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# CSS-80a Sun-Earth Distance - TSI – 1800 to 2029 (Daily, Yearly, 11 YMA)

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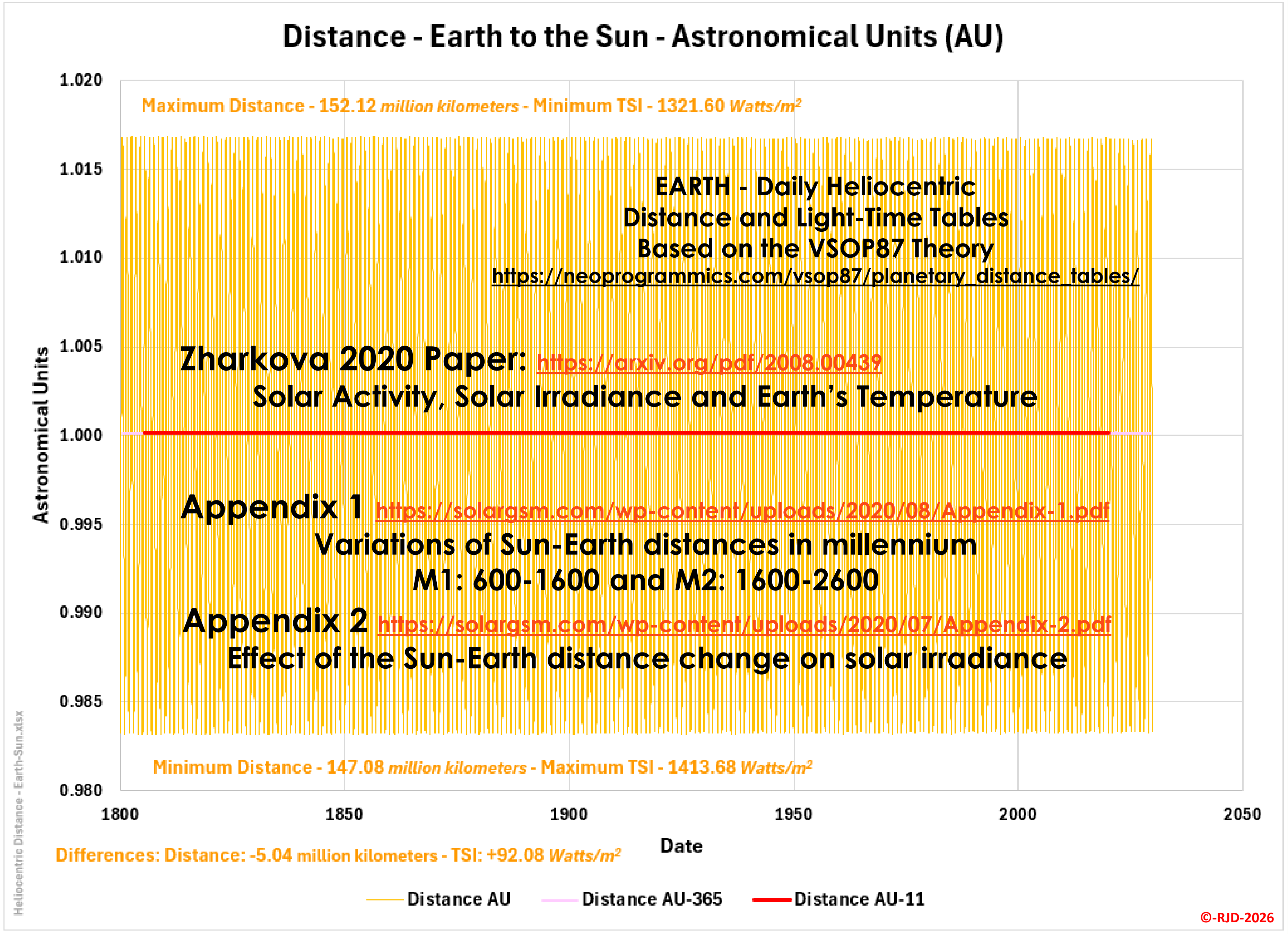
The chart (to the right) was produced based on the heliocentric Sun-Earth distance calculations available at neoprogammics.com. Hat tip to Valentina Zharkova for bringing the website to my attention. In their 2020 paper (with Appendices 1 and 2 (links to the right)), Zharkova et al show some work that they have done on Sun-Earth distances and Total Solar Irradiance (TSI). The gold curves show the daily Sun-Earth distance (S-$E_D$) in Astronomical Units (149,597,900 kilometers) from 1800 to 2029. The pink curve is the Yearly Moving Average (YMA, barely visible here but well represented in the next slide). The red 'line' is an 11 YMA. The only takeaway for this graph is the magnitude of the fluctuations present in the data. At its furthest, the Earth is roughly 152.12 million million kilometers from the Sun. At its closest, the Earth is 147.08 million kilometers from the the Sun. That is a difference of 5.04 Million kilometers (3.3%). Based on the calculations presented in Zharkova's work, that distance change represents an energy magnitude difference of 92.08 Watts/m$^2$ between S-$E_{Dmax}$ and S-$E_{Dmin}$. That is significant and will impact the planet's climate. More discussion on the following yearly focused slide.

