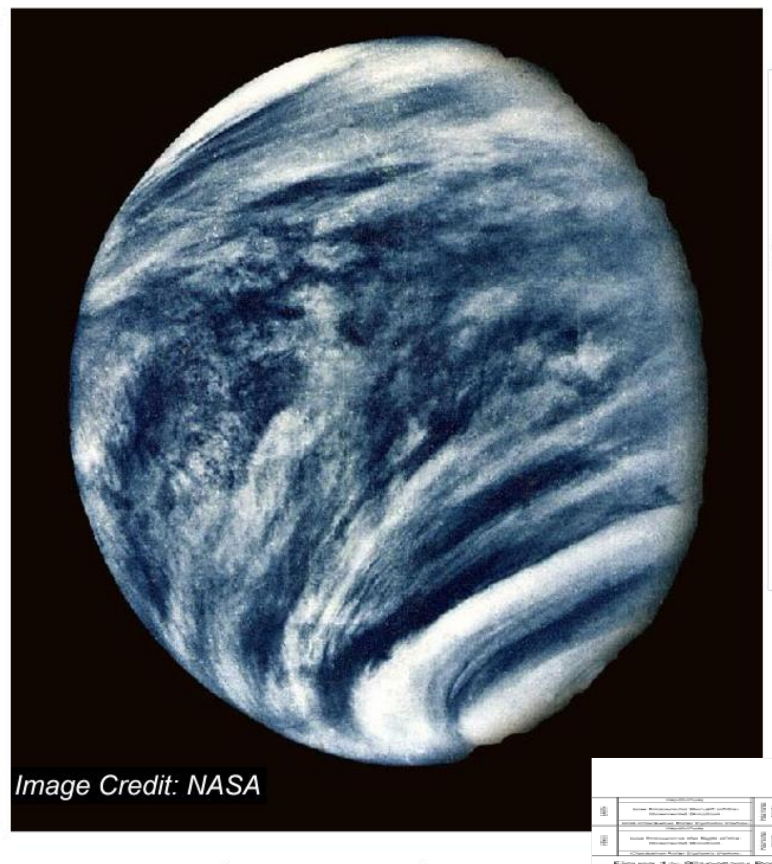
The Venusian Insolation Atmospheric Topside Thermal Heating Pool

P. Mulholland and S.P.R. Wilde

In this view the North Pole clockwise vortex is top left and the South Pole anti-clockwise vortex is bottom right. On Venus the sun rises in the west so the dawn terminator is seen on the right side of this image. The bow-shockwave in centre of the disk is the solar zenith tracking east, the disruptor point of maximum solar heating.



Made using an ultraviolet filter in its imaging system, the photo has been colour-enhanced to bring out Venus's cloudy atmosphere as the human eye would see it

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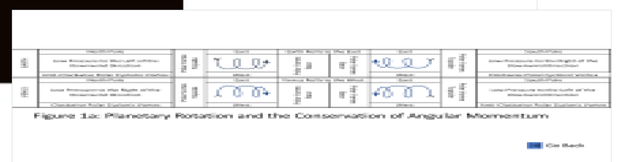

Figure 1: NASA 1974 Mariner 10's Portrait of Venus.

1. Method

- Modelled Pressure Profile for Venus Atmosphere from Surface to 100 Km at 1 metre increments [1].
- Two Equations of State Used:
  - The Pressure Volume Temperature (PVT) Relationship of Boyle's Law
  - Newton's Gravity Law of Spherical Shells [1].
- Four Linked Predictive Lapse Rate Equations based on Published Data Calibrated to a Revised Surface Datum Temperature of 699 Kelvin [2, 3].
- Using the thermal lapse rate for the troposphere of Venus in its top-down mode of application, we calculate the depth below the tropopause that solar irradiance is able to achieve effective heating of the Venusian atmosphere.

