

Solar magnetic field, solar radiation and their impact on terrestrial temperature

<https://solargsm.com/solar-activity/>

Valentina Zharkova

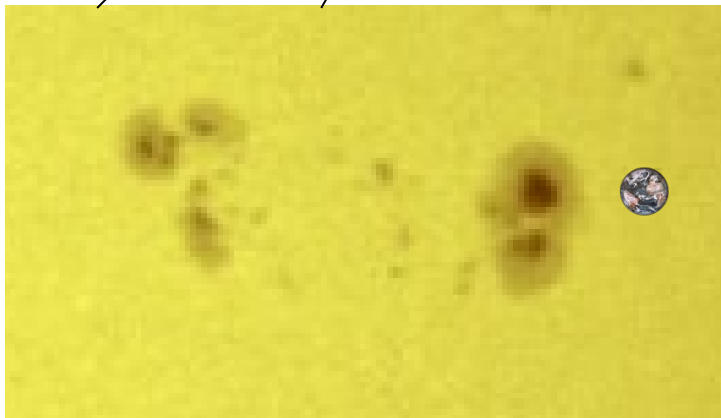
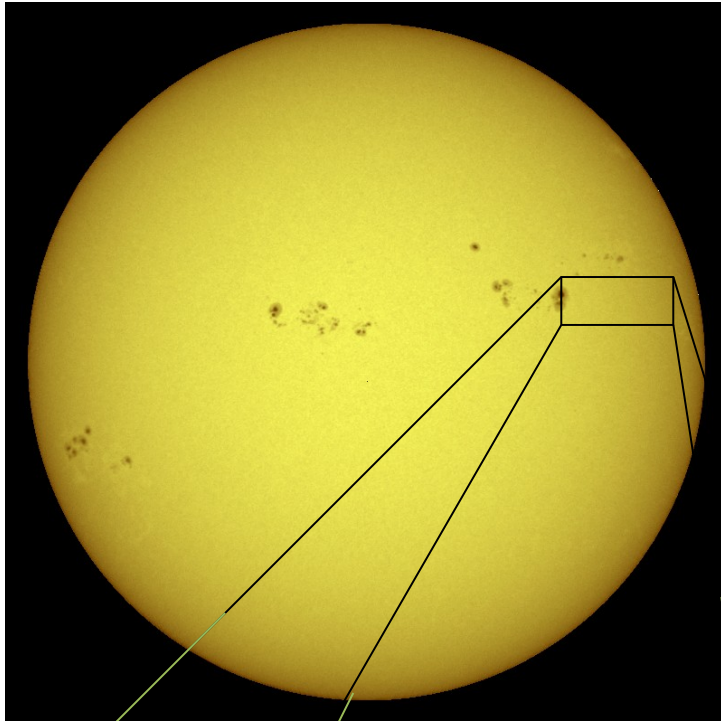


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<https://solargsm.com/publications/>

With thanks to Drs. S. Shepherd (UK), E. Popova (Russia) and S. Zharkov (UK)

Solar activity



Sunspots

Sunspots are dark (and cooler) regions on the surface of the Sun. They have a darker inner region (the Umbra) surrounded by a lighter ring (the Penumbra).

Sunspots usually appear in groups that form over hours or days and last for days or weeks.

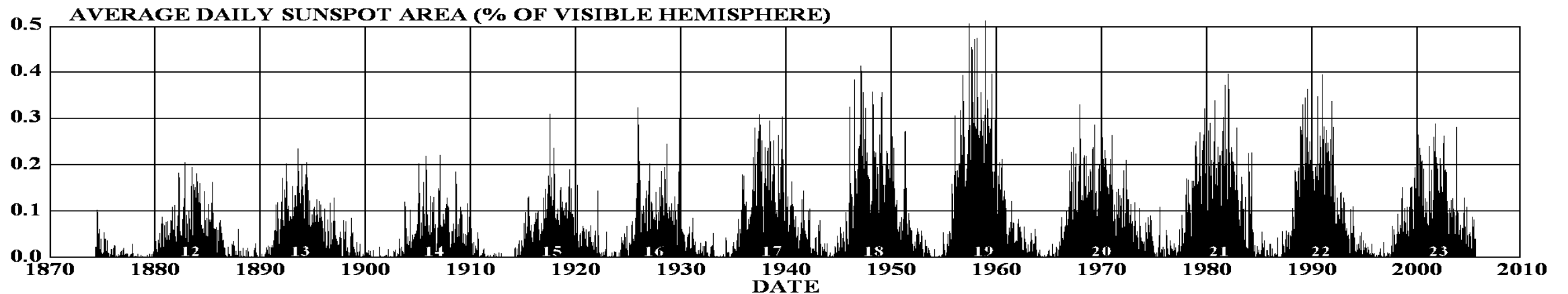
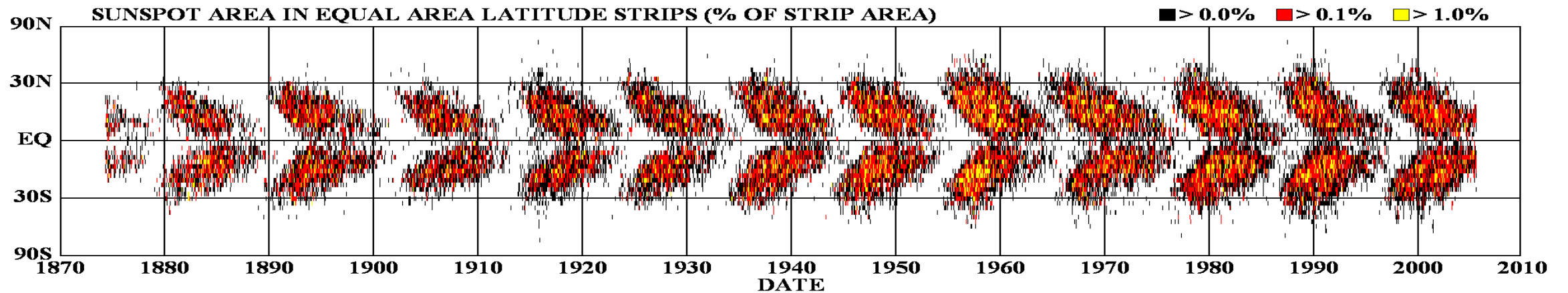
These early sunspot observations indicated that the Sun rotates once in about 27 days.

Solar activity index – average sunspot numbers

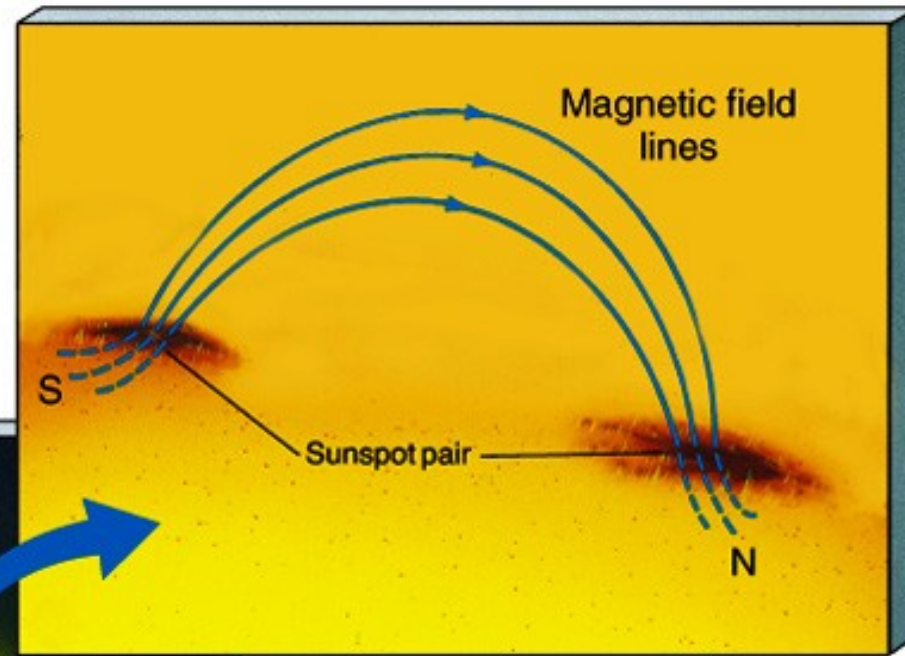
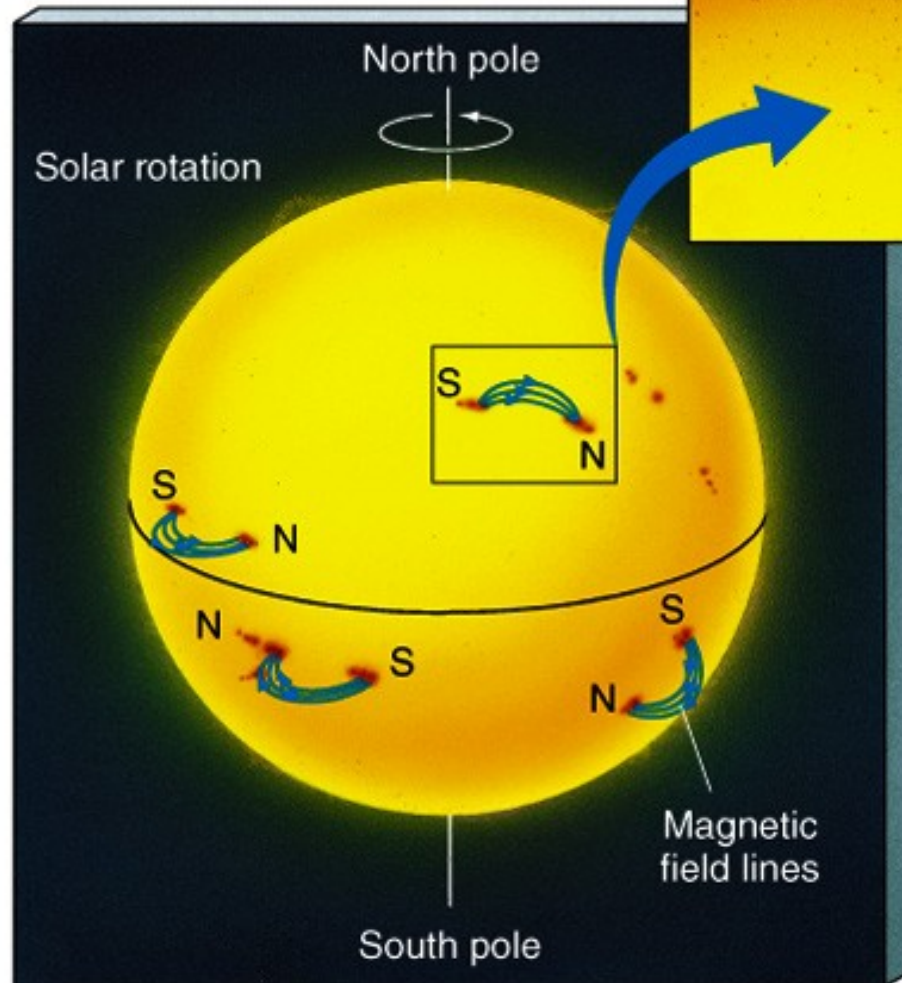


Current solar activity index

DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS

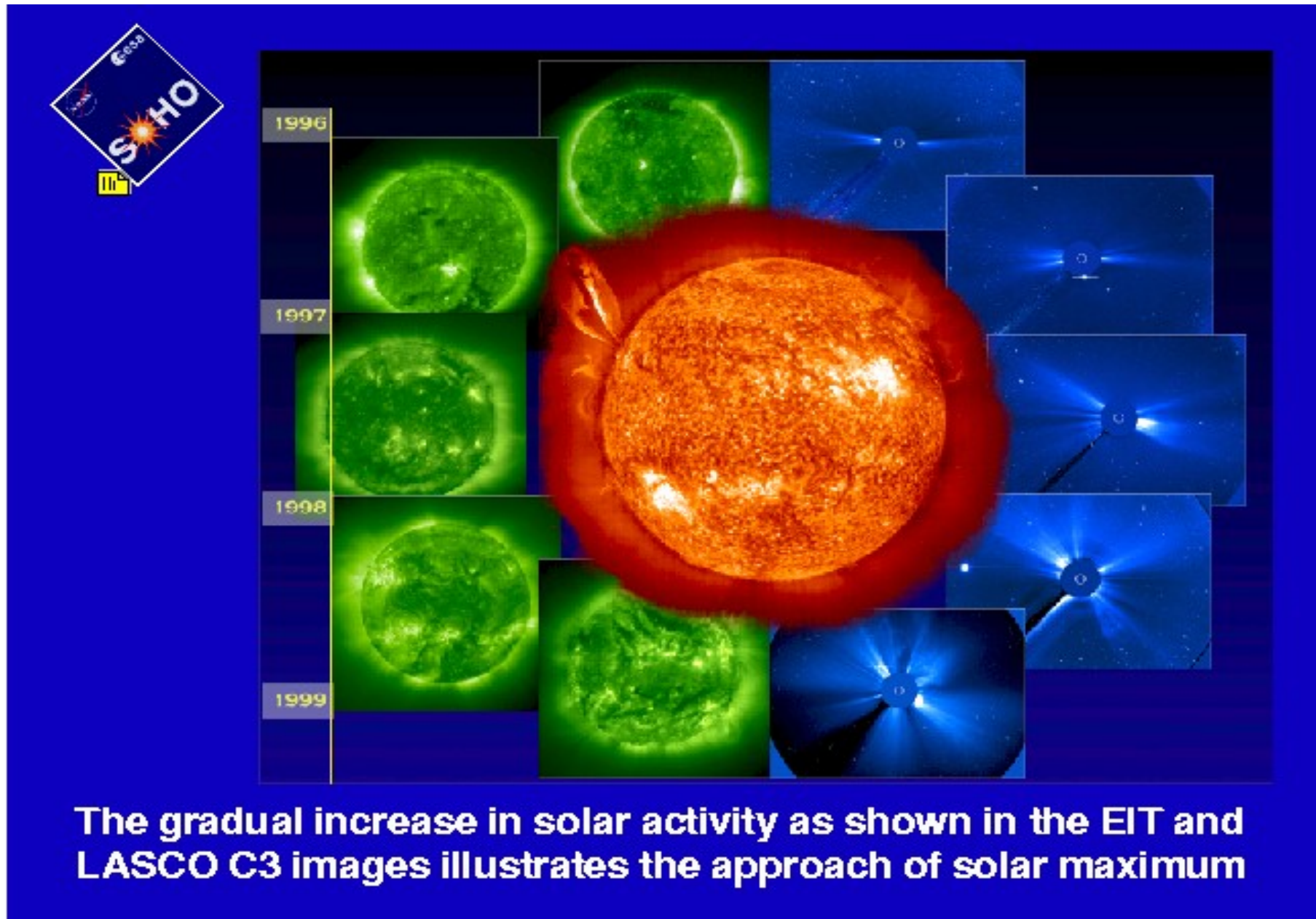


Sunspots & Magnetic Fields



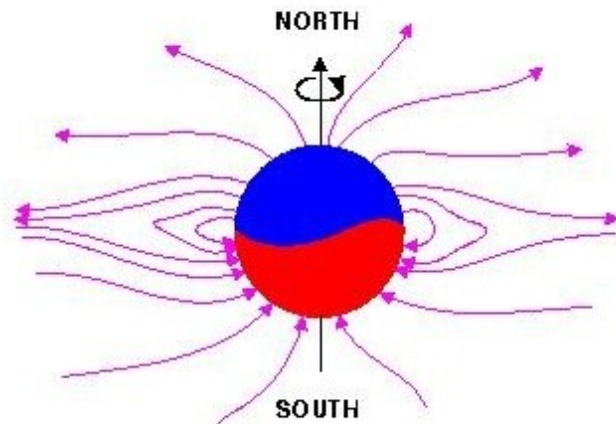
- ✂ The magnetic field in a sunspot is 1000x greater than the surrounding area
- ✂ Sunspots are almost always in pairs at the same latitude with each member having opposite polarity
- ✂ All sunspots in the same hemisphere have the same magnetic configuration

What is the active Sun?

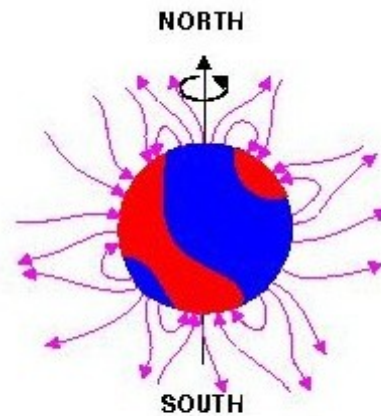


The gradual increase in solar activity as shown in the EIT and LASCO C3 images illustrates the approach of solar maximum

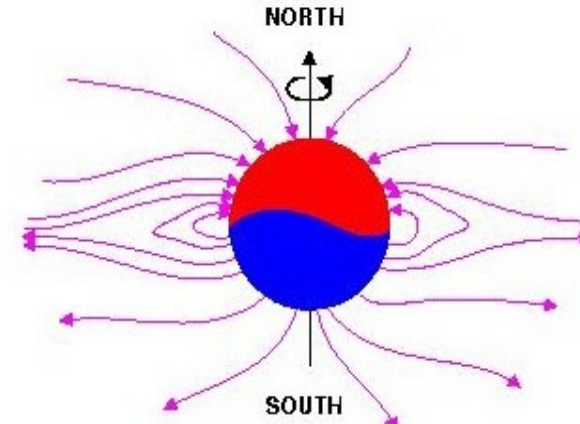
Solar magnetic field reversal



CORONAL MAGNETIC FIELD LINES AT SOLAR MINIMUM ACTIVITY



CORONAL MAGNETIC FIELD LINES AT SOLAR MAXIMUM ACTIVITY



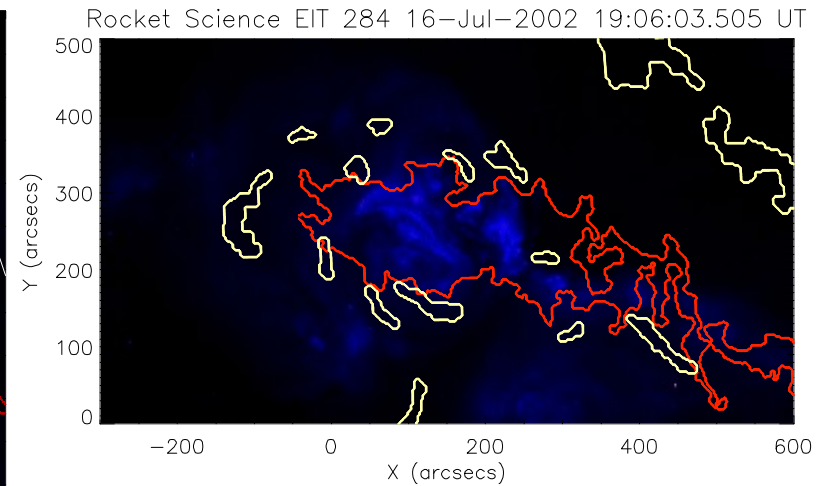
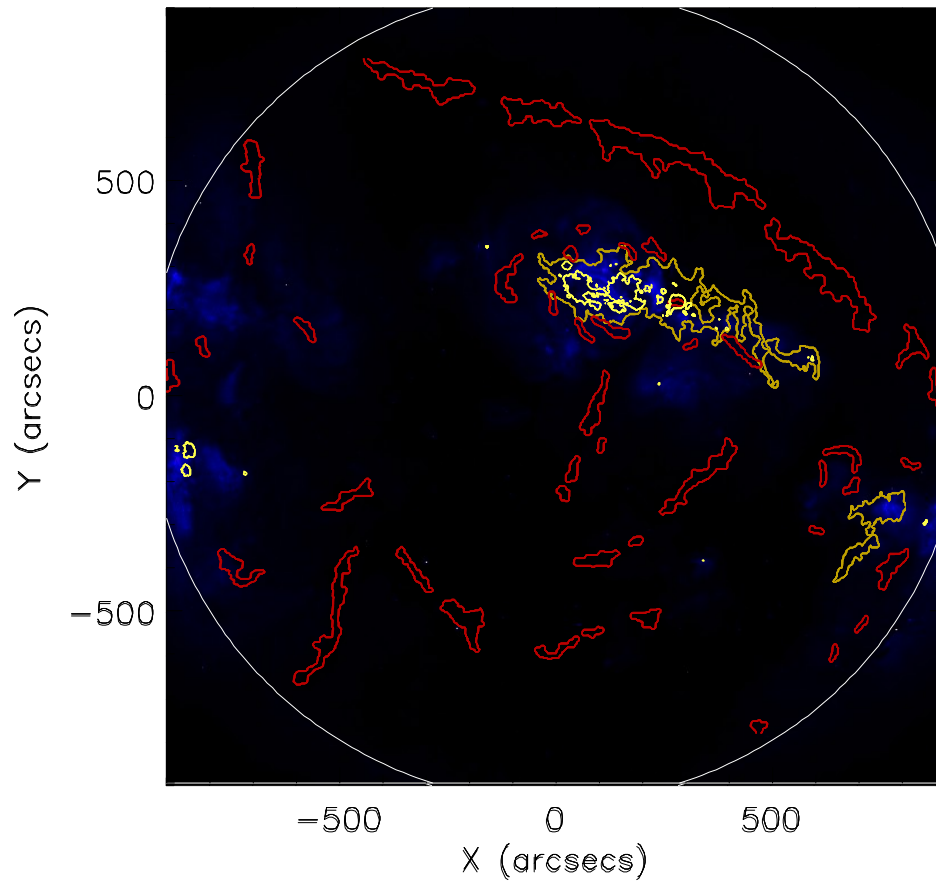
CORONAL MAGNETIC FIELD LINES AT NEXT SOLAR MINIMUM

- Strong toroidal magnetic fields (TMF) forming Active Regions (ARs)
- are created in a shear layer beneath the base of the Solar Convection zone (SCZ).



Automated feature extraction

Rocket Science EIT 284 16-Jul-2002 19:06:03.505 UT



SFCs created in EGSO project 2002-2005

European Grid of Solar Observation
Solar Feature Catalogues

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Solar Feature Catalogues

The searchable Solar Feature Catalogues (SFCs) are created from digitized solar images using automated pattern recognition techniques developed in the European Grid of Solar Observation (EGSO) project. The techniques were applied for detection of sunspots, active regions, filaments and line-of-sight magnetic neutral lines in the automatically standardized full disk solar images in Ca II K1, Ca II K3 and H α taken at the Meudon Observatory and white light images and magnetograms from SOHO/MDI. The results of automated recognition are verified with the manual synoptic maps and available statistical data from other observatories that revealed high detection accuracy. A structured database of the Solar Feature Catalogues (SFCs) are built on a mysql server for every feature based on the recognized parameters. An SFCs are published with the pre-designed web pages for search by time, size, location on the Bradford University web site. The SFCs with 10 year coverage (1996-2004) is to be used for deeper investigation of the feature classification and solar activity forecast.

Solar Feature Catalogues are intended to contain comprehensive statistics of active solar events (sunspots, active regions (plages), filaments, prominences, etc.), overlapping in a given period of time and to allow the extraction of physical characteristics, which are essential for the solar activity forecast. Since digitized solar images for the catalogues are taken from different sources so they have a variety of sizes, resolutions, dynamic ranges and instrumental and weather associated distortions. This requires designing advanced image recognition techniques in order to identify individual features (sunspots, active regions, filaments, magnetic neutral lines, etc.) on the images with strongly varying background caused by different observing atmospheric conditions of solar atmosphere activity period, irregularities in shape caused by instrumental errors or any other noise in images like strips or signatures etc. In order to provide reliable data on the locations of features and their evolution at different times relative to solar rotation, all images are subjected to automated recognition processes of image standardization procedure developed by WPS for the images from Meudon (Ca, H α), Big Bear (H α -alpha) and SOHO/MDI (white light/magnetogram) Observatories. For a selection of most suitable algorithms for the detection of each feature a detailed survey of existing was carried out for existing manual and semi-automated techniques. Based on the survey, the best algorithms were selected for the feature detection, namely: edge-based algorithms for sunspots, region growing ones for active regions, filaments and prominences and magnetic inversion lines. For added reliability, these algorithms used cross-reference criteria at multiple wavelengths or magnetograms in order to correctly identify the features of interest while fully utilizing all the datasets linked into the Grid. Using the combination of image standardization and detection procedures a number of parameters is extracted from the detected features that are essential for their characterization in the solar activity process related to their intensity, size, location, morphology, association with magnetic field, etc. that is provided in the general page and Feature

European Grid of Solar Observation
Solar Feature Catalogues

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Introduction

EGSO, the "European Grid of Solar Observations", is a Grid test-bed that will lay the foundations of a "Virtual Solar Observatory".

With a substantial increase in size of solar image data sets, the automated detection and verification of various features of interest is becoming increasingly important for, among other applications, the reliable forecast of the solar activity and space weather and data mining. However, this raises the accuracy and reliability requirements to the detection techniques applied for an automated recognition that have to be significantly improved in comparison with the existing manual ones. One of the chief objectives for European Grid of Solar Observations (EGSO) Project Work Package 2 is a production of Solar Feature Catalogues by means of the automated feature recognition methods. Amongst such features of interest are sunspots, active regions and filaments. There is a growing number of archives of digitized images of the Sun, taken from ground-based and space instruments in various wavelengths. These archives are available from different locations and are to be included into a unified catalogue by the European Grid for Solar Observations (EGSO) project (Bentley, 2003). Digitized solar images from different sources have a variety of sizes, resolutions, dynamic ranges and instrumental and weather associated distortions. All are to be subjected to automated recognition processes in order to provide reliable data on the locations of features and their evolution at different times relative to solar rotation. This is aimed partly at the growing demand for solar activity forecasts by the space weather project and by many industrial organizations, which have a great need for the development of reliable and fast techniques for feature recognition on solar disks and their presentation in Solar Feature Catalogues. These catalogues are intended to contain comprehensive statistics of active events (sunspots, active regions, filaments, flares, etc.), overlapping in a given period of time and to allow the extraction of physical characteristics, which are essential for the solar activity forecast. This

EGSO News

- March 2005
The EGSO Solar Feature Catalogue (SFC) is now available for experimentation here
- February 2005
4 Papers based on results obtained from EGSO SFC are accepted for publication in Solar Physics Frontiers in Image Processing Special Issues
- January 2005
Started work on generating Active Region/Plage data from Meudon H α observations. Data will be available by June 2005.
- January 2004
EGSO presents two posters at the 2nd European X-ray/Odds Conference, Cyprus. EGSO Architecture (pdf) EGSO Overview (pdf)
- December 2003
EGSO team at the AGU Fall Meeting, achieving a

European Grid of Solar Observation
Solar Feature Catalogues

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Search Sunspot Catalogue by Feature size or diameter

Sunspot Area: from degrees (Available Range from 0.01 to 73.42 degrees)

Sunspot Diameter: from degrees (Available Range from 0.00 to 20.14 degrees)

Use DATE (check the box if you want to narrow down the results by date)

Start Date: - hh:mm:ss

End Date: - hh:mm:ss

Order By:

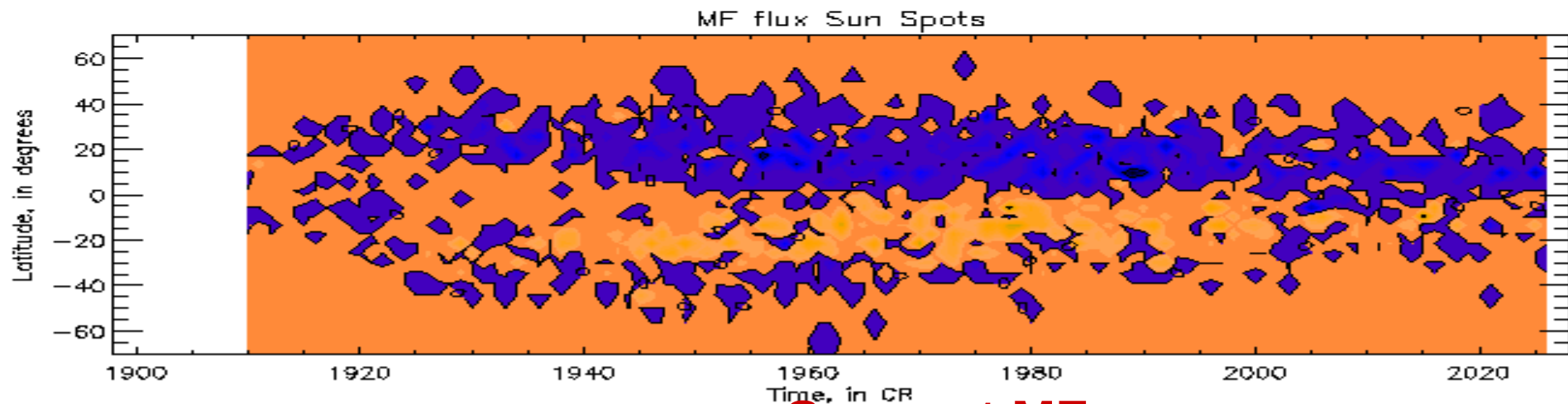
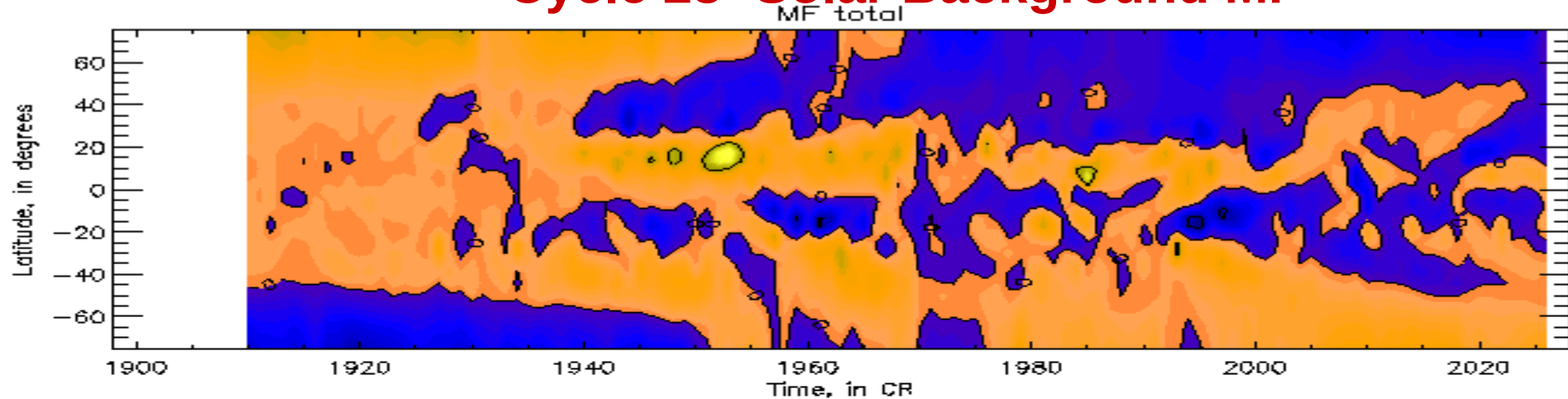
Date Diam (Desc) Diam (Asc) Area (Desc) Area (Asc)

Generate ASCII & XML files

New proxy for solar activity index

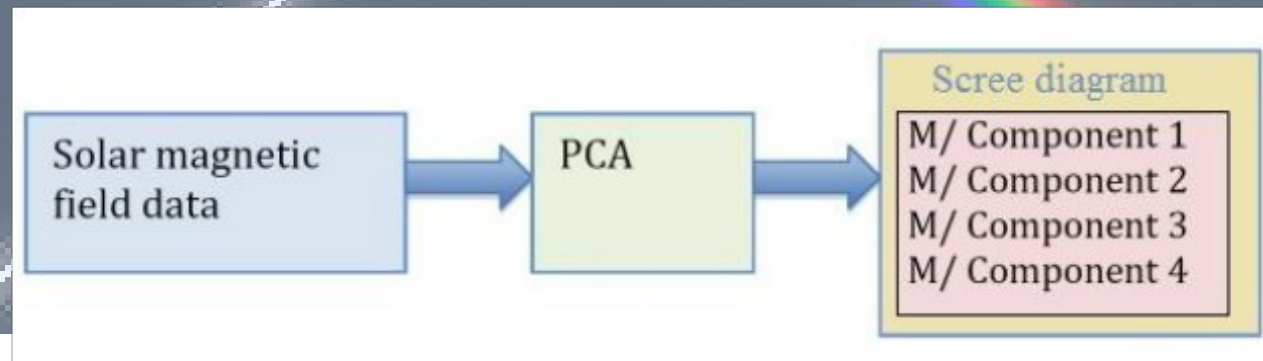
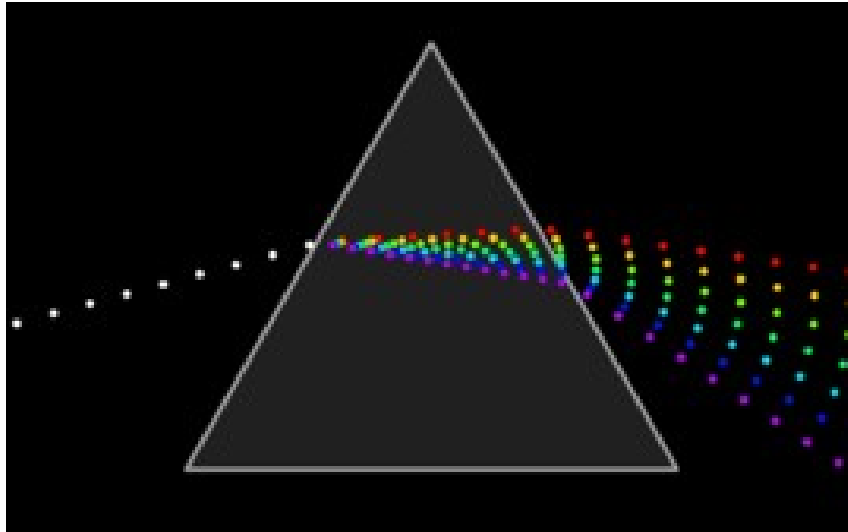
SBMF (top) and sunspot MF (bottom)
(Zharkov et al, 2008, Stix 1976)

Cycle 23 - Solar Background MF



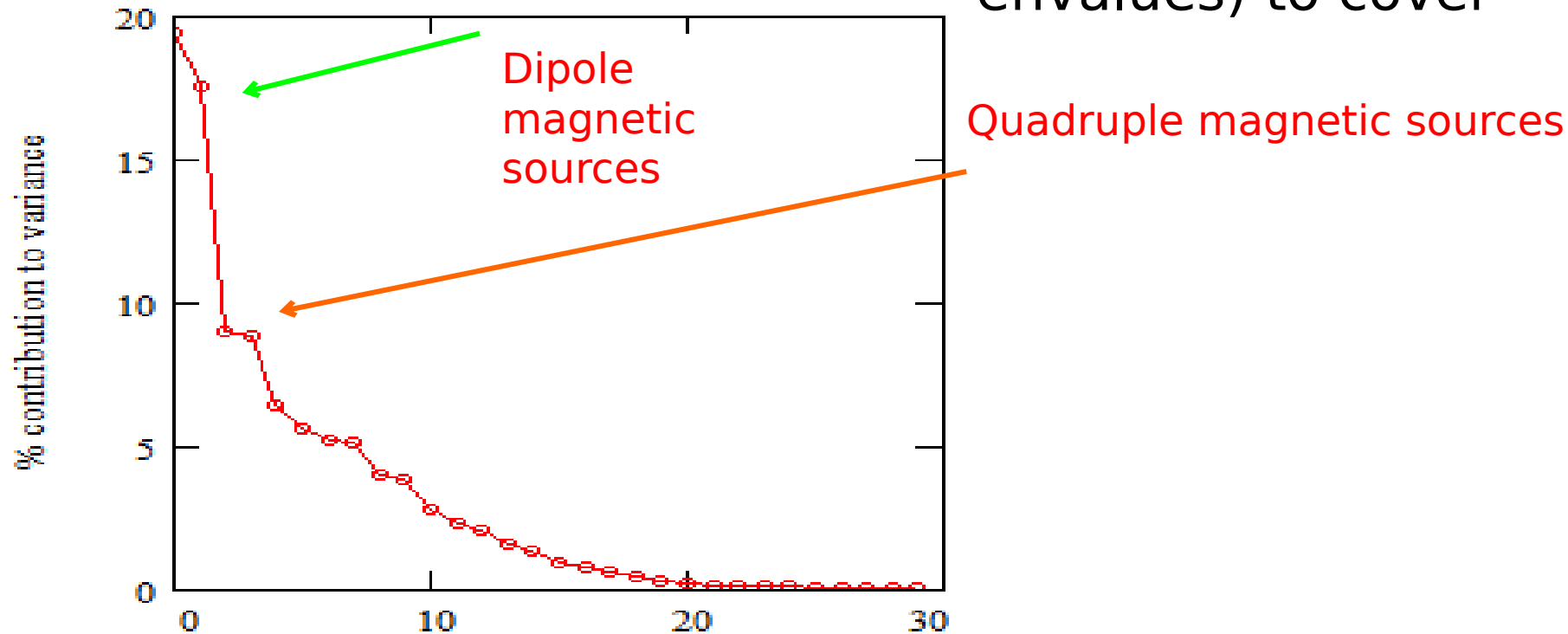
Sunspot MF

White light refraction into waves of different colors, or wavelengths

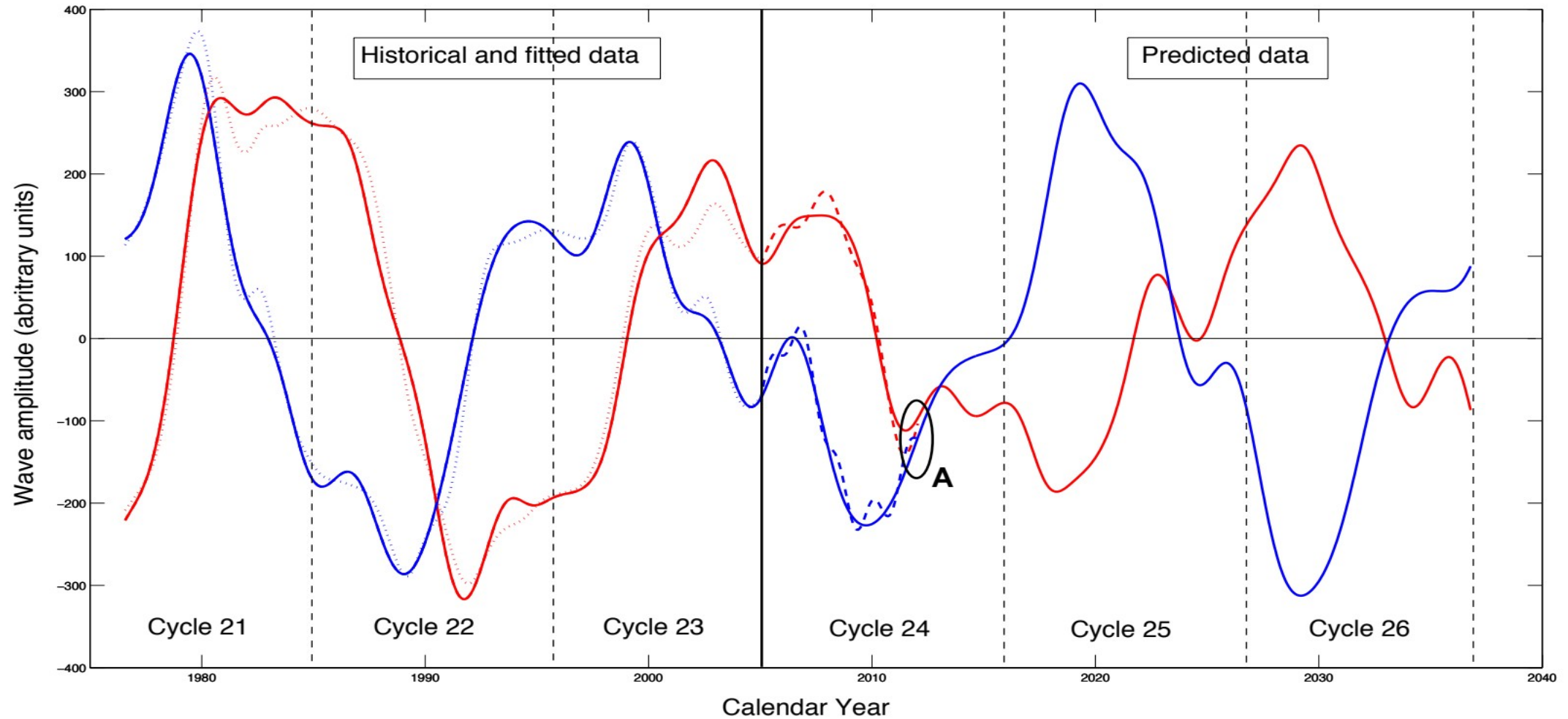


SBMF results: Scree plot (->prizm) Eigenvalues vs variances (Zharkova et al, 2012)

