The Abdus Salam
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SMR/1884-16

Conference on Milankovitch cycles over the past 5 million years

22 - 24 March 2007

Pleistocene Climate Variations

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36 Nakhimovsky Prospekt

Polyphony of the multiscale climatic variations during the Pleistocene and the role of the Milankovitch drivers

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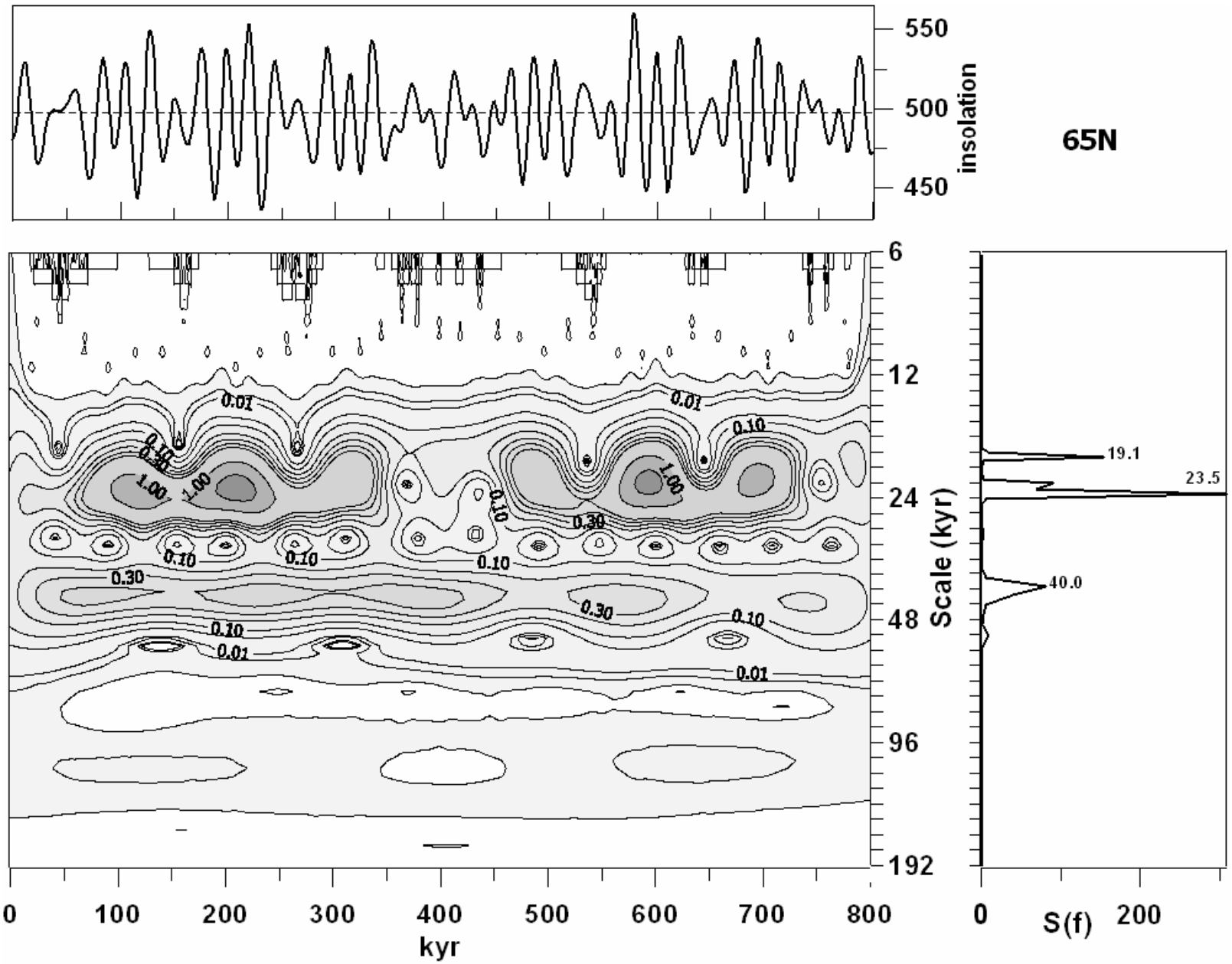
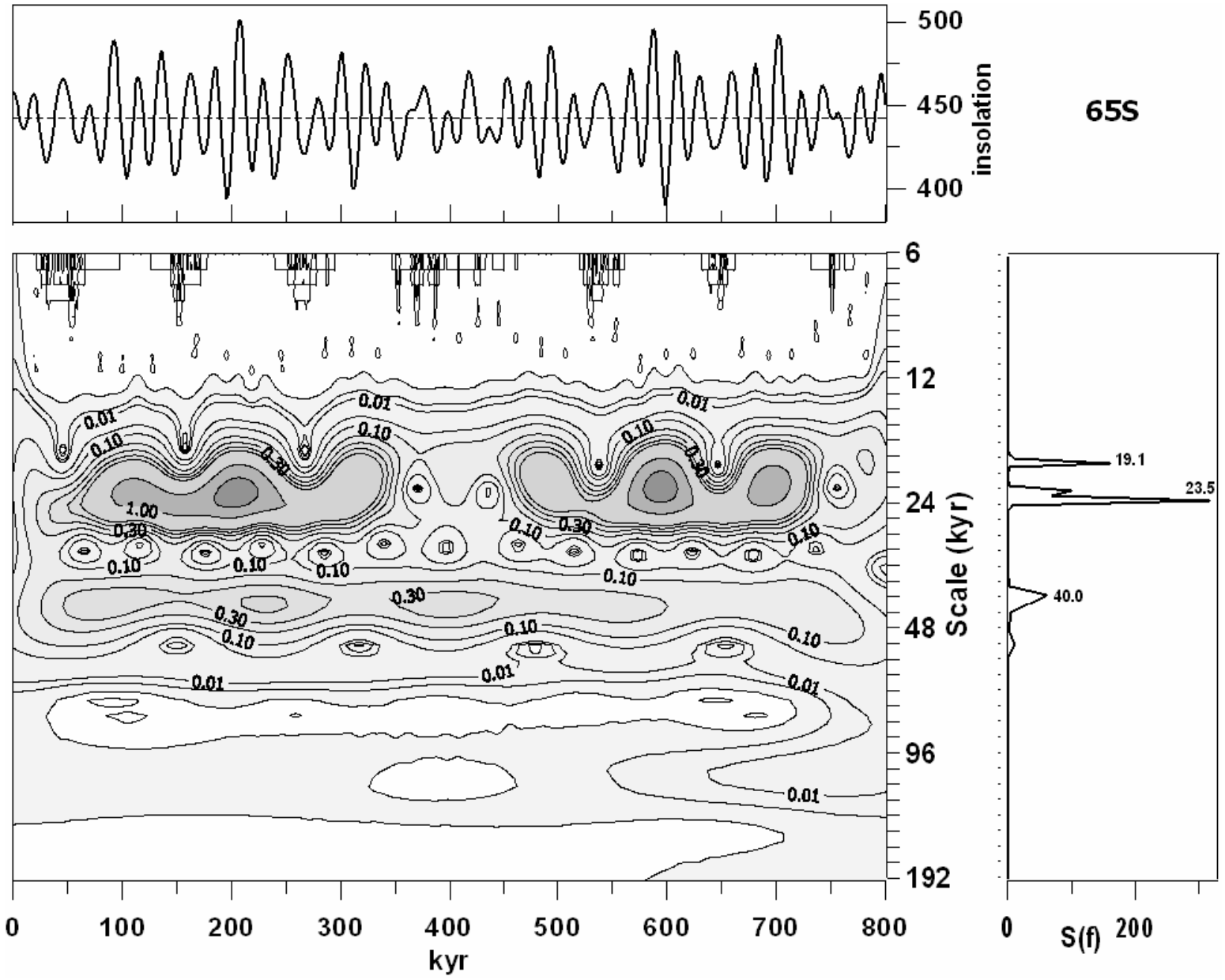
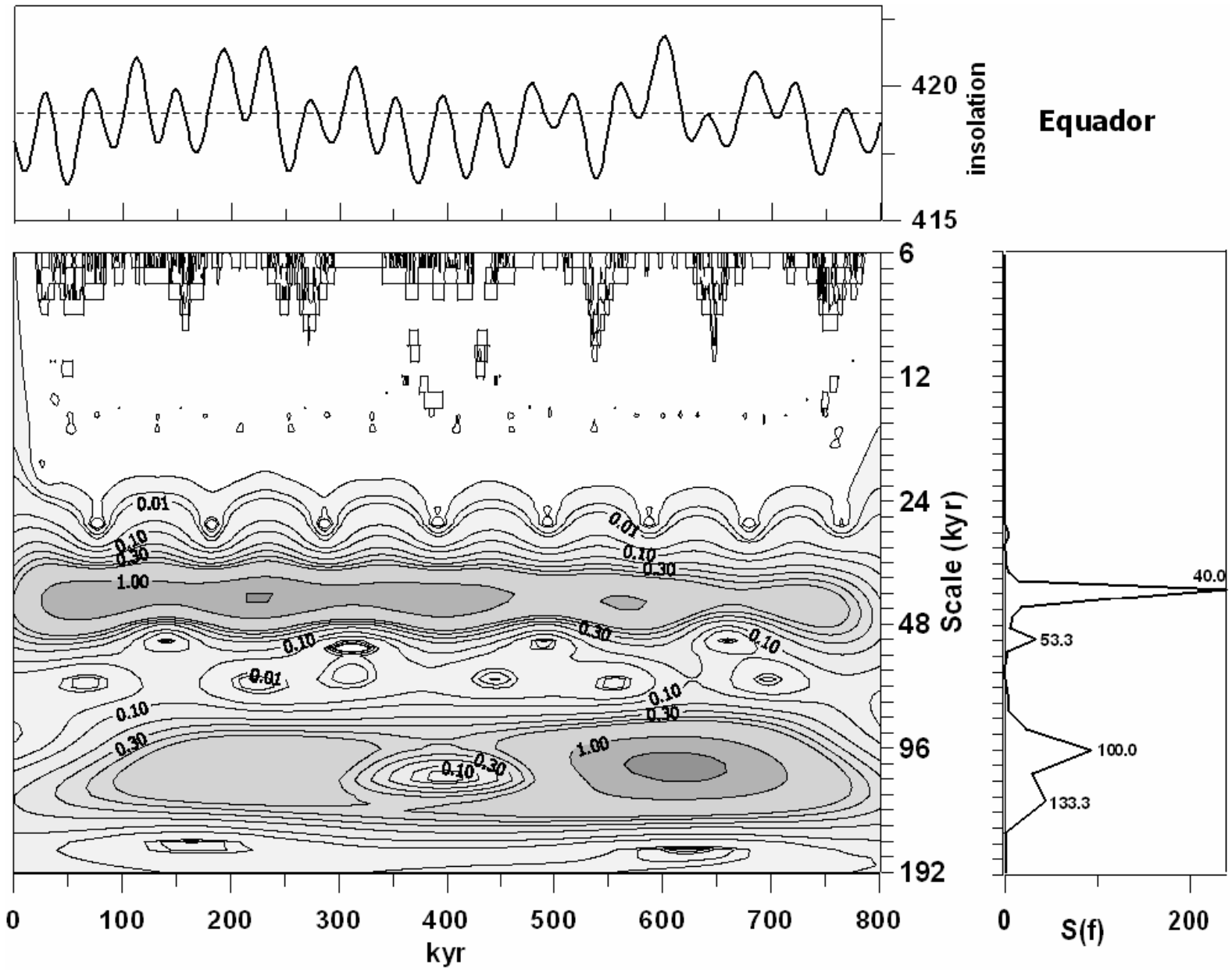
The ratios of the Milankovitch cycles 19/23 and 19/41 are similar to the “worst” irrational numbers 0.8393... and 1-1/1.9383... respectively, and the frequency 1/100 may be represented as the “worst” irrational number 1/19-1/23=0.1607... .

