It should be noted that these frequency changes with speed are not doppler shifts. There are no doppler shifts in the laser speedometer. Even in the outside routing of the two laser beams from the laser to the output detector there is no doppler shift. That is because the distance between the laser output and the output detector is fixed. There is no doppler shift in a moving system when the distance between the source and receiver is fixed.

Summary

It has been shown from ordinary time and space physics that the laser gyro generates oscillatory frequencies, sustained by the gain supplied by the lasing process. Not one, but two oscillator frequencies develop when the device is in rotational motion with respect to the space medium. The frequency difference is proportional to the angular velocity. Frequency difference is converted to angular information, useful in navigation.

Of most importance in this paper is the theory of the two-mirror two-output laser speedometer. The same physics, as that in the laser gyro, yields two oscillatory frequencies in its laser cavity as it moves with constant velocity in the space medium. The resonance condition is standing waves with electric nodes at the mirrors between which are equal half-wavelengths. In both the laser gyro and laser speedometer the laser's frequency bandwidth is sufficient to provide the gain at both frequencies, and narrow enough to prevent extraneous resonance frequencies.

The present technology limits this speedometer to low speed. The problem is the limited frequency range of the readout detector. That is a matter of improving technology, not a limitation in the physics of the theory. If this speedometer's detection of constant velocity is verified by experiment, even at low speed, it will falsify Einstein's special theory of relativity.*

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*Dr. Barnes has stated that he would welcome criticism on the concept presented in this paper.

RADIATIVE EQUILIBRIUM IN AN ATMOSPHERE WITH LARGE WATER VAPOR CONCENTRATIONS*

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Abstract

Equilibrium temperatures are found for several hypothetical atmospheres with large water vapor concentrations (vapor pressure from 50 mb to 1013 mb) at stratospheric levels. Radiative equilibrium is computed using the Air Force radiation algorithm LOWTRAN 7 with no clouds or aerosols. The initial starting condition of an isothermal atmosphere at about -100°C warms to over +100°C at the base of the water vapor layer and becomes isothermal to the surface within 1 to 2 years. Temperatures are sufficiently warm to maintain large quantities of water in vapor form but are too hot for the surface to be habitable. The temperature and pressure in the highest levels are such that cirrus clouds will form. These clouds would reflect a large portion of incoming solar radiation, thereby likely altering atmospheric stability and surface temperature.

Introduction

Climate modelers have varied the concentration of carbon dioxide in order to explain the evidence for different climate regimes in the earth's past. However, few have seriously considered large water vapor concentrations at stratospheric levels. The idea that the atmosphere of the ancient earth may have been overlain by water in one phase or another was apparently first suggested, at least in modern times, by Vail (1965). For Vail, many water canopies existed throughout earth's long history. They resulted from out-gassing of the earth's interior, and their collapse over geologic time formed the oceans. The idea of a vapor canopy appealed to creationists, where it took root and began to be incorporated by them in models of earth history (Whitcomb and Morris, 1961). A water vapor canopy played an important part in their model. It continues to have a major role in many creationist models of the ancient earth (e.g. Dillow, 1982).

There is no direct support for the existence of a water vapor canopy surrounding the earth in the past. However, a survey of the solar system reveals that five of the nine planets, including the one closest to us in distance and size, Venus, have thick cloud canopies. An important effect of canopies in the solar system today is to moderate temperatures beneath them. Planets that do not have canopies show a much wider variance in temperature-diurnally, yearly, and latitudinally. Earth is characterized by a fairly large and permanent temperature gradient between its equator and poles. This temperature gradient produces a pressure gradient, which becomes the driving force behind

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weather systems of the planet. Nearly all climate modelers agree that at some time in the past the earth enjoyed a warmer, more uniform climate from pole to pole.

Possible Causes of a Warm Climate

In modeling the ancient earth, climate modelers usually assume that the total amount of water vapor in the atmosphere has not changed significantly in the past. That is, even though the mixing ratio today varies widely with location and time, the assumption is that the total amount of water vapor in the atmosphere has been essentially unchanging over very long periods of time. The amount of ozone, which has a fairly minor effect overall compared to others, has also been assumed constant. So, large amounts of carbon dioxide are normally introduced into their models (e.g. Hunt, 1984; Budyko et al., 1988, p. 3; Berner et al., 1983). Carbon dioxide is uniformly mixed throughout the atmosphere (unlike water vapor and ozone), and is assumed to have had a much higher concentration in the past. The excess carbon dioxide is now thought to be present in rocks of the crust.

