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Six-hourly changes in the lower tropospheric winds over Bombay

A. THIRUVENGADATHAN, C. V. V. S. RAO and S. S. IYER

Regional Meteorological Centre, Bombay

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सार — बम्बइ के ऊपर 3 किलो मीटर की ऊंचाई से नीचे की ऊपरी पवनों में प्रतिः छः घण्टे में होने वाले परिवर्तनों का अध्ययन किया गया है। इसमें 1958–1967, 10 वर्ष के आंकड़ों के आधार पर माध्य ग्रीनविच समयानुसार 00 बजे, 06 बजे, 12 बजे तथा 18 बजे सामान्य मूल्यों का उपयोग किया गया है।

ABSTRACT. Six-hourly changes in the upper winds over Bombay below 3 km have been studied, utilising the normals for 00, 06, 12 and 18 GMT based on the data for the 10-year period, 1958-1967.

1. Introduction

A study of the diurnal variation of upper winds over Bombay is important not only from the theoretical point of view, but also because of its practical utility in the issue of forecasts to the helicopter flights in and around Bombay. The forecast winds would be more realistic, if the forecaster adds vectorially the normal diurnal variation in addition to the expected synoptic changes to the latest available upper winds.

Parthasarathy and Narayanan (1952) studied the problem by comparing the pibal normals of Bombay for the night (0000-0230), morning (0730-0900) and afternoon (1430-1600) IST based on a 5-year period after 1944. The frequency of upper wind measurements over Bombay has increased to four times a day since April 1958, the balloon being tracked by radio means at 00 and 12 GMT and by optical theodolite at 06 and 18 GMT. The data collected for the 10-year period from April 1958 to March 1968 have been utilised in this study. Monthly normals of upper winds have been computed for different months separately for 00, 06, 12 and 18 GMT observations for all standard levels from surface to 3.0 km asl. Except for the 06 and 18 GMT observations during the monsoon season, the ascents generally extended to 3.0 km asl on almost all the days.

From the normals thus computed, the vectorial difference between the normals for the same level and same month, for successive six-hourly periods (*i.e.*, from 00 to 06, 06 to 12, 12 to 18 and 18 to 24 GMT) have been calculated and the meridional and zonal components of the six hourly wind changes worked out. This has been repeated for all standard levels and all the twelve months of the year.

2. Results

2.1. *Meridional components*

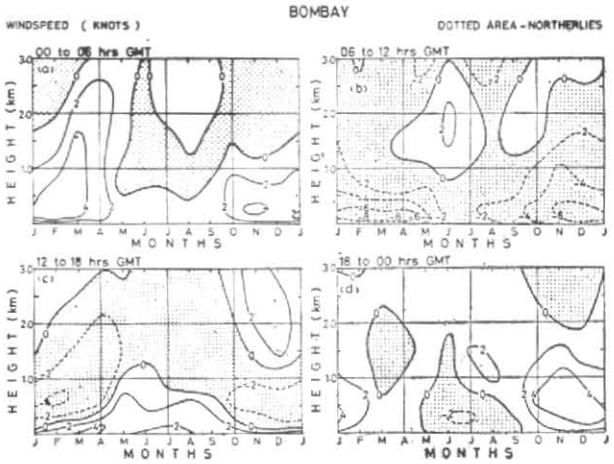
Figs. 1 (a-d) show the variation of the 6-hourly changes in the meridional components of the lower tropospheric winds over Bombay in different months during the periods 00 to 06, 06 to 12, 12 to 18 and 18 to 24 GMT respectively. The salient features noticed are :

(*i*) The 6-hourly changes are generally much less during the monsoon season than in the other seasons.

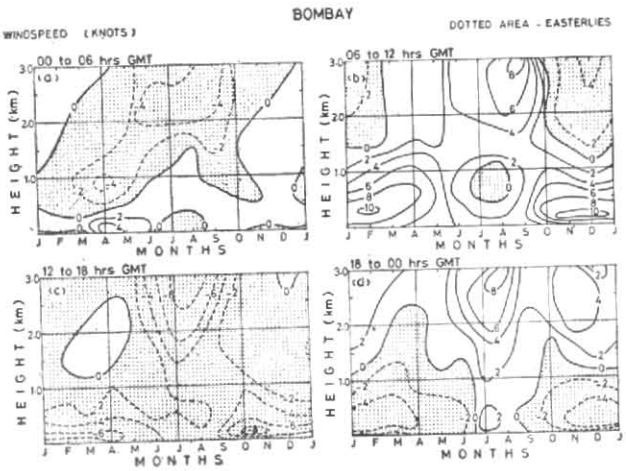
(*ii*) The changes are generally more in the layer below 0.6 km asl and much less above 1.0 to 1.5 km asl.

(*iii*) In the layer below 0.6 km asl, the northerly component increases during the period noon to evening (06 to 12 GMT) and generally southerlies increase during the other periods, the notable exception occurring during the monsoon season, when the northerly components increase from midnight to dawn (18 to 24 GMT).

