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GLOBAL HEAT BALANCE WITH A LIQUID WATER AND ICE CANOPY

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Abstract

A new model of the pre-Flood canopy is proposed, consisting of large water globules at about 2 km altitude over equatorial regions and large ice fragment clouds at about 2200 km altitude over the polar regions. This canopy would have maintained both temperature and solar radiation at proper levels for good plant growth from pole to pole. The water globules would have collapsed at the time of Noah and the ice clouds would have collapsed several hundred years later to start the ice age.

Introduction

The first few chapters of Genesis indicate that the climate of the earth was once much different from what we now experience. There was no rain, but rather a mist rising from the earth to water the ground (Genesis 2:4-6). Adam and Eve apparently did not need clothes (Genesis 2:25) for comfort, indicating a rather narrow temperature range. The first mention of rain occurs in Genesis 7 at the time of the Flood. Then in chapter 9, God uses the rainbow as a sign of a covenant. If rain had occurred before the Flood, the rainbow would have occurred also and would not have been useful as a sign.

The temperatures on the early earth would have needed to be nearly uniform from pole to pole, or otherwise the temperature gradients would have caused weather systems similar to what we experience today, with the associated rain. The earth would have been like a greenhouse, with lush plant growth from pole to pole. The earth's temperature must have been moderated by some mechanism in order for this greenhouse effect to exist. The only possibility suggested is that of the water above the firmament (Genesis 1:6-8).

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It can be argued that this water canopy would have to meet several requirements, such as:

1. It should contain enough water for 40 days and nights of heavy rain.
2. The water should be liquid, at least where Noah could see it.
3. The water should be at a height where the potential energy stored in the gravitational field would not be large enough to cause undue atmospheric heating when the water fell as rain.
4. There must be enough solar radiation incident upon the earth's surface to allow vigorous plant growth, from pole to pole.
5. The temperature at the earth's surface must be in the proper range for both human comfort and plant growth.
6. There should be a source or mechanism for very cold ice over the polar regions, to account for the

ice age, including quickly frozen mammoths (Dillow, 1982 pp. 311-420).

7. There should be adequate light in the polar regions for plant growth or at least plant maintenance in the winter months, when the sun is normally below the horizon for up to six months.
8. The canopy should allow the sun, moon, and stars to be seen.
9. The canopy support system should be readily explained in terms of presently-understood physics.

A number of models have been proposed for the canopy, but all have some problem with one or more of these requirements. Similarly, this model meets all the requirements except the last one. Either a miracle or unknown physical laws must have been operating for the proposed canopy to have existed. This is not a reason for immediate rejection because God has used miracles in other situations, such as the pillar of fire by night and pillar of cloud by day seen by the Israelites for 40 years in the wilderness.

Other Canopy Models

Dillow has suggested a model whereby 40 feet of liquid water was placed above the firmament and immediately turned into steam (Dillow, pp 221-310). This extra mass above the earth would have caused the atmospheric pressure to be 2.18 of today's atmospheres. There would have been a strong temperature inversion above the earth, with the temperature rising from about 20°C at the earth's surface to 38°C at only 120 m above the surface to 111°C at 9.8 km above the surface.

One of the difficulties of Dillow's model, as with most of the other canopy models, is the heat load or heat energy content of the canopy. The canopy must somehow be cooled from approximately 100°C to the condensation point, the latent heat of condensation must then be removed at the same temperature, and then the liquid must be cooled to the present atmospheric temperature of about 25°C. The potential energy (mgh) of the canopy must also be removed. Dillow (pp. 269-72) shows that if all this energy were released to the atmosphere in a short period of time, the temperature of the atmosphere would rise to 2100°C, an obviously impossible value. Dillow's model also does not deal with the winter darkness near the poles. The combination of high temperatures and darkness would actually be detrimental to plant life. The dominant species might be mushrooms in such an environment. This model therefore has several difficulties.

Other models also have difficulties. Probably the most obvious model would be for the water to be maintained in a permanent heavy cloud cover. This is not a satisfactory model for several reasons. One is that such a cloud cover will contain only a few inches of water equivalent, not enough for the rain at the time of the Flood. Another problem is that a cloud cover will reflect a greater amount of the sun's energy away from the earth, lowering the temperature of the earth's surface below freezing. The present albedo of the earth is about 0.34 (Houghton, 1954). A heavy cloud cover over the earth would increase the albedo to as high as 0.8, which would yield a mean surface temperature of -60°C. If the albedo were increased to only 0.5 from the present 0.34, the mean surface temperature would drop to +5°C (Dillow, p. 217). Yet another objection to the cloud canopy is that it would block all starlight, while Genesis 1:14-18 seems to imply that the stars were visible before the Flood.

Another model suggested by many writers is that of an ice canopy (Dillow, pp. 195-215). They propose a cylindrical or spherical shell, perhaps 350 miles above the earth's surface and a few hundred feet thick, held in place by centrifugal force. The idea of centrifugal force would seem to eliminate the need for a miracle, but actually just changes the character and timing of the miracle (elimination of the heating effect of the potential and kinetic energy stored in the ice).

