
Inverse Climate Modelling Study of the Planet Venus

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Abstract: The terrestrial planet Venus is classified by astronomers as an inferior planet because it is located closer to the Sun than the Earth. Venus orbits the Sun at a mean distance of 108.21 Million Km and receives an average annual solar irradiance of 2601.3 W/m², which is 1.911 times that of the Earth. A set of linked forward and inverse climate modelling studies were undertaken to determine whether a process of atmospheric energy retention and recycling could be established by a mechanism of energy partition between the solid illuminated surface and an overlying fully transparent, non-greenhouse gas atmosphere. Further, that this atmospheric process could then be used to account for the observed discrepancy between the average annual solar insolation flux and the surface tropospheric average annual temperature for Venus. Using a geometric climate model with a globular shape that preserves the key fundamental property of an illuminated globe, namely the presence on its surface of the dual environments of both a lit and an unlit hemisphere; we established that the internal energy flux within our climate model is constrained by a process of energy partition at the surface interface between the illuminated ground and the overlying air. The dual environment model we have designed permits the exploration and verification of the fundamental role that the atmospheric processes of thermal conduction and convection have in establishing and maintaining surface thermal enhancement within the troposphere of this terrestrial planet. We believe that the duality of energy partition ratio between the lit and unlit hemispheres applied to the model, fully accounts for the extreme atmospheric “greenhouse effect” of the planet Venus. We show that it is the meteorological process of air mass movement and energy recycling through the mechanism of convection and atmospheric advection, associated with the latitudinal hemisphere encompassing Hadley Cell that accounts for the planet’s observed enhanced atmospheric surface warming. Using our model, we explore the form, nature and geological timing of the climatic transition that turned Venus from a paleo water world into a high-temperature, high-pressure carbon dioxide world.

Keywords: Atmospheric Dynamics, Venus Atmosphere, Geophysics, Terrestrial Planets

1. Introduction: The Planet Venus

Venus the *asteres planetai* or “star that wanders” of ancient Greek astronomy is one of the four terrestrial planets in our solar system, and is the one that is closest in distance and most similar in form to the Earth. In terms of its atmosphere however the planet Venus has a set of characteristics that are distinct from those of our home world. Unlike the Earth, Venus is a veiled world with a high albedo atmosphere of 0.77 [1]. This makes it the brightest of the observable planets, it is also a slowly rotating planet where the day is longer than its year, and consequently Venus is a spherical orb that has no rotation induced equatorial bulge [2]. The

slow daily rotation rate means that on Venus the atmosphere does not experience any significant Coriolis force [3]. Therefore, there are no latitudinal constraints on atmospheric motion [4]. Mariner 10 ultraviolet images of Venus obtained by NASA in 1974 (Figure 1) show the structure of the upper atmospheric circulation as a pair of latitudinal hemisphere-encompassing Hadley cells, each linked to a descending polar vortex at the respective pole of rotation [5]. Unlike Earth the atmosphere of Venus has a surface pressure of 92 bars, a surface temperature of 737 K (464°C) and an atmospheric composition of 96.5% by volume of carbon dioxide, with nitrogen gas as the other significant component (3.5%) [1]. The diurnal surface temperature range on Venus is circa 0.1 K [6]. This lack of a diurnal surface temperature

contrast forms one of the key elements that must be addressed in the establishment of a climate model for Venus.

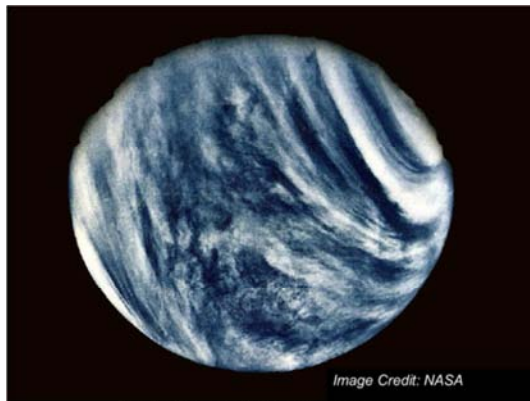


Figure 1. NASA 1974 Mariner 10's Portrait of Venus.

1.1. The Science of Climate

A planetary climate consists of a dynamic mobile-fluid mass-transport and energy delivery system, organised in the form of closed loops, or cells, that advects mass and energy over the surface of a terrestrial planet. The mobile-fluid transport system collects energy from a region of net incoming energy surplus in the tropics, and delivers it to a region of net energy deficit towards the poles. At the location of energy deficit, the energy imported by the climate system is then lost to space by thermal radiation from the planet. As with any mass transport system it must form a closed loop, otherwise all of the energy necessary for the dynamic flow will be dissipated and the system will run down. Indeed, if too much energy is lost from the cell at the region of energy deficit, then the transport mechanism will cease as the mobile fluid freezes solid, and the planet remains with only a tenuous atmosphere, as is observed for the dwarf planet Pluto [7]. Consequently, it is a fundamental requirement that sufficient energy is retained by the mobile fluid, for it to return to the original location of incoming energy surplus. On its return to this origin, the mobile fluid is then able to gain additional energy and the mass transport system becomes recharged. This interception of additional solar energy by the planet's surface rewarms the mobile-fluid, and so the cycle that comprises the mass-transport and energy delivery circulation system continue and repeats indefinitely, and is a sustainable system (Figure 1).

1.2. The Forward Climate Model

The process of Forward Modelling creates a numerical prediction that must be matched and verified against external data for the model to be both valid and useful. The modelling process starts with the concept that "Everything Should Be Made as Simple as Possible, But Not Simpler" [8]. This statement is a derivation of Occam's razor and the modelling process consist of four phases; Analysis, Design, Construction and Implementation. With the identification of the irreducible set of fundamental principles established by

analysis, these can next be used to state a set of axioms from which a system can be designed. Then the mathematical algorithm that combines these elements can be constructed, and the resulting numerical output created by implementation of the model. With forward modelling studies of a planet's energy budget, the first and overarching assumption is that the only way that a planet can lose energy is by thermal radiation from the planetary body to space. For a planet with a stable atmospheric mass this assumption is not in dispute, and it leads to the adoption of the Stefan-Boltzmann (S-B) equation of thermal radiation, which is used to establish the direct relationship between energy flux in Watts per square metre (W/m^2) and the absolute thermal temperature of the emission surface in Kelvin (K). The second critical assumption made in the analysis of a planet's energy budget, is that it receives incoming thermal energy in the form of radiation from a single source. Solar system planets orbit around this central source of sunlight, and consequently all planets have both a lit (day) and a dark (night) hemisphere. The presence of the dark night in a climate model is a fundamental requirement; its absence from the standard concept as exemplified by the divide by 4 reduction of solar power intensity, shows that the standard model has gone a step too far in its reduction analysis, and all models based on this over simplification should be discarded.

A technique for establishing the energy budget of a planet, and hence how the power being consumed is distributed within its climate system, is a technical challenge that has already been addressed by astronomy. An equation was required that could be used to compute the average surface temperature of any planet, by establishing its thermal emission temperature under a given solar radiation loading. To solve this problem, a set of modelling assumptions were made that included the following simplifications:

1. That the planet being observed maintained a constant average surface temperature over a suitably long period of time.
2. To make this assumption valid, the total quantity of solar energy intercepted by the planet is averaged out over its annual year.
3. This annual averaging therefore removes the effect of distance variation from the Sun, inherent for the trajectory of any planet's elliptical orbit.

Next the complex problem of how a planetary globe intercepts solar energy, and how this sunlight energy is distributed over the planet's surface, was addressed. Planets contain the following geometric features in common:

1. They are spherical globes.
2. They are only lit on one side from a sun that is located at a focus of their orbit's ellipse.
3. They typically have a daily rotation rate that is significantly faster than their annual orbital period.
4. They commonly have an obliquity or axial tilt, although each planet's angle of tilt is unique.

Given the above list of distinct features, it is clear that the computation for the surface capture of solar energy on an orbiting, rotating, axially tilted planet is a complex

mathematical calculation. To address this complexity the following simplification was applied:

That all planets intercept solar energy at their orbital distance as if they are a disk with a cross-sectional area that is equal to the planet's radius (i.e. πR^2). However, due to daily rotation and seasonal tilt, planets emit surface radiation from all parts of their surface over the course of each year.

Therefore, the total surface area of the planet that emits thermal radiation to space is four times the surface area of its intercepting disk (i.e. $4\pi R^2$). It is this geometric fact that is responsible for the "divide by 4" rule that is contained within the calculation of planetary radiative thermal balance.

Having devised a simplified way of calculating the amount of energy that the total surface of an orbiting, rotating, axially tilted planet would receive during the course of its year, we now move to the next stage of the calculation. Namely, the computation of the annual average surface temperature associated with this energy flux.

Table 1. The Expected Surface Temperature for an Airless Venus compared with its actual Atmospheric Temperature [9].

