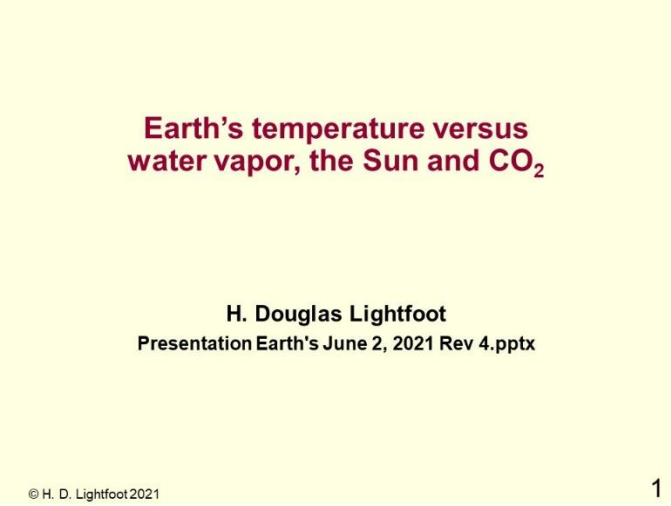
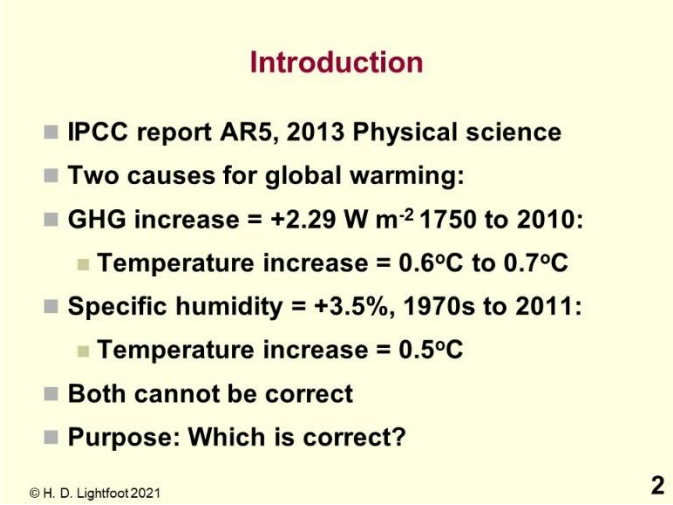
**Earth's temperature versus water vapor, the Sun and $CO_2$**

**Presented by: H. Douglas Lightfoot**
**2021**

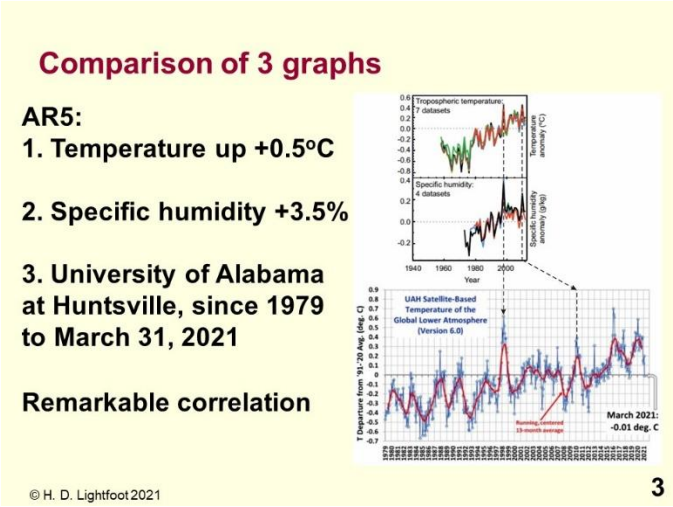
**Slide 1: Earth's temperature versus water vapor, the Sun and $CO_2$.** These PowerPoint slides and the words that go with them are the scientific evidence in the published paper with the same title [1]. The slides are numbered prominently to facilitate discussion because much of the material will be new to most people, including scientists.



