

Сагитовские чтения, ГАИШ, 2007

**Движение геоцентра
и его геодинамическое содержание**

Баркин Ю.В. (ГАИШ), Зотов Л.В. (ГАИШ), Любушин А.А., (ОИФЗ РАН)

MOTION OF THE EARTH'S CENTER OF MASS INDUCED BY GLOBAL CHANGES IN ITS DYNAMIC STRUCTURE AND BY TIDAL DEFORMATIONS

Yu. V. Barkin

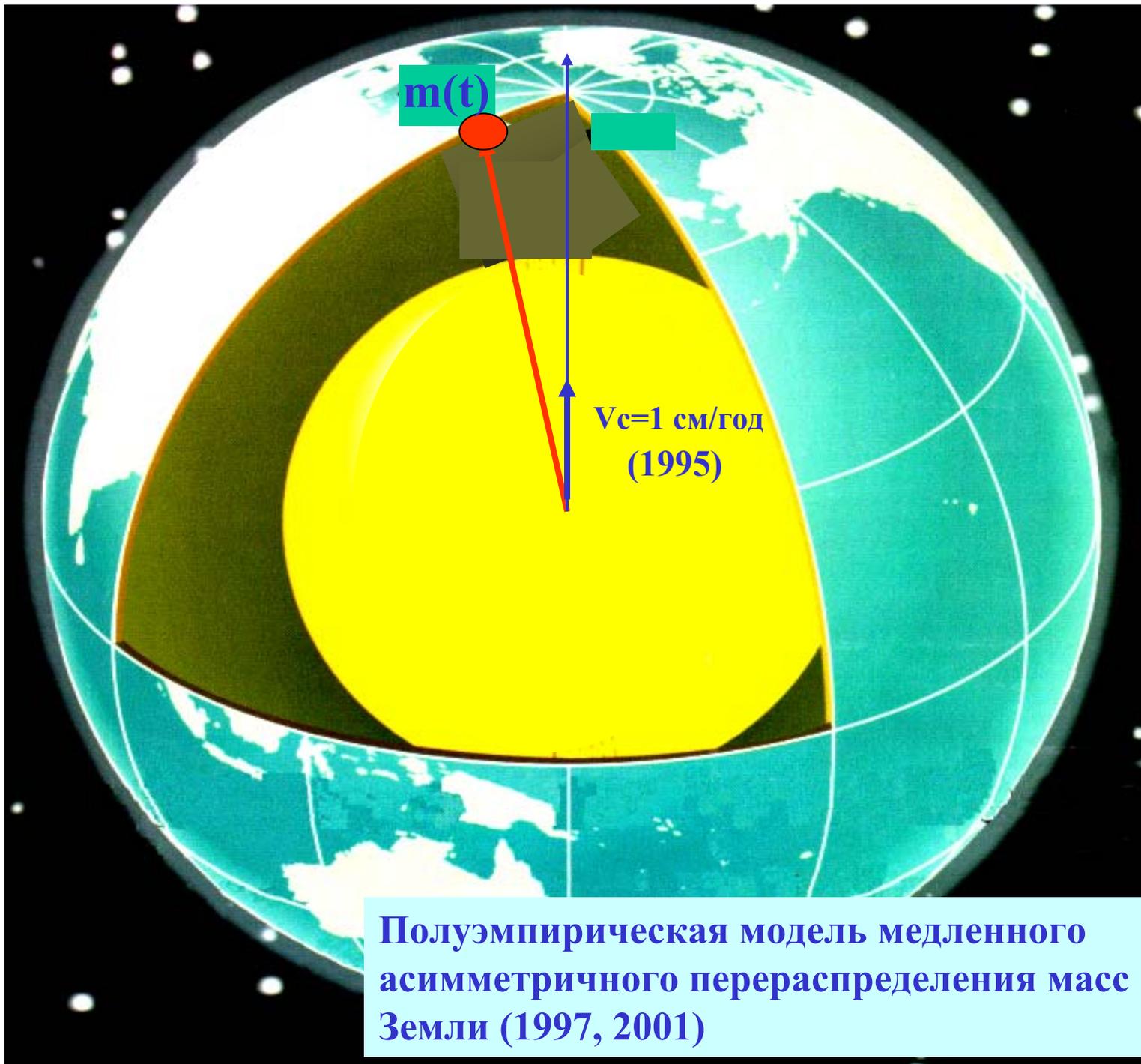
Using a simple model of a changeable Earth, we studied the displacement of its center of mass with respect to the characteristic point on the Earth's axis for which the coefficient of the third zonal geopotential harmonic is zero. Because of global changes in the dynamic structure of the Earth, the velocity of the secular displacement of its center of mass toward the North pole can be as high as 2 cm/ year. The basic periodic motion of the center of mass, resulting from tidal deformation of the Earth, has an amplitude of 8.9 cm and a period of 27.32 days.

A global change in the dynamic structure of the Earth is demonstrated by the secular variations in the parameters of the Earth's gravitational field revealed by laser observations with the *Lageos* and *Etolon* satellites [1-3] (Table 1).

Table 1

Parameters J_2 and J_3 and Calculated Values of Velocity \dot{z}_C

Authors, year	$J_2 \times 10^9$, 1/century	$J_3 \times 10^9$, 1/century	\dot{z}_C , cm/ year
Yoder et al., 1983	-3.0 ± 0.3	-1.0	1.96
Cheng et al., 1989	-2.5 ± 0.1	-0.1 ± 0.3	0.21 ± 0.59
Marchenko, 1992	-2.7 ± 0.7	-0.1 ± 0.6	0.21 ± 1.18
Ibid	-2.74 ± 0.20	-0.91 ± 0.23	1.80 ± 0.46



**Полуэмпирическая модель медленного
асимметричного перераспределения масс
Земли (1997, 2001)**

Баркин Ю.В. (1995) О движении центра масс Земли, обусловленном глобальным изменением ее динамического строения и приливными деформациями. Вестник Моск. гос. ун-та. Сер. 3 Физика, астрономия, 1995, т. 36, № 5, с. 99-101.

San Fransisco, 1997

Barkin, Yu. V. (1997) Secular Effects in the Geocenter Motion. Fall Meeting of the American Geophysical Union (December 8-12, 1997, San-Francisco, California). Eos Trans. AGU, Fall Meet. Suppl., V. 78, p. F145.



Theoretical Study and Prediction of Secular Geocenter and Gravity Variations

YU. V. BARKIN¹

Abstract

A semi-empirical model of the secular relative displacements of the Earth's mantle and core is developed. Known data about non-tidal acceleration of diurnal Earth rotation, about secular pole drift and about variation of geopotential coefficient of second zonal harmonic are used for construction of a mentioned model. It was shown that secular changes of Earth rotation, of gravity, of geopotential, of geocenter position, of Earth figure and some from observed natural planetary processes (variations of volcanism activity, seismic activity, sea level change and others) can be interpreted as variations which are dictated and controlled by mechanism of secular relative displacement of the mantle and core.

