



Monitoreo y pronóstico de fenómenos meteorológicos y climáticos 2023 - 2024 y la variabilidad climática

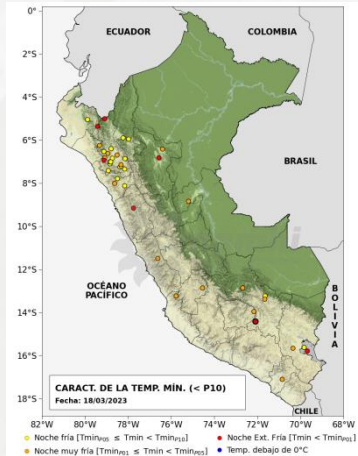
Lima, 27 de marzo de 2023

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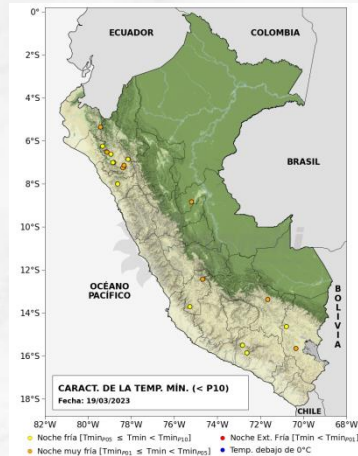


Monitoreo meteorológico y climático

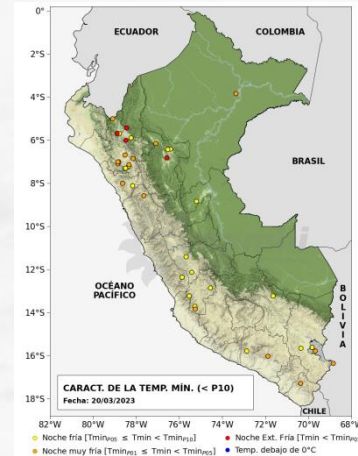
18 de marzo



19 de marzo



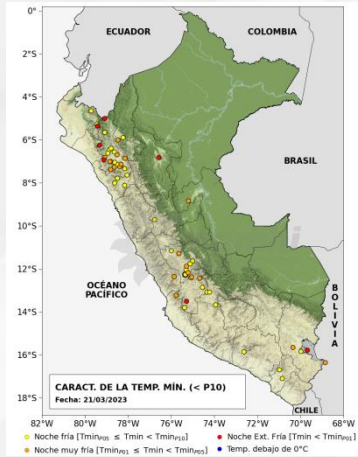
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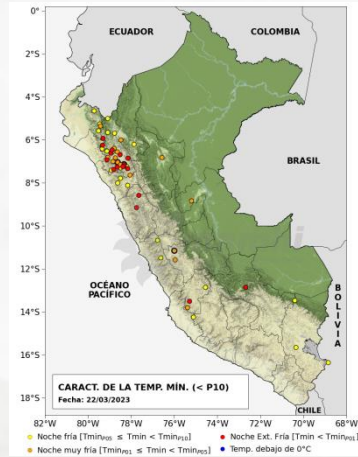
CARACTERIZACIÓN DE TEMPERATURA NOCTURNA

Descenso de temperaturas en el sector norte y en la sierra central.

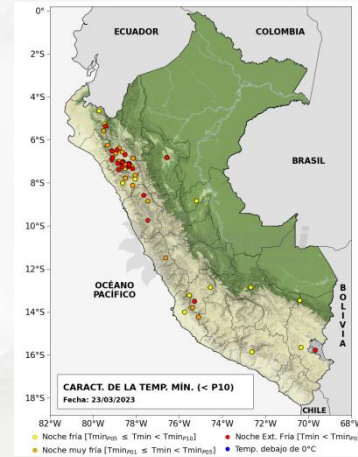
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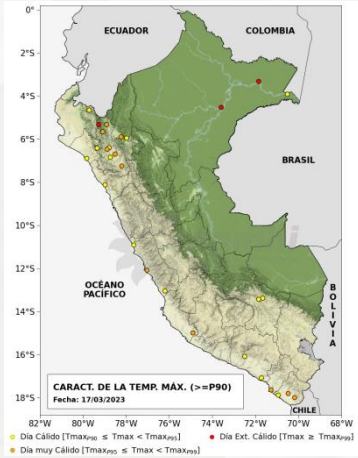
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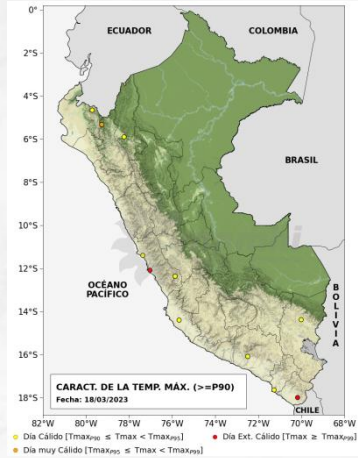
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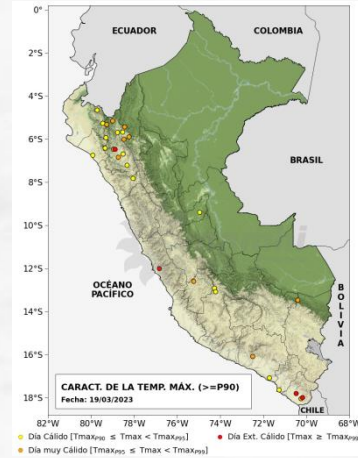
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18 de marzo



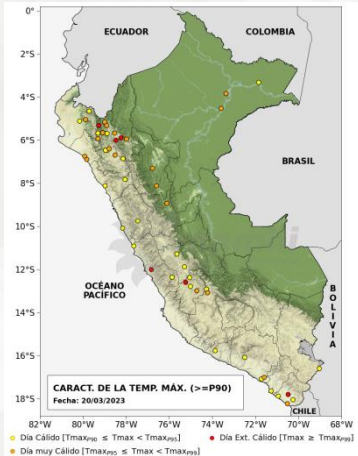
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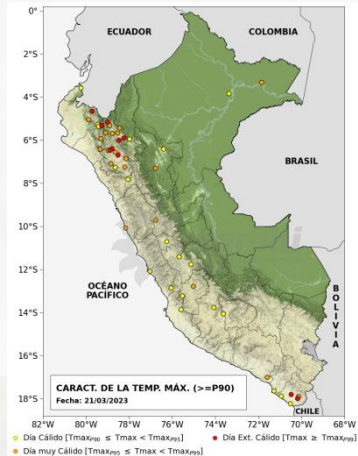
CARACTERIZACIÓN DE TEMPERATURA DIURNA

Incremento de temperaturas en la costa, en la sierra norte y en la sierra central

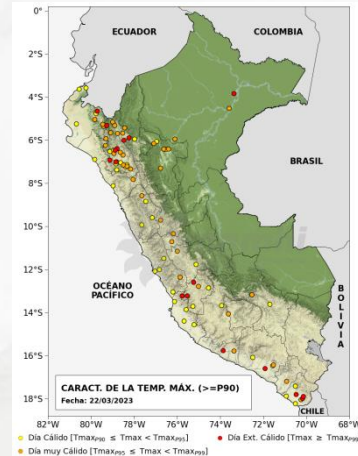
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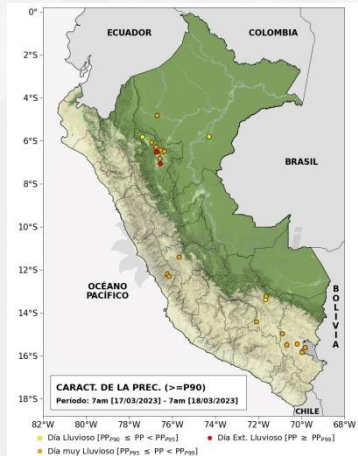
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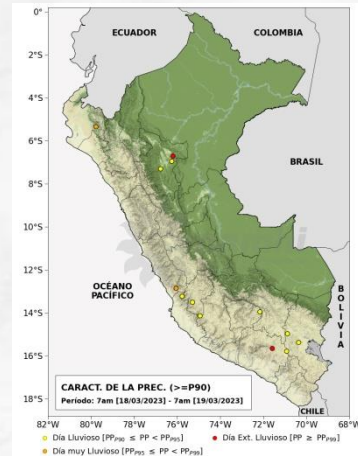
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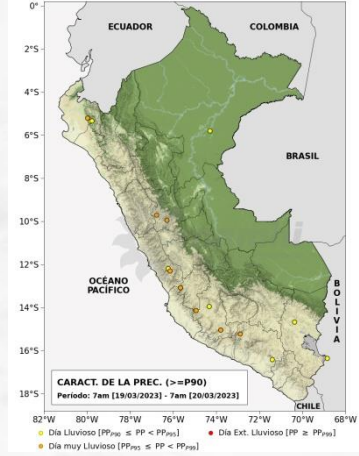
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18 de marzo



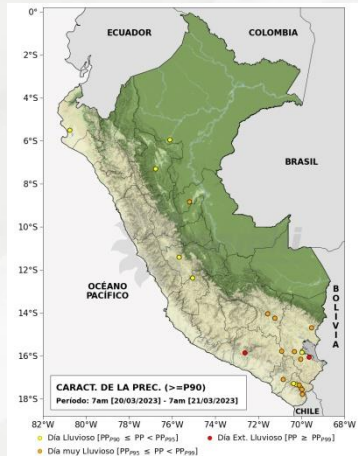
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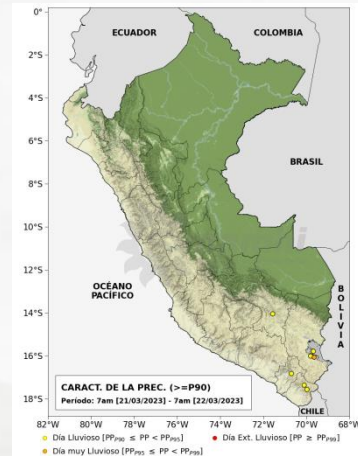
CARACTERIZACIÓN DE LLUVIAS

Lluvias aisladas en la sierra central y en la sierra sur.

