Validation of INSAT derived Cloud Motion Vectors (CMVs) and their use for improving the analysis of synoptic scale weather systems.

by

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ABSTRACT

Extensive validation exercise done recently for INSAT derived CMVs has shown that their quality is good. These are found to be comparable with radiosonde winds and the winds reported in the Aircraft reports (AIREP). Direction and speed of the CMVs derived in the Southern Hemisphere has been validated using the Satellite pictures showing the movement of Extra tropical cyclones. CMVs very well reflect the position of these migratory systems.

INSAT derived CMVs are being used operationally for analysis of synoptic scale weather systems. These have been found to be extremely useful for improving the analysis of synoptic charts. Particularly in the vast oceanic areas to the South of India which are data gap regions for conventional meteorological data. CMVs are found to be very useful for locating the position of anticyclones, upper air troughs and ridges. The analysis of Extra tropical systems of the Southern Hemisphere is also improved by using CMV data. Sometimes it is found that the low level circulations and the waves in the Easterlies are also brought out in the CMVs, thereby improving the synoptic scale analysis.

1. Introduction:

Derivation of Cloud Motion Vectors (CMVs) was started on an operational basis by the India Meteorological Department in 1984 using INSAT-l VHRR data processed at Meteorological Data Utilisation Center (MDUC) established during 1982 under INSAT-l programme. CMVs were derived only once a day at 06 hrs UTC with two consecutive half hourly visible images using automatic techniques (Kelkar et al 1986 and Kelkar et al, 1992). Coverage area was restricted to Bay of Bengal, Arabian Sea and a very limited Indian Ocean area. A few useful studies (Yadav et al,

1990 and Sant Prasad et al, 1990) were done with the INSAT derived CKVs. They were also disseminated on the GTS for International utilisation. Kelkar et al (1987) have also studied the spatial and temporal homogeneity in a half hourly sequence of satellite derived upper winds. With the upgradation of MDUC to the new INSAT Meteorological Data Processing System (IMDPS) in September, 1992 under the INSAT-II programme, computation of improved quality CMVs was started operationally covering a much larger area of the Indian Ocean. Speed of computations of CHVs was also improved considerably and they were derived twice daily at 00 and 12 hours UTC using three consecutive half hourly IR images of improved resolution data (8 km) transmitted by the new INSAT-2 satellite series. Detailed methodology for CMV computations with IMDPS, alongwith the preliminary validation results, were presented during the 2nd International wind workshop held in Tokyo during 1993 (Kelkar et. al 1993). It was reported that the general quality of INSAT derived CMVs is good.

2. Quality of INSAT derived CMVs:-

Based on the validation exercise undertaken during 1993 for INSAT derived winds, it was found (Kelkar et al. 1993) that INSAT derived CHVs compare well with the Japanese GMS derived winds within the overlapping coverage area of the two satellites. Upper level winds derived with INSAT were also found (Kelkar et al. 1993) to compare well with the winds reported in the AIREP reports received over the routes generally covered by various aircrafts.

Further qualitative evaluation of CMVs over large oceanic areas on a few occasions was also done by examining whether the derived CHVs bring out the large scale flow patterns in the lower and upper levels. It was found that CMV data is a useful addition to the synoptic analysis charts as the flow patterns brought out in the CMVs usually conform to the satellite pictures taken at the corresponding times. It was also found that the upper and lower level flow patterns over the oceanic areas affected by a Tropical disturbance are well brought out in the INSAT derived CMVs. Regular operational use of CMVs was therefore started from middle of 1994 at Meteorological Office, Safdarjung, New Delhi which has also the responsibility of issuing local forecast for Delhi and adjoining areas.

3. Use of CMVs for improving Synoptic analysis:

INSAT derived CMVs were plotted daily on the synoptic upper air charts along with the conventional upper air data. Over the data sparse oceanic areas INSAT-CMVs are the only source of upper air data. Over the land areas they provide additional data to supplement the conventional observations. They generally fit the synoptic analysis charts very well. During the last two years a number of instances have been found when CMVs have proved to the useful in improving the synoptic analysis.

On many occasions it is found that the CMVs bring out the synoptic scale flow patterns and they are in general agreement with the analysed charts; thus proving their validity in qualitative terms. Details of a few specific cases where this

data has proved to be useful on operational basis by the synoptic analysts are given below. Some specific cases where INSAT derived CMVs are further validated in qualitative terms are also presented.

3.1 Case-1: (26-27 July, 95)

On 26 July, 95 (00 hrs UTC) a well marked low pressure area lay over southwest Rajasthan and neighbourhood. It was moving in its normal track in a west-north westerly direction. Very good rainfall activity was associated with this system almost over the entire peninsular India and central parts of India. However, over extreme north-west parts of the country there was no rainfall. With further northwest ward movement of the system some rainfall activity was seen in North Western parts also. On this day a trough in westerlies (Fig.1b) was also anticipated with meagre conventional data which was indicative of recurvature of the well marked low pressure area. However, after merger of conventional and CMV data (Fig.1a) of middle level (500 hpa), the trough line could be marked very clearly thereby indicating beyound doubt the movement of low pressure area towards north east. It was therefore anticipated that very heavy rainfall activity will occur over Western Himalayas and adjoining plains and a forecast was given for the same. Actual data received after 24 hrs indicated that the forecast was correctly issued.

On this day 12 hour UTC data, both conventional and CMVs, was insufficient to locate the position of trough precisely. However, on the next day (27th July 1995) again middle level CMVs were extremely helpful in precisely marking the trough position. This had, in turn, helped predicting the movement of low pressure area to Punjab and neighbourhood and associated heavy rainfall activity. Middle level CMVs were found to be extremely useful by the operational forecaster in issuing the heavy rainfall warnings. Relevant upper air charts with and without CMVs are shown in Figs. 2a and 2b.

3.2 Case-2: (19 April, 96)

Upper air analysis charts of 19 April 96 (00Z) showed very meagre conventional data at 500 hpa level. Even though there was some indication (Fig.3b) of a westerly trough, it was difficult to mark it precisely on the charts. But the merger of middle level CMVs and the conventional data (Fig.3a) clearly brought out a northwest-South East tilting very deep trough in westerlies with a blocking high over north west India. It was not possible to make even the blocking high with the meagre conventional data. On the some chart with the availability of middle level CMVs over Bay of Bengal showing easterly and South Easterly winds, the Seasonal anticyclone over this area could be marked with more confidence. In this case CMVs have helped to improve the analysis of Synoptic Charts over the data sparse regions.

3.3 Case-3: (20 April, 96):

An upper air cyclonic circulation lay on 20 April, 96

over Haryana and adjoining Punjab and Rajasthan. It was extremely difficult to mark the extent of this circulation due to paucity of data from Pakistan (Fig.4b). The low level CMVs however clearly indicated a circulation over larger area covering central parts of Pakistan and north Rajasthan. Northwesterly winds further to the west as revealed in the CMVs, clearly brought out the prevailing low level flow pattern. This is another case where CMVs have helped improving the analysis of synoptic charts.