This paper addresses another possible cause for a worldwide equable climate—a canopy of pure water vapor resting on top of today's atmosphere. The layer of water vapor is assumed to compress the atmosphere beneath and mix downward only by molecular diffusion. To prevent the water vapor from condensing, its radiative equilibrium temperature must be hot enough to produce a saturation vapor pressure greater than the total pressure due to the water vapor above. The expectation is that the temperature at the base of such a canopy is quite warm, producing extremely stable atmospheric conditions beneath. Concentrations of water vapor up to one atmosphere will be considered in the canopy.

A successful vapor canopy will meet two criteria:

- The canopy must be stable.
- The surface temperature must be hospitable to humans.

Development of the Model

A number of simplifying assumptions have been made:

- The problem is addressed in one dimension only. Two and three dimensional analyses, which involve meridional heat and mass transfer, in the atmosphere and preferably the oceans also, are much too complex for the first phase of this study. Such routines require expensive main-frame time, and in any case are extensions of a one-dimensional analysis.
- Radiation only will be considered. Other processes active in today's atmosphere are convection, diffusion, conduction, and latent heat release/gain. Of these, only convection and latent heat processes (besides radiation) noticeably modify the temperature profile in the stratosphere and below. However, the radiation calculation must be done first, and its shape will determine whether or not convection can take place. If convection is active, knowledge of water vapor content as a function of altitude may then be used to figure latent heat effects, which will further modify the temperature profile. The addition of these two effects is relatively simple, and could be added to this work if necessary.
- Calculations will be done for a clear sky, with no clouds and no aerosols.

The goal of this initial study is to obtain, purely radiative temperature profiles for various water vapor canopies covering today's atmosphere. The key element in this whole process is determining radiances. For nearly 20 years scientists at the U.S. Air Force Geophysical Laboratories (AFGL) have developed a public domain atmospheric radiance (and transmission) program called LOWTRAN. The present version, LOWTRAN 7, is dated 1989, and contains 18,000 source lines of Fortran code (Kneizys et al., 1988). The spectral data used is from the Laboratories and is generally considered the finest available anywhere. The program is capable of calculating atmospheric absorption and radiance for a wide range of absorber concentrations, pressures, and temperatures (Kneizys et al., 1983 and 1988). Its primary purpose is not for climate modeling as such, but since it gives radiances it may be used to calculate fluxes, and hence temperature profiles. A number of programs, totaling some 2200 Fortran lines, were written for this research to manage LOWTRAN 7 for the task.

The atmosphere is divided into 20 or more "atmospheric levels" of specified altitude, pressure, temperature, and absorber concentration. Pressure and absorber concentration at each level are constant, altitudes and temperatures vary with time. All radiance calculations are taken at constant pressure "flux levels," chosen so that each atmospheric level is exactly halfway between two flux levels. The region between two flux levels is called a layer. The cooling rate of a given layer is then:

$$\frac{dT}{dt} = \frac{g\Delta F}{C_P \Delta P} \tag{1}$$

where dT/dt is the rate of change in temperature of the layer, g is the acceleration due to gravity, C_p is heat capacity at constant pressure, and ΔP is the pressure change across the layer. The heating (cooling) rate is then converted to a new atmospheric level temperature by the equation,

$$T_{n+1} = T_n + \frac{dT}{dt}\Delta t \tag{2}$$

where T_n is the temperature at the nth iteration, and Δt is the time interval. The process is then repeated as often as needed until pre-set criteria for equilibrium are met. For more detail on development of the canopy model see Rush (1990).

