Climate change signals and LOD

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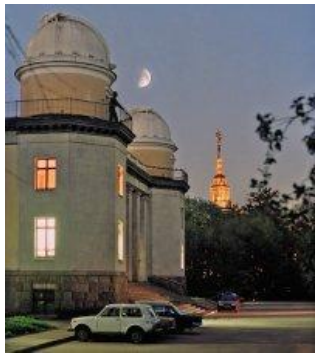
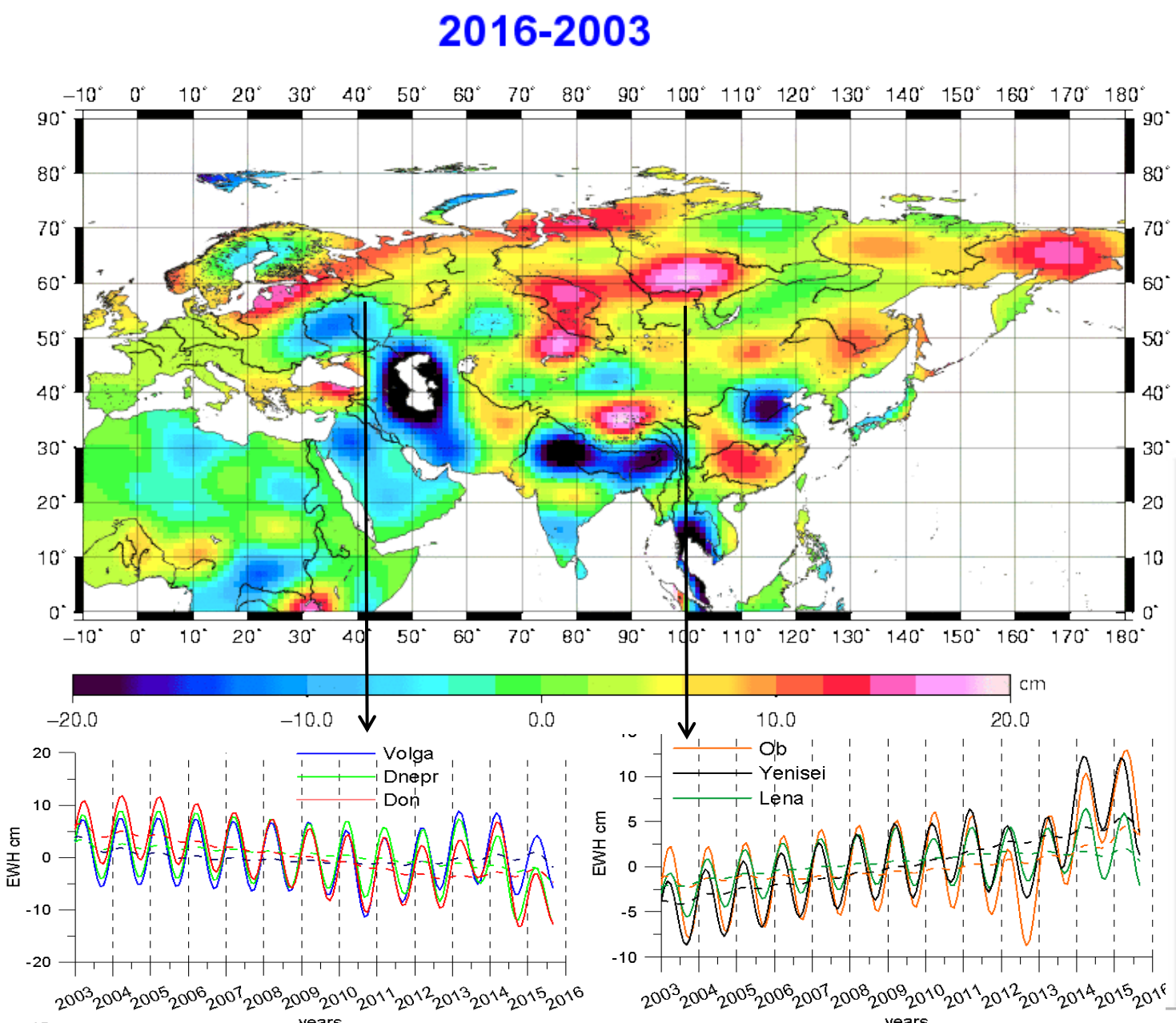


GSTM 2016
Potsdam

Mass change trends for Russia from GRACE

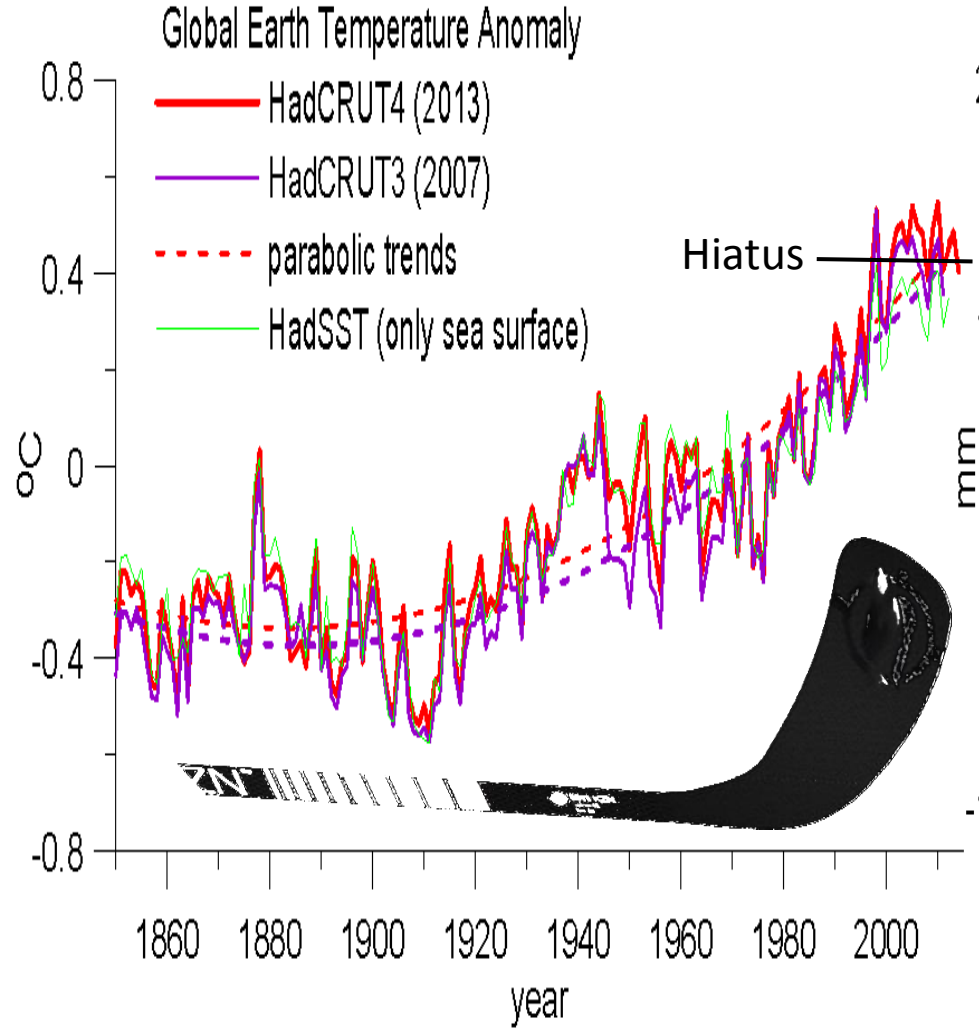


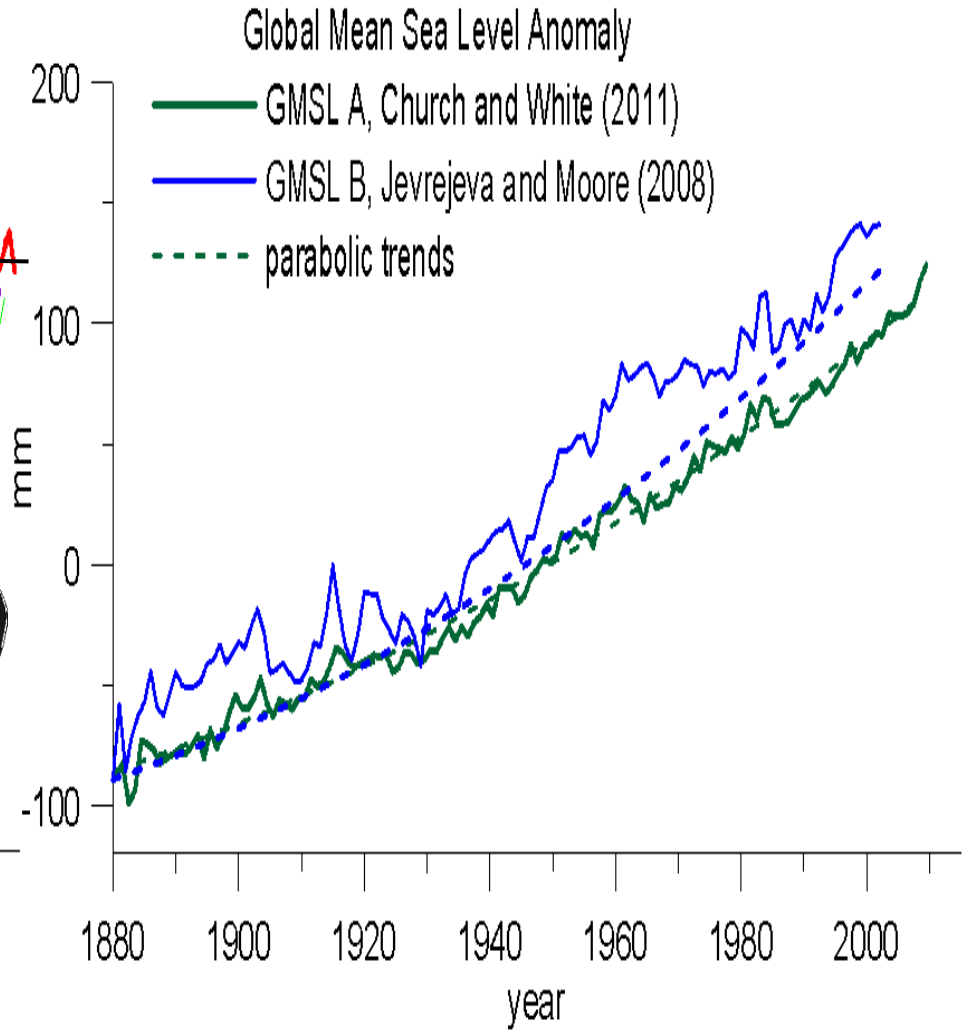
Леонид Валентинович Зотов, *физико-математических наук, доц ковского института электрони тематики Национального исслед ского университета «Высшая ш номики», старший научный сотр сударственного астрономическог тута имени П.К.Штернберга М М.В.Ломоносова. Область научных сов — вращение Земли, гравита поле, климатические изменения.*

Наталья Леонидовна Фролова, *сор, доктор географических наук, щая кафедрой гидрологии суши г ческого факультета Московского ственного университета имени М носова. Занимается изучением сн дистанционными методами иссл Земли, горной гидрологией.*

С.К.Шам (C.K.Shum), *профессор ния геодезии Школы наук о Земле ситета штата Огайо (г.Колумб Один из авторов отчета IPCC п ту 2007 г. Специалист в област тических изменений, спутников зии, геодинамики, исследований моря, данных GRACE.*

Global Climate Change





Multichannel Singular Spectrum Analysys MSSA

SSA- generalization of PCA

1) Lag parameter *L* selection

Multichannel signal

$$x = (x_1, x_2, \ldots, x_N)$$

Embedded into block matrix X

2) SVD — singular value decomposition of the matrix is performed

1D-SSA – "Caterpillar"

