6. Milankovitch Cycles and Global Warming

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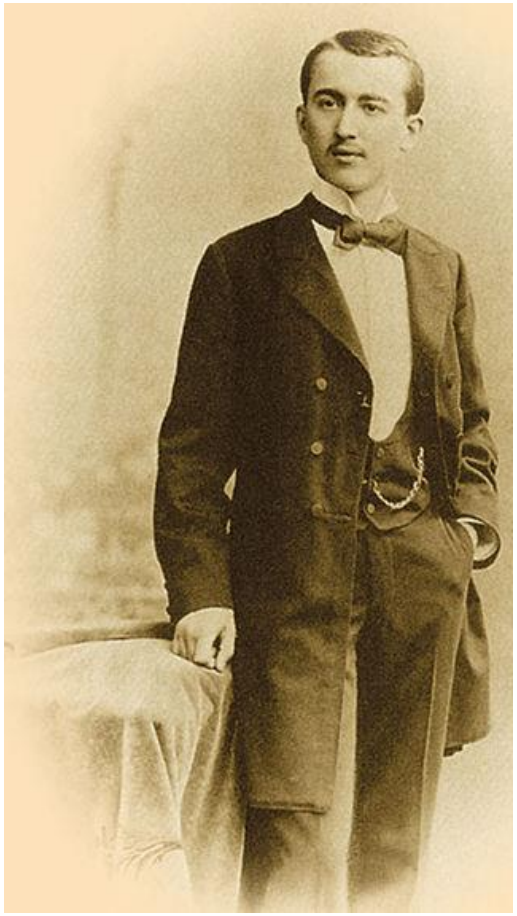
Based on the Book:
"Fundamentals of Global Warming"

Contents

INTRODUCTION

Milutin Milankovitch (1879-1958)



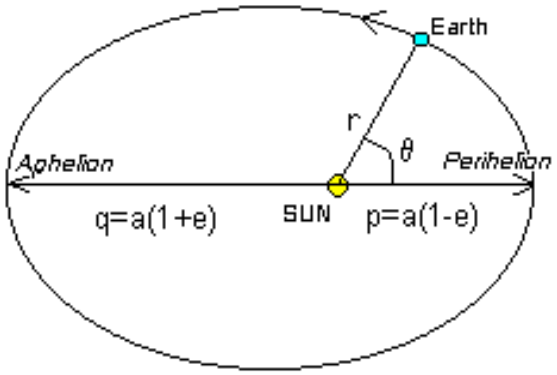
Sebian Civil Engineer.
Mathematician, Professor

"*Distribution of the sun radiation on the earth's surface*" and was published on 5 June 1913

"*About the issue of the astronomical theory of ice ages*" in 1914

Calculated solar irradiance curves for past 650,000 years

Eccentricity



Eccentricity is the deviation of earth's orbit from circle

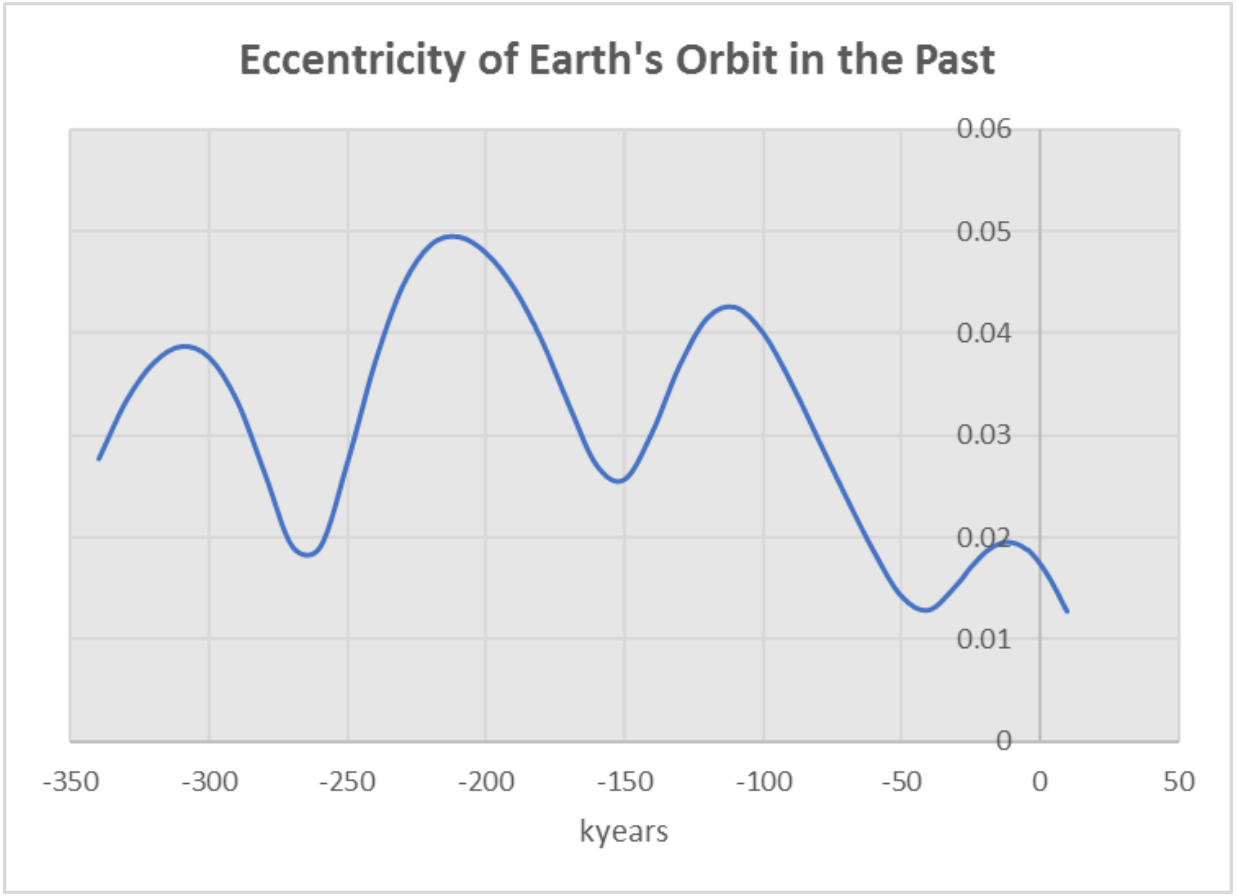
Distance at Perihelion

P = a(1-e)

