

# 聖嬰現象與地球轉速變化之初探

第三屆時頻分析與地球科學研討會

王逸民

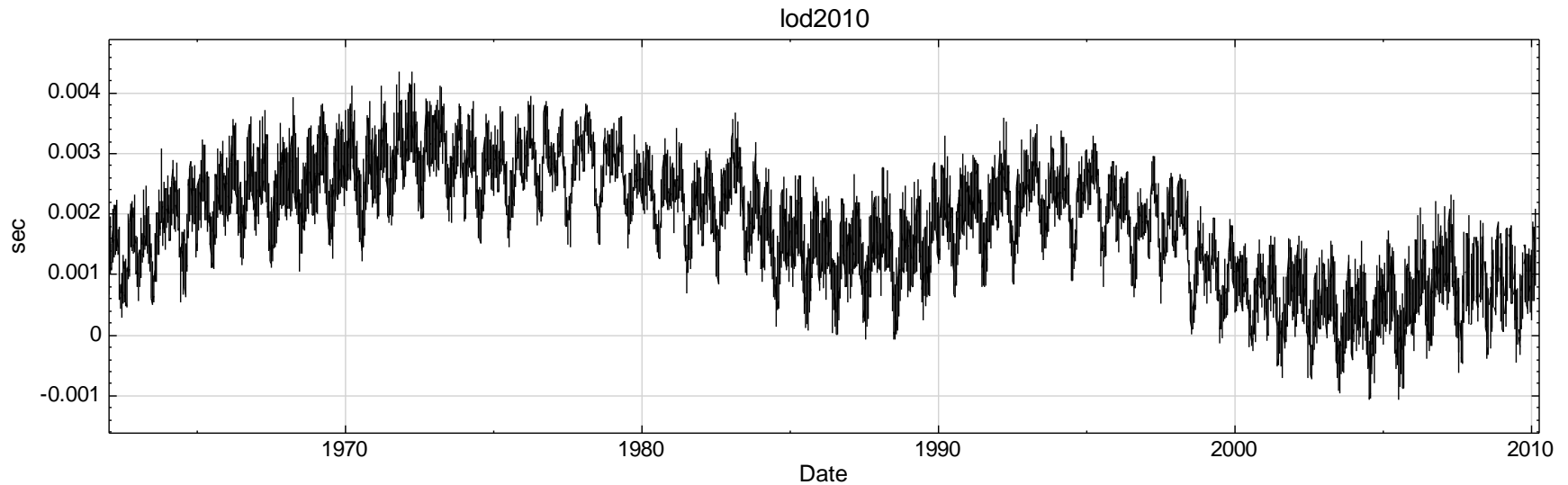
AnCAD, Inc.

2010/10/13

1. Trend estimation using iterative Gaussian filter
2. Fourier Spectrum Analysis
3. Empirical Mode Decomposition with Intermittency Test
4. Length of Day's relating to MEI Index

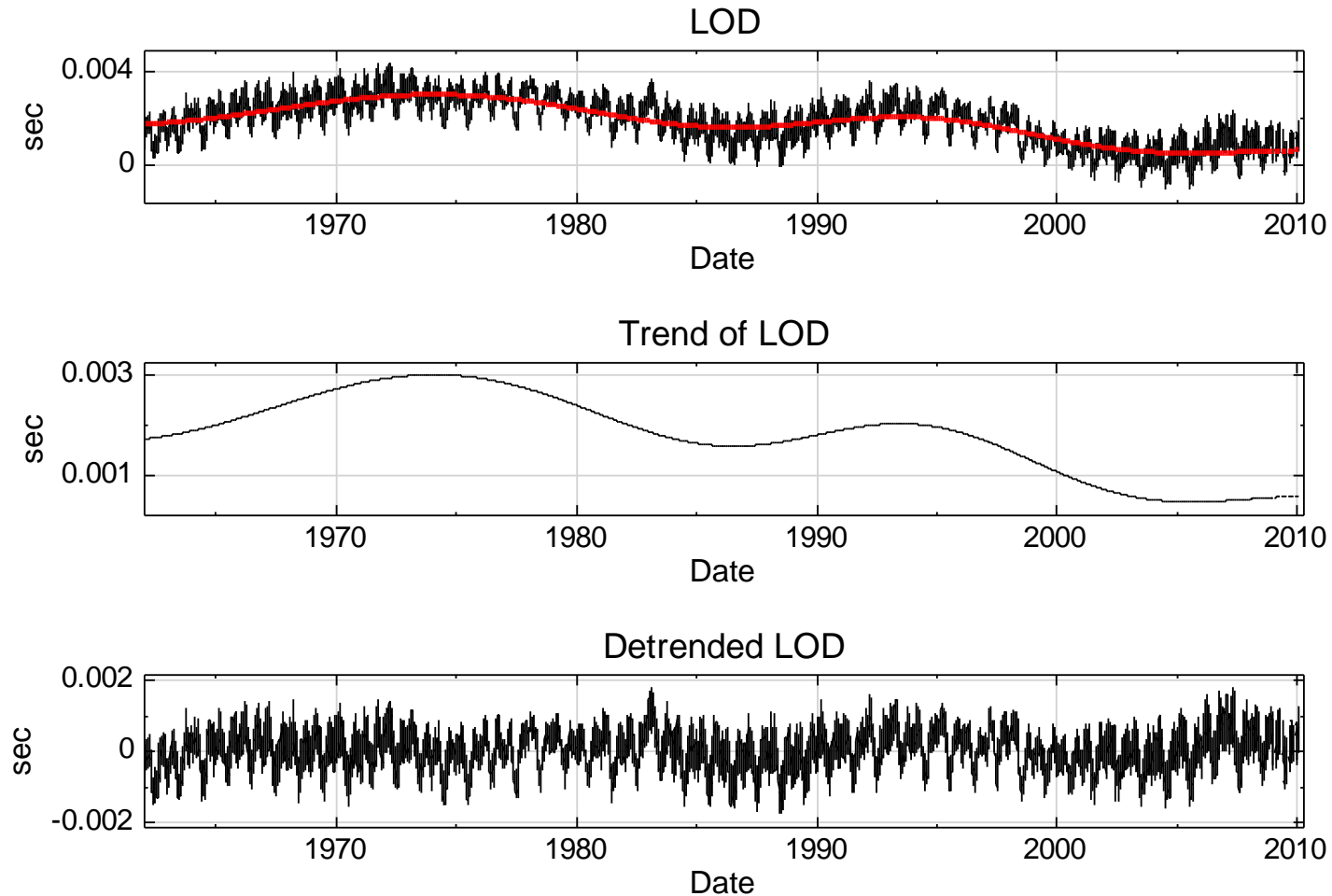
## LENGTH OF DAY

# Length of Day (LOD)

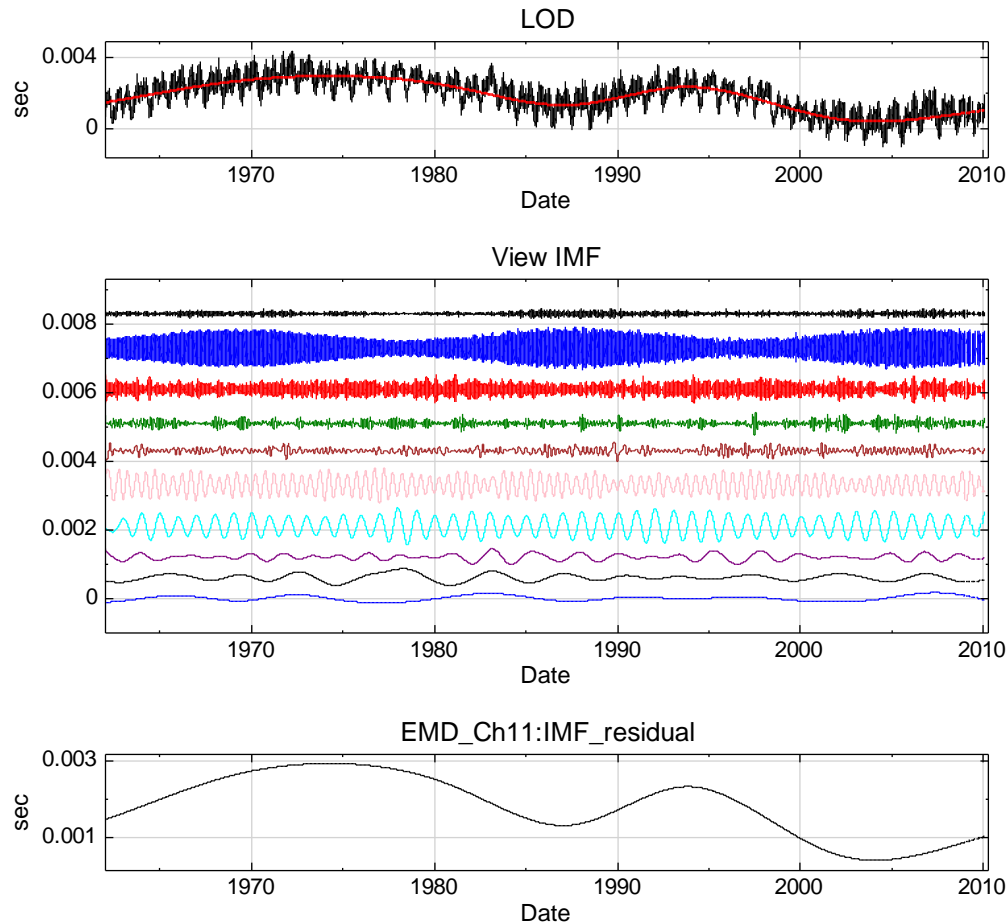


source: <http://www.iers.org/ IERS/EN/ IERSHome/home.html>

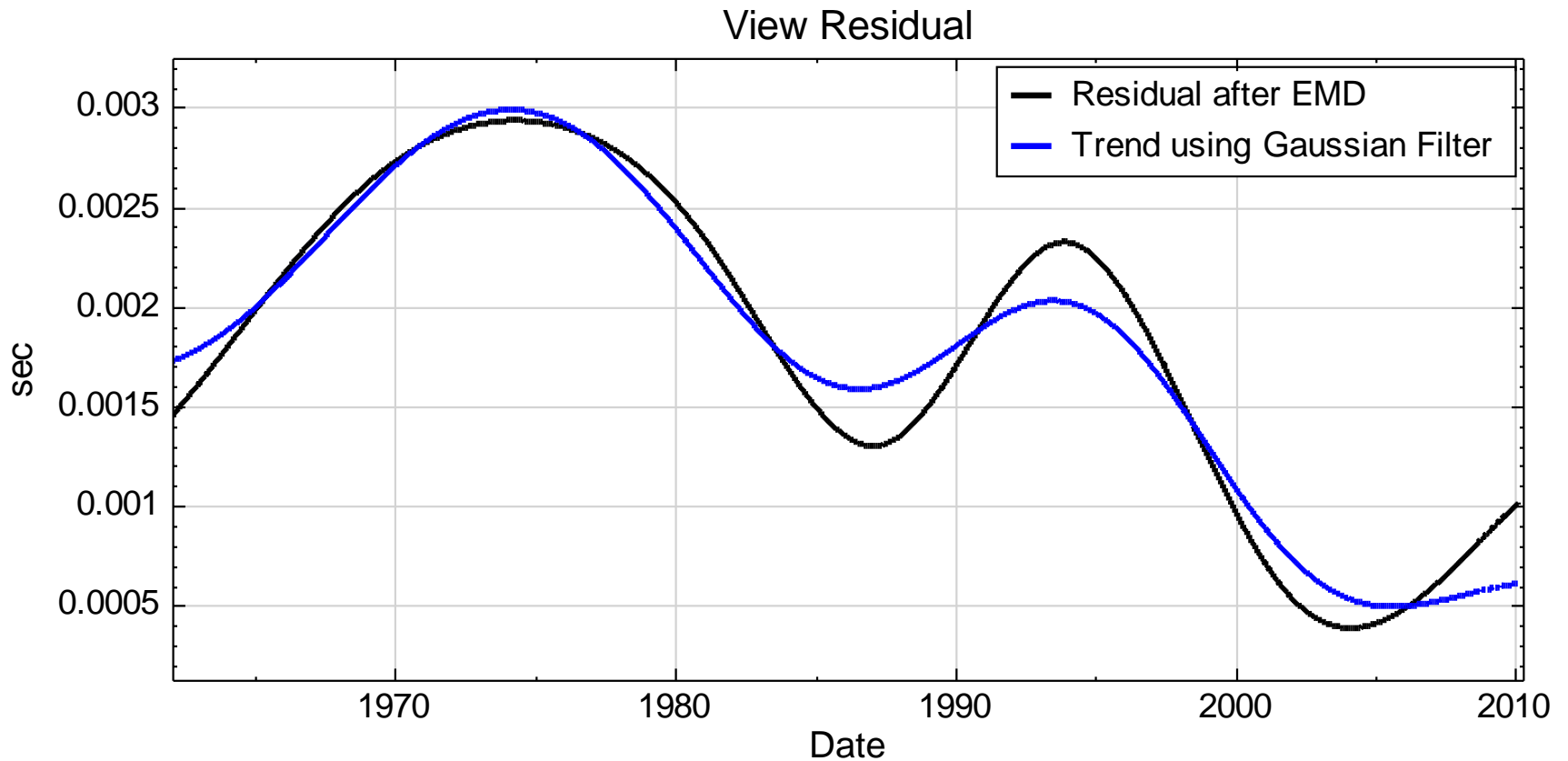
# Trend Removal using Iterative Gaussian Filter