$$X = USV^T$$

3) For each singular number s_i the matrices are reconstructed

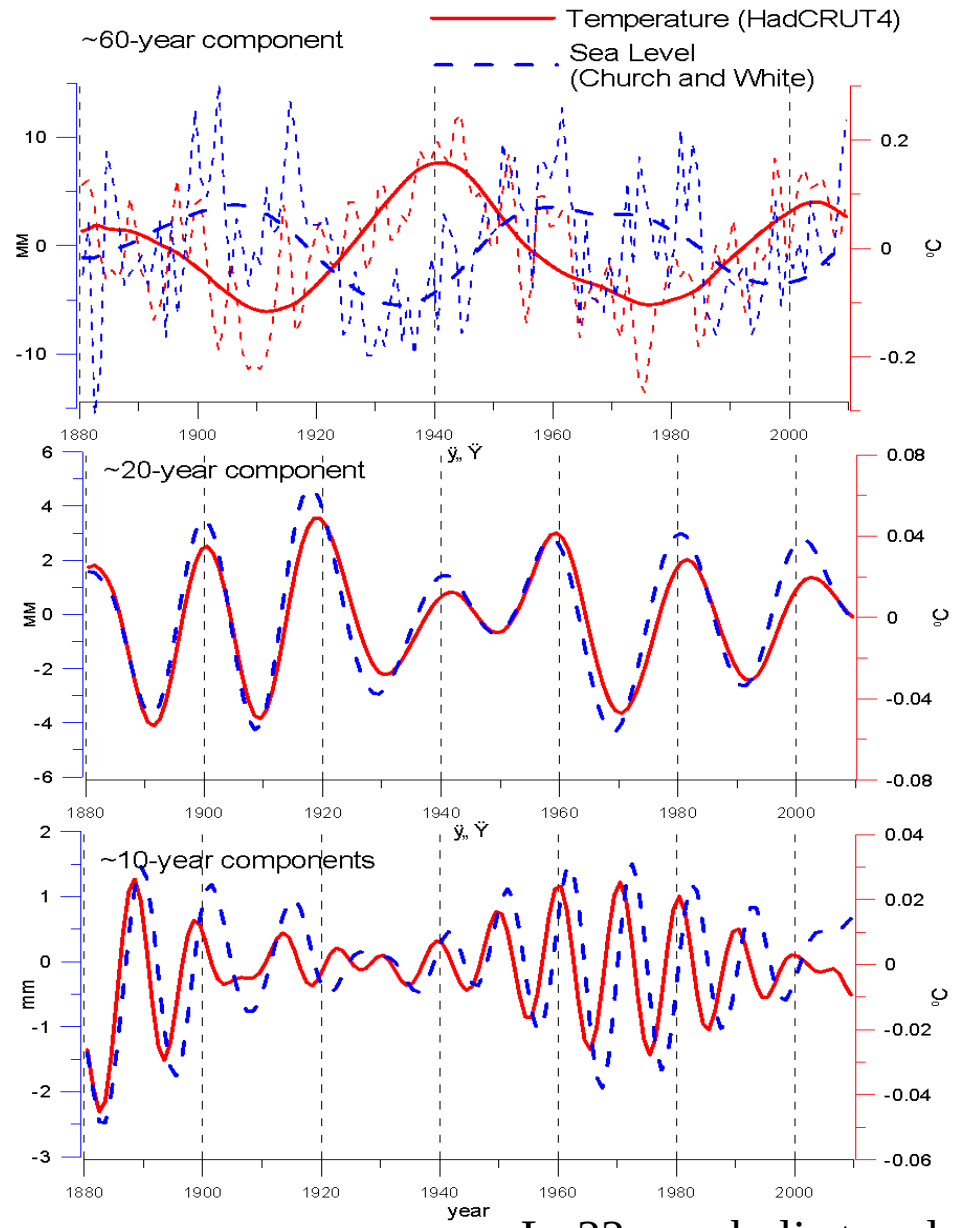
$$X^i = s_i u_i v_i^T,$$

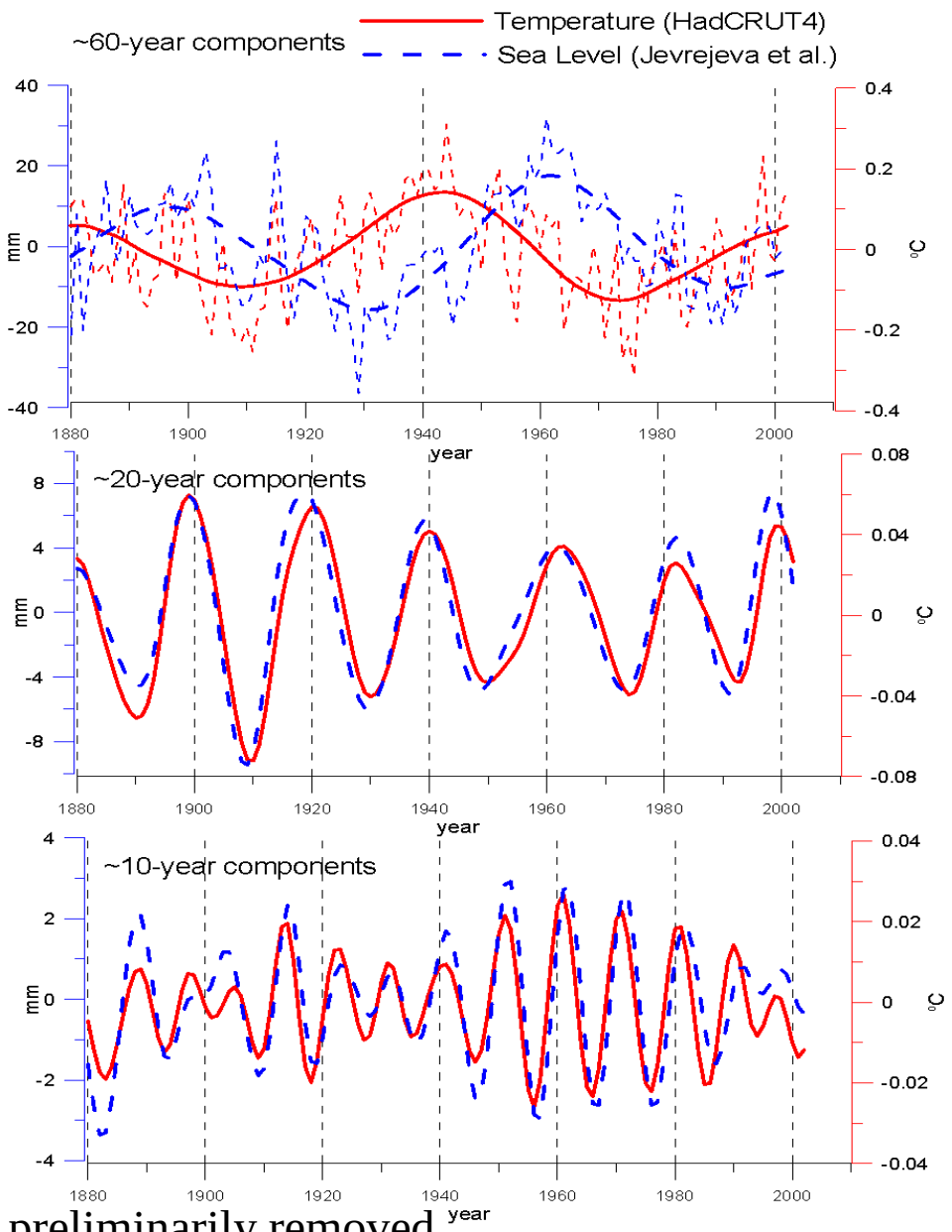
and signal for every component is obtained by Hankelization

4) Similar signals are grouped into Principal Components (PCs)

PC1, PC2, PC3…

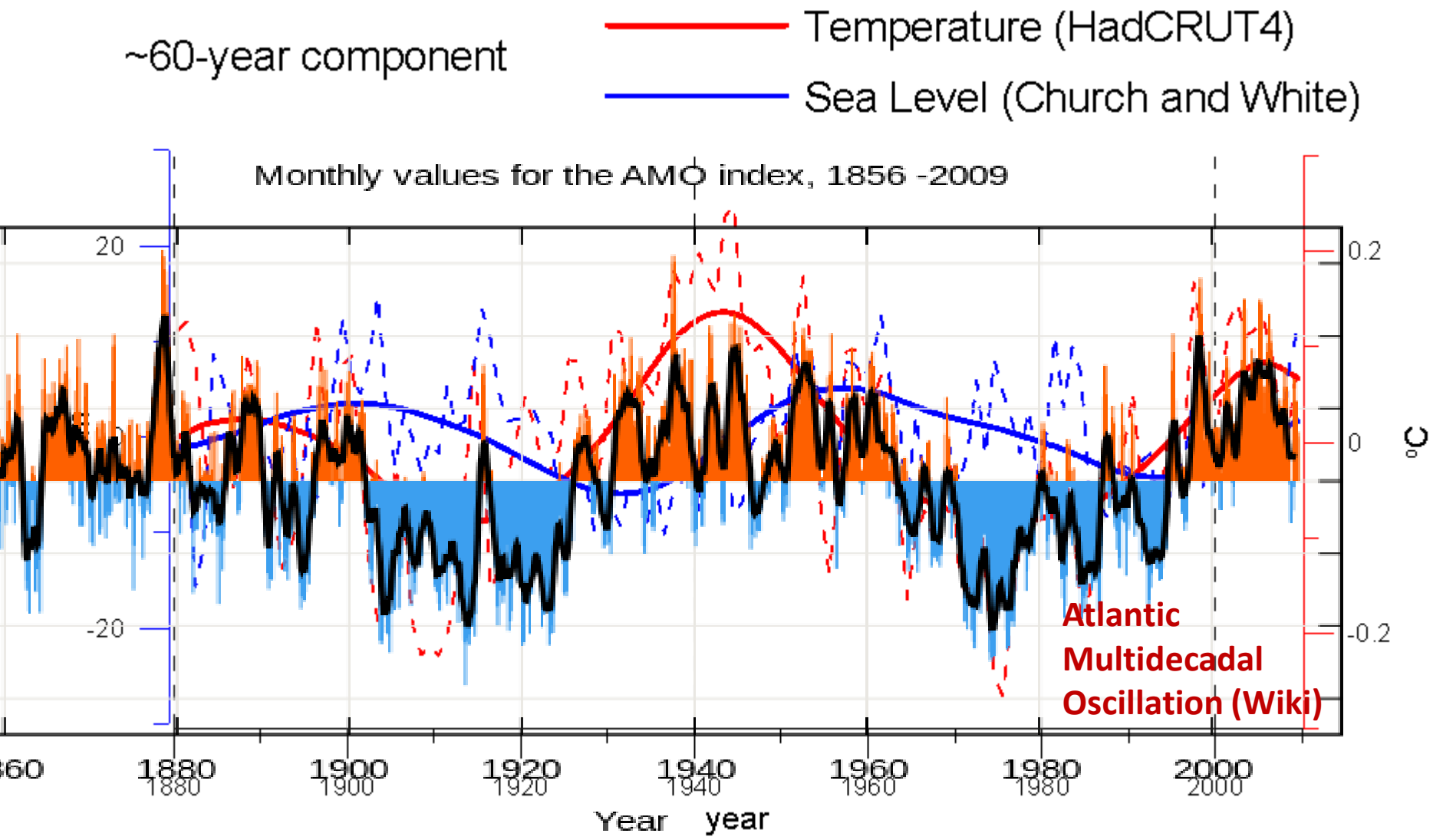
Results of MSSA for Temperature and Sea Level





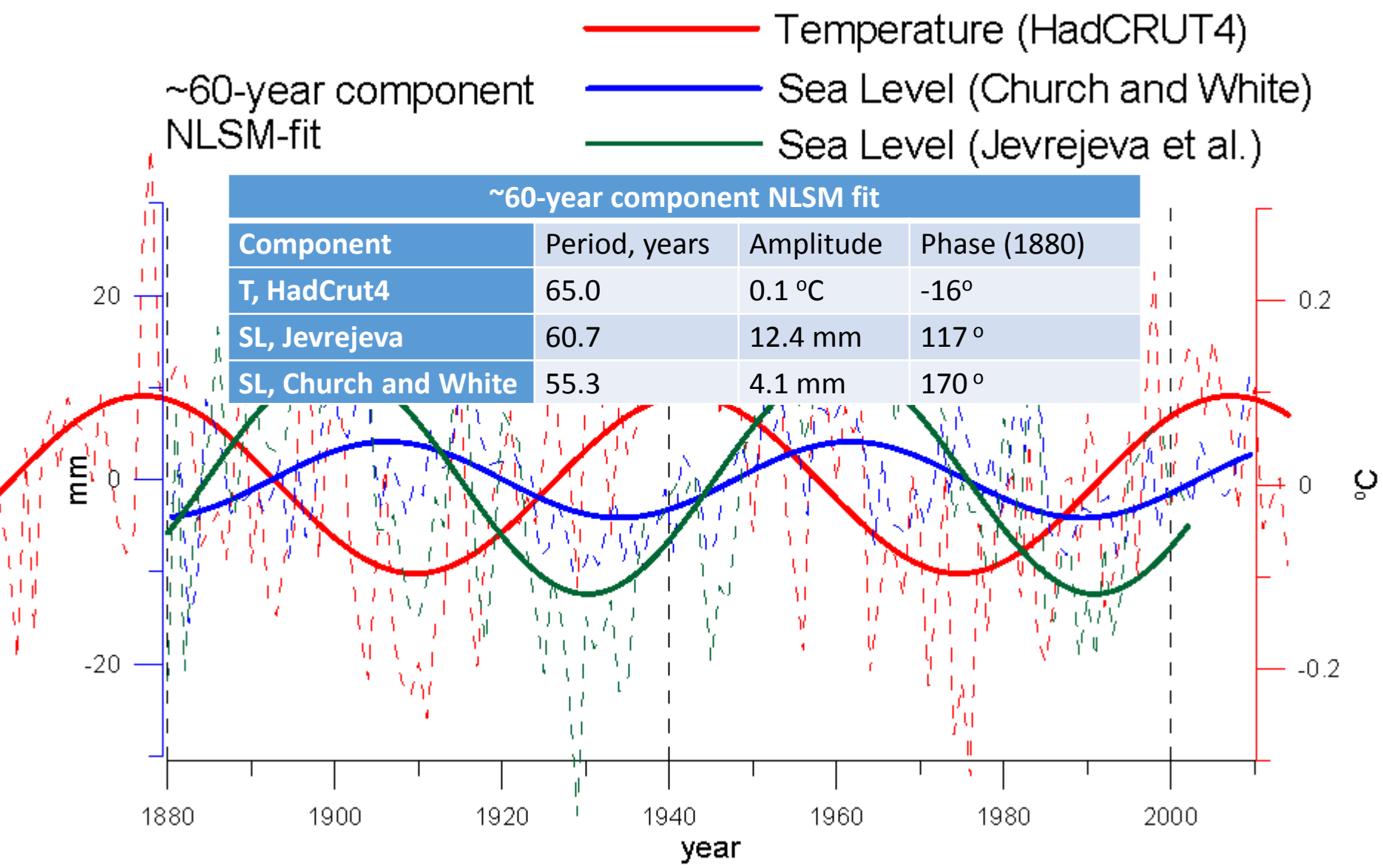
L=22, parabolic trends preliminarily removed

