What Climate Models Can and Cannot Do

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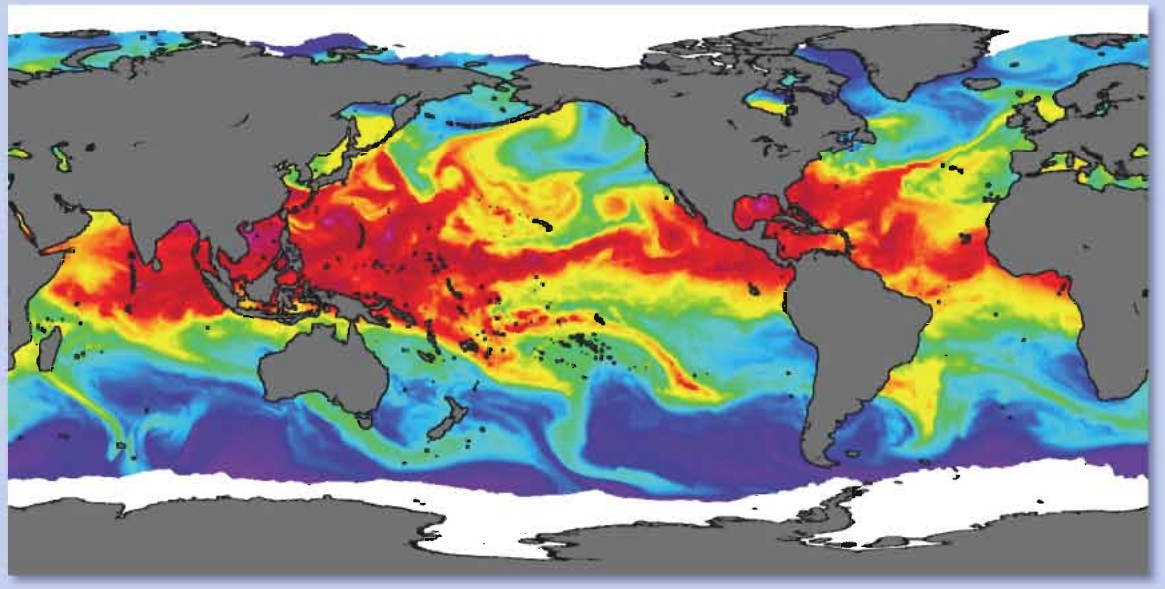
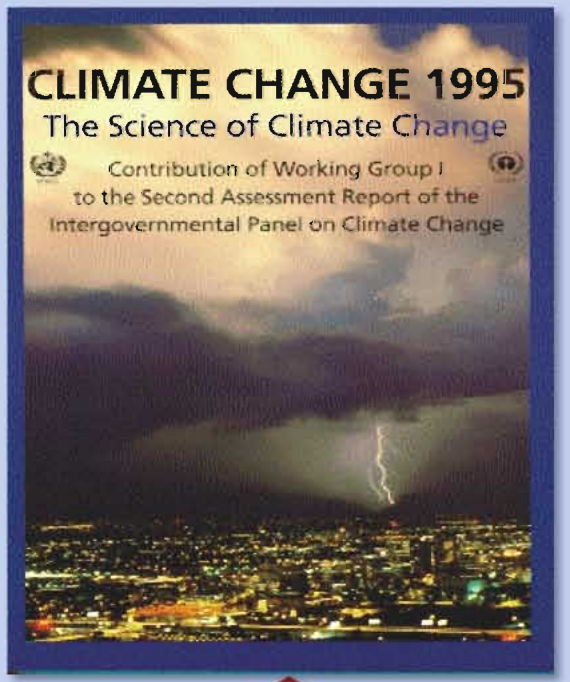


