

# The January 2021 Zonal Atmospheric River in central Chile: a non-fatal disaster

Felipe Ugalde<sup>1</sup>, Cedomir Marangunic<sup>2</sup>, and Ashley Apey<sup>2</sup>

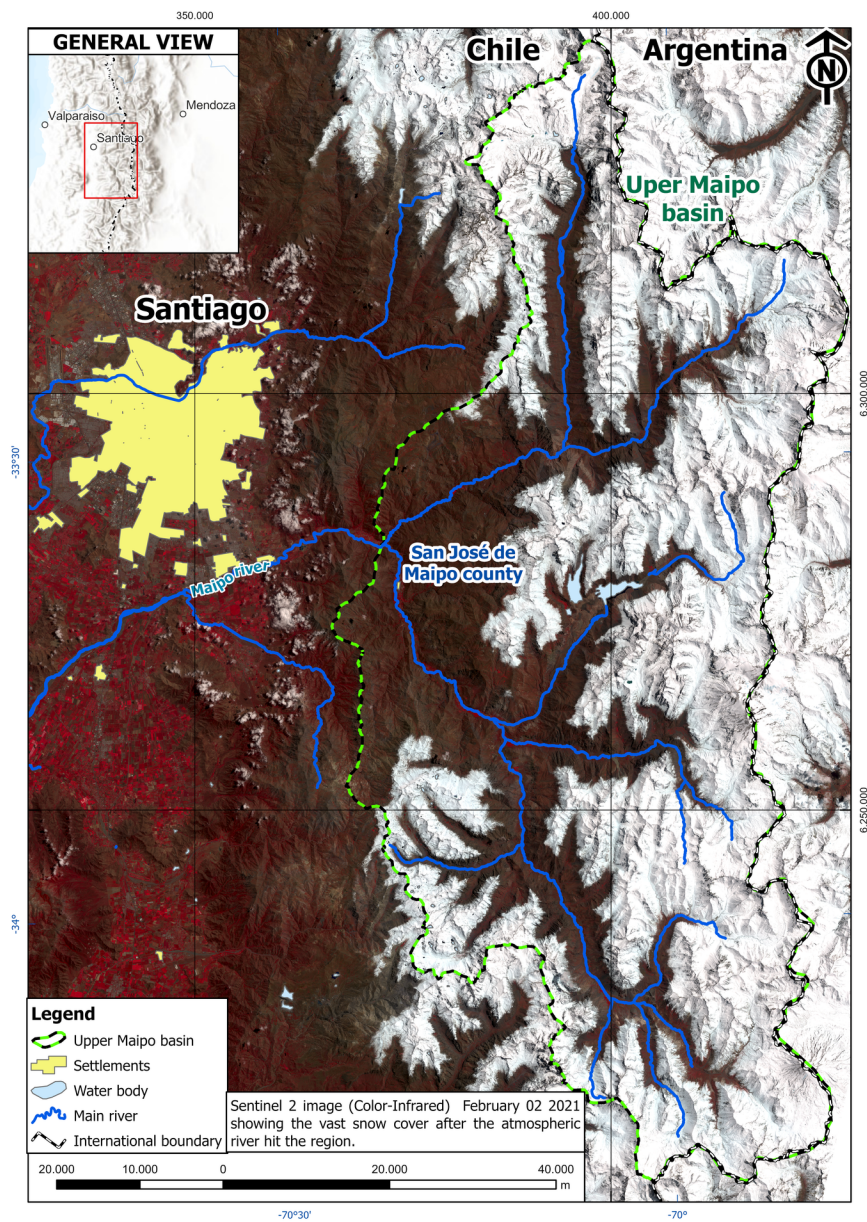
<sup>1</sup>Geoestudios, Universidad de Chile

<sup>2</sup>Geoestudios

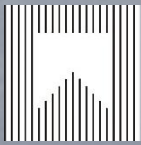
November 22, 2022

## Abstract

Although scarcely described, intense summer precipitation events in central Chile aren't an unknown phenomenon, their recurrence is estimated at 40 years. In the last 5 years, 2 heavy rainfall episodes triggered massive debris flows in the San Jose de Maipo county of the Metropolitan Region, located on the upper Maipo river basin, where average precipitation for summer months is only 7 mm. A summary of the current knowledge of the January 28 to 31, 2021 summer rain event is presented. The episode has been attributed to a Zonal Atmospheric River (ZAR), which allowed for a direct transfer of vapour and moisture on a W-E trajectory perpendicular to the Chilean coast. The latter favoured high altitude precipitation, with 0 degree isotherm estimated at 3.700 m a.s.l. On a local range, the snow line was observed between 2,800-3,100 m a.s.l. The event precipitation reached unprecedented values over 60 mm on all stations along the Maipo valley, with a local maximum of 117 mm. 3 pulses have been accounted for rainfall, with a maximum intensity of 11 mm/hour; at the peak of the pulses the Maipo river flow increased 8 times its pre-event flow of 60 m/s. In the following days after the event, 55% of the Upper Maipo basin was covered with snow. Due to sudden higher temperatures a consequent rapid snow melt increased the turbidity of the Maipo river, compromising freshwater supply. Agriculture was also affected, mainly grapes. According to the National Geological and Mining Service, over 120 landslides were triggered during the event, most of them being debris flows with some rock fall affecting the main roads. 700 persons were affected, more than 100 houses resulted with damages, 50 with severe damages and 33 destroyed, mostly at the San Alfonso village. Cost of infrastructure's lost was estimated over US\$4MM. Luckily, there weren't any fatalities. This feature contrasts with the 25 February 2017 debris flow episode in the same region, with 8 fatal victims. Although local inhabitants have coexisted with this kind of hazards since historical times, uninterrupted urban growth on mountain areas has contributed substantially to an increase in the level of exposure. In this case, the accurate forecasting of the ZAR coupled with an effective risk communication avoided fatalities, nonetheless, it is most likely that this kind of phenomenon will occur again.







**GEOESTUDIOS**



**fcfm**

**Geología**

FACULTAD DE CIENCIAS  
FÍSICAS Y MATEMÁTICAS  
UNIVERSIDAD DE CHILE

# **The January 2021 Zonal Atmospheric River in central Chile: A non-fatal disaster**

**Felipe Ugalde Peralta  
Cedomir Marangunic  
Ashley Apey**

**AGU FALL  
MEETING**



# Preface



Maipo river (-33.58/-70.45) 796 m a.s.l. 24<sup>th</sup> June 2020



# Preface



Maipo river (-33.58/-70.45 ) 796 m a.s.l. 30<sup>th</sup> January 2021



# The last ZAR

- 25-26<sup>th</sup> February 2017
- 0° isotherm over 4500 m a.s.l.
- 22.8 mm of rainfall. Intensity up to 5.7 mm/hr
- 8 fatalities because of landslides



<http://www.soychile.cl/Santiago/Sociedad/2017/02/26/448970/Mas-de-mil-aislados-y-siete-desaparecidos-tras-alud-en-San-Jose-de-Maipo.aspx>