Results of MSSA for temperature and Sea Level



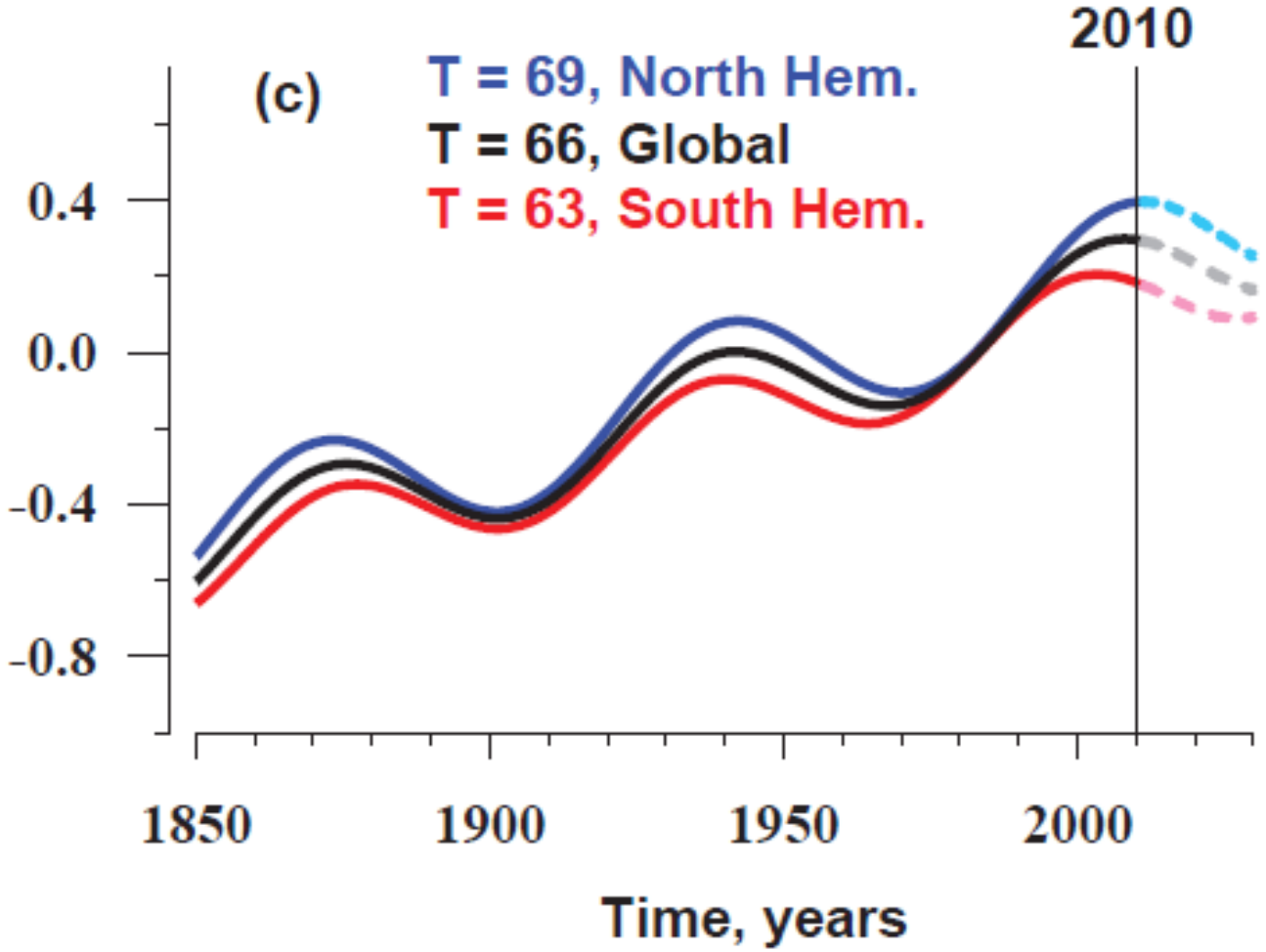
L=22, parabolic trends preliminarily removed

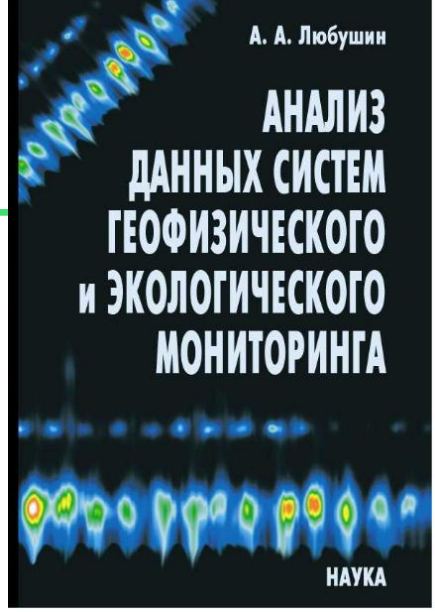
Results of non-linear LS-adjustment



~60-year component NLSM fit			
Component	Period, years	Amplitude	Phase (1880)
T, HadCrut4	65.0	0.1 °C	-16°
SL, Jevrejeva	60.7	12.4 mm	117 °
SL, Church and White	55.3	4.1 mm	170 °

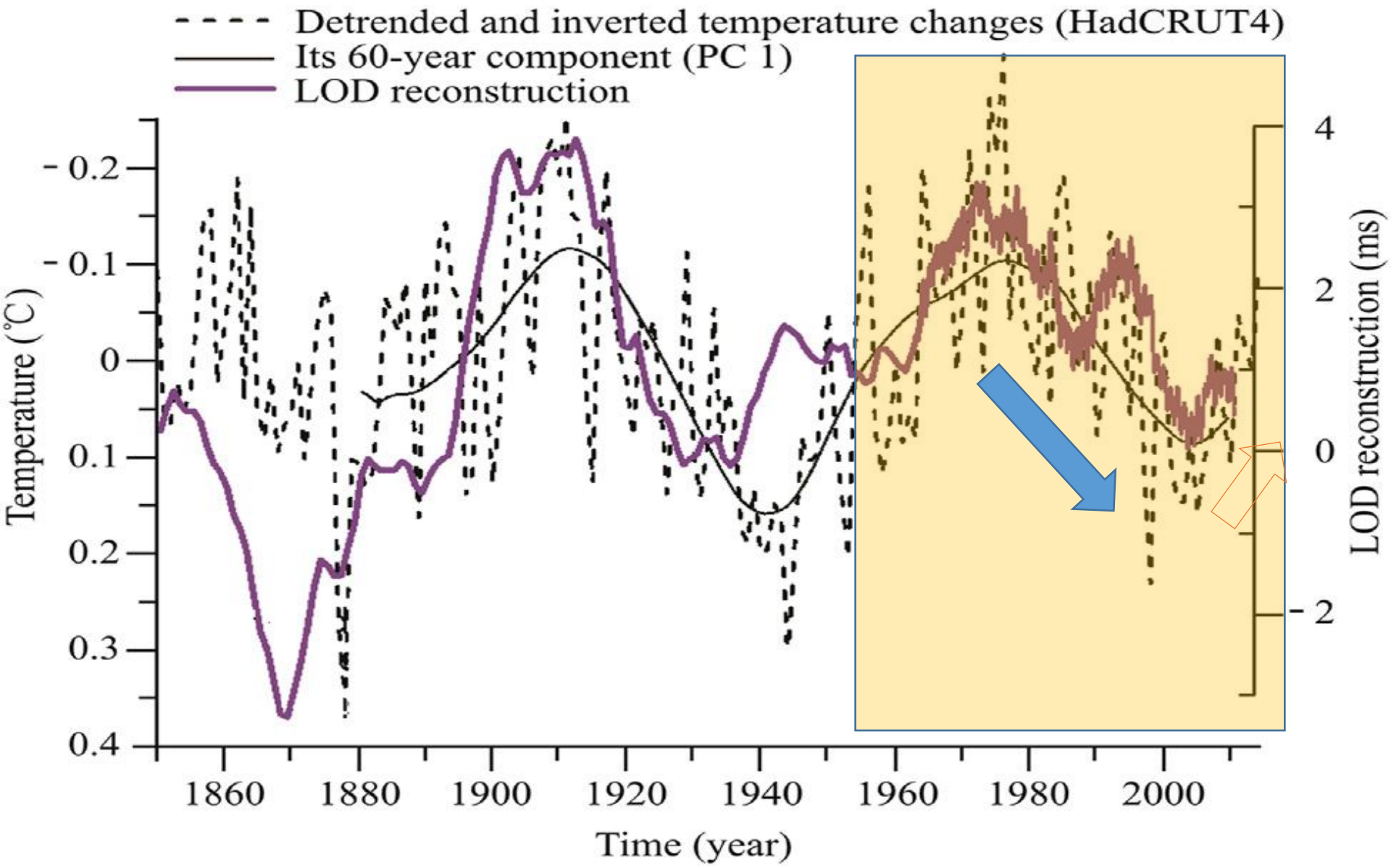
Prediction of the Global Earth Temperature based on cyclic and polynomial trend made by Alexey Lyubushin in his book and in his article with L. Klyashtorin



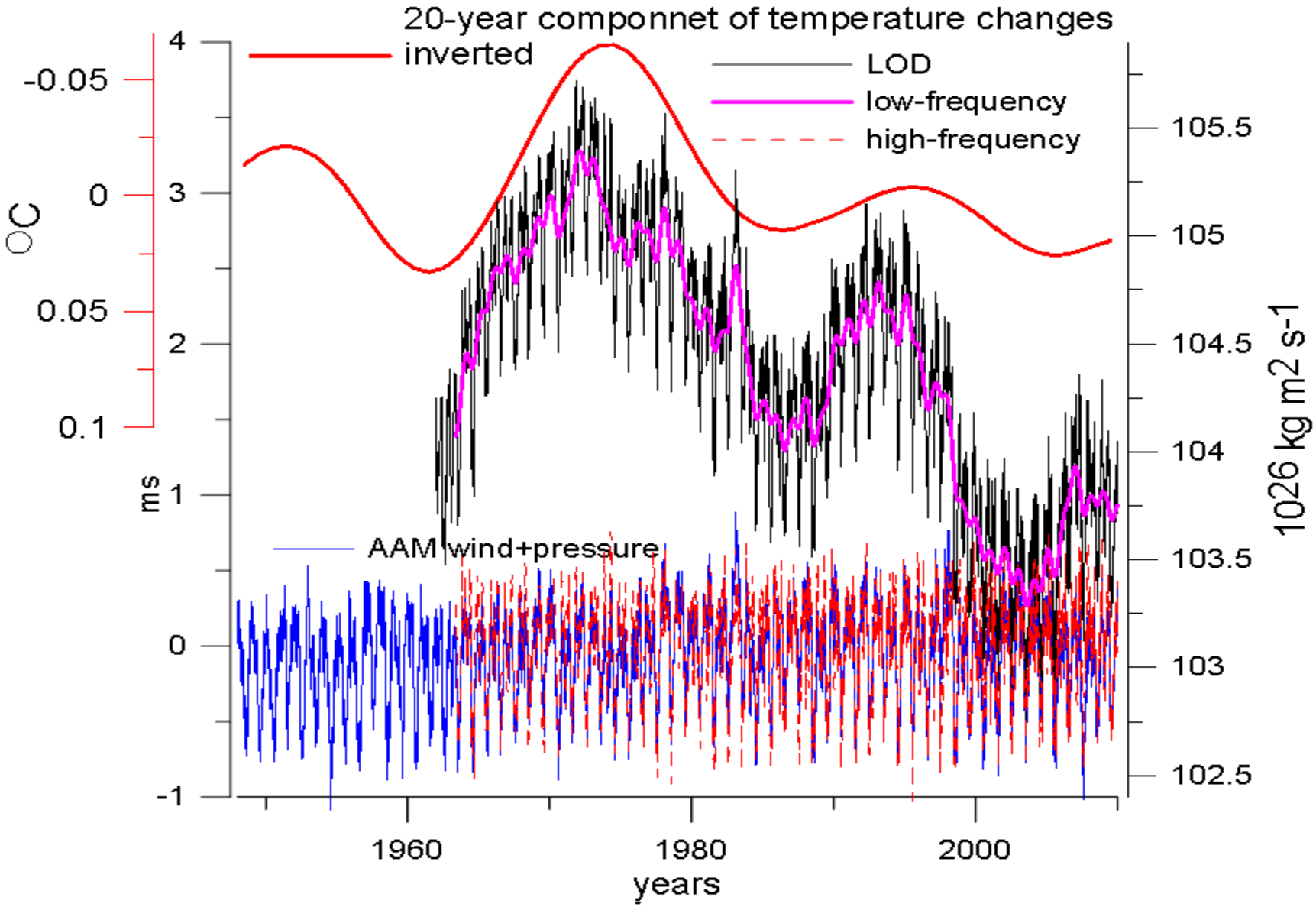


http://alexeylyubushin.narod.ru/Geophysical_Monitoring_Systems_Data_Analysis_Book_Rus.pdf