The kinetic energy for an ice shell at 350 miles above the earth would be 6,855 cal/gm and the potential energy would be 1,114 cal/gm for a total of 7,969 cal/gm. The latent heat of fusion of water is 80 cal/gm, the latent heat of vaporization is 540 cal/gm, and the heat needed to raise the temperature of water from 0 °C to 100°C is 100 cal/gm. The kinetic and potential energy in the rotating ice shell is 10 times the amount needed to turn ice at 0°C into steam at 100°C. The collapse of such a canopy would immediately destroy all life on earth unless a miracle was performed to remove the heat.

It appears that a miracle is necessary for any canopy model, either to hold the water up, or to get it down without destroying the earth. I will not deal with this issue, but will work backwards from the other requirements listed earlier to determine as many of the canopy characteristics as possible.

Liquid Water and Ice Canopy

If the water is in a continuous layer above the earth, there is a conflict between the requirement for a large quantity of water on one hand and adequate solar energy at the earth's surface on the other. A layer of water 25 m thick, for example, will absorb or reflect about 96 percent of the incident solar radiation when the sun is directly overhead, with a larger percentage for the sun closer to the horizon. The four percent of solar radiation reaching the earth would be enough to meet the needs of a few shade loving plants, but would not be nearly enough to produce the lush vegetation which became our coal, oil, and gas deposits. A continuous water layer would also obscure the stars, which were apparently created to be seen by people before Noah. It is suggested therefore that the water was not in a continuous layer but rather in large globules separated by air. The appearance from the earth would be similar to a sky filled with scattered clouds.

Having open spaces between globules means that each globule must be thicker in order to hold the same amount of water. If the globules occupied 25 percent of the sky in a single layer, then each globule must be 100 m thick to contain an average of 25 m of water over the earth. The horizontal dimension of a globule is probably greater than the vertical dimension by a factor of three to five to maximize the direct solar radiation on the earth for solar positions away from the vertical.

The globules would need to be high enough above ground level that the area under the globule would be illuminated by the sun at mid-morning and mid-afternoon. The globules cannot be too high, however, or they would freeze in the cold temperatures of the upper atmosphere. The dry adiabatic lapse rate of today's atmosphere is about 1°C per 100 m. This is probably an upper limit on the temperature gradient existing in the pre-Flood atmosphere. The minimum surface temperature in the lower latitudes would probably be in the vicinity of 20°C (68°F). If the dry adiabatic lapse rate applied, a temperature of 1°C would be reached at 2000 m above the earth's surface. The earth before the Flood was probably much flatter than it is today, so this could have been above the highest mountain. Therefore I assume that the water globules were not much above 2000 m or much below 1000 m above the earth.

The proposed layer of water globules close to the earth does not deal with the question of plant growth in polar regions with up to six months of darkness. As mentioned earlier, if the canopy were able to maintain temperature (and humidity) during the dark period, many plants would not be able to survive. For normal plant growth and survival, either the temperature and humidity need to drop during the winter so the plants can go dormant, or significant amounts of light need to be provided during the winter so growth can continue. The geological record seems to indicate polar regions that were warm and supported plant growth during the entire year, so evidently the polar regions were not entirely dark during part of each year before the Flood as they are now.

One suggestion that has been made is that the earth has somehow changed its axis of rotation. Before the Flood there was no tilt, and after the Flood something had happened to give the earth its 23.45° tilt from its plane of rotation around the sun. Such a change of angular momentum would require another miracle or perhaps a visiting planet from space (Patten, 1966).

Another suggestion would be solar reflectors in space. If some of the water above the firmament were placed at heights of several hundred km above the polar regions, it would freeze and become highly reflective of solar radiation, much like the rings of Saturn. A reasonable size would be for the ice to extend from each pole for 23.45°, or to 66.55°N or S. The ice could be in either one continuous piece or in fragments. The surface probably would be rough so most

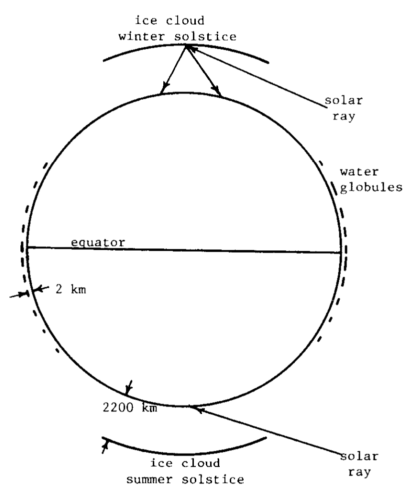

Figure 1. A pre-Flood canopy model of liquid water globules and ice clouds above the earth.

of the reflection is diffuse rather than specular. The layer would probably be relatively thin, a few hundred meters if solid, and a few kilometers if in fragments. My proposed canopy model therefore consists of liquid water globules in the equatorial regions and a hemispherical cap or cloud of ice fragments over each pole, as shown in Figure 1.

