

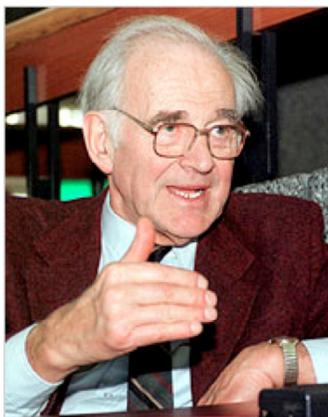
# IPCC AND CLIMATE CHANGE ASSESSMENT

Is the science robust enough for reliable societal advice?

Stephen E. Schwartz

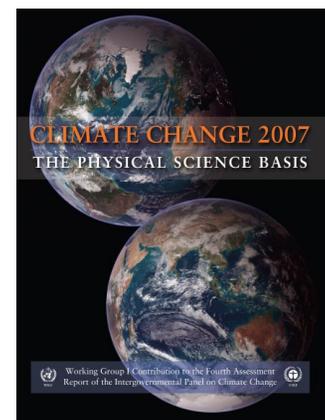
**BROOKHAVEN**  
NATIONAL LABORATORY

Upton NY USA



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THE ROYAL SWEDISH ACADEMY OF SCIENCES



Natural and Man-made Climate Change  
Symposium in Honour of Bert Bolin

Stockholm, Sweden

May 21-23, 2012

*viewgraphs available at [www.ecd.bnl.gov/steve](http://www.ecd.bnl.gov/steve)*

# THE BIBLE OF CLIMATE CHANGE

*It's big and thick.*

*Every household should have one.*

*No one reads it from cover to cover.*

*You can open it up on any page  
and find something interesting.*

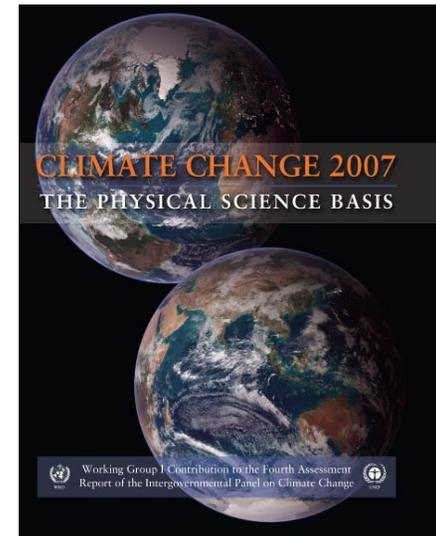
*It was written by a committee.*

*It is full of internal contradictions.*

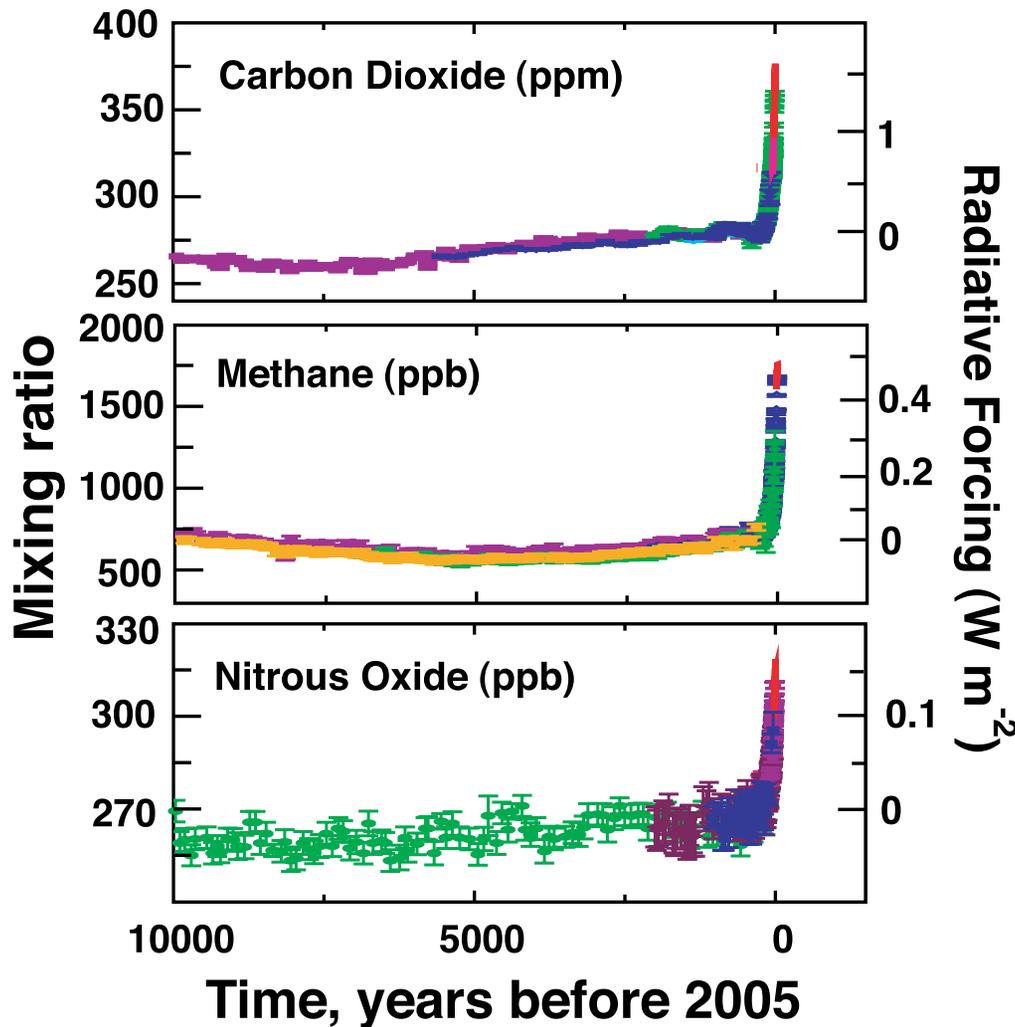
*It deals with cataclysmic events such as  
floods and droughts.*

*It has its true believers and its skeptics.*

*It can be downloaded free from the web.*

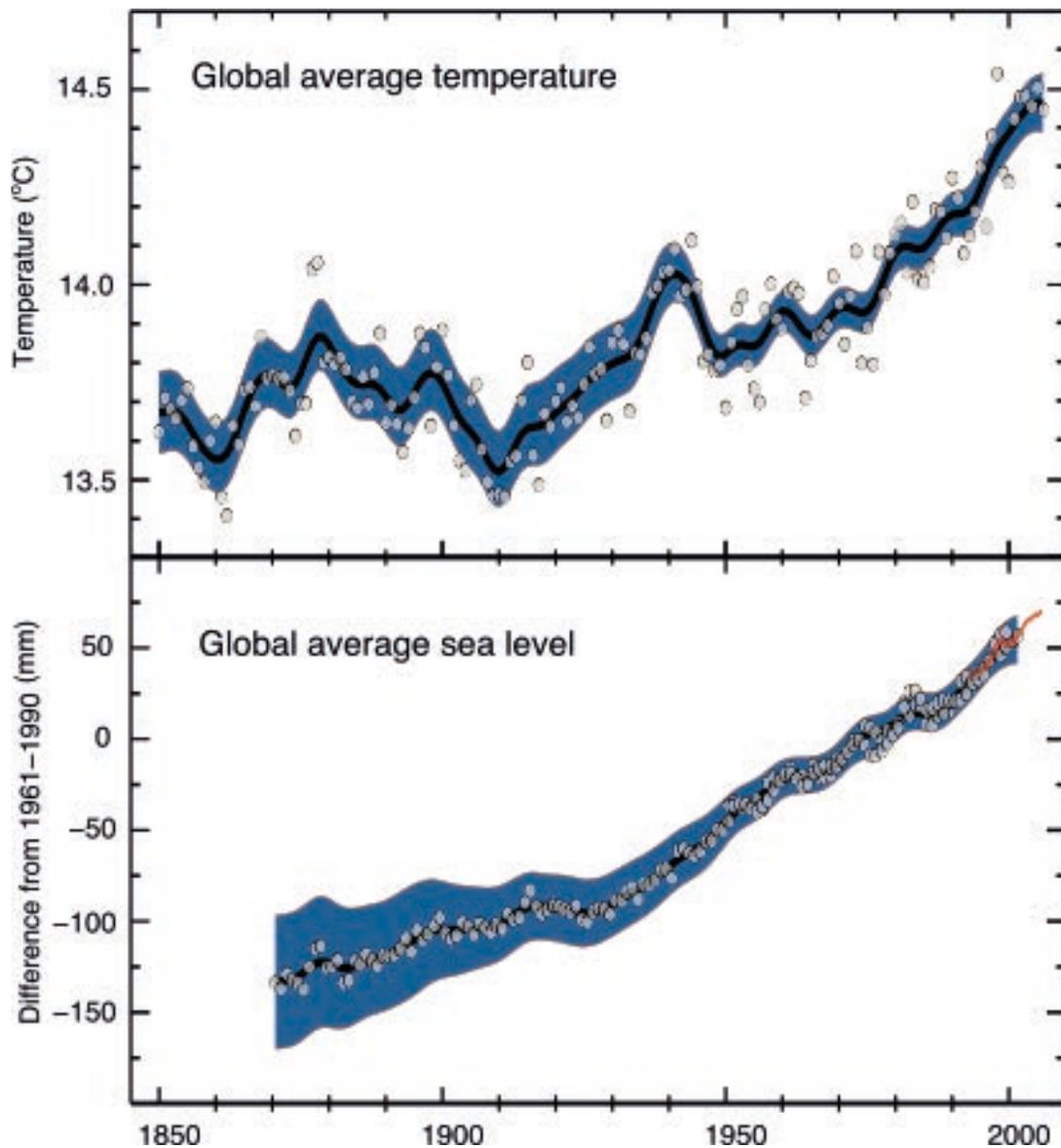


# OBSERVED INCREASES IN GREENHOUSE GASES



- “ Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have *increased markedly since 1750 as a result of human activities* and now far exceed pre-industrial values.
- “ The global increases in carbon dioxide concentration are due *primarily to fossil fuel use and land use change*; those of methane and nitrous oxide are primarily due to *agriculture*.

