A13H-0335 Inconsistencies and Fallacies: IPCC 20th Century Simulations, Multi-Model Ensembles and Climate Sensitivity

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How the IPCC explains the unexplained.

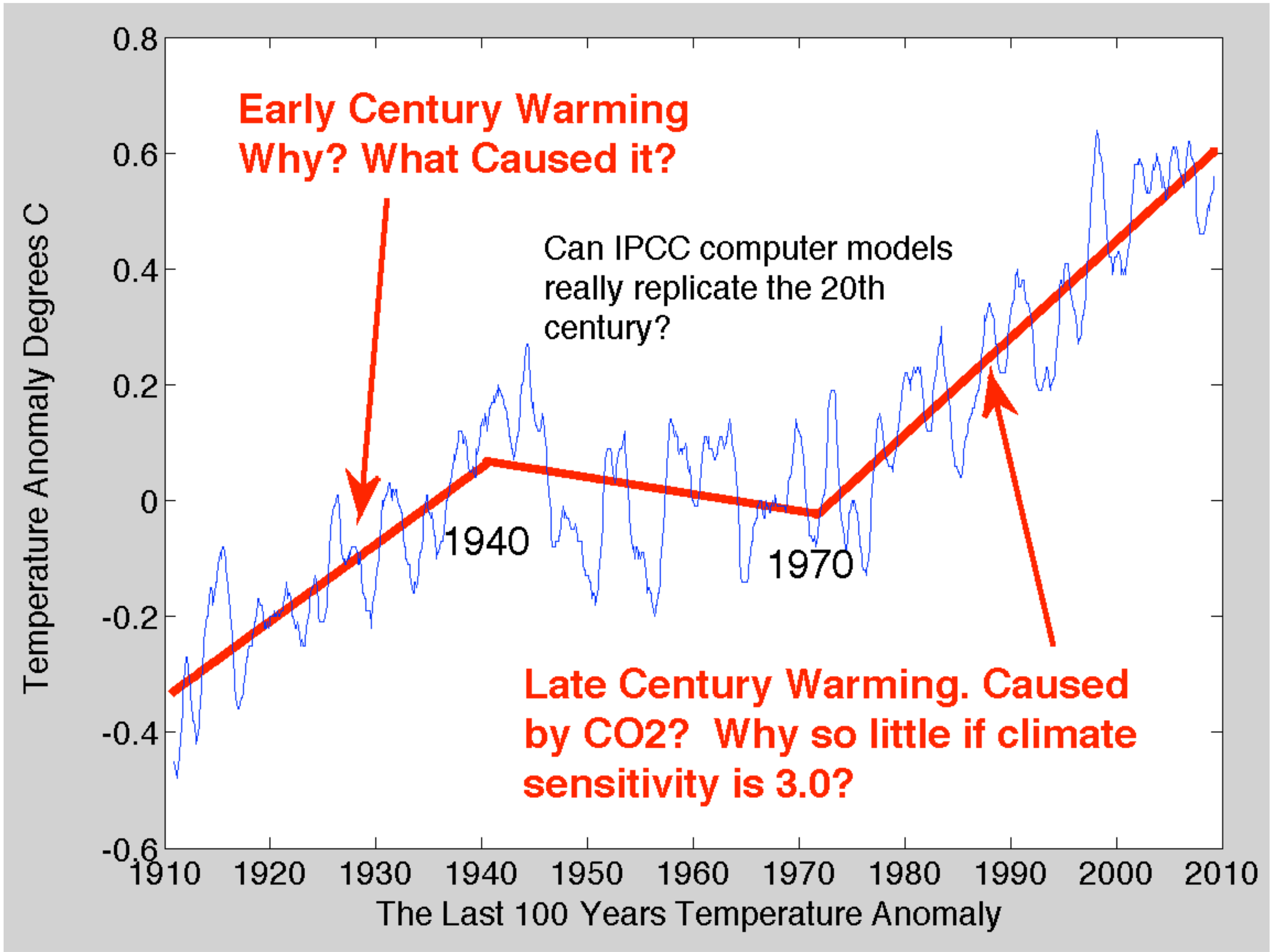


Figure 1

The Problem	The IPCC Explanation	The Reality
What caused the early century warming?	Solar forcing / Natural variability	Nobody knows. It's a mystery.
What caused the late century warming?	Greenhouse gases.	The amount of greenhouse warming is unknown but less than the IPCC says.
Why is the late century warming so weak if climate sensitivity is 3.0 for CO2 doubling?	Cooling from aerosols or heat flux into ocean.	The IPCC explanations don't work. The warming is too low for 3.0 climate sensitivity.

The IPCC "proof" of anthropogenic global warming

Simulation of 20th century climate history including greenhouse gases.

Simulation of 20th century climate history with greenhouse gas forcing removed.

