Upper Air Temperatures and Humidities in the Indian Peninsula

SINCE October 1928, more or less regular ascents of sounding balloons have been carried out from Poona and Hyderabad (Deccan) with meteorographs of the Dines type manufactured at the Upper Air Observatory, Agra. The ascents at Hyderabad were made from

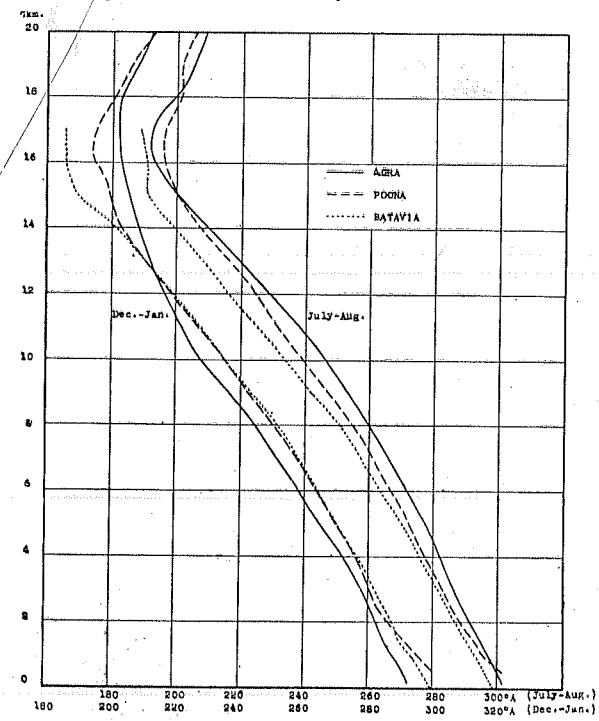

FIG. 1.—Upper air temperature over Agra, Poona, and Batavia.

the Nizamiah Observatory, Hyderabad, with the kind co-operation of its director. It may be of interest to summarise here some results of outstanding importance obtained as a result of these soundings.

(1) During the monsoon months, July and August, the atmosphere over the Deccan is invariably colder than that over Agra in northern India, up to a level of about 14 geodynamic kilometres—the maximum mean difference of temperature being 7° C. at a level of 10 gkm. Temperatures over Batavia in these months are lower still. The level of the tropopause in this season is about the same, or slightly lower, and its temperature higher in the Deccan than in northern India (Fig. 1). Considering the troposphere as a whole, the thermal equator over Indian longitudes lies over northern India at a latitude of about 25° N.

These results are specially interesting in view of the westerly to north-westerly movement of monsoon depressions. The normal upper winds are consistent with the temperature distribution.

During the months July-September, the relative humidity in the air over the Deccan generally shows a maximum (saturation) between 1·5 gkm. and 3·5 gkm., and is followed by a more or less rapid fall, extending over one or two kilometres, and at still higher levels by a rise. In about half the number of available records, the humidity falls off above 6-8 km., the fall being gradual. The decrease of humidity above the lower level of maximum humidity is sharper and larger during times of weak monsoon. It may be mentioned that the westerly winds of the monsoon give place to the easterlies of the inter-tropical circulation normally between 6 km. and 8 km.

(2) Conditions are markedly in contrast in the winter. In the period November-February, temperatures over northern India are lower than those over Poona up to 13 gkm., and above that level higher. Between 4 gkm. and 14 gkm., there is little difference between the temperatures over Batavia and Poona, but the tropopause is higher nearer the equator, and colder.

(3) The semi-permanent anticyclone in the upper air over the central parts of India during the months November-January shows itself in the temperatures over Poona as a well-marked region of small lapse-rate extending over 0·5-1 km., and starting at a level ranging from 2·5 km. to 3·5 km. The trajectories of air movement in the upper air show that the air below the inversion usually comes from the Punjab and northern Rajputana through east Central India and the Central Provinces; while above the inversion, the air supply is from a direction varying from north to west, and has, in general, a higher velocity. The air below the inversion is surface-heated continental air from higher latitudes, and has a high lapse-rate. As may be expected, there is a maximum of humidity at the top of the lower convective layer.