# OBSERVED CHANGES IN CLIMATE



“ *Warming of the climate system is unequivocal*, as is evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.

“ At continental, regional and ocean basin scales, *numerous long-term changes in climate have been observed*. These include changes in Arctic temperatures and ice, precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather.

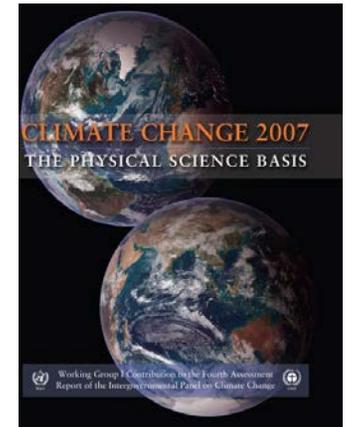
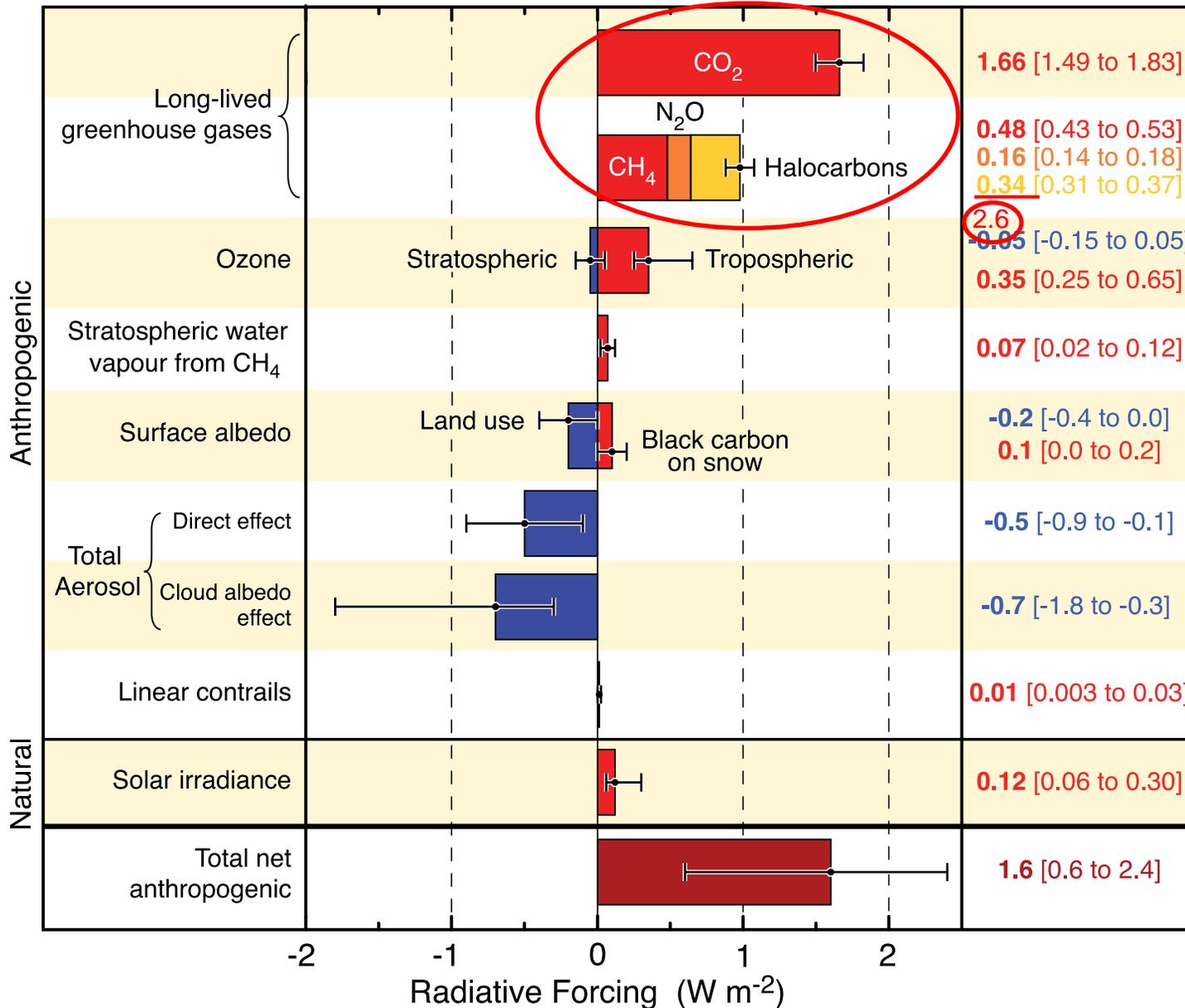
# FIRM CONCLUSIONS AND PROJECTIONS

- “ Palaeoclimatic information supports the interpretation that the warmth of the last half century is *unusual in at least the previous 1,300 years*.
- “ The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to *4 to 6 m of sea level rise*.
- “ Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely be larger than those observed during the 20th century*.
- “ Even if greenhouse gas concentrations were to be stabilised, *anthropogenic warming and sea level rise would continue for centuries* due to the time scales associated with climate processes and feedbacks.

# GLOBAL-MEAN RADIATIVE FORCINGS

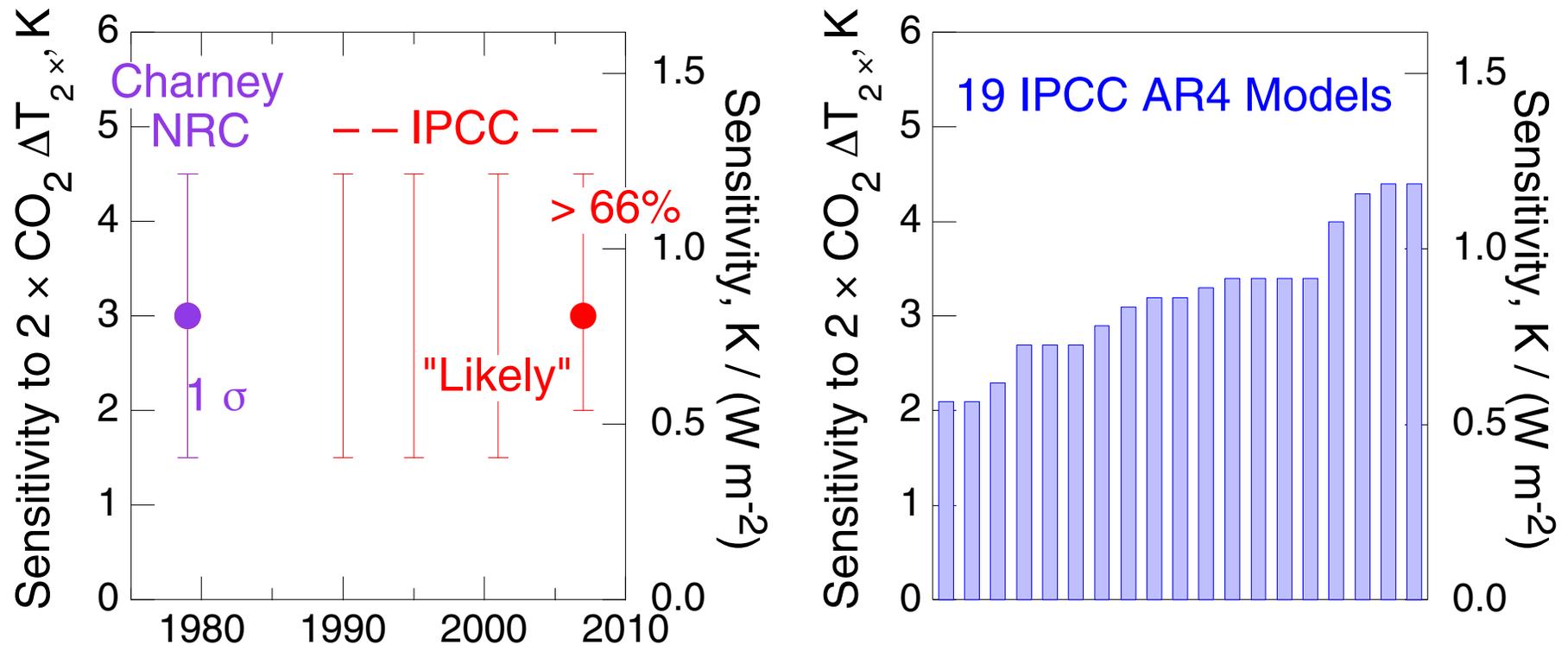
Preindustrial to present (Intergovernmental Panel on Climate Change, 2007)

