NEW APPROACH FOR HEIGHT ASSIGNMENT AND STRINGENT QUALITY CONTROL TESTS FOR INSAT DERIVED CLOUD MOTION VECTORS

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ABSTRACT

Modifications have been done in derivation of CMVs from INSAT 1D satellite. These include a change in acceptable correlation peak from 0.5 to 0.65 , a new approach to height assignment and the reduction in tolerance limits of speed and direction used in QA tests . Earlier height was assigned on the basis of modal temperature for the identified cloud type , now it is done in two steps . First assignment is on the basis of mean temperature of 25% of the coldest pixels of identified cloud type. In next step height is reassigned as level of best fit after comparing with 24 hr forecast field . Finally CMVs are submitted to QA tests against forecast field with stringent tolerance limits in direction and speed. Test runs show improved mean absolute error for low medium and high clouds in speed (direction) 8.5 (25) , 7.6 (25) and 6.1 (15) respectively when compared with RAOB winds. Revised height assignment attempts to partially sort out emissivity problem , while stringent limits attempt to improve overall quality.

1. INTRODUCTION

Mass field and flow field, both are essential to specify current state and future state of the atmosphere, specially in tropics where flow field cannot be inferred from mass field. Geo-stationary satellite ATS 1 launched in 1966 provided first set of CMVs by tracking cloud tracers from sequence of images. GOES derived satellite winds over Indian Ocean were first used during May - June 1979 (Young et al. 1980) . INSAT 1 A launched in 1982 provided first operational set of CMVs over Indian Ocean from 1984 (Kelkar et al. 1986) . CMVs are being operationally generated three times a day, using INSAT Meteorological Data Processing System (IMDPS) and quality controlled CMVs are transmitted globally on GTS . Satellite derived winds need improvements and world wide efforts are on to improve their quality . Better data assimilation approaches in numerical models have put further pressure to improve satellite winds.

2. BASIC PROBLEMS IN SATELLITE WIND DERIVATION

a) Navigation and frame to frame registration problems introduce error to the derived CMVs.

b) All tracers are not passive . In southern hemisphere tracers are generally passive. It results in good coverage of consistent CMVs in south Indian Ocean (fig. 1). It has been generally observed by all the centers .

c) Cloud tracers may be sub-pixel sized or thin transparent Cirrus resulting error in height assignment .

d) Multi-layered clouds generate CMVs that do not belong to any single level . These represent some weighted average of different layers .

e) Tracers in shear zone show negative speed bias .

f) Coarser resolution also creates problem in tracers identification specially when sub- pixel sized tracers are present . CMVs from INSAT 1D visible tracers show better coverage than those from IR tracers (fig. 2 , 3) . IR CMVs show more zonal flow . The resolution restricts least count of U, V components of derived CMVs .

Navigation and mis-registration aspects are treated during real time image data processing . Active tracers , multi-layered cloud complexes , emissivity and tracers in shear zones pose greatest challenges . Satellites having water vapour and sounding channels , make use of the additional information for correcting height assignment problem, using CO_2 ratioing and H_2O Intercept techniques (Schmetz et al . 1993 , Valden et al . 1996) . In the absence of any additional information available on INSAT 1D, attempts are made to improve height using two step height assignment.

3. CMV DERIVATION FROM INSAT 1D IMAGERY

Passive cloud tracers of relatively lower vertical extent are assumed to flow with wind flow prevailing at cloud level . These are ideal tracers . Navigated images help in tracking cloud tracers in sequence of images . The cloud top temperatures are used for height assignment . Currently INSAT 1D is operational satellite that provides CMVs over India Ocean . Satellite winds are derived three times a day at 00, 05:30 and 12:00 hr UTC . INSAT 1D is positioned at 83 deg east providing images in visible band (0.55 µm - 0.75 µm) and Infrared band (10.5 µm - 12.5 µm) with spatial resolution of 2.75 and 11 km respectively for the two bands.

Triplet of images 30 min. apart with tracers image centered at 00:00 , 05:30 and 12:00 UTC are used for CMV derivation . Satellite winds at 05:30 are generated using visible images for cloud tracers and targets , for 00 and 12 UTC IR imagery is used for cloud tracking . Height assignment is done using IR image data at all times. Wind computation is fully automatic . Input parameters are configurable through a file . The tracer image is scanned for valid tracers at pre-specified line , pixel locations (fig . 4). A reference window (size configurable) around the specified location (fig . 5) is analyzed for cloud tracers. Two bin histogram for visible image (cloud or no cloud on basis of specified threshold) and four bin histogram for IR image (clear, low, medium or high clouds) are generated . The target images are then analyzed with larger search window around specified locations , size of search window depends on cloud identified (bin with maximum frequency) . The reference window is mapped on all the lag positions in the target search window (fig. 6) and pattern matching is done using cross correlation . In order to speedup , cross correlation is done in two stages . First correlation is found at coarser resolution , in next step , correlation is again computed at the arrived lag position using full resolution data .