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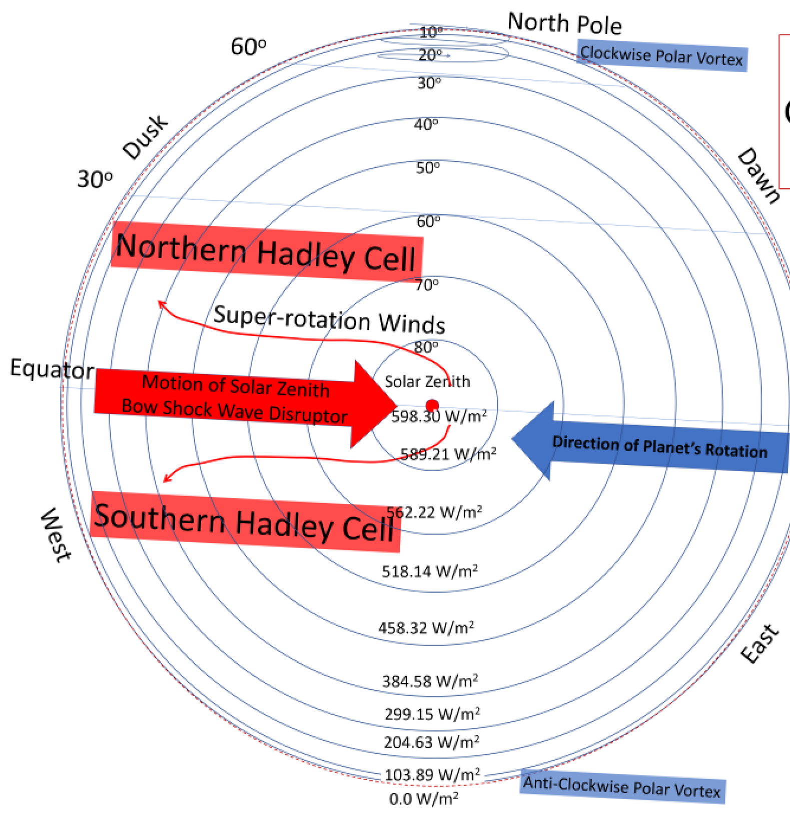

Solar Elevation Angle 5° Defines the Grazing Angle Limit of Effective Solar Heating

Illumination Intensity versus Solar Elevation

Location	Latitude (Degrees)	Elevation Angle (Degrees)	Solar Power Intensity (W/m²)	Effective Flame Temperature (Kelvin)	Quenching Limit Height (Km)
North Pole	90.00	0	0.00		
Z1: Heating Limit	86.43	3.57	37.25	160.10	110.000
Z1:	85	5	52.15	174.14	88.092
Z1:	80	10	103.89	206.89	76.617
Z1:	75	15	154.85	228.60	70.502
Z1:	70	20	204.63	245.10	64.669
Z1:	65	25	252.85	258.41	61.065
Z5: Hemisphere Average Flux	60	30	299.15	269.51	58.461
Z1:	55	35	343.17	278.92	56.454
Z1:	50	40	384.58	286.97	54.850
Z1:	45	45	423.06	293.90	53.540
Z1:	40	50	458.32	299.84	52.461
Z1:	35	55	490.10	304.91	51.570
Z1:	30	60	518.14	309.18	50.839
Z1:	25	65	542.24	312.71	50.247
Z1:	20	70	562.22	315.55	49.798
Z1:	15	75	577.91	317.73	49.474
Z1:	10	80	589.21	319.27	49.244
Z1:	5	85	596.02	320.19	49.107
Z1: Equator	0	90	598.30	320.50	49.061

Figure 2: Venus Lit Hemisphere Illumination Interception Geometry.

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2. Results

- Using the troposphere model lapse rate profile as the constraint on cooling by vertically convecting air, we show here that the height of the tropopause convection limit is a close match to the level of the observed static atmosphere height for the 250 Kelvin freezing point level of 75% by weight of concentrated sulphuric acid, the primary condensing volatile in the Venusian atmosphere [4, 5].
- We hypothesise that the impact on planetary albedo by the solidification of this planet's atmospheric condensing volatile suggests that the observed albedo is a response to and not a cause of planetary atmospheric solar radiant forcing.
- We have established that this radiant quenching depth delineates a pool of upper tropospheric air that both captures and responds to solar radiant forcing.
- We note that the observed cloud patterns on Venus recorded in 1974 by the Mariner 10 NASA probe do appear to support the development of this type of insolation induced convective disturbance. It is the solar induced disruption of the mass/gravity lapse rate slope at upper levels that forces convection to begin.