## RADIATIVE FORCING COMPONENTS



# ESTIMATES OF EARTH'S CLIMATE SENSITIVITY AND ASSOCIATED UNCERTAINTY

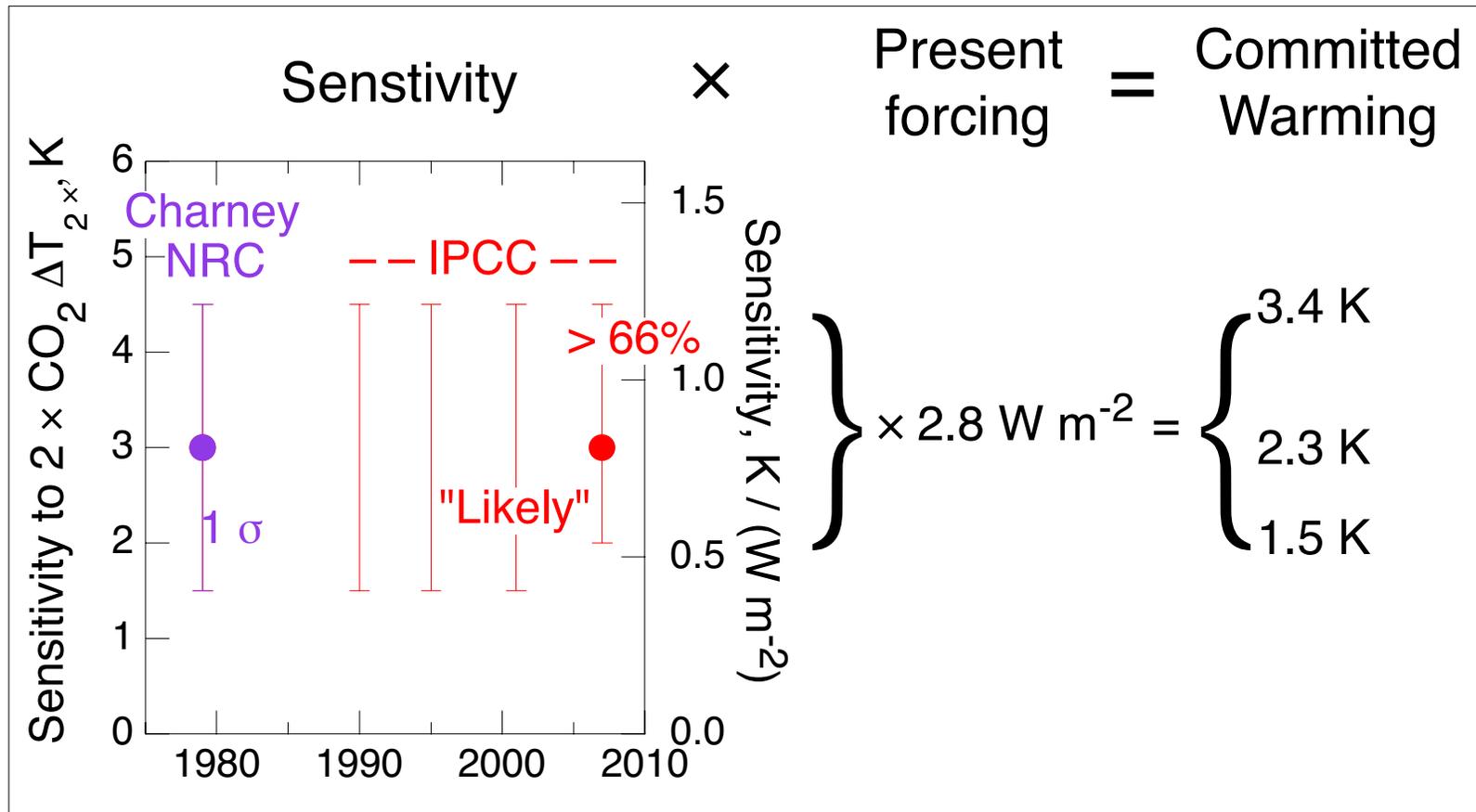
Major national and international assessments and current climate models



Current estimates of Earth's climate sensitivity are centered about a CO<sub>2</sub> doubling temperature  $\Delta T_{2x} = 3$  K, but with substantial uncertainty.

# COMMITTED FUTURE WARMING

Temperature increase above preindustrial, for forcing by long-lived greenhouse gases alone maintained at present value

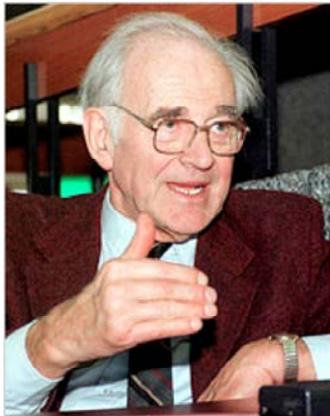


IPCC *can, should, and does* state with confidence the consequences of such committed future warming.

# IPCC AND CLIMATE CHANGE ASSESSMENT

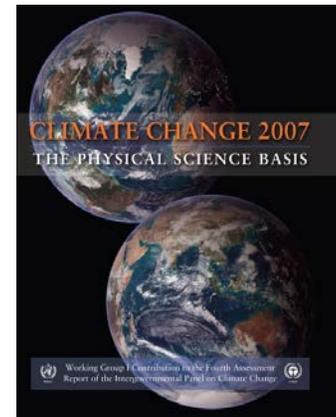
Is the science robust enough for reliable societal advice?

*Yes, yes a thousand times yes!*



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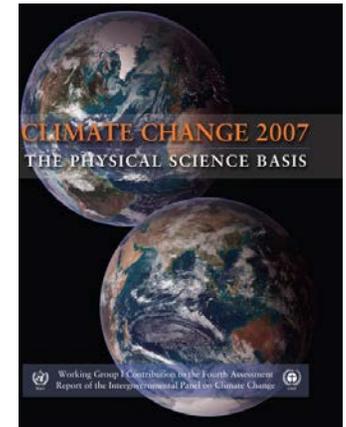
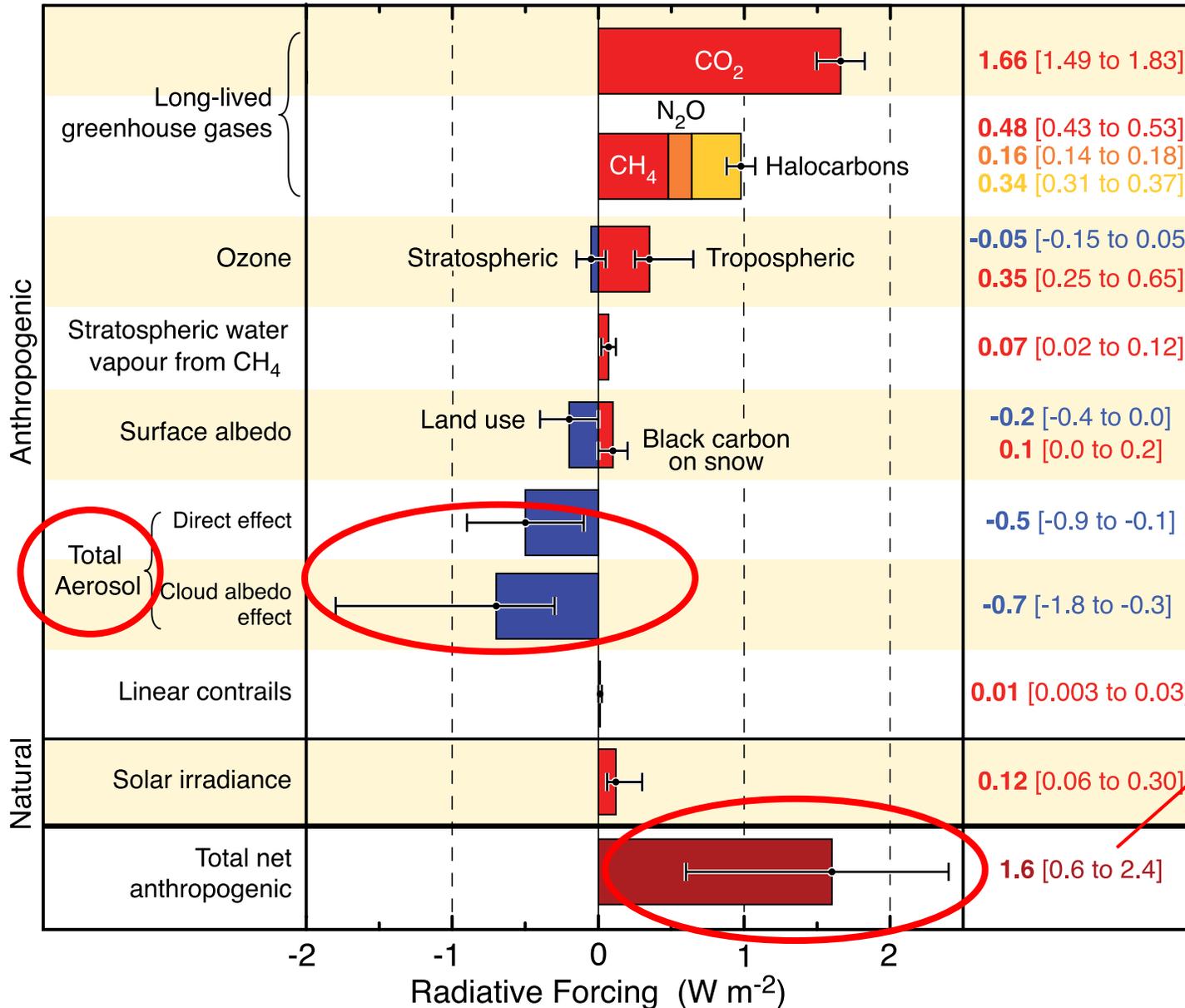
Natural and Man-made Climate Change  
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# GLOBAL-MEAN RADIATIVE FORCINGS

