E- ICES 2
“International Center for Earth Sciences”
2º. Encuentro

2006

STUDY OF THE 1973-2002 VARIABILITY OF THE ANNUAL CICLE OF ERA-40 GEOPOTENTIAL HEIGHT: AN INTERHEMISPHERE COMPARISON

Patricia Repossi and Pablo Canziani

30 years tropospheric and lower stratospheric ECMWF ERA-40 geopotential height data are studied.

The zonal mean annual cycle from pole to pole

evaluate the interanual variability and determine interhemispheric differences in the annual cycle evolution during the 30-year period (1973-2002).

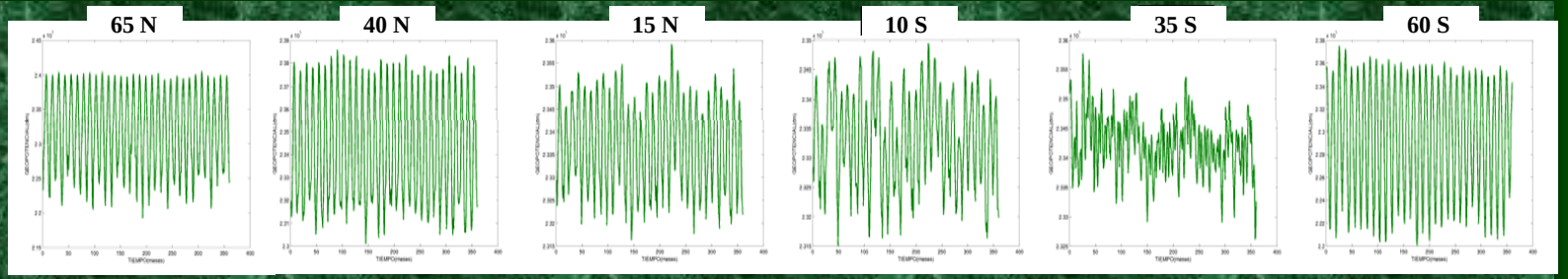
Analysis

- ⇨ Zonal average (latitudinal)
- ⇨ Monthly average
- ⇨ Fourier Analysis

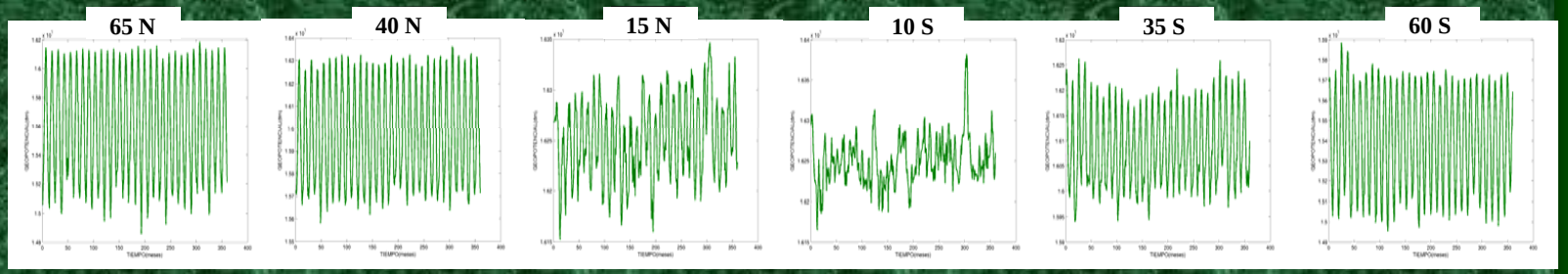
Results

I_ Annual cycle reconstruction and variability along 30 years by an inverse transform of the spectral band

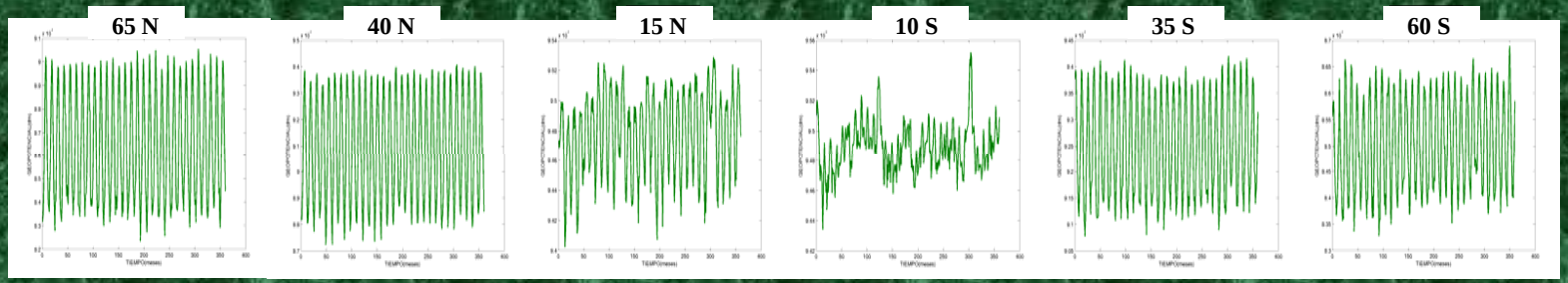
30mb



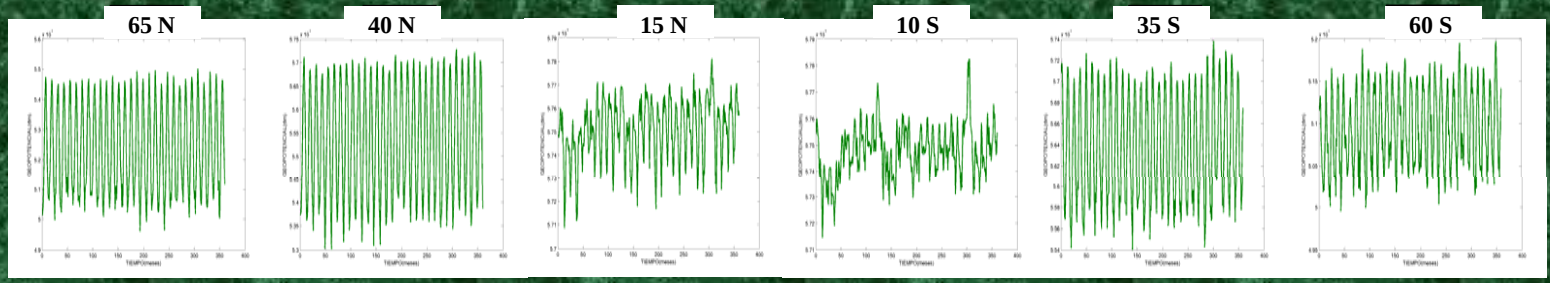
100mb



300mb



500mb



For all heigths

* tropical latitudes: QBO modify the annual cycle

* Higher latitudes: annual cycle is dominant

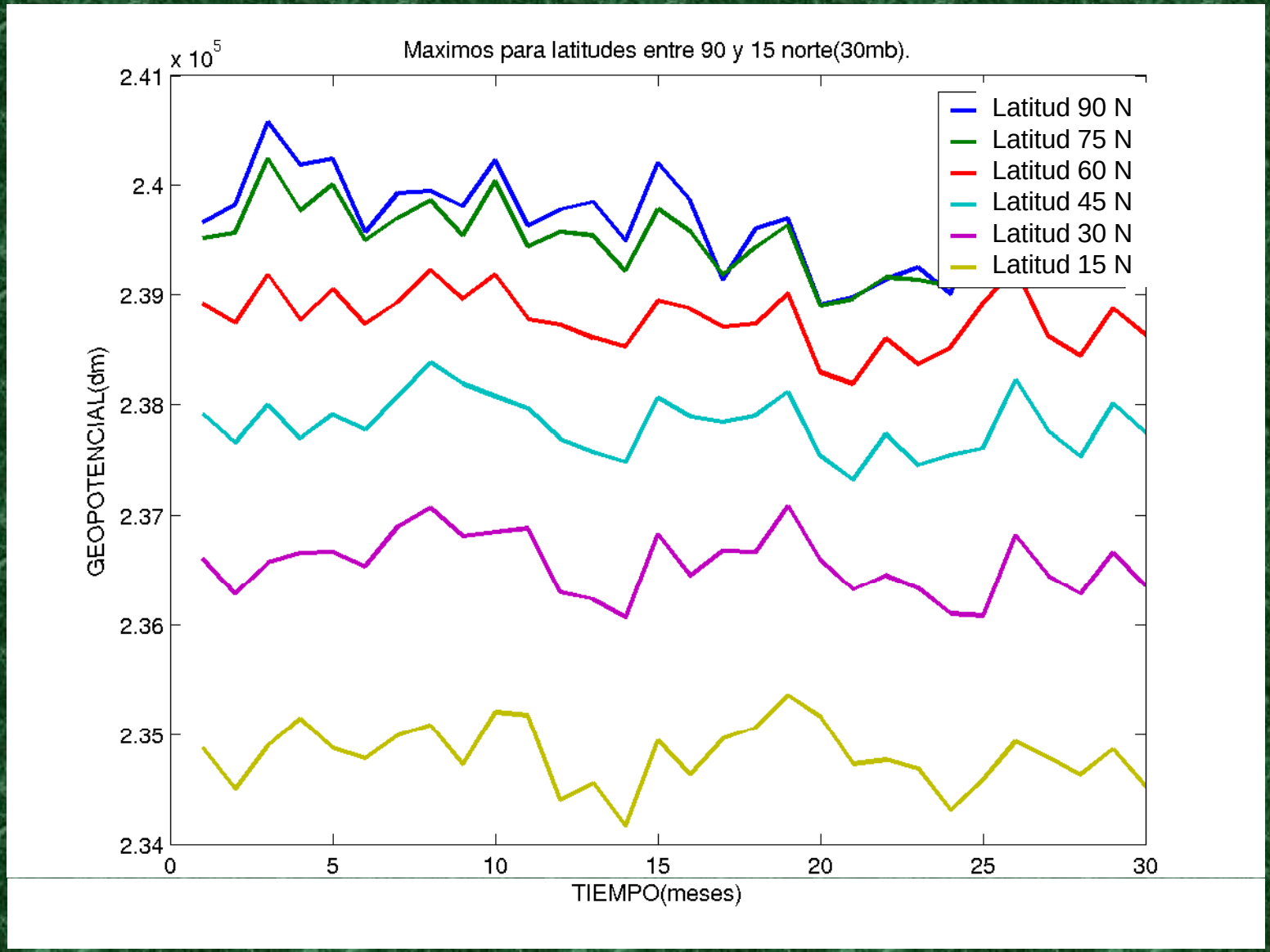
➔ interannual modulation is stronger for annual minima than for maxima

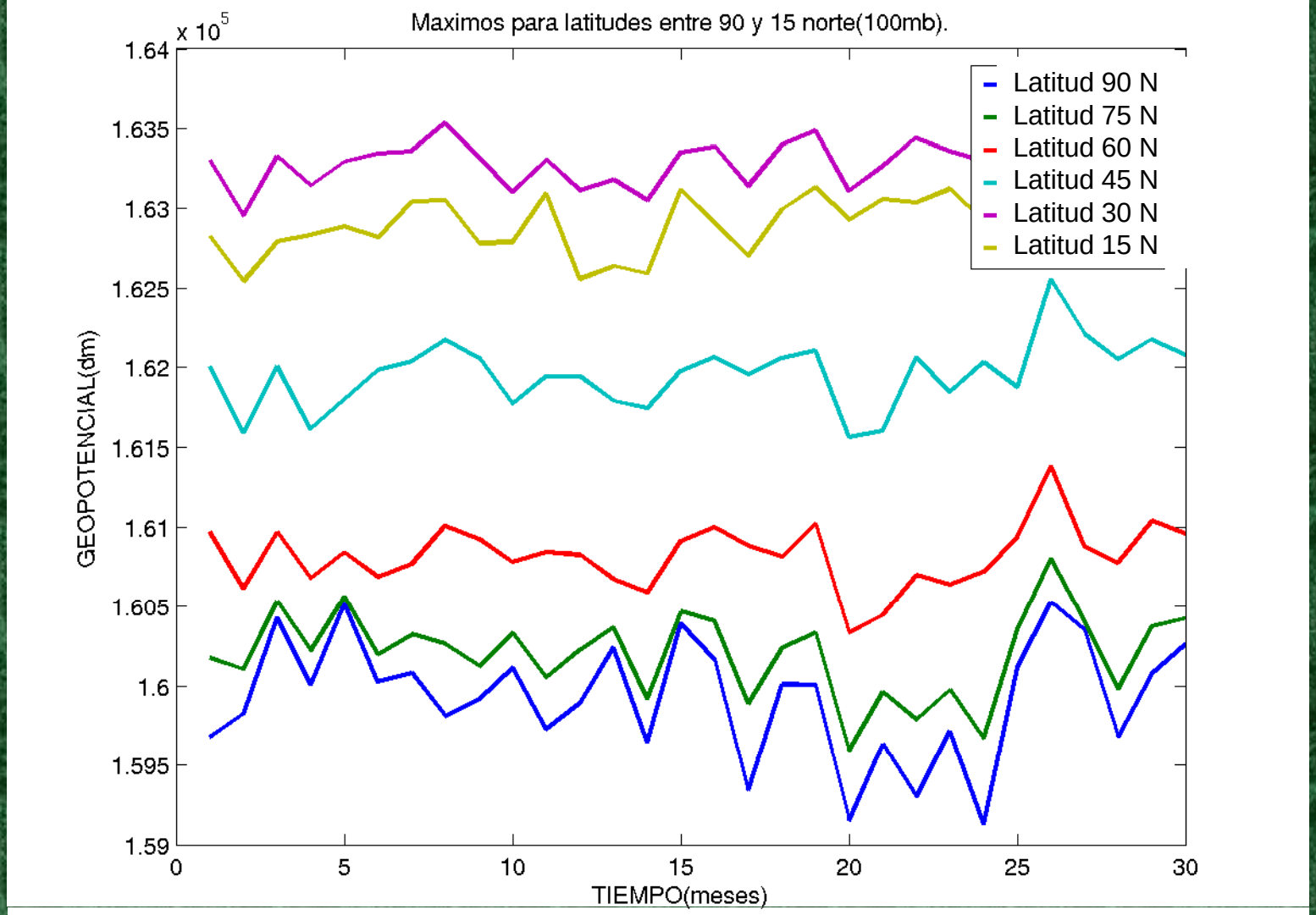
➔ Both significant variability in the annual mean and annual mean amplitude can be observed at all latitudes and heights.

Amplitude modulation suggests the existence of non-linear interactions and vacillations in the annual cycle.