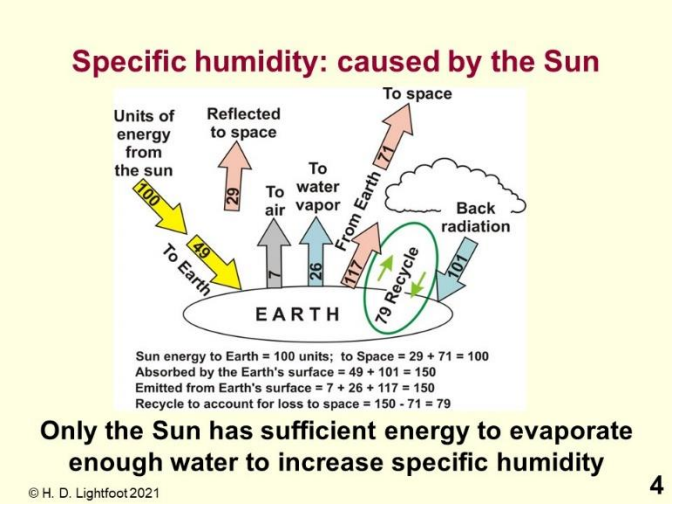

**Slide 2 Introduction.** In the Intergovernmental Panel on Climate Change (IPCC) report Climate Change 2013: The Physical Science Basis (AR5) are two competing causes for the increase in the Earth's temperature from the mid-1970s to today. One cause is the increase in greenhouse gases from 1750 to 2011. In Figure SPM.5, radiative forcing (RF) of all of the GHG increased by 2.29 W $m^{-2}$ and the increase for $CO_2$ alone is 1.68 W $m^{-2}$. On page 17 it is claimed this increase in RF caused an increase in temperature of 0.6 to 0.7°C since 1750. The second cause is on pages 38 and 42. It is an increase in specific humidity by 3.5% from the 1970s to 2011 that causes a temperature increase of 0.5°C. Both causes cannot be correct. The purpose of this presentation is to determine which is correct.



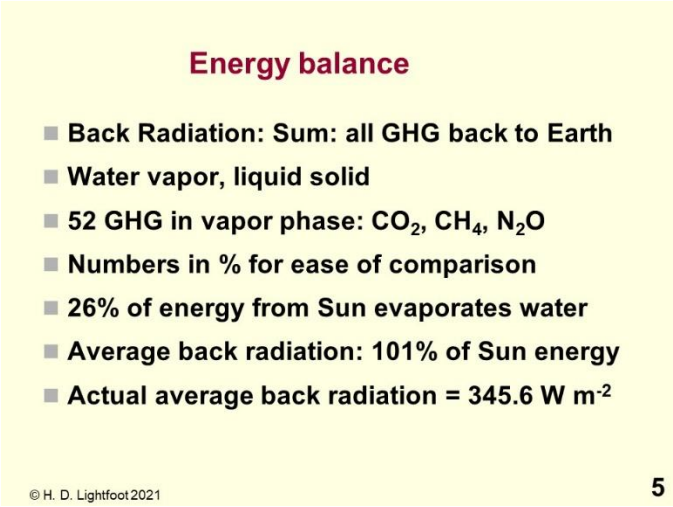

**Slide 3: Comparison of 3 graphs.** On page 38 of AR5 are graphs of temperature and specific humidity measurements from the first half of the 1970s to 2011. Specific humidity is the level of water vapor in the air in units of "grams of water per kilogram (kg) of dry air". Specific humidity is compared with two records of the Earth's temperature. The lowest chart by the University of Alabama at Huntsville (UAH) is satellite measurements of the Earth's temperature. The correlation is remarkably good. The question then becomes "Is there a cause for this correlation and, if so, what is it?"



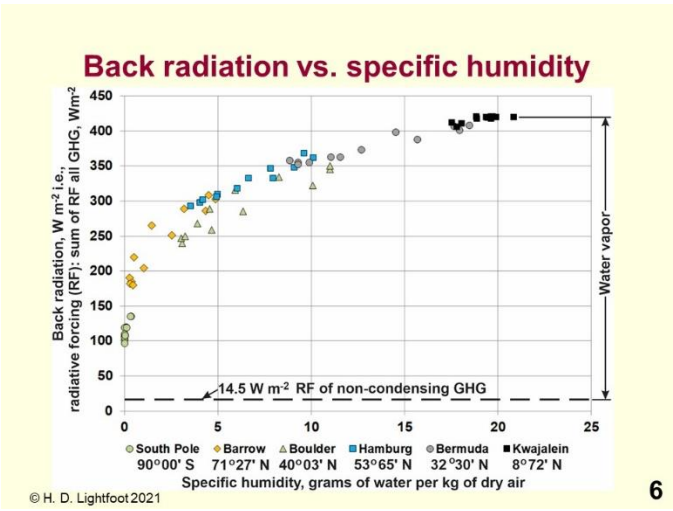
**Slide 4:** **Specific humidity: caused by the Sun.** An increase in specific humidity requires a large amount of water to be evaporated into water vapor. The sun is the only source of energy available to evaporate sufficient water to make a significant difference to the specific humidity. On average, 26%, or approximately one quarter, of the Sun's energy directed towards Earth is estimated to go to evaporating water, Stephens et al. (2012). On this slide, the numbers for the estimates of flows of energy are in percentages of the incoming solar energy for ease of comparison by the reader. Thus, it appears obvious the Sun controls the amount of water vapor in the air.