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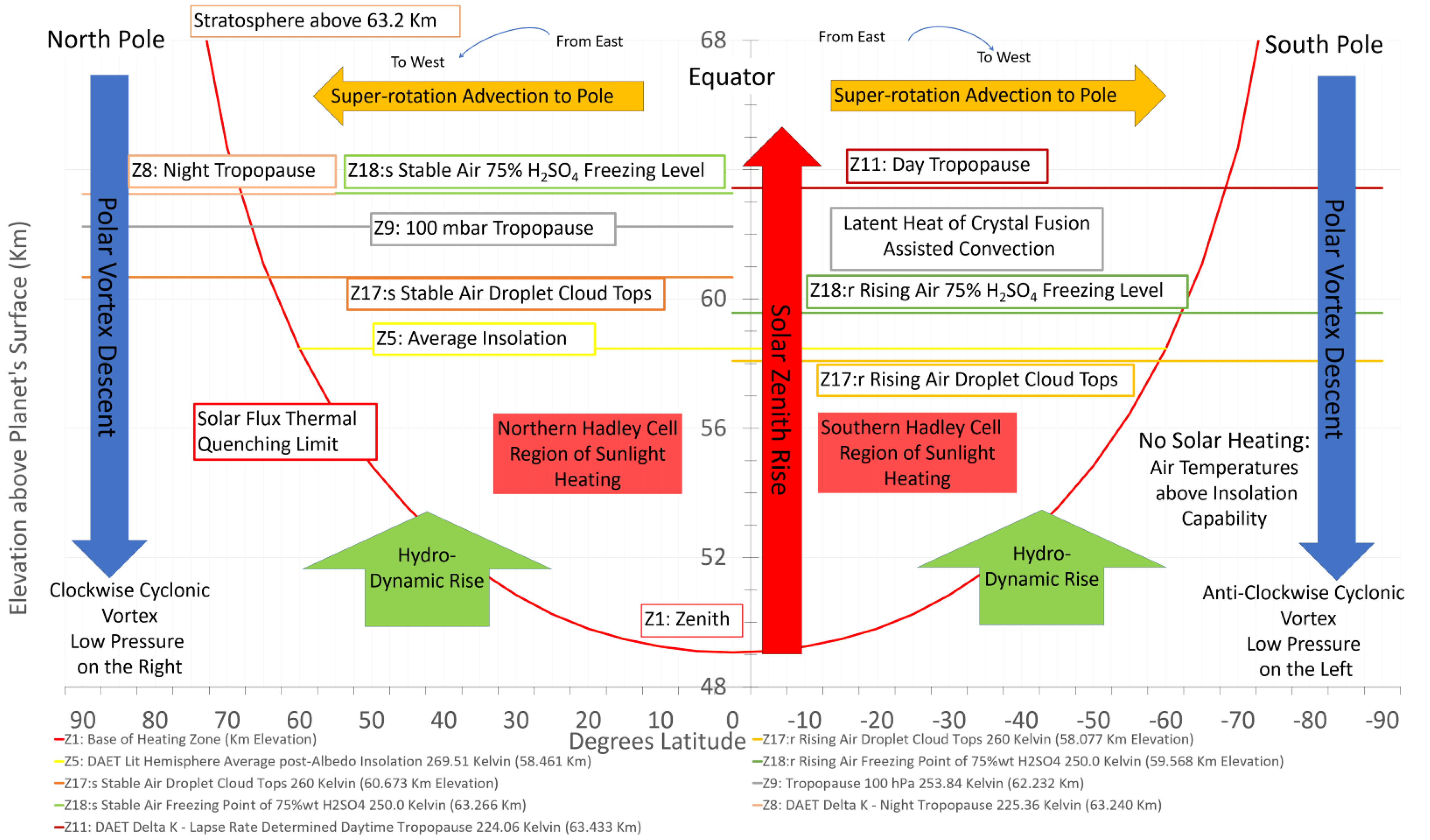
Figure 4: Venus Atmospheric Solar Radiant Thermal Heating Pool



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3. Deductions

- As a consequence of this top of the troposphere insolation forcing, a process of full troposphere convective overturn occurs and delivers solar heated air to the ground via the action of forced air descent in the twin polar vortices of Venus.
- This forced descent of the topside heated air means that it undergoes adiabatic heating as it falls in the gravity field of Venus [6]. The descending mass flow within the polar vortex provides a hydrodynamic piston drive that causes the planet's air to circulate vertically in a pair of giant hemispheres encompassing Hadley cells.
- By this means the compressed air is heated as it falls, therefore the thermal limit to radiative forcing set by the insolation of Venus is easily surpassed [7].
- From this analysis we conclude that the high surface temperatures observed at the surface of Venus are a direct consequence of, and maintained by, a process of topside thermal radiant capture by the air followed by mass motion energy delivery to the surface.