Extratropics ➡ the modulation is more significant in the annual minima than in the annual maxima

Evolution of the Maxima

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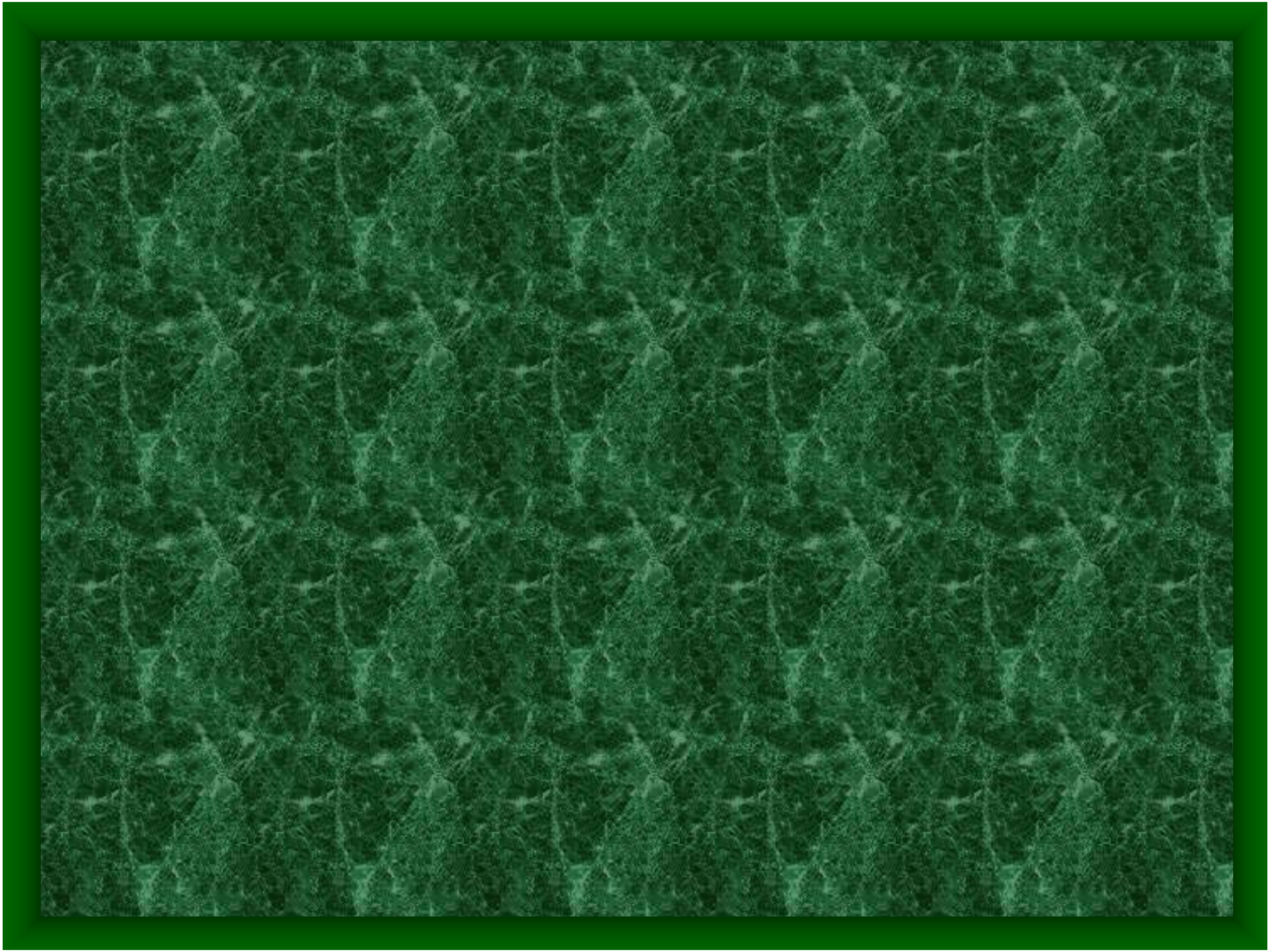
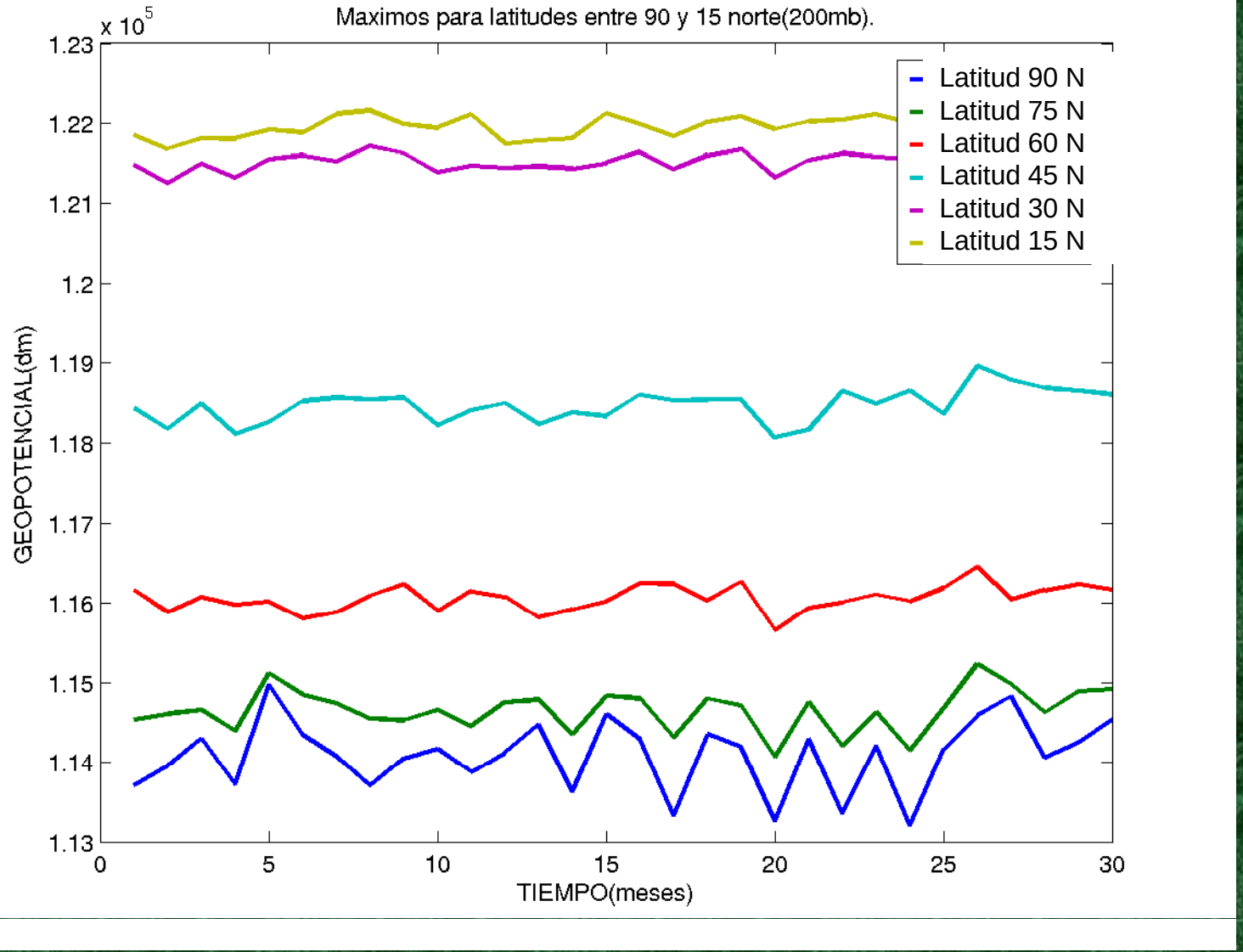
1.63
1.625
1.62
1.615
1.61
1.605
1.6
1.595
1.59
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 N
Latitud 75 N
Latitud 60 N
Latitud 45 N
Latitud 30 N
Latitud 15 N

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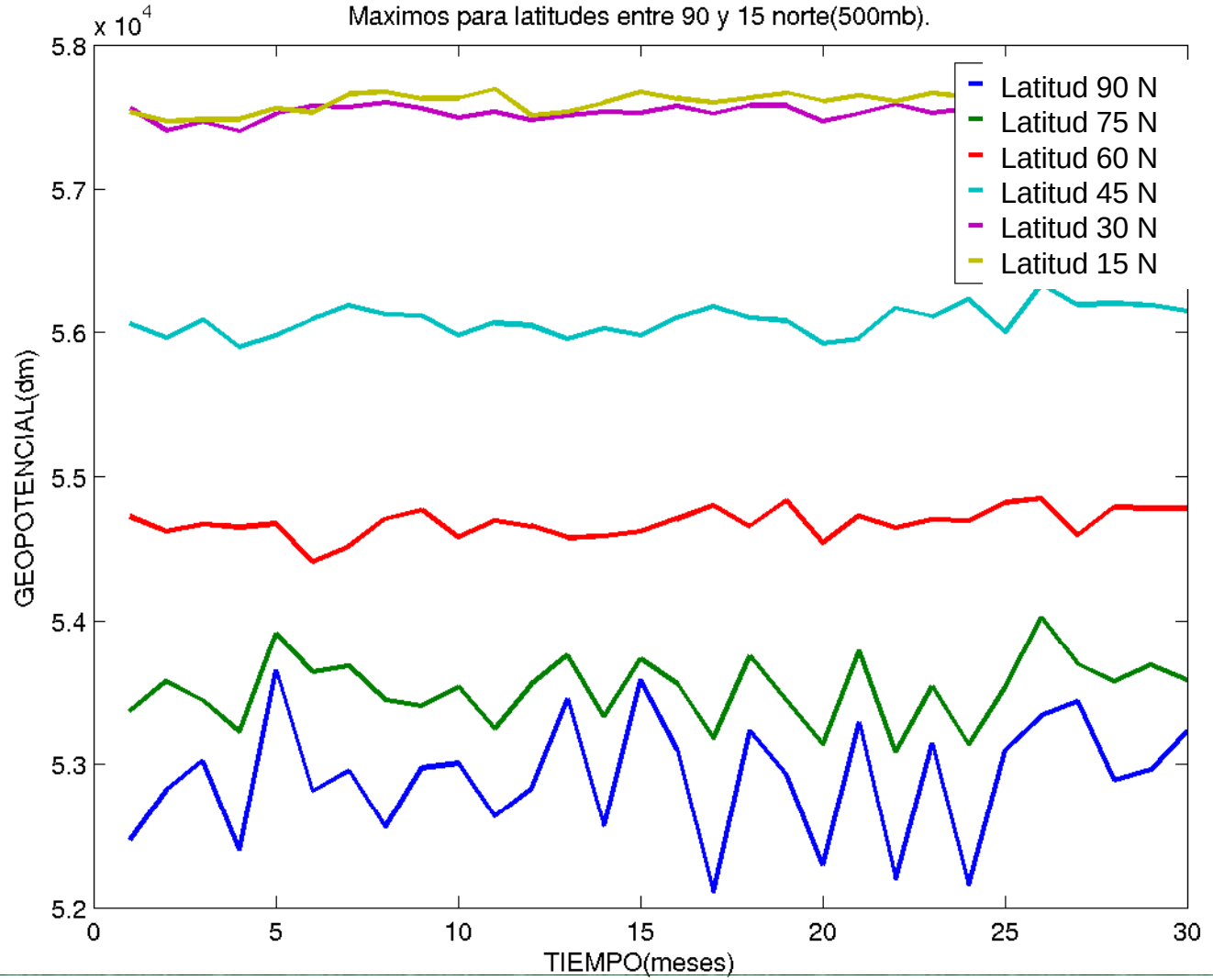
x 10^5
1.23
1.22
1.21
1.2
1.19
1.18
1.17
1.16
1.15
1.14
1.13
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 N
Latitud 75 N
Latitud 60 N
Latitud 45 N
Latitud 30 N
Latitud 15 N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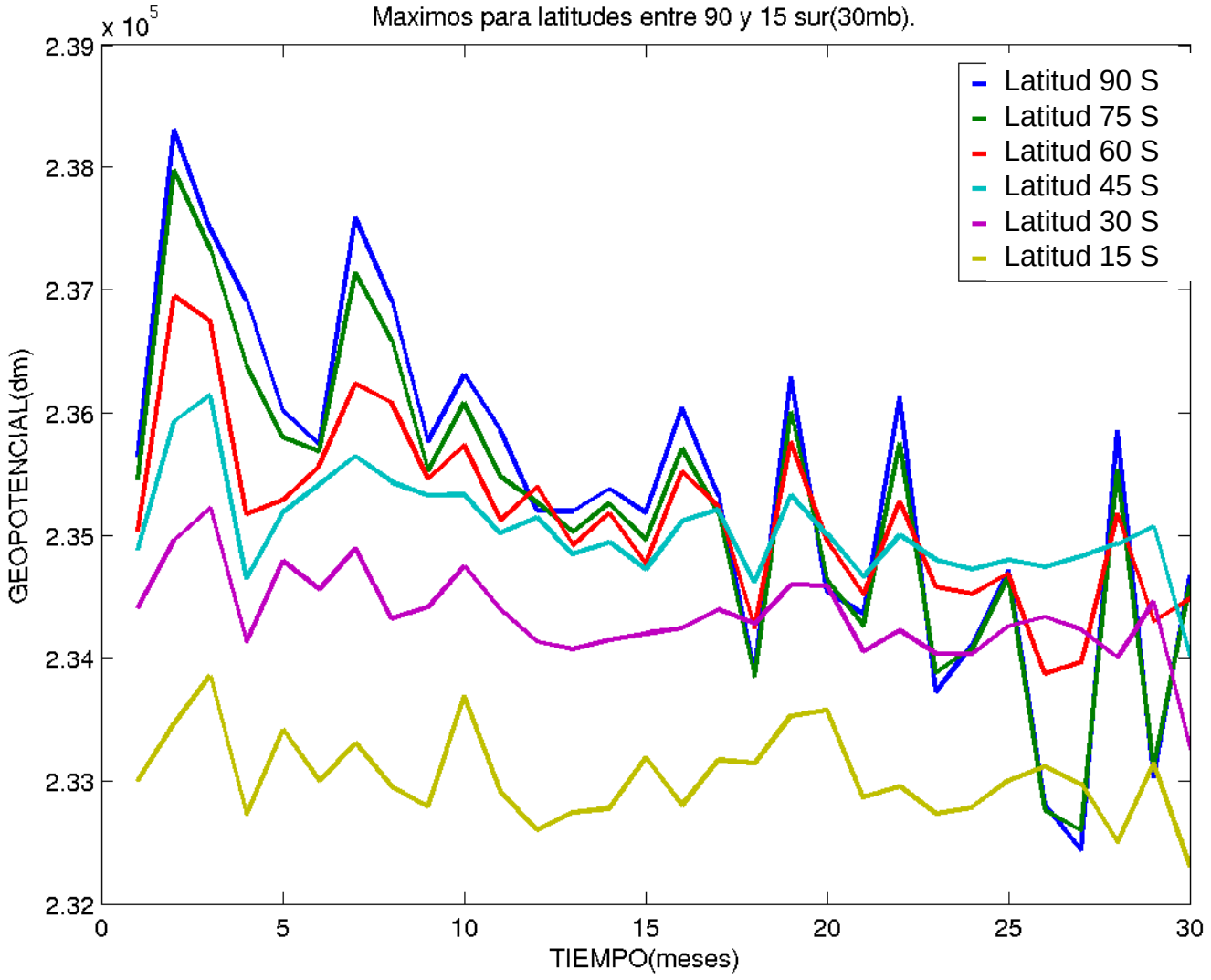
x 10^4
5.8
5.7
5.6
5.5
5.4
5.3
5.2
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 N
Latitud 75 N
Latitud 60 N
Latitud 45 N
Latitud 30 N
Latitud 15 N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2.38
2.37
2.36
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2.34
2.33
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0
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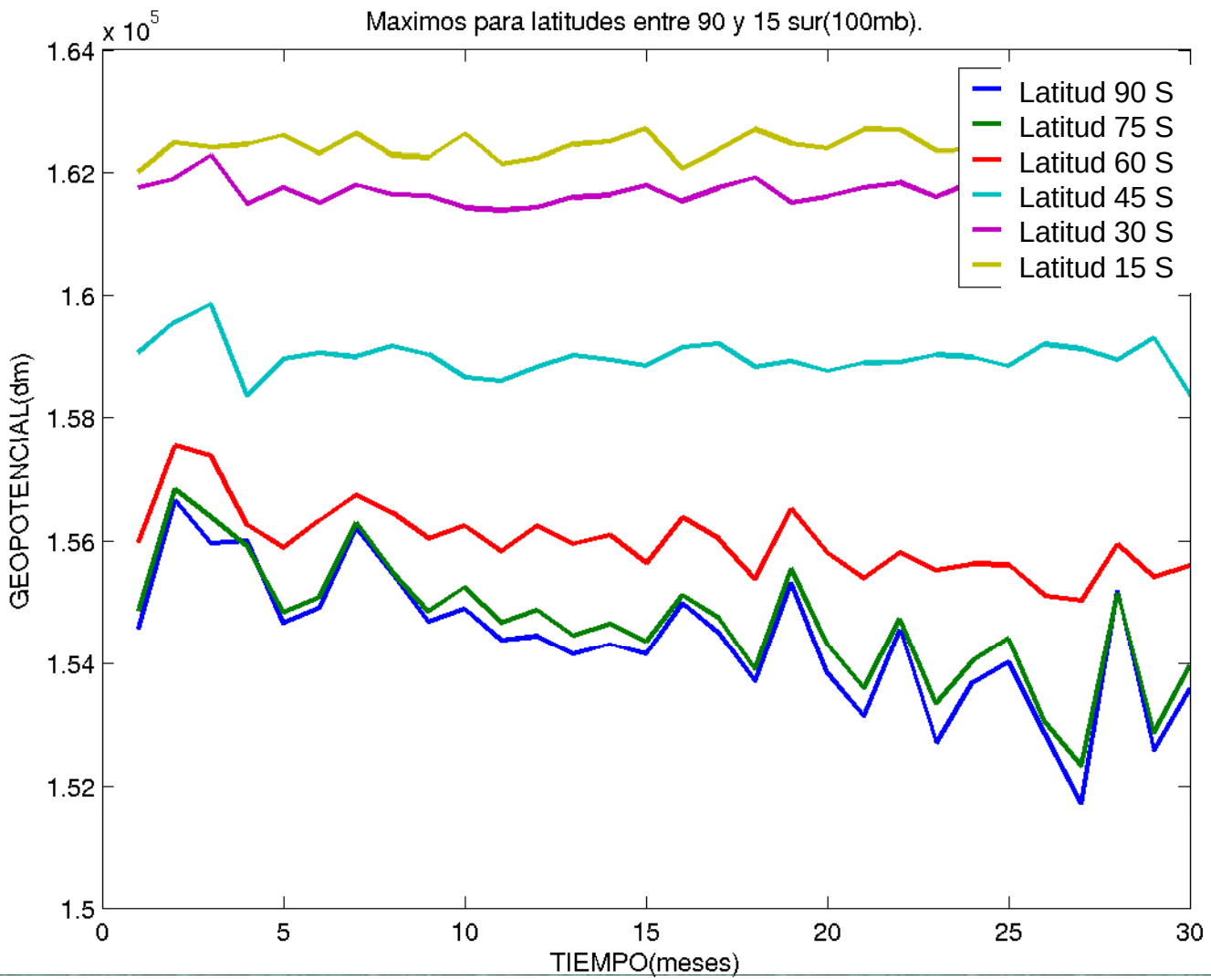
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S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x 10^5
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1.62
1.6
1.58
1.56
1.54
1.52
1.5
GEOPOTENCIAL(dm)
0
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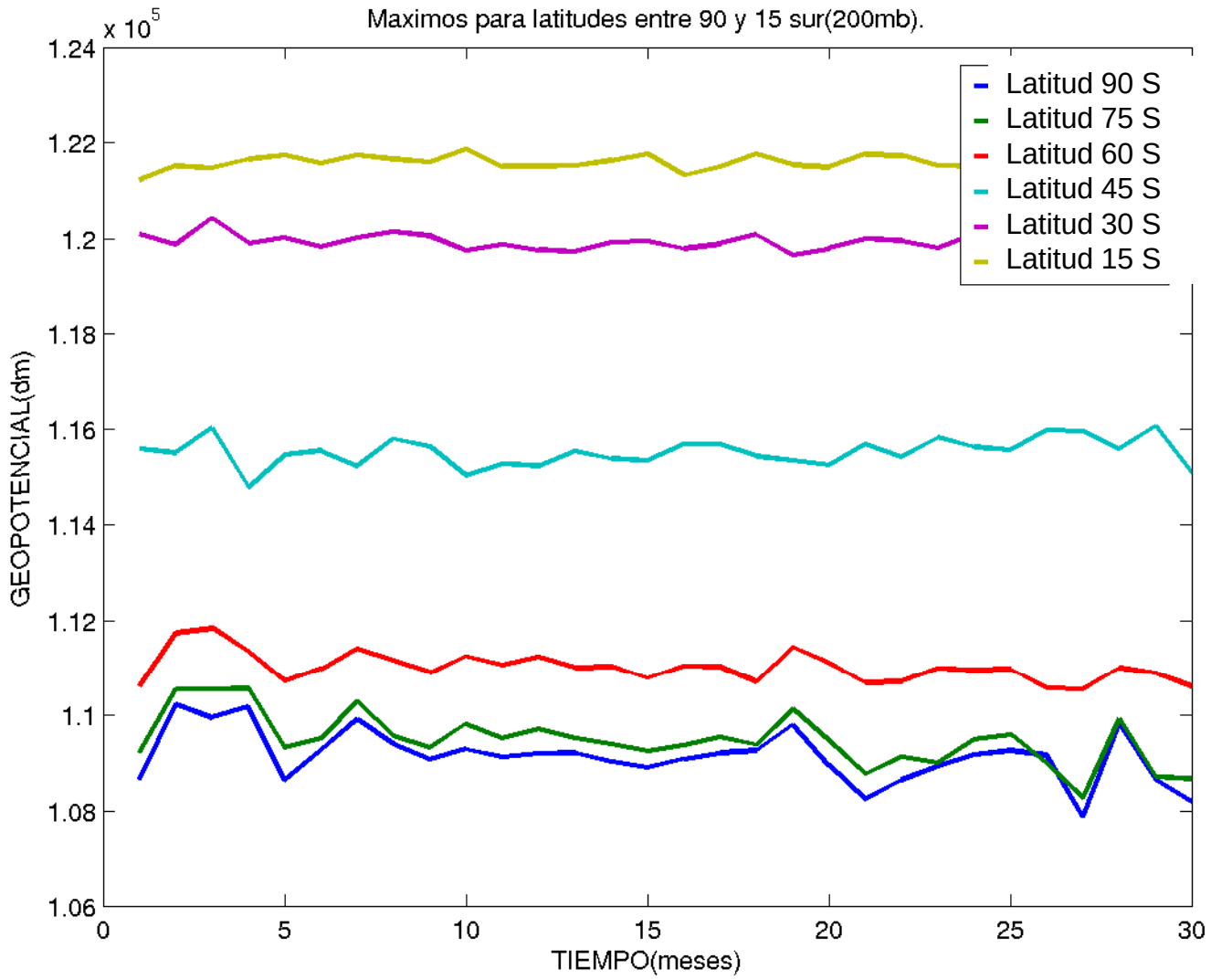
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S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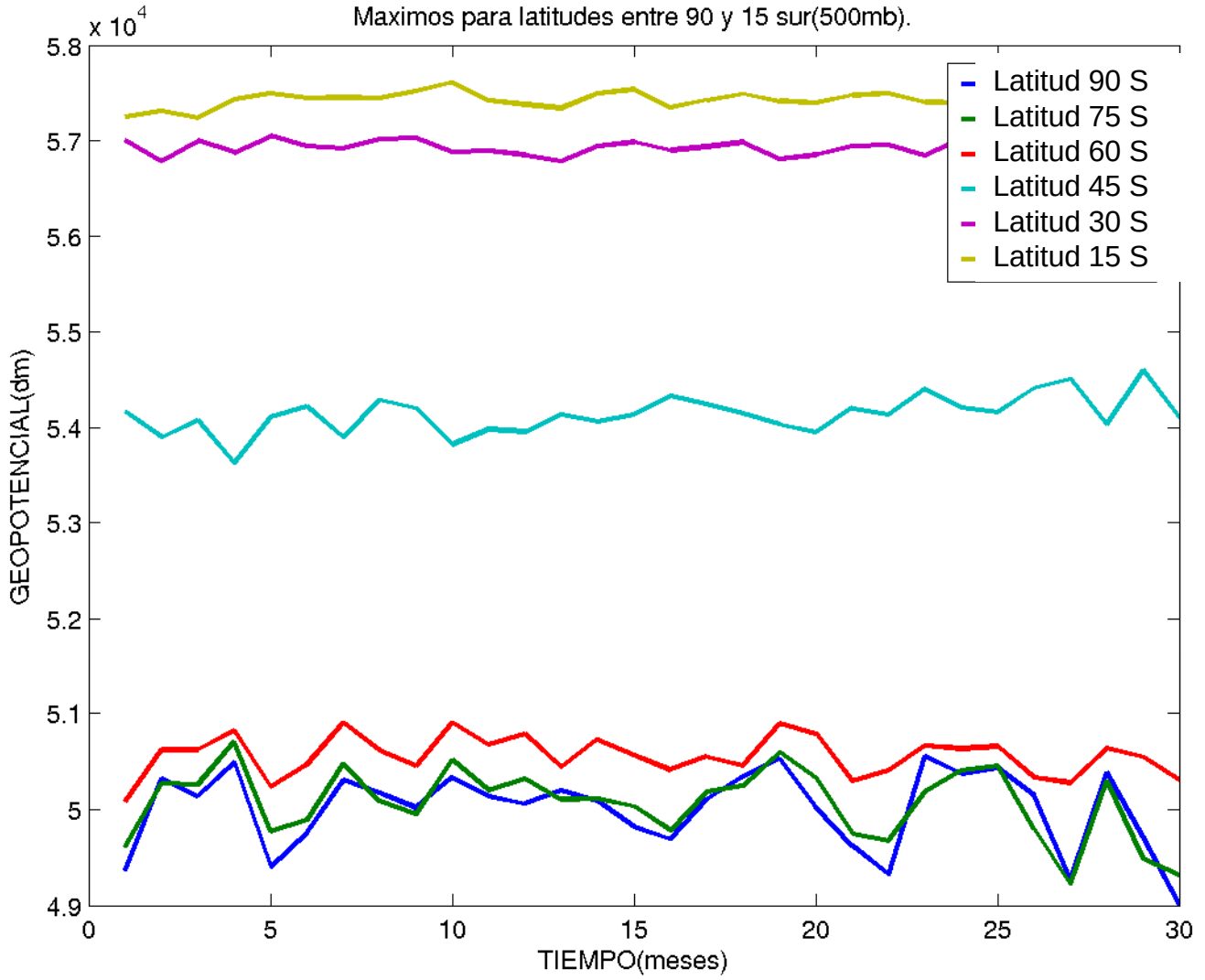
1.22
1.2
1.18
1.16
1.14
1.12
1.1
1.08
1.06
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S