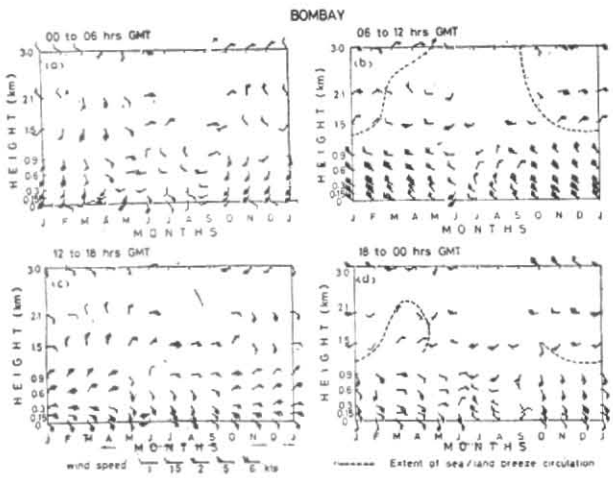
(*iv*) The largest 6-hourly changes are those occurring during the period, 06 to 12 GMT from 0.1 to 0.3 km asl during the months November to April,



Figs. 1(a-d). 6 Hourly changes in meridional winds



Figs. 2(a-d). 6-Hourly changes in zonal winds



Figs. 3(a-d). 6-hourly vectorial changes in upper winds

when northerly components increase by more than 6 knots.

(*v*) The largest 6-hourly increase of southerly components is about 4 to 5 knots in the layer from 0.3 to 0.9 km asl during the period, 18 to 24 GMT, from October to December and in the period, 00 to 06 GMT from January to March.

2.2. *Zonal components*

Figs. 2 (a-d) show the 6-hourly changes in the zonal components of upper winds over Bombay in different months during the periods, 00 to 06, 06 to 12, 12 to 18 and 18 to 24 GMT. The salient features noticed are :

(*i*) The 6-hourly changes above 1.5 km asl are small except during the monsoon season when the westerly components decrease by about 4 to 6 knots from 00 to 06 GMT and by about 4 to 10 knots from 12 to 18 GMT, while they increase by about 4 to 8 knots from 06 to 12 and again from 18 to 24 GMT.

(*ii*) The changes are small during the interval 00 to 06 GMT below 1.5 km asl except from March to May.

(*iii*) During the period, 06 to 12 GMT, westerly components increase by about 6 to 10 knots from surface to about 0.8 km asl during the months, October to April. The changes during the monsoon months are small.

(*iv*) From 12 to 18 GMT, the westerlies generally decrease. Below 0.5 km asl, the 6-hourly fall is about 4 to 6 knots during the months, September to June.

(*v*) Westerlies decrease by about 4 to 5 knots from 18 to 24 GMT during the months, November to March between 0.1 and 0.6 km asl.

2.3. *6-hourly vectorial wind changes*

Figs. 3 (a-d) show the 6-hourly vectorial changes in the winds over Bombay in the lower troposphere in the different months of the year for the periods, 00 to 06, 06 to 12, 12 to 18 and 18 to 24 GMT respectively. The salient features noticed are given below :

(*i*) The vectorial change in the wind direction from 00 to 06 GMT in the lowest layers of the atmosphere (below 1 km asl) is southerly during the months, October to April and the speed is about 5 knots. The wind generally backs from southsouthwesterly at 0.15 km asl to southsoutheasterly at 0.9 km asl. The southerly component extends upto 1.5 km asl from December to February, upto 2.1 km in March and even to 3 km in April and May. Aloft, the vectorial wind change is northnorthwesterly. Vectorial changes are small and variable during the monsoon months.

(*ii*) The vectorial wind change in the lower troposphere from 06 to 12 GMT is generally westnorthwest to northwest and represents the sea-breeze. The maximum change takes place between 0.15 and 0.3 km asl and is about 10 to 15 knots from October to April. This wind-field is weakest during the monsoon season, probably because the main driving force for the sea-breeze circulation, differential heating of the land and sea is small due to overcast skies. The sea-breeze circulation goes upto about 1.3 km asl in January and extends further with the advance of the season, reaching 3 km or more in May. It drops to 1.5 km in October and falls slowly further to about 1.3 km in January. The vectorial wind change is easterly, aloft the sea-breeze circulation (The return-current). The values of the vertical extent of the sea-breeze circulation obtained by Mukherjee and Kundu (1982) are of comparable magnitudes.

(*iii*) The vectorial wind change from 12 to 18 GMT is generally southeasterly to easterly. The layer where the speed is about 5 knots extends from surface to 0.5 km asl during the monsoon months and upto 1.0 km asl during the non-monsoon months. The easterly component may be due to a decrease in the strength of the sea-breeze and/or increase due to setting in of land-breeze. The decrease in solar insolation during the day-time and in nocturnal cooling during the night caused by increased cloudiness during the monsoon season possibly accounts for the lower depth of easterlies during the monsoon months, as compared to the non-monsoon months.

(*iv*) During the period, 18 to 24 GMT, the vectorial wind change is southeasterly in the non-monsoon months and has a maximum of 5 to 8 knots between 0.15 and 0.6 km from November to February. The easterly regime in the vertical which can be considered as the vertical extent of the land-breeze circulation increases from 1.2 km in January to a maximum of 2.1 km in March-April and falls somewhat in May. The decrease in the vertical extent of the land breeze circulation is probably due to the smaller amount of nocturnal cooling in May caused by comparatively more cloudy nights in May than in April. Land breeze circulation is not perceptible during the monsoon season, when the skies are overcast.

3. Conclusions

There is a pronounced diurnal variation of winds in the lower troposphere over Bombay, particularly below 1 km asl during the non-monsoon months. This has to be taken account of in the issue of forecast winds for helicopter flights. The vertical extents of both the sea and land-breeze are maximum in April-May. When the solar insolation is maximum and minimum in the monsoon months due to skies overcast with low clouds leading to decrease in solar insolation.

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