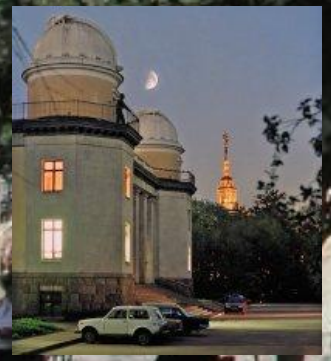
Could the mass changes from GRACE and GFO explain recent anomalies in the Earth rotation?

Leonid Zotov [1,2]

[1]SAI MSU [2]MIEM NRU HSE



9 October 2025
GRACE-GFO Science Team Meeting

Which EOP variability we call anomalous:

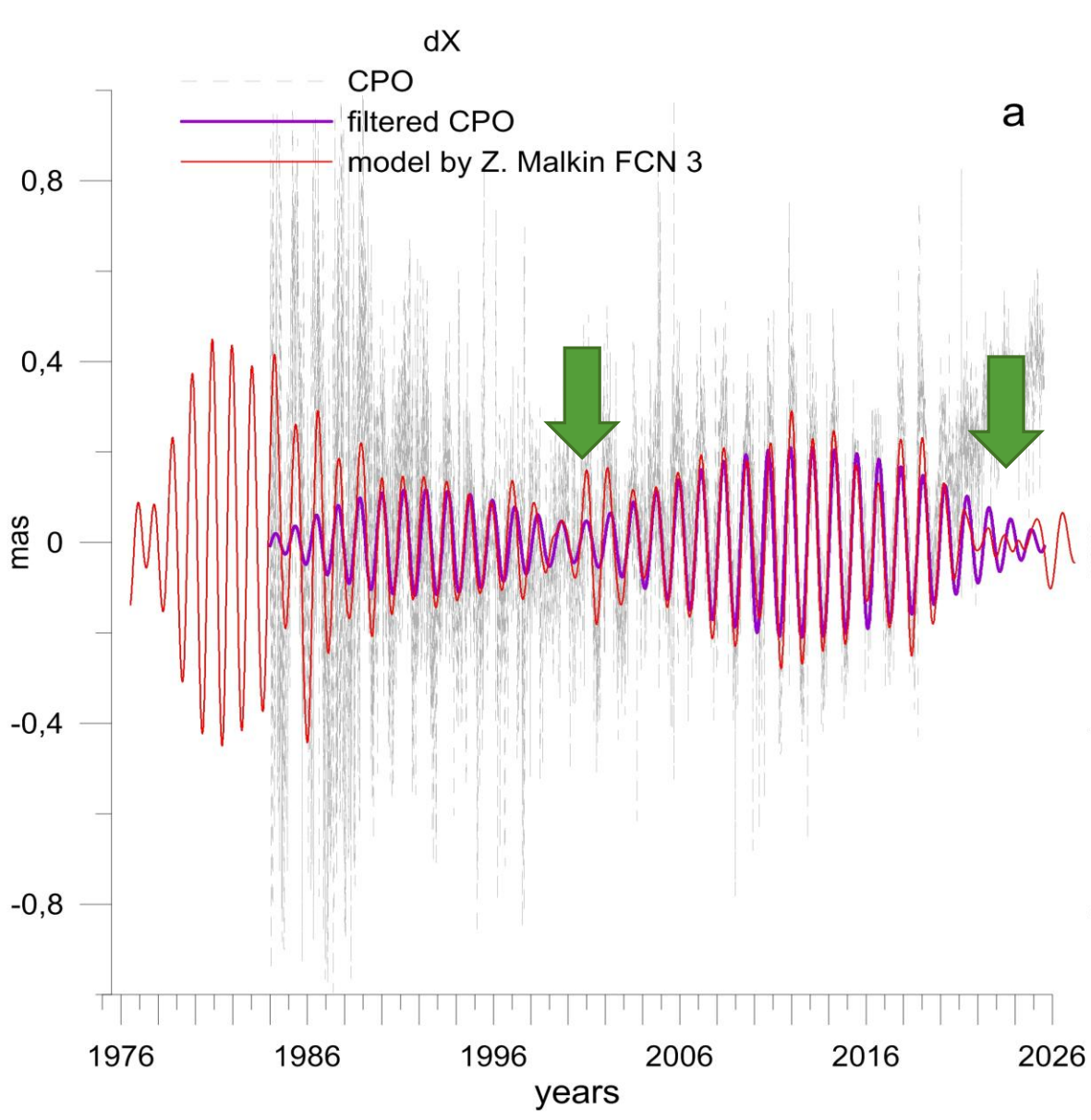
- Free core nutation signal decrease in 2020
- Earth rotation velocity maximum in 2023-2025
- Chandler wobble disappearance and phase shift in 2017-2020

