CAN THE CANOPY HOLD WATER?

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Calculations of the surface temperature of the Earth with a water vapor canopy, under the assumption of radiative equilibrium, yield temperatures too high for life to exist. Moreover, when the results about radiation are combined with the barometric law, only certain solutions to the physical description of the canopy are found to be possible for a given set of assumptions; and those solutions generally either lead to impossible environmental conditions or else do not fulfil the purpose for which the canopy was proposed. It appears that some new thinking about the antediluvian climate, and the cause of the Flood, is due.

In the past twenty years since the vapor canopy model first became widely accepted among creationists, remarkably little work has been done on the physics of a world with a canopy. A work was recently published by Dillow[1,2] which attempted a fairly comprehensive physical treatment of the canopy; and although he directly stimulated this author's interest in these problems, we have come to opposite conclusions as to the validity of the canopy model. This paper is not intended to deny the Biblical account of the flood, nor anything which the Bible teaches about the world before the flood.The intent is, however, to challenge some of the beliefs about the canopy in order to show that new answers to our questions about the flood must be sought.

Two conditions must be fulfilled if the vapor canopy hypothesis is to be successful. First, the surface temperature of the Earth must be near 300 °K. Much more than a 25 °K variation from this would eliminate the possibility of life. Second, the canopy must be above the boiling point of water at all levels. The boiling point will vary with the pressure.

For a canopy of any appreciable thickness these two criteria mean that the Earth's atmosphere must have had a tremendous temperature inversion. Table 1 shows the pressure and temperature at the base level for canopies of various thicknesses. Since these values are the boiling points of water at the given pressure, if the temperature of the canopy base dips below these values the canopy would become supercooled and hence very unstable. From this one can easily see that the canopy base must be hotter than the Earth's surface.

The effect of this temperature inversion is that no large-scale vertical convection could have taken place. The reason for this is that as cooler air is forced upward into a warmer layer the cooler air is denser and hence heavier than the surrounding air. Thus the colder air sinks back to its own layer. Since convection can not remove any excess heat from the surface of the canopied Earth, and conduction of heat is not only slow but also the wrong direction (heat always flows from a warmer to a cooler object), the only avenue for heat transport away from the surface is by radiation.

Regardless of the type of atmosphere one is dealing with, the variation of pressure with altitude can be expressed as,[3]

$$\frac{dP}{dZ} = -\varrho g \qquad (1)$$

where P is the pressure, Z is the altitude, ϱ is the density of the gas and g is the acceleration of gravity.

The density can be expressed as,

$$\varrho = \frac{P}{RT} \qquad (2)$$

where R is the gas constant divided by the molecular mass of the atmosphere, and T is the temperature.

Therefore,

$$\frac{dP}{dZ} = -\frac{Pg}{RT} \qquad (3)$$

Assuming that the change of temperature with altitude is linear (as is about true today) then we can define the lapse rate as:

$$\frac{dT}{dZ} = \lambda \qquad (4)$$

Substituting this into Equation (3), rearranging, and integrating, we find,

Table 1. Pressure, and boiling point of water, for canopies containing various amounts of water. (Expressed in terms of the depth of liquid water, in feet, to which the canopy would amount.)

	Base of Canopy		*Surface*	
Feet of Water	*Pressure PSI*	*Temperature °K*	*Pressure PSI*	*Temperature °K*
50	21.68	384	36.37	401
45	19.51	381	34.21	399
40	17.34	378	32.04	397
35	15.17	374	29.87	394
30	13.01	370	27.70	392
25	10.84	365	25.54	389
20	8.67	359	23.37	386
15	6.50	352	21.20	383
10	4.33	342	19.03	380
5	2.17	327	16.87	377
1	.43	297	15.13	374

