How reliable are climate models?

A review of a recent EOS discussion

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PCMDI comment in EOS concerning climate models validity – March 6 2007

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FORUM

On the Validity of Climate Models

We object to contributor Kevin Corbett's assertions, in his article "On award to Crichton" (*Eos, 87*(43), 464, 2006), that "Too often now, models are taken as data and their results taken as fact, when the accuracy of the models in predicting even short-term effects is poor and the fundamental validity for most climate models is opaque…." Corbett cites (among other references) our *Eos* article "Coupled climate model appraisal: A benchmark for future studies" [*Phillips et al.*, 2006], implying that our findings support his remarks. In fact, our evaluation of model simulations relative to observational data leads us to very different conclusions.

As noted in our *Eos* article, the 20-year mean statistics of most climate variables simulated by 11 recent-vintage Coupled Model Intercomparison Project Expanded Phase 2 (CMIP2+) ocean-atmosphere global climate models (OAGCMs) were similar to observed climatologies on global and continental scales but deviated regionally, where the typically coarse model grid spacing (approximately 3 × 3 degrees latitude-longitude) was an inherent limitation. We also noted that most of the CMIP2+ model simulations captured essential features of modes of variability such as the El Niño–Southern Oscillation (ENSO). Moreover, the ENSO simulations of current-vintage 'CMIP3' models [*Program for Climate Model Diagnosis and Intercomparison (PCMDI)*, 2006a] show further improvements [*AchutaRao and Sperber*, 2006], and without the CMIP2+ model's need to include ad hoc adjustments of ocean surface fluxes in order to maintain a stable coupled climate state. These strengths strongly argue against Corbett's sweeping dismissal of climate models.

To be sure, the CMIP2+ simulations also exhibit many shortcomings that demand critical scrutiny and further model improvement. For a balanced and detailed analysis of both the strengths and weaknesses of these coupled OAGCMs, we recommend a perusal of our full climate model appraisal [*AchutaRao et al.*, 2004], since only selective highlights could be included in the *Eos* summary article.

But why not just analyze 'data,' as Corbett recommends? First, no truly global data exist prior to the modern satellite era (circa 1980). There also are substantial disparities among satellite-derived estimates of the same climatic phenomena owing to cross-platform differences in instrumentation, data retrieval methods, and sampling frequencies. There are, as well, nontrivial variations among alternative in situ instrumental data sets owing to different choices of observational networks or gridding algorithms. Even larger observational uncertainties are present in reconstructions of climate records from proxy data (e.g., tree rings, lake sediments, ice cores, etc.). Thus, while the existing historical climate record is an indispensable resource, its limitations also should be recognized.

Further, in order to draw connections between apparent trends in observational time series and historical changes in forcings (e.g., variations in solar output, atmospheric constituents, land use, etc.), physical or statistical models need to be applied [e.g., *Mann et al.*, 2006]. We also must rely on models to project how global climate may respond to putative future changes in forcings. The CMIP3 models, for example, provide projections of the future climates associated with various greenhouse gas emissions scenarios [*Intergovernmental Panel on Climate Change*, 2000; *PCMDI*, 2006b]. Because the accuracy of a model projection depends on how well the feedbacks among components of the climate system are simulated (e.g., water vapor, clouds, thermal lapse rate, snow, and sea ice), analysis of these interactions is crucial, although this too must include modeling of the relevant physical processes in addition to observational studies [*Bony et al.*, 2006].

It is thus not easy to disentangle the observing of climatic phenomena from their modeling, nor is this likely to prove scientifically beneficial. For instance, a thorough evaluation of the CMIP3 simulations of recent historical climate relative to available global observations is a prerequisite for assessing the credibility of these models' projections of future climate. This challenging task now engages much of our collective effort, as well as that of scores of our fellow international climate scientists [*PCMDI*, 2006c].

