

# **BOUNDING GHG CLIMATE SENSITIVITY FOR USE IN REGULATORY DECISIONS**

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## **Executive Summary**

**A Report of The Right Climate Stuff Research Team**

**The Full Report can be found at:**

<http://www.therightclimatesstuff.com/BoundingClimateSensitivityForRegDecisions>

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**February 2014**

**Houston, Texas**

# **BOUNDING GHG CLIMATE SENSITIVITY FOR USE IN REGULATORY ACTIVITY**

## **EXECUTIVE SUMMARY**

The Right Climate Stuff (TRCS) research team is a volunteer group composed primarily of more than 25 retired NASA Apollo Program veterans, who joined together in February 2012 to perform an objective, independent study of scientific claims of significant Anthropogenic Global Warming (AGW). AGW is theorized to result primarily from emissions into the atmosphere of Greenhouse Gases (GHG), primarily Carbon Dioxide (CO<sub>2</sub>), as a result of fossil fuel burning. We believe our TRCS research team represents an important national asset, developed through our manned space program. As some US government agencies have already concluded that atmospheric CO<sub>2</sub> is an extremely serious threat that must be controlled at a great cost to our nation and economy, we believe that we can and should “weigh-in” on the AGW issues facing our nation.

### **SUMMARY OF OUR CONCLUSIONS**

We have concluded that, at most, 0.7°C AGW has occurred since 1850, but that it is possible that some of this observed warming was caused by naturally occurring cycles of global temperature variation. Other small amounts of global warming since 1850 were caused by an increase in solar irradiance. The naturally occurring global temperature cycles are clearly evident in the 8000 years of climate data before the dawn of the Industrial Age. Earlier, much greater changes in global temperature were exhibited during the ice age cycles, and are destined to occur again as the current Holocene ice age cycle unfolds.

We have also concluded that increasing levels of GHG in the atmosphere cannot cause more than 1.2°C of additional warming above current global average temperatures, before all economically recoverable fossil fuels on the planet are consumed. This maximum possible additional AGW should be offset to some extent by a forecast of reduced solar output over the next couple of centuries, and that has already started to occur. Longer term, because of orbital mechanics cycles of the earth’s orbit around the Sun and small cyclical variations in tilt of the earth’s spin axis with respect to the earth’s orbital plane, we should continue a gradual global cooling trend into the next major glacial advance that should begin in about 10,000 years and last for about 70,000 years before the next major warming trend begins.

## **WHY ARE OUR CONCLUSIONS IMPORTANT?**

We are a group of retired scientists and engineers, highly trained and experienced in making critical decisions on complex issues where human safety is involved, and have the requisite education and experience to comprehend the critical issues in AGW research. We are often criticized because we are not educated and experienced in the field of climate science. That may be true, but **totally irrelevant** considering our excellent performance in the totally new discipline of manned spaceflight, outside of earth orbit. We went into the Apollo Program knowing that our success would depend on adherence to scientific discipline, personal honesty and integrity, and a lot of stressful hard work. Then as now, we grade on performance, not credentials. Then as now, our motto and the way we do our work is “In God we trust, all others bring data.” Also important is that we are objective, impartial arbiters of the ongoing AGW debate without any conflicts of interest associated with the continued flow of research grants sought by scientists in universities who want to continue to “study” the problem, without any assigned responsibility for solving the problem they have proposed.

