Analysis of possible physical factors that accelerate downdrafts in storm clouds over Cuba

Gleisis Alvarez-Socorro

Mario Carnesoltas-Calvo

Alis Varela-de la Rosa

José Carlos Fernández-Alvarez

2. Introduction

- Severe Local Storms (SLS) are considered one of the most dangerous phenomena on the mesoscale.
- One of the manifestations of severity in the SLS is the strong horizontal linear winds (greater than or equal to 25 m/s) observed along a line that moves through the land surface called the Gust Front.
- This air mass is due to the cold downward current of the storm cloud, known as downbursts (DB).

Figure 1. Downburst.

2. Material and Methods

Table 1. WRF model configuration.

Parameters	Configuration
Spatial resolution	27, 9 and **3 km**
Number of points in x	145, 262, **469**
Number of points in y	82, 130, **184**
Vertical levels	28, 28, **28**
Domain center	21.8º N y −79.74º W
Time step	150 s
Microphysics	WSM5, WSM5, **Morrison double moment**
Cumulus	Grell-Freitas, Grell-Freitas, **no activated**
PBL	Mellor-Yamada-Janjic, Mellor-Yamada-Janjic**, Mellor -Yamada-Janjic**

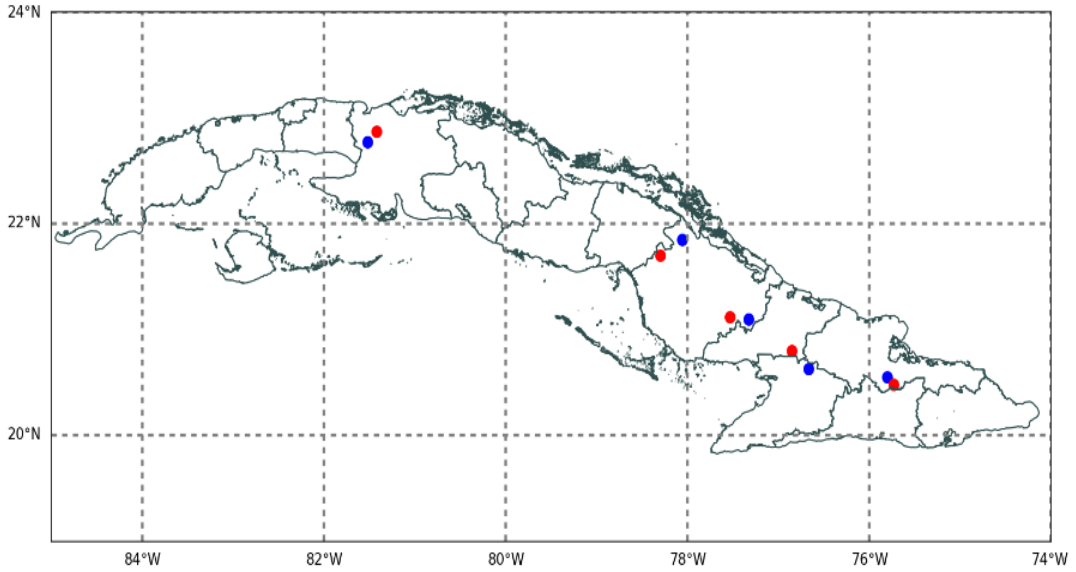

Figure 2. Geographical distribution of the storms analyzed. Red dots represent storms that produced downbursts and blue dots represent thunderstorms.