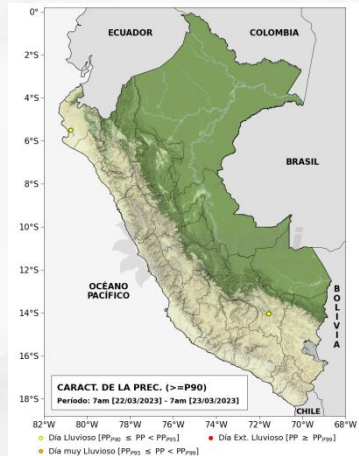
20 de marzo



21 de marzo



22 de marzo



Mejora de resolución temporal y espacial de datos hidroclimáticos para su aplicación en modelos de pronóstico de crecida de ríos



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Data Article

High-resolution gridded hourly precipitation dataset for Peru (PISCOp_h)

Adrian Huerta^a, Waldo Lavado-Casimiro, Oscar Felipe-Obando

Servicio Nacional de Meteorología e Hidrología (SENAMHI), Calle Cahui de 785, 11, Jesús María, Lima, Perú

ARTICLE INFO

Article history:

Received 10 June 2022
Revised 23 August 2022
Accepted 29 August 2022
Available online xxx

Keywords:

Hourly precipitation
Andes
Peru
PISCOp
Satellite precipitation products
Temporal disaggregation
Automatic weather stations

ABSTRACT

This article introduces a high-resolution (0.1°) gridded dataset of hourly precipitation across Peru for the period 2015–2020, called PISCOp_h. The product was developed using a temporal disaggregation technique based on the gridded daily precipitation dataset PISCOp and additional data from 309 automatic weather stations and three satellite precipitation products (IMERG-Early, PERSIAN-CSS, and CSMaP-NRT). The workflow of PISCOp_h involved the spatial interpolation of hourly precipitation and a bias correction of the diurnal rainfall cycle. Based on a technical validation, we demonstrated that PISCOp_h provides moderate to high efficiency in characterizing the frequency, intensity, and temporal coherence of hourly precipitation, particularly in central and southern Peru. PISCOp_h represents an important advance to construct gridded hourly precipitation products under challenging environmental conditions in, e.g., mountain regions with complex terrain. This new dataset provides a useful baseline for future studies in hydrology, climatology, and meteorology. The data collection described is available on figshare: <https://doi.org/10.6084/m9.figshare.c.5743166>.

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Article

PISCO_HyM_GR2M: A Model of Monthly Water Balance in Peru (1981–2020)

Harold Llauca ^{1,*}, Waldo Lavado-Casimiro ^{1,2}, Cristian Montesinos ¹, William Santini ² and Pedro Rau ³

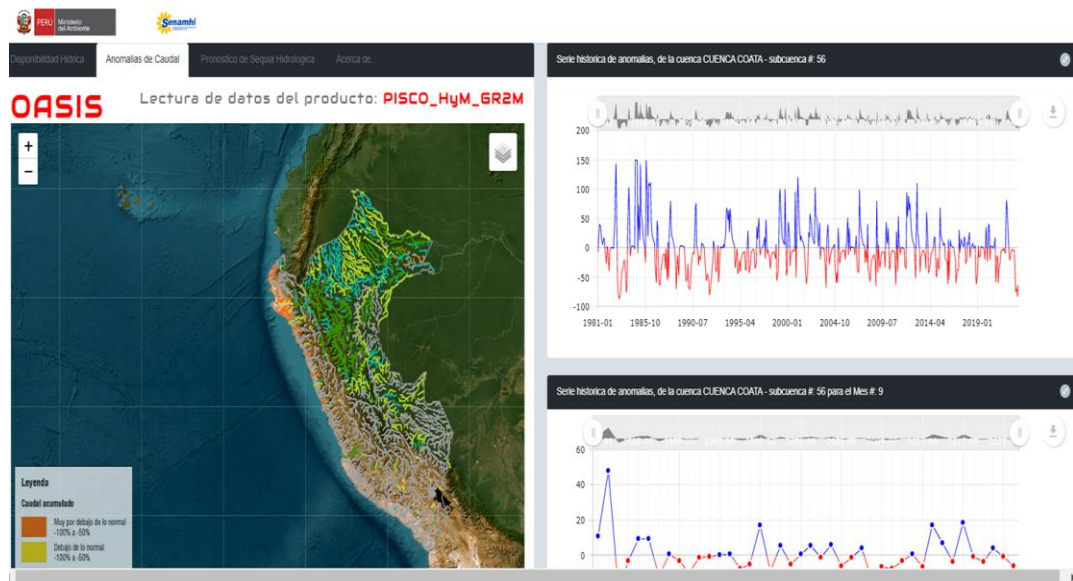
- ¹ Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI), Lima 15072, Perú; w.lavado@senamhi.gob.pe (W.L.-C.); c.montesinos@senamhi.gob.pe (C.M.)
- ² Laboratoire GET (IRD, CNRS, UPS, CNRS), Institut de Recherche pour le Développement, 31400 Toulouse, France; william.santini@ird.fr
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Abstract: Quantification of the surface water offer is crucial for its management. In Peru, the low spatial density of hydrometric stations makes this task challenging. This work aims to evaluate the hydrological performance of a monthly water balance model in Peru using precipitation and evapotranspiration data from the high-resolution meteorological PISCO dataset, which has been developed by the National Service of Meteorology and Hydrology of Peru (SENAMHI). A regionalization approach based on Fourier Amplitude Sensitivity Testing (FAST) of the rainfall-runoff (RR) and runoff variability (RV) indices defined 14 calibration regions nationwide. Next, the GR2M model was used at a semi-distributed scale in 3594 sub-basins and river streams to simulate monthly discharges from January 1981 to March 2020. Model performance was evaluated using the Kling-Gupta efficiency (KGE), square root transformed Nash-Sutcliffe efficiency (NSE_{sqrt}), and water balance error (WBE) metrics. The results show a very well representation of monthly discharges for a large portion of Peruvian sub-basins (KGE ≥ 0.75 , $NSE_{sqrt} \geq 0.65$, and $-0.29 < WBE < 0.23$). Finally, this study introduces a product of continuous monthly discharge rates in Peru, named PISCO_HyM_GR2M, to understand surface water balance in data-scarce sub-basins.

Keywords: Peru; water balance model; GR2M; PISCO product; Fourier Amplitude Sensitivity Testing

1. Introduction

In Peru, surface water resources are distributed heterogeneously throughout its three geographic regions: Pacific (western Andean slopes and Peruvian coast), Tihicaca (endorheic part of the Peruvian altpalano), and Atlantic (Amazon basin). The densely populated Pacific slope is characterized by high water stress due to its low water supply and high demand by its economic activity. In contrast, the sparsely populated Atlantic slope has a large surplus due to low demand and, above all, because it is supplied by the Amazon basin [1]. In this context, adequately quantifying water supply is critical for properly managing and planning water resources in the country [2–4]. However, the low density of stations and their short-term data records make it difficult to monitor and forecast streamflows at a national level, so hydrological modeling emerges as a promising option for complementing the hydrometric records, improving the understanding of the rainfall-runoff relationship [5,6] and for seasonal hydrological forecasting [7,8]. Implementing a large-scale hydrological model requires precipitation data with wide spatiotemporal coverage, so the use of satellite precipitation products has become increasingly important in recent years [9], especially for their application in Peruvian basins with scarce information [10]. For example, the recent meteorological gridded product development for the Peruvian domain called PISCO (Peruvian Interpolated data of SENAMHI's Climatological Observations) [11] might drive a large-scale hydrological model to estimate monthly discharges at a national level in a data-scarce context.



Aplicación de modelos hidrológicos para la generación de caudales a nivel nacional con cobertura de cuencas y subcuencas



Citation: Llauca, H.; Lavado-Casimiro, W.; Montesinos, C.; Santini, W.; Rau, P. PISCO_HyM_GR2M: A Model of Monthly Water Balance in Peru (1981–2020). *Water* **2021**, *13*, 1048. <https://doi.org/10.3390/w13081048>

Academic Editor: Koichiro Kusaji

Received: 2 March 2021
Accepted: 6 April 2021
Published: 10 April 2021

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PISCOeo_pm, a reference evapotranspiration gridded database based on FAO Penman-Monteith in Peru

Adrián Huerta^{1,2,3}, Vivien Bonneoeur^{4,5}, José Cuadros-Adriazola^{2,3,4}, Leonardo Gutiérrez¹, Boris F. Ochoa-Tocachi^{3,4,5,6}, Francisco Román-Dañobeytia^{2,3} & Waldo Lavado-Casimiro²

A new FAO Penman-Monteith reference evapotranspiration gridded dataset is introduced, called PISCOeo_pm. PISCOeo_pm has been developed for the 1981–2016 period at ~1 km (0.01°) spatial resolution for the entire continental Peruvian territory. The framework for the development of PISCOeo_pm is based on previously generated gridded data of meteorological subvariables such as air temperature (maximum and minimum), sunshine duration, dew point temperature, and wind speed. Different steps, i.e., (i) quality control, (ii) gap-filling, (iii) homogenization, and (iv) spatial interpolation, were applied to the subvariables. Based on the results of an independent validation, on average, PISCOeo_pm exhibits better precision than three existing gridded products (CRU_T5, TerraClimate, and ERA5-Land) because it presents a predictive capacity above the average observed using daily and monthly data and has a higher spatial resolution. Therefore, PISCOeo_pm is useful for better understanding the terrestrial water and energy balances in Peru as well as for its application in fields such as climatology, hydrology, and agronomy, among others.

Background & Summary

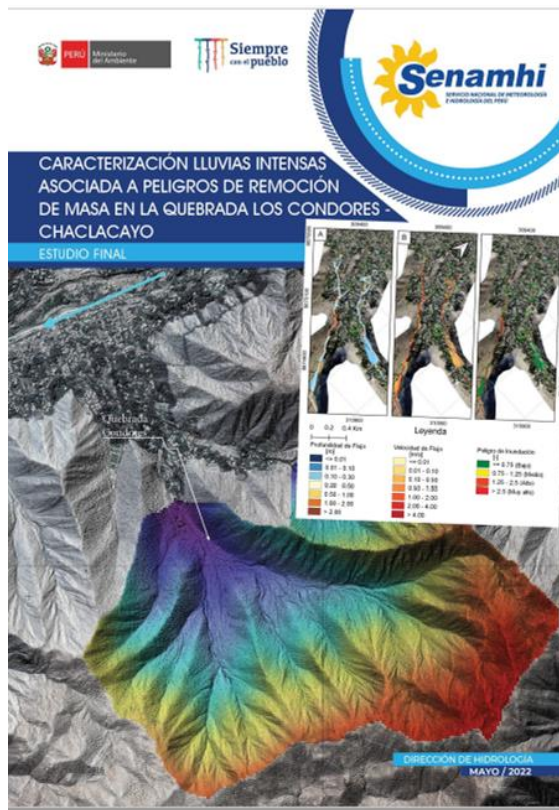
Evapotranspiration plays an essential role in terrestrial, water, and to a lesser extent, carbon energy cycles^{1,6}. Terrestrial evapotranspiration is the water transfer from the land surface to the atmosphere and is generally parameterized as a sum of soil evaporation, vegetation evaporation, and vegetation transpiration¹. The evapotranspiration rate of a reference surface (a hypothetical grass reference crop with specific characteristics), which occurs without water restrictions, is known as the reference evapotranspiration (ET_r)¹. ET_r is a variable of great interest for estimating actual evapotranspiration in agronomy, for example, from the crop coefficients.