- 2 main eigenvalues covering 40% of variance - (67% of SDV) - 2 pairs (6 eigenvalues) to cover



Eigen vectors come in pairs, here are PCs



(Shepherd et al, 2014, Zharkova et al, 2015)

Mathematical laws from PCs: Symbolic regression -Hamiltonian approach (Schmidt and Lipton, 2009, Science)

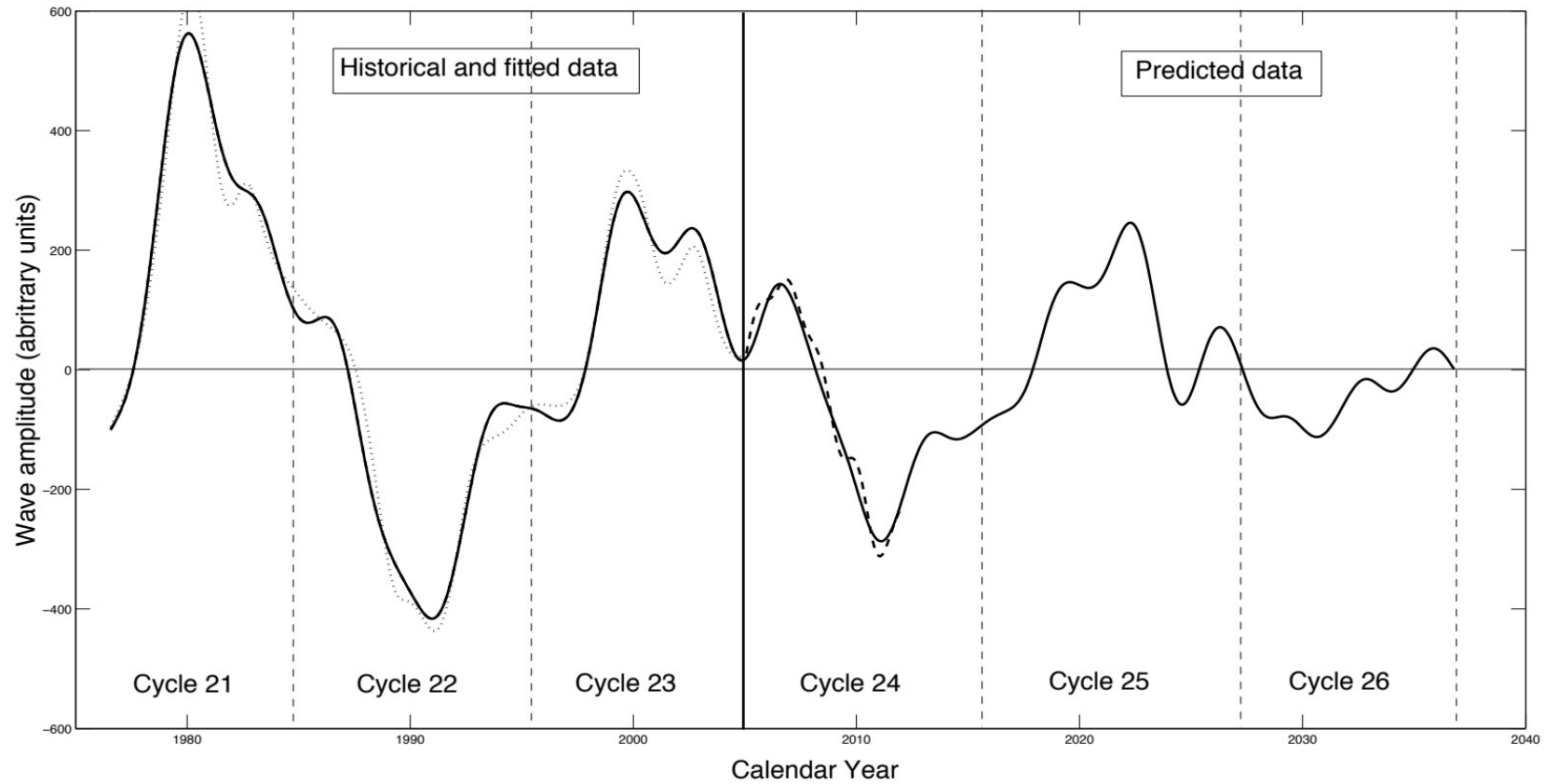
- Mathematical law for the first principal component:

$$F_1(t) = \sum_{k=1,\dots,5} A_k \cos(\omega_{k,1} t + \phi_{k,1}) \cos(B_{k,1} \cos(\omega_{k,1} t + \phi_{k,1}))$$

- Mathematical law for the second principal component:

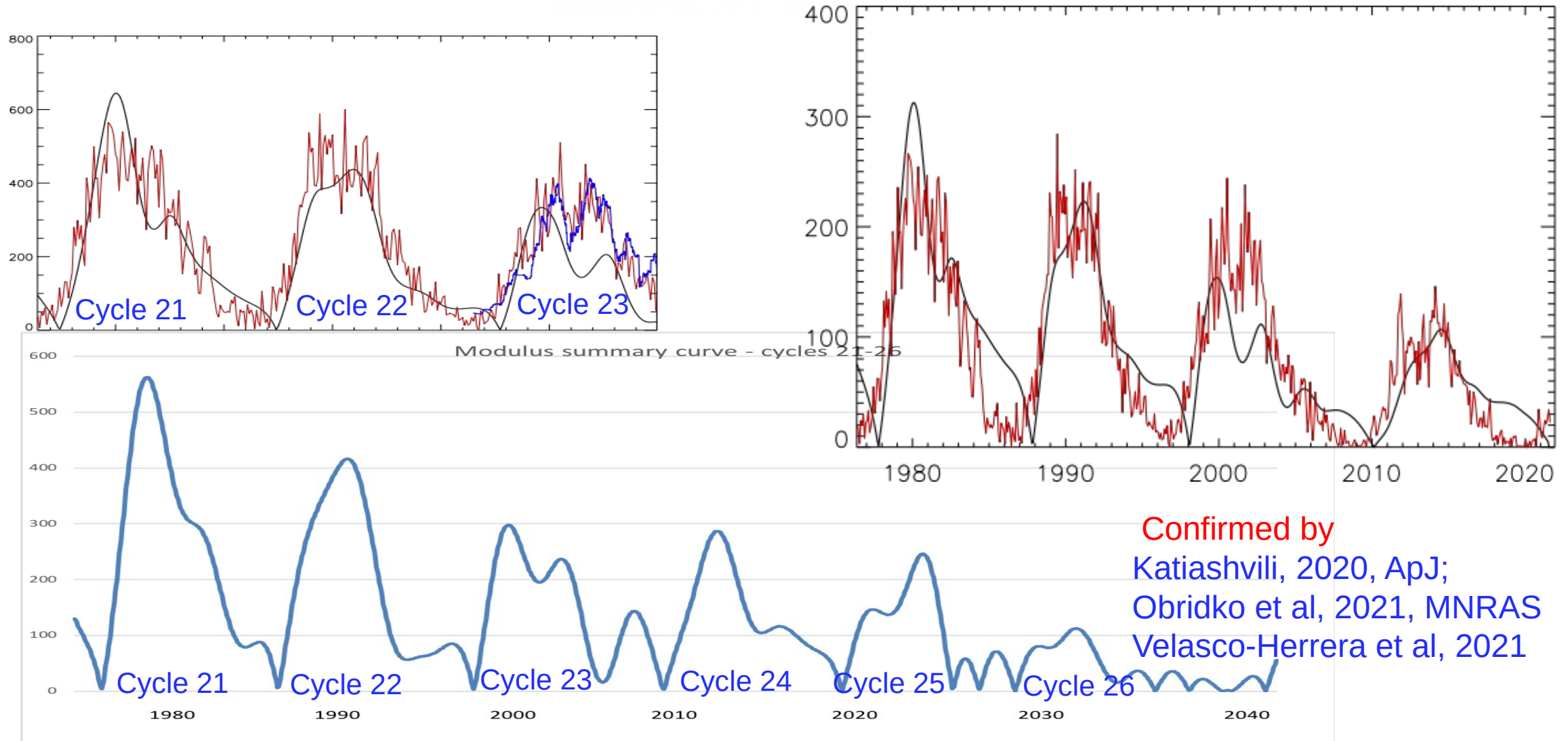
$$F_2(t) = \sum_{k=1,\dots,5} A_k \cos(\omega_{k,2} t + \phi_{k,2}) \cos(B_{k,2} \cos(\omega_{k,2} t + \phi_{k,2}))$$

Summary curve of 2 PCs

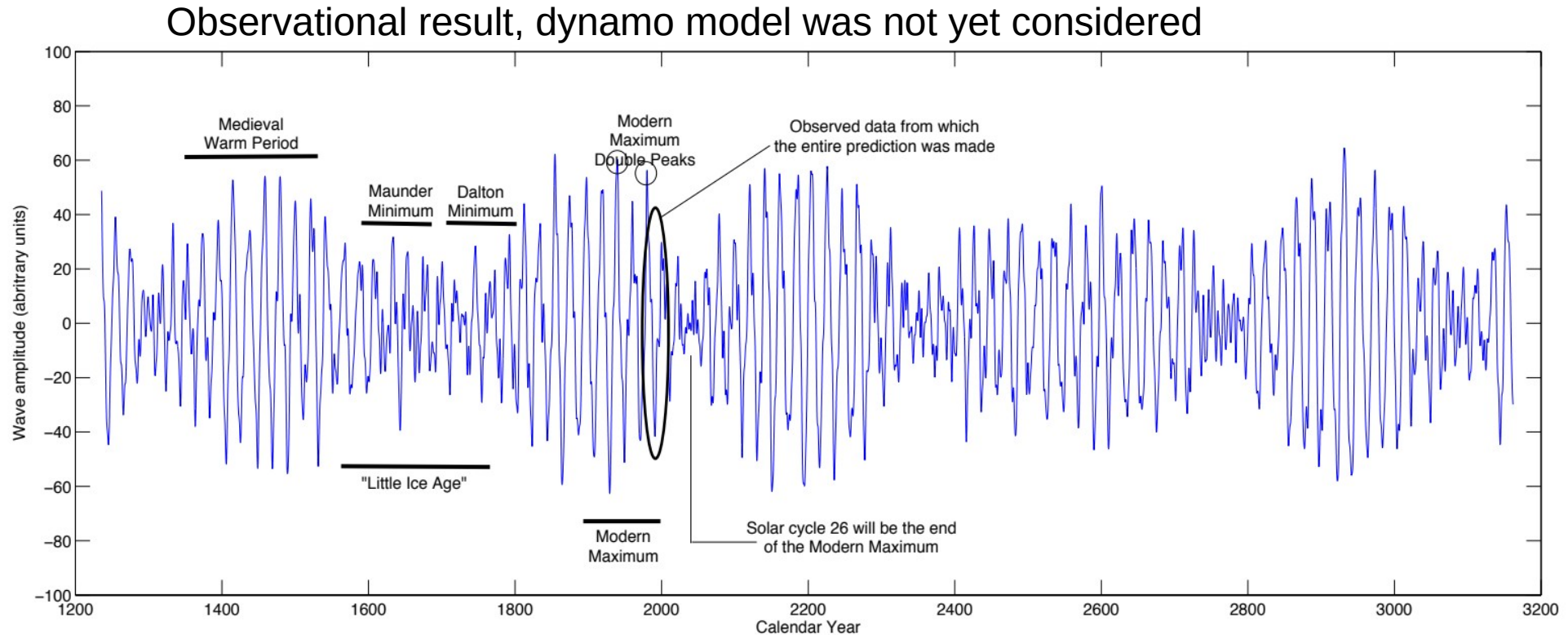


Modulus summary curve

Zharkova et al, 2015, SciRep; 2020, Temp., Zharkova et al, 2022, MNRAS



Predicted solar activity (Zharkova et al, 2015, SR <https://www.nature.com/articles/srep15689>)



Discovery of grand solar cycles :350-400 years

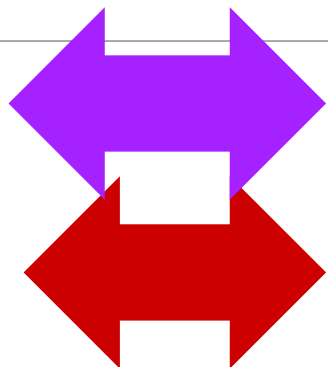
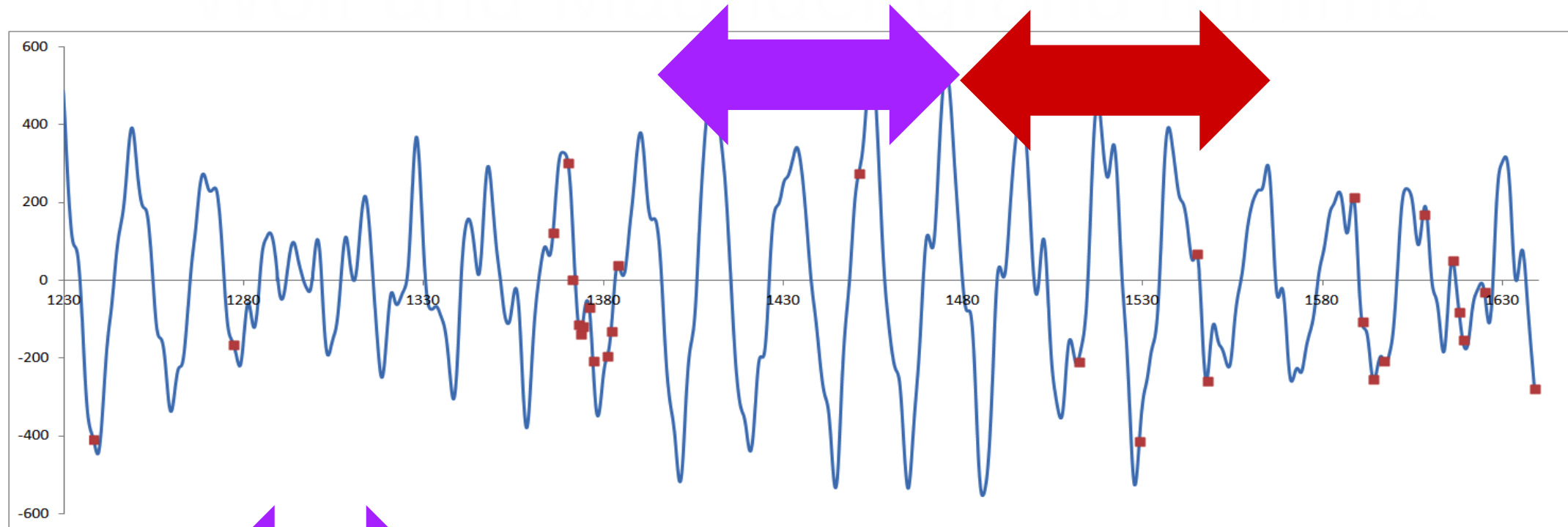
In addition to 11 year cycles

<https://solargsm.com/solar-activity/> - my webpage

This result was reported at

- the National Astronomy Meeting in Llandudno and covered by the RAS press-release
<https://nam2015.org/index.php/press-releases/64-irregular-heartbeat-of-the-sun-driven-by-double-dynamo>
- media
<https://www.sciencedaily.com/releases/2015/07/150709092955.htm>
and
<https://www.chroniclive.co.uk/business/business-news/mini-ice-age-could-freeze-11607587>
- U-tube talks
https://www.youtube.com/results?search_query=double+dynamo+and+grand+solar+minimum

Verification of summary curve with large s/s for grand cycle prior MM (Zharkova et al, 2017, 2018)

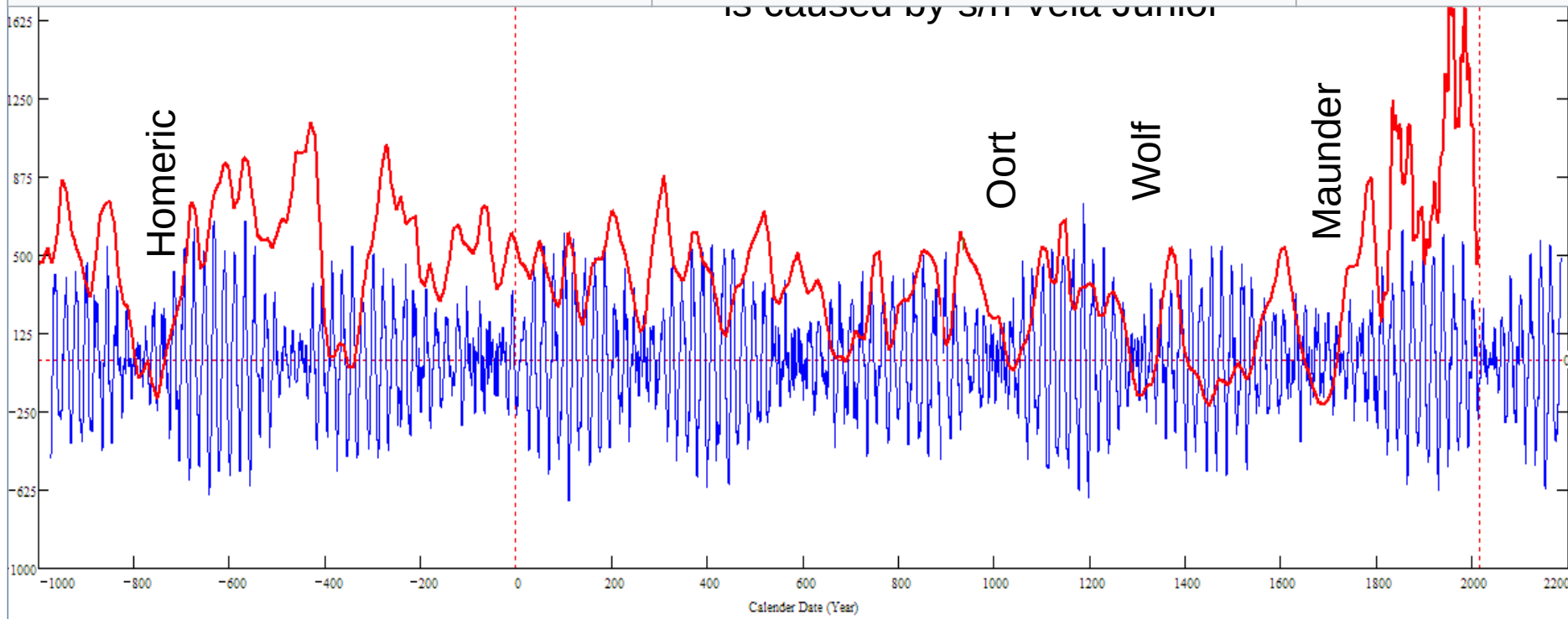


Severe diseases in China, no observers

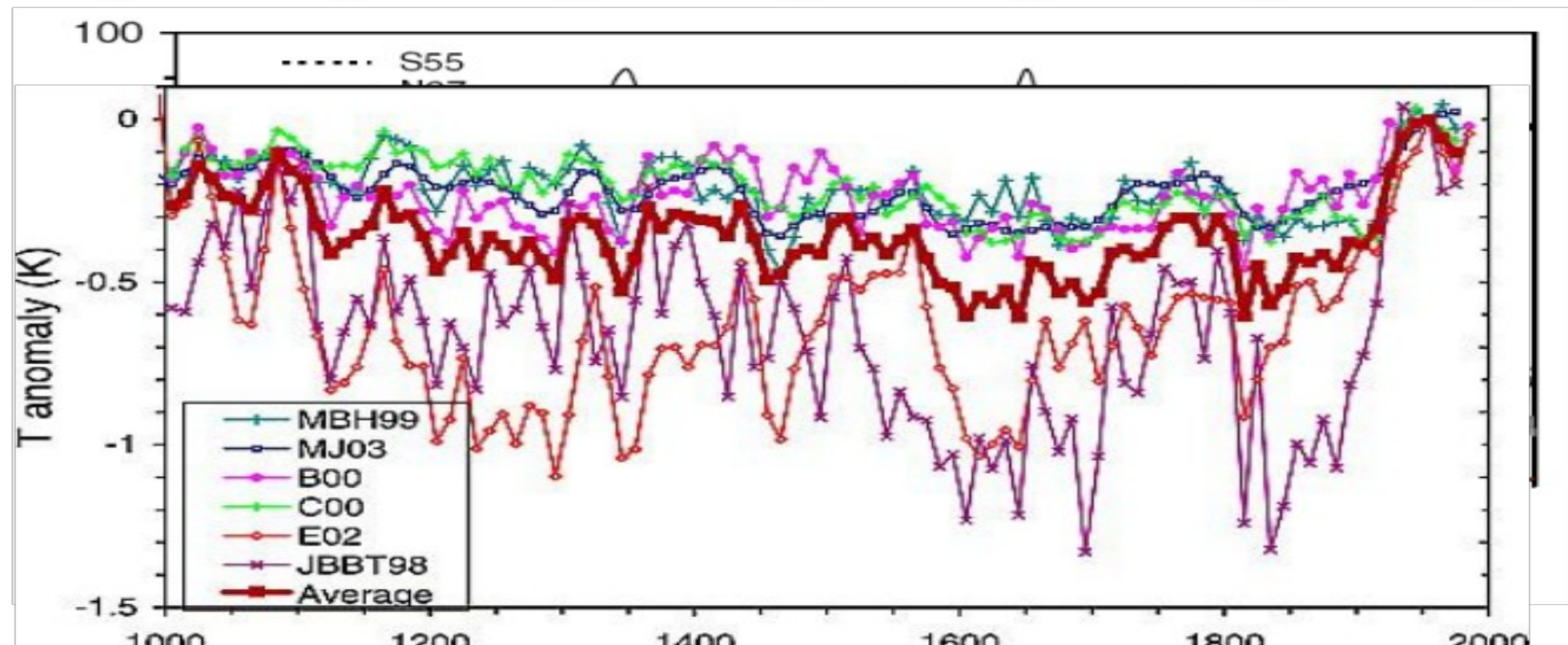
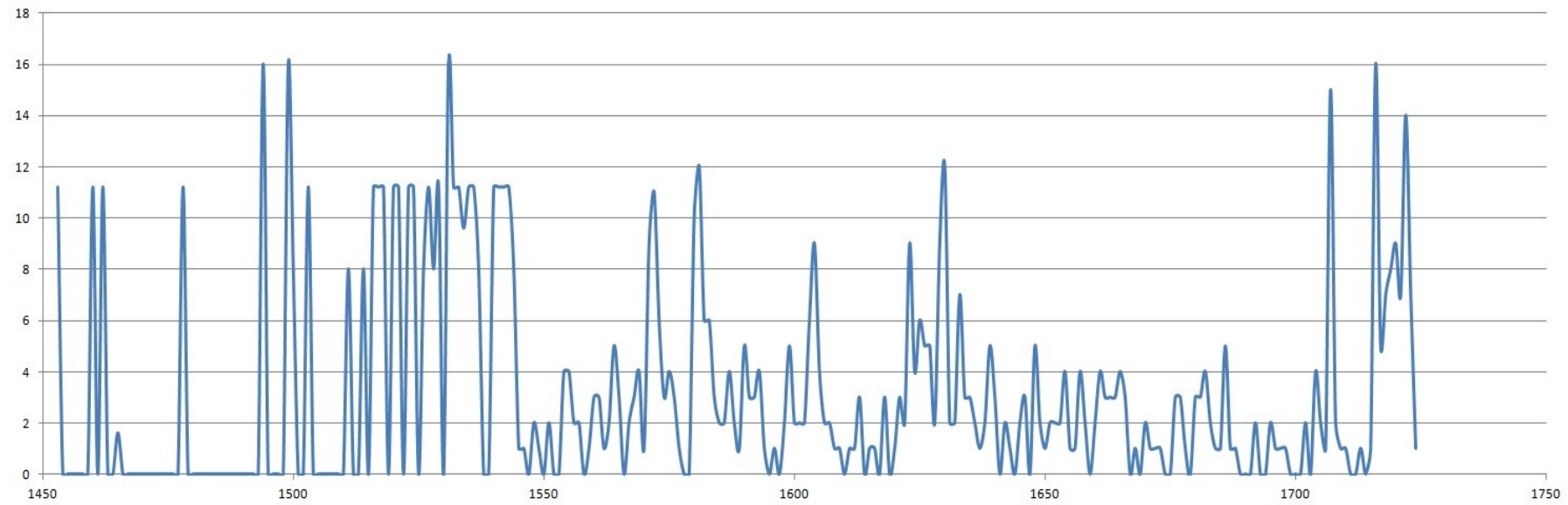
New dynasty in China, Great Wall project

Do
ver

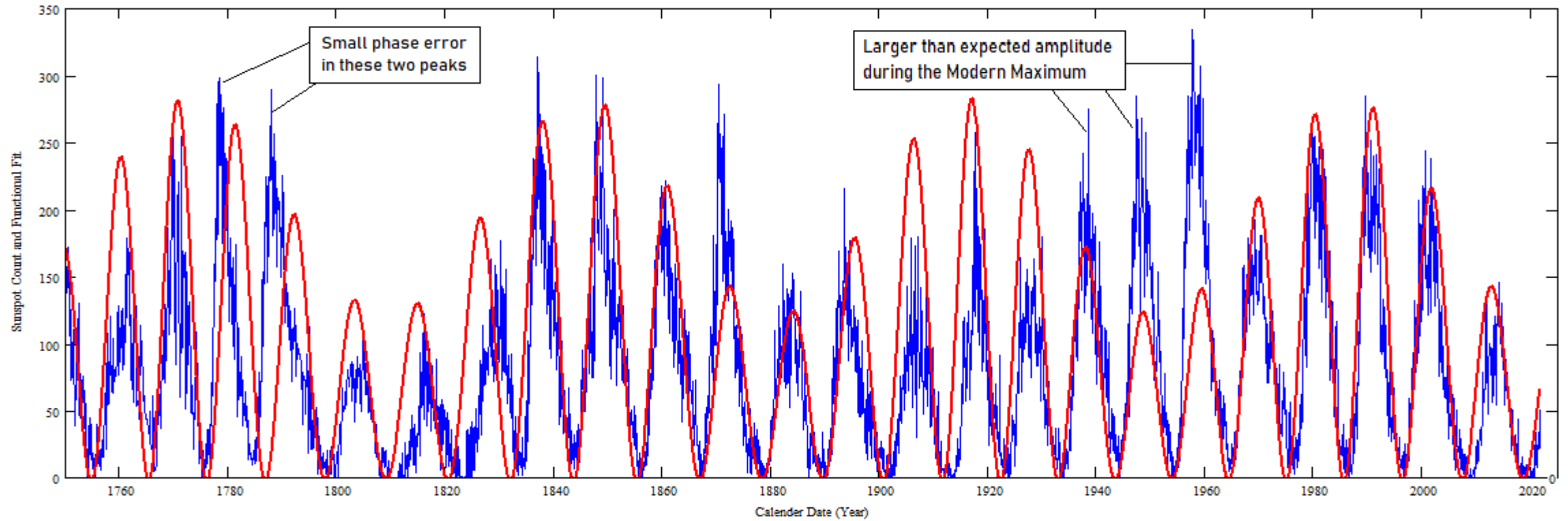
Homeric minimum ^[13]	750 BCE	550 BCE
Oort minimum	1040 CE	1080 CE
Medieval maximum	1100	1250
Wolf minimum	1280	1350
Spörer Minimum	1450	1550
Maunder Minimum	1645	1715
Dalton Minimum	1790	1820



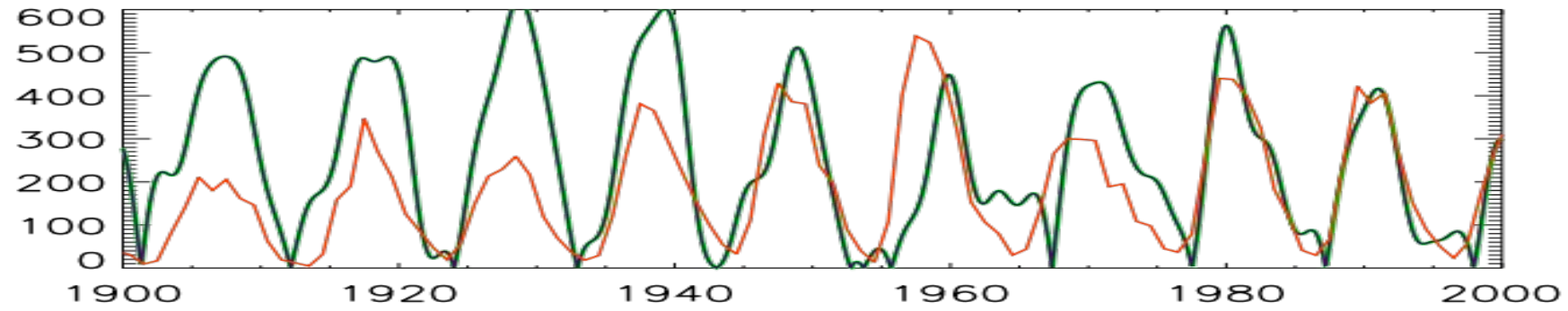
Periods – grand cycle: 350-400 years and super-grand cycle :2000-2100 years



Verification of summary curve with sunspot index Zharkova et al, 2022b



Zharkova et al, 2022b



Summary:

new proxy of solar activity

- New proxy of SA -Principal components of SBMF
- PCs are paired – double dynamo waves
- The strongest 2 PCs cover more than 40% of variance or 67% of SD
- Prediction of the solar activity on a millennium scale shows grand solar cycle with a period of 350-400 years
- Next grand solar minimum is underway **in 2020-2053**
- **Prediction for 3000-10000 years backwards fits the main grand minima and warming periods**

<https://solargsm.com/solar-activity/>

2 layer dynamo model explaining some PCA features

Zharkova et al, 2015, Popova et al, 2013

We included the meridional flows in each layer:

$$\frac{\partial B}{\partial t} + \frac{\partial(VB)}{\partial \theta} = \beta \Delta B, \quad \frac{\partial A}{\partial t} + V \frac{\partial A}{\partial \theta} = \alpha B + \beta \Delta A, \quad (2.3)$$

$$\frac{\partial b}{\partial t} + \frac{\partial(vb)}{\partial \theta} = D \cos \theta \frac{\partial a}{\partial \theta} + \Delta b, \quad \frac{\partial a}{\partial t} + v \frac{\partial a}{\partial \theta} = \Delta a, \quad (2.4)$$

here $V(\theta), v(\theta)$ are the meridional flows in the respective layers.

Following Parker we prescribe $r = 0$ for the radial boundary between two layers and use boundary conditions:

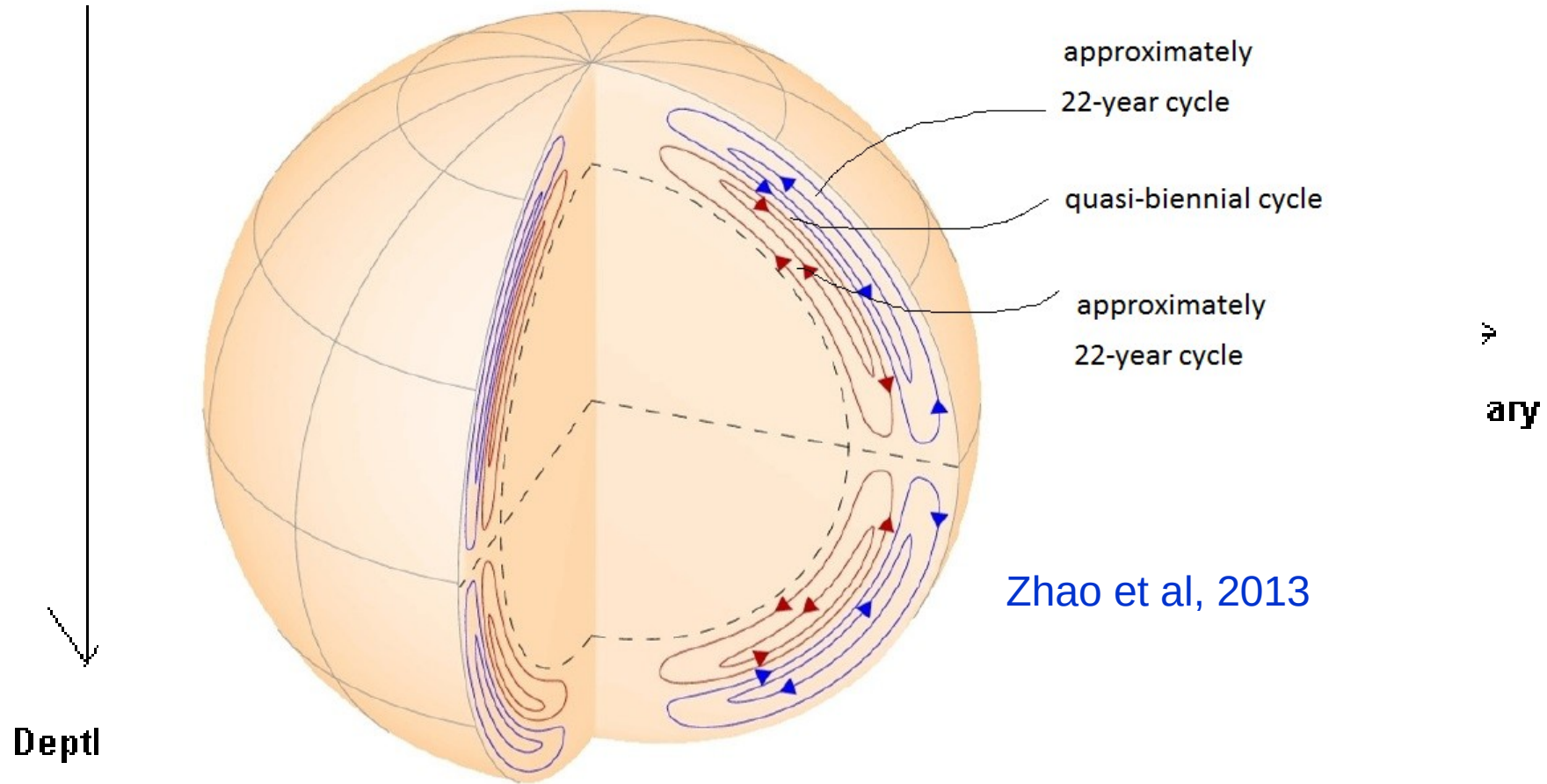
$$b = B, \quad a = A, \quad \frac{\partial b}{\partial r} = \beta \frac{\partial B}{\partial r}, \quad \frac{\partial a}{\partial r} = \frac{\partial A}{\partial r}. \quad (2.5)$$

In view of the symmetry conditions $\alpha(-\theta) = -\alpha(\theta)$, $V(-\theta) = -V(\theta)$ the above system of equations can be considered in only one (e.g., the northern) hemisphere using anti-symmetry (dipolar symmetry) or symmetry (quadrupolar symmetry) conditions at the equator.

We obtained Hamilton-Jacobi equation for eqs. (2.3) and (2.4) by a method similar to the method described in Popova et al. (2010).