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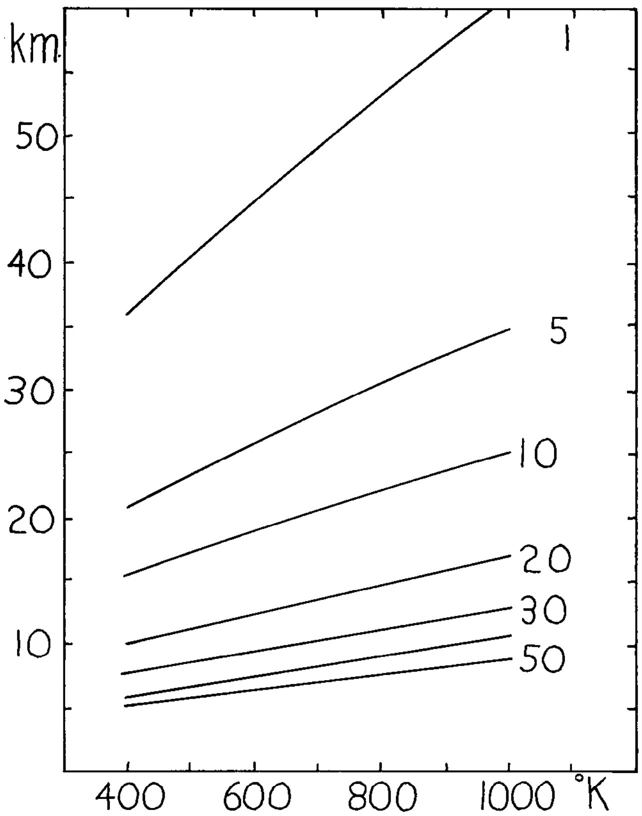

Figure 1. The height, in km., of the canopy, vs. basal (i.e., at the base of the canopy) temperature, in °K. The surface temperature is assumed to be 300°K. The various curves are for different amounts of water, (expressed in terms of depth in feet of liquid water to which the canopy would amount) in the canopy.

$$\lambda = \frac{g \ln \frac{T_0}{T_c}}{R \ln \frac{P_c}{P_o}} \qquad (5)$$

where T_0 and P_0 are the surface temperature and pressure respectively. Equation (5) when combined with the integration of Equation (4) yields the height of the canopy base.

$$Z_c = \frac{R \ln \frac{P_c}{P_o} (T_c - T_0)}{g \ln \frac{T_0}{T_c}} \qquad (6)$$

where Z_c, P_c, and T_c are the canopy height, pressure and temperature.

Figure 1 and Table 2 shows the basal height for canopies of various sizes and various basal temperatures, assuming a 300°K surface temperature. (By "basal" is meant "of or at the base of the canopy.")

Under the assumption of radiative equilibrium only certain solutions are physically realizable for a given set of parameters.

The Radiation Solution

Since, as was pointed out earlier, radiation is the only means by which heat can escape from the surface of a

Table 2. The height of the canopy for various amounts of water, and various basal (i.e., at the base of the canopy) temperatures (in °K.) The temperature at the surface is assumed to be 300°K.

Feet of Water	*Minimum Height (km)*	*400*	*500*	*600*	*700*	*800*	*900*	*1000*
50	5.24	5.24	5.91	6.53	7.12	7.69	8.23	8.77
45	5.66	5.70	6.42	7.09	7.74	8.36	8.95	9.53
40	6.20	6.25	7.04	7.78	8.48	9.16	9.82	10.45
35	6.84	6.91	8.17	8.60	9.38	10.13	10.85	11.56
30	7.58	7.68	8.65	9.56	10.43	11.26	12.07	12.84
25	8.37	8.51	9.59	10.60	11.56	12.48	13.38	14.24
20	9.86	10.06	11.33	12.52	13.66	14.75	15.80	16.82
15	11.72	12.01	13.53	14.96	16.31	17.62	18.87	20.09
10	14.60	15.04	16.94	18.73	20.43	22.06	23.63	25.16
5	20.19	20.91	23.55	26.04	28.40	30.67	32.86	34.98
1	34.51	36.02	40.57	44.85	48.92	52.83	56.60	60.25

habitable canopied Earth, it is to that problem that we must now direct our attention.