Parameter	Symbol	Venus	Units	Dimensions
Solar Constant at distance a	S	2601.3	W/m ²	MT ⁻³
Radius of Body	R	6,051,800	m	L
Bond Albedo	A	0.77	Constant	Constant A
Stefan-Boltzmann Constant	σ	5.67E-08	W/m ² /K ⁴	MT ⁻³ K ⁻⁴
Effective surface emissivity	ϵ	1	Constant	Constant ϵ
Expected T _e	T _e	227	Kelvin	K
Greenhouse Effect	GE	510	Kelvin	K
Expected T _s	T _s	737	Kelvin	K
Distance from the Sun	a	1.0821E+11	m	L

Clearly both the equation and the parameters applied to the Venus calculation were valid. So, the discrepancy must lie in a previously unknown effect, the greenhouse effect, that needs to be invoked to explain the difference between model computations and actuality [10]. It is by this means that the concept of back-radiation, caused by the presence of greenhouse gases blocking the transmission of outgoing radiant energy, was devised [11]. Greenhouse gases are those polyatomic molecular gases, present in the atmosphere, which intercept and then re-emit thermal radiation by molecular vibration and flexure of their covalent bonds. Greenhouse gases consequently reduce atmospheric thermal radiant opacity. This reduction in atmospheric opacity then leads to the concept of back-radiation. Back-radiation is the hypothetical mechanism by which thermal energy is retained in the atmosphere, and the surface temperature of the planet is consequently enhanced. This process of surface heating by back-radiation is the currently accepted paradigm in Climate Science [11].

1.3. The Radiative Feed-back Climate Forward Model

Lying at the heart of the modern Climate Model is the concept of thermal back-radiation, a feed-back loop caused by atmospheric opacity, that leads to enhanced surface heating. The hypothesis states that thermal energy leaving the planet's surface for space is intercepted by greenhouse gases in a terrestrial planet's atmosphere. This trapped energy is

To achieve this we use the Stefan-Boltzmann law to determine the absolute temperature in Kelvin (K), associated with the average radiative energy flux in Watts per square metre (W/m²) of the planet's emitting surface.

$$j^* = \sigma T^4 \quad (1)$$

Where j^* is the black body radiant emittance in Watts per square metre; σ is the Stefan-Boltzmann constant of proportionality, and T is the absolute thermodynamic temperature raised to the power of 4. The equation that encapsulates this analysis is the Vacuum Planet equation [9]. However, when we apply this logic to calculate the average surface temperature of the planet Venus, then the parameters appropriate for Venus at its average orbital distance from the Sun do not produced the expected answer of 464°C (737 K). Instead the equation produces a value of minus 46.4°C (226.6 K), some 510°C too low. (Table 1).

then re-emitted by the atmosphere, with half of the energy leaving directly to space, and half returning to the surface. At the surface, the returned and halved flow of energy is then re-sent upwards and once again trapped by the greenhouse gases. As before, this intercepted energy is re-emitted, with half of a half leaving directly to space and half of a half returning to warm the surface. This loop repeats endlessly, but with less and less energy being retained for each repeat of the cycle.

Therefore, this feed-back loop is an endless sum of halves of halves. It has the mathematical form of a geometric series, and is a sum of the descending fractions in the power sequence 2^{-n} , where minus n is a continuous sequence of natural numbers ranging from zero to infinity.

$$1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \dots + 2^{-n} = 2 \quad (2)$$

Equation 2 describes the cumulative effect of the feed-back loop (after an infinite series of additions), where for each turn of the cycle, half the ascending radiation is passed out to space and lost, and the other half is returned back to warm the ground surface and then be re-emitted. It is a feature of this form of an infinite series that the sum of the series is not itself an infinite number, but in this case, the limit is the finite natural number 2.

When the concept of energy feedback by back-radiation is used to model planetary climate the parameters appropriate for Venus do not compute the surface atmospheric temperature of this alien world (Table 2).

Table 2. Venus Atmospheric Modelling Parameters.

Venusian Energy Budget Items [1]	Power Intensity Watts/m ²	S-B Sigma	Kelvin	Celsius	Comments
Planetary Disk Beam Interception	2601.3	5.67E-08	462.8	189.8	Top of the Atmosphere (TOA)
Venus Bond albedo	0.77				Planetary Brightness (Bypass filter)
Bond albedo Filter Applied	598.3	5.67E-08	320.5	47.5	Absorbed by the Planet
Lit Hemisphere Intensity Dilution (Divide by 2 rule)	299.15	5.67E-08	269.5	-3.5	Averaged over the surface area of the lit hemisphere
Total Incoming Absorption "Divide by 4" Rule Applied	149.6	5.67E-08	226.6	-46.4	Vacuum Planet Equilibrium Temperature. Distributed over the full Globe
Venusian Surface Flux Target	16728.3	5.67E-08	737	464	Actual Surface Temperature
Surface Power Flux Deficit	16578.8		510	510	Required Thermal Enhancement
Balanced Outgoing Radiation	149.6	5.67E-08	226.6	-46.4	Top of Atmosphere Emission Temperature

By invoking the action of back-radiation the current climate paradigm enhances the action of a weak “divide by 4” solar power intensity, and attributes the observed surface atmospheric temperature to the presence of greenhouse gases [10]. In this paper we attribute the atmospheric greenhouse effect to a process of energy retention by mass motion of air within a gravity field and not to a process of radiative feedback. Consequently, our model can be applied to all atmospheric types including single composition atmospheres of pure nitrogen gas, and the model can also be applied to all planetary bodies, including those that are tidally locked with a permanently dark hemisphere that receives no direct solar radiant energy.

2. Methods: The Dynamic-Atmosphere Energy-Transport (DAET) Forward Model

The Dynamic-Atmosphere Energy-Transport Model of Planetary Climate, presented here, is a 2-dimensional climate model that preserves the dual hemisphere component of planetary illumination (Figure 2). This new forward model represents a planetary globe with two environmentally distinct halves. A dayside lit by a continuous incoming stream of solar energy which creates an energy surplus, and a nightside that is dark and has an ongoing energy deficit, due to the continuous exit to space of thermal radiant energy. Consequently, a mobile fluid atmosphere that transports energy from the day to the night side is the fundamental requirement of our climate model.

2.1. The Climate System of “Noonworld”; a Hypothetical Captured Rotation Planet

On all rotating terrestrial planets, the solid ground cools by thermal radiation to space all of the time (both day and night), but the surface only gains radiant energy during the hours of sunlight throughout the day. The current climate paradigm claims that it is the effect of daily rotation and seasonal axial tilt that distributes the energy intercepted from the sun over the full surface area of a planet. In order to remove the complications associated with planetary rotation, and the impact that rapid daily rotation has on global atmospheric cell

circulation patterns; we will assume that the model world presented here is tidally locked in its orbit around the Sun, and so the Coriolis Effect on air motion is minimised [3]. We will call this hypothetical solar system planet “Noonworld”, and like the Moon is to the Earth, for Noonworld the same face is always presented towards the Sun. Consequently, one hemisphere is permanently warmed and the other hemisphere is in cold perpetual darkness. Therefore, on Noonworld all surface energy distribution must be conducted by atmospheric motion, both vertical convection and horizontal advection, rather than by daily planetary rotation.

In order to study the processes of energy transmission within the model climate system of Noonworld, we have made a number of simplifications. The primary one is that the planetary atmosphere of the model contains no greenhouse gases. The model has a free-flowing atmosphere of pure Nitrogen gas that connects the two hemispheres. Consequently, because the model atmosphere is fully transparent, it can only gain or lose energy from the solid surface at its base.

2.2. Designing the Dynamic-Atmosphere Energy-Transport (DAET) Engine

Unlike the radiative feed-back loop of the standard climate model (Equation 2) which does not discriminate between day and night, with a tidally locked planet there is no possibility of daily rotation being invoked as a mechanism for solid surface energy distribution. We have on Noonworld two distinct and separate radiation environments; the lit day hemisphere and the dark night hemisphere, and all energy distribution between these two environments must be achieved by the mobility of the atmosphere. To model the energy flows within and between the two hemispheres we require two separate geometric series of energy recycling that tend to different limits, one series for the lit hemisphere and one for the unlit dark side.

The geometric series limit for the lit side energy loss to space is:

$$\frac{1}{2} + \frac{1}{8} + \frac{1}{32} + \frac{1}{128} \dots + 2^{-n(\text{odd})} = 2/3 \quad (3)$$

While the geometric series limit for the dark side energy loss to space is:

$$\frac{1}{4} + \frac{1}{16} + \frac{1}{64} + \frac{1}{256} \dots + 2^{-n(\text{even})} = 1/3 \quad (4)$$

Note that the aggregate sum for the limits of both series is:
 $2/3+1/3=1$
 and so, the total energy recycling system is in radiative balance (Table 3).

We can consider that the consequence of this process of

infinite recycling is the formation and maintenance of a dynamic machine made of air. This machine is a planet's atmospheric Hadley Cell, a thermal and mass motion entity formed as the result of the cyclical movement of air (Table 3).

Table 3. The Dynamic-Atmosphere Energy-Transport Engine running with diabatic (equipartition) of energy at the system surface boundary.

