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Surface Temperature Responses to Natural and Anthropogenic Influences: Past, Present, and Future

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Earth's surface temperature is highly variable. Regional and seasonal changes, which can exceed the global mean variations by an order of magnitude, arise from both natural and anthropogenic influences, On time scales of years to a decade, naturally induced surface temperature changes related to the El Niño Southern Oscillation (ENSO), volcanic aerosols and solar activity can dominate current anthropogenic warming of 0.2°C per decade, especially in some locations. Knowledge of surface temperatures in the immediate future aids in energy usage, land management and crop productivity, tourism and public health. A multivariate analysis that decomposes the observed surface temperature record (globally, regionally and in different seasons) suggests that increasing concentrations of greenhouse gases caused much (∼90%) of the long-term warming in the twentieth century. But declining global temperature since 1998, the warmest year on record, has produced wide-spread speculation that anthropogenic influences were not, in fact, the cause of the twentieth century warming or, if so, that their impact has now ceased. However, the exceptional warmth in 1998 was the result of a "super" El Nino. Subsequent global surface temperatures have not reach this level because cooling from La Nina events combined with declining solar brightness has countered much of the anthropogenic warming of the past 6 years. Using the best available estimates of future solar and anthropogenic influences we anticipate that global surface temperatures will increase 0.15°C, from 2009 to 2014, at a rate 50% greater than predicted by IPCC. But as a result of declining solar activity in the subsequent five years, average temperature in 2019 is only 0.03°C warmer than in 2014. A major volcanic eruption or a super ENSO would modify these projections, in ways that can be factored into the forecasts.