

TEMPERATURE PROFILES FOR AN OPTIMIZED WATER VAPOR CANOPY

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ABSTRACT

Calculations of equilibrium temperatures under a water vapor canopy which minimizes the greenhouse effect show that if the solar constant was less than 25% of today's value the surface temperature would be livable. In fact, for a solar constant approaching 1% of today's value it appears that a dense water vapor canopy would be necessary to avoid the entire atmosphere, including the oxygen and nitrogen, from precipitating to the surface as snow. If appropriate conditions can be demonstrated which justify the assumption of a much lower solar constant than typically studied, these calculations could revive consideration of an early earth covered by a water vapor canopy.

INTRODUCTION

The water vapor canopy theory, an attractive climate model for integrating several statements in Genesis about the pre-Flood environment, has alternately received support and criticism. In recent years the theory has fallen on hard times primarily because of findings that even relatively small quantities of water in vapor form would produce such large greenhouse effects that life on earth would be intolerable.

After about twenty-five years of modeling efforts to ameliorate this effect, I decided to try one final approach to solving this problem, write up the results, and proceed to other research projects. However, a new exploration of the full range of the solar constant on atmospheric temperature profiles under a vapor canopy has led to a renewed enthusiasm for the vapor canopy model.

This paper will demonstrate that a thicker vapor canopy containing significantly greater quantities of water vapor can exist under conditions of a smaller solar constant. For values less than about 25% of today's solar constant most of the atmosphere would freeze and fall to the ground as snow. If large quantities of water vapor and/or carbon dioxide were also present under such conditions the temperature would remain warm enough to prevent the oxygen and water vapor from freezing out. This would require a much thicker canopy with a higher surface pressure and create different light conditions.

Of course, the question then arises, why would the solar constant have been lower prior to the Flood? There are at least four possible sets of conditions which would lead to a lower solar constant: 1) the sun's output was less, 2) the distance from the sun to earth was greater, 3) some of the radiation from the sun was captured en route, or 4) a greater percentage of the solar radiation was reflected from the top of the atmosphere. Possible scenarios will be suggested which could have caused these conditions. The consequences of such an environment will also be discussed.

HISTORY OF THE VAPOR CANOPY THEORY

There have been many approaches to modeling “the waters above”. A review of most of these may be found in Dillow [1]. Some have considered liquid water canopies, cloud canopies, solid ice canopies, ice crystal canopies, ice rings, charged water ions, and water vapor. All but a few have considered such canopies to be in contact with the atmosphere. A recent, popular treatment by Humphreys [5] suggests that “the waters above” are actually a cosmic canopy which was originally near earth but is now far out in space. This paper will address the traditional “vapor canopy theory” which is believed to have been present from Creation to the Flood and likely contributed to the heavy rain of the Flood.

Whitcomb and Morris [20] resurrected the vapor canopy theory with a brief description in their landmark book, *The Genesis Flood*. The discussion was primarily based on Scriptural evidence with some scientific reasoning. Dillow [1] published the most complete treatment of the water vapor canopy in, *The Waters Above*. He gathered supporting documentation for a vapor canopy not only from Scripture, but also from archeology, mythology, and science. He began the first serious attempt at developing a numerical model of the vapor canopy. Dillow was able to maintain a livable surface temperature under a massive water vapor canopy by assuming a high albedo at the top of the canopy which reflected most of the incident solar radiation, a large infrared emission coefficient which allowed a large amount of heat to escape back to space, and a large flux of heat from the atmosphere to the ocean and transfer to the poles. These assumptions were based on extensions of theoretical considerations by Kondratyev [9, 10] but are not supported by observation or current atmospheric modeling.

Rush [14] extended Dillow’s efforts by using a widely accepted radiation code to model the temperature profiles under a two-layer atmosphere, the upper layer of which was pure water vapor. Details of the model and the results of the simulations may be found in Rush [14] and Rush and Vardiman [15]. Canopies ranging in size from 10 to 1013 mb of water vapor (i.e., 10 cm to 1013 cm of precipitable water) were found to produce temperatures in radiational equilibrium at the canopy base hot enough to maintain water in the vapor phase. Unfortunately, except for the 10-mb (10 cm of precipitable water) canopy, all modeled canopies produced inhospitably high surface temperatures. It was suggested that the addition of cirrus clouds at the top of the canopy where supersaturated vapor conditions had been noted in the model might help reduce the extremely high temperatures found at the surface.