Maximos para latitudes entre 90 y 15 sur(500mb).
x 10^4
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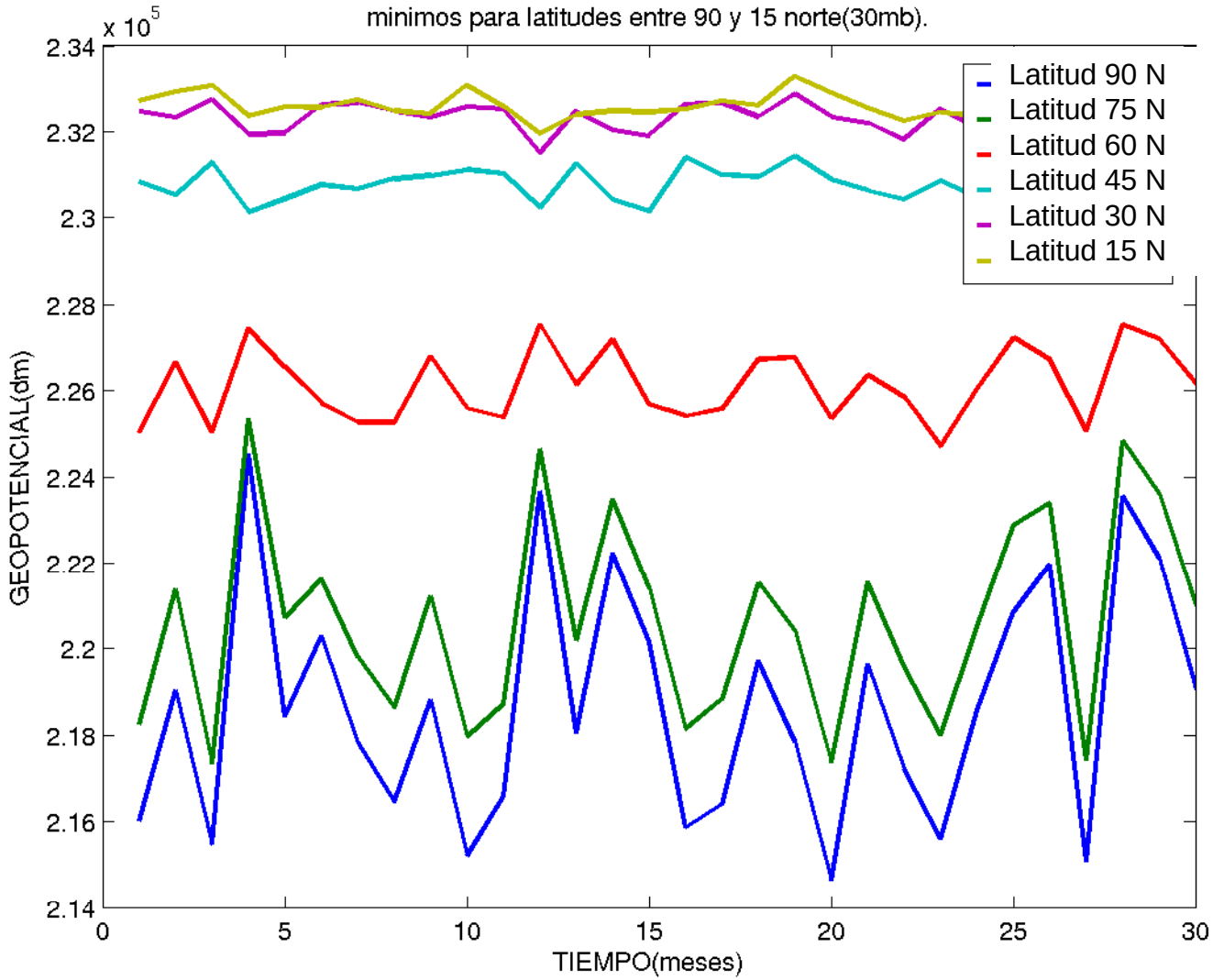
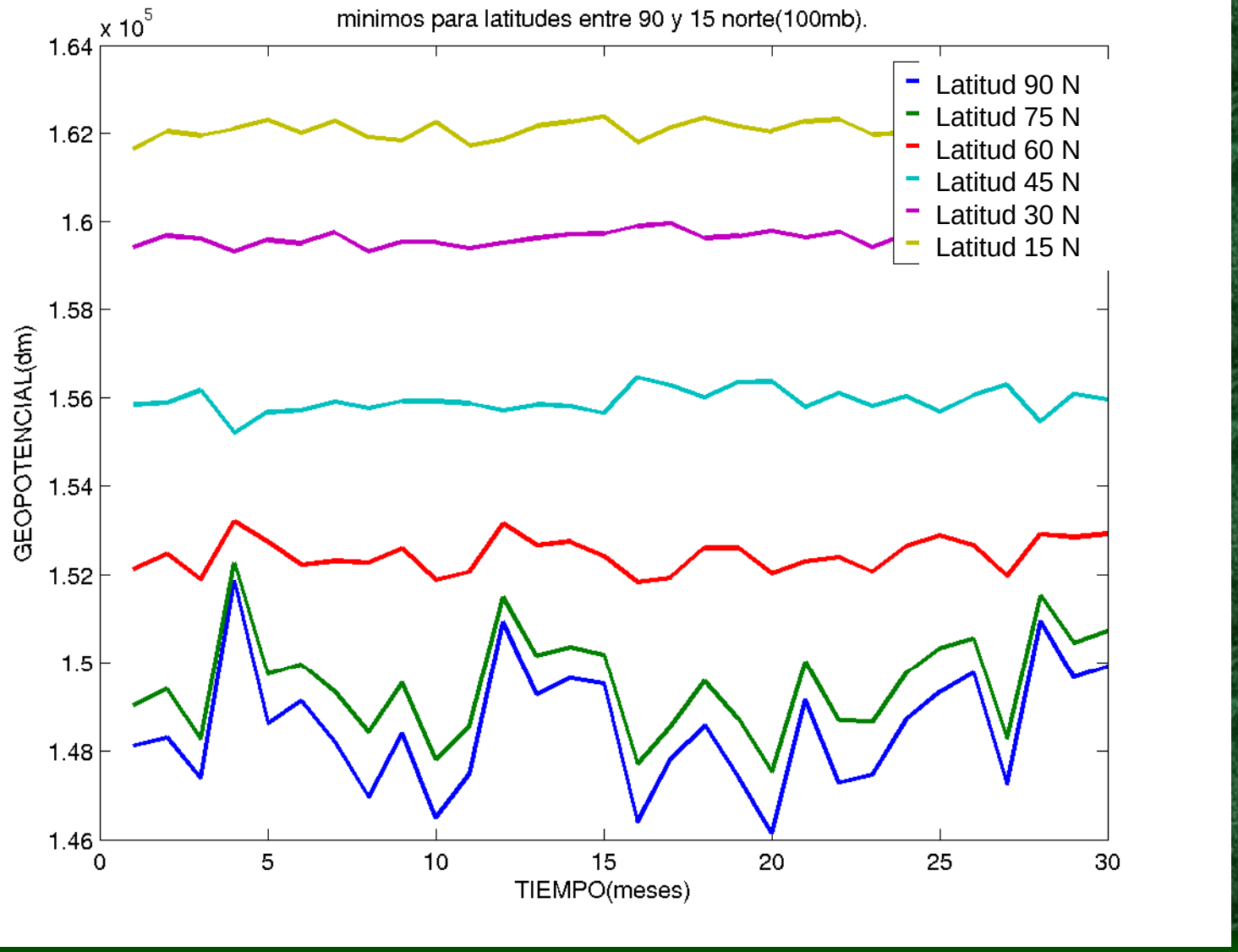
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S