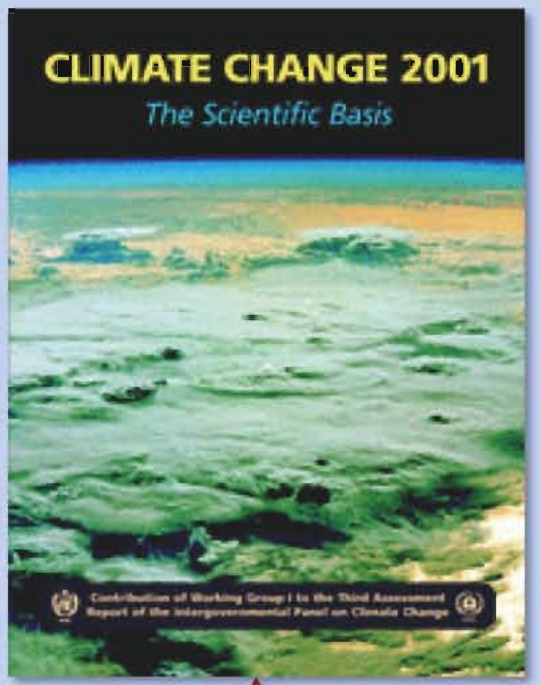
Structure

- What climate models can do

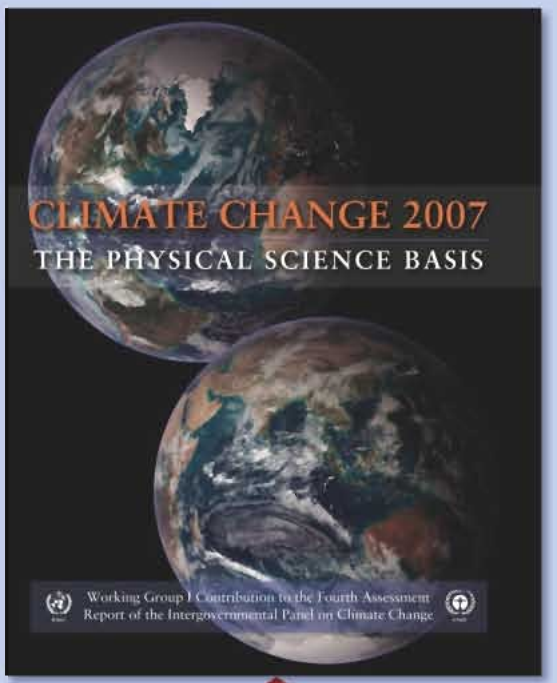
Human activities have affected global climate



"The balance of evidence suggests a discernible human influence on global climate"

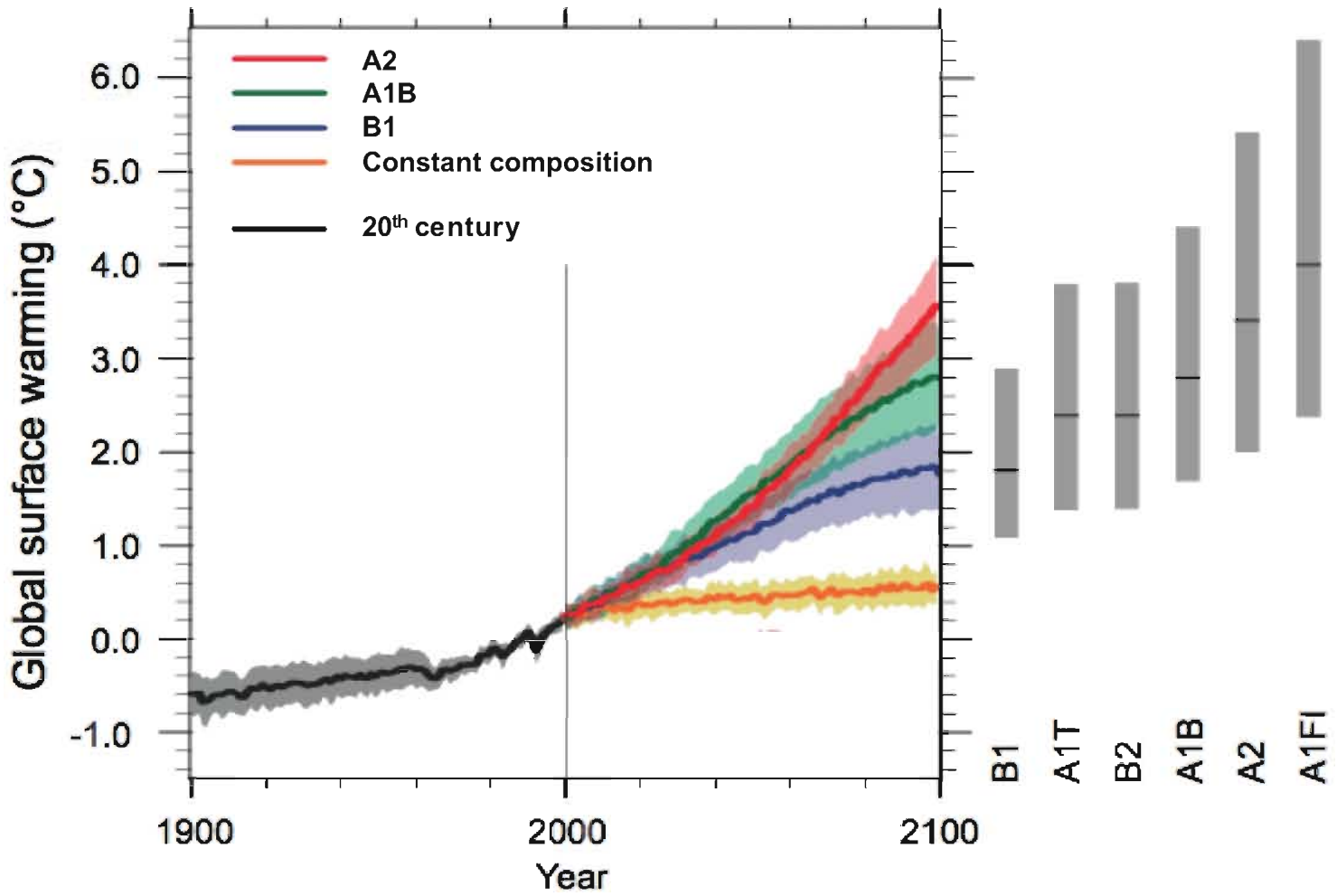


"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities"



