A relationship between repiquetes, rainfall and circulation low-level wind regimes over the Andean-Amazon river basin

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OBJECTIVES

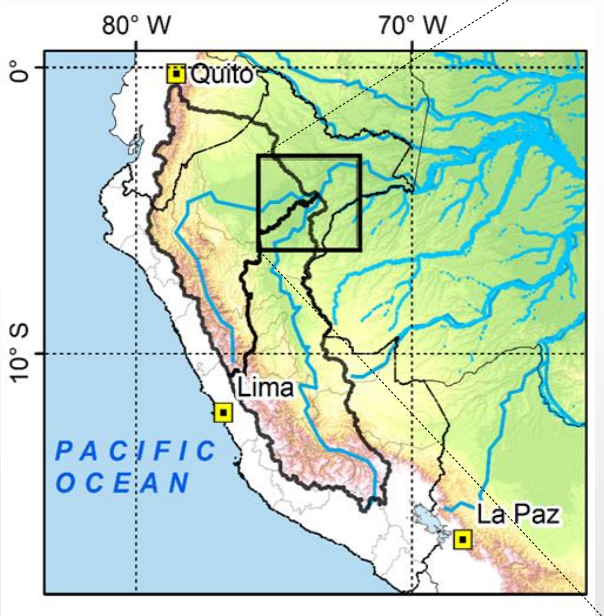
- To characterize the occurrence of repiquetes over the Amazonas, Marañón and Ucayali Rivers in terms of frequency, duration and magnitude and quantify the influence of the main tributaries on the Amazonas River.
- To identify rainfall and large-scale atmospheric circulation patterns related to the occurrence of the repiquetes events.

JUSTIFICATION

The repiquetes affect riparian farmers' economy and are associated with high crop loss due to either crop damage or seeds being washed away, so they cause a reduction of the household potential outputs. For instance, repiquetes halved household production on average in 2012 (List and Coomes, 2017).

Rice (foreground) and cowpea (bakground) production next to the Amazon River, 2014.
Photo: Geneva List.

STUDY AREA

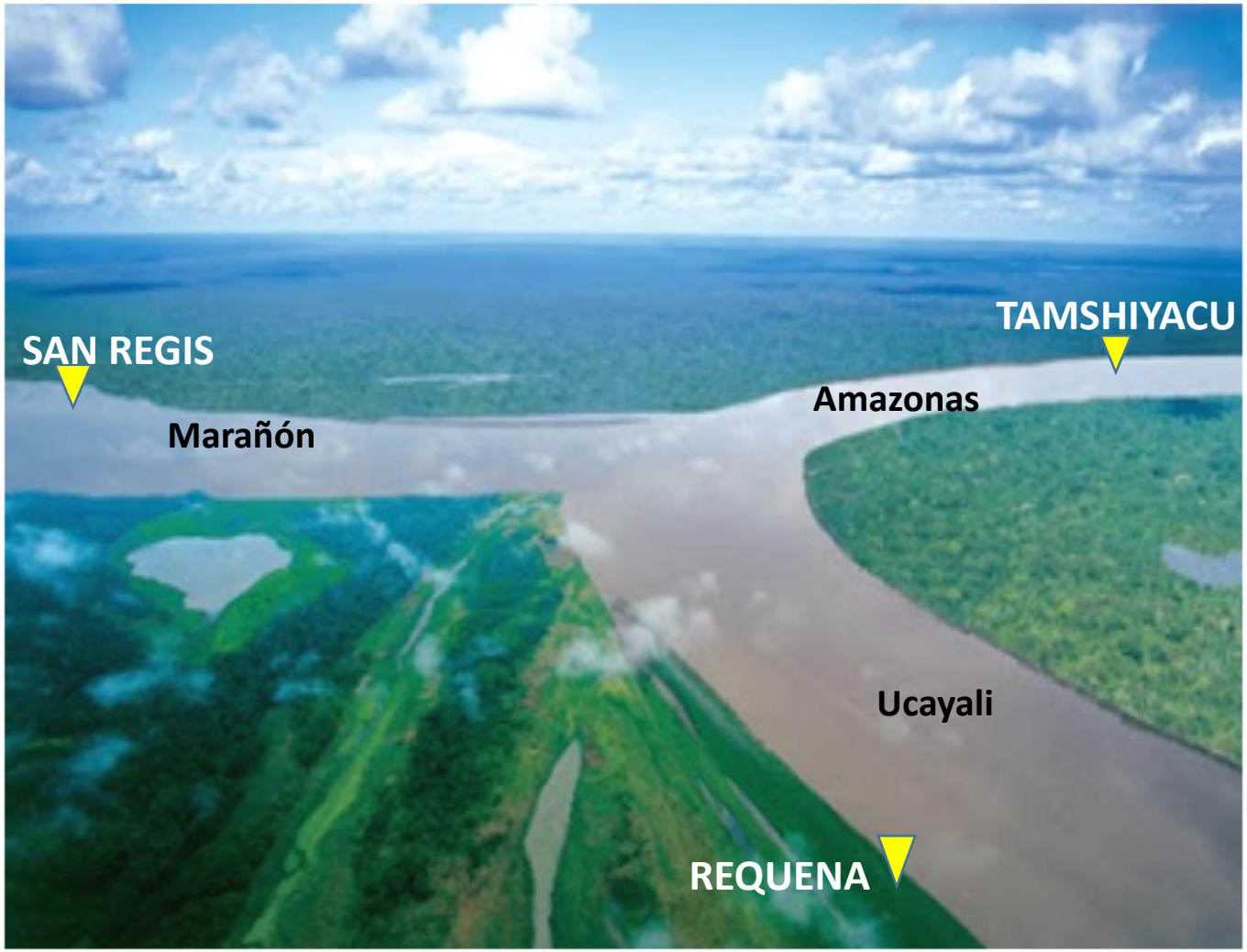


Marañón Basin (North)
Ucayali Basin (South)

Photo: Magalí del Solar - PromPerú

STUDY AREA

- Daily river stage from Requena Station on the Ucayali River, San Regis Station on the Marañon River and Tamshiyacu Station on the Amazonas River for the 1996-2018 period.