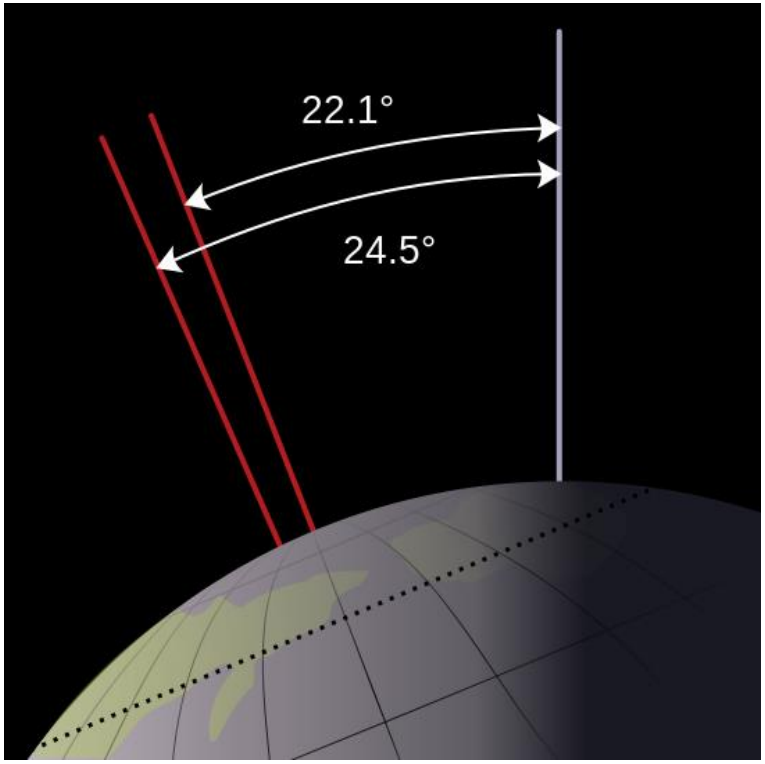
e = eccentricity
= 0.017 today

Changes with a 100,000-year cycle

Eccentricity is decreasing



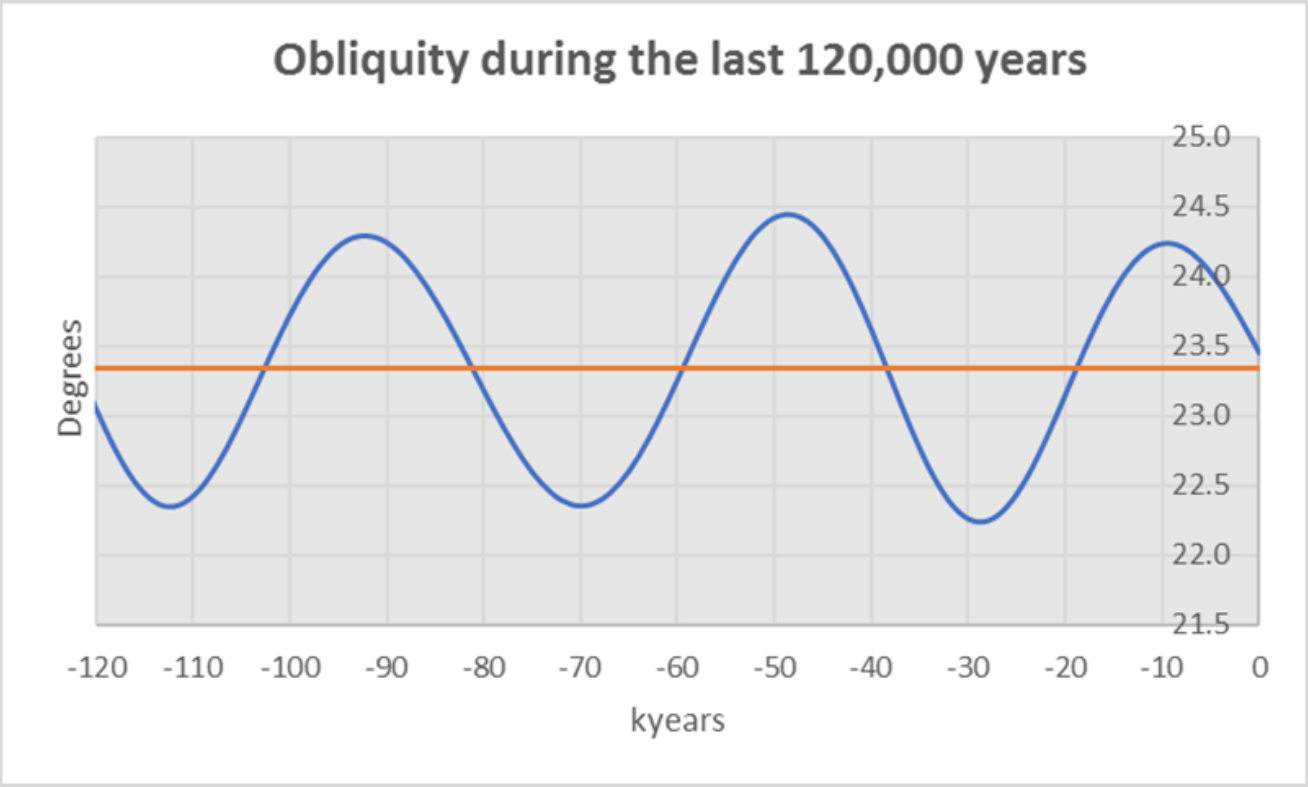
Axial tilt (Obliquity)



Axial tilt is angle between earth's axis and earth's orbital plane.