- Responses of the nonlinear dynamical systems to such quasiperiodic external drivers is known to be of the strange and nonchaotic nature, i.e. their spectrum is discrete and with many peaks.

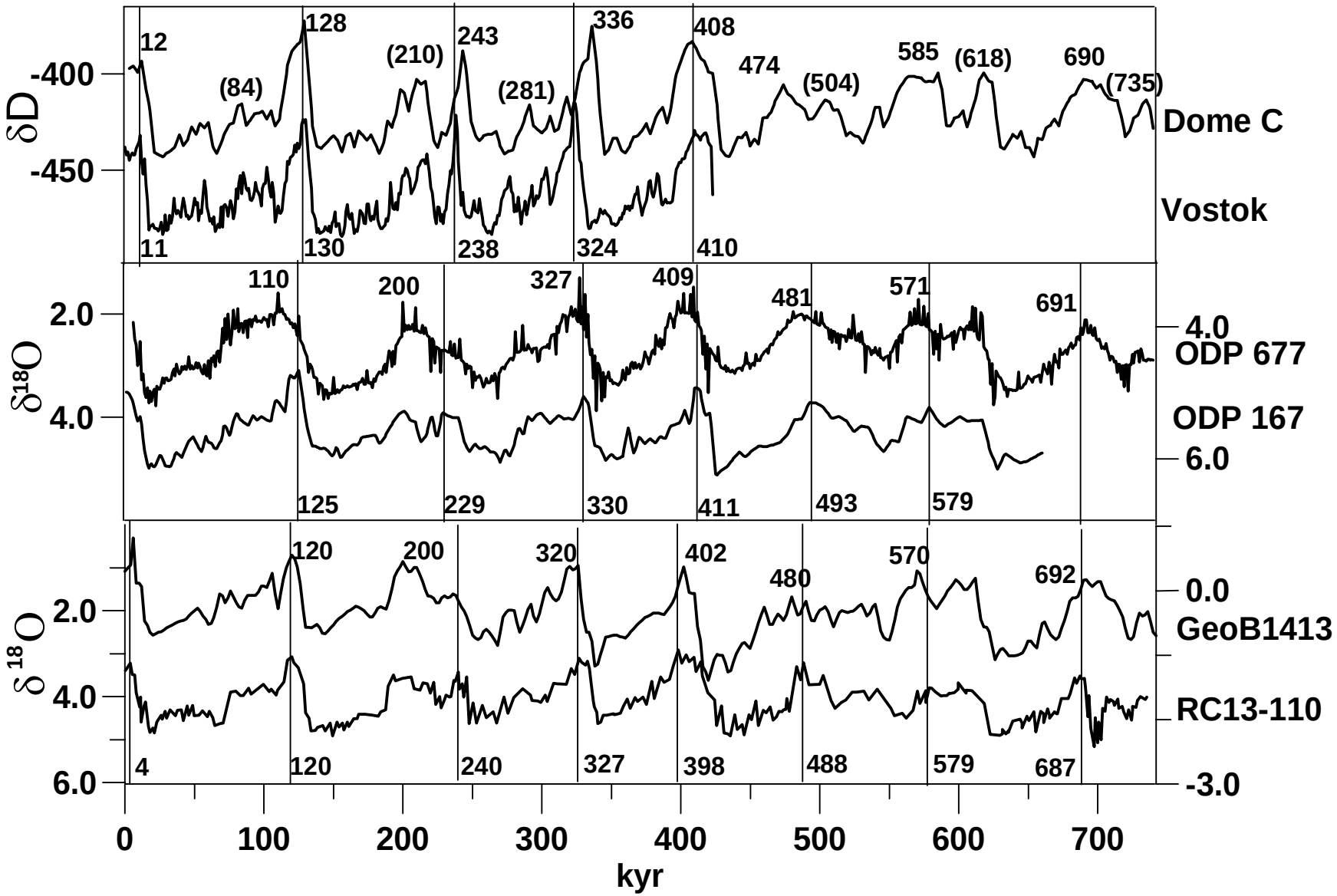
The dynamics of the Milankovitch orbital cycles of insolation as such (a wavelet-based consideration)


550
500
450
insolation
65N
6
12
24
48
96
192
Scale (kyr)
19.1
23.5
40.0
0.01
0.10
0.30
1.00
0
100
200
300
400
500
600
700
800
kyr
0
S(f)
200

