



A Proposed Mesoscale Simulation of Precipitation in Yosemite National Park with a Warm Ocean

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Abstract

This paper interprets the landforms of Yosemite National Park in light of a catastrophic, young-earth model. It hypothesizes that glaciation in Yosemite was driven by processes following the Genesis Flood. Essentially, the energy stored as heat in the oceans following the Flood is believed to have generated a gigantic El Niño effect. Enhanced precipitation fell as snow in polar latitudes and on mountains as far south as the southern Sierra Nevada. This event occurred over a short period of time following the Flood and movements of glaciers produced by the heavy snowfall reworked the topography as seen today. Plans are formulated to simulate precipitation over Yosemite National Park using MM5, a conventional mesoscale meteorology model, under strong westerly flow across a warm Pacific Ocean. The warm sea-surface temperature (SST) of the Pacific Ocean in this simulation should produce heavier rainfall at low elevations and snowfall at higher elevations for progressively warmer SSTs. It is anticipated that precipitation rates computed from this simulation will be sufficient to explain the formation of glaciers in the Sierra Nevada over only a few hundred years. Fluctuations in SST during deglaciation are also expected to explain the resurgence of glacial coverage observed in Yosemite National Park similar to the Younger Dryas on the East Coast. The current "cold" Pacific Ocean doesn't maintain permanent glaciers in Yosemite today. The contrast in climates between today and the early post-Flood world should be dramatic.

Keywords

Mesoscale, Numerical simulation, Precipitation, Yosemite National Park, Warm ocean, Glacier, Glaciation, Deglaciation, Younger Dryas, Sea-surface temperature, SST, MM5, Sierra Nevada, Ice, snow

Introduction

When traveling in the Sierra Nevada, particularly in the Yosemite region, one is struck by a host of unusual landforms not currently being formed. Smooth granite surfaces near Tioga Pass, parallel gouge marks in rocks at Tuolumne Meadows, linear ridges of rock debris near Lee Vining, isolated boulders standing on Olmsted Point, the dried lake basin in Death Valley, and the huge U-shaped Yosemite Valley with its hanging waterfalls, testify to dramatic geologic process on a grand scale. Conventional wisdom attributes these features to a series of ice ages that spanned several million years, the latest of which reached its peak about 20,000 years ago.

Yet, if the literal interpretation of scripture is correct, only thousands of years have transpired since the Genesis Flood ended and the Sierra Nevada were formed. Is it possible to interpret the evidence for glacial action in Yosemite within a recent biblical timeframe? How could massive glaciers have formed and retreated in only a few thousand years when conventional wisdom says a single ice age has a period of approximately 100,000 years?

This paper will interpret the landforms of the Yosemite region in the light of ice core data from Greenland and Antarctica and from numerical climate simulations which have previously been conducted by Spelman (1996) on a global scale. It will be hypothesized that glaciation in Yosemite was driven by catastrophic processes of the Genesis Flood. Essentially, the catastrophic climate model says that a portion of the massive amount of energy released during the Genesis Flood was stored as heat in the oceans following the Flood and generated a gigantic **El Niño effect** (definitions for bolded words may be found in the Glossary at the end of the paper). Enhanced precipitation fell as snow in polar latitudes and on mountains as far south as the southern Sierra Nevada. This event occurred once over a short period of time following the Genesis Flood and movements of glaciers produced by the heavy snowfall reworked the topography as seen today.

Glacier and Ice Sheet Coverage over the Earth

Glaciers and **ice sheets** once covered a much greater portion of the earth's surface (Crowley &

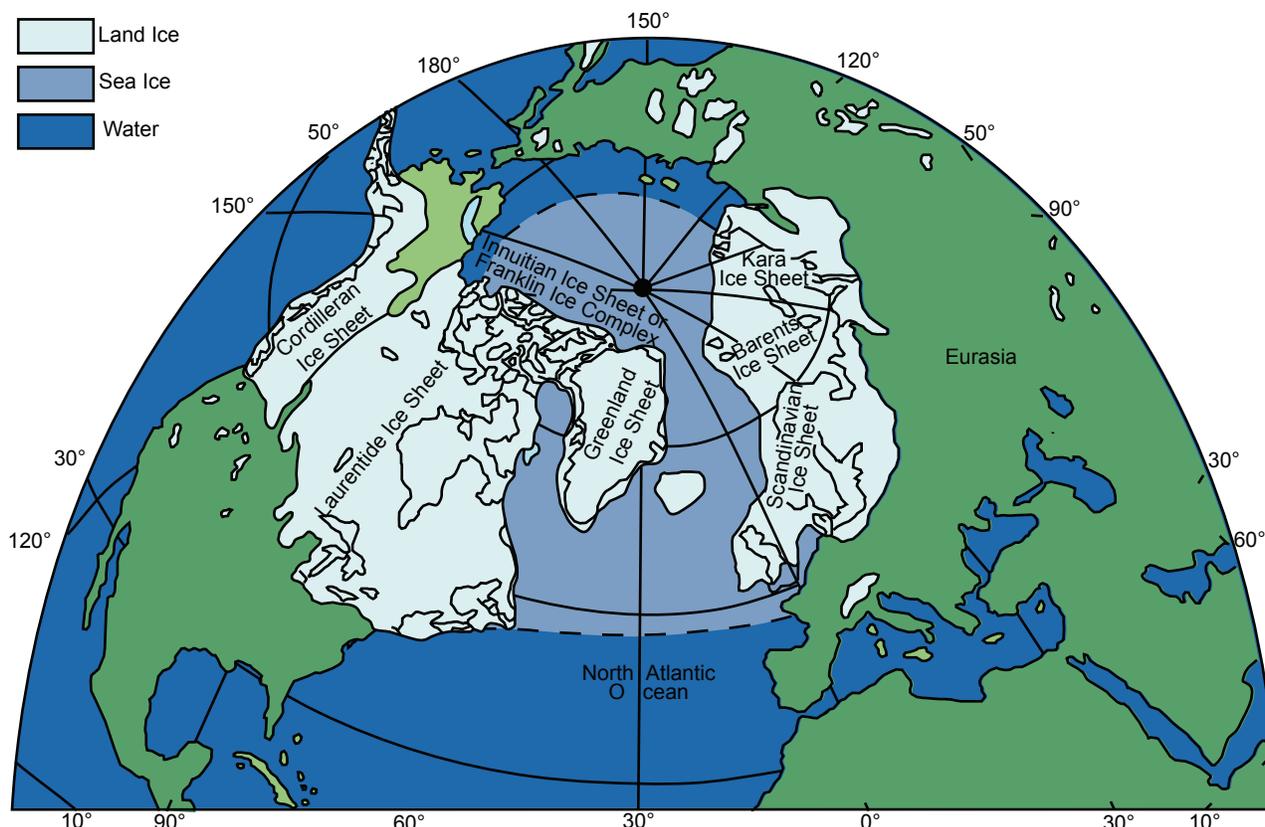


Figure 1. Coverage in the Northern Hemisphere by ice sheets, glaciers, and sea ice at the last glacial maximum (after Crowley & North, 1991, p. 49).

