THE DRY MASSIVE MODEL OF THE ATMOSPHERE OF VENUS AND THE MICROWAVE PHASE EFFECT

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If water droplets or dust make no large contribution to the microwave opacity of the Venus atmosphere, and the lapse rate is approximately adiabatic, pressure induced absorption in a 50% CO_2 atmosphere requires a ground pressure of about 60 atm to fit the passive radio observations[1]. The heat capacity of such an atmosphere is so large that only slight cooling ($\approx 3^{\circ}K$) occurs during the 60 day night of Venus. A proponent of the dry, massive model must then incline to one of two views concerning the microwave phase effect.

(1) He can question its reality, since it is a small change in intensity superimposed on the very large variation of the same periodicity produced by the planet's varying distance, and the measurements are thus fraught with possible systematic errors. The history of the phase effect at λ = 8mm encourages this point of view[2],[3], but on the other hand, the repeatability of the λ = 10cm phase effect observed by Drake[4] over two synodic periods discourages it.

(2) He can attribute it to a convective boundary layer. It is well known that on windless summer days the lapse rate in the lowest meter of the atmosphere can approach 10^3 times the adiabatic, and that the diurnal temperature variation at the ground ($\approx 30^{o}K$) is at such times much greater than the diurnal temperature change averaged over all altitudes in the troposphere--a number constrained to less than $1^{o}K$ by the heat capacity of the atmosphere. An observer with a radiotelescope who studied the diurnal temperature variation of the earth's surface, and mistakenly assumed that the troposphere shared this variation, would calculate a mass for the atmosphere which would be low by one to two orders of magnitude.

Of course, on Venus we cannot suppose an inversion to exist at night near the ground since the mean infrared opacity of the atmosphere must be at least 100 for the Greenhouse mechanism. A schematic illustration of the situation I am proposing is instead shown in the Figure. Let us suppose that in view of the large atmospheric heat capacity and small Coriolis force even a gentle general circulation is effective in maintaining a temperature profile above the boundry layer which is independent of latitude or longitude, and that the entire burden of explaining the phase effect falls on the boundary layer. Also, assume that the polar axis on Venus is perpendicular to the orbital plane. Without more knowledge than we now possess of the nature of thermal convection and the general circulation on Venus we cannot be very specific about the thickness of this boundary layer. If the flow is laminar at the ground, however, and characteristic horizontal lengths relating to convection are at all comparable on Venus and the Earth, dimensional analysis indicates that the thickness of the boundary layer scales as $\rho^{-\frac{1}{2}} v^{-\frac{1}{2}}$, where ρ is the density, and v is the characteristic velocity above the boundry. There are thus some grounds for suspecting that the thickness of the boundary layer on Venus is comparable to that on earth, and is in any case less than 1 meter. The important point is that if the lower scale height has a mean infrared opacity of the order of 10^2 due to the resonant and induced transitions of CO_2 and N_2--a number which I estimated several years ago, and which Solomon and Danielson now also find from a more precise calculation, using all the laboratory data on induced processes--then the boundary layer is still optically thin in the infrared.

Radiative transfer in this event sets an upper limit to the possible temperature drop ΔT across the boundary layer at the subsolar point. Making the most charitable assumption, that all the sunlight not reflected by the clouds finds its way to the ground, this limit is

$$\Delta T \leq (T_c/T_p)^3 T_c \approx 30^{\circ}K \quad (1)$$

where $T_c \approx 250^{\circ}K$ is the infrared, or cloudtop, temperature, and $T_p \approx 500^{\circ}K$ is the atmospheric temperature just above the boundary layer, also in our model the ground temperature at the poles.

If the microwave skin depth δ_m at $\lambda = 10cm$ is small with respect to the thermal skin depth δ_t, a radiotelescope such as Drake's would see a difference in brightness temperature T_B between the sub and antisolar points, but none between the antisolar point and the poles. On the other hand, if δ_m is appreciable with respect to δ_t--the case shown in the Figure and a quite likely case for dry, sandy material--then T_B (subsolar) > T_B (antisolar) > T_B (polar) as shown. This is the correct sequence of brightness temperatures indicated by the 10cm phase effect, and the 10cm interferometry of Clark and Kuz'min[5], but it is clear that the inequality (1) does not allow a spread at all comparable to the values found by these authors.

