Winter wind field over SHAR

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Daily upper wind data up to about 25 km obtained by Rawin flights during IMAP equatorial wave campaign, 1986 and ASLV D1 campaign, 1987 have been analysed by forming vertical time sections. The tendencies of the easterly and westerly wind regimes have been derived. The jet stream wind speeds of the order of 80-90 knot which are common at north Indian latitudes are found to occur at SHAR latitudes also. The synoptic situation during the period and the wind shears have also been discussed. The comparison of observation with the upper air features of Madras around the same time has also been made.

1 Introduction

Study of upper wind field is an integral part of space physics and meteorology. The study is useful to understand the atmospheric energy distributions and circulation as well as the tropospheric-stratospheric coupling, if any, and the consequent influence on the weather systems of both synoptic and planetary scales.

Wind is the parameter which aerospace scientists are especially interested in. An aerospace vehicle responds to environmental perturbations, and the response to the wind field has to be carefully evaluated to ensure an acceptable design relative to operational requirements. The analysis, solution and interpretation of wind information are, therefore, important tasks of the atmospheric scientists for the aerospace programmes and missions.

An aerological observatory has been established in 1977 at the Sriharikota Range (SHAR). Upper wind measurements are recorded twice a week by releasing a balloon-borne corner reflector and following the same with the help of a ground based radar. The data so collected help to derive the monthly average wind values. However, in order to understand the day-to-day changes in circulations, intense daily upper wind measurement is necessary. Such a possibility was achieved during 1986 and 1987 under IMAP (Indian Middle Atmosphere Programme) and ASLV campaign. The data so achieved have been analysed and the results are presented.

2 Programme and data

Daily Rawin flights were carried out at SHAR during the following campaign periods in winter.


(ii) As a part of meteorological support for ASLV-D1 campaign from 5-24 Mar. 1987.

Cosmoprene spherical balloon weighing 1200 g were filled with hydrogen gas and attached with a corner reflector made of aluminium foil was released and the same was followed by the radar of ISRO Range Complex (IREX). The balloon was followed till its burst. The coordinates of the balloon can be known from the azimuth, elevation and slant range information at an interval of every minute. Using the computer software developed by Meteorology Facility, winds at each kilometre level up to the lower stratospheric heights were obtained.

3 Methodology

The winds so recorded from surface to the maximum height reached by the balloon were plotted in the resultant wind form at 1 km interval, and thus a vertical time section of wind was constructed. This was done separately for 1986 observations and 1987 measurements. Similar time sections were constructed separately for meridional and zonal components also. The tendencies of the easterly and westerly regimes were examined. Shears at different layers were also evaluated and the distributions were scrutinized.

4 Results and discussion

The easterlies were dominantly seen on all days in January and February 1986 up to 2 km of height which is in agreement with the mean level of change of wind direction from east to west as found earlier. However, the easterlies could penetrate through most part of troposphere (10 km) during 20-25 Jan. 1986 and 19-23 Feb. 1986. On certain other days east-
erlies could extend up to 4 km. The extension to the higher levels from lower layers was found to be a bit random. The mid- and upper tropospheres have normally westerly winds during January, February and March climatologically with moderate wind speeds (30 knot approximately). But, during the first ten days of Feb. 1986, the westerlies in the upper troposphere strengthened both in the intensity and the extent of layers (Fig. 1). Wind speeds reached even 80 knot. Such high wind speeds are normally seen with westerly jet streams of the mid-latitudes, which used to appear over north India between about 20 and 25° north latitudes during these months. Extension of the strong westerlies to the lower latitudes like that of SHAR is not a common phenomenon.

The zonal and meridional wind fields along the time axis (dates) were separately plotted and depicted in Figs 2 and 3. Till about 9 February the zonal field was uniformly westerly and till 8 February the meridional field was uniformly southerly up to 18 km. The wind flow was very strong in both the fields between 10 and 15 km level. However, the period 9-14 February is the time of transition in directions in both zonal and meridional fields at the mid-levels. There was easterly intrusion between 16 and 19 km from 10 to 14 February. During 9-12 February there was a descent of northerlies down to 12 km. Thus a period of simultaneous changes in zonal and meridional field had started from 10 February 1986. Consequently, from 11 February onwards the westerlies decreased in
strength significantly. In fact, the core of westerlies of speed more than 50 knot which was 7 km thick (between 8 and 15 km levels) between 6 and 9 Feb. 1986 collapsed from 11 February onwards.

Above 22 km level easterlies were found to dominate as per the earlier statistics. The uniform wind field up to 14 km with the intense westerly regime and the disturbed flow above, during the period 10-14 February, are shown in Fig. 1.