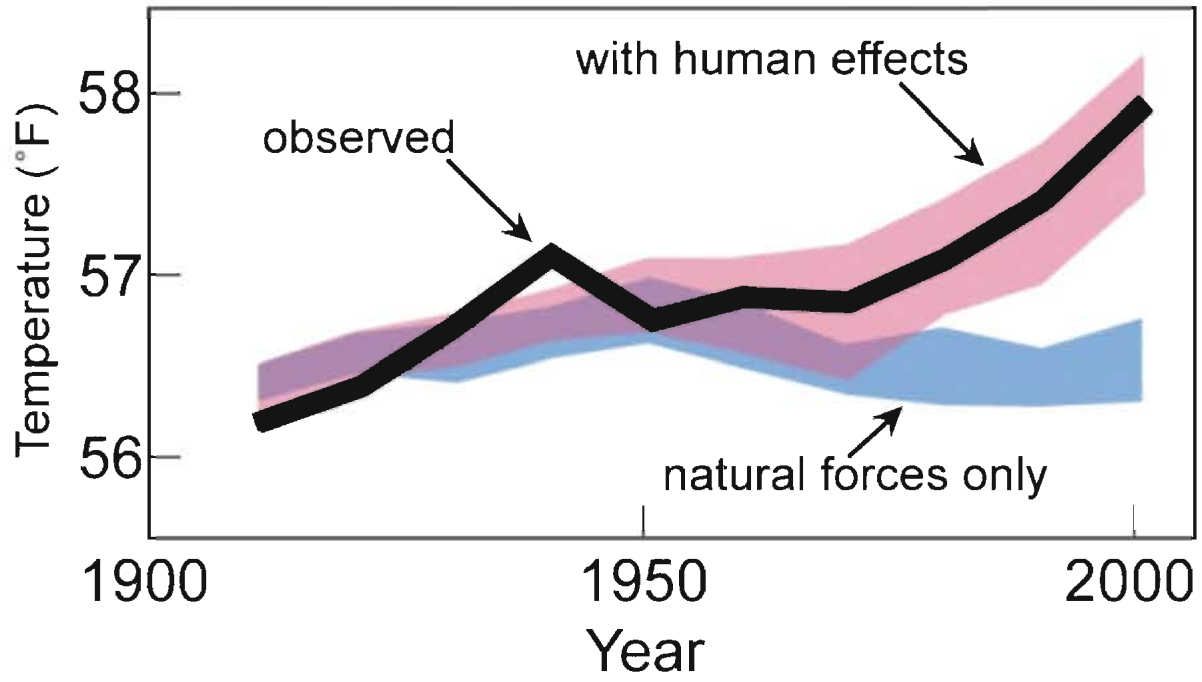
"Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely** due to the observed increase in anthropogenic greenhouse gas concentrations"

Climate models can help us to understand the climatic "shape of things to come"



Source: IPCC Fourth Assessment Report (2007)

Climate models can perform the “Gedankenexperimente” we cannot conduct in the real world