Introduction

Analysis of secular variations of activity of many geodynamical and geophysical processes, analysis of the secular

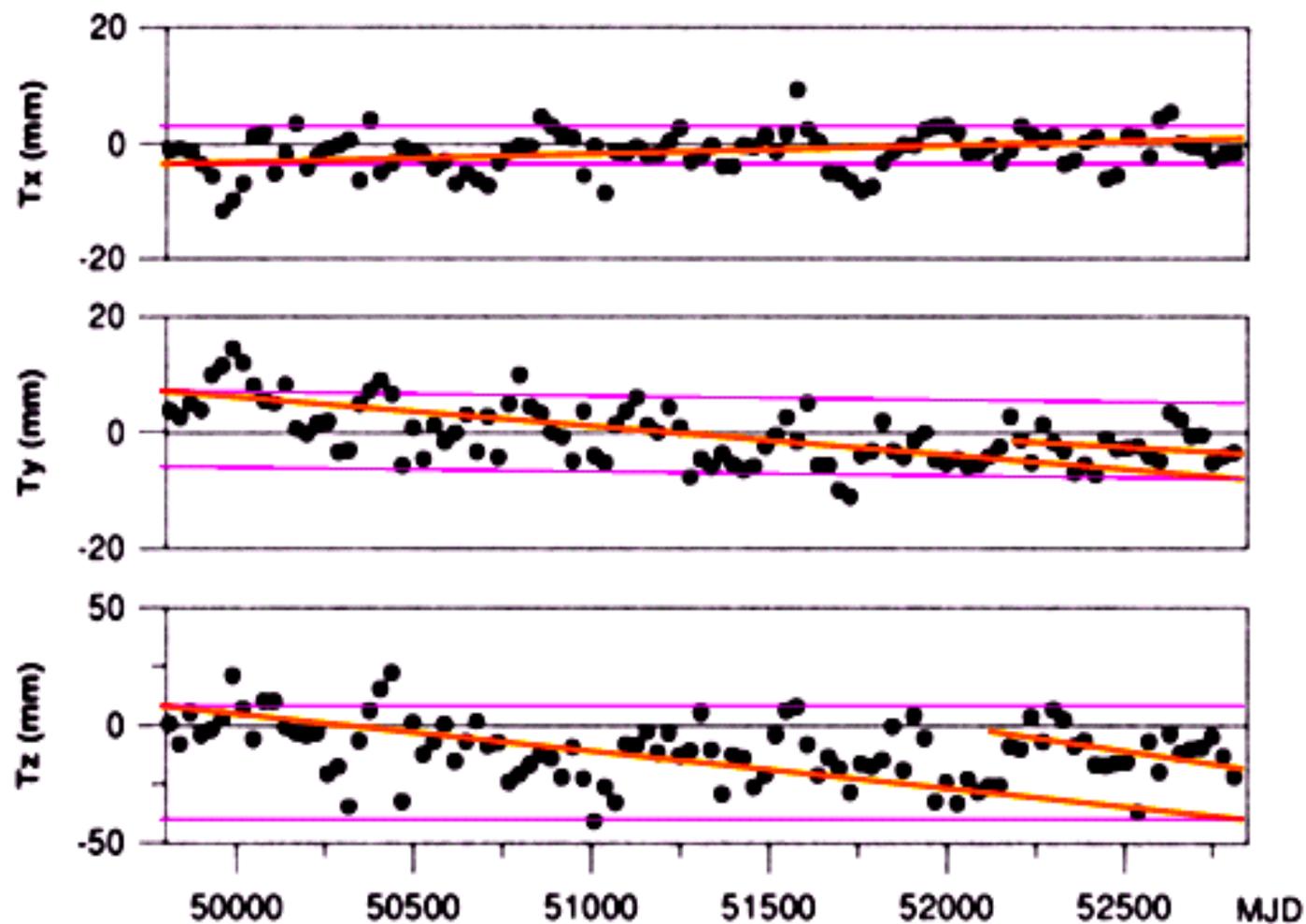
processes of the ice-water transformation (post glacial rebound etc.) can be considered as surface processes, which are controlled by the main mechanism of the shell dynamics.

1. Mechanism of mass redistribution and its models

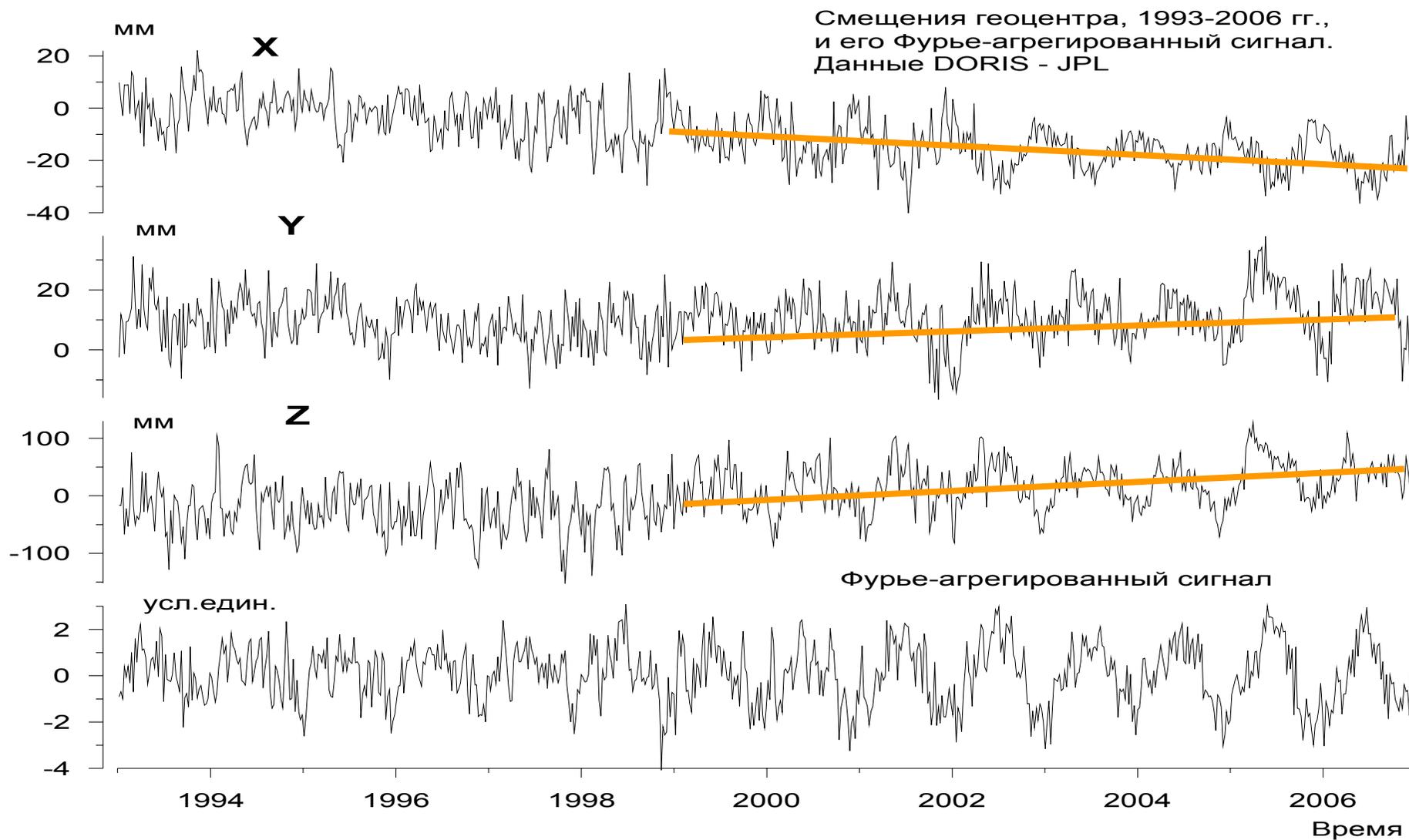
PARIISKY N.N. has shown that observed secular and decade variations of the Earth rotation can not be explained by any surface processes of the planet and these variations are caused by an inner mechanism of the Earth mass redistribution (PARIISKY, 2000). The possible inner reasons of observed effects in the Earth rotation and in its physical fields were studied by many authors (AVSJUK 1996; GREINER-MAI et al., 1999 and others), including the studies of the role of rigid core influence.

