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Research Article

South-West monsoon onset forecast by analysis of satellite images using objective dialectical classifier

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Abstract

Arrival of the South-West monsoon in Sri Lankan region is an abrupt phenomenon and with this annual climatological event, many meteorological parameters such as rainfall, wind, pressure etc. would remarkably change. Therefore, determination of the SW monsoon onset is socio economically significant as it influences agriculture and hydropower generation. With the advent of satellite imagery, pattern recognition techniques have been implemented favorably for forecasting the SW Monsoon onset. This study explains a methodology based on the Objective Dialectical Classifier to determine the onset dates utilizing only the clouds images. Results obtained in this research match well with the onset dates determined by the regional authorities.

Keywords: South-West Monsoon, Objective Dialectical Method

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1. INTRODUCTION

The South-West (SW) monsoon is the heavy organized rainfall season in Sri Lanka, particularly in the south-west or wet zone of the Island. Activities or phenomena such as agriculture, river drainage pattern, flora, aviation, fishing, and hydropower generation are highly influenced by the occurrence of this monsoon. Because of this, forecasting the SW monsoon onset is very important and it is a challenging task to determine monsoon onset, with a reasonable accuracy, using only one parameter, as climate involves so many parameters such as precipitation, humidity, temperature, pressure, clouds, wind speed and direction etc.

Chen et. al. studied the Asian summer monsoon and they found that it first appears on South China Sea (SCS) and then gradually propagates to northwest direction [10,11,12]. SW monsoon over the Indian subcontinent is considered when there is a substantial level of rainfall received in the region of "Kerala" and onset date keep fluctuating anywhere between 10th of May and 15th of June[2]. The study that was carried out for the years from 2012 to 2018 to determine the SW monsoon onset in Sri Lankan region, found that it was kept fluctuating between 15th of May and 3rd of June[6].

Due to advancement of the technologies, more satellite images with high resolution are available now and a substantial amount of weather data can be extracted from them. It will be useful to analyze and use this data for a more accurate weather forecast. Substantial studies have been carried out related to the SW monsoon in India, South China Sea Summer monsoon (SCSSM) and South East Asian Summer Monsoon (EASM)[1,2,10,11,12]. To the best of author's knowledge, less attempts have been made to explain the SW monsoon commencement within the Sri Lankan region, which motivated the author to fill the research gap by a detailed study of SW monsoon onset dates in and around that region.

Summer monsoon onset definition varies from region to region as well as year to year according to the studies carried out in region and time duration[10,11]. Rainfall and wind field are the mostly used parameters to determine the arrival of the monsoon in early days[1]. Due to the advancement of technologies such as remote sensing and satellite imagery, recent studies are now defining onset of the SW monsoon in more global scale with many parameters[2]. In this study, an effort is made to define simple yet effective SW monsoon onset date using satellite cloud images.

The dialectical method of Historical Materialism is a tool to study systems by considering the dynamics of their contradictions, as dynamic processes with interwind phases of evaluation and revolution crisis[3,5]. It has inspired researchers to conceive an evolvable computational intelligent method for classification that is able to solve problems commonly approached by neural networks and genetic algorithms[8]. In this study, Objective Dialectical Classifier (ODC) is adapted to figure out the revolutionary changing point of the cloud images when monsoon phenomenon is developed.

In this section, a brief introduction is given about this study and the next section explains the data used along with classification methodology. Results are shown in the next section followed by the some concluding remarks.

2. MATERIALS AND METHODS

The satellite data available on “www.mosdac.gov.in” which is maintained by the Space Application Center (SAC) of Indian Space Research Organization (ISRO) were used. The INSAT-3D spacecraft which is parked at 82^0 East, carries two meteorological payloads: imager and sounds. Spectral channel TIR 1 with 10.3-11.3 µm of resolution 4 Km GEOTIFF formatted grey scale images provided by the imager were ordered and downloaded from the above site. In order to include the potential onset period, from 1st of April to 30th of June with cover between 65E to 90E longitude and between 0 to 25N latitude, 30 minutes interval images were used in this work. Downloaded sample image of May 03, 2021 at the acquisition time of 0230 (India standard time) is shown in Figure 1.

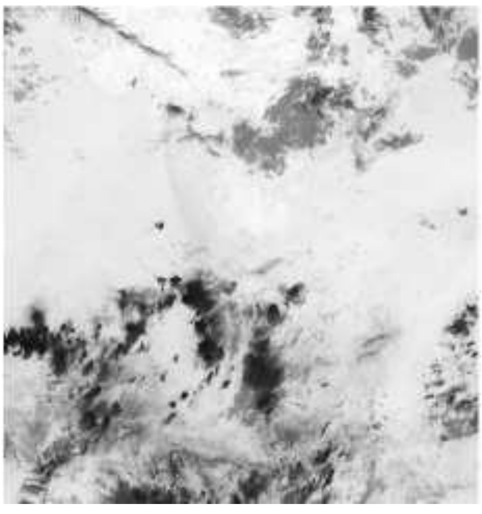

Figure 1. Image of
“3DIMG_03MAY2021_0230_L1C_ASIA_MER_V01R00_IMG_TIR1.tif"

Pixels of the geoTIFF Image were separated into five bins using “imhist” function of the MATLAB based on its colour values and then normalized. Preprocessing was not carried out to minimize the computational cost. The line plots of the last four bins’ colour values shown the upward or downwards trends in almost all concerned years. Therefore, last four bins’ values are taken as the feature vector of the Objective Dialectical Classifier (ODC) classification.