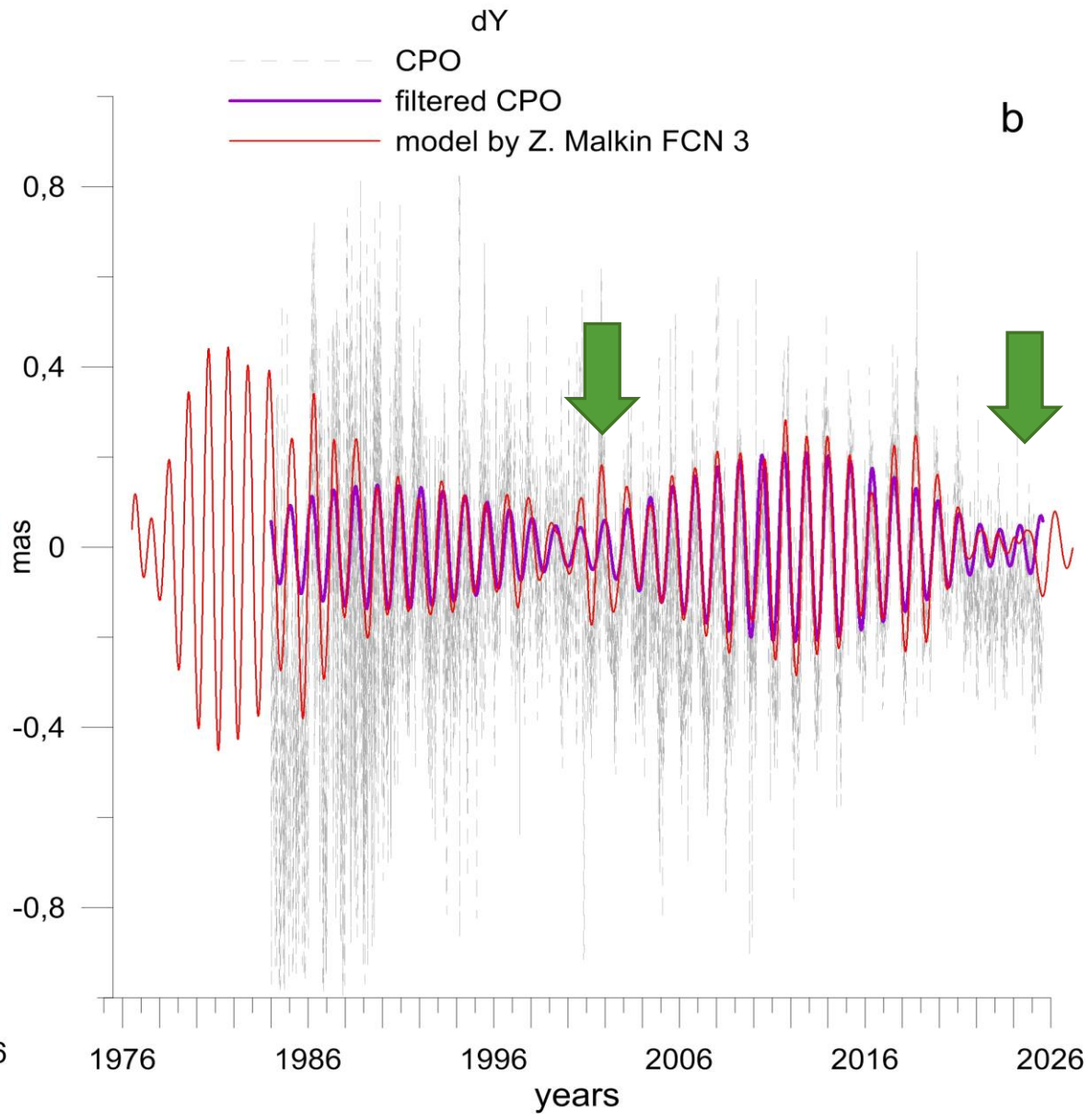
What we can get from GRACE-GFO:

- C_{20} changes and their effect on LOD
- C_{21}, S_{21} changes and their effect on polar motion
- tides!?

Hydrological Angular Momentum HAM, mass term

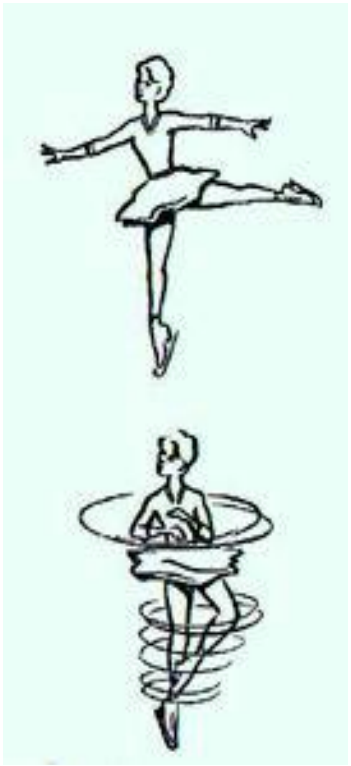
FREE CORE NUTATION SIGNAL FCN IN CELESTIAL POLE OFFSETS (CPO)

