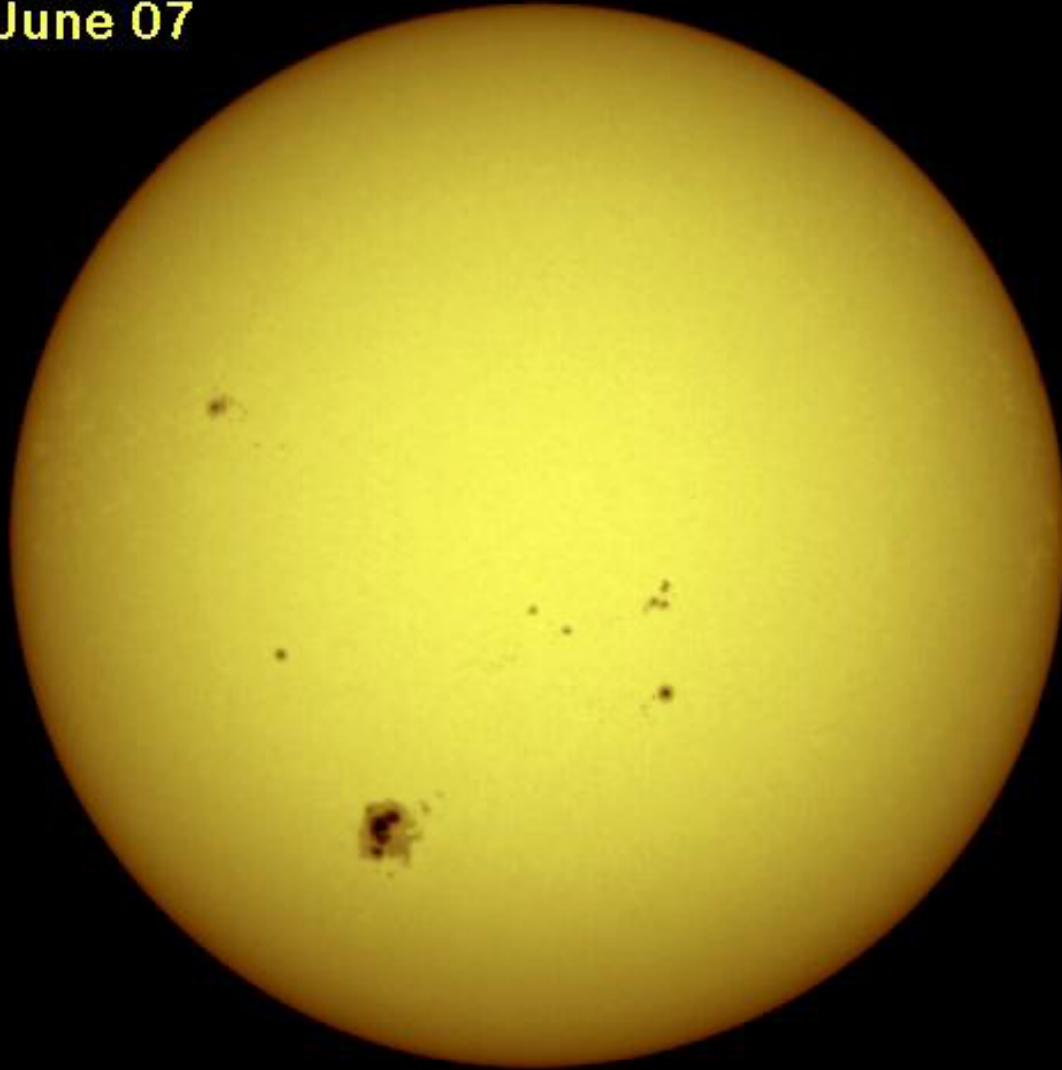
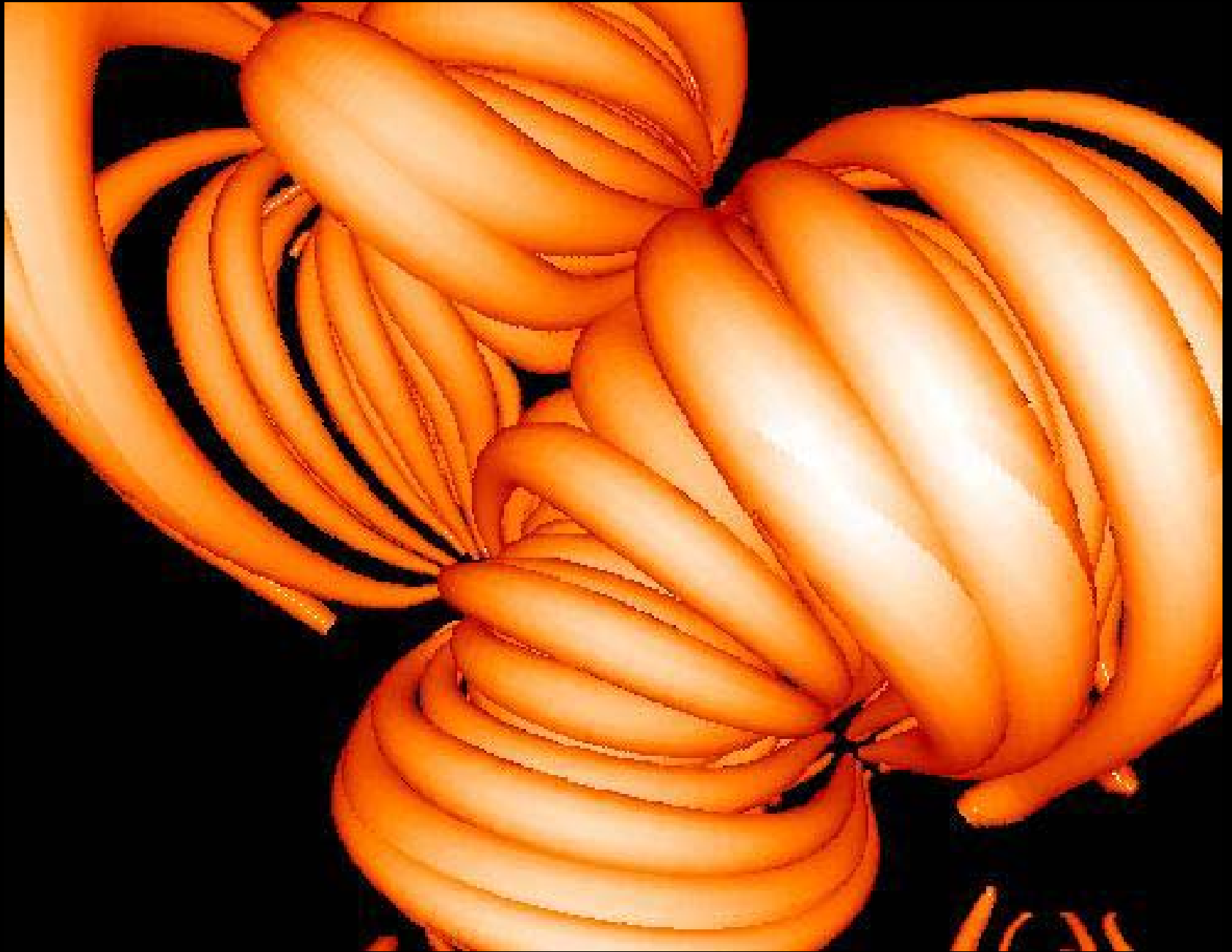
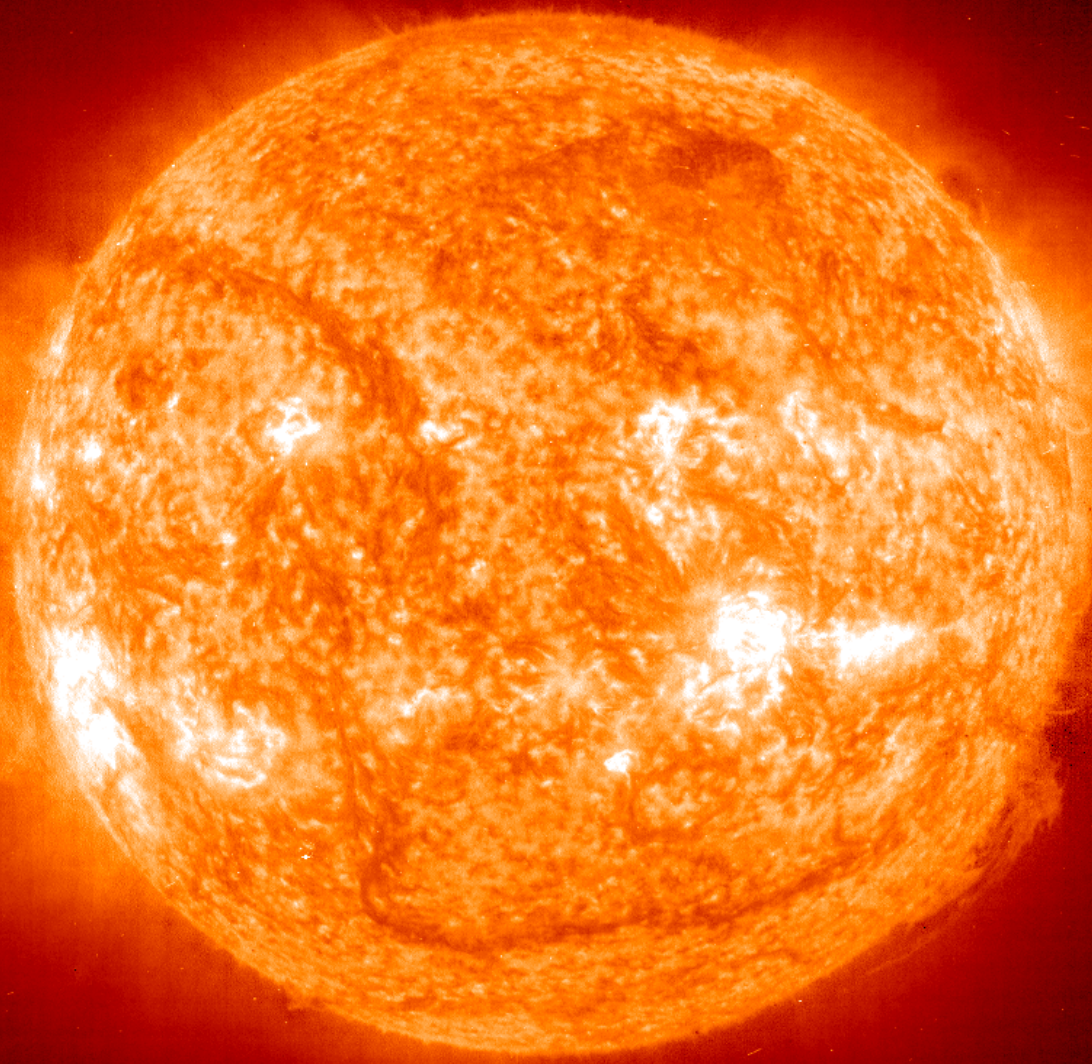