Navigated tracer and target images then provide wind vector. The height is assigned in two steps to the CMVs derived . Mean temperature of 25% coldest pixels is used to assign initial height (Merril R. T et al . 1990) . Finally comparing CMVs with 24 hr forecast and getting the level of best fit helps in better height assignment . The tracers are tracked backward and forward to generate two sets of CMVs . Each set is then submitted to spatial and temporal consistency test followed by the forecast grid comparison. Finally single CMVs set generated , is submitted to manual editing by experienced synoptician .

4. IMPROVEMENTS IN CMV RETRIEVAL

Initial validation done by ECMWF recorded that INSAT IR winds show more zonal flow. Direction was poor for low and medium clouds . Speed was generally over-estimated . High level CMVs were better . Later improvements were reported in INSAT derived CMVs from IR imagery as reported in the third International Wind Workshop (Bhatia et al . 1996) . Further modifications made , have shown some improvements in INSAT derived winds . The resolution causing problems in getting passive tracers is a limitation of the satellite system . This makes tracer identification in large scale cloud system with multiple layers more challenging . Such situations are generally associated with disturbed weather , where CMVs information is really required . INSAT derived IR winds do show poor coverage near centre of disturbances . INSAT CMVs derived from finer resolution visible imagery have better coverage near disturbance centre in contrast to CMVs from IR imagery . Due to operational non-availability of 6 or 12 hour forecast , 24 hour forecast has been used . Height assignment and validation results will improve if 06 or 12 hour model forecast becomes available which includes INSAT derived CMVs in its data assimilation scheme . With these limitations , stringent QA limits and two stage height assignment have shown encouraging results . The results of modifications are shown in table 1.

5. SCOPE FOR FURTHER IMPROVEMENT

In order to restrict tracers to be of passive class , the mean and standard deviation of the tracer bin of maximum frequency pertaining to low, medium, or high cloud were analyzed , bin with larger ratio of standard deviation and mean was rejected to ensure tracking a cloud layer of limited thickness . Further when tracer passed the test , each lag position in search window was tested if mean temperature of bin in tracer and matching target lag position show large difference . If the two means differed by an amount exceeding pre-defined threshold for cloud type the lag position was rejected . These steps attempt to ensure that only passive tracers are further processed for pattern matching . This saves computation time and speedup the processing . The comparison of this test run without QA test was done with routine CMVs products . A large cover of data from southern hemisphere was shown rejected by forecast field . The cloud orientation and movement as seen in image sequence suggested that the winds were correct and provided additional information (fig . 7 , 8) . However there were some spurious winds that did need rejection by manual editing or with forecast comparison.

6. CONCLUSIONS

INSAT 2E is slated to be launched towards 1998 end . It will have water vapour channel (5.7 µm - 7.1 µm) with 8 km spatial resolution , beside marginally improved visible and IR imagery of 2 and 8 km resolution . It will also have Charged Couple Device (CCD) payload with 1 km resolution at sub - satellite point with Visible (0.62 µm - 0.68 µm) , Near IR (0.77 µm - 0.86 µm) and Short Wave IR (1.55 µm - 1.69 µm) . Better resolution VHRR and CCD image data will improve CMVs . Water vapour image data will improve height assignment of CMVs using H_2O technique , Water vapour derived winds and 06 or 12 hour forecast will further improve the satellite wind information with larger coverage from middle and upper troposphere .

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Table 1. Mean absolute error in low , medium and high level CMVs after recent test improvements .

