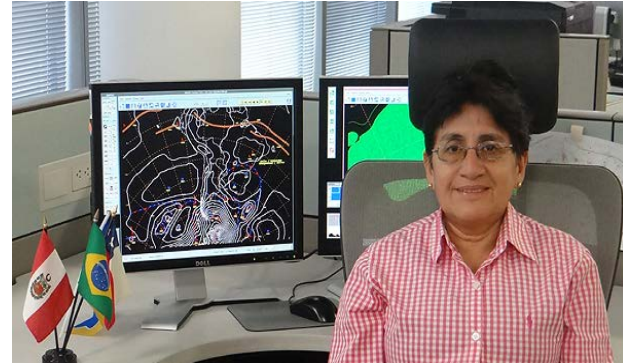


# Heavy rains and mudslides in the Central Andes of Peru: March 23, 2015

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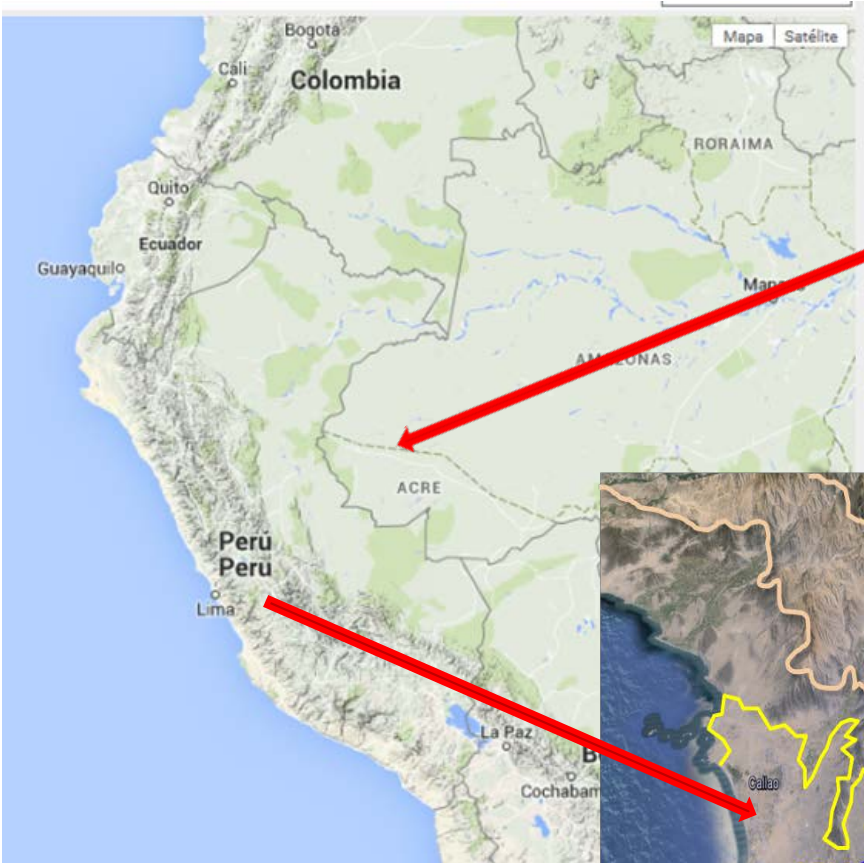
South American Desk - April 2015

# Heavy rains and mudslides in the Central Andes of Peru during March 23 2015.

## Objective

Identify a synoptic model and key meteorological parameters associated with the heavy rains in the Central Andes of Peru during March 22 and 23 2015, which triggered several mudslides.

# Geographic location



**Cobertura vegetal**

**Suelo SIN cobertura vegetal, óptimo para aluviones**

**Cobertura vegetal invernal:lomas**

**Planicie costera**

# 1.- Introduction

Unusually heavy rains occurred in the Central Andes of Peru during the 22-23 of March 2015. These rains lead to several mudslides that lead to 8 dead, 6 missing, 25 injured and 250 families affected/displaced half-hour away from Lima.

Mudslides In the Andean Region:

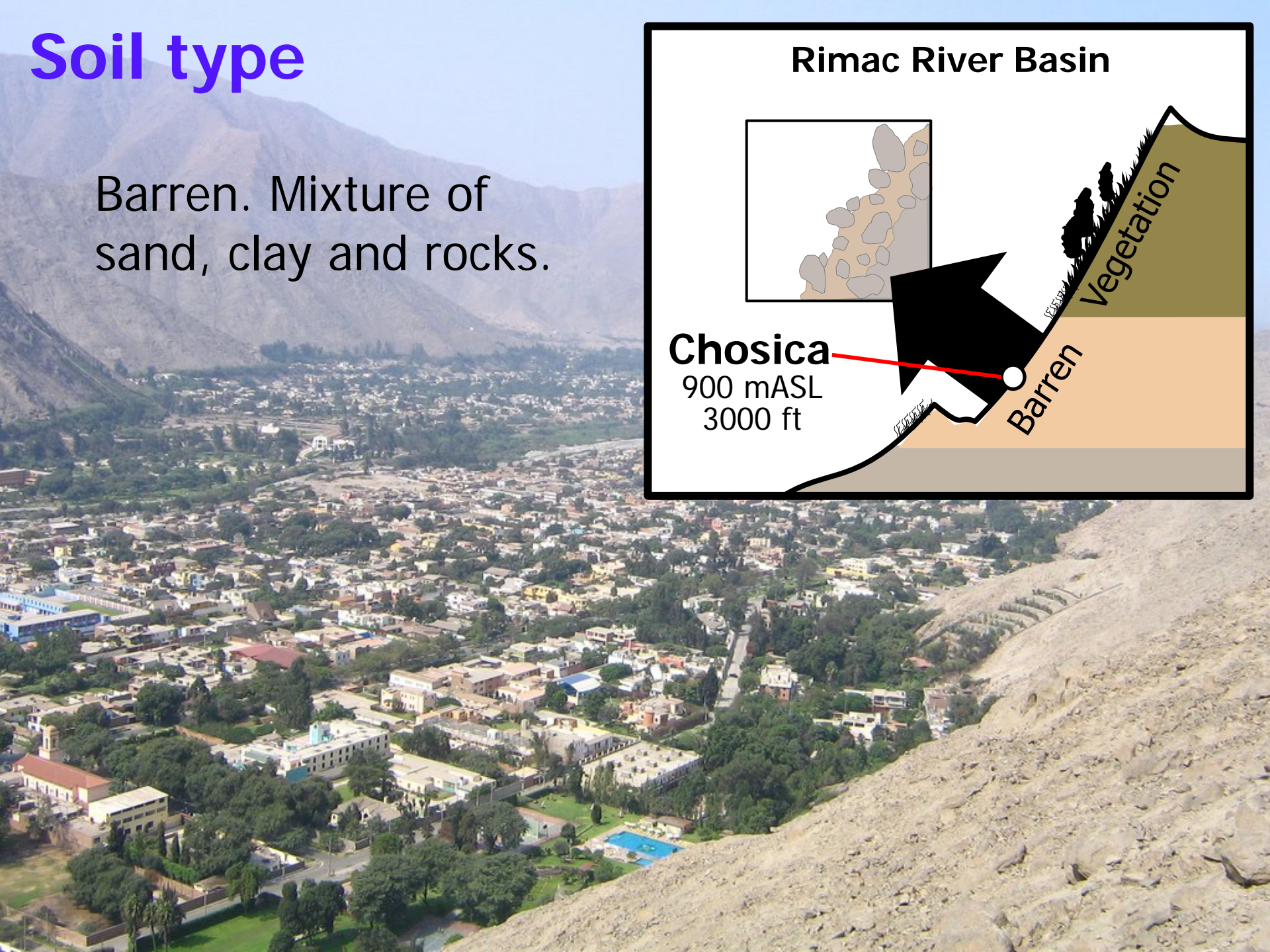
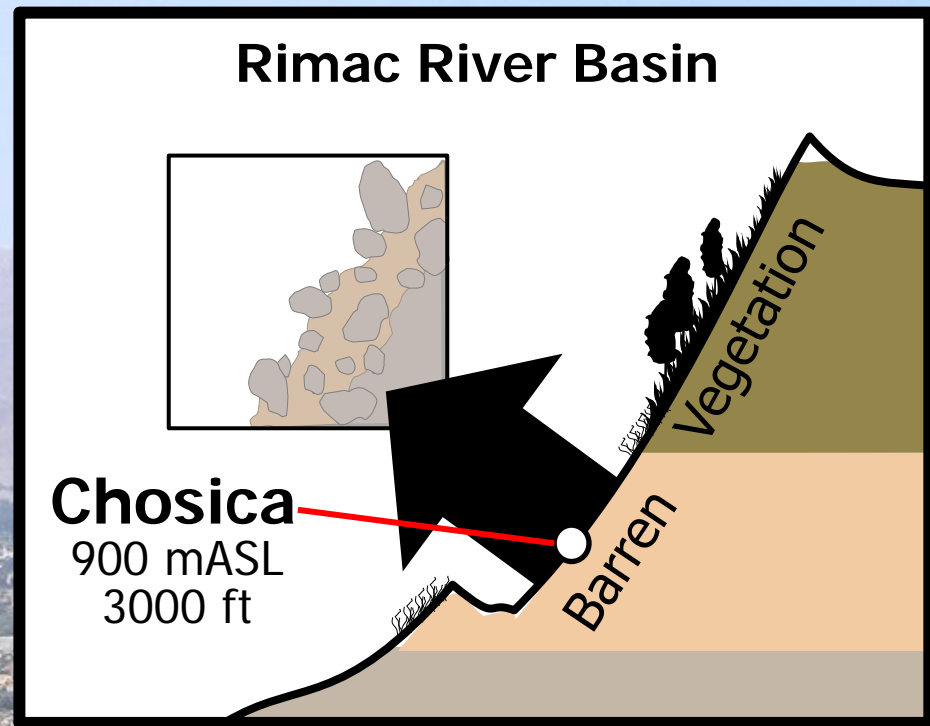
**Huayco ó huaico** comes from the quechua “**wayqu**”, which means creek.

