

Stratospheric and mesospheric temperatures and solar activity

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(Received 8 October 1982)

संक्षेप—11-वर्षीय सौर चक्र में 10.7से० मी० सौर रेडियो अभिवाह विचरण पर समतापमंडल और मध्यमंडल के माध्यतापमानों की प्रतिक्रिया का अन्वेषण किया गया है। इसके लिए 10.7से० मी० वाले सौर रेडियो अभिवाह के वार्षिक माध्य और 1970-1980 की अवधि थुम्बा (8°उ०, 77°पू०), भारत के वायुमंडल के दो क्षेत्रों के औसत तापमानों के बीच सहसंबंध एवं समाश्रयण का अध्ययन किया गया है। मध्य मंडल में इन दो प्राचलों के बीच एक उच्च सार्थक धनात्मक सहसंबंध (0.94) है। समतापमंडल में सहसंबंध गुणांक (-0.28) नगण्य है। समतापमंडल एवं मध्यमंडल के लिए परिकल्पित समाश्रयण गुणांक क्रमशः—0.006° से/इकाई अभिवाह एवं +0.096° से/इकाई अभिवाह स्पष्ट संकेत देते हैं कि जिस स्टेशन का अध्ययन किया गया है उस पर केवल मध्यमंडल में 10.7 से० मी० वाले सौर रेडियो अभिवाह विशेष प्रभावी हैं। इस निष्कर्ष से रामकृष्ण एवं सेशामणी (1973) द्वारा एक वर्ष के आंकड़ों के आधार पर ज्ञात किए निष्कर्षों की भी पुष्टि होती है।

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), India, during the period 1970-1980. A highly significant positive correlation (0.94) exists between these two parameters in the mesosphere. The correlation coefficient (-0.28) in the stratosphere is insignificant. The calculated regression coefficients of -0.006 deg. C/unit flux and +0.096 deg. C/unit flux for the stratosphere and mesosphere, respectively, point out clearly that the 10.7 cm solar radio flux influences strongly only in the mesosphere over the station studied, which supports the earlier findings by Ramakrishna and Seshamani (1973) based on one year data.

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-rhenium resistance wire sensors on board the M-100 rocket flights, conducted weekly over Thumba, taken for a solar cycle (1970-1980) were used for the present study (The data have been published by the Hydrometeorological Services, USSR). Defining the mean stratospheric temperature as the temperature averaged at every 5 km in the region between the tropopause and the stratopause (15 to 45 km), and similarly the mean mesospheric temperature as the one obtained in the same way between the stratopause and the meso-

pause (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

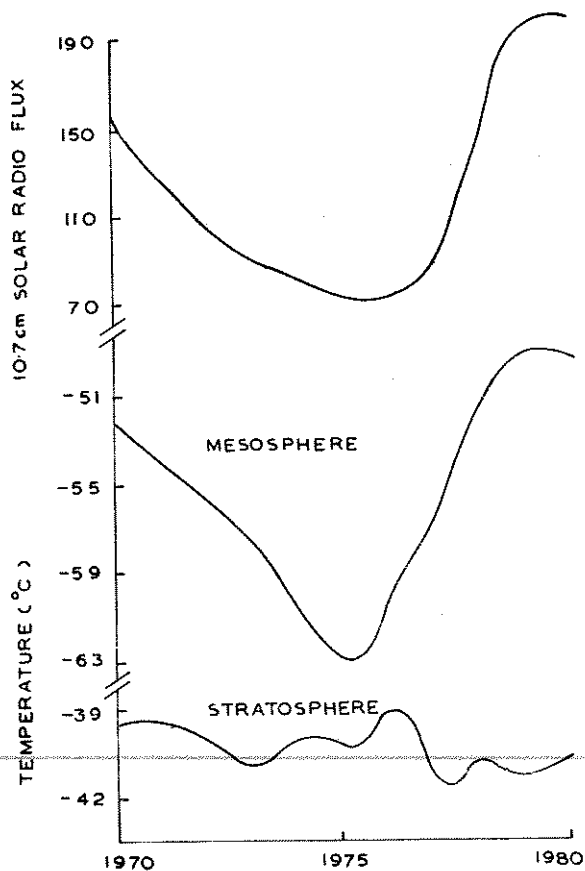


Fig. 1. Variations of the annual mean stratospheric and mesospheric temperatures and the 10.7 cm solar radio flux, during a solar cycle (1970-1980) over Thumba

exactly the same trend as the annual mean variation of the 10.7 cm solar radio flux. While the variation of mean stratospheric temperature during the solar cycle is found to be less than 3 deg. C, that in the mesosphere is as high as 13.9 deg. C. The correlation coefficient estimated between the annual mean temperature and the 10.7 cm solar radio flux for the period of 11 years gave a value of -0.28 for stratosphere and $+0.94$ for mesosphere. Since correlation coefficients are subject to errors due to sampling, these values can be better interpreted only through probable errors. The probable errors involved have been found to be 0.21 and 0.026, respectively, for the stratosphere and mesosphere. Since the value of the probable error (0.21) is only slightly less than the magnitude of the correlation coefficient of the stratosphere (0.28), the latter is considered to be insignificant. The correlation coefficient of the mesosphere (0.94) is nearly 36 times larger in magnitude than the estimated probable error (0.026) thereby pointing out a statistically significant high correlation existing between the mean mesospheric temperature and 1.07 cm solar radio flux. Applying the *Student's 't' test*, for the stratosphere, the computed value of '*t*' (*viz.*, -0.88) is seen to be much less than the tabular value (*viz.*, 2.26) at 5 p.c. level of significance and $N - 2$ (*i.e.*, 9) degrees of freedom.

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 em flux and 0.096 deg. C/unit em flux respectively (1 unit of em flux = $10^{-22} \text{Wm}^{-2} \text{Hz}^{-1} \text{sec}^{-1}$ 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.

Acknowledgement

One of the authors (KM) wishes to thank the University Grants Commission, New Delhi for awarding a Research Fellowship.

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