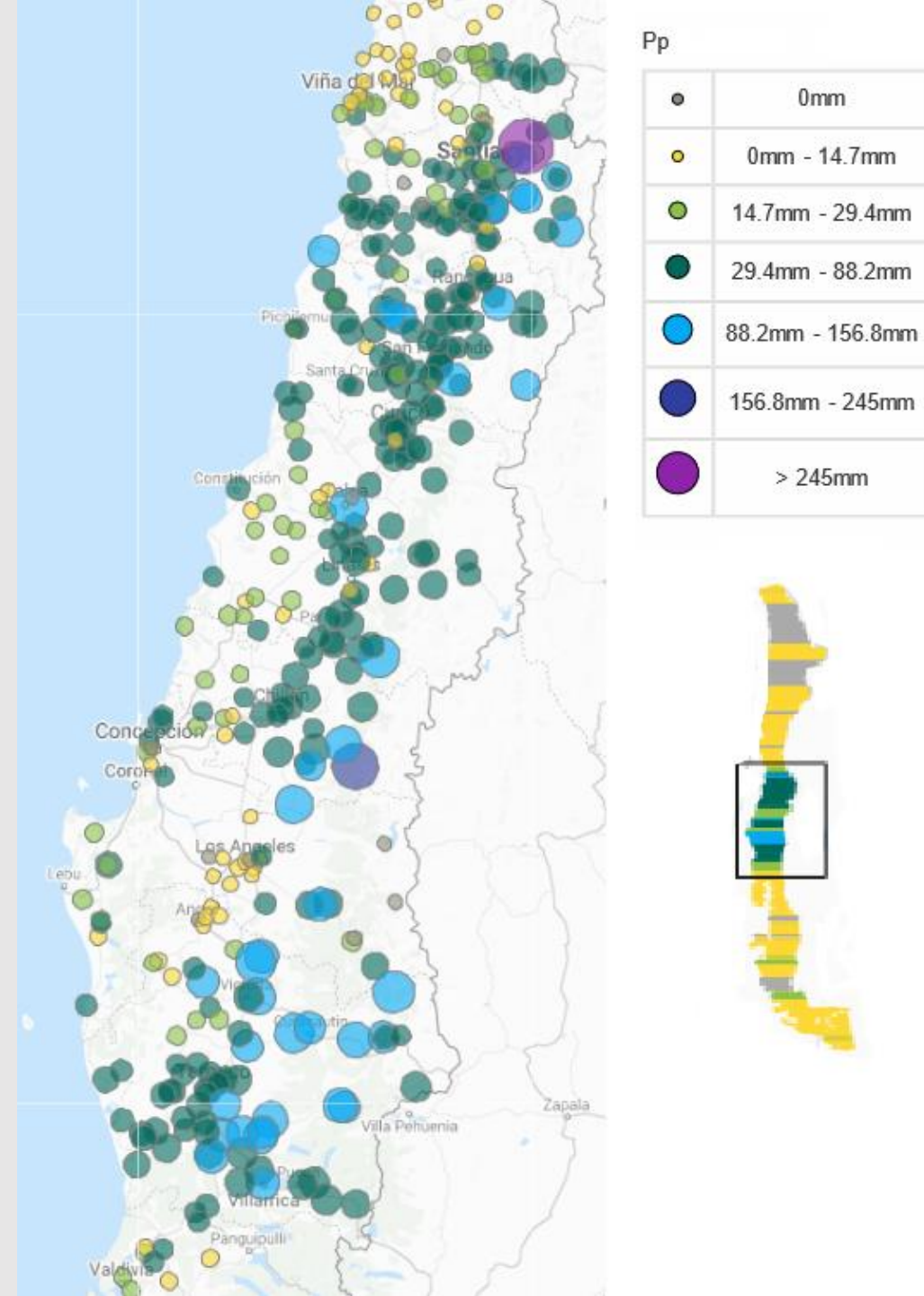
# The event





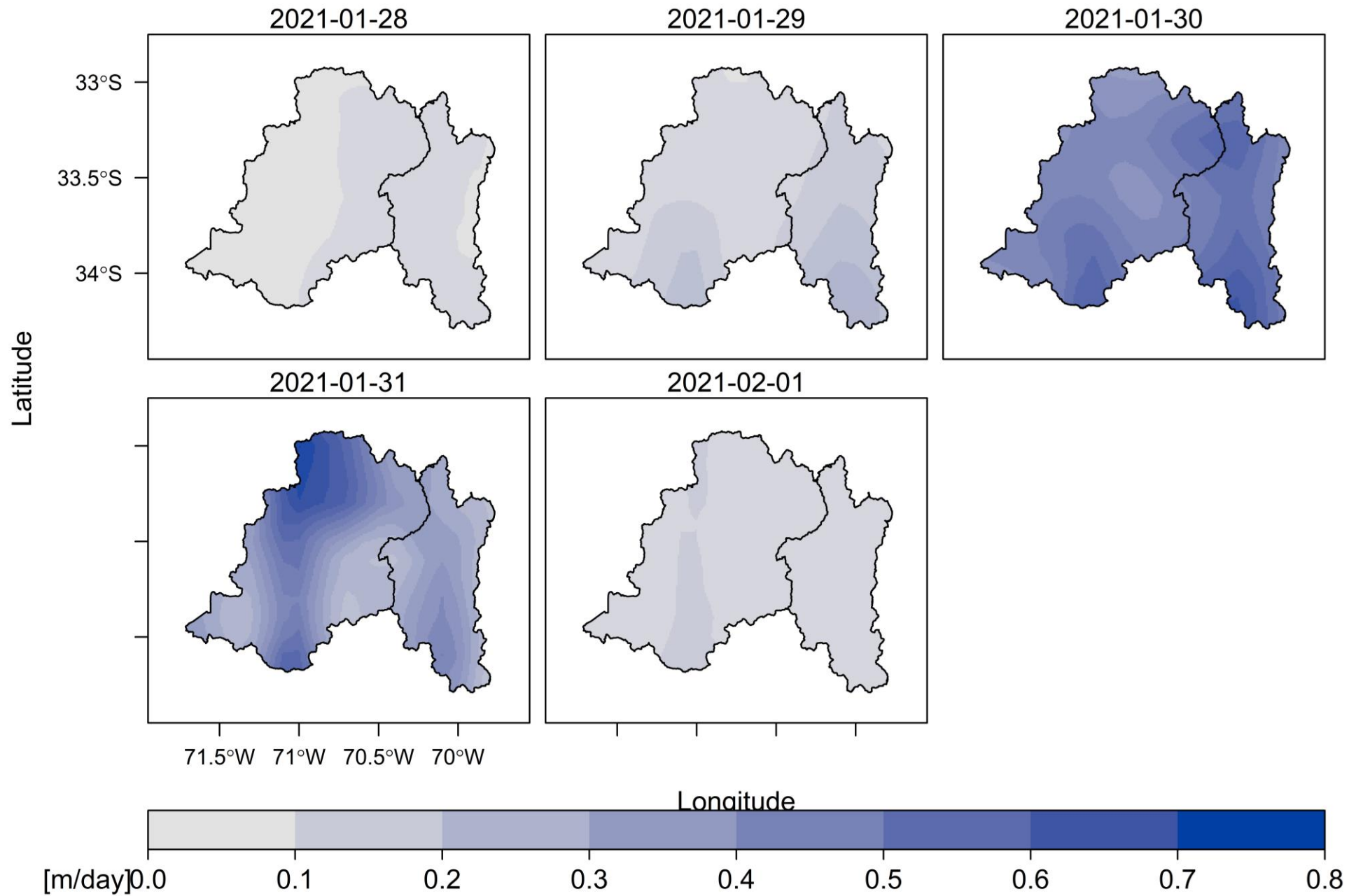
# General overview

- ZAR on 28<sup>th</sup>-31<sup>st</sup> Jan. 2021
- Latitudinal range: -32° to -40°
- 0° isotherm: ~ 3700 m a.s.l.
- Cumulated Pp values over 120 mm





