

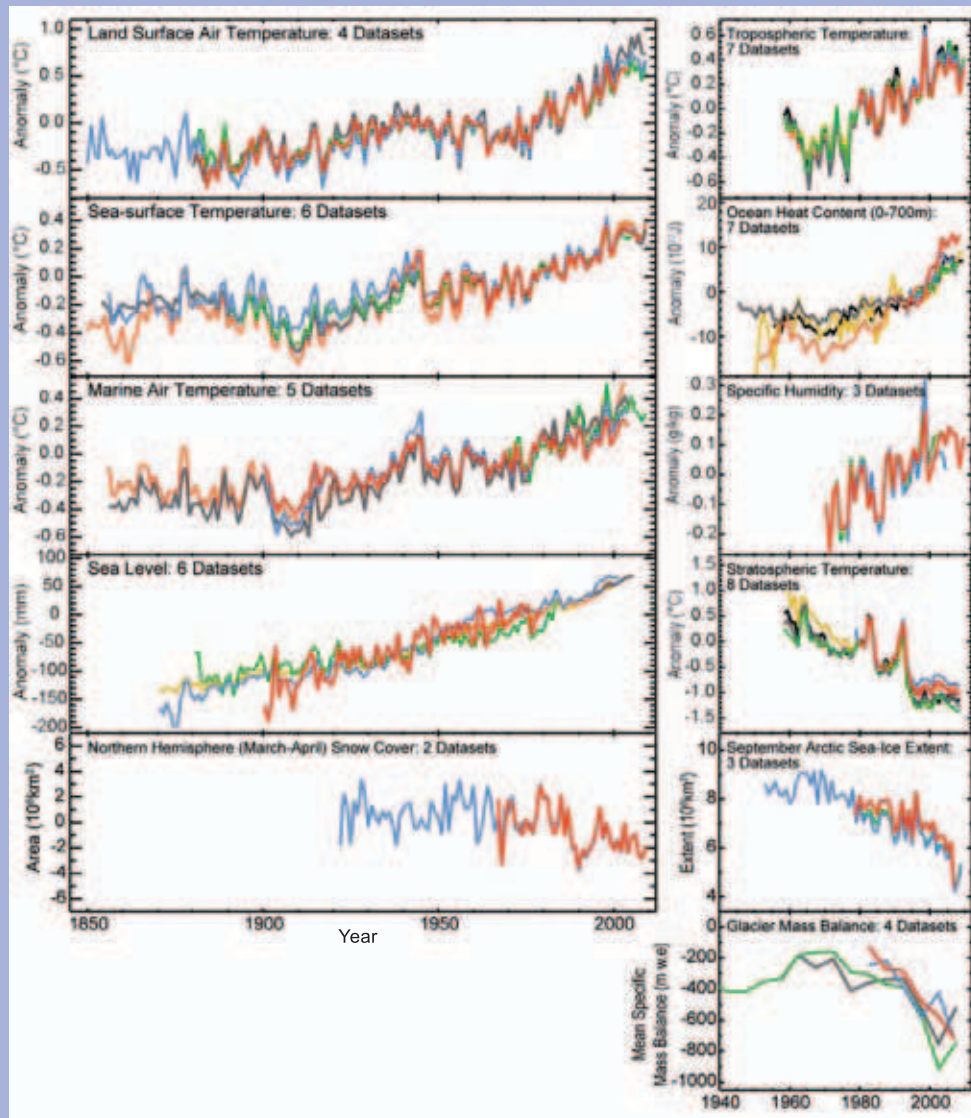
## HOW DO WE KNOW THE WORLD HAS WARMED?—J. J. Kennedy, P. W. Thorne, T. C. Peterson, R. A. Ruedy, P. A. Stott, D. E. Parker, S. A. Good, H. A. Titchner, and K. M. Willett

Although the IPCC AR4 concluded that “warming of the climate system is unequivocal,” public debate over the evidence for global warming continues. However, it is often confined to a small set of reiterated disputes about Land Surface Air Temperature (LSAT) records, diverting attention from the broader evidence basis.

The methods used to derive the principal estimates of global surface temperature trends—HadCRUT3 (Brohan et al. 2006), NOAA (Smith et al. 2008), and NASA/GISS (Hansen et al. 2001)—are largely independent (Table 2.2). So, the spread of the three estimates indicates the likely degree of uncertainty in the evolution of the global mean surface temperature. It is noteworthy that independently-derived estimates of tropospheric temperature trends for the whole troposphere channel (distinct from section 2b2) from satellites differ by an order of magnitude more than do estimated surface temperature trends (Thorne et al. 2010, manuscript submitted to *Wiley Interdisciplinary Reviews: Climate Change*).

Numerous studies attest to the robustness of the global LSAT records and their nonreliance on individual stations (e.g., Jones et al. 1997; Peterson et al. 1999; Parker 2006; Parker et al. 2009; Menne et al. 2010). Evidence from recent reanalyses lends further support (Simmons et al. 2010).

The IPCC conclusion (Alley et al. 2007) that “warming of the climate system is unequivocal” does not rest solely upon LSAT records. These constitute only one line of evidence



**FIG. 2.5.** Time series from a range of indicators that would be expected to correlate strongly with the surface record. Note that stratospheric cooling is an expected consequence of greenhouse gas increases. A version of this figure with full references is available at [www.ncdc.noaa.gov/bams-state-of-the-climate/](http://www.ncdc.noaa.gov/bams-state-of-the-climate/).

among many, for example: uptake of heat by the oceans, melting of land ice such as glaciers, the associated rise in sea level, and increased atmospheric surface humidity (Fig. 2.5). If the land surface records were systematically flawed and the globe had not really warmed, then it would be almost impossible to explain the concurrent changes in this wide range of indicators produced by many independent groups. The observed changes in a broad range of indicators provide a self-consistent story of a warming world.