Two-Layer Medium observed with

HMI/SDO helioseismic observations



Undamped Equation: Solution to Initial Value Problem (1 of 2)

- Thus our solution is

$$y(t) = \frac{F_0}{m(\omega_0^2 - \omega^2)} (\cos \omega t - \cos \omega_0 t)$$

- To simplify the solution even further, let $A = (\varphi_0 + \varphi)/2$ and $B = (\varphi_0 - \varphi)/2$. Then $A + B = \varphi_0 t$ and $A - B = \varphi t$. Using the trigonometric identity $\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$,

it follows that

$$\cos \omega t = \cos A \cos B + \sin A \sin B$$

$$\cos \omega_0 t = \cos A \cos B - \sin A \sin B$$

and hence

$$\cos \omega t - \cos \omega_0 t = 2 \sin A \sin B$$

Undamped Equation: Beats (2 of 2)

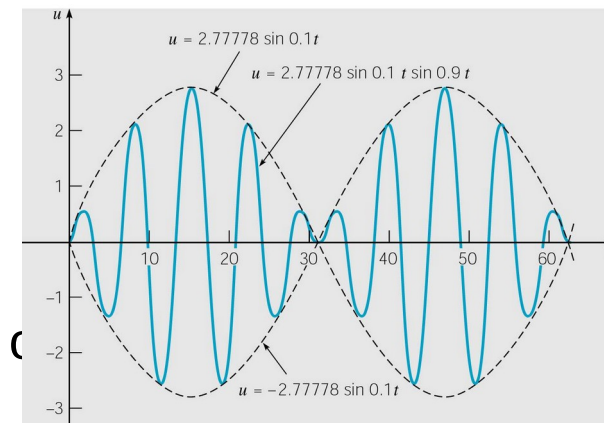
- Using the results of the previous slide, it follows that oscillations are described by the formula:

$$y(t) = \left[\frac{2F_0}{m(\omega_0^2 - \omega^2)} \sin \frac{(\omega_0 - \omega)t}{2} \right] \sin \frac{(\omega_0 + \omega)t}{2}$$

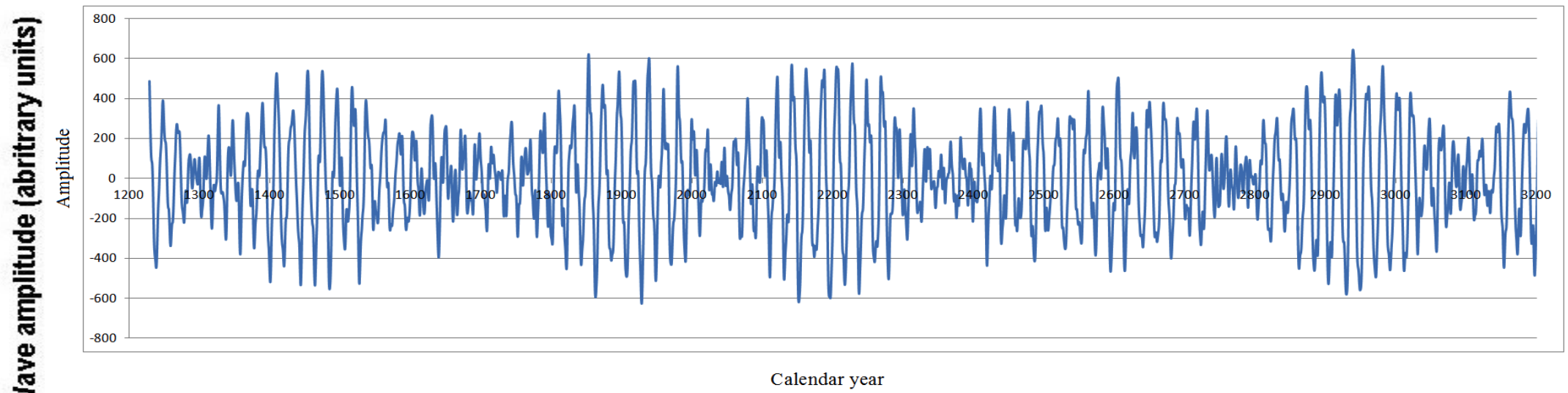
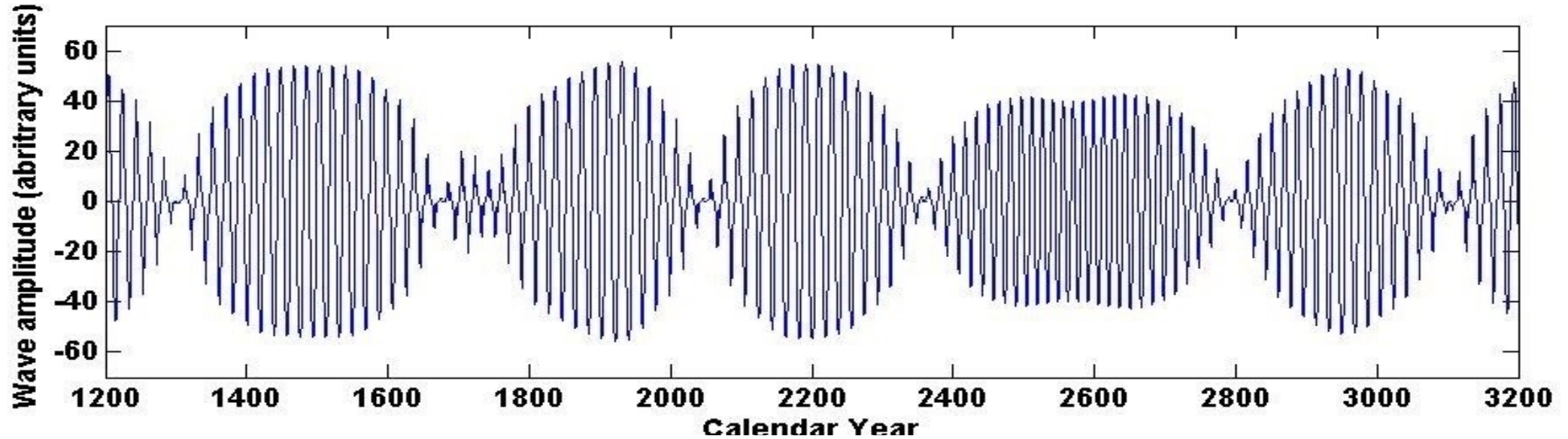
- When $|\omega_0 - \omega| \ll \omega_0 + \omega$, $\omega_0 + \omega$ is much larger than $\omega_0 - \omega$, and $\sin[(\omega_0 + \omega)t/2]$ oscillates more rapidly than $\sin[(\omega_0 - \omega)t/2]$ (amplitude of faster oscillation).
- Thus motion is a rapid oscillation with frequency $(\omega_0 + \omega)/2$, but with slowly varying sinusoidal amplitude given by formula:

$$\frac{2F_0}{m|\omega_0^2 - \omega^2|} \left| \sin \frac{(\omega_0 - \omega)t}{2} \right|$$

- This phenomenon is called a **beat**.
- Beats occur with two tuning forks of nearly equal frequency (beats used for tuning piano c



Dynamo model (top) and summary curve (bottom)



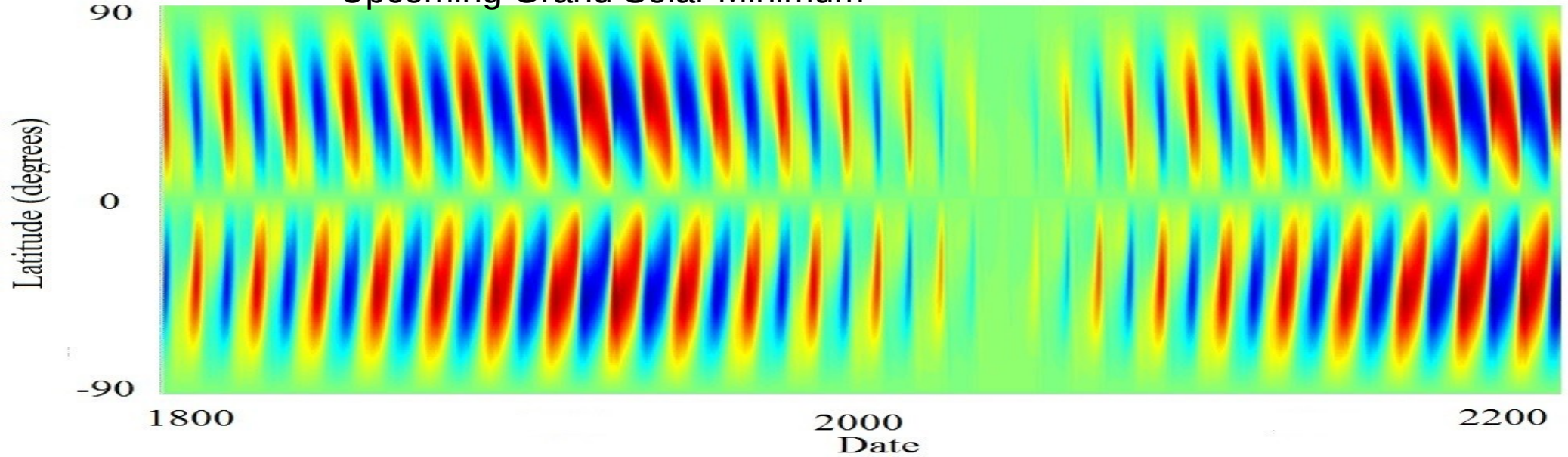
Popova et al, 2013

Calendar Year

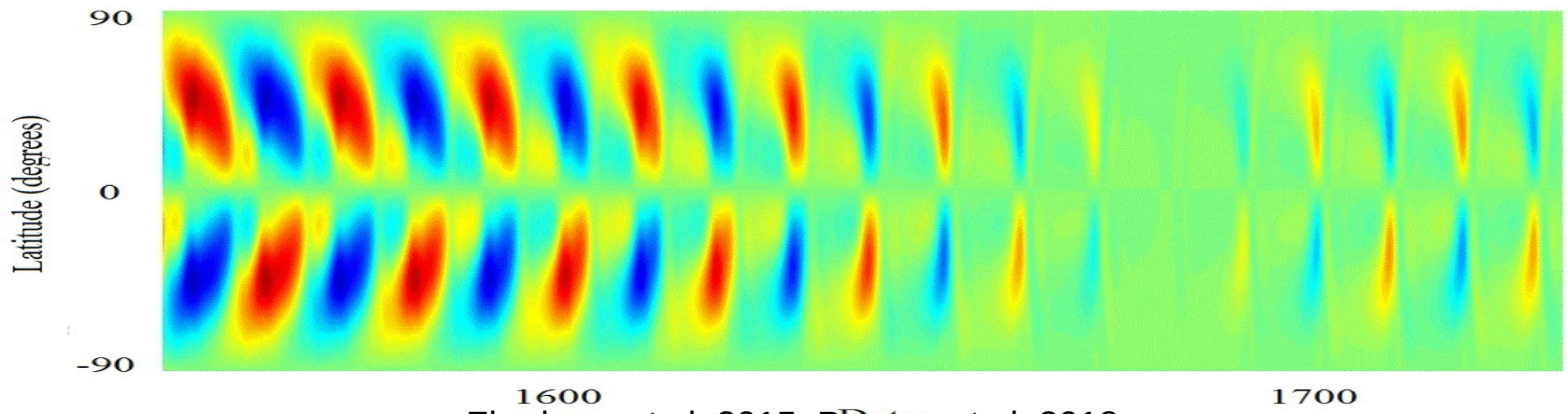
Zharkova et al, 2015, SR

<https://www.nature.com/articles/srep15689>

Upcoming Grand Solar Minimum



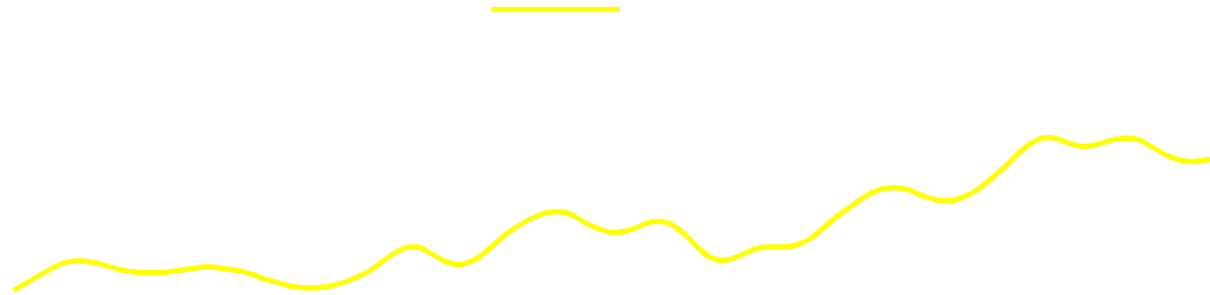
Maunder Grand Solar Minimum



Zharkova et al, 2015, Popova et al, 2018

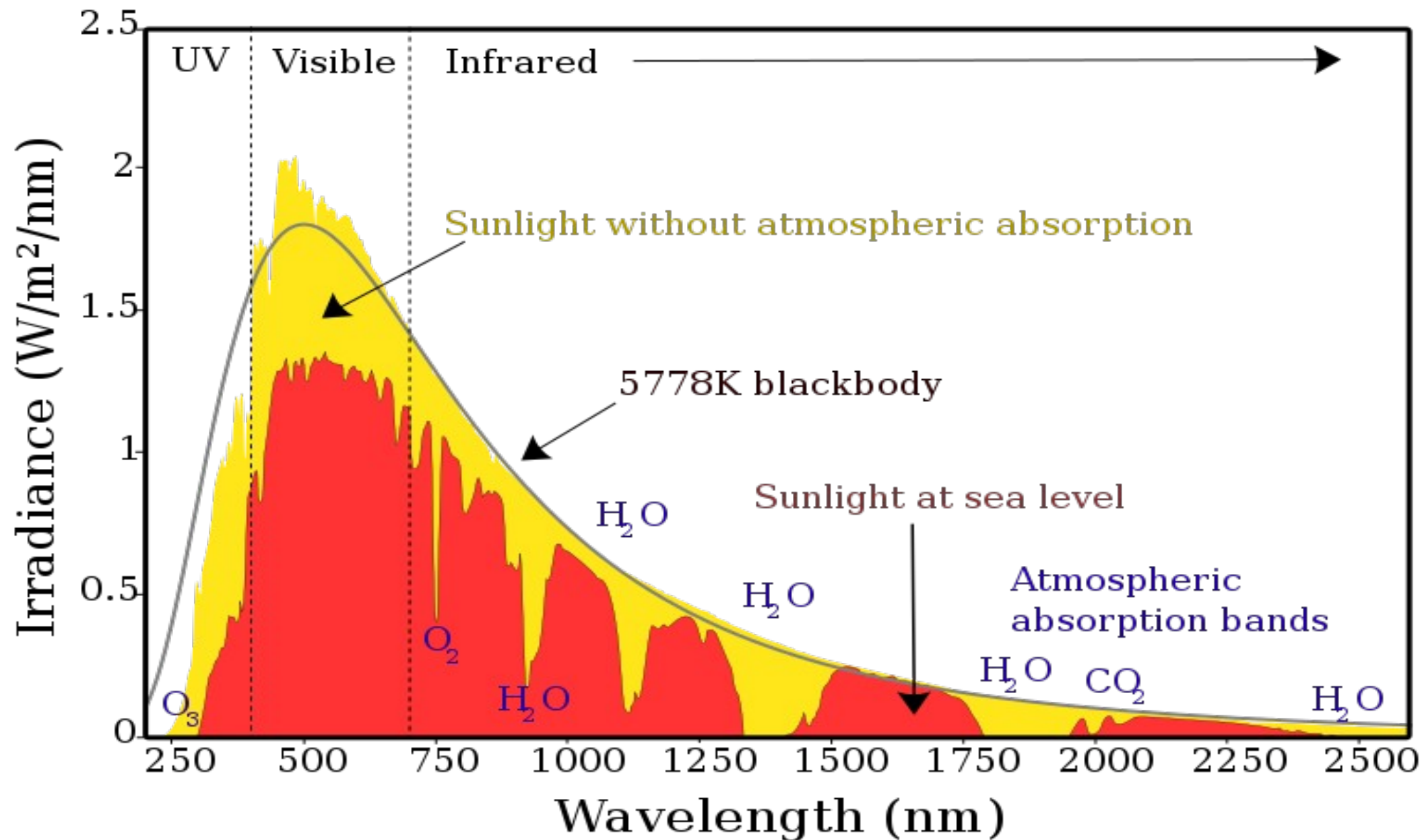
Solar activity, Total Irradiance and Climate

The 0.1% change in the Total Solar Irradiance seen over the last three solar cycles only produces a 0.1° C temperature change in climate models. However, the Sun seems to have a bigger impact.

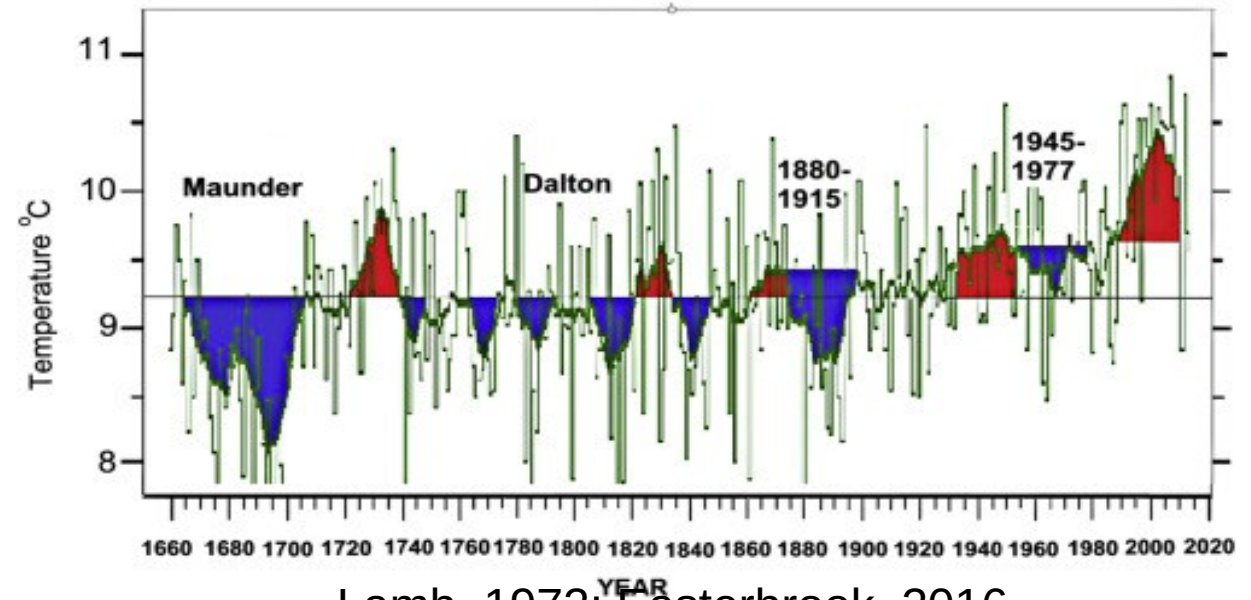
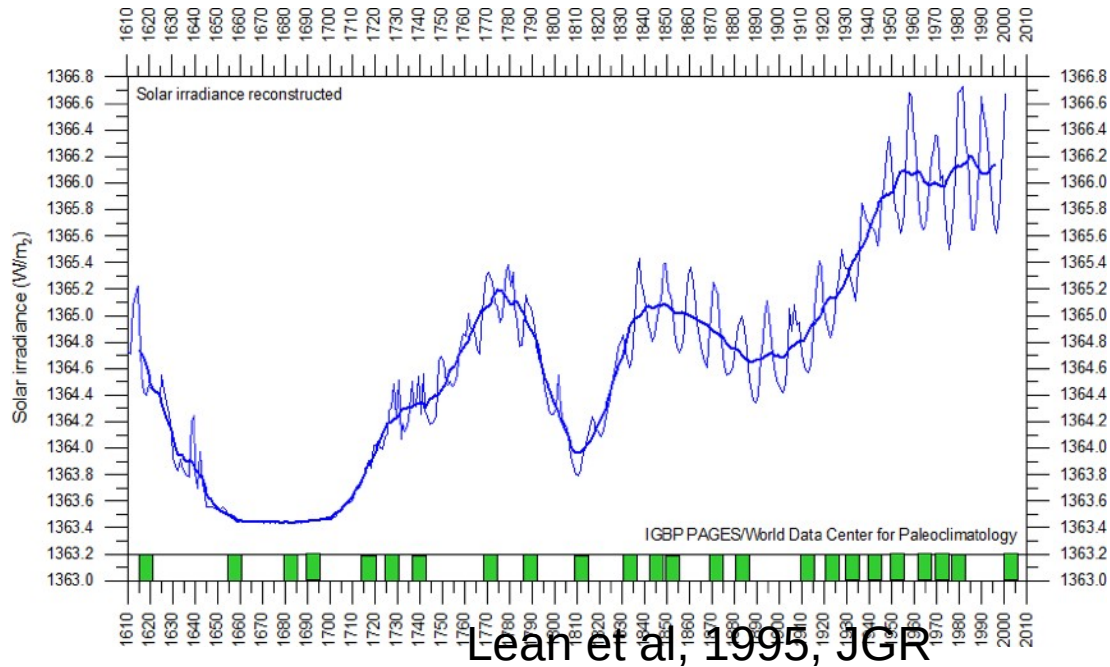


Two other mechanisms (besides direct forcing by the Total Solar Irradiance variations) are under study: 1) **solar ultraviolet and extreme ultraviolet variability** and 2) **Cosmic Ray modulation on cloud cover.**

Spectrum of Solar Radiation (Earth)



Solar irradiance and terrestrial temperature during MM

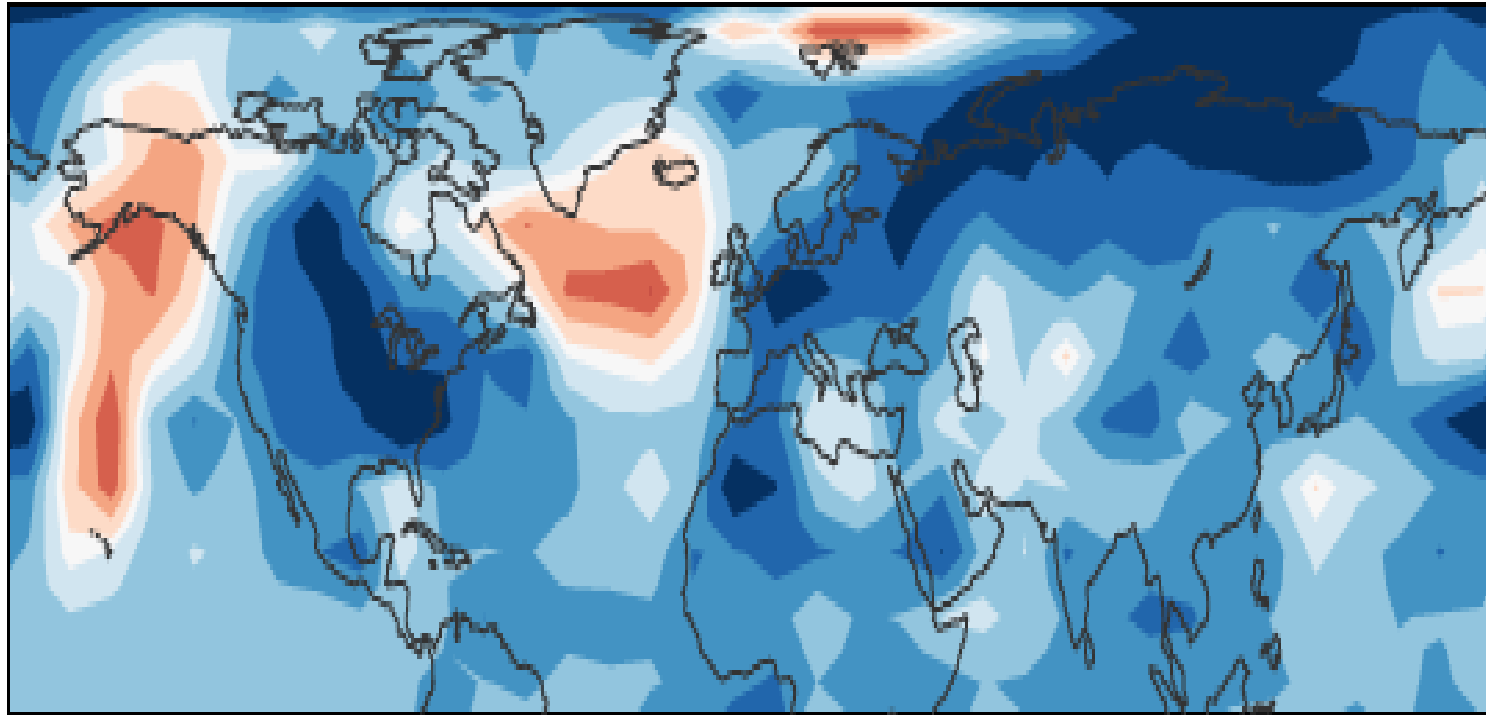


Authors	S, Maunder minimum, W/m ²	S 1990-2000, W/m ²	ΔS from MM, %
Lean et. Al., 1995	1363	1366	0.22
Steinhilber et al, 2012	1364	1366	0.22
Shirley et al., 1990	---	1370	0.51
Wolff and Hickey, 1987	---	1371	0.51
Lee et al., 1995	---	1372	0.51

After the TSI data were re-normalized the old data are hardly usable

Temperature restoration during/after MM

(Shindell et al., 2001, Science)



Temperature Change: 1680-1780 (°C)

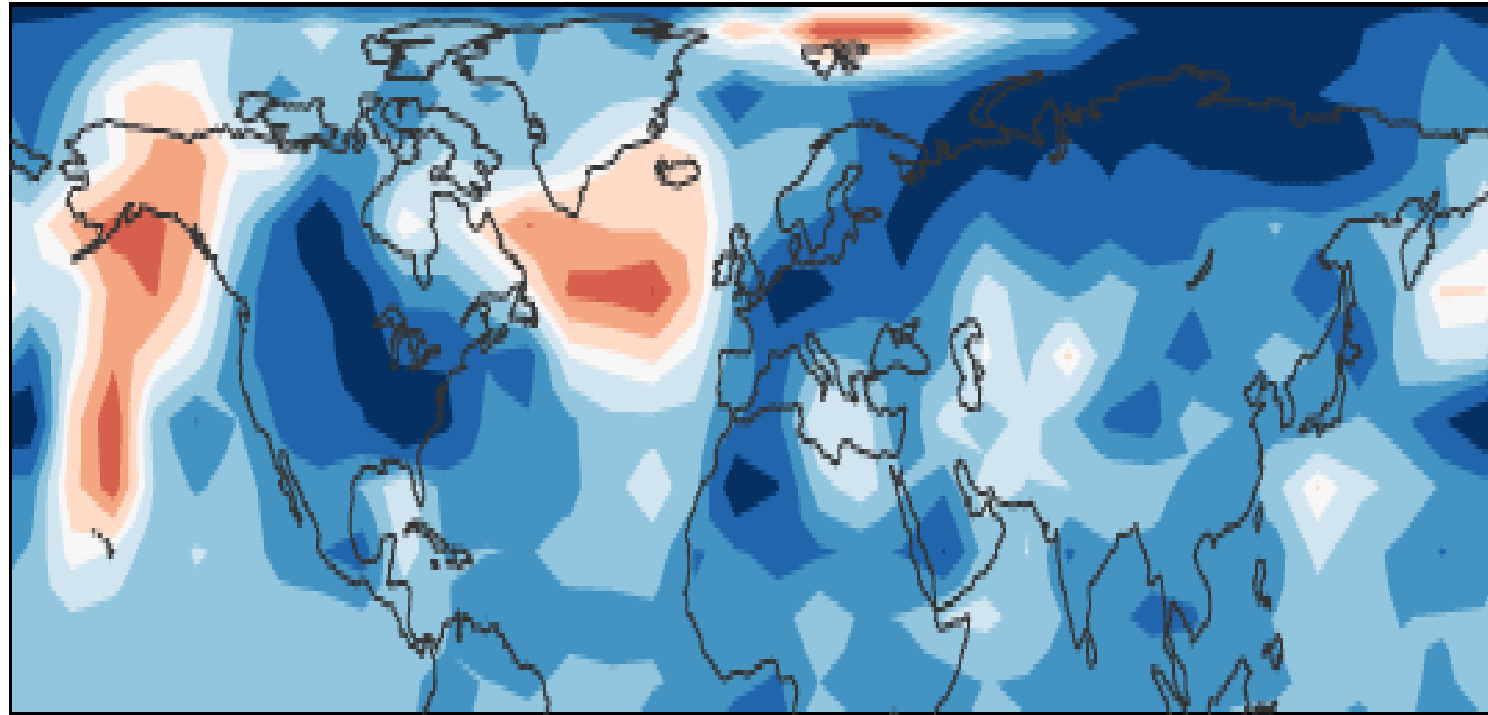


-0.7 -0.5 -0.35 -0.2 -0.05 0.05 0.2 0.35 0.5 0.7

- The surface temperature of the Earth was reduced all over the Globe
- Europe and North America went into a deep freeze
- Alpine glaciers extended over valley farmland
- Sea ice crept south from the Arctic
- Dunab and Thames rivers & canals in the Netherlands froze regularly

Temperature restoration during MM

(Shindell et al., 2001, Science)



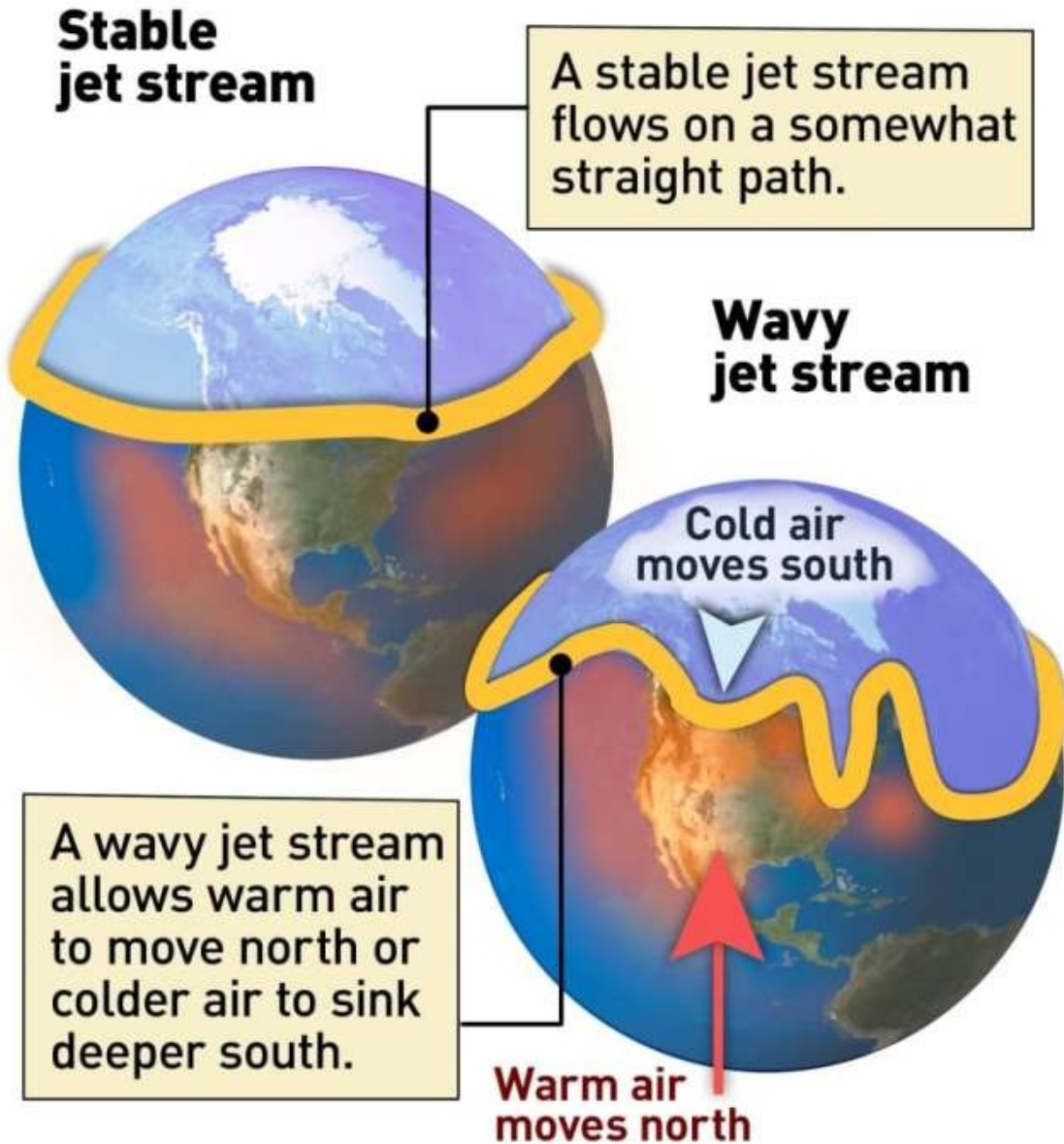
Temperature Change: 1680-1780 (°C)



-0.7 -0.5 -0.35 -0.2 -0.05 0.05 0.2 0.35 0.5 0.7

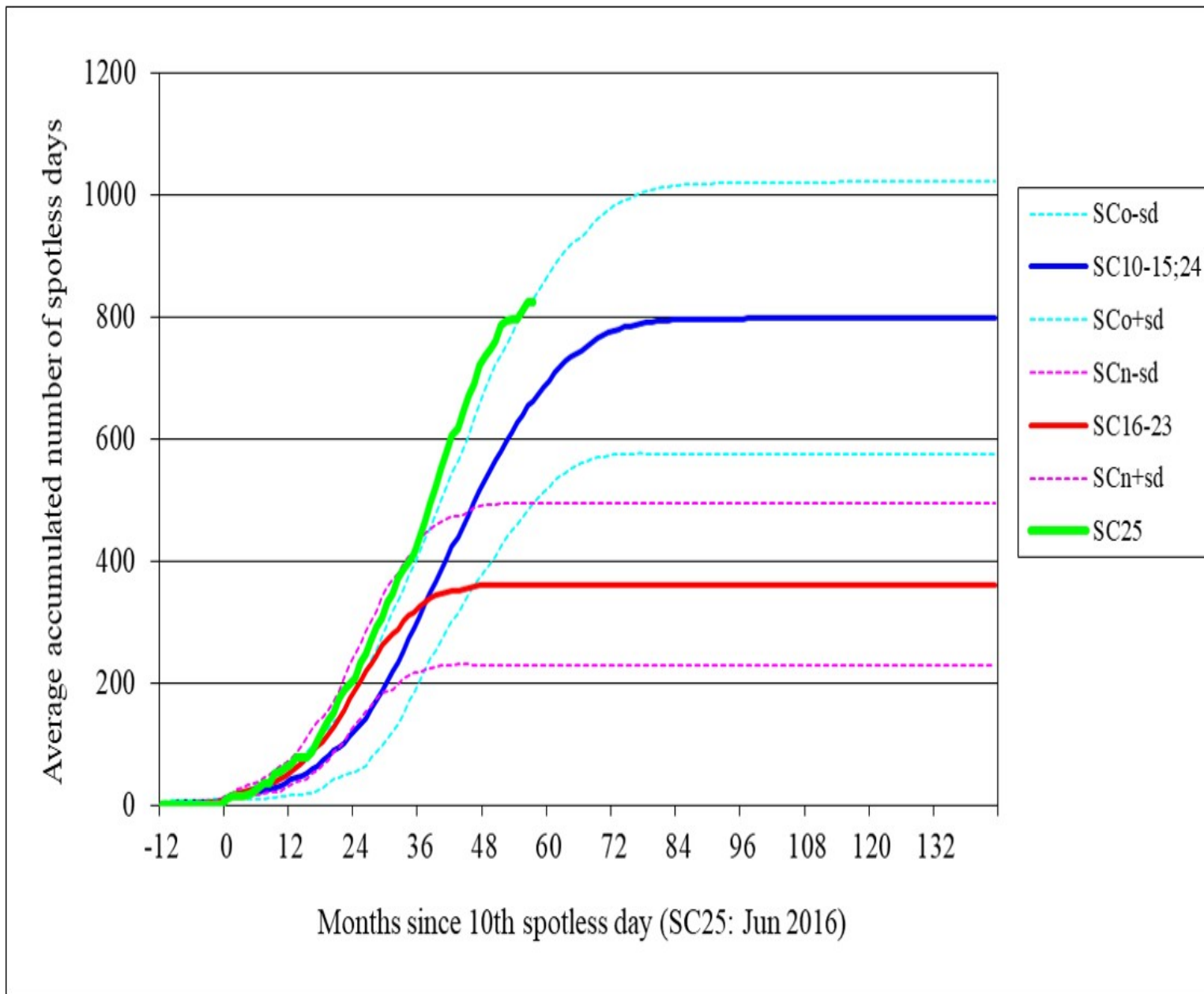
- the drop in the temperature was related to dropped abundances of ozone created by solar ultraviolet light in the stratosphere, the layer of the atmosphere located between 10 and 50 kilometers from the Earth's surface

The Changing Jet Stream



- Less ozone affected planetary atmosphere waves
- They, in turn, caused the giant wiggles in the jet stream as shown in picture on the left
- It kicked the North Atlantic Oscillation (NAO)—the balance between a permanent low-pressure system near Greenland and a permanent high-pressure system to its south—into a negative phase
- that led to Europe to remain unusually cold during the MM

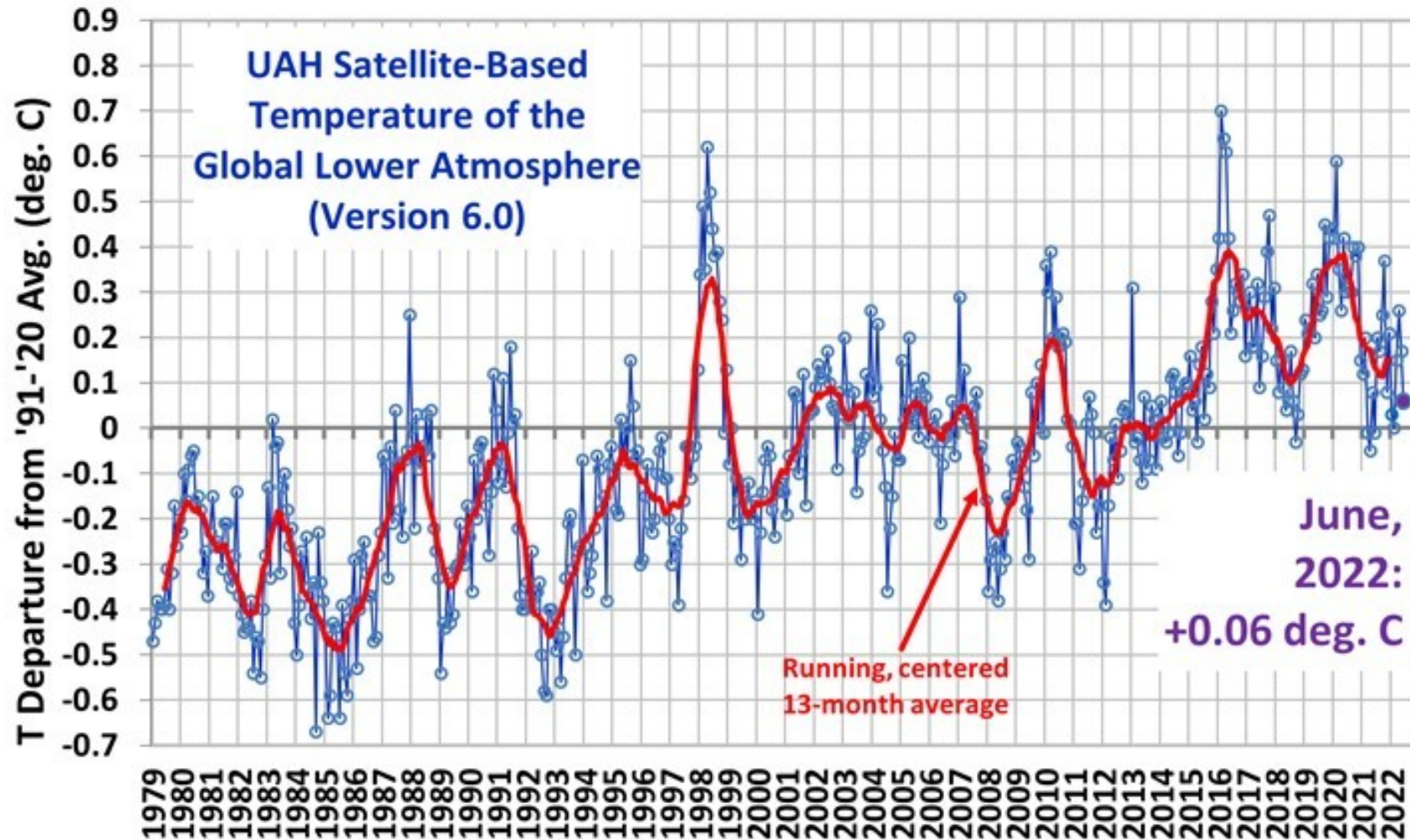
Shindell et al., 2001



- **Cycle 25** (green line) shows a steeper growth of the number of spotless days than any other cycles including the ones during Dalton min (cycles 15 and 24) (blue line)

Stop The Climate Stupidity

Has the world warmed?