Sunspots are areas of intense, arched magnetic field

1992 June 07

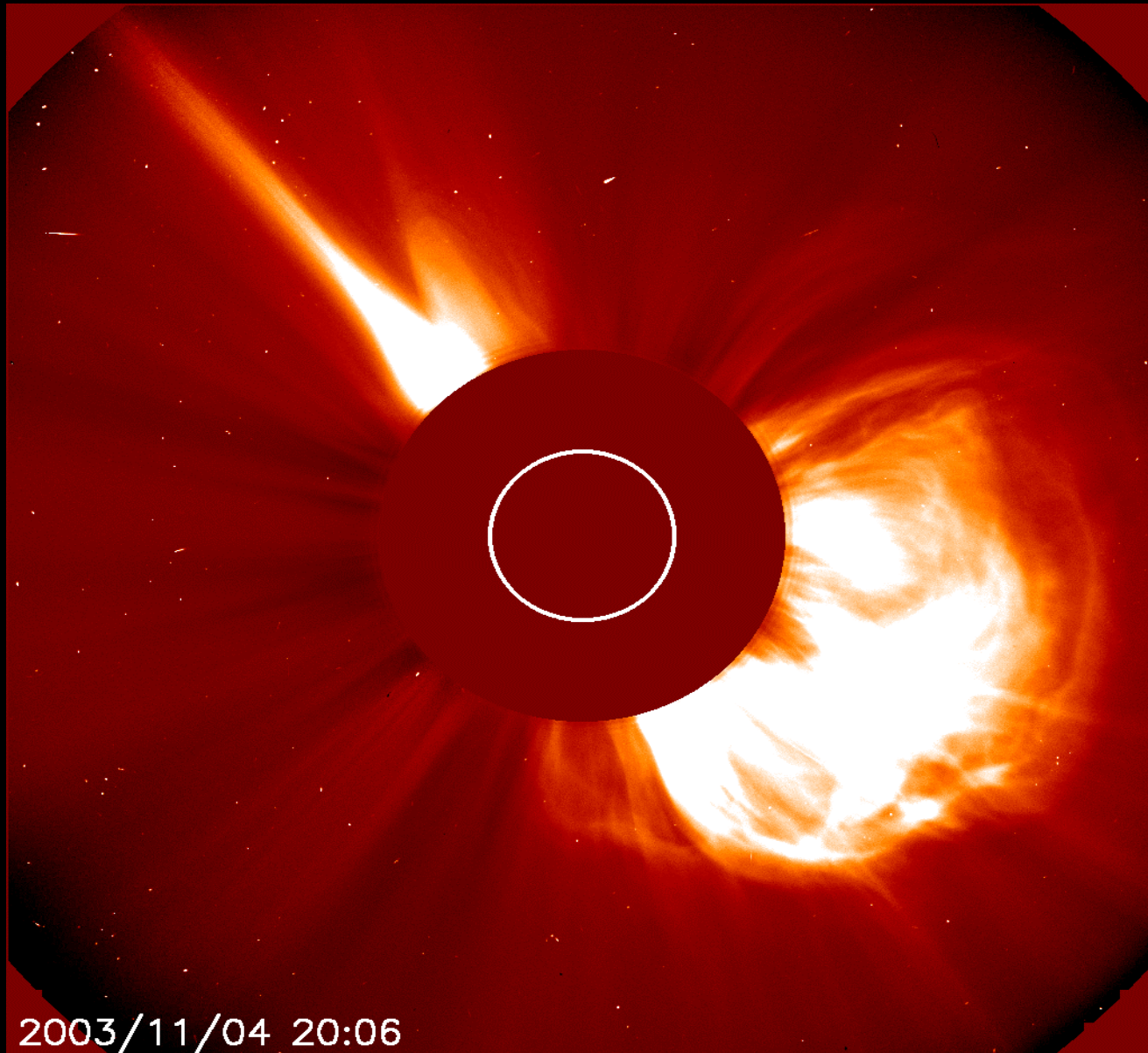






Skylab

Extreme solar flare November 4, 2003



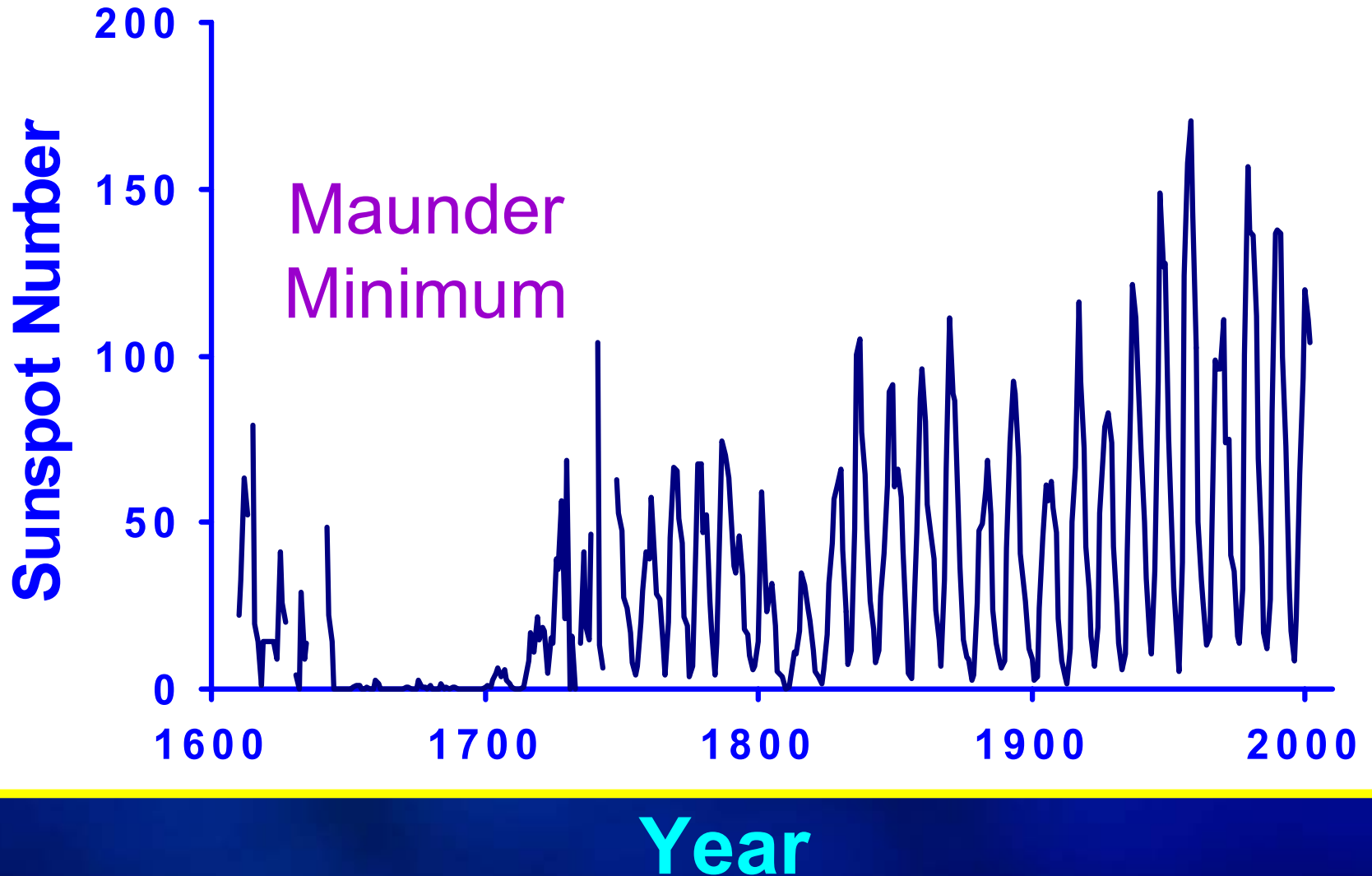