A huayco is a violent flood where a large amount of material from the slopes is collected and transported by water down the creek into the valleys.



# Soil type

Barren. Mixture of sand, clay and rocks.



# Mudslides in Chosica (population 170 000 hab) Afternoon of March 23, 2015



# Warning Communication Process

**Weather Service warns “Civil Defense” (Emergency Management)**

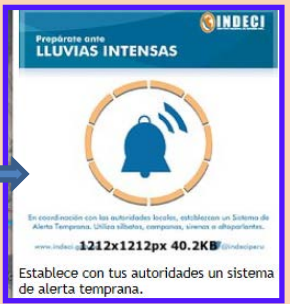


**March 20, 2015  
3 days in advance**

**SENAMHI informs that the rains over the western slopes of the Andes will continue, being the most intense over the Lima region. Furthermore, isolated hailstorms and strong winds are expected in areas over 3500m (~11500ft)**



**Civil Defense warns majors**



**Majors warn population**





## 2.- Materials

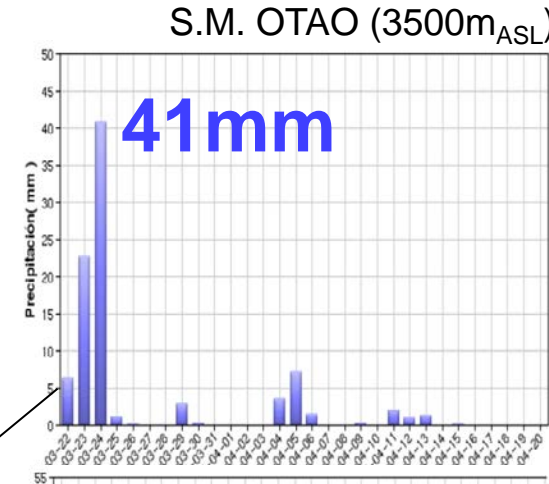
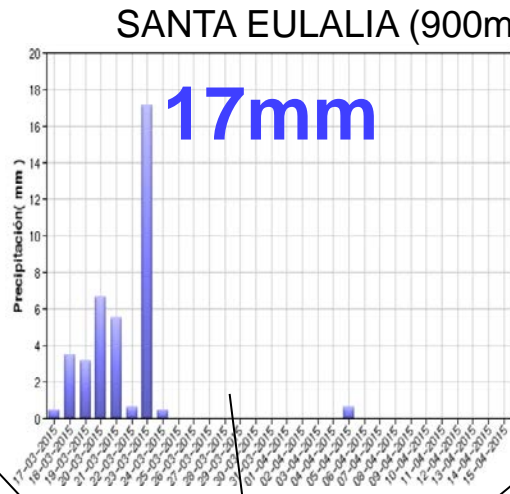
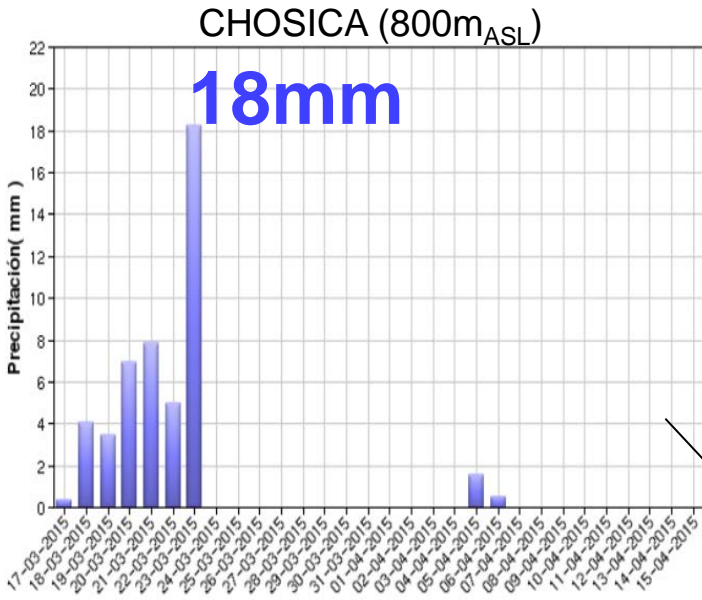
- GFS Data March 18-23, 2015
- Satellite Imagery (CPTEC, RAMSDIS)
- Weather station data from Peru (Weather Service or Servicio Nacional de Meteorología e Hidrología – SENAMHI).
- Wingrids

## 3.- Variable Analysis (Forecast Funnel Method)

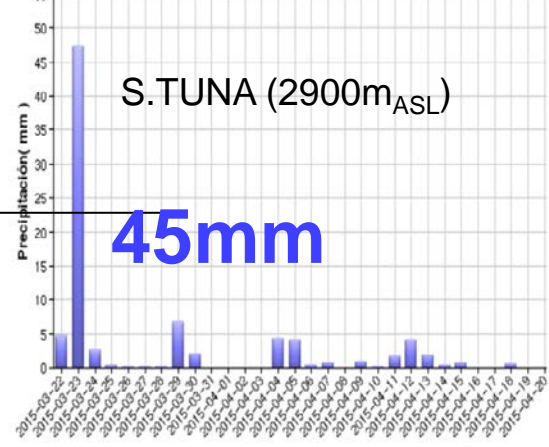
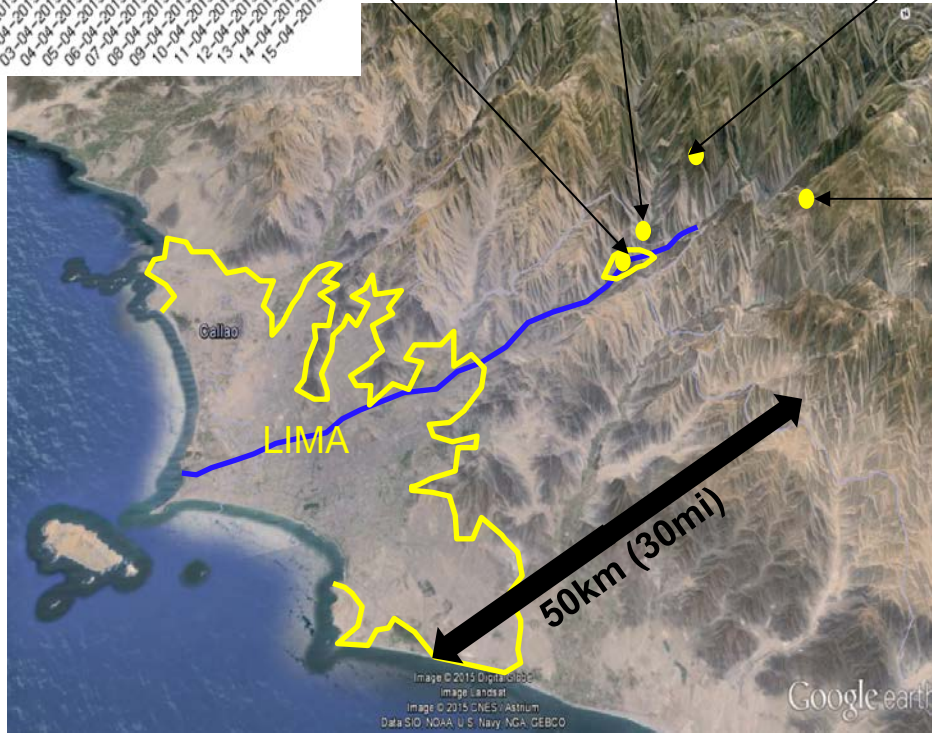
- Low-level convergence (CB)
- Upper level divergence (UD)
- Humidity: PWAT ,  $r$ , HR, SSTs (indirectly)
- Stability: GDI, K
- Trigger: ciclo diurno (breeze convergence)