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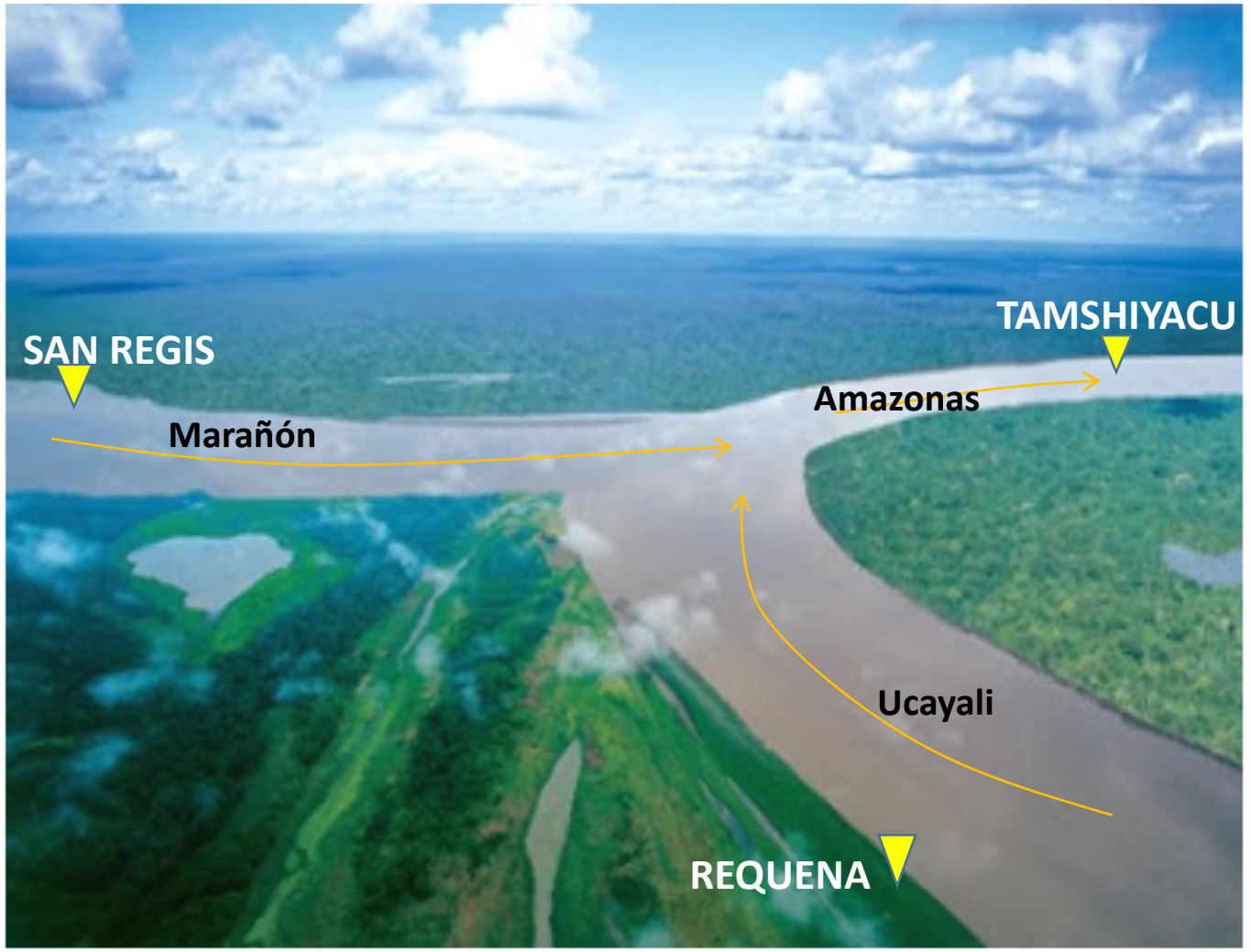
Flow direction