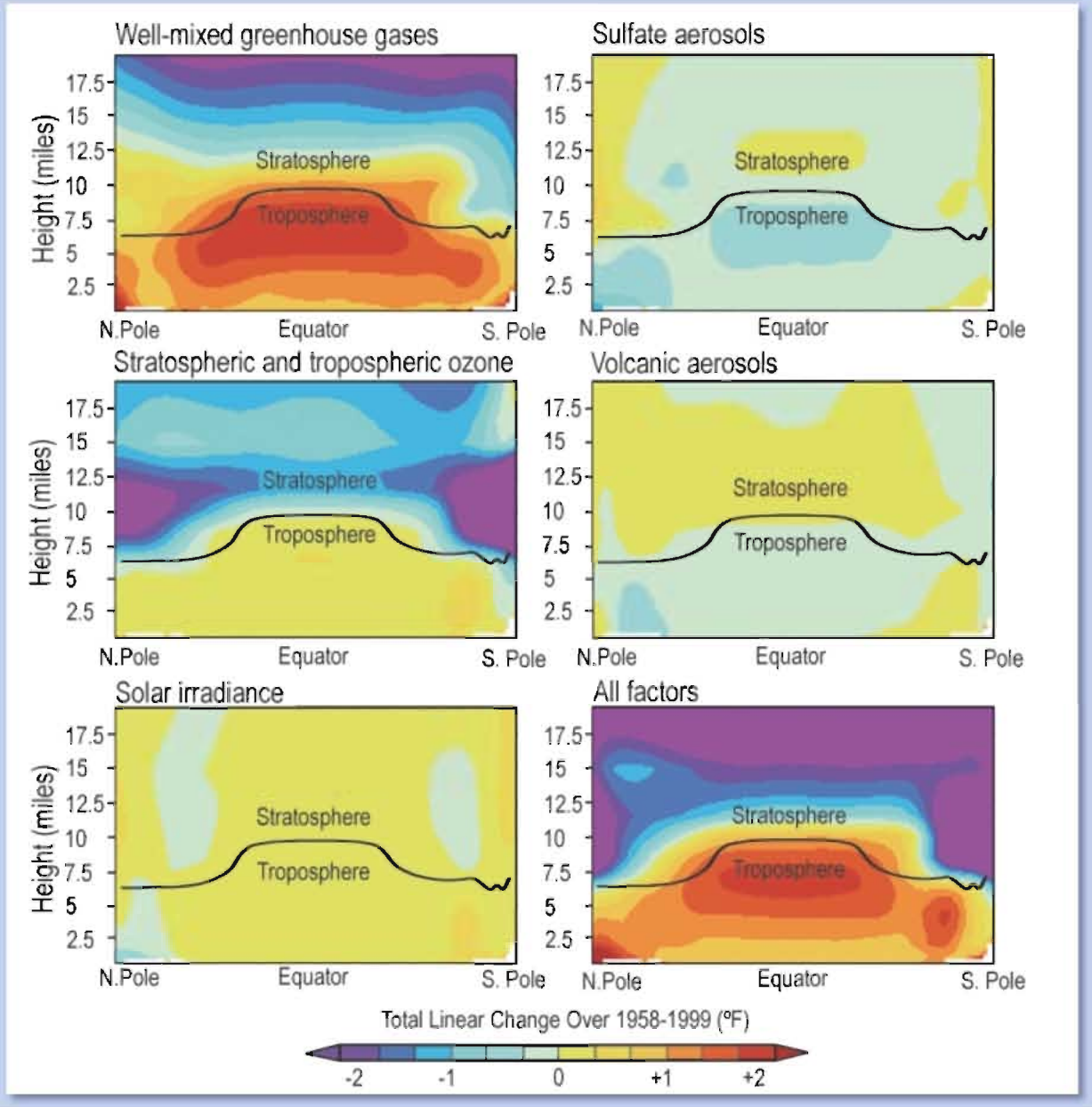


Observations
Models using only natural forces
Models using both natural and human forces

Hegerl *et al.*[49]

Source: IPCC Fourth Assessment Report (2007)

Models can help us to estimate the climate "fingerprints" caused by different factors



U.S. Climate Change Science Program State of Knowledge Report (2009)
(after Santer *et al.*, 2006)

