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The Thermal Structure of the Stratosphere over the Tropics

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ABSTRACT. Recent temperature measurements in the stratosphere over the tropics point out that there is no isothermal layer in the lower stratosphere in these regions. An examination of the mean height temperature curves, both for the northern and southern hemispheres indicates that the lower stratosphere to the poleward half of 45° exhibits a deep isothermal region, while that to the equatorial half does not. The transition in the northern hemisphere along 80°W meridian has been found to occur between 48 and 51° N in summer and between 38 and 42°N in winter and coincides with the transition of the tropopause pointed out by Hess. A similar transition has been found for the southern hemisphere.

1. Introduction

In a recent paper[1] the author pointed out that the isothermal region which is found in the lower stratosphere over middle latitudes does not exist over India and that mean temperature steadily increases above the tropopause. At Agra (Lat. 27°N) the mean temperature for February increased from 201·2°A at 17 km to 221·5°A at 26 km and for September from 193·1°A at 17 km to 234 9°A at 26 km.[2] Ramanathan[3] as early as 1929, had drawn attention to this rise of temperature in the lower levels of the stratosphere over tropical regions, and this has been generally accepted since. The question whether this inversion in the tropical stratosphere extends above the lower levels, *i.e.*, above 25 or 26 km or

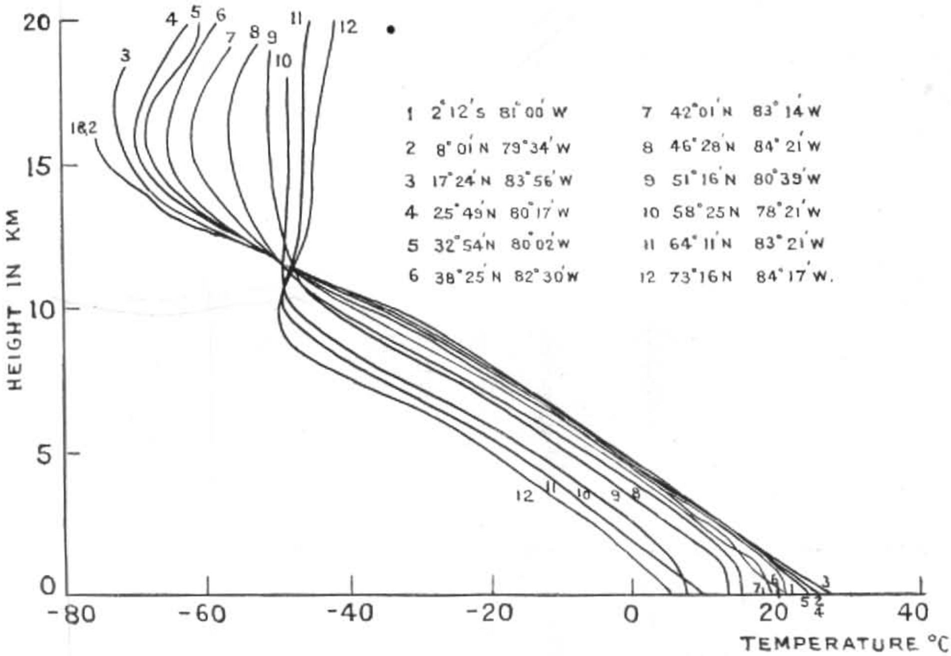

Fig. 1. Mean distribution of temperature
Northern hemisphere(SUMMER) along 80°W

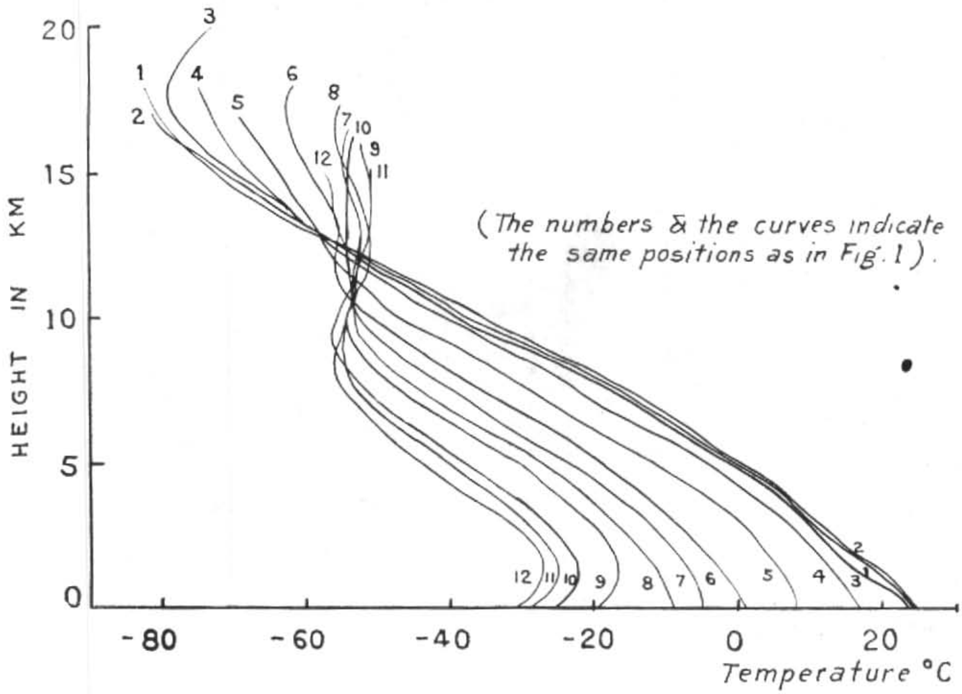

Fig. 2. Mean distribution of temperature
Northern hemisphere (WINTER) along 80°W

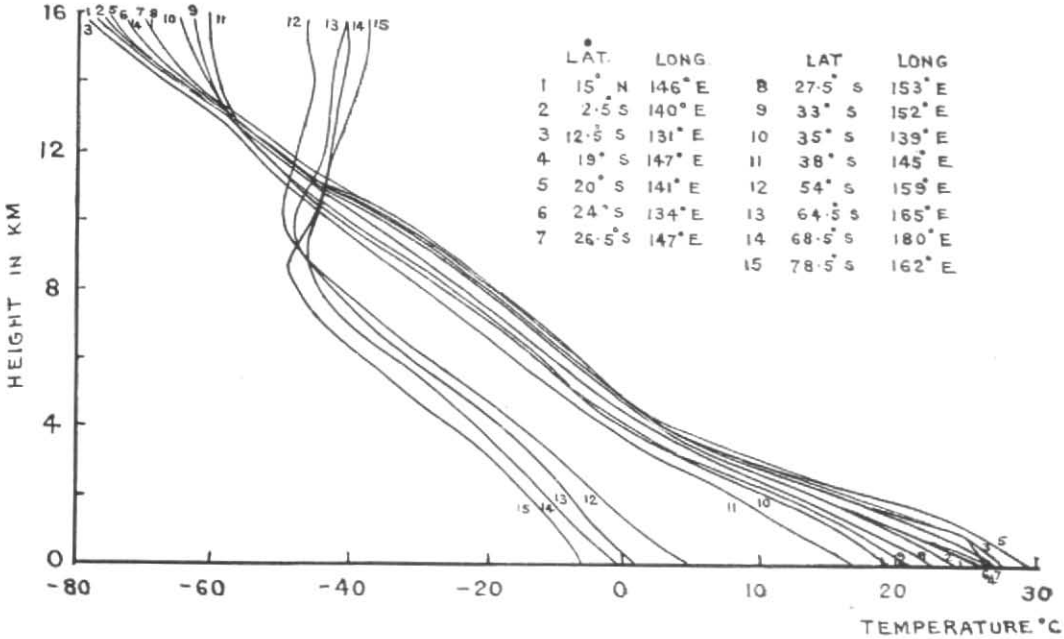

Fig. 3. Mean distribution of temperature
Southern hemisphere (SUMMER)