Evolution of the Minima




minimos para latitudes entre 90 y 15 norte(100mb).
x 10^5
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1.56
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1.46
GEOPOTENCIAL(dm)
0
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10
15
20
25
30
TIEMPO(meses)
Latitud 90 N
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Latitud 60 N
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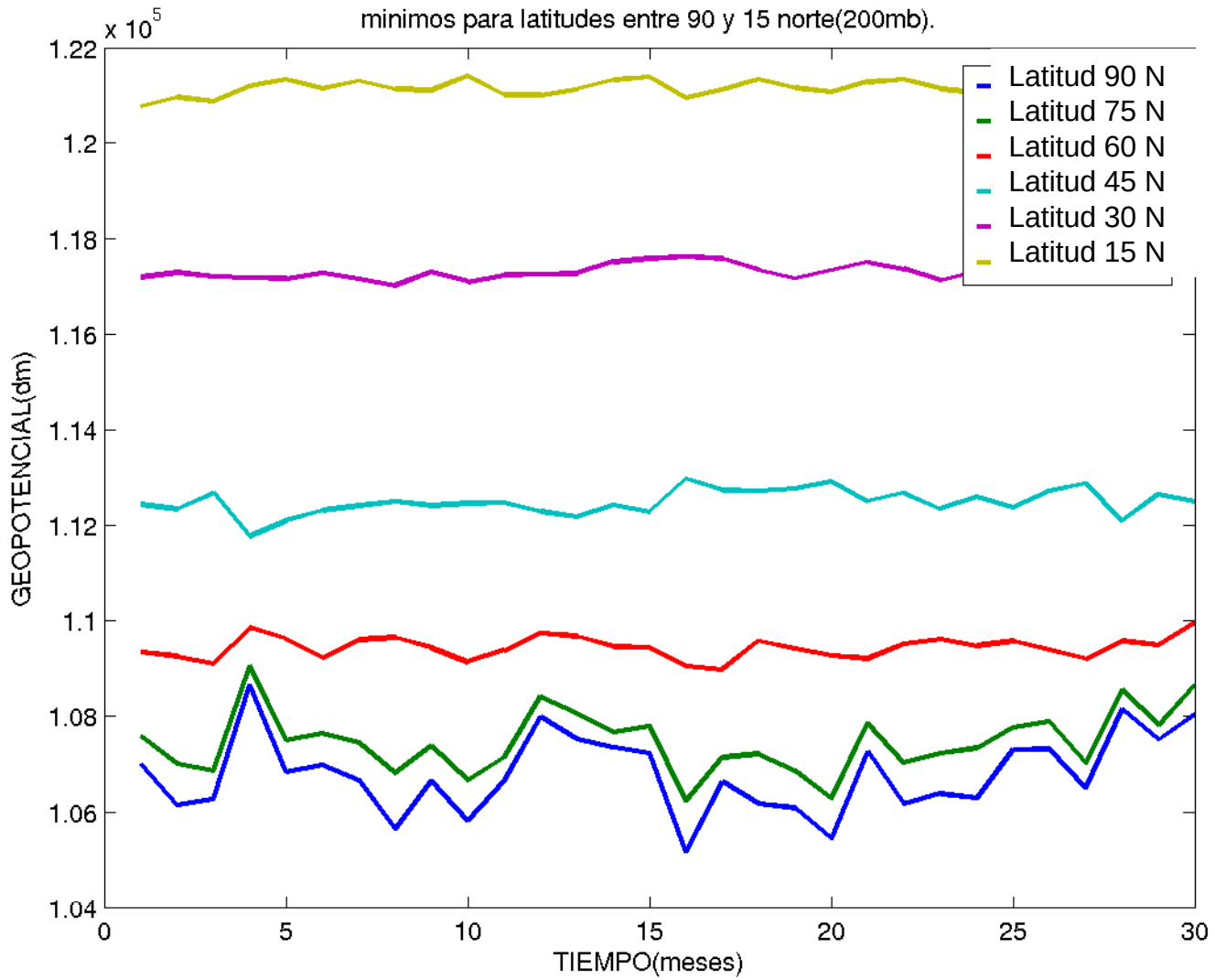
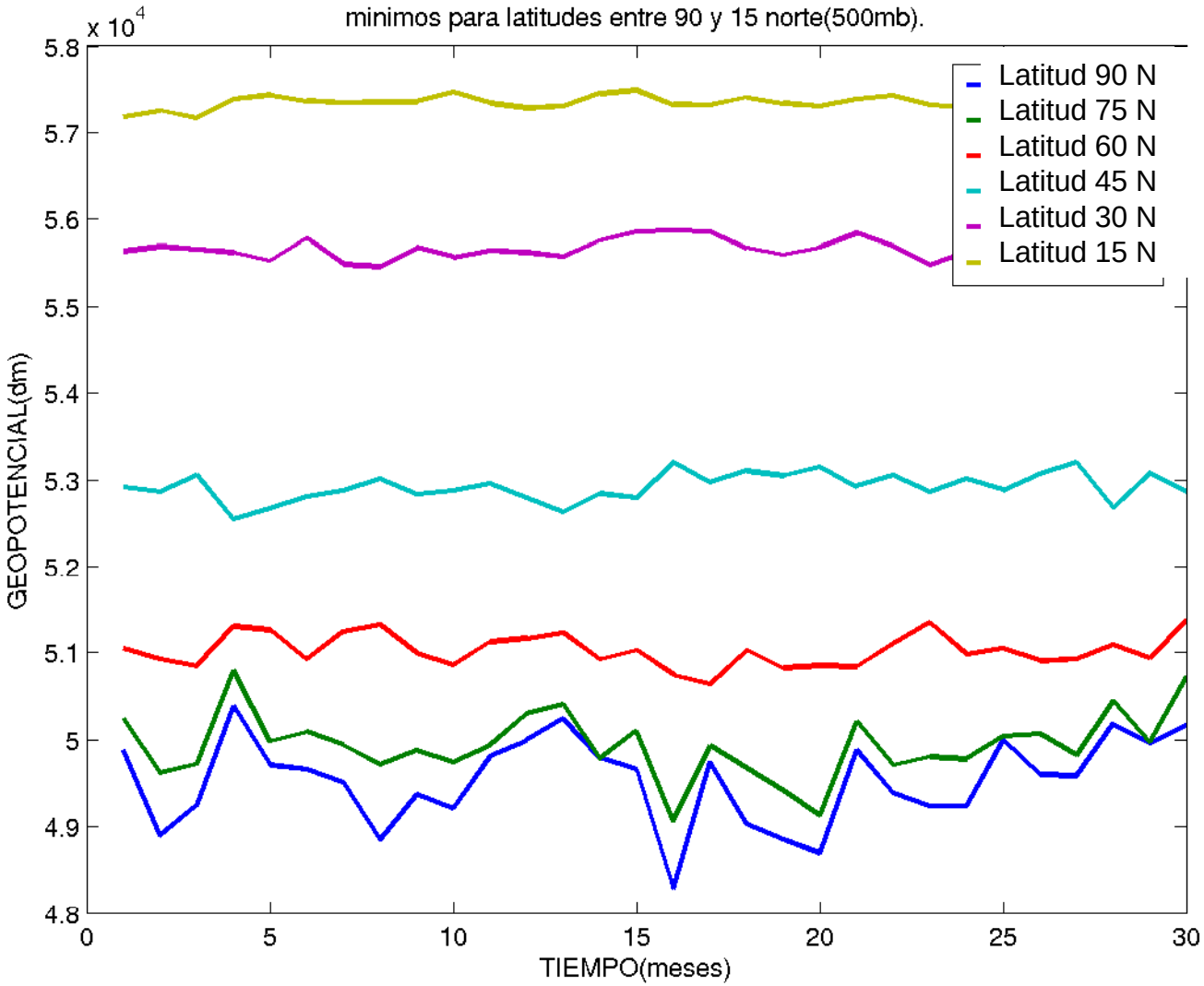
Latitud 15 N


minimos para latitudes entre 90 y 15 norte(200mb).
x 10^5
1.22
1.2
1.18
1.16
1.14
1.12
1.1
1.08
1.06
1.04
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 N
Latitud 75 N
Latitud 60 N
Latitud 45 N
Latitud 30 N
Latitud 15 N


minimos para latitudes entre 90 y 15 norte(500mb).
x 10^4
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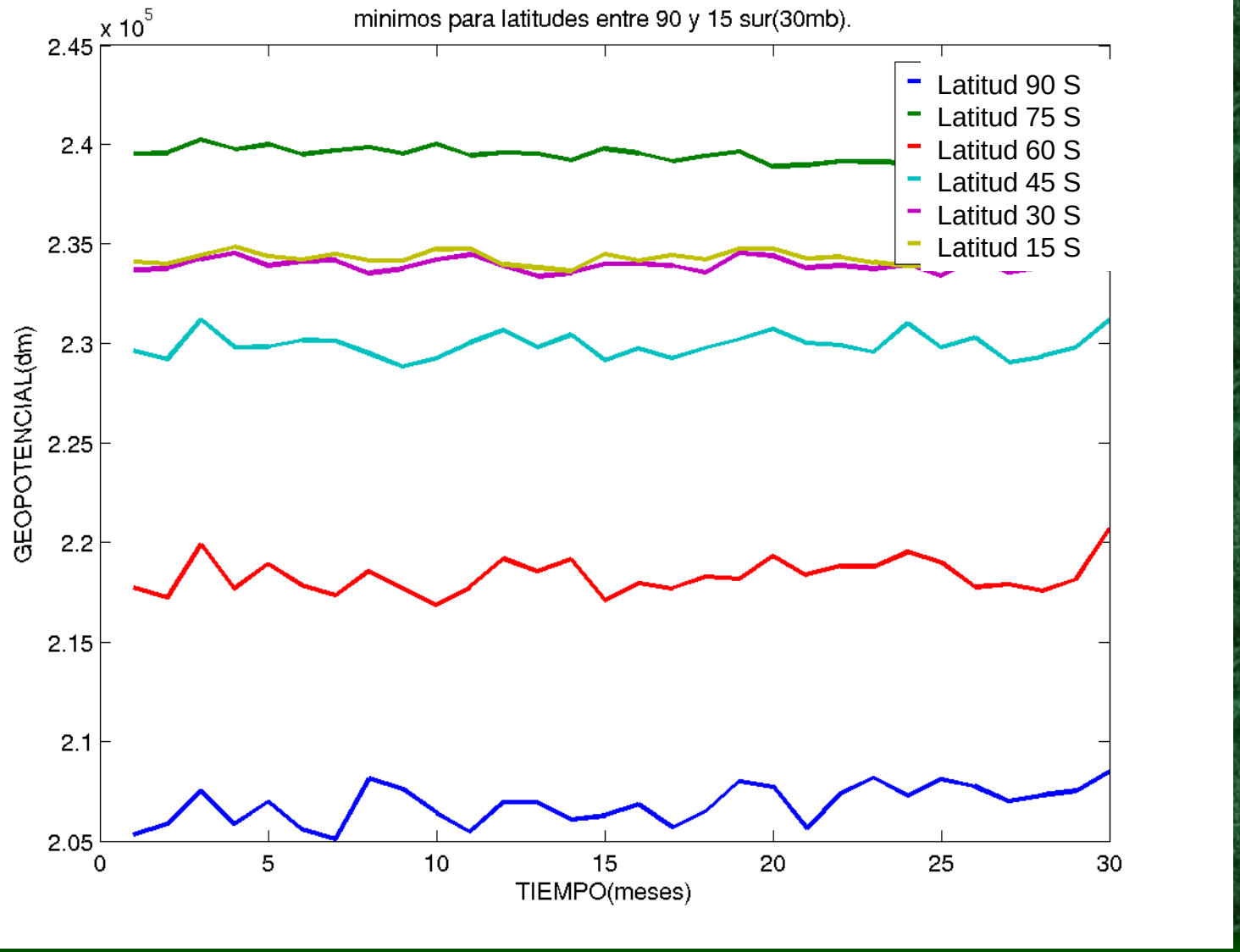
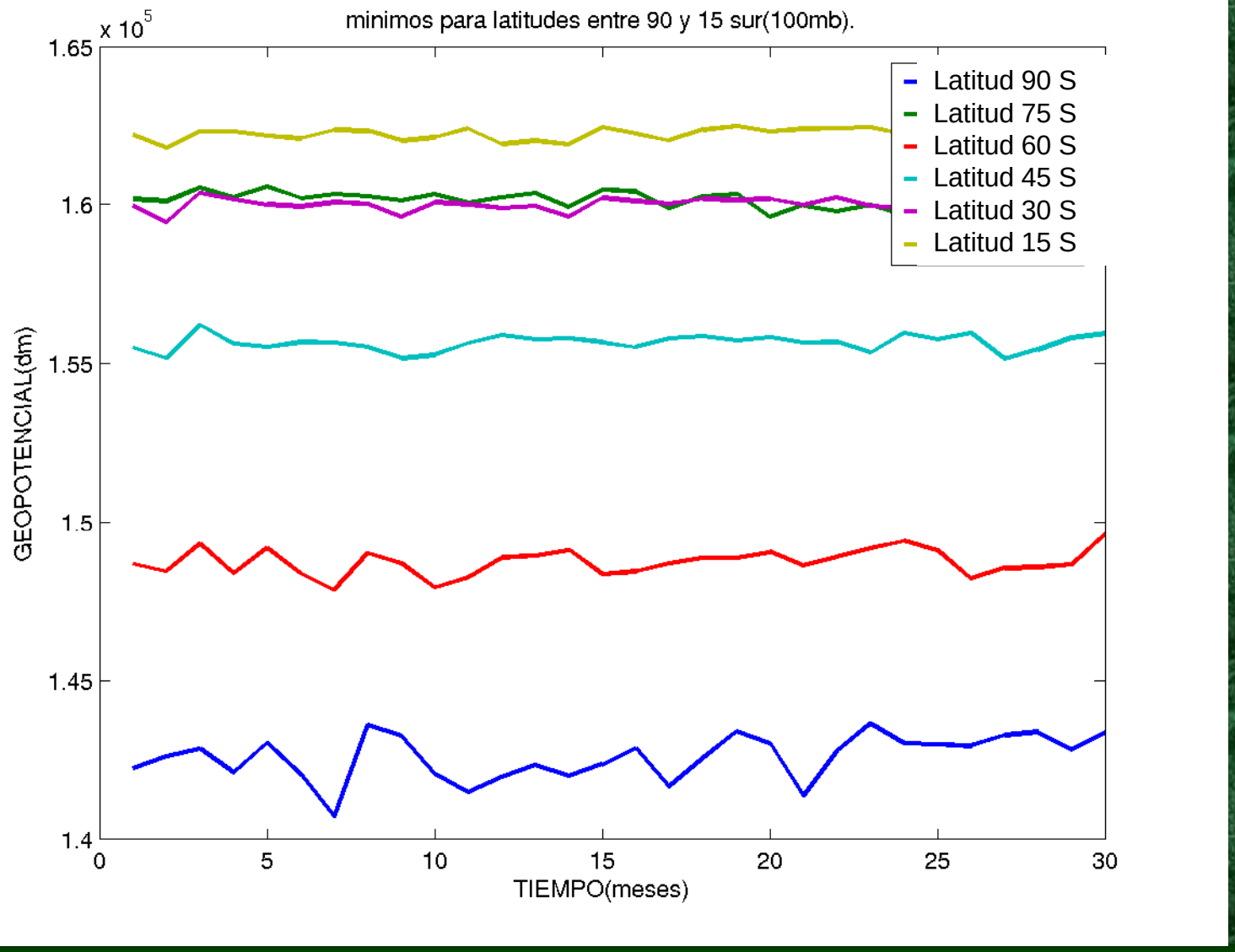
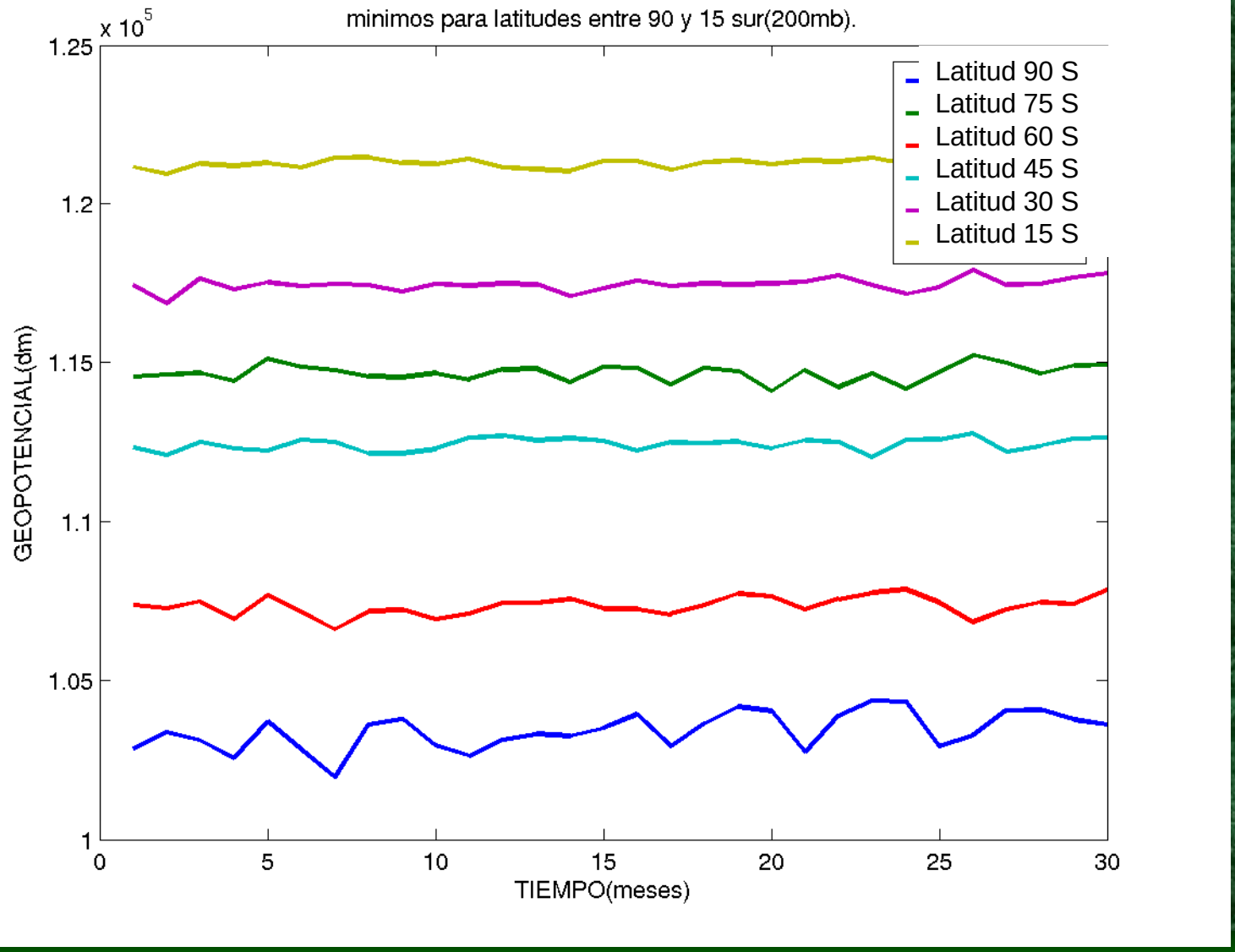
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 N
Latitud 75 N
Latitud 60 N
Latitud 45 N
Latitud 30 N
Latitud 15 N