3.4 Case-4: (25 Feb., 96):

On 25 Feb, 96 (00 UTC) an upper air cyclonic circulation lay over northwest Rajasthan and neighbourhood. Due to meagre conventional data (Fig.5b) its center was marked with difficulty and with practically little confidence. The additional data provided by the CMVs helped to mark the centre of the system very clearly. It is seen that the centre could be clearly brought out (Fig.5a) in CMVs data, even without plotting conventional data on the charts. In the same chart, availability of CMV data over Arabian Sea has helped to mark very clearly the position of anticyclone over Saudi Arabia. Analysis of such systems over this area is based mainly on climatology due to insufficient conventional data.

3.5 Case-5: (14 May, 96)

This is another case showing improved synoptic analysis over data sparse areas of Arabian Sea, Saudi Arabia, Tibet and Burma. Availability of a few CMVs has helped in clearly marking the position of anticyclone over Arabian Sea and Saudi Arabia. CMVs have also helped to clearly bring out the flow patterns over Tibet and Burma.This would not have been possible based only on conventional data.

3.6 Case-6: (2 July, 95)

In this case availability of low level CMVs over Indian Ocean and Arabian Sea has helped to mark clearly the cross-equational flow which is an important feature of the Southwest-monsoon season. Conventional data (850 mb) over the West Coast of India on 2 July, 95(Fig.6b) shows north westerly flow. In the absence of conventional data from oceanic areas around India analysis of upper-air charts has to be based primarily on the normal climatological data. However, the additional CMVs data on this day clearly shows the cross-equational flow becoming South Westerly in Arabian Sea and Westerly close to the West Coast of India. Precise Analysis of weather charts bringing out important features of monsoon flow is thus possible with CMVs data (Fig.6a).

3.7 Case-7: (9 February, 96)

An upper air cyclonic circulation lay on 9 Feb, 96 (00 UTC) over Northwest Rajasthan and adjoining central Pakistan. It was difficult to mark the centre of this circulation with the conventional data due to insufficient data from Pakistan. With the availability of a few CMVs, however, its centre became guite

clear on the synoptic charts. Rather it was possible to mark the centre only with the help of CMVs. The anticyclone over Saudi Arabia could also be marked very clearly because of availability of CMVs in Arabian Sea.

4. Conclusions:

INSAT derived Cloud Motion Vectors are very useful for improving the Synoptic analysis, especially when conventional data is not available. Over the vast oceanic areas around India where conventional data are not available, CMVs are of vital importance to bring out the prevailing flow patterns in the upper air charts. Improved analysis of charts is very much helpful for predicting the weather more precisely. Such improved analysis plays a very important role in providing better aviation meteorological services also. Important features such as subtropical highs, cyclonic circulations, Cross-equatorial flow, troughs in the upper air etc. are better delineated with the help of CMV data.

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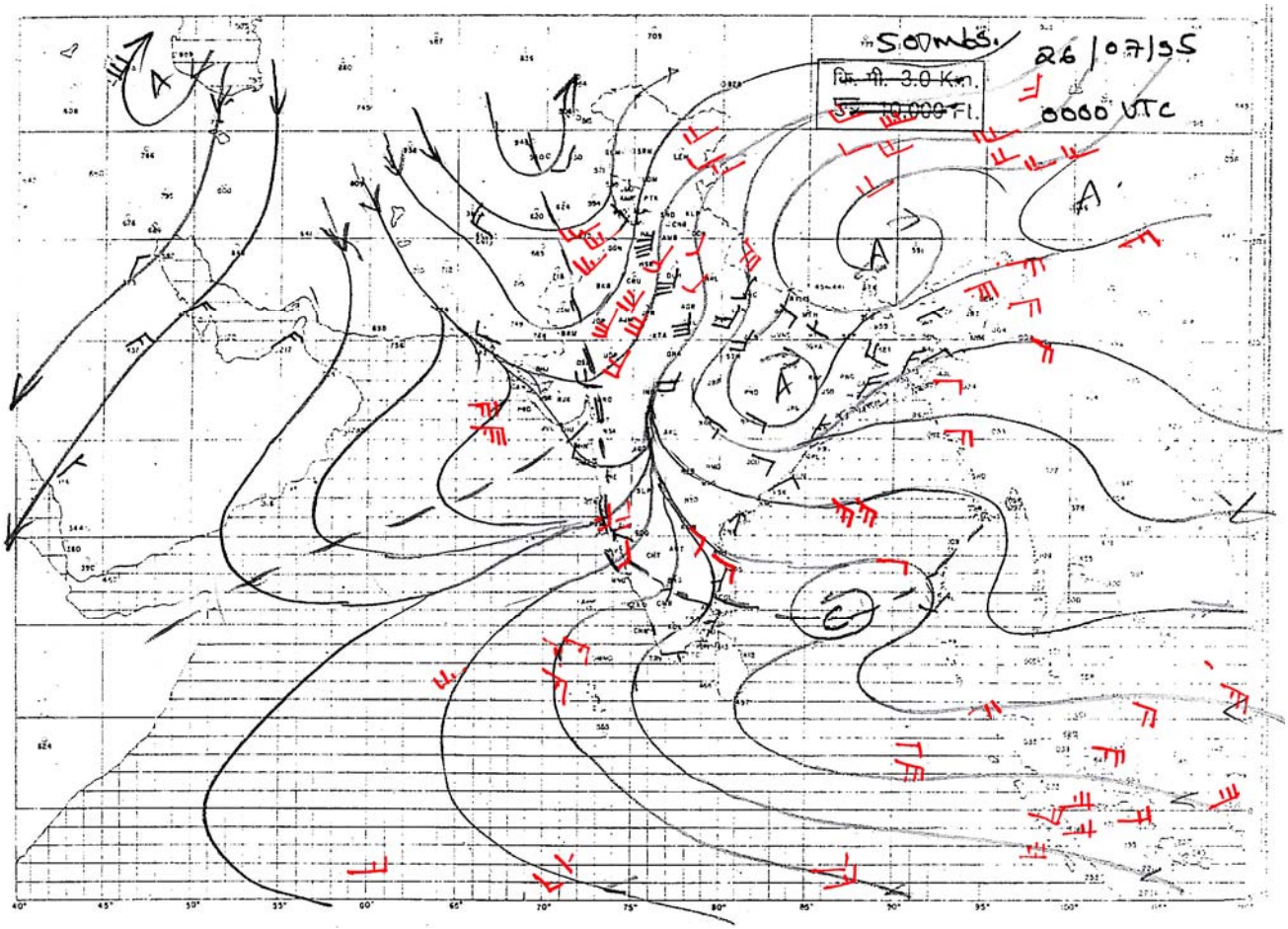