In Vardiman [17] the solar constant, surface albedo, solar zenith angle, cirrus cloud thickness, and cirrus cloud-base height were varied and the effect on vertical temperature distributions studied. It was found that changes in the solar constant most strongly affected the surface temperature. The addition of a 4-km thick cirrus layer at the top of the vapor canopy produced a completely isothermal layer from the bottom of the cirrus layer to the ground. This helped to reduce greatly the surface temperature but none of the effects were so dramatic as to eliminate the concern over limitations of water content in the canopy on hot surface temperatures. It was suggested that optimum values of all five parameters should be introduced into the same 10-mb (10 cm of precipitable water) model simultaneously to minimize the surface temperature. This paper reports on the results of conducting such a study.

The one-dimensional model by Rush and Vardiman [15] is used here to calculate the equilibrium vertical temperature profiles which result from heating by solar and infrared radiation at each of 20 or more layers in a two-component atmosphere. The heating was tabulated from radiance calculations using the atmospheric radiance and transmission program LOWTRAN 7 developed by the U.S. Air Force (Kneizys et al. [8]). The two-component atmosphere was structured with an upper layer of pure water vapor containing approximately 10 cm of precipitable water resting hydrostatically on a lower layer of dry air identical to today’s atmosphere. The initial vertical temperature distribution was isothermal at 170 K. Since this is a one-dimensional radiation model, no heat is transported by conduction or convection or north and south. The solar constant, the solar zenith angle, the surface albedo, and cloud geometries and properties could all be varied.

OPTIMIZING THE CANOPY

In Vardiman [17] surface temperature and lower atmospheric layer temperatures were shown as a function of five variables: 1) solar constant, 2) solar zenith angle, 3) surface albedo, 4) cirrus cloud thickness, and 5) cirrus cloud base height. Surface temperature decreased strongly for lower values of the solar constant. It was varied from 50% to 150% of today's value and exhibited the strongest effect on surface temperature of all the variables.

Surface temperature decreased moderately for larger values of the solar zenith angle. The solar zenith angle can be thought of as the angle the sun's rays make relative to the local zenith (vertical) at the time of the year of the vernal or autumnal equinox (when the Sun stands directly over the equator). A solar zenith angle of 15° represents a latitude of 15° , or the tropics. A solar zenith angle of 75° represents a latitude of 75° , or the polar regions. So, as would be expected, solar heating is the least in the polar regions and greatest in the tropics.

Surface temperature decreased weakly for larger values of surface albedo. The surface albedo is the fraction of short-wave solar radiation which is reflected by the earth's surface. Since the equilibrium temperatures in the earth-atmosphere system are dominated by infrared radiation under canopy conditions, even large changes in the surface albedo have a relatively small effect on surface temperature.

It is generally accepted today, although just the opposite is sometimes reported, that low clouds produce surface warming and high clouds produce surface cooling (Ramanathan and Collins [13]). In this simulation surface temperature decreased weakly for larger values of cirrus cloud base height. Within the height constraints of the model, surface temperature reached a minimum for a cirrus cloud-base height of 50 kilometers.

Surface temperature decreased moderately for larger values of cirrus cloud thickness. The thicker the cirrus clouds the greater the absorption and scattering of radiation, either solar or infrared. At 4 kilometers thickness the cirrus cloud produced isothermal conditions between the cloud base and the earth's surface. This is important for reducing the minimum equilibrium surface temperature, because with no layer aloft or a thin layer, the temperature distribution near the surface exhibited a "foot" of high temperatures at the ground. The 4-km thick cirrus cloud creates an absorbing layer. Under such conditions convective motions will not occur and conduction and radiation transfer will bring the lower atmosphere to an isothermal state, in accordance with Sandstrom's theorem discussed in Houghton [4].

In an attempt to minimize the temperatures at the earth's surface, the optimum values of the variables above were studied. Cirrus cloud thickness was set at 4 kilometers. Cirrus cloud-base height was set at 50 kilometers. Surface albedo was set at 30%. The solar zenith angle was set at the two extreme values of 15° and 75° . This was done to simulate polar and equatorial conditions since both are present in the atmosphere at the same time. This polar condition will actually constrain the potential precipitation of oxygen, nitrogen, and other gases from the atmosphere. If polar temperatures fall below the boiling point of a gas (e.g., 90 K for oxygen) the gas will form liquid droplets and precipitate out of the atmosphere. Knowing both polar and equatorial temperature distributions will also allow pole-to-equator temperature gradients to be estimated and, consequently, pressure gradients and wind fields. The solar constant was varied from 1% to 100% of today's value.