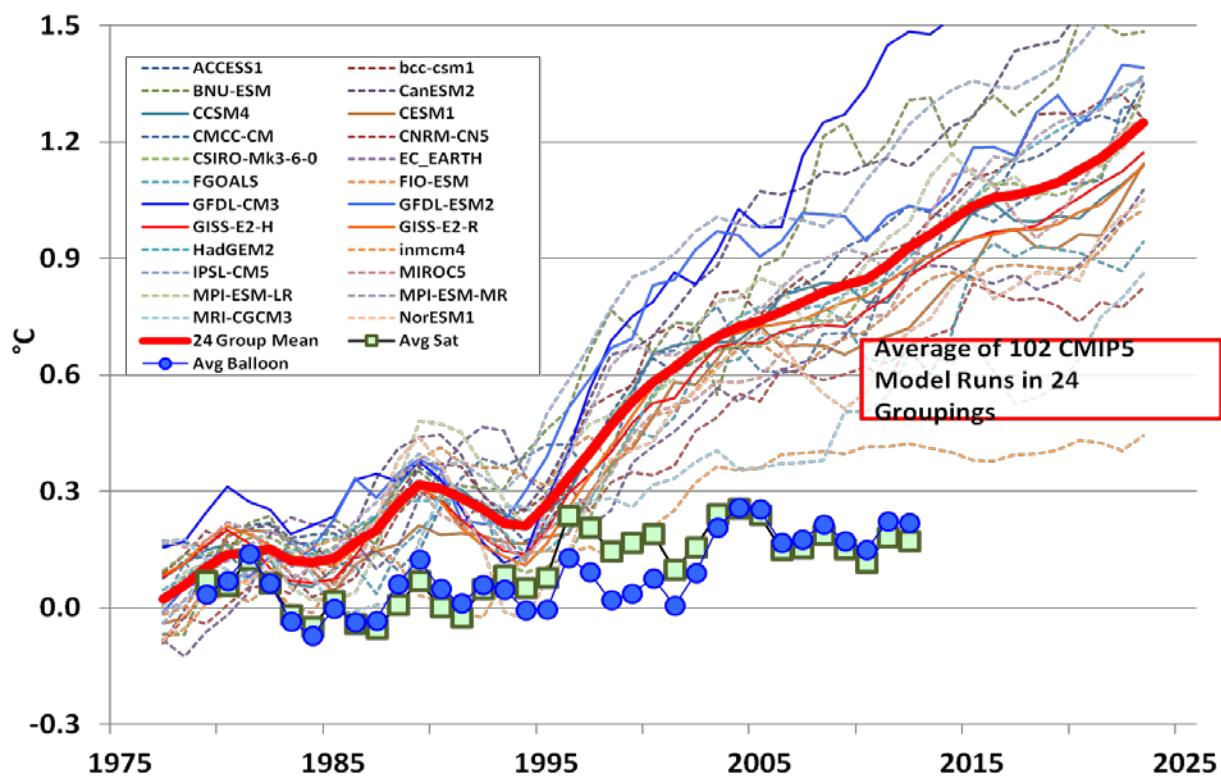
We encourage the credentialed climate scientists, government agencies and US citizens that have concluded man-made global warming is an impending crisis that we must take action to avoid, to consider our assessment of the AGW issue based on scientific data, not unproven climate simulation models.

A substantial volunteer effort has been made by our team to understand and objectively reconcile the differences between the AGW point of view and that of the “skeptics” of AGW through detailed discussions and deliberations of the conflicting elements of the narratives. We have been successful in our attempt to include members of the study group from both sides of the AGW argument, and we believe this is important to study all appropriate inputs and viewpoints.

## **CLIMATE SENSITIVITY UNCERTAINTY**

We have reviewed, studied and debated available data and scientific reports regarding many factors that affect temperature variations of the earth's surface and atmosphere. Our nation, and others, have spent billions of dollars on climate research over the last 35 years. Although many aspects of climate change are now better understood from this research, the “official” uncertainty of the sensitivity of our climate to increasing atmospheric CO<sub>2</sub> concentration, first assessed in the 1979 Charney Report, has not been reduced. Specifically, this was a global temperature increase of 1.5°C to 4.5°C for a doubling of CO<sub>2</sub> concentration from 280 ppm (parts per million by volume) to 560 ppm. We believe this uncertainty range has not been reduced because climate scientists have been overly influenced by predictions of un-validated climate simulation models instead of actual scientific observations.

In recent testimony to the Subcommittee on Environment of the US House – Science, Space and Technology Committee, Dr. John Christy, the Alabama State Climatologist, presented stark evidence that none of the climate models referenced in the 2013 Intergovernmental Panel on Climate Change (IPCC) AR5 report accurately predicted the earth's temperature history over the last several decades. Yet these are the same models that are the basis for establishing their climate sensitivity uncertainty range. Dr. Christy used Figure 1 in his testimony to demonstrate the very poor performance of the IPCC models in predicting temperature trends actually measured by US satellites and weather balloons. Figure 1 presents simulation results from 73 different climate models studied by the IPCC to support conclusions in its AR5 report. Because the AGW hypotheses predicts a significant increase in atmospheric temperatures in tropical regions, that will lead to an increase in global average surface temperatures (GAST), Dr. Christy compared the model simulations of AGW tropical mid-Troposphere temperature rise over the last 35 years, to actual scientific data. By 2013 the models were over-predicting actual measured temperatures by factors of 2 to 7.5. The average error in 2013 measured by the difference of the solid red line and actual data was biased to the high side by a factor of 4.5.



