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Collaborative research: To confirm Dr. T. J. Blasing of Oak Ridge National Laboratory greenhouse gas data.

### **Intellectual Merit**

The IPCC (The Intergovernmental Panel on Climate Change) uses a Global Warming Potential (GWP) calculation. However, the calculation is flawed. The IPCC uses a calculation which is not based in reality. Their calculation assumes incorrectly all concentrations are equal. The IPCC ignored more than 15 published manuscripts which show the same order of GHG as Dr. Blasings. These are in Appendix 2. Methane is less of a greenhouse gas (GHG) than carbon dioxide. The table in appendix 2 shows 16 published manuscripts with similar results to Dr. Blasing's. See an excellent discussion of Absorption spectra of atmospheric gases in the IR, visible and UV regions[2]. Table 1 shows the absorbance spectra of greenhouse gases. Also TROP ICSU : Climate Change Education Across the Curricula Across the Globe has a good discussion of the Beer-Lambert Law[3]. Table 2 shows emissivity A. E. Galashev and O. R. Rakhmanova Emissivity of the Main Greenhouse Gases. This clearly shows water in the atmosphere is the worst GHG. Followed by carbon dioxide then methane and Nitrous oxide.

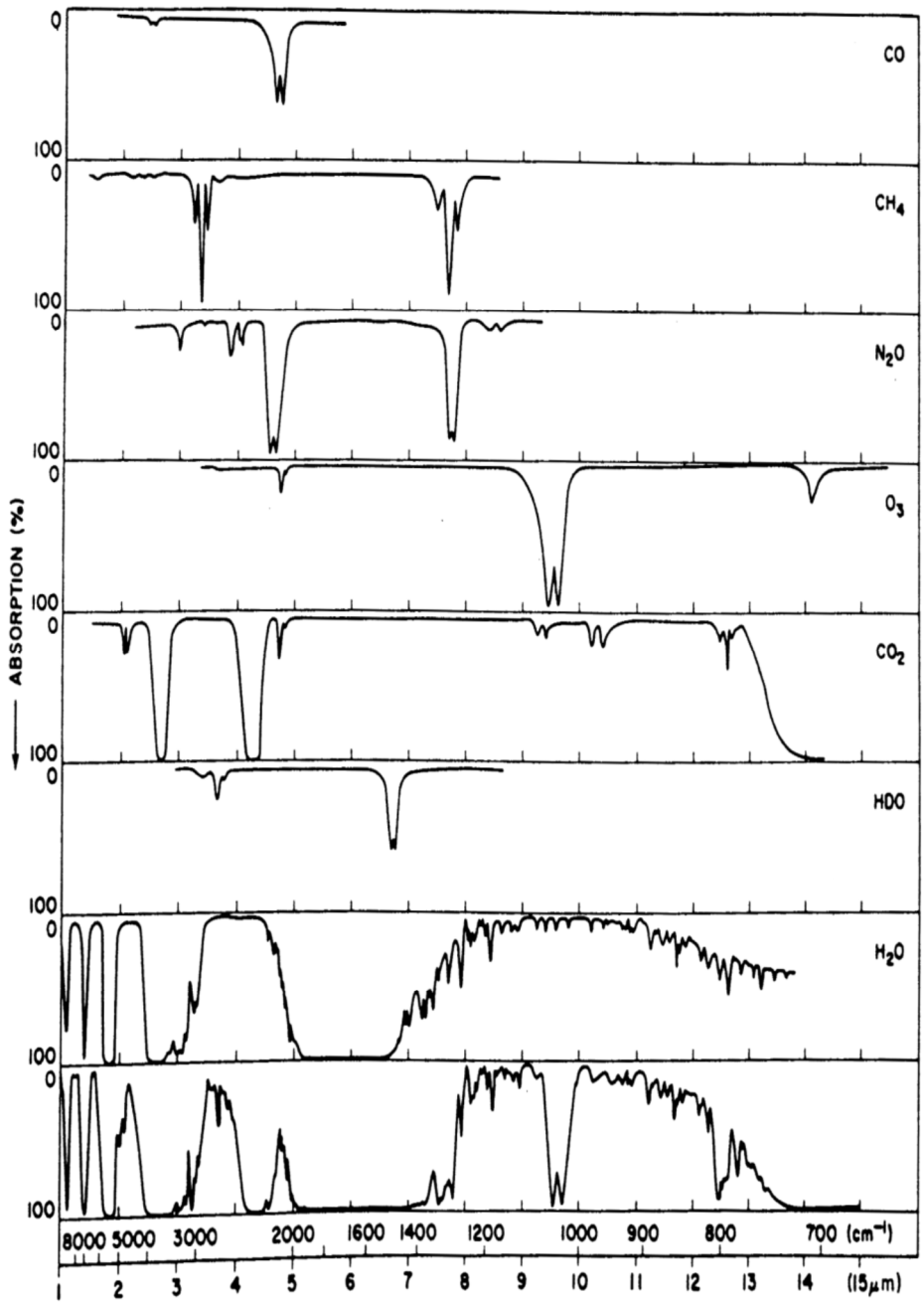


Table 1. Absorption spectra of atmospheric gases in the IR, visible and UV Regions[2].

Greenhouse Gas	Emission band $\text{cm}^{-1}$	Radiation Flux $\text{W/m}^2$
H <sub>2</sub> O	All bands	303.8
CO <sub>2</sub>	All bands	30.9-37.3
CH <sub>4</sub>	1200-1400	1.0-1.2
N <sub>2</sub> O	1200-1300	1.1-1.3
O <sub>3</sub>	900-1100	3.0-3.3

Table 2. Measured values of the radiation flux for a number of IR emission bands of the greenhouse gases