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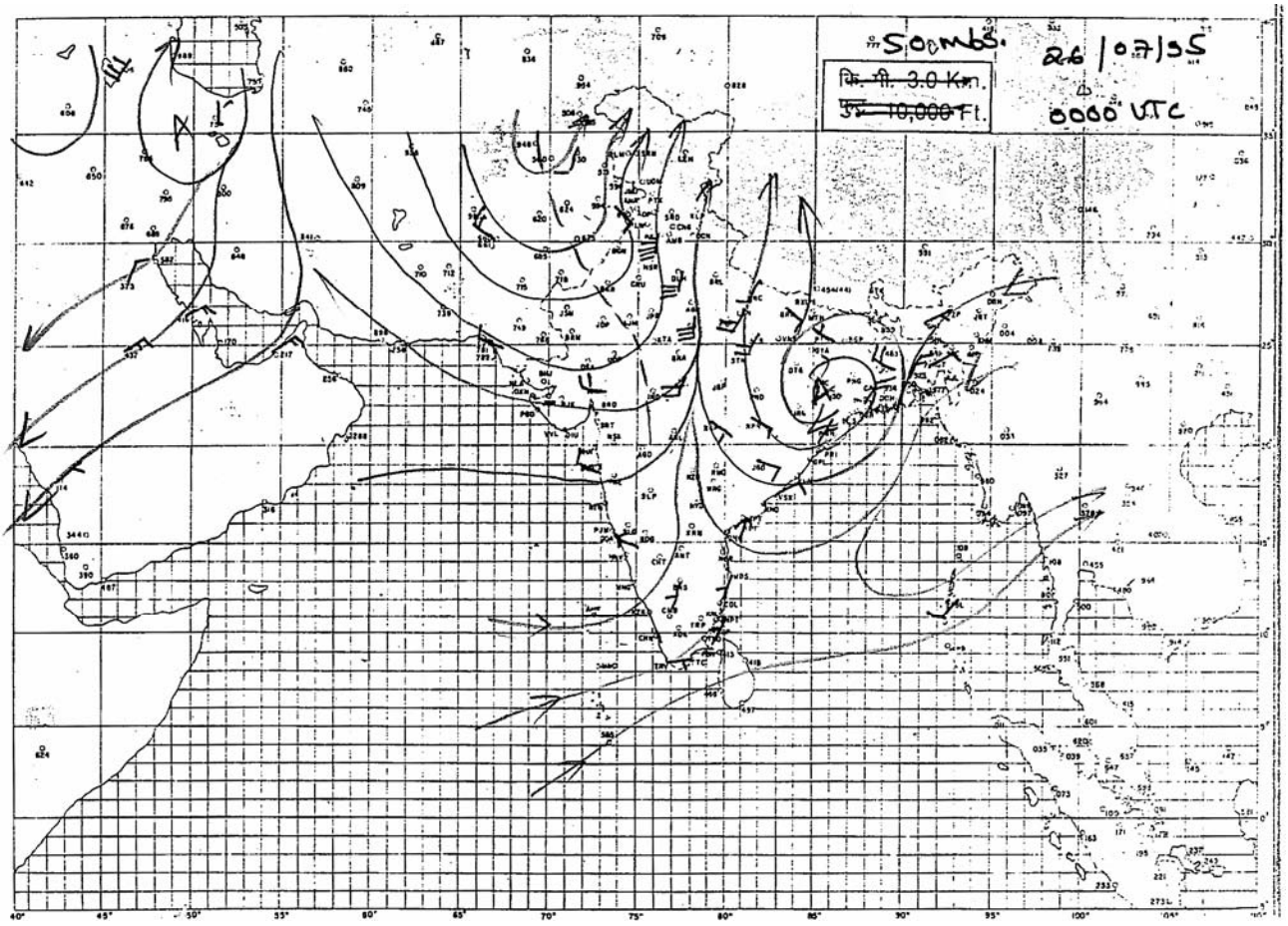