**SED-TSI**
**Daily, Yearly**
**11 YMA**



Maximum Distance - 152.12 *million kilometers* - Minimum TSI - 1321.60 *Watts/m²*

**EARTH - Daily Heliocentric**
**Distance and Light-Time Tables**
**Based on the VSOP87 Theory**
https://neoprogrammics.com/vsop87/planetary_distance_tables/

**Zharkova 2020 Paper:** https://arxiv.org/pdf/2008.00439
**Solar Activity, Solar Irradiance and Earth's Temperature**

**Appendix 1** https://solargsm.com/wp-content/uploads/2020/08/Appendix-1.pdf
**Variations of Sun-Earth distances in millennium**
**M1: 600-1600 and M2: 1600-2600**

**Appendix 2** https://solargsm.com/wp-content/uploads/2020/07/Appendix-2.pdf
**Effect of the Sun-Earth distance change on solar irradiance**

Minimum Distance - 147.08 *million kilometers* - Maximum TSI - 1413.68 *Watts/m²*

Differences: Distance: -5.04 million kilometers - TSI: +92.08 *Watts/m²*

# CSS-80b Sun-Earth Distance - TSI – Comparing 1700 to 2025 – S-E Distance, TSI

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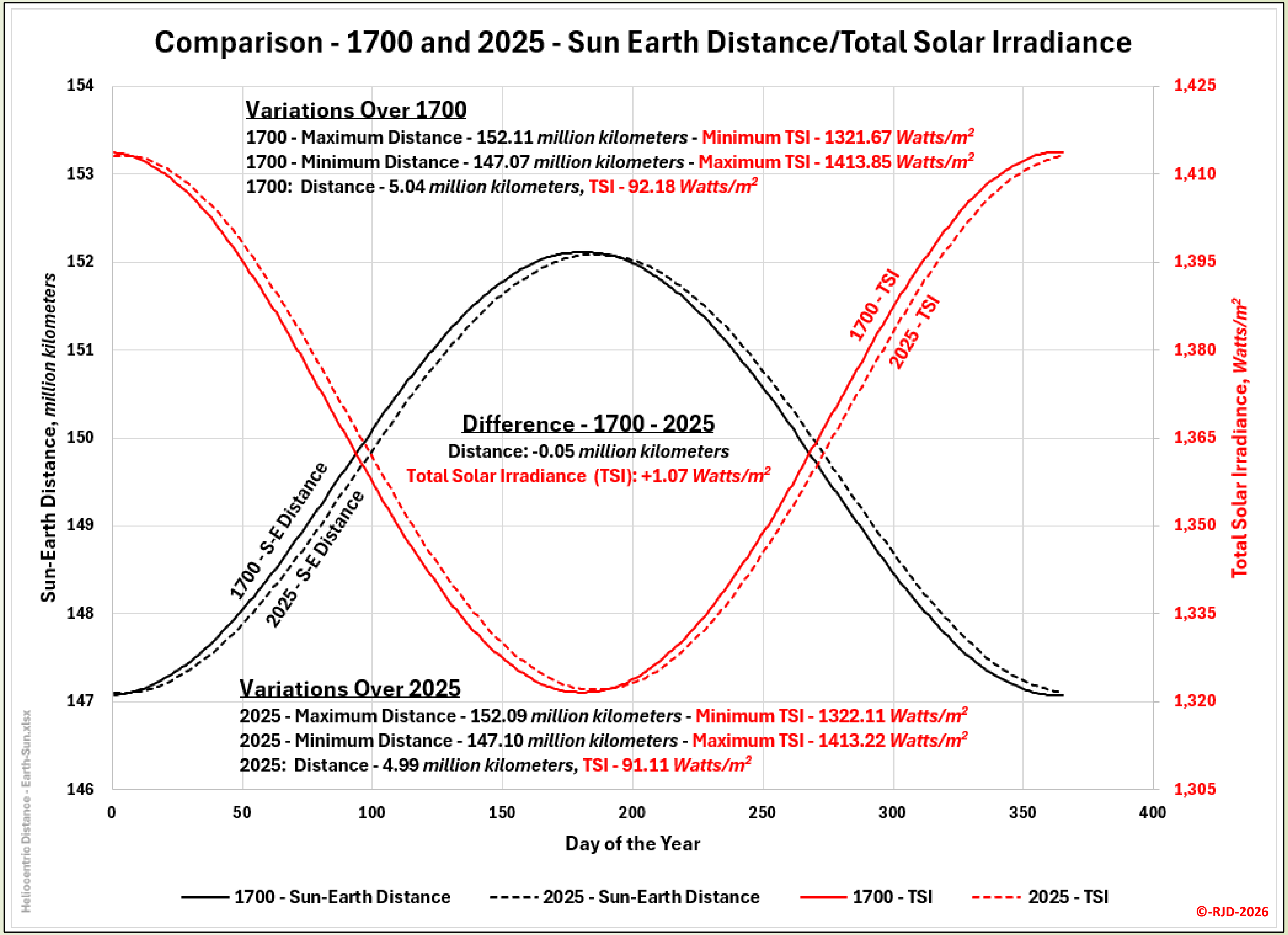
This slide focuses in on just two years (1700 and 2025). The year 1700 is used because it corresponds to the year (from Zharkova's documents) that *"the TSI restored at 1700 (Lean et al. 1995) as shown in Figure 10.2 (middle) is $S_0$ = 1366 W/m²"*. I personally am not that confident in the Lean et al 1995 estimate of 1366 W/m². In 1700, the planet was still in the depths of the Maunder Minimum. TSI estimates for that year range from 1358.6 (Lean (2000) to 1360.8 W/m². Ultimately, the absolute value does not change the calculated differences significantly. So, the following estimates are still based on the 1366 W/m². They do not consider changes in the Solar Radiation at the Sun, $I_0$. Peak TSI (minimum S-$E_D$) occurs during the northern hemisphere winter and vice versa. There are obviously other factors driving our seasons (axial tilt (relative to the Sun), land/ocean hemispherical ratios, etc.). The S-$E_D$ peak has shifted a few days later in the year between 1700 and 2025), but yearly magnitudes are still similar. 2025 TSI is 1.07 W/m² less than 1700.