1. The Global Warming Potential (GWP) provides a simple measure of the radiative effects of emissions of various greenhouse gases, integrated over a specified time horizon, relative to an equal mass of CO<sub>2</sub> emissions. The GWP with respect to CO<sub>2</sub> is calculated using the formula:

$$GWP_i = \frac{\int_{TR}^{TH} a_i c_i(t) dt}{\int_{TR}^{TH} a_{CO_2} c_{CO_2}(t) dt}$$

where  $a_i$  is the instantaneous radiative forcing due to the release of a unit mass of trace gas,  $i$ , into the atmosphere, at time  $TR$ ,  $C_i$  is the amount of that unit mass remaining in the atmosphere at time,  $t$ , after its release and  $TH$  is  $TR$  plus the time horizon over which the calculation is performed (100 years in this table). The formula is adapted from page 210 of IPCC (2007). The GWPs given are from Table 8.A.1 of IPCC (2013). The short lifetime of ozone (hours-days) precludes a meaningful calculation of global warming potential on the time horizons (20, 100, and 500 years) listed in IPCC documents, however at higher altitudes in the atmosphere where ozone can accumulate, GWP of that gas may become significant, as its re-radiative function may eclipse other GHGs, albeit at lower pressures. Pressure variation will also be an indicator of GWP for the other gasses being considered. The IPCC GWP is based on each gas having an equal concentration. This of course is not reality. In reality, this would never happen. For example if we had as much nitrous oxide as carbon dioxide then people would be walking around with permanent smiles. The IPCC GWP is only good for comparison. To find out the actual effect of GHG we need to measure them like Dr. Blasings group did.