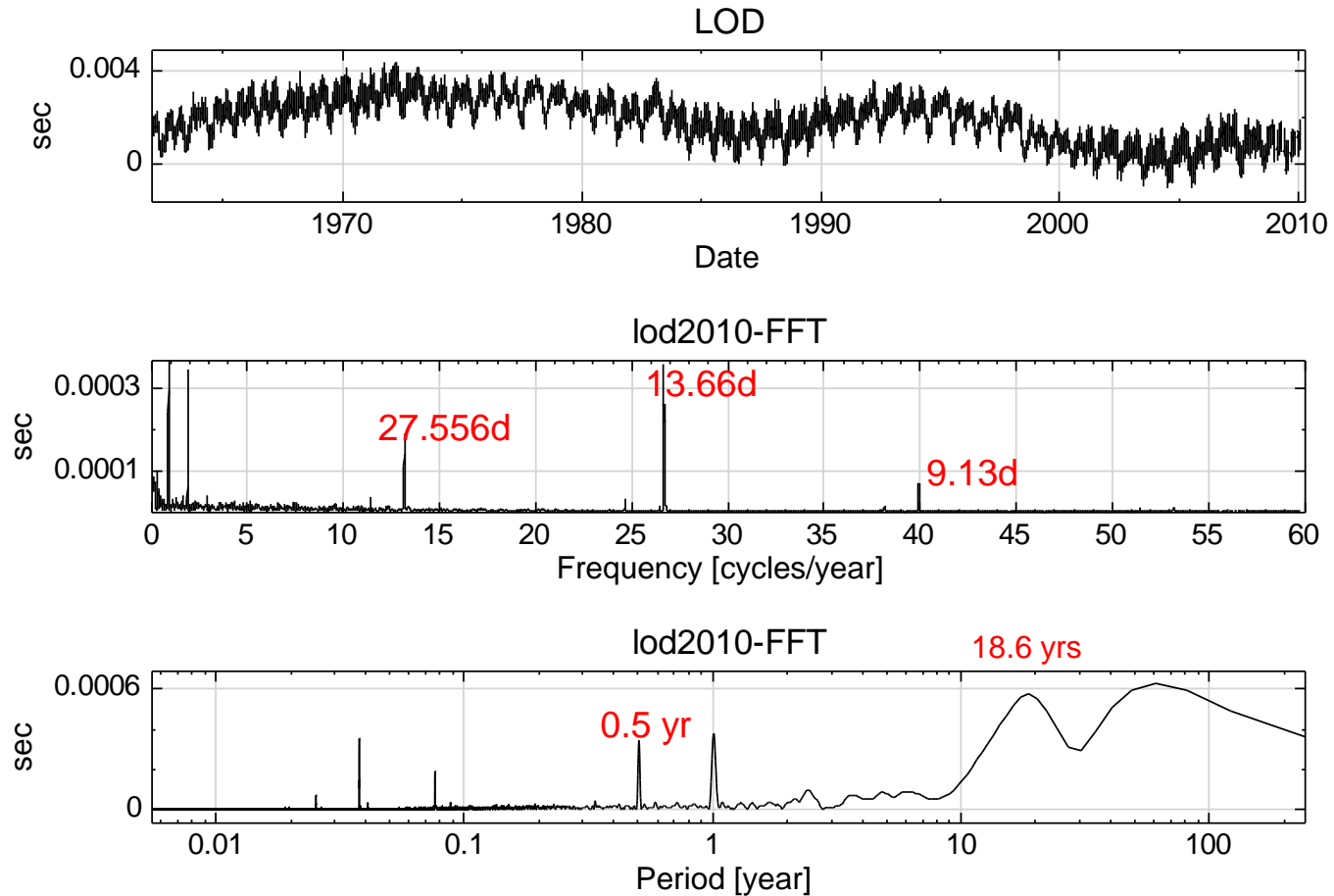
# EMD with Intermittency Test



# Trend Comparison



# Spectrum Analysis



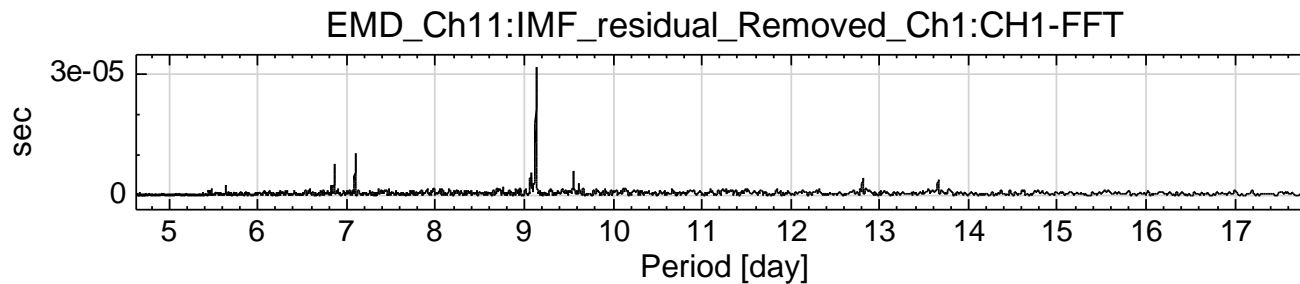
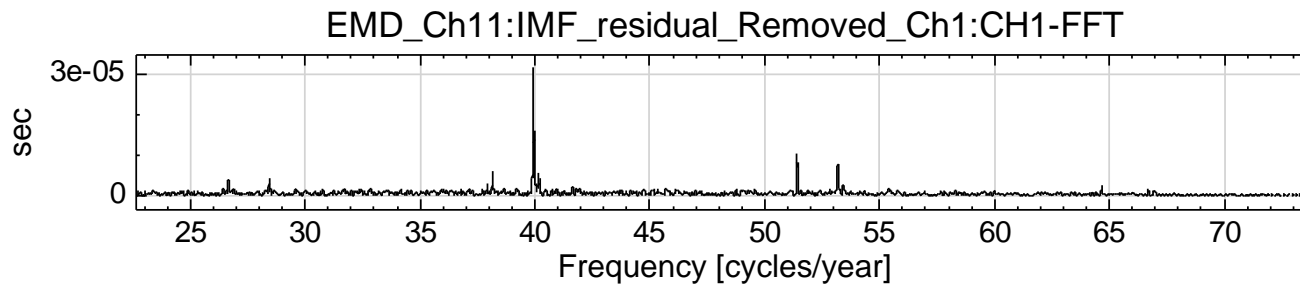
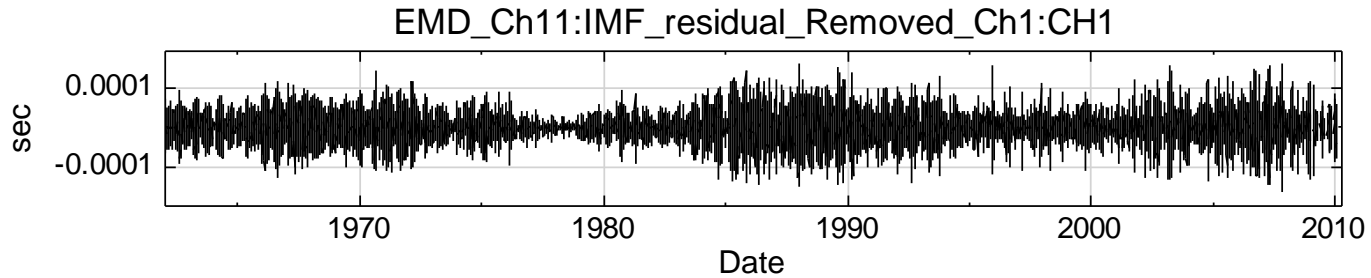
# Principal body tide constituents\*

Semi-diurnal			
Tidal constituent	Period	Vertical amplitude (mm)	Horizontal amplitude(mm)
$M_2$	12.421 hr	384.83	53.84
$S_2$	12.000 hr	179.05	25.05
$N_2$	12.658 hr	73.69	10.31
$K_2$	11.967 hr	48.72	6.82
[edit] Diurnal			
Tidal constituent	Period	Vertical amplitude (mm)	Horizontal amplitude(mm)
$K_1$	23.934 hr	191.78	32.01
$O_1$	25.819 hr	158.11	22.05
$P_1$	24.066 hr	70.88	10.36
$\phi_1$	23.804 hr	3.44	0.43
$\psi_1$	23.869 hr	2.72	0.21
$S_1$	24.000 hr	1.65	0.25
[edit] Long term			
Tidal constituent	Period	Vertical amplitude (mm)	Horizontal amplitude(mm)
$M_f$	13.661 days	40.36	5.59
$M_m$	27.555 days	21.33	2.96
$S_{sa}$	0.50000 yr	18.79	2.60
lunar node	18.613 yr	16.91	2.34
$S_a$	1.0000 yr	2.97	0.41

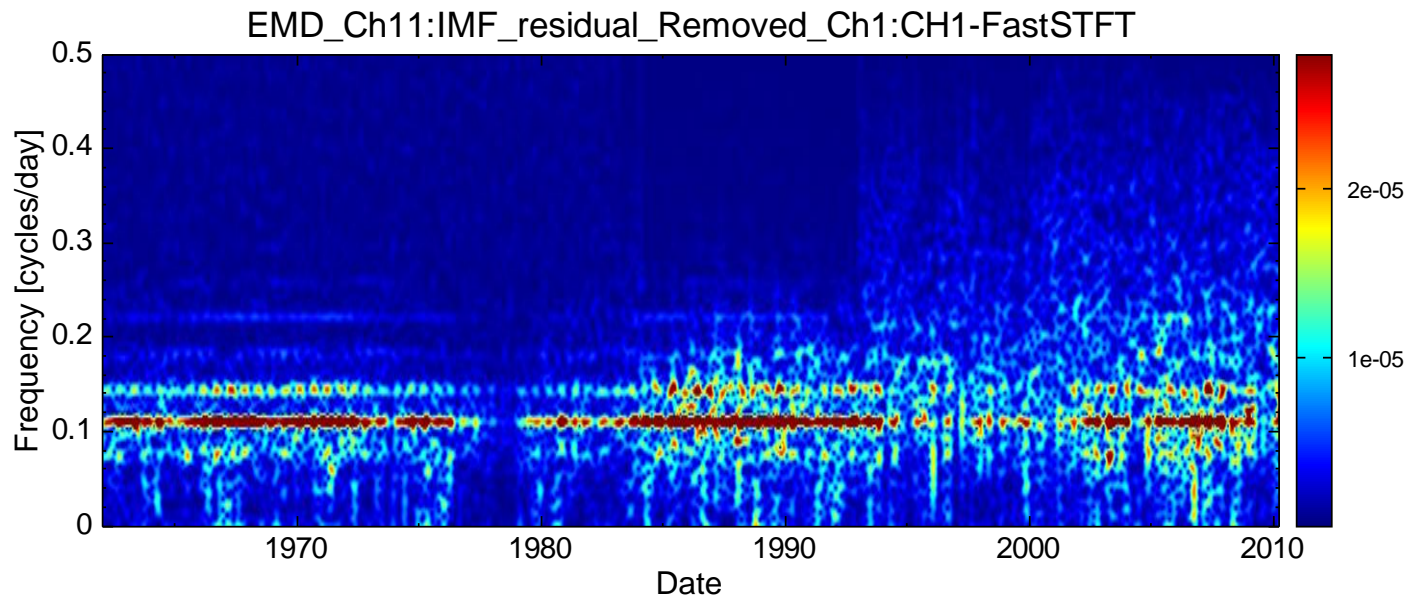
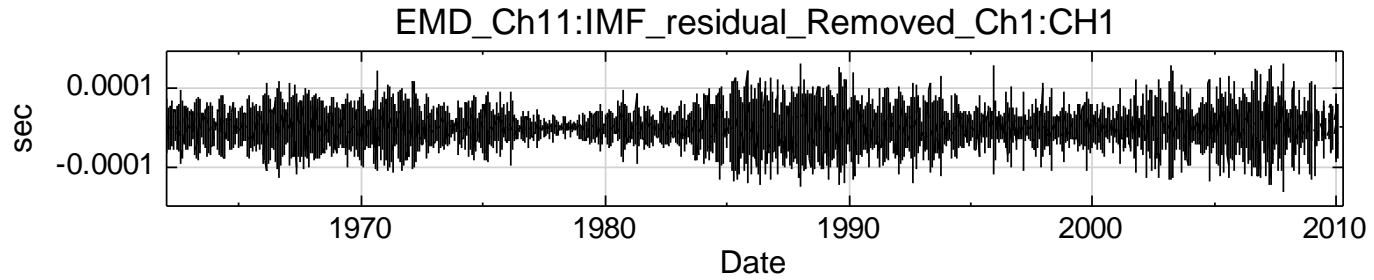
\* from Wiki [http://en.wikipedia.org/wiki/Earth\\_tide](http://en.wikipedia.org/wiki/Earth_tide)



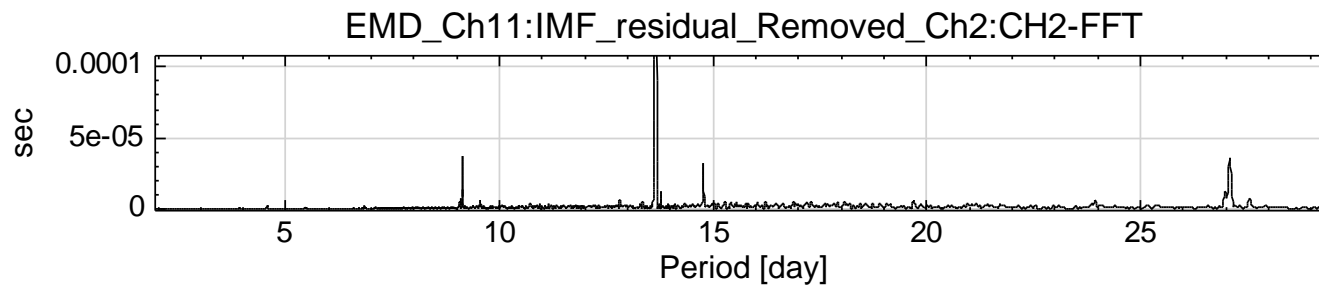
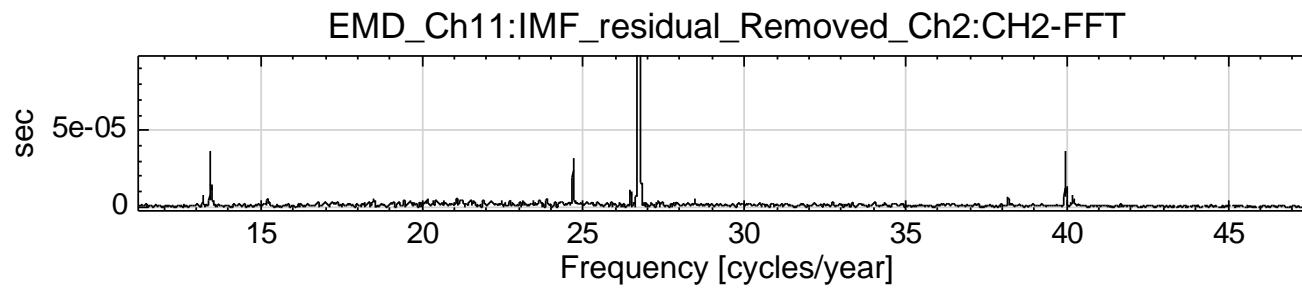
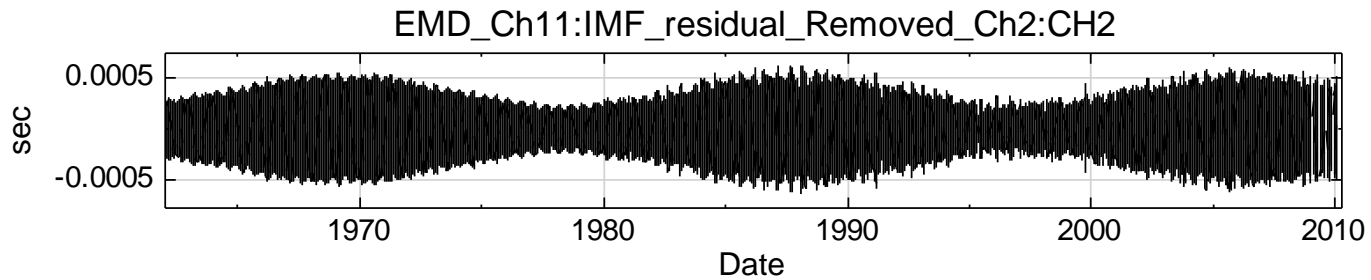
# LOD: IMF1