North, 1991, p. 49). Figure 1 shows the inferred ice sheet, glacial, and sea ice coverage in the Northern Hemisphere during the last glacial maximum. Today permanent ice sheets cover only Greenland and Antarctica, and glaciers cover only the highest mountains and nearby valleys. Yet, remnant evidence of more extensive coverage indicates that ice sheets also once covered practically all of Canada (some of the lowlands of the Yukon are not glaciated, as well as the Wood Mountain Plateau in south-central Saskatchewan), much of Alaska, a large portion of the upper U.S., portions of western Europe, Scandinavia, and northern Asia. In the Southern Hemisphere the southern mountains of South America, New Zealand, Tasmania, and one small mountainous area of southeastern Australia were once ice covered. In addition, mountains which have permanent glaciers today, show evidence of more extensive mountain coverage which was thousands of feet lower. Valley glaciers ran many miles farther downhill than today. Many mountains which have no permanent glaciers today, even near the equator, likely were once ice covered. And, the oceans were apparently more extensively covered with sea ice, particularly around Antarctica and in the North Atlantic where it is believed ice shelves extended as far south as 45° latitude.

Glaciers in Yosemite National Park Glacial signatures

Glacial features are ubiquitous in Yosemite National Park from Lee Vining on the east side of the Park to Yosemite Valley on the west. Figure 2 shows a map of Yosemite National Park with state highway 120 crossing through its center. Outside of the Park to the east moraines stretch down many of the valleys from the cirques that collect the snow. For example, lateral moraines border both sides of the lower Lee Vining Canyon east of Tioga Pass. A cirque is a bowl-shaped, theater-like basin at the head of a glacial valley. Above the headwall of a cirque, steep, rugged peaks and ridges often occur. A needle-like peak or ridge is called a **Horn** or **Arête**, respectively, and testify to past plucking and erosion of rock from the sides of higher terrain. As the ice moves downward from the mountains the movement at the bottom surface of the glacier crushes and fractures the underlying rocks because of the extreme weight. The underlying rocks are eroded as the glacier descends from the cirque. A moraine is an accumulation of glacial till formed into a ridge by a glacier as it moves down a valley. A lateral moraine is formed parallel to the flow of the glacier and occurs typically near the edges of the glacier. **End Moraines** are formed in a bow shape near where the glacier stopped or retreated. A glacier is normally filled

with debris, which it has accumulated by eroding the floor and walls of the valley down as it moves. The surfaces over which the glacier has moved are planed down with distinctive features and the valleys are left U-shaped. June Lake north of Lee Vining was formed by the damming of such a valley on the east side of the Sierra Nevada by end moraines.

Near Tioga Pass a series of small lakes add to the evidence that glaciers once covered these mountains thousands of feet deep. When the glaciers began to melt at the end of the ice age, large blocks of ice were left behind to slowly melt in place. Because the ice blocks remained in place on the lower terrain longer than on the surrounding terrain, sediments didn't quickly fill the depressions until the blocks melted. Today small lakes fill these depressions called **kettles** or kettle lakes and are slowly filling with sediment.

About two miles west of Tioga Pass in Tuolumne Meadows, evidence for ice movement occurs in the shape of glacial domes, called **roche moutonnée**. There are at least four of them in Yosemite—Lembert

Dome (see Figure 3), Pothole Dome, Fairview Dome, and Polly Dome. These domes were shaped by glacial smoothing and **plucking** as thick layers of ice moved from the southeast to the northwest over the exposed granite. As thick layers of ice moved over the granite, it abraded the upstream side leaving it with a smooth, shallow slope. On the downstream side the ice plucked the rock from the granite surface leaving it with a rugged, steep slope. The dual processes of abrasion on the upstream and upper surfaces and plucking on the downstream side are directional indicators for the flow of the glacier. Some of these chunks of granite plucked from the underlying surface, occasionally the size of large trucks, were moved downstream by the glacier and became **erratics**.

Water flowing beneath the glacier also polished the rock surface and formed **potholes** in selected locations. Potholes are cylindrical holes where small rocks trapped in a depression are moved in a circular motion by a stream of water and grind holes into the granite.



Figure 2. Yosemite National Park and vicinity (after Huber, 1989).



Figure 3. Lembert Dome, a large roche moutonnée on the west side of Tuolumne Meadows shaped by glacial smoothing and plucking (Vardiman, 2003).

The shapes of mountain valleys also tell a story. The Lyell Fork of the Tuolumne River drains into the Tuolumne Valley. It and the main Yosemite Valley provide excellent examples of U-shaped valleys formed by the movement of glaciers down the mountain. Valleys formed by erosion from the flow of water tend to have a V-shape. An example is the Owens River gorge between Crowley Lake and Bishop. Valleys ground out by glaciers tend to be U-shaped. U-shaped valleys will frequently have waterfalls along the edge because the glaciers formed steep walls, leaving rivers entering the valley high above the floor (see Figure 4). Processes operating today cannot explain these hanging valleys (that is, they are relicts). Yosemite is the classic example of this occurrence.



Figure 4. Bridal Veil Falls, a waterfall issuing from a hanging valley far above the U-shaped Yosemite Valley (photograph by Ernie Morey).

The Question of Multiple Glaciations

As in most other locations where glaciers and ice sheets were once present, there appears to be evidence that the glacial coverage fluctuated greatly as the ice retreated. The depth and areal extent may have decreased and then increased again several times during deglaciation. Most conventional glaciologists suggest these variations in coverage were due to separate glacial events and may have been tens or hundreds of thousands of years apart. Multiple glaciations over a protracted ice age are claimed for many regions in North America. For example, in the American Midwest the conventional name given to the last major advance of continental glaciers in North America is the Wisconsin. This glaciation is thought to have been composed of three glacial maxima (commonly called ice ages) separated by interglacial periods (such as the one we supposedly are living in). These ice ages are called, from oldest to youngest, *Tahoe*, *Tenaya*, and *Tioga*. The Tahoe reached its maximum extent perhaps 70,000 years ago according to the conventional time frame. Little is known of the Tenaya. The Tioga was the least severe and last of the Wisconsin group. It supposedly began about 30,000 years ago, reached its greatest advance 20,000 years ago, and ended about 10,000 years ago (Wikipedia, 2007).

The glaciers in Yellowstone and Teton National Parks were believed to have advanced in three major episodes called the Buffalo, Bull Lake, and Pinedale glaciations. The ice sheet that invaded Puget Sound in Washington state during what is called the Fraser glaciation is also believed to have advanced during three episodes called the Evans Creek, Vashon, and Sumas stades (Schreiner, 1994). In all these examples, the latter glaciations are smaller than the earlier ones. From a young-earth view, it is believed that these multiple glaciations are simply fluctuations in the deglaciation of a single ice age following the Genesis Flood. Rather than tens of thousands of years between glaciations there may have been only tens or hundreds of years between advances and retreats.