SW Monsoon of Sri Lankan region establishes in between second week of the May and first week of the June according to the previous studies[6,12]. Training data were chosen based on those findings and for each class of pre-monsoon and monsoon. For the pre-monsoon class, 50 days were taken from April 13 to May 7 in the years 2018 and 2019 while 50 days were taken for the monsoon class from June 6 to June 30 in same years as training data.

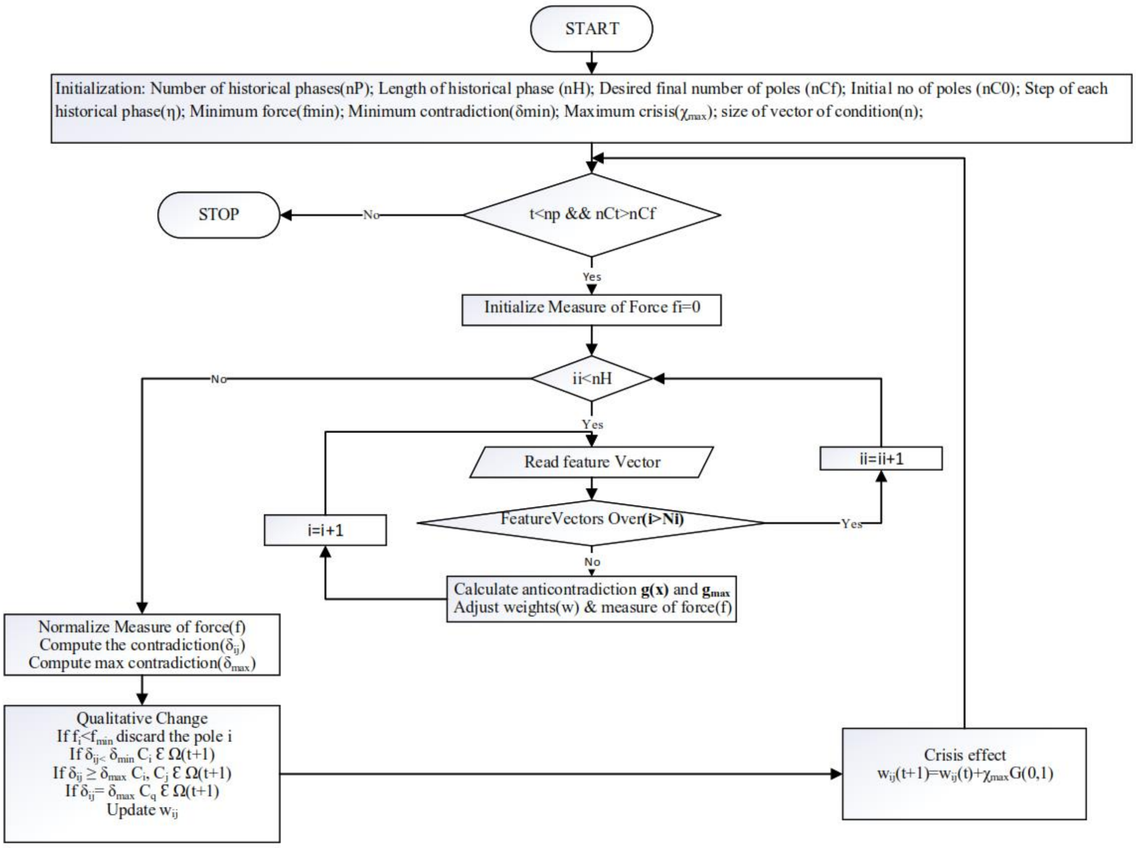

Figure 2: flowchart of the objective dialectical method

The Objective Dialectical Method is an evolvable computational method based on the conception of parts of reality or phenomena, as dynamic systems. Hegal, Marks and Engles philosophy of social development is the source of inspiration[3,5,7]. System consists of the dialectical poles or classes and system input is the vector of conditions representing a main feature of the problem in hand. Each pole is associated with vector of weights with the same size of vector of conditions, an anti-contradiction function, and measure of force. The system is evolving through historical phases which consist of two stages: evolution and revolutionary crisis.