The model proposed by Dillow in his thesis assumes a three-layer atmosphere. The top layer is the water vapor canopy. Beneath this he proposes a cloud layer with anywhere from 2 to 5 feet of precipitable water. It is not proposed to be a continuous cloud cover. This

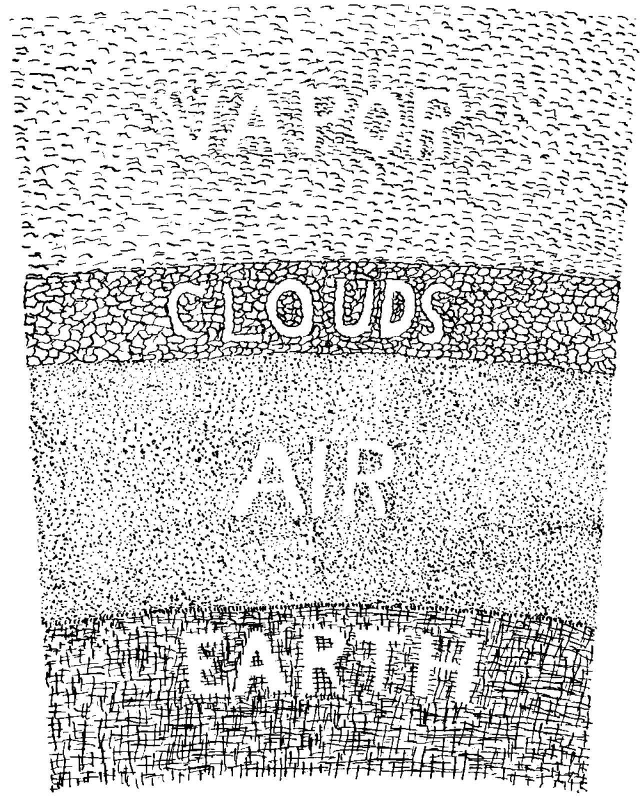

Figure 2. The model of the canopy and the underlying atmosphere, as used by several authors, was mostly recently by Dillow, in References 1 and 2. Not necessarily to scale.

means that some of the direct and diffuse solar radiation will be absorbed at the earth's surface. This means that there cannot be a temperature inversion under the canopy as can easily be shown. Finally the lowest layer is an atmosphere identical to the one surrounding the earth today. Thus this model is simply today's atmosphere surrounded by clouds and a vapor canopy. (see Figure 2)

This model will be used as a starting point. Two things will be investigated: 1) the temperature distribution of this atmosphere and, 2) the validity of the model itself; i.e. can clouds form underneath the canopy?

In any study of the thermal radiation in an atmosphere several assumptions must be made. These are as follows.

1. It is assumed that the atmosphere is optically stratified. This means that we can treat the atmospheric radiation by dividing the atmosphere into layers.

2. It is assumed that the emission of the atmospheric gases does not depend upon the direction. This is known as the Eddington approximation.

3. Energy from the sun is assumed to be absorbed only at the Earth's surface. This assumption is nearly the case today for a cloudless atmosphere, since only a small percentage of the incident solar radiation is absorbed directly by the atmosphere. Ignoring the atmospheric absorption in calculating the temperature profile tends to yield temperatures which are cooler than they should be. The reason for this is that some of the energy absorbed by the atmosphere would be reradiated to the surface, thus making it hotter. Ignoring the atmospheric absorption is equivalent to raising the albedo of the earth by an amount which will make the earth reflect the same quantity of energy as the atmosphere absorbs. This assumption greatly simplifies the calculations.

4. It is assumed that radiative equilibrium is achieved. More accurately, the method of Emden which will be used calculates the temperature profile once equilibrium has been achieved.

5. The final assumption is that the atmosphere acts as a gray absorber. This simply means that the absorption coefficients can be considered constant over the spectral range being considered.

Consider a beam of electromagnetic radiation traveling through the atmosphere with an initial intensity I. A small portion of it is absorbed by each element of mass through which it passes. This portion is defined as, $dI = Jk\,da$ where k is the absorption coefficient, J is the source function and da is the mass per unit area along the ray's path. The source function is the energy contained in the mass element which is capable of emission. This includes not only radiation absorbed by the mass element but also energy contained in the rotational and translational motions of the individual atoms.