2. Results and Discussion

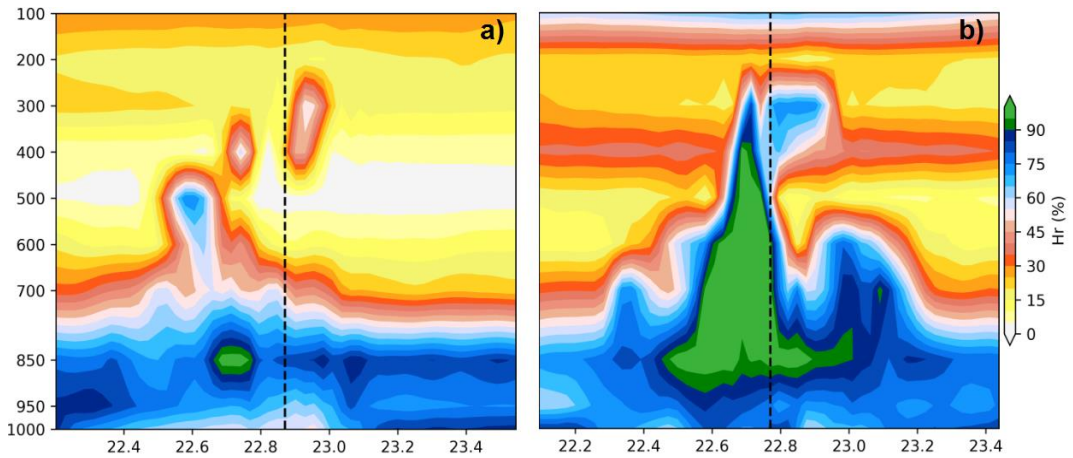

Figure 3. Cross section of relative humidity in latitude from the numerical outputs of the WRF. a) 27 April, 2017 (DB) and b) 30 April, 2017 (TS).

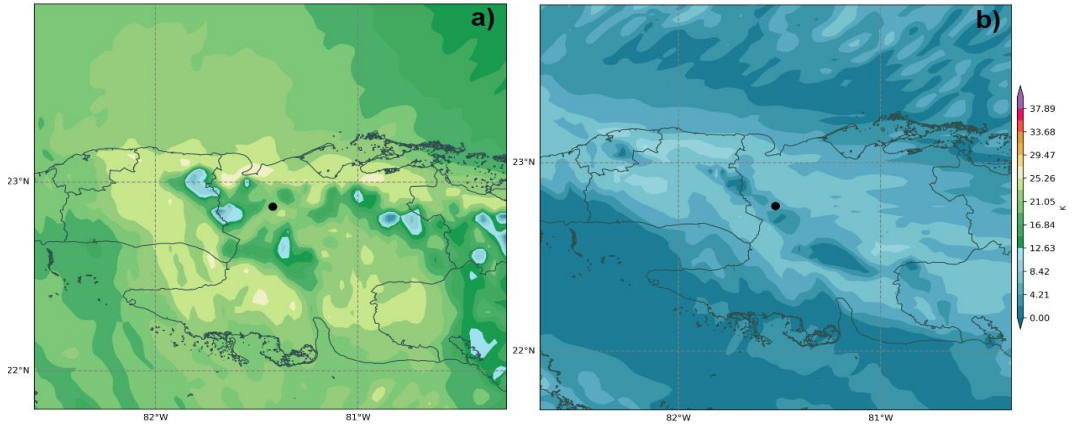

Figure. 4. Equivalent potential temperature difference fields from the numerical outputs of the WRF. a) 27 April, 2017 (DB) and b) 30 April, 2017 (TS).

Table 2. Possible critical values of the variables that can discriminate between the occurrence of DB and TS. Latent heat absorption by evaporation, latent heat absorption by fusion, the equivalent potential temperature difference between the level of maximum humidity in the low levels and minimum humidity in the middle levels, buoyancy.

Date	Type	ΔQ_{LE}(J)	ΔQ_{LF}(J)	Δθeq(K)	B(m/s^2)
27-4-2017	DB	47766.23	6346.72	14.73	0.1429
01-7-2017	DB	48338.42	6435.03	11.99	0.1572
20-7-2017	DB	41797.15	5562.41	12.19	0.1376
21-11-2017	DB	39596.14	5269.84	15.05	0.1133
14-5-2019	DB	32799.18	4364.37	8.99	0.1345
30-4-2017	TS	12749.92	1688.76	6.30	0.0456
03-7-2017	TS	30537.16	4064.28	1.68	0.1002
18-7-2017	TS	27030.77	3587.75	6.48	0.0828
23-11-2017	TS	24607.77	3277.13	4.62	0.0869
13-5-2019	TS	21510.58	2860.20	3.08	0.0785
Possible critical value		32000	4200	8	0.11

2. Results and Discussion

Table 3. Possible critical values of the variables that can discriminate between the occurrence of DB and TS. Energy advection, downdraft velocity, DCAPE.