**SED-TSI**
**1700 and 2025**
**SED &TSI**

$S = I_0/d^2$ where, **(Formulas)**

S – TSI
$I_0$ – Solar Radiation at the Sun
d – Sun-Earth Distance

$S_1 = S_0 * d_0^2 / d_1^2$



## Comparison - 1700 and 2025 - Sun Earth Distance/Total Solar Irradiance

**Variations Over 1700**

1700 - Maximum Distance - 152.11 *million kilometers* - Minimum TSI - 1321.67 *Watts/m²*
1700 - Minimum Distance - 147.07 *million kilometers* - Maximum TSI - 1413.85 *Watts/m²*
1700: Distance - 5.04 *million kilometers*, TSI - 92.18 *Watts/m²*

**Difference - 1700 - 2025**

Distance: -0.05 *million kilometers*
Total Solar Irradiance (TSI): +1.07 *Watts/m²*

**Variations Over 2025**

2025 - Maximum Distance - 152.09 *million kilometers* - Minimum TSI - 1322.11 *Watts/m²*
2025 - Minimum Distance - 147.10 *million kilometers* - Maximum TSI - 1413.22 *Watts/m²*
2025: Distance - 4.99 *million kilometers*, TSI - 91.11 *Watts/m²*

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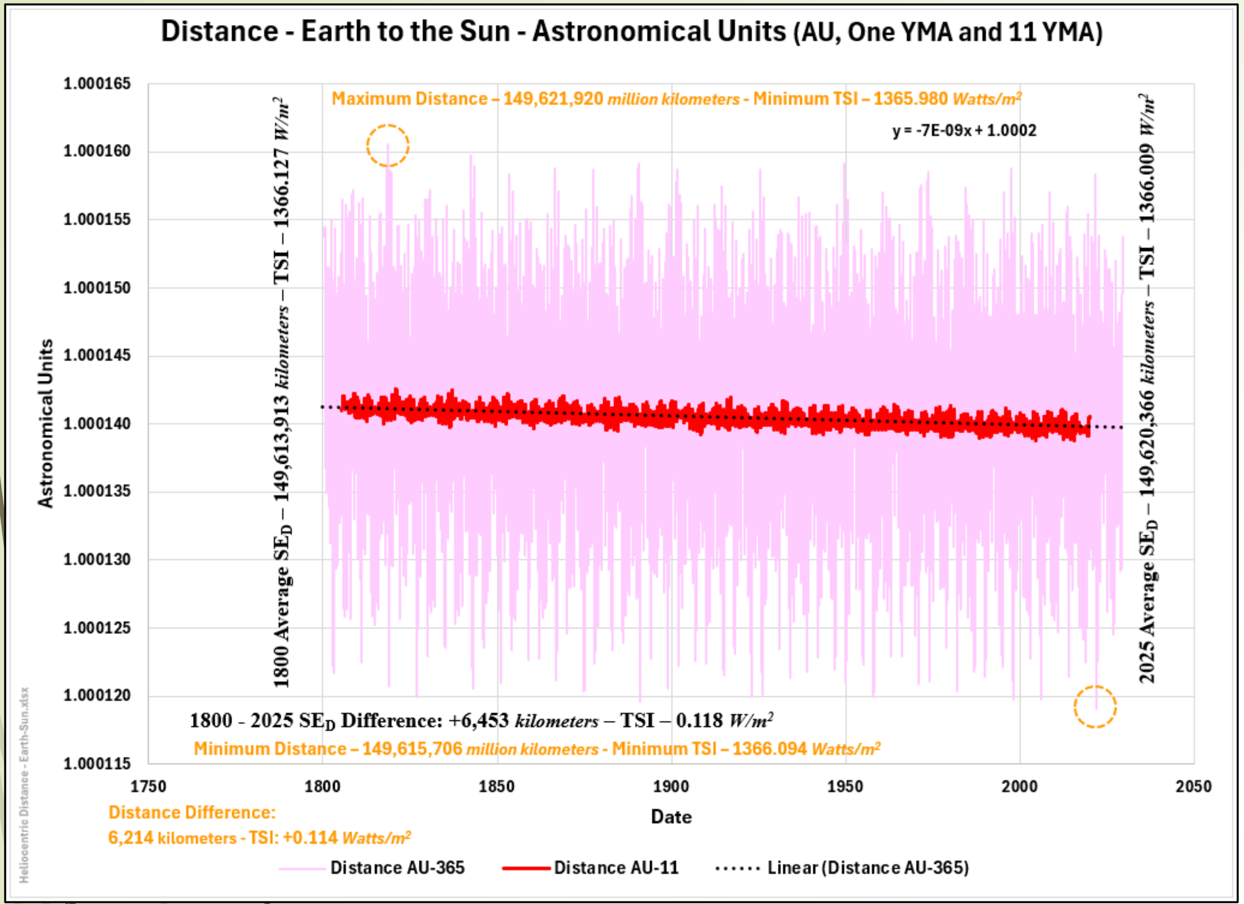
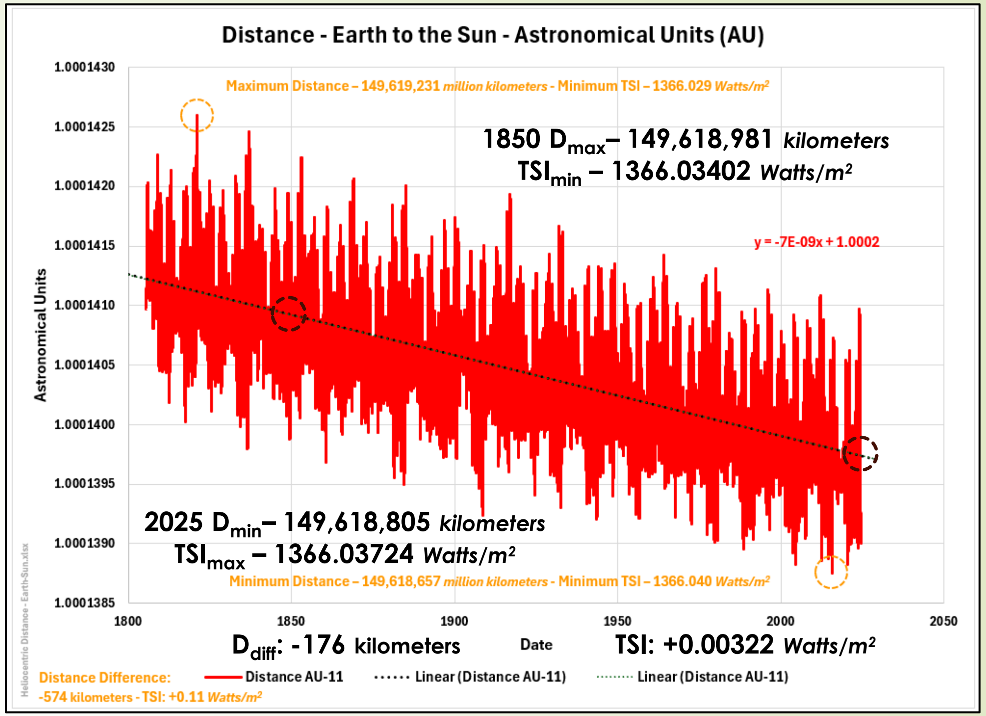
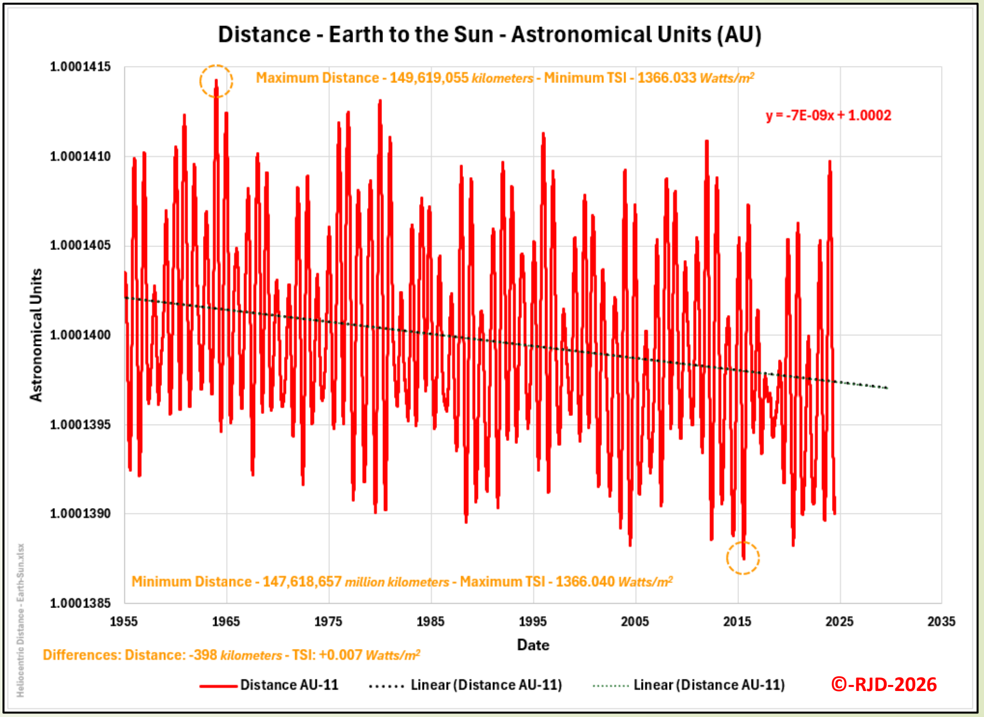