Initial Canopy Conditions and Testing

Model runs for today's atmosphere and four different canopies were carried to completion. Water vapor amounts in the canopies were 10, 50, 125, and 1013 millibars. Unless otherwise noted, characteristics of the atmosphere and other assumptions were similar to Manabe and Möller (1961) and Manabe and Strickler (1964), hereinafter called MS. The atmosphere beneath the canopy differed only slightly from the U.S. Standard Atmosphere. The solar zenith angle was set at 60°, the day fraction at 0.5, and the latitude at 35°N. This approximates average conditions on the earth. A surface albedo of 0.13 was used (Barron et al., 1981), a value midway between today's values of 0.08-0.20 in humid regions (Laval and Picon, 1986). It happens that the ocean albedo at a solar zenith angle of 60° is also 0.13 (Ramanathan et al., 1989). This is somewhat less than today's average surface albedo for the earth (including polar regions) of 0.14-0.18 (Ramanathan and Coakley, 1978).

The day of the year is 109, a day in mid-April, a time of average earth-sun distance. This gives an average value for the solar constant. Spectral intervals used unless otherwise noted: Solar direct — 3500-40000 cm^{-1} (2.86-0.25μm^{-1}) $d\nu = 20\ cm^{-1}$; Scattering — 8000-40000 cm^{-1} (1.25-0.25µm-1) $d\nu = 1000\ cm^{-1}$; Longwave — 20-3500 cm^{-1} (500-2.86μm^{-1}) $d\nu = 20\ cm^{-1}$. Longwave fluxes were calculated by the formula $F = pI$. Shortwave scattering fluxes were calculated by numerical integration of radiances over the hemisphere. Shortwave directly transmitted flux is obtained straight from LOWTRAN 7. It was not necessary to calculate each of the solar fluxes at every iteration, as they are only slightly temperature dependent. New solar fluxes were obtained only once every 30 iterations, or less often as equilibrium was approached, saving much computer time.

The model run for today's atmosphere showed very close agreement with MS, which is widely used for calibration yet today (Liou, 1980). Our profile was typically colder than MS below 10 km and warmer above. Our surface temperature was 320 K, in good agreement with modern values.

Discussion of 50 mb Canopy results

The 50 mb canopy model run will be described in some detail and the other results summarized. 50 mb of water vapor is equivalent to 20 inches of precipitable water. Figure 1 shows radiative equilibrium approached from a cold isothermal beginning point of 170 K. The top of each line represents the "top" of the canopy. Thus at Day 0, the atmosphere canopy is cold and low. By Day 10, the surface is already heated to 296 K, and lower layers of the atmosphere are also rapidly heating. This is due to the intense solar radiation that has been absorbed by the ground and reemitted as infrared, where it is readily absorbed by the relatively high water content of the lower layers. The middle layers are relatively low in water vapor and ozone (carbon dioxide has the same mixing ratio everywhere) and so they tend to be transparent to both shortwave and longwave. The upper layers constitute the stratosphere in today's atmosphere and therefore are low in water vapor and high in ozone. They are heated by absorption of solar ultraviolet.

The discontinuity at about 18 km in Day 10 represents the top of the atmosphere and base of the canopy. Note that the great majority of the mass of the atmosphere-canopy is below 18 km. The lower portion of the canopy is heated primarily by absorption of longwave from the ground, but also somewhat by solar absorption. From 18 km (pressure = 50 mb) to about 52 km (pressure = 1 mb) the canopy cools as longwave radiation is emitted to space. The top cools so well that it is several months before it again attains its starting point of 170 K. However, additional months of heating do not have much effect, and it ends at