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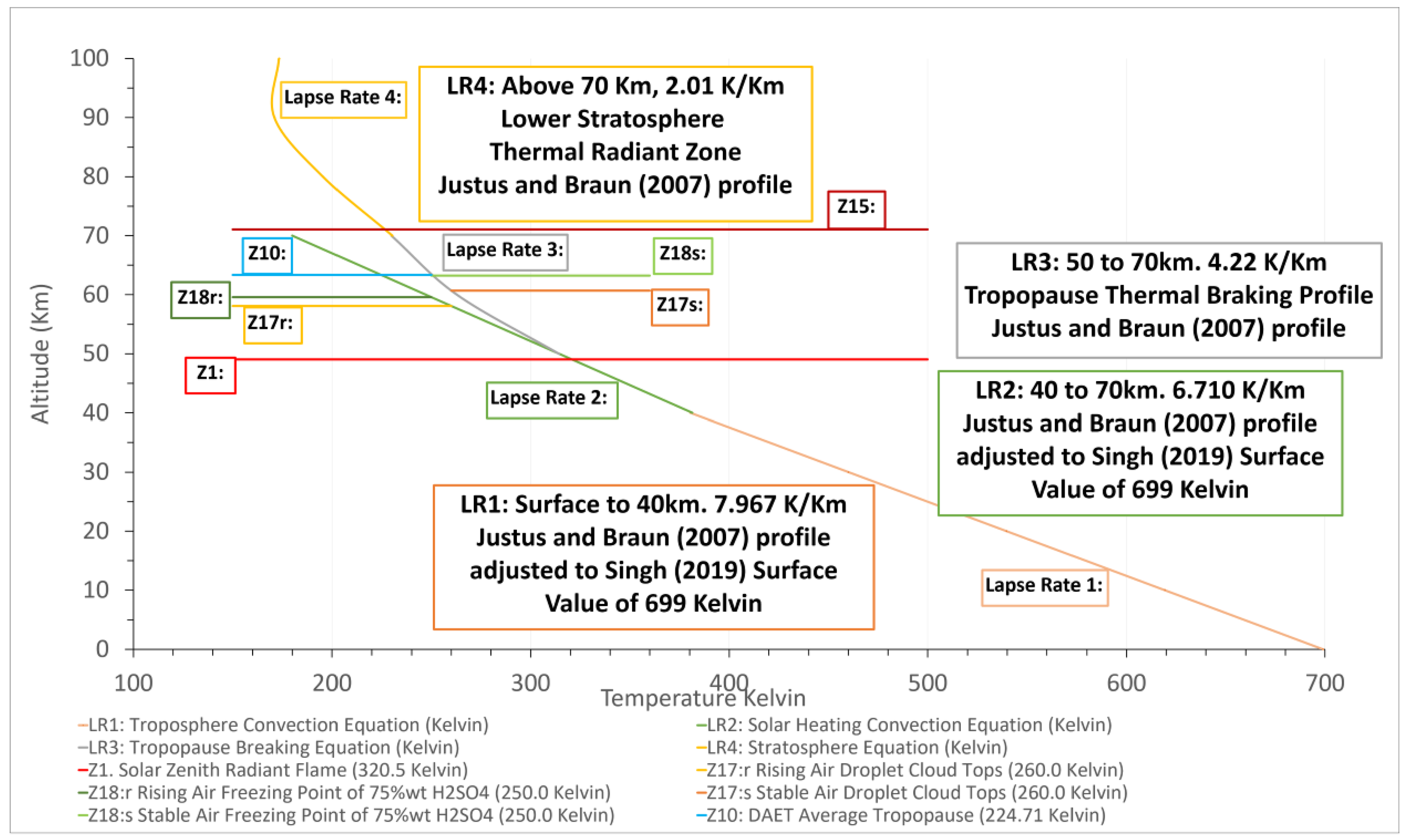