In the Yosemite region at least three glaciations have been suggested, the Tioga glaciation (~20,000 years ago), the Tahoe glaciation (~100,000 years ago), and a much more ancient pre-Tahoe stage (~1 million years ago) (Huber, 1989). For the purposes of our discussion, the terms pre-Tahoe and Tioga are used, but without the time connotations. Figure 5 shows a schematic of Yosemite Valley with Half Dome and a few other high elevation peaks extending above the maximum level of glaciation. The extent of the Tahoe and Tioga glaciations and glacial Lake Yosemite following the retreat of the Tioga glaciation are also shown.

Figure 6 shows the distribution of the Tioga

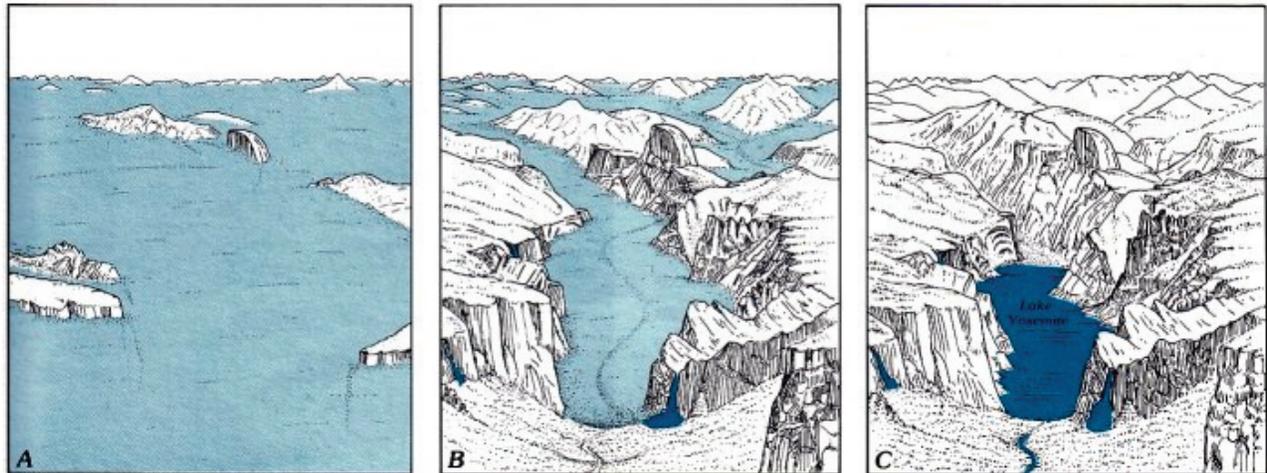


Figure 5. Sketches of Yosemite Valley and Half Dome, showing the extent of the pre-Tahoe glacier (A), the Tioga glacier (B), and glacial Lake Yosemite after retreat of the Tioga ice (C) (after Huber, 1989).

glaciation over the entire Yosemite National Park region. In addition to the coverage of the glaciation, the direction of movement of the ice as it flowed downhill is also shown. Notice, that the flow is predominantly from southeast to northwest on the west side of the highest terrain north of Mt. Lyell. Large collection

basins fed valley glaciers on the west side, primarily into what is now the Hetch Hetchy Reservoir and the Tuolumne River, the Yosemite Valley and the main Merced River, the south edge of the Park near Wawona and the South Fork of the Merced River, and from near Devil's Post Pile west of Mammoth Lakes into

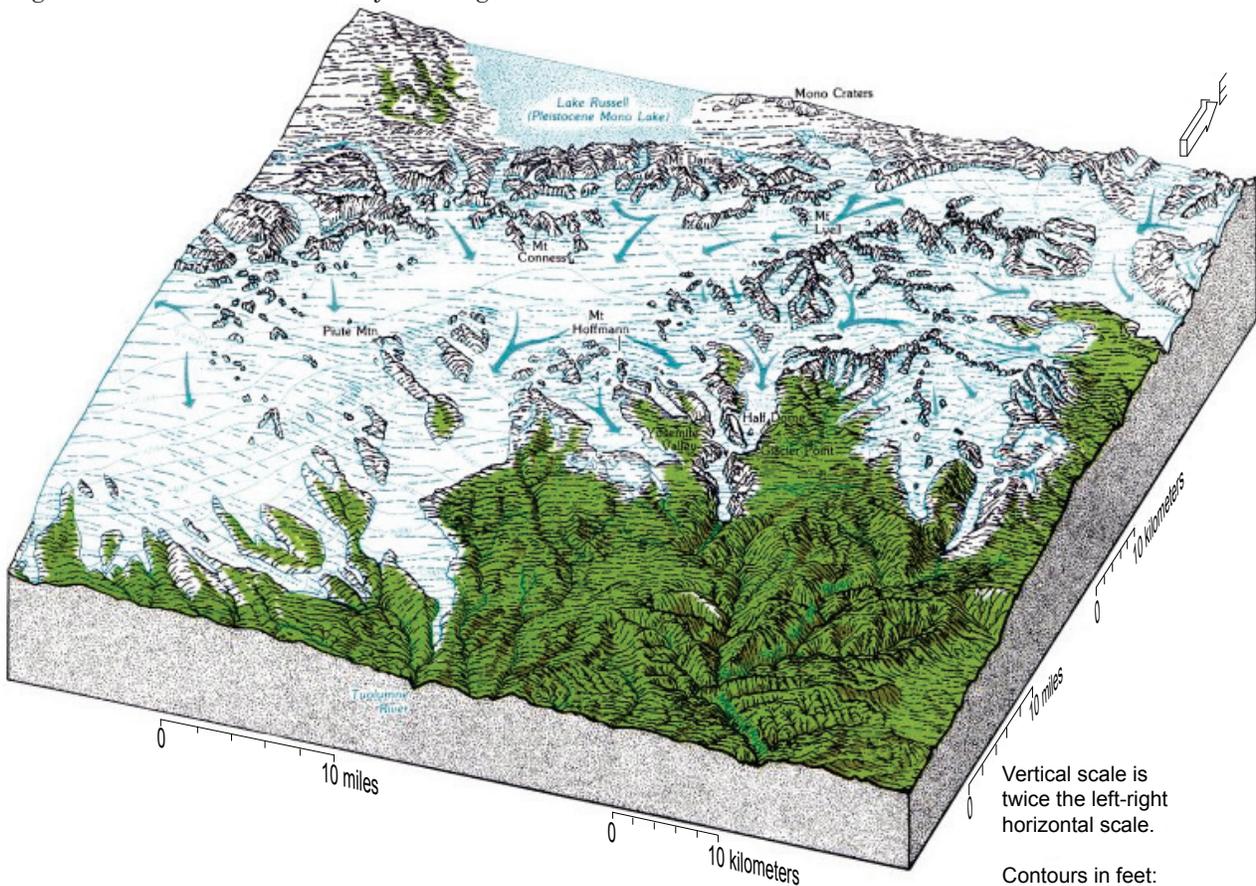


Figure 6. The Tioga icefield and valley glaciers in and near Yosemite National Park, showing the maximum extent during the last glaciation. Vertical scale is twice the left-right horizontal scale. Contours in feet; blue arrows indicate direction of flow of ice (after Huber, 1989).

the San Joaquin River. An interesting flow pattern occurs near Half Dome where the flow is split and flows down both Yosemite Valley and Little Yosemite Valley. On the east side of the Sierra Nevada the ice is strongly channeled by narrow valleys including the Lee Vining Canyon. In at least two of these valleys the ice flowed all the way to Mono Lake.