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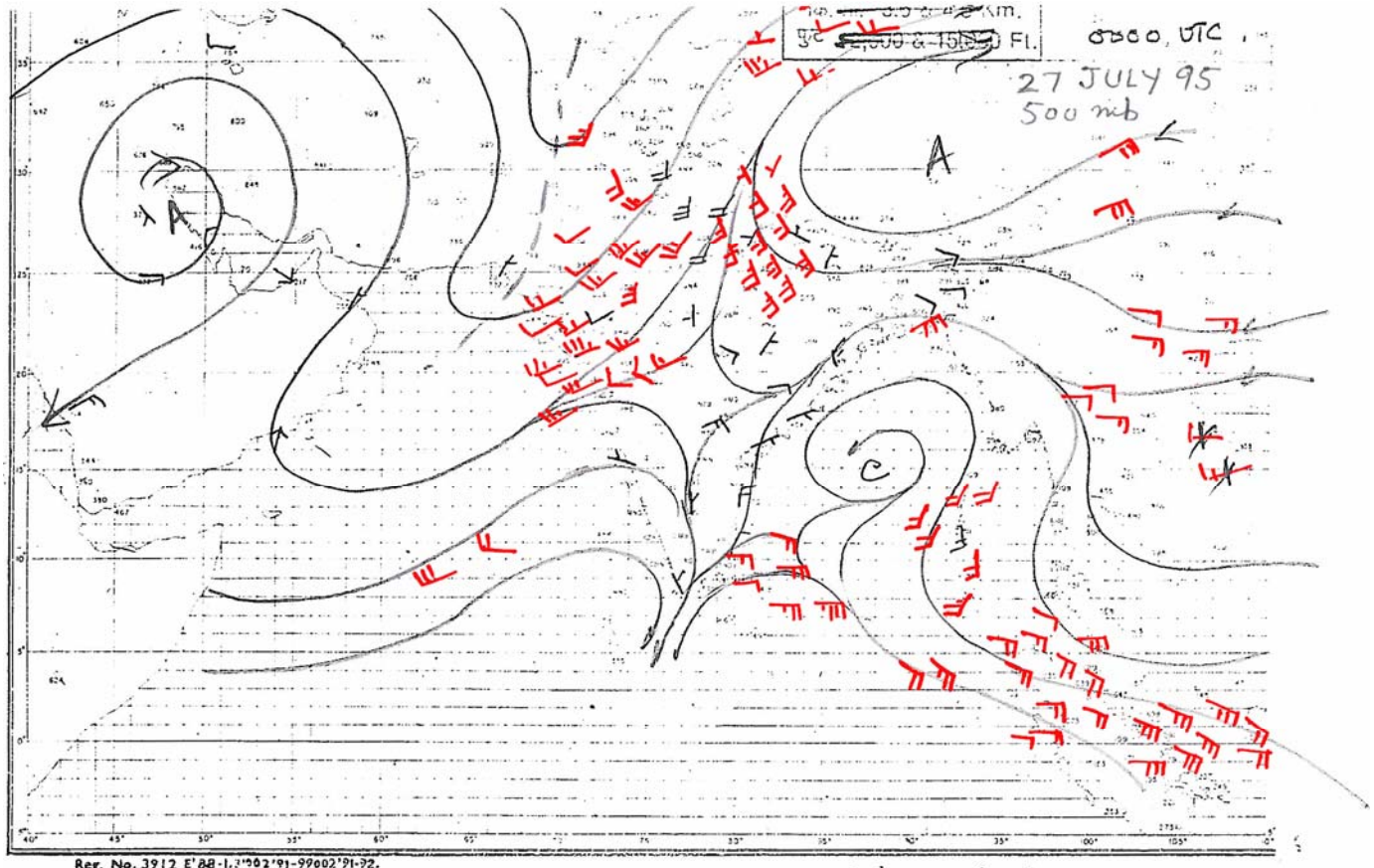
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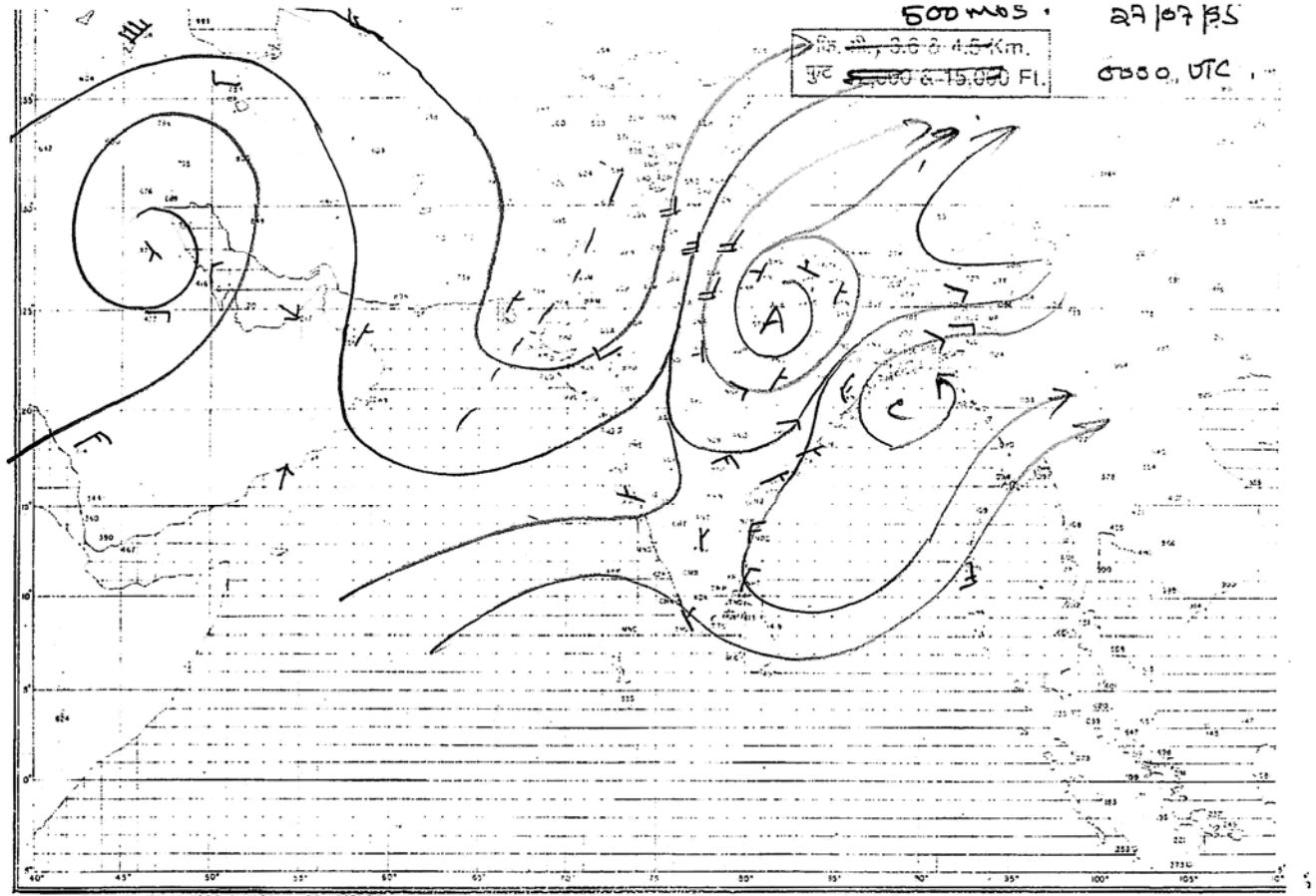
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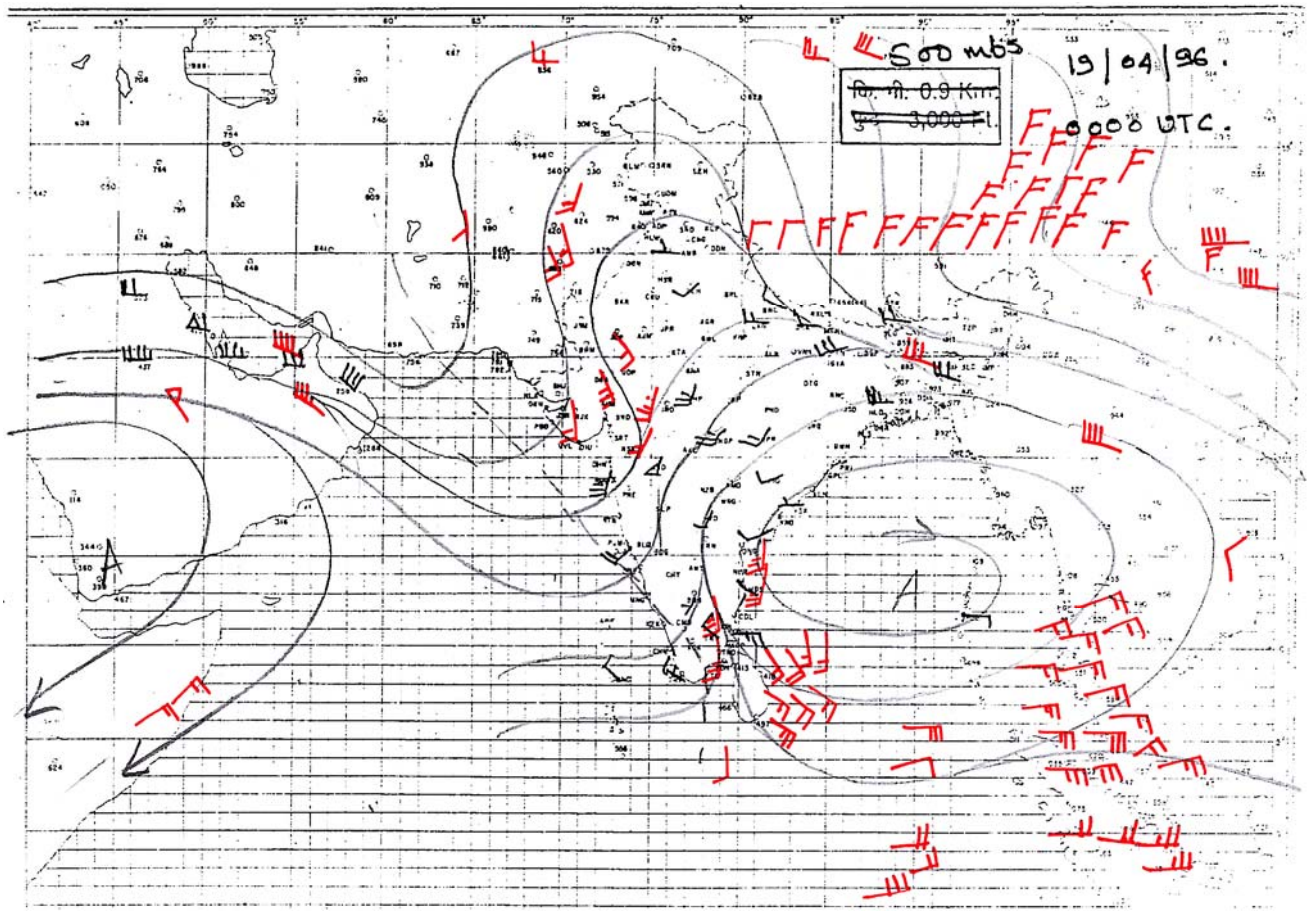