Twelve different model runs are reported here, six at a solar zenith angle of 15° representing conditions in the tropics and six at 75° representing the polar regions. The equilibrium temperature distributions in the atmosphere will be displayed by altitude and as a function of the solar constant, the independent variable.

RESULTS

Figs. 1 and 2 show the change in the vertical distribution of temperature with time for a solar constant of 1% of today's value in the polar regions and 100% of today's value in the tropics, respectively. These conditions are the extremes modeled in this paper. The initial distribution of temperature in the atmosphere is set at a constant 170K with height in all simulations. This is done to follow the procedure first introduced in this type of modeling by Manabe and Strickler [11] and to avoid the possibility that different initial values would influence the final result. Time is shown in days after the simulation is

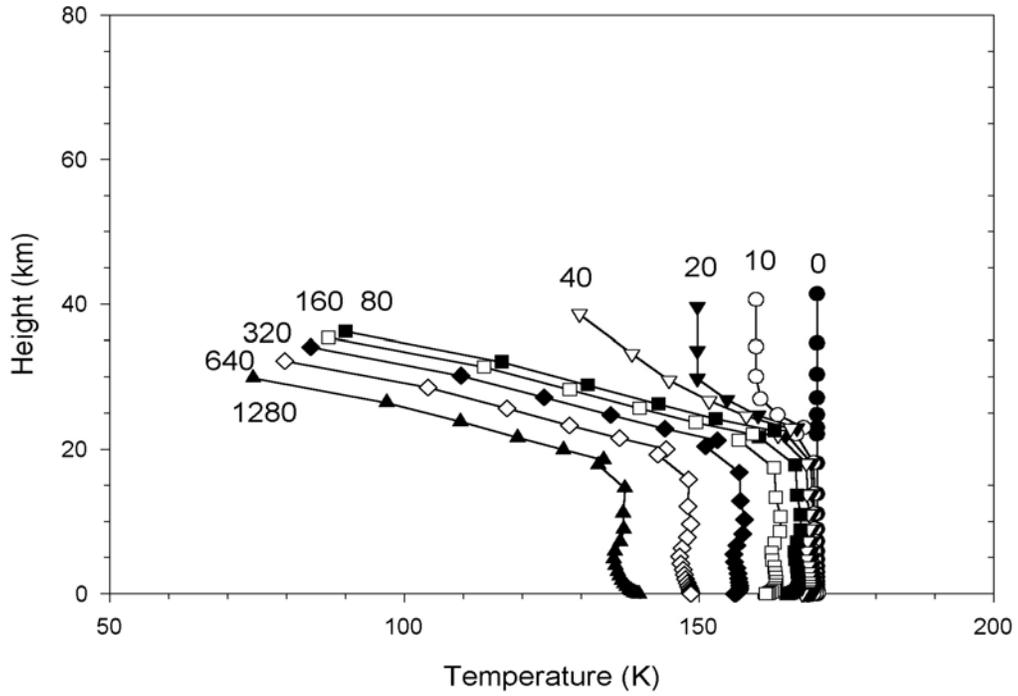


Figure 1. The vertical distribution of temperature for 1% of today's solar constant in the polar regions. Each curve is for the time in days after the start of the simulation.