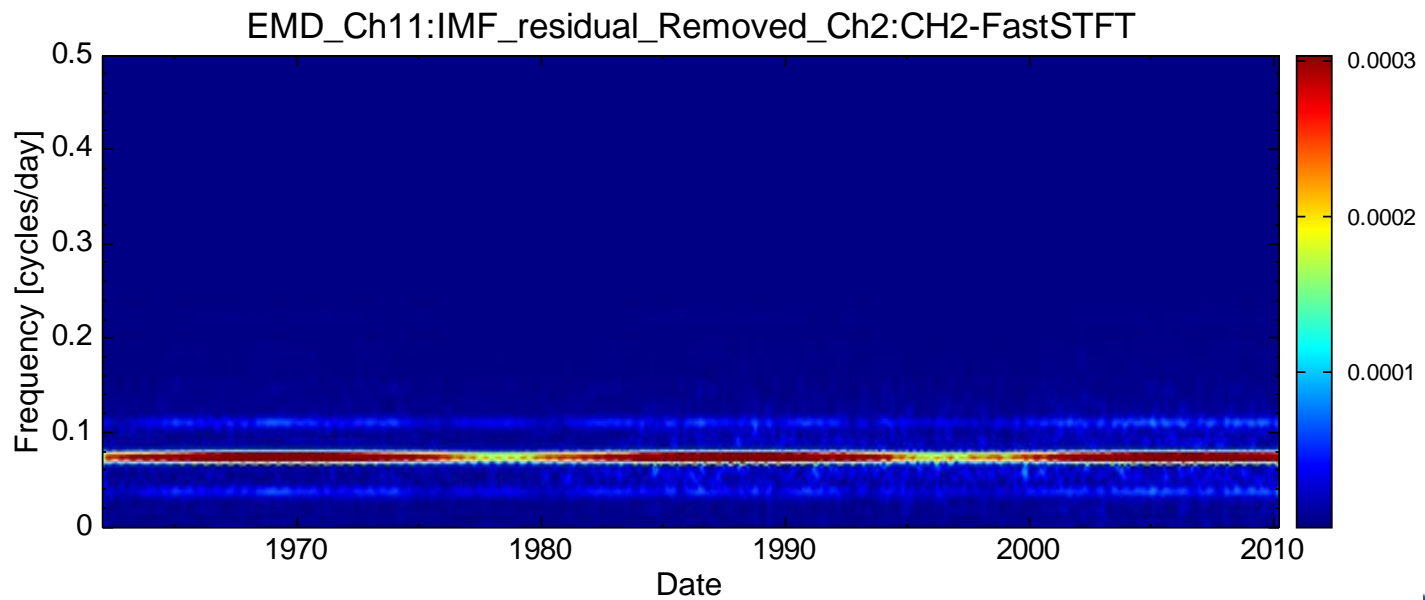
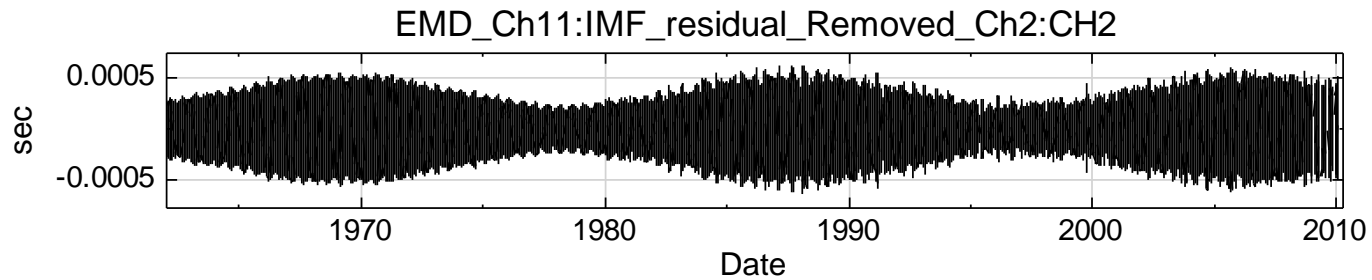
# LOD: IMF1



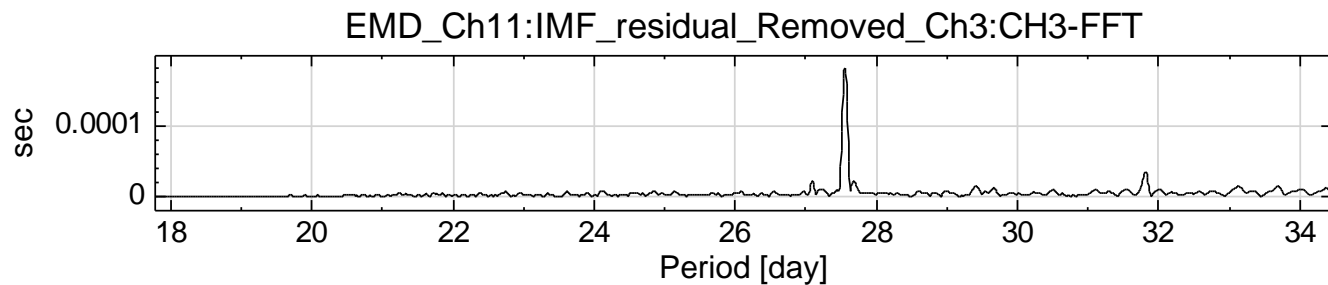
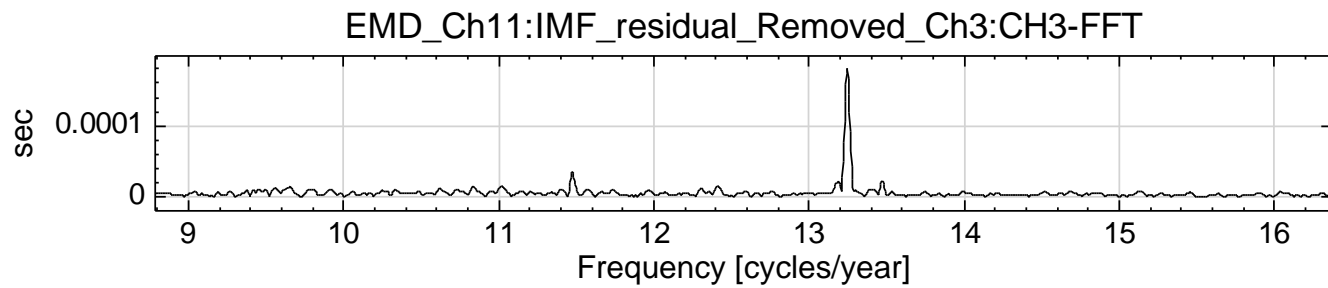
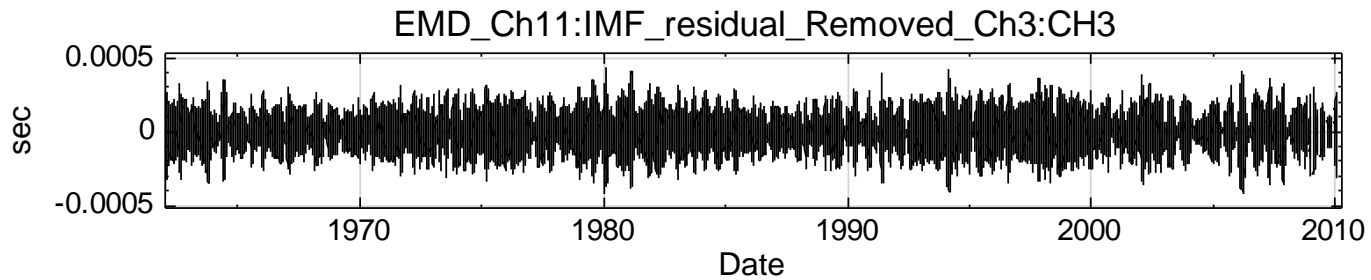
# LOD: IMF2



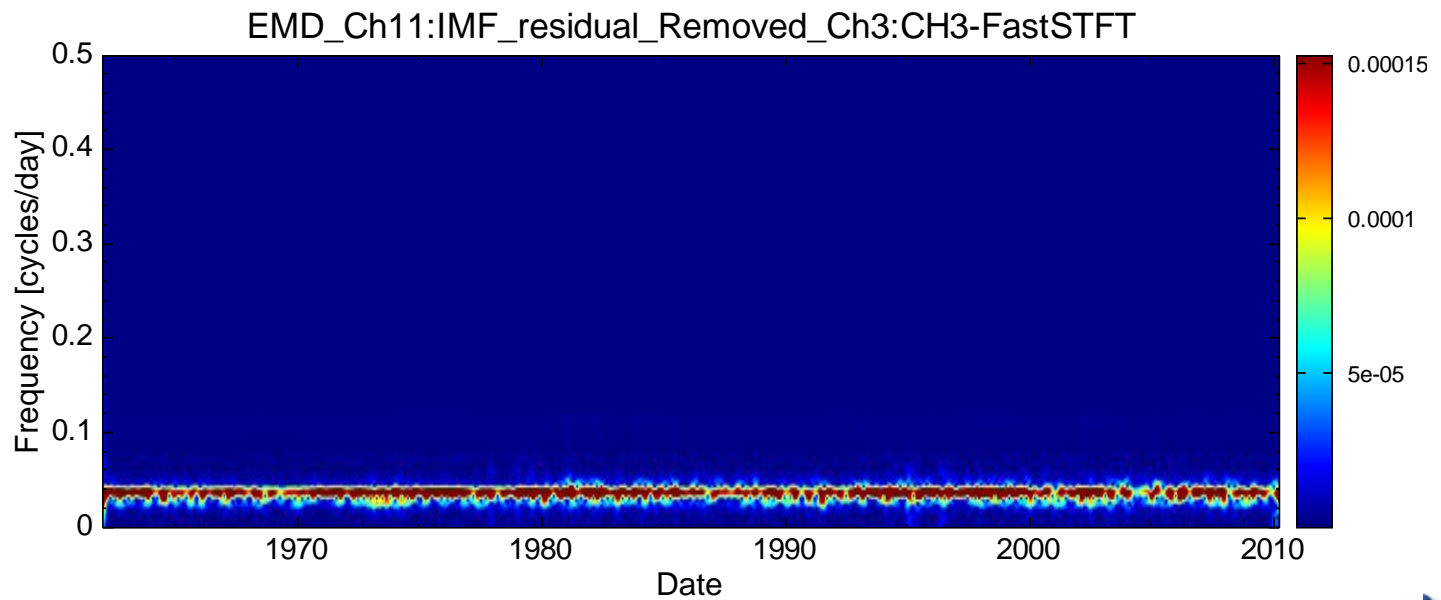
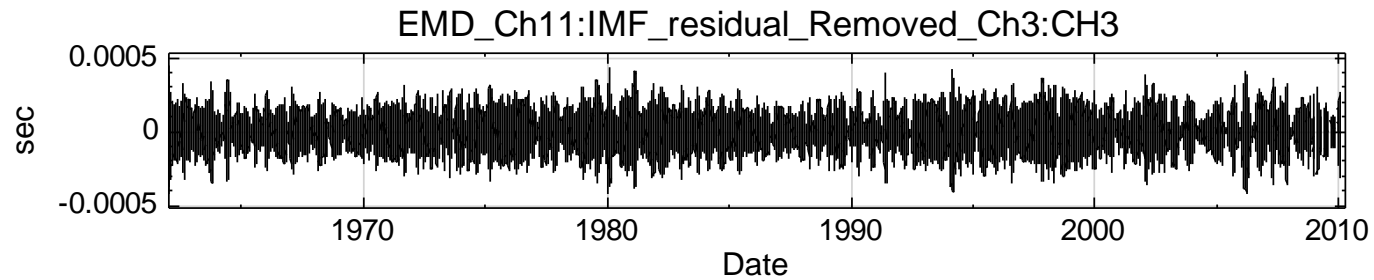
# LOD: IMF2



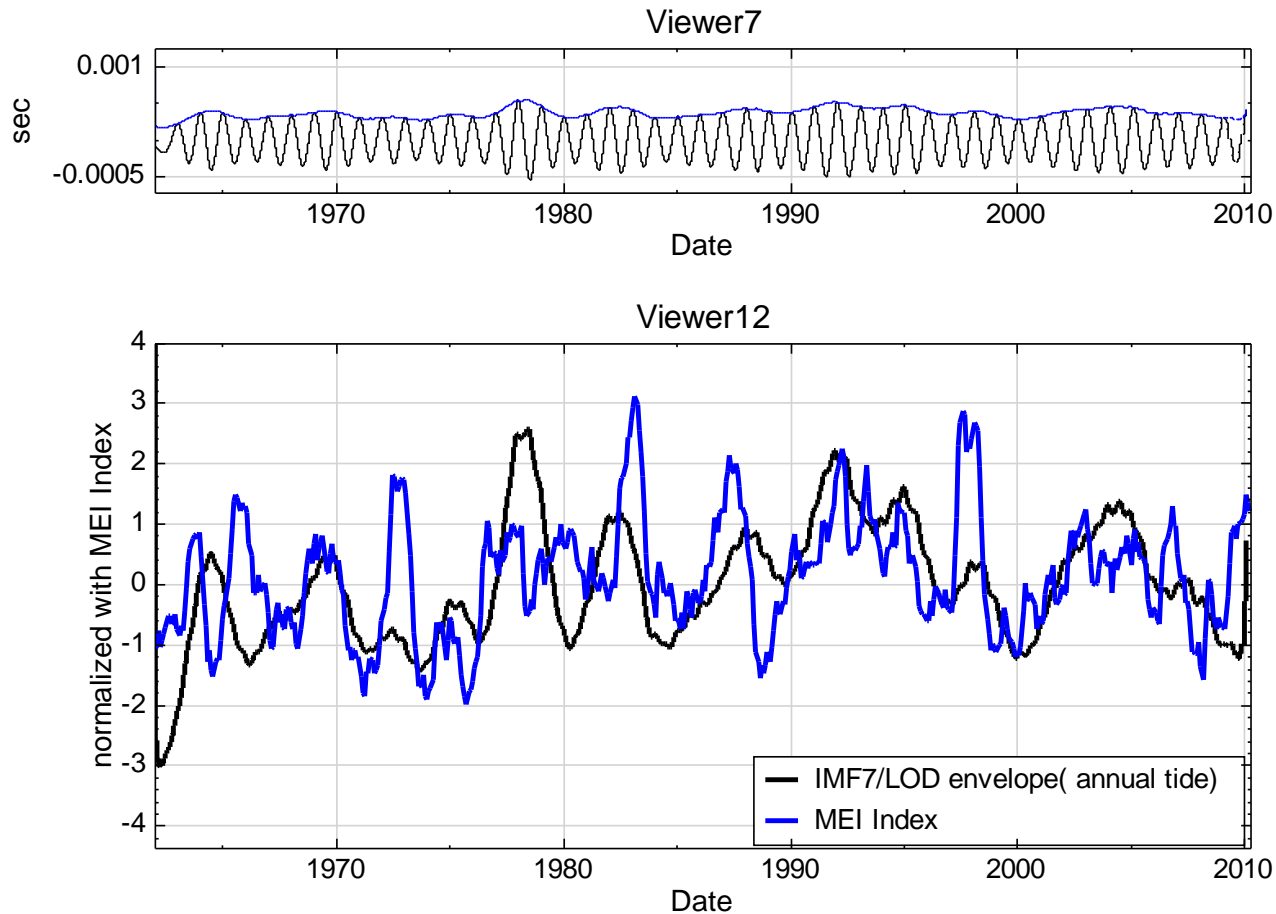
# LOD: IMF3



# LOD: IMF3



# LOD/IMF7: Annual tide vs. MEI Index



Huang in his paper pointed out close relation of the envelope of annual tide to El Niño, and suggested the effect of El Niño slow down the Earth's rotational speed.