Acknowledgments

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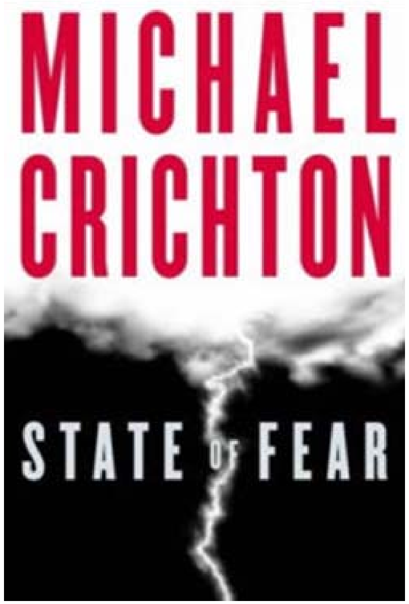
Kevin Corbett « On award to Crichton » EOS 24 October 2006

« Too often now, models are taken as data and their results taken as facts, when the accuracy of the models in predicting even short-term effects is poor and the fundamental validity for most climate models is opaque »



American Association of Petroleum Geologists (AAPG) 2006 Journalism Award

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On the Validity of Climate Models

• "20-year mean statistics for most climate variables simulated by 11 different models are similar to observed data on global and continental scales, although they do deviate regionally".

• "The models captured essential features of modes of variability."

In response to Corbetts "let the data, all of the data, speak, if you dare":

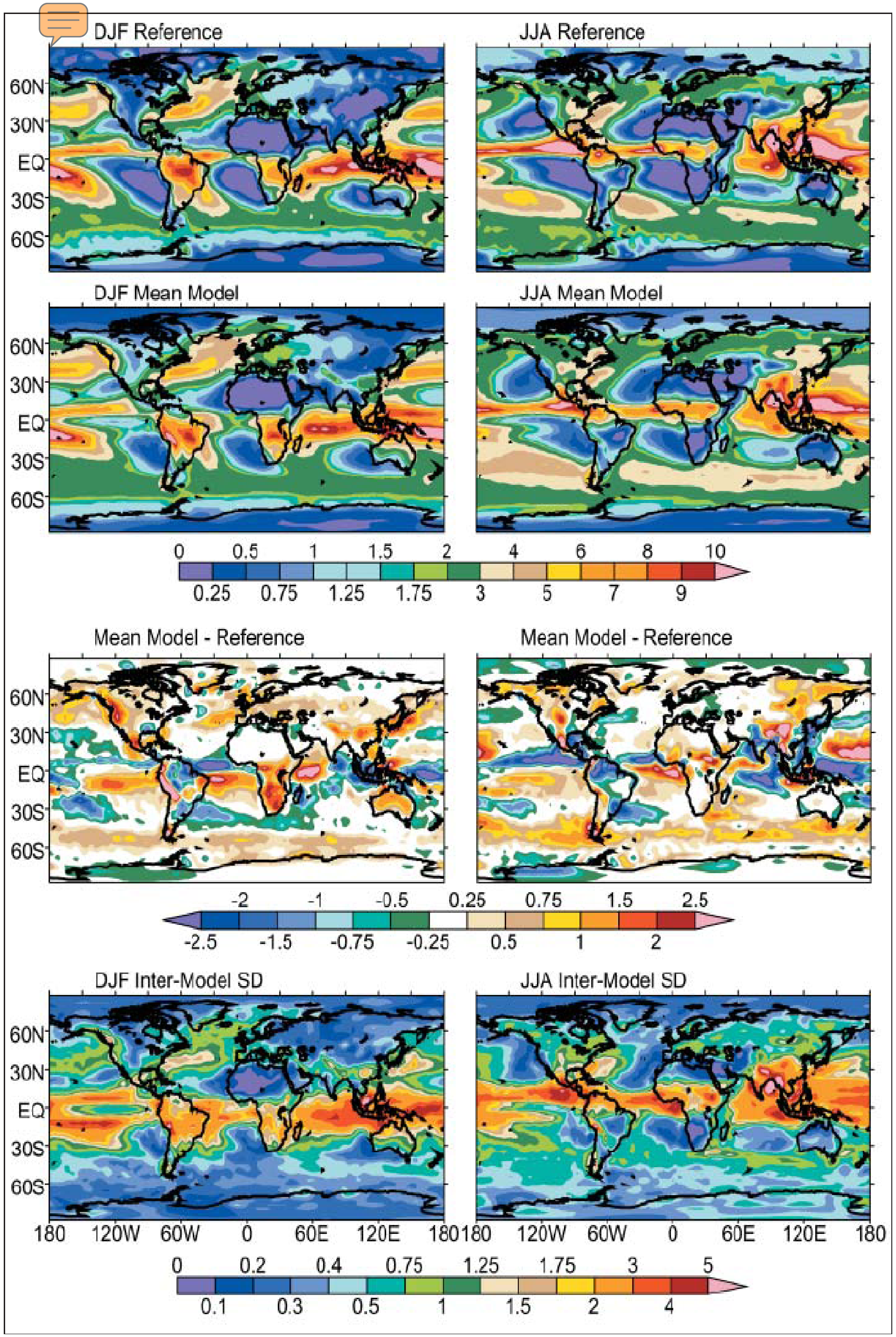
Data should not be considered as "reality"