# CSS-80c

# Sun-Earth Distance TSI – 1800 to 2029 (Yearly, 11 YMA)

The daily data has been removed in the chart to the left. The downward trend is now visible (in both the 365 Day and 11 Year Moving Averages). On average, the Sun and Earth are getting closer to one another.





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**SED – TSI**
**1800 -2029**
**Yearly, 11 YMA**

Based on the linear regressions, we are 176 kilometers closer to the sun than when temperatures began rising out of the Little Ice Age in 1850. Those calculations are shown in the top right chart (which just shows the 11 Year Moving Average (YMA). The chart on the bottom right is just the 11 YMA over a typical lifetime (1955 to 2025).

Every spike represents one year. All these plots show that the general decline trends are negligible. But over millennia those changes are significant and as shown in the Zharkova documents, the subtleties in the data are also important. The chart to the right shows the Hallstatt solar cycle as expressed in Zharkova's work.

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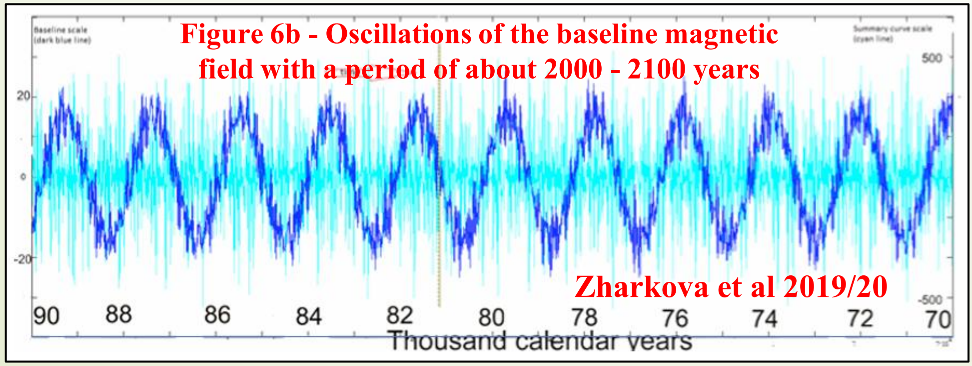

Figure 6b - Oscillations of the baseline magnetic field with a period of about 2000 - 2100 years

