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Winter swells over Bombay High area

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ABSTRACT. The swells over Bombay High area during the winter months are investigated here. Changes in swell heights do occur in winter. Apart from the seasonal high pattern and the passage of western disturbances, the seasonal easterly trough off west coast is also found to be intimately connected in causing the changes in swell parameters.

1. Introduction

Forecasting of the meteorological conditions is an esstential requisite for the off-shore drilling projects the main concern being the 'swells'. The earlier works on swells and waves by Sverdrup and Munk (1947), Phillips (1957) and Kaplan (1953) have been subsequently modified. As far as Indian Seas are concerned Mukherjee *et al.* (1961) could first estimate the waves over Konkan coast due to the cyclonic storm. Dattatri *et al.* (1970, 1971) have also analysed some methods for wave forecasting in west coast of India. Mukherjee *et al.* (*see* Ref.) have recently calculated the maximum swell heights over Bombay High area due to Arabian Sea cyclones. Even in fair weather seasons, changes in swell heights are not uncommon. An analysis of this problem in the light of the prevailing synoptic situations is tried here for winter season (December, January and February).

2. Data and method

Ever since ONGC (Oil and Natural Gas Commission) started the drilling operations in 1973 at Bombay High area 'swell data' are available. The two prominent synoptic features of the season are : (*i*) the seasonal high extending well into north and central India and (*ii*) the passage of western disturbances. Being near the coast, the seasonal easterly trough along off west coast is also linked with the problem. As the preliminary survey has established that the upper air phenomenon in the absence of any allied surface feature does not at all affect the 0300 and 1200 GMT surface charts, all the auxillary charts have been analysed for the synoptic study.

All the western disturbances that passed through India have been taken into account for the purpose of this study. Apart from that any significant change in swell height has also been scrutinised. As December and January are typical months of the season, emphasis is given only on the data of those two months though February data have also been studied. The period considered is December 1973 & 1974 and January and February 1974 & 1975.

3. Discussion

The normal swell height in December is more or less the same as that in November, (*viz.*, 3 to 4 ft) but, by the first week of January an increasing trend is developed, and that height is maintained till the middle of February. But the heights are less than the values during monsoon. In no case during the season the normal value can exceed 5 ft. Nevertheless during February the values at times go beyond 10 ft.

(*i*) *Systems during December* — In 1973 and 1974, during December seven (four in 1973 and three in 1974) western disturbances passed through Indian region. Most of the systems were very feeble and primary systems could not induce any low in lower latitudes. No change was brought about in swell heights during their passage nor the seasonal pattern was changed. Nevertheless two systems came to lower latitudes and their passage affected the swells over Bombay High area.

On 13 December 1973, a western disturbance could be located in western Iran along about 30°N. On 14th and 15th it moved east/northeastwards, though on some charts it could not be located on the surface. A weak trend of decrease in pressure gradient could be observed along the west coast.

The low level associated circulations and the corresponding stream lines were such that on 15th a