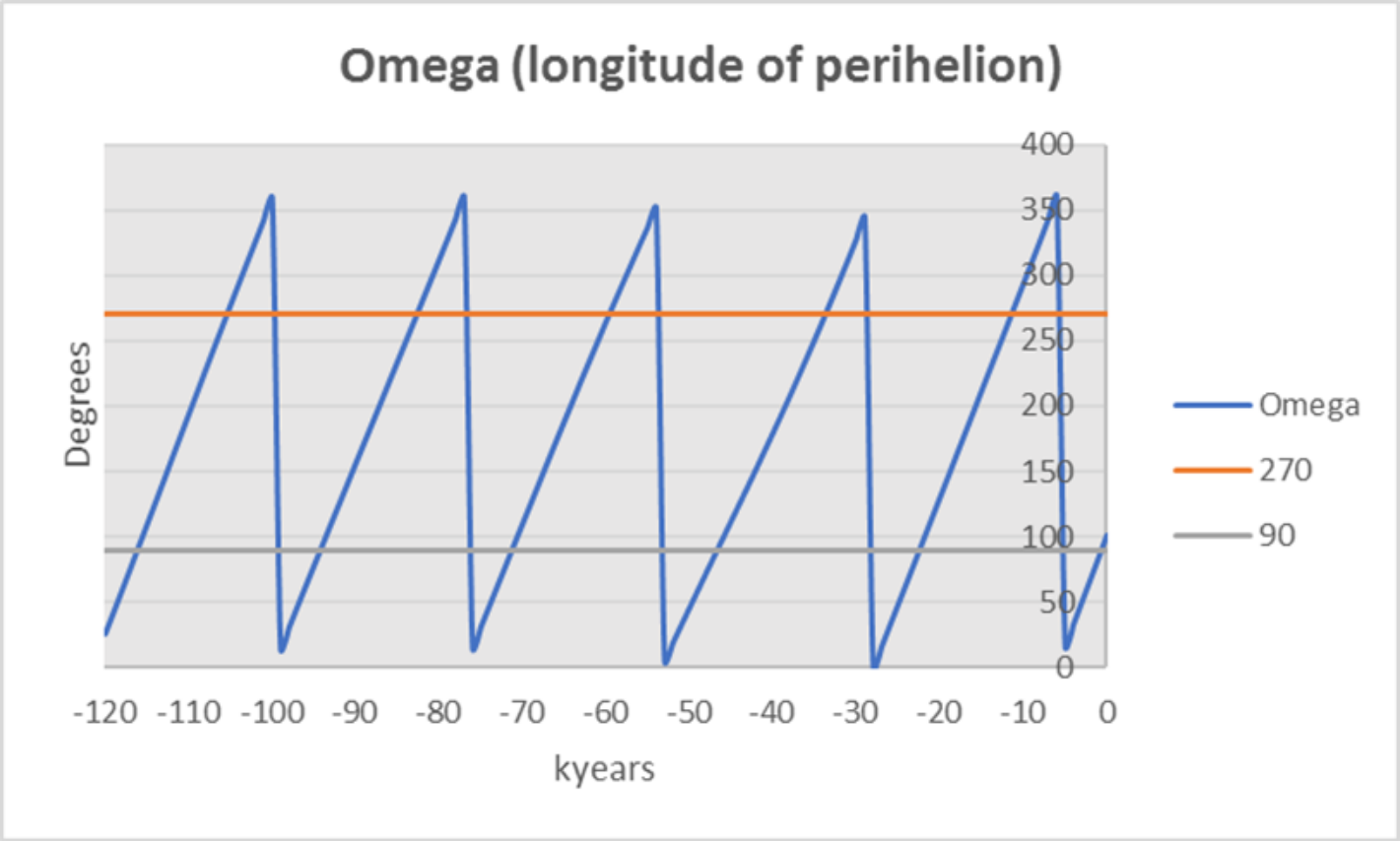
Changes with 41,000-year cycle

Obliquity is decreasing



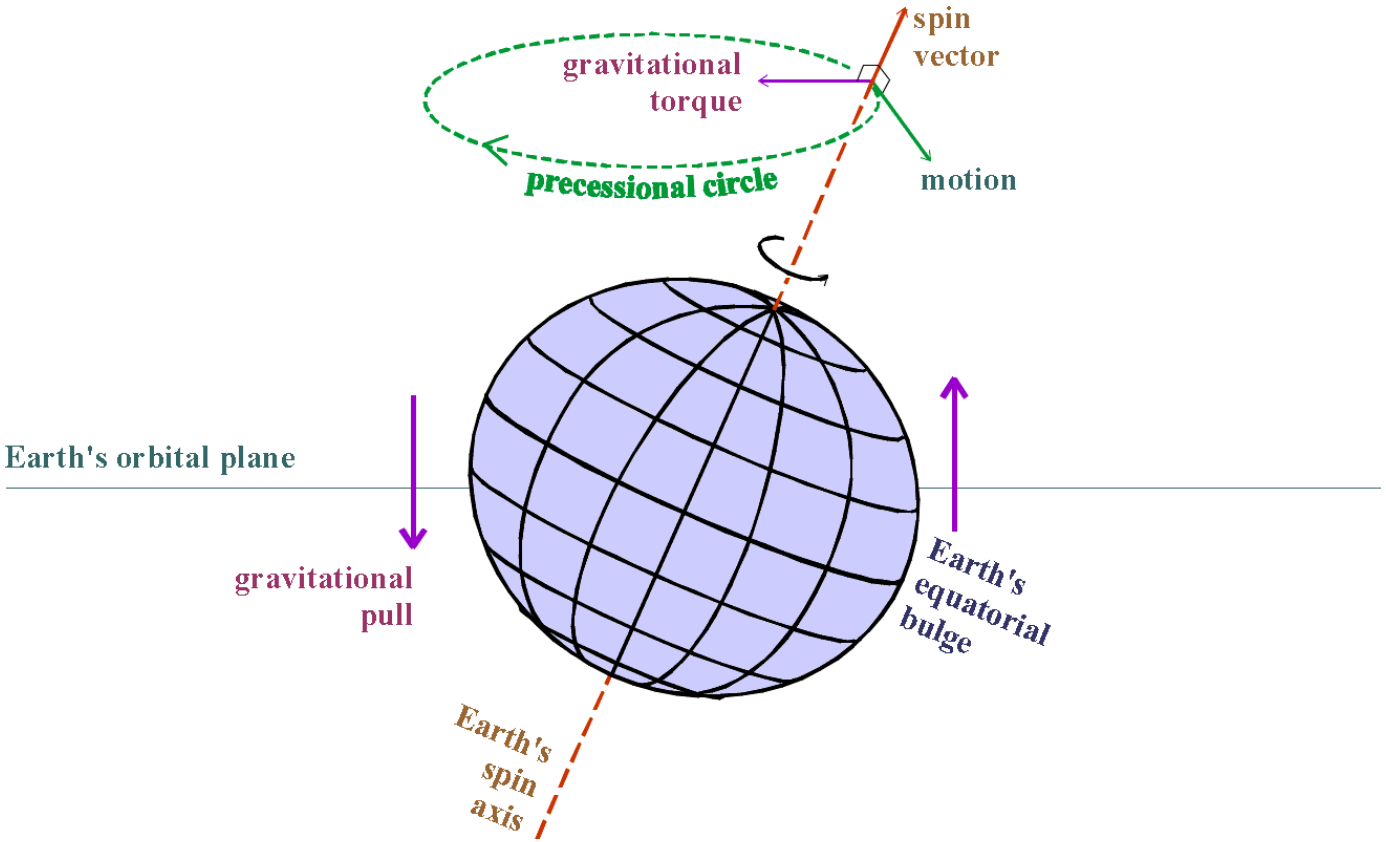
Obliquity is 23.45 today and is decreasing towards 22.2

