# Journal of Chemical, Biological and Physical Sciences

An International Peer Review E-3 Journal of Sciences

Available online atwww.jcbsc.org

Section D: Environmental Science



CODEN (USA): JCBPAT

**Research article** 

# **Analyses of IPCC's Warming Calculation Results**

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Received: 27 September 2013; Revised: 15 October 2013; Accepted: 20 October 2013

Abstract: Some researchers have noticed that the warming calculations of Intergovernmental Panel on Climate Change (IPCC) are not always based on the atmospheres, which use the global average values. CO2 effect of 26% in greenhouse phenomenon is based on the modified U.S. Standard Atmosphere 1976 (USST 76 atmosphere) containing only 50% of water in comparison to the true value. The calculations prove that the warming of 0.76 °C can be achieved if the USST 76 atmospheric model is applied and constant relative humidity (RH) assumed. The analysis also reveals that IPCC's scenario presentation contains choices, which make the warming results looking higher than they should be. All the climate sensitivity values above 1.7 °C conflict with the explanation given by IPCC for the 1750 - 2005 periods. The global warming potential (GWP) values of CH<sub>4</sub> and N<sub>2</sub>O are applicable only for small concentration changes and in higher concentrations these greenhouse (GH) gases are even weaker than CO<sub>2</sub>. The ultimate worst case scenario is the release of methane from the methane clathrates on the ocean floor. The calculations show that the release would cause 2.1 °C temperature increase, which is only 68% of the CO<sub>2</sub> warming effect. The spectral analysis show that in the prevailing atmospheric conditions the warming potency of methane is about 14% from the potency of CO<sub>2</sub>, and the same of N<sub>2</sub>O is about 17%. The effect of water in the same conditions is 15.2 times greater than that of CO<sub>2</sub>.

**Key words:** Climate change, Greenhouse Effect, Greenhouse Gases, CO<sub>2</sub> Contribution, IPCC Scenarios, GWP Values, Global Warming Potentials, Methane Clathrate, Warming Calculations

#### INTRODUCTION

All scientists have not approved the warming calculations reported by IPCC. Miskolczi and Mlynczak<sup>1</sup> were the first in their finding that the CO<sub>2</sub> accounts only 9% greenhouse (GH) phenomenon, which is much less than 26% reported by Kiehl and Trenberth<sup>2</sup>. Ollila<sup>3</sup> has found that CO<sub>2</sub> can contribute about 10% in GH phenomenon.

The reason for this big difference is in the atmospheres applied. Kiehl and Trenberth<sup>2</sup> have used modified USST 76 atmosphere which contains about 50% less water than the real average global atmosphere (AGA). Even though this has no direct effect on the real warming calculations, it creates a strong erroneous image that  $CO_2$  is a very powerful GH gas.

Another big disagreement concerns so called positive feedback of water. IPCC supports the mechanism, which doubles the effects of GH gases. According to the radiosonde humidity measurements since 1948 the real relative humidity (RH) has been slightly falling<sup>4-6</sup>.

IPCC's latest report includes the scenarios, which forecast rather high temperature changes during the next 100 years, which may be not be in line with the reported GH gas effects. IPCC has also updated the GWP values for GH gases. It looks like that even many climate researchers having no spectral analysis knowledge interpret the GWP values to mean that for example methane is 25 times stronger infrared radiation absorber than  $CO_2$  over large concentration range.

### AVERAGE GLOBAL ATMOSPHERE PROFILES

A common practise in spectral analyses is to apply a single atmospheric composition at a time. Therefore, it is crucial that the values of an applied atmosphere are as close as possible to the average values of the Earth.

I have calculated the average global atmosphere (AGA) profiles<sup>3</sup> by combining the values of three climate zones published by Ellingson *et al.*<sup>7</sup>. These profiles are available also in the Spectral Calculator program<sup>8</sup>, which I have used in the spectral analyses of this paper.

The AGA's surface temperature is 15 °C, and the concentrations of the anthropogenic GH gases were measured in 2005 (AGA 2005) or in 2012 (AGA 2012). The GH gas concentrations (2005/2012) are:  $CO_2$  (379/393 ppm),  $CH_4$  (1.774/1.866 ppm), and  $N_2O$  (0.319/0.324 ppm), as reported by IPCC<sup>9</sup> and Blasing<sup>10</sup>.

It has not been possible to define user profiles with Spectral Calculator, and, instead, I have used Polar Summer atmosphere values, modifying the profiles where needed. The temperature and pressure profiles of AGA are the same as Polar Summer values, but GH gas profiles have been adjusted to the 2005 and 2012 values, using scale factors.

A key issue in the spectral analyses and warming calculations seems to be the water content of the atmosphere. Vonder Haar et al.<sup>11</sup> have published a summary of the atmospheric water content based on the NASA Water Vapor Project (NVAP) dataset, and the graph spanning 20 years is copied in **Figure 1**. The water content expressed in prcm (precipitable water in centimetres) varies in some degree. I have used the average value of 2.6 prcm – the same value as used by other researchers<sup>1,5</sup>.



**Figure 1:** The global monthly average values of water content in the atmosphere<sup>11</sup>. TPW means total precibitable water.

As noticed before, some researchers have applied the USST 76 atmospheric model, the values of which have two major differences in comparison with those of AGA. The first difference is in GH gas concentrations: USST 76 uses the values of the year 1976, which are considerably lower than those of 2005 or 2012.