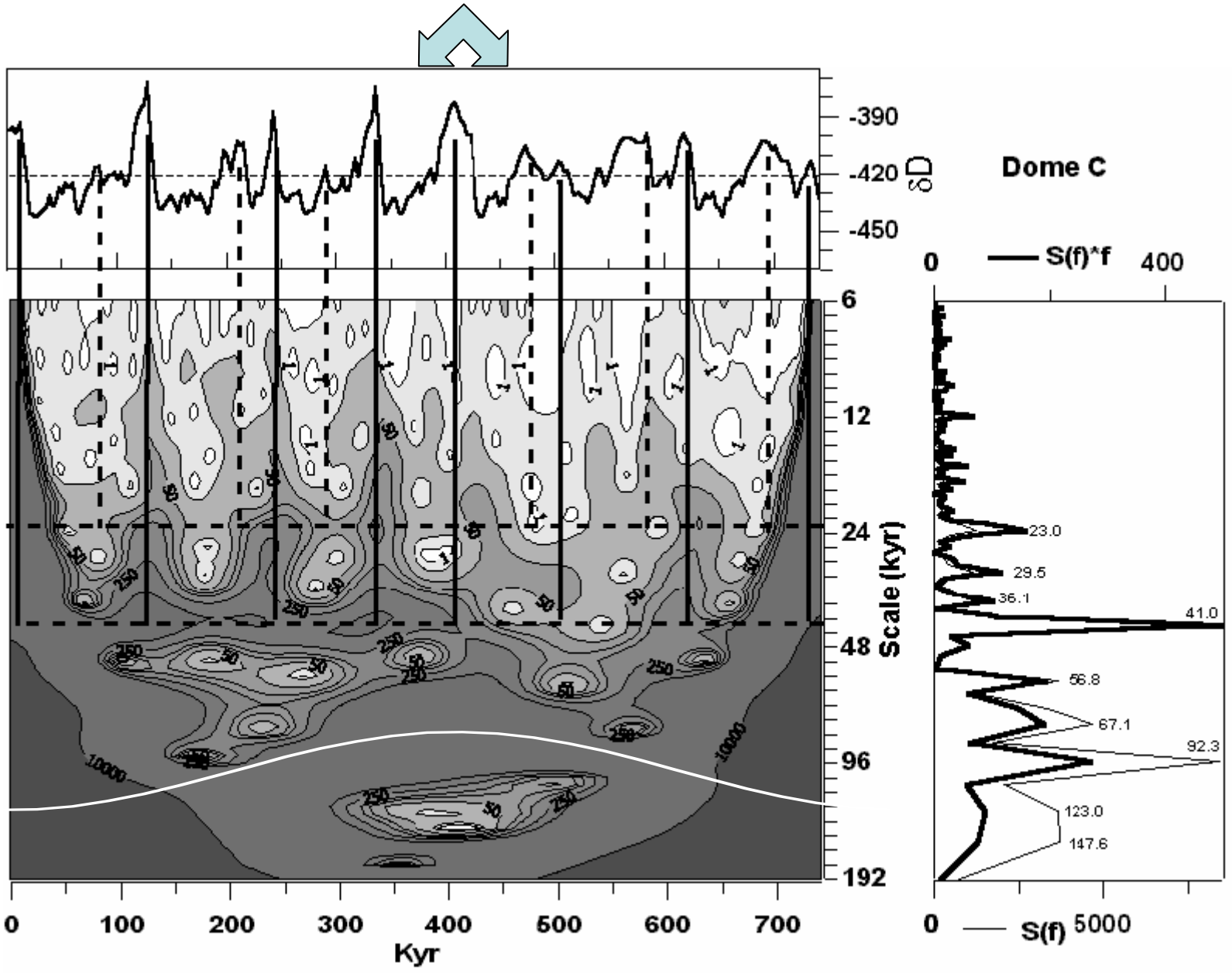

500
450
400
insolation
65S
6
12
24
48
96
192
Scale (kyr)
0.01
0.10
0.30
1.00
19.1
23.5
40.0
0
100
200
300
400
500
600
700
800
kyr
0
S(f)
200

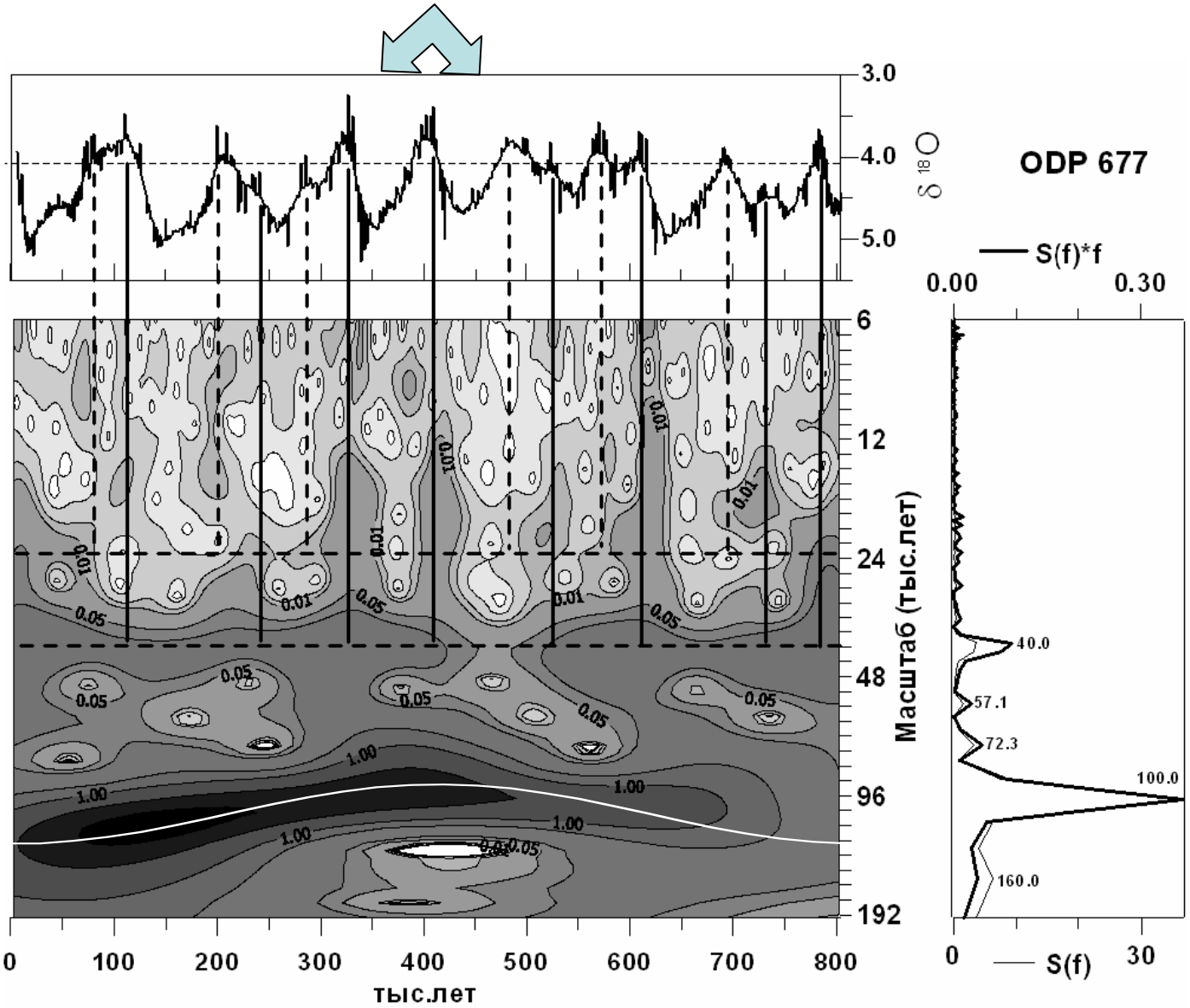

420
415
insolation
Equador
6
12
24
48
96
192
Scale (kyr)
0.01
0.10
0.30
1.00
0
100
200
300
400
500
600
700
800
kyr
40.0
53.3
100.0
133.3
0
S(f)
200

