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Mesoscale convective complexes on the northeastern coast of Brazil

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Abstract

Physical and morphological features analysis of all Mesoscale Convective Complexes (CCM) during 4 years (2003 - 2006) in the Alagoas State of Brazil is the principal goal of the study. Data of the seventeen Alagoas`s pluviometric stations were used for precipitation analysis in the CCM events. National Center for Environmental Prediction (NCEP) reanalysis products were used for weather systems monitoring. Low level troughs and Wave Disturbances in the Trade Winds were mostly associated with the CCM formation. The CCMs were responsible for the precipitation measures ≥ 5,0 mm in only 7% of cases, but in 70% for the intense precipitation events. Zona da Mata region of the Alagoas was most affected by heavy precipitation. CCM dimensions were determined by the satellite infrared images using MATLAB software. The variation of the CCM diameter was from 200 to 900 km with the average value of 500 km. The next average CCM`s parameters were determined: area - 190.000km², duration -11hours. The maximal development stage was observed in the morning. METEOSAT data by EUMETSAT's UMARF Online Ordering and software xrit2pic were used for cloud shield top temperature analysis. The average top cloud temperature was equal to -60°C with the minimum value of -70°C. Temperature and humidity vertical sounding data and NCEP reanalysis data were used for CCM thermodynamics features study. Storm identification by K, TT and LI indexes have shown the satisfactory results, but indexes's values were always below than in the manual. CCM have caused the greater part of the storms (90%) in the west Alagoas, which was not found in the east part.

1. Introduction

Heavy precipitation in the Alagoas State (northeastern Brazil (NEB) is the principal meteorological phenomenon, which affected the population, created many transport and health problems (Marques [1]). The conditions of heavy precipitation generation in some selected cases on NEB were studied in different papers: Brabo Alves et al.; Brito et al.; Calheiros et al.; Costa et al.; Levit et al.; Molion & Bernardo, Molion et al.; Pontes et al.; Salvador, Brabo Alves [2-13]. But all cases of heavy precipitation in any time period together have not studied up to now.

On the other hand, study has shown that significant precipitation in Alagoas was forecasted never by meteorological service on 2007 (Santos [14]). But 10 days of heavy precipitation were registered by the conventional meteorological stations during 2007.

Verification of the precipitation forecast method, elaborated on the base of high resolution (10 km) ETA model (Fedorova et al.; Cavalcanti et al. [15, 16]) for Alagoas State presents unsatisfactory results. Significant precipitation (>40mm/24h) was forecasted with 24h antecedence for 7 days, but there were observed by conventional meteorological data during 27 days and only 3 forecasts were correct. Therefore unfortunately, no any special precipitation forecast method for the Alagoas State was elaborated up to now.

The first study goal is identification of all synoptic systems related to intensive precipitation during 4 years (2003-2006). The second aim is to study morphological characteristics of the Mesoscale Convective

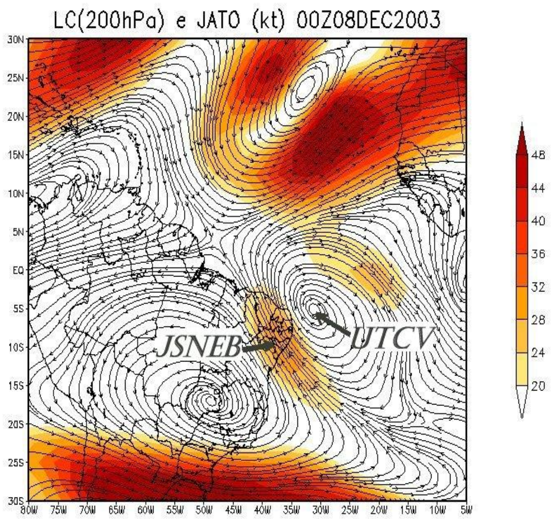
Complexes (CCM) and CCM influence on heavy rain formation in the Alagoas.

2. Data Source and Methodology

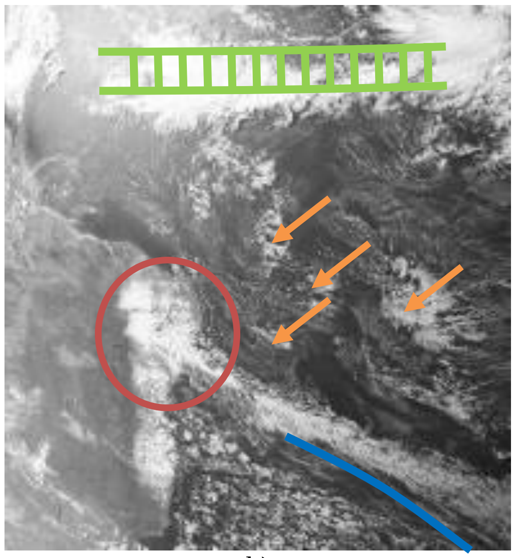
Precipitation was analyzed during 4 years (2003-2006). Precipitation data were obtained from 17 pluviometrical stations in Alagoas by ***DECEA/SEMARH-AL e PROCLIMA*** (*Departamento de Controle do Espaço Aereo* - *DECEA*, *Diretoria de Meteorologia da Secretaria de Estado do Meio Ambiente e dos Recursos Hidricos de Alagoas* - DMET-SEMARH/AL and *Programa de Monitoramento Climático em Tempo Real da Regiao Nordeste* -PROCLIMA: http://www.cptec.inpe.br/proclima/). The intensive precipitation was defined according to climatological yearly data for tree ambient regions of Alagoas: 1) ≥100mm/24h for Coastal region; 2) ≥60mm/24h for Zona da Mata e Baixo San Francisco regions and 3) ≥40mm/24h for Agreste, Sertao e Sertao do San Francisco regions.

Synoptic systems were analyzed daily using different products (jet streams at the low, middle and high levels, temperature and omega) of NCEP reanalysis and satellite images. Infrared (IR), visible (VIS) and Water Vapor (WV) satellite images (from *Centro de Previsao de Tempo e Estudos Climaticos do Instituto Nacional de Pesquisas Espaciais* - *CPTEC/INPE*: http://www.cptec.inpe.br and from *Space Science and Engineering Center Images and Data, Wisconsin University - Madison*: http://dcdbs.ssec.wisc.edu/inventory/) and products of the *National Centers for Environmental Prediction* reanalysis data (NCEP: http://www.cdc.noaa.gov.) were used for identification of the synoptic systems related to intensive precipitation. Causes of heavy precipitation were determined and weather systems responsible for precipitation formation were analyzed using these databases.