2003/11/04 20:06

SOHO-
LASCO

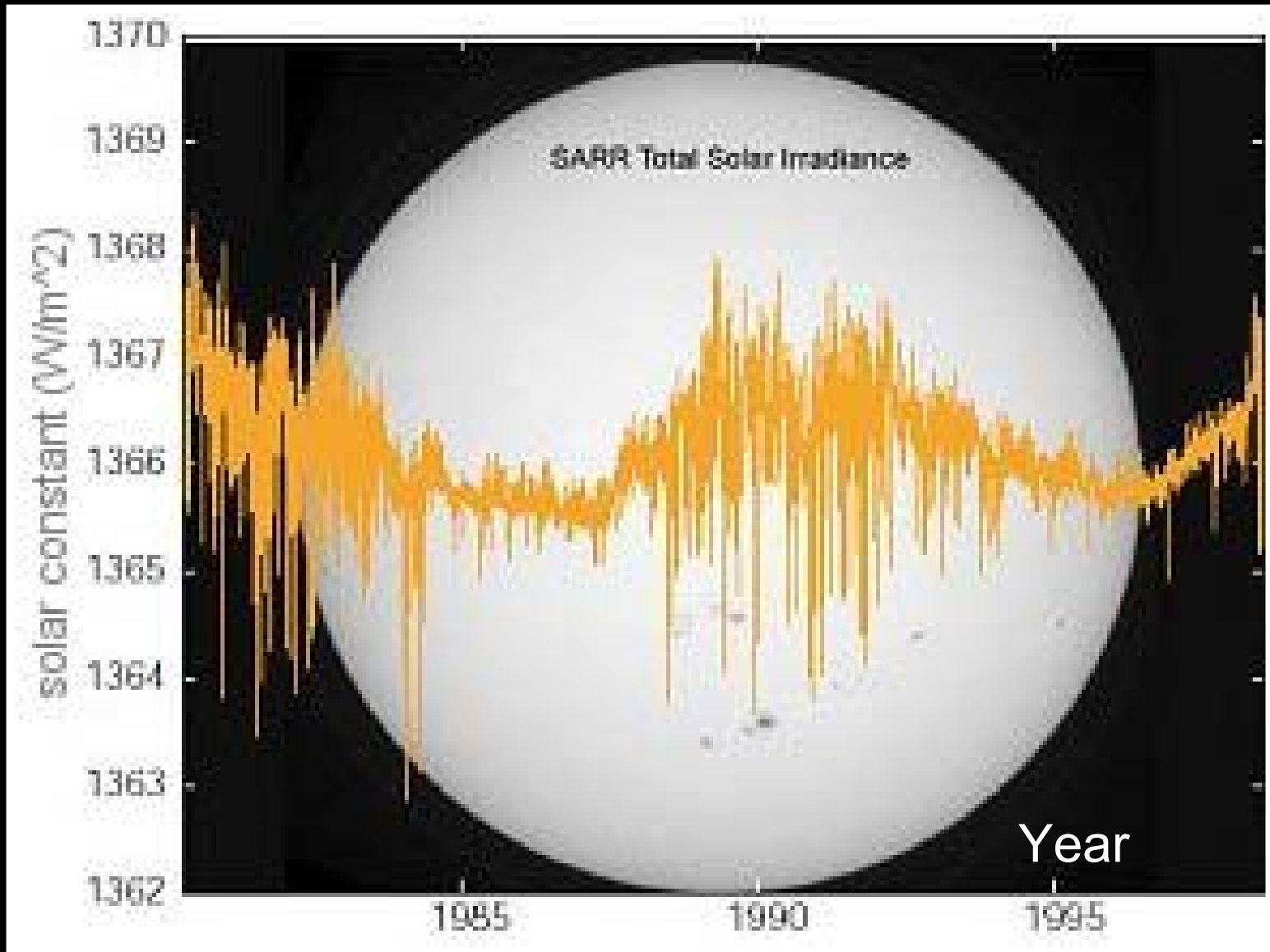
Earth's magnetic environment



The sun's magnetism has been strengthening in four centuries of telescope records