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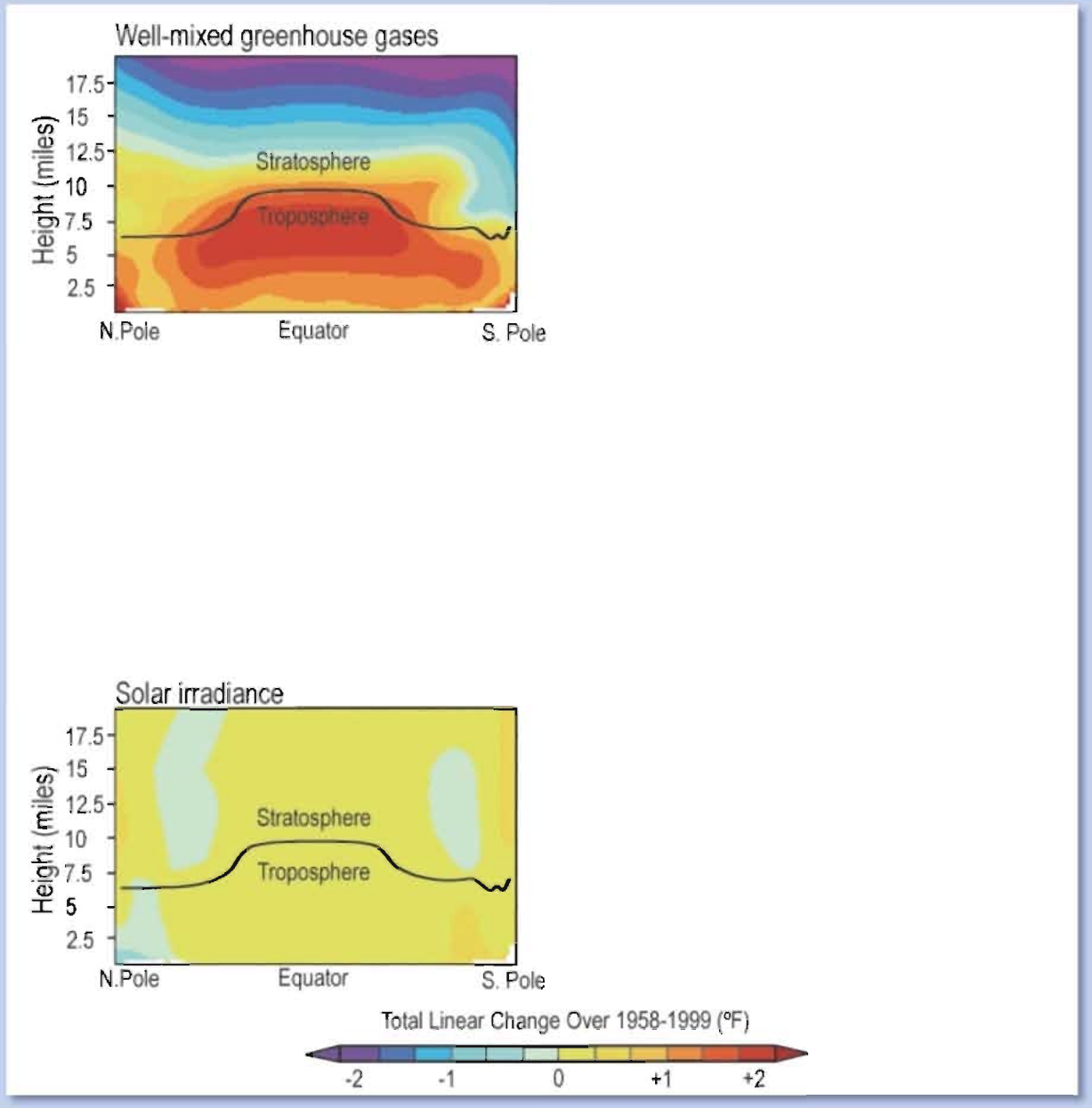
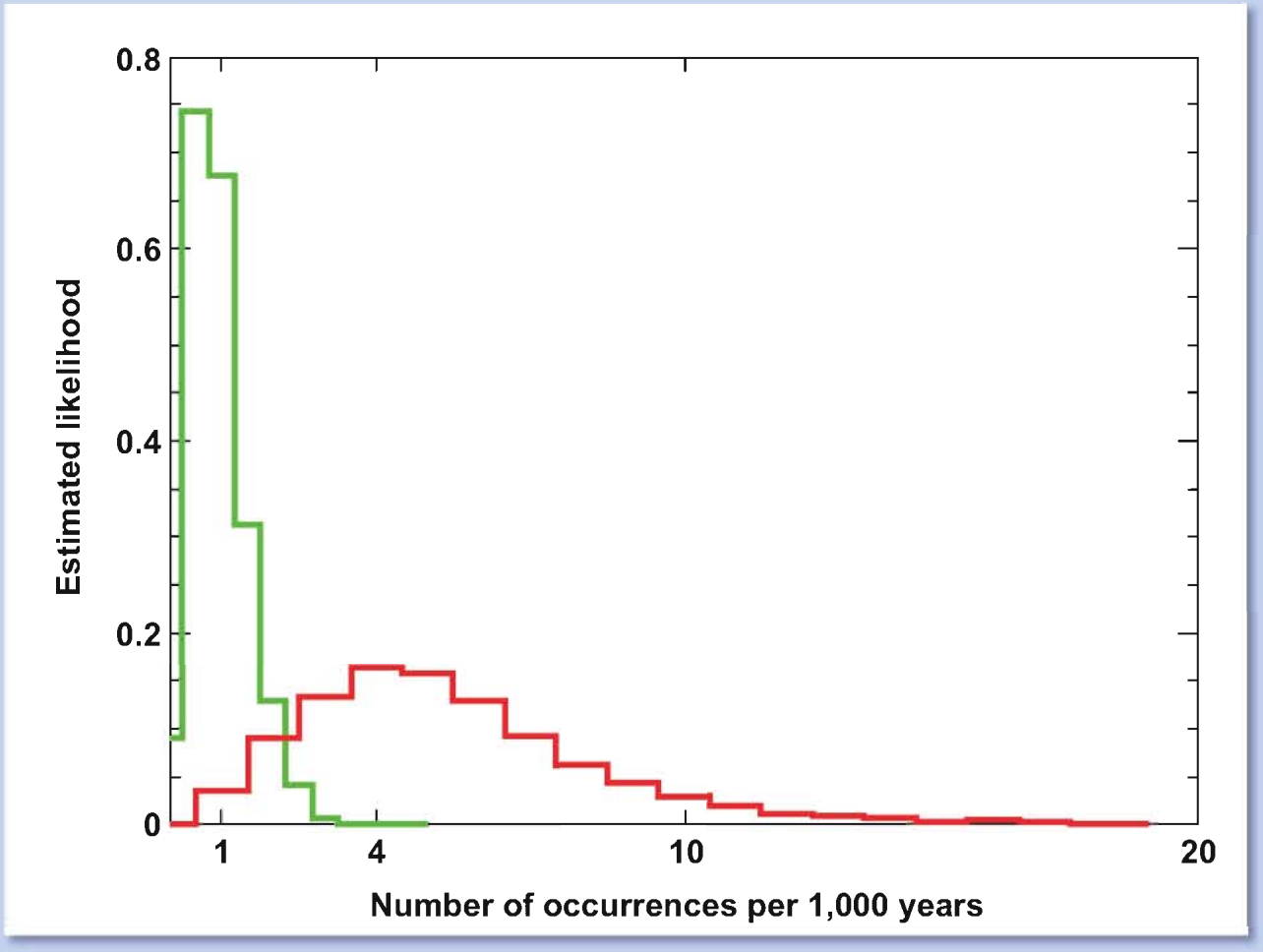