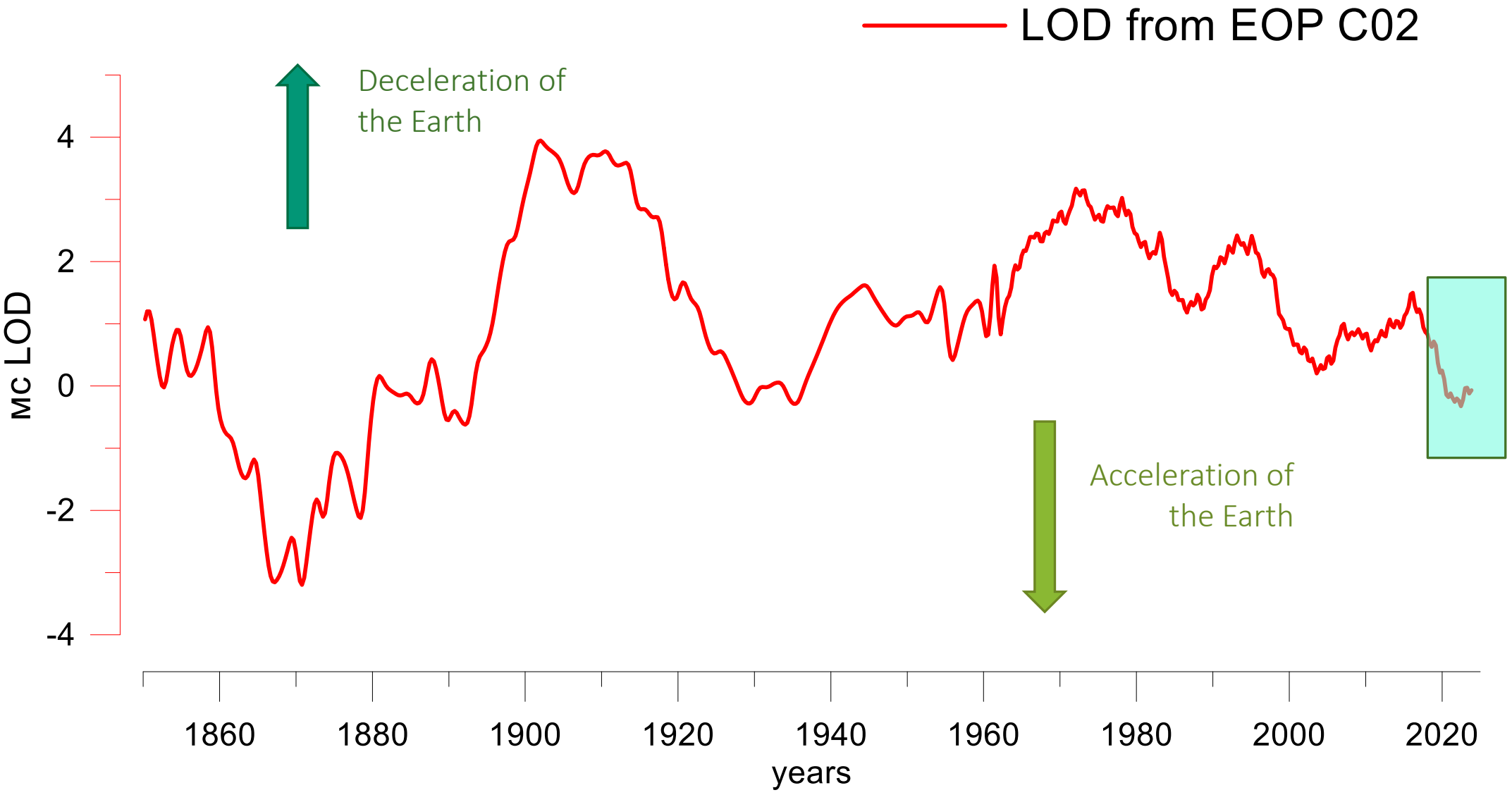




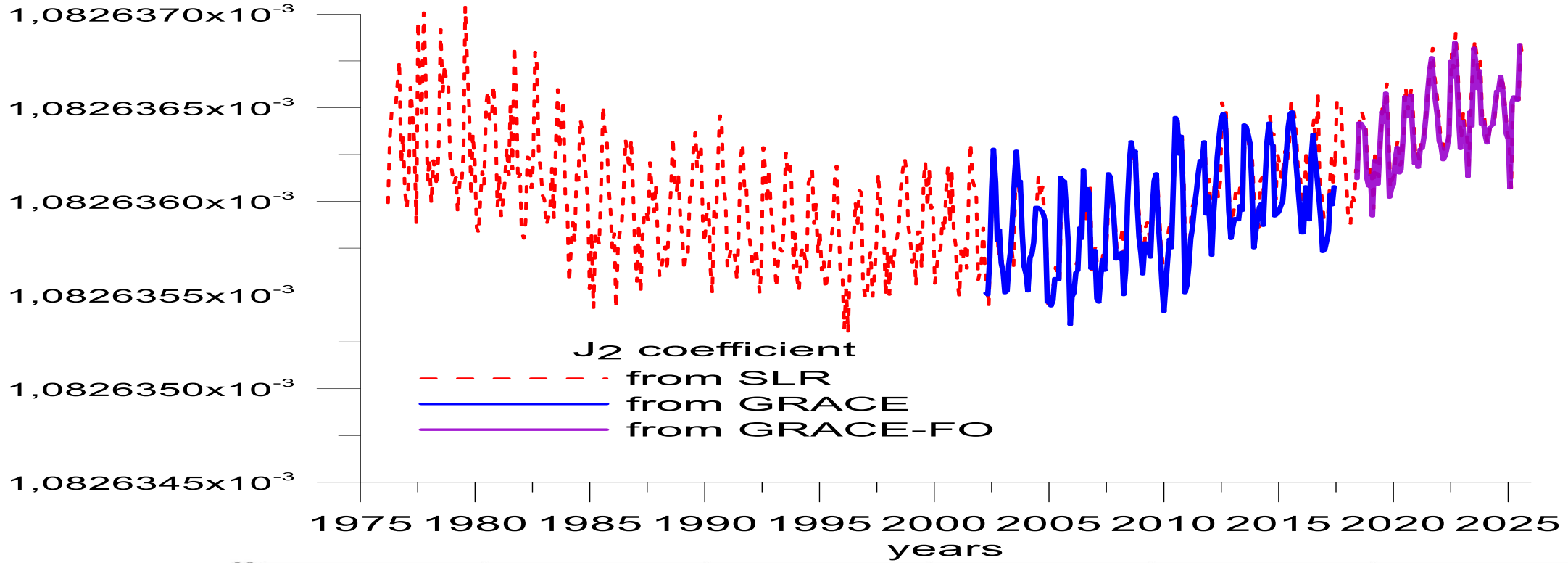
Zotov L.V., GFO STM, 2025

LONG-TERM LENGTH OF DAY (LOD) CHANGES



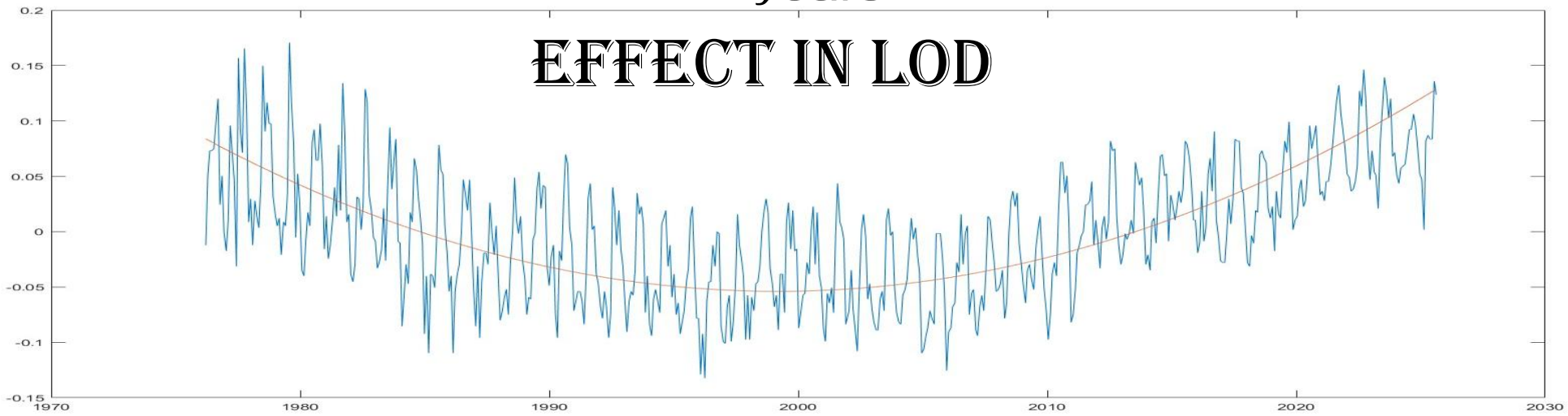


FORM-FACTOR $J_2=-\sqrt{5}C_{20}$ FROM SLR, GRACE, GFO

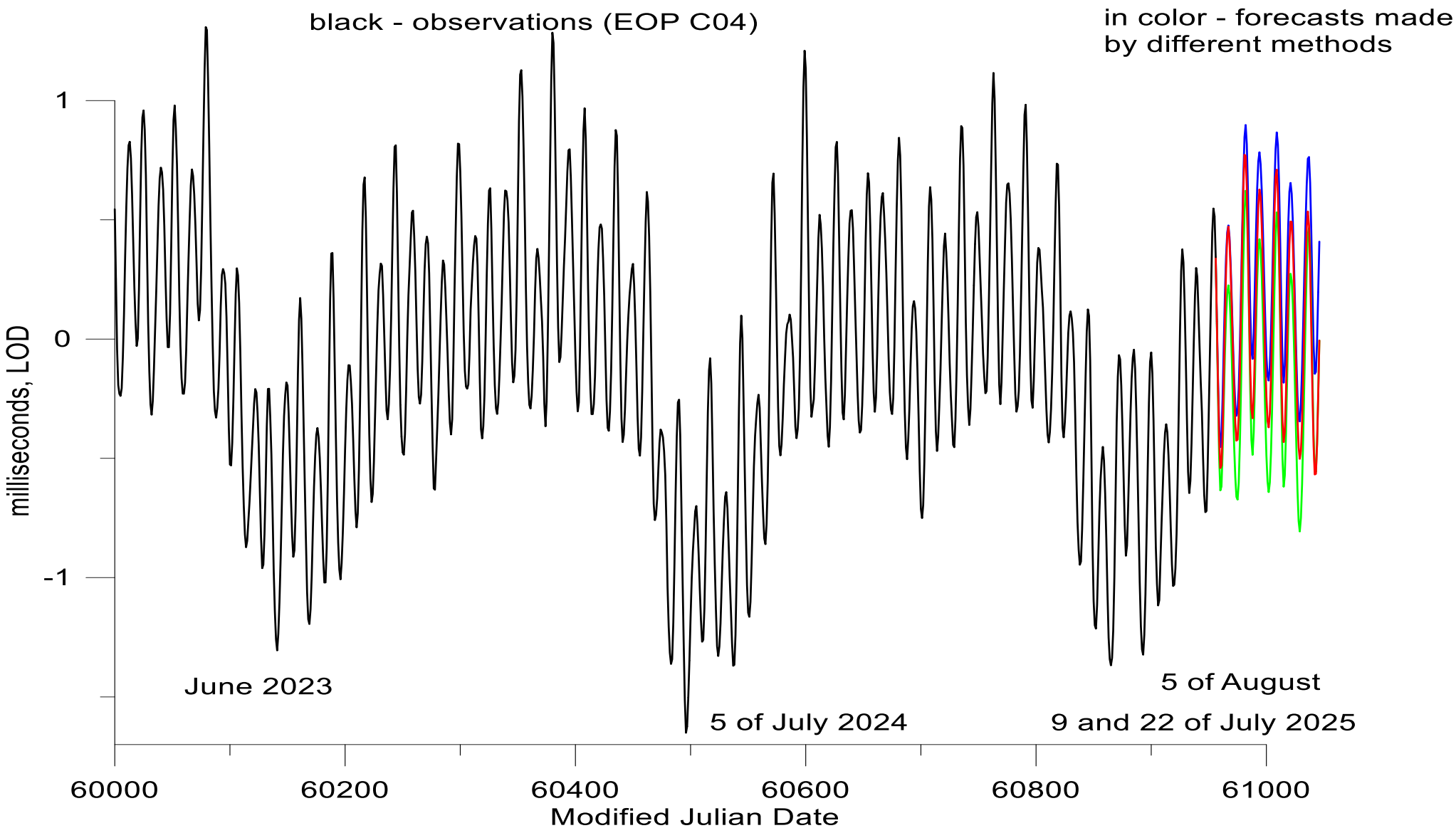


INFLUENCE ON LOD, ~0.1 MS

EFFECT IN LOD



SHORT-TERM LENGTH OF DAY (LOD) CHANGES



Plot made on MJD 60956, 8 Oct 2025

timeanddate

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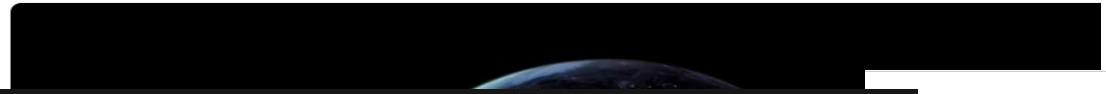
Home / News / Astronomy News / Earth Will Spin Unusually Quickly in July and August

Earth Will Spin Unusually Quickly in July and August

Since 2020, Earth has notched up unprecedentedly short days midway through the year. It will ha
again in 2025 around July 9, July 22, and August 5.

