SECOND LOW-LATITUDE IONOSPHERIC SENSOR NETWORK WORKSHOP
São José dos Campos - SP Brazil, November 7-10, 2011

Ionosphere Response to the M9 Tohoku Earthquake Revealed by Satellite Observations on South American Stations. Preliminary results.

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Introduction

- Since 1960 there were done numerous observations of acoustic gravity waves in the ionosphere induced by phenomena of the solid Earth, such as earthquakes, explosions in mines and ways, tsunamis (Bolt 1964; Harkrider 1964; Calais et to., 1998). They attribute that the generation of such atmospheric waves are generated in the terrestrial surface with small extent but with big values of wave length.

- The principal reason to have such a coupling solid land - atmosphere, is the exponential decrease of density with the height, it causes an exponential amplification in the atmospheric waves, by the mechanism of conservation of the kinetic energy. In the F layer of the ionosphere (150-600 km from height), the speed of the disturbance is amplified typically in a factor of 10^4 compared by the speed in the surface, and therefore they will be detectable so much in the observations realized in the surface, and the observations realized on board of satellites too (Blanc 1985).

Concerning the physical explanation, two main hypotheses (with some modifications or options) have competed to describe these phenomena. The first of these was the influence of acoustic gravity waves generated in the earthquake zone on the ionosphere, and the second was anomalous vertical electric fields penetrating from the earthquake zone into the ionosphere.

There are a number of publications discussing a possibility for atmospheric gravity waves (AGW) to occur at ionospheric altitudes before earthquakes (see appropriate papers in Hayakawa (1999) and Hayakawa and Molchanov (2002)).

In the paper (Hegai et al., 1997), a possible mechanism has been proposed for the generation of atmospheric gravity waves in the ionosphere before strong earthquakes. According to the proposed mechanism, the AGW generation occurs due to non-stationary Joule heating of a local region of the ionosphere above the epicentral zone of an imminent earthquake. As a primary source of the Joule heating we have adopted a perturbation of the vertical atmospheric electrostatic field on the Earth`s surface in the epicentral zone of forthcoming earthquake.

JAPAN
Earthquake as of March 11, 2011

Scale: 1:3,000,000

Location Diagrams

Interpretation

General information:

- 8.8 Magnitude earthquake hits north-east Japan followed by a series of powerful aftershocks
- Epicentre (38.23°N, 142.53°E): 250 miles (400km) from the capital at a depth of 20 miles (32km)
- Tremor occurred at 14:46 local time (05:46 GMT)
- Most affected prefectures: Miyagi, Fukushima, Iwate
- Massive surge of debris-filled water sweeping away buildings, cars and ships and reaching far inland
- Fires in several areas including Tokyo
- Nuclear power plants, trains, refineries, Narita airport, transport network in Tokyo shut down

Cartographic Information

0 50 100 150 200 250 Kilometers

N

Local projection: UTM Zone 54N, Datum: WGS 1984
Geographic projection: Lat/Lon (DMS), Datum: WGS 84
Scale: 1:3,000,000 for DIN A1 prints.

Data Sources

Vector data © ESRI 2005, DLR 2011

Framework

The products elaborated for this Rapid Mapping Activity are realised to the best of our ability, within a very short time frame, optimising the material available.
All geographic information has limitations due to the scale, resolution, date and interpretation of the original source materials. No liability concerning the content or the use thereof is assumed by the producer.

Map produced March 11, 2011 by ZKI
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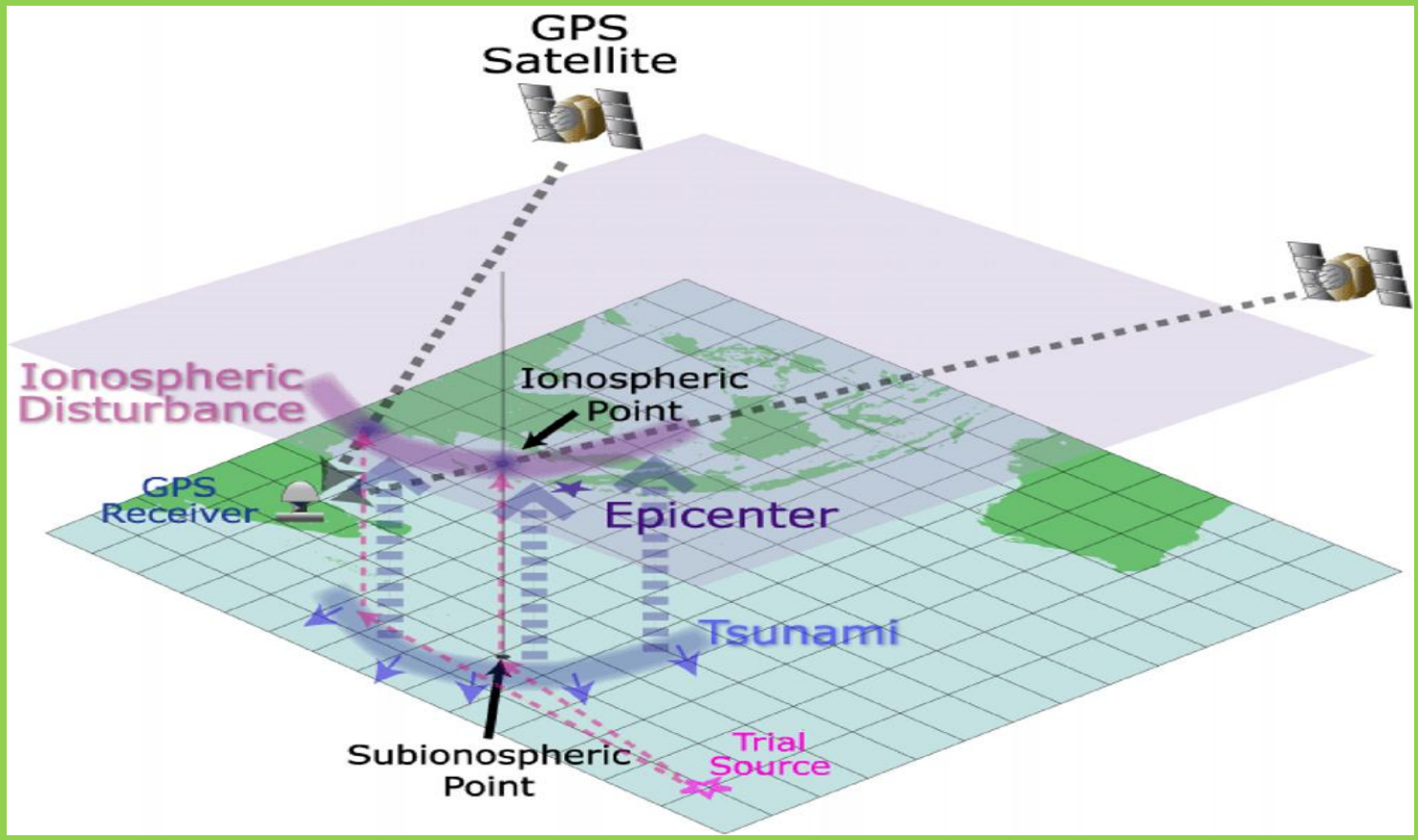
Center for Satellite Based Crisis Information
-- Emergency Mapping & Disaster Monitoring --
a service of DFD

German Remote Sensing Data Center
German Aerospace Center
DLR



- Tsunami
- Acoustic gravity waves
- Ionospheric perturbations
- GPS detect

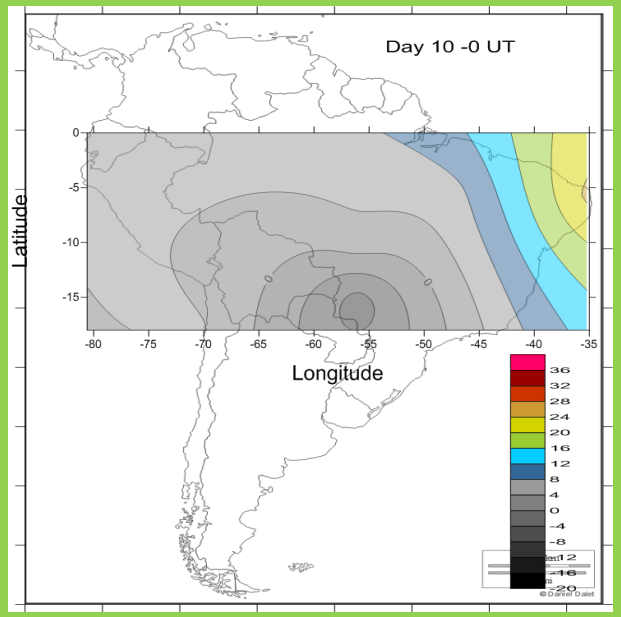
Results

Stations in Longitude

Station	Latitude	Longitude
Alta	-9.8	-56.1
Impe	-5.5	-47.4
Tacna	-18	-70.2
Nata	-5.8	-35.2
Cuib	-15.5	-56
Piura	-5.1	-80.6


Venezuela
San José
Panamá
Panamá
Georgetown
Guyana
Paramaribo
Cayena
Surinam
Guayana Francesa
Bogotá
Colombia
Quito
Ecuador
PIURA
IMPERATRIZ
NATA
Brasil
ALTA FLORESTA
PALMAS
Perú
JIPARANA
Lima
CUIABA
Brasilia
La Paz
TACNA
Bolivia
© 2011 MapLink/Tele Atlas
US Dept of State Geographer
© 2011 Europa Technologies
© 2011 Google
©2010 Google
6°17'46.08" S 57°08'09.85" O elevación 227 m
Alt. ojo 4180.18 km

Day 10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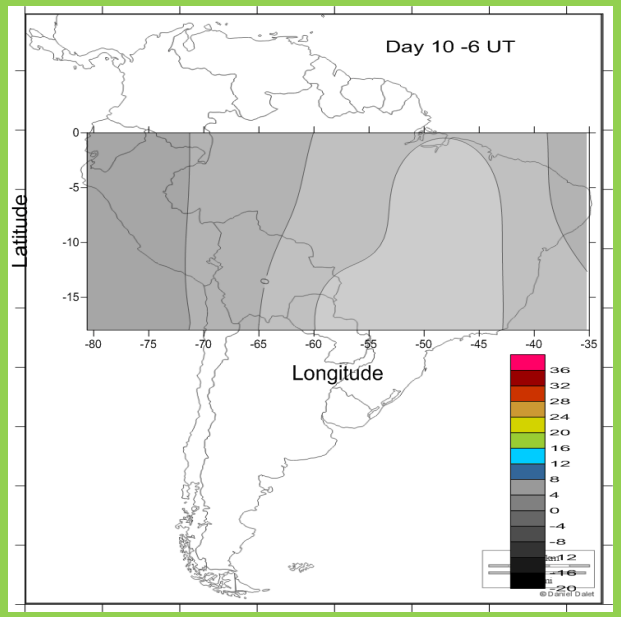
Latitude
Longitude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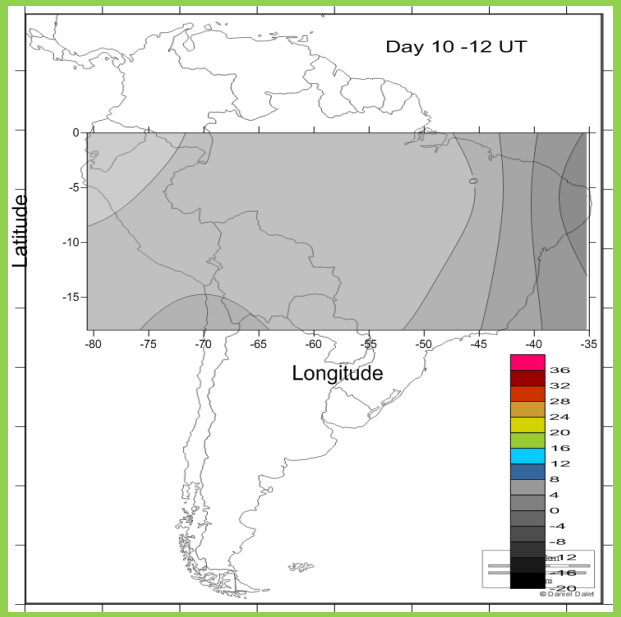
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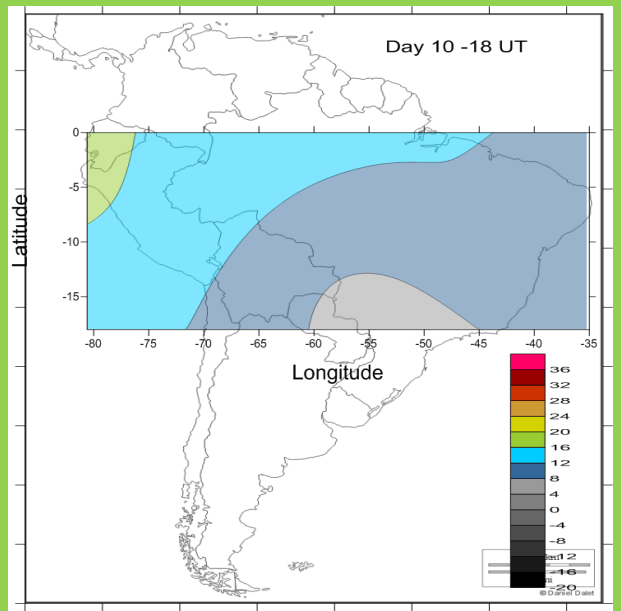
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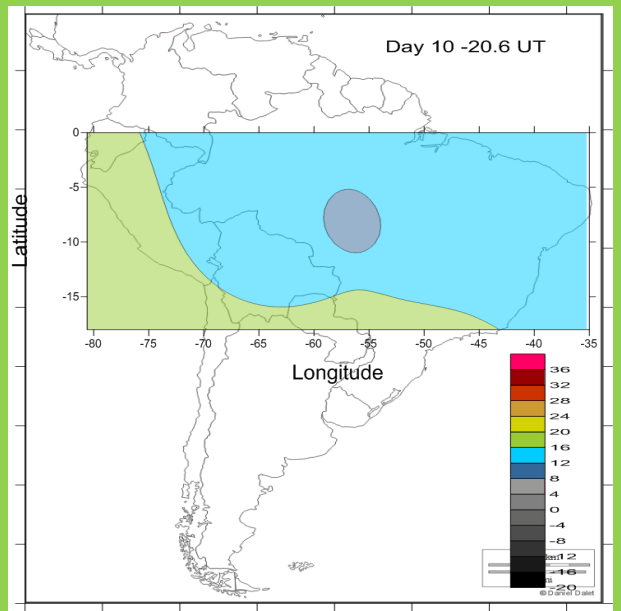
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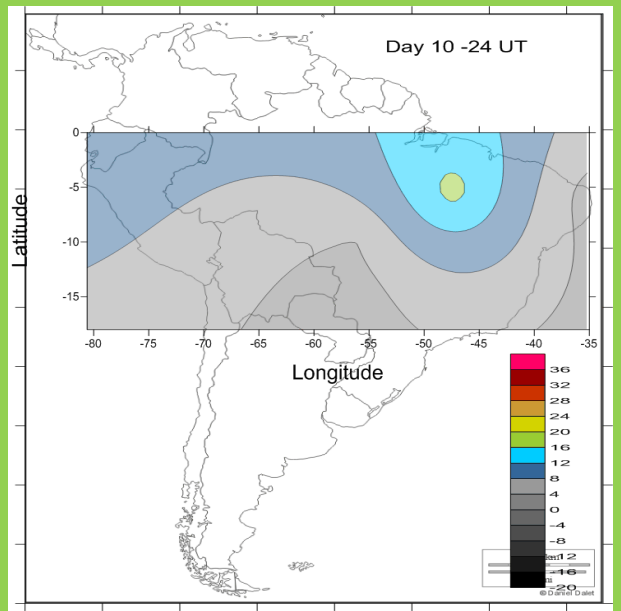
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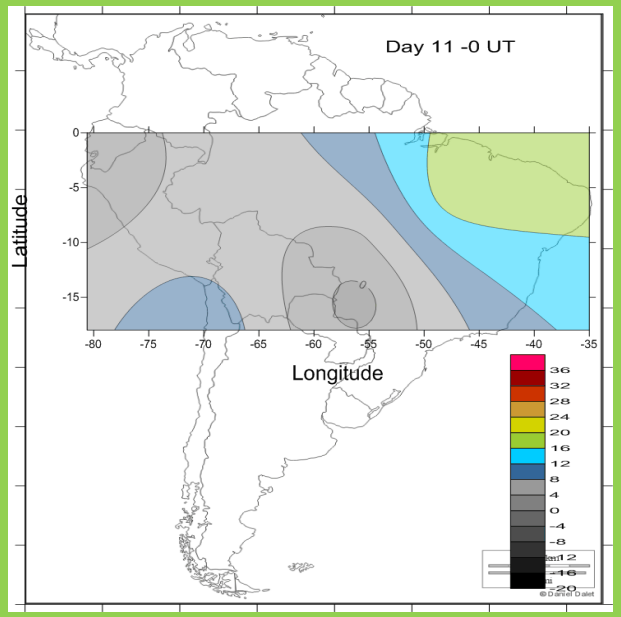
Longitude