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Distortion of the Tropopause due to Meridional Movements in the Sub-Stratosphere

In the neighbourhood of the equator, the height of the tropopause is about 17 gkm. and at latitude 70° N. about 10 gkm. The rate at which the height of the tropopause changes with latitude is, however, not uniform, the change being very rapid between 45° and 20° in winter, and between 50° and 30° in summer. The ring of cold air which collects near the tropopause over tropical latitudes will tend to spread out with a slight downward component towards higher latitudes. To compensate this movement, we may expect that there will be at lower levels a movement towards lower latitudes.

At the latitude of Agra (27° N.) in winter, the meridional variation of temperature is least at about 12 gkm., while at higher levels the temperature increases towards the pole and at lower levels towards the equator. The lower boundary of the spreading equatorial cold air will lie in the neighbourhood of 12 gkm. It is also known from pressure data that

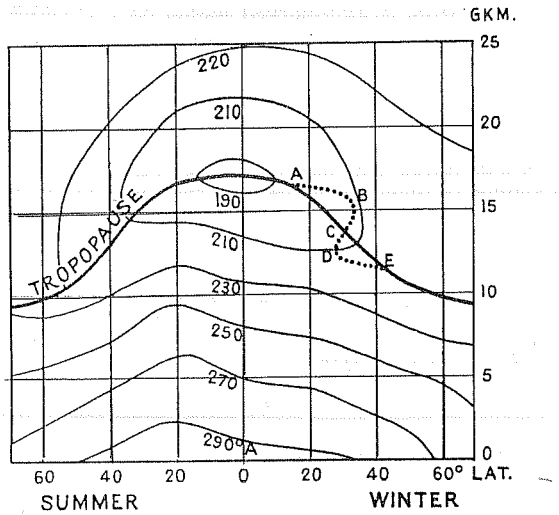

Fig. 1. Meridional distribution of temperature in the atmosphere over the northern hemisphere showing the tropopause and its distortion.

the westerly winds of the season in sub-tropical latitudes have their maximum strength at a height of 10–12 km. As an interesting consequence, it will follow that in the region of latitudes where there is a rapid variation of the height of the tropopause, it will often have a folded structure such as is represented by the dotted line in Fig. 1.

At Agra, in winter, the type of tropopause which occurs most frequently is one in which the transition from the troposphere to the stratosphere occurs in two stages, the lower one being at a height of 12–13 gkm., with the lapse-rate suddenly changing from a high to a low value, often reaching zero above the transition, and the second transition at a height of about 17 gkm., this being invariably an inversion. Immediately below the upper inversion, there is frequently a layer of positive lapse-rate with a mean value of 5° C. per km. of about 2 km. thickness.

This thermal structure is what one would expect if the lower transition corresponds to the tropopause of higher latitudes and the upper inversion transition to the tropopause of lower latitudes. Between these two, the air will be partly stratospheric air from higher latitudes and partly tropospheric air from lower latitudes. In summer, with the movement of the hump in the level of the tropopause towards higher latitudes, this folded structure of the tropopause is either absent at Agra, or if present, the difference of level between the transitions is very small.

At the latitude of Poona (18° N.), the double transitions are much less conspicuous than at Agra, though one can often notice them in winter and early summer. When present, the difference of level between the two transitions is smaller than at Agra, the lower one being at a height of about 14 gkm. and the upper at 16–17 gkm.

On the other hand, many of the temperature-height curves of places like Avalon (lat. 33° N.), Groesbeck (31° N.) and Fort Omaha (41° N.) in the United States[1] in summer show the double transition distinctly.

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[1] *Mon. Weather Rev.*, U.S.A., July 1914, May 1916, and June 1919; *Bulletin, Mount Weather Observatory*, 4, part 4, 1911.