By Graham Jones
Published 16-Jun-2025. Changed 11-Jul-2025



Latest estimates from mid-August confirm that **the shortest days of 2025** fell around July 9, July 22, and August 5—but were not quite as short as the shortest day of 2024. "It seems Earth has started to decelerate and the most extreme lengths of day have been left in 2024," notes Leonid Zotov.

Year	Date	Length of Day (LOD)
2025	July 9	-1.34 ms (to be confirmed)
2025	July 10	-1.37 ms (to be confirmed)

Forbes

BREAKING | INNOVATION > SCIENCE

Get Ready For The Shortest Day Since Records Began As Earth Spins Faster

By Jamie Carter, Senior Contributor. An award-winning reporter writing ab... Follow Author

Published Jun 20, 2025, 05:00am EDT, Updated Jun 21, 2025, 09:21am EDT

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TOPLINE

Earth could be about to record its fastest-ever rotation. Since 2020, Earth has been rotating faster than at any point since records began in 1973, with each successive year producing the shortest day. Last year, the shortest day was recorded on July 5, and Earth is expected to get close to this again on or close to July 9, July 22 and August 5, according to Timeanddate.com.

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The New York Times

Earth Is Spinning Faster and Days Are Getting Shorter, for Now

The planet's rotation fluctuates as it travels around the sun, and measurements suggest we're losing more than a millisecond during the long days of summer.

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JULY 14, 2025

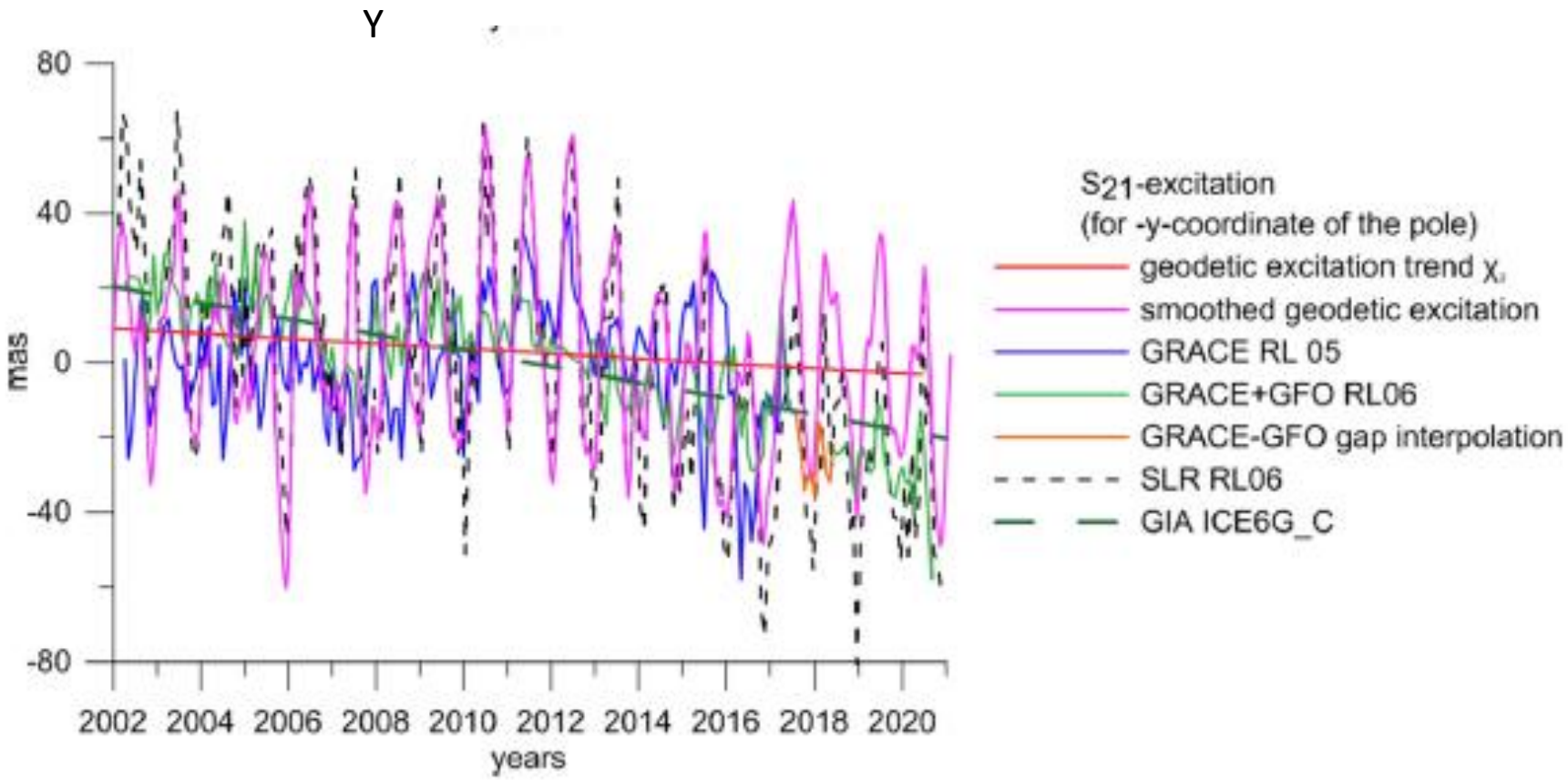
Earth Just Had One Of The Shortest Days Ever And More Are Coming