# 4.- Results

# 24-hr Rainfall March 23 Ending Mar 24 7am LST

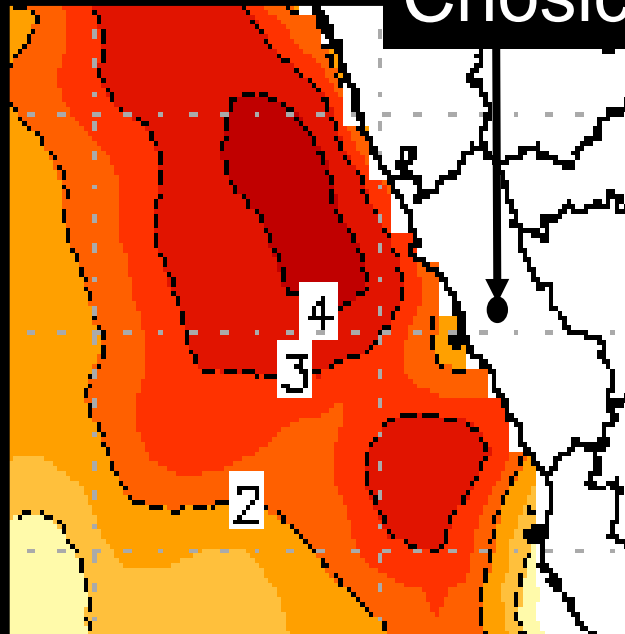


**46mm/5 days**  
**Climatology:**  
**~60mm/yr**

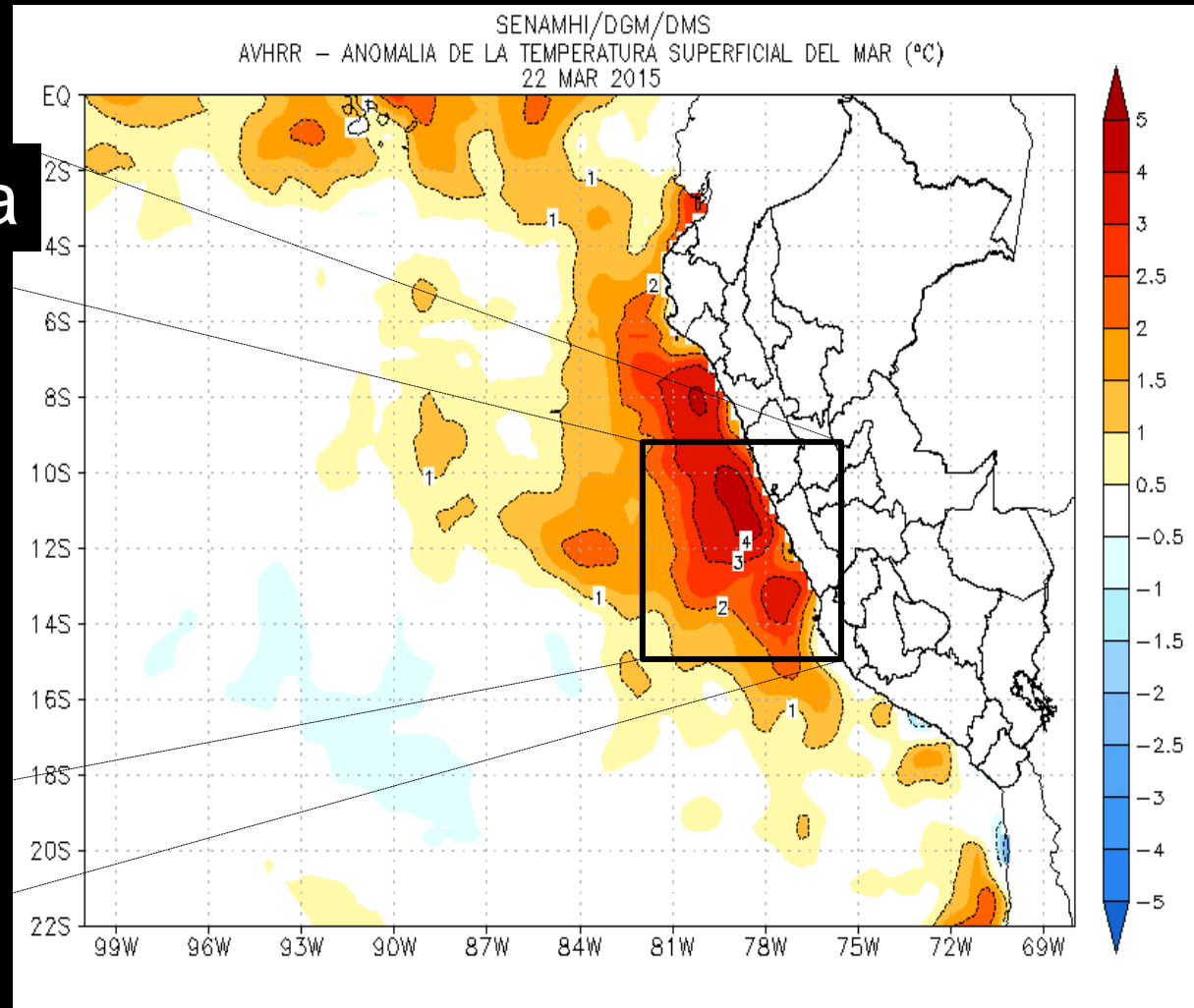


**Heaviest rains**  
**14-21 LST**

# Sea Surface Temperature warming



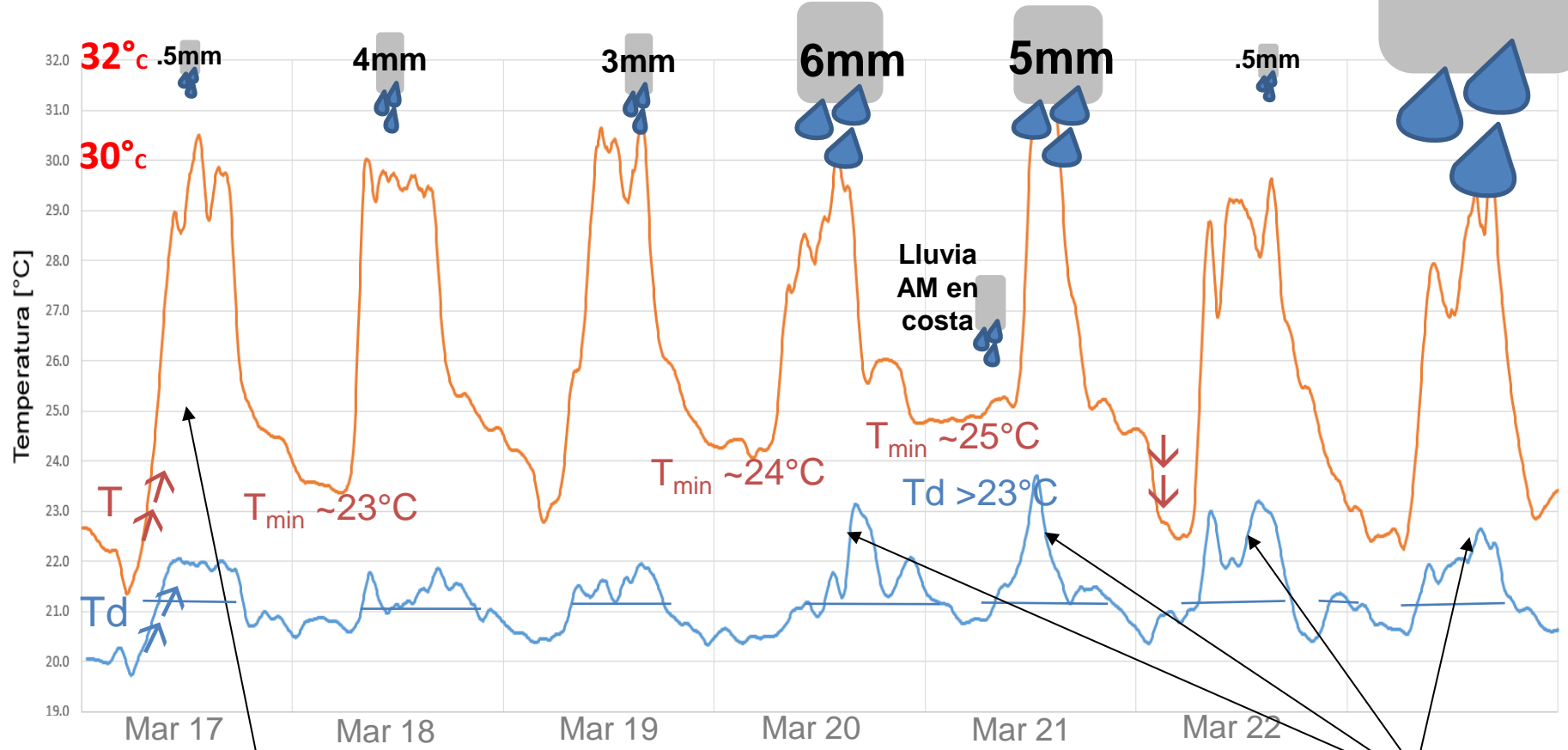
Chosica



# High temperatures and dewpoints in Lima and increased rainfall in Chosica

Temperatura y rocío en Miraflores, Lima, Peru durante la Ola de Calor del 17-24 de Marzo de 2015