In evolution stage, pole interaction is taking place when vector of conditions is feeding to the system. Due to this pole straggle, an anti-contradiction function associated with each pole is evaluated. The pole with higher anti-contradiction value or the winner pole increases its parameters such as weights and measure of force. This process continues until the end of the historical phases is reached[7,8,9].

The Revolutionary crisis begins after end of the historical phase. In this stage, all the poles with a measure of force less than a minimum force are eliminated and a contradiction between two poles is less than a given minimum contradiction, one of two poles is also eliminated.

Main contradiction or overall maximum contradiction is also calculated, and new pole is generated from poles that were involved for main contradiction. Vector of weight of the new pole is calculated from the vector of weights of that pair of poles. It is also possible to choose more than one main contradiction and new poles are generated accordingly. Finally, vector of weights of all new poles and survivors are randomly modified at the end of revolutionary crisis. Figure 2 presents the flowchart of the objective dialectical method adapted for the classification task.

Objective Dialectical Classification was conducted all the years from 2018 to 2022 and results are presented in the next section

3. RESULTS

The ODC was trained using an initial system of ten (10) integrating classes with four (4) input conditions, studied during five (5) historical phases with 100 length durations. Random numbers were taken as the initial vector of conditions. The initial historical step was η_0 = 0.1. At the stages of revolutionary crisis, a minimum measure of force of 1%, minimum contradiction of 10% and maximum crisis of 10% were considered. The stop criterion was the final number of classes, two from each and final total number of classes were four (4).

The input conditions are the number of pixels belonging to the last four grey scale bins. The very first bin was omitted as it was not showing a regular trend for most of the years.

Adapted criteria to determine the onset date of this study is fifth consecutive day of turning to monsoon pattern after May 15 in each year. Results are shown in the table 1 below and evaluated onset dates are highlighted.

Table 1: Day wise ODM classifier output from April 1 to June 30

	April					**May**					**June**				
	2018	**2019**	**2020**	**2021**	**2022**	**2018**	**2019**	**2020**	**2021**	**2022**	**2018**	**2019**	**2020**	**2021**	**2022**
1	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1
2	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
3	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
4	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
5	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
6	0	0	0	0	0	1	0	0	0	0	1	1	1	1	1
7	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
8	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
9	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1
10	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1
11	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
12	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1
13	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1
14	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1
15	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1
16	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
17	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1
18	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1
19	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1
20	0	0	0	0	0	1	0	1	1	0	1	1	1	0	1
21	0	0	0	0	0	1	0	1	1	0	1	1	1	0	1
22	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1
23	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1
24	0	0	1	0	0	1	0	0	1	0	1	1	1	1	1
25	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1
26	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1
27	0	0	0	0	0	1	0	0	1	0	1	1	1	1	1
28	0	0	1	0	0	1	0	1	0	0	1	1	1	1	1
29	0	1	0	0	0	1	1	1	0	0	1	1	1	1	1
30	0	1	0	0	0	1	1	1	0	1	1	1	1	1	1
31						1	1	1	0	1					

It is observed that the actual onset dates of the southwest monsoon in the island occurred just before southwest monsoon entered the island. Table 2 shows the actual onset dates of the southwest monsoon, as determined by the Indian Meteorological Department[4], and the onset dates predicted by this study.

Table 2: SW Monsoon onset dates, actual and predicted.

Year	Actual Onset Date Next to the Island	Predicted Onset Date
2018	25 – 26 May	21 May
2019	3 – 4 June	2 June
2020	27 – 28 May	19 May
2021	22 – 24 May	22 May
2022	16 – 19 May	19 May

As May 15 is taken the reference date for the adopted criteria of SW Monsoon onset date determination, erroneous classification percentage in each year from April 1st to May 15 as pre monsoon and May 16 to June 30 as monsoon are shown in the Table 3.

Table 3: Erroneous ODM Classification Percentage

	2018	2019	2020	2021	2022
Pre Monsoon	20.45	6.82	13.64	6.82	15.91
Monsoon	4.26	29.79	12.77	23.4	23.4
Average	12.36	18.31	13.21	15.11	19.66
			15.726		

4: CONCLUDING REMARKS

Results tabulated on the table 2 show that the Southwest monsoon onset dates predicted through ODM classification reasonably match with those as determined by the Indian Meteorological Department, for the years considered. In the year 2018, monsoon arrivals occurred 4 days earlier than its determination by the Indian Meteorological Department. In 2019, it is just one day earlier and in 2020, it is 8 days earlier. Indian Meteorological Department determine the monsoon onset date, using many parameters such as rainfall, wind, temperature, pressure etc. as well as cloudiness and most of those values are taken in Indian territory.

Average classification accuracy was 84.3% and year-wise classification accuracy was more than 80% in concerned years, according to table 3. Therefore, considering reasonable number of features and choosing effective parameters of ODM classification, it is possible to forecast SW monsoon onset date more accurately and further research in this regard is envisioned in future.

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