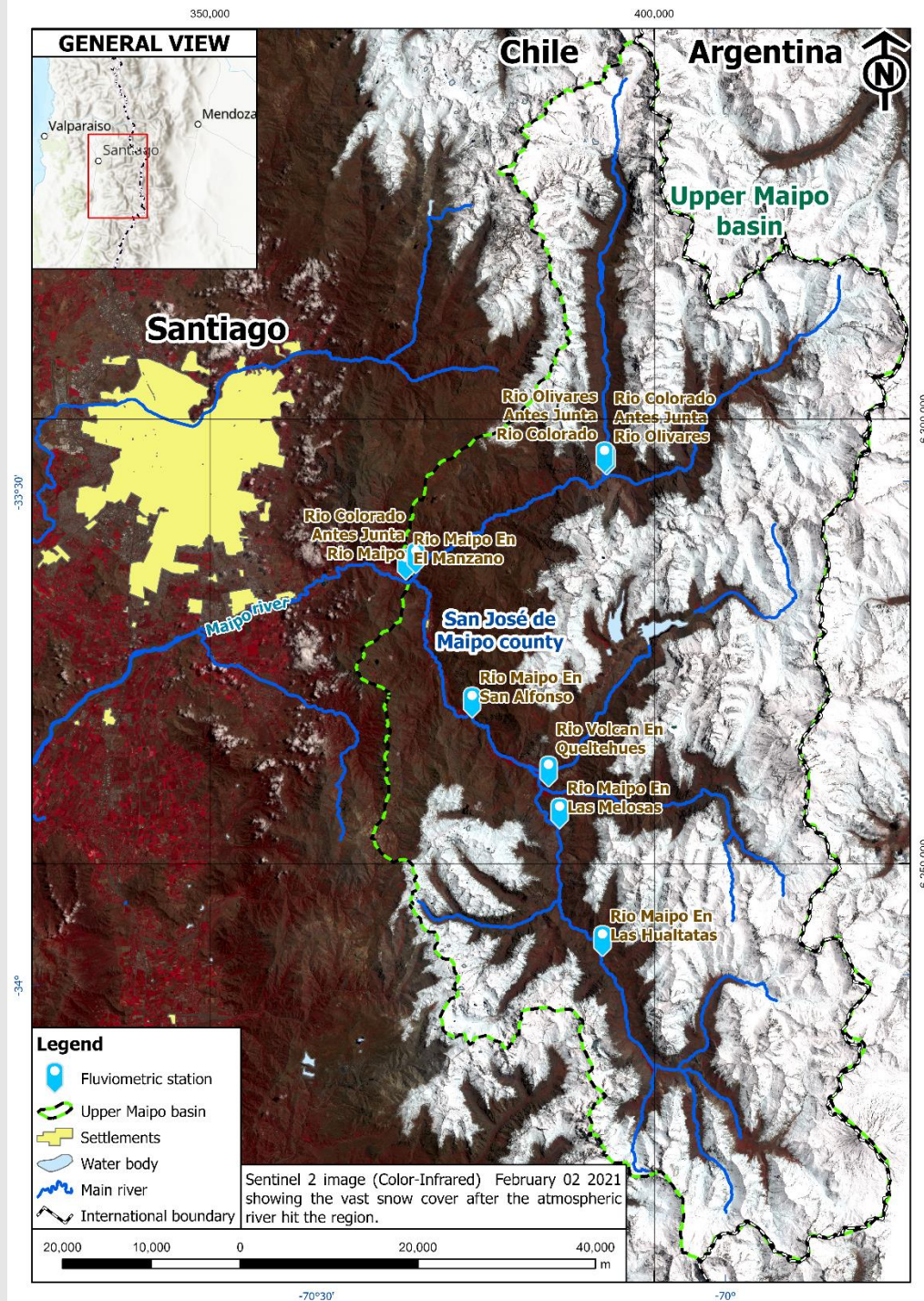
## Daily precipitation





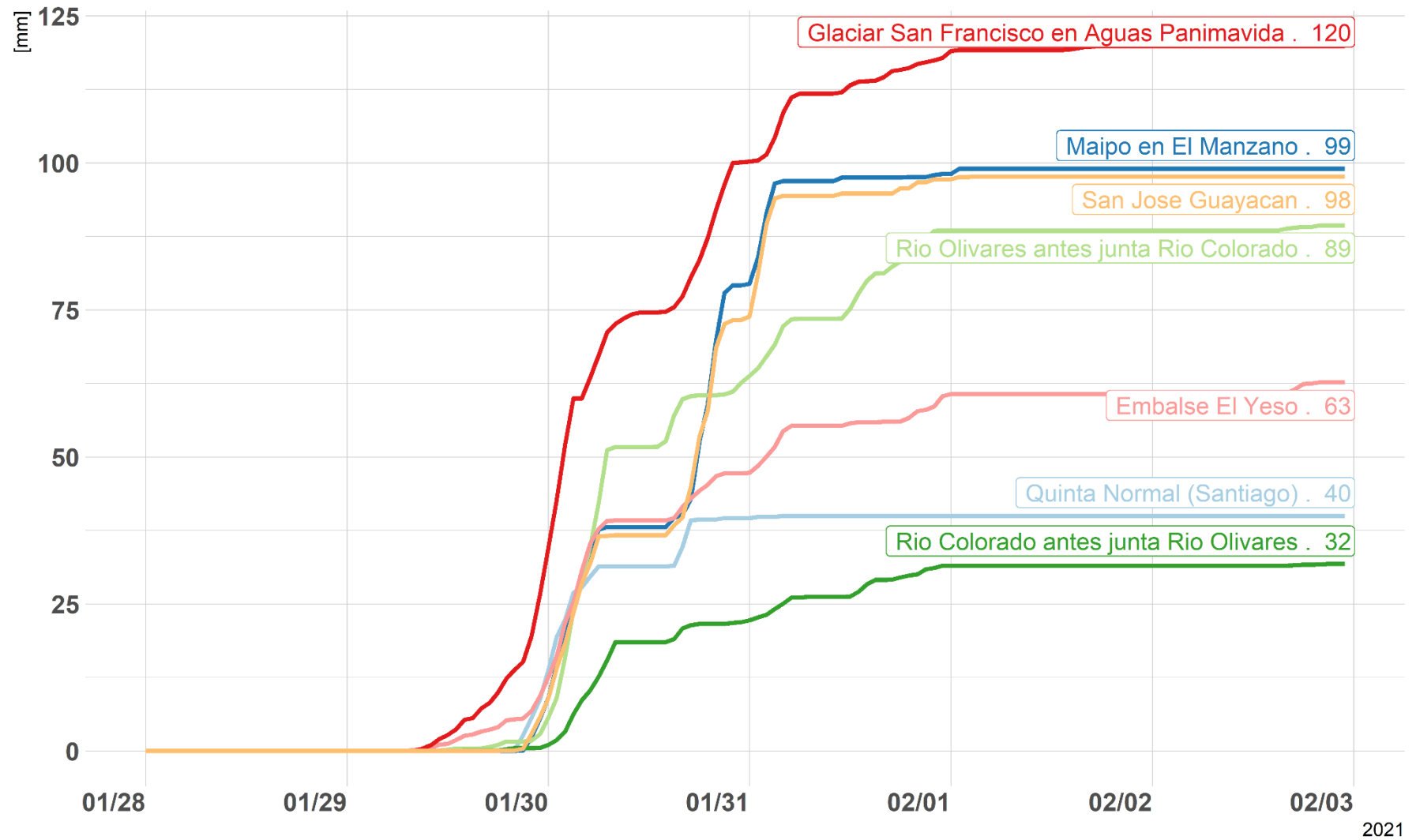
# At a local scale:

- Heavy rainfall on 29<sup>th</sup>-31<sup>st</sup> Jan. 2021
- Snow line: 2800-3100 m a.s.l.
- Over 60 mm of precipitation
- Local maximum of 117 mm
- 60% of the basin was covered with snow in summer!!!