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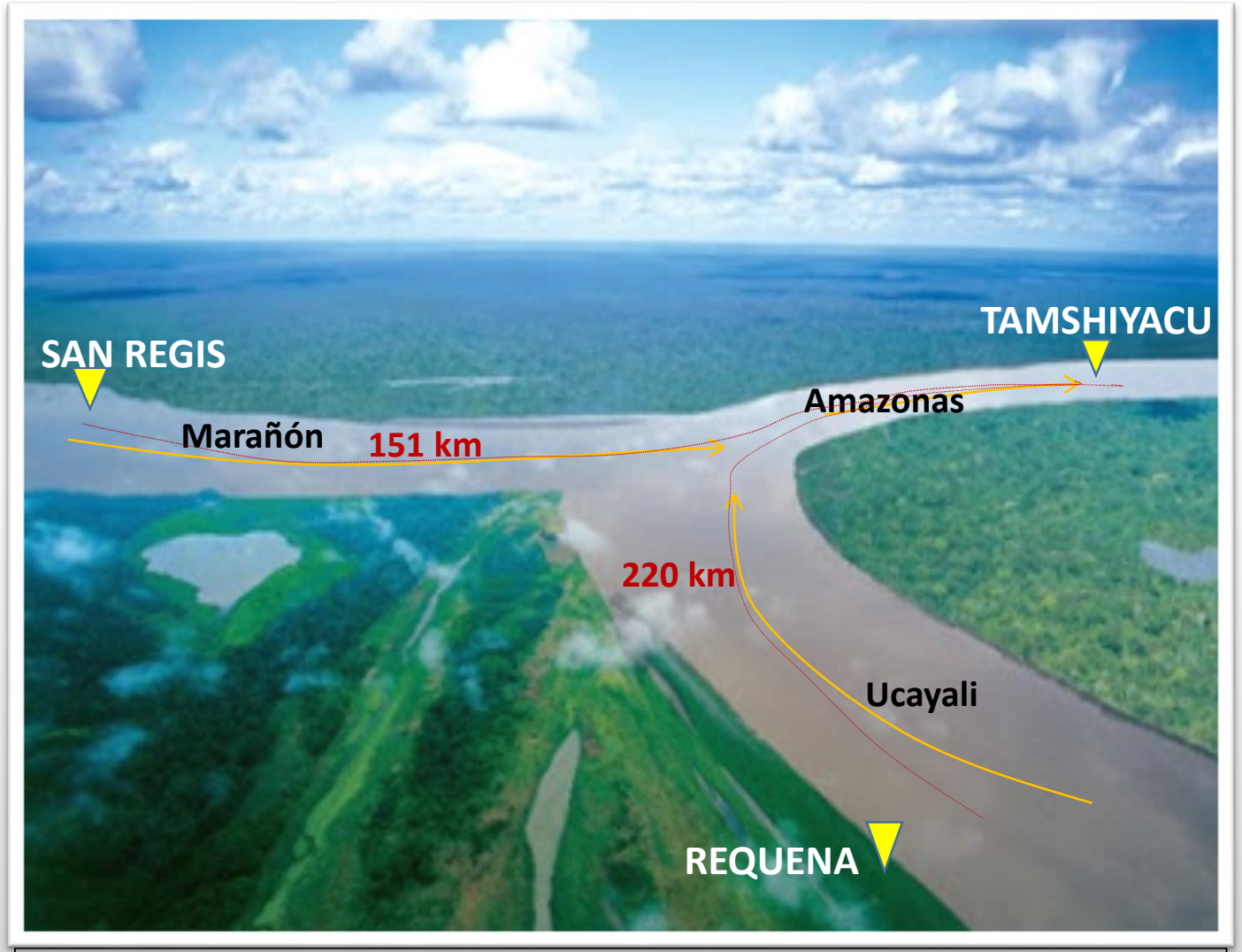
Distance between upstream and downstream stations.



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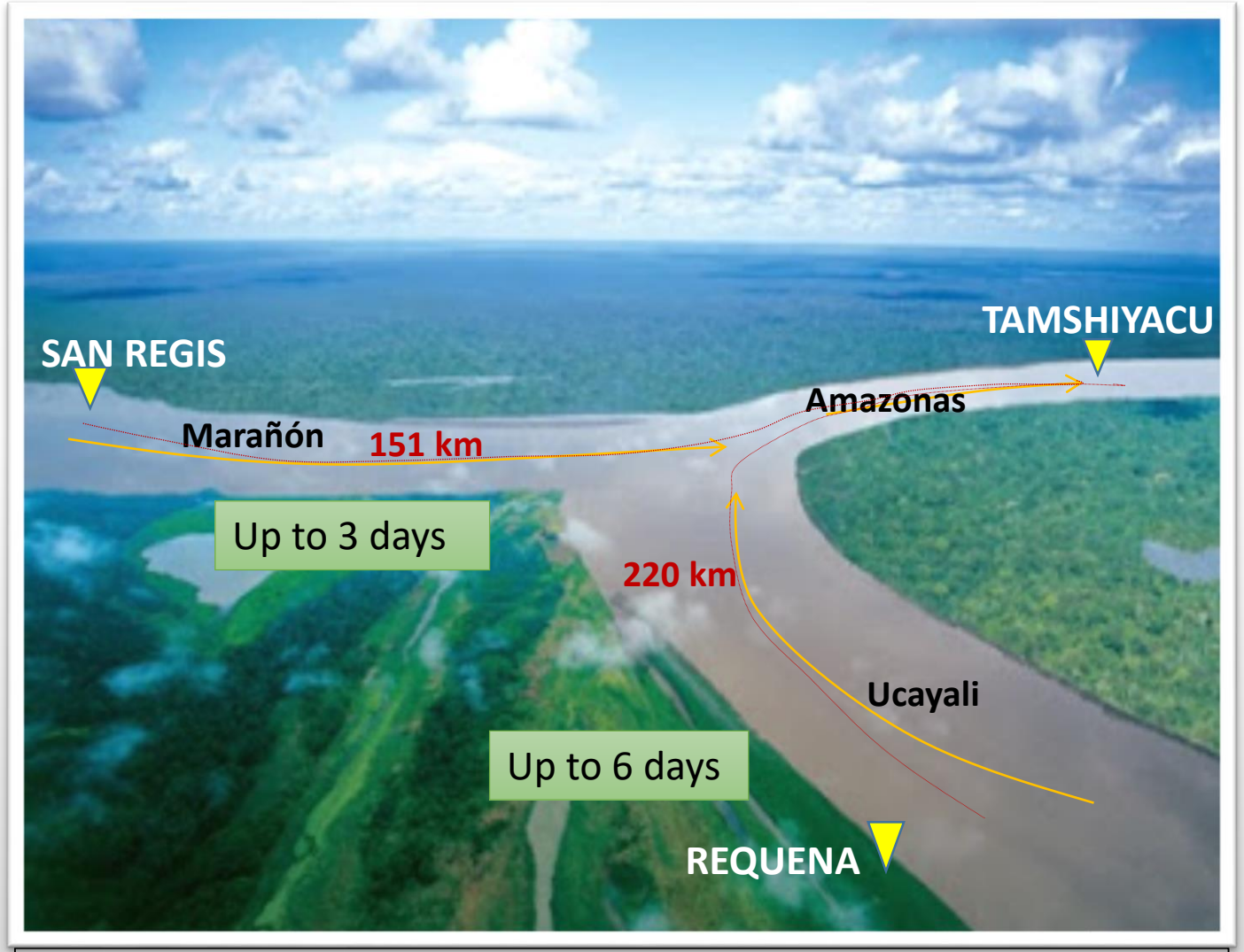
Flow direction

Distance between upstream and downstream stations.