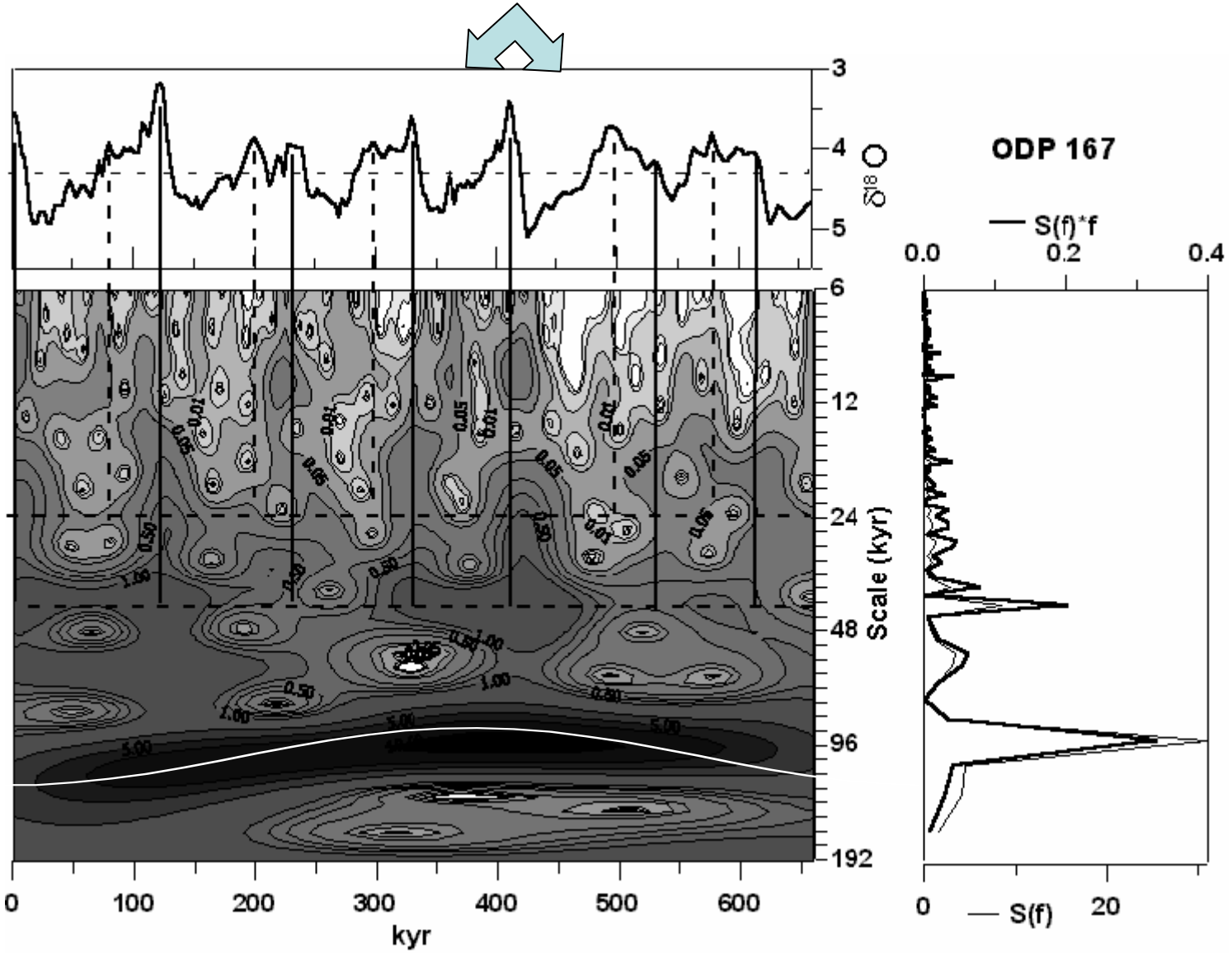
The multiscale climate dynamics during the Pleistocene as revealed by ice core and oceanic bottom drill records

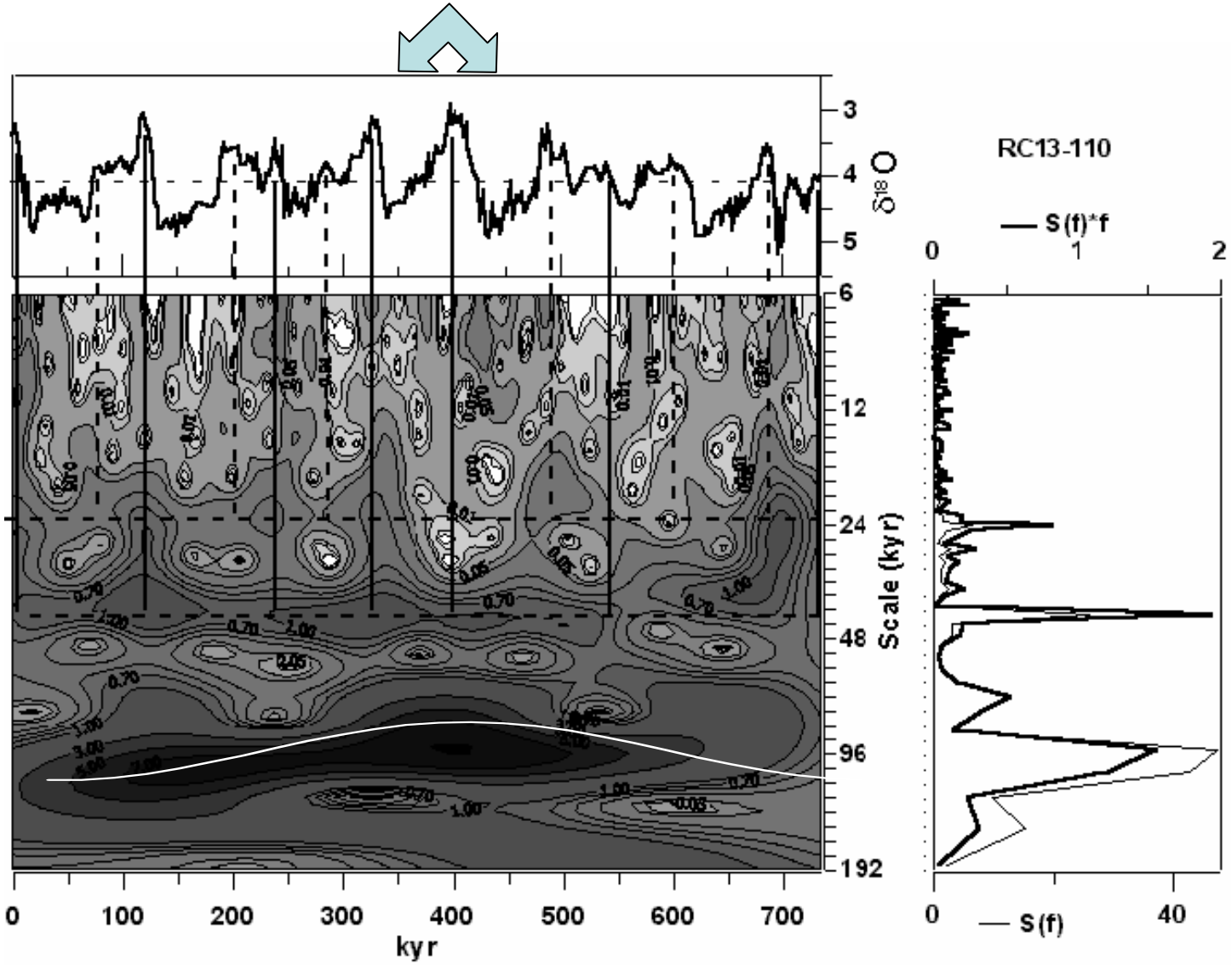

δD
-400
-450
12
(84)
128
(210)
243
(281)
336
408
474
(504)
585
(618)
690
(735)
11
130
238
324
410
Dome C
Vostok
δ18O
2.0
4.0
110
200
327
409
481
571
691
125
229
330
411
493
579
4.0
ODP 677
ODP 167
6.0
δ 18 O
2.0
4.0
6.0
120
200
320
402
480
570
692
4
120
240
327
398
488
579
687
0.0
GeoB1413
RC13-110
-3.0
0
100
200
300
400
500
600
700
kyr

