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Research paper



Fuzzy logic based convective cloud detection from the Kaplan data

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Abstract

The cloud classification and analysis of the distinctive convective clouds from the satellite data have been mobilized using many traditional classification methods in atmospheric models for foreseen the natural hazards. In this paper one promising method makes use of fuzzy logic to perceive the convective clouds with strong triangular and trapezoidal membership functions. Convective clouds extracted from satellite images are compared with INSAT Multispectral Rainfall Algorithm (IMSRA).The development of the fuzzy logic rule based expert system with Kalpana satellite spectral data consist of advanced very high resolution (AVHRR) channels, which include Water vapour, infrared windows. In this proposed method shows that the fuzzy logic method offers greater correct results than conventional algorithms to identify the convective clouds.

Keywords: *AVHRR Convective Clouds; Fuzzy Logic; Spectral Data.*

1. Introduction

Identification and classification of the clouds in multispectral satellite imagery provides the broad way for the climate studies. Unlike ground observation, which is normally observed by human eye from the earth surface the satellite observation the scattering and absorption characteristics of clouds .thus it should be noted that the cloud types recognised by the satellite are distinct from the cloud forms identified by surface observation[1].The limited success of some early studies by Goodman and Sellers [2] suggests that the accurate detection of clouds in satellite imagery both during the day and at night is a challenging problem. The main motivation of this work is to introduce new method for identification of multispectral rain bearing clouds from kalpana satellite imagery.

Clouds can be classified in many ways. When the vertical profile is strong enough, cumuliform clouds like cumulonimbus where water vapour and ice particle are more and horizontal profile is strong enough stratus form clouds. Classified according to their altitude, at higher altitude i.e above 6km they can be called as cirrus, cirrostratus, and cirrocumulus clouds. At lower altitude (2km from the ground) they can be find stratocumulus, nimbostratus, and stratus. Altostratus and altocumulus at middle altitude (2km to 6km) [3].

Much of the work has done with traditional methods to find convective clouds .The approaches including maximum likelihood [4], neural network [5]. There is no single methodology prevails over other method in terms of accuracy, the preference of algorithm is mainly dependent on the weather the purpose of the classification and detecting the rain bearing clouds. For example neural network to classify single and multi layer clouds [6],While a k-mean clustering approach classifies six types of clouds (Cirrus,cirrostratus,cumulus,cumulonimbus,stratus,stratocumulus) which are frequently used in weather forecasting analysis[7]. In this paper, it is proposed that fuzzy logic approach to identify the convective clouds with triangular, Gaussian and trapezoidal membership functions. The fuzzy logic based cloud detection is discussed in section II, followed by the results and conclusion.

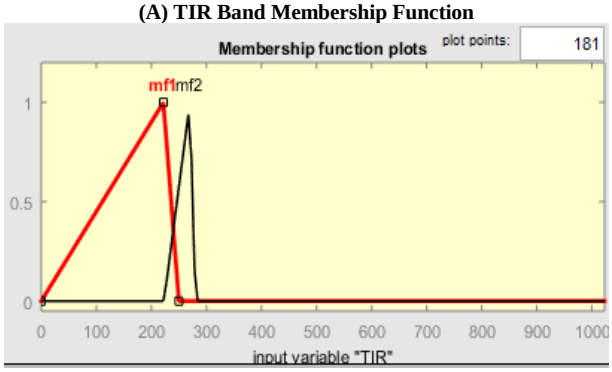
2. Convective cloud detection by fuzzy logic

From the data of Visible light image and infrared image used previously; it is reliable detection and classification of some clouds but recognize of convective rain bearing clouds cannot be identified. On the basis of fuzzy logic approach, a detection of cumulonimbus clouds has introduced kalpana data with spatial resolution of 1.1km2 and this fuzzy logic system approach uses triangular, Gaussian and trapezoidal membership functions as inputs and outputs of membership function as shown in the figure1.

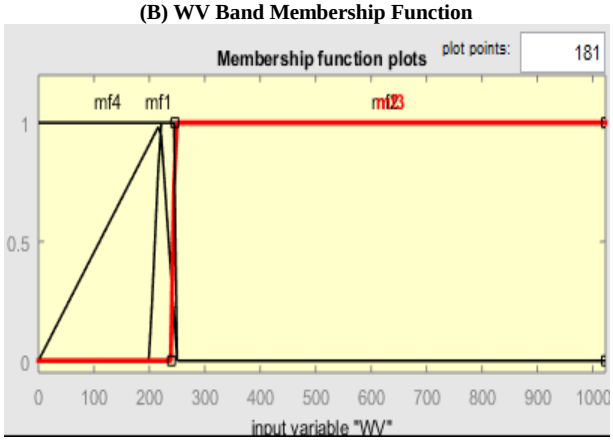
TIR image gives the temperature profile which can be observes both day and night without any difference [8].The CTBT is one of the crucial parameter for clouds in low, medium and high clouds. Temperature profile is converted the cloud top temperature into cloud top height. Clouds which are possessed high in atmosphere have low CTBT, where as the clouds close to the surface the earth has high CTBT.

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(A) TIR Band Membership Function



(B) WV Band Membership Function



(C) Membership Function for Resultant Cloud

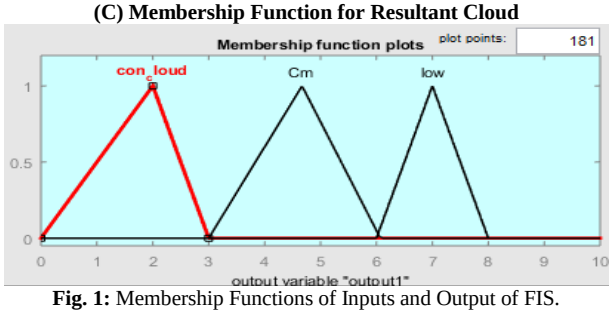


Fig. 1: Membership Functions of Inputs and Output of FIS.