Longitude at perihelion



At 270 deg. North summer occurs at perihelion and summer is warmer
At 90 deg. winter occurs at perihelion and summer is warmer in South

Precession is rotation of earth's axis in a precessional circle



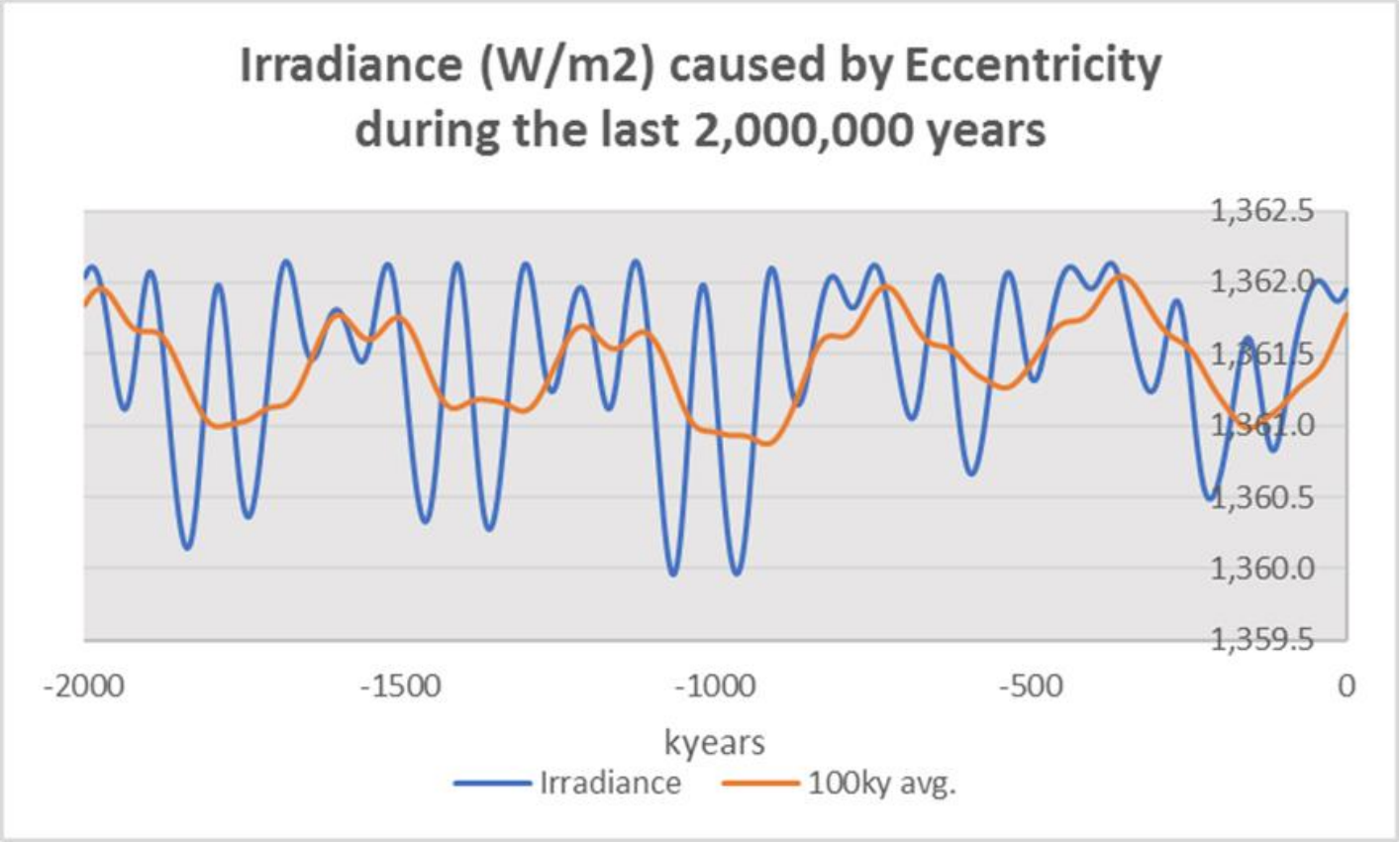
CLIMATE CHANGE IN THE PAST