Evidence for a Wetter Desert

Deserts east of the Sierra Nevada were once much wetter than today. **Pluvial lakes** now exist throughout eastern California, Nevada, Arizona, and Utah. Pluvial lakes are basins that contain little or no water today but show evidence for ancient lakeshores at much higher levels in the past. Figure 7 shows a map of ancient pluvial lakes throughout the American Southwest. Probably the pluvial lake east of the Sierra Nevada familiar to most people is the Great Salt Lake in Utah. The full ice-age lake called Lake Bonneville, covered almost 1/3 the state of Utah, and was about 300 meters deep (1,000 feet). However, the surface of the lake dropped from 1,556 meters (5,135 feet) to 1,456 meters (4,780 feet) above sea level in about a month's time when a breach occurred at the northern end and a massive amount of water flowed into the Snake River. This is called the Bonneville flood (Gilbert, 1890; Malde, 1968). The lake level then slowly dropped after this catastrophic event to

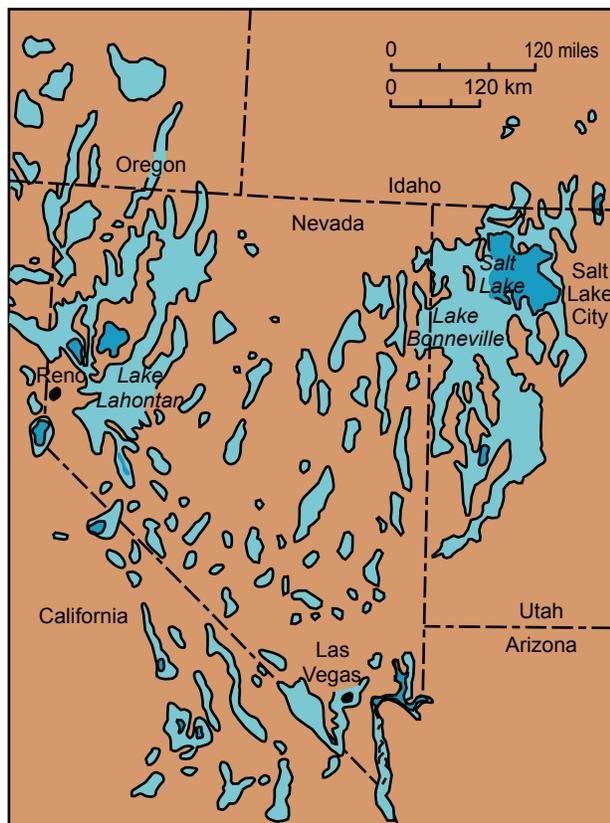


Figure 7. Pluvial lakes throughout the American Southwest.

its current elevation of 1,280 meters (4,200 feet). It is only about 10 meters deep (35 feet) at its deepest point now and contains high concentrations of salt caused by the evaporated water. Similar pluvial lakes occur over the deserts of the American Southwest although many are completely dry, leaving only salt flats. Others are wet only during the rainy season. A few pluvial lakes, like Pyramid Lake and Mono Lake, are maintained at higher levels by controlled releases of water from mountain lakes and reservoirs.

Elevated past shorelines provide strong evidence for a wetter desert in the past. Artifacts of different types of vegetation, which required more precipitation in the past, are also common. In a few places where such vegetation has been able to maintain itself because of subsurface sources of water, the evidence is direct. A few isolated trees have been found in the desert, which would not be present today unless there was more precipitation in the past. Seeds and preserved artifacts from currently absent trees and other vegetation have also been found.

Archeological findings that native Americans, who lived in a location that has now become a hostile environment, is also evidence for a wetter environment. For example, the Anasazi lived not only in the canyons of northern Arizona near the rivers but also raised corn and beans on top of the mesas which experienced sufficient precipitation at one time to raise vegetables. Evidence remains of irrigation works, which they used to store and divert rainwater for their crops. Such canals and ponds would be useless in today's environment. It is thought by many archeologists who specialize in tribal cultures of the Southwest that the Anasazi likely migrated from the mesas of Northern Arizona and southwestern Colorado around 1200AD to the lower reaches of the Rio Grande River in New Mexico primarily because of a change in climate (Ferguson, 1996; Gumerman, 1988).

Global climate modeling indicates that the **jet stream** in the upper atmosphere, which directs the path of storms moving from west to east across the North American continent, was much further south over the U.S. during the ice age (Crowley & North, 1991, pp. 71–75). As the ice sheets in eastern Canada grew in depth and horizontal extent they produced the effect of a massive mountain barrier in southeast Canada. This caused a split in the flow of storms over the eastern U.S. and a greater frequency of storms at lower latitude. The jet stream tended to flow directly over California, across the Midwest, and into the Atlantic Ocean near New York.

At the **glacial maximum** sea ice developed from near New York across the Atlantic Ocean to Spain. The jet stream would have tended to track near the boundary of the ice sheet/sea ice and the open ocean,

moving it to more southerly latitudes. The movement of the jet stream southward across the American Southwest would have produced much greater precipitation in the Sierra Nevada and across the deserts. The mountains in the Southwest tend to be north-south barriers parallel with the Sierra Nevada. Air lifted by storms from sea level to 2,400–3,600 meters (8–12,000 feet) and moving from west to east across the Sierras would likely have produced much greater quantities of snow at the highest elevations and rain at lower elevations than today. This was probably the primary reason for the formation of glaciers in Yosemite and wetter deserts during the ice age. Other lower barriers in the intermountain region between the Sierra and the Rocky Mountains would probably have also been capped by ice and snow.