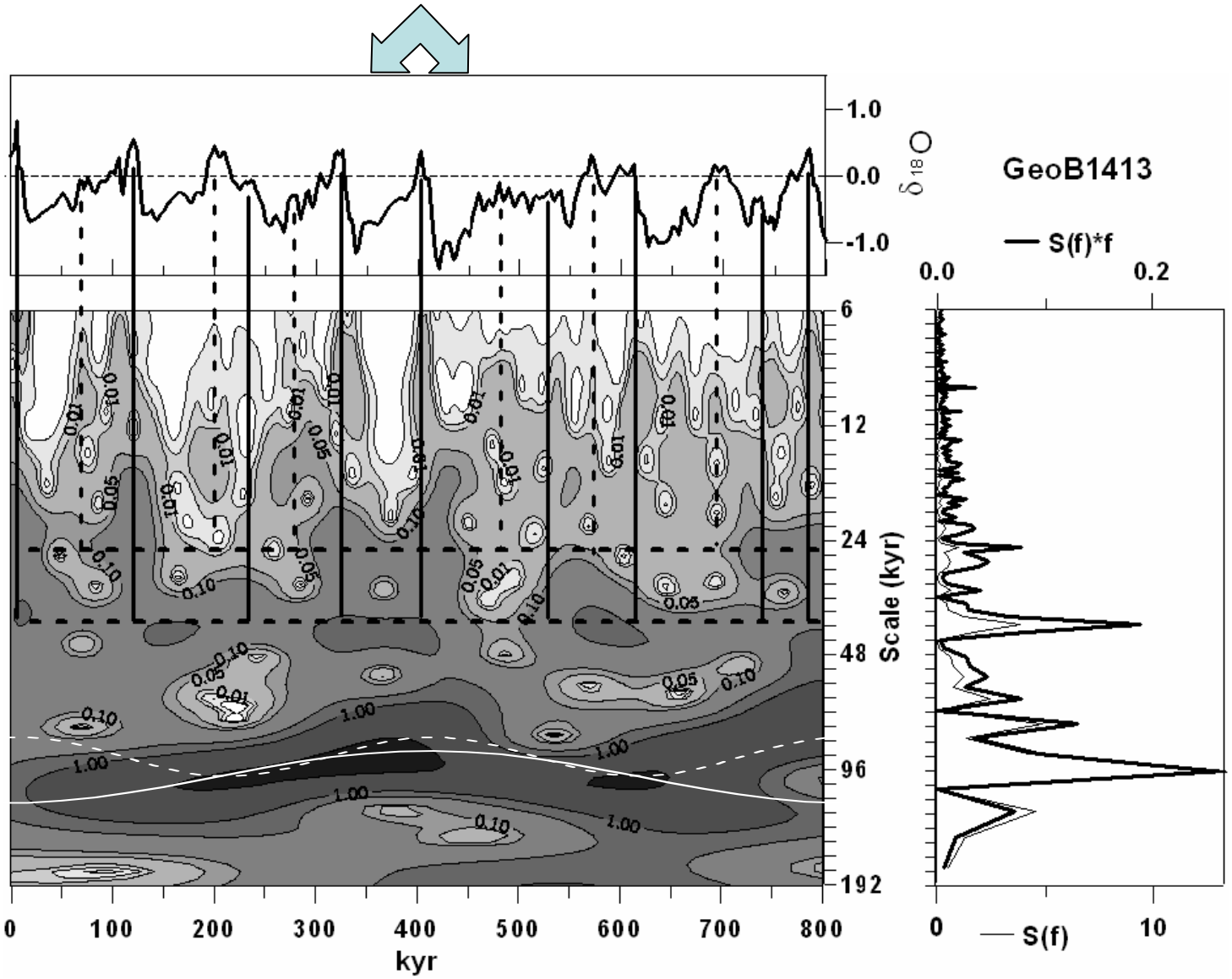
Amplitude and frequency modulations of the climatic variations during the Pleistocene period (a wavelet-based consideration)

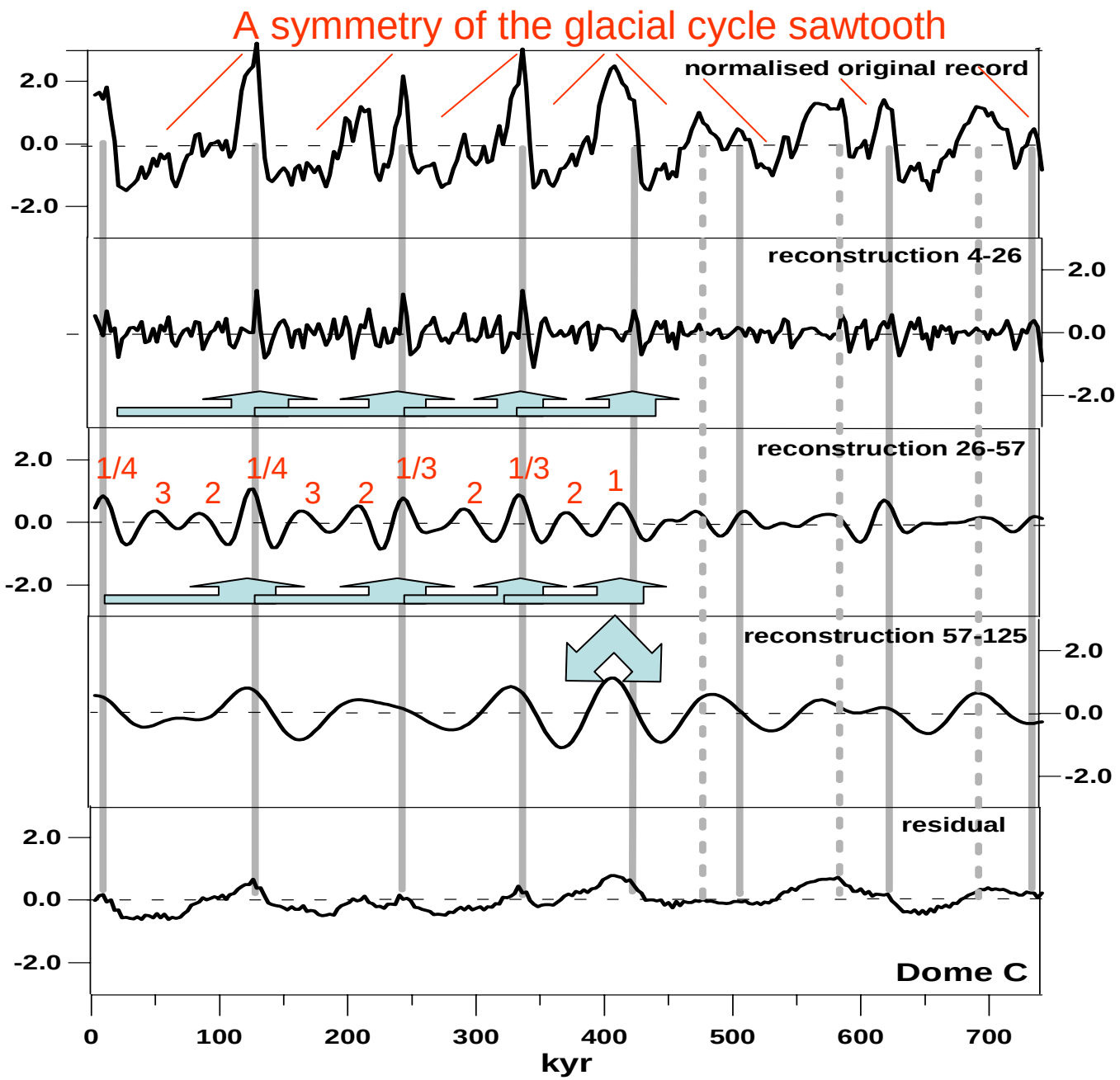

-390
-420
-450
δD
Dome C
0
S(f)*f
400
6
12
24
48
96
192
Scale (kyr)
23.0
29.5
36.1
41.0
56.8
67.1
92.3
123.0
147.6
0
100
200
300
400
500
600
700
Kyr
0
S(f)
5000