minimos para latitudes entre 90 y 15 sur(30mb).
x 10^5
2.45
2.4
2.35
2.3
2.25
2.2
2.15
2.1
2.05
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S


minimos para latitudes entre 90 y 15 sur(100mb).
x 10^5
1.65
1.6
1.55
1.5
1.45
1.4
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S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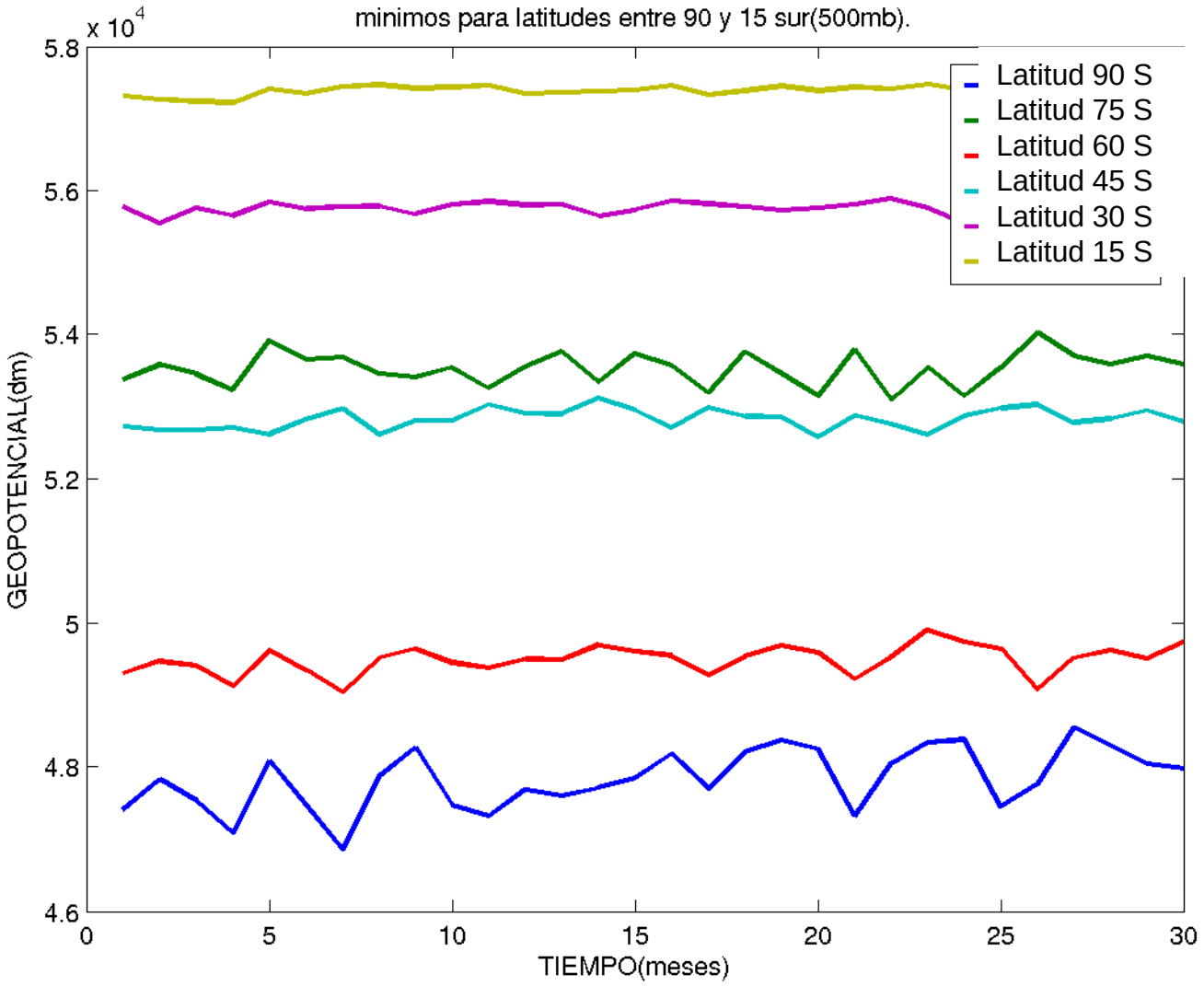
1.2
1.15
1.1
1.05
1
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S


minimos para latitudes entre 90 y 15 sur(500mb).
x 10^4
5.8
5.6
5.4
5.2
5
4.8
4.6
GEOPOTENCIAL(dm)
0
5
10
15
20
25
30
TIEMPO(meses)
Latitud 90 S
Latitud 75 S
Latitud 60 S
Latitud 45 S
Latitud 30 S
Latitud 15 S

- The amplitude is inversely proportional to the distance to the pole.
- the maxima interannual variation is smaller for heights nearer the ground.
- The series of the maxima at stratospherics levels show a negative trend los latitudes near the poles (both hemispheres)
- The series of maxima y minima in tropical zone, don´t show diffrences beetwen both sides of ecuador nor trends .

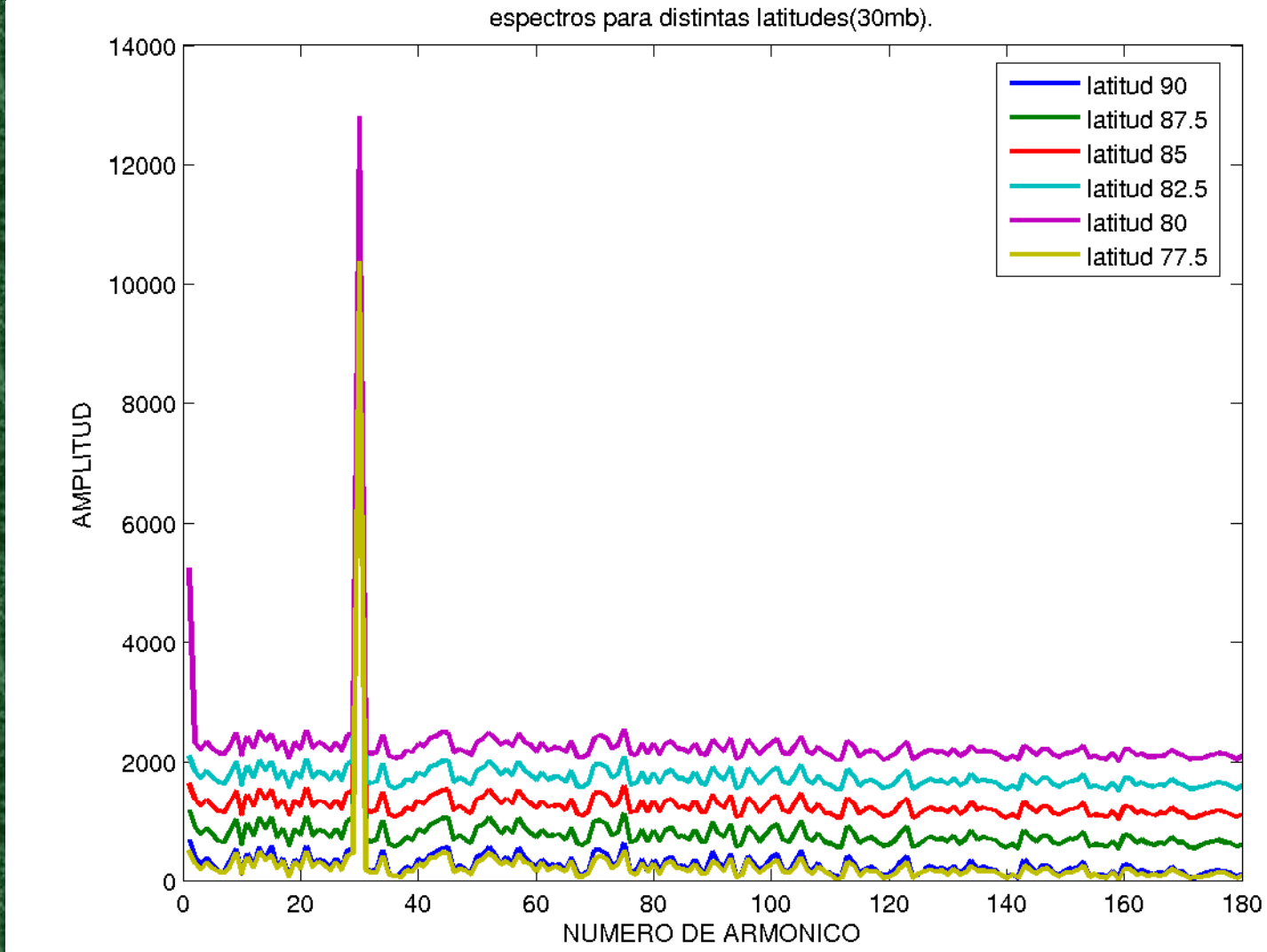
II_ Spectra

The mean annual evolution shows a modulation in the amplitudes of the annual cycles.

a number of factors such as a significant contribution to the mean by low frequency oscillations, internal vacillation of the harmonics of the annual cycle and modulation by non-linear interactions between annual cycle components and low frequency oscillations.

