APPLICATION OF SOLAR MAX ACRIM DATA TO ANALYSIS
OF SOLAR-DRIVEN CLIMATIC VARIABILITY ON EARTH

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Abstract. Climatic change caused by solar variability has been proposed for at least a century, but could not be assessed reliably in the past because the uncertainty in solar irradiance measured from the Earth’s surface is too large. Now satellite measurements by such instruments as the Active Cavity Radiometer Irradiance Monitor (ACRIM) permit a preliminary assessment. The satellite data exhibit irradiance variations over a spectrum of shorter timescales, but the first 5-yr overall trend indicates slightly decreasing luminosity. The global temperature response to monthly-mean ACRIM-measured fluctuations from 1980–1984 was computed from the NYU 1D transient climate model—which includes thermal inertia effects of the world oceans—starting from an assumed pre-existing steady state, and the results compared with observations of recent global temperature trends. The modeled surface temperature evolution exhibited a complex history-dependent behavior whose fluctuations were an order of magnitude smaller than observed, primarily owing to oceanic thermal damping. Thus solar variability appears unlikely to have been an important factor in global-scale climate change over this period. The possibility of using the measurements to develop simple correlations for irradiance with longer term solar activity observable from the surface, and therefore to analyze historical effects, was considered, but is not supported by the satellite data. However, we have used a model of solar irradiance variation with time (Schatten, 1988), covering the period 1976–1997 in order to assess our model’s response to forcing whose fluctuation timescale is comparable to the thermal relaxation time of the upper ocean. Continuous monitoring of solar flux by space-based instruments over timescales of 20 yr or more, comparable to timescales for thermal relaxation of the oceans, and of the solar cycle itself, is probably needed to resolve issues of long-term solar variation effects on climate.

1. Introduction

Global climatic change is thought to arise primarily from four factors (Hoffert and Flannery, 1985): (a) variations in solar luminosity; (b) variations in planetary albedo associated with changing amounts of aerosols or dust, surface reflectivity and cloudiness distributions; (c) variations in amounts of infrared absorbing gases in the atmosphere (H₂O, CO₂, O₃, and various trace gases); and (d) internal feedbacks between elements of the climate system. This report will

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focus on what can be learned from direct satellite measurements of solar irradiance fluctuations from 1980–1984 about the contribution of solar variability to the global surface temperature history of the Earth.

2. Global Temperature Histories and Solar Variability

Considerable effort has been expended in recent years to describe the temperature history of the Earth from instrumental records over the past century. Figure 1, for example, illustrates two recent reconstructions of surface temperature anomalies (relative to the year 1980) extending back in time over a century developed independently by Jones et al. (1986) at the University of East Anglia, UK, and Hansen et al. (1988) at the Goddard Institute for Space Studies in New York. The Jones et al. curve is based on area-weighted averages of both land and sea records, with sea surface temperatures from the Comprehensive Ocean Atmosphere Data Set (COADS) corrected for the transition from the sailing ship ‘bucket’ temperatures to the water inlet temperatures of steamships; 1980–1984 temperatures are from NOAA observations adjusted for compatibility with earlier data. The Hansen and Lebedeff curve is based on slightly different data sources and methodologies, but exhibits essentially the same trends: a systematic global warming of some ~0.5 °C per century superimposed on considerable variability on interannual to decadal timescales. Both analyses indicate the rate of global warming has increased over the past several years – perhaps signaling the emergence of the fossil fuel greenhouse effect.

To establish whether, and how much, of this variation is due to anthropogenic greenhouse gas emissions, it is necessary to know the relative contributions