ET_r can be calculated from meteorological data, and the climatic parameters are the only factors that affect its estimation¹. The most accepted formula for calculating ET_r and the one used in this work is that of FAO Penman-Monteith (FPM)¹. The main obstacle to apply FPM is the availability of information in meteorological stations, because data on maximum and minimum air temperature, solar radiation (sunshine duration), actual vapour pressure (dew point temperature), and wind speed are needed but usually absent. An interesting study developed in Ecuador⁷, a country with climatic characteristics comparable to Peru, showed that the absence of some of the variables (subvariables) for the calculation of FPM can lead to unreliable estimates. It was found that using estimated wind speed data has no major effect on calculated ET_r; however, solar radiation data can yield erroneous estimations of ET_r by as much as 24%. If relative humidity data are estimated indirectly, the error may be as high as 14%; and if all data except air temperature are estimated indirectly, errors might be larger than 30%. In general, the impact of the lack of information on subvariables in the FPM procedure depends on

Mejora de resolución temporal y espacial de datos hidroclimáticos para su aplicación en modelos de pronóstico de crecida de ríos

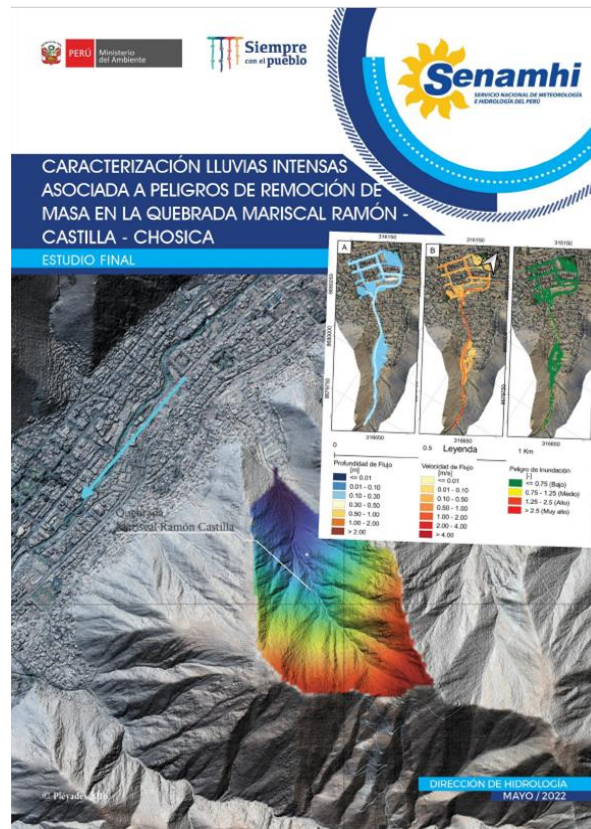
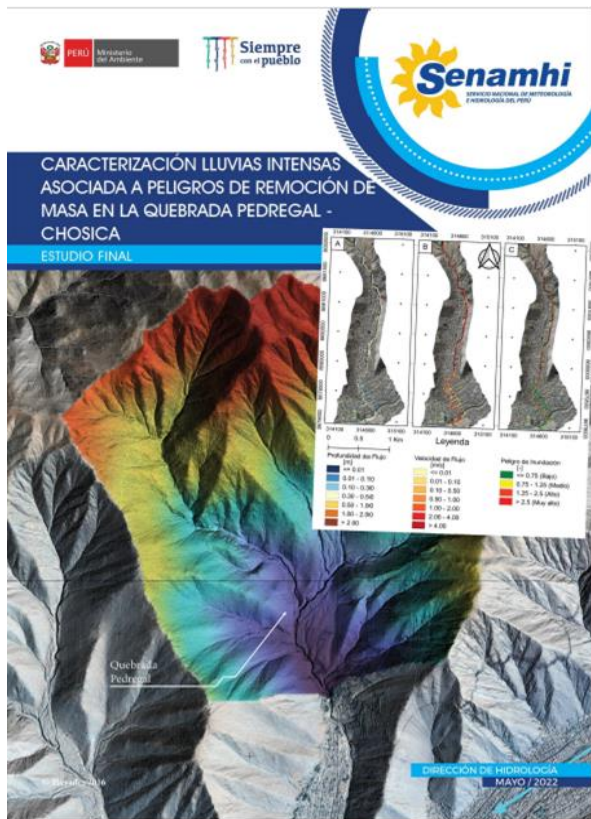
¹Servicio Nacional de Meteorología e Hidrología (SENAMHI), Calle Cahui de 705 - Jesús María, Lima, 11, Peru. ²Consortio para el Desarrollo Sostenible de la Ecorregión Andina (CONDESAN), Calle Las Codornices 253 - Surquillo, Lima, 14, Peru. ³Iniciativa Regional de Monitoreo Hidrológico de Ecosistemas Andinos (IRMEEA), Av. Ricardo Palma 692 - Miraflores, Lima, 15, Peru. ⁴Department of Civil and Environmental Engineering, Imperial College London, London SW7 2AZ, UK. ⁵ATUK Consultoría Estratégica, Luis Pasteur y Copacabana, Cuenca 010105, Ecuador. ⁶Forest Trends, 1203 19th Street, N.W., 4R Washington D.C. 20036, USA. ⁷✉e-mail: adhuerta@gmail.com

Estudios de lluvias intensas asociados a peligros de remoción de masas Quebradas de Chaclacayo y Lurigancho



<https://repositorio.senamhi.gob.pe/handle/20.500.12542/476>

Estudios de lluvias intensas asociados a peligros de remoción de masas Quebradas de Pedregal y Ramón castilla. Con fines de Alerta Temprana



Investigación en modelos hidráulicos para sistema de Alerta de inundaciones en cuencas Chillón y Lurín



Emitido el 20 de marzo



Emitido el 21 de marzo



Emitido el 21 de marzo



Emitido el 22 de marzo



AVISOS METEOROLÓGICOS PUBLICADOS

Próximos eventos:

- Lluvias en la costa norte desde finales de marzo a inicios de abril.
- Ingreso del tercer friaje del año para los primeros días de abril.

LOS MODELOS NUMÉRICOS TIENEN MAYOR INCERTIDUMBRE PARA LOS ÚLTIMOS DÍAS DE PRONÓSTICO, POR LO QUE LAS FECHAS E INTENSIDADES PODRÍAN TENER CAMBIOS

NOTA DE PRENSA EMITIDA

Continuarán los episodios de lluvia en la zona norte y central y altas temperaturas en la costa

Nota de prensa



17 de marzo de 2023 - 7:22 p. m.

El Servicio Nacional de Meteorología e Hidrología del Perú (Senamhi), organismo adscrito al Minam, informa que durante marzo e inicios de abril, se presentarán episodios de lluvia de moderada a fuerte intensidad en la zona norte y centro del país, desde Tumbes a Ica. También se presentarán lluvias localizadas de extrema intensidad en la costa norte y se prevé que continúen las altas temperaturas a lo largo de la costa.

PRONÓSTICO DE LLUVIA

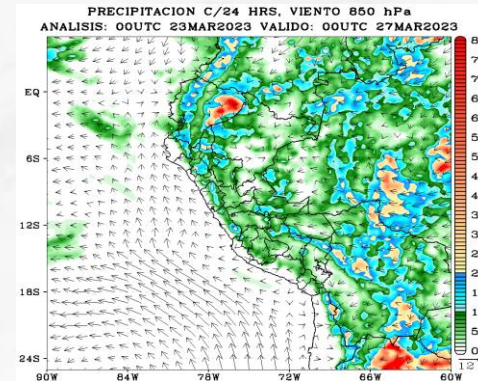
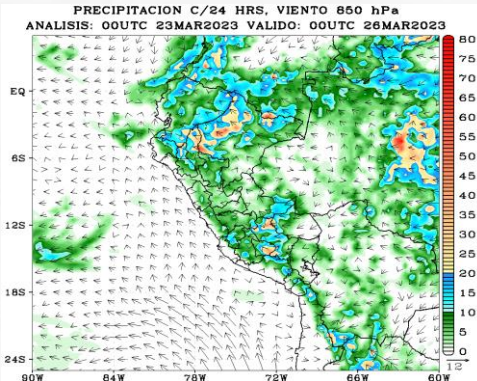
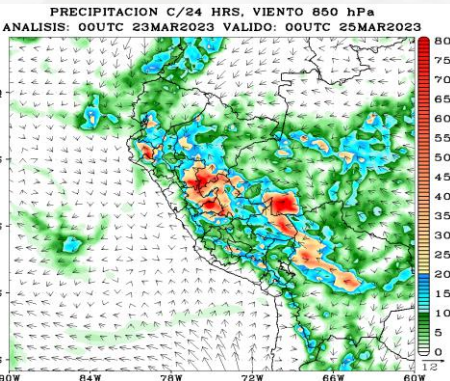
24 de marzo

25 de marzo

26 de marzo

Según el análisis realizado, existe la probabilidad de presentar lluvias en la costa norte el 24 y 25 de marzo, con un segundo periodo iniciando a finales del mes.

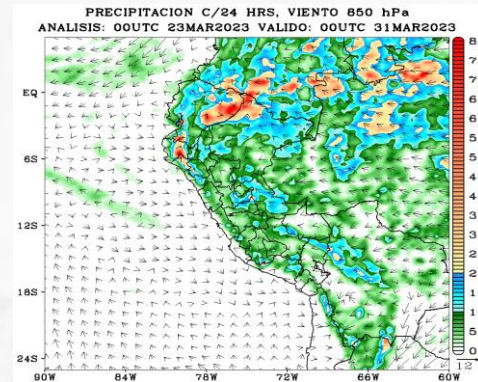
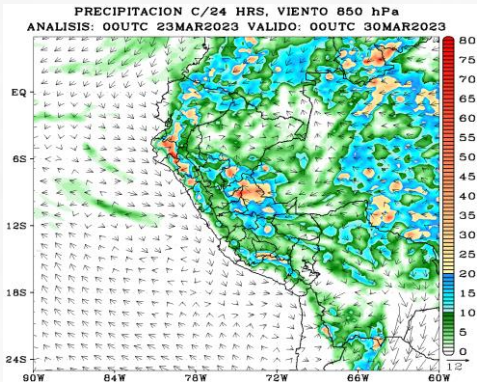
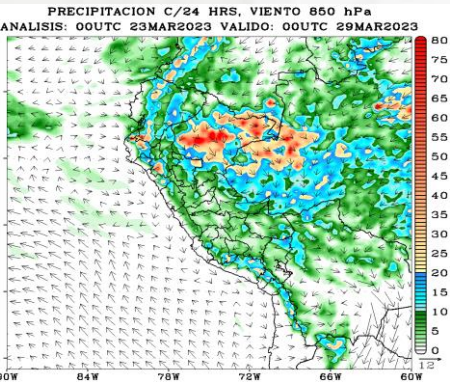
Continuarán las precipitaciones (lluvia/nieve) en la sierra centro y sur. Asimismo, se espera lluvia de moderada a fuerte intensidad en la selva.