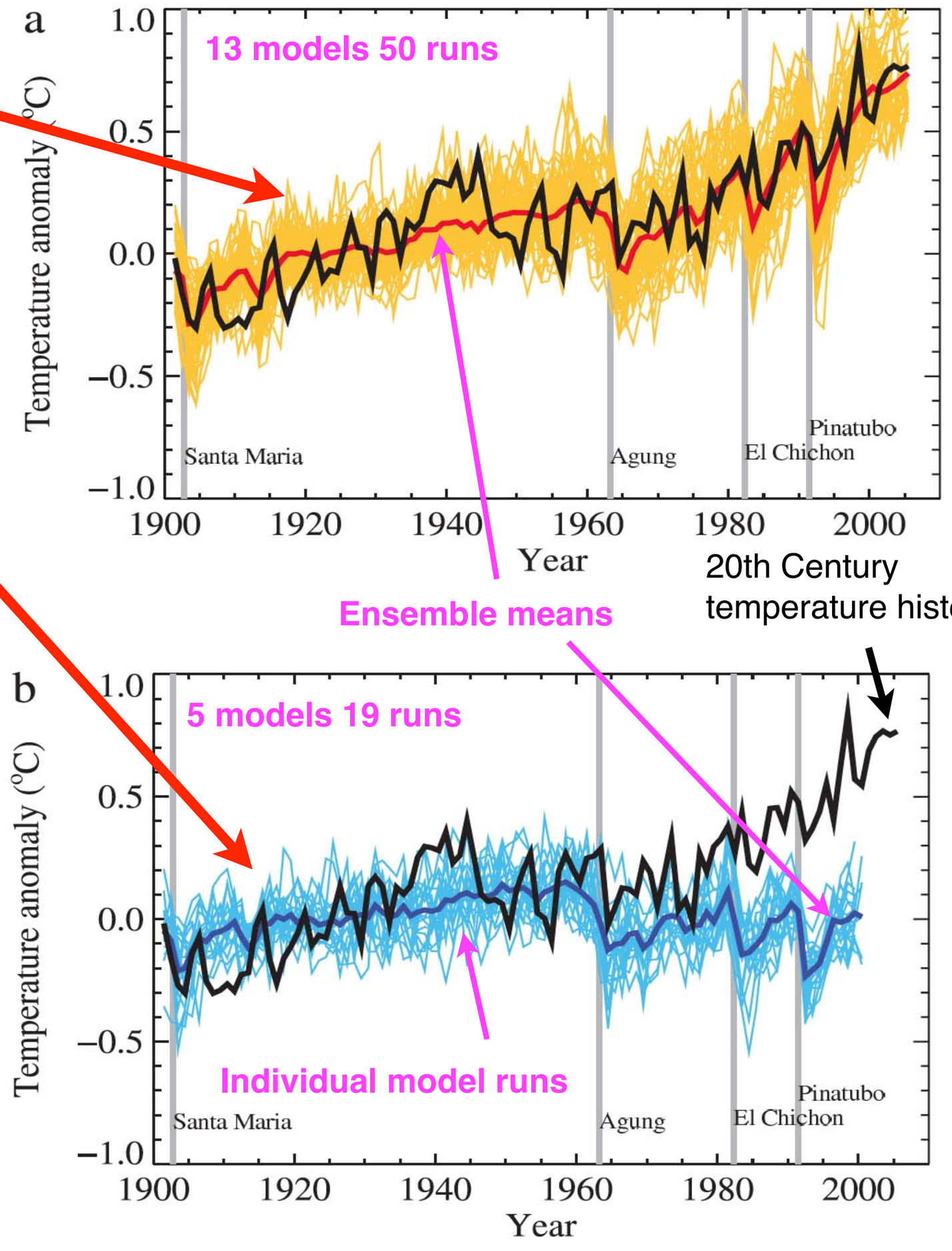


Figure 2

Problems:

1. The same models are not used in the two graphs.
2. The different models do not use the same forcing.

These graphs are from figure 9.5 from the IPCC 2007 scientific report[1]. The lower graph is *not* the same ensemble as the upper graph as one would normally expect[2]. The climate models used differ by more than 2-1 in climate sensitivity. How can the model outputs all cluster together in the late 20th century when CO2 is rapidly increasing[3]? They shouldn't but they do. ***Bizarrely, rather than use common forcings, each modeling group was directed to use forcings that it "deemed appropriate[4]!" So the various modeling groups are not using the same assumptions for the model inputs. Each group is modeling a different virtual planet.*** But, in spite of these weaknesses in experimental protocol these graphs have been widely reproduced. If you know the full story the graphs seem quite dubious.

Multi-Model Ensemble - The Fallacy

Averaging together the output from different models created at separate laboratories is supposed to give a better result. If this is true we only need to finance many more modeling groups to greatly improve modeling accuracy. The "improvement" seen from averaging different models assumes that the models don't share common systematic errors, even though they share common approaches and even computer code[5].