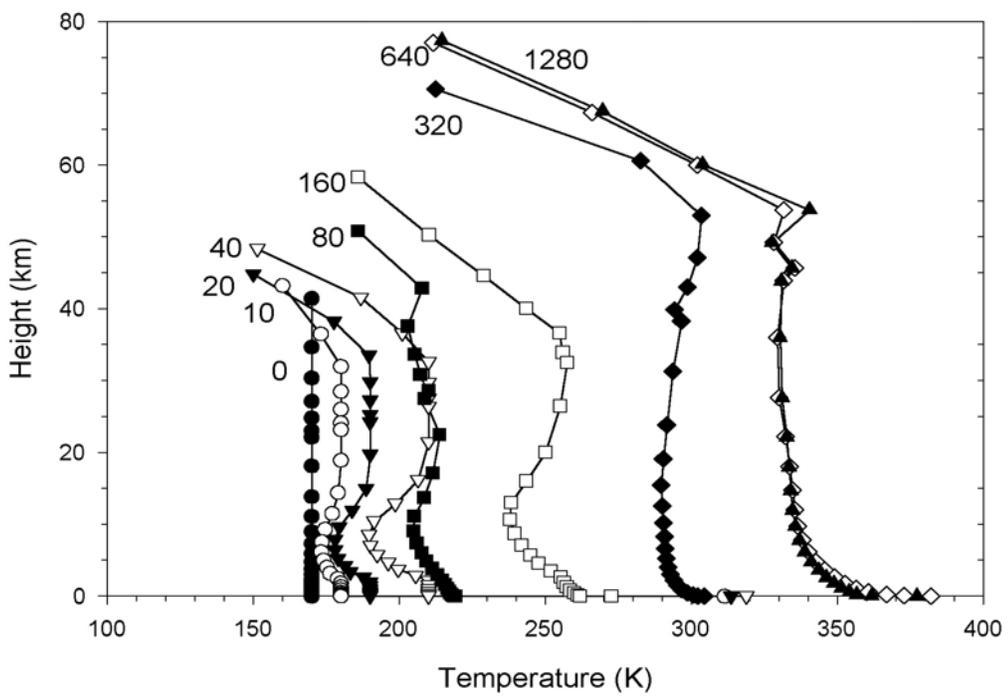


Figure 2. The vertical distribution of temperature for 100% of today's solar constant in the tropics. Each curve is for the time in days after the start of the simulation.

begun. Radiational equilibrium is reached when the vertical temperature distribution stops changing with time. Note, that equilibrium was not reached in the simulation of Fig. 1, but was reached in all others.

For a solar constant of 1% in the polar regions, shown in Fig. 1, the amount of solar radiation entering the atmosphere is not sufficient to compensate for the loss to space by infrared radiation. The entire atmosphere cools from its initial isothermal 170K. It cools more strongly in the upper atmosphere as shown by the bending to cold temperatures near the top of the plot. However, the entire atmosphere cools and contracts with time, approaching absolute zero. It will not reach absolute zero, but the simulation shows that sufficient cooling occurs that all the water vapor in the canopy will be turned to ice and fall out as snow.

In addition, as the temperature falls below 90 K, the condensation point for oxygen is reached, so even the oxygen in the atmosphere will turn to a liquid and precipitate out. The boiling point for nitrogen is 77 K, so if the temperature continues to cool, even the nitrogen in the atmosphere will turn to a liquid. At colder temperatures oxygen and nitrogen may even turn to a solid.

This model does not account for heat flowing from the equator to polar regions. This heat flow poleward in the atmosphere and oceans is what causes the global circulation and eddies which we know as weather. We will discuss below why these weather patterns may have been weakened under a canopy. This model also does not consider dynamic changes in the total gaseous concentration on radiation. All gas concentrations are initially set at a fixed value. The gases are allowed to expand and contract as the temperature changes. The contraction of the atmosphere at the poles with time can be seen in the temperature distributions. As the atmosphere cools, the heights of the data points, which are shown at constant pressure levels, decrease. This contraction is due to cooling, not the removal of mass. The model treats radiation effects only. If the water vapor was removed from the canopy in the model, the cooling would be even greater. For a solar constant of 100% at the equator shown in Fig. 2, the atmosphere rapidly warms from the isothermal 170K to an equilibrium temperature distribution of approximately 400K at the surface and isothermal to the base of the cirrus cloud deck above. The surface temperature is hotter than the boiling point of water, making life as we know it on earth, impossible.

The expansion of the atmosphere at the equator with time can also be seen here in the temperature distributions. As the atmosphere warms, the heights of the data points increase. This expansion is due to warming, not the addition of mass. In the real world, if the atmosphere were warmed, water vapor would be evaporated from the oceans and the temperature would become even greater. This would be similar to the extreme surface temperatures in the carbon dioxide atmosphere of Venus which has been given the name, "The Runaway Greenhouse".