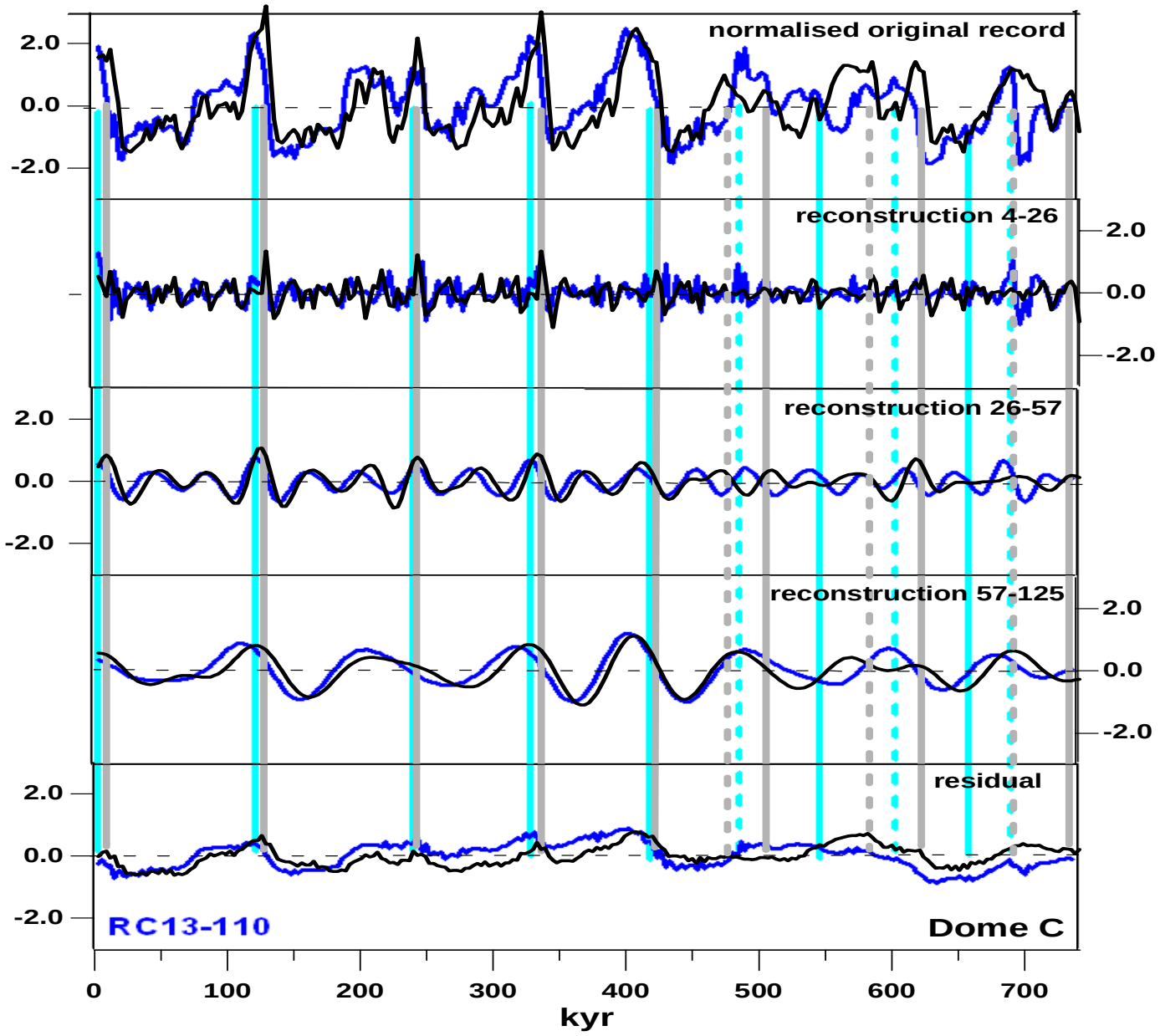

ODP 677
δ 18O
3.0
4.0
5.0
S(f)*f
0.00
0.30
6
12
24
48
96
192
Масштаб (тыс.лет)
40.0
57.1
72.3
100.0
160.0
0.01
0.05
1.00
0
100
200
300
400
500
600
700
800
тыс.лет
0
S(f)
30

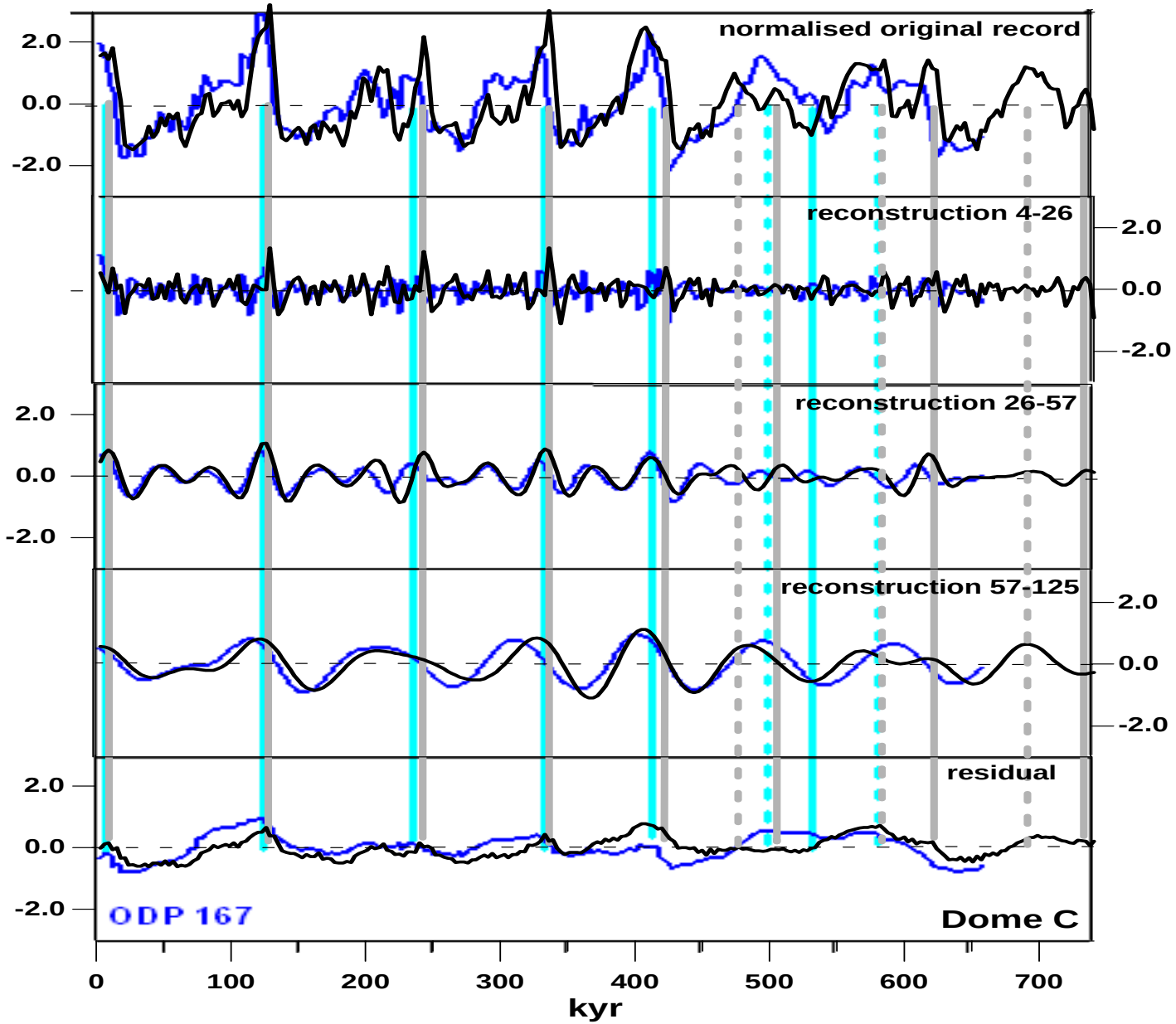

ODP 167
δ18O
3
4
5
6
12
24
48
96
192
Scale (kyr)
0
100
200
300
400
500
600
kyr
S(f)*f
0.0
0.2
0.4
0
20
S(f)


RC13-110
δ18O
3
4
5
6
12
24
48
96
192
Scale (kyr)
0
100
200
300
400
500
600
700
kyr
S(f)*f
0
1
2
S(f)
0
40

