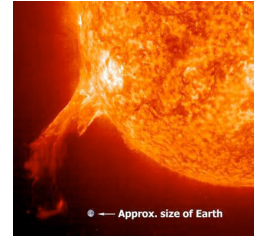


The 2006 Exploring Space Lectures

Our Home in Space: The Earth – Sun System

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The Sun and the terrestrial biosphere are intricately and inextricably linked. Life would be impossible on Earth without the Sun, even with modern technology. All energy used by Humans, excepting that released by nuclear reactions, has as its ultimate source, the Sun. From the Human perspective, the Sun is an unchanging presence, with precisely-predictable movements, nourishing all. But is the Sun really that way? Given how dependent our lives are on the Sun, and the fact that Human activity is now capable of altering the climate of the only habitat in which we can live, it behooves us to know as much as possible about the Sun-Earth connection, in all its details.

How Can We Determine Past Climate?

- Historical records: Excellent for the “recent” past (few centuries); no good beyond
- Daily/seasonal/annual cycles: Tree rings, varves (annual lake beds), coral growth rings
- Paleomagnetic data from rocks (determine magnetic latitude at time of formation)
- Fossil/pollen record: Determine types of biota present at time of formation
- Astronomical observations and theory: Constancy of solar heating over geologic time
- Stable isotope geochemistry: Temperatures at time of formation

The Sun is a Variable Star!

- Longest-term variation: Stellar evolution models imply that the Sun’s output has increased over billion-year time periods
- There is some evidence that solar output varies on ~1000 year timescales
- Does the 11-year sunspot cycle affect climate change significantly?
- Have there been any other changes in solar output of late?
- While not really variability in the actual energy output of the Sun, another factor affects insolation nonetheless. Tidal forces in the Earth-Moon system are causing the Moon to slowly increase its distance from Earth and for the Earth’s rotation rate to slow. For example, in the Devonian Period, there were ~400 days per year, making the Devonian day proportionally shorter, which would affect a variety of climatic and bioclimatic elements. [This makes a great case study in the process of scientific investigation. The slowing rate of the Earth’s rotation can be calculated from astronomical observation and basic physics. From that, a prediction of day length (number of days per year) can be made for past geologic epochs. When Devonian-age corals, with radiometric ages of ~380 million years, were examined, they showed ~400 days per year, exactly the predicted number if they were, in fact, 380 million years old. Cross-checking is NOT a penalty in Science! See also: http://www1.umn.edu/umnnews/Columns/SciFri/SciFri_3.4.05_Time_and_Tides.html]

Other potential causes of climate change

- Deep-seated irregularities and/or changes in terrestrial heat flow
- Movement of continents by plate tectonics (latitude, ocean circulation, other changes)
- Cyclical variations in Earth orbit parameters (Milankovitch cycles) – The Moon prevents large excursions in the Earth’s obliquity (inclination of Earth’s rotation axis relative to a perpendicular to the plane of Earth’s orbit, presently at 23.5 degrees – the “reason for the Seasons”). We have



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good theoretical evidence that Mars, lacking a large satellite, has suffered extreme swings in obliquity, with attendant profound effects on climate, throughout its history. The eccentricity and longitude of perihelion of the Earth's orbit also undergo periodic variation, and the Earth's axis of rotation precesses at a known rate; both have measurable effect on climate.

- Volcanoes: the effect of explosive volcanism on climate is well-documented. Volcanic dust injected into the stratosphere partially blocks incoming radiation, resulting in a potentially-significant net cooling effect that can last years
- Biological activity has caused, and presently is affecting, climate change
- Short-term changes in key climate-affecting parameters (El Nino)

The Big Question!

How much of the climate change we are presently observing is due to natural causes, and how much is due to human activities?

- Undeniable correlation between global average temperature and atmospheric CO₂ content
- Undeniable increase in CO₂ and other greenhouse gases during last century
- Undeniable natural climate change independent of human activities
- Long-term climate change (hundreds of million years time scales) is (partially) due to changes in solar output
- Which is more important: Atmospheric composition or solar output? Or does it really matter?

Our Speaker

Dr. Lean is a recognized expert on the Sun's role in global climate change.

She received a B.Sc. (Hons), Physics in 1974 from the Australian National University, Australia, where she was awarded the Priscilla Fairfield Bok Prize as the university's best female science student. In 1980, she completed a Ph.D. in atmospheric physics from the University of Adelaide, Australia.

Dr. Lean is a Fellow of the American Geophysical Union, and a member of the International Association of Geomagnetism and Aeronomy, the American Astronomical Society-Solar Physics Division, and the American Meteorological Society. She currently serves as a member of the National Science Foundation's (NSF's) Advisory Committee for Geosciences, and has previously served on numerous panels and advisory groups for NASA, NSF and the National Research Council, including recently the Board on Atmospheric Science and Climate.

References

CNN story about Dr. Lean's work: <http://www.cnn.com/NATURE/9911/24/greenhouse.enn/>

Article by Dr. Lean and David Rind: <http://www.gcrio.org/CONSEQUENCES/winter96/sunclimate.html>

Dr. Lean was elected to the prestigious National Academy of Sciences in 2003:

<http://www.nrl.navy.mil/pao/pressRelease.php?Y=2003&R=37-03r>

Solar output can now be measured quite precisely: <http://solarscience.msfc.nasa.gov>

Milankovitch cycles: ; <http://www.ncdc.noaa.gov/paleo/milankovitch.html> ;

<http://earthobservatory.nasa.gov/Library/Giants/Milankovitch>

Climate change information from the EPA: <http://www.epa.gov/epaoswer/non-hw/reduce/wstewise/pubs/pew.pdf>

From the Pew Center on Global Climate Change: <http://www.pewclimate.org/global-warming-basics/>