Тренд геоцентра по Гаязову (2003)

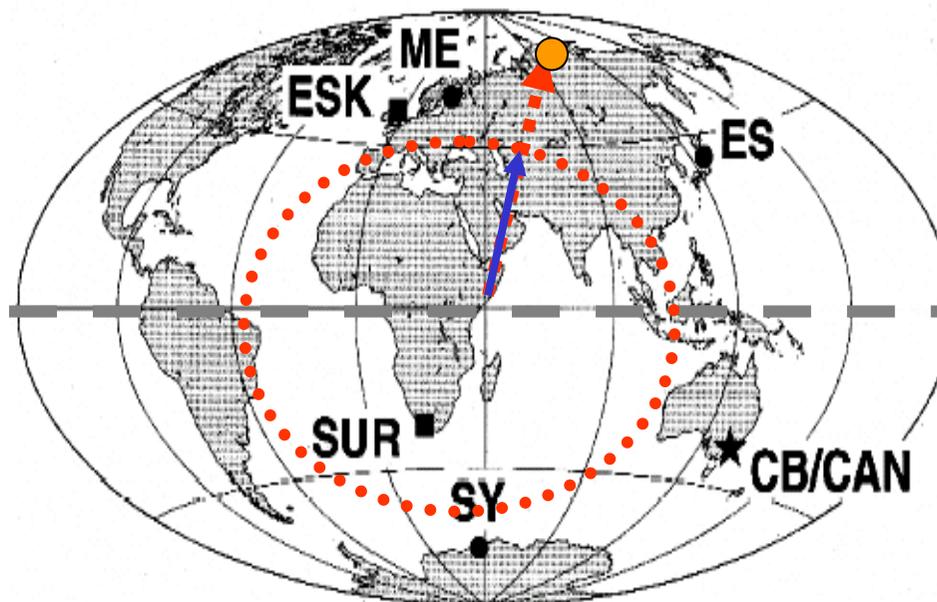
$V = 6.05$ мм/год, $\varphi = 72^{\circ}9$ с.ш., $\lambda = 115^{\circ}7$ в.д.



**Вариации координат центра масс Земли в период 1993-2007 гг.
Полярный тренд центра масс к северу 6-8 мм/год**

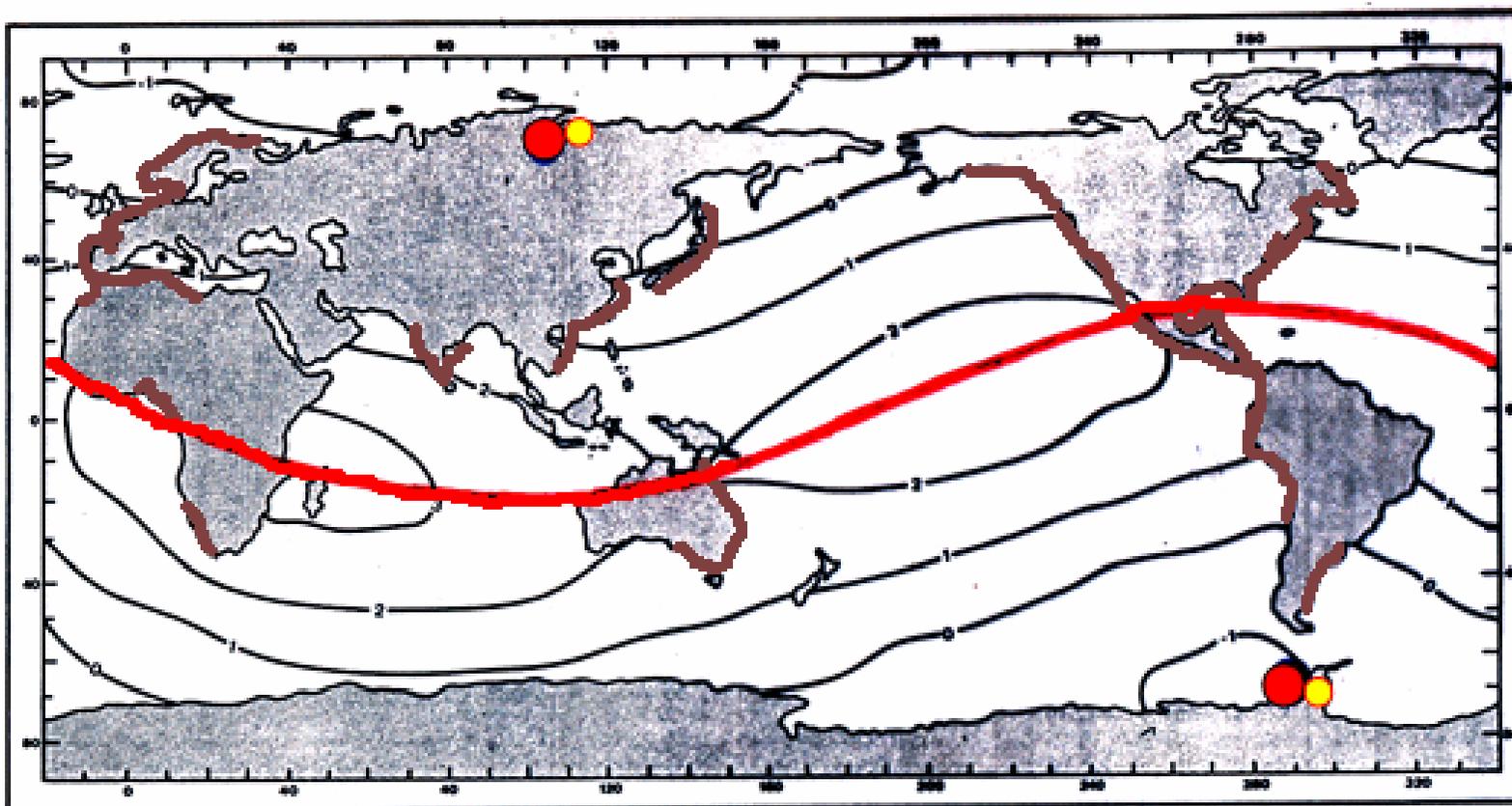


Дрейф центра масс к полуострову Таймыр



Авторы Год	Баркин 1995	Баркин 2001	Гаязов 2003, SLR	Татевян, Кузин, Кафтан, 2003, DORIS	Зотов, 2007 DORIS
V_C	18 ± 7 мм/год	6.69 мм/год	6.05 мм/год	6.8 мм/год	5.5 мм/год
φ_C (с.ш.)	$90^{\circ}0$	$70^{\circ}0$	$72^{\circ}9$	$62^{\circ}6$	$71^{\circ}3$
λ_C (в.д.)	---	$104^{\circ}3$	$115^{\circ}7$	$190^{\circ}9$	$172^{\circ}2$