- no truly global data exist prior to modern satellite era (circa 1980),
- disparities between satellite measurements exist,
- non-trivial variations among in situ instrumental datasets,
- large error in proxy data (e.g. tree rings, ice cores, lake sediments, etc.)

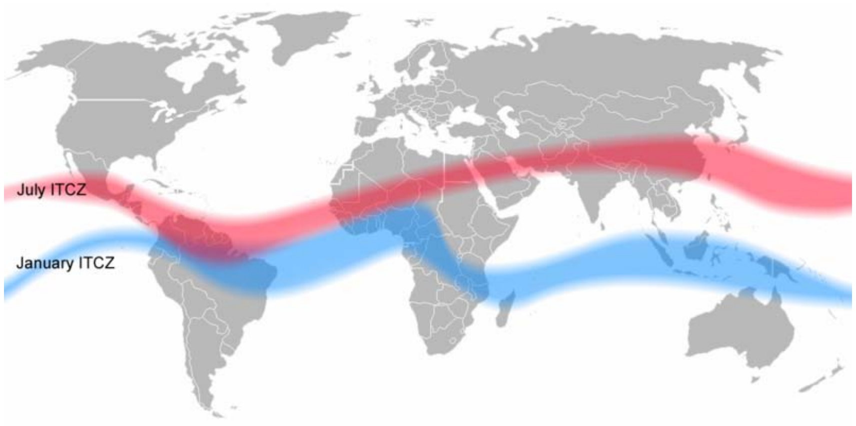
$\Rightarrow$ climate record is an indispensable resource but with limitations