Zharkova et al 2019/20

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# CSS-80d Sun-Earth Distance – Solar Inertial Motion (SIM) and TSI

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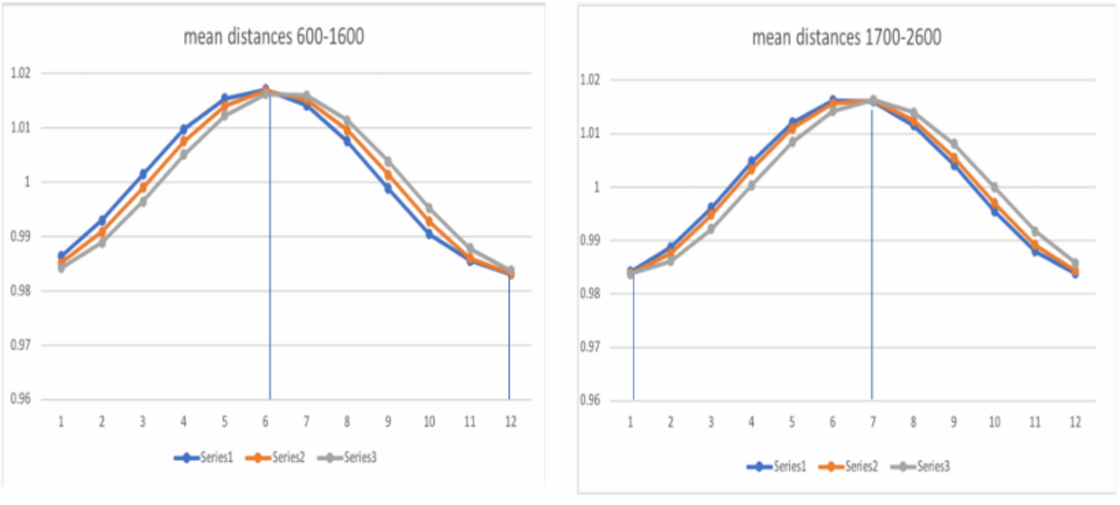


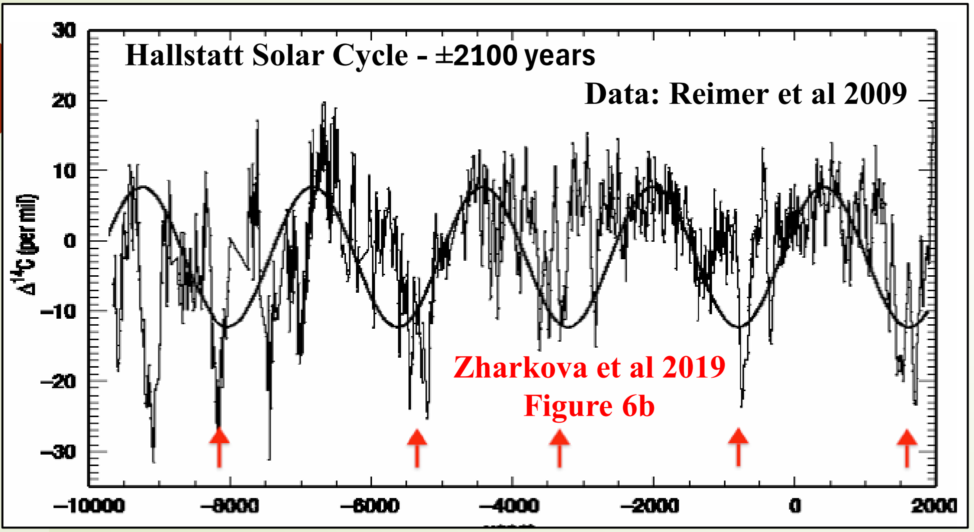
a - Sun - in focus

b - Sun shifted by SIM to spring equinox and summer solstice

**FIGURE 9.** Left: Annual variations of the mean monthly Sun -Earth distances (au) for the years of 600-1600. Right: Annual variations of the mean monthly Sun -Earth distances (au) for the years 1700-2600 (right). X axis indicate months of a year. The vertical lines indicate times when the maximum distances (local aphelion) are achieved. Note, we selected for the second plot year 1700 in the right plot to avoid a duplication of the curve from the left plot.

**Zharkova et al reviewed the Hallstatt solar cycle (chart, bottom left) we are currently living through. They compared the millennial cooling (M1, 600-1600, culminating in the Maunder Minimum) to the millennial warming (M2, 1600-2600). The difference between M1 and M2 is the additional warming in M2 due to Solar Inertial Motion (SIM). The mechanism is shown in the figure to the left. SIM shifts the S-$E_D$ curves 20-25 days towards the spring equinox (the S-$E_D$ declines from February-July (M2) versus January-June (M1)). That change in timing manifests as an increase in TSI during the warming phase (M2) as compared to the cooling phase (M1). As per Zharkova (Figure 10 below), *"It is evident that these two plots clearly show that owing to SIM the monthly TSI variations (case a) show the increase of TSI by about 1-1.2 W/m$^2$ in 2020 compared to 1700"*. The longer term TSI increase is, as per Zharkova, *"However, the annual TSI magnitudes, calculated from the daily S-E distances and solar irradiance data, reveal much larger annual increase of solar irradiance by about 20-25 W/m$^2$ (1.8%) in M2 by 2500 than in millennium M1 (Figure 10, right plot)"*. Roughly a temperature rise of 4.0 °C by 2500 with no help from $CO_2$. The TSI has risen since 1700. That translates into temperature increases. Add in the other solar forcings (that the IPCC neglect/ignore) and there is more evidence that the role of $CO_2$ is overstated. Now add in the Grand Solar Minimum cycles (every 350 – 400 years) and the ±11-year cycles for more context.**