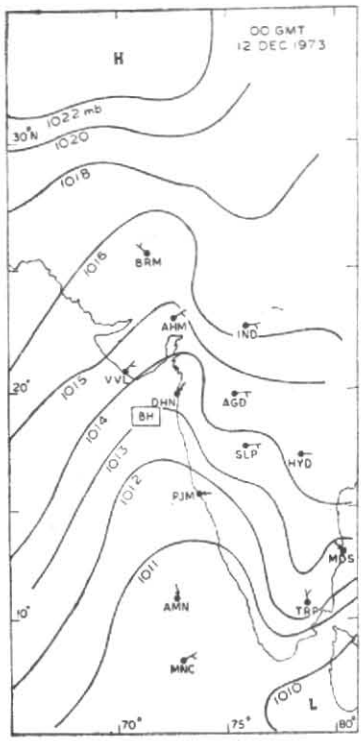

Fig. 1

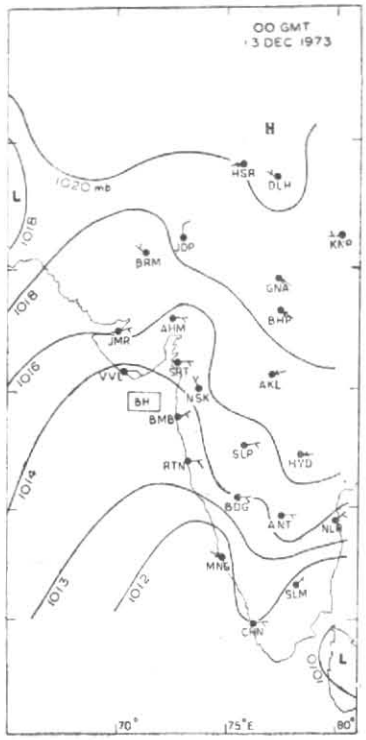

Fig. 2

col region could come over Bombay High/Saurashtra coastal region. In fact the 0000 GMT chart of 15th showed the position of low along Long. 70°E and also along about Lat. 28°N. The Bombay High area was just on the edge of easterly trough on 15th. The swell height was only 2-3 ft on 14th, 15th and 16th. On 16th this low subsequently became a western depression. On 16th/17th it moved away rapidly eastnortheastwards across the hills of west Uttar Pradesh. This resulted in sudden increase of the pressure gradient of the easterly trough and the alignment of isobars to become seasonal. This sudden change increased the swell height to 6-8 ft on 17th which became 4-6 ft on 18th and subsequently became normal. Fig. 1 gives the pressure pattern on 12 December 1973 which is normal. Fig. 2 gives the pattern of 13 December 1973 when the approach of the system created a decreasing trend in pressure gradient over the area. Fig. 3 gives the pattern on 16 December 1973 when the system has just crossed the longitude of Bombay High area. The isobars tend to reorient in this area and Fig. 4 gives the pattern on 17 December 1973 wherein the increased pressure gradient due to the rapid passage of the system can be seen.

On 14 December 1974 a low was located in south Pakistan along about Long. 70°E. This resulted in pushing down the seasonal easterly trough off west coast, well south of Lat. 15°N. Winter swell height went down below 3 ft on 14th. The low subsequently moved over to Punjab on 15th. Another induced system was noticed to be forming in central Rajasthan. The swell height fell and did not rise though the easterly trough crossed the Lat. 15°N. On 16th the induced low became prominent around about Lat. 26°N, Long. 74°E. The movement of this system was steady and on 17th it could be located in northwest Madhya Pradesh. But on 18th it gradually became unimportant. This resulted in the extension of easterly west coast trough upto Lat. 26°N. The swell height accordingly rose to 4-6 ft. The height was maintained on 19th and 20th also. No new system was found to be approaching the Indian region at lower latitudes during this period.

(*ii*) *Systems during January*—Eleven cases of western disturbances during 1974-1975 have been studied. Four western disturbances in 1974 and two in 1975 moved along or north of Lat. 30°N and so no change was brought about in swell heights at the Bombay High area. The seasonal pattern was prominent till 10 January 1974 as no western disturbances could be traced at the surface level. But on 11th a western disturbance could be located at the surface level in Pakistan around about Lat. 27°N, Long. 70°E. However, the seasonal high pattern was not disrupted upto

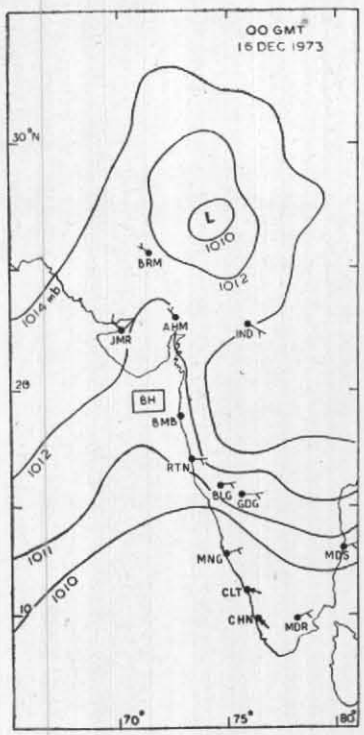

Fig. 3

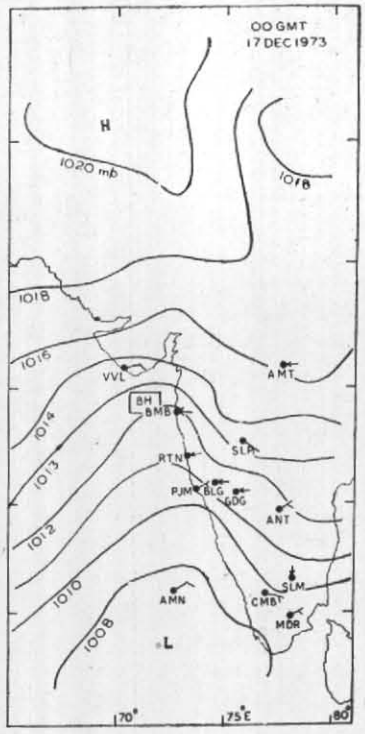

Fig. 4

Long. 65°E and the Bombay High area was just at the border of the seasonal easterly trough. The arrival of western disturbances thus did not bring about any change of pressure gradient and hence the change in swell heights. The movement was steady eastnortheastwards. The seasonal easterly trough gradually shifted southwards to Lat. 15°N. By 14 January 1974 the system had moved to Uttar Pradesh and adjoining areas. The Bombay High area was covered by the isobaric pattern from the 'High' of the Arabian side. But on 15 January 1974 the system became unimportant and the easterly trough started moving north. This resulted in a small increase in the swell height (5-7 ft) on 16 January 1974.