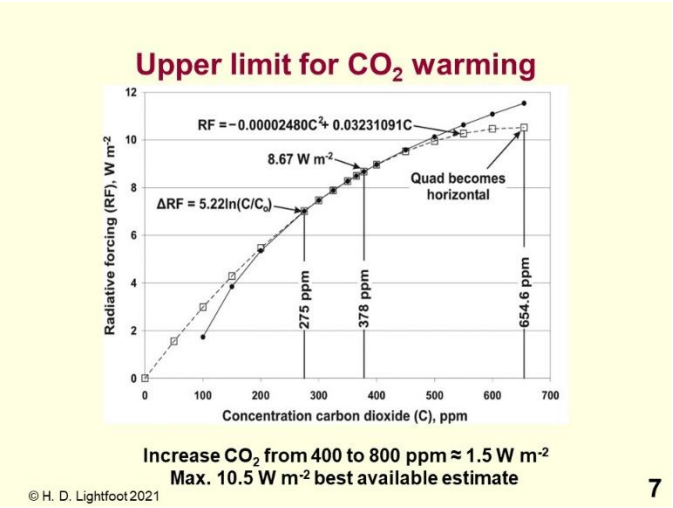

**Slide 5:** **Energy Balance.** Back radiation is the sum of the radiation back to the Earth from all of the greenhouse gases (GHG), such as, water vapor, $CO_2$, methane and nitrous oxide. Water vapor is subject to phase change under conditions found on Earth. However, the 52 GHG in Table 2.14 of AR4, including $CO_2$, methane ($CH_4$) and nitrous oxide ($N_2O$), are in the vapor phase under conditions found on Earth and obey the Gas Laws. Hereafter they are identified as the non-condensing GHG. The actual average back radiation is 345.6 W $m^{-2}$ in Stephens et al. (2012). This number is consistent with the measured back radiation by Wild (2001) as in the next slide.



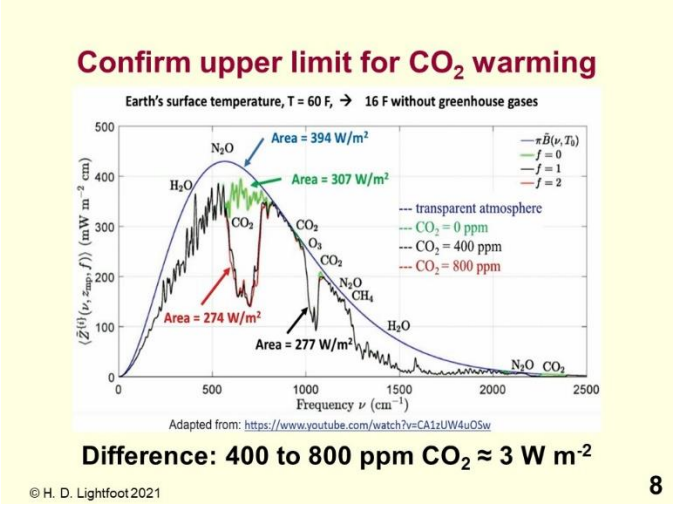

**Slide 6:** **Back radiation vs. specific humidity.** The warming by back radiation. Wild (2001) [5], is from a low of 97 W $m^{-2}$ at the South Pole to a high of 420 W $m^{-2}$ in the Tropics. There are six locations with an average back radiation for each of twelve months for a total of 72 points. The horizontal axis is in units of specific humidity. A line at 14.5 W $m^{-2}$ is added to show the maximum warming by all of the non-condensing GHG. The procedure to develop this line is on the next two slides.