The optical depth of a medium is defined as, $d\beta = \mathrm{k}\,\mathrm{da}$, so β is found by integrating kda between A and B where β is the optical depth of the travel path from point A to B. $\beta = 0$ is defined to be at the top of the atmosphere since it can be safely assumed that there is no significant amount of matter to absorb the radiation in space.

It can be shown that for a medium in radiative equilibrium,[4]

$$\frac{dJ}{d\beta} = \frac{3}{4\pi}F \tag{7}$$

where F is the flux of radiation. It is related to intensity by $F = \pi(I^+ - I^-)$ where I^+ and I^- are the upward and downward intensities of the radiation.

It can also be shown[5] that for a medium in radiative equilibrium with blackbodies B^* (0) and B^* (β^*) emitting at the top and bottom respectively that

$$\frac{F}{2\pi} = B^*(\beta^*) - J(\beta^*) = J(0) - B^*(0) \tag{8}$$

where $B^*(\beta^*) = \sigma T^4/\pi$ and β^* is the total optical depth of the atmosphere measured at the surface. σ is Stefan-Boltzman's constant.

For a planetary atmosphere B^* (0) is zero since there is no blackbody above the atmosphere. Any energy that passes the upper boundary of the atmosphere leaves the earth altogether.

Therefore,

$$J(0) = \frac{F}{2\pi} \tag{9}$$

Rearranging and integrating Equation (7) we find,

$$J(\beta) = \frac{3}{4\pi}F\beta + C \tag{10}$$

where C is defined by Equation (9). Hence,

$$J(\beta) = \frac{3}{4\pi}F\beta + \frac{F}{2\pi} \tag{11}$$

At the lower boundary $B^*(\beta^*)$ is the emission from the earth's surface. Rearranging Equation (8) we find,

$$B^*(\beta^*) = \frac{F}{2\pi} + J(\beta^*) \tag{12}$$

Now from Equation (11),

$$J(\beta^*) = \frac{3}{4\pi}F\beta^* + \frac{F}{2\pi} \tag{11*}$$

so,

$$B^*(\beta^*) = \frac{F}{2\pi}(2 + \frac{3}{2}\beta^*) \tag{13}$$

This equation defines the surface temperatures of the Earth given the flux of long wave radiation escaping into space and the total optical depth of the canopied atmosphere.

In order to determine what the flux is one needs to find the amount of energy which is absorbed at the Earth's surface. Each element of area of the surface absorbs $dE_a = \pi R^2 S(1 - A)\cos L \sin\theta\, d\theta\, dL$ where R is the radius of the earth, S is the solar constant, θ is the solar height, L is the latitude and A is the albedo. Integrating over the sunlit half of the Earth we find that the energy absorbed is

$$E_a = \pi R^2 S(1 - A) \tag{14}$$

Each surface element at the top radiating layer emits F. Multiplying this by the total surface area of the Earth yields

Table 3. The surface temperature, in °K, for various amounts of water in the canopy, and various albedos.

Feet of Water	Albedo .1	.2	.3	.4	.5	.6	.7	.8	.9
50	1574	1528	1478	1422	1359	1285	1196	1080	908
45	1533	1488	1439	1385	1323	1251	1165	1052	885
40	1488	1445	1398	1345	1285	1215	1131	1022	859
35	1440	1398	1352	1301	1243	1175	1094	988	831
30	1386	1345	1301	1252	1196	1131	1053	951	800
25	1324	1285	1243	1196	1143	1081	1006	909	764
20	1252	1215	1175	1131	1081	1022	951	859	722
15	1165	1131	1094	1053	1006	951	885	800	672
10	1053	1023	989	952	909	860	801	723	608
5	886	860	832	801	765	723	673	608	511
1	596	578	559	538	514	486	452	409	344