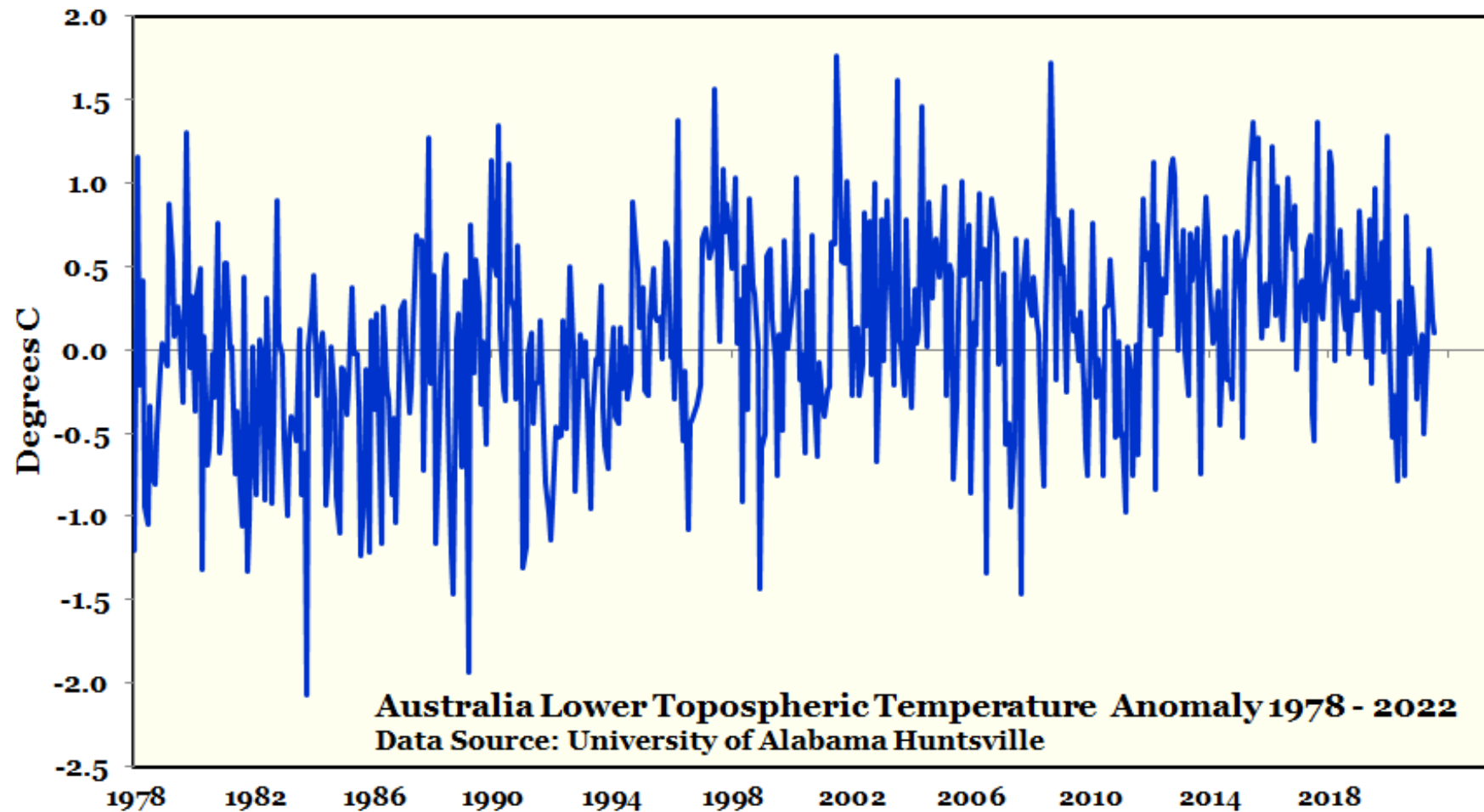


37

The atmosphere hasn't warmed - in downtrend from 2016.

Stop The Climate Stupidity

Australia is much the same.



Nothing has happened really - sideways for the last 25

Modern Grand Solar Minimum 2020-2053

Snow in Carpathian mountains

7, 14 July'19 July –Ukraine, 12 July 2019, 2021-2021 – many examples



- Contrary to the prediction of JAMES HANSEN, 1989: “NEW YORK CITY’S WEST SIDE HIGHWAY WILL BE UNDERWATER BY 2009”
- January 2020 snow and frost -2C was recorded in Amman, Arabia, first in 150 years
- Early snow in Canada in September’ 20, May 21
- Summer snow in south of Australia 2021

Snow in Africa's desert 8 December 2020

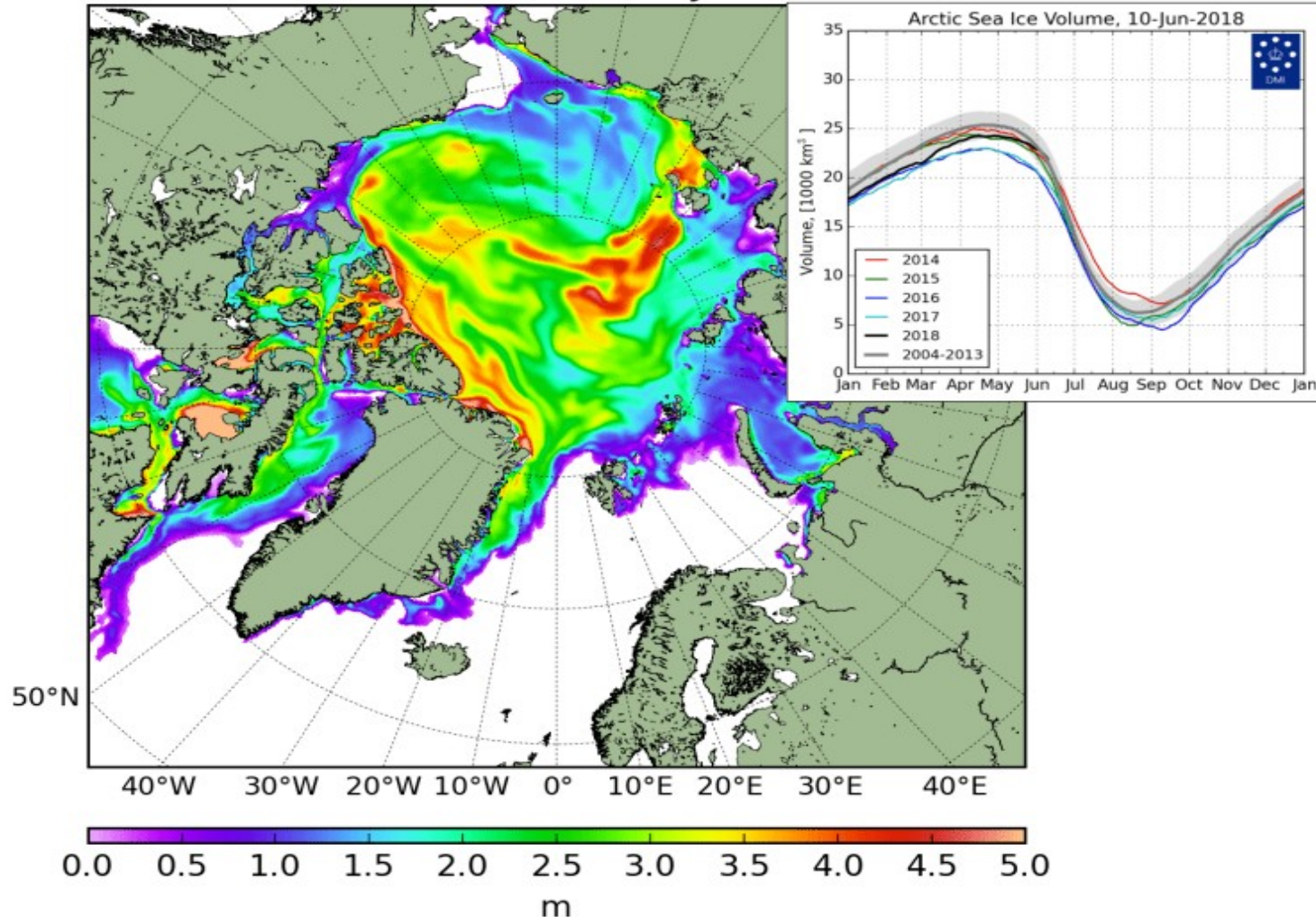
<https://twitter.com/GerryAMcG/status/1336420778582138886>



During covid days the Nature retake it initial

Modern GSM: Sea ice thickness increase in 2018-2020

Sea Ice Thickness, 10-Jun-2018



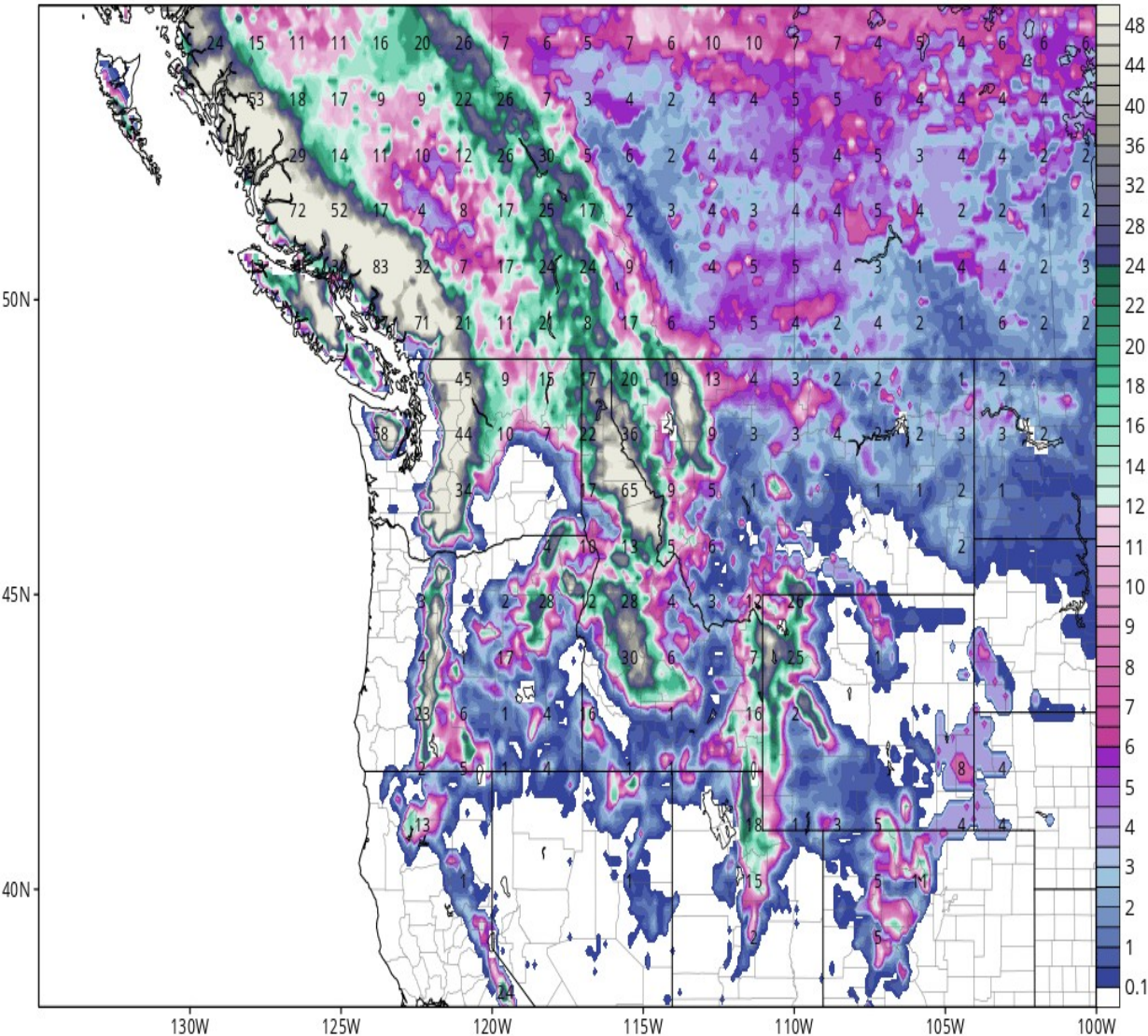
- Contrary to prediction of JAMES HANSEN, 1989: “NEW YORK CITY’S WEST SIDE HIGHWAY WILL BE UNDERWATER BY 2009”
- Arctic sea ice thickness grown significantly in 2018 and continues to grow

Modern GSM is progressing –November 2020- June 2022

GFS Total Snowfall [*includes sleet*] (inches) (assuming 10:1 snow:liquid ratio)

Init: 00z Nov 11 2020 Forecast Hour: [384] valid at 00z Fri, Nov 27 2020

TROPICALTIDBITS.COM



- UNPRECEDENTED WINTER STORM HITS BRITISH COLUMBIA
- Both NOAA and NASA appear to agree, *if you read between the lines*, with NOAA saying we're entering a 'full-blown' Grand Solar Minimum in the late-2020s
- NASA seeing this upcoming solar cycle (25) as "the weakest of the past 200 years", with the agency correlating previous solar shutdowns to prolonged periods of global cooling here.

HOW ICE SHEET GREW 533,000 SQUARE MILES IN A YEAR

AUGUST 2012



CONTRACTION: This Nasa satellite image shows the ice at the smallest extent on record, with much of the Arctic Ocean uncovered

AUGUST 2013



RECOVERY: Contrary to predictions that the ice would have vanished by this summer, it has actually increased by 29 per cent from last year

Volcanic activity correlates with SA cycles of southern polarity

(Vasilieva and Zharkova, 2022, ApJ in press)

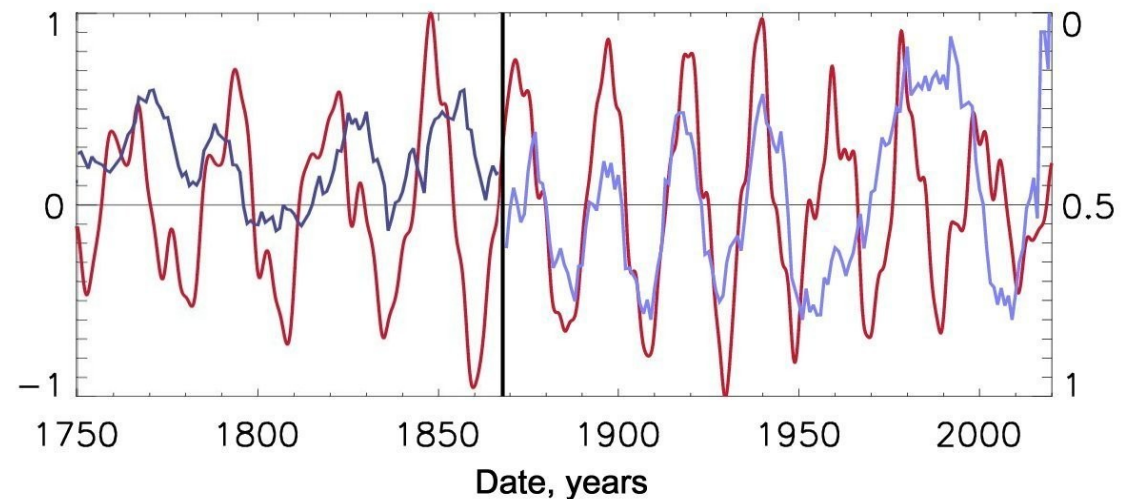
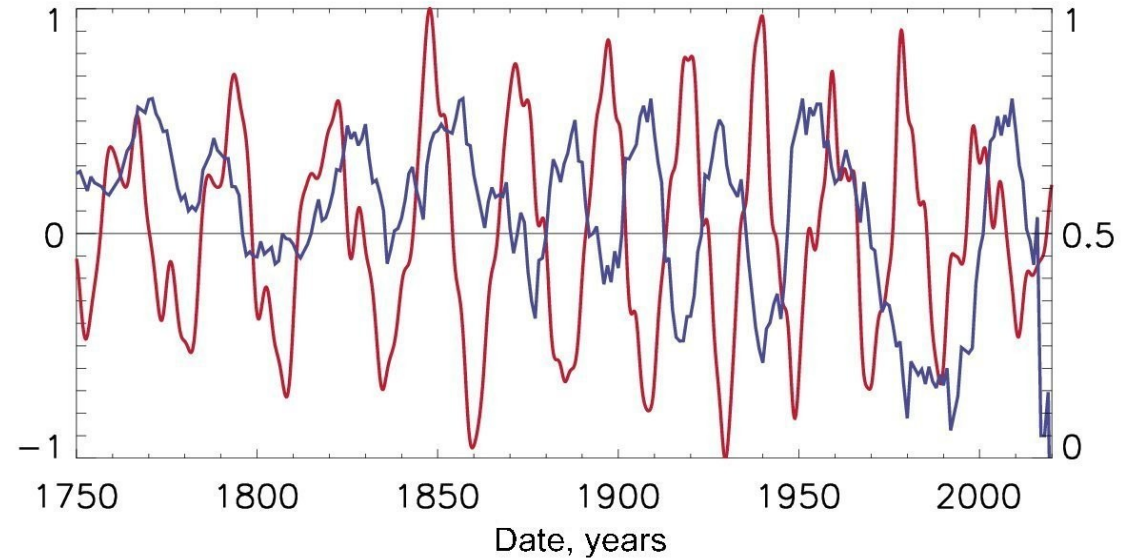
Top plot

Blue – frequencies of volcanic eruptions
Red - the summary curve of solar background magnetic field. Positive magnitudes – northern polarity, negative - southern polarity.

Bottom plot

Volcanic eruption frequencies highly (0.84) correlate with the summary curve with southern polarity with a period of 22 years (1860-1950).

Next maximum of volcanic eruptions will occur in cycle 26 (2031-2042).

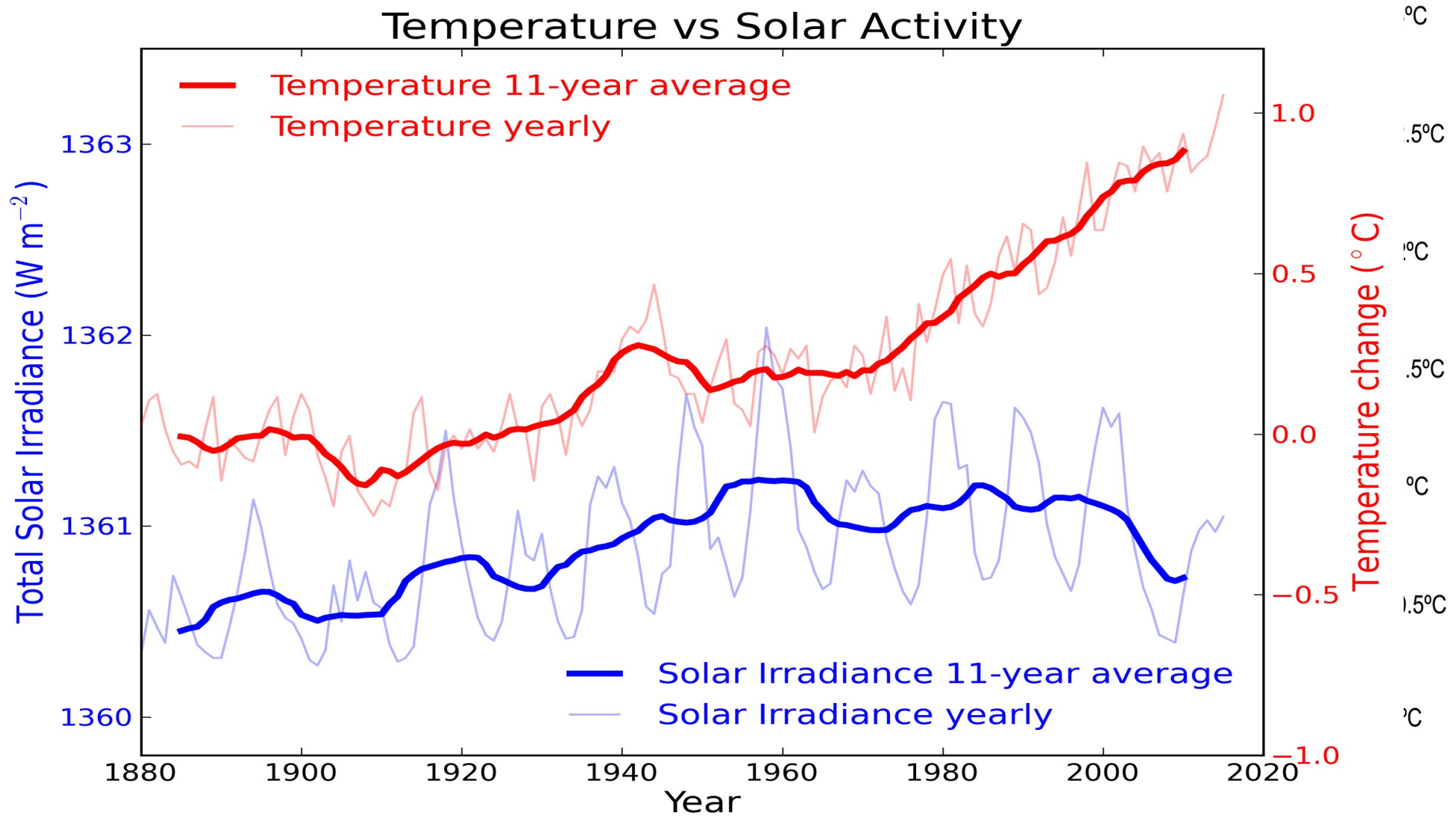


Modern Grand Solar Minimum

<https://solargsm.com/solar-activity/>

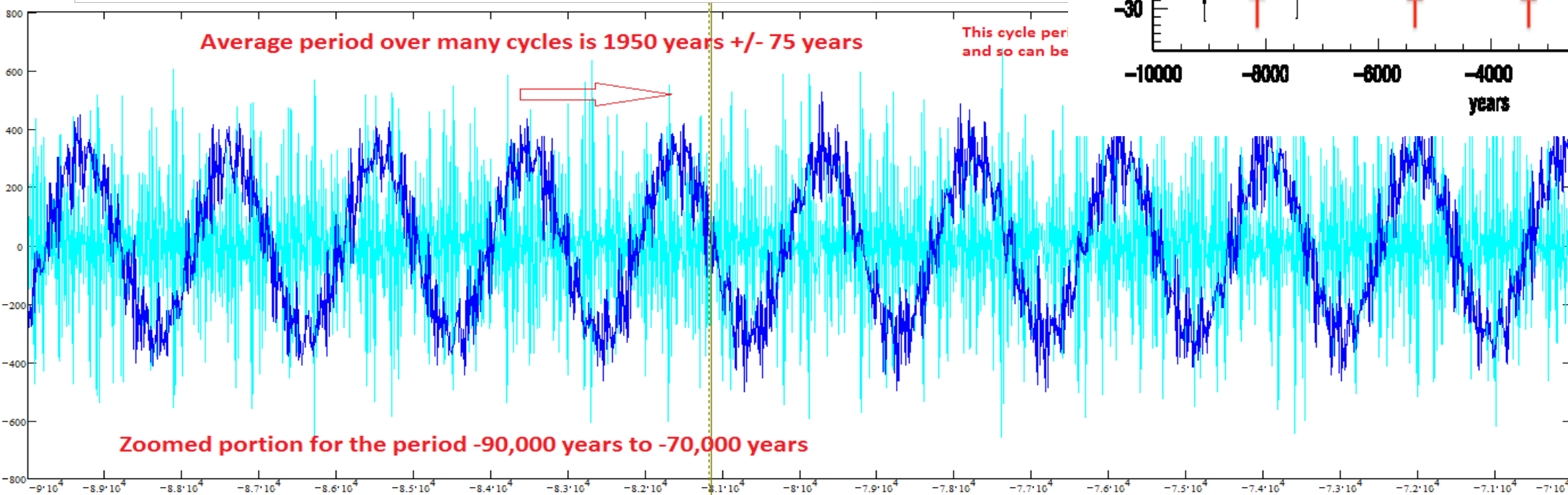
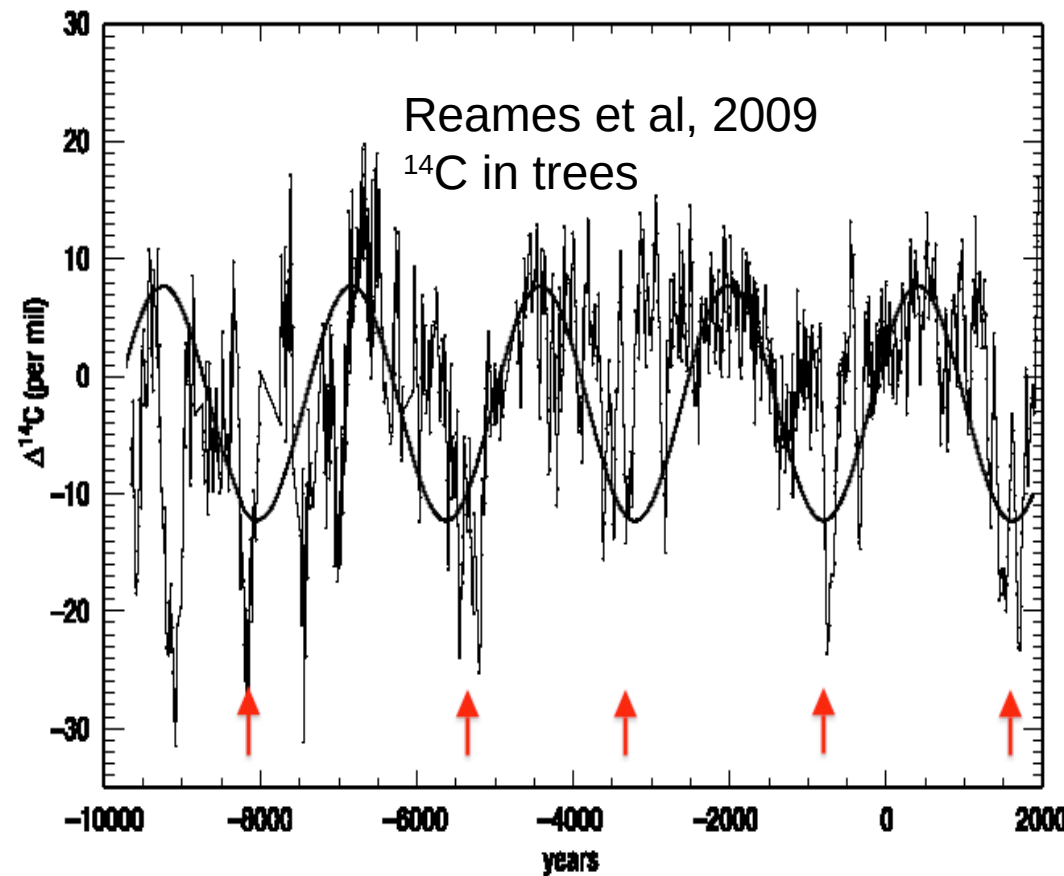
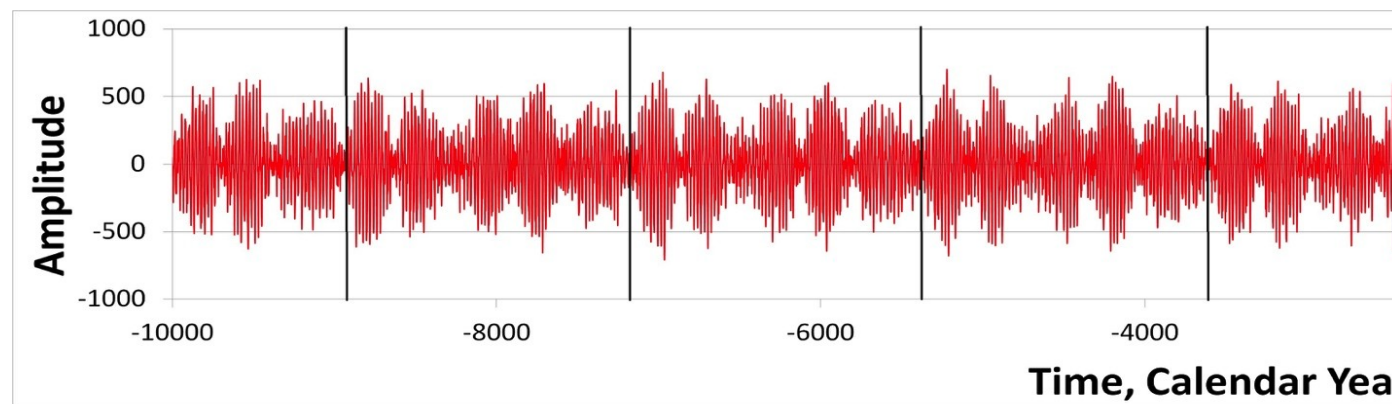
- To occur in 2020 – 2053
- This is a unique event in solar-terrestrial connection □ will reveal the pros and cons of solar dynamo models
- Decrease of solar magnetic field □ big impact ozone reduction, high cloud formation, jet direction changes, cosmic rays increase
- Increase of volcanic and earthquake activities
- Effects on the terrestrial temperature via TSI, jets and volcanic activity
- Shortage of vegetation periods can lead to possible food shortages in 2028-2042
- Need inter-government efforts to avoid disasters

Terrestrial temperature recovery recovery after mini ice age during



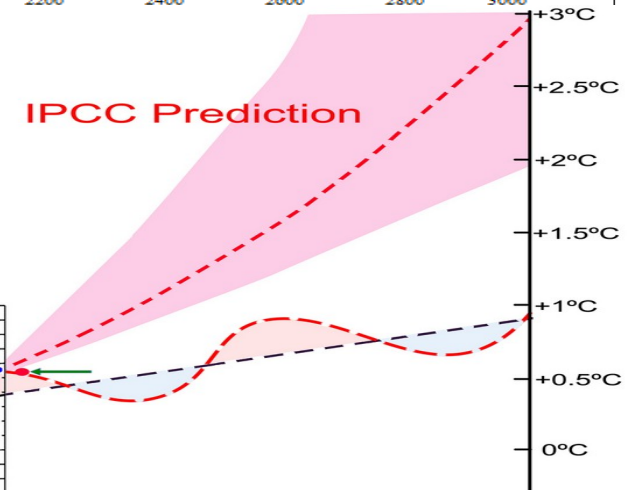
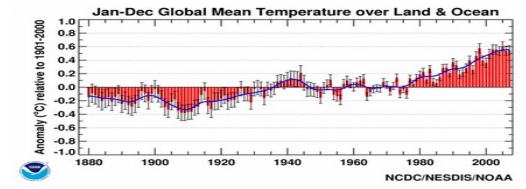
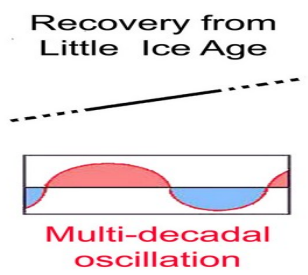
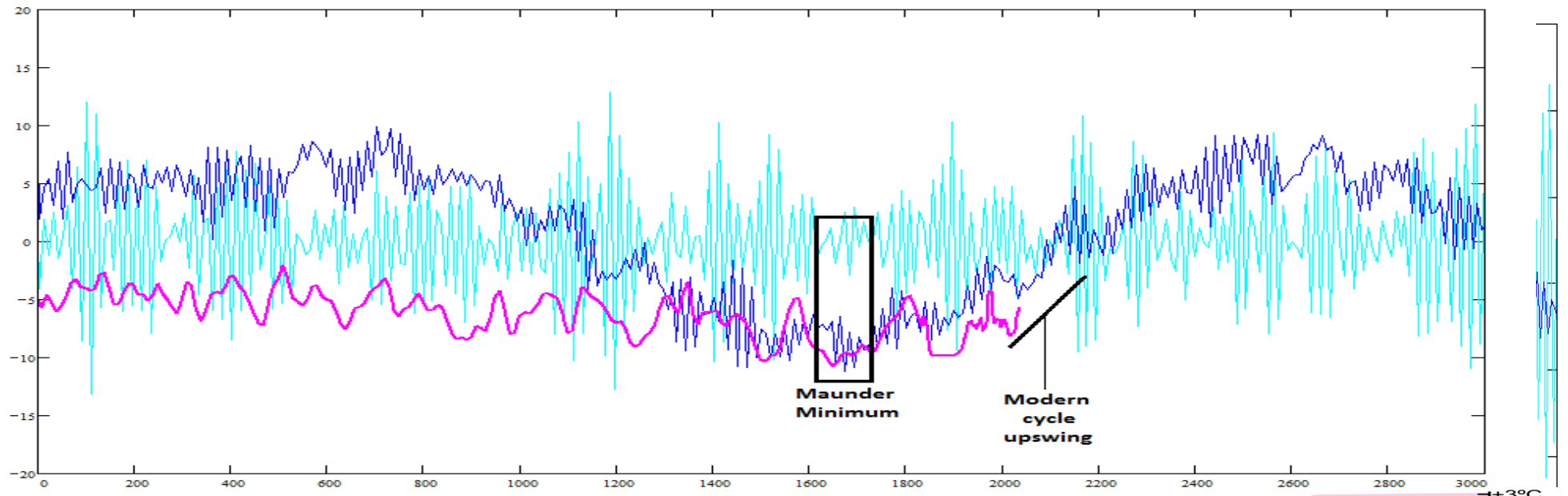
Solar magnetic field (top) baseline oscillations (bottom)

Zharkova et., 2019, 2021



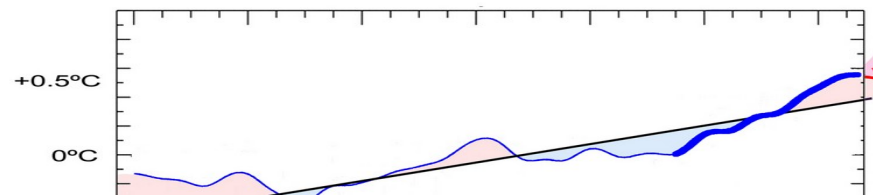
2000-2100 year oscillations (Zharkova et al, 2019, 2020)

of the MF baseline coincides with that of the solar irradiance (Vierra et al, 2011)



Little Ice Age

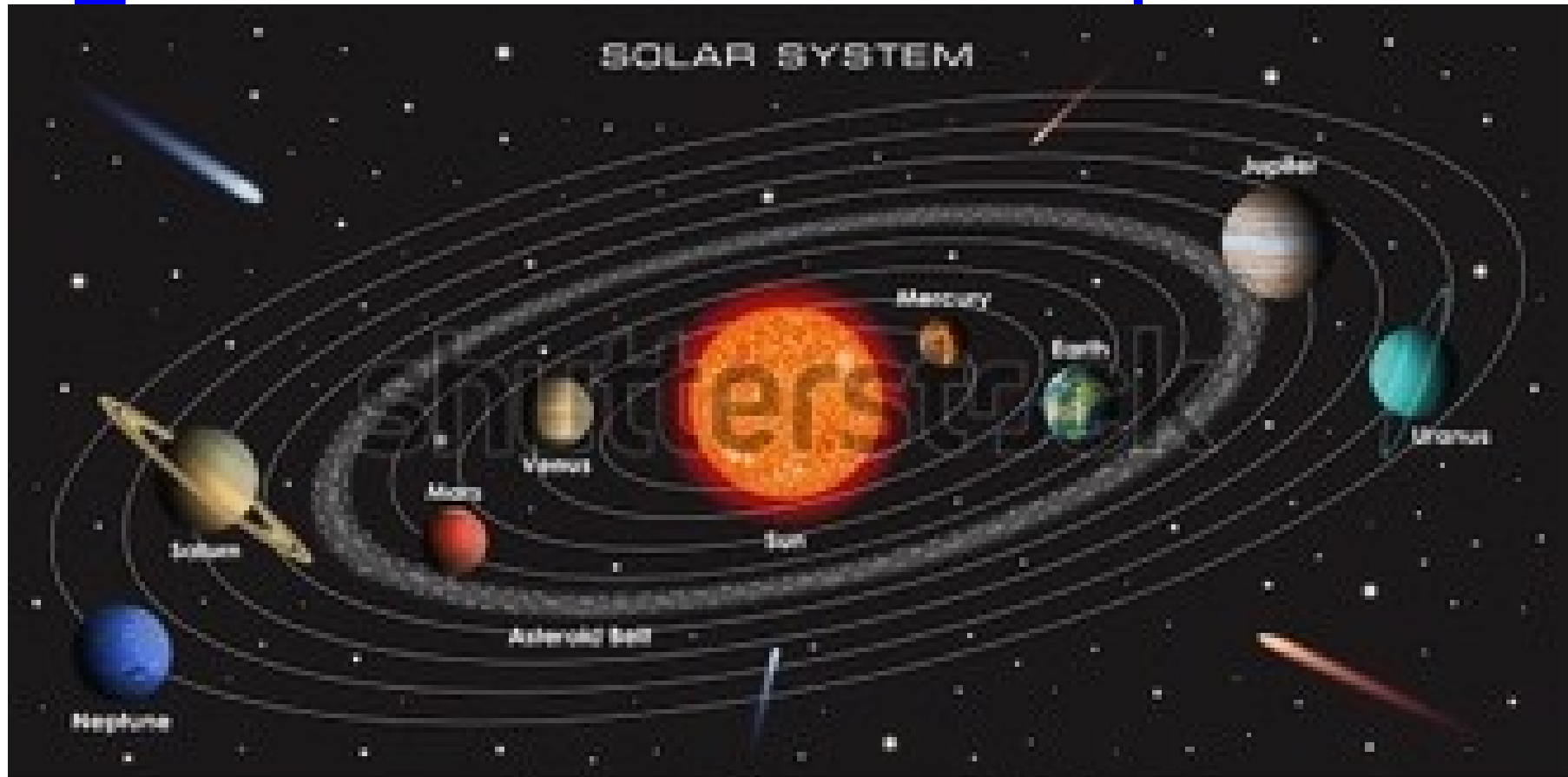
(Akasofu, 2010)



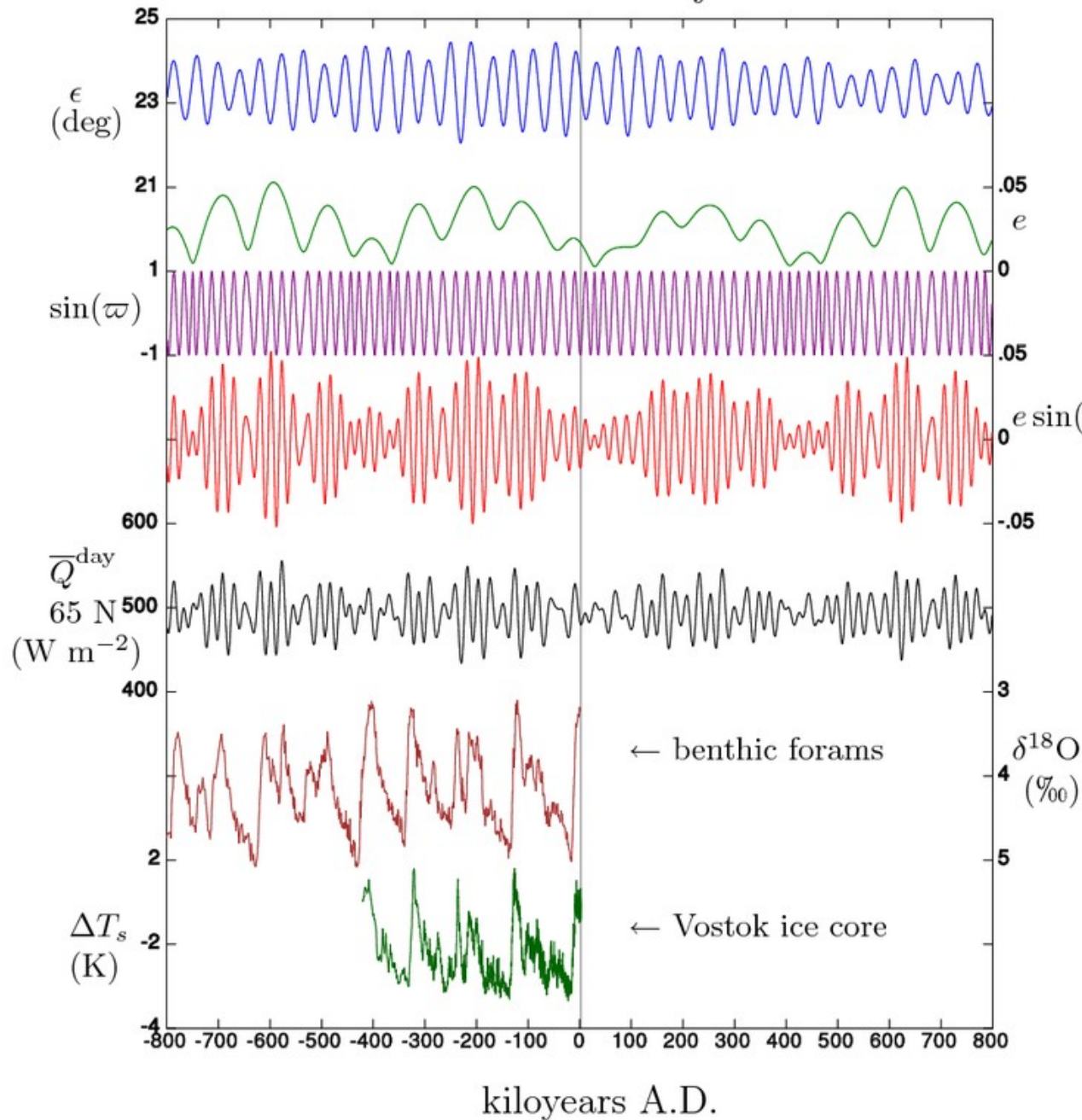
Zharkova et al, 2019, 2020

What are the reasons of solar irradiance oscillations?