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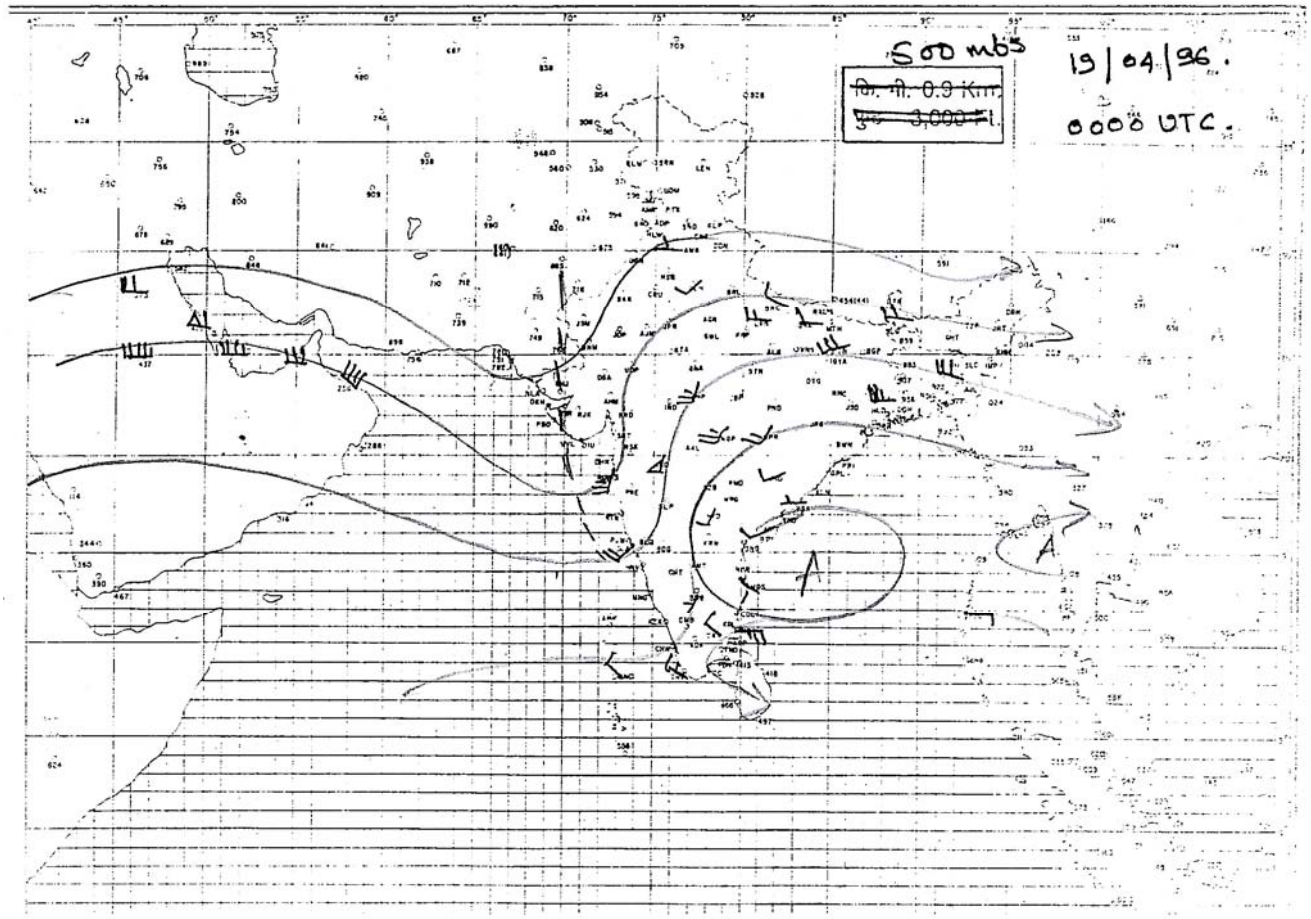