$$E_e = 4\pi R^2 F \tag{15}$$

For radiative equilibrium $E_a = E_e$ thus,

$$F = \frac{S(1-A)}{4} \tag{16}$$

Substituting this into Equation (13) we have the surface temperature,

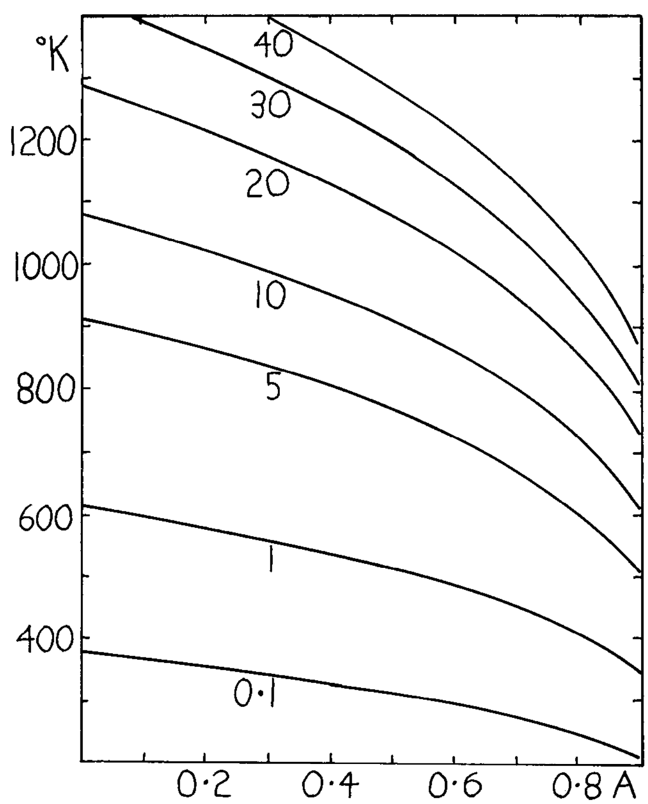

Figure 3. The surface temperature, in °K, vs. the albedo. The curves again indicate different amounts of water in the canopy, in feet of liquid water as previously.

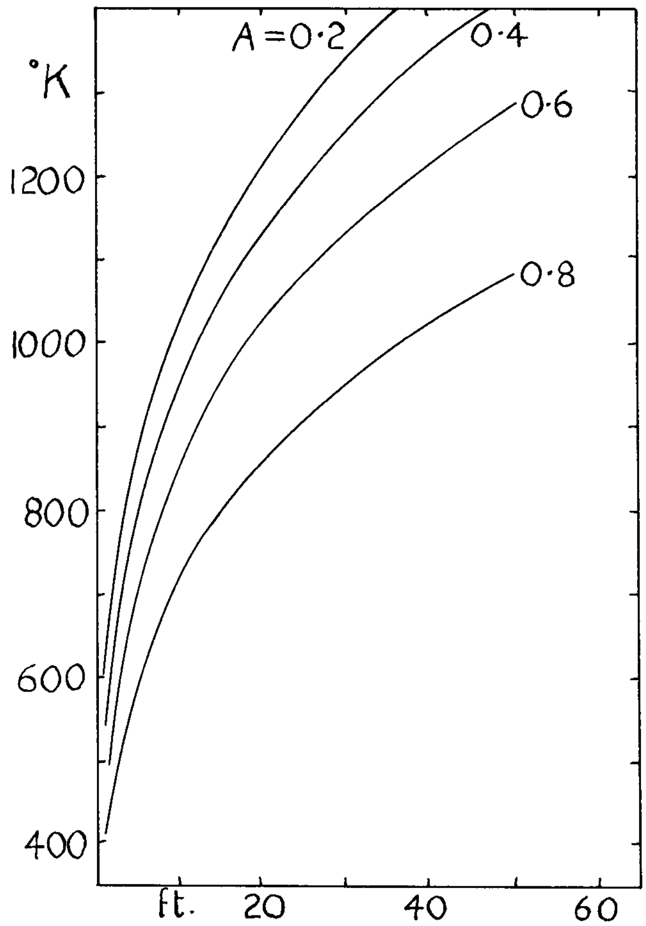

Figure 4. The surface temperature, in °K, vs. the depth of the canopy, expressed in feet of precipitable water. The curves are for various albedos, indicated by A.