	Initial		1996		1998	
Level	DD	FF	DD	FF	DD	FF
low	37.63	16.45	36.22	10.75	25.12	8.5
Med.	47.32	9.63	41.27	8.26	25.24	7.6
High	36.01	7.97	31.58	7.86	15.16	6.1

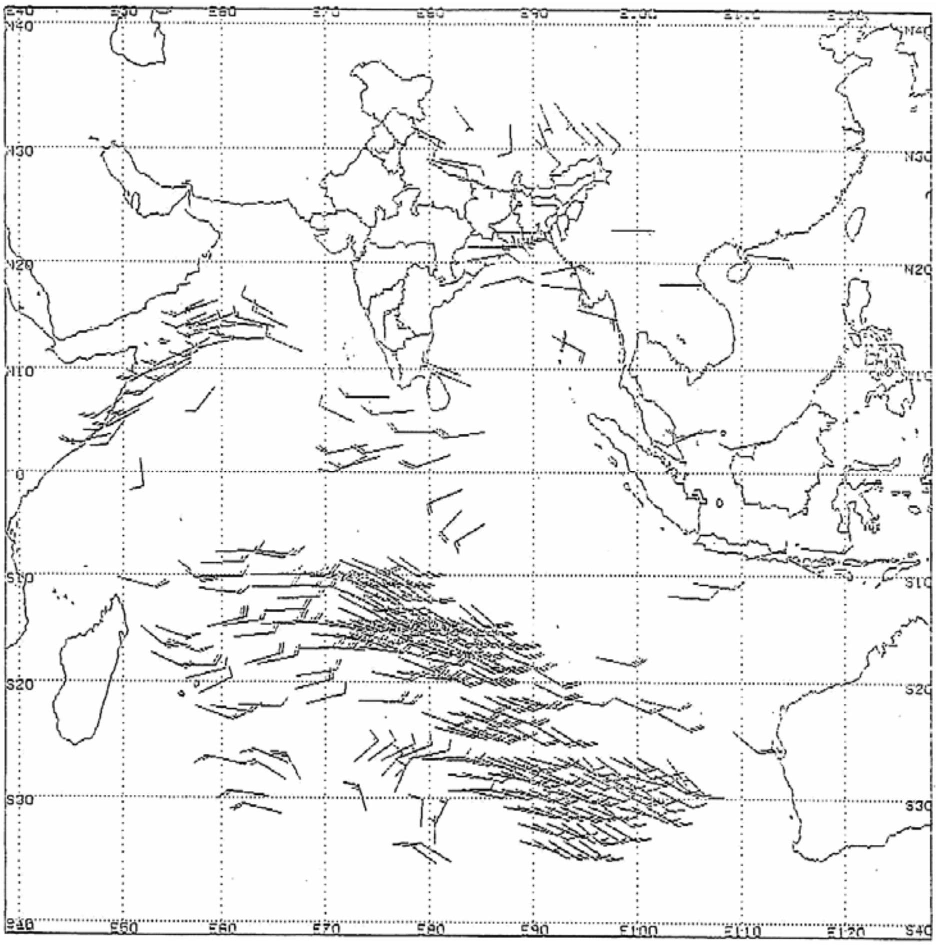

Fig . 1 Passive tracers in South Indian Ocean give consistent CMVs from INSAT 1D 6:00 UTC. Oct. 5 1998 .