Models can help us to understand how human activities may change the likelihood of extreme events

Risk of European heat wave exceeding 1.6°C threshold with and without human influence (Stott, Stone, and Allen, *Nature*, 2004)



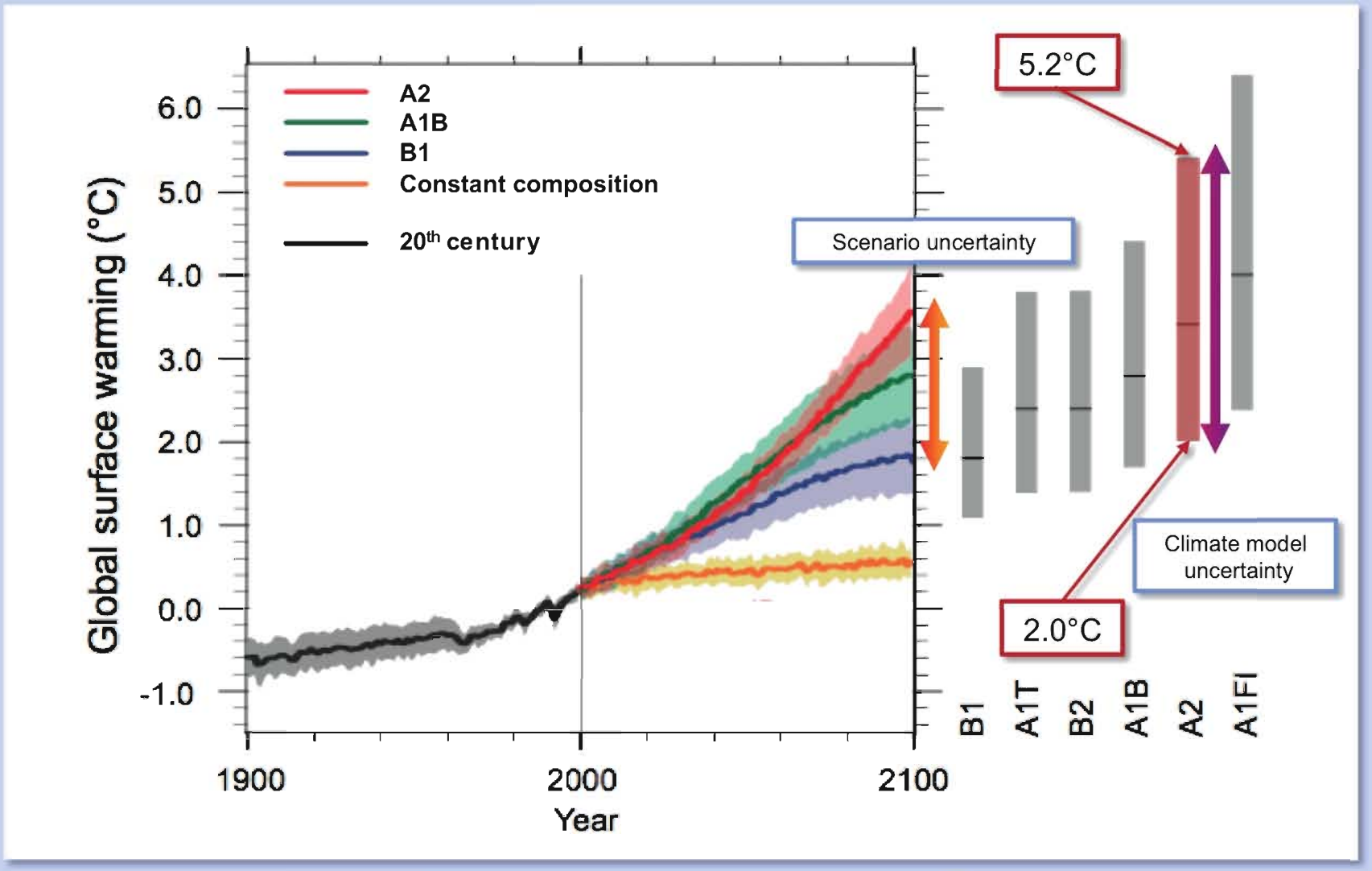
Average simulation omitting human influence