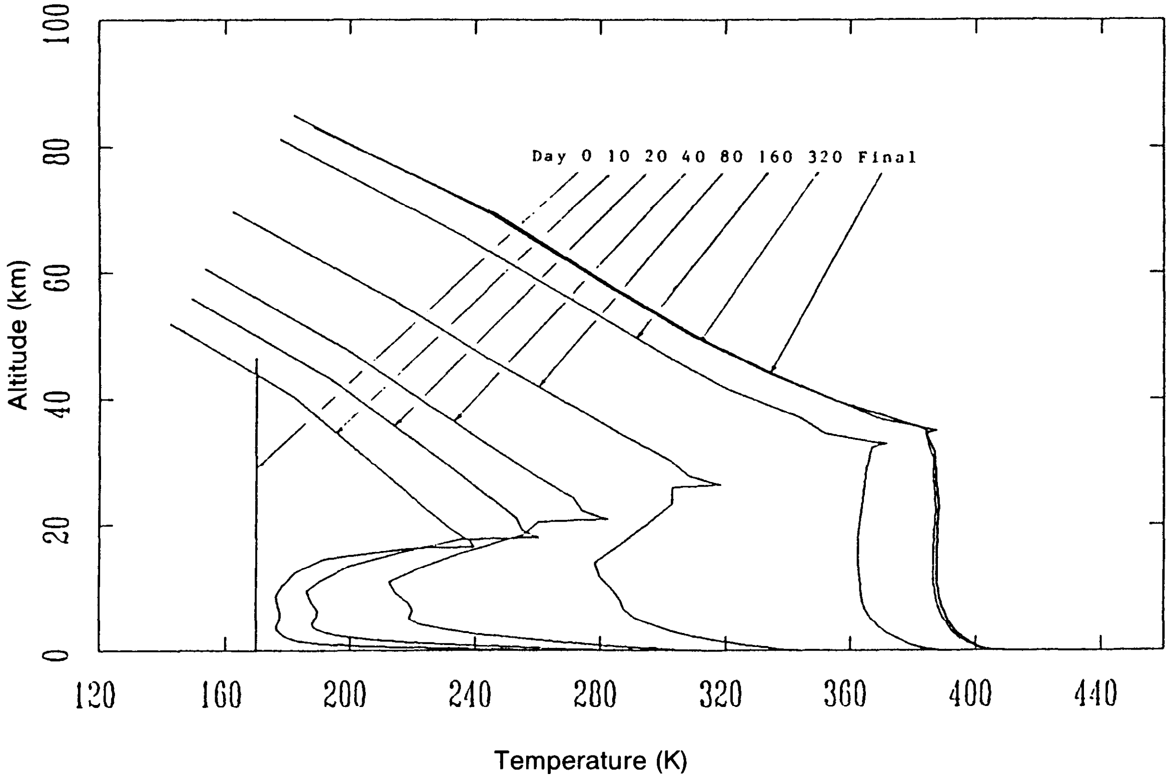

Figure 1. Vertical temperature profiles of a 50 mb canopy above today's atmosphere starting from an isothermal 170 K condition approaching equilibrium.

only 189 K, or -84°C. Since the water vapor pressure at the top of the canopy is much higher than the saturation vapor pressure at 189 K (2 x 10^{-5} mb), the vapor will turn to ice. At the next level, this is also true. The vapor pressure is 4.615 mb, the saturation pressure (at 246 K) only 0.27 mb, and the vapor will also tend to become ice. At the next level down however, the vapor pressure is 11.597 mb, the saturation pressure (at 284 K) is 13 mb, and the vapor will remain in the vapor form. At all lower levels of the canopy the vapor pressure is lower than the saturation pressure and the water will be in the vapor phase. A temperature of 387 K at the base of the canopy (50 mb) guarantees the vapor phase. In the final profile, the canopy base has risen to 35 km and the top (1.279 mb) to 83 km.

The critical lapse rate for water vapor, if we assume no phase change, is the adiabatic lapse rate, which is 5.3 deg/km. If the observed lapse rate exceeds this, convection will occur as hotter, less dense gas tends to rise and colder, more dense gas tends to sink. If the observed lapse rate is less than the critical one, there is no tendency to overturn and the canopy is stable. The lapse rate in the lowest canopy layer between 48 and 50 mb is 9.6 deg/km. Therefore, convection will begin. The next layer also shows a tendency to convect. Beyond this, all higher layers have a lapse rate less than 5.3 deg/km, and will be stable.

The situation is similar to that of the atmosphere today, where unstable lower layers often send mass and heat up into higher, stable layers. The model does not contain any convective adjustment, so the very thin layer of instability near the bottom of the canopy will dissipate quickly in a real atmosphere where layers are allowed to release the instability. The thick stable layer above will cap any minor adjustments at the bottom of the canopy.

The topmost layers of the canopy involve a phase change, so their critical lapse rate will be different from the adiabatic one. The atmosphere itself is nearly isothermal down to the lower layers, which show slightly higher temperatures. Only in the lowest two (thin) layers is the critical (adiabatic) lapse rate of 10 deg/km for "air" exceeded. There will be a slight convective transport of heat from the surface into the first several hundred meters. This will lower the surface temperature by a degree or two, and raise the temperature just above by a corresponding amount. Overall, the atmosphere will be quite stable. At the surface, the initial rapid heating has slowed so much that the final six months see a rise of only one degree, to 409 K, or 35 degrees above the boiling point of water at 1063 mb.