To change from the GWP Calculation to a data driven experience, we need to confirm the Dr. Blasing's data with another experiment at another facility. Our Oregon Lab is such a facility. Gases typically measured in parts per million (ppm), or parts per billion (ppb). Gasses measured in-Parts per trillion (ppt) are presented separately to facilitate comparison of numbers; however we will not be measuring them in this particular experiment. Global Warming Potentials (GWPs) and atmospheric lifetimes are from the Intergovernmental Panel on Climate Change (IPCC, 2013, Table 8.A.1), except for the atmospheric lifetime of carbon dioxide (CO<sub>2</sub>) which is explained in footnote 4. Additional material on greenhouse gases can be found in CDIAC's [Reference Tools](#). To find out how CFCs, HFCs, HCFCs, and halons are named, see [Name that compound: The numbers game for CFCs, HFCs, HCFCs, and Halons](#). Concentrations given apply to the lower 75-80 percent of the atmosphere, known as the troposphere. Sources of the current and preindustrial concentrations of the atmospheric gases listed in the table below are given in the footnotes. Investigators at the National Oceanic and Atmospheric Administration have provided the recent concentrations. Much of the data provided results from the work of various investigators at institutions other than CDIAC, and represent considerable effort on their part. We ask as a basic professional courtesy that you acknowledge the primary sources, indicated in the footnotes below, or in the links given in the footnotes. Concentrations of ozone and water vapor are spatially and temporally variable due to their short atmospheric lifetimes. A vertically and horizontally averaged water vapor concentration is about 5,000 ppm. Locally averaged water vapor concentration is difficult to measure precisely because it varies from one place to another because of quickly changing meteorological factors and from one season to the next. This precludes a precise determination of changes in water vapor on a global basis since pre-industrial time. However, a warmer atmosphere will likely contain more water vapor than at present, yet meteorological factors will dominate for any given locality. For a more detailed statement on water vapor from the National Oceanic and Atmospheric Administration, see the "water vapor" page at <http://lwf.ncdc.noaa.gov/oa/climate/gases.html>

## 2. Broader Impacts

1. The world population needs to know methane is less of a greenhouse gas than carbon dioxide. After publishing a paper in a journal such as PNAS the media will report the facts in the report. This will let the world know the IPCC GWP

calculation is wrong. Then we will present the findings at a conference like the AGU fall conference.

3. However using data such as Dr. Blasings is a much more preferred way to measure and calculate warming.

Dr. Blasings partial data are below.

Gas (Watts/m <sup>2</sup> )	Increased radiative forcing
CO <sub>2</sub> concentration is in ppm. (parts per million)	1.94
CH <sub>4</sub> Methane concentration is in ppb. (parts per billion)	0.50
Nitrous oxide (N <sub>2</sub> O)	0.20
Tropospheric ozone (O <sub>3</sub> )	0.40

We intend to calculate exposure time to raise each gas to 0.5 and 1.0°C at three different pressures, 1012mb, 500mb and 200mb. The beam is 250 watts from 2-24 um, The concentration will be troposphere concentration like 415ppm for CO<sub>2</sub>, 1.8ppm for CH<sub>4</sub>, 0.3ppm for N<sub>2</sub>O, and 0.07ppm for O<sub>3</sub>. We will determine whether the temperature change through three pressure ranges for each gas is linear or some other function. If non-linear, we will determine a predictive formula using polynomial regression. Gas concentrations will be > 98% pure. Pressure will be equilibrated throughout the measuring process. We cannot calculate the beam time required without first checking carbon dioxide. Therefore the funding required might be more than the initial funding.

Other greenhouse gases are even less effect and are called negligible in science. The complete data is in Appendix 1.

Project:

Start Date: after funding. End Date: Sixteen months after funding

Intellectual Merit

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NSF Program(s): Directorate For Geosciences (GEO) - Atmospheric and Geospace Sciences-  
Atmospheric Chemistry

This project will confirm or deny Dr. Blasings data in appendix 1. The chemicals tested will be: Carbon dioxide, Methane, Nitrous oxide, and Tropospheric ozone. For Infrared exposure, the beam has wavelengths from 2um to 24um. This is the higher energy portion of the infrared spectra. See figure 1 below.