27 de marzo

28 de marzo

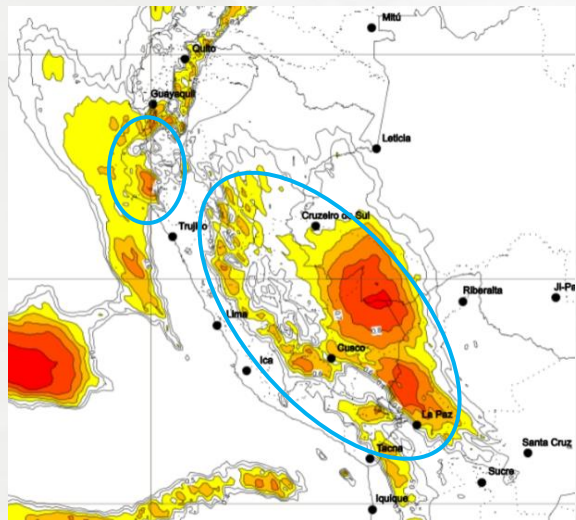
29 de marzo



LOS MODELOS NUMÉRICOS TIENEN MAYOR INCERTIDUMBRE PARA LOS ÚLTIMOS DÍAS DE PRONÓSTICO, ADEMÁS DEBEN SER ANALIZADOS Y MONITOREADOS DE MANERA DIARIA.

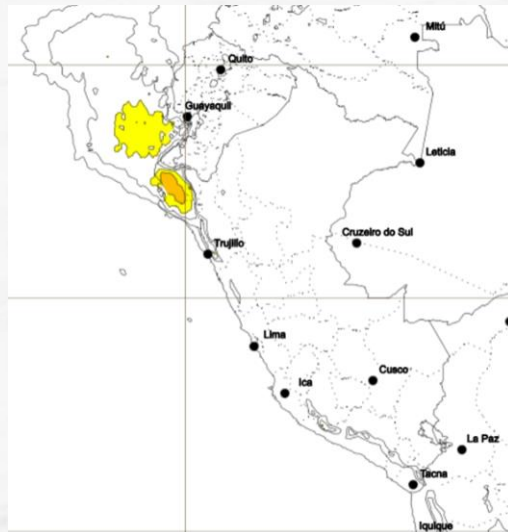
PRONÓSTICO

24 de marzo



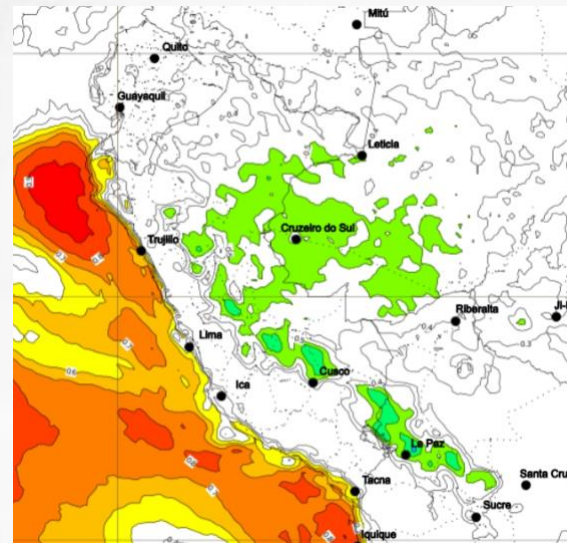
Desde el 24 se esperan precipitaciones a nivel nacional, incluyendo la zona norte, sierra centro y sur, y la selva

28 de marzo



Desde fines de marzo e inicios de abril se esperan lluvias intensas en la costa norte

28 de marzo

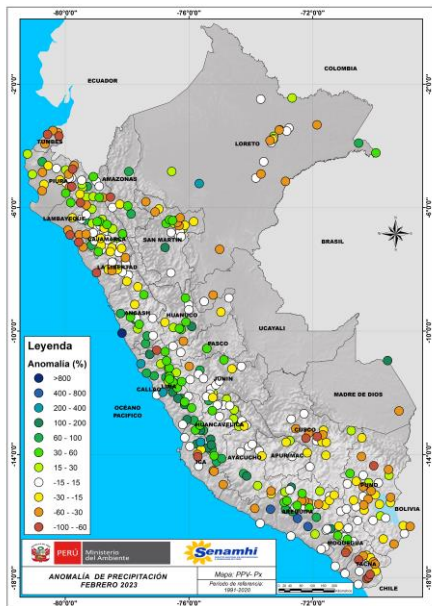


Continuarán las altas temperaturas en el sector costero (coloración roja) y se espera un descenso de las temperaturas en la selva (coloración verde)

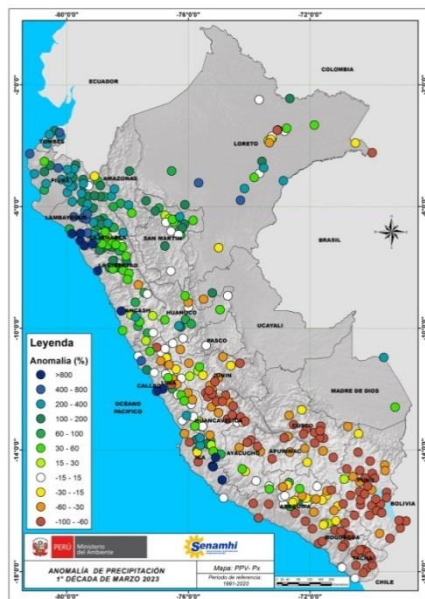
Monitoreo climático de la precipitación

ANOMALÍAS PORCENTUALES DEL ACUMULADO DE PRECIPITACIÓN

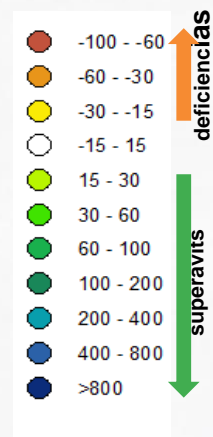
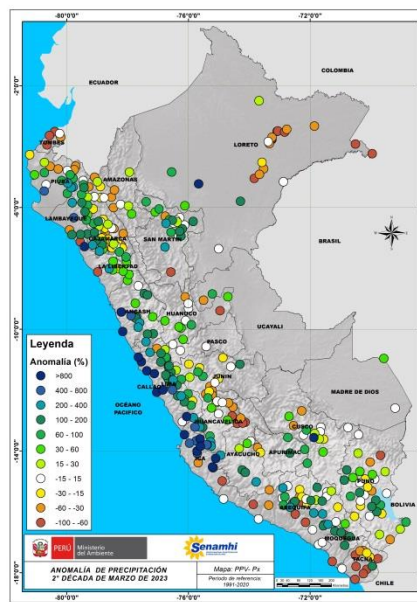
FEBRERO 2023



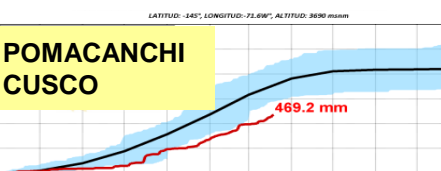
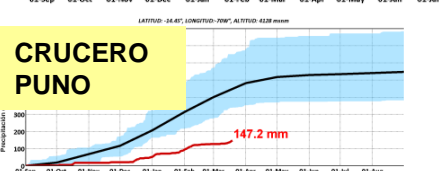
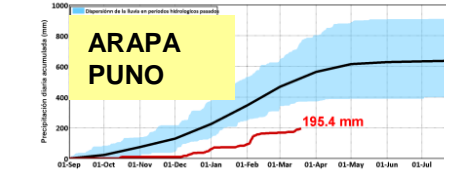
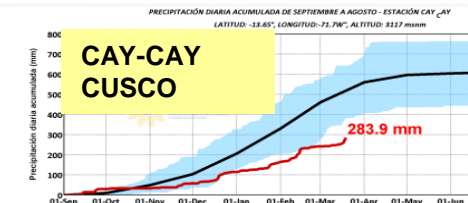
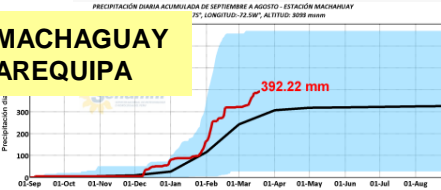
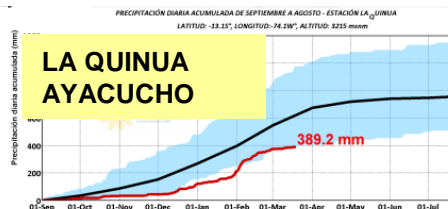
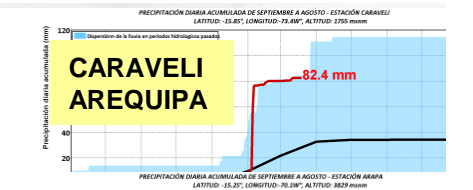
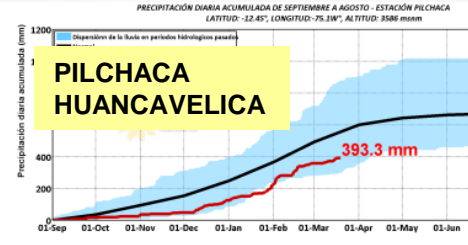
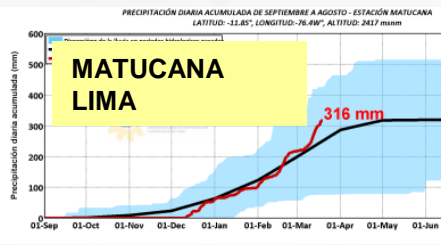
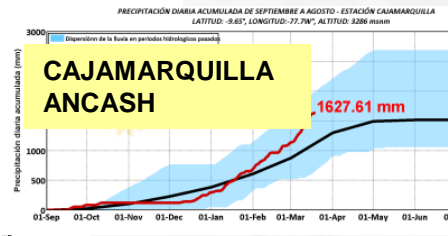
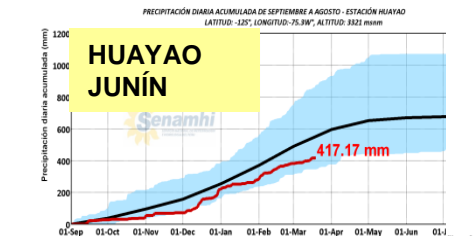
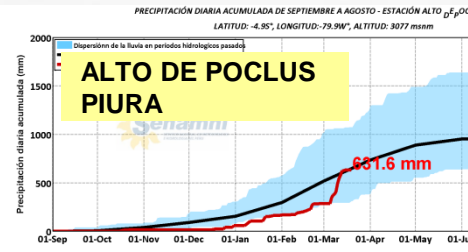
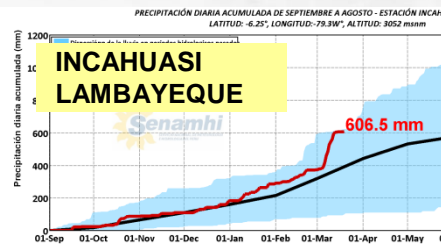
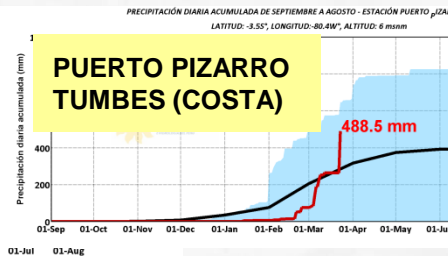
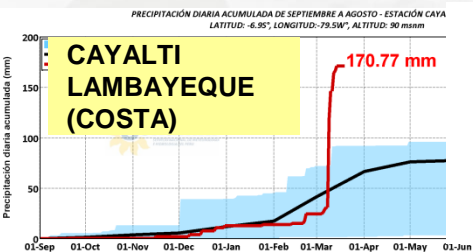
DEL 01 AL 10 DE
MARZO 2023