Figure 2 shows the heat balance of the earth at equilibrium and transmission values for the infrared, all for the 50 mb canopy. Of 100 units of incoming solar, 19 units are absorbed by water vapor in the canopy, (all absorption values include a small amount due to absorption of reflected [outgoing] solar) 8 additional units (of the 100) are absorbed by the atmosphere, and 5 units reflected by the atmosphere-canopy to space. That leaves 68 units that reach the surface, most transmitted directly but some scattered. 8 units are reflected at the surface, contributing to the total planetary albedo of 13 units, and leaving 60 units absorbed by the earth. These 60 units are then re-emitted as longwave radiation. Actually, because of the very high surface temperature 478 units total are emitted by the surface, but 418 of these have been received as longwave from the canopy and atmo-

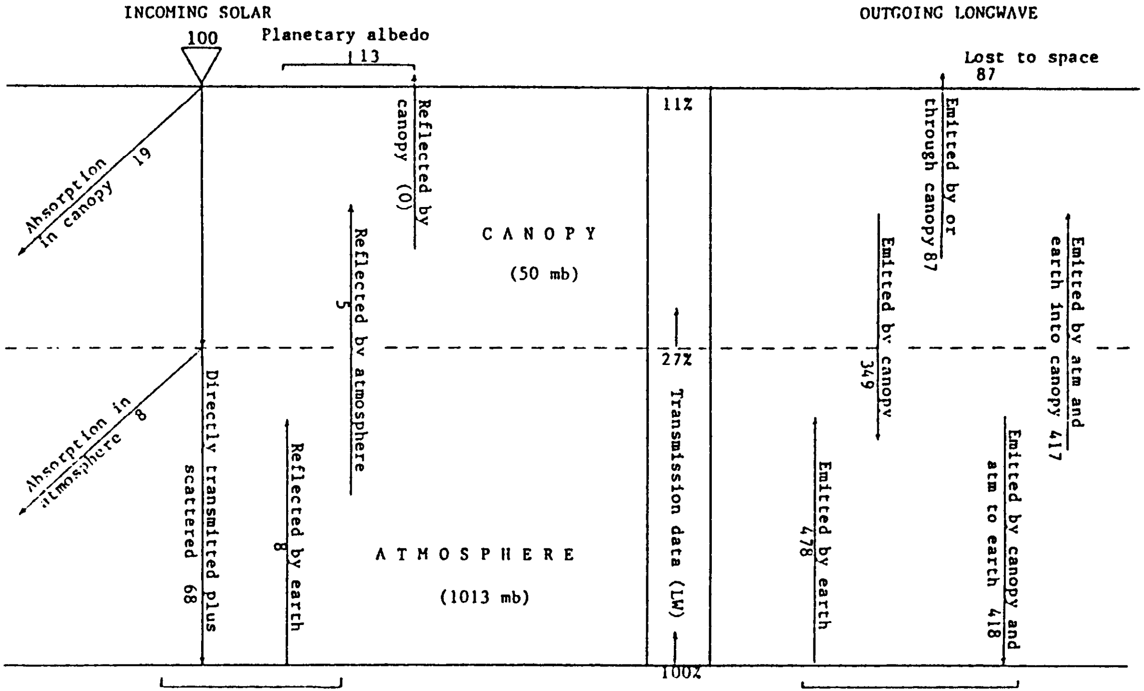

Figure 2. The heat balance of the earth-atmosphere-canopy system for a 50 mb canopy over today's atmosphere. The left portion of the diagram shows the flux of short-wave radiation, the right portion the flux of long-wave radiation, and the middle portion the transmission of long-wave radiation upward to space. The canopy is above the dashed line and the atmosphere is below the dashed line.

sphere, for a net infrared loss of 60. This balances the net solar gain of 60.

