Climate Change
Addendum: Analysis of pro-AGW arguments.

1. There is a time delay: Conjectures range from decades to millennia between when heat is absorbed by atmospheric CO_2 and when the consequent temperature rise is "measured" by the environment. AGW requires this conjecture as Vostok-measured temperatures do not correspond to the CO_2 rises over the past several thousand years.

Figure 2 shows otherwise, that the reaction time is less than a year. For example, the measured temperature rises associated with El Ninos and the falls associated with La Ninas and significant terrestrial volcanic eruptions occur in the year those events were recorded. Mt Pinatubo caused the drop after 1991 and its air-borne ash blocked incoming solar radiation for a few years.

2a. Satellite IR measurements produce different results from ground-based. Figure 6 (Schmidt 2010) is a typical presentation to show the spectrum recorded at satellites. (AGW proponents prefer satellite measurements and choose to *ignore* the perfectly valid ground-based IR measurements of eg figure 5 – on the sole grounds these are imcompatible with AGW.) Although it shows energy flux rather than figure 5's transmission, the important thing in both is the relative drop at CO_2's absorbing wavelength, eg 15 micron, or its equivalent 667 cm^{-1}. Although both methods are equally valid means of assessment, ground-based show ***zero*** direct transmission whereas satellites indicate about ***30%.***

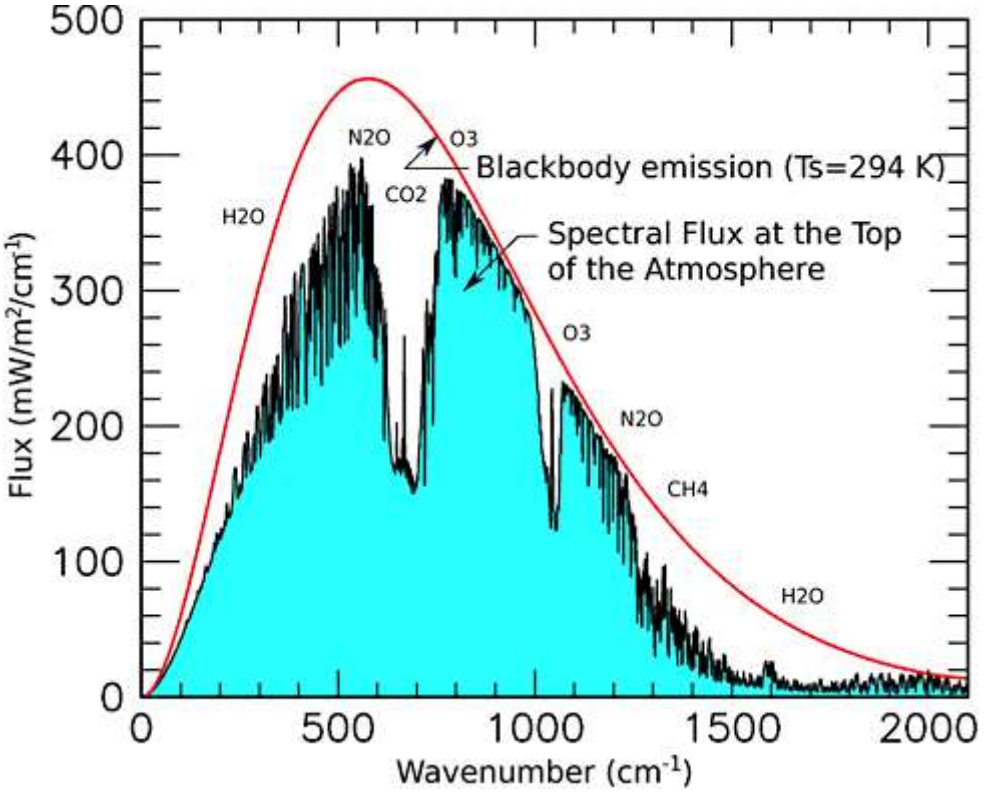

Figure 6: Outgoing spectral radiance at the top of Earth's atmosphere showing the absorption at specific frequencies and the principle absorber. For comparison, the red curve shows the flux from a classic "blackbody" at 294°K (≈21°C ≈ 69.5°F)

*The two types can be reconciled …. **if** the satellite data are correctly interpreted.*

