Warming Due To Ultraviolet Effects Through Ozone Chemistry

Research by Robert Hodges and Jim Elsner of Florida State University (GRL June 2010) found the probability of three or more hurricanes hitting the United States goes up drastically during low points of the 11-year sunspot cycle (see story here).

Years with few sunspots and above-normal ocean temperatures spawn a less stable atmosphere and, consequently, more hurricanes, according to the researchers. Years with more sunspots and above-normal ocean temperatures yield a more stable atmosphere and thus fewer hurricanes.

The sun's yearly average radiance during its 11-year cycle only changes about one-tenth of one percent, according to NASA's Earth Observatory. But the warming in the ozone layer can be much more profound, because ozone absorbs ultraviolet radiation. Between the high and low of the sunspot cycle, radiation can vary more than 10 percent in parts of the ultraviolet range, Elsner has found. When there are more sunspots and therefore ultraviolet radiation, the warmer ozone layer heats the atmosphere below (figure 1).

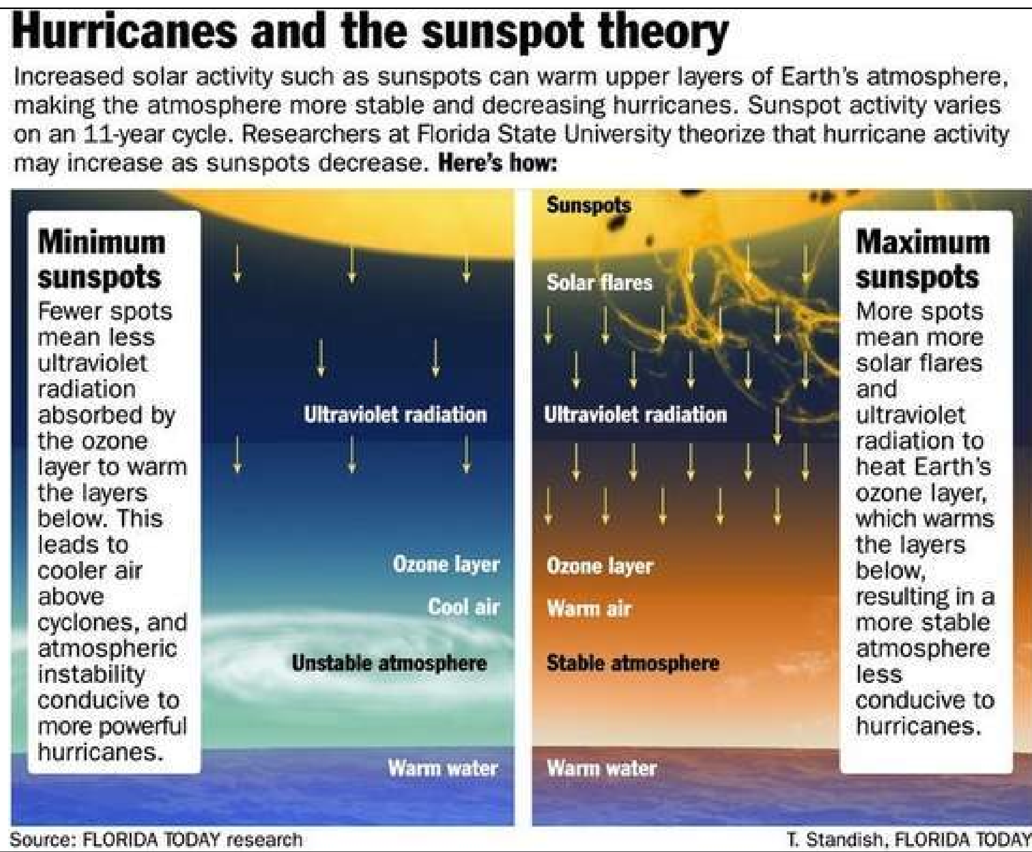

Figure 1: Research by Robert Hodges and Jim Elsner of Florida State University found the probability of three or more hurricanes hitting the United States goes up drastically during low points of the 11-year sunspot cycle, such as we're in now. Years with few sunspots and above-normal ocean temperatures spawn a less stable atmosphere and, consequently, more hurricanes, according to the researchers. Years with more sunspots and above-normal ocean temperatures yield a more stable atmosphere and thus fewer hurricanes

Baldwin and Dunkerton (2004) had found similarly, although solar irradiance varies 0.1-0.15 (this cycle) over the 11 year cycle, radiation at longer UV wavelengths increased by several (6-8% or more) percent with still larger changes (factor of two or more) at extremely short UV and X-ray wavelengths.

