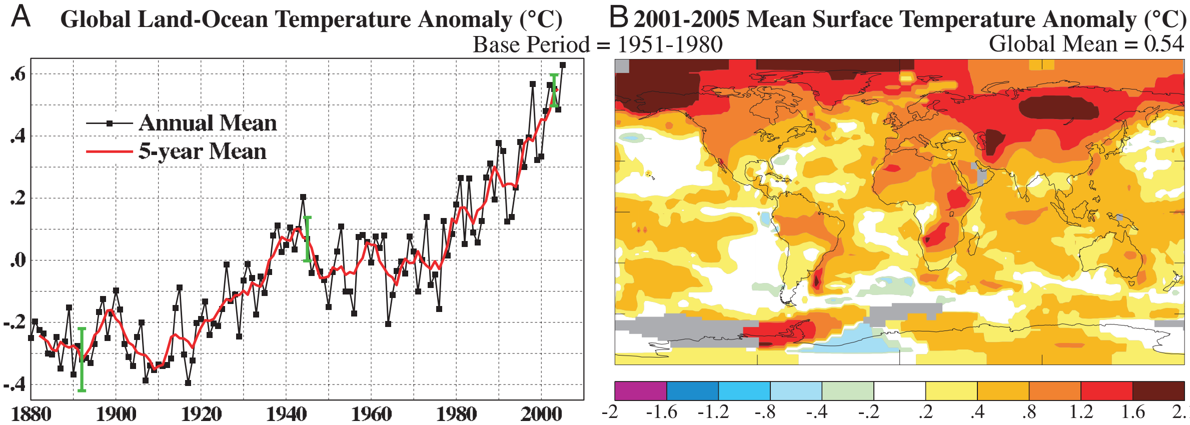

Fig. 1. Surface temperature anomalies relative to 1951–1980 from surface air measurements at meteorological stations and ship and satellite SST measurements. (*A*) Global annual mean anomalies. (*B*) Temperature anomaly for the first half decade of the 21st century.

to instant doubling of atmospheric CO_2. The first GCM calculations with transient greenhouse gas (GHG) amounts, allowing comparison with observations, were those of Hansen *et al.* (12). It has been asserted that these calculations, presented in congressional testimony in 1988 (13), turned out to be "wrong by 300%" (14). That assertion, posited in a popular novel, warrants assessment because the author's views on global warming have been welcomed in testimony to the United States Senate (15) and in a meeting with the President of the United States (16), at a time when the Earth may be nearing a point of dangerous human-made interference with climate (17).

The congressional testimony in 1988 (13) included a graph (Fig. 2) of simulated global temperature for three scenarios (A, B, and C) and maps of simulated temperature change for scenario B. The three scenarios were used to bracket likely possibilities. Scenario A was described as "on the high side of reality," because it assumed rapid exponential growth of GHGs and it included no large volcanic eruptions during the next half century. Scenario C was described as "a more drastic curtailment of emissions than has generally been imagined," specifically GHGs were assumed to stop increasing after 2000. Intermediate scenario B was described as "the most plausible." Scenario B has continued moderate increase in the rate of GHG emissions and includes three large volcanic eruptions sprinkled through the 50-year period after 1988, one of them in the 1990s.

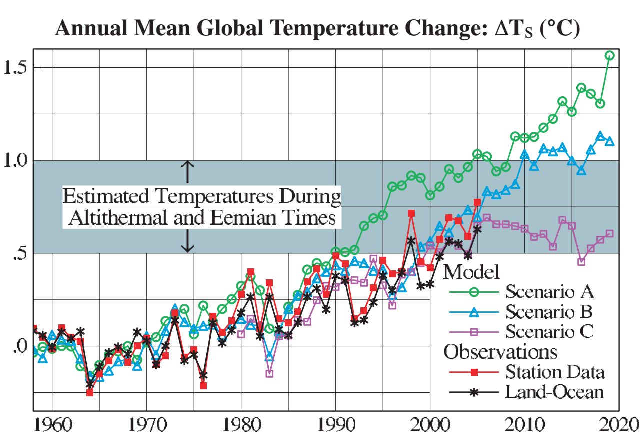

Fig. 2. Global surface temperature computed for scenarios A, B, and C (12), compared with two analyses of observational data. The 0.5°C and 1°C temperature levels, relative to 1951–1980, were estimated (12) to be maximum global temperatures in the Holocene and the prior interglacial period, respectively.

Real-world GHG climate forcing (17) so far has followed a course closest to scenario B. The real world even had one large volcanic eruption in the 1990s, Mount Pinatubo in 1991, whereas scenario B placed a volcano in 1995.

Fig. 2 compares simulations and observations. The red curve, as in ref. 12, is the updated Goddard Institute for Space Studies observational analysis based on meteorological stations. The black curve is the land–ocean global temperature index from Fig. 1, which uses SST changes for ocean areas (5, 6). The land–ocean temperature has more complete coverage of ocean areas and yields slightly smaller long-term temperature change, because warming on average is less over ocean than over land (Fig. 1*B*).

Temperature change from climate models, including that reported in 1988 (12), usually refers to temperature of surface air over both land and ocean. Surface air temperature change in a warming climate is slightly larger than the SST change (4), especially in regions of sea ice. Therefore, the best temperature observation for comparison with climate models probably falls between the meteorological station surface air analysis and the land–ocean temperature index.

Observed warming (Fig. 2) is comparable to that simulated for scenarios B and C, and smaller than that for scenario A. Following refs. 18 and 14, let us assess "predictions" by comparing simulated and observed temperature change from 1988 to the most recent year. Modeled 1988–2005 temperature changes are 0.59, 0.33, and 0.40°C, respectively, for scenarios A, B, and C. Observed temperature change is 0.32°C and 0.36°C for the land–ocean index and meteorological station analyses, respectively.

Warming rates in the model are 0.35, 0.19, and 0.24°C per decade for scenarios A, B. and C, and 0.19 and 0.21°C per decade for the observational analyses. Forcings in scenarios B and C are nearly the same up to 2000, so the different responses provide one measure of unforced variability in the model. Because of this chaotic variability, a 17-year period is too brief for precise assessment of model predictions, but distinction among scenarios and comparison with the real world will become clearer within a decade.

Close agreement of observed temperature change with simulations for the most realistic climate forcing (scenario B) is accidental, given the large unforced variability in both model and real world. Indeed, moderate overestimate of global warming is likely because the sensitivity of the model used (12), 4.2°C for doubled CO_2, is larger than our current estimate for actual climate sensitivity, which is 3 ± 1°C for doubled CO_2, based mainly on paleoclimate data (17). More complete analyses should include other climate forcings and