- Sun, Earth and other planets



Milankovitch Cycles



Obliquity (axial tilt) (ϵ) ($22^{\circ}.1-24^{\circ}.5$)
 current 23.5 - $T \sim 41\,000$ years

Eccentricity (e). Change on semi-minor axis
 $T \sim 100-400\text{K}$ years effects of Jupiter and Saturn

Longitude of perihelion ($\sin(\varpi)$).

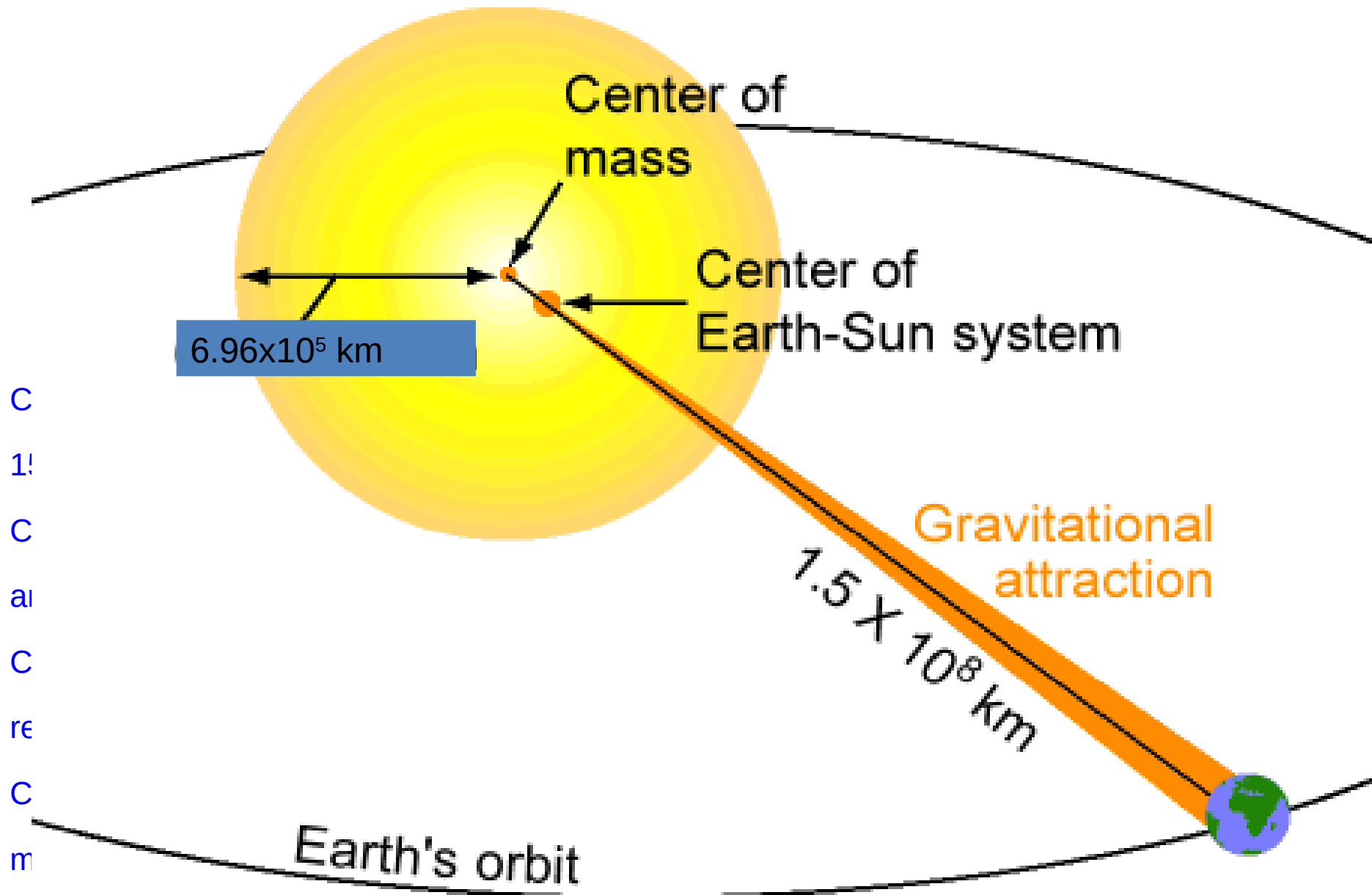
Precession index ($e \sin(\varpi)$) –

- Axial - Earth's axis of rotation relative to fixed stars – $T \sim 25,771.5$ y
- **Apsidal** - orbit ellipse relative to fixed stars – $T \sim 113\,000$ y
- Orbital inclination – $T \sim 70\,000$ y

Earth's movements:

- 1.1 Orbital shape (eccentricity)
 - 1.1.1 Effect on temperature
 - 1.1.2 Effect on lengths of seasons
- 1.2 Axial tilt (obliquity)
- 1.3 Axial precession
- 1.4 Apsidal precession
- 1.5 Orbital inclination (

Solar Inertial Motion



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Solar Orbit Simulator

About

Quit

The simulator shows the orbit of the solar system centre of mass with respect to the Sun, as a function of time.

Select start and end dates and watch the pattern evolve.

Start date

January 1192

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

End date

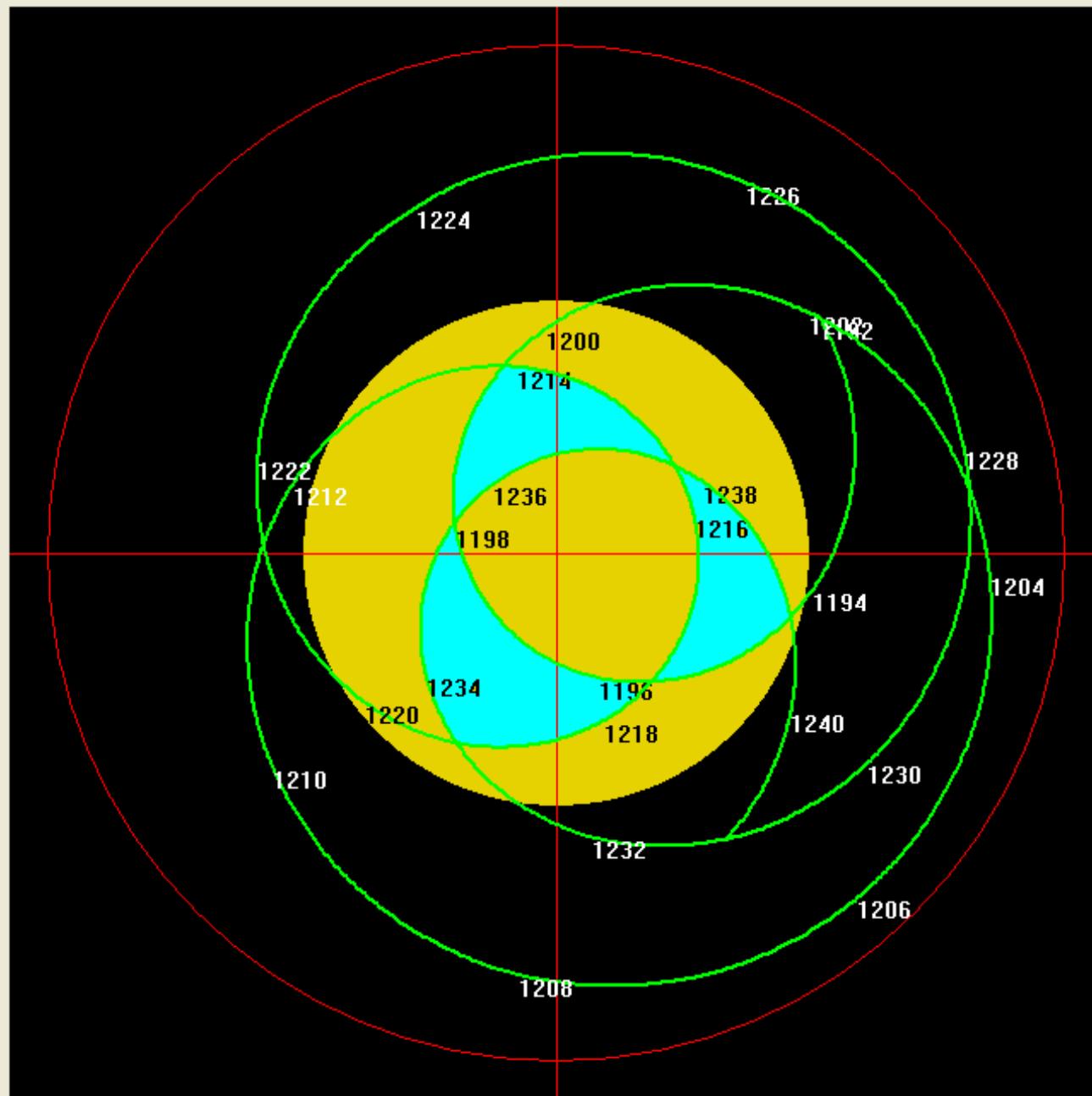
January 1241

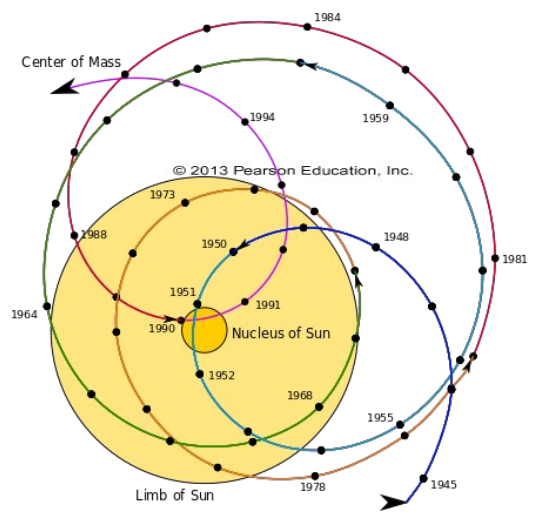
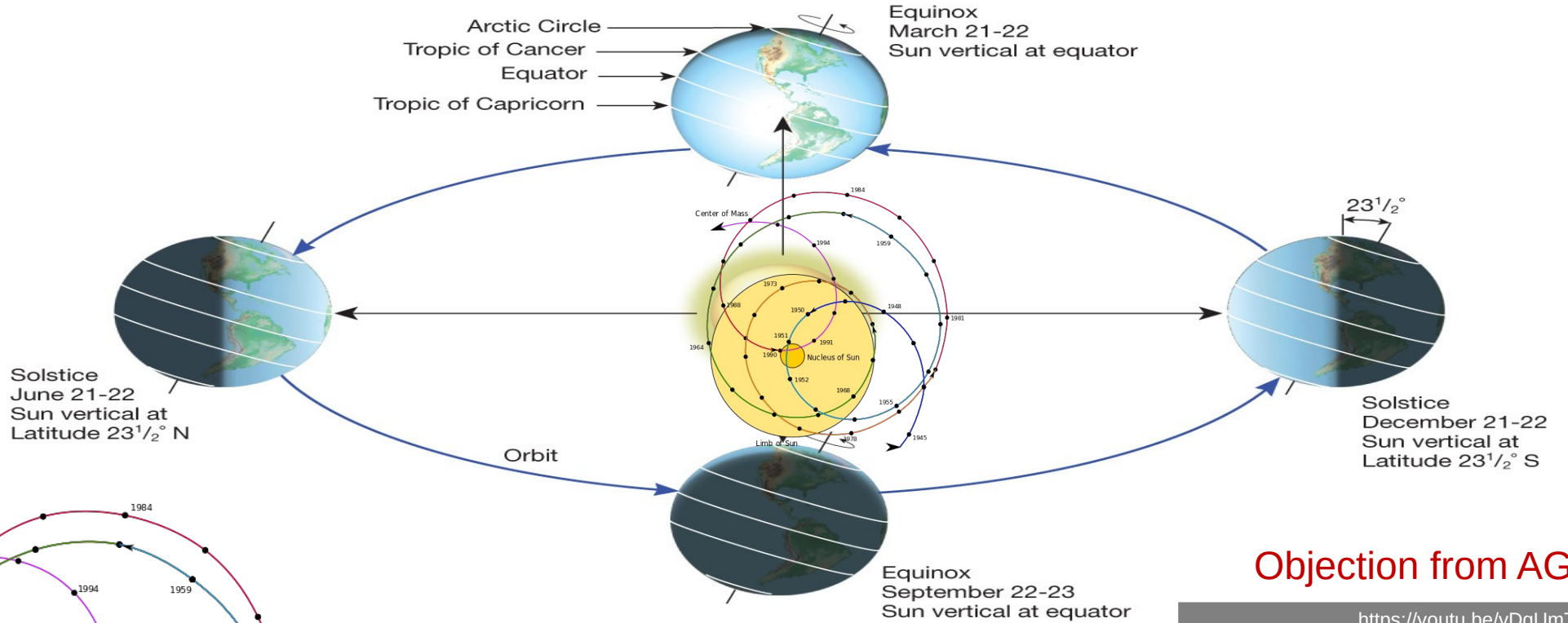
Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Increment [days] 7

 Show years

Start/Stop

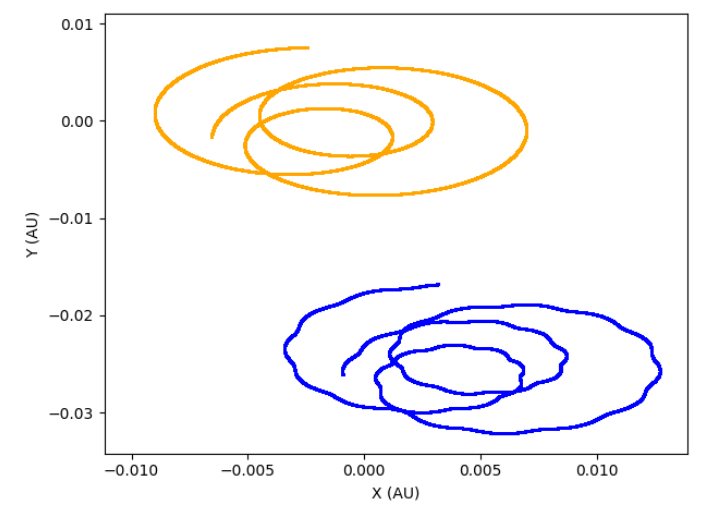




The Sun moves inside a circular area which has a diameter of 0.02 AU (= 4.3 solar radii = 3.106 km). The Sun moves with a velocity between 9 and 16 m/s.

Objection from AGW people

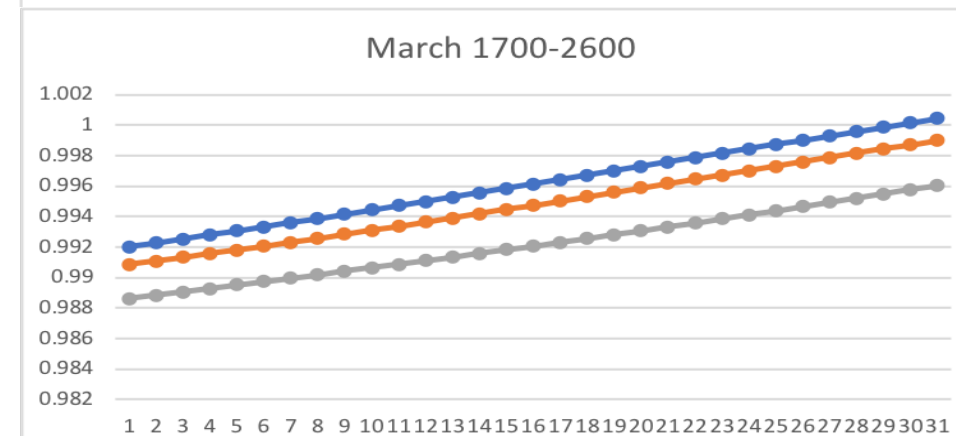
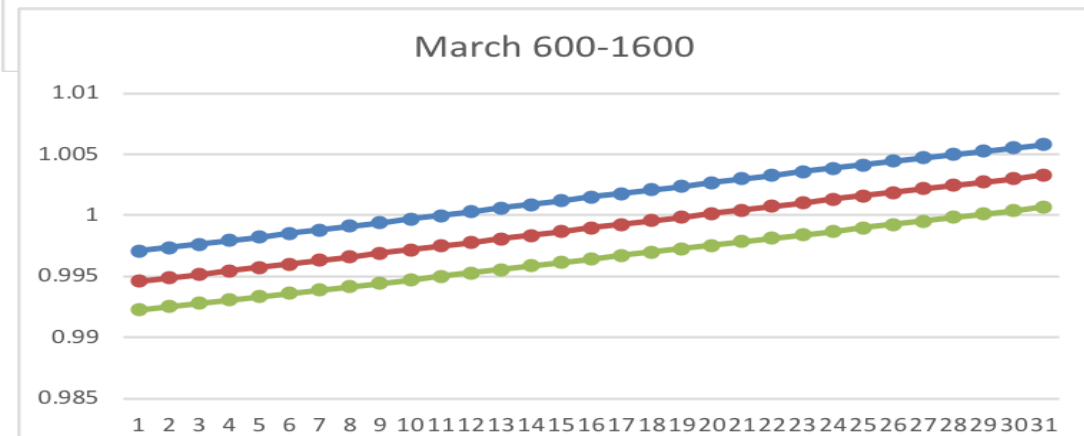
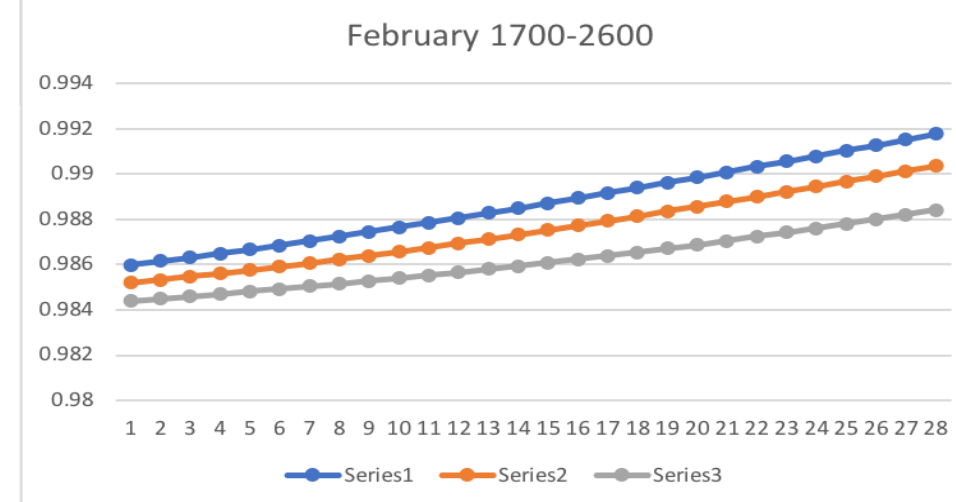
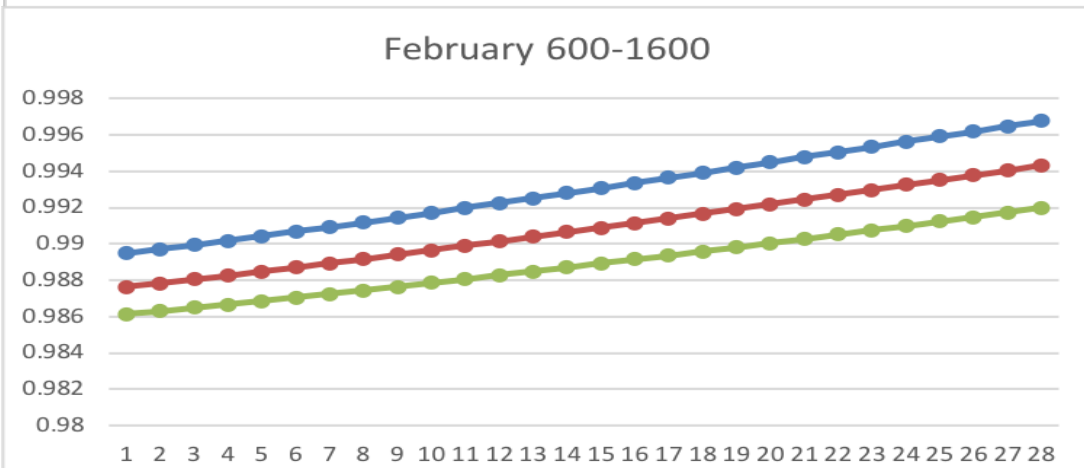
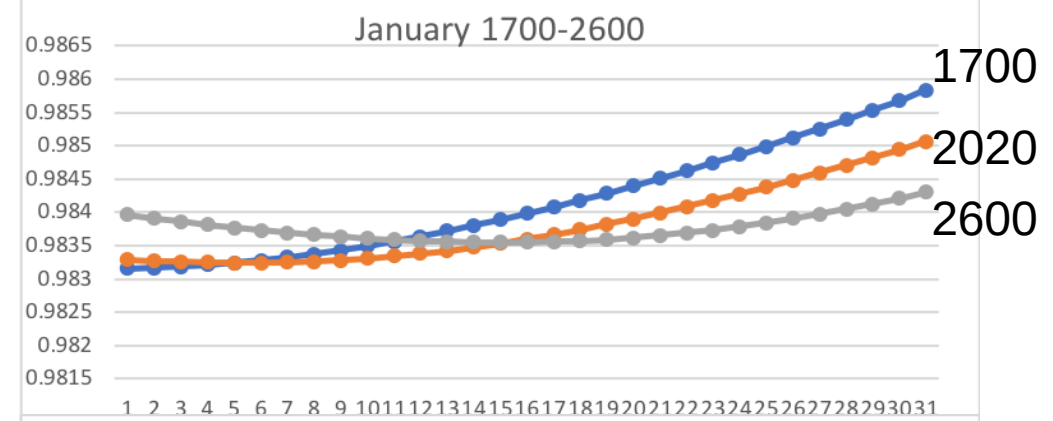
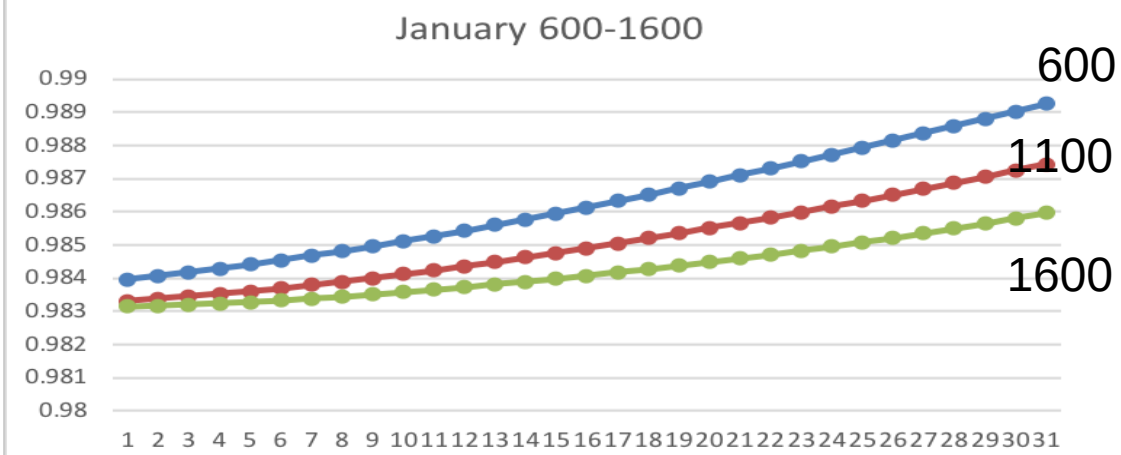
<https://youtu.be/vDgUmTq4a2Q>



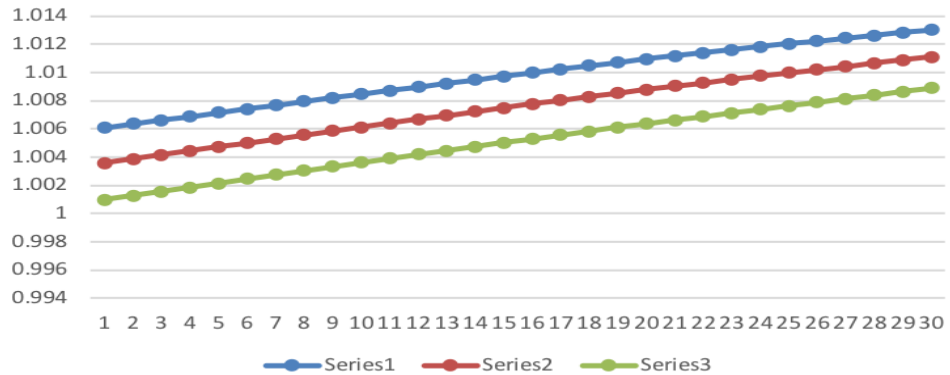
S. Perminov, E.D. Kuznetsov, 2018
SIM imposed by planets Jupiter, Saturn, Neptune and Uranus

