Propagation of Error and The Reliability of Global Air Temperature Projections

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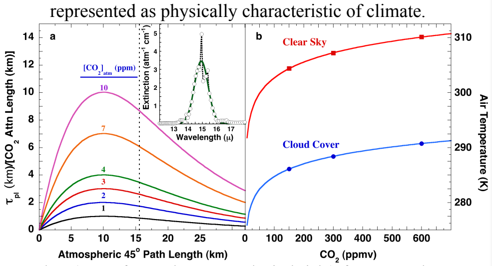
Abstract: General circulation model (GCM) global surface air temperature projections are accurately simulated using the equation, $\Delta T = f_{cd} \times 33K \times [(F_0 + \Sigma_i \Delta F_i)/F_0] + b$, indicating projections are just linear extrapolations of GHG forcing. Linear uncertainty propagates as the r.s.s.e. CMIP5 models average ±12% theory-bias error in total cloud fraction (TCF), equating to ±4 Wm^{-2} long wave cloud forcing uncertainty in the energy state of the projected atmosphere. Propagated TCF uncertainty is always much larger than the projected global air temperature anomaly, reaching ±15 C in a 100-year projection. CMIP5 projections thus have no predictive value.

Introduction

Propagation of error, a standard measure of predictive reliability, is applied to CMIP5 GCM global air temperature projections. A valid lower limit of physical accuracy is presented.

1. The Fractional *wve* Greenhouse Effect of CO_2

The GH fractions below are relevant to GCMs, and are not represented as physically characteristic of climate.



Panel a. (Mean free path ÷ tropospheric height) for a 15μ photon at varying [CO_2]. Inset: (○), the CO_2 15μ band, and; (—), Gaussian fit. Panel b. greenhouse air temperature with varying [CO_2] *wve* forcing under clear or cloud covered sky. [1] Lines: fit of $T(K) = a \times ln[CO_2] + c$, (a, c, R² (clear; cloudy): 4.13, 283.71, 0.94, and; 3.35, 269.33, 0.94). Absorption mean free path is defined by $I/I_0 = e^{-\epsilon cl} = 1/e = 0.368$

Panel a: when $[CO_2]_{atm}$< 1 ppm, the average 15μ photon escapes the troposphere without absorption. Climatologically significant water vapor enhanced (*wve*) green house (GH) warming begins only when [CO_2] > 1 ppm. Absorbance of 15μ photons becomes log-linear at 1 ppm < [CO_2] < 2 ppm. [2]

Panel b: modeled *wve* CO_2 forcing (constant relative humidity) [1] extrapolated to 1 ppm yields equilibrium air temperatures for *wv*-only forcing, under clear or cloud covered skies, of 284 K or 269 K.

Global cloud fraction=0.67 [3]; the modeled fraction of GH air temperature due to water vapor forcing alone is: f_{wv} = [(284 K×0.33)+(269 K×0.67)-255 K] ÷33 K = 0.58 (255 K is $T_{radiative}$; 33 K is net unperturbed GH $T_{surface}$. The modeled GH fraction due to CO_2 is $f_{cd} = 1 - f_{wv} = 0.42$.

References

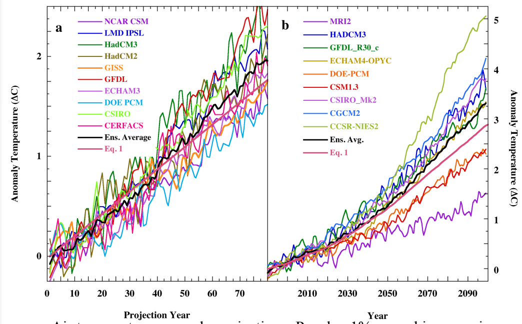
[1] Manabe, S. and R.T. Wetherald (1967) J. Atmos. Sci. 24, 241-259.
[2] Howard, J.N., D.E. Burch, and D. Williams (1956) J. Opt. Soc. Am. 46 237-241.
[3] Jiang, J.H., et al. (2012) J. Geophys. Res. 117 D14105.
[4] Gates, W.L., et al. (1999) Bull. Amer. Met. Soc. 80, 29-55.
[5] Lauer, A. and K. Hamilton (2013) J. Climate 26 3823-3845.

2. The Structure of GCM Air Temperature Projections

GCM air temperature projections can be modeled as:

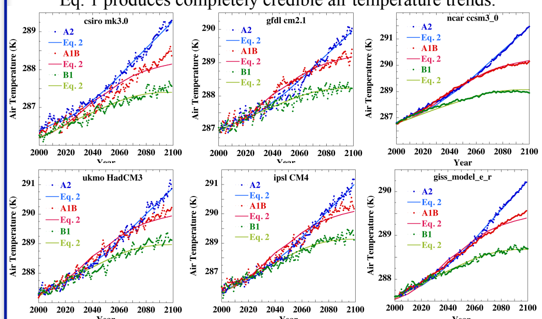
$$\Delta T = 0.42 \times 33K \times [(F_0 + \Sigma_i \Delta F_i)/F_0] \quad (1)$$

where F_0 is the total GHG forcing of projection year zero, and ΔF_i is the increment of GHG forcing in the i^{th} year.



Air temperature anomaly projections: Panel a. 1% annual increase in atmospheric CO_2 [4]; (—), eq. 1. Panel b. SRES A2 scenario; (—), eq. 1.

Eq. 1 produces completely credible air temperature trends.