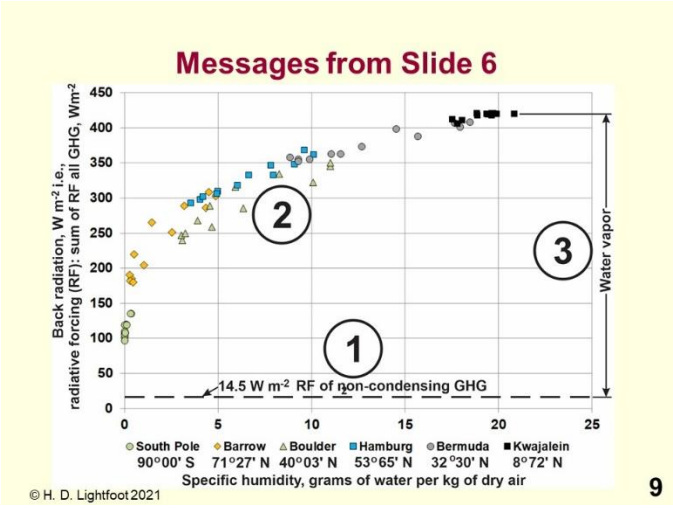
**<u>Slide 7:</u> Upper limit for $CO_2$ warming.** Increasing the current level of $CO_2$ from approximately 400 parts per million (ppm) to 800 ppm increases its warming effect by 1.5 W $m^{-2}$ from 9 to 10.5 $Wm^{-2}$ [2]. For practical purposes, $CO_2$ is at the upper limit for warming the Earth. Added to the 10.5 W $m^{-2}$ is methane currently 1.86 ppm, it has 28 to 36 times the warming of $CO_2$ for 0.67 W $m^{-2}$. The current level of nitrous oxide is 0.334 ppm. It is 265 to 298 times the warming of $CO_2$ for 0.94 W $m^{-2}$. The remaining GHG is 0.9 W $m^{-2}$ from Figure SPM.5 for a total of 13.0 W $m^{-2}$.



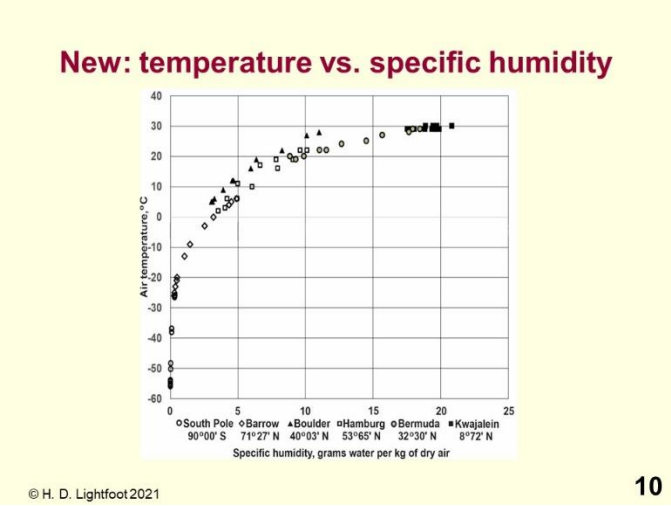

**<u>Slide 8:</u> Confirm upper limit for $CO_2$ warming.** This diagram is from a presentation and a paper by Will Happer [3]. The green line shows where the plot would be if there were no $CO_2$ in the atmosphere. The black line is for $CO_2$ at 400 ppm. The red line that is almost on top of the black line is for $CO_2$ at 800 ppm. Increasing the level of $CO_2$ from 400 to 800 ppm increases warming by 3.0 W $m^{-2}$. As this is larger than the 1.5 W $m^{-2}$ on the previous slide, the difference of 1.5 W $m^{-2}$ is added to 13.0 to give 14.5 W $m^{-2}$.