The main difference between AGA and USST 76 atmosphere is in the water content: AGA 2.6 prcm and USST 76 atmosphere 1.43 prcm. The water profiles of the USST 76 atmosphere and the AGA are depicted in **Table 1**.

H <sub>2</sub> O	USST 76	AGA	USST 76	AGA
alt, km	vmr	vmr	g/m <sup>3</sup>	g/m <sup>3</sup>
0	7.750*10 <sup>-3</sup>	$1.656*10^{-2}$	5.857	12.037
1	6.070*10 <sup>-3</sup>	1.246*10 <sup>-2</sup>	4.171	8.264
2	4.630*10 <sup>-3</sup>	9.539*10 <sup>-3</sup>	2.885	5.756
3	3.180*10 <sup>-3</sup>	5.705*10 <sup>-3</sup>	1.792	3.122
4	$2.160*10^{-3}$	3.234*10 <sup>-3</sup>	1.096	1.607
5	1.400*10 <sup>-3</sup>	2.226*10 <sup>-3</sup>	0.640	0.999
6	9.250*10 <sup>-4</sup>	1.412*10 <sup>-3</sup>	0.379	0.571
7	5.720*10 <sup>-4</sup>	8.685*10 <sup>-4</sup>	0.210	0.316
8	3.670*10 <sup>-4</sup>	5.078*10 <sup>-4</sup>	0.120	0.166
9	1.580*10 <sup>-4</sup>	2.814*10 <sup>-5</sup>	0.046	0.082
10	7.000*10 <sup>-5</sup>	1.433*10 <sup>-4</sup>	0.018	0.037
11	3.610*10 <sup>-5</sup>	5.475*10 <sup>-5</sup>	0.008	0.013
Precipitated water in cm's (prcm)			1.43	2.60

Table -1: Water profiles of U.S. Standard Atmosphere 1976 (USST 76) and average globa	al
atmosphere (AGA). Acronym vmr is volume mixing ratio.	

My conclusion is that there are many climate researchers who are not aware about this major difference or they do not understand the impacts of water on the GH effect.

#### COMMON FEATURES OF LW ABSORPTION IN THE ATMOSPHERE

Normally, researchers use wavenumbers in presenting the results of absorption calculations. I prefer wavelengths, because some basic features that are relevant here can be readily seen in graphical presentations. The emitted radiation from the Earth's surface and the band areas absorbed by GH gases in the troposphere are depicted **Figure 2**.



Figure 2: The absorption graphs of the main GH gases in the AGA 2005 conditions in the troposphere.

The band area of each GH gas in **Figure 2** is calculated when it is the only gas in the AGA conditions. The real combined absorption of GH gases is not a simple summary of the band areas. The real total absorption can be calculated only when all the GH gases are present at the same time. The total absorption is depicted by the purple line. The maximum wavelength in the absorption presentations is  $25 \,\mu$ m, because several calculations show that water can totally absorb the infrared radiation in the range from 22 to 100  $\mu$ m in any atmosphere.

Some important conclusions can be drawn from the absorption graphs. The GH gases have different effects on the total absorption when compared to the absorption caused by water. The light green area is the main absorption area due to  $CO_2$ . The absorption area of the wavelength band from 12.5 to 14  $\mu$ m is much bigger than that of the wavelength band from 16.5 to 19  $\mu$ m on the other side of the  $CO_2$  peak top. The reason for this is that the emitted radiation decreases gradually as the wavelength gets longer and the absorption of water gets stronger. It can be seen that the emitted radiation is practically fully absorbed already by the  $CO_2$  concentration of 379 ppm from the wavelength 14  $\mu$ m onward as a combined effect of H<sub>2</sub>O and CO<sub>2</sub>.

Oxygen pushes the total absorption curve effectively upward, but  $CH_4$  and  $N_2O$  only minimally increases the total absorption in comparison to water absorption. The light blue are in **Figure 2** represents the area which is not absorbed by GH gases. The radiation flux transmitted into space in the clear sky conditions is 84.6 W/m<sup>2</sup>, and it is the only potential area for increased absorption caused by higher GH gas concentrations. In all-sky conditions, clouds absorb about 66% of the transmitted flux, and thus about 28.5 W/m<sup>2</sup> - that is, only about 9% of the emitted LW radiation - escapes directly into space.

It is not generally known that the absorption LW (longwave) radiation emitted from the Earth's surface proceeds very quickly.

This feature is illustrated in **Figure 3** showing that at the height of 1 km already 90% of the total absorption has been achieved<sup>3</sup>.



Figure 3: The absorption of LW radiation as a function of the altitude.

## **CONTRIBUTIONS OF GH GASES IN GREENHOUSE PHENOMENON**

As referred earlier Miskolczi and Mlynczak<sup>1</sup> were the first in their finding that the CO<sub>2</sub> accounts only 9% greenhouse (GH) phenomenon, which is much less than 26% reported by Kiehl and Trenberth<sup>2</sup>. Ollila<sup>3</sup>has reported that using USST 76 atmosphere the CO<sub>2</sub> impact would be 26% and in average global atmosphere (AGA) it would be 11% (9.5% if nonlinearity is observed).

Kiehl and Trenberth have referred to the atmosphere specified by Liou<sup>12</sup>. Even though Liou calls it "Standard Atmosphere", it turns out that it is exactly the same USST 76 atmosphere as specified in Spectral Calculator. Because Kiehl and Trenberth<sup>2</sup> used actually modified USST 76 atmosphere containing 12% less water than the original USST 76, I carried out further analyses, using exactly the same atmosphere. In these calculations Spectral Calculator<sup>8</sup> program was applied, which utilizes line-by-line (LBL) calculation method and HITRAN database. The details are the same as described by Ollila<sup>3</sup>.