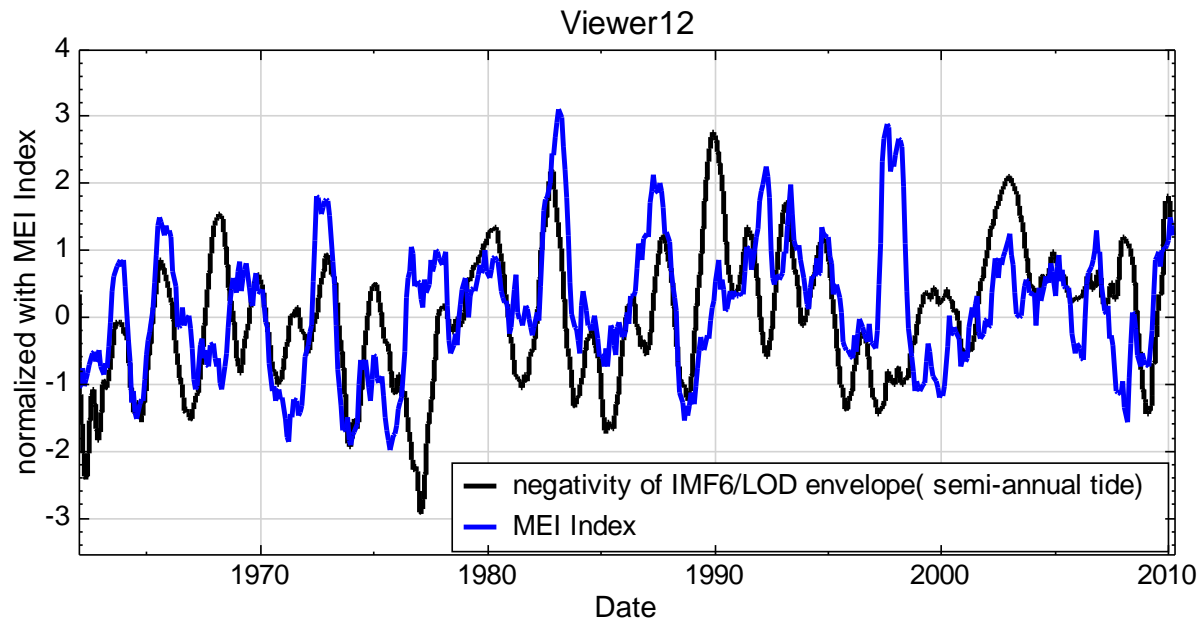
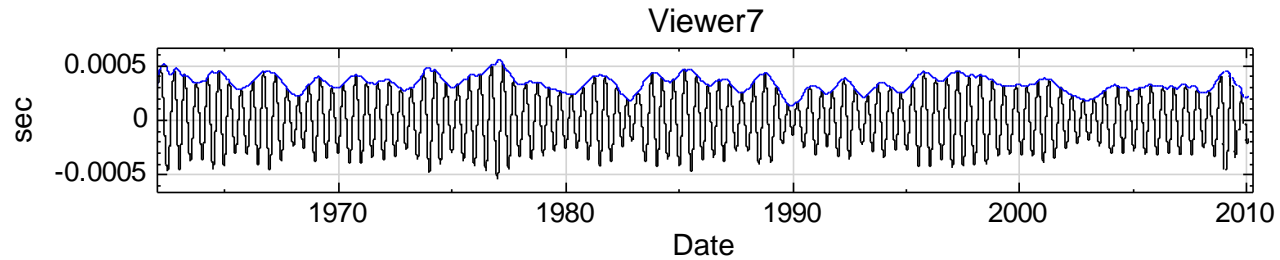
# What is MEI Index?

- “El Niño/Southern Oscillation (ENSO) is the most important coupled ocean-atmosphere phenomenon to cause global climate variability on interannual time scales. Here we attempt to monitor ENSO by basing the Multivariate ENSO Index (MEI) on the six main observed variables over the tropical Pacific. These six variables are: sea-level pressure (P), zonal (U) and meridional (V) components of the surface wind, sea surface temperature (S), surface air temperature (A), and total cloudiness fraction of the sky (C). ...”
- “Negative values of the MEI represent the cold ENSO phase, a.k.a. La Niña, while positive MEI values represent the warm ENSO phase (El Niño). “

Extracted from: <http://www.esrl.noaa.gov/psd/people/klaus.wolter/MEI/>



# LOD/IMF6: Semi-Annual tide vs. MEI Index



1. The specific change of the Earth's moment of inertia
2. The period of 4.46 years and its correlation to MEI Index
3. EMD vs. Fourier based analysis

## DIFFERENCE OF LOD

# Length of Day (LOD)

lod = Deviation from the nominal length of day

In the Earth, Sun and Moon system, the rotation of the Earth can be assumed to be a torque free process. That is, conservation of angular momentum applies that

$$I\omega = \text{const}, \quad (1)$$

where  $I$  and  $\omega$  denote angular moment of inertia and rotational angular velocity respectively.

# Conservation of Angular Momentum

$$I\omega = \text{const}$$

Take difference

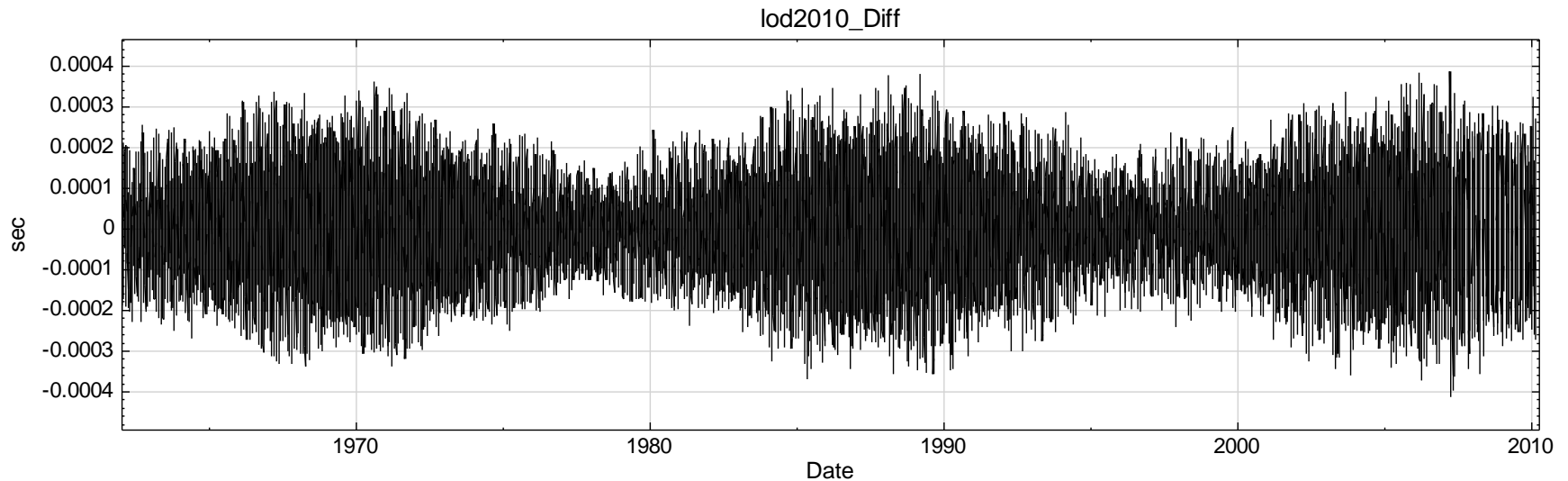
$$\frac{\Delta I}{I} = \frac{\Delta\omega}{\omega} = \frac{\Delta T}{T} = \frac{\Delta lod}{T_0 + lod}$$

where  $T_0 = 86400\text{sec}$

So the difference of lod is proportional to the Earth's specific change of the moment of inertia. That is

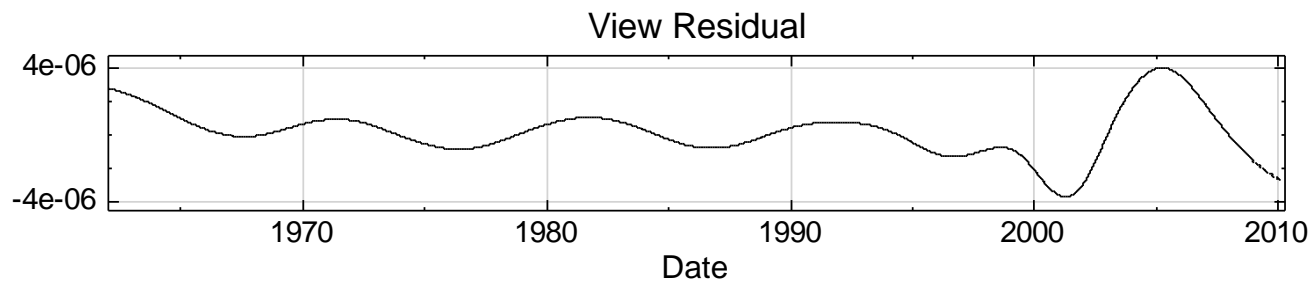
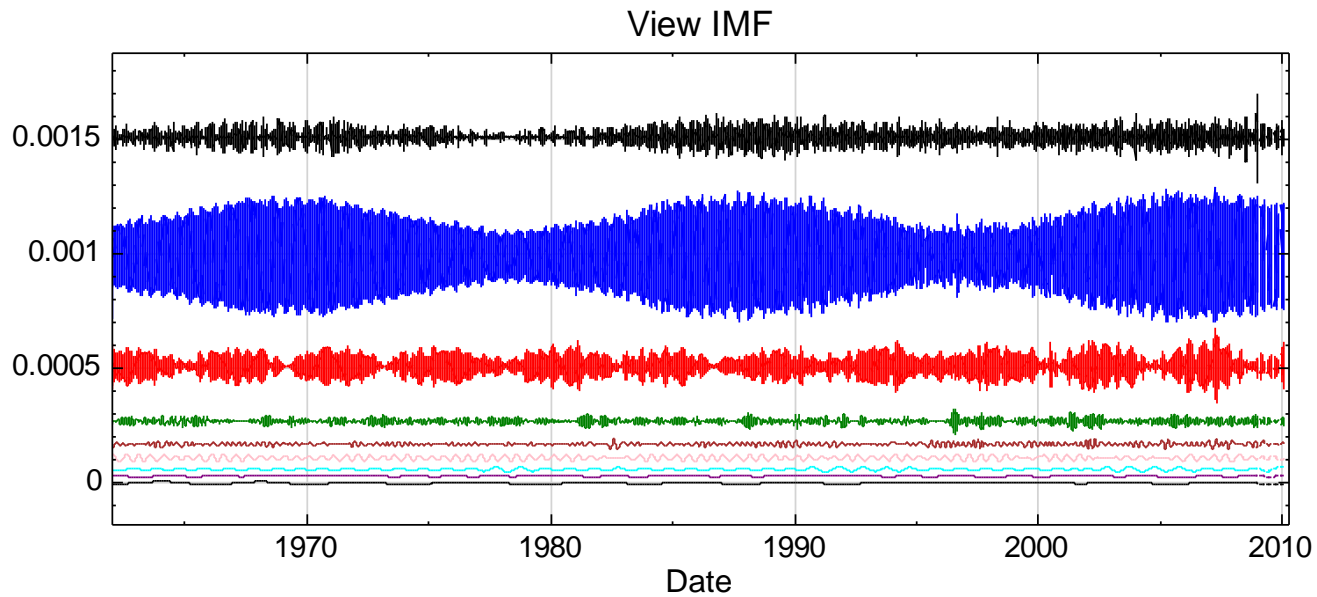
$$\Delta lod = T_0 \frac{\Delta I}{I} \quad (1)$$

# Specific Change of Moment of Inertia

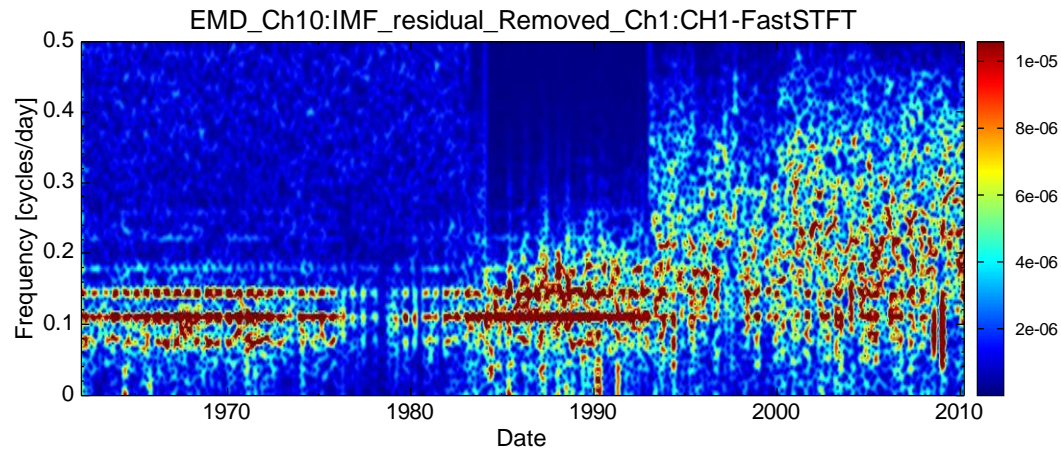
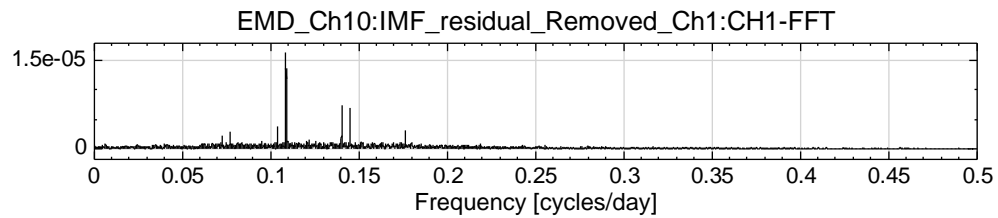
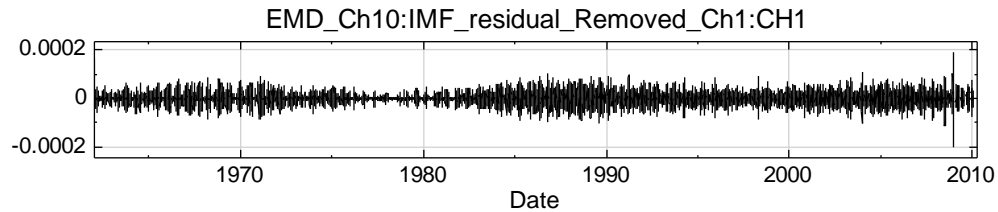


Taking difference of lod results in the specific change of the Earth's moment of inertia.