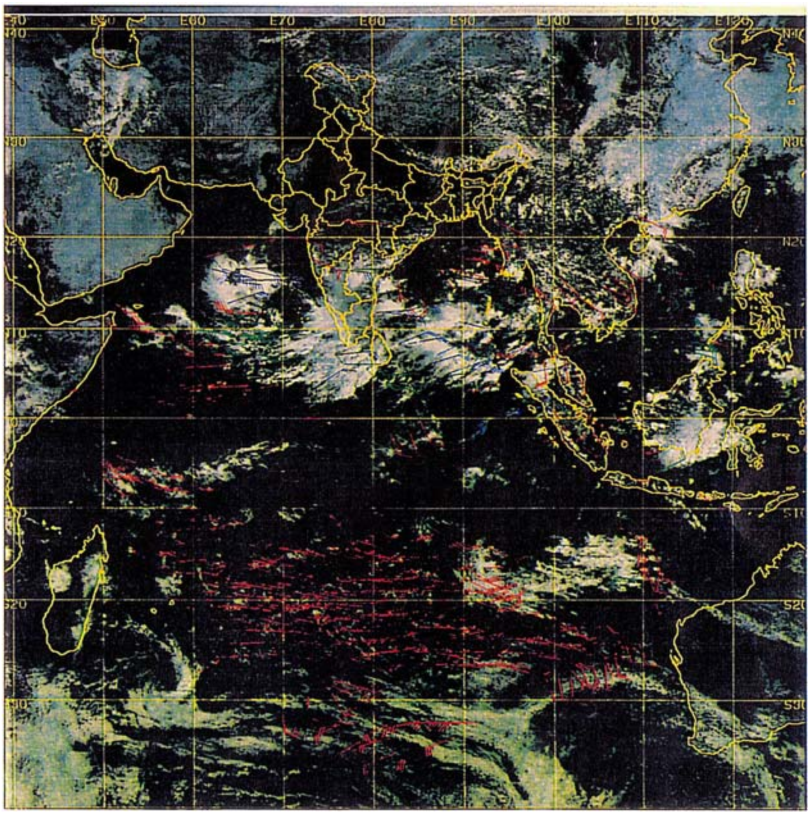

Fig . 2 Visible CMVs from INSAT 1D 06:00 UTC . Oct. 11 , 1998.

LOW RED , MED. GREEN , HIGH BLUE

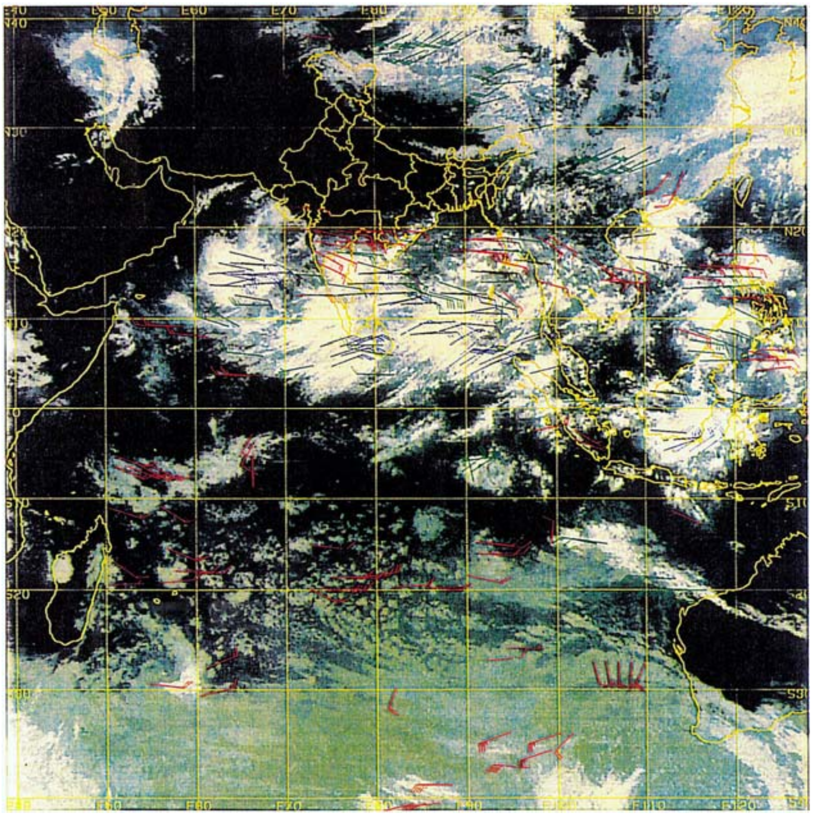

Fig . 3 IR CMVs from INSAT 1D 06:00 UTC . Oct. 11 , 1998.