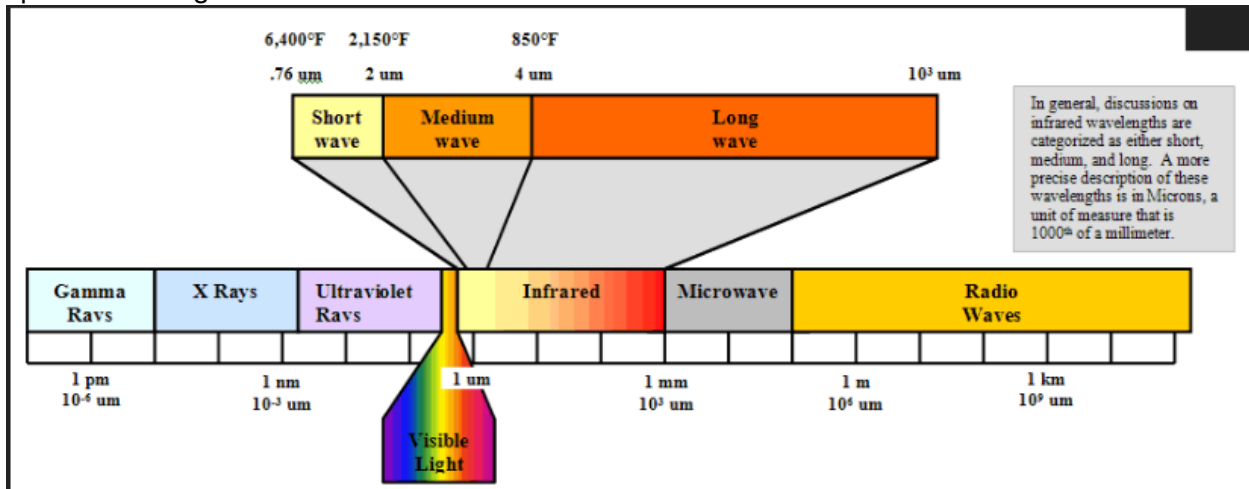


Figure 1 IR spectra [1]

**Experimental Plan (High Level):** We will expose four gases, (CO<sub>2</sub>, CH<sub>4</sub>, O<sub>3</sub> and N<sub>2</sub>O) at four pressure settings with long wavelength energy at 250 watts. Then measure the time to achieve a 0.5 °C and 1 °C temperature increase for each setup. Then calculate the watts per meter squared number and compare it with Dr. Blasings. After the experiment is finished, we will gather all the data, write a paper and publish it.

**Experimental Plan (Detail):** We will design and manufacture a pressure container to inject the gas prior to exposure. The design is Figure 2 below.

For temperature we will use the equation  $Q = m \cdot C_p \cdot (T_1 - T_2)$ , Where Q=watts, m=mass of sample, Cp is heat capacity of sample, ΔT is temperature change. Rearranging we have:  $\Delta T = Q / m \cdot C_p$

Procedure:

1. Evacuate the box to remove any air or previous gas in it.
2. Fill the box with a gas from the table until the pressure achieves set point.
3. Expose gas with 3X the watts in the table and measure the ΔT over time.
4. For carbon dioxide the watts will be  $1.94 \cdot 3 = 5.82$  watts
5. Measure the change in temperature and record it.
6. Repeat steps 1-5 for each species and pressure set points.
7. Summarize the data.
  - a. Plot for each gas Watts per pressure set point.