Total Solar Irradiance (TSI) is a function of eccentricity*

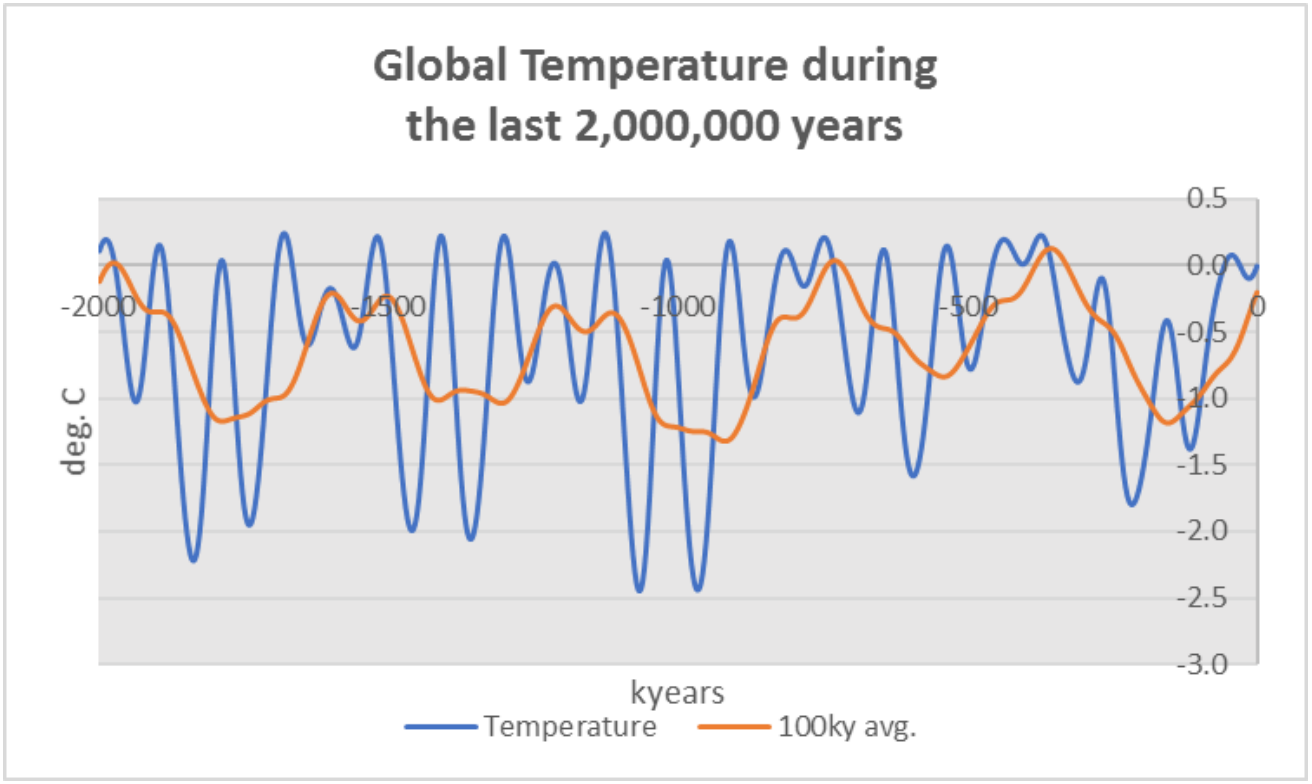
$$TSI = S_o \; x \; (1-e^2)^{1/2}$$

** J. Laskar et. al. Orbital, precessional and insolation quantities for the Earth from -20Myr to + 20 Myr*

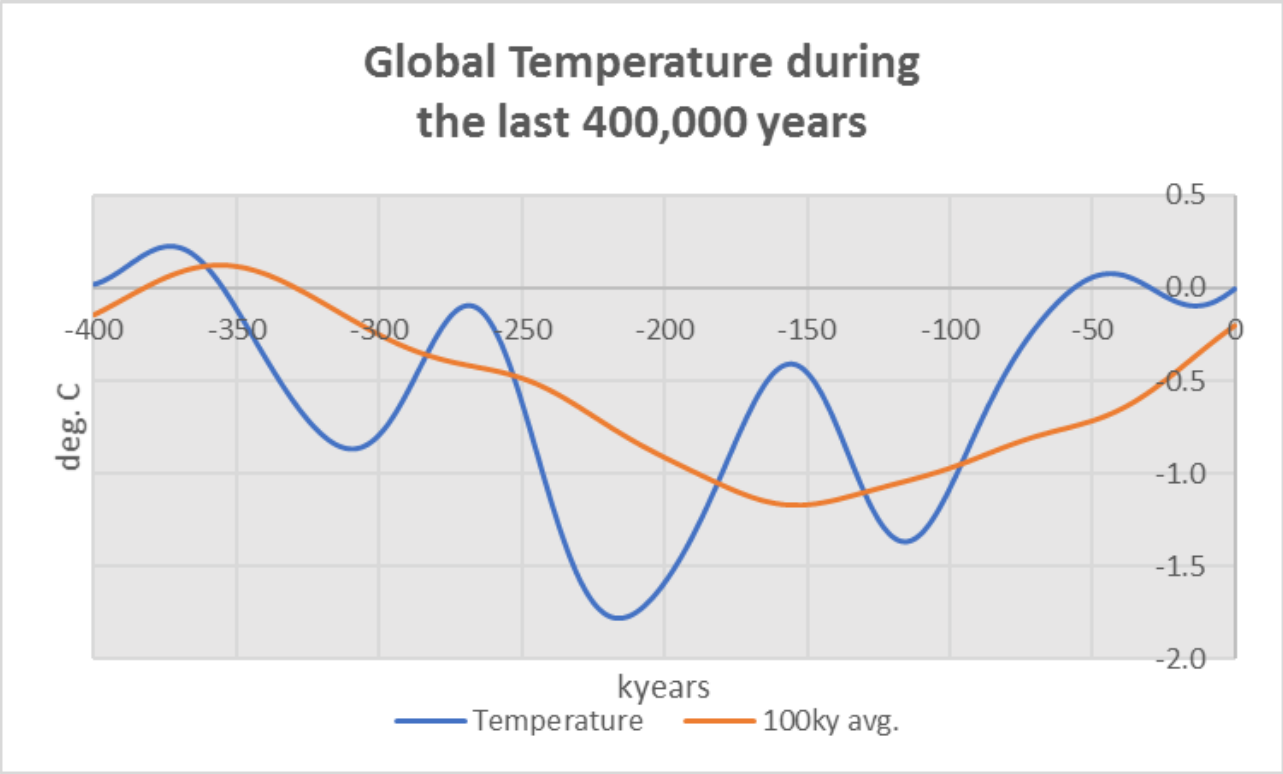
Total Solar Irradiance