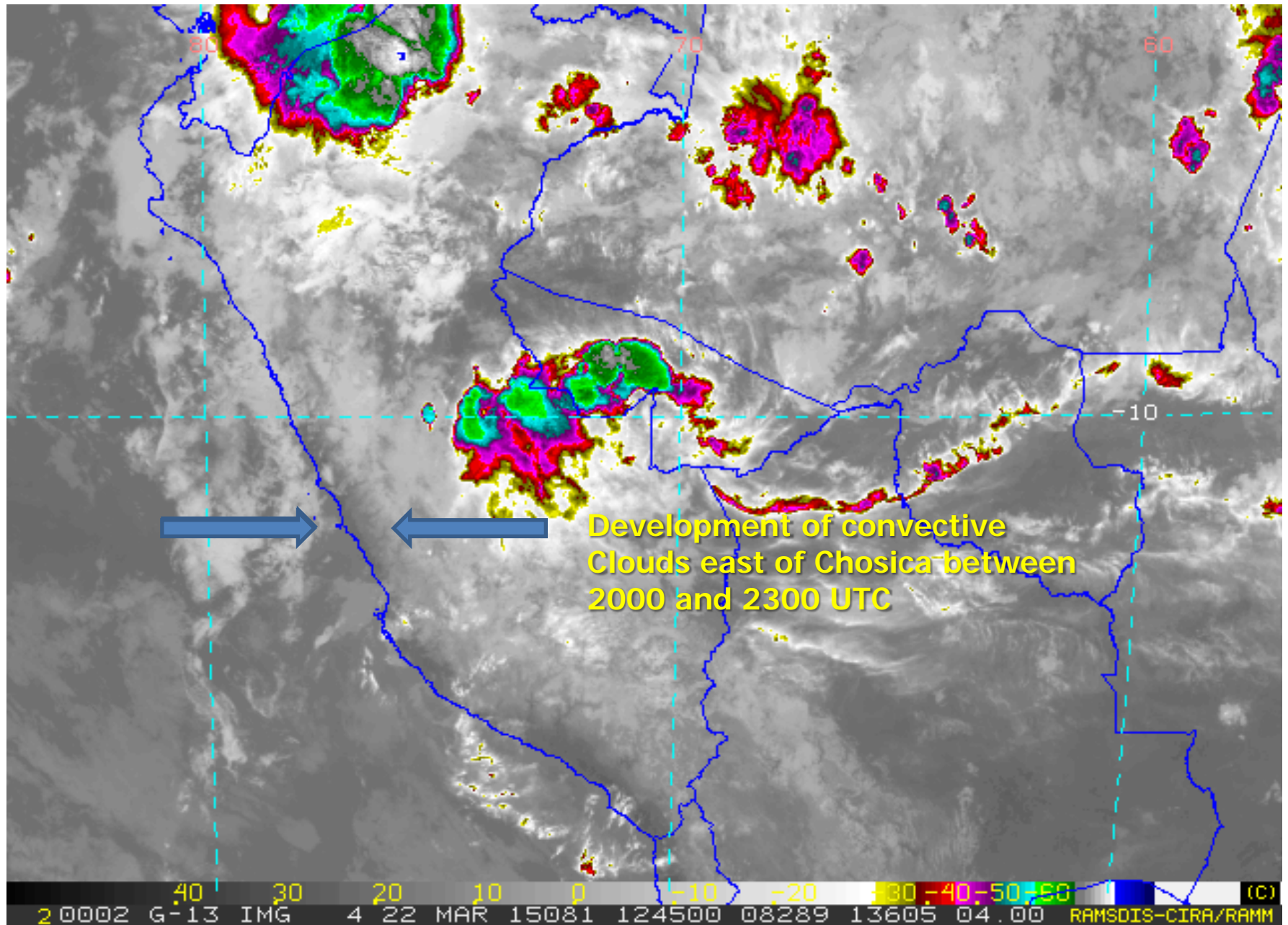
Lluvias en Chosica  
**18mm**



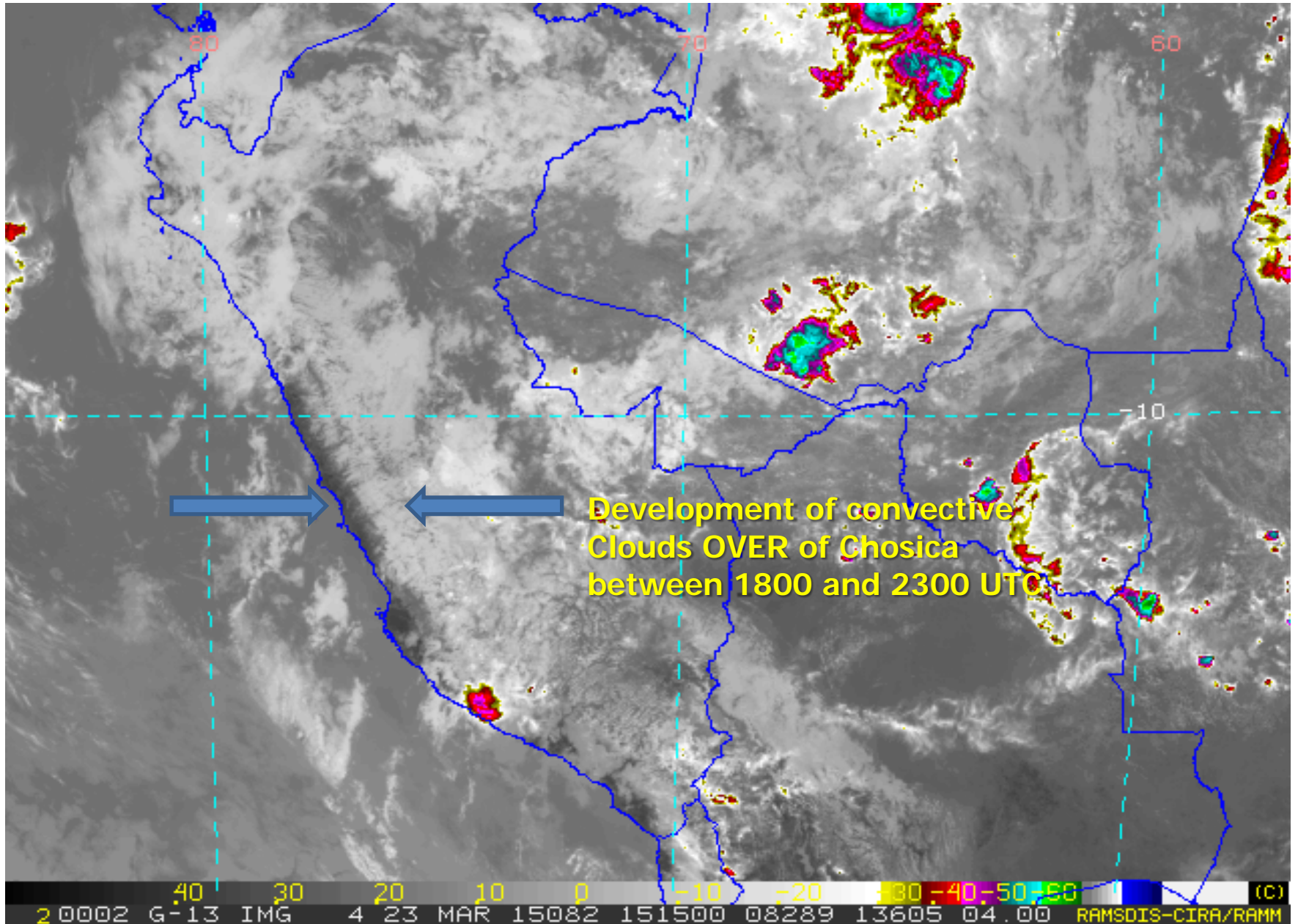
**Inicio de la ola de calor**

**Td > 22**

# IR4 Satellite March 22, 2015



# IR4 Satellite March 23, 2015



# Low-level convergence migrated towards the coast (west) during rainy days

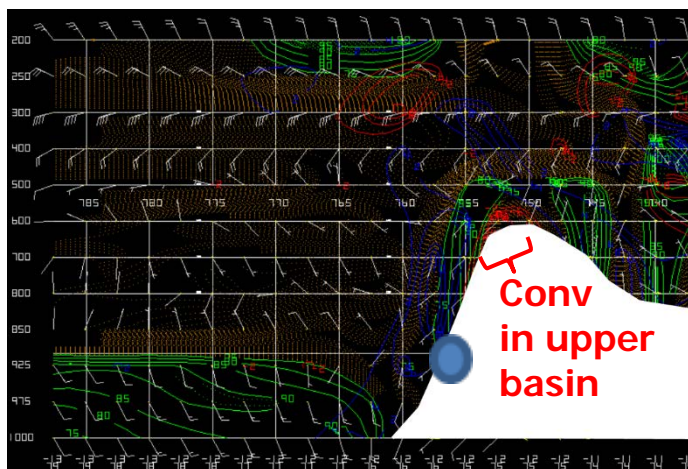
Section: XSCT -14 82 -11 74.5						
	Corrida 1deg	Corrida .25deg	Corrida .25deg	Corrida .25deg	Corrida .25deg	
Analisis de Convergencia Nivel Bajo 1pm	Mar1800	Mar1800z	Mar1900z	Mar2000z	Mar2100z	
18-mar	-5	-16				-16.00
19-mar	-5	-12	-16			-14.00
20-mar	-3	-16	-15	-16		-15.67
21-mar	-4	-16	-12	-12	-12	-13.00
22-mar	-3	-24	-12	-20	-25	-20.25
23-mar		-16	-12	-16	-16	-15.00
24-mar			16	12		-14.00
				-8		-8.00
Posicion del eje de convergencia						
18-mar		-76.3				-76.30
19-mar		-76.4	-76.25			-76.33
20-mar		-76.4	-76.4	-76.3		-76.37
21-mar		-76.5	-76.4	-76.3	-76.4	-76.40
22-mar		-76.5	-76.45	-76.5	-76.5	-76.49
23-mar		-76.4	-76.45	-76.4	-76.45	-76.43
24-mar			-76.4	-76.3		-76.35
Profundidad				-76.25		-76.25



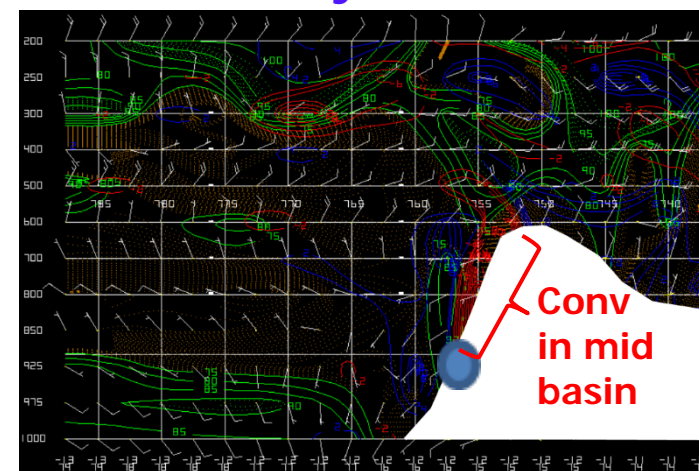
Normal

Rainy Period

March 30  
18 UTC  
(Example)