Climate Sensitivity - What is it 2? 3? 4?

The climate sensitivity, or temperature increase for doubled CO2, is shown in the bar graph (right) for 19 of the IPCC models. The models differ on this index, from 2.1 to 4.4 degrees.

IPCC models disagree substantially on climate sensitivity. It seems that climate sensitivity is an unstable property of models since it varies dramatically even though the modeling groups are trying to solve the same problems.

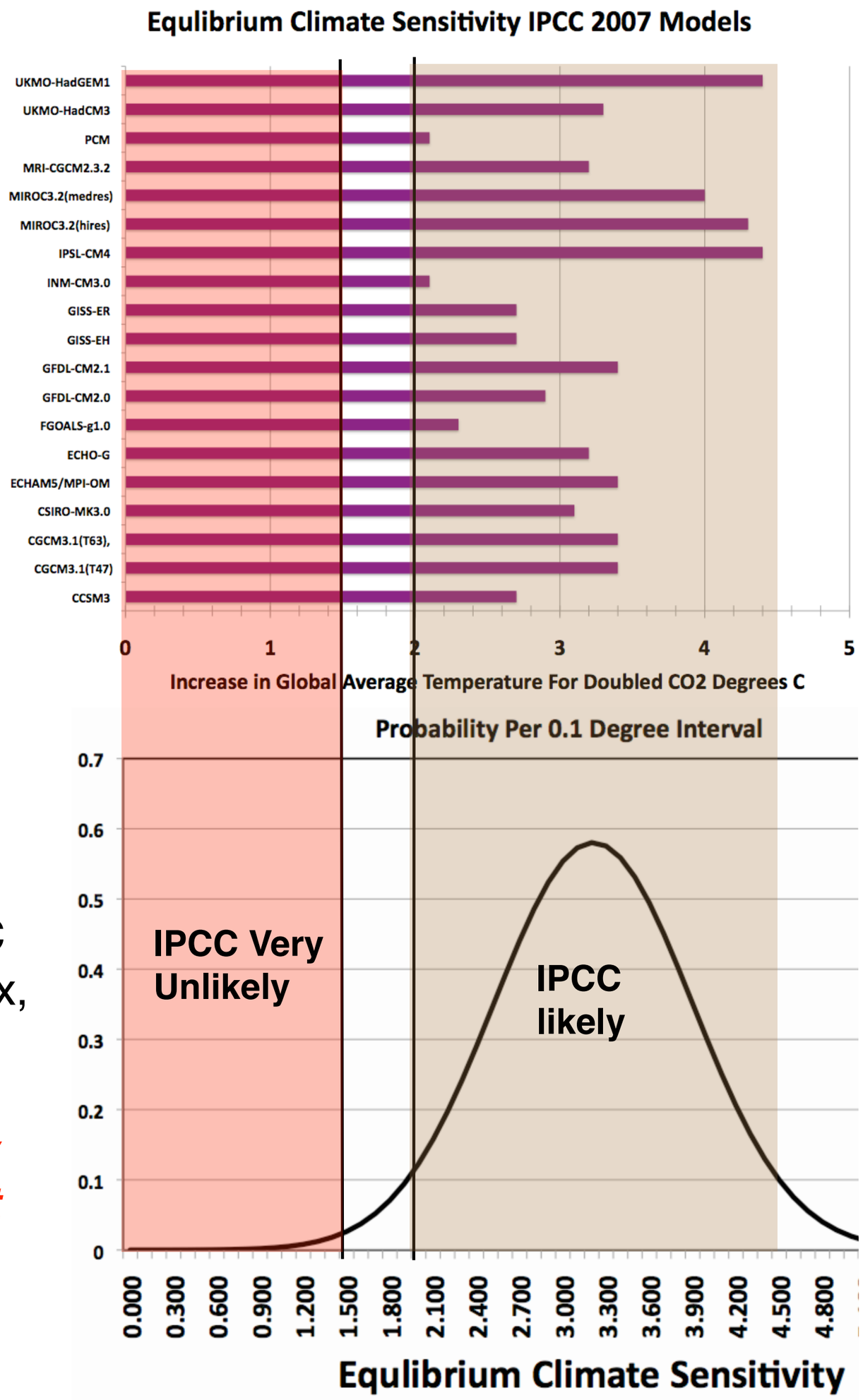


Figure 3

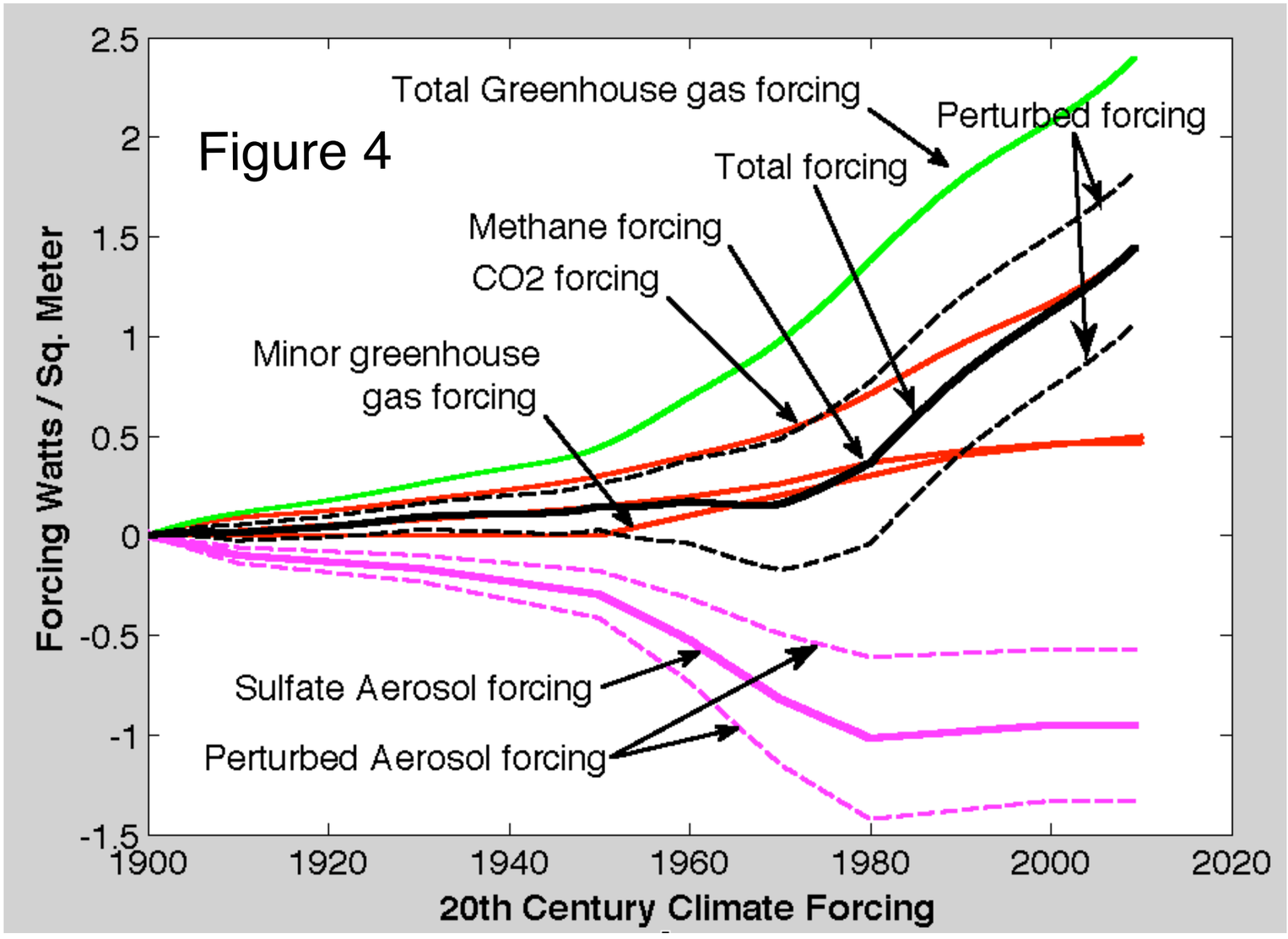
Do the disparate models cluster about a true value?