We're in a spin

Ruby Feneley

PRINT

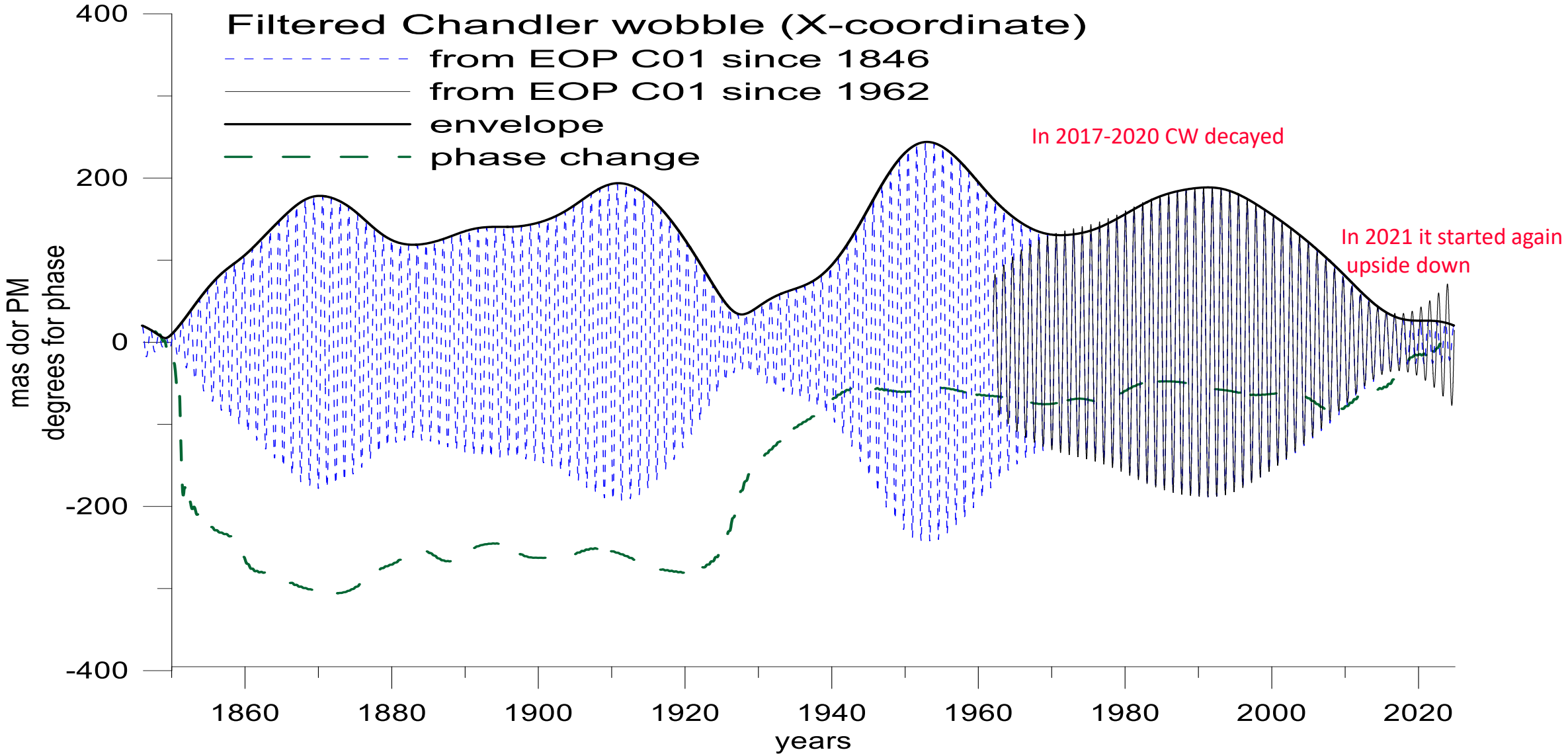
C_{21}, S_{21} AGREEMENT WITH POLAR MOTION TRENDS



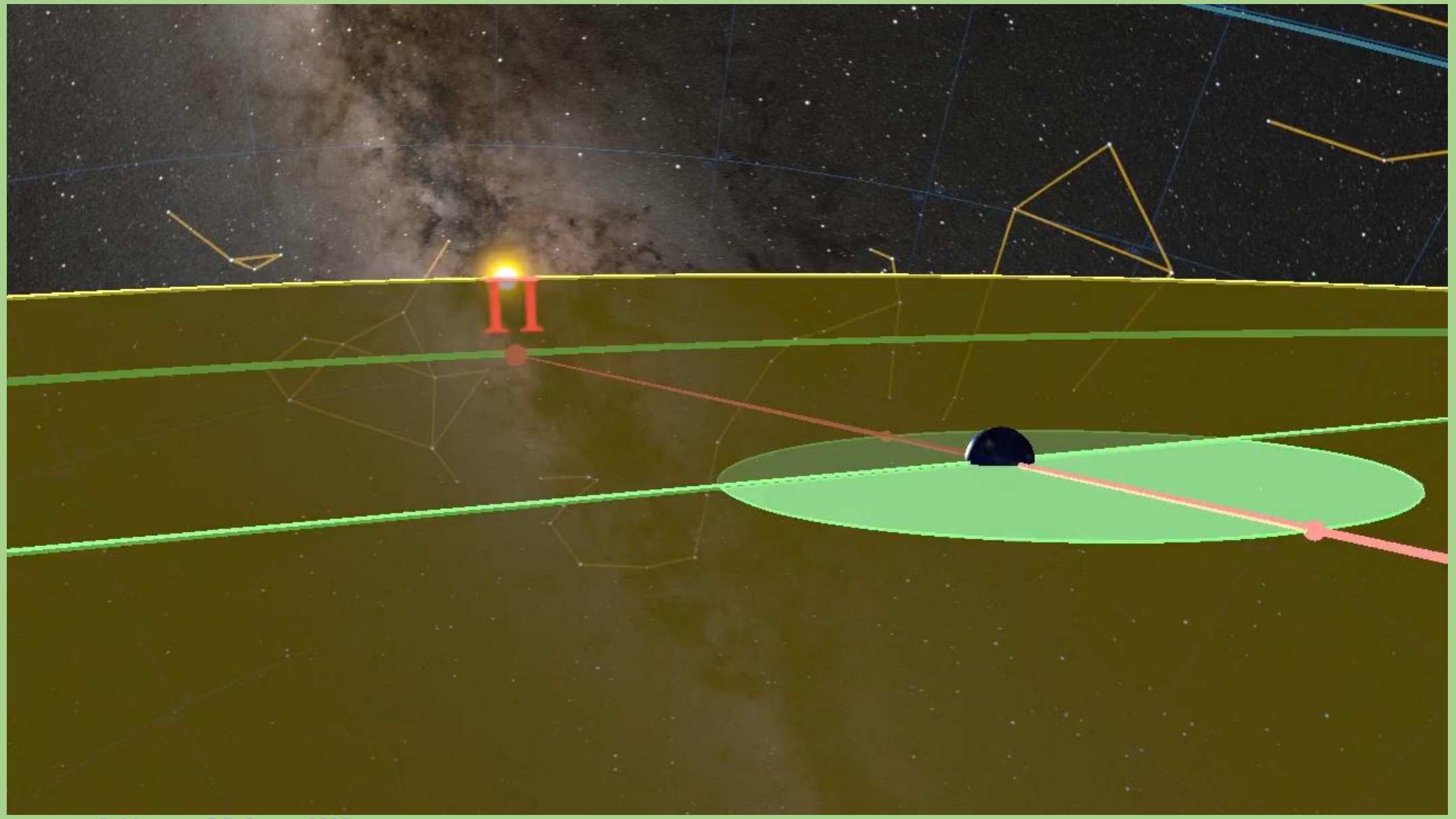
Climatological mass transport is responsible for polar drift changes