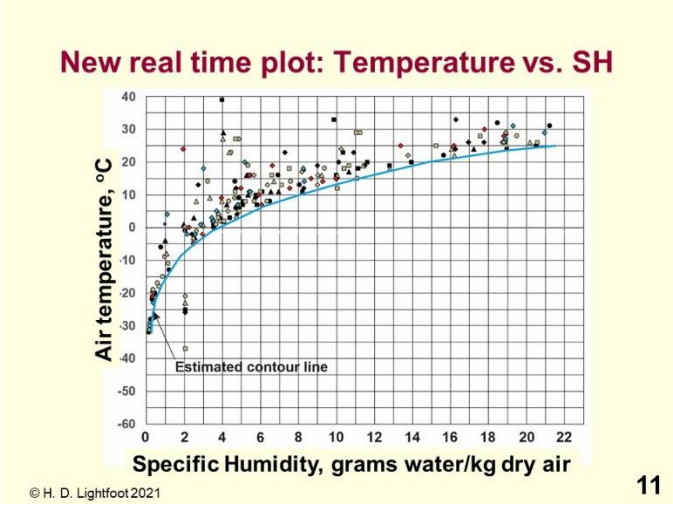

**<u>Slide 9:</u> Messages from the back radiation slide.** **Message 1:** Little, if any, change in warming by the non-condensing GHG from the Poles to the Tropics; they are passive with no apparent change from one day to the next. They contribute 14.9 % to 3.5 % of back radiation. **Message 2:** back radiation is dynamic and changes by a factor of 4.3 between the Poles and the Tropics. Warming by back radiation is 6.7 to 29.0 times that of the non-condensing GHG. **Message 3:** water vapor makes up 85.1 % to 96.5 % of back radiation. Water vapor contributes more warming than the non-condensing GHG by 5.7 to 28 times. The non-condensing GHG are overwhelmed by water vapor and are rendered ineffective as warming gases.



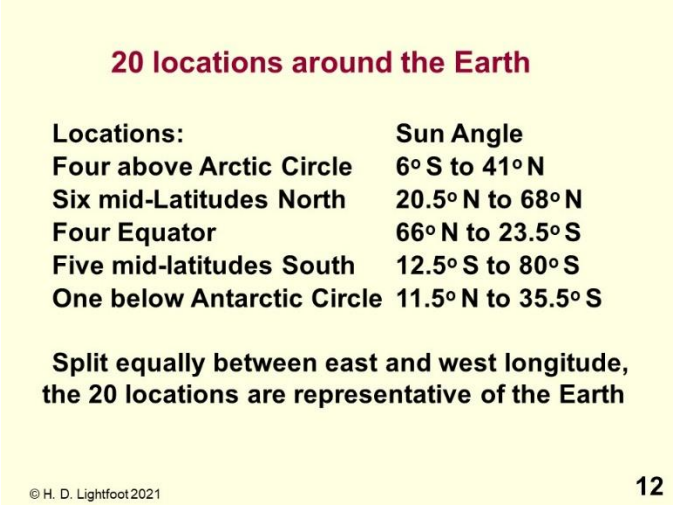
**Slide 10:** **New: temperature vs. specific humidity.** Using the same data as for constructing the previous slide, temperature versus specific humidity is plotted on this chart. This is new and useful information. The area under the curve is temperature caused by water vapor. Unfortunately, the data cannot be extended because the source of relative humidity from which to calculate specific humidity is no longer available. The plot appears fairly smooth because the temperature and relative humidity are averages. Fortunately, better information is readily available in real time as on the next slide.



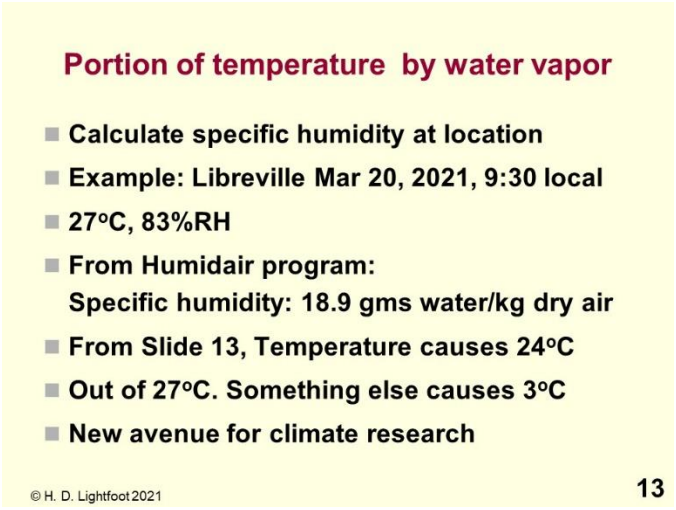

**Slide 11.** **New real time plot: Temp. vs. SH.** This plot is constructed of 200 points in sets of 20 locations in representative areas of the Earth. The points are recorded at the equinoxes and solstices from the autumn equinox in 2018 [4] to the spring equinox in 2021. The time at each event is random. Temperature and relative humidity (RH) are recorded from AccuWeather on a cellphone. The Humidair psychrometric program converts temperature and RH into specific humidity. The area below the smooth contour line is the portion of a temperature caused by water vapor. The portion above is caused by something else. For example, at specific humidity of 11, the temperature is 15°C at the contour line; temperatures above 15°C have another cause.



