New Climate Science Findings

The evidence that climate change is occurring and human activities are playing a role in causing such change continues to accumulate. Below, we list some of the important new results of the last year.

■ **The warming trend in the surface temperature record of the past 100 years is undoubtedly real, and the surface warming trend of the last 20 years is substantially greater than that seen during the rest of the century.** Differences remain between the surface records and satellite-derived trends, but there are plausible physical explanations for the differences. (National Research Council, Reconciling Observations of Global Temperature Change, Washington, DC: National Academy Press, 2000)

■ **There is increasing evidence that greenhouse gases from human activities are an important driver of these global-average temperature increases in the 20th century.** Much of the climate history of the past millennium can be explained in terms of a few well-established, natural processes, such as volcanic eruptions and solar variability. However, natural processes cannot explain the dramatic warming of the 20th century. Instead, the effects of human-induced global warming must be included in order to reproduce the temperature history. (*Crowley*, Causes of climate change over the past 1,000 years, Science, Vol. 289, 270-277, 2000)

■ **The oceans are warming.** Measurements of ocean temperatures taken over the last 50 years have revealed that the top 1,000 meters of the ocean has warmed by 0.06 degrees C, while the top 300 meters has warmed by 0.31 degrees C. Although these values seem small, the large heat capacity of water means that these small increases represent a tremendous amount of energy being stored in the ocean. These results are consistent with global climate model results that indicate that excess heat is accumulating in the ocean. (*Levitus* et al., Warming of the world ocean, Science, Vol. 287, 2225-2229, 2000)

■ **New research findings have identified declines in the extent and thickness of arctic sea ice over the last several decades.** Data from satellites show that perennial ice (ice that survives all year) declined by 14 percent between 1978 and 1998, while data from submarine cruises show that ice thickness has declined by about 40 percent over the last 20-40 years. A related study used climate models to estimate the chance that the observed trends could be entirely due to natural variability is less than 2 percent, suggesting that human activities are likely contributing to the loss of arctic sea ice. (*Rothrock* et al., Thinning of the arctic sea-ice cover, Geophys. Res. Lett., Vol. 26, 3469-3472, 1999; *Vinnikov* et al., Global warming and northern hemisphere sea ice extent, Science, Vol. 286, 1934-1937, 1999)

■ **New research reveals that the Greenland ice sheet is melting.** New data from a comprehensive survey of the ice cap suggest that the high elevation portions of the ice sheet are unchanged, while the lower elevation portions are melting. Over the last few years, this melting has released about 50 billion tons of water into the ocean each year; the melting is consistent with a warming of the Earth's high latitudes. (*Krabill* et al., Greenland ice sheet: High-elevation balance and peripheral thinning, Science, Vol. 289, 428-430, 2000, and *Thomas* et al., Mass Balance of the Greenland Ice Sheet at High Elevations, Science, Vol. 289, 426-428, 2000)

■ **Measurements of temperature profiles in boreholes provide**

independent verification of surface warming over the last 500 years. These data reveal that the Earth's average surface temperature has increased by about 1 degree C over the last 500 years, with 80 percent of the warming occurring since 1800 and 50 percent since 1900. The data set also is consistent with the temperature history derived from proxy climate data. (*Huang* et al., Temperature trends over the past five centuries reconstructed from borehole temperatures, Nature, Vol. 403, 756-758, 2000)

■ **Measurements of freshwater spring ice melt and fall freeze-up changes show increases in the ice-free season, concentrated in the past century.** The development and analysis of a freeze and thaw data base reveals that thaw dates advanced 6.5 days/century, and freeze-up dates, 5.8 days/century between 1846 and 1996, corresponding to an air temperature increase of about 1.2° C/century. (*Magnuson*, et al., Historical trends in lake and river ice cover in the Northern Hemisphere, Science, Vol. 289,1743-1746, 2000)

■ **Snow accumulation in the Himalayas for the last 1,000 years reveals increased warming in the 20th century.** Cores from glaciers on the Tibetan Plateau describe the imposition of a common warming trend at all sites during the 20th century, whereas the sites demonstrated more independent climate records during the previous 900 years. Temperature increases were greatest at the highest elevations. (*Thompson*, et al., A high-resolution millennial record of the South Asian Monsoon from Himalayan Ice Cores, Science, Vol. 289, 1916-1919, 2000)