An ice cloud of this size and a height of 2200 km would admit direct solar radiation to the pole during the summer for the same 24 hour period it now enjoys. During the winter it would reflect diffuse light to the polar area. There would be continuous daylight at the poles on a year around basis. Areas away from the poles but still inside the Arctic and Antarctic circles which had a short night in the summer would not have night in the winter.

Heat Balance

Solar radiation incident on the atmosphere may be reflected back into space or it may be absorbed by the earth or atmosphere. The absorbed energy may be radiated back into space as infrared radiation, it may be stored on a seasonal basis by raising the temperature of soil or water, or in the present climate it may be physically transported to a different latitude by atmospheric movements and ocean currents. In the canopy model presented here, it is assumed that there were no atmospheric movements or ocean currents before the Flood. Incoming solar radiation and outgoing infrared radiation must therefore have been balanced at each latitude when integrated over a yearly cycle. In the present climate, equatorial regions are cooled and polar regions are heated by a poleward energy flux. Water globules provide the equatorial cooling in this canopy model by shading the earth, while the poles are heated by reflection from an ice cloud.

The approach taken here is basically that of working backward from the presumed pre-Flood climate to determine the characteristics of the canopy. Accepted equations for solar radiation reflection and absorption and infrared radiation to space have been used in a computer program to determine the temperature of the earth and of the liquid water canopy. Parameters such as the fraction of sky covered by globules, the reflectivity of the ice cloud, and the albedo of the earth were varied until the temperatures were in a plausible range.

According to this computer model, no shading of the Earth is necessary, and the water globules cannot be maintained in liquid form at higher latitudes than about 45°N or S. This computer model shows that it is necessary for the fraction of sky covered by the globules to decrease with distance from the equator, from a maximum of about 50 percent to about 10 percent at 40°N or S. From about 45° to about 66.5° there would not be a canopy of any type in this model.

Available Radiation

The average value of radiation from the sun on the top of the earth's atmosphere is the solar constant, SC = 1353 W/m^2 [= 1.940 cal/(cm^2 min) = 1.94 ly/min = 428 BTU/(ft^2 hr) = 4.871 MJ/(m^2 hr)].

The angle of incidence of beam radiation on a horizontal surface is found from (Duffie and Beckman, p. 16)

$$\cos\theta = \sin\delta\sin\phi + \cos\delta\cos\phi\cos\omega \qquad (1)$$

where ϕ = latitude (north positive), δ = declination (i.e., the angular position of the sun at solar noon with respect to the plane of the equator) (north positive), θ = the angle of incidence of beam radiation, the angle being measured between the beam and the normal to the plane, ω = hour angle, solar noon being zero, and each hour equaling 15° of longitude with mornings positive and afternoons negative (e.g., ω = +15 for 11:00, and ω = -37.5 for 14:30).

The declination can be found from the approximate equation (Duffie and Beckman, p. 15)

$$\delta = 23.45 \sin(360(284 + N)/365) \quad (2)$$

where N is the day of the year.

The radiation (P_{top}) incident on a horizontal surface at the top of the atmosphere is then given by

$$P_{top} = (SC) \cos \delta \quad W/m^2 \quad (3)$$

Absorption and Scattering in the Atmosphere

The amount of radiation available on a horizontal surface at the top of the atmosphere is relatively easy to determine from these formulas. Not all of this radiation will reach the ground, due to absorption and scattering in the atmosphere.

Both absorption and scattering are functions of the distance traveled in the atmosphere. There will be less absorption, for example, when the sun is directly overhead than when it is close to the horizon. This distance is referred to as the air mass or the optical distance. The distance is normalized so the unit air mass is a vertical path through the atmosphere from sea level. The air mass for a beam arriving at some angle (θ) from the vertical is approximately $1/(\cos\theta) = \sec\theta$ for angles near the vertical. A good approximation for this normalized air mass (m) for any angle θ is (Carroll, 1985 p. 106)

$$m = \frac{35}{(1224\cos^2\theta + 1)^{1/2}} \quad (4)$$

The direct beam radiation incident on the earth is assumed to be (Carroll, p. 105)

$$P_{er} = P_{top}T_{ra}T_{rw}T_{rl}T_{rp} \quad (5)$$

where T_{ra} is the transmissivity of the atmosphere after absorption by the fixed gases, T_{rw} is the transmissivity after absorption by water vapor, T_{rl} is the transmissivity after Rayleigh scattering* by fixed and variable gases, and T_{rp} is the transmissivity after Mie scattering** by particles.

