A Content Secondary Science Newsletter from the
Southern Nevada Regional Professional Development Program

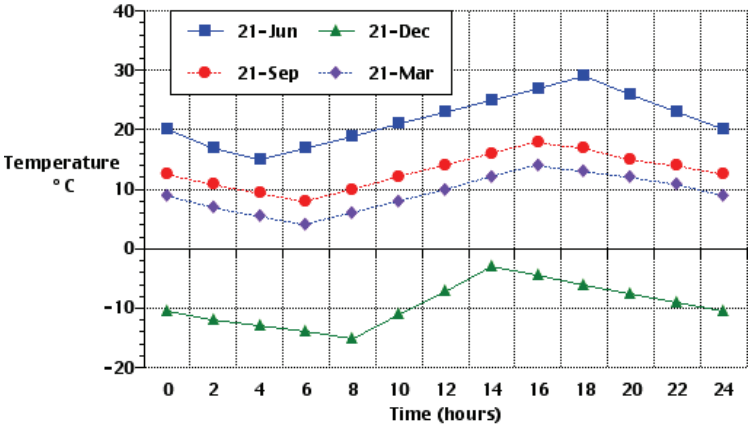
Science Dissected

Solar Radiation as a Primary Source of Earth's Energy

Many students believe the temperature at Earth's surface is derived from the outward escape of heat from Earth's core. In reality, heat from the core contributes around only 1/10,000 of the total energy found at Earth's surface. Solar radiation provides the remainder of the energy which drives all of the surface processes on Earth, and which makes the existence of life possible.

A simple exercise to help students understand the relatively minor contribution of heat from the core is to ask them to consider the temperature of Earth throughout the day. From personal experience, students know Earth heats up during the daylight hours and cools significantly during the evening hours. If Earth's core was the primary source of our surface temperature, we would not have as wide a range in temperature during a 24 hour period. To make a scientific investigation out of this, students could research the temperatures recorded each hour by setting up an experiment to collect the data, or by availing themselves of weather history data from a website such as Weather Underground. To further drive home the minimal contribution of heat from the core, ask the students to consider Earth's warmth during summer months versus the warmth during winter months. Again, if the core made a significant contribution to surface temperatures, we would not observe major differences in temperature during the seasons.

Temperature v Time

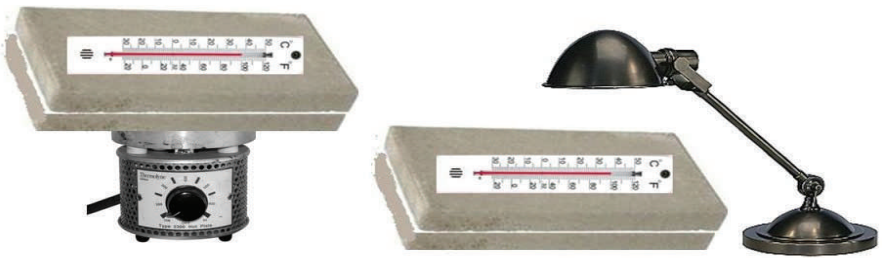


Hourly variations in surface temperature for a location at 45° North latitude over a 24 hour period at four different times during the year.

Image Reference http://www.physicalgeography.net/fundamentals/7l.html

The disparity in energy contribution does seem counterintuitive, considering the distance from the center of Earth's core to Earth's surface is around 6371 km while the distance from Earth to the Sun is approximately 150 million km. Students might fail to account for the almost 2900 km of rock (mantle and crust) separating core from surface, and for the fact that rock is a good thermal insulator.

To help students make this connection, they can conduct the following experiment.



Experimental Setup

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Solar Radiation as a Primary Source of Earth's Energy Continued...

Stack two 12 in x 12 in x 2 in stepping stones (generally less than a dollar each at home improvement stores) and lay a thermometer on the topmost stepping stone such that the bulb is roughly centered. As advance preparation, turn a hot plate to its highest setting. Stack two more of the stepping stones some distance away and place a thermometer atop them. Position a heat lamp 10 centimeters above the thermometer. In this first stage of the experiment, the heat from the hot plate and the radiant energy from the lamp will both travel 10 centimeters to reach and warm the thermometer. Record the initial temperature of each thermometer, then place one set of stepping stones on the hot plate and turn the heat lamp on over the other set of stepping stones. Record the temperature of each thermometer every minute during a five minute period, then shut off the power to the hot plate and to the heat lamp. If supplies are adequate, another group of students could run the same experiment, but with the heat lamp 20 or 30 centimeters away. In each case, the thermometer will register a higher temperature under the heat lamp than above the hot plate. As an extension, if a non-contact laser thermometer is available, the students could determine the temperature of the hot plate element and of the heat lamp bulb and consider how that factors into the observed differences in temperature.

By this point, students should have a firm grasp on the importance of radiant energy from the Sun as the critical source of energy driving Earth's surface processes. In their studies, students may have learned that convection within fluids distributes heat. Liquids and gases both are fluids. Energy from the Sun drives the convection currents within our oceans, as well as the convection currents within our atmosphere.

Key Points

- The Sun is the major source of Earth's energy
- Radiant energy from the Sun drives Earth's weather and climate

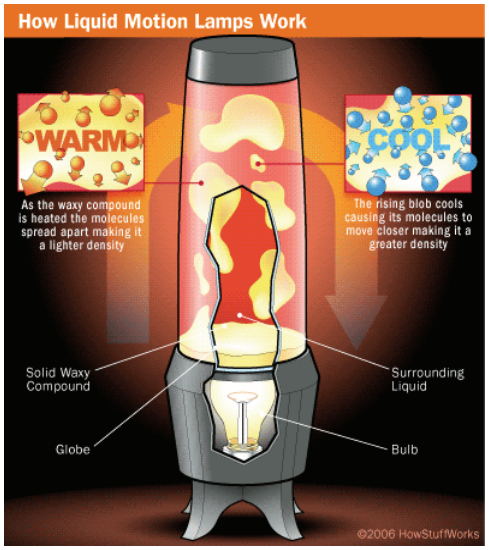

Image Reference, http://www.babyboomerdaily.com/2011/12/08/baby-boomers-dig-the-lava-lamp/

A good demonstration of radiant energy causing convection involves lava lamps. A light bulb rests within the base of the lava lamp. The light bulb is not in direct contact with the glass vessel containing the liquid and "lava". Rather, as the filament heats up, radiant energy in the infrared range is emitted from the bulb. It is the radiant energy which warms the glass vessel and which causes the observed convection. By first showing students how the lava lamp is constructed, then turning the lava lamp on and letting it run, students will be able to observe the effects of the radiant energy from the bulb on the liquid portion of the system. The longer the lava lamp is on, the warmer the system gets and the more pronounced the observed convection. By turning the lamp off after it has run awhile and allowing students to watch the motion slow and finally stop, students might surmise what would happen to the convection in Earth's oceans and atmosphere were the radiant energy from the Sun to substantially diminish.

Related Links

Weather Underground, http://www.wunderground.com/history

Windows to the Universe, http://www.windows2universe.org/earth/climate/sun_radiation_at_earth.html