Step	Action	Energy Flow (Units)
1	Interception of solar energy by the lit surface	1
2	Return flow of cold air from the dark side	1/3
3	Total Lit hemisphere energy available to drive the system	4/3
4	50% _{Surface} : 50% _{Air} partition of the intercepted energy between the ground and the air leading to: -	Lit side Partition
5	Direct radiant loss to space from the warm surface	2/3
6	Retention of energy by the lit air, followed by transport and delivery of this warm air to the dark side	2/3
7	50% _{Surface} : 50% _{Air} partition of the delivered energy between the ground and the air leading to: -	Dark side Partition
8	Radiant loss to space from the ground on the dark side	1/3
9	Return flow of cold surface air from the dark side to the lit side	1/3
10	Total Planetary Radiant Emission to Space	1
11	Total Global Energy Budget (Sum of both hemispheres)	2

2.3. Building the Dynamic-Atmosphere Energy-Transport (DAET) Engine

Table 3 forms the basic design structure of an Excel worksheet that can be used to create a forward model to study planetary climate. Within the Excel program both geometric series can be formulated to run as a paired sequence of interacting cascades. The program takes the output of one calculation on one side of the model and uses this as the input to the calculation on the other side, thereby

mimicking the cyclical transfer of energy between day and night. A key feature of the Excel program is the option to embed a specific single variable within a continuous cascade of calculations that form an iterative loop. The system cascade can be constructed to run to any required level of precision, and is stopped when this precision level is achieved. Table 4 record the results of applying the diabatic (equipartition) model of Noonworld to Venus using standard Venusian parameters [1].

Table 4. Diabatic Model of Venus showing Internal Energy Recycling with Equipartition of Energy for Both Hemispheres.

Diabatic Model Partition Test 50% _{Surface} : 50% _{Air} Venus Insolation Parameters							
Cycle Number	Space Incoming Radiation (W/m ²)	Lit Ground Received Energy (W/m ²)	Lit Hemisphere 50% Thermal Radiation Loss to Space (W/m ²)	Lit Hemisphere 50% Export to Dark Side (W/m ²)	Dark Hemisphere 50% Thermal Radiation Loss to Space (W/m ²)	Dark Hemisphere 50% Surface Return Loop to Lit Side (W/m ²)	Space Outgoing Radiation Balance (W/m ²)
Diabatic Equipartition Ratio			50.00%	50.00%	50.00%	50.00%	
0	299.1495						
1	299.1495	299.1495	149.5748	149.5748	74.7874	74.7874	224.362
2	299.1495	373.9369	186.9684	186.9684	93.4842	93.4842	280.453
3	299.1495	392.6337	196.3169	196.3169	98.1584	98.1584	294.475
4	299.1495	397.3079	198.6540	198.6540	99.3270	99.3270	297.981
10	299.1495	398.8656	199.4328	199.4328	99.7164	99.7164	299.149
11	299.1495	398.8659	199.4330	199.4330	99.7165	99.7165	299.149
12	299.1495	398.8660	199.4330	199.4330	99.7165	99.7165	299.149
13	299.1495	398.8660	199.4330	199.4330	99.7165	99.7165	299.149
14	299.15	398.87	199.43	199.43	99.72	99.72	299.15
S-B	5.67E-08	5.67E-08	5.67E-08	5.67E-08	5.67E-08	5.67E-08	5.67E-08
Kelvin	269.5	289.6	243.5	243.5	204.8	204.8	269.5
Celsius	-3.5	16.6	-29.5	-29.5	-68.2	-68.2	-3.5
	Statistic	Mean Exit Temp	Mean Air Temp	Lit-side	Dark-side	Global	
		Kelvin	224.2	224.2	W/m ²	W/m ²	
		Celsius	-48.8	-48.8	398.87	199.43	598.30
	Thermal Enhancement (Celsius)	Atmospheric Response		Lapse rate	Top of Atmosphere (TOA)		
				K/Km	Delta K	Km	
		Lit Hemisphere		7.843	46.1	5.9	
		Dark Hemisphere		7.843	38.7	4.9	

The purpose of the diabatic model is to replicate the principle mechanical aspects of an atmospheric cell, which we believe is the fundamental base unit of planetary climate.

On Venus there are two hemisphere encompassing Hadley circulation cells that reach from the planet's equator to its poles. These Hadley Cells are dynamic systems that transport

air and energy across the planet from the tropical regions of energy surplus to the polar regions of energy deficit, and then return to endlessly repeat this cyclical process of energy transport. (Figure 2).

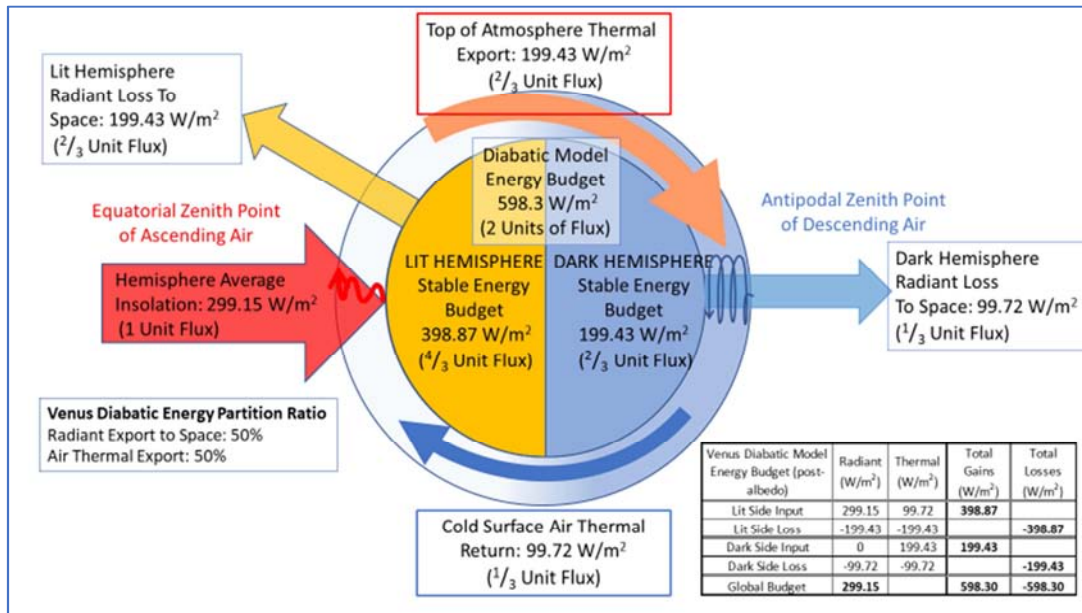


Figure 2. Stable Diabatic Advection Model of Venus: Showing Energy Vectors and Total Energy Distributions.

It is important to understanding the process of energy retention and thermal enhancement by the climate system, that the planetary Bond albedo, though critical in establishing the average annual energy influx received by the climate system, acts primarily as an external filter. The model presented here is studying the process of internal energy retention, that is independent of the rate of energy supply. The climate system is inherently leaky, it is by slowing down the leaks, by internal energy recycling within the atmosphere, that the system is able to retain energy. In studying the process of energy retention, the supply of energy as determined by the albedo, is a given.

Converting the energy values recorded in Figure 2 into temperatures in Kelvin by using the S-B equation shows that the lit side air temperature is 243.5 Kelvin (-29.5°C), while

the dark side air temperature is 204.8 Kelvin (-68.2°C) which means that the global modelled average surface temperature is 224.2 Kelvin (-48.8°C) (Table 4). The forward modelling study shows that the global atmospheric recycling system, while redistributing energy from the lit to the dark hemisphere, also stores and retains an additional 100% of the solar influx within the atmosphere (Figure 2). The system however has not retained sufficient energy to raise the Global Air Temperature to the expected Venusian surface temperature value of 737 Kelvin (464°C) (Table 2).

Thus far the diabatic modelling process of atmospheric energy recycling has only achieved a global average temperature of 224.2K (minus 48.8°C) for the planet Venus and so the model is clearly not applicable to the reality of the planet's surface temperature conditions (Table 5).

Table 5. Stable Energy Values for a Diabatic Model of Venus achieved by Global Air recycling using a 50%_{surface}: 50%_{air} flux partition at the Air to Ground interface.

Process	Power Intensity W/m ²	Thermodynamic Temperature	Temperature (Celsius)	Comments
Incoming Captured Radiation	299.150	269.5	-3.5	Venus Surface post-albedo Lit Hemisphere Power Intensity
Lit Ground Received Energy	398.866	289.6	16.6	Solar and recycled thermal power intensity combined
Lit Ground Partition	199.433	243.5	-29.5	Direct through the atmosphere surface radiant loss to Space
Lit Air Partition	199.433	243.5	-29.5	Lit Air Thermal export to Dark side
Dark Ground Partition	99.716	204.8	-68.2	Direct through the atmosphere surface radiant loss to Space
Dark Air Partition	99.716	204.8	-68.2	Darkside Surface Air Thermal return to Lit side
Space Outgoing Radiation Balance	299.149	269.5	-3.5	Balanced Sum of Radiant losses
Total Global Energy Budget	598.299	320.5	47.5	Sum of all 4 components
Diabatic Model Average Global Air Temperature	149.575	224.2	-48.8	Mean of Warm Daytime and Cold Night-time air temperatures
Vacuum Planet Equation	149.575	226.6	-46.4	Assumes an even global distribution of power intensity

However, our model has closely repeated the results of applying the Vacuum Planet equation to Venusian planetary data, and this replication of the standard equation is consistent over a wide range of insolation loadings (Table 6).