Day 11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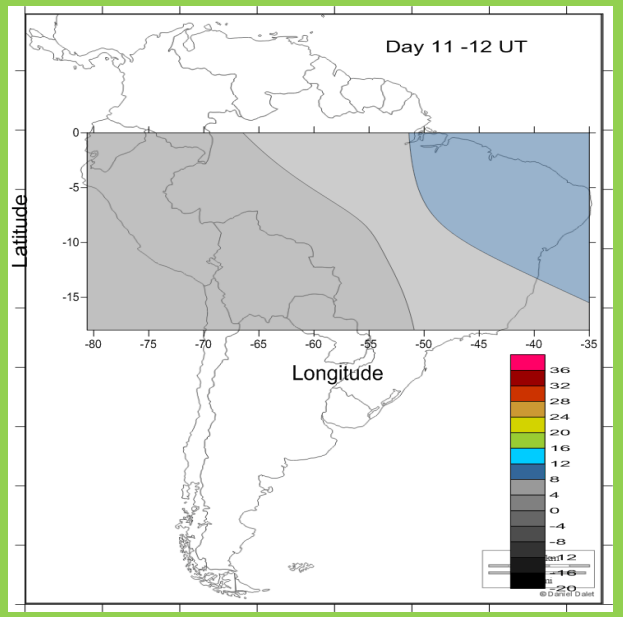
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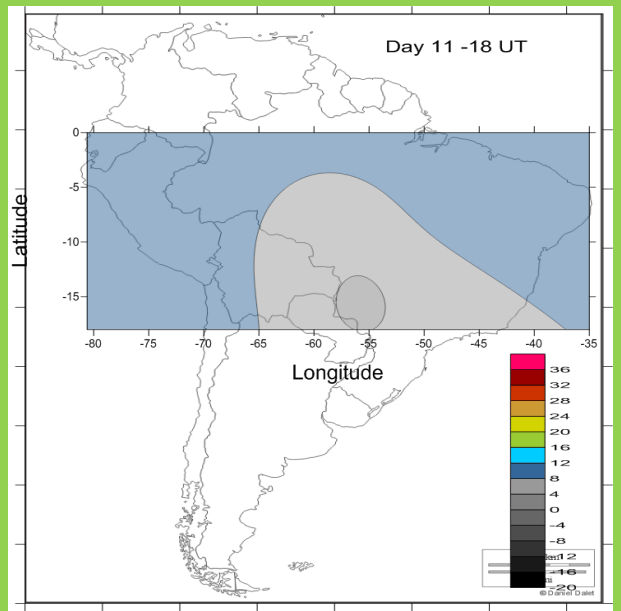
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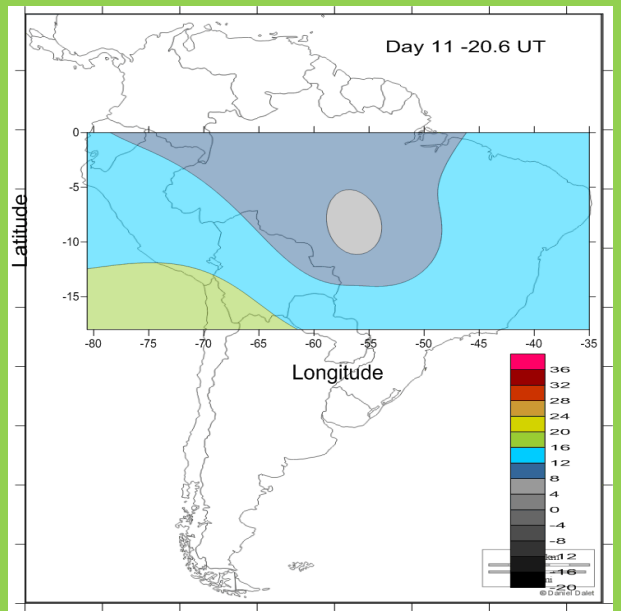
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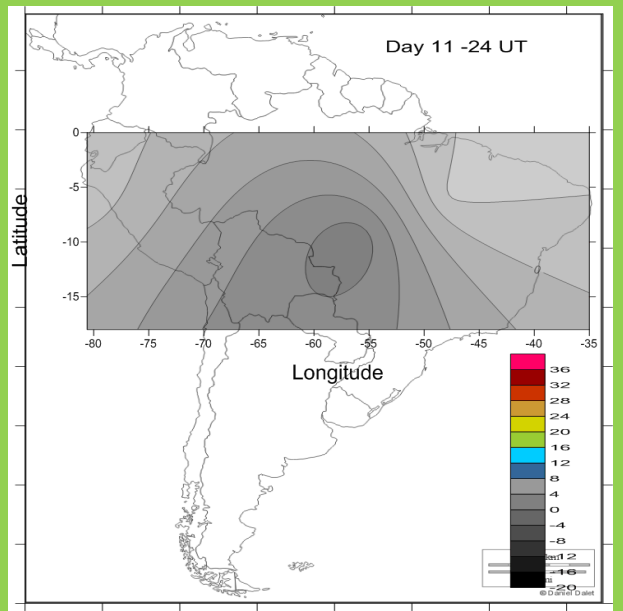
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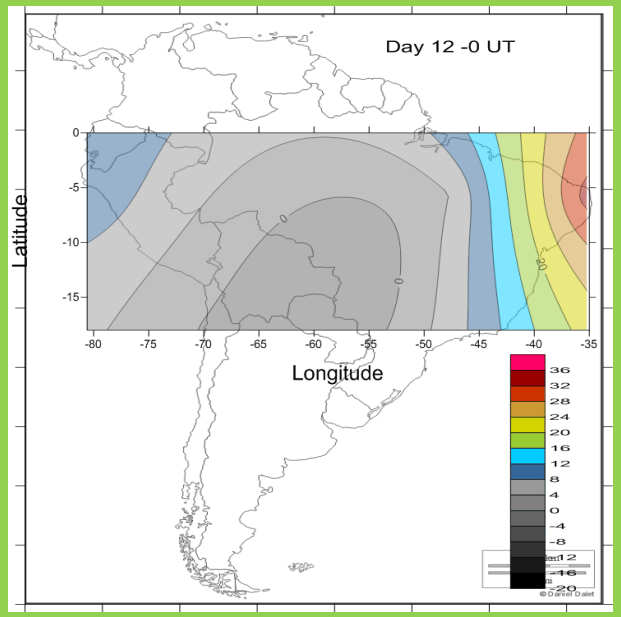
Latitude
Longitude