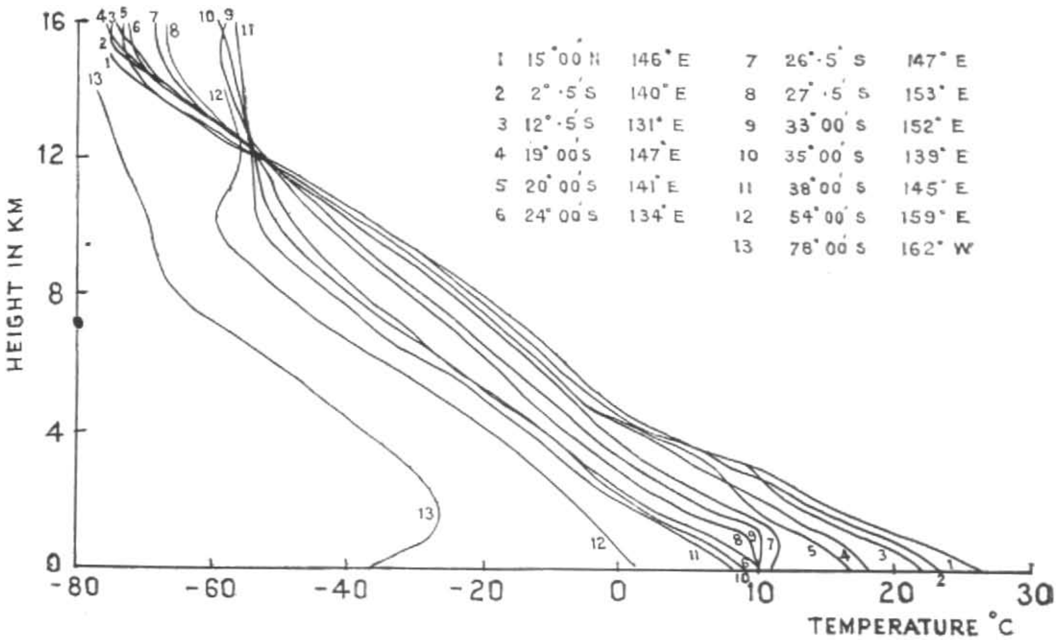

Fig. 4. Mean distribution of temperature
Southern hemisphere (WINTER)

whether the isothermal layer familiar in higher latitudes is found over the tropics also above that level had to await further experiments before an answer could be given. Penndorf[4] while noting this inversion in Chiplonkar's curves[5] thought that an isothermal condition may prevail between 26 and 28 km and that in any case any further rise in temperature is very slight and probably corresponds to the summer rise of temperature in middle latitudes. Goldie[6] had argued that in the stratosphere above the tropopause and upto 24 km the density differences would promote a circulation in which air subsides *en masse* in the tropics towards the tropopause and hence the tropical stratospheric temperatures should increase slowly with height. Recent sound propagation experiments conducted by the India Meteorological Department however indicated temperatures of 304°A and 312°A at 34 km over Central India as worked out by Mathur[7]. Thus the increase of temperature which is found above the tropopause upto 26 km appears to be maintained from 26 to 34 km also.

This result is in agreement with Nazarek's conclusion[8] from V—2 rocket experiments over Whitesands, New Mexico (Lat. 32°N) that the isothermal region does not exist there in the lower stratosphere. Gutenberg[9] gave mean temperature height curves for Whitesands, New Mexico and found a steady rise in temperature from 16 to 35 km during all seasons. Brasfield[10] from radisonde ascents over Belmar, New Jersey (Lat. 40·2°N) found that the mean day time temperature of the stratosphere is about —60°C from 50,000 to 60,000 ft above which the mean temperature rises at the rate of about 5°C per 1000 ft to a temperature of —30°C at 120,000 ft. McDowell[11] in a Rawin sonde flight over Puerto Rico (Lat. 26·8°S) on 29 January 1948 also found a steady increase in temperature from the tropopause at 18 to 28 km.