Preindustrial to present (Intergovernmental Panel on Climate Change, 2007)

## RADIATIVE FORCING COMPONENTS

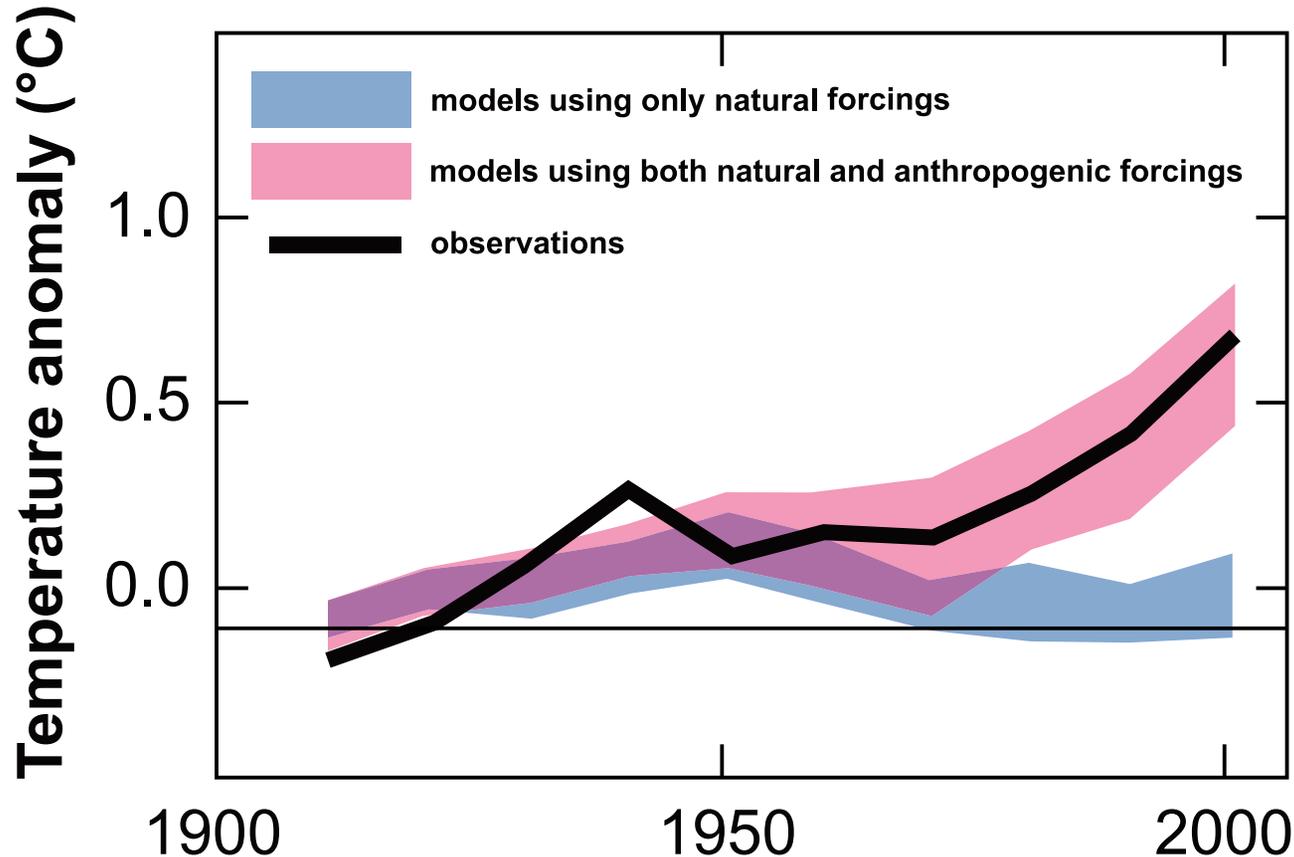


Factor of 4 limits empirical inferences and model evaluation.

Uncertainty in aerosol forcing dominates uncertainty in total forcing.

# TOO ROSY A PICTURE?

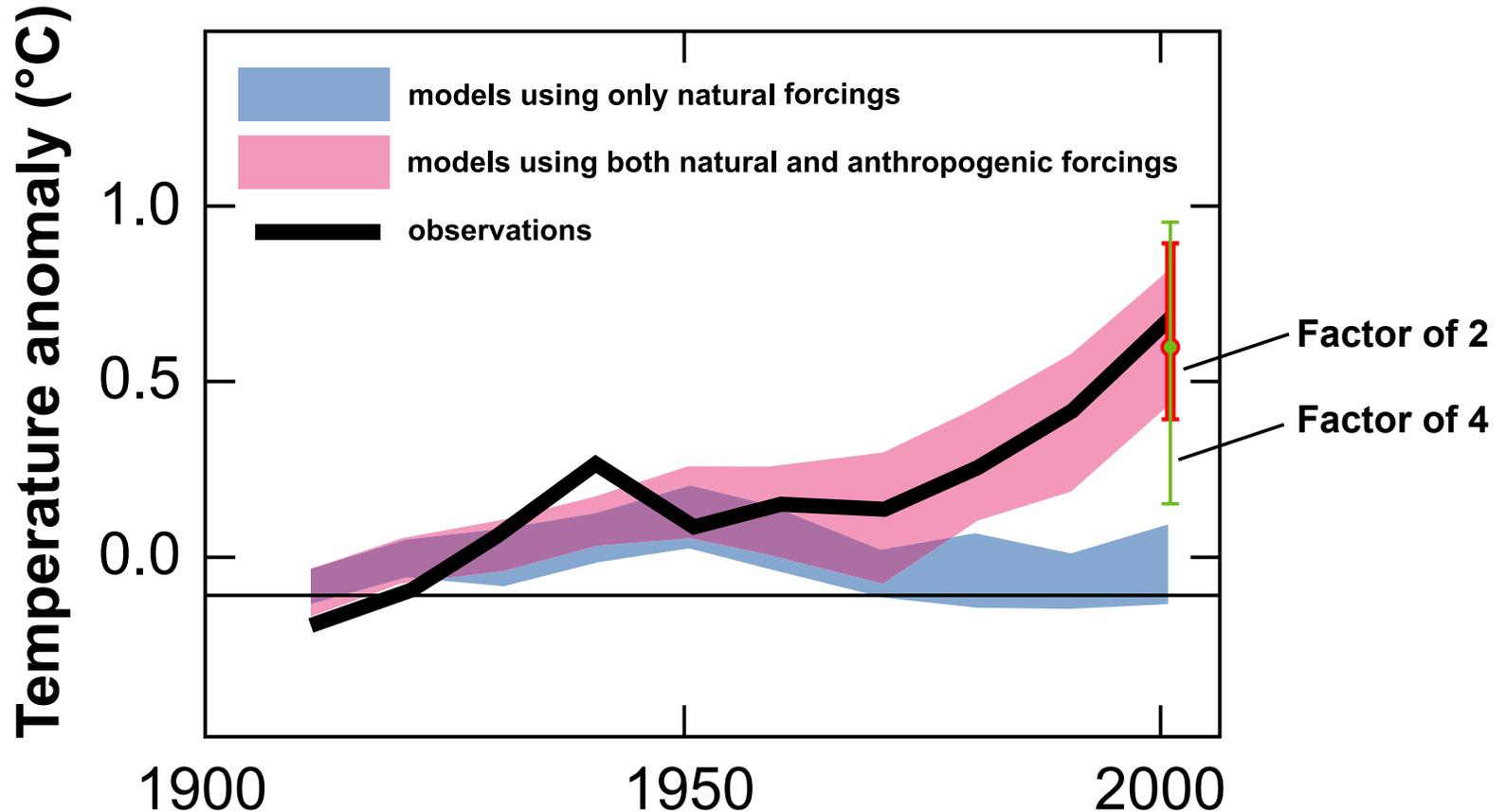
Ensemble of 58 model runs with 14 global climate models



- “ Simulations that incorporate anthropogenic forcings, including increasing greenhouse gas concentrations and the effects of aerosols, and that also incorporate natural external forcings provide a *consistent explanation of the observed temperature record*.
- “ These simulations used models with *different climate sensitivities, rates of ocean heat uptake and magnitudes and types of forcings*. IPCC AR4, 2007