The next synoptic systems were observed: Upper Tropospheric Cyclonic Vortex (UTCV) (Kousky, Gan, Mishra et al., Rao, & Bonatti [17-20]), Middle Tropospheric Cyclonic Vortex (Carvalho, Fedorova et al. [21-22]), jet stream near the NEB (JSNEB) (Gomes, Campos& Fedorova et al. [23-24]), intertropical convergence zone (ITCZ), ITCZ pulses (ITCZp) (Xavier et al., Uvo et al., Hubert et al., Ferreira et al., Coelho-Zanotti et al. [25-29]), easterly waves (EW) (Coutinho et al., Espinoza, Rodrigues et al., Fedorova et al., Coelho-Zanotti et al. [30-33]) and frontal extremity (FE) (Fedorova et al., Kousky, Gemiacki, Cruz, Souza et al., [21, 34-37]). Also two mesoscale systems were identified: wave disturbance in the trade wind (WDTW) (Molion et al., Espinoza, Rodrigues et al., Fedorova et al., [7, 31-33]) and mesoscale convective complex (MCC) (Maddox, Silva Dias, Velasco, & Fritsch, Reeder, & Smith [38-42]). The peculiarities in the pressure field were noted: troughs at the low, middle and high levels, (Tl, Tm and Th, respectively); High at the middle (Hm) and high (Hh) levels, (Fedorova et al., 2004); wind Confluence at the low and middle levels (CONFl and CONFm, respectively); Diffluence at the middle and high levels (DIFm and DIFh, respectively). Examples of UTCV, JSNEB identification can be seen in figure 1a and ITCZ, CCM, Front an WDTW in figure 1b. The MTCV example is presented in figure 2.



a)



b)

Figure 1 – a) Map of stream lines and wind velocity (m s^{-1}) with JSNEB and UTCV at the 200hPa level, 00UTC 8 December 2003; b) ITCZ ( ), CCM (circle) , Front (line), WDTW (arrow) in VIS satellite images 31 July 2007, 18UTC. Sours: Dundee University.

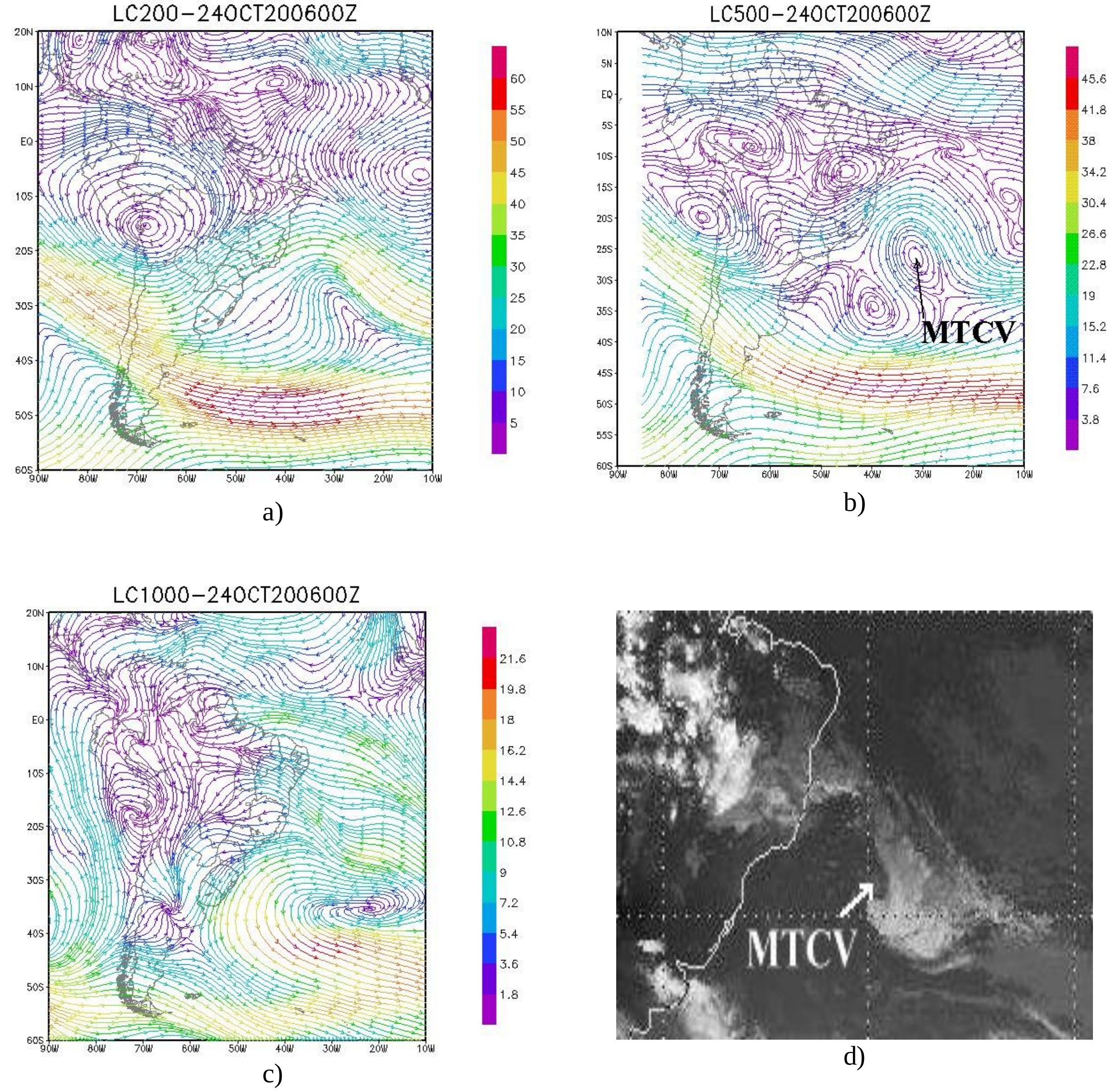
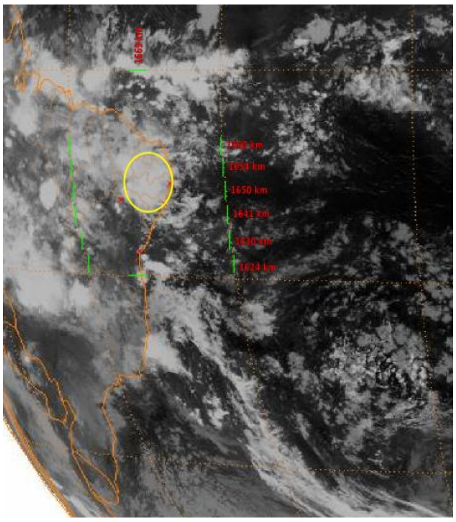