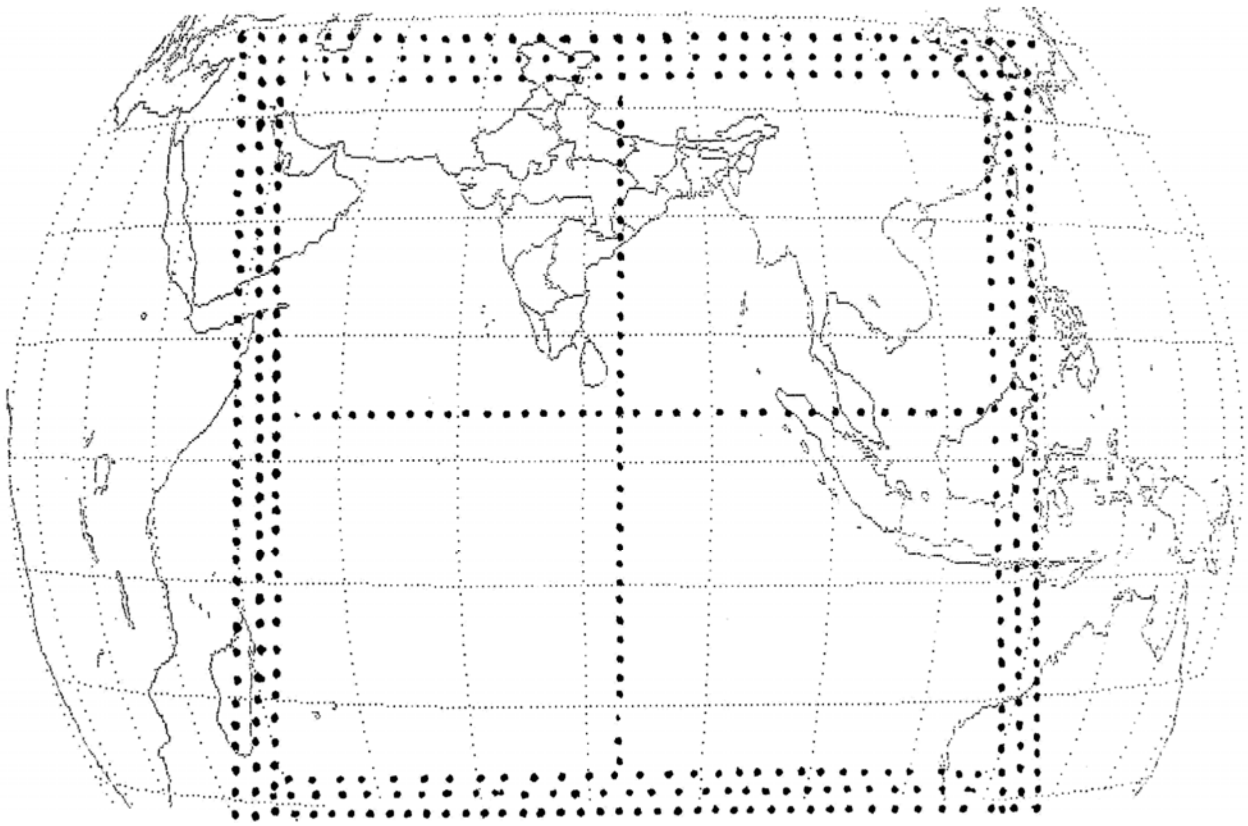

Fig . 4 Tracers at pre-specified locations in tracer image .

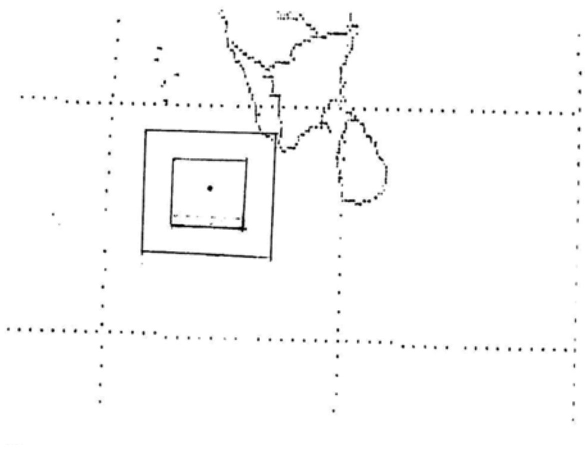

Fig . 5 Search window in target image around centre of tracer in tracer image .

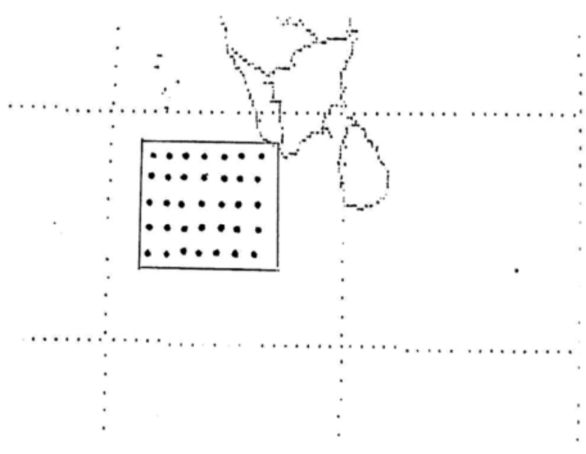

Fig . 6 Mapping reference window image at different lag positions in search window