The **Table 2** summarizes the calculation results. Utilising the modified USST 76 atmosphere up to 120 km altitude, the results are very close to Kiehl and Trenberth<sup>2</sup>. The biggest difference is in the warming effects of methane and nitrogen oxidule. I have analysed this difference more closely in section "Warming Caused by Methane Clathrates Releases".

Table- 2: CO <sub>2</sub> contribution percentages according to different studies. AGA is the average globa
atmosphere and USST 76* is the modified U.S. Standard Atmosphere 1976 with 12% less water

GH gas	AGA	USST 76*	USST 76*	Kiehl & Trenberth
_	11 km	11 km	120 km	
H <sub>2</sub> O	87	66	63	60
$CO_2$	10	29	27	26
CH <sub>4</sub> & N <sub>2</sub> O	1	3	3	6
O <sub>3</sub>	2	2	7	8

If the calculation was carried out up till 11 km, the CO<sub>2</sub> impact was 29% and it decreased to the value of 27%, when it was calculated up till 120 km. This may look like an illogical result knowing that CO<sub>2</sub> concentration is practically the same from the ground up to 80 km. The explanation is the increased absorption of ozone. The maximum concentration of ozone in the stratosphere is even 100 times greater than that in the troposphere. The ozone absorption band is between 9...10  $\mu$ m, where water absorption is very low. These are the reasons, why ozone absorption increases from 2% to 7% as the altitude increases. This is illustrated in **Figure 8**, where ozone absorption band areas are depicted in the troposphere and in the altitude of 120 km.

Myhre and Stordal<sup>13</sup> have achieved the same kind of results concerning the warming effects of  $CO_2$  in the upper atmosphere. They even make a conclusion that  $CO_2$  has a cooling effect in the stratosphere.

The author's conclusion is that  $CO_2$  is so powerful GH gas in its absorption wavelength zone that the absorption does not increase above the troposphere at all. Actually, the  $CO_2$  effect is fully developed already at the altitude of 2 km. Because ozone increases the total absorption, the relative portion of  $CO_2$  decreases but this is not a cooling effect. The total absorption increase from 11 km (302.71 Wm<sup>-2</sup>) to 120 km (308.94 Wm<sup>-2</sup>) was found to be divided in the following way:  $O_3$  81%, H<sub>2</sub>O 14% and CH<sub>4</sub>& N<sub>2</sub>O 5%. Because the absorption areas of CH<sub>4</sub> and N<sub>2</sub>O overlap almost totally, it makes sense to calculate the combined effect.

The behaviour of  $CO_2$  absorption in the upper atmosphere is one of the good reasons to restrict the GH phenomenon into the troposphere. The exact altitude is not easy to specify. Miskolczi has calculated that the GH effect stops at the altitude of 12.3 km<sup>14</sup>. The author has used the average troposphere altitude of 11 km. The choice has a very small effect on the results. The calculations show that the total absorption increases only 0.3% from 11 km to 13 km.

# IMPACTS OF ATMOSPHERES IN WARMING CALCULATIONS

IPCC refers to three studies on the radiative warming by  $CO_2$  in the third assessment report  $(TAR)^{15}$ . These research articles are published by Myhre et al.<sup>16</sup>, Shi<sup>17</sup>, and Hansen et al.<sup>18</sup>. All these studies give a mathematical equation for the radiative forcing caused by  $CO_2$ . The most commonly referred is Equation (1) presented by Myhre et al.<sup>16</sup>

$$\Delta F = 5.35 * \ln(C/280), \tag{1}$$

where  $\Delta F$  is the radiative forcing increase (W/m<sup>2</sup>) and C is the CO<sub>2</sub> concentration (ppm). The other equations are more complicated but the results are close to each other.

IPCC has a contradictory way to calculate the effects of atmospheric humidity changes. According to IPCC, actually 50% of the radiative forcing of GH gases is caused by water<sup>19</sup>, because the computer models maintain constant RH. IPCC calls this feature a positive feedback of water. On the other hand the historical warming till 2005 contains no water vapor effect. I have analysed this issue more closely in section "Climate Sensitivity Analysis".

The author has found the use of water feedback in the Shi's paper<sup>17</sup> but not in other two papers<sup>16,18</sup>. It is easy to believe that the equations include water feedback effect, because the radiative warming values according to these equations are very high. That is why I have analyzed the historical warming values of IPCC based on the assumption of positive water feedback in the calculations.

Constant RH assumption is not in line with the actual humidity measurements. Miskolczi<sup>5</sup> has analyzed the TIGR (The Thermodynamic Initial Guess Retrieval) and NOAA (National Oceanic and Atmospheric Administration) databases and he found that  $H_2O$  content has decreased 0.0106%

annually and totally 0.6466% in 61 years since 1948. There might be a freezing problem of hygrometer humidity measurements in the higher altitudes but even the lower altitude measurements above 0 °C show descending trends of humidity. Paltridge<sup>4</sup> has found clear negative humidity trends in the troposphere during the period of 1973 - 2007. Hoinka<sup>6</sup> has analyzed that during the period of 1979-1993 the mixing ratio of water vapor in the troposphere has decreased about 10% per decade. There are other interpretations like that of Dai et al.<sup>20</sup> who have readjusted the raw radiosonde measurements mainly from IGRA (the Integrated Global Radiosonde Archive). Their conclusion is that there is a slight increase in troposphere water vapor.