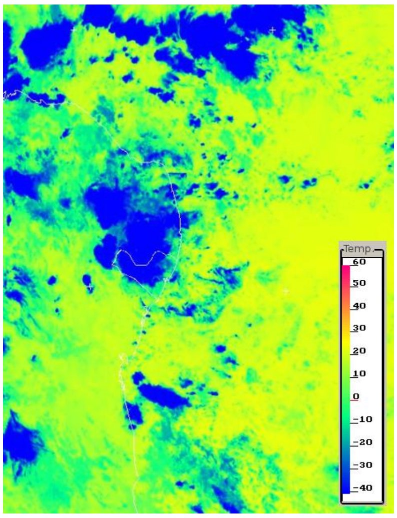
Figure 2 – MTCV identification by maps of stream lines and wind velocity (m s^{-1}) (a, b, and c) and at IR satellite image (d) on 00UTC 24 October 2006: MTCV existence at 500hPa level (b) and at satellite image (c) and MTCV absence at 1000 and 200hPa levels (a, c).

CCM analysis. Baric systems related to CCM formation were identified by NCEP reanalysis data at 1000, 500 and 200hPa levels. CCM diameter and eccentricity were obtained by IR images using MATLAB®. For example, CCM diameter calculation is presented in figure 3a. Top clouds temperature was determined by EUMETSAT data (UMARF online ordering, http://archive.eumetsat.org/umarf/) and software xrit2pic (http://www.alblas.demon.nl/wsat/software/soft_msg.html). For example figure 3b shows the top clouds temperature in NEB, 19 January 2004.

Thermodynamic processes were studied by vertical profiles, elaborated by two data sources: 1) NCEP reanalysis data in CCM center and 2) radiosonde for cities near CCM. The instability formation was available using K, TT, LI indexes and CAPE (Convictive Available Potential Energy) by Djuric [43].



a)



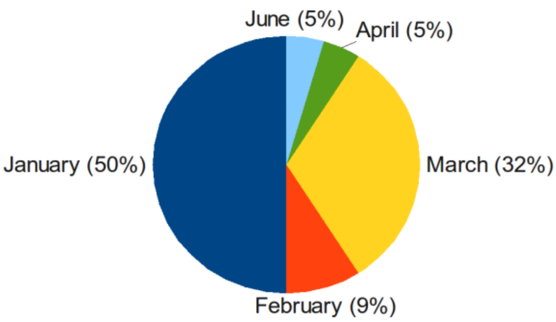
b)

Figure 3 – CCM characteristics calculation in NEB on 27 March 2005, 06UTC:
a) IR images with CCM diameter calculation, b) top clouds temperature identification.

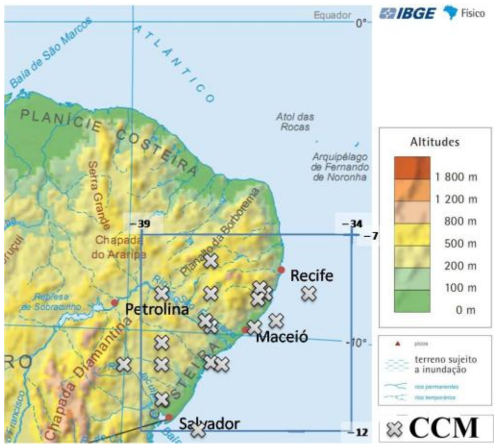
3. Results

3.1 CCM characteristics in Alagoas

CCM were registered principally in more hot time period, 50% of cases in January and 32% in March. Only 9% of CCM were observed in February (Figure 4a). Also, CCM were identified in rain and more cold time period, April and June (5% of events in each month). CCMs localization in the maximal development stage is presented in figure 4b. All this CCM were passed through Alagoas in the same period of life. Also, figure 4b has shown that CCM in that stage were predominated above the continental region than over ocean. It is interesting to note that classical CCM investigations (Silva Dias, Velasco & Fritsch [40, 41]) did not show CCM presence in this region.



a)

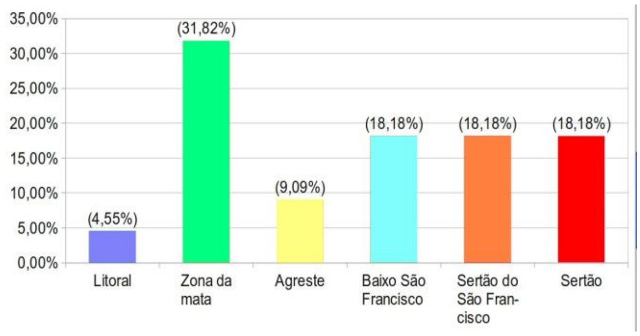


b)

Figure 4 – a) Seasonal CCM frequency in Alagoas State for four years (2003-2006),
b) CCM localization in the maximal development stage.

CCM were observed more frequently (31,8% of events) in Zona da Mata region (Figure 5). This ambient region has mountains (up to 800m) and is localized near less deep ocean with warm ocean current (Mattos,[44]). It is important to note, that in more dry regions in west (Sertao and Sertao do Sao Francisco) and south (Baixo do Sao Francisco) of State are registered 18,2% of CCM events in each region. More rarely CCM were observed in Litoral region, which is localized on the ocean coast.

a)



b)

Figure 5 – CCM localization in Alagoas State: a) Alagoas map with precipitation stations (point) and ambient regions (color) and b) CCM formation frequencies in the ambient regions for four years (2003-2006).

CCM morphological characteristic are presented in table 1. Average CCM duration was 11h, in two events in January the duration were reached 18h. Maximal CCM dimensions were observed in the morning, between 00 and 12UTC. This conclusion is different, comparing with (Maddox, Velasco & Fritsch, [38, 41]) information. By Maddox and Velasco, CCM in the central region of South America present the maximal development during night.

Table 1 – CCM characteristics.