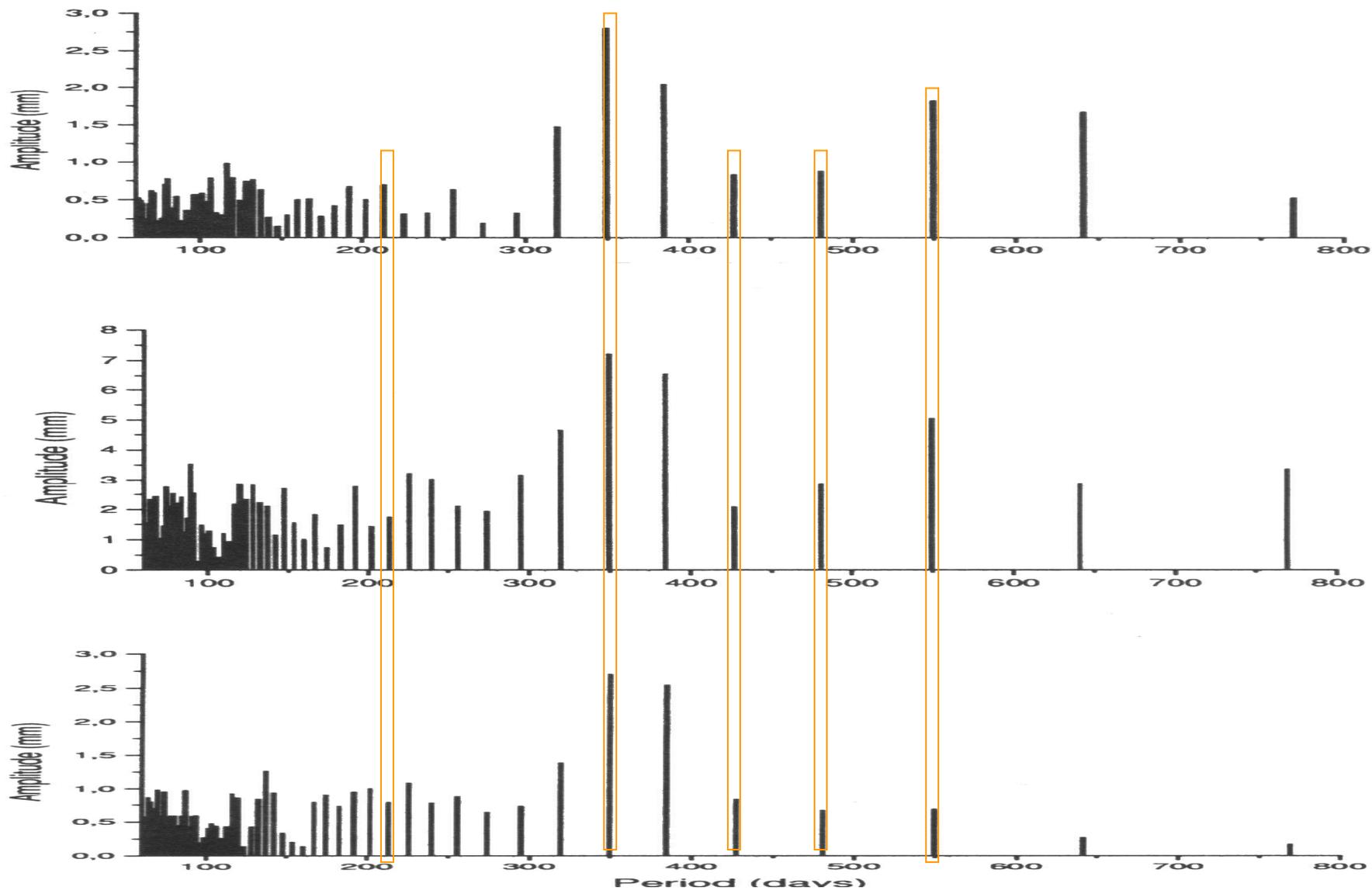
Дрейф центра масс Земли



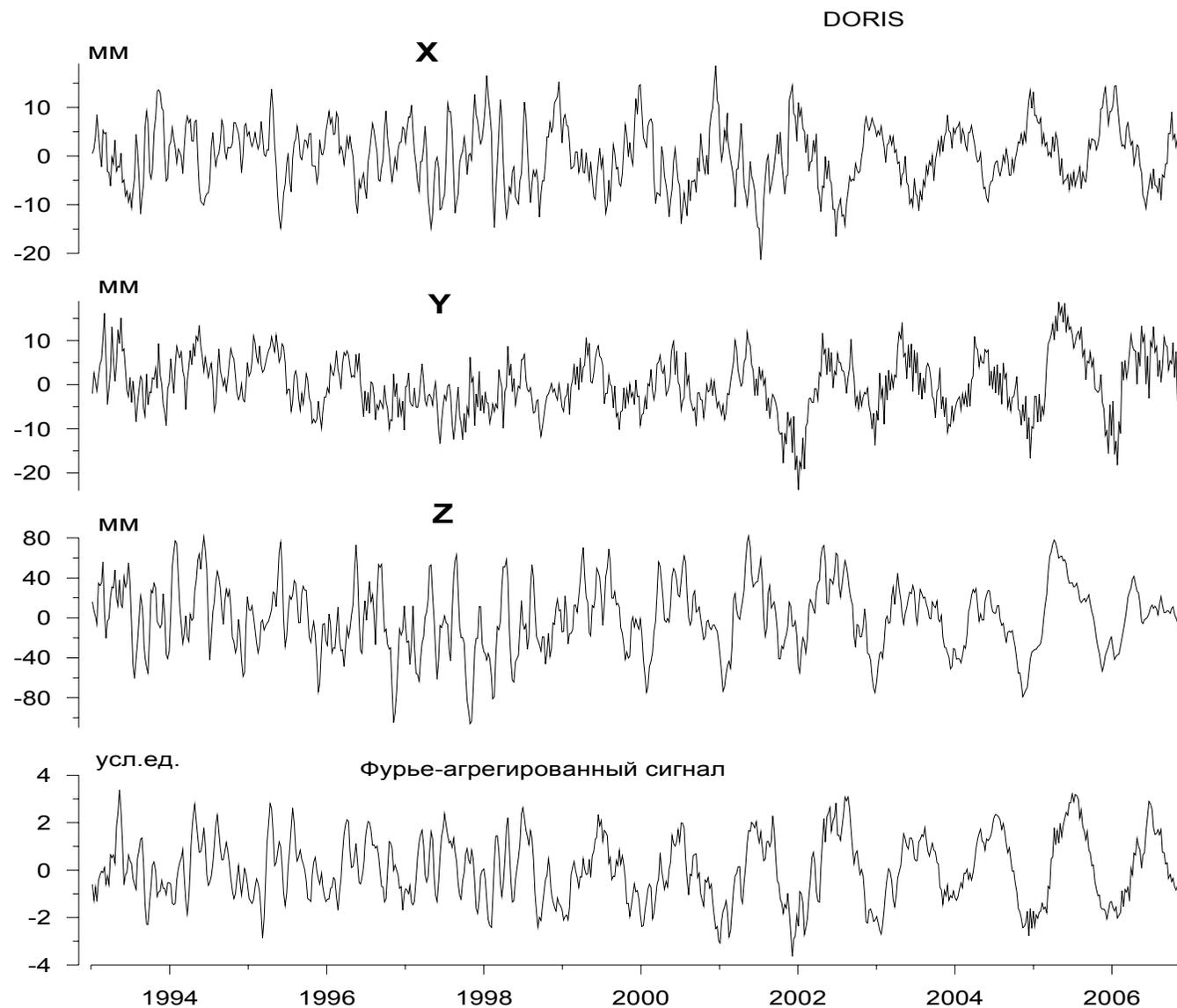
● Observed pole of the center of mass drift ● Point model pole (Barkin, 1997)

V_C	6.69	6.05	Gayazov, 2003	mm/yr
φ_C	70 ⁰ 0	72 ⁰ 9	Gayazov, 2003	degrees
λ_C	104 ⁰ 3	115 ⁰ 7	Gayazov, 2003	degrees

Единство спектров частот колебаний геоцентра по координатам x, y и z (Гаязов, 2003)



Вариации координат геоцентра по данным наблюдений DORIS (Любушин А.А.)