Day 12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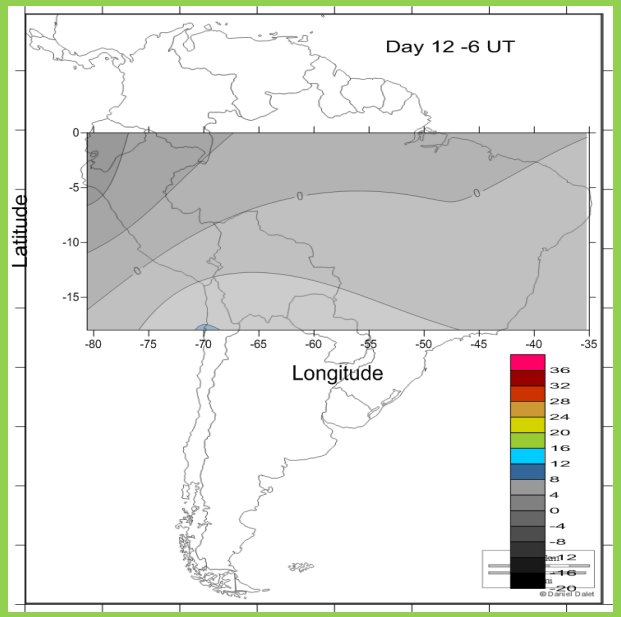
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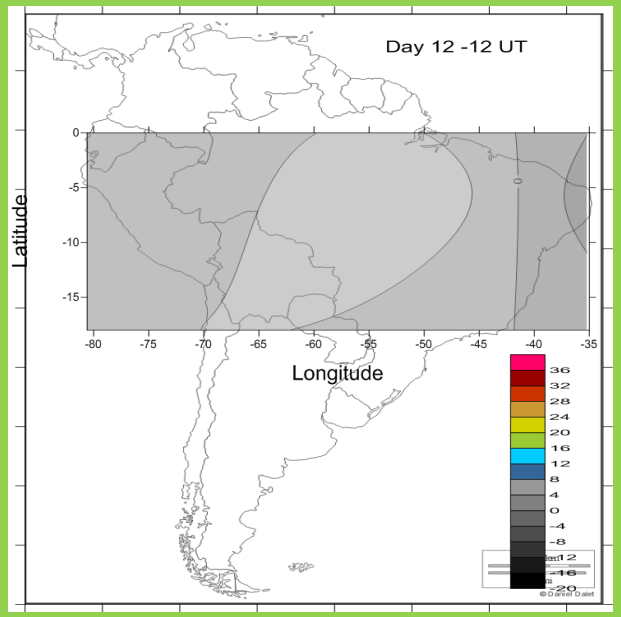
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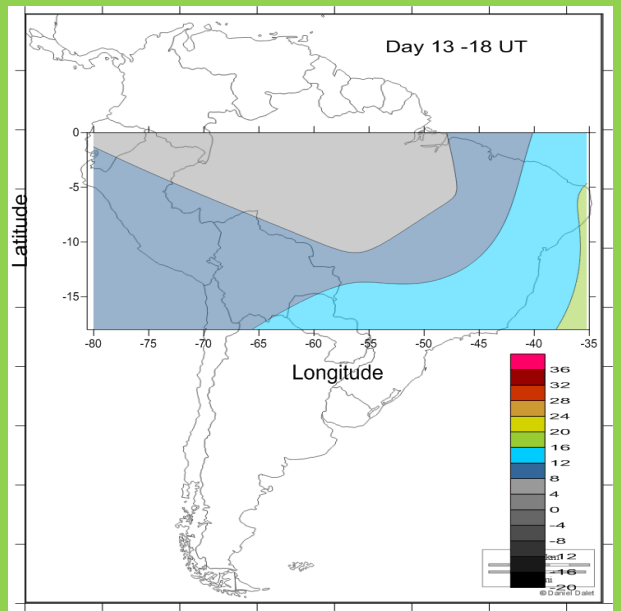
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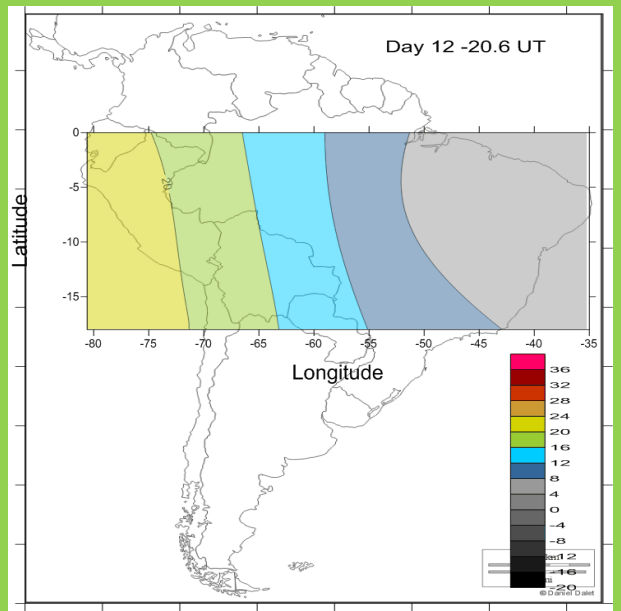
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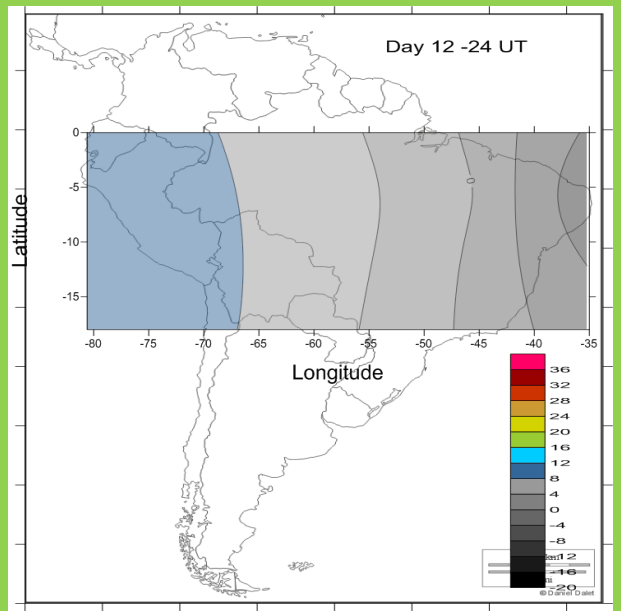
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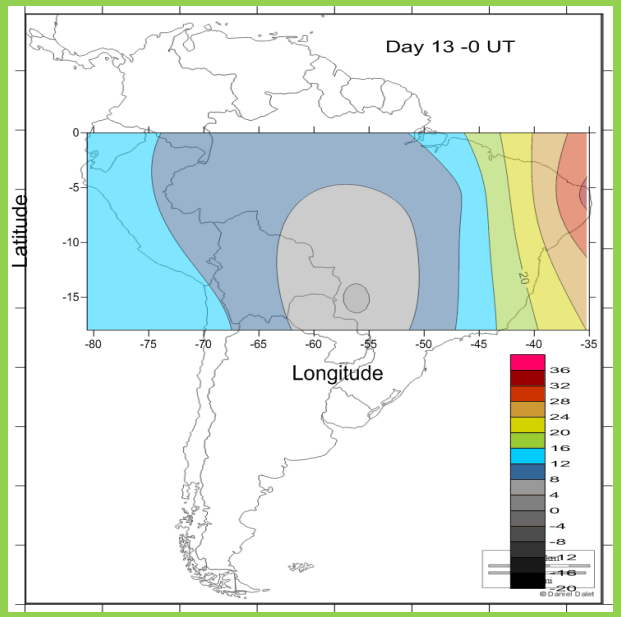
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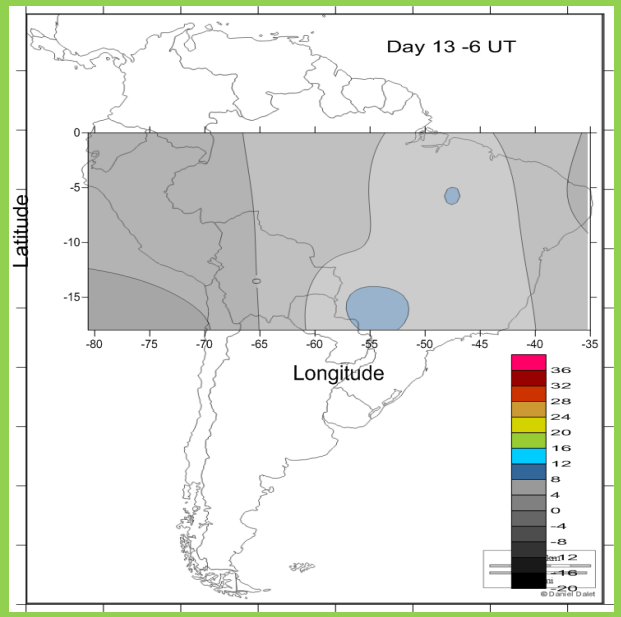
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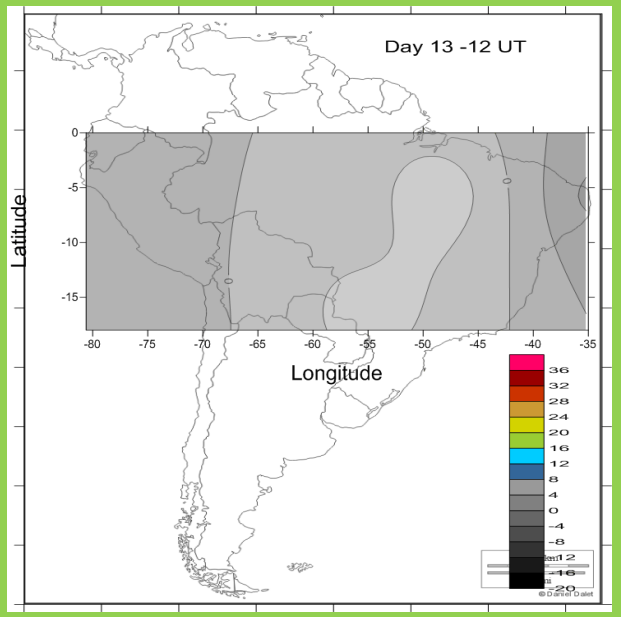
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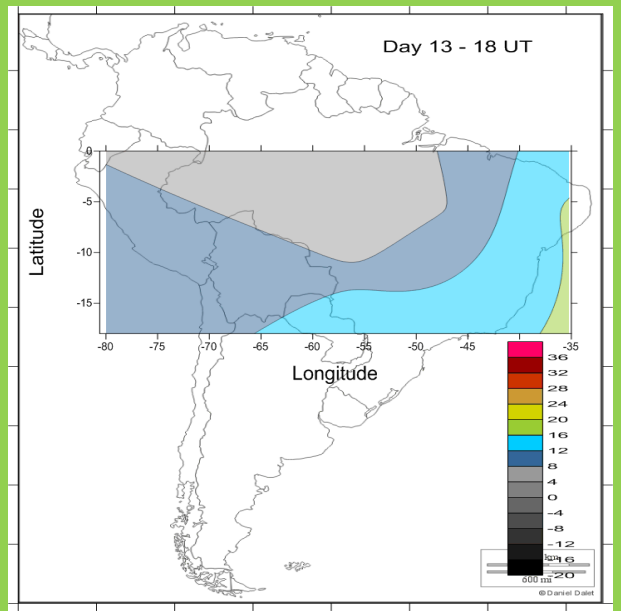
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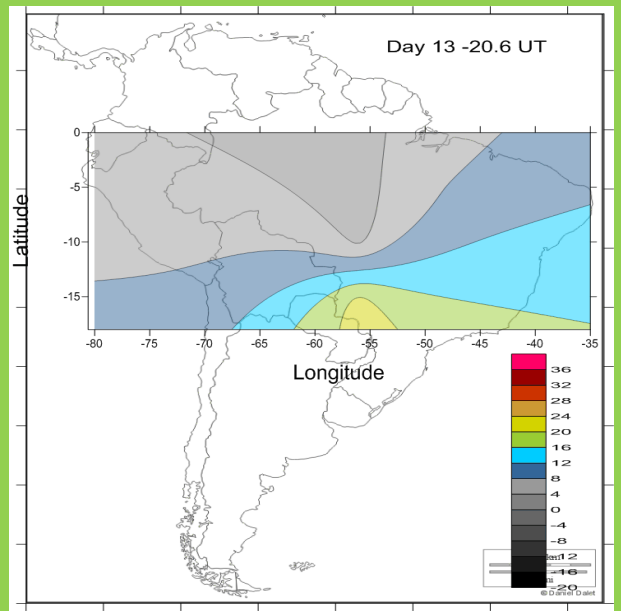
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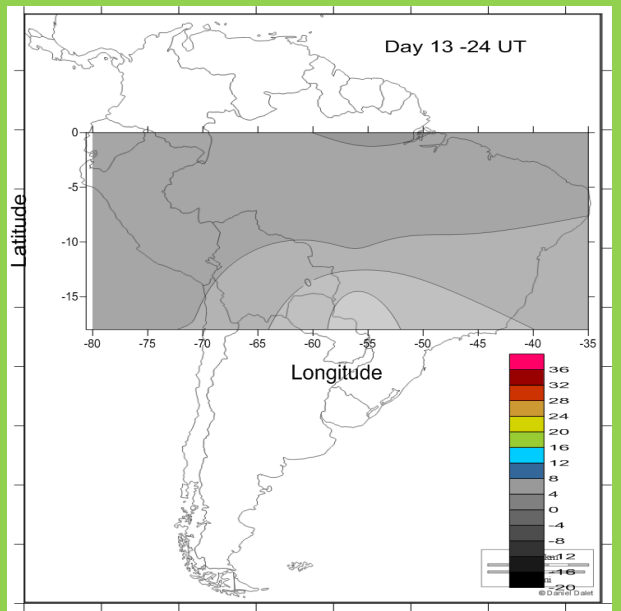
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Longitude