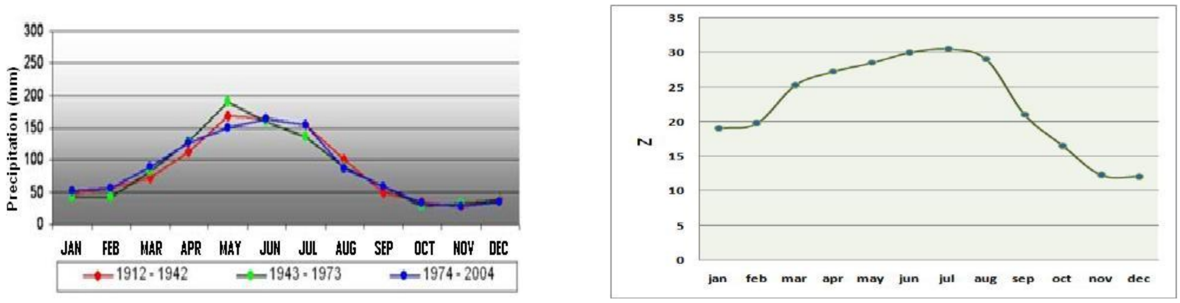
D- CCM duration (hours), ***h***- maximal development hours (UTC), ***Lat*** and ***Lon:*** CCM center coordinates (*Lat* – latitude, *Lon* - longitude) on the maximal development hours, ***Z*** and ***M***- Zonal and Meridional diameters in the maximal development CCM, ***E***- Eccentricity, ***A*** - top clouds area with T<-40°C (km²), ***T*** - minimal top clouds Temperature (°C).

Events		***D***	***h***	***Coordinates***		***Diameters***		***E***	***A***	***T***
#	***Date***			***Lat***	***Lon***	***Z***	***M***			
1	01/23/03	12	09	-09	-35	398	227	1,75	70956	-
2	01/28/03	09	09	-08	-38	602	321	1,88	151768	-
3	03/19/03	09	06	-08	-34	349	376	0,93	103061	-
4	01/12/04	12	00	-10	-38	522	556	0,94	227943	-
5	01/16/04	12	06	-11	-38	479	579	0,83	217818	-
6	01/17/04	15	18	-09	-36	345	344	1,00	93209	-
7	01/18/04	18	21	-10	-37	742	916	0,81	533800	-
8	01/19/04	18	06	-12	-36	626	462	1,35	227141	-60
9	01/31/04	09	06	-08	-35	518	299	1,73	121641	-55
10	04/13/04	09	06	-09	-37	450	360	1,25	127231	-65
11	01/15/04	09	06	-10	-39	282	282	1,00	62456	-55
12	02/11/05	09	24	-08	-36	634	352	1,80	195271	-70
13	02/17/05	15	00	-10	-37	668	908	0,74	476367	-60
14	03/27/05	12	12	-08	-37	514	493	1,04	199019	-50
15	03/28/05	06	06	-09	-37	408	289	1,41	92606	-65
16	03/30/05	09	09	-10	-38	491	188	2,61	72591	-65
17	31/03/05	12	12Z	-7	-37	716	415	1,73	233368	-60
18	02/06/05	12	12Z	-8	-34	662	383	1,73	199130	-65
	Average	**11,5**				**522,6**	**430,6**	**1,36**	**188071**	**-60,9**

Average zonal and meridianal CCM dimension are 522 and 430km, respectively, and maximal values 742 and 916km (table 1). These CCM dimension were less than in typical CCM region in the Argentina North and Brazilian South (Maddox, Velasco & Fritsch, [38, 41]). Average CCM eccentricity was 1.4 and its variation was between 0,7 and 2.6. The CCM region with top clouds temperature less than -40°C was an average 188.071km^2, minimal and maximal values were 533.800km^2 and 62.456km^2. The minimal top clouds temperature reached -70°C and at an average was -61°C.

3.2 Precipitation frequency in Alagoas State

The rain (April - July) and dry periods are observed in Alagoas by climatological data (figure 6a). During studied period the days number with precipitation more than 0,1 mm were higher between March and August (figure 6b). The heavy precipitation cases commonly occurred in autumn/winter except January, when half of all spring/summer intense precipitation events occurred.



a) b)

Figure 6 –Mean precipitation by climatological data for 1912-1942 (red), 1943-1973 (green) and 1974-2004 (blue) years (a) and average days number (N) with precipitation ≥0,1 mm/24h in Alagoas during the study period 2003-2006 (b).

3.3 Synoptic processes related to rain formation

Precipitation (≥ 5mm/24h) was associated more frequently with WDTW (168 events) and Tl (160 events) (Table 2). JSNEBs were weak (with maximal wind velocity 32-36m/s) during all study period. It is important to note that JSNEBs help in ascendant movement formation and they have influenced on the precipitation development in 114 events. New synoptic scale system MTCV (baroclinic cyclonic vortex only in middle atmosphere) was identified and MTCV evolution was described in 7 events with precipitation. High at the high levels was observed in 13 precipitation events.

Table – 2 Quantity (***Q***) of systems related to precipitation ≥ 5mm/24h for four years (2003-2006).
Synoptic Systems: UTCV - Upper Tropospheric Cyclonic Vortex, MTCV - Middle Tropospheric Cyclonic Vortex , JSNEB - jet stream near the NEB, ITCZ - intertropical convergence zone, ITCZ - ITCZ pulses, EW - easterly waves, FE - frontal extremity.
Mesoscale Systems: WDTW - wave disturbance in the trade wind and MCC - mesoscale convective complex (MCC).
Pressure field: Tl, Tm and Th - troughs at the low, middle and high levels, respectively;
Hm and Hh - High at the middle and high levels; CONFl and CONFm - wind Confluence at the low and middle levels, respectively; DIFm and DIFh - diffluence at the middle and high levels, respectively.

Systems	***Q***	Systems	***Q***
WDTW	168	CONFm	25
Tl	160	Hm	23
JSNEB	114	DIFh	23
Th	49	MCC	18
DIFm	47	UTCV	17
Tm	41	Hh	13
ITCZp	35	MTCV	7
FE	33	EW	3
CONFl	28	ITCZ	1

MCC (7 events) and Cb conglomerations (7 events) development were the principal process, which provoke the intensive precipitation (Table 3). Tables 2 and 3 comparison shows that only 7 of all 18 CCM events were associated with intensive precipitation in Alagoas. Only CCM cloudiness was registered in other events in the State. JSNEB were presented during 9 events and were accompanied by intensive convection (Table 3). Also, intensive precipitation was formed in the frontal extremity (7 events) and in WDTW (6 events). Easterly waves and ITCZ were observed rarely during intensive precipitation days (each system was detected only once). The UTCV is the principal synoptic scale system in summer near NEB, but in this situation precipitation was formed only once.

