

Can an IR Thermometer detect the GHE?

By Andy May (2/4/2025)

Much has been written about observing downwelling infrared radiation from clouds and open sky using infrared (IR) thermometers, see Roy Spencer's 2013 post [here](#). However, IR thermometers and imagers, as a necessity, work mostly in the atmospheric window, the range of frequencies that can pass through the troposphere with little absorption. In the case of Spencer's imager, this is the frequency band from about 7.5 to 13 microns. My IR imager is an HFSTools HF96 and it has a range of 7.5 to 14 μm . Water vapor and CO_2 have little influence in this frequency range and the only significant IR absorber in this range is ozone or O_3 as marked in figure 1.

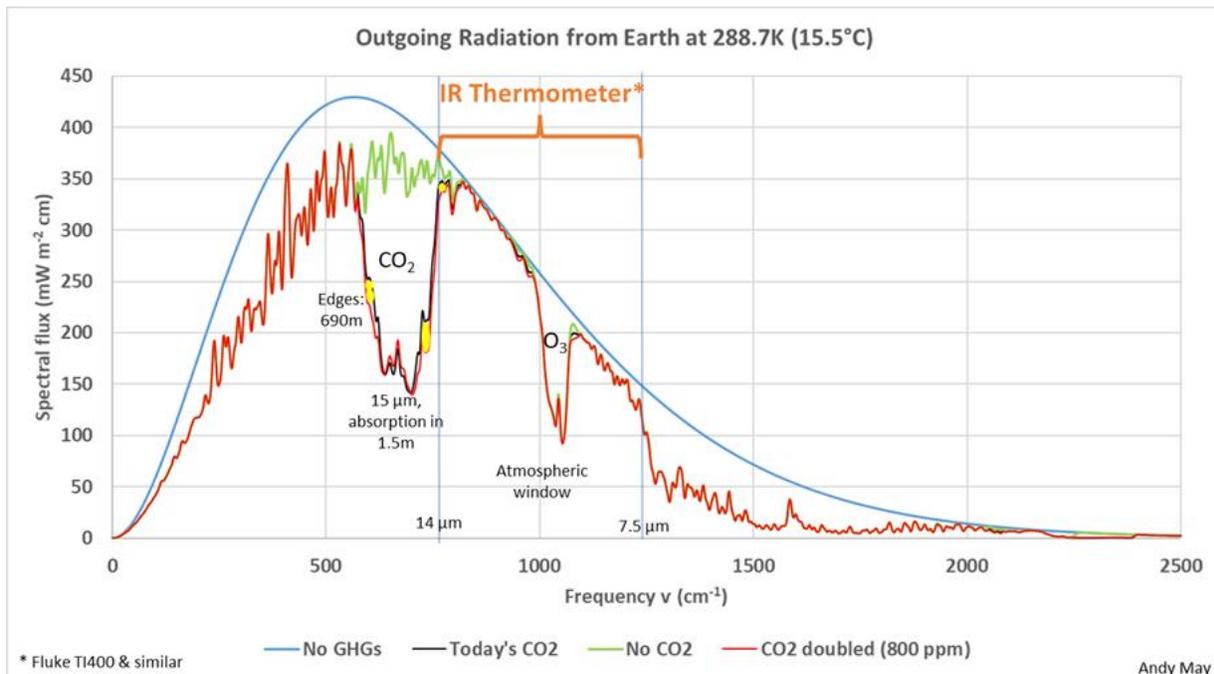


Figure 1. This is a plot of the outgoing radiation spectrum from Earth. Within the normal IR thermometer and scanner range of 7.5 to 14 micrometers, only ozone (O_3), which is mostly above cloud level absorbs and emits significant radiation. Within the 15 μm CO_2 "divot" nearly all surface emissions are absorbed within 1.5 meters of the surface, at the edges of the divot, emissions are absorbed within 690 meters. There is very little absorption and emission by GHGs in the IR thermometer range in the troposphere, aka the atmospheric window.

Emissions, whether from water vapor, clouds or other GHGs are going to be at a specific frequency and that frequency must be outside the atmospheric window which is what ground-based devices work in. If IR thermometers saw in the GHG emission range they would see nothing, just a fuzzy glow from the GHGs around them and maybe some fuzzy images of things that are close, say a few meters away, they would not see clouds which are over a kilometer high.

This is obvious because emitted frequency is also the frequency that GHGs capture. Scattering does not change the frequency of the radiation, ergo the detectors are getting minimal radiation from emissions, it will only detect small and isolated emissions in the window range and that comes from a few weak water vapor frequencies.

IR thermometers and scanners “see” clouds as opposed to open skies because clouds scatter more surface emitted IR in the window range. The temperature you “see” for the cloud is a false temperature.

The troposphere contains little ozone, most of it is in the stratosphere, well above cloud level. So, one might ask, if the IR imager is seeing a range of frequencies where water vapor and CO₂ have minimal influence, how can changes in the IR reading be due to the greenhouse effect? Indeed what they see is not the greenhouse effect.

The lower troposphere contains a lot of particulate matter, condensed water droplets, and aerosols that scatter radiation. When the imager is pointed directly upward in a clear sky, it sees minimal scattering of surface emitted radiation in the frequency window it works in and detects minimal radiation, so it sees a low temperature. When pointed at an angle near the horizon, it is seeing through more of the lower atmosphere, with maximal scattering, so the detected temperature is higher, but it isn't a real temperature.