Temperature flollows Irradiance
dT =1.234 x dTSI



Temperature follows Irradiance during the last 400,000 years



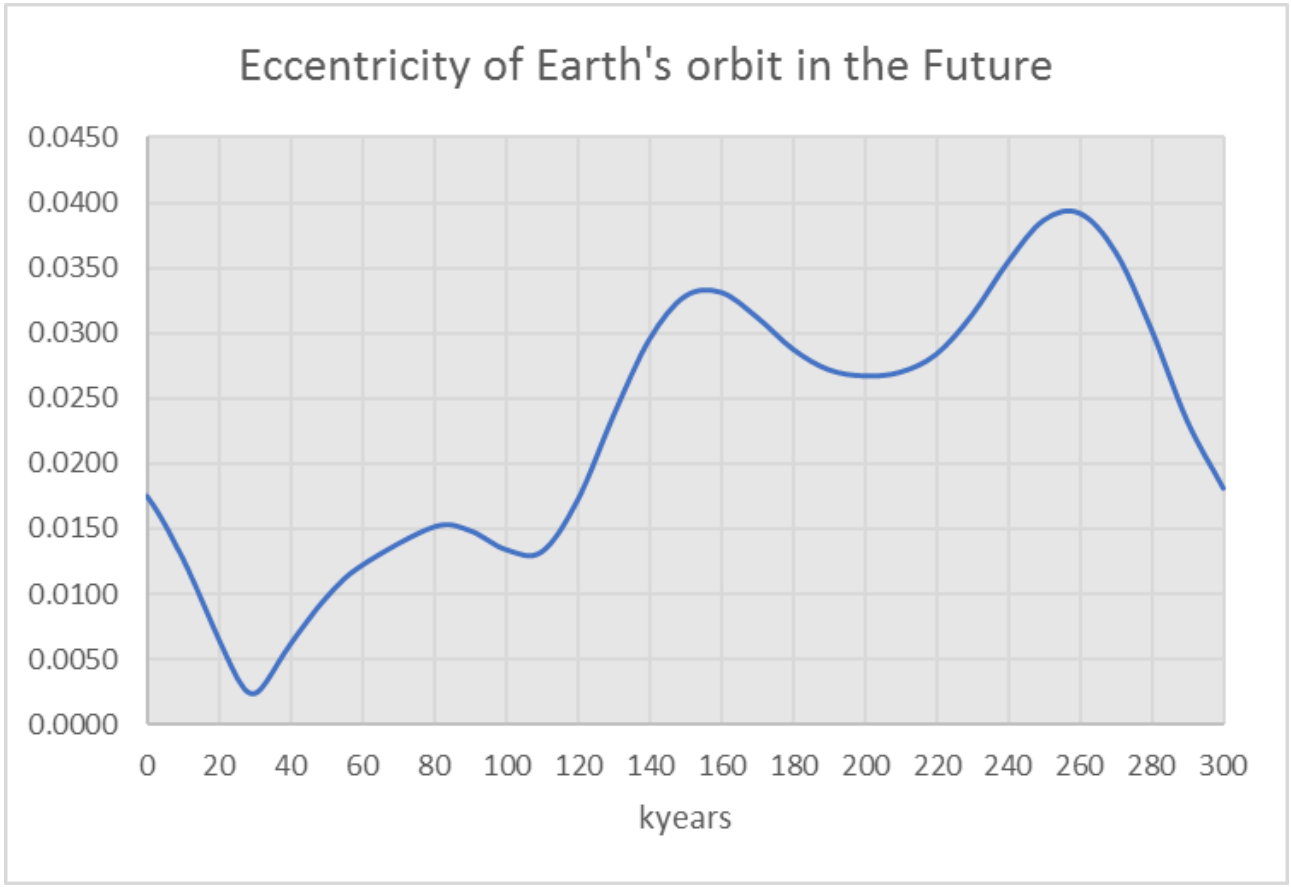
The last two Ice Ages started 120,000 and 220,000 years ago

At 11,500 BP Salpausselkä sand formation was created through Finland, at the coastline of the sea