**Figure 1 - Dr. John Christy Study - Climate Model Comparison to Actual Physical Data**

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[It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong. Richard Feynman](#)

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Our research team has concluded that the CO<sub>2</sub> and other GHG climate sensitivity metric defined by the IPCC as Equilibrium Climate Sensitivity (ECS) and computed by these complex climate simulation models, is a totally academic concept that can never be verified by actual physical data, and is not a practical metric for GHG climate sensitivity used for public policy decision-making focused on the next 300 years of AGW. Global temperature rise uncertainty, based on this ECS metric, is extracted from un-validated climate models which have been unable to accurately predict global temperature trends. The IPCC ECS **uncertainty range extracted from these models** has been picked up and, we believe, unjustifiably expanded by the US Interagency Working Group (IWG), for input to three different economic projection computer programs, called the Integrated Assessment Models (IAM), to compute their so-called "Social Cost of Carbon (SCC)" for each ton of CO<sub>2</sub> emitted into the atmosphere. The highly uncertain ECS metric is not suited for use in regulatory matters focused on the next three centuries because it is a global temperature rise that is simulated to occur after more than 1000 years of doubled CO<sub>2</sub> levels in the atmosphere, a totally implausible scenario. Other transient climate sensitivity metrics defined and discussed in the full report are much better suited for use in SCC calculations. Moreover, much of the uncertainty in the ECS metric results from modeled effects that would occur after 2300, beyond the time for which the SCC are calculated. The SCC, expressed in a dollar "cost", is being used as rationale for regulations and rule-making by the Environmental Protection Agency (EPA), particularly aimed at CO<sub>2</sub> emissions, which will, and are intended to, raise the cost of fossil fuel use. This unilateral US CO<sub>2</sub> emissions control policy will in our view, result in highly certain and immediate significant deleterious effects on the US economy and employment, while causing negligible effects on the atmospheric CO<sub>2</sub> concentration or the climate in the future, as other rapidly expanding economies in China and India continue to increase their CO<sub>2</sub> emissions.

The full report provides detailed and well documented analysis methods and findings that we have reached at this point into our investigation. Our opinion that output of un-validated models should not be used for critical decision-making results from more than 50 years of experience with complex models in our manned space program.

## **OUR DATA-FOCUSED ASSESSMENT OF AGW**

Because of the extreme complexity of the physical interrelationship of the thermodynamic aspects of the sun, the earth, the oceans and the space between, it is difficult if not impossible to construct a computer model that provides an accurate simulation of the heat transfer with variable inputs. For these reasons and for a multitude of other reasons, we are not surprised that those scientists, who rely almost exclusively on climate models, have not been able to validate their models.

For these reasons the TRCS studies have been and will continue to be based on actual data approaches. Specifically our current goal is:

**Determine to what extent human-related releases of CO<sub>2</sub> into the atmosphere can cause earth surface temperature increases that would have unacceptably harmful effects.**