$$T^4 = \frac{S(1-A)\,(2 + \frac{3}{2}\beta)}{8\sigma} \tag{17}$$

In order to find the atmospheric temperature profile as a function of optical depth we can represent $J(\beta) = B(\beta)$. Using Equation (11) we have

$$T^4 = \frac{S(1-A)\,(1 + \frac{3}{2}\beta)}{8\sigma} \tag{18}$$

Thus Equations (17) and (18) give us a total description of the temperature of the atmosphere and the Earth's surface as a function of optical depth. Using the approximation that one centimeter of precipitable water is equal to one optical depth over most of the infrared region, Table 3 lists the surface temperatures derived from the radiation solution (Equation 17). Figures 3 and 4 show how this temperature varies with albedo and canopy thickness. Figure 5 and Table 4 illustrate how the temperature of the canopy base varies with canopy thickness and albedo. These calculations, derived from Equation (18), assume that the lower layer of the canopied atmosphere is 3 optical depths thick.

As can be seen from inspection of Tables 1 and 3 the only parameters which will allow clouds to form under

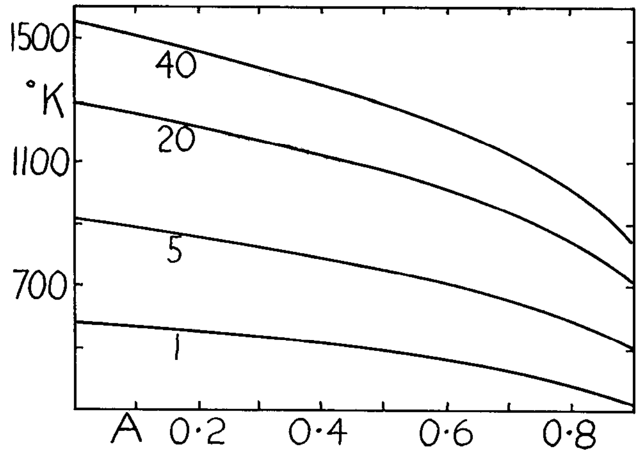

Figure 5. The temperature at the base of the canopy, in °K, vs. albedo. The curves are for various amounts of water in the canopy.

the canopy are a one-foot canopy with an albedo of 0.9. A canopy which only has one foot of precipitable water in it could hardly have produced a worldwide flood of a year's duration. Thus Dillow's model has a serious flaw in that clouds could not form under a very thick canopy. Thus ignoring the atmospheric absorption in our calculations turns out to be fairly close to the actual situation in a canopied atmosphere since very little of the direct solar radiation will be in spectral ranges which water vapor strongly absorbs. Had the clouds been able to form the situation would have been different because the clouds would have absorbed a fair amount of the incident solar energy and the temperatures derived from Equation (17) would have been cooler than actually would exist.

As mentioned previously only certain canopy heights are realizable given the radiation solution. Since Equation (17) defines T_0 and Equation (18) defines T_c these can be substituted into Equation (6) to show the variation of the canopy height with canopy thickness and the

Table 4. The temperature, in °K, at the base of the canopy, for various amounts of water in the canopy, and various albedos.

Feet of Water	*Albedo* .1	.2	.3	.4	.5	.6	.7	.8	.9
50	1573	1527	1477	1421	1358	1284	1195	1080	908
45	1532	1487	1438	1384	1322	1251	1164	1052	884
40	1487	1444	1397	1344	1284	1214	1130	1021	859
35	1439	1397	1351	1300	1242	1174	1093	988	830
30	1384	1344	1300	1251	1195	1130	1052	950	799
25	1322	1284	1242	1195	1141	1079	1004	908	763
20	1250	1213	1174	1129	1079	1020	949	858	721
15	1163	1129	1092	1051	1004	950	884	798	671
10	1050	1020	986	949	907	857	798	721	606
5	881	855	827	796	760	719	669	604	508
1	577	561	542	522	498	471	439	396	333

Table 5. The height, in km., of the canopy, according to the radiation solution, for various amounts of water in the canopy, and various albedos.

