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The models' fatal error

The Viscount Monckton of Brenchley

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LONG has the *Europäisches Institut für Klima und Energie* stood firm for truth in science. It is an honour to share your platform with my distinguished co-author, Michael Limburg, to deliver the Karl Popper Memorial Lecture at this your 11th climate and energy conference. I am grateful for Michael's learned introduction. The discoveries that he and I are laying before you today bring the climate scare to an end.

Neither I nor any of my co-authors in this work has any conflict of interest in the climate question. Like al-Haytham, the mathematician and philosopher of science in 11th-century Iraq who established the scientific method in the east following Thales of Miletus in the west, we are simply "seekers after truth", who, as al-Haytham said, do not put their faith in any mere consensus, however venerable or widespread. Instead, we check. "The road to the truth is long and hard," he said, "but that is the road we must follow." Our manifesto is that of the defendant in history's most celebrated show trial: "To this end was I born, for this cause came I into the world, that I should bear witness unto the truth." Science uninformed by morality is mere climatology.

This lecture addresses not only the eminent audience here present but also the wider world. I shall demonstrate that grave errors of physics, inbuilt into every climate model, have led to exaggerated predictions of global warming, which will in reality scarcely exceed 1 K per CO_2 doubling; to answer the objections to our discovery; and to make the text, slides and video, as well as the underlying learned paper, available for universal scrutiny. There will be many slides, each appearing for a few seconds only. The slides can be freeze-framed by anyone who watches the video of this lecture and wishes to study our discoveries in more detail.

We shall follow the scientific method codified in Sir Karl Popper's masterwork *Logik der Forschung*. Sir Hermann Bondi, Master of my college at Cambridge, used to say: "There is no more to science than its method, and no more to its method than Popper has said." Popper described the scientific method as an iterative algorithm starting with the mathematical definition of a general problem "**GP**". A tentative theory "**TT**" is advanced to address the problem. Thereupon, in the error elimination phase "**EE**", other scientists falsify the tentative theory. If it fails, the algorithm terminates. If not, the general problem is modified and restated, the new theory becomes less tentative, and the cycle of truth-seeking recommences.

GP

The general problem: modellers greatly over-predict medium-term warming

Today's general problem is that climate modellers greatly over-predict medium-term global warming. Yet they have neither enquired why nor cut their long-term projections to reflect the failure of their medium-term predictions. Since IPCC first made a prediction in 1990 to the effect that by 2016 there would be 0.75-0.9 K global warming, there has been only 0.45 K. The models overshot by about double.

IPCC, which predicted about 0.3 K/decade warming in 1990, near-halved its medium-term predicted warming rate to 0.2 K/decade in 2013, replacing models' predictions with what it called its "expert judgment." Observed warming from 1990-2016 was 0.15 K/decade. Warming rates predicted in learned papers have plummeted. Yet IPCC has left its long-term prediction of Charney sensitivity unaltered at [1.5, 4.5] K per CO_2 doubling, and the models of the Climate Model Intercomparison Project are still worse, predicting 3.3 [2.0, 4.5] K.

Warming is officially diagnosed from ensembles of models using a simple zero-dimensional model equation. The models do not use this equation, but climatology uses it to diagnose outputs from model ensembles. Equilibrium sensitivity ΔT, after all but the longest-acting

feedbacks, is the ratio of reference or zero-feedback sensitivity ΔT_S to (1 minus the feedback fraction f): ΔT_S is the product of a forcing ΔQ_0 and the reference-sensitivity parameter λ_0.

To derive λ_0, find the emission-altitude radiative flux Q_0 ($= 241.2$ W m^{-2}) and, from that, the Earth's emission temperature T_E ($= 255.4$ K). To a first approximation, then, λ_0 is the first derivative $T_E/(4Q_0)$ ($= 0.27$ K W^{-1}m^2) of the fundamental equation of radiative transfer, but, allowing for latitudinal and altitudinal asymmetries, the usual value, which we shall adopt, is 0.3125 K W^{-1}m^2, or, conveniently, 3.2^{-1}. Though λ_0 varies with albedo, albedo will vary little today, so, as is customary, we shall take λ_0 as constant.