Sun's magnetism and brightness vary with 11-year cycle

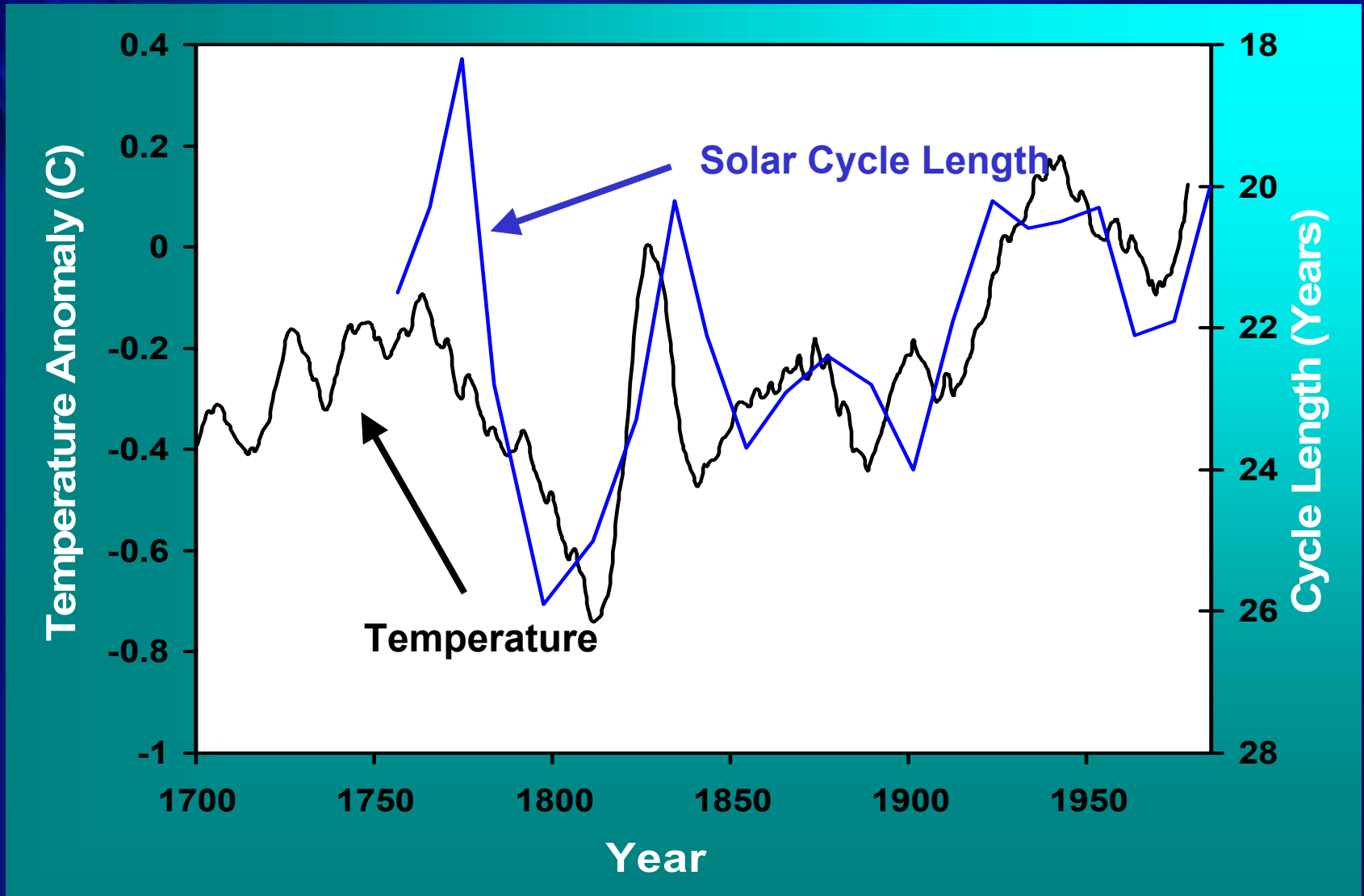


Supernovae create cosmic rays



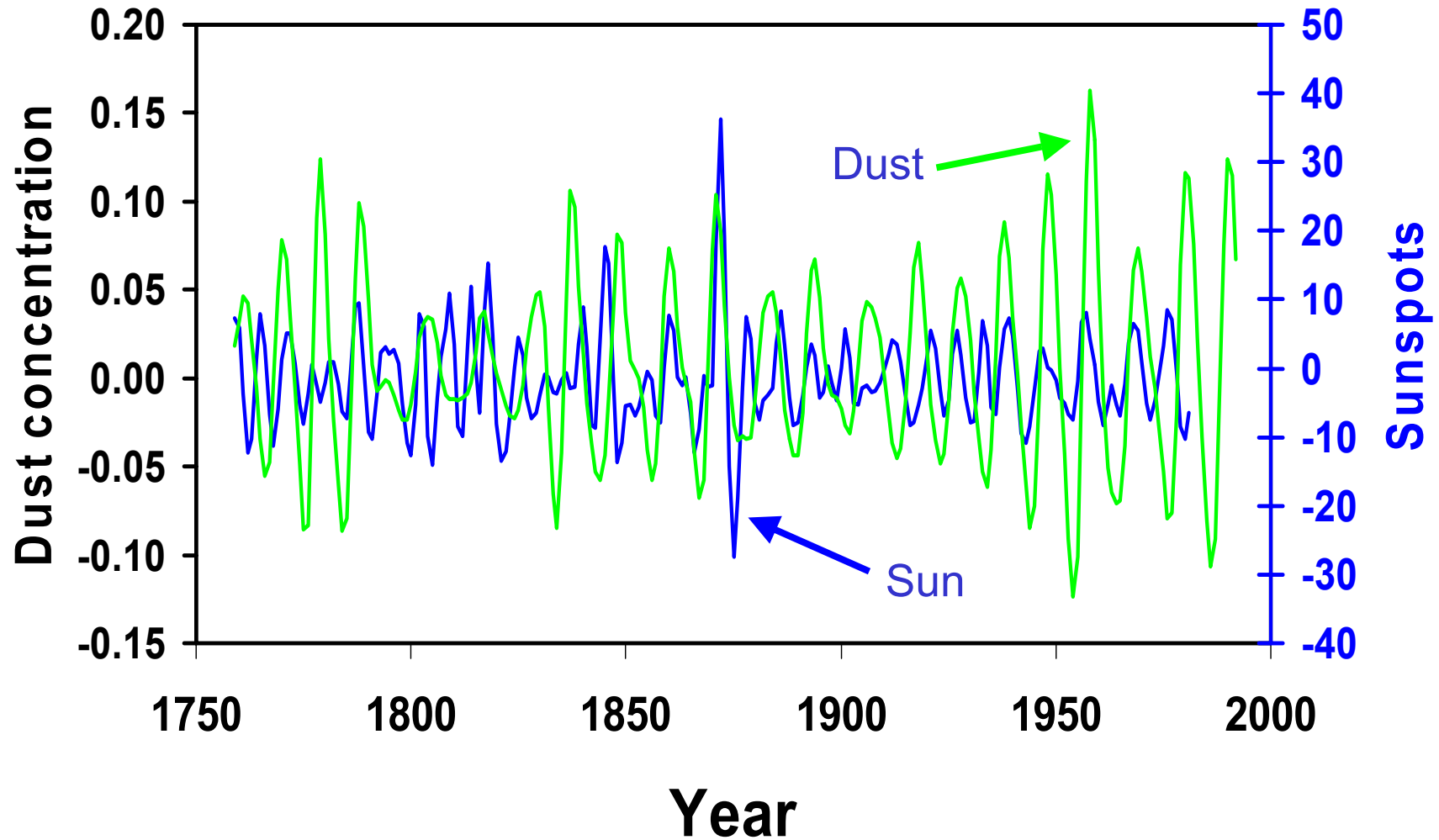
© Anglo-Australian Obs./Royal Obs. Edinburgh