Average model simulation with combined human and natural effects

Structure

- What climate models cannot do

Climate models cannot give us exact answers…



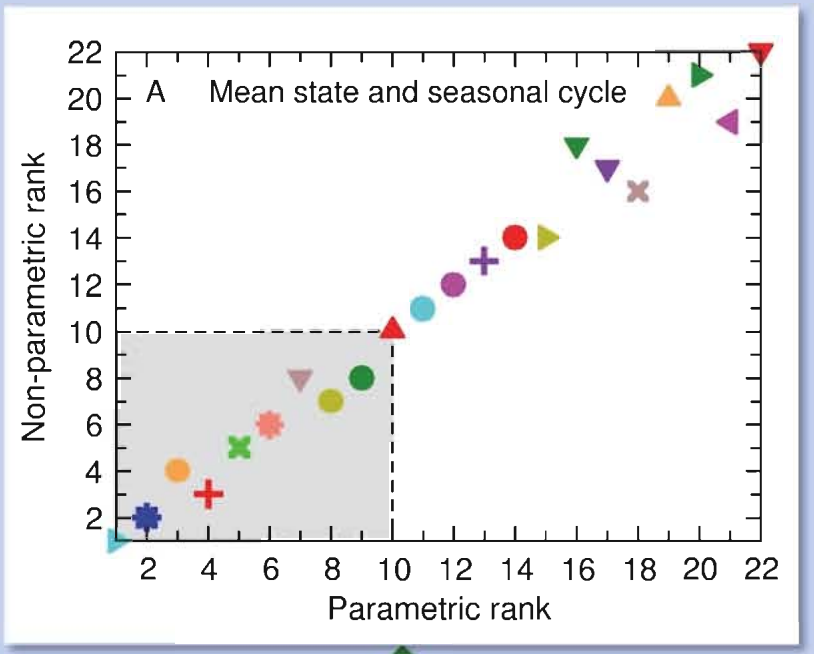
Source: IPCC Fourth Assessment Report (2007)

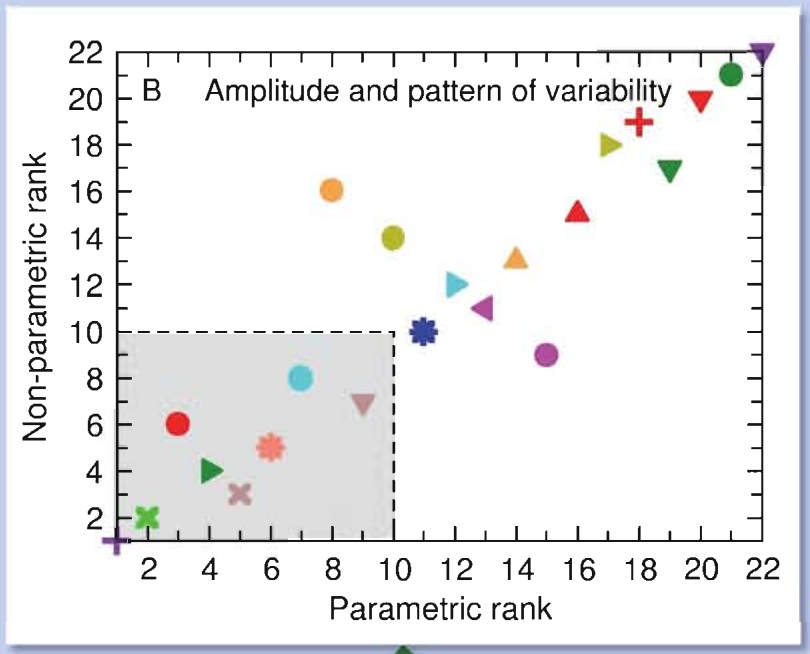
It is difficult to identify the “best” climate models

- Not all computer models are of equal quality
- Because of differences in model quality, there is increasing interest in “weighting” computer projections of future climate change
- Most studies have weighted individual models by simple measures of their performance in simulating today’s average climate
- Is it a model democracy (“One model, one vote?”) Or should we pay more attention to “better” models?