Maximum delay considered to match events that occur upstream with those that occur downstream.
It is calculated using distance and stream velocity (Table S1).



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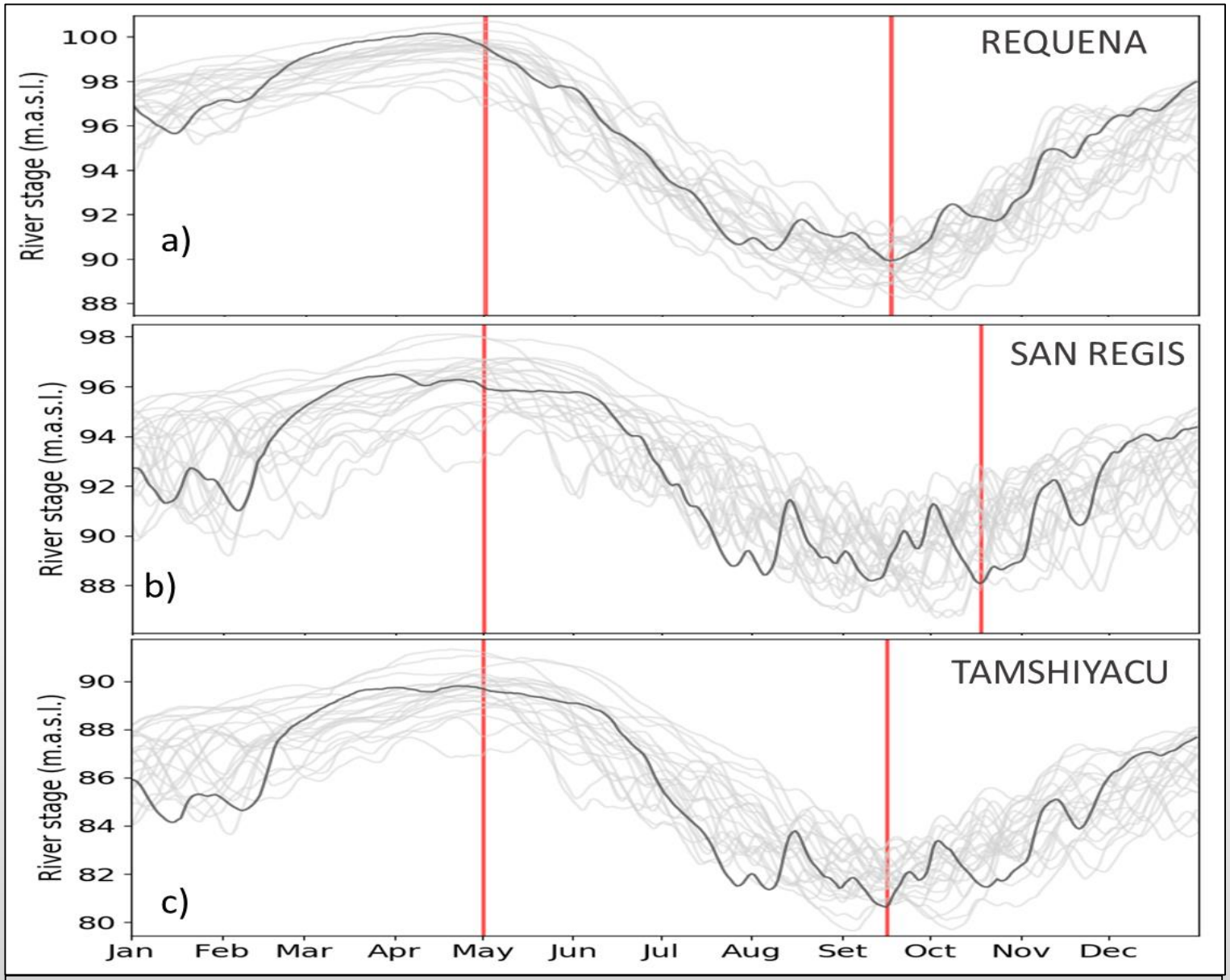
What is a REPIQUETE?

Unexpected reversal or inversions in direction (sign) of water level equal or greater than 1cm (Coomes et al., 2016; Ronchail et al., 2018).

Study period:
maximum after May and minimum before November (dates related to local agriculture)



River stage in 1997.