2. Latitudinal variation of mean temperature distribution with height

(*a*) *Northern Hemisphere*

All the results quoted above point to the non-existence of the isothermal region over some stations in the tropics. With a view to determine whether this is a general feature over the tropics, and if so, where the transition between isothermal and inversion regions occurs, an attempt was made to compare the height-temperature curves at various latitudes in each hemisphere. Hess[12] worked out mean vertical distribution of temperature upto about 20 km for summer and winter from radiosonde data at a number of stations along the 80°W meridian. Height-temperature curves were plotted for all the 12 stations from his data and are given in Figs. 1 and 2.

It may be seen from the figures that the height-temperature curves form into two distinct types—those with an isothermal region above a low tropopause and those with a temperature-rise above a high tropopause. The transition occurs between 46° and 51°N in summer and 38° and 42°N in winter along longitude 80°W. The transition is likely to be a meandering one around the globe corresponding with the course of the Jet Stream.

(*b*) *Southern Hemisphere*

An attempt was made to see whether such a transition occurs in the southern hemisphere also. Loewe and Radok's mean temperature results[13] for a number of stations in the southern hemisphere were used and the height-temperatures plotted. The curves are given in Figs. 3 and 4.

It may be seen that in the southern hemisphere also two distinct types exist as in the case of the northern hemisphere. Since the heights of the ascents did not exceed 16 km, the tropical curves do not reach the stratosphere, but the difference in the structure of the two sets of curves is clear. The transition along 150°E (roughly) occurs between 38° and 54°S in summer and 27° and 33°S in winter. Recent data of Huchings[14] along 170°E indicates the transition between 37° and 43°S in summer and 29° and 37°S in winter.

3. The non-existence of the isothermal layer in the lower stratosphere over the tropics

From the above it appears that the lower stratosphere does not uniformly consist of an isothermal region all over the globe but that the isothermal region is confined only to the polar half of each hemisphere, say from latitude 45°. In summer the transition shifts towards the poles and in winter to the equator. The appearance of the isothermal region from 45,000 to 75,000 ft in winter in Brasefield's curves for Belmar (Lat. 40·2°N) and its absence in summer, is a striking illustration of the above phenomenon. In summer in the northern hemisphere the transition lies to the north of 46°N and hence Belmar at 40°N is entirely under tropical conditions while in winter the transition is between 38° and 42°N and hence Belmar exhibits the isothermal layer in its mean curves.

Hess had pointed out that an abrupt break in the characteristic of the tropopause occurs in the mean curves of summer and winter along 80°W and designated the the tropopause as tropic and arctic. The present analysis indicates that in addition to the tropopause break, the stratosphere itself can be divided into two distinct parts, *viz.*, the polar stratosphere with a low tropopause and deep isothermal region in the lower layers and a tropical stratosphere with a high tropopause and an inversion above it with no isothermal region.

Fig. 5 illustrates the probable thermal structure of the tropical and polar atmospheres upto the top of the stratosphere. The nomenclature " incline " and " decline " for regions of increasing and decreasing temperatures in the stratosphere has been adopted from Chapman[15] and the term stratopause for the top of the stratosphere has already been suggested by the author[1]. Chapman, however, suggests the use of stratosphere for the isothermal layer above the tropopause and stratopause for the top of this layer. This does not appear desirable due to the absence of the isothermal layer over the tropics as pointed out in the preceding paragraphs.

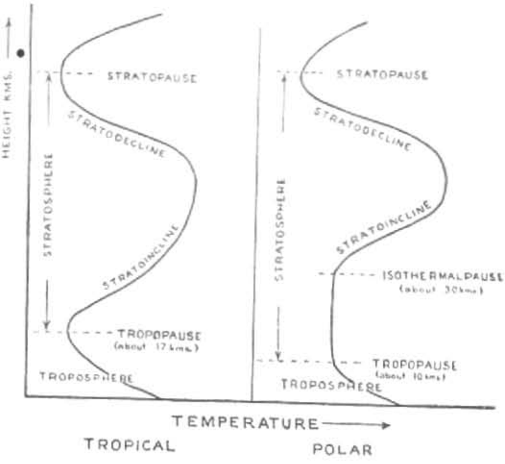

Fig. 5. Tropical and Polar Stratospheres

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