Figure 3: Venusian Atmosphere: Temperature versus Altitude

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4. Conclusions

- With the Dynamic-Atmosphere Energy-Transport (DAET) framework we have the first model of a planetary surface and atmosphere which treats each as a separate grey body with both in equilibrium with each other [8].
- It is that internal system equilibrium that makes it possible to regard the system as a whole as a black body for radiation purposes when viewed from outside.
- By splitting the planet into an energy collection region and an energy discharge region we can achieve equilibrium by having the two sides mirroring each other as a by product of hydrostatic equilibrium.
- It follows that once hydrostatic equilibrium is in place one can also treat objects within an atmosphere as black bodies because they are in thermal equilibrium with the mobile gases surrounding them.
- It is only when hydrostatic equilibrium is lost that the surface and atmosphere become grey bodies again and that never happens in normal circumstances due to convective adjustments.

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5. References

- [1] Mulholland, P. and Wilde, S.P.R. 2021. A Modelled Atmospheric Pressure Profile of Venus. *Venus Gravity Profile 01Mar21.xlsx* Research Gate Project Update
- [2] Justus, C.G. and Braun, R.D., 2007. Atmospheric Environments for Entry, Descent, and Landing (EDL). NASA Natural Environments Branch (EV13)
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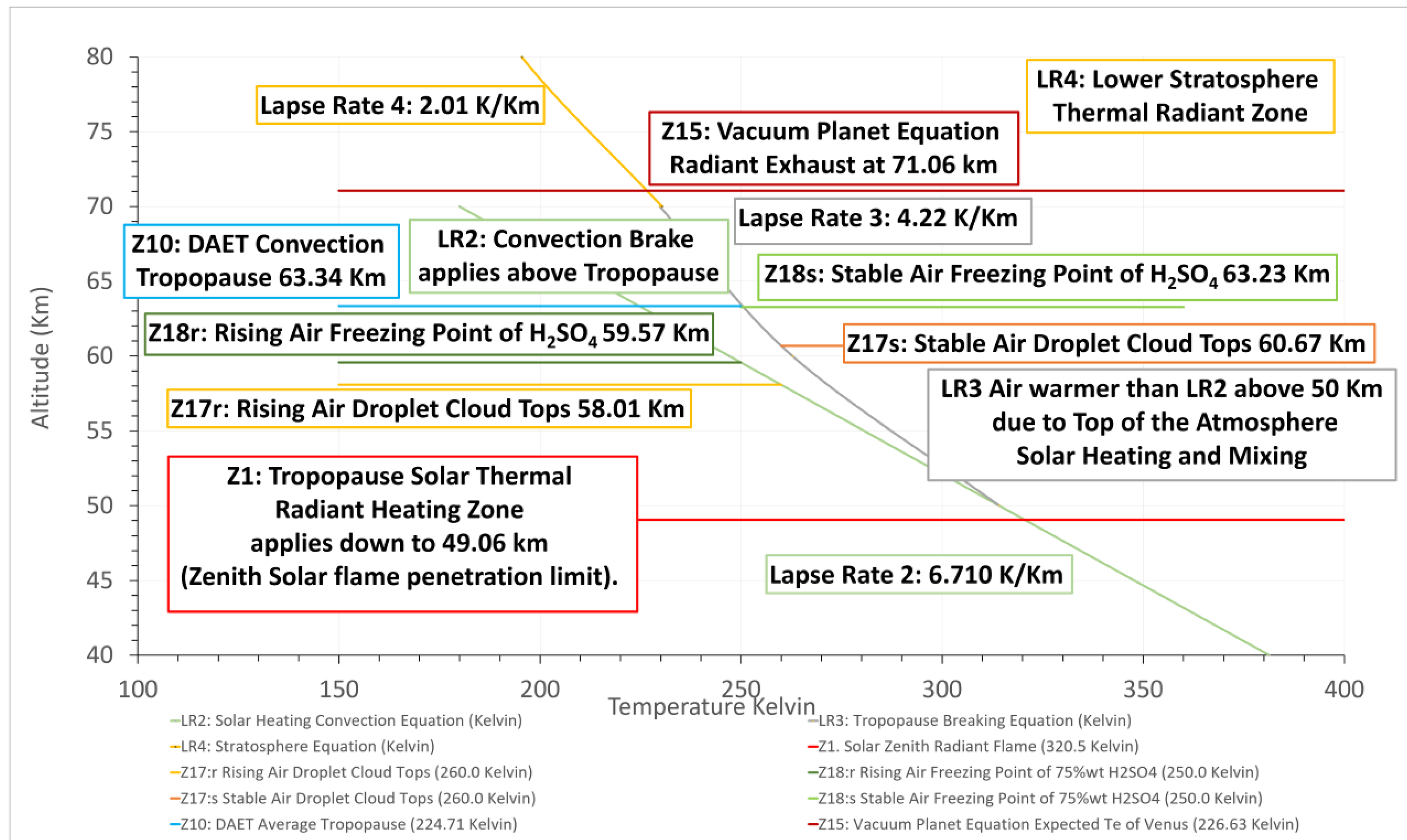