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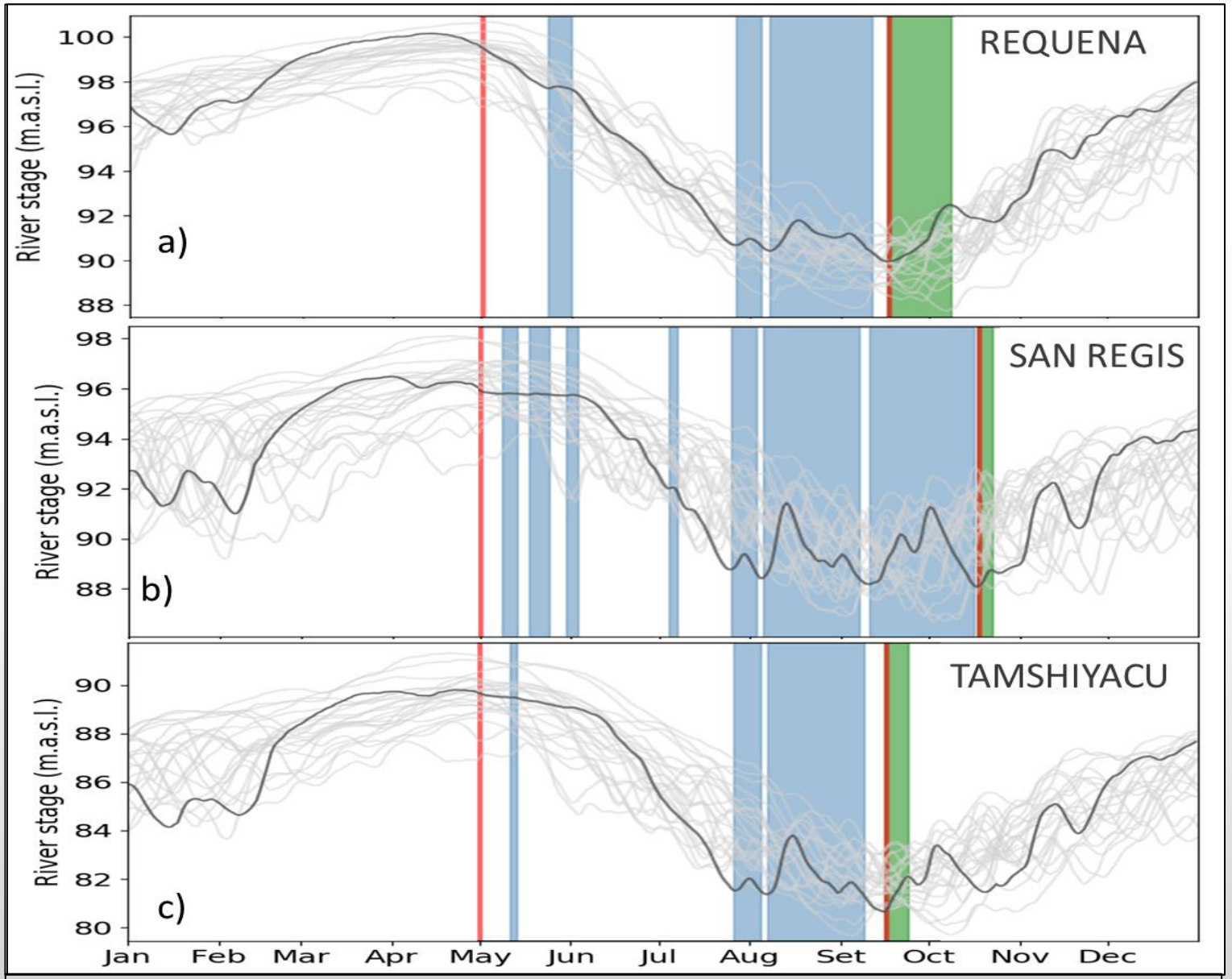
Repiquetes events
Last annual repiquete