Northern Hemisphere Land Temperature and Sun

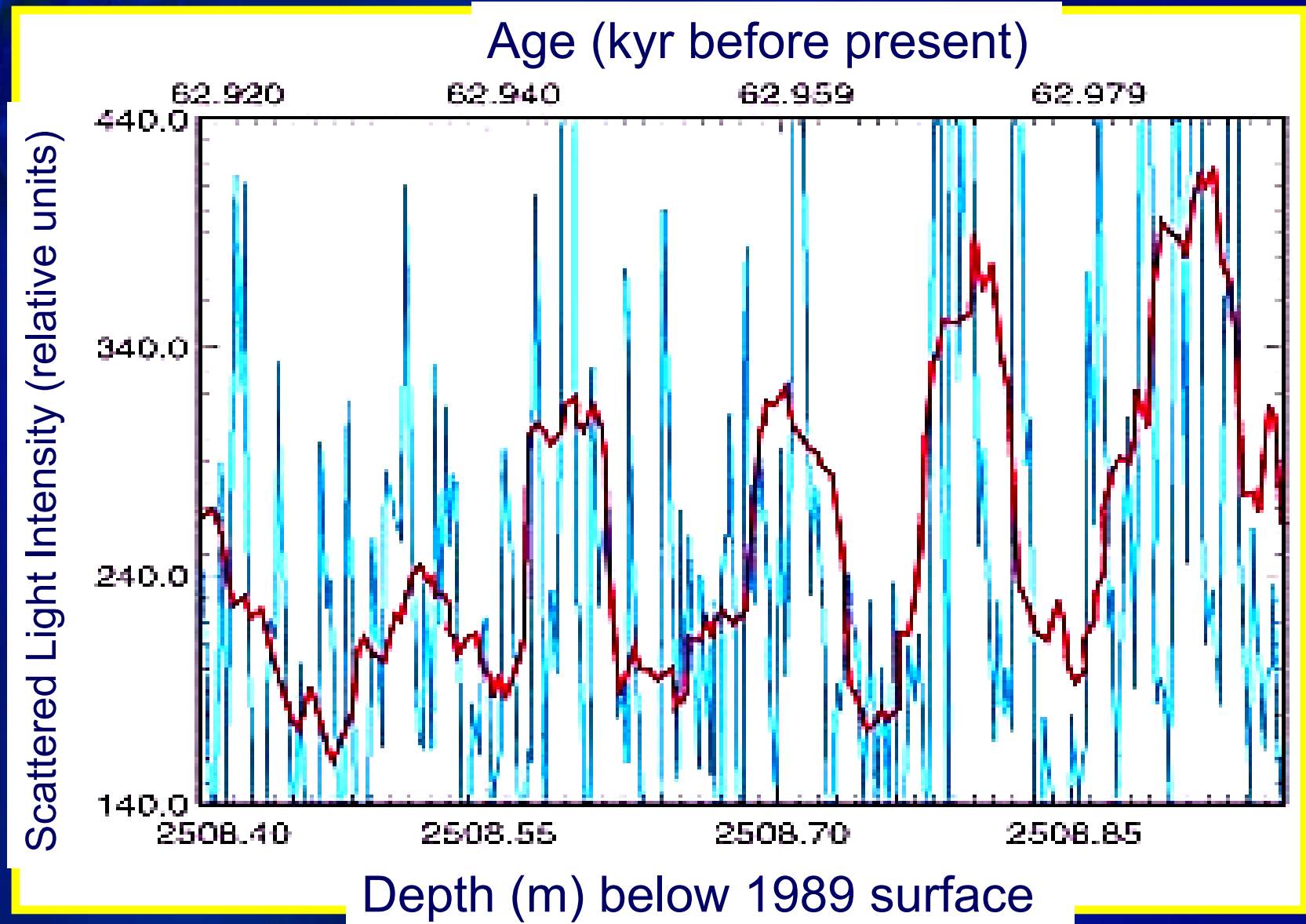


S. Baliunas and W. Soon 1995 *Astrophys. J.*

Greenland ice core dust content changes with 11-year sunspot cycle, 1750 - 1981

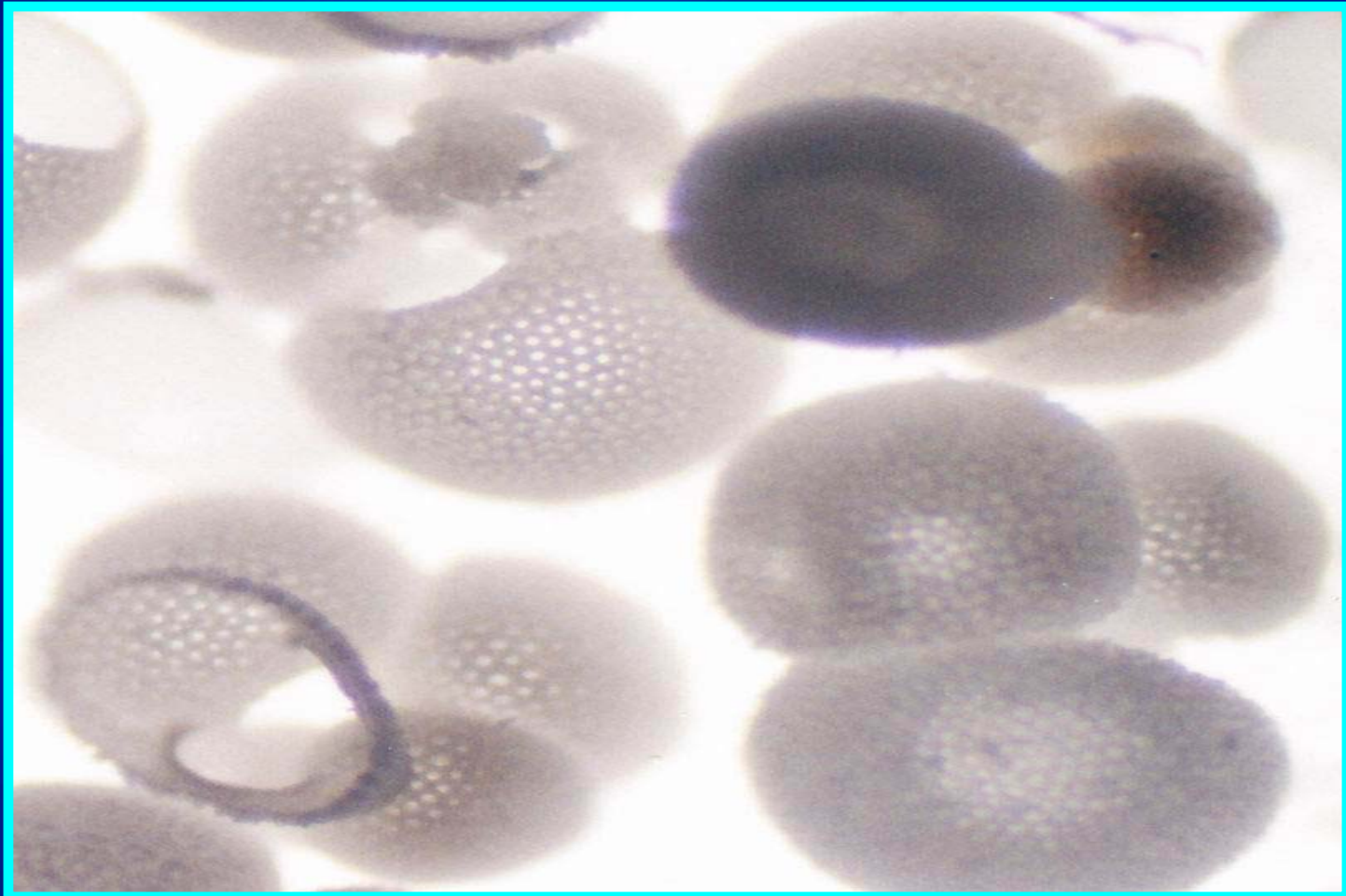


11-year cycle (sun?) of dust in Greenland ice core, over 62,000 years ago