L. Zotov, Ch. Bizouard, C.K. Shum, Ch. Zhang, N. Sidorenkov, V. Yushkin, Analysis of Earth's Polar Motion and Length of Day Trends in Comparison with Estimates Using Second Degree Stokes Coefficients from Satellite Gravimetry, Advances in Space Research, N69, 2022, pp. 308-318, https://doi.org/10.1016/j.asr.2021.09.010

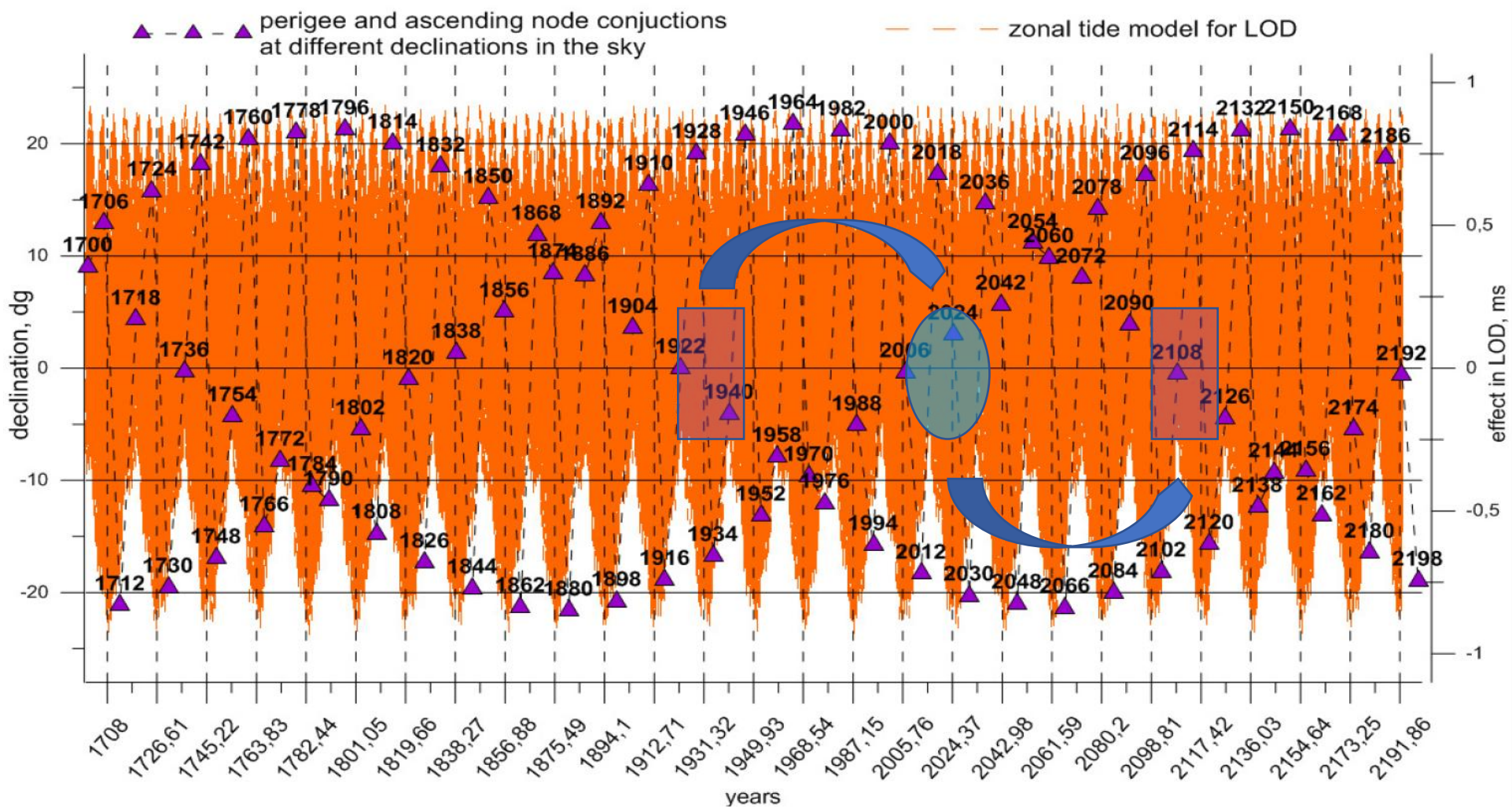
CHANDLER WOBBLE (CW) 1846 - 2025 AND ITS PHASE CHANGES