Coupled Climate Model Appraisal: A Benchmark for Future Studies EOS May 2006

Table 1. Salient Features of the CMIP2+ Models and Respective Simulations of the Present Climate[a]						
Model, Vintage	**Institutional Sponsor, Country**	**Atmosphere:** Resolution TOA pressure	**Ocean:** Resolution Vertical Coordinates	**Sea Ice:** Dynamics Structure	**Land:** Soil Plants	**Coupling:** Spin-Up Duration Flux Adjustments
BCM02,2002	University of Bergen, Norway	1.9° × 1.9° L31 10 hPa	2.4° × 2.4° L24 density	rheology leads	layers canopy	25 years heat, freshwater
CCCma_CGCM2,2002	Canadian Centre for Climate Modelling and Analysis, Canada	3.7° × 3.7°L10 5 hPa	1.9° × 1.9° L29 depth	rheology leads	bucket no canopy	50 years heat, freshwater
CCSM2.0, 2002	National Center for Atmospheric Research, U.S.	2.8° × 2.8°L26 2.9 hPa	1.0° × 1.0° L40 depth	rheology leads	layers canopy	350 years no adjustments
CSIRO_Mk2,1997	Commonwealth Scientific and Industrial Research Organisation, Australia	3.2° × 5.6° L9 21 hPa	3.2° × 5.6° L21 depth	rheology leads	layers canopy	105 years heat, freshwater, momentum
ECHAM4_OPYC3, 1996	Max Planck Institute for Meteorology, Germany	2.8° × 2.8° L19 10 hPa	2.8° × 2.8° L11 density	rheology leads	bucket canopy	100 years heat, freshwater
ECHO-G, 1999	Model and Data Group, Germany	3.8° × 3.8° L19 10 hPa	3.8° × 3.8° L20 depth	rheology leads	bucket canopy	310 years heat and freshwater anomalies
GFDL_R30_c, 1996	Geophysical Fluid Dynamics Laboratory, U.S.	2.3° × 3.8° L14 15 hPa	1.9° × 2.3° L18 depth	no rheology no leads	bucket no canopy	900 years heat, freshwater
HadCM2, 1995	Hadley Centre, Met Office, U.K.	2.5° × 3.8° L19 5 hPa	2.5° × 3.8° L20 depth	no rheology leads	layers canopy	~ 500 years heat, freshwater
HadCM3, 1997		2.5° × 3.8° L19 5 hPa	1.5° × 1.5° L20 depth	no rheology leads	layers canopy	400 years no adjustments
MRI_CGCM2.3, 2002	Meteorological Research Institute, Japan	2.8° × 2.8° L30 0.4 hPa	2.0° × 2.5° L23 depth	no rheology leads	layers canopy	95 years heat, freshwater
PCM, 1999	Department of Energy, U.S.	2.8° × 2.8° L18 2.9 hPa	0.7° × 0.7° L32 depth	rheology leads	layers canopy	50 years no adjustments



Decadal-scale climatologies



"The 20-year mean statistics for most climate variables simulated by 11 […] different models were similar to observed climatologies on global and continental scales, but deviated regionally where the typically coarse model grid spacing was an inherent limitation."