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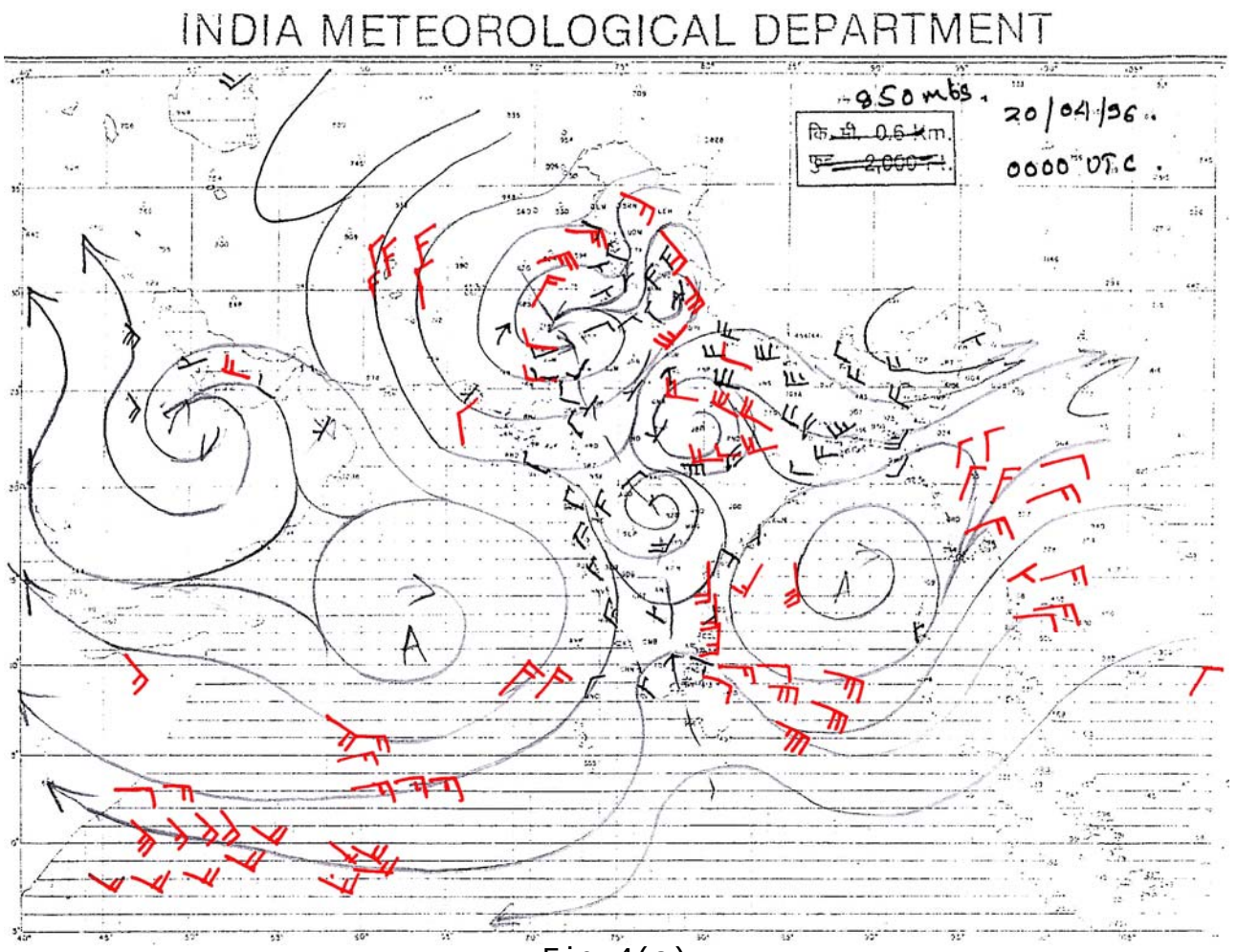
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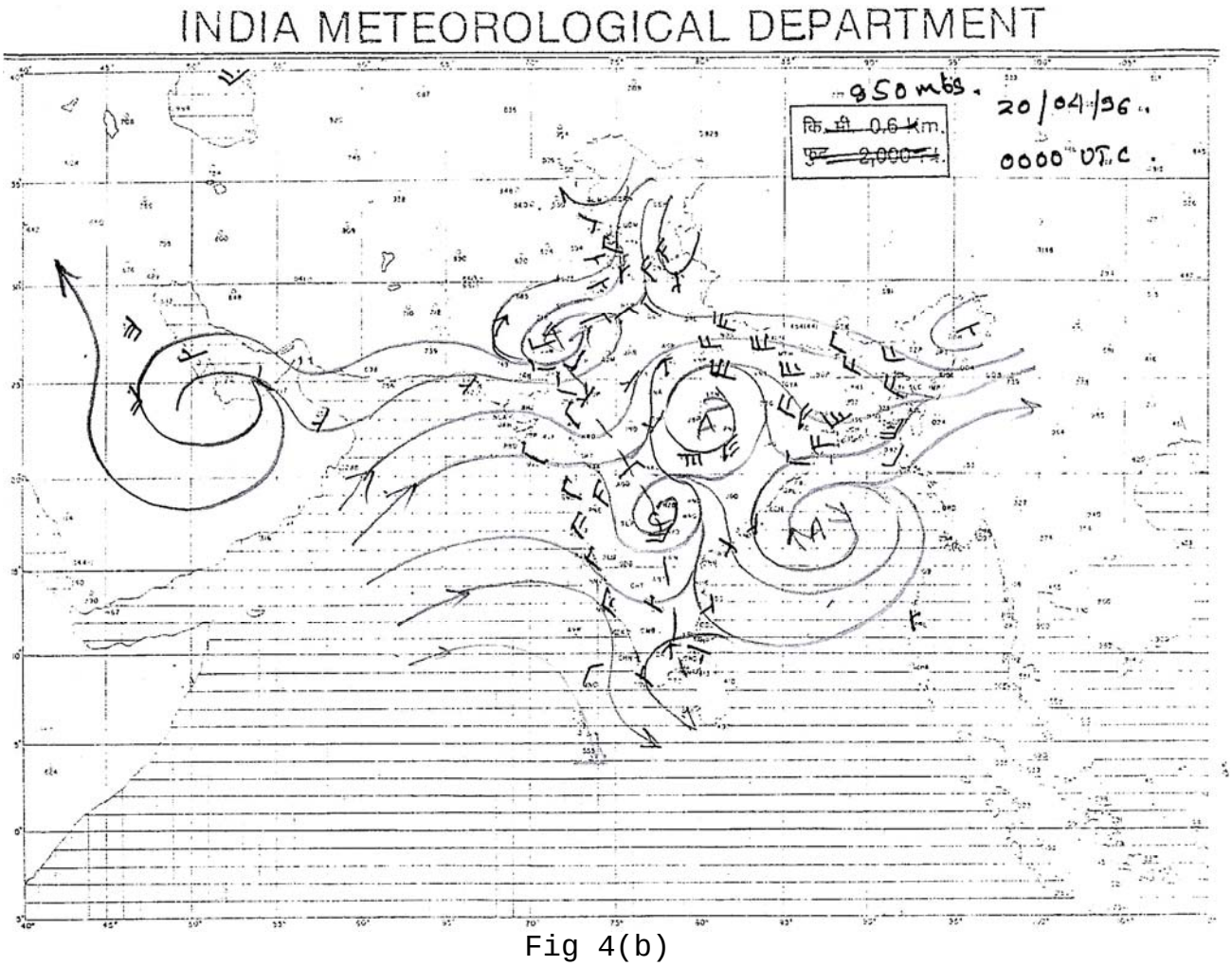
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