The diffuse radiation incident on the earth is

$$P_{ef} = f_1(P_{w1} - P_{er}) + f_2(P_{w2} - P_{er}) + f_3 \quad (6)$$

where f_1 is the forward scatter fraction from Rayleigh scattering, f_2 is the forward scatter fraction for Mie scattering, and f_3 is a correction to account for surface albedoes other than 0.25. P_{w1} and P_{w2} are the direct radiative components in the absence of Rayleigh scattering and Mie scattering, respectively (Carroll, p. 105).

*Rayleigh scattering applies where the wavelength of the radiation is very short compared with the size of the particle causing the scattering (in the visible and infrared region).

**Mie scattering applies where the wavelength of the radiation is approximately the size of the particle causing the scattering (in the infrared region).

The power absorbed by the earth is

$$P_e = (1 - AL)(1 - FW)(P_{er} + P_{ef}) \quad W/m^2 \quad (7)$$

where AL is the effective albedo of the earth's surface and FW is the fraction of the sky covered with liquid water.

The transmissivities are assumed to be (Carroll, p. 105)

$$T_{ra} = 10^{-0.02m} \quad (8)$$

$$T_{rw} = 10^{-(0.04y^{0.1} + 0.01y)m} \quad (9)$$

$$T_{rl} = 10^{-\gamma m} \quad (10)$$

$$T_{rp} = 10^{-0.666\beta m} \quad (11)$$

where

$$\gamma = 0.054 - 0.0088m + 0.00108m^2 - 0.000051m^3 \quad (12)$$

is the Rayleigh extinction coefficient. The parameter β is Angstrom's turbidity coefficient which falls in the range 0.01-0.3 in the present climate, but probably in the low end of this range for the pristine conditions before the Flood. The parameter y is the centimeters of precipitable water vapor in the atmosphere.

Carroll (p. 105) rewrites the first two terms of Equation 6 as

$$P'_{ef} = (0.5 + 0.3\beta)(P_w - P_{er})\cos^{1/3}\theta \quad W/m^2 \quad (13)$$

The third term is written as

$$f_3 = (0.98 + 0.1AL + 0.36\beta(AL - 0.25))(P_{er} - P'_{ef}) - (P_{er} - P'_{ef}) \quad (14)$$

The total diffuse radiation incident on the earth is then

$$P_{ef} = P'_{ef} + f_3 \quad W/m^2 \quad (15)$$

In these equations, P_w is the direct component if no scattering has occurred. The Rayleigh forward scattering fraction (0.5) and the Mie forward scattering fraction (0.3β) have been combined as one factor.

The radiation absorbed by the atmosphere on the way into the surface is

$$P_{ain} = P_{top}(1 - FW)(1 - T_{ra}T_{rw}) \quad W/m^2 \quad (16)$$

I assume that the liquid water in the globules has a shortwave albedo of 0.08, so 0.92 of the radiant energy incident on the atmosphere above the globules is absorbed by the globules (Sellers, 1965 p. 21). The total radiation absorbed by the atmosphere/canopy is then

$$P_a = P_{ain} + 0.92(FW)(P_{out}) \quad W/m^2 \quad (17)$$

The total daily radiation energy absorbed by the earth or atmosphere is then found by a summation of the radiation over all hours of the day. If the solar constant is expressed as 1353 W/m^2, the hourly energy outside the atmosphere is 1353(60)(60) = 4,870,800 $J/(m^2hr)$ = 4.8708 $MJ/(m^2hr)$. Adding all the hourly energies yields the daily energy in $MJ/(m^2day)$.

The daily energy absorbed by the earth would then be

$$Q_e = 4.8708 \sum_{\omega} P_e \quad MJ/(m^2day) \quad (18)$$

Computationally, I start at solar noon with ω = 0. At the next step, ω = 15°, and the hourly energy value is multiplied by two to get the symmetrical contribution from plus and minus ω or from 11:00 AM to 1:00 PM solar-time. The summation continues until cos θ becomes negative (that is, the sun has gone below the horizon). A similar expression holds for Q_a, the energy absorbed by the atmosphere (including the liquid water).

Long-Wave Radiation to Space

The heat transfer by infrared radiation from the earth to the atmosphere/water layer is given by (Duffie and Beckman, p. 127):

$$Q_{ea} = \frac{\sigma(T_e^4 - T_a^4)}{1/\epsilon_e + 1/\epsilon_a - 1} \qquad \text{MJ/(m}^2\text{ day)} \qquad (19)$$

where T_e is the temperature (K) of the earth, T_a is the temperature of the atmosphere, ε_e is the emissivity of the earth, ε_a is the emissivity of the atmosphere, and σ is the Stefan-Boltzmann constant, 5.6697 x 10^{-8} W/(m^2K^4). The infrared emissivity of water is between 0.92 and 0.96, and is between 0.9 and 0.98 for the vegetation covered earth (Sellers, p. 41).