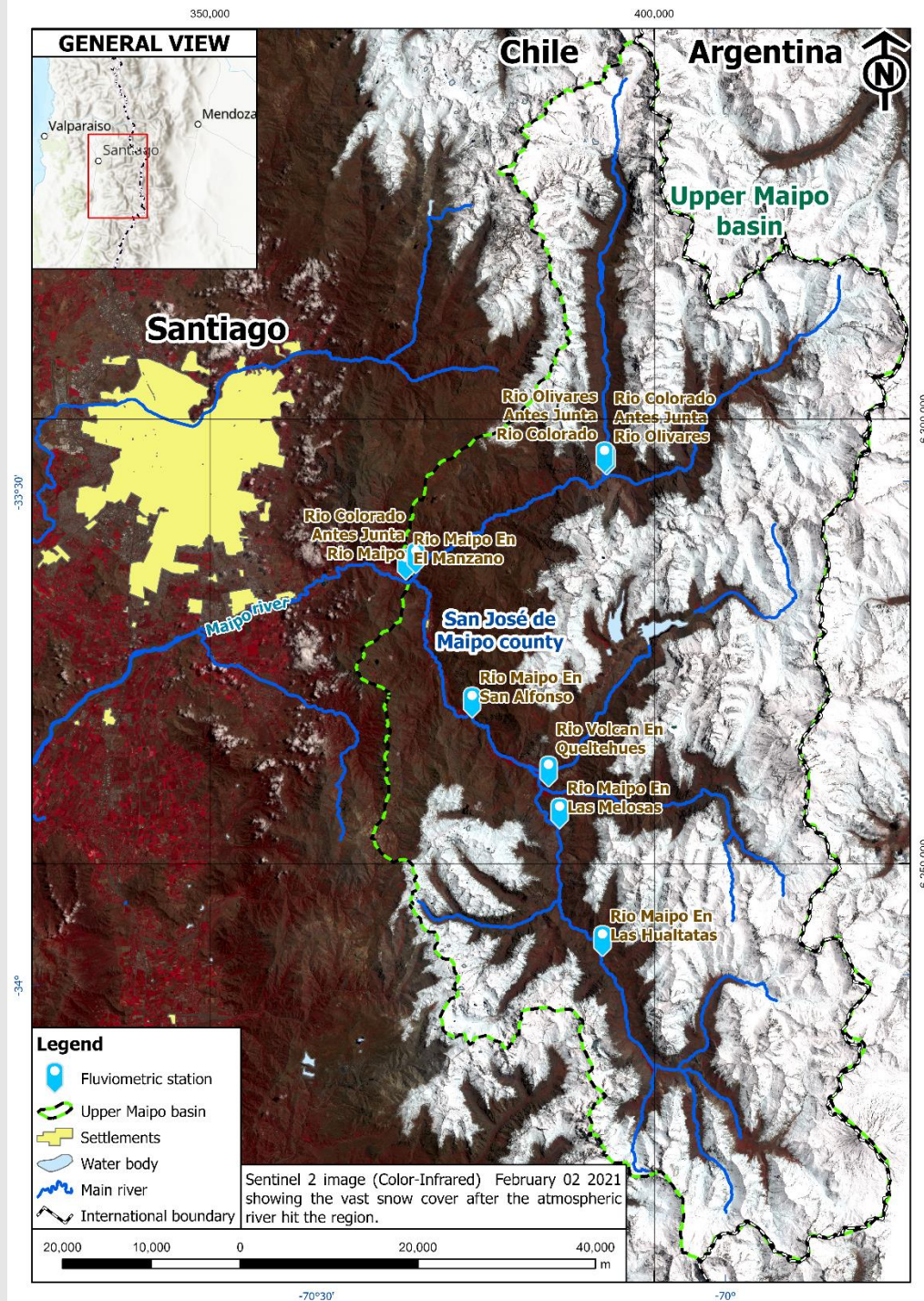
## Accumulative precipitation





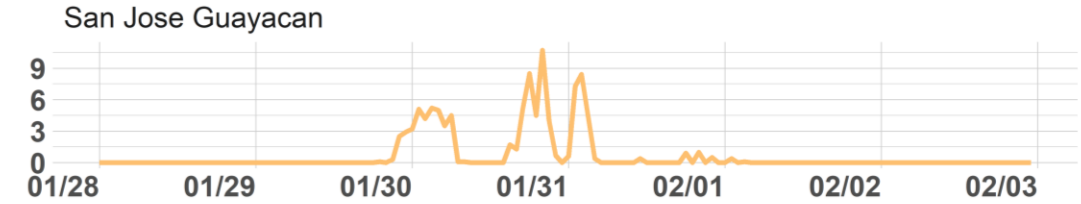
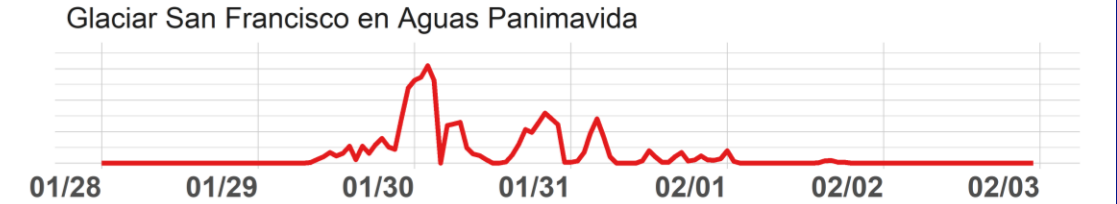
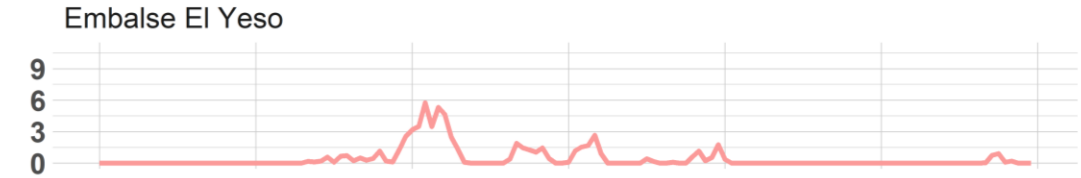
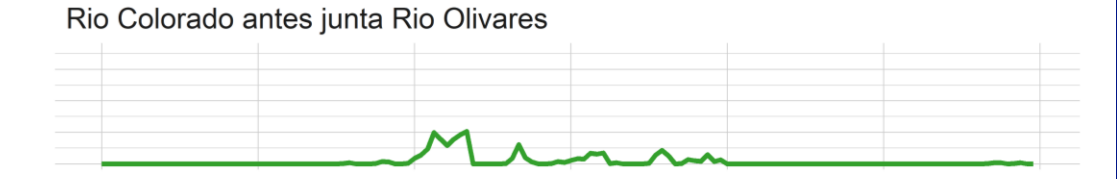
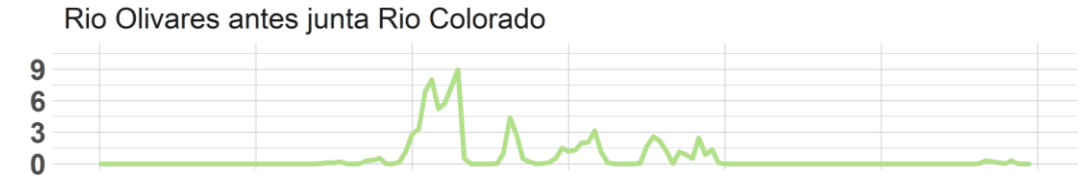
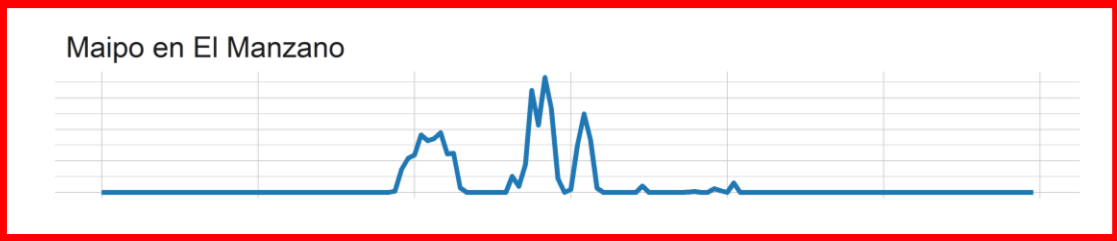
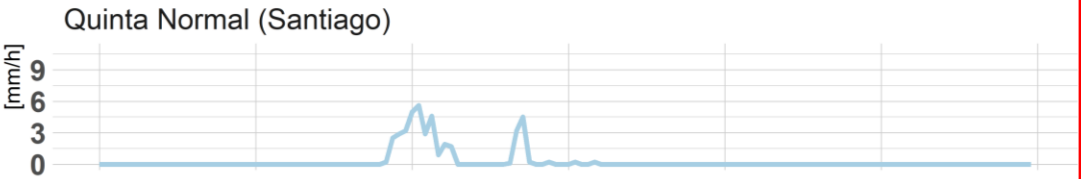
# At a detailed scale