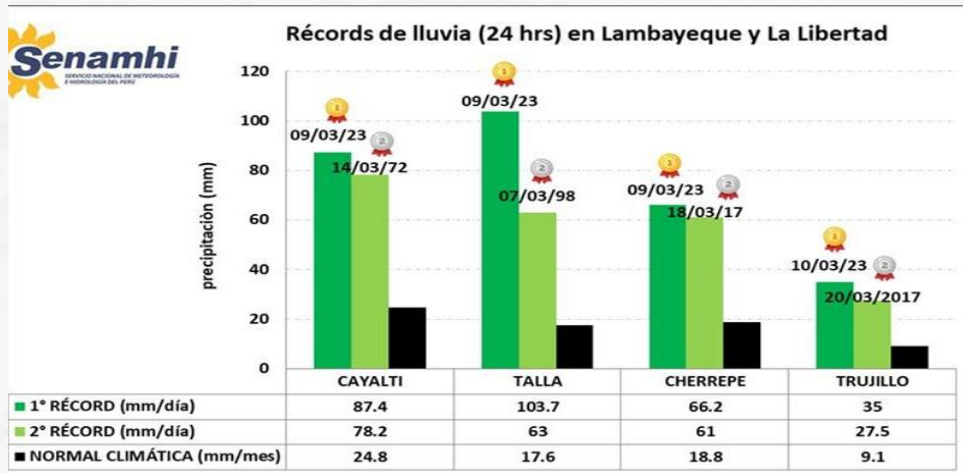
DEL 11 AL 20 DE
MARZO 2023



ACUMULADOS DIARIOS DE PRECIPITACIÓN DE 01 DE SETIEMBRE 2022 AL 23 DE MARZO 2023



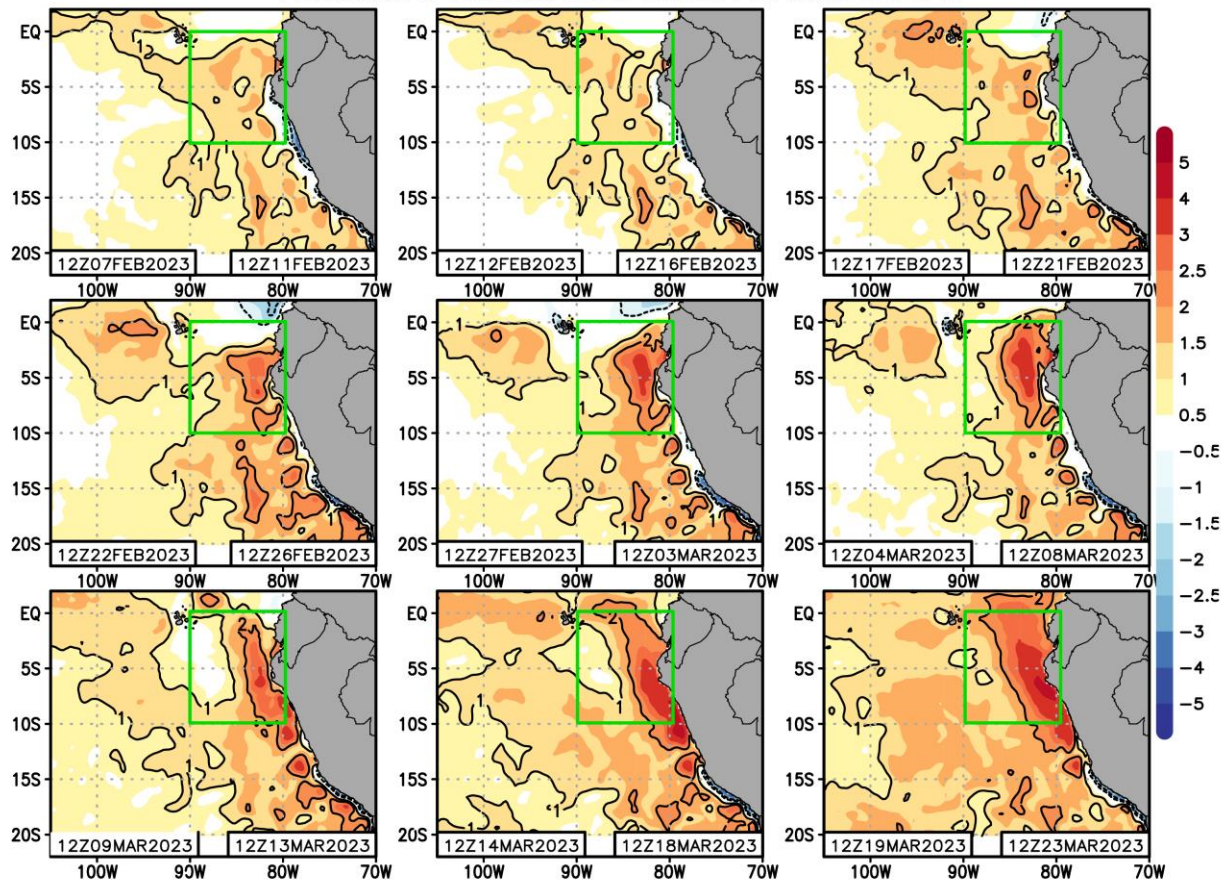
Récords históricos



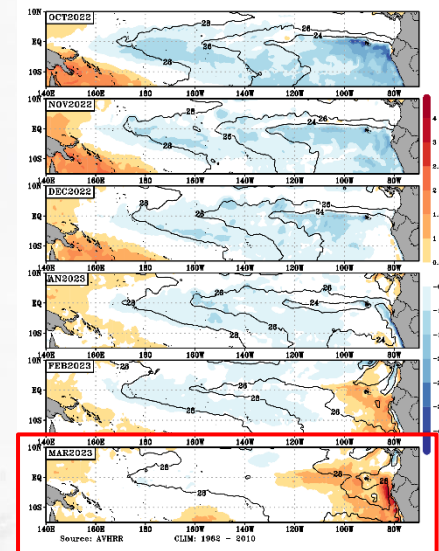
En los primeros 10 días de marzo se han registrados 4 nuevos récords de lluvias, que han superado a los anteriores récords que se registraron durante años El Niño y el **23 de marzo Puerto Pizarro registró un valor de 225.1 mm.**

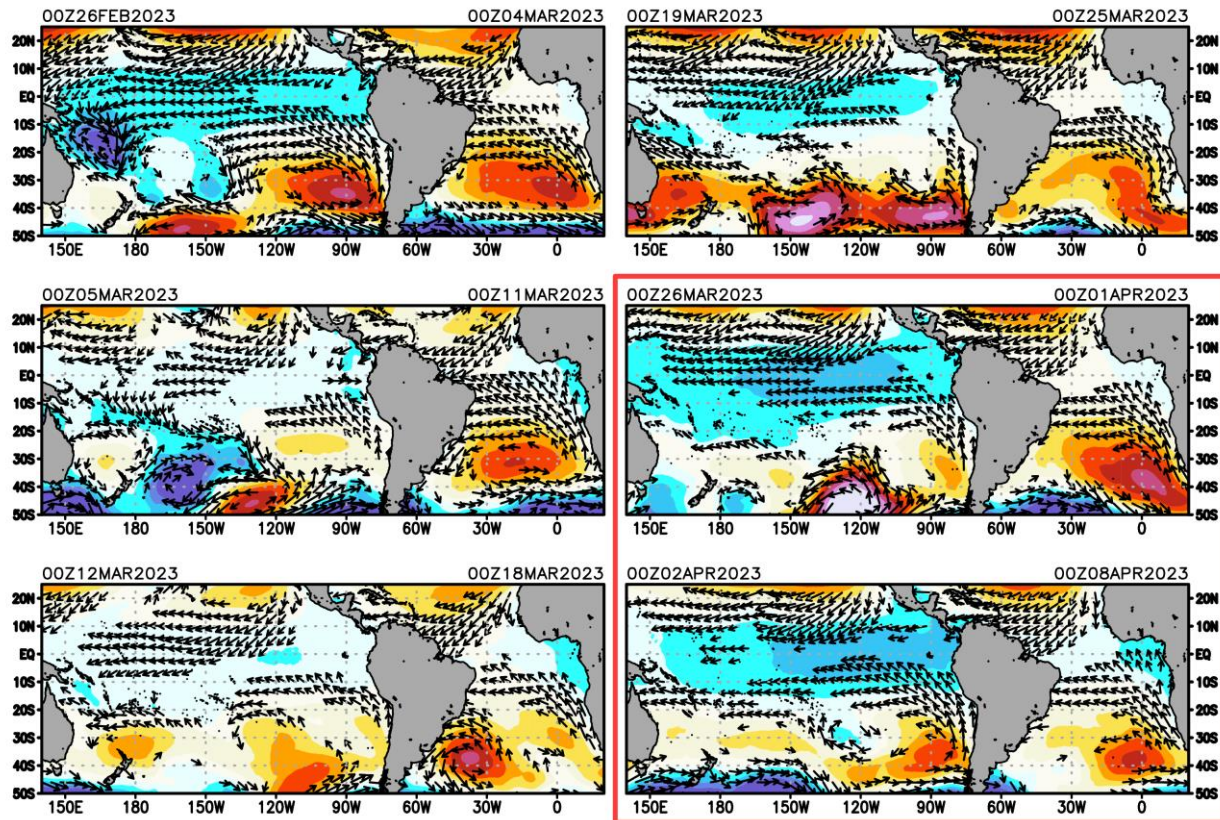
Condiciones océano atmosféricas actuales

ANOMALIA DE LA TEMPERATURA SUPERFICIAL DEL MAR



Las anomalías positivas de la Temperatura Superficial del Mar se han expandido y abarcan la costa norte y central del país