Charvatova, 1988,
Palus et al, 2007

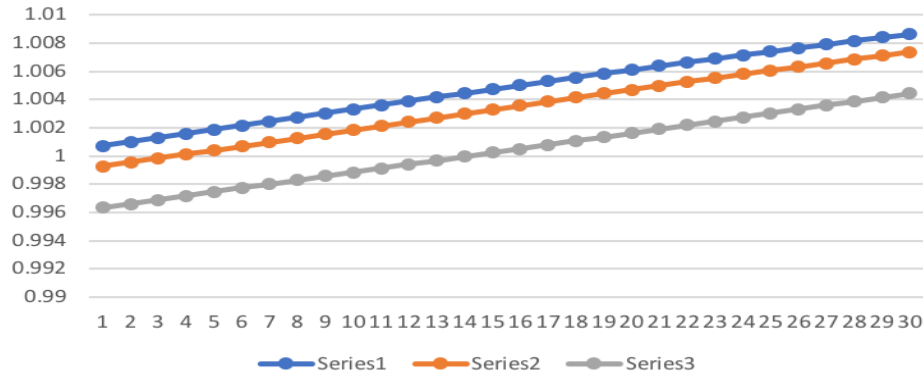
Rice et al, PP comments #72, 96



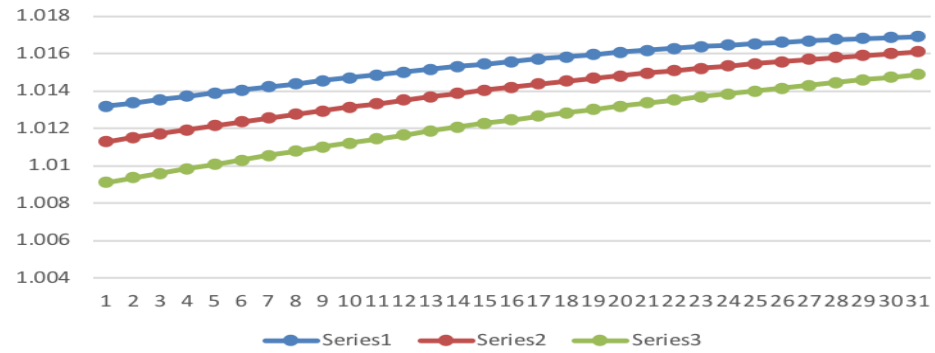
April 600-1600



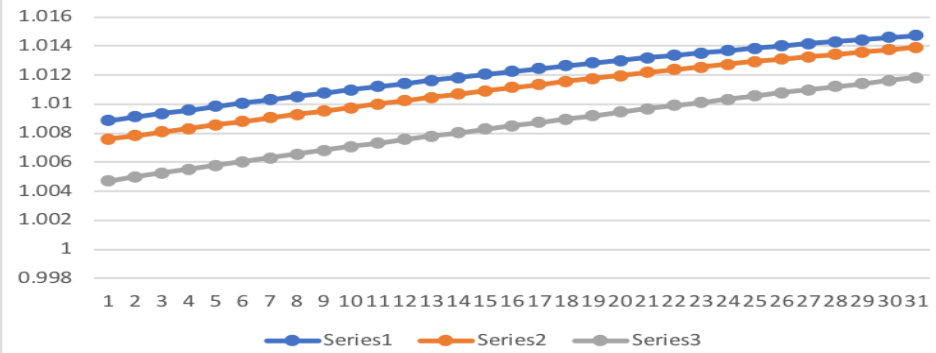
April 1700-2600



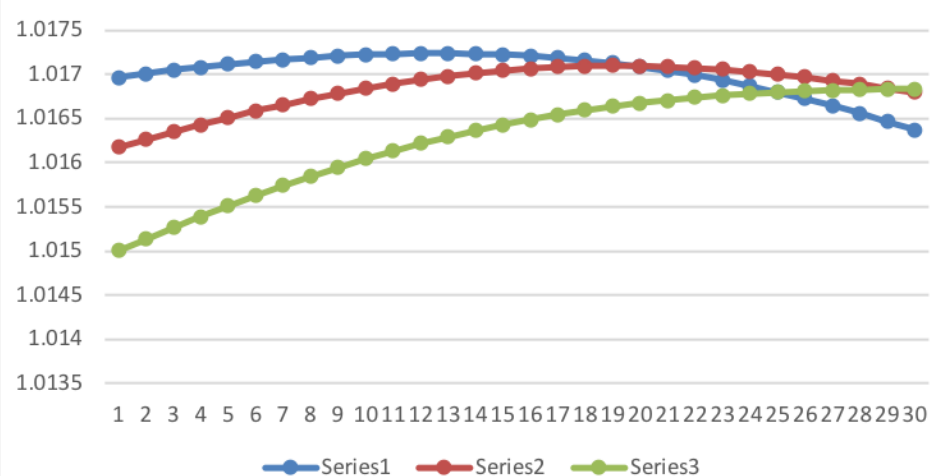
May 600-1600



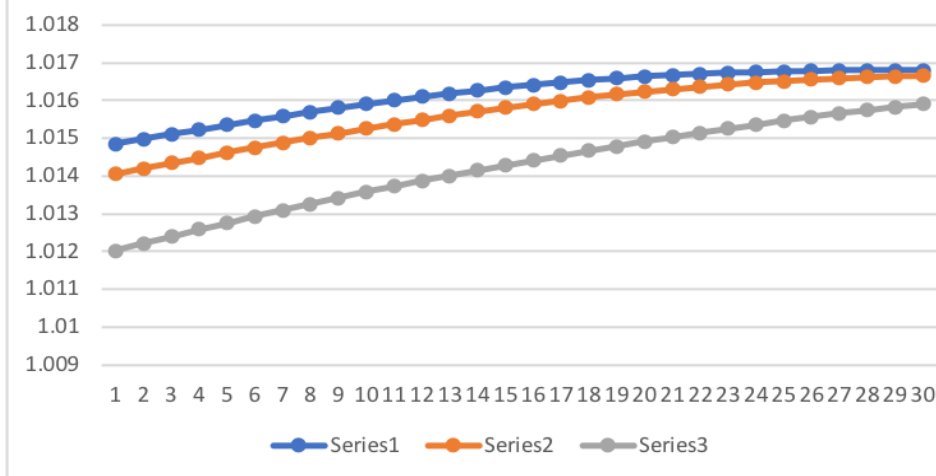
May 1700-2600



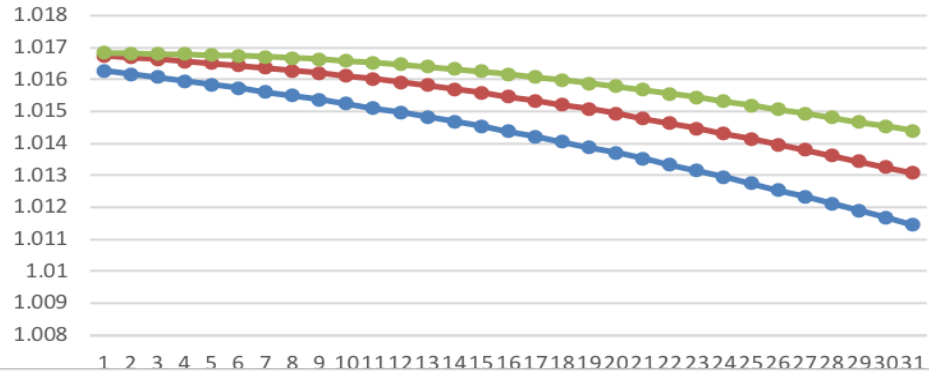
June 600-1600



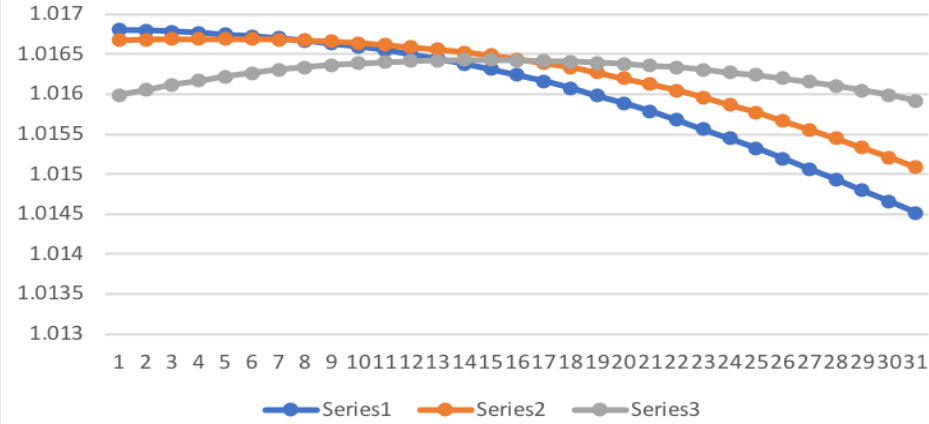
June 1700-2600



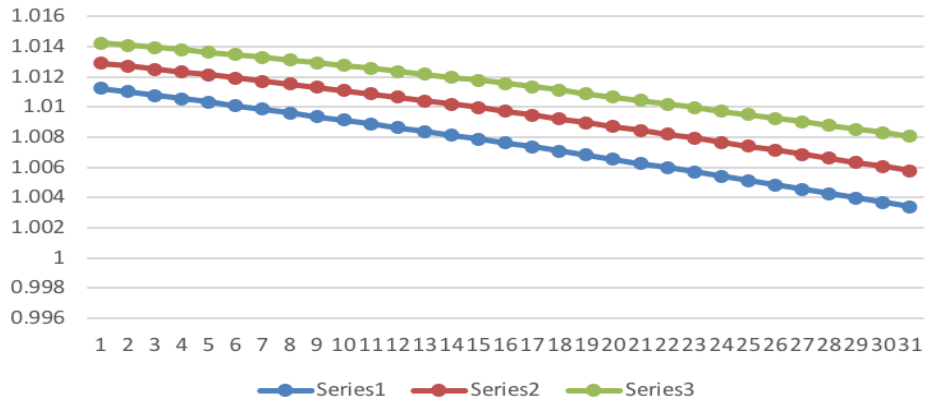
July 600-1600



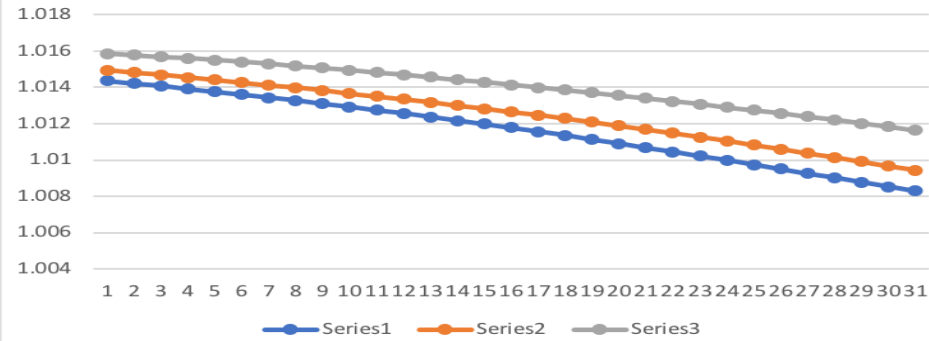
July 1700-2600



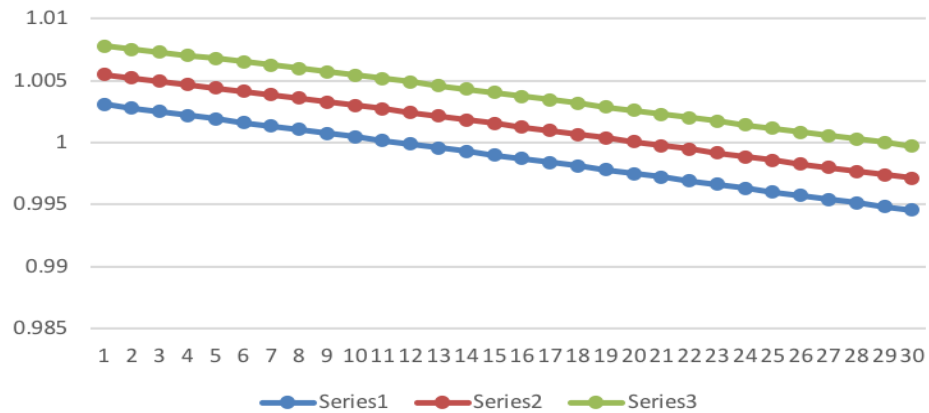
August 600-1600



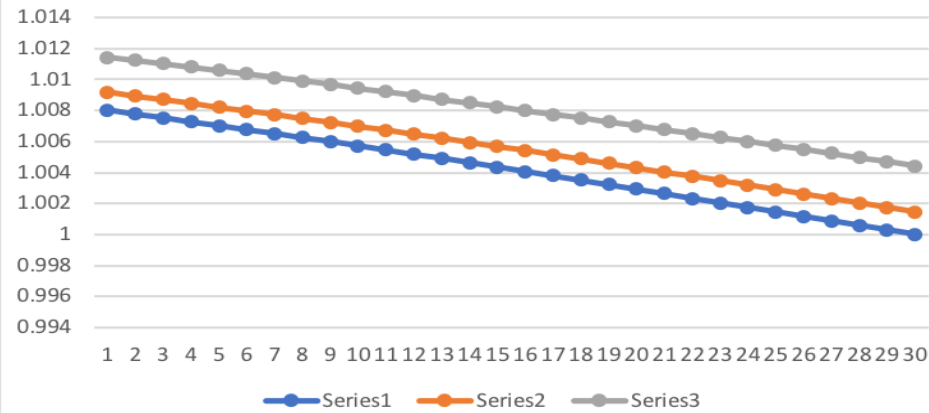
August 1700-2600



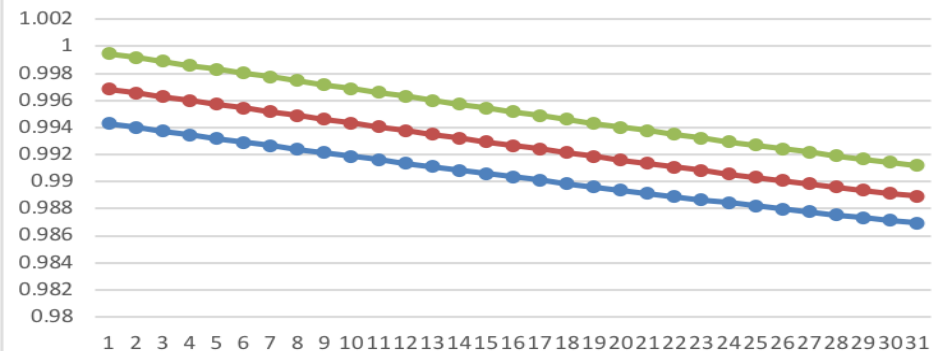
September 600-1600



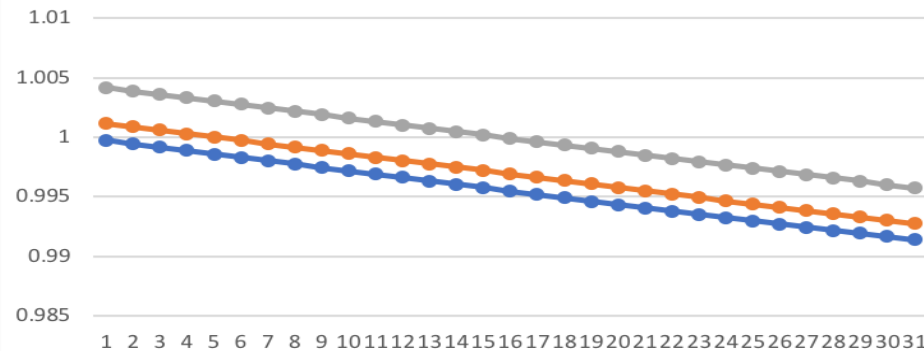
September 1700-2600



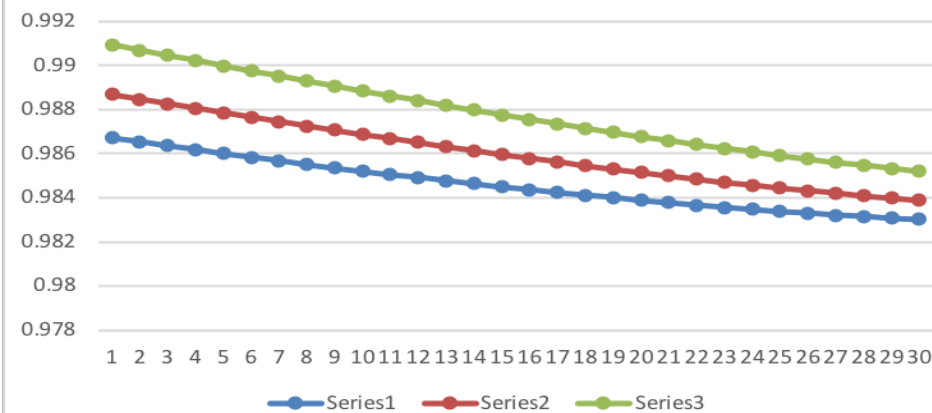
October 600-1600



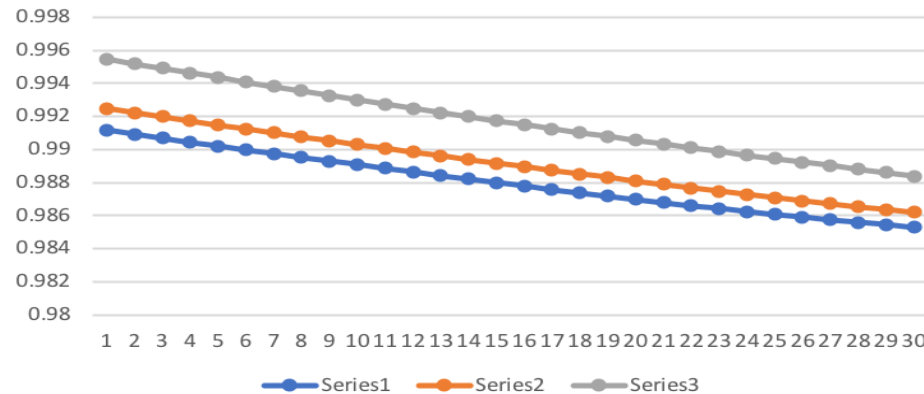
October 1700-2600



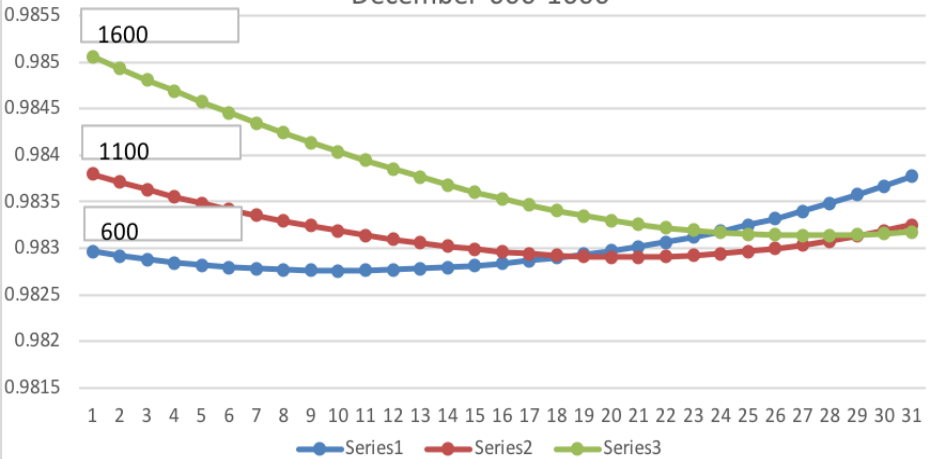
November 600-1600



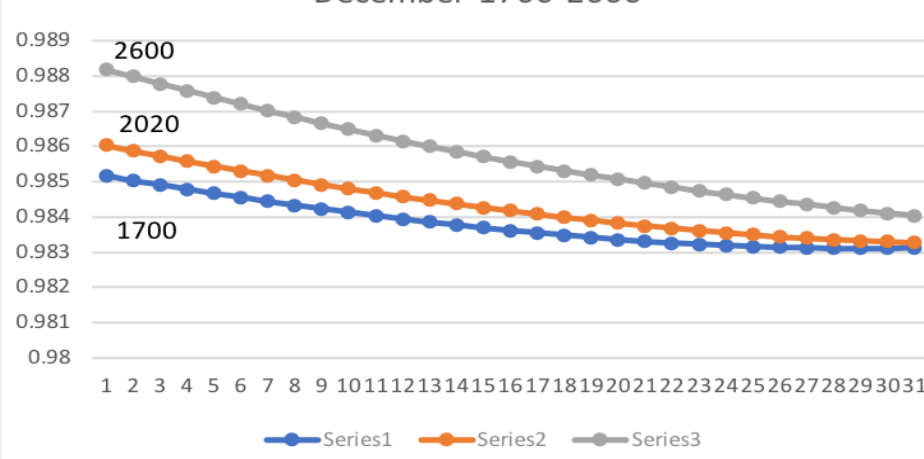
November 1700-2600

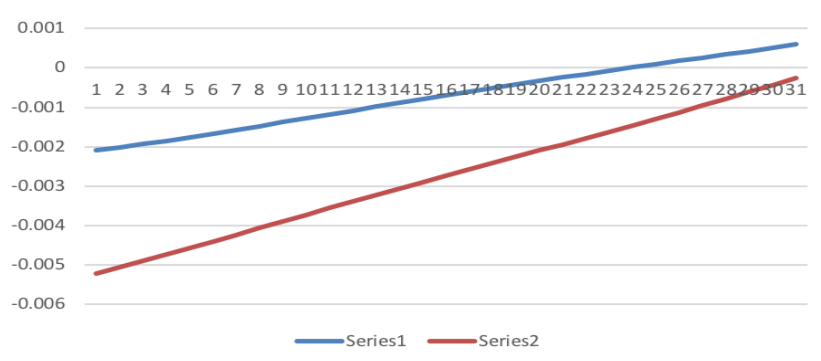
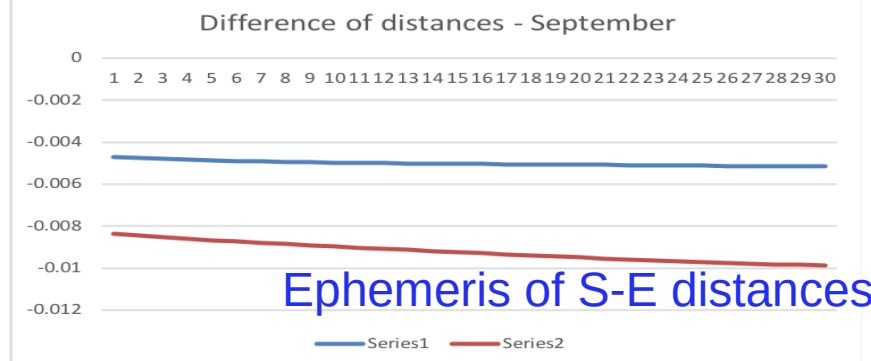
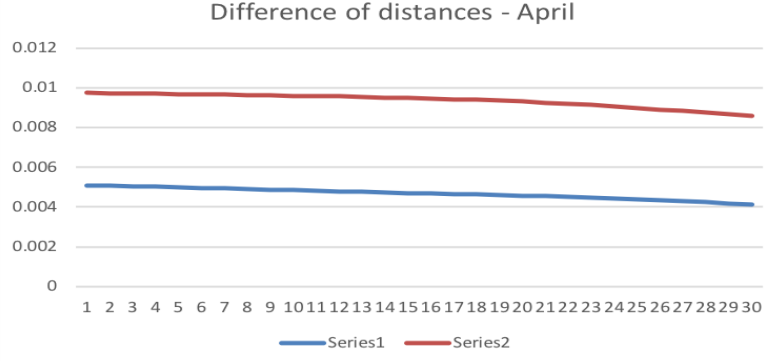
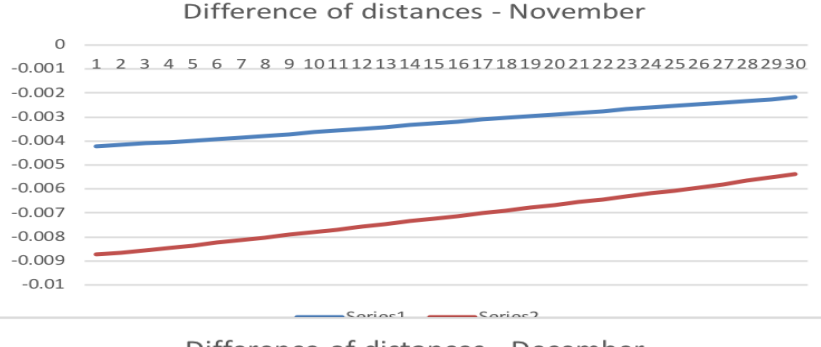
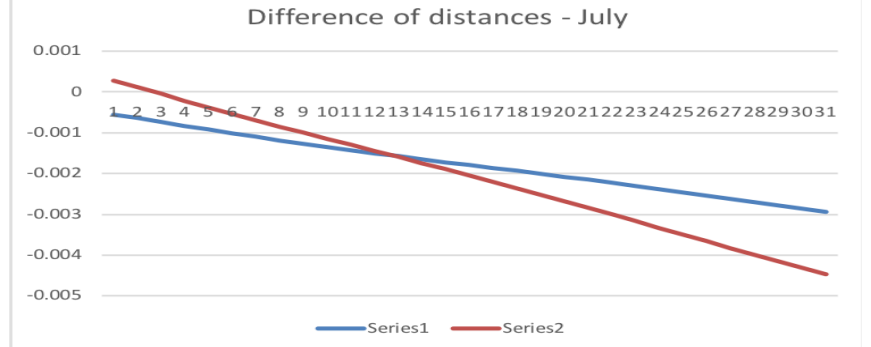
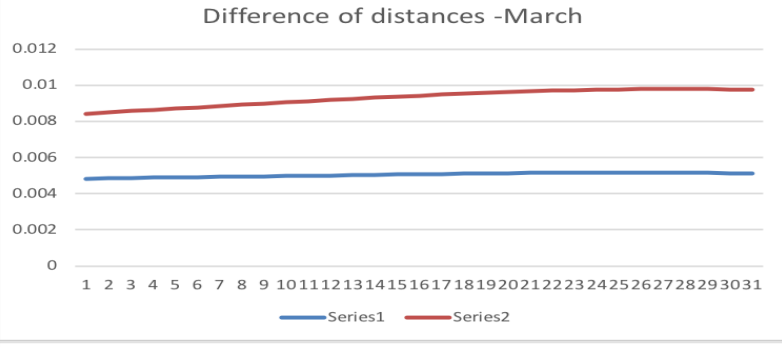
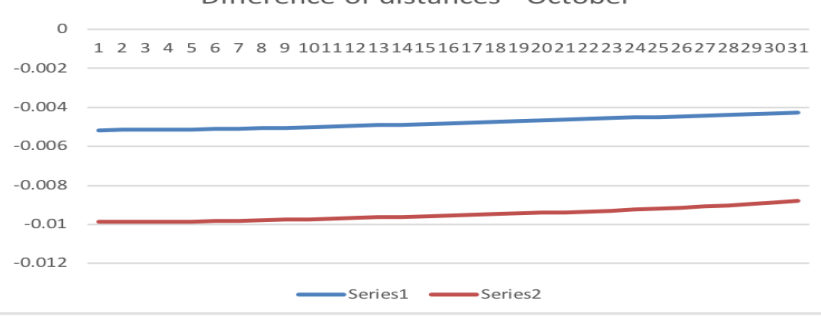
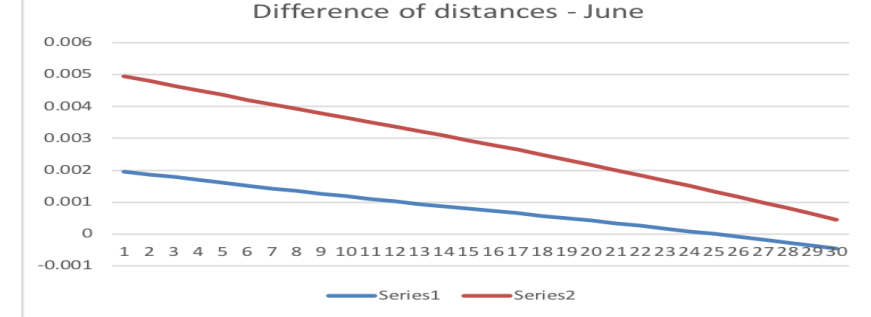
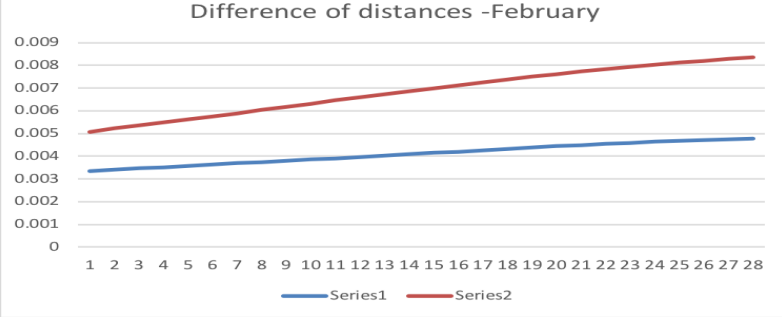
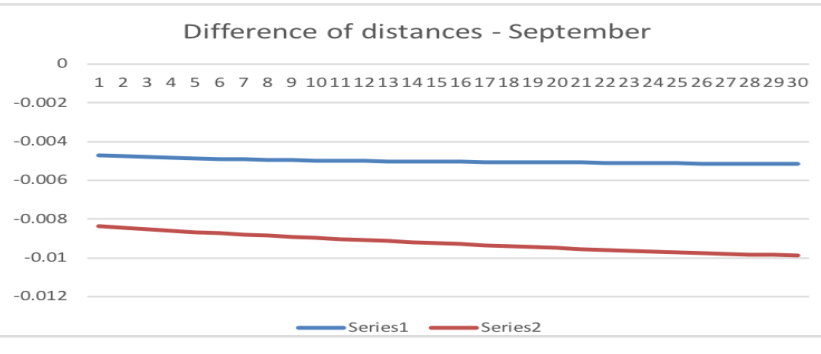
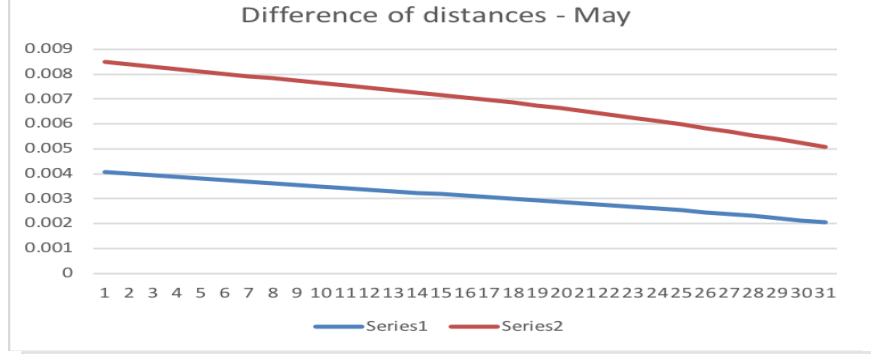
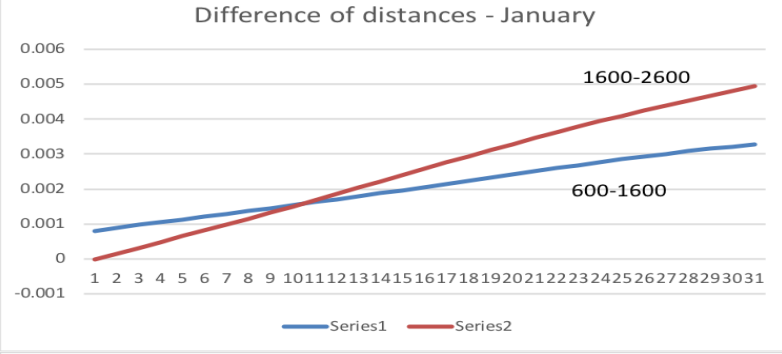


December 600-1600



December 1700-2600

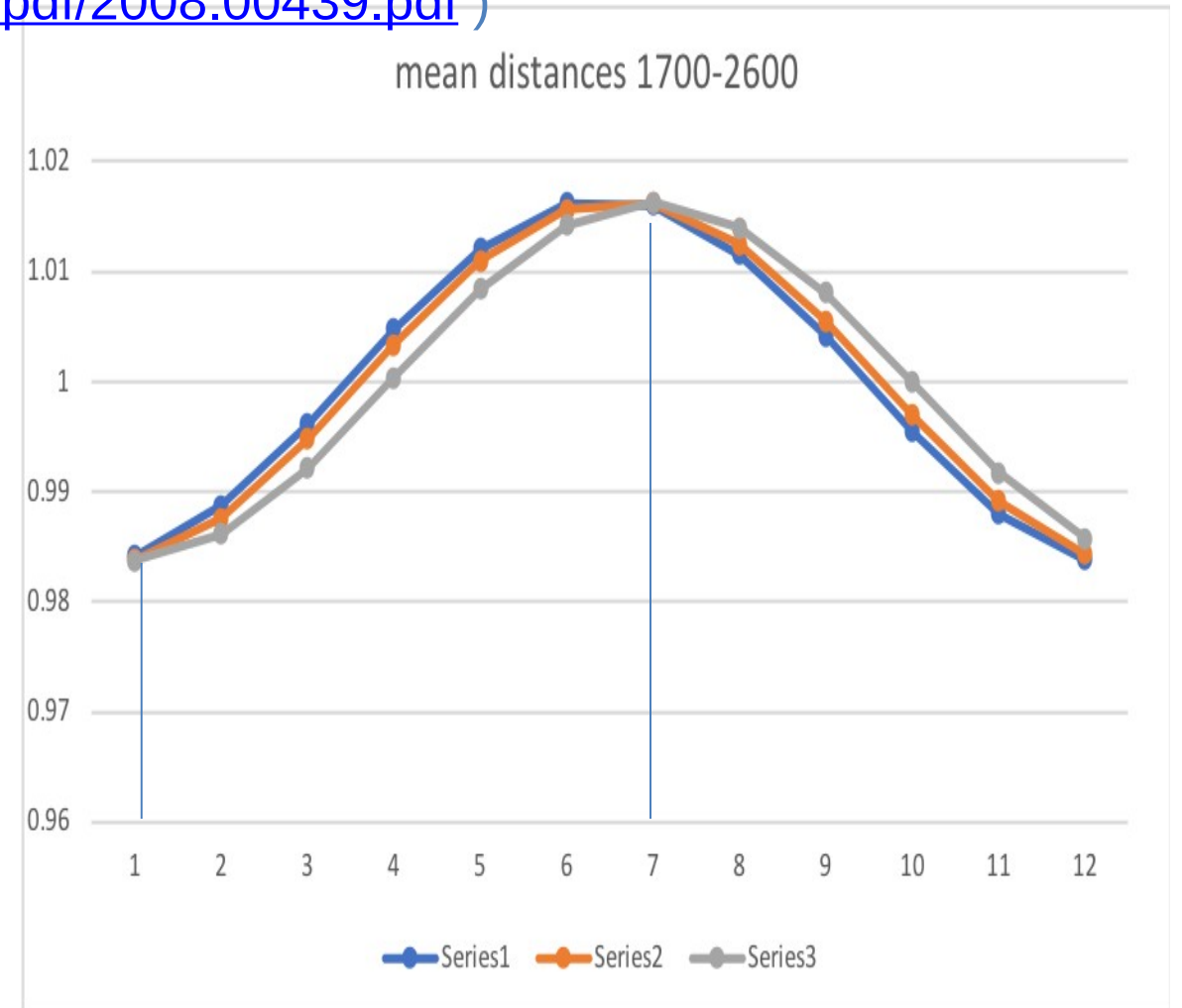
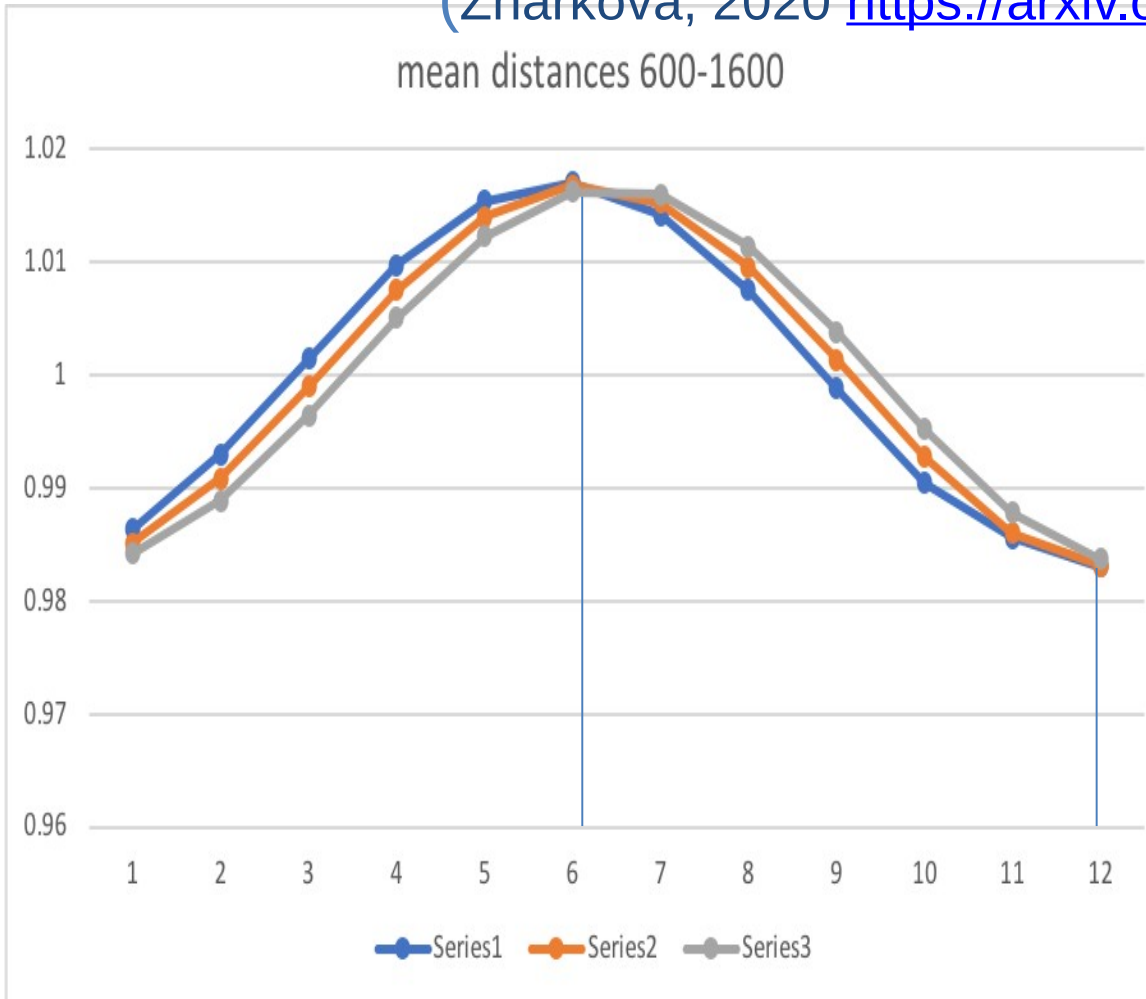




Ephemeris of S-E distances

Annual variations of mean S-E distances (ephemeris) in M1 (600-1600) and M2 (1700-2600)

(Zharkova, 2020 <https://arxiv.org/pdf/2008.00439.pdf>)



M1 – aphelion is in June, shifting to mid-July in M2

a - Sun - in the ellipse focus

b - Sun shifted by SIM to spring equinox

Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn

Equinox
March 21-22
Sun vertical at equator

2600

Aphelion □. 16 July

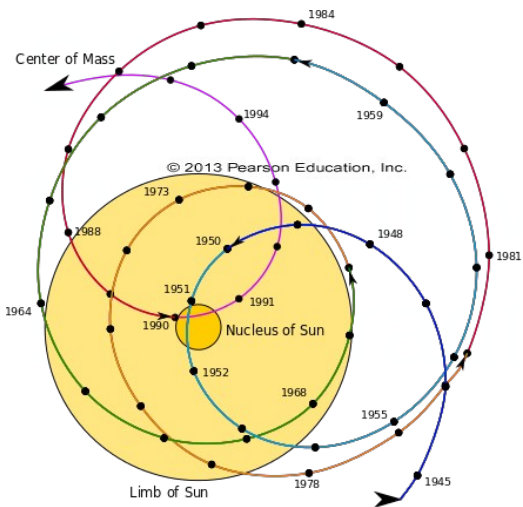
Perihelion □ 16 January

Solstice
June 21-22
Sun vertical at
Latitude $23\frac{1}{2}^\circ$ N

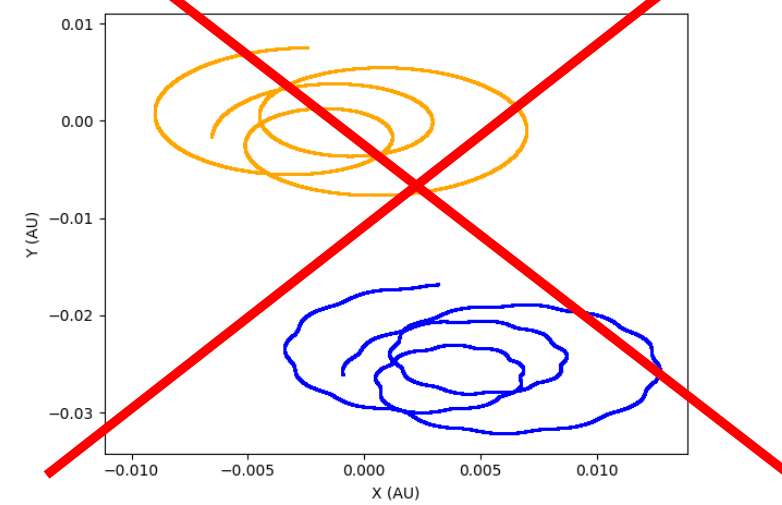
Solstice
December 21-22
Sun vertical at
Latitude $23\frac{1}{2}^\circ$ S