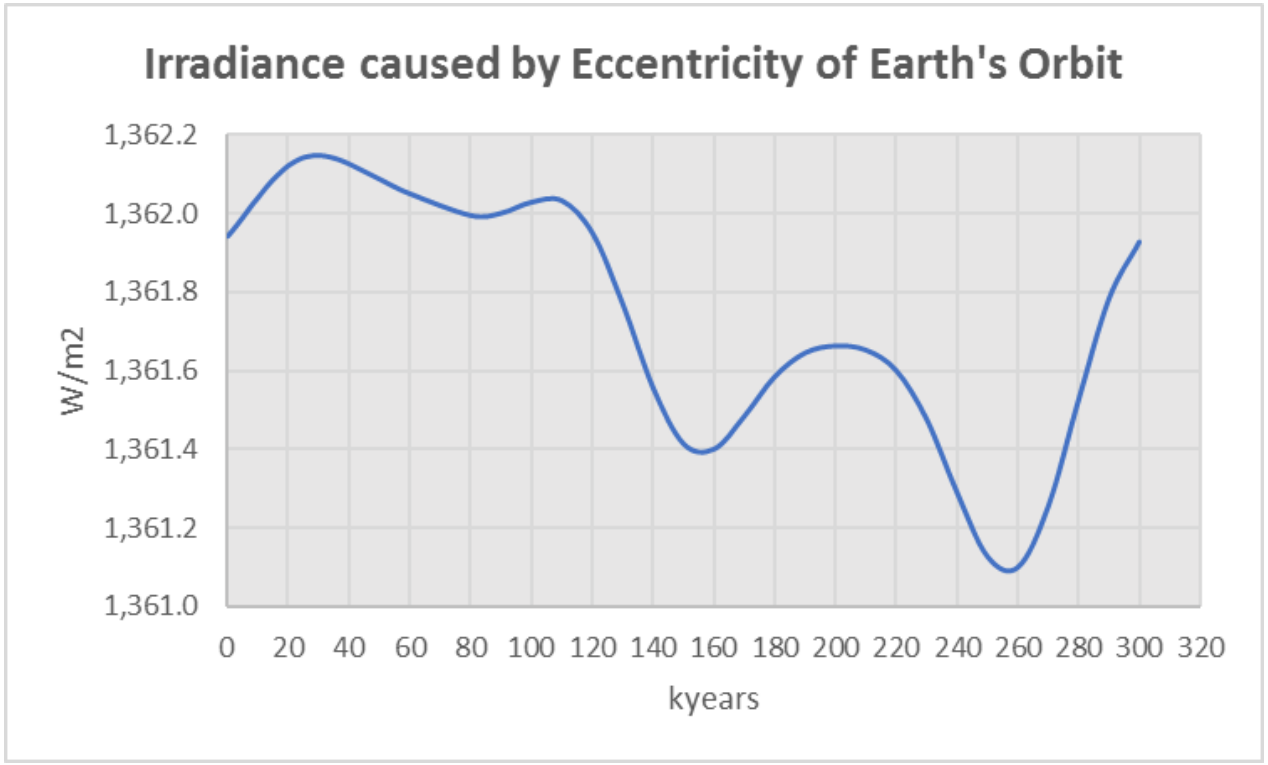
Eccentricity started increasing and global temperature decreased (See former slide)

CLIMATE CHANGE IN THE FUTURE

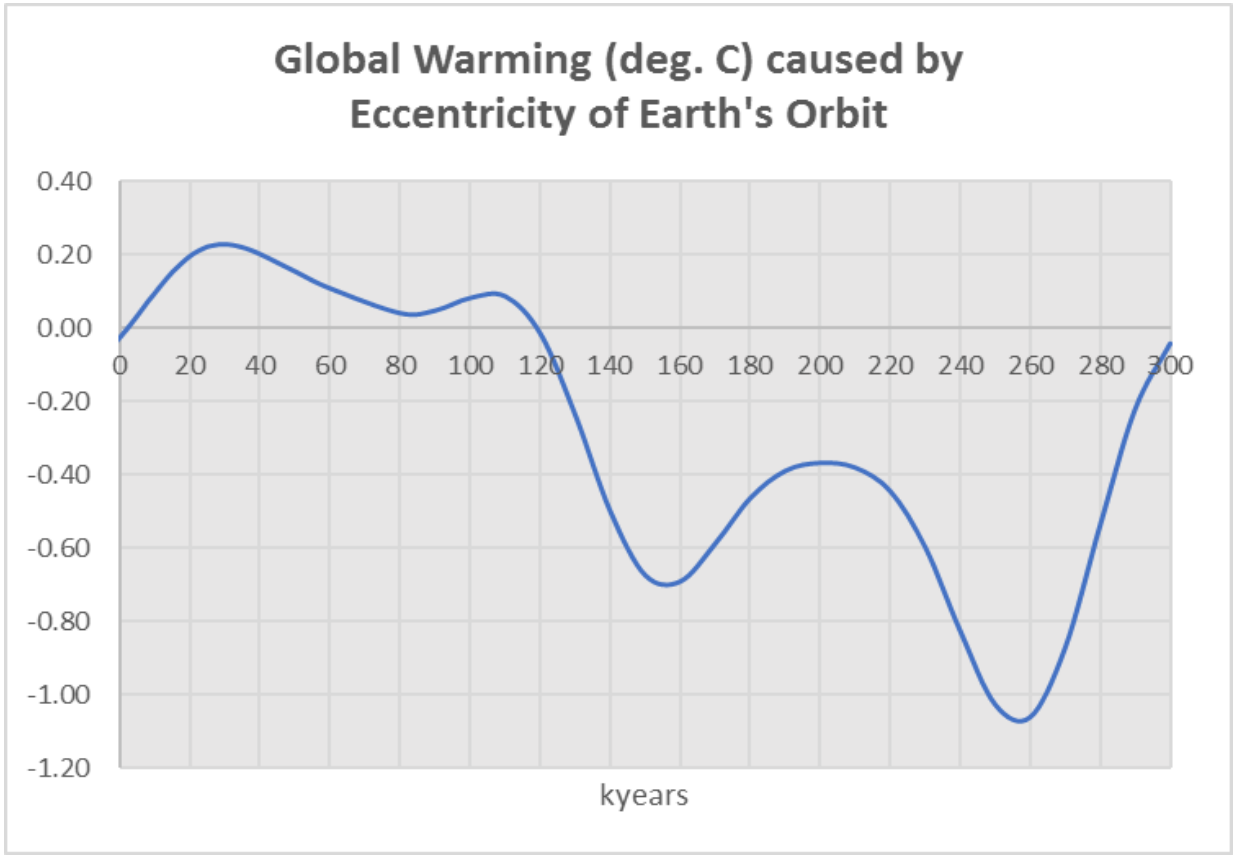
Eccentricity will decrease during the next 30,000 years and starts increasing