⇨ Obtained from Fouriers analysis

⇨ Show the amplitude of each harmonic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latitud 85
latitud 82.5
latitud 80
latitud 77.5
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8000
10000
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60
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140
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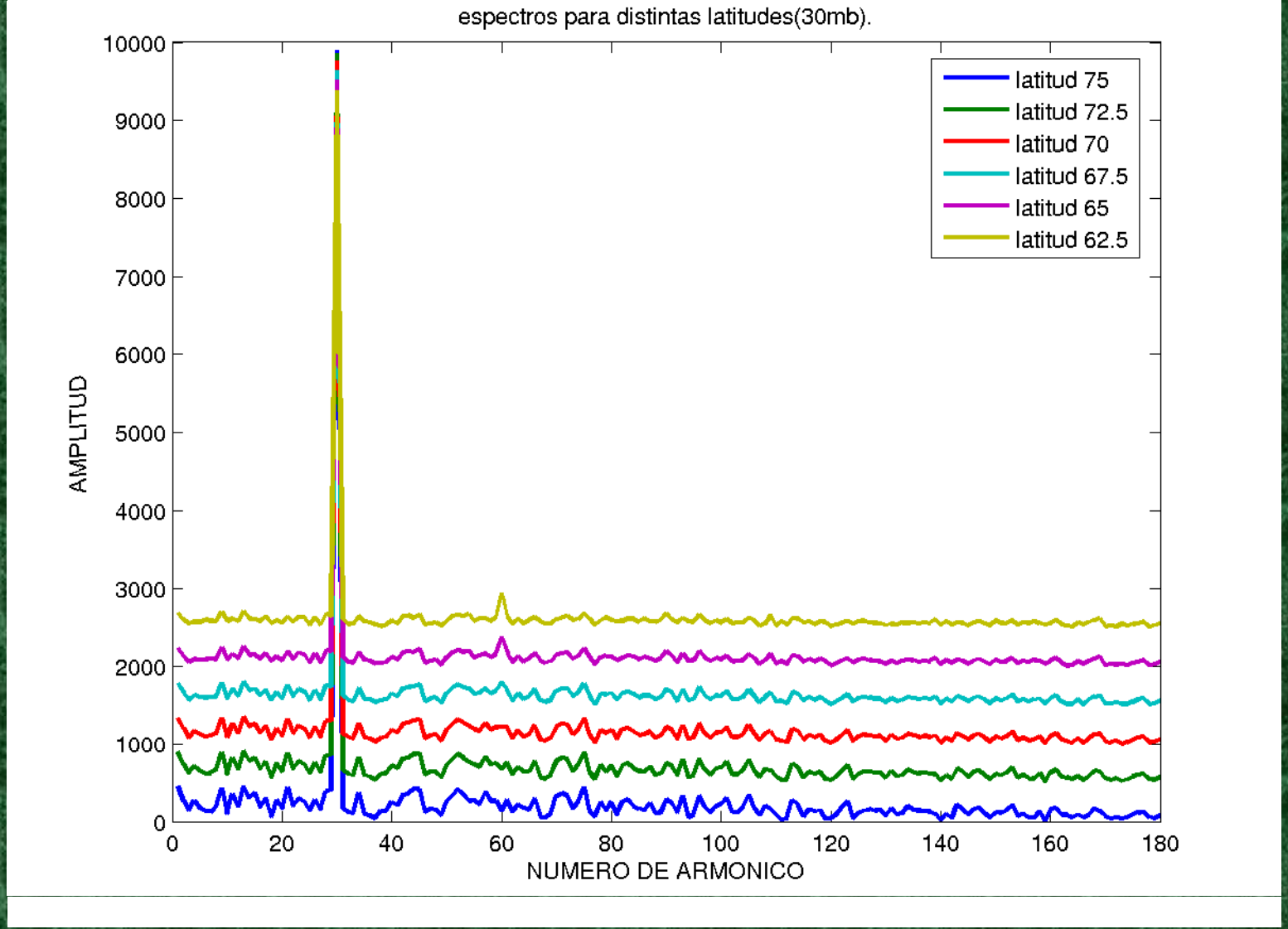
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AMPLITUD
NUMERO DE ARMONICO
latitud 75
latitud 72.5
latitud 70
latitud 67.5
latitud 65
latitud 62.5
0
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4000
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8000
9000
10000
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20
40
60
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100
120
140
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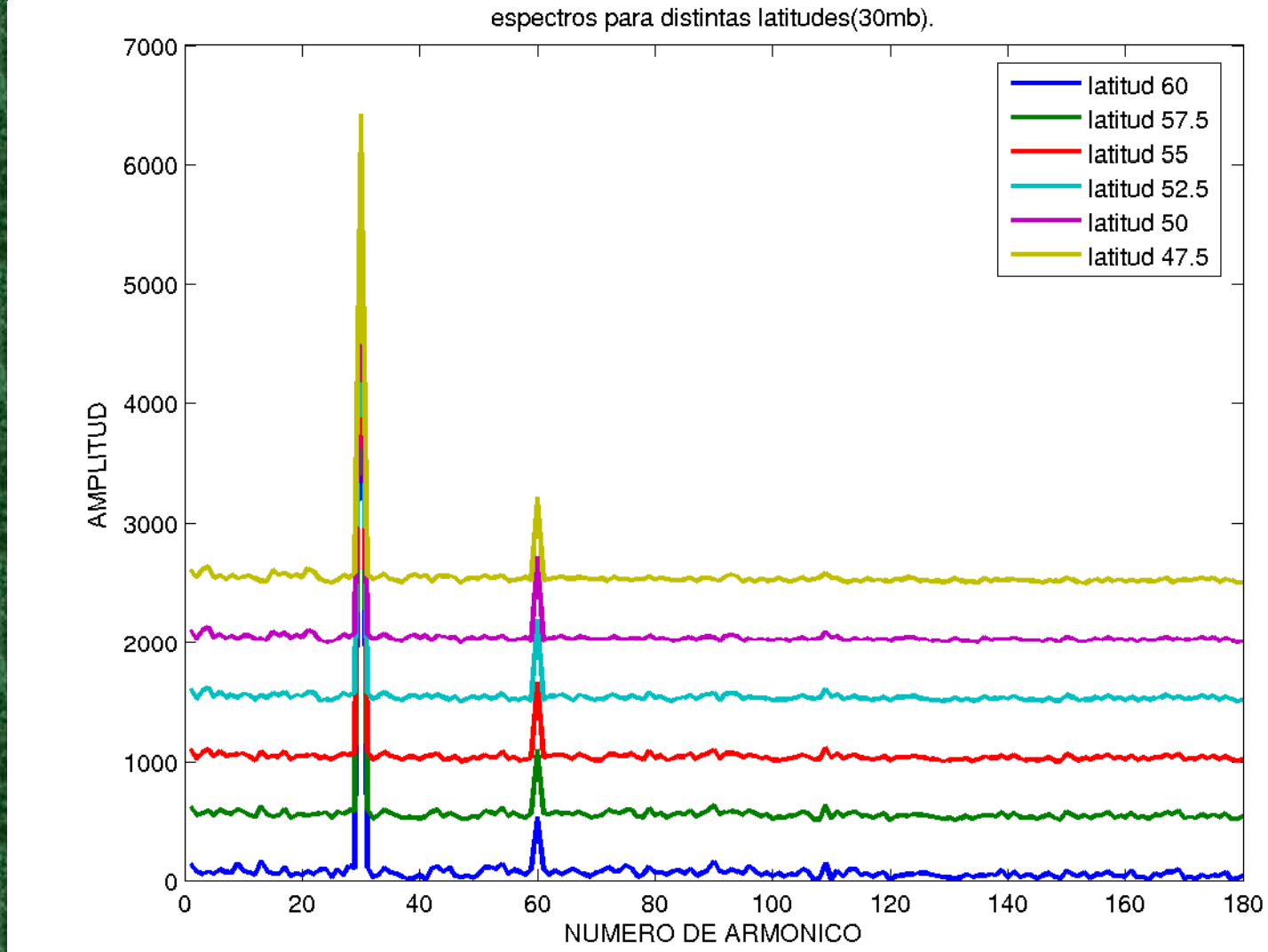
180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latitud 55
latitud 52.5
latitud 50
latitud 47.5
AMPLITUD
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3000
4000
5000
6000
7000
0
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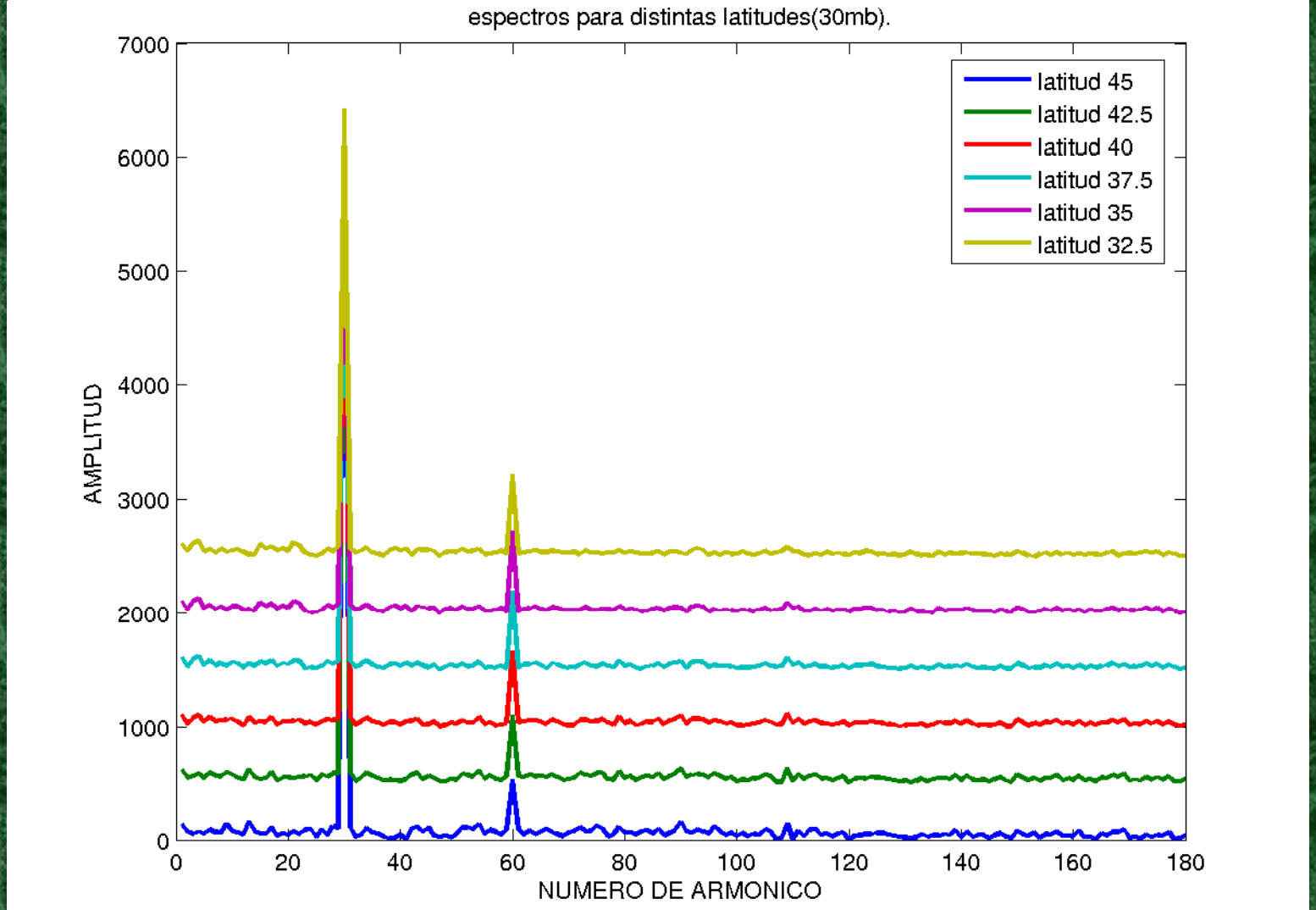
40
60
80
100
120
140
160
180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latitud 40
latitud 37.5
latitud 35
latitud 32.5
AMPLITUD
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4000
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6000
7000
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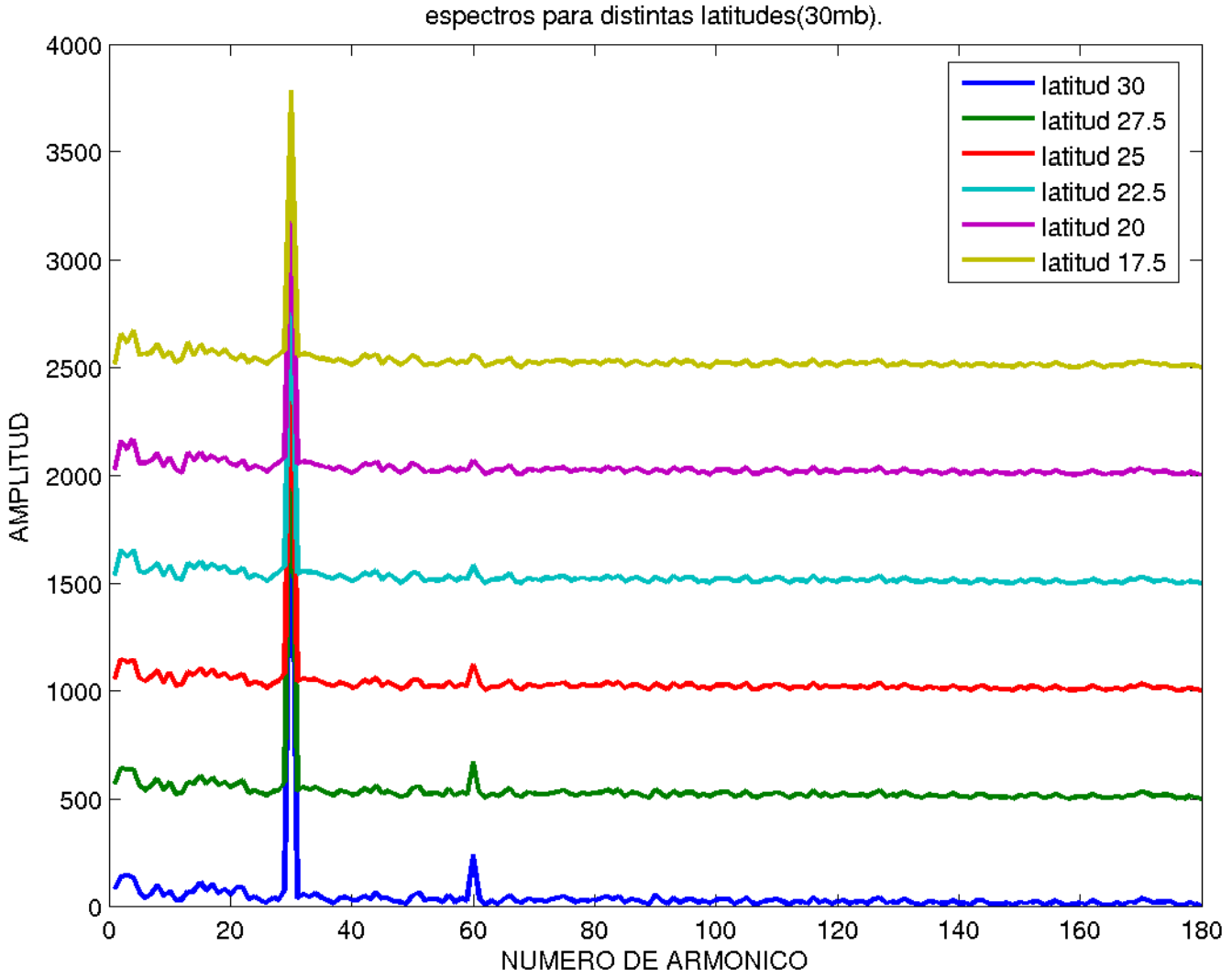
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latitud 30
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latitud 25
latitud 22.5
latitud 20
latitud 17.5
AMPLITUD
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3500
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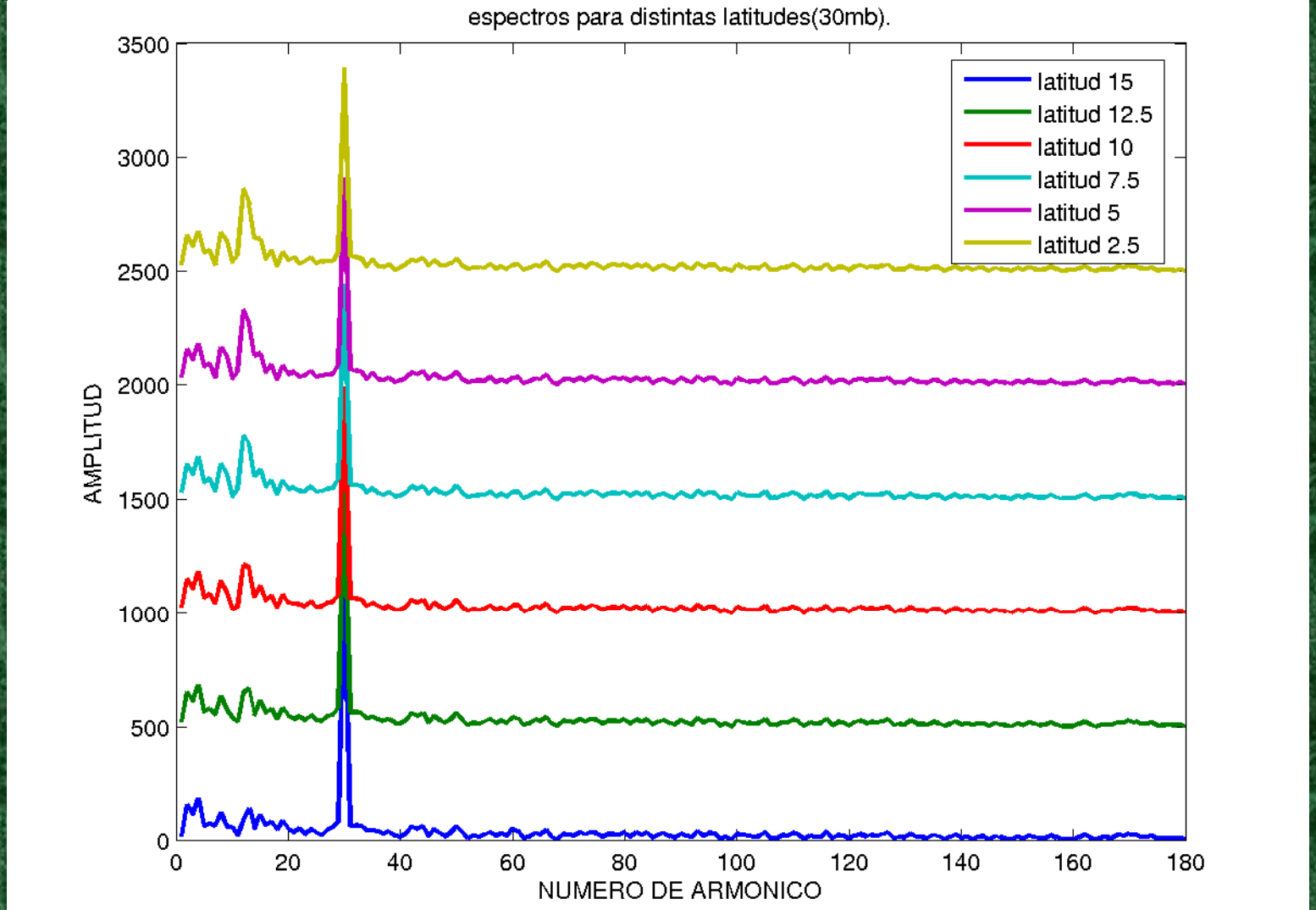
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latitud 10
latitud 7.5
latitud 5
latitud 2.5
AMPLITUD
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1000
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40
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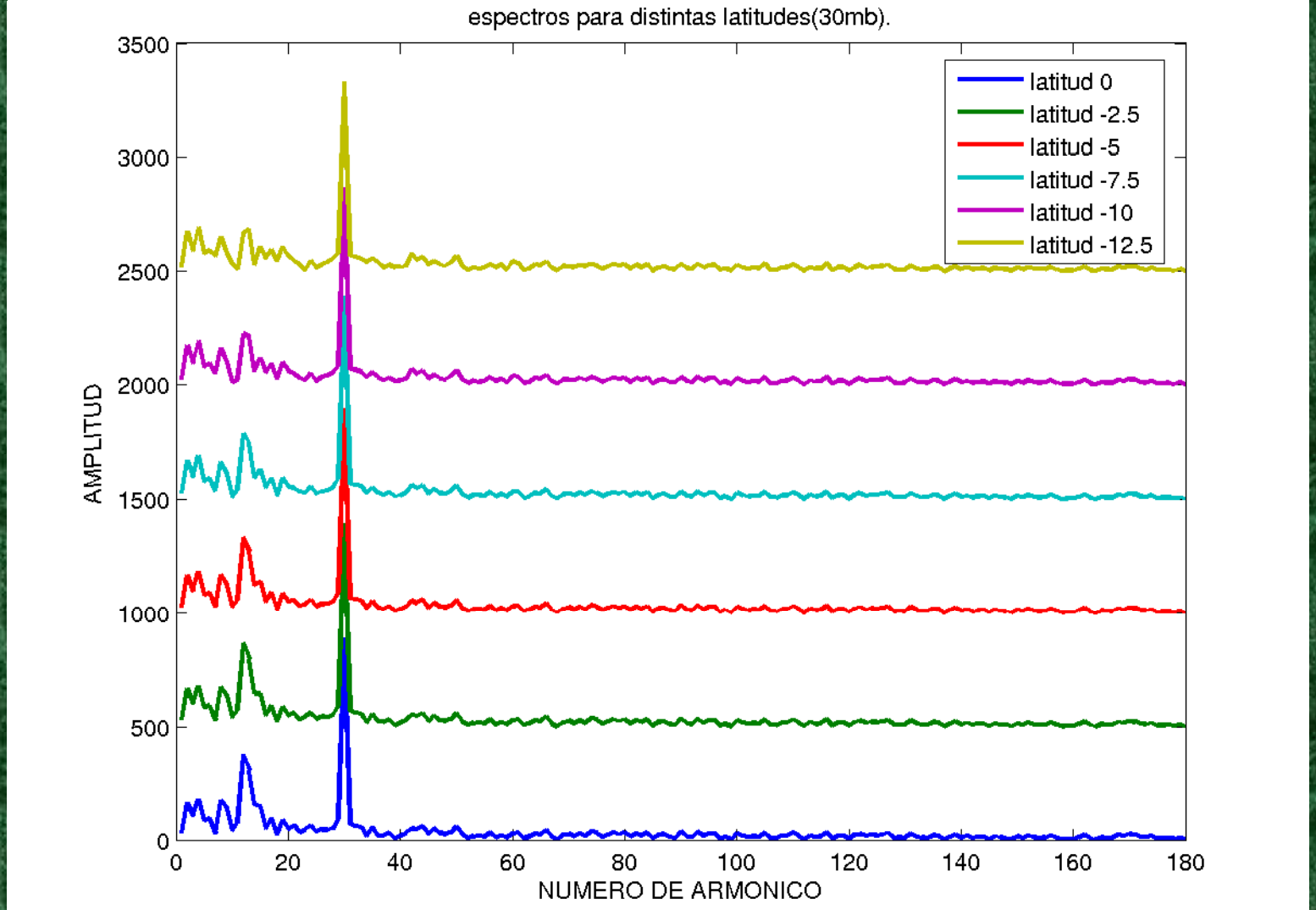
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AMPLITUD
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3000
3500
0
20
40
60
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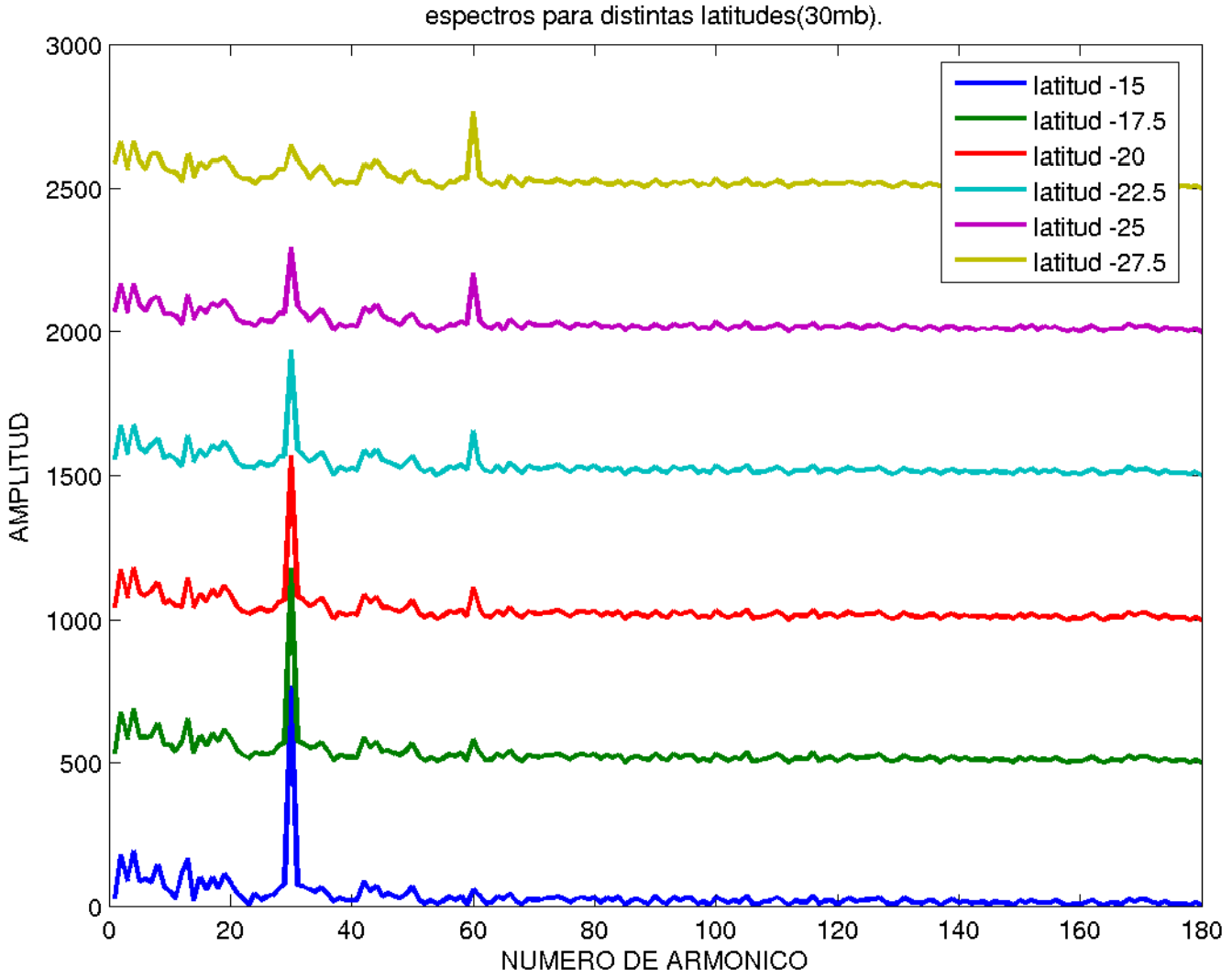
100
120
140
160
180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latitud -15
latitud -17.5
latitud -20
latitud -22.5
latitud -25
latitud -27.5
AMPLITUD
NUMERO DE ARMONICO
0
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2500
3000
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40
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120
140
160
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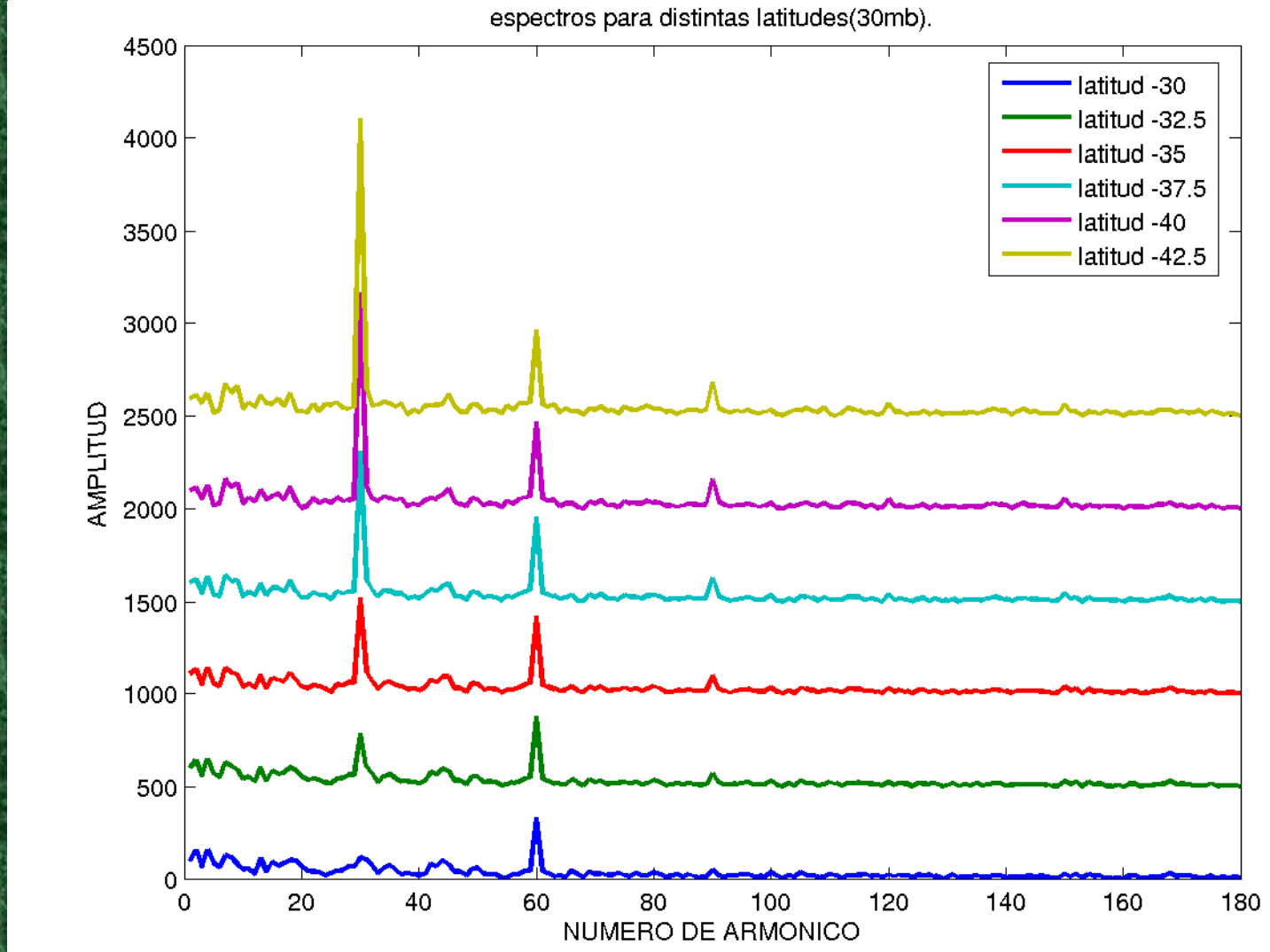
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latitud -35
latitud -37.5
latitud -40
latitud -42.5
AMPLITUD
NUMERO DE ARMONICO
0
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3500
4000
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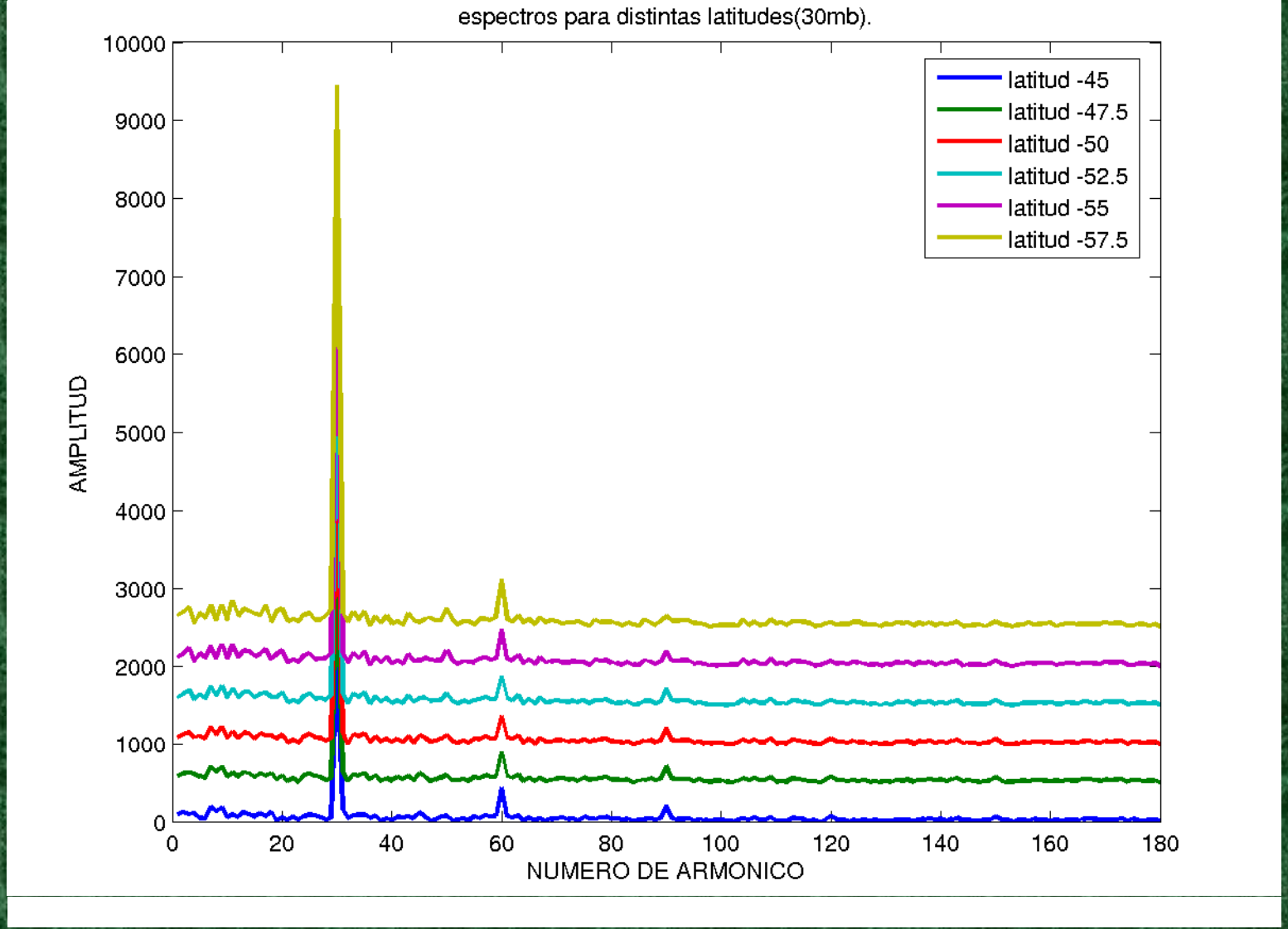
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latitud -50
latitud -52.5
latitud -55
latitud -57.5
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NUMERO DE ARMONICO
0
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7000
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9000
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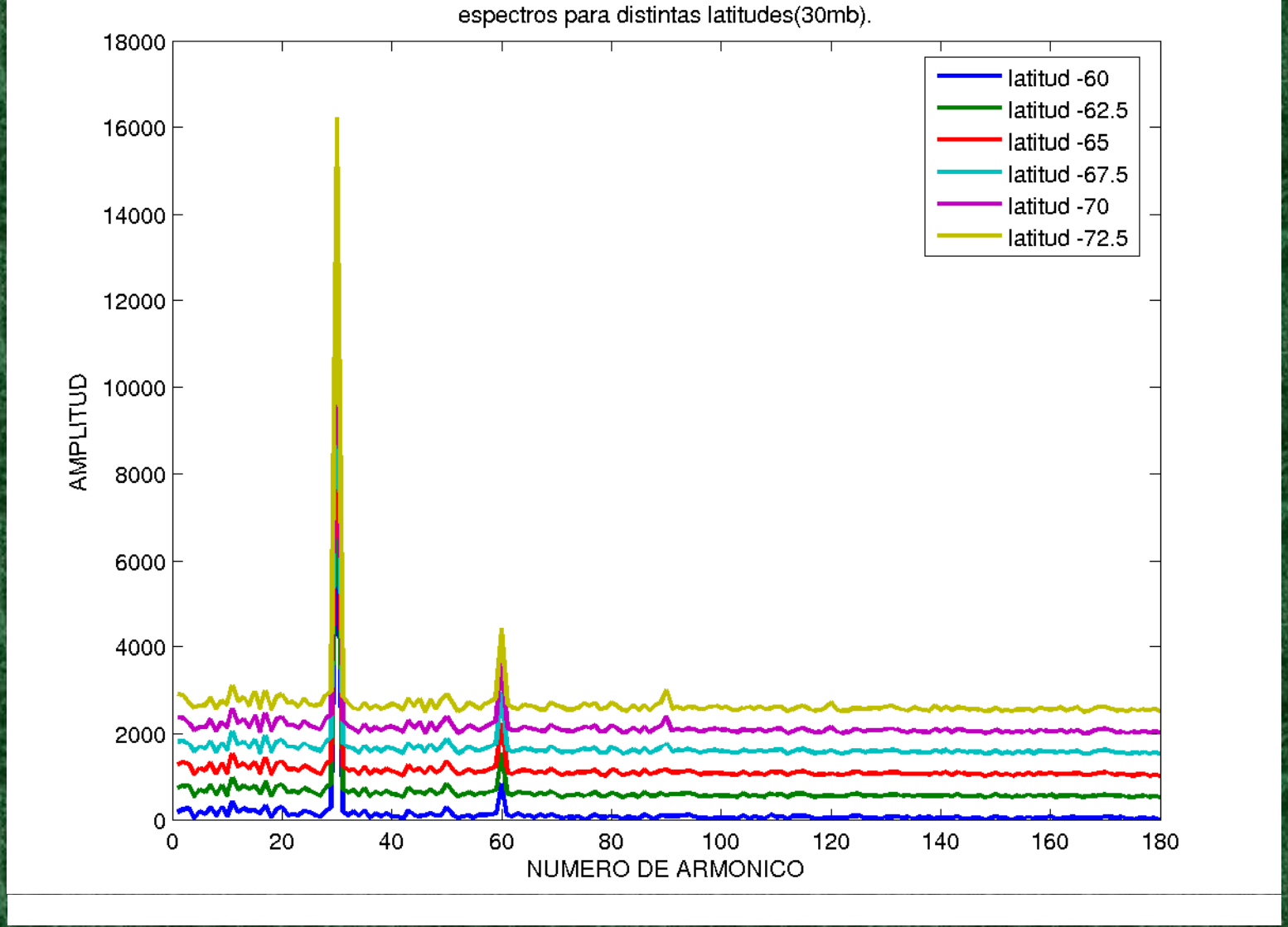
espectros para distintas latitudes(30mb).
AMPLITUD
NUMERO DE ARMONICO
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
0
20
40
60
80
100
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140
160
180
latitud -60
latitud -62.5
latitud -65
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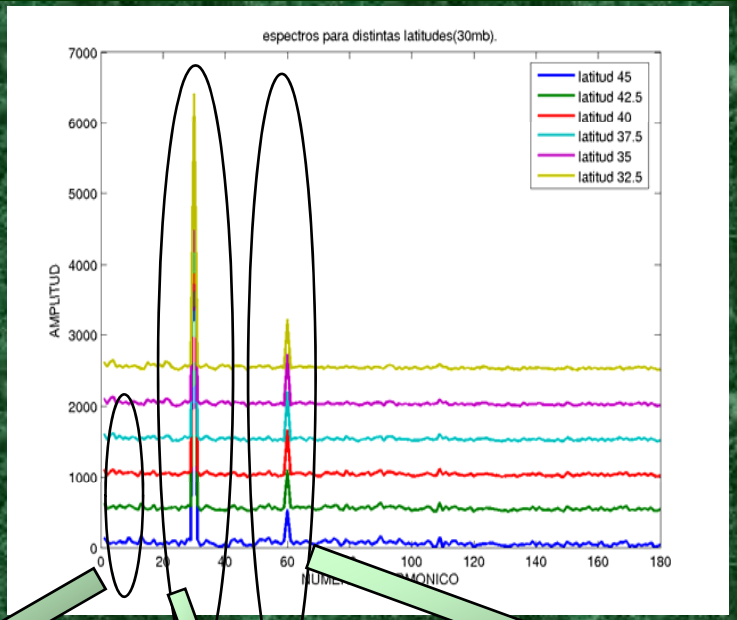
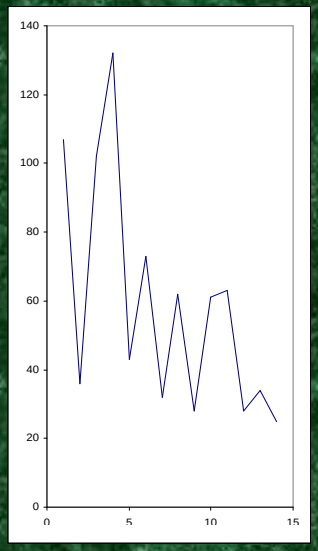
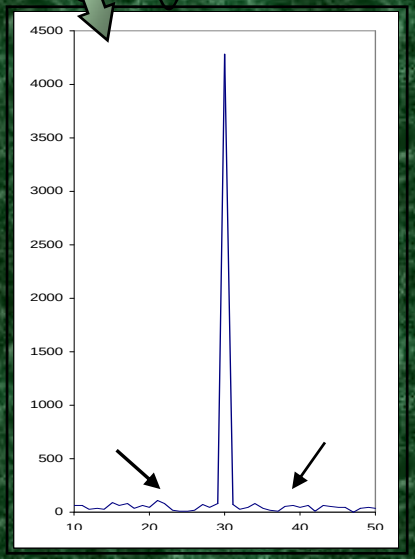
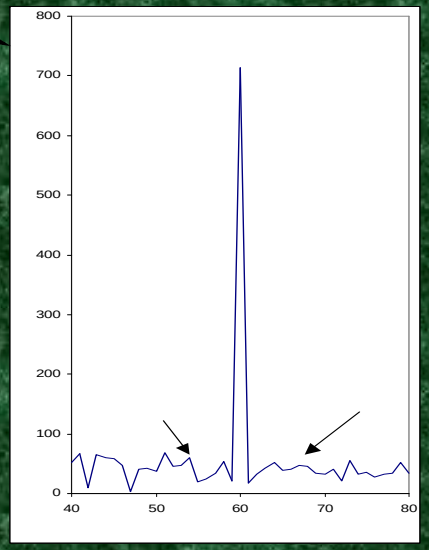
latitud -70
latitud -72.5









