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INFLUENCE OF SOLAR ACTIVITY ON MIDDLE ATMOSPHERE ASSOCIATED WITH PHASES OF EQUATORIAL QUASI-BIENNIAL OSCILLATION

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Earlier studies on the influence of solar activity variations within a 11-year solar cycle on temperature changes in the middle atmosphere revealed that while the temperature in the mesosphere showed strong response to changes in solar activity, the stratosphere remained almost unaffected (MOHANAKUMAR, 1985; 1987; 1988). Recent studies (LABITZKE, 1987; LABITZKE and VAN LOON, 1988; LABITZKE and CHANIN, 1988) showed that when the temperature data were grouped into east or west phase of the equatorial quasi-biennial oscillation (QBO) in stratospheric zonal wind, significant relationships of temperature in the lower stratosphere and troposphere could be obtained with 10.7 cm solar radio flux. Positive correlations in high latitude regions and negative correlations in mid-latitude and tropical regions were obtained during winter when the QBO was in its west phase. During the east phase, converse relationships were indicated. These interesting results inspired the present study on the response of solar activity in 11-year cycle on the temperature structure of the middle atmosphere in the two phases of equatorial QBO of zonal wind at 50 mb, in tropics, mid-latitude and antarctic regions

Soviet M-100 rocketsonde-derived temperature data collected from Thumba (8°N, 77°E) in tropics, Volgograd (49°N, 44°E) in mid-latitude and Molodezhnaya (69°S, 46°E) in antarctic for a 14-year period from 1971 to 1984 were used for the present study. The temperature data at every 5 km interval from 15 to 80 km altitude region were selected for the above three stations. The winter-time temperature was obtained by averaging the data during January and February, and the summer-time temperature by averaging data during July and August for the two Northern Hemispheric stations, whereas, for the antarctic station, the months representing these two seasons are just reverse. These were then grouped according to the periods of easterly and westerly phases of QBO at 50 mb. 10.7 cm solar radio flux was taken as the solar activity parameter for the corresponding periods.

The linear correlation coefficients computed for every 5 km levels between the solar radio flux and temperatures at the three stations are shown in Fig.1. Scattergrams of solar radio flux and temperatures for few selected levels in the stratosphere are also given in the figure to highlight the effect of solar activity on temperature in the two phases of QBO.

During both the seasons, the temperatures in the tropical stratosphere show strong negative correlation with solar radio flux during the westerly phases of QBO and positive or weak negative correlation during the easterly phases. Below 20 km, over tropics, strong positive correlations are obtained during both the seasons and the two phases of QBO. The scattergrams at 30 and 40 km altitude over Thumba indicate that the temperature changes during the westerly phases of QBO are consistently out-of-phase with the changes in solar activity, while during the easterly phase, the variations are inconsistent.

In mid-latitude and antarctic regions, the lower stratospheric temperatures in summer show positive correlation during the easterly phases and negative correlation during the westerly phases of QBO. During winter, on the other hand, lower stratospheric temperature register positive correlation during the westerly phases and negative correlation during the easterly phases. Changes in the slope of the regression line in the scatter diagrams further indicates the lower stratospheric circulation pattern modulates the solar induced changes in the stratospheric thermal structure.

The response of mesospheric temperature to the solar activity is not at all altered by the variations in equatorial stratospheric zonal winds. During both the phases of QBO, the temperatures in mesosphere indicate a direct association to the solar activity at all the three stations. The altitude of maximum response to solar variations is found to be a function of season. The thermal response to solar variations attains its peak value in lower mesosphere (55-60 km) during winter and in middle mesosphere (65-70 km) during summer. The summertime temperature in mesosphere shows a better relation with the solar activity than during winter, irrespective of the change in phases of QBO.

Middle atmospheric temperature departures from the long period (14 year) mean, computed for January and July at every 5 km intervals, over the three stations are illustrated in Fig.2. The vertical arrows in the lower part of Fig.2 depict the periods of quasi-biennial west wind maximum. Periods of high and low solar activity are indicated on the upper part of the Fig.2.

During both summer and winter, consistent and marked cooling is observed in mesosphere in association with the period of low solar activity. The maximum cooling is observed when the solar activity attains its minimum. Maximum cooling occurs slightly early in winter than in summer. As the solar activity increases from minimum to maximum, the temperatures in mesosphere steadily increases and produces consistent heating. Inwinter, the heating occurs early during solar maximum in the upper mesosphere, whereas, in summer it occurs slightly later during solar maximum in the middle mesosphere. The rate of heating decreases as the solar activity gradually subsides and the mesosphere becomes cooler after 1982.