In **Figure 4** some RH graphs from the NOAA database (maintained by Kalnay et al.<sup>21</sup>) are depicted for different altitudes since 1948. The descending trends can be found also for the altitudes below 3 kilometers, where freezing problem should be very rare.

Both Miskolczi<sup>14</sup> and Ollila<sup>3</sup> have calculated that the decreased water amount has practically compensated the  $CO_2$  effect since 1750 up to date. Miskolczi has introduced so called constant GH effect theory, which means that the atmosphere maintains the constant GH effect<sup>14</sup>. If this is true, then the increased  $CO_2$  concentrations would be compensated by water also in the future.

Ollila has used the factor 5.35 in transforming an absorption energy change into a temperature change, which is applicable for small changes in the AGA conditions<sup>3</sup>. For the USST 76 atmosphere this factor can be calculated utilizing two points containing the actual temperatures and total absorptions<sup>3</sup>: the USST 76 atmosphere (15 °C / 279.90 Wm<sup>-2</sup>) and the polar winter atmosphere (-1 °C / 216.57 Wm<sup>-2</sup>). The calculated factor is 3.96 and it has been used in transforming the calculated absorption values into temperature changes in **Table 3**.

The calculation results of CO<sub>2</sub> radiative warming using USST 76 atmosphere have been depicted in **Table 3**. Also the IPCC values have been added without constant RH effect. The IPCC values have been calculated as values of Equation (1) according to Myhre et al.<sup>22</sup> and the temperature changes can be calculated by multiplying the radiative forcing values by the climate sensitivity parameter  $\lambda$ , which is typically 0.5.

CO <sub>2</sub> , ppm	Absorption, W/m <sup>2</sup>	IPCC, CO <sub>2</sub> effect, °C	USST 76 atm., °C
280	278.26	0	0.00
379	279.90	0.40	0.41
550	281.97	0.90	0.94
580	282.27	0.97	1.01
700	283.36	1.23	1.29
800	284.16	1.49	1.49
950	285.21	1.63	1.76
1200	286.73	1.95	2.14

**Table- 3:** Absorption energies and temperature changes in the USST 76 atmosphere. The IPCC values are according to Equation (1) by Myhre at al.<sup>22</sup> multiplied by 0.5 for cutting off water impact.

The different temperature graphs as a function of  $CO_2$  concentration have been depicted in **Figure 5**. The lowest values originate from the AGA conditions<sup>3</sup>.

When a logarithmic fitting is calculated for AGA values, the Equation (2) is obtained:

 $\Delta E = -0.10089 + 3.8195 * \ln(C/280),$ 

Where  $\Delta E$  is the change of the absorption energy flux starting (W/m<sup>2</sup>) and C is the concentration of CO<sub>2</sub> (ppm). The correlation r<sub>2</sub> is 0.998. The logarithmic fitting seems to be a very accurate form. It should be noticed that  $\Delta F$  and  $\Delta E$  in the equations (1) and (2) are not the same thing.

(2)





It is easy to see in **Figure 5** that the temperature graph calculated in the USST 76 atmosphere values multiplied by 2 (constant RH effect) is almost the same as the graph of Myhre et al.<sup>16</sup>. A conclusion can be drawn that the IPCC's warming values could be achieved by carrying out the  $CO_2$ 

calculations in the USST 76 atmosphere and by multiplying the achieved results by the factor 2, because the constant RH roughly duplicates the warming values.

In **Figure 5** is the linear graph assuming that the  $CO_2$  radiative forcing would be the same as in the range from 280 ppm to 379 ppm (green line). The IPCC's scenarios of the Fourth Assessment Report (AR4) are close to this linear straight.

The IPCC's AR4 does not specify accurately the  $CO_2$  effect in scenario calculations<sup>22</sup> but there is a table containing the equilibrium surface temperature changes versus  $CO_2$  concentrations and they are depicted in **Figure 5** (brown line). The temperature change values are very high and they even exceed the linear dependence of  $CO_2$  concentration (green line). Therefore the equilibrium values do not seem realistic at all.

The CO<sub>2</sub> is the major factor in IPCC's warming calculations, and it is well-known that the relationship cannot be that of a straight line for the increasing CO<sub>2</sub> concentrations, as also confirmed by IPCC in the form of Equation (1). The year 2100 scenario values of the IPCC's AR4 fulfill at least this limitation and therefore the scenario values of the year 2100 have been depicted in **Figure 5**. Another good reason for presenting 2100 values is that IPCC's historical analysis of the temperature change of 0.76 °C from 1750 to 2005<sup>9</sup> is still based on the CO<sub>2</sub> radiative forcing of 1.66 W/m<sup>2</sup> and it can be based only on the presentations of the referred three studies<sup>16-18</sup>.

In **Figure 5**, the black graphical line represents the new scenarios of the IPCC's fifth Assessment Report (AR5). These scenarios are referred to as RCP scenarios (Representative Concentration Pathways)<sup>23</sup>. The numerical value in the end of a scenario indicates the final radiative forcing  $(W/m^2)$ , and there are four scenario values: 2.6, 4.5, 6 and 8.5. The corresponding final equivalent CO<sub>2</sub> concentrations are also available and have been used in depicting the RCP graphs. The IPCC scenarios RCP 2.6 and RCP 4.5 are above the straight line, and in this sense these warming values are unrealistically high.