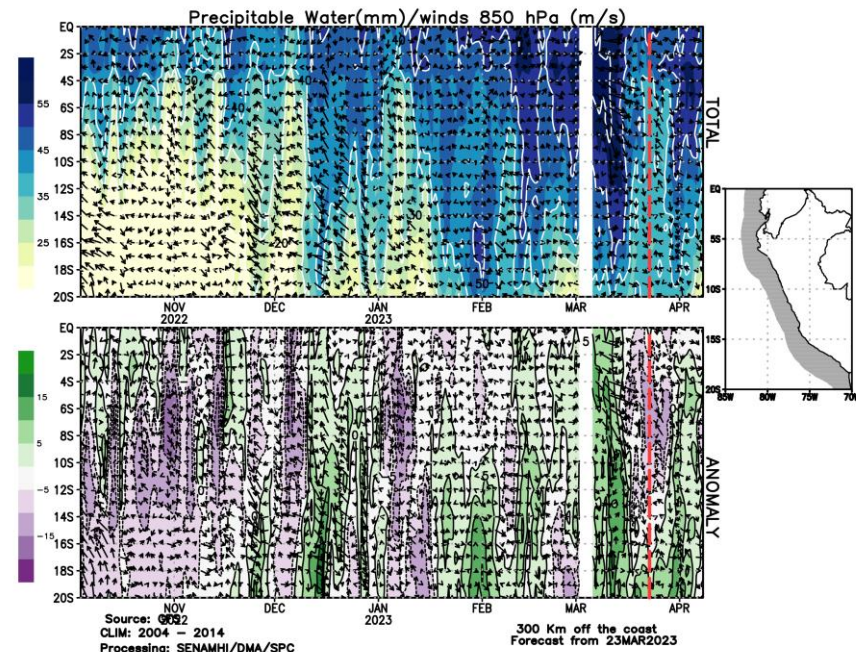
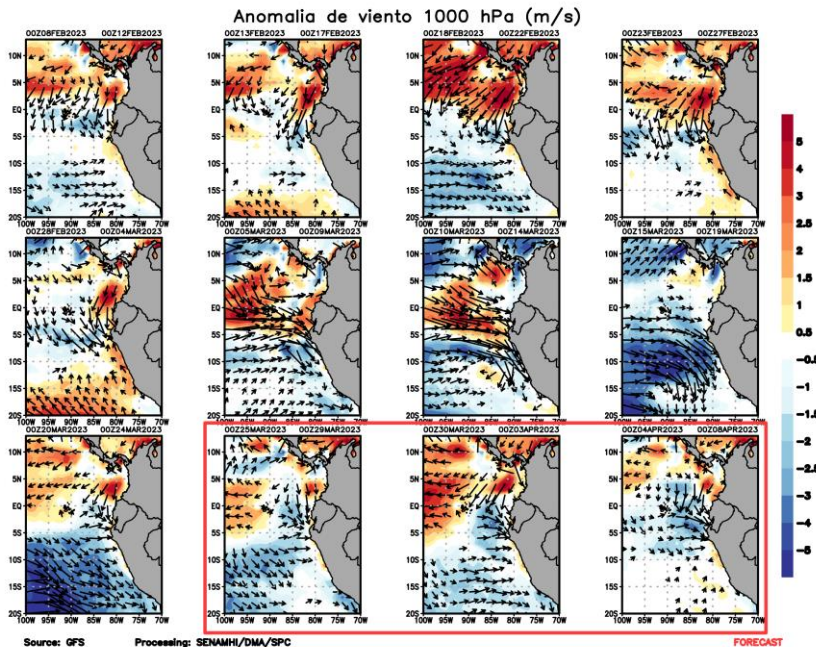




En promedio, el Anticiclón del Pacífico Sur se mantendrá cercano a las costas de Sudamérica, aunque con un núcleo más débil en la próxima semana.



FORECAST

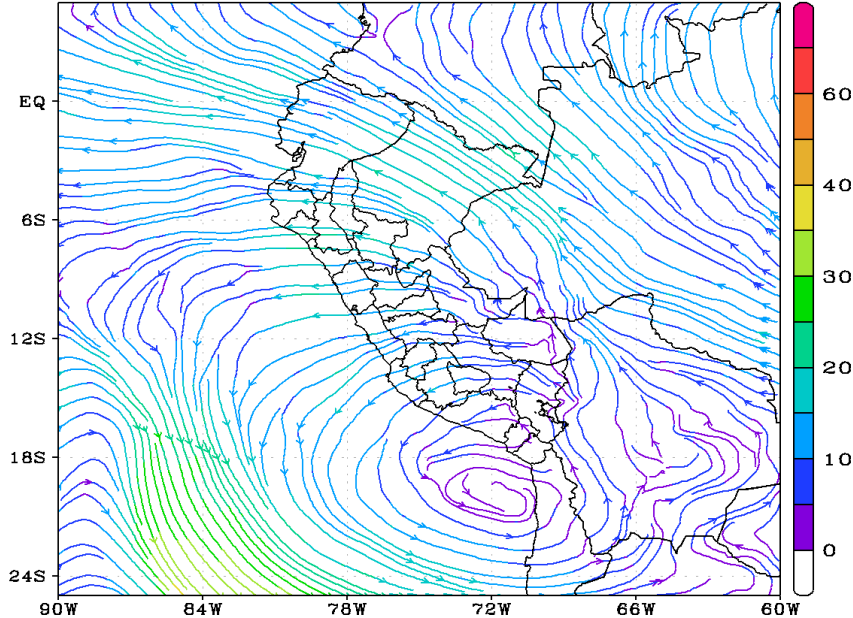


De acuerdo al modelo de pronóstico se prevé una mayor convergencia de vientos en niveles bajos se así como una mayor cantidad de agua disponible para lluvia en la costa norte entre fines de marzo e inicios de abril

CONFIGURACIÓN SINÓPTICA

NIVELES ALTOS

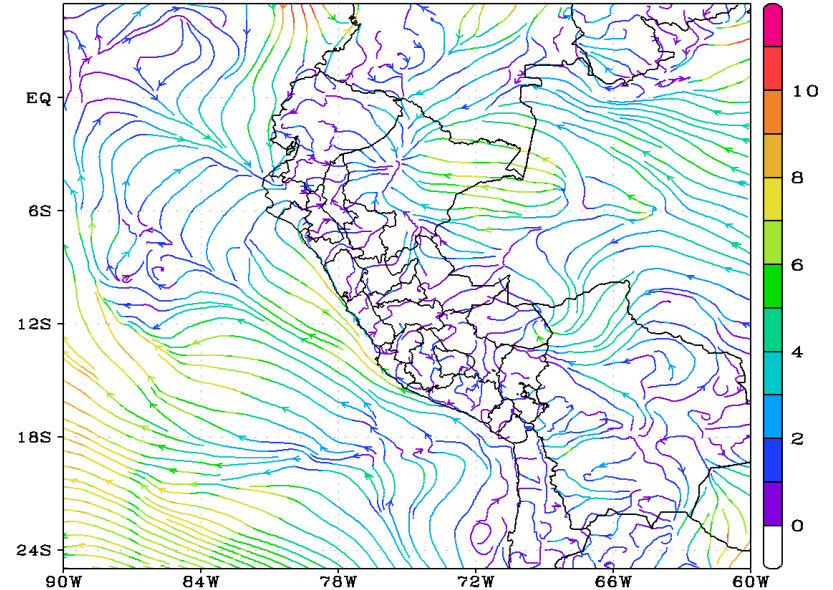
LINEAS DE CORRIENTE (m/s) 200 hPa
ANALISIS: 00UTC 24MAR2023 VALIDO: 21UTC 24MAR2023



Difluencia en niveles altos aportando divergencia sobre la zona norte apoyado por desplazamiento de la Alta de Bolivia hacia el océano Pacífico.

NIVELES BAJOS

LINEAS DE CORRIENTE (m/s) 975 hPa
ANALISIS: 00UTC 24MAR2023 VALIDO: 09UTC 24MAR2023



Ingreso de vientos del norte sobre la costa norte generando confluencia sobre ese sector aportando aire cálido y húmedo.

Aviso 59
METEOROLÓGICO

Precipitaciones en la costa norte y sierra

Niveles de Peligro



Rojo

Lunes
27 marzo



Martes
28 marzo



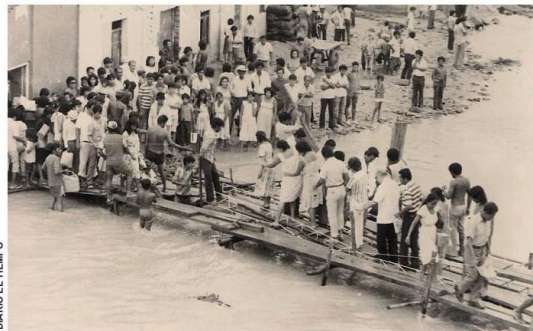
Miércoles
29 marzo



Amazonas / Ancash / Apurímac / Arequipa / Ayacucho / Cajamarca / Cusco / Huancavelica / Huánuco / Ica / Junín /
La Libertad / Lambayeque / Lima / Madre de Dios / Moquegua / Pasco / Piura / Puno / Tacna / Tumbes



Previsión climática 2023-2024



DIARIO EL TIEMPO



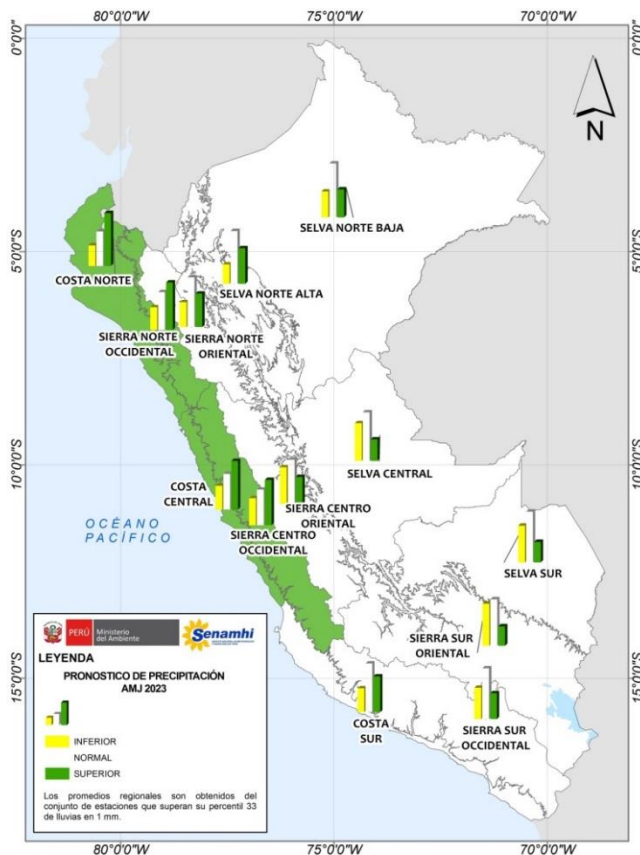
1982-83

1997-98

2016-17



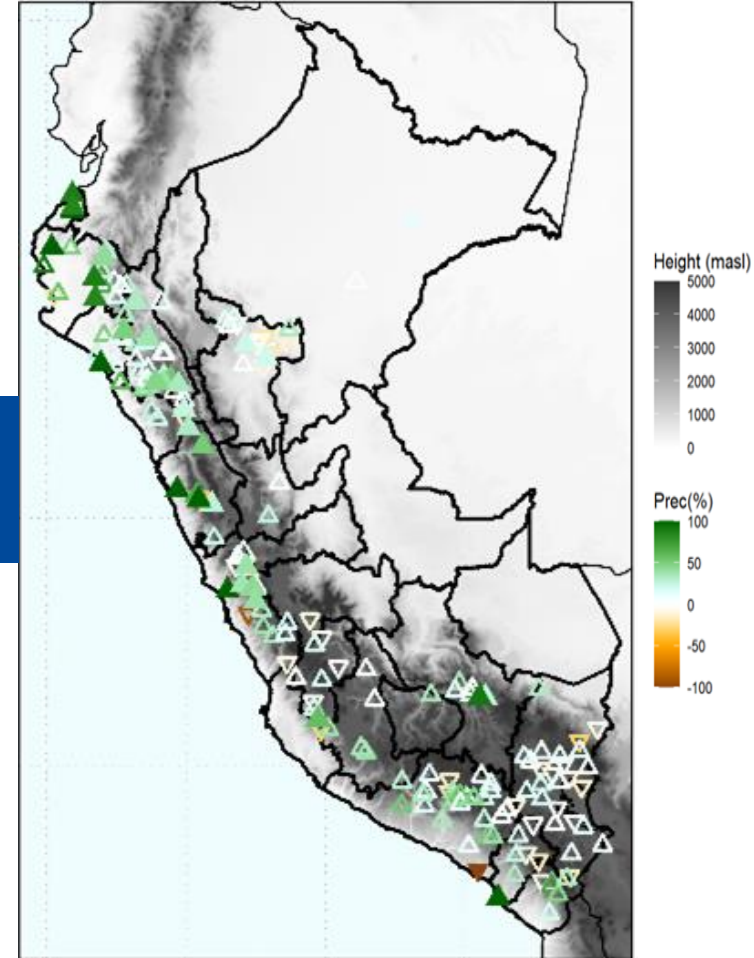
ESCENARIOS MENSUALES DE PRECIPITACIONES 2023