The heating/cooling regimes in mesosphere, produced during the active/weak phases of solar activity, are transported downwards to the stratosphere. The downward transport of the heating/cooling regimes is slow during winter, whereas, there is a rapid downward spreading observed during summer. The temperature changes in middle stratosphere are found to have an inverse relation with those in mesosphere. The middle and lower stratosphere register cooling during solar maximum and heating during solar minimum in both summer and winter seasons at all the three stations. The rate of heating/cooling observed in stratospheric layers are comparatively lower in magnitude than the mesosphere.

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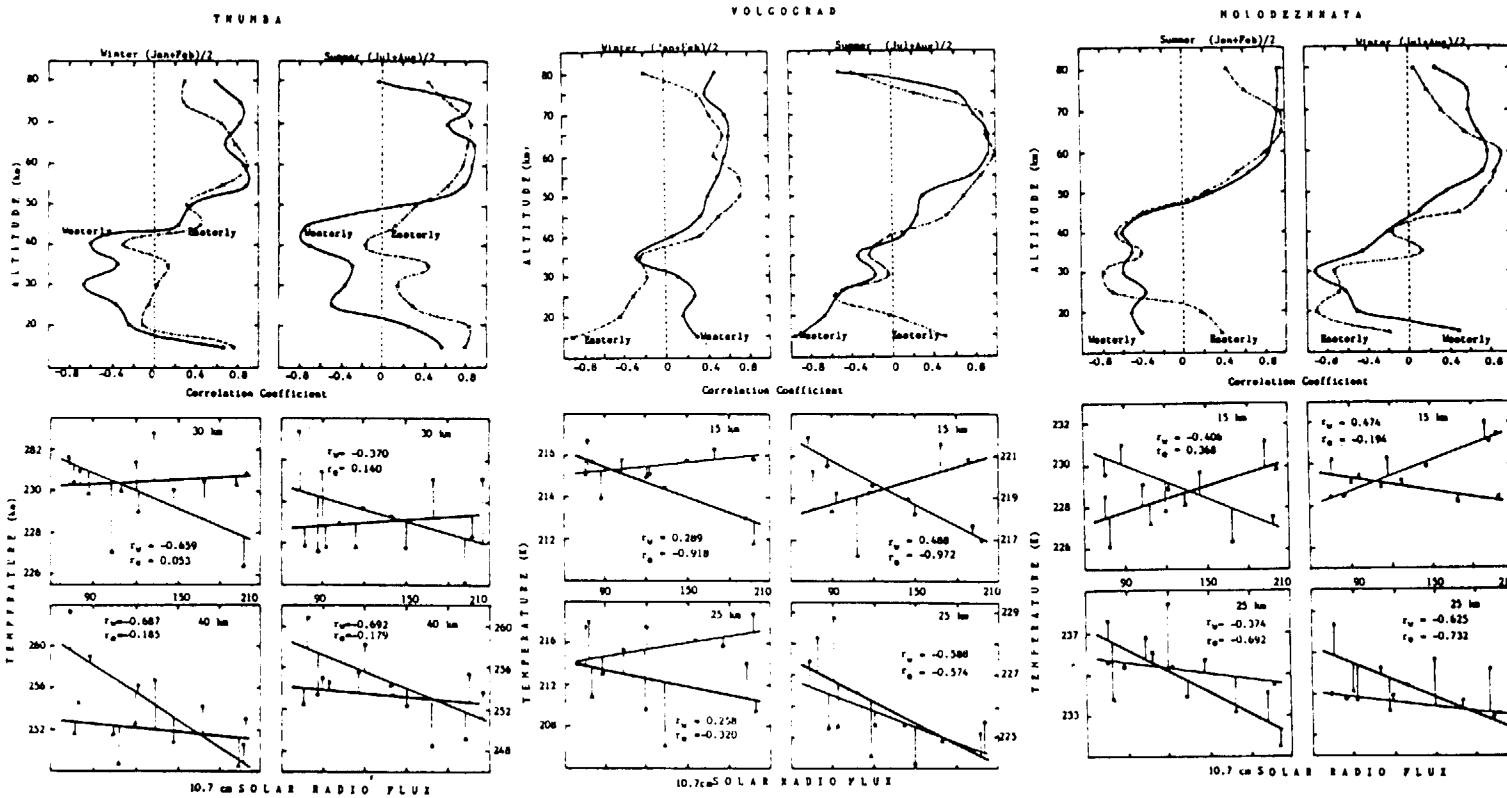

Figure 1. Vertical profiles of correlation coefficients (upper part) and scatter diagrams (lower part).