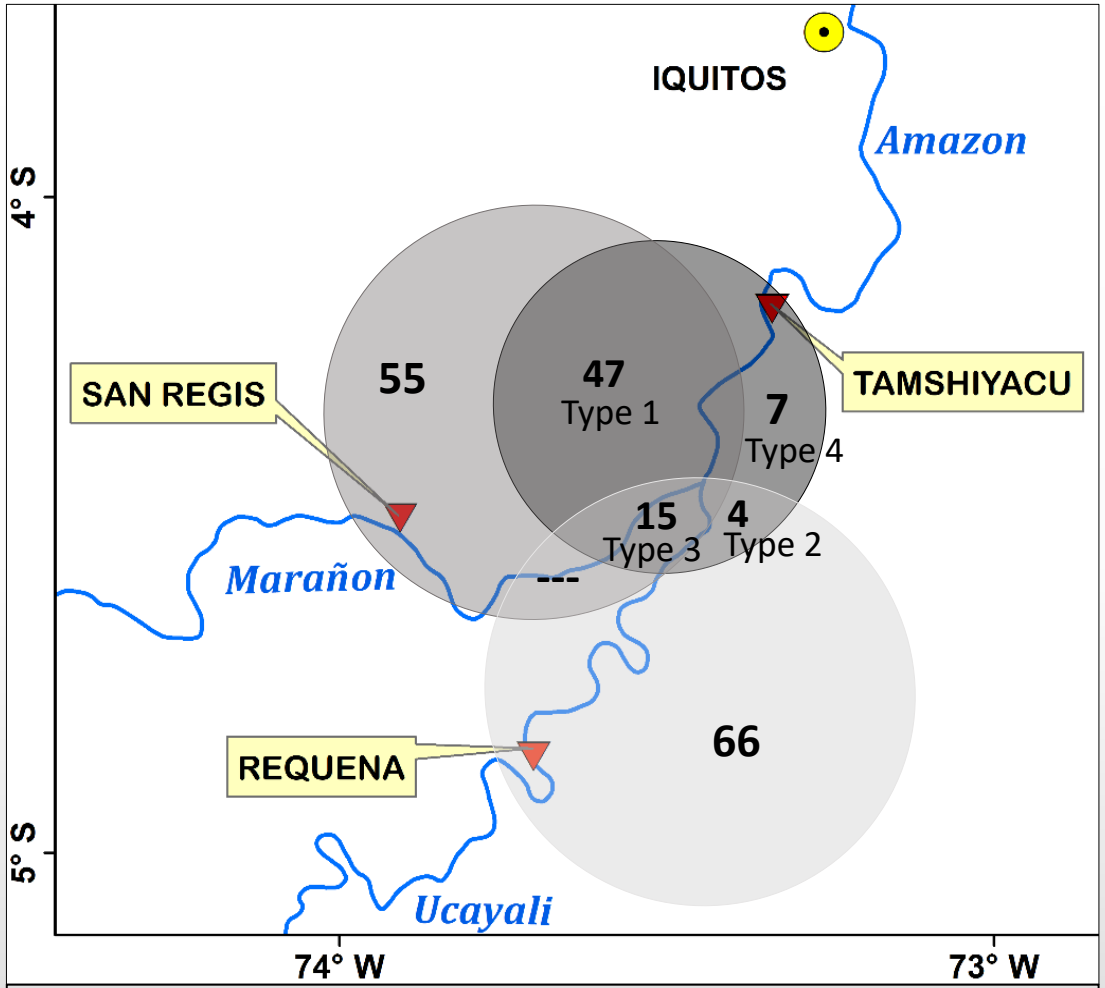


Repiquetes in 1997.

The use of maximum delays (the maximum time for water to arrive from one station to another) and repiquetes sorted by the beginning day of each event allows to associate upstream and downstream repiquetes into types:

TYPE 1: Marañón → Amazonas
TYPE 2: Ucayali → Amazonas
TYPE 3: Marañón and Ucayali → Amazonas
TYPE 4: Only Amazonas

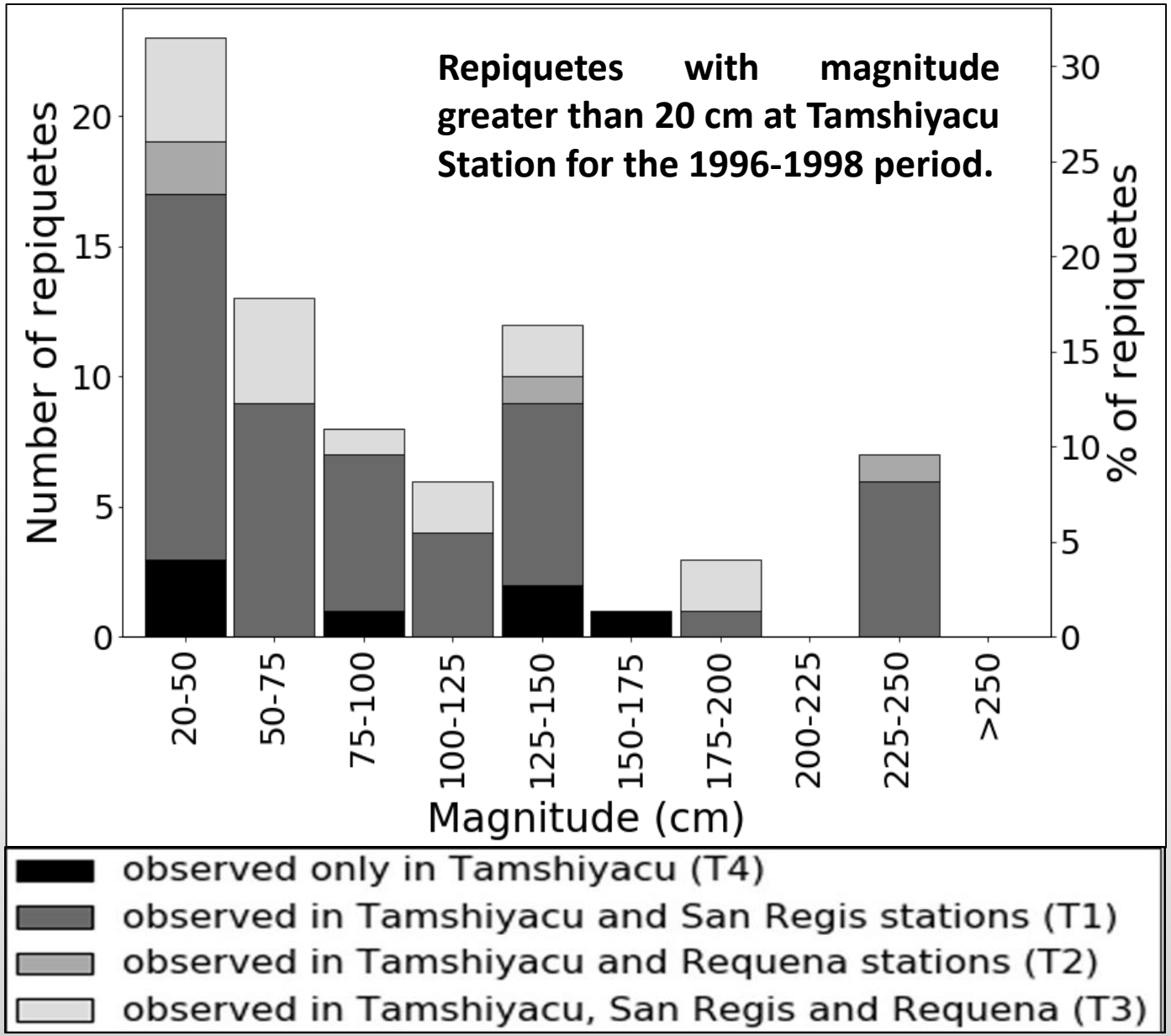
We focus on Type 1 repiquetes (the intersection of the dark gray and gray circles without light gray circle), i.e., the 47 repiquetes observed in Amazonas River with a precursor in the Marañón River. See Table S2 for further details.