On 23 and 24 January 1974, a western disturbance was seen over Arabia moving northeastwards. On 25th, this system induced a low around Lat. 25°N, Long. 70°E. This caused the movement of the west coast easterly trough below Bombay High area. On 26th, the system moved northeastwards and on 27th it moved rapidly to Uttar Pradesh. The swell height never showed any appreciable fall, as there was no approach of the system on 24th/25th at lower latitudes. However, the swell height increased to 6-8 ft on 26th and 27th. The area which was under the influence of the system on 25th, was not covered by easterly trough regime on 26th or 27th. However the elongations from the Arabian High covered Bombay High region with the system to the northeast of it. Yet on 28th, with the system moving away across the Himalayas, the easterly trough came up and covered the region. In fact, an appreciable height increase to 8-10 ft was observed on 28 January 1974. Subsequently the value became normal.

Another western disturbance was noticeable on 30 December 1974 surface chart which induced a low near about Lat. 25°N, Long. 70°E. The associated circulation was, however, not strong. Perhaps due to this, the seasonal trough in easterly could still cover the Bombay High region. On 31 December/1 January the movement was rapid northeastwards. Though no reduction in swell height could be observed on any day, on 1 January 1975 the height was 6-9 ft which subsequently became normal.

On 14 January 1975, a western disturbance could be noticed but the induced low could only be located, on 15 January 1975. As the system could be well within Indian region, the seasonal high from northwest was not at all affected and the pattern was seasonal to the west of Long. 70°E. On 16th, it moved away to about Long. 78°E. The seasonal trough just covered Bombay High region on 15th. Only a moderate perturbation could come so that the swell height was observed as 5-7 ft on 16th. When the easterly trough extended northwards on other days, it was normal.

On 19 January 1975, a western disturbance was apparently lying in Pakistan around Lat. 30°N, Long. 68°E. This became marked in north Pakistan, on 20th with its induced low in southwest Rajasthan, near Lat. 25°N, Long. 72°E. On 21st, the seasonal easterly trough was found to be pushed down. The associated low level upper air circulation showed a col region above Bombay High-Saurashtra region. The swell height went down to below 3 ft on that day. The movement of system was slow and on 22nd it was near Lat. 25°N, Long. 72°E. On 23rd also it could be located ever central Madhya Pradesh and ajoining places with the passage of another system northeastwards towards Jammu, the seasonal northwest high pattern was also disturbed till 24th. On 25th only the swell height became normal with the easterly trough covering Bombay High area.

On 30 January 1975, a western distrubance was seen to the north of Lat. 30°N but an induced low appeared near about Lat. 25°N, Long. 74° E with the associated circulation extending upto 1·5 km a. s. l. only on 31st. Next day it has extended over central India. This has not affected the easterly trough pattern though the northwesterly high pattern was disturbed. No change in the swell height was observed on any day during the passage of this system.

(*iii*) *February systems* — The changes in the swell heights were very high, if brought about in this month. However, the passage of western disturbance does not seem to be so intimately linked with them. A western depression in 1975 has not brought about any change. Similarly, in 1974, a western disturbance moved along Lat. 27°N in later part of the first week, but the swell height remained practically constant. Instead during 7-9 February 1974 and 20-23 February 1975 appreciable peak values of swell heights have been recorded while no western disturbances have passed through India below Lat. 30°N. No apparent reason could be found.

4. Conclusions

During the fair weather (winter) season, changes in swell heights occur over Bombay High area. The passage of the western disturbance has a great part to play in causing this. The three factors to be considered in swell change forecast at Bombay High area during the winter months are : (*i*) the easterly trough along west coast, (*ii*) the seasonal high pattern from northwest and (*iii*) the passage of western disturbance at lower latitudes, *i.e.*, south of Lat. 27°N. The approach of the system has a tendency to reduce the pressure gradient along west coast and at the same time affecting the seasonal high pattern. As a result, the swell height over Bombay High area falls. On some occasions, the low level stream line pattern also has a tendency to show a col region over Bombay High/Saurashtra. With the passage of the system to the east and/or weakening further of the system the easterly trough tries to occupy the normal position and the increase in pressure gradient results in the increase of swell heights immediately after the passage. This could persist for two days. At this stage the *rapid movement* seems to be an essential criterion. The intensity of the system also plays a part in causing the changes. In December the sequence of changes is more systematic. In January, sometimes the low gradually spreads to the east of the longitude of Bombay High in which case rapid extension northwards of the trough does not occur, and the decreased swell height merely comes to normal. On occasions when the induced low could first be located just near about Bombay High longitude, only the increase in swell height in the rear of western disturbance could be observed. Thus forecast of swell height during January is comparatively difficult.

In February also, changes in swell heights do occur and the change is abrupt and more. But the passage of western disturbance does not seem to bring about these changes. Perhaps a study with more data which may be possible in future, can reveal the mechanism in a clearer manner.

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