Thailand — China's skies have darkened over the past 50 years, possibly due to haze resulting from a nine-fold increase in fossil fuel emissions, according to researchers from the U.S. Department of Energy. The researchers, writing in this month's edition of Geophysical Research Letters, found that the amount of solar radiation measured at more than 500 stations in China fell from 1954 to 2001 despite a decrease in cloud cover.

"Normally, more frequent cloud-free days should be sunnier and brighter but this doesn't happen in our study," said Yun Qian of the energy department's Pacific Northwest National Laboratory in Washington state. The pollution (that) resulted from human activity may have created a haze which absorbs and deflects the sun's rays," Qian, the study's lead author, said in an e-mail interview Friday.

Air pollution is widespread in China. Antiquated factories billow smoke, many residents still use coal to heat their centuries-old houses, and a sharp increase in car ownership has bathed the motorways in exhaust fumes. Using data from more than 500 weather stations in China, researchers found the amount of sunlight hitting the ground has fallen by 3.7 watts per square yard in each of the last five decades amid a nine-fold increase in fossil fuel emissions, the study said.

The cloud cover data used in this study was obtained from the China Meteorological Administration through a bilateral agreement with the U.S. Department of Energy on global and regional climate change, the researchers said.
Herbert G. Fabian, who studies urban pollution and transportation issues for the Asian Development Bank, said the study's conclusion "makes sense" but that more information is needed. "There really is (an) air pollution problem and a haze problem in China because (of) dust storms and pollution," said Fabian, who was not connected to the study. "But we can't say conclusively that the reduction in sunlight is due to haze."

The study also said haze appears to have masked the impact of global warming by reflecting sunlight back into space and cooling the Earth's surface. "The haze may have masked the effects of global warming across large parts of China, particularly in the central and eastern regions, where daily high temperatures have actually been decreasing," Qian said. "This may seem like good news, but any success China has in curbing emissions will accelerate the effects of global warming in those areas when the cooling mask is lifted."

Source: Associated Press Researcher Finds Pollution Limiting Sunny Days in China
January 30, 2006 — By Michael Casey, Associated Press BANGKOK,
A model of Earth’s Effective Temperature
A simple energy balance equation

Incoming radiation: \[ S(1-A)(\pi R^2) \]
Outgoing radiation: \[ \sigma T^4 (4\pi R^2) \]

This is the model – assume that incoming radiation equals outgoing radiation. In this case, you can set the two expressions equal to each other.
Solving for $T$:

$$T = \left[ \frac{S(1-A)}{4\sigma} \right]^{1/4}$$

Using values appropriate for Earth, we find $T = 255 \text{ K}$ (about $-18^\circ \text{C}$ or $0^\circ \text{F}$)

$S = 1370 \text{ W m}^{-2} (\text{W/m}^2)$ at Earth’s distance from the sun
$A = 0.30$ (30% reflectivity, on average)
$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
We know that Earth’s average surface temperature is warmer than this – in fact, it’s probably somewhere close to the freezing point of water, since ice and liquid water are found in many places of the globe on any given day. So, what are we missing?
Short Question 4

Earth’s average surface is warmer than its effective temperature because:

(c) Earth’s true albedo is much smaller than 0.30

(b) The solar constant is much larger than 1370 W m\(^{-2}\)

(c) Boltzmann’s constant is smaller than 5.67 \times 10^{-8} W m\(^{-2}\) K\(^{-4}\)

(d) The atmosphere traps infrared radiation that is being radiated back toward space

(e) The Earth isn’t in thermal balance.
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How absorption of infrared light emitted by the earth varies with wavelength

Fig. 3.13
Incoming:  $\frac{S}{4}(1-A) + \sigma T_e^4$
Outgoing:  $\sigma T_s^4$

Box Fig. 3.2
Incoming: \( S/4(1-A) + \sigma T_e^4 \)

Outgoing: \( \sigma T_s^4 \)  
Same form, just \( T_s \) for surface

Box Fig. 3.2
Incoming: \( \frac{S}{4}(1-A) + \sigma T_e^4 \) now, two terms!

Outgoing: \( \sigma T_s^4 \)

Box Fig. 3.2
Effective temperature must stay the same (the Earth, as viewed from space, hasn’t changed).

The surface is warmer because it can’t radiate the heat back to space without getting some of it back.
How is energy distributed into the atmosphere from the surface?

Fig. 3.9

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Forms of heat transfer that are important in the atmosphere

Fig. 3.10
Short Question 5

Clouds are important for Earth’s climate because:

(c) They reflect radiation back to space, cooling the earth

(b) They trap radiation from the surface, warming the earth

(c) They serve as a way to store energy and transport it from one place to another

(d) None of the above

(e) All of the above
A schematic of Earth’s energy budget
a bit more complex model!
What about clouds?
Project 1 (approximately 2 pages, double spaced)
Due next Friday (February 3)

As you are traveling around CU and the Boulder area, observe three examples of ways in which the natural environment has been changed by human activities. Discuss how the environment has been changed and speculate about how the environment might be different if the changes had not occurred.