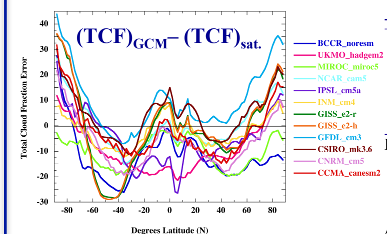


Generalized eq. 2: $\Delta T = f'_{cd} \times 33K \times [(F_0 + \Sigma_i \Delta F_i)/F_0] + b$, reproduced all 54 realizations of the SRES A2, A1B, and B1 projection scenarios in the IPCC 4AR, made using 21 CMIP3 GCMs; f'_{cd} and b are GCM-dependent.

Eq. 2 Coefficients Specific to CMIP3 GCM AR4 SRES Projections

CMIP3	SRES A2		SRES A1B		SRES B1	
	f'_{cd}	b (K)	f'_{cd}	b (K)	f'_{cd}	b (K)
CSIRO mk3.0	0.444	271.16	0.383	274.39	0.434	271.32
GFDL cm2.1	0.460	271.18	0.482	270.45	0.460	271.20
GISS model e r	0.409	273.53	0.406	273.60	0.402	273.76
UKMO Hadcm3	0.547	268.56	0.581	267.34	0.627	265.71
IPSL cm4	0.564	267.52	0.600	266.28	0.658	264.23
NCAR ccsm3.0	0.556	268.26	0.519	269.52	0.463	271.39

3. CMIP5 Global Cloud Fraction Error



Error in total cloud fraction (TCF) for 12 CMIP5 GCMs. $(TCF)_{sat.}$ = averaged MODIS and ISCCP2.

CMIP5 error correlation matrix, lag-1 R, and RMS Uncertainty

GCM[b]	Noresm	Hadgem	Miroc5	Cam5	CM5	CM4	giss-er	giss-eh	gfdl	csiro	cnrm	Canesm	Lag-1 R	±RMS
Noresm	1.00	0.34	0.70	0.63	0.32	0.69	0.81	0.80	0.67	0.76	0.77	0.70	0.98	15.4
Hadgem		1.00	0.14	0.88	0.87	0.51	0.64	0.64	0.84	0.64	0.73	0.82	0.99	12.7
Miroc5			1.00	0.45	0.11	0.77	0.69	0.69	0.54	0.74	0.67	0.53	0.97	11.9
CAM5				1.00	0.81	0.79	0.85	0.83	0.97	0.89	0.92	0.91	0.99	9.4
CM5a					1.00	0.43	0.46	0.44	0.71	0.59	0.69	0.76	0.97	11.4
CM4						1.00	0.87	0.87	0.85	0.93	0.82	0.75	0.95	6.2
GISS-er							1.00	1.0	0.92	0.89	0.88	0.81	0.99	15.5
GISS-eh								1.00	0.91	0.88	0.86	0.80	0.99	15.7
GFDL									1.00	0.92	0.93	0.92	0.99	15.8
CSIRO										1.00	0.93	0.88	0.97	10.0
CNRM											1.00	0.95	0.98	11.3
Canesm												1.00	0.97	10.3
Avg.													0.98	12.1

Lag-1 R≥0.95 indicates spatially non-random CMIP5 TCF error.

Of the 66 pair-wise error correlations 12 show R≥0.9 and 46 0.9>R≥0.5, indicating CMIP5 TCF error is due to theory-bias. Theory-bias error does not average away.

Average CMIP5 TCF error produces ±4 W/m² uncertainty in long wave cloud forcing (LCF). [5] LCF, like *wve* CO_2 forcing, contributes to and is part of the thermal energy flux of the atmosphere.

CMIP5 LCF error means that the thermal state of the atmosphere cannot be modeled to better accuracy than ±4W/m²; ±110× larger the average 0.036 W/m² annual increase in GHG forcing.

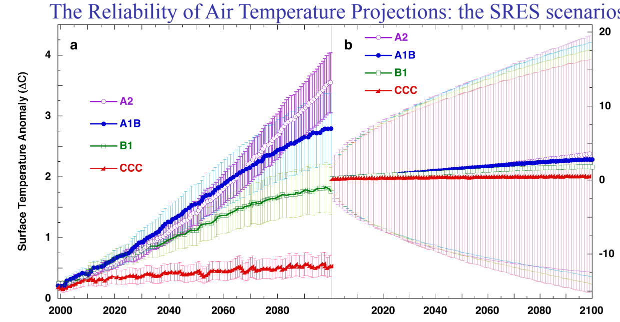
4. The Reliability of Global Air Temperature Projections

GCM global air temperature projections are just linear extrapolations of GHG forcing. Therefore GCM forcing errors propagate linearly into global air temperature projections.

Serial propagation of physical error through *n* steps of an air temperature projection yields the uncertainty variance in the final state as: $\sigma_f^2 = \sum_{i=0}^{n} \sigma_i^2$

Uncertainty increases step-wise because theory-bias LCF error means climate response is unknown by ±4W/m² in each and every projection step. The Figure below provides a typical propagation of CMIP5 LCF error.

The Reliability of Air Temperature Projections: the SRES scenarios



Panel b: Each scenario lays within the 1σ confidence limits of all the others. None is unique; None is predictive; None is reliable.

Similar confidence limits will attend any CMIP5 hindcast.

Panel a: SRES scenarios with 1σ confidence limits as in IPCC 4AR SPM.5 and TS.32.
Panel b: SRES scenarios with 1σ confidence limits from ±4W/m² CMIP5 LCF error.

Conclusions

1. **Climate models are unable to resolve the effect of anthropogenic GHGs.**
2. **Global air temperature projections presently have no predictive value.**
3. **Detection and attribution currently remain impossible.**

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