Оценки спектров мощности данных DORIS

Оценки спектров мощности данных DORIS

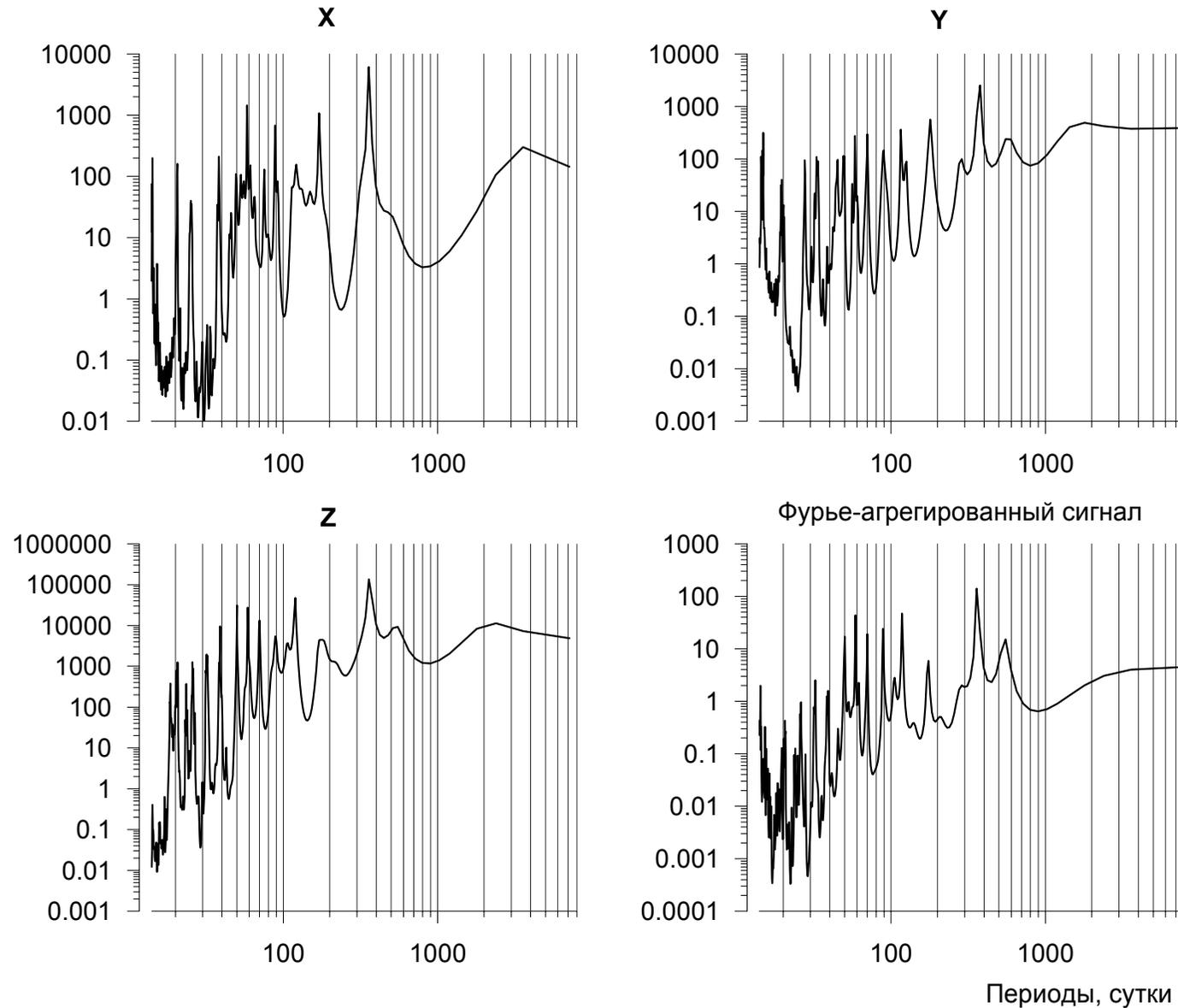


Таблица 17 основных гармоник z координаты геоцентра

$$z_C = \sum A \cos\left(\frac{2\pi}{T}t - \varphi\right)$$

Период T (сутки)	Амплитуда A мм	Фаза φ , градусы
2389	9.92	66.57
551	6.99	44.68
358	25.04	205.52
175	5.38	162.20
119	13.60	69.83
107	3.36	248.22
88	6.18	238.55
70	9.80	129.39
59	6.65	208.47
50	5.60	253.92
39	5.61	130.42
38	0.84	57.65
32	1.44	88.46
26	0.80	172.03
21	0.37	90.36
20	0.16	148.60
18	0.25	-11.98

DORIS

(Любушин А.А.)

Table 1. General base of periods.

a) Short periods (in days)			b) Interannual and decade periods (in years)			
476 (471.9)	172 (173.3)	504	102	7.09	22.39	70.00
415 (411.9)	161 (169)	40.4 (39.0)	1.41	8.00	25.92	73.00
402 (409.2)	152	38.1 (38.5)	1.62	8.58	27.63	76.23
380 (386.0)	146	30.5 (29.8)	183	9.02	30.25	80.25
365 (365.3)	140	27.4 (27.4)	2.11	9.49	32.99	88.08
346 (346.6)	131 (131.7)	19.4	2.49	10.10	37.63	99.60
326 (329.8)	122 (121.8)	15.9 (15.9)	2.80	10.99	40.69	112.0
285	113 (117.5)	13.8 (13.8)	3.25	12.05	46.31	116.4
237	100 (96.8)	9.02 (9.06)	3.54	13.24	49.72	147.0
221 (212.3)	90.7 (91.3)	7.24 (7.24)	4.10	14.66	52.60	160.0
206 (205.9)	80.4	6.76 (6.86)	4.70	16.23	55.53	181.7
200 (199.8)	765		5.19	17.06	58.54	211.0
192 (193.6)	698		5.97	18.68	62.77	344.0
183 (182.6)	60.1		658	2010	6643	5390

Таблица 17 основных гармоник z координаты геоцентра

Период T	Период T (теория)	Амплитуда A мм	Фаза φ , градусы
2389	2403	9.92	66.57
551	515, 592	6.99	44.68
358	365	25.04	205.52
175	172	5.38	162.20
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107	100, 113	3.36	248.22
88	90.7	6.18	238.55
70	69.8	9.80	129.39
59	60.1	6.65	208.47
50	50.4	5.60	253.92
39	40.4	5.61	130.42
38	38.1	0.84	57.65
32	30.5	1.44	88.46
26	27.4	0.80	172.03
21	19.4	0.37	90.36
20	19.4	0.16	148.60
18	19.4	0.25	-11.98

DORIS

$$z_c = \sum A \cos\left(\frac{2\pi}{T}t - \varphi\right)$$

Сравнение результатов (Любушин А.А., Зотов Л.В.)