**SED**
**Solar Inertial Motion & TSI**



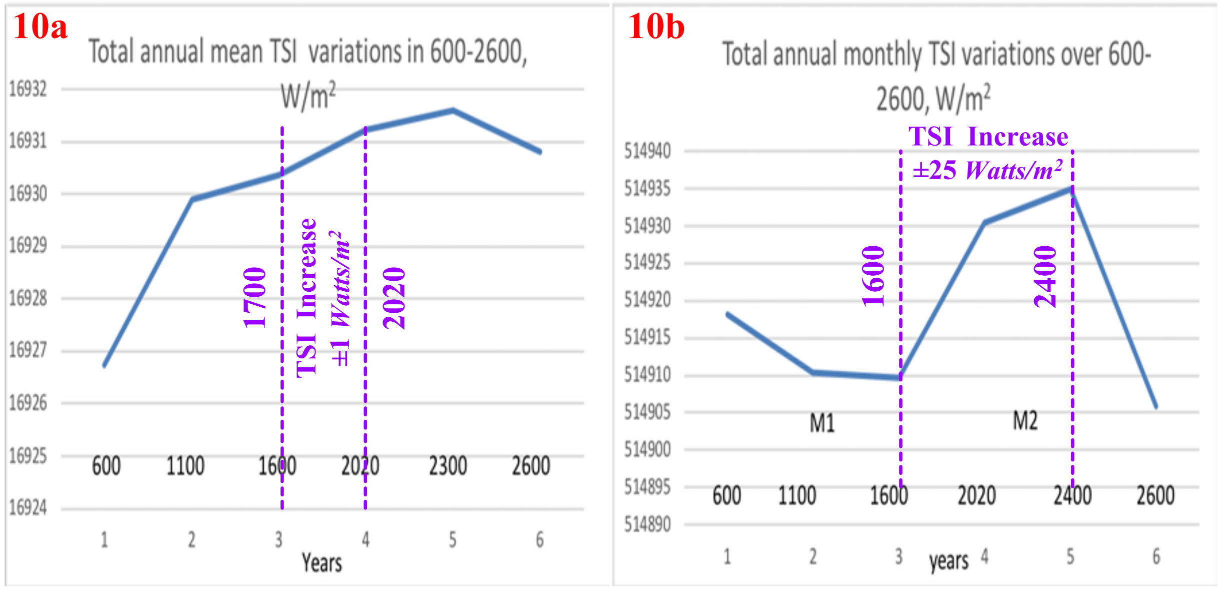


**Figure 10.** Millennial variations of the annual solar irradiance in the millennium M1: 600-1600 and M2: 1600-2600 calculated from the TSI averaged per month (left plot) and not-averaged (daily) TSI (right plot).

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# CSS-80e Sun-Earth Distance - TSI – 1800 to 2029 – 11 YMA Trends Analysis

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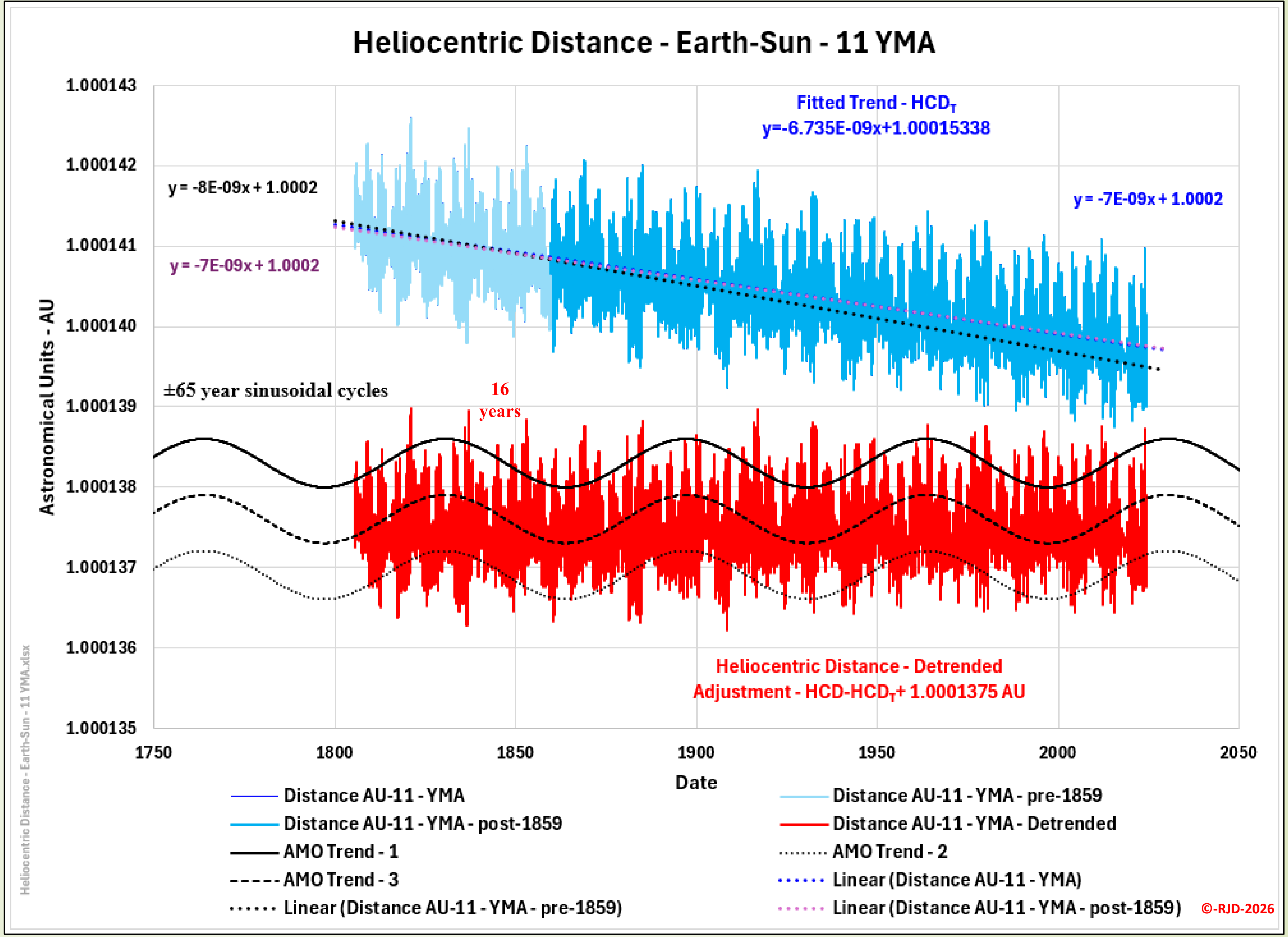
The reason I started looking at the heliocentric data was to get a feel for the spatial relationship between the two bodies. We have already seen that the yearly $S\text{-}E_D$ (and therefore TSI) varies significantly and the longer-term trend (shown here to the right) is a very erratic but steady slow decline. What lies in that organized chaos? There would be many things over the millennia. The gravitational and electromagnetic interactions within the solar system and beyond are complicated. One expression of those interactions is the Sun Earth orbit around their barycenter. Is the 60ish year Barycenter Cycle visible in the heliocentric $S\text{-}E_D$ data? To check that out, I detrended the data and laid over some sinusoidal curves with a ±65-year frequency. There is not a convincing match to the 65-year cycle But there does appear to be a 16-year cycle. Four of those 16-year cycles would be 64 years. Maybe a longer dataset would provide evidence of the longer cycle. I also wanted to see if the solar shift responsible for the increased solar activity around the 1859 Carrington event and the subsequent pole wander acceleration was visible in the data. There is a small inflection point around 1859, but like the 60ish year cycle, the data is a long way from definitive.

