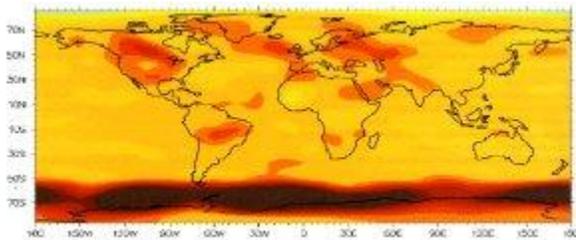
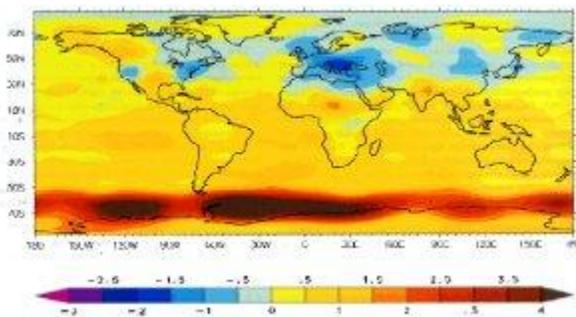


6.28 Human Effects on Global Warming



Greenhouse gas forcing only.



Greenhouse gas and sulfate aerosol forcing.

By themselves, droplets of sulfuric acid resulting from the burning of fossil fuels are of little consequence. But vast numbers of them form an aerosol haze that moderates and obscures the "greenhouse effect" caused by heat-trapping gases. In 1995, Benjamin Santer of Lawrence Livermore National Laboratory was the first to quantify and explain the link between fossil fuel emissions and climate change, including the role of greenhouse gases and aerosol particles. Using a statistical pattern detection method, Santer and colleagues reviewed records of the past century and identified the anthropogenic "fingerprint" of climate change that took into account the confounding effects of natural variations. This work explored the implications of earlier research by Karl Taylor and Joyce Penner of Lawrence Livermore, who showed that sulfate aerosols have strong local cooling effects and significantly modify the climate change pattern associated with greenhouse gases alone. Santer's studies demonstrated that the inclusion of sulfate aerosol effects helped to bring model simulations in closer statistical agreement with observations, and that this correlation is improved further by the inclusion of other relevant factors, such as

ozone depletion and the effects of volcanic eruptions.

Scientific Impact: Most climate modeling centers now emulate the work of these scientists by incorporating a sulfate chemistry model within an atmospheric/ocean climate model. The statistical technique of fingerprinting has since become the foundation for more complex methods of separating signals from noise in climate records.

Social Impact: Santer's studies provided hard evidence that human activities have global-scale consequences. The internationally acclaimed research by all three scientists contributed to the scientific underpinning for the Intergovernmental Panel on Climate Change's 1996 conclusion regarding a "discernible human influence" in climate change.

Reference: Santer, B.D., T.M.L. Wigley, T.P. Barnett, and E. Anyamba, 1996: "Detection of Climate Change and Attribution of Causes," *Climate Change 1995: The Science Climate Change*, 407-443, United Nations Intergovernmental Panel on Climate Change (Available Cambridge University Press, New York).

Santer, B.D., K.E. Taylor, T.M.L. Wigley, J.E. Penner, P.D. Jones and U. Cubasch, 1995: "Towards Detection and Attribution of an Anthropogenic on Climate," *Clim. Dyn.*, 12, 79-100.

SC-Funding Office: Office of Biological and Environmental Research