Energetic flares increase the UV radiation by 16%. Ozone in the stratosphere absorbs this excess energy and this heat has been shown to propagate downward and affect the general circulation in the troposphere.

Both the production and destruction of ozone in the stratosphere are exothermic (heat releasing) processes. The ozone in the stratosphere is produced by photochemical reactions involving O_2. When diatomic oxygen in the stratosphere absorbs ultraviolet radiation with wavelengths less than 240 nm, it breaks apart into two oxygen atoms.

$$O_2(g) \xrightarrow{\text{uv light}} 2\,O(g) \qquad \text{(light wavelength < 240 nm)}$$

The resulting oxygen atoms combine with O_2 molecules to form ozone.

$$O(g) + O_2(g) \longrightarrow O_3(g)$$

This reaction is exothermic, and the net effect of the previous two reactions is the conversion of three molecules of O_2 to two molecules of ozone with the simultaneous conversion of light energy to heat. Ozone absorbs ultraviolet radiation with wavelengths as long as 290 nm. This radiation causes the ozone to decompose into O_2 molecules and oxygen atoms.

$$O_3(g) \xrightarrow{\text{uv light}} O_2(g) + O(g) \qquad \text{(light wavelength < 290 nm)}$$

This, too, is an exothermic reaction. The overall effect of this reaction and the previous reaction is the conversion of light energy into heat. Thus, ozone in the stratosphere prevents highly energetic radiation from reaching the Earth's surface and converts the energy of this radiation to heat.

Labitzke and Van Loon (1988) and later Labitzke in numerous papers has shown that high flux (which correlates very well with UV) produces a warming in low and middle latitudes in winter in the stratosphere with subsequent dynamical and radiative coupling to the troposphere. Shindell (1999) used a climate model that included ozone chemistry to reproduce this warming during high flux (high UV) years.

The winter of 2001/02 (figure 2), when cycle 23 had a very strong high flux second maxima provided a perfect verification of Shindell and Labitzke and Van Loon's (figure 3) work.