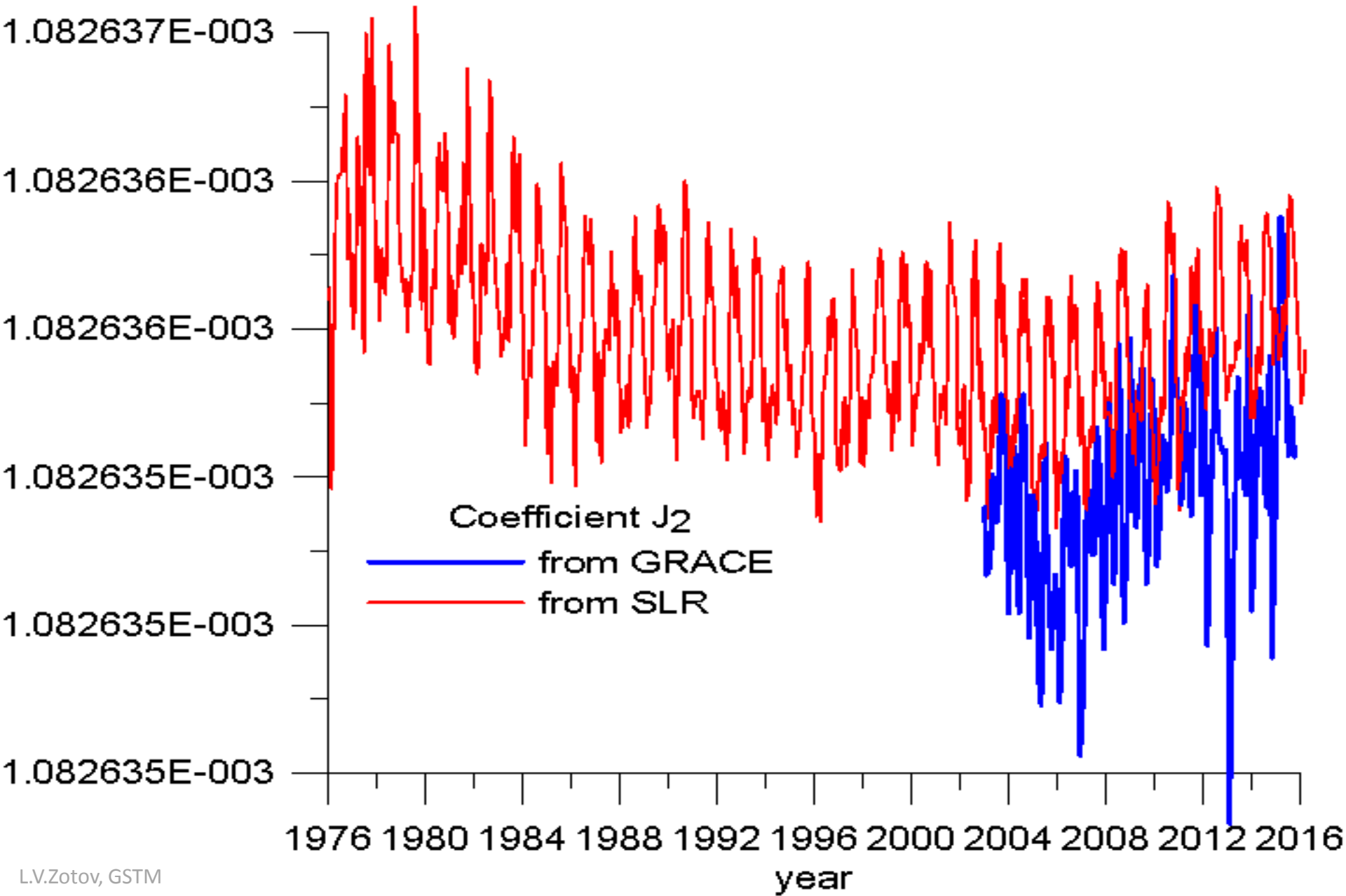
Long-term (60-year) changes in Temperature and LOD



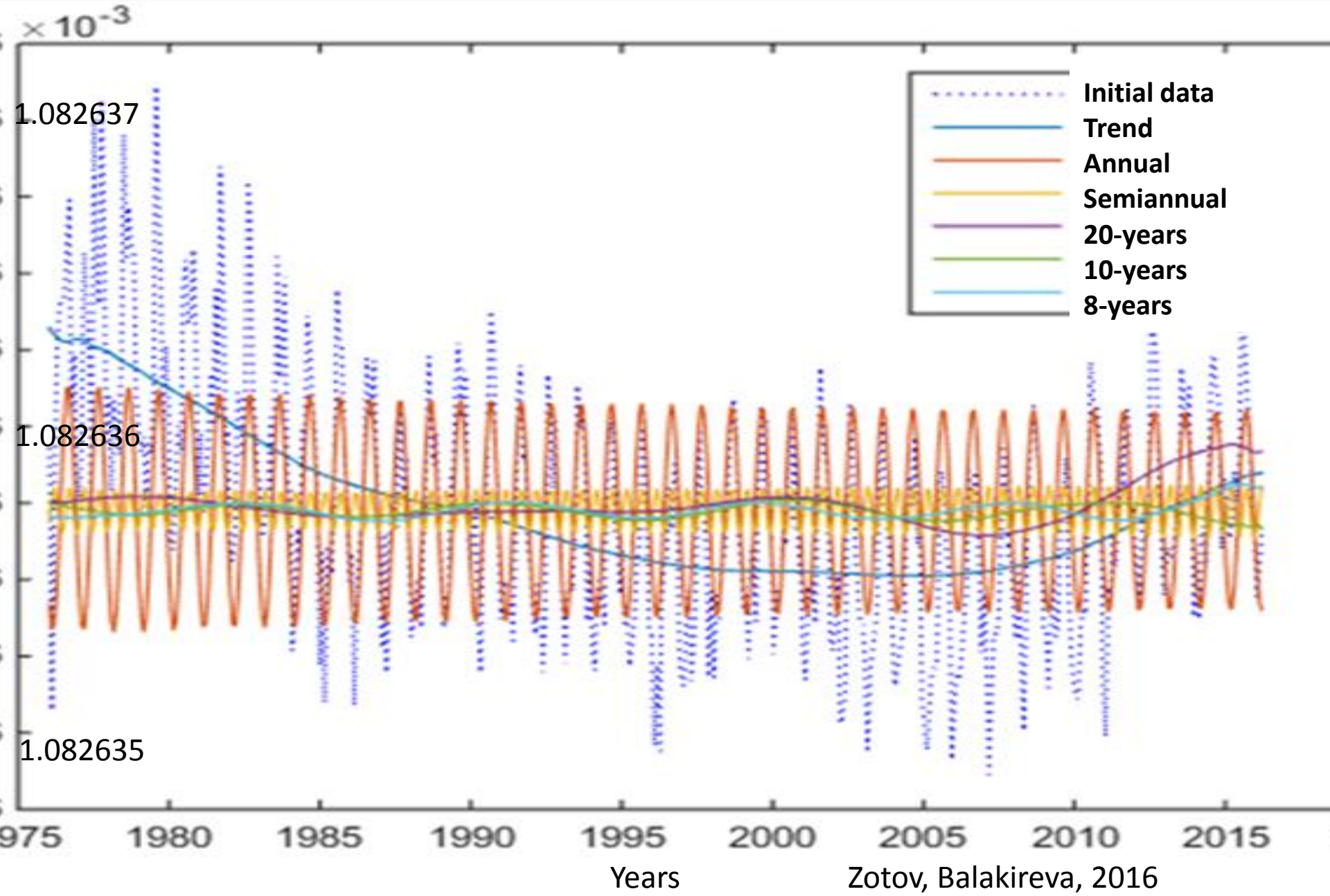
Non-tidal LOD and 20-year temperature changes