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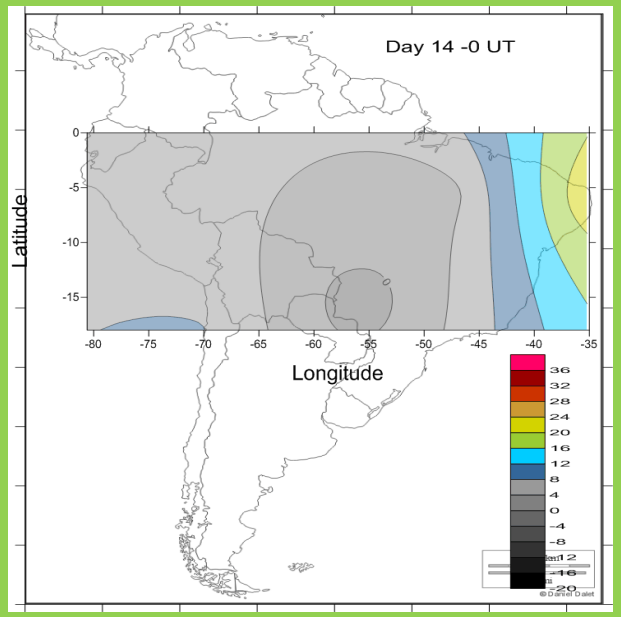
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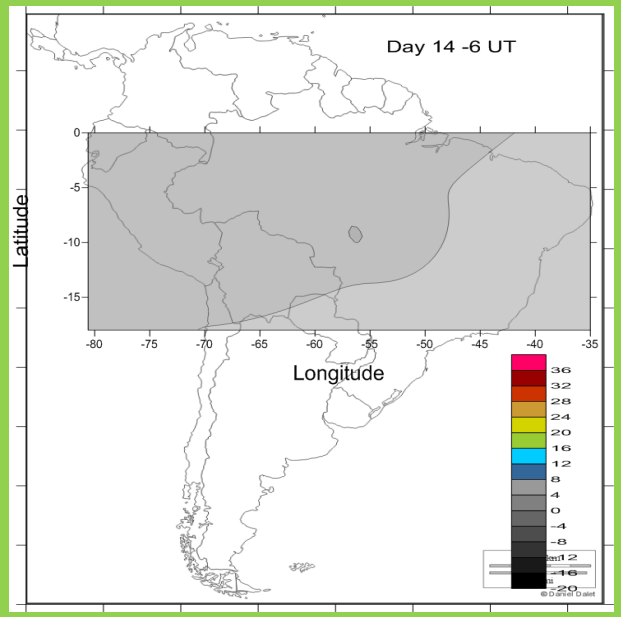
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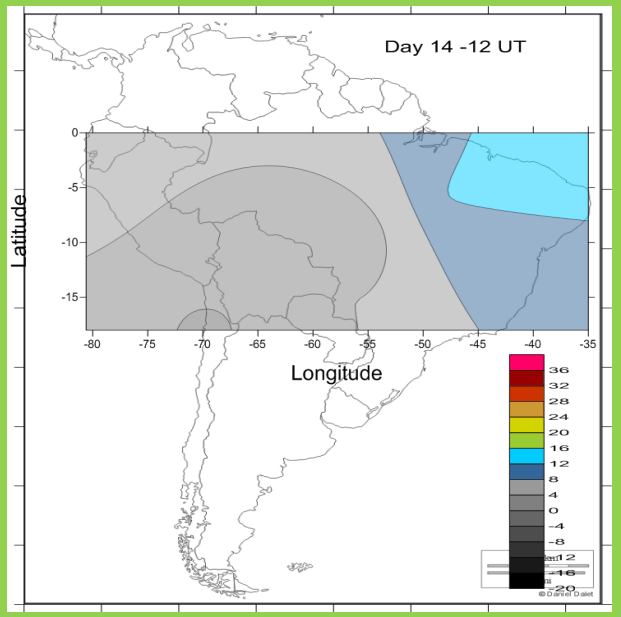
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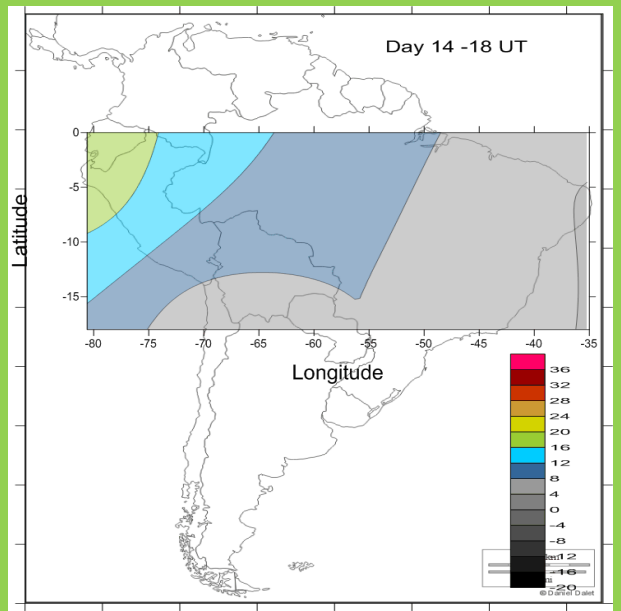
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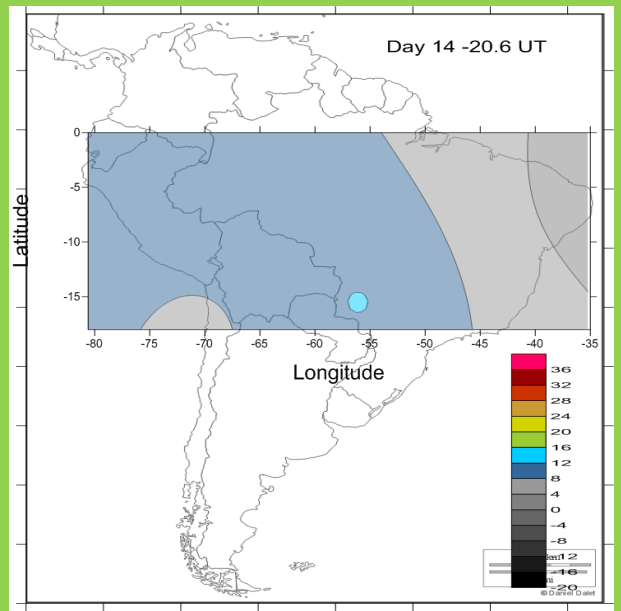
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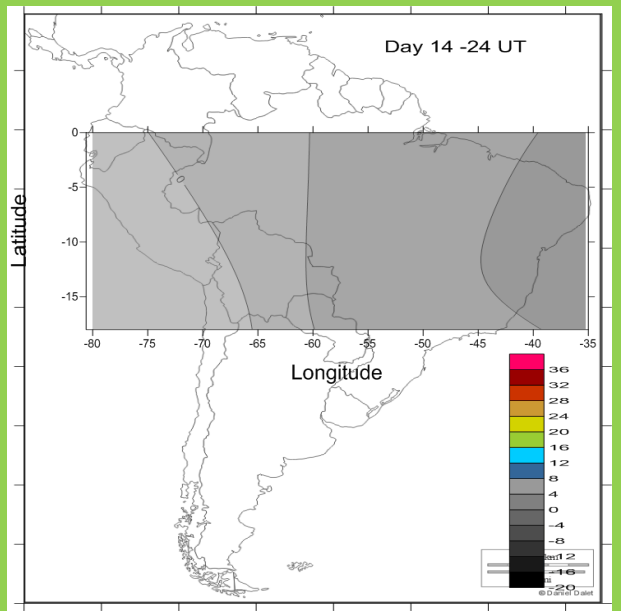
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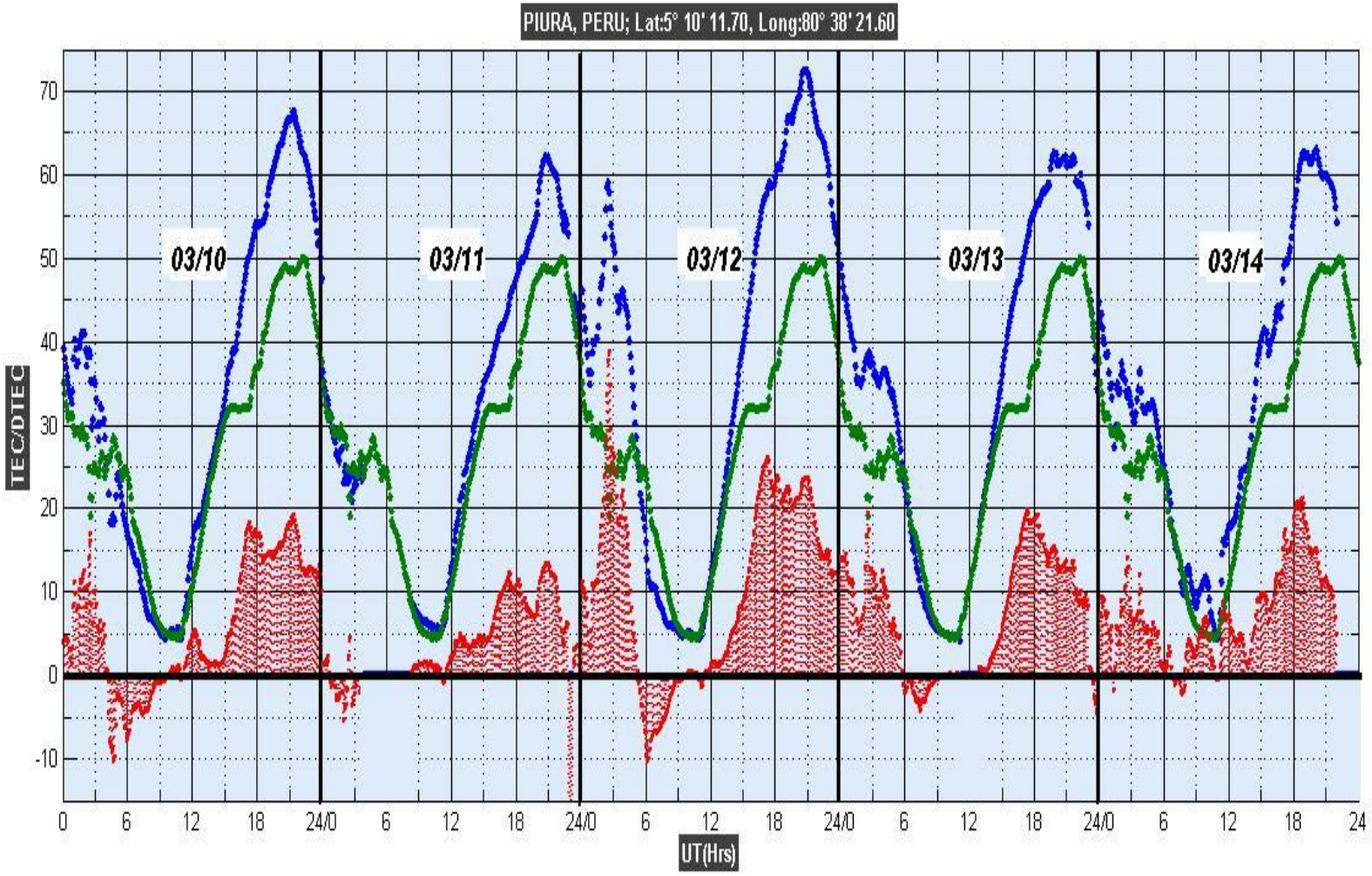
PIURA, PERU; Lat:5° 10' 11.70, Long:80° 38' 21.60
TEC/DTEC
70
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50
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30
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10
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-10
03/10
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03/13
03/14
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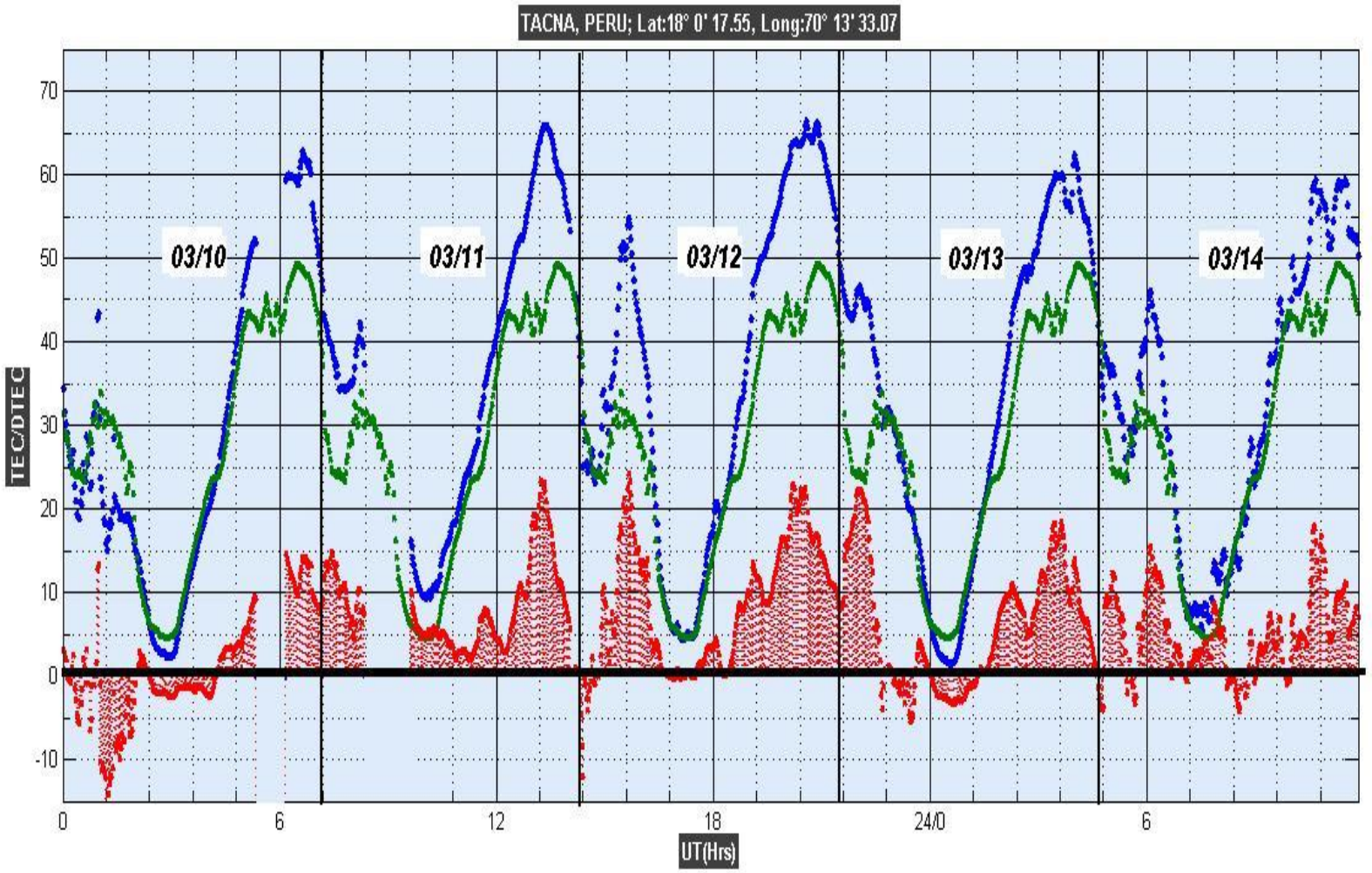
UT(Hrs)


TACNA, PERU; Lat:18° 0' 17.55, Long:70° 13' 33.07
TEC/DTEC
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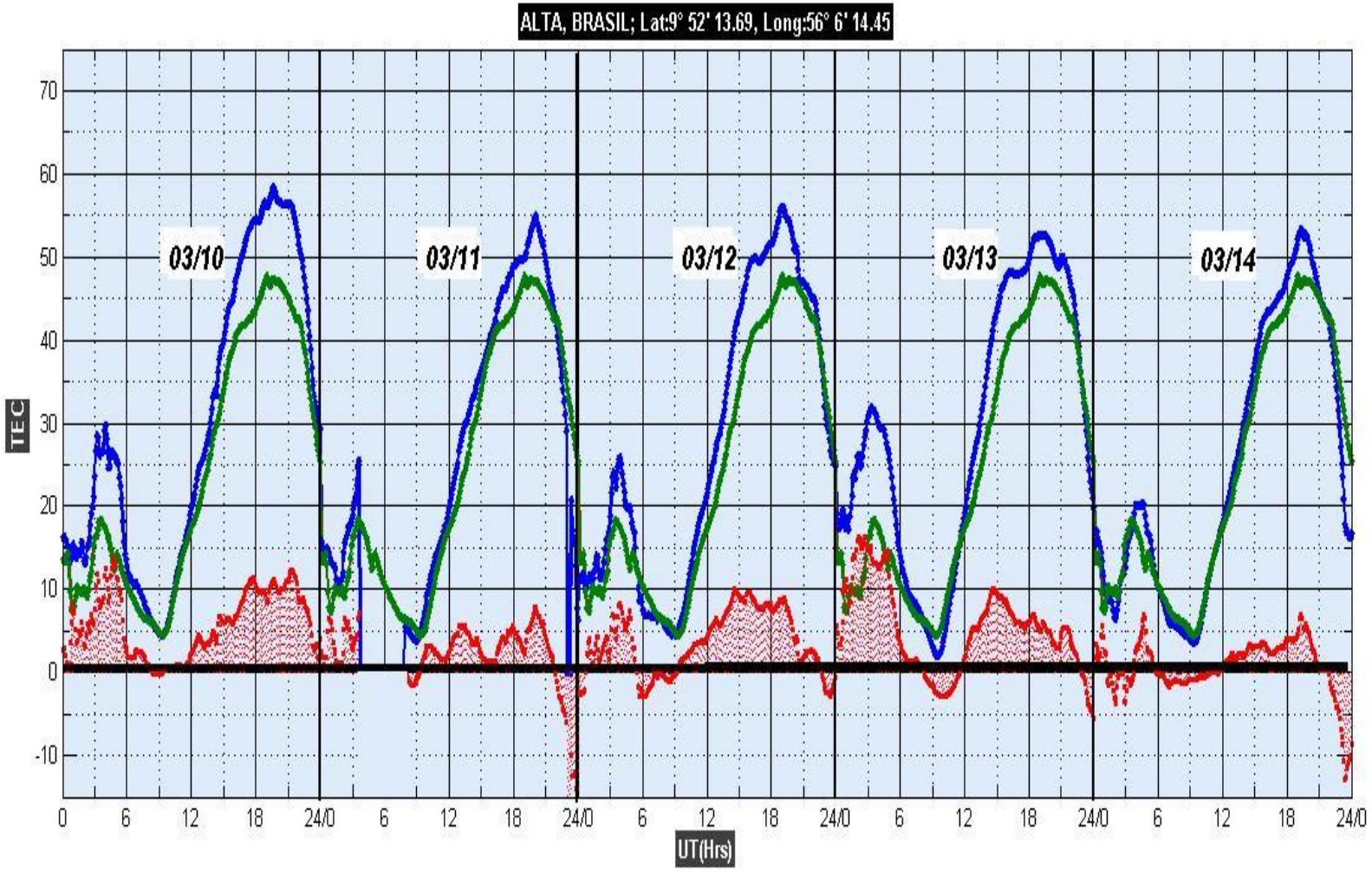
UT(Hrs)


ALTA, BRASIL; Lat:9° 52' 13.69, Long:56° 6' 14.45
TEC
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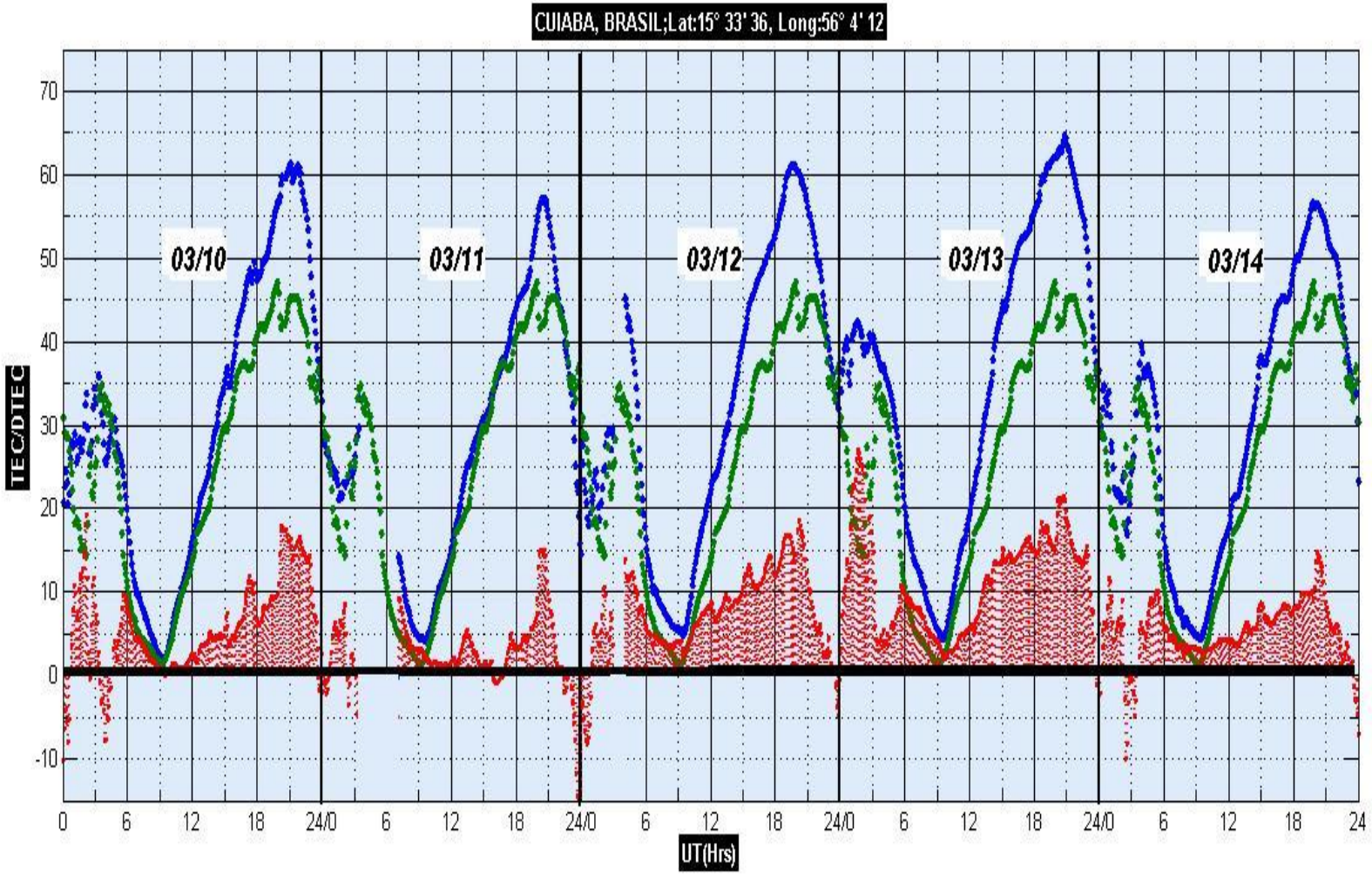
UT(Hrs)