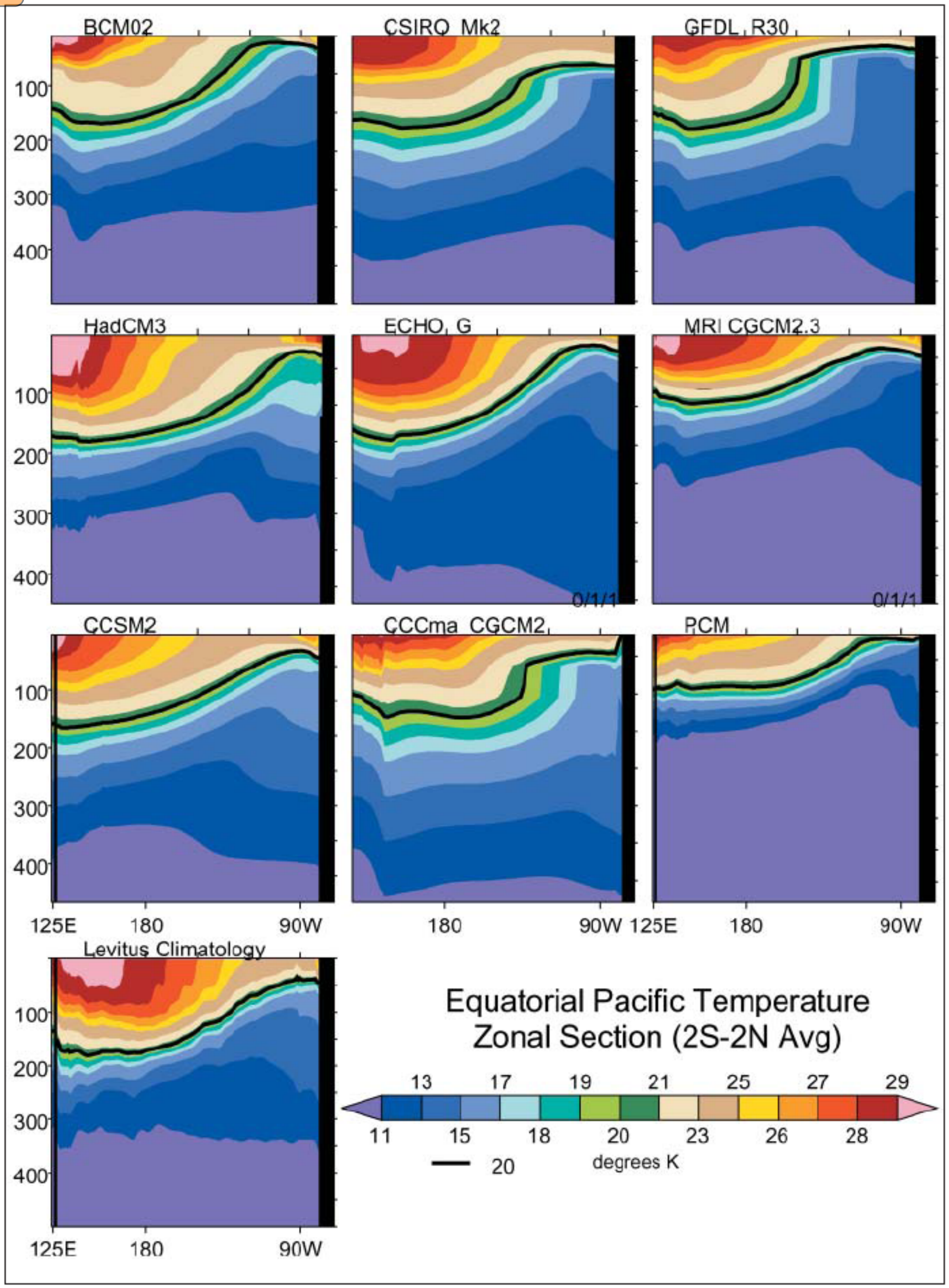