	ABRIL 2023	MAYO 2023	JUNIO 2023	JULIO 2023	AGOSTO 2023
COSTA NORTE	SUPERIOR(53%)	SUPERIOR(44%)	CLIMA SECO	CLIMA SECO	CLIMA SECO
COSTA CENTRO	SUPERIOR(49%)	SUPERIOR(44%)	CLIMA SECO	CLIMA SECO	CLIMA SECO
COSTA SUR	NORMAL(46%)	NORMAL(45%)	CLIMA SECO	CLIMA SECO	CLIMA SECO
SIERRA NORTE OCCIDENTAL	SUPERIOR(41%)	SUPERIOR(43%)	CLIMA SECO	CLIMA SECO	CLIMA SECO
SIERRA NORTE ORIENTAL	SUPERIOR(45%)	SUPERIOR(35%)	BAJO(52%)	BAJO(40%)	SUPERIOR(51%)
SIERRA CENTRO OCCIDENTAL	SUPERIOR(45%)	NORMAL(41%)	CLIMA SECO	CLIMA SECO	CLIMA SECO
SIERRA CENTRO ORIENTAL	NORMAL(45%)	BAJO(44%)	SUPERIOR(48%)	SUPERIOR(41%)	SUPERIOR(42%)
SIERRA SUR OCCIDENTAL	NORMAL(41%)	BAJO(38%)	CLIMA SECO	CLIMA SECO	CLIMA SECO
SIERRA SUR ORIENTAL	NORMAL(40%)	BAJO(46%)	BAJO(45%)	SUPERIOR(45%)	BAJO(42%)
SELVA NORTE ALTA	NORMAL(41%)	NORMAL(34%)	SUPERIOR(55%)	BAJO(42%)	NORMAL(41%)
SELVA NORTE BAJA	NORMAL(42%)	SUPERIOR(47%)	SUPERIOR(37%)	BAJO(40%)	SUPERIOR(42%)
SELVA CENTRAL	NORMAL(40%)	SUPERIOR(51%)	SUPERIOR(39%)	SUPERIOR(41%)	BAJO(47%)
SELVA SUR	NORMAL(45%)	BAJO(45%)	NORMAL(40%)	SUPERIOR(41%)	BAJO(43%)

Cambio Climático al 2050 (2036-2065)

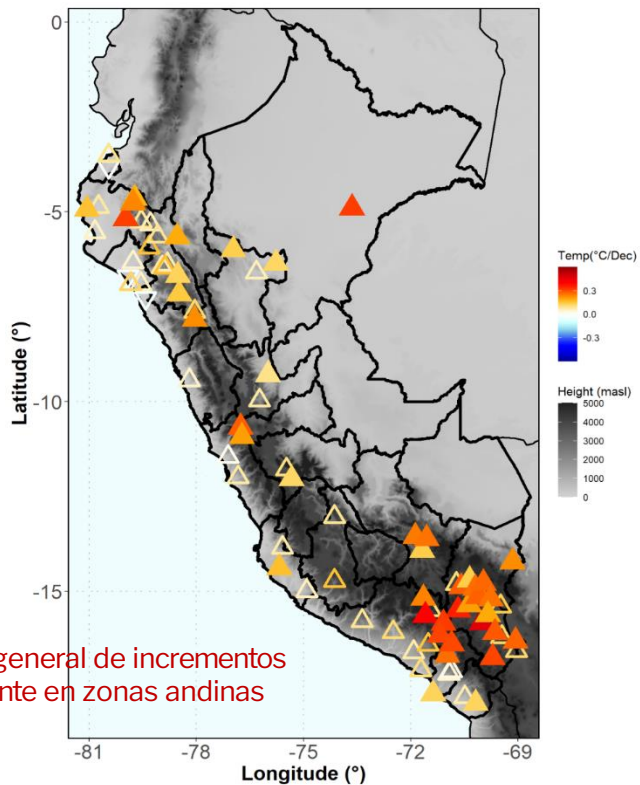
Tendencia de la precipitación 1965 - 2019



Nota: Los triángulos pintados son aquellos que presentan tendencias significativas al 95% de confianza según Test de Mann-Kendall

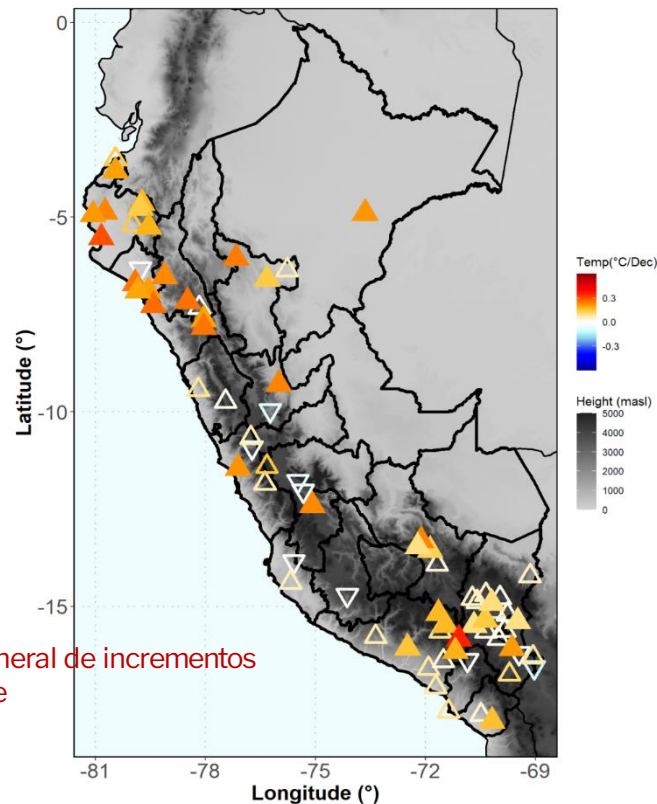
Tendencia de temperaturas máximas y mínimas 1965 - 2019

TEMPERATURA MÁXIMA

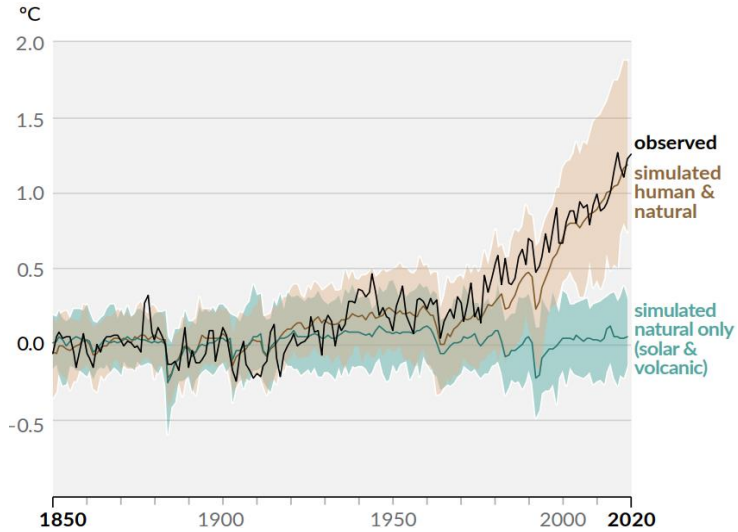


Tendencia general de incrementos principalmente en zonas andinas

TEMPERATURA MÍNIMA



Tendencia general de incrementos principalmente costa y sierra



IPCC-AR6(2021)

Clima futuro al 2050

Cambios en la precipitación y temperatura al 2050

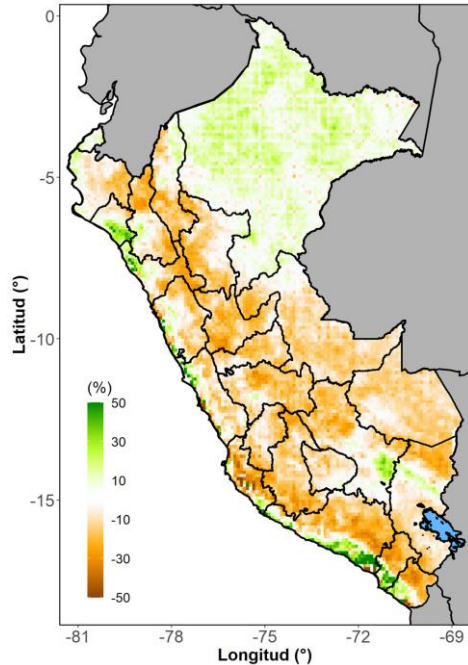


- *Incremento de la precipitación en la zona costera y la ladera oriental sur de los Andes*
- *Reducción de la precipitación en la zona amazónica y ladera occidental sur de los Andes*