- 3 pulses accounted
- Maximum intensity of 11 mm/h
- Pre-event flow increased 8 times
- Increased turbidity of Maipo river after snow melted



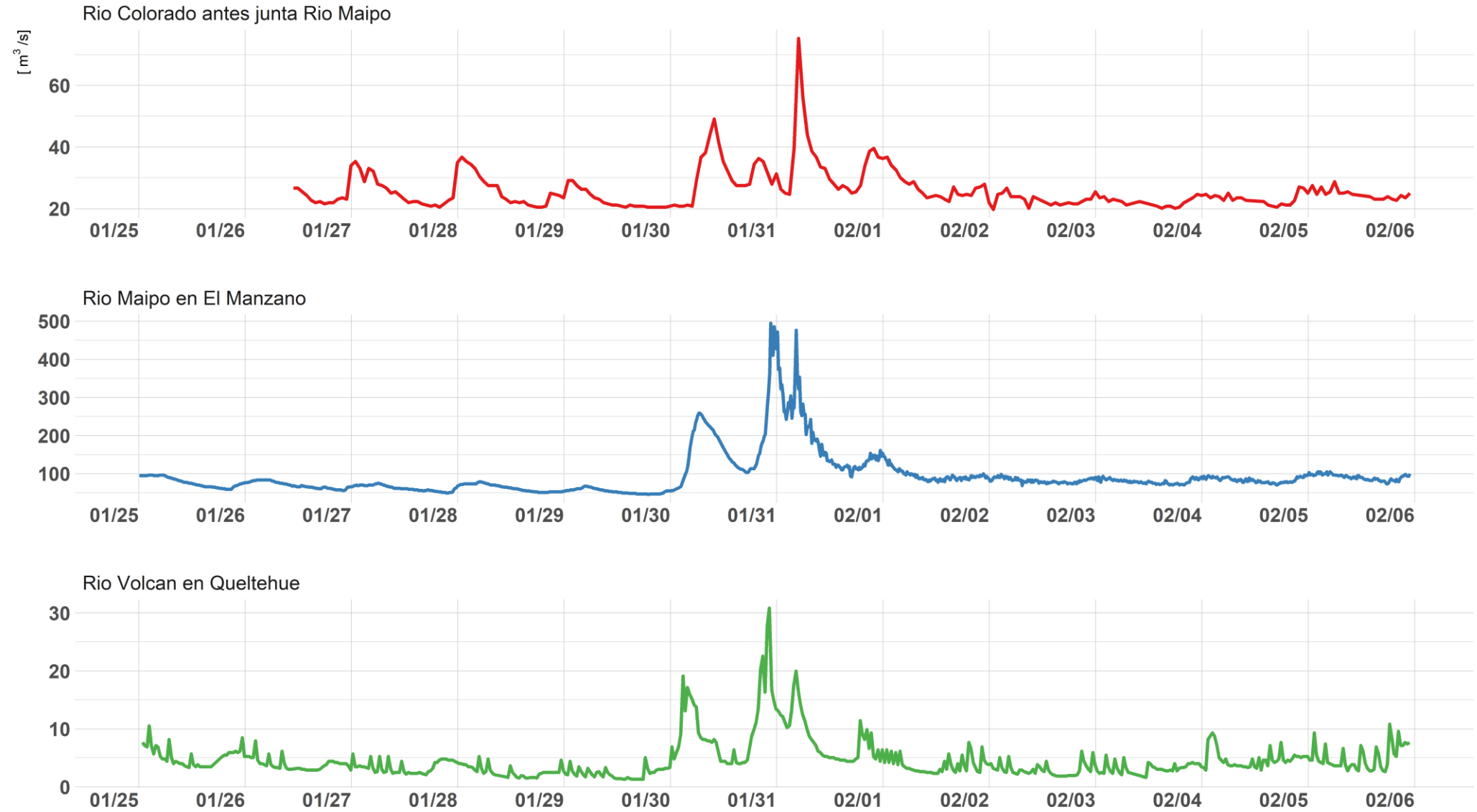


# Hourly precipitation





# Runoff



2021



# Landslides

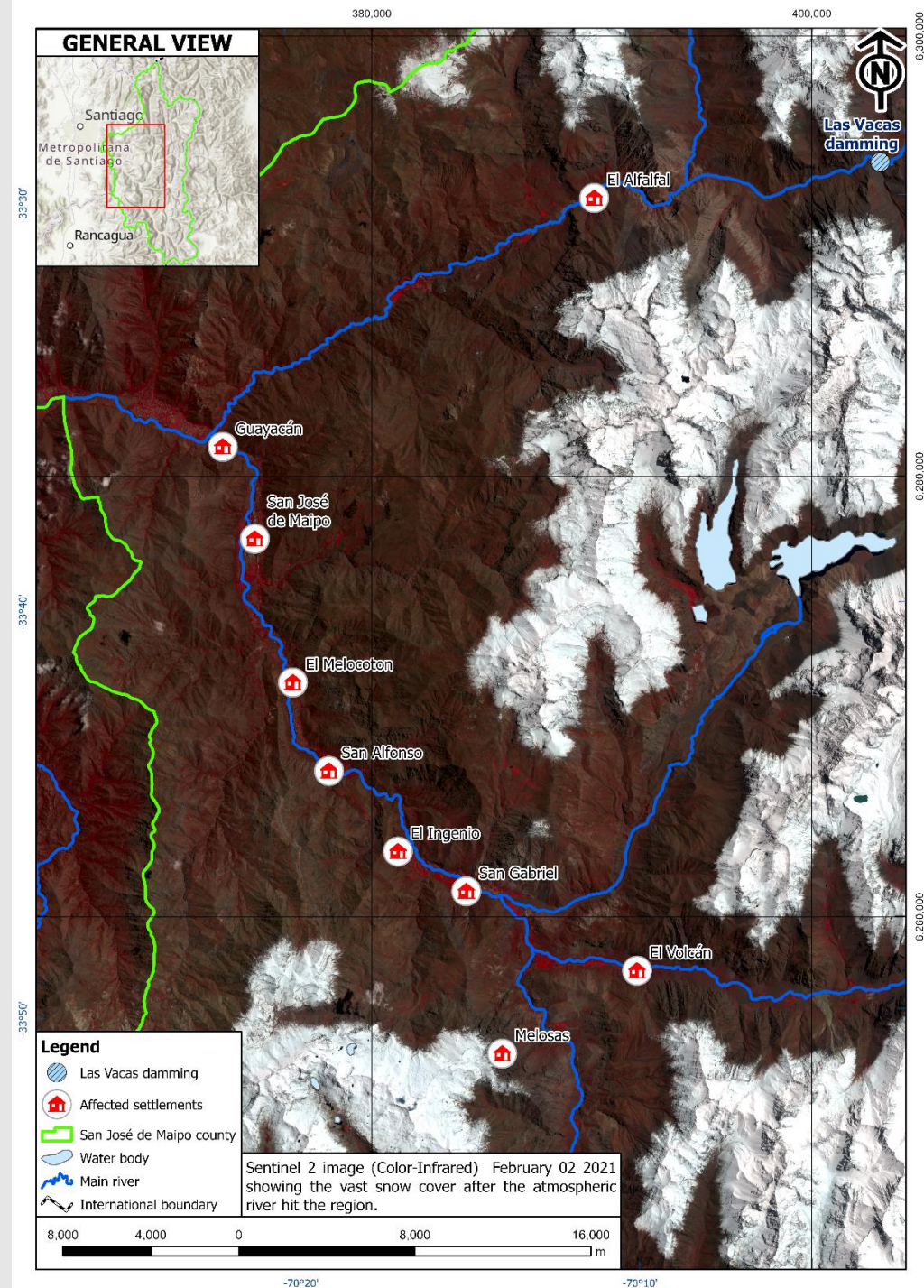


Upper Maipo (-33.83/-70.05 ) 2132 m a.s.l. 1<sup>st</sup> May 2021



# Landslides

- Over 120 landslides triggered
- Mostly debris flows.
- ~700 persons affected
- Hundreds of damaged homes
- 33 houses destroyed







<https://www.adnradio.cl/nacional/2021/02/01/cajon-del-maipo-asi-amanecio-san-alfonso-tras-aluvion-por-intensas-lluvias.html>