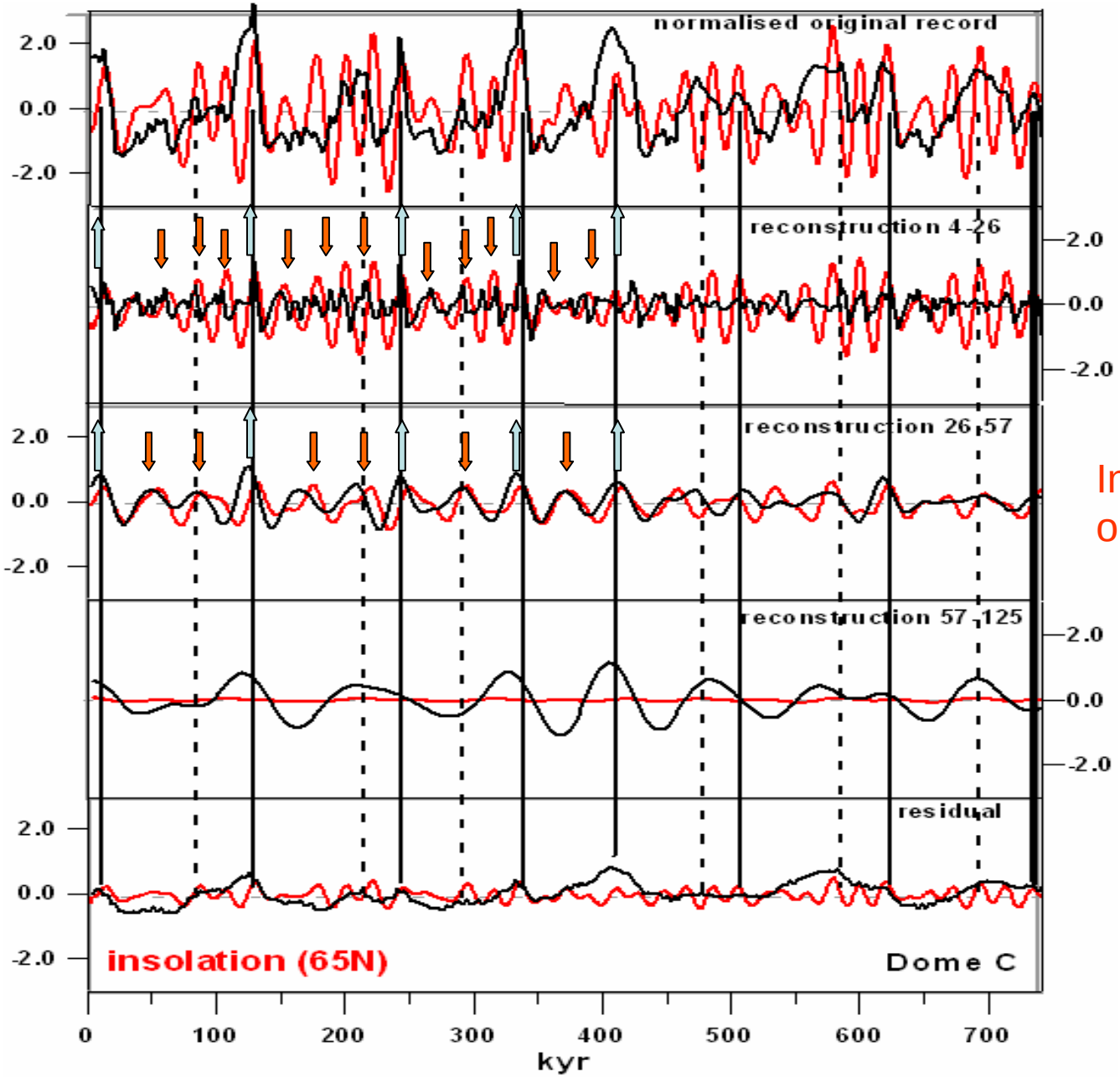

1.0
0.0
-1.0
δ18O
GeoB1413
S(f)*f
0.0
0.2
6
12
24
48
96
192
Scale (kyr)
0
100
200
300
400
500
600
700
800
kyr
0
10
S(f)


A symmetry of the glacial cycle sawtooth
normalised original record
reconstruction 4-26
reconstruction 26-57
reconstruction 57-125
residual
Dome C
2.0
0.0
-2.0
1/4
3
2
1/4
3
2
1/3
2
1/3
2
1
0
100
200
300
400
500
600
700
kyr


normalised original record
reconstruction 4-26
reconstruction 26-57
reconstruction 57-125
residual
2.0
0.0
-2.0
RC13-110
Dome C
0
100
200
300
400
500
600
700
kyr


normalised original record
reconstruction 4-26
reconstruction 26-57
reconstruction 57-125
residual
2.0
0.0
-2.0
ODP 167
Dome C
0
100
200
300
400
500
600
700
kyr

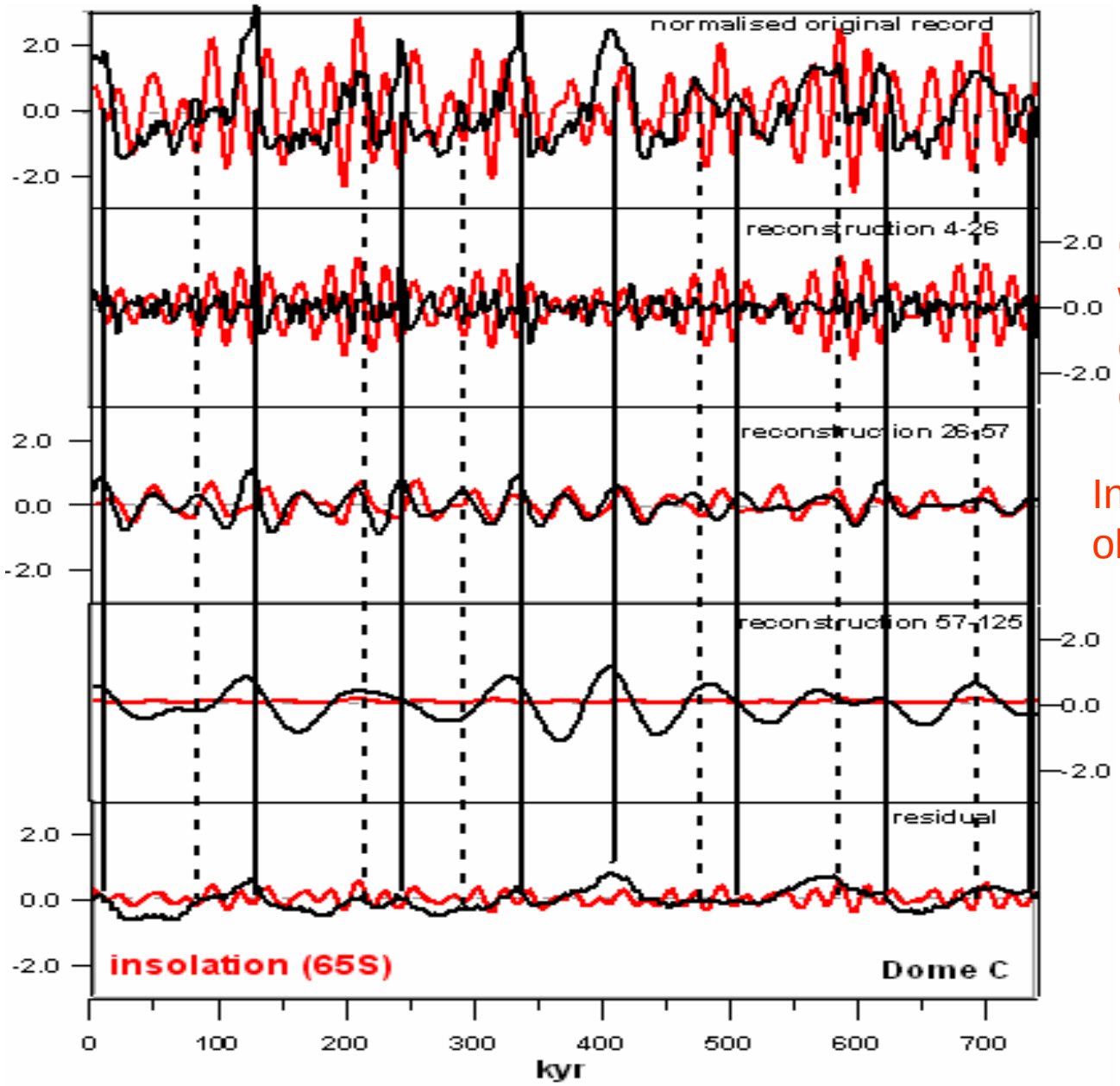
Interrelations between insolation and climatic variations