Figure 5: Venusian Tropopause: Temperature versus Altitude

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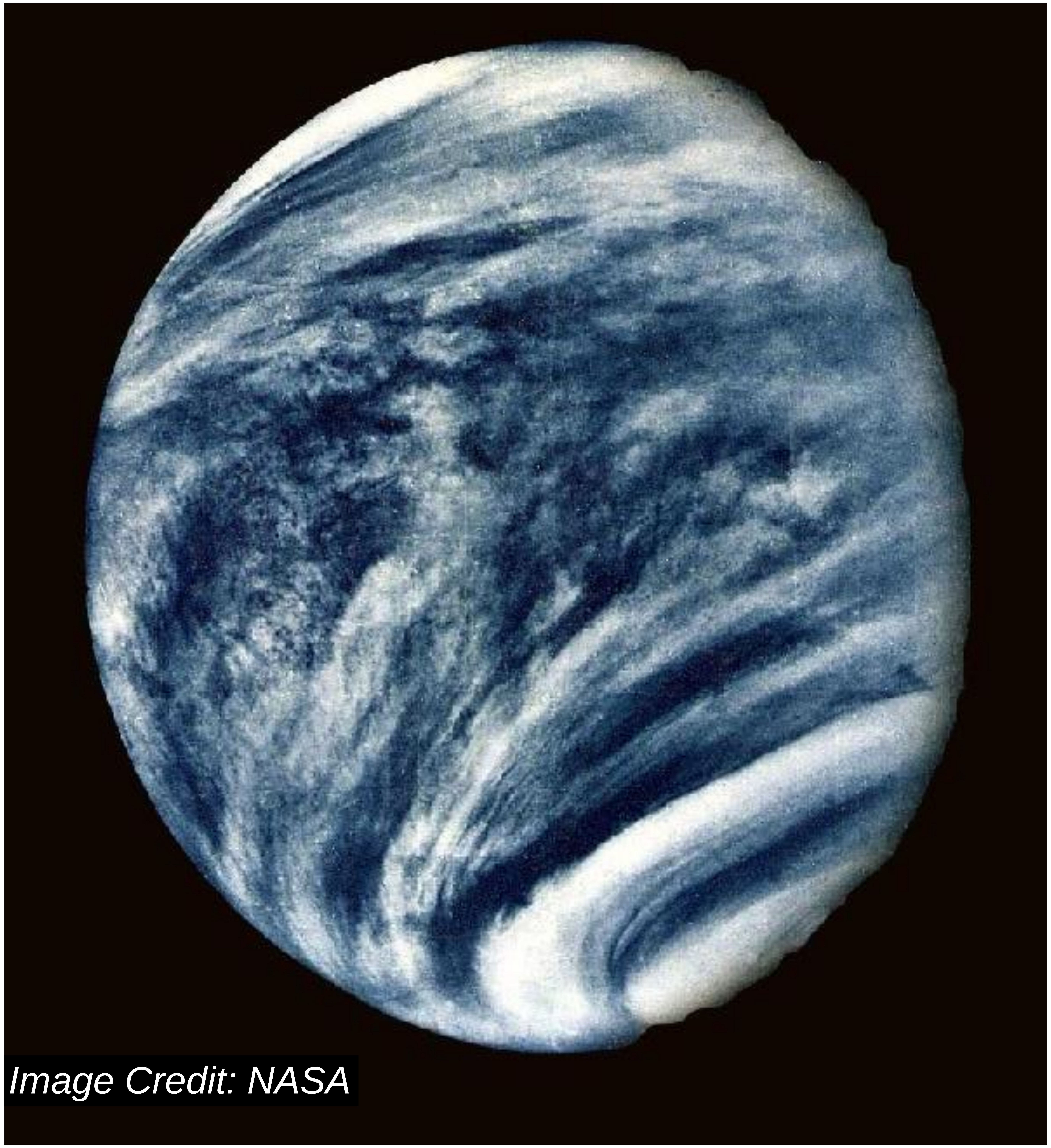

