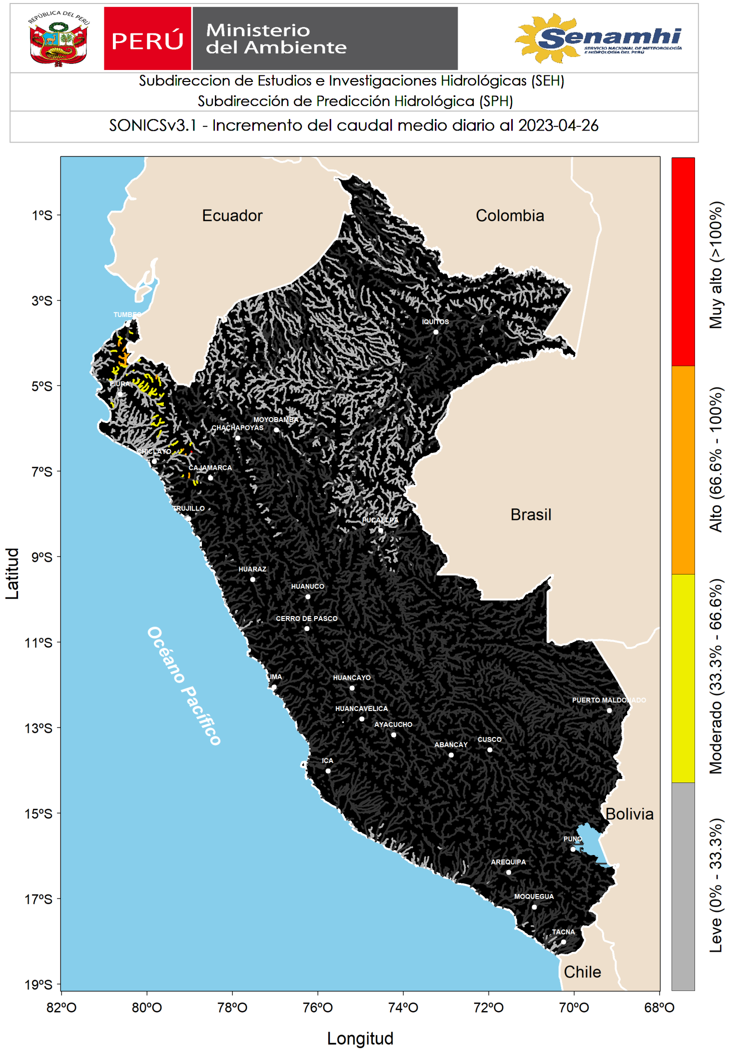
Llauca et al. (In prep)

FLOOD FORECASTING USING SONICSv3.1

Daily flow simulations at the current state and forecasts (1-7 days)