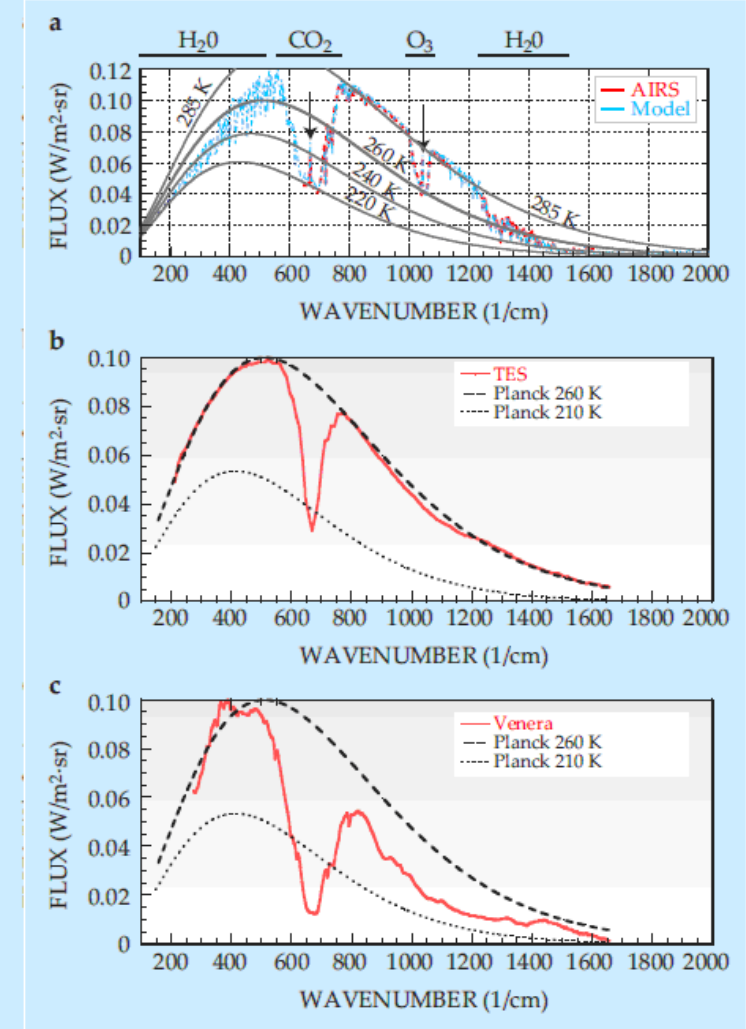

Figure 7: Planets' Satellite IR flux measurements (from Pierrehumbert)
From top: Earth (AIRS), Mars (TES), Venus (Venera 15).

Ground-based measure the Earth's radiated energy that is being transmitted - or inversely, being trapped by the atmosphere, the concern of greenhouse warming.

Satellites measure energy leaving the *top of the atmosphere* - energy originally radiated by Earth, but only after it has been "processed" by the atmosphere.

- Energy is first absorbed at lower altitudes by greenhouse molecules.
- These warmed molecules then re-radiate that extra energy in all directions.
- Less than all of this re-radiation is directed back towards Earth (actually less than half) but will not reach Earth* (confirmed by ground-based instruments) because it will be completely re-absorbed, then re-radiated, etc, by CO_2 on the way back through the higher density lower altitudes. There is a greater density

* [Put more simply and unequivocally:
- Net heat (ie IR) energy flows from higher to lower temperatures – "Zeroth" Law of Thermodynamics.
- Temperatures at lower altitudes are greater than at higher altitudes.
- Therefore, the direction of energy flow is from low to high altitudes.]

of CO_2 molecules at lower altitudes to "catch" the downwards re-radiation of the lower density CO_2 at higher altitudes.

- Thus all Earth's radiation will be eventually directed outwards, and some of this re-radiation will *always* hit, and be measured by, satellites.

This refutes the interesting arguments (eg Pierrehumbert 2011) put forward that, despite the reality of CO_2 completely absorbing the IR available to it at lower altitudes, that somehow a portion of high altitude energy which is initially retransmitted downwards will reach and warm Earth's surface.