Feet of Water	*Albedo* .1	.2	.3	.4	.5	.6	.7	.8	.9
50	23.8	23.1	22.4	21.5	20.6	19.5	18.1	16.4	13.8
45	25.2	24.5	23.7	22.8	21.8	20.6	19.1	17.3	14.5
40	26.7	26.0	25.1	24.1	23.1	21.8	20.3	18.4	15.4
35	28.5	27.7	26.8	25.8	24.6	23.3	21.7	19.6	16.5
30	30.7	29.8	28.8	27.7	26.5	25.0	23.3	21.0	17.7
25	33.2	32.2	31.2	30.0	28.7	27.1	25.2	22.8	19.2
20	36.3	35.2	34.1	32.8	31.3	29.6	27.6	24.9	20.9
15	40.3	39.1	37.8	36.4	34.8	32.9	30.6	27.7	23.3
10	45.6	44.2	42.8	41.2	39.3	37.2	34.6	31.3	26.3
5	53.1	51.5	49.8	47.9	45.8	43.3	40.3	36.4	30.6
1	61.0	59.2	57.3	55.1	52.7	49.8	46.4	41.9	35.2

albedo of the Earth. The results are illustrated in Table 5, Figure 5 and Figure 7. Figure 8 shows how the atmospheric temperature varies with optical depth for an albedo of 0.4.

Conclusions

The temperature profile for a canopied Earth appears to be too high for life to have existed. One might argue that since there is a "window" in the absorption spectrum of water vapor between 8.5 and 13.5μ that the excess heat at the Earth's surface can escape via those wavelengths. The Earth today radiates most effectively at those wavelengths. However, for a canopy of any appreciable thickness the optical depth for even the most weakly absorbing part of the window is still enough completely to block the direct escape from the surface of radiation of those wavelengths. For a forty-foot canopy the optical depth of this part of the window is approximately 122. If one insists upon retaining the

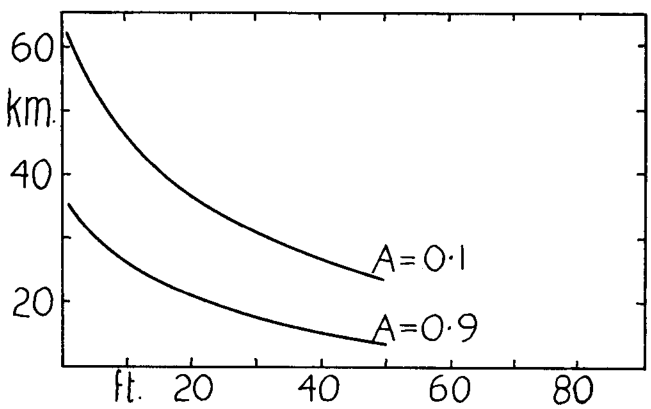

Figure 6. The height, in km., of the canopy, vs. the amount of water, in feet of precipitable water. The curves are for different albedos.

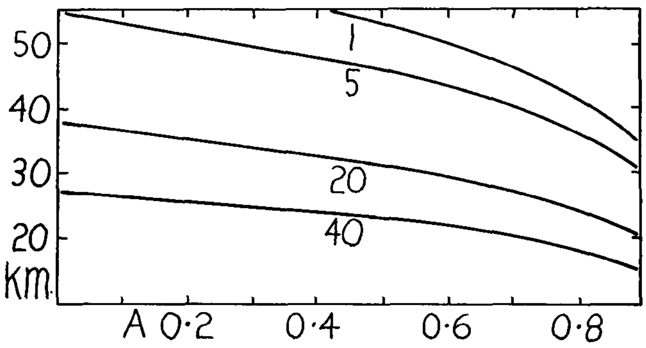

Figure 7. The height of the base of the canopy vs. albedo. The curves are for different amounts of water in the canopy.

clouds under the canopy even this argument fails. Since clouds are made up of water droplets, and liquid water absorbs very strongly in this window, the escape of heat via the window would be slowed considerably.