The major reason for the lower  $CO_2$  warming results in AGA 2005 conditions in **Figure 5** can be found in **Figure 8**, where are the absorption graphs for  $CO_2$  concentrations of 379 ppm and 580 ppm. It is true that the  $CO_2$  absorption band is getting broader as the concentration increases, but only the frequency band range from about 12 to 14  $\mu$ m can increase the total absorption.

The final conclusion is that the IPCC warming values for increased  $CO_2$  concentrations are about four times higher than calculated in the AGA conditions without water impact and they can be obtained using the USST 76 atmosphere and the constant RH.

## GWP VALUES AND THE REAL ATMOSPHERIC EFFECTS OF GH GASES

Global warming potential (GWP) definition means how much a GH gas can absorb infrared energy, if 1 kg has been released into the atmosphere over a specified time period (20, 100, 500 years) when compared to the same amount of  $CO_2$  gas<sup>24</sup>. The 100 year GWP of methane is 25, which means that if the same mass of methane and carbon dioxide were introduced into the atmosphere, methane would trap 25 times more heat than the carbon dioxide over the next 100 years<sup>25</sup>.

The definition of GWP is highly theoretical, because the warming effects of 1 kg of a GH gas pulse are impossible to calculate in the real conditions. In order to illustrate this problem the GWP values were calculated in AGA 2005 conditions for pulse sizes from 1 ppm to 50 ppm of CH<sub>4</sub> and N<sub>2</sub>O. Because methane is lighter gas than CO<sub>2</sub>, the pulse size must be 2.744 times bigger than CO<sub>2</sub>. IPCC<sup>25</sup> has used the lifetime of 12 years for CH<sub>4</sub>, and 114 years for N<sub>2</sub>O, and these values were used also in this study. The lifetime of CO<sub>2</sub> is complicated to calculate and the used formula produces the

lifetime about 45 years<sup>26</sup>. The discounting rate of a pulse over time was the same exponential form as defined by  $IPCC^{24}$ , and the time horizon was 100 years. The results calculated in AGA 2005 conditions are depicted in **Figure 6**.



Figure 6: GWP values calculated in AGA 2005 conditions for different gas pulse sizes of  $CH_4$  and  $N_2O$ . The IPCC values<sup>25</sup> are presented as references.

All other GH gases except  $CO_2$  and  $H_2O$  have very low concentrations in the atmosphere. It means that small increases of these gases have relative high warming effects (Beer-Lambert law) in comparison to  $CO_2$  which has a small warming effect because of rather saturated absorption capability in the AGA conditions. This is illustrated in **Figure 7**.



Figure 7: The warming effects of GH gases in the AGA 2005 conditions as function of concentration in the troposphere. In 2005 the  $CO_2$  concentration was 379 ppm,  $CH_4$  was 1.8 ppm and  $N_2O$  was 0.32 ppm.

The GWP values do not give the right total picture of  $CH_4$  and  $N_2O$  warming effects, because they are calculated for the unrealistic small amounts of  $CH_4$  and  $N_2O$ . If the  $CH_4$  and  $N_2O$  concentrations would have increased to 379 ppm, the effects were smaller than those of  $CO_2$ .

The only reliable way to calculate the real warming effects of a GH gas is to use spectral absorption calculations in the real climate conditions for each case. The GWP values are applicable only for comparing relatively small emissions caused by human activities.

As illustrated in **Figure 7**  $CH_4$  and  $N_2O$  have smaller warming effects than  $CO_2$ , if increased to the  $CO_2$  concentration of about 379 ppm.

# CRITICAL ASSESSMENT OF THE IPCC'S SCENARIO ANALYSIS

In preparing the graphical presentation of **Figure 5**, the author realized some discrepancies in the IPCC's scenario table SPM.3 in the publication "Summary for Policymakers"<sup>9</sup>. The first finding was that even though IPCC addresses the future temperature changes in scenarios, their starting points are far away in the history – actually in the preindustrial time.

The common definition for a scenario is that it presents a future situation developed from the present situation with selected conditions and terms. Usually the scenarios include a case called "business as usual" and "the worst case". The policymakers are used to analyse different scenarios and they have no idea that in this case the scenarios do not start from the present time.

The year 2005 is the present time in the IPCC's 2007 report AR4 for historical analysis. Why this year has not been used in the scenarios as the starting year? There are the choices 1980 and 2000 in the Table SPM3<sup>9</sup>. The values of the year 2000 are as a separate line in the Table SPM3 probably therefore that a clever minded reader could decrease the value 0.6 °C from all other scenario values. If the logical starting point 2005 would have been used, it would mean that all scenario values would be 0.8 °C lower (0.76 °C being the accurate value).

The scenarios have been labeled by acronyms only. The policymakers have no time to find out, which kind of conditions each acronym presents. The "business as usual scenario" is normally a base line scenario. Because the present growth rate of  $CO_2$  is about 1.9 ppm/year, the 100 years estimate would be the 580 ppm of  $CO_2$  end concentration.

The scenarios A1T (local environmental sustainability) may be closest to this development path<sup>9</sup>. The temperature change for this scenario is 2.4 °C. When the base line value (0.76 °C) is decreased, the value is 1.64 °C. The Equation (1) produces 1.86 °C for the 580 ppm and if 0.76 °C is decreased, the final temperature change would be about 1.1°C caused by CO<sub>2</sub> increase. Conclusion is that in the historical analysis, the final temperature change is about 3.5% higher than produced by the CO<sub>2</sub> but even in the lowest scenario CO<sub>2</sub> produces only 67% of the final temperature changes. This means that according to IPCC, the radiative warming mechanisms are essentially different in the future.

