Name: ________________________ Period: _____

Earth's Orbit and Climate Change

The shape of the Earth's orbit cycles from elliptical to almost circular every 90,000-100,000 years because of the gravitational pull of other nearby planets. When the orbit is highly elliptical, the amount of solar energy reaching the Earth is 20-30 times more when the Earth is closest to the Sun, than when it is at its furthest point away from the Sun. Examine the images at "Orbital Variations" for illustrations of orbital variations.

Objective: These data activities will enable you to analyze the astronomical/orbital forces on the Earth's climate operating on geological timescales.

Activity 1: Examining Earth's Irregular Orbit—Eccentricity

Learn more about the Earth's irregular, or eccentric orbit (eccentricity), with the "Vostok Core & Milankovitch Cycles Climate Applet".

On the right side of the applet is the temperature record reconstructed for the past 400,000 years from the Vostok (Antarctica) ice core. For now, review just this temperature record and look for any cycles in the data.

1. Imagine that you are a scientist seeing this data for the first time. Describe any patterns you see in the temperature record from the Vostok Ice Core.

Now go back to the "Vostok Core & Milankovitch Cycles Climate Applet" and click on the gray, rectangular button on the left so it displays "Show Top View." This will give you a better idea of the true geometry of the Earth's orbit. Today, there is only a difference of 3%, or 5 million kilometers, between the closest and furthest distances of the Earth from the Sun during its orbit.

2. Describe the orbit that you see when the Earth and Sun system are viewed from the top.

Next, check the "Eccentricity" field to add eccentricity curves to the record. You will notice magenta curves over the temperature graph that represent the calculated eccentricity of the Earth's orbit over the past 400,000 years.

3. What is the relationship between the Vostok temperature graph and the eccentricity plot?

Play with the slider on the left of the graph to see the very slight changes in the Earth's orbit that result from eccentricity.

4. Do you think there is any difference in the total amount of radiation over the course of a year during the time when the orbital is most eccentric?

Activity 2: Exploring Earth's Axial Tilt—Obliquity

Eccentricity is only part of the puzzle. Since it does not change the amount of total solar energy, it cannot be the factor that caused the natural climate cycles we see during the Ice Ages. Now look at another astronomical factor: the Earth's tilt on its rotational axis, called Obliquity. Examine the images at "Orbital Variations" for illustrations of axial tilt (obliquity) by scrolling down towards the middle of the page.

It may come as a surprise to learn that the Earth's tilt on its axis has changed over time. On the other hand, you may have heard that the Earth's axis tilt increased slightly (25 cm) because of the 2011 9.0 magnitude earthquake in Japan. Today, the Earth's axis is tilted at 23.5 degrees from the plane of the Earth's orbit. Return to the "Vostok Core & Milankovitch Cycles Climate Applet" to learn more about the Earth's axis tilt and its relationship with climate.

Uncheck the "Eccentricity" field and check the "Tilt" field. Look back at the temperature graph to see a magenta line that shows the calculations for changes in tilt over time.

5. Describe the curve and its relationship to the Vostok temperature data.

Now check the "Eccentricity" field again while leaving the “Tilt” field checked and review the magenta line on the temperature graph, which shows the data combining the curves from eccentricity and tilt.

6. How does this combined curve fit with the temperature graph?

The Earth's tilt/axial obliquity on its rotational axis is the "reason for the seasons." More tilt creates exaggerated seasons and less tilt creates milder seasons.

Activity 3: Precession of the Seasons

Changes in axial tilt also play a role in the timing of when a hemisphere is at its closest point in its orbit round the Sun. When a hemisphere is at its closest point (perihelion), it receives more solar energy. When the hemisphere is at the furthest point from the Sun in its orbit (aphelion), it receives less. Examine the images at "Orbital Variations" for illustrations of precession which refers to a change in the orientation of the rotation axis of a rotating body.

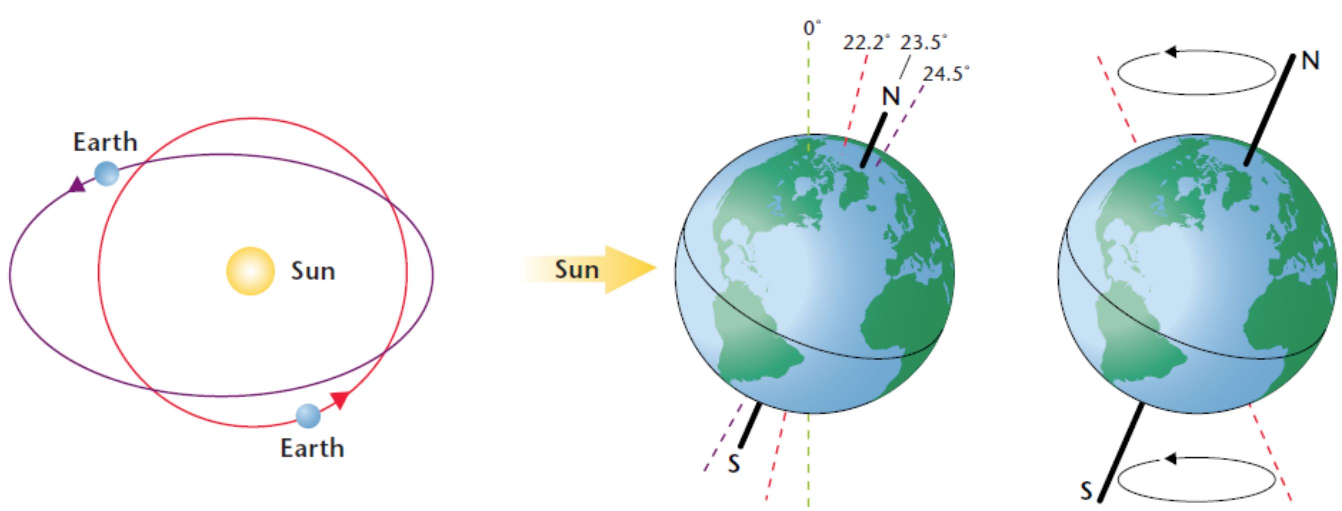
Return to the "Vostok Core & Milankovitch Cycles Climate Applet" to learn more about precession.

Uncheck any selected fields and then check the "Precession" field. Look back at the temperature graph to see a magenta line that shows the calculations for changes in precession over time.

7. Describe the curve and its relationship to the Vostok temperature.

Now check all three parameters: "Eccentricity," "Precession," and "Tilt" and observe the results.

8. What do you notice about the alignment between the temperature curves and the three orbital parameters?



Eccentricity Earth encounters more variation in the energy that it receives from the sun when Earth's orbit is elongated than it does when Earth's orbit is more circular.

Tilt The tilt of Earth's axis varies between 22.2° and 24.5°. The greater the tilt angle is, the more solar energy the poles receive.

Precession A gradual change, or "wobble," in the orientation of Earth's axis affects the relationship between Earth's tilt and eccentricity.