Calibration of the official model equation

We now calibrate the official equation to find Charney sensitivity, i.e., equilibrium sensitivity to doubled CO_2. Each IPCC *Assessment Report,* chose a single paper to diagnose Charney sensitivity from the models. In 2013 it was Vial *et al.* Values of the CO_2 forcing have fallen from 4.4 to 3.5 W m^{-2} since 1990, but Vial counted some of the short-acting feedbacks as part of the forcing ΔQ_0, so that $\Delta Q_0 = 4.5$ W m^{-2} and, consequently, $\Delta T_S = 4.5/3.2 = 1.4$ K.

Finally, the feedback-sum λ, when multiplied by λ_0 (i.e., divided by 3.2) gives the feedback fraction f. The feedbacks from water vapor, from the lapse-rate of temperature with altitude, from clouds and from albedo sum to 1.5 to 1.6 W m^{-2} K^{-1}. Since these feedbacks act on timescales of years at most, we shall assume that no committed but unrealized warming is to be expected. Note that the official upper bound of the feedback sum λ is 3.2, implying $f = 1$ and hence $\Delta T = \infty$, further demonstrating our general problem and indicating its cause.

Vial gives 1.57 W m^{-2} K^{-1} as the mid-range estimate of the feedback-sum λ, so that $f = 1.57/3.2 = 0.49$, with 2 σ uncertainty bounds $\pm 40\%$, or $[0.29, 0.69]$.

Calibration immediately follows. Plugging ΔT_S ($= 1.4$ K) into the zero-dimensional-model equation along with these values of f gives ΔT on 2.8 [2.0, 4.5] K. The bounds are near-exactly those officially published for both the CMIP3 and CMIP5 model generations.

The mid-range estimate shows a discrepancy because the curve of equilibrium-sensitivity responses to feedback fractions f is not a straight line but a rectangular hyperbola. In 340 BC, Menaechmus of Alopeconnesus in Asia Minor found at the intersection of a rectangular hyperbola and a parabola one of the two mean proportionals that enabled him to solve one of the longest-standing problems of ancient mathematics: the duplication of the cube.

The models erroneously place their mid-range estimate of equilibrium sensitivity ΔT about halfway between the bounds of ΔT. However, they should start with the mid-range estimate of f and derive from it the mid-range value of ΔT, which is not the models' 3.3 K but 2.8 K.

An interesting observation from our successful calibration exercise is that where f is as defined, where its mid-range value is the mean of the bounds of its interval and where the mid-range estimate of ΔT is twice the lower bound, the upper bound of ΔT will always be ∞, another pointer to the fact and probable cause of official climatology's over-predictions.

Seven tests of the calibrated model against observation

In the CMIP5 models, the mean forcing ΔQ_0 in response to doubled CO_2 is 3.5 W m^{-2}, so that reference sensitivity $\Delta T_S = 3.5/3.2 = 1.1$ K. Since the published CMIP3 and CMIP5 central estimate of Charney sensitivity ΔT is 3.3 K, the implicit mid-range estimate of f is $1 - 1.1/3.3$, or 0.67. Taking these values, we used published net anthropogenic forcings for

each of seven periods to calculate how much warming the official equation would predict, and then found the ratio of predicted to observed warming. The mean ratio should be ~1.0 but is 2.5. The models are over-predicting by a substantial margin. So, what went wrong?

TT

Tentative theory: grave errors of feedback method cause over-prediction

The direct warming caused by doubled CO_2 is 1.1 K. That is nothing like enough to be a problem. Why, then, do climate extremists predict the end of the world? It is the contribution from the large predicted feedback to that direct warming that is the pretext for their alarm.

As Michael says, feedback is a universal principle in dynamical systems, including climate. The theory was developed by Harold S. Black at Bell Labs in New York in the 1920s to stabilize telephone circuits, and codified by his colleague Hendrik Wade Bode in a textbook so popular that it was published annually from 1945 till the mid-1970s. Many climatological authorities cite Bode feedback loops as the basis for climate feedback analysis.