In phase with precession during the main climatic jumps

In phase with obliquity

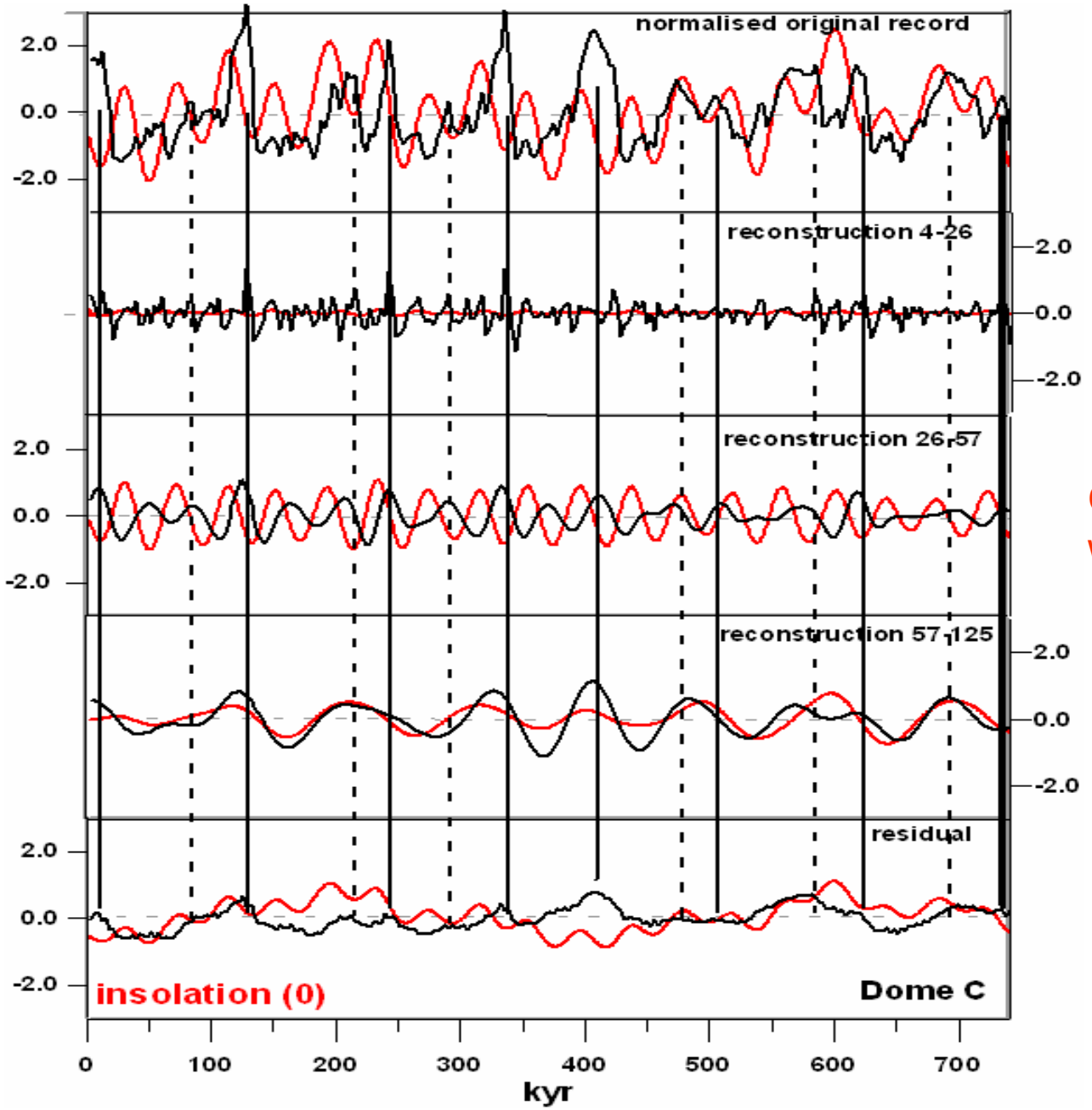
Not sensitive



Out of phase with precession during the main climatic jumps

In phase with obliquity

Not sensitive

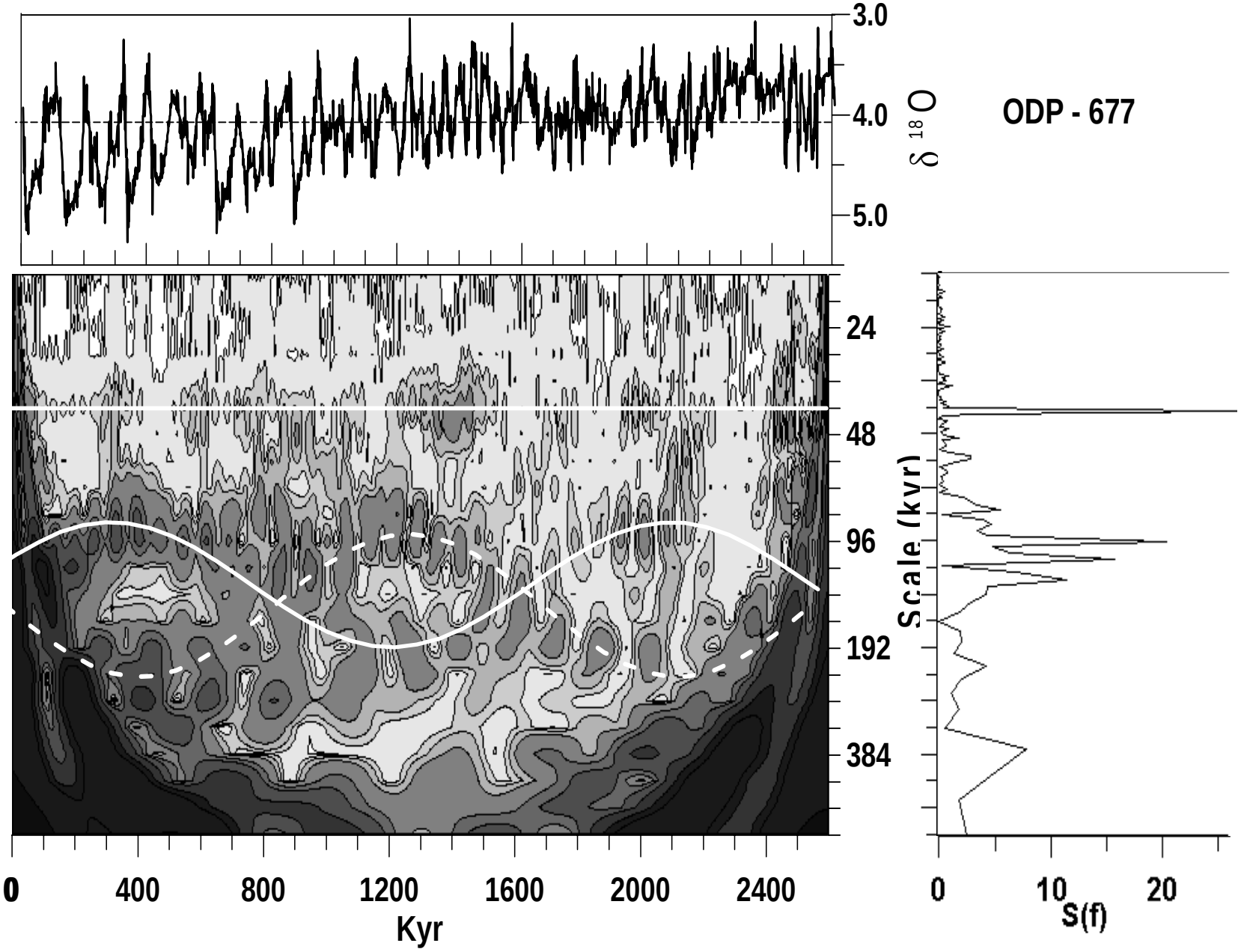


Not sensitive

Out of phase with obliquity

In phase with eccentricity

HYPERLONG-TERM CLIMATIC VARIATIONS during the PLEISTOCENE/PLIOCENE time period


3.0
4.0
5.0
δ 18O
ODP - 677
24
48
96
192
384
Scale (kyr)
0
400
800
1200
1600
2000
2400
Kyr
0
10
20
S(f)

GENERAL CONCLUSIONS

- Climate evolved during the entire Earth history.
- Past climates reveal themselves as a mix of interwoven multiscale variations. These are of very complex shapes but (probably) nonchaotic.
- They are mutually ordered and adjusted with each other.

SOME SPECIFIC CONCLUSIONS

-Climatic variations over the precession time scale look to be essentially nonlinear as responses of the global climate system to the extratropical insolation variations (a direct energy cascade from the 41-kyr cycle to shorter time scales).

- Climatic variations over the obliquity and (especially) eccentricity time scales look to be more or less direct (quasilinear) as responses of the global climate system to the insolation variations within the equatorial belt.