Figs. 3 and 4 show the equilibrium temperature distributions in the polar regions and at the equator, respectively, as a function of the percentage of the solar constant. Note first, that the depth of the atmosphere and the equilibrium temperatures are directly proportional to the magnitude of the solar constant. Even with all the complexity of the absorption, scattering, and re-emission of the radiation in the atmosphere, the final equilibrium temperature is a fairly simple function of the amount of energy entering the system.

Second, for the same percentage of solar constant the temperature distribution at all levels in the atmosphere is colder in the polar regions than at the equator. In fact, the relative temperature differential between the poles and equator is similar to that of today. This is somewhat of a surprise, since Dillow [1], Rush [14], and Rush and Vardiman [15] had anticipated the temperatures would be more uniform from pole to equator than today. This is significant because the pole-to-equator temperature differential is what drives the general circulation of the atmosphere and, in particular, the jet stream which circles the globe in both hemispheres. This means that the intensity of the global circulation was probably about the same as that of today. The jet stream probably had about the same velocity and barotropic instability as today. A barotropic instability is the tendency to form eddies in the west-to-east flow patterns because of strong wind shear at mid-latitudes. Baroclinic instabilities (those caused by temperature gradients) were probably also weaker because of increased convective stability, to be discussed below.

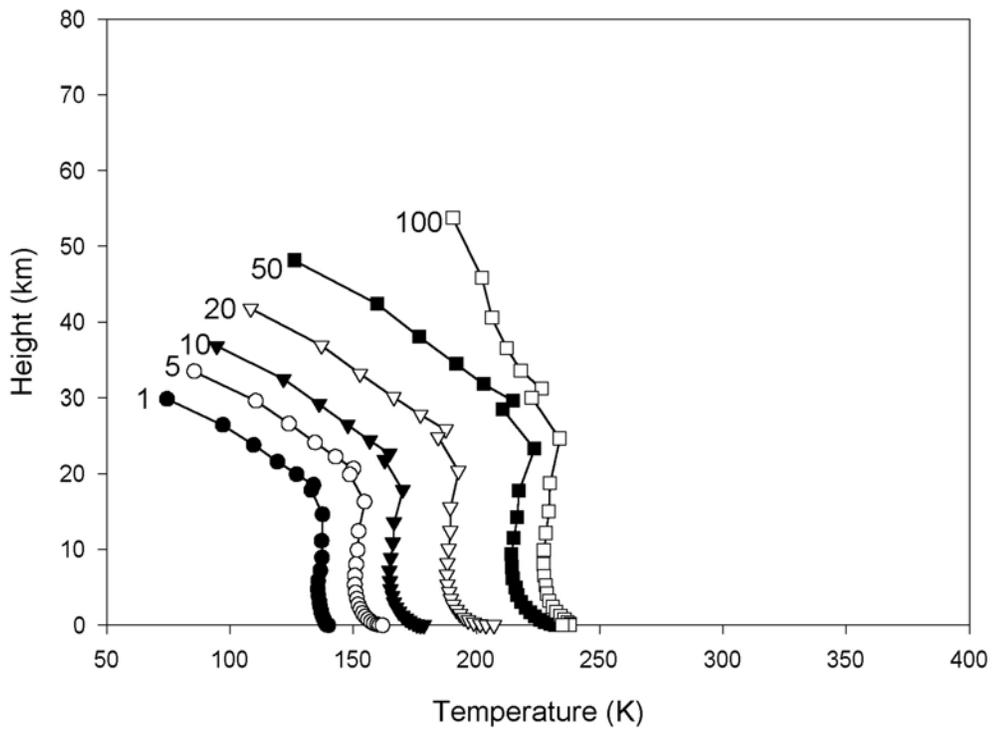


Figure 3. *Equilibrium temperature distributions in the polar regions as a percentage of today's solar constant.*