Orbit

Equinox
September 22-23
Sun vertical at equator



~~<https://youtu.be/vDgUmTq4a2Q>~~



S. Perminov, E.D. Kuznetsov, 2018

SIM imposed by planets Jupiter, Saturn, Neptune and Uranus

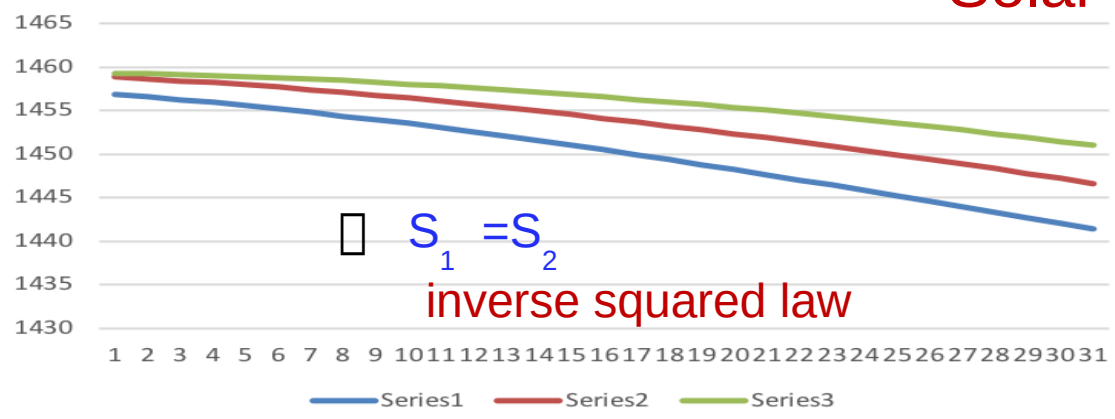
Charvatova, 1988,

Palus et al, 2007

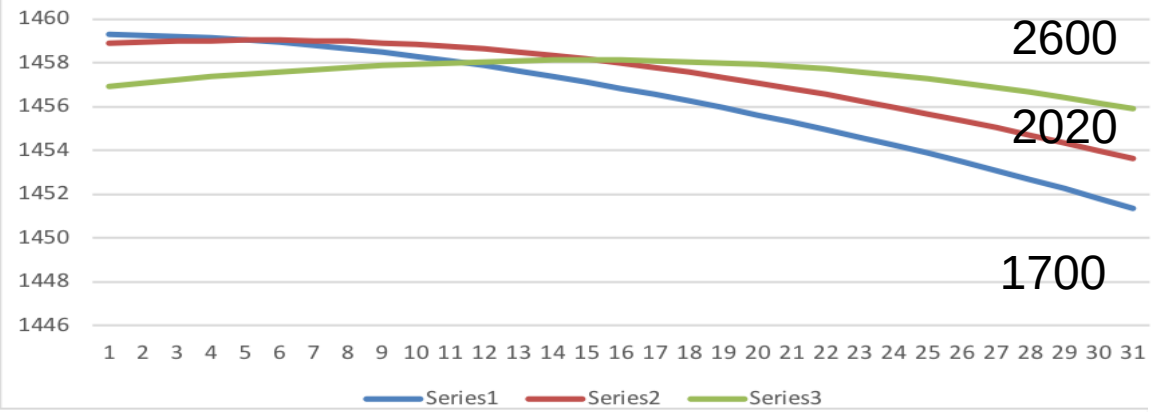
Rice et al, PP comments #72, 96

Solar irradiance

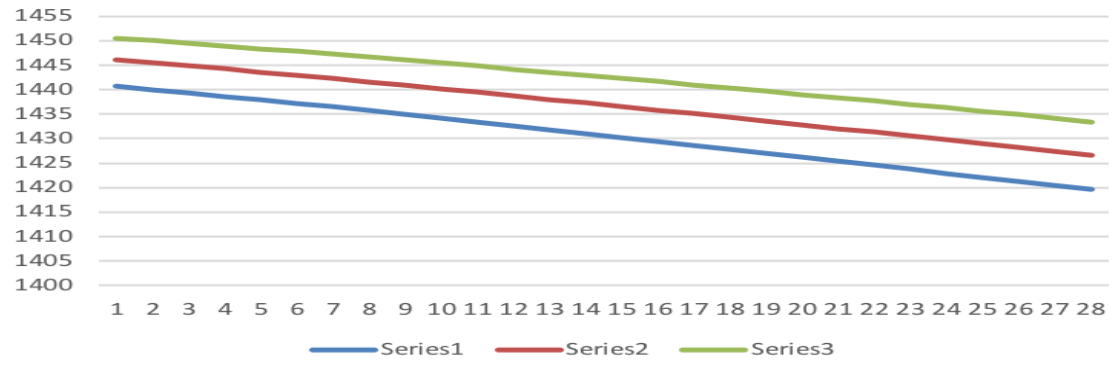
TSi variations January 600-1600



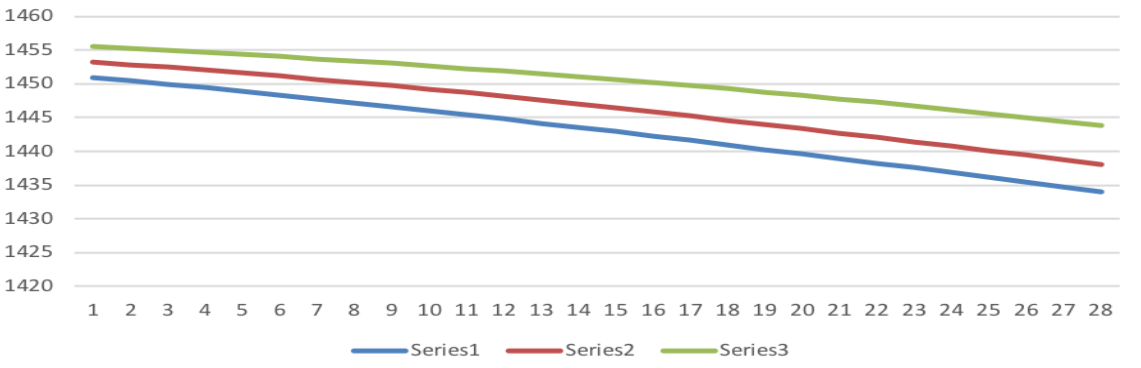
TSi variation January 1700-2600



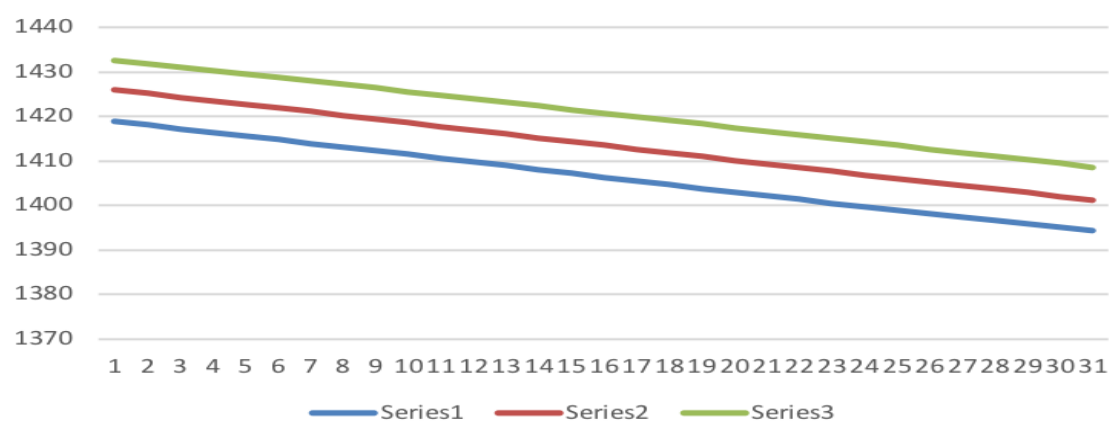
TSi variations February 600-1600



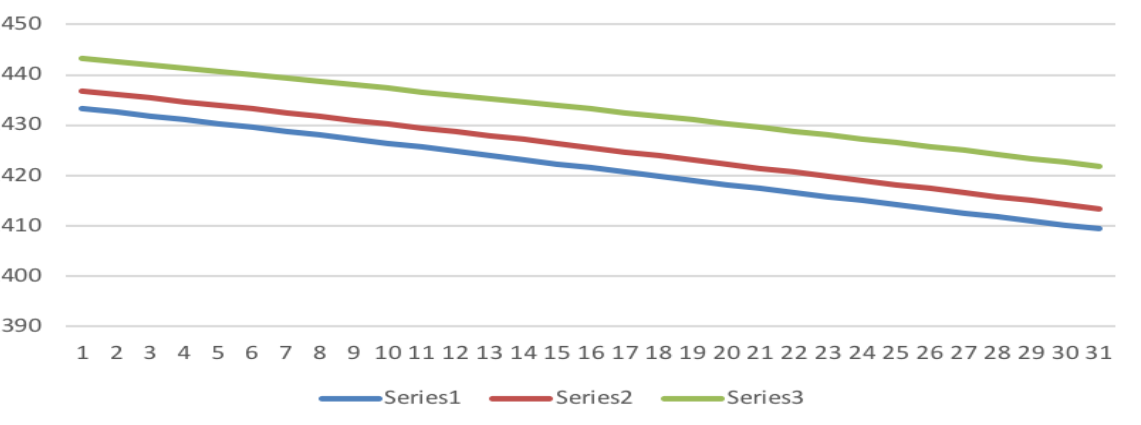
TSi variations February 1700-2600



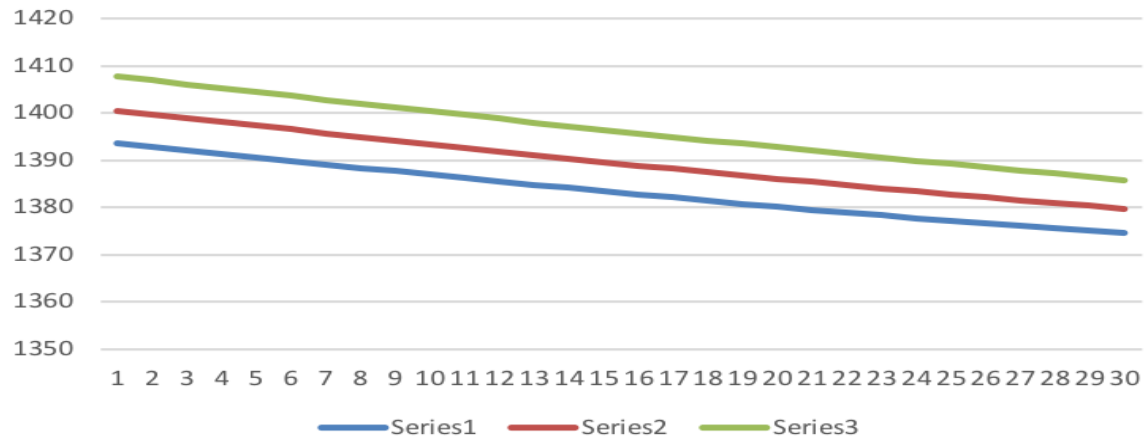
TSi variations March 600-1600



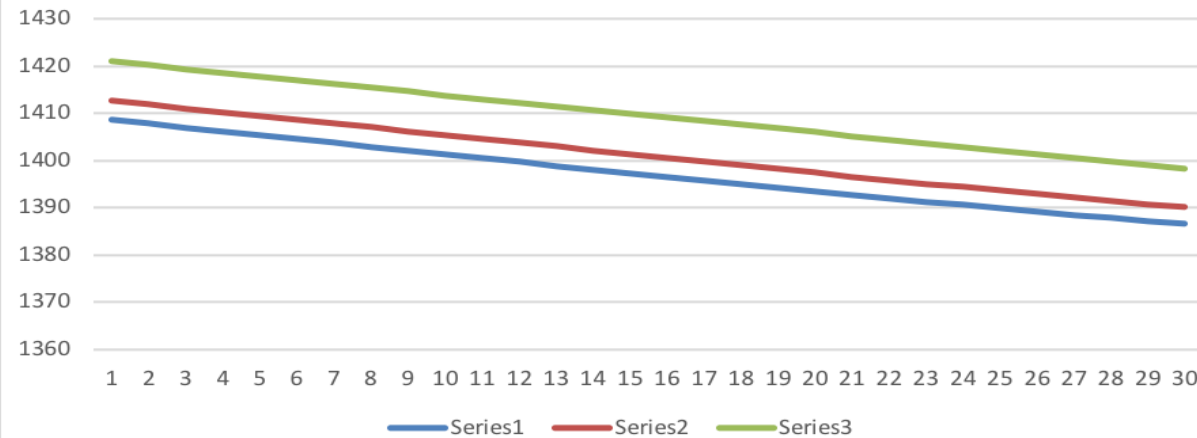
TSi variations March 1700-2600



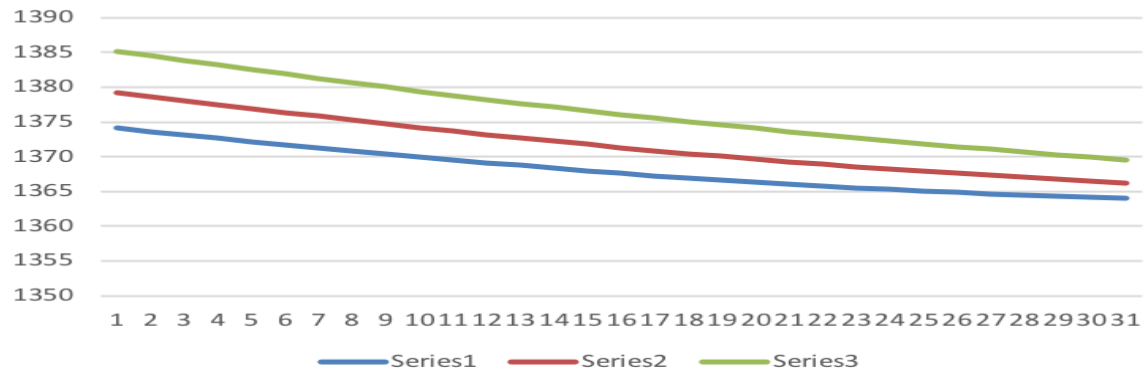
TSI variations April 600-1600



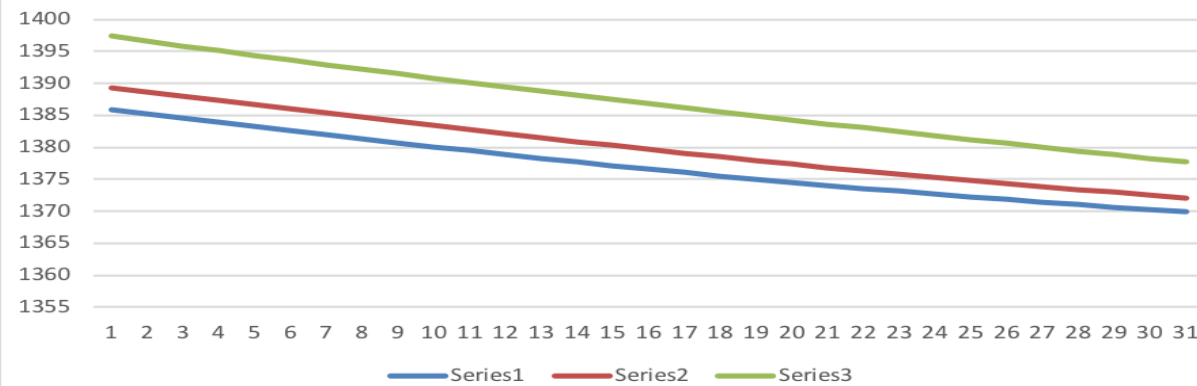
TSI variations April 1700-2600



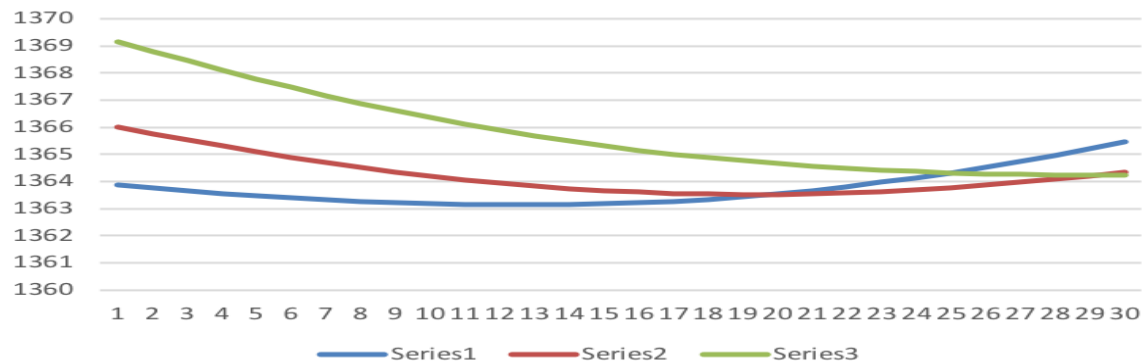
TSI variations May 600-1600



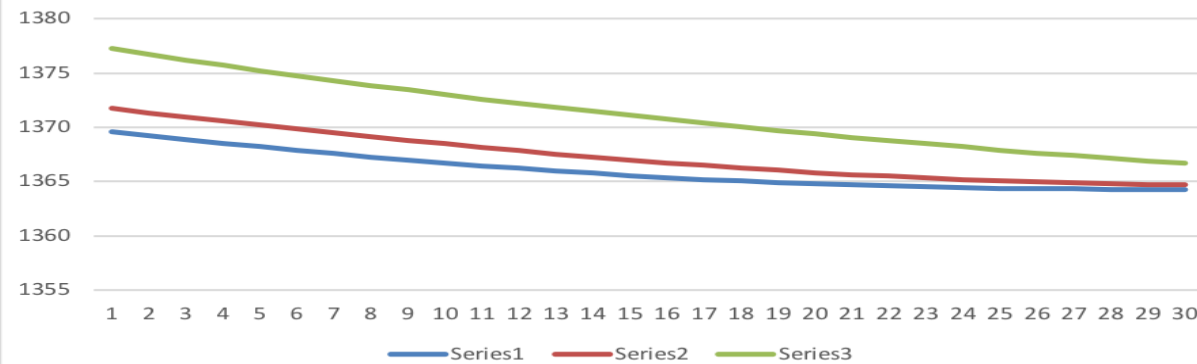
TSI variationsa May 1700-2600



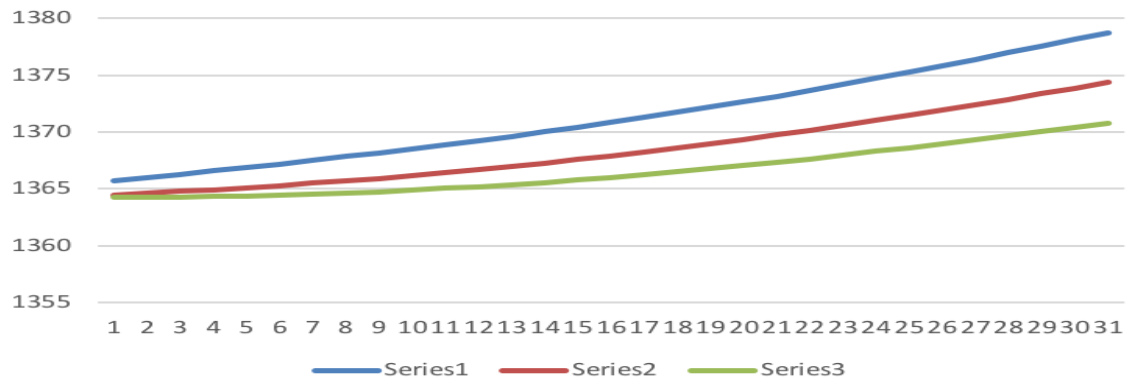
TSI variations June 600-1600



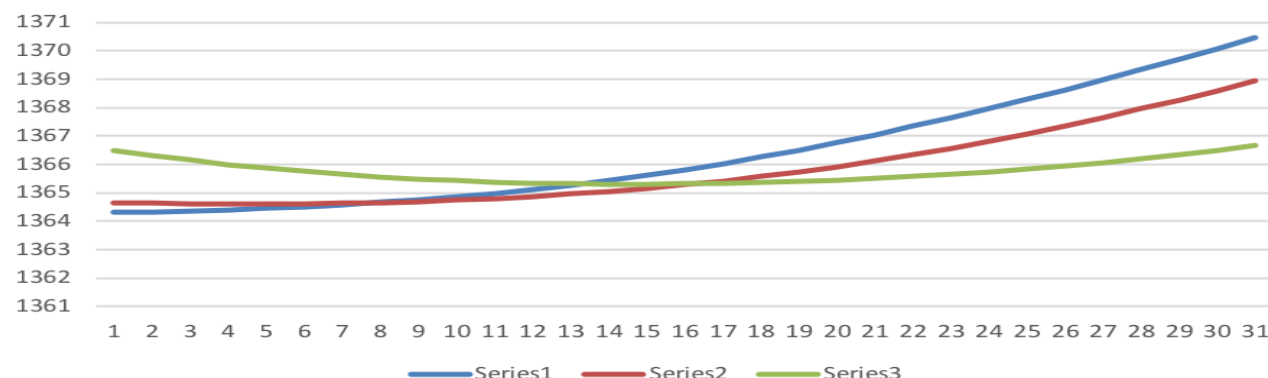
TSI variations June 1700-2600



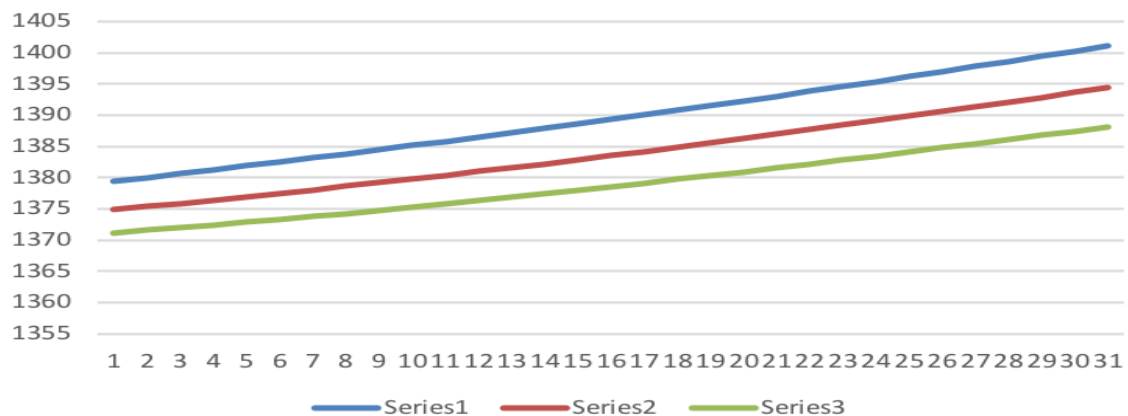
TSI variations July 600-1600



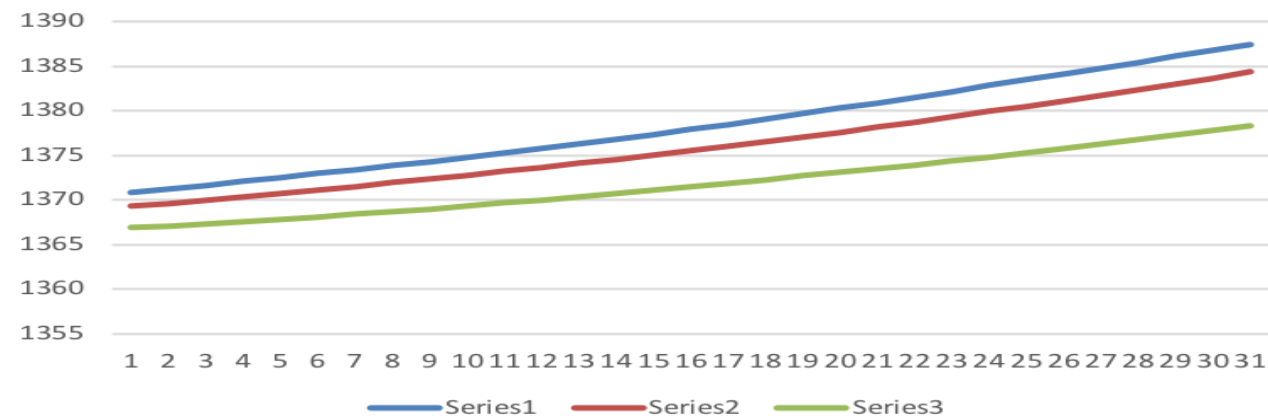
TSI variations July 1700-2600



TSI variations August 600-1600



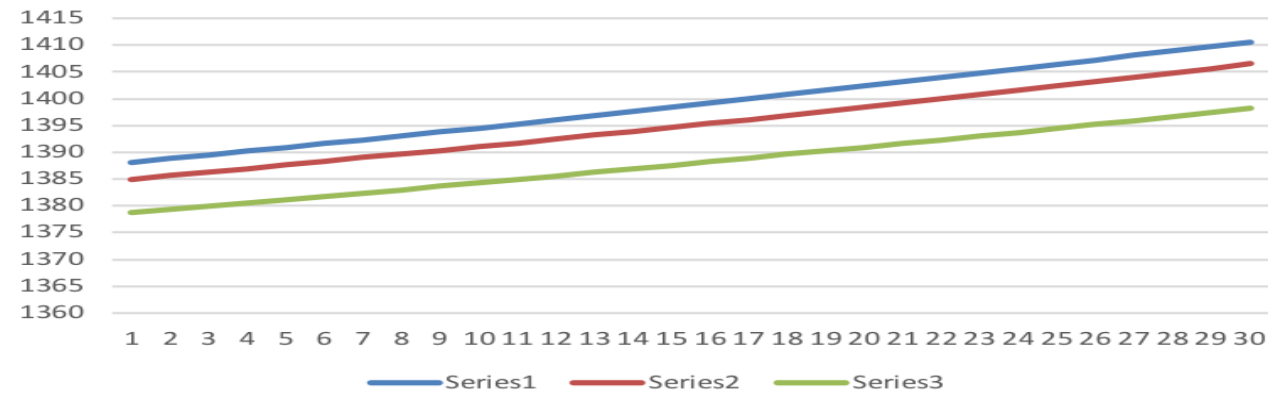
TSI variations August 1700-2600



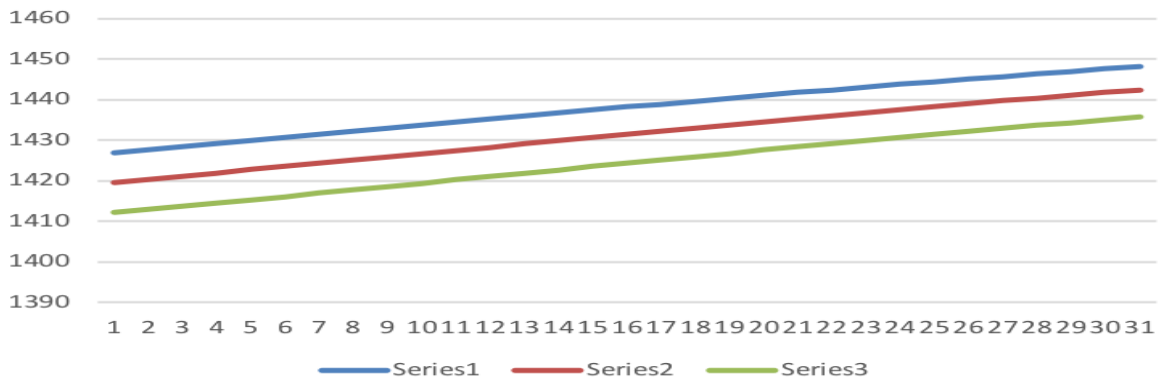
TSI variations September 600-1600



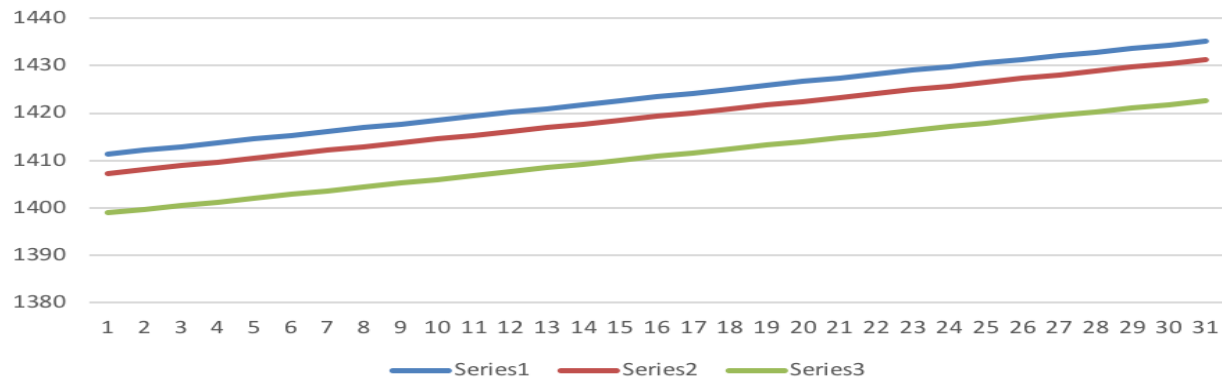
TSI variations September 1700-2600



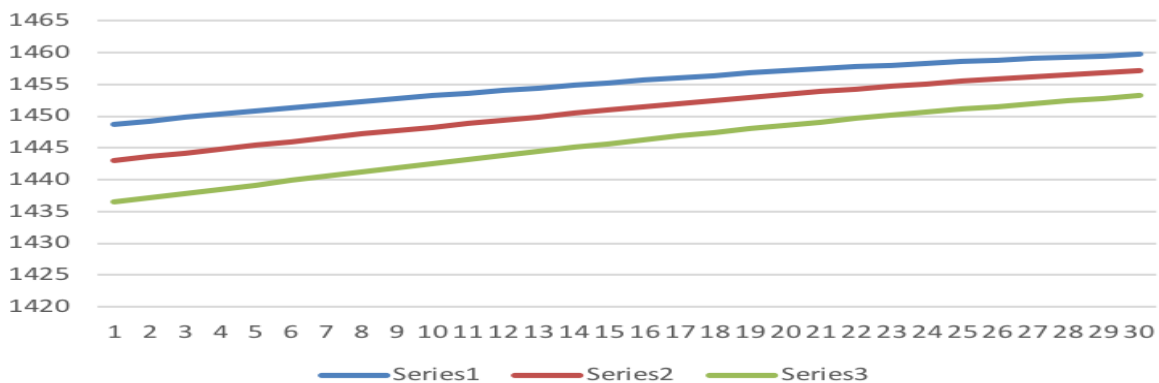
TSI variations October 600-1600



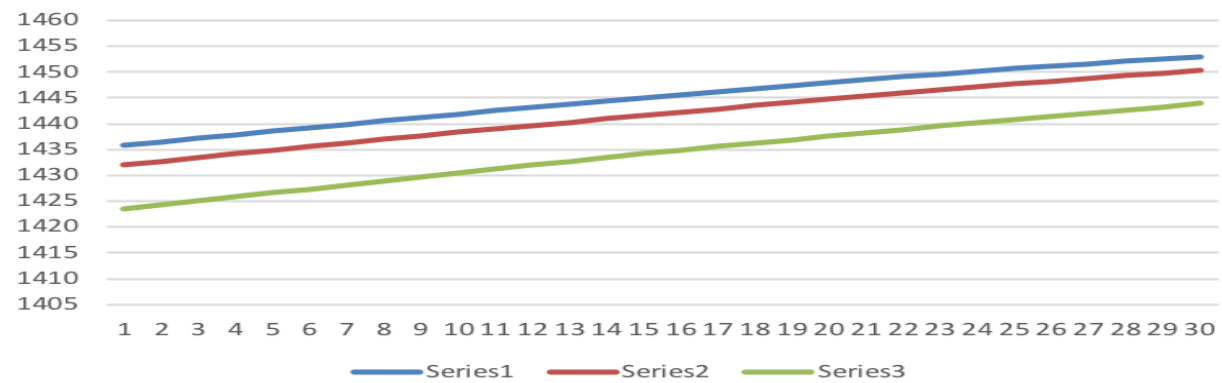
TSI variations October 1700-2600



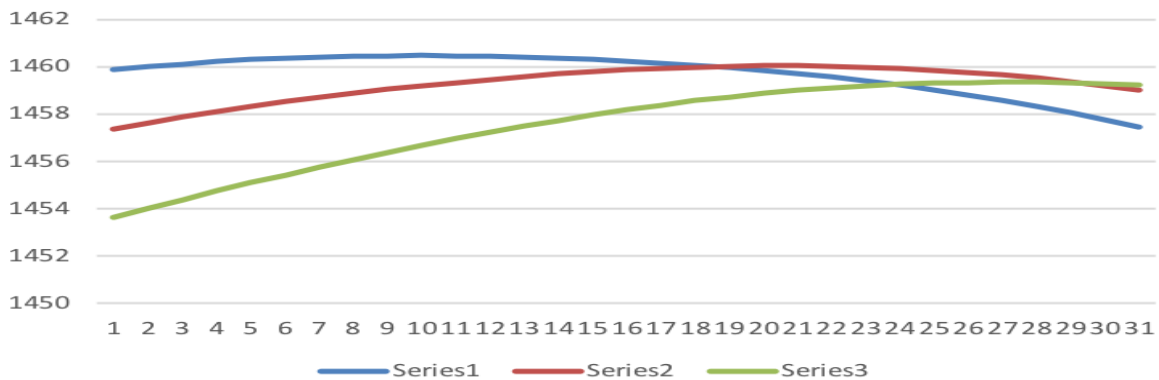
TSI variations November 600-1600



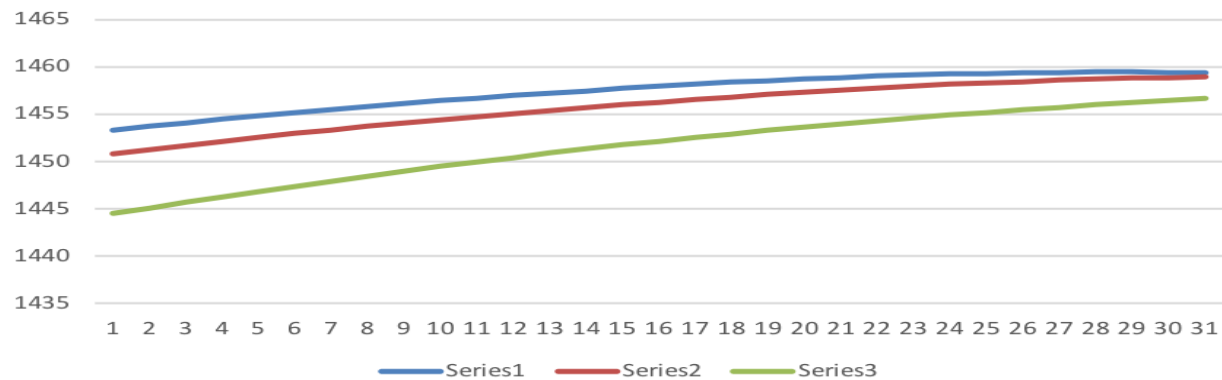
TSI variations November 1700-2600



TSI variations December 600-1600



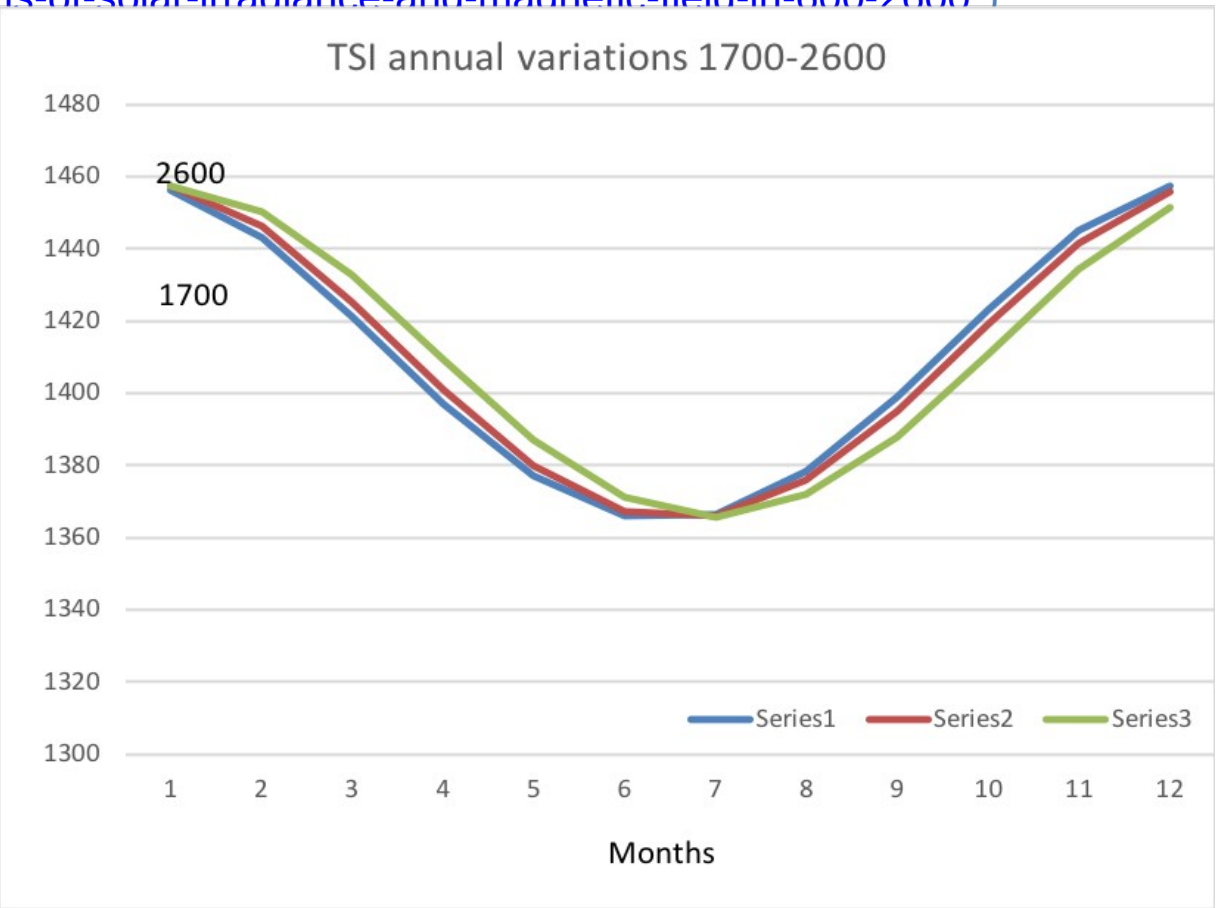
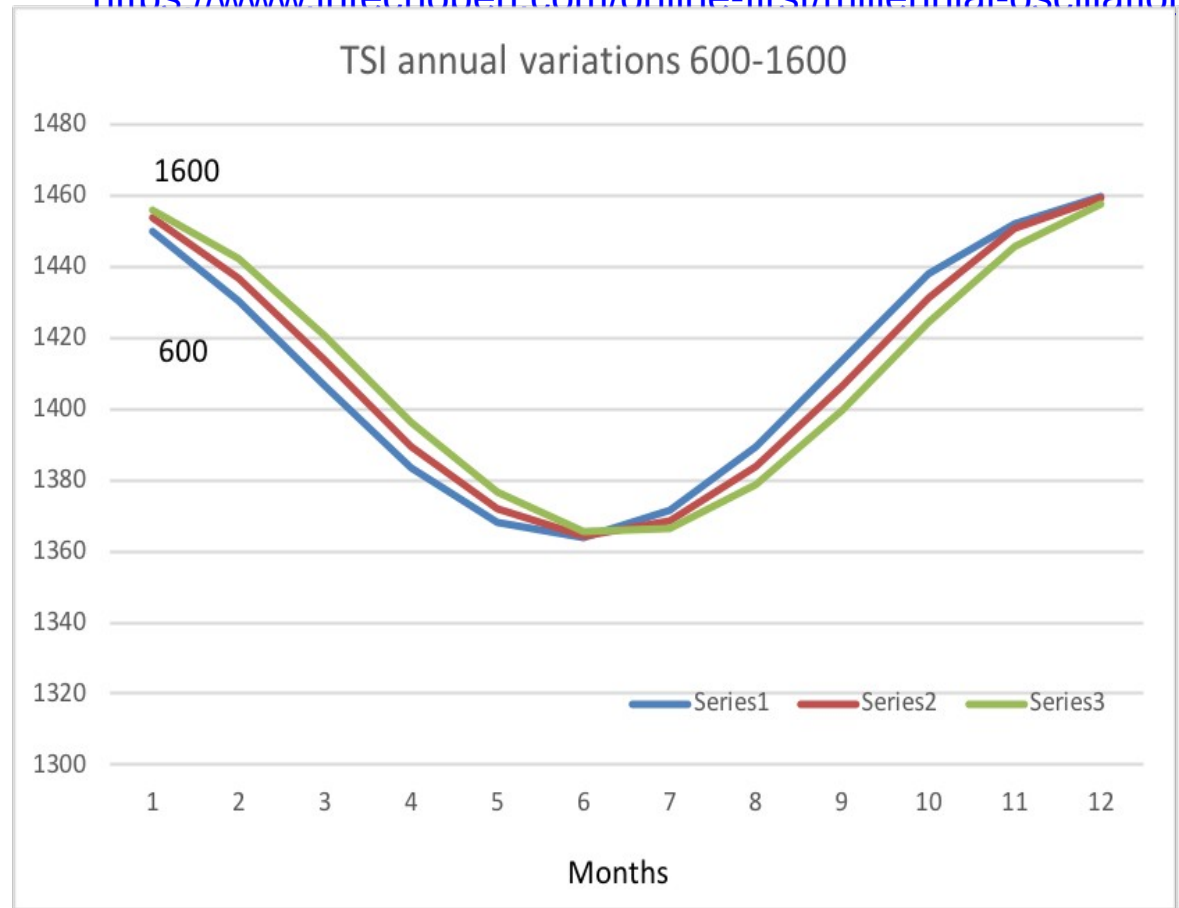
TSI variations December 1700-2600



Annual TSI variations in M1 (600-1600) and M2 (1700-2600)

Zharkova, 2021

<https://www.intechopen.com/online-first/millennial-oscillations-of-solar-irradiance-and-magnetic-field-in-600-2600>)

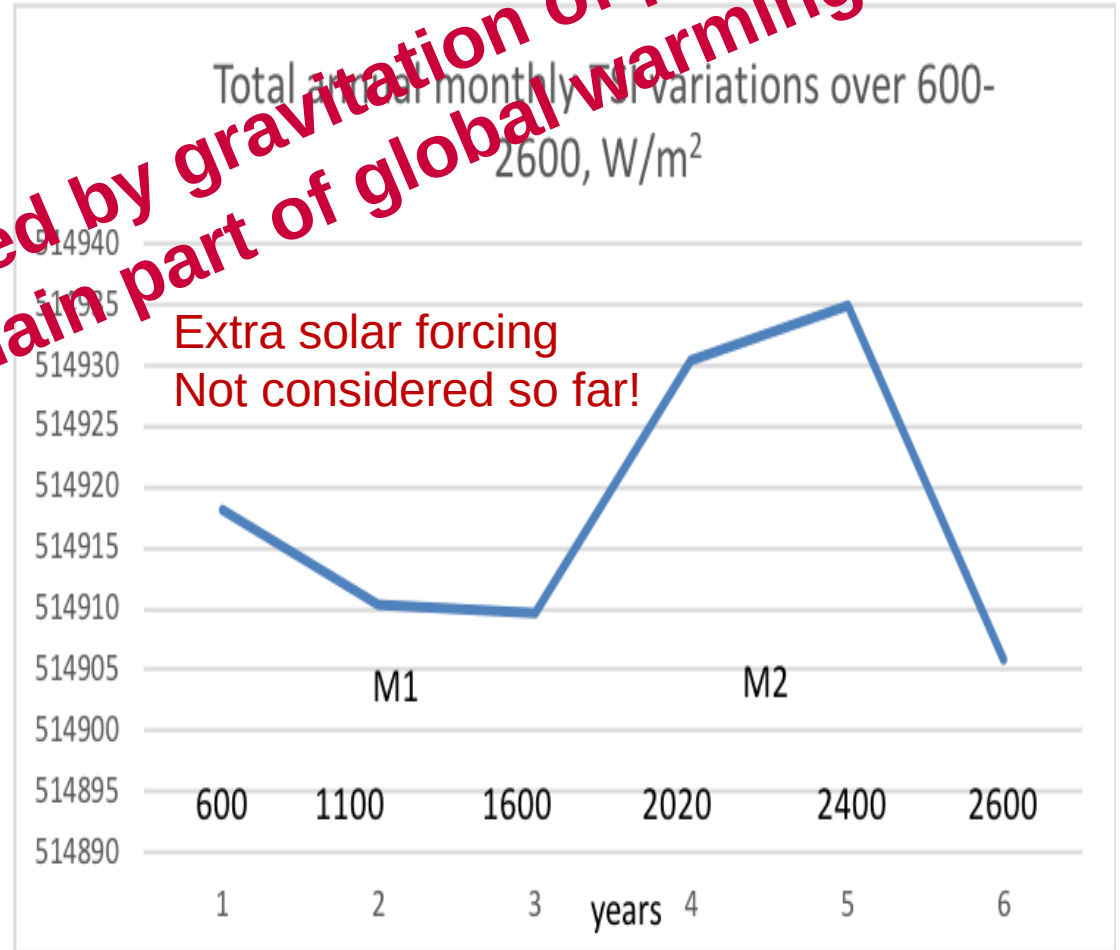
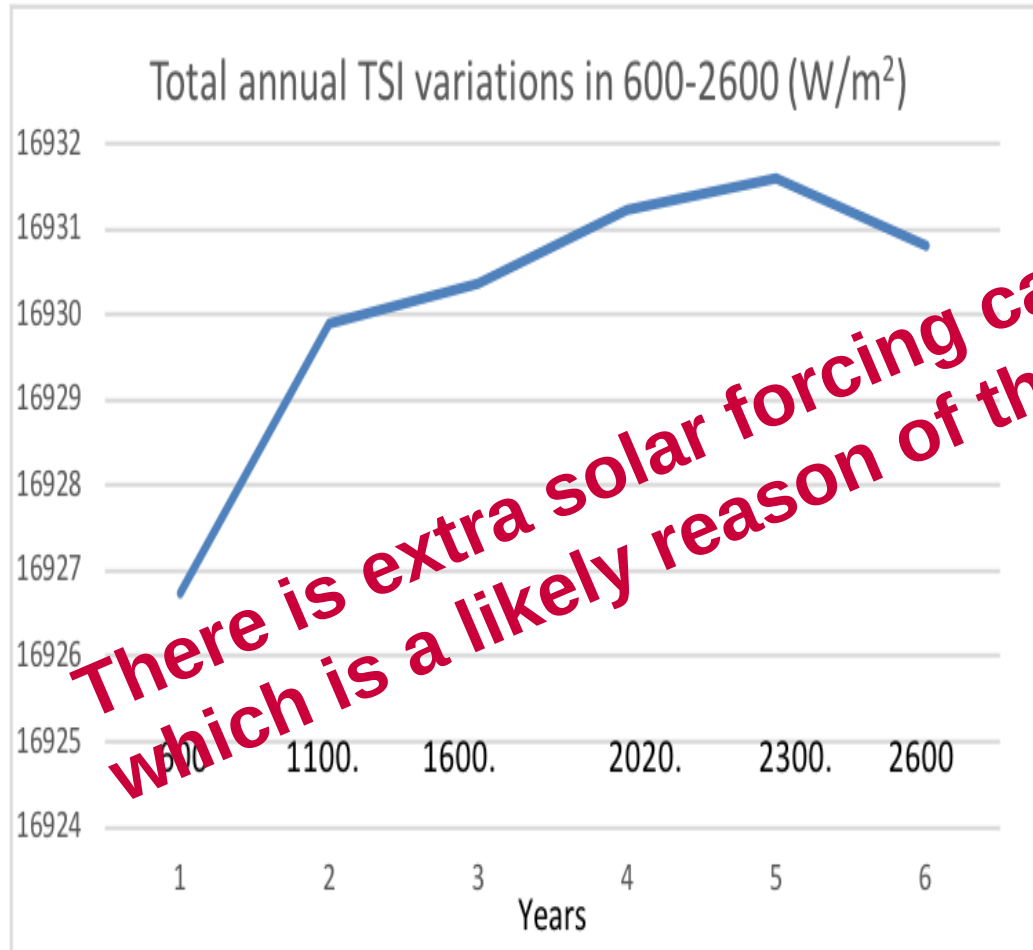


M1: TSI significantly increases in February – June, and decreases in June-December. M2: the aphelion shifts to mid-July □ TSI decrease in July – January is not fully compensated!