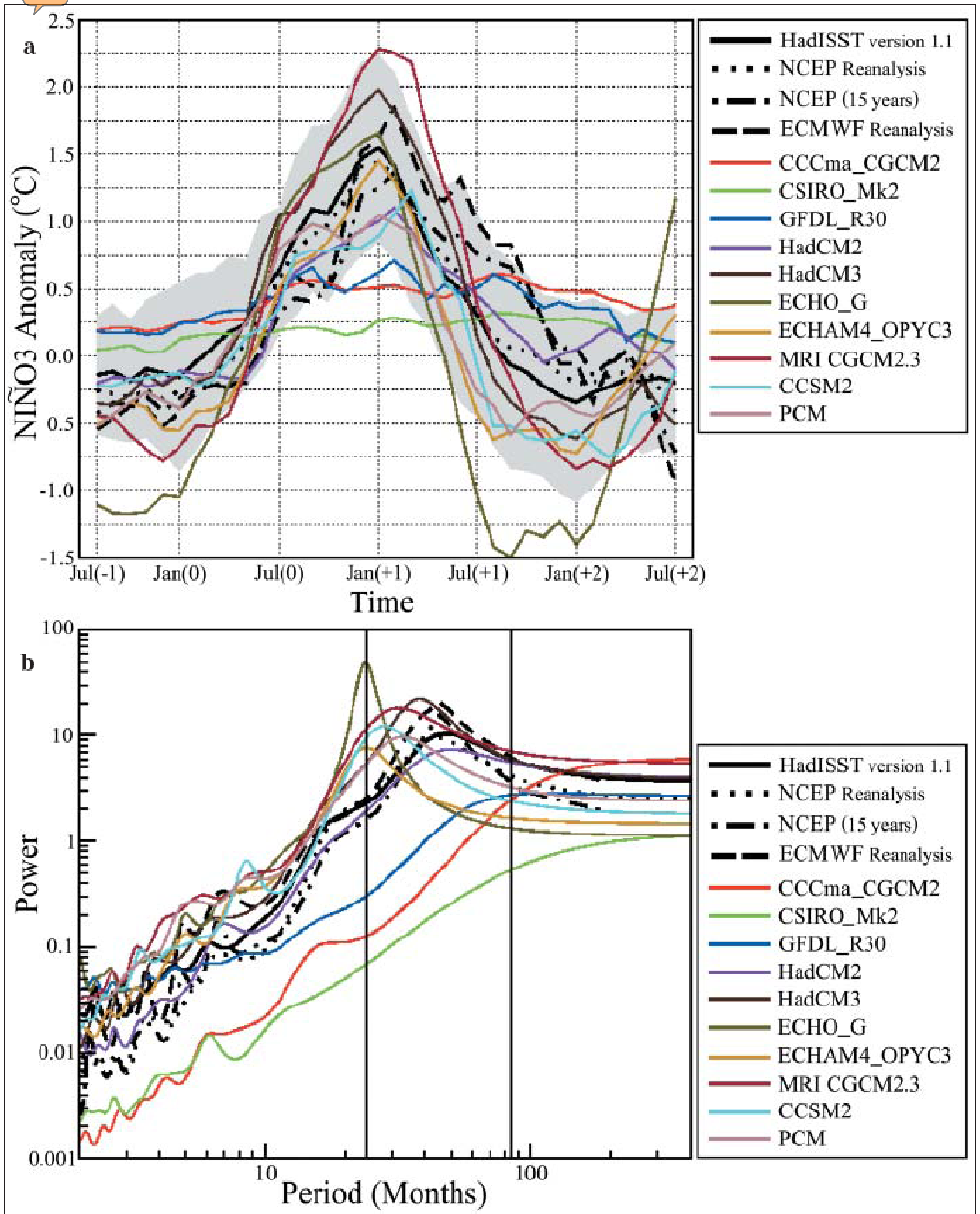


