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Looping tropical cyclones over Indian seas

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सार — भारतीय सागरों पर उष्णकटिबंधीय चक्रवातों का जलवायु विज्ञान संबंधी अध्ययन किया गया है और इस शोध पत्र में विशिष्ट लक्षणों को प्रस्तुत किया गया है।

ABSTRACT. A climatological study of the looping tropical cyclone over Indian seas is made and characteristic features are presented in this paper.

1. Introduction

A typical movement is, operationally speaking, the most difficult aspect of tropical cyclone forecasting which the warning centres have to deal with. Since most of the movement forecast techniques depend to a large extent on climatology, a typical motion often throws the projected time frame completely out of gear, even when they do not disturb the projected landfall point to any significant extent. It is for this reason that there is such a tremendous need to understand the causes of all such unusual movement. Unexpected and quick change in direction and sudden slowing down or speeding up are the most common of such movement aberrations. This article is about the most uncommon atypicality of tropical cyclone motion over Indian seas, namely, "looping" motion.

2. Climatology of looping storms over Indian seas

"Loops" appear to be rather rare in the tropical cyclone tracks in Indian seas as compared to other basins (Gray 1981). In fact in the storm tracks for the years from 1877 to 1970 there is not a single occasion where a "loop" has been executed, *i.e.*, when the storm has come back to the same point of its track after moving away from that point. The first incidence of "looping" appears in the tracks of 1972 in which year there were two occasions of looping, one each in Bay of Bengal and Arabian Sea, around the same time in the month of November. Thereafter there was one "looping" incident each over the sea in the years 1975, 1976, 1977 and 1979. Fig. 1 gives the tracks of these looping cyclones. There were also two more loops, one each in the years 1939 (July) and 1940 (September), but these were over land and the systems were not tropical cyclones and the season was well within the monsoon. What follows is a description of the tracks of these tropical storms which executed loops over sea and the upper air flows associated with them. The tracks upto 1970 are taken from *Tracks of Storms and Depressions* (IMD 1979) and subsequent tracks upto 1984 are taken from the reports of the ACR meetings.

Table 1 gives some details about these looping storm during the period from 1877 to 1984.

3. Looping storm and their associated flow patterns

3.1. *Severe cyclonic storm of* 15-23 *November* 1972

This system made a clockwise loop in its track during 19-21 November. During 18th to 19th 12GMT, the storm was under influence of an anticyclone in the upper troposphere over Thailand-Indochina area and it moved in a northwesterly direction. But, subsequently there was another anticyclone over north Andhra Pradesh and adjoining Bay area which persisted from 20th till it crossed coast. Fig. 2 gives the 300 and 200 mb flow patterns of 19th (looping begins) and 21st (looping ends), with the surface position of the centre of the system together with the subsequent direction of motion marked on the charts. During the period upto 21 November, the system was in the col zone and was under the influence of variable wind field till it came completely under influence of the upper tropospheric anticyclone over Bay on 22nd.

3.2. *Bay of Bengal severe cyclonic storm of* 24 *November to* 1 *December* 1975

This system made a clockwise loop during the period 29 November to 1 December 1975. From 24th to 28th the system was under the steering influence of the mid and upper air anticyclone extending from Indo-China area to Bay of Bengal with its western limb around 80 °E and the ridge axis running roughly along 13°N.

On 29th, it could be seen that instead of one large extended anticyclone, there were two mid-tropospheric anticyclones, one confining to Thailand-Indochina area and another over extending from Arabian Sea to west central Bay.

This situation persisted till 30th morning when the system was under the steering influence of the latter anticyclone and started moving across the eastern limits of the anticyclone resulting in initial eastnortheast movement, changing to southward movement and subsequent