Table – 3 Synoptic Systems (***SS***) related with intensive precipitation four years (2003-2006) in ambient regions (***AR***) of Alagoas State.

Symbols are the same as in the table 2 and also Cb – Cumulonimbus conglomeration; fat - in rain period.

Time period	***SS***	***AR***	***Time period***	***SS***	***AR***
28/1/2003	MCC	C	2-4/5/2005	**FE/Cb**	**B, C**
15/6/2003	**EW/JSNEB**	**A, B**	13-14/6/2005	**WDTW**	**B**
4-5/9/2003	FE/JSNEB/ WDTW	B	5/12/2005	MCC /FE/ JSNEB	C
17/10/2003	FE	B	23-24/3/2006	MCC /JSNEB/ITCZp	C
12/1/2004	FE/MCC/JSNEB	C	19-20/4/2006	Cb/ /ITCZ	C
18/1/2004	MCC /FE/	B, C	25/4/2006	Cb/ JSNEB	B
13/4/2004	**MCC**	**B, C**	30/4-/5/2006	Cb/ JSNEB	B, C
12/5/2004	**Cb**	**C**	15/5/2006	FE/ JSNEB	B
1-2/6/2004	**Cb / WDTW /**	**A, B, C**	17/6/2006	WDTW	B
14-17/6/2004	**Cb** / WDTW **/JSNEB**	**A, B**	9-10/9/2006	WDTW	B, C
13-14/1/2005	MCC / UTCV	C			

The intensive precipitation was registered, principally, in region 2 (Zona da Mata, figure 7). This precipitation was associated with MCC and WDTW and was accompanied by JSNEB. Also, the intensive precipitation was formed in region 5 (Sertao de Sao Francisco) under high level trough.

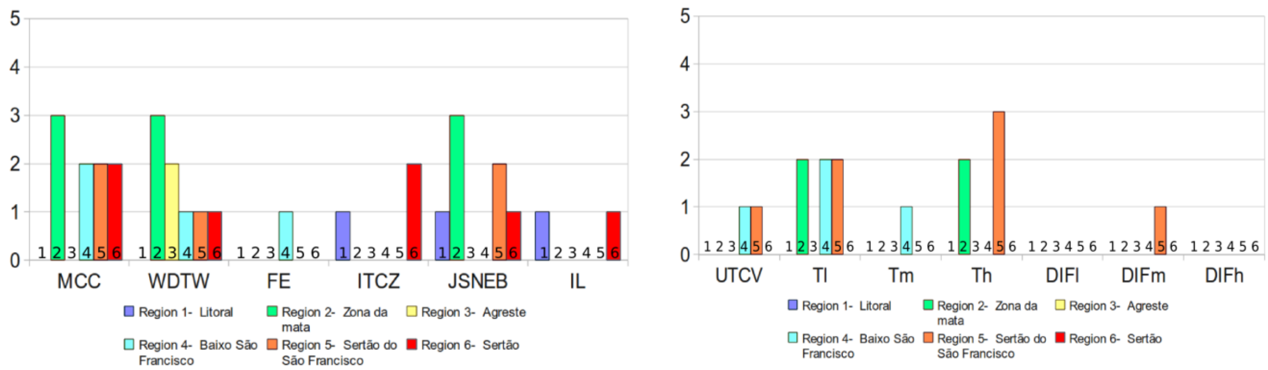


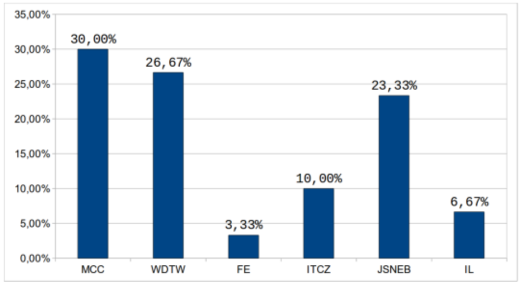
Figure 7 – Quantity of intensive precipitation events (axis Y) related with synoptic systems in ambient regions of Alagoas State.

Symbols are the same as in the table 2

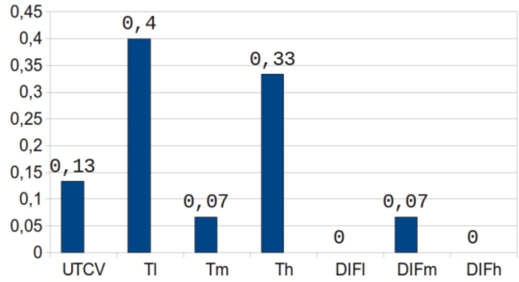
3.4 Synoptic and baric systems related to CCM formation

The CCMs are responsible for 30% of intensive precipitation in Alagoas (Figure 8a, first pillar). The CCMs were formed in WDTW in 26,7% and these CCMs were accompanied by JSNEB in 23,3% (Figure 8a). The CCM s were as a part of the ITCZp in 10,0% and of instability line (IL) in 6,7% . Frontal zone have observed very rarely in tropical region (Fedorova et al., Gemiacki, Cruz, [21, 35, 36]), but a frontal extremity were responsible for CCM formation in 3,3% of all CCMs.

Low levels troughs were the principal baric systems associated with CCM formation and were observed in 40,0% of CCM events (Figure 8b). High levels troughs (Th) were related with CCM in 33,3% of events. UTCV were observed in 13,3% of CCM events. Middle level baric systems have not important role in CCM formation: troughs and air current diffluence in these levels were observed only in 6,7% of events.



a)



b)

Figure 8 – Synoptic (a) and baric (b) systems associated with CCM formation in the Alagoas State for four years (2003-2006).

Percents (a) were calculated as a relative quantity day with intensive precipitation in that time period and first pillar show CCM percent in intensive precipitation formation. Percent in (b) was calculated relative a quantity days with CCM.

Symbols are the same as in the table 2

The UTCV at the high levels were associated with diffluent air current in the low levels in the CCM events (Table 4). CCM events in trade wind were related predominately to ridge at the middle and high levels. The low levels ridges were reached at the middle levels in CCM events.