Table 6. The relationship between the Diabatic Model and the Vacuum Planet Equation for the Planet Venus at various values of Bond Albedo.

Bond Albedo	Post Albedo Power Intensity (W/m ²)	Vacuum Planet Expected Te (Kelvin)	Lit Hemisphere Diabatic Equation (W/m ²)	Diabatic Model Global Temperature (Kelvin)	Temperature Difference (Kelvin)
0	650.33	327.3	1300.65	323.7	3.57
0.065	608.05	321.8	1216.11	318.3	3.51
0.165	543.02	312.8	1086.04	309.4	3.41
0.265	477.99	303.0	955.98	299.7	3.30
0.365	412.96	292.1	825.91	288.9	3.18
0.465	347.92	279.9	695.85	276.8	3.05
0.565	282.89	265.8	565.78	262.9	2.90
0.665	217.86	249.0	435.72	246.3	2.71
0.77	149.57	226.6	299.15	224.2	2.47
0.865	87.79	198.4	175.59	196.2	2.16
0.965	22.76	141.5	45.52	140.0	1.54
0.999	0.650	58.2	1.30	57.6	0.63

The stability of this relationship is shown graphically in Figure 3.

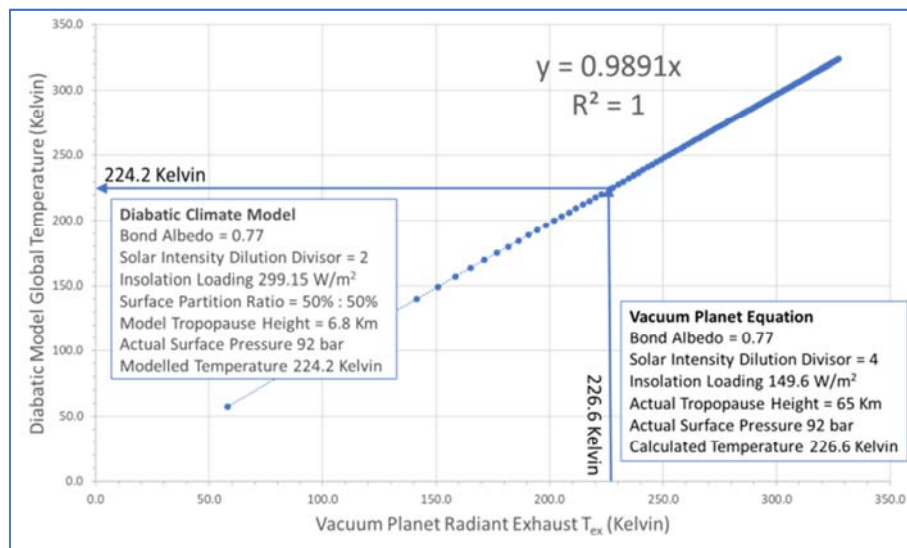


Figure 3. The Relationship between the Diabatic Climate Model Surface Temperature (Meteorology) and the Vacuum Planet Equation Top of Atmosphere Radiant Exhaust Temperature (Astronomy).

2.4. Applying Meteorological Principles to the Dynamic-Atmosphere Energy-Transport Climate Model

We have now established the following important facts about modelling planetary climate on terrestrial globes:

1. That a model which uses the properties of a fully transparent mobile-fluid atmosphere can replicate the average thermal emission temperature of a rotating globe, as calculated by using the canonical Vacuum Planet equation.
2. That this model with a fully transparent atmosphere both retains and recycles solar energy, and achieves a stable energy flow across the planet's surface even when the planet is tidally locked.
3. That the stable limit of the energy flow within the system is set by the partition ratio of energy between the radiant loss directly to space of the emitting surface, and the quantity of energy retained and recycled by the air.

We have also established that by using forward modelling techniques to apply an energy partition ratio of 50% surface

radiant loss to space, and 50% thermal retention by the air; (hereafter 50%_S: 50%_A); the average global air temperature of the DAET climate model is approximately minus 49°C (224 Kelvin); a value that is very significantly below the measured average surface air temperature of the planet Venus of 464°C (737 Kelvin) (Table 1).

The canonical radiative climate model envisages a process of atmospheric radiative feed-back by greenhouse gases. It is a key feature of this process of radiative greenhouse gas feed-back that it must apply equally to both the day time and night-time hemispheres. Consequently, the energy partition ratio, by which energy is distributed between the ground surface and the air above it, is the same for both night and day. The standard model implicitly assumes that thermal equilibrium is achieved and maintained across this critical system boundary, and hence a 50%_S: 50%_A energy partition ratio is applied for this fundamental interface.

Convection is a fluid movement buoyancy process that takes place in the presence of a gravity field. When warmed at its base air becomes less dense and more buoyant; because

of gravity the air rises away from the source of warmth at the surface, to be replaced by cooler air, either arriving from the side (surface advection) or from above (convection overturning). The more energy put in to the warming side the faster the mobile fluid system cycles between hot and cold, in effect the process of convection “steals” energy from the ground. In a dynamic mobile convecting atmosphere a 50%_S: 50%_A thermal equilibrium energy partition ratio is only rarely ever achieved; so, the partition of energy on the lit side must always be in favour of the air (conduction loss) and not the ground surface (radiation loss). Consequently, a lit surface thermal equilibrium ratio of 50%_S: 50%_A should not as a general rule be expected or applied.

3. Creating an Adiabatic Climate Model of the Planet Venus

A key and fundamental difference in the dynamics between the twin planets Earth and Venus is that our world is a rapidly rotating planet with 365.25 days per annual orbital

cycle, whereas on Venus, its day lasts longer than its year [1]. Modelling studies have demonstrated that the latitudinal reach of a planet’s Hadley Cell is inextricably linked to its daily rotation rate [4, 12]. Slowly rotating Venus does not have a mechanical Ferrel Cell in its atmosphere, and consequently each hemisphere of the planet is dominated by a single Hadley Cell that takes buoyant heated equatorial air directly to the polar vortex, where it can descend back to the planetary surface. (Figure 1).

Direct observations of the atmosphere of Venus have established that its surface temperature is 737 Kelvin (464°C) [13]. Also, that both the lit and dark hemispheres of the planet have approximately the same temperature [1]. Consequently, only one unique energy partition ratio needs to be established by inverse modelling to explain this equivalence of diurnal temperatures. The “Goal Seek” Inverse Modelling Tool was run on the Excel algorithm cascade for the Venus diabatic model (Table 4), and the energy partition ratio required to reach a surface temperature of 737 Kelvin (464°C) was identified (Table 7).

Table 7. The Identification by the Process of Inverse Modelling of the Required Partition Ratio for the Atmosphere of Venus.

Step	Action	Energy Flow
1	Interception of solar energy by the lit surface	1 unit.
2	Return flow of air from the dark side	55.671 units
3	Total energy available to drive the system	56.671 units
4	0.886% _S : 99.114% _A partition of the intercepted energy between the ground and the air leading to: -	Lit side Partition
5	Direct radiant loss to space from the lit surface	0.502 unit
6	Retention of energy by the lit air, followed by transport and delivery of this energy to the dark side	56.169 units
7	0.886% _S : 99.114% _A partition of the delivered energy between the ground and the air leading to: -	Dark side Partition
8	Radiant loss to space from the ground on the dark side	0.498 unit
9	Return flow of surface air from the dark side to the lit side	55.671 units

The process of inverse modelling was applied to the DAET forward model of climate, by constructing a cascade algorithm of sufficient length that allowed the initial unknown energy partition ratio of the lit hemisphere to be determined by using the Excel Inverse Modelling Tool called “Goal Seek”. It was established that the inverse modelling

process needs a partition ratio of 0.8862%_S: 99.1138%_A to achieve the observed 737 Kelvin (464°C) surface temperature of Venus, and that for the average planetary insolation loading of 299.15 W/m² the model required a cascade of 1,136 cycles (Figure 4) to achieve a stable thermal outcome to a precision of 6 decimal places (Table 8).

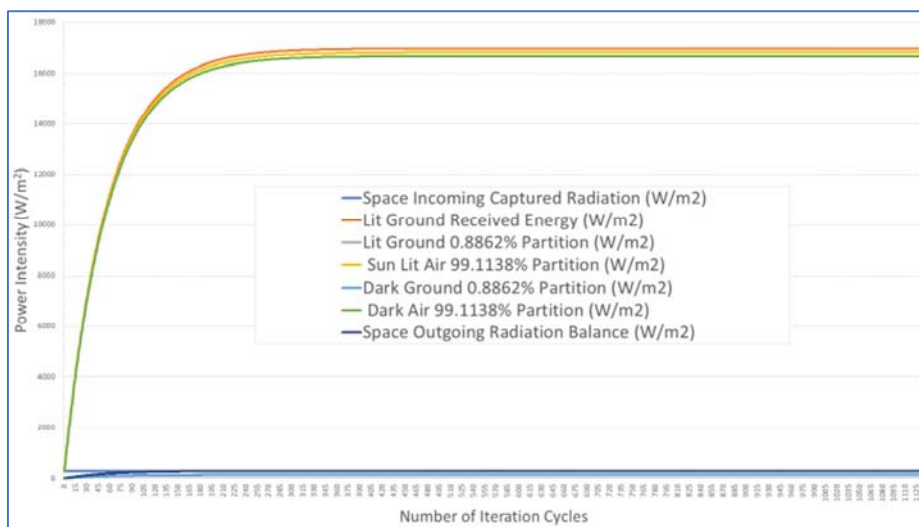


Figure 4. Inverse Modelling Energy Partition Test 0.886%_S: 99.114%_A using Venus Insolation Parameters.