TABLE 1

Some details of looping cyclonic storms

S. No.	Storm period	Place of crossing	Looping period	Intensity changes while looping	Direction of looping	Maximum looping diameter (°)	Mean Lat. of looping (°N)
			Bay of Bengal				
1	15-23 Nov 1972 severe cyclone	Near Sriharikota on 22 Nov	19-21 Nov	No change (Perhaps weakened)	Clockwise	1½°	13.5°
2	24 Nov-1 Dec 1975 severe cyclone	Came close to Madras but later died over sea after looping	29 Nov-1 Dec	Weakened	Do.	2°	15°
3	29 Dec 1976-3 Jan 1977 severe cyclone	Came close to Bay as low on 31 Dec. Weakened thereafter over Bay	31 Dec-1 Jan	Do.	Do.	1½°	12°
4	5-13 May 1979 severe cyclone	Near Ongole, Andhra Pradesh on 13 May	8 May (Less than a day)	Intensified	Anticlockwise	1½°	6°
			Arabian Sea				
5	13-20 Nov 1972 Deep depression	Weakened over Arabian Sea and moved away westwards	15-17 Nov	Weakened	Clockwise	2°	13½°
6	27 Aug-8 Sep 1976 cyclonic storm	Emerged from land to Arabian Sea and moved away westwards	1-6 Sep	Intensified	Anticlockwise	5½°	22°
7	12-23 Nov 1977 severe cyclone	Between Honavar and Mangalore on 21st	14-21 Nov	Do.	Do.	8°	12°

westward movement. Later on, by the evening of 30th, there was again only a single anticyclone extending from Indo-China area to Bay of Bengal—which resulted in a northwesterly movement thereby the track executing a loop. Fig. 3 gives the sequence of 300 mb flow patterns during 28 November to 1 December together with surface centre and direction of motion, explaining the looping in its track.

3.3. *Bay of Bengal severe cyclonic storm of* 28 *December* 1976 *to* 3 *January* 1977

This system made a clockwise loop in its track on 31 December 1976 to 1 January 1977. From 30th morning to 31 December the system was under the influence of the southwesterly mid and upper level anticyclonic flow with ridge line to the south of the storm centre. By 1 January there was a passage of a trough in the westerlies in the mid-tropospheric levels. The system moved south with the trough to its northeast. Subsequently by 2nd morning the trough had moved away eastwards and the mid and high level anticyclone also shifted northwards on 2 January. The cyclone came under the influence of easterlies to move westwards and thereby closes the loop. Fig. 4 gives the 500 mb flow patterns on 31 December and 1 and 2 January 1977 explaining the loop, with surface position and movement also marked on them.

3.4. *Bay of Bengal severe cyclonic storm of* 5 *to* 13 *May* 1979

The system executed an anticlockwise loop on 8 May, attained hurricane intensity, the looping period lasting for less than a day (about 18 hours). From 00 to 12 GMT of 6th a strong mid-tropospheric anticyclone extended westward of the system along 15°N with southeast flow dominating the upper air. At the time, a short wave easterly trough evident both at middle and upper levels deepened and the system fell in the col zone of light variable wind.

Also during the same time, another cyclone was located in the southern Indian Ocean about 1400 km to the southwest of this cyclone. The intensity of these two systems were identical on 5th to 7th but subsequently the Bay of Bengal system became well organised while the southern hemispheric system began moving slowly to the southeast, weakened and later dissipated. The presence of the other vortex also possibly initiated a Fujiwhara type interaction contributing to the erratic motion of the concerned system.

3.5. *Arabian Sea deep depression of* 13-21 *November* 1972

The depression made a clockwise loop in its track during 15 to 17 November 1972. Fig. 5 gives the 300 mb flow patterns on 14th (before looping), 16th (while looping) and 17th (after looping) together with surface cyclone position and direction of movement.

However, it may be relevant to mention that in the absence of data in the Arabian Sea and its adjoining land areas to the west, the above flow pattern could be taken as the only probable ones, mainly supported by the observational changes over the Indian land areas to the east of the system. It is seen that from 13 to 15 November, the system was under the influence of the middle