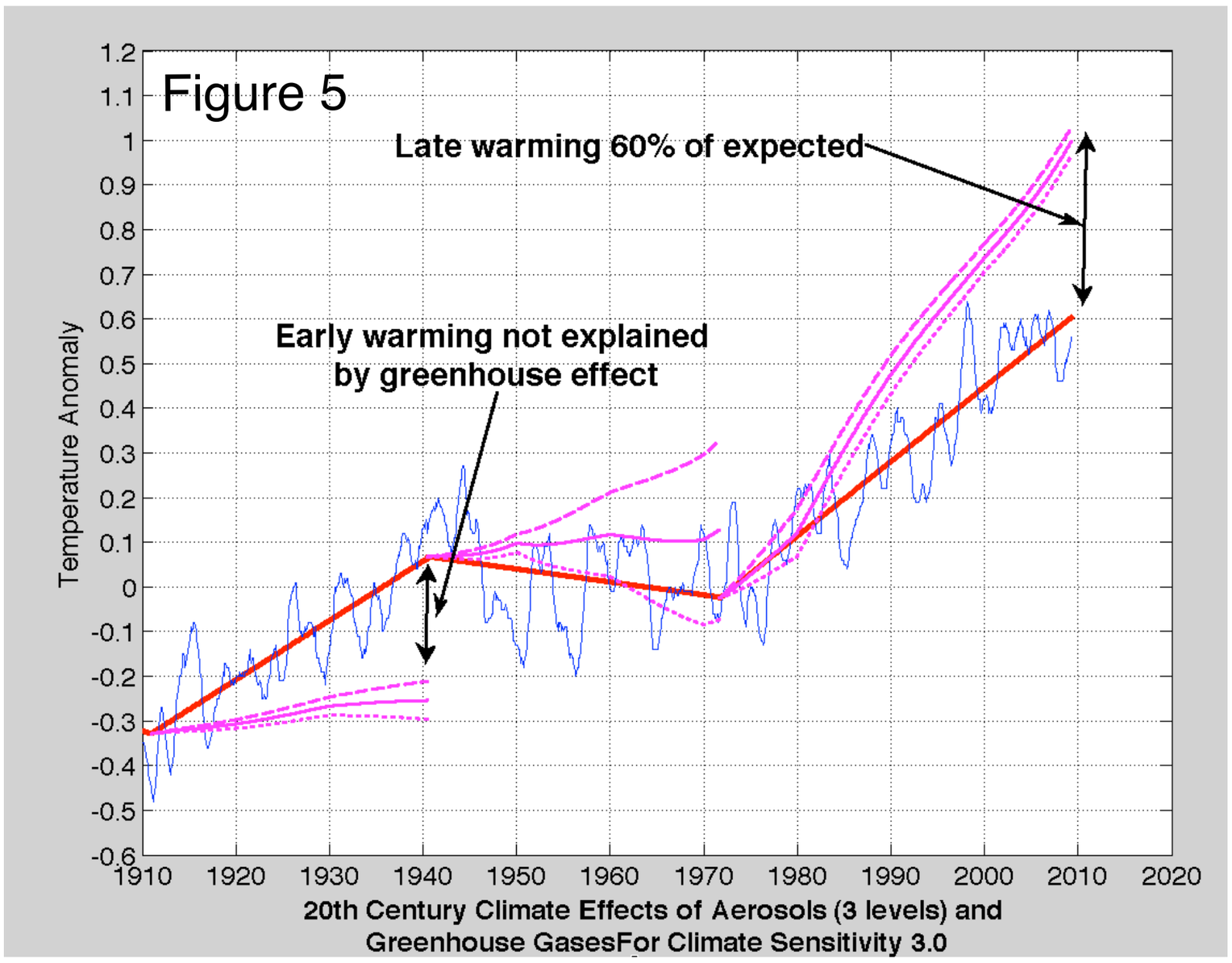
If models outputs cluster around a true value then you might as well fit the outputs to a normal curve and compute relative probabilities. The IPCC does something like that and comes up with precise sounding estimates such as: *as likely as not* or *very likely*. The normal curve above seemingly provides visual support for the IPCC claim that it is very unlikely that climate sensitivity is less than 1.5. Is this a reasonable application of statistical methods?

Climate Forcing

Figure 4 (right) shows the various climate forcings. The important points are:

1. Greenhouse gas forcing started to rapidly increase after World War II as the world economy grew[6].
2. Aerosol negative forcing or cooling started to increase at the same time but flattened out after 1980 due to sulfur emissions control[7].
3. We know that most aerosol forcing is caused by sulfur emissions. We know the shape of the forcing curve but not the amplitude[8].
4. Because sulfur based aerosols are relatively flat after 1970 they cannot influence the strength of the late century warming.





Does the Forcing Explain the 20th Century Climate?

1. The early century warming is not explained.
2. The late century warming should be much larger given 3.0 climate sensitivity and the known forcings.