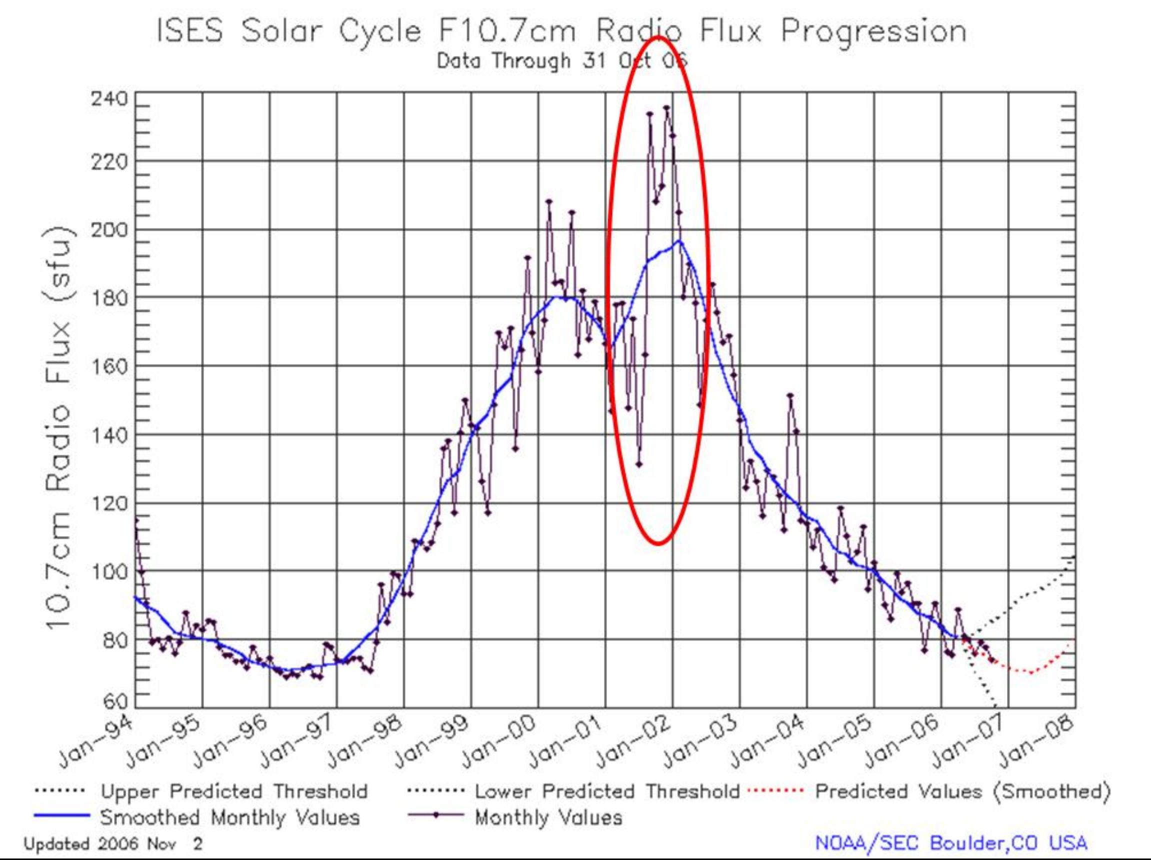

Figure 2: NOAA SEC solar flux (10.7cm) during cycle 23. Note the second solar max with extremely high flux from September 2001 to April 2002.

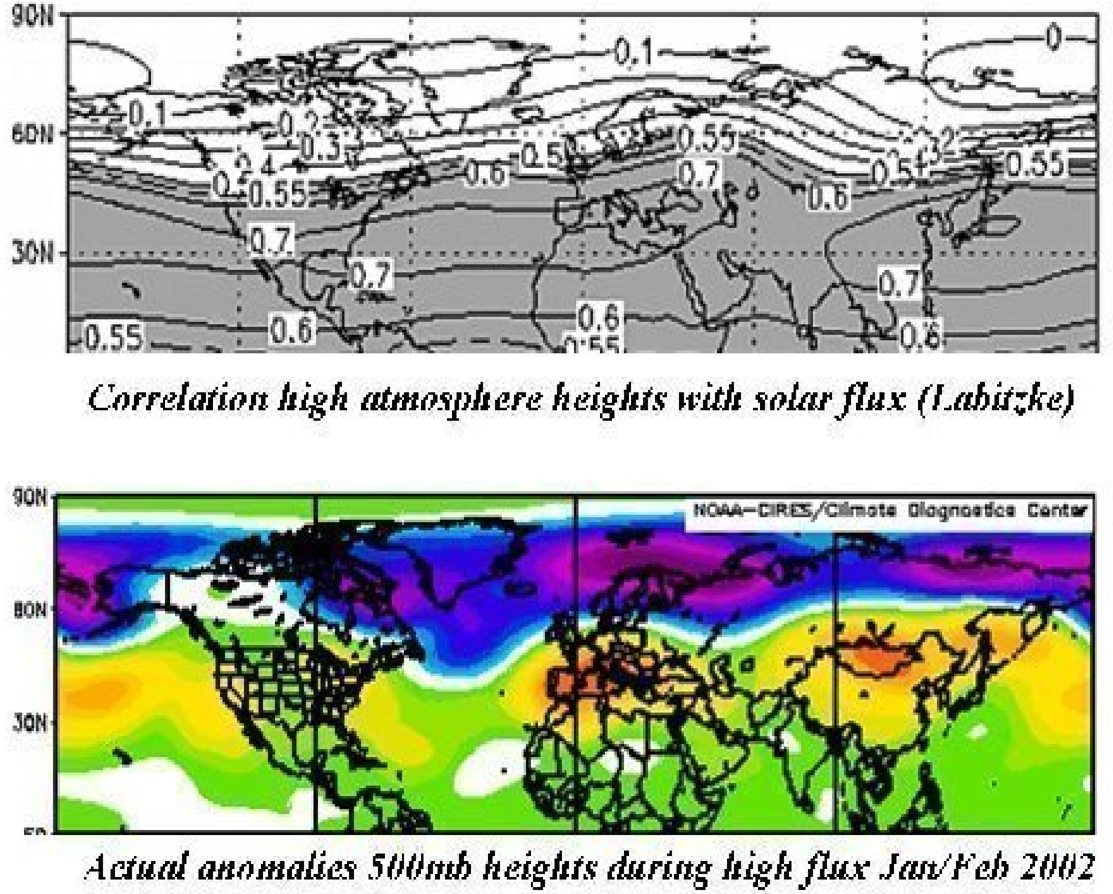

Figure 3: Labitzke correlated stratospheric heights with solar flux and actual height anomalies in the mid-troposphere during the high flux mode of the second solar max in early 2002.