# TOO ROSY A PICTURE?

Ensemble of 58 model runs with 14 global climate models



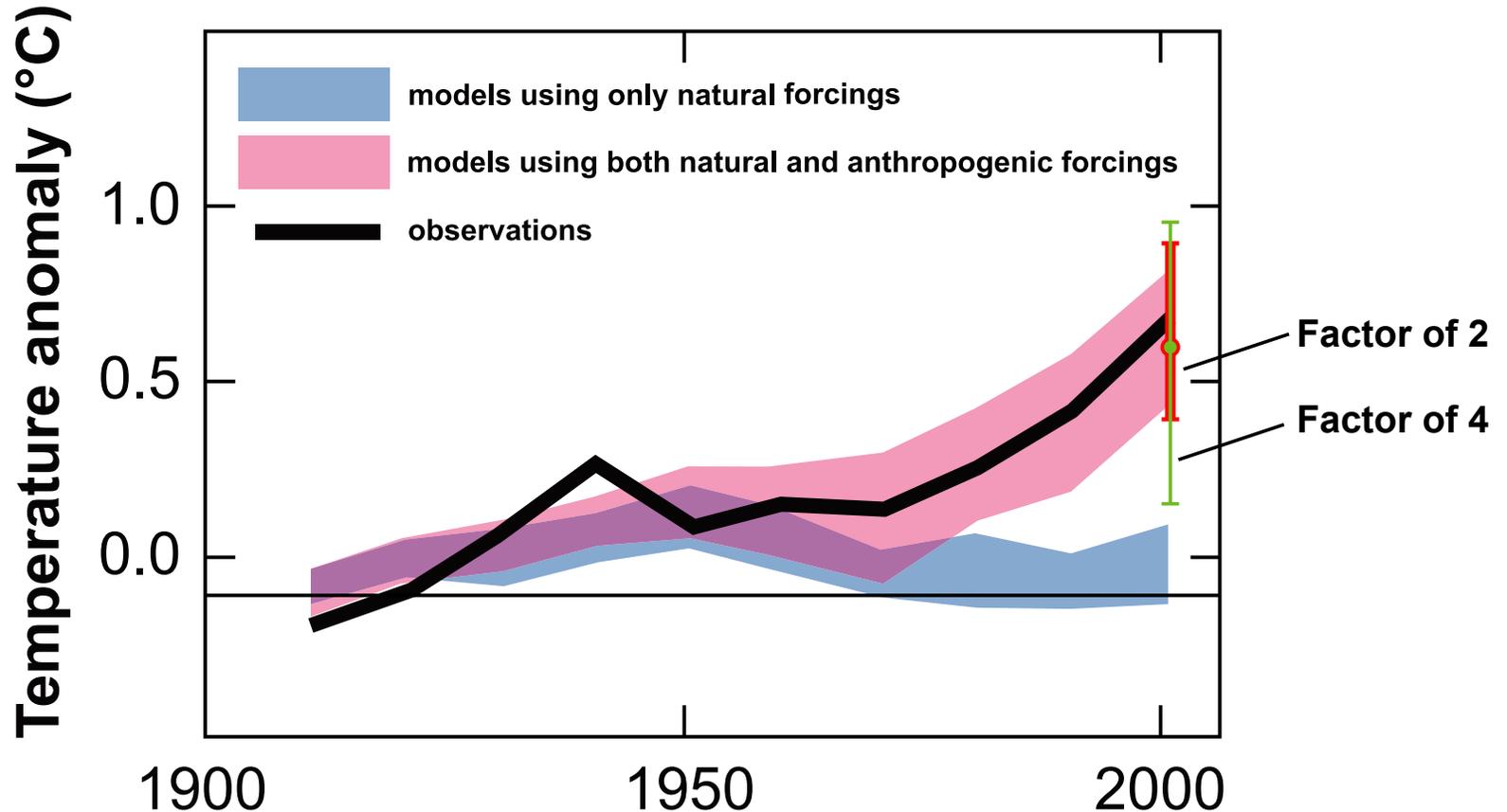
*Schwartz, Charlson & Rodhe, Nature Reports – Climate Change, 2007*

Uncertainty in modeled temperature increase is less than the range of model sensitivity (factor of 2, red) and *well less than the uncertainty in forcing* (factor of 4, green).

*How can this be?*

# TOO ROSY A PICTURE?

Ensemble of 58 model runs with 14 global climate models



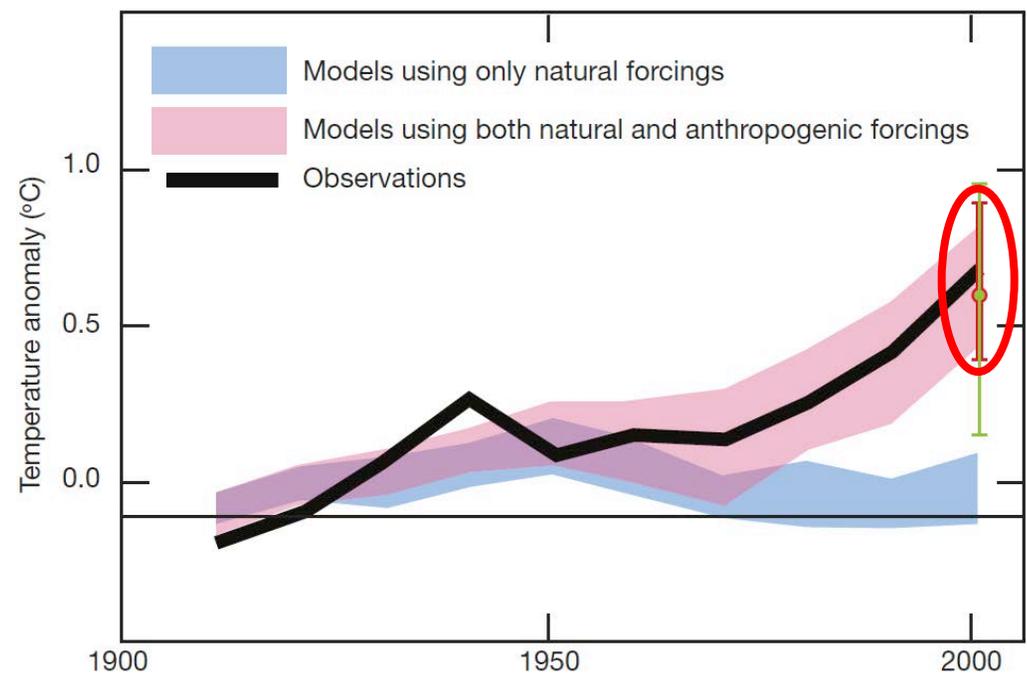
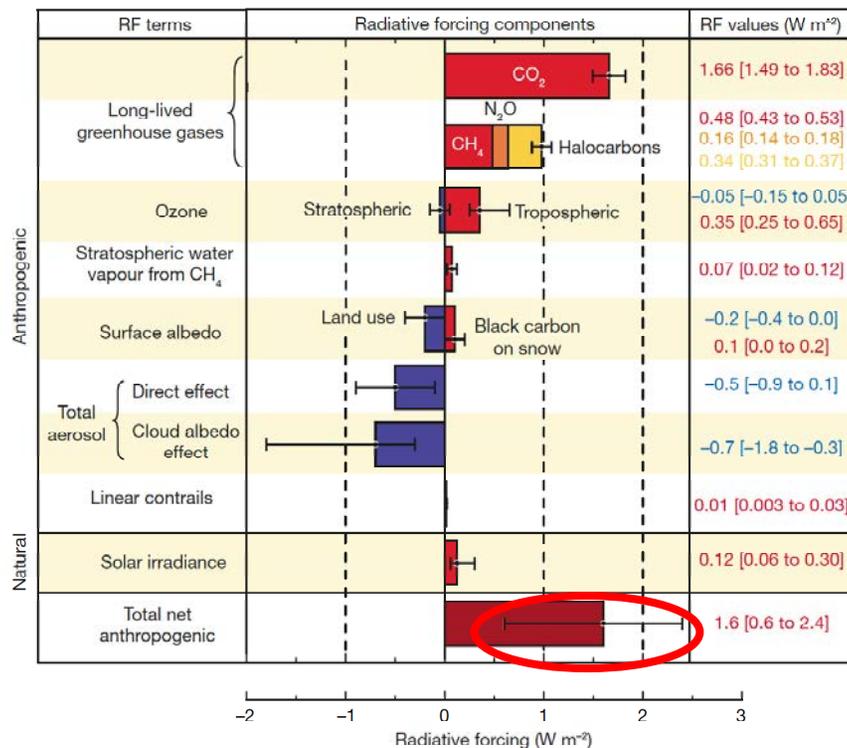
*Schwartz, Charlson & Rodhe, Nature Reports – Climate Change, 2007*

The models *did not span the full range of the uncertainty* and/or . . .  
The forcings used in the model runs were *anticorrelated with the sensitivities of the models*.

# Quantifying climate change – too rosy a picture?

STEPHEN E. SCHWARTZ, ROBERT J. CHARLSON AND HENNING RODHE

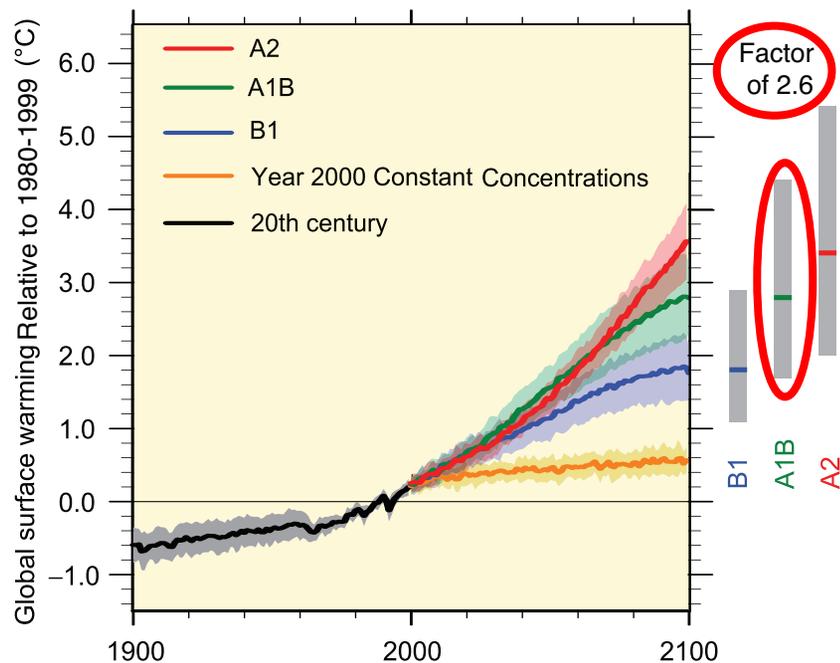
The latest report from the Intergovernmental Panel on Climate Change assesses the skill of climate models by their ability to reproduce warming over the twentieth century, but in doing so may give a false sense of their predictive capability.