Variations in J_2 from SLR and GRACE

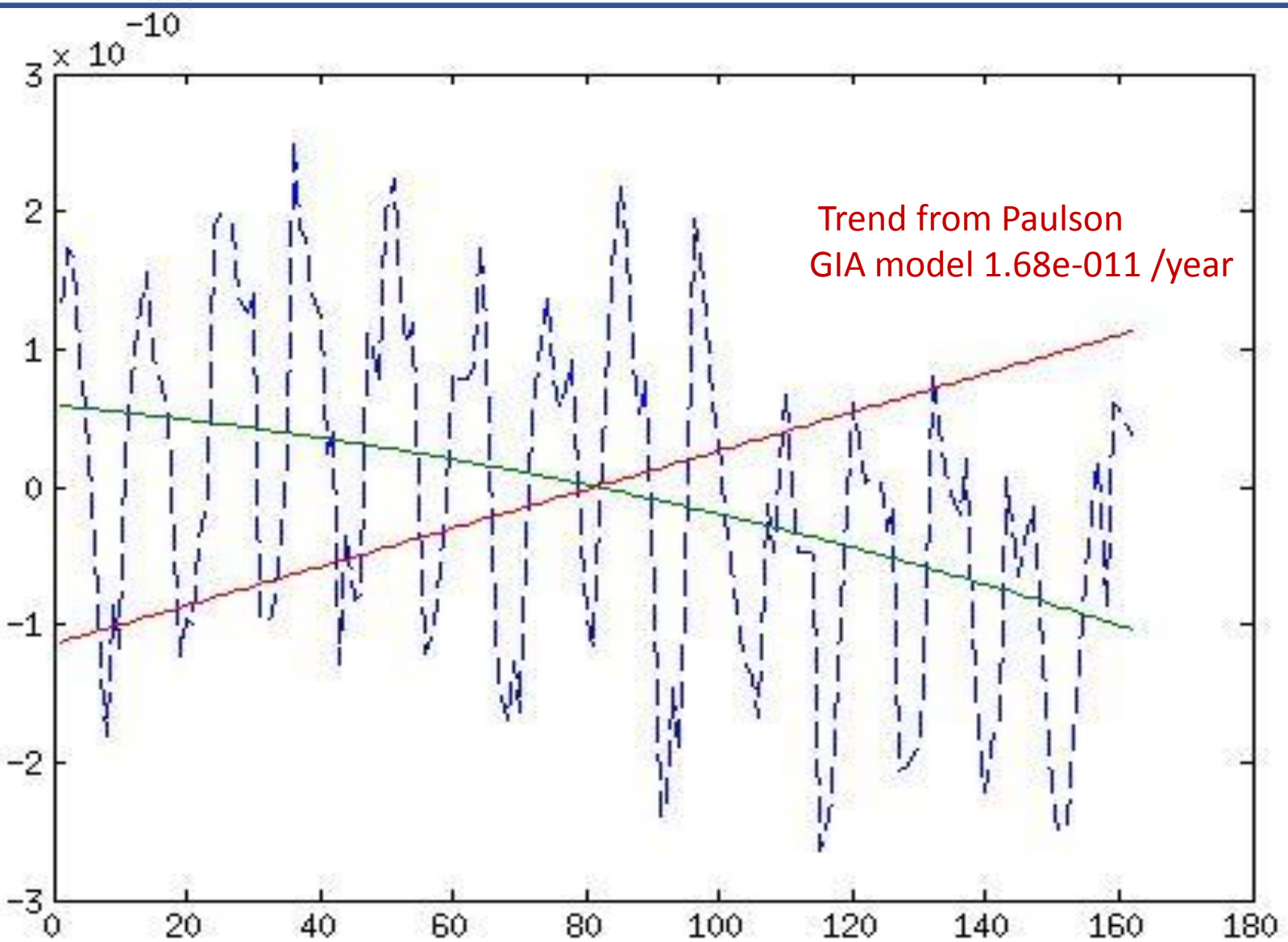


MSSA of variations in J_2

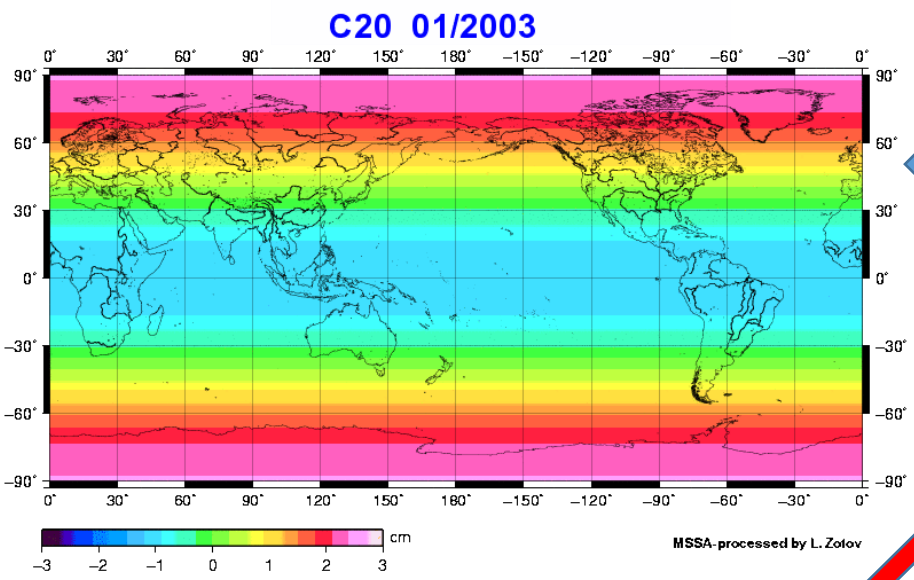


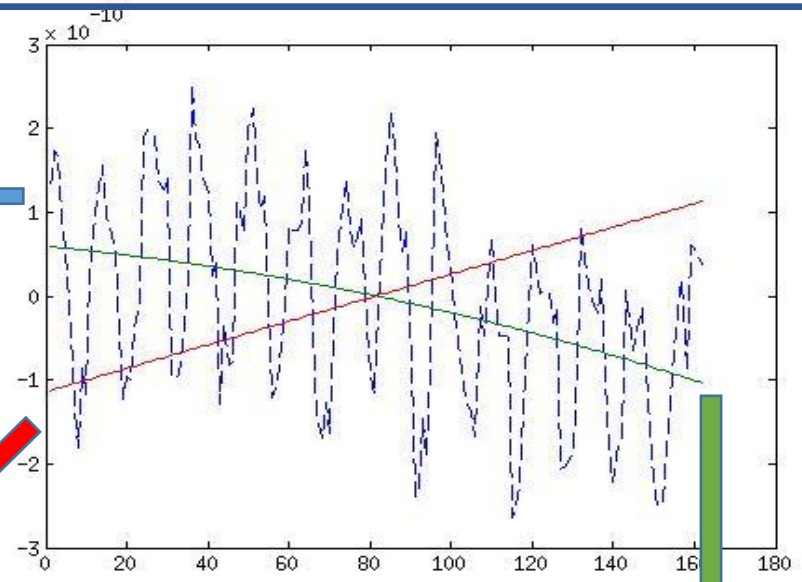
Zotov, Balakireva, 2016

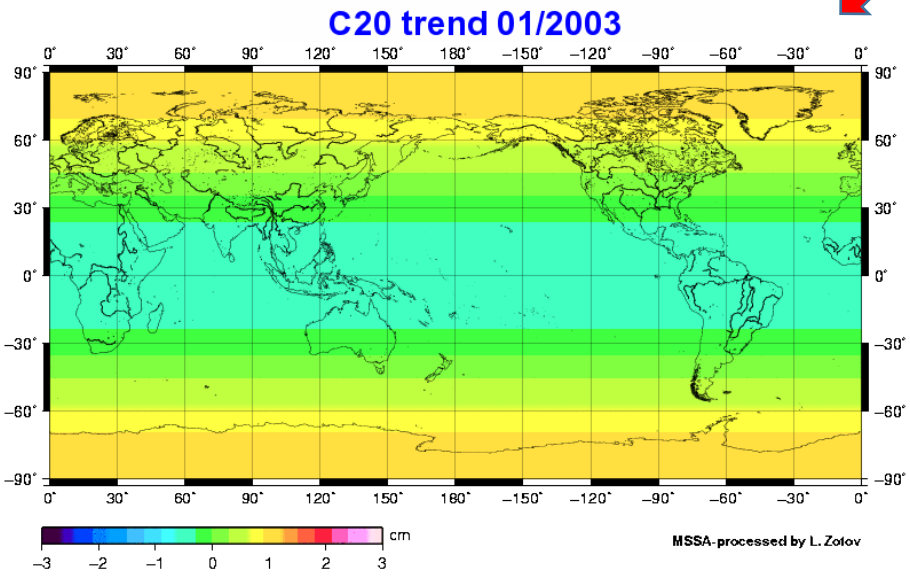
C_{20} changes from GRACE and GIA model

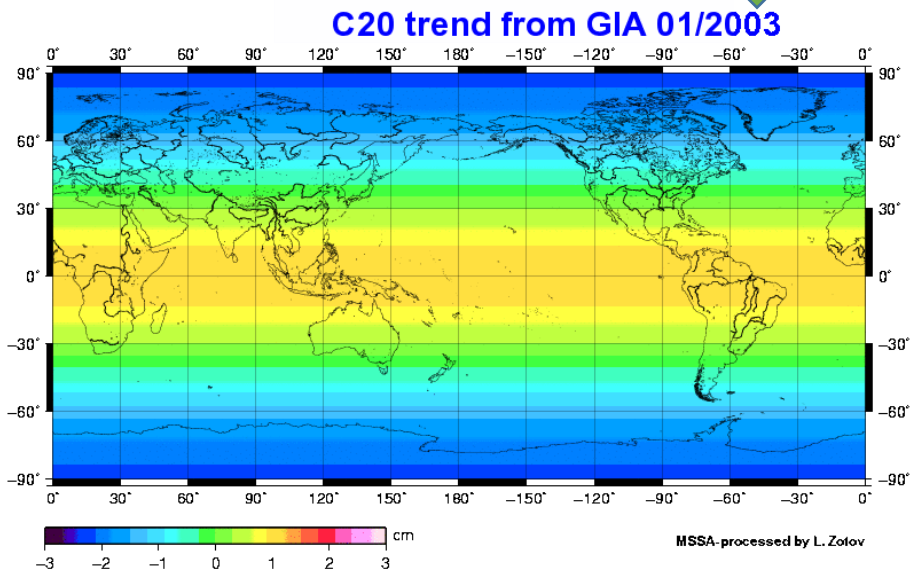


C_{20} changes from GRACE and GIA model

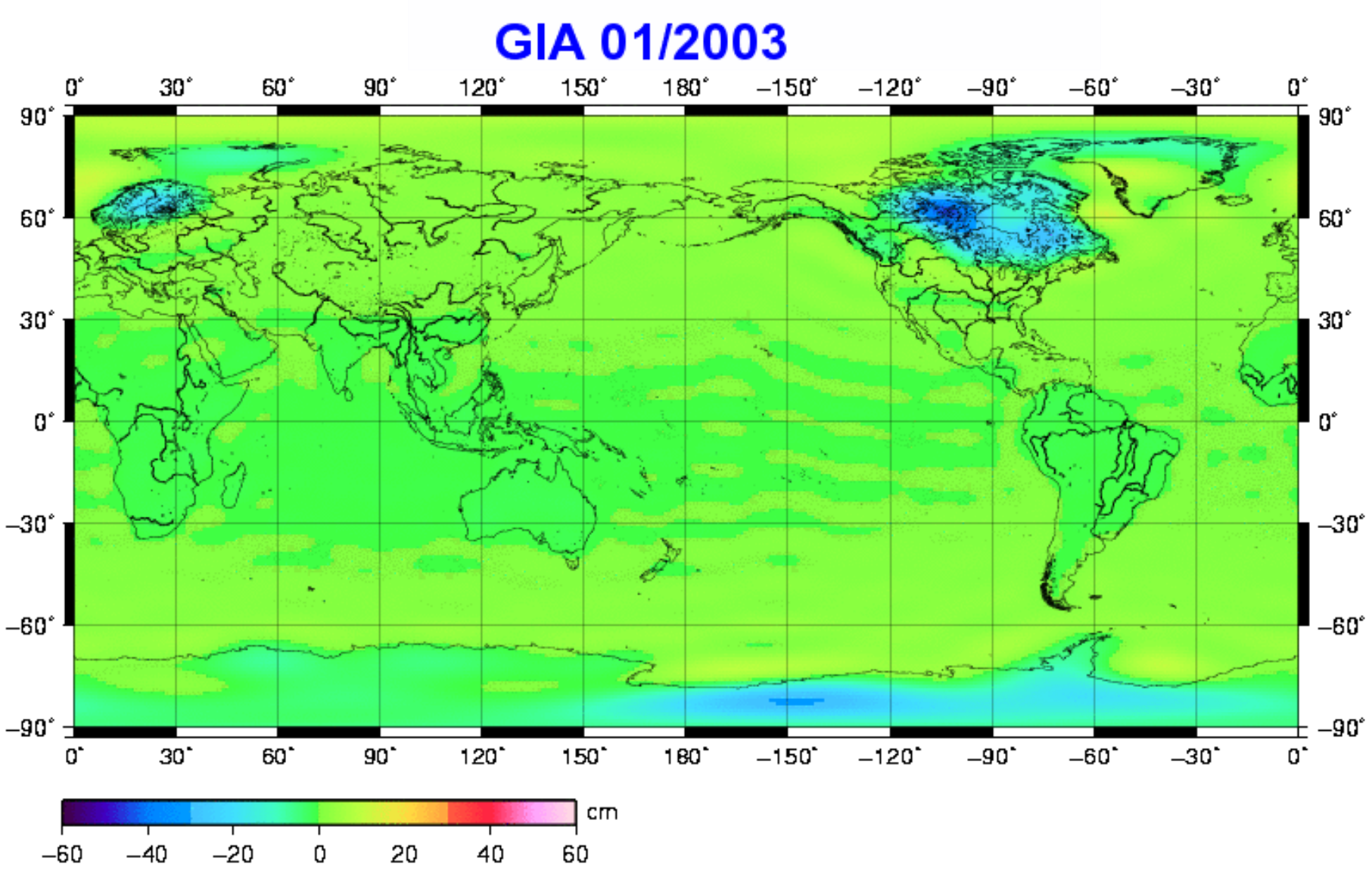






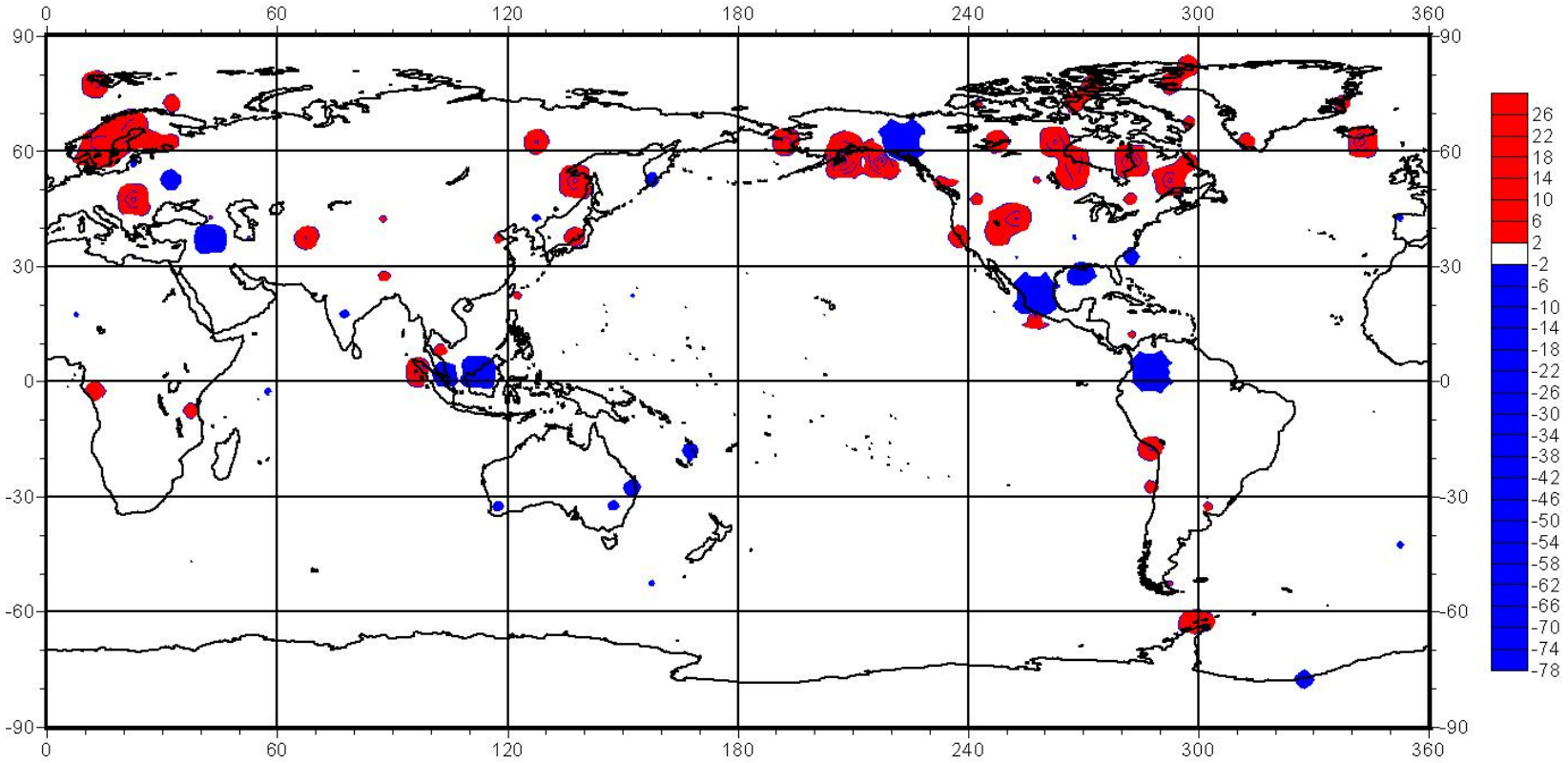


Glacial isostatic adjustment GIA model (Paulson 2007)



The radial velocity of the Earth‘s crust movement according to ITRFi2008, variation range of -74.00 mm/year ÷ 21.78 mm/year

Contour interval of 4 mm / year , red colour - positive values, blue colour - negative values



Chujkova N.A., Maximova T.G., Tchesnokova T.S., Grushinsky A.N., Vertical motions of the Earth crust from ITRF2000, ITRF2005, ITRF2008, ITRF2014 and their comparison. Physical geodesy, Russia, 2016 (in press)

Table 2. Global characteristics of vertical velocities for different Earth hemispheres and different coordinate systems.

z S %	z Eq %	z N %	V S mm/y	V Eq mm/y	V N mm/y	c10	c11	d11	c20	Coord Syst
2.89	11.63	18.71	1.93	-2.01	1.66	0.02	-0.14	1.17	2.09	2000
2.89	10.44	17.21	1.93	-2.12	0.84	0.38	0.12	0.31	1.19	i2000
3.26	9.92	18.06	-0.35	-0.81	1.80	0.71	0.24	1.18	1.37	2005
3.26	10.17	18.15	-0.34	-0.84	1.39	0.54	0.35	1.07	1.25	i2005

Chujkova N.A., Maximova T.G., Tchesnokova T.S., Grushinsky A.N., Vertical motions of the Earth crust from ITRF2000, ITRF2005, ITRF2008, ITRF2014 and their comparison. Physical geodesy, Russia, 2016 (in press)