Schematic depiction of the number of repiquetes at each gauging station for the 1996-2018 period. The dark gray circle, gray circle and light gray circle correspond to Tamshiyacu, San Regis and Requena, respectively.

From 73 repiquetes in the Amazonas River, 64.4% are Type 1 repiquetes, 20.5% Type 3 repiquetes and 5.5% Type 2 repiquetes .

“The main precursor of repiquetes in Amazonas River is the Marañón River”



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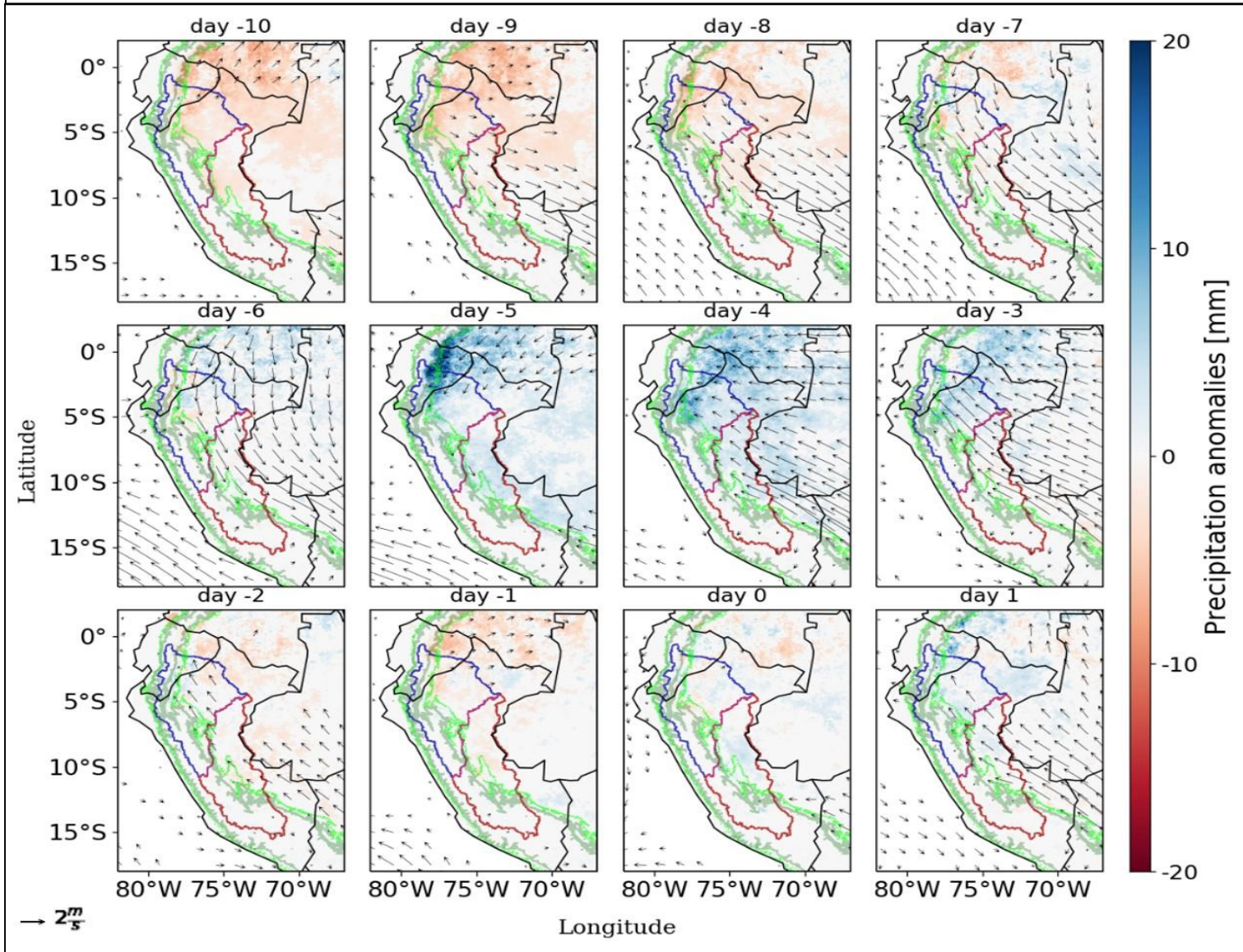
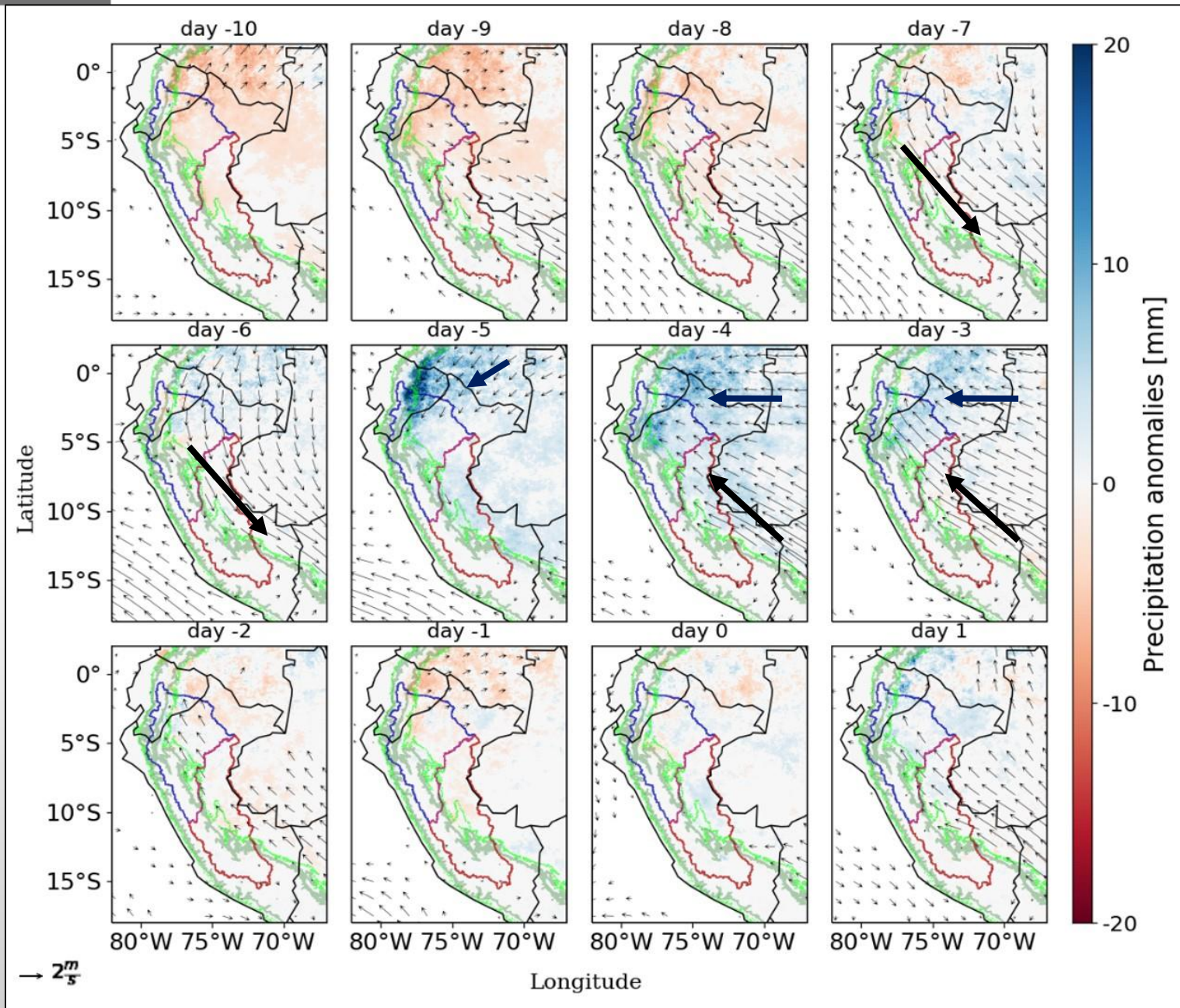
Composite of 850 hPa winds (ERA-Interim 0.25°) and rainfall (CHIRPS 0.05°) daily anomalies from the preceding ten days (d-10) to the first day after (d+1) of the 47 observed repiquete events at Tamshiyacu and San Regis stations (Type 1) for the 1996-2018 period, taking as day zero (d0) the beginning day of the repiquetes at Tamshiyacu station. Rainfall and winds anomalies are computed considering monthly mean climatology values averaged for the 1997-2017 period and only anomalies higher than a standard deviation are plotted. Finally, green and dark green lines represent elevations of 500 masl and 1500 masl, respectively.