# Assessing uncertainty in climate simulations

Piers Forster, Gabriele Hegerl, Reto Knutti, V. Ramaswamy, Susan Solomon, Thomas F. Stocker, Peter Stott and Francis Zwiers

MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING



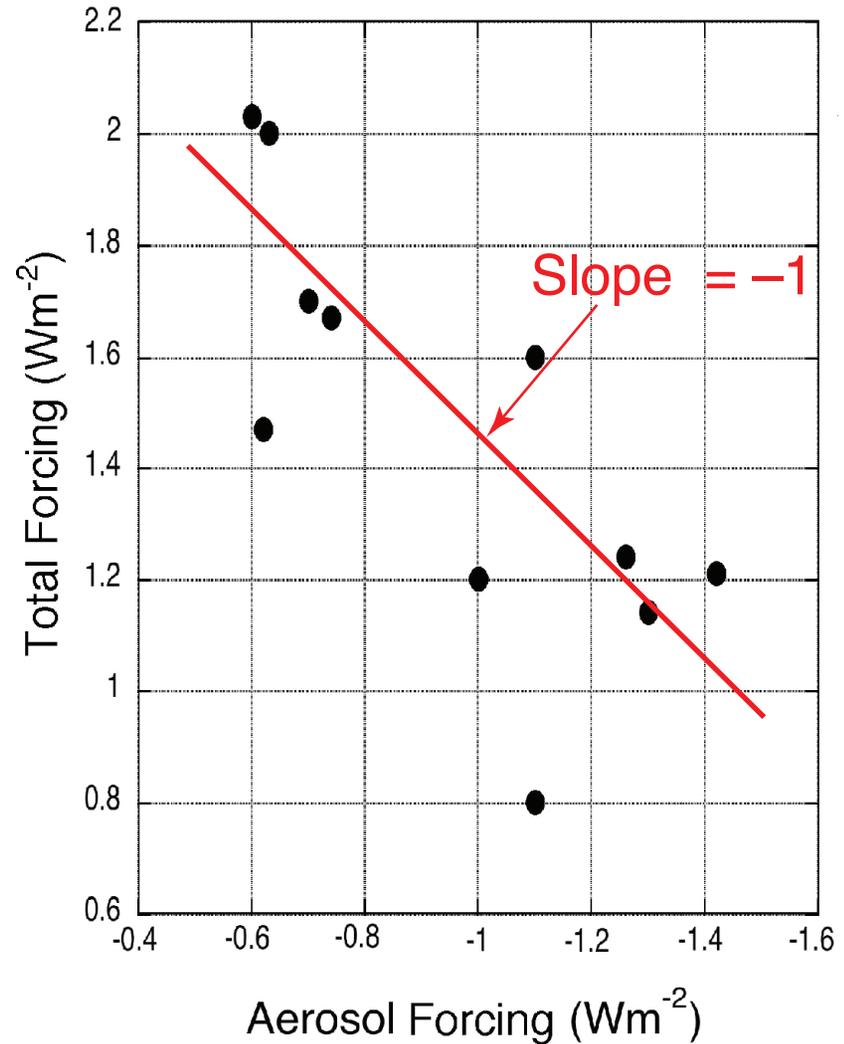
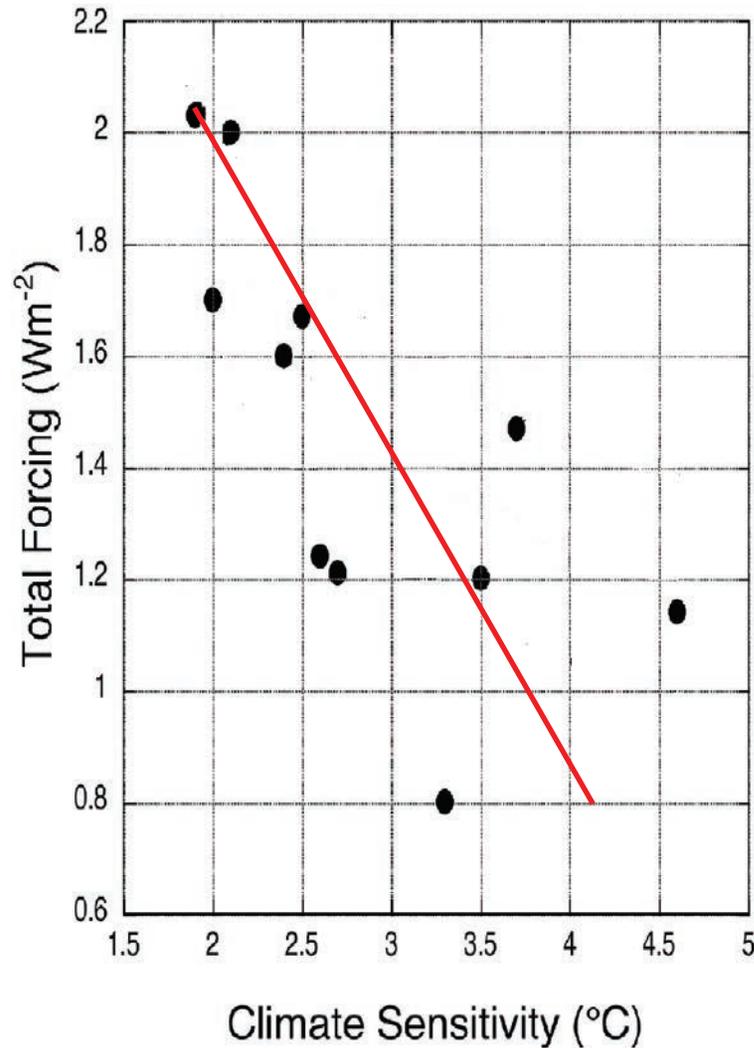
“It is clear that the twentieth century climate simulations do not span the full range of uncertainty in radiative forcing or climate sensitivity.

“As is well known, models with differing sensitivities and forcings can produce similarly skilful twentieth century simulations.

“We conclude that the skill of climate models in reproducing warming over the twentieth century shown in AR4 does not imply that the IPCC has under-estimated uncertainty in future warming.

# CORRELATION OF AEROSOL FORCING, TOTAL FORCING, AND SENSITIVITY IN CLIMATE MODELS

Nine fully coupled models and two energy-balance models

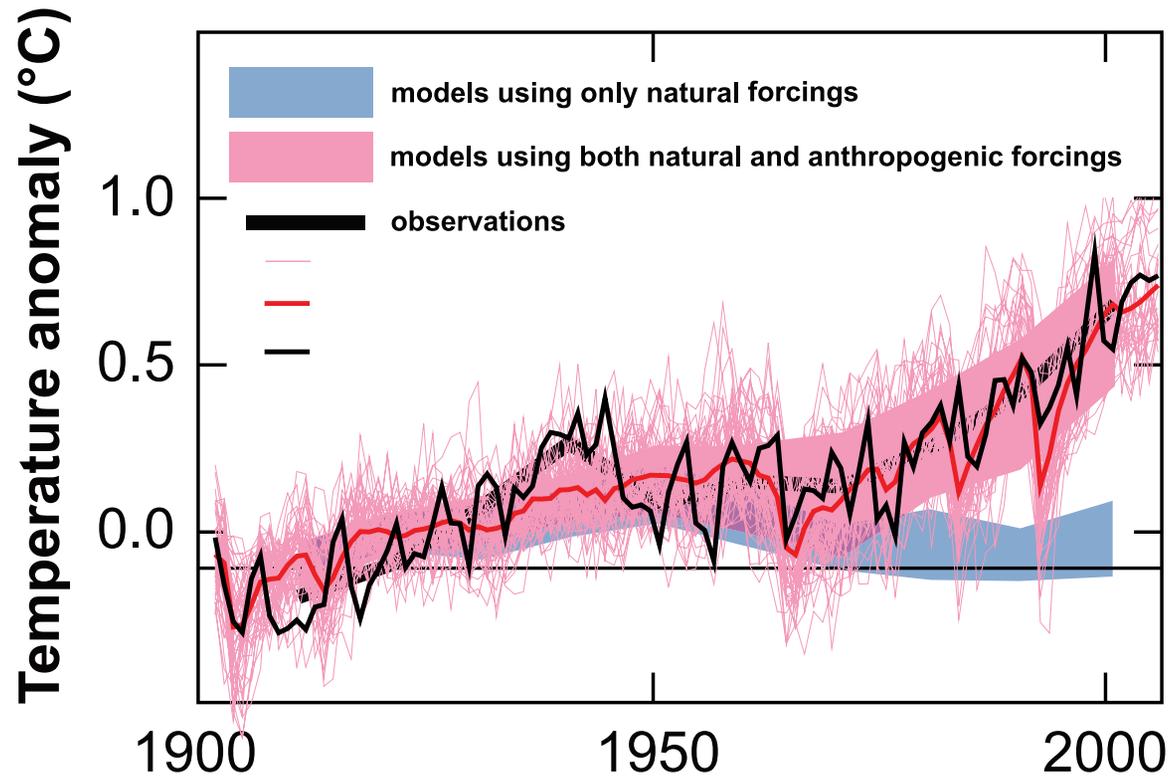


*Modified from Kiehl, GRL, 2007*

Climate models with higher sensitivity have lower total forcing.  
Range in forcing is due mainly to uncertainty in aerosol forcing.