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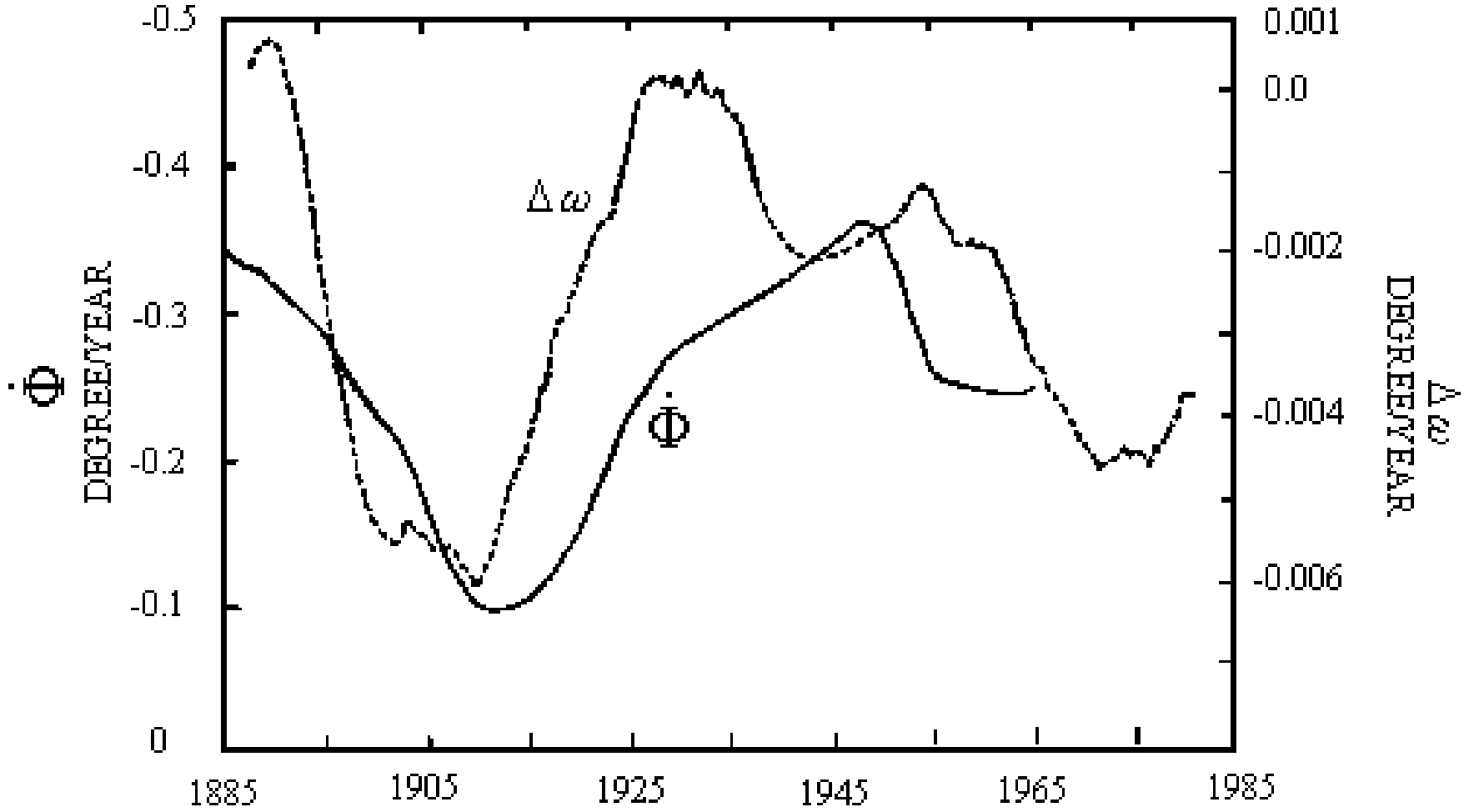
z S %	z Eq %	z N %	V S mm/y	V Eq mm/y	V N mm/y	c10	c11	d11	c20	Coord Syst
4.33	14.32	22.65	0.18	-1.52	1.95	0.47	0.57	-0.27	1.81	2008
4.33	14.32	22.45	0.18	-0.74	1.74	0.47	0.25	0.43	1.36	i2008
5.32	20.75	26.90	-0.31	-2.27	1.88	1.00	-0.07	-0.11	1.32	2014
5.32	20.75	26.46	-0.31	-1.52	1.88	0.80	-0.09	0.13	1.56	i2014

Chujkova N.A., Maximova T.G., Tchesnokova T.S., Grushinsky A.N., Vertical motions of the Earth crust from ITRF2000, ITRF2005, ITRF2008, ITRF2014 and their comparison. Physical geodesy, Russia, 2016 (in press)

Eccentric geomagnetic dipole motion (solid lines) and change in the length of day expressed as angular deviations of rotation (deg· y^{-1}) (dashed line.)



Sidorenkov et al.

Russian Meteorology and Hydrology
No. 8, pp. 1–8, 2005

Meteorologiya i Gidrologiya
UDC 551.324.24+525.35/.37

VARIATION OF THE MASS OF THE ICE SHEET OF ANTARCTICA AND INSTABILITY OF THE EARTH'S ROTATION

N. S. Sidorenkov*, O. V. Lutsenko*, N. N. Bryazgin**,
E. I. Aleksandrov**, and V. G. Zakharov***

A theoretical series of the Antarctic ice mass variation from 1891 to 2000 is calculated using astronomical data on the movement of the North Pole and variation in the velocity of the Earth's daily rotation. The series is compared with the data of V. N. Petrov [3] on the annual layers of snow accumulation in Antarctica and precipitation series at Antarctic stations. It is shown that the theoretical series agrees well with results of actual snow measurements. It is concluded that the theoretical series can be used to test the results of empirical studies of the temporal variability of the ice sheet of Antarctica and of atmospheric precipitation in Antarctica.

$$-\frac{1}{\sigma}\frac{dv_2}{dt}+v_1=\frac{n_{13}}{C-A}=-\frac{r^2}{2(C-A)}\iint_s\zeta(\theta,\lambda,t)\sin2\theta\cos\lambda\,ds;$$

$$\frac{1}{\sigma}\frac{dv_1}{dt}+v_2=\frac{n_{23}}{C-A}=-\frac{r^2}{2(C-A)}\iint_s\zeta(\theta,\lambda,t)\sin2\theta\sin\lambda\,ds;$$

$$\delta v_3=-(1+k')\frac{\delta n_{33}}{C}=-(1+k')\frac{r^2}{C}\iint_s\zeta(\theta,\lambda,t)\sin^2\theta\,ds.$$

$$\nu_1 \cdot 10^{11} = 24149\zeta_O + 1337\zeta_A - 2102\zeta_G - 23387\zeta_C,$$

$$\nu_2 \cdot 10^{11} = 37714\zeta_O + 3820\zeta_A + 1909\zeta_G - 43443\zeta_C,$$

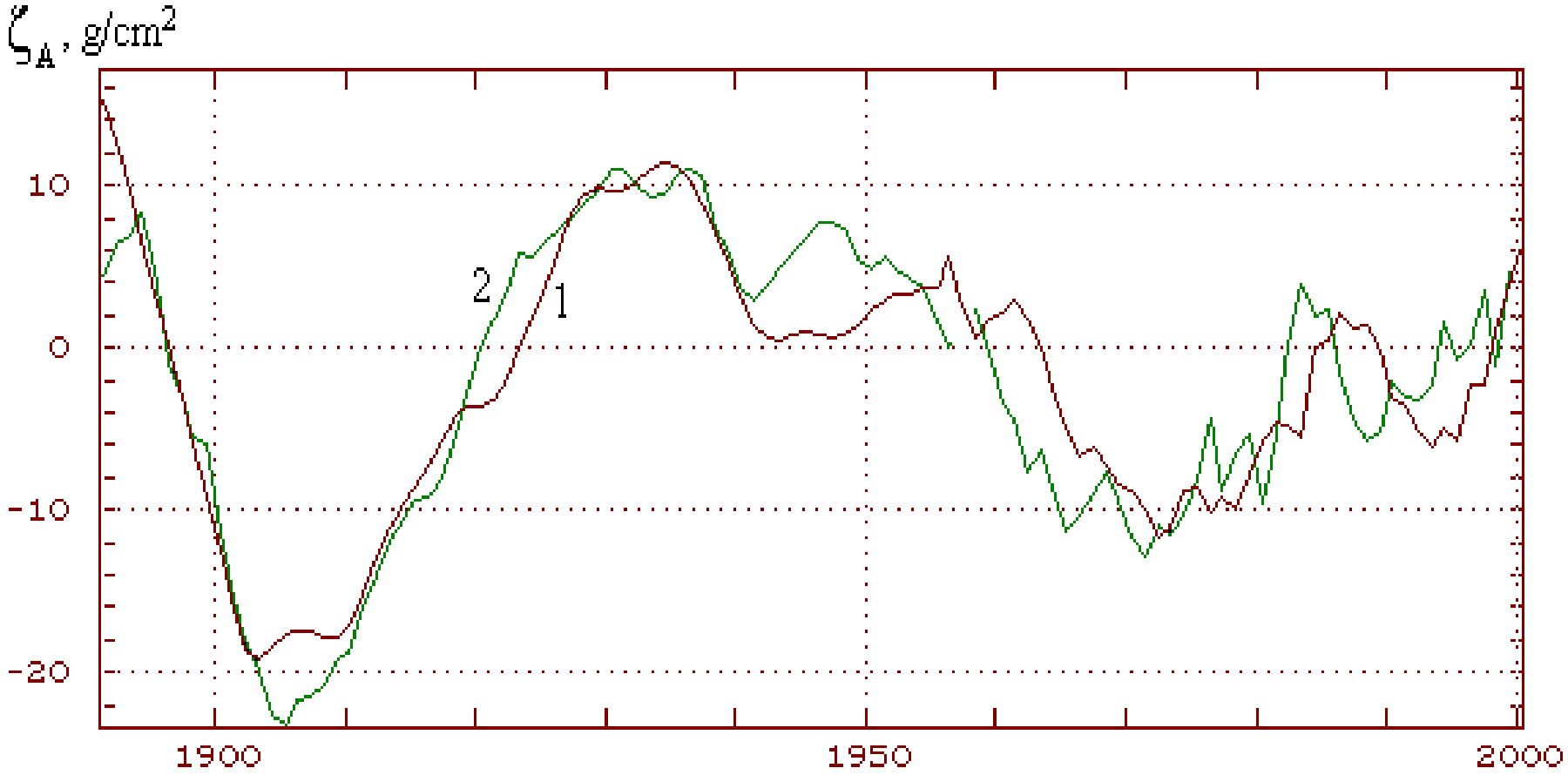
$$\nu_3 \cdot 10^{12} = -26746\zeta_O - 87\zeta_A - 28\zeta_G - 9268\zeta_C,$$

$$0 = .71436\zeta_O + .02820\zeta_A + .00414\zeta_G + .25330\zeta_C.$$

Here, ζ_O, ζ_A, ζ_G and ζ_C – are the averaged fluctuations of the specific amount of water or ice, g·cm^{-2}, in the World Ocean, Antarctica, Greenland and "the rest part of land", respectively.

The simple algebraic system (7) enables us to solve not only direct problems, take known time series of ζ_O, ζ_A, ζ_G and ζ_C, that is to define the secular polar motion and variations of the earth's rotation, but also to solve the reverse problems, i.e. using the pole's coordinates ν_1 and ν_2 and of the long-term Earth's rotation velocity components ν_3, to compute the unknown global water exchange parameters ζ_O, ζ_A, ζ_G and ζ_C.

Ice mass of Antarctica and its reconstruction from LOD and PM

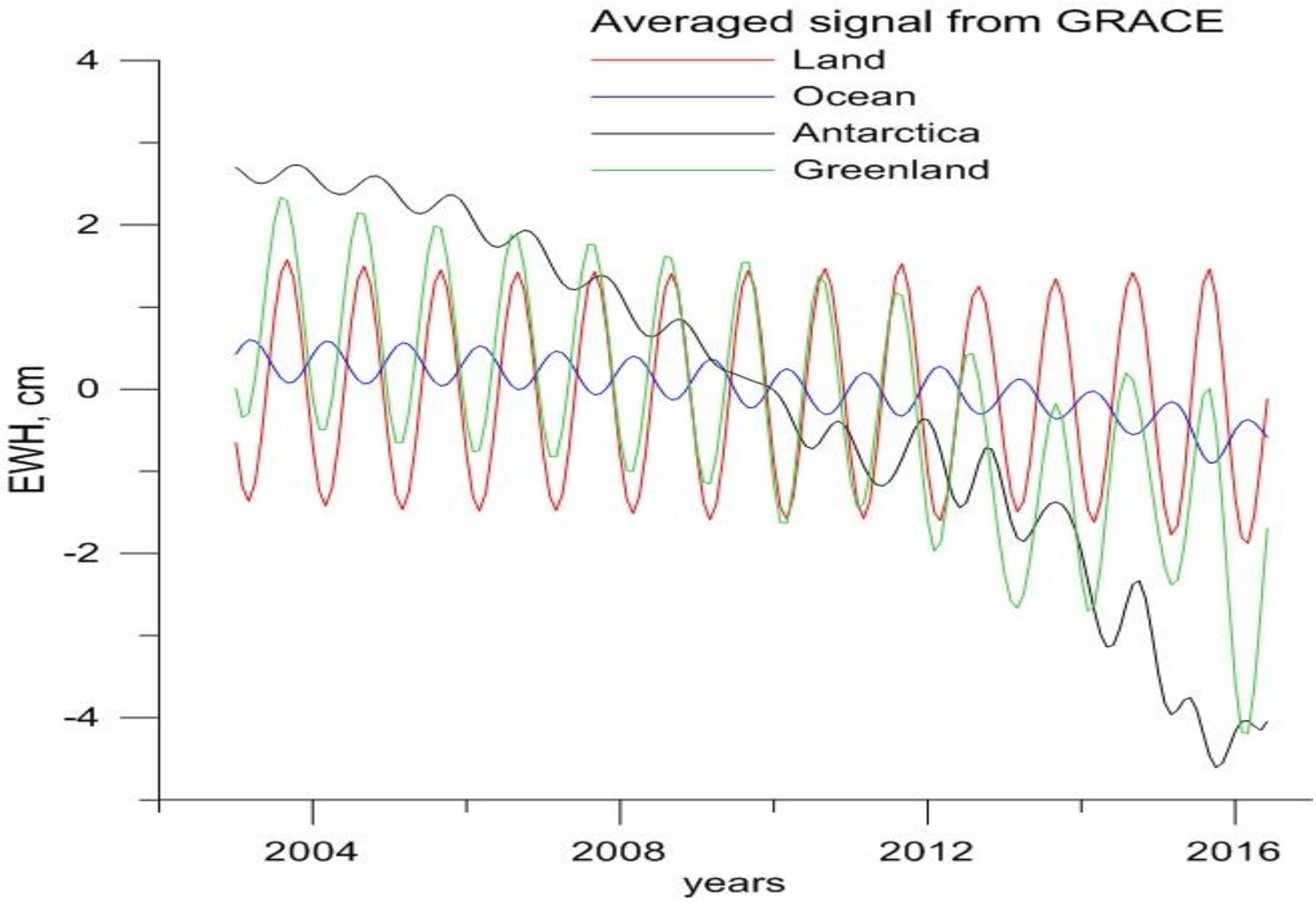


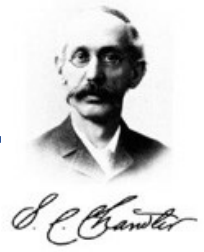
Temporal variations of the specific mass of ice in Antarctica, g·cm^{-2}. 1 – the theoretical value ; 2 – the empirical value (Petrov, 1975; Bryazgin, 1990).