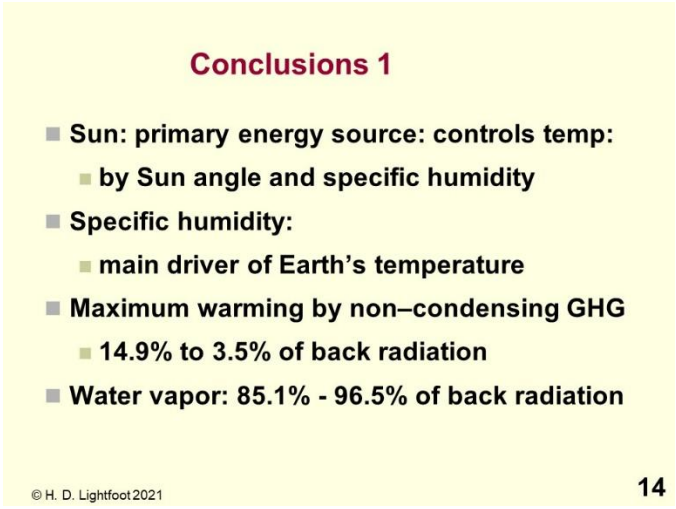

**Slide 12:** **20 locations around the Earth.** The 20 locations are reasonably representative of the Earth's temperatures and relative humidity. The locations are split relatively evenly between east and west longitude and among the latitudes. The Sun angle is shown because it controls the specific humidity. At the location below the Antarctic Circle, the sun goes from a high of 35.5° above the horizon at the summer solstice to 11° below it at the winter solstice. The same occurs above the Arctic Circle, but half a year out of phase. At the Equator, the Sun is always between 23.5° north and 23.5° south. The amount of Sun energy striking the Earth increases from a minimum at the Poles to a maximum at the Equator as shown by the specific humidity in the previous slide.



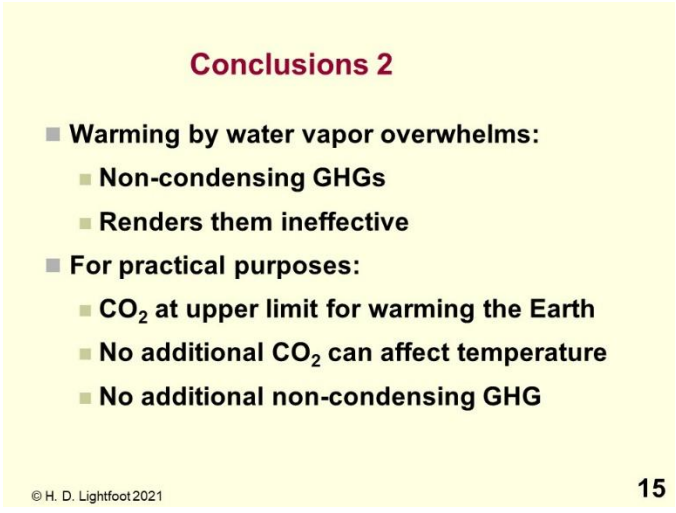
**Slide 13:** **Portion of temperature by water vapor.** Start by calculating the specific humidity at a location of interest. The example here is Libreville, Gabon. From AccuWeather on March 20, 2021, at 9:30 am local time it was 27°C and 83% RH. Using the Humidair psychrometric program, the specific humidity was 18.9 grams of water per kg of dry air. The temperature at this specific humidity on Slide 11 is approximately 24°C. The cause of the additional 3°C is unidentified. This is a new avenue for climate research.