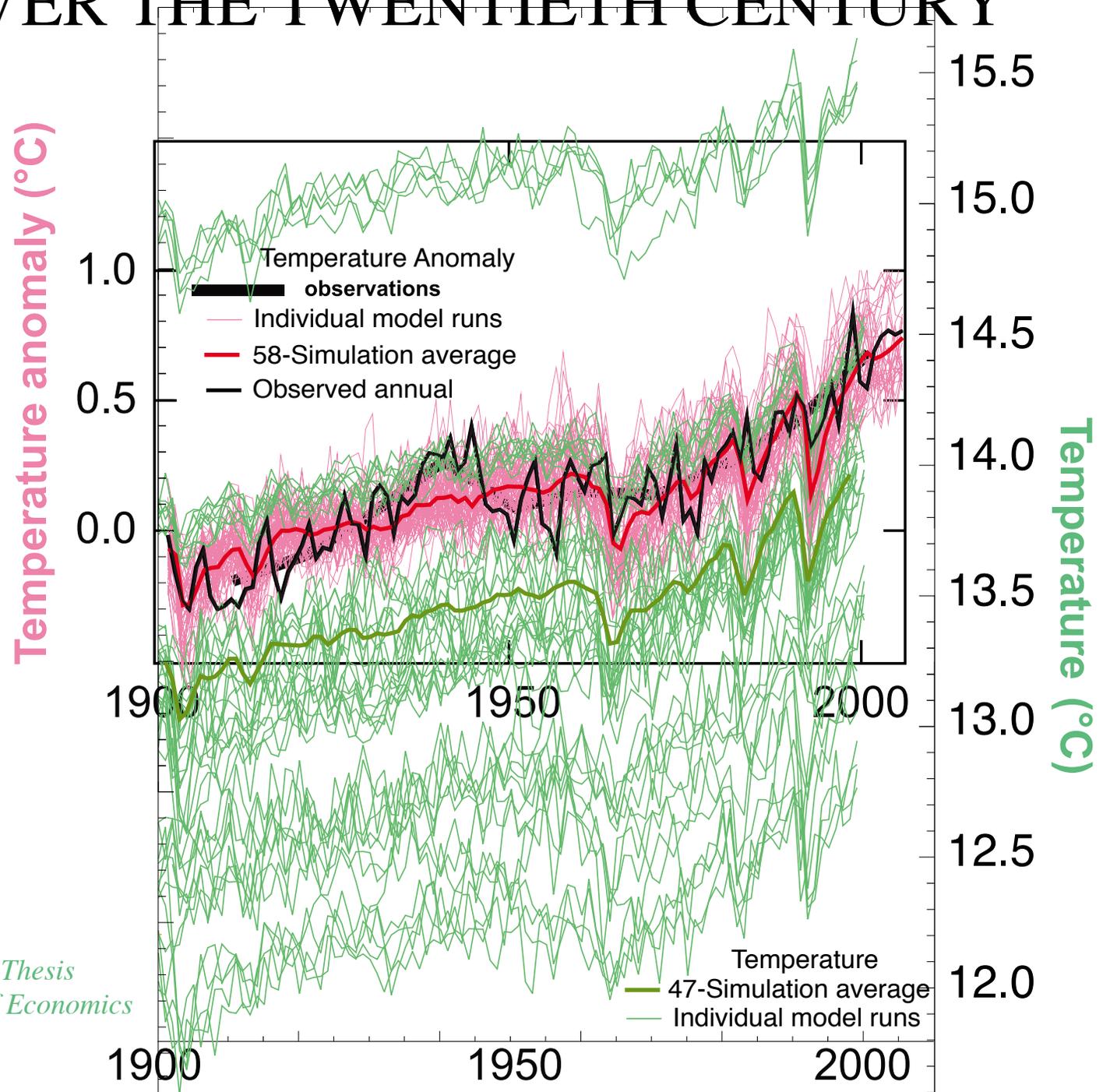
# GLOBAL MEAN SURFACE TEMPERATURE ANOMALY OVER THE TWENTIETH CENTURY

Ensemble of 58 model runs with 14 global climate models



*IPCC AR4, 2007*

# GLOBAL MEAN SURFACE TEMPERATURE OVER THE TWENTIETH CENTURY

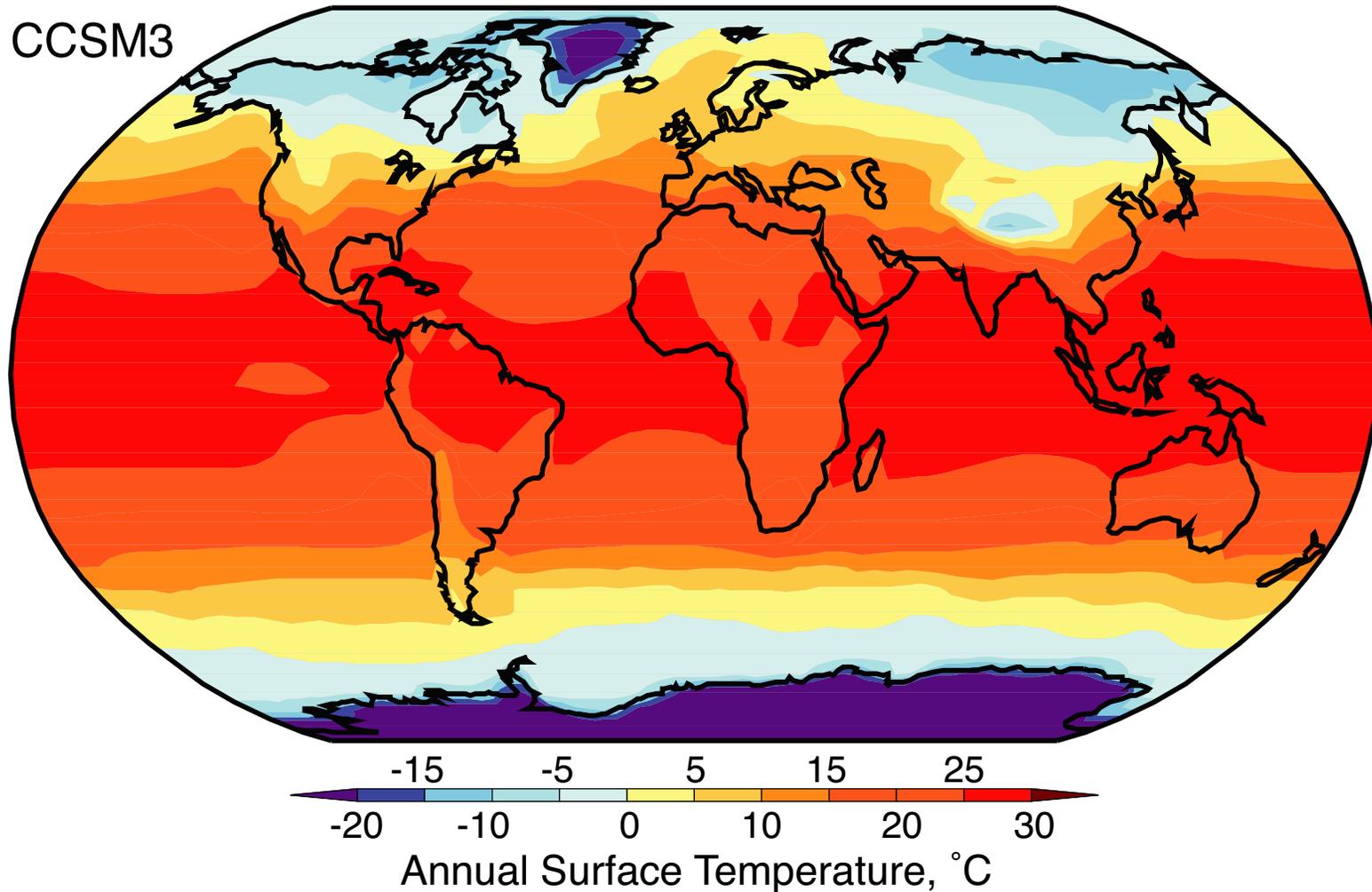


*E. Tredger, 2009, Thesis  
London School of Economics*

# ANNUAL MEAN SURFACE TEMPERATURE

Calculated with Global Climate Model

CCSM3



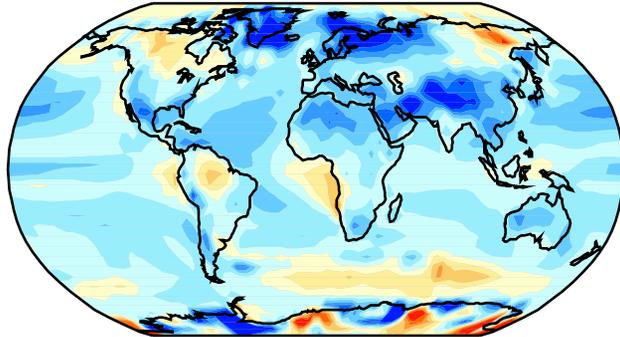
*IPCC, 2007, Chapter 8, Suppl.*

Model output is richly detailed. Overall pattern is quite good, given that *the entire climate system is modeled from first principles.*