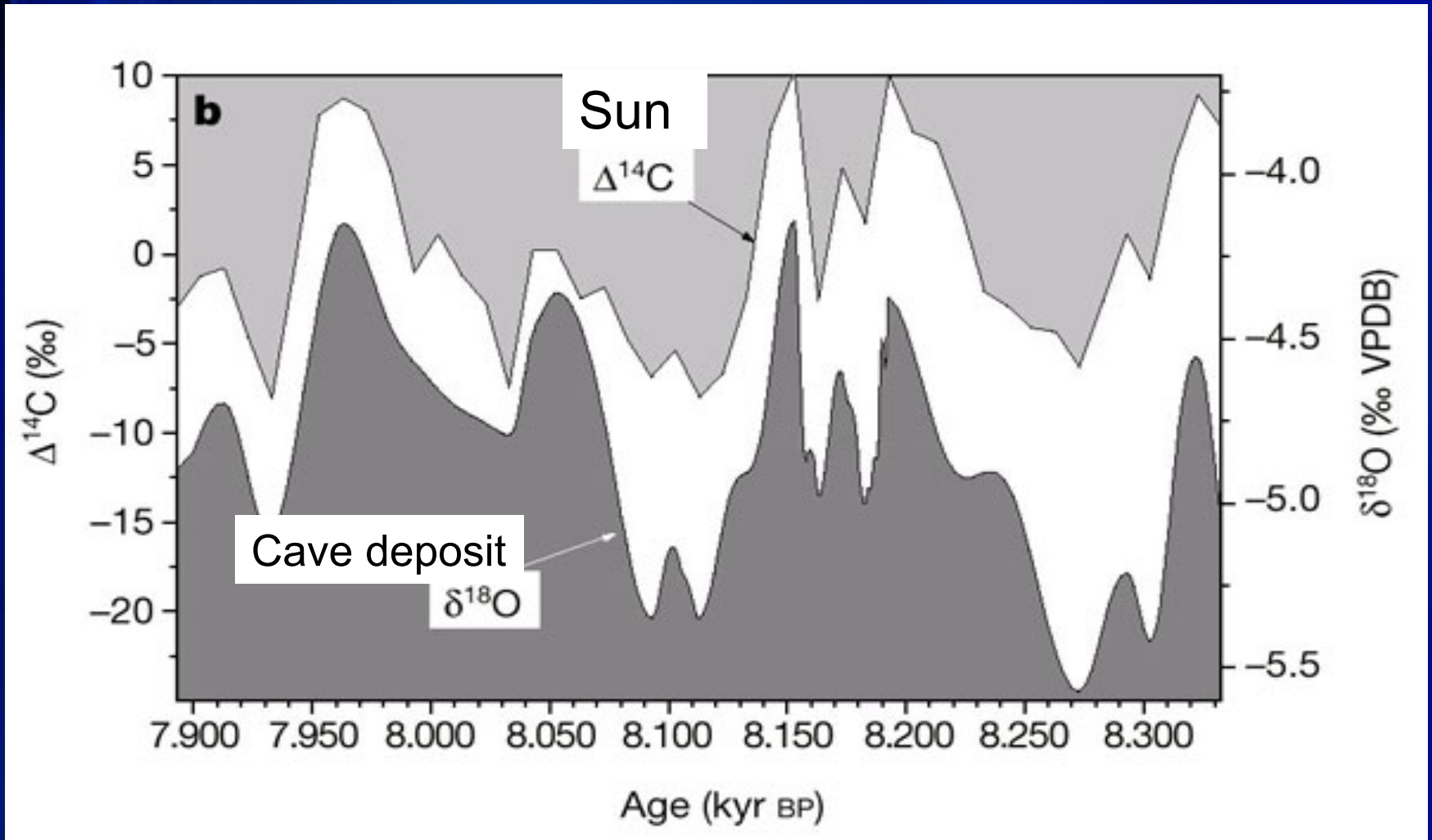


Past environmental indicator: *G. sacculifer* in Gulf of Mexico
cores shows sun-like periods of 200, 300, 550 years

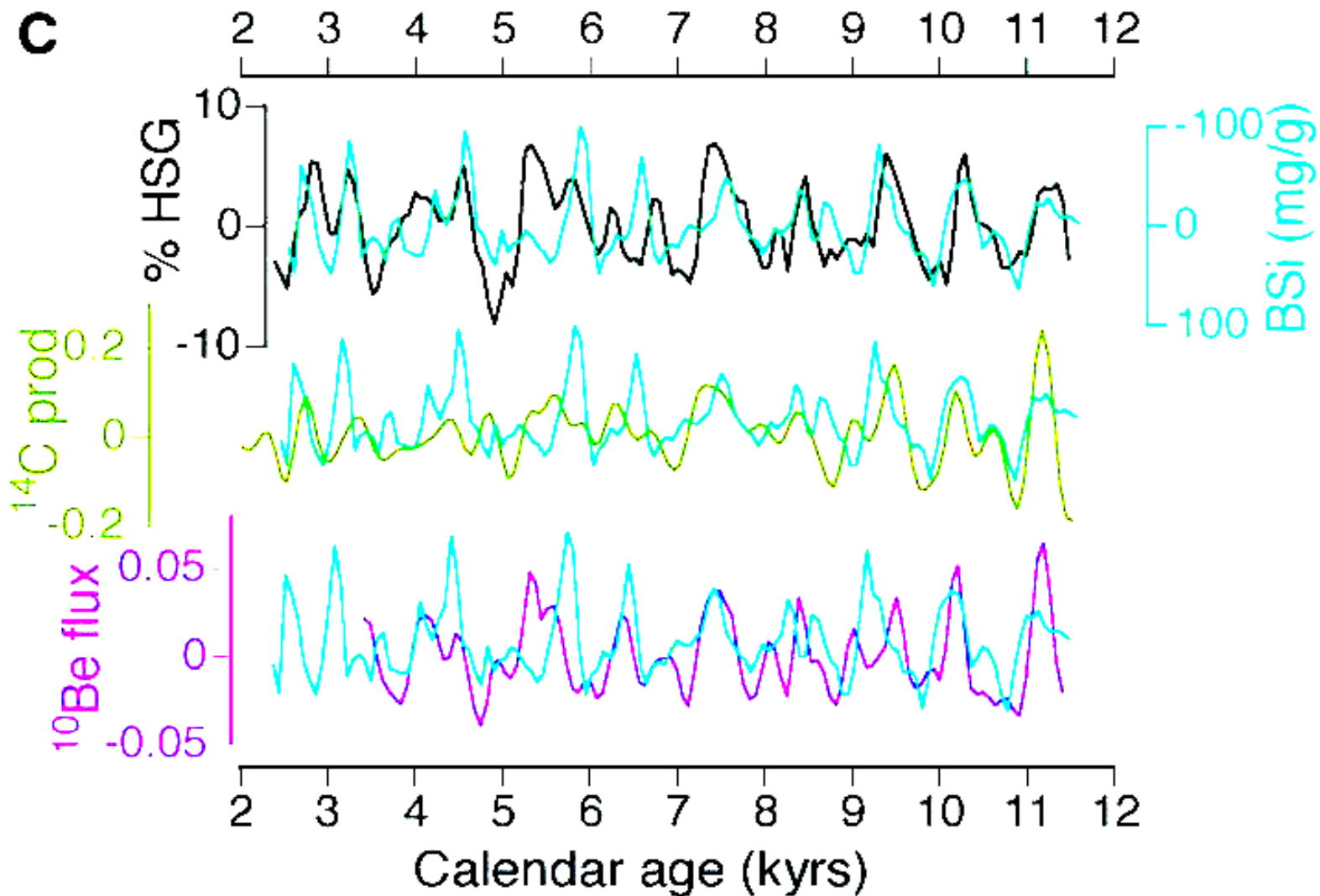
R.Z.Poore et al. 2003, *Paleoceanography* 18 1048



Past environmental indicator: Monsoon intensity from cave deposits in Arabia changes with sun