358	26.01	-71.63
358	25.04	205.52

175	5.97	-11.58
175	5.38	162.20

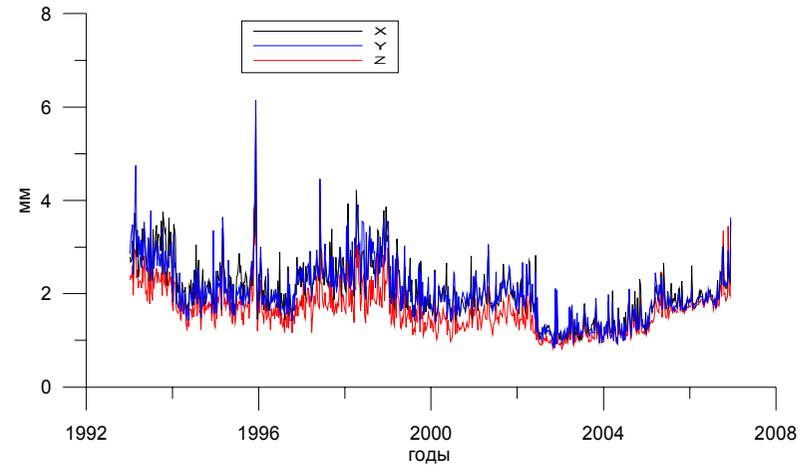
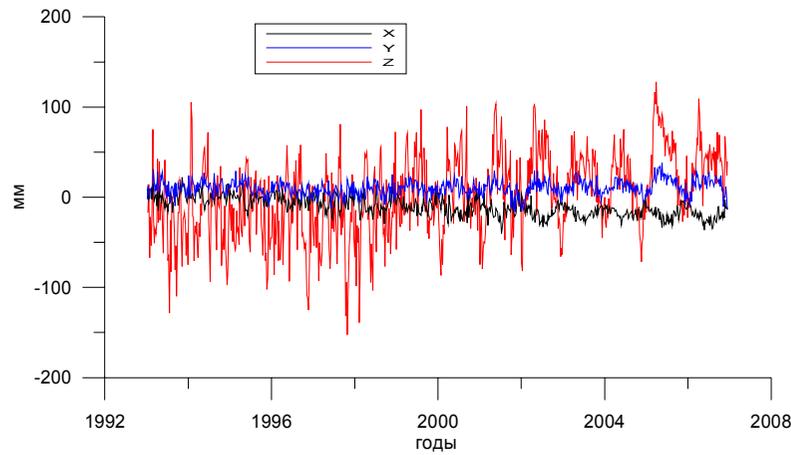
119	13.60	69.83
119	12.83	-54.27

90	3.03	18.34
88	6.18	238.55

Исходные данные

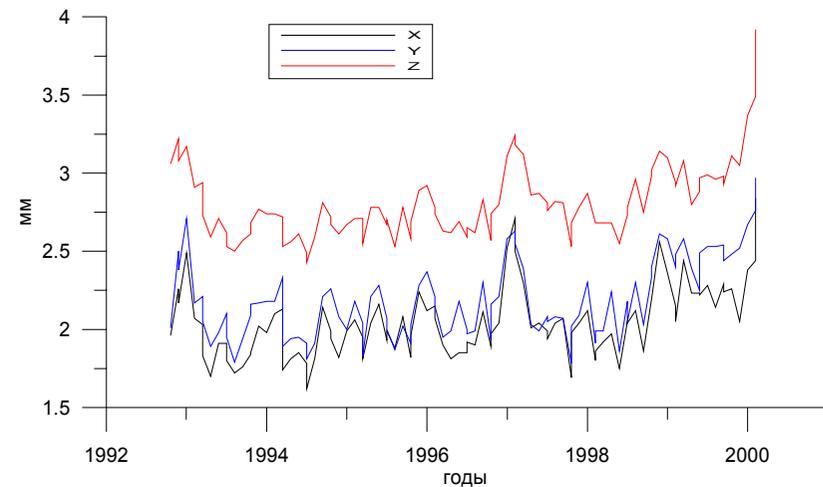
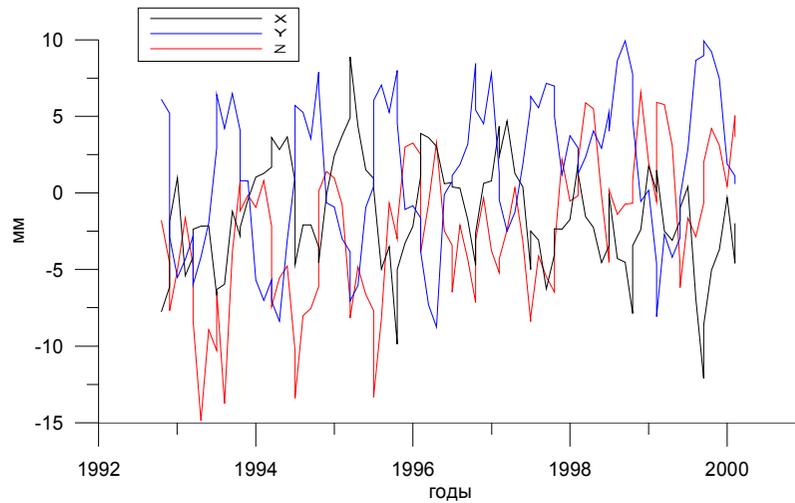
Данные JPL по DORIS

1993.02 - 2006.95 г., 727 точек с шагом 7 дней



Данные ILRS по LAGEOS

1992.8 - 2000.1 г., 99 точек с шагом 27 дней.



X,Y,Z

Погрешности

Линейный тренд (Зотов Л.В.)

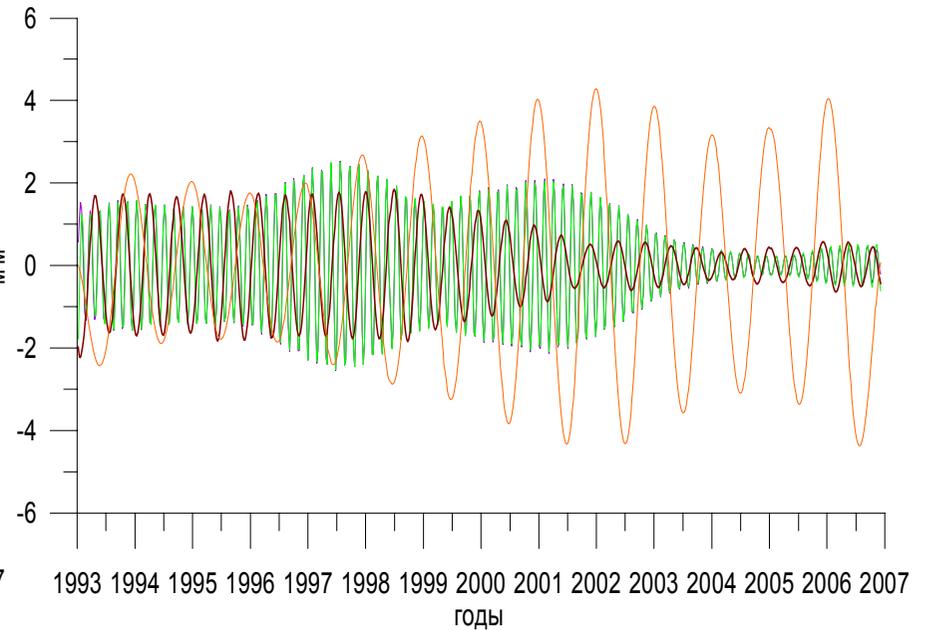
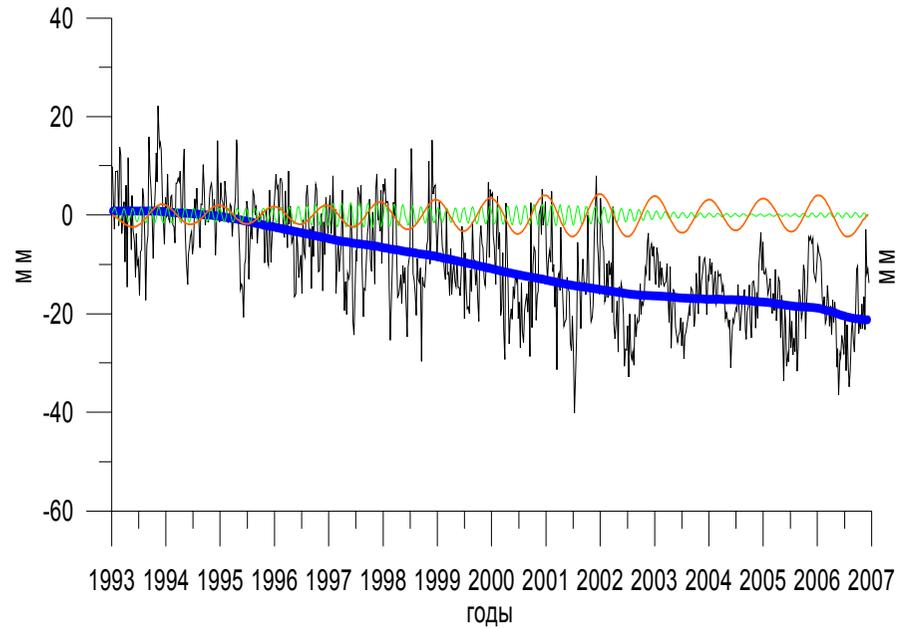
DORIS