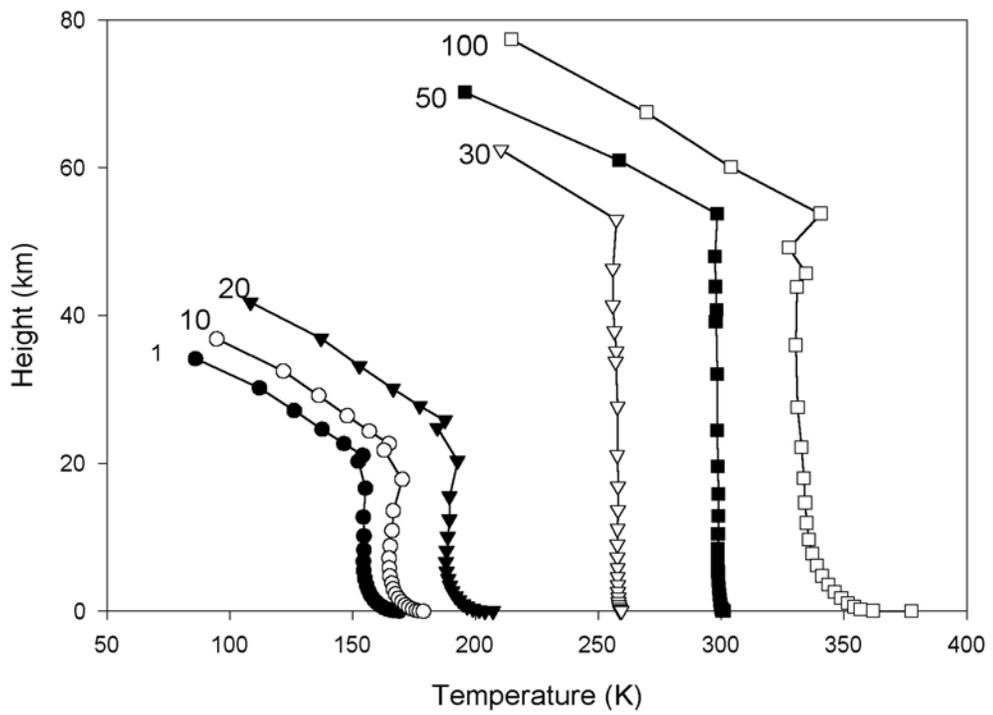


Figure 4. *Equilibrium temperature distributions in the tropics as a percentage of today's solar constant.*

Third, for all simulations, particularly at high values of solar constant and at the equator, the vertical temperature distribution is isothermal in the lower atmosphere. This means that vertical air motions are suppressed. It is unlikely that convection will occur and precipitation would be eliminated or greatly reduced. Baroclinic instabilities would also be weaker because of little or no release of latent heat at frontal boundaries. The net result of a similar pole-to-equator temperature gradient with much greater vertical stability would probably be a world with much less precipitation and fewer clouds. The Richardson Number, a measure of dynamic instability would be much less (see Hess [3] p. 290). Rossby waves would probably be weaker (see Hess [3] pp. 253-256). Jetstream patterns with associated clouds, if any, might be more similar to those on Venus and Saturn. Clouds would probably girdle the earth as more continuous circular bands and exhibit fewer waves and eddies. This implies that less heat would probably be transported from the equator to the poles than today, and pole-to-equator temperature gradients might be even greater.

Fourth, under a vapor canopy containing 10 cm of precipitable water the solar constant must lie somewhere between 1% and 100% of today's value for the mass of the atmosphere to remain in equilibrium. At 1% of today's solar constant all of the water vapor and maybe even a part of the oxygen would precipitate out at the poles. At 100% the oceans would evaporate in the tropics. This doesn't happen today because the solar constant is high enough to prevent excessive cooling at the poles and there is relatively little water vapor in the atmosphere to produce such high temperatures in the tropics. It appears that the solar constant needed to balance these two extremes is about 25% of today's value. At 25% the surface temperature at the poles stays above the boiling point for oxygen and the surface temperature at the equator stays below the boiling point for water.

DISCUSSION

The earth's atmosphere, ocean, and cryospheric systems are like a very complex still—an apparatus for distilling liquids. The Sun is the heat source, the tropics is the firebox, and the polar regions are the condensers. Solar radiation is converted to sensible and latent heat in the tropics, transported by the general circulation to the poles, and emitted to space. Water plays a major role in this process because of its unique capacity to hold large quantities of heat in its various states and to absorb and release this heat during phase changes. In addition, water in vapor form modulates the radiational properties of the atmosphere in major ways through its greenhouse properties.

If, in addition to an initial vertical distribution of water vapor in the atmosphere, the solar constant has varied in the past, it might be possible to discover various states in which this "atmospheric still" operates. It appears that we have now discovered some boundary conditions which constrain a vapor canopy and lead to estimated conditions under which it could function if, in fact, it existed. These conditions appear to require the magnitude of the solar constant to have varied in the past. It will be necessary to extend these studies to explore thicker canopies again as was originally done by Dillow [1] and Rush [14], however, these studies are beyond the scope of this paper. In the meantime, it is instructive to discuss the implications of a changed solar constant.