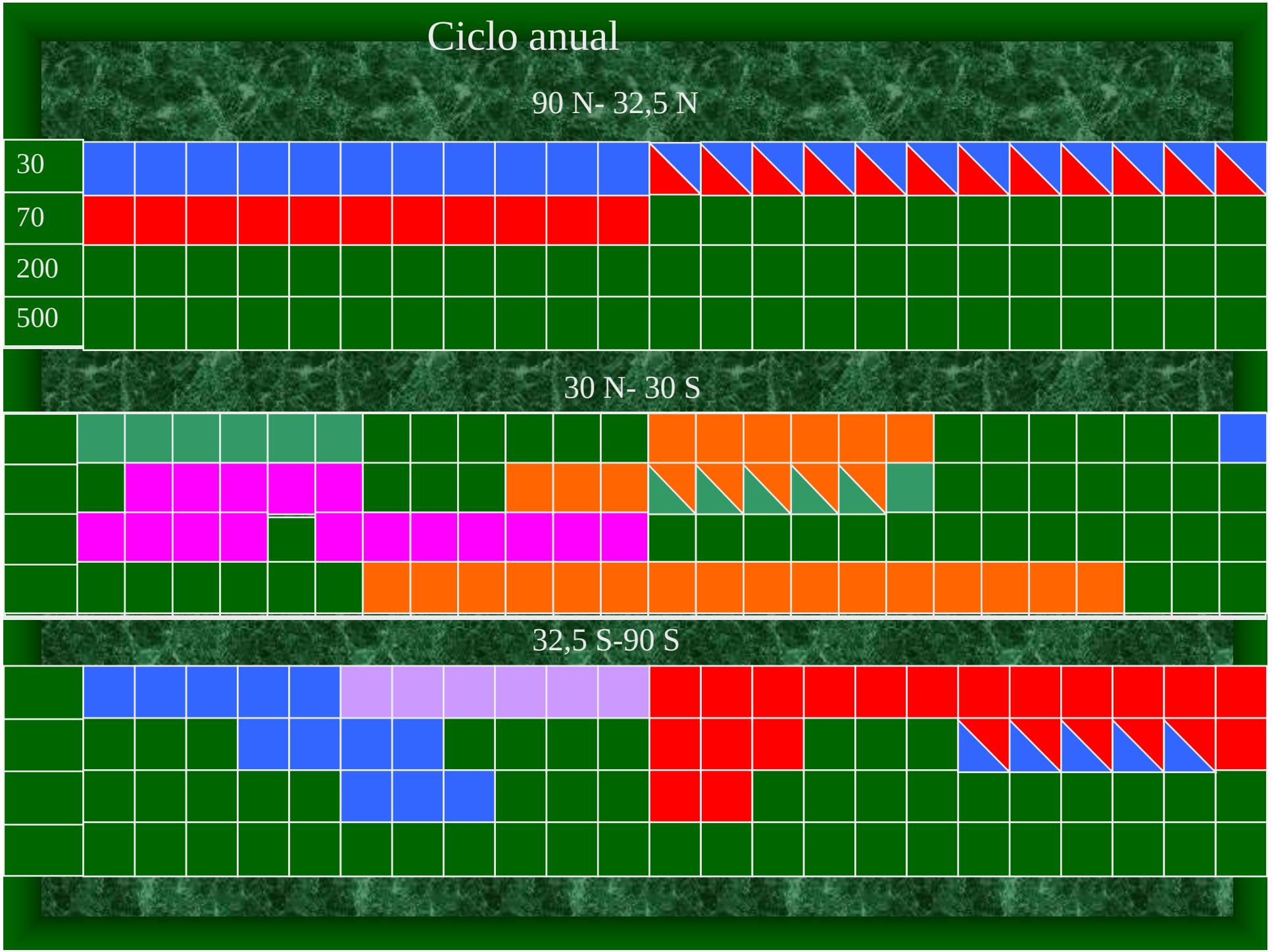
Low frecuency **12-month +side bands** **6-month +side bands**