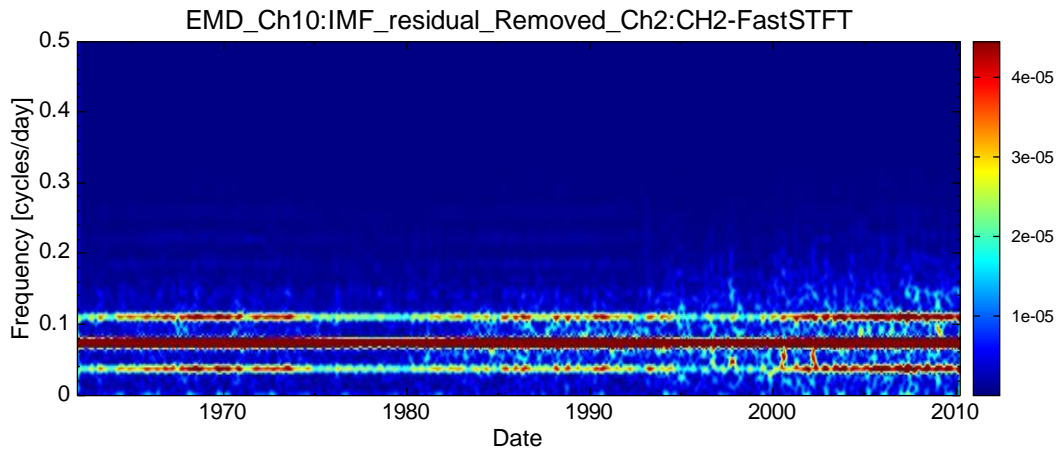
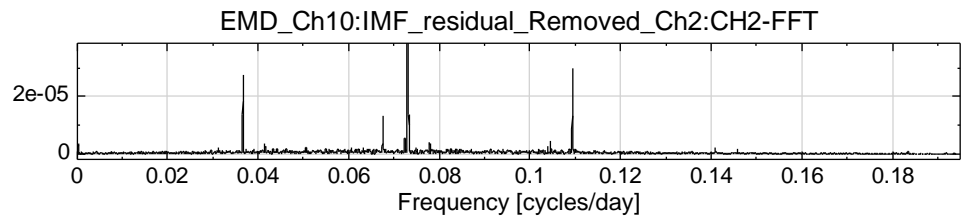
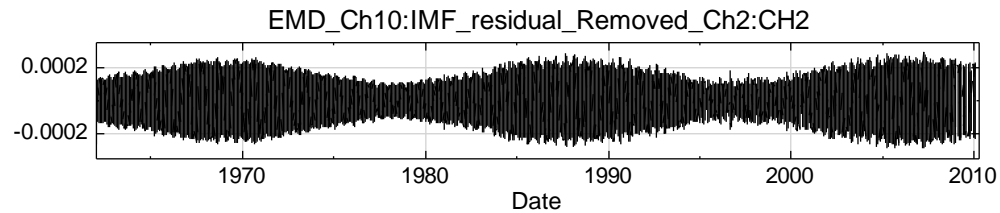
# EMD of difference of LOD



# IMF1: 1/40 year

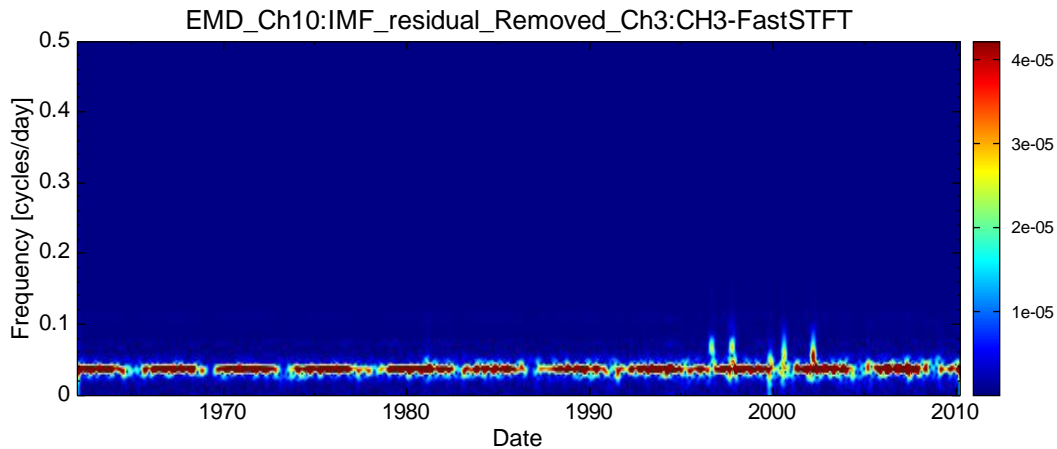
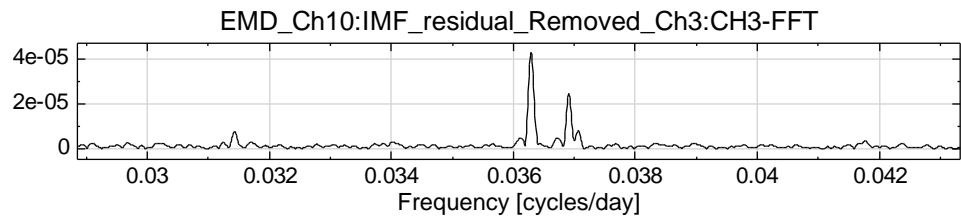
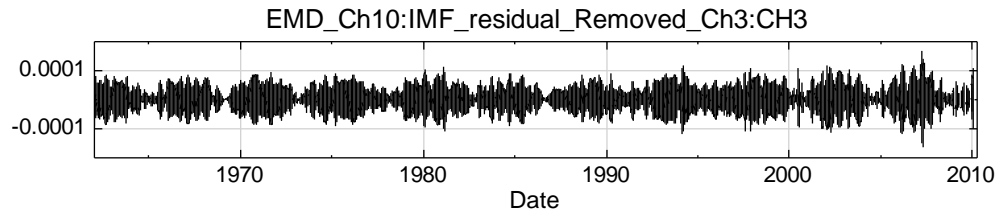


