V16A TRACKING MESOSCALE CONVECTIVE SYSTEM CORES, OVER NORTHERN SOUTH AMERICA, USING OVERLAPPING TECHNIQUE

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It has been observed in recent years that usually, during the hurricane season, tropical storms start traveling close to northern South America (e.g., tropical storms Bonnie 2022, Julia 2022, Franklin 2023). Even if the core of the storm doesn't cross northern South America the mesoscale convective systems, particularly its core which forms in the surrounding storm bands, can cause severe economic damage and life threats. Thus, tracking these systems can provide valuable information for forecasting and research purposes.

1. INTRODUCTION

Image overlapping has been extensively used to track Mesoscale Convective Systems (MCS) using satellite imagery (Wielicki & Welch 1986, Williams & Houze 1987, Machado et al. 1998, Mathon and Laurent 2001, Machado & Laurent 2004, Vila et al. 2008, Feng et al. 2012, Kolios & Feidas 2013, among others) and more recently (Chen et al. 2019, Feng et al. 2021, Galarneau et al. 2022). A shortcoming of this method (Vila et al. 2008, Fiolleau and Roca 2013, Kolios & Feidas 2013) is that when merging or splitting occurs, this tracking technique gives nonphysical values. Alternatively, other methods have been developed such as spatial correlation Patterns (Carvalho and Jones 2001), projected-cloud-edge tracking techniques (Kelly et al. 2020), variational data assimilation procedure (Thomas e. a. 2011) and others. Due to its simplicity, the overlapping technique is applied in the present study for tracking mesoscale Convective system Cores (CC) over northern South America.

2. THE METHODOLOGY

Generally, the overlapping approach (Vila et al. 2008) is used. First, CC in the GOES IR image with brightness temperature less than a threshold value (215°K, i.e., the core of the cloud mesoscale system) are initially identified. This brightness temperature threshold is a bit lower than the value used in (Machado et al. 1998) for active deep convection. Then, the CC is tracked in subsequent images every 10 minutes. If, within two successive IR images (see Feng e. a. 2012) a CC overlaps itself by more than 25% of its area, this cloud system is considered as the same system and its track continues. The path connecting the different positions (with time) of the geometrical center of the CC is then drafted. The geometric center, or center of mass, is defined as in Machado, et al. (1998) by the average latitude and longitude of all pixels belonging to one CC. CC with area less than 100 pixels (200 km²) are not considered. When two or more CC merge together, the largest overlapped CC is assumed to continue, and the smaller overlapped CC are terminated. Similarly, when a CC splits into several smaller CC, only the largest overlapped fragment continues carrying the characteristics of the original system.

3. DATA USED, COMPUTATIONAL AND PLOTTING DETAILS

GOES infrared (10 µm) and GFS wind data are used in this work. The computation was initiated at 02:30 GMT of 20 August 2023 and lasted till 18:00 GMT of the same day. Due to limited computational resources, CC extracted from the satellite image along with the path traveled since the moment of its formation, is plotted within a small domain of 10x10 degrees. Also, wind vectors at 250hPa, extracted from GFS analysis at the nearest time, is superimposed over the tracked CC. Additionally, all paths occurred from the beginning of the computation until a selected time, are superimposed over the satellite image in the larger plotting domain (see, Fig. 4).

4. RESULTS

The proof of concept of this technique, was tested with the tropical storm Franklin while approaching the Caribbean coast of Guyana, Venezuela and Colombia on august 20, 2023 Year. At 02 : 40z, tropical storm Franklin (F) was located (approximately) at 63W 13N.

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At this time, several hundred km south of F (at 66W 6N, see Fig.1), a convective core (CC1) was registered.

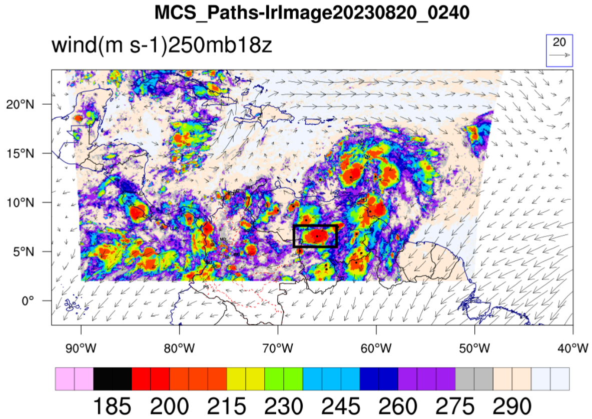

Fig 1. Infrared image at 02:40z with superimposed wind vectors at 250 hPa level. A convective core CC1, formed in one of the bands of storm Franklin is highlighted within a rectangle.