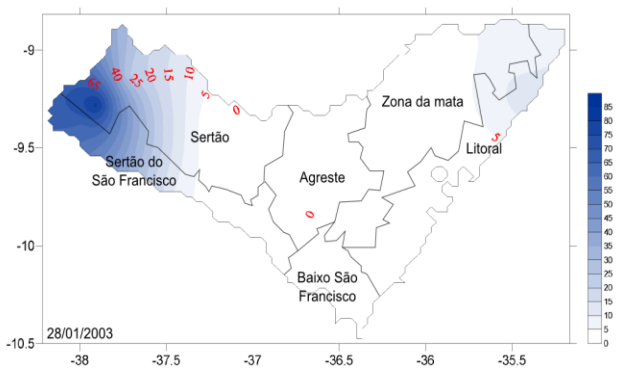
Table – 4 Baric Systems related with CCM formation at 1000, 500 and 200hPa levels for four years (2003-2006).

UTCV: Upper Tropospheric Cyclonic Vortex, ***MTCV***: Middle Tropospheric Cyclonic Vortex, ***JSNEB***: jet stream near the NEB, ***T***: trough, ***R***: ridge, ***BTR***: between T and R, ***TW***: trade wind, ***CONF***: wind Confluence, ***DIF***: wind Diffluence.

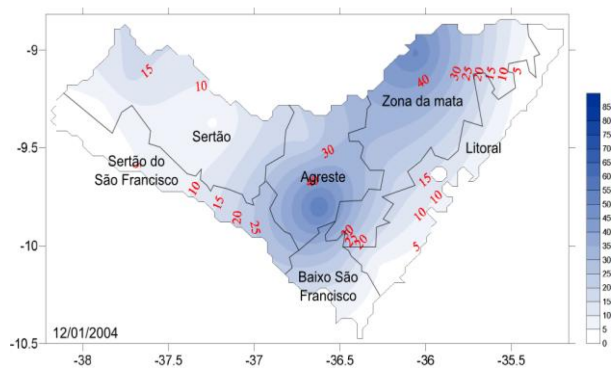
Events		*Baric-Systems*			*Events*		*Baric-Systems*		
#	Date	200hPa	500hPa	1000hPa	#	Date	200hPa	500hPa	1000hPa
1	01/23/03	UTCV	CONF	DIF	12	01/31/04	R	R	TW
2	01/28/03	T	BTR	R	13	04/13/04	T	R	TW
3	03/19/03	R	BTR	TW	14	01/15/04	UTCV	MTCV/H/CONF	DIF
4	03/31/03	-	R	TW	15	02/11/05	T	DIF	TW
5	01/12/04	DIF	CONF	R	16	02/17/05	-	DIF	DIF
6	01/14/04	-	BTR	R	17	03/27/05	-	DIF	ITCZ
7	01/15/04	-	R	R	18	03/28/05	-	DIF	TW
8	01/16/04	-	R	R	19	03/30/05	T	R	T
9	01/17/04	R	R	R	20	06/02/05	JSNEB	CONF	T
10	01/18/04	R	CONF	CONF	21	03/23/05	R	-	TW
11	01/19/04	R	MTCV	CONF	22	03/24/06	R	R	TW

3.5 Precipitation in CCMs

Precipitation maps are presented for more intensive precipitation events (Figure 9). The maximal precipitation reached 70- 80 mm/day in some events. Heavy precipitation in drier Alagoas region (Sertao) is presented in Figure 9a and f which show precipitation up to 80 and 50mm/24h, respectively. Heavy precipitation in coastal region in CCM events (Figure 9c and d) were up to 60 and 75mm/day. According to climatological yearly data and Institute of Meteorology (INMET) precipitation >100mm/day are intensive for this region.



a)



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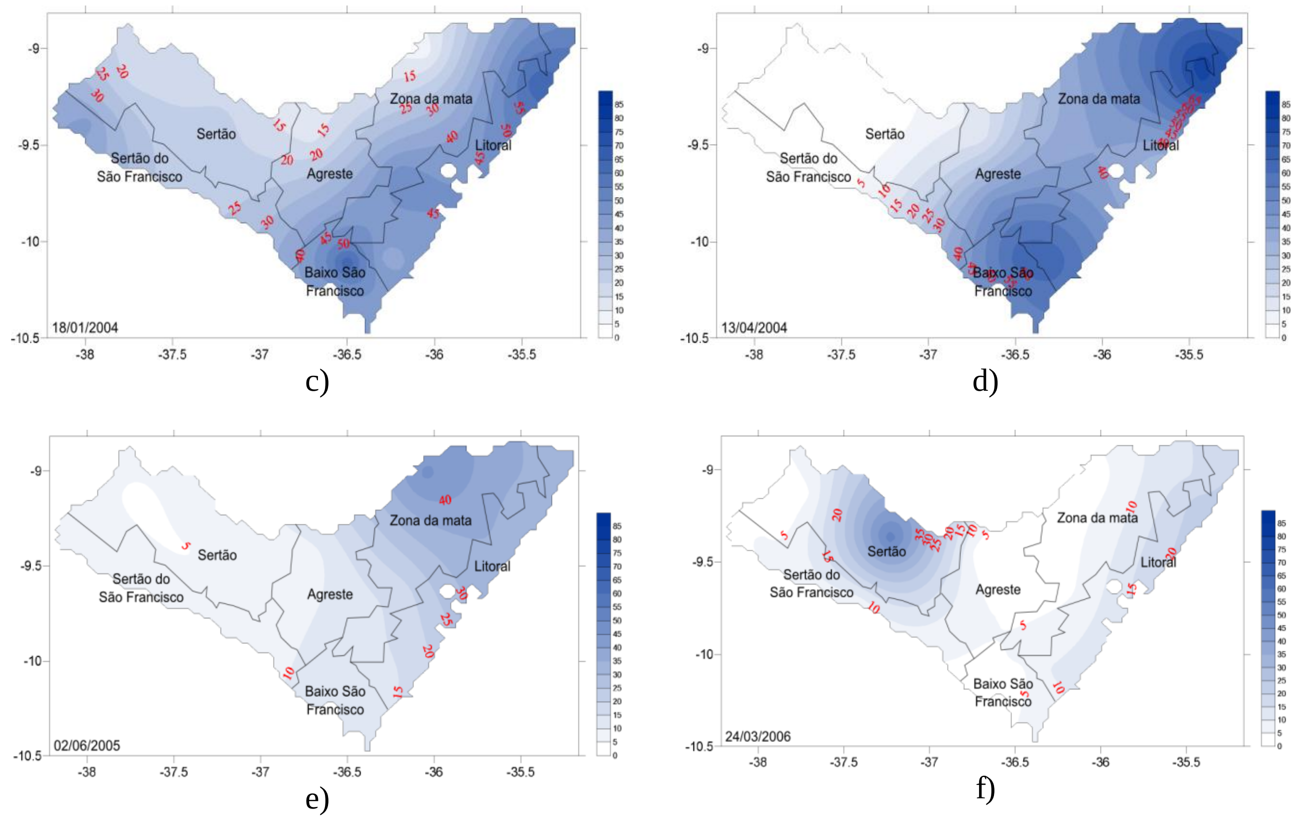

Figure 9 – Precipitation distribution for intensive CCM events: a) 28 January 2003, b)12 January 2004, c) 18 January 2004, d) 13 April 2004, e) 2 June 2005 and f) 24 March 2006.