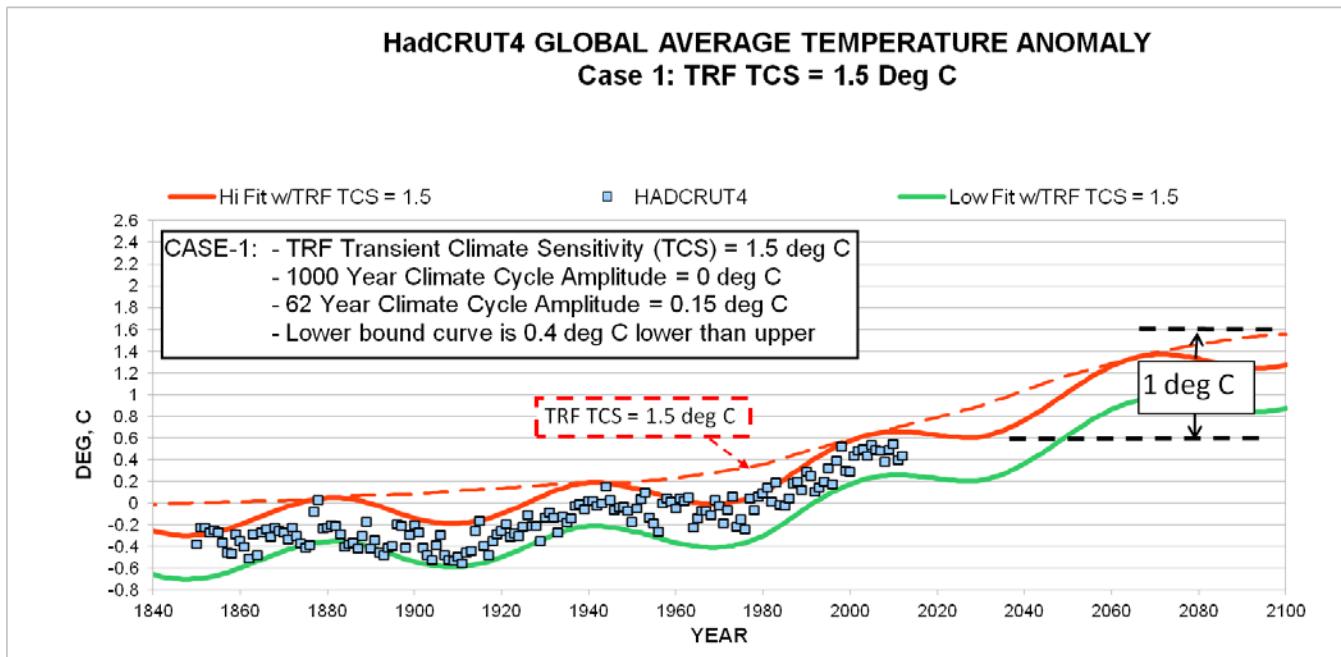
As is commonly practiced in climate science, we have expanded this statement to include GHG other than CO<sub>2</sub> that can warm the atmosphere and also cause significant AGW. We also devised a method to separate the warming effects of CO<sub>2</sub> from warming effects of other GHG, a necessary step ignored in current IWG calculations of the Social Cost of Carbon. We undertook to use the real temperature record as compiled by one of the several databases used worldwide that we evaluated as “best available data”. We selected the database maintained by the UK Hadley Climate Research unit (HadCRUT4), to develop the relevant climate sensitivity metric. This metric, referred to as the Transient Climate Sensitivity (TCS) was developed to provide a best match and bound to the actual temperature record of that database. Similar TCS values for other databases can be determined by the same method and should have similar values. We believe that by performing an independent and objective scientific review of this aspect of the AGW controversy, with a clear objective in mind as evidenced by this report, we have been able to confidently and significantly reduce the climate sensitivity uncertainty applicable to any concerns over the next 200-300 years when available fossil fuels will be consumed. Any continued global warming due to fossil fuel use more than 200 years from now, cannot be a realistic concern that need be considered in CO<sub>2</sub> regulatory activity.

For several hundred years prior to the beginning of the Industrial Revolution the concentration of atmospheric CO<sub>2</sub> was about 280 ppm. It has taken 163 years from 1850 when atmospheric CO<sub>2</sub> levels were still near pre-industrial levels of about 280 ppm, to rise 40 percent to 397 ppm in 2013. Figure 2 demonstrates an analytical curve fit to the HadCRUT4 temperature anomaly data measurements since 1850. It is obvious that the temperature data points have a cyclic pattern of about 62 years cycle period. However, the long-term temperature data trend upward may be

caused by a small amount of heating due to the increasing concentration of CO<sub>2</sub> and other GHG in the atmosphere. It could also be partially caused by natural climate warming that has continued to occur since the 1600's from the abnormally cold minimum temperatures of the Little Ice Age. However, in the Case 1 fit of Figure 2 we assumed all warming was from CO<sub>2</sub>, other GHG and solar irradiance effects with no long term warming from natural causes. We defined the sensitivity of the longer term temperature rise to atmospheric CO<sub>2</sub> rise to be Transient Climate Sensitivity (TCS). This metric is defined as the global average surface temperature increase caused by the actual slowly increasing CO<sub>2</sub> concentration in the atmosphere when atmospheric CO<sub>2</sub> concentration doubles to 560 ppm. This metric, is derived from the curve fit equation and then corrected for other external factors such as effects of GHG other than CO<sub>2</sub> and solar irradiation changes. For Case 1 of Figure 2, the best fit of the data was obtained with a value of TCS = 1.5°C.