In a feedback-moderated dynamical system, the input and output signals are absolute values, not deltas. The reason is that the response-curve of output signals is non-linear, so that the uncertainty in the feedback response leads to far greater uncertainty in the consequent temperature response at the high feedback fractions arising from the incorrect use of deltas than at the lower fractions – and hence significantly lower equilibrium sensitivities – that are evident when, in accordance with mainstream control theory, absolute values are used.

Today's mean temperature ΔT_S is 288.4 K. Warming ΔT_A since then, all of which we shall assume to be anthropogenic, is 0.9 K. Therefore, pre-industrial temperature ΔT_N in 1850 was ~287.5 K. Since official climatology's natural greenhouse effect $\Delta T_G = 34.8$ K, baseline temperature T_0 $(= 252.7$ K) without any greenhouse gases is close to T_E $(= 255.4$ K).

In a simple climate feedback loop corrected to conform to mainstream control theory, baseline temperature T_0 is the input; the μ gain block directly amplifies that input to reflect forcings; and some fraction βT of the amplified output T is returned to the input node and reamplified before passing to the output node. The system-gain factor A determines the gain of the entire system, namely the ratio of output temperature T to input temperature T_0.

It is easy to prove that $A = \mu/(1 - \mu\beta)$. Therefore, the correct ZDM equation for equilibrium sensitivity is $\Delta T = T_0\mu/(1 - \mu\beta) - T_S$. But, as we shall see, climatology errs by not using it.

Error 1: Using ΔT_S instead of T_0 as the input to the feedback loop
Error 2: Omitting the direct-gain factor μ from the feedback loop
Error 3: Replacing the feedback fraction β with the defective form f
Error 4: Using ΔT instead of T as the output from the feedback loop

These errors led official climatology to a greater mistake, as we shall prove by contradiction.

Error 5: Impossibly overstating feedbacks' contribution

Assume, impossibly, that the entire difference of 34.8 K between pre-industrial temperature T_N $(= 287.5$ K) and baseline temperature T_0 $(= 252.7$ K) is feedback-driven. Then the impossible maximum feedback fraction $\beta_{\max}$ is simply $34.8/287.5$, or 0.12. Yet the feedback fractions f on 0.67 $[0.46, 0.76]$ in the CMIP3/5 models are 4-6 times greater. And that is the proof – in our submission simple, powerful and irrefutable – of the models' error.

Error 6: Counting feedbacks to T_0 as feedbacks to the greenhouse effect

Official climatology has long and erroneously imagined that the contribution ΔT_B (= 8.7 K) from feedbacks in response to the direct forcings from pre-industrial greenhouse gases could be as much as 26.1 K, or three-quarters of the 34.8 K difference between baseline temperature T_0 (= 252.7 K) and natural or pre-industrial temperature T_N (= 287.5 K): i.e., that the feedback fraction f might be as great as 0.75.

Climatology's central error of physics – its *culpa culparum* – consists in its implicit and magical assumption that feedbacks are not induced by baseline temperature T_0 but are induced by greenhouse-gas warming ΔT_B (= 8.7 K).

True, in a generic feedback loop both μ and β can be tuned to any value, but only where the incremental or perturbation input is isolated from the original input signal. In the climate, no such separation subsists.

Feedbacks do not know where the temperature that triggered them originated. They treat the sum of the original baseline temperature and any subsequent forcing-driven direct changes thereto as a single temperature by which they are induced.

Therefore, using the corrected equations it is possible simply to calculate the mean feedback fraction during the pre-industrial accumulation of greenhouse gases. First, the natural system gain factor A_N is equal both to $\mu_N/(1-\mu_N\beta)$ and to $T_N/T_0 = 287.5/252.7 = 1.1377$.

Next, recalling that the direct warming ΔT_B from the pre-industrial greenhouse gases is $(T_N - T_0)/4$, or 8.7 K, and that $\mu_N = 1 + \Delta T_B/T_0 = 1 + 8.7/252.7 = 1.0344$, rearranging the first equation for A_N gives $\beta = (A_N - \mu_N)/(A_N\mu_N) = 0.0878$, or about 0.09.

We shall adopt official climatology's simplifying assumption that the feedback fraction β as greenhouse gases accumulated applies today too. Since β in that era was greater than today, by adopting this customary assumption we shall not be underestimating climate sensitivity.