Russian Meteorology and Hydrology
No. 8, pp. 1–8, 2005

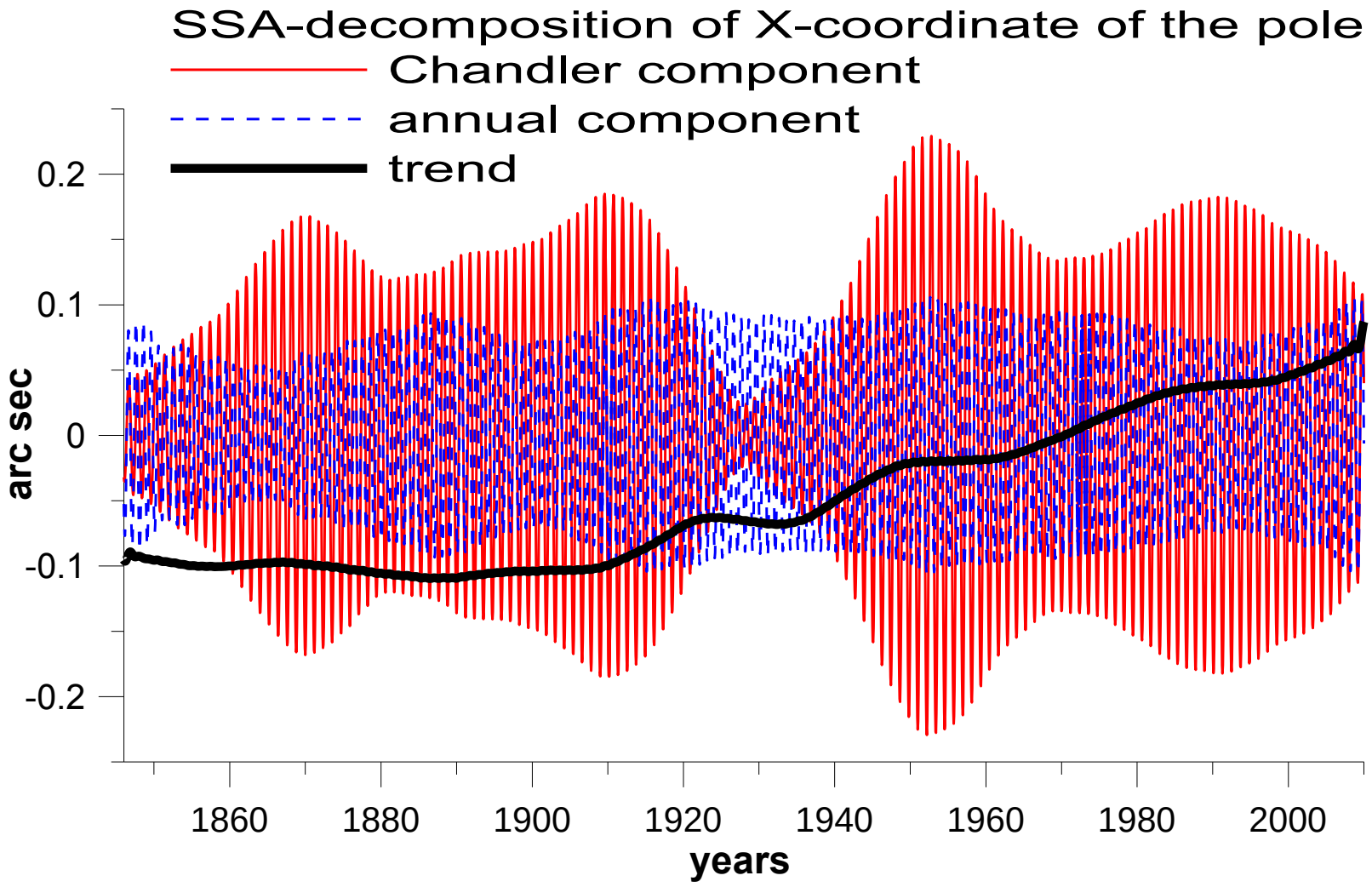
Meteorologiya i Gidrologiya
UDC 551.324.24+525.35/.37

Contemporary data from GRACE



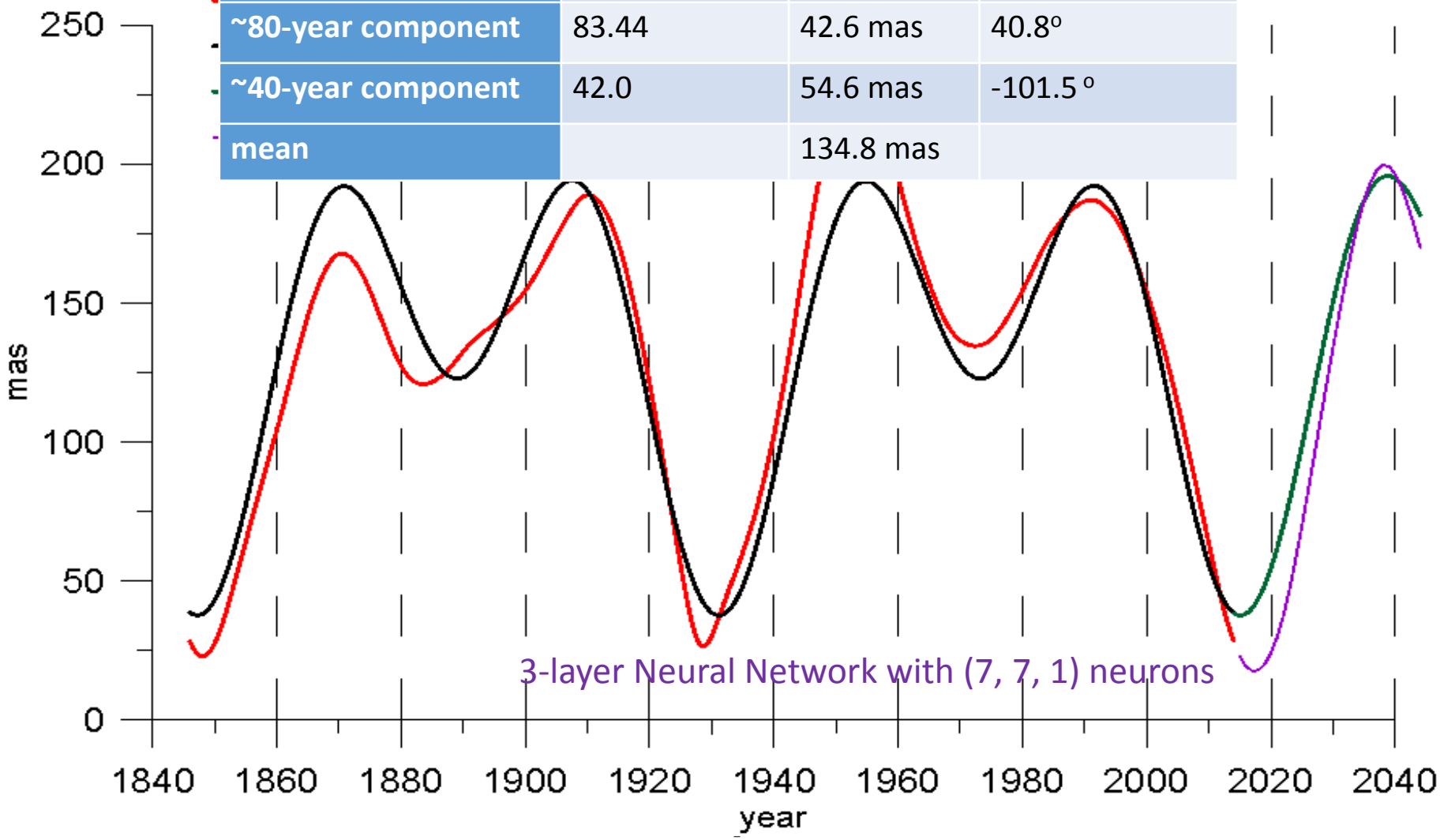


Singular Spectrum Analysis of Polar Motion

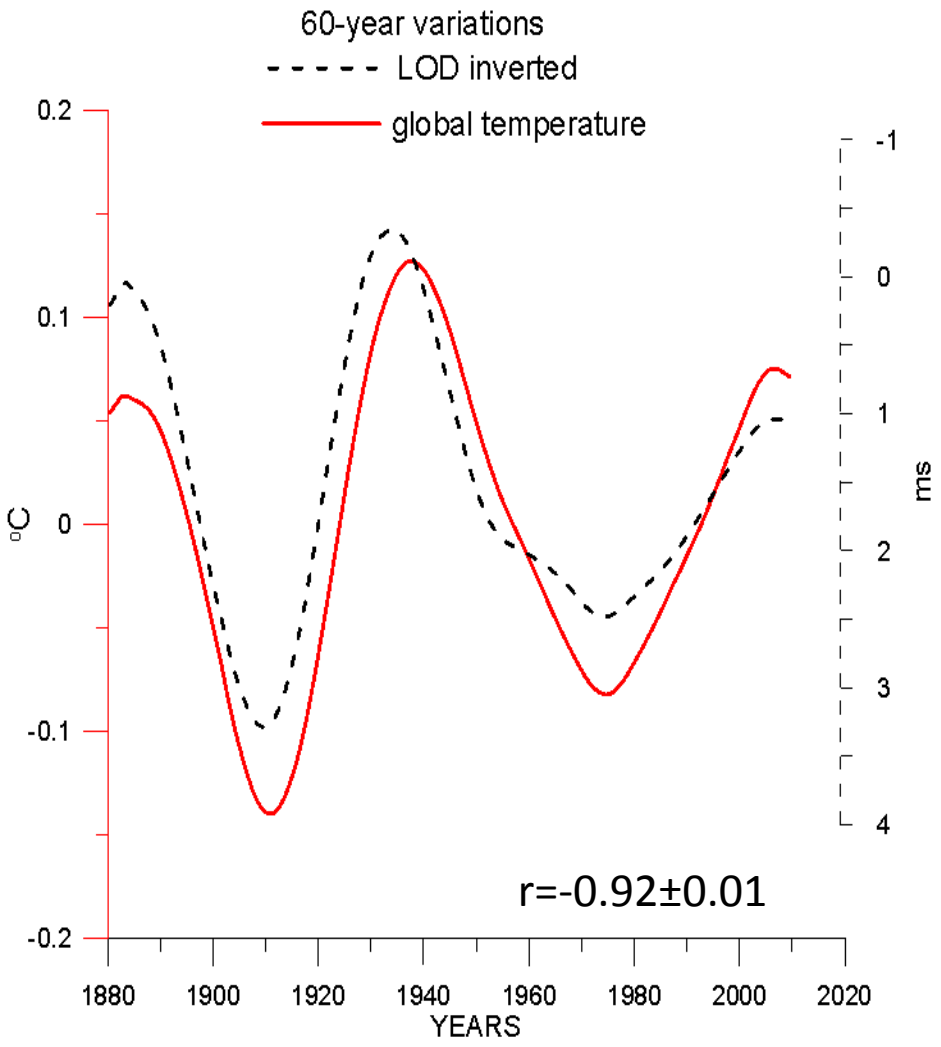


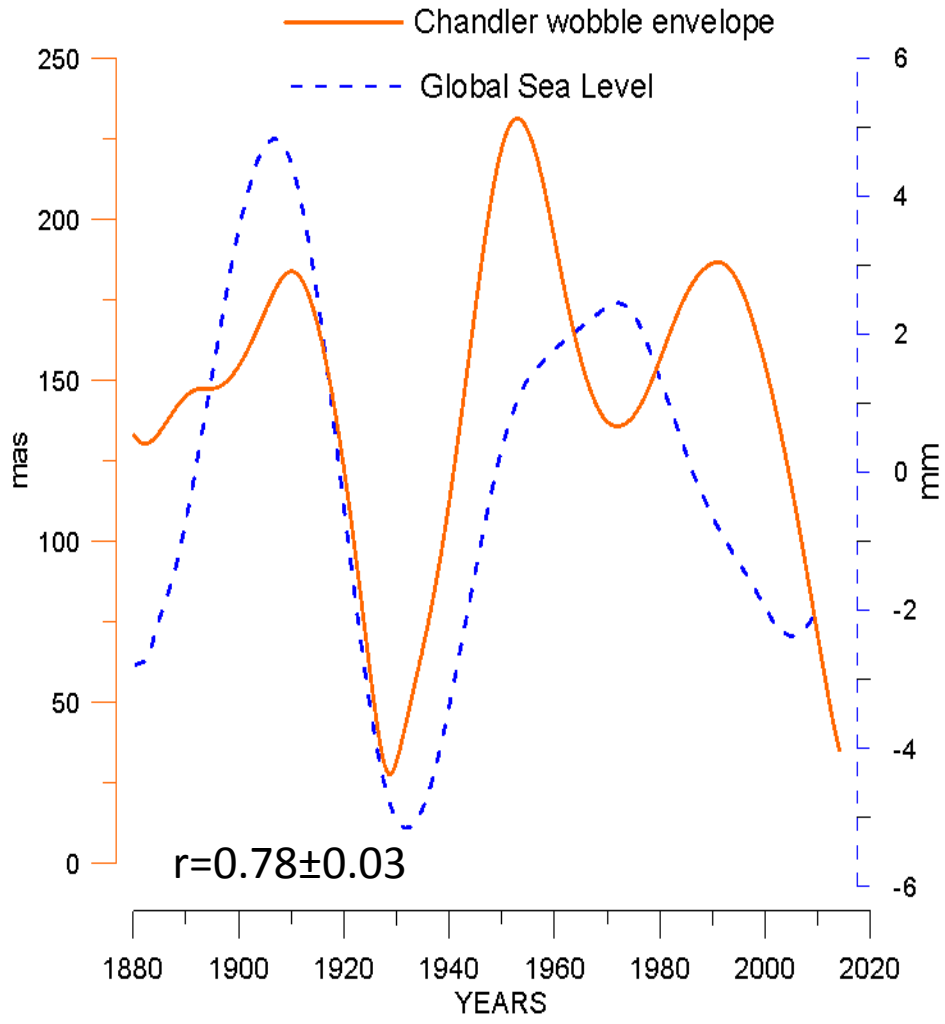
ChW Amplitude model and forecast

~Chandler wobble amplitude NLSM fit			
	Period, years	Amplitude	Phase (1880)
~80-year component	83.44	42.6 mas	40.8°
~40-year component	42.0	54.6 mas	-101.5 °
mean		134.8 mas	