CURRENT STATE

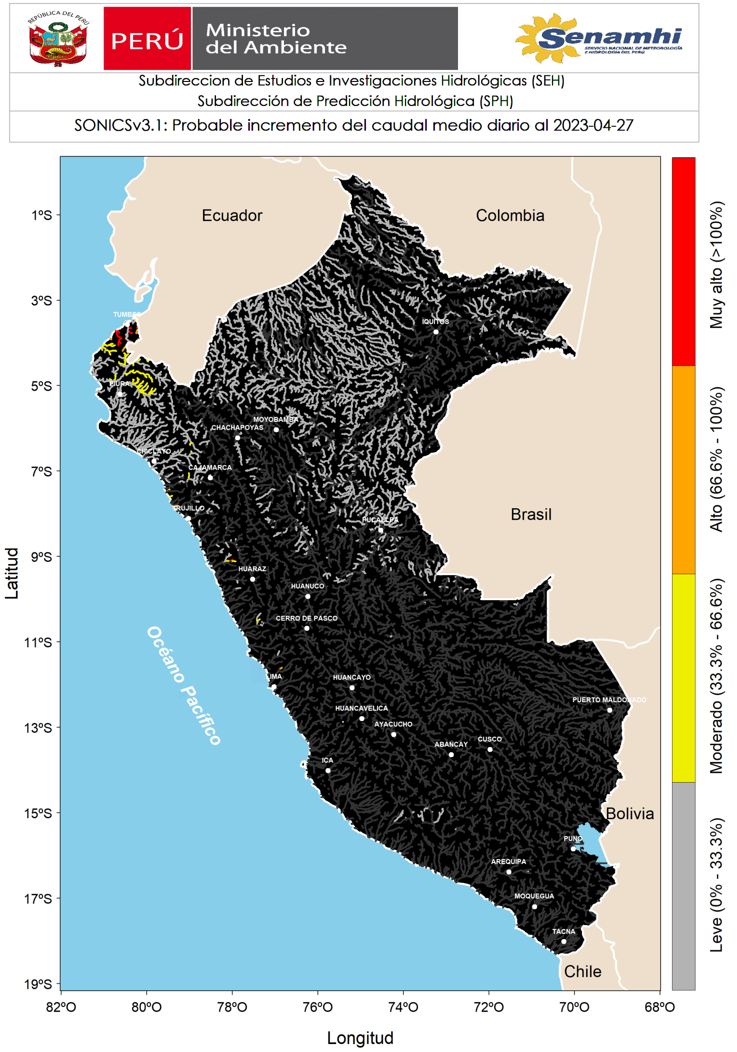
2023-04-26



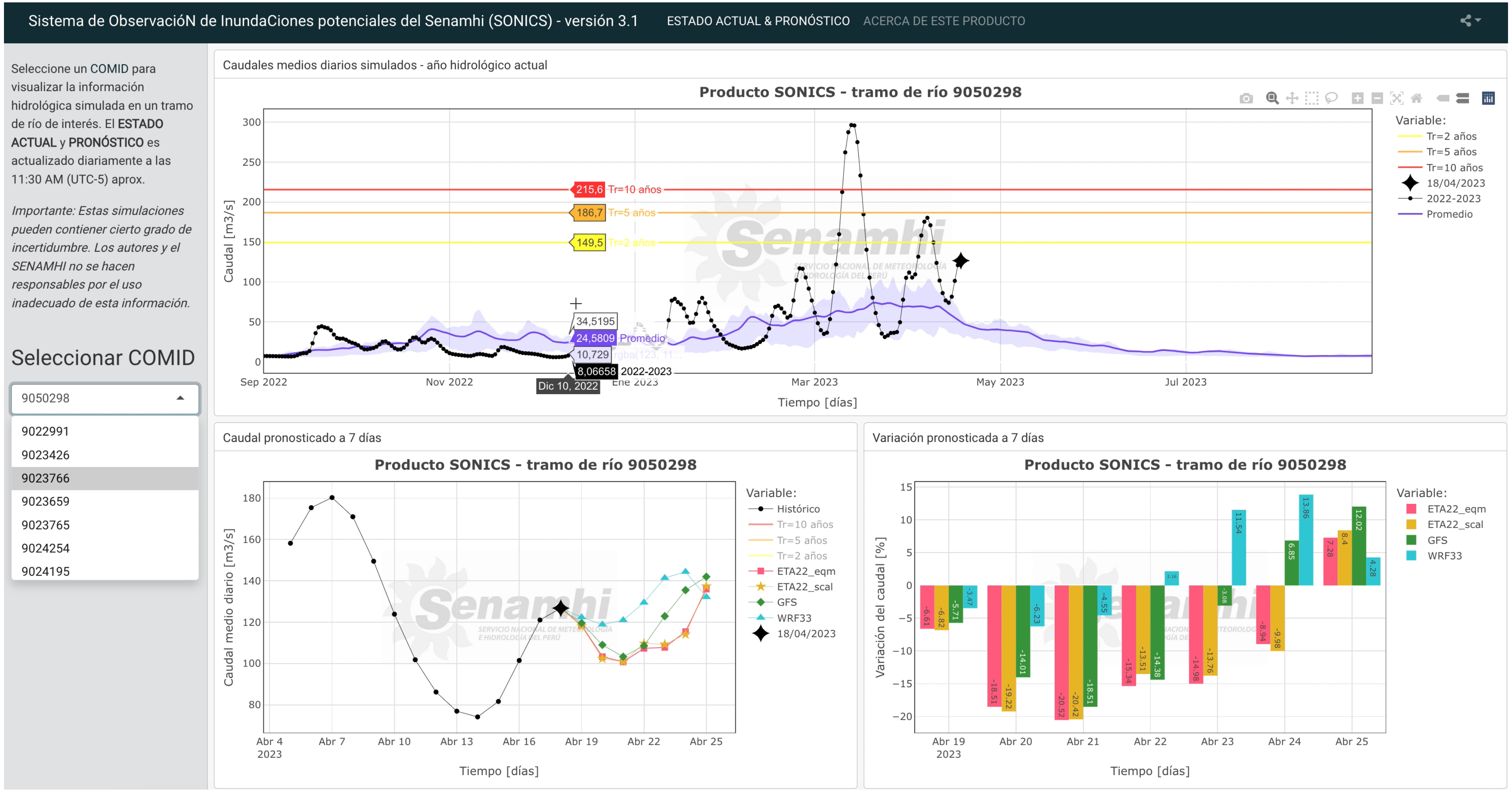
FORECAST –FROM 1 TO 7 DAYS

2023-04-27

2023-05-03



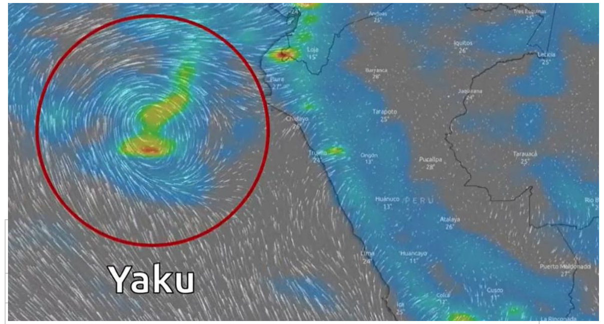
The SONICS dashboard (access to simulation results)