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Figure 1a: Planetary Rotation and the Conservation of Angular Momentum

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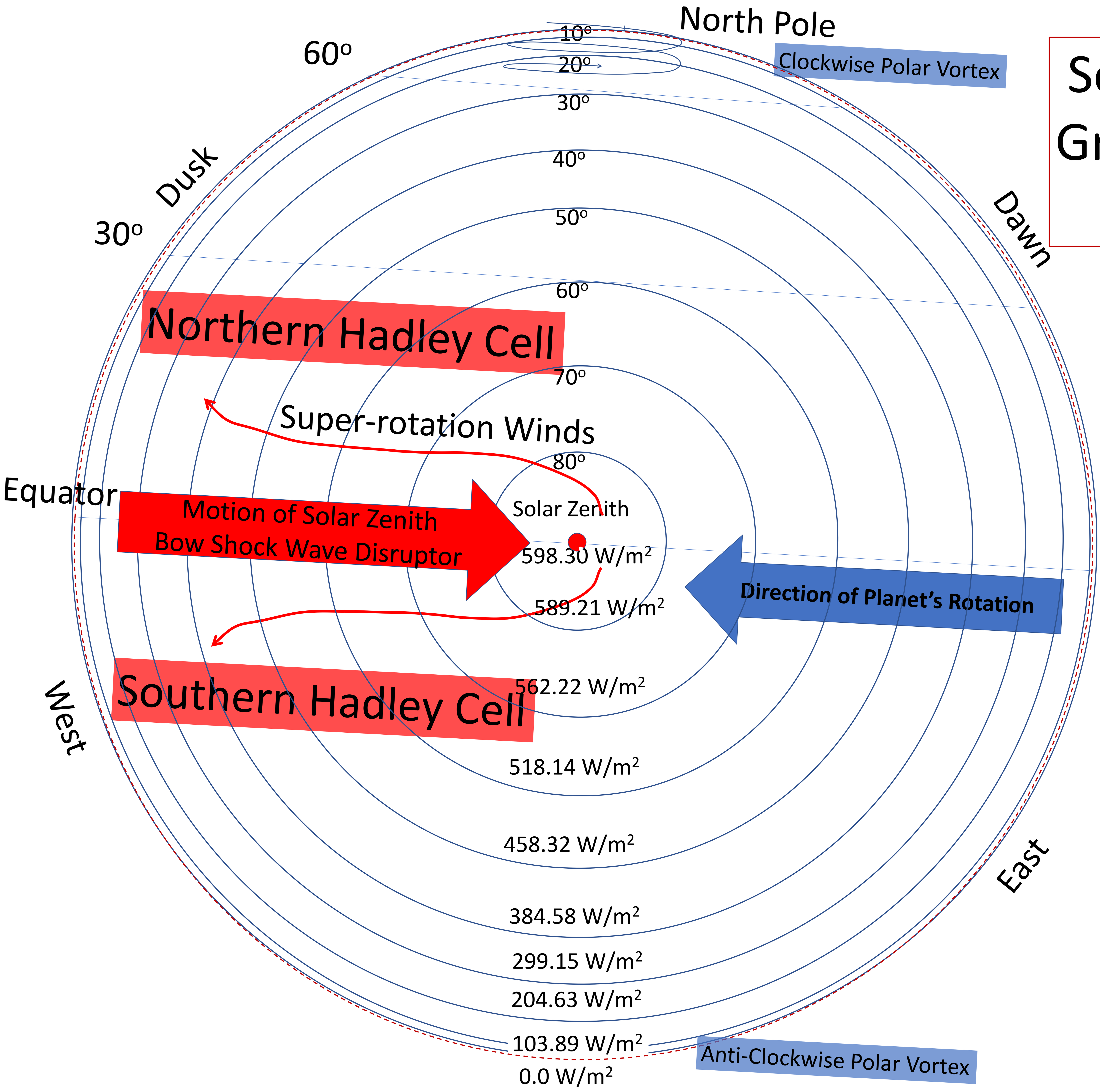