CO<sub>2</sub> Cp= 1.53 m=415 ppm= 415/10000=0.0415%= 0.0415 mole fraction

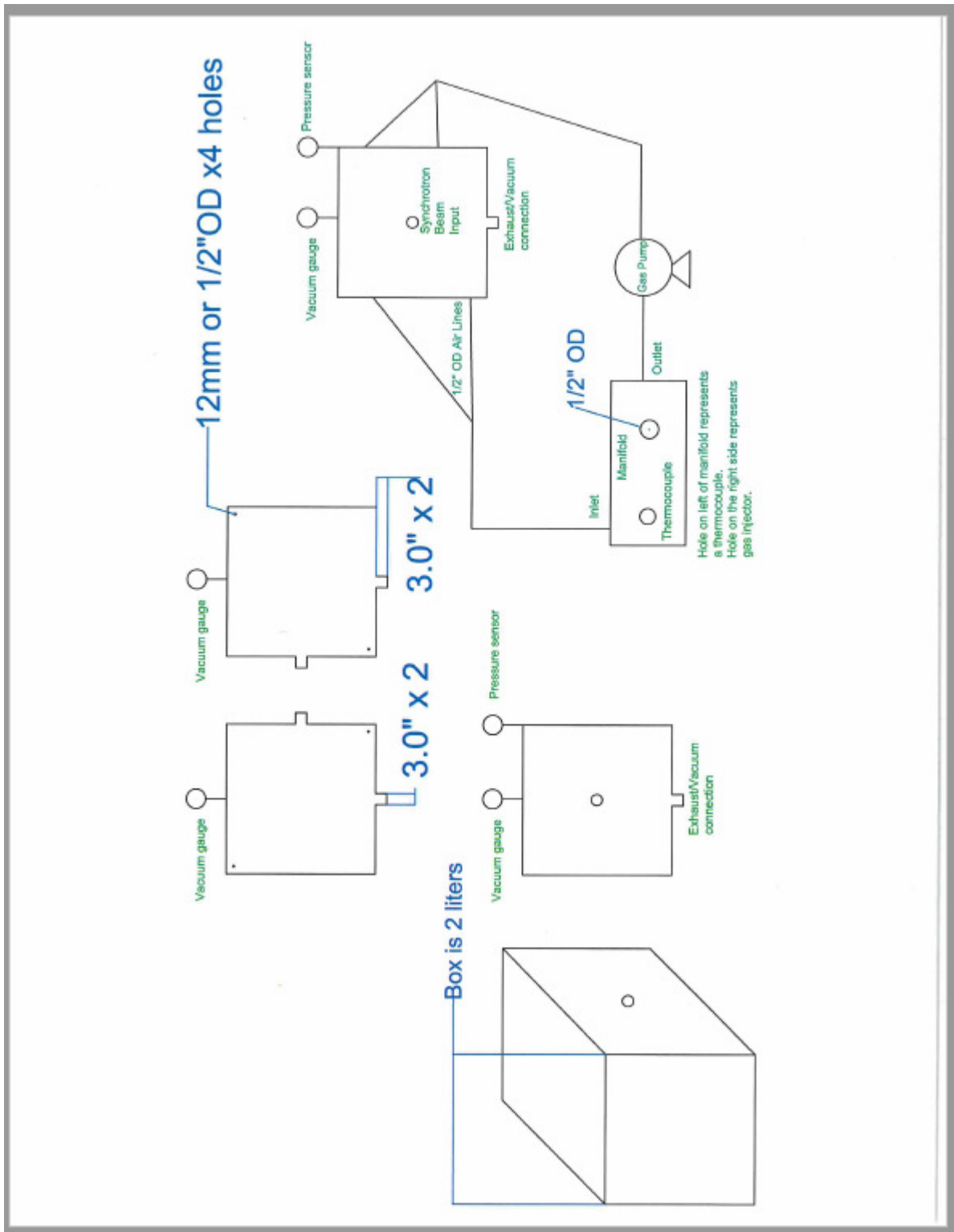


Figure 2.

Gas injector connection with MFC (mass Flow controller). Pressure controller with Argon. Thermocouple connection for temperature measurement. Pressure and Vacuum sensors the gas pump can choose along with the temperature, pressure and Vacuum sensors. Also the Mass flow

controller (MFC). The total volumes should be 2 liters. We will need small pressurized bottles of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>) and O<sub>3</sub>. The exposure box will be constructed with 316 stainless steel.

Gas pump for mixing.

cross flow for mixing.

Exposure to the exposure container is by fiber optics. The exposure tool in these wavelengths generates heat so we will use fiber optics to deliver the exposure. Then use an intensity meter to measure the input to the container.