An infrared energy balance of the atmosphere shows 478 units of terrestrial radiation, 349 units of infrared from the canopy entering, 418 units leaving to the ground, and 417 leaving for the canopy, for a net infrared cooling of 8 units. This balances the solar absorption of 8 units. A balance on the canopy shows it receiving 417 units from below, losing 349 units downward, and 87 upward to space. This is a net infrared cooling of 19 units, which balances the solar absorption of 19 units.

Overall, the 87 longwave units emitted to space plus the 13 shortwave units reflected to space account for the original 100 units received from the sun. It is readily apparent that the canopy is very effective at trapping the earth's radiation. Without the windows to space that exist today, temperatures build until the canopy's emission to space finally equals the net incoming solar. To be more precise, the windows are not totally closed with the 50 mb canopy. Also shown in Figure 2 are transmission data. These percentages show the amount of surface longwave radiation that arrives unimpeded at the canopy base (27%) and at the canopy top (11%). Without the canopy, 27% of the terrestrial radiation would escape straight to space, but only 11% does. This difference may at first seem small, but it means that the entire earth-atmosphere-canopy system must heat to the point where it radiates enough extra energy to space to make the difference.

In conclusion, only 50 mb of water vapor added above the present atmosphere would raise the surface temperature as determined by a radiation balance from 320 K to 409 K. A better comparison is to include convection effects. Convection lowered the MS ground temperature in today's atmosphere (less clouds) from a pure radiational 332 K to 300 K, much closer to the observed 288 K. As mentioned in discussion earlier, convection in the atmosphere under the 50 mb canopy would probably lower the surface temperature only a degree or two. So it seems that addition of only 50 mb of water vapor above the present atmosphere would raise the surface temperature more than 100 degrees.

Kasting and Ackerman (1986) added 10 *bars* of CO_2 and obtained a surface temperature of only 400 K, including convection effects, at present solar luminosity. Truly, the water molecule has an amazing ability to absorb radiation. The contrast with CO_2 is all the more marked when it is seen that a large part of the Kasting and Ackerman "CO_2 caused" temperature increase is actually caused by water vapor from increased oceanic and lake evaporation. In the 50 mb canopy, there certainly would be increased tropospheric water content from evaporation, but it has not been considered.

Discussion of Other Canopy Results

Vertical temperature profiles for canopies with 10, 125, and 1013 mb of water vapor show similar distributions as the 50 mb canopy but hotter for thicker canopies and cooler for the thinner canopy. Figure 3 shows the surface temperature as a function of the mass of the canopy. As the mass of the canopy is slowly increased from zero, the surface temperature rapidly increases. At a canopy mass of 125 mb, the longwave windows to space are nearly closed, and additional water vapor has little marginal effect. At 1013 mb (1 atm), the windows are totally closed. No longwave terrestrial radiation escapes straight to space.

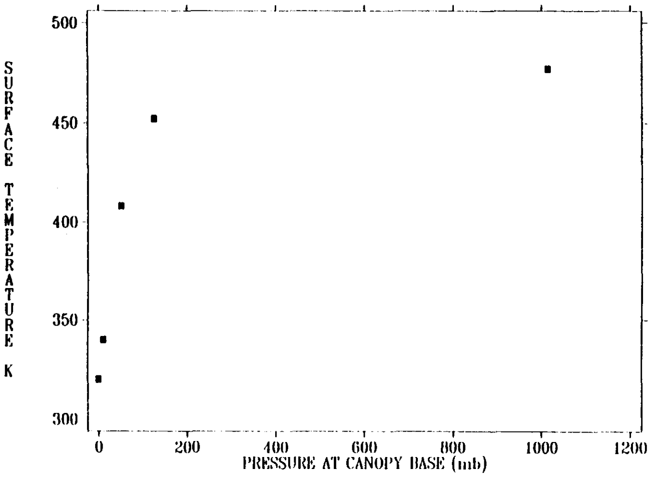

Figure 3. Radiative equilibrium surface temperature as a function of mass of the overlying canopy.

Surface temperatures are directly related to the mass of the canopy and produce too warm a surface temperature to be hospitable for life under pure radiative equilibrium for all canopies studied. However, for the 10 mb case inclusion of convection would noticeably decrease the surface temperature, perhaps into the suitable 300-310 K range. In each case the temperature at the top of the canopy is below freezing. The cold temperature causes the saturation vapor pressure to fall below the ambient pressure, producing a cirrus cloud layer. Near the surface of the earth and at the base of the canopy, thin layers are convectively unstable, based on the temperature lapse rate.