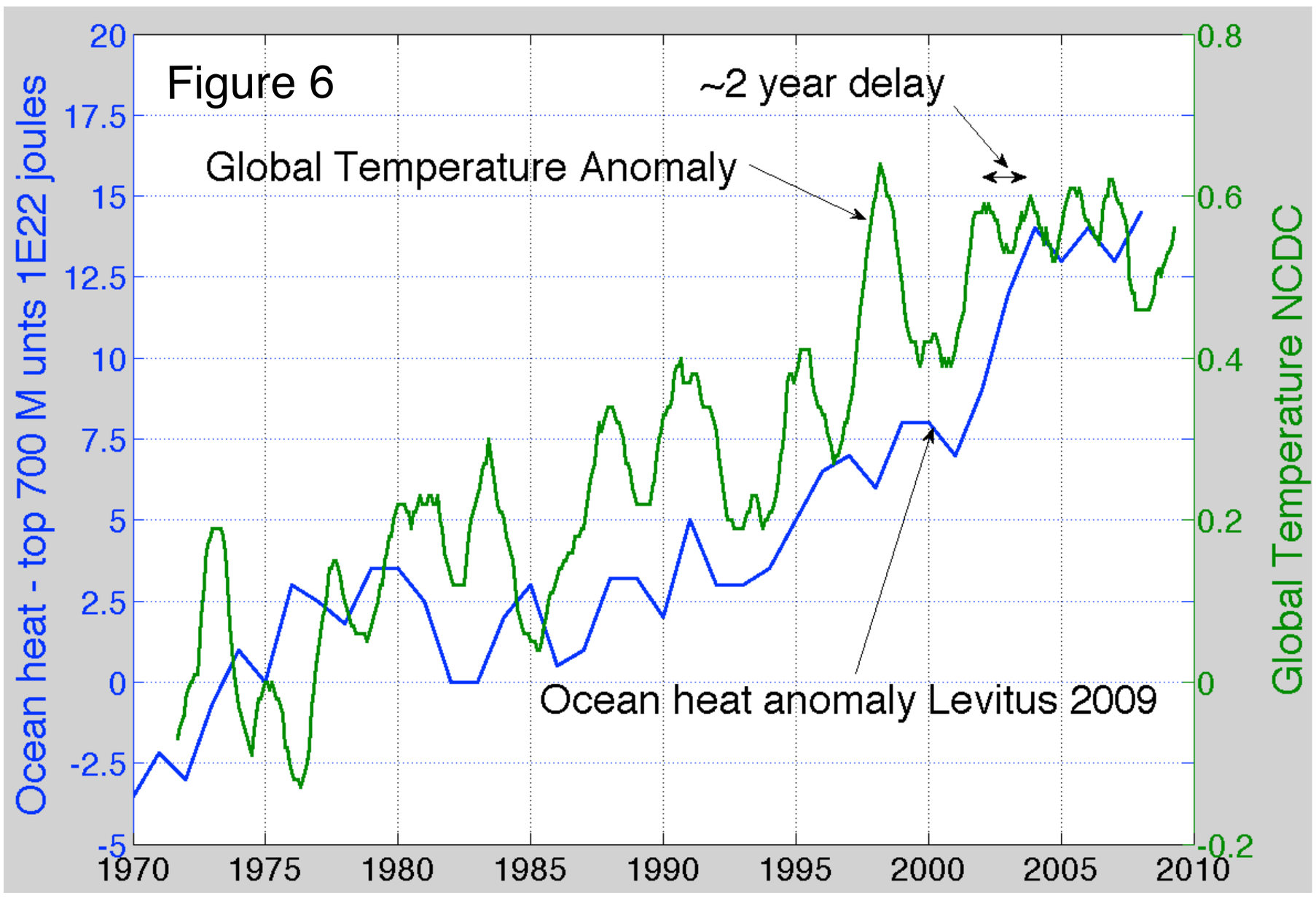
Figure 5 above shows the theoretical temperature change within each 20th century zone given the combined greenhouse and aerosol forcing[9]. The dashed lines show the effect of perturbing aerosol forcing as shown in figure 4.

How to Explain the 20th Century Climate History?

Greenhouse gases and aerosols alone cannot explain the 20th century if the climate sensitivity is 3.0 as the IPCC assumes. The modeling groups were given carte blanche to use forcings as they "deemed appropriate." Exactly what they did is poorly documented, but they were able to make the models with widely differing climate sensitivity closely match the 20th century temperature anomaly history.

It is clear that the modeling groups solved the early century warming problem by assuming that a strong solar forcing warmed the climate from 1910 to 1940. There are no measurements of solar irradiance to support this idea that is based on shaky extrapolations from sunspot counts. The modeling groups probably took care of the late century either by manipulating aerosol forcing or by assuming that the ocean is absorbing heat and thus creating a negative forcing or cooling. Clearly in their quest for a good model match they found something "appropriate."