Why would the solar constant have been lower prior to the Flood? There are four possible sets of conditions which could have caused a lower effective solar constant: 1) the sun's output was less, 2) the distance from the sun to the earth was greater, 3) some of the radiation from the sun was captured *en route* to the earth, or 4) a greater percentage of the solar radiation was reflected from the top of the atmosphere.

1. Reduced Solar Output

Even to suggest that the Sun's output has been significantly different during past historical time seems to be unimaginable to most people. However, both Biblical and scientific evidence lends support to such an idea. The view that the Sun has always been the same brightness falls into the category of uniformitarianism, except for one supposed long-period trend early in the old earth system. The "faint young sun paradox" seems to be one exception to the belief that the present is the key to the past. But, Joshua 10:12-14 speaks of the Sun standing still for an entire day so that the Children of Israel could prevail over the Amorites. Although this incident doesn't involve the darkening of the Sun, which is harder for God to do, make the Sun stand still or reduce its output?

Exodus 10:21-27 says that during the ninth plague on Egypt the Sun was darkened for three days. This was not a slight dimming, but a complete darkness which could be felt. Luke 23:44-45 speaks of the

Sun being darkened for three hours during the time of Christ's crucifixion. It may be that God caused clouds or the Moon to cover the Sun, but the most straight-forward interpretation of this passage is that the Sun's radiation was reduced or stopped.

Evidence continues to mount that at some time in earth's history increased concentrations of oxygen and carbon dioxide were present in the earth's atmosphere (Graham et al. [2]). Carbon dioxide is almost as effective a greenhouse gas as water vapor, so if such high concentrations existed, similar simulations as conducted in this paper would require the solar output to also be reduced to avoid extreme surface temperatures. Nuclear models of the Sun call for it to have had a reduced intensity early in its life (Sagan [16]). Of course, early in its life means millions or even billions of years ago according to the conventional scientific community, but if nuclear processes were slower in the past and then accelerated, as some now suggest (Humphreys [6]), then reduced solar output could have been present as well.

One associated effect of a reduced solar constant which might be of interest to young earth creationists and experts in radiocarbon dating, would be the reduction in ^{14}C and the effect on radiocarbon dating. If the solar constant in the early history of the earth were 25% of today's value, the production rate of ^{14}C would be 25% of today's value as well, significantly reducing the estimated age of buried organics. For example, if the equilibrium concentration of ^{14}C in the atmosphere was 25% of that of today, assuming nothing else changed, the estimated age of a bone or other once living organism would need to be reduced by about 11,500 years.

The RATE project, a group of young-earth creationists exploring the possibility that accelerated nuclear decay in earth's early history could explain the evidence for large quantities of nuclear daughter products (Vardiman [18] and Vardiman, *et al.* [19]), has begun to collect evidence that nuclear processes were, in fact, accelerated for periods of time in the historical past. This acceleration of nuclear processes doesn't appear to be limited to events on the earth, but may have been caused by cosmological effects which are universal in their extent. Such causes would likely have produced many changes, including process rates in the sun. Humphreys [7] suggests that these changes would be consistent with a greater solar intensity during these periods.

2. Greater Distance from the Sun

Humphreys [7] has also suggested that the same cosmological effects could possibly have affected gravity. If, for example, the gravitational constant were halved, the orbit of the earth around the Sun would be twice as large as before and the solar constant would be one fourth as much. In other words, the solar constant would have been 25% of today's value before such a change in the cosmological constants. These hypotheses must be explored further before any significance should be placed on these conjectures, but at least the possibilities are consistent.

3. Solar Radiation Captured *en route* to Earth

Suggestions have been made that early in earth's history a greater concentration of dust was present in intergalactic and interplanetary space (Zeilik [21], pp. 327-348). Depending upon the amount and size distribution of the dust particles present, a portion of the solar radiation coming to earth could have been captured and reradiated in all directions. A significant percentage of the solar radiation could have been prevented from reaching earth. If this dust was then removed, either slowly or in some catastrophic event, the percentage of solar radiation reaching the earth would have increased.

