ATMOSPHERIC TEMPERATURE RESPONSE TO SOLAR CYCLE UV FLUX VARIATIONS

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Abstract. A radiative-convective climate model was used to explore the response of the mean global vertical temperature structure to a variation in the solar UV flux over the solar cycle. The model predicted a cooling of the troposphere and a warming of the stratosphere from solar minimum to solar maximum. The response of the atmospheric temperature to solar UV variations was found to be moderated by a concomitant change in the mean global stratospheric ozone content.

1. Introduction

Solar cycle UV flux variations can affect the chemistry of the upper atmosphere and in particular the ozone concentration which determines the thermal structure of the stratosphere and hence the tropospheric temperature structure through radiative-convective coupling. Further, any redistribution of UV flux to the visible, and vice versa, will modify the transfer of solar radiation through the atmosphere and, hence, alter the earth’s radiation budget.

According to current UV flux observations over the solar cycle, the flux can vary by a factor of two at Lyman-\(\alpha\) and by \(\sim 20\%\) near 200 nm (Hanser and Sellers, 1983; Simon, 1981; Mentall et al., 1981). Variations in the UV flux near 200 nm are important because they can modify the rate of \(O_2\) and NO photolysis, and hence ozone concentration, in the mesosphere and stratosphere while a variation in the solar Lyman-\(\alpha\) flux can lead to a variation in the ozone concentration through changes in mesospheric OH arising from variations in the photo-dissociation of atmospheric water vapour (Lewis et al., 1983).

As the Sun moves from solar sunspot minimum to sunspot maximum the UV flux increases due to magnetic field activity. Many workers have thus analysed atmospheric and weather data in an attempt to correlate variations in atmospheric temperature and ozone concentration with solar sunspot number (for example, see McCormac, 1983). Amongst the many empirical analyses are those of Schwentek and Elling (1981) and Hanson and Cotton (1983), which predict an anti-correlation between tropospheric temperatures and solar cycle UV flux and those of Angell and Korshover (1978, 1983) and Quiroz (1979) which have found a correlation between stratospheric temperatures and solar maximum. On the other hand, Schwentek and Elling (1984) found no clear dependence of lower stratospheric temperatures (11–36 km) on the solar cycle. According to the analysis of Keating et al. (1981) there may be a variation in the global mean ozone concentration over the solar cycle.
In this work the response of the Earth's atmospheric temperature structure to solar cycle UV flux variations is examined using a 1-D radiative-convective model to generate the mean vertical temperature profile. The model predicts an anti-correlation between tropospheric temperatures and solar UV flux variation and a strong correlation between stratospheric warming and solar maximum. The tropospheric cooling trend from solar minimum to solar maximum may, however, be moderated by a concomitant increase in stratospheric ozone.

2. UV Flux Variation Models

Model solar cycle UV flux variations are shown in Figure 1 together with the solar flux relative to its value at 300 nm. According to the model of Heath and Thekaekarra (1977), which was based on measurements over solar cycle 20, the UV flux exhibits a variation of \( \sim 250\% \) at 175 nm decreasing to \( \sim 18\% \) at 300 nm. Recently, Brasseur and Simon (1981) and Lean (1984) have developed models which give a variation of \( \sim 20\% \) at 180 nm decreasing to almost zero at 300 nm, based on solar cycle 21 measurements (e.g., Hinteregger, 1981; Mentall et al., 1981; Hall, 1983; Mount and Rottman, 1983). Evidence for a stronger UV flux variation with decreasing wavelength is further supported by the observations of Vidal-Madjar and Phissamay (1980) who reported an

![Figure 1](image-url)