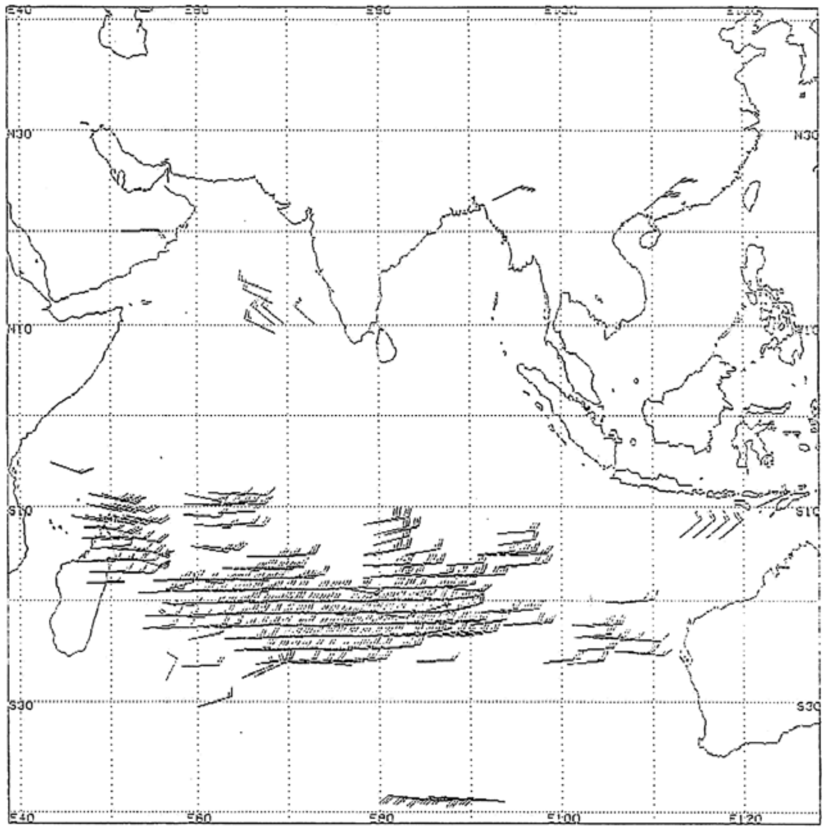

Fig . 7 Low level IR CMVs 00:00 UTC Sept. 18 1998 after routine routine QA and forecast tests.

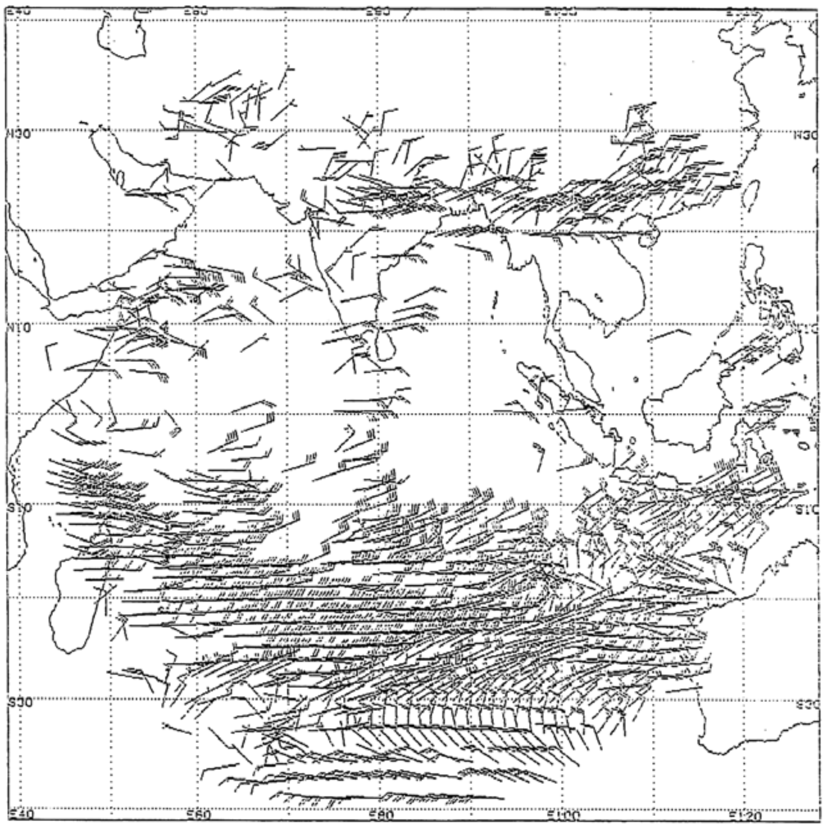

Fig . 8 Low level IR CMVs 00:00 UTC Sept. 18 1998 after applying sigma to mean ratio tests