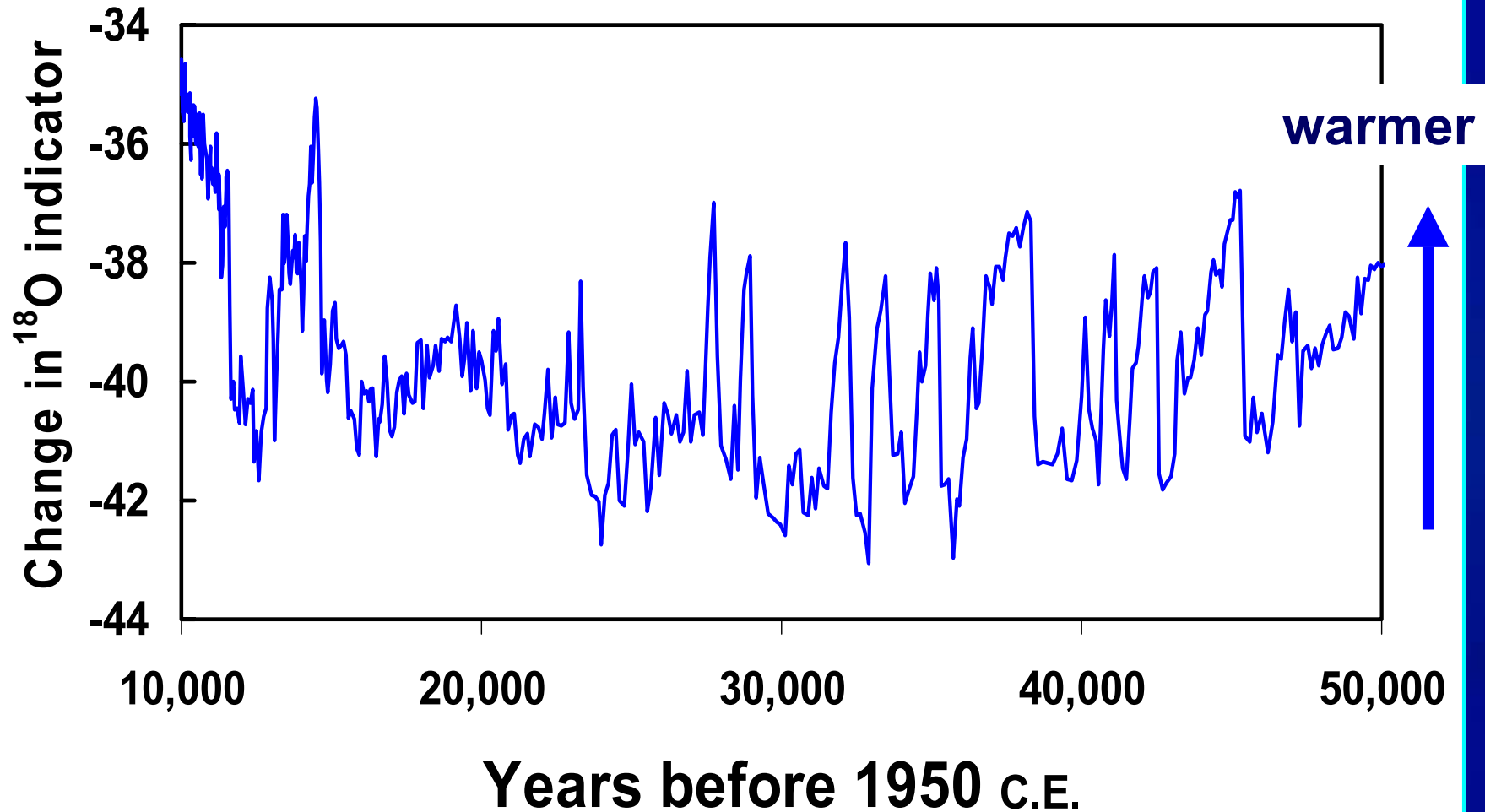


Alaskan lake ecosystem varies as sun does, periods ~200, 400-500, 950 years

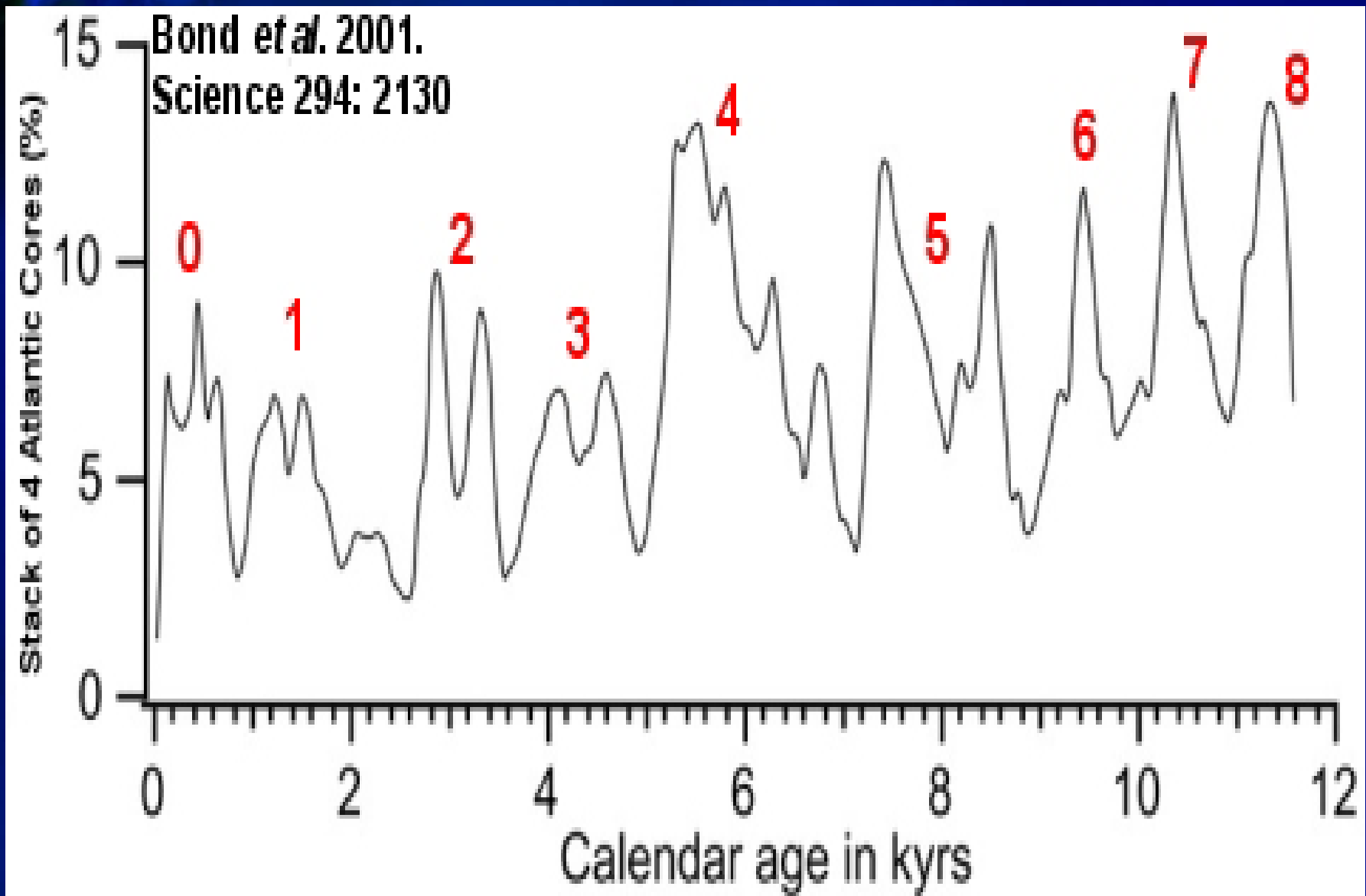


Greenland ice core shows warming pulses paced at 1,470 years

S. Rahmstorf 2002 *Nature* 419, 207-214



Cold events paced at 1,500 years



New sun-climate links from past climate

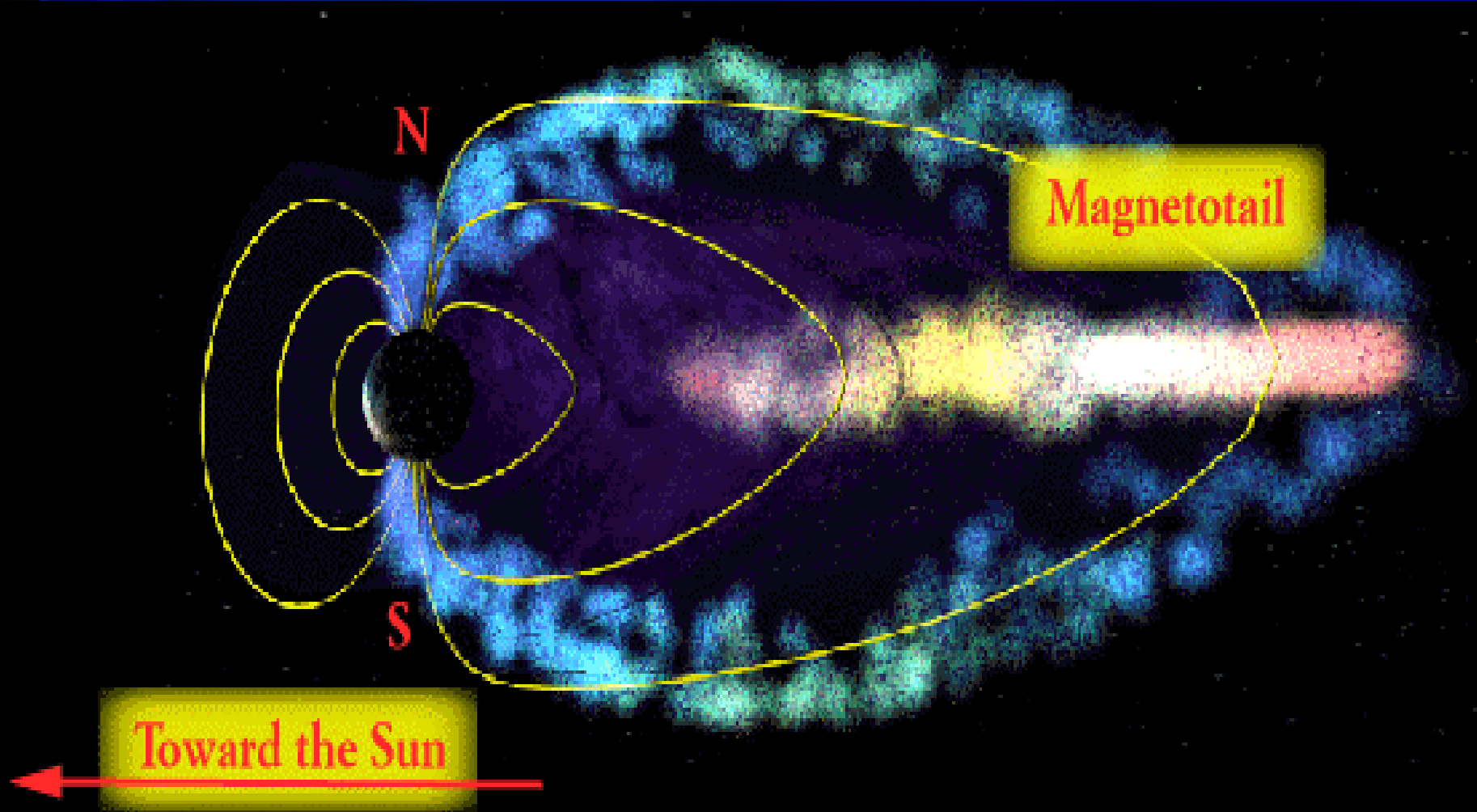
Surprisingly high, natural climate variability during last 10,000 years

Century-scale climate changes similar to solar periods

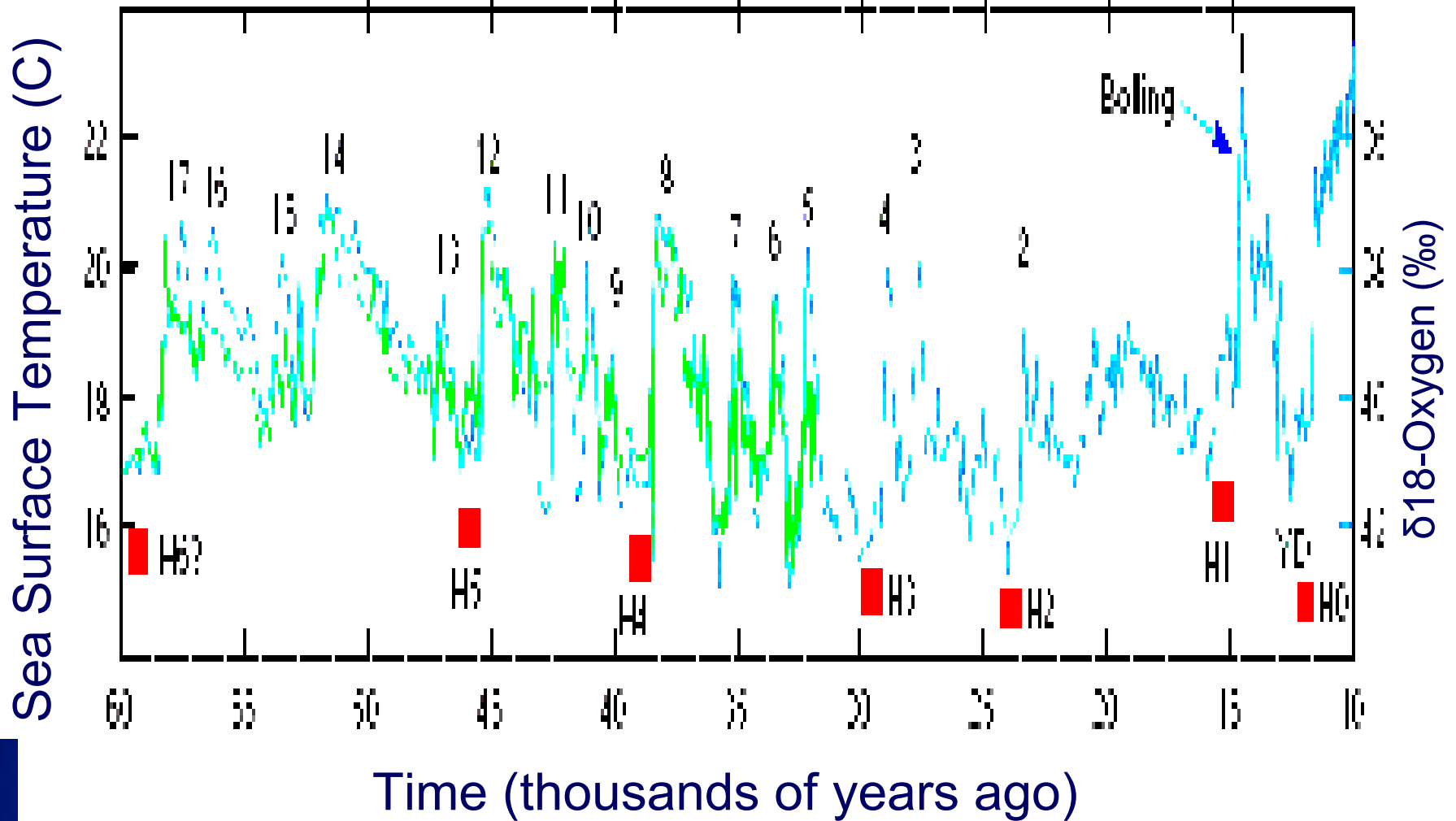
Abrupt climate changes paced at 1,500 years seems not solar

Physical links remain poorly understood, both for sun and climate response

Earth's magnetic environment



Warm events paced at 1,470 years



New sun-climate links from paleoclimate

Greenland ice core – ^{18}O ratio record from 50,000 to 10,000 years ago shows persistent 1,470-year cycle (triggered?) of Dansgaard-Oeschger events. Little Ice Age last cold phase?
S. Rahmstorf 2003 GRL 30, No. 10, 1510.

Gulf of Mexico cores – ^{18}O ratio and populations of plankton remains going back 14,000 years “...[C]entury-scale variability is a pervasive feature of Holocene climate.” 300-yr period, plus 2000, 550 200, 170 year cycles. R.Z. Poore et al., 2003 *Paleoceanography*, 18, 1048.

North Atlantic cores – “pervasive” 1500-yr period of cooling events during Holocene G. Bond et al. 2001 *Science* 294 2130-6

“...[P]roxy records provide clear evidence that the climate of the Holocene is highly variable...” (Poore et al. 2003)