Conclusions

It was stated earlier in this paper that two criteria for the vapor canopy would need to be met: 1) Stability, and 2) A surface temperature suitable for habitation. The first criterion was met. For any size canopy considered, at least from radiation analyses of pure water vapor canopies, it was shown that the temperature is always sufficienty high throughout most of the canopy, particularly at the base, to easily ensure the vapor phase. The second criterion is not as straightforward to evaluate. Radiation considerations strongly suggest surface temperatures are not suitable for the 50, 125, and 1013 mb canopies. The greenhouse effect of the canopy is simply so effective that the surface temperature becomes inhospitable. This could also be true for the 10 mb canopy, though convection considerations may alter this conclusion. Inclusion of convection in the denser canopies would not change this verdict.

It does seem reasonable to suppose that somewhere between 0 and 50 mb there exists a value that would lead to a successful canopy. Remarkably, this is the same conclusion reached by Kofahl (1977) with his "sliderule estimates." He suggested a total water vapor content in the atmosphere-canopy of six inches, or five inches (12 mb) more than the atmosphere alone.

Morton (1979) was apparently the first to conclude that the canopy would have made the earth's surface too hot for human habitation (Kofahl did not calculate surface temperatures). Morton made a number of assumptions that greatly simplified the problem, and his surface temperatures are much higher than ours, but the general conclusion is the same: Life as we know it would not have been possible under a canopy of 1013 mb (1 atm), nor even with a canopy of only 50 mb.

When other features such as clouds are added to the model, this conclusion could be modified greatly, however. Preliminary explorations with cloud layers at the top of the 50 mb canopy have shown significant radiation effects which lower the surface temperature drastically. Unfortunately, while the surface temperature decreases when clouds are added, so does the temperature of the canopy, reducing its stability.

Recommendations*

Numerous improvements in this model need to be made including convection, latitudinal transport of heat, and inclusion of aerosols and other minor gases. However, the first effort should be to determine the effect of cirrus cloud layers near the top of the water vapor layer.

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*Editor's Note: Readers may be interested in a recent Quarterly paper on the vapor canopy. Walters, T. W. 1991. Thermodynamic analysis of a condensing vapor canopy. *CRSQ* 28:122-131.

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My colleague at *National Review,* Joseph Sobran, however, has assayed the task, and in conclusion I would like to draw upon his words in one of his recent essays.

The liberal, he writes, possesses an "integral world view" that

> sees man as an animal; an animal whose destiny is a life of pleasure and comfort. Those who view things in this light tend to believe that this destiny can be achieved by means of enlightened governmental direction in removing (and discrediting) old taboos, and in establishing a new economic order wherein wealth will be distributed more evenly. It is interesting to note that they describe such a redistribution as being "more equitable," because that suggests [note: the environmental thesis again] that they ascribe inequalities of wealth to differences in circumstances rather than ambition, intelligence, fortitude, or any of the myriad other moral virtues that may lead to fortune. . . .
>
> It is interesting to note, too. . . . that they never deride or censure human behavior as "bestial" or "animal," because they see man himself as an animal in essence, and cannot be indignant about behavior proper to an animal. They are indigant about suffering, which is to say animal suffering—pain, hunger, physical discomfort—and the frustration of animal appetites in general. . . .
>
> This is a morally passive view of man. . . . The middle-class virtues are assumed to blossom spontaneously under the right material conditions; progress comes inevitably, so long as there are not reactionaries "impeding" it. . . . Although [this view] asserts the obligation of those who are well off to share their abundance with the "less fortunate," they can never make demands of the less fortunate themselves. . . . It is characteristic of them to invoke the poor early in any public discussion. . . . As James Burnham has penetratingly put it, the liberal feels himself morally disarmed before anyone he regards as less well off than himself. . . . If pleasure is man's destiny, it is his right. Nobody should have to endure hardship, even if he brings it on himself. Parenthood, when it comes unlooked for, is cruel and unusual punishment, and people who fornicate no more deserve to be assigned its duties than a man who kills somebody deserves to be hanged.

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