

## 1.1 Supplementary Figures



**Supplementary Figure S1.** Daily precipitation from weather stations in Mocoa (see red dots in **Figure 2a**). Accumulated precipitation is computed from 07:00LT to 07:00LT of the following day. The red lines mark the daily precipitation during the day of the case of study for each weather station, March 31<sup>st</sup> 2017: for both weather stations the case of interest is the fourth largest value in record, which includes data between 1984 and 2022.



**Supplementary Figure S2.** Time series of hourly precipitation rate (left) and accumulation (right) over some locations, according to *in situ* observations (IDEAM, see **Figure 1**) and satellite estimates (GPM). Last row shows values averaged over the sites corresponding to the six weather stations. The red lines mark the interval of the event. For most locations, rain rates from observations (IDEAM) were larger than GPM estimates, with peak values between 22:00 and 00:00 LT (**Figure S2**, left column). In particular, the weather station in Mocoa (Acueducto-Mocoa) recorded 55 mm/hr at one time during the event. Taking into account the non-zero values of precipitation records from the available weather stations, hereafter we define the interval between 19:00 LT of March 31<sup>st</sup> to 03:00 of April 1<sup>st</sup> as the time window of the precipitation event (vertical red lines in **Figures 3 and S2-S3**). Over each site, the duration of the precipitation event was at least 4 hours; in particular, the station in Mocoa recorded 103.3 mm during the event. Note that GPM estimates suggest larger accumulations during the event than the records from the weather stations, except for the Mocoa site (**Figure S2**, right column). In general, GPM is able to identify the event, with overestimations over part of the available stations, mostly from longer recorded events, not from higher precipitation rates. Other heavy precipitation events were also recorded during the previous hours (leading to the 129.3mm total in Mocoa)



**Supplementary Figure S3.** Precipitable water and wind field at 850hPa (a) and their anomalies (b) at 20:00 LT. Time series of spatial averages of precipitable water and vertically integrated moisture flux convergence (Qc) (c) and anomalies in precipitable water and specific humidity (d). Base period is 1979-2019. Spatial averages are computed for the Mocoa Event Region (MER: 76.875°W-74.875°W, 0.125°N-2.125°N), represented by the red box in a) and b).

According to ERA5, large values of precipitable water (PW) were present over the Colombian Amazon prior to the precipitation event (Figure S3a), with positive anomalies of PW over most of Colombia, especially over the Orinoco basin and the Andes-Amazon transition region, where the MCS formed (Figure S3b). In addition, strong low-level northeasterly winds helped with the transport of moisture and the formation of lines of convergence in the vicinity of the Andes, as suggested by the 850hPa winds and corresponding vector anomalies (Figures S3a and S3b, respectively). The time series of the spatial average of PW over the Mocoa Event Region (MER, red box in Figures S3a, b) shows a peak between 23:00LT and 00:00LT (Figure S3c), one hour before the peak precipitation in the Mocoa station (Figure 3a). During the event, the spatial average of PW remained above 46 mm, with positive anomalies PW' throughout the event, reaching almost 6 mm at midnight (Figure 4d). Interestingly, both PW and PW' exhibited a sharp increase since around 17:00LT, i.e. approximately 5 hours prior to the onset of precipitation (at around 22:00LT) in most of the weather stations in the region (Figure 3). A similar increase is noted in the convergence of the vertically integrated moisture flux (Qc), but starting an hour earlier (at around 16:00LT) than PW, reaching peak values at around 21:00LT. Finally, note that moisture anomalies in the mid and lower troposphere were positive prior and during the event, as suggested by the spatial average (over MER) of specific humidity at 850, 700 and 500hPa (Figure 4d). In particular, anomalies at 850 and 500hPa exhibit an increase around 17:00LT, with peak values at 850hPa at around 22:00LT, and the largest values at 500hPa by the end of the time window of the event. Thus, low-level moisture and winds were associated with an increase in the convergence of moisture and precipitable water over the area of interest, with a time scale of up to 5 hours between the onset of positive anomalies in moisture and the occurrence of the precipitation maxima.



**Supplementary Figure S4.** Fields of Outgoing Longwave Radiation (OLR) at 00:00LT from the CP simulations. The rectangle marks the "Mocoa Region" (MR) and the red dot the location of Mocoa. See Table 1 for naming conventions for each resolution and PBL scheme.



**Supplementary Figure S5.** Vertical cross-sections of reflectivity (shades) and vertical velocity (contours, purple (black) for positive (negative) values) at the latitude of Mocoa (first three rows, coordinates for longitudes in third row). First row: 1:00LT. Second row: 2:00LT. Third row: 3:00LT. Fourth row: maximum reflectivity at 2:00LT. Left column: dx = 4.0km. Right column: dx=1.33km. Black dot in maps of the fourth row show the location of Mocoa city, the thin rectangle represents the location of the vertical cross-sections, the outer rectangle is the MR, and black contours represent topography for each resolution. Convective elements tend to be narrower in the 1.3km simulation: the 32.5dBZ contour spans over substantially larger regions in the 4.0km simulation, of the order of twice the longitudinal length of the structures in the 1.3km simulations. The maps showing maximum reflectivity (**Figures S5d**, **h**) also show larger values over the mountains when dx = 4.0km. Finally, note that Figures S3d, h show that the model simulated organized linear-like convective structures in the vicinity of the convergence lines produced by the southwestward propagating perturbation in the lower levels of the troposphere (see e.g. **Figures 5 and 6**).



**Supplementary Figure S6.** Vertical profiles of virtual potential temperature (top), water vapor mixing ratio (middle) and meridional momentum (bottom). Spatial averages computed between latitudes 2.0°N and 2.46°N, along the vertical cross-sections in **Figure 11**.