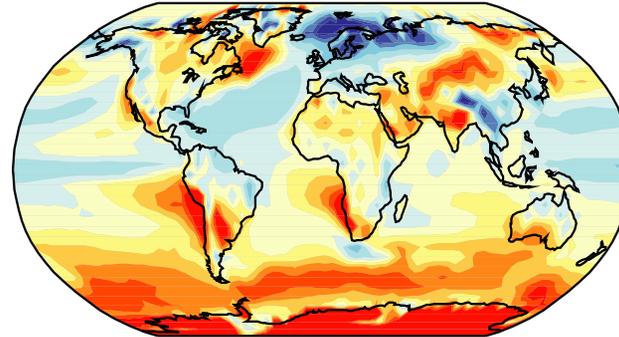
# ANNUAL MEAN SURFACE TEMPERATURE

Difference from observations, calculated with Global Climate Models

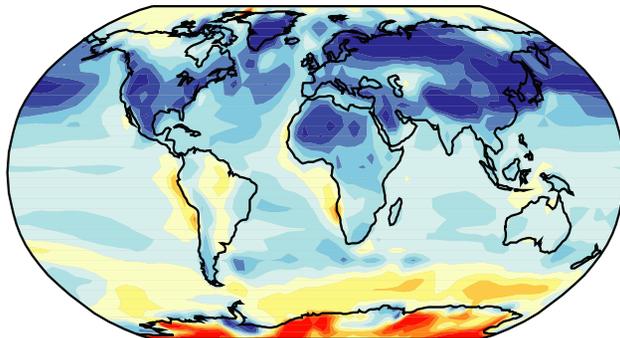
CSIRO-Mk3.0



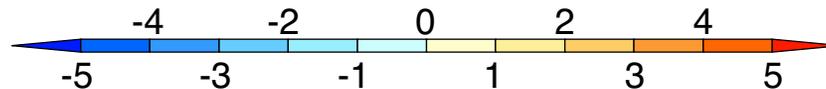
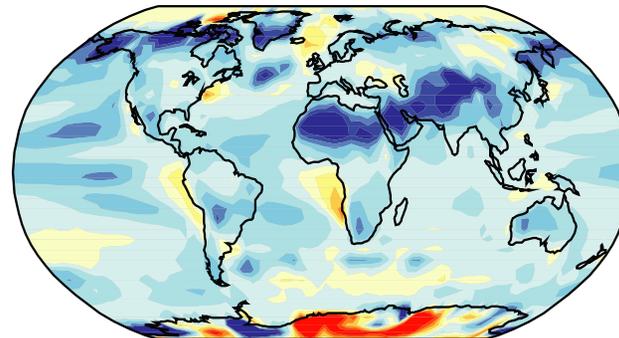
GISS-EH



GFDL-CM2.0



UKMO-HadGEM1



Model error, simulated - observed, °C

IPCC, 2007

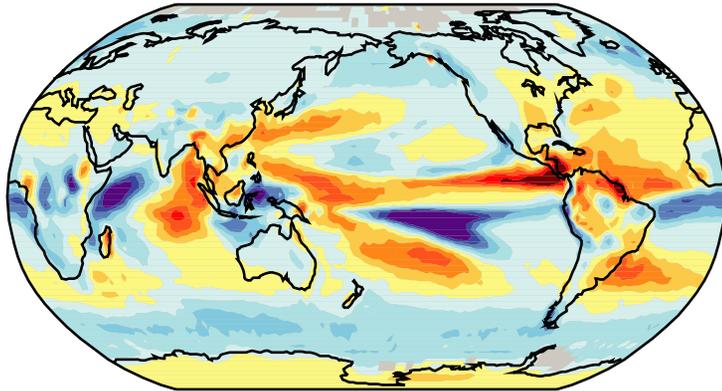
IPCC, 2007, Chapter 8, Suppl.

Departure from observations and model-to-model differences are substantial in some locations.

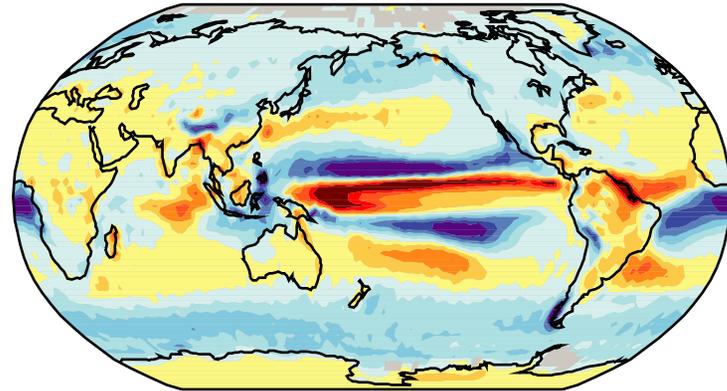
# ANNUAL MEAN PRECIPITATION

Difference from observations, calculated with Global Climate Models

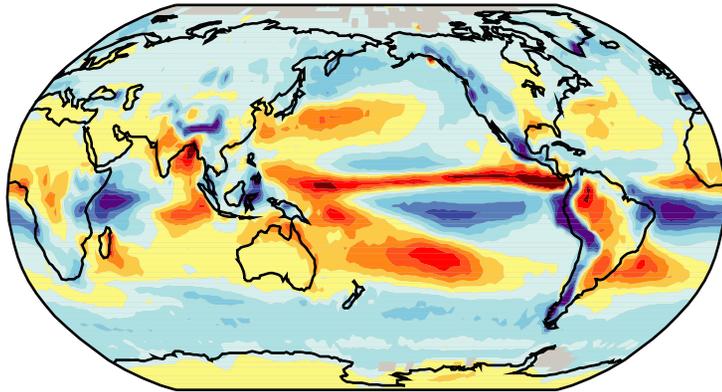
CCSM3



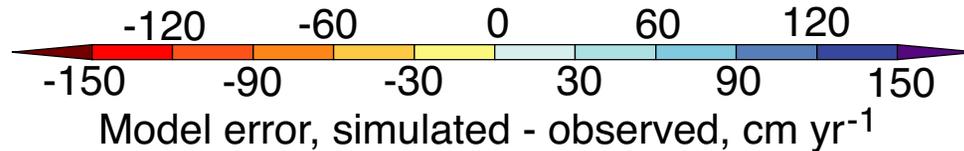
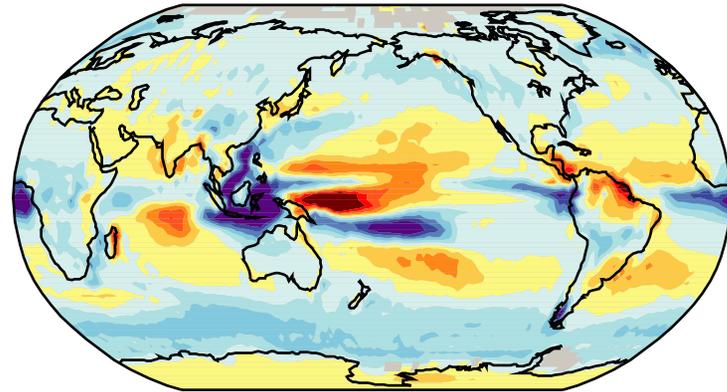
ECHAM5/MPI-OM



GISS-AOM



UKMO-HadCM3



*IPCC, 2007, Chapter 8, Suppl.*

Departure from observations and model-to-model differences are substantial in some locations.

“None of the climate states in the models [used by IPCC] correspond even remotely to the current observed climate.



- “The state of the *oceans, sea ice, and soil moisture* has no relationship to the observed state at any recent time in any of the IPCC models.
- “There is neither an *El Niño sequence* nor any *Pacific Decadal Oscillation*. . . .
- “The *Atlantic Multidecadal Oscillation* . . . is *not set up to match today’s state*. . . .
- “Moreover, the *starting climate state* in several of the models may *depart significantly from the real climate* owing to *model errors*.
- “I postulate that *regional climate change is impossible to deal with properly* unless the models are initialized.

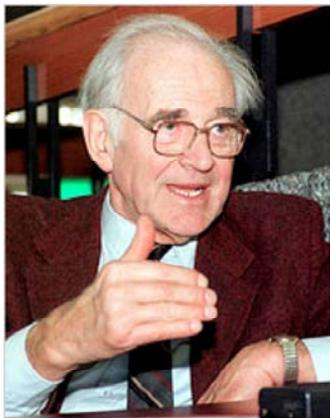
*Kevin Trenberth, Lead Author, 2001 IPCC WGI report; Nature, 2007*

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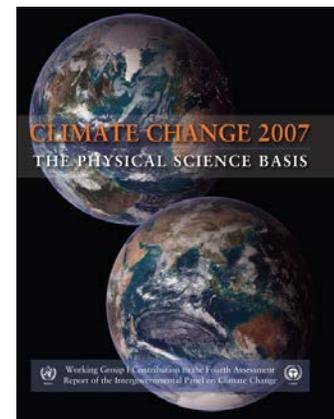
*Yes, yes a thousand times yes!*

*But we must stay with what is confidently known,  
Pay attention to the uncertainties and their implications,  
Value GCMs for insights about Earth's climate, but not  
(yet) rely on them for confident climate projections.*



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