Average 850hPa wind and rainfall anomalies during the 10 days prior a repiquete type 1 in Tamshiyacu station



"A change of low-level circulation patterns is observed days before the beginning of repiquetes"

Positive rainfall anomalies over the Peruvian and Ecuadorian Andes-Amazon transition region (Marañón Basin) appears to be significant at the beginning of repiquetes in Tamshiyacu station on the Amazon River. This result is in agreement with a change from northerly to southerly winds regimes that produce rainfall over the northwestern Amazon (Paccini et al., 2017; Wang and Fu, 2002).



CONCLUSIONS

- The main precursor of repiquetes in the Amazonas River is a repiquete in the Marañón River as ~85% of the repiquetes in Tamshiyacu station were previously observed upstream in San Regis station.
- An easterly wind flow and a change from northerly to southerly low-level wind regimes related to positive rainfall anomalies over the northwestern Andes-Amazon transition region appears to be significantly associated with the beginning of repiquetes in Tamshiyacu station on the Amazon River.

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SUPPLEMENTARY MATERIAL

Mean velocity (m/s) of the river section measured with Acoustic Doppler Current Profiler (ADCP), where *n* is the total of field measurements, and *t* is the number of transects. Measures were conducted during low stage season (from May to October) during the 2002-2011 period (http://www.ore-hybam.org).

Table S1: Stream velocity (m/s) in the Marañón (San Regis station) and Ucayali Rivers (Requena station)

Station		*may*	*jun*	*jul*	*aug*	*set*	*oct*
San Regis	*mean*	1.56	1.5	1.45	1.13	1.04	1.1
	std	0.02	0.02	0.04	0.02	0.02	0.02
	n	9	3	1	3	3	5
	t	49	12	5	19	14	23
Requena	*mean*	1.35	1.09	0.92	0.5	0.54	0.73
	std	0.05	0.01	0.03	0.01	0.02	0.02
	n	6	4	1	2	2	5
	t	39	21	4	11	10	19

Number (N), mean duration (days) and mean magnitude (cm) of the significant repiquetes observed in the Amazonas, Marañón and Ucayali Rivers.

Table S2: Characteristics of types of repiquetes

		Tamshiyacu Amazonas	SanRegis Marañón	Requena Ucayali
T1	N	47	47	-
	Magnitude	95.7	140.2	-
	Duration	15.5	15.2	-
T2	N	4	-	4
	Magnitude	105.8	-	133
	Duration	13	-	13.3
T3	N	15	15	15
	Magnitude	89.1	132.8	63.3
	Duration	16.8	15.7	10.6
T4	N	7	-	-
	Magnitude	92.1	-	-
	Duration	8.9	-	-