Long-term (60-year) changes in Temperature, SL Chandler wobble envelope and LOD





4D MSSA with L=22 years, parabolic trends preliminarily removed

GEODESY AND GEODYNAMICS 2016, VOL X NO X, 1–7

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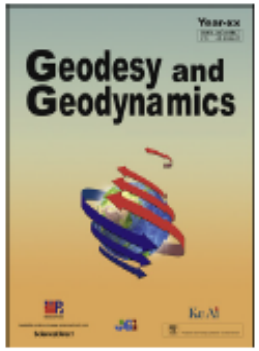

A possible interrelation between Earth rotation and climatic variability at decadal time-scale

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[b] Lomonosov Moscow State University, Sternberg Astronomical Institute, Moscow, Russia

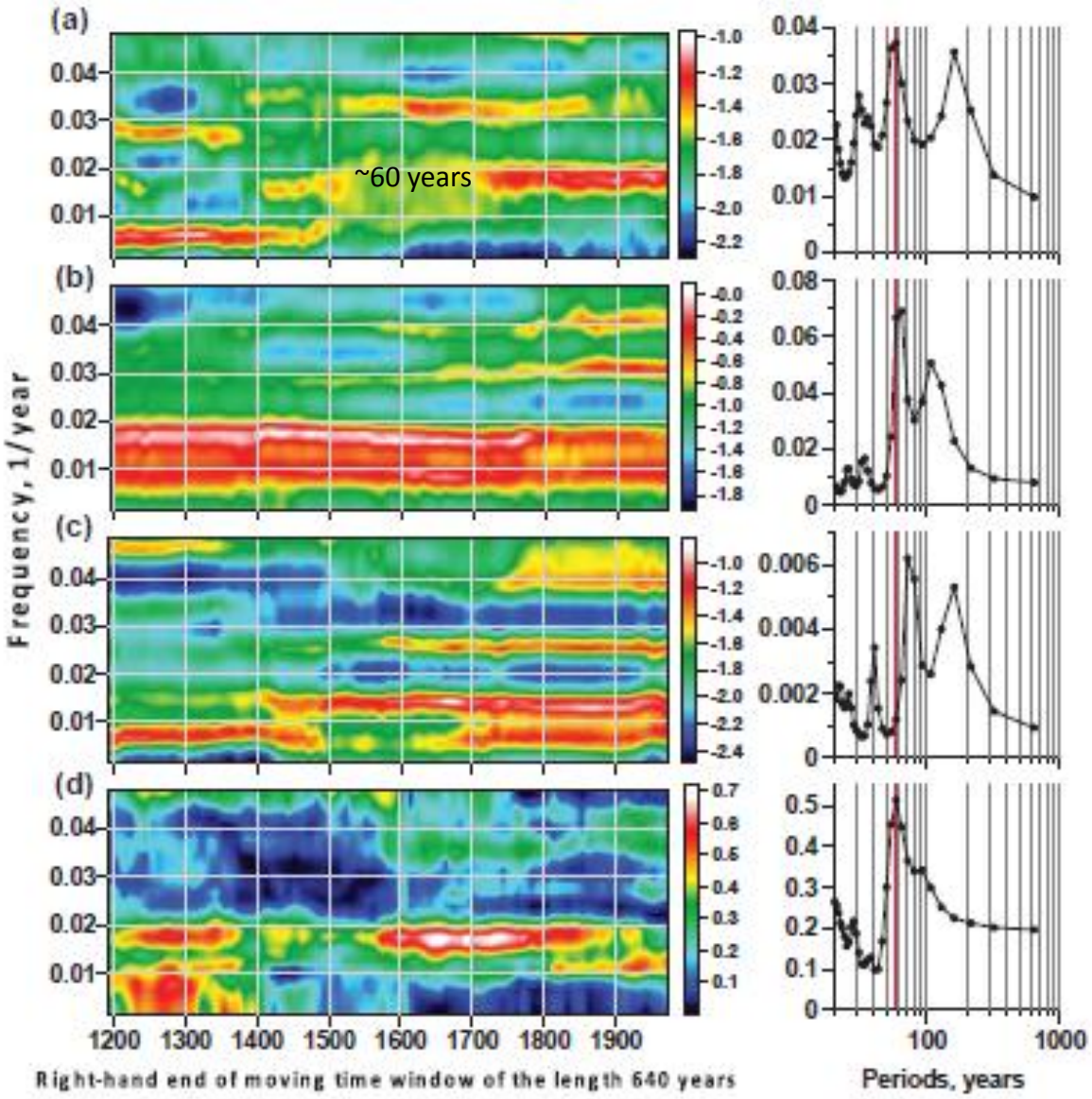
[c] SYRTE, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, 61 avenue de l'Observatoire, 75014 Paris, France

[d] Division of Geodetic Science, School of Earth Sciences, The Ohio State University, USA

[e] State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy & Geophysics, Chinese Academy of Sciences, Wuhan, China

Geodesy and Geodynamics, China,
Volume 7, Issue 3, May 2016, Pages 216–222

Long-term (60-year) historical changes in Temperature



a) Mean winter temperatures in Greenland for time interval (553-1973) from ice cores (Dansgaard et. Al 1975)

b) Temperature anomaly on Sweden from tree rings of arctic pine 500-1980 (Briffa et al. 1990)

c) Humidity in Southern California from tree rings of moutaine pine 6000 B.C.-1979 (Graybill et all 1994)

d) Global temperature anomalies (Lawrimour et al. 2001)

A.Lyubushin, L. Klyashtorin Short term global dT prediction… Energy and Environment Vol 23 N 1 2012

Conclusions

- We extract natural variations in global Earth temperature (HadCRUT4) and Sea Level (Jevrejeva, or Church and White) since 1850. Global worming trends (~0.7^{o} and ~20 cm) were removed.
- MSSA analysis of showed that besides the warming trend there are quasi - 60, 20 and 10-year oscillations in temperature and sea level
- 60 and 20-year components of temperature are anticorrelated with LOD
- Chandler wobble envelope is correlated with ~60 –year sea level changes
- J2 from SLR shows long-term trend with maxima in 1970th and minima in 2005 proved by GRACE data
- There are enough arguments collected to conclude that Earth rotation and Climate Changes are interrelated
- LOD could be connected with climate stronger then Polar Motion

P. Brueghel the Yonger *Landscape with a Bird Trap* (1565), Tokyo museum of Western art

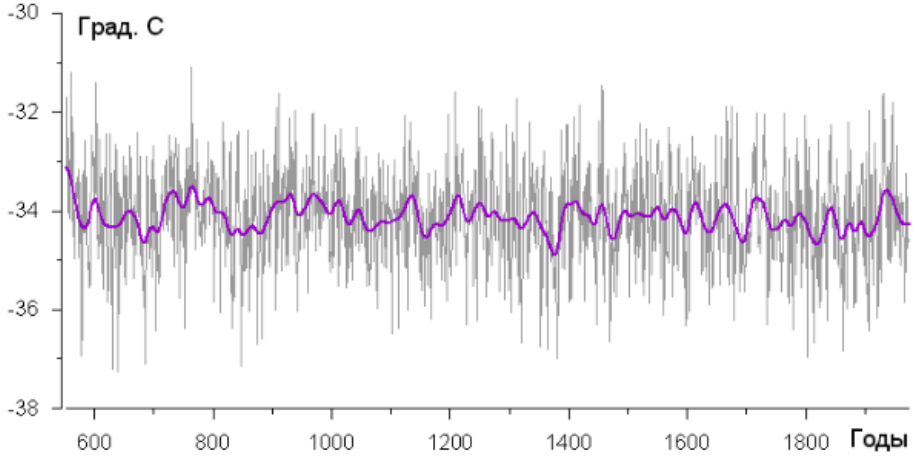
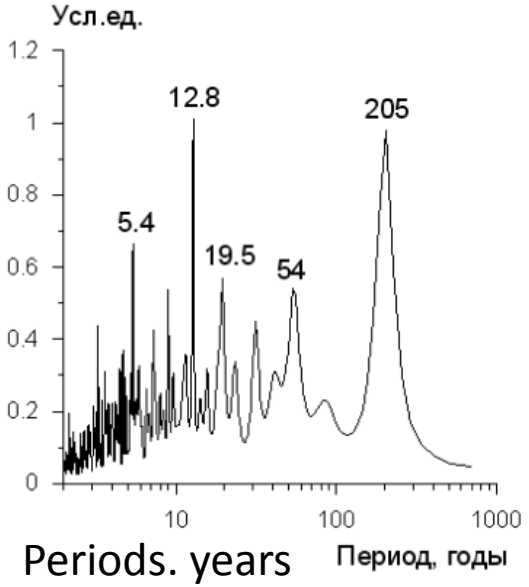


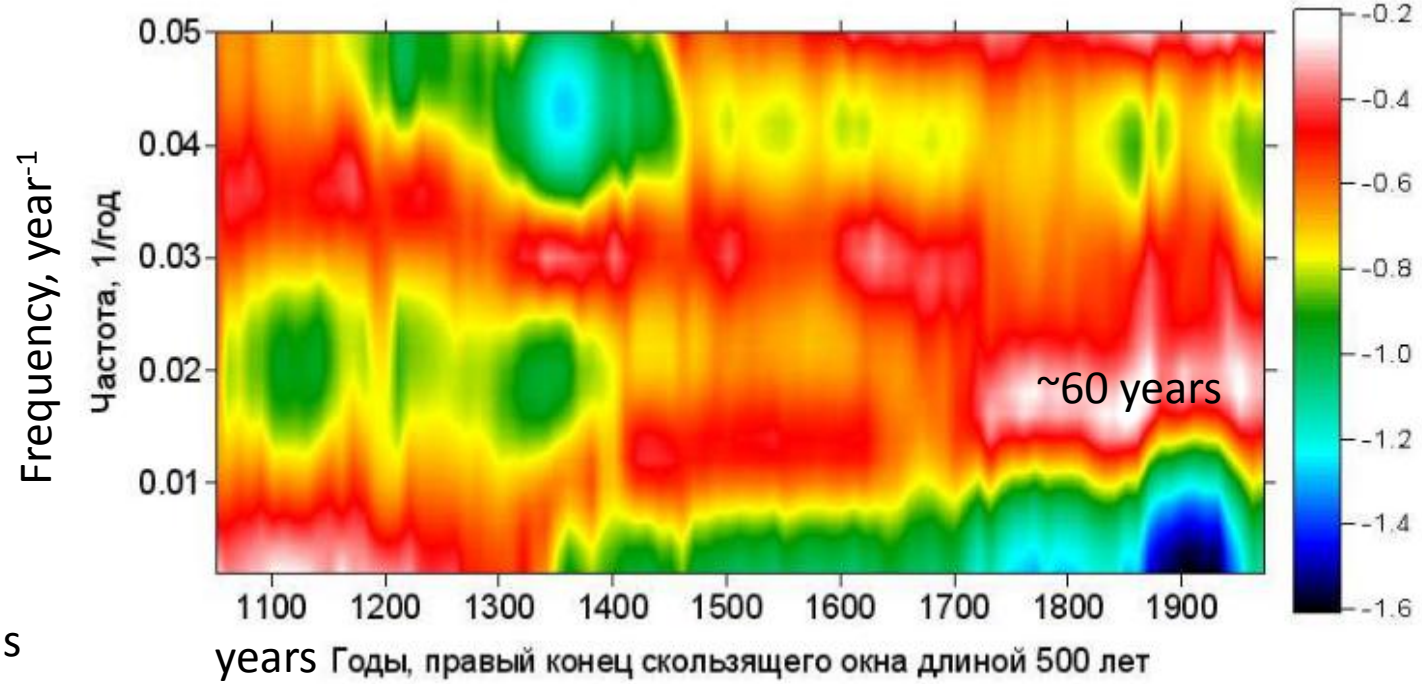
Рис.1.2. Гауссовский тренд с параметром усреднения 10 лет (толстая линия) данных ежегодных реконструкций зимних температур в Гренландии (553-1973 гг.) по содержанию изотопа ^{18}O в ледовых кернах (тонкая линия).



Periods. years

Greenland winter temperature reconstructions (553-1973) based on ^{18}O isotope (Dansgaard, 1975)

Its autoregressive spectrum and time-frequency analysis estimated by Alexey Lyubushin in his book



http://alexeylyubushin.narod.ru/Geophysical_Monitoring_Systems_Data_Analysis_Book_Rus.pdf