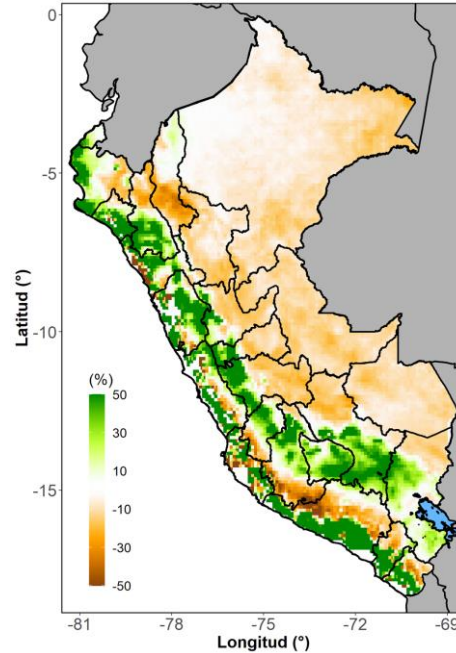
Fuente: SENAMHI, 2021

Cambios (%) de extremos de precipitación periodo 2036-2065

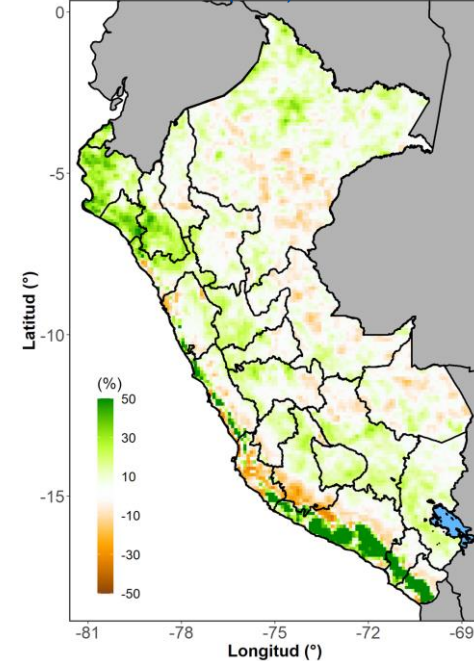
DÍAS HÚMEDOS CONSECUTIVOS
(CWD)



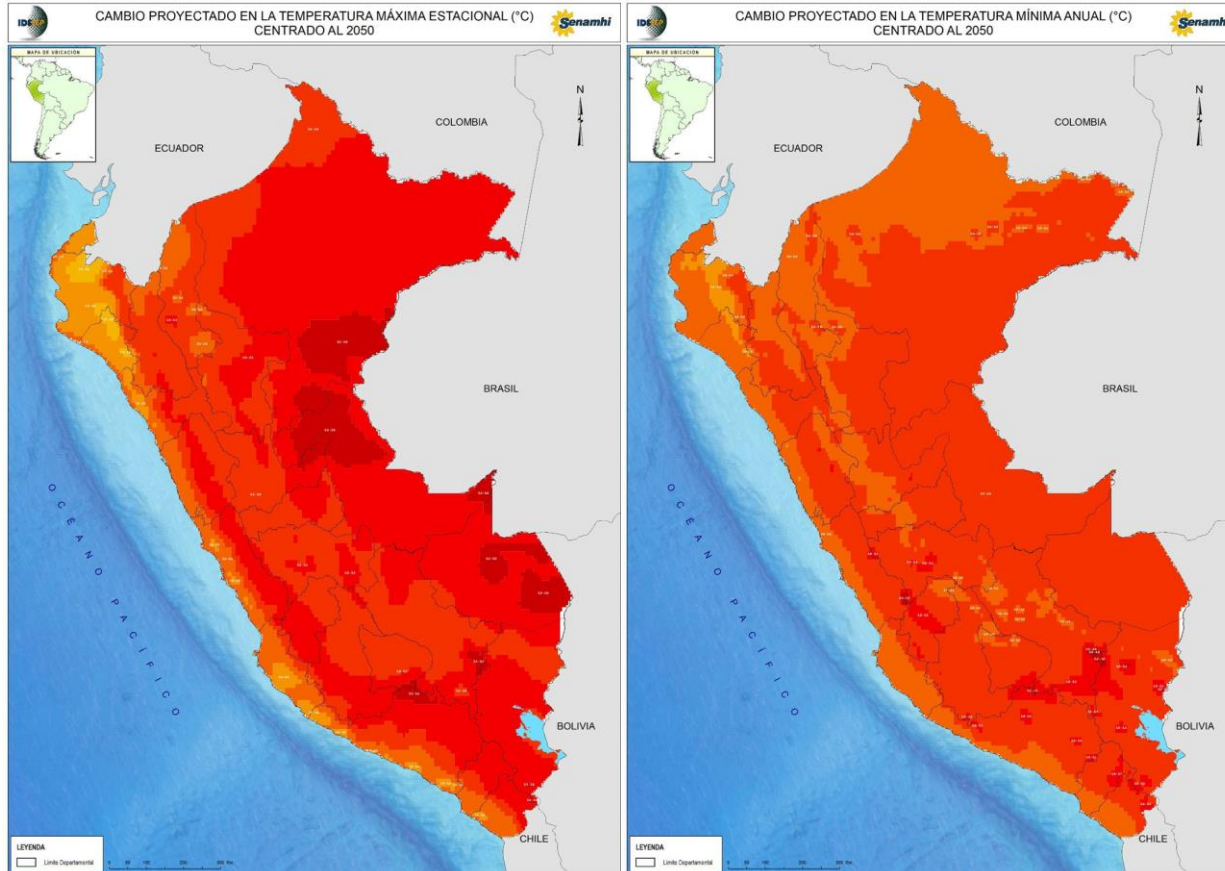
LLUVIAS MAYORES A 10 mm
(R10)



LLUVIAS MÁXIMAS EN UN DÍA
(R1X)

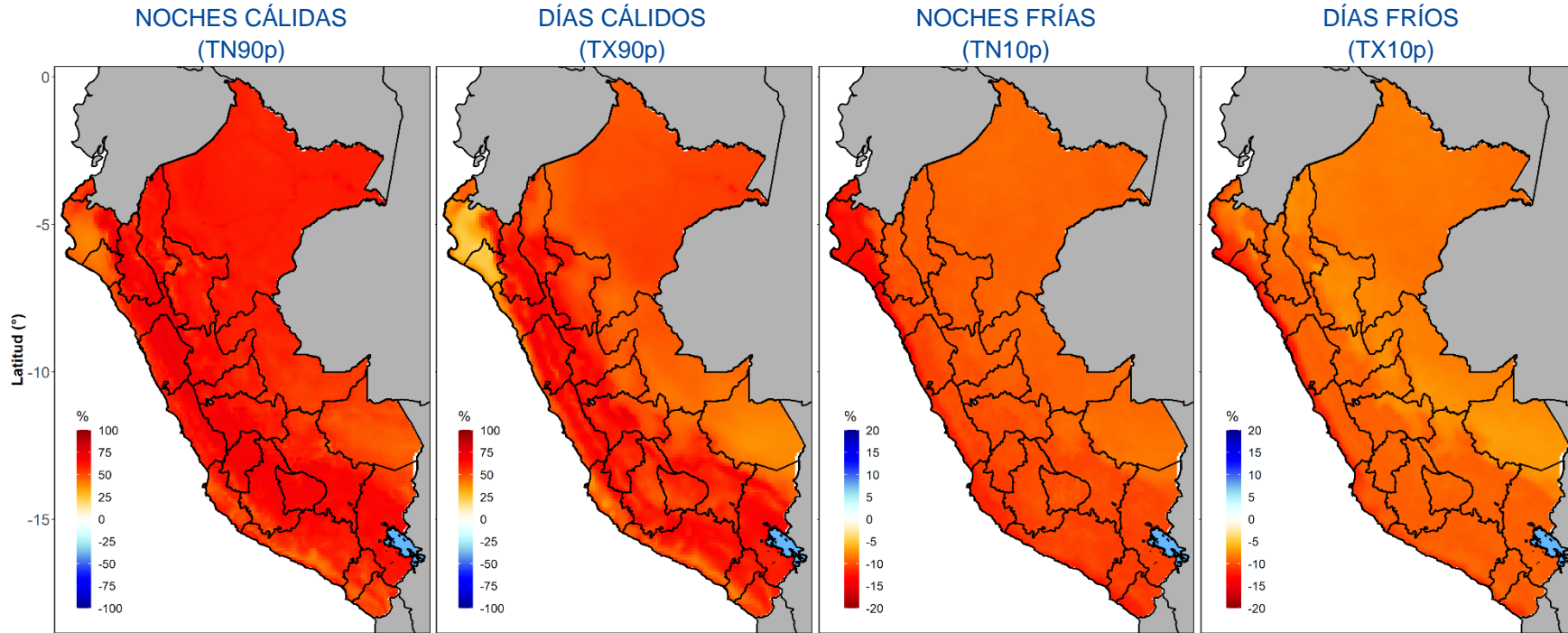


Cambios en la precipitación y temperatura al 2050



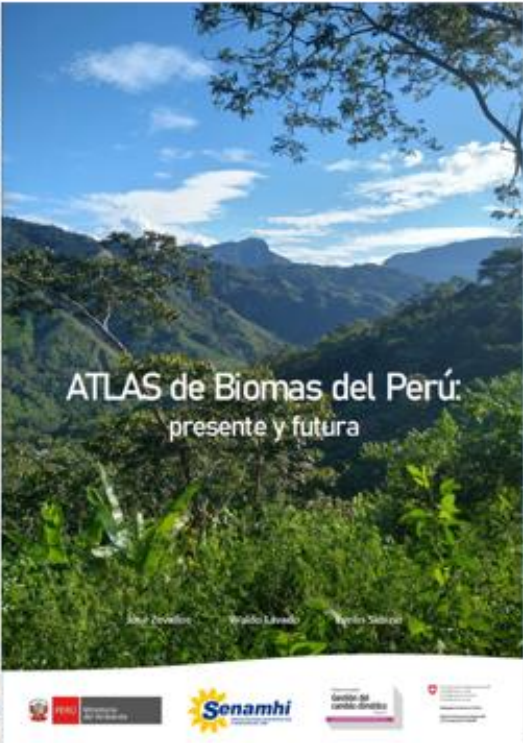
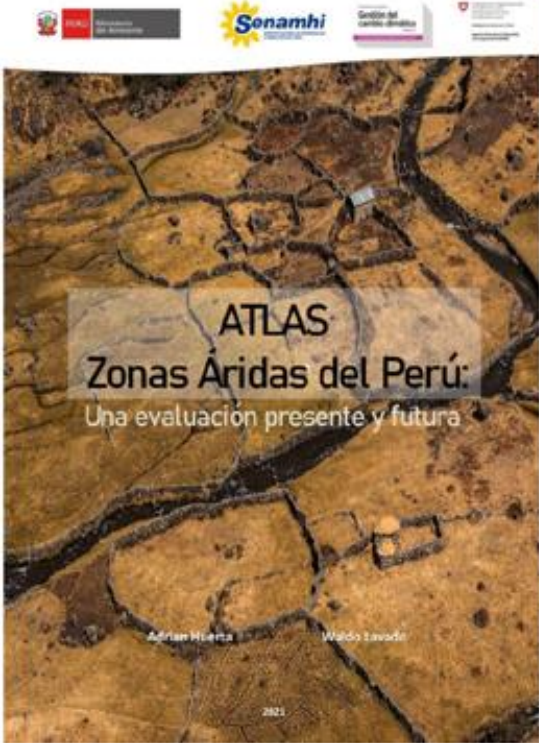
- *Incremento de la temperatura máxima y mínima generalizada sobre todo el territorio, con especial incidencia en la Amazonía y los Andes.*

Cambios (%) de extremos de temperatura periodo 2036-2065



Fuente: SENAMHI, 2021. Cambios en los Extremos climáticos en el Perú al 2050 – GDLM

Estudios de impactos del cambio climático en los recursos hídricos y biomas



Estudios de impactos del cambio climático en los recursos hídricos y producción de sedimentos