Irradiance will be lower than today after 120,000 years from today

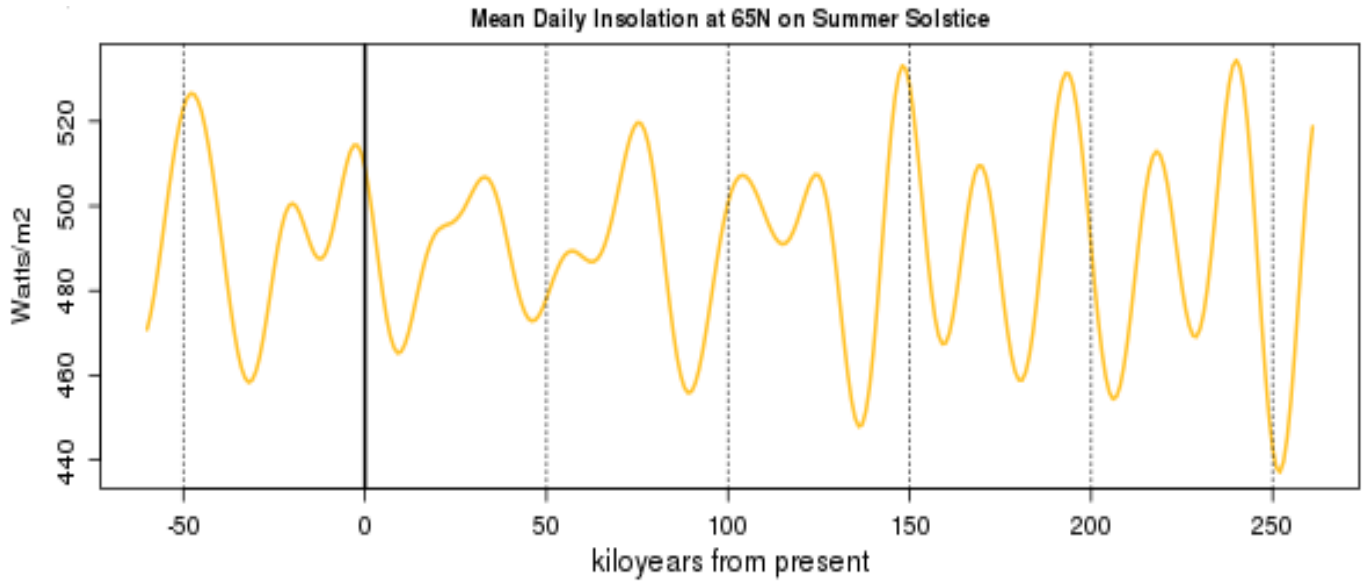


Global cooling will start after the year 120,000



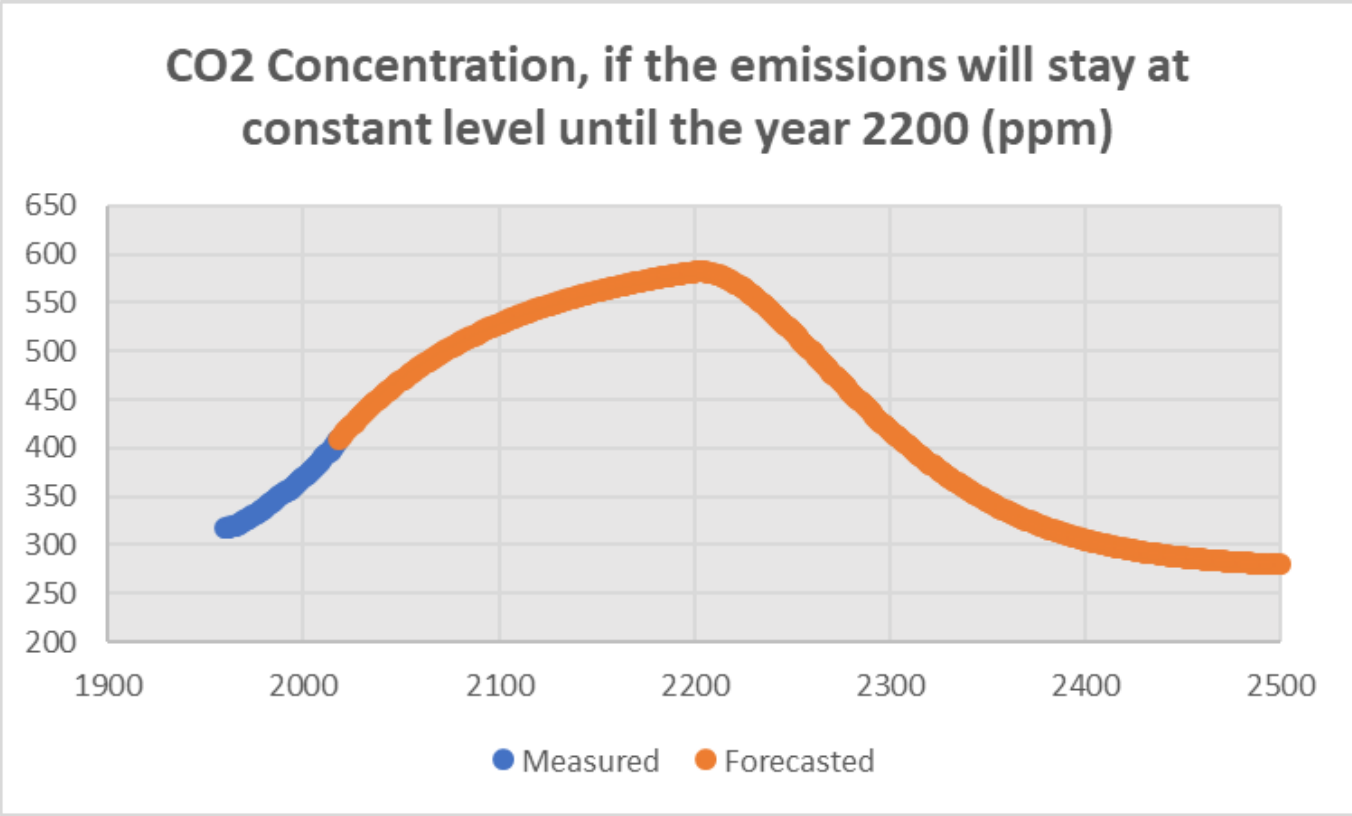
A new ice age might be coming about 250,000 year from today

Daily insolation in summer at 65N is decreasing for the next 10,000 years



Minimum value of daily insolation in North summer will be achieved in about year 250,000.

Change in CO2 emissions cannot prevent cooling after 300 years



Summary

Milankovitch Cycles determine the climate in the long range.

Ice ages have been coming in a 100,000-year cycle, with eccentrity in earth's orbit

The next ice age will probably come about 250,000 years from today