Space Science Seminar
Tuesday, 2022 July 12
10:30 a.m.
NASA/MSFC TEAMS

The Faint Young Sun Paradox -- Perhaps the Young Sun Was Not Faint

Prof. Petrus ("Piet") Martens / Professor in Physics and Astronomy / Georgia State University
Host: Dr. Alphonse Sterling (Sponsored by NASA/MSFC/ST13)

While much (necessary) attention is being paid to the possible influence of the Sun on global climate variation, there is an even more astounding problem in the mismatch between solar luminosity and terrestrial climate in the first several billions of years of the Earth's existence, an issue known as the Faint Young Sun Paradox (FYSP). In brief, the paradox is this: The geological and biological record support that the Earth's biosphere was considerably warmer than currently during the origin of life on Earth and for several billions of years thereafter. Yet, stellar evolution calculations support the Sun reaching the Zero Age Mean Sequence (ZAMS) at about 70% of its present luminosity, and linearly increasing in time up to its current level. Climate models predict a "Snowball Earth" for such a low solar constant, unless the greenhouse effect was much stronger than what it is now. However, there is no geological evidence for a hugely increased presence of greenhouse gases in the early atmosphere.

In my seminar I will present a possible solution for the FYSP in that the Sun has been close to its current luminosity since reaching the ZAMS. This can be achieved by the Sun starting out 3-5% more massive than it is now, and maintaining a large mass loss, about 300 times the current value, for the first several billion years of its existence. This scenario could explain at the same time why Mars has had liquid surface water, perhaps even oceans, for the first several billion years of its existence.

We are investigating our scenario in several different manners:

1. Stellar evolution calculations with a large initial mass loss and concurrent slow down in rotation rate by magnetic breaking, to verify whether there is a pathway for our proposed solution
2. Observations that can verify a large initial solar mass loss, such as analysis of moon rocks and the cometary material.
3. Observations of nearby Sun-like stars at earlier stages in their evolution, to determine rotation rates and possibly mass loss.
4. Helioseismology: A young Sun at an initial mass of ~ 1.04 M sun would have a different core composition from one that started out at 1.0 M sun.

I will dive deeper into these approaches during my presentation and present preliminary results.