# IMF2: 13.6days/18.6years

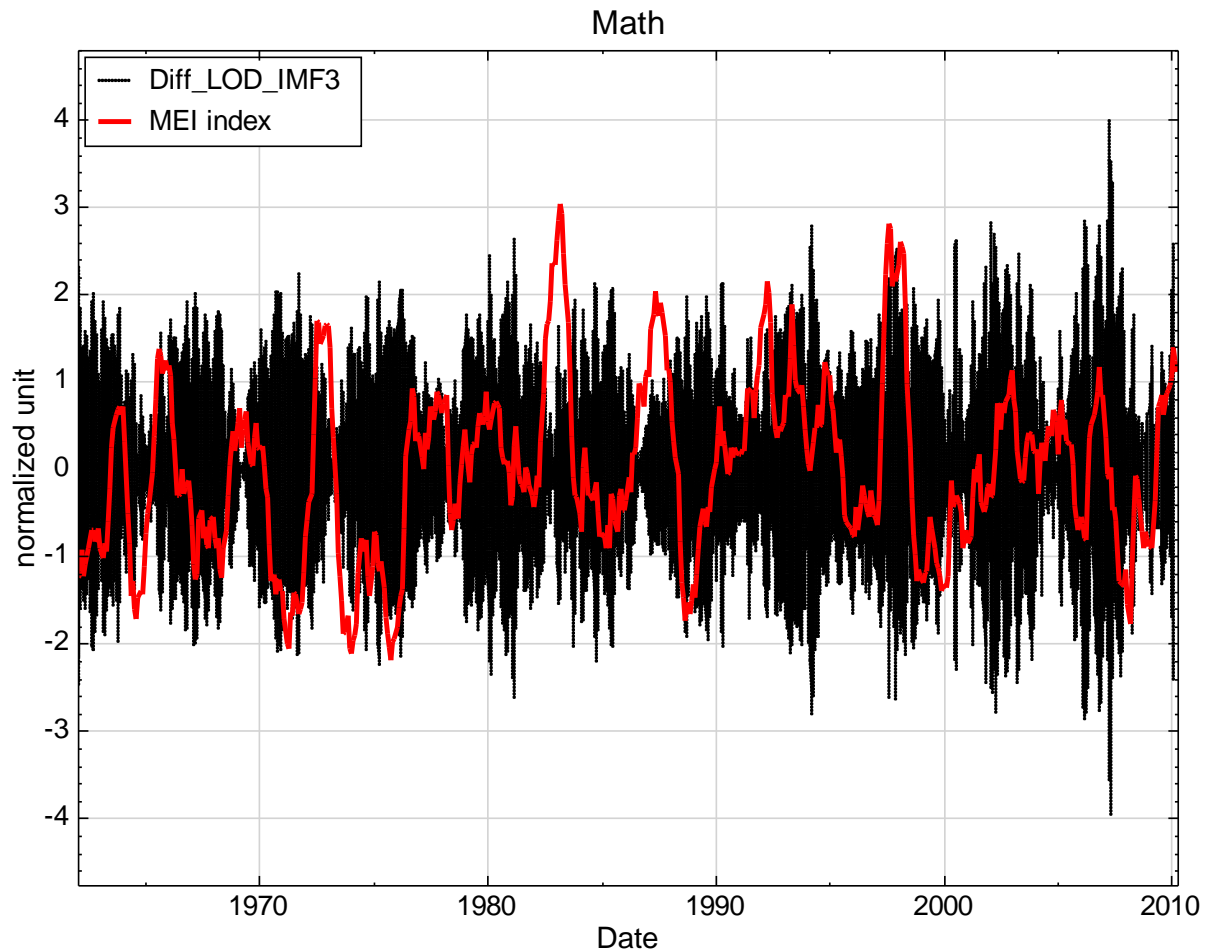




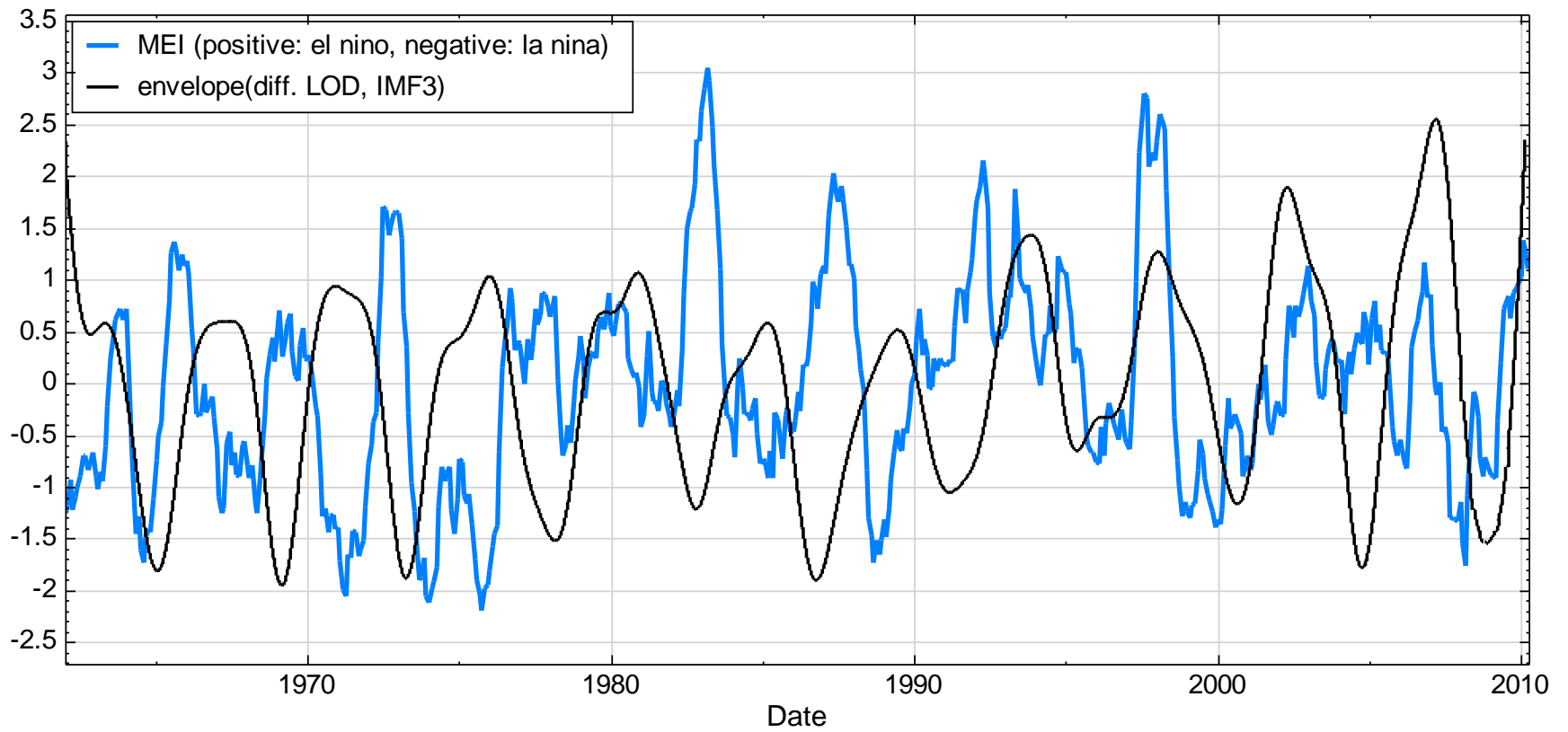
# IMF3: 27.3days/8.9years



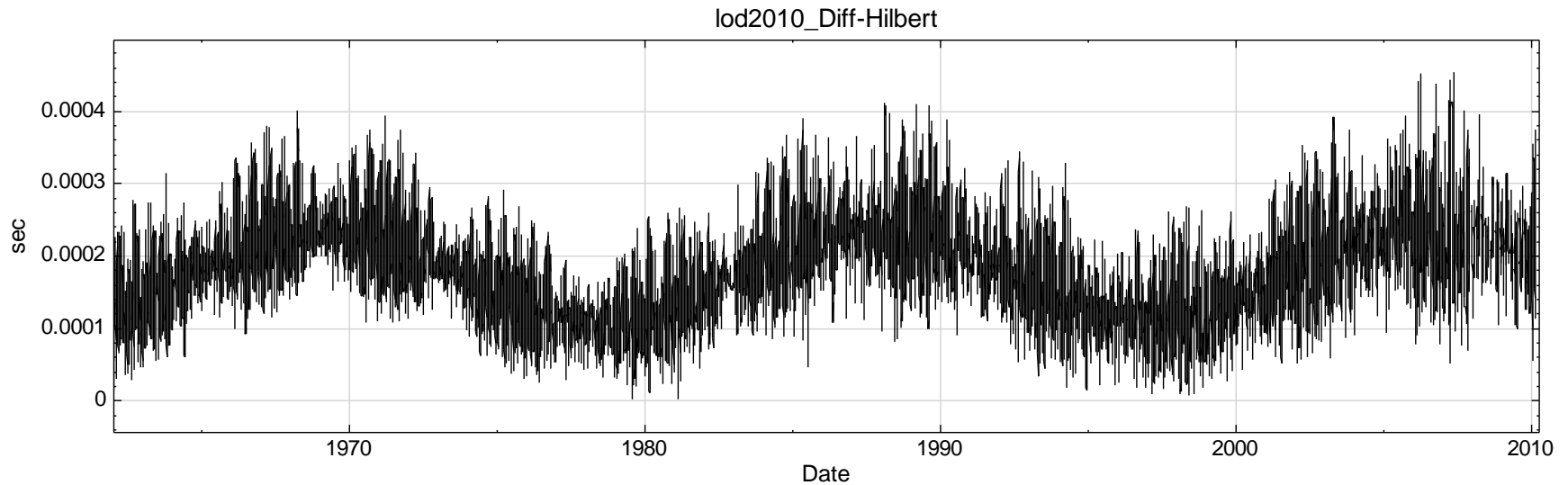
# IMF3 vs. MEI Index



# Math

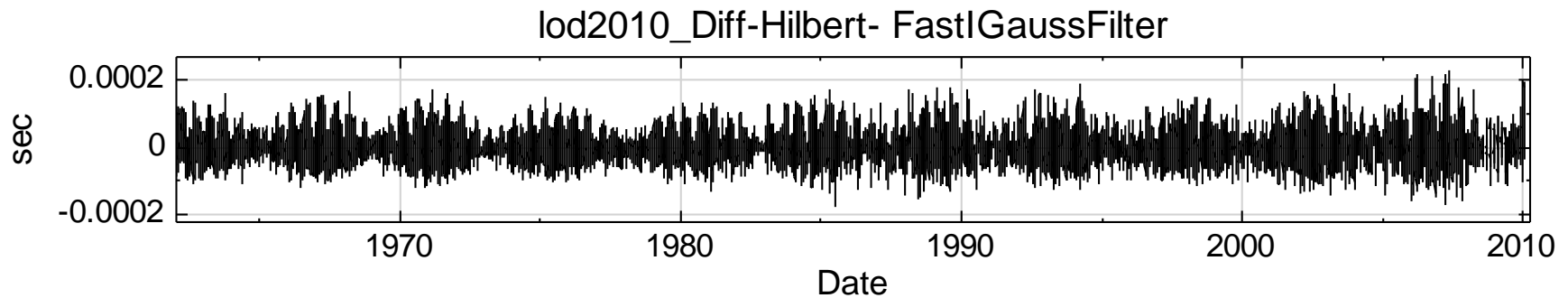


# Envelope of the acceleration



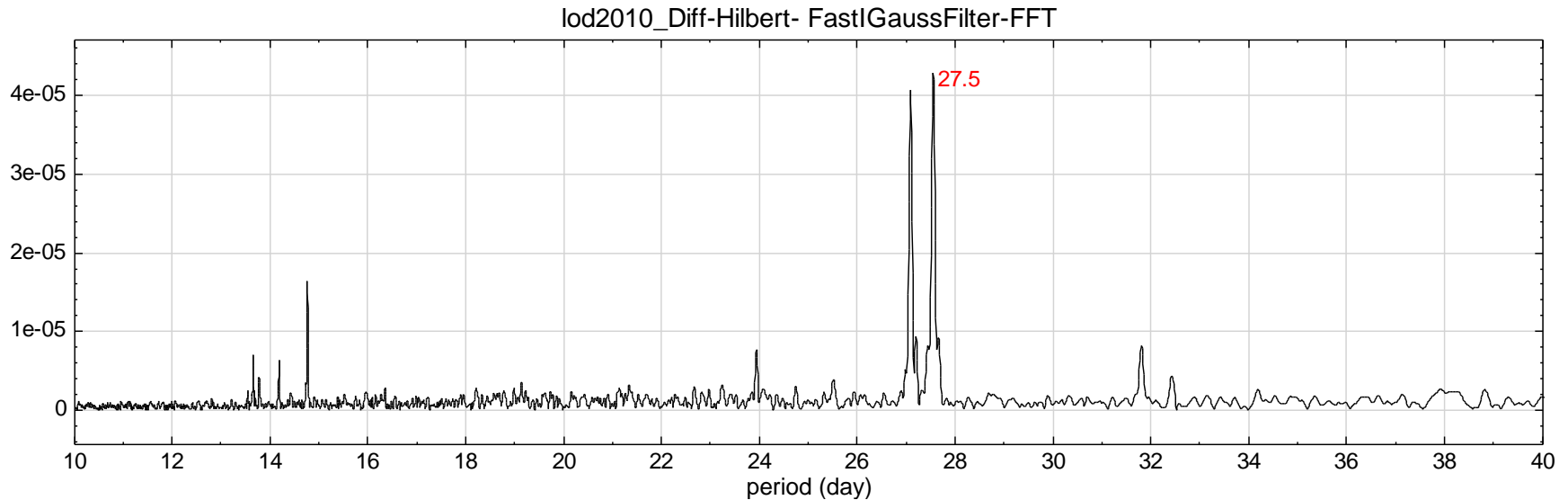
Take Hilbert Transform to retrieve the envelope of differential LOD.

# Detrend the signal using Iterative Gaussian Filter



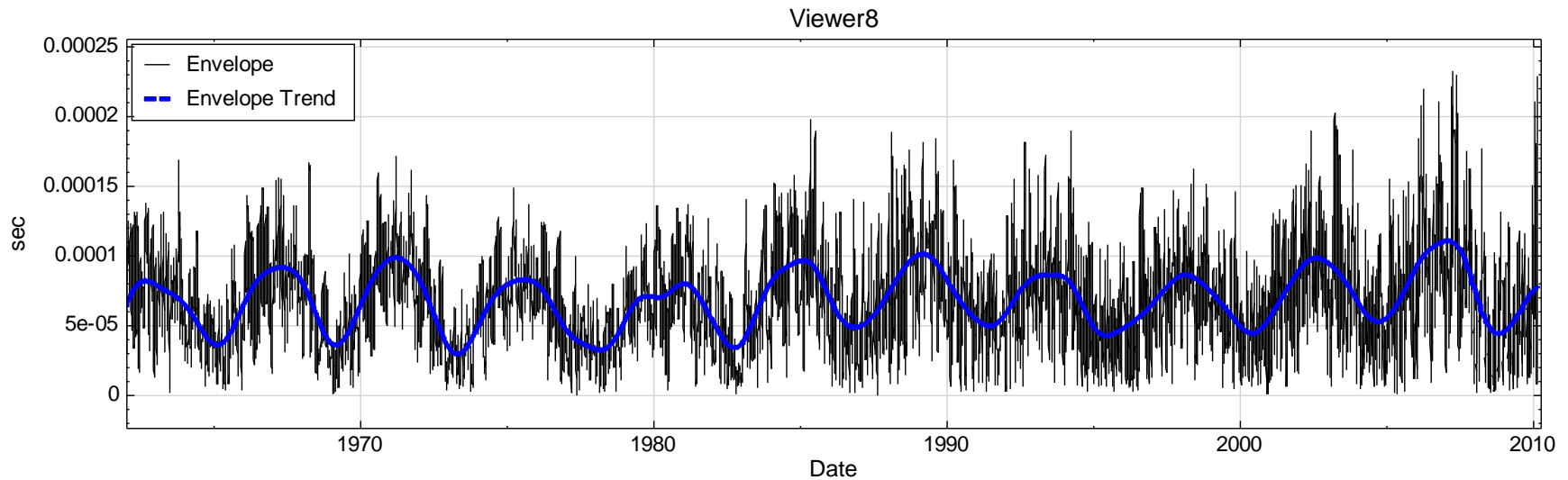
Detrend is applied for better spectrum analysis. The beat-wave like signal has a period of 4.46 years.

# Spectrum analysis shown in period



The envelope is composed of mainly two frequencies.  
The period of the carrier frequency is 27.5 days.

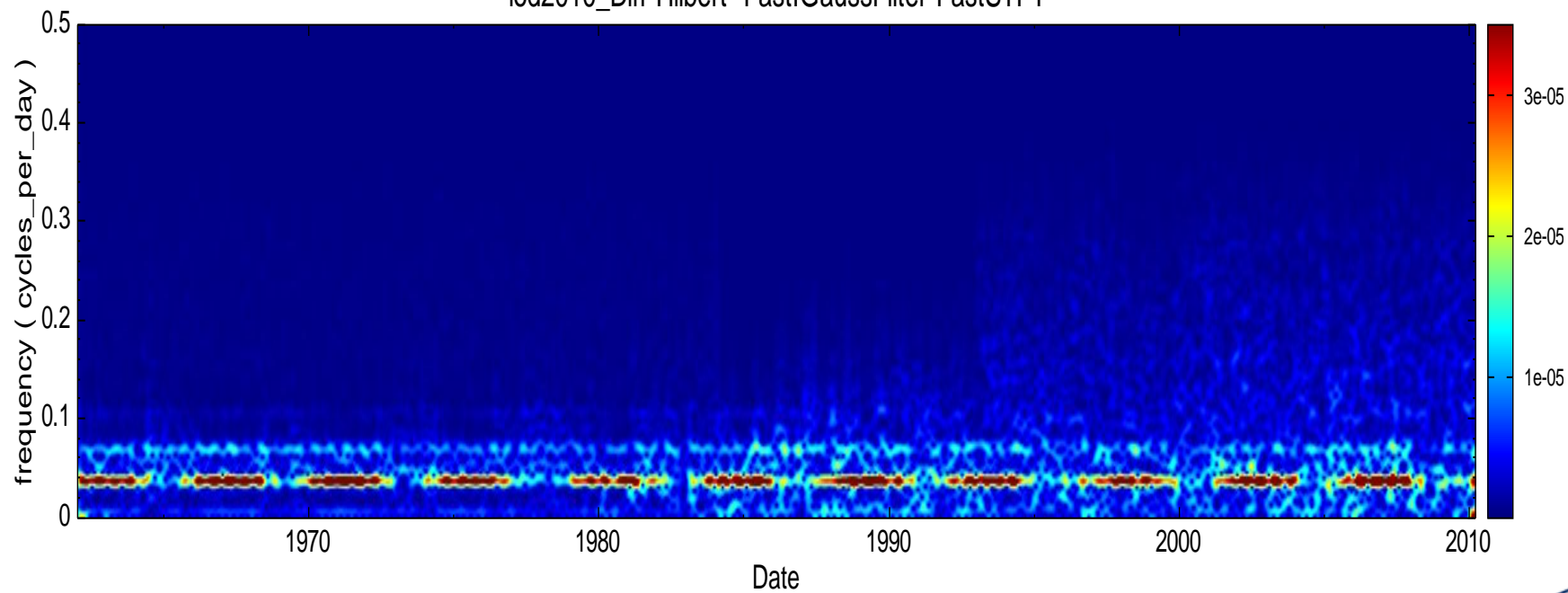
# Derived LOD: Trend of the envelope



Take Hilbert Transform to obtain the envelope and then apply Iterative Gaussian Filter to extract the trend.