Causes of the Ice Age

The conventional old-earth model

The conventional explanation for the ice age is the astronomical theory, initially developed by Milankovitch (1930, 1941). Also, see CLIMAP (1976, 1981), Hays, Imbrie, and Shackleton (1976), Oard (1990), and Vardiman (2001, p.54). Milankovitch first suggested a relationship among the three **orbital parameters** of the earth-sun system, which cause a variation in the amount of solar radiation striking the earth and the average temperature. The three orbital parameters—**eccentricity**, **obliquity**, and **precession**—with periods of about 100,000 years, 40,000 years, and 26,000 years, respectively, supposedly produced ocean and atmospheric temperature changes over comparable periods. Paleotemperature variations derived from sea-floor sediments are suggested to have been caused by dozens of ice ages over millions of years.

Numerous difficulties have been identified with this theory, however. The correlation between the calculated and “observed” temperature variations for the 100,000-year eccentricity cycle and the temperature change in the ocean-atmosphere system is so weak that some type of **feedback mechanism** is needed to amplify the temperature effect to even conceivably produce a climate change. Yet, the feedback mechanism needed to amplify the temperature effect has not been identified. Without this hypothetical addition, the astronomical theory fails completely (Crowley & North, 1991, pp. 132–151; Hays, Imbrie, & Shackleton, 1976).

The astronomical theory of climate change relies on very small natural variations in radiation over many years. The cooling of the atmosphere and ocean and the development of permanent ice sheets in an ice age occur slowly over tens of thousands of years according to the conventional theory, but the melting of ice sheets at the end of an ice age happens relatively rapidly over

only thousands of years. These trends produce a sawtooth pattern in ocean and atmosphere temperature estimates derived from sea-floor sediments with a period between ice ages of about 100,000 years for the past 800,000 years.

It has also been suggested that each **glacial period** is separated from the preceding and following ones by **interglacials** lasting approximately ten thousand years, in which the ice sheets are minimal in areal coverage and the ocean and atmosphere are uniformly warm (Bradley, 1999; Crowley & North, 1991). The climate condition in these interglacials is supposedly stable and resists a return to ice age conditions until the driving forces reach a certain stage. As the driving forces exceed some critical value, the system can become unstable and suddenly plunge into a new ice age.

Such speculation is the source of some of the hyper-environmental concerns expressed today about increased carbon dioxide and air pollution. The fear behind many statements about global warming is that we may cause hot periods or another ice age from small fluctuations in radiation patterns introduced into the environmental system from releases of particulates, gases, or other pollutants. They may cause an unstable climate system to be triggered into a new undesirable state. Such fears are not justified, however, for they are model-dependent and based on conjecture. Furthermore, Scripture says that God is in control and “While earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease.” Genesis 8:22.

A young-earth, Flood model

A biblical explanation for the ice age was first suggested by Oard (1990). The basic concept is that the oceans were tens of degrees warmer after the Genesis Flood than they are today. The release and mixing of massive quantities of heat following this global catastrophic event introduced a major one-time heat pulse to the earth’s climate system. Tectonic upheavals, continental movements and reconfigurations, volcanic activity, the release of magma at mid-ocean ridges, and accelerated nuclear decay likely occurred during the Genesis Flood. Due to the geologic work done by these catastrophic events the ocean was likely left 50°C (120°F) or even warmer. It has been shown that it took several thousand years for the ocean temperature to cool to the temperature observed today (see Vardiman’s plot in Austin, Baumgardner, Humphreys, Snelling, Vardiman, & Wise, 1994, p. 615 or a calculation in Oard, 1990).

The evaporation of water vapor from the oceans of the world under these warm conditions would have been many times greater than today producing a massive El Niño effect. The precipitation of rain and

snow would have remained heavy following the Flood in certain locations on the earth, particularly near the edges of continents and on mountain barriers. In the American Southwest **orographic clouds** forming over the Sierra Nevada would have piled snow hundreds to thousands of feet deep, all along the mountain range (Huber, 1989). It is likely that snow would have accumulated year round early in the ice age on the mountains and in the interior of the continents forming glaciers and permanent ice sheets. Rather than an ice age producing cold oceans, which likely limited more ice and snow (as the conventional model suggests), the Genesis Flood model would have produced warm oceans, which easily produced ice and snow on cold continents. This component to the model may help explain the observations in the tropical mountains of South America that glaciation occurred at the same time as at higher latitudes—a puzzle for conventional paleoclimatologists (Thompson, et al., 1998). For many years paleoclimatologists have questioned the finding that ocean temperatures off the South American coast seem to have been warm during the formation of glaciers in the Andes. And, rather than multiple ice ages occurring over millions of years, this model predicts only one ice age over a thousand-year period.

Non-uniform cooling is also possible which caused fluctuations in the storminess and coverage of ice sheets. A recent young-earth creationist study has shown that during the **deglaciation** at the end of the ice age in the north Atlantic Ocean a sudden, massive flood of cold fresh water from melting ice sheets in Canada caused the warm ocean to be covered with cold, fresh water and rapid, short-term reversals in the atmospheric temperature (Goodenow, 2004). Cold, fresh water is generally less dense than warmer, saline water allowing it to float atop warmer water below. This rapid, short-term pulse of meltwater is believed to explain the **Younger Dryas**, a short-term decrease in temperature observed during deglaciation in the northeastern U.S. and Europe. In fact, the ice age appears to have ended very spasmodically with catastrophic *glacial outburst floods* in many parts of the world such as from the Canadian ice sheet (Barber, et al., 1999; Leverington, Mann, & Teller, 2000; Teller, 2001).

Possibly something similar happened along the West Coast of North America, particularly in the Sierra Nevada. As, the ice sheets melted in the Sierra Nevada the cold, fresh water could have flowed into the Sacramento River in northern California and the San Joaquin River in central California, through San Francisco Bay and into the Pacific Ocean. Here, it would have flowed southward along the California Coast and out into the Pacific Ocean forming a cold pool of surface water upstream of the Sierra Nevada.

This cold water would have reduced the production of snow in the Sierra Nevada and caused a retreat of the ice sheets. As the flow of cold water slowed, the warm ocean water would have been re-exposed and more snow dumped in the Sierras to once again expand the glacial coverage. However, each glaciation would have been shallower and of smaller areal extent as the ocean cooled to the equilibrium temperature of today, just as observed in Yosemite by the Pre-Tahoe and Tioga glaciations. This typical effect may have also contributed to the variations in glacial and ice sheet coverage during the deglaciation observed farther north in Puget Sound and Yellowstone National Park.

No matter how an ice age is produced, however, it is generally agreed that the jet stream that drives the earth's weather system at mid-latitudes would have been energized and likely shifted southward to produce stormier conditions nearer the equator. This means that in the American Southwest a higher frequency of moist, Pacific storms would have crossed the Sierra Nevada during the ice age accumulating more snow each year. If more snow fell in the winter and less snow melted in the shorter summers, permanent snowfields would have accumulated in the high mountains and canyons forming permanent glaciers.