<https://codexverde.cl/greenpeace-por-aluviones-en-cajon-del-maipo-santiago-no-esta-preparado-para-estas-contingencias/>





[https://cooperativa.cl/noticias/pais/tiempo/san-jose-de-maipo-los-estragos-que-dejaron-los-aluviones-en-el-sector/2021-01-31/144348.html#gal\\_id&slide=foto\\_14](https://cooperativa.cl/noticias/pais/tiempo/san-jose-de-maipo-los-estragos-que-dejaron-los-aluviones-en-el-sector/2021-01-31/144348.html#gal_id&slide=foto_14)





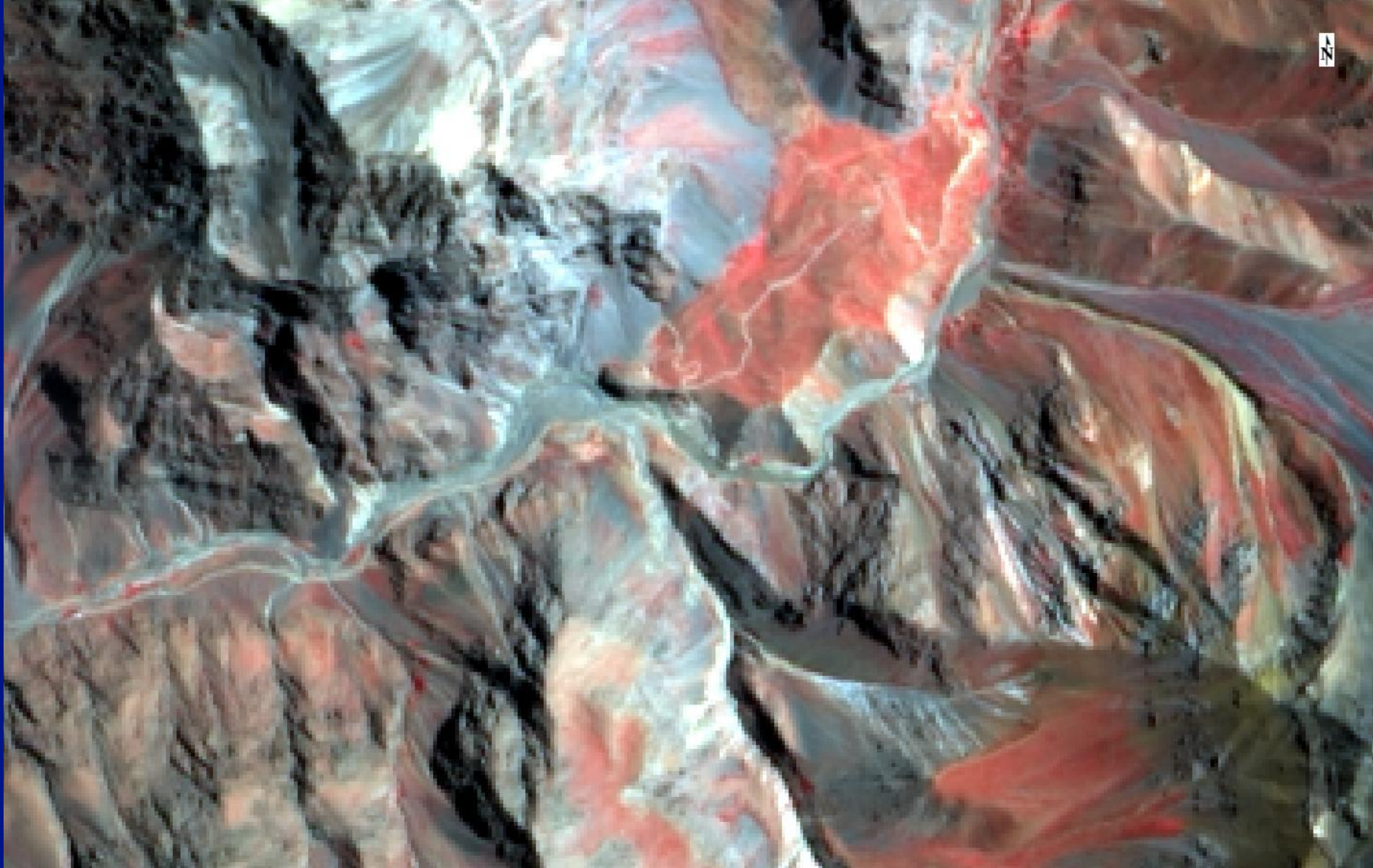
<https://www.adnradio.cl/nacional/2021/02/01/cajon-del-maipo-asi-amanecio-san-alfonso-tras-aluvion-por-intensas-lluvias.html>