The warming that took place with the high flux from September 2001 to April 2002 caused the northern winter polar vortex to shrink (figure 2) and the southern summer vortex to break into two centers for the first time ever observed. This disrupted the flow patterns and may have contributed to the brief summer breakup of the Larsen ice sheet (figures 4, 5 and 6).

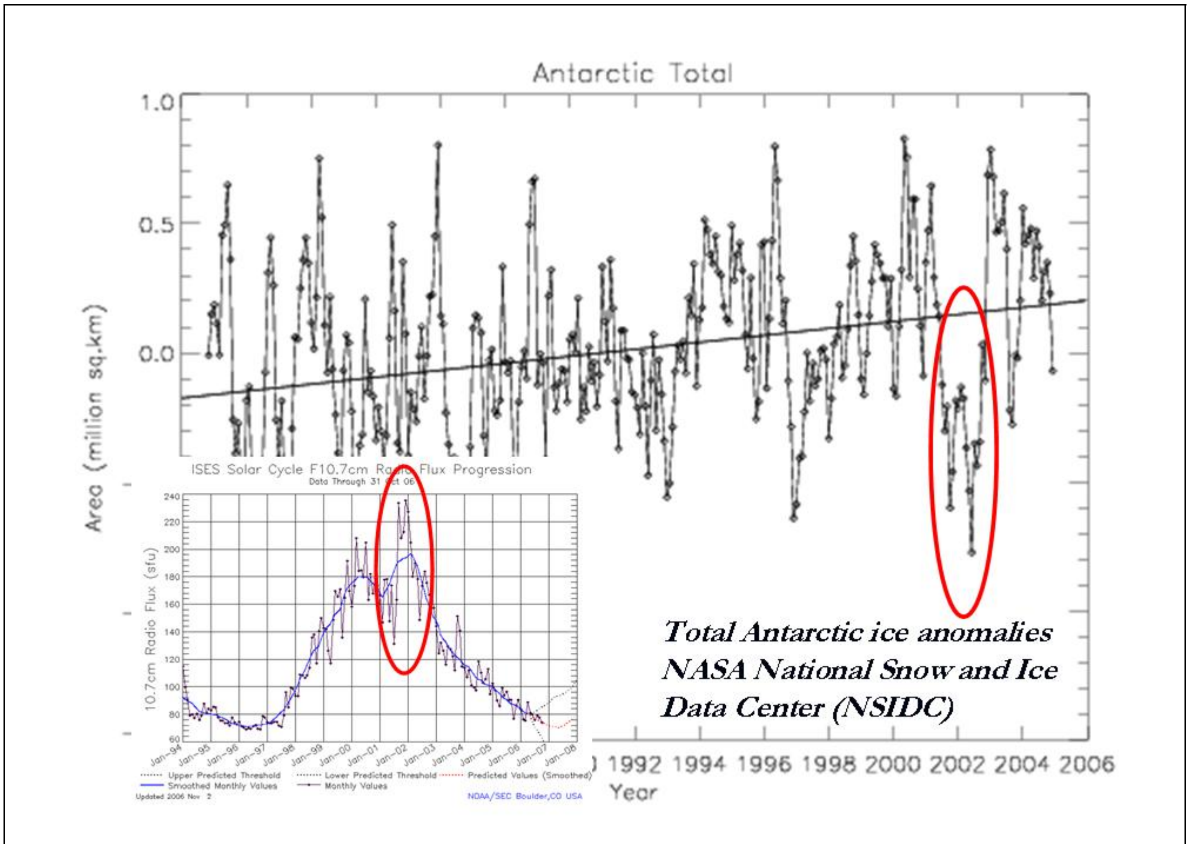

Figure 4: NASA NSIDC satellite derived Total Antarctic ice extent anomalies from 1979 to 2005. Note the dropoff with the Larsen ice sheet break-up in the summer of 2002 corresponding to major atmospheric changes during the high flux second solar max.