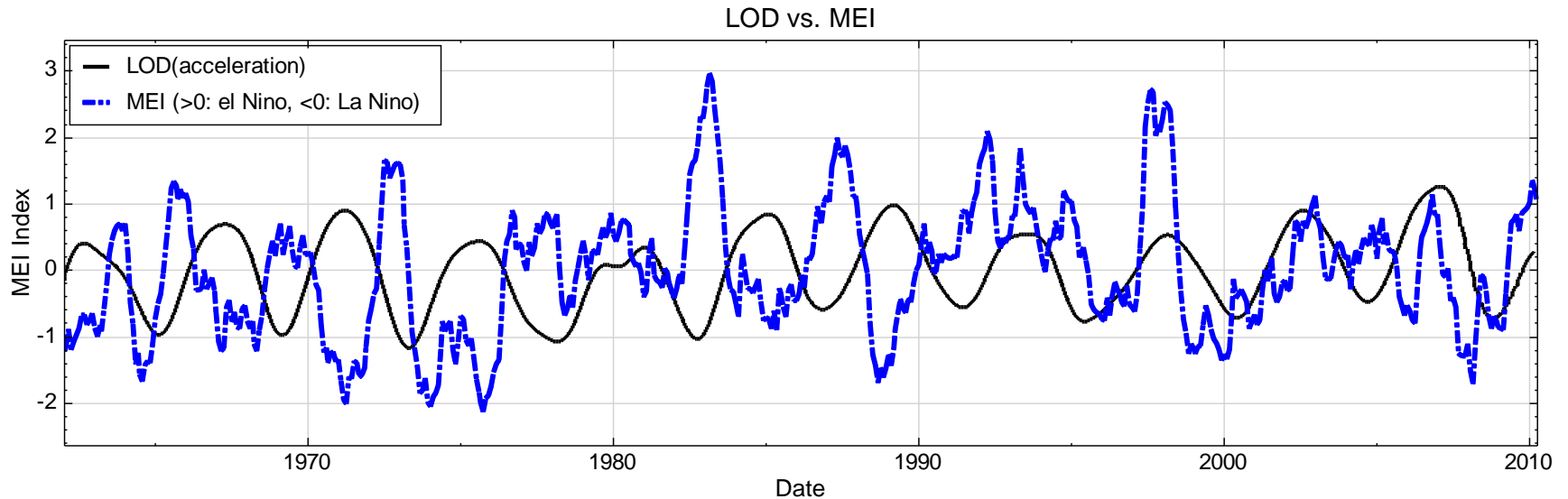


lod2010\_Diff-Hilbert- FastlGaussFilter-FastSTFT





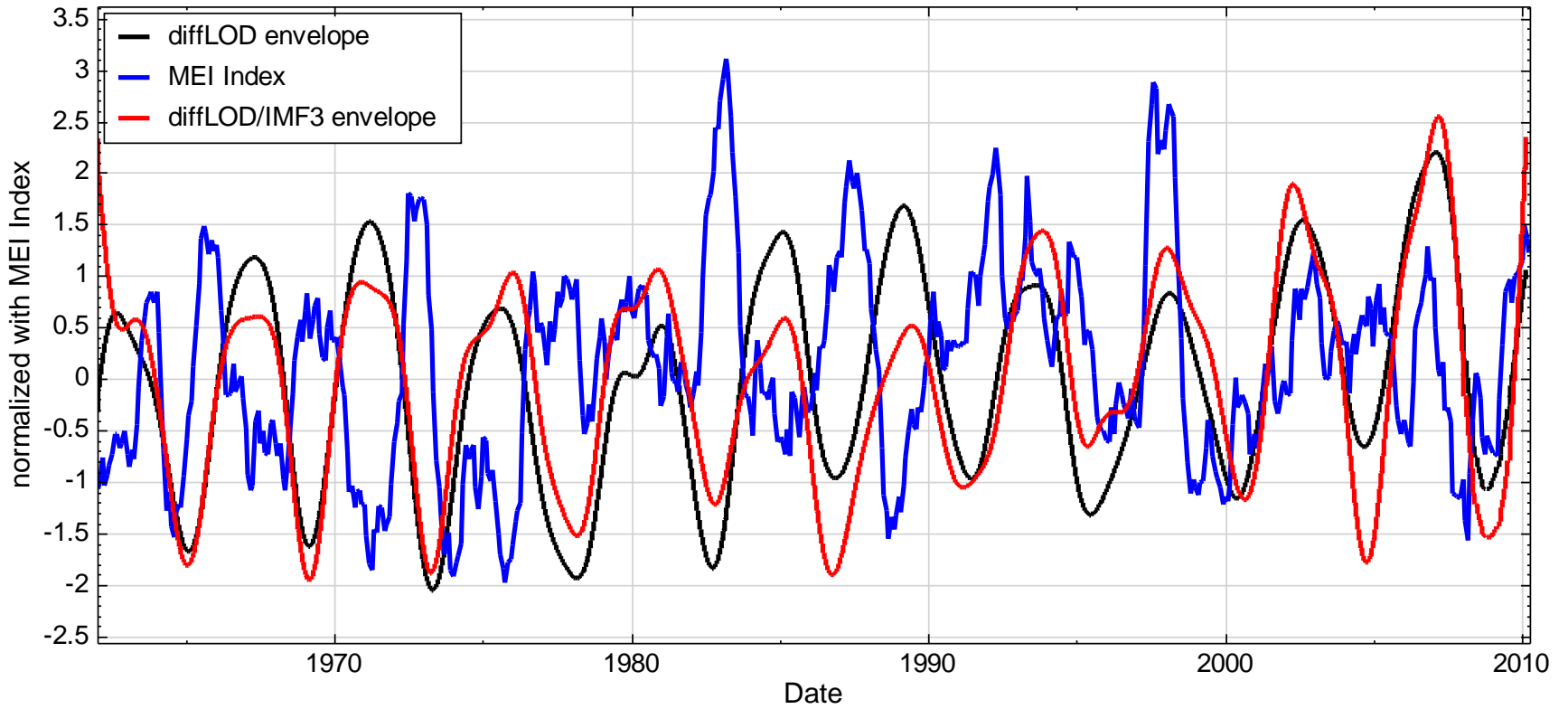
# LOD vs. MEI Index



The extracted component from LOD is compared with MEI index.

Data source: <http://www.esrl.noaa.gov/psd/people/klaus.wolter/MEI/>

Viewer12



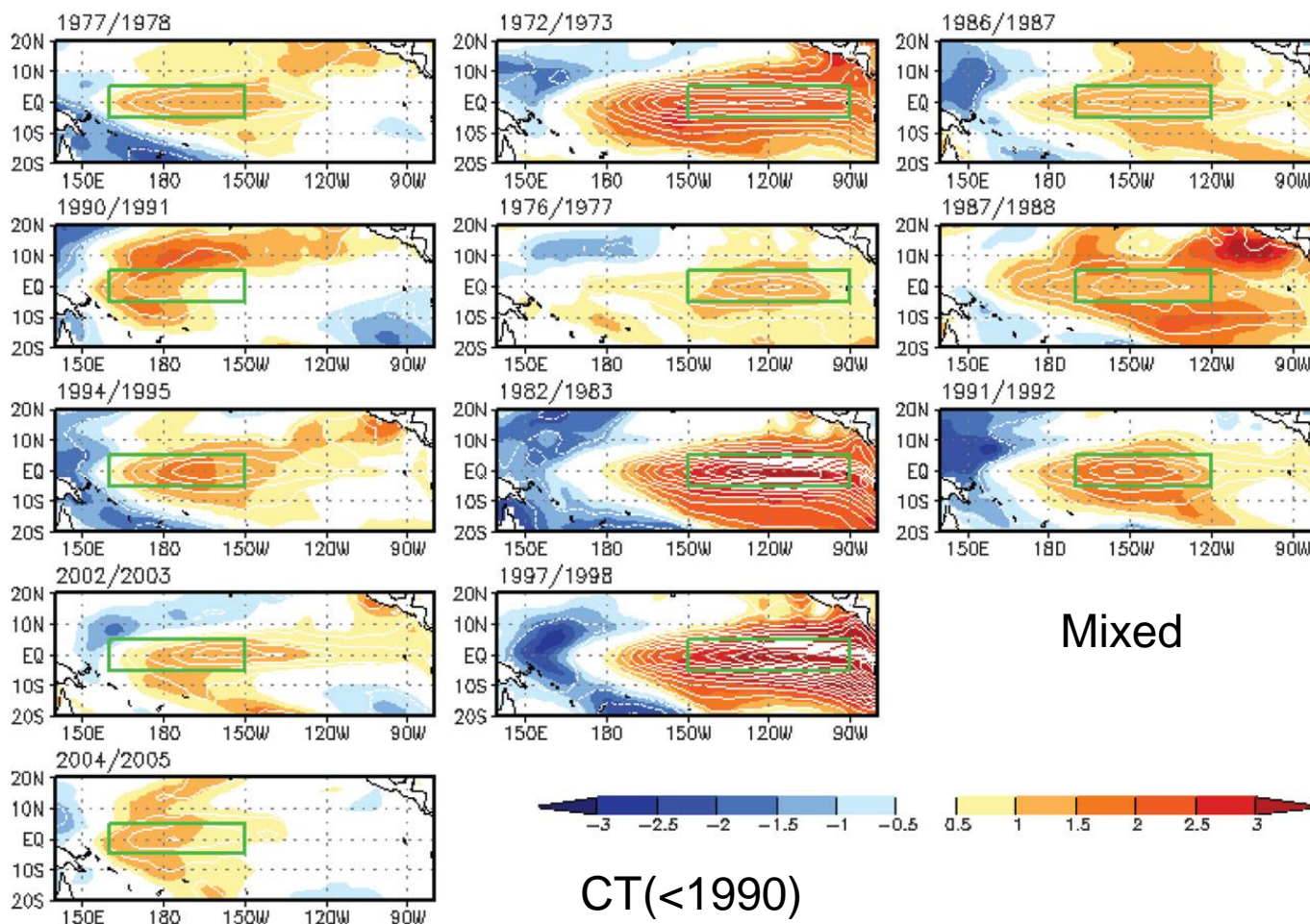
# Some Observations

- Before 1990, peak values of the derived LOD is out of phases coincide with MEI Index. Year 1990 has set the turning point that these two indices' peak values coincide in phases ever since.
- If ENSO were the cause of change of the derived LOD, the signal would not be that regular with a precise amplitude modulated period of 4.46 years. We would then reasonably assume, if these two signals are correlated, that change of earth's rotation would somehow influence the rise or fall of ENSO phenomenon.
- The period 4.46 years has somehow related to the eclipse period. If that so, the derived LOD is related to the change of gravitation depending heavily on relative positions of the Earth, Moon, and the Sun.
- With all the hypothesis, the ever increase of gravitation force on the Earth in 2012 might result in extreme ENSO phenomenon.

1. What's so significant in 1990?
2. The moon's orbiting
3. Retrograde of the Sun

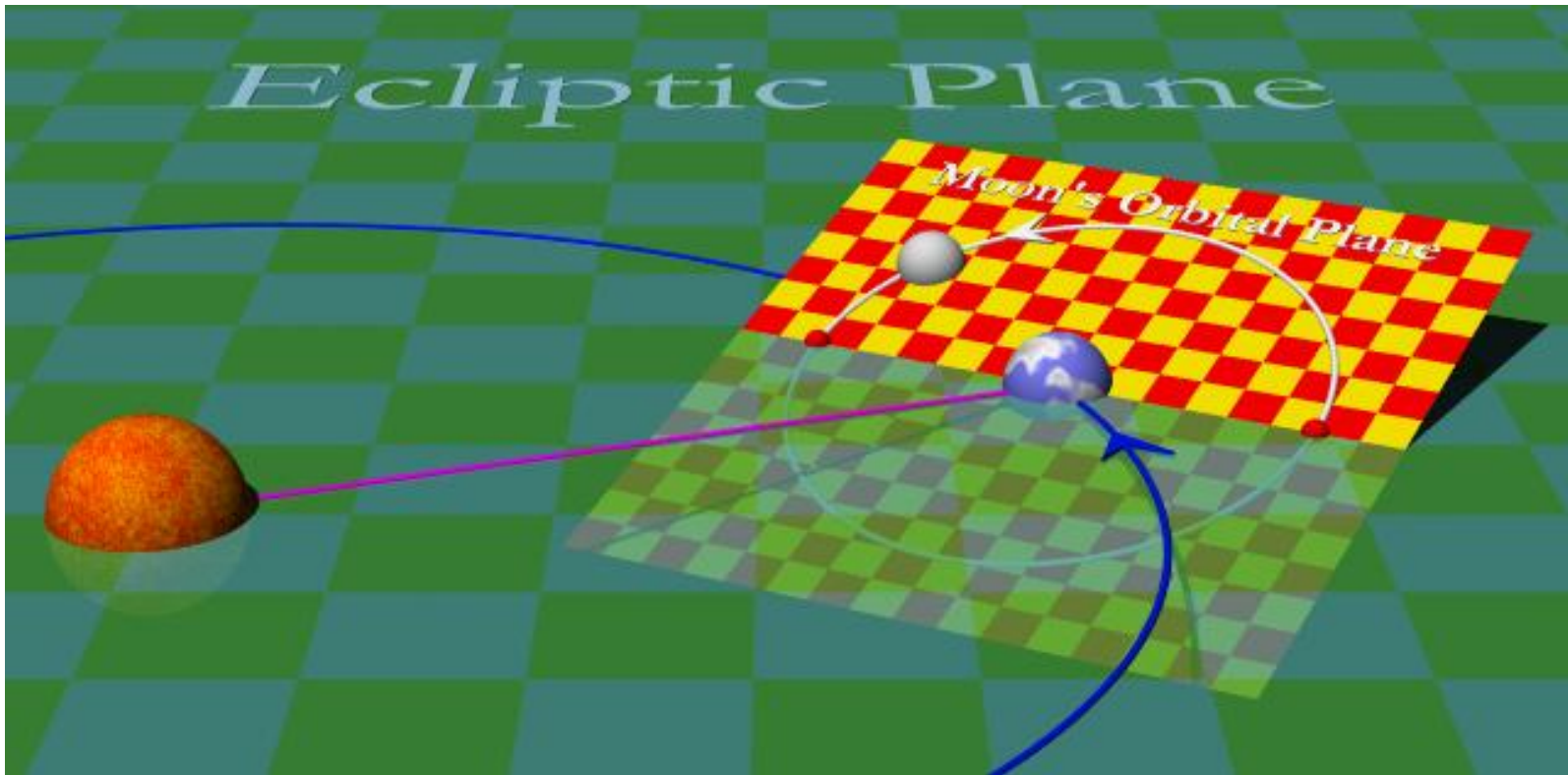
**IT'S ALL ABOUT ANGULAR  
MOMENTUM?**

# CT (cold tongue) vs. WP (Warm Pool) El Nino\*



\*Kug et al., 2009

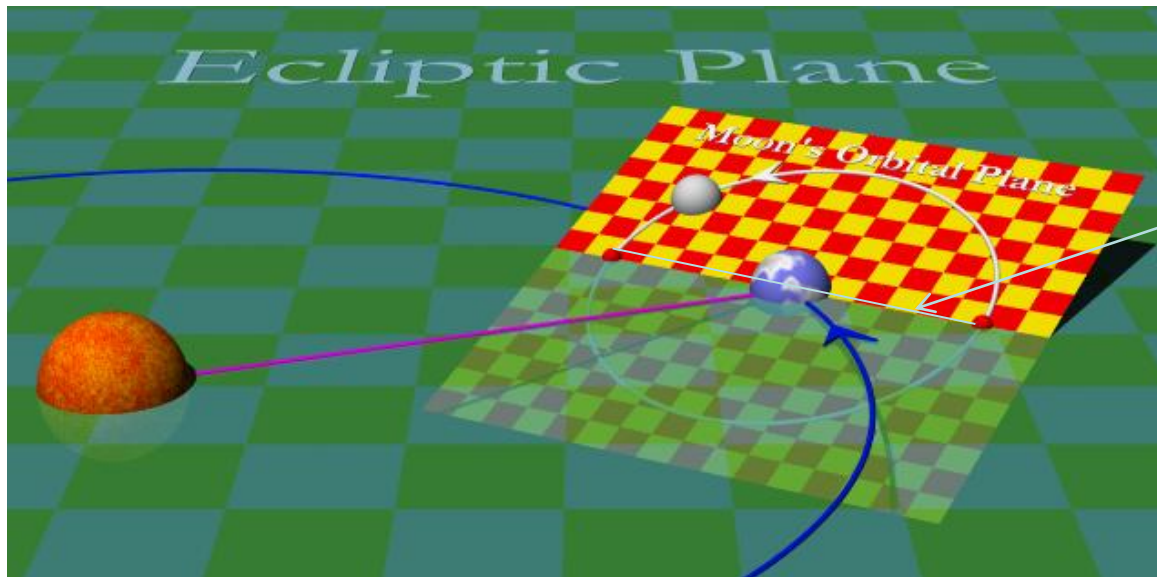
# The Moon's Orbit



Adapted from: [http://www.hermit.org/eclipse/why\\_cycles.html](http://www.hermit.org/eclipse/why_cycles.html)