**Slide 14:** **Conclusions 1**. The Sun is the primary energy source and controls Earth's local temperature through the Sun angle and specific humidity. Specific humidity is the main driver of the Earth's temperature and it is controlled by the Sun. The maximum warming by the non-condensing GHG, such as $CO_2$, methane and nitrous oxide, is 14.9% of back radiation at the low end and 3.5% at the upper end. Water vapor is 85.1% at the low end of back radiation and 96.5% at the upper end.




**Slide 15:** **Conclusions 2.** Warming by water vapor is so much larger that it overwhelms warming by the non-condensing GHGs and renders them ineffective. For practical purposes, $CO_2$ is at its upper limit for warming the Earth. Thus, no additional amount can increase the Earth's temperature. Specific humidity determines the portion of the Earth's temperature caused by water vapor. The temperature above this level is caused by something else. This opens a new avenue for climate science research.



**Slide 16:** References 1.

## References 1


- [1] Lightfoot H D, *Earth's Temperature Versus the Sun, Water Vapor and $CO_2$.* Journal of Basic & Applied Sciences, SET publisher, 2021, *17, 44-53*
- [2] Lightfoot H D, Mamer O A, *Calculation of atmospheric radiative forcing (warming effect) of carbon dioxide at any concentration,* Vol. 25, No. 8, 2014. See Fig. 4
- [3] W. A. van Wijngaarden W A, Happer W, *Dependence of Earth's Thermal Radiation on Five Most Abundant Greenhouse Gases*, Cornell University, Physics Atmospheric and Oceanic Physics, June 8, 2020.





**Slide 17:** References 2.

## References 2


- [4] Lightfoot H D, *The IPCC Made Three Fatal Errors in Assumptions about $CO_2$,* Journal of Basic and Applied Science, SET, 2020. See Appendix.
- [5] Wild M et al. *Evaluation of downward long wave radiation in general circulation models,* Journal of Climate, Vol. 14, 2001, Table 4, page 3233.