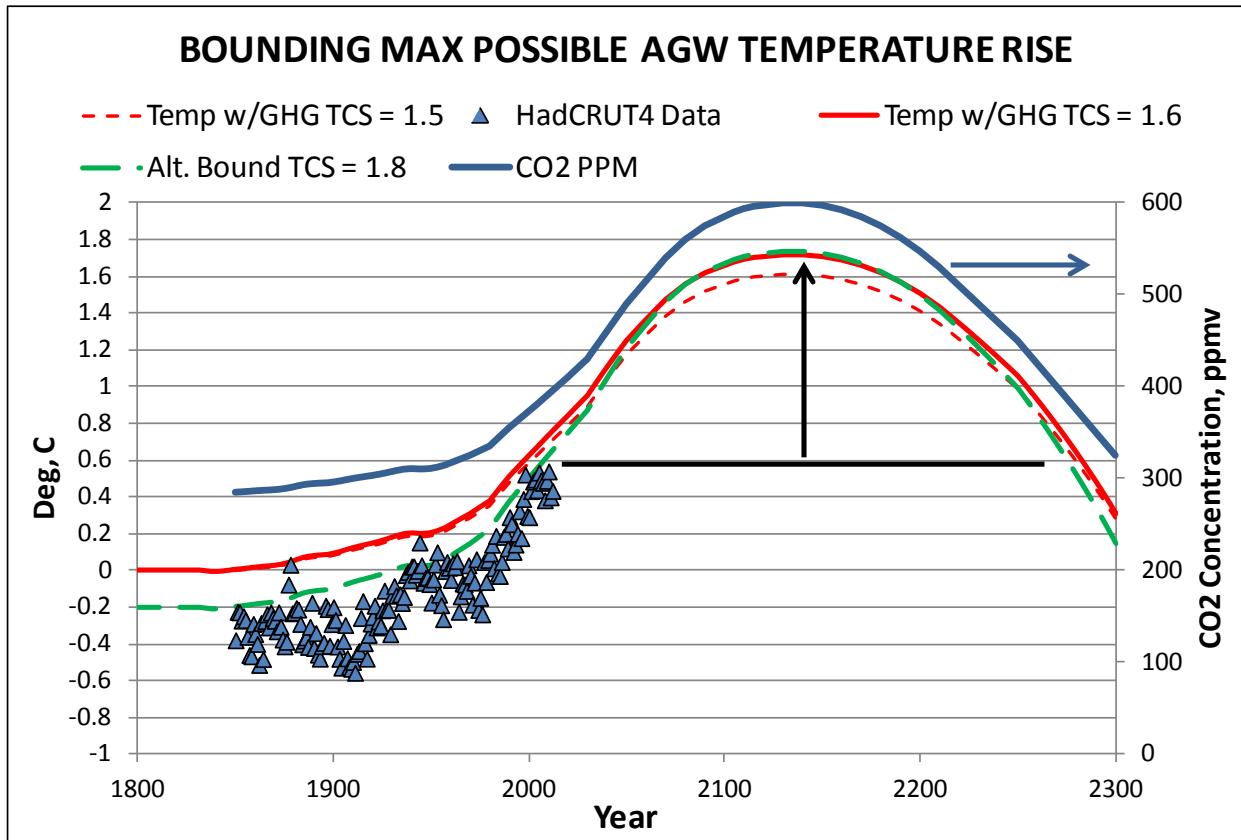
The process we used allows the climate system's responses to CO<sub>2</sub> rise (highly uncertain in models) to be recorded and accurately detected in the actual physical data available. The nature of our TCS calculation allows any projected future value of CO<sub>2</sub> concentration to be used to project the change in global temperature anomaly. For example, if atmospheric CO<sub>2</sub> concentration doubled from the pre-industrial value of 280 ppm to 560 ppm in the future, this would cause, at most, an increase in the global surface temperature anomaly of 1.5°C since the dawn of the Industrial Age. In our complete report, the 560 ppm level is projected to occur in 2080 and continue rising to the 585 ppm level in 2100 without any world-wide CO<sub>2</sub> emissions control agreements. The rise in temperature anomaly from this projected rise in CO<sub>2</sub> over the remainder of this century is shown in Figure 2. Using the data extracted value of TCS = 1.5°C, the projected maximum possible temperature anomaly in 2100 is 1°C higher than present. However, since the best fit value of TCS = 1.5°C includes not only effects of CO<sub>2</sub> rise, but also the rise in other atmospheric GHG and a continued rate of increase in solar output observed since 1850, 1/3 of the maximum projected 1°C temp rise by 2100 would be due to these other factors.

Figure 2 projects an even lower temperature rise by 2100. The TCS factor is derived from the red dashed line which bounds the uppermost data points in Figure 2.



**Figure 2 - Transient Climate Sensitivity (TCS) Curve Fit of HadCRUT4 Data**

Since we derive the TCS factor from “worst case” considerations of actual measured temperature data, we are confident that it can be used to conservatively predict any AGW temperature rise over the next 300 years for regulatory purposes, as demonstrated in Figure 3. In Figure 3 projections are made with two different bounding equations. The two red curves are for one type of bounding equation with TCS values of  $1.5^{\circ}\text{C}$  and  $1.6^{\circ}\text{C}$ , and that include sensitivity to all GHG, not just CO<sub>2</sub>. The dashed green curve is for a different bounding equation using a max possible upper bound value of TCS =  $1.8^{\circ}\text{C}$ , that includes CO<sub>2</sub>, other GHG and assumed continued solar activity increases, determined from more conservative fits of the data in Figures 2 and 3. The dashed green curve is obtained by ignoring some extraneous data points in the HadCRUT4 data that result in a larger estimated temperature rise since 1850. All of these very conservative projections result in less than  $1.2^{\circ}\text{C}$  temperature rise above current levels. There are many probable factors, including a forecast of reduced solar activity from the current level, that make the actual temperature rise expected much less than these maximum possible values.