Evidence for a Brief Ice Age

Biblical paleoclimatology has been the focus of a research program at the Institute for Creation Research for about 20 years. In addition to general atmospheric research a large emphasis has been placed on the analysis of ice core data collected from ice sheets (Oard, 2005; Vardiman, 1993), seafloor sediment data (Vardiman, 1996), and numerical modeling of ice-age conditions (Vardiman, 1994). Vardiman reported (Austin et al., 1994, p.615) that ocean temperatures derived from seafloor sediments indicated that the oceans had been extremely warm during the Cretaceous Period and cooled exponentially following the Cretaceous to that observed today. If the Cretaceous period was actually the Flood event and the period from the Cretaceous to the present was post-Flood, this could potentially explain the ice age. Vardiman (1994, p.561) first reported the development of a young-earth flow model for ice sheet formation using the Camp Century ice core data from Greenland. The model suggested that the accumulation of the entire depth of the ice sheets in Greenland and Antarctica could easily occur in less than a thousand years. Zavacky (2006) and Oard (2005) extended this analysis to the deeper, more precise GISP2 ice core. Their findings supported the earlier results and further suggested that the conventional explanation for a 100,000-year ice age

may be faulty because the so-called “annual layers” of ice used by the conventional community to date ice sheets may actually be the result of hundreds of individual storms per year.

Vardiman (1997, pp.52–60; 2001, pp.55–68) proposed an explanation for the trend of $\delta^{18}\text{O}$ to more negative values upward from the base of the ice sheets in Greenland ice cores followed by a sudden change to more positive and then uniform values near the top. The conventional explanation for these trends suggests that slow cooling and then warming occurred over a period of 100,000 years and the trends were induced by fluctuations in the orbital parameters of the earth/sun system. Vardiman (1997) suggested a mechanism by which these same trends could occur in a period of less than 5,000 years following the Genesis Flood. The mechanism suggested was the slow formation of an ice shelf, which covered the ocean surface as the oceans cooled during the ice age following the Genesis Flood. The ice shelves grew to distances farther away from the site in Greenland where the snow was deposited and cores later drilled. This movement of the source of water vapor from the open ocean caused the $\delta^{18}\text{O}$ to decrease slowly with time. During the rapid deglaciation at the end of the ice age the source of water vapor moved rapidly closer to the core location again, reversing the trend. The dispersion of the different types and sizes of ice crystals formed in the storms near the edge of the ice shelf also contributed to the changing trends in $\delta^{18}\text{O}$.

Goodenow (2004) developed a catastrophic mechanism for the apparent rapid, short-term fluctuation in $\delta^{18}\text{O}$ during the deglaciation of the ice sheets in North America called the Younger Dryas. This has been a difficulty for the conventional old-earth paleoclimatologists because increasing evidence seemed to be accumulating that the event was initiated and concluded over intervals as short as two years. Goodenow’s research supports the idea that frigid melt water from the glaciers in central Canada accumulated behind ice dams and was suddenly released to flow down the Mississippi River and the St. Lawrence Seaway, forming a gigantic fresh-water lens over the North Atlantic. This temporary, cold sea surface suddenly returned the slowly warming climate to near ice-age conditions briefly in the Northeast U.S. and Europe. This brief episode lends credibility that the time frame for the entire ice age is also much shorter than originally thought.

In addition to the ice-core studies, several numerical simulations of the ice-age under warm sea-surface conditions were conducted. Spelman (1996) reported the results of a climate simulation using warm sea-surface temperatures on precipitation patterns using CCM1, a global climate model provided by the National Center for Atmospheric Research (NCAR).

She found that uniform sea-surface temperatures up to 45°C energized the atmosphere, producing stronger winds and more precipitation, particularly along continental boundaries and in polar regions. Many of the heavy precipitation regions were located in areas like Greenland and the North Atlantic Ocean where paleoclimatic evidence points to heavy precipitation during the ice age. The precipitation rates in some regions like Greenland indicated that the entire ice sheet present today could have accumulated in less than 500 years.

Zavacky (2004) used MM5, a mesoscale meteorology model developed at The Pennsylvania University, to explore intense small-scale features like hurricanes, which likely formed during and immediately following the Genesis Flood. Zavacky simulated the development of a historical hurricane (Hurricane Florence in 1988) in the Gulf of Mexico to see how it would respond to warm sea-surface temperatures. As expected, Hurricane Florence was energized by the warm sea-surface temperatures and spun up quickly into a **hypercane**. The horizontal and vertical winds increased by 50% and 100%, respectively, and the precipitation rate increased by a factor of ten within 24 hours for the hottest temperature simulated (45°C). If such hypercanes occurred following the Genesis Flood they could have contributed significantly to the transport of moisture to the polar regions adding to the ice sheets. They would have also produced torrential rainfall on unconsolidated sediments in tropical and mid-latitude regions of the continents, particularly on the east side, producing massive erosion.

Simulation of an Ice Age in Yosemite National Park

It is proposed that numerical simulations for winter storms in the Sierra Nevada be conducted to determine if warm sea-surface temperatures will produce much more precipitation, helping to explain the formation and fluctuation of glaciers in Yosemite National Park. Estimates of snow accumulation depend not only on the period of accumulation, but also on many other variables such as air temperature, moisture in the air, stability of the atmosphere, and wind speed. Oard (1993) has provided a crude calculation that three to eight times the precipitation could have fallen in the Southwest United States. This study should show that an ice age in the Sierra Nevada is not possible unless the Pacific Ocean is considerably warmer than today. If the estimated depth and areal extent of glacial coverage in Yosemite National Park can be duplicated by numerical means under warm ocean conditions, but can not under cold ocean conditions, a strong argument can be made for the young-earth, Flood model. It may also be possible to duplicate fluctuations in the deglaciation of glaciers

in Yosemite by varying the sea-surface temperature upstream from the Sierra Nevada.

Vardiman (2003, pp.17–28) and Zavacky (2004) used the numerical model MM5 to study hypercane development following the Genesis Flood. MM5 is a widely-used numerical model for simulating mesoscale meteorological features (typically for time intervals of minutes to hours and spatial scales of tens to hundreds of kilometers). It was developed by Anthes and Warner (1978, pp.1045–1078) at the Pennsylvania State University and is operated and supported by the National Center for Atmospheric Research (NCAR) (see Dudhia, 1993, pp.1493–1513). ICR acquired a distribution copy of MM5 from NCAR and adapted it to run on a PC with a LINUX operating system for the hypercane study. A later version of MM5 has now been acquired for the Yosemite study and installed on the ICR Epiphany Cluster. The data display package VIS5D will be used to visualize the results of the simulation.

The ICR Epiphany Cluster shown in Figure 8 is a 44-processor computer mounted on 20 blades using AMD 2.0 GHz 64-bit Opteron technology. Each processor has a 1 Gbyte DRAM. The collection of processors has a dual-processor front end with

1Tbyte of RAID level-5 disk storage and a 250 Gbyte hard drive on each blade. The multiple processors are controlled by a Gigabit Ethernet network via a 24-port switch. The machine uses a Linux operating system and Intel Fortran/C/C++ compilers.