**Slide 18:** The end.

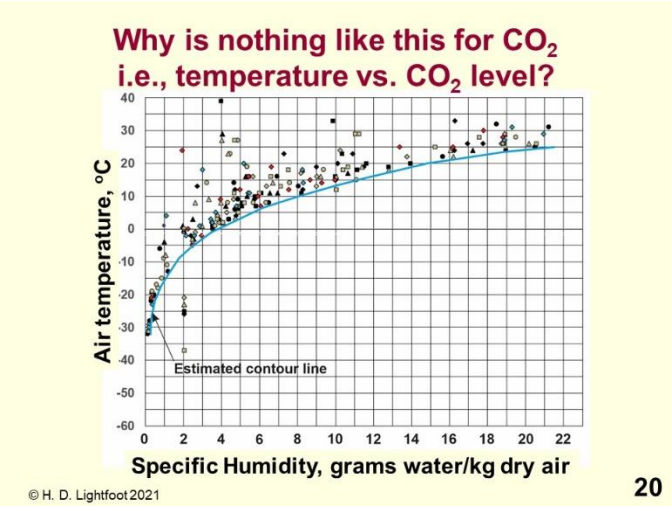
## The end



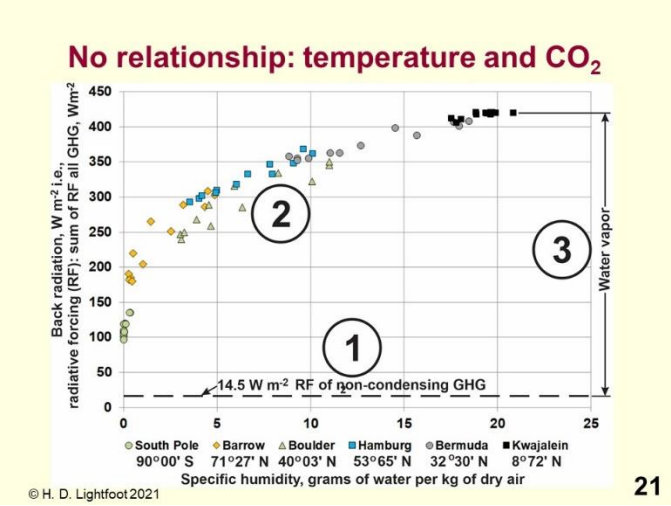

**Slide 19:** Supplementary information.

## Supplementary information

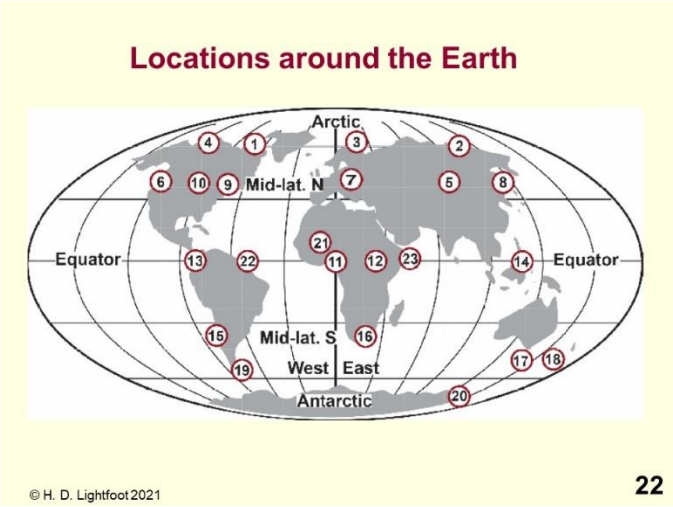
**Slide 20: Why nothing like this for $CO_2$, i.e., temperature vs. $CO_2$ level?** This chart is possible because of the large change in temperature from the Poles to the Tropics.



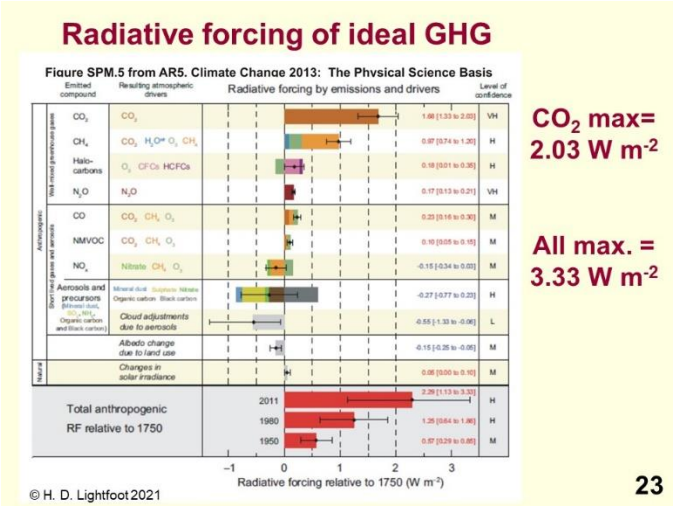

**Slide 21: No relationship: temperature and $CO_2$.** There is no change in the warming by the non-condensing GHGs from the cold Poles to the warm Tropics. Thus, there can be no temperature relationship between the warming by the non-condensing GHGs and the Earth's temperature.




**Slide 22: Locations around the Earth.** This is a pictorial representation of the locations around the Earth used in this study. It is the same information as in Table 1. This is Figure 4 from Reference [4].




**Slide 23: Radiative forcing of ideal GHG.** This slide is here in case it is needed for explanation.



**About the author:**

**H. Douglas Lightfoot:** Co-founder of the Lightfoot institute: www.thelightfootinstitute.ca

A retired Mechanical Engineer, H. Douglas Lightfoot graduated from the University of British Columbia, in Applied Science in 1952, and received an MBA from Concordia University in 1976. He spent eighteen years with Domtar Inc. at the Research Centre in Senneville, Quebec, working on research, engineering and economic studies of alternate energies as well as a wide variety of projects for the pulp and paper, chemicals and construction materials businesses. During this period, he wrote 21 research reports as sole author and 18 with co-authors.

Prior to joining Domtar, he spent a year as Business Analyst and five years as Design Engineer designing, building and starting up chemical plants at Dupont of Canada, Montreal, Quebec. Before that, twelve years of project engineering at Standard Chemical Limited, Beauharnois, Quebec.

He is a retired member of the Order of Engineers of Quebec, Professional Engineers of Ontario, and a Life Member of the American Society of Mechanical Engineers.

He continues to have an active interest in energy related subjects and the environment. For 23 years from 1992 he was an affiliated member of the McGill University Centre for Climate and Global Change Research ($C^2$GCR) that morphed into the Global and Climate Change Centre GEC3) and closed in 2015.

Since 1992, he has a dozen published scientific papers, contributed to published works and has written reports for the Centre on various subjects related to energy.

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