Table 8. Adiabatic Climate Model of Venus.

Venus Insolation Adiabatic Model Partition Parameters 0.886% Loss: 99.114% Retained							
Cycle	Space Incoming Radiation (W/m ²)	Lit Ground Received Energy (W/m ²)	Lit Ground Partition is 0.8862% (W/m ²)	Lit Air Partition is 99.1138% (W/m ²)	Dark Ground Partition is 0.8862% (W/m ²)	Dark Air Partition is 99.1138% (W/m ²)	Space Outgoing Radiation Balance (W/m ²)
0	299.1495						
1	299.1495	299.1495	2.651090867	296.4984091	2.627596652	293.8708125	5.27868752
2	299.1495	593.0203	5.255401512	587.764911	5.208827652	582.5560833	10.4642292
3	299.1495	881.7055833	7.813757401	873.8918259	7.744511152	866.1473148	15.5582686
4	299.1495	1165.296815	10.32696944	1154.969845	10.23545087	1144.734394	20.5624203
5	299.1495	1443.883894	12.79583421	1431.08806	12.68243633	1418.405624	25.4782705
1132	299.1495	16953.15793	150.2404723	16802.91746	148.9090272	16654.00843	299.149499
1133	299.1495	16953.15793	150.2404723	16802.91746	148.9090272	16654.00843	299.149499
1134	299.1495	16953.15793	150.2404723	16802.91746	148.9090272	16654.00843	299.149499
1135	299.1495	16953.15793	150.2404723	16802.91746	148.9090272	16654.00843	299.149499
1136	299.14950	16953.15793	150.2404723	16802.91746	148.9090272	16654.00843	299.1495
S-B	5.67E-08	5.67E-08	5.67E-08	5.67E-08	5.67E-08	5.67E-08	5.67E-08
Kelvin	269.5	739.5	226.9	737.8	226.4	736.2	269.5
Celsius	-3.5	466.5	-46.1	464.8	-46.6	463.2	-3.5
Statistic		Mean Exit Temp	Mean Air Temp	Lit-side	Dark-side	Global	
Kelvin		226.6	737.0	W/m ²	W/m ²	W/m ²	
Celsius		-46.4	464.0	16654.01	16802.92	33456.93	
Thermal Enhancement (Celsius)		Atmospheric Response		Lapse rate K/Km	Top of Atmosphere (TOA) Delta K	Km	
510.4		Lit Hemisphere		7.843	512.6	65.4	
		Dark Hemisphere		7.843	511.4	65.2	

The final stable adiabatic DAET climate model output achieved by the dynamic recycling of air and energy generates a total global energy budget for Venus of 33,756 W/m² (Figure 5).

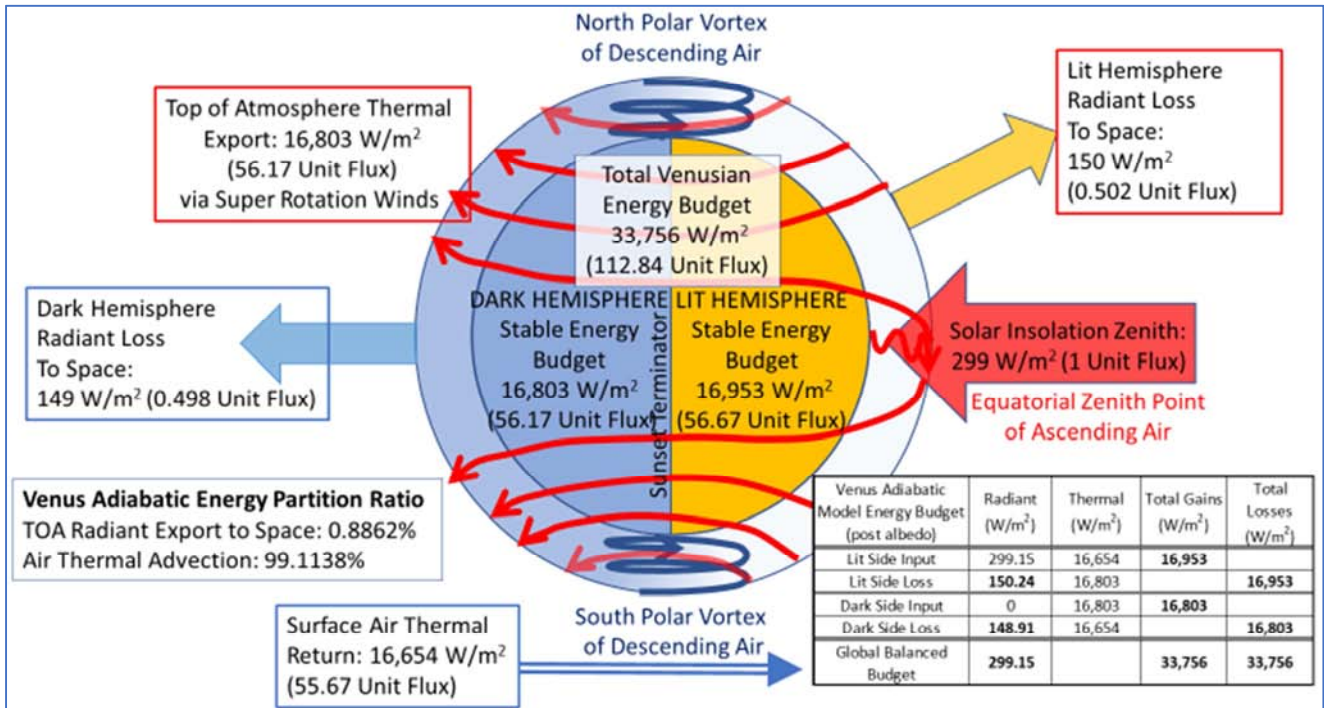


Figure 5. Adiabatic Climate Model of Venus: showing Energy Vectors and Final Energy Distributions.

The surface thermal results of the inverse modelling run of the Adiabatic Climate model of Venus are shown in Table 9.

Table 9. Stable Energy Values for Venus achieved by Global Air Recycling using a 0.8662%_s: 99.1138%_a Flux Partition.

Step	Process	Energy Flow (Units)	Power Intensity Flux (W/m ²)	Thermodynamic Temperature (Kelvin)	Temperature (Celsius)	Comments
1	Interception of solar energy by the lit surface	1	299	269.5	-3.5	Venus post-albedo Lit Hemisphere Power Intensity
2/9	Return flow of colder air from the dark side	55.671401	16,654	736.2	463.2	Dark Air Thermal return to Lit side
3	Total energy available to drive the system	56.671401	16,953	739.5	466.5	Solar and recycled thermal combined
4	Lit side partition: 0.886% _{Surface} : 99.114% _{Air} partition of the intercepted energy between the ground and the air leading to:					
5	Direct radiant loss to space from the lit side	0.502225	150	226.9	-46.1	Direct radiant loss to Space
6	Retention of energy by the lit air, followed by transport and delivery of this warm air to the dark side	56.169176	16,803	737.8	464.8	Lit Air Thermal export to Dark side
7	Darkside partition: 0.886% _{Surface} : 99.114% _{Air} partition of the delivered energy between the ground and the air leading to:					
8	Radiant loss to space from the dark side	0.497775	149	226.4	-46.6	Direct radiant loss to Space
9/2	Return flow of colder air from the dark side	55.671401	16,654	736.2	463.2	Dark Air Thermal return to Lit side
10	Total Planetary Radiant Emission to Space	1	299	269.5	-3.5	Space Outgoing Radiation Balance
11	Total Global Energy Budget (Sum of both hemispheres)	112.840577	33,756	737.0	464.0	Average Global Air Temperature: Mean of Daytime and Night-time airs