REFERENCES

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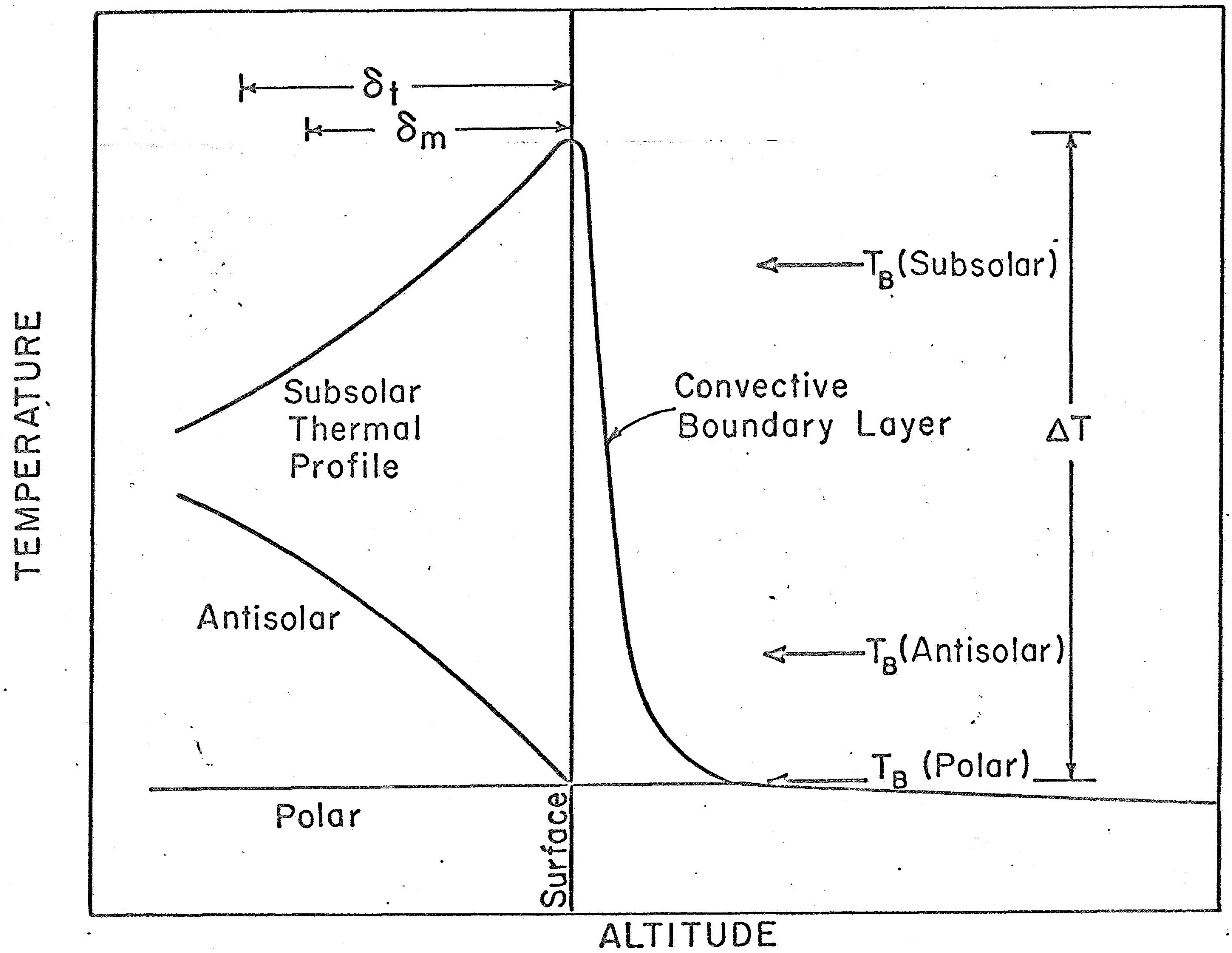
FIGURE CAPTION

Schematic illustration of the temperature profiles in the thermal and convective boundary layers.



δ_t
δ_m
T_B(Subsolar)
Subsolar Thermal Profile
Convective Boundary Layer
ΔT
Antisolar
T_B(Antisolar)
T_B (Polar)
Polar
Surface
TEMPERATURE
ALTITUDE