**SED – TSI**
**11 YMA Trend Analysis**



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# CSS-80f Sun-Earth Distance - TSI – Barycenter Position

**CSS-75 – Solar Cycle Discussion**

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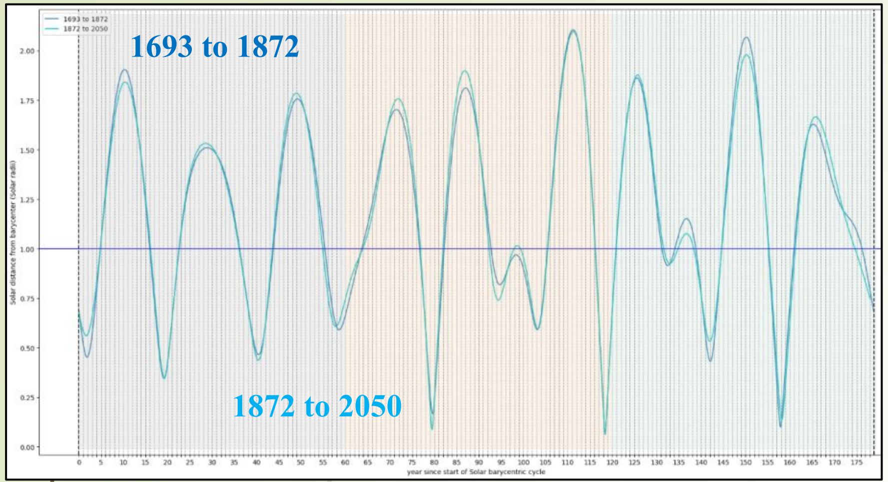
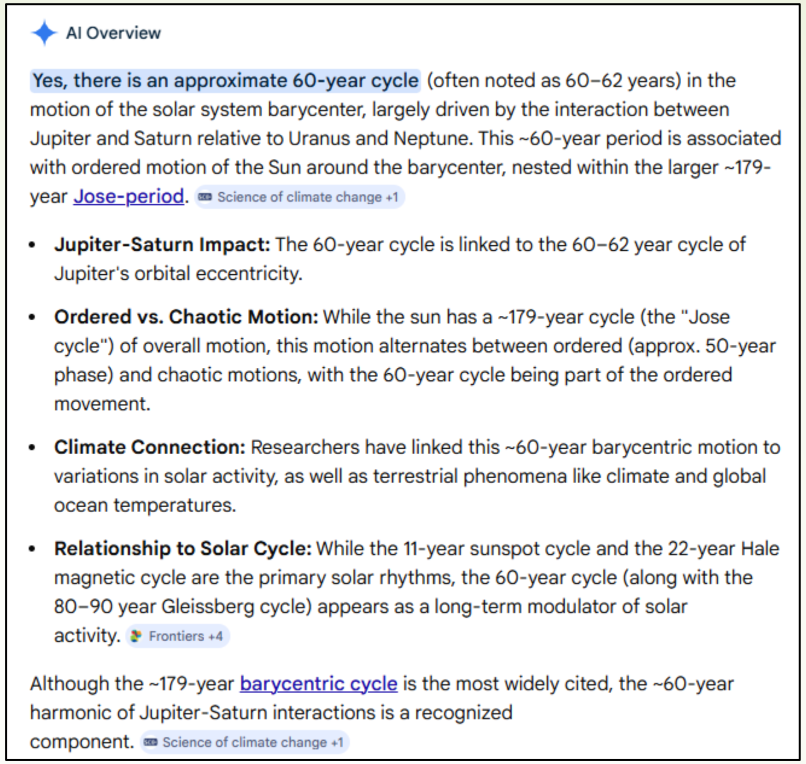