The radiation from the atmosphere/water layer to the sky would be given by

$$Q_{as} = \epsilon_a\sigma(T_a^4 - T_{sky}^4) \qquad \text{MJ/m}^2\text{day)} \qquad (20)$$

For a flat plate solar collector radiating to the open sky above, the temperature T_{sky} is really an equivalent atmosphere temperature and is only a few degrees lower than the air temperature at the solar collector. For our model, with the earth radiating to the atmosphere and the atmosphere radiating to space, it would seem that the equivalent sky or space temperature should be the temperature of deep space, close to absolute zero. We will assume T_{sky} to be absolute zero, except under the ice cloud where it will be closer to the temperature of the ice, perhaps 200 K.

Reflection From Ice Layers

During the winter, the underside of the ice cloud is illuminated by the sun, reflecting light to the earth. Using trigonometry, the radius of the largest ice cloud which will not shade the earth at the summer solstice can be shown to be about 3400 km.

The albedo of the ice cloud could be rather high, in the range of 0.6 to 0.8 or even higher. Part of the reflected radiation will be specular or beam radiation and the remainder will be diffuse radiation. A ray from the sun which strikes a horizontal specularly reflecting surface in the ice cloud will have the same angle of reflection as incidence (from Snell's Law or Fermat's Principle) and will not strike the earth. This does not help illuminate the polar region, so we need a good fraction of diffuse radiation which is radiated in all directions. Even if the diffuse radiation is isotropic (the same in all directions), only a fraction will be intercepted by the earth. The remainder will be radiated through the gap between the earth and the ice cloud and lost in space. The fraction of diffuse radiation from the ice cloud that is actually intercepted by the earth will probably not be larger than about 0.5.

The radiation reflected toward earth is given by

$$P_{ice} = (SC)(R_{ice}) \sin \delta \qquad \text{W/m}^2 \qquad (21)$$

where R_{ice} is an equivalent reflectance factor, including the albedo of the ice cloud, the ratio of diffuse to total radiation, the fraction of diffuse radiation intercepted by the earth, and any difference between the area of the ice cloud and the illuminated area on the earth. An albedo of 0.6, no specular reflection, 0.5 of the diffuse radiation intercepted by earth, and no differences in sizes would yield a value of R_{ice} = 0.3, which would probably be the maximum that could be anticipated.

The sun maintains the same angle δ with respect to the ice cloud during a 24 hour period, so the total daily radiation energy to the area under the ice cloud would be

$$Q_{ice} = -24(SC)(R_{ice}) \sin \delta \qquad \text{MJ/(m}^2\text{ day)} \qquad (22)$$

The minus sign is present to make Q_{icc} positive during the winter when the declination δ is a negative value.

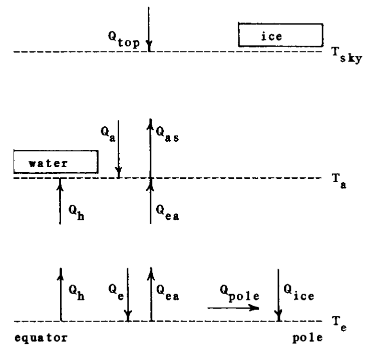

Figure 2. Energy flux diagram of canopy model. Temperatures are of the earth, the atmosphere/water layer, and the sky.

Heat Flows

The heat flows within this model of the earth/atmosphere system are as shown in Figure 2. All quantities are expressed in MJ/(m^2 day) or the energy per square meter of horizontal surface per day. The incoming heat flow from the sun is Q_{top}. Q_a is absorbed by the atmosphere and Q_e or Q_{ice} is absorbed by the earth.

The energy absorbed by the earth can be radiated back out as infrared radiation, can go into storage by raising the temperature of either the soil or water, can be transferred to the atmosphere as sensible heat Q_h, or it can be physically transported to a different latitude. The latter heat flux is shown by a horizontal arrow and is designated by Q_{pole}. Considerable quantities of energy are transported toward the poles by atmospheric movements and ocean currents in today's environment. This is an important component in today's climate in that equatorial temperatures are lowered and polar temperatures are raised from the values they would otherwise have.

Sensible heat is transferred by convection and conduction rather than infrared radiation. In today's climate, the average sensible heat transfer is 24,000 ly/yr = 66 ly/day = 2.7 M J/(m^2day) over land surfaces (Sellers, p. 105). The pre-Flood climate would have had very little wind, which reduces the convection term, so Q_h would probably have been in the range of 1 to 2 MJ/(m^2day).

Because of energy storage, there will not be an exact energy balance for either the earth or the atmosphere on any one day. The difference or the net energy input to the earth would be

$$Q_{e,net} = Q_e - Q_{ea} - Q_{pole} - Q_h \qquad (23)$$

Likewise, the net energy input to the atmosphere would be

$$Q_{a,net} = Q_a + Q_{ea} - Q_{as} + Q_h \qquad (24)$$

There will be a change in temperature based on the thickness of the earth or atmospheric layer which is available for storage, and on the heat capacity of this storage. For simplicity, I will model the storage capability of both the earth and atmosphere as that of equivalent layers of water of thickness d_e and d_a, respectively. The mass of the present atmosphere would be the same as that of a layer of water about 9 m thick, but the atmosphere does not hold as much heat due to the lower heat capacity of the atmospheric gases as compared with water. Air has a specific heat of 0.241 at one atmosphere and 25°C, so the atmosphere without any water globules would be equivalent to a water layer somewhere between 2.0 and 2.5 m in thickness. The water globules would then add to this thickness depending on their area and thickness.