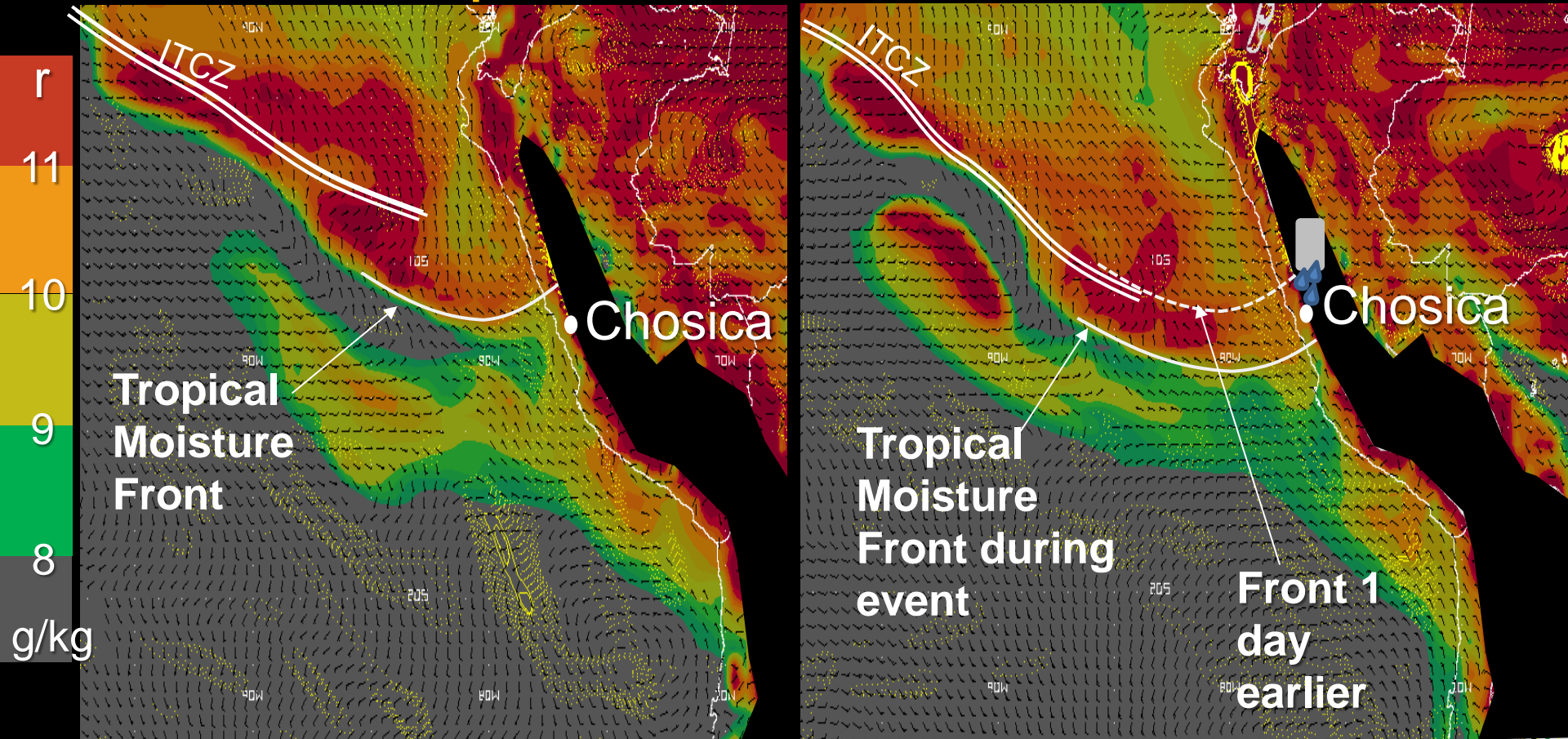
March 22  
18 UTC



# Mixing ratio and winds (700-850 hPa layer)

Mar 22 7pm LST

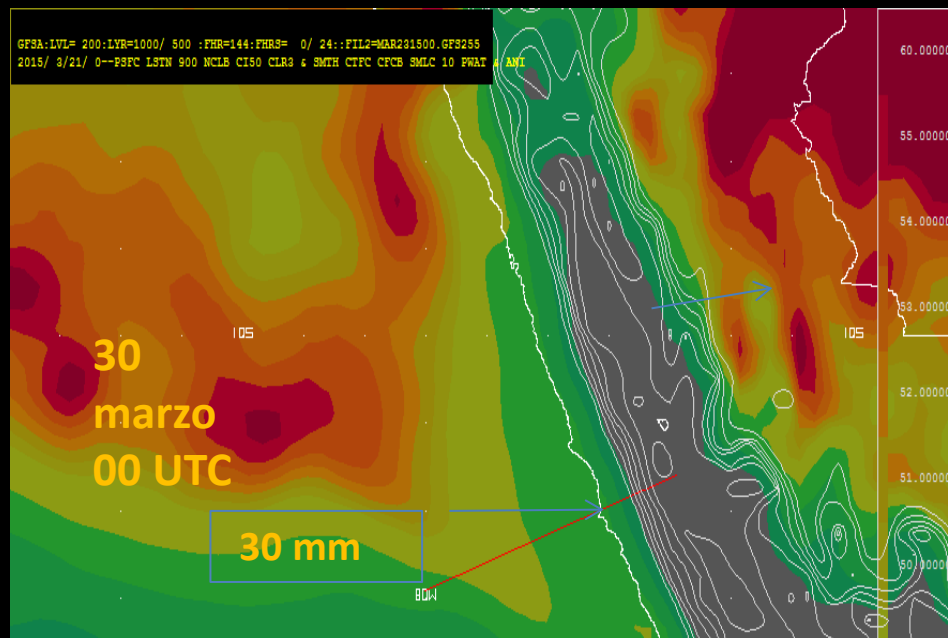
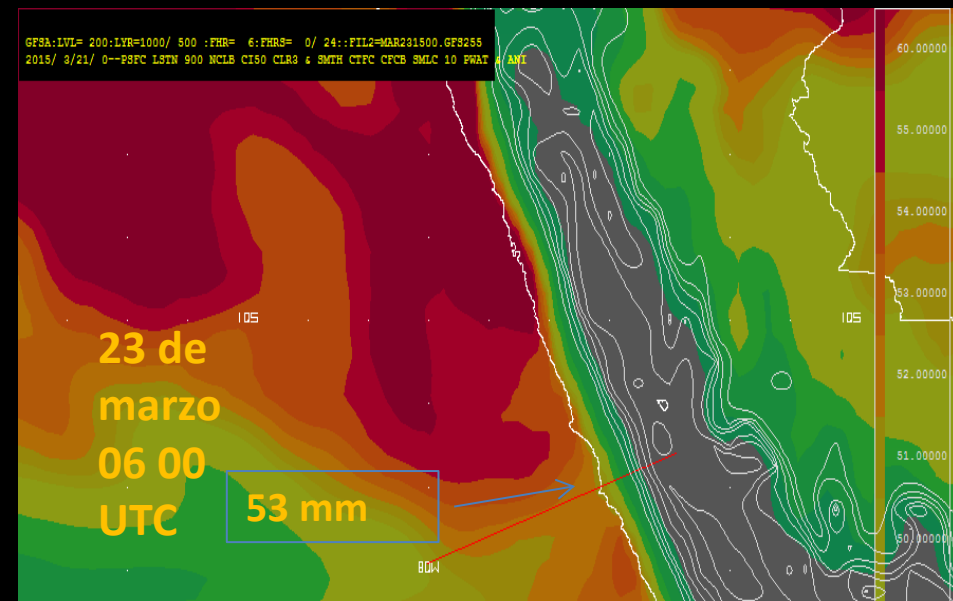
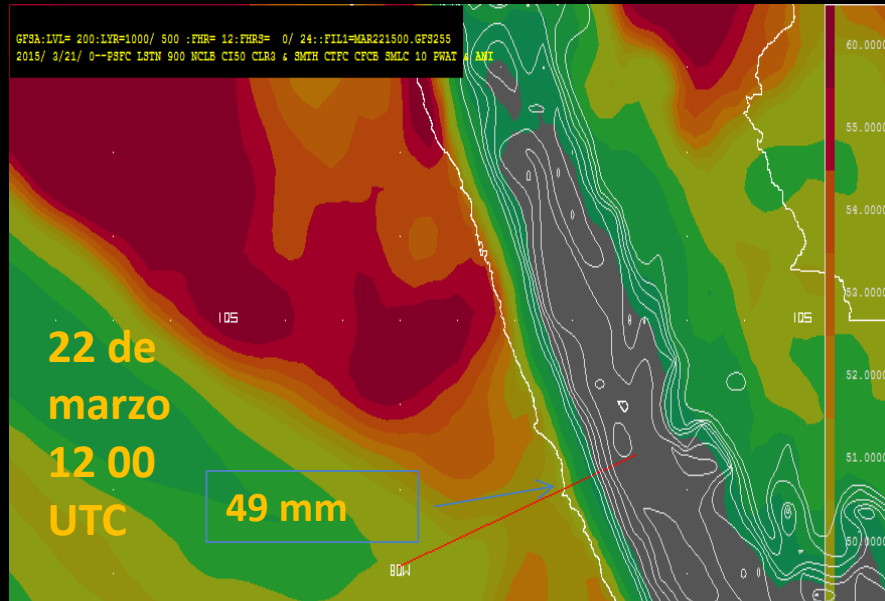
Mar 23 7pm LST



Tropical moisture front, well defined in the 700-850 hPa layer was the essential contribution to the heavy rains in Chosica. The front passed around 7am LST, 10 hours before the event.

