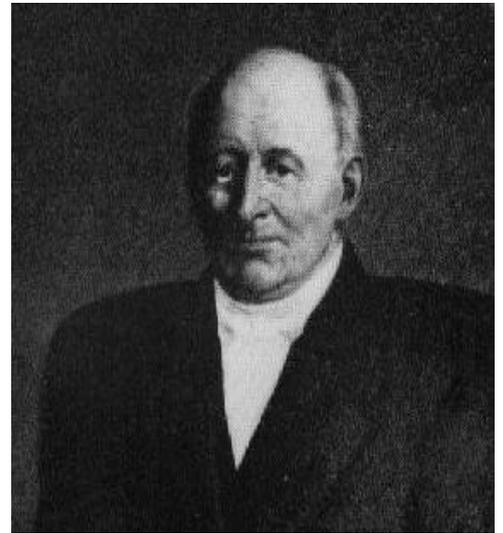


## SUNSPOTS, COSMIC RAYS AND EARTH'S CLIMATE

Data provided by the students of Earth to Sky Calculus and **Dr. Tony Phillips** of SpaceWeather.com show cosmic ray levels are intensifying as the Solar Minimum approaches, with an approximately 13% increase since March 2015.



Forecasters expect the sunspot cycle to reach its minimum in 2019 - 2020. Sunspots are dark blemishes on the surface of the Sun, caused by a periodic reversal of the Sun's magnetic field. The cyclic sequence of this was discovered in 1843 by **Samuel Heinrich Schwabe**, who after 17 years of observations noticed an eleven year periodic variation in the number of sunspots visible. **Rudolf Wolf** compiled and studied these and other observations, reconstructing the cycles back to 1745, eventually pushing these reconstructions to the earliest observations of sunspots by **Galileo** and contemporaries in the early seventeenth century. Wolf created a standard sunspot number index, the Wolf index, which continues to be used today. The 1755–1766 cycle is traditionally numbered "1". **Edward Walter Maunder** extensively researched Sunspot history and noted periodic change in the number of spots in each cycle. The period between 1645 and 1715, a time of few sunspots, is known as the Maunder minimum after him.

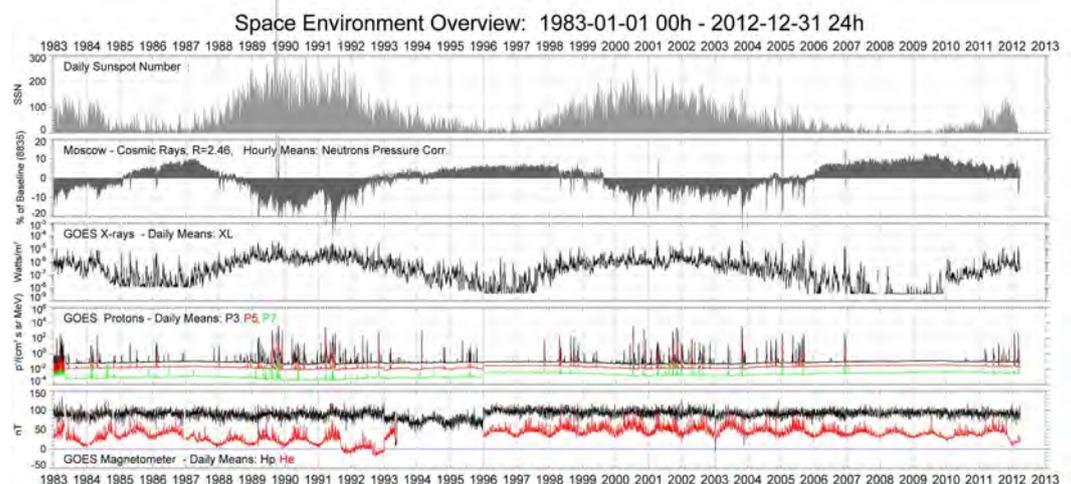


Samuel Heinrich Schwabe (1789–1875). German astronomer, discovered the solar cycle through extended observations of sunspots

Modern research seems to indicate that during the nadir (minimum) of the sunspot cycle, the entire heliosphere changes its personality with many consequences for the space around our planet. One of the most important changes involves cosmic rays, high-energy radiation reaching Earth from deep space. As sunspot numbers decline, cosmic rays seem to intensify. During Solar Maximum coronal mass ejections are abundant and cosmic rays are held at bay and made to sweep past the Earth. Now, 300 years past the Maunder Minimum, the solar cycle is again swinging toward a Solar Minimum, allowing cosmic rays to intensify. **So what exactly are cosmic rays and how does this affect us?**

Cosmic rays are highly energetic photons and subatomic particles travelling through space at a speed approaching that of light. They are accelerated by distant supernovas and other violent events. Cosmic rays penetrate commercial airlines, dosing passengers and flight crews enough that pilots are classified as occupational radiation workers. Some research shows that cosmic rays can seed clouds and trigger lightning, potentially altering weather and climate. Although it may vary from place to place, all parts of the world will be experiencing elevated levels of cosmic rays.

**A. C. Maycock**, using a global climate model, examined the potential impacts of the onset of an extreme solar minimum and feels this could have significant impacts on Earth's climate over the century. Temperatures will drop and the Arctic will freeze over again. Historical Sunspot minima have also been detected by analysis of carbon-14 in tree rings.



These show 18 periods of minima in the last 8,000 years. AK, with Notes from E Marso and R Giles