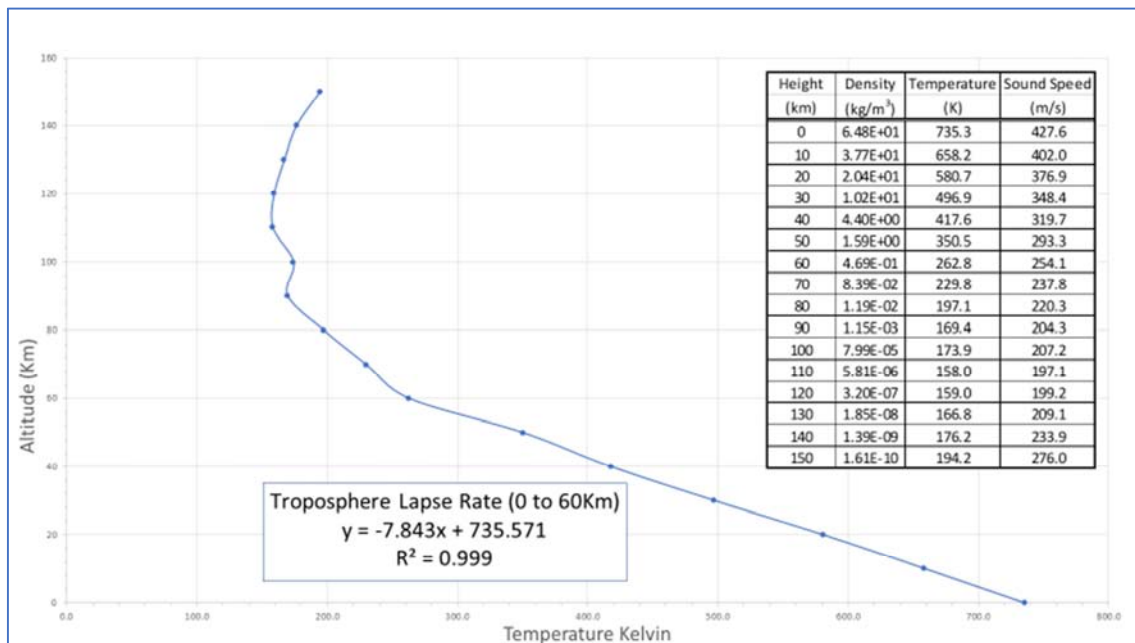


Figure 6. Venusian Atmosphere: Temperature versus Altitude.

4. Exploring the Results of the Adiabatic Convection Model that Creates the Venusian Greenhouse World

The results of the inverse modelling process, that was applied to the DAET forward model of climate created in Section 2, and applied in Section 3 with the aim of establishing a Venusian Greenhouse World, have

demonstrated that it is eminently feasible to achieve energy retention, and thermal atmospheric enhancement within a climate system that does not contain any greenhouse gases. The key insight gained from this analysis is that it is energy partition in favour of the air, at the lit surface boundary that achieves this energy boost within a dynamic atmosphere; and that the greenhouse effect is a direct result of the standard meteorological process of convection. Put simply energy retention by surface conduction and buoyancy driven convection wins over energy loss by radiation, and that the

retention of energy by the air is a critical feature of planetary atmospheric thermal cell dynamics.

The Dynamic-Atmosphere Energy-Transport (DAET) Model has its limitations, as does every model. The most critical limitation with the DAET model of Venus is that the model was populated by a fully radiatively transparent, non-greenhouse gas atmosphere. Consequently, all radiative loss to space in the model takes place from the ground surface at the base of the atmosphere. On Venus we have a thermally opaque atmosphere and radiative energy loss to space takes place at the planetary emission zone which is located near the tropopause [14]. If we now apply to our model an opaque atmosphere that can only emit radiation to space from its upper boundary, or Top of Atmosphere (TOA) altitude, in common understanding this would be a greenhouse gas atmosphere that heats the surface by back-radiation.

The DAET climate model however partitions the power intensity flux between two modes of action, radiant energy loss to space and thermal energy retention by the air. These two modes of energy propagation have different rates of flux and consequently different S-B thermodynamic temperatures. It is a completely unexpected property of the adiabatic climate model that the difference in S-B temperature between the two modes of energy loss, when combined with the measured atmospheric lapse rate of the Venusian troposphere generate a credible estimate of the spatial separation between the planetary surface, where radiant insolation occurs, and the tropopause, where radiant emission to space is concentrated.

By using a calculated adiabatic lapse rate of 7.84 K/Km for Venus derived from published data [15]. We can estimate the thickness of the opaque Venusian atmosphere at its TOA altitude. Its topside surface will be emitting energy to space at a point where the lapse rate achieves the same temperature in air, as our model radiant ground surface maintained under the original fully-transparent model atmosphere (Figure 6).

The results of this computation show that the thermal emitting TOA zone will be at an altitude of 65.4 Km for the lit side and 65.2 Km for the dark side (Table 8). However, we do not need to invoke any back-radiation energy retention process for such an atmosphere [16]. Its radiant opacity merely acts as a delaying mechanism to the transmission of radiant energy, rather than a feed-back amplifier.

4.1. Results of Inverse Climate Modelling Applied to the Venusian Atmosphere

The DAET inverse modelling process applied to the atmosphere of the planet Venus produces the following results: -

1. That the process of energy retention and thermal warming of the planet Venus can be achieved by using an energy partition ratio weighted ~99.1% in favour of the air for a fully transparent, no greenhouse gas atmosphere (Table 8).
2. That the total Venusian energy budget is 33,756 W/m² (Figure 5), and that this retained energy is almost 122 times the amount of energy intercepted by the Venusian

planetary disk (after accounting for the reduction in solar intensity to 299 W/m² because of albedo by-pass losses).

3. That this total Venusian planetary energy budget of 33,756 W/m² maintains the surface temperature of the planet at 737 Kelvin (464°C) (Table 9).
4. That the adiabatic climate model of Venus predicts a surface diurnal temperature contrast of 1.7 Kelvin (739.5-737.8) and a TOA diurnal temperature contrast of 0.5 Kelvin (226.9-226.4) (Table 8).
5. That by applying a troposphere lapse rate of 7.84 K/Km to the Venusian atmosphere [15]. The thermal separation between the surface air temperature, and the temperature of the radiant emitting surface can be achieved for an opaque atmosphere at an altitude of ~65 Km (Table 8).
6. That the modelled thermal emission temperature for the Venusian atmosphere of the lit hemisphere is 226.9 Kelvin (-46.1°C) and that this temperature closely corresponds to a temperature cusp of -43°C in the freezing point curve for concentrated sulphuric acid at 69% by weight [17]. Solid particles are efficient radiators of thermal energy and so our modelling study suggests a causal link between the bright sulphur veil albedo of Venus and its atmospheric thickness.
7. The requirement for a tropopause at a temperature that allows for the formation of solid particles of a planet's main condensing volatile, which for Venus is sulphuric acid, indicates that planetary Bond Albedo is an interlinked consequence of atmospheric mass and thermal profile [18]. Consequently, Bond Albedo is an emergent property and not a cause of a planet's atmospheric thermal profile, because the freezing point requirement to form solid particles of a condensing volatile specifically determines the planet's TOA thermal emission temperature.
8. The Dynamic-Atmosphere Energy Retention model of Venus, with its extremely large energy retention by the air, provides a possible meteorological explanation for the high wind velocities of over 400 Km/hour observed in the upper atmosphere of Venus [19].

4.2. Assessment of the Inverse Climate Modelling Results

The novel feature of our DAET climate model is its predictive capability, specifically the ability of the inverse model to determine the altitude of the radiant emission zone, a property of the planetary climate of Venus that the standard radiative model cannot determine. We can also use the adiabatic climate model to perform a series of sensitivity tests to explore the relationship between flux partition ratio and atmospheric pressure. This is achieved by adjusting the Bond Albedo (a proxy for energy flux) then determining the partition ratio required to return the model output temperature back to the stable surface temperature of Venus (737 Kelvin). This adjusted partition ratio then generates a new atmospheric thickness, which is itself a determinant of surface atmospheric pressure. The relationship between

atmospheric thickness and pressure for the Venusian atmosphere was derived from published data [1, 15, 20-23].

Results of this analysis are shown in Figure 7.

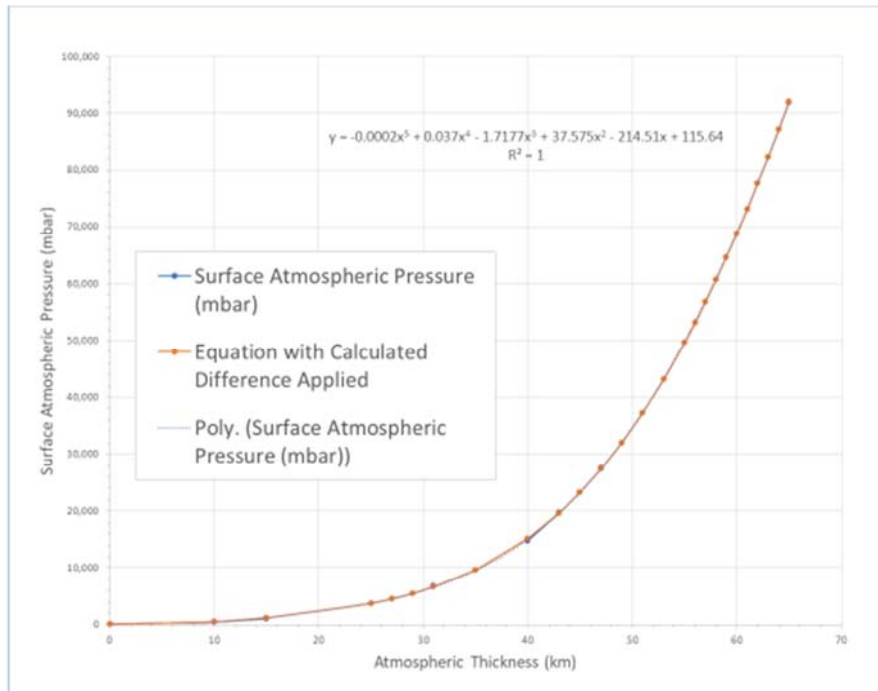


Figure 7. Venus Source Pressure Data - Datum 65Km Altitude Tropopause.