Clouds are denser, have more particles and water droplets in them, and produce more scattering. When you point the imager at a cloud, it sees a lot of scattering and interprets this as a higher temperature, but it isn't the actual temperature of the cloud.

Radiation intensity from IR thermometers and from satellites

If the following passage is confusing to you, I will explain it.

“It is also true that OLR (as measured by satellites) approximately follows surface temperature. So, a properly constructed radiative model can reproduce some observations. However, the instruments on satellites measure radiation intensity in a specific direction, not the real net radiation flux or the true direction of the flux. As explained by Michael Mishchenko, and earlier by Max Planck, radiation emissions have no directionality, they move in all directions independently. They are not a collection of “localized point-like particles of light.” ***So, how useful satellite measurements are in determining the energy imbalance of the Earth is uncertain.”***

OK, this can be difficult, but satellites measure radiation intensity in a small window pointed at Earth. The point that both Mishchenko and Planck have made is that radiation intensity in any given direction does not equal the energy flux computed from that intensity, as is often assumed. Thus, satellite data cannot be used to measure Earth's energy imbalance. No matter how well you measure radiation intensity in the direction of the Earth, you do not know the net energy flux coming from the Earth at the detector location.

Michael Mishchenko was a [senior scientist for NASA](#) and worked on satellite remote sensing projects for them until he passed away in 2020. He was the foremost expert in this area. His most important papers on this subject are [\(Mishchenko, 2013\)](#) and [\(Mishchenko, 2014\)](#).

Energy is not a particle or stream of particles; photons do not fly through the air from one point to another. It is a wave and is sent from a source in all directions, although it can be [collimated](#) in a laser or with reflectors. The photon concept only applies when energy is absorbed by an atom or molecule, the result is always a specific jump in energy, that quanta, when re-emitted or emitted

due to stimulation has been termed a photon. This is just because atoms and molecules do not emit half-photons. But that does not mean that energy is a particle, it is still a wave. Energy problems are always solved using [Maxwell's equations](#) which do not involve photons. In Mishchenko's words on page 14 in his 2014 paper:

“Eventually, the outgoing spherical wave switches back to being a bunch of localized point-like photons. Needless to say, such mysterious transformations of photons into waves and then back into photons can only happen in the confused human mind rather than in nature. The only outcome of such **verbal speculations can be – and has been – the notorious “photonic confusion”**”

Measuring net energy flux

To measure net energy flux or the flow of energy in a particular direction, e.g. from Earth, you need to measure the intensity in all directions, then compute both the net intensity and the net direction, that is a [Poynting vector](#). Pointing a radiometer at the Earth from space does not measure the energy flux from Earth or allow us to calculate the Poynting vector, just the intensity in one direction. This intensity is then assumed to be the Poynting vector in calculations, but it isn't. This is critical because Earth's energy imbalance is a very small number and it is the difference between two very large numbers. The only way to accurately estimate the imbalance is with ocean temperatures and we don't know those very well either.

Take a look at page 17 in Mishchenko's 2013 paper:

“Subsequently, they were supplemented by the seemingly obvious concept of a directional radiometer. Since then, measurements with **WCRs (well-collimated radiometers, which are used in satellites, they measure radiation intensity in a specific direction like an IR thermometer)** and calculations based on the **RTE (the radiative transfer equation, used to calculate the amount of radiation)** have been at the very heart of the disciplines of atmospheric radiation, remote sensing, astrophysics, heat energy transfer, and biomedical optics. Yet from the fundamental-physics perspective, both the discipline of DR (directional radiometry) and the **RTT (radiative transfer theory)** have been based on phenomenological notions many of which turned out to be profound misconceptions. It has been demonstrated that contrary to the widespread belief, a **WCR does not, in general, measure the flow of electromagnetic energy along its axis**, while the radiance cannot be interpreted as quantifying the amounts of electromagnetic energy transported simultaneously in various directions. It is thus fundamentally important to understand why the phenomenological RTT and DR have often “worked” in the practical sense and determine the range of their applicability. The ultimate way to achieve this key objective is via the microphysical approach based directly on the Maxwell equations since it can clarify the physical nature of measurements with WCRs and the physical content of the RTE. This approach has finally been developed and has been used to demonstrate **that the radiance has no fundamental physical meaning besides being a mathematical solution of an equation formally coinciding with the phenomenological RTE**. Only under certain restricted conditions can it be used to compute the time-averaged local Poynting vector (the net energy flux in a particular direction) as well as be measured by a WCR. These firmly

established facts make the combination of the RTE and a WCR useful in some well-defined applications and help “rescue” the majority of documented uses of the phenomenological RTT. **However, outside the range of validity of the microphysical RTT the practical usefulness of measurements with WCRs remains uncertain. It is likely that in many cases the measurement with a WCR must be modeled with a more sophisticated tool than the RTE, which implies that the use of WCRs in quantifying the energy budget of the Earth’s climate system can be problematic and requires a detailed first-principal analysis.”**

Satellite measurements of radiation intensity from the Earth do not measure energy flow from the Earth and may not be appropriate for making energy flow diagrams for the Earth (Mishchenko, 2013). [Trenberth, et al.](#) try and get around this problem by using ocean heat content (OHC), but estimates of OHC are quite inaccurate, relative to Earth's energy imbalance, and, in any case, the Earth energy imbalance is a constantly moving target, as Trenberth, et al. admit.

Works Cited

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