Lunar perigee (8.85 years eastward) and nodes (18.6 years westward) motion in the sky



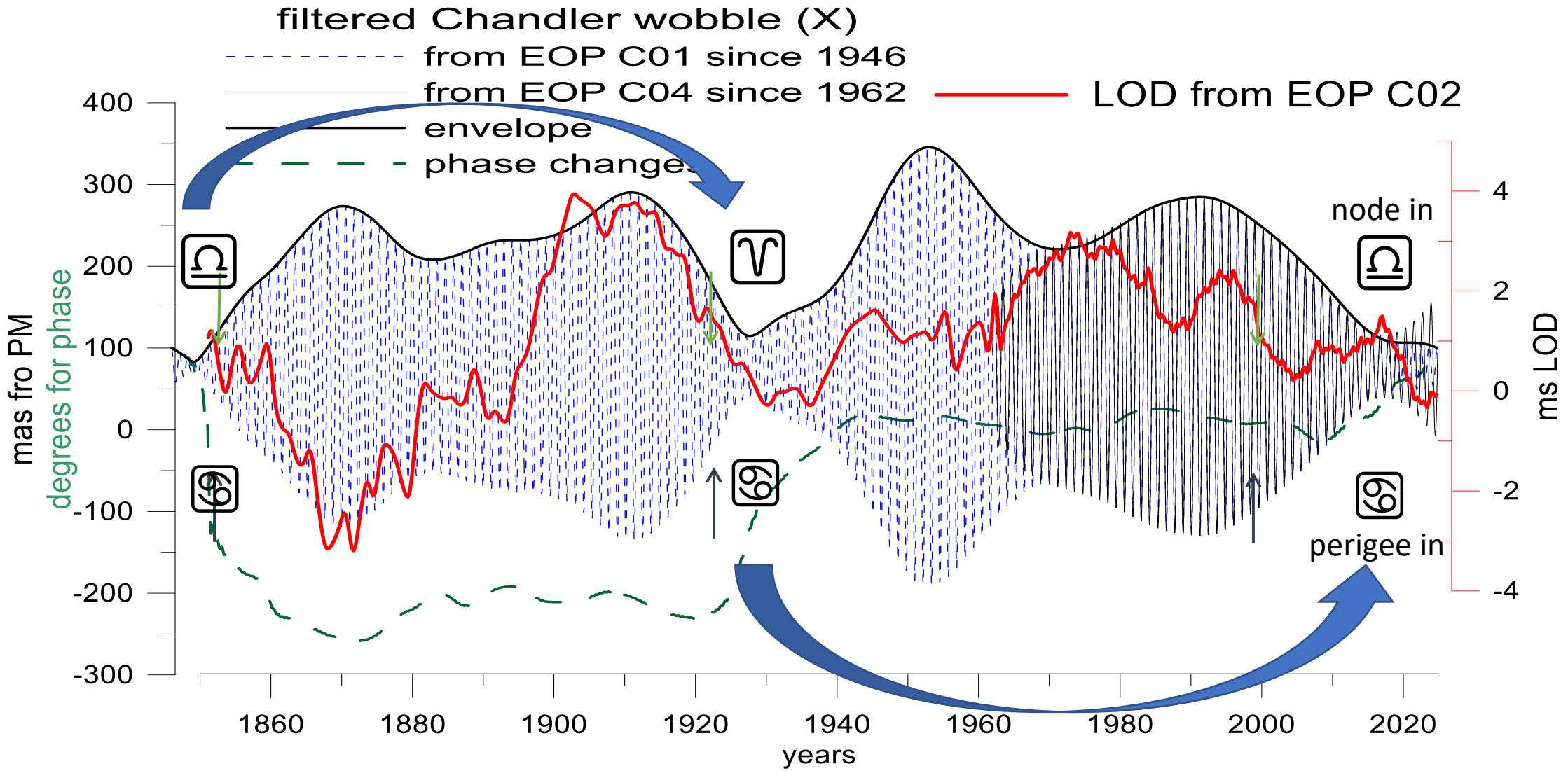
PERIGEE AND NODE OF THE LUNAR ORBIT MEETS EVERY 6 YEARS



Zonal tide model in LOD

Zotov L., N. Sidorenkov, Ch. Bizouard, Earth rotation variations and the Moon apsidal-nodal effects, A. Kosterov et al.(eds.), Problems of Geocosmos, Springer, 2025, in press, https://doi.org/10.1007/978-3-031-92928-1_21

PROBABLY CW AND LOD ANOMALIES OCCUR ONCE IN 90 YEARS IN RESULT OF APSIDAL-NODAL EFFECTS



L.Zotov, Anomalies in the Earth rotation and Syzygies in Perigee, at Industry 4.0 VIII, Iss. 5, p. 166-168, 2023 WEB ISSN 2534-997X; PRINT ISSN 2534-8582

Conclusions

- GRACE and GFO derived mass term explains small (up to 0.1 ms) changes in LOD (from J_2) and almost all polar drift (from C_{21}, S_{21})
- Climate change can be the reason for some Earth rotation deceleration and change of the polar motion drift
- Disappearance of Chandler wobble in 1930-s and 2020-s occurs simultaneously with the epochs of largest LOD minima
- mass component excitation from GRACE and GRACE-FO can not explain these decadal anomalies in the Chandler wobble and LOD
- But if the tidal mass transport has relation to the EOP anomalies (usually subtracted from GRACE/GFO data) satellites can help to improve understanding of LOD minimum and CW decay