Fig. 4 gives the vertical time section of the winds during Mar. 1987. Accidentally, a similar situation of the strengthening of tropospheric westerlies occurred during 6-13 Mar. 1987. Here also wind speeds had gone up to 85 knot and the thickness of intense westerlies was the same (about 7 km). An interesting event this time is the extension of westerly regime right down to the boundary layer. Thus the normal winter pattern of lower troposphere changed during 10-14 Mar. 1987. However, from 18 Mar. 1987 onwards the easterly components were recorded. Figs 5 and 6 present the component wind time sections. There was a sudden descent of easterlies down to 16 km on 14 March and further down by next day. The weak northerlies started strengthening the same day over these levels. Again southerlies had suddenly appeared between 13 and 17 km on 17 March. Thus, in this month also a period of changes in both zonal and meridional winds had succeeded a period of very strong westerlies in mid- and upper troposphere.

Unfortunately, there were no temperature observations available for SHAR. However, the temperature observations taken from Madras airport (about 70 km south of SHAR) by India Meteorological Department (IMD) for the period under study were analysed. The temperature observations were available up to a maximum height of about 15 km only. The temperatures at 300, 200 and 100 mbar levels during 10-20 Mar. 1987 are plotted and shown in Fig. 7. While no notable feature could be correlated with the wind field during the period 1986, an appreciable warming was
noticed during 14-15 Mar. 1987 at 200-100 mbar level (12-16 km) which is followed by a period of changes in zonal flow field between 13 and 15 km from 15 to 17 March. However, the cause and effect cannot be determined precisely with the available data.

The comparison of the observations with those of the nearest aerological observatory of IMD which is located at the international airport at Madras is interesting. Though the methodology of using radar for balloon tracking is same, meteorologists prefer constant pressure levels rather than constant height intervals. So the data available are for standard pressure levels namely, 850, 700, 500, 400, 300, 200 and 100 HPA. The analysed winds of Madras for the period 3-17 February are shown in Fig. 8. It can be seen that the features observed over SHAR during the same period are reproduced in Madras wind field also at higher levels. Similar reproduction of features over SHAR in the Madras wind field has also been verified for the period in March 1987, though not shown in this paper.

Hence available upper air data for Madras for the period January-March from 1982 to 1987 were scrutinized. Wind speeds of the order of 50-60 knot have been reported occasionally in all the years except 1984. But speed reaching 80 knot could be seen in 1986 and 1987 only. Thus occurrence of high jet stream wind speeds is not frequent in winter over this low latitude.

The overall synoptic situation at low and higher levels during 1986 and 1987 winter was inspected to see the possible cause of occurrence of such high speed winds. During the data period of January/February...
1986 and March 1987, almost on all days a western disturbance was moving at surface and/or in the lower troposphere along the extreme north Indian latitudes (Punjab and Jammu Kashmir areas). In fact, this is the common feature for winter season. These disturbances induce low pressure or cyclonic circulations in central India. On a few occasions such induced circulations were seen over Gujarat and north Madhya Pradesh. However, during 4-6 February a secondary cyclonic circulation at lower tropospheric levels could be induced as south as over south Madhya Pradesh, Telengana and adjoining areas. This period coincides with the period of the presence of very high speed upper winds over SHAR latitudes in that year (1986).

Nevertheless, in 1987, no such circulation was spotted in the first week of March. However, there was a deep trough of low pressure in the westerly wind field from 300 HPa level (about 9.5 km a.g.l) onwards right down to south peninsular India. Precisely during this period strong winds were witnessed over SHAR latitudes as seen in the time sections. Thus some noticeable synoptic developments could be detected coinciding with the occurrence of jet stream wind speeds over SHAR. The present 2 years’ data may not be sufficient to derive conclusively the details of the synoptic events and the sequence of wind changes. Perhaps a study with the data planned to be collected in the next few years may bring out the synoptic features and the sequence of high speed wind occurrence over SHAR latitude in a clearer manner.

Thus the jet stream wind speeds of the order of 80-90 knot which are quite common during winter in the upper troposphere over north Indian latitudes, can descend to SHAR latitudes. This is a useful information for aviation and space physicists. A period of almost simultaneous changes in zonal and meridional flow occurrences is found to reduce drastically the intensity of the westerlies in the troposphere. The change-over of easterlies to westerlies at low levels occurs between 2 and 5 km during winter months. This status is found to get affected by the strengthening of the westerly regime in the upper troposphere.

The wind shear varied between 5 and 12 m s$^{-1}$km$^{-1}$ at levels above 6 km, while the same was only 2-6 m s$^{-1}$km$^{-1}$ at lower levels. No correlation could be established between the shear values and the wind patterns or the change of direction in winds at any level.

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References