A simple calculation further shows that satellite spectra are actually measuring the radiation emerging from an atmospheric layer somewhere above Earth's surface *rather than from the surface itself.* The maximum "dip" of CO_2 spectrum relative to the Planck Blackbody curve (figure 6 & 7) can be calculated simply from the height of the measuring satellite – *only if* one accepts that all the IR corresponding to CO_2 has been previously absorbed, then re-emitted at higher altitudes as described above.

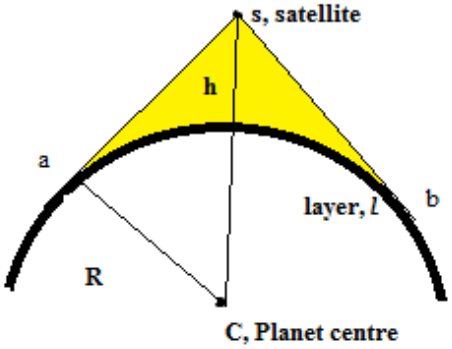

Figure 7: Calculation diagram

The *experimental* relative dip (eg from figure 6 or 7) is the ratio
(*measured* IR) / (hypothetical directly transmitted IR, ie black body curve).

Calculated dip:
a. IR wavelengths emitted by a planet's surface to which the atmosphere is transparent are detected by the satellite at height, h, in straight lines from the sector of the planet to which it is exposed (yellow shading in figure 8).
b. Absorbed IR is re-emitted in all directions.
c. IR which is completely absorbed (and then re-emitted, etc,) finally emerges from bunched nebulous layers, *l* (thick black curve of fig 8) above the planet surface.
d. Fortunately, the calculation is rather insensitive to the actual - unknown - value of *l.* A good approximation, giving a cleaner calculation, is to assume the height of the final emitting layer is small compared to the satellite's height, ie set $l = 0$.
e. IR emitted at CO_2's wavelengths from Earth's surface that were travelling towards s (yellow area) are trapped then re-emitted *in all directions* at *l.* The amount of CO_2's IR received at s is thus reduced from that which was emitted from sector ab.
f. Then the *calculated* relative dip is the ratio ≈

(planet sector area exposed to satellite) / (satellite-centred sphere area)

$$= 2 * \sin^{-1}(R/(R+h)) / 360$$

The good agreement with data is shown in Table 1.

Table 1: Data & Results for Planets.

	Venus	Earth	Mars
Radius, R	6200	6378	3400
Satellite	Venera15*	Aqua	Mars Global Surveyor**
% CO2	96	0.04	95
Pressure, bar	92	1	0.007
Orbit ht, km	881 x 66878	691 x 708	120 x 450
ht, h, km	5700	700	(400)
Calculated %	**17.4**	**35.7**	(35.3)
cf measured* **	**17.**	**36.**	**33.**

*Venera 15 measurement position is equatorial.

**Mars GS measuring height was not stated but the guesstimate shown is for mid-latitudes.

*** Measured dips for Venus, Earth and Mars are calculated from Pierrehumbert.

The table's calculated vs measured for Venus and Earth are ample to confirm that the ***"dips" are simply artefacts of the planet radius and satellite height***. Thus when properly interpreted, rather than supporting AGW, the satellite data are further proof of the argument against it, as AGW *requires* that a proportion of Earth's surface CO_2 infrared can sneak through from Earth *directly* into space so that increasing greenhouse CO_2 would necessarily trap more heat. **That doesn't happen.**

Such calculations hold for ALL satellite spectrometric data, not just IR.

[The above calculations are nice but not really necessary in order to show that CO_2's absorbed IR is not reaching Earth's surface, and thereby causing measured warming. Figure 5 by itself is sufficient; if CO_2's IR was reaching the surface, the Transmission at CO_2's wavelengths would be non-zero because of the IR being received at the sensor.]

2b. A secondary AGW argument put forward, for example by Pierrehumbert, is that the CO_2 bandwidth *widens* with its increasing concentration so that Figure 5 would not impose an upper limit to the amount of CO_2's absorption. (This effect is known as *line broadening*.) However, as can be seen, the CO_2 bandwidth is the same on Earth as Venus (figure 8), despite the vastly different concentrations, so that effect can no longer be significant at such pressures - but apparently is at Mars' low pressure.

References

R.T. Pierrehumbert. (Jan 2011, Physics Today, www.physicstoday.org)

Gavin Schmidt. NASA **Science Briefs: Taking the Measure of the Greenhouse Effect,** October 2010, updated 30Sept 2014.