This CC1, which formed about 2 hours earlier within one of the bands of F, had (at this time) an area of about 15000 km² and continued developing to the west. Fig. 2 shows this CC1 (marked with number 14) in small domain. Approximately 1 hour later, several hundred km west of CC1, another convective core (CC2) formed at 71W 6N near to Arauca Colombia (see Fig. 3). The formation of this second CC2, developed during the nocturnal convection, apparently had no relationship with the F storm bands. This second CC2 continued its development to the south, east and north directions. Six hours later, at 10: 20z, these two systems merged and formed a huge convective system (see Fig. 4). The tracks of all CC formed since the beginning of the computation, until 10: 30z, are superimposed over this Figure. We can see that while the track of CC2 is oriented in the southeast – northwest direction, the path of the merged system has a quasi-horizontal (east west) orientation following the wind circulation over the south, southwestern side of the tropical storm Franklin.

The new system occupied an area larger than 36000 km² and began dissipating approximately at 14:00z.

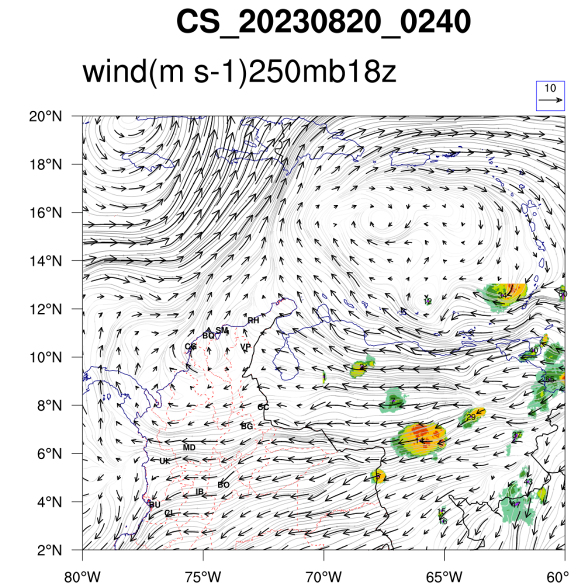

Figure 2. Tracked CC on the small domain. In this Fig. the convective core CC1 (see text) is marked with the number 14. The two-character names within the map, point to some ICAO named airports, over Colombian territory. The overlapped arrows represent the wind at 250hPa.

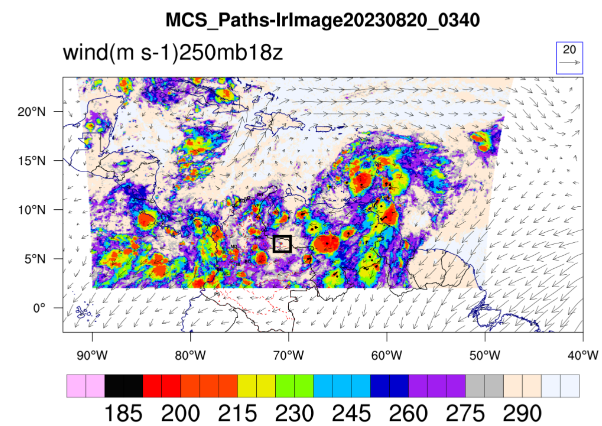

Fig 3 Same as in Fig.1 but for the convective core CC2 (highlighted within rectangle) at time 0340z.

5. Summary

Two convective cores (CC1 and CC2) were tracked over Northern South America. The computation started at 02: 30z of August 20, 2023 Year and ended at 18z of the same day. The MCS tracked in this work last about 12 hours.

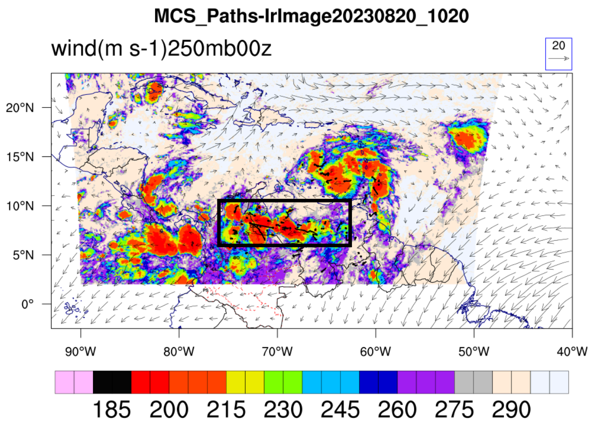

Figure 4. The squall line type mesoscale convective system (highlighted within rectangle) formed as a result of merging of the convective cores CC1 and CC2. Broken black segments indicate the CC track of present and past Convective cores formed since 02:30z.

Useful information, as origin of the disturbance, life cycle, area occupied, strength and direction of propagation and interactions among MCS associated and not associated with tropical storms, can be inferred with help of this tracking technology.

As mentioned above, a shortcoming of overlapping technique is that it produces nonphysical values when merging or splitting occurs. Thus, a new methodology based on a mass conservation criterion, is under developing. A test of this new approach showed encouraging results when merging or splitting of CC occur. These new findings will be presented in a future work.

This MCS tracking technology can be helpful for many practical purposes like severe storm weather warning, photo voltaic energy production, and research studies involving diurnal-nocturnal convection, mountain-valley and sea breeze circulations, etc.

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