The mesoscale meteorology model MM5 has a nesting capability, that is, multiple grids with smaller areas and finer grids nested inside larger ones. For this study one large rectangular grid will be used which extends from 25° to 50° North latitude and from 100° to 140° West longitude centered on Yosemite National Park at 37°50'N and 119°30'W. The inner rectangular grid will be centered on Hoffman Peak in the Park and extend 1°30' in the North/South and East/West directions. The distance between grid points for the outer grid will be 1km and the inner grid 100m. The number of grid points will number about 10 million for each grid. This strategy will allow the synoptic scale weather to be simulated in the larger grid over an area that extends from half way to Hawaii eastward to Colorado and from south of the Mexican border to north of the Canadian border. The small grid will allow atmospheric processes to be simulated from the Central Valley of California to the high terrain of Nevada and for about 300km

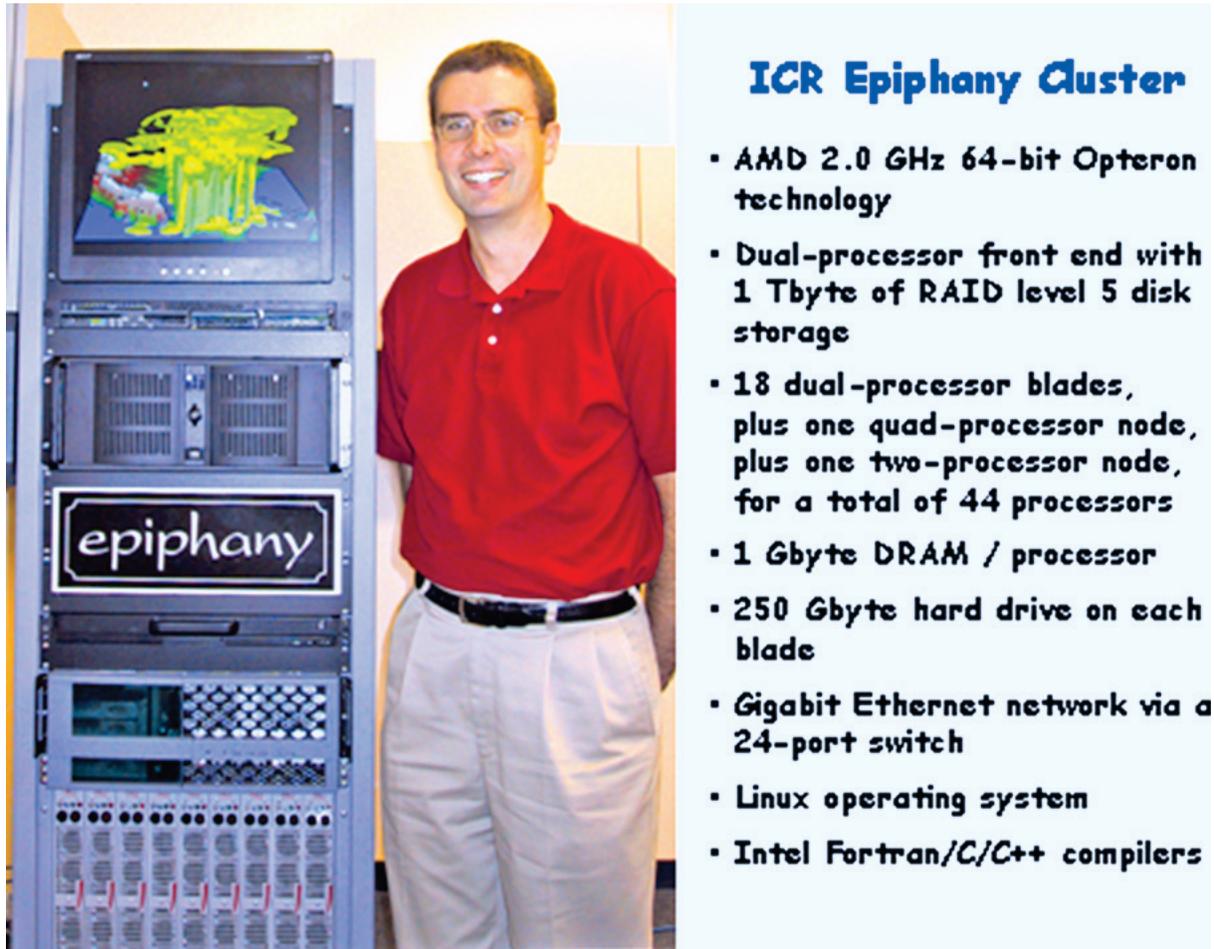


Figure 8. The ICR Epiphany Cluster (photograph by Kelly Griffin, 2006)

along the Sierra Nevada. The distance of 100 meters between grid points in and around the Park will allow meteorological elements to be determined in fine enough detail to characterize them even in relatively narrow canyons and rapidly changing elevation.

Precipitation rates, temperature, and wind will be computed in three dimensions over the Sierra Nevada and particularly within Yosemite National Park for different sea-surface temperature patterns off the coast of California. The sea-surface temperature will be varied from 0°C to 45°C in 5°C increments. A uniform pattern of sea-surface temperature over the Pacific Ocean west of California will initially be tried and more complex patterns used later if the earlier simulations are successful. Sea-surface temperature in banded patterns parallel to the coast will also be tried.

MM5 is a multi-level, primitive-equation model which uses initial and boundary conditions to solve for the unknown variables. The model solves a set of five hydrodynamic equations for the five unknowns u , v , w , ρ , and P for each grid point in a nonviscous adiabatic atmosphere similar to the following:

$$\begin{aligned}\frac{\partial u}{\partial t} &= -\left\{u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z}\right\} - \frac{1}{\rho} \frac{\partial P}{\partial x} + 2\Omega(v \sin \phi - w \cos \phi) \\ \frac{\partial v}{\partial t} &= -\left\{u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z}\right\} - \frac{1}{\rho} \frac{\partial P}{\partial y} + 2\Omega \sin \phi \\ \frac{\partial w}{\partial t} &= -\left\{u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z}\right\} - \frac{1}{\rho} \frac{\partial P}{\partial z} - 2\Omega u \cos \phi - g \\ \frac{\partial \rho}{\partial t} &= -\left\{u \frac{\partial \rho}{\partial x} + v \frac{\partial \rho}{\partial y} + w \frac{\partial \rho}{\partial z}\right\} - \rho \left\{\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right\} \\ \frac{\partial P}{\partial t} &= -\left\{u \frac{\partial P}{\partial x} + v \frac{\partial P}{\partial y} + w \frac{\partial P}{\partial z}\right\} - \gamma P \left\{\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right\}\end{aligned}$$

Equation 1. Primitive equations.