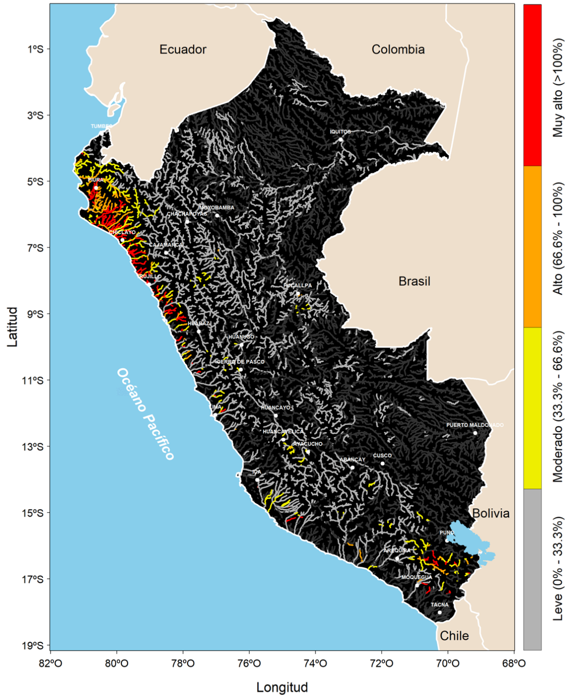


Available in: https://harold-llauca.shinyapps.io/sonics

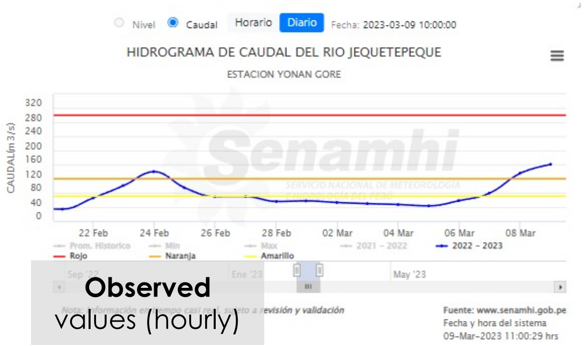
SONICS applications in Peru

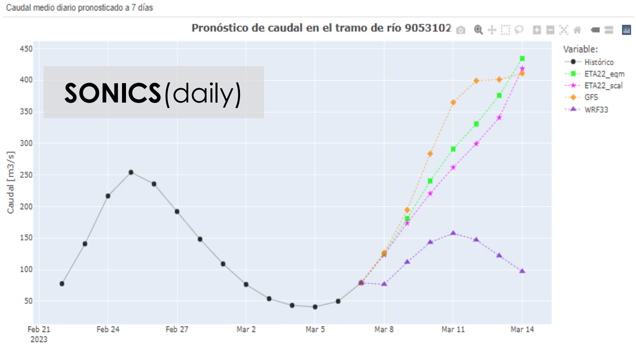
Flood forecasting during the "Yaku" event (March, 2023)



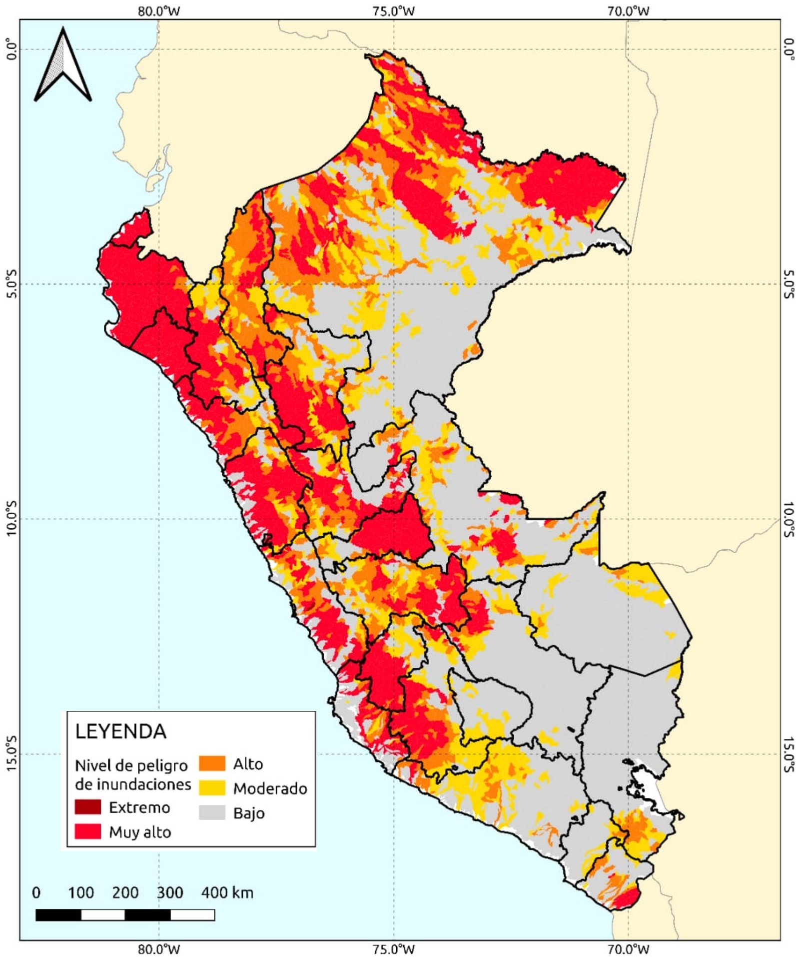


YONAN GORE STATION





Potential flood hazards during ENSO events in Peru (preliminar results)



Gutierrez et al. (In prep)

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¡Muchas gracias!

Thanks!