Fig. 2. Equatorial Pacific (averaged 2°S–2°N) simulations of 20-year climatologies of upper ocean temperature in CMIP2+ models (ECHAM4_OPYC and HadCM2 models (see Table 1) not included) compared with the Levitus observations.

"Did not work in the Arctic Ocean where the generally poor quality of the simulations may have been due to

- flawed model representations of heat/salinity transport,
- vertical mixing,
- the insulating effects of sea ice"

Intradecadal modes of climatic variability



"The models captured essential features of modes of variability."

Corbett or PCMDI?

"Too often now, models are taken as data and their results taken as facts, when the accuracy of the models in predicting even short-term effects is poor and the fundamental validity for most climate models is opaque"

Models do show potential

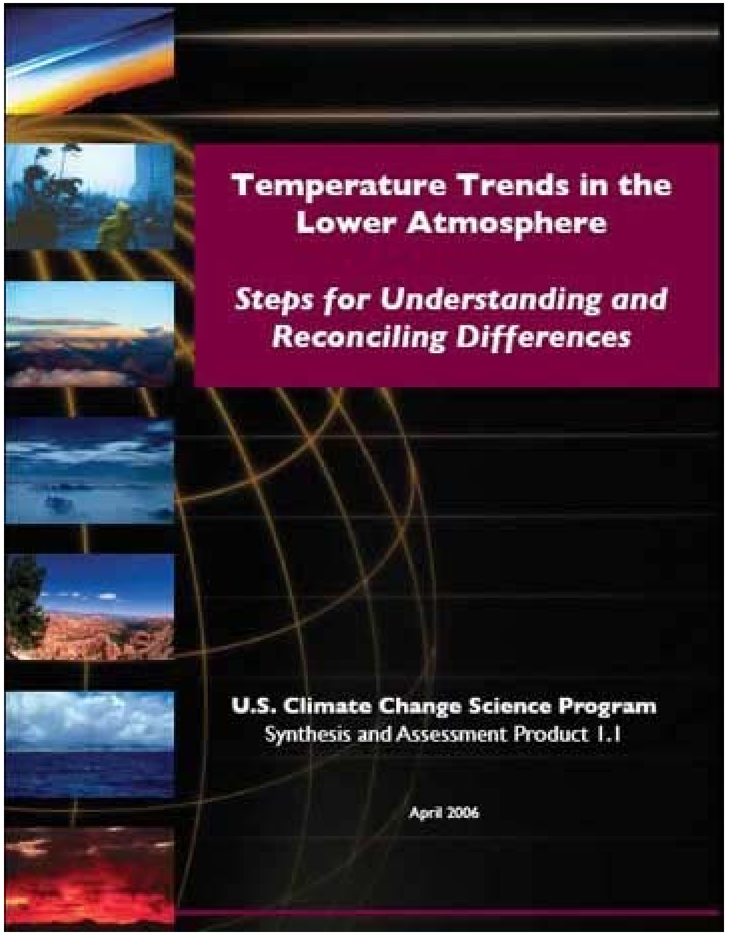
1) Climate variables can be fairly simulated at the global and continental scales, although they do deviate regionally