The mechanism by which the dust was removed could have been by simple planetary sweeping of the dust; removal by the Poynting-Robertson Effect, in which solar radiation produces a net force on the particles; or by movement of our solar system into a clear region of our galaxy. Of course, these considerations are normally suggested within an old universe, uniformitarian model of the origin of the solar system. Most of these considerations would not apply in a young universe, creationist framework unless there was some large scale, catastrophic process. We don't propose such a mechanism here.

4. Reflection from the Top of the Atmosphere

In the upper layers of the atmosphere the temperature is colder than 0°C and water vapor can freeze and form ice crystals. It is not sufficient that the temperature just be colder than 0°C, however. The vapor pressure must exceed the saturation vapor pressure, as well. If pure water vapor existed in the upper atmosphere, these conditions would be met, according to the modeling studies done by Rush [14]. When this condition was discovered he at first feared that any ice crystals formed would precipitate entirely through the vapor canopy to the base of the canopy and fall out of the canopy as rain, slowly depleting the water mass. However, upon closer investigation, it was found that below the upper layer of ice crystals, the canopy was not saturated, so that ice crystals falling from above would sublimate and replenish the upper canopy with vapor. The sublimating ice crystals below the cirrus layers cause this portion of the canopy to expand as the molecules change state from a solid to a gas. The water vapor is then forced to higher levels where it is again converted to ice crystals and precipitates out. A type of convection cell driven by phase changes recycles the upper portions of the canopy.

The upper-most ice crystal layers of the canopy would produce a reflective layer for solar radiation, preventing a portion of the incident radiation from entering the atmosphere. This reflection of solar radiation at the very top of the atmosphere would reduce the solar constant by some yet unknown factor. By reflecting this radiation at the top of the atmosphere it would not become involved in the complex absorption, scattering, and emission processes lower in the atmosphere. If this layer was thin, relatively little incident radiation from the Sun would be removed. However, if the layer was thick, permitting greater amounts to be removed, it would probably become less transparent for viewing of the Sun, Moon, and Stars from the ground. It is possible that the cirrus layer could also be “patchy” or “broken” giving intermittent visibility. The necessity for visibility to see the sun, moon, and stars before the Flood is required from Genesis 1:14-19.

For purposes of simulations reported in this paper, the solar extinction equation for cirrus developed by the National Oceanic and Atmospheric Administration and distributed by a commercial software company (Ontar [12]) was used. It calculates the extinction of solar radiation at 0.55 micron wavelength as:

$$CEXT = 0.14 CTHIK \quad \text{Eq. 1}$$

where *CEXT* is the extinction of solar radiation and *CTHIK* is the thickness of a cirrus cloud in kilometers. The optimum cooling for cirrus clouds in the canopy model occurred at a thickness of 4 kilometers at an extinction of just over 50%.

Further studies need to be conducted on the reflective, absorptive, and transmission properties from the top of thin cirrus clouds. It would be helpful to determine if thin layers of cirrus clouds can reflect large percentages of solar radiation while at the same time permitting planetary and stellar objects to be seen through them. Obviously, much more work needs to be done.

CONCLUSIONS

It appears then that if a more dynamic view of solar history is entertained, earth's climate may not only allow a thicker vapor canopy, but may require one. Evidence seems to exist that solar radiation was much less in the past. The radiation reaching the atmosphere may have been as little as 25% of today's value. A thicker vapor canopy and weaker solar radiation could have balanced the rates of incoming and outgoing radiation and produce equable surface temperatures. A thicker vapor canopy would probably reduce the solar radiation reaching the surface at short, ultraviolet wavelengths and increase the surface pressure. These effects would be expected to create healthier conditions on earth than exist today.

RECOMMENDATIONS

It is recommended that further climate simulations be conducted with thicker vapor canopies and smaller solar constants. Canopies of 100 to 1000 millibars should be explored for solar constants of 25% or less of today's value. Effects of such thick canopies and high cirrus decks on visibility should be checked to ensure that enough visible light reaches the ground to allow the sun, moon, and stars to be seen. The health benefits of reduced ultraviolet wavelengths and increased pressure on plants and animals should also be verified.

It would be useful if three dimensional global atmospheric general circulation models with a coupled ocean model were used to test the vapor canopy. This would be much more suitable for testing polar and equatorial effects of radiation effects and including the dynamics as well. Such models are now becoming available and sufficiently economical that creationists may soon be able to utilize them. The vapor canopy model is still alive and worth testing.

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