**Figure 3 - HadCRUT4 Data Bounding Forecast**

The atmospheric CO<sub>2</sub> profile used for temperature projections in Figure 3 considers that the increasing cost of recovery of existing fossil fuels will cause a gradual transition to alternative energy sources that will be complete by 2130, and at which time atmospheric CO<sub>2</sub> concentration will be at a maximum of 600 ppm. After 2130, when CO<sub>2</sub> emissions are curtailed due to this orderly, market-driven transition to alternative fuels, atmospheric CO<sub>2</sub> concentration should start to decline slowly as natural on-going CO<sub>2</sub> exchanges between the earth surface and atmosphere begin to remove CO<sub>2</sub> from the atmosphere.

The TRCS Research Team recommends this data-focused method to conservatively bound the AGW effects over the next 300 years, as atmospheric CO<sub>2</sub> levels rise to a peak value and will then decline after the transition from depleting fossil fuels to alternative fuels must occur. The measured temperature data has risen 0.8°C from 1850 to current times. At most, the AGW caused temperature rise is limited to an additional 1.2°C by the year 2130. After CO<sub>2</sub> emissions

have stopped, when the completed transition to alternative fuels occurs in about 2130, the temperature is predicted to return to the current level by 2300.

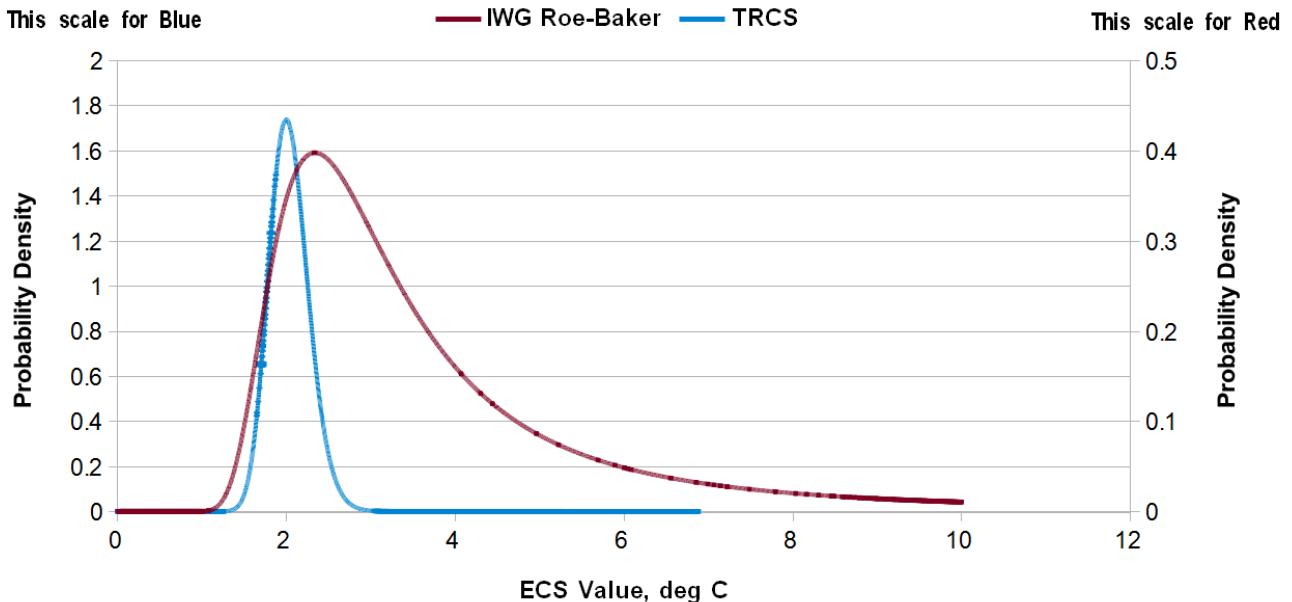
## SOCIAL COST OF CARBON CALCULATIONS

Social Costs of Carbon (SCC) calculations should be based on the data observation constrained “worst case” AGW scenario of Figure 3 in lieu of the highly uncertain and exaggerated AGW predicted by the current Monte Carlo statistical method developed by the IWG. That method uses a “guesimated” statistical distribution for the entirely inappropriate ECS metric as input to the IAM cost models. The transient climate sensitivity metric, TCS, developed in this report and with much less uncertainty, is a much more appropriate metric to use for temperature forecasts out to 2300, the time period for which CO<sub>2</sub> emissions regulations are based. Much of the uncertainty in the ECS value, in contrast to the tightly bounded TCS metric, results from very long term climate model effects that would not occur until after 2300. To demonstrate the unwarranted exaggeration of actual climate sensitivity used in current SCC calculations, we show in Figure 4 the ECS probability distribution used by the IWG compared to the ECS probability distribution that can be computed from our uncertainty distribution of the TCS metric. Our data-constrained ECS metric denoted by the blue curve of Figure 3, is obtained from

$$\text{ECS} = (\text{TCS})(1.8)$$

The factor 1.8 was taken from the average for this relationship computed by climate models studied by the IPCC for its 2007 AR4 report. Therefore our conservative upper bound value of TCS = 1.6°C used in the projection of Figure 3, equates to a maximum value of ECS = 2.9°C in the TRCS probability distribution of Figure 4. We only compute an ECS value from our more appropriate and recommended TCS metric to compare to the IWG ECS distribution, and do not recommend ECS be used in calculations for SCC focused on the next 300 years. The exaggerated IWG ECS uncertainty distribution in Figure 4 allows AGW temperature increases that would cause rapid melting of the Greenland and West Antarctica Ice Sheets, causing massive global coastal flooding and enormous damages, with enough probability to compute a high statistically “expected value” for SCC. Such an ECS probability distribution is based on wild speculation and is inappropriate for regulations that are required to be based on the best science the USA has to offer. Because the vertical scales of the two Probability Density Functions (PDF) in Figure 3 are so different, that makes their shapes difficult to compare, the values for the red IWG distribution are plotted on the right vertical scale to give the plots approximately the same vertical height.