Obviously this result leaves quite a problem in interpreting Genesis 1:7. As shown here the waters spoken of can not be in the gaseous phase; neither can they be in the liquid form. That leaves only ice, or no canopy at all. A solid ice canopy can easily be shown to mechanically unstable;[6] so there remains only one alternative. That is that the Earth before the flood had a set of rings like Saturn's or Jupiter's, only made up of ice particles.

This author in conjunction with another plans to publish in the near future a new flood model based upon an expansion of the Earth due to a change in the permittivity of free space. The expansion of the Earth and its atmosphere is proposed as the explanation of why these rings no longer exist.

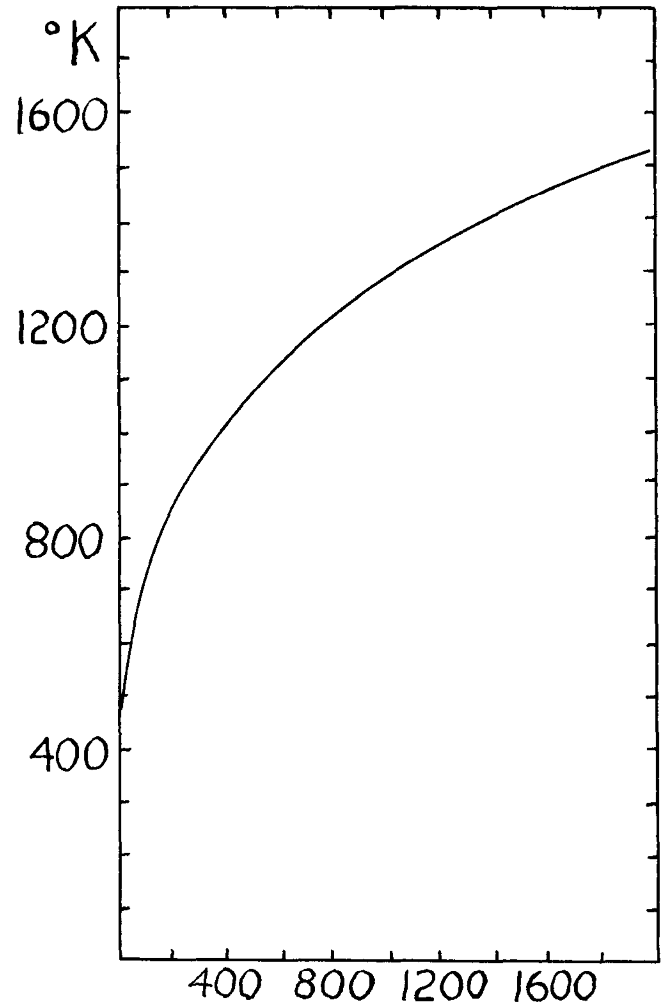

Figure 8. The atmospheric temperature, in °K, vs. optical depth (see the text). It is assumed that A = 0.4. Here A indicates the albedo.

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[1]Dillow, Joseph C., 1978. Mechanics and thermodynamics of the pre-Flood vapor canopy. *Creation Research Society Quarterly* 15(3): 148-159.
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[3]Cambel, Ali Bulent, and Burgess H. Jennings, 1958. Gas dynamics. McGraw-Hill, New York. P. 11.
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[5]*Ibid.*, p. 54.
[6]Kofahl, Robert E., 1977. Could the Flood waters have come from a canopy or extraterrestrial source? *Creation Research Society Quarterly* 13(4):202-206. See especially the end of p. 203 and the beginning of p. 204.

THE RIVERS OF EDEN

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About the only geographical information about the antediluvian world is that given in Genesis 2:10-14. Some have suggested that the Flood so changed the face of the Earth that the present topography has no relation to that before the Flood. No doubt the Flood did cause great changes. But commonly in the early books of the Bible changes, such as different names for cities, are mentioned. So in this case the fact that no change is mentioned may suggest that the topography in Moses' time had at least some resemblance to that before the Flood.[1] This present investigation is an attempt, supposing that the above suggestion is true, to reach some conclusion about the location of the Garden of Eden, and the identity of the four rivers mentioned.

First, the Bible does not compel one to understand one source pouring into four outlets. For example, the

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