Координата	A, мм	SigmaA, мм	B, мм	SigmaB, мм
X	-1.75	0.07	2.16	0.59
Y	0.24	0.08	8.50	0.63
Z	5.20	0.38	-34.6	3.00

СИНГУЛЯРНЫЙ СПЕКТРАЛЬНЫЙ АНАЛИЗ

Годовое и полугодовое колебания

DORIS (Зотов Л.В.)



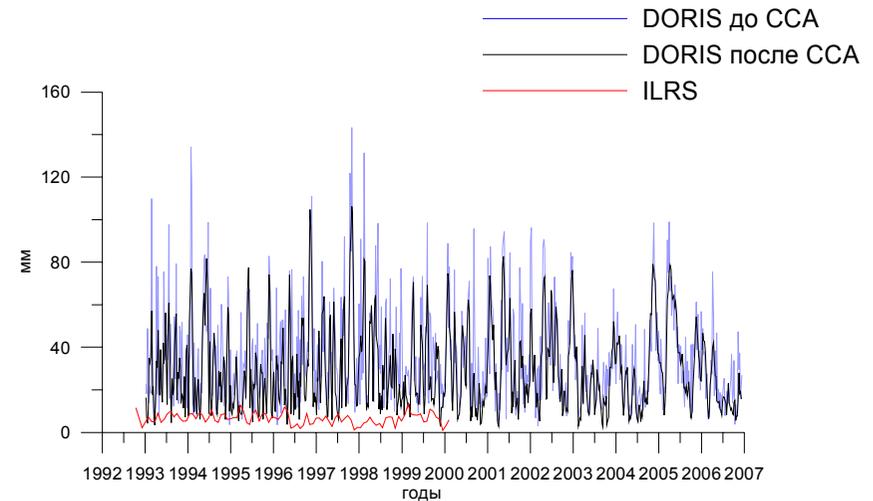
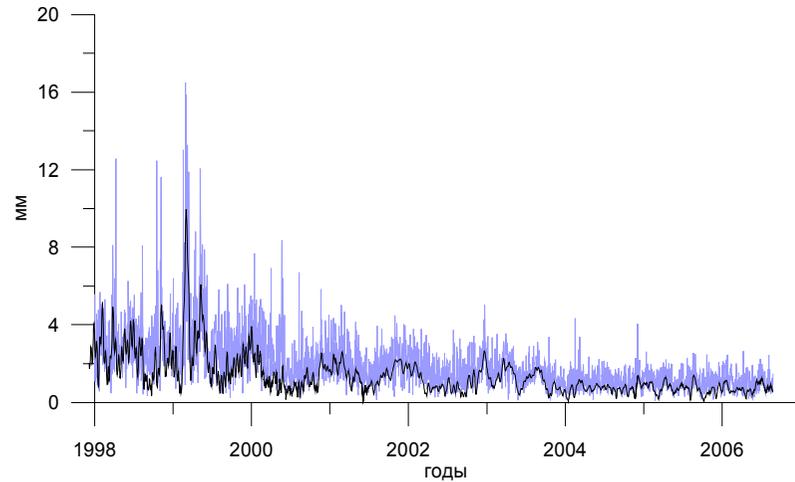
ИЗМЕНЕНИЯ РАДИУСА И УГЛА

(Зотов Л.В.)

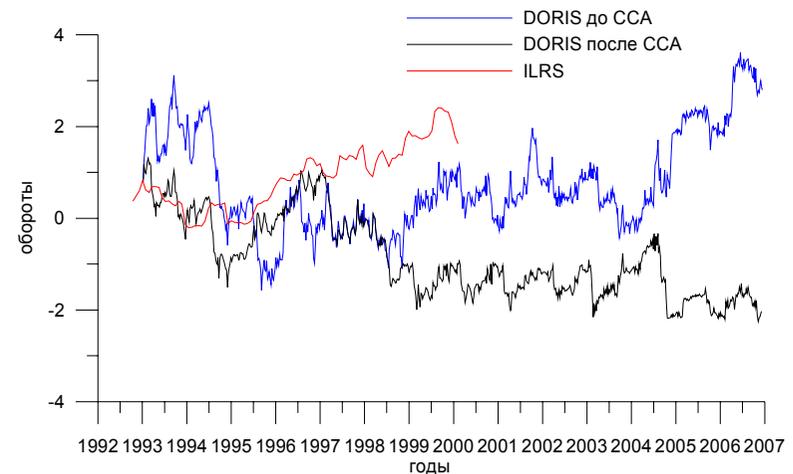
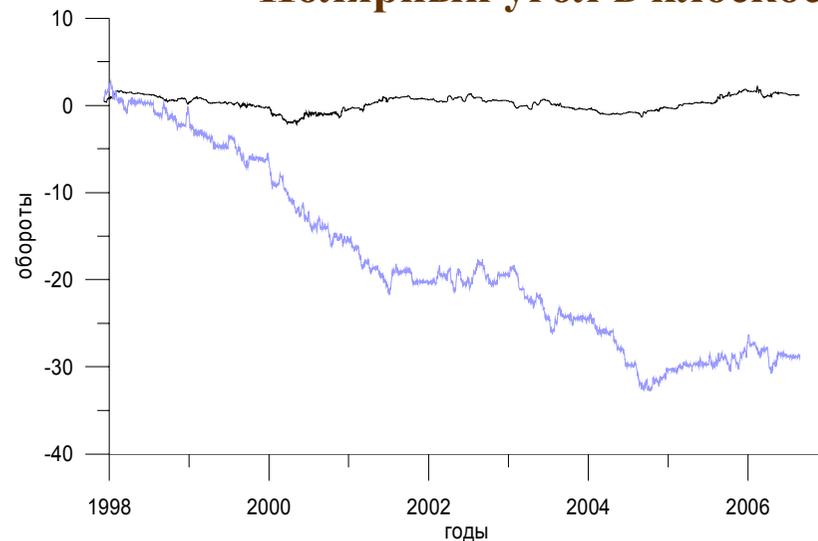
GPS