In the WV image and associated their properties like bright, gray and dark gray corresponding to rich water content ,low water content ,no water content. IMSRA is a hybrid satellite rainfall algorithm developed particularly for Indian region rain bearing cloud area detection developed by Roca et al [10] is shown in table1.Using the fuzzy logic interfacing system, clouds classes can be justified by the linguistic variables range listed in the above table2. The interfacing of linguistic variables performed by max-min method [9].Membership degree of resultant output is defuzzified by centroid method.

Table 1: IMSRA Cloud Segregation Scheme

Cloud type	Test
Clear sky	TIR BT > 282K
Deep convective cloud	TIR BT <= 230K
Low level cloud	TIR BT > 270K && WV BT > 246

Table 2: Fuzzy Logic Membership Function Limits of 3 Clouds Types

Class	TIR	WV
Convective clouds	(0,222,250)*	(0,220,250)
Middle level clouds	(0,222,250)	(200,220,1023,1023)**
Low level clouds	(223,270,280)	(240,246,1023,1023)

*limits of triangular membership function. ** limits of trapezoidal membership function.

3. Results

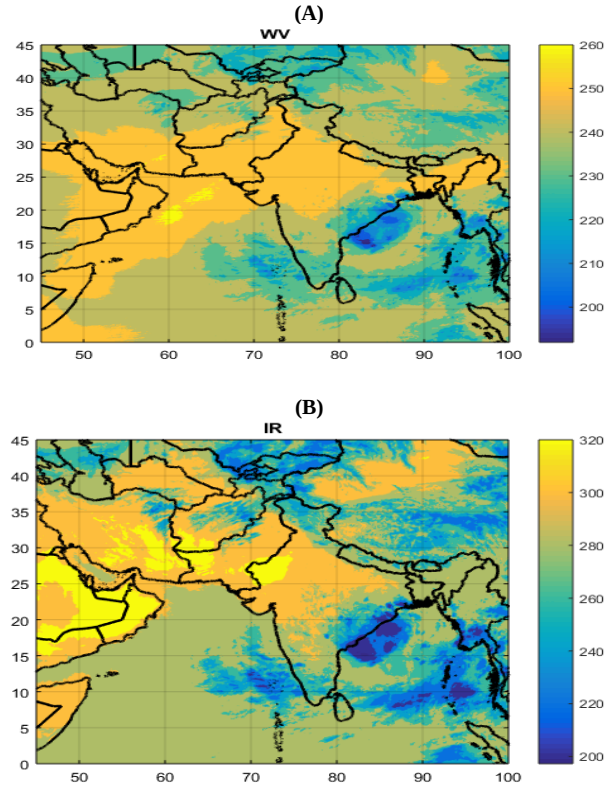


Fig. 2: Kalpana Satellite Images of 03june2016 A) WV Image of B) TIR Image.

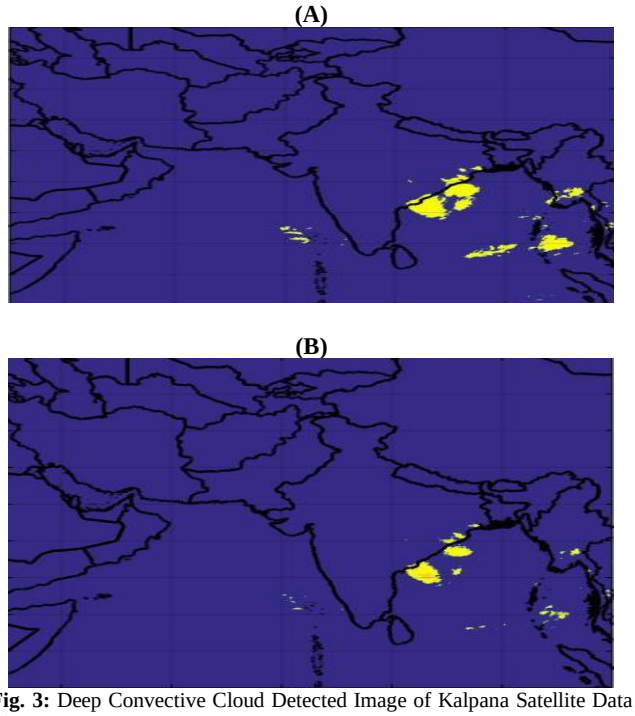


Fig. 3: Deep Convective Cloud Detected Image of Kalpana Satellite Data of 03june2016 A) Using IMSRA Algorithm B) Using Fuzzy Logic.

Kalpana data from the figure2 the suitable TIR and WV values are around 220K for deep convective clouds in the Indian region. This may vary with region and corresponding defuzzification value evaluated by centroid method is less than or equal to 3 for deep convective clouds.

4. Conclusion

Through many available methods to classify clouds types from satellite images, no single algorithm outstand the others on accuracy nor is any single method widely suitable for all practical situation. Fuzzy logic interfacing system is one among the methodology that could be used in this paper because it distinguishes the convective cloud from other cloud efficiently.

In this paper, we proposed a new method to classify cloud and detect convective cloud using fuzzy logic interfacing system. Convective cloud detected with accuracy of 97% from TIR and WV band of kalpana satellite data with suitable membership function. This accuracy value may modulated with region changed. Based on IMSRA algorithm clouds are classified for TIR and WV band of kalpana data. This paper shows the alternate way for convective cloud detection by fuzzy interfacing system. From the results, it can be concluded that the extracted convective cloud from kalpana satellite data using fuzzy logic technique yields a similar results to that of IMSRA algorithm .However the accuracy of yields is not uniform in all the regions.

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