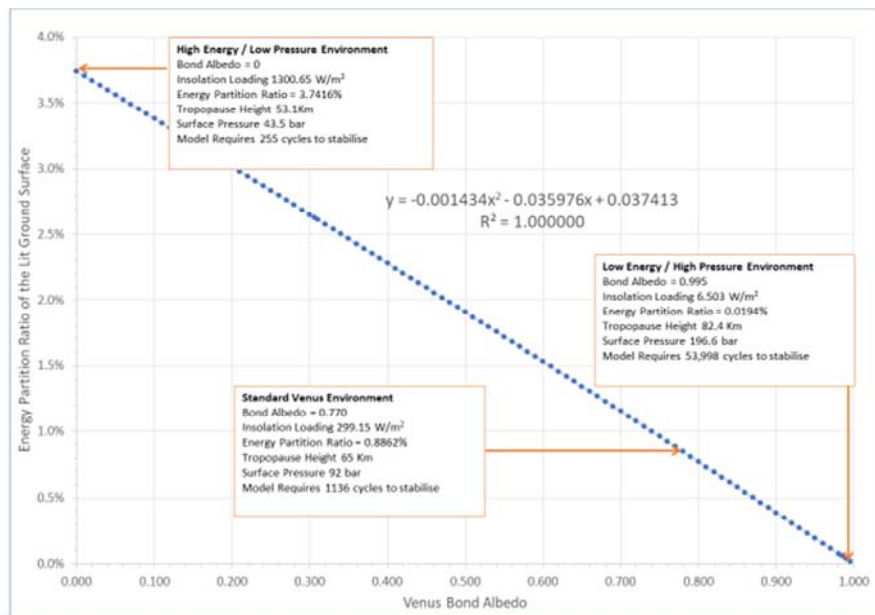


Figure 8. Venus Bond Albedo vs Lit Ground % Energy Partition for a Constant Global Temperature of 464°C.

A literature search to establish the correct lapse rate for the troposphere of Venus for modelling purposes identified a range of possible values. Detailed temperature versus altitude data suggest that to constrain our model to a tropopause height of 65 Km under standard Venusian atmospheric conditions, a lapse rate of 7.89 K/Km should be applied to the full modelled atmospheric profile of Venus [21]. This value is within the bounds of the nominal 8.0 K/Km marginally stable lapse rate of [22]. It is below the upper troposphere lapse rate of 9.9 K/Km reported [23]. In the

event the value of 7.84 K/km was adopted after performing a graphical analysis of the published data (Figure 6) [14].

4.3. Sensitivity Tests of the Venus Adiabatic Climate Model

The first hypothesis we are going to test using our new climate model, is that the energy partition ratio of the lit surface is a function of atmospheric pressure, specifically that the higher the surface pressure then the more energy that is retained within the climate system by the air. Figure 8 is

the graph of Bond Albedo versus Lit Side Tropopause Height for a constant average Venusian temperature of 737 Kelvin (464°C). This curve shows the variation in energy shed to space by the lit surface of the new climate model under different surface insolation loadings.

For a Bond Albedo of zero the model surface of Venus experiences the maximum possible insolation loading of 1,300.65 W/m². Under this high insolation scenario, the

surface needs to shed the maximum possible radiant surface energy back to space, for it to bypass the atmospheric process of energy retention, and so avoid atmospheric overheating (Figure 9). To achieve this the model requires an energy partition ratio of 3.7416% radiant loss to space, and therefore the computed lit surface tropopause height is at 53.1 Km, which is commensurate with a surface atmospheric pressure of 43.5 bar (Figure 7).

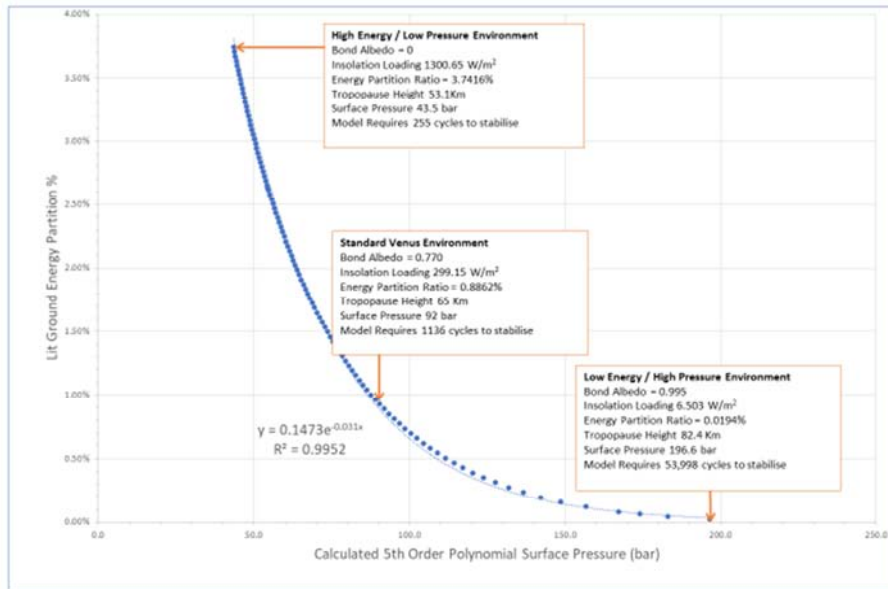


Figure 9. Surface Atmospheric Pressure vs Lit Surface % Energy Partition Ratio for a Constant Venus 464°C.

At the other extreme, the Venus model predicts that the maximum possible Bond Albedo that is commensurate with a global average temperature of 464°C is an albedo of 0.995. With this high albedo the surface receives a lowered insolation loading of 6.5 W/m². However, the model needs to retain all of this energy to maintain a global atmospheric temperature of 464°C, and consequently the energy partition ratio for the loss of radiant energy to space tends to zero (Figure 9). To achieve this high 100% quantity of energy retention within the atmosphere, the tropopause height, and consequently the surface atmospheric pressure, grow exponentially. Eventually, under this lowered surface radiation loading scenario, Venus will fail to maintain an average surface temperature of 464°C by the process of atmospheric pressure, because the required atmospheric thickness will exceed the planetary atmospheric retention capability of the Venusian gravity field.

We have now created the following chain of consequences: -

A thicker planetary atmosphere creates a greater surface pressure, that creates a greater partition ratio in favour of the air, that creates more atmospheric warming.

4.4. Applying the Results of the Venusian Climate Model

The next hypothesis we will test, is that the planet Venus was capable of supporting a surface water ocean, under the reduced insolation conditions of the young Sun, in the early history of the solar system. The faint Sun paradox was first

applied to the early history of the Earth. In the Archean Eon, 4 billion years ago (4Ga), the Sun is estimated to have been radiating solar energy at an intensity only ¼ of current values [9]. Consequently, the quantity of solar energy reaching the Earth was insufficient to account for the geological evidence of liquid water on our planet under the prevailing climate paradigm. However, in the case of Venus, because of its closer orbit to the Sun, with a distance ranging from a perihelion of 107.48 *10⁶ Km to an aphelion of 108.94 *10⁶ Km [1]. We can expect that even under the conditions of low solar energy, the planet Venus would have had a surface water ocean in the Archean under a nitrogen atmosphere. The modern Venusian atmosphere has a surface pressure of 92 bar and a gaseous composition by volume that includes 3.5% nitrogen [1]. By applying Dalton's Law of Partial Pressure and assuming that the nitrogen component of the Venusian atmosphere is primal in origin, then the surface pressure of the early Venusian nitrogen rich atmosphere would have been 3.22 bar.

We can use our new climate model to study this early climate history of Venus. By assuming a constant rise in solar energy with geologic time, and a constant rate of planetary out-gassing of carbon dioxide from the mantle, then as the Venusian atmosphere accumulates carbon dioxide, grows in pressure and the Sun gets hotter, we can establish the geologic age at which Venus made the crossover from a low temperature, low albedo water world to the modern high temperature, high albedo sulphur world [23].

To achieve this analysis, we must first assume that Venus has always been a slowly rotating planet. If we adopted a fast-daily rotation rate for the early Venus, then an additional component of rotational slowing would need to be added [24]. Although this dynamic has been studied, we simply wish to demonstrate here the applicability of our model under the constant conditions of a slowly rotating planet. To reach this objective, we must first establish the relationship between surface atmospheric pressure and the energy partition ratio that pertains for slowly rotating Venus. Using Venus atmospheric data from the Venera-5 and Venera-6 probes [20]. A predictive curve of atmospheric thickness versus pressure was created (Figure 7). This curve has been datumed to an altitude of 65 Km, using the detailed Venusian upper atmosphere pressure data, which shows that a standard tropopause pressure of 0.1 bar is recorded at this altitude, see Table 2 in [21]. This datum pressure of 0.1 bar (10 kPa) was chosen to follow the planetary tropopause definition of previous workers [14].