Data	Type	Adv_e(nm)(10^{-3}J/s)	wDCAPE(m/s)	DCAPE (J/kg)
27-4-2017	DB	62.50	48.62	4727.8
01-7-2017	DB	30.34	44.65	3986.69
20-7-2017	DB	36.77	36.33	2640.2
21-11-2017	DB	**147.19**	**34.52**	**2382.71**
14-5-2019	DB	54.96	36.18	2618.66
30-4-2017	TS	123.86	30.22	1826.79
03-7-2017	TS	74.17	33.19	2203.25
18-7-2017	TS	79.59	35.97	2587.93
23-11-2017	TS	124.28	27.82	1547.9
13-5-2019	TS	131.09	34.47	2375.98
Possible critical value		70	36	2600

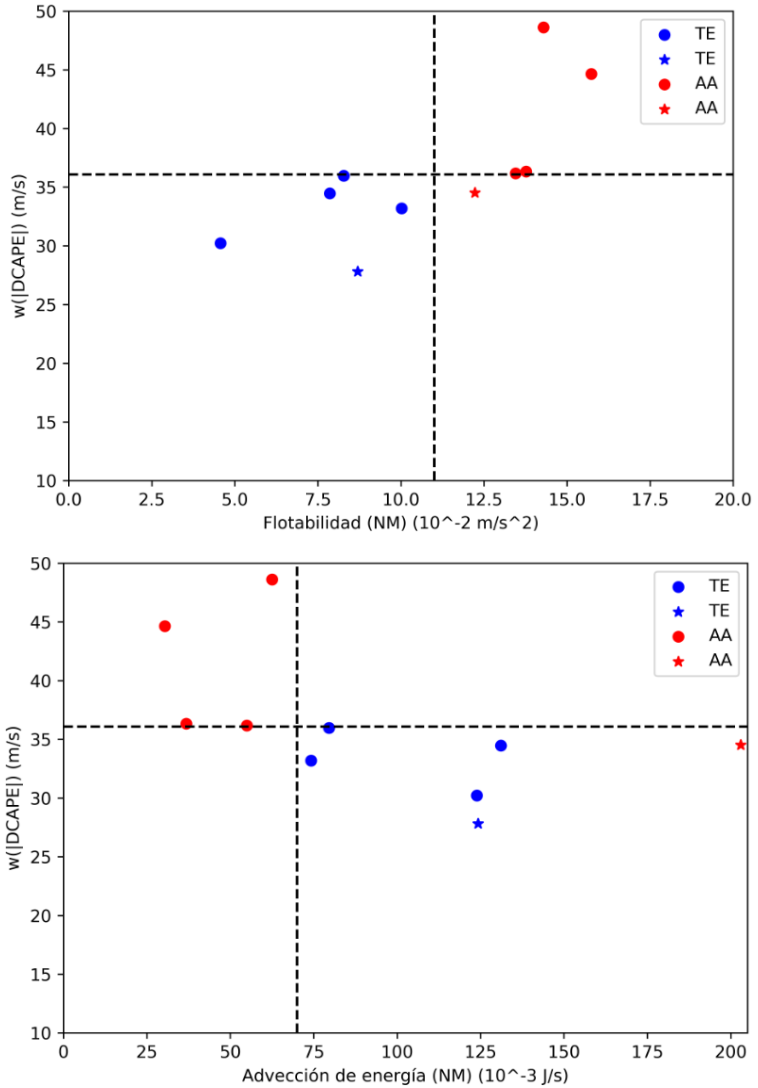

Figure 5. Relationships between: a) buoyancy and vertical speed; b) horizontal advection of energy and vertical velocity.

Conclusions

- The factors that discriminated between the downbursts and thunderstorms without severity for different study cases in Cuba were determined.
- For all the cases analyzed, these are the absorption of latent heat by evaporation and fusion, both in the updraft, the buoyancy at the mean levels, and the equivalent potential temperature difference between the maximum humidity level in the low levels and the minimum humidity level in the middle levels.
- Unlike previous research, buoyancy and energy advection, both in the middle levels of the troposphere, were identified as discriminating factors between the occurrence of downbursts and non-severe thunderstorms.
- Viscosity, precipitable water, Coriolis vertical acceleration, and horizontal mass advection, although contributing to the acceleration of downdrafts, were not able to discriminate between the occurrence of downbursts and thunderstorms without severity, due to the order of magnitude so small that they have compared to the rest of the factors.
- The downbursts of 21 November 2017 did not comply with the critical values established for the horizontal advection factors of energy in the medium levels, the speed of the downdraft and the DCAPE, being able to be related to the time of the exit used and to belong to the dry season of the year.

Analysis of possible physical factors that accelerate downdrafts in storm clouds over Cuba

Gleisis Alvarez-Socorro

Mario Carnesoltas-Calvo

Alis Varela-de la Rosa

José Carlos Fernández-Alvarez