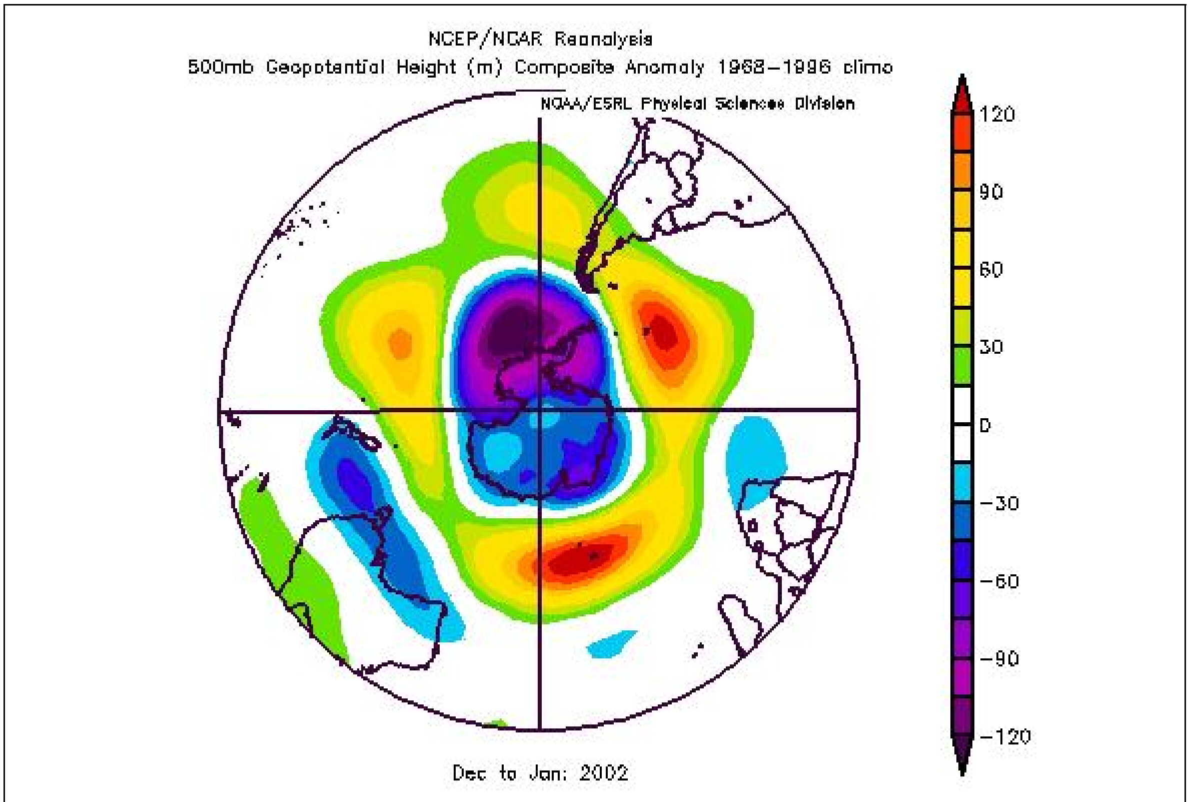

Figure 5: December 2001 to January 2002 500mb height anomalies for Southern Hemisphere. Note the ring of warming with the high flux induced UV ozone chemistry as a ring surrounding a shrunken polar vortex as seen in the Northern Hemisphere in figure 2. Note how the vortex actually became a dipole with weakness in center. The changing winds and currents very likely contributed to the ice break of the Larsen ice sheet.