Ocean Heat Absorption



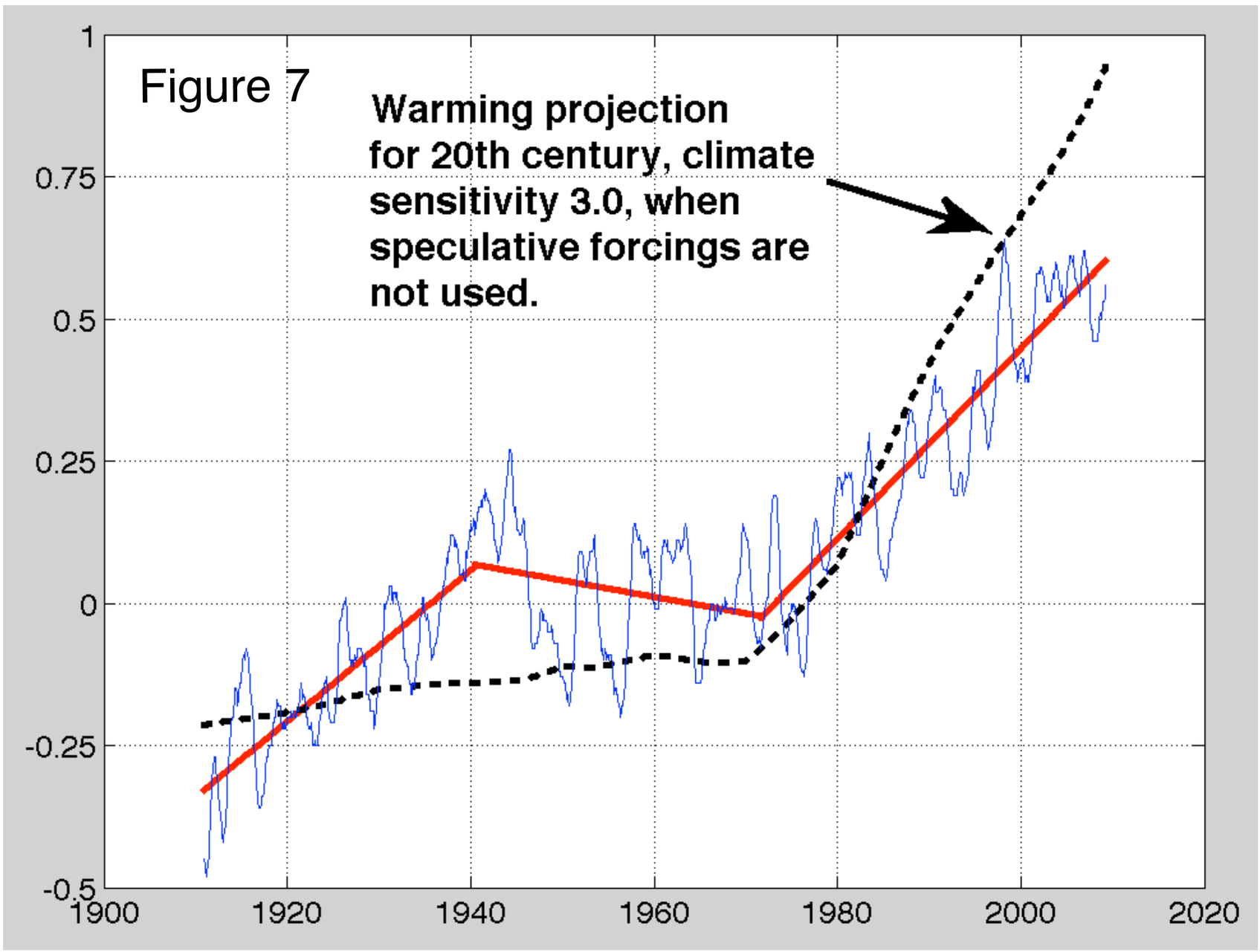
If the atmosphere is warming the ocean will be out of equilibrium due to its thermal mass and temperature stratification. If the warming trend stops it will take a period of time for the warming of the ocean to catch up with the atmosphere or ocean surface. This leads to the concept of warming in the pipeline. The models disagree substantially as to how fast heat moves into the ocean[10]. But in long model simulations the effect is quite large. However by examining experimental data[11] (graph figure 6) it can be seen that the pipeline in the late 20th century may be very short. Global temperature stabilized starting in 2002 and the ocean heat content stabilized about 2 years later. The clear implication is that there is little forcing or net heat flow due to ocean heat absorption

after 2003. Thus ocean heat absorption cannot explain the lack of late 20th century warming needed to be consistent with a 3.0 degree climate sensitivity[12]. The ocean heat content in the graph is only for the top 700 meters, but heat transfer to the deeper ocean is a minor consideration. (After 2003 ocean heat content is especially well measured due to the Argo system of robotic floats.)

Solar Forcing

Accurate measurements of solar irradiance only began during the satellite era around 1980. Most of the IPCC models used for generating figure 2 use an early century solar forcing from a paper by Lean[13] that is highly speculative. The same author in a later paper[14] more extensively discussed the speculative nature of the forcing. The solar forcing used by the IPCC only explains about 50% of the early warming as can be seen from figure 2. A later paper by a different author[15] postulates an even stronger early century increase in solar irradiance.

There is plentiful evidence that solar activity affects climate. The influence may not be due solely to changes in irradiance as there are theories involving the sun's magnetic field and cosmic rays[16] as well as theories involving changes in the sun's UV spectrum[17]. Blaming the early century (but not the late century) warming on the sun is poorly supported.



The Climate History of the 20th Century is Unexplained

Figure 7 (right) shows the expected temperature during the 20th century for 3.0 climate sensitivity using greenhouse and aerosol forcing but not the speculative forcings[18]. This graph can be compared with the IPCC's graph shown in figure 2. When realistic forcings are used it is apparent that the temperature history of the 20th century is not explained. The early warming remains a mystery and the late warming is insufficent for 3.0 climate

sensitivity. It is not known if the late warming was caused all or in part by the same actors that caused the early warming (not CO2).

Summary and Conclusions

Because the IPCC models differ widely in climate sensitivity an ensemble of models can't be expected to fit well to the late 20th century when CO2 was rapidly increasing. Each modeling group was permitted to use different forcings and the result was impressive looking fits to the 20th century.