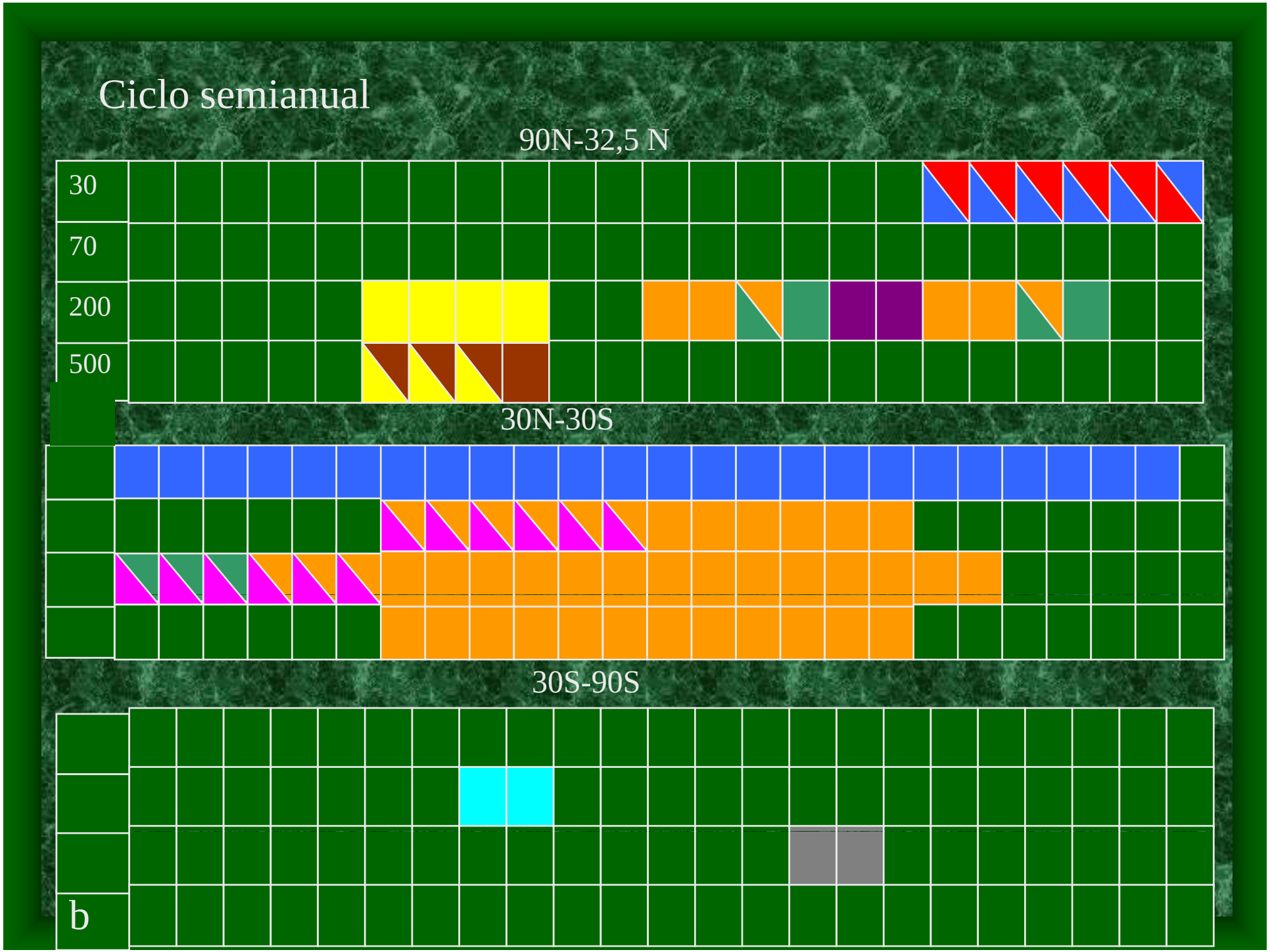
We explore the non-linear interactions which can be described as follows:

w_o is one of the annual cycles frequencies (12, 6 or 4 months)

w_1 is the frequency of a low frquency perturbation with periods at least 2 years long.

If a non-linear interaction occurs it should be possible to observe w_o, w_1, and side bands corresponding to $w_o \pm w_1$, which appear as small peaks on each side of the main frequency w_o. If one of the side peaks is not detectable and or the low frequency then the possible modulation by non-linear interactions was disregarded.


Ciclo anual
90 N- 32,5 N
30
70
200
500
30 N- 30 S
32,5 S-90 S


Ciclo semianual
90N-32,5 N
30
70
200
500
30N-30S
30S-90S
b

Ciclo teranual

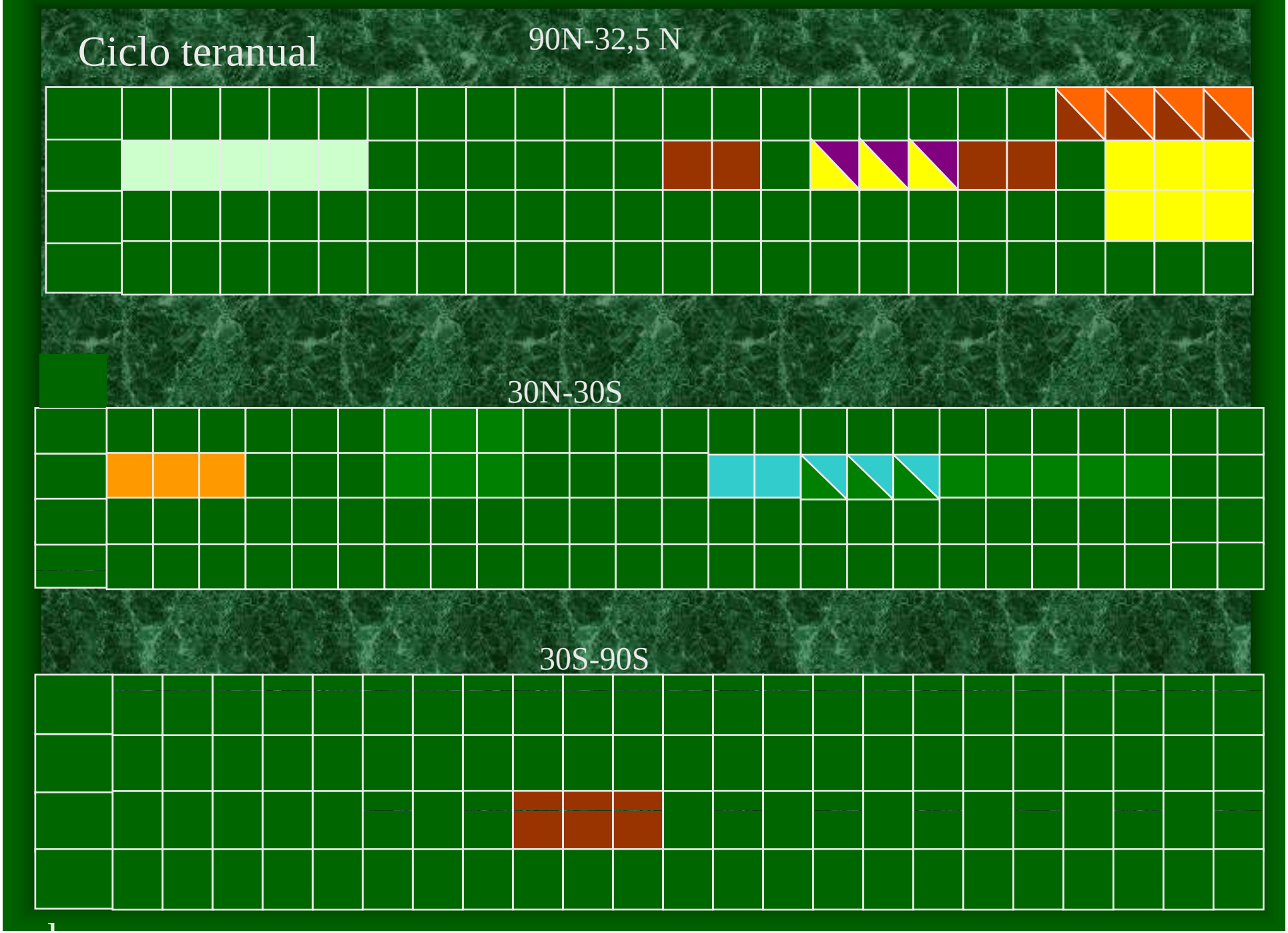


Chart Modulation Period Color Code

Grey: 180 months (15 years)

Red: 90 months (7.5 years)

Lilac: 72 months (6 years)

Orange: 60 moths (5 years)

Turquoise: 51.4 months (4.3 years)

Green: 45 months (3.75 years)

Brown: 40 months (3.3 years)

Dark blue: 36 months (3 years)

Yellow: 32.7 months (quasi QBO)

Pink: 30 months (quasi QBO)

Blue: 27.7 months (QBO)

Violet: 25.7 months (quasi QBO)

Light Green:24 months (2 years)

Conclusion

1. **Analysis of the spectra shows the possible existence of such a non-linear modulation process, particularly in the stratosphere.**
2. **The 12-month cycle appears to have the most significative and consistent modulation, with different regimes between polar regions, mid latitudes of both hemispheres and the Tropics, where the modulation appear to extend consistently throughout the sampled height range.**
3. **The most frequent non-linear interactions between the 12 month cycle and to a lesser extent the 6 month one occur with 7.5 and 5 year oscillations (also detected in the behaviour of polar vortices using PCA, Huth and Canziani, 2002) and the QBO and quasi-QBO frequencies (3 to 2.5 years).**

To be continue.....