**The image on the far right, top shows the Sun-Earth Barycenter position from 1945 to 1995. There is complexity there, but that movement is well understood as shown in the bottom right chart. There is a very definitive 179-year cycle in that model (the red curve in the bottom panel is a copy of the black curve laid over the underlying blue curve). The above chart presents the same 179-year data in a different format. The upper middle image is the Bing AI response to my question, *“Is there a 60-year cycle in the Sun-Earth Barycenter data?”*. The answer was *“Yes, there is an approximate 60-year cycle”*, that is associated with Jupiter’s 60-year orbital eccentricity which is nicely *“nested within the larger ≈179-year Jose-period”*. It is noteworthy that Jupiter’s 60-year orbital eccentricity cycle matches up with climate parameters like the temperature and rainfall data shown in the figure to the right. There are many 60-year cycles (CSS-75) visible in the earth’s historical data that have nothing to do with $CO_2$.**

**SED – TSI Barycenter Position**

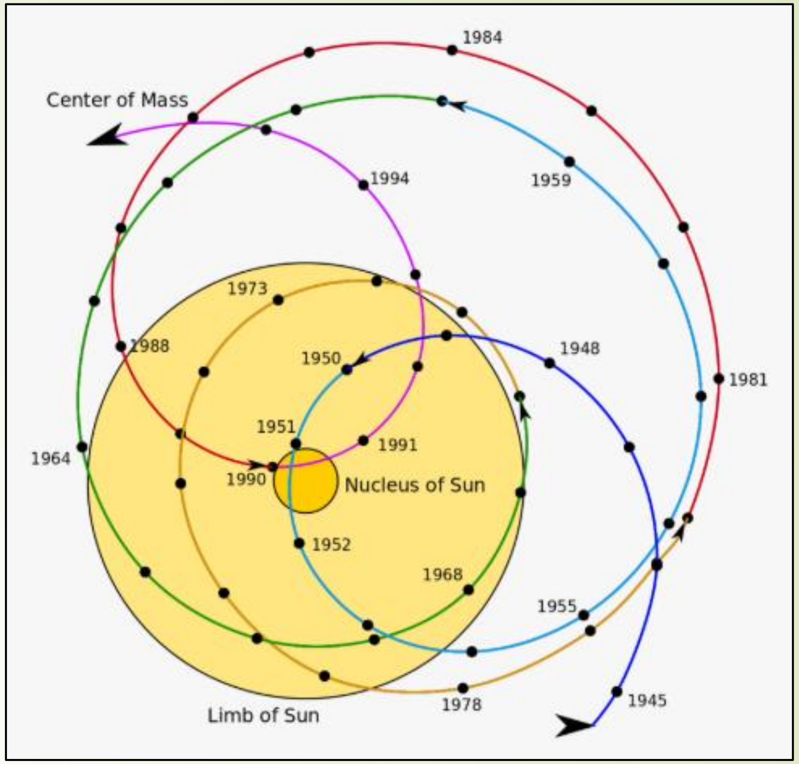


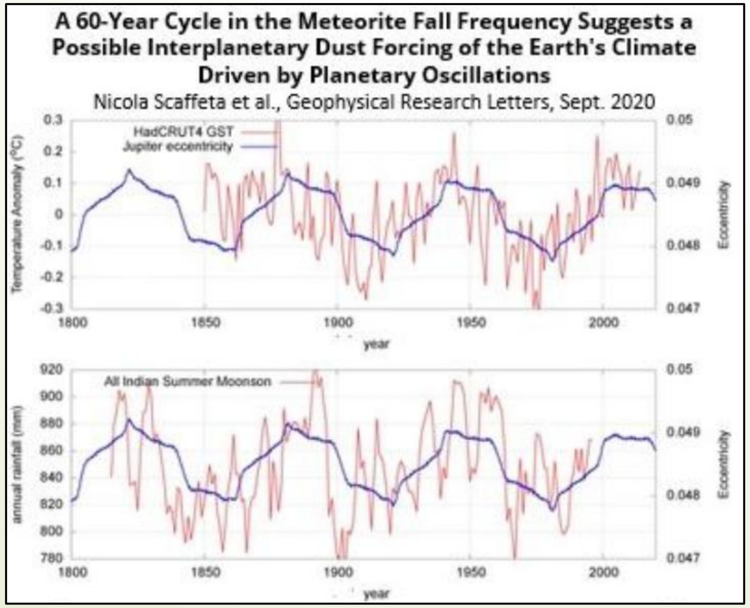
AI Overview

Yes, there is an approximate 60-year cycle (often noted as 60–62 years) in the motion of the solar system barycenter, largely driven by the interaction between Jupiter and Saturn relative to Uranus and Neptune. This ~60-year period is associated with ordered motion of the Sun around the barycenter, nested within the larger ~179-year Jose-period. Science of climate change +1

- **Jupiter-Saturn Impact:** The 60-year cycle is linked to the 60–62 year cycle of Jupiter's orbital eccentricity.
- **Ordered vs. Chaotic Motion:** While the sun has a ~179-year cycle (the "Jose cycle") of overall motion, this motion alternates between ordered (approx. 50-year phase) and chaotic motions, with the 60-year cycle being part of the ordered movement.
- **Climate Connection:** Researchers have linked this ~60-year barycentric motion to variations in solar activity, as well as terrestrial phenomena like climate and global ocean temperatures.
- **Relationship to Solar Cycle:** While the 11-year sunspot cycle and the 22-year Hale magnetic cycle are the primary solar rhythms, the 60-year cycle (along with the 80–90 year Gleissberg cycle) appears as a long-term modulator of solar activity. Frontiers +4

Although the ~179-year barycentric cycle is the most widely cited, the ~60-year harmonic of Jupiter-Saturn interactions is a recognized component. Science of climate change +1





A 60-Year Cycle in the Meteorite Fall Frequency Suggests a Possible Interplanetary Dust Forcing of the Earth's Climate Driven by Planetary Oscillations

Nicola Scaffeta et al., Geophysical Research Letters, Sept. 2020