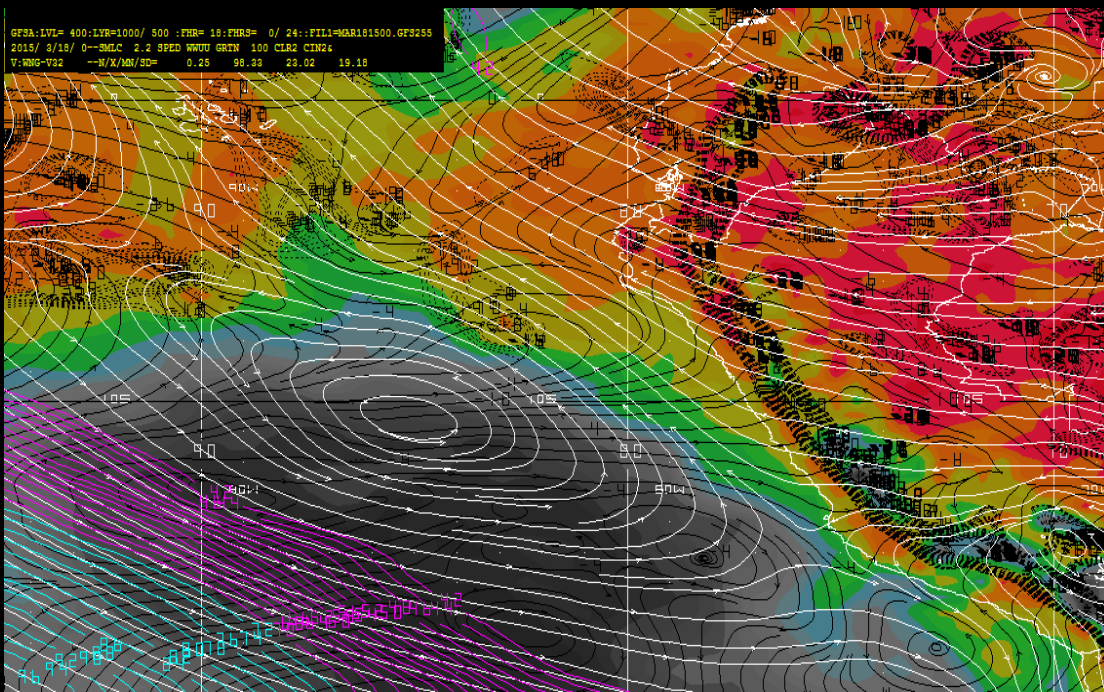


# PWAT 22 y 23 de marzo



**Normal**

# GDI (Galvez-Davison Stability Index)



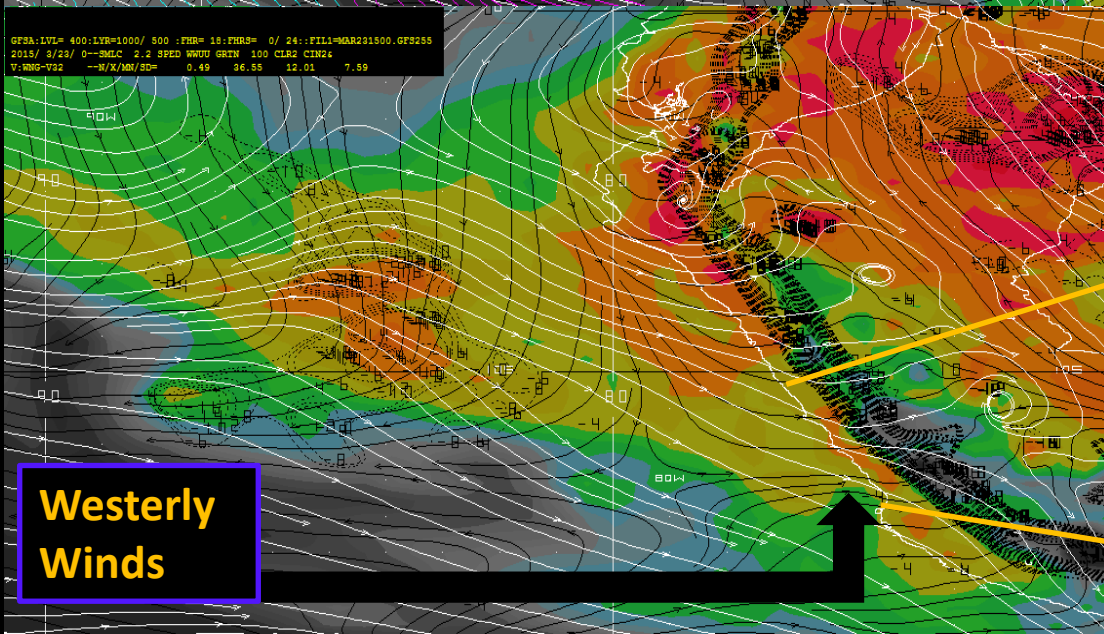
**March 18th, 18 00 UTC**

**EVENT ONSET**

Lineas Blancas : flujo del viento 400 - 250 hPa.

Lineas Negras : flujo del viento 1000 - 850 hPa.

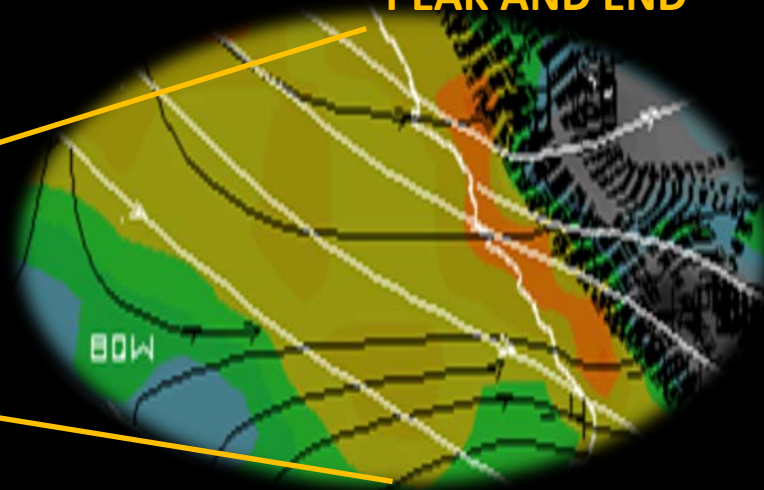
Coloración del amarillo al rojo (inestabilidad) : GDI.