#### Appendix 1

Gas	Pre-1750 tropospheric concentration <sup>1</sup>	Recent tropospheric concentration <sup>2,3</sup>	GWP <sup>4</sup> (100-yr time horizon)	Atmospheric lifetime <sup>5</sup> (years)	Increased radiative forcing <sup>6</sup> (W/m <sup>2</sup> )
<b>Concentrations in parts per million (ppm)</b>					
Carbon dioxide (CO <sub>2</sub> )	~280 <sup>7</sup>	399.5 <sup>2,8</sup>	1	~ 100-300 <sup>5</sup>	1.94
<b>Concentrations in parts per billion (ppb)</b>					
Methane (CH <sub>4</sub> )	722 <sup>9</sup>	1834 <sup>2</sup>	28	12.4 <sup>5</sup>	0.50
Nitrous oxide (N <sub>2</sub> O)	270 <sup>10</sup>	328 <sup>3</sup>	265	121 <sup>5</sup>	0.20
Tropospheric ozone (O <sub>3</sub> )	237 <sup>1</sup>	337 <sup>2</sup>	n.a. <sup>3</sup>	hours-days	0.40
<b>Concentrations in parts per trillion (ppt)</b>					
CFC-11 (CCl <sub>3</sub> F)	zero	232 <sup>3</sup>	4,660	45	0.060
CFC-12 (CCl <sub>2</sub> F <sub>2</sub> )	zero	516 <sup>3</sup>	10,200	100	0.166



CFC-113(CCl <sub>2</sub> CIF <sub>2</sub> )	zero	72 <sup>3</sup>	5,820	85	0.022
HCFC-22(CHClF <sub>2</sub> )	zero	233 <sup>3</sup>	1,760	11.9	0.049
HCFC-141b(CH <sub>3</sub> CCl <sub>2</sub> F)	zero	24 <sup>3</sup>	782	9.2	0.0039
HCFC-142b(CH <sub>3</sub> CClF <sub>2</sub> )	zero	22 <sup>3</sup>	1,980	17.2	0.0041
Halon 1211 (CBrClF <sub>2</sub> )	zero	3.6 <sup>3</sup>	1,750	16	0.0010
Halon 1301 (CBrClF <sub>3</sub> )	zero	3.3 <sup>3</sup>	6,290	65	0.0010
HFC-134a(CH <sub>2</sub> FCF <sub>3</sub> )	zero	84 <sup>3</sup>	1,300	13.4	0.0134
Carbon tetrachloride (CCl <sub>4</sub> )	zero	82 <sup>3</sup>	1,730	26	0.0140
Sulfur hexafluoride (SF <sub>6</sub> )	zero	8.6 <sup>3,11</sup>	23,500	3200	0.0049

Appendix 2.

Year	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Total Anthropogenic	Total natural	Total
1750	0.00	0.00	0.00	0.00	0.26	0.26
1850	0.16	0.05	0.01	0.18	0.16	0.35

1900	0.36	0.12	0.03	0.23	0.13	0.36
1910	0.42	0.15	0.04	0.20	0.15	0.35
1920	0.51	0.17	0.05	0.29	0.17	0.46
1930	0.55	0.20	0.05	0.32	0.18	0.50
1940	0.63	0.22	0.06	0.36	0.20	0.56
1950	0.66	0.24	0.07	0.35	0.21	0.57
1960	0.72	0.29	0.07	0.29	0.25	0.54
1970	0.86	0.36	0.09	0.30	0.13	0.43
1980	1.10	0.43	0.10	0.66	0.19	0.85
1990	1.34	0.49	0.12	1.13	0.22	1.35
2000	1.58	0.51	0.15	1.63	0.26	1.89
2010	1.88	0.52	0.17	1.97	0.11	2.08
2015	2.03	0.53	0.18	2.30	0.15	2.44
208	2.15	0.54	0.19	2.53	0.09	2.62

Table 1. Effective Radiative Forcing ( $\text{Wm}^{-2}$ ) time series from 1750-2018

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[3] TROP ICSU : Climate Change Education Across the Curricula Across the Globe  
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[4] A. E. Galashev and O. R. Rakhmanova Emissivity of the Main Greenhouse Gases. Institute of Industrial Ecology, Ural Branch, Russian Academy of Sciences, Yekaterinburg, Russia email:galashev@ecko.uran.ru Received July 6, 2012, ISSN 19907931, Russian Journal of Physical Chemistry B, 2013, Vol. 7, No. 3, pp. 346–353. © Pleiades Publishing, Ltd., 2013. Original Russian Text © A.E. Galashev, O.R. Rakhmanova, 2013, published in Khimicheskaya Fizika, 2013, Vol. 32, No. 6, pp. 88–96.

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