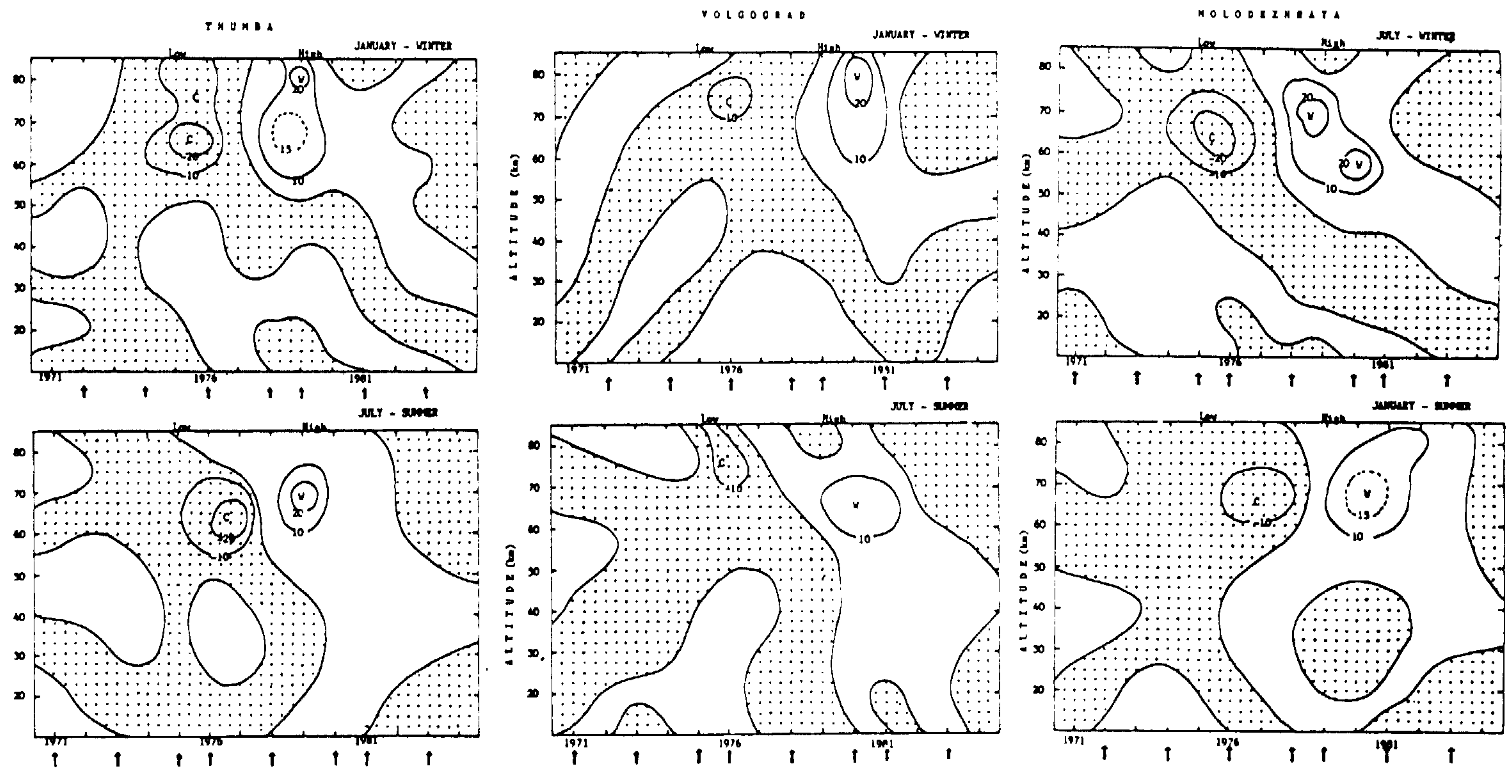

Figure 2. Middle atmospheric heating/cooling associated with solar activity.