**March 23rd, 18 00 UTC**

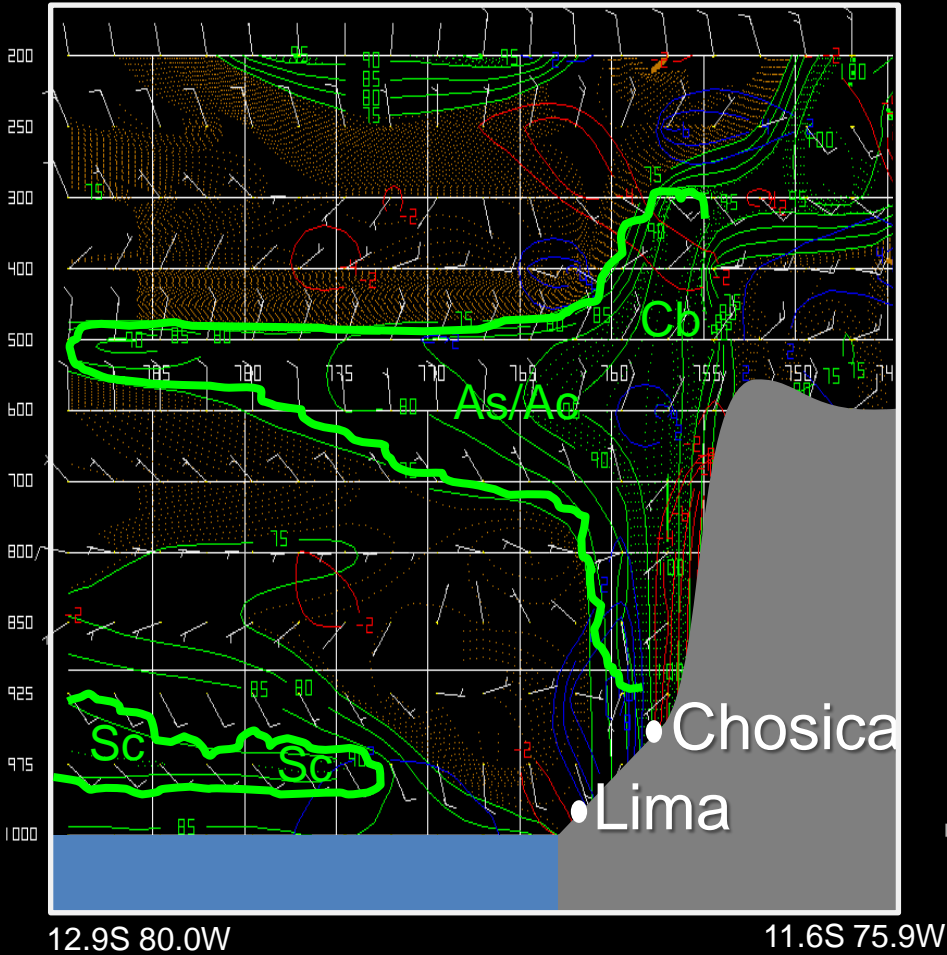
**PEAK AND END**

**Westerly Winds**

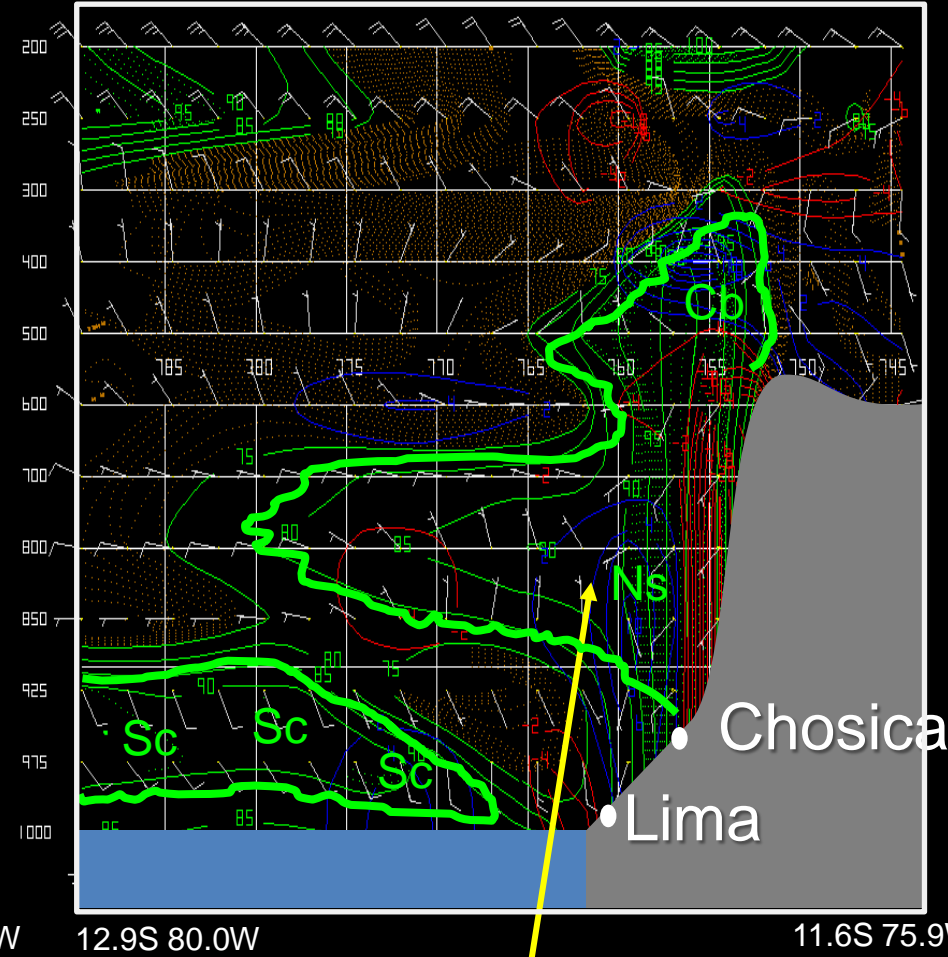


# Increase in 800 hPa Relative Humidity in 24hrs

Mar 22, 19LST



Mar 23, 19LST



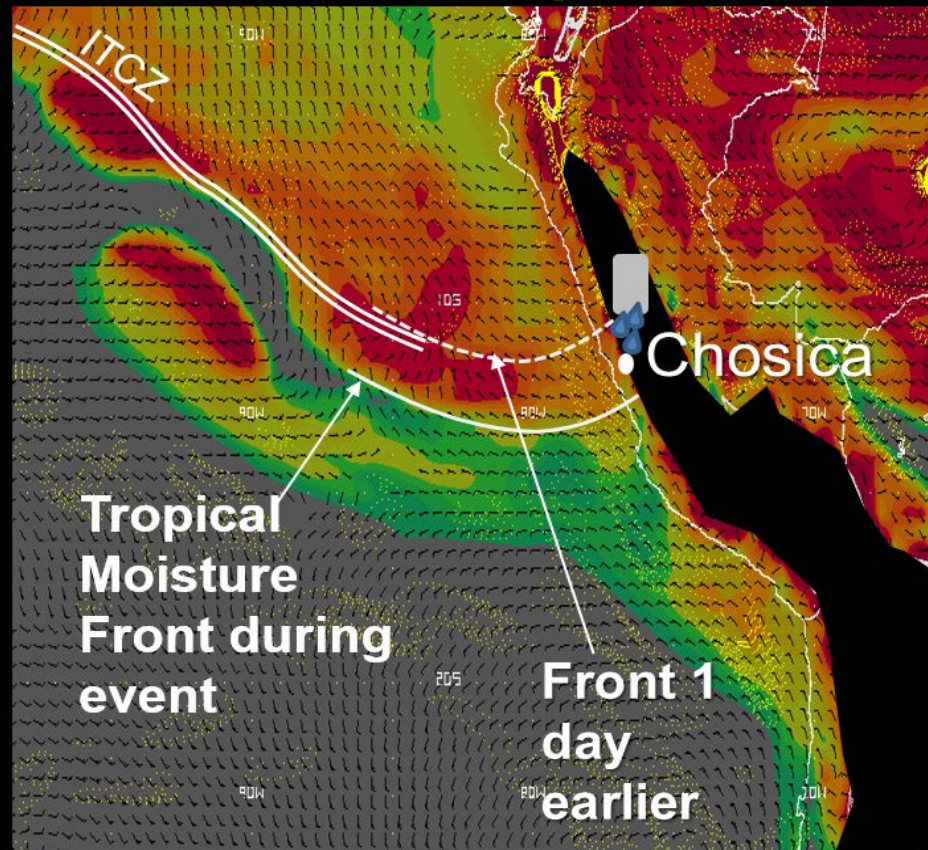
Increase in RH at cloud layer

# Conclusions

- The tropical moisture front in the 700-850 hPa layer was the main predictor in the generation of heavy rains in the Chosica region. The front passed at 7am LST of March 23<sup>rd</sup> 2015, 10 hours before the event.