CUIABA, BRASIL;Lat:15° 33' 36, Long:56° 4' 12
TEC/DTEC
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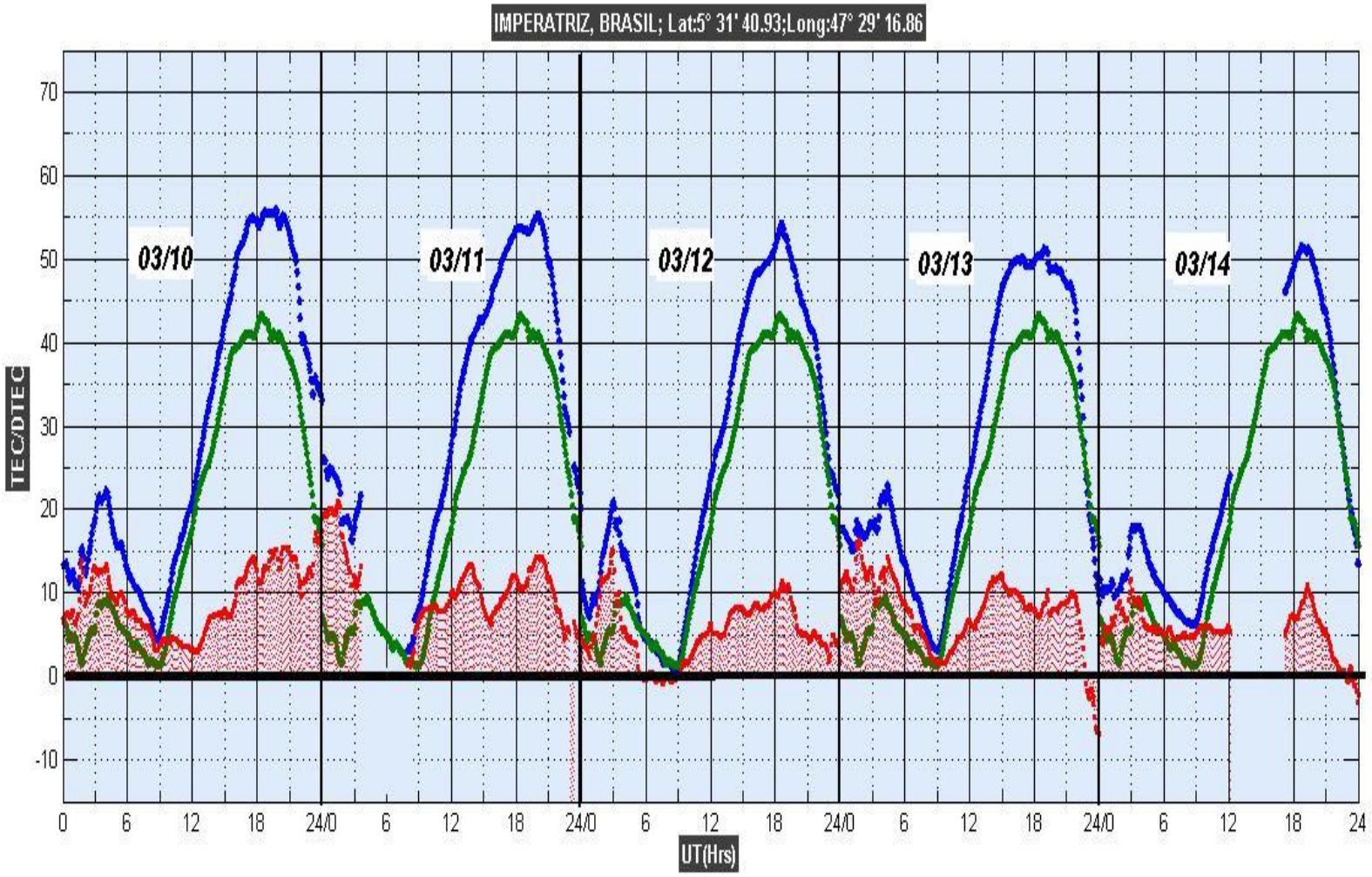
UT(Hrs)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24/0
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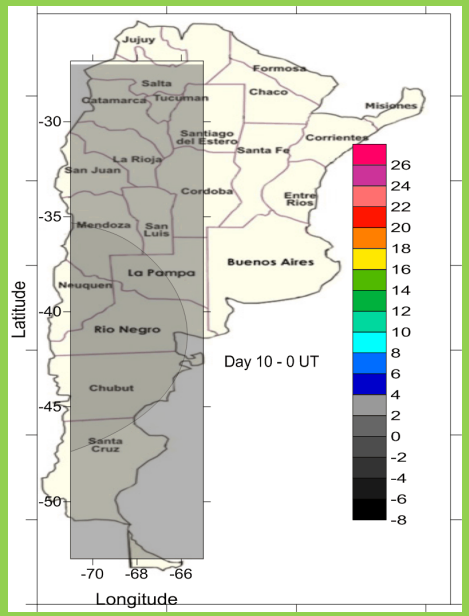
18
24/0
6
12
18
24
UT(Hrs)

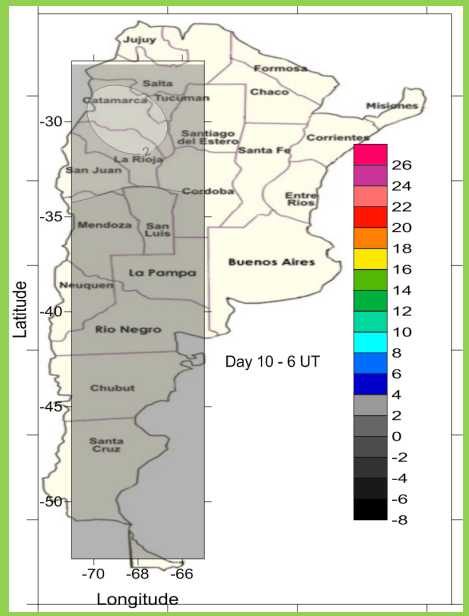
Station in Latitude

Station	Latitude	Longitude
CSLO	-31	-69
ESQU	-42	-71
JBAL	-27	-65
MZSR	-34	-68
RIO	-53	-67
TUCU	-26.8	-65
UNSJ	-31	-68

República Argentina - parte continental americana

Day 10


Day 10 - 0 UT
Latitude
Longitude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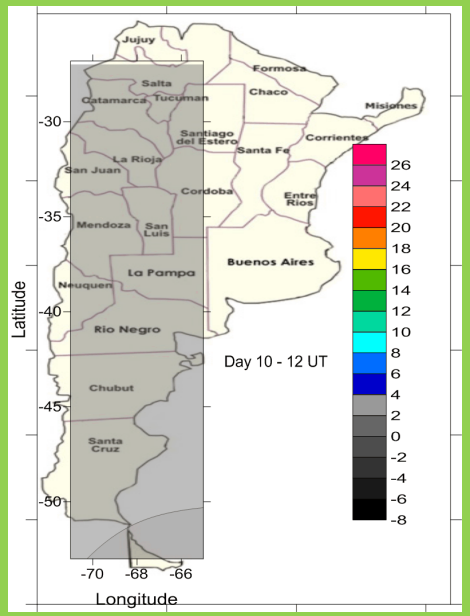
Latitude
Longitude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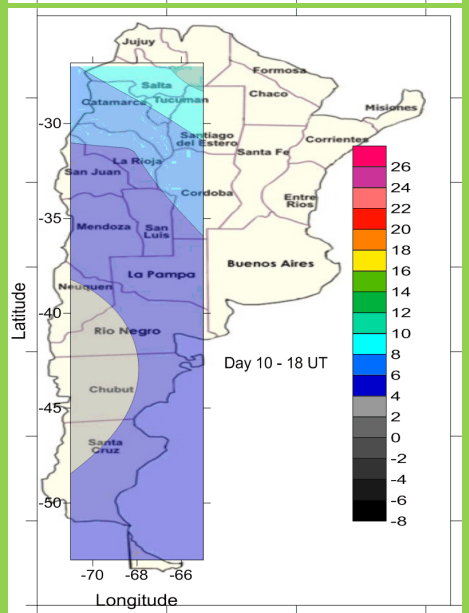
Latitude
Longitude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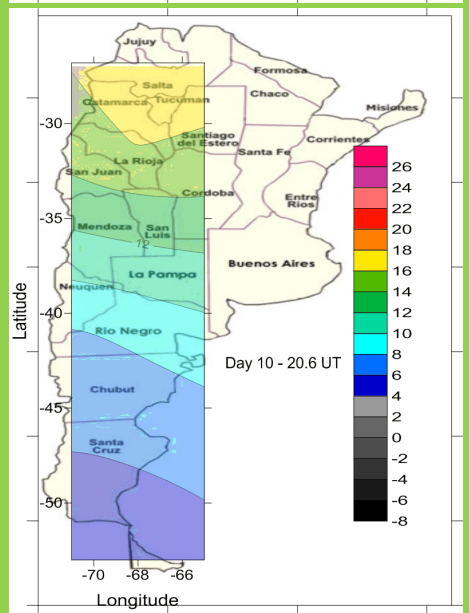
Latitude
Longitude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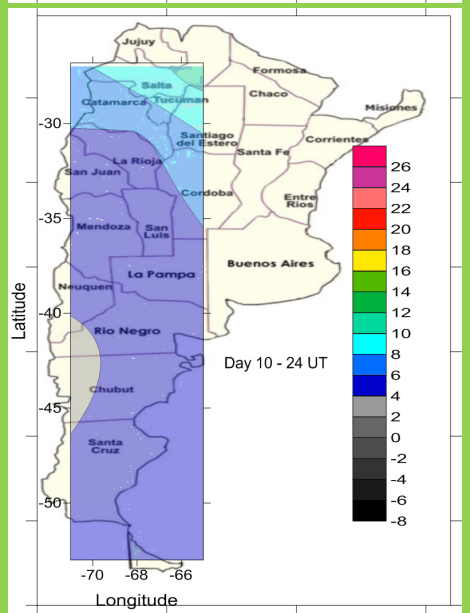
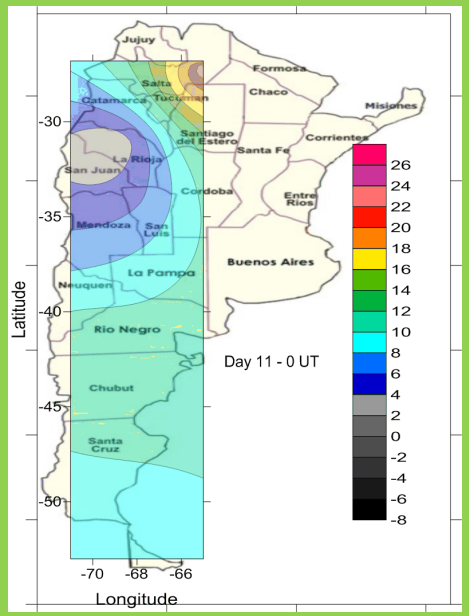
Latitude
Longitude