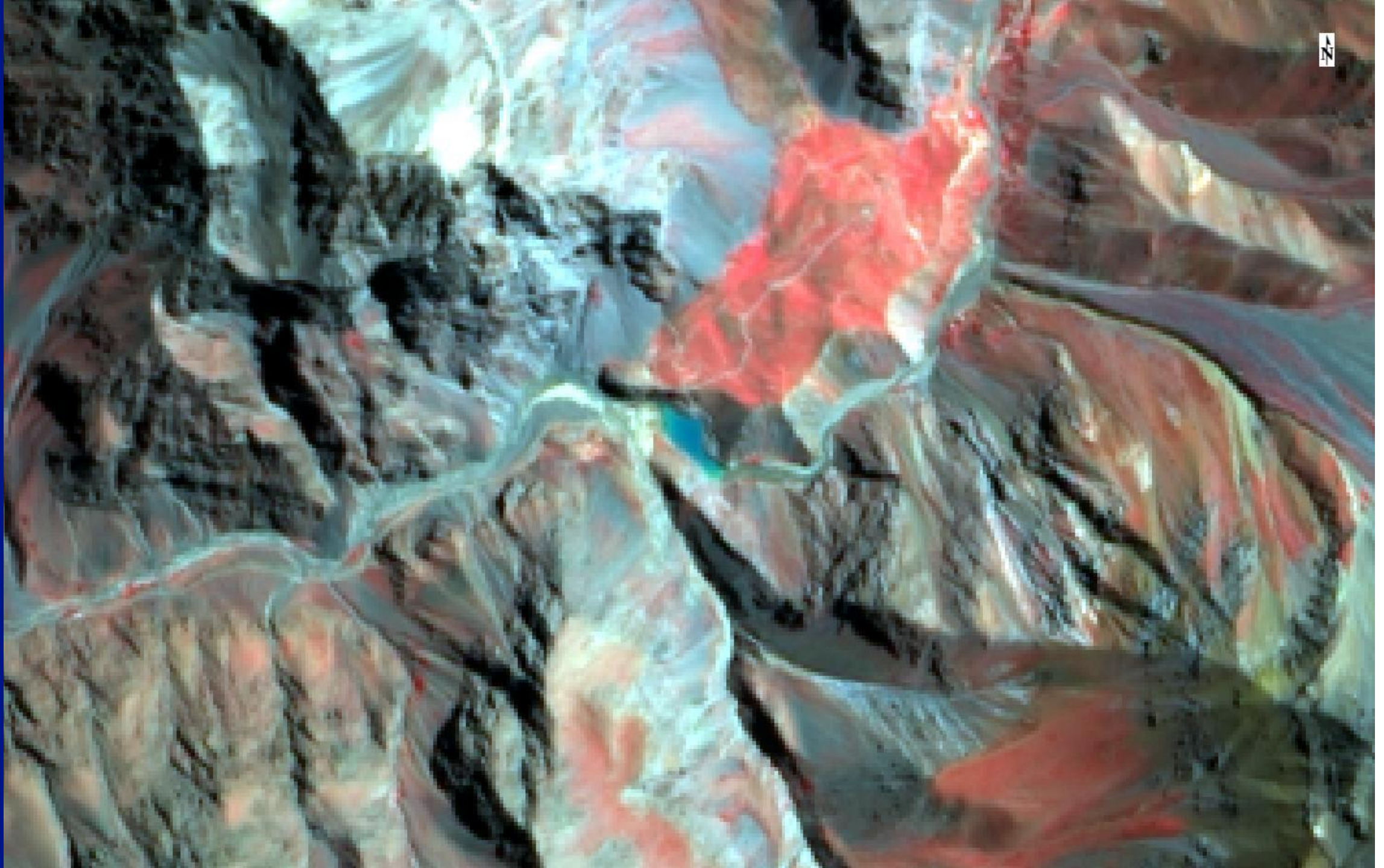


**Estero Las Vacas. SERNAGEOMIN (2021)**











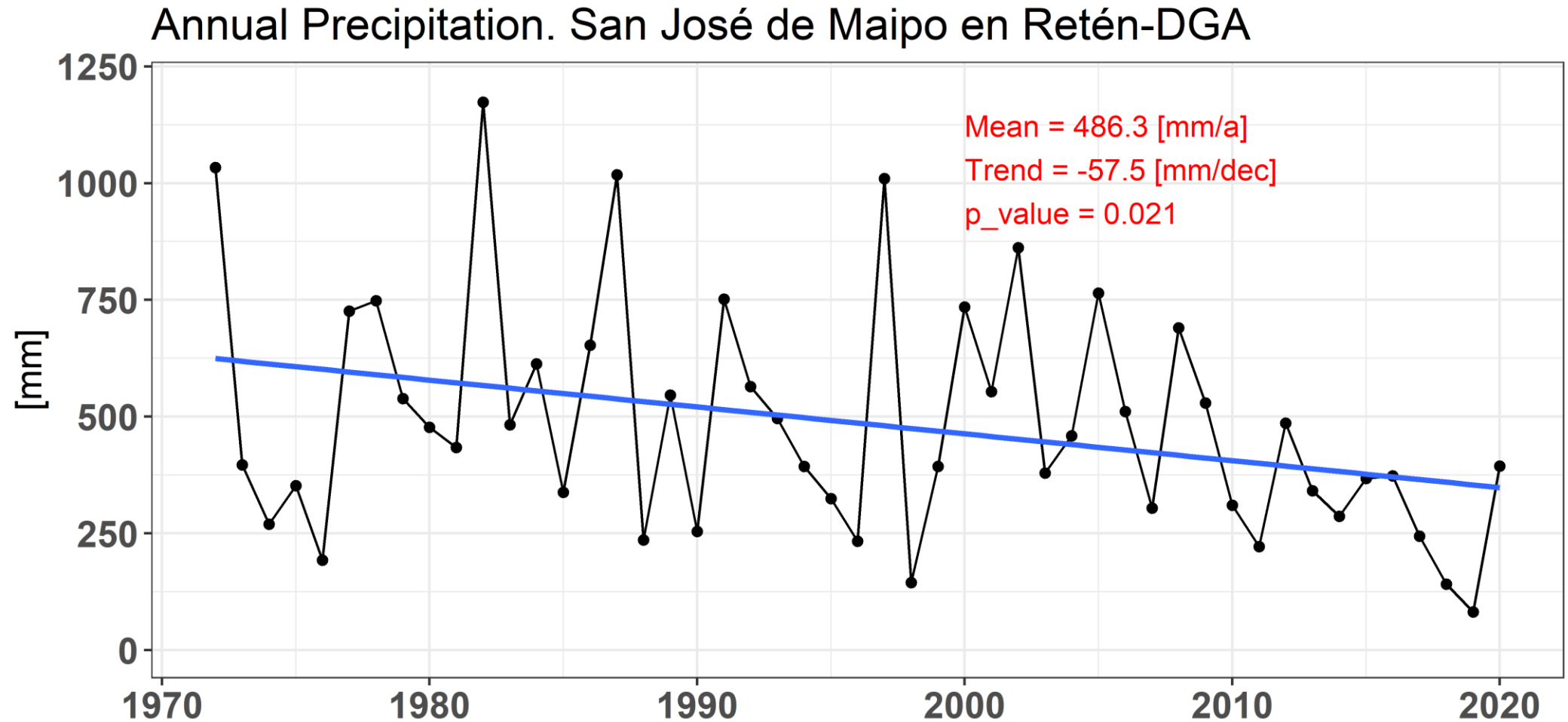
# Final remarks



El Volcán (-33.82/-70.18 ) 1425 m a.s.l. 1<sup>st</sup> May 2021



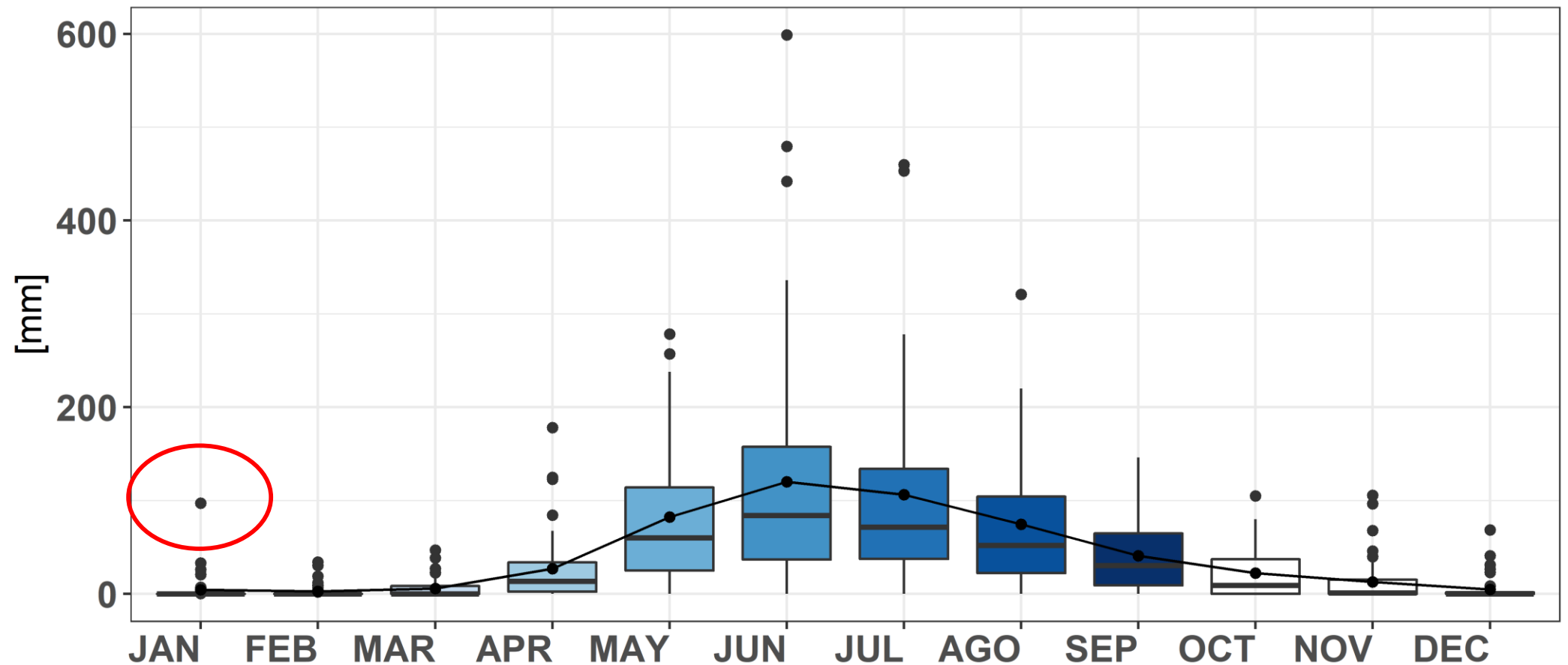
# Precipitation is decreasing





# A regular summer: 1970-2020

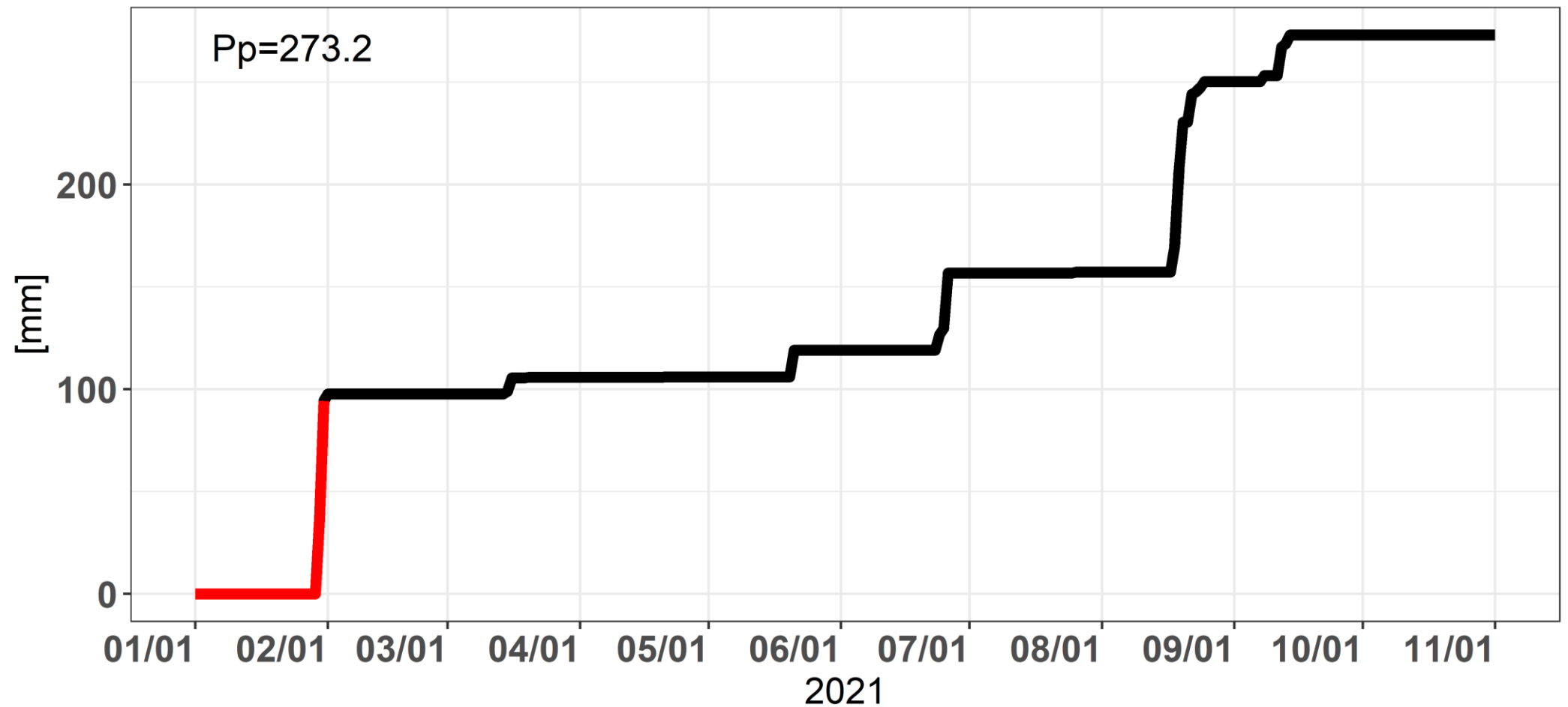
Monthly precipitation. San José de Maipo en Retén-DGA





# A substantial contribution

Accumulative precipitation 2021. San José Guayacán - DMC





# Lessons learned

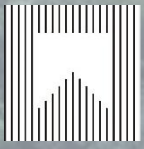
- Accurately forecasted event
- Warning systems do work
- Need to reduce exposure: San José de Maipo, El Melocoton and San Alfonso



# Final remarks

- Do we need more ZARs with less risk involved?
- Did COVID-19 help avoiding any casualties?
- Are we prepared for the next ZAR?





**GEOESTUDIOS**



**fcfm**

**Geología**

FACULTAD DE CIENCIAS  
FÍSICAS Y MATEMÁTICAS  
UNIVERSIDAD DE CHILE

**The January 2021 Zonal Atmospheric River  
in central Chile:  
A non-fatal disaster**

**AGU** FALL  
MEETING