In scenario analyses the factors can be freely selected but it looks like that IPCC does not want to produce a scenario "business as usual". Also the presentation of scenarios gives wrong ideas about the temperature change magnitudes.

# WARMING CAUSED BY METHANE CLATHRATES RELEASES

The worst case scenario in the climate change is probably the release of methane from the methane clathrates ( $CH_4 \cdot 5.75H_2O$ ) on the ocean floors. This has been assumed to be possible, if the warming of climate results in the warming of the layers deep below the ocean surface. The present estimate of the methane clathrate amount corresponds to 500-2500 GtC<sup>27</sup> (GtC is gigatons of carbon). The amount of carbon in the atmosphere is 850 GtC. This means that the methane concentration

corresponding 2500 GtC would be about 1400 ppm, if the methane's profile would be the same as today.

Utilizing the Spectral Calculator the author calculated the warming caused by the methane concentrations of 379 ppm (same as  $CO_2$  in 2005) and 1400 ppm in the AGA conditions up to 11km altitude. The results were 7.76 W/m<sup>2</sup> for 379 ppm corresponding to 1.5 °C temperature rise and 11.37 W/m<sup>2</sup> for 1400 ppm corresponding to 2.1 °C rise (about 68% of  $CO_2$  warming). The graphical presentation of 1400 ppm absorption band is in **Figure 8**.

These calculations show two things. Firstly the assumed catastrophic temperature increase caused by the total methane release from the ocean floors is not as serious as believed. The reason is that methane absorption band situates in the wavelength zone, where water is an efficient absorber. According to some research papers, the lifetime of methane is only 8.3 years<sup>28</sup>. The GWP value<sup>25</sup> of 25 does not mean that methane is 25 times stronger GH gas than  $CO_2$  in high concentrations.

The radiative forcing of methane in the IPCC's AR4<sup>9</sup> is  $0.48 \text{ W/m}^2$  and the RF of CO<sub>2</sub> is  $1.66 \text{ W/m}^2$ , which means that methane's warming potency would be 28.9% of the CO<sub>2</sub> potency in the CO<sub>2</sub> range 280-379 ppm. The same value calculated in AGA conditions is 34.5%, which is 19.4% higher than the IPCC's value. These percentages are not proper measures of the relative strengths of these gases, because they do not take into account the concentration changes.



Figure 8: Absorption band graphs of increased concentrations of methane and carbon dioxide in AGA 2005 conditions in the troposphere

In this case the concentration change of  $CH_4$  has been 4.3 times greater than that of  $CO_2$ . The methane's contribution of the whole GH effect is only 0.5%. The relative strength is the warming effect of a GH gas caused by one percent concentration change in respect to the same effect of  $CO_2$ . The relative strength of  $CH_4$  today is 0.144 (14.4% of  $CO_2$  potency). Actually methane can absorb only 46.2% what  $CO_2$  can do at the same concentration and the  $CH_4$  concentration of 15.16 ppm (25 times lower than  $CO_2$ ) can absorb only 14.3% of  $CO_2$  absorption.

The interesting feature of the methane concentration is the trend in the atmosphere that there has been about 10 years period of zero growth<sup>29</sup>. The Australian scientists<sup>30</sup> have analysed that the major reason has been probably the better maintenance and management of gas pipelines - particularly in Russia - decreasing considerably the leakage.

## SATURATION AND THE REAL WARMING CAPACITIES OF GH GASES

The available LW radiation from the Earth's surface determines that all GH gases have limited capacity to increase the GH effect and global warming. These limitations can be seen in **Figure 7** very clearly. The concentrations of  $CH_4$  and  $N_2O$  are so low that they are not close to saturation, but the growth rates of the concentrations are so small that the real warming effects are very small for the coming centuries.

 $H_2O$  and  $CO_2$  have the main roles in global warming, because the  $CO_2$  concentration increases steadily (about 1.9 ppm annually) and water has a dominant role as a GH gas. One can see from **Figure 7** that water has much steeper angle coefficient than  $CO_2$ , indicating the higher warming capacity of water. The behavior of water and the temperature can be seen in **Figure 9**.



Figure 9: Absorption band graphs of H<sub>2</sub>O and CO<sub>2</sub> in AGA 2005 and in the tropical atmosphere.

When the water concentration increases from 2.6 prcm to 4.1 prcm, the absorption increase is prominent. A simple explanation for this is that water absorbs LW radiation in the whole radiation range from 5 to 100  $\mu$ m, including the maximum LW radiation band around 10  $\mu$ m. In **Figure 8**, one can see that CO<sub>2</sub> concentration increase to 580 ppm creates a rather small increase in the absorption band area.

Pierrehumbert<sup>31</sup> has come to a conclusion that  $CO_2$  is not near to saturation and that its contribution in the tropical climate is about 33%. **Figures 8** and **9** show this conclusion to be incorrect. The warming values calculated for a 100 ppm increase of  $CO_2$  concentration for the indicated bands are as follows: 280 - 379 ppm 0.2 °C, 379 - 560 ppm 0.14 °C, 560 - 800 ppm 0.11 °C, 800-1200 ppm 0.088 °C, and 1200-2400 ppm 0.055 °C. Nonlinear warming capacity is imminent here. The total saturation has not yet been reached, but the effects are smaller than generally believed.