Day 10 - 24 UT
Latitude
Longitude

Day 11


Jujuy
Salta
Catamarca
Tucuman
Formosa
Chaco
Misiones
Santiago del Estero
Corrientes
Santa Fe
La Rioja
San Juan
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Entre Rios
Mendoza
San Luis
Buenos Aires
La Pampa
Neuquen
Rio Negro
Chubut
Santa Cruz
Day 11 - 0 UT
26 24 22 20 18 16 14 12 10 8 6 4 2 0 -2 -4 -6 -8
-30 -35 -40 -45 -50
-70 -68 -66
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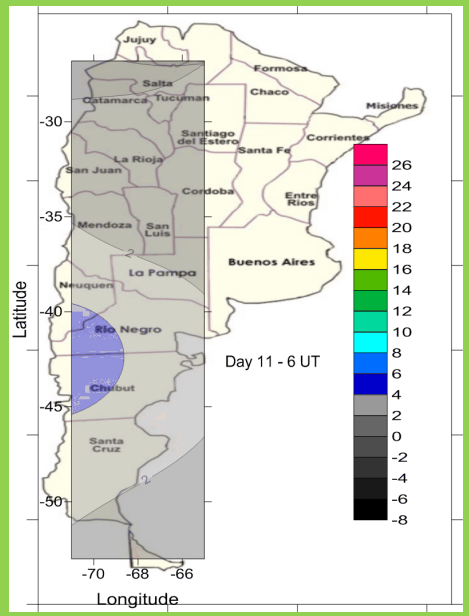
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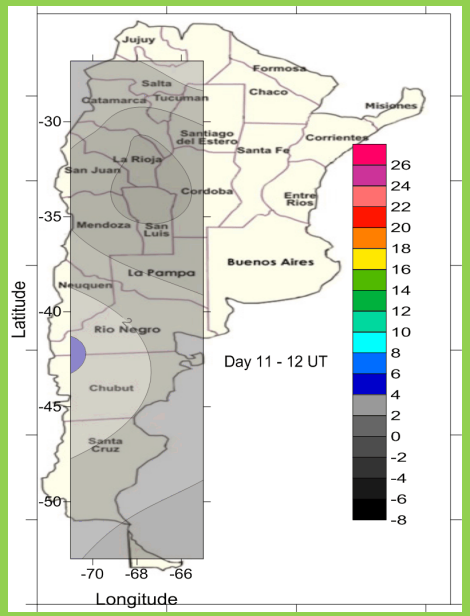
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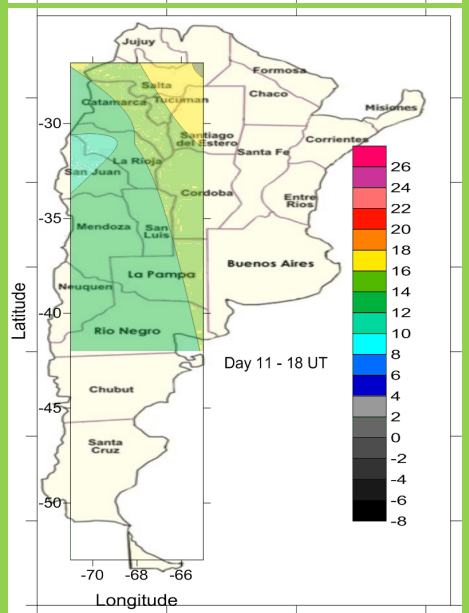
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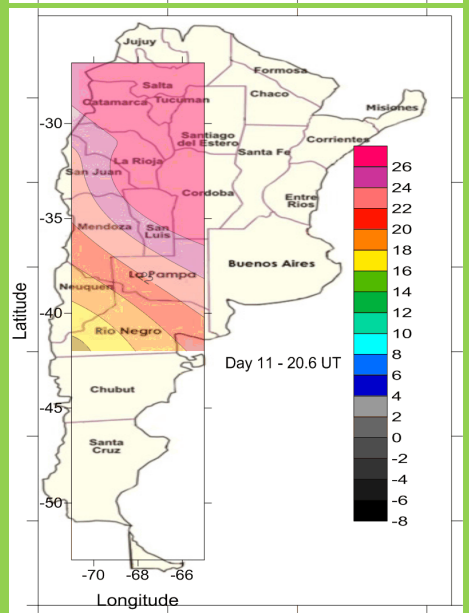
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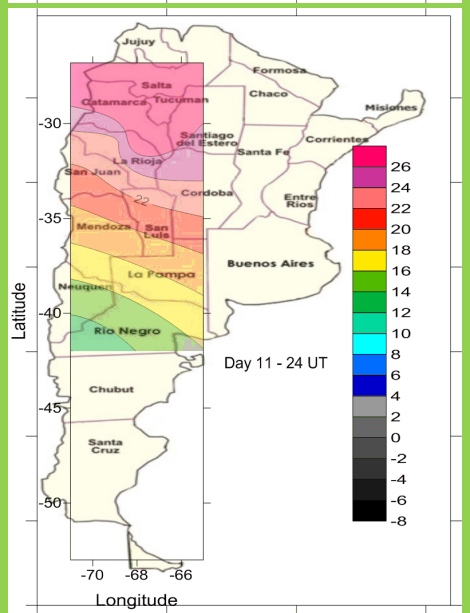
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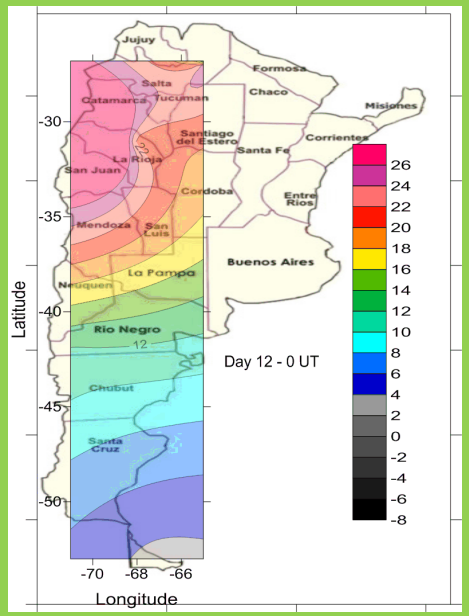
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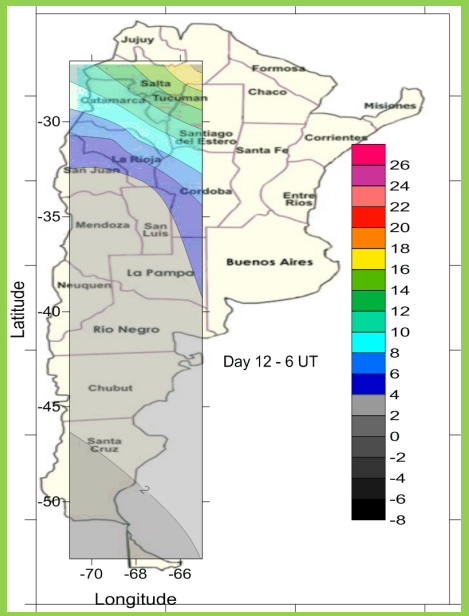
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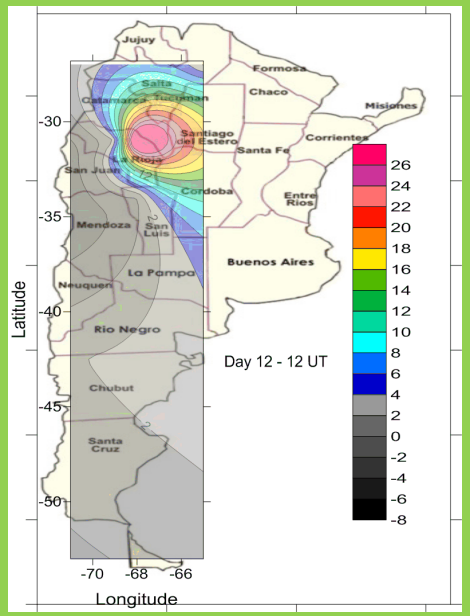
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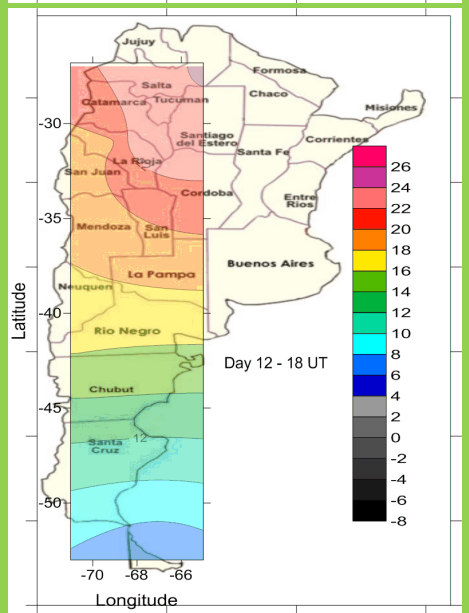
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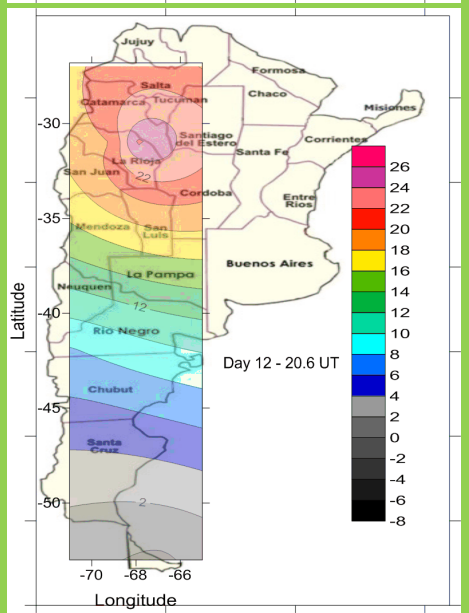
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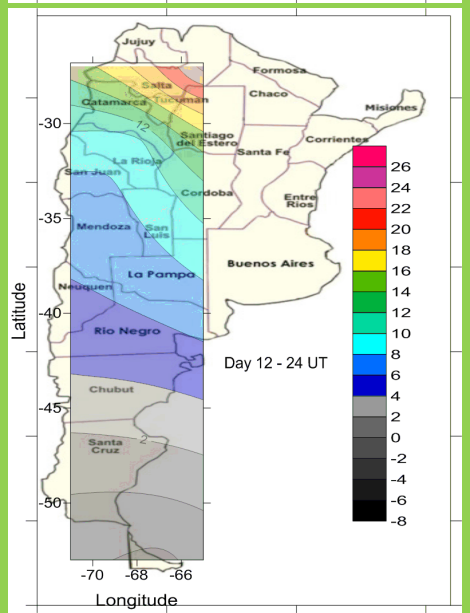
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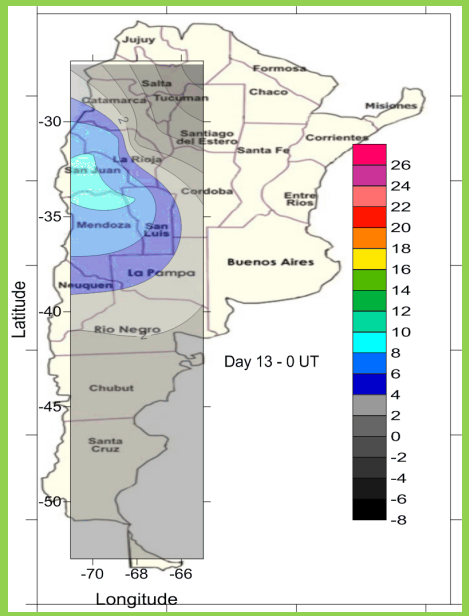