The thickness of the equivalent water layer representing the energy storage of the earth is more difficult to estimate. Only about the top two meters of soil actually participate in the annual cycle of heat storage, so soil might be represented by a water layer perhaps one meter thick. However, part of the earth's surface is covered by water so we could have 100 m or more of water thickness participating in the annual cycle. Since we have very little information on the fraction of the earth's surface which was dry land before the Flood, or on the depth of the water, we will consider the entire earth, both land and water, to be modeled for heat storage purposes by a layer of water of thickness d_e. This thickness is varied in the computer model to determine the effects of different depths of water.

For this model, it is quite accurate to assume that the temperature of one cm^3 of water is increased one °C by one calorie or 4.184 J. One m^3 of water would have its temperature raised one degree by 4.184 MJ. Energy flows are expressed in MJ/(m^2 day) so that 4.184 MJ/(m^2 day) will raise the temperature of a 1 m thick water layer by one degree or a 2 m thick layer by 0.5 degrees, etc. In equation form,

$$\Delta T_e = Q_{e,net}/4.184d_e \qquad (25)$$

Likewise, the change in temperature in the atmospheric layer will be

$$\Delta T_a = Q_{a,net}/(4.184(d_a + (FW)d_w)) \qquad (26)$$

where d_w is the thickness of the water globules. I arbitrarily assumed d_w = 100 m, which even with the spacing increasing in a poleward direction would still contain ample water for a 40-day rain.

An iterative technique is used to determine the temperature variations of both the earth and the atmosphere. Starting temperatures for January 1 are assumed for both the earth and the atmosphere, e.g. 20°C for the earth and 0°C for the atmosphere. The daily energy absorbed by the earth would be computed from Equation 18, and likewise for the daily energy absorbed by the atmosphere. The daily heat transfer from the earth to the atmosphere is computed by Equation 19 and the daily heat transfer from the atmosphere to space is computed by Equation 20 for the current temperature, which will be changing throughout the year. The net daily input to storage is computed from Equations 23 and 24 and the change in temperature is found from Equations 25 and 26. The temperature at the end of the day is found by adding ΔT to the temperature at the beginning of the day.

By repeating this process for each day of the year, a final temperature can be found for both the earth and the atmosphere. If the final temperature is not the same as the initial temperature, the temperature profile is not correct to radiate the same amount back into space as was incident from the sun. The difference between incident and radiated energy has been accommodated by the storage in earth and atmosphere. The final temperature can be used as the initial temperature for the following year, and the process repeated until the final temperature is within some small amount, e.g. 0.1°C, of the initial temperature. This indicates a convergence to a solution for the annual temperature profile of both the earth and the atmosphere.

Temperature and Energy Curves

The variation of the average annual temperature with latitude as predicted by this model is shown in Figure 3. T_e(ice) refers to the surface temperature with only the ice portion of the canopy present, T_e(water/ice) is the surface temperature with the entire pre-Flood canopy in place, and T_e(present) is the temperature predicted by the model under present conditions. T_a(water/ice) is the temperature of the atmosphere at the level of the water globules. The variation of the summer and winter temperatures with latitude for the same set of parameters is shown in Figure 4.

These curves are the result of varying parameters until the temperatures seemed 'reasonable,' or, in the case of the present climate, until the temperatures agreed with presently measured values. The parameters for the curves shown are listed in Table I.

The fraction of sky covered with water globules, FW, needed to vary from 0.5 at the equator to 0.1 at 40°N or S. to prevent overheating of the equatorial region. The amount of precipitable water vapor in the atmosphere is proportional to temperature, and was arbitrarily assumed to vary linearly from 1.0 of its

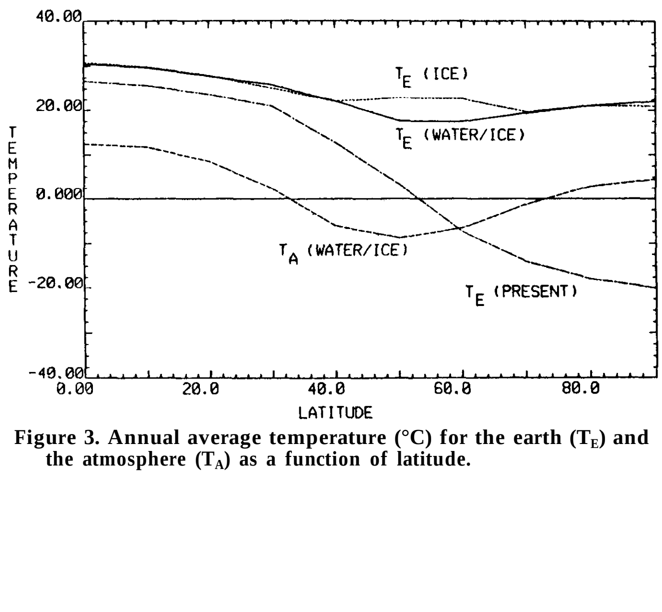

Figure 3. Annual average temperature (°C) for the earth (T_E) and the atmosphere (T_A) as a function of latitude.