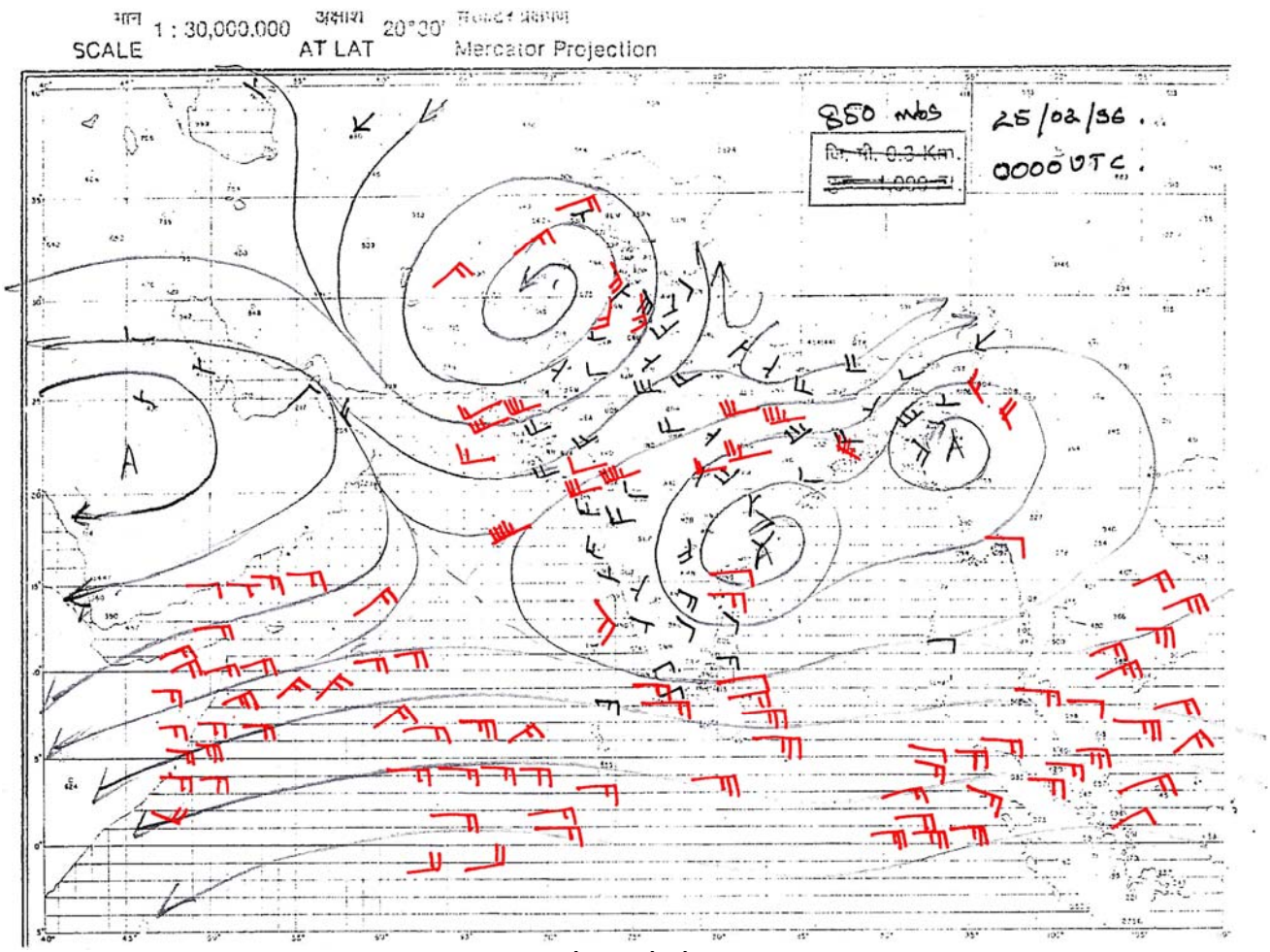
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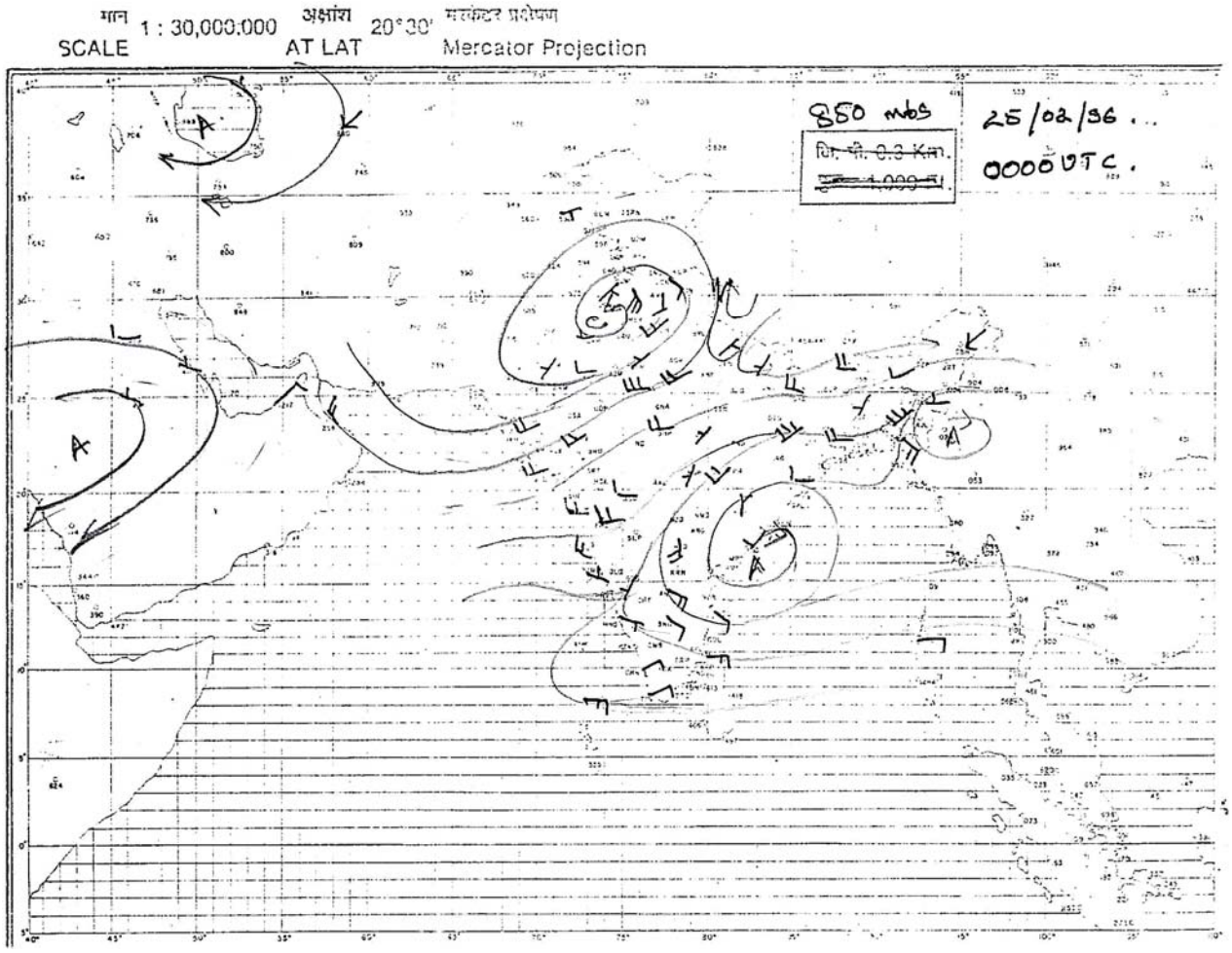
Fig 5(a)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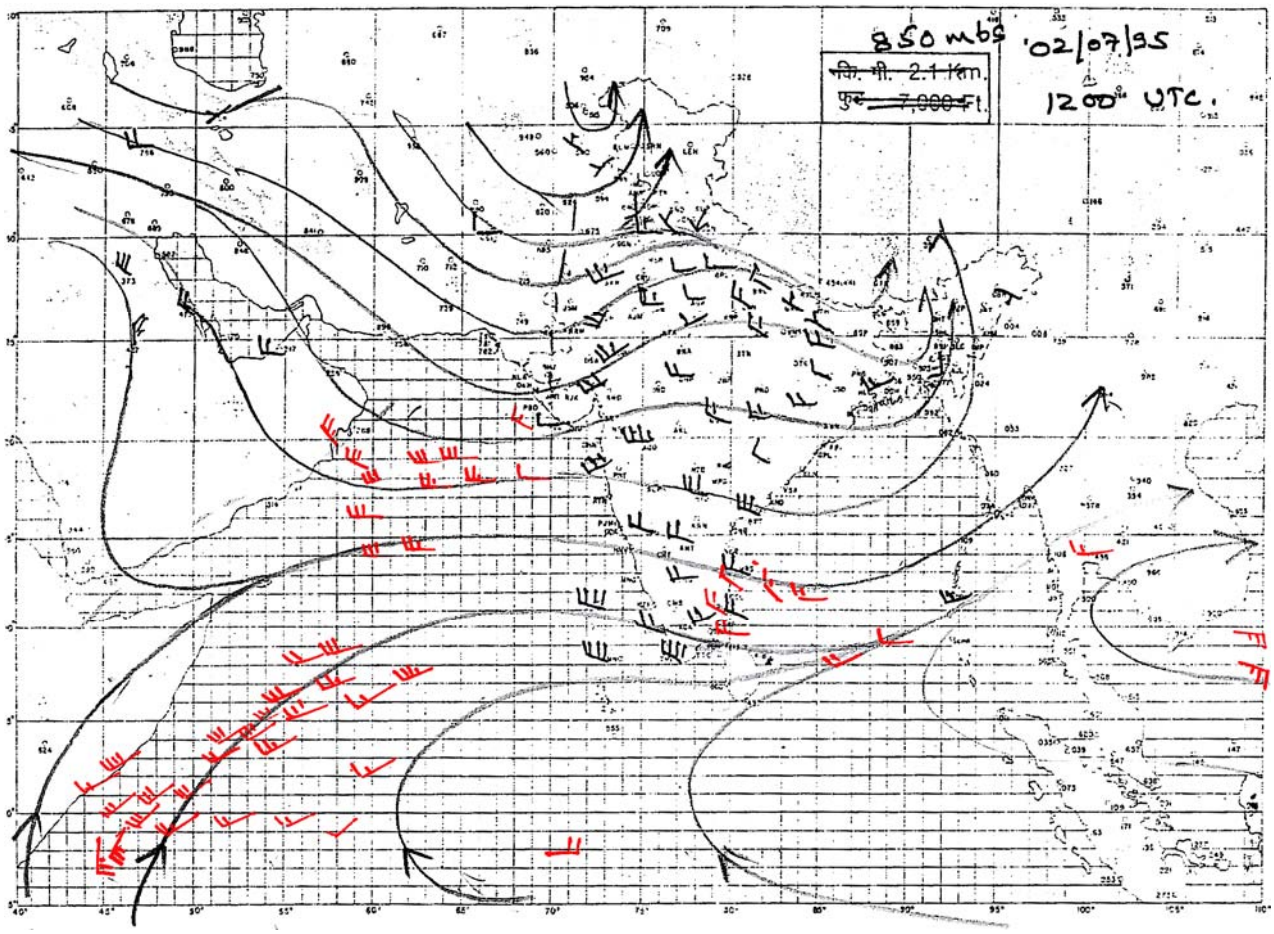