DORIS и ILRS

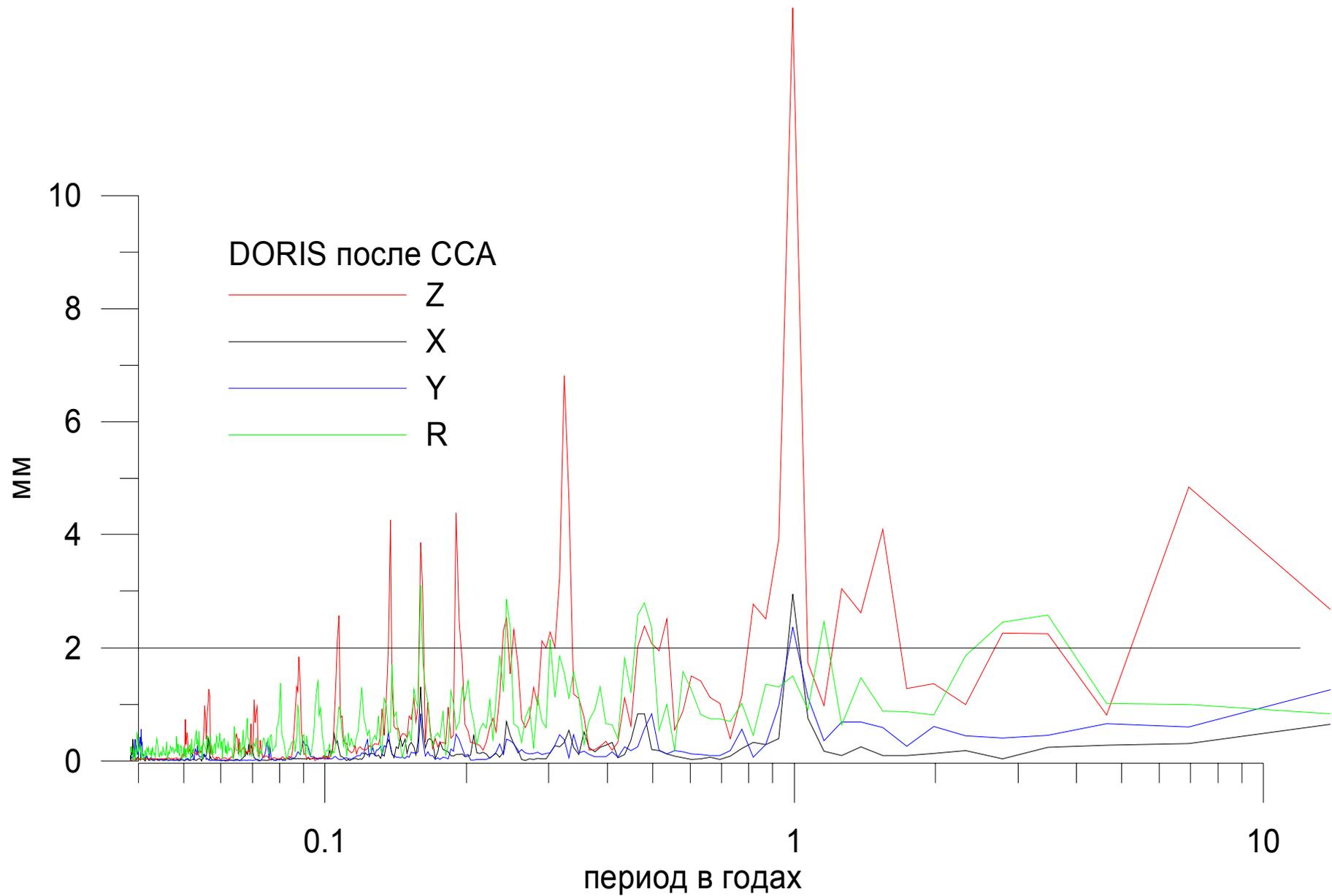
3D радиус до (синим) и после (черным) извлечения тренда и ССА



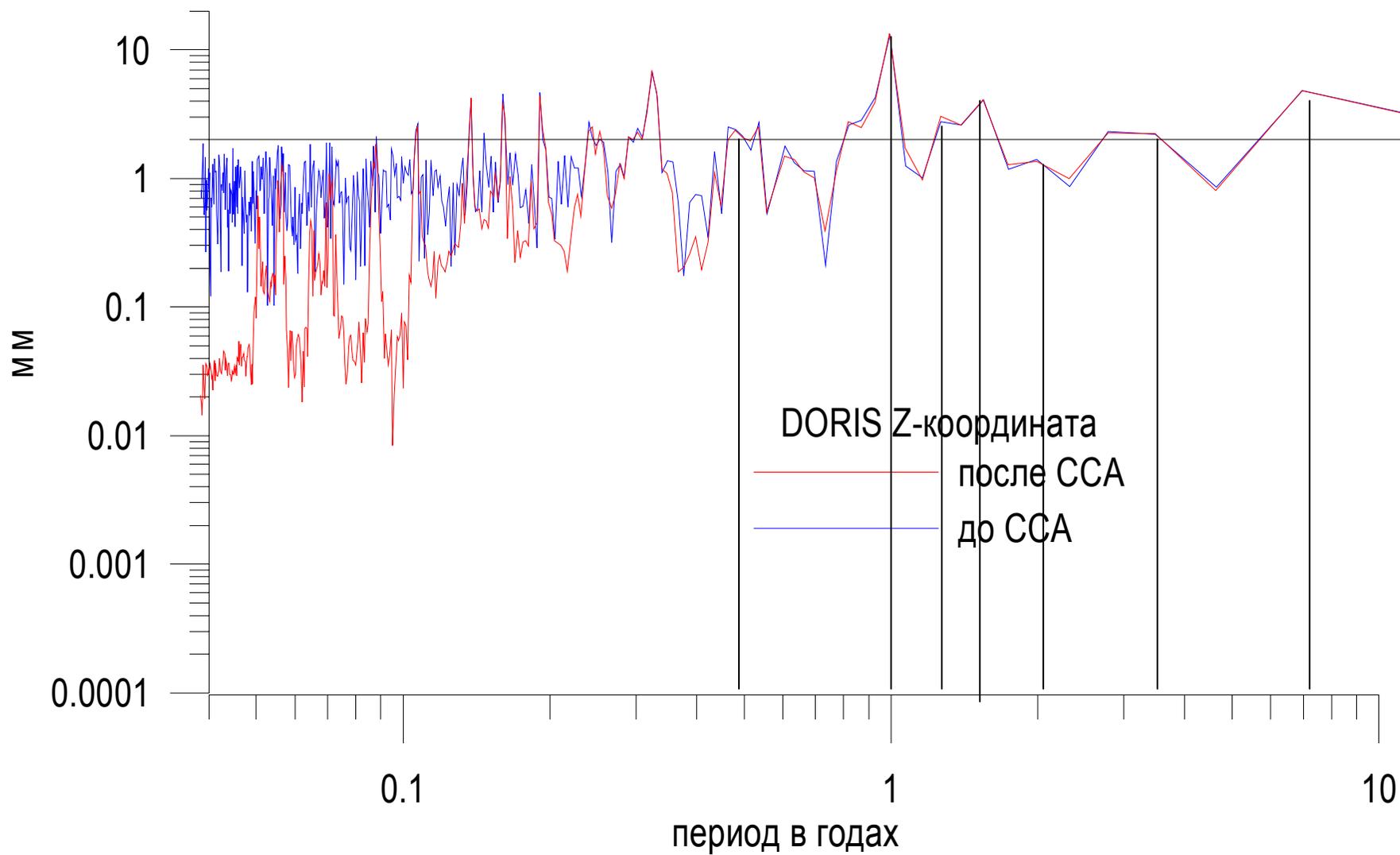
Полярный угол в плоскости ХУ (вращение на запад - вниз)



Спектры вариаций координат (Зотов Л.В.)



Спектры Z координаты (Зотов Л.В.)



Эпицентры положений геоцентра на поверхности Земли