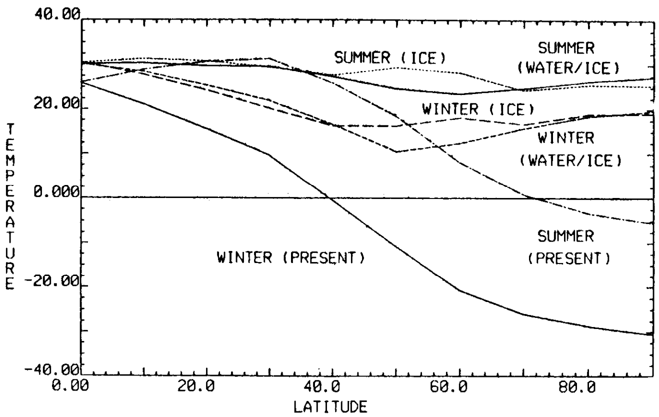

Figure 4. Average summer and winter temperatures (°C) for the earth as a function of latitude.

Table I. Model Parameters

	Water/ ice	Ice	Present
Value of FW at equator	0.5	0	0
Ice reflectance factor R_{ice}	0.3	0.3	0
Equivalent surface water thickness, d_e(m)	8	8	4
Equivalent atmosphere thickness, d_a(m)	2.5	2.5	2.5
Emissivity of atmosphere	0.96	0.96	0.96
Emissivity of earth	1	1	1
Albedo of earth/atmosphere	0.15	0.25	0.30
Centimeters of precipitable water, y_o	4	4	4
Turbidity coefficient	0.01	0.01	0.01
Maximum sky temperature, K	220	220	0
Sensible heat transfer, Q_h	1	1	1

Quantities that varied with latitude are shown in Table II.

equatorial value to 0.55 of that value at the poles. An equatorial value of 4 cm of water vapor was assumed in all cases. The equivalent thickness of the mass of the atmosphere was maintained at 2.5 m of water in all cases. The emissivity of the atmosphere was assumed to be 0.96 and the emissivity of the earth was taken as 1.0. An emissivity of 0.96 for the earth might be better but would raise the earth's temperature about 3°C and would require adjustment of other parameters to get a more acceptable temperature profile.

The turbidity coefficient was maintained at 0.01 throughout. The sensible heat transfer from earth to atmosphere Q_h was maintained at 1 M J/(m^2day). These are not very good assumptions for the present climate, but it seemed good to maintain as many parameters at about the same value as possible.

The poleward energy flux Q_{pole} was assumed to be zero before the Flood. With only the ice clouds above the earth, Q_{pole} must be positive near the equator and negative poleward of 40° latitude to prevent overheating near the equator and frigid conditions poleward. The energy flux under the ice cloud would not need to be large. With the ice cloud gone, the poleward energy flux near the poles must increase to prevent the poles from being even colder than they are at present.

The albedo of the earth before the Flood would be the albedo of green plants, about 0.15. After the Flood, there would be clouds, which would raise the effective albedo to perhaps 0.25. After the ice clouds collapsed, the earth would be colder and drier, and the snow, ice, and desert regions would raise the effective albedo to perhaps 0.3.

The other parameter that was varied between the example cases was the equivalent thickness of water involved in heat storage on the earth's surface. It was assumed to be 8m before the ice clouds collapsed, when all the water on earth was in the liquid form, and 4 m after the collapse, when much of the water was in the form of ice, which is not as good for heat storage purposes.

The model yielded the present day temperature profiles very well, both for the annual average and the profiles at the summer and winter solstices. Since any parameter modifications were minor, and in a reasonable direction, the temperature profiles before the Flood and after the Flood with only the ice clouds present may be close in value to the actual values. The temperatures near the equator appear to be about 3°C warmer than today's mean temperature, which would have encouraged the growth of dinosaurs. There would have been little temperature variation in summer but a significant variation in winter, with minimum temperatures occurring at latitudes of 50 and 60°. Regions with less than the assumed 8 m of equivalent surface water for heat storage or on low mountains of 1000 to 2000 m in elevation would experience winter frost, which is necessary for the survival of some plant species.

The average radiation energy absorbed by the earth is shown in Figure 5. It is seen that the water globules lower the incident radiation substantially near the equator while the ice clouds raise the radiation near the poles. The average radiation before the Flood would be that currently experienced between 35 and 45° N or S. If temperature, moisture, soil, and nutrient levels are correct, this is quite adequate to produce heavy plant growth.