## COMPARISON OF IWG AND TRCS ECS DISTRIBUTIONS



**Figure 4 - IWG and TRCS Probability Density Function Distributions for ECS**

## Conclusions & Recommendations Jan 2013 & Feb 2014

Detailed proof and references available at <http://www.therightclimatestuff.com> in Reports dated Jan 2013, April 2013, and Feb 2014

1. The science that predicts the extent of Anthropogenic Global Warming (AGW) is not settled science. (Jan 2013)
2. Our US government is over-reacting to concerns about AGW. (Jan 2013)
3. It is scientifically embarrassing that the EPA has declared CO<sub>2</sub> to be a pollutant that must be regulated, since it is a naturally occurring substance required to sustain human, animal and plant life, and for which there is no substitute. (Jan 2013)

4. We have concluded that the IPCC climate models are seriously flawed because they don't agree very closely with measured empirical data. After a 35 year simulation the models over-predicted actual measured temperatures by factors of 200% to 750%. One could hardly expect them to predict with better accuracy 300 years into the future required for use in regulatory decisions. (Feb 2014)
5. We have developed a straightforward analysis, based on empirical data, not unproven models, which bounds the maximum possible global warming that could be caused by increases in atmospheric CO<sub>2</sub> concentration. (Feb 2014)
6. We have defined and demonstrated use of a more appropriate Transient Climate Sensitivity (TCS) metric derived from empirical data for use in regulatory decisions requiring accurate predictions of global temperature changes due to changes of CO<sub>2</sub> levels in the atmosphere. (Feb 2014)
7. There is no convincing evidence that Anthropogenic Global Warming (AGW) will produce catastrophic climate changes. AGW can only produce modest amounts of global warming that will likely be beneficial when the substantial benefits to crop production from more CO<sub>2</sub> in the atmosphere are considered. (Jan 2013) and (Feb 2014)
8. Because there is no immediate threat of global warming requiring swift corrective action, we have time to study global climate changes and improve our prediction accuracy. A wider range of solution options should be studied for global warming or cooling threats from any credible cause. (Jan 2013)
9. Social Cost of Carbon (SCC) calculations should be based on empirical data-based transient climate sensitivity metrics with much less uncertainty than the inappropriate IPCC Equilibrium Climate Sensitivity (ECS) metric uncertainty range that is computed from the flawed IPCC climate simulation models. (Feb 2014)
10. ECS is computed from a hypothetical, unrealistic scenario, used only for comparison of computer model results, where CO<sub>2</sub> levels are suddenly doubled in the atmosphere and the ECS temperature change is computed over 1000 years later. It is unscientific to base CO<sub>2</sub> regulations on ECS computed from unproven climate models, as currently planned by EPA and DoE. (Feb 2014)
11. The ECS uncertainty statistical distribution used for justifying EPA and DoE CO<sub>2</sub> emissions regulations is based on wild speculation, not reliable empirical data. (Feb 2014)