The total contributions of GH gases (see **Table 2**) are subject to speculation: some researchers think that smaller concentrations of  $CO_2$  would cause also water content to decrease because lower temperatures would increase precipitation. Other researchers think that water is such a strong GH gas that the atmosphere could compensate the lower  $CO_2$  concentration by evaporating more water from the oceans.

Actually this question has value only in creating images for GH gases: is the total contribution of  $CO_2$  9% or 33%? In reality the key figures of the kind presented in **Table 2** are not needed in warming calculations. The present GH gas concentrations determine the operating point of the climate today. It is more important to know what the strengths of today are in the prevailing atmosphere. The precipitation of water is not a question at all because of the increasing concentration of  $CO_2$ . **Table 4** lists the results of the calculations for the GH gas concentration changes<sup>9</sup> from 1990 to 2005 except that of water and ozone, which are based on 1% change.

Miskolczi<sup>5</sup> has calculated that the doubling of  $CO_2$  concentration of 280 ppm can be compensated by the water increase of 2.77%. This means relative strength of 36.1.

GH	Conc. change,	Conc.	Abs. flux	Relative
gas	ppm	change, %	change, W/m <sup>2</sup>	strength
H <sub>2</sub> O		1	0.47	15.2
$CO_2$	26	7.365	0.246	1
$CH_4$	0.064	3.743	0.018	0.144
$N_2O$	0.011	3.571	0.020	0.168
O <sub>3</sub>		1	0.021	0.629

 Table 4: The relative strengths of the GH gases during the period 1990 - 2005.

IPCC has reported that the climate has a positive feedback of water and that water can cause 50% of warming<sup>19</sup>. This principle can be applied also to the historical warming till 2005, because the year 2005 is the turning point between the models. The mechanism is that  $CO_2$  increase of 99 ppm (35.4% addition) warms the climate first by 0.38 °C, and then because of constant RH, the temperature will increase the same amount caused by increased water amount. I calculated the absolute humidity values based on a constant 0.38 °C increase of the temperature profile in the troposphere. This change increased the total water amount from 2.6 prcm to 2.66 prcm (2.3%). These values mean that the strength of water is 15.4 in comparison to  $CO_2$ , which is very close to the value as calculated in AGA conditions.

The comparison of different GH effects of GH gases is summarized in **Table 5**. The values other than GWP are based on the results presented in this paper. One can say that all the values in **Table 5** are correct, but they can be used only according to their specifications.

GH	GWP	Total contribution	Relative strength
gas		till 2012	1990-2005
H <sub>2</sub> O	-	8.7	15.2
$CO_2$	1	1	1
$\mathrm{CH}_4$	25	0.05	0.11
$N_2O$	298	0.05	0.17
$O_3$	-	0.17	0.63

 Table 5: The relative strengths of GH gases based on the different calculations methods in respect to CO2.

The total contribution values are correct for the  $CO_2$  concentration range from 0 to 393 ppm. The relative strengths describe the warming capacities from 1990 to 2005 and they are applicable also for the next 100 years, assuming a linear growth rate of anthropogenic GH gases.

#### CLIMATE SENSITIVITY ANALYSIS

The climate sensitivity (CS) specifically due to  $CO_2$  is expressed as the temperature change in °C associated with a doubling of the concentration of  $CO_2$  from 280 ppm to 560 ppm. The starting point of the analysis of the IPCC's CS is the calculations of the RF values and the global warming values in the AR4. The RF value of  $CO_2$  in the AR4 is 1.66 W/m<sup>2</sup> from 280 ppm to 379 ppm. If the equation (1) would be fully applicable, the RF value would be 1.62. The coefficient value of 5.35 of the Equation (1) should be 5.49 for achieving the RF value of 1.62.

Radiative forcing can be related to the global mean equilibrium temperature change at the surface  $(\Delta T_s)$  according to Equation (3)

$$\Delta T_{\rm s} = \lambda RF, \tag{3}$$

Where  $\lambda$  is the climate sensitivity parameter<sup>22</sup>. According to IPCC,  $\lambda$  is a nearly invariant parameter having a typical value of 0.5 K/(W/m<sup>2</sup>). Because the total RF value<sup>9</sup> is 1.72 W/m<sup>2</sup>, the  $\Delta T_s$  would be 0.86 °C but the reported value is 0.76 °C. IPCC does not explain this discrepancy. The author has concluded that actually IPCC has used the  $\lambda$  value of 0.442, because  $\lambda$  is not totally invariant parameter.

There are now two alternatives for calculating the CS value. The Equation (1) and the  $\lambda$  value of 0.5 gives the CS value of 1.85 °C and using the modified Equation (1) with coefficient value of 5.49 and the  $\lambda$  value of 0.442 gives the CS value of 1.68 °C. The author's choice is the latter value, because this value matches with the calculation methods and the parameter choices of IPCC.

IPCC has reported<sup>22</sup> that the CS is likely in the range 2 °C to 4 °C, with the best estimate value of 3 °C. The reason for the big difference between the value of 1.68 °C and 3 °C is the different calculation basis of the CS value for the future  $CO_2$  radiative forcing. The use of Atmosphere-Ocean General Circulation Models (AOGCM) has had an important role in the IPCC's assessment. AOGCMs as well GCMs have a common feature that they strongly favor the positive water feedback, which roughly doubles the GH gas radiative forcing<sup>19</sup>.