These equations are defined for a parcel of air in a tangent-plane system using Cartesian coordinates shown in Table 1.

The surface temperature and terrain elevation are required and a set of initial atmospheric conditions prescribed at each grid point. Budgets of temperature, moisture, and other variables of interest can be traced through the system. Complex radiation codes and cloud physics equations for converting the moisture to cloud water and precipitation are also maintained in the model.

The surface terrain was obtained from the United States Geological Survey (USGS) for 100m grid spacing. Three sets of storm data were obtained from the National Oceanic and Atmospheric Administration

Table 1. Cartesian coordinates.

x	= distance from the tangent point in the eastward direction
y	= distance from the tangent point in the northward direction
z	= distance from the tangent point in the upward direction
u	= speed in the eastward direction
v	= speed in the northward direction
w	= speed in the upward direction
t	= time
Ω	= the angular velocity of the earth
Φ	= the latitude
g	= acceleration due to gravity
P	= air pressure
ρ	= air density

(NOAA) that are characteristic of weak, moderate, and heavy winter storms. Data for both stable and convective storms were acquired. For the first effort storm conditions will be assumed to be steady-state, that is, the storm conditions will not change with time in the simulation. Later, time-dependent simulations will be attempted.

Numerical modeling of climate and weather have inherent limitations. Although attempts have been made to include as many physical processes as possible to make the results accurate and precise, not all have yet been fully included. Over the years as the MM5 model has become more complex, it has become more realistic. Validation studies conducted by Dudhia (1993) and others have shown good correspondence between model output and proxy variables derived from paleoclimates. Of course, there may be considerable uncertainty in these comparisons from the interpretation of some of the paleoclimates themselves. Many of the model calculations are based on the parameterization of precipitation, radiation, biology, and cryogenic processes, not derived from fundamental driving equations. Such parameterizations limit the range over which boundary conditions are valid. For example, previous simulations by Spelman (1996), Vardiman (2003), and Zavacky (2004) found that the CCM1 and MM5 models became unstable at sea-surface temperatures warmer than about 45°C.

There are many conditions built into the model and its application to the Yosemite area that could be the focus of sensitivity studies in addition to sea-surface temperature. However, there are three that seem to merit more consideration than the others: (1) the size of the inner grid where detailed calculations will be made, (2) the orientation of the air flow over the Sierra Nevada, and (3) the stability of the air flowing over the mountain barrier. As time permits, multiple runs will be made to explore the influence of changes in each of these conditions.

The two primary questions addressed in this study will be:

- (1) Do warm sea-surface temperatures off the California Coast cause ice age type conditions in Yosemite National Park?

(2) Do short periods of cold sea-surface temperatures off the California Coast produce cooling over the mountains, which would cause a hiatus in glacial melting similar to the Younger-Dryas on the East Coast of the U.S.?

It is anticipated that this research will require several years to make the model operational and fully explore all the intricacies of these questions. It will likely take a year or more to get MM5 fully functional with the selected nested grids. Another year will be needed to install the meteorological data and conduct comparisons with observed data using today's sea-surface temperatures. Finally, another year will likely be needed to complete 20 or more simulations for the various temperature and storm conditions and complete the reports.

Conclusions

Previous modeling studies have shown the significance that warm sea-surface temperature can have on ice sheet and glacier buildup on the continents and the energizing of tropical hurricanes. The availability of the mesoscale meteorology model MM5 and the new computer cluster at ICR makes numerical simulation of the growth and melting of glaciers in Yosemite National Park a promising likelihood. A research plan has been developed which holds great promise of success. It is anticipated that a young-earth model of climate change following the Genesis Flood will explain how massive glaciers grew and molded the terrain in Yosemite in just a few thousand years.

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- Glossary**
- Arête—a needle-like mountain peak or ridge formed by the erosion of glaciers.
- Cirque—a bowl-shaped basin at the head of a glacial valley.
- Deglaciation—the melting of glaciers and ice sheets at the end of an ice age.
- Eccentricity—a measure of the elliptical shape of the orbit of the earth around the sun.
- El Niño effect—the increase in storminess and precipitation, particularly along the West Coast of North and South America, caused by a slight warming of the upstream ocean surface and consequent increase in evaporation.
- End moraine—a moraine formed at the foot of a glacier.
- Erratic—a rock moved by a glacier downhill from where it was dislodged or plucked.
- Feedback mechanism—a process by which changes in a variable in a system cause changes in a second variable which, in turn, affect the first variable and amplifying the process.
- Glacial maximum—the time at which glaciers and ice sheets reach the greatest areal coverage during an ice age.
- Glacial period—an interval of time in earth history when glaciers and ice sheets are predominant, conventionally thought to exhibit a cold, stormy climate.
- Glacier—a mass of ice and snow which moves relatively rapidly downhill from high mountainous terrain or a mountain valley.
- Horn—an alternative name for Arête.
- Hypercane—a super hurricane formed over warm sea-surface temperatures. Not observed today.
- Ice age—an interval of earth history during which glaciers and ice sheets are growing or quickly melting.
- Ice sheet—a mass of ice and snow which moves slowly to lower elevation or flattens out on gently sloping terrain.
- Ice shelf—a layer of ice covering the ocean, generally surrounding continents in polar regions and thick enough to maintain some rigidity.
- Jet stream—a high-speed band of air flowing from west to east between about 20,000 and 50,000 feet in the atmosphere that determines the placement and intensity of storms.
- Interglacial—an interval of time in earth history between two glacial periods, conventionally thought to exhibit an equable climate.
- Kettle—a depression in regions where glaciers and ice sheets once existed, often filled with water, thought to have been formed by blocks of ice melting slowly during deglaciation.
- Lateral moraine—a moraine formed parallel to the path of a glacier.
- Moraine—an accumulation of glacial till in the shape of a ridge.
- Obliquity—the angle of the axis of the earth's rotation relative to the plane of the earth's orbit around the sun.
- Orbital parameter—one of three measures of the earth's motion around the sun, the three parameters being eccentricity, obliquity, and precession.
- Orographic clouds—stationary clouds forms over mountains by moisture being lifted in the air flow perpendicular to the barrier.
- Plucking—the removal of blocks of underlying rock by the motion of a glacier.
- Pluvial lake—a geographic basin which contains little or no water today but shows evidence for ancient lakes.
- Pothole—a cylindrical hole worn in a large rock by the swirling motion of water containing small rocks.
- Precession—the rotation of a fixed location on the orbit of the earth around the sun relative to the stars, for example, the movement of the winter solstice.
- Roche moutonnée—an outcrop of rock overrun and smoothed by a glacier.
- Sea ice—a layer of ice covering the ocean, generally in polar regions, not necessarily near continents and thin enough or composed of individual pieces so that it is not rigid.
- Younger Dryas—a short interval of time during the last deglaciation in which the climate appeared to suddenly return to glacial conditions.