- 12. A market-driven transition from fossil fuels to alternative fuels must begin by 2055 just to meet energy demand as dwindling reserves of economically recoverable fossil fuels drive up their costs. (Feb 2014)**
- 13. Assuming an orderly market driven transition from fossil fuels to alternatives that do not emit CO<sub>2</sub>, atmospheric CO<sub>2</sub> will remain below 600 ppm. (Feb 2014)**
- 14. The maximum CO<sub>2</sub> level of 600 ppm is expected to occur after 2100, probably about 2130, and will begin to decline thereafter. (Feb 2014)**
- 15. Based on our analysis of empirical data measured over a period of 163 years, that provides a conservative TCS value of 1.6°C, the maximum expected Green House Gas (GHG) temperature rise from present levels will be less than 1.2°C (2.1°F) (Feb 2014)**
- 16. CO<sub>2</sub> emissions regulations should be based on climate sensitivity to CO<sub>2</sub>-only, not the higher sensitivity to all GHG incorporated into the IPCC ECS uncertainty range. (Feb 2014)**
- 17. CO<sub>2</sub> emissions regulations should be based on climate sensitivity to CO<sub>2</sub> emissions, not climate sensitivity to atmospheric CO<sub>2</sub> levels, such as in the ECS and TCS metrics, since a large fraction of CO<sub>2</sub> emissions each year enter our oceans, not our atmosphere. (Feb 2014)**
- 18. Transient Climate Sensitivity (TCS) has low uncertainty and is a more appropriate metric than ECS for predicting GHG global warming trends over the next few centuries since much of the uncertainty in ECS results from hypothesized climate changes that take place more than 300 years into the future. (Feb 2014)**
- 19. High values of SCC computed by EPA and DoE using their flawed computational process, result from unrealistically high temperatures causing rapid melt of permanent ice sheets on the planet that have been growing for thousands, and in some cases, millions of years. The scientific reality of such speculation needs to be reviewed. (Feb 2014)**
- 20. An independent and objective scientific review board should be convened to review the EPA and DoE methodology for computing Social Cost of Carbon used in regulatory decisions. (Feb 2014)**

## **Expanded Conclusions & Recommendations**

Our atmospheric CO<sub>2</sub> concentration bounding calculations, together with confidently bounded lower estimates of transient climate sensitivity developed in this report, should lead to significantly lower damage estimates for SCC currently being computed in the GHG emissions regulatory process. The current emissions control public policy proposals reacting to the AGW alarm offers very little chance of success in actually lowering global temperatures by a significant amount.

Our severe criticism of the current SCC computation methodology, that has been largely hidden from outside interested parties, indicates why a more in-depth and independent scientific review of this process is needed. The decision processes being used do not have the rigor and applicable experience of other agencies of government such as NASA, the NTSB and FAA that clearly know why un-validated models are never used for design or operations involving human safety and well-being. We offer this report to the IWG to carefully consider and scrutinize for any conclusions that they can refute with actual data. Confident that the IWG cannot disprove any conclusions about AGW stated in this report, we challenge the IWG to reconsider their current SCC methodology against the reasoned temperature forecasts made in this report and that are grounded in the actual data on AGW for the last 163 years.

Our TRCS research team experience with the Shuttle Challenger and Columbia accident investigation boards, as well as numerous independent and non-advocacy review boards regularly conducted on NASA manned and unmanned programs, leads us to believe that a similar independent review activity for the SCC calculation methodology is required. Following the template for successful independent review familiar to us, we recommend that in addition to climate science experts, numerous review board members should be selected from a broad array of technical fields that utilize the same basic technical disciplines, but are not funded to conduct climate science research. Such diverse credentials of review board members are needed to achieve an adequate independent and objective review. Review board members should be vetted for identification and resolution of any possible conflicts of interest.

### **Editor's note:**

We have not shown the references to supporting data in this summary. The full report is adequately annotated with supporting references. If this report leaves you with any questions, the full report has a more comprehensive discussion on each topic. For full report see:

<http://www.therightclimatestuff.com>

and

<http://www.therightclimatestuff.com/BoundingClimateSensitivityForRegDecisions>