Feedbacks' contribution $\Delta T_{(0)}$ to T_N is then $T_0[\mu_B/(1-\mu_B\beta) - 1]$, noting that $\mu_B \coloneqq 1$, since baseline temperature T_0 has not been directly amplified yet by any forcing. Accordingly, $\Delta T_{(0)} = 24.3$ K. In short, 24.3 K of the 34.8 K that had been blamed on the natural greenhouse effect really arises from feedbacks' contribution to pre-industrial temperature T_N induced by baseline temperature T_0.

Correctly determining Charney sensitivity for the first time

As a rough and ready worked example, we shall now derive the approximate value of Charney sensitivity from the parameter values we have discussed so far.

Stage 1: The natural greenhouse effect ΔT_G is not 34.8 K but $34.8 - 24.3 = 10.5$ K.

Stage 2: Where natural greenhouse-gas forcing ΔT_B is 8.7 K, only $10.5 - 8.7 = 1.8$ K, not 26.1 K as had previously been thought, is the feedback-driven contribution $\Delta T_{(b)}$.

Stage 3: After a little algebra, some 0.16 K of the 0.9 K anthropogenic warming ΔT_A is found to be feedback-driven.

Stage 4: Take μ as the sum of baseline temperature T_0, direct natural greenhouse-gas warming ΔT_B, direct anthropogenic warming ΔT_A to date and the CO_2-driven warming ΔT_S, all divided by T_0. With $\beta = 0.0878$, the bottom line is that Charney sensitivity ΔT is just 1.33 K. Deducting 1.1 K reference sensitivity, the feedback contribution is only 0.24 K.

The corrected Charney-sensitivity equations

Direct gain factor:	$\mu = (T_0 + \Delta T_B + \Delta T_A + \Delta T_S)/T_0.$
Feedback fraction:	$\beta = (A_N - \mu_N)/(A_N \mu_N).$
Equilibrium sensitivity:	$\Delta T = T_0[\mu/(1 - \mu\beta) - 1].$

Anthrogenic forcings from 1850 to doubled CO_2 total 1.8 K, and the consequent feedback-driven forcings amount to a further 0.4 K. Therefore, feedbacks no longer matter much, and that is the reason why dangerous global warming is hereby proven to be a non-problem.

Uncertainties

IPCC gives the uncertainty in ΔT arising from the CO_2 forcing as ± 0.1 K. If baseline temperature ΔT_B, after feedbacks have acted, is 50% to 100% of 34.8 K, the uncertainty attributable to feedbacks is a further ± 0.1 K, and this very low uncertainty is a measure of the robustness of our conclusion. Fine-tuning our rough and ready method will not greatly change Charney sensitivity, which thus tumbles from the official models' 3.3 ± 1.3 K to a small, harmless and beneficial 1.3 ± 0.2 K.

If we are correct, and if Professor Happer was also correct in reporting to the World Federation of Scientists in 2015 that the CO_2 forcing had been overestimated by 40%, Charney sensitivity falls again to just 0.8 ± 0.1 K.

If Professor Harde is additionally correct in finding a further 30% overestimation distinct from that of Professor Happer, Charney sensitivity becomes 0.6 K. Today, though, we have demonstrated definitively that – if official climatology has made no other errors – IPCC's minimum Charney sensitivity, 1.5 K, is the new maximum. That ends the climate problem.

EE

How well does our model perform?

We tested our corrected form of the zero-dimensional model against the current defective model and against observation. For fair comparison, identical official anthropogenic forcings were used in both models. To neutralize IPCC's detuning of medium-term predictions to match observation, we disregarded all official predictions except the CMIP5 mid-range estimate that Charney sensitivity $\Delta T = 3.3$ K, from which we derived the mid-range estimate $f = 0.67$ for the feedback fraction, while our value for β is 0.0878.

We did not tune the corrected model to make it fit the data. Instead, we designed it from first principles and we investigated fairly whether observation and prediction matched. Finally, for both models we assumed that all warming after 1850 was manmade.