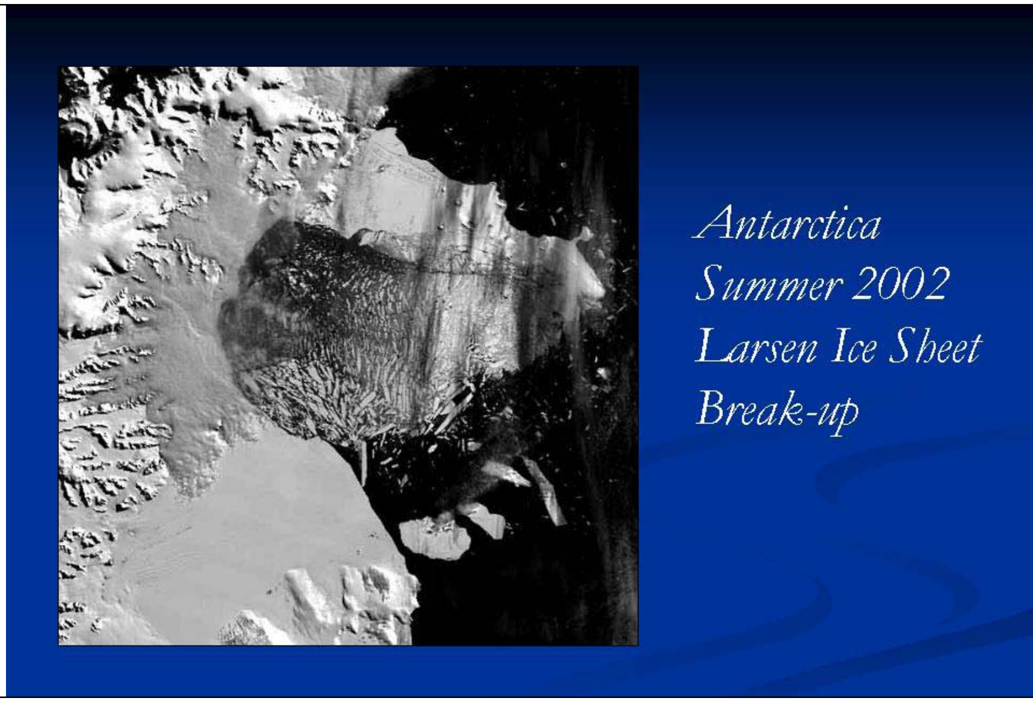

Figure 6: Larsen ice sheet break up late summer 2002 following strong solar flux break-up of southern polar vortex.

NASA reported on the use of the Shindell Ozone Chemistry Climate Model to explain the Maunder Minimum (Little Ice Age) (figure 7).

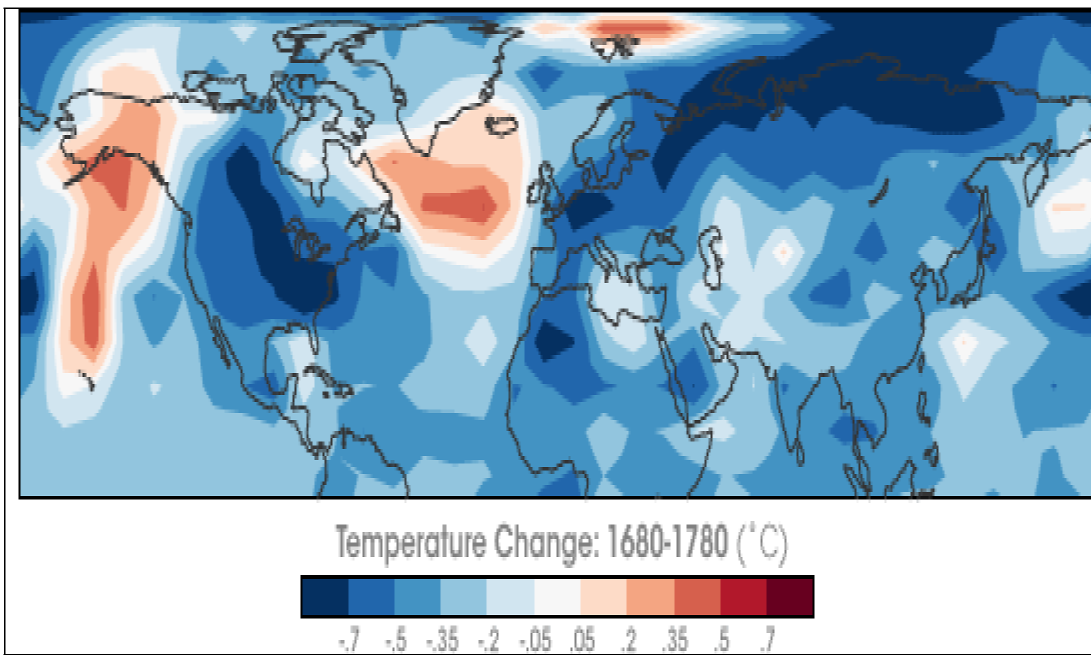

Figure 7: Shindell ozone chemistry model forecast of the difference between the quiet solar period of the Maunder Minimum and the active late 18th century.

Their model showed when the sun was quiet in 1680, it was much colder than when it became active again one hundred years later. "During this period, very few sunspots appeared on the surface of the Sun, and the overall brightness of the Sun decreased slightly. Already in the midst of a colder-than-average period called the Little Ice Age, Europe and North America went into a deep freeze: alpine glaciers extended over valley farmland; sea ice crept south from the Arctic; and the famous canals in the Netherlands froze regularly—an event that is rare today."

The UV is only one candidate solar related variance that may influence climate. Though the IPCC and alarmist scientists like to point to the small changes in the brightness/irradiance as evidence that the sun does not rule the climate, these other factors collectively likely make the sun the primary candidate for climate change. This is true even for any warming from 1977 to 1998 that is above and beyond the urbanization and land use change effects. It may be the sun works through the oceans as an intermediary or amplifying factor by influencing the multidecadal oscillations as Scafetta (2010) (PDF here) and others have suggested. See more on the various candidate solar factors here.

References:

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