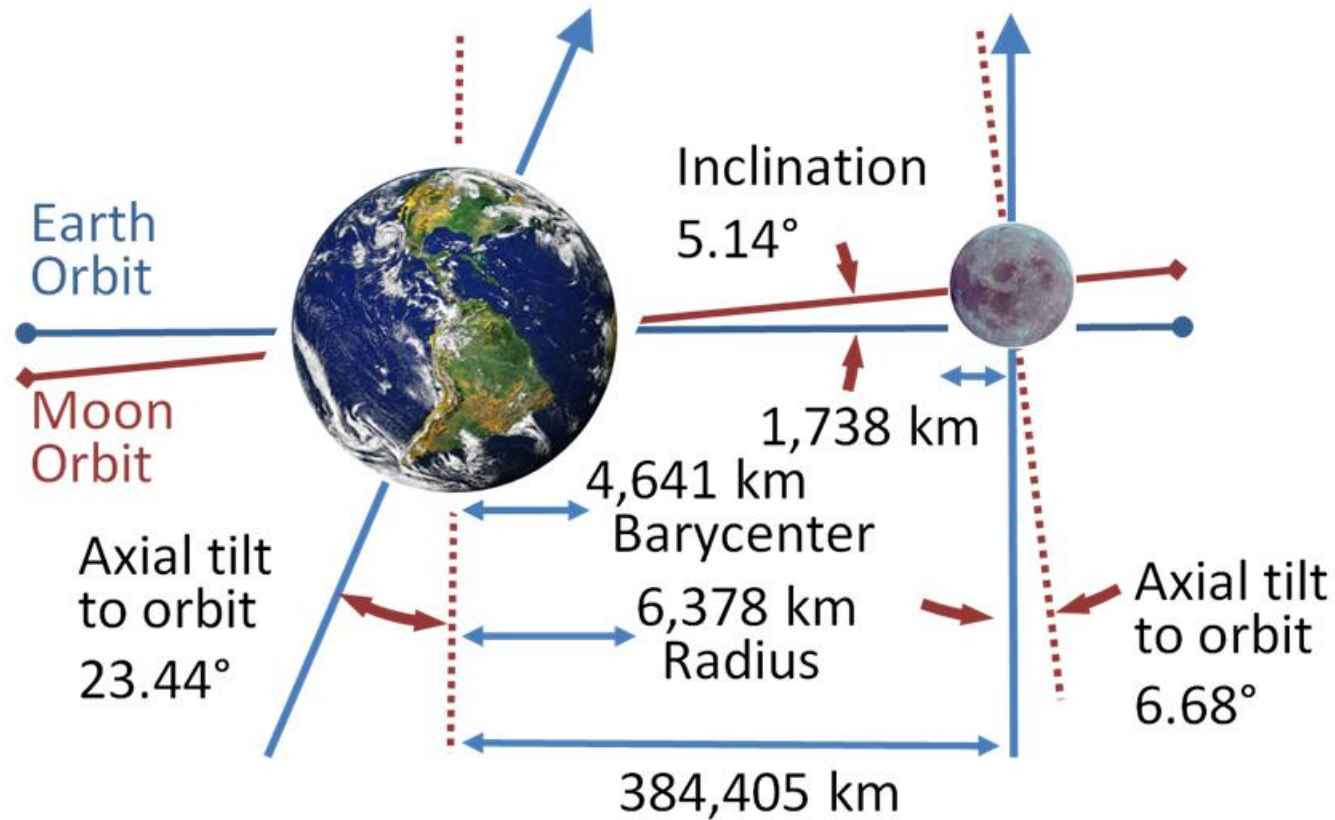
# The Moon's periods

- Regression of the line of nodes => 18.6 years
- Line of apsides motion => 8.9 years
- Oscillation of orbital inclination => 18.6 years
- Oscillation of eccentricity => 8.9 years



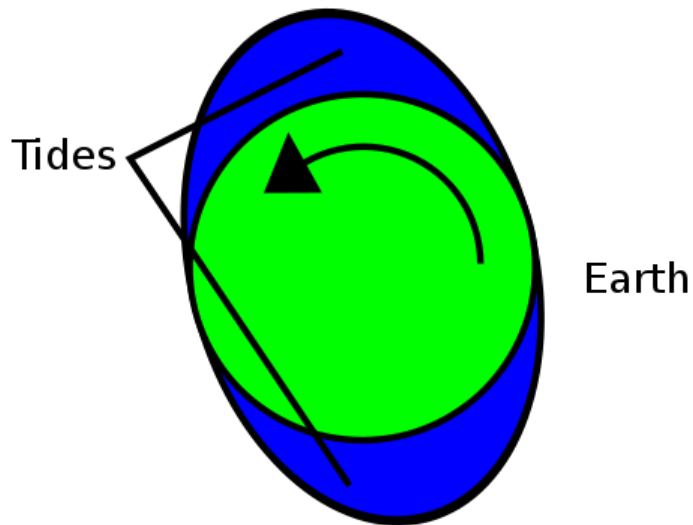
Line of nodes

# The Sun and the Moon



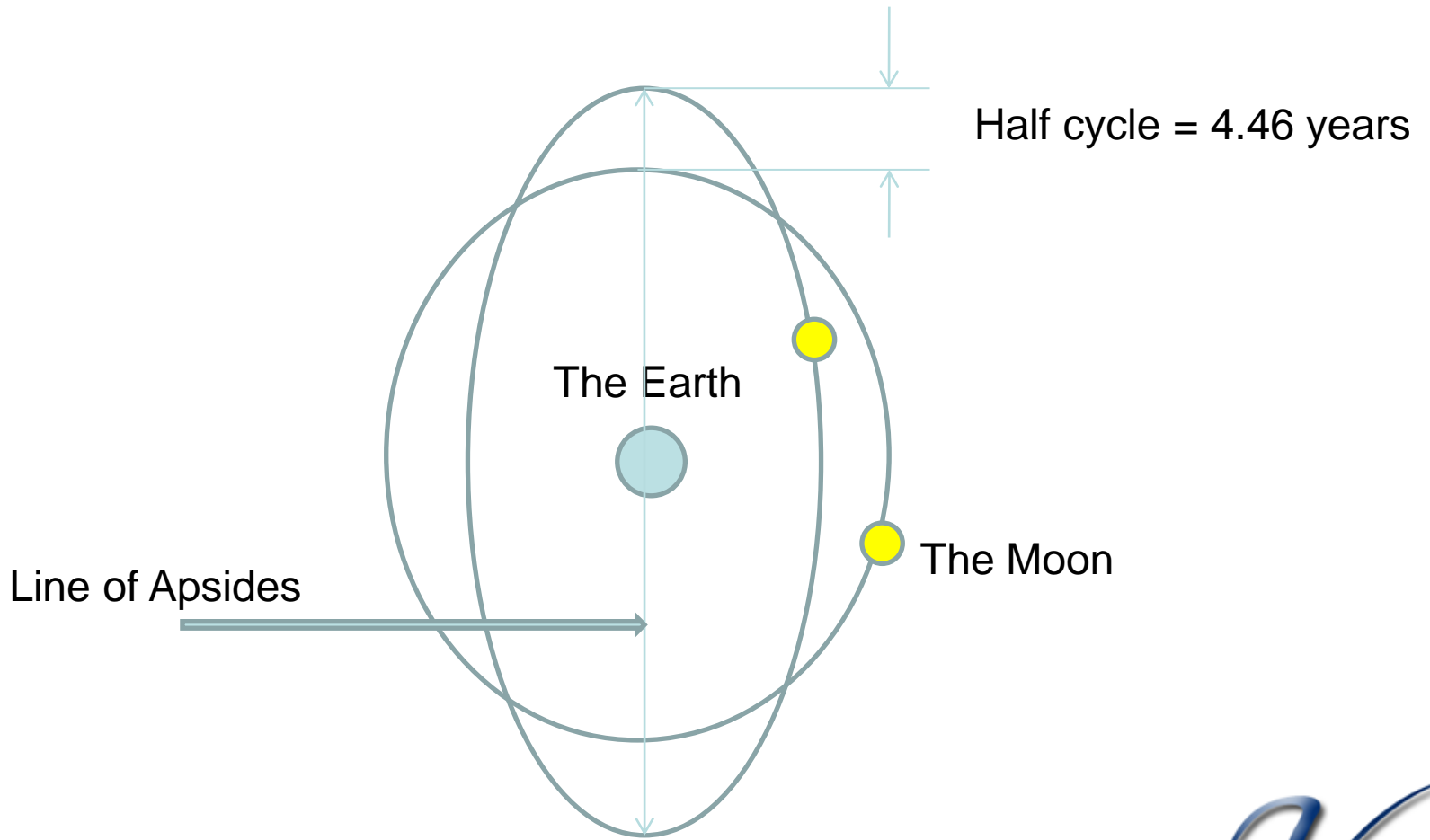


# Tidal Bulge Induced Torque

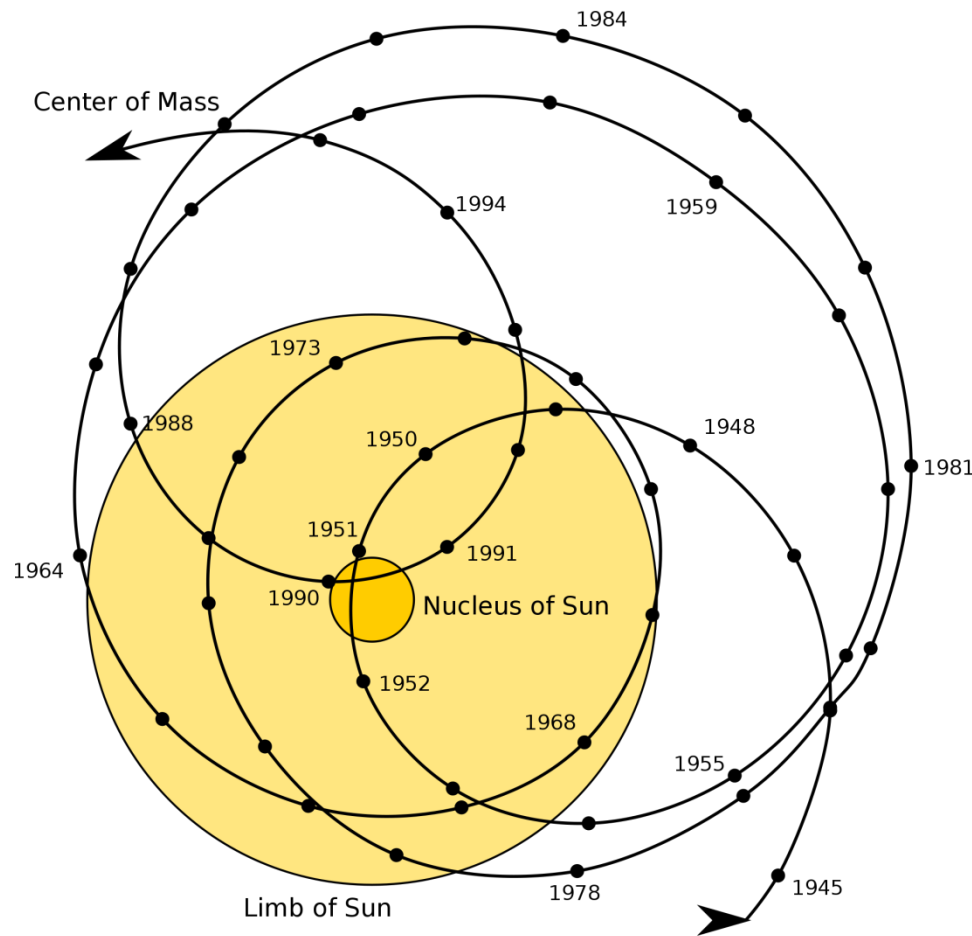


A diagram of the Earth-Moon system showing how the tidal bulge is pushed ahead by the Earth's rotation. This offset bulge exerts a net torque on the Moon, boosting it while slowing the Earth's rotation.

[http://en.wikipedia.org/wiki/Tidal\\_acceleration](http://en.wikipedia.org/wiki/Tidal_acceleration)



# Retrograde Sun\*



[http://en.wikipedia.org/wiki/File:Solar\\_system\\_barycenter.svg](http://en.wikipedia.org/wiki/File:Solar_system_barycenter.svg)

\*Theodor Landscheidt, 1999



# Acknowledgement

- Professor Yang (楊穎堅) of Naval Academy pointed out the nodes of the difference LOD might be related to the occurrences of El Nino. (personal conversation)
- Dr. 包舜華 of ITRI provided related papers inspiring the search for the cause of the Moon's period of 4.46 years.
- Dr. 賈新興 of CWB provides papers related to El Nino anomaly.

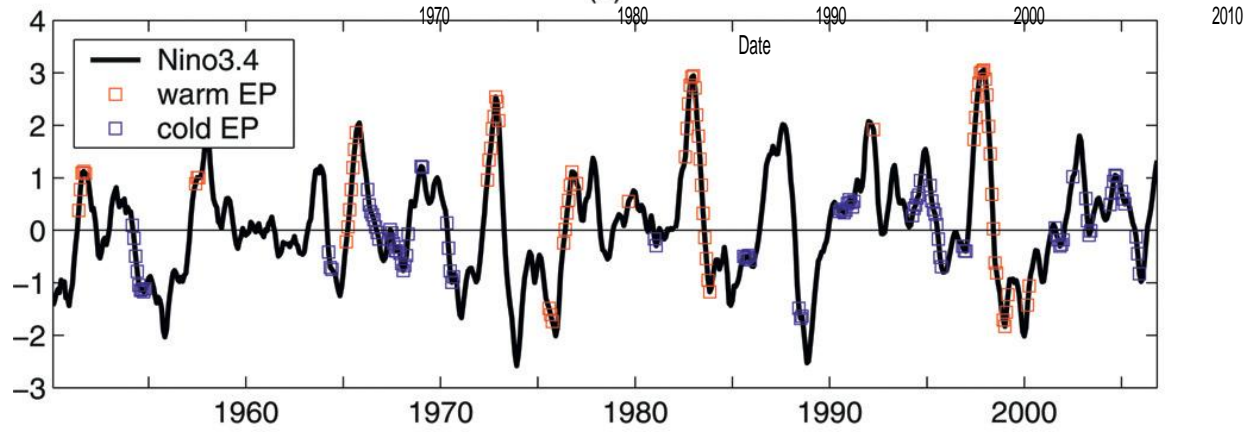
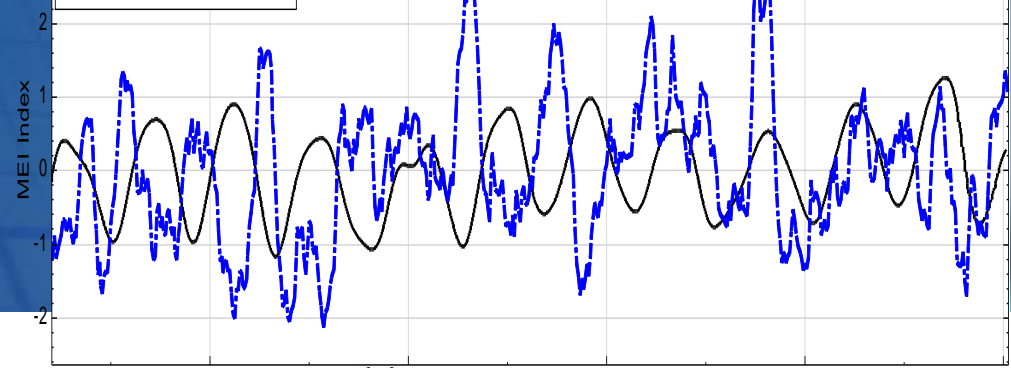
Thank you!

# The period of 4.46 years

- **All Eclipses**
- The database contains 24085 eclipses over 5000 years, from -1999 (2000 BC) to 3000 AD. There are between 4 and 7 eclipses in any calendar year; with an average of 4.82 eclipses per year.
- There are:
- 2352 years with 4 eclipses (47.0%, 1 in 2.13 years)
- 1370 years with 5 eclipses (27.4%, 1 in 3.65 years)
- **1119 years with 6 eclipses (22.4%, 1 in 4.47 years)**
- 159 years with 7 eclipses (3.2%, 1 in 31.45 years)
- 7 eclipses occur in 1908, 1917, 1935, 1973, 1982, 2038, 2094, among others.

[http://www.hermit.org/eclipse/search.cgi?mode=filter&file=when\\_stats.html&keywords=4.5#SearchMatch0](http://www.hermit.org/eclipse/search.cgi?mode=filter&file=when_stats.html&keywords=4.5#SearchMatch0)





(b)