3.6 Thermodynamic CCM characteristics

Radiosonde data near CCM show the low instability values (Table 5) because the most intensive clouds area did not observed near those meteorological stations. For example, cloud thickness was an average 7 km (*HLCL- HEL* = 6799m), mean CAPE was 147 J/kg, and LI equal 0. Space radiosonde station localization did not permit to use this data for intensive convection analisys.

Table – 5 CCM thermodynamic characteristics by radiosonde data for cities near CCM.
D - CCM duration, ***h*** - maximal development hours (UTC), ***Lat*** and ***Lon*** - CCM center coordinates on the maximal development hours, ***Indexes****:* instability indexes K, TT, LI and CAPE,
Information: additional information about vertical profile, ***LCL*** - Lifting Condensation Level (*hPa* and *K*), ***LFC-*** Level of Free Convection (*hPa), **EL*** - equilibrium level, convection top (hPa), ***THI*** - thickness 1000-500 (m), ***PW*** - precipitable water (mm/m^2), ***HLCL*** - LCL height (m), ***HEL*** - EL height (m), ***HLCL - HEL*** (m), ***TEL*** - EL temperature (^oC).

Events		D	h	Coordinates		Station	TP	Indexes				Information									
#	Data			Lat	Lon			K	TT	LI	CAPE	LCL (hPa)	LCL (K)	LFC	EL	THI	PW	HLCL	HEL	HLCL-HEL	TEL
2	20.01.2003	09	09	-08	-38	Petrolina	12	30	42	01	00	894	289	-	-	5747	43	1000	-	-	-
3	19.03.2003	09	06	-08	-34	Recife	12	29	38	00	00	935	293	-	-	5770	49	800	-	-	-
4	12.01.2004	12	00	-10	-38	Petrolina	12	28	41	01	00	854	288	-	-	5783	43	1530	-	-	-
5	16.01.2004	12	06	-11	-38	Salvador	12	30	39	-02	925	903	293	895	158	5789	49	800	1300	500	-65
8	19.01.2004	18	06	-12	-36	Salvador	12	32	40	02	00	920	291	462	460	5760	54	800	6000	5200	-10
9	31.01.2004	09	06	-08	-35	Recife	12	28	41	00	47	928	293	553	237	5777	49	790	11000	10210	-45
11	15.01.2005	09	06	-10	-39	Petrolina	12	33	44	-01	181	895	291	704	287	5758	47	800	9000	8200	-30

12	11.02.2005	09	24	-08	-36	Recife	12	23	40	02	00	865	288	-	-	5770	39	1300	-	-	-
13	17.02.2005	15	00	-10	-37	Petrolina	12	29	40	00	119	903	292	676	357	5782	45	800	8000	7200	-30
14	27.03.2005	12	12	-08	-37	Recife	12	27	42	00	23	896	291	521	391	5771	48	900	7500	6600	-17
15	20.03.2005	06	06	-09	-37	Recife	12	26	41	-01	172	913	292	651	323	5772	48	850	8000	7150	-30
16	30.03.2005	09	09	-10	-38	Recife	12	27	43	-02	476	915	293	628	186	5791	49	870	12500	11630	-57
17	31.03.2005	12	12	-07	-37	Recife	12	08	41	-01	110	901	291	616	274	5778	38	800	9000	8200	-25
18	02.06.2005	12	12	-08	-34	Recife	12	33	41	01	01	913	291	590	571	5769	52	900	4000	3100	-10
	Average	11	-	-	-	-	-	27	41	0	147	902	291	630	324	5773	47	924	7630	6799	-32

Vertical profile drawn by NCEP reanalysis data in CCM center, confirmed the intensive instability: K, TT, LI indexes were at an average 28, 42 and -5, respectively, and mean CAPE was 1399J/kg. These K and TT indexes have shown the intensive precipitation formation and LI index also present thunderstorm development. It is important to note, that these thermodynamic characteristics were less than for middle latitude CCMs.

Table – 6 CCM thermodynamic characteristics by NCEP reanalysis data in CCM center
The symbols are same in the table 5.

Events		***D***	***h***	***Coordinates***		***Indexes***				***Information***			
#	***Data***			***Lat***	***Lon***	***K***	***TT***	***LI***	***CAPE***	***LCL (hPa)***	***LCL (°C)***	***PW***	***HLCL***
1	23.01.2003	12	09	-09	-35	24	38	-03	1336	950	21	31	400
2	20.01.2003	09	09	-08	-38	31	42	-05	1607	990	24	41	150
3	19.03.2003	09	06	-08	-34	30	40	-05	1604	985	24	43	200
4	12.01.2004	12	00	-10	-38	21	41	-05	1489	979	24	34	300
5	16.01.2004	12	06	-11	-38	30	41	-04	1385	985	24	44	200
6	17.01.2004	15	18	-09	-36	33	40	-05	1401	955	23	47	400
7	18.01.2004	18	21	-10	-37	35	43	-06	1587	969	24	52	300
8	19.01.2004	18	06	-12	-36	39	45	-04	979	964	22	54	300
9	31.01.2004	09	06	-08	-35	32	42	-04	1352	997	24	44	20
10	13.04.2004	09	06	-09	-37	13	40	-04	814	894	20	30	950
11	15.01.2005	09	06	-10	-39	38	47	-06	1353	985	23	48	200
12	11.02.2005	09	24	-08	-36	16	37	00	138	863	17	29	1300
13	17.02.2005	15	00	-10	-37	30	45	-04	1134	938	22	39	600
14	27.03.2005	12	12	-08	-37	31	42	-05	1530	990	24	41	150
15	28.03.2005	06	06	-09	-37	30	42	-06	1772	972	24	39	300
16	30.03.2005	09	09	-10	-38	28	43	-08	2015	977	25	38	300
17	31.03.2005	12	12	-07	-37	28	41	-06	1822	963	24	41	400
18	02.06.2005	12	12	-08	-34	22	38	-06	1856	982	24	38	300
	Average	12	-	-	-	29	42	-5	1367	960	23	42	409

4. Conclusion

The patterns of the synoptic and mesoscale systems associated with precipitation more than 5mm/24h and with intensive precipitation were established. The important role of WDTW and troughs at the low levels was distinguished. The influences of MTCV and JSNEB in heavy precipitation formation were revealed.