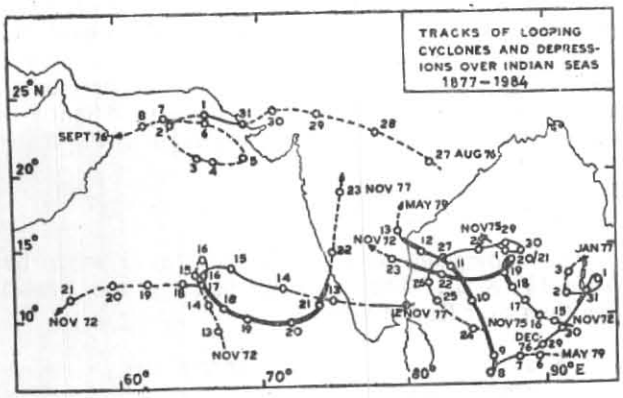

Fig. 1. Tracks of looping cyclones

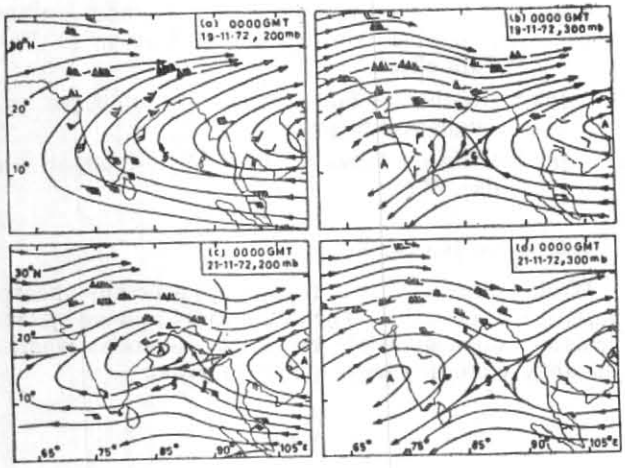

Fig. 2. 300 and 200 mb flow patterns

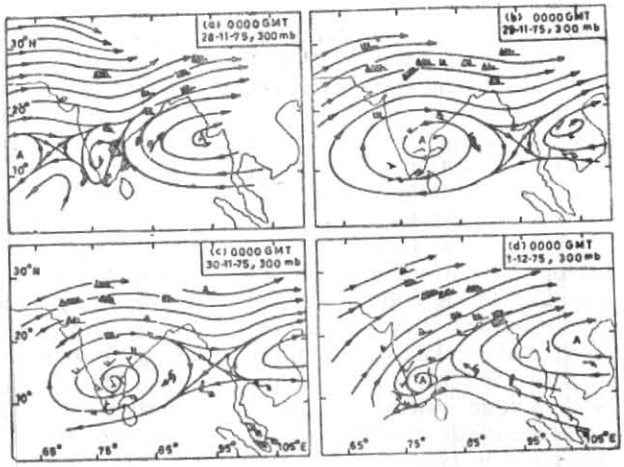

Fig. 3. Flow patterns at 300 mb

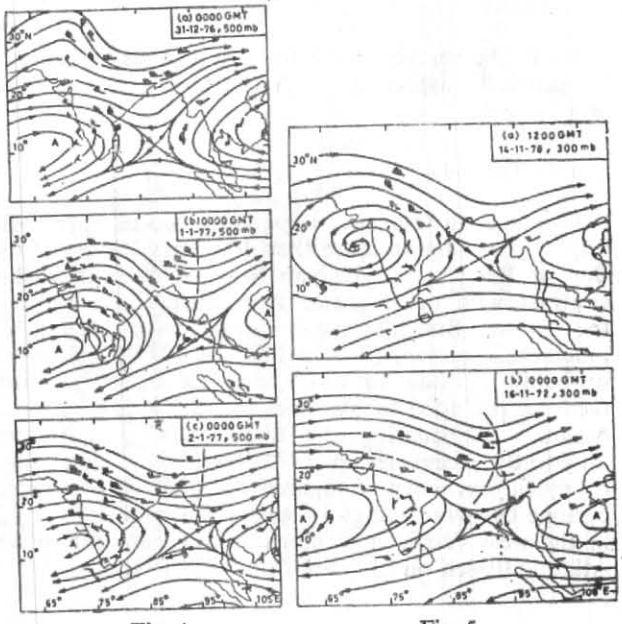

Fig. 4 Fig. 5

Figs. 4 & 5. Flow patterns at 300 mb

and upper tropospheric anticyclones extending over Peninsular India and adjoining sea areas with ridge line running roughly along 17 °N. The system was to the south of the anticyclone and moved along its western periphery, resulting in a northwesterly direction. Then on 16th, the mid/upper level anticyclones over Peninsula and adjoining Arabian Sea area shifted southwards with the axis running roughly along 13 °N which also became much more elongated with the western limb shifting much to the west and the system, therefore, coming under the steering influence of the eastern periphery. The above changes in the mid and upper level flow patterns thus, steered the system resulting in the looping motion.