Variations of the total annual TSI in M1 (600-1600) and M2 (1600-2600) averaged for each month (left) and daily (right)

<https://arxiv.org/pdf/2008.00439.pdf>

Zharkova et al, 2019, Zharkova, 2020



**There is extra solar forcing caused by gravitation of planets,
which is a likely reason of the main part of global warming**

Global Warming Over Last Century (Hardy, 2017)

■ Total Temperature Balance if extra 5 W/m² radiation is added:

– Solar warming over last century:

for solar anomaly $\Delta TSI = 2.6\%$

$$\Delta T_{Sun} = \Delta TSI \times S_S = 0.44^\circ\text{C}$$

→ 60%

– CO₂ warming over last century:

100 ppm CO₂ at ECS = 0.70°C

$$\Delta T_{CO_2} = 0.30^\circ\text{C}$$

→ 40%

➤ Full agreement with observed temperature increase: 0.74°C

➤ Full agreement with observed cloud cover changes

**We have extra 20-25 W/m² radiation every year!
Hence, the hating comes from this radiation!**

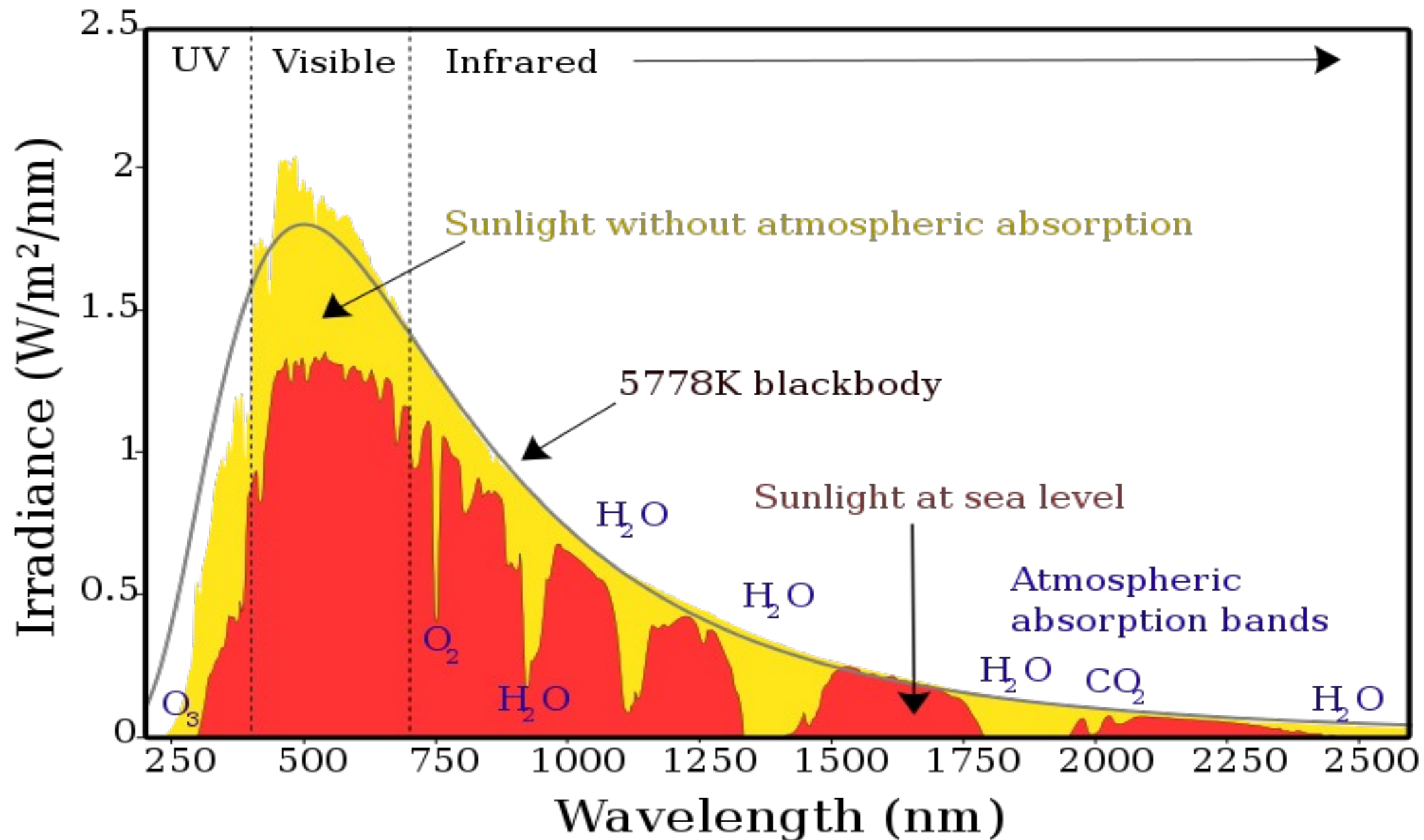
How IPCC models can account for extra-heating from CO2



Radiative Transfer:

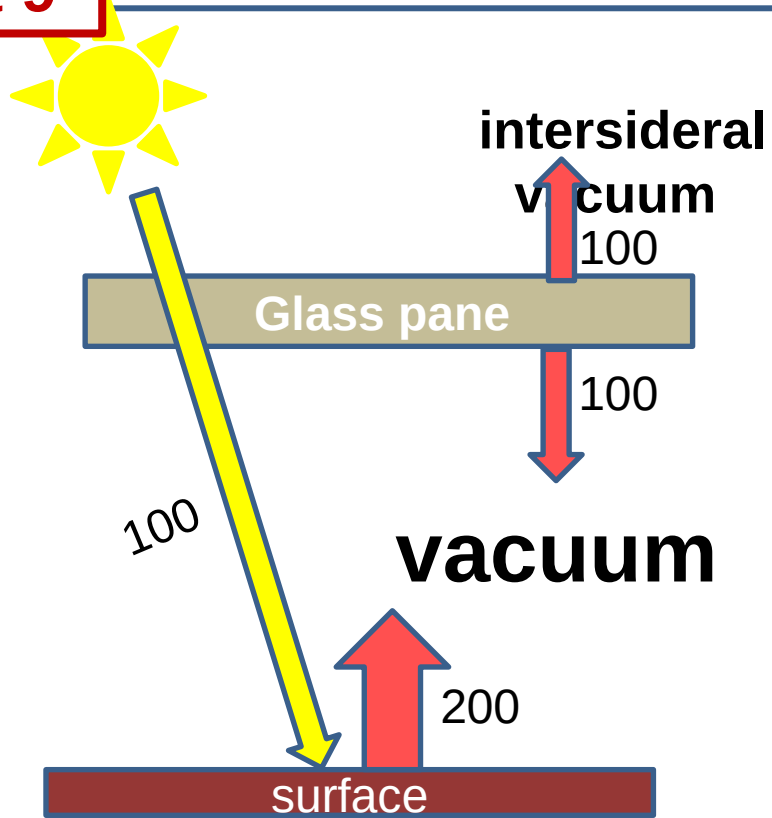
What IPCC missed
when interpreting the emission of CO2?

Spectrum of Solar Radiation (Earth)

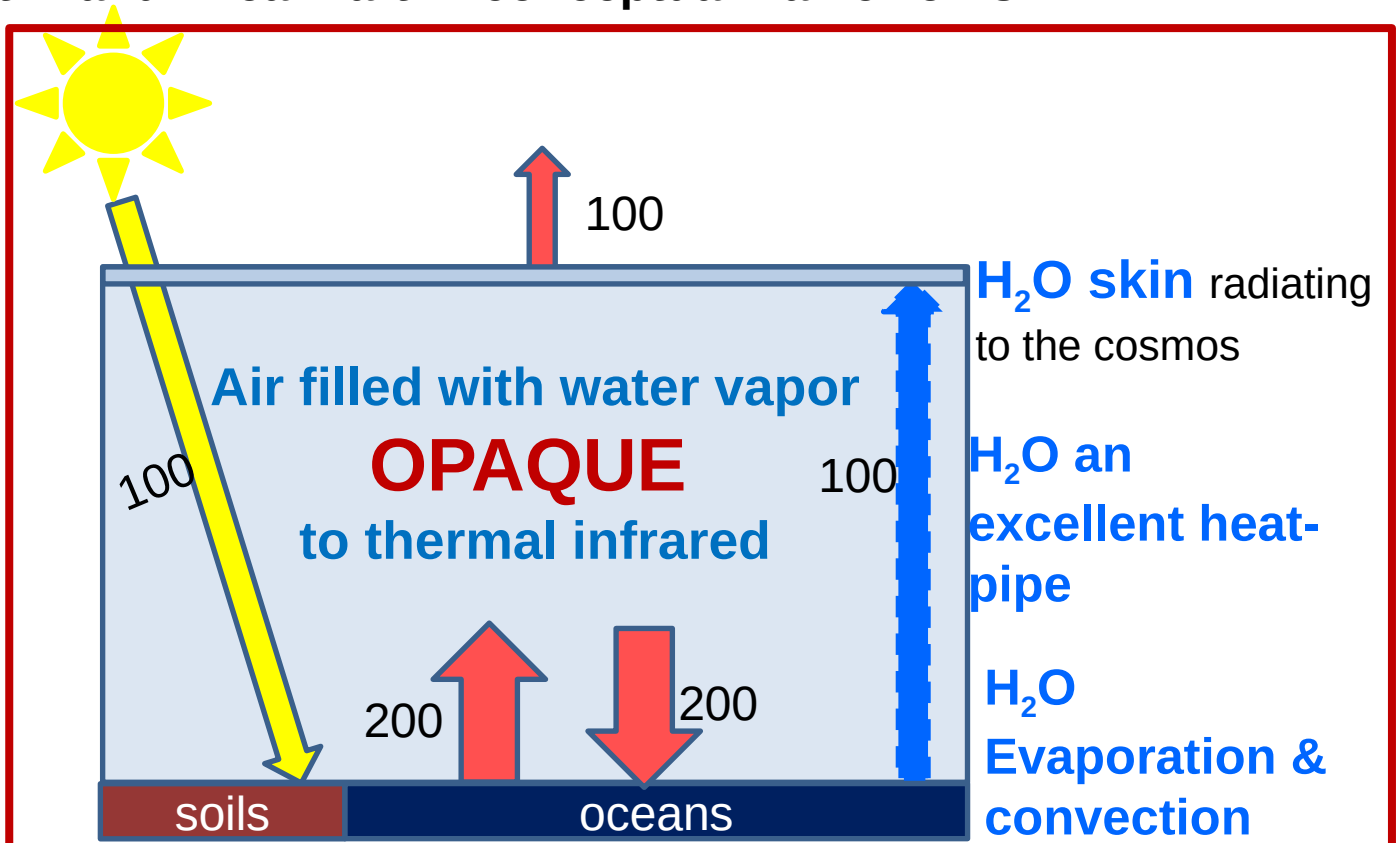


Fact 9

Imaginary Greenhouse effect and real Earth: conceptual frameworks



A glass pane in vacuum, the wall of a thermos bottle, a good insulator, is by no way a model for **a turbulent and water-vapor laden air, which is an excellent heat-pipe, carrying latent and sensible heat!**



No heat transfer by thermal infrared from the surface as $200 - 200 = 0$

No radiative carriage of heat through the air made **opaque** by the water vapor

$$(T_{\text{surface}}) / (T_{\text{radiating pellicle}}) = ((P_{\text{surface}}) / (P_{\text{pellicle}}))^{0,19}$$

Note : the flows 100 or 200 are not W/m² but simple numbers to help the understanding of what happens

The optical thickness τ of the atmosphere is the parameter to use to compute the diffuse radiation in an absorbing and radiating medium like the atmosphere

(Chandrasekhar 1948, K. Ya. Kondratiev 1969)

$$f_{\text{down}}(\nu, z) =$$

$$\pi \int_0^{\tau(\nu, z)} B(\nu, T(t')) 2 E_2(\tau(\nu, z) - t') dt'$$

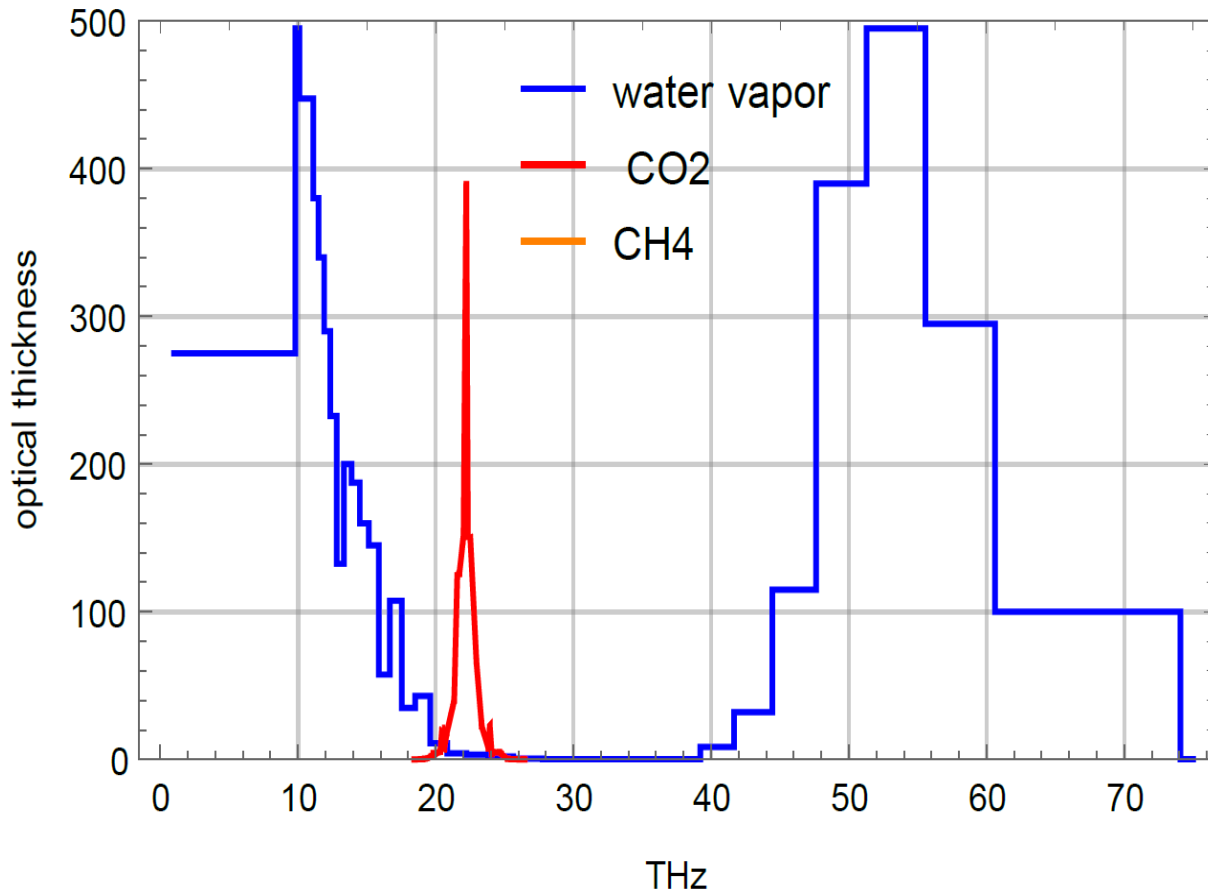
$$f_{\text{up}}(\nu, z) =$$

$$= \pi \int_{\tau(\nu, z)}^{\tau_{\text{max}}} B(\nu, T(t')) 2 E_2(t' - \tau(\nu, z)) dt'$$

$$f_{\text{surface}}(\nu, z) = \pi B(\nu, T_{\text{surface}}) 2 E_3(\tau_{\text{max}} - \tau(\nu, z))$$

• **B** Planck's function, E_2 and E_3 exponential integral functions

optical thickness 25kg/m² water vapor & CO₂



80% of the thermal radiation from a body is produced in its skin or "pellicle" of optical thickness $\tau = 1,07$

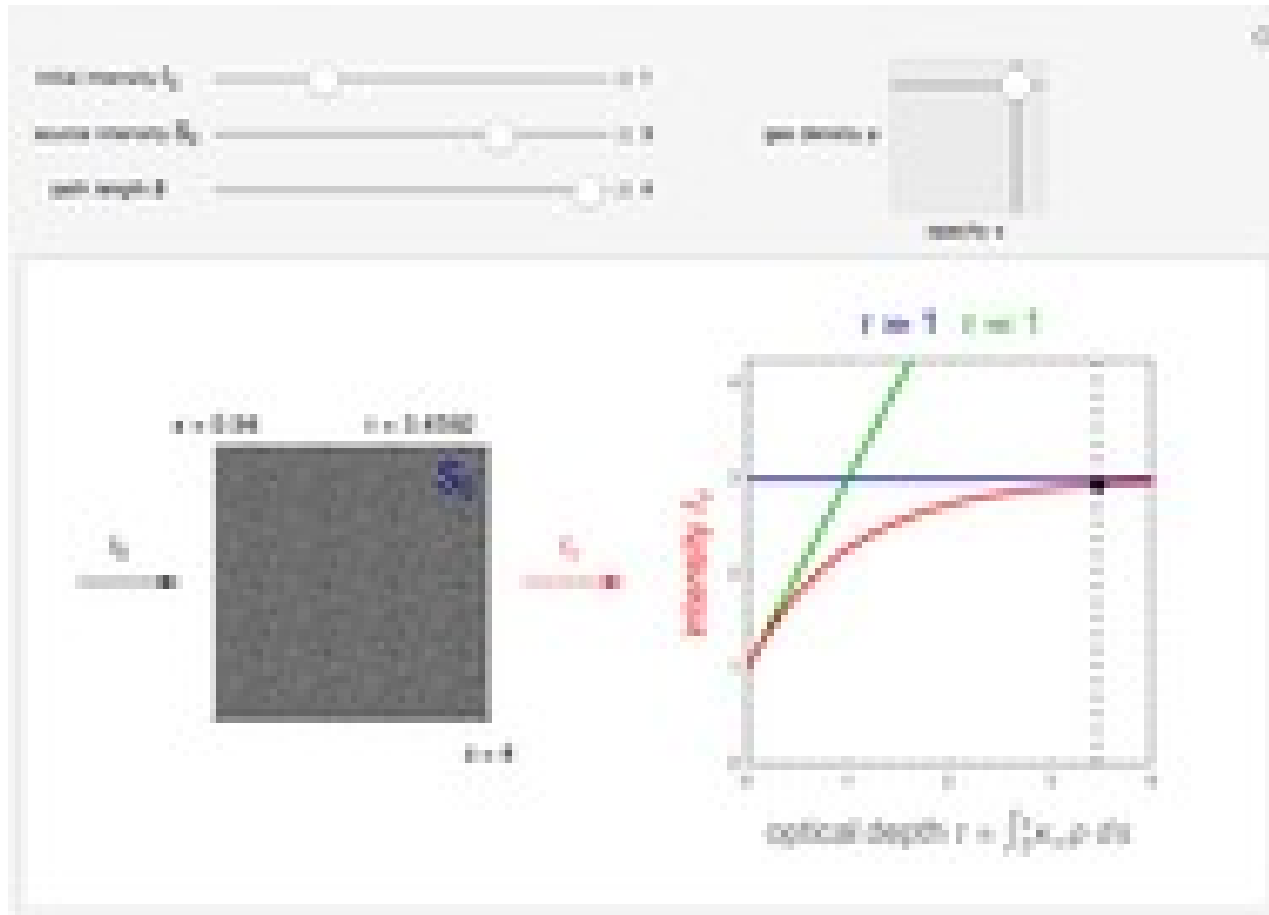
Interpretation of the equation of radiative transfer

- **The formal solution of the radiative transfer equation yields the observed intensity of the radiation:**

$$I_\nu = I_\nu(0) e^{-\tau_\nu} + \int_0^{\tau_\nu} S_\nu e^{-\tau_\nu} d\tau_\nu$$

- **The frequency absorption coefficient and emission and/or absorption features.**

Radiative transfer in action



<https://demonstrations.wolfram.com/ComputationOfRadiativeTransfer/>

- intensity of emission from the gray area on the left.
- for $\tau < 1$ emission (green curve) the emitted intensity is proportional to the density of excited molecules (CO_2)
- for $\tau > 1$ it becomes saturated (red curve).
- IPCC assumes that all CO_2 emitting as green curve while its $\tau \gg 1$, so it is emitting as the red curve (saturated).

Optical depth

The overall optical depth of a batch of gas is an important number. It tells us right away if the cloud falls into one of two useful regimes:

optically thin: $\ll 1$

- Chances are small that a photon will interact with particle
- Can effectively see right through the cloud
- In the optically thin regime, the amount of extinction (absorption plus scattering) is linearly related to the amount of material: double the amount of gas, double the extinction
 - if we can measure the amount of light absorbed (or emitted) by the gas, we can calculate exactly how much gas there is

Optical depth

Optically thick: $\tau \gg 1$

$$I = I(0) \exp(-\tau) \quad \square \quad I/I(0) =$$

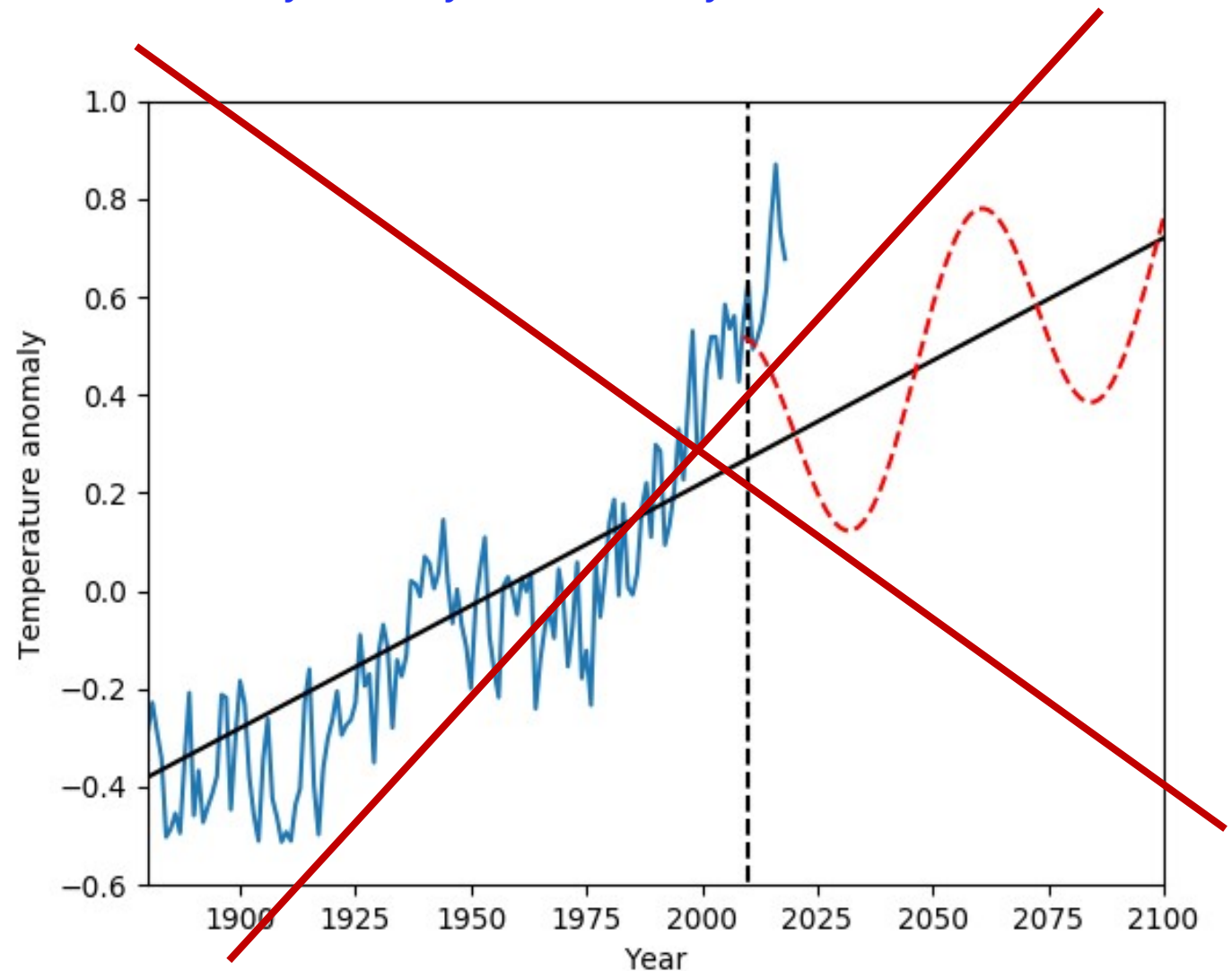
$\text{Exp}(-10) = 5e-5$
 $\text{Exp}(-1) = 0.37$
 $\text{Exp}(-0.1) = 0.9$
 $\text{Exp}(-0.0001) = 0.99$

- **Certain that a photon will interact many times with particles before it finally escapes from the cloud**
- **Any photon entering the cloud will have its direction changed many times by collisions -- which means that its "output" direction has nothing to do with its "input" direction.** *\square Cloud is opaque*
- **You can't see through an optically thick medium; you can only see light emitted by the very outermost layers.**
 \square i.e., can't 'see' interior of a star - only see the 'surface' or the photosphere
- **One convenient feature of optically thick materials: the spectrum of the light they emit is a blackbody spectrum, or very close to it** *\square layers deep within a star (can assume LTE)*

Increase of SI with a decrease of S-E distance would lead to the increase of T by 1.2C by 2010, and by further 2.5-3.0 C in 2500.

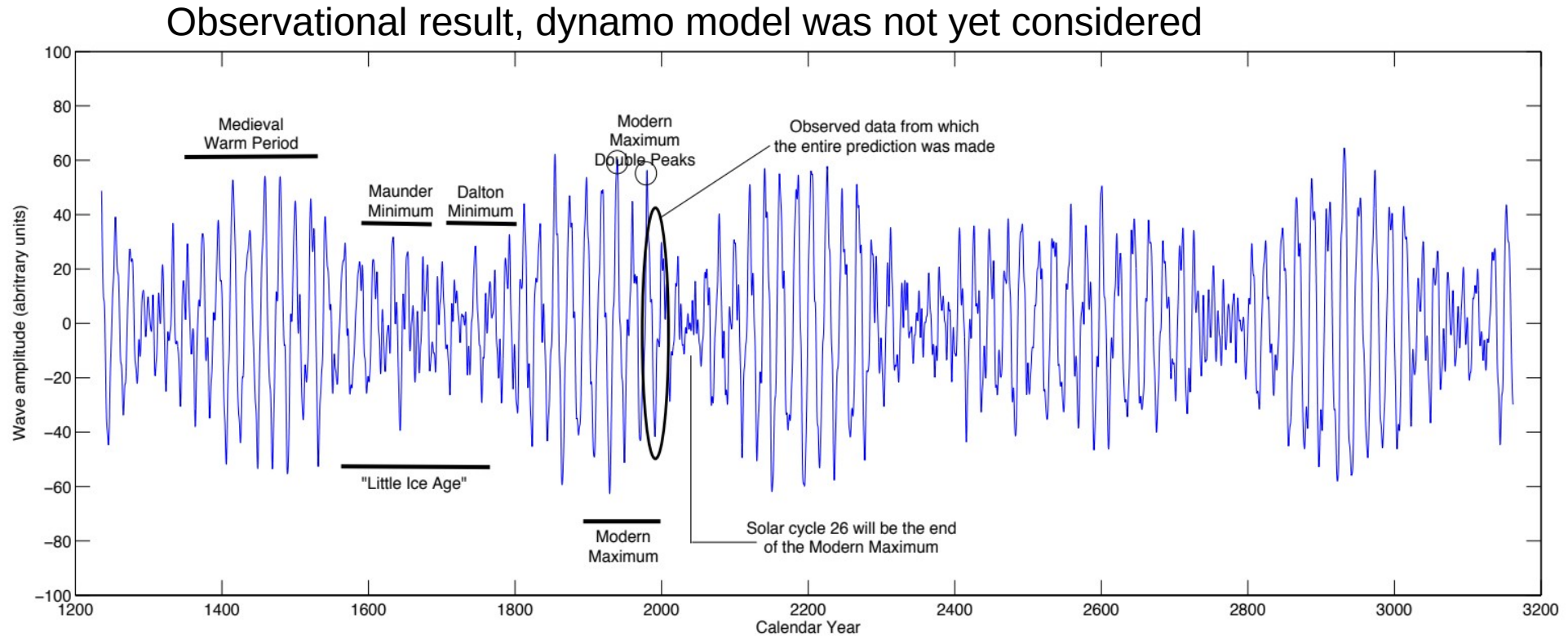
SIM solar forcing and green house (GH) effects

- The terrestrial temperature increase induced by change of the S-E distance can only account for the **baseline temperature variations (straight line)** here and in Akasofu's curve (2010).
- K.Rice Pubpeer comment #38 (shown in the figure on the right) that whole T is defined by **the blue curve. The T increase above the baseline is interpreted by the current terrestrial models including GH gases**
- **Harde et al., 2017 (IJAS, id 9251034)** modelled radiative transfer of CO₂ with extra solar forcing of the similar magnitudes found from SIM □ T increase: 60% solar and 40% by CO₂



K.Rice Pubpeer comment #38

Predicted solar activity (Zharkova et al, 2015, SR <https://www.nature.com/articles/srep15689>)

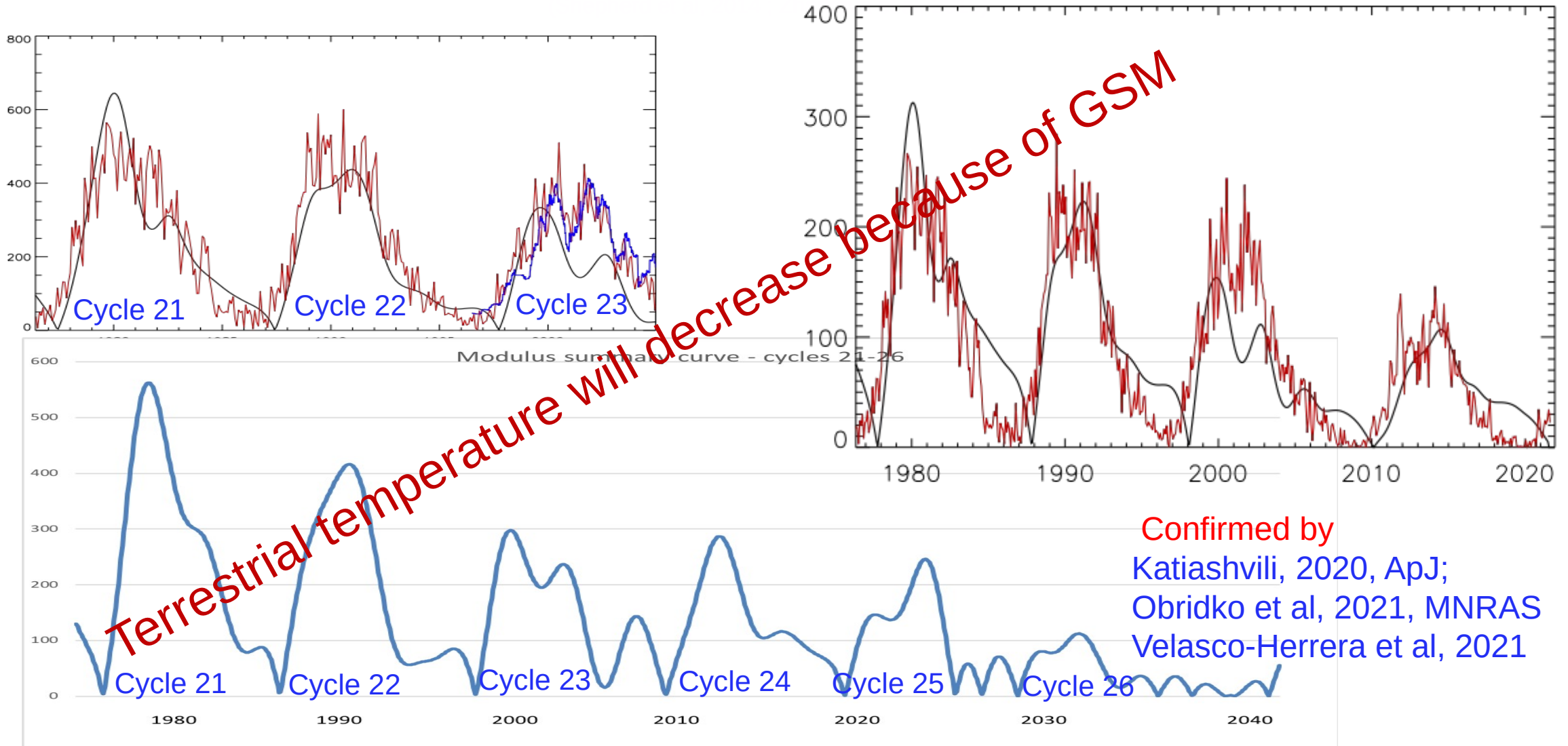


The Sun entered the grand solar minimum in 2020 until 2053

<https://solargsm.com/solar-activity/> - my webpage

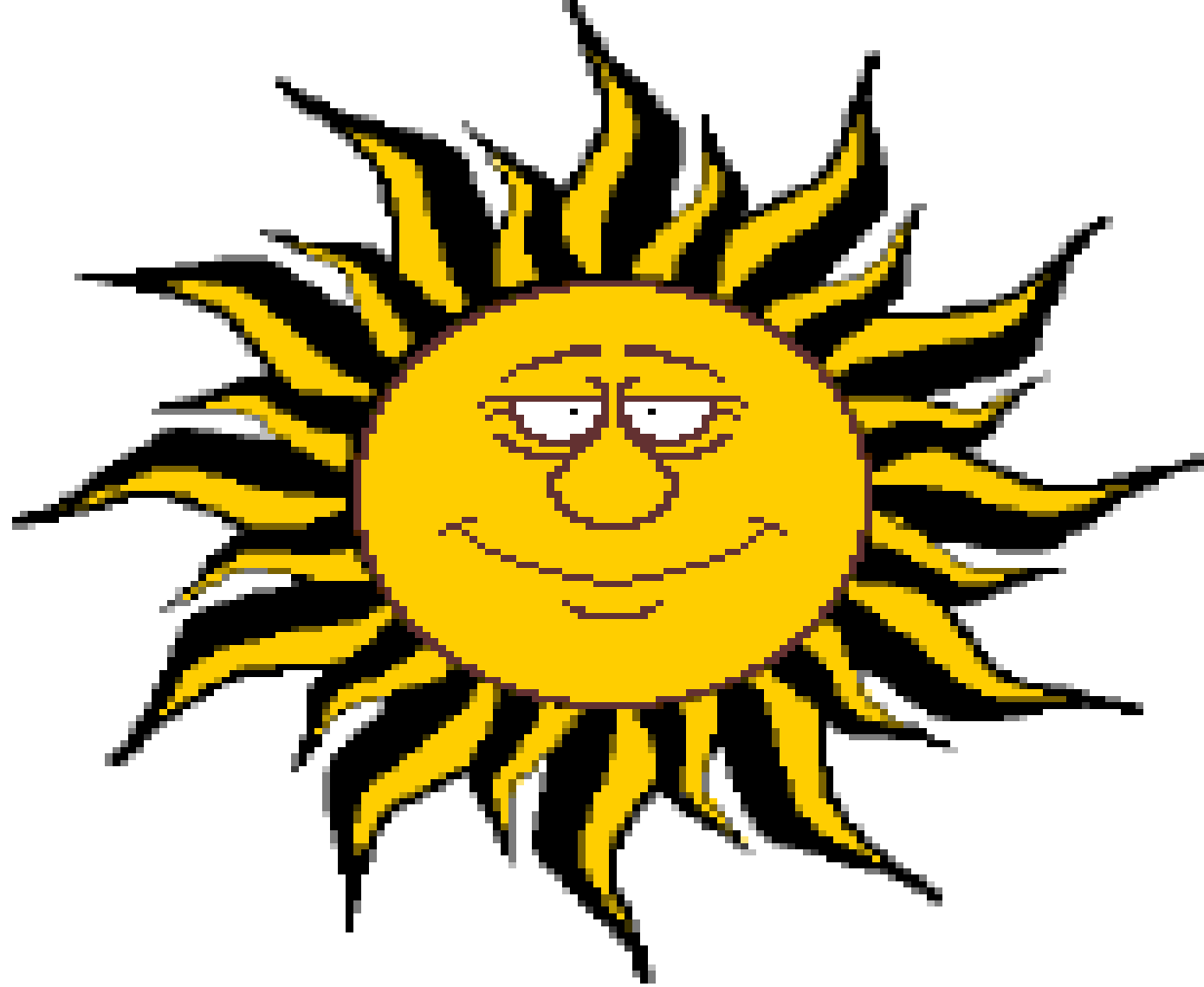
Modulus summary curve

Zharkova et al, 2015, SciRep; 2020, Temp., Zharkova et al, 2022, MNRAS



Conclusions

- **PCs of solar magnetic field are paired – double dynamo waves**
- **Prediction of the solar activity on a millennium scale shows grand cycle variations with period of 350-400 years**
- **Global cooling: the modern GSM to occur in 2020 – 2053 □ Different narratives for governments!**
- **What about global warming? It occurs independently to any solar activity!**
- **Analysis of summary curve for 100,000 years detects weak variations of the magnetic field baseline with a period of ~2100-2200 years – Hallstatt's cycle**
- **These MF variations are closely linked to the solar inertial motion about a barycentre of the solar system**
- **Owing to SIM SI would increase from 1600 to 2500 by further 20-25 W/m² per year (10-12 W/m² per hemisphere)**
- **Increase of SI with a decrease of S-E distance would lead to the increase of T by 1.2C by 2010, and by further 2.5-3.0 C in 2500.**
- **Is there AGW effect? If Sun SIM covers this heating than not much left to think so!**



Thanks for your attention!