In AR4 section 9.4.1.5 the IPCC admits uncertainty as to the causes of the early century warming. But the IPCC plunges ahead with model fits to the early century based on speculative solar forcing. Would it be better to simply accept that the causes of the early century warming are unknown?

The concept of a multi-model ensemble is deeply flawed. However there is an important political advantage to multi-model ensembles. If the IPCC picked one best model from 23 modeling groups it would make one friend and 22 enemies. Picking the best model from the various models would threaten the losers' funding and surely create a storm of protest. The obvious solution is politically impossible.

Aerosols cannot explain the lack of late 20th century warming because sulfur emissions were near flat in the late 20th century. Ocean warming cannot explain it because (as shown in figure 6) ocean heat flux quickly stabilizes and is near zeroed out by 2002. There may be long term, smaller ocean fluxes, but these are too small to provide significant forcing in the late 20th century according the the evidence of figure 6. As detailed in reference (8) models differ by 2-1 on ocean heat fluxes.

The IPCC model fits to the 20th century are probably intended to demonstrate the power and effectiveness of climate models. They demonstrate the opposite - how little we know. We don't know what caused the early century warming. We don't know how big the greenhouse contribution is to the late century warming.

> *Yet, in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite.*
>
> Dwight D. Eisenhower - Farewell Address 17 January 1961

[1] Abbreviated as AR4 and available at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm

[2] See table S9.1 in AR4 for a listing of the models used for the “A+N” and “N” graphs.

[3] Remarked on in: Quantifying climate change — too rosy a picture? Stephen E. Schwartz, Robert J. Charlson & Henning Rodhe. *Nature Reports Climate Change* Published online: 27 June 2007. Also discussed for the 2001 IPCC report in: Kiehl, J. T. (2007), Twentieth century climate model response and climate sensitivity, Geophys. Res. Lett., 34 (2007)

[4] Meehl, G.A. et. al. The WCRP CMIP3 multimodel dataset: A new era in climate change research. Bulletin of the American Meteorological Society September 2007.

[5] The apparent improvement in fitting error obtained by averaging outputs of different models can possibly be explained as the consequence of averaging independent fitting alogrithms whose errors are not highly correlated.

[6] Formulas for forcing from: NOAA’s annual greenhouse gas index (http://www.esrl.noaa.gov/gmd/aggi/) extended before 1978 to using historical CO2 and CH4 data.- CO2 prior 1957 from law dome: http://cdiac.ornl.gov/trends/co2/lawdome.html - CH4 prior 1978: http://cdiac.ornl.gov/trends/atm_meth/lawdome_meth.html

[7] Historical Sulfur Dioxide Emissions 1850-2000: Methods and Results Pacific Northwest Laboratories report: PNNL-14537. A reasonable guess supplied results for the 1st decade of the 21st century not covered in the report.

[8] See table 2.12 AR4.

[9] Figure 5 is constructed by using the 3 alternate forcing anomalies with assumed climate sensitivity of 3.0. In each of the 3 eras of the 20th century the theoretical change for that era is plotted.

[10] Raper, S.C.B., J.M. Gregory, and R.J. Stouffer, 2002: The role of climate sensitivity and ocean heat uptake on AOGCM transient temperature response, J. Climate, 15, 124-130. See also the poster: Inter-model climate sensitivity, J.T. Kiehl and C.A. Shields NCAR. http://www.cgd.ucar.edu/ccr/shields/posters/ccppsensitivity.pdf

[11] Levitus, S., J. I. et. al. (2009), Global ocean heat content 1955–2008 in light of recently revealed instrumentation problems, Geophys. Res. Lett., 36,

[12] Given chaotic variation and measurement error I don’t claim that the graphs in figure 6 are proof positive that the time constant of ocean warming is very short, but the correlation between the graphs is remarkable for a coincidence.

[13] Most of the IPCC models use solar forcing specified in the paper: Reconstruction of solar irradiance since 1610: Implications for climate change Judith Lean, et. al. Geophysical Research Letters Vol. 22 No. 23 (1995). The author makes it clear that reconstruction of irradiances in the past depends on many assumptions and is fraught with uncertainty and speculation.

[14] Lean, J, Rind, D. Climate forcing by changing solar radiation. Journal of Climate (1998).

[15] Solanki, S.K., Fligge, M. Solar Irradiance since 1874 revisited. Geophysical Research Letters (1998).

[16] Svensmark, H., Influence of Cosmic Rays on Earth's Climate Phys. Rev. Lett. 81, 5027 - 5030 (1998)

[17] Rind, D., Do Variations in the Solar Cycle Affect Our Climate System? http://www.giss.nasa.gov/research/briefs/rind_03/

[18] The forcings shown in the bold black line in figure 4 are used and the average temperature in the graph is adjusted by adding a constant to match the average value over the period (1910-2008).

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