Figure 10: Illustration of two IPCC's models: historical warming and climate sensitivity model.

The **Figure 10** illustrates the CS model of IPCC, in which the CS value of 3 °C is caused by water and GH gases in relationship 50/50, which is a robust feature of AOGCMs and GCMs as reported by IPCC<sup>19</sup>. The warming result of this CS model is impossible to fit to the values of year 2005/2012 and to the historical warming. Radiative forcing relationship to  $CO_2$  according to logarithmic equation and the positive feedback of water conflict with the warming till 2005 or 2012. The trend graph of GH gases shows the behavior after 2012 which is not logarithmic as it should be but more like a "hokey stick". The warming values from 1750 to 2012 are the mandatory points for calibrating any model.

According to the AR4, IPCC has two different calculation bases for the global warming. Carbon dioxide has caused 96.5% (100\*1.66/1.72) of the historical warming till 2005 but the contribution of CO<sub>2</sub> is only 56% of the best future warming estimate. The essential reason is that the climate response to the radiative forcing changes from the pure GH gas radiative forcing to the GCMs and AOGCMs including the positive water feedback. Of course the year 2005 or the CO<sub>2</sub> concentration increase from 379 ppm cannot be the reason for this kind of change in the warming mechanism.

## **CONCLUSIONS AND DISCUSSION**

The calculations carried out in the modified USST 76 atmosphere show that the Spectral Calculator simulation produces the value 27% for  $CO_2$  effect, when calculated up to 120 km altitude, which is very close to 26% calculated by Kiehl and Trenberth<sup>2</sup>. The calculations carried in the true global average atmosphere (AGA 2005) produces a  $CO_2$  effect of only 11% total contribution from 0 to 379 ppm in the troposphere and 9.5% where nonlinearity is observed.

There are two issues concerning the temperature changes under dispute, which are the constant RH effect and the atmosphere choice. IPCC has used the equation of Myhre et al.<sup>16</sup> in calculating the warming effect of CO<sub>2</sub>. Only Shi<sup>17</sup> has reported that the calculations have been carried out in the constant RH conditions. Myhre et al.<sup>16</sup> and Hansen et al.<sup>18</sup> do not address the humidity effect in any way. The equations of these three referred papers include only the CO<sub>2</sub> concentrations and there are

no remarks, that actually water would have caused the same effect as  $CO_2$ . Because the calculations have been carried out digitally in the artificial atmospheres, the water effect must have been included in the calculations.

All these three studies have produced practically the same results concerning the radiative warming caused by  $CO_2$ . The conclusion is that the atmospheres must have been very similar, because atmosphere choice has a dominant effect in calculations.

The analyses carried out by Spectral Calculator show that the global warming changes (1750 - 2005) of IPCC as the function of increased  $CO_2$  concentrations can be achieved by using the USST 76 atmosphere and by increasing the  $CO_2$  effect by multiplying these values by factor 2, which is the effect of constant RH. The final result is that IPCC values are about four times higher than produced in the AGA 2005 conditions without constant RH effect. The use of USST 76 atmosphere is so common in spectral calculation that some researchers have realized that it is the IPCC accepted standard for atmospheric calculations<sup>30</sup>.

The radiative absorption calculations carried out by  $CH_4$  and  $N_2O$  show that the GWP values are applicable only for restricted emission calculations. The Spectral Calculator simulations point out that methane can cause only 46.2% temperature change in comparison to  $CO_2$ , if the same concentration has been applied. This result reveal that methane is not 25 times stronger GH gas in higher concentrations than  $CO_2$  as commonly believed based on the GWP value of methane. The carried out calculations also show that the release of methane from the ocean floor methane clathrate has smaller effects than believed.

Even though the warming calculations for the period of 1750-2005 show that methane's warming contribution is 34.5% of the CO<sub>2</sub> contribution, it is not a measure about the methane's real warming potency. The first reason is that the concentration changes are different. The second reason is that the nonlinear relationships change the effects of GH gases according to their concentrations. The spectral analysis show that in the prevailing atmospheric conditions the warming potencies are in respect to CO<sub>2</sub> (being 1): H<sub>2</sub>O 15.2, CH<sub>4</sub> 0.14, N<sub>2</sub>O 0.17, and O<sub>3</sub> 0.63. These relative strength values are the best estimates of the real warming effects of the GH gases, because GWP values cannot be used at all and the total contribution values describe the historical effects.

The critical assessment of the IPCC's scenario analysis points out that IPCC presents the scenario results in the way that the warming values are higher than they should be. The estimated warming values above  $1.7 \,^{\circ}$ C for the 2005 - 2105 period are calculated essentially on the different bases than the warming values for the 1750 - 2005 period. It seems that IPCC abandons the model of logarithmic relationship between CO<sub>2</sub> concentration increase and the temperature (the effect of anthropogenic GH gases only) and replaces it with AOGCMs and GCMs calculations with constant RH. This conclusion comes from the fact that values higher than 1.7 °C conflict with the logarithmic relationship, which has not been reported to be incorrect. At the same time, IPCC has not introduced any other warming mechanism than the GH effect.

The most critical issue in the global warming is the behaviour of water as  $CO_2$  concentration increases. IPCC accepts so-called positive feedback, but direct measurements show negative trends of atmospheric water over a long historical period. Because water is 15.2 times stronger GH gas than  $CO_2$ , it is an ideal component for natural negative feedback mechanism to compensate the warming effects of  $CO_2$ .

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