CCM were observed predominately in summer months, from January to March. CCM were affected more frequently in the Zona da Mata region (mountainous), and some less frequently in more dry regions of west and of south of the State. Wave Disturbances in the Trade Winds and low levels troughs were principal systems related to CCM development.

The CCM characteristics did not show any grate values. The mean CCM diameter was 500 km with variation between 200 and 900 km. The average CCM area was 190.000km² and mean CCM duration was 11hours. The CCM were developed during night period with the maximal development in the morning. The average top cloud temperature was equal to -60°C with the minimum value of -70°C.

Vertical profiles drawn by NCEP reanalysis data in CCM center, confirmed the intensive instability, but all thermodynamic characteristic were less than for middle latitude CCMs. Radiosonde data near CCM show the low instability values and did not permit to use this data for intensive convection analysis. The Mesoscale Convective Complexes have caused the greater part of the storms in the west Alagoas, which was not found in the coastal area.

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Мезомасштабный конвективный комплекс на северо-восточном побережье Бразилии

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Резюме

Основная цель исследования - физический и морфологический анализ особенностей всех Мезомасштабных Конвективных Комплексов (*МКК*) в течение 4 лет (2003 - 2006) в штате Алагоас (Бразилия) в период с 2003 по 2006 гг. При наличие *МКК* для анализа осадков использовались данные семнадцати плювиометрических станций Алагоаса. Национальный Центр Прогноза Окружающей Среды результаты ре-анализа использовал для системы мониторинга погоды. Ложбины и волновые возмущения в области пассата были главным образом связаны с формированием *МКК*. При *МКК* осадки количеством ≥ 5,0 мм были лишь в 7 % случаев, тогда как интенсивные осадки в - 70 % случаев. Обильными осадками больше всего был затронут регион Zona da Mata штата Алагоас. Регистрация *МКК* была проведена по спутниковым инфракрасным изображениям, с использованием программного обеспечения *MATLAB*. Диаметр *МКК* измененялся от 200 до 900 км со средним значением 500 км. Были определены следующие средние параметры *МКК*: площадь - 190000 км ^{2}, продолжительность - 11 часов. Максимальная стадия развития наблюдалась утром. Для анализа температуры верхушки облаков использовались данные *METEOSAT* оперативной системы *EUMETSAT UMARF* и программное обеспечение *xrit2pic*. Средняя температура верхушки облаков была равна -60°C с минимальным значением -70°C. Для исследования термодинамических особенностей *МКК* использовались данные вертикального зондирования температура и влажности, а также данные ре-анализа *NCEP*. Идентификация штормов по индексам *K, TT* и *LI* показала удовлетворительные результаты, но значения индексов были всегда ниже, чем в практическом руководстве. В западной части штата Алагоас большая часть штормов (90 %) связана с *МКК*, тогда как в восточной части – этой связи нет.

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ავთანდილ გ. ამირანაშვილი

რეზიუმე

გამოკვლევის ძირითადი მიზანი – ყველა მეზომასშტაბური კონვექტიური კომპლექსის (მკკ) თავისებურებების ფიზიკური და მორფოლოგიური ანალიზი 4 წლის განმავლობაში (2003-2006) ალაგოასის შტატში(ბრაზილია). მკკ-ს არსებობისას ნალექების ანალიზისათვის გამოიყენებოდა ალაგოასის ჩვიდმეტი პლუვიომეტრიული სადგურის მონაცემები. გარემოს პროგნოზის ნაციონალური ცენტრი რე-ანალიზის შედეგებს იყენებდა ამინდის მონიტორინგის სისტემისათვის. ღრმულები და ტალღური შეშფოთებები პასატის გარემოში ძირითადად დაკავშირებული იყო მკკ-ს ფორმირებასთან. მკკ-ს დროს ნალექები ≥ 5,0 მმ-ზე იყო მხოლოდ შემთხვევების 7% -ში, მაშინ როდესაც ინტენსიური ნალექები შემთხვევების 70%-ში. Uუხვი ნალექები ყველაზე მეტად შეეხო ალაგოასის შტატის Zona და Mata–ს რეგიონს. მკკ-ს რეგისტრაცია ჩატარდა თანამგზავრული ინფრაწითელი გამოსახულებებით, MATLAB-ის პროგრამული უზრუნველყოფის გამოყენებით. მკკ-ს დიამეტრი იცვლებოდა 200-დან 900-ს კმ-მდე 500-კმ საშუალო მნიშვნელობისას. განსაზღვრული იყო მკკ-ს შემდეგი საშუალო პარამეტრები: ფართობი - 190000კმ^2, ხანგრძლივობა – 11 საათი. განვითარების მაქსიმალური სტადია დაიკვირვებოდა დილით. ღრუბლების წვეროების ტემპერატურის ანალიზისათვის გამოიყენებოდა EUMETSAT UMARF ოპერატიული სისტემის METEOSAT – ის მონაცემები და პროგრამული უზრუნველყოფა x1it2pic. ღრუბლების წვეროების საშუალო ტემპერატურა -60°C იყო, -70°C-ის მინიმალური მნიშვნელობით. მკკ-ს თერმოდინამიკური თავისებურებების გამოკვლევისათვის გამოიყენებოდა ტემპერატურისა და ტენიანობის ვერტიკალური ზონდირების მონაცემები, და აგრეთვე NCEP-ს რე-ანალიზის მონაცემები. ქარიშხლების იდენტიფიკაციამ K, TT და LI ინდექსების მიხედვით აჩვენა დამაკმაყოფილებელი შედეგები, მაგრამ ინდექსების მნიშვნელობები ყოველთვის უფრო დაბალი იყო, ვიდრე პრაქტიკულ სახელმძღვანელოში. ალაგოასის შტატის დასავლეთ ნაწილში ქარიშხლების უმეტესი ნაწილი (90%) დაკავშირებულია მკკ-ს თან, მაშინ როდესაც აღმოსავლეთ ნაწილში ასეთი კავშირი არ არის.