3.6. *Arabian Sea cyclonic storm of* 27 *August*-8 *September* 1976

This system made an elongated anticlockwise loop into the track during the period 1-6 September 1976 depression. Available data do not reveal any significant feature which could be associated with the unusual track of the system over north Arabian Sea.

However, this disturbance is essentially a southwest monsoon depression which attained cyclone intensity only for a day but otherwise remained as a depression throughout and even while looping.

3.7. *Arabian Sea severe cyclonic storm of* 13-23 *November* 1977

This severe cyclonic storm was the remnant of the Bay severe cyclone which crossed Tamil Nadu coast near Nagapattinam on 12 November. After weakening, it moved westwards across the south Peninsula and emerged into Arabian Sea as a deep depression on 13 November.

Simultaneously, with this storm there was another severe cyclone over Bay of Bengal also. Both these storms came within 1500 km of each other on 16th

which resulted in the change of the tracks of both the cyclones from 16th to 19th due to Fujiwhara effect. While the Arabian Sea severe cyclone executed a counter-clockwise loop, the Bay cyclone, the killer Andhra cyclone changed its course abruptly, from westnorth-westerly direction to more northerly direction. The interaction between these two vortices has already been studied in detail (Balasubramaniam and Jayanthi 1982). It was showed that the two storms turned cyclonically around each other with a common point of gyration during 16th to 19th, the Bay cyclone crossing Andhra coast on 19th. When the Bay system crossed coast and weakened, its influence on the system over Arabian Sea also weakened. Later on, the Arabian Sea cyclone started moving northeastwards under influence of the middle level anticyclone over Bay and adjoining areas.

4. Conclusion

From the foregoing the following characteristics can be generally associated with the looping storms over Indian seas.

4.1. *Frequency*

Looping storms are apparently quite rare being only 7 in number in more than 100 years history of over Bay of Bengal and Arabian Sea. This is in striking contrast with other major tropical cyclone basins of tne globe. But all these storms have occurred in nineteen seventies (during 1972 to 1979). This may probably be due to availability of better detection facilities provided by satellites to track storms over the ocean. Considering the above frequency pertains only to the recent period 1972-1984, still it appears to be much less when compared to other major tropical cyclone basins of the globe where it is about 4 per year in the west Pacific and more than 1 per year in west Atlantic (based on 21 years data 1957-1977).

4.2. *Direction of looping*

There are equal number of clockwise and anticlock-wise looping cyclones over Indian seas as is the case in the Atlantic where also clockwise and counter-clockwise loops have similar frequency while in the Pacific counter-clockwise movements are more frequent than the clockwise (Gray 1981).

4.3. *Duration of looping*

Looping over Indian seas can take anywhere from less than a day (in case of May '79 cyclone) to more than 7 days (as is the case of Honavar cyclone of November 1977). As in the Pacific the mean looping period over Indian seas is about 2 days only while in Atlantic the looping periods are longer, the mean being 4 to 5 days (Gray 1981).

4.4. *Looping diameter*

The looping diameter in degrees latitude range between $1\frac{1}{2}°$ & 8°. The loops are larger in the Arabian Sea than over Bay of Bengal.

4.5. *Broad scale circulation patterns associated with looping storms*

The looping motions, as expected, relate closely to the large scale environmental flow fields in which the cyclones are embedded.

The looping motion is mostly associated with one or more of the following causes :

(*a*) Proximity of a neighbouring cyclone resulting in double vortex motion known as Fujiwhara effect;

(*b*) Strength and latitudinal extent of upper level troughs and ridges;

(*c*) Interaction between the mid and upper level ridges & troughs.

4.6. *Intensity changes*

While executing a loop, the systems generally undergo variation in intensity. The cyclonically moving systems generally intensify while executing the loops whereas the anticyclonically looping system weaken.

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