Figure 9 is the graph of Surface Atmospheric Pressure

versus Lit Side % Energy Partition Ratio for a constant average Venus temperature of 464°C. This curve shows the variation in energy shed to space by the lit surface of the new Venusian climate model under the different surface pressures require to achieve the standard Venusian temperature of 737 Kelvin (464°C). The relationship with pressure is derived from a series of sensitivity tests under which variations in Bond Albedo, and hence variations in input solar energy, are constrained to a constant Venusian surface temperature of 464°C. These variations in the lost energy partition ratio therefore drive the variations in the modelled atmospheric thermal profile, and so are directly linked to atmospheric pressure via the chosen planetary lapse rate of 7.84 K/Km.

Using the predictive equation of surface atmospheric pressure versus lit surface energy partition ratio (Figure 9) we can now determine the degree of energy retention, and hence average surface temperature, for the early Venus with time. Table 10 records the modelling of the progressive development of the Venusian atmosphere under the increasing solar energy output from the Sun.

Table 10. Modelled Transition of Venus from a low albedo Water World to a high pressure, high temperature, high albedo Carbon Dioxide World.

Event	Age of Planet Venus (Ma)	Venusian Ambient Atmospheric Pressure (bar)	Pressure Dependent Lit Surface % Energy Loss to Space	Venusian Ambient Solar Insolation (W/m ²)	Water Venus Bond Albedo	Sulphur Venus Bond Albedo	Water Venus Lit Surface Radiant Energy (W/m ²)
Formation of Venus	0	0	100.00%				
Blue Water Venus	600	12	10.3472%	650.33	0.306		225.663
Blue Water Venus	1000	20	8.0745%	845.42	0.306		293.362
Blue Water Venus	1300	26	6.7041%	991.75	0.306		344.136
Blue Water Venus	1350	27	6.4994%	1016.13	0.306		352.598
Blue Water Venus	1470	29.4	6.0334%	1074.66	0.306		372.908
Blue Water Venus	1650	33	5.3963%	1162.46	0.306		403.372
Blue Water Venus	1750	35	5.0719%	1211.23	0.306		420.297
Blue Water Venus	1760	35.2	5.0406%	1216.11	0.306		421.989
Simmering Venus	1770	35.4	5.0094%	1220.99	0.306		423.682
Boiling Water Venus	1775	35.5	4.9939%	1223.42	0.306	0.3063	424.528
Yellow Sulphur Venus	1780	35.6	4.9784%	1225.86	0.306	0.309	425.374
Yellow Sulphur Venus	1800	36	4.9171%	1235.62	0.306	0.320	428.759
Yellow Sulphur Venus	2000	40	4.3437%	1333.17	0.306	0.419	462.609
Yellow Sulphur Venus	4600	92	0.8862%	2601.30		0.770	

Table 10. Continued.

Event	Sulphur Venus Lit Surface Radiant Energy (W/m ²)	Water Venus Lit Surface Energy Budget (W/m ²)	Sulphur Venus Lit Surface Energy Budget (W/m ²)	Water Venus Global Average Temperature (Celsius)	Sulphur Venus Global Average Temperature (Celsius)	Boiling Point of Water (Celsius) at Ambient Venusian Pressure
Formation of Venus						
Blue Water Venus		1,149.9		89.3		188.3
Blue Water Venus		1,893.0		141.2		212.5
Blue Water Venus		2,655.6		180.3		225.9
Blue Water Venus		2,803.6		186.8		227.9
Blue Water Venus		3,186.5		202.7		232.6
Blue Water Venus		3,841.1		226.8		239.2
Blue Water Venus		4,251.2		240.2		242.6
Blue Water Venus		4,294.2		241.5		243.0
Simmering Venus		4,337.5		242.9		243.3
Boiling Water Venus	424.316	4,359.3	4,357.1	243.6	243.5	243.5
Yellow Sulphur Venus	423.260	4,381.2	4,359.4	244.2	243.6	243.6
Yellow Sulphur Venus	420.042	4,469.8	4,378.9	247.0	244.3	244.3
Yellow Sulphur Venus	387.109	5,443.3	4,555.0	274.5	250.6	250.6
Yellow Sulphur Venus	299.150		16,953.2		464.0	304.8

Figure 10 shows that at a Venusian planetary age of 1,775 Ma (2.825 billion years ago) a planetary crisis occurred on Venus as its oceans boiled. The increasing solar radiation from the developing Sun, combined with the greater atmospheric pressure, due to outgassing of carbon dioxide from the planet's mantle, and the increasing ocean water temperature, which itself also enhances the outgassing into

the atmospheric reservoir of oceanic carbon dioxide (Henry's Law), meant that Venus could no longer maintain a surface water ocean under its then ambient surface pressure. Consequently, Venus irrevocably changed from a blue-water Earthlike planet into the high pressure, high temperature, high yellow sulphur Bond Albedo planet of the modern Venusian world [23].

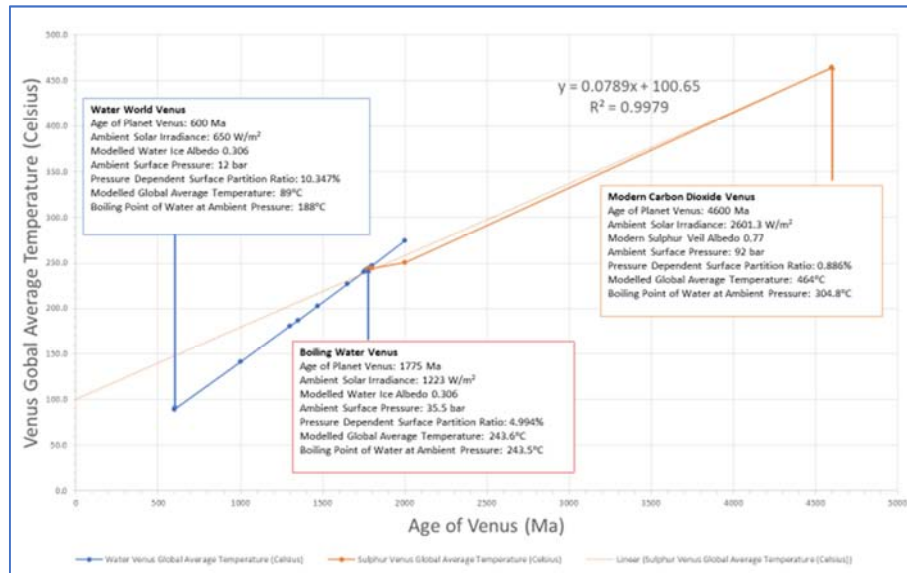


Figure 10. Venus Boiling Water Crisis: The Transition from a Water to a Carbon Dioxide World.

5. Conclusions and Recommendations

1. By applying forward and inverse modelling techniques to the atmospheric dynamics of the hypothetical captured-rotation model planet “Noonworld”, we have demonstrated that the presence of a greenhouse gas in the atmosphere is not an *a priori* requirement for the retention of energy within a climate system.
2. By applying the Dynamic Atmosphere Energy Transport (DAET) Climate model to the atmosphere of Venus we have established that by using a process of Forward Modelling the results of the canonical Vacuum Planet equation of astronomy can be replicated.
3. By applying a process of inverse modelling to the DAET model, and accounting for the fact that there is no surface thermal contrast between day and night on Venus, we have established the value of the energy partition ratio for the Venusian environment that creates the enhanced surface temperature of this high atmospheric pressure carbon dioxide world.
4. By using the appropriate planetary lapse rate for Venus, our adiabatic climate model predicts the tropopause height for the Venusian atmosphere.
5. Our work suggests that there is an interlinked relationship between Bond Albedo and the freezing point of the dominant condensing volatile within a planetary atmosphere.
6. The energy partition concept in favour of the air,

inherent in the structure of the adiabatic model, may account for the previously unexplained high wind velocities observed in the upper atmosphere of Venus.

Our fundamental criticisms of the standard radiative climate model currently used by Climate Science are as follows:

First all materials warm and cool diabatically (laminar exchange of energy through the warmed surface), solids do not change position when they warm. Gaseous atmospheres not only warm and cool diabatically, but in addition air also warms *adiabatically*, which is a turbulent process of energy acquisition, as a critical part of surface daytime warming.

Second it is physically impossible to lose potential energy by radiant thermal emission. So atmospheric adiabatic energy transport is a meteorological process that delivers energy without transport loss to a distant surface, that is itself undergoing cooling by radiant thermal emission to space.

We have designed our DAET climate model to retain the critical dual surface element of a lit globe, namely night and day. The standard canonical climate model is a single surface model that does not include lit surface adiabatic energy transfer, because diabatic thermal equilibrium is assumed at all times (both night and day). Our simple process diabatic model matches the results of the standard Vacuum Planet equation of astronomy. However, when we add the process of adiabatic energy transfer from the lit side, then the requirement of the current paradigm for back radiation greenhouse gas heating is no longer necessary.

We are able to quantify the degree of adiabatic lit surface

energy partition in favour of the air by using the process of inverse modelling, a standard geoscience mathematical technique. The issue of atmospheric thermal radiant opacity then becomes a passive process, and the purported atmospheric action of greenhouse gas heating by back-radiation can be discounted.

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