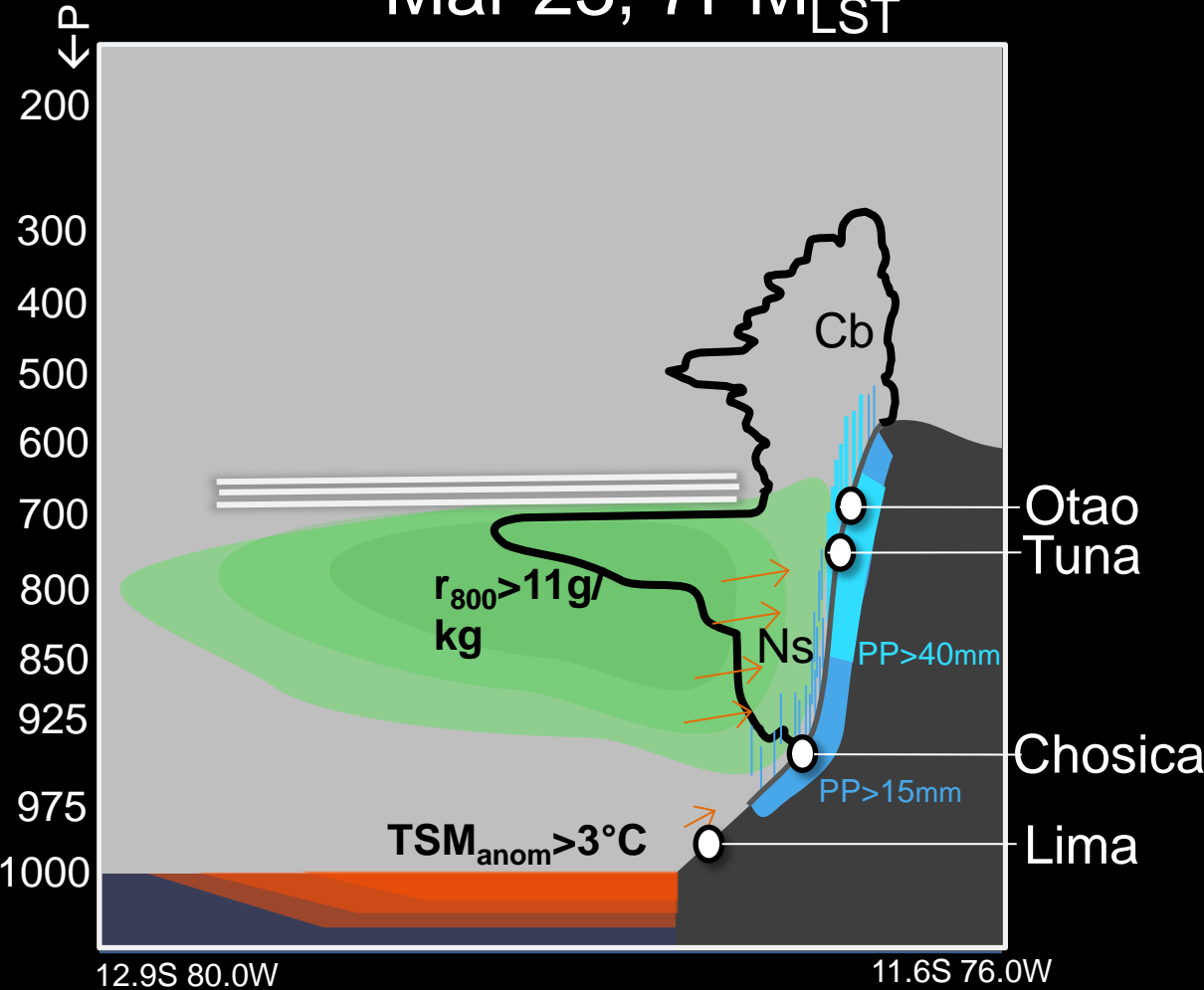
## Mixing ratio and wind in the 700-850 hPa layer

Mar 23 7pm LST



# Relevant factors

Mar 23, 7PM<sub>LST</sub>



Warm ocean generates warm, moist and unstable air mass over the coast and western slopes

**TSM<sub>anom</sub> >3°C**

Moisture front: advection of moist air mass from the NNW with peak at 800 hPa

**r<sub>800</sub> > 11g/kg**

Weak (<10kt) wind regime over coast/slopes favors diurnal breeze and moisture convergence.

Inversion at ~650hPa reduces mixing with dry air aloft and stimulates saturation in/over the BL

Clouds: Ns with isolated embedded Cb

# Role of the Soil

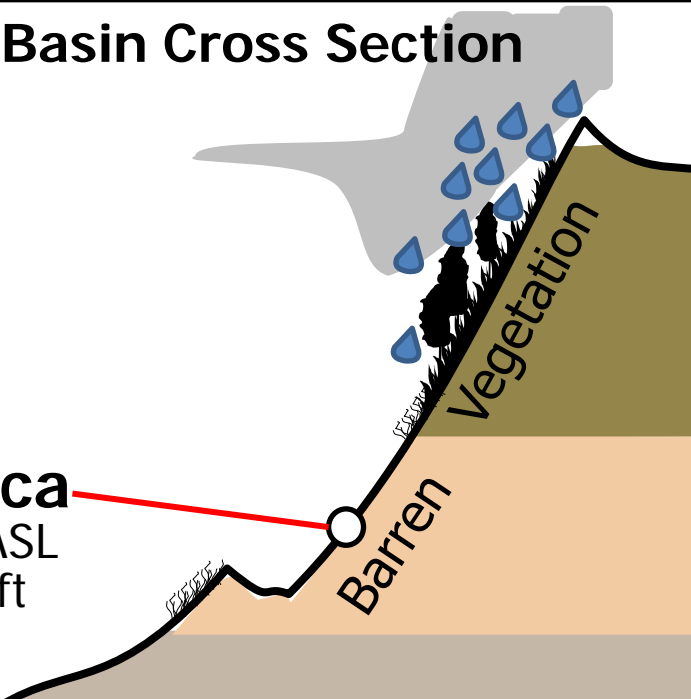
Several days with rain on soil with NO vegetation cover:

- (1) Weakened the soil making it prone to mudslides
- (2) Generated soil moisture, local enhancement of water vapor often absent.

**NORMAL**

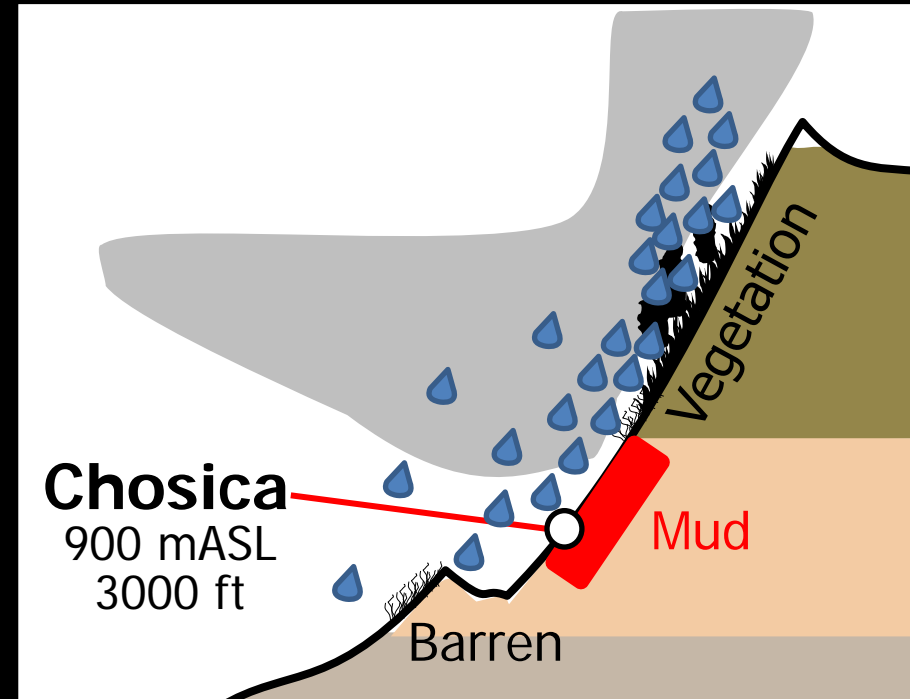
**Rimac Basin Cross Section**

**Chosica**  
900 mASL  
3000 ft



**Mar 23, 2015**

**Chosica**  
900 mASL  
3000 ft



**Muchas Gracias!**

**Thank you!**