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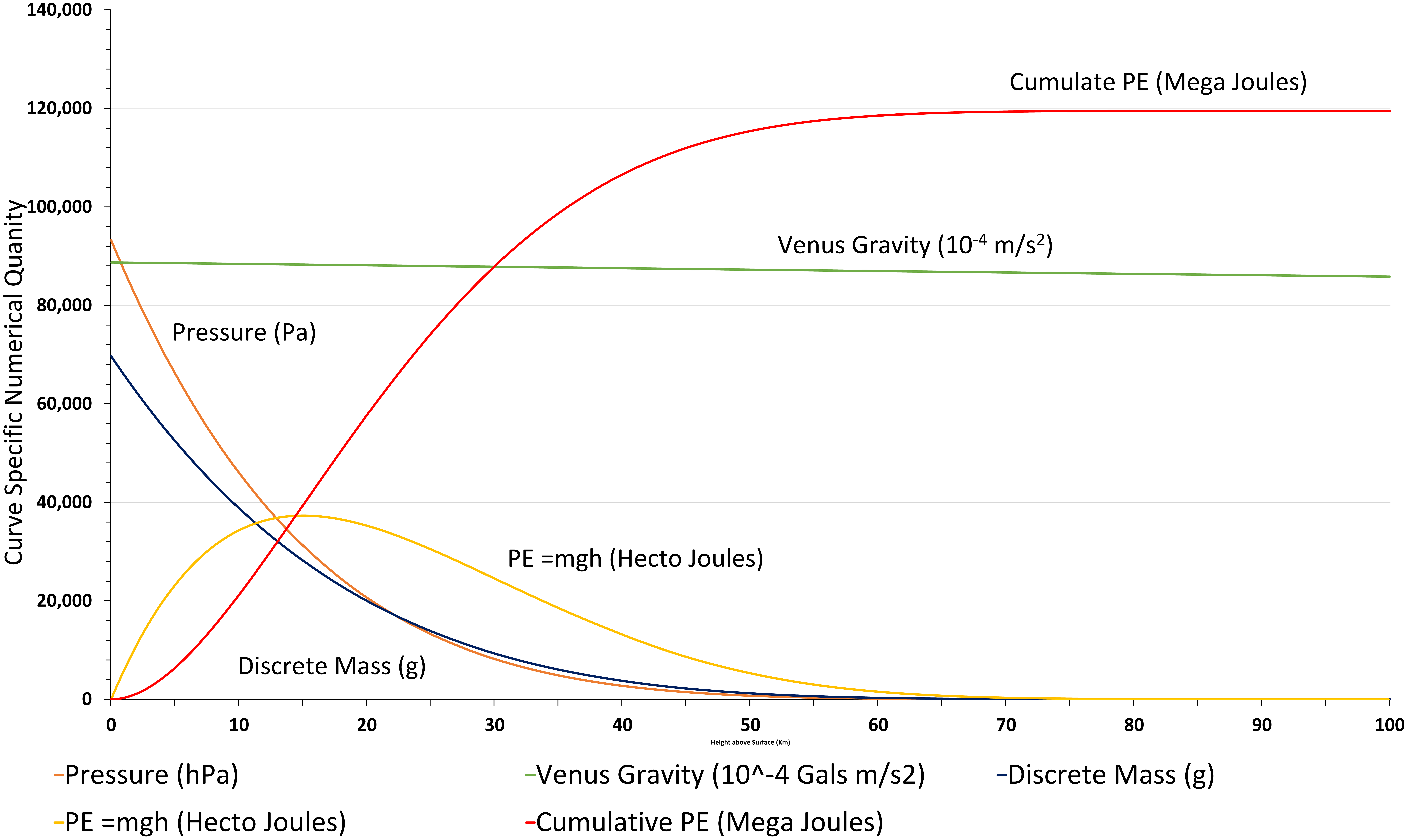
Figure 6: Scaled Comparison Chart of Pressure, Gravity, Discrete Mass, Discrete Potential Energy (PE) and Cumulative PE Curves for Venus.



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