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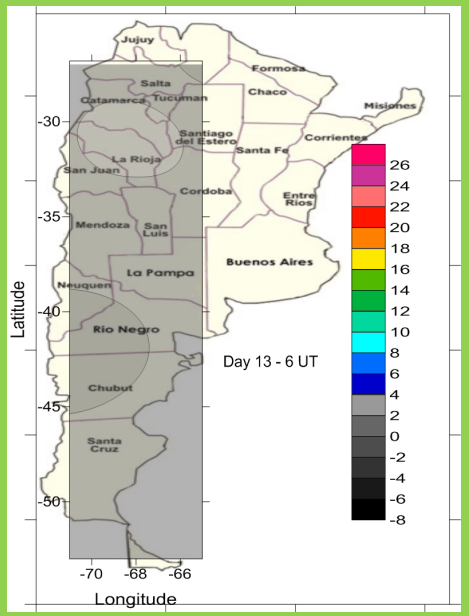
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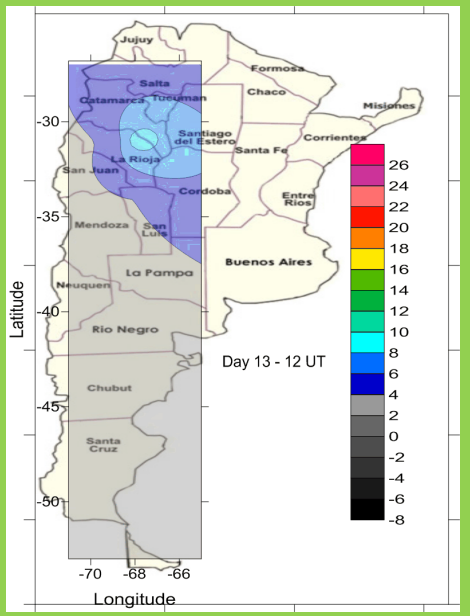
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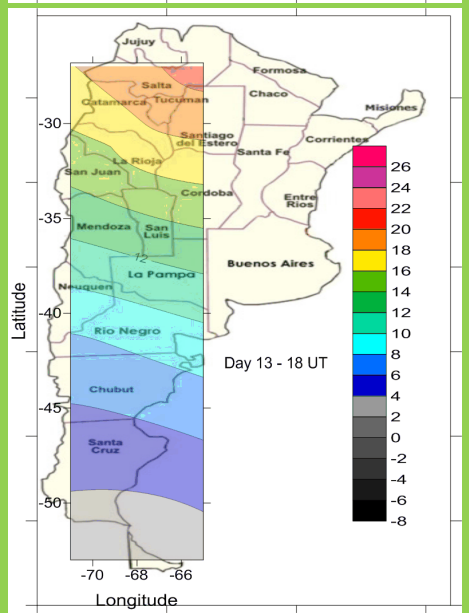
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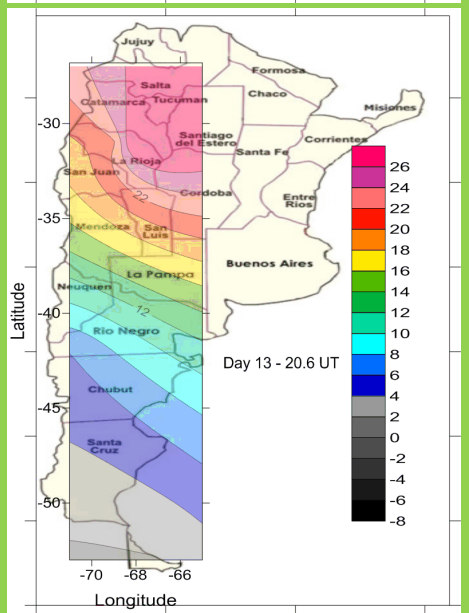
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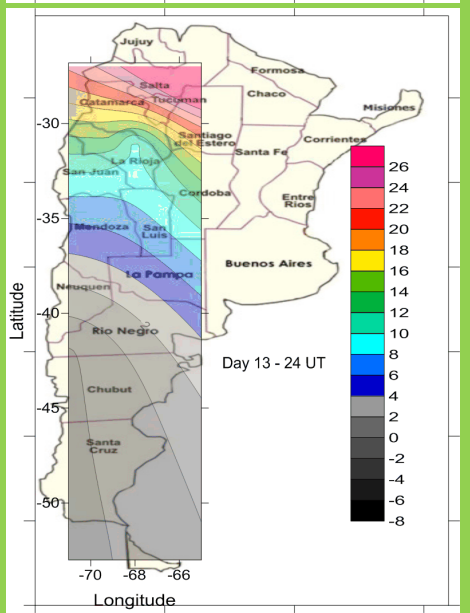
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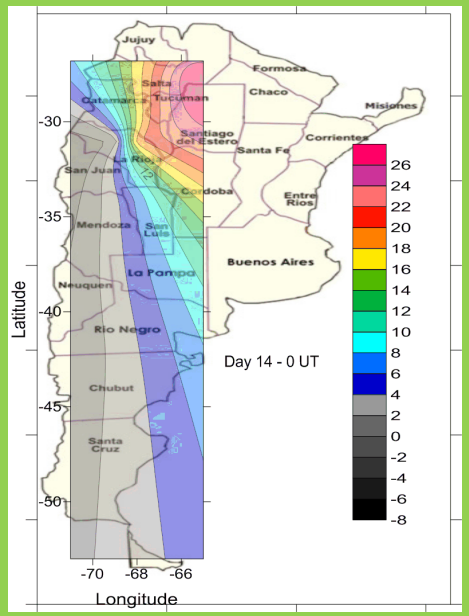
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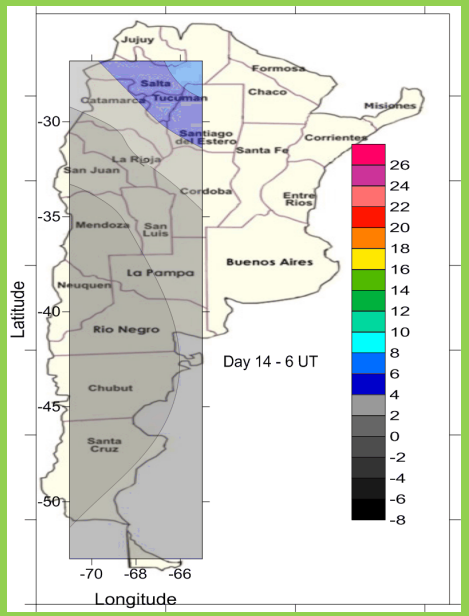
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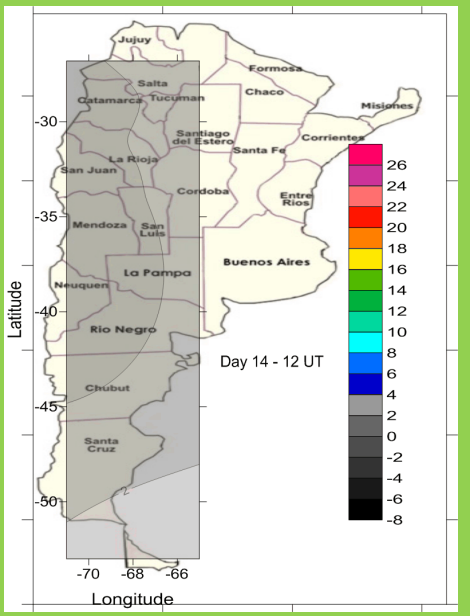
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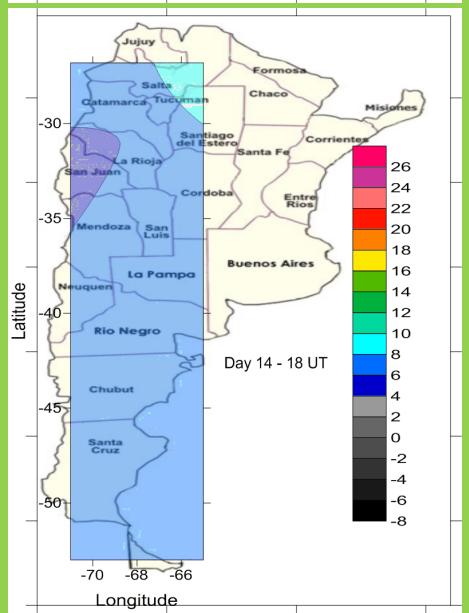
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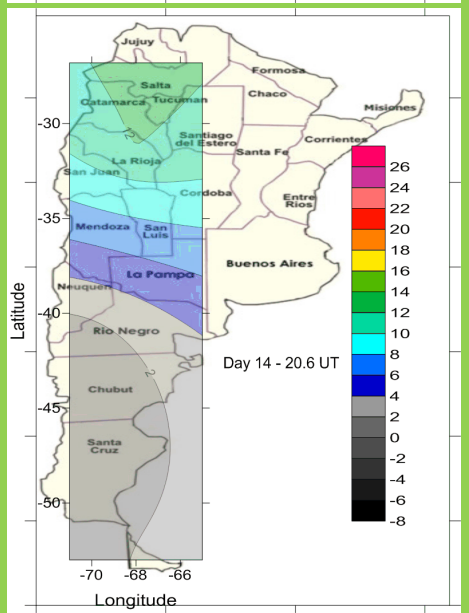
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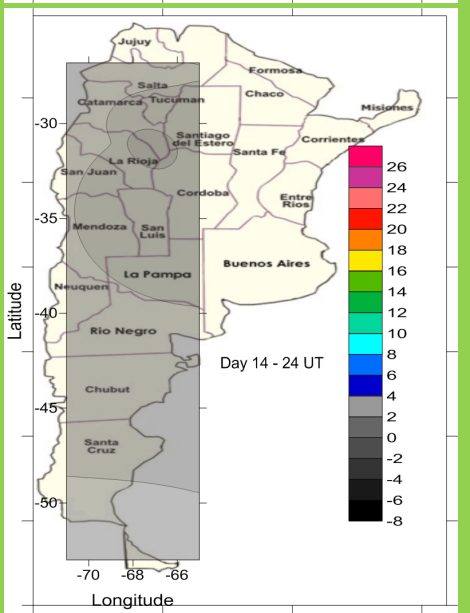
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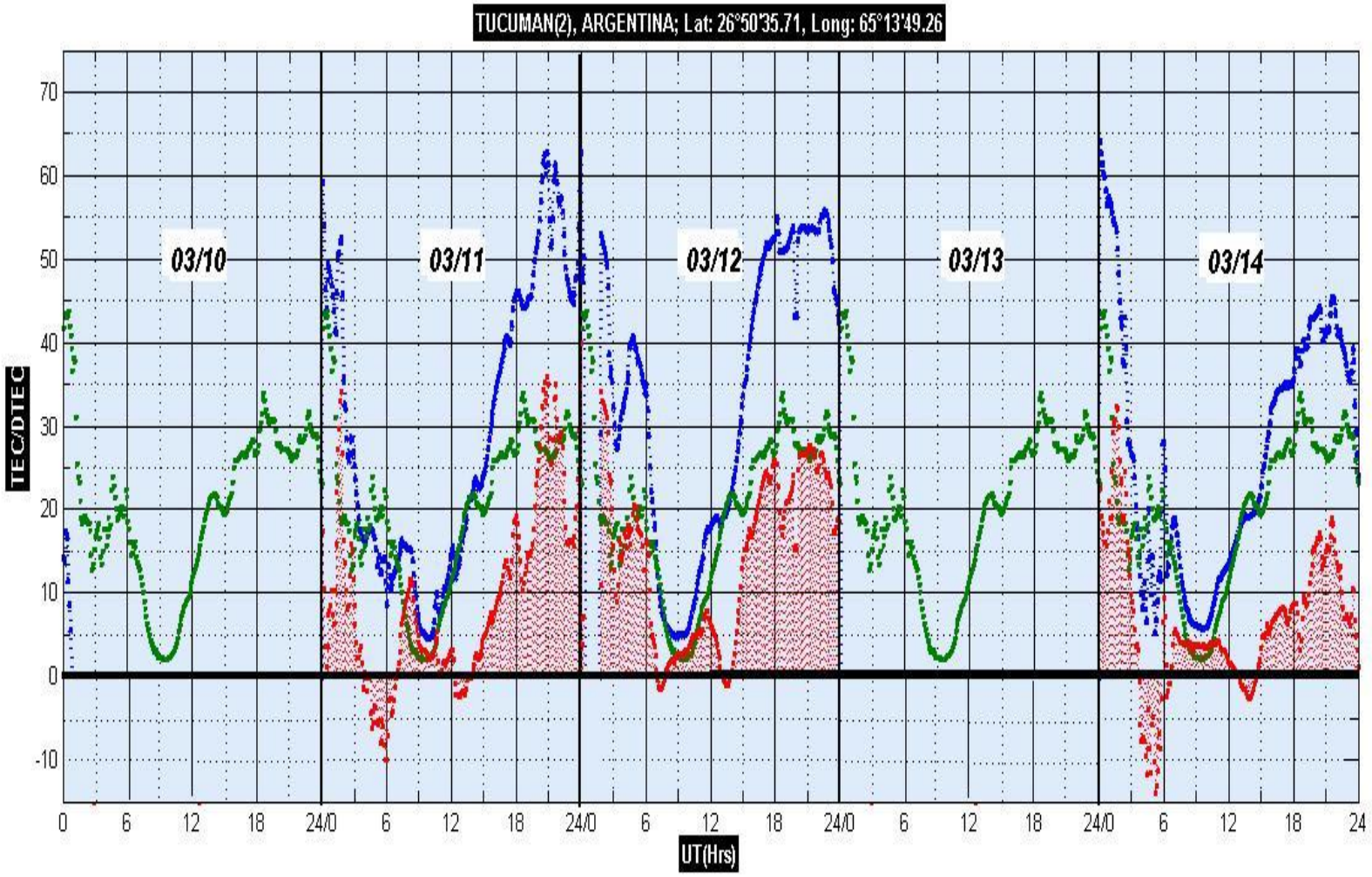
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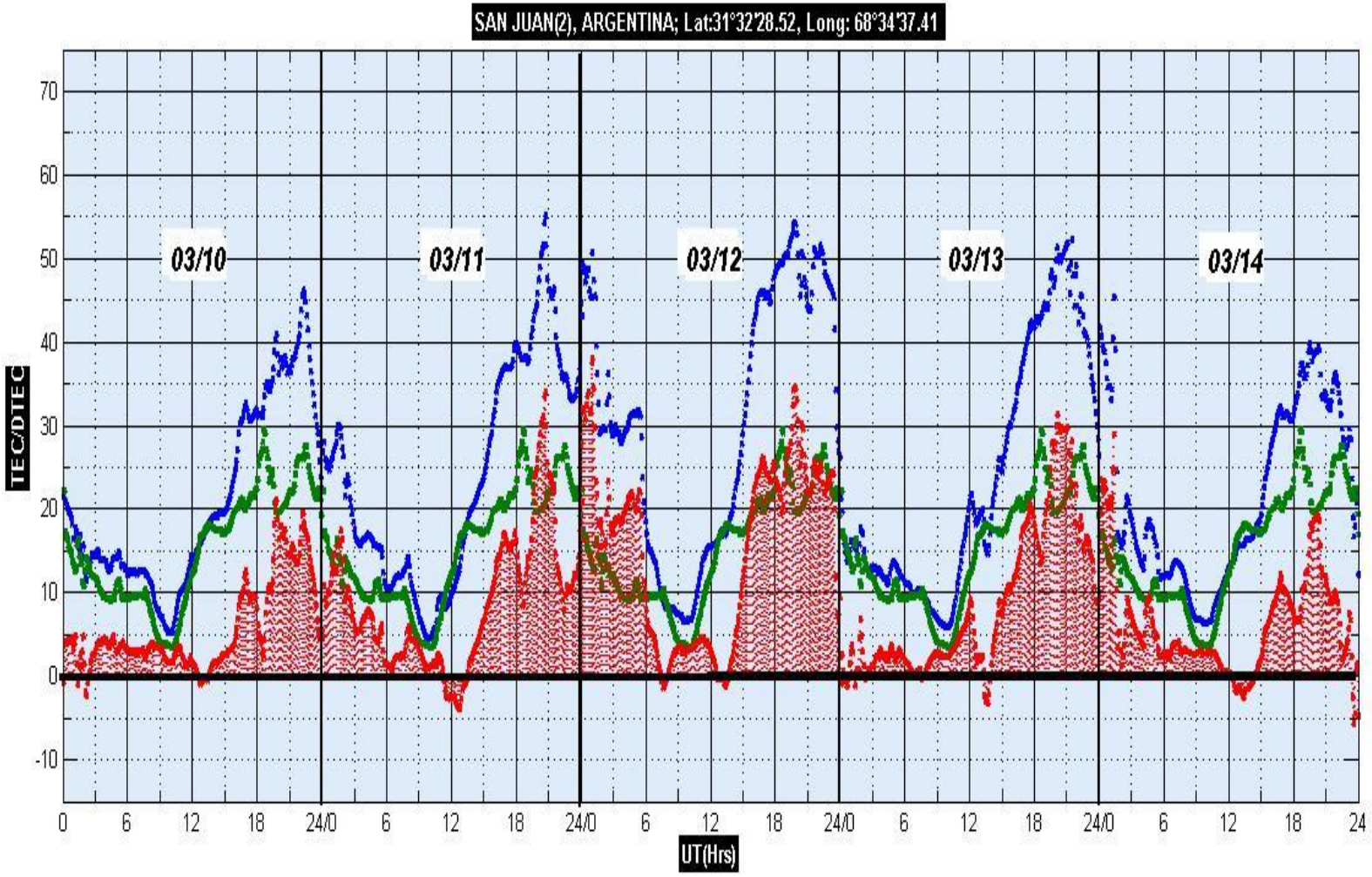
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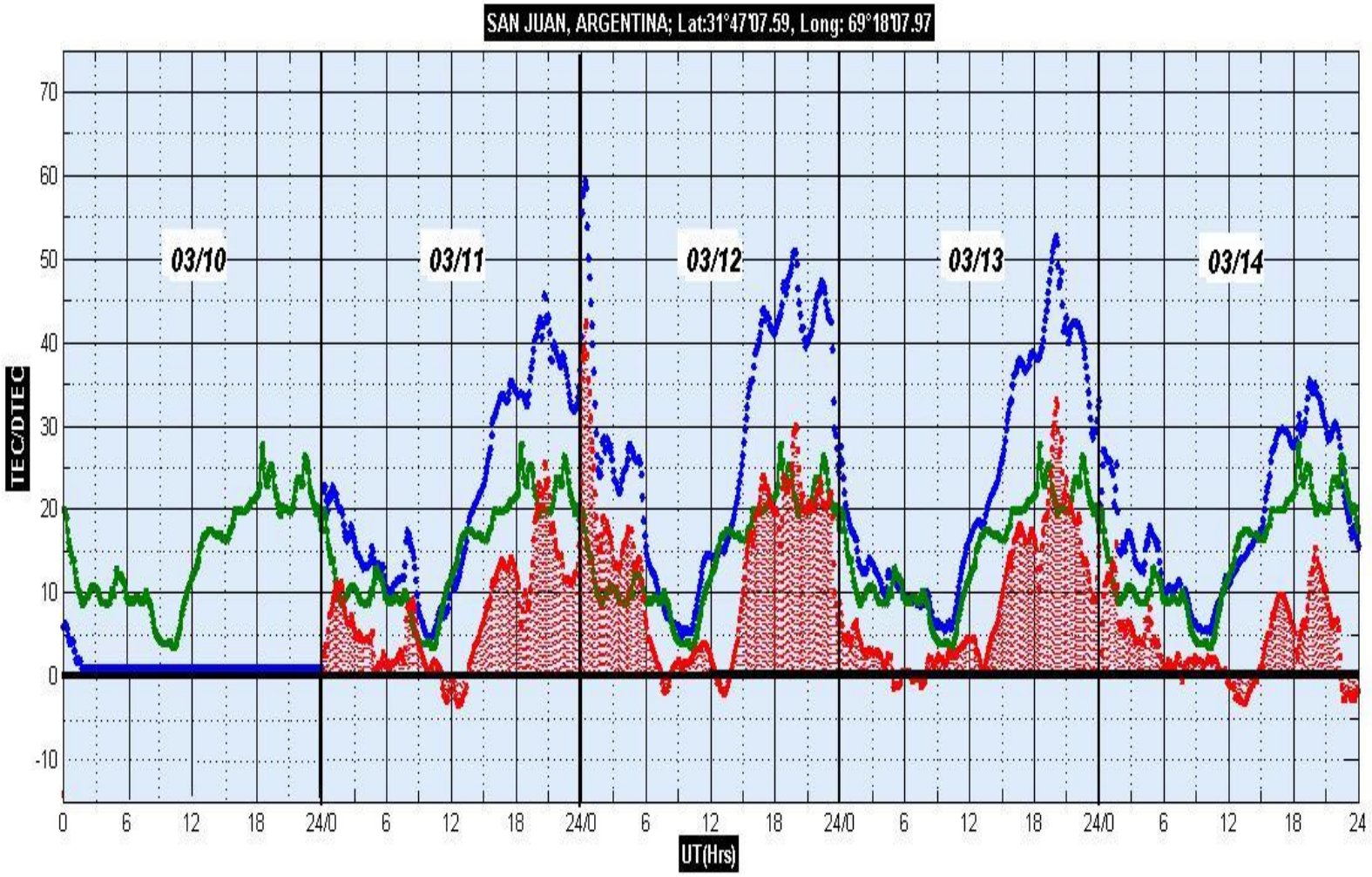
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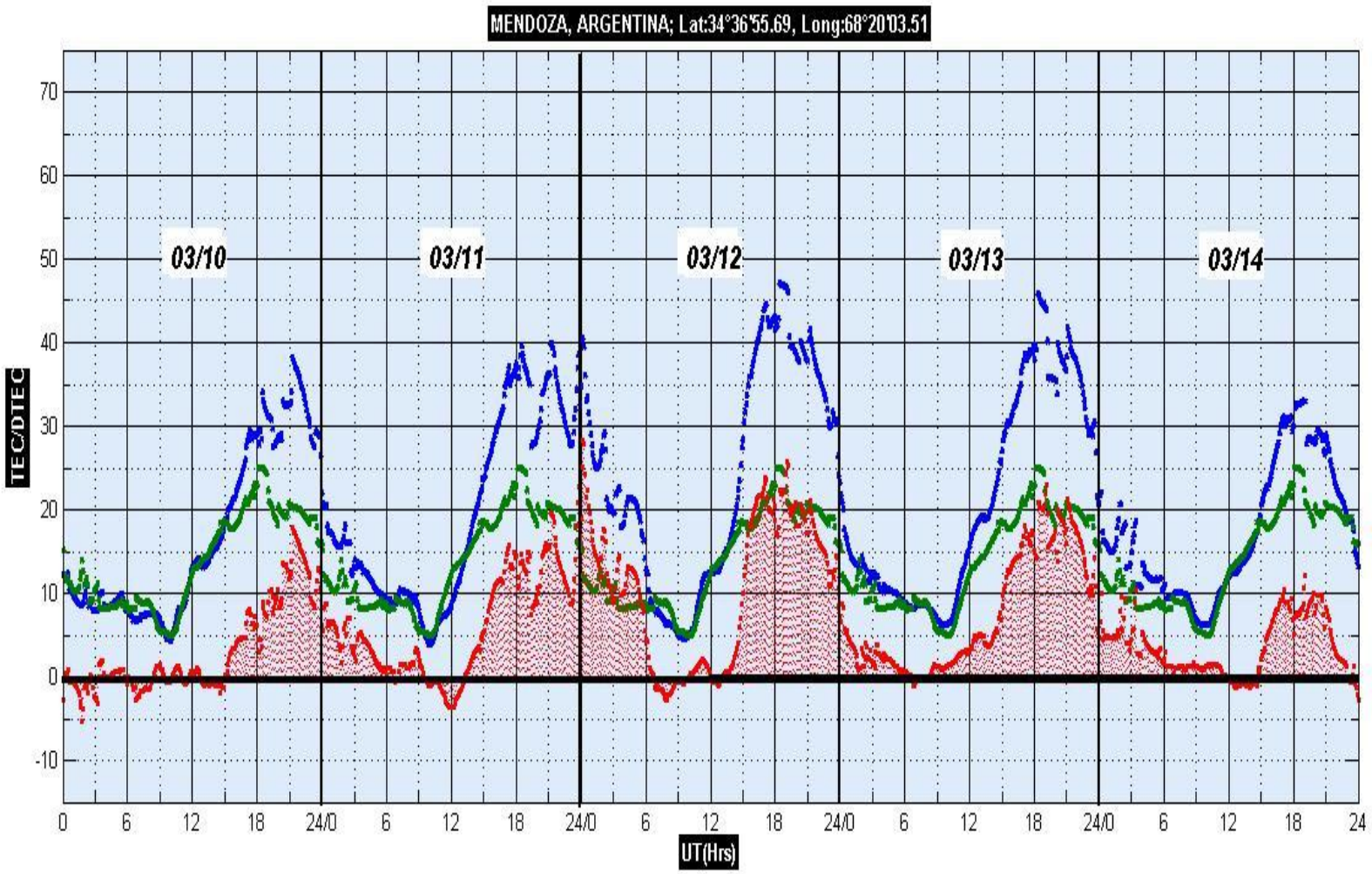
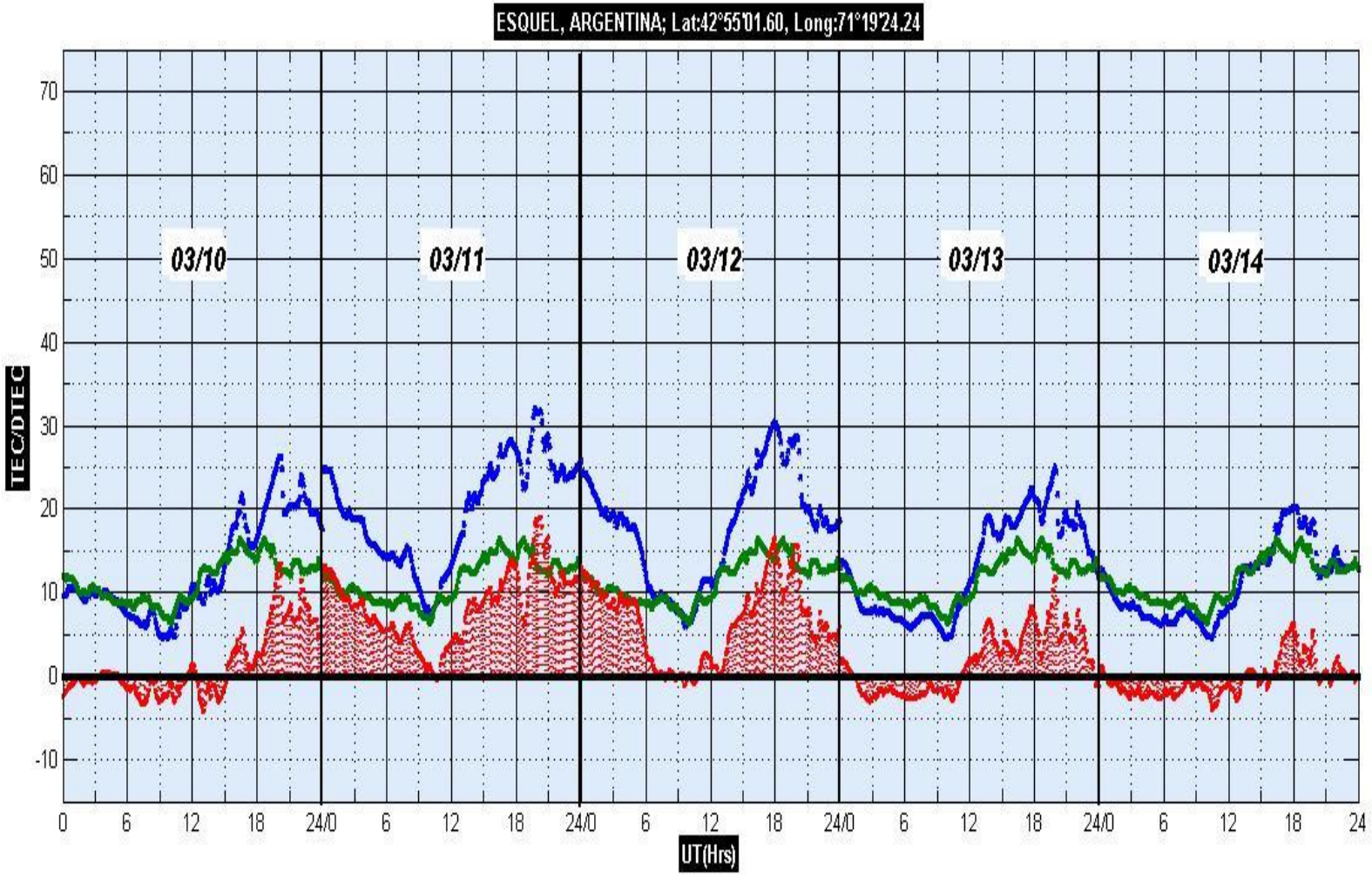
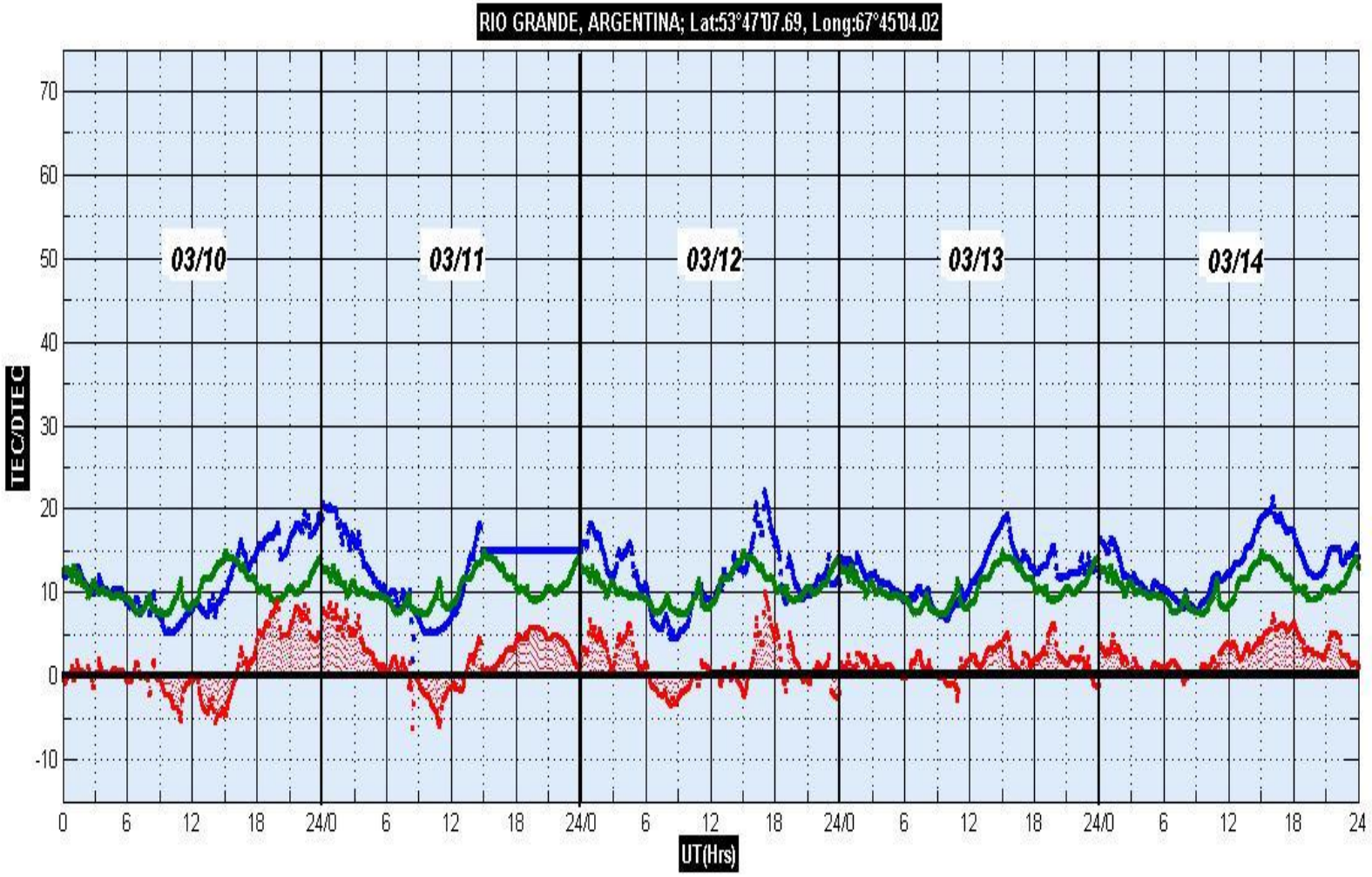
UT(Hrs)
24