Official climatology's mean ratio of predicted to observed warming was 2.5. The table of calculations for each of seven periods shows that the mean ratio for our model is 1.0, and our model's hindcast for each of the seven periods is respectably close to that ideal ratio

Our test rig

John Whitfield built an electronic circuit designed to emulate the climate. Some 23 tests in four groups, performed on that rig, validated our understanding of feedback theory. For instance, the measured outputs simulated the expected rectangular-hyperbolic curve.

Verification of our approach at a government laboratory

We commissioned a government laboratory to build a test circuit to verify our approach to feedback theory. We asked the laboratory to perform the same 23 tests in four groups.

> Group 1 showed climate sensitivity to be overstated even before we corrected official climatology's feedback errors.
>
> Group 2 showed that, with absolute rather than delta inputs and outputs, the interval of climate sensitivity narrows and the upper bound falls further.
>
> Group 3 verified that even without any amplification but with feedback the output signal exceeds the input signal by the expected margin, confirming our central result: the great majority of what had been thought to be the "natural greenhouse effect" is in fact driven by feedbacks induced by baseline temperature T_0.
>
> Group 4 verified that the magnitude and interval breadth of output responses to the feedback fraction β are small even when β is at its impossible maximum ~0.12.

In all 23 individual tests, outputs were as we had predicted, equivalent to the nearest tenth of a Kelvin.

Verification by fathers of science

We sent an early draft of our paper to Professor Happer at Princeton. He said, "It's too long!". We shortened it. He said, "I like this paper!" We sent three successive drafts to Professor Ray Bates at University College, Dublin. He kindly took immense pains to review them and concluded that "the paper has a strong logic". He recommended publication.

Popper-falsification by peer review

We sent a short version of the paper to the *Journal of Climate,* which usually decides on short papers within two weeks. The editor-in-chief personally supervised the review. The *Journal* took three months before rejecting our paper. Why so long? I shall reveal the answer later. For now, I shall answer the reviewers' objections.

1. The reviewers said that instead of inputting absolute baseline temperature we should input only the temperature anomaly. Our method, they said, was "without physical justification" and "just plain rubbish". I have set out the physical justification today. Many climate authorities cite the textbook that encapsulates the proven feedback theory we have used. The reviewers also ignored the physical justification provided by two test circuits, one of them at a government laboratory.
2. The reviewers said that using absolute temperature as the input to the feedback loop violates energy conservation. Our test rigs would have exposed any such violation, but there was none. The reviewers ignored the formidable stability of global temperature over the past 810,000 years. They ignored indications in the learned journals, from the very early stages of the debate until the present, that negative feedbacks are strong enough substantially to offset positive feedbacks. It is their method, not ours, that violates energy conservation. Inputting their feedback fraction $f\ (= 0.67)$ into the corrected simple-model equation would predict > 500 K of feedback-driven response to baseline temperature $T_0\ (= 252.7$ K).
3. The reviewers said that isolating ΔT_S from T_0 would bring our analogy to a Bode feedback circuit closer to reality. Yet feedbacks to temperature cannot and do not distinguish between baseline temperature T_0 and any subsequent amplification.
4. The reviewers said climate is not an electronic circuit. They ignored the extensive learned literature on the universality of feedback theory in dynamical systems, and on the specific applicability of the Bode feedback loop to the climate system.
5. The reviewers said that because feedbacks were a Taylor-series expansion of the energy budget linearized around the current mean state of the climate it was improper to take account of pre-

existing absolute temperature. However, any Taylor-series expansion must take account of the true value of the feedback sum λ. At present, such expansions in the models are based on an inflated value of λ and hence of the feedback fraction f, taking the calculation to a point on the response curve too far from the origin and too close to the singularity at $f = 1$. Besides, Taylor-series expansions in the climate are chiefly useful in describing interactions between feedbacks, but our model says nothing about the value of any individual feedback. Instead, it constrains the magnitude of the sum λ of all feedbacks.

6. The reviewers said the feedback fraction β was not the same while natural greenhouse gases were accumulating as it is today. Yet that very assumption, used in official climatology, is precisely the basis for the exaggerated but erroneous feedback factors currently used in the models. Today's value of β is certainly less than it was in earlier times: yet, for caution, we have taken the higher earlier value. Nevertheless, climate sensitivity is small.