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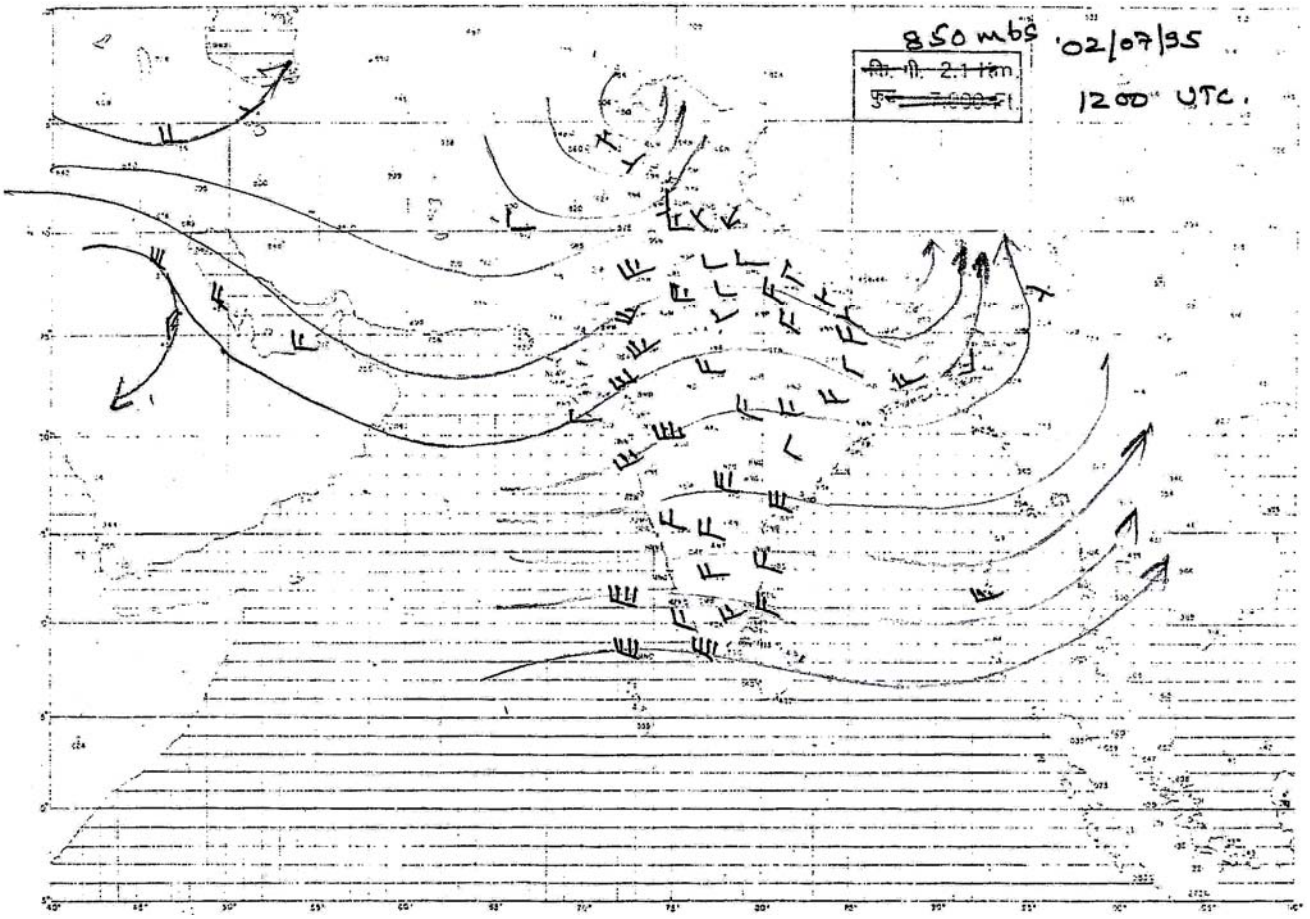

Fig 6(b)