It is difficult to identify the "best" climate models

Santer *et al.*, *Proceedings of the U.S. National Academy of Sciences* (2009)

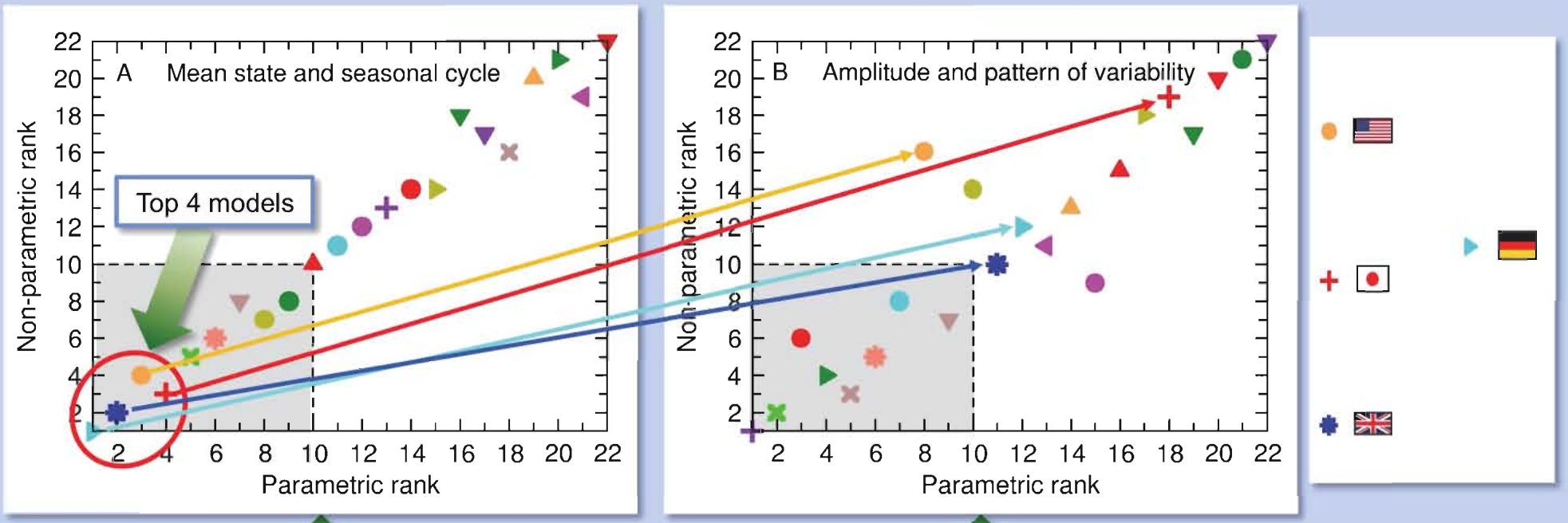




Rankings based on 20 different "performance metrics"

Rankings based on 50 different "performance metrics"

It is difficult to identify the “best” climate models



Rankings based on 20 different “performance metrics”

Rankings based on 50 different “performance metrics”

Structure

- Conclusions

What climate models can and cannot do

What models can do

- Climate models are the only credible tools we have for trying to understand
  - The rate and magnitude of likely changes in climate over the 21st century
  - The seasonal and geographical aspects of these changes
  - The relative contributions of human and natural factors to historical and future climate change
  - How human factors may alter the likelihood of certain extreme events

What climate models cannot do

- Climate models cannot provide us with
  - Exact answers (only probabilities)
  - Reliable information on the regional-scale details of future climate change
  - Reliable information on the contributions of ice sheet dynamics to sea-level rise
- We do not know which models yield the most reliable climate change projections

Trust and Accountability

- Despite claims to the contrary
  - Climate models are routinely confronted with observations
  - Climate modeling (and the analysis of climate model simulations) is now an open, community-wide endeavor
  - Tools like the "Earth System Grid" have enabled the sharing of simulation output, observational data, and analysis and visualization software
  - The CMIP-3 archive of climate model output (which provided much of the scientific underpinning for the IPCC's Fourth Assessment Report) consists of over 35 Terabytes of data, and is now being used by over 3,000 scientists around the world
- "Climategate" does not call into question IPCC and NRC conclusions that
  - Warming of the Earth's surface over the past 150 years is "unequivocal"
  - Human activities have significantly contributed to this warming
- Accountability is a two-way street
  - Federal agencies funding climate research in critical areas (paleoclimate, "climate fingerprinting", *etc.*) have a responsibility to defend the work they fund when it is subject to unjustified political attacks