7. The reviewers told us to educate ourselves on the nonlinearity of feedbacks. Yet the zero-dimensional model we used to calibrate the general-circulation models' outputs from the official, published inputs was successful even though it was linear, indicating that nonlinearities in feedbacks have little net effect. After all, where the contribution of feedbacks to global warming is of order 0.2 K nonlinearities in those feedbacks are academic.

8. The reviewers said we should not have blamed IPCC for its over-predictions in 1990, because IPCC had over-predicted anthropogenic forcings. However, our careful comparison between the defective model's expected outputs, our corrected model's outputs and observed warming was not based on IPCC's detuned predictions. It was based on using identical published forcings in each model, applying to the current zero-dimensional-model equation the feedback fraction $f = 0.67$ derived from the CMIP5 prediction of 3.3 K Charney sensitivity.

9. The reviewers said existing models hindcast accurately. But our fair, like-for-like comparison shows they do not hindcast accurately except when replaced by IPCC's "expert judgment" – or, rather, expert hindsight. Our model hindcasts accurately, without "expert judgment".

Six questions for the control-theory community

The reviews were inadequate. We have now submitted our paper to a journal of control theory, taking it out of the prejudice-laden climate realm and into the real world of true science. We have asked the control theorists six questions about dynamical systems.

1. Whether, in a dynamical system where the input signal cannot be isolated from some amplification of that signal, the entire input signal rather than merely the amplification should be the input to the feedback loop.

2. Whether, in a dynamical system, an amplification of the input signal is correctly represented by a gain block with μ equal to the ratio of the amplified to the input signal.

3. Whether, in a dynamical system, non-zero feedbacks may modify the output signal even in the absence of any direct signal gain from the amplifier block.

4. Whether, in a dynamical system where the input and output signals are known, feedbacks' contribution to the output signal can ever exceed the difference between the two signals.

5. Whether, in a dynamical system where the input and output signals are known and the difference between the two signals is a small fraction of either signal, the feedback fraction β may ever exceed the ratio of the difference between the two signals to the input signal.

6. Whether, in a dynamical system in which the input and output signals are known, and in which the difference between the two signals is an order of magnitude less than the input signal, the magnitude and interval breadth of output-signal responses to feedback fractions β are necessarily small, even when β represents the entire difference between the two signals.

Are They worried about our discovery?

In August 2016, while our paper was under review, a copy somehow found its way from the *Journal of Climate* to the vice-chancellor of East Anglia University, Professor Kevin Richardson. He called 65 professors and doctors in the environmental sciences faculty to a meeting, and yelled: "This is a *catastrophe!* If the general public ever hear of Monckton's paper, there will be hell to pay!" He ordered the entire faculty to drop everything and concentrate on going back and recalculating feedbacks so as to refute our paper. Two months later, students had become so concerned at the unavailability of their tutors that they planned a demonstration to demand the instruction they had paid for. The source for this news is one who heard Professor Richardson speak. We know, then, that official climatology is worried. How revealing that a senior academic describes the good news that, after all, dangerous anthropogenic global warming will not occur as a *catastrophe*.

We who live in the real world and have no financial vested interest can now celebrate. My team, after up to 15 years' work for some of us, has proven –

- that official climatology has incorrectly applied mainstream control theory to temperature feedback analysis for more than a century;
- that the erroneous use of perturbation rather than absolute temperature as the input to the feedback loop has led to extravagant overstatements of the feedback fraction;
- that the current feedback fraction is thus about five times the impossible maximum;
- that feedbacks in reality contribute little to global warming;
- that the long-standing problem of the unduly broad interval of climate sensitivities, an artefact of official climatology's errors of feedback method, is now solved;
- that, after correction of the errors, Charney sensitivity is $\sim$1.3 K, not the 2 to 4.5 K imagined by the models, and certainly not the 10 or even 12 K mentioned by extremists;
- that dangerous global warming was and is a fiction;
- that nothing need be spent on global efforts to control greenhouse gases;
- that the IPCC and UNFCCC are no longer needed;
- that the Paris accord and all suchlike agreements can be torn up;
- that prices for fuel and power can be halved;
- that "green" taxes and subsidies can be ended; and
- that, as for the climate scare, *es ist vorbei!*

Vielen dank!