Orbital cycles make glaciers come and go

by Ed Berg

The arrival of Fall reminds us once again of the Cycle of Seasons, and that indeed we live our lives in accordance with a great variety of cycles. Some short-term cycles, like those of eating and sleeping, are hard to avoid, but others are less noticeable, their duration being longer. I usually don't know where today is in the 29.5-day lunar cycle, but I do know that this cycle brings two periods of higher high tides, as well as a Full Moon with barking dogs and restless sleep. Medics tell me that a Full Moon also brings more visits to the Emergency Room, more murders, and more babies being born.

Here in the Far North the seasonal cycle strongly structures the life of every creature; many insects overwinter as eggs or larvae, bears hibernate, humans bundle up, and plants shut down photosynthesis. The seasonal cycle is caused by the tilt of the Earth's axis of rotation at 23.5° from the axis of its orbit around the Sun. In the winter the axis of rotation tips away from the Sun, and the Sun's rays hit the northern latitudes at a low angle. In the summer the Earth is on the opposite side of the Sun, with the axis of rotation tipped toward the Sun, and the Sun's rays hit at a high angle.

There are, however, longer cycles in this Earth-Sun story, which affect the comings and goings of great continental glaciers. These are long-term cycles in the Earth's orbital characteristics (parameters). The spinning Earth bobs and precesses like a child's top. The angle of tilt varies from 22° to 24.5° in a cycle of 17,280 years. The axis itself precesses in a clockwise direction in a cycle of 25,920 years. These two motions combine to return the axis to the same starting point on a cycle of 41,000 years. When the axis is tilted at 24.5°seasonally is greatest: summers are warmest, and winters are coldest.

The Earth travels in a slightly elliptical orbit around the Sun, with the Earth being somewhat offset from the center of the ellipse. On a scale of one year this offset is hardly noticeable; the Sun is closest to the Earth on January 4, but this doesn't do a whole lot of good for handwarming at that time of year. In time, however, this closest point (called the "perihelion") migrates later into the year, making a full swing around the calendar in 20,293 years. When perihelion is in the summer, it makes summers warmer and winters colder, just like increased axial tilt.

You may not have noticed that periodically the Earth's elliptical orbit flattens out a bit. This allows the Sun to warm the Earth more effectively, because the Sun is closer for a longer part of the year. This cycle takes 100,000 years, and it has been described as the real "pacemaker of the ice ages," because it has the strongest effect on the Earth's temperatures.

When the cycles of axial tilt, perihelion, and ellipticity come together, they can warm up the Northern Hemisphere very effectively. This happened "recently" over several millennia, with the warmest time being about 9000 years ago. At that time axial tilt was near its maximum at 24.2°, ellipticity was at a local maximum, and the Earth was closest to the Sun on July 30. Summers were 5°F warmer, and the glaciers pulled back rapidly.

It took the last great ice age about 50,000 years to build up, and only 6-7,000 years to fall apart. At the ice age maximum 20,000 years ago, the Cook Inlet Basin was almost wall-to-wall ice, from the Alaska Range to the Kenai Mountains, with only a narrow string of glacial lakes stretching from Sterling to Anchor Point. By 18,000 years ago the ancestral Kenai River was major glacial sluiceway, but it flowed southwest from Sterling through Headquarters Lake to Kasilof and Cohoe, rather than through Soldotna and Kenai. At 16,500 years ago the city of Kenai was at the foot of a marine tidewater glacier, whose sediments formed the lower layer visible in the bluff below the Senior Citizens home. By 13,000 years ago Hidden Lake and Paradox Lake on the Kenai Refuge were open water, with glaciers at one end. The last ice age thus collapsed quickly, like a house of cards, once the orbital cycles lined up and the heat increased.

The "astronomical theory of ice ages," which I have outlined above, was primarily developed by the Serb mathematician Milutin Milankovitch during the 1910's to the 1930's, including a stint of quiet working time as a prisoner-of-war in 1914. At first, most geologists generally didn't take the theory seriously because there was no way to verify it. There were no good temperature records, and there were no accurate ways of dating geologic deposits, even if you could tell at what temperature the deposits were formed.

By the 1970's, however, both dating and temperature technologies had improved. In 1976 two sediment cores were examined from the southern Indian Ocean which had a continuous 450,000-year record of ocean floor mud accumulation. Fossils in the sediments were analyzed layer by layer for both age and temperature, and a graph was prepared which showed major warm periods every 100,000 years, and minor warm peaks at intervals of 41,000, 23,000 and 19,000 years, just as Milankovitch had predicted. Since that time interest in geologic cycles has sky-rocketed, and Milankovitch-type cycles have now been identified in rocks hundreds of millions years old, as well as in sediment cores from other parts of the world. Most geologists today accept Milankovitch's orbital parameters as the basic motor of the ice ages, recognizing that the motor is governed by a variety of other factors, such as the position of the continents and the flow of ocean currents.

Studying cycles has been a hobby of mine for many years, with a certain ebb and flow, and I will be teaching a short course on the natural cycles at the Kenai Peninsula College, starting next Tuesday, Sept 19. It will meet for four Tuesday evenings, and have a field trip to Kachemak Bay on Saturday, Sept. 30. Topics will include the tides, orbital cycles, and geologic cycles in Kenai Peninsula rocks. Kenai Refuge studies of tree-rings, bark beetles, the hare-lynx cycles, and small mammal cycles will also be presented.

Ed Berg has been the ecologist at the Kenai National Wildlife Refuge since 1993. Previous Refuge Notebook columns can be viewed on the Web at http://kenai.fws.gov.