Stratospheric and mesospheric temperatures and solar activity

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ABSTRACT. The response of the stratospheric and mesospheric mean temperatures to the variations of 10.7 cm solar radio flux during a 11-year solar cycle has been investigated. This involves the correlation and regression studies between the annual mean 10.7 cm solar radio flux and the annually averaged temperatures for the two regions of the atmosphere, over Thumba (8 deg N, 77 deg E) — an equatorial station — by carrying out both correlation and linear regression analysis between the annual mean neutral temperatures of the stratosphere and mesosphere with annually averaged 10.7 cm solar radio flux.

1. Introduction

The study of the middle atmosphere (10-100 km) and its treatment has become necessary to understand atmospheric phenomena. This work is the result of a study of the 10.7 cm solar radio flux induced variations on temperature as well as its magnitude in both stratosphere and mesosphere over Thumba (8 deg N, 77 deg E) — an equatorial station — by carrying out both correlation and linear regression analysis between the annual mean neutral temperatures of the stratosphere and mesosphere with annually averaged 10.7 cm solar radio flux.

Temperature data, recorded by 40 μm tungsten resistance wire sensors on board the M-100 rocket flights, conducted weekly over Thumba, was used for the solar cycle (1970-1980) period for the present study (The data have been published by the Hydro-meteorological Services, USSR). Defining the mean stratospheric temperature as the temperature averaged at every 5 km in the region between the tropopause and the stratosphere (15 to 45 km), and similarly the mean mesospheric temperature as the one obtained in the same way between the stratosphere and the mesopause (50 to 80 km), the two annual mean temperatures have been found from them for each year. The annual mean temperatures obtained so have been then statistically correlated with the annual mean 10.7 cm solar radio flux (Geomagnetic and solar data published by Virginia Lincoln in Journal of Geophysical Research) for the same period. The data have been used in the form in which they were available while the errors were not taken into consideration as they do not affect the magnitude of the correlation coefficient. The estimated correlation coefficients are tested by using the probable error estimation and applying Student’s ‘t’ test by using standard expressions. The regression coefficients of temperature on 10.7 cm solar radio flux have also been estimated.

2. Results and discussion

Fig. 1 shows the annual mean temperatures of the stratosphere and mesosphere for the years 1970-1980, along with the annual mean of the 10.7 cm solar radio flux. It is seen that the stratospheric temperature is not directly affected by the variation of 10.7 cm flux during the solar cycle above. On the other hand, variation of the annual mean mesospheric temperature has
Therefore, the correlation is insignificant for the stratosphere. But for the mesosphere, the calculated ‘t’ value of 8.27 is very much higher than its tabular value (viz., 3.26) at 1 per cent level of significance with the same degrees of freedom, showing the correlation present to be highly significant. The calculated regression coefficients of stratospheric and mesospheric temperatures on 10.7 cm solar radio flux are — 0.006 deg. C/unit cm flux and 0.096 deg. C/unit cm flux respectively (1 unit of cm flux = $10^{-22}$ W m$^{-2}$ Hz$^{-1}$ sec$^{-1}$ bandwidth).

A high positive correlation between daily variations of 10.7 cm solar radio flux and temperature variations in the mesosphere (51-70 km) over Thumba for 1970 December to 1971 December, reported (Ramakrishna and Seshamani 1973) was attributed to heating effects caused by the solar EUV radiation, particularly in the wavelength range 100-912 Å. Accordingly the heat source for this effect was located in the thermosphere at altitudes of 120-150 km, with the waves generated by this source propagating downwards into the mesosphere. Regression coefficient peak occurring in the 51-70 km region may be attributed to the variable heating due to the absorption by ozone of varying solar UV fluxes in the wavelength range 2000-3000 Å, and this is insignificant below 50 km (Seshamani 1980). Thus it may be likely that the combined effect of these two heat sources is giving rise to a high correlation in the mesosphere. But in the lower layers below the mesosphere, well below 50 km, where the correlation is negative and insignificant, there is a reversal in behaviour.

3. Conclusion

The highly significant positive large correlation and regression coefficients, obtained in the mesosphere indicate that the solar activity plays an important role in the variation of the temperature of the mesosphere. The low and insignificant value of correlation and low regression coefficient found in the stratosphere reveal that the solar activity certainly does not have any direct relationship on stratospheric temperatures.

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References