The difference between Q_e(ice) and Q_e(present) at low latitudes, and between Q_e(water/ice) and Q_e(ice) at high latitudes is due to the assumed differences in albedo. Albedo varies substantially with latitude in

Table II. Latitude Variation of Model Parameters

Latitude	0	10	20	30	40	50	60	70	80	90
Sky temperature	0	0	0	0	0	154	176	202	216	220
FW	0.5	0.5	0.45	0.3	0.1	0	0	0	0	0
Precipitable water y/y_o	1.0	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6	0.55
Q_{pole}(ice)	2.0	2.0	1.5	0.5	-1.0	-2.5	-2.2	-0.8	-0.6	-0.3
Q_{pole}(present)	2.0	2.0	1.5	0.5	0.2	-0.4	-1.0	-2.0	-2.5	-2.5

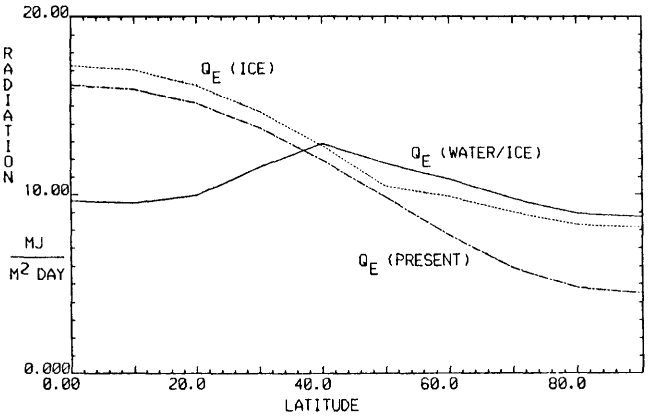

Figure 5. Average daily radiation energy incident on the earth as a function of latitude for the original water/ice canopy, the ice canopy, and the present.

today's climate and may have had some variation under the ice cloud, so these minor differences should not be considered significant.

Canopy Collapse

This simple model shows that a two level canopy over the earth between the times of Adam and Noah is quite plausible. The lower level would have consisted of liquid water and would not have extended under the upper level of ice. The earth would have been somewhat warmer under the water canopy, favoring the development of large numbers of dinosaurs. The liquid water canopy would have collapsed at the time of Noah, contributing to the Flood. The ice canopy would have remained, however. The earth would still have good growing conditions from pole to pole.

The animals on the ark would have multiplied rapidly over several hundred years after Noah. For a variety of climatic and forage reasons, the mammoths could have been concentrated in the northern latitudes. When the ice layer finally collapsed, it would have buried the mammoths and permanently changed the climate of the polar regions. The heat input would have decreased, lowering the temperature, but perhaps more importantly, there would not be adequate light for plant growth for six months of the year.

The collapse of the ice would not have been directly visible to Noah's descendants living in the middle east, which may explain why it is not mentioned in the Bible. It would have the effect of lowering the earth's temperatures even more for a period of time, which would certainly have destroyed any remaining dinosaurs. There are several references in the book of Job (6:16, 9:30, 24:19, 37:6, 10, 38:22, 29, 30) to ice and snow which are not commonly observed today throughout much of the middle east, so perhaps it was written during this period of depressed temperatures. The human population tended to live in one region until the tower of Babel incident, so it is possible that there was little or no loss of human life with the collapse of the ice layer because people had not yet migrated into the polar regions. Without direct impact on God's people, there would have been little reason to mention the event.

Conclusions

A computer simulation with a simple global heat balance model has shown that a combination of a liquid water canopy and an ice canopy meets the requirements of both temperature and radiant energy for the pre-Flood era. Collapse of the water layer at the time of the Flood and collapse of the ice layer perhaps several hundred years later would explain the ice age and the burial of the mammoths as a totally separate catastrophe from the Flood.

A miracle would have been required to maintain the canopies above the earth, or some as yet undiscovered physical phenomenon. This is similar to each of the other canopy theories which require a miracle either in maintaining the canopy above the earth or in dissipating the heat when it descends to the earth.

This model is consistent with Scripture in that Noah would have seen liquid water above him, but would also have seen the sun, moon, and stars between the water globules. It therefore eliminates several major problems experienced with the other canopy theories.

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QUOTE

We can begin, then, by noting several relevant aspects of the biblical world-view:

(1) Certainly the biblical world-view implies that since God is the creator of all that exists, He ultimately is the rightful owner of all that exists. Whatever possessions a human being may acquire, he holds them temporarily as a steward of God and is ultimately accountable to God for how he uses them. However omnipresent greed and avarice may be in the human race, they are clearly incompatible with the moral demands of the biblical world-view.

(2) The biblical world-view also contains important claims about human rights and liberties. All human beings have certain natural rights inherent in their created nature and have certain moral obligations to respect the rights of others. The possibility of human freedom is not a gift of government but a gift from God.

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