MENDOZA, ARGENTINA; Lat:34°36'55.69, Long:68°20'03.51
TEC/DTEC
70
60
50
40
30
20
10
0
-10
03/10
03/11
03/12
03/13
03/14
0
6
12
18
24/0
6
12
18
24/0
6
12
18
24/0
6
12
18
24/0
6
12
18
24
UT(Hrs)


ESQUEL, ARGENTINA; Lat:42°55'01.60, Long:71°19'24.24
TEC/dTEC
70
60
50
40
30
20
10
0
-10
03/10
03/11
03/12
03/13
03/14
0
6
12
18
24/0
6
12
18
24/0
6
12
18
24/0
6
12
18
24/0
6
12
18
24
UT(Hrs)


RIO GRANDE, ARGENTINA; Lat:53°47'07.69, Long:67°45'04.02
TEC/dTEC
70
60
50
40
30
20
10
0
-10
03/10
03/11
03/12
03/13
03/14
0
6
12
18
24/0
6
12
18
24/0
6
12
18
24/0
6
12
18
24/0
6
12
18
24
UT(Hrs)

Conclusion

- We find that the phenomenon appears like a perturbation in the day 10 and modify the next days
- In the longitude the effects “travel” to the east in a accorde to the propagation of the earthquake
- In the latitude, we observe variations in increase, from day 10, with maximum in day 11 and decrease to day 14.
- We have an important network to analysis the perturbation in the ionosphere related with the events like a earthquake

Thank you!!!