2) Some models can capture essential features of modes of variability.

Observations are not « reality »

S. Fred Singer « On award to Crichton » EOS 24 October 2006

Report summary claim “clear evidence” for anthropogenic global warming, but that the “report itself clearly contradicts this”.



April 2006 U. S. Climate Change Science Program report

Cites Fig. 5.4G “which compares key observations with the calculations of major greenhouse models, shows a considerable disparity […] and falsifies the anthropogenic global warming hypothesis”

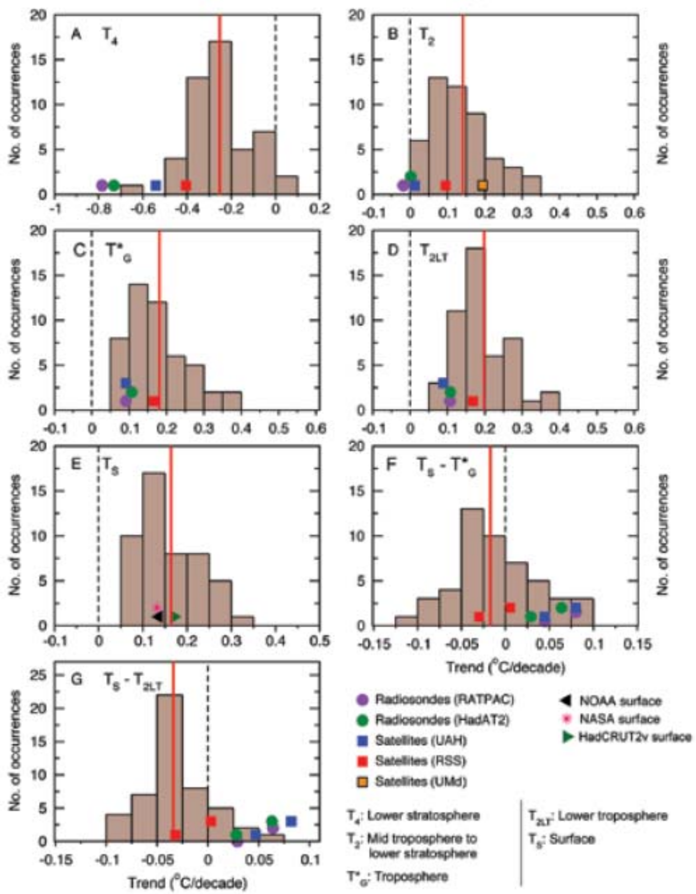


Figure 5.3: Modeled and observed trends in time series of global-mean T_4 (panel

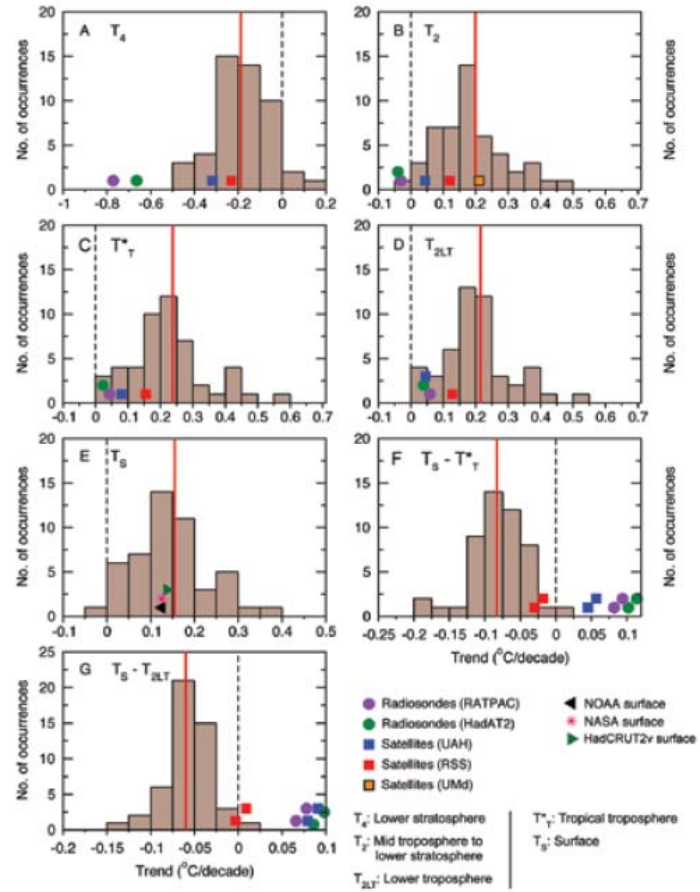


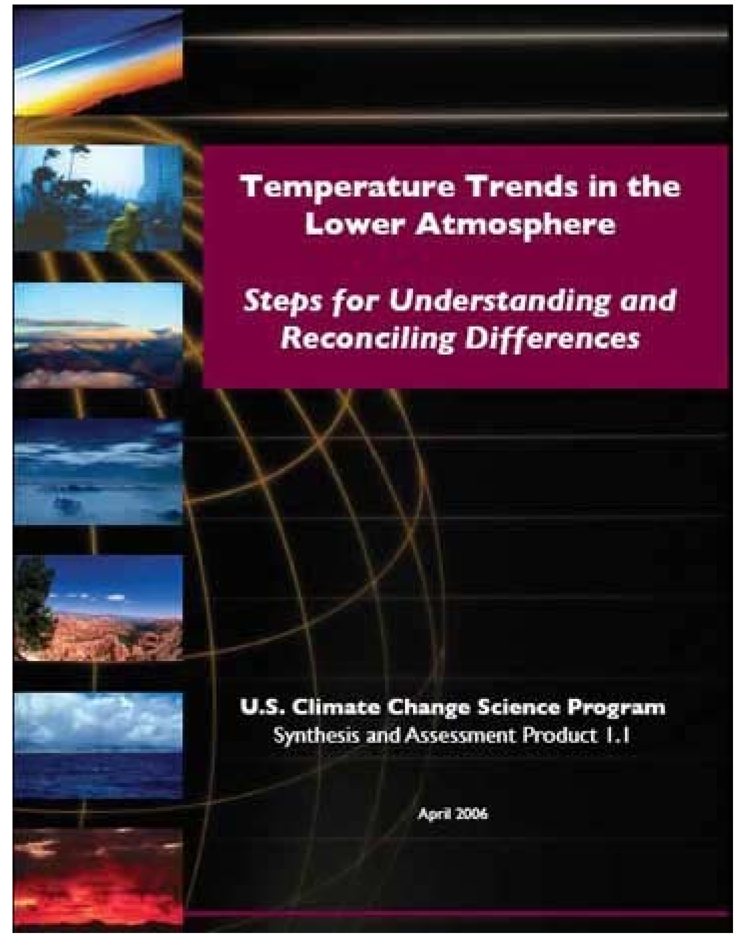
Figure 5.4: As for Figure 5.3, but for trends in the tropics (20°N-20°S).

Global trends

Tropic trends

S. Fred Singer « On award to Crichton » EOS 24 October 2006

« The obvious disparity between the U.S. Climate Change Science Program report and its summary illustrates the common problem of relying